SUPPLEMENT
VOLUME 1

Vepco

SURRY POWER STATION
UNITS 1 & 2

APPLICANT'S ENVIRONMENTAL REPORT

CENTRAL FILES

VIRGINIA ELECTRIC AND POWER COMPANY

DOCKETS 50-280 AND 50-281

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VIRGINIA ELECTRIC AND POWER COMPANY

APPLICANT'S ENVIRONMENTAL REPORT SUPPLEMENT

OPERATING LICENSE STAGE

SURRY POWER STATION

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OUTLINE OF SURRY ENVIRONMENTAL REPORT SUPPLEMENT

SECTION 1

OUTLINE OF SURRY ENVIRONMENTAL REPORT SUPPLEMENT

SECTION II

INTRODUCTION

By application dated March 20, 1967, and 28 amendments thereto, The Virginia Electric and Power Company (Applicant) applied to the U. S. Atomic Energy Commission for a license to construct and operate a nuclear power station on a site at Gravel Neck in Surry County, Virginia, to be known as the Surry Power Station. The station consists of two virtually identical pressurized water reactors supplied by Westinghouse Electric Corporation, each designed for a warranted power output of 2441 megawatts thermal (MWt) with an equivalent warranted gross output of 822.6 megawatts electric (MWe). Each unit is designed to be capable of attaining a maximum capacity of 2546 MWt, corresponding to a gross electrical output of 855.2 MWe. The design of Surry Power Station is based upon proven concepts which have been developed and successfully applied in the construction of other Westinghouse supplied pressurized water reactor systems recently authorized by AEC: eg., H. B. Robinson No. 2, Indian Point No. 2 and Diablo Canyon.

Each unit at Surry Station incorporates a closed-cycle pressurized water Nuclear Steam Supply System, a turbine generator and their necessary auxiliaries. The Reactor Coolant System for each unit consists of three loops, each loop having a steam generator, pump and two reactor coolant loop stop valves. Radioactive waste disposal systems, a fuel handling system and all auxiliaries, structures and other on-site facilities were designed and installed so as to curtail radiological releases to the environment to the lowest practicable limits.

This project is being constructed by Vepco with the assistance of its architect-engineer, Stone & Webster Engineering Corporation. Site preparation of both units began in December 1966. Unit 1 is currently 95% complete and the current construction schedule indicates that fuel loading for Unit 1 will be possible no later than April 1972, and that commercial operation can be attained in the early summer of 1972. The appropriate corresponding periods for Unit 2, which is 79% complete, are the late summer of 1972 and the latter quarter of 1972. The Surry Power Station will provide the additional base-load generating capacity required to enable the Applicant to meet projected system load conditions and reserve requirements of the public served by Vepco in Virginia, North Carolina and West Virginia.

I. INTRODUCTION

A. Location of the Facility

Surry Power Station is in Surry County, Virginia, on the south shore of the James River, on a point of land called Gravel Neck which projects into the James from the south, as shown in Figures I A-1 and I A-2. The coordinates are approximately 76°42' west and 37°10' north.

The region 20 to 30 miles southeast of the site is the urban area of Hampton, Newport News, Norfolk, and Portsmouth, Virginia. This area includes a major Atlantic Coast seaport and a U. S. naval base. The largest industry encompassed in the area is shipbuilding.

The regions immediately north and south of the site, except for the Williamsburg historical area, are principally rural and agricultural. The same is true to the west until one reaches the Richmond-Petersburg region. Richmond is an industrial center as well as the State capital, with chemicals and tobacco the two major industries.

There are several military and naval reservations within a twenty-mile radius of the site. Camp Wallace Military Reservation is north-northeast of the site; Fort Eustis Military Reservation is east of the site along the northern shore of the James River; a U. S. Naval Reservation including Cheatum Annex and Camp Peary, occupies a large portion of the land area north and northeast of the site between the James and York Rivers. The U. S. Naval Reservation is bordered to the east-southeast by the Yorktown portion of the Colonial National Historical Park. None of the aforementioned military installations are within a five-mile radius of the Surry site.

Jamestown Island, part of the Colonial National Historical Park, is on the northern shore of the James River some three miles to the northwest. The city of Williamsburg, seven miles north of the site, is a major national tourist attraction and educational center. The only manufacturing facilities located in or around Williamsburg and Jamestown are a synthetic fiber plant and a brewery employing 250 to 500 people each. There is relatively little agricultural production in James City County. The military reservations previously discussed represent a major source of employment in the area.

Adjacent to the site, on a contiguous island, is a State waterfowl refuge, with a public access road running through the site. Public parking and viewing points are provided by the State within the refuge.

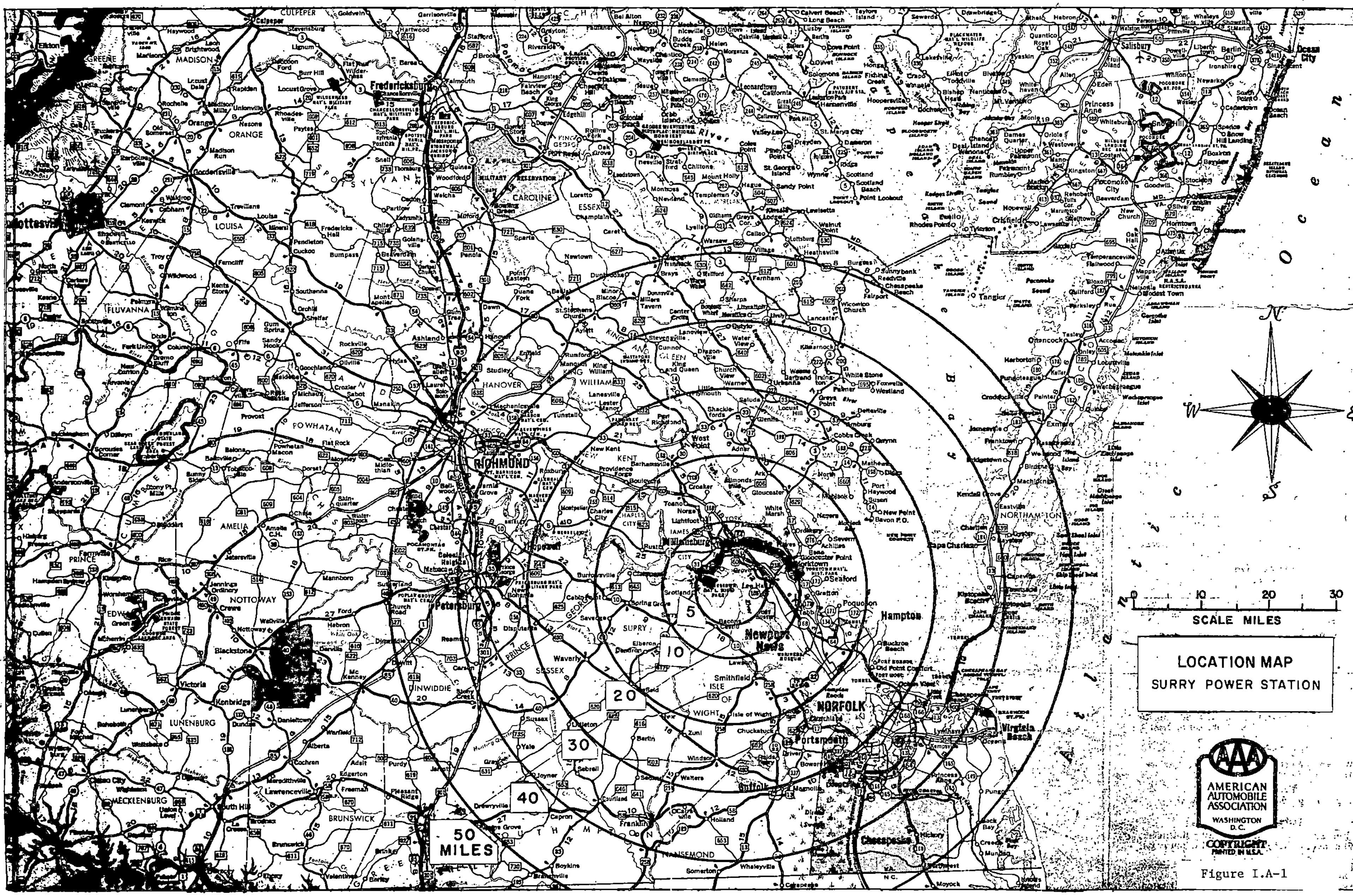
LOCATION MAP
SURRY POWER STATION
SCALE MILES
0 10 20 30
5
10
20
30
40
50 MILES
RICHMOND
Petersburg
Williamsburg
Newport News
Hampton
NORFOLK
Portsmouth
Suffolk
Virginia Beach
Fredericksburg
Chesapeake Bay
Atlantic Ocean
AMERICAN AUTOMOBILE ASSOCIATION
WASHINGTON D.C.
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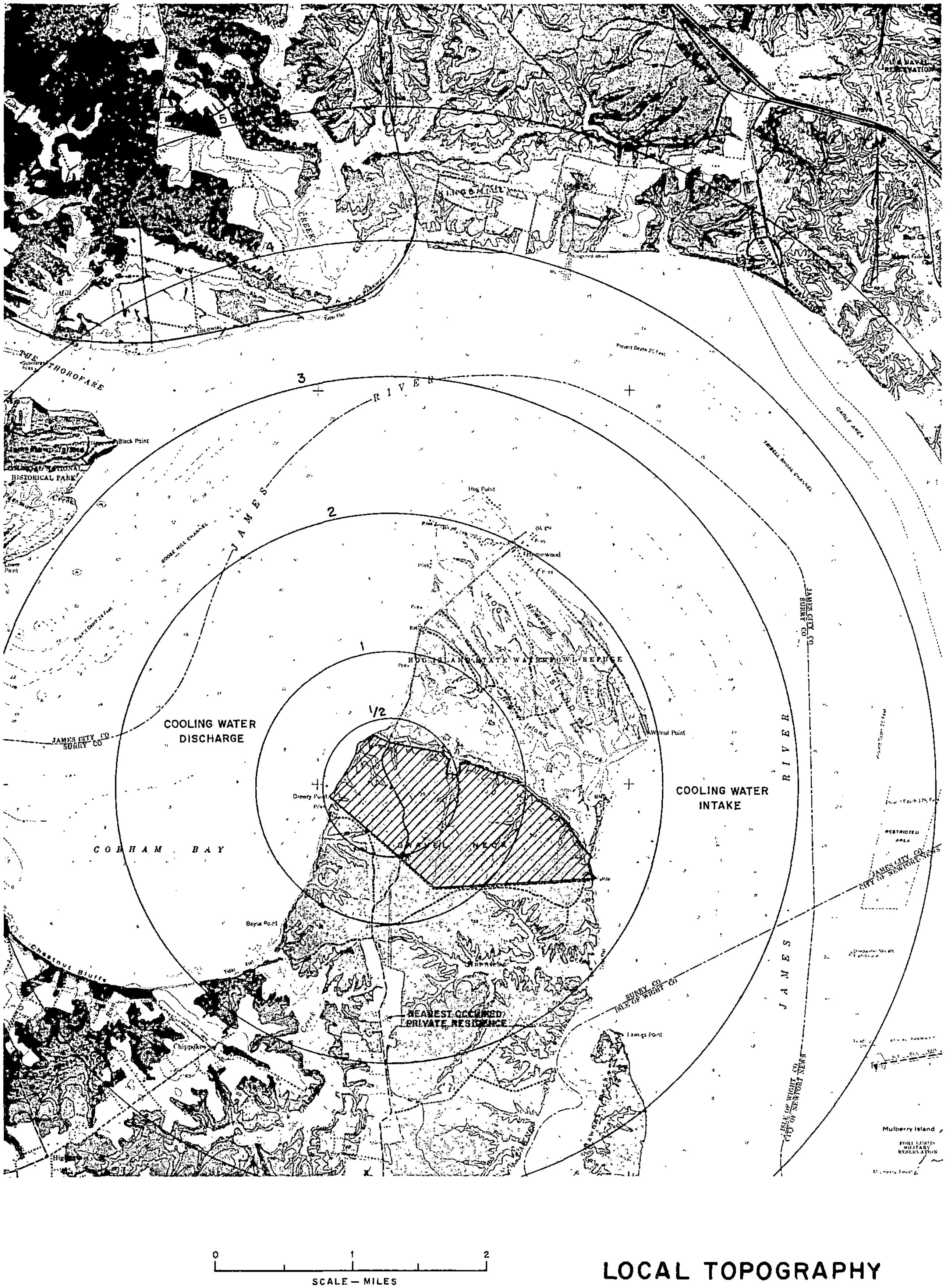
Figure I.A-1



LOCAL TOPOGRAPHY
SURRY POWER STATION

Figure I.A-2

B. Physical Characteristics of the Facility

The Surry Power Station consists of two virtually identical pressurized water reactors, each designed for a warranted power output of 2,441 megawatts thermal (MWt) with an equivalent warranted gross output of 822.6 megawatts electric (MWe). Each unit is designed to be capable of attaining a maximum capacity of 2,546 MWt, corresponding to a gross electrical output of 855.2 MWe.

The Reactor Coolant System consists of three loops, each loop having a steam generator, pump, and two reactor loop stop valves.

The reactor containment vessel for each of the Surry units is a domed structure of reinforced concrete with a steel innerliner. It is designed and constructed so that subatmospheric conditions will normally be maintained within the structure, thereby positively terminating out-leakage to the environment under normal operating conditions and within 40 minutes after the hypothetical "loss of coolant" known as the design basis accident.

The containment and the engineered safeguards together protect the public and the station in the event of a design basis accident. The engineered safeguards minimize the accident by performing three functions.

1. Supply borated water to the Reactor Coolant System to cool the core, decrease reactivity, limit fuel rod cladding temperatures and metal-water reaction, and ensure that the core remains intact.
2. Reduce the concentration of airborne fission products that can be released to the environment by leakage.

3. Limit the driving potential of differential pressure and the time duration for leakage out of the containment structure.

1. Nuclear Steam Supply System Operation

a. Reactor

The reactor core, the source of heat energy, is installed in a heavy wall steel pressure vessel which is connected to the reactor coolant system. Heat generated within the core is removed by the reactor coolant (water) which transfers the heat in turn to three steam generators before returning to the core. The reactor coolant system is a closed system contained within corrosion-resistant stainless steel components. The reactor vessel, reactor coolant system, and steam generators are enclosed within a reinforced concrete containment structure. This containment is maintained at pressures below atmospheric to ensure that leakage out of the containment will not occur during normal operations.

Heat which has been transferred to the steam generators is used to produce steam. Steam from each steam generator is piped to the turbine located in the turbine-generator building outside the containment structure. The exhaust steam from each turbine is cooled in a single-pass condenser. The residual heat from the steam is transferred to the James River as the steam is condensed to water in the condenser. This condensate is then returned to the steam generators for subsequent reuse.

Several events related to the brief description above may produce environmental effects. The necessity of removing heat from the condenser releases heat to the environment. Small amounts of radioactivity will be released from the nuclear steam supply system by required coolant sampling, maintenance, and control functions associated with reactor operation.

b. Radioactive Waste Disposal System

The Waste Disposal System includes the equipment required to collect, process, and prepare for disposal the radioactive liquid, gaseous and solid wastes which are generated by the station in the course of power operations with two units in service.

Liquid wastes are collected and then subjected to filtration, demineralization and/or evaporation as appropriate prior to discharge to the river. The sequence of processes used may vary depending on the activity concentration of liquid waste to be handled and will be selected to ensure that releases are as low as practicable. Evaporator residues and noncombustible solid wastes are drummed for off-site disposal as are combustible solid wastes that can be baled or drummed. The ultimate disposal will be at an authorized location off-site.

Gaseous wastes will be collected, processed to reduce the hydrogen concentration, and then held-up a minimum of sixty days in gas-decay tanks prior to controlled release to the environment.

A more detailed discussion of the various components of the Radioactive Waste Disposal System can be found in Appendix A.

2. Condenser Cooling Water System Operation

The circulating water system is designed to provide once-through cooling water for both units. The system is comprised of an inlet channel, an intake structure and pumps, a high-level intake canal, intake screen structure, once-through condenser, a sea-level discharge canal, and a rock groin mixing facility.

Circulating water is taken from the James River on the downstream side of the site, transported through the condensers, and discharged into the river on the upstream side. The shoreline distance between intake and discharge points is about 5.7 miles; the overland distance across the peninsula, about 1.9 miles.

Each unit requires 840,000 gpm of river water to supply condensing and service water needs. The maximum temperature elevation of this water as a result of passage through the condensers is 14°F. After passing through the station, the water is rapidly mixed with river water through a jetting action and heat dissipation occurs rapidly. Complete discussion of thermal effects produced on the water body is provided in the treatment of thermal effects in the text at ¶ II.I.C.2.c.(2) and in Appendix B.

Circulating water is withdrawn from the James River through a channel dredged in the riverbed between the main river channel and the eastern shore of the site, a distance of approximately 5,000 ft. The channel invert is 150 ft wide at El. -13.3, permitting use of the channel for shipping materials and equipment to the permanent dock on the east side of the site.

The circulating water intake structure is an eight-bay reinforced concrete structure located at the shore end of the river intake channel. The exposed deck of the structure is at El. +12; however, the pillbox enclosure for the service water pumps is protected from flooding to El. +21 and from wave run-up to El. +33.5. The invert of the intake structure is at El. -25.25. Each bay houses one of the eight circulating water pumps. These pumps are rated at 210,000 gpm at 28 ft total dynamic head when running at 220 rpm. Each pump is driven by a vertical, solid-shaft, 2,000 hp induction motor. Each pump discharge line is a 96 in diameter steel pipe which conveys the water over the embankment of and into the intake canal.

The intake canal is about 1.7 miles long and is designed to convey the circulating water flow for the station. The canal is lined with concrete for erosion protection and has an average bottom width along its length of 32 ft. The side slopes are 1 1/2 horizontal to 1 vertical. The invert elevation varies from El. +5 at the station end of the canal to El. +6.8 at the river end of the canal. The berm along each bank of the canal is at El. +36.0.

The water levels in the canal are controlled by the piping system friction losses within the power station and the prevailing river level. The normal water elevation at the power station end of the canal will vary between El. +21 and El. +23, depending upon the tide. A minimum freeboard of 10 ft is to be maintained between the canal water surface and the berm during hurricane flooding of the river thereby preventing any spillage from the canal. This freeboard is also adequate to contain surges in the canal which could occur with a loss of station power with the river flooded; it will be maintained under these circumstances by progressively reducing the number of pumps in operation by manual control as the river level rises above El. +5.0.

A reinforced concrete structure is provided in the canal at the intake of each power station unit. Each structure contains four bays, and each bay contains a trash rack, a traveling screen, and an inlet to a 96 in diameter condenser intake line which is made of reinforced concrete in the station yard and welded steel encased in concrete under the station.

Electric-motor-operated butterfly valves are provided at the condenser inlets for condenser isolation when required. An "Amertap" condenser tube cleaning strainer is installed in each of the four condenser discharge lines between the condenser discharge nozzle and the motor operated condenser discharge butterfly valves to maintain clean condenser tubes thereby eliminating the need for chemical injection. These discharge lines terminate at the reinforced concrete discharge tunnel, which then carries the water to the common circulating water discharge canal.

The discharge canal is designed to carry the flow of the two units with a velocity of about 2.2 fps at mean low water. The invert of the canal is at El. -17.5 and the sides slope at 2 horizontal to 1 vertical; this slope is stable under design basis earthquake conditions. The bottom width of the canal varies between 20 ft and 65 ft.

The discharge canal extends about 1,200 ft into the James River on the west side of the site and is lined with concrete to prevent erosion of banks and sub-surface soil. This extension has rock-filled groins along each side to minimize siltation and to provide the means to maintain a 6 fps terminal velocity of the discharge water. The opening between the groins is sized to ensure proper mixing with the river. A timber pile trestle having five 10-foot-wide bays, in which timber gates may be placed, extends about halfway across the opening in the groin. The timber gates may be installed in this structure using mobile hoisting equipment to reduce the net area of the opening between groins and thereby maintain the 6 fps terminal flow velocity for various operating conditions and when a unit is taken out of service.

The canals and supporting facilities have been constructed to function properly under accident conditions. In the event of complete loss of off-site power, the intake canal would contain enough water for 45 days emergency service water supply.

3. Switchyard and Transmission Lines Description

Surry Power Station is connected with the Vepco system at a transmission substation and switchyard on the site, across the intake canal from the turbine building (See Figure I.B.3-1). Major structures in this area are transformers, circuit breakers, electrical disconnects, and the "backbone" structures which are used to convey overhead high voltage lines from the turbine building to the substation.

The substation is divided into two switchyards. Electrical energy generated by Unit 1 at 22 kv is raised to 230 kv by the main transformer and delivered to the 230 kv switchyard. Electrical energy generated by Unit 2 at 22 kv is raised to 500 kv by the main transformer and delivered to the 500 kv switchyard. Figure I.B.3-2 is a single line diagram of the transmission substation for Surry Power Station.

The 230 kv switchyard is of the "breaker and a half" design with facilities for six 230 kv lines in service with Unit 1 and seven 230 lines in service with Unit 2. The 500 kv switchyard is also of the "breaker and a half" layout. Initially, when Unit 1 is placed in service, it will be connected to a single 500 kv line by one of the autotransformers. When Unit 2 is placed in service, the 500 kv substation will be expanded to a five position ring bus with connections to the Unit 2 generator, two 500 kv lines, and two 500/230 kv autotransformers.

With Unit 1, both 500/230 kv autotransformers are in service to supply reserve station power from the 34.5 kv tertiary windings. Initially one autotransformer is connected to the 500 kv and 230 kv systems and the other connected at 230 kv only, but, with the addition of Unit 2 the connection is completed to the 500 kv substation. The 500 kv and 230 kv systems are generally independent and provide alternate sources of reserve station power. The substation can be expanded for future units and lines as required.*

Station service transformers connected to the isolated phase bus from each main generator normally supply power to the auxiliaries of each unit at 4,160 v. During start-up and emergencies, reserve station service power for the auxiliaries of either unit is supplied from tertiary windings of two 500/230 kv transmission intertie autotransformers which connect the 500 kv and 230 kv sections of the substation.

Transmission system connections for Unit 1 consist of the following lines which are an integral part of the Vepco transmission system:

1. One 500 kv line to Elmont substation near Richmond, Virginia.
2. Two 230 kv lines to Hopewell substation near Hopewell, Virginia.
3. One 230 kv line to Suffolk substation near Suffolk, Virginia. It will connect to two 230 kv lines going to Vepco service area in North Carolina and one 230 kv line to the Norfolk area.
4. One 230 kv line to Churchland substation in Portsmouth, Virginia.
5. One 230 kv line to Newport News substation in Newport News, Virginia.
6. One 230 kv line to Whealton substation in Hampton, Virginia.

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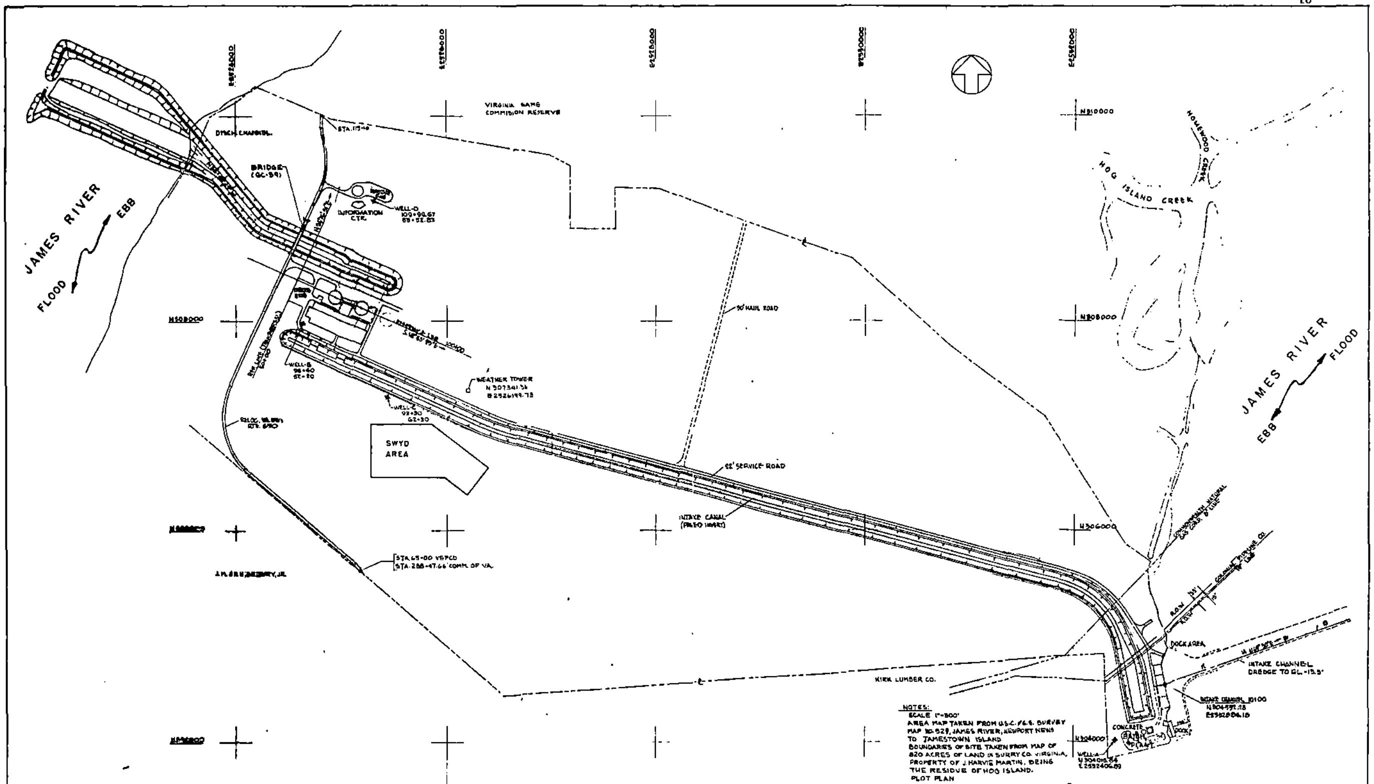
*Also located on the substation site adjacent to the 230 kv switchyard are two gas turbines with combined capacity of 41 MW, installed in 1970. These turbines, used to supply peaking power, are not related to the Surry nuclear facility and are located at Surry for area peak load capability. They have been located on a gas transmission line which passes conveniently through the site. (See Figure I.B.3-3)

Additional transmission system connections for Unit 2 consist of:

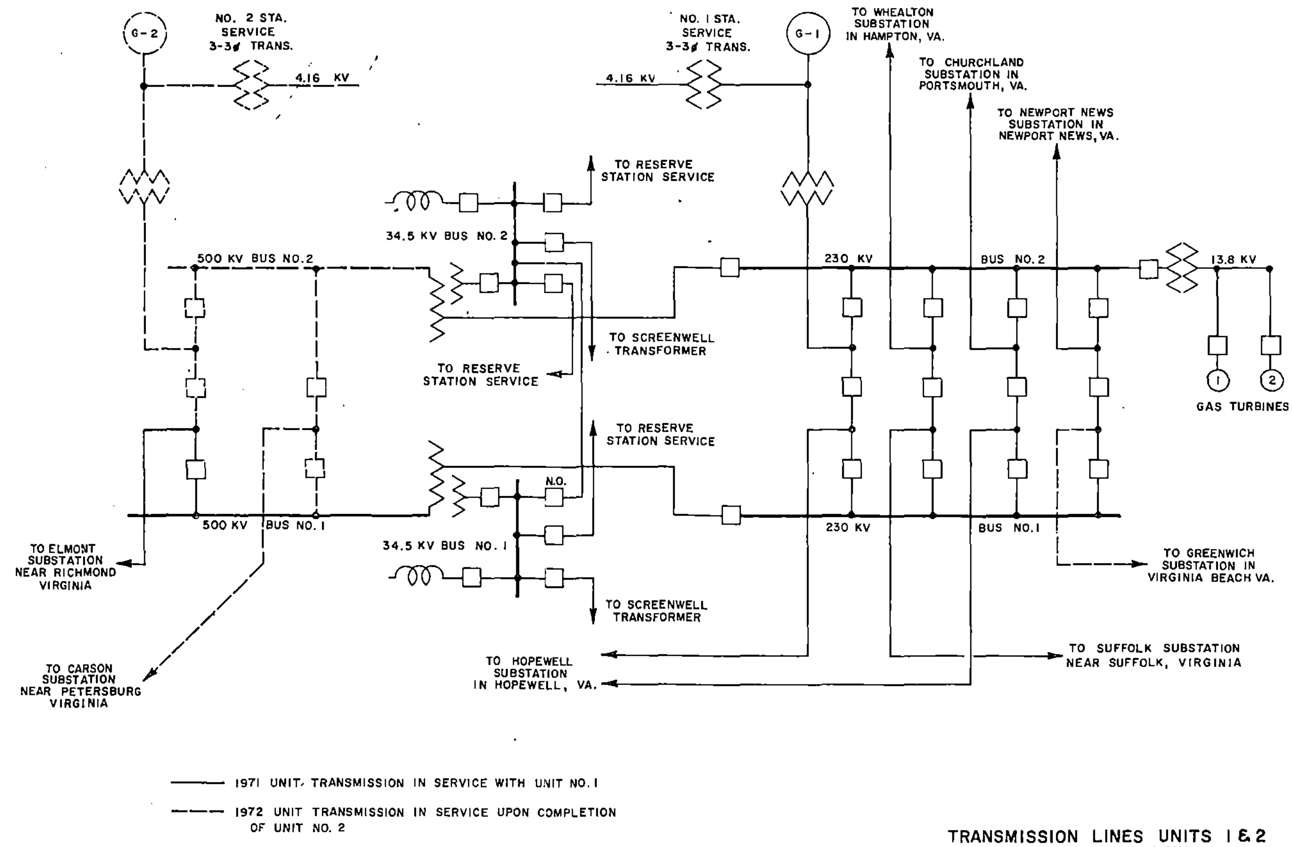
1. One 500 kv line to Carson substation near Petersburg, Virginia.
2. One 230 kv line to Greenwich substation in Virginia Beach, Virginia.

The transmission lines leave the high voltage substation along two main rights-of-way. Each right-of-way includes transmission lines which principally route toward east and west locations in the Virginia Electric and Power Company system. The transmission system can handle the full output of both units at Surry upon the loss of any two transmission circuits connected to the Surry substation. Figure I.B.3-4 is a location map showing Surry Power Station, the associated transmission lines, and their system connections.

Additional information relating directly to the environmental effects of Surry transmission is provided in the text at ¶ II.I.C.2.e. below.



SITE PLAN
SURRY POWER STATION
Figure I.B.3-1



TRANSMISSION LINES UNITS 1 & 2
SWITCHYARD ARRANGEMENT
SURRY POWER STATION

Figure I.B.3-2

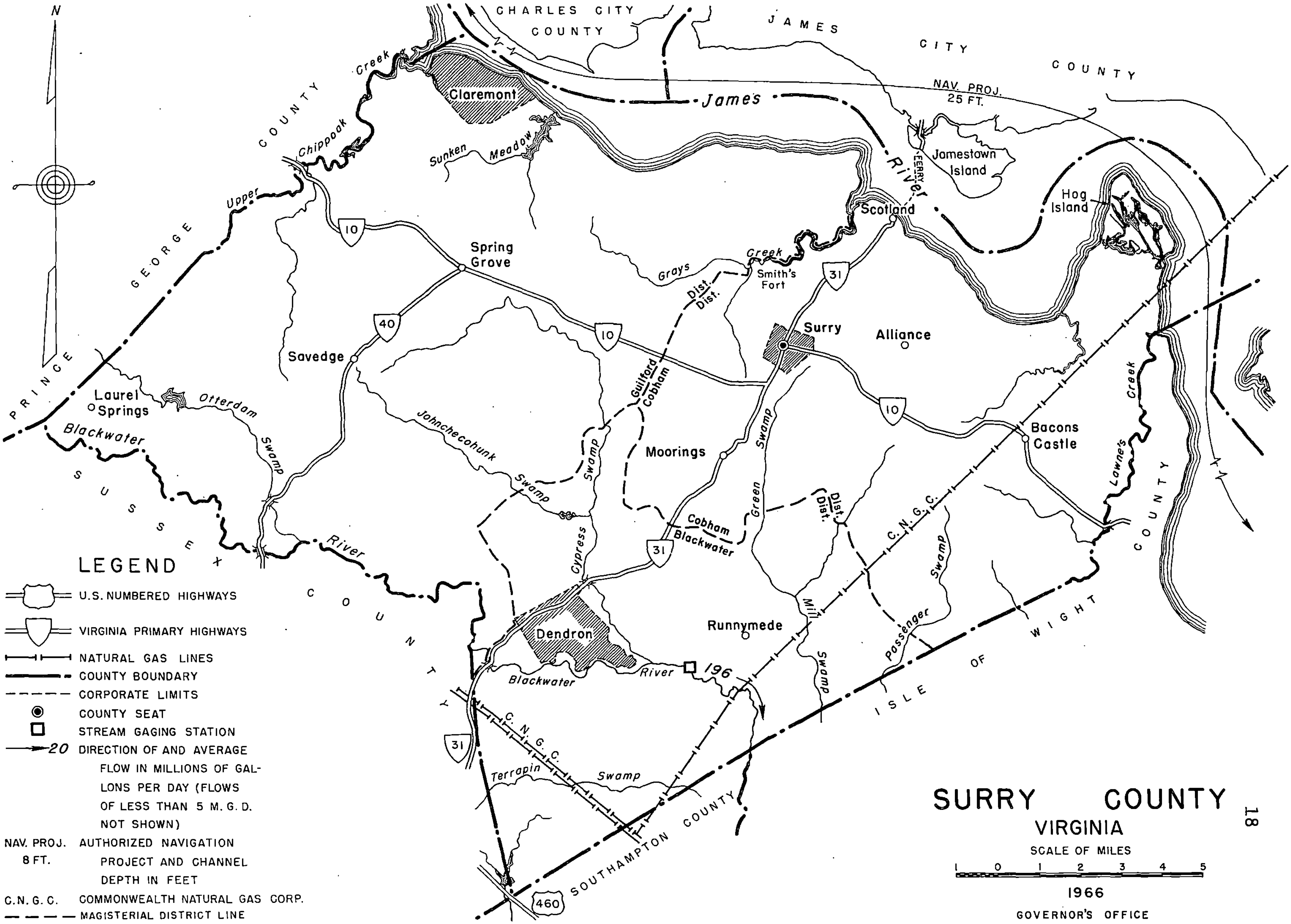
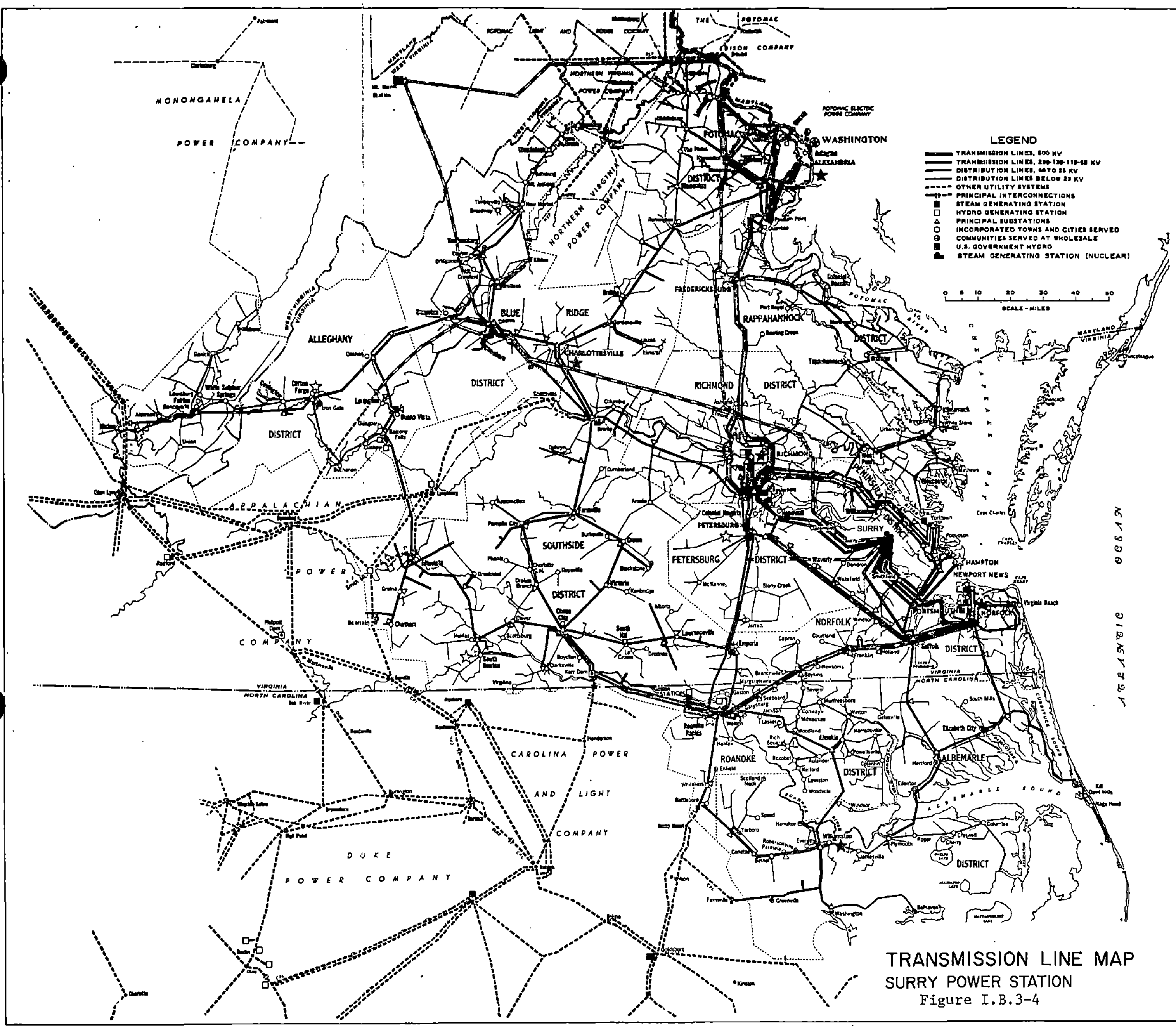

N
CHARLES CITY
COUNTY
JAMES
CITY
COUNTY
NAV. PROJ.
25 FT.
James
River
FERRY
Jamestown
Island
Hog
Island
Claremont
Chippoak
Creek
PRINCE
GEORGE
COUNTY
Upper
Sunken
Meadow
Scotland
Grays
Creek
Smith's
Fort
Dist.
Dist.
Spring
Grove
Surry
Alliance
Savedge
Guilford
Cobham
Laurel
Springs
Otterdam
Swamp
Blackwater
SUSSEX
COUNTY
River
Johnchecohunk
Swamp
Moorings
Green
Swamp
Cobham
Blackwater
Bacons
Castle
Lawne's
Creek
C.N.G.C.
Cypress
Dendron
Runnymede
Mill
Swamp
Passenger
Swamp
Blackwater
River
196
ISLE
OF
WIGHT
COUNTY
Terrapin
Swamp
SOUTHAMPTON
COUNTY
10
31
40
460
LEGEND
U.S. NUMBERED HIGHWAYS
VIRGINIA PRIMARY HIGHWAYS
NATURAL GAS LINES
COUNTY BOUNDARY
CORPORATE LIMITS
COUNTY SEAT
STREAM GAGING STATION
20 DIRECTION OF AND AVERAGE FLOW IN MILLIONS OF GALLONS PER DAY (FLOWS OF LESS THAN 5 M.G.D. NOT SHOWN)
NAV. PROJ. 8 FT. AUTHORIZED NAVIGATION PROJECT AND CHANNEL DEPTH IN FEET
C.N.G.C. COMMONWEALTH NATURAL GAS CORP.
MAGISTERIAL DISTRICT LINE
SURRY COUNTY
VIRGINIA
SCALE OF MILES
1 0 1 2 3 4 5
1966
GOVERNOR'S OFFICE
DIVISION OF PLANNING

Figure I.B.3-3



TRANSMISSION LINE MAP
SURRY POWER STATION
Figure I.B.3-4

4. Accident Prevention and Control System

There are three general categories of accident prevention and control systems which have been employed along with an extensive quality assurance program throughout construction. The first category is the personnel who operate the reactor. The reactor operators, who are trained in accordance with ANS-3, can detect problems before they reach the accident stage through redundant alarm systems. Continual surveillance of plant operations is fundamental to safe reactor operation and is instilled in the operators by constant drilling.

The second category of systems includes those mechanical and electrical systems designed to prevent or control accidents. The reactor protection and control system is installed to monitor, control, and respond automatically to abnormal conditions, and to cope with an emergency even without the assistance of the operator. All protection systems are redundantly installed to guard against potential failures of components or connecting wiring.

The third category of systems includes the inherent stability of pressurized water reactors resulting from negative reactivity coefficients that are characteristically present during operating conditions.

For more detailed discussion of accident prevention and control systems, see the discussion of accident effects at ¶ II.I.C.2.c. in the text below and Appendix A.

5. Miscellaneous Remaining Systems

The Surry facility contains several additional major systems essential to its functioning as a power plant, though they are not commonly associated with the plant's principal environmental effects. These systems are the fuel handling systems, turbines and auxiliaries, and electrical systems. They will be described in summary form here, with references to more complete treatment of the environmental effects with which they are indirectly associated.

a. Fuel Handling Systems

The reactor is refueled using equipment designed to handle spent fuel underwater from the time it leaves the reactor vessel until it is placed in a cask for shipment from the site. Transfer of spent fuel underwater permits the use of an optically transparent radiation shield, and provides a reliable source of coolant for removal of residual heat. Monitoring throughout the transfer process is achieved by underwater television specially designed for nuclear power plant applications.

b. Turbines and Auxiliaries

Each turbine is a tandem-compound, three element, 1,800 rpm unit having 44 inch last stage exhaust blading in the low pressure elements. Four combination moisture separator-reheaters are employed to dry and superheat the steam between the high and low pressure turbine cylinders for each unit. A single-pass, deaerating surface condenser installed in two sections, two 100% capacity steam jet air ejectors, three 50% capacity condensate pumps, two 50% capacity steam generator feedwater pumps, two auxiliary feedwater pumps, and six stages of feedwater heating are provided.

c. <u>Electrical Systems</u>

The main generator for each unit is an 1,800 rpm, 22 kv, 3 phase, 60 cycle, hydrogen inner-cooled unit. A main step-up transformer delivers power to the high voltage switchyard.

The Station Service System for each unit consists of auxiliary transformers, 4160 volt and 480 volt switchgear and busses, 480 volt motor control centers, 115 a-c volt vital bus, and 125 d-c volt batteries and equipment. The normal source of station service power is obtained from the main generator, and standby sources serving both units are available from the high voltage sub-station.

Emergency power is supplied by alternate sources, including one emergency diesel-driven generator for each unit and a third diesel-driven generator shared by both units. Each diesel driven generator is capable of operating post-incident containment recirculation spray pumps as well as charging pumps and low head safety injection pumps and other equipment essential in an emergency to ensure an acceptable containment pressure transient during design basis accidents.

C. Environment of the Area

1. Land Systems

a. Natural Aspects

(1) Geographic and Topographic

(a) Site Area

The location of the Surry Power Station is in Surry County, Virginia, on a point of land called Gravel Neck which juts into the James River from the south. The site comprises 840 acres south of and adjacent to the Hog Island State Waterfowl Refuge and is bordered by the James River on either side of the peninsula. The coordinates are approximately 76°42' W, and 37°10' N. The Atlantic Ocean lies some 40 miles east of the site. Figure I.A-2 above shows the site and the general topography over an area to a radius of about 50 miles. Greater detail of site topography is shown in Figure I.C.1-1.

The ground surface at the site is generally flat, with steep banks sloping down to the river and to the low level waterfowl refuge. Preconstruction elevations within the site boundaries ranged from river level to a maximum of 39 ft with a mean elevation of approximately +34 feet. Station ground grade has been established at an elevation of 26.5 feet above the USC&GS mean sea level datum at Hampton Roads, Virginia. Beyond the site boundaries, maximum land elevations within a 5 mile radius are generally in the range of 40 to 60 feet. Further away, the countryside is gently rolling, with few land elevations in excess of 200 feet within 50 miles. Much of the region is characterized by marshes, extensive swamps, small streams, and pocosins. Water tables are very near to the surface throughout the entire area, accounting for the large amount of surface waters.

Drainage throughout the area is toward Hampton Roads, on the Atlantic Ocean and near the mouth of the Chesapeake Bay.

(b) Surry Region

Surry County, in which the Surry Station is located, was formed in 1652 from James City County, the county where Jamestown, the first permanent English settlement, is located. Surry was named for Surrey County in England, although the "e" was dropped in the spelling of the American county. Surry lies just across the James River from Jamestown and was explored and settled early by the colonists. In 1609 Captain John Smith built a fort, Smith's Fort, on Gray's Creek, just north of the town of Surry. By 1623 there were 64 settlers living in Surry County - 31 of these were living on Hog Island.

Surry County, whose topography is representative of that of the whole Tidewater region, lies in the Coastal Plain bordering the James River. Its area consists of 280 square miles of land (179,200 acres) and 26 square miles of inland water. The surface is gently rolling or quite level, with some high points that rise about 93 feet above sea level in the eastern part of the county and about 120 feet in the western part of the county. Temperature averages 41° in January, 78° in July. Precipitation amounts to about 46 inches annually and is well distributed. About 76 percent of the land area is wooded, and production of pulpwood and lumber is an important business in Surry. Marl, clay, sand, and gravel are the only significant mineral resources. There are no significant mineral resources at the site.

Beyond the northern boundary of the site on Gravel Neck is Hog Island Waterfowl Refuge, a 4,285 acre tract on the James River set aside as a winter home for Canadian geese and other migratory fowl. On Blackwater River, northeast of

Dendron is the Heron Rookery Natural Area, a new sanctuary, recently donated to the State as a heron preserve.

The James River, which provides cooling water for Surry Power Station, comes together with the Nansemond and Elizabeth Rivers 25 miles downstream to form that part of Chesapeake Bay known as Hampton Roads. The Atlantic Ocean is some 40 miles east of the site. The James River drainage basin above the station is 9,517 square miles, contained wholly within Virginia.

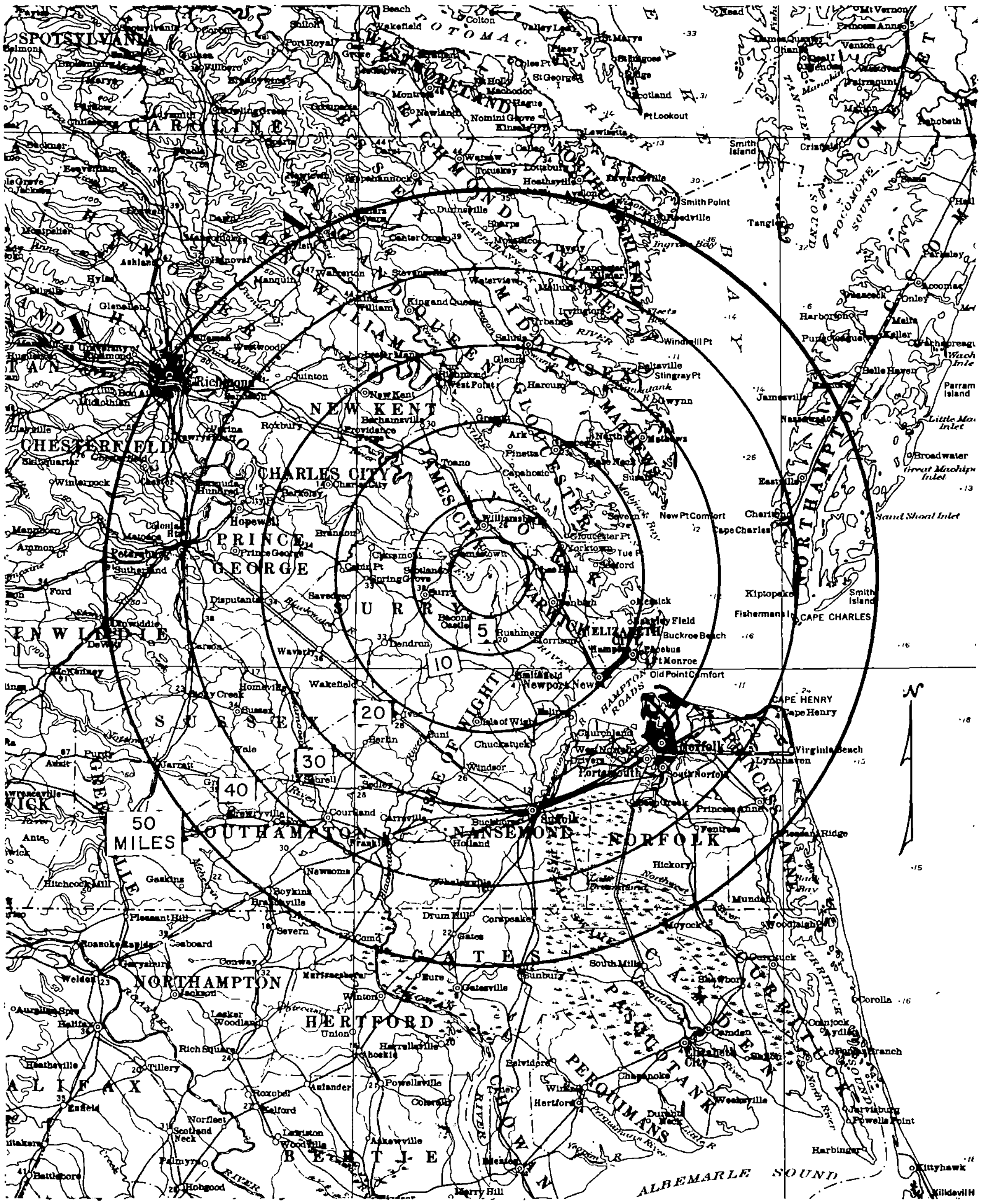
The climate of the area is a modified marine variety, primarily due to the proximity of the Atlantic Ocean and Chesapeake Bay. Winters are mild and short; spring and fall are usually very comfortable and summers are long, hot and humid, frequently tempered by cool periods associated with east and north-east winds off the Atlantic Ocean.

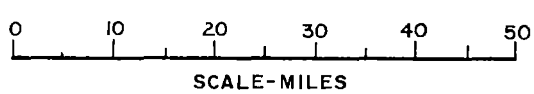
The area around the site receives a total annual average rainfall of approximately 46.0 inches. Tropical and subtropical storms frequently travel northward along the Atlantic Coast and 15 hurricanes or tropical storms were experienced during the period 1871 through 1963. Snowfall is scarce and dissipates rapidly because of relatively warm winter temperatures.

(2) <u>Geologic</u>

East of the Blue Ridge, Virginia may be divided into two broad physiographic units, the Piedmont Province and the Coastal Plain Province.

The Piedmont is essentially a bedrock plateau. Surface deposits are primarily





GENERAL
TOPOGRAPHY

SURRY POWER STATION

Figure I.C.1-1

residual soils derived from weathering of underlying bedrocks which are basically a complex of meta-sediments of pre-Cambrian and early Paleozoic age, with some areas of sedimentary and igneous rocks of Triassic age.

The boundary between the Piedmont and Coastal Plain Provinces, termed the Fall Line, extends from New Jersey to Alabama and passes through Richmond and Petersburg. Slow regional downwarping along the axis of the Fall Line began in early Cretaceous time, about 120 million years ago, and continued through Tertiary time.

South and east of the Fall Line, the Piedmont surface was depressed to a gentle downward slope until at Cape Henry it is about 2,800 feet below sea level. This downwarped surface formed a base on which Cretaceous and later sediments have been deposited in a general wedge-shaped mass, with individual members also being wedge-shaped and thickening toward the southeast. Based on regional data, these sediments are undeformed. They show no evidence of metamorphism and even the earliest are still essentially clays and sands. All available evidence indicates that, since early Cretaceous time, the crystalline basement beneath the Coastal Plain has been tectonically dormant. No faults are known or suspected on the site or in the vicinity of the site.

The surface of the Coastal Plain slopes gently in an east to southeast direction from about El. +200 at the Fall Line to sea level at the coast and thence out under the ocean. The slope is not uniform, but is characterized by essentially flat areas separated by gentle slopes of a few degrees which are termed scarps. The average slope in the region of the site is about 1.5 ft per mile.

During the progressive downwarping of the crystalline basement of the Coastal Plain, various portions of the area were above, at, or below sea level, with alternating periods of marine and continental deposition occurring. A columnar geologic section for the site area is shown on Figure I.C.1-2.

The morphologic boundaries of Gravel Neck are the James River on the west, north and east sides, and the Chippokes scarp to the south. This scarp is about five miles long, lies in a southeast-northwest direction, is 45 to 50 feet in height, and has a surface sloping downward toward the northeast at about 3 degrees.

In the site area, surface deposits are sediments of the Norfolk Estuarine Formation of the Pleistocene age, extending to depths of about 50 to 80 ft. The upper 20 to 35 feet of the Norfolk Formation consists of layers of brown and mottled brown sand, silty sand, organic and inorganic silts and clay. Interspersed are thin lenses of iron oxide cemented sands. The lower part of the formation consists of layers of gray sand, silty sand, and organic and inorganic silts and clays, many of which contain decayed vegetation and shell fragments. These most probably were deposited under estuarine, lagoonal and swamp conditions.

The Norfolk Formation unconformably overlies the Chesapeake Group of Miocene age. Upper Miocene, Pliocene and early Pleistocene deposits, which may have existed, have been removed by erosion. Within the site area, the surface of the Miocene sediments, estimated to be 240 ft thick, are found at elevation varying from 16 to 47 ft below mean sea level.

The Chesapeake Group (Miocene age) in the site area consists of compact, very stiff, tough clays green to dark gray in color, with occasional compact sand and silt members. Shell fragments are common. These soils are strong and stable with moderate to high shearing strengths. Underlying the Miocene sediments are Eocene, Paleocene, and Cretaceous sediments. These are estimated to be about 45, 55, and 800 feet thick, respectively, based on wells drilled in the general area. From seismic investigations about two miles southeast of the site, crystalline bedrock is estimated to be at a depth of about 1,300 ft.

The above analysis has been obtained through combined effort of Stone & Webster Engineering Company and Dames & Moore, Consultants in the Earth Sciences. Relative to site suitability for Applicant's use, Dames & Moore have considered the following:

"a. The Coastal Plain sediments at and in the vicinity of the site are undeformed. The younger strata in the stratigraphic section occur in simple layered sequence.

b. No fault is known or suspected at the site.

c. The Miocene sediments at the site will provide adequate foundation support for the proposed facilities.

d. The geologic conditions at and in the vicinity of the site are satisfactory for the construction of the proposed facilities."

In addition to these general investigations, Applicant has also established locations of natural radioactivity sources in the area. Routine water samples have been taken from the James River in the area of the station, where the river water is brackish. Basic sulfide and carbonate precipitation methods were used to analyze the water instead of simply boiling the water to dryness and counting the residue. During mid-1968, a sample from Cobham Bay had a carbonate activity of 20 pCi/liter. This was greater than other samples taken from the river.

To investigate possible causes, the beaches along Cobham Bay were explored. There are numerous locations where the high banks along the river have been wasted away, exposing outcroppings of the Yorktown formation which date from the Miocene Epoch (approximately more than 12 million years old). It seems that wherever the outcroppings exist, strata of a black, heavy, sand-like material are very abundant on the beaches in formations up to about one inch thick and several feet wide. Several samples of the black sand were taken and in addition, numerous fossilized whale bones which were also found in the area were taken. Gamma spectral analysis by Vepco indicated a relatively high Thorium-232 content in the black sand and a relatively high Uranium-238 content in the fossils.

In early 1969 a representative of Froehling and Robertson, Inc., of Richmond, Virginia took six (6) samples of the black sand and sent them to International Chemical and Nuclear Corporation for an analysis. The existence of Thorium-232 and its decay daughters was confirmed.

During the early part of 1969 a majority of the beaches along the James were explored in an effort to determine the extent of the black sand deposits. Deposits were found scattered all along the southern shore of Cobham Bay. Locations were also found at outcroppings on Burwell's Bay south of Hog Island. In addition, deposits were found on the north shore of the James, near Camp

Wallace, which is northeast of the station site.

In June 1969, a representative of the Bureau of Radiological Health, Department of Health, Commonwealth of Virginia was shown the deposits on Cobham Bay.

Since the sample of Cobham Bay water of 1968, other grab samples have varied from non-detectable limits up to 49 pCi/liter, with the majority below 10 pCi/liter.

(3) Seismologic

(a) Tectonics

The site is located in the Coastal Plain Physiographic Province. In Virginia, the province is bounded on the east by the Atlantic Ocean and on the west by the Fall Line and the Piedmont Physiographic Province. The crystalline basement rock crops out near the Fall Zone about 50 miles west of the site. From the Fall Zone, the basement surface slopes gently to the southeast and is overlain by Cretaceous and Tertiary sediments which are about 1,300 feet in thickness at the site.

The Coastal Plain sediments effectively mask the crystalline basement rock so that no faulting can be identified in the area. However, the available regional data and the geologic studies at the site indicate that the overlying Cretaceous and Tertiary sediments are essentially undeformed in the site area. The absence of folding and faulting in the exposed sedimentary strata of the Coastal Plain in the vicinity of the site indicates that any displacements along possible unknown faults have been negligible.

The closest known fault systems are found in the rocks of the Piedmont Province in central Virginia about 50 miles west of the site. The rocks of the Piedmont

Province generally consist of igneous and metamorphic materials of Precambrian and early Paleozoic age. Smaller areas of sedimentary and igneous rocks of Triassic age have also been mapped.

The geologic history of the Piedmont Province is complex. Major tectonic activity has occurred in the distant geologic past and many zones of major faulting have been identified. However, geologists believe there has been no significant orogenic activity since mid-Mesozoic Time, approximately 140,000,000 years ago. Most of the minor earthquake activity near the site can be related to known faulting in the Piedmont.

A possible fault was at one time postulated, trending northwest-southeast in the basement rock beneath the James River. This postulation is based upon anomalies in the contour of the base of Miocene sediments in the area. The data supporting this postulation are extremely limited and there are other probable reasons for the anomalies in the base of the Miocene, such as erosion of the surface on which the deposits were laid down. The thickening of the Eocene deposits, on which this postulation was made, has now been disproven and this postulated fault may be discounted.

(b) Seismicity

The site is situated in a region which has experienced only infrequent minor earthquake activity. The closest major earthquakes to the site, the Charleston earthquakes of 1886, (with a maximum epicentral intensity of IX), had their epicenters about 350 miles southwest of the site.* No shock within 50 miles

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*All intensity values in this report refer to the Modified Mercalli Scale as abridged in 1956 by Richter. The intensity scale is a means of indicating the relative size of an earthquake in terms of its perceptible effects.

of the site has ever been large enough to cause structural damage. Since the region has been populated for over 300 years, it is probable that any earthquake of moderate intensity, VI or greater, would have been reported during this period. It is very likely that all earthquakes with intensities of V or greater within the last 200 years have been reported.

Most of the nearer recorded earthquakes in the region have occurred in the Piedmont Province, west of the Fall Zone. The closest approach of the Fall Zone to the site is about 50 miles. These shocks are generally related to known faults in the Piedmont rocks. Several shocks have occurred in the Richmond, Virginia area, which is on the Fall Zone. This activity along the Fall Zone is consistent with similar occurrences both to the north and south of the site area. An earthquake which occurred near Richmond, Virginia, in 1875, is the largest reported earthquake within 100 miles of the proposed station. It is not possible to locate precisely the epicenter of this shock with the limited data available, but it is probable that the earthquake occurred just to the southwest of Richmond. It may be associated with some of the intrusions along the James River or the Triassic-Age Richmond basin. Based on the available damage reports and the area of perceptibility, we estimate that the epicentral intensity was about VI or VII. This shock was felt throughout most of Virginia and North Carolina. The main shock and an aftershock the following day were felt at Williamsburg, less than 10 miles from the site.

There have been some reported earthquakes in the Coastal Plain Province. These shocks are probably related to unidentified faulting deep in the basement rock beneath the Coastal Plain sediments. Most of these reported shocks were minor. However, there have been several moderate to large shocks with epicenters in the Coastal Plain, the largest of which was one of the Charleston, South Carolina earthquakes in 1886. We estimate the magnitude* "m" of the largest shock was about VII. The intensity of this shock in the region of the Surry site was about V or VI. This earthquake was most likely related to faulting in the basement rock near Charleston.

Another significant series of earthquakes in the Coastal Plain occurred near the northern New Jersey coast about 250 miles northeast of the Surry site in 1927. The maximum reported epicentral intensity of these earthquakes was VII. Three shocks were felt over an area of about 3,000 square miles from Sandy Hook to Toms River, New Jersey. Highest intensities were felt from Asbury Park to Long Branch, where several chimneys fell, plaster cracked, and articles were thrown from shelves. This shock has not been related to any known geologic feature, although there is some suggestion that they could be related to possible geologic structure associated with the Hudson River Valley to the north.

There have been small shocks in the Coastal Plain closer to the site. Few of these earthquakes caused any structural damage, and they are of interest only in that they indicate the possible presence of unidentified faulting in the basement rock beneath the Coastal Plain.

The closest reported earthquakes to the site were two small shocks, felt only at Suffolk, Virginia, on April 19, 1918. It is possible that these shocks were not of tectonic origin; however, if they were valid earthquakes, they could

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*Earthquake magnitudes in this section, designated by "m", refer to the magnitude scale developed by Richter. The magnitude scale is a means of indicating the size of an earthquake in terms of its total energy release.

indicate the presence of minor faulting in the basement rock close to the site. The locations of these and other earthquakes in the region surrounding the site are shown in Figure I.C.1-3.

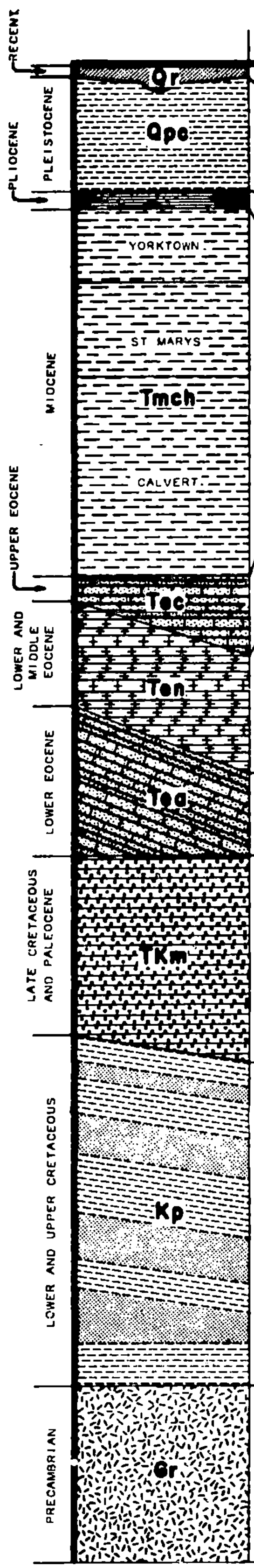
(c) Ground Acceleration

From the above discussion, it is apparent that the site is in a region of infrequent and minor seismic activity. It is estimated that its maximum horizontal particle acceleration at planned foundation levels at the site from the Design Basis Earthquake would be no more than about 15% of gravity. Vertical acceleration is assumed to be 2/3 of the horizontal value, acting simultaneously. The design basis analysis for determination of the above values is given in Chapter 2.5 of the FSAR.

Applicant has considered several associated effects. They include soil conditions, liquefaction potential, piling requirements for structure support, relative displacements, and stability of slopes and banks. A discussion of each is contained in Chapter 2 of the FSAR.

(4) Inventory of Natural Flora

Various shoreline segments of the Surry Power Station site consist of tidal marshes. Lower portions of the marshes, areas affected by normal tidal inundations, are discussed elsewhere in this report. In the higher, fresher, and less watery portions of these marshes, marsh elder (*Iva frutescens*), as well as the groundsel tree (*Baccharis halimifolia*) and the partridge pea (*Cassia fasciculata*), two flowering tracheophytes, are common, along with bush clover (*Lespedeza capitata*) above the shorter grasses and shrubs.



GEOLOGIC AGE AND DESCRIPTION	ORIGIN	DISTRIBUTION	WATER-BEARING PROPERTIES
Recent alluvium, beach and organic sediments such as found on Hog Island Waterfowl Refuge.	Deposited by ocean currents.	Thick deposits present only at Hampton	May yield a little water to shallow wells.
Pleistocene Columbia group. Consists of clays and sands that make up the surficial terraces. Marly strata are present in easternmost terraces only.	The higher westerly terraces are of continental origin, but the lower easterly terraces are of marine origin.	Exposed at the surface throughout the area.	Excellent water-bearing formation for domestic and small industrial supplies.
Bacon's Castle formation and Sedley formation of Pliocene age.	Sediments of Bacon's Castle formation are of fluvial origin. Sedley formation is of marine origin.		
The Chesapeake group of Miocene age consists of shell marl, dark-blue or gray clay, and subordinate sandy strata. The Yorktown formation is sandy and very fossiliferous. The St. Marys formation consists of tough blue or gray clays. The Calvert formation is diatomaceous and sandy but is less fossiliferous than the Yorktown formation.	Deposited in marine waters but may have extended inland some distance west of the present Fall Line.	Exposed in stream beds except at Hampton and lower Warwick, where it is concealed by younger sediments. The Yorktown and St. Marys formations crop out throughout the central and western area and the Calvert formation crops out along the Fall Line.	Yorktown formation yields small quantities of hard water to wells. St. Marys formation is not water-bearing. Calvert formation yields small to moderate supplies of water in many places. At Yorktown and in the lower peninsula area the water may be somewhat brackish.
Upper Eocene Chickahominy formation. Consists of gray marl beds containing glauconite and pyrite. Highly foraminiferal.	Deposited in marine waters.	Known from well cuttings at Yorktown, Camp Peary, Jamestown, Fort Eustis, Newport News, and Fort Monroe. Thins to a vanishing point before approaching the Fall Line.	Not a water-bearing formation at Yorktown. Some thin water-bearing sand beds in central part of the peninsula are probably Chickahominy formation.
Lower and Middle Eocene Nanjemoy formation. Consists of gray marl glauconite and quartz sand, and thin limestone beds.	Deposited in marine waters.	Typical exposure from the Fall Line to Williamsburg, but may be thinner or absent east of Williamsburg. Lower Eocene part of the formation thins to a vanishing point about 20 miles east of the Fall Line. Middle Eocene part may be quite thin in vicinity of Newport News.	Yields ample water for domestic supplies along the lower Chickahominy River and at the head of the York River. Water for industrial use is pumped at West Point.
Lower Eocene Aquia formation. Consists of glauconitic marl and basal quartz sand beds. Maximum thickness about 125 feet.	Deposited in marine waters.	Occurs along the Fall Line. Formation is exposed at the surface near Richmond. No unconformity with underlying Mattaponi formation.	Basal sands yield moderate supplies of water to wells in Hanover, Henrico, and western King William Counties.
Late Cretaceous and Paleocene Mattaponi formation. Consists of mottled clay, glauconitic sand and marl, and thick basal quartz sand.	Deposited in estuaries and bays.	Occurs at depth in central and eastern parts of the Coastal Plain as far west as the Fall Line.	A prolific water-bearing formation tapped by many domestic and a few industrial wells, notable at West Point and Newport News. The formation constitutes a vast reserve of fresh water in the central Coastal Plain. East of Williamsburg, the formation yields brackish water.
Potomac group of lower and Upper Cretaceous sands and clay beds.	Deltaic sediments deposited in fresh to slightly brackish waters.	The formation crops out in the vicinity of Richmond but lies beyond the reach of most wells a short distance east of the Fall Line (See plate 1).	The formation yields water to a few wells near the Fall Line but elsewhere it is not yet reached by wells.
Pre-Cambrian metamorphosed igneous and sedimentary rock. Granite.	Igneous intrusive rocks.	Crops out along the Fall Line except where Triassic units are present. Underlies entire Coastal Plain.	Yields small to moderate supplies of water to wells along or near the Fall Line.

COLUMNAR GEOLOGIC SECTION

SURRY POWER STATION

Figure I.C.1-2

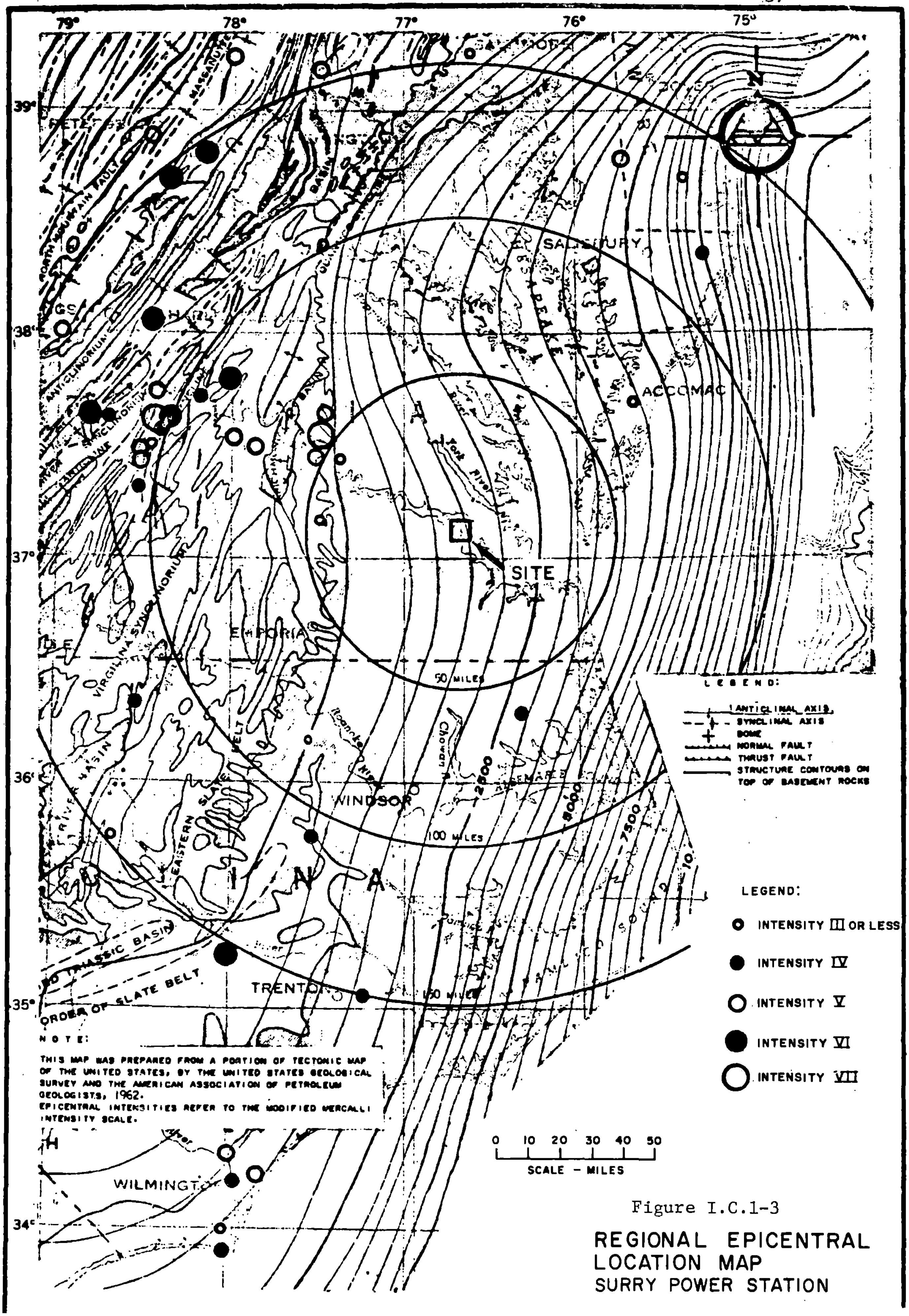


Figure I.C.1-3

REGIONAL EPICENTRAL LOCATION MAP
SURRY POWER STATION

Wax myrtle (Myrica cerifera) and buttonwood (Cephalanthus occidentalis) grade into pine and softwood forests on the higher inlands; occasionally they line the shore itself. (Wass, M. L. and Wright, T. D., Coastal Wetlands of Virginia, Virginia Institute of Marine Science, Gloucester Point, Virginia, December, 1969).

The general woodland type for the entire region and, more specifically, for the site of the Surry Power Station, is mixed pine and hardwood. The pine is predominantly loblolly (Pinus taeda) with a scattering of Virginia pine (Pinus virginiana) and shortleaf pine (Pinus echinata). White oak (Quercus alba) and post oak (Quercus stellata) constitute the bulk of the hardwood population, along with the red oak (Quercus rubra) and scarlet oak (Quercus coccinea). Completing the bulk of the biomass on the site, other merchantable species are hickory (Carya sp.), black gum (Nyssa sylvatica), red gum (Liquidambar styracilua), and red maple (Acer rubrum).

The primary understory species consist of dogwood (Cornus florida), sourwood (Oxydendrum arboreum), farkleberry (Vaccinium arboreum), and the American holly (Ilex opaca). Noteworthy is an individual I. opaca, 40 feet tall with a circumference of 10.5 feet, that was found on the southern edge of the Hog Island Wildlife Preserve property. This is believed to be the largest example of this species east of the Mississippi River. Particular care has been taken by the State to preserve this specimen although it is in an advanced stage of decay from insect infestation.

In a preliminary survey of the property before constructuion was begun, an interesting observation was made. Yellow poplar (Liriodendron tulipifera) and honeysuckle (Lonicera japonica), which are generally prevalent in the understory fauna of the Coastal Plain of Virginia, were almost nonexistent on this particular tract of land.

In nearby areas such as on the Chippokes Plantation site, cypress-gum swamps occur. They are characterized by growths of red cedar (*Juniperus virginiana*), black gum (*Nyssa sylvatica*), red ash (*Fraxinus pensylvanica*), and elm (*Ulmus* sp.). Along the river, in certain areas, one may see cypress (*Taxodium distichum*) growing abundantly at the water's edge.

(5) Inventory of Natural Fauna

(a) Birds

The immediate area surrounding the Surry Power Station site is composed of a variety of different avian habitats including tidal brackish marshes, non-tidal freshwater marshes, swamps, pine and softwood forests, hardwood forests, and cleared and fallowed fields. The overall region is located on the Atlantic Flyway, a north-south migratory bird route. This highly productive area, especially the Hog Island Wildlife Preserve, supports a diverse and stable resident and migratory avian population.

The Virginia game, inland fish, and dog Code (Virginia Code Titles X and XXIX) defines the area's non-migratory game birds as the grouse, bobwhite, pheasant, and wild turkey. Migratory game birds are identified as the dove, duck, brant, goose, swan, coot, gallinule, sora and other rails, plover, snipe, woodcock and yellowleg (Reprinted Articles from "Virginia Wildlife", May 1960. "Virginia's Game Birds", Virginia Commission of Game and Inland Fisheries, Richmond, Virginia).

The following Table I.C.1-1 is an annotated list of common names of birds that have been recorded in the area or whose known range includes the area surrounding the Surry Power Station site: (Murray, Joseph James, A Checklist of the Birds of Virginia. Virginia Society of Ornithology. 1952)

TABLE I.C.1-1

Greater Common Loon
Holboell's Red-necked Grebe
Northern Pied-billed Grebe
Gannet
Northern Great Blue Heron
Common Snowy Egret
Little Blue Heron
Black-crowned Night Heron
Eastern Least Bittern
Whistling Swan
American Brant
Blue Goose
Black Duck
American Pintail
Blue-winged Teal
Shoveler
Redhead
Canvasback
Lesser Scaup Duck
Oldsquaw
Surf Scooter
Northern Ruddy Duck
Lesser Red-breasted Merganser
Black Vulture
Northern Red-shouldered Hawk
American Marsh Hawk
American Peregrine Falcon
Eastern Pigeon Hawk
Eastern Bob White
Northern King Rail
Sora
Eastern American Oystercatcher
Eastern Piping Plover
Black-bellied Plover
Wilson's Common Snipe
Eastern Solitary Sandpiper
Western Willet
Greater Yellowlegs
American Know

Least Sandpiper
Sanderling
American Herring Gull
Laughing Full
Forster's Tern
Eastern Least Tern
Cooper's Hawk
Eastern Dowitcher
Semipalmated Sandpiper
Red-throated Loon
Horned Grebe
Atlantic Wilson's Petrel
Northern Double-crested Cornorant
American Common Egret
Louisiana Tricolored Heron
Eastern Green Heron
American Bittern
Wood Ibis
Canada Goose
Greater Snow Goose
Common Mallard
Gadwall
Green-winged Teal
American Widgeon
Wood Duck
Ring-necked Duck
American Greater Scaup Duck
Bufflehead
Eastern White-winged Scooter
American Black Scooter
American Common Merganser
Eastern Turkey Vulture
Northern Sharp-shinned Hawk
Eastern Red-tailed Hawk
Southern Bald Eagle
American Osprey
Northern Sparrow Hawk
Eastern Wild Turkey
Northern Virginia Rail

TABLE I.C.1-1 (Cont'd)

Northern American Coot
Semipalmated Ringed Plover
Northern Killdeer
American Woodcock
Spotted Sandpiper
Red-backed Dunlin
Stilt Sandpiper
Western Sandpiper
Great Black-backed Gull
Ring-billed Gull
Bonaparte's Gull
Northern Common Tern
Caspian Tern
Common Dovekie
Eastern Mourning Dove
North American Barn Owl
Eastern Horned Owl
Northern Short-eared Owl
Eastern Whip-Poor-Will
Chimney Swift
Eastern Belted Kingfisher
Southern Pileated Woodpecker
Southern Hairy Woodpecker
Eastern Kingbird
Eastern Phoebe
Eastern Wood Pewee
Tree Swallow
American Barn Swallow
Northern Common Raven
Fish Crow
Tufted Titmouse
Eastern Brown Creeper
Northern Carolina Wren
Wayne's Marsh Wren
Eastern Mockingbird
Eastern Brown Thrasher
Wood Thrush
Olive-backed Swainson's Thrush
Eastern Blue-Gray Gnatcatcher
Eastern Ruby-crowned Kinglet
Northern White-eyed Vireo
Southern Parula Warbler
Northern Black-throated Blue Warbler
Eastern Yellow-throated Warbler
Northern Prairie Warbler
Eastern Ovenbird
Maryland Yellowthroat
Hooded Warbler
European House Sparrow
Eastern Common Meadowlark
Orchard Oriole
Purple Crow-blackbird
Florida Crow-blackbird
Eastern Cardinal
Indigo Bunting
Eastern Red Crossbill
Ipswich Sparrow
Eastern Grasshopper Sparrow
Northern Seaside Sparrow
Eastern Chipping Sparrow
Eastern Fox Sparrow
American Royal Tern
American Black Tern
Northern Black Skimmer
Rock Dove
Eastern Yellow-billed Cuckoo
Southern Screech Owl
Northern Barred Owl
Chuck-Will's Widow
Eastern Common Nighthawk
Ruby-throated Hummingbird
Yellow-shafted Flicker
Eastern Red-bellied Woodpecker
Southern Downy Woodpecker
Northern Great-crested Flycatcher
Acadian Flycatcher
Prairie Horned Lark
Common Bank Swallow
Northern Purple Martin
Northern Blue Jay
Eastern Common Crow
Southern Carolina Chickadee
Northern Brown-headed Nuthatch
Eastern House Wren
Long-billed Marsh Wren
Catbird
Eastern Robin
Eastern Hermit Thrush
Eastern Common Bluebird
Eastern Golden-crowned Kinglet
Common Starling
Prothonotary Warbler
Eastern Yellow Warbler
Eastern Myrtle Warbler
Northern Pine Warbler
Western Palm Warbler
Louisiana Waterthrush
Eastern Yellow-breasted Chat
Southern American Redstart
Bobolink
Red-wing Blackbird
Rusty Blackbird
Eastern Common Cowbird
Eastern Blue Grosbeak

TABLE I.C.1-1 (Cont'd)

Eastern American Goldfinch	Eastern Song Sparrow
Red-eyed Eastern Towhee	Mississippi Song Sparrow
Eastern Savannah Sparrow	Atlantic Song Sparrow
Labrador Savannah Sparrow	White-throated Sparrow
Sharp-tailed Sparrow	Southern Swamp Sparrow
Northern Slate-colored Junco	Eastern Snow Bunting

The Department of the Interior, Bureau of Sport Fisheries and Wildlife has compiled a list of 101 species and subspecies of wildlife in the United States that are now threatened with extinction. There are 50 species of birds on that list, of which two occur in the area of the Surry Power Station. One species is the Southern bald eagle, Haliaeetus leucocephalus leucocephalus. It is of interest to note that a pair of bald eagles nested and reportedly hatched young on the Hog Island Wildlife Preserve in the spring of 1969. In the fall of 1971, two adults were still present on Hog Island. The other species is the American Peregrine Falcon, Falco peregrinus anatum. (Rives, W. C., 1890, A Catalog of the Birds of the Virginias. Proc. Newport Nat. Hist. Soc., Doc. VII, Newport, R. I. 100p.) Occupied nests were found near Cape Henry in 1946 (Auk, Vol. 63, p. 592). Described as "not uncommon on the Eastern Shore", there are four records of occurrences at Richmond with probable occurrences at sites between Richmond and the Eastern Shore.

(b) Amphibians

Amphibians, smallest in number of the five major classes of vertebrates, are intermediate in many characteristics between fish and reptiles; indeed, most amphibians must return to the water to reproduce. Because of the many brackish and freshwater swamps and marshes in the area surrounding the Surry Power Station, amphibians abound, with frogs and toads by far the most prolific.

The following Table I.C.1-2 is an annotated list of amphibians which have been recorded or whose range is in the area of Gravel Neck, Surry County, Virginia (Reprinted Article from "Virginia Wildlife", September, 1959. "A Checklist of Virginia's Mammals, Birds, Reptiles, and Amphibians", Virginia Commission of Game and Inland Fisheries, Richmond, Virginia).

TABLE I.C.1-2

Hellbender (Cryptobranchus alleganiensis alleganiensis)
Mudpuppy (Necturus maculosus)
Dwarf Waterdog (Necturus punctatus)
Greater Siren (Siren lacertina)
Two-toed Amphiuma (Amphiuma means)
Marbled Salamander (Ambystoma opacum)
Spotted Salamander (Ambystoma maculatum)
Red-spotted Newt (Notophthalmus viridescens viridescens)
Northern Dusky Salamander (Desmognathus fuscus fuscus)
Southern Dusky Salamander (Desmongnathus auriculatus)
Red-backed Salamander (Plethodon cinereus cinereus)
Slimy Salamander (Plethodon glutinosus glutinosus)
Wehrle's Salamander (Plethodon wehrlei)
Four-toed Salamander (Hemidactylium scutatum)
Many-lined Salamander (Stereochilus marginatus)
Eastern Mud Salamander (Pseudotriton montanus montanus)
Northern two-lined Salamander (Eurycea bislineata bislineata)
Three-lined Salamander (Eurycea longicauds guttolineata)
Eastern Spadefoot (Scaphiopus holbrooki)
Southern Cricket Frog (Acris gryllus gryllus)
Green Tree Frog (Hyla cinerea cinerea)
Pine Woods Tree Frog (Hyla femoralis)
Squirrel Tree Frog (Hyla squirrella)
Northern Spring Peeper (Hyla crucifer crucifer)
Little Grass Frog (Hyla ocularis)
Upland Chorus Frog (Pseudacris triseriata feriarum)
Brimley's Chorus Frog (Pseudacris brimleyi)
Eastern Narrow-mouthed Toad (Gastrophyryne carolinensis)
Bullfrog (Rana catesbeiana)
Carpenter Frog (Rana virgatipes)
Green Frog (Rana clamitans melanota)
Southern Leopard Frog (Rana sphenocephala)
Pickeral Frog (Rana palustris)
Southern Toad (Bufo terrestris)

(c) Reptiles

While the Age of Reptiles, the Mesozoic Era, ended about seventy million years ago, a diverse and hardy population of reptiles still exists. Virginia, and specifically the Gravel Neck Area of Surry County, contains habitats for representatives of two of the four reptilian orders: the turtles and the snakes and lizards. While amphibians are generally dependent upon water for at least part of their life cycle, reptiles are almost completely terrestrial (realizing, of course, that species such as the snapping turtle and water snake are occasional re-entrants to the water). Most reptiles are land breeders.

The following Table I.C.1-3 is an annotated list of reptiles which have been recorded in, or whose range includes, the area near the site of Surry Power Station (Reprinted Article from "Virginia Wildlife", September, 1959. "A Checklist of Virginia's Mammals, Birds, Reptiles, and Amphibians", Virginia Commission of Game and Inland Fisheries, Richmond, Virginia).

TABLE I.C.1-3

Common Snapping Turtle	Stinkpot
Eastern Mud Turtle	Spotted Turtle
Eastern Box Turtle	Northern Diamondback Terrapin
Eastern Painted Turtle	River Cooter
Red-bellied Turtle	Northern Fence Lizard
Six-lined Race Runner	Ground Skink
Five-lined Skink	Broad-headed Skink
Southeastern Five-lined Skink	Eastern Slender Glass Lizard
Brown Water Snake	Red-bellied Water Snake
Northern Water Snake	Queen Snake
Glossy Water Snake	Northern Brown Snake
Northern Red-bellied Snake	Eastern Garter Snake
Rough Earth Snake	Eastern Earth Snake
Eastern Hognose Snake	Southern Ringneck Snake
Eastern Worm Snake	Northern Black Racer
Rough Green Snake	Corn Snake
Black Rat Snake	Northern Pine Snake
Eastern King Snake	Eastern Milk Snake
Coastal Plain Milk Snake	Mole Snake
Southeastern Scarlet Snake	Northern Copperhead
Eastern Cottonmouth	Timber Rattlesnake
Canebrake Rattlesnake	

(d) Mammals

Despite man's dramatic alteration of the land over the last 350 years, the mammalian fauna in the immediate area of the Surry Power Station still retains its diversity. Most mammals can co-exist naturally with man in the rural environment. Important or dangerous species such as the mountain lion (Felis concolor couguar), and the timber wolf (Canis lupus lycaon), the American elk (Cervus canadensis), and possibly the bison (Bison bison bison) which was never common locally, had all been eradicated from the Virginia Coastal Plain by the year 1700.

Today, the popular index animal is the white-tailed deer (Odocoileus virginianus virginianus) which is fairly abundant in the area, feeding from the river's shore to the lowland swamps and marshes and on to the wooded uplands. The omnivorous black bear (Ursus americanus americanus) and the strictly carnivorous bobcat (Lynx rufus) are rare game animals which share similar habitats.

In Virginia, the otter (Lutra canadensis lataxina) is a threatened species although it is now making somewhat of a comeback. Partially because of the otter, mink (Mustela vison mink), weasel (Mustela frenata noveboracensis), and skunk (Memphitis memphitis nigra), the area has a stable rodent population.

The gray fox (Urocyon cinereoargenteus cinereoargenteus) abounds throughout the brush and forest habitats of the area. The red fox (Vulpes fulva) is extending its range, quite possibly as far east as southeast Virginia. They are important predators, especially in controlling varmints.

The opossum (Didelphis virginiana virginiana) occurs nearly everywhere. Undaunted by civilization, its habitats range from inland forests to marshes and swamps to farms and fields. It is both now and historically one of the most prolific mammal species. The opposum shares a similar habitat with the popular raccoon (Procyon lotor lotor).

The family Sciuridae--squirrels--are second only to the rabbit in number killed by hunters in the area. The range-extending woodchuck (Marmota monax monax), the abundant gray squirrel (Sciurus carolinensis carolinensis) and the common southern flying squirrel (Glaucomys volans volans) comprise the family.

The largest of the North American rodents, the beaver (Castor canadensis canadensis) was totally exterminated by man from Surry County in 1895. Reintroduced in the 1930's, the beaver has accomplished a spectacular comeback. Requiring streams of low gradient with a forested margin, typical of inland areas in Surry and nearby counties, the beaver and its dam aid in flood and silt control. (Virginia Academy of Science. "The James River Basin; Past, Present, and Future", Richmond, Virginia, 1950).

The rabbit is the most commonly hunted and killed game animal in Virginia. Probably more abundant than ever, the eastern cottontail rabbit (Sylvilagus floridanus mallurus) is likely now the only species of native rabbit in the area.

No other mammals in the area can equal the rats and mice in number of species or in number of individuals. Virtually every terrestrial niche has its complement. Comprising three families, rats and mice are the base food, either directly or indirectly, of nearly all predators. Oddly, in this manner and because of their role in insect control, the native rats and mice--family Cricetidae--are beneficial to man, despite certain nuisance habits. In all likelihood the white-footed mouse (Peromyscus leucopus leucopus) is the most abundant mammal in the region. Other cricetids recorded in the region are the rice rat (Oryzomys palustris palustris) which is found in fresh and brackish marshes, the golden mouse (Peromyscus nutalli nutalli) of which the James River marks the northern boundary of its range, and the meadow mouse (Microtus pennsylvanicus nigrans); the pine mouse (Pitymys pinetorum pinetorum) probably occurs. Along the water courses and in marshes, the economically important muskrat (Ondrata zibethica macrodon) is abundant, being most numerous in the sanctuary-managed tidal marshes such as the Hog Island Wildlife Preserve.

Little good can be said about the family Muridae, or introduced rats and mice. They are of the most unwanted of all mammals. Originally introduced from Europe, they live by preference in and about the haunts of mankind. However, in many parts, house mice are now established as a permanent part of the fauna of forests, fields, and marshes. The black rat (Rattus rattus rattus) may now be exterminated due to competition by the house rat. The roof rat (Rattus rattus alexandrinus) fared better and exists today in isolated abundance. The house rat (Rattus norvegicus) is very abundant in all settled parts of the region, as is the house mouse (Mus mustulus).

Perhaps the most insignificant and economically unimportant mammals in the region are the jumping mice or Zapodidae. The only local species is the sparse and irregularly distributed meadow jumping mouse (Zapus hudsonius americanus). Feeding solely on weed seeds and green vegetation, it is the only area mouse which truly hibernates in winter.

The rarely seen moles commonly occur throughout the region. Chiefly represented by the common mole (Scalopus aquaticus aquaticus), the very rare star-nosed mole (Condylura cristata cristata) may also be found. Nearly completely subterranean mammals, they are ecologically valuable as insect eaters and soil aerators.

Shrews are one of the few mammal groups which can be said to be wholly beneficial to man. An insectivorous species, they feed primarily on beetles and grubs found in decaying vegetative matter. Three species may be found locally; the long-nosed shrew (Sorex longirostris longirostris) which is relatively uncommon, the least shrew (Cryptotis parva parva) which is relatively common, and the short-tailed shrew (Blarina brevicauda) which, in a defined habitat, may outnumber even the mice.

Bats, the nocturnal flying mammals, are strictly insect predators. With few natural enemies, the presence of man has probably enhanced the numbers and range of bats. Six species commonly occur in the region. The little known brown bat (Myotis lucifugus lucifugus) and the long-eared bat (Myotis keenii septentrionalis) are similar appearing bats preferring natural or man-made structures for roosts. The silver-haired bat (Lasionycteris noctivagans) which is a migratory species, probably occurs briefly locally. The evening bat (Nycticeius humeralis) is a sparse inhabitant, preferring hollow trees to roost. The pipistrelle (Pipistrellus subflavus subflavus), a common species, prefers roosts similar to Myotis. The most abundant and widespread bat is the red bat (Lasiurus borealis borealis), a migratory species, which occurs in summer only and roosts under the concealment of leaves and trees and shrubs.

(e) Insects

Invertebrates by far surpass the vertebrates in numbers and diversity; arthropods, and especially insects, are unquestionably the most prolific. Many insect populations have been enhanced by man. Consequently, certain insects are regarded contemptuously as pests and carriers of disease. The common black widow spider (Latrodectus mactans), an arachnid, not a true insect, is the only arthropod lethal per se, to man that is actually recorded for the area. Another venomus spider with lethal capabilities, the brown recluse spider (Loxosceles reclusa), is presently extending its range and may occur in the area.

The class Arachnida contains spiders, ticks, and mites among others. With the above exceptions, spiders are generally beneficial; they abound in the marshes, fields, and forests, and through the buildings in the area. Ticks are disease carriers, notably of spotted fever. Several species occur abundantly. Chiggers (Eutrombicula alfreddugesi), a mite, abound in the underbrush.

Insects, in one manner or another, inhabit virtually every niche imaginable in the area. Several important orders include such insects as springtails (Collembola), silverfish (Thysanura), dragonflies (Odonata), cicadas and aphids (Hemiptera), beetles (Coleoptera), fleas (Siphonaptera), true flies and mosquitoes (Diptera), moths and butterflies (Lepidoptera), grasshoppers, crickets, cockroaches, termites and mantids (Orthoptera), wasps, bees, ants (Hymenoptera), and three separate orders of lice (Barror, D. J. and White, R. E., A Field Guide to the Insects of America North of Mexico, Houghton, Mifflin Co., Boston, 1970).

Of all the arthropods, and insects particularly, only a relatively few are deleterious to man. On Gravel Neck, perhaps the greatest insect pest is the mosquito. With over thirty species known in Virginia, at least two species (Aedes sollicitans and Aedes taeniorhynchus) are salt marsh breeders.

A variety of flies, notorious pests and disease carriers, occur; the common housefly (Musca domestica) constitutes about 90% of all flies that enter houses. Sand flies (Culicoides sp.), black flies (family Simuliidae), horse flies (family Tabanidae), marsh flies (family Sciomyzidae), and others are notoriously bothersome.

Three species of ticks are important pests of man and animals in the area: The American dog tick or wood tick (Dermacentor variabilis), the transmitter of spotted fever; the brown dog tick (Rhipicephalus sanquinius), and the lone star tick (Amblyomma americanum).

There are three important species of cockroaches in the area; the American cockroach (Periplaneta americana), German cockroach (Blattella germanica), and the oriental cockroach (Blatta orientalis).

The above are but a few of the more important and economically significant arthropods. Others, of course, are the bees, wasps, etc. with their role pollination, and the destructive grasshoppers, aphids, and termites. The larval stages of many moths and butterflies are tremendously destructive in the area. Many beetles are important factors in wood and tree destruction and decay.

Arthropods are vital participants in ecological cycles. They are a base and staple diet for many vertebrates. They are vital in plant reproduction and most exist benevolently and congruously with man.

Other invertebrates beside arthropods are significant terrestrial animals. Many of the lower, unsegmented worms exist, primarily in moist areas, although some are parasites. Snails and slugs (class Gastropoda) are common inhabitants. Annelids are represented by three classes: (Polycheata) - the tube worms; (Oligochaeta) - earthworms; and (Hirudinea) - leeches.

(6) Overall Terrestrial Ecological Balance

The land area surrounding the site of the Surry Power Station, with its diversity of flora and fauna, is typical of most areas in Coastal Plain Virginia. The overall ecological balance of the terrestrial system appears to be based on sound environmental relationships between flora and fauna and, hence, is good. An incident of overpopulation which was brought naturally back into balance will illustrate the point. Deer in recent years had surged dramatically in number; then, in the late summer of 1971, an epizootic caused by a virus killed about 35 deer in an overpopulated area of James City County across the river from the Surry site. Similar epizootics also occurred about the same time in other areas of Virginia and North Carolina.

b. Human Uses of Land Systems

(1) Population Patterns

(a) Permanent Population Densities

The population center nearest to the Surry Power Station is the city-county of

Newport News, whose nearest point is 4.7 miles southeast of the site boundary. Table I.C.1-4 below lists all the population centers of 25,000 population or greater within 50 miles from the site:

TABLE I.C.1-4

POPULATION CENTERS WITHIN 50 MILES OF SITE

Population Center	Direction From Site	Distance From Center of Site, Miles	1970 Census Population
Norfolk	SE	25.0	307,951
Richmond	NW	46.5	249,621
Virginia Beach	SE	45.0	172,106
Newport News	SE	17.0*	138,177
Hampton	SE	18.5*	120,779
Portsmouth	SE	20.0	110,963
Chesapeake	SE	45.0	89,580
Petersburg	W	40.0	36,103

*Nearest distance to high population density areas.

Distribution of the estimated 1966 population, as determined by field checking of homes in 16 directional sectors within a five-mile radius of the station location, is shown in Figure I.C.1-4. In addition to the population shown in this figure, there are approximately 200 summer residents distributed along the southern shore of the James River west of the site.

Figure I.C.1-5 shows the 1960 and the projected 1980 population in eight directional sectors within 50 miles of the station. The 1960 figures are based on the 1960 census populations of minor civil divisions and urban areas. The projected 1980 populations are based on projections performed by the Virginia Outdoor Recreation Study Commission, information provided by the Williamsburg Chamber of Commerce, and extrapolation of 1940, 1950, and 1960 census data. In 1970 the population of Surry County was 5,882. The State Division of Planning and Community Affairs has predicted that the county's population will decrease at an average annual rate of 0.5 percent and will reach 5,600 by 1980.*

(b) Transient and Military Populations

Local areas of interest and their distance and direction for the Surry site are as follows:

Jamestown National Historical Park	5 mi WNW
Jamestown Festival Park	6 1/2 mi WNW
Colonial Williamsburg	7 1/2 mi NNW
Yorktown National Historical Park	10 mi ENE
Fort Eustis	6 mi ESE
Smith's Fort	6 mi WNW
Chippokes State Park	3 mi WSW
Anheuser Busch (projected) Brewery	6 mi N

*Center Planning District Commission, Toward a Land Development Plan (August 1971), p. 43.

According to the Virginia State Travel Service, Jamestown Island National Historical Park had an annual attendance of 368,146 in 1968, 433,464 in 1969, and 601,824 in 1970. Over the period from 1964-1969 the attendance data indicates an average annual growth of 4.3%. Count is taken at the Jamestown Entrance of the Colonial Parkway which also carries some local commuter traffic. Peak attendance occurs in August with approximately 16% of the annual attendance occurring in that month. For purposes of projection to the year 1980 the Virginia State Travel Service count is used.

Jamestown Festival Park, according to the Virginia State Travel Service had an annual attendance of 411,158, 407,236 and 423,540 in 1968, 1969, and 1970 respectively. Peak attendance normally occurs in August with about 18% of the annual attendance at this time.

Colonial Williamsburg (1970 population of 9,036) had paid admissions of 765,716 in 1968 and 800,847 in 1969, with peak attendance occurring during the month of August. Smith's Fort (Rolfe-Warren House) had a 1968 attendance of 2,436 and a 1969 attendance of 3,562 for an increase of 46%, and the Surry Information Center at the Surry site has drawn 38,655, 40,564, and 49,200 in 1968, 1969, and 1970 respectively. This illustrates a marked annual increase since the facility was opened in late 1967.

Figures supplied by the Virginia State Travel Service indicate that Yorktown National Historical Park had an annual attendance of 189,563 in 1968 and 196,612 in 1969. Between 1964 and 1969 the annual attendance shows a growth rate of 3.5% per year. Yorktown National Historical Park also experiences peak attendance in August of each year with approximately 18% of the annual attendance occurring in that month.

The Virginia State Travel Service has surveyed the attendance of all the above tourist attractions since 1961. Since that time attendance at these attractions has shown an increase at an annual rate of 5-10% according to that source. Attendance figures of the National Park Service on the other hand, would indicate that a 5% per year growth is conservative. The attendance at the State and National historical and other tourist attractions is displayed on Figure I.C.1-6 for the year 1969 and for the year 2000. The year 2000 attendance figure is arrived at by assuming a 5% annual growth rate in attendance which is consistent with the observations of the Virginia State Travel Service and the National Park Service. Peak attendance can be reasonably assumed to occur in August with about 20% of the annual attendance occuring in that month.

In addition to the established tourist attractions, the State of Virginia has recently opened the Chippokes State Park 3 miles WSW of the Surry site. This park when completed will have facilities for camping, swimming, and boating in addition to other normal State park facilities. The park was opened in late summer of 1970, hence attendance figures are not reliable for estimating annual attendance. However, a comparable State park (Seashore State Park at Virginia Beach) had 584,000 visitors for the first 10 months of 1970 or an annual attendance of slightly less than 700,000. The estimated attendance for the Chippokes State Park is included in Figure I.C.1-6.

The Anheuser Busch Company is constructing a 2,000,000 barrel/year brewery six miles from the site on the north side of the James River. Construction is to be completed in 1971 and conducted tours are planned starting in 1972. Also planned at the brewery site is a Busch Gardens scheduled to open 3-5 years after the brewery is completed similar to others the firm has constructed in other parts of the country. Combined attendance is expected to eventually reach 1,000,000 visitors per year.

Fort Eustis, located six miles east-southeast of the Surry site has personnel assigned to it at the following average strengths:

Personnel assigned to Fort Eustis	13,313
Dependent wives living on post	1,500
Children and others, living on post	3,750
Total on post	18,563

Fort Eustis has in addition, a transient population consisting of students stationed temporarily at the training schools and reservists who take annual training at the Fort. The maximum transient strengths occur during the summer months. Based on data supplied by the Fort Eustis Public Information Office, the transient strength from April 24, 1970 to September 4, 1970 was 6,671. There are no presently known announced plans to change the manning of the post. The future of the Fort and its level of activity are dependent upon several factors, primarily the prevailing international military, political and economic situations. Therefore, it is not possible to accurately predict its permanent or transient population for the year 1980.

(c) Radiation Requirements and Population Distribution

In compliance with 10 CFR 100, Applicant has defined a restricted area, an exclusion area, and a low population zone for Surry Power Station. The restricted area, as shown in Figure I.C.1-7 is the area enclosed by the site boundary. The Applicant owns and controls access to this area and exposure of individuals to radiation in this area will be within limits established in 10 CFR 20. The boundary of the restricted area will be clearly posted to ensure that unauthorized personnel will not transgress the boundary.

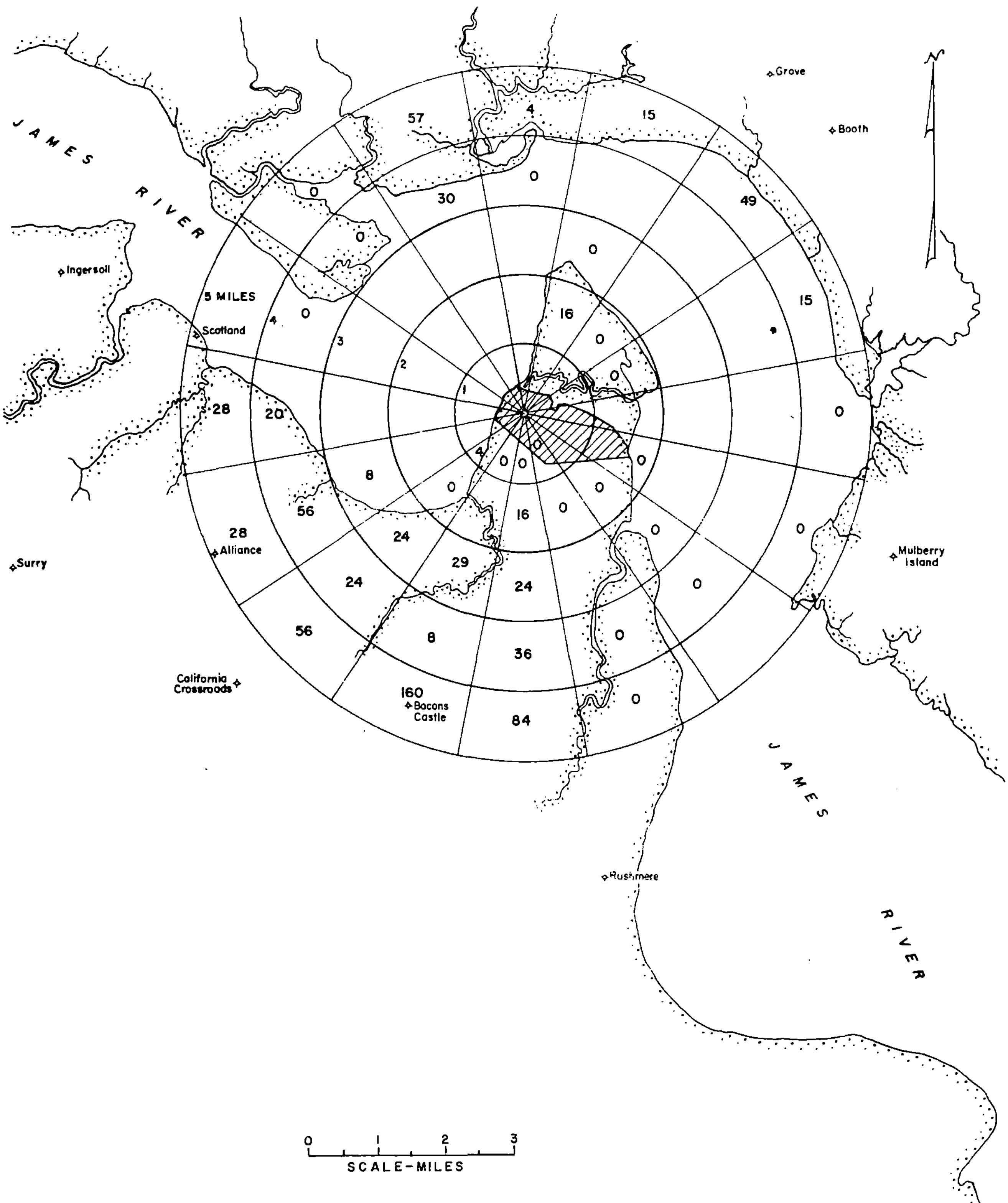
The exclusion area, as shown in Figure I.C.1-7, is bounded by a 1,650 ft radius circle centered at reactor containment building No. 1 and entirely on the facility site. The circle size was determined by the shortest distance to the site boundary and is sufficient, in conjunction with the plant design, to ensure that the dose limitations of 10 CFR 100 are met. The site includes more land than that indicated as the exclusion area, and it is entirely owned and under the control of the Applicant.

The low population zone, as shown in Figure I.C.1-7, is bounded by a three-mile-radius circle centered at reactor containment building No. 1. The nearest boundary of Newport News (the nearest densely populated center) is 4.7 miles and this distance, is known as the population center distance which is greater than one and one-third times the low population zone boundary distances as required by 10 CFR 100. In addition, the dose limitations of 10 CFR 100 are met with considerable conservatism.

(2) Land Use Patterns

(a) State, Regional or Local Land Use Plans

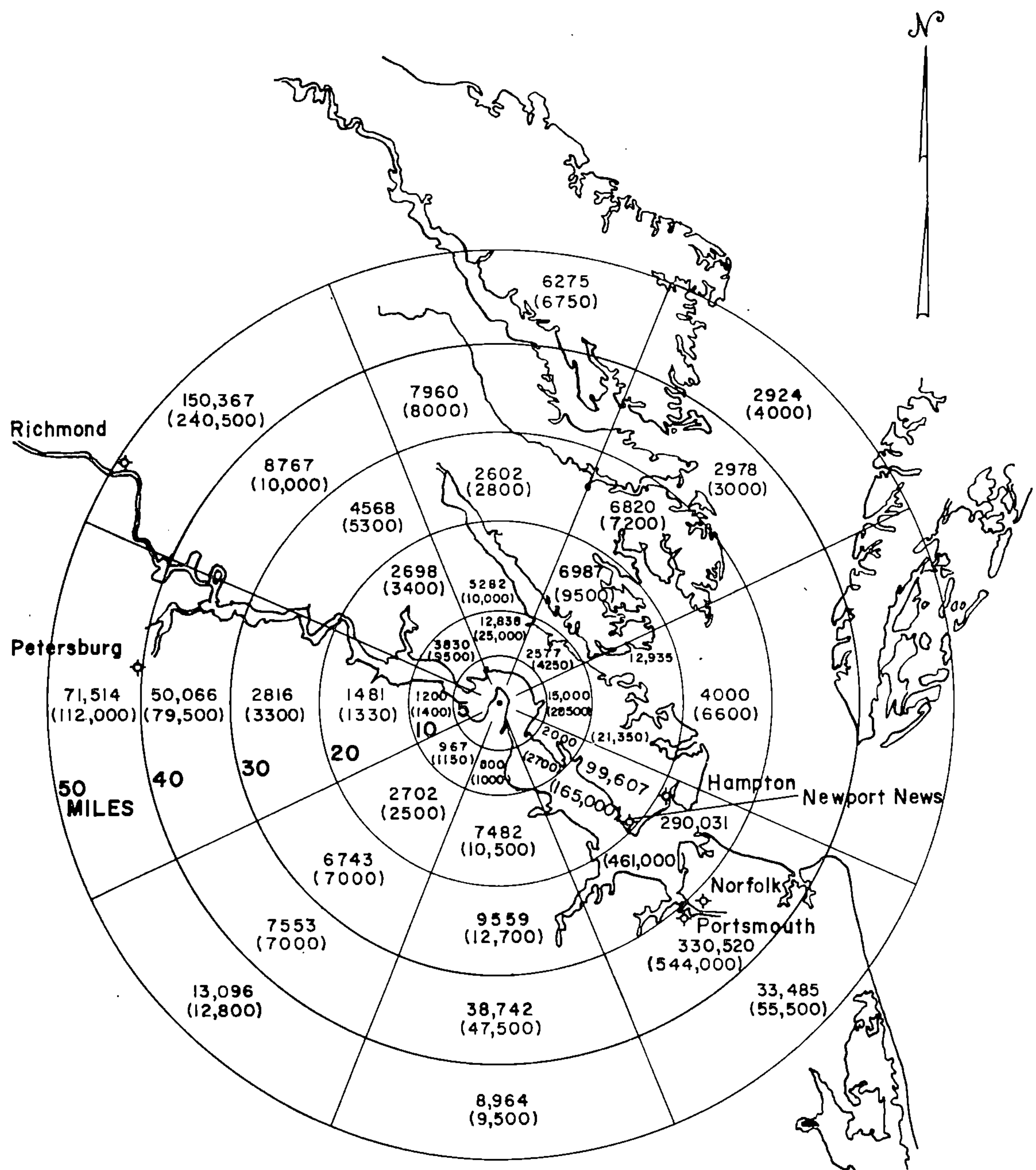
Surry County has been placed in Virginia Regional Planning District Number 19 (Crater District), which also contains the counties of Dinwiddie, Prince George, Sussex, and Greensville and the cities of Colonial Heights, Emporia, Hopewell, and Petersburg. Crater District has had board members appointed from each governing body and has recently appointed an executive director.



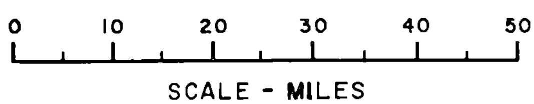
1966 POPULATION OUT TO 5 MILES

SURRY POWER STATION

Figure I.C.1-4



NOTE:
FOR DATA WITHIN 5 MILE RADIUS
SEE FIG. 2.1-4

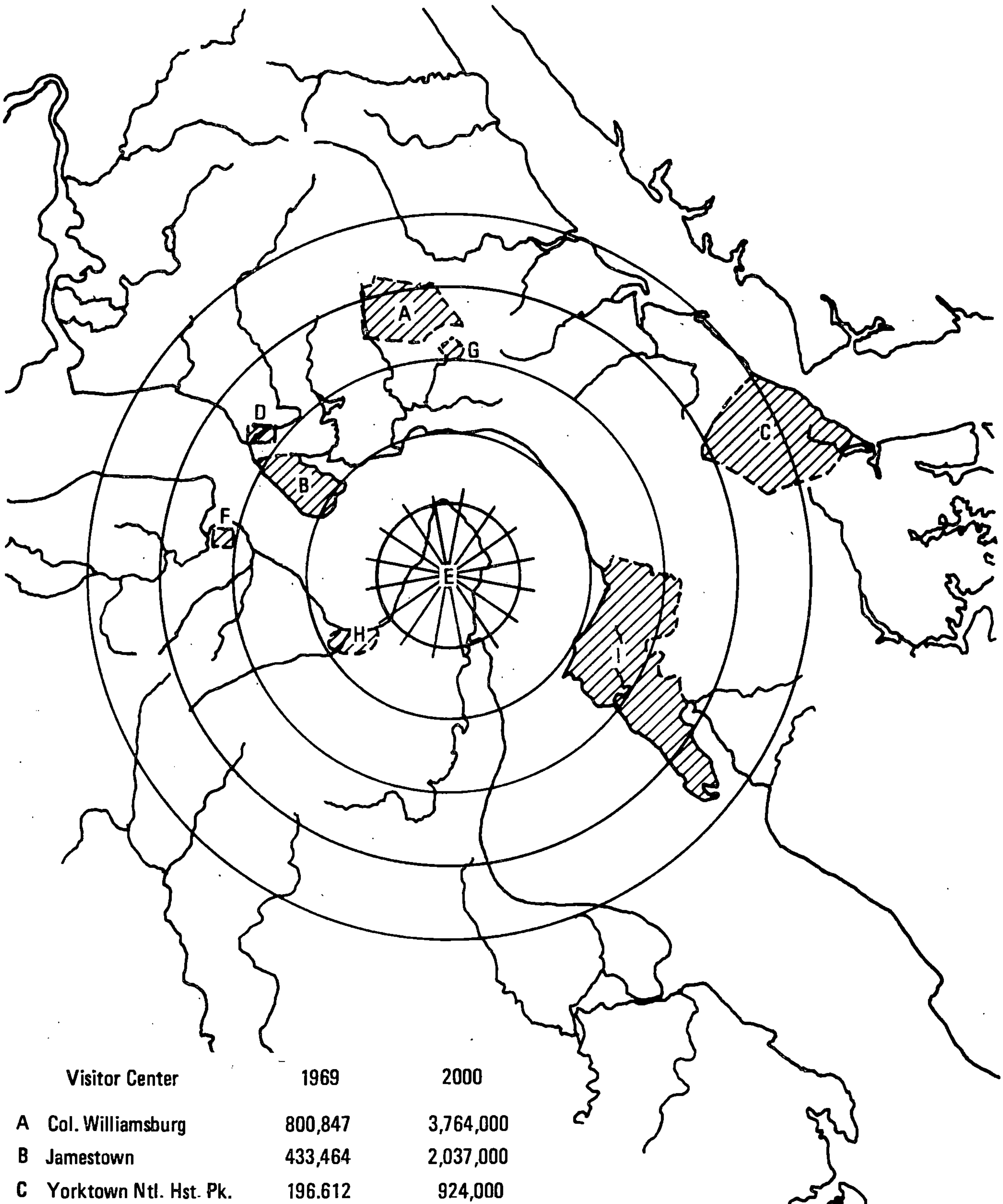


1960 AND PROJECTED 1980 POPULATION FROM 5 TO 50 MILES

(PROJECTED 1980 POPULATION FIGURES ARE IN PARENTHESES)

SURRY POWER STATION

Figure I.C.1-5



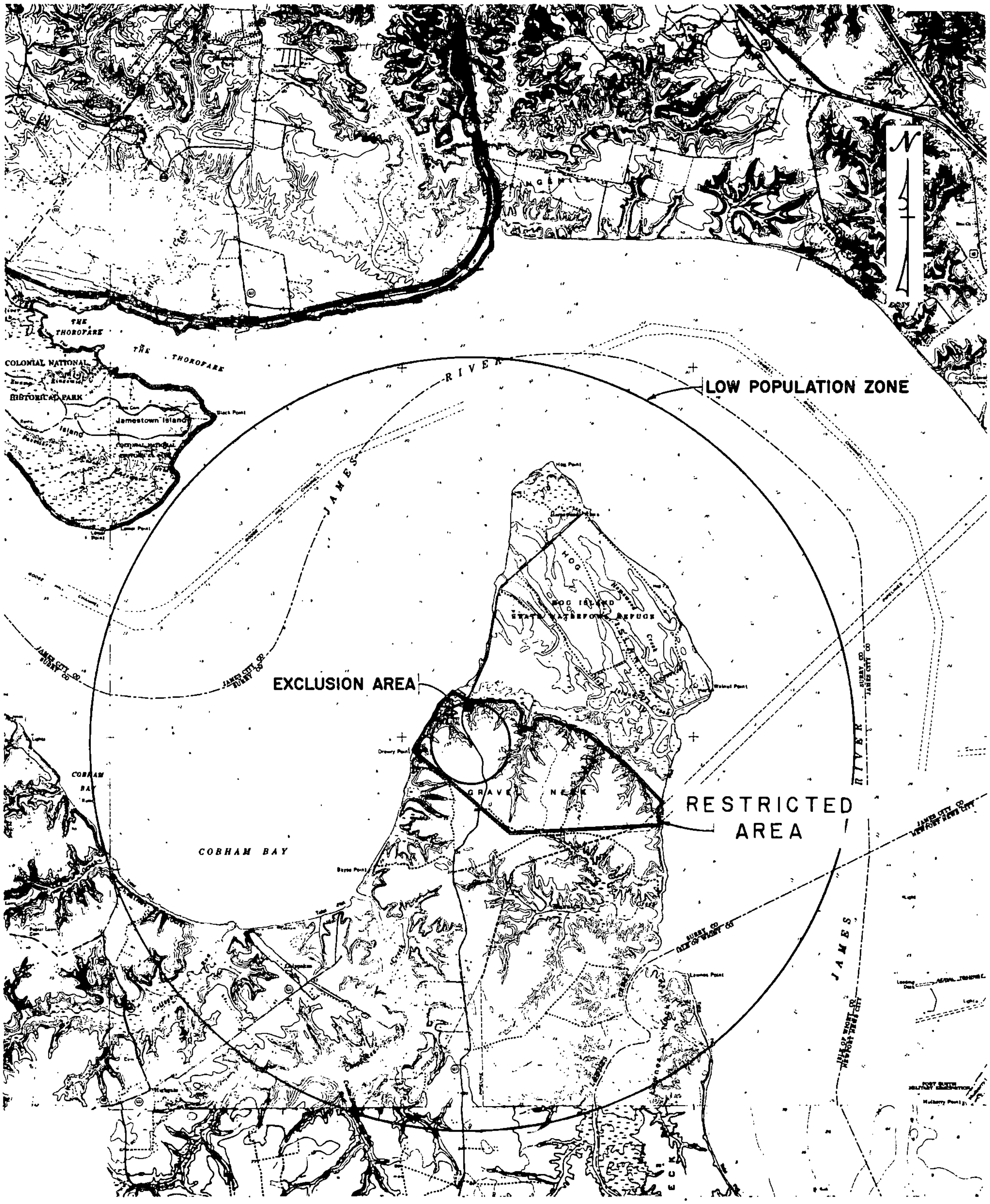
	Visitor Center	1969	2000
A	Col. Williamsburg	800,847	3,764,000
B	Jamestown	433,464	2,037,000
C	Yorktown Ntl. Hst. Pk.	196.612	924,000
D	Jamestown Fest. Pk.	411,158	2,035,000
E	Surry Info. Cntr.	40,564	190,600
F	Smiths Fort	3,562	16,700
G	Anheuser Busch	—	1,000,000
H	Chippokes Natl . Park	—	700,000
I	Fort Eustis	6,671	Not Available

Scale of Miles
0 2 4 6

1969 AND PROJECTED YEAR 2000
POPULATION MAP

SURRY POWER SITE

Figure I.C.1-6



LOCAL TOPOGRAPHY
SHOWING LOW POPULATION ZONE
RESTRICTED AREA
AND EXCLUSION AREA
SURRY POWER STATION
Figure I.C.1-7

Thorough factual studies have been completed (See Appendix D), but no overall plan has yet been developed in final form for the district. A preliminary map containing the rudiments of a suggested land use plan for Surry County has recently been drawn up by the district and is shown in Figure I.C.1-8. Its land-use projections and the Surry Power facility are not in conflict, however. Surry County has a local planning commission and an industrial development commission to attract new industry into the county. The county has no zoning ordinance, but in 1967 adopted subdivision regulations; however, these do not conflict with the plans for Surry Power Station. The only effects from the facility on land use will be indirect, in that the additional revenues generated from added local jobs and the approximately million-dollar annual increase in tax money should provide the capital necessary to carry out future State, Regional or Local land use plans.

(b) Transportation Facilities

Surry Power Station is located on Route 650 approximately seven miles north of Virginia State Route 10, the only major east-west State highway passing through Surry County. Route 650, a State secondary road, provides the only land access to the Surry facility. No railway lines or airport exist in the immediate area of the Surry Station.

The James River flows in an easterly direction past the northern end of Gravel Neck peninsula, on which the Surry site is located, and is navigable from Hampton Roads as far west as the City of Richmond. The U. S. government

A PRELIMINARY GUIDE FOR PLANNING AND DECISION-MAKING

BY GOVERNMENT/BUSINESS/INDUSTRY

THE PRELIMINARY LAND DEVELOPMENT PLAN FOR THE CRATER PLANNING DISTRICT DESCRIBED IN ABBREVIATED FORM ON THIS PAGE WAS PREPARED AND SUBSEQUENTLY ADOPTED ON SEPTEMBER 22, 1971, FOLLOWING CONCENTRATED STUDY BY THE CRATER PLANNING DISTRICT COMMISSION, A VOLUNTARY ASSOCIATION OF FIVE COUNTY AND FOUR CITY GOVERNMENTS, AS THE REGIONAL LAND DEVELOPMENT CONCEPT WHICH APPEARS TO PROVIDE THE MAXIMUM OPPORTUNITY AND POTENTIAL FOR ACHIEVING A BALANCED GROWTH IN RELATION TO THE PRELIMINARY DISTRICT DEVELOPMENT GOALS AND OBJECTIVES. THESE PRELIMINARY DISTRICT GOALS AND OBJECTIVES ARE SUMMARIZED BELOW:

GOALS

GOALS DEFINE WHAT IS INTENDED TO BE ACCOMPLISHED IN THE PREPARATION OF A COMPREHENSIVE LONG-RANGE PLANNING AND DEVELOPMENT PROGRAM FOR THE CRATER DISTRICT. SOME GENERAL GOALS INCLUDE:

1. DEVELOP AN EFFICIENT PATTERN OF LAND USAGE, INCLUDING BALANCED GROWTH AND DEVELOPMENT, THROUGH IMPROVED AND EXPANDED PUBLIC FACILITIES.
2. SECURE AND MAINTAIN A QUALITY OF LIVELIHOOD AND ENVIRONMENT THAT MEETS THE PHYSICAL, SOCIAL AND ECONOMIC NEEDS OF ALL RESIDENTS OF THE CRATER DISTRICT.
3. DEVELOP A STABLE ECONOMIC BASE PROVIDING A WIDE RANGE OF EMPLOYMENT OPPORTUNITIES AND AN ADEQUATE INCOME LEVEL IN ALL AREAS OF THE DISTRICT.

[illegible] GOALS ARE IDEALS TOWARD WHICH THE DISTRICT CAN STRIVE.

OBJECTIVES

OBJECTIVES ARE ESTABLISHED TO GUIDE THE PREPARATION OF MAJOR ELEMENTS OF THE PROGRAM FOR REGIONAL DEVELOPMENT AS WELL AS TO PROVIDE A BASIS FOR CONTINUAL PROGRESS EVALUATION.

OBJECTIVES MUST BE ATTAINABLE IF THEY ARE TO BE SUCCESSFULLY USED AS GUIDELINES FOR PROGRAMMING FUTURE GROWTH. IT IS THE PURPOSE OF THE FOLLOWING OBJECTIVES TO GUIDE THE DISTRICT'S GROWTH OVER THE NEXT TWENTY YEARS:

LAND USE
TO PLAN FOR A SYSTEMATIC RELATIONSHIP IN THE DISTRIBUTION, DIRECTION, AND PROPORTION OF LAND USES IN THE DISTRICT.

TRANSPORTATION
TO PLAN FOR THE DEVELOPMENT OF A COORDINATED, BALANCED TRANSPORTATION SYSTEM TO SATISFY FUTURE LAND USE REQUIREMENTS, LOCAL AND REGIONAL TRAVEL DEMANDS, AND SERVE AS A COORDINATED LINK WITHIN THE LARGER MULTI-REGIONAL NETWORK FOR THE FLOW OF PEOPLE, GOODS, AND SERVICES.

ECONOMY AND HUMAN RESOURCES
TO PLAN FOR THE ECONOMIC GROWTH THROUGH THE OPTIMUM USE OF EMPLOYMENT OPPORTUNITIES, AS WELL AS THE UTILIZATION AND DEVELOPMENT OF ECONOMIC RESOURCES.

PUBLIC UTILITIES AND FACILITIES
TO PLAN FOR THE STRENGTHENING OF THE QUANTITY AND QUALITY OF EXISTING AND PROPOSED PUBLIC UTILITIES AND FACILITIES THROUGHOUT THE DISTRICT.

PRIVATE FACILITIES
TO ASSIST PUBLIC AND PRIVATE AGENCIES IN THE INTEGRATION AND PROMOTION OF COMMERCIAL, RESIDENTIAL, AND INDUSTRIAL EXPANSION AND DEVELOPMENT.

EDUCATION AND CULTURAL
TO PROMOTE ADEQUATE EDUCATION AND CULTURAL OPPORTUNITIES FOR ALL CITIZENS TOWARD THE PREPARATION FOR A USEFUL AND GRATIFYING LIFE FOR EVERYONE

RECREATION AND OPEN SPACE
TO PLAN FOR THE PROTECTION, PRESERVATION, AND PROPER DEVELOPMENT OF THE DISTRICT'S NATURAL RESOURCES.

HOUSING
TO PLAN AND PROMOTE THE PUBLIC AND PRIVATE PROVISION OF ADEQUATE HOUSING FOR ALL CITIZENS OF THE DISTRICT.

LAW ENFORCEMENT
TO PROMOTE THE SAFETY OF ALL CITIZENS OF THE DISTRICT THROUGH A COMPREHENSIVE APPROACH TO LAW ENFORCEMENT, CIVIL DEFENSE, AND SAFETY PROGRAMS AND POLICIES.

COMPREHENSIVE HEALTH
TO PLAN FOR AND PROMOTE THE COMPREHENSIVE DEVELOPMENT OF ADEQUATE MEDICAL FACILITIES, MEDICAL CARE PROGRAMS, AND HEALTH SERVICES THROUGHOUT THE DISTRICT.

THE THEORIES AND THE METHODS OF REGIONAL PLANNING ARE USEFUL ONLY IF IN THE FINAL ANALYSIS THEY RESULT IN ACTION. A PLAN IS ONLY GOOD IF ITS GOALS, OBJECTIVES, AND POLICIES CAN BE IMPLEMENTED FOR THE BETTERMENT OF THE ENTIRE DISTRICT. THE ABOVE LISTED GENERALIZED PLANNING GOALS AND OBJECTIVES WILL ONLY BE USEFUL IF THE MEANS TO IMPLEMENT THEM IN RELATION TO THE PRELIMINARY LAND DEVELOPMENT PLAN ARE INITIATED.

AS AN INITIAL STEP TO BE TAKEN IN THE IMPLEMENTATION OF THE PRELIMINARY LAND DEVELOPMENT PLAN FOR THE CRATER PLANNING DISTRICT, THE GOVERNMENTAL UNITS OF THE COMMISSION SHOULD ADOPT THE PLAN. ADOPTION OF THE PLAN AND ADHERENCE TO THE GOALS, OBJECTIVES, POLICIES, AND RECOMMENDATIONS OF THE PLAN WILL AID TO ASSURE THE PLANNED AND COORDINATED GROWTH OF THE CRATER DISTRICT.

PURPOSE OF THE PLAN

THE COMMISSION IDENTIFIED THE NEED FOR ADOPTING A PRELIMINARY LAND DEVELOPMENT PLAN AT THIS TIME FOR THE FOLLOWING REASONS:

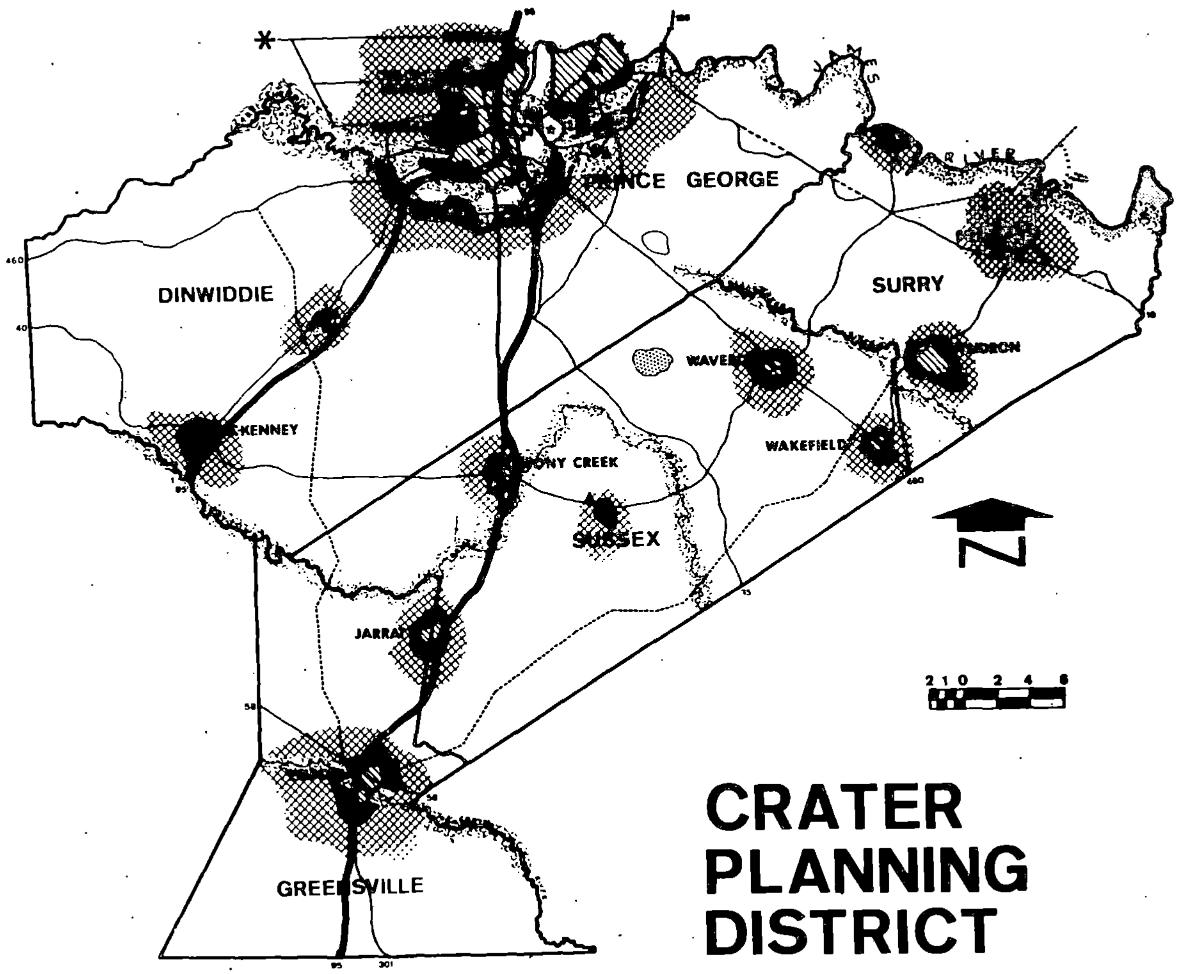
1. SERVE AS A DEVELOPMENT GUIDE FOR THE PREPARATION OF FUNCTIONAL PLANNING AND PROGRAMMING STUDIES FOR THE DISTRICT, INCLUDING WATER AND SEWER SYSTEMS, TRANSPORTATION, COMMUNITY FACILITIES, RECREATION AND OPEN SPACE.
2. SATISFY STATE LEGAL REQUIREMENTS FOR COMPREHENSIVE PLANNING ON A CONTINUING BASIS.
3. MEET FEDERAL CERTIFICATION REQUIREMENTS WHICH DIRECTLY INFLUENCE ANY LOCAL APPLICATIONS FOR GRANTS OR LOANS FOR WATER, SEWER, AND OPEN SPACE.
4. PROVIDE EACH MEMBER JURISDICTION AN OPPORTUNITY TO STUDY, DISCUSS, AND EVALUATE THE PLAN IN RELATION TO LOCAL PLANNING GOALS, OBJECTIVES, AND PROGRAMS.
5. FOR THE FIRST TIME, PROVIDE A COORDINATED, INTERRELATED APPROACH TO DECISION-MAKING BY THE LOCAL GOVERNING BODIES AND LOCAL AND REGIONAL PLANNING AGENCIES. ACTION-ORIENTED DECISIONS WHICH TRANSLATE PLANS INTO PROGRAMS WILL BE MORE INFORMED LEADING TO THE BEST USE OF TAX DOLLARS.

FEATURES OF THE PLAN

THE ADOPTED PRELIMINARY REGIONAL LAND DEVELOPMENT PLAN SEEKS TO CHANNEL NEW URBAN DEVELOPMENT RESULTING FROM AN ANTICIPATED INCREASE IN DISTRICT POPULATION INTO EXISTING AND PLANNED URBAN CENTERS. THESE CENTERS WOULD BE SURROUNDED BY PRESERVED OPEN SPACE TO FORM AN OVERALL PATTERN OF RELATED, BUT SEPARATE URBAN CENTERS. THE OPEN SPACE WOULD ACT AS A CONTAINMENT FOR URBAN SPRAWL AND WOULD AT THE SAME TIME OFFER THE URBAN CENTERS NECESSARY RECREATION, FARMING, CONSERVATION, OR PRESERVATION USES FOR THE LAND. COMMUNITY IDENTITY WOULD BE ENCOURAGED TO THE POINT OF SELF-SUFFICIENCY IN TERMS OF SUPPLYING PUBLIC SERVICES AS WELL AS PLANNED HOUSING, SHOPPING, AND EMPLOYMENT FACILITIES. THE PLAN FOSTERS THE URBAN SUBCENTERS TO BE INDEPENDENT SATELLITE CENTERS OF THE TRI-CITY METROPOLITAN AREA, EACH SUBCENTER HAVING ITS OWN SET OF GOALS, OBJECTIVES, AND IMPLEMENTING ACTIONS. THE PLAN WOULD FURTHERMORE ENCOURAGE THE DEVELOPMENT OF EXISTING AND PROPOSED TRANSPORTATION LINKAGES BETWEEN URBAN CENTERS AND THROUGHOUT THE ENTIRE DISTRICT.

COMMENTS INVITED

FOLLOWING REVIEW AND STUDY OF THE PLAN, YOU ARE SINCERELY INVITED TO SUBMIT ANY COMMENTS AND SUGGESTIONS TO THE CRATER PLANNING COMMISSION OFFICE AT 2825 SOUTH CRATER ROAD, BOX . 38, PETERSBURG, VIRGINIA, 23803, IN ORDER TO ASSIST THE COMMISSION DURING THE 1971-72 WORK-YEAR TO FURTHER REFINE AND EXPAND UPON THE PRELIMINARY GOALS, OBJECTIVES, AND PLANS FOR THE DEVELOPMENT OF THE CRATER PLANNING DISTRICT OVER THE NEXT TWENTY YEARS.



CRATER PLANNING DISTRICT

PRELIMINARY LAND DEVELOPMENT PLAN

1971 - 1991

- HIGH INTENSITY URBAN
- MEDIUM INTENSITY URBAN
- LOW INTENSITY URBAN
- WHITE RURAL AND AGRICULTURAL
- PUBLIC LAND
- ★★★ MAJOR INDUSTRIAL CENTERS
- ▲▲▲ MAJOR COMMERCIAL CENTERS
- ✱ REGIONAL METROPOLITAN CENTER
- WATER BODIES
- INTERSTATE HIGHWAYS
- MAJOR ROADS
- PROPOSED URBAN ARTERIALS
- PROPOSED BUFFER ZONES

Figure I.C.1-8

maintains a channel 25 feet deep and 300 feet wide in the vicinity of the station. The site borders on the James River on the east and west side of Hog Island and is easily accessible by a variety of water craft. A channel dredged on the east side of the island from near the intake structure to the 25-foot channel allows heavy equipment to be transported by water to the site. Service roads then connect to the plant, allowing all major equipment to be delivered to the reactor site without congesting the limited land routes available. No other means of transportation exist in the area.

(c) Other Present and Projected Land Use

(i) Commercial

Available statistics on retail, wholesale and service trades in Surry County show only a marginal increase in recent years. The economy of this county is basically agricultural and the buying pattern of county residents is to shop in nearby metropolitan areas such as Petersburg, Hopewell, Hampton Roads, and Newport News. The Surry station is not expected to alter significantly the existing commercial structure.

(ii) Industrial

The present limited industrial economy of the county consists of two sawmills and one meat processing plant. Each of these enterprises employs fewer than 50 workers and, according to Virginia Employment Commission statistics, wages range from \$1.60 to \$2.40 per hour. The Surry station will employ approximately 100 persons on a normal basis when both units are in operation. The resulting changes in the present local employment situation are expected to be minimal. A number of factors would seem to discourage massive industrial expansion in the county. These include a lack of transportation facilities, the depressed state of the present economic base, and the large percentage of untrained labor. It should also be noted that Tidewater industrial and governmental facilities employ most of the out-migrating workers in the county.

(iii) Agricultural

Surry is a rural county and agriculture is the principal industry. The sandy loam soil is well adapted to general crops. In particular, Surry is known for its peanuts and ranked sixth among Virginia's peanut-producing counties in 1970. In recent years hog production has increased and the county ranks sixth among Virginia counties in value of farm income from hogs. There is a ready market in the meat-packing houses of neighboring counties in this famous "Virginia ham" country. Soybeans and corn are also raised in rather large quantities. Some farms specialize in poultry, hogs, and cattle. Surry County's usable agricultural land is nearly saturated and no significant future expansion of agricultural production is foreseen. The land immediately bordering the site to the south is undesirable or unsuitable for farming. There are three dairy farms in the county, with a total of approximately 120 cows, and all three are located near Bacon's Castle. The dairy farm closest to the site is approximately 3.5 miles NNW on the northern shore of the James River.

The county has only about 600 persons involved full-time in agriculture. However, the economy is based on agriculture and Surry County farming operations are among the more prosperous in the state. Following the national trend, however, the number of agricultural operations in the county is expected to decline by about three (3) percent per year during the 1970-1980 decade. The Surry Station should have little or no effect on the agricultural sector of the economy.

(iv) Regional Demographic Structure

Surry County declined in population by 5.4 percent from 1960 to 1970. Total population in 1970 according to figures from the U. S. Census Bureau was 5,882. This trend is not expected to change appreciably during the next ten years. (Population may move up slightly as a result of some in-migration and natural increase). Surry County, the slowest growing area within Planning District 19, is projected to increase only to 7,400 by the year 2020. The Virginia Division of Planning and Community Affairs believes that the Surry Station will not effect the population appreciably.

The closest dwelling to the facility, presently used only as a part-time summer cabin, is 0.6 miles SW of the nearest reactor containment. The nearest currently occupied private year-round residence is 1.7 miles south of the nearest reactor containment.

(v) Regional Employment Structure

Employment in supporting services and contract construction has increased in the past four years and is expected to remain stable for the next two to three years because of the presence of 2,300 construction workers employed in building the Surry Plant. When the major portion of construction is completed in 1972, the employment in construction and supporting services is expected to decline rather rapidly. Virginia Division of Planning estimates that approximately 350 or more persons will be employed permanently in service trades than were at the beginning of the construction phase. Other types of employment are not expected to be effected substantially because most of the permanent residents of the county who are employed in manufacturing out-migrate to Tidewater area jobs. This trend is not expected to change considerably in the near future.

(vi) Regional Supply of Government Services

Any change in the type, quantity, or quality of services from local government will be as a direct result of the additional tax monies put into Surry County by the physical presence of the Surry Station. At present, the governing body of the county has not indicated any firm plans as to how these additional revenues will be used.

(vii) Miscellaneous Land Uses

No other land uses such as parks, wildlife areas, wilderness areas, hunting areas, etc. are expected to result from the presence of the Surry Station.

(d) Esthetic Character of Site Area

The site is located near the center of the Hog Island peninsula on Gravel Neck and is essentially surrounded by over 700 acres of forest land. The point of the peninsula has the esthetic values associated with a controlled marsh land form and serves as a wildlife preserve. Wooded areas envelop the reactor site from the southern edge of the marsh around the entire perimeter. Thus, viewed from any direction, the reactor site should be described as having the esthetic character of a naturally wooded landscape.

(3) Historic and Cultural Background of the Site Area

Surry County is just across the James River from Jamestown Island, the site of the first permanent English settlement in America. The settlement of Surry started shortly thereafter. Several old houses built in the 17th Century still stand and attract visitors during "Historic Garden Week" and the "Annual Autumn Pilgrimage". Among them is the Warren House built on land given in 1614 by Chief Powhatan to John Rolfe on the occasion of his marriage to Pocahontas, daughter of Powhatan. Near this is the site of Fort Smith built in 1609 by Captain John Smith. Not far from Scotland Wharf Ferry is Pleasant Point, said to be the third oldest house in Virginia, and nearby stand three of its original dependences, the spring house, smokehouse, and one of the kitchens. Another place of interest is "Bacon's Castle".

Directly adjacent to the power facility are Hog Island Wildlife Management Area and Chippokes State Park, the only State Park on the James River. Both of these locations played significant roles in the historic development of the area and on the basis of information set out below, it is felt that each will benefit directly or indirectly by the location of this power facility.

The Applicant and the Virginia State Game and Inland Fisheries Commission mutually agreed on a program to prevent salt water intrusions into the water surrounding the Hog Island Game Management Area by constructing and improving dikes in the vicinity. This program should improve the reservoir food supply, thus providing a better winter home for migratory water fowl and attracting more tourists and nature lovers to this part of the State.

Continuing with its efforts to inform the populace about nuclear power, Applicant has constructed an informative Nuclear Information Center which has attracted over 170,000 visitors since opening in December, 1967. A number of these people indicated that their visit to the Information Center also included a tour of nearby Chippokes Plantation. It is felt, therefore, that the net effect of the Surry Power Station on the cultural and historic areas of Surry County will be to the advantage and enhancement of the entire area.

(4) Governmental Patterns of Site Area

The incorporated towns in Surry County are Claremont, Dendron, and Surry. Each is governed by a town council, composed of either five or six men, and a mayor who is elected by the voters of the respective towns. Since towns are part of the county, the ordinances and regulations of the county are effective in them and since the residents of the towns are effected by two governments--both town and county--the qualified voters of the towns vote for officials of the two governing bodies. However, county residents do not vote for, or come under, the government of the town officials.

Surry County is currently in the process of redistricting the county's magisterial districts in order to comply with the principle of one-man-one-vote. Pending the approval of the U. S. Attorney General the county will be divided, politically, into five election districts, effective January 1, 1972. From each of these, a representative is elected to serve for four years on the board of supervisors, the county's governing body. These supervisors have no election district functions, but are individually responsible to their electorate. Collectively the board serves as the legislative and policy-making branch of the county government. They meet once a month, or more often if necessary, at the court house in Surry. Meetings are open to the public. Other elected officials of the county are chosen by the electorate of the entire county including the towns which are politically a part of the county and district in which they are located. Surry County is a member of the 19th District (Crater District) Planning Commission, whose role in land planning has been discussed above in ¶ I.C.1.b.(2).

Neighboring military installations are cited in Sections I.A. and I.C.1 above. There are no present plans to use the site area for military or other governmental purposes. There will, however, be continued emphasis on maintaining the Hog Island Waterfowl Refuge and Chippokes Plantation as State attractions.

(5) Unique, Rare, or Irreplaceable Land Forms or Land Uses

(a) Scenic Vistas

The site surrounding the Surry Power Station is typical of most Coastal Plain

Virginia rivers which are characterized by a few high bluffs overlooking the flatlands and water. Although the overview of the river and surrounding land at these particular points is extremely impressive, neither the configuration of the land nor the view afforded could be considered unique for the area.

(b) Open Spaces

The site of the Surry Power Station cannot be considered as unique, rare, or irreplaceable from the standpoint of open spaces.

(c) Geologic Formations

High bluffs which contain exposed outcroppings from the Miocene geologic epoch occur near Chippokes Plantation upstream on the south side of the river, and near Carters Grove Plantation on the north side of the river. These formations, which contain innumerable shells, whale bones, and shark teeth, are estimated to be 10,000,000 to 30,000,000 years old. One unique feature of the shark teeth and whale bones is that they contain concentrations of Uranium-238. Applicant's studies have also determined that extensive deposits of black sand containing Thorium-232 exist not only at Chippokes Plantation beach, but on every major river system in Virginia. Radiation from these fossils and sand deposits is several times greater than that from the natural background. Miocene outcroppings are readily apparent on all of Virginia's major river systems since the Miocene lens or layer extends from southern Virginia into Maryland and has been generally exposed by erosion along the edge of the river. This layer is not exposed at the station site because it has dipped beneath the more recent layers at that point. These outcroppings can be considered to be unique in that most contain remnants of species peculiar to that particular geographical location in the ancient Miocene Sea. They might also be considered irreplaceable because of their age and because they represent an important span of geologic time. Nevertheless, they are not unique to the site area itself and the construction of the facility has had no significant effect on these geologic formations.

(d) Other Unique Natural Environments

There are no unique natural land environments in the site area that would come under this classification except the Hog Island Wildlife Preserve and possibly some of the pocosins or swamps which are unique unto themselves. The Hog Island Wildlife Preserve is unique in that it is a low, controlled marsh and pond area that offers protection and food to migratory waterfowl as they migrate north and south during the course of the year. There are few sights as unique or breathtaking as the spontaneous flight of thousands of Canadian geese.

(e) Sites, Buildings, or Other Structures of Historical and/or Cultural Significance

In the area surrounding the station site are a number of sites and buildings of historical and/or cultural significance. This is not an unusual occurrence since Eastern Virginia is rich with the history of Indian and Colonial cultures. Some of the more notable areas of significance include: Jamestown Island, Colonial Williamsburg, Carters Grove Plantation, Bacon's Castle, Rolfe-Warren house, Chippokes Plantation, Smith's Fort, Hog Island, Yorktown, and the site of the New World's first glass furnace near Jamestown. The site of an original colonial church, Lawnes Creek Parish, was thought to be on station property but, after a careful archaeological excavation funded by Applicant and coordinated by the Virginia Historical Society, this belief proved to be false. The original site is still unknown.

2. Water Systems

a. Natural Aspects

(1) Hydrology

(a) Watershed or Waterbody Description

The James River Basin, the southernmost of Virginia's major river basins, contains 10,102 square miles, just over 25% of the State's total land area.* The basis stretches from Highland, Bath, Alleghany, and Craig Counties in the west, to Hampton Roads at the edge of Chesapeake Bay in the east. From its mouth to its headwaters, the James River Basin extends about 230 miles in length with width variations of 10 to 90 miles.

The James River proper arises in the mountains of Virginia and courses mainly through rapids and shallow water to the City of Richmond. Here, the river becomes tidal as it crosses the natural fall line, and meanders east to the Chesapeake Bay. From Richmond downstream, the channel depth of the river is maintained at 25 feet; however, depths of 60-90 feet are not uncommon in the lower reaches. The river's width varies from about 600 feet to about 6 miles. The river is about 3 miles wide at Hog Point.

(b) Streamflow

In the vicinity of the Surry Power Station, the James River is a tidal estuary. The oscillatory ebb and flood of the tide constitute the dominant motion in both the estuary proper and the tidal river upstream. Just above the upstream influence of the tide, at Richmond, is the last downstream gaging

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*Information in this section, unless otherwise specifically attributed, is drawn from a report by the consulting firm of Pritchard-Carpenter, "Hydrology of the James River Estuary", attached as Appendix E.

station on the main body of the James. This gage monitors a drainage area of 6,757 square miles. About 875 cubic feet per second (cfs) of water, on the average, is diverted around this gage through the Kanawha Canal at the City of Richmond. There is an additional drainage area of 2,760 square miles between Richmond and Hog Point which is also considered for purposes of estimating the fresh water inflow of the James River to Hog Point. The following Table I.C.2-1 gives the monthly mean discharge of the James River at Hog Point for the water years 1935 through 1965.

TABLE I.C.2-1

James River Mean Monthly Discharges, 1935-65

Minimum monthly mean discharge	857 cfs
90% of monthly mean discharges greater than............	2,660 cfs
75% of monthly mean discharges greater than............	4,370 cfs
Median monthly mean discharge..........................	7,860 cfs
Mean monthly discharge.................................	9,952 cfs
25% of monthly mean discharges greater than............	14,336 cfs
10% of monthly mean discharges greater than............	20,225 cfs
Maximum monthly mean discharge.........................	39,778 cfs

(c) Current-flow Patterns

The James River in the vicinity of the Surry Power Station is a tidal estuary. As such, the river is subject to a predominantly semi-diurnal tide with two high waters and two low waters each lunar day of 24.84 hours. The periodic rise and fall of the water surface at the mouth of the James River causes a progressive wave which proceeds up the river from its mouth. Attenuation takes place as the wave proceeds upstream with resulting energy loss. Without energy loss, a standing wave would result in the waterway. In the vicinity of Hog Point, maximum flood current precedes high slack water by about 50 minutes, causing tidal characteristics intermediate between a progressive wave and a standing wave. Based on a datum plane of mean low water, the mean tide level at Hog Point is +1.0 foot, mean tidal range is 2.1 feet, and mean spring tide range is 2.5 feet.

At Hog Point the ebb current is stronger and has a longer duration than the flood current. The average maximum ebb current is about 1.3 knots while the average maximum flood current is about 1.1 knots. Spring tide current is about 1.9 knots for ebb conditions and about 1.6 knots for flood conditions. The predominance of ebb flow over flood flow will decrease with decreasing river discharge.

(d) Characteristics of Salinity Interface with Fresh Water

Salinity characteristics of the fresh water/salt water interface around Hog Point have been studied extensively by the Virginia Institute of Marine Science. Hog Point, in the vicinity of the Surry Power Station, is located directly in the transition zone between fresh and salt water. With the exact location of the interface being largely dependent on fresh water inflow from upstream, the waters around the site are subject to wide salinity variations of between 0.0 parts per thousand and about 18 parts per thousand.

Salinity in this tidal estuary generally increases with depth and is greatest on the north shore of the river due to the rotation of the earth. In the vicinity of Hog Point the salinity on the bottom of the channel is from 1 to 4 parts per thousand greater than the salinity on the surface. A discussion of salinity and other aspects of water quality is given in the following section.

Moderate to heavy ice has been known to occur in James River waters around the station site. This ice cover, usually occurring in January or early February, reaches from shore to shore except in the main channel of the river, where formation is minimal because of tidal flow and shipping traffic.

Wave heights in the river range from dead calm to about three feet. The intensity and physical location of wave action in the area is a direct function of wind speed, wind direction, and tidal stage. For example, water on the discharge side of the station during a westerly wind would be very choppy while water on the intake side at the same time would be relatively calm.

(2) Water Quality

The Surry site is located at the transition point in the James River between the tidal river and the saline estuary, with salinity depending upon fresh water run-off from upstream. The following Table I.C.2-2 gives salinity ranges observed around the power station site by Pritchard-Carpenter:

TABLE I.C.2-2

Observed Salinity Range (Parts Per Thousand)

Off the downstream side of power plant site.................	Surface	0.0 to 16.95 °/00
	At 25 feet	0.0 to 21.13 °/00
Off Hog Point....................	Surface	0.0 to 12.20 °/00
	At 20 feet	0.0 to 14.20 °/00
Off upstream side of power plant site.................	Surface	0.0 to 9.19 °/00
	At 20 feet	0.0 to 11.16 °/00

Other sea water solids will vary directly as the salinity values outlined above.

Table I.C.2-3 below shows results of chemical data gathered at Buoy #42, off Hog Point, by the Commonwealth of Virginia State Water Control Board from July 1968 through August 1971. Average, maximum and minimum values and the number of analyses involved in each average are shown.

TABLE I.C.2-3

Parameter	Avg.	Max.	Min.	Number Tests
pH - field	7.80	9.00	6.80	15
pH - Laboratory	7.20	7.50	6.80	5

Mg/L UNLESS STATED OTHERWISE

Parameter	Avg.	Max.	Min.	Number Tests
Total Solids	1736.00	4130.00	250.00	5
Suspended Solids	26.00	43.00	11.00	5
Dissolved Solids	1711.00	4119.00	217.00	5
Total Alkalinity as $CaCO_3$	34.00	42.00	26.00	5
Ammonia Nitrogen as N	0.22	0.73	0.02	14
Nitrite Nitrogen as N	0.02	0.08	0.01	15
Nitrate Nitrogen as N	0.59	1.09	0.02	15
Total Nitrogen as N	0.59	1.13	0.30	15
Total Phosphorous as P	0.11	0.20	0.05	15
Ortho Phosphates as P	0.05	0.14	0.01	15
Dissolved Oxygen	8.10	11.20	6.20	15
B.O.D., 5 day 20°C	1.10	2.10	0.20	5
Lead, Pb	0.01	---	---	1
Mercury, Hg	0.0005	---	---	1
Copper, Cu	0.02	0.04	0.01	2
Zinc, Zn	0.02	0.03	0.01	2
Chromium, Cr	0.02	0.03	0.01	2
Arsenic, As	0.005	---	---	1
Pesticides, ppb DDE	0.01	0.03	0.00	4
Pesticides, ppb DDT	0.02	0.06	0.00	4
Turbidity, Jackson Candle Units	18.00	20.00	15.00	4
Total Coliform, MPN/100 ml	127.00	930.00	30.00	17
Fecal Coliform, Millipore Filter	180.00	400.00	100.00	5

Table I.C.2-4 is a listing of the analyses performed on a "grab" sample of the James River water on the downstream side of the site (circulating water intakes) and submitted to the U. S. Army Corps of Engineers as required under the 1899 Refuse Act.

TABLE I.C.2-4

pH	7.20

Mg/L UNLESS OTHERWISE STATED

Alkalinity as $CaCO_3$	33.00
Total Solids	1330.00
Total Dissolved Solids	1325.00
Total Suspended Solids	5.00
Total Volatile Solids	296.00
Ammonia as N	0.22
Kjeldahl Nitrogen as N	1.60
Nitrate as N	0.27
Phosphorus as P	0. 0.15
B.O.D., 5 day	4.20
C.O.D.	8.50
Chlorides as Cl	4220.00*
Chromium as Cr	0.006*
Zinc as Zn	0.000*
Pheols	0.000*
Sulfite as SO_3	0.000*
Radioactivity** (See further data in Appendix C)	
Alpha (no analysis due to saline water)	
Beta pCi/L	4 ± 1
Gamma (none detected over background and system sensitivity)	
Tritium pCi/L	0 ± 1

*Sampled at later date than remainder of values.
**Results from Eberline Instrument Company, Consultants on pre-operational radioactivity surveillance program.

The data given above and in Tables I.C.2-3 and I.C.2-4 indicate that the waters of the James River in the vicinity of the Surry site conform with State standards for the stream classification at this point, namely, "II-B-a" which covers estuarine waters generally satisfactory for use as public or municipal water supplies, primary contact recreation, propagation of fish and other aquatic life, and other beneficial uses and propogation of shell fish.

(3) Inventory of Natural Flora

(a) Emergent and Submergent Aquatic Vegetation

Very little emergent or submergent aquatic vegetation has been observed in the James River proper in the vicinity of Surry Power Station. Eelgrass (Zostera marina) and widgeon grass (Ruppia maritima), however, are known to occur in the area downstream in the more saline parts of the river.

Brackish, slightly brackish, and fresh water marshes, notably those in the area of the Jamestown Thorofare, Lawnes Creek, Lower Chippokes Creek, College Creek, and College Run, contain species such as giant cordgrass (Typha cynosuroides), common cattail (Typha latifolia), narrow-leaved cattail (Typha angustifolia), arrow arum (Peltandra virginica), and various insignificant marsh species. Other grasses, rushes, and sedges become more abundant upstream with decreasing salinity. During times of extreme high tide or high runoff from the marshes, these marshes contribute significantly to the biological production of the river.

(b) Phytoplankton

Phytoplankton collections in the vicinity of the station were started on a monthly basis by the Virginia Institute of Marine Science in January, 1971.* For purposes of this report, samples have been sorted and identified for the sample months of February, May and August, 1971. Samples were taken using a Kemmerer Bottle at mid-depth from the intake area and from two instrument towers located near the discharge groin (one just off the groin, one directly across the river). From a one-liter whole water sample, 0.20 milliliter of water

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*For a description of the methodology and time schedule of VIMS biological studies in the Surry Area, see Appendix F.

from each sample was examined with an inverted microscope using the Utermöhl Method. Cell counts were recorded as the number of cells per milliliter of sample. Cells are enumerated by species and recorded as percentages of the total identified population. The following Table I.C.2-5 illustrates the breakdown by phylum, the percentage occurrence, the number of species in a phylum, and cell counts per milliliter:

TABLE I.C.2-5

24 February	Diatoms (Chrysophyta)	96.72% (21 sp)	96.70% (27 sp)
	Greens (Clorophyta)	2.46% (1 sp)	0.00%
	Dinoflagellates (Pyrrophyta)	0.82% (1 sp)	3.30% (5 sp)
	Count	610 cells/ml	905 cells/ml
19 May	Diatoms (Chrysophta)	95.91% (28 sp)	97.45% (16 sp)
	Greens (Clorophyta)	0.00%	2.04% (11 sp)
	Dinoflagellates (Pyrrophyta)	4.09% (4 sp)	0.41% (1 sp)
	Count	1225 cells/ml	1225 cells/ml
9 August	Diatoms (Chrysophyta)	90.53% (17 sp)	94.38% (18 sp)
	Greens (Clorophyta)	0.59% (1 sp)	1.26% (1 sp)
	Dinoflagellates (Pyrrophyta)	8.88% (4 sp)	3.36% (3 sp)
	Count	845 cells/ml	1190 cells/ml

Sources: Unpublished data generated by VIMS under Vepco contract, February - September, 1971.

It is of interest to note that no genera of the phylum Cyanophyta (Myxophyta), the blue-green algae, appeared in the samples. They are undoubtedly present, however, and may appear in subsequent samples.

(4) Inventory of Natural Fauna

(a) Zooplankton

An inventory of the species and abundance of zooplankton that inhabit the waters of the James River in the vicinity of Surry Power Station has been underway since January 1971, by the Virginia Institute of Marine Science. Samples have been collected monthly near the station intakes and at two instrument towers in the vicinity of the discharge groin. A sample consisting of three vertical tows was taken with a 1/3 meter net of number 30 mesh.

Zooplankton samples for the year 1971 have been sorted and identified and show a relative paucity of zooplankters for the James River waters around the station. The most abundant species collected at any one time during the course of the year consisted of 13 amphipods (*Gammarus* sp.). This particular collection also yielded 3 specimens of another amphipod (*Corophium* sp.) to complete the sample. The most productive samples came during April, May and June, during the upstream spawning of anadromous fish such as striped bass, *Morone saxatilis*, shad and herring, *Alosa* sp. These samples contained amphipods (*Gammarus* sp.), copedods (*Acartia* sp., *Cyclops* sp., *Eurytemora* sp., *Diaptomus* sp.), cumaceons (*Diastylis* sp., *Leptodora* sp.), dipterans of the family Tendipedidae, shrimp (*Palaemonetes* sp.), mysids (*Neomysis* sp.), decapods (*Rhithropanopeus* sp. zoea), harpacticoids (*Ectinosoma* sp.), and various rotifers.

(b) Meroplankton

Meroplankton samples are being collected, sorted, and identified in conjunction with zooplankton sampling by the Virginia Institute of Marine Science. Known to exist are temporary planktonic forms such as oyster larvae, crab zoea, barnacle larvae, and miscellaneous fish eggs and larvae. Their relative abundance to date, however, has been slight.

(c) Macroinvertebrates

Baseline studies conducted by the Virginia Institute of Marine Science have indicated a typical transition zone fauna that is characterized by relatively few species and large biomass. The overwhelmingly dominant benthic invertebrate in the area of Surry Power Station is the marsh clam, *Rangia cuneata*, which contributes over 90% of the total biomass of the benthos. *Rangia cuneata* has probably been in the James River for about 10 years and is presently extending its range northward to other Virginia rivers. Other invertebrates found during benthic sampling at 31 stations in the James River around Hog Island include: worms (*Scoleocolepides viridis*, *Laeonereis culveri*, *Tubulanus pellucidus*, *Heteromastus filiformis*); amphipods (*Gammarus* sp., *Corophium lacustre*, *Lepidactylus dytiscus*, *Monoculodes edwardsi*); an isopod (*Cyathura polita*); various insects (Dipteran larvae); mussels (*Congeria leucophaeta*, *Brachidontes recurvus*); and clams (*Macoma phenax*, *Macoma balthica*).

Probably the most abundant seasonal macroinvertebrate in the area is the decapod crustacean *Callinectes sapidus*, the blue crab. All stages in the life cycle from zoea to adult are present in varying numbers in the vicinity of the station at different times of the year. When the adults migrate up the estuary for a short time in the spring, there is a considerable crab pot fishery in the area.

Oysters, Crassostrea virginica, are present in commercial abundance at Deep Water Shoal across the river from the intake side of Surry Power Station. The upstream limit of commercial abundance on the south side of the river is Burrells Bay, about 5 miles downstream. Whereas oyster larvae are present in varying numbers in the waters around the station because of their planktonic nature and the tidal flows, those that set in the area are usually killed by natural spring freshets which lower the salinity of the water for prolonged periods of time. Upstream availability of oysters is a direct function of the average salinity of the water in which they set.

Barnacles, Balanus sp., abound in the waters around Hog Point. This species, like the oyster, will set and grow during periods of suitable salinity. They also, like the oyster, are killed by increased fresh water inflow from the river. The largest size observed for this species in the vicinity of the station is about one-quarter inch in diameter.

Small Penaeid and Palaemonid shrimps occur along the edge of the river in varying numbers. These shrimps occur along the edge of the river in varying numbers. These shrimps appear to exhibit a good tolerance to wide salinity changes in their environment.

(d) Fish Population Studies

Fish collections have been underway for many years by scientists of the Virginia

Institute of Marine Science, who utilize shallow-, mid-, and deep-water trawling gear. Three of their James River sample stations are Deep Water Shoal, Hog Point, and Jamestown Island. In addition, Applicant instituted monthly supplemental haul seine studies in early 1970 at 7 locations around the station site. Ichthyoplankton and shallow water trawl samples are also being collected monthly at selected stations in the river for future reference. Haul seine and trawl collections during the past 20 months have yielded the following species of fish as illustrated below:

TABLE I.C.2-6

Gobiosoma bosci	Naked goby
Micropogon undulatus	Atlantic croaker
Dorosoma cepedianum	Gizzard shad
Bairdiella chrysura	Silver perch
Anguilla rostrata	American eel
Lepomis sp.	Sunfish
Gambusia affinis	Mosquitofish
Cyprinus carpio	Carp
Etheostoma olmstedi	Tessellated darter
Notropis bifrenatus	Bridle shiner
Umbra pygmaea	Eastern mudminnow
Paralichthys dentatus	Summer flounder
Micropterus salmoides	Largemouth bass
Fundulus diaphanus	Banded killifish
Alosa aestivalis	Blueback herring
Alosa pseudoharengus	Alewife
Alosa mediocris	Hickory shad
Alosa sapidissima	American shad
Morone americana	White perch
Morone saxatilis	Striped bass
Perca flavescens	Yellow perch
Menidia sp. (menidia and beryllina)	Silversides
Brevoortia tyrannus	Atlantic menhaden
Anchoa mitchilli	Bay anchovy
Fundulus heteroclitus	Mummichog
Notemigonus crysoleucas	Golden shiner
Pomatomus saltatrix	Bluefish
Lepomis gibbosus	Pumpkinseed
Ictalurus catus	White catfish
Trinectes maculatus	Hogchoker
Ictalurus nebulosus	Brown bullhead

TABLE I.C.2-6 (Cont'd)

Cynoscion regalis	Weakfish
Leiostomus xanthurus	Spot
Ictalurus punctatus	Channel catfish
Notropis hudsonius	Spottail shiner
Strongylura marina	Atlantic needlefish
Fundulus majalis	Striped killifish
Caranx hippos	Crevall jack

(5) Subsurface Water Resources

The hydrologic boundaries of the site proper are the James River on the east and west, Hog Island to the north and Chippokes and Hunnicut Creeks about one mile to the south. A water budget analysis indicates that, of the total precipitation, 37 percent runs off and the remaining 63 percent is lost through evapotranspiration. Low soil permeabilities preclude significant ground water recharge from local precipitation.

The soils in the site area consist of a series (50 to 80 ft thick) of lenticularly interbedded fine sands, clays, and silts. These clay and silt members are essentially impermeable and the sand member showed field permeabilities on the order of 1×10^{-4} cm/sec. Eleven shallow wells within a five-mile radius of the site yield small supplies of water for domestic purposes from these sands.

The above deposits are underlain by 240 to 270 ft of tough impermeable clay containing only occasional and limited sand members. At a depth of about 320 ft below the surface, Eocene and older sediments are encountered. The sand members of these sediments are excellent aquifers; many domestic wells and some industrial wells in the area obtain water supplies from this source. There are 18 wells ranging in depth from 280 to 799 ft within a five-mile radius of the site which obtain supplies from this source. In general, yields range from 15 to 50 gpm; however, a well 799 ft deep at Bacon's Castle, about five miles to the south, yielded under test 940 gpm with only 20.25 ft of drawdown.

In addition to the 340 ft well on the State Waterfowl Refuge which existed prior to station construction, there are four operating water wells on the site property which were constructed to serve several purposes. These wells are about 400 ft deep and obtain water from the Eocene sediments. Two of these wells yield 200 gpm each and are for makeup and domestic uses at the station. A separate well having a 120 gpm pump supplies the Visitors Information Center and the fourth well supplies 75 gpm to the concrete batch plant at the eastern end of the site.

Based on the results of borings, the general geology of the area and the location of the site, the coefficient of permeability of the soil mass in a horizontal direction is estimated to be several orders of magnitude greater than in the vertical direction. The coefficient of permeability of material at the site to the depth tested ranges from a minimum of .0036 feet per day to a maximum of .5240 feet per day. The average permeability of the entire section is 0.0521 feet per day. Water that does enter the soil will move laterally to the east, north or west and discharge to the James River. There is no possibility of surface or near-surface water migrating downward to enter the aquifers of Eocene or older ages.

(6) Overall Ecological Balance of the Water System

That portion of the James River around Surry Power Station site is characterized biologically by a relatively high biomass representing a relatively few species (exclusive of migratory fishes). Salinity, one of two ecological master factors in the aquatic environment governing the distribution and abundance of both fresh and salt water species, ranges from 0 parts per thousand to 18 parts per thousand depending on tidal stage and fresh water inflow. This particular salinity regimen, found in most tidal Virginia rivers, dictates the aquatic fauna and flora, which is typical of both fresh and salt water environments.

The dominant benthic organism, representing over 90% of the biomass, is the marsh clam, Rangia cuneata, a species that appears to be tolerant of relatively wide temperature and salinity changes. Despite its apparent abundance, Rangia cuneata is not now of significant commercial importance, as it is in some areas of Maryland and Texas. With an estimated 75,000 tons available for harvest in the James River alone, it appears to be only a matter of time before commercial harvest becomes a reality.

During the course of the year, many species of fish as well as the blue crab, Callinectes sapidus, make an appearance in the river around the station site. The fish species are largely migratory, anadromous species such as the shad, herring, and striped bass that appear in the spring and fall. Few species of fish are considered resident in the area and these are largely intra-estuary migrants. These include the hogchoker, Trinectes maculatus; white perch, Morone americana; brown bullhead, Ictalurus nebulosus; and white catfish, Ictalurus catus. The American eel, Anguilla rostrats, is a catadromous species that spends a large part of its adult life in the area, returning to sea to spawn. Centrarchids such as the pumpkinseed, Lepomis gibbosus, and largemouth bass, Micropterus salmoides, appear in the sample catches but this species is probably a straggler to this part of the James River proper, coming rather from the tributaries to the river or from upstream. Other resident species, inhabitants of the shore zone, include important bait fish such as the mummichog, Fundulus heteroclitus, and the striped killifish, Fundulus majalis.

The area is known to support a population of larval and juvenile fish during certain times of the year. This age group, composed mainly of striped bass, Morone saxatilis, shad and herring, Alosa sp., Atlantic croaker, Micropogon undulatus, spot, Leiostomus xanthurus, and white perch, Morone americana, utilize the estuarine portion of the James River as a nursery ground. Based on preliminary data from the fish collections, the extent and composition of the population appears to be a function of peak spawning time for a particular species, strength of the year-class, and the prevailing salinity range at the particular time of the year. Additional studies are currently underway to obtain comprehensive data on these populations in terms of diversity, size range, abundance, and seasonality.

Oysters, Crassostrea virginica, are limited in their commercial abundance to Deep Water Shoal on the North side of the river and Burrells Bay on the south side of the river, both downstream from the station intake. The success of these populations is more or less directly dependent on the salinity range of their environments. Oyster larvae that set upstream from these two points appear to be killed by freshets in the river which lower the salinity of the water to 0.0 parts per thousand for extended periods of time.

The shrimp, Neomysis sp., in other rivers of Virginia, constitutes a major staple in the diet of juvenile striped bass. In the James River, however, there appeared to be a scarcity of Neomysis sp. in 1967, thereby causing a shift in the diet of the striped bass. One theory as to why the scarcity of Neomysis sp. was so prevalent is that the abundance of the clam, Rangia cuneata, has caused a reduction in detritus resulting in little available food for the shrimp. As this clam extends its range northward into other Virginia rivers, this theory can be proved or disproved by a stomach content analysis of juvenile striped bass in conjunction with other studies.

There is only one species of fish appearing on the list of endangered species published by the U. S. Department of the Interior, Bureau of Sport Fish and Wildlife, that may or may not be present in the waters of the James River. The shortnose sturgeon, Acipenser brevirostrum, was taken in 1899 by Smith and Bean in the Potomac River. Hildebrand, in 1928, expressed some doubt as to its occurrence in the Chesapeake Bay, notwithstanding the fact that it had been recorded in the scientific literature. Its close relative, the Atlantic sturgeon, Acipenser oxyrhynchus, after a sharp decline in numbers near the turn of the century, appears to be holding its own in Virginia waters. The latter species is under protection by the State in that it is unlawful to remove a sturgeon that is less than five feet in length. The Atlantic sturgeon is known to occur in the James River commercial fishery but has not been taken during the present biological surveys.

In general, it can be said that the overall ecological balance of the James

River in the vicinity of Surry Power Station is relatively good and is typical of that found at the fresh water/salt water interface in most relatively unpolluted tidal rivers in Virginia. While it is true that the James River is highly polluted between the cities of Richmond and Hopewell, natural purification has, for the most part, occurred by the time waters reach Hog Island.

The only exception that might be taken to this assessment of the ecological balance of the James River would be the possible eventual detrimental effect of a shift in the feeding habits of juvenile striped bass. Otherwise, healthy populations exist and co-exist, each a part of its own particular ecological niche or as an interwoven part of an ecologically important functional group.

b. Human Uses of the Water System

(1) Water Resources Planning

A comprehensive water resources plan for the James River Basin is being prepared and published in six volumes by the Virginia Department of Conservation and Economic Development, Division of Water Resources, as Planning Bulletin 213. Volumes V and VI had not been published at the time of preparing this environmental report. Volume VI will contain the comprehensive plan with recommendations necessary for accomplishing orderly basin development and in anticipation of the final report, the following comments are pertinent.

Human uses of the James River around the site of the Surry Power Station, while not developed to their fullest extent, are many and diverse. Sport fishing upstream in the Chickahominy River, waterfowl hunting, and boating in the James and its tributaries draw many participants as does sightseeing in this historically rich area. Commercial fishing for oysters, crabs, and finfish provides a livelihood for many residents living in the area of the river. With an increase in the national population and personal income, it is anticipated that such utilization of James River resources would increase proportionately.

The potential for development of human uses of the surface waters of the James River, especially from the standpoint of recreation, is still extensive at the present time.

(2) Existing and Anticipated Future Uses of the Water Resources

(a) Other Anticipated Future Uses

The major content of this section has been covered in a preceding discussion. There are no known municipal users of James River water from the city of Hopewell downstream. The reason for this is that the middle reaches of the river are relatively undeveloped and the river becomes increasingly saline as one travels downstream, thereby precluding its use as a source of municipal water. Likewise, there are no known irrigation diversions. Industrial users of significance in the area at the present time are limited to the Dow-Badische Company which discharges process water into Skiffes Creek, a tributary of the James River, across the river from the station intakes; and the Newport News Shipbuilding and Dry Dock Company, which withdraws 17 million gallons per day from the river. The city of Newport News withdraws 27 million gallons per day from the Chickahominy River, an upstream tributary of the James.

(b) Recreational Uses

Public recreation facilities in the vicinity of the site consist of several bathing beaches and boat landings upstream and downstream of the site as well as fishing areas along the James River and its tributaries, some of which are stocked by the Virginia Department of Game and Inland Fisheries.

A public ferry, which connects Jamestown Island to Surry County, operates at Scotland Wharf, upstream from the site. This ferry provides the only river crossing between the Harrison Bridge at Hopewell and the James River Bridge at Newport News. An attempt is being made by Surry County interests at the present time to induce the State to construct a bridge or tunnel to replace the existing ferry. Should such a bridge or tunnel be approved, construction would not be completed until the late 1970's or early 1980's, but would undoubtedly play a major role in the development of Surry County. Another use of the surface waters is realized in the anchorage of the reserve mothball fleet in the river adjacent to and downstream from the station intake. The fleet is comprised of about 100 ships.

(c) Subsurface Water

There are, however, no present or anticipated withdrawals of subsurface water from the resources at the site. Public water in most of James City and York Counties and the City of Newport News is supplied by an aqueduct running from the Chickahominy River through a reservoir about 7 1/2 miles east of the site, on the north side of the James River, and then down to Newport News. Public water is also supplied to Newport News from the Williamsburg reservoir, located about 10 miles northwest of the site, also fed from the Chickahominy. A few homes have private wells.

There are public water supplies in two small communities in Surry County: one at Claremont, 16 miles west-northwest of the site, and the other in Surry, 7 1/2 miles west-southwest of the site. In addition, the community of Dendron is presently considering the installation of a public water supply. All other water is supplied from private wells, some of which are mentioned above.

There are no public water supplies from the James River downstream of Hopewell, Virginia, approximately 40 river miles upstream from the site.

(3) Unique, Rare or Irreplaceable Water Systems

(a) Surface Waters

(i) Physical Environment

The one unique feature of the James River in the vicinity of Surry Power Station is that this particular stretch of the river, in relation to the river as a whole, is the transition zone between salt water from the Chesapeake Bay and fresh water from upstream. Every major river in Virginia has such a zone that is unique to that particular river. Its uniqueness lies mainly in the environmentally tolerant floral and faunal species found in this zone.

(ii) Esthetic Aspects

There are no unique, rare or irreplaceable water system environments or water uses from the esthetic point of view unless one considers that each river has its own unique beauty.

(iii) Cultural Aspects

There are no unique, rare or irreplaceable water system environments or water uses from the cultural point of view.

(iv) Historic Aspects

The James River in the vicinity of the Surry Power Station is unique historically, since English ships first sailed into these waters in 1607. The ships' company landed across the river from the site on Jamestown Island and established the first permanent English settlement in the New World. These waters served as the life line shipping lanes during the first few years of the settlement's existence. Hog Island, which is now the Hog Island Wildlife Preserve, as its name implies, was the site where settlers kept their livestock in early Colonial years. Access to Hog Island from Jamestown Island was by row boat and history records the loss of several settlers who were attempting to cross the river during times of rough water. Waters of the James River were also important during the Revolutionary and Civil Wars in that men and equipment were transported extensively by ship during these times.

(b) Subsurface Waters

There is nothing unique, rare or irreplaceable about the water system environments or water uses of the subsurface waters around the Surry Power Station site.

3. Air Systems

a. Natural Aspects

(1) Climatology

(a) Methodology of Base-Line Study

The methodology of the base-line climatological studies of the Surry site was to summarize the best available and relevant data applicable to this area. This purpose was accomplished through the use of weather stations and a search of the literature on acknowledged techniques for predicting the frequency of unusual adverse climatological conditions which could have a direct significance in the design and operation of the Surry Station.

(b) General Discussion

The climatology of the lower James River Basin, the area in which the Surry site is located, is of a temperate variety. It is moderated by a marine influence due to the area's proximity to the Chesapeake Bay and the Atlantic Ocean. Winters are mild and short; spring and fall are typically comfortable and summers are long, hot and humid, frequently tempered by east and northeast winds from the Atlantic.

(c) Temperatures

The annual average temperature for the site is approximately 60°F. The annual area temperatures range from approximately a monthly mean low in January of 42°F to a monthly mean high in July of 78°F. Table I.C.3-1 presents the monthly mean temperatures for selected area weather stations.

Surry

TABLE I.C.3-1

Lower James River Basin Temperature (°F)
Monthly Averages

STATION	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	AN'L	HIGH	LOW	YRS
Hopewell	40.4	41.3	49.2	58.6	68.3	74.7	77.6	77.4	72.1	60.5	50.0	41.2	59.3	106	-10	64
Newport News	43.9	45.2	49.2	60.8	68.5	76.8	81.1	79.7	73.5	63.6	53.5	44.6	61.7	105	10	13
Norfolk	42.1	42.8	49.0	57.7	67.1	75.0	78.8	77.7	72.6	62.4	52.2	43.8	60.1	105	2	90

(d) Precipitation

(i) Rainfall

The area around the site receives a total annual mean rainfall of approximately 46 inches. Rainfall is fairly evenly distributed throughout the year except during July, August and September, when monthly totals rise to approximately 5 inches because of thunderstorm activity. Table I.C.3-2 presents annual mean, maximum annual and maximum monthly precipitation data for several locations near the site.

Twenty-four hour precipitation data available for Norfolk Weather Bureau Airport shows a maximum value of 11.40 inches (August, 1964).

V. Yankee

During a one-year study at the site, inversions (as measured by a 140-foot tower) occurred nearly 39% of the time. The average wind speed during inversions was about 6.3 mph.

Temperature and Precipitation

Temperature data from the records of Vernon (one-half mile south) and Brattleboro (6 miles north) are representative of the values for the site and are shown in Table 2.6-1.

Precipitation at the site averages 43 inches per year and is distributed rather evenly throughout the 12-month period. Snowfall is moderately heavy on the average, but there is considerable variation in amounts from year to year. Nearly all winter precipitation is in frozen form, although not entirely as snow. Sleet and freezing rain are not uncommon.

Intense rainfall will be produced by the occasional severe thunderstorm or modified hurricane.

Snowfall

The site being located in the northeastern part of the United States is subjected to a wide range of snowfall, which may be as little as 30 inches or as much as 118 inches. Average snowfall statistics for Vernon (25 years of record) follow and are representative for the site.

Average Monthly Snowfall (inches) for Vernon

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Ann
16.4	15.7	12.1	2.1	0.1	0.0	0.0	0.0	0.0	T	3.3	10.5	60.2

T = Trace

The most significant departure from the historical values occurred in the amount of snowfall at Vernon between November 1968 and February 1969.

TABLE I.C.3-2

Precipitation Data 1951-1960
(All Data in Inches)

Station			
Cape Henry	43.76	52.12 (1957)	9.28 (Aug. 1958)
Cheriton	44.98	57.36 (1958)	10.46 (Aug. 1955)
Hopewell	45.81	52.28 (1958)	12.92 (July 1959)
Langley A.F.B.	42.78	51.80 (1958)	10.91 (July 1959)
Newport News	44.44	55.46 (1958)	9.19 (Oct. 1956)
Norfolk W.B.A.P.*	44.94	57.78 (1958)	15.61 (Aug. 1942)
Smithfield	44.71	51.83 (1960)	9.94 (Aug. 1955)
Suffolk	47.56	50.88 (1954)	11.61 (July 1959)
Williamsburg	47.81	58.24 (1958)	10.76 (Aug. 1955)
Area Average	45.19	54.19	

*Data cover years 1871 through 1965.

(ii) Snowfall

Snowfall is sparse and dissipates rapidly because of the relatively warm winter temperatures. Norfolk data is available for snowfall and shows a maximum annual snowfall of 37.7 inches (winter, 1935-1936); a maximum monthly fall of 18.6 inches (December, 1892); and a maximum 24-hour fall of 17.7 inches (December, 1892). Norfolk generally records approximately 7 inches of snowfall annually.

(e) Extreme Winds and Storms

The Surry site lies in the occasional paths of low pressure tropical or subtropical depressions and hurricanes. From 1871 through 1969, over 15 hurricanes or tropical storm centers have passed in the vicinity of the site. High winds and unusually low barometric pressures are associated with the passage of these centers. The lowest recorded barometric pressure at Norfolk weather station was 28.35 in Hg, in 1932. A maximum barometric pressure decline of .30 in Hg over an 18 minute period was recorded in 1960.

During the period 1959 through 1968, tornadoes were reported in Virginia about four times per year. During this period, an annual average of 0.8 tornadoes was reported in the 35-mile radius surrounding the site. According to statistical forecasting techniques by Thom*, and the mean area frequency of 0.8 occurrances per year within a 35-mile radius, the probability of a tornado striking a particular point within that 35-mile radius is 4.74×10^{-5} per year. At a confidence level of 95% this frequency level indicates a recurrence interval of one tornado in 12,500 to 68,000 years. On the basis of 21 years of wind data and the forecast by Thom, extreme winds in excess of 50 mph are not to be expected more than once in 2 years, winds in excess of 71 mph are not to be expected more than once in 15 years, winds in excess of 80 mph are not to be expected more than once in 50 years and winds in excess of 100 mph are not to be expected more than once in 100 years. These recurrence intervals are for winds at 30 foot elevation and have probabilities of 0.50, 0.07, 0.02 and 0.01 recurrences per year respectively.

(2) Site Meteorology

(a) Methodology of Base-Line Study

The methodology of the on-site base-line meteorological studies being conducted

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*Thom, H. C. S., "Tornado Probabilities", Monthly Weather Review, Vol. 91. No. 10-12.

at the Surry site is to monitor those atmospheric parameters which effect the dilution capability of the atmosphere and its ability to disperse radioactive material releases. This approach calls for the recording of wind speed and wind direction and the use of these and other relevant factors in the calculation of the general site atmospheric dilution characteristics.

Two data stations were established on site to transmit data. A 150-foot meteorological tower is located near the center of the site in a clearing among trees which are approximately 70 feet high and approximately 75 feet away from the tower in all directions. Instrumentation includes a set of Belfort type "M" wind speed and wind direction transmitters (starting threshold of 2.0 miles per hour) located at the 150-foot level on the tower.

The second data station, referred to as "Hog Island", is located near the tip of the peninsula. The Hog Island sensors also consist of Belfort type "M" transmitters on a 20-foot mast. This site has only low "scrub brush" to effect the accurate recording of wind patterns. Figure I.C.3-1 illustrates the geographic locations of these towers.

The data collected at these meteorological conditions monitoring stations are reduced on a real-time basis by a NUS Variance Computer to provide four 15-minute averages per hour of wind speed and wind direction to be used in the data analysis The periods 2/1/68 - 2/1/69 for the Hog Island station and 1/1/68 - 1/1/70 for the Surry Tower Station have been chosen for the purpose of establishing baseline conditions.

(b) Dispersion Characteristics

(i) General Discussion

In assessing the base-line meteorology of a nuclear reactor site, the purpose is to ascertain the dilution capacity of the atmosphere for the dispersion of radioactive material releases. Wind direction and speed are obvious factors since the direction determines the trajectory of the material, and the speed is a measure of the flow into which the discharge is diluted. Wind turbulence expands and dilutes the plume about its centerline and is also considered.

(ii) Wind Speed

Tables I.C.3-3 and I.C.3-4 present the base-line wind speed characteristics of the power station locality.

TABLE I.C.3-3

Summary of Wind Speed and Distribution

Hog Island Station (2/1/68 - 2/1/69)

Wind Speed Distribution, Percent

Calm	1to2	3to4	5to6	7to8	9to11	12to14	15to18	19to23	GT 23
3.52	14.25	19.54	19.78	19.13	14.36	5.91	2.42	.64	.44

Surry Tower Station (1/1/68 - 12/31/69)

TABLE I.C.3-4

Wind Speed Distribution, Percent

Calm	1to2	3to4	5to6	7to8	9to11	12to14	15to18	19to23	GT 23
.73	4.66	13.07	21.73	26.14	18.93	8.15	4.59	1.52	.48

The wind speed is slightly higher at the Surry Tower Station than at the Hog Island Station due to the difference in elevation of the sensors. The wind speeds are consistent with the general meteorological history of this portion of Virginia as recorded at the various weather stations in the area.

(iii) Wind Direction

Tables I.C.3-5 through I.C.3-7 present the wind direction characteristics and the relation of the wind direction and wind speed monitored during the baseline meteorological survey.

TABLE I.C.3-5

Wind Direction Distribution, Percent
(Calm Conditions Not Included)

Hog Island Station (2/1/68 - 2/1/69)

NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
5.61	5.83	3.21	5.02	4.93	4.82	4.77	6.41	3.30	5.42	7.11	8.80	7.68	7.27	9.03	9.90

TABLE I.C.3-6

Surry Tower Station (1/1/68 - 12/31/69)

NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
5.31	4.44	4.11	4.89	4.98	5.35	3.91	5.92	7.87	8.21	6.57	6.31	6.86	9.23	8.29	7.23

There appears to be no annual predominant wind direction at the Surry site, although there are some minor seasonal variations in wind direction distributions which reflect the large-scale wind systems of the area. In general, the wind systems seem to be comparable to historical speed and directional patterns of the area as recorded at various weather stations in this portion of the State.

TABLE IC 3-7

Wind Speed Versus Direction, Percent
(Calm Conditions Not Included)

Hog Island Station (2/1/68 - 2/1/69)

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
1 to 2	.40	.54	.48	.81	.43	.63	.61	1.00	.90	1.26	.78	1.29	1.18	1.12	1.79	1.56
3 to 4	1.04	.81	.51	.78	.55	.83	1.16	1.61	1.18	1.15	1.35	1.99	1.84	1.46	2.15	1.85
5 to 6	1.35	1.01	.58	.83	.93	.98	1.20	1.62	1.06	1.10	1.39	2.31	1.72	1.03	1.62	1.76
7 to 8	1.12	1.26	.52	.98	.93	1.06	.90	1.26	.70	1.13	2.33	1.87	1.18	1.18	1.65	1.75
9 to 11	.87	1.18	.41	1.13	1.47	.92	.66	.75	.23	.55	1.06	.97	.92	1.29	.97	1.50
12 to 14	.57	.61	.25	.23	.32	.34	.21	.17	.08	.11	.18	.26	.58	.70	.57	.95
15 to 18	.21	.21	.17	.05	.14	.06	.03	0.00	.05	.12	.02	.11	.21	.37	.26	.51
19 to 23	.05	.18	.21	.06	.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.03	.06	0.00	.02
GT 23	0.00	.03	.08	.15	.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.02	.06	.02	0.00

Surry Power Station (1/1/68 - 12/31/69)

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
1 to 2	.27	.23	.22	.24	.23	.28	.22	.24	.26	.33	.37	.47	.37	.41	.28	.22
3 to 4	.80	.81	.64	.71	.81	.72	.48	.73	.66	.74	.74	1.06	1.16	1.24	1.01	.85
5 to 6	1.37	1.35	1.27	1.62	1.58	1.34	.86	1.11	1.27	1.47	1.45	1.30	1.25	1.36	1.55	1.63
7 to 8	1.50	1.20	1.22	1.86	1.56	1.50	1.53	2.02	2.45	2.16	1.75	1.18	1.14	1.49	1.67	2.09
9 to 11	1.03	.60	.57	.68	.54	1.08	.68	1.45	2.23	1.96	1.10	1.04	1.05	1.69	1.71	1.64
12 to 14	.26	.17	.11	.10	.11	.31	.10	.25	.74	.95	.59	.72	.76	1.41	1.07	.54
15 to 18	.16	.05	.03	.03	.04	.10	1.04	.10	.20	.47	.44	.45	.75	.98	.69	.21
19 to 23	.02	.02	.03	.04	.01	.02	.00	.01	.04	.14	.09	.07	.31	.42	.26	.05
GT 23	.00	.01	.02	.03	0.00	0.00	0.00	0.00	.02	0.00	.03	.02	.07	.23	.05	.00

(iv) Atmospheric Stability

By definition, a stable atmosphere is non-turbulent and an unstable one is quite turbulent. Since atmospheric turbulence is used to establish the dilution capability of the atmosphere, this capacity must first be approached by estimating atmospheric stability due to wind direction variance in terms of categories proposed by Pasquill.*

The stability classes proposed by Pasquill range from "A", the most unstable, to "F", the most stable. Wind direction variance, or standard deviation, can be used to classify data in the various categories. A still more stable classification, category "G", has been recognized by the Atomic Energy Commission to revise atmospheric measurement further.

A low degree of wind turbulence and consequently relatively unfavorable diffusion conditions can be expected for stable conditions. Conversely, during periods of instability, a high degree of wind turbulence associated with favorable dilution conditions can be expected.

Pasquill σ_θ stability distribution have been prepared from the base-line meteorological data. Table I.C.3-8 summarizes the stability distribution data.

(c) Atmospheric Dilution

Annual average atmospheric dilution factors (χ/Q) have been calculated for the Surry Station site. These factors, expressed in the units sec/m^3, enable one

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*Pasquill, F., "Estimates of the Dispersion of Windborne Material", Meteorology Magazine, 1961.

TABLE I.C.3-8

METEOROLOGICAL DATA SUMMARY

HOG ISLAND (2/68 - 2/69) AND SURRY (1/68 - 1/70)

PASQUILL σ_Θ STABILITY DISTRIBUTION

		A	B	C	D	E	F	G	Frequency of calms,%
Spring	20' Hog Island	3.89	17.84	30.63	31.80	14.62	1.22	0.00	2.33
	150' Surry	7.95	18.10	37.55	27.75	6.99	1.19	0.47	0.29
Summer	20' Hog Island	7.39	22.47	41.56	21.65	6.93	0.00	0.00	3.32
	150' Surry	11.61	16.09	31.29	28.36	10.29	1.60	0.77	1.08
Fall	20' Hog Island	5.61	22.74	36.21	22.11	12.98	0.35	0.00	6.25
	150' Surry	7.65	13.85	35.53	29.31	10.56	2.28	0.83	0.81
Winter	20' Hog Island	6.75	15.59	34.80	28.38	13.23	1.21	0.05	2.74
	150' Surry	5.75	8.52	28.55	41.75	12.93	1.97	0.52	0.54
*Annual	20' Hog Island	5.91	19.44	35.70	26.26	11.95	0.72	0.01	3.52
	150' Surry	8.28	13.99	33.20	31.67	10.36	1.83	0.67	0.73
**Average	20' Hog Island	0.11	10.18	36.34	27.33	10.43	0.59	0.02	3.21
	150' Surry	8.24	14.14	33.23	31.79	10.19	1.76	0.65	0.69

* Based on total observations

** Based on equally weighting each season to calculate the human dose to be received at a given distance from the plant site for any radioactive gaseous release.

The (χ/Q) factor incorporates the dilution due to atmospheric turbulence expressed as a Pasquill σ_θ stability, the distance of the point in question from the source, the wind speed from the source to the point in question and a vertical dispersion factor based upon the change in atmospheric temperature with a 1,000 foot change in elevation.

Temperature-elevation (ΔT) data was not available for the Surry Site. Very conservative ΔT data from Beaver Valley, Pennsylvania was used in conjunction with the base-line meteorological data accumulated on-site.

The annual average χ/Q value with a 95% confidence level at the north site boundary (503 meters), based on the Surry data, is 4.0×10^{-6} sec/m^3; and 7.8×10^{-6}, based on Hog Island data. Hog Island data is more conservative.

(3) Site Air Quality

(a) Radioactivity

(i) General Discussion

Virginia Electric and Power Company initiated in 1968 an extensive environmental monitoring program for establishing base-line radiological conditions in the environment surrounding the Surry Power Station site. The surveillance program is currently being conducted on a consultant basis by Eberline Instrument Corporation, in cooperation with Vepco. One phase of this program is the monitoring of airborne radiation. Radiation levels associated with both air particulates and radioactive gases are being monitored for the purpose of establishing normal background conditions.

(ii) Radioactive Gases

Lithium fluoride thermoluminescent dosimeters (TLD's), double sealed in plastic, are being used for the surveillence of area background radiation levels. Figure I.C.3-2 indicates the distribution of sampling locations in the area surrounding the station site. Prior to May 1970, a single dosimeter was placed at each location; subsequent measurements are based on 5 TLD's at each point. TLD's are exposed for approximately one month. Each dosimeter is analyzed using an Eberline Model TRL-5 reader with results reported as cumulative dose (mrem) for the exposure period.

Tables I.C.3-9 and I.C.3-10 present the results of the area monitoring program from January 1970 through June 1971.

(iii) Particulates

Air particulate samples are also collected at the land-based sampling points as shown on Figure I.C.3-2. These samples are collected to measure the low background radioactivity associated with particulate radioisotopes.

The sampling apparatus is a low-volume electric pump equipped with a glass fiber filter, vacuum gauge, rotameter and timer. Air samplers are on for 2 hours and then off one hour. When possible, samplers are located within substation

TABLE I.C.3-9

Area Monitors - TLD

(Dose for Period - mrem)*

1970

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Control	5	0	28	52	20	19	15	10	15	19	27	22
Richmond	10	5	33	61	20	18	15	10	15	21	36	28
Surry Station	5	6	35	50	11	15	12	10	15	20	29	23
Hog Island Reserve	7	9	33	57	15	15	15	9	15	17	30	22
Bacon's Castle	6	4	34	51	14	13	14	8	12	17	27	19
Alliance	7	5	34	46	16	12	12	9	12	17	26	19
Colonial Parkway	5	4	28	60	14	17	15	10	13	18	28	21
Dow	8	8	28	63	15	19	14	9	13	18	31	24
Fort Eustis	6	13	14	43	17	16	13	10	13	24	30	24
Newport News	7	7	32	50	19	14	16	9	13	22	30	25
Smithfield	8	3	31	50	16	18	14	10	14	25	32	23

*Control not subtracted from dosimeter readings

TABLE I.C.3-10

Area Monitors - TLD

(Dose for Period - mrem)*

	Jan	Feb	Mar	April	May	June
Control	24	24	9	13	7	18
Richmond	**	28	12	**	**	23
Surry Station	24	24	11++	12	7	22
Hog Island Reserve	24	22	11	13	7	25
Bacon's Castle	22	22	10	11	8	***
Alliance	25	**	9	12	7	17
Colonial Parkway	24	23	11	11	8	16
Dow	24	24	11	13	7	16
Fort Eustis	24	22	12	12	7	19
Newport News	**	25	11	13	8	19
Smithfield	25	25	11	16	11	20
Scotland Wharf		18	11	11	8	18
Jamestown		17+	11	11	7	16
Lee Hall		**	13	15	10	21
Route 10 and 676		20	11	12	7	15

* Control not subtracted from dosimeter readings.
** Dosimeters lost.
*** Readings not available due to instrument malfunction.
\+ Dosimeter was out for 21 days.
\++ Dosimeter was out for 29 days.

enclosures; otherwise they are located 12 feet above ground on distribution poles with a transformer for the power supply.

The filters are exchanged weekly and are analyzed after decay of radon daughters for gross beta with a Nuclear-Chicago Low Beta Counter. These initial gross beta measurements are confirmed by sending nine (9) samples per month to Eberline Instrument Corporation where they are analyzed for gross beta with a Beckman Wide Beta I or Beckman Wide Beta II low background beta counter. The results are reported as pCi/m^3 based upon the actual sample volume.

Since there are many variables involved in the collection of this sample, measurements are only interpreted relative to the activity of previous samples.

Tables I.C.3-11 through I.C.3-16 present the low background levels recorded from January 1970 through June 1971.

Appendix C, Surry Power Station Environmental Radiation Surveillance Report contains a complete discussion of the airborne radioactivity monitoring phase of the environmental program being conducted at Surry.

(b) Other Air Pollutants

(i) General Discussion

Base-line air contaminant inventory studies for non-radioactive pollutants are

TABLE I.C.3-11

Gross Beta Activity in Air Particulates

First Quarter 1970

(Concentrations in pCi/m^3)

Location	Number of Analyses	Minimum	Maximum	Average	Avg M^3 Sampled Per Sample
Richmond	11	0.06±.01	0.18±.01	0.10±.03	161
Station	13	0.04±.01	0.19±.01	0.10±.04	152
Bacons Castle	13	0.08±.01	0.26±.01	0.16±.05	160
Alliance	12	0.07±.01	0.48±.02	0.17±.10	151
Colonial Parkway	13	0.06±.01	0.20±.01	0.11±.03	158
Dow	12	0.06±.01	0.19±.01	0.11±.03	155
Newport News	13	0.06±.01	0.20±.01	0.11±.04	157
Hog Point	4	0.08±.01	0.18±.01	0.15±.03	140
Fort Eustis	13	0.06±.01	0.14±.01	0.10±.03	197

TABLE I.C.3-12

Gross Beta Activity in Air Particulates

Second Quarter 1970

(Concentrations in pCi/m^3)

Location	Number of Analyses	Minimum	Maximum	Average	Avg M^3 Sampled Per Sample
Richmond	13	0.14±.01	0.52±.01	0.34±.11	157
Station	13	0.15±.01	0.45±.01	0.32±.09	158
Bacons Castle	13	0.20±.01	0.77±.02	0.53±.17	158
Alliance	13	0.19±.01	0.71±.02	0.49±.15	143
Colonial Parkway	13	0.15±.01	0.46±.02	0.35±.10	156
Dow	13	0.14±.01	0.48±.01	0.36±.11	153
Newport News	13	0.18±.01	0.47±.02	0.34±.09	162
Hog Point	10	0.15±.01	0.50±.02	0.32±.09	144
Fort Eustis	13	0.13±.01	0.43±.02	0.31±.10	202

TABLE I.C.3-13

Gross Beta Activity in Air Particulates

Third Quarter 1970

(Concentrations in pCi/m^3)

Location	Number of Analyses	Minimum	Maximum	Average	Avg M^3 Sampled Per Sample
Richmond	10	0.12±.01	0.48±.02	0.22±.10	199
Station	13	0.10±.01	0.40±.02	0.02±.09	149
Bacon's Castle	13	0.14±.01	0.44±.02	0.31±.15	165
Alliance	13	0.11±.01	0.56±.02	0.26±.14	142
Colonial Parkway	13	0.12±.01	0.42±.02	0.22±.10	152
Dow	13	0.11±.01	0.42±.02	0.22±.09	146
Newport News	13	0.10±.01	0.38±.01	0.22±.10	153
Hog Point	13	0.07±.01	0.42±.02	0.20±.10	149
Fort Eustis	13	0.07±.01	0.30±.01	0.17±.07	199

TABLE I.C.3-14

Gross Beta Activity in Air Particulates

Fourth Quarter 1970

(Concentrations in pCi/m^3)

Location	Number of Analyses	Minimum	Maximum	Average	Avg M^3 Sampled Per Sample
Richmond	9	0.11±.01	0.37±.01	0.18±.09	156
Station	13	0.06±.01	0.26±.01	0.12±.05	161
Bacon's Castle	12	0.08±.01	0.42±.02	0.17±.02	186
Alliance	12	0.03±.01	0.37±.01	0.14±.08	157
Colonial Parkway	13	0.07±.01	0.28±.01	0.14±.05	155
Dow	13	0.07±.01	0.32±.01	0.14±.07	149
Newport News	13	0.08±.01	0.33±.01	0.14±.07	149
Hog Point	13	0.06±.01	0.27±.01	0.12±.06	156
Fort Eustis	13	0.06±.01	0.28±.01	0.13±.07	199

TABLE I.C.3-15

Gross Beta Activity in Air Particulates

First Quarter 1971

(Concentrations in pCi/m^3)

Location	Number of Analyses	Minimum	Maximum	Average	Avg M^3 Sampled Per Sample
Richmond	10	0.02±.01	0.09±.01	0.03±.02	105
Station	13	0.06±.01	0.25±.01	0.13±.06	171
Bacon's Castle	13	0.09±.01	0.33±.01	0.19±.08	146
Alliance	13	0.02±.01	0.30±.01	0.17±.08	172
Colonial Parkway	13	0.06±.01	0.22±.01	0.14±.05	163
Dow	13	0.07±.01	0.30±.01	0.15±.07	154
Newport News	13	0.06±.01	0.30±.01	0.15±.07	155
Hog Point	13	0.06±.01	0.26±.01	0.13±.06	156
Fort Eustis	12	0.05±.01	0.28±.01	0.13±.07	184

TABLE I.C. 3-16

Gross Beta Activity in Air Particulates

Second Quarter 1971

(Concentrations in pCi/m^3)

Location	Number of Analyses	Minimum	Maximum	Average	Avg M^3 Sampled Per Sample
Station	13	0.28±.01	0.62±.02	0.40±.12	161
Bacon's Castle	13	0.25±.01	0.84±.02	0.56±.16	160
Alliance	13	0.07±.01	1.00±.03	0.47±.29	157
Colonial Parkway	12	0.26±.01	0.52±.01	0.38±.11	173
Dow	13	0.18±.01	0.63±.02	0.42±.13	163
Newport News	13	0.15±.01	0.62±.02	0.42±.12	154
Hog Point	13	0.15±.01	0.67±.02	0.41±.12	151
Fort Eustis	13	0.17±.01	0.59±.01	0.41±.12	166

not being conducted for the Surry area. The base-line conditions have been evaluated by a review of the air quality control regional plans proposed for the State of Virginia by the Division of State Planning and Community Affairs in cooperation with the State Air Pollution Control Board.

The Surry site is located within the proposed region V of this plan. Region V would encompass Charles City, Chesterfield, Goochland, Hanover, New Kent, Powhatan, Dinwiddie, Greensville, Prince George, Sussex and Surry Counties.

The regional approach to air pollution is based upon several administrative guidelines. An effort is made to make regions self-contained with respect to both air pollution receptors and sources. Future air system use is anticipated in order to prepare for foreseeable air quality impacts and regions are delineated to optimize inter-jurisdictional cooperation in handling present and future air resource management.

The metropolitan areas of Richmond and Petersburg - Hopewell - Colonial Heights are also located within Region V. All of the major industrial pollutant sources of the region are located within these metropolitan areas and future industrial expansion is anticipated to be concentrated in these metropolitan areas also. The regional proposal indicated no major industrial pollution sources located within Surry County.

(ii) Non-Radioactive Particulates

The sampling program for radioactive airborne particulates has been used for establishing total particulate background level trends. The system was not established for extra-radioactivity monitoring purposes and the data has been treated on a qualitative comparison rather than strictly quantitative basis. The data is indicative of the general rural nature of the area and is consistent with the description of this section of the proposed Region V. Several sampling points tend to increase in total particulates during early spring; this is felt to be associated with the plowing of fields in the immediate vicinity. The Surry Station location reflects the added dust loading due to localized vehicle traffic.

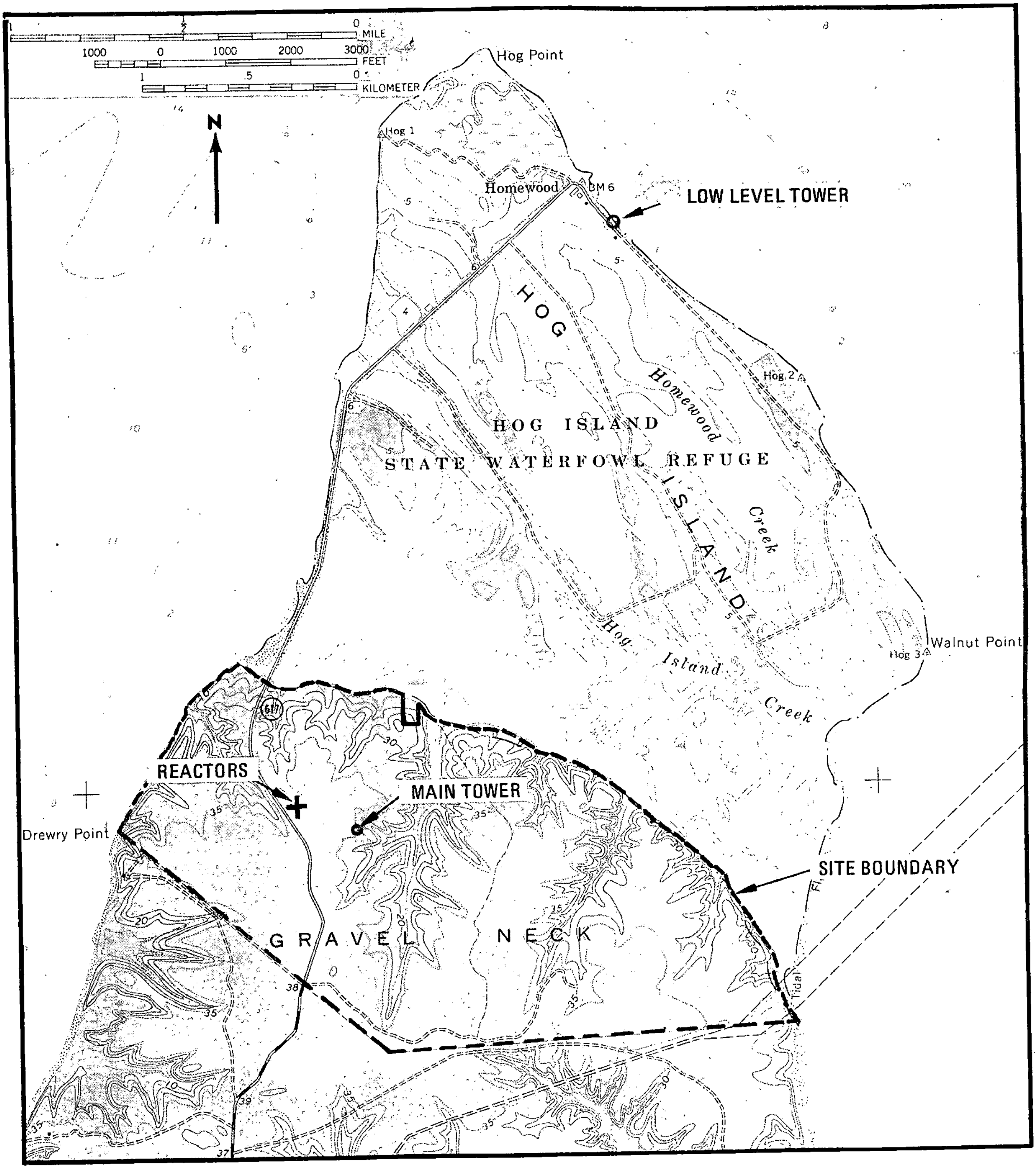
(4) Overall Ecological Balance of Air Resource System

The air resource of the area potentially under the influence of Surry Power Station is a complex and dynamic medium. As is typical of all air systems, it is in constant interplay with every other environmental parameter. The summation of these interactions constitutes the natural environment.

Due to the dynamic nature of any ecosystem, the balance or lack of balance in the system is a nebulous characteristic to address. No set of concrete measurements can be made which will totally describe the entire picture. Nevertheless, on the basis of the best available subjective analysis of the air system in this area, the Applicant can find no set of cause-and-effect relationships which leads it to believe that the air resource system in its interaction with other ecosystems is in a state of ecological imbalance.

b. Human Aspects

The base-line air shed use patterns in the area potentially under the influence of the Surry Station are typical of a rural setting. This area is neither reputed as a sanctuary from air quality degradation nor does it display the extensive air contamination conditions found in many metropolitan environments. The human-use characteristics of the air shed are neither precluded by nor dependent upon its air quality. The projected land use patterns and the air quality effects associated with these uses tend to predict a continuation of present air quality conditions and human uses of the area air shed.



VEPCO SURRY SITE PLAN
LOCATIONS OF METEOROLOGICAL INSTRUMENTS

Figure I.C.3-1

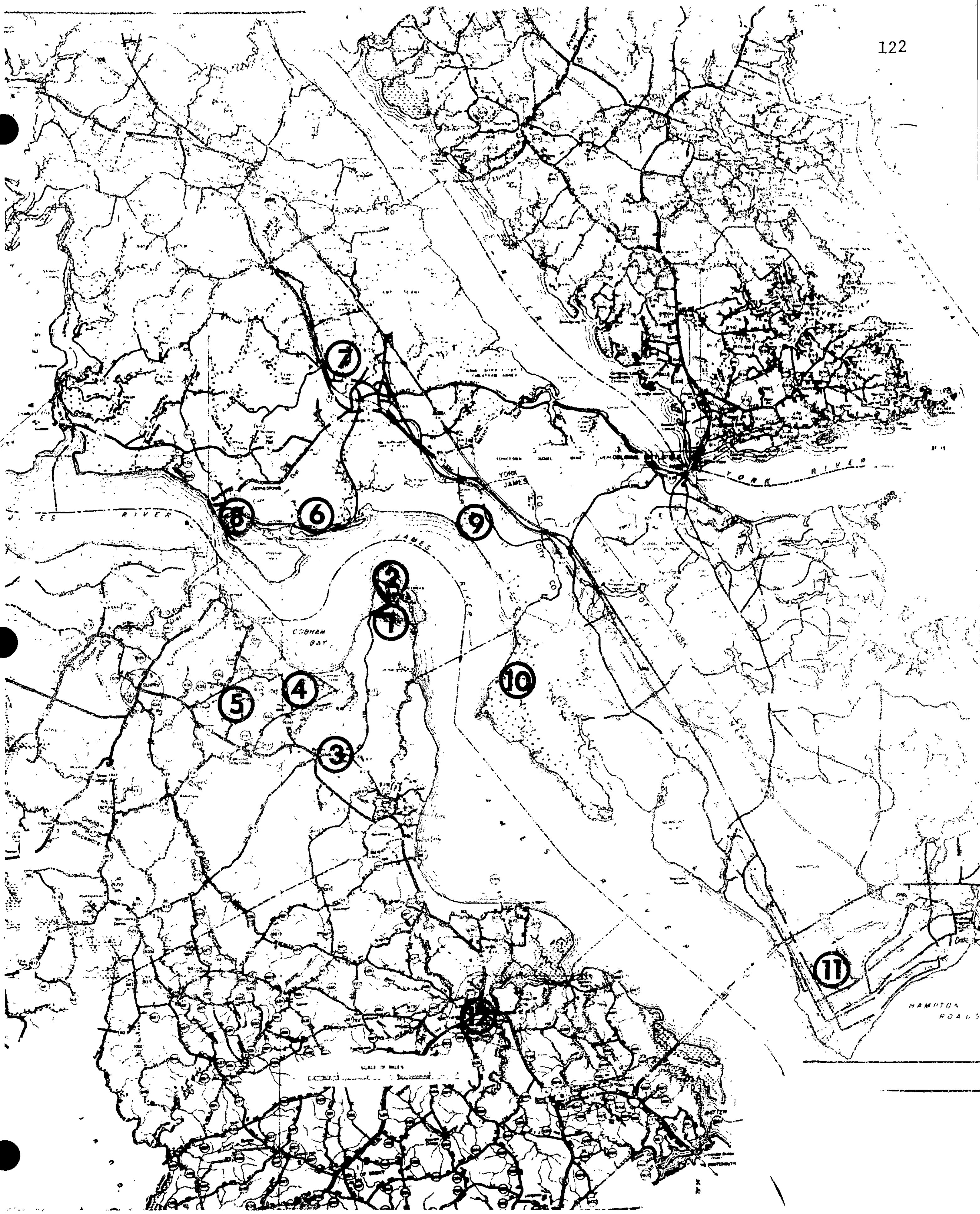

7
8
6
9
2
1
4
5
3
10
11
12
JAMES RIVER
YORK RIVER
COBHAM BAY
YORK
JAMES
HAMPTON ROADS

Figure I.C.3-2

D. Environmental Approvals and Consultations

Numerous governmental bodies responsible for environmetal standards must be dealt with in the course of licensing a nuclear power facility. What follows is a discussion of the specific relationship existing with each cognizant governmental agency, including permits, if any, which must be obtained.

1. Required Governmental Approvals

This section discusses the course of dealings between Vepco and the various Federal, State, and Local agencies contacted from which some form of specific approval is required for construction or operation of the Surry Power Station. Each of the immediately following pages presents a discussion, in standardized form, of one of the specific approvals listed immediately below, in the order in which they are listed. In addition to the titles of the relevant permit, license or approval, the discussion lists the cognizant governmental agency, its statutory authority, the environmental effect with which each permit is concerned, and the status of each. Copies of certifications issued are attached as Appendix G to this report.

a. Federal

(1) Atomic Energy Commission
- (a) Nuclear Station Construction Permit
- (b) Nuclear Station Operating License
- (c) Nuclear Station Operating Personnel Licenses
- (d) Special Nuclear Material License
- (e) Byproduct Material License

(2) U. S. Army Corps of Engineers
- (a) Refuse Discharge Permit
- (b) Intake Channel Markers Permit
- (c) Instrument Towers Permit
- (d) Dredging Permit

(3) U. S. Coast Guard (Department of Transportation)
   (a) Daybeacons Authorization
   (b) Groin Lights Authorization
   (c) Tower Lights Authorization

b. <u>State</u>

(1) Virginia State Corporation Commission

(2) Virginia State Department of Health

(3) Virginia State Department of Highways

(4) Virginia State Water Control Board

c. <u>Local</u>

(1) Surry County Department of Health (See Virginia State Department of Health)

2. Specific Approvals Not Required

The material below contains comments on the Surry Power Station rendered by governmental and private agencies which are interested in the project but hold merely advisory power in relation to it.

Listed first are Federal agencies which have commented on the original environmental report submitted by Vepco to the Atomic Energy Commission. Also included in this section are comments and recommendations from State and Local agencies and associations having special interest in environmental matters in the State. The comments of each agency are treated on individual pages, as was done in the discussion of required approvals. Copies of relevant, specific comments are included in Appendix G to this report.

a. Federal

(1) Department of Agriculture

(2) U. S. Army Corps of Engineers

(3) Department of the Interior

(4) Advisory Council on Historic Preservation

(5) Department of Transportation

(6) Federal Power Commission

(7) Environmental Protection Agency

b. State

(1) Virginia Air Pollution Control Board

(2) Governor's Council on the Environment (for itself and numerous other State agencies).

(3) Virginia Commission of Game and Inland Fisheries

(4) Virginia Commission of Outdoor Recreation

(5) Virginia Department of Conservation and Economic Development

(6) Virginia Historic Landmarks Commission, Archeological Society of Virginia and Association for the Preservation of Virginia Antiquities

(7) Virginia Institute of Marine Science

REQUIRED ENVIRONMENTAL APPROVALS

(A) License, Permit, Etc. Name: Construction Permit

(B) Government from which it must be obtained:

U. S. Atomic Energy Commission

(C) Statutory or Regulatory Authority:

Atomic Energy Act of 1954; 10 CFR 50 and National Environmental Policy, Act of 1969 § 102 (2)(c); Executive Order 11514 (March 4, 1970)

(D) Environmental effects to which directed:

Pre-NEPA, primarily radiological, all ecological systems; under NEPA, all environmental effects, all ecological systems

(E) Whether obtained yet or not:

(1) If obtained, enclose copies of any certifications issued.

Appendix G-1

(2) If not yet obtained, indicate status of efforts to obtain.

N/A

(F) Whether or not obtained, set forth date or projections showing compliance or how compliance will be accomplished.

Reference: AEC Dockets 50-280 and 50-281

REQUIRED ENVIRONMENTAL APPROVALS

(A) License, Permit, Etc. Name: Operating License

(B) Government from which it must be obtained:

U. S. Atomic Energy Commission

(C) Statutory or Regulatory Authority:

ACRS (Advisory Committee on Reactor Safety)
ALSB (Atomic Licensing & Safety Board)
AEC, Division of Reactor Licensing
Atomic Energy Act of 1954, as amended; 10 CFR 2, 20, 30, 50, 70, 71, 140
National Environmental Policy Act of 1969 § 102 (2)(c)
Executive Order 11514 (March 4, 1970)

(D) Environmental effects to which directed:

Under Atomic Energy Act, radiological and Public Health & Safety factors must be considered.

Under NEPA, all types of environmental considerations in all ecosystems must be examined before an operating license may be issued.

(E) Whether obtained yet or not: Not obtained yet.

(1) If obtained, enclose copies of any certifications issued.

N/A

(2) If not yet obtained, indicate status of efforts to obtain.
The following required items have been submitted:
(1) Operating License Application, Part A
(2) FSAR, Part B
(3) Initial and Supplementary Environmental Reports

The following procedural stages must yet be completed:
(1) ACRS hearing
(2) Public hearing on welding problems (no date set)
(3) NEPA hearing (date unknown)

(F) Whether or not obtained, set forth date or projections showing compliance or how compliance will be accomplished.

Application for operating license includes Applicant's Initial and Supplementary Environmental Reports.

Reference: AEC Dockets 50-280 and 50-281

REQUIRED ENVIRONMENTAL APPROVALS

(A) License, Permit, Etc. Name: Operating Personnel License

(B) Government from which it must be obtained:

U. S. Atomic Energy Commission

(C) Statutory or Regulatory Authority:

Atomic Energy Act of 1954 as amended
National Environmental Policy Act of 1969, § 102 (2)(c); Executive Order 11514 (March 4, 1970)

(D) Environmental effects to which directed:

None

(E) Whether obtained yet or not: Not obtained yet.

(1) If obtained, enclose copies of any certifications issued.

N/A

(2) If not yet obtained, indicate status of efforts to obtain.
Resumes of qualifications of people expected to take exams forwarded to DRL, requesting DRL comments on employee qualifications. No comments yet received.

Exams presently scheduled for Jan. 4 & 5, 1972.

(F) Whether or not obtained, set forth date or projections showing compliance or how compliance will be accomplished.

Results of exams should be obtained approximately one month after exam.

Reference: AEC Dockets 55-1402, 3253, 3254, 1741, 3636, 3403, 3154, 1112, 3158, 3162, 3402, 3517, 3518, 3405, 3406, 3627 - 3635.

REQUIRED ENVIRONMENTAL APPROVALS

(A) License, Permit, Etc. Name: Special Nuclear Material License and amendment thereto

(B) Government from which it must be obtained:

U. S. Atomic Energy Commission

(C) Statutory or Regulatory Authority:

Atomic Energy Act of 1954, as amended;
10 CFR 30, 40, 70
National Environmental Policy Act of 1969 § 102 (2)(c)
Executive Order 11514 (March 4, 1970)

(D) Environmental effects to which directed:

Primarily radiological, all ecological systems

(E) Whether obtained yet or not: Issued 8/11/70 and 8/20/71

(1) If obtained, enclose copies of any certifications issued.

Appendix G-2.

(2) If not yet obtained, indicate status of efforts to obtain.

N/A

(F) Whether or not obtained, set forth date or projections showing compliance or how compliance will be accomplished.

Expires 31 December 1972 or conversion of CPR-43 and CPR-44 to operating licenses, whichever occurs earliest.

Reference: AEC Dockets 70-1249, 70-1295

REQUIRED ENVIRONMENTAL APPROVALS

(A) License, Permit, Etc. Name: Byproduct Material License

(B) Government from which it must be obtained:

U. S. Atomic Energy Commission

(C) Statutory or Regulatory Authority:

Atomic Energy Act of 1954, as amended
10 CFR 30, 32, 33, 34, 35
National Environmental Policy Act of 1969 § 102 (2)(c)
Executive Order 11514 (March 4, 1970)

(D) Environmental effects to which directed:

Primarily radiological, all ecological systems.

(E) Whether obtained yet or not: Issued 5/20/70, amended 4/14/71

(1) If obtained, enclose copies of any certifications issued.

Appendix G-3.

(2) If not yet obtained, indicate status of efforts to obtain.

N/A

(F) Whether or not obtained, set forth date or projections showing compliance or how compliance will be accomplished.

Expiration 31 May 1974 or upon attainment of Unit 1 Surry Operating License (CPR-43), whichever is sooner.

Reference: AEC Dockets 50-280 and 50-281

REQUIRED ENVIRONMENTAL APPROVALS

(A) License, Permit, Etc. Name: Refuse Discharge Permit

(B) Government from which it must be obtained:

U. S. Army Corps of Engineers

(C) Statutory or Regulatory Authority:

Rivers and Harbors Act of 1899, § 407; 33 USC § 407
National Environmental Policy Act of 1969 § 102 (2)(c)
Water Quality Improvement Act of 1970 § 21(b), 33 USC § 1171(b)
Executive Order 11514 (March 4, 1970)

(D) Environmental effects to which directed:

All kinds of refuse matter, including heat, discharged into navigable waters.

(E) Whether obtained yet or not:

(1) If obtained, enclose copies of any certifications issued.

N/A

(2) If not yet obtained, indicate status of efforts to obtain.
(1) Letter to Army Corps of Engineers covering Application, Part 1 and indicating grounds of protest, June 29, 1971. Appendix G-4
(2) Letter covering Application, Part II, October 22, 1971. Appendix G-4a.

(F) Whether or not obtained, set forth date or projections showing compliance or how compliance will be accomplished.
The Discharge Permit can be secured from the Army Corps of Engineers only after a Certificate of Assurance has been granted pursuant to § 21(b) of the Water Quality Improvement Act of 1970, by the State Water Control Board Applicant has applied for a Certificate of Assurance and is confident that it will be granted, and that the Discharge Permit can therefore be issued. For more complete coverage, see the discussion of the application for a Certificate of Assurance, below, and in Appendix G-14.

REQUIRED ENVIRONMENTAL APPROVALS

(A) License, Permit, Etc. Name: Timber Pile Channel Markers Permit for Intake Channel

(B) Government from which it must be obtained:

U. S. Army Corps of Engineers

(C) Statutory or Regulatory Authority:

Rivers and Harbors Act of 1899, § 10 (33 USC, §403); 33 CFR 209, 120
National Environmental Policy Act of 1969 § 102 (2)(c);
Executive Order 11514 (March 4, 1970)

(D) Environmental effects to which directed:

Protection of navigation by marking location of Surry Intake Channel with seven timber pile channel markers.

(E) Whether obtained yet or not: Obtained 2/12/68

(1) If obtained, enclose copies of any certifications issued.

Appendix G-5.

(2) If not yet obtained, indicate status of efforts to obtain.

N/A

(F) Whether or not obtained, set forth date or projections showing compliance or how compliance will be accomplished.

Installation completed 4/8/68, in accordance with attached permit conditions.

REQUIRED ENVIRONMENTAL APPROVALS

(A) License, Permit, Etc. Name: Instrument Towers Permit

(B) Government from which it must be obtained:

U. S. Army Corps of Engineers

(C) Statutory or Regulatory Authority:

Rivers and Harbors Act of 1899, § 10 (33 USC § 403); CFR 209, 120 (b), (d)
National Environmental Policy Act of 1969 § 102 (2)(c)
Executive Order 11514 (March 4, 1970)

(D) Environmental effects to which directed:

Protection against navigational hazards posed by placement of seven instrument towers in the James River to measure water temperatures and salinity.

(E) Whether obtained yet or not: Obtained 7/16/69

(1) If obtained, enclose copies of any certifications issued.

Appendix G-6.

(2) If not yet obtained, indicate status of efforts to obtain.

N/A

(F) Whether or not obtained, set forth date or projections showing compliance or how compliance will be accomplished.

Construction completed 9/16/69 in accordance with conditions set out in attached construction permit. Towers must be removed no later than 31 March 1975.

REQUIRED ENVIRONMENTAL APPROVALS

(A) License, Permit, Etc. Name: Dredging Permit (also screenwell, docks, and groins installation)

(B) Government from which it must be obtained:

U. S. Army Corps of Engineers

(C) Statutory or Regulatory Authority:

Rivers and Harbors Act of 1899, § 10 (33 USC § 403)
National Environmental Policy Act of 1969 § 102 (2)(c)
Executive Order 11514 (March 4, 1970)

(D) Environmental effects to which directed:

Effects on navigability of water and on fish and wildlife, from dredging and depositing dredged soil outside of navigable waters.

(E) Whether obtained yet or not: Issued 8/21/67

(1) If obtained, enclose copies of any certifications issued.

Appendix G-7.

(2) If not yet obtained, indicate status of efforts to obtain.

N/A

(F) Whether or not obtained, set forth date or projections showing compliance or how compliance will be accomplished.

Construction-associated dredging has been completed. Additional permits will be obtained as the need arises. Current permit extended to 12/31/71.

REQUIRED ENVIRONMENTAL APPROVALS

(A) License, Permit, Etc. Name: Daybeacons (intake channel markers) Authorization

(B) Government from which it must be obtained:

Department of Transportation (U. S. Coast Guard)

(C) Statutory or Regulatory Authority:

14 USC §§ 81, 83, 85, 633; 49 USC § 1655(b)
33 CFR 66

(D) Environmental effects to which directed:

Protection of navigation against hazards arising from construction of intake canal.

(E) Whether obtained yet or not: Approved 3/15/68

(1) If obtained, enclose copies of any certifications issued.

Appendix G-8.

(2) If not yet obtained, indicate status of efforts to obtain.

N/A

(F) Whether or not obtained, set forth date or projections showing compliance or how compliance will be accomplished.

Constructed in compliance with permit.

REQUIRED ENVIRONMENTAL APPROVALS

(A) License, Permit, Etc. Name: Installation of Groin Lights along Discharge Canal

(B) Government from which it must be obtained:

Department of Transportation (U. S. Coast Guard)

(C) Statutory or Regulatory Authority:

14 USC §§ 81, 83, 85, 633; 49 USC § 1655 (b)
33 CFR 66
Private Aids to Navigation Application (CG 2554)
National Environmental Policy Act of 1969 § 102 (2)(c)
Executive Order 11514 (March 4, 1970)

(D) Environmental effects to which directed:

Protection of navigation against hazards arising from the placement of rock pilings along the edges of the discharge canal

(E) Whether obtained yet or not: Approved 2/18/70

(1) If obtained, enclose copies of any certifications issued.

Appendix G-9

(2) If not yet obtained, indicate status of efforts to obtain.

N/A

(F) Whether or not obtained, set forth date or projections showing compliance or how compliance will be accomplished.

Construction was in compliance with terms of permit. Lights are permanently installed; permit is permanent.

REQUIRED ENVIRONMENTAL APPROVALS

(A) License, Permit, Etc. Name: Instrument Tower Lights

(B) Government from which it must be obtained:

Department of Transportation (U. S. Coast Guard)

(C) Statutory or Regulatory Authority:

14 USC §§ 81, 83, 85, 633; 49 USC §1655(b)
33 CFR 66

(D) Environmental effects to which directed:

Protecting navigation against potential hazards caused by placement in river of towers to support instruments to monitor water temperatures and salinity (See also Corps of Engineers Instrument Towers Permit, above and Appendix G-12).

(E) Whether obtained yet or not: Approved 8/25/69

(1) If obtained, enclose copies of any certifications issued.

Appendix G-10

(2) If not yet obtained, indicate status of efforts to obtain.

N/A

(F) Whether or not obtained, set forth date or projections showing compliance or how compliance will be accomplished.

Construction completed 9/16/69. According to the terms of an additional permit required by the Corps of Engineers, the towers on which these lights are mounted must be removed from the James River by the date on which an Operating License is obtained, or March 1975, whichever occurs sooner.

REQUIRED ENVIRONMENTAL APPROVALS

(A) License, Permit, Etc. Name: Certificate of Public Convenience and Necessity

(B) Government from which it must be obtained:

Virginia State Corporation Commission

(C) Statutory or Regulatory Authority:

Utilities Facilities Act
Code of Virginia, Titles 5b § 265

(D) Environmental effects to which directed:

No specific consideration of environmental problems is required by Utilities Facilities Act.

(E) Whether obtained yet or not: Issued 7/16/68

(1) If obtained, enclose copies of any certifications issued.

Appendix G-11, G-11a

(2) If not yet obtained, indicate status of efforts to obtain.

N/A

(F) Whether or not obtained, set forth date or projections showing compliance or how compliance will be accomplished.

Construction of transmission lines and related facilities is proceeding in accordance with the Certificate.

REQUIRED ENVIRONMENTAL APPROVALS

(A) License, Permit, Etc. Name: Sewage Treatment Plant for Surry Facility

(B) Government from which it must be obtained:

Surry County Health Department (in cooperation with the State Water Control Board and Department of Health)

(C) Statutory or Regulatory Authority:

Code of Virginia, Title 32 §§ 9, 61

(D) Environmental effects to which directed:

Effects on land and water system from construction and use of septic tank and of sewage disposal facility.

(E) Whether obtained yet or not: Obtained 2/27/69

(1) If obtained, enclose copies of any certifications issued.

Appendix G-12.

(2) If not yet obtained, indicate status of efforts to obtain.

N/A

(F) Whether or not obtained, set forth date or projections showing compliance or how compliance will be accomplished.

Construction of facilities mentioned above has been completed in accordance with terms of permit.

REQUIRED ENVIRONMENTAL APPROVALS

(A) License, Permit, Etc. Name: Relocation of Route 617

(B) Government from which it must be obtained:

State of Virginia Department of Highways

(C) Statutory or Regulatory Authority:

Code of Virginia, Title 33.1, § 18

(D) Environmental effects to which directed:

Land

(E) Whether obtained yet or not: Approved 12/12/66

(1) If obtained, enclose copies of any certifications issued.

Letter granting approval, Appendix G-13, G-13a

(2) If not yet obtained, indicate status of efforts to obtain.

N/A

(F) Whether or not obtained, set forth date or projections showing compliance or how compliance will be accomplished.

Road constructed in accordance with plans approved by the Department of Highways.

ENVIRONMENTAL CONSULTATION OR COMMENTS

(A) Type of Consultation/Comments

Comments to AEC on Surry Environmental Report filed 22 March 1971, by Federal Power Commission

(B) Governmental Agency Involved

U. S. Federal Power Commission

(C) Applicable Statutory or Regulatory Authority

National Environmental Policy Act of 1969 § 102 (2)(c)
Executive Order 11514 (March 4, 1970)
C.E.Q. Guidelines 36 Fed Reg 7724 (23 April 1971) ¶ 7

(D) Environmental Effects to Which Directed

Need for generating capacity in Vepco service area.

(E) Comments on Other Documents

Letter of 6/4/71. See Appendix G-21

Applicant's present and projected power needs are outlined in Section II.I.E.

ENVIRONMENTAL CONSULTATION OR COMMENTS

(A) Type of Consultation/Comments

Comment to AEC on Surry Environmental Report filed 22 March 1971, by Environmental Protection Agency

(B) Governmental Agency Involved

Environmental Protection Agency

(C) Applicable Statutory or Regulatory Authority

National Environmental Policy Act of 1969 § 102 (2)(c)
Executive Order 11514 (March 4, 1970)
C.E.Q. Guidelines (April 23, 1971), ¶7

(D) Environmental Effects to Which Directed

All effects on ecosystem

(E) Comments on Other Documents

EPA letter of comment, August 16, 1971. Apendix G-22 and G-22a

ENVIRONMENTAL CONSULTATION OR COMMENTS

(A) Type of Consultation/Comments

Consultations relating to emission standards with Virginia State Air Pollution Control Board

(B) Governmental Agency Involved

Virginia State Air Pollution Control Board

(C) Applicable Statutory or Regulatory Authority

Air Pollution Control Law of Virginia, Title 10, §§ 10-17.10 through 10-17.30

(D) Environmental Effects to Which Directed

"To achieve and maintain such levels of air quality as will protect human health, welfare and safety and to the greatest degree practicable prevent injury to plant and animal life and property."

(E) Comments on Other Documents

A permit or license is not required for an air pollution source in Virginia under the present rules.

The Surry Power Station has two package boilers used only for start-up steam and building heating - each rated at 80,000 pounds of steam per hour. These units are to be operated infrequently and are designed to burn No. 2 commercial grade fuel oil with a 0.75% maximum sulfur content. These units will be regulated under Rule 3 (smoke opacity not to exceed Ringelman 2) and Rule 7 of the Air Pollution Control Board, and are expected to comply with their regulations.

The estimated regulated emissions from each of these units is expected to be as follows:

(a) 0.7565 pounds SO_2 per 10^6 Btu heat input for each hour of operation. (No Virginia statute or regulation presently directly limits SO_2 emissions.)

(b) 0.1065 pounds particulate per 10^6 Btu heat input for each hour of operation. (Rule 7 requires that emissions not exceed 0.8 pounds particulate per 10^6 Btu heat input.)

(c) Ringelman opacity cannot be estimated in advance, but is expected to be well below Ringelman 2.

ENVIRONMENTAL CONSULTATION OR COMMENTS

(A) Type of Consultation/Comments

Comments from Governor's Council on Environment (for itself and numerous other State agencies).

(B) Governmental Agency Involved

See Appendix G-23.

(C) Applicable Statutory or Regulatory Authority

(D) Environmental Effects to Which Directed

(E) Comments on Other Documents

See Appendix G-23 for comments from:

(1) Virginia Department of Health
(2) Virginia Department of Conservation and Economic Development
(3) Commission of Outdoor Recreation
(4) Commission of Game and Inland Fisheries
(5) State Corporation Commission
(6) Virginia State Water Control Board

ENVIRONMENTAL CONSULTATION OR COMMENTS

(A) Type of Consultation/Comments

Discussions with Virginia Commission of Game and Inland Fisheries

(B) Governmental Agency Involved

(C) Applicable Statutory or Regulatory Authority

Code of Virginia, Title 29, §§ 3-23.1

(D) Environmental Effects to Which Directed

Effects on wildlife and fish due to thermal discharges. Discussion on disposal of surplus material from construction.

(E) Comments on Other Documents

See Appendix G-23.

ENVIRONMENTAL CONSULTATION OR COMMENTS

(A) Type of Consultation/Comments

Discussions with Virginia Outdoor Recreation Commission

(B) Governmental Agency Involved

(C) Applicable Statutory or Regulatory Authority

Code of Virginia, Title 10, § 21 et. seq.

(D) Environmental Effects to Which Directed

Assessment of effects in all ecosystems of locating power plants on existing, proposed, or potential recreation areas.

(E) Comments on Other Documents

See Appendix G-23.

ENVIRONMENTAL CONSULTATION OR COMMENTS

(A) Type of Consultation/Comments

Discussions with Virginia Department of Conservation and Economic Development

(B) Governmental Agency Involved

(C) Applicable Statutory or Regulatory Authority

Code of Virginia, Title 10, §§ 17, 117

(D) Environmental Effects to Which Directed

Improvement of the hydrologic characteristics of the stream effected for the purpose of beneficial uses consistent with the primary function of the energy producing facility.

General ecological effects on water systems.

(E) Comments on Other Documents

General comments only. See Appendix G-23.

ENVIRONMENTAL CONSULTATION OR COMMENTS

(A) Type of Consultation/Comments

Discussions with:
(1) Virginia Historic Landmarks Commission
(2) Association for the Preservation of Virginia Antiquities

(B) Governmental Agency Involved

Virginia Historic Landmarks Commission

(C) Applicable Statutory or Regulatory Authority

Code of Virginia, Title IV, § 135 *et. seq.* (Virginia Historic Landmarks Commission)

The Association for the Preservation of Virginia Antiquities is a private organization.

(D) Environmental Effects to Which Directed

Preservation of historic landmarks

(E) Comments on Other Documents

See Appendix G-24, and G-24a

ENVIRONMENTAL CONSULTATION OR COMMENTS

(A) Type of Consultation/Comments

Document relating to Ecological Research Program undertaken with Virginia Institute of Marine Science

(B) Governmental Agency Involved

Virginia Institute of Marine Science

(C) Applicable Statutory or Regulatory Authority

Code of Virginia, Title 28.1 § 195 et. seq.

(D) Environmental Effects to Which Directed

Ecological study of the environment and the aquatic life in the James River.

(E) Comments on Other Documents

See Appendix F.

E. Electric Power Supply and Demand

1. Present and Projected Power Needs of Area

a. Load Forecasts

(1) Regional

The Applicant is located in the Southeastern portion of the United States and in the Federal Power Commission's Region III. The Applicant is a member of the Southeastern Electric Reliability Council. Regional forecasts of loads for the Southeast are accumulations of load forecasts by individual operating entities. One such accumulation is shown in the "Regional" column Figure I E .1-1. These forecasts covering the period 1971-1975 indicate a sustained growth rate greater than the national average over the entire period included.

(2) Power Pool*

The Applicant is not now a member of a formal power pool. The Southeastern Electric Reliability Countil is divided into subregions having mutuality of interest and a history of cooperation. The Applicant is a member of the VACAR (Virginia-Carolinas) subregion which also includes Carolina Power and Light Company, Duke Power Company, South Carolina Electric and Gas Company, South Carolina Public Service Authority, Southeastern Power Administration and Yadkin, Inc. The forecast for the subregion is also an accumulation of individual forecasts by the VACAR participants. The latest published VACAR peak load forecast is shown on Figure I.E .1-1 under the VACAR column. The growth rate for VACAR is very similar to that of the entire region.

(3) System

The Applicant serves a large portion of Virginia, the northeastern corner of

*Applicant is still under contractual obligations with members in the VACAR Pool until April 30, 1973. See ¶ I.E.1.c.(2).

North Carolina and five counties in West Virginia. The Applicant now has more than one million electric customers in its service areas. Its load forecasts for the next five years are indicated by the Vepco column of Figure I.E.1-1. This forecast indicates a growth rate in excess of those of the VACAR subregion, the Southeast Region and the nation as a whole. While the 19% growth rate predicted for 1972 may appear excessive, local conditions over the past two years prevented the Applicant from reaching its estimated loads in both 1970 and 1971. A return to more normal conditions in 1972 will also return the Applicant's load to anticipated levels. The high growth rate of the Applicant's load is based on the continuing extension of the eastern seaboard megalopolis southward from Washington through the urban corridor of Virginia to Richmond and Norfolk.

b. Nature of the Demand and Growth Pattern

(1) Population Growth

Growth of population in the Applicant's service area for the decade 1960 to 1970 was 17.2% compared with a national average of 13.3%. The Applicant believes this larger-than-average growth will continue through at least 1980. Projections of population for the State of Virginia show a 16.5% increase over the next ten years. The Applicant's present service area, including the urban corridor, has 75% of the State's population; the urban corridor alone contains 59% of the State's population. Population growth in the urban corridor from 1960 to 1970 was about 26%, a rate almost twice the national rate and one and a half times the overall State rate. The exceptionally rapid growth of this portion of the State is expected to continue during the coming decade.*

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*Demographic data and projections are based on U. S. Department of Commerce-Census, and Virginia Chamber of Commerce.

FIGURE I.E.1-1

FORECAST OF LOAD

NATIONAL, REGIONAL, POWER POOL SYSTEM

	NATIONAL		REGIONAL		VACAR GROUP		VEPCO	
YEAR	LOAD	GROWTH RATE	LOAD	GROWTH RATE	LOAD	GROWTH RATE	LOAD	GROWTH RATE
1970	274.6		52.6				4.9	
1971	304.3	10.8%	58.7	11.6%	19.0		5.3	9.1%
1972	330.5	8.6%	64.9	10.6%	21.0	10.5%	6.3	19.0%
1973	359.8	8.9%	71.8	10.5%	23.2	10.5%	7.0	11.3%
1974	390.1	8.9%	79.2	10.3%	25.6	10.4%	7.8	11.1%
1975	421.9	8.2%	86.5	9.3%	28.2	10.2%	8.7	11.2%
1976	455.0	7.9%	94.6	9.4%	30.8	10.1%	9.6	11.0%

Notes: (1) All loads in thousands of Megawatts

(2) National and Regional data taken from EEI 49th Semi-Annual Electric Power Survey

(3) VACAR data taken from SERC Report to FPC dated 4/1/71.

(4) Vepco data is forecast approved 9/23/71.

(2) New Industry

While heavy industry is not the mainstay of the economy of the Applicant's service area, its desirable location, willing work force, transportation facilities and other natural inducements continue to attract industry. The Applicant had 639 customers classified as industrial in 1960; by 1970 this number had increased by 36.5%, to 873. The Applicant sold two billion kilowatt-hours of electricity of industrial customers in 1960 and four and a half billion kilowatt-hours in 1970. During 1975 the Applicant has forecast sales of six and one quarter billion kilowatt-hours to industrial customers. The Applicant continues to work with State and local bodies engaged in attracting new industry to its service area.

(3) Increased Per Capita Demand

In 1960 the average annual use of kilowatt-hours by residential customers in the Applicant's service area exceeded the national average by 133 kilowatt-hours or 3.5%. In 1970 the average annual use of kilowatt-hours by these residential customers exceeded the national average by 1815 kilowatts of 25.7% above the national average. By 1975 the Applicant has forecast the average residential use on its system will have increased 42.6% over the 1970 value.*

c. Reserve Requirements

(1) System

The Applicant has established a minimum reserve level of 15% for use on its

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*Forecast based on statistical projections which consider sales, population growth, load growth, weather, economic conditions, etc.

system. The optimum maximum level which the Applicant strives for is 18%. In general, reserve levels are established based on a thorough knowledge of the individual system and on the experience and judgment gained through years of successful operation of a bulk power supply system. The reserve level requirement is based on the size, type and condition of generating equipment, on the capability and extent of the transmission system, and on the existence of useful interconnections and emergency power contracts with neighbor supply systems. The Applicant plans for a strong transmission system with interconnections suitable for relaying, on an emergency basis, any sudden loss of a major generator. Applicant's reserve is expected to provide for four major contingencies: loss of the largest generator on the system, incidental curtailment or reductions in capacity of generation in service, errors in forecasts, and occurrence of weather more severe than anticipated. To provide for these contingencies the Applicant has established its reserve level to range from 15-18% of the forecasted load. All the Applicant's plans now are aimed at providing this reserve. Figure I.E.1-2 is a tabulation of the Applicant's peak load, capacity and reserve as now anticipated through 1976.

(2) Power Pool

Until April 30, 1973 the Applicant is under contractual obligations to share reserves with Carolina Power and Light Company, Duke Power Company, and South Carolina Electric and Gas Company. This arrangement is designed to provide members of the former CARVA pool with time to establish their own individual reserves. Sharing of reserves is based on the principle that each participant will retain the same percentage level of reserves as the

FIGURE I.E.1-2

PEAK LOAD CAPACITY AND RESERVE

1972 - 1976

YEAR	PEAK LOAD	CAPACITY	RESERVE MW	RESERVE %
1972	6300	7271	971	15.4*
1973	7010	7958	948	13.5
1974	7790	9349	1559	20.0
1975	8660	10133	1473	17.0
1976	9610	11050	1440	15.0

Note: All values are megawatts

*Based on Surry 1 and Oconee 1 in service.

other participants. The Applicant expects to purchase 387,000 kilowatts from the other participants during the summer of 1972. Beginning May 1, 1973 the Applicant has no plans for sharing reserves with any other system or pool.

2. Regional Power Supply

a. Institutional Arrangements

With the exception of sharing of reserves through April 30, 1973 as described in paragraph I.E.1.c.2 above, the Applicant, now and in the future, will plan for and develop its own power supply resources. Through participation in the Southeastern Electric Reliability Council the Applicant is able to cooperate with other companies in developing resources and facilities adequate to the electric requirements of the region. Because of the Applicant's location at the edge of the Southeast Region, the Applicant has undertaken joint studies with the power systems to the north and west to ensure orderly development of the resources and facilities of the combined areas.

The Applicant follows a long-established policy of owning sufficient generation to serve its peak loads. When generation additions are delayed or load growth is greater than anticipated, the Applicant must arrange for capacity enough to allow it to serve its load and provide an adequate reserve. The Applicant will, when necessary, arrange for purchases from neighboring systems. At this time, the Applicant has contracts for purchases through 1976, as shown on Figure I.E.2-1.

In addition to purchases now under contract, the Applicant has contracts with the Allegheny Power System, the Appalachian Power Company, the Carolina Power and Light Company and the Pennsylvania-New Jersey-Maryland Interconnection which provide for purchase and sale of capacity and energy when both parties agree and which provide for assistance in times of emergency.

FIGURE I.E.2-1

ALL PURCHASES

1972 - 1976

SELLER	1972	1973	1974	1975	1976
Southeastern Power Administration	132	132	132	132	132
Appalachian Power Company	300	300			
Allegheny Power Company	332	100			
Carolina Power & Light Company-Limited Term	387				
Carolina Power & Light Company	43	29	15		
South Carolina Electric & Gas Company	99	99	99	___	___
Total Purchases	1293	660	246	132	132

Note: All values are megawatts

b. Physical Interconnections

The Applicant maintains thirteen major interconnections with neighboring utilities as shown on Figure I.E.2-2. The Applicant has plans for adding three major interconnections within the next five years:

(1) 500 kv with Carolina Power & Light Company

(2) 230 kv with Carolina Power & Light Company

(3) 500 kv with PJM Interconnection

The Applicant will continue to study, in conjunction with its neighbors, the need for and usefulness of additional interconnections. The Applicant expects to construct interconnections that will provide for continuing reliability of service in its service area, but does not plan to develop interconnections as a permanent alternative to providing its own power supply.

FIGURE I.E.2-2

MAJOR INTERCONNECTIONS

OF

VIRGINIA ELECTRIC AND POWER COMPANY

COMPANY	INTERCONNECTION DESIGNATION	VOLTAGE
Carolina Power & Light Co.	Aurora - Greenville	230 000
	Rocky Mount - Everetts	230 000
	Rocky Mount - Lakeview	230 000
	Henderson	115 000
	Farmville	115 000
	Rocky Mount - Battleboro	115 000
Appalachian Power Company	Cloverdale - Lexington	500 000
	Hinton	138 000
	Altavista	138 000
	Bremo	138 000
Allegheny Power System	Ft. Martin - Mt. Storm	500 000
	Doubs	500 000
PJM Interconnection	Dickerson - Pleasant View	230 000

3. Relation of Proposed Facility Output

The Applicant has proposed the addition of the Surry No. 1 and Surry No. 2 units to expand its power supply resources to meet its growing load requirements and to provide a reserve consonant with its established reserve policy. Extraordinary load growth followed the decision to construct these units, requiring adjustments in both the Applicant's generation and purchase schedules. The Applicant has installed 391,000 kilowatts of peaking gas turbines in the years 1967 to 1970. The delay in commercial generation of both of the Surry units required the Applicant to secure additional gas turbines capable of generating 140,000 kilowatts for 1971 summer operation. In addition, the Applicant has made relatively large purchases of capacity to meet its peak loads in 1970 and 1971. Figure I.E.3-1 is a summary of the Applicant's power supply resources through 1976. Section A summarizes the conditions that will prevail if Surry No. 1 and Surry No. 2 units are placed in commercial operation prior to the summers of 1972 and 1973, respectively. Even with Surry No. 1 available the Applicant expects to purchase 1293 megawatts from its neighbors in order to meet its minimum reserve standard of 15.4%. Following commercial operation of the Surry units, and assuming orderly progress of the Applicant's announced generation program, the amount of purchases will decline while the reserve level remains at or near the Applicant's established standard. Section B of Figure I.E.3-1 summarizes the condition that would prevail if neither Surry unit were placed in operation. In 1972 the reserve would fall to 11.5%. Reserve is kept from falling lower because the Applicant's portion of shared reserves, discussed in paragraph I.E.1.c.2

FIGURE I.E.3-1

SUMMARY OF POWER SUPPLY RESOURCES

WITH AND WITHOUT SURRY #1 & SURRY #2

1972 - 1976

	1972		1973		1974		1975		1976	
	CAPACITY	RESERVE	CAPACITY	RESERVE	CAPACITY	RESERVE	CAPACITY	RESERVE	CAPACITY	RESERVE
A. With Surry #1 & #2										
Installed Capacity	5978		7298		9103		10001		10918	
Purchases	1293		660		246		132		132	
Total	7271	15.4%	7958	13.5%	9349	20.0%	10133	17.0%	11050	15.0%
B. Without Surry #1 & #2										
Installed Capacity	5190		5722		7465		8363		9280	
Purchases	1834		660		246		132		132	
Total	7024	11.5%	6382	(9.0%)	7711	(1.0%)	8495	(1.9%)	9412	(2.1%)

( ) Denotes negative value

Notes: (1) All loads in megawatts.
(2) Assumes Oconee #1 to be in service prior to June 1, 1972.

above, would increase by 541 megawatts if only Surry No. 1 were delayed and the other participating companies were able to make their planned generation available. Specifically, the reserve of 11.5% is predicated on a purchase of 1834 megawatts, a substantial portion of which is dependent on the operability of Duke Power Company's Oconee Unit 1 by June 1, 1972. Continuing purchases of this magnitude will load the interconnections with our neighboring companies, making their assistance during an emergency on the Applicant's system almost impossible. Without assistance during an emergency a high degree of probability would exist that the Applicant would find it necessary to curtail service to its customers. Beginning in 1973, and continuing without the Surry units, the Applicant would have less generating capacity than load - a condition that would certainly require load curtailment. This evaluation assumes that, with the exception of Surry No. 1 and No. 2, the Applicant's planned generation addition program is carried out.

4. Consequences of Delays in Constructing the Facility

The major consequences of a delay, short or extended, to either or both Surry No. 1 and Surry No. 2, is a sharp decrease in the reliability of electric service to the Applicant's customers, the reliability of the Applicant's bulk power supply system and to the bulk power supply in the Southeast and in other neighboring systems. The delay would necessarily increase our required purchases, placing a reciprocal burden on our neighbors: first, the Applicant would have to call upon them for help, especially during periods of heavy load, during incidental curtailments of generation, and a major loss of generation; and second, neighboring utilities would not, in the event of trouble on their own systems, be able to rely upon capacity assistance from the Applicant, even temporarily.

A second consequence of delay would be the inevitable increase in cost of electric service to the Applicant's customers. The Surry Power Station is expected to provide significantly lower generating cost than other alternative generating methods when it goes into service: saving in fuel expenditures was one of the major reasons for electing this particular form of generation. Delay will not only preclude the advantage of low-cost fuel, but will also penalize the Applicant's customers by increasing the use of high-cost generation which would otherwise not be used, and by increasing the amount of purchases which will cost much more than the delayed capacity would.

A third consequence of delay would be the loss in flexibility of operation of the bulk power supply system. Purchases of the magnitude needed to serve the load and meet reserve requirements, will burden transmission facilities, including the interconnections with other systems, to the extent that no major change in supply or in level of load may be taken without the possibility of overloading specific circuits or the transmission network generally. This loss of flexibility may effect neighboring systems which desire to make operating adjustments but may not be able to do so because of internal conditions on the Applicant's system.

II.I. ENVIRONMENTAL IMPACT

A. Construction Phase

1. Land System Effects

a. Natural Effects

(1) Physical Effects

(a) Placement of Fill From Excavation

Construction of Surry Power Station has required the excavation of a significant amount of earth in connection with the construction of the reactor containments and associated structures. The earth excavated from the site has been put to two primary uses. A relatively small portion of it was used as necessary in the site area for fill landscaping, etc. The greater portion and more significant environmental use of the fill, however, has been that used for the erection of barriers for the benefit of the Hog Island Game Preserve.

The Hog Island Preserve area offers refuge for a large variety of migratory waterfowl such as brant, coot, duck and geese, in the semi-freshwater marsh areas formed by a system of dikes. In the past it has experienced a substantial amount of "washing" resulting from brackish water spilling over the dikes, causing sudden increases in the salinity of the marsh water. These periodic salt water intrusions result in a large reduction of available food for migratory fowl and a number of years are required, under normal tidal conditions, for the marsh water and food supply to return to normal.

To aid in eliminating these periodic salinity intrustions, Applicant at the request of the Virginia State Game and Inland Fisheries Commission, transported the excess excavated material from plant construction and deposited it in fill areas of the Preserve as designated by the Virginia State Game and Inland Fisheries Commission. This work which is virtually completed, has involved the placement of an estimated 1,500,000 cubic yards of surplus material on the Hog Island Preserve in order to improve the existing dikes and roads.

(b) Sanitary Waste Disposal

The sanitary waste system in use at the station and at the Information Center has the approval of and is checked periodically by the Virginia Department of Health. The system consists of septic tanks, tile fields, level-control tanks, chlorine treatment, and hold-up tanks. Ultimate release is into the cooling water discharge canal where the effluent is rapidly dissipated.

The treatment system meets all standards of both the Virginia Department of Health and the State Water Control Board and contributes no BOD (Biochemical Oxygen Demand) to the estuary. No effects on water quality from sewage discharges are anticipated from the use of this system.

Portable chemical toilets have been provided at the site for use by construction personnel. These are of approved construction, are serviced regularly, and have no environmental impact on the station or site area.

(c) Erosion

As in all cases of land disturbance, there is a potential for erosion. The local flat topography has assisted Applicant in its erosion control measures, however, and the overall effect on the James River from site erosion has been insignificant.

At the present stage of construction, little erosion potential remains in areas other than those surrounding the discharge canal, where dredging and lining operations are still in progress. Spoil from dredging operations is being placed on-site, and planting and other erosion-control measures are being taken to reduce any adverse environmental impact.

(2) Biological Effects

(a) Timber and Other Flora Destroyed From Clearing Access Construction, Etc.

The general woodland near the Surry Power Station site is a mixture of pine and hardwood. Before construction started, this tract of land had been cut over at least twice, once about 20 years ago and once more recently about 10 years ago. The better pines and hardwoods were removed each time.

In constructing the Surry facility, only that land actually required to build the station and adjoining roads was cleared to ground level. Excavations for the intake canal, discharge canal, reactor containments, and adjoining buildings resulted in about 1,500,000 cubic yards of excess material which was reused for stabilizing the adjoining Hog Island Wildlife Preserve against adverse environmental conditions such as salt water intrusion into waterfowl ponds. The net effect of land clearing and excavations is judged to be beneficial in that the resulting system of stabilized, controlled dikes and ponds on the game preserve should result in more suitable habitats for waterfowl during their migrations.

(b) Wildlife Displaced by Clearing, Fencing, Etc.

When clearing 453 acres of land, a number of animals are unavoidably displaced.

These mainly include deer, rabbits, squirrels, forest birds, reptiles, and others. Few amphibians were displaced because of the elevated topography of the land that was cleared. These animals probably retreated to adjacent wooded areas which are located north and south of the site. Although a fence was placed around the cleared area of the site and around the intake canal, free access to Hog Island for these animals was maintained near the discharge canal. Reseeding with pine seedlings and natural regrowth of the cut areas has resulted in increased growth of herbs and hardwood sprouts within the easy reach of deer and rabbits. Reasonable care has been taken to retain the forest environment over a large portion of the Surry tract.

b. Human Use Effects

(1) Economic Effects of Construction

Construction of Surry Power Station posed no human relocation problems since no persons were living within the exclusion boundary initially. A station emergency plan has been provided to cover a spectrum of measures necessary to protect the public health and safety in the event of an accident; no involuntary relocations from or within the low population zone are thus under consideration.* No damage has been done to nearby property by blasting or other construction activities.

Employment in supporting services and contract construction has increased in the past but is expected to remain stable in the near future, because of the continued presence of about 1,600 construction workers employed in building the Surry Power Station. Construction and supporting services are expected to decline

*See Paragraph II.I.B.1.b.(4) for a complete discussion of the Surry Emergency Plan.

rather rapidly following completion of the station in 1972. The Virginia Division of Planning and Community Affairs estimates that approximately 350 more persons will be employed permanently in service trades than were at the beginning of the construction phase. Other types of employment are not expected to be effected substantially.

Highway transportation in Surry County is the only available mode of land travel. The county has one Virginia Primary Highway running east-west; two Virginia Primary Highways running north-south; and several Virginia Secondary Highways interconnecting the Primary Routes. The nearest major U. S. Highway east-west is located approximately 18 miles south of the site; the closest Interstate Highway running north-south is 37 miles to the west and the nearest Interstate Highway running east-west is 29 miles to the northeast. Except for routine repair and improvement projects under the State Department of Highways and temporary congestion from construction personnel, no changes in the existing network or traffic are expected to result because of construction of the station.

It is not anticipated that the addition of 350 employed persons with their families will significantly increase the level of demand for governmental services within the County. Such increases as occur will clearly be more than compensated for, however, by the tax revenues generated by the plant, which alone will more than equal the County's entire present tax revenues. At present, the County's Board of Supervisors has not indicated any firm plans as to how these additional revenues will be used.

For additional regional effects resulting from the location of the Surry facility, refer to projections booklet from the Virginia Division of Planning and Community Affairs contained in Appendix D of this letter.

(2) Effects on Area Esthetics

Since the project, in its present state, is incomplete, there is a temporary adverse impact on local esthetics. Whereas incomplete buildings and construction equipment (cranes, scaffolding, etc.) may be somewhat objectionable, their adverse effect is only temporary and will be decreased as the station progresses toward completion.

The containment structures, auxiliary and service buildings, fuel storage buildings, high voltage switchyard, Information Center, and various external storage tanks are 95% completed. Principal remaining construction activities will involve completion, checkout and testing of interior systems and some limited deliveries of equipment being procured off-site for Unit 2. Continued construction of these facilities will have negligible effect upon area esthetics. Although there will be some noise associated with these activities, as well as dust, they will not constitute a general nuisance to others because of the site's remoteness to any population center.

Applicant has, in fact, expended considerable effort to plan a completed facility which will blend harmoniously with the surrounding landscape. As examples, the containment foundations were constructed approximately 50 ft below grade to lower the tops of the domes and minimize their effect on the skyline of nearby

Colonial Williamsburg and Jamestown Island. The use of blue-green-colored steel siding will also help to blend the major structures into the natural forest background; and a protecting stand of trees will partially screen the station from the river.

Continued construction of the station will result in a continually diminishing adverse impact on the local esthetics, as structures are completed and landscaping efforts continue.

2. Water Systems

a. Natural Effects

(1) Physical Effects

(a) Effects on Stream Flow and Water Body Dimensions from Erection of Structures in water.

Seven instrument towers have been placed at selected positions in the James River to provide a support for instrumentation in order to measure temperature and salinity (Figure II.I.A.2-1). These towers will have no adverse effect on stream flow and water body dimension.

(b) Placement of Fill

The majority of the excavation fill materials was placed on the Hog Island Wildlife Preserve and has had no effect on the waters of the James River except possibly some temporary and intermittent increase in local turbidity.

(c) Silting from Disruption of Flow and Erosion

No appreciable siltation resulted from erosion during the construction phase at the Surry Power Station. There was no disruption of the James River flow.

Due to the elevated nature of the Surry site, no flooding resulted from the removal of timber and other cover. Minor erosion occurred for a short time at the downgrades of the intake and discharge canals until landscaping resulted in stabilization of the project.

(2) Chemical Effects

Chemical waste discharges during construction are minimal. Blowdown from the auxiliary heating boilers, when in service; blowdown of the flash evaporator, at approximately five times the concentrations of well water; and neutralized regeneration solutions from the mixed bed polishing demineralizer, comprise the chemical additions to the environment. These small quantities of wastes are discharged to the circulating water discharge canal and diluted with cooling water flows.

The chemical solutions used for cleaning the auxiliary boilers are hauled by tank truck to one of the Company's fossil stations for proper disposal.

Cleaning solutions used in cleaning the secondary cycle, composed of alkaline phosphate solutions and rinse water, will be diverted to a lagoon for storage and eventual evaporation at which time the lagoon will be back-filled with earth.

Wastes discharged during construction comply with State standards and a permit has been obtained from the State Water Control Board that covers all the discharges mentioned (See Appendix G for permits).

Sanitary wastes from the Information Center and from the plant proper have secondary treatment.

This secondary treatment is provided by septic tanks, the discharge of which goes to a subterranean sand filter. The effluent of the sand filter goes to level control tanks, is chlorinated, forwarded to hold-up tanks and is ultimately released to the circulating water discharge canal where it is immediately diluted and loses its chemical identity.

Portable chemical toilets, provided around the construction site for use by construction personnel, pose no problem to water systems.

This combination of systems was designed with the assistance of the Virginia Department of Health and meets all standards of this Department and the State Water Control Board. No effects are anticipated on the natural water systems.

(3) Biological

Overall, little, if any, permanent effect on the fauna and flora of the James River has been observed as a result of the construction of the Surry Power Station. Several aspects of the construction, however, merit individual consideration in connection with assessing effects on aquatic flora and fauna.

An "L"-shaped channel, about 150 feet wide by 13 feet deep by 6,450 feet long has been dredged from the main channel of the river to the area of the intakes on the southeast side of the plant. The purpose of this channel is to provide water access to the station site. This particular project resulted in short-term siltation and a semi-permanent disruption of the benthic biota in the area. Shore and migratory fish movement patterns were temporarily disrupted resulting from dredging operations although some species such as catfish were probably attracted to the area to feed on stirred up benthos. The hydrologic and physico-chemical characteristics of the river in this area dictate that this dredged channel will eventually silt in unless it is maintained. The major organism displaced was the marsh clam, *Rangia cuneata*, which is the dominant benthic species in the area. Haul seine samples for fish taken along the shore on both sides of the channel show little difference in species composition and abundance between the two sides indicating that, in the long run, fish populations were little affected. No aquatic plants were affected.

Construction of a floating dock, intake structure, and concrete batch plant at the shore end of the channel resulted in a short-term disruption in the migrations of shore fish such as the mummichog, Fundulus heteroclitus. However, now that intake structure construction is complete, the fish population appears once again to have resumed its previous migratory movement.

A channel dredged for the discharge groin resulted in temporary displacement of the marsh clam, Rangia cuneata. Since the completion of dredging, however, the clam has once again occupied a niche at the bottom of the channel.

A discharge groin constructed of granite rock, about 1200 feet long and 11 feet deep, protrudes into the river. This construction resulted in a temporary disruption of migratory patterns of shore fish, but since the completion of construction, fish appear to be moving around the end of the structure again. One benefit of the structure has been to provide additional surface areas for the growth of sessile forms which attract zooplankters, which serve as food for certain shore zone fish species.

Construction of the station itself has had little effect on the biology of the James River. Limited localized siltation resulted during construction, but this has since stabilized.

b. Human Use Effects

(1) Navigation -- Effects from Placement of Structures, Silting, Dredging, Etc.

Seven instrument towers were placed in strategic locations in the James River to house instrumentation for recording salinity and temperature. These towers are of steel pile construction, lighted according to Coast Guard specifications, and located out of the navigable shipping channels. Since they are easily seen by day or night, they do not constitute any hazard to navigation in the area.

Channel markers have been placed at intervals specified by the Coast Guard along the dredged intake channel, and constitute no more of a hazard to night navigation than the numerous pound net and gill net stakes that abound in the James River in this area.

Dredging, and the limited associated siltation, has not resulted in a hazard to navigation.

The construction of the Surry plant has not produced a volume of traffic on the navigable channel of the James River sufficient to interfere in any way with the normal use of that channel by commercial traffic. On occasion heavy equipment has been transported to the Surry site by water, and occasional intermittent use will likely be made of the channel for similar purposes during the life of the plant. These infrequent uses of the water body should not disrupt the normal flow of commercial traffic on the river.

Aside from the structures mentioned earlier, and the infrequent use to be made of the James River in transporting heavy equipment to the facility, the Surry Power Station will have no effect whatever on the navigability of the James River. The effects mentioned will not be harmful.

(2) Economic -- Effects on Downstream Industrial Uses of Water

There has been no aspect of station construction that has resulted in any measurable effect on downstream industrial uses of James River water.

(3) Human Consumption -- Quality of Water Supply for Human Use

Since the water of the James River immediately above or below the station is not used for human consumption, there has been no effect of station construction on the quality of James River water that could be classed as detrimental for human consumption.

(4) Recreational -- Effects on Fishing, Boating, Swimming, and Other Water Sports

Station construction has had no appreciable effect on recreation in the James River. Commercial fishing pound and gill nets in the area of the discharge groin appeared to remain productive during the construction in the discharge groin area.

(5) Esthetics -- Effects of Discoloration, Odor, and Silting on Scenic Aspects of the Water Body

The turbidity of the James River is more or less directly dependent on upstream water flow: the river runs muddy during periods of high flow, clear during periods of low flow. The construction of the station has produced no appreciable general or enduring discoloration, odor, or siltation. Localized discoloration and siltation did occur during dredging operations, but these were short-term, as is the case with any dredging operation. Water around historic areas such as Jamestown Island and Chippokes Plantation was not effected by station construction.

3. Air Systems Effects

a. Natural Effects

(1) Climatology

There exist no detrimental effects on the natural air systems as a result of site clearing or construction efforts at Surry Power Station.

(2) Meteorology

During the clearing of the Surry site, some minor changes in the ground level wind patterns, either in velocity or direction distributions, might be expected from the loss of foliage. Due to efforts to minimize the area cleared, the minor effects, if any, experienced would have been limited to only those individual areas where clearing operations were actually conducted. There should be no noticeable meteorological effects outside the Station property boundaries due to this removal of natural ground-level foliage.

On-site continuous meteorological monitoring instruments record wind speed and direction patterns and any slight changes in the wind patterns due to the removal of trees and other ground level growth would be monitored at the instrument sites. These conditions would then be accounted for in developing gaseous release procedures. No further meteorological effects resulted from construction, per se, of the facility.

(3) Air Quality

During the pre-construction site preparation, a limited amount of burning was conducted to dispose of timber cuttings. All burning was conducted in accordance with applicable air pollution and fire safety regulations; precautions were taken to ensure that favorable weather conditions prevailed and that accepted forest management procedures for burning were followed. The adverse air quality effects on the area-wide airshed from this type of burning were minimized by the remote nature of the site and by minimizing clearing burning of the site property.

During the excavation and general construction phases of the project, some minor adverse air quality effects were expected and experienced. These effects were limited to an increase in atmospheric dust caused by the movement of trucks and heavy equipment and the operation of a small batch concrete mixing facility, and to the introduction of small amounts of gaseous air contaminants into the atmosphere from the operation of an open burning pit, and from emissions by mobile sources at the site.

During periods of extended dry weather, on-site mobile construction equipment and vehicles resulted in small quantities of dust being picked up by the air. In addition, during the hauling of excavation material to the wildlife preserve, small amounts of this refuse were blown from truck beds.

Initially, water was sprayed to wet down exposed ground surfaces; later, additives were substituted to improve dust control. It is felt that increased fugitive dust loadings from the movement of construction vehicles were essentially confined to the station property and that any off-site effects were indistinguishable from normal background level fluctuations.

Some small additions of particulate matter to the airshed would be expected during operation of a batch concrete mixing installation on the site. The dust associated with this installation was limited by the small size of the operation, and the adverse air quality effects are felt to have been minor and primarily confined to the site property.

Discarded wooden or other combustible construction materials were often disposed of in an open burning pit. Use of this pit had the approval of local fire authorities and was in compliance with applicable open burning ordinances. Burning was suspended during periods of high forest fire potential. No gaseous air pollutant monitoring programs were initiated in regard to this burning. Due to the relatively small amounts of material burned and the remote and open nature of the site, only an insignificant, temporary adverse impact to the area airshed has been observed.

The internal combustion construction equipment and vehicles on-site emit typical amounts of combustion by-product pollutants. No control devices or monitoring programs have been used to limit emissions or to monitor ambient concentrations of the contaminants. It appears reasonable, however, to assume that the relatively limited number of mobile sources operating on the site have only a minor adverse impact on the area air quality.

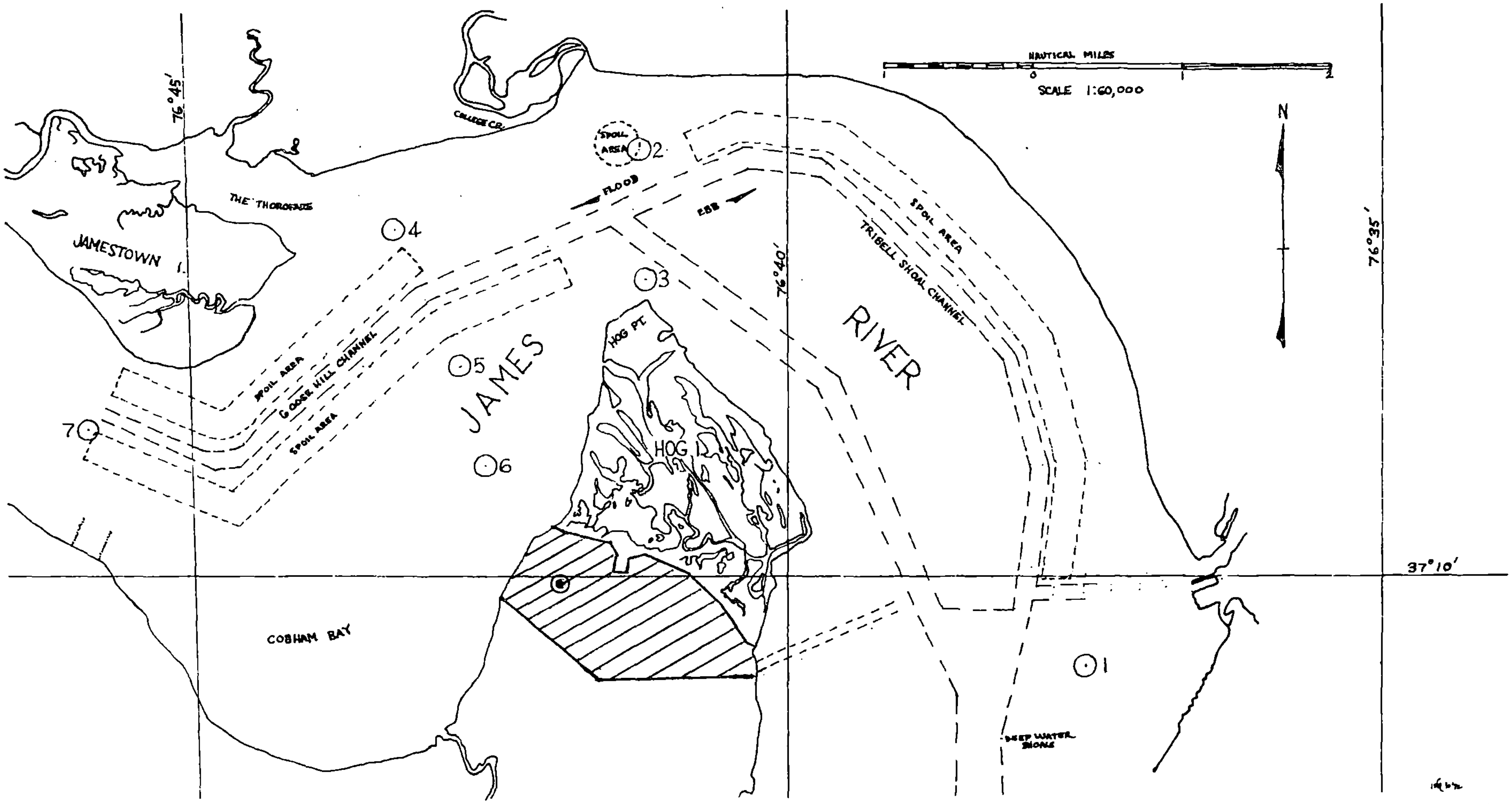
(4) Biology

Adverse biological effects on plant life attributable to a particular gaseous air pollutant are dependent upon the sensitivity of the individual plant and the duration and concentration of the pollutant. The organic matter being burned during pre-construction site preparation did not produce sufficiently high concentrations of the detrimental products of combustion to cause acute short-term plant exposure damage. The burning did not last long enough to cause the adverse effects on plants due to chronic low level pollutant exposure. Even had damage to very sensitive species been caused by air pollutants generated in the burning operations, the impact would have been localized to the area immediately adjacent to the burning and the effect on the flora beyond the property boundaries would be virtually undetectable.

There have been no reported or observed adverse effects to the air bio-systems from air contamination associated with the construction activities on-site. This lack of evidence of ecological disturbance is consistent with the limited number and extent of construction practices which could cause more than a very localized air-contamination-related biological effect.

b. Human Use Effects

The limited and localized air contamination resulting from site preparation efforts or subsequent site construction activities at Surry Power Station has had no effect upon human uses of the local air resources.



TOWER NO.	GEODETIC COORDINATES
1	37°09'25" N 76°37'30" W
2	37°12'52" N 76°41'14" W
3	37°12'00" N 76°41'10" W

TOWER NO	GEODETIC COORDINATES
4	37°12'20" N 76°43'15" W
5	37°11'25" N 76°42'47" W
6	37°10'45" N 76°42'28" W

TOWER NO	COORDINATES
7	37°11'00" N 76°45'52" W

⦿ REACTOR LOCATION

INSTRUMENT TOWERS
in
JAMES RIVER
NEAR
HOG ISLAND, VIRGINIA
Application by

VEPCO
October 1971

Figure II.I.A.2-1

B. Effects From the Facility's Existence

1. Land Systems Effects

a. Natural Effects

(1) Physical/Topological

Of the 840 acres purchased for Surry Power Station, approximately 450 acres were forest and scrub land. The total transmission line rights-of-way have displaced approximately 3,540 acres of wooded land out of the 4420 acres purchased for transmission line purposes. The remaining acreage on the site has been either landscaped or placed under a forest management program. The cleared wooded rights-of-way have rapidly revegetated and these "edges" in the forest are now providing a variety of food for wildlife. The open rights-of-way are still being farmed as in the past.

No significant erosion problems have occurred or are anticipated from land clearing or landfill operations. Banks of the intake canal are protected by a concrete apron to retain the best water quality practicable prior to entry into the condensers.

The discharge canal upper banks will be earthen, but the bottom and sides will be concrete-lined to the high water line to preclude scouring and extensive erosion.

(2) Geological

A full summary of Applicant's foundation design studies is contained in the record of Section 2.4.7 of the FSAR. Long-term settlement of the major structures is not expected to exceed 0.5 inches.

With respect to mineral resources, existence of the station has not precluded future exploitation of any significant known reserves. Surry County is situated in the Coastal Plain province and is underlain by sedimentary rocks, over which there is a 1000-foot layer of sand, gravel, marl, and clay. Sand and gravel occur along the James River and at other localities in the county and have been utilized in the past for building purposes and for highway construction, and maintenance. Calcareous marl has been produced near Claremont for use in agriculture. Clay samples from various localities have been tested and found potentially suitable for use in the manufacture of face brick, flue tile, porous ware and earthenware. However, there has been no commercial mineral production in Surry County to date. There are no commercially developable sand, clay or gravel deposits at the reactor site and the facility will thus have no appreciable adverse effect on the limited mineral supply in the Surry area.

(3) Biological

(a) Permanent Obstacles Posed by Roads, Railroad Tracks, Etc. to Wildlife Use of Land

Although Surry Power Station, including the intake and discharge canals, stretches across the width of Hog Island peninsula, it is not considered to be a permanent obstacle to wildlife migrating to and from the Hog Island Wildlife Preserve. Animal access to the preserve is retained by road. The station is expected to have minimal impact on the migration of wildlife.

(b) Effect of Removal of Land Area from Use as Wildlife and Flora Habitat

While about 453 acres of the Applicant's 840 acre tract has been cleared and is no longer available for use by wildlife, the remaining estimated 387 acres has been placed under a forest management program. Selective cutting and pine tree seeding have been conducted; these efforts should result eventually in a more suitable habitat for wildlife. The overall effect of removing 453 acres from wildlife production is thus expected to be negligible in view of the other hundreds of acres of similar habitat both on and adjacent to the site.

(c) Effect of Water Level Fluctuation on Terrestrial Wildlife

Results of borings indicate that the coefficient of permeability of the soil mass in a horizontal direction is estimated to be several orders of magnitude greater than that in the vertical direction. Water that does enter the soil will move laterally to the east, north, or west and discharge into the James River. With little vertical migration, there are expected to be no water fluctuations that would adversely effect terrestrial wildlife. Likewise, construction of the station has caused no effect on water level fluctuations normally caused by the oscillatory tidal movement in the James River.

b. Human Use Effects

(1) Economic

(a) Regional Effect of Surry Nuclear Plant

Conversations with staff members of the Virginia Division of Planning and Community Affairs confirm our belief that the regional effect of the station will be limited to Surry County and Isle of Wight County. The increases in population and employment that have occurred during the construction of the station will be substantially reduced upon completion of construction. These effects are summarized below:

Land Use: Surry County has been placed in Regional Planning District Number 19, which consists of the additional counties of Dinwiddie, Prince George, Sussex, and Greensville and the cities of Colonial Heights, Emporia, Hopewell, and Petersburg. Region 19 (Crater District) has had board members appointed from each governing body and is presently formulating an overall plan, the first draft of which was made available in August 1971. Surry County is included in the preliminary plan which is shown in Figure I.C.1-8.

Tax Base: Applicant will pay approximately one million dollars to Surry County in annual real and personal property taxes on the plant site and improvements, based on present tax and assessment rates. This will approximately double the present tax revenues of that county. The revenues from sale of the electric power generated at Surry will also increase substantially the amount of taxes paid by Applicant to the State and Federal governments.

(b) Regional Economic Structure

Commercial: The latest available statistics on the retail, wholesale and service trades in Surry County show only a marginal increase when compared with previous years.

Volume of Sales - Surry County

	No. of Establishments			Sales (000)		
	1963	1967	% Change	1963	1967	% Change
Retail	45	37	-17.78	$2,845	$2,846	+0.035
Wholesale	2	3	+50.00	(*)	512	--
Services	12	10	-16.67	87	93	+6.890
Totals	59	50	-15.26	$2,932	$3,451	--

* Not given in source material.
Source: U. S. Department of Commerce, Census of Business, 1967.

The economy of the county is basically agricultural. The buying pattern of county residents is to shop in nearby metropolitan areas such as Petersburg, Hopewell, and the cities bordering Hampton Roads. The Surry station is not expected to change this pattern.

Industrial: The present limited industrial economy of the county consists of two saw mills and one meat processing plant, which together employ fewer than 100 workers. According to the Virginia Employment Commission statistics, wages range from \$1.60 to \$2.40 per hour. The Surry station will employ approximately 100 persons on a normal basis with an annual payroll in excess of \$800,000 when both units are in operation. Effects on the present local employment situation are expected to be minimal. A number of factors would seem to discourage massive industrial expansion in the county. These include a lack of transportation facilities, the depressed state of the present economic base, and the large percentage of labor which is untrained. It should also be noted that Tidewater industrial and governmental facilities employ most of the out-migrating workers in the county.

Agricultural: The county has only about 600 persons involved full-time in agriculture, according to the latest available statistics. However, the economy is based on agriculture and Surry County farming operations are among the more prosperous in the State. Following the national trend, however, the number of agricultural operations in the county is expected to decline about three (3) percent per year during the decade 1970-1980. The Surry station should have little or no effect on the agricultural sector of the economy.

(c) Regional Demographic Structure

The population of Surry County declined by 5.4 percent to 5,882 from 1960 to 1970. This trend is not expected to change appreciably during the next ten years although population may move up slightly as a result of some in-migration and natural increase. Isle of Wight County had an increase of about five (5) percent between 1960 and 1970 to 17,952 persons. This rise in population is probably the result of some housing development and in-migration from nearby metropolitan areas. The Virginia Division of Planning believes that the Surry station will not affect population appreciably, so that the demand for schools, local services, and fire and police protection will be only nominally increased.

(2) Land Use

The existence of the Surry facility will have no effect on the land use plans within the region, which are discussed in Section I.C.1.b. and Section II.I.B.1.b.(1) above. The general design of the plant is consistent with the regional land use and Applicant has cooperated with all concerned parties sharing mutual interest in the preservation of Virginia historical sites prior to and during the entire construction phase. The Applicant will continue to operate the facility in a manner consistent with local plans and policies within the area.

(3) Esthetics and Recreational

(a) Effects on Area Esthetics

The Surry Power Station is located in the heart of colonial America, and preservation of historic values was considered in the location and construction of the facility. The facility is located in the center of the Hog Island peninsula on Gravel Neck and is essentially surrounded by over 700 acres of forest land. It is remote from any residential areas and from frequently traveled roads. The plant was located "in shore" and screening timber surrounding the plant site has also been maintained to the maximum extent possible. Initially there was concern that the tops of the containment structures would be plainly visible from Jamestown Island and would thus detract from the beauty of the natural historic surroundings. To avoid this, Applicant designed its containment buildings so their elevation would be low enough to blend with the adjoining forests and thus not intrude on the skyline view from the sites across the river. In order to verify its conclusion, Applicant conducted an experiment prior to construction by raising a cluster of 10 ft diameter weather ballons to the height of the finished containment building. Photographs were then taken at various locations, as shown in the Figure II.I.B.1-1. These experiments have been verified by more recent photographs of the actual structures. Considering that finished containment structures will be a natural gray in color and that the profile of the facility is relatively low, its visual impact when viewed from the surrounding areas and historical sites will be insignificant.

(b) Effects on Cultural and Historical Landmarks

The Applicant has cooperated with all concerned parties sharing mutual interest in the preservation of Virginia historical sites prior to and during the entire construction phase. On one occasion, the Applicant supplied the manpower needed to excavate what was believed to be the ruins of a colonial period church in a wooded area near the facility. This exploration was to no avail and there are no known archaeological or historical sites worthy of preservation or additional study which will be affected by the construction or operation of the Surry Power Station. The general opinion of acceptance of the facility in the area has been summed up in a letter from the Director of the Thomas Rolfe Branch of the Association for the Preservation of Virginia Antiquities, Mrs. George L. Mumford, attached in Appendix G-24a.

The Applicant has also designed and constructed the entire power facility in an effort to minimize any adverse esthetic effects on national landmarks. The Surry station is finished in a blue-green color and its relatively low profile is shielded from Colonial Williamsburg and Jamestown Island by trees and vegetation that surround the Hog Island peninsula.

Chippokes Plantation is in the area adjacent to the power facility. The Advisory Council on Historical Preservation stated in their letter dated April 13, 1970 that "....the probable effect upon the Chippokes Plantation cannot be judged to be sufficiently adverse to warrant Council comment." Attached in Appendix G-19 is a copy of the letter from Mr. Robert Garvey, Jr., Executive Secretary of the Advisory Council on Historical Preservation to the Division of Reactor Licensing.

(c) Effects on Recreation

As in all the Tidewater counties, hunting and fishing provide good recreational activities. Many deer and some wild turkey are found in Surry County and Hog Island Waterfowl Refuge is the winter home of Canadian geese and many varieties of duck. Although the waterfowl may not be hunted on the Island or within 1,000 yards of its shore, geese and duck seeking refuge on the Island spread out and feed on nearby farms and streams to provide excellent waterfowl shooting.

Surry County is just across the James River from Jamestown Island, the site of the first permanent English settlement in America. The settlement of Surry started shortly after the settlement of Jamestown; several old houses built in the 17th century still stand and attract visitors during "Historic Garden Week" and the "Annual Autumn Pilgrimage". Among them is the Rolfe-Warren House built on land given in 1614 by Chief Powhatan to John Rolfe on the occasion of his marriage to Pocahontas, daughter of Powhatan. Near this is the site of Fort Smith built in 1609 by Captain John Smith. Not far from Scotland Wharf Ferry is Pleasant Point, said to be the third oldest house in Virginia, and nearby stand three of its original dependencies, the spring house, smokehouse, and one of the kitchens. Another place of interest is "Bacon's Castle".

The attached Figure II.I.B.1-2, prepared by the Division of Water Resources of Virginia Deaprtment of Conservation and Economic Development, lists only two existing recreation areas of major importance in the James River Basin near the Surry facility. These are Hog Island Wildlife Management Area (#41) and Chippokes State Park (#25). It is felt that both of these locations will benefit directly or indirectly by the location of the power facility as explained below.

As mentioned earlier, the Applicant and the Virginia State Game and Inland Fisheries Commission have mutually agreed on a program to stabilize the reservoir food supply by constructing and improving the dikes surrounding the Hog Island Game Management Area. It is hoped that by providing a better winter home for migratory fowl, this area will attract more tourists and nature lovers, while also providing an excellent hunting environment.

Chippokes Plantation, the only State Park on the James River, was opened recently

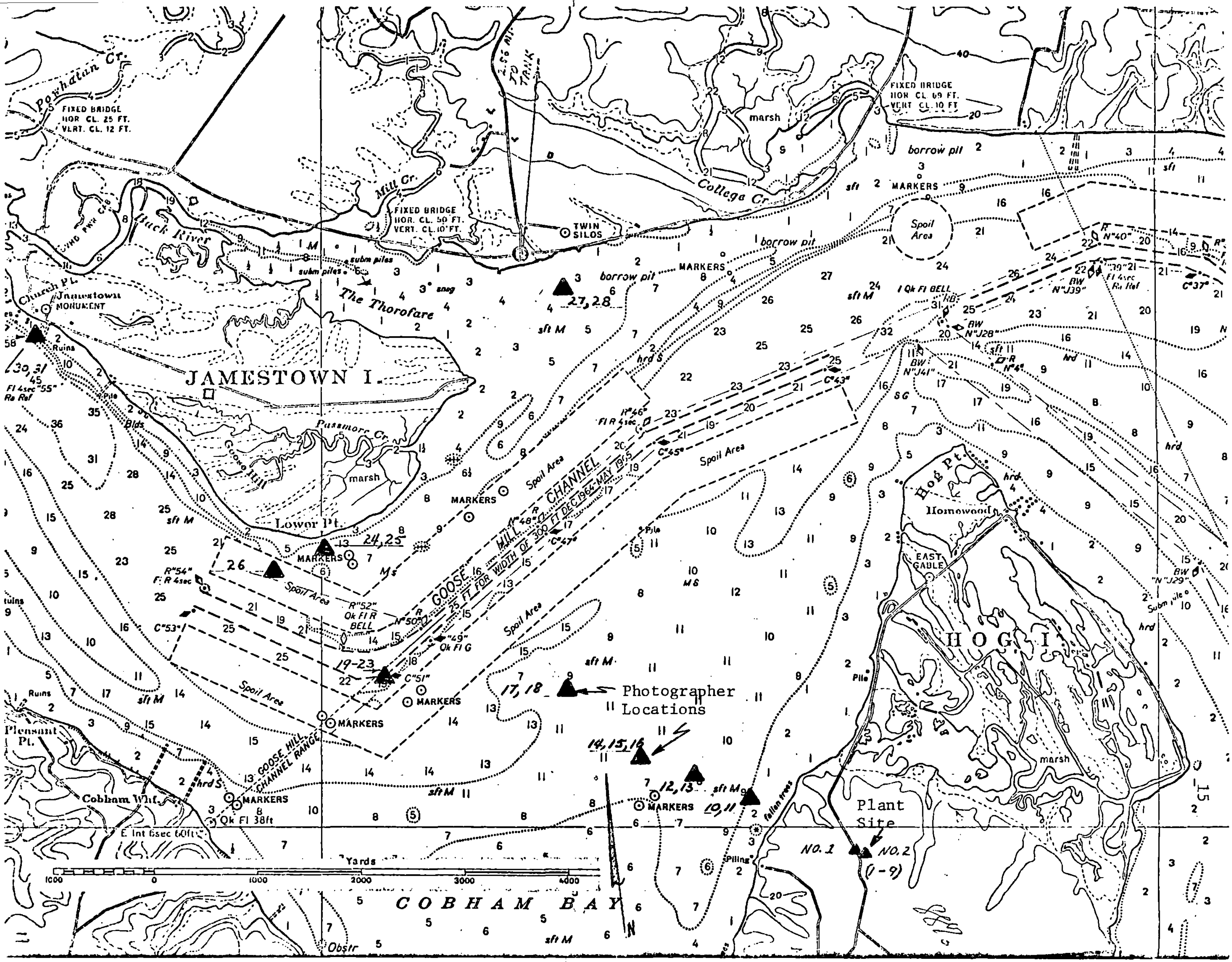
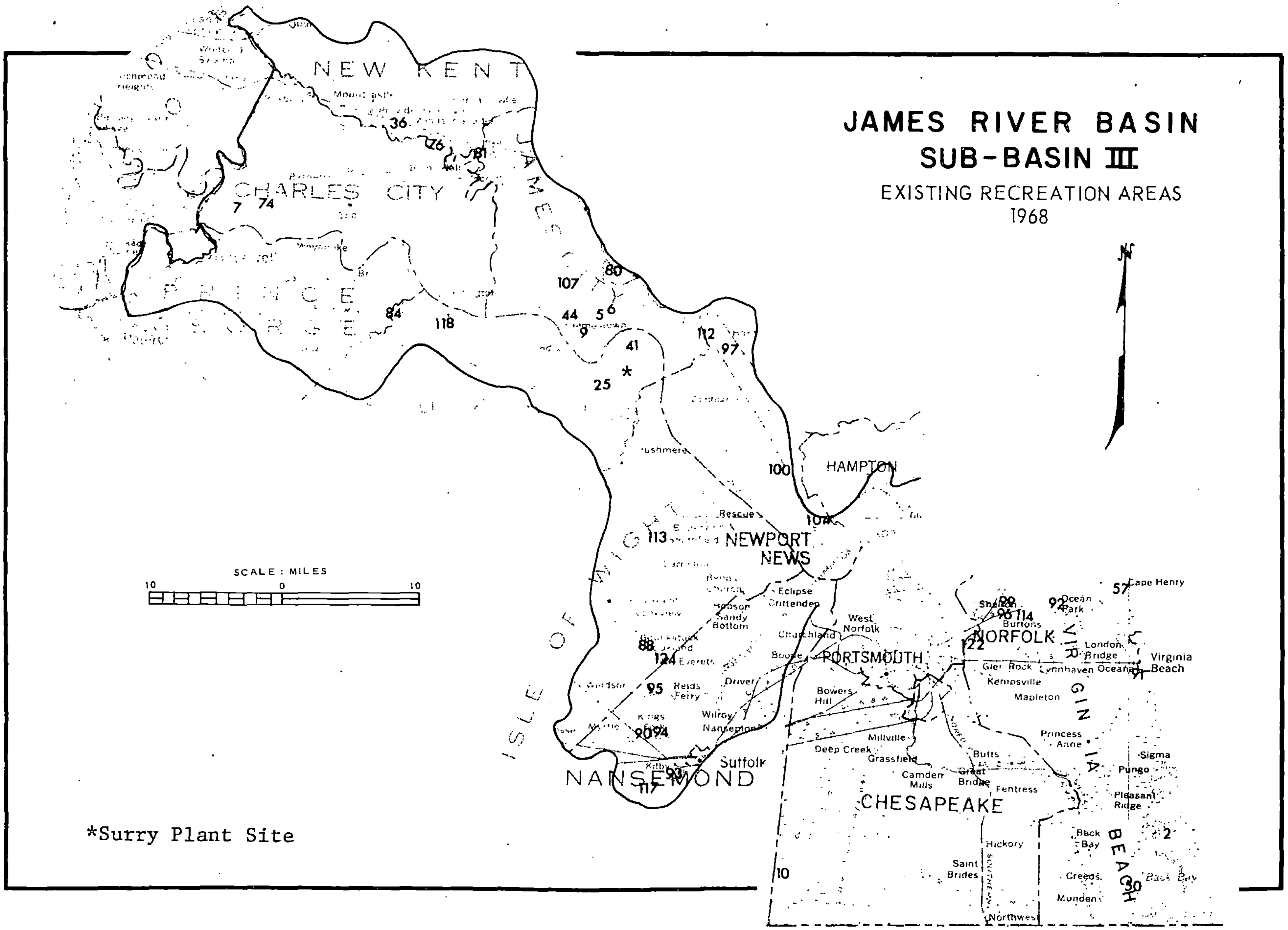


Figure II.I.B.1-1



Source: Virginia Division of Water Resources

Figure II.I.B.1-2

by the Division of Parks. It is felt that visitation to Chippokes will be significantly increased due to close proximity of the Surry Information Center. The Applicant has canvassed a number of the 170,000 visitors to the Surry Information Center and found that their visitation also included a tour of the Chippokes Plantation. Therefore, it is felt that the net effect of the Surry Power Station on the recreation areas and facilities will be to the advantage and enhancement of the entire area.

(4) Emergency Plan

The Surry Power Station Emergency Plan has been submitted to the Atomic Energy Commission as an appendix to the Final Safety Analysis Report. The fundamental objective of this plan is to ensure protection of the health and safety of station personnel and the general public in the event of an emergency situation at the facility. The plan provides the necessary guidelines for station personnel to follow during emergency situations and is sufficiently flexible to be adapted to all emergency situations. Detailed information related to responsibility, duties, training, emergency equipment, exposures, reports, liability, and notification are among some of the major areas covered in the plan.

The Emergency Plan is supplemented by an outline of Emergency Procedures and the Emergency Operating Procedures. The Emergency Procedures provide definite and detailed guidelines for credible postulated emergencies. The full spectrum of postulated, credible emergencies, ranging from a minor accident effecting only the station and not involving radioactive materials, to an accident resulting in the release of radioactive materials, is addressed. The Emergency Operating Procedures provide detailed step-by-step procedures for manipulation of plant controls and equipment to minimize the consequences of specific accidents and to place the reactor plant in a safe condition after an accident.

In the formulation of emergency plans, the Applicant has consulted with those off-site agencies, both governmental and private, whose assistance may be required during an emergency. Among the off-site agencies who may render aid during an emergency are:

(1) AEC Compliance Office

(2) AEC Radiation Emergency Team

(3) Virginia Health Department, Bureau of Radiological Health

(4) Civil Defense

(5) Medical College of Virginia

(6) Surry and Smithfield Rescue Squads

(7) Surry and Smithfield Fire Departments

(8) Surry County Sheriff

(9) Virginia State Police

(10) State Department of Game and Inland Fisheries

(11) State Forestry Department

Large scale off-site evacuation is not required, even in the highly unlikely event of a Design Basis Accident.* Because of the subatmospheric design of the Surry Power Station's containment structures, outleakage of radioactive

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* The Design Basis Accident, a hypothetical event postulated in accordance with the requirements of 10 CFR 100 to include the most severe accident effects credible, provides the basis for the design of the safety systems of the facility. This accident, and the systems for coping with it, are discussed in detail in the Surry Power Station Final Safety Analysis Report, Docket Nos. 50-280 and 50-281, Section 14.5.

material and the formation of a radioactive plume will be terminated within a maximum of forty minutes after the Design Basis Accident. This design feature reduces the calculated off-site radiation doses resulting from the postulated accident and eliminates the need for off-site personnel evacuation. Nevertheless, in accord with regulatory requirements, Applicant's Emergency Plan, therefore, is designed to assess the potential effects of any releases, and to permit selected evacuation of Low Population Zone segments, if it appears that individuals, be remaining within those areas, could receive a significant whole body dose.

As is stated in the Emergency Plan, the Virginia Health Department, Bureau of Radiological Health, would have the prime responsibility for handling off-site radiation emergencies by supplying trained manpower to coordinate the response of all other agencies, and by furnishing basic monitoring equipment. Any evacuation that would be initiated would be an orderly, planned evacuation and would be similar to evacuations conducted in anticipation of floods, with the exception that measures would be employed to limit, as practicable, the spread of contamination. The number of off-site persons to be evacuated would be dependent upon the distribution of population and of contamination. The 1966 off-site population distribution within five miles of the station is shown in Figure II.I.B.1-3. As can be ascertained from the figure, the 1966 population within the Low Population Zone was 121. The population of this area should not increase significantly during the lifetime of the station.

If on-site evacuation were to be ordered, personnel would assemble in assigned locations, accountability would be established and maintained, and necessary personnel radiation monitoring and decontamination would be performed as practicable. Normally, evacuees would proceed in their automobiles to a Remote Assembly Area, at the intersections of Highway Routes 650 and 617. (Figure II.I.B.1-4). Evacuees would remain at the Remote Assembly Area to await further instructions and monitoring if required. Any individuals requiring hospital treatment would be transported to the Medical College of Virginia in Richmond, by the local rescue squads. Training off-site personnel in the caring for, and transporting of, contaminated patients has been conducted.

The number of individuals that would have to be evacuated from the station would depend on the type of accident and the number of individuals at the site. The staff of the station will be approximately 135 people. During the completion of construction of Surry Unit No. 2, there will also be construction personnel on-site. After additional monitoring, if required, at the Remote Assembly Area, the majority of the evacuees can return to their homes. No temporary shelters or other measures would be required for these individuals.

(5) Effect of Project on Unique, Rare, or Irreplaceable Land Forms or Land Uses

(a) Scenic Vistas

Surry Power Station has been designed to minimize environmental impact on scenic vistas. The reactor containment structures, for example, have been lowered into the ground so that they will blend in with the tree line when viewed from across the river. Instead of one large vent stack, numerous small vent pipes located on the containment dome were installed to also reduce the impact. Furthermore, the turbine buildings have been painted blue-green so that their appearance will not be unpleasing when viewed from a distance. Long-boom cranes will have only a temporary adverse effect on scenic vistas, since they will be removed when construction is complete.

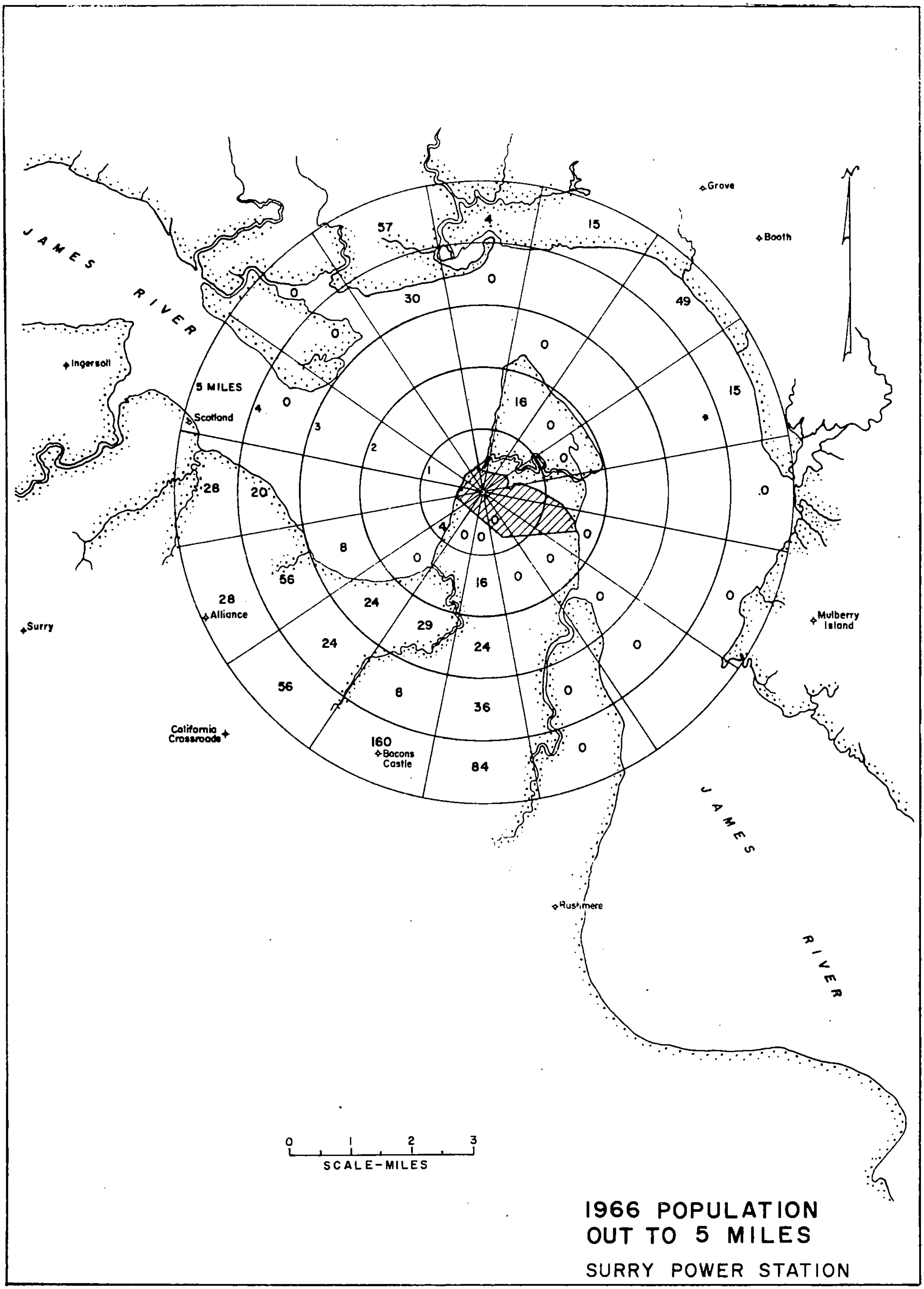

Figure II.I.B.1-3

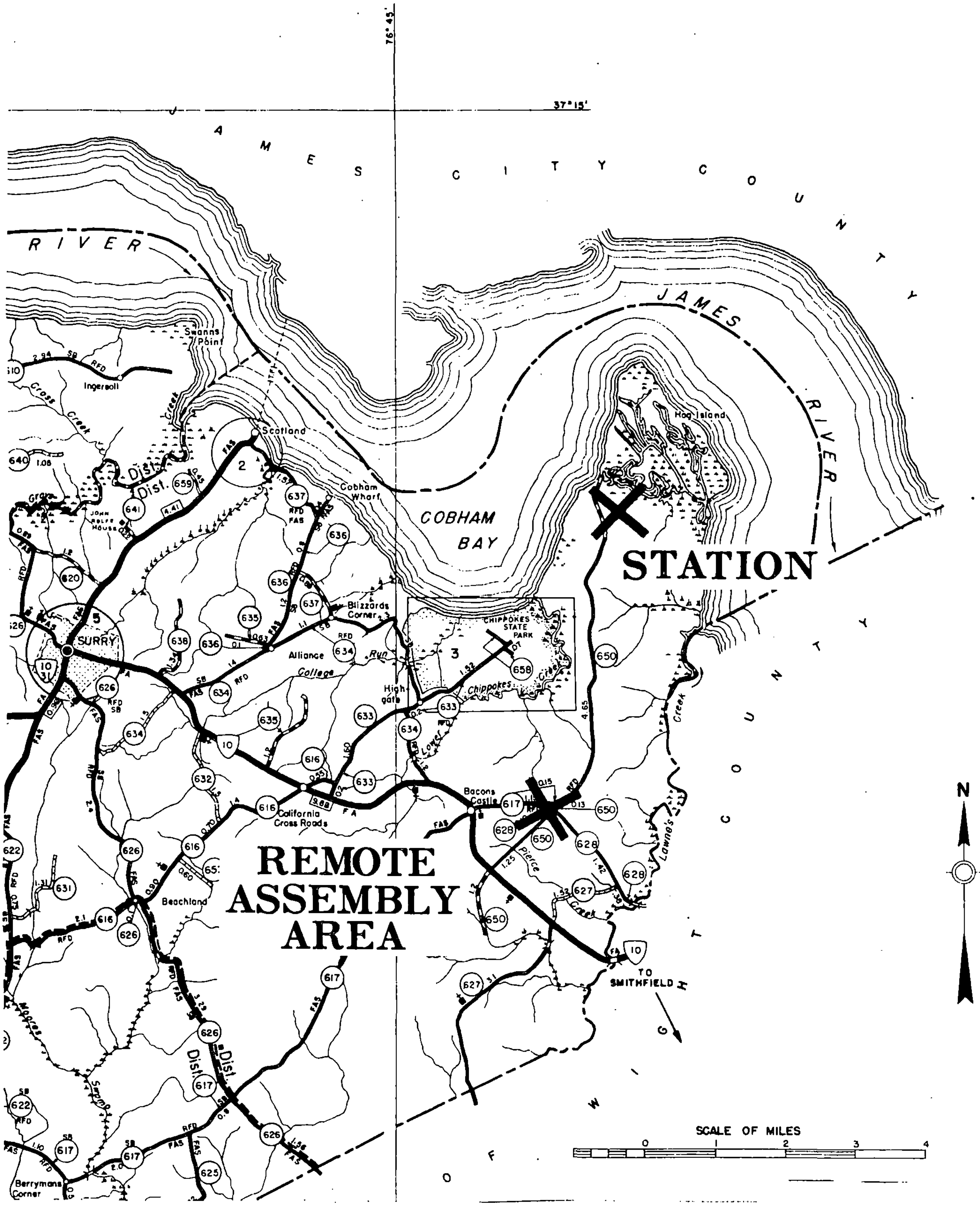

Figure II.I.B.1-4

(b) Open Spaces

Existence of the Surry Power Station has no appreciable effect on open spaces.

(c) Geologic Formations

The existence of Surry Power Station has no effect on the Miocene outcroppings which are considered unique, rare, and irreplaceable. Subterranean Miocene layers were removed during excavation for the reactor containments and were reused for building dikes on the Hog Island Wildlife Preserve and resulted in no effect on existing outcroppings.

(d) Other Unique Natural Environments

Construction of Surry Power Station has had a significant effect on the Hog Island Wildlife Preserve. This effect, however, is, on balance, beneficial since excavation soil has been used to build dikes and roadways on the preserve to create stabilized ponds suitable for waterfowl. There have been no effects on the pocosins or swamps in the area. Without the upgrading as a result of station construction, the preserve could not have been stabilized until the year 2000 according to State employees.

(e) Sites, Buildings, or Other Structures of Historical and/or Cultural Significance

Despite the number of sites and buildings of historical and/or cultural significance surrounding the site, existence of the station will have no adverse effect on these areas. In fact, a recent poll revealed that a significant number of the approximately 170,000 visitors to the Surry Information Center also visit Chippokes Plantation State Park. Although the primary attraction is undetermined, it is clear that some of the tourists who visited Chippokes Plantation State Park would not have done so if the Information Center at Surry Power Station had not also been nearby.

2. Water Systems Effects

a. Natural Effects

(1) Physical Effects on Current, Water Body Shape, Tidal Behavior, Etc., from Permanent Physical Structures, Fill, Etc.

Existence of the intake channel and related structures will have no adverse effect on current, water body shape, or tidal behavior of the James River.

Existence of the discharge groin will cause localized eddies in the current of the water from its physical presence. These eddies, however, will be small in relation to the size of the river, which is about 3 miles wide at this point. The eddies will also aid in mixing as the tide flows by the groin. There will be no effects on water body shape or tidal behavior in the James River.

(2) Silting, Layering, Euthrophication, Thermal Stratification

No effect in any of these categories will occur from the existence of either intake, discharge, or instrument tower structures.

(3) Biological

(a) Effects on Fish, Other Biota, and Plants from Physical Phenomena Outlined Above

There will be no adverse effects noted from the physical phenomena outlined above due to the existence of either intake, discharge, or instrument tower structures on the flora and fauna in the aquatic environment.

(b) Effects on Water Birds from Physical Phenomena

The effects of the existence of intake, discharge, or instrument tower structures on water birds, either migratory or resident, should be negligible.

(c) Effects on Amphibians and Water-Dependent Mammals

No permanent adverse effects have been observed on amphibians and water-dependent mammals from the existence of either intake, discharge, or instrument tower structures. The discharge canal, however, was constructed partially through a small natural valley and swamp which resulted in the displacement of a small, though undetermined number of amphibians.

b. Human Use Effects

(1) Navigation Obstructions from Physical Structures in Water

The seven instrument towers in the James River pose no obstruction to navigation. They are out of the main shipping lanes and are lighted according to Coast Guard specifications. The channel markers for the intake channel might possibly pose a hazard to small boats at night but no more so than the hundreds of other unlighted obstructions such as fish net stakes already in the water. The discharge groin, although well away from shipping channels and lighted on the end, could conceivably pose a hazard to small boats at night.

(2) Effects on Downstream Uses

There will be no effects from the existence of the station that would preclude present or anticipated future uses of the downstream waters of the James River.

(3) Recreation -- Swimming, Boating, and Fishing

The existence of the physical structures of the station will have no adverse effect on swimming, boating, or fishing in the James River except as listed previously.

(4) Esthetic Effects

(a) Appearance of the Shoreline

As stated previously, the Surry Power Station has been designed to blend in with the natural background wherever possible and is judged to have no adverse effect on the appearance of the shoreline.

(b) Discoloration, Excessive Algae Growth, Odors in Water

The existence of the station will have no effect on the discoloration of the water, excessive algae growth, or odors in the water of the James River.

(c) Effects on Historical Sites

Effects of the site on historical sites in the region have been entirely discussed in section II.I.B.1.b.(3) above.

(5) Effect of Project on Unique, Rare, or Irreplaceable Water Systems Environments

The existence of the project will have no adverse effect on unique, rare, or irreplaceable water system environments.

3. Air Systems

a. Natural Effects

(1) Climatology

No effects exist on the regional climatology as a result of the existence of Surry Power Station.

(2) Meteorology

The physical presence of the completed Surry Station would be expected to cause minor localized modification, if any, of the surface level wind flow. To incorporate the effect of any disturbance that the station presence could cause in the dilution capability of the atmosphere at the point of disturbance, a building wake factor has been incorporated into the calculations of atmospheric dilution capability.

b. Human Effects

The presence of Surry Power Station will have no effect on human uses of the site air systems, and will present no hazards to normal aircraft flight patterns.

C. Plant Operation Effects

1. Uranium Mining, Processing, Transportation, and Ultimate Disposal

In the following section the environmental impact of the entire nuclear fuel cycle will be discussed. Emphasis will be placed on those aspects of the fuel cycle which are peculiar to Surry Power Station itself, Thus, transportation of new fuel to the station and spent fuel and radioactive wastes from the station will be discussed in more specific detail than uranium mining or spent fuel reprocessing, which may provide services for a number of different reactors.

An additional restriction on the specificity of discussion of several phases of the fuel cycle stems from the fact that (a) no single vendor supplies all of the product or service in question or (b) no contract has been let for its provision to Surry. In addition, such contracts as have been let are all of much shorter duration than the plant life. Hence, any discussion of the environmental impact of a current supplier may not apply to his successor.*

a. Fuel Exploration and Extraction

(1) Mining and Milling

The nature of the current Surry nuclear fuel contract does not require Applicant to procure uranium in the form of U_3O_8 (yellowcake). The present contract permits purchase of finished fuel assemblies. Since Applicant has not established any U_3O_8 procurement contracts, the environmental impact of uranium mining and milling

*Several of the current Surry suppliers had not submitted an environmental impact report prior to the preparation of this document. Hence, in these areas, the discussion of environmental impacts is based on the information contained in Environmental Reports filed by other firms in the same area. Such information, while considered to be accurate and generally representative of solutions reached by competent firms in the particular area, perforce, cannot attain the same level of specific accuracy as would information gained from the firm actually supplying Surry.

will be discussed in an overall industry context rather than one limited to a specific supplier's impact.

(a) Mining

When the search for uranium began in earnest in the late 1940's, there were many "lone wolf" prospectors in small mining ventures. Today, uranium mining and milling has developed into a mature industry.

The bulk of the ore deposits in the United States occur in two western regions. One is the Colorado plateau which encompasses parts of Utah, Colorado, Arizona, and New Mexico; the other is central Wyoming. There are also some uranium deposits in Texas, South Dakota, and Washington. The average uranium content of these deposits is currently about four pounds of U_3O_8 per ton of ore.[1*]

Two methods of mining (open-pit and underground) are used to extract the ore from the ground. Open-pit mining is usually selected when the ore is located close to the surface. Overburden removal is necessary to permit access to the ore. The waste overburden is normally stored close to the pit site. The size of the open-pit area is determined by the formation of the ore body. In general, uranium deposits are concentrated in small ore bodies compared to those of other mineral deposits. One such open-mine area at the Humble Highland mine is not expected to exceed 120 acres.[2]

In general, ore bodies are located below the water table, which necessitates removal or lowering of the water level in order to operate equipment in the mine. The traditional method for lowering the water table is to allow the water to drain

*The numbered footnotes are shown following section II.I.C.1.

into the pit and collect at a low point sump. From the sump water is pumped out of the pit. The water present in the pit walls reduces their strength, making necessary relatively flat pit slopes and large stripping requirements. Another method of dewatering is the use of a ring of wells located around the periphery of the mine. With proper placement, these wells can cause a localized depression in the water table and a drier mine.

The actual mining of the ore body is usually accomplished by large earth shovels. The ore is loaded into trucks and hauled to storage areas at the mill site.

The second method of mining, underground, is selected when the ore body lies deep beneath the surface and the cost of removing the waste material to expose the ore as in open-pit mining would be extremely high. The ore bodies are outlined by underground longhole drilling and the holes probed to determine the location of ore. Vertical holes (shafts) are sunk to the ore-bearing formations. From each shaft, various levels or tunnels are driven horizontally outward. These levels are located beneath the ore bodies in order to utilize gravity for ore handling and for drainage of ground water. The ground water flows from the levels to the shaft and down to a collecting sump at the bottom of the shaft. The water is then pumped through a vertical pipe to the surface. Raises for ore passes and manway accesses are driven vertically from the levels to the ore bodies. The ore is drilled, blasted and removed by mechanical slushers to the raises, from which it is pulled out of chutes at the bottom of the raises into ore car trains. The trains move the ore to the shaft where it is hoisted to the surface for subsequent transportation to the ore storage site at the mill site.

Because of the radiation hazard in the mine, fresh air must be forced into the mine, normally through one of the shafts; used air is usually returned to the surface through a second shaft.

Waste material in the mine is handled the same as the ore except, that it is dumped onto a waste storage pile and not processed in the mill.

(b) Milling

The milling process involves placing the uranium contained in the ore into solution, concentrating the uranium, and converting it into a salable form. The process consists of preparation of the ore, leaching, concentration, packaging, and handling of waste products.

In general, mill designs are based on some average ore concentration characteristic. Blending ore from various parts of the mine is required to maintain average characteristics. The blended ore is crushed to reduce the particulate size. This is necessary for two reasons: (1) exposure of substantially all of the uranium mineralization to the leaching agent is necessary for maximum recovery, and (2) the ore particles must be fine enough so that they can be pumped through pipes and process equipment without settling out and clogging the system.

The crushed ore is mixed with water and ground in rod mills to form a mud slurry. The slurry is fed into a leaching process where the uranium minerals are dissolved from the bulk of the valueless material. There are two leaching processes which can be used: (1) acid leach, with the use of sulfuric acid and sodium chlorate;

and (2) alkaline leach, with the use of a carbonate solution.

The recovery of uranium from the leach solution is accomplished in four sequential steps. The first involves the separation of the dissolved uranium from the insoluble waste material or tailing; the second is the concentration of uranium by extraction from the leach solution; the third is the precipitation of the uranium from solution as yellowcake; and the final step involves drying and packaging the yellowcake product. The standard shipping container for yellowcake is a 55-gallon drum.

The tailings from the milling process are pumped to a tailing pond for permanent storage.

(2) Environmental Impact

(a) Land Systems

(i) Mining

Both open-pit and underground mining will temporarily limit the use of the land in the vicinity of operations. In general, current uranium mining operations are performed in remote areas where the land has little value for other commercial uses.

The overburden and waste storage areas around the mine can create erosion problems and esthetic effects if not properly managed. This problem is more severe in open-pit than in underground mining. Steps have been taken within the industry to minimize these effects. Revegetation has been used on the disturbed land to reduce erosion, and the shape and size of the storage piles can be controlled to blend into the surroundings.

It should be mentioned that the problems discussed above are typical of all open-pit mining; however, the environmental impact of waste displacement in open-pit uranium mining is less severe than it is, for instance, in open-pit coal mining. The open-pit area in uranium mining is usually in the range of hundreds of acres as compared to the thousands of acres required for open-pit coal mining. The total amount of earth displaced in open-pit uranium mining is less, by about a factor of ten, than that displaced in open-pit coal mining.

After mining operations are completed, the land can be returned to normal use. Open pits can be refilled with the overburden and shafts to the underground mines can be closed off with concrete caps.

(ii) Milling

The esthetic effects of the mill facilities will be minimal since they are normally located in remote areas near the uranium mines. After operations are closed down, these facilities can be removed to permit normal use of the land.

The major impact on the land will be caused by the tailings impoundment area. After operations are terminated, the tailings pile must be stabilized to prevent wind and water erosion. The present method of tailings pile stabilization is accomplished by backfilling the whole pile surface and revegetating the area. Because of the residual radioactivity in the tailings from radium and the remaining uranium, access to this area must be prohibited until the radiation levels have decreased to a value that has been determined as being safe for the general public. Access is normally controlled by posting signs and fencing off the area.

(b) Water Systems

(i) Mining

The pumping of water for mine dewatering will lower the water table in the immediate area. This effect on the ground water is exptected to be only temporary, and the aquifer in the immediate area is expected to refill to or near its original level when operations cease.

The sediment content of the water being pumped from the mine may be very high. If this is the case, the water will be discharged to the tailing pond, treated and used in the milling process, or treated and discharged to local streams. Before discharging to the local streams, the water will be monitored to ensure that the radioactive level meets pertinent local and federal regulations.

(ii) Milling

The water requirements for the milling process will tend to suppress the local water table. The Humble mill is designed to require about 500 gallons per minute.[3] Some of this requirement can be fulfilled by the water from the mine dewatering operation. The additional water must be supplied from local wells or possible recycling of the water from the tailings pond.

Contamination of ground water can occur if spills from the milling processes are not contained. In general, buildings are designed to contain spills with overflows being drained to the tailings ponds.

The design and location of the tailings storage site is extremely critical because of potential contamination of local ground water. The tailings pond is designed to: (1) serve as a collection point for all of the liquid and solid wastes generated in the milling process, (2) permit the evaporation of most of the contained water, and (3) serve as a permanent receptacle for the residual solids.

Because of the radioactive content of the tailings effluent (the milling process only removes 15% of the radioactivity present in the untreated ore[4]) and its pH level (2 for acid leaching[5] and 9.5 for alkaline leaching[6]), it must be impounded. Seepage of the tailings solution into the ground water can be prevented by proper construction of the tailing basin. Sampling wells are used by the milling industry to detect any excess seepage. If contamination is discovered which could be harmful to the environment, additional wells can be constructed to permit recycling of the contaminated ground water to the tailing pond.

(c) Air Systems

(i) Mining

In the open-pit mining operations, the only impact on air quality would come from dust discharges produced by wind erosion of the disturbed soil and by equipment movement in and around the mine. Revegetation of the disturbed soil will greatly surpress dust originated from wind erosion. Where there is much mechanical agitation of the surface such as on haul roads, dust can be controlled with water sprinkling to reduce any potential health hazard to employees.

For underground mining, dust discharges are not so severe as in open-pit mining simply because the disturbed surface area is not so great. The most severe impact on the air environment is caused by airborne radiation in the mines. The new mine safety regulation effective July 1, 1971, limits exposure for mines to 4 working level months (WLM).* To meet this requirement, large volumes of fresh air must be forced down into the mines. The exhaust air does contain some airborne radiation; however, the high velocity at discharge will cause good dispersion. Radiation detection equipment will be located around the site to ensure that radiation concentrations are not harmful to the public or mining employees.

(ii) Milling

Dust can be generated in the milling process by (1) dust from ore crushing operations, (2) dust from tailing ponds, and (3) dust from yellowcake. The use of dust collectors and wet grinding equipment can help reduce much of this dust. Humble presented evidence in its Environmental Report showing that discharges from the dust collector systems would not expose the public to harmful radiation doses.[7] The radioactivity in the tailing solution is principally due to dissolved thorium-230 and radium-226. Since the tailings pile is primarily underwater, there is very little possibility that this radioactivity will become airborne. In the event that solid tailings material should become exposed, these areas can be covered to stabilize the exposed part of the pile.

The milling industry uses frequent air sampling techniques to detect any potentially hazardous condition prior to its becoming harmful to the public and employees.

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*The working level (WL) was defined by Dr. Paul C. Tompkins at the 1967 Hearings as: "...the working level (WL), a unit which is any combination of radon daughters in 1 liter of air that will result in the emission of 1.3×10^5 Mev. of potential alpha energy. This concentration, in turn is equivalent to the radon daughters at radioactive equilibrium with 100 pCi. (10^{-10} curies) of radon -222 in 1 liter of air....Exposure to radon daughters over a period of time may be expressed in terms of cumulative working level months (WLM). Inhalation of air containing a radon daughter concentration of 1 WL for 170 working hours (4 1/4 - 40 hour work weeks) results in an exposure of 1 WLM." Radiation Exposure of Uranium Miners, Hearings Before the Joint Committee on Atomic Energy on Radiation Exposure of Uranium Miners, Congress of the United States, Ninetieth Congress First Session, (1967), Part 1, p. 20.

(d) Irreversible and Irretrievable Commitments of Resources

The removal of the uranium from the ground is the largest irreversible and irretrievable commitment of a natural resource resulting from the mining and milling operations. The uranium will eventually be utilized as fuel to generate energy in the electric power industry. This uranium will replace fossil fuel. It should be mentioned that fossil fuels such as coal and oil have other industrial uses besides generating energy. This is not yet so for uranium. The only present peaceful use for uranium is in the generation of energy.

b. Fuel Processing

(1) U_3O_8 Conversion

As in mining and milling, Applicant has not yet been required to contract for the conversion of U_3O_8 to UF_6. The discussion in this section will thus be generic rather than limited to any specific vendor.

(a) Background

There are a number of chemical techniques which can be used to accomplish yellowcake (U_3O_8) refining and conversion, but only two have been developed to a point where they have proved useful as large-scale economic industrial processes. One is a wet process used by Kerr-McGee and the other is a dry process used by Allied Chemical. Both processes produce uranium hexafluoride meeting United States Atomic Energy Commission specifications at about the same overall efficiency and cost; both processes guarantee a yield of 99.5%. They differ primarily in the method used to separate the uranium from the impurities present in the concentrate.

In the wet process, the impure yellowcake is dissolved in nitric acid (HNO_3) in digester tanks. The acid solution from the digesters is contacted in a series of pumper-decanters, where, within a 30% solution of tributyl phosphate (TBP) in hexane, the uranium is preferentially transferred from the aqueous to the immiscible organic phase. The aqueous phase, containing the impurities and trace amounts of uranium, is sent to waste disposal. The uranium-bearing organic phase, after a wash cycle to remove residual impurities or entrained aqueous phase, is recontacted in pulse columns under conditions where the uranium is transferred to an aqueous phase as highly pure uranyl nitrate.

The purified uranyl nitrate solution is concentrated by evaporation and the uranyl nitrate hexahydrate (UNH) thus formed is denitrated to orange oxide (UO_3) by heating. The UO_3 from the denitrators is pulverized and treated with hydrogen made from cracked ammonia and reduced to brown oxide (UO_2) in a fluid bed. The UO_2 is then converted to uranium tetrafluoride (UF_4), commonly known as green salt, with anhydrous hydrofluoric acid (AHF) in a two-stage fluid bed. The UF_4 is converted in a flame-type reactor by reaction with elemental fluorine generated by electrolysis of molten KF-HF. Excess F_2 is used to assure complete conversion to UF_6. The gaseous UF_6 product is condensed in cold traps from which it is loaded into cylinders for shipment to gaseous diffusion plants.

In the dry process, impure yellowcake is treated directly with hydrogen, produced by cracking ammonia, in a solid-gas contacting fluid bed to produce impure uranium dioxide (UO_2). This impure UO_2 is contacted with anhydrous hydrofluoric acid (AHF) in a second fluid bed to produce impure uranium tetrafluoride (UF_4).

The primary purification steps take place in the course of the conversion of UF_4 to UF_6, which is accomplished by treating the uranium tetrafluoride with elemental fluorine. Here, UF_4 is mixed with the diluent calcium fluoride (CaF_2) and fluorinated in a fluid bed reactor. The elements which form non-volatile fluoride remain with the diluent which is removed from the reactor. The UF_6 and other volatile fluorides such as molybdenum and vanadium fluorides, together with the excess F_2, leave the reactor and are routed through coolers and filters to cold traps where the volatile fluorides are condensed.

The UF_6, which contains only the volatile fluoride impurities after being condensed in the cold traps, is finally purified by a two-stage fractional distillation process in large bubble-cap distillation columns. The purified UF_6 from this operation is transferred to cylinders for shipment to the gaseous diffusion plants.

(b) Environmental Impact

(i) Land Systems

The impact on the land from conversions is very small. A certain amount of land will be required to site the chemical conversion facilities. The commitment of this land is not irretrievable since it can be restored to its original condition at the end of the plant lifetime. There are no residual effects such as radioactivity which would limit the use of the land.

(ii) Water and Air Systems

Very little information is available about the U_3O_8-to-UF_6 conversion processes that would establish the environmental impact of the liquid and gaseous effluents.

Both the wet and dry processes do employ condensation operations so there must be some thermal discharges. Because of the acid content and trace amounts of uranium, the liquid waste generated during the conversion processes will require monitoring and possible treatment prior to its release to the environment. The same types of controls are required for the gaseous releases.

With the technology and equipment available today, it is reasonable to assume that the environmental impact of this industry can be kept to a minimum.

(2) Enrichment

The gaseous diffusion facilities, which are used to enrich the natural uranium, are owned and operated by the U. S. Atomic Energy Commission. The details of the gaseous diffusion operations are presently classified by the Government. Because of this, information on the environmental impact of this industry is not available.

(3) Uranium Oxide Fuel Fabrication

The discussion in this area of the fuel cycle will be of a general nature. Much of the information used in this section was obtained from the environmental report submitted by Jersey Nuclear Company since no other fabricator has thus far submitted an environmental report.

(a) Background

The fabrication of nuclear fuel has evolved into a rather significant industry. Many individual companies have become or are planning to become involved in at least some portions of the fuel fabrication industry. A current list of these companies includes Babcock & Wilcox Co., Combustion Engineering Inc., General Electric Co., Gulf United Nuclear Corp., Jersey Nuclear Co., Kerr-McGee Corp., Nuclear Fuel Services, Inc., and Westinghouse Electric Corp.

The fabrication of nuclear fuel is still considered an art by most of the companies involved in this industry, and detailed information about the processes utilized is considered proprietary to the individual vendors and is not published in public documents.

The operations involved in manufacturing nuclear fuel are listed below to provide some general insight into the steps involved.

(a) Slightly enriched uranium (less than or equal to 5w/o U-235 is received in the form of Uranium hexafluoride [UF_6])

(b) The UF_6 is vaporized and mixed with water to form a uranyl fluoride (UO_2F_6) solution.

(c) The UO_2F_2 solution is treated with ammonium hydroxide to form a slurry of ammonium diuranate (ADU or $[NH_4]_2U_2O_7$).

(d) The ADU slurry is dewatered, dried and fired (at approximately 1200°F) in a reducing atmosphere to form UO_2.

(e) The UO_2 chunks from the reduction furnace are pulverized, blended and treated in preparation for pelletizing.

(f) The granulated UO_2 powder is compacted and pressed to form what are generally called "green" pellets.

(g) The "green" pellets are placed in trays and sintered in a controlled atmosphere furnace at about 3,000°F.

(h) The sintered pellets are wet centerless ground to final dimensions.

(i) The ground pellets are dried and prepared for fuel tube loading.

(j) The UO_2 pellets are loaded into fuel tubes.

(k) The fuel tubes are sealed with end plugs and loaded into an assembly structure.

(b) Environmental Impact

(i) Land Systems

The impact on land is very small. A certain amount of land will be required to site the facilities; however, the amount of land required is no greater than that required for any other medium-sized industry. The commitment of this land is not irretrievable since it can be restored to its original condition at the end of the plant lifetime. There are no effects such as those from residual radioactivity which would limit the use of the land.

(ii) Water Systems

To support the fabrication processes, water is required, primarily to cool chemical reactions and process equipment. In the case of the proposed Jersey Nuclear facilities, approximately 110,000 gallons[8] of water per day will flow through the plant. This quantity of water should have only a negligible effect on the water supply in most industrial areas in the United States.

As mentioned above, much of the water is required for cooling, so there is some thermal discharge associated with the fabrication processes; the increase in cooling water temperatures, however, is considered very small. Jersey Nuclear has shown, for example, that the heat added to the coolant will be dissipated to the ground in the sewer run between their plant and Richland sewage treatment plant.[9]

Uranium discharges to the sewage system must be minimized to eliminate any public hazards. Methods are available to the industry to protect against such discharges. The following methods are frequently used as deemed appropriate.

Floor drains in process areas where uranium could be spilled can be capped or equipped with filters. Liquid waste streams from the UF_6-UO_2 conversion process and smaller streams such as rinse waters from other processes known or suspected to contain uranium can be passed through high efficiency centrifuges and clarifiers for particulate uranium recovery. The waste streams can be further processed through ion-exchange columns to remove soluble uranium and then routed to quarantine tanks to be held for evaluation and eventual waste disposal.

Jersey Nuclear has taken additional action to protect against inadvertent entry of uranium into the Richland sanitary sewage system. They will install in the sewage line a sensitive radiation detector, capable of detecting and alarming for uranium activity. Provisions will be made for manual diversion of the process waste water to one of two 30,000-gallon retention tanks if there is any indication that the uranium concentration exceeds 5×10^{-4} μci/ml (the applicable Federal and State limits). Waste water, so diverted, will be pumped out of the retention tanks and either disposed of by a licensed waste disposal contractor or processed to reduce the uranium concentration. Table II.I.C.1-1 lists the daily average concentrations of liquid radioactive effluents for the Jersey Nuclear plant at full operation. The radioactivity being discharged is well below any biologically significant levels.

Other processes will also generate liquid wastes containing fluorides, sulfates, sodium, and nitrates or wastes which are strongly acidic or basic. These wastes will be collected, the pH adjusted to within the acceptable range, and the chemical concentration assured to be well within safe criteria.

(iii) Air Systems

The principal gaseous releases will come from the UF_6-UO_2 conversion process. These gaseous releases must be treated by liquid scrubbing, primarily for fluoride and ammonia removal, and by filtering to remove the uranium before discharging the gases to the environment. Table II.I.C.1-2 lists the expected annual average concentrations from gaseous radioactive effluents for the Jersey Nuclear plant. If one assumes that the concentration shown in Table II.I.C.1-2 at the maximim concentration point exists for the entire year, the annual release of uranium from the stack is 1.5×10^{-4} curies.[10] This complies easily with the permitted amount of 10 curies per year specified in 10 CFR 20.106.

Air monitoring programs have been established throughout the industry in order to assure no adverse radiological effects on the environment.

(iv) Material Resources

The fuel fabrication industry will require the commitment of a certain amount of land, water, and various chemicals. The commitment of water is temporary since it is returned to the local water source. The land commitment is not irretrievable since it can be restored to its original condition at the end of the plant lifetime. Chemicals used in the various processes, such as nitrogen, propane, ammonia, hydrofluoric acid, nitric acid, etc., are all common and are in no sense limited resources.

(4) Spent Fuel Reprocessing

(a) Techniques of Reprocessing

Spent fuel discharged from nuclear reactors is transported to the spent fuel

TABLE II.I.C.1-1 [11]

ESTIMATED LIQUID RELEASES

Daily Average Concentrations at Various Discharge Points

Radioisotope	Plant Boundary		Municipal Sewage Treatment Plant		Confluence of Yakima & Columbia Rivers	
	Estimated	State & Federal Limit[a]	Estimated	State & Federal Limit[b]	Estimated	Already Press
Uranium (Mass)	0.24 ppm	225 ppm	1.2×10^{-2} ppm	9 ppm	5.8×10^{-7} ppm	$<1.9\times10^{-3}$
Uranium (Curiage)	5.4×10^{-7} μCi/ml	5×10^{-4} μCi/ml	2.6×10^{-8} μCi/ml	2×10^{-5} μCi/ml	1.3×10^{-12} μCi/ml	$<1.3\times10^{-9}$ μCi/ml[c]

Assumptions: (1) Maximum throughput in UO_2 plant.

(2) Average water (total) flow from plant.

(3) Average flow through municipal sewage treatment plant.

(4) Minimum flow in Columbia River (Daily average).

(5) Uranium assumed to 5% enriched U-235.

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a 10 CFR 20.303 and WAC-402-24-140

b 10 CFR 20.106 and WAC-402-24-050

c If measured total alpha emitters were all natural uranium.

TABLE II.I.C.1-2[12]

ESTIMATED GASEOUS DISCHARGES

Annual Average Concentrations at Various Points

Radioisotope	At Plant Stack	At Maximum Concentration Radius (450 feet) Estimated	State & Federal Limit
Uranium	$2x10^{-13}\mu Ci/cc$	$3x10^{-18}\mu Ci/cc$	$2x10^{-12}\mu Ci/cc$[a]

Assumptions: (1) Maximum throughput in UO_2 Plant

(2) Sutton diffusion equations used in analysis

(3) Average meteorological conditions for site

(4) Double filtering of 99.95% efficiency for 0.8μ particles.

[a]10 CFR 20.106 and WAC-402-24-050

reprocessor for recovery of uranium and plutonium. The basic operations in reprocessing spent fuel, which are normally performed remotely either beneath a water shield or inside a massive concrete chamber, are summarized below.*

1. Shipping casks containing spent fuel are unloaded from the carrier and placed in a deep water-filled unloading pool. The cask is unloaded and the assembly is placed in an underwater storage rack to await reprocessing.

2. The fuel assemblies are sheared into small pieces to expose the fuel material.

3. Nitric acid is used to dissolve the fuel from the hulls, which are removed for packaging and burial.

4. Uranium and plutonium are chemically separated from the bulk of the fission product mixture, then separated from each other and further treated to remove residual fission products.

5. The purified uranium and plutonium are packaged and shipped to other sites for reuse.

The treatment and disposal of the resulting high level wastes are discussed in Section II.I.C.1.c.

Fuel reprocessing plants are subject to many of the same design considerations and stringent licensing requirements as nuclear reactors.

1. The design must be such that multiple simultaneous independent errors or malfunctions, each of very low probability, would have to exist before an accident of consequence to plant personnel or the public could occur.

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*Information on this stage of the fuel cycle is not presently available from specific contractors with Surry Power Station, and has therefore been abstracted from a number of disparate sources. However, Allied Gulf Nuclear Services has indicated that their environmental impact report is being prepared on approximately the same schedule as this Report.

2. Potentially mobile radioactivity must be confined in multiple barriers of determinable integrity.

3. The plant must be designed to withstand, without loss of safety functions, the same earthquake and tornado conditions specified for reactor facilities.

4. The sequence of AEC staff analysis, ACRS review, and ASLB Public Hearing prior to issuance of a construction permit or operating license required of reactor facilities is also required for reprocessing plants.

The only radioisotopes escaping from reprocessing plants in significant quantities are Kr-85 and tritium, which have approximately 10-year half-lives and relatively low biological toxicity. Other shorter-lived fission products will have decayed sufficiently during the cooling period at the reactor sites and subsequent transportation so as to make detection difficult even on-site.

Measurement of releases by the Nuclear Fuel Services, Inc. West Valley, N.Y., indicates that gaseous effluents have never exceeded 35% of the permitted annual concentration and in 1967 were only 3.8% of the permitted concentration. Liquid effluents range from 6% to 18% of the limit permitted by federal regulations, with a typical value of 10%. Off-site measurements of water activity in the area outside the site boundary were at least an order of magnitude below the 10 CFR 20 limits while air activity was essentially indistinguishable from background.[13]

Based on estimates of the growth of the nuclear industry, as late as the year 2000 the respective predicted annual average doses from Kr-85 and tritium would be approximately 10% and 0.001% of background. Prior to that time, one of several methods for reducing the release of these isotopes now under study will have been developed and implemented.[14]

(b) Environmental Impact

(i) Land System

The site upon which each of the existing or planned reprocessing plants are constructed cannot be used for any other purpose until the radioactive material has been removed and decontamination to permissible levels has occurred. At such time the land could be returned to general use. The sites of these facilities will occupy a total of 6300 acres. However, the security or exclusion areas will be much smaller. Since the sites are in remote areas, primarily farmland and forest land has been displaced.

(ii) Water Systems

Certain isotopes, chiefly tritium, may be released in small quantities to the liquid effluent. However, as discussed above, the quantities which are carefully monitored, have been and will continue to be well within permitted limits.

(iii) Air Systems

Release of Kr-85 through the stack constitutes the chief local source of radioactivity in the air. However, there are indications that technological advances (such as the ORNL Freon Scrubbing System or the INC cryogenic recovery system) will reduce an already low release rate to extremely low levels. All gaseous effluents are passed through high-efficiency filters to remove particulate material and gases other than noble gases.

In light of these considerations it is felt that the processing of nuclear fuel will have little effect on the air system.

c. Transportation

(1) Transportation of New Fuel

(a) Procedures for Shipment

Each year approximately one-third of the core of each Surry unit will be removed and replaced by new fuel. This will necessitate the transportation of 104 fuel assemblies from the fabrication plant to the site. Every precaution is taken to ensure that both the public and the environment are protected from any possible risks. Under present contractual arrangements, new fuel for approximately 10 years' operation of each unit will be fabricated by Westinghouse Electric Corporation at their plant near Columbia, South Carolina. Westinghouse will also be responsible for transporting the assemblies from Columbia to the plant site. Fuel assemblies will be trucked in shipping containers designed to meet the criteria of the United States Atomic Energy Commission set forth in 10 CFR 71, "Packaging of Radioactive Materials for Transportation," and the Department of Transportation as established in 10 CFR 173 subpart G. "Poisonous Materials and Radioactive Materials". The requirements for shipping fissile and radioactive materials are more stringent than the requirements for shipping any other potentially hazardous material.

Shipment will be in Westinghouse containers, either of type RCC or type RCC-1, under USAEC Special Nuclear Materials License No. SNM-338* and DOT Hazardous Materials Regulation Board Special Permit No. 5450.* A single truck will

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*Obtaining these licenses is the responsibility of Westinghouse. They have not, therefore, been included among the licenses discussed in the portion of this Environmental Report (¶I.D.) which covers this area.

transport a maximum of seven containers (fourteen assemblies). Normally there will be a maximum of one shipment per week during the time that shipping is required. The routing of the shipment will be over U.S. 96/378 from Columbia, South Carolina to Sumter, South Carolina; I-95 from Sumter to Stony Creek, Virginia; Va. U.S. 40 from Stony Creek to Spring Grove, Virginia; Va. 10 from Spring Grove to Surry Virginia; Va. 650 from Surry to the plant site. The total distance from Columbia to the plant is 408 miles. The Surry Station will receive eight shipments each year. Current plans call for refueling one unit each spring and the other each fall.

The primary reason for using a shipping container is to protect the fuel. Since the assemblies have not been irradiated, the only radioactivity is due to the natural decay of U-235. This radioactivity results in the emission of alpha particles, which are quite easily absorbed. They are stopped by a few centimeters of air and are incapable of penetrating the skin. Therefore, the major concern in shipment is the possibility of accidental criticality.

The fuel being shipped is of low enrichment, meaning that a relatively small amount of fissile material is present; the shipping containers are designed so that it is physically impossible for any critical configuration to form accidentally. The criticality standards for transportation of fissile material state that the package shall remain subcritical even if water leaks into the container such that moderation occurs to the most reactive extent possible, with the shipping container reflected on all sides by water.

The shipping package is thoroughly tested to ensure that these standards are met both during normal transportation and under accident conditions. The container must withstand the following events in the most adverse sequence without permitting criticality:

1. A thirty-foot drop onto a flat, unyielding surface.

2. A forty-inch drop onto a six-inch diameter cylindrical steel bar mounted on a flat, unyielding surface.

3. A thirty-minute exposure to a 1475°F heat source.

4. Immersion in at least three feet of water for eight hours.

The shipment of new fuel elements is analogous to the shipment of any other heavy cargo. There is no radiological hazard. The possibility of accidental criticality has been eliminated. All shipments may be made safely with no adverse effects on the environment.

(b) Environmental Effect of New Fuel Transportation

The overall effect of transportation on the air, water, and land systems is small. The portion of the route to Surry which experiences the lowest trailer truck traffic density on the entire route, Va. Route 10, sees over 35,000 trucks each year. An additional 16 trucks (eight trucks into the site and eight trucks leaving) is inconsequential even on that highway. An accident, which is unlikely because of the small number of shipments, the experience of the drivers, and the low accident rate experienced by trailer trucks, would be no more harmful than an accident involving any other heavy object carrier. There would be no radiological emissions and no possibility of inadvertant criticality even under the most severe hypothetical conditions.

(i) Land System

The pollution conditions created by the shipment of the new fuel are no more severe than those of any other type of truck shipment. Land area will be occupied by the trucks, but it will be area already allocated to highways. No additional land space will be required. It will not change any natural areas. Other people will continue to have access to the highways. Human usage will not be limited under normal conditions. Under accident conditions access may be restricted in a specific area for a short period of time; however, no long-term effect will be produced by the vehicle.

(ii) Water System

There will be no effect on water quality resulting from the shipment. There is no interaction between the transportation and the water system; that is, no effluents are emitted to the water system, no waste heat is discharged, and the waterways are not used as a means of transportation.

(iii) Air System

The impact on the air system will be minimal. Some gaseous and particulate matter will be given off by the engine of the truck. Again, it is noteworthy that these trucks represent only a very small portion of total truck traffic. The minute additional discharges are negligible when compared to those of the trucking industry as a whole.

The new fuel shipping containers have met rigid Federal regulations for shipping and have passed stringent tests for mechanical integrity. The levels of radioactivity in the fuel elements are extremely low. The first core for Surry 1 and portions of the first core for Surry 2 have been delivered with no incidents and no environmental impact. Therefore, it may be concluded that the shipment of new fuel elements will continue to be compatible with the ideals of conservation of natural resources and the protection of the environment.

(2) Spent Fuel Transportation

(a) Procedures for Shipment

In the course of power generation utilizing nuclear reactors, the fissionable isotopes in the nuclear fuel will be partially depleted, and part of this fuel must be discharged annually and replaced with fresh fuel. At this point, the depleted or "spent" fuel still contains about one-third of the original fissionable uranium and also plutonium, both of sufficient value to warrant recovery. This operation can most safely and economically be carried out at a separate fuel recovery facility serving many individual customers. Therefore, such fuel must be transported to the recovery facility where valuable uranium and plutonium are recovered and residual radioactive wastes are packaged for safe disposal.

Failure to recover the uranium and plutonium would increase the costs between $6,000,000 and $8,000,000 per year for the two Surry units. In addition, the fuel would have to be transported either to an off-site storage facility, which would involve the same considerations as the shipment to the reprocessors or stored on-site, which is not feasible for extended periods without the construction and licensing of a special spent fuel storage facility. In either event, the additional expenses associated with the disposal would be considerable.

The two units of Surry Power Station will discharge approximately 104 spent fuel assemblies containing 48 metric tons of uranium and 400 kg of plutonium each year after the first 16 months of operation. The spent fuel will be cooled in the reactor plant storage pool for about four to five months to reduce the radioactivity and heat generation in the spent fuel before being shipped. During this period, the fuel assemblies will be inspected to determine whether the fuel is normal(fuel that can be shipped in standard packaging), or leaking (fuel which may have developed minor defects requiring special packaging). Both standard and special packaging will be used for safe transportation of all fuel discharged. When cooled, the spent fuel will be packaged in containers designed and constructed to meet rigorous hypothetical accident requirements of the USAEC and USDOT as described in section II.I.C.1.c.(1)(a). These requirements provide for protection of the public from abnormal and accident conditions as well as under normal conditions of transport. Under normal conditions the following maximum radiation limits apply.

1. 1000 millirem per hour at 3 feet from the external surface of the cask.

2. 200 millirem per hour at any point on the exterior surface of the vehicle.

3. 10 millirem per hour at 6 feet from the external surface of the vehicle.

4. 2 millirem per hour at any normally occupied position in the vehicle.

Under hypothetical accident conditions the direct radiation dose shall not exceed criterion 1 above and the mechanical integrity of the cask shall be maintained such that the release of radioactivity is limited to gases and contaminated coolant containing total radioactivity exceeding neither 0.1 percent of the total radioactivity of the shipping cask contents nor 0.01 curies of Group 1 radionuclides, 0.5 curies of Group II radionuclides and 10 curies of Group III radionuclides, except that for inert gases, the limit is 1000 curies.

Prior to use, each container design and its transport system will be reviewed and approved by USAEC and USDOT, and transportation will be authorized by a license issued by the USAEC. License provisions will include adequate Quality Assurance and Testing Programs and Operating Procedures to ensure that equipment is constructed and used in accordance with approved designs and procedures. When loaded, containers will be carefully surveyed and inspected to ensure that they have been properly prepared for shipment and fully comply with the license provisions governing transportation. Shipments will also be placarded in accordance with federal regulations to warn the public that radioactive materials are contained in the vehicle. The loaded vehicle will not be left unattended while in transit.

Spent fuel will be transported by exclusive-use truck, since rail service is not available at the Surry site. Capacity is limited to one fuel assembly per shipment. The trailer which will carry the shipping cask will be specially designed to support and protect the cask in the event of an accident. Thus the trailer will provide added assurance that the cask will not be subjected to forces in excess of those specified for the hypothetical accident. Approximately 104 truck shipments will be made each year from the Surry station. The destination during the period 1973 to 1978 will be Allied-Gulf Nuclear Services in Barnwell, South Carolina. The destination beyond 1978 is unknown since contracts for reprocessing beyond 1978 have not been let. Truck routing to Barnwell will be via Va. 650 and 10, I-95, and S. C. 64, a distance of 455 miles, which will require approximately 15 hours of travel. This represents a total of approximately 480,000 round-trip vehicle miles over the five-year contract life, of which 240,000 miles will involve the transportation of spent fuel.

The total yearly spent fuel shipping program will be carried out in approximately 2-3 months by exclusive-use truck. In all cases where possible, truck shipments will be routed to avoid heavily populated and congested areas as well as grade crossings and tunnels, bridges or toll roads which prohibit such shipments. Each truck will be manned by personnel specially trained in driving skills, health physics, and container operation; and progress will be frequently reported enroute. Instruments for detection of abnormal conditions and instructions for immediate action will accompany all truck shipments. Should a vehicle become disabled in a public area the operators will make every effort to establish an exclusion area.

Before the first shipment a formal Accident Control and Recovery Plan will be developed which will provide for rapid and orderly utilization of utility, carrier, Allied-Gulf, State and municipal emergency personnel, and USAEC radiological assistance teams as required, in the event that any abnormal condition or accident is encountered. Even though the probability of an accident which could effect container integrity is extremely remote, the plan will include control of contamination and exposure to the public. The plan will also include salvage and recovery as well as control of bodily injury and property damage. Similar plans will be provided by subsequent reprocessors.

Insufficient data exist to establish meaningful accident statistics for the commercial shipment of spent nuclear fuel. In 1963 F. F. Leimkuhler of Johns Hopkins published the results of an analysis of truck accident frequencies for various types of interstate carriers.[15] He anticipated a rate of 3.63 accidents per million vehicle miles for radioactive shipments. This agrees fairly well with the Virginia statistics for conventional trailer trucks for 1970, which indicate a rate of slightly over 3 accidents per million vehicle miles. However, as he pointed out, the available statistics do not adequately correlate cargo damage to accident rate.

The forces on the cask associated with the hypothetical accident which the cask must survive are so great that extensive vehicle damage would almost certainly be incurred if these forces were approached. Therefore, attempting to equate total accident rates to cask damage and subsequent release of radioactivity produces highly conservative estimates. One measure of the frequency of accidents in which significant damage might occur would be to assume that such damage occurs in accidents involving one or more fatalities.* This assumption was also utilized in a discussion of spent fuel transportation in Italy.[16]

According to Virginia highway statistics for 1970 there were 71[17] fatal accidents involving trailer truck combinations in approximately 850,000,000 vehicle miles.[18] The postulated rate is therefore 0.09 fatal accidents per million vehicle miles. During the five years of the contract with Allied Gulf Nuclear Services, (AGNS), approximately 240,000 vehicle miles involving spent fuel transportation will be accumulated. Communications with the North Carolina and South Carolina highway departments indicate that the Virginia statistics are consistent with those for

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*Some severe accidents may not involve fatalities, while some accidents which involve fatalities may produce no substantial physical damages. Still, this measure will eliminate consideration of a number of clearly minor accidents.

their states; therefore, over the five years of the AGNS contract the upper limit for number of accidents of at least moderate severity as defined above is 0.02 accidents. If the vehicle miles accumulated during the remaining years of the plant life are comparable, then one could expect a maximum of 0.12 accidents with the potential for cask damage over the 30 year plant life. Since the fatality data include deaths in the trailer truck, passengers in other vehicles involved in the same accident, and/or pedestrians; these accident rates as a measure of the rate of accidents involving severe damage to the trailer truck are probably very conservative. AGNS, in their draft environmental impact report, projects 0.04 accidents which might involve cask damage per million vehicle miles based on Federal Highway Administration statistics for large interstate motor carriers.[19]

Virginia highway statistics for 1970 indicate that the average annual trailer truck density on the portions of Va. 10 and I-95 to be traversed by spent fuel shipments are approximately 35,000 and 620,000 vehicle miles/mile respectively. As a result, the additional traffic load from 208 trips per year (including return trips with empty casks) would be 0.6% for Va. 10 and insignificant on I-95. Since the average annual increase in trailer truck traffic is 7.2% per year, the effect on Va. 10 would also be very small.

Data are not available for Va. 650. However, it is anticipated that the traffic involved with spent fuel transportation will form a significant portion of the total trailer truck traffic. The mileage is very small (1040 vehicle miles/year).

(b) Environmental Impact

On the basis of the preceding discussion, we can draw the following conclusions regarding the effects of spent fuel transportation on the environment.

During normal conditions the additional environmental impact of the spent fuel transportation over and above the effects of current trailer truck traffic is negligible (see above). The only characteristic which distinguishes spent fuel shipments from ordinary heavy object shipments is radiation which must be maintained within the limits specified earlier in this section. These limits, which have been set low enough so as not to endanger the public health and safety, are monitored prior to and during shipment to ensure compliance. In actual practice the radiation field several yards away from a typical spent fuel shipment is virtually undetectable.[20]

The probability of severe accidents involving heavy object carriers in general appears to be very low. The careful screening and training which drivers will receive and the additional equipment design and operational safety requirements associated with spent fuel shipments will further reduce the accident probability.

Should an accident involving cask damage occur, the effect of the release of volatile fission products would be small. AGNS estimates the doses from an accident involving a ten-assembly rail cask. These estimates extrapolated to a single assembly cask indicate a 2 mrem whole body and a 23 mrem thyroid dose at 100 meters. Both are small when compared with background.

The safety record thus far for a limited number of commercial spent fuel shipments plus numerous shipments of spent fuel from various research, production, prototype power reactors, and naval propulsion reactors has been excellent. Although transportation accidents have occurred there has been no instance of radiation injury resulting from spent fuel shipments.[21]

(3) Radioactive Wastes Transportation and Disposal

Several types of solid, non-fissile radioactive wastes are generated from the operation of the Surry Power Station, namely:

(1) Spent demineralizer resins

(2) Filter basket assemblies

(3) Evaporator bottoms

(4) Low-level rubbish

For ultimate disposal, these wastes must be properly packaged and transported off-site to specially approved burial grounds.

(a) Procedure for Shipment

The spent resins and filter assemblies will be transported in disposable containers placed inside shielded casks. This packaging will meet all applicable USAEC and USDOT regulations (10 CFR 71 and 49 CFR 170-179) for transportation of radioactive materials, which include:

(1) Under normal conditions, a maximum dose rate of 200 mrem/hr on the external surface of the package

(2) Under accident conditions, a maximum dose rate of 1000 mrem/hr three feet from the external surface of the package. [These accident conditions are the same as those for new and spent fuel shipping casks, and are described in Section II.I.C.1.(c)(1)(a)]. The evaporator bottoms, which will be mixed with cement, and the low-level rubbish will not have a surface dose rate of greater than 200 mrem/hr. These wastes will be transported in 55-gallon drums.

The method of transport is expected to be by legal-weight trailer truck. Approximately 60 shipments will be required per year, of which one half will be drummed evaporator bottoms and low-level rubbish, one-third filter assembly casks, and the remainder spent resin casks. Normally, each shipment will consist of either one cask or about 40 drums. When loaded, the containers will be carefully surveyed and inspected to ensure that they have been properly prepared for shipment and fully comply with all Federal and State regulations. Also, they will be periodically monitored during shipment.

For the foreseeable future, all of the wastes will be buried at the Nuclear Engineering Company's (NECO) facility near Morehead, Kentucky. Of the five burial sites currently available for solid, non-fissile, radioactive wastes, this facility is the nearest to Surry Power Station. It is approximately 500 miles from the station via the most direct route: Va. 650 to Va. 10 to I-95 to I-64 to I-81 to I-77 to I-64.

(i) Effects of Shipment

The effect on the environment of the solid wastes shipments, from a traffic increase standpoint, is negligible. Over the primary and interstate routes from the station to the burial site, the average trailer truck traffic density ranges from on the order of 30,000 to 600,000 vehicle miles per mile (1970). The maximum added traffic density resulting from the 120 trips per year for waste shipments (including return) is less than 0.5%.

The only other possible impact of the shipments on the environment is from the release of radiation. Under normal conditions, the maximum surface dose rate of any of the waste containers will be below 200 mr/hr and the dose rate outside the transport vehicle will be one order of magnitude below this. Therefore, even if a member of the general population were to remain close to the vehicle (within a few feet) for as long as an hour, he would receive a dose of at least an order of magnitude below typical annual natural background levels. For accident conditions, the containers are designed such that, even under the most severe circumstances, the maximum dose rate will be 1000 mrem/hr at three feet from the container. The probability of a severe accident is very small, even using the very conservative accident rates given in Section II.I.C.1.c.(2) on the order of 0.1 severe accidents can be expected over the life of the station. However, even in the unlikely event that an accident does occur, and a member of the general population were near the container, the dose received would only be on the order of the annual natural background dose during one hour's period. In addition, even under severe accident conditions, there should be no release of radioactive material outside the containers since there are no gaseous or liquid materials involved. The effect on the environment from solid waste shipments, therefore, will not be significant.

(ii) Ultimate Disposal

As indicated above, all the wastes will be buried at the NECO facility near Morehead, Kentucky. This facility, which is located at Maxey Flats in Fleming County, has been licensed by the Kentucky Department of Health, under authority granted by the USAEC, to dispose of "low-level" wastes. The term "low-level" as applied to this burial site refers to the fact the wastes are solids and as such there is little likelihood that they will be dispersed into the environment.

Prior to issuance of a license for the facility, the topographical, geological, meteorological, and hydrological characteristics of the site, as well as the usage of ground and surface water in the general area, are examined. In addition, in order for the license to remain in effect, the wastes have to be buried in accordance with strict regulations on the quantity and type of radioactive material that can be buried, the depth of trenches and type of backfill, the marking of the filled trenches, the records kept on the material buried, and the ground water sampling program, to ensure that the radioactivity is contained. These measures ensure that there will be no undue meterological hazard to the general public or any significant effect on the environment outside the site.

The wastes from the Surry Station will be buried in disposable containers in conformance with the applicable regulations. Over the life of the station, approximately 300,000 ft^3 of wastes will be buried. Under present burial regulations and procedures, this will require only about three acres of land.

On the basis of these considerations, it is concluded that the burial of the solid, non-fissile wastes will not have a significant impact on the general environment.

(iii) Irreversible and Irretrievable Commitments of Resources

The transportation of radioactive wastes will have no permanent effect upon land use. However, the burial site will be lost to general use for an indefinite period.

(4) High Level Radioactive Waste Disposal

(a) Background

The storage of high level radioactive waste concentrates on an industrial scale has been dealt with successfully for more than two decades at AEC plutonium production facilities. The experience gained is being factored into the design of new facilities in which wastes from commercial spent fuel reprocessing will be stored.

In two of the three existing or projected reprocessing facilites, high level liquid wastes will be generated at a rate of approximately 100 gallons/metric ton uranium (MTU). In the third facility high level wastes will be generated in solid form at between 2 and 2.5 ft^3/MTU. These rates indicate that the Surry nuclear units will generate either 4800 gallons of waste in liquid form or approximately 100 ft^3 of solid wastes annually. If all wastes are solidified*, the total amount of waste accumulated over the life of the Surry station would be 3000 ft^3. This is approximately the volume enclosed within a 15 foot cube.

During the interim between formation and solidification, high level liquid wastes are stored in large welded steel underground storage tanks which are installed in massive concrete vaults far underground at the site of the reprocessing plant. Elaborate precautions are taken to prevent leakage, and multiple barriers with detection equipment at each barrier are provided in the event that leakage does occur. Standby tanks of identical size and design are available to receive the contents of any tank which shows signs of leakage. The design life of the tanks is 50 years. However, alternate storage methods, i.e., solidification and shipment to off-site repositories, will probably be utilized before that time.

The most promising method for the storage of solid high level wastes appears to entail the use of abandoned salt mines as Federal repositories. The wastes

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*It is anticipated that, eventually, processes will be required which will dispose of all high level wastes in solid form.

would be solidified and encapsulated in high-integrity containers, shipped to the repository, and imbedded in salt deep within the mine.

Transportation of the solid wastes would involve many of the same considerations as spent fuel shipment, and the same regulations for shipping would apply. However, the probability for release of radioactivity to the environment would be even lower because of the solidification.

(b) Environmental Impact

(i) Land Systems

The use of land occupied by the reprocessing plants (1500 acres each for two of the plants and 3300 acres for the third) will be lost to the general public for the life of the reprocessing plant and beyond, until the last of the stored high level wastes can be shipped to a repository and the on-site storage facilities decontaminated. At this point in time the land could be used for other purposes.

Since the Federal repositories will most probably be deep underground in salt mines, the environmental impact on the surface from this method of disposal will be minimal.

(ii) Water Systems

(a) Liquid Waste Storage

Careful design of liquid waste storage tanks, redundant barriers, automatic leak detectors, standby tanks, and careful siting should preclude the contamination of ground water. With solidification long, continuous utilization of the tanks will not be required.

(b) Solid Waste Storage

Solid wastes will be encapsulated in high-integrity containers and buried in salt formations remote from ground water supplies. Should the containers fail and water be present, the solid material will resist leaching.

(iii) Air Systems

The design of the liquid waste storage tanks and the nature of the solid wastes and the associated repository preclude release of radioactivity to the air.

(iv) Irreversible Commitment of Resources

Unless some leakage occurs in a liquid waste storage area there will be no permanent loss of land use.

Solid waste repositories would monopolize the use of the area around the mine mouth for handling incoming wastes until the repository was filled. Afterwards, a limited amount of land would be required to monitor the repository.

(5) Miscellaneous Transportation

(a) Background

Other stages of the nuclear fuel cycle include transportation of nuclear material not covered in the preceding sections. These are:

1. Yellowcake from the mill to the converter.
2. UF_6 from converter to AEC.
3. Enriched UF_6 from AEC to fabricator.
4. Recovered UF_6 from reprocessor to AEC.
5. Recovered plutonium nitrate from reprocessor to fabricator.

Of these only plutonium nitrate is significantly toxic or radioactive. The remaining shipments involve mildly radioactive material and hence the environmental impact is comparable to that for the new fuel transportation.

Plutonium will be transported as plutonium nitrate in a liquid solution of nitric acid for the near term. The prime objective for plutonium product packaging and transportation is "absolute containment" even under the most severe realistic accident conditions that can be postulated. In addition, the safeguards against loss or diversion of plutonium under all conditions will be given prime consideration. It is believed that these objectives are realistic for plutonium nitrate and can be achieved.[22]

(b) Environmental Impact

It is felt that the environmental impact of the transportation of these miscellaneous items will be minimal.

d. Economic Impact of the Nuclear Fuel Cycle

A beneficial effect of the nuclear fuel cycle for the Surry Station is that it will increase the number of people needed to work in the industries that produce nuclear fuel. An estimate of the number of new jobs created was made by comparing the number of employees in a particular plant and the output of the plant. Data from several suppliers was compared to determine an industry-wide average. For example, statistics were obtained concerning several mining and milling companies, five conversion facilities, two reprocessors, and others. The Atomic Energy Commission was consulted about the enriching process. An estimate of the number of people needed to supply the Surry units is given.

Number of People Employed for Surry in Nuclear Fuel Cycle

Mining and Milling	40
Conversion	20
Enrichment	30
Fabrication	15
Transportation	2
Reprocessing	8
Total	115

Thus over one hundred new jobs in the industry comprising the nuclear fuel cycle are created by the needs of the Surry site. Many of these will be filled by people who are at present unemployed or underemployed. For example, many uranium miners are living in areas which are economically depressed. The demand for nuclear fuel will cause the opening of new mines and open up new jobs for these men. A skilled labor pool will be utilized to a much greater extent than it is presently being used. Furthermore, jobs will not necessarily be lost in competing fields. In the extreme energy crisis facing the nation over the next decade and the limited amount of low sulfur coal and oil available on the east coast, the fossil fuels which are being replaced by nuclear fuels can be used profitably by other utilities and industries. For example, coal can also be used by the chemical industry and to produce synthetic natural gas. In addition, there will continue to be a large market for fossil fuels among utilities. Uranium has no significant uses other than as an energy source or in nuclear weapons.

The creation of one hundred new jobs in a manufacturing area can also create other new jobs in areas. According to a 1963 study by Fred D. Lindsey of the

U. S. Chamber of Commerce, one hundred new jobs in a single town would have the following effects:

Total Population Increase	359
New Households	100
Added School Children	91
New Personal Income (year)	$710,000
New Bank Deposits (year)	$229,000
More Passenger Cars	97
More Workers Employed (non-manufacture)	65
New Retail Establishment	3
More Retail Sales (year)	$331,000

Data are being compiled for these statistics based on the 1970 census but are not available at the present time. The 1963 estimates are conservative. The enriching process must be considered a special case, in that enrichment uses an enormous amount of power. The impact on the power industry is much greater than that of mining or fabrication. Therefore, one could expect more than 65 new jobs in non-enrichment areas for each 100 jobs in enrichment, due to the increased need for power and workers to produce it. In addition to creating new employment, the nuclear fuel industry will increase the purchasing power in specific areas by increasing total cash influx. It will contribute a large sum in taxes to Federal, State and Local governments.

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[3]Ibid.

[4]"Deposition and Control of Uranium Mill Tailings Piles in the Colorado River Basin", U.S. Department of Health, Education and Welfare, FWPCA, Region VIII, March 1966, page 9.

[5]Humble Oil and Refining Company

[6]"Applicant's Environmental Report Operating License Stage for Uranium Concentration", submitted by Rio Algom Corporation, Moal, Utah, page 41.

[7]Humble Oil and Refining Company, pp. 44-47.

[8]"Applicant's Environmental Report--Jersey Nuclear Company Uranium Oxide Fuels Plant", Docket No. 70-1257, September 1970, page 26.

[9]Ibid., page 20.

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2. Operating Effects

a. Mechanical Effects

(1) Water Systems

(a) Physical Effects

(i) Volume of Water Used

Surry Power Station is comprised of two pressurized water reactors, each requiring 840,000 gallons per minute of river water to supply the condenser and service water needs. This amounts to a total of 1,680,000 gpm or about 3,740 cubic feet per second. The James River is tidal in this section of the river, and it has been estimated by Pritchard-Carpenter, Consultants, that the total new dilution water flow rate to the tidal segment adjacent to the plant site is approximately 25,000 cfs. Comparing this with the 3,740 cfs passed through the station, it is seen that only 14.96% of the net new dilution water available is utilized for cooling purposes. The 14.96% figure appears to be a valid figure in that Pritchard-Carpenter have stated that the total new dilution water available is very nearly independent of fresh water river flow.

The effect of utilizing 3,740 cfs of water for cooling purposes on the fresh water/salt water boundary is expected to be negligible since the location of the boundary is governed largely by the fresh water inflow from upstream. During times when the intake water is higher in salinity than the waters of the discharge area (about 2 parts per thousand on the average), it is anticipated that the inshore waters of Cobham Bay around Hog Point will be increased in salinity by less than 1 ppt, if at all, well within the tolerance limits for euryhaline species. Data from Deep Water Shoal has shown, for example, as much as 8 ppt fluctuation on a tidal cycle.

designed low velocities, are expected to be insignificant.

To further ensure that nekton are not drawn into the intake structures, various techniques for diverting fish are now undergoing investigation. One such method utilizes an "air bubbler" technique. This device is being installed because of its demonstrated operational effectiveness and lack of harmful effects to the fish that inhabit the area.

A two-inch pipe will be laid along the river bottom in a semi-circular arrangement in front of the intake bays. The pipe will contain holes 1/16 inch in diameter and four inches apart. A compressor will supply the pipe with 100 psi compressed air. The air from the pipe forms a curtain of air bubbles which serves to divert a large percentage of fish approaching the intake trash racks. At least one user has reported the air curtain to be 90 - 95% effective* and it is hoped that similar performance can be obtained at Surry.

If there is evidence that large quantities of nekton are drawn into the intake structure even with the air bubbler system in service, then the Applicant will take additional steps to protect the aquatic environment taking full cognizance of the cost-benefit relationship of such additional devices. Applicant has already provided the slots and supports for traveling screens on the structure at the intake to the pumps; however, it believes that the effort to keep the fish away from the intake has greater merit than keeping them out by traveling screens.

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*EEI Prime Movers Committee Operating Experience Report, Consumer Power Company. May 10-12, 1971.

(ii) Effects on Ground Water

The use of the James River waters for cooling purposes will have no adverse effect on the ground water levels in the area of Gravel Neck. As stated previously, water drains to the east, north, and south toward the river in the vicinity of the site. Since the elevated intake canal is concrete-lined, there will be no fluctuation of the ground water table.

(iii) Turbulence at Discharge Point

Turbulence will be produced at the point of discharge due to the design of the discharge groin. The discharge structure has been designed as a variable jet which will have an exit velocity of 6 feet per second with a transverse current due to the tide of about 1.2 feet per second. The purpose of this design is to utilize the Venturi principle and entrain cooler waters rapidly to aid in mixing. When considering the overall width of the river, the area of turbulence is expected to be small.

(iv) Effects of Intake Structures

The intake structures, consisting of eight bays containing one circulating water pump each, are located on the south shore of the James River downstream from Hog Point. There are no appurtenances protruding into the water to any extent sufficient to cause eddies around the structure. River water passes through a trash rack at the mouth of each bay. Each rack is serviced by a manually actuated movable trash rack rake which cleans the face of the racks. Maximum velocity at the face of the racks will be approximately 1.0 fps to reduce the probability that fish will be attracted or drawn into the intake canal. The physical effects of the pumps, and the intake structures with their specially

(b) Biological Effects

(i) Effects on Fish and Other Life Forms From Intake Mechanisms

Haul seine shore fishery studies, conducted over the past 18 months upstream and downstream from the intake structures, have shown a substantial population of silversides, Menidia sp., which have appeared in 98% of samples taken. The next most common species, the white perch, Morone americana, has occurred in 59% of the total samples. Silversides are strongly positive-rheotactic and have been observed maintaining their position in a tidal current as strong as 3-4 fps. They are not expected to pose a problem. The white perch is not as strongly positive-rheotactic, however, as is the silversides.

(ii) Non-Thermal Effect on Aquatic Biota Passage Through Condenser

In order to reach and pass through the condenser of the Surry Power Station, any organism would have to pass through 14 gage wire with 3/8 in mesh traveling screens located ahead of the condenser box at the station. Phytoplankton and zooplankton, as well as ichthyoplankton, however, will pass through the condensers. There has been little research into the mechanical effects of plankton passage through power station condensers. Problems have been encountered in sampling techniques at the outfall, in that mechanical effects from passage through condensers could not be separated from mechanical effects of the sampling gear. Results generally show, however, that phytoplankton and zooplankton were not adversely effected when passed through a condenser or a similar mechanical structure.

Research by the Johns Hopkins University and Natural Resources Institute bear similar results in this respect. Generally, the smaller the organism passing through the condenser, the less likely it is to sustain harm.

Flemer, D. A., et al, in a study entitled "Preliminary Report on the Effects of Steam Electric Station Operation on Entrained Organisms" that appeared in C. B. L. Reference #71-24a, showed either no mechanical effects or depression of 21% in the photosynthetic rate of phytoplankton that had been passed through a cold condenser. They concluded that, from work on temperature effects, there was only minor effect on the passage of phytoplankton through a power station condenser. In related work, they concluded that, even under test conditions of maximum temperature rise, effects on zooplankton were slight. These studies also included mechanical effects. Effects on fish eggs and larvae were not considered significant due to too few numbers.

(iii) Effect From Scouring and Other Physical Outfall Phenomena

Limited scouring is expected in the discharge canal which will be lined to the area of the groin. Any scouring that does occur will, after stabilization of the bottom in the area of the scour, have no adverse effect on fish or other biota. Turbulent mixing is expected to occur in the vicinity where the discharge from the station enters the discharge canal. Other turbulent mixing will occur where the discharge groin jet goes back into the James River. Such turbulence will have no adverse effect on fish as finfish will either cope with the situation or shy away from it. Scouring is also expected over a limited area in the vicinity of the jet discharge. Initially, this scouring will uncover some individuals of the marsh clam, Rangia cuneata, and possibly wash them to less turbulent areas where they should be able to survive. This scouring will have little or no effect on floating organisms.

(2) Human Use: Effect of Intake or Outfall Turbulence on Swimmers or Boaters

There will be little or no turbulence around the intake structures. Boaters will be warned by signs to keep away from the area. No swimming is expected to occur in the area.

Turbulence created by the variable jet discharge will be marked and noted by signs warning boaters of the hazards associated with boating in the immediate vicinity. The closest swimming beaches are located near the Colonial Parkway across the river near Jamestown Island, and upstream near Scotland Wharf. Future swimming activity is anticipated at Chippokes Plantation State Park. In any event, discharge turbulence will have no effect on swimming at these locations. No swimming activity has been observed in the vicinity of the station discharge.

b. Thermal Effects

(1) Land Systems

(a) Natural Effects

The heat rejection rate at full load for the condenser cooling water system with two 822 MWe units in operation will be 12 x 10^9 BTU per hour. The corresponding "delta-T" rise will be 14°F. Based on operating experience at other Vepco stations, namely Yorktown and Portsmouth, localized fogging might be expected to occur under certain atmospheric conditions. Fogging occurs naturally already in the James River Basin, however; particularly in the spring and fall, it is known to occur in densities great enough to limit visibility to less than 100 feet. There may be localized fogging in the vicinity of the discharge canal but the contribution of the station to overall area atmospheric fogging is expected to be minimal. The once-through cooling utilized by the Surry Power Station is not expected to produce water drift or salt deposition effects of any measurable significance. This conclusion is based on observations at Yorktown, Portsmouth, and on waste heat reservoirs such as those located at Par Pond, South Carolina; near Roxboro, North Carolina; and near Asheville, North Carolina. Vegetation adjacent to these heated reservoirs is lush and plentiful.

(b) Human Uses

(i) Effects on Roads, Etc.

The only effect anticipated from operation of the condenser cooling water system is possible localized fogging on the bridge over the discharge canal under certain atmospheric conditions. There will be no effects on other roads, airports, nearby population centers, agriculture, or forests. Operation of the condenser cooling water system is expected to eliminate or minimize the incidence of ice formation during winter along the south shore of the James River from Chippokes Plantation State Park downstream to the eastern shore of Hog Island peninsula.

(ii) Inhibition of Industrial Development

Industrial development will not be hampered in the area since the majority of the heated effluent will be discharged on the south shore of the James River along the boundaries of the Hog Island Wildlife Preserve and, will not, therefore, effect the availability of land for future development.

(iii) Compatibility with Planning

Since there will be no inhibitions to further industrial development, the cooling water system use does not conflict with anticipated regional planning guidelines.

(2) Water Systems

(a) Natural Effects

(i) Physical Effects

(a) Mixing Zone

A mixing zone is produced in the James River by the heated discharges from Surry Power Station. Physical model studies of the mixing zone have been conducted by the consulting firm of Pritchard-Carpenter, on the Army Corps of Engineers' model of the James River in Vicksburg, Mississippi. These studies were filed in connection with Vepco's application for Virginia State Water Control Board Certificate #1843 (Appendix G-14); they are also attached as Appendix B to this report. The studies indicate, in general, that the anticipated thermal plume will swing upstream into Cobham Bay proper on an incoming tide and downstream around Hog Point on an outgoing tide. They also indicate that the mixing zone complies with the State Water Control Board's requirements that a thermal barrier not be created. With the special design of the variable jet discharge, the artificially produced thermal gradients will decrease rapidly as the heated water mixes with cooler river water and moves away from the point of discharge.

Temperature recorders at seven locations in the James River as seen in Figure II.I.A.2-1 measure mid-depth and bottom temperature and have recorded natural pre-operational river temperatures as high as 87°F at mid-depth. Diurnal variation has been as great as 3°F with little change noted as result of tidal fluctuations. Most of this diurnal variation is probably induced by solar radiation. It is interesting to note that, around the first of November, 1970, there was a decrease in water temperature of 16°F in a period of 3 days. Thermal stratification between mid-depth and bottom has been on the order of 0-3°F, dependent on time of year and tidal stage.

Oxygen levels are not expected to be significantly effected during operation of the station. Pre-existing dissolved oxygen levels in the James River around the Hog Island Peninsula were near saturation and ranged from a low of about 7.0 parts per million upwards to about 12.0 parts per million, dependent on temperature. In past operating experience at other stations, oxygen levels have tended to increase about 1 ppm in the summer and decrease by a like amount in the winter as a result of passage of water through the station. Though this result may appear puzzling in light of the fact that increased temperature reduces the solubility of oxygen in water, it is explained by the fact that the stations where this phenomenon occurs employ specially designed seal pits which afford aeration for the condenser water through turbulence prior to returning it to the main stream. The design of the jet discharge at Surry should result in a similar type phenomenon. The following table illustrates the solubility of oxygen in water at various observed temperatures:

Temperature (°F)	Dissolved Oxygen (ppm)
32	14.6
41	12.8
59	10.2
77	8.4
86	7.6
95	7.1
104	6.6

As can be seen, even at 104°F, it is theoretically possible to have more than an adequate amount of oxygen dissolved in water for the maintenance of fish life.

Phytoplankton, zooplankton, meroplankton, and fish larvae will unavoidably be passed through the station during the process of heat dissipation. Whether any of these organisms would be effected during passage through the station is a function of the temperature rise, exposure duration, pressure changes, size of the organism, age of the organism, and past thermal history of the organism. Previous discussion has dealt with the effects of entrainment alone on organisms. Based on limited research, the effects of pumping alone on aquatic organisms appears to be insignificant.

Assuming that the worst possible condition, i.e., retention time at 14°F "delta-T" is long enough and at a high enough temperature to kill 100% of the entrained organisms, the question arises as to what effect this situation would have on the ecological balance in the James River. By assuming that the station passes less than 15% of the net water available for dilution and uniformity exists in the distribution of phytoplankton and zooplankton populations, one might assume that 15% of the standing crop were destroyed and hence 15% of the productivity of the river. However, due to the tidal nature of this estuary and some re-use of the cooling water, this statement is not statistically supportable. Considering the rapidity of the reproduction rates of phytoplankton and zooplankton, the influence of the mixing zone on stimulation of reproduction, and the variability between seasons and years, this reduction could hardly be measured with any statistical reliability.

The distribution of fish eggs and larvae, however, is not uniform. The only eggs that would be drawn into the station are the pelagic eggs of the interface spawners that happen to be in the water column subject to the intakes of the station. The majority of the pelagic fish eggs found in the intake are probably those of the Bay anchovy, Anchoa mitchilli, and hogchoker, Trinectes maculatus. Fish larvae are free to move about but are more or less at the mercy of the currents. While the intake structure has been designed with an approach velocity of approximately one foot per second to minimize attracting or drawing in small fish, a small unknown percent will still enter the intake canal. After passage through the station, these larvae may or may not survive. Ichthyoplankton samples have been taken, but not sorted, to attempt to identify fish egg and larvae populations and their season of occurrence. To date, the spring and summer months appear to produce the most larvae which are largely *Menidia* sp. and *Anchoa mitchilli*. Few eggs have been taken in the intake samples to date.

The physical arrangement of the cooling cycle was engineered as the best alternative for the reduction of temperatures in the waters of the James River. Several alternatives were explored both from the physical model and a mathematical model by Pritchard-Carpenter, Consultants. Results of their studies are attached in Appendix B to this report. In addition to the present arrangement utilizing a jet discharge of 6 feet per second, discharges of 12 feet per second were explored as a possibility. Also, spray coolers in conjunction with a 12 feet per second discharge, and a deep water diffuser were explored as possible means of dispersing waste heat. Each method had both good and bad features and some entailed a thermal blockage of the river at some stage in the tidal cycle. It was concluded that the present arrangement utilizing a 6 feet per second jet discharge would produce the minimal impact on the ecology of the James River.

The segment of the James River from the Chickahominy River downstream to Deep Water Shoal appears to be utilized by young-of-the-year and juvenile fishes as a nursery area. Young-of-the-year white perch, striped bass, shad, and herring have been taken along the shore zones. In addition, the Atlantic croaker and spot have been taken in deep water trawl studies. Any fish exposed to the thermal plume of the discharge, have the choice of seeking water temperatures more suitable for their development or remaining in the thermal plume. The plume from the station will, in the summer months, cause temperature intolerant shore zone fish to move away from the shore zones on either side of the discharge structure. When water temperatures in the area become more suitable for these young, mainly in the fall and winter, there will be an increase in the populations in this zone. The net effect of the station on the anticipated shift in population distribution is expected to be minimal; however, post-operational studies by Virginia Institute of Marine Science will be carried out to determine the net effect (Appendix F).

(b) Water Sources Outside Mixing Zone

There is expected to be little effect from the temperature of the James River water outside the area of the mixing zone. The warmer water discharged from the station is designed, utilizing the Venturi principle, to quickly mix with surrounding ambient water. This mixed water will eventually stratify and be confined to the upper ten feet of the water column, leaving the remainder of the water column unaffected by an increase in temperature. Outside the mixing zone, the operation of the station will have no appreciable effect on diurnal and seasonal variations, systematic temperature changes over time, changes in oxygen supply, solubility of salts, or rates of chemical reaction. Data taken from the seven instrument towers in the James River will be used to assess the accuracy of the physical model and to compare pre-operational and post-operational conditions in the river.

(c) Projection Models

The thermal plume characteristics for the James River have been predicted based on simulation of station operation in the U. S. Army Corps of Engineers model of the James River at Vicksburg, Mississippi. These variable intake-discharge arrangements, and variable tide stages, are outlined in the appended report by Pritchard-Carpenter, Consultants (Appendix B). In addition, winter operating conditions and resulting thermal plume characteristics have been simulated with a mathematical model by Dr. D. W. Pritchard whose results are appended. The physical effects of the operation of the station on the James River are outlined in these reports.

(d) Applicable Regulations

Water quality standards for the State of Virginia became effective on July 20, 1970 with subsequent approval by the Federal Government. Criteria applicable to the James River in the vicinity of the Surry Power Station include: a minimum dissolved oxygen content of 4.0 mg/1 and a daily average of 5.0 mg/1, pH range of 6.0 - 8.5, and an allowable rise above natural temperature of 4.0°F from September through May and 1.5°F from June through August. The temperature rise will be measured at the edge of a defined mixing zone, the boundaries of which are to be determined on a case-by-case basis. These zones, however, shall occupy as small an area and length as possible, and shall not prevent free passage of fish.

In the case of the Surry Power Station, waters of other states will not be effected by effluents from the station.

The effect of the station on water quality is a subject within the jurisdiction of the Virginia State Water Control Board. The Company applied to that Board and obtained a permit for use by its two nuclear generating units of the James River for cooling in the manner proposed. The Company has applied to the Board for a certificate of compliance under Section 21 (b) of the Federal Water Pollution Control Act and has reasonable assurance that, within the required three-year grace period specified in Section 21 (b), a certificate can be obtained.

(ii) Biological Effects

(a) Effects on Plant Life

The effects of the condenser cooling water system on plant life in the James River is expected to be minimal. As indicated earlier, emergent and submergent vegetation is practically nonexistent in this portion of the river except in the marsh areas. Phytoplankton production is expected to be slightly reduced in the summer months and stimulated during the winter months, based on studies at other power stations that are in operation. Blue-green algae may be produced in the discharge canal during the summer months although none has been collected. This should pose no problem in the river proper due to the availability of cooler waters. The heating of the intake water by 14°F at maximum station load is expected to have little, if any, effect on the oxygen levels in the river that might result in a detriment to plant or algae production.

(b) Effects on Fish, Shellfish, and Functional Groups

Particular attention was paid to the effects of plant operation on fish, shellfish, and supporting functional groups from changes in temperatures, oxygen level, and plant life level in water during passage through the condenser and within the discharge canal in discussion of physical effects (section II.I.2.a.(1)(a)). Within the mixing zone the effects, if any, on these parameters are expected to decrease with decreasing temperature levels. Beyond the mixing zone, effects are expected to be insignificant if indeed they can be reliably measured at all.

It is of interest to note that the model studies show a continuous zone of passage for anadromous fish species both horizontally (no thermal blockage of the river) and vertically (thermal stratification). Upstream, at Vepco's Chesterfield Power Station, studies have shown that no thermal blockage exists since the heated effluent tends to stratify on the surface. As a result, anadromous species such as shad and herring have free access to their spawning grounds all the way to the fall line at Richmond, Virginia. During the shad spawning season, an extensive sport fishery exists at Richmond despite heavy sewage pollution in that section of the river.

Of the commercially important fish that pass the area during spawning runs, such as striped bass, Morone saxatilis, and the shads and herrings, none appears to utilize the waters around the Surry Power Station as a spawning area. Rather, these species spawn upstream from the station; the striped bass spawn in the Chickahominy River and in the James River between the Chickahominy and Hopewell, while the shads and herrings utilize the river and its tributaries from the Chickahominy to Richmond. There is expected to be little, if any, effect on species composition. Studies are currently in progress, however, which will give information on species composition that will be used in comparison with post-operational data to assess these effects.

The question often arises as to the possibility of a "cold kill" caused by a thermal shock to fish resulting from a sudden shutdown of a unit in the winter. With at least two units utilizing a common discharge canal, as is the case at all other Vepco stations, this possibility is minimized in that the probability of both units shutting down at the same time is remote.

Species stability and total productivity of the James River in the vicinity of the station should not be affected by the operation of the station. It is anticipated that they will remain within the normal seasonal and annual cyclic variability encountered in estuarine biological systems. Nutrient circulation should be increased in the immediate area of the discharge, but, due to the strong tidal currents in the river, there will be no net effect on the river proper.

(b) Human Uses

(i) Industrial

(a) Reduction in Available Cooling Capacity Downstream

Model studies have shown that the bulk of the heated plume will remain in the vicinity of the Hog Island Peninsula. Since this is a State wildlife refuge, the chances for industrial development in this area are nil. Therefore, the effect of heated water on the available cooling capacity of downstream waters is insignificant.

(b) Increase in Corrosion Rate

Operation of this facility is not expected to increase the rate of corrosion in water or structures exposed to the water. Rather, the level of salinity is expected to be the governing factor in the rate of corrosion.

(c) Commercial Effect of Biological Effect

The effects of the operation of the station on the commercial fisheries in the area are expected to be beneficial rather than detrimental. There will be no net effect on the seed oyster industry located 5 miles downstream from the intake structure. There is an extensive seasonal crab pot fishery in the area of the station. Part of this fishery is located in the area to be covered by the discharge plume and lasts about 1-2 months during a year. Based on operating experience at other stations, the blue crab, Callinectes sapidus, will be attracted to the heated discharge area. The net result may be increased catches and an extension of the crab season by an estimated 1 month. An extensive gill net fishery also exists in the area of the discharge during anadromous fish runs. During the time of these runs, mainly spring and fall, certain species are likely to be attracted to the area of the plume. This, also, should result in an intensified fishing effort with resulting increased catches for commercial fishermen. The regular fishing season is not expected to be lengthened. A possibility exists for the development of an extensive winter fishery for white perch and catfish in that both species appear to be attracted by a heated plume.

(ii) Recreational Effects

Sport fishing activity in the area of the heated effluent is expected to increase in the fall and spring months. Also, a wintertime fishery is expected to develop. There is, at present, no significant summertime sport fishery in the area of Hog Point. Farther downriver, in Burwells Bay, there is a summer sport fishery for Atlantic croaker and spot. The operation of the station is not expected to have an effect on boating in the area except in the immediate area of the jet discharge, where turbulence may preclude the use of boats. Swimming, across the river near the Colonial Parkway and upstream near Scotland Wharf, will not be affected due to the operation of the station.

(iii) Effect on Other Uses

There are no known municipal users of James River waters that will be affected by operation of the station. Likewise, no irrigation uses are known. Federal installations, possibly using James River waters, are located across the river from the intakes at Fort Eustis and downstream at Newport News. These installations will not be affected by the operation of the station.

(c) Air Systems

The effect of station operation on fogging in the James River is expected to be limited to the area of the discharge canal and exist only under certain atmospheric conditions; i.e., when the air is cooler than the water. The James River proper normally experiences heavy fog at such times, usually early in the morning, with associated burn-off occurring by noon. Fog produced in the discharge canal is not expected to add appreciably to the overall fog produced in the river proper.

The James River in the vicinity of the Surry Power Station has experienced icing conditions, usually once or twice a year. The ice varies from surface sheet ice to layers as much as 6 inches thick in shallow waters. Operation of the Surry Power Station is expected to minimize ice conditions in the area off the south shore of the river under the influence of the heated plume.

Condensation resulting from heated water in the discharge canal is expected to be limited to the area immediately adjacent to the canal. Storm frequency or intensity in the area will not be effected by operation of the station.

c. Chemical Effects

(1) Land Systems

Absorption of effluents from water into the earth is highly improbable. All wastes are discharged to the circulating water discharge canal where they will be diluted with such large quantities of cooling water they will in effect lose their identity. In addition, the soil at the site is highly impervious and absorption would not proceed to any degree.

No direct discharge of liquid wastes into the earth is anticipated with the exception of sanitary waste which is discussed in ¶ II.I.A.1.a.(1)(b).

(2) Water Systems - (Non-Radioactive)

(a) Physical Aspects

Liquid wastes with their expected flows and chemical composition are listed below:

(i) Condenser cooling water with a flow of approximately 840,000 gpm of river water for each unit. No biocides or other chemical solutions will be added to this water. No biocides are required due to the fact that mechanical condenser cleaning will be employed through use of an "Amertap" system which passes sponge rubber balls through the tubes to maintain cleanliness.

(ii) Bearing cooling water with a flow of 36,000 gpm of river water for each unit. No biocides or other chemical additions will be added to this water.

(iii) Component cooling system with a flow of 18,750 gpm of river water. No biocides or other chemical additions will be added to this water.

(iv) The chilled water system will have a flow of 2,190 gpm per unit of river water with no biocides or other chemical additions.

(v) Steam generator blowdown will be 22 gpm per unit and will discharge to the circulating water system unless a steam generator tube leak occurs, at which time the blowdown will be diverted, under administrative control, to the radioactive waste disposal system as necessary. Normal chemical concentrations will be 5 to 10 ppm of PO_4 as sodium phosphate and 0.5 to 1.0 ppm of cyclohexylamine.

(vi) The waste sump from the flash evaporator of each unit will discharge to the circulating water discharge line and will normally be flash evaporator blowdown composed of three (3) to five (5) concentrations of well water. Approximately each thirty days the polishing demineralizer will be regenerated and the neutralized acid and caustic plus rinses will be combined with the flash evaporator blowdown. The regeneration will require about 67 lbs of sulfuric acid and 78 lbs of sodium hydroxide plus 3000 gallons of rinse water. These neutralized wastes will be slowly released to the discharge canal and result in no significant environmental impact.

(vii) The air conditioning system will use 100 gpm of river water for cooling. This flow will be returned to the circulating water discharge tunnel with no chemical or biocide addition.

No treatment of chemical waste, other than neutralization of demineralizer wastes, is necessary.

(b) Sanitary Wastes

Sanitary wastes will be treated in the same manner as during construction namely, secondary treatment approved by the State Health Department and State Water Control Board.

(c) Ground Water Quality

No effect on ground water quality is anticipated from operation of the station.

(d) Chemical Discharges

No concentration of chemical discharges in the bottom sediments is anticipated. No measurable suspended solids, other than those in the inlet cooling water, will be discharged.

(e) Corrosion of Structures

Corrosion of structures erected in the water will contribute no measurable quantities of corrosion products to the environment. Most corrodible materials are protected by non-leaching, non-toxic coatings.

(f) Biological Aspects of Chemicals

In view of the minuteness of the station chemical releases and the voluminous amount of discharge water for dilution purposes, there are not anticipated to be any chemical effects on either aquatic flora or fauna.

Since there will be no chemical effects on plants or animals, there likewise will be no effect on human use of the water source to obtain these plants and animals. Nor will chemical concentrations, which are within regulatory limits, effect the utility of the water for other economic or recreational purposes.

d. Radiological Effects

This portion of the Environmental Report will consider the radioactive releases from the Surry Power Station and their environmental effects under both normal operating conditions and accident conditions. At the outset, it should be noted that the Surry Power Station is designed to preclude the occurrence of any significant adverse radiological effects on the environment. Small quantities of radionuclides will be released to the environment under carefully controlled and monitored conditions and in accordance with the applicable requirements specified by the Atomic Energy Commission. It must be noted that the assumptions used in this section are the result of realistic evaluations and are not the same as the conservative assumptions used for design in the FSAR or Appendix H.

Realistic analyses show that radioactivity levels in the discharge canal, resulting from liquid releases from the station's liquid waste disposal system, will be less than 1% of the maximum permissible concentrations currently specified in 10 CFR 20. It is expected that no significant adverse effects on the environment will result from the very small quantities of radionuclides released during normal station operations. In the event of postulated major incidents, primarily the highly unlikely and hypothetical "design basis loss-of-coolant accident", there would be no accidental discharges of radioactive liquid wastes to the James River or into the subterranean acquifers.

Gaseous release from the facility, under normal operation, will be less than 0.4% of the allowable limit as specified in 10 CFR 20. Realistic analyses show that in the event the design basis accident should occur, all gaseous outleakage from the containment would be terminated within 10 minutes by the restoration of sub-atmospheric pressure and any off-site doses would be well below the limits suggested by 10 CFR 100.*

(1) Normal Operations

The following paragraphs will treat the radiological effects stemming from normal plant operation. The discussion will begin with a summary of background information

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*In the realistic case, we assume all safeguards are functional. For additional information see the accident analysis in Section II.I.C.2.d.(2) following.

on the plant operating modes which produce radiological effects, the principal sources of these effects, and general assumptions used in the subsequent analysis. The actual releases expected from the plant are then presented; their expected effects on living organisms are outlined, with emphasis on the principal pathways to human exposure and expected levels of exposure. The format of discussion of radiological effects is slightly different from that of the other portions of this report , since radioactive releases from a power plant actually occur only in the water and in the air, there will be no separate treatment of "land systems". Effects on land systems will be considered in the context of the pathway to exposure; the possibility of human exposure to radioactivity through eating contaminated shellfish, for example, would be treated under the general heading of "water systems".

(a) Background

Radioactive effluents are produced in three modes of normal plant operation; start-up, normal power operation, and transient power conditions. The levels of releases from the Surry Plant which are outlined below are those expected during a hypothetical year of operation, when all three relevant modes of operation would occur. It has been assumed, in accordance with the hypothetical planned plant operating procedures, that the plant will undergo one scheduled start-up from cold conditions after refueling and one additional start-up from cold conditions per year. In normal power operation, the plant will be continuously base loaded unless conditions dictate a reduction in output. Transient power conditions for the analyses below include a hypothetical load reduction to 20% of power on three out of every four weekends and load reductions to 0%

power on the fourth weekend of every month for the 1-year period. The radioactive effluents resulting from these three hypothetical modes of operation have been combined in the presentation below.

There are several sources of radioactive release from within the Surry plant. First, as the plant's fuel is depleted, the concentration of boric acid in the primary cooling system is reduced proportionately. Approximately 92% of this boron let down flow will be recycled to the primary coolant system; the remaining 8% will be processed in the liquid waste disposal system prior to release.* The amount of boron let down flow, and hence of releases therefrom, is, of course, directly dependent on the number of hours the plant has operated during the year. In addition, several sources of liquid or gaseous release will occur at a rate independent of the level of operation of the plant. These sources include steam generator primary-to-secondary leakage, laundry, the liquid waste sampling system, primary coolant system leakage, spent resin flush, and laboratory waste. Table II.I.C.2-1 lists the expected non-tritium activities released from each source.

During normal operations, all effluents processed by the liquid waste disposal system will be held up in excess of 10 hours for processing through the waste disposal evaporator. The gaseous waste disposal system will be operated so that gases are held up for at least 60 days before release. Further delay in releasing gaseous wastes would not significantly reduce their activity since more

*Figures based on operation of Surry's Boron Recovery System

TABLE II.I.C.2-1

Expected Non-Tritium Activity

Released by Each Source

Source	Non-Tritium Release (Curies/Year)
Steam generator blowdown	23.2000
Laundry	0.0040
Sampling system	0.0160
Boron recovery letdown	0.1800
Spent resin flush	0.0020
Laboratory wastes	0.0006
Primary coolant system leakage	0.0020
TOTAL	23.4046

NOTE: Expected releases based on 0.2% failed fuel are listed above. The maximum design condition releases are presented in Appendix H.

than 95% of the content of the tank after 60 days is Kr-85, which has a half-life in excess of 10 years.

Before enumerating the plant's specific radiological effects on the environment it is well to consider the unit of dose which will be used and its level in comparison with radiation encountered in normal daily life. All doses are presented in units of mrem per year. It has been estimated that the average annual dose in the United States from medical x-rays is 50 mrem/year.[1*] The exposure to the population from materials of house construction will vary from 50 to 65 mrem/year for wood, increase to 75 to 90 for brick or concrete and reach 85 to 130 mrem/year for stone construction.[2] As another illustration of the average exposure of the population to radiation, it has been shown that the average person receives from 80 to 200 mrem per year whole body exposure from naturally occurring background radiation.[3] These examples should serve to put the doses that follow in perspective.

(b) Water Systems

(i) General

The amount of each radionuclide released to the circulating water discharge canal during expected normal operation is shown in Table II.I.C.2-3 . This calculation considers the following based on an expected performance of the facility:

a. 0.2% failed fuel**

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*The numbered footnotes are shown following this section.

**A failed-fuel rate of 0.2% has been assumed on the basis of the operating experience of plants similar to Surry in design. These plants estimated failed-fuel levels and accompanying radionuclide liquid releases are set out in Table II.I.C.2-2.

TABLE II.I.C.2-2

LIQUID RELEASE OF MIXED FISSION AND CORROSION PRODUCTS (Ci)[4,5]

POWER STATION	YEAR OF OPERATION 1967	1968	1969
Indian Point	28.000	34.600	28.000
Yankee	0.056	0.009	0.019
Connecticut Yankee	0.390	3.800	12.000
San Onofre	0.320	1.500	8.000
Ginna	-----	-----	0.020

EXPECTED SURRY RELEASE = 23.4 Ci (Non-Tritium)

ESTIMATED FAILED FUEL EXPERIENCE % (1971)[6]

Indian Point	<0.10
Rowe	0.00
Ginna	0.50
San Onofre	0.10
Yankee	0.02

EXPECTED SURRY = 0.2% (Estimated based on actual experiences with above operating PWR's)

NOTE: Each of these plants is similar in design to Surry, and therefore should have failed fuel rates similar to those to be expected at Surry.

TABLE II.I.C.2-3

Radionuclide Concentration in Circulating Discharge Canal

NUCLIDE	EXPECTED* DISCHARGE (Ci/yr)	ACTIVITY IN DISCHARGE CANAL (μc/cc)
H^3	9.4 + 2	3.1 - 7
Cr 51	1.2 - 2	3.8 - 12
Mn 54	9.9 - 3	3.2 - 12
Mn 56	4.3 - 2	1.4 - 11
Co 58	3.2 - 1	1.0 - 10
Fe 59	1.3 - 2	4.3 - 12
Co 60	9.6 - 3	3.1 - 12
Sr 89	9.6 - 3	3.2 - 12
Sr 90	3.0 - 4	9.6 - 14
Sr 91	1.5 - 3	4.8 - 13
Y 90	3.4 - 4	1.1 - 13
Y 91	1.7 - 3	5.6 - 13
Y 92	4.8 - 4	1.5 - 13
Zr 95	1.9 - 3	6.0 - 13
Nb 95	1.9 - 3	6.0 - 13
Mo 99	6.0	2.0 - 9
I 131	5.4	1.7 - 9
I 132	6.8 - 1	2.2 - 10
I 133	4.8	1.6 - 9
I 134	5.8 - 2	1.9 - 11
I 135	1.3	4.0 - 10
Te 132	5.2 - 1	1.7 - 10
Cs 134	6.2 - 1	2.0 - 10
Cs 136	5.6 - 2	1.8 - 11
Cs 137	3.4	1.1 - 9
Ba 140	5.2 - 4	1.7 - 13
La 140	3.2 - 3	1.0 - 12
Ce 144	7.2 - 3	2.4 - 12
TOTAL NON-TRITIUM	23.4 Ci	

ABBREVIATIONS USED ABOVE: 2 - 3 = 2×10^{-3}

NOTE: Releases based on conservative design performance are contained in Appendix
The values listed above are the realistically expected values.

b. 1 liter/hour primary-to-secondary leak rate/unit

c. two units, 2546 MWt each

d. DF of mixed - bed demineralizer equal to 10 for all radionuclides, except Y-90, Mo-99, Cs-134, Cs-137, for which DF equals 1.

e. DF of waste disposal evaporator equal to 10^4 for all radionuclides.

f. decay time of 10 hours for all radionuclides which pass through the waste disposal evaporator.

g. no decay time for radionuclides which do not pass through the waste disposal evaporator.

h. discharge canal flow resulting from two unit operation equal to to 1.55×10^6 gpm*

The eight assumptions listed above are used to provide a realistic assessment of the effluents from the Surry Power Station. The doses resulting from liquid releases are primarily dependent upon fission product release which is a function of percentage of failed fuel. The 1% failed fuel parameter has been used consistently in the NUS Corporation report which is included in Appendix H. This section is directed toward a realistic dose assessment based on 0.2% failed fuel.

(ii) Pathways to Man

(a) Ingestion of Seafood

Since there are no public water supplies from the James River downstream of Hopewell, Virginia, approximately 40 river miles upstream from the site, and no irrigation activities, the major exposure pathway to man of concern is that from edible marine organisms harvested from the James River.

*The flow used in this analysis is somewhat less than the actual case. This reduced flow reflects the postulated actual average flow for one year.

Marine organisms through biological processes have the ability to concentrate the radionuclides released from the plant. This concentration of activity in seafood which in turn may be ingested by man must be considered in determining the possible dose to man. The ratio of the concentration of a radionuclide in a marine organism to that in its medium is known as the concentration factor (CF). The concentration factor varies among the different species of marine life and, for a given species, varies with the different radionuclides. Also, the concentration may vary considerably between different organs of an organism. For the dose calculations presented, appropriate concentration factors were used for the edible portions of the fish and shellfish[7], shown in Table II.I.C.2-4. Another variable is the difference in concentration factors between fresh water and seawater. Whenever there were different concentration factors given in the reference for fresh water and seawater, the most conservative value of the two, i.e., the highest concentration factor, was selected.

In order to determine the maximum individual dose to humans, the quantity of seafood eaten is estimated at 50 grams/day. This is about four times the per capita consumption of seafood in the United States.

The maximum expected whole body doses shown in Table II.I.C. 2-4 were calculated assuming that an individual consumed 50 grams of seafood per day for 365 days of the year, and that the seafood had been raised in water with activity concentrations equal to that of the discharge canal. No credit was taken for depletion by radioactive decay or deposition once the material left the plant. In addition, the calculated doses include a factor of a 10% increase to account for any recirculation effects due to the fact that the discharge for the Surry plant is located upstream from the intake. The recirculation effect could vary from 0% at flood tide to an estimated maximum of 15% at ebb tide; a recirculation factor of 10% is considered to be conservative.

The maximum expected whole body dose to an individual is calculated to be less than 1.0 mrem per year from eating seafood raised in the discharge canal. During operations at the maximum design condition of 1% failed fuel, the dose would be less than 5 mrem per year.*

The dose rate to specific organs of the human body from ingestion of seafood was calculated for the critical organs which concentrate certain radionuclides. Figure II.I.C.2-1 shows the dose to critical organs for an individual who consumes 50 grams/day of shellfish raised in the discharge canal. The highest doses were found to exist for I-131 in the thyroid and Cs-137 in the liver, spleen, and muscle. Doses resulting from consumption of seafood raised in the James River will be about a factor of four lower than those shown on Table II.I.C.2-4.

The total population whole body dose from eating seafood raised in the James River adjacent to the site was realistically estimated at 16.4 man-rem/yr, and the maximum design condition dose estimated at 81.7 man-rem/yr. This number can be compared with the population whole body dose from natural background radiation of 2.45 x 10^5 man-rem/yr, or less than 0.01% of the natural background dose in the realistic case.

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*The term "maximum expected dose" refers to the dose resulting from the best estimate of anticipated releases. The term "maximum design condition dose" is used in reference to the dose resulting from operation with 1% failed fuel.

TABLE II.I.C.2-4

NUCLIDE	CONCENTRATION FACTOR FISH	CONCENTRATION FACTOR SHELLFISH	MAXIMUM EXPECTED WHOLE BODY DOSE (REM/YR) FISH	MAXIMUM EXPECTED WHOLE BODY DOSE (REM/YR) SHELLFISH
H^3	9.3 - 1	9.3 + 1	7.2 - 7	7.2 - 7
Cr 51	4.0 + 2	2.0 + 3	3.3 - 10	1.8 - 10
Mn 54	3.0 + 2	5.0 + 3	1.5 - 8	2.5 - 7
Mn 56	3.0 + 2	5.0 + 3	1.8 - 9	2.9 - 8
Co 58	5.0 + 2	1.5 + 3	1.6 - 6	4.8 - 6
Fe 59	3.0 + 3	2.0 + 4	8.1 - 7	5.4 - 6
Co 60	5.0 + 2	1.5 + 3	1.9 - 7	5.7 - 7
Sr 89	4.0 + 1	7.0 + 2	2.2 - 8	4.0 - 7
Sr 90	4.0 + 1	7.0 + 2	1.2 - 7	2.2 - 6
Sr 91	4.0 + 1	7.0 + 2	1.2 - 10	2.2 - 9
Y 90	1.0 + 2	1.0 + 3	4.6 - 14	4.6 - 14
Y 91	1.0 + 2	1.0 + 3	3.6 - 12	3.6 - 11
Y 92	1.0 + 2	1.0 + 3	7.2 - 15	7.2 - 14
Zr 95	1.0 + 2	1.0 + 3	7.6 - 13	7.6 - 12
Nb 95	3.0 + 4	1.0 + 2	5.6 - 10	2.2 - 12
Mo 99	1.0 + 2	1.0 + 2	3.2 - 6	3.2 - 6
I 131	1.0 + 1	5.0 + 1	1.1 - 6	5.4 - 7
I 132	1.0 + 1	5.0 + 1	7.8 - 8	3.4 - 7
I 133	1.0 + 1	5.0 + 1	2.2 - 7	1.1 - 6
I 134	1.0 + 1	5.0 + 1	2.4 - 10	1.2 - 9
I 135	1.0 + 1	5.0 + 1	2.6 - 8	1.3 - 7
Te 132	1.0 + 1	1.0 + 2	4.2 - 8	4.2 - 7
Cs 134	1.0 + 3	1.0 + 3	2.8 - 4	2.8 - 4
Cs 136	1.0 + 3	1.0 + 3	2.6 - 6	2.6 - 6
Cs 137	1.0 + 3	1.0 + 3	7.0 - 4	7.0 - 4
Ba 140	1.0 + 1	2.0 + 2	4.2 - 11	8.6 - 10
La 140	1.0 + 2	1.0 + 3	6.6 - 13	6.6 - 12
Ce 144	1.0 + 2	1.0 + 3	9.8 - 11	9.8 - 10
TOTAL			9.9 - 4	9.9 - 4

ABBREVIATION USED ABOVE: 2 - 3 = 2×10^{-3}

NOTE: Doses listed above are the maximum realistically expected doses. Doses based on conservative design performance are contained in Appendix H.

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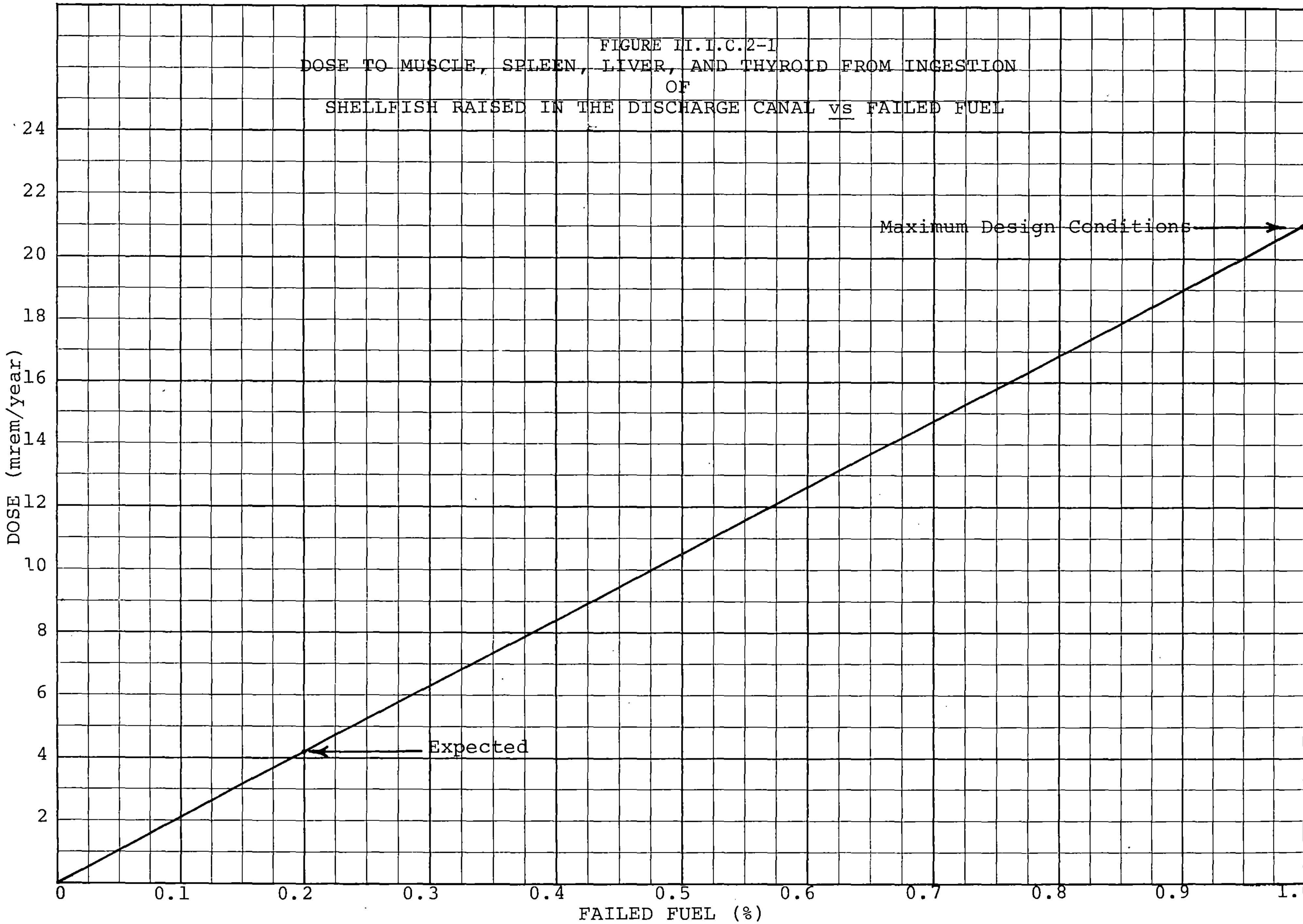
FIGURE II.I.C.2-1
DOSE TO MUSCLE, SPLEEN, LIVER, AND THYROID FROM INGESTION
OF
SHELLFISH RAISED IN THE DISCHARGE CANAL vs FAILED FUEL



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(b) Internal Dose From Ingestion of Drinking Water

Although there are no public water supplies taken from the James River downstream of the Surry site because of its relatively high salinity, a calculation was performed to estimate the maximum dose to an individual from ingestion of drinking water containing radioactive nuclides discharged from the plant. The assumption was made that an individual drank 2200 cc/day of water with a concentration of activity equal to that shown in Table II.I.C.2-3 for the discharge canal. The whole body dose from ingestion of this water (including tritium) was calculated to be less than 1 mrem/year for both the realistic and design condition releases.

(c) Doses Resulting From Swimming and Sunbathing

An assessment of the maximum design doses to swimmers and sunbathers in the area of the station is given in a report by NUS Corp. (Appendix H). The total annual whole body dose to swimmers is 3.8×10^{-3} mrem/yr assuming 200 hours submerged exposure.

The total annual whole bcdy dose resulting at design conditions to sunbathers, assuming a total annual exposure on the beach of 200 hours, is about .5 mrem/yr.

This analysis assumes a reconcentration factor in sand of 10^3, excluding tritium, with the sunbather receiving one-half of the dose expected from full immersion in the sand.

(c) Air System

(i) General

The estimated maximum design quantities of gaseous radioactivity released from the Surry Power Station on an annual basis are shown in Table II.I.C.2-5. These values are based on the assumption that one percent of the fuel elements in both units have defective cladding, and that the waste gas system operates on a 330 day fill, 60 day decay, and 10 day bleed cycle. Under these conditions and the design station operation as described in introductory paragraphs above, the maximum gaseous activity release is estimated to be 16,200 curies per year.

The conservatism of the assumptions employed in reaching this estimate of gaseous activity release is illustrated by comparing this figure with the much lower figures obtained on gaseous releases from operating pressurized water reactors to date. The annual average release rate experience[8] is summarized in Table II.I.C.2-6 . On the basis of this experience (with the exception of the first year of Ginna experience, which is atypical), the Surry extrapolated release rate would range from a minimum of 22 Ci/yr to a maximum of 2680 Ci/yr, assuming a total of 7.10 x 10^6 MWe-hr per year from the two Surry units (see Appendix H).

(a) Dispersion

The calculation of radioactive gas dispersal during normal modes of plant operation is dependent upon the atmospheric dilution of those gases.

Annual average atmospheric dilution factors (χ/Q) were determined for the Surry Power Station site. Figure II.I.C.2-2 shows the distribution of χ/Q in

TABLE II.I.C.2-5

MAXIMUM GASEOUS RELEASES FROM SURRY POWER STATION

NUCLIDE	ANNUAL AVERAGE GASEOUS ACTIVITY RELEASE (Curies)
Kr 85	1.62×10^4
Xe 131m	4.5
Xe 133	1.2×10^1
Xe 135	3.4×10^{-47}
I 131	1.06×10^{-4}
TOTAL	1.62×10^4

Based upon: Two units, 2546 MWt each

1% failed fuel

330-day fill, 60 day decay, 10-day bleed

90% filter efficiency for iodine removal

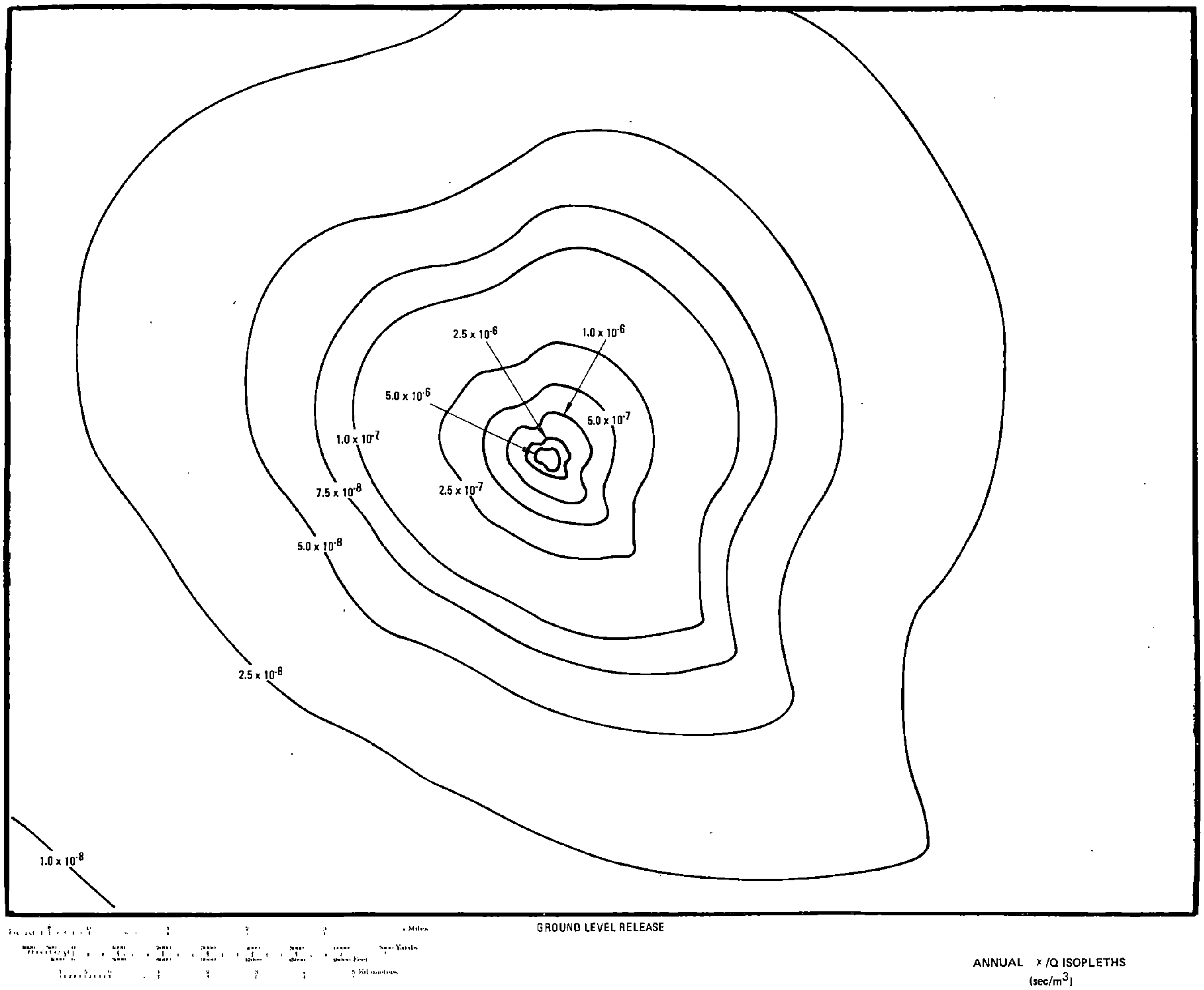
TABLE II.I.C.2-6

PWR WASTE GAS RELEASE EXPERIENCE[8]

PLANT	ANNUAL AVERAGE RELEASE RATE (μCi/sec)/1000 MWe-hr		EXTRAPOLATED EXPECTED SURRY RELEASE RATE* Ci/yr
Indian Point #1 (265 MWe)	1.2×10^{-2}	(1963-1970)	2,680 (Maximum)
Yankee Rowe (175 MWe)	1.0×10^{-4}	(1964-1970)	22 (Minimum)
San Onofre (430 MWe)	5.0×10^{-3}	(1967-1970)	1,120
Connecticut Yankee (600 MWe)	3.0×10^{-3}	(1967-1970)	671
Ginna (420 MWe)	1.4×10^{-1}	(1970)	31,300 (Atypical maximum)

NOTE: Surry design basis annual average gaseous release rate = 16,200 Ci/yr

*Based on a total of 7.10×10^6 MWe-hr per year from both units operating in a load following mode at 65 percent of full power and an annual load factor of 80 percent.



ANNUAL χ/Q ISOPLETHS
(sec/m^3)
SURRY SITE–MAIN TOWER
Figure II.I.C.2-2

seconds per cubic meter based on Surry tower data. The results set out below represent sector-average concentrations obtained from the following standard Pasquill-Gifford diffusion equation for a ground-level release:

$$\chi/Q = \sqrt{\frac{2}{\pi}} \quad \frac{8}{\pi} \quad \sum_{i}^{n} \frac{F_i f_i}{\sigma_z \bar{u}\ x}$$

where:

χ = concentration, units per cubic meter

Q = source strength, units per second

$\bar{u}$ = mean wind speed, meters per second

σ_z = vertical dispersion parameter, meters

i = Pasquill stability categories (A-G) with numerical values (1-7)

n = number of stability classes (seven-from A-G)

F_i = fraction of time stability conditions "i" exists

f_i = fraction of time wind associated with conditions "i"

x = distance downwind, meters

Dilution factors can be considered as relative concentrations, i.e., concentration relative to the source strength. The configuration of χ/Q isopleths reflects the annual distribution of wind direction, wind speed, and atmospheric stability. The annual average dilution factor value based on Surry data at the north site boundary is 5.0×10^{-6} sec/m^3 and 8.8×10^{-6} sec/m^3 based on Hog Island data. At the south boundary the dilution factor is 1.0×10^{-6} sec/m^3 based on Surry data and 3.0×10^{-6} sec/m^3 based on Hog Island data.

The dilution factor at the nearest off-site habitation, located six-tenths of a mile southwest of the reactor containment, is 5.5 x 10^{-7} sec/m^3 based on Surry data and 7.8 x 10^{-7} sec/m^3 based on Hog Island data.

However, it is important to consider that diffusion at the Surry site will not be confined to the 20' height (the elevation at which Hog Island data were procured) but will be effected and in fact dominated by conditions at higher elevations (similar to the 150' height of the Surry tower) which are associated with better diffusion conditions with increasing distance downwind for ground level releases. Releases at greater heights will be effected by wind and stability conditions associated with higher elevations at the time of release.

(b) Pathways to Man

There are a number of potential pathways through which local populations may be exposed to the radioactive effluents from nuclear operations. These are illustrated in Figure II.I.C.2-3 . Three general pathways may be identified for the gaseous effluents: (1) direct radiation exposure, (2) inhalation exposure and (3) exposure to particulates through food chains.

(ii) Noble Gas Dose

The importance of each of the three pathways is determined by the quantity and chemical nature of the gases released. It may be observed in Table II.I.C.2-5 that the primary constituents in the gaseous effluent are the noble gases, krypton and xenon. Since the noble gases do not react chemically with other substances under normal conditions, there is no physical basis either for their transport through food chains or their reconcentration within the human body.

EXPOSURE PATHWAYS

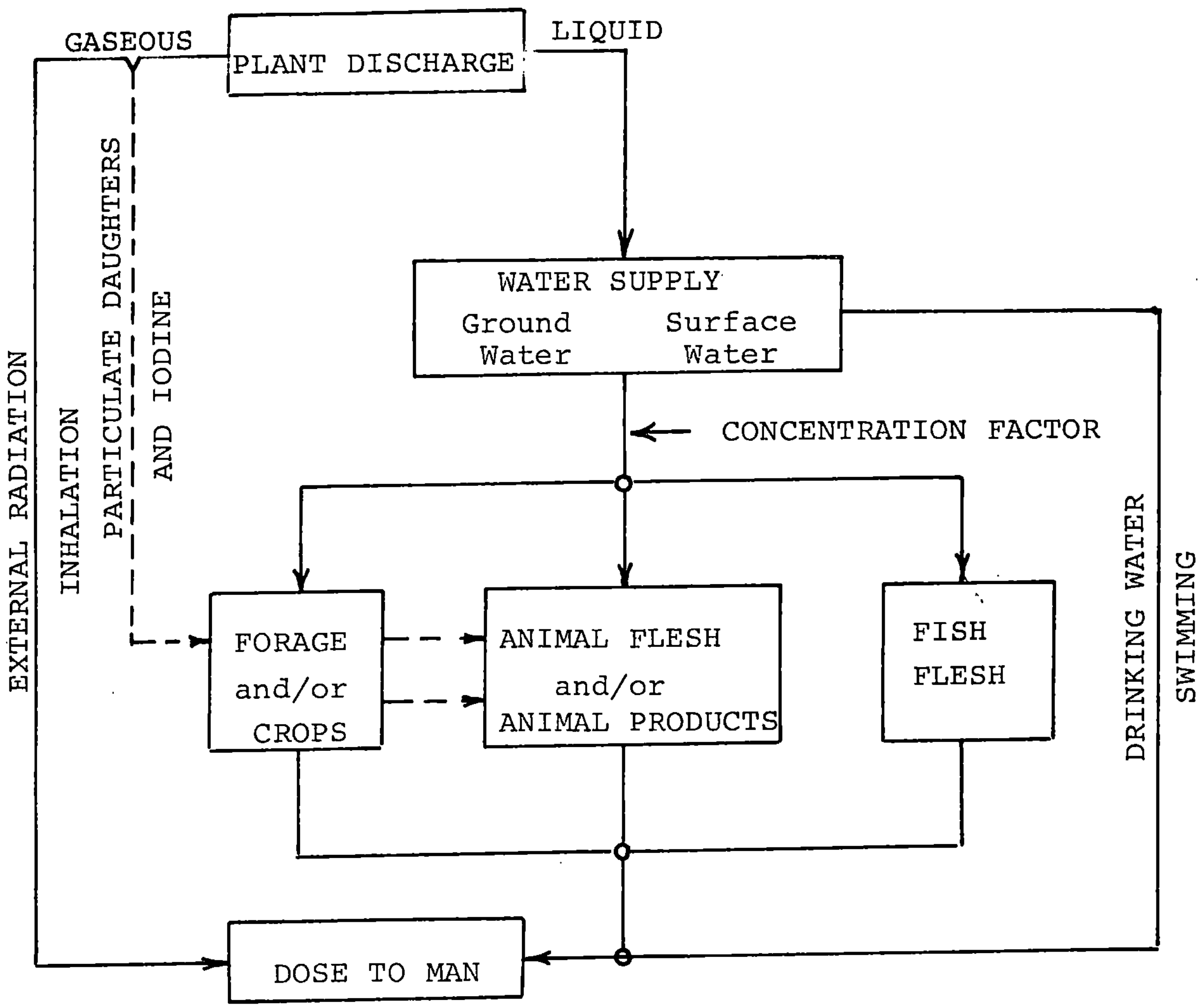


Figure II.I.C.2-3

In terms of inhalation and absorption in the body, both krypton and xenon may be present in physical solution, chiefly in the body water and fat.[9] Several human exposure experiments revealed that inhalation of relatively large amounts of radioactive noble gases only resulted in less than 10 millirem tissue exposures.[10,11] In general, it may be estimated that the internal dose from radioactive noble gases dissolved in body tissue following inhalation from a cloud is negligible, i.e., less than one percent of the associated external whole body dose.[12] The resultant doses from exposure to noble gases, therefore, are considered to be external whole body doses only.

Although external doses are the only concern from the parent noble gases, there is one particulate daughter product (Cs-135) from the parent noble gas nuclide Xe-135 which is theoretically available for food chain transport. The two routes of exposure, external and food chain transport, are considered in the following paragraphs.

(a) External Cloud Dose

The external doses were calculated using the ICRP[13] "infinite semispherical cloud" model; that is, the exposed individual is assumed to be located at the center of an infinitely large semispherical cloud of uniform radioactivity concentration equal to that of the centerline, or maximum, concentration level of the plume at the specified distance.

The ICRP method for calculating whole body dose assumes that beta radiation with an energy of 0.1 MeV or greater is considered as contributing to the external whole body dose to the same extent as gamma radiation. This is a conservative assumption and in the case of nuclides which are primarily beta emitters, such as Kr-85 (the major contributor to the dose from the Surry gaseous effluents), results in a substantial over-estimate of the genetically significant dose.[12]

Since the dose calculations included atmospheric diffusion parameters, meteorological information was required. Data was obtained from the Surry Weather Station. Based on this data the highest annual average χ/Q value (8.8×10^{-6} sec/m^3) was found to occur at the north site boundary.

The annual average whole body doses from exposure to the noble gases are presented in Table II.I.C.2-7 for an individual at the site boundary and for the population within 50 miles of the plant. The doses were calculated for the maximum annual average release for the plant with one percent fuel defects. The doses were also calculated for the high and low extrapolated expected Surry releases, based on the releases per unit of energy generated at operating U. S. PWR stations (Table II.I.C.2-6). Included for comparison are the individual and population doses estimated to result from natural background radiation.

(b) Food Chain Transport

One of the gaseous radionuclides has a particulate daughter which can enter the food chain and be transported to man. The decay chain of interest is:

$$Xe^{135} \xrightarrow[\text{hour}]{9.2} Cs^{135} \xrightarrow[\text{year}]{2 \times 10^{6}} Ba^{135}$$

TABLE II.I.C.2-7

ANNUAL WHOLE BODY RADIATION DOSES FROM SURRY GASEOUS RELEASES

Type of Dose	Maximum Dose Based on Release with 1% fuel defects	Dose Based on Expected Releases Extrapolated from Previous Operating Experience — Maximum
1. INDIVIDUAL DOSE, PLANT ORIGIN		
a. Dose rate (mrem/yr) at site boundary	8.87	1.46
2. NATURAL BACKGROUND DOSE (mrem/yr)	125	125
3. POPULATION DOSE* WITHIN 50 MILES OF THE PLANT		
a. Total Plant derived dose (man-rem/yr)	5.93	0.978
b. Total natural background dose (man-rem/yr)	$\sim 2.45 \times 10^5$	$\sim 2.45 \times 10^5$

*Based on a projected 1980 population of 1,959,000 within 50 miles of the Surry Power Station

(iii) Radioiodine Doses

A small amount of radioactive iodine in addition to the noble gases will be released with the gases from the Surry plant. Iodine is an insignificant contributor to the external whole body dose but may produce potentially significant internal doses due to the preferential concentration of iodine in the human thyroid gland. Iodine may enter the body either through inhalation or by ingestion. The most critical pathway for environmental transport of the routine releases of radioiodine is the pasture-cow-milk-man pathway.

(a) Thyroid ingestion dose

Iodine-131 has been identified as the principal iodine nuclide of concern due to the relatively greater amount released and its long half-life compared to the other iodine nuclides. The critical exposure pathway is through its absorption by pasture grass, which is ingested by grazing cows, transferred to milk and subsequently ingested by man. The most sensitive receptor in the population (in terms of total thyroid dose per unit intake) has been determined to be a young child six months to one year of age. This is due to the child's smaller thyroid mass and greater radiosensitivity.

Using the conservative child dose model detailed in Appendix H, the maximum annual thryoid dose was calculated to be less than 0.03 mrem/yr.

(b) Thyroid Inhalation Dose

The adult thyroid dose at the site boundary resulting from inhalation of the released radioiodines was calculated for the Surry plant. The dose was determined to be less than 4×10^{-4} mrem/yr.

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*The functions of the Federal Radiation Council were incorporated into those of the above Environmental Protection Agency in December, 1970.

(d) Land Systems

Existence of the exclusion and low population density zones has posed no undue hardship on local level use patterns. Although any use of the site area for homesites and commercial/recreational development of segments of Gravel Neck have been precluded, there was no significant preconstruction use for either of the above categories.

The exclusion area is primarily forest; other than timber value, no additional loss has resulted from existence of the station. Preconstruction agricultural activities will continue in the low population zone since the normal radiological impact will be negligible. No other local uses have been initiated for these areas, but alternatives are not considered impossible during the anticipated useful life of the plant.

(e) Other Miscellaneous Effects

Since the river is very wide near the plant and the plant is located inland on Gravel Neck Peninsula, the exclusion area does not extend into or preclude the use of local waters for navigation and recreational purposes. There are no restrictions on navigation in the main river channel. Similarly, releases expected from the station will necessitate no restrictions on swimming or boating activities in the area. Except for the physical presence of the discharge canal groin, the station will have no effect upon these activities.

FOOTNOTES

[1]Morgan, K. Z., "Acceptible Risk Concepts", presented before Pittsburgh Section of ANS, Pittsburg, Pa. (Nov. 19, 1969)

[2]Report of the United Nations Scientific Committee on the Effects of Atomic Radiation, General Assembly 13th Session, Supplement No. 17 (A/3838)

[3]Statement of Dr. Theos J. Thompson, Commissioner, U. S. Atomic Energy Commission, before the Joint Committee on Atomic Energy. Oct. 30, 1969.

[4]Testimony of Dr. Theos J. Thompson, Commissioner, U. S. Atomic Energy Commission before the Joint Committee on Atomic Energy, Oct. 30, 1969.

[5]Hearings before the Joint Committee on Atomic Energy, "AEC Report on Releases of Radioactivity from Power Reactors in Effluents During 1969", Feb. 1970

[6]Personal communication between Mr. W. H. House of Vepco and
Mr. Connally of Yankee Atomic Electric Co.
Mr. W. Stein of Consolidated Edison Co.
Mr. C. Platt of Rochester Gas and Electric Co.
Mr. M. Sullivan of Southern California Edison Co.
Mr. D. Lemph of Connecticut Yankee Atomic Power Company
on October 13, 1971.

[7]Chapman, W. H., et al, "Concentration Factors of Chemical Elements in Edible Aquatic Organisms", UCRL - 50564, December 1968.

[8]Goldman, M. I. and A. W. De Agazio, "New Developments in Nuclear Power Plant Waste Treatment", presented at the American Nuclear Society, Annual Meeting, Boston, Mass., June 1971.

[9]Hytten, F. E., K. Taylor and N. Taggart, "Measurement of Total Body Fat in Man By Absorption Of Kr-85". Clinical Science, Vol. 31, 1966.

[10]Tobias, C. A., H. B. Jones, J. H. Lawrence and J. G. Hamilton, "The Uptake and Elimination of Krypton and Other Inert Gases By The Human Body". Journal of Clinical Investigation 28: 1375-1385.

[11]Lassen, N. A., "Assessment of Tissue Radiation Dose in Clinical Use of Radioactive Inert Gases, With Examples of Absorbed Doses From ^{3}H, ^{85}Kr, and ^{133}Xe". Minerva Nucleare Vol. 8, 1964.

[12]Hendrickson, M. M., "The Dose From ^{85}Kr Released To The Earth's Atmosphere", in "Environmental Aspects of Nuclear Power Stations", IAEA Symposium, New York, August 1970.

[13]ICRP Publication 2, "Report of Committee II on Permissible Dose For Internal Radiation", International Commission on Radiological Protection, Pergamon Press, New York, 1959.

(2) Accidents and Occurrences

(a) Introduction

This section evaluates the environmental impact of postulated accidents and occurrences which may occur, however remote the probability, during the operating life of the Surry Power Station. The evaluation follows the guidelines given in the AEC document "Scope of Applicants' Environmental Reports with Respect to Transportation, Transmission Lines, and Accidents" issued on September 1, 1971. The assumptions and calculations used in this evaluation indicate that the consequences and occurrences have no significant adverse environmental effects.

The postulated accidents and occurrences are divided into the nine accident classes identified in the AEC guide of September 1, 1971 as shown in Table II.I. C.2-8. The environmental impact of the postulated incidents is evaluated using assumptions in the analyses as realistic as the state of knowledge permits. Past operating experience has been considered in selecting the assumptions, and the analyses are based on those conditions that are expected to exist if the postulated accident were to occur. The radiological consequences of an accident are evaluated on the basis that average meteorological conditions, as calculated from the actual site meteorology data and the population distribution at 1980, exist at the time of an accident. This is considered realistic for random events.

In the following pages, a typical accident for each class is described and its consequences evaluated. Where only one accident example is considered in a class, the postulated accident was selected from consideration of several possible accidents in that class. Consideration of the nine classes reveals that these classes can be conveniently grouped on the basis of their likelihood of occurrence as follows:

Class 1 through Class 5

This group deals with events which may occur at one time or another during the life of the plant. The compilation of a complete list of events with their corresponding frequency which fall in this group is neither practical nor necessary. The environmental impact of each event, as will be shown later, is very small. Throughout plant operating life, a record of the magnitude and consequences of each event will be maintained and the cumulative effect of subsequent occurrences evaluated. This procedure will give timely identification of any possible cumulative effects or trends leading to environmental effects. This will also allow corrective actions (such as equipment repair, changes in procedure, frequent inspection, temporary plant shutdown, etc.) to be taken before a significant adverse impact on the environment can be imposed.

Postulated occurrences for Classes 2 through 5 are considered in the following pages. Class 1 events are considered small spills or leaks inside the containment. Release to the environment, if any, would be insignificant, therefore, they need not be considered because of their trivial consequences.

Classes 6 and 7

This group deals with refueling and fuel handling accidents inside and outside the containment. Detailed procedures are provided to handle irradiated fuel properly. However, considering the large number of fuel assemblies handled during the life of the plant, an incident falling in this category could conceivably occur during the plant life. The consequences of such an accident, as shown in the subsequent pages, would cause no significant adverse impact on the environment.

Class 8

This class includes those accidents that are not expected to occur during the life of this plant and whose initiation events are considered in the Final Safety Analysis Report available in the public record.

Each accident is treated separately in the following pages. The treatment consists of a brief description of the accident, a summary of the steps taken in the design, manufacturing, installation and operation to minimize the possibility of its occurrence, a list of the most significant assumptions used in the analyses and the results of the dose calculations. The accident consequences are evaluated by using the analytical models described in the FSAR. The basic difference between the FSAR evaluations and those presented in this section is represented by the values of the parameters used as inputs in the analytical models. The FSAR analyses are based on extremely conservative input parameters while the analyses performed in this report are based on realistic assessments of the performance of the nuclear plant safeguards.

It can be concluded that accidents falling in this class will have no significant adverse environmental effects because:

i) hypothetical FSAR types of accident initiation events are not expected to occur during the life of this plant because of the numerous steps taken in design, manufacture, construction, operation, and maintenance to prevent them, and

ii) the expected environmental consequences if any one of the accidents were to occur are below the limits considered safe for normal operation (10 CFR 20).

Class 9

This accident class involves hypothetical sequences of failures more severe than Class 8, i.e., successive failures of multiple barriers normally provided and maintained.

Considering, as an example, the rupture of a Reactor Coolant System pipe, Class 8 covers the case of this initiation event and expected performance of plant safeguards. Class 9, on the contrary, would consider the initiation event, i.e., rupture of a Reactor Coolant System pipe, plus hypothetically deteriorated performance of plant safeguards, for example, failure of outside power supply, and/or failure of a diesel, and/or failure of a high head safety injection pump, and/or failure of a low head safety injection valve, and/or failure of a containment spray pump, and/or failure of a containment spray valve, etc.

The Final Safety Analysis Report contains studies on the consequences of many successive failures. The likelihood of the combustion of the initiation event and these successive failures is extremely remote. The consequences, as presented in the FSAR, are within the allowable limits for remote probability accidents (10 CFR 100 limits).

The possibility of occurrence of successive failures as presented in the FSAR or beyond is so remote that its environmental risk is extremely low. Hence, it is not necessary to discuss these multiple barrier failures in the present report, as indicated in the AEC guide published on September 1, 1971.

TABLE II.I.C.2-8

CLASSIFICATION OF POSTULATED ACCIDENTS AND OCCURRENCES

NO. OF CLASS	DESCRIPTION	EXAMPLE(S)
1	Trivial Incidents	Small spills Small leaks inside containment
2	Misc. Small Releases Outside Containment	Spills Leaks and pipe breaks
3	Radwaste System Failures	Equipment failure Serious malfunction or human error
4	Events that release radioactivity	Fuel failures during normal operation. Transients outside expected range of variables.
5	Events that release radioactivity into secondary system	Class 4 & Heat Exchanger Leak
6	Refueling accidents inside containment	Drop fuel element Drop heavy object onto fuel Mechanical malfunction or loss of cooling in transfer tube
7	Accidents to spent fuel outside containment	Drop fuel element Drop heavy object onto fuel Drop shielding cask - loss of cooling to cask Transportation incident on site
8	Accident initiation events considered in design-basis evaluation in the Safety Analysis Report	Reactivity transient Rupture of primary piping Flow decrease - Steamline break
9	Hypothetical sequences of failures more severe than Class 8	Successive failures of multiple barriers normally provided and maintained

(b) Meteorology And Population Distributions

(i) Meteorology

The meteorological data used in this section is obtained from the site atmospheric stability analysis contained in the Final Safety Analysis Report (FSAR). Average values are used for establishing the χ/Q for each sector which is a conservative estimate of the exponential type χ/Q versus distance function.

The annual average dilution factor at the site boundary used in this report is the maximum annual average value occurring at the site boundary.

(ii) Population Distribution

The population distribution used in this analysis is taken from the FSAR. Using this population distribution, the average environmental effect of the plant over its expected lifetime is estimated by the methods shown in Section II.I.C.2.d.(2)(j).

(c) Evaluation of Class 2 Events

Discussion Of Class 2 Events

Class 2 events include spills and leaks from equipment outside the containment. Small valve leaks and pipe leaks may be expected during the lifetime of the plant. There is expected to be a low level of continuous leakage from components such as valve packing and stems, pump seals, flanges, etc. Infrequent increases in leakage from specific components might occur; however, these would be detected by operators and/or inplant monitoring and repaired to minimize any potential off-site effect.

Description Of Representative Class 2 Event

A significant valve and/or pipe leak in the reactor coolant letdown line may occur during the lifetime of the plant. A representative example of such an occurrence would be a leak in the volume control tank sampling line which would allow a fraction of the contents of the volume control tank to be released. Were such a leak to occur, the Radiation Monitoring System would detect the activity and with appropriate operator action the release could be limited to 10% of the noble gas contained in the tank. The event used to evaluate the environmental effect is defined as the release to the outside atmosphere of 10% of the noble gas activity in the volume control tank.

Discussion Of Remoteness Of Possibility Of Volume Control Tank Release

The volume control tank is designed to withstand 75 psig with a normal internal operating pressure of approximately 15 psig.

The volume control tank design philosophy provides for level alarms, pressure relief valves and automatic tank isolation and valve control to assure that a safe condition is maintained during system operation.

Quality control in the design, manufacture, and installation introduces a high degree of reliability and confidence to further assure that no failure in this system will occur.

Since the volume control tank is not subject to high pressure or stress, and is designed to ASME III, Class C Code, an accidental release from the tank is considered very remote.

Analysis And Evaluation Of Volume Control Tank Release

Assumptions

The following assumptions are used in the evaluation of the environmental effect of the release of the volume control tank activity.

The activity in the tank is based on 0.2% equivalent fuel defects.

Within two hours after initiation of a noble gas activity release from the volume control tank, 10% of the tank noble gas inventory is released.

Immediately after the noble gas activity escapes from the volume control tank, it is released from the auxiliary building at ground level to the outside atmosphere. Holdup in the auxiliary building is expected, thus reducing even further the environmental effect of this occurrence. However, no credit is taken in the analysis for this additional hold-up time.

Natural decay is neglected after the activity is released to the outside environment.

Justification for Assumptions

The 0.2% defect level is based on reactor operating experience with WPWR Zircaloy fuel to date.

Nonvolatile fission product concentrations are greatly reduced as the reactor coolant is passed through the purification demineralizers. An iodine removal factor of at least 10 is expected in the mixed bed demineralizers.

The released noble gas will be detected by the plant vent monitor and cause an alarm in the control room. Once the operators have been alerted, the leak can be detected and isolated to hold the activity release to 10% of the total noble gas inventory of the volume control tank.

Doses at the Site Boundary and Total Population Dose (Man-Rem)

The parameters used to calculate the noble gas activity in the volume control tank are given in Table II.I.C.2-9. Based on these parameters, 10% of the total noble gas activity in the tank, which is assumed to be released instantaneously to the environment, is 250 curies of equivalent Xe-133.

The whole body dose at the site boundary, as calculated by the method shown in Section II.I.C.2.d.(2)(j), is 0.1 mrem from the released noble gas activity, while the total population dose is 0.076 man-rem.

TABLE II.I.C.2-9

PARAMETERS FOR COMPUTING VOLUME CONTROL TANK

SPECIFIC ACTIVITY OF EQUIVALENT Xe-133

1. Core thermal power, MWt	2456
2. Fraction of fuel containing clad effect	0.002
3. Reactor coolant liquid volume, cu ft	9380
4. Reactor coolant average temperature, ^{o}F	560
5. Purification flow rate (maximum), gpm	60
6. Volume control tank volumes	
a. Vapor, cu ft	180
b. Liquid, cu ft	120
7. Fission product escape rate coefficients:	
a. Noble gas isotopes, sec^{-1}	6.5×10^{-8}

(d) Evaluation Of Class 3 Events

Discussion Of Class 3 Events

Class 3 events cover equipment malfunction and human error which may result in the release of activity from the Waste Disposal System. The malfunction of a valve or the inadvertent opening of a valve by an operator may cause such a release. This type of event is expected to occur infrequently during the operation of the plant.

Description Of Representative Class 3 Events

The major collection point for activity outside the containment is the gaseous waste section of the Waste Disposal System. A representative example of a Class 3 event would be a malfunction or error which would allow initiation of activity release from the waste gas decay tank. It is assumed that the gaseous waste disposal flow control valve fails open and that 10% of the contents of a full waste gas decay tank discharges to the atmosphere. Normally this accident is prevented by (1) the fail-safe mode of operation of the flow control valve which requires the presence of control air pressure to open, (2) normally closed manually operated valves on the discharge of the waste gas decay tank prior to the flow control valve, (3) alarm of the radiation monitor of gaseous effluents, and (4) the automatic closure of the flow control valve upon alarm of the radiation monitor.

Discussion Of Remoteness Of Possibility Of A Gas Decay Tank Release

The gas decay tanks contain the gases vented from the reactor coolant system and the volume control tank. Sufficient volume is provided in each of these tanks to store the gases evolved during 330 days of reactor operation.

Because of the conservative design, quality assurance, the close monitoring and sampling throughout the system, and since the gas decay tanks are not subjected to any high pressures or stresses, an accidental release from any of the tanks is highly unlikely.

For these reasons the release of 10% of the noble gas stored in the gas decay tank is considered to represent the consequences of accidents and occurrences falling in this class.

Analysis And Evaluation Of Gas Decay Tank Release

Assumptions

The following assumptions are used in the evaluation of the environmental effect of the release of activity from the waste gas decay tank.

0.2 percent fuel defects.

Within 2 hours after initiation of noble gas activity release from the gas decay tank, 10% of the noble gas is released.

Immediately after the noble gas activity escapes from the waste gas decay tank it is released through the process vent to the outside atmosphere.

Natural decay is neglected after the activity is released to the outside environment.

Justification for Assumptions

The 0.2% equivalent fuel defect level is based on reactor operating experience with W PWR's.

The process vent monitor will detect the noble gas activity being released to the outside atmosphere and cause closure of the waste gas control valve and annunciate in the control room. This alerts the operator and the leak can be detected and isolated to hold the activity release to 10% of the total noble gas activity in the waste gas decay tank.

Doses at Site Boundary and Total Population Dose (Man-Rem)

The noble gas activity released to the environment is 2520 curies of Xe-133 equivalent. From this activity release the whole body dose at the site boundary is 1.0 mrem and the total population dose is 0.76 man-rem.

(e) Evaluation Of Class 4 Events

Discussion Of Class 4 Events

These are described as those events that release radioactivity into the primary system. Examples given include assumptions of fuel failures during normal operation and transients outside expected range of variables.

The nuclear steam supply system is designed so that it may operate with an equivalent 1% fuel defect. The defect level averaged over the life of the plant will be much less than the design value as shown by the experience of similar plants to date. The occurrence of a fuel defect in itself will not result in any environmental impact because of the multiple barriers provided in the Westinghouse pressurized water reactor. Nevertheless, this occurrence may result in activity levels which could affect the consequences in other accident classes which are evaluated in other appropriate sections of this report. Operational transients for the plant such as turbine trip, load changes, rod withdrawals and any other conceivable transient within accident conditions covered in other classes are not expected to increase the defect level. The FSAR demonstrates this as follows:

Analysis And Evaluation Of Fuel Defects

Assumptions For Termination Of Transients

A plant operational transient could result in an uncontrolled addition of reactivity. Assuming the source and intermediate range alarms are ignored, a transient will be terminated by the following automatic Safety Features:

(1) Source range flux level trip - actuated when either of two independent source range channels indicates a flux level above a preselected, manually adjustable value. This trip function may be manually bypassed when either intermediate range flux channel indicates a flux level above the source range cutoff power level. It is automatically reinstated when both intermediate range channels indicate a flux level below the source range cutoff power level.

(2) Intermediate range control rod stop - actuated when either of two independent range channels indicates a flux level above a preselected, manually adjustable value. This control rod stop may be manually bypassed when two out of the four power range channels indicate a power level above approximately 10 percent of full power. It is automatically reinstated when three of the four power range channels are below this value.

(3) Intermediate range flux level trip - actuated when either of two independent intermediate range channels indicate a flux level above a preselected, manually adjustable value. This trip function may be manually bypassed when two of the four power range channels are reading above approximately 10 percent of full power and is automatically reinstated when three of four channels indicate a power level below this value.

(4) Power range flux level trip (low setting) - actuated when two out of the four power range channels indicate a power level above approximately 25 percent of full power. This trip function may be manually bypassed when two of the four power range channels indicate a power level above approximately 10 percent of full power and is automatically reinstated when three of the four channels indicate a power level below this value.

(5) Power range control rod stop - actuated when one out of the four power range channels indicates a power level above a preset setpoint. This function is always active.

(6) Power range flux level trip (high setting) - actuated when two out of the four power range channels indicate a power level above a preset setpoint. This trip function is always active.

Justification For Assumptions

The nuclear power response to a continuous reactivity insertion is characterized by a very fast rise terminated by the reactivity feedback effect of the negative fuel temperature coefficient. This self-limitation of the initial power burst results from a fast negative fuel temperature feedback (Doppler effect) and is of prime importance during a startup incident since it limits power to a tolerable level prior to external control action. After the initial power burst, the nuclear power is momentarily reduced and then if the incident is not terminated by a reactor trip, the nuclear power increases again, but at a much slower rate. Termination of the reactivity incident by the above protection features prevents core damage. In addition, the reactor trip from high reactor pressure serves as a backup to terminate the incident before an overpressure condition could occur.

Consequences

None from this class.

(f) Evaluation Of Class 5 Events

Discussion Of Class 5 Events

The Class 5 events are defined as those accident events that transfer the radioactivity in the reactor coolant into the secondary system through steam generator tube leakage, with a fraction of the transferred radioactivity in turn being released into the environment through the condenser off-gas. A release of radioactivity into the environment from accidents in this class requires a concurrence of two independent events: fuel defects and steam generator tube leakage. The likelihood of simultaneous occurrence of these two independent events, and hence of significant release of radioactivity to the environment, is unlikely. However, even if those events do occur simultaneously, at worst they would be evaluated continuously within plant secondary system activity technical specification limits, and corrective steps taken before any limit is approached.

Description Of Class 5 Events - Fuel Defects With Steam Generator Tube Leakage

In the unlikely concurrent incidence of fuel defects and steam generator tube leakage, the secondary system would contain fission products and radioactive corrosion products. The degree of fission product transport into the secondary side is a function of the amount of defective fuel in the core and the primary-to-secondary leak rate. These parameters also determine the radioactivity releases from the secondary system if the plant were to continue to operate under these off-normal conditions. Since the condenser off-gas effluent is automatically monitored for radioactivity, an alarm would sound upon detection of the steam generator tube leakage and the resultant radioactivity releases. Blowdown is terminated upon receipt of a high radiation signal. In addition, the steam generator liquid sample monitor provides backup information to indicate primary-to-secondary leakage. The operator must evaluate secondary system activity in terms of the plant technical specifications. If the primary-to-secondary leak rate and the resultant releases are insignificant, the operator may continue to operate the plant until a convenient time is available to shut down and repair the leaking steam generator.

Discussion Of Remoteness Of Possibility Of An Off-Normal Operational Release

An off-normal operational release requires fuel defects and a simultaneous steam generator tube leakage. Since each of these events has an independent, low probability of occurrence, the likelihood of their simultaneous occurrence resulting in an off-normal release is very remote.

In addition, the radiation level of the condenser off-gas discharge and steam generator liquid are monitored and any excessive gaseous or liquid releases would be detected by the monitor system and terminated by the operator.

To represent events in Class 5 conservatively, it has been assumed, for the purpose of analysis, that full power operation with 1 gpm primary-to-secondary leakage and 0.2% equivalent fuel defects is continued for 1 day.

Analysis And Evaluation Of Off-Normal Operational Release

Assumptions

An analysis has been performed of possible releases of radioactivity from the secondary system in the event of fuel defects with concurrent steam generator tube leakage. The analysis is based on the following assumptions:

1) 0.2% defective fuel

2) The primary-to-secondary leak rate is 1 gpm

3) No steam generator blowdown during off-normal operation; the condenser off-gas discharge is the only release.

4) The period of off-normal operation is 1 day at full power.

5) The atmospheric dispersion factor at site boundary used in the dose calculation is the annual average.

6) Secondary system decontamination factors:

Steam generator water to steam

$$DF = 10 \; \frac{\mu c/gm \text{ SG water}}{\mu c/gm \text{ Steam}} \quad \text{(all halogens)}$$

$$DF = 1 \; \frac{\mu c/gm \text{ SG water}}{\mu c/gm \text{ Steam}} \quad \text{(all noble gases)}$$

Steam to condenser off-gas

$$DF = 10^4 \; \frac{\mu c/gm \text{ Steam}}{\mu c/cc \text{ Air}} \quad \text{(all halogens)}$$

$$DF = 1 \; \frac{\mu c/gm \text{ Steam}}{\mu c/cc \text{ Air}} \quad \text{(all noble gases)}$$

7) No noble gas accumulated in the steam generator water since these are continuously released from the condenser off-gas system.

8) Air flow rate through the condenser off-gas system is 12.5 scfm.

Justification for Assumptions

The first assumption is based on plant operating experience to date. The second assumption is a conservative one well within the leak-rate which can be detected and result in remedial action. The third assumption is based on the fact that the steam generator blowdown is terminated within a few minutes of institution of the off-normal operation. The 1 day off-normal operation therefore will not result in blowdown release. The 1 day off-normal operation at full power of the fourth assumption is the expected off-normal operational time; the operator can shut the plant down sooner if the releases are excessive. Assumption 5 is based on the site meteorological data. Assumption 6 is based on the reference:

> Styrikovich M. A., Martynova O. I., Katkovska K. Ya., Dwbrovskii I. Ya., Smrinova I. N. "Transfer of Iodine from Aqueous Solutions to Saturated Vapor," Translated from Atomnaya Energiya, Vol. 17 No. 1, P. 45-49, July, 1964.

The condenser off-gas flow rate of 12.5 scfm is a system parameter.

Doses at Site Boundary and Total Population Dose (man-rem)

With the above assumptions the thyroid dose and the whole body dose at the site boundary resulting from the condenser off-gas release are 3.3×10^{-4} mrem and 0.11 mrem, respectively. The total population whole body dose is .083 man-rem.

(g) Evaluation Of Class 6 Events

Discussion Of Class 6 Events

Accidents which fall into accident Class 6 are: fuel element mishandling and mechanical malfunctions or loss of cooling in the transfer tube.

The only event in this accident class which may possibly result in a release of radioactive gases from a fuel assembly is the mishandling of a fuel element. Fuel handling procedures are such that no objects can be moved over any fuel elements during their transfer or storage. A loss of cooling in the transfer tube will not cause the cladding of a fuel assembly to be damaged. The residual heat generated by the assembly will be removed by natural convection.

Description Of Class 6 Events - Refueling Accident Inside Containment

The accident is defined as the mishandling of a spent fuel assembly. The accident is assumed to result in the equivalent of one row of fuel rods in the assembly being damaged. The subsequent release of radioactivity from the damaged fuel element will bubble through the water covering the assembly, where most of the radioactive iodine will be entrained, and be released to the containment atmosphere.

Discussion Of Remoteness Of Possibility Of A Fuel Handling Accident Inside Containment

The possibility of the postulated fuel handling incident is remote due to the administrative controls and physical limitations imposed on fuel handling operations; these are described immediately below. All refueling operations are conducted in accordance with prescribed procedures under the direct surveillance of personnel technically trained in nuclear safety. In addition, before any refueling operations begin, verification of complete rod cluster control assembly insertion is obtained by tripping each rod individually to obtain indication of rod drop and disengagement from the control rod drive mechanisms. Boron concentration in the coolant is raised to the refueling concentration and verified by sampling. Refueling boron concentration is sufficient to maintain the clean, cold, fully loaded core subcritical with all rod cluster assemblies withdrawn. The refueling cavity is filled with water meeting the same boric acid specifications.

After the vessel head is removed, the rod cluster control drive shafts are removed from their respective assemblies. A spring scale is used to verify that the drive shaft is free of the control cluster as the lifting force is applied.

The fuel handling manipulators and hoists are designed so that fuel cannot be raised above a position which provides adequate shield water depth for the safety of all operating personnel. This safety feature applies to handling facilities in both the containment and in the spent fuel pit area.

Adequate cooling of fuel during underwater handling is provided by convective heat transfer to the surrounding water. The fuel assembly is immersed continuously while in the refueling cavity or spent fuel pit. Even if a spent fuel assembly becomes stuck in the transfer tube, natural convection will maintain adequate cooling.

Two Nuclear Instrumentation System source range channels are continuously in operation and provide warning of any approach to criticality during refueling operations. This instrumentation provides a continuous audible signal in the containment, and would annunciate a local horn and a horn and light in the plant control room in the unlikely event that the count rate increases above a present low level.

Refueling boron concentration is sufficient to maintain the clean, cold, fully loaded core subcritical by at least 10 percent $\Delta\rho$ with all rod cluster control assemblies inserted. At this boron concentration the core would also be more than 2 percent $\Delta\rho$ subcritical with all control rods withdrawn. The refueling cavity is filled with water meeting the same boric acid specifications.

Special precautions are taken in all fuel handling operations to minimize the possibility of damage to fuel assemblies during transport to and from the spent fuel pit and during installation in the reactor. All handling operations on irradiated fuel are conducted under water. The handling tools used in the fuel handling operations are conservatively designed and the associated devices are of a fail-safe design. In addition the motions of the cranes which move the fuel assemblies are limited to a low maximum speed.

The design of the fuel assembly is such that the fuel rods are restrained by grid clips which provide a total restraining force on each fuel rod. If the fuel rods are in contact with the bottom plate of the fuel assembly, any force transmitted to the fuel rods is limited due to the restraining force of the grid clips. The force transmitted to the fuel rods during fuel handling is not sufficient to pierce the fuel rod cladding. If the fuel rods are not in contact with the bottom plate of the assembly, a 60 pound friction force would have to be overcome before the rods would be able to slide. This would absorb the shock and thus limit the force on the individual fuel rods.

After the reactor is shut down, the fuel rods contract during the subsequent cooldown and would not be in contact with the bottom plate of the assembly.

Considerable deformation would have to occur before the rod would make contact with the top plate and apply any appreciable load on the fuel rod. Based on the above, it is felt that it is unlikely that any damage would occur to the individual fuel rods during handling. If one assembly is lowered on top of another, no damage to the fuel rods would occur that would break the integrity of the cladding.

Refueling operation experience that has been obtained with Westinghouse reactors has verified that no fuel cladding integrity failures have occurred during any fuel handling operations involving over 50 reactor years of W PWR operating experience, during which more than 2200 fuel assemblies have been loaded or unloaded.

Analysis and Evaluation of Fuel Handling Accident Inside Containment

Assumptions

The following assumptions are postulated for a calculation of the fuel handling accident:

a) The accident occurs at 100 hrs following the reactor shutdown; i.e., the time at which spent fuel would be first moved.

b) The accident results in the rupture of the cladding of the equivalent of one row of fuel rods.

c) The damaged assembly is the one that had operated at the highest power level in the core region to be discharged.

d) The power in this assembly, and corresponding fuel temperatures, establish the total fission product inventory and the fraction of this inventory which is present in the fuel pellet-cladding gap at the time of reactor shutdown.

e) The fuel pellet-cladding gap inventory of fission products in these rods will be released to the spent fuel pit water at the time of the accident.

f) The spent fuel pit water retains a large fraction of the gap activity of halogens by virtue of their solubility and hydrolysis. Noble gases are not retained by the water as they are not subject to hydrolysis reactions. A decontamination factor of 760 for the halogens is used in this analysis.

g) A small fraction of fission products which are not retained by the water are dispersed into the containment.

h) Since the operator has the option of releasing the radioactive effluents under controlled conditions with better than average meterology, a fuel handling accident inside the reactor containment will result in a smaller dose at the site boundary than a fuel handling accident outside the reactor containment.

Justification for Assumptions

a) It is approximately 100 hours after shutdown that the first fuel assembly is removed from the core. The time delay between shutdown and removal of the first assembly is due to the time required to depressurize the reactor coolant system, remove the vessel head and other refueling procedures.

b) Analyses have shown that mishandling of a spent fuel assembly is not expected to result in damage of the cladding of any fuel rods in the assembly. The impact of a spent fuel assembly onto a sharp object may result in the rupture of the cladding of some fuel elements in the assembly. Damage to the equivalent of one row of fuel elements is considered to be a conservative upper limit.

c) The highest-powered assembly in the discharged region would have the largest quantity of radioactivity in the fuel pellet-cladding gap of all the assemblies to be discharged.

d) The quantity of radioactivity in the fuel pellet-cladding gap is dependent on the power level and temperature distribution of the assembly.

e) Since all fuel handling operations are conducted under water, the release of any radioactive gases from a damaged assembly would be in the form of bubbles to the water covering the assembly.

f) An experimental test program was conducted by Westinghouse to evaluate the extent of iodine removal as the halogen gas bubbles rise to the surface of the pool from a damaged irradiated fuel assembly.

g) The radioactive gases remaining in the bubbles when they reach the surface of the pool are released to the atmosphere atop the pool.

h) Any increase in radioactivity concentrations in the containment will be detected by radiation monitors. Upon high radiation signal the purge line from the containment will be isolated.

i) Since the pressure in the containment will be atmospheric at the time of the postulated accident and no pressure rise is expected due to the accident, the leak rate from the containment is expected to be near zero.

Consequences

Less severe than those listed for Class 7.

(h) Evaluation of Class 7 Events

Discussion of Class 7 Events

Accidents which fall into accident Class 7 are: Mishandling of fuel element, dropping of heavy object onto fuel, dropping of shielding cask or loss of cooling to cask and transportation incident on-site.

The only event in this accident class which could possibly result in a release of radioactive gases from a fuel assembly is the mishandling of a fuel element. Fuel handling procedures are such that no objects can be moved over any fuel elements being transferred or stored. Shielding and shipping casks are designed to be dropped with no subsequent damage to the cask or the assembly. Spent fuel is not moved off-site until 90-120 days after refueling, by which time most of the major contributing isotopes to the thyroid and whole body dose have decayed to a negligible level.

Description of Class 7 Event - Refueling Accident Outside Containment

The accident is defined as the mishandling of a spent fuel assembly. The accident is assumed to result in the equivalent of damage to one row of fuel rods in the assembly. The subsequent release of radioactive gases from the damaged fuel element will bubble through the water covering the assembly, where most of the iodine will be entrained, and be released to the spent fuel building. The activity is then exhausted to the environment via the plant vent.

Discussion of Remoteness of Possibility of a Fuel Handling Accident Outside Containment

A fuel handling incident outside the containment is considered to be as remote as that inside the containment. The administrative controls and physical limitations imposed on fuel handling operation are essentially the same as those described for the Class 6 events. As was noted earlier, the fuel handling manipulators and hoists are designed so that the fuel assembly is continuously immersed while in the spent fuel pit. In addition, the design of storage racks and manipulation facilities in the spent fuel pit is such that:

Fuel at rest is positioned by positive restraints in an eversafe, always subcritical, geometrical array, with no credit for boric acid in the water.

No more than one fuel assembly can be manipulated at a time.

Violation of procedures by placing one fuel assembly in with any group of assemblies in racks will not result in criticality.

In summary, those factors which are discussed under Section II.I.C.2.d.(2)(g) regarding remoteness of possibility of fuel handling accidents within the containment also apply here.

Analysis and Evaluation of Refueling Accident Outside Containment

Assumptions

The identical assumptions a) through g) of the above referred section are also postulated for calculation of the fuel handling accident outside the containment.

Justification for Assumptions

The justification for the assumptions are the same as given in Section II.I.C.2.d.(2)(g).

Doses at Site Boundary and Total Population Dose (man-rem)

The doses at the site boundary from a refueling accident outside the containment are 0.015 mrem thyroid and 0.33 mrem whole body. The total population dose from this accident is 0.25 man-rem whole body.

(i) Evaluation of Class 8 Events

Discussion of Class 8 Events

Accidents considered in this class include events resulting from loss of coolant, steam line break and steam generator tube rupture. These extremely unlikely accidents are used, with highly conservative assumptions, as the design basis events to establish the performance requirements of engineered safety features. For purposes of this environmental report, the accidents are evaluated on the realistic basis that these engineered safeguards will be available and will either prevent the progression of the accident or mitigate the consequences.

Loss of Coolant (LOCA)

Description of Class 8 Event - Loss of Coolant

A LOCA is defined as the loss of primary system coolant due to a rupture of a Reactor Coolant System (RCS) pipe or any line connected to that system. Leaks or ruptures of a small cross section would cause expulsion of the coolant at a rate which can be accommodated by the charging pumps. The pumps would maintain an operational water level in the pressurizer, permitting the operator to execute orderly shutdown. A small quantity of the coolant containing fission products normally present in the coolant would be released to the containment.

Should a break occur beyond the capacity of the charging pumps, depressurization of the RCS causes fluid to flow from the pressurizer to the break resulting in a pressure decrease in the pressurizer. Reactor trip occurs when the pressurizer low pressure set point is reached. The Emergency Core Cooling System (ECCS) is actuated when the pressurizer low pressure and low level set points are reached. Reactor trip and ECCS actuation are also provided by a high containment pressure signal. These countermeasures limit the consequences of the accident in two ways:

a. Reactor trip and borated water injection supplement void formation in causing rapid reduction of the core thermal power to a residual level corresponding to the delayed fission product decay.

b. Injection of borated water ensures sufficient flooding of the core to limit the peak fuel cladding temperature to well below the melting temperature of Zircaloy-4 in addition to limiting average core metal-water reaction to substantially less than 1%.

Before the reactor trip occurs, the plant is in an equilibrium condition, i.e., the heat generated in the core is being removed via the secondary system. Subsequently, heat from decay, hot internals, and the vessel is transferred to the RCS fluid and then to the secondary system. The ECCS signal terminates normal feedwater flow to the steam generators by closing the main feedwater line isolation valves and initiates auxiliary feedwater flow by starting the motor-driven auxiliary feedwater pumps. If off-site power is available, steam may be dumped to the condenser, depending on the size of the break. The secondary flow aids in the reduction of Reactor Coolant System pressure. If the Reactor Coolant System pressure falls below the setpoint, the passive accumulators inject borated water due to the pressure differential between the accumulators and the reactor coolant loops.

While the ECCS prevents fuel clad melting, as a result of the increase in cladding temperature and the rapid depressurization of the core, some cladding failures may occur in the hottest regions of the core. Some of the volatile fission products contained in the pellet-cladding gap may be released to the containment. These fission products, plus those present in that portion of the primary coolant discharged to the containment, are partially removed from the containment atmosphere by the spray system and plateout on the containment structures. Some of the remaining fission products in the containment atmosphere will be slowly released to the external environment through minute leaks in the containment during the time when the containment pressure is above atmospheric pressure. These minute leaks could be expected to be choked by water and water vapor, although credit for this was not taken in evaluating releases.

Discussion of Remoteness of Possibility of Loss of Coolant

The rupture of a reactor coolant pipe or a pipe connected to it is not expected to occur because of very careful selection of design, construction, operation, and quality control requirements. A very strict and detailed "Quality Assurance Program" is conducted to make sure that the specific requirements are met during the various stages of design, construction, erection, and fabrication.

The reactor coolant system is designed to withstand the "maximum potential earthquake" at the site and assure capability of shutdown and maintain the nuclear facility in a safe condition. Pressure-containing components of the reactor coolant system are designed, fabricated, inspected and tested in conformance with the applicable codes. The design loads for normal operational fatigue and faulted conditions are selected by conservatively predicting the type and number of cycles that the plant is expected to experience, as described in the FSAR. Also, essential equipment has been placed in a structure which is capable of withstanding extraordinary natural phenomena, such as tornados, flooding conditions, high winds or other natural phenomena.

The materials and components of the reactor coolant system are subjected to thorough non-destructive inspection prior to operation, and a preoperational hydro test is performed at 1.25 times the design pressure.

The plant is also operated under very closely controlled conditions to ensure that the operating parameters are kept within the limits assumed in the design. The concentration of oxygen ($\leq$0.10 ppm) is kept to low levels so that the integrity of the reactor coolant system is assured under all operating conditions. The reactor pressure vessel is given particular attention because of the shift in nil ductility transition temperature (NDTT) with irradiation. Therefore, technical specification limits are imposed on the maximum heatup and cooldown rates to make sure that the vessel wall temperature is above the NDTT whenever stresses become significant. Construction materials are selected for expected environmental and service conditions in accordance with the appropriate code requirements.

It is expected that for pipes of the size, thickness, and material used in the RCS, significant leakage <u>will</u> occur before catastrophic failure. The plant is provided with various means of detecting leakage from the reactor coolant system. The sensitivity of these leak detection systems gives reasonable assurance that a small crack will be detected and repaired before it reaches the size that will cause failure.

Furthermore, provisions are made for periodic inspection, in situ, of all areas of relatively high stress in order to discover potential problems before significant flaws develop. The inspection processes vary from component to component and include such techniques as visual inspection and ultrasonic, radiographic and magnetic particle examinations. This in-service inspection program (described in the FSAR) provides additional assurance of the continuing integrity of the Reactor Coolant System.

To further demonstrate the adequacy of the reactor coolant system, certain abnormal conditions are analyzed in detail in the FSAR.

Those credible transients which could cause pressure surges have been designed for by:

Reactor protection system trips

Incorporation of relief and safety valves in the pressurizer and appropriate sizing of the steam side safety and relief valves.

These ensure that the system pressures and temperatures attained under expected modes of plant operation or anticipated system interactions, will be within the design limits, giving further assurance that a rupture of the Reactor Coolant System is very remote.

Analysis and Evaluation of Loss-of-Coolant Accident

Assumptions

The analysis for this accident is based on:

Only activity in the fuel pellet-clad gap (∿1.5% of core halogen and 1.2% of core noble gases) would be available for release.

Fuel clad perforation ranges from zero for small breaks to a maximum of 70%. The fuel rods represented in this 70%, however, generate ∿90% of the core power, so that ∿90% of the total gap inventory would be released.

Of the fission product activity which is released from the gap, 25% of the halogens and 100% of the noble gases are available for leakage from the containment.

The containment leak rate is 0.1% for the first 10 minutes after which the containment is returned to subatmospheric pressures.

(ii) Justification for Assumptions

Fission product diffusion through the fuel pellet is a temperature-dependent process. Since the reactor has been made subcritical, fissioning ceases and the pellet temperature begins to drop from the operating value almost immediately. The gap activity represents 1-1/2 years of operation. The additional fission product diffusion to the gap after the accident is negligible.

Extensive analyses of the core behavior during a LOCA, based on theoretical and experimental evidence, has been performed. These analyses are reported in the FSAR, supplemented by Amendment 25, (Appendix C), Emergency Core Cooling Performance, September 30, 1971.

As used in the model in TID 14844, 25% of the released iodine is considered available in the containment atmosphere after plate-out on reactor internals and containment structures and entrainment in the coolant and condensed steam.

Data presented in the FSAR indicate that little organic iodine is released from the fuel.

The calculation of the spray effectiveness for iodine removal is based on the drop diffusion model developed by L. F. Parsly.* The spray drop size data used in this model are based on drop size measurements performed by Westinghouse, which have been previously reported in the FSAR. The effects of liquid phase resistance, steam condensation, and drop coalescence are accounted for in the model. The input parameters for spray evaluation are based on realistic estimates of the expected performance of the spray system.

The containment is tested for leakage as specified in Technical Specification 4.4-1 of the FSAR to ensure that the integrated containment leakage rate does not exceed 0.1 percent of the containment volume per 24 hours.

Doses at Site Boundary and Total Population Dose

With the above assumptions the thyroid dose and the whole body dose at the site boundary are 1.6 mrem and 0.013 mrem, respectively. The total population whole body dose is 0.0103 man-rem.

Steam Line Break

Description of Class 8 Event - Steam Line Break

A rupture of a steam line is assumed to include any accident which results

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* L. F. Parsly, "Design Considerations of Reactor Containment Spray Systems, Part VII", ORNL-TM-2412, Part VII, Oak Ridge National Laboratory.

in an uncontrolled steam release from a steam generator. The release can result from a break in a pipeline or a valve malfunction. The steam release results in an initial increase in steam flow which decreases during the accident as the steam pressure falls.

The following systems limit the potential consequences of a steam line break:

1) Safety Injection System actuation on any of the following:

   a) One of three pressurizer coincident low pressure and low level signals
   b) Two of three differential pressure signals between any main steam line and the main steam header

   c) High steam flow in two of three main steam lines (one of two per line) in coincidence with either low Reactor Coolant System average temperature (two of three) or low main steam line pressure (two of three).

   d) Three of four high containment pressure signals.

2) The overpower reactor trips (nuclear flux and ΔT) and the reactor trip occurring upon actuation of the Safety Injection System.

3) Redundant isolation of the main feedwater lines. Sustained high feedwater flow would cause additional cooldown; thus, in addition to the normal control action which will close the main feedwater valves, any safety injection signal will rapidly close all feedwater control valves, trip the main feedwater pumps, and close the feedwater pump discharge valves.

4) Trip of the fast acting steam line isolation valves on:

   a) High steam flow in two of three main steam lines in coincidence with either low Reactor Coolant System average temperature or low steam line pressure.

   b) Three of four high containment pressure signals.

Each steam line has a fast closing isolation valve and a check valve. These four valves prevent blowdown of more than one steam generator for any break location even if one valve fails to close. For example, for a break upstream of the isolation valve in one line, closure of either the check valve in that line or the isolation valve in the other line will prevent blowdown of the other steam generator.

If there are no steam generator tube leaks (Class 5), there would be no fission product release to the atmosphere from this accident. With tube leaks, a portion of the equilibrium fission product activity in the secondary system will be released. In addition, some primary coolant with its entrained fission products will be transferred to the secondary system as the reactor is cooled down. The steam is dumped to the condenser, and the noble gases transferred from the primary system would be released through the condenser off-gas system.

<u>Discussion of Remoteness of Possibility of a Steam Line Break Accident</u>

A steam line break is considered highly unlikely; the steam system valves, fittings, and piping are conservatively designed according to ASME Code for Pressure Piping, ANSI B 31.1. The piping is a ductile material completely inspected prior to installation. After installation, the entire system undergoes hot functional testing prior to fuel loading.

In addition to pre-operational tests to ensure the steam system integrity, during operation the water in the secondary side of the steam generators is held within chemistry specifications to control deposits and corrosion inside the steam generators and steam lines. A chemical treatment is used to prevent the formation of free caustic which would cause this corrosion.

With this combination of conservative design, quality control and assurance, pre-operational testing, and control over steam chemistry, the potential for a steam line break is minimal.

Analysis and Evaluation of Steam Line Break

Assumptions

The analysis for this accident is based on:

An equilibrium radioactivity in the secondary system of 0.2% equivalent fuel defects with a 20 gpd steam generator leakage prior to the accident.

No additional fuel defects or additional releases from fuel occur due to the accident.

Primary-to-secondary leakage of 20 gpd occurs for 8 hours after the accident.

The break occurs outside the containment.

The condenser (and thus off-site power) is available for steam dump after the faulted line is isolated.

Justification for Assumptions

The fuel defect level and steam generator leak rate are derived from operating experience with Westinghouse pressurized water reactors.

Fuel rods will not have a minimum DNBR (Departure from Nucleate Boiling Ratio) of less than 1.3, and thus there is no clad damage.

Eight hours is required for an orderly cooldown and depressurization of the primary system. Primary-secondary coolant transfer occurs for this time period.

Doses at Site Boundary and Total Population Dose

With the above assumptions the thyroid dose and the whole body dose at the site boundary are 5.6×10^{-3} mrem and 2.3×10^{-4} mrem respectively. The total population whole body dose is 1.7×10^{-5} man-rem.

Steam Generator Tube Rupture

Description of Class 8 Event - Steam Generator Tube Rupture

This accident consists of a complete single tube break in a steam generator. Since the reactor coolant pressure is greater than the steam generator shell side pressure, contaminated primary coolant is transferred into the secondary system. A portion of this radioactivity would be vented to the atmosphere through the condenser off-gas. The sequence of events following a tube rupture is as follows:

The operator will be notified within seconds by the condenser off-gas vent monitor of a radioactivity release.

Pressurizer water level will decrease for one to four minutes before an automatic low pressure trip occurs. Seconds later, low pressurizer level will automatically complete the safety injection acutation signal.

Automatic actions and cooldown precedures are as follows:

Automatic boration by high head safety injection pumps.

Restoration of discernible fluid level in the pressurizer by safety injection pump operation.

Operator-controlled reduction of safety injection flow to permit the RCS pressure to decrease below the setting of the lowest affected steam generator safety valve.

Operator-controlled steam dumping to the condenser in order to: (1) reduce the reactor coolant temperature; (2) maintain primary coolant subcooling equivalent to a suitable over-pressure; (3) to minimize steam discharge from the affected steam generator.

Isolation of the affected steam generator will be achieved by:

Identifying the affected steam generator by observation of rising liquid sample activity monitor.

Closing the steamline isolation valve connected to the affected steam generator.

Securing the auxiliary feedwater flow to that steam generator.

Blowdown from all steam generators is terminated at the start of accident.

Discussion of Remoteness of Possibility of Steam Generator Tube Rupture

It is expected that rupture would be preceded by cracking, induced by fretting, corrosion, erosion or fatigue. This type of failure is of such a nature as to produce tell-tale leakage. Activity in the secondary system is continuously monitored via the condenser off-gas discharge and periodic sampling and continued unit operation is not permitted if the leakage exceeds technical specification limits. As a result, any failure of this nature would almost unquestionably be detected before the large safety margin of pressure strength is lost and a rupture develops.

Finally, in over 400,000 tube years for Westinghouse-built steam generators, there have been no gross tube ruptures. This experience, combined with stringent quality control requirements in the construction of the generator tubes and constant monitoring of the secondary system, renders the likelihood of a steam generator tube rupture highly remote.

Analysis and Evaluation of Steam Generator Tube Rupture

Assumptions

The analysis of this accident is based on:

Activity in primary coolant based on 0.2% equivalent fuel defects. The accident will cause no additional fuel damage.

126,000 pounds of primary coolant are carried over to the secondary side.

An iodine partition factor of 10 $\frac{\mu c/gm\ water}{\mu c/gm\ steam}$ in the steam generator.

The faulty steam generator is isolated within 30 minutes.

An iodine partition factor of 10^4 $\frac{\mu c/gm\ steam}{\mu c/gm\ air}$ in the condenser.

Justification for Assumptions

The 0.2% defect level is based on average reactor operating experience with W PWR Zircaloy fuel. No clad damage is anticipated as described in the FSAR.

The steam generator leakage is based on plant operating experience with W PWR Inconel steam generators.

The 126,000 pounds of primary coolant carryover is based on the amount of time it takes for the primary system pressure to come into equilibrium with the secondary side, as described in the FSAR.

The iodine partition factors in the steam generator and condenser are based on the following reference:

Styrikovich M. A., Martynova O. I., Katkovska K. Ya., Dwbrovskii I. Ya., Smrinova I. N. "Transfer of Iodine from Aqueous Solutions to Saturated Vapor", Translated from Atomnaya Energiya, Vol. 17, No. 1, P. 45-49, July, 1964.

The 30 minute steam generator isolation time is based on estimates on the time it would take for the operator to identify the faulted steam generator from the instrumentation provided in the control room, and effect isolation.

Doses at Site Boundary and Total Population Dose

With the above assumptions the thyroid dose and the whole body dose at the site boundary are 2.8×10^{-4} mrem and 1.56 mrem respectively. The total population whole body dose is 1.18 man-rem.

(j) Table of Doses for Each Class

For each of the accident classes considered in this report an average site boundary thyroid and whole body dose were computed. The average total body dose includes the beta skin dose contribution. In addition, the total dose to the total population within a 50 mile radius of the site was analysed for each accident class using the meteorological and projected 1980 population data.

The results are summarized in Table II.I.C.2-10

The models used to compute the thyroid, whole body and population doses are presented below.

1) Thyroid Dose

The average thyroid dose at the site boundary was computed using the equation:

$$\text{Thyroid Dose} = \overline{(\chi/Q)}_{S.B.} \times \overline{B} \times \sum_i A_i \times DCF_i$$

where: A_i = Activity release to the environment of isotope i

DCF = Dose conversion factor of isotope i

$\overline{B}$ = average breathing rate of the average man

$\overline{(\chi/Q)}_{S.B.}$ = average annual χ/Q at the site boundary (7.5×10^{-6} sec/m^3)

2) Whole Body Dose

The average whole body dose, including the beta contribution, at the site boundary was computed using the equation for a semi-finite spherical cloud as given by:

$$\text{Whole Body Dose} = 0.246 \times \overline{(\chi/Q)}_{S.B.} \times \sum_i A_i \times (\overline{E}_{\gamma_i} + \overline{E}_{\beta_i})$$

where: A_i = activity released to the environment of istope i

$\overline{E}_{\gamma_i}$ = Gamma energy of isotope i

$\overline{E}_{\beta_i}$ = Beta energy of isotope i

$\overline{(\chi/Q)}_{S.B.}$ = Average annual χ/Q at the site boundary (7.5×10^{-6} sec/m^3)

(The assumption of a semi-infinite spherical cloud is conservative.)

3) Population Dose

The total population dose was computed using the equation:

$$\text{Population Dose} = 0.246 \left[\sum_i A_i \times (\overline{E}_{\gamma_i} + \overline{E}_{\beta_i})\right] \left[\sum_r \sum_\phi \frac{\chi}{Q}_{r,\phi} P_{r,\phi}\right]$$

where:

A_i, $\overline{E}_{\gamma_i}$ and $\overline{E}_{\beta_i}$ are the same as given for the total body dose model, and

$x/Q_{r,\phi}$ = the χ/Q for a given sector (ϕ) and distance (r)

$P_{r,\phi}$ = the population estimate for a given sector (ϕ) and distance (r)

The releases from a plant are monitored by the environmental monitoring system which provides additional information which would indicate any inadvertent exposures.

TABLE II.I.C.2-10

CLASS ACCIDENT	SITE BOUNDARY DOSE (mrem) THYROID	WHOLE BODY	WHOLE BODY POPULATION DOSE (man-rem)
2	---	0.1	.076
3	---	1.0	0.76
4	---	---	---
5	3.3×10^{-4}	0.11	0.083
6	<0.015	<0.33	<0.25
7	0.015	0.33	0.25
8*	2.8×10^{-4} - 1.6	2.3×10^{-4} - 1.56	1.7×10^{-5} - 1.18

* Class 8 accident doses are given in ranges

(k) Conclusions

On the basis of the evaluations of the various postulated accidents and occurrences in Sections (c) through (i) and the resultant radiological results as tabulated in Section (j), it is concluded that the environmental impact from these accidents and occurrences is insignificant. In fact, the maximum man-rem realistically established as a result of any accident is well within the increment of exposure to the general public corresponding to variations in natural background.

e. Transmission Effects

Right of way clearing began on the Surry project in March of 1967. Approximately 4420 acres of land have been bought, and 3543 acres of wooded land cleared for transmission lines and rights-of-way connected with this project.

(1) Land Systems

Much of the land purchased for transmission rights-of-way was forest before purchase and clearing. The area occupied by commercial forests in Surry County, Virginia accounts for 75.7% of the total area. Tree types are represented within the county in the following levels: loblolly pine, 36%; oak-hickory, 27%; oak-pine, 19%; oak-gum-cypress, 13%; and short leaf and Virginia pine, 5%. The forested area in Surry County has been divided into classifications with respect to timber size. These classifications are sawtimber - 52%, pole size timber - 27%, and seedlings and saplings - 21%. During the 1965 - 1969 period, the area grew more timber than was cut. The timber sales associated with this project contributed economically to the area, but did not substantially reduce the ability of the area to produce commercial timber.

(a) Physical Effects

The transmission clearing and associated timber sales were conducted on rights-of-way varying in width from 120 feet to 350 feet. The 350-foot-wide rights-of-way were cut and cleared from the power site to a point approximately 11 miles south of the station. At this point, transmission lines branched off in four directions in order to serve the major substations in the general area.

(i) Construction Effects, Etc.

Prior to the clearing operation, estimates were made of the amount of timber involved. It was determined, based on information from this survey, to sell the timber prior to the clearing of the right-of-way. Each property owner was given the option of cutting his own timber or of allowing the Company to remove the timber after acquisition of its right-of-way. A number of large land owners, including lumber companies, pulp and paper companies and other land owners with significant commercial timber land, elected to cut and market their own timber, and realized an economic benefit from this timber cutting. Vepco contracted with a local logger to remove timber from the other properties. These properties involved primarily small timber holdings from owners who were not experienced or knowledgeable in timber sales. Therefore, the timber harvested under the Vepco program represents timber that normally would have been lost during the right-of-way clearing operation.

(a) Amount of timber cut

The amount of timber cut represented a significant economic benefit to the area. The actual money received from the sale of this timber on the entire project was \$48,274.41. This value represents a harvest of 2,554,971 board feet of timber and 24,048,692 pounds of pulpwood. Figure II.I.C.2-4, gives a breakdown of the timber sold in conjunction with the transmission right-of-way clearing project.

(b) Other land uses interrupted

Interruption of land use by the project, except for timber production, has been minimal. Transmission lines constructed over open land do not interfere with an owner's right to grow crops, graze the land or make other uses that are not inconsistent of the safe operation of the transmission line. The remaining land was virtually unaffected by the transmission construction.

(c) Effects of excavation

Some land was disturbed during the excavation of tower sites and by construction of roads to facilitate erection of towers. The disturbed area was revegetated by a crew after construction and the land was fertilized, disced and seeded in order to restore it to an acceptable condition. The cover established by this reseeding operation will be of significant value to wildlife. Expenditures for rehabilitation on the Surry - Hopewell transmission line amounted to \$19,853.56. Expenditures on the Surry - Chuckatuck line totaled \$5,344.68. Rehabilitation work has not yet been completed on other transmission line rights-of-way.

(ii) Effects of lines once in existence

The cleared right-of-way resulting from the construction of transmission lines offers certain benefits to the area, particularly if the line is routed through

FIGURE II.I.C.2-4

TIMBER SALES - SURRY TRANSMISSION LINE

Timber Sale Number	Date Contract Signed	Description Of Sale	Volume Cut Pine & Poplar Board Feet	Volume Cut Hardwood Board Feet	Volume Cut Pine Cordwood - Lbs.	Volume Cut Hardwood Cordwood-Lbs.	Money Received
5	2-17-67	R/W E & W Leg	1,087,308	502,393	4,187,480	8,504,502	$26,717.89
Total 1,589,701 bd. ft. 12,692,000 lbs.							
5A	8-22-67	R/W Surry-Hopewell	47,569	33,923	58,080	837,500	1,330.79
Total 81,492 bd. ft. 895,580 lbs.							
5		R/W E & Leg Company Property	135,165	18,761	495,240	1,088,900	2,834.40
Total 153,926 bd. ft. 1,584,140 lbs.							
EW-2	7-26-68	R/W Elmont-Wards Creek	4,051	6,746	--	46,800	350.00 Est.
Total 10,796 bd. ft. 46,800 lbs.							
25	10-7-68	R/W Surry-Suffolk	340,590	18,683	1,661,380	1,858,480	8,628.75
Total 359,273 bd. ft. 3,519,860 lbs.							
45	9-4-70	R/W Surry-Newport News Company Property	2,500	3,230	235,140	--	234.75
Total 5,730 bd. ft. 235,140 lbs.							
47	3-30-70	R/W Surry-Greenwich Surry-Carson Company Property	16,225	--	95,570	--	421.06
51	6-15-70	R/W Surry-Carson	302,582	35,245	3,770,870	1,208,750	7,756.77
			1,935,990	618,981	10,503,760	13,544,932	$48,274.41

Pine & poplar - International 1/2" Rule
Hardwood - Doyle Rule
Pine - 5,200 lbs. = 1 standard cord
Hardwood - 6,000 lbs. = 1 standard cord

areas of standing timber. The right-of-way clearing provides a fire lane and easy access to the property. It also provides an attractive area for wildlife. These cleared areas are recommended by game biologists in order to improve wildlife habitat. It has been estimated that approximately 90% of upland wildlife is located within a few hundred yards of clearings.

In the commercially managed forests found widely in Surry County, these rights-of-way often contain the only clearings to be found, and therefore make a substantial contribution to the quality of wildlife habitat.

(a) Land used for right-of-way, total acreage taken; voltage of each line

The transmission lines constructed in association with Surry Power Station are: Surry - Elmont 500 KV, 698 acres cleared; Surry - Suffolk 500 KV, 432 acres cleared; Surry - Chuckatuck (Greenwich) 230 KV, 234 acres cleared; Surry - Hopewell 230 KV, 982 acres cleared; Surry - Newport News 230 KV, 612 acres cleared; and Surry - Carson 500 KV, 586 acres cleared.

(iii) Effect of Constructed Lines: Consumptive Land Use

Transmission lines of 500 and 230 kv will be used by the Applicant to transmit the approximate 1700 megawatt capacity of the two generating units at this facility. Utilization of these high voltage lines will decrease the number of circuits, towers and width of rights-of-way necessary to transmit this power. For instance, one 500 kv circuit is equivalent to approximately five (5) 230 kv circuits in power transmission capabilities. Also, by placing several circuits on one right-of-way, Applicant has minimized the total land area and right-of-way clearing required, while maintaining necessary system reliability with at least two major corridors for each line.

One right-of-way extending south from the power station will accommodate one 500 kv circuit and three (3) double circuit 230 kv tower lines, on a 350' utility corridor. An additional southerly right-of-way contains two 500 kv circuits and one 230 kv double circuit tower line. The right-of-way width for this corridor is also 350 feet. Centerline separation between tower lines on both corridors meets or exceeds requirements set forth by the National Electric Safety Code. Tower line separations that exceed the code requirements were made specifically to afford safe and satisfactory construction, maintenance and operation of these lines.

Care has been taken to route the lines through rural and undeveloped areas in an effort to minimize their impact on any communities. Uniquely scenic and recreational areas and historic landmarks, such as Bacon's Castle, have been avoided. A northerly route across the James River near the plant was **not** considered since the transmission lines would have skirted close to the historic Williamsburg area. Instead, expansions of the Yorktown Power Plant have been undertaken to serve the projected load requirements of the Peninsula area.

The Applicant has employed a number of techniques to minimize the visual impact of the lines upon the environment, including the use of a steel alloy material for all tower structures which oxidizes to a russet brown color to blend with the predominantly sylvan landscape. The routes have been selected in such a manner as to avoid long views of transmission lines parallel to highways and the James

River. Major road crossings have been kept to a minimum, and when such crossings were necessary, angles in the line were incorporated to provide crossings at sharp angles to the road, thus eliminating long views of the line from the motoring public. Natural screening at these crossings was maintained if possible, and when natural screening did not exist, steps were taken to plant such screening. The line route through wooded areas will provide fire breaks and at the same time provide a feeding place for wild game.

(b) Biological Effects

It is estimated that the biological effects of transmission line construction will tend to increase wildlife production in the immediate area. Right-of-way clearing produces what is referred to as an "edge effect". A mature forest contains, in addition to grass, low-growing species which often provide food and protection for small game animals. The resulting right-of-way clearing operation provides several hundred miles of transitional zone which is beneficial to small game animals.

(i) Construction: disruption of wildlife or plantlife

Disruption of wildlife and plantlife by right-of-way clearing and line construction is of a temporary nature. The area rapidly revegetates as a result of stump sprouting, reseeding and invasion of species which respond to seeding on bare soil. Approximately every three years the right-of-way requires chemical re-treatment, which destroys only wooded plant species but leaves grasses and low-level bushes intact. The chemical solutions are not harmful to either birds or wildlife which feed on grasses growing in the right-of-way.

Rights-of-way benefit wildlife only in forested areas. If the area is already clear, there is a neutral effect.

The difference between right-of-way and the adjoining forest may be compared with an abandoned field left to return to forest. There are certain plants that seed and colonize a cleared area almost immediately. These alter the site somewhat, restrict temperature fluctuations and evaporation by wind, and increase the relative humidity. This improvement in the micro climate prepares the way for new species to move in and dominate the site. If seed is available, pine starts to influence the area in the 3rd or 4th year. By the 15th year, crown closure is complete and those species that originally were dominant are shaded out and buried under pine needles. By the 30th year, seedlings of broadleaf trees have come up under the pine. In the southeast, the oak-hickory is the climax forest type or the forest type that will perpetrate itself indefinitely, barring an unusual disturbance.

Edge effects are the interspersion of different species of plants over any area where forest meets field, forest joins river, or plant meets plant. Wildlife utilize those areas that have the greatest edges.

Plants growing in the rights-of-way grow rapidly, provide cover, and produce abundant seed and forage, which is also very nutritious and is readily available with a minimum of effort. Wildlife use rights-of-way not only for the necessities of life, such as cover and food, but also as places to bed down, sun themselves and dry out after a rain.

(c) Human uses

The transmission lines are routed through predominantly rural areas consisting primarily of farm land and forest land. It is known that one family was displaced as a result of the line construction. However, this family relocated to a newly constructed home which was a considerable improvement over the building which was vacated as a result of the line construction.

II.II. UNAVOIDABLE ADVERSE EFFECTS

This section lists the adverse environmental effects discussed in detail in section II.I. above. The list is broken down among effects associated with construction, physical presence and operation of Surry Units 1 and 2.

Construction is 95% complete on Surry Unit 1 and 79% complete on Surry Unit 2. Thus, virtually all of the environmental effects numbered 1 through 13, below, have been incurred and are therefore unavoidable. Any remaining effects to be incurred as a result of construction are negligible.

The effects numbered 14 through 22 and 23 through 33, below, are unavoidable if the Units are completed and operated.

It should be emphasized that this list includes all adverse effects, whether significant or insignificant, is for convenient reference only and should be used only in connection with the comprehensive discussion of such effects in Section II.I. That discussion reveals that few of the effects listed below will be significant.

The following effects have resulted from construction of Surry Units 1 and 2 (see Section II.I.A.):

(1) Excavation of earth during construction

(2) Erosion during construction

(3) Timber and other flora destroyed during construction

(4) Wildlife displaced during construction

(5) Effects of area esthetics from construction

(6) Effect of placement of fill on James River

(7) Chemical waste during construction

(8) Construction effects on fish, smaller biota, amphibians, and plant life

(9) Effect on navigation from placement of structures in James River and infrequent use made of James River in transporting heavy equipment

(10) Construction effects on fishing, boating, swimming, and other water sports

(11) Effects of construction on meteorology

(12) Effects of construction on air quality

(13) Construction effects of transmission lines (see Section II.I.C.2.e)

The following effects will result from the physical presence of Surry Units 1 and 2 (see Section II.I.B.):

(14) Use of land for plant site

(15) Permanent obstacles to wildlife use of land posed by roads and site

(16) Effect of Surry on the local demand for schools, local services, fire and police protection

(17) Visual impact of Surry on surrounding historic sites

(18) Effect of excavation on subterranean Miocene strata

(19) Minor effects of the discharge groin on currents of the James River

(20) Effects of the completed plant on micro-meteorology of the site

(21) Land occupied by transmission lines (see Section II.I.C.2.e.)

(22) Esthetic effects of transmission lines necessitated by the Surry Project (see Section II.I.C.2.e.)

The following effects will result from the operation of Surry Units 1 and 2 (see Section II.I.C.):

(23) Effects from uranium mining, and processing, transportation and ultimate disposal of fuel

(24) Effect of water use on the fresh water/salt water boundary

(25) Effect of intake structure and canal on fish and other life forms

(26) Non-thermal effect on aquatic life from passage to condenser

(27) Effect from scouring or other physical outfall phenomena

(28) Potential fogging effect of thermal discharges

(29) Effect on aquatic life from heat due to passage from condenser

(30) Effect on aquatic life from thermal plume entering James River

(31) Effect of chemical releases on the James River

(32) Effect of radioactive releases during normal operations

(33) Effects due to radiation exposure from accidents

SUPPLEMENT
VOLUME 2

Vepco

SURRY POWER STATION
UNITS 1 & 2

APPLICANT'S ENVIRONMENTAL REPORT

...ATORY CENTRAL FILES

VIRGINIA ELECTRIC AND POWER COMPANY

DOCKETS 50-280 AND 50-281

Regulatory File Cy.

Received w/Ltr Dated 12-1-71

VIRGINIA ELECTRIC AND POWER COMPANY

APPLICANT'S ENVIRONMENTAL REPORT SUPPLEMENT

OPERATING LICENSE STAGE

SURRY POWER STATION

UNITS 1 AND 2

AEC DOCKET NOS. 50-280 AND 50-281

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II.III. ALTERNATIVES TO THE PROPOSED ACTION

A. Power, Site, and Environmental Considerations

1. Alternatives of Not Providing Power

The Code of Virginia, which confers on Vepco a service monopoly in its franchise area, also imposes a correlative "duty . . . to furnish reasonably adequate service and facilities at reasonable and just rates to any person, firm, or corporation along its lines desiring same. . . ." (§ 56-234). The statute excuses the power company from its duty of providing service under certain conditions beyond the utility's control (§ 56-250); under these conditions, the State Corporation Commission, which regulates power companies in Virginia, may prescribe rationing systems for the allocation of available power. Under normal circumstances, however, the State Corporation Commission may compel the utility to perform its duty of service by injunction or mandamus (§ 56-6). Under extreme circumstances, the General Assembly may even revoke the utility's charter (§ 56-8).

It is thus clear that Vepco, a power company operating under Virginia law, is legally compelled to provide customers within its service area with the power demanded by them. It possesses no legally compulsive means of controlling or regulating their demands for that power. The General Assembly is empowered to change the law governing Vepco's service obligations; it could amend the statutes either to permit or to require that Vepco not meet local demand. However, short of such legislation or of similar legislation by Congress Vepco has no legally permissible option but to provide service to anyone in its service area who demands it.

Nothing in the Atomic Energy Act of 1954, the National Environmental Protection Act (NEPA) or any other Federal statute evidences any Congressional intent to pre-empt State law on this point. Moreover, to the extent the Congress has declared the public policy of the United States as to adequacy of electric power supply, Section 202 of the Federal Power Act declares the objective of "assuring an abundant supply of electric energy throughout the United States with the greatest possible economy with regard to the proper utilization and conservation of natural resources."

The pros and cons of the Federal Government's adoption of (1) end-use allocation of all fuels, including the basic fuels as well as converted energy, or (2) deliberate energy curtailment and rationing, may appropriately be addressed to Congress, but they are beyond the scope of appropriate inquiry in this proceeding even under the broad scope of NEPA.

2. Alternative Means of Generation

The Applicant began considering the possible addition of a nuclear facility in 1964. Preliminary evaluation indicated the need for additional base-load capacity. The Applicant studied an expansion of its generation facilities under a proposed program for mixing new base-load with new peaking equipment that would allow for maximum base-load operation of the new, efficient equipment with lower operating costs. Older steam equipment, as well as newer peaking equipment, would be used to assist in meeting the peak loads. The study indicated the need for new base-load equipment in 1969 and 1971, with the first new major peaking addition in 1972. Thus, in 1964, the Applicant publicly announced plans for a 1972 pumped-storage[1] hydro installation with an initial capacity of approximately 340 MW, with provisions for increase in capacity. An economic evaluation showed that, when compared on the same basis, nuclear generation was more favorable than coal-fired generation. However, to compete with this alternative, rail carriers proposed favorable freight tariffs for Applicant's Chesterfield Power Station and other generating facilities. This single factor shifted the balance of the evaluation to favor installing a coal-fired unit in 1969 and a nuclear facility in 1971 for the base-load requirements. A summary of the 1965 - 1966 generation requirement studies for the 1971 addition follows.

a. Peaking Considerations

In reviewing its 1971 requirements, the Applicant determined that no additional new peaking capacity, other than the announced pumped-storage hydroelectric project, would be required in the years prior to 1973. An economic evaluation of this type of project in 1966 revealed its advantages over the other types of

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[1]There are no major potential conventional hydroelectric sites in Applicant's service area. The pumped-storage hydro must be complemented by a large low-cost base-load power source.

peaking generation equipment available at that time. The initial project was scheduled for 340 MW in 1972, to be expanded to 510 MW in 1973, which was the maximum firm capacity considered for the project site.

For the remaining portions of peak and intermediate load, Applicant planned to use 458 MW of existing peaking equipment which was normally held in reserve. The total peaking capacity scheduled to be in service by 1972, then, was 798 MW (including the first year of the pumped-storage project). For 1973 this capacity was scheduled to expand by 170 MW of pumped-storage capacity, and by an additional 540 MW as another fossil unit that could be used for intermediate purposes became operational. Consequently, no peaking capacity was considered necessary for the 1971 addition, and Applicant continued with efforts to increase its base-load capabilities.

b. Base Load Considerations

The Applicant had thus eliminated peaking equipment for 1971 operation. The choice now lay between a base-load nuclear unit and a base-load fossil fuel unit. The fuel chosen for the fossil fuel alternative was coal. Gas was eliminated as a possible fuel since the Applicant had already been denied the use of natural gas by the Federal Power Commission as a boiler fuel for generation purposes. Fuel oil was eliminated on the basis of price levels at the time and projections made from the existing price level.

Coal was the most economical, as well as the most available, fuel at that time, and thus presented the most favorable alternative to nuclear generation. In 1966 a comprehensive evaluation of the costs involved in constructing, operating and maintaining both types of facilities was prepared. The results showed a significant annual savings in costs - more than four million dollars - in favor of the nuclear alternative. The Applicant continued to evaluate all proposals and began design of the installation. In 1967 new data were furnished on costs of both alternatives. This evaluation indicated an even larger savings associated with the nuclear alternative. (See Section II.III.B. below).

c. <u>The Alternative of Purchasing Power</u>

Purchasing power did not represent a satisfactory solution to the problem of supplying a part of Applicant's base-load generation requirements. First of all, no known source could readily supply the large amounts of capacity required. Secondly, even had such a source existed, the factors listed below raised serious doubt whether purchased base-load power would allow Applicant to provide even minimally acceptable service. The major objections were these:

(1) The Applicant's load center is very close to its territorial center. Since the Applicant's service area is relatively large in land area and compact in configuration, (32,000 square miles), any capacity purchased would be located a minimum of 100 miles from the load center.

(2) With purchased capacity located far from the load center, and the need for capacity fixed, at least for the level of firm purchase, the Applicant would require additional interconnection facilities suitable for moving the large block of purchased power into its service area. In addition, sufficient capacity would be required of these interconnection facilities to sustain the loss of at least one significant transmission line without

requiring curtailment of purchases.

(3) The Applicant would require internal transmission facilities to move the power purchased to power-deficient areas. Again, sufficient transmission facilities would be required to avoid curtailment of load in the event of a transmission line outage.

(4) The Applicant must provide for relaying the loss of the firm purchase from outside its system. If the Applicant has sufficient reserve capacity within its system, this is not difficult. Should Applicant determine that sufficient in-system reserve capacity would be unavailable, it must also arrange for additional reserve capacity outside the system.

(5) With purchased power coming from relatively distant sources, greater transmission losses would be experienced than would be the case if the Applicant generated its own power. Since the Applicant as a purchaser would have to bear the cost of these transmission losses, the unit price of power into its system would be raised at least by that extent.

(6) The Applicant may be unable to exert control over the operation of any unit from which it purchases power. While arbitrary operation of a unit from which power is purchased is not to be expected, the selling company's idea of proper operation may not be consistent with the buying company's requirements. Since the buyer does not own the unit, it has no choice but to accept that portion of capacity which the seller makes available. For these reasons the Applicant did not consider the purchase of generation from sources outside of its system to be a satisfactory long-term solution to its generation needs.

3. Factors Causing Elimination of Certain Methods of Generation or Fuel

The Applicant did not arbitrarily or automatically exclude from consideration any alternative form of generation for any reason. Sufficient lead time was available, barring significant delays or slowdowns, to construct any type of facility and have it in operation on schedule in 1971. A complete discussion of the alternatives of generation by types and fuels is contained in the immediately preceding paragraphs.

4. Site Selection

The 1965 evaluation of the estimated growth of area loads within the Applicant's system through 1971 showed that a significant gap was developing between the load in its eastern area and the generation capacity available to supply that load. The Applicant, in 1965, was placing into service its first mine-mouth unit, with the second scheduled for the following year. These units were located at a single site west of the Applicant's service area. A 500,000 volt transmission loop through the central and northern parts of Virginia was constructed to transport the bulk power from the station to these load areas.

Some consideration was given to the possibility of locating additional capacity at another site somewhere in the coal fields. However, the site of the Applicant's announced pumped storage hydroelectric facility, scheduled for 1972 operation, was expected to be in or near the far western part of its system, and would utilize most of the remaining capacity of the 500,000 volt transmission line. Construction of additional capacity outside the service area would have necessitated construction of another 500,000 volt transmission system to ensure reliability and continuity of service. Furthermore, with this addition, Applicant would have had almost 40% of its total generating capacity located outside of its service area by 1973. Locating the 1971 generation additions external to the Applicant's system was discarded after considering the effect of these conditions on system operating reliability and efficiency.

The next step in the search for site locations involved evaluation of existing generating station sites. Again, since the load requirement was substantially in the Applicant's Norfolk - Portsmouth area, those station sites located relatively far from that area were eliminated because of the expense of developing a transmission network capable of reliably carrying the bulk power required for serving the load. The two remaining existing sites, Portsmouth Power Station and Reeves Avenue Power Station, were eliminated because sufficient space was not available at either to construct and operate a unit of the size under consideration.

It was thus necessary to utilize a new site, somewhere in the eastern area of the Applicant's system. The first site considered, Pig Point, was one which the Applicant owned just west of Portsmouth. This site was satisfactory for a fossil fuel unit, but, because of its proximity to large population concentrations, was not suitable for a nuclear installation under the then current rules of the Atomic Energy Commission. A site on the James River in Prince George County, Virginia was considered, but the physical arrangement of the land would have required construction of the station within full, unobstructed view of several historic plantations. In addition, the land that would have had to be acquired to meet AEC requirements included the site of one of these historic buildings. As a result of these considerations, this site was eliminated. Two other sites appeared to have merit: one in Surry County, Virginia, and the second on Currituck Sound in northeastern North Carolina. The Applicant began developing transmission plans based on generation located at both sites and also at Pig Point. At the same time, a closer evaluation of all three sites was undertaken to ascertain the overall adequacy of each.

The Applicant discovered that, given a generating installation of the ultimate size contemplated, the Currituck site did not have sufficient water available for once-through cooling purposes. This lack of sufficient water for once-through cooling focused attention on the other two sites, since they did have sufficient water.

The Surry County site is located on the south side of the James River opposite Jamestown Island, a site of considerable scenic and historic importance. However, Applicant's studies determined that with the adjacent game preserve partially screening the station site and with adjustments in engineering design to minimize the view of the station structures from across the river, this site appeared to meet all the esthetic criteria for favorable acceptance as well as the standards governing the siting of a major nuclear station.

The use of fossil fuel at the Surry site was never seriously considered. The construction of the stacks associated with such a station would have detracted from the scenic view from Jamestown and normal stack emissions from such a station would have further increased objections to the installation. In addition, the Applicant would have had to construct, or cause to be constructed, a spur line from the Norfolk & Western Railroad at least 20 miles in length to provide for coal deliveries.

Pig Point had already been rejected as a nuclear site because of its relative nearness to the heavily populated Hampton Roads area. But the site was suitable for fossil fuel generation, and a spur line railroad track suitable for moving in coal already existed. The Applicant, then, had located two sites, one suitable for nuclear, and the other for fossil fuel, that would effectively serve as permanent generation locations in the general area in which the power would be needed. Installation of a unit at Surry would at first require transmission facilities in excess of those required if a unit at Pig Point were built, however, full development of generation at each site would, of course, eventually require nearly identical ultimate transmission facilities.

The Applicant now had to decide between the two alternatives: nuclear at Surry versus fossil fuel at Pig Point.

5. Cost Benefit Analysis

A quantitative cost-benefit comparison of Surry and its fossil fuel alternative, evaluated as of the present time, is set out in Section II.III.B. immediately below. The chain of decisions actually followed by the Applicant at the time the site and type of generation were selected in 1966 is set out in the following three sections. The Applicant had eliminated from consideration all but two sites and had narrowed the type of generation to one possibility at each site. Selection between the two possibilities was primarily based on economic benefits: determining which choice would provide the lowest cost of energy.

a. Pig Point Evaluation

The evaluation of the installation at Pig Point was based on installation of a 665 MW generator in 1971 and the addition of 56 MW of peaking gas turbines in 1973 at Portsmouth. Transmission additions were minimal with only one major new line required. This plan would have utilized existing or proposed 230 kv transmission lines to supply the Norfolk area. The one transmission addition would have been a 230 kv line bypassing the Pig Point station.

The following factors were taken into account in the evaluation:

(a) Fixed charges on investment in generation, transmission, and substation equipment,

(b) annual operating and maintenance expenses, excluding fuel costs,

(c) fuel oil, coal and coal inventory costs.

An inflation factor of 3% per year was included in the operation, maintenance and fuel costs on this project.

b. Surry Evaluation

The evaluation of the Surry installation was based on the installation of a 633 MW generator in 1971 with an additional stretch capability of 65 MW to be available in 1972. Construction included a 500 kv substation as well as a 230 kv substation. While the Applicant was able to utilize many lines already in service or planned, construction of two additional 230 kv transmission lines was necessary. One of these lines was the same as that required in the Pig Point evaluation; the other was an 11 mile 230 kv transmission line from Surry toward the east.

The following factors were taken into account:

(1) Fixed charges on investment in generation, transmission and substation equipment,

(2) annual operation and maintenance expenses, excluding fuel costs,

(3) nuclear insurance,

(4) fixed fuel charges,

(5) variable fuel charges.

An inflation factor of 3% per year was included in the operation and maintenance expenses. Inflation had already been taken into account in working out detailed nuclear fuel costs and it was not necessary to inflate them further.

c. Conclusions from evaluation

The Applicant made a detailed comparison of costs between the two selected sites. Based on a fossil fuel cost of 28.8 cents per million BTU, a variable fuel cost of nuclear fuel of 1.58 mills per Kwh, a 3% inflation factor and not allowing credit for plutonium produced from the uranium burn-up, the Applicant determined that a levelized annual savings of more than four million dollars would be realized if the nuclear unit were constructed rather than the fossil-fired alternative. A second evaluation, given in Section II.III.B. below, indicated levelized annual savings of four and one-half million dollars if the Applicant were to select the nuclear alternative.

d. Selection

The Applicant reviewed all of the data collected, including marine laboratory studies of thermal effects on the James River, and, on the basis of the facts, estimates, and evaluations, including the relatively clean profile of the nuclear station, and the anticipated economic attractiveness of the nuclear alternative, elected to construct the nuclear unit on the Surry site.

e. Expansion

Although the initial evaluation was for a unit of approximately 700 MW, Applicant expanded this capacity to 820 MW to take advantage of the larger size unit being offered commercially at that time. This decision, because of the large advantage of nuclear over fossil fuel for base-load units (see Section II.III.B. below) reinforced the analysis.

In addition, based upon a late-1966 review of larger-than expected loads during the previous summer, the Applicant determined that an additional 820 MW of capacity would be required in the same geographic area by 1972.

The site was therefore expanded to include a second nuclear unit of 820 MW capacity. This was consistent with the Applicant's policy of constructing multiple units on its power station sites, where practicable, to take advantage of shared facilities and to reduce overall costs. Expansion of the site to include Surry Unit 2 would necessarily produce a large economic advantage over any fossil-fueled alternative, at no significant increase in environmental costs. These advantages will be partially quantified in Section II.III.B.

6. Alternative Methods of Environmental Control at the Surry Site

a. Construction Effects

The principal environmental effects from construction at Surry have already occurred. None of the remaining construction activities will create adverse environmental effects; thus, consideration of alternatives would produce no net beneficial results.

b. Plant Physical Facility Effects

The effects of the plant existence and operation are extensively set out in Section II.I above. Although no significant adverse environmental effects are anticipated from Surry Power Station, there are no aspects of plant design or construction which preclude, as a practical matter, consideration of alternatives which may contribute to the improvement of existing environmental conditions.

(1) Thermal Effects

Applicant's studies of thermal discharges provide reasonable assurance that the operation of Units 1 and 2 as presently designed will be acceptable by current water quality standards. Even if ongoing NEPA review should indicate that additional measures are desirable, the most logical alternatives would not involve any basic redesign of the facilities now being constructed. These alternatives include: (a) tempering the station cooling water at its exit into the discharge canal and (b) installation of spray systems in the discharge canal. Neither of these alternatives would be precluded by continued construction of Surry Units 1 and 2 under the AEC construction permits since there is sufficient space to accommodate necessary equipment and systems, and nothing in the station design and arrangement prohibits their installation.

(2) Seismic Effects and Effects on Hydrology

Applicant has conducted extensive studies of seismic effects upon the plant as presently designed. These studies are a matter of public record as part of the Construction Permit application (SAR Sections 2.3, 2.4 and 2.5). Results of the seismic investigations were then used in the subsequent system and equipment analyses. Where modifications were required corrective work was performed to reduce the potential geologic effect upon the plant.

Effects upon site hydrology resulting from radiological releases during station operation are minimal (See Section II.I.C.2).

(3) Effects on Local Ecosystems

Applicant has in effect large-scale pre-operational monitoring programs which will assist in determining the long range ecological impact of the power station. The effectiveness of these programs, as well as that of the proposed post-operational continuation programs, is reviewed periodically, and comments relative to possible improvements receive proper consideration. In any event, continued construction of Surry Units 1 and 2 during the prospective NEPA review period will not preclude any improvements in the environmental monitoring programs. One example of a recent change in the program is the increase in gaseous waste products hold-up time from 20 to 60 days, following the suggestion of EPA.

(4) Radiological Effects

The radiological protection and waste disposal systems are believed to be consistent with the latest technological developments and will limit releases to small fractions of the existing permissible limits, thus providing no significant radiological effects. Should improved technological developments become available or more stringent effluent release measures become effective, there is no aspect of the station design which would preclude, as a practical matter, incorporation of additional treatment facilities, either from a design or an operational standpoint.

c. Alternate Cooling Methods

Several types of cooling systems could theoretically be installed at the Surry Power Station to provide alternate means for coping with the thermal load. Applicant has considered several methods, but since there is sufficient water available in the river to support once-through cooling without affecting the ecological balance of the river, this was the method selected. Other methods were not incorporated for this and for the following additional reasons:

(1) Dilution

Dilution of the cooling water effluent would require additional expenditures for pumping the excess water into the cooling water system, without a net reduction in the heat load to the river. The Pritchard-Carpenter studies of several discharge configurations exit temperatures and flow rates, for example, revealed that neither of the alternate sets of operating conditions would change the effluent diffusion pattern or net temperature rise in the river significantly.

(2) Reservoirs, Lagoons, Cooling Ponds

The Surry site is not suitable for reservoirs or cooling ponds as means for effecting a large water/air interface surface. Since the river itself provides much more than adequate surface area, and since the topography of the land is not suitable for large water holdup facilities, these alternatives are not feasible.

(3) Spray Systems

At the present time, spray or sparger systems in the discharge canal, for instance, are not considered necessary nor particularly effective. However, should such systems be required in the future, there is no aspect of the cooling system design which would preclude their consideration. As noted in section (4) below, however, the environmental effects of salt-laden spray from such an installation could have adverse environmental effects.

(4) Initial Studies, Cooling Towers

Initial studies and preliminary investigations of the Surry County site made in 1965 indicated that the area would be suitable for a nuclear station. Topographic maps of the James River around the peninsula were prepared and indicated that adequate river surface area and water volume were available to effectively dissipate heat rejected from a nuclear station with an ultimate capacity of 3000 MWe. The river is about three miles wide at this point, and flows in a semi-circular bend around the site property. There are approximately seven miles of water between the cooling water discharge on the upstream side of the river and the intake which is located on the downstream side of the peninsula. Because this abundance of river water was available and because the configuration of the peninsula lent itself to designing the circulating water intake and discharge structure to protect downstream oyster beds, alternative techniques for providing cooling were not believed necessary.

Even so, initial thought and design consideration was given to the installation of cooling towers. Further study indicated, however, that they were not feasible at Surry. There are not now in operation any salt-water towers of the size required for the Surry installation. Preliminary estimates were that two cooling towers would be required for each unit and the size of each tower would be approximately 370 feet in height and 400 feet in diameter at the base. These towering structures would soar high above the 132 foot containment domes and as such would be the dominant feature at the power station. It was estimated that they would be quite visible from Jamestown and from other points miles away, and that their vapor plume would be visible for even greater distances, creating an effect which would have been considered esthetically undesirable by many.

The cooling towers would have had to operate on saline river water which contains chlorides or salt in concentrations approaching 20,000 ppm during certain portions of the year. These salts would be carried over into the cloud plume and this saline "drift" or "mist" would probably have a deleterious effect on plant life and on the environment of the area. With a high deposition rate, the off-site area, particularly the adjacent game preserve, could experience serious problems with the growth, diversity and abundance of vegetation. The inherent operating and maintenance problems that would be experienced, such as fouling and corrosion of installed electrical and mechanical control equipment, were of equal concern.

Costs were not considered in the above analysis since the cooling tower method was rejected on the basis of (1) need and expected technical problems, (2) esthetic intrusion upon nearby park and historic areas, and (3) the availability of the once-through system. Applicant did conduct a study in 1970 for cooling towers at its Chesterfield Power Station, however. The expected cost for a system which would process 489,000 gpm (58.2% of the requirement, per unit, at Surry) of fresh water was on the order of $10 million for forced draft wet towers and $19 million for natural draft wet towers. A direct comparison of these costs with those which could be expected at Surry is not feasible because of the vastly different operating conditions. The figures do, however, give a conservative estimate of what such an installation at Surry could be expected to cost should it be considered at a future time.

d. Alternative Chemical Waste Disposal Systems

All chemical additions utilized in maintaining efficient support systems at the facility will either be diluted or neutralized to the extent that their environmental impact will be negligible. Any sources of chemical addition that normally exist in fossil fired plant operation that could have a significant environmental impact are not employed at Surry. Condenser cleanliness is required at any power facility to help maintain the efficiency of the units and this is normally achieved by either a mechanical system or through the use of a biocide such as chlorine. Introduction of elemental chlorine into the circulating water reduces biomass build-up by destroying the organisms as they pass through. At Surry a mechanical system is employed at an approximate installed cost of $507,000/unit whereas a biocide system could have been installed for approximately $54,000/unit but the impact on the environment would have been more pronounced. The mechanical system accomplishes a high degree of cleanliness by the wiping and polishing action of sponge rubber balls as they pass through the condenser tubes pushing out the biomass. Applicant has thus installed a much more expensive alternate system to reduce the overall environmental impact.

e. Alternative Radioactive Waste Systems

Consistent with Applicant's program of continuing reviews, the design and operation of the Surry Waste Disposal System has been reviewed and compared with the information that has been presented on other announced systems having essentially zero or minimal release characteristics. The Westinghouse "essentially zero release" system is designed to be incorporated in units to be constructed later in time than Surry, such as 1976 or 1977, since portions of the system require further component development. The present Surry system is designed to restrict releases of radionuclides to a fraction of the 10 CFR 20 limits and the Applicant plans to use this equipment to its fullest practical capacity in order to meet these requirements. As shown below, the basic difference between the "zero release" system and the Surry system is one of operating philosophy.

The boron recovery system for Surry (which evaporates reactor coolant prior to the normal waste disposal in order to reclaim boric acid and primary grade water for future use) provides approximately 360,000 gallons of storage for both letdown and primary water make-up. This capacity provides substantial flexibility in water reuse during load follow cycles and consequently minimizes the discharge of liquid effluents from the plant. Boron recovery at Surry will be accomplished by evaporators instead of the ion exchange methods under development for a proposed "essentially zero release" system. This evaporation process is well known and has been demonstrated to be of proven value in virtually all nuclear plants which have radioactive discharges of only a few percent of the maximum permissible concentrations.

Low level wastes are treated essentially the same in both systems. High level liquid waste mechanisms in both systems permit recycling of purified effluent back to the reactor make-up system to reduce tritium and other radioactivity release to the environment; however, in the current design for Surry, strict 100% recycling is not anticipated, even though the capability for such recycle exists, and primary grade water management operations will balance tritium levels in the reactor coolant system with tritium releases to the environment to ensure that maintenance operations and the safety of station personnel are not jeopardized while releases to the environment are kept to a minimum, only a few percent of the maximum permissible concentration (MPC).

The desirability of strict 100% recycle of tritiated water is questionable at this time because:

(1) Due to the long half-life of tritium, its equilibrium concentration in the primary system components could continue to build up to undesirable exposure levels in the reactor containment for station personnel. This would have the adverse effect of limiting ready access to the containment for performing maintenance and safety related tests. It could thus affect the reliability and eventually the safety of plant operation. Furthermore, during refueling operations, there is no practical method of removing tritium from water vapor in the containment atmosphere prior to purging, so that some radionuclide releases would have to occur. The proposed method of waste management of tritiated water at Surry will allow for maximum recycle consistent with ensuring that radiation exposures to station personnel will be kept within allowable limits, and maintaining the tritium release to the environment below MPC.

(2) Use of purified liquid water for primary plant make-up has the potential for accidentally contaminating the reactor coolant system with relatively high levels of such deleterious ions as chloride and fluoride. Fluoride contamination, with its potential for corrosive effects on the Zircaloy fuel cladding is of particular concern. Present Surry waste management policy of a balance between recycle and controlled release of tritium will avoid this problem.

In the Surry Station, the reactor coolant letdown is treated in the boron recovery system to produce a concentrated boron solution and purified water, and the effluent water can then be stored for reuse as primary water make-up. The concentrated boron solution can also be stored for reuse. To ensure that mechanical failure or lack of water storage capacity does not result in the need to dump primary grade water during a period of high reactor coolant letdown, such as during back-to-back heatup of two reactor plants, redundancy of pumps, heat exchangers, evaporators, and other processing equipment is provided. In addition, water storage of approximately 360,000 gallons for letdown coolant and 360,000 gallons for purified water make-up is provided. This compares favorably with a reactor coolant system volume of approximately 68,000 gallons/unit.

The "essentially zero release" system and the Surry waste gas systems are similar in concept except for the disposal of the end product gas. The Surry system presents the recycling of gas back to the reactor coolant system to minimize the discharge of gas to the waste handling system. During recycle, no gaseous activity would be released to the environment. The Surry gaseous waste disposal system also includes a catalytic recombiner to remove hydrogen from the gases, thereby reducing the volume of waste gases entering the waste gas decay tanks. In the "essentially zero release" system it has been proposed that the radioactive waste gases be bottled and stored on-site for eventual disposal off-site. Although the Surry design is compatible with such waste disposal techniques, we believe further analysis is required to make certain that such a technique would not adversely affect plant safety and operation.

The Applicant is continuing to study and evaluate the various techniques and other aspects of the evolving technology in the area of radioactive waste disposal and believes that the Surry design provides sufficient flexibility to incorporate new concepts and techniques that are shown to be feasible and of practical value in further reducing the releases from the Surry Station.

f. Transmission Effects

Applicant has designed and constructed the transmission network at Surry Power Station to minimize its impact to the environment. By utilizing 500 kv circuits which are each equivalent to approximately five (5) 230 kv circuits, the right-of-way required was greatly reduced as well as the number of corridors needed to transmit 1640 megawatts capacity. In addition to reducing the total area required to transmit the power, Applicant has also employed a number of techniques to minimize the visual effect on the environment. These techniques include the use of steel alloy material for all tower structures which oxidizes to russet brown color that blends with the predominantly wooded landscape. The transmission routes have all been selected in such a manner as to avoid long views of transmission lines parallel to highways and rivers, scenic attractions, and crossings. Natural screening was maintained wherever possible.

When clearing the rights-of-way, all property owners were given the option of cutting their own timber or allowing the Applicant to remove the timber after acquisition. Therefore, the timber harvested under this arrangement was not lost because of right-of-way clearing operations.

B. Cost-Benefit Analysis of Surry Power Station

1. Introduction

As set out in Section II.III.A. above, the immediate power requirement in the Applicant's service area is for 1640 MWe of base-load capacity near the Norfolk-Portsmouth load centers. The purpose of this section is to compare the economic and environmental costs and benefits of meeting this requirement through Surry Power Station with those of available alternatives. This comparison shows that the generation of nuclear power at Surry has clear advantage over any alternate power source now available to the Applicant and can provide the power needed at a lower cost than any presently feasible alternative.*

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*All of the following discussion must be read together with Section II.III.A. which discusses in detail alternative sites, means of generation and methods of environmental control.

It should be further emphasized that the comparable costs given herein are costs to the Applicant only. Applicant's actual costs are of course important to the rates it must charge its consumers. Unless increases in Applicant's costs are offset by other system economies, they must be passed on eventually to Applicant's consumers. Often because of the effect of income taxes, rate increases must be greater than the cost increases in order to produce the return on investment allowed by regulatory authorities. Increases in costs to the public through rate increases resulting from requiring alternatives to the proposed action may in many instances exceed the costs to the Applicant set forth above.

2. Benefits from the Project

The value to society (a "benefit") of the electric energy to be supplied by Surry Power Station is properly measured by the price consumers would be willing to pay for that electric energy. The price consumers actually do pay is below this level (in this case principally because it is regulated) and, therefore, greatly understates the value of the benefits the consumers derive.[1]

Nevertheless, a bare minimum value for the benefit of the electricity supplied by Surry can be derived by multiplying the total generation by the average price per kilowatt-hour paid by all customers for their electricity purchases from the Applicant in 1971. Surry is expected to generate 3.73 billion Kwh after start-up in 1972, and 8.2 billion Kwh thereafter annually, averaged over the expected 30-year economic life of the two units.

The latter figure represents an annual figure of 1640 MWe at 57% load factor (5000 hrs/yr). The average price paid by the customers of Vepco in 1971[2] was 1.64 cents per kilowatt-hour. On this basis, the direct benefit of electricity expected to be supplied by Surry is $134 million annually. This compares with annual costs for generating this quantity of electricity of $33.2 million, excluding capital costs of construction already incurred, and $72.4 million with these capital costs included.[3]

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[1]No attempt has been made at this time to estimate the value of the benefits based on prices consumers would be willing to pay. To do so would require an analysis of the price elasticity of demand (the percent change in demand for a given percentage change in price). The lower the elasticity (the less responsive demand is to changes in price) the greater the benefits exceed the actual price. Elasticity of demand for electricity, it is generally agreed, is less than unity, i.e., demand changes less than proportionately to the change in price.

[2]12 months average through September 30, 1971 on sales of 24,459,791,000 Kwh.

[3]The capital costs considered are the $65,000,000 remaining to be expended on the project and the previous expenditures of $305,000,000. Transmission and distribution costs are not included in the calculations since these would be relatively the same for any type of power source.

Other benefits from the existence and operation of Surry Power Station, some of which would accrue from an alternative means of generation, include:

a. Educational and tourist benefits from the Visitor Center;

b. Improvement to the game preserve;

c. Creation of additional employment;

d. Increase in the local tax revenues.

Since quantitatively the benefits from the power constitute the greatest portion of total direct benefits, only the power benefits will be considered in this analysis. Also because these benefits greatly exceed the costs of the project, as set forth hereinafter, we need not attempt to quantify indirect benefits from the project for this analysis.

Calculated on the same load factor and capacity basis, an alternative source of the same quantity of electricity would provide the same benefits. For the purposes of this cost-benefit analysis, therefore, the controlling objective is to determine the difference between the cost of generation supplied by Surry and the cost of electricity from available alternatives, including, in both cases, the cost of their respective environmental effects.

3. Available Alternatives

This section will set forth the alternates which are theoretically available to the Applicant and will show that, for one or more reasons in each case, the alternate is either not feasible for this specific power need, or else is not legally permissible.

a. Not Providing the Power

As noted in Section II.III.A.1 above, failure to supply the demand for electricity is not an acceptable alternative under present law. The Applicant must, therefore, meet its obligations under State law and plan to satisfy the anticipated demands for its service, and as these demands increase with population and economic growth so must the Applicant continue to enlarge its system capabilities.

The continued growth in the economy of the area served by the Applicant, particularly in the urban corridor of Virginia running from Washington, D.C. through Richmond to the Hampton Roads area, is also expected to increase greatly the public demand for electricity for such general purposes as schools, hospitals and street lighting. Associated with this public demand is the need for reliable electric service to many defense oriented facilities in Applicant's service area. Furthermore, there is an increasing need for electricity to reduce present environmental effects by means of rapid transit, sewage treatment, recycling, and a wide range of other services.

The question, then, is whether any alternative to Surry for supplying power would be preferable, taking into account both the direct economic costs and the cost of the environmental impacts of each.

b. Alternative Methods of Generation

As noted in Section II.III.A. above, the original 1966 choice between alternative methods of generation was in favor of a nuclear station at Surry versus a coal-fired station at the Pig Point site near Portsmouth. At this time, however, the most attractive alternate fuel source is oil. In order to meet anticipated air pollution standards, any new fossil-fired station will have to be designed for low sulfur, low ash content fuel. Low sulfur oil is presently available for this use (October 1971 price, delivered, is in the range of $.60-.70/$10^6$BTU. Applicant has recently conducted studies of coal having low sulfur and ash content and has determined that the quantities needed for a 1640 MW alternate station are not reliably available and that the small amounts which possibly could be located would be comparably priced at at least $0.65 per million BTU. Furthermore, since coal-fired units in Applicant's system presently require an additional $10/kw of capital funds, the costs of a coal-fired station are clearly greater than those of an oil-fired station. Thus, at this time, coal does not provide a feasible alternative to the Surry nuclear station.

Natural gas also is not a viable alternative. A sufficient natural gas supply cannot be made available in adequate quantities because of the present gas supply shortage. This shortage is evidenced by the fact that limitations on gas usage are presently in force in certain areas of Virginia.

Combustion turbine peaking units do not represent a feasible alternative to base-load units, whether fossil or nuclear. These peaking units are designed to operate for only a relatively few hours during the year; operation over extended periods of time can be attained only with drastic reductions in capacity. Operation of combustion turbines much in excess of 1,000 hours annually at rated peak load would require an extensive maintenance effort resulting in very high maintenance and replacement costs, and would impair their essential availability during the relatively short peak periods. Such peaking units, therefore, cannot substitute for base-load units designed to operate around the clock for many thousands of hours annually. In addition, peaking turbines are extremely costly sources of power. While their capital cost is somewhat lower than the cost of base-load units, they normally use very expensive No. 2 fuel oil or jet fuel, either of which costs much more than the oil consumed in steam boilers. Furthermore, their thermal efficiency is about one-third lower than the thermal efficiency of base-load steam generation. Their extended use, therefore, would have a significant adverse effect on fuel supply and would add to the costs of generation.

c. Purchased Power

The purchase of power from other electric utilities is not a feasible alternative. As described in the Applicant's "Request to Continue Construction of Surry Power Station", dated October 9, 1971, and filed in Docket Nos. 50-280 and 50-281 pursuant to Section E of Amended Appendix D to 10 CFR 50, in the absence of Surry, and given the possibility of delay or suspension of other nuclear units in neighboring systems, the power supply situation in Virginia will be marginal at best and the Applicant will have a precariously low reserve margin for the summer of 1972. Almost continuous investigation over the past two years of the possibility for obtaining supplementary supplies of power from areas outside Virginia indicates a lack of availability of adequate capacity for this purpose in adjoining areas. This power supply situation is discussed in Section I.E. of this Environmental Report.

Construction of an oil-fired base-load plant (two or more units at the site) is the only feasible alternative.

4. Costs

The Applicant's original choice was between a nuclear unit at Surry and a coal-fired unit at Pig Point. However, because the Applicant now needs two new units and because coal is no longer the least expensive fossil fuel in the site area, the following analysis will compare a two-unit nuclear plant at Surry with two replacement oil-fired units of equal capacity which might be built at the Pig Point site, based upon present costs.

Whenever accurate quantification has been unavailable, conservative assumptions are used to complete the analysis. The discussion proceeds in accordance with the following general outline:

a. A comparison of the direct costs associated with the nuclear and oil-fired alternatives, based upon present capital costs and fuel prices, and a comparison of the nuclear and coal-fired alternatives based upon the original 1966-1967 studies.

b. A discussion of the unquantifiable costs which must be considered in addition to the direct costs of each alternative.

c. A discussion of the comparative environmental costs of each alternative.

a. Direct Costs

The costs of electricity generated by Surry and by two alternative oil-fired units which might be built at Pig Point as a replacement are as follows:

TABLE II.III.B.4-1

	Surry-Nuclear (including capital costs expended)	Surry-Nuclear (excluding capital costs expended)	Pig Point Oil-Fired
Plant capital cost (million)			
Expended	\$305		\$244[5]
Remaining	65	\$ 65	
New site capital cost	___	___	10[6]
Total (million)	\$370[4]	\$ 65	\$254
Capital cost (\$/Kw)	226	39.6	155
Cost per Kwh (Mills):			
(a) Capital (5000 hrs/yr)[7]	5.81	1.02	3.97
(b) Operating & Maintenance[8]	0.50	0.50	0.50
(c) Special Insurance[9]	0.20	0.20	--
(d) Fuel	2.33[10]	2.33[10]	6.12[11]
Total	8.84	4.05	10.59
Annual cost (million)	\$72.4	\$33.2	\$86.9

[4] Total estimated cost for the project in 1971 prices.

[5] Cost of 1976 oil-fired station, reflected in 1971 prices.

[6] Base unit used for costs in (5) is an addition to an existing plant. This number is added to account for site area and development costs and additional cooling water system costs.

[7] Capitalization rate, 12.8%, 30-year life.

[8] Includes normal insurance.

[9] Additional liability insurance cost for nuclear plants.

[10] Fuel cost (levelized) including carrying charges

[11] October 1971 energy cost from using 1% sulfur oil assuming 6.2×10^6 BTU/BBL, 9260 BTU/Kw heat rate, and \$4.10/BBL, delivered.

As Table II.III.B.4-1 shows, the direct cost of electricity from an oil-fired replacement alternative is more than the cost of electricity generated by Surry (nuclear) -- 10.59 mills/Kwh compared to 8.84 mills/Kwh - even when the capital costs already incurred at Surry (sunk costs) are included. With this approach the total costs on an annual basis are $86.9 million for the oil-fired units and $72.4 million for Surry.

It is correct, however, for purposes of this cost-benefit analysis, to exclude from Surry's costs those capital expenditures already incurred. They cannot be eliminated by cessation of construction and the construction of an alternative generating source. Indeed, this is exactly how capital costs of all units are treated when scheduling their generation. As shown in Table II.III.B.4-1, the capital costs remaining to be expended to complete the Surry plant are $65 million, compared to the $305 million previously expended. Exclusion of these previously expended costs would result in a nuclear cost of 4.05 mills/Kwh, or $33.2 million per year for the station energy output. Plainly, the removal of the $305 million of sunk costs places Surry in an even more favorable economic position compared to that of the most feasible alternative.[12]

Stated another way, complete abandonment of the Surry site would cause a loss of the $305 million, in addition to contract severence and shutdown costs, already invested. At the present carrying charge of 12.8% this amount would represent $39.2 million per year. It should be included as a cost of the alternative oil-fired units if it is not subtracted from the total capitalized cost of Surry.

[12]The cost comparison between Surry and an alternative oil-fired station at Pig Point has been presented on the basis of costs as they would be incurred today. However, if we project back in time to when the decision was made to construct Surry, the nuclear cost advantage still resulted. This original comparison was between a nuclear station at Surry and a coal-fired station at Pig Point. The comparison was as follows (at its up-date on April 1, 1967), with prices estimated

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Viewed in this light, yearly costs (without regard at this point to the need for replacement energy while the oil-fired alternative is built) would be represented as follows:

	Surry (Nuclear)	Oil-Fired (Pig Point)
Remaining Costs	$33.2 million	$86.9 million
Sunk Costs	39.2	39.2
Total	$72.4 million per year	$126.1 million per year

The capital costs shown in the above table for the oil-fired alternative have been estimated on the basis of plans for oil-fired units which would be in service in 1976. The capital costs have been converted to mills per kilowatt-hour on the basis of 5000 hours use annually and 1971 dollars. This method of comparison, however, tends to understate the cost advantage of the nuclear units, since over the useful economic life of the plants the annual hours of operation of the oil-fired alternative are likely to decline much more rapidly than those of the nuclear units. Nevertheless, to be conservative and for purposes of simplification, it has been assumed that both the nuclear and fossil fuel units will have the same number of hours of operation.

12-continued-

at that time, for 1971:

	Surry (nuclear)	Pig Point (coal-fired)
Capital cost ($/kw)	146	121
Annual fixed charges (mills/Kwh)	2.57	2.34
Operating, Maintenance (mills/Kwh)	0.51	.352
Insurance (mills/Kwh)	0.13	.015
Fuel (mills/Kwh)	1.79	3.21
Power Cost (000)	$24,715	$29,221
Mills/Kwh	5.00	5.92

These figures are for an 820 MW coal-fired unit and an 800 MW nuclear unit, with "stretch" to 820 MW. There is a predicted nuclear advantage of $4.5 million per year. By constructing two units at Surry, Applicant increased this advantage, since several systems could be used in common by both units (e.g., fuel building, boron recovery system), reducing the capital cost per unit of energy.

Even though the capital cost of the nuclear plant has increased rapidly over the last several years to $226/Kw, capital costs of fossil plants have also increased considerably, and the fuel differential cost (fossil vs. nuclear) is increasing.

Once the generating units of an electric utility system are operational, they are assigned load in accordance with incremental costs; i.e., for any given increase in system load the generating unit with the lowest cost increment for the increase is assigned the additional load. The most important incremental cost factor is fuel cost. Since, over time, oil prices are expected to rise more rapidly than nuclear fuel prices, the total annual hours of operation for the oil-fired alternative are likely to fall more rapidly, and the total kilowatt-hours produced over the life of the oil-fired alternate unit on which to base the capital cost changes can be expected to be lower than shown here. The total generating cost per kilowatt-hour would thus be raised.

The fuel costs per kilowatt-hour of energy generated also understate the advantage of the nuclear unit. Over the useful life of the nuclear unit, its fuel costs are expected to rise much more slowly than 1% sulfur oil prices. Indeed, if the rate at which nuclear units are installed should be retarded, the resulting upward demand pressure on oil supply could be expected to aggravate pressures for increases in oil prices. In any case, there appears to be little prospect of a significant reduction in oil prices below present levels so that the use of present prices tends, again, to understate the nuclear advantage.

Should it become necessary to replace the capacity of Surry with an oil-fired generating station at Pig Point the earliest that such a station could be brought into service would be 1976.[13] During the period 1972 - 1976, replacement capacity

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[13]The four-year period is a conservative minimum, especially when considering a two-unit station. It is probable that this time period should be extended by one or two years, considering the necessary environmental review and licensing procedures.

and energy would have to be provided, assuming that the capacity and energy could be obtained, to replace the capacity and energy expected to be supplied by Surry. Assuming current fuel costs hold for the 1972 - 1976 period, replacement power would cost at least an extra $68.0 million[14] which must be added to the cost of the oil-fired alternative. The additional generation would be supplied either by purchase of available power, or by the use of peaking equipment with more intensive use of existing plants on the Applicant's system. As indicated earlier, units are assigned load on the basis of incremental cost with newer, more efficient generating units being loaded first. The increment in generation required by the shutdown of Surry, therefore, would greatly increase the generation supplied by the older, less efficient, higher cost fossil units. Increased use of these units will, of course, result in increased emission of the various air pollutants that they produce. Indeed, failure of the Surry nuclear units to come on line would jeopardize compliance with air quality standards in at least one case, since Applicant now has a commitment to the Commonwealth of Virginia to retire its Bremo Units 1 and 2 (30 MW total) when Surry 1 and 2 attain commercial operation. Applicant currently has a variance from air quality standards based on this commitment and utilizes these units only when necessary to supply peak load demands.

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[14] Replacement of 28.3 billion Kwh over the four-year period @ 2.4 mills/Kwh differential cost. This differential cost assumes that replacement power would be available and represents the difference between nuclear costs and average system generation costs. There is no provision for increased capital costs to install replacement capacity for a portion of the time period. Costs of energy from the older plants would, of course, be much higher.

b. Unquantifiable Direct Costs

The complete abandonment of Surry would necessitate producing replacement energy equivalent to that in 43 million barrels of oil during the 1972-1976 period, based on a heat rate of 9260 BTU/Kwh and 6 million BTU per barrel[15] of oil. By comparison, the total amount of oil consumed by the Applicant in the first 9 months of 1971 amounted to 13.5 million barrels. In changing existing coal-fired units over to oil, the Applicant has found that it could not arrange for long-term contractual commitments at a fixed price for the needed oil supply. In order to assure a continuing supply of oil it was necessary to grant substantial price increases. Apart from the difficulties which may be encountered in obtaining the needed increase in oil supplies, it is likely that still higher prices will have to be paid to obtain so large an additional quantity of oil, either by the Applicant or by other utilities which would supply replacement power. The above estimate of the cost of replacement energy on the basis of current oil prices is, therefore, conservative.[16]

It is clear, from a comparison of direct costs, that the nuclear plant under construction at Surry is far superior to the next best alternative available at this time. This is also true if the costs of environmental effects are included.

c. Environmental Costs

The major environmental impacts of construction of Surry have already been

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[15]Some degree of conservatism is employed in this heating value of oil.

[16]Increased oil prices are not likely to be confined to the particular utility concerned. The increased demand for oil to replace nuclear capacity would tend to result in oil price increases for all consumers. Indeed, to the extent that such demand and price increases are concentrated on low-sulfur oil in view of the limited supplies of such low-sulfur oil, consumers, where feasible, would tend to shift to the higher sulfur product. The result may be no net gain in air quality from the national point of view and there may even be a deterioration.

produced. No large additional environmental effects of construction at the site would be incurred as a result of continued construction and operation of the units. Thus, this aspect of the environmental effects of Surry resulting from continued construction and operation has a negligible cost. The construction of an oil-fired alternative in lieu of Surry, however, would require the development of an additional site earlier than it would normally have been developed and, ultimately, the development of an altogether new site. The plant and its oil storage facilities would require the disturbance of a minimum of 250 acres together with the erection of the necessary structures. In addition it would require the construction of oil delivery facilities capable of handling oil tankers and barges, ash retention and disposal facilities, and transmission facilities.

The major environmental effects of the nuclear and oil-fired units which need to be compared are those which result from the condenser cooling water system operation and from radiation releases. As described in Appendices B, C and F of this Report, extensive studies have been made of the aquatic environment in the Surry area. These studies have indicated that no significant effect upon the aquatic environment would result from the operation of the condenser cooling water system.

On the basis of the studies that have been carried out, it can be concluded that the cost of the thermal impact on aquatic ecology from the operation of Surry will be virtually negligible. It can be assumed that these effects would be essentially the same with oil-fired units at Pig Point having the same type of condenser cooling water system. Whether the generating units were nuclear or oil-fired, they would be designed to meet the same water quality criteria imposed by State regulation. The costs for doing so at each site are incorporated in the capital costs for each alternative outlined above. Therefore, there is no reason to expect any difference in the cost of the aquatic effects of Surry and an oil-fired alternative at Pig Point. They are both virtually zero.

Although the studies and experience to date indicate that there is no significant effect on the aquatic environment of the once-through condenser cooling system employed at Surry, alternative cooling systems have been investigated. Given the fact that there are no significant adverse effects on the aquatic environment of the condenser cooling system and that the thermal discharge of the condenser cooling water meets the State water quality standards, however, there would be no significant environmental or other benefits to be gained from the substantial additional expenditures that would be required for their installation.

The second major environmental cost to be considered is that resulting from the radiation effluent of Surry and the gaseous and particulate effluent of the oil-fired alternative. The monitoring program at Surry and its vicinity described earlier, will continue in the future during operation. The expected normal gaseous and liquid radioactive releases from Surry have been described earlier in Section II.I.C.2 and Appendix C. These radiation releases are expected to amount to only small percentages of the levels permitted by AEC limits and to have no adverse environmental effects. It is concluded, therefore, that the environmental effects of normal radiation releases from the Surry plant will have virtually no costs.

As described earlier in Section II.I.C.2.d., various types of accidents which have been postulated by the AEC do not materially increase the total radiation releases to the environment of this plant. Therefore, the cost to the public from such accidents would also be negligible.

The oil-fired alternative to Surry would effect air quality. Oil-fired units would have an optimum heat rate of about 9260 BTU per kilowatt-hour and would therefore consume approximately 75,800 billion BTU annually or 12.6 million barrels of oil. Assuming that 1.0 percent sulfur oil can be made available in sufficient quantities, such a station would emit approximately 43,600 tons of SO_2 annually.

A measure of the cost to society of environmental effects is the price society would be willing to pay in order to avoid those effects. The October 1971 price of 2.9 percent sulfur oil in the Virginia area averaged $2.30 per barrel; 1% sulfur oil was $4.10 per barrel. Thus the market value of a reduction in sulfur content of oil by 1.9% was $1.80 per barrel. On this basis, a reduction of 0.1 percentage point in the sulfur content would appear to be worth 9.47 cents per barrel. The sulfur emissions, therefore, associated with an oil-fired station using 12.6 million barrels of 1.0 percent sulfur oil annually would have a minimum annual environmental cost of $11.9 million per year based on the price that now exists for a 0.1 percentage point reduction in the sulfur content of the fuel.[17]

Particulate emissions of alternate oil-fired units would be about 4810 tons annually. At present, Federal regulations do not require particulate removal

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[17] Clearly, this is a conservative estimate since at each step the next level of reduction in sulfur content becomes more costly.

from oil-fired effluents; however, the price for the oil-fired station used in the comparison above includes mechanical collectors which are 75-80% effective, and which Applicant is now providing on its oil-fired stations. It is estimated that particulate collectors to remove 99.5+ percent (assuming it were technically possible, as it is not), would cost an extra $4.0 per kilowatt of installed cost. For a 1640 megawatt alternative, the environmental effect of the particulate effluent would be equivalent to $6.56 million in capital costs. The annual capitalized operating costs of the collectors would greatly increase that figure.[18]

In addition to this effluent of SO_2 and particulates from the oil-fired alternative, if extensive use of older generating units in the 1972-1976 period were necessary to generate replacement power until the new units could be completed and brought into service, effluents of SO_2 and particulates would increase even more. Furthermore, if these older units are needed to satisfy load requirements during this period, their retirement, if scheduled would necessarily be delayed.

Thus, the table on page 399 with the environmental costs included would be as follows:

	Surry (including sunk costs)	Surry (excluding sunk costs)	Pig Point
Capital Cost ($/kw):			
Plant	$226	$39.6	$155
Particulate Emissions	--	--	4.0
Total	$226	$39.6	$159.0
Cost Per Kwh (Mills):			
Capital (5000 hrs annually)	5.81	1.02	4.07
Sulfur Emissions	--	--	1.46
Fuel	2.33	2.33	6.12
Operation and Insurance	0.50	0.50	0.20
Insurance	0.20	0.20	--
Total	8.84	4.05	12.15
Total Yearly Cost (Million)	$72.4	$33.2	$99.6

[18]As is the case of sulfur content, the higher the precipitator efficiency the more costly the next step in efficiency becomes.

5. Summary

Consideration of a conservative comparison of costs and benefits for Surry Power Station and its alternatives has clearly demonstrated that no feasible alternative is available for supplying the power required at economic or environmental costs lower than those for Surry.

The benefits which will accrue from the existence and operation of the power station may be evaluated at a minimum of $134 million per year. The annual direct costs for providing these benefits with Surry Power Station would be $33.2 million with sunk costs excluded and $72.4 million if one were to consider all capital expenditures for the project.

To produce the same benefits with an oil-fired alternative station, the annual costs would be $86.9 million, excluding environmental costs, and $99.6 million with environmental costs included.

Thus, using the approach least favorable to nuclear, the costs of the oil-fired alternative units would exceed the costs of Surry by $27.2 million annually. On this basis, over the 30-year life of the project, the cost of oil would exceed the cost of nuclear by $816 million. Using the approach appropriate for a cost-benefit analysis and thus excluding the capital costs of Surry already incurred, the costs of the oil-fired alternative units would exceed the costs of Surry by $66.4 million annually or $1.99 billion over the life of the project.

In both cases the cost of replacement energy required during construction of the alternative oil-fired units - an additional cost of these units, estimated at $68.0 million - has been omitted.

In conclusion, therefore, it is clear that continuing with the construction and operation of Surry Power Station, both from environmental and economic considerations, is justified and would provide the benefits sought at a lower cost than any feasible alternative.

II.IV. RELATIONSHIP BETWEEN SHORT TERM AND LONG TERM PRODUCTIVITY OF ENVIRONMENT

The short term use of the Surry site and of the necessary fuel resources by this generation and the next is for the conversion of heat energy to electrical energy using a pressurized water reactor. The facility will not produce the airborne products of fossil fuels combustion such as sulfur dioxide, oxides of nitrogen and flyash. There will be no emission of particulate matter, and no massive daily shipments of fuel. No large land areas will be covered with solid waste (ash). The electric power generated is required for the health, safety and general well-being of all persons living with the Applicant's service area.

In addition to the relatively clean production of electrical energy the short term uses of the Surry area will be enhanced by the creation of an improved water fowl refuge area which will indirectly serve local residents as well as the Tidewater area.

The control of radioactive by-products is fully discussed herein and there is adequate assurance that these will not have any substantial adverse effects on the environment, either short term or long term.

The heat rejection from this process is being handled in a manner to optimize cooling by lowering the area of temperature influence. Rapid mixing of the circulating water discharge with the receiving waters by a jetting action provides this optimization. By using downstream water for cooling and discharging upstream, the downstream commercial oyster beds will not be exposed to heated effluents.

II.V. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The useful life of a nuclear power station of the Surry type is expected to be approximately 30 years, or until improved generating plants warrant replacement for economic or other reasons. Since it is not inconceivable that the facility could be dismantled, we believe there are no absolutely irreversible and irretrievable commitments of resources in the long run except for the materials of construction and the Uranium-235 atoms fissioned in the uranium dioxide fuel. This depletion of Uranium-235, is, of course, partially offset by the production of fissile plutonium. It is the opinion of the Applicant that the benefits to be derived from resource commitments clearly justify them.

APPENDIX A

SOLID, LIQUID AND GASEOUS RADIOACTIVE WASTE CONTROL SYSTEMS

RADIOACTIVE WASTE CONTROL

Radioactive waste control is provided through the continuous use of the Waste Disposal Systems.

These Waste Disposal Systems separate, treat and dispose of radioactive liquid, gaseous, and solid waste materials. Each of the liquid, solid, and gaseous Waste Disposal Systems is a common system designed to serve both reactor units. These systems incorporate one or more of the following basic processes:

1. Filtration, for removal of particulate matter.
2. Evaporation, for concentration of constituents into a smaller liquid volume and to enable the separation of liquid and gaseous phases.
3. Demineralization, for removal of dissolved material.
4. Baling, for reduction of the volume of compressible wastes.
5. Natural decay of radioactive isotopes.
6. Dilution, for reduction of concentration.

Adequate sampling, analysis, and monitoring of the Waste Disposal Systems is provided to comply with the operating requirements. Radiation monitoring and parameter measuring equipmentare provided for surveillance of gaseous waste and process steam effluent to assure compliance with applicable regulations and to maintain releases of radioactive materials in effluents as far below the applicable regulations as possible. Some of the features included in the design of the station that reduce the discharge radioactivity to the lowest practical level include:

a. Use of Zircaloy-4 fuel cladding which minimizes the release of tritium to a level well below that experienced with stainless cladding used in earlier pressurized water nuclear power plants.

b. High throughput boron recovery and liquid waste disposal evaporators which enable maximum water re-use and maximum separation of nonvolatile nuclides for burial disposal as solids.

c. Special treatment of waters containing low levels of radioactivity filtration, and demineralization prior to release

A discussion of each type of radioactive waste disposal system (i.e., liquid, gaseous, and solid) is included below.

LIQUID WASTE DISPOSAL SYSTEMS

The Liquid Waste Disposal System, as shown on Figs. A-1-3, is designed to receive liquid wastes, either directly from various sources or from the Vent and Drain System discussed in the Final Safety Analysis Report (FSAR). The Vent and Drain System classifies process liquids either for re-use or for disposal. The influent from the Vent and Drain System to the Liquid Waste Disposal System is a small fraction of the Vent and Drain System throughout.

System influents from the Vent and Drain System are discharged to either the high level waste drain tanks or the low level waste drain tanks, according to influent activity level.

Laundry waste, Personal Change Area (PCA) shower drains, and PCA lavatory drains will be discharged to the contaminated drain tanks.

Laboratory drains and various flush lines from the drumming of concentrated liquid wastes, including spent resin flush drains, will be discharged directly to the high level waste drain tanks.

The contents of the high level waste drain tanks, which may have activity levels in the order of up to 10^{-1} μCi/cc are processed by evaporation. The evaporator subsystem is designed to produce liquid effluents of an activity level no greater than 10^{-4} to 10^{-8} μCi/cc, which are pumped to the waste disposal test tanks. The contents of the test tanks are sampled to determine the radioactivity level and the chemical composition. The evaporator effluent in the test tanks, if contaminated, may be purified by circulating the contents through a mixed bed demineralizer and filter or reprocessed. The test tank effluent is, after confirmation that activity and chemical concentrations are below the specified maximum level, discharged directly through the liquid waste radioactivity monitoring station and flow control station. Off gas from the evaporator is vented to the Gaseous Waste Disposal System. The concentrated bottoms in the evaporator is then packaged for shipment off-site and ultimate disposal.

Provision is made for the transfer of the high level waste drain tank contents to the low level waste drain tanks by means of a line under administrative control in the event that the high level waste drain tank contents do not require evaporation.

Provision is also made for conveying the contents of the low level waste drain tanks and contaminated drain tanks to the high level tanks if the activity level of any of these liquids should exceed about 10^{-3} µCi/ml.

The contents of the contaminated drain tanks are filtered by the contaminated drain filters and conveyed into the liquid waste effluent header, where the effluent is monitored by a radiation monitor and ultimately discharged into the circulating water discharge canal, via steam generator blowdown piping. If the activity level of the water exceeds the normal limits, it can be pumped to the high level waste drain tanks for reprocessing.

The contents of the low level waste drain tanks are discharged through filters and a radiation monitoring station to the circulating water discharge canal. If the activity level of this effluent is not within the discharge tolerance then it is pumped to the high level waste drain tanks for subsequent evaporation.

All liquid waste discharges to the Circulating Water System are monitored to provide radiation control of this discharge. Periodic sampling of the liquid waste effluent is conducted by station health physics personnel. The discharge rate is controlled by either of two parallel flow control valves, one handling low range, and the other handling high range flows. Excessive activities detected by the monitor overrides both valve controls and stop all discharge flow.

The discharge flow from the Liquid Waste Disposal System is combined and mixed with the circulating water such that the net activity of the combined effluent will not exceed 10CFR20 unrestricted area limits and will be as far below these limits as practical.

Components

High Level Waste Drain Tanks

Two high level waste drain tanks are provided. Each tank has a capacity of 2,390 gal. Level indicators will be provided. These will be stainless steel tanks designed according to Section IIIC of the Boiler and Pressure Vessel Code.

Low Level Waste Drain Tanks

Two low level waste drain tanks will be provided. Each tank will have a capacity of 2,847 gal. Level indicators will be provided. These will be stainless steel tanks designed according to Section IIIC of the ASME Boiler and Pressure Vessel Code.

Waste Disposal Evaporator and Auxiliaries

One externally heated forced circulation evaporator with a feed and distillate capacity of 6 gpm will be provided. The evaporator shell will be fabricated from a high nickel alloy in accordance with Section IIIC of the ASME Boiler and Pressure Vessel Code. Internals will be fabricated from an austenitic stainless steel not susceptible to stress cracking.

The external heat source will be a shell and tube steam reboiler fabricated from a high nickel alloy in accordance with Section IIIC of the ASME Boiler and Pressure Vessel Code, and TEMA Standards.

Distillate is condensed in a water cooled shell and tube condenser fabricated from austenitic stainless steel in accordance with Section IIIC of the ASME

Boiler and Pressure Vessel Code and TEMA Standards.

The condensed distillate is held in the distillate accumulator. This tank is fabricated from austenitic stainless steel in accordance with Section IIIC of the ASME Boiler and Pressure Vessel Code.

A distillate cooler is provided to further cool the distillate. The distillate cooler is fabricated from austenitic stainless steel in accordance with Section IIIC of the ASME Boiler and Pressure Vessel Code.

Waste Disposal Evaporator Test Tanks

Two waste disposal evaporator test tanks, each of 548 gal. capacity, with level indicators are provided. These tanks are stainless steel and designed according to Section IIIC of the ASME Boiler and Pressure Vessel Code.

Waste Disposal Evaporator Demineralizer

One waste disposal evaporator demineralizer is provided for evaporator distillate polishing. The demineralizer will be fabricated from austenitic stainless steel not susceptible to stress cracking in accordance with Section IIIC of the ASME Unfired Boiler and Pressure Vessel Code.

Waste Disposal Filters

Liquid waste effluent filters, and the distillate demineralizer filters are cartridge type pressure filters. The vessels will be fabricated from austenitic stainless steel in accordance with Section IIIC of the ASME Boiler and Pressure Vessel Code, where applicable. The filter elements are the synthetic fiber disposable type. Filter cartridges are designed for removal as a single or multiple basket assembly.

Contaminated drain tank filters are provided to remove lint and other laundry waste matter which could be radioactive. This filter is operated on a precoat-filter-backwash cycle.

Pumps

Centrifugal frame mounted pumps with single or double mechanical seals are provided. The waste disposal evaporator bottoms pump is a canned pump. One pump is provided for each tank with cross ties where appropriate, such as on high level waste drain tank pumps. External cooling and seal water will be supplied to radioactive pump services as required.

SOLID WASTE DISPOSAL SYSTEM

The Solid Waste Disposal System provides holdup, packaging and storage facilities for the eventual shipment offsite and ultimate disposal of radioactive waste material. Materials handled as solid waste include concentrated liquid wastes from the waste disposal evaporator, concentrated boric acid not to be reused in the system from the boron recovery bottoms tank, spent resin slurries, spent filter cartridges, and other miscellaneous solid materials resulting from station operation and maintenance. The operation of this system involves various unit operations described below.

Drumming Operation

The drumming operation involves the mixing of the concentrated solution in a drum with an absorbant and solidifier such as cement, the mixing and setting up of the mixture, and the storage of the drum for ultimate offsite disposal.

The drumming of concentrated evaporator bottoms is performed by mixing the concentrated waste with cement and/or diatamaceous earth in 55 gal. drums. The amount of waste liquid per drum is predetermined by analysis of the waste. The liquid waste is cooled in a heat exchanger prior to drumming.

The drum is transported by overhead monorail to the drum rolling machine. The concentrated waste and absorbant is mixed by means of rotating the drum. After a predetermined time, the drum is transported to a storage area.

The radioactivity level on contact with the surface of the drum is measured, recorded, and attached to the drum in accordance with the applicable Federal Regulations. The drums are stored until such time as they are to be shipped off site for ultimate disposal.

Baling Operation

Contaminated solid material resulting from station maintenance is stored in specified areas of the auxiliary building and decontamination building. The items are placed in polyethylene bags, if required, during storage with suitable labeling.

Materials which are compressible, such as absorbant paper, cloth, rubber, and plastic are placed in 55 gal. drums. The drum and its contents, including the plastic bags, are placed in position on the solid waste baler. The compression plate compacts the contents of the drum into a high density bale. Additional compressible materials are added and the contents of the drum recompacted until the drum is filled. During baling operation the area is closed and the ventilation air filtered to remove particulate matter. Contaminated metallic materials and other highly contaminated solid objects are placed inside a cylindrical concrete core at the center of a 55 gal. drum. The annular space between the core and drum and the bottom section of the drum is concreted prior to insertion of materials inside the core. After insertion of the contaminated materials, additional concrete is added to fill all remaining void spaces inside the drum.

Spent Resin Handling Operations

A spent resin holdup tank properly shielded is provided to accumulate resin from ion exchangers. A spent resin transfer system permits spent resin to be flushed from the holdup tank either to a disposable spent resin shipping cask or to a shielded tank truck. The disposable cask with its associated concrete shielding is normally in place and ready to receive high activity spent resin, while other casks may be in shipment to or from a licensed disposal site. To ready this equipment for receipt of spent resins, the shipping container and cask is placed in the spent resin cask pit at the decontamination building, with piping connections made up in advance. Provision is also made to transfer spent resin directly to the disposable shipping drum from the ion exchanger. The spent resin from all high activity ion exchangers is handled in the same manner.

The resin in an ion exchanger is considered to be "spent" when the decontamination factor drops below a predetermined value or the dose rate on the outside of the ion exchanger approaches predetermined limits. The unit is then isolated and primary grade water used to flush the spent resin into the spent resin holdup tank. The spent resin remains in the holdup tank and the flush liquid passes through a filter element and discharges by way of the spent resin dewatering tank and the Vent and Drain System into one of the waste drain tanks. When all spent resin from a single source has been transferred to the holdup tank, the flushing flow is stopped. A similar procedure transfers the resin to the spent resin shipping cask. After transferring the resin to the disposable drum, the disposable drum is dewatered in its cask and stored in the yard area until it can be transported for ultimate disposal. In general, disposal procedures will be available and appropriate for the prevailing conditions.

Expended Filter Cartridge Handling Operations

Filters in radioactive liquid service are removed from service when the pressure drop across the filters becomes excessive or when the radiation level exceeds a predetermined maximum. The filter cover is opened by personnel using appropriate tools, and protected by a filter removal shield, when required. High activity expended filter cartridges in their disposable basket are raised into the filter removal shield and placed in the filter shipping container shielded by a reinforced concrete shipping cask. Filter cartridges are packaged for ultimate disposal in 55 gal. drums to the extent possible. In each case, the packaging procedure is appropriate for the prevailing conditions.

Ultimate Disposal Operations

All packages containing radioactive non-fissionable material and the procedures used to prepare these for offsite shipment are in accordance with U. S. Department of Transportation regulations. All waste material is transferred either to a licensed disposal contractor or to a common carrier for delivery to a licensed disposal contractor.

Components

Spent Resin Holdup Tank

One spent resin holdup tank is provided. The holdup tank is permanently installed in a concrete cubicle below grade. The tank capacity is designed to contain the total dewatered resin volume of approximately four demineralizers. The vessel is designed according to Section IIIC of the ASME Code for Boiler and Pressure Vessels.

Baler

One solid waste baler for contaminated, compressible materials is provided.

Drum Roller

Two 55 gal. drum rollers are provided for use at the bottoms drumming station.

Spent Filter Shipping Cask

Concrete shielded filter shipping casks, acceptable under the regulations, and related tools are provided.

Spent Resin Dewatering Tank

One spent resin dewatering tank is provided. The tank will be designed in accordance with Section IIIC of the ASME Code for Boiler and Pressure Vessels.

Spent Resin Disposable Shipping Drum and Cask

A number of standard 55 gal. shipping drums and casks, acceptable under the regulations, are available.

GASEOUS WASTE DISPOSAL SYSTEM

The gaseous Waste Disposal System regulates the discharge of activity waste gases to the atmosphere. A ventilation vent subsystem controls potentially low activity air streams from the nuclear auxiliary facilities and a description of this subsystem can be found in the FSAR. Radioactive waste discharges from both systems are monitored by particulate and gas monitors.

Gaseous wastes enter the Gaseous Waste Disposal System from the stripper in the Boron Recovery System, the Vent and Drain System, various pressure relief valves and the Containment Vacuum System as shown on Figs. A-4 and A-5.

Waste gases, primarily hydrogen, nitrogen and minor amounts of fission product gases, such as xenon and krypton, are removed from reactor coolant letdown by the stripper in the Boron Recovery System. The stripped gases are processed in the Gaseous Waste Disposal System.

Before processing the stripped gases in the recombiner, nitrogen and oxygen are added as required and the entire mixture preheated. The maximum hydrogen concentration is normally maintained at about 3 percent which is below the lower hydrogen flammability limit of 4.4 percent. The gas mixture flows to the waste gas recombiner where about 99 percent of the hydrogen and oxygen is catalytically reacted to produce water vapor. The gas volume to the waste gas tanks from the recombiner will be reduced by tenfold relative to the influent stripped gas entering from the boron recovery gas stripper. The effluent gas from the recombiner is cooled in the recombiner aftercooler and then flows to the moisture separator. Condensed liquid from these two vessels is drained to the Liquid Waste Disposal System.

The waste gas stream from the moisture separator is recycled to the recombiners by the blowers.

The recombiners are maintained at a pre-set pressure by bleeding from the recycle line upstream of the blowers using pressure control. The bleed stream is pumped from a small surge tank to the buried gaseous waste decay tanks by diaphragm compressors. The redundant hydrogen analyzers on the effluent line from the moisture separator shut the valves in the bleed stream in event of a high hydrogen concentration in the effluent from the catalytic recombiner.

Duplicate oxygen analyzers on the moisture separator effluent reset the oxygen addition controller.

Redundant hydrogen analyzers on the recombiner feed stream shut the two valves in series on the stripped feed for hydrogen concentrations exceeding 4 per cent. Simultaneously, redundant nitrogen purge lines open to dilute the hydrogen.

Two double-walled waste gas decay tanks will be provided. Each tank is buried for tornado protection. The inner tank is fabricated from austenitic stainless steel in accordance with Section IIIC of the ASME Code for Boiler and Pressure Vessels and the outer tank from carbon steel in accordance with Section VIII of the ASME Code for Boiler and Pressure Vessels. Sampling connections are provided for the tank contents, and for leakoff in the annular intercept space between the tanks. The decay tanks have piping connections for parallel operation with alternate feed and bleed.

Overpressure relief protection is provided at the waste gas decay tanks in accordance with Section IIIC of the ASME Code. The protective devices consist of bellows sealed pressure relief valves followed by rupture disc assemblies. Rupture disc bypasses with a higher pressure rating are provided around the relief valves. The use of bellow seals and rupture discs preclude leakage of the waste gas to the environment during normal operation of the Gaseous Waste Disposal System. The piping down stream of the protective devices relieve to the process vent through the radiation monitor station.

Effluent from the waste gas decay tanks is mixed with dilution air, effluent from the Containment Vacuum System, and the aerated vents from the Vent and Drain System. The combined gaseous wastes are filtered through charcoal filters prior to being released to the atmosphere. The process vent blowers maintain a small vacuum in the charcoal filters to prevent out leakage from the filter assembly. The decay tank pressure relief valves discharge to the discharge side of the process vent blowers. The decay tank contents are sampled prior to any release to the process vent.

The entire discharge stream of radioactive letdown gas and dilution air is monitored for flow rate, pressure, temperature, and particulate and gaseous activity prior to release through the process vents. The total flow is regulated by a flow control valve on the dilution air. The ratio of dilution air to waste gas letdown flow is such that the mixed streams never enter the flammability region of the air, steam, hydrogen phase diagram.

The process vent and the process vent blowers are sized such that the minimum exit velocity is approximately 100 fps. This exit velocity prevents any significant downdrafting of the effluent with atmospheric winds as high as 35 mph. The process vent terminates at an elevation approximately 10 ft. above the top of one of the containment structures.

The process vent monitors are set such that the effluent activity release rate will result in concentrations less than those suggested as limits in 10CFR20 at the site boundary. In the event the activity of the effluent stream exceeds the setting of the monitors, the process vent control station automatically terminates the release of waste effluents with the exception of relief valve discharges. The monitor also alarms in the Control Room prior to valve closure if the activity approaches a preset value. Subsequent restart of the system is manual in accordance with administrative procedures. Discharge gases from the waste gas decay tanks are initiated and controlled separately.

The Waste Gas Disposal System is designed to provide adequate radioactive decay storage time for the waste gases and, in addition, provide long term holdup of these gases when either high flow letdown is required or adverse meteorological conditions make it desirable to discontinue release of waste gas to the environment.

Components

One skid mounted catalytic recombiner system is provided. The system includes duplicate full capacity catalytic recombiners, duplicate electric preheaters, one aftercooler-condenser, one moisture separator, duplicate recycle blowers, duplicate hydrogen analyzers of the thermal conductivity type, for the recombiner influent and effluent, duplicate oxygen analyzers of the paramagnetic type on the recombiner effluent, a single oxygen analyzer on the recombiner influent, and one bleed stream cooler. The recombiner system operates at approximately 22 psia and has a feed capacity of 1.15 scfm. The dilutent is nitrogen. The catalytic recombiner system will be designed according to Section IIIC of the ASME Code for Boiler and Pressure Vessels.

Waste Gas Surge Tank

One waste gas surge tank with 15.7 cu. ft. capacity is provided. This tank is operated at a pressure of approximately 10 to 20 psia. The tank is fabricated from austenitic stainless steel in accordance with Section IIIC of the ASME Code for Unfired Boiler and Pressure Vessels.

Waste Gas Compressor

Two waste gas compressors of the diaphragm type are provided. Each has a capacity of 1.5 scfm and is capable of producing 120 psig. The compressor heads are leak tested to insure that the leakage does not exceed a predetermined amount.

Waste Gas Decay Tank

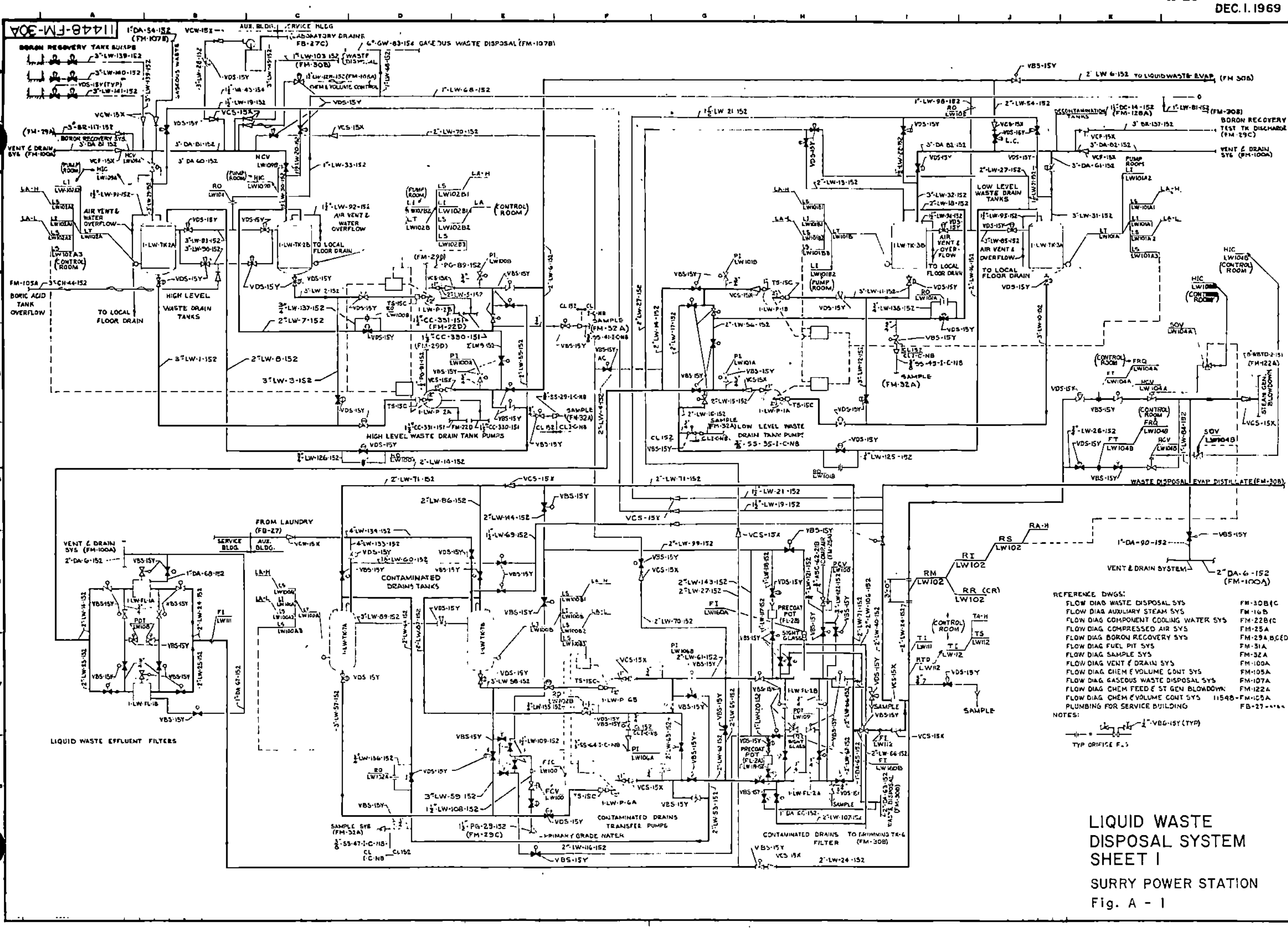
Two buried waste decay tanks are provided. These tanks have double wall construction with feed and bleed lines, sample nitrogen purge, drain and relief valve lines to the inner tank, and sample, nitrogen purge, drain, and relief valve lines from the outer tank. An access opening is provided to the inner tank. In addition, adequate grounding and corrosion protection is provided. The inner tank is fabricated from stainless steel in accordance with Section IIIC and the outer tank from carbon steel in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code.

Process Vent Blower

Two full capacity dilution air blowers of 300 cfm capacity at 2 psia are provided. The blowers are the centrifugal type located in the field fabricated box with the blower suction from the box's interior. Some inleakage is tolerated.

Charcoal Filters

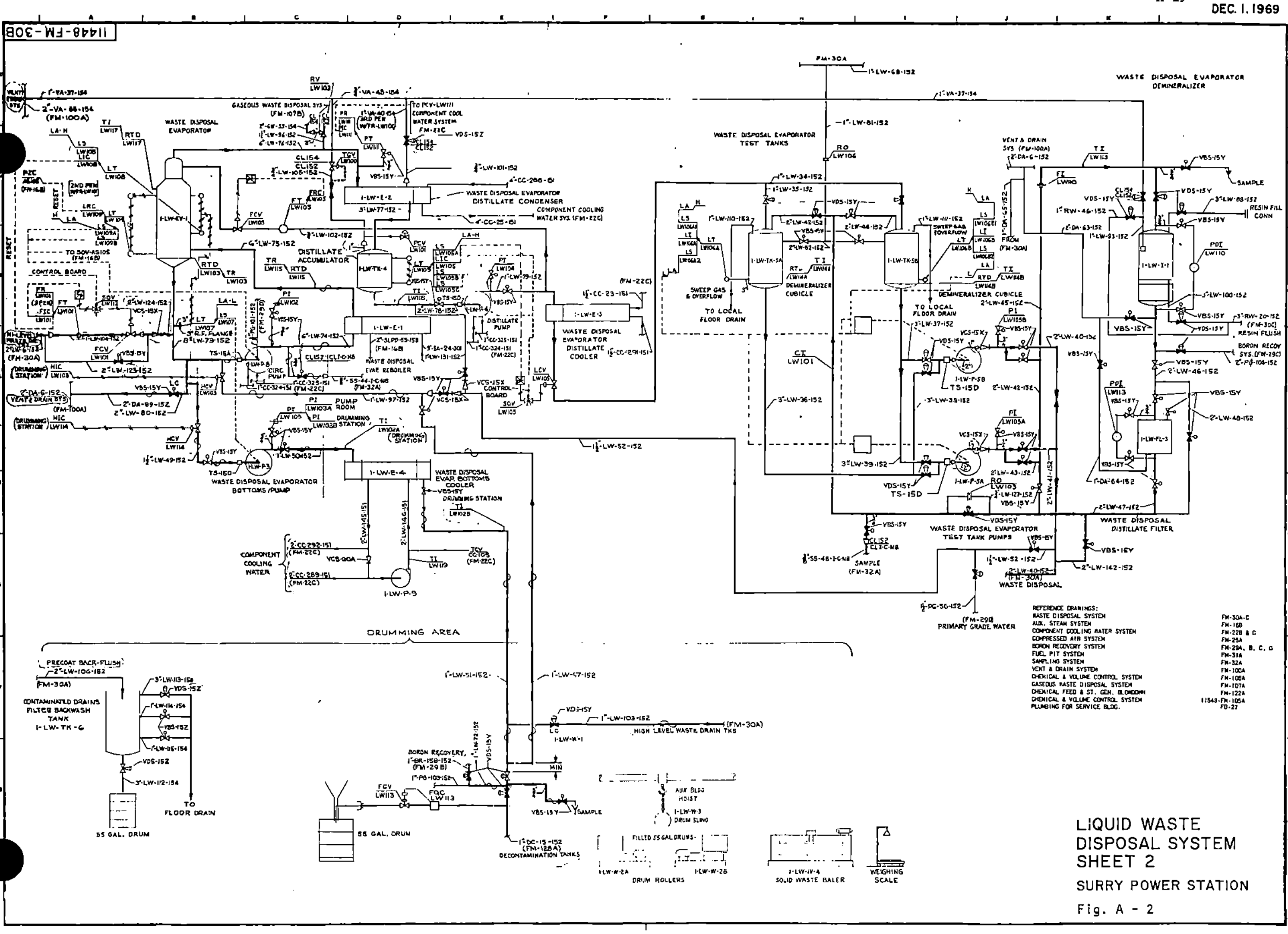
Two charcoal filter beds are provided to service approximately 300 scfm radioactive gas. The filters are maintained at a subatmospheric pressure.



LIQUID WASTE DISPOSAL SYSTEM SHEET I

SURRY POWER STATION

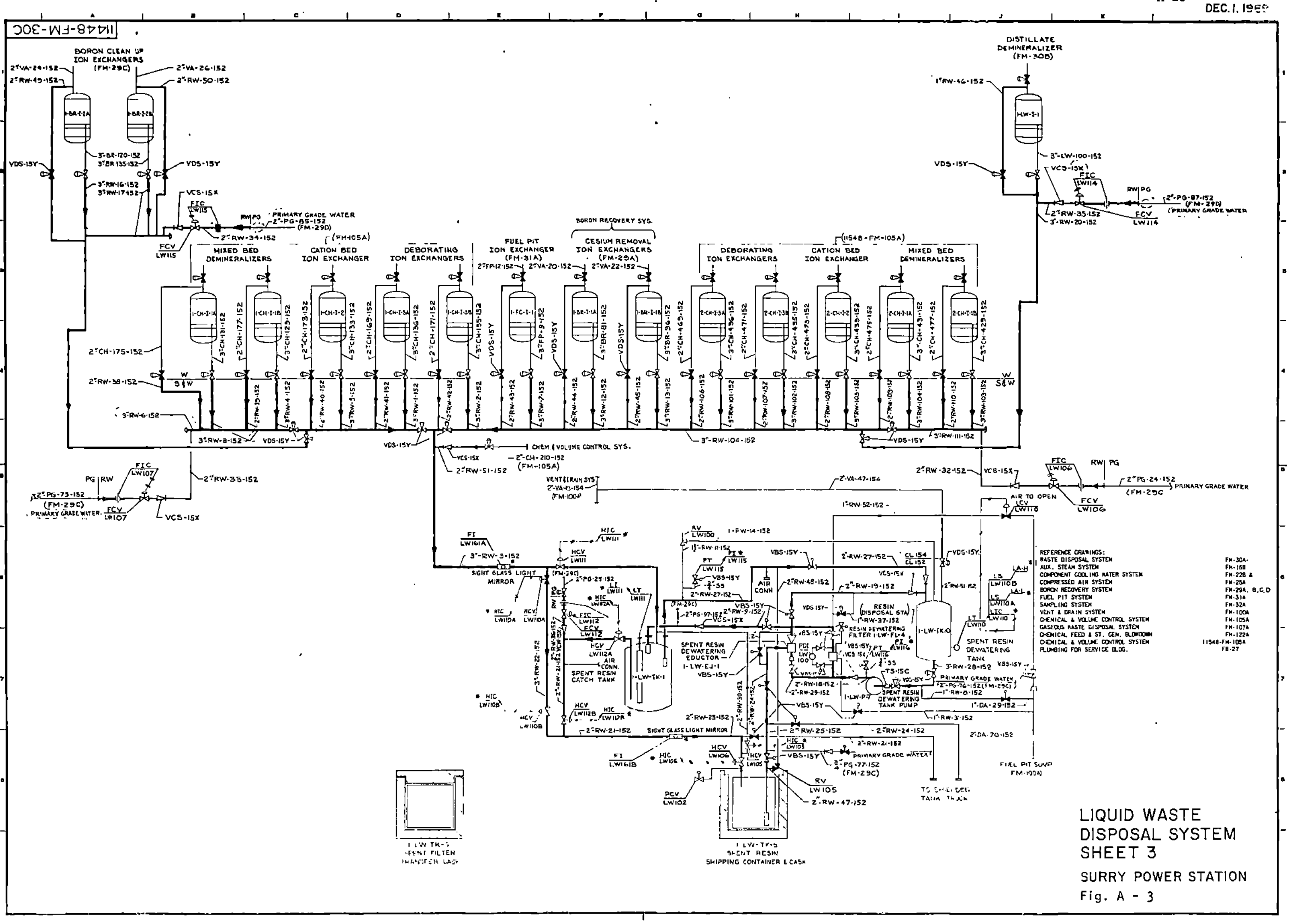
Fig. A - 1



LIQUID WASTE DISPOSAL SYSTEM SHEET 2

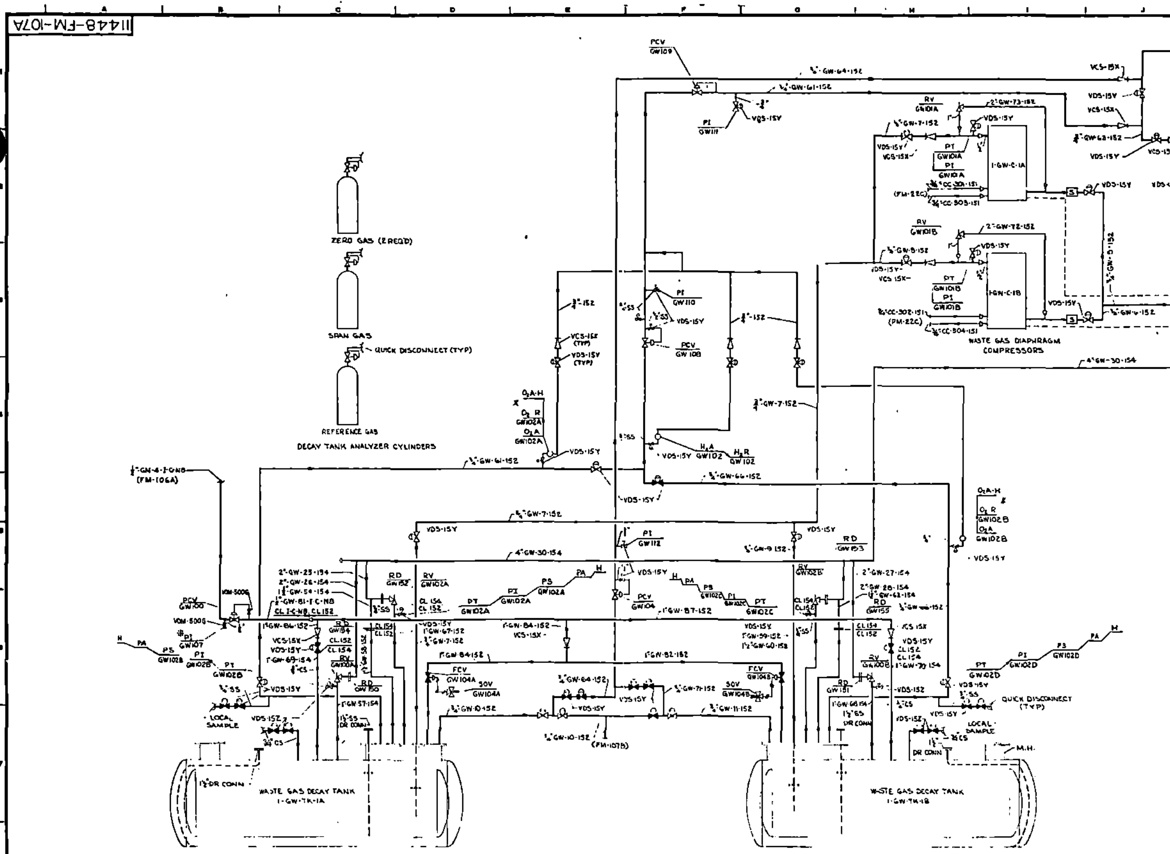
SURRY POWER STATION

Fig. A - 2



LIQUID WASTE
DISPOSAL SYSTEM
SHEET 3
SURRY POWER STATION
Fig. A - 3

11448-FM-107A

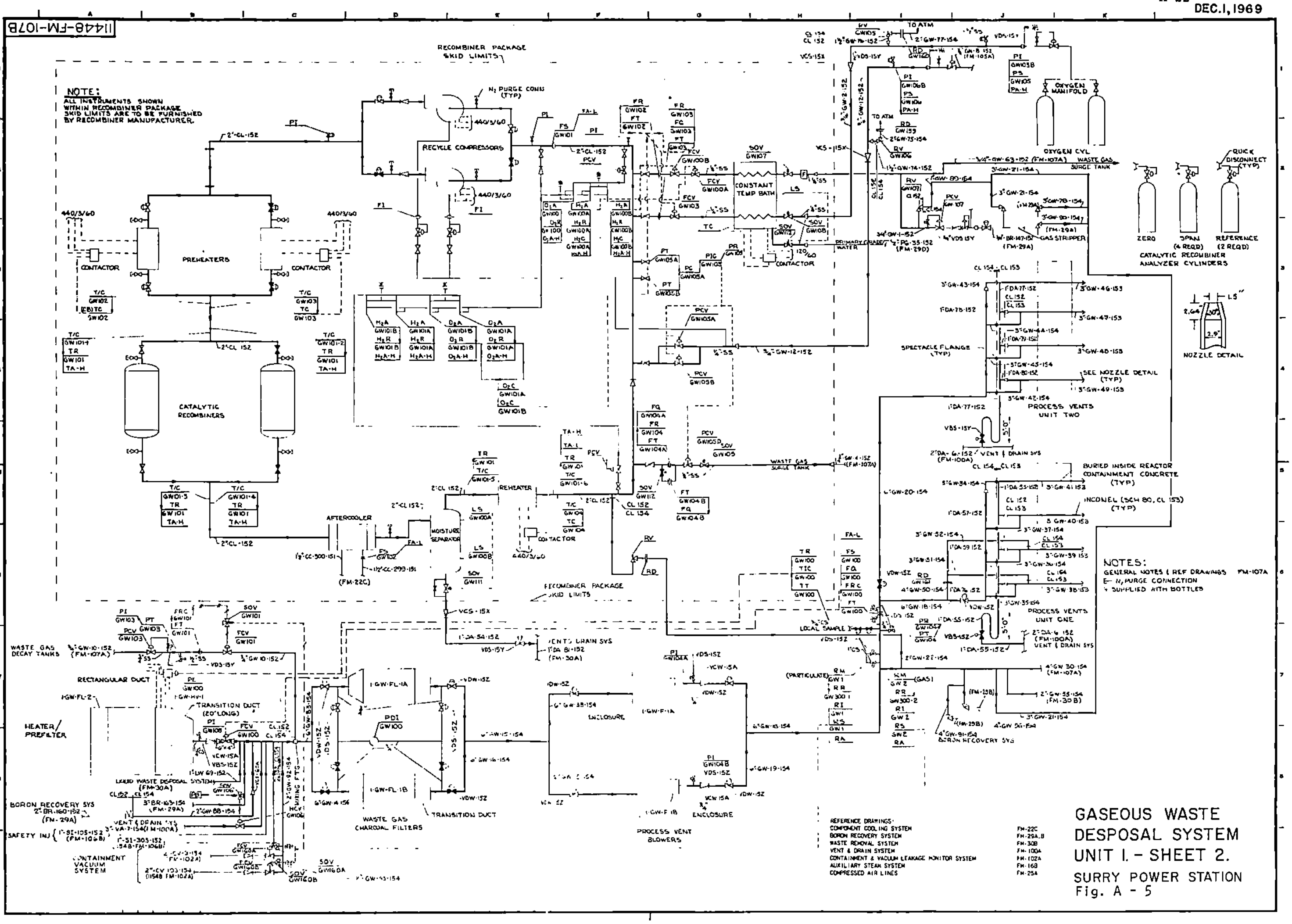


NOTES:
PRESS CONN ON CL 154 TO BE ¾" WITH VDS-15Z
PRESS CONN ON CL 152 TO BE ¾" WITH VDS-15Y
X INDICATES ZERO, SPAN & REFERENCE GAS CONNS.
= FLOW ORIFICE = VDS-15Y (TYP)
* SUPPLIED WITH BOTTLES

REFERENCE DWGS:

FLOW DIAGRAM –	COMPONENT COOLING WTR SYS	FM-22C
	BORON RECOVERY SYS	FM-29A, B
	WASTE DISPOSAL SYS	FM-30B
	VENT & DRAIN SYS	FM-100A
	CONTAINMENT & VACUUM LEAKAGE MONITOR SYS	FM-102A
	AUXILIARY STEAM SYS	FM-16B
	COMPRESSED AIR LINES	FM-25A

GASEOUS WASTE DISPOSAL SYSTEM
UNIT 1. – SHEET 1.
SURRY POWER STATION
Fig. A - 4



GASEOUS WASTE DESPOSAL SYSTEM
UNIT I. - SHEET 2.
SURRY POWER STATION
Fig. A - 5

APPENDIX B

TEMPERATURE DISTRIBUTION IN THE JAMES RIVER ESTUARY WHICH WILL RESULT FROM THE DISCHARGE OF WASTE HEAT FROM THE SURRY NUCLEAR POWER STATION

and

DISTRIBUTION OF EXCESS TEMPERATURE IN THE JAMES RIVER ESTUARY ADJACENT TO THE SURRY NUCLEAR POWER STATION FOR WINTER CONDITIONS

Temperature Distribution in the James River Estuary Which Will Result From the Discharge of Waste Heat From the Surry Nuclear Power Station

A Report Prepared for

Virginia Electric and Power Company
Richmond, Virginia

As Part of the

Surry Nuclear Power Station Site Study

Prepared by
Pritchard-Carpenter, Consultants
208 MacAlpine Road
Ellicott City, Maryland

Background

The Virginia Electric and Power Company is constructing a nuclear power station on the James River estuary. The site of this station, called the Surry Nuclear Power Station, is located approximately 30 miles above the mouth of the James River at Old Point Comfort and 55 miles below Richmond, Virginia. This 85-mile stretch of the river is subjected to tidal motion, and hence is a tidal estuary. It is usual to designate that part of the tidal waterway between the mouth and the point of most upstream intrusion of measurable ocean salt as the estuary proper, while the fresh water segment above that point up to the head of tide is called the tidal river.

Hog Point is the northernmost point of a peninsula formed by a large bend in the James River estuary, as shown in Figure 1. The Surry Nuclear Power Station site extends across the central portion of the peninsula, the river forming both the eastern and western boundaries of the site. The peninsula to the north of the site is a low lying area of tidal marshes, tidal channels, and islands which serve as a wild fowl refuge, and terminates at Hog Point.

The eastern boundary of the site, which borders the river along the downstream side of the peninsula, is approximately opposite Deep Water Shoals. The western boundary borders the river on the upstream side of the peninsula at the northeastern end of Cobham Bay. In the following frequent reference will be made to Deep Water Shoals, or downstream, side, and to Cobham Bay, or upstream, side of the site.

The purpose of this report is to present the results of studies made to determine the probable effect of the discharge of waste heat in the condenser cooling water from the Surry Nuclear Power Station on the distribution of temperature in the adjacent James River estuary. It will aid the discussion of the results of the thermal studies, however, to first briefly consider the pertinent features of the hydrography of the estuary.

Hog Point is in the region of transition between the fresh tidal river and the estuary proper. Under conditions of very high river flow fresh water extends downstream of Deep Water Shoals. During periods of moderately high river flow, brackish water extends past Deep Water Shoals to the vicinity of Hog Point, while the Cobham Bay side of the site remains in the fresh water tidal river. Under flow conditions characteristic of most of the year the upper boundary of the estuary proper is located upstream from the Cobham Bay side of the site.

Under all but the most extreme river flow conditions, the oscillatory ebb and flood of the tide constitute the dominant motion in both estuary proper and the tidal river. The net downstream flow required to discharge the fresh water seaward through any cross section represents but a small fraction of the tidal flows.

The James River estuary has been classified in the literature as a partially mixed estuary. In such an estuary the salinity decreases in a more or less regular manner from the mouth toward the head. The salinity also increases with depth at any location. There usually occurs a layer near mid-depth in which the salinity increases more rapidly with depth than is the case in the overlying fresher layer or in the deeper, more saline layer. In spring and summer this intermediate layer is also a region of relatively rapid decrease in temperature with depth.

The upper, less saline, layer has a net non-tidal motion directed toward the mouth of the estuary, while the lower, more saline, layer has a net non-tidal motion directed toward the head of the estuary. The boundary between these layers is generally sloped across the estuary so that the seaward moving surface layer extends to greater depths on the right side of the estuary (looking seaward) than on the left. Under some conditions, particularly in the wider sections of the estuary, the boundary between the counter-flowing layers intercepts the surface, so that there is a net seaward flow surface to bottom on the right side of the estuary (looking seaward) and a net flow toward the head of the estuary on the left side of the estuary.

This net non-tidal circulation pattern involves flow volumes large compared to the river discharge, but still small compared to the oscillatory tidal flow. For example, measurements made in July 1950, at a time when the fresh water discharge at Hog Point was approximately 6000 cfs, showed a net non-tidal, seaward directed flow in the surface layers at Deep Water

Shoals of 18, 000 cfs, and a counter-flow in the deeper layers of approximately 12, 000 cfs (note that the difference in non-tidal flow of the surface and deep layers must equal the river discharge). By comparison, the average volume rate of up-river directed flow during the flood-tide period, and of seaward directed flow during the ebb-tide period amounted to some 130, 000 cfs through the Deep Water Shoals section.

At the time of the above described flow measurements, the salinity at the surface at Deep Water Shoals was about 4.2‰, and at the bottom about 6.1 ‰. At a point farther down the estuary, where the surface and bottom salinities were, respectively, about 11.0‰ and 14.5‰, the net non-tidal seaward-directed flow in the surface layers was observed to be about 24, 000 cfs, or some 4 times the fresh water river discharge. In general, the volume rate of flow of the net non-tidal circulation increases toward the mouth of the estuary.

As the river flow decreases, the salinity distribution moves up the estuary, so that at any location the salinity increases with decreasing river flow. Also, in general, the higher the salinity, the larger the ratio of the net non-tidal flow to the river flow. Thus, within the estuary proper, the water available for dilution of an introduced waste material at a given section does not decrease in direct proportion to the decrease in river flow.

A more detailed description of the hydrology of the estuary is contained in the report "Hydrology of the James River Estuary with Emphasis upon the Ten-Mile Segment Centered on Hog Point, Virginia", previously submitted to the Virginia Electric and Power Company.

Condenser Cooling Water System

In order to convert the thermal energy produced by the reactors into electrical energy, a certain amount of heat must be rejected at the condensers. This waste heat, which for a nuclear power source at current practical efficiencies amounts to approximately 6.8×10^6 BTU$\cdot$hr^{-1} per MW produced electric power, is carried away from the condensers in the condenser cooling water. The volume rate of flow of the condenser cooling water is therefore determined by the design temperature rise at the condensers and the number of MW of electric power the plant is designed to produce.

The studies described in this report were designed to determine the probable distribution of excess temperature in the James River estuary resulting from the discharge of 12×10^9 BTU$\cdot$hr^{-1} of waste heat (corresponding to 1764 MW produced electric power, or two units at 882 MW each), and of 24×10^9 BTU$\cdot$hr^{-1} of waste heat (corresponding to 3528 MW produced electric power, or four units at 882 MW each). A temperature rise at the condensers of 15°F was used in these studies, and hence the volume rate of flow of the condenser cooling water for two units is 3530 cfs and for 4 units 7060 cfs.

The first unit now being constructed at the Surry Nuclear Power Station site is actually sized at 850 MW electrical power, and the heat rejected under full load for this unit will therefore be 5.2×10^9 BTU. Some tests were conducted on the James River estuarine hydraulic model using this heat loading; however, since it is planned that a second unit, perhaps somewhat larger than the first unit, will be added within a few years, and since it may be desirable ultimately to develop the site for 4 units, most of the results presented here are for the higher values of rejected heat given in the previous paragraph.

At the Surry Nuclear Power Station condenser cooling water is to be drawn from the estuary from one side of the Hog Point peninsula and discharged from the other side, thus the intake and discharge are separated by something over a tidal excursion. Tests were conducted both for the intake on the downstream side of the plant site and the discharge on the upstream side, and for the opposite arrangement. On the basis of these tests, it was determined that any possible influence of the heated discharge on the environment would be minimized if the condenser cooling water were withdrawn from the downstream, or Deep Water Shoals, side of the plant site and discharged from the upstream, or Cobham Bay, side. The major portion of the data presented here is therefore for this arrangement of intake and discharge.

Description of Thermal Studies

The distribution of excess temperature which will result from the discharge of waste heat from the Surry Nuclear Power Station as presented in the later sections of this report is based on studies conducted on the hydraulic model of the James River estuary located at the U. S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. This model covers the entire tidal waterway from Richmond to the mouth, and also part of the lower Chesapeake Bay. The model has a horizontal scale of 1:1000, and a vertical scale of 1:100. The approximately 90 nautical miles of the estuary are therefore represented by a model about 550 feet long. The time scale of this model is 1:100; hence one day in the prototype occurs in about $14\frac{1}{2}$ minutes in the model.

All pertinent features of tide, current, river inflow and mixing of sea water and fresh water (and hence the distribution of salinity) are properly scaled in the model. Density, temperature and salinity are all scaled 1:1 in this model, and it has been shown that for models of this relative size, the thermal exchange processes at the water surface are also properly scaled.

A model thermal plant was constructed which consisted of a pump, a flow control system, an accurate volume rate of flow gage, electric heaters to simulate the condensers, a temperature sensing and control system to maintain a constant temperature rise of 15°F between intake and discharge. This model plant was set up on the hydraulic model of the James River estuary at the location corresponding to the Surry Nuclear Power Station site.

Tests were conducted during two different periods. The first set of tests were made during the period 29 July through 1 August 1966, and the second series during the period 19 October through 23 October 1966. During the July-August studies, the model was run for a total of 475 tidal cycles, corresponding to approximately 246 days of prototype time. The river inflow at Richmond was maintained throughout this series at a simulated 2000 cfs. One of the main purposes of this first series of tests was to determine the degree of mixing produced by discharging the condenser cooling water as a jet having an initial velocity equal to or larger than the tidal velocity in the estuary. Tests were run with the velocity of the condenser cooling water, at the point of discharge into the waterway, of 2 $ft \cdot sec^{-1}$, 4 $ft \cdot sec^{-1}$, 4.56 $ft \cdot sec^{-1}$, 6 $ft \cdot sec^{-1}$ and 9.15 $ft \cdot sec^{-1}$. On the basis of these studies, it was determined that a discharge velocity of 6 feet per second would be most suitable for design of the condenser discharge structure.

Tests were conducted during this July-August series with a simulated heat rejection at the condensers of $5.2 \times 10^9 BTU \cdot hr^{-1}$, corresponding to a single 850 MW unit, and at $12 \times 10^9 BTU \cdot hr^{-1}$, corresponding to a total of 1764 MW electrical power production. Temperatures in the model were measured using a rapid response thermistor bead mounted on a motor driven trolley structure which ran across the model on a 16-foot long aluminum beam. A single run consisted of setting the beam across the model at a designated cross-section, and running the thermistor sensor across the model to obtain a plot of temperature vs lateral distance made on a strip chart recorder. At each location runs were made each $1\frac{1}{2}$ hours throughout a tidal cycle. During the July-August test series a total of 496 such temperature runs was made.

For the October series improvements were made in the temperature measuring system, so that two thermistor bead sensors were towed across the model on each run. The sensors were placed 18 inches apart, representing a prototype distance of 1500 feet. Thus near the discharge structure one run provided data for two adjacent temperature cross sections. Farther away from the discharge, where the horizontal temperature gradients were small, the two simultaneous sections provided a check on the consistency of the data. During the October studies the model was run for a total of 784 tidal cycles, corresponding to about 379 days of prototype time. Some 489 temperature runs were made, each consisting of at least one and in many cases two records of surface temperature across a section of the estuary. The locations of the sections at which temperature runs were made are shown in Figure 2. Again, as in the earlier series of tests, runs were repeated at each section for each $1\frac{1}{2}$ hours of the tidal cycle, for each set of test conditions.

Tests were conducted for river inflows at Richmond of 2000 cfs and 6000 cfs, and for heat rejected at the condensers of 12×10^9 $BTU \cdot hr^{-1}$, corresponding to two 882 MW units, and of 24×10^9 $BTU \cdot hr^{-1}$, corresponding to 4 such units. Most of the tests were run with the intake on the Deep Water Shoals side of the plant site, and the discharge on the Cobham Bay side, as marked in Figure 2. One set of tests were, however, run with the intake and discharge reversed.

During the October studies a special test was made to determine the surface heat exchange coefficient for the model. For this test Cobham Bay was blocked off from the rest of the model using a long rubber dam. Motor driven paddle wheels were mounted in the enclosed area to circulate the water at a speed corresponding to the mean tidal current. Thermistor bead temperature sensors were placed at several locations in the enclosed water area. Water from this area was circulated through the heaters until the temperature in the enclosed area was 20°F above the ambient water temperature in the adjacent model. A temperature-time record was then made as the water in the enclosed basin cooled. The rate of cooling provided a measure of the surface heat exchange coefficient.

With the tests in the model running over several days during each series, the base or ambient temperature of the water in the model varied during the tests. It was therefore necessary to monitor the water temperature in the model in areas which were sufficiently removed from the plant site so that the temperature of these areas represented the ambient water temperature. During both series of tests, fixed thermistor bead temperature sensors were therefore placed in the model at positions well upstream and well downstream from the plant site.

Treatment of Temperature Data; Some Theoretical and Empirical Relationships

In the following the term excess temperature is used to designate the incremental increase in temperature of the water at a given point in the estuary over that which would occur if there were no discharge of waste heat to the estuary. Thus, if T_h represents the temperature of the water at a given position in the estuary under conditions of waste heat discharge, and T_n represents the temperature which would occur under natural conditions, then

(1) $\Theta = T_h - T_n$

defines the excess temperature, Θ.

Designating Q_h as the rate of introduction of waste heat into the condenser cooling water, Q_c as the volume rate of flow of the condenser cooling water, and Θ_o as the temperature rise at the condensers, then

(2) $Q_h = \rho C_p \Theta_o Q_c$

where ρ is the density of the water and C_p is the specific heat at constant pressure. Further, if H_n designates the heat content per unit volume of a water parcel under natural conditions, and H_h designates the heat content per unit volume of that water parcel under conditions of discharge of waste heat to the waterway, then

(3) $h = H_h - H_n$

defines the excess heat content, h. Also,

(4) $h = \rho C_p \Theta$.

Consider a small parcel of water at the surface, having a vertical thickness D_h. This parcel will gain or lose heat through the sides and bottom due to exchange of water with adjacent parcels of different heat content (i. e., the processes of advection and turbulent diffusion). The parcel will also gain and lose heat across the water surface due to radiation processes and to exchange processes with the atmosphere. Under steady state conditions, all these gains and losses must be in balance. Hence, for natural conditions, the heat budget of the parcel can be written

(5) $(Q_s)_n - (Q_r)_n + (Q_a)_n - (Q_b)_n - (Q_e)_n - (Q_t)_n + (Q_v)_n + (Q_d)_n = 0$

where: Q_s = incident solar radiation on the water surface

Q_r = reflected solar radiation at the water surface

Q_a = long wave atmospheric radiation adsorbed by the water

Q_b = long wave radiation emitted by the water surface

Q_e = heat carried away from the surface by evaporation

Q_t = heat loss from water surface to atmosphere by conduction

Q_v = heat gained by advective processes

Q_d = heat gained by processes of turbulent diffusion

A similar expression can be written for the case of introduction of waste heat to the waterway. Thus:

(6) $(Q_s)_h - (Q_r)_h + (Q_a)_h - (Q_b)_h - (Q_e)_h - (Q_t)_h + (Q_v)_h + (Q_d)_h = 0$

Now the incoming solar radiation, the reflected radiation and the radiation from the atmosphere will be the same for both cases; that is

$$(Q_s)_n = (Q_s)_h$$

$$(Q_r)_n = (Q_r)_h$$

and $$(Q_a)_n = (Q_a)_h$$

Hence, when equation (5) is subtracted from equation (6), we have

(7) $q_v + q_d - q_b - q_e - q_t = 0$

where

$$q_v = (Q_v)_h - (Q_v)_n \qquad \text{etc.}$$

Equation (7) can be considered to express the budget for the excess heat. Note that this budget is independent of solar and atmospheric radiation.

The last three terms in (7) represent the exchange of excess heat from the water to the atmosphere. The long wave radiation emitted by the surface of a parcel of water is proportional to the fourth power of the absolute temperature of the parcel. Because the difference in absolute temperature between the heated and natural conditions is relatively small, it can be shown that

(8) $q_b \doteq F_1 \cdot \Theta$

where F_1 is a slowly varying function of the ambient temperature, T_n.

The amount of heat lost by evaporation from a parcel of water is given by

$$Q_e = \rho L (a + bW) (e_s - e_a)$$

where L is the latent heat of vaporization, W is the wind speed, e_s the saturated vapor pressure, and e_a the vapor pressure of the air over the water (which in turn is given by $R \cdot e_s$ where R is the relative humidity). Now, since

$$q_e = (Q_e)_h - (Q_e)_n$$

then

(9) $q_e = \rho L (a + b W) \left\{(e_s)_h - (e_s)_n\right\}$

since e_a will be the same for both natural and heated conditions. Thus the rate of excess heat loss by evaporation is dependent on the wind speed, and on the difference between the saturated vapor pressure for the heated and natural conditions. It is not dependent on the relative humidity. Now the saturated vapor pressure over a water surface is dependent only on the temperature of the water surface, and it can therefore be shown that

(10) $(e_s)_h - (e_s)_n \doteq F_2 \Theta$

where F_2 is a slowly varying function of the ambient temperature, T_n, and to a lesser degree, of the excess temperature, Θ.

The sensible heat loss term is related to the evaporative heat loss through the Bowen ratio. It can therefore be shown that

(11) $q_t = F_3(a + bW) \cdot \Theta$

where F_3 is a slowly varying function of the ambient temperature, T_n, and to a lesser degree of the excess temperature, Θ.

Combining these expressions, we have

(12) $q_b + q_e + q_t = \rho C_p \gamma \Theta$

where γ, the surface heat exchange coefficient, is primarily a function of wind velocity, but also varies somewhat with the ambient temperature T_n, and only slightly with the excess temperature, Θ. The various constants which enter the terms comprising γ have been determined. Table 1 is an abbreviated table of γ as a function of wind velocity, ambient temperature, and excess temperature, to show the primary dependence on wind velocity, the secondary dependence on ambient temperature, and the slight dependence on the excess temperature.

Table 1

The surface heat exchange coefficient, γ, as a function of the wind velocity W (miles per hour), the ambient temperature, T_n(°F), and the excess temperature, Θ(°F)

	For Θ = 10° F			For Θ = 2° F		
W \ T_n	40°	60°	80°	40°	60°	80°
0	0.017	0.020	0.022	0.014	0.016	0.017
5	0.040	0.052	0.074	0.034	0.045	0.064
10	0.062	0.085	0.125	0.055	0.075	0.111

Returning to equation (7), it is seen that the excess heat budget can be written

(13) $q_v + q_d + \rho C_p \gamma \Theta = 0$

Now the advective and diffusive terms in this budget (the q_v and q_d) depend on the velocity field, the intensity of turbulence, and on the spatial gradients of the excess temperature, Θ. The hydraulic model is designed to reproduce the prototype velocity field and the intensity of turbulence. The relative pattern of the distribution of excess heat, as shown by the excess temperature isolines as observed in the model, should be applicable to the prototype. However, the model is subject to a different heat exchange coefficient than will prevail in the natural environment. It is therefore necessary to adjust the excess temperature distributions, as observed in the model, to take into account the difference in surface exchange coefficient between model conditions and prototype conditions. The correction procedure is based on the expression:

(14) $(A_\Theta)_2/(A_\Theta)_1 = f\left\{\frac{\gamma_1}{\gamma_2}, \Theta\right\}$

where $(A_\Theta)_1$ is the area inside the isoline of excess temperature Θ for a surface exchange coefficient γ_1; and $(A_\Theta)_2$ is the area inside the isoline of excess temperature Θ for a surface exchange coefficient γ_2. In the region near the discharge, where the highest values of Θ are found, cooling has had little time to act. Hence the areas are to a first approximation independent of γ, and the ratio given in (14) is close to unity. For regions removed from the source, the area within an isotherm is inversely proportional to the surface exchange coefficient. However, since the total heat lost to the atmosphere must in all cases equal the heat rejected at the condensers, the ratio of the areas for the two cases of surface cooling must be, for small Θ, slightly less than the inverse ratio of the surface exchange coefficients. Therefore:

(15) $(A_\Theta)_2/(A_\Theta)_1 \longrightarrow \begin{cases} 1 & \text{for } \Theta \text{ large} \\ n \times \gamma_1/\gamma_2 & \text{for } \Theta \text{ small, where } \underline{n} \text{ is a number slightly less than unity} \end{cases}$

On the basis of available data, we have used the following relationships in converting the temperature data observed in the model to the conditions expected in the prototype

(16) $$\begin{cases} (A_\Theta)_p/(A_\Theta)_m = 1 & \text{for } \Theta \geqslant 0.5\,\Theta_o \\ (A_\Theta)_p/(A_\Theta)_m \doteq 0.9\dfrac{\gamma_m}{\gamma_p} & \text{for } \Theta \leqslant 0.15\,\Theta_o \end{cases}$$

and a linear variation in the ratio for intermediate temperatures.

The procedure in developing the expected distribution of excess temperature for the James River estuary from the data obtained in the model involved the use of the isothermal patterns as observed in the model, with an adjustment to the areas contained within the isotherms in accordance with equation (16).

The Results of the Thermal Studies

The results presented here are based primarily on the data collected during the October test series. A comparison of the results of the two series showed somewhat lower excess temperatures in the August tests, as compared to the October tests, than could be accounted for by the difference in ambient temperature in the two cases. During the August tests the large doors to the building containing the model were generally kept opened, and circulating fans were operating over various areas in the building (although not directly on the test area). The surface exchange coefficient increases rapidly with wind speed at wind speeds near zero. It is likely that the surface exchange coefficient applicable to the August tests corresponded to a finite but unmeasured wind speed. Further, there was an appreciable temperature gradient along the length of the model, and with time during the August series of tests not related to the introduction of waste heat. Hence the precise establishment of a base temperature was difficult for this series.

During the October series, the building was kept closed. Direct measurements of the surface exchange coefficient gave values appropriate for zero wind speeds. The ambient temperature variation in space and time was much less in this series than in the August studies, and the base temperature could be established with considerable confidence.

While the results of the August tests show somewhat better conditions (lower excess temperatures) than the results of the October series, the differences are not of large magnitude. It was felt most appropriate to restrict the presentation here to the data collected under conditions for which the greatest confidence could be placed in the results.

Figure 2 shows the locations of the sections along which temperature data were obtained. The actual observed temperature for each of the sections occupied during the October test series, expressed in terms of excess temperature, Θ, is given in the appendix.

Figures 3 through 34 present the excess temperature distribution as determined for the James River estuary, under conditions of an ambient temperature of 80°F and a wind velocity of 5 mph. The distribution is given as isolines of constant excess temperature, expressed in °C. These figures show the expected excess temperature distribution for the condenser cooling water discharge on the Cobham Bay side of the plant site, and the intake on the Deep Water Shoals side.

For each combination of river discharge and rejected heat, the excess temperature distribution is given for each $1\frac{1}{2}$ hours over a tidal cycle. The conditions of river flow and rate of heat rejection for each set of figures are as follows:

Figure No.'s	River Flow, cfs	Rate of Heat Rejection	(Power Production)
3 through 10	2000	$12 \times 10^9 BTU \cdot hr^{-1}$	(1765 MW)
11 through 18	6000	$12 \times 10^9 BTU \cdot hr^{-1}$	(1765 MW)
19 through 26	2000	$24 \times 10^9 BTU \cdot hr^{-1}$	(3530 MW)
27 through 34	6000	$24 \times 10^9 BTU \cdot hr^{-1}$	(3530 MW)

As stated earlier in this report, tests were also conducted with the intake located on the upstream side of the plant site and the discharge on the downstream side. The distributions of excess temperature for this intake-discharge arrangement, and for a river flow of 2000 cfs and a rate of heat rejection of $12 \times 10^9 BTU \cdot hr^{-1}$ are given for each $1\frac{1}{2}$ tidal hours in Figures 35 through 42. Commercial oyster leases occur just downstream of the discharge on the west side of the river, and also just across the river from the discharge. It is evident that these oyster bars would be subject to considerably higher excess temperatures with the discharge on the downstream side than for the case of the discharge on the upstream side. Discharge of the condenser cooling water to the upstream, or Cobham Bay, side of the plant site has been shown by these studies to provide less possibility of harm to the environment, and further discussion is therefore limited to this discharge arrangement.

A comparison of Figures 3 through 10, which are for a river flow of 2000 cfs, and with Figures 11 through 18, which are for a river flow of 6000 cfs, shows that there is very little difference in the distribution of excess temperature under different river flows. The following factors contribute to this lack of significant dependence on river discharge:

(a) The initial mechanical mixing produced by the jet discharge, which provides for a rapid decrease in the maximum excess temperatures, functions independent of river flow.

(b) Mixing provided by the oscillatory ebb and flood of the tide, which on a single flood tide passes an average of 190,000 cfs past the plant site, is not significantly influenced by river discharge except for very high river flows.

(c) The net new water made available to the tidal segment adjacent to the plant site, as a result of tidal mixing, is relatively constant over a wide range of river discharges. The net flow of new water to the tidal segment is related to the vertical salinity distribution by the following relationship:

$$(17) \quad Q_i = R\left[1 + \frac{S_u}{S_\ell - S_u}\right]$$

where Q_i is the volume rate of inflow of net new water, R is the volume rate of inflow of fresh water (the river discharge), S_u is the mean salinity in the upper layers of the estuary and S_ℓ is the mean salinity of the lower layers of the estuary. Salinity data taken in the model during these thermal studies showed that at the Deep Water Shoals section, for a river discharge of 2000 cfs, $S_u = 11.60‰$ and $S_\ell = 12.52‰$. Hence:

$$Q_i = 2000 + 2000 \times \frac{11.60}{0.92} = 2000 + 25,220 = 27,220 \text{ cfs}$$

For the river discharge of 6000 cfs, the salinity data at Deep Water Shoals gave $S_u = 5.02‰$ and $S_\ell = 6.46‰$. Hence for this river flow

$$Q_i = 6000 + 6000 \times \frac{5.02}{1.44} = 6000 + 20,940 = 26,940 \text{ cfs} .$$

Thus it is clear that the water available for dilution is relatively independent of river flow except perhaps at high river discharges.

An inspection of Figures 3 through 18, which are for a rate of heat rejection of $12 \times 10^9 \text{BTU}\cdot\text{hr}^{-1}$, reveals that the area of the estuary having excess temperatures greater than 5°C is quite small compared to the area of the tidal segment into which the discharge is being made. The size of this area of warmest water is largest at tidal hour $4\frac{1}{2}$ for a river flow of 2000 cfs (Figure 6), when it comprises a plume 3500 yards long with an average width of less than 300 yards. On the average over the tidal cycle, water having surface excess temperatures of 2°C or greater occupies less than one-third of the width of the estuary.

The warmest water is confined primarily to the upper 10 feet of the water column. Only when the excess temperatures are less than 2°C is there likely to be penetration of excess heat to greater depths.

Inspection of Figures 19 through 34, which are for a rate of heat rejection of 24×10^9BTU, corresponding to 3530 MW produced electric power, reveals that while the areas within given isolines of excess temperature are greater for this heat loading than in the case of a rate of heat rejection of 12×10^9BTU, the area of the estuary subjected to warm water is still not excessive. Averaged over the tidal cycle, the area having excess temperatures greater than 5°C occupies less than 14% of the width of the estuary, while the area having excess temperatures greater than 2°C occupies less than half of the width of the estuary.

As discussed earlier in this report, the distribution of excess temperature in the estuary results from a combination of mixing and cooling. The mixing produced by the jet discharge and by the tidal flow is very important in reducing to a minimum the area having excess temperatures which might be of biological significance. Surface cooling alone could not accomplish this rapid reduction in excess temperatures. To see this consider the data given in Table 2. Here the area having excess temperatures greater than a given value, Θ, as determined for the James River estuary for a rate of heat rejection at the condensers of $12 \times 10^9 BTU \cdot hr^{-1}$, is compared to the area of a flow through cooling pond required to reduce the excess temperatures to the given value, Θ, by surface cooling alone. The cooling pond areas are based on the relationship

$$(18) \quad A_\Theta = \frac{Q_c}{\gamma} \ln \frac{\Theta_o}{\Theta}$$

where A_Θ is the area of the cooling pond required to reduce the excess temperature of the condenser cooling water from Θ_o, the temperature rise at the condensers, to the value Θ; Q_c is the volume rate of flow of the condenser cooling water; and γ is the surface heat exchange coefficient. For this comparison, the value of γ has been taken for an ambient water temperature of 80°F and a wind velocity of 5 mph, which are the conditions taken for the estuary. Θ_o in both cases is 15°F (8.33°C).

Table 2

Area (A_Θ) having excess temperatures greater than the given value of Θ, as determined for the James River Estuary and for a Flow Through Cooling Pond, for a Rate of Heat Rejection of $12 \times 10^9 BTU \cdot hr^{-1}$, an Ambient Temperature of 80°F (26.7°C), a Wind Speed of 5 mph, and a Temperature Rise at the Condensers of 15°F (8.33°C)

	Area, A_Θ (ft^2) For	
Θ°C	James River	Cooling Pond
5	0.29×10^7	0.93×10^8
4	1.63×10^7	1.33×10^8
3	2.04×10^7	1.86×10^8
2	4.91×10^7	2.59×10^8
1	1.55×10^8	3.86×10^8

This table shows that the area having excess temperatures greater than 5°C would be over 30 times as large for the case of surface cooling alone as for the case of the James River estuary where mixing and cooling are important. The area in the James River having excess temperatures for this rate of heat rejection of 2°C or greater is only about one-half of the area of a cooling pond required to reduce the excess temperatures to 5°C.

Conclusions

1. The results of the thermal studies in the James River estuarine model for a rate of heat rejection of $12 \times 10^9 BTU \cdot hr^{-1}$, corresponding to 1765 MW electric power production, (Figures 3 through 18) show that only a small portion of the estuarine water in the tidal segment adjacent to the plant site is subjected to excess temperatures which might have biological significance. Averaged over a tidal cycle, the area having excess temperatures exceeding 5°C occupies less than 7% of the width of the estuary. Over 2/3 of the width of the estuary in the tidal segment adjacent to the discharge would have excess temperatures less than 2°C. The highest excess temperature which completely closes a cross-section would be 0.80°C which occurs on only one of the eight distributions over the tidal cycle. The average closing excess temperature over the tidal period is 0.66°C.

2. The excess temperature distribution in the James River estuary adjacent to the Surry Nuclear Power Plant site, as determined for a rate of heat rejection of 24×10^9BTU, reveals that even for this loading there is not an unreasonable use of the estuarine environment as a heat sink. Averaged over a tidal cycle, the area having excess temperatures exceeding 5°C occupies less than 14% of the width of the estuary. Approximately one-half of the width of the estuary in the tidal segment adjacent to the discharge would have excess temperatures less than 2°C. The highest excess temperature which completely closes a cross-section would be 1.09°C, and this occurs on only one of the eight distributions over the tidal cycle. The average closing excess temperature over the tidal cycle is 0.82°C.

3. A condenser cooling water circulating system with the intake on the downstream side of the site and the discharge on the upstream side is more desirable, from the standpoint of the estuarine environment, than the opposite arrangement.

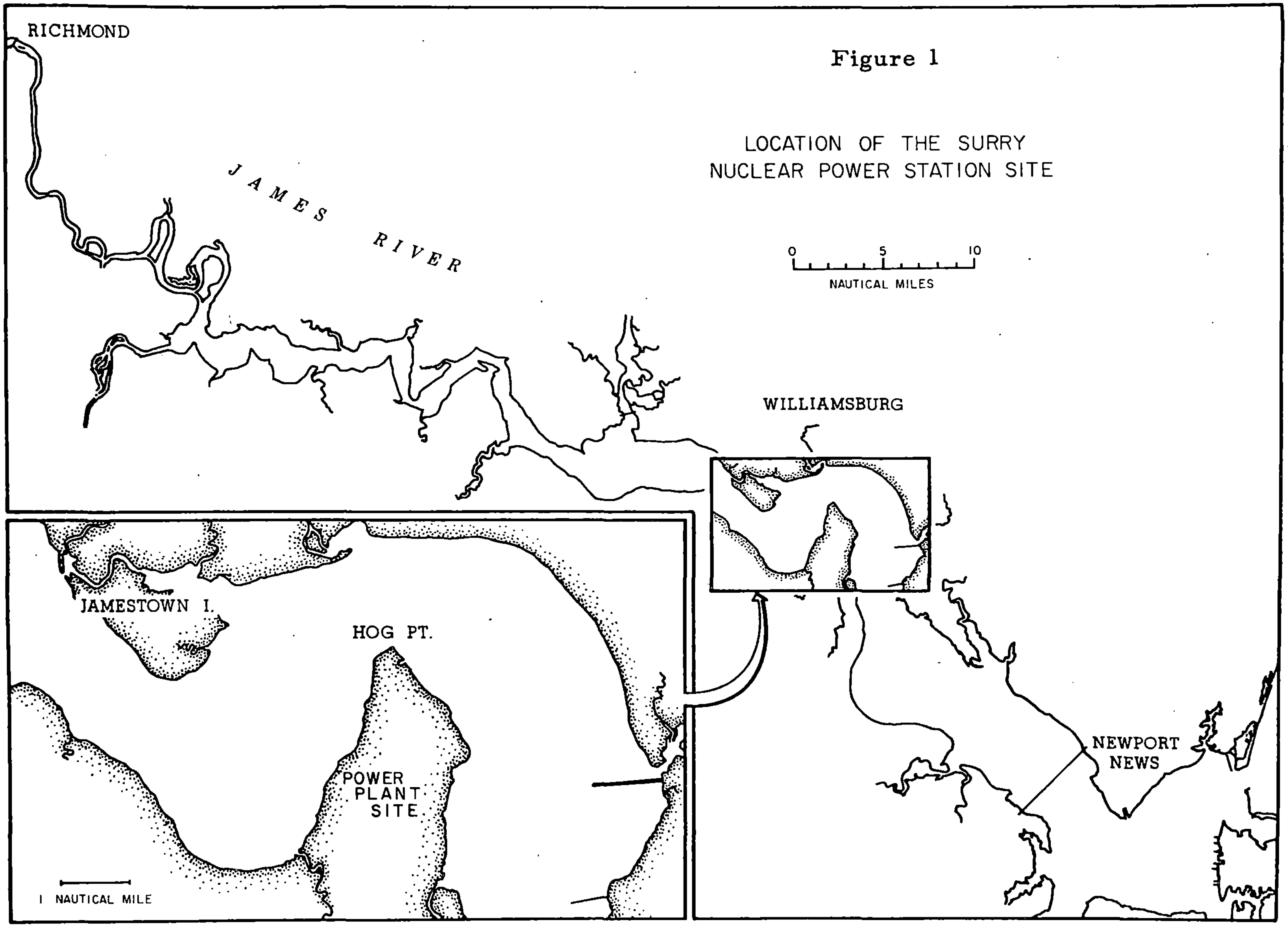
4. The magnitude of the river discharge has little effect on the excess temperature distribution, except perhaps at very high discharges.

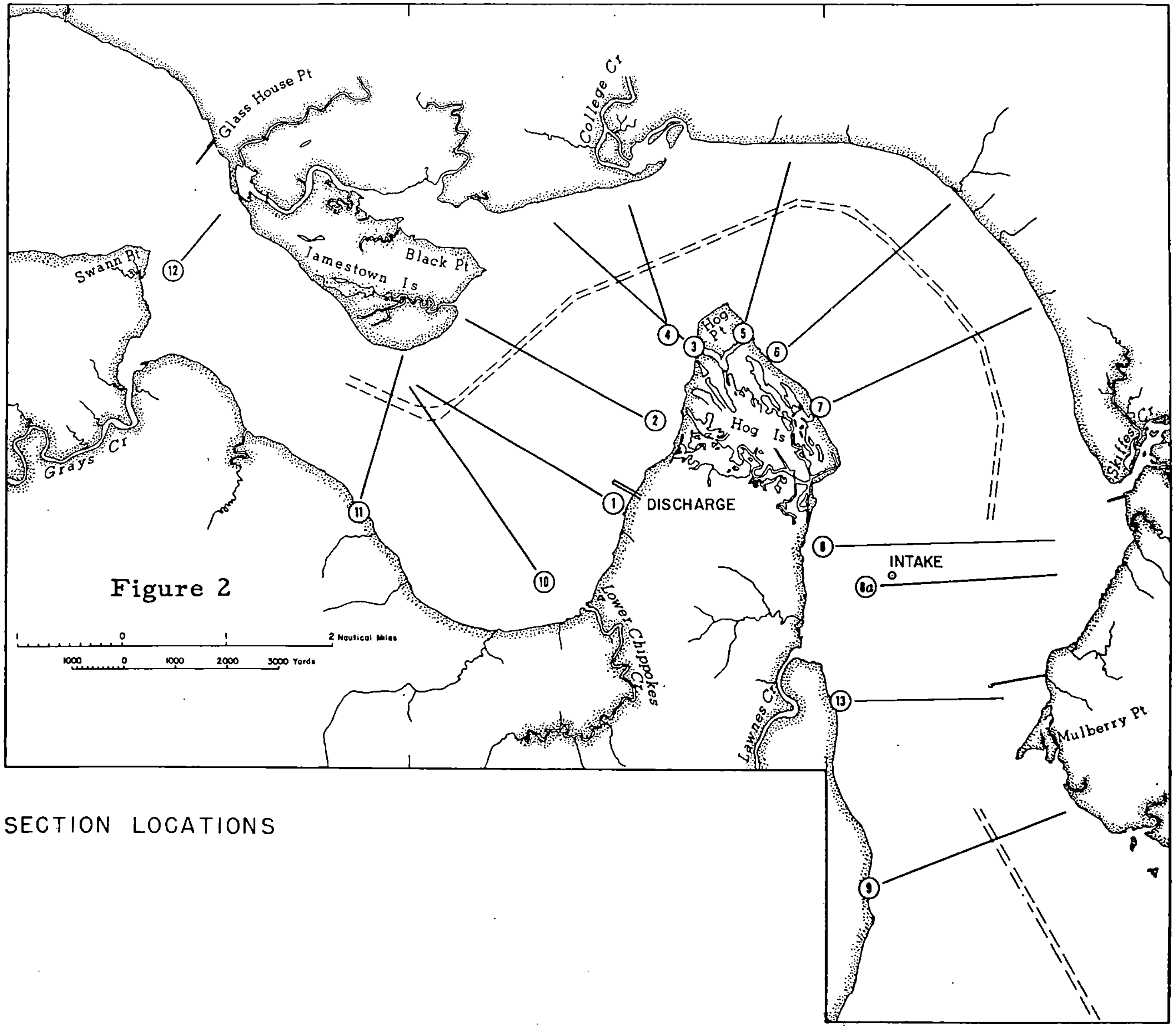
5. The mechanical mixing produced by a jet discharge, and the turbulent mixing resulting from the tidal currents, contribute significantly to reducing the area occupied by the warmest water. Cooling alone would not be sufficiently effective in restricting the area subjected to the warm water to acceptable size.

The attached appendix contains the observed temperature data, as read from the strip chart records, expressed as the difference between the observed temperature in °F and the base, or ambient temperature for the time of each temperature section. These observed excess temperatures are entered along a line representing the section on which the measurements were taken, at a position on the line representing the corresponding position on the section. The section locations are shown in Figure 2.

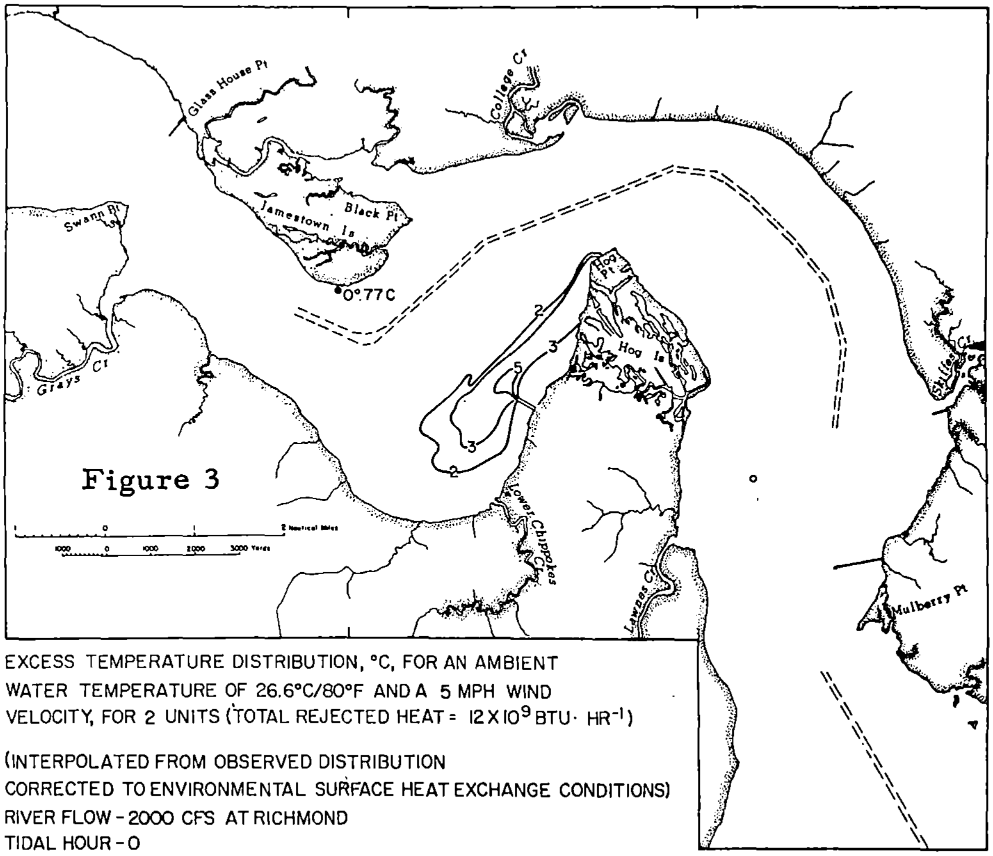
D. W. Pritchard
Consultant

August 30, 1967


RICHMOND
Figure 1
LOCATION OF THE SURRY
NUCLEAR POWER STATION SITE
JAMES RIVER
0
5
10
NAUTICAL MILES
WILLIAMSBURG
JAMESTOWN I.
HOG PT.
POWER
PLANT
SITE
1 NAUTICAL MILE
NEWPORT
NEWS

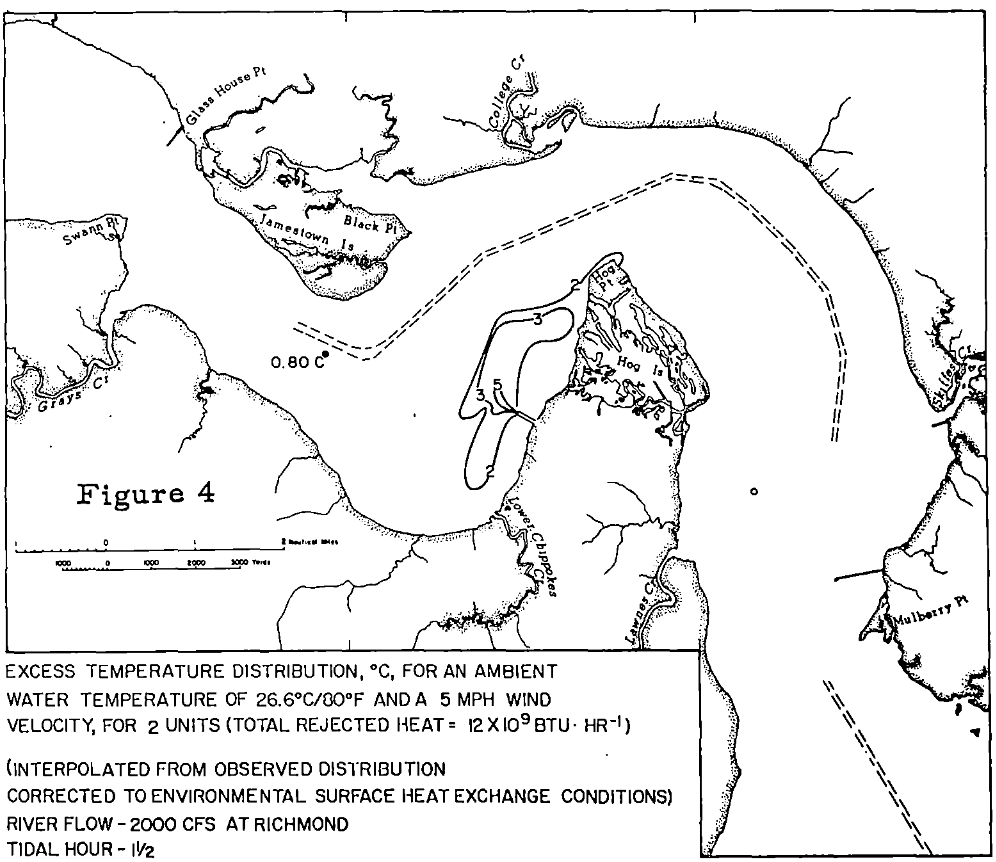


SECTION LOCATIONS



EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU· HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 0



EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU· HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 1½

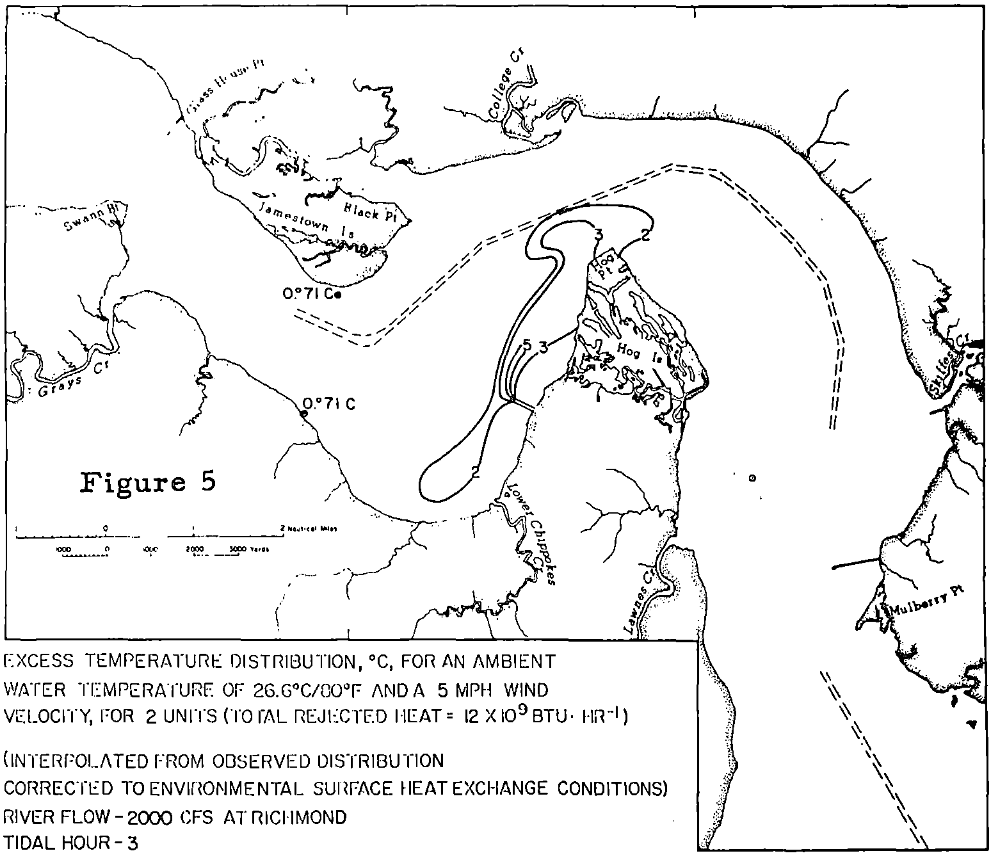


Figure 5

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)

RIVER FLOW - 2000 CFS AT RICHMOND

TIDAL HOUR - 3

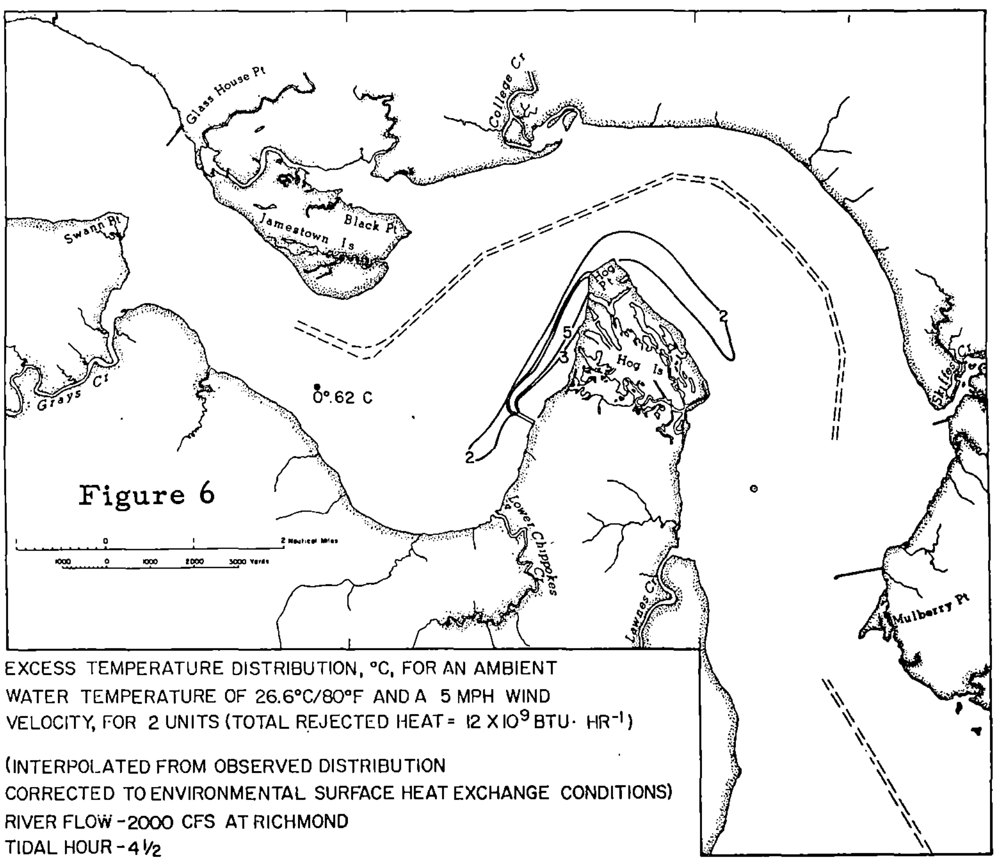


Figure 6

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)

RIVER FLOW - 2000 CFS AT RICHMOND

TIDAL HOUR - 4 1/2

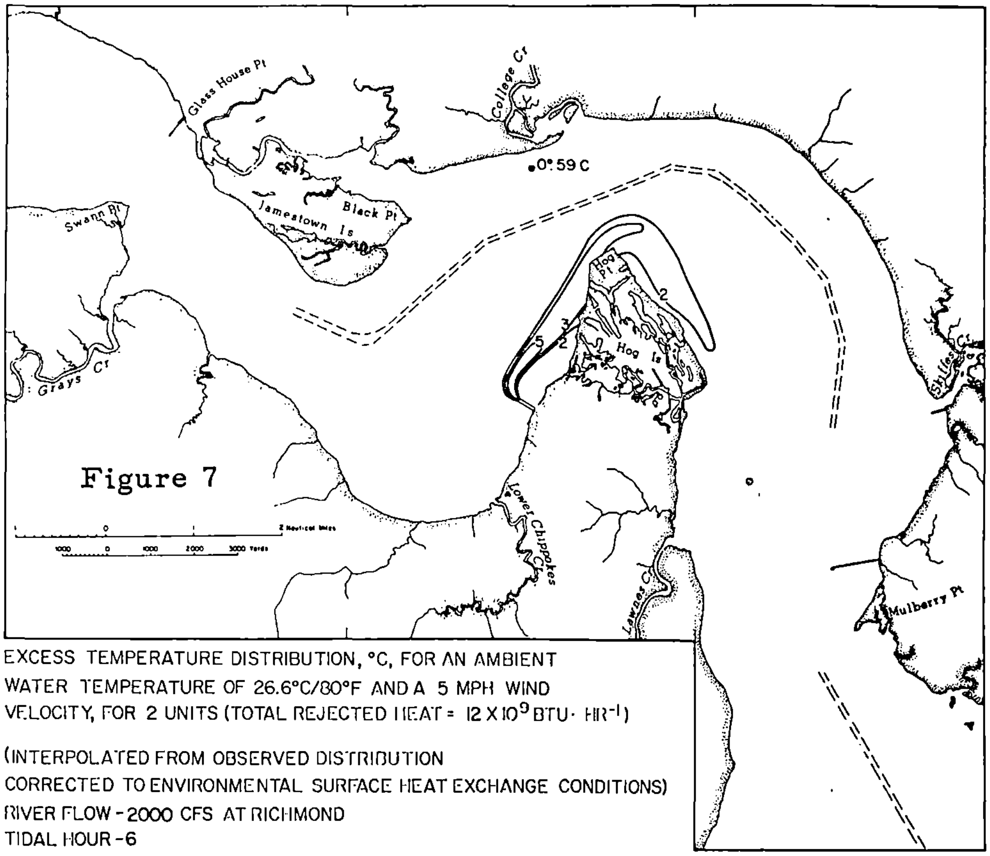


Figure 7

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU· HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 6

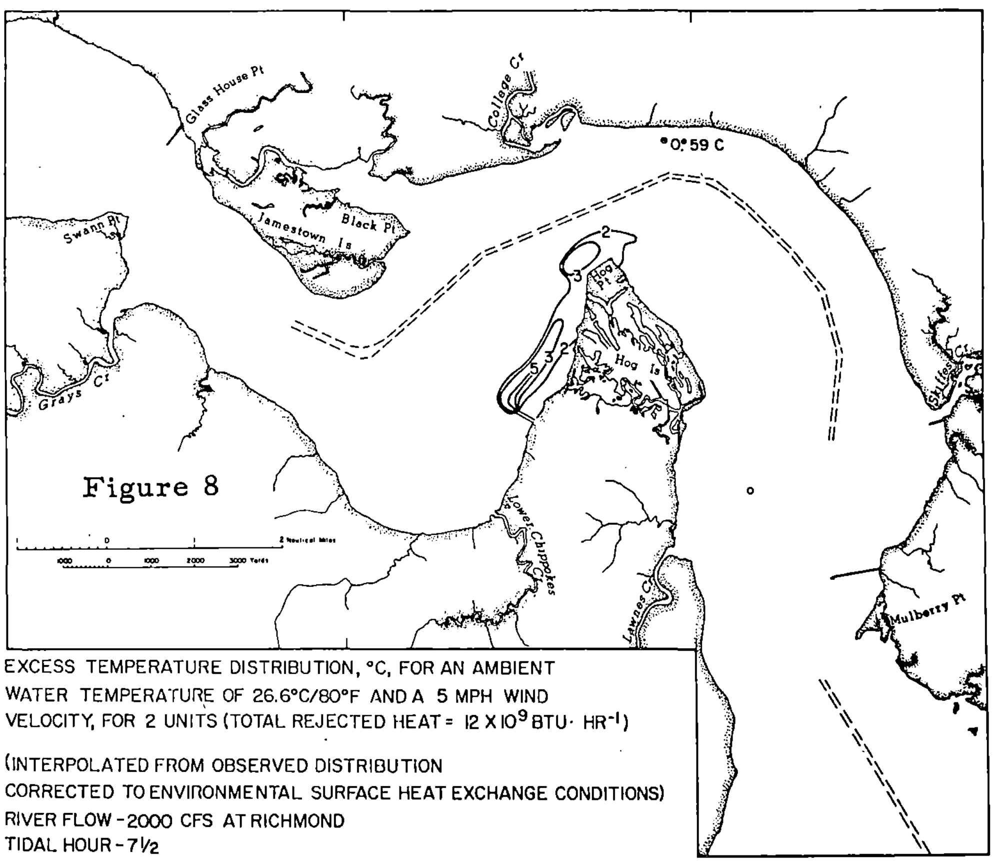


Figure 8

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU· HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 7½

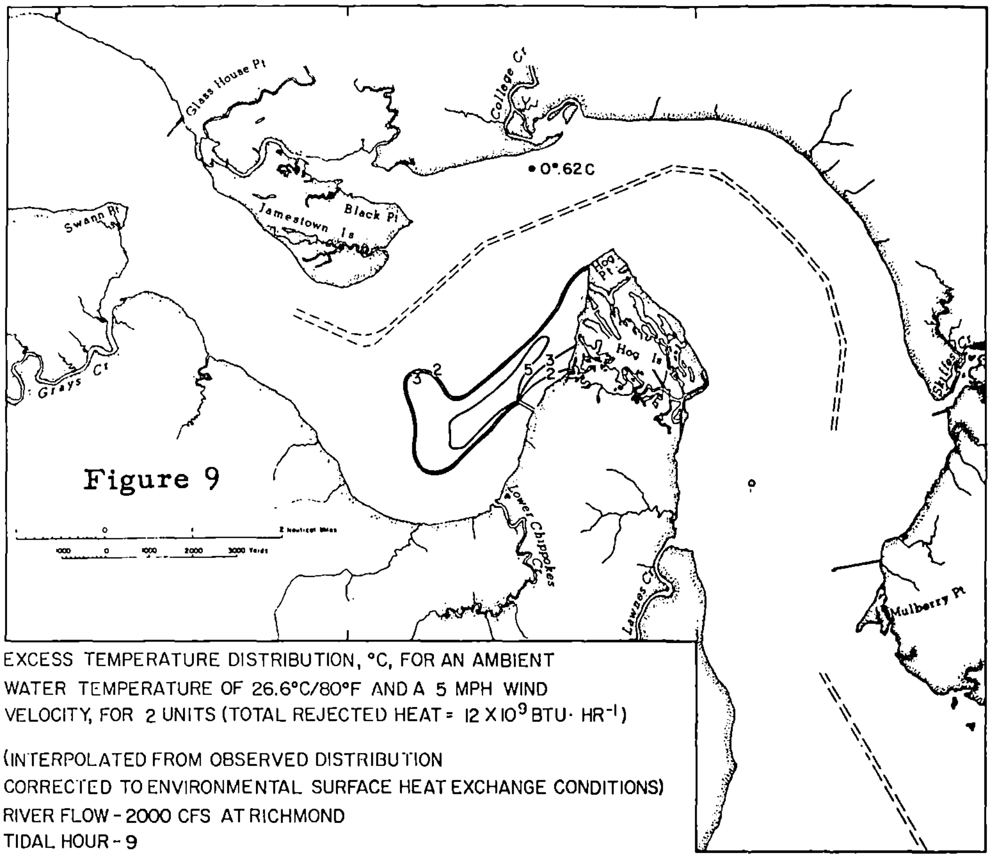


Figure 9

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU· HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 9

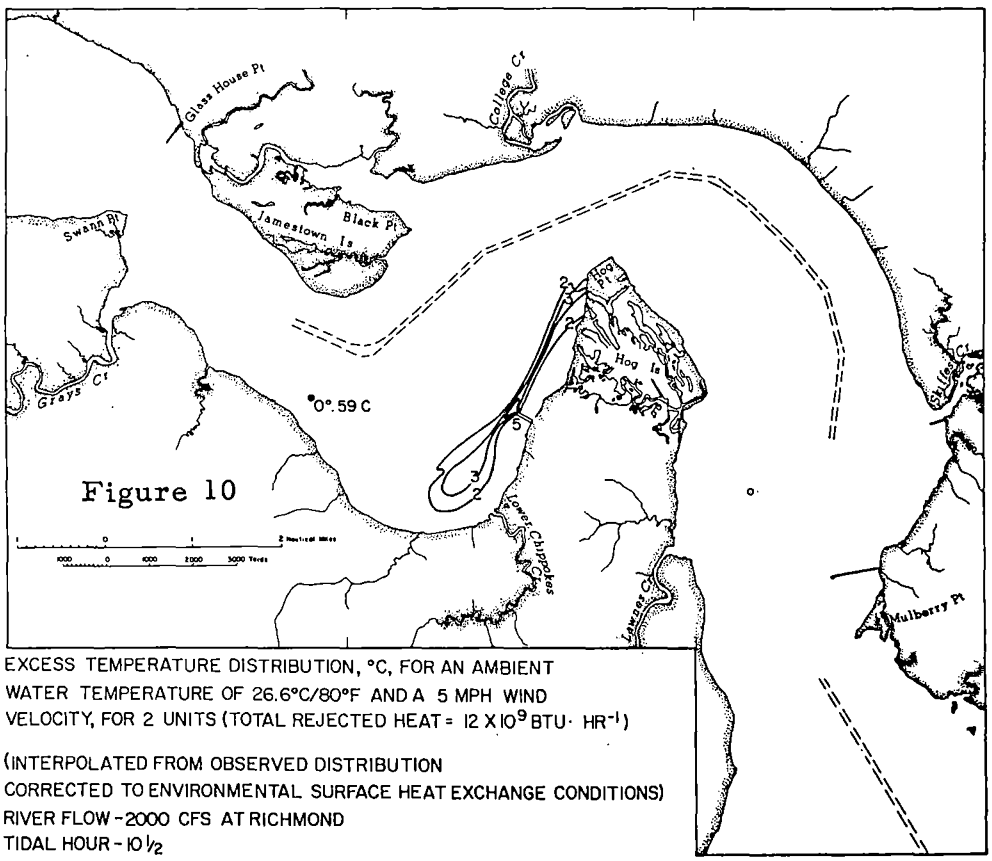
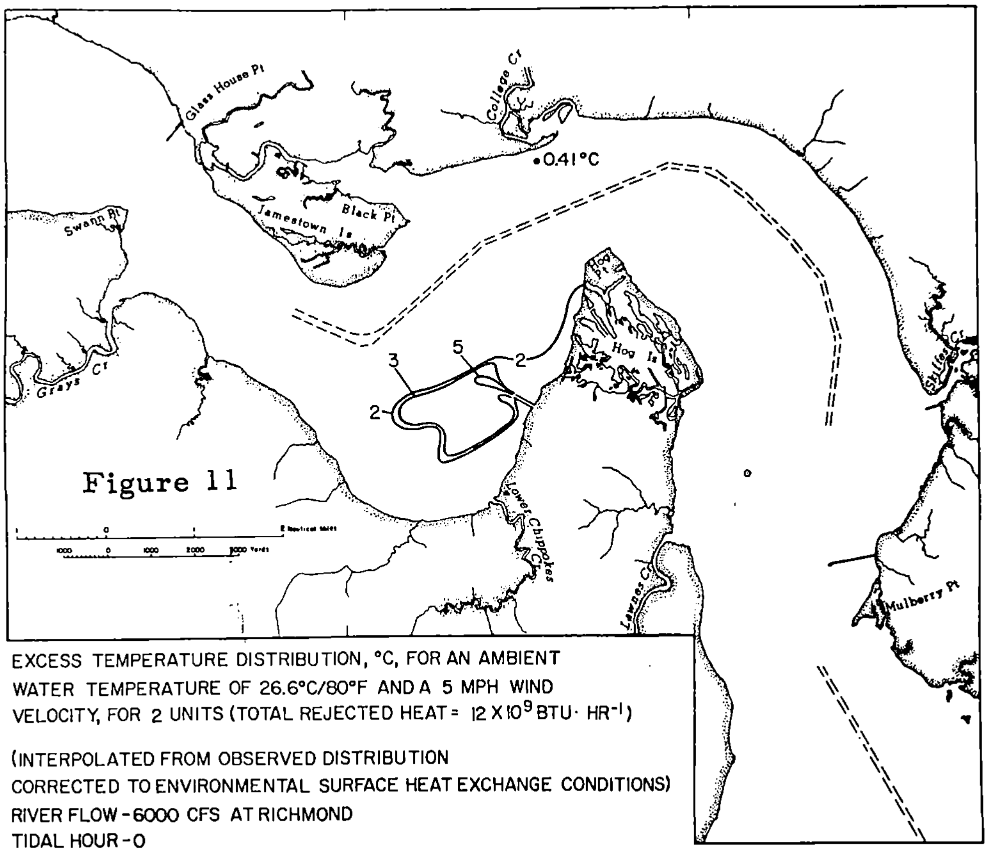


Figure 10

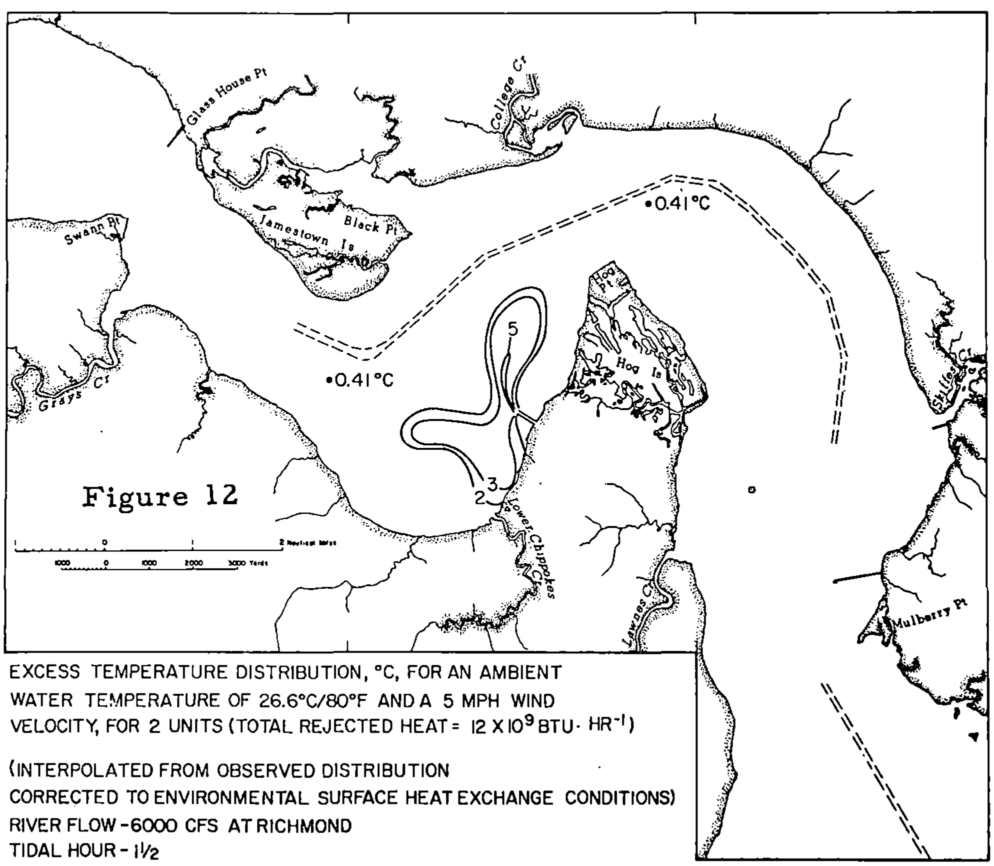
EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU· HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 10 1/2



EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 0



EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 1½

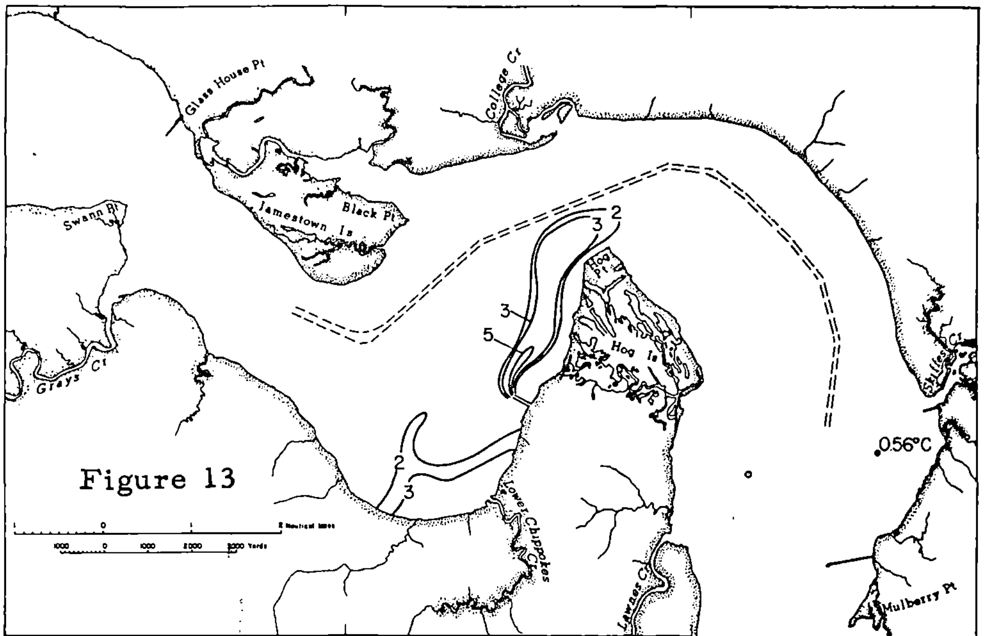


Figure 13

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 3

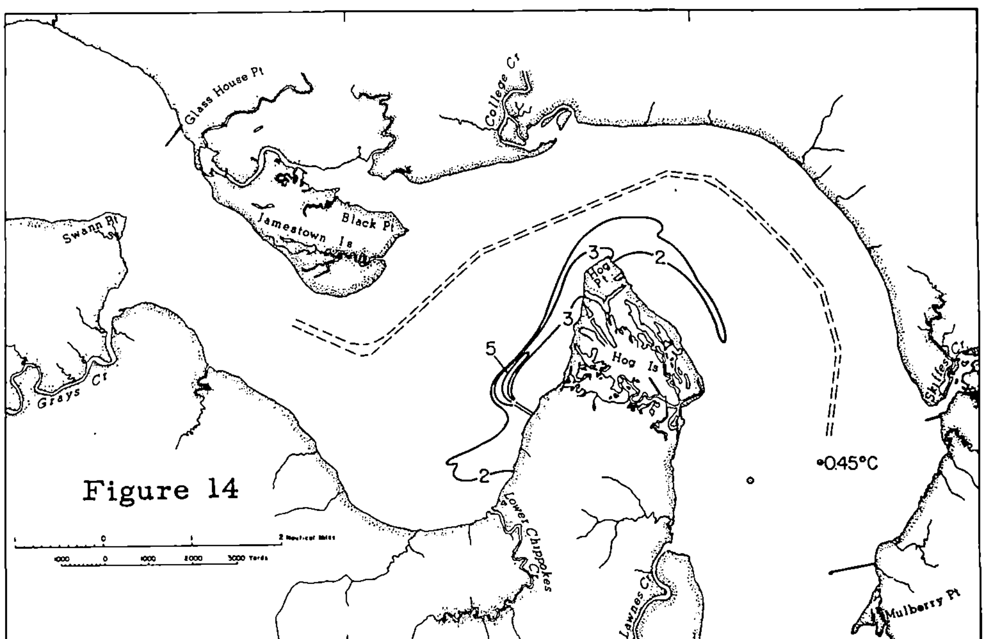


Figure 14

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 4½

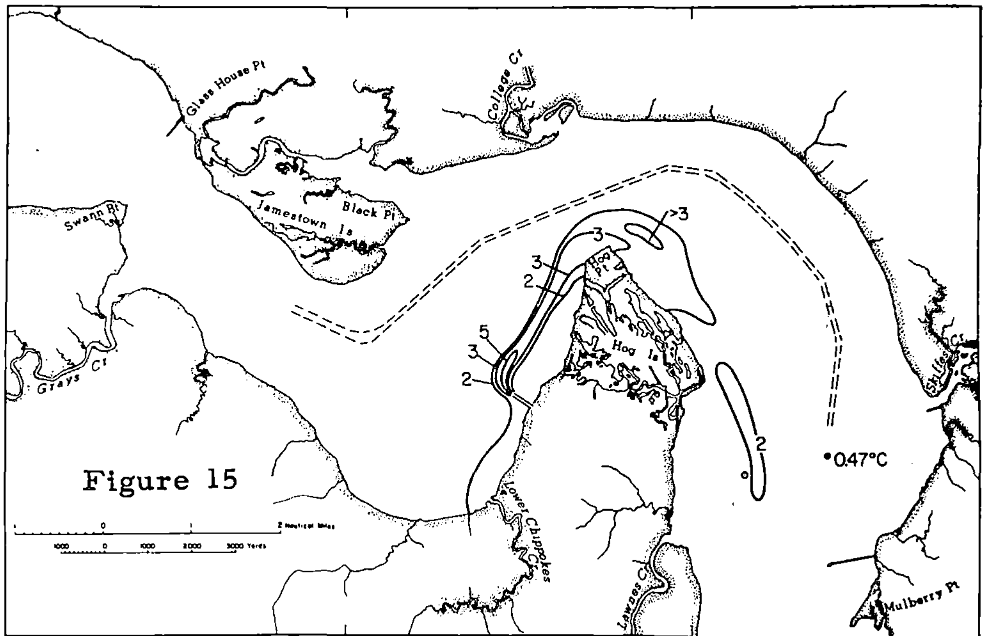


Figure 15

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU· HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 6

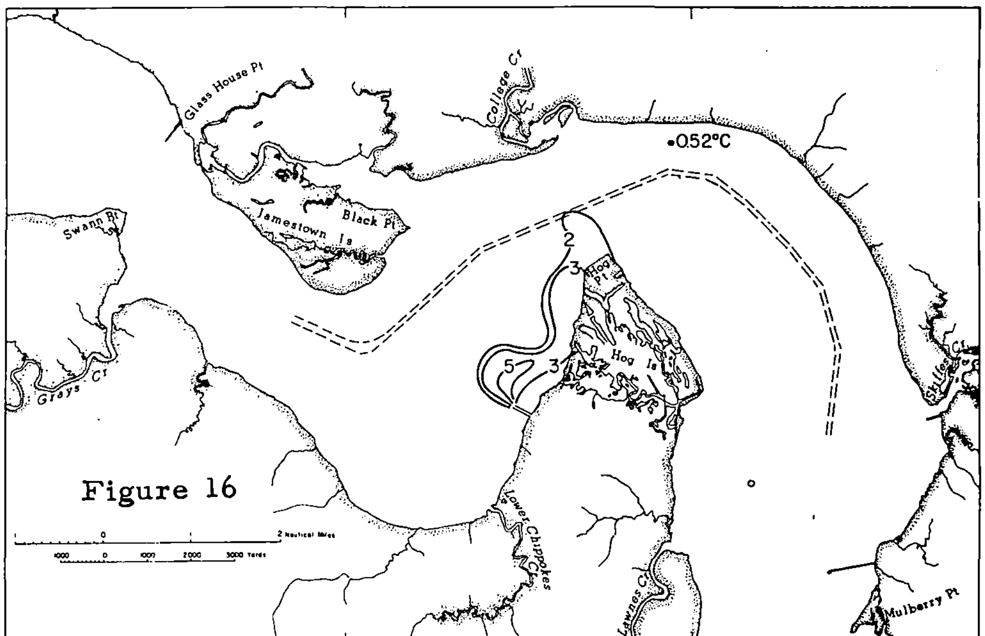


Figure 16

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU· HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 7½

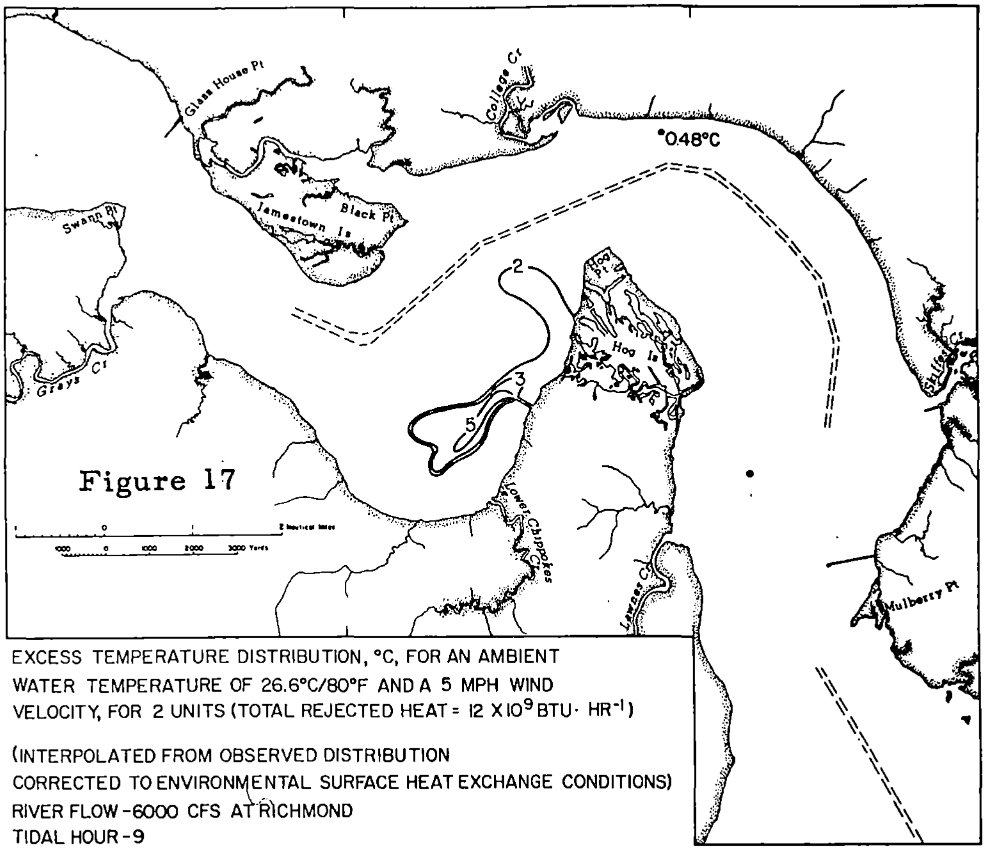


Figure 17

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU $\cdot$ HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 9

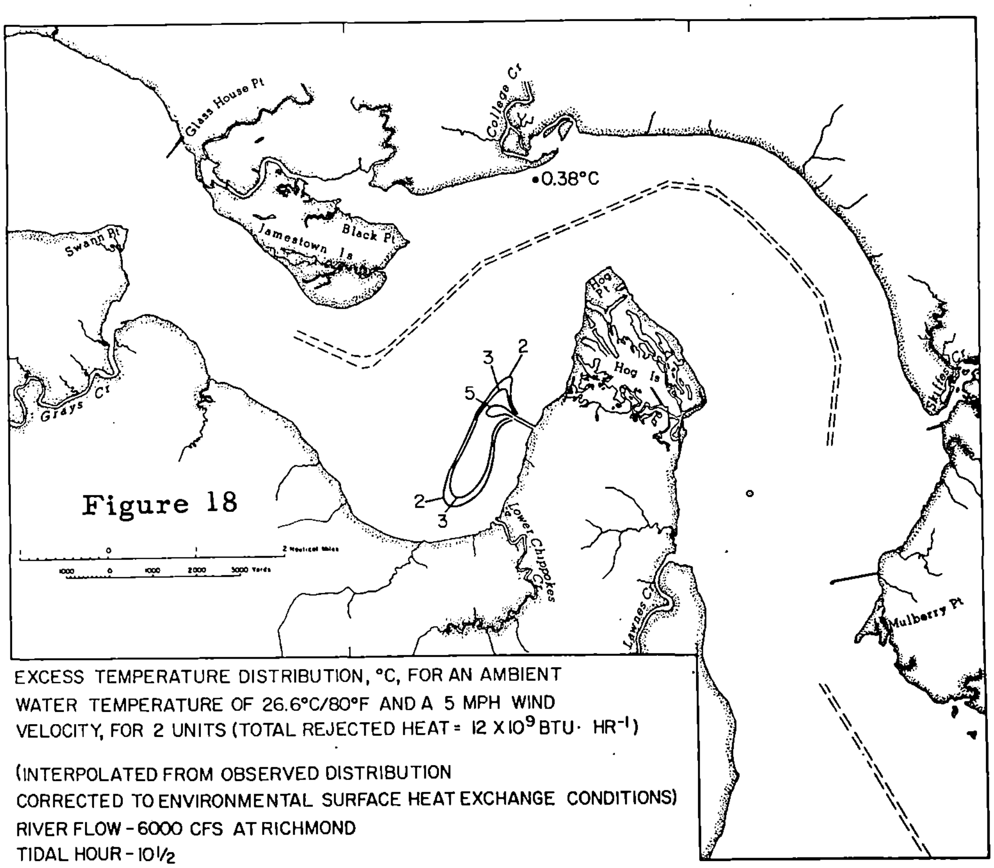


Figure 18

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU $\cdot$ HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 10 1/2

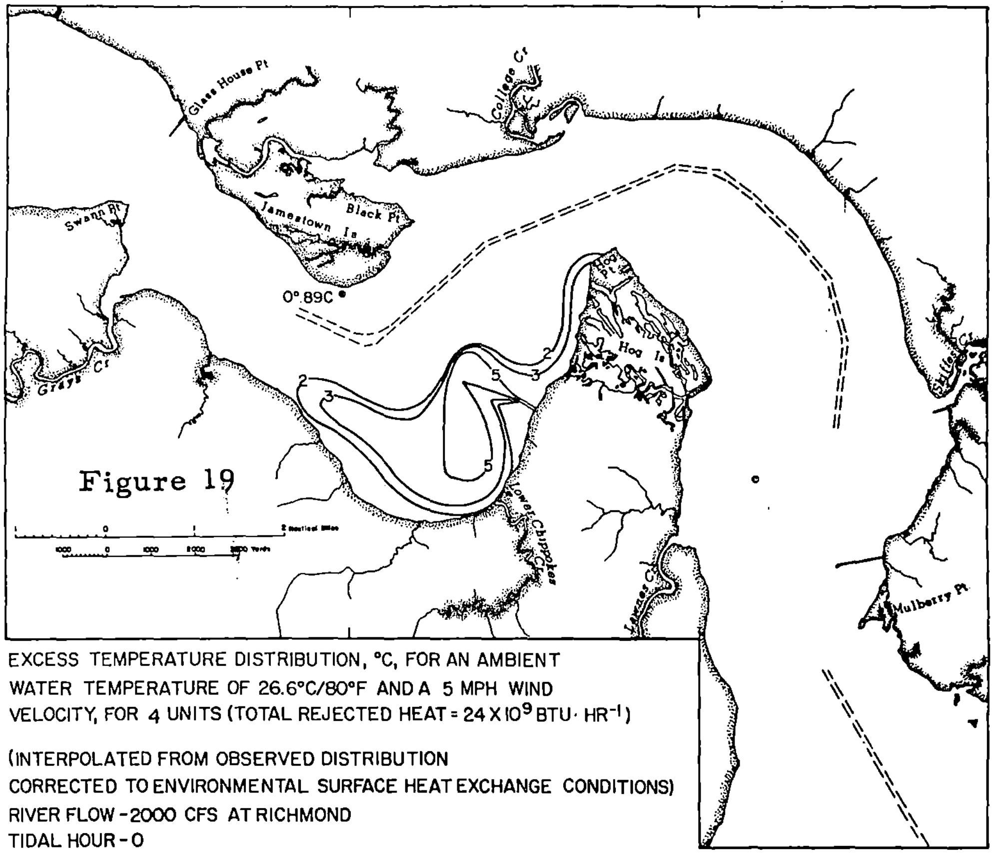


Figure 19

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION
CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 0

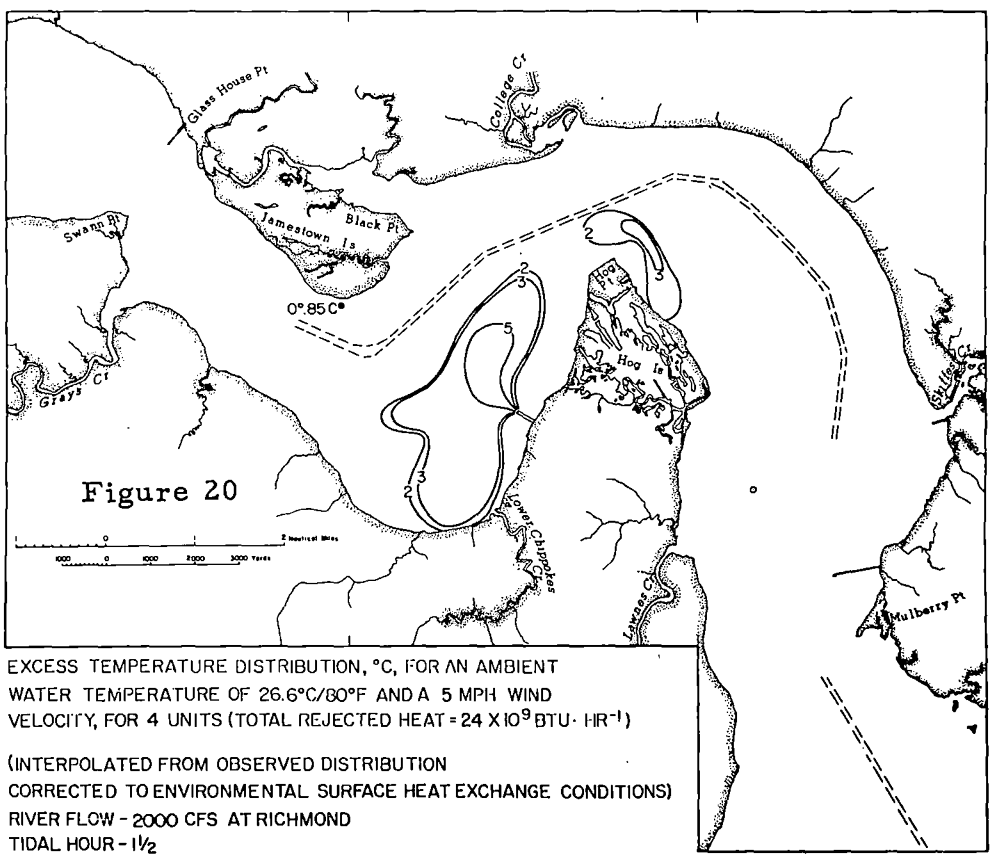


Figure 20

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION
CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 1½

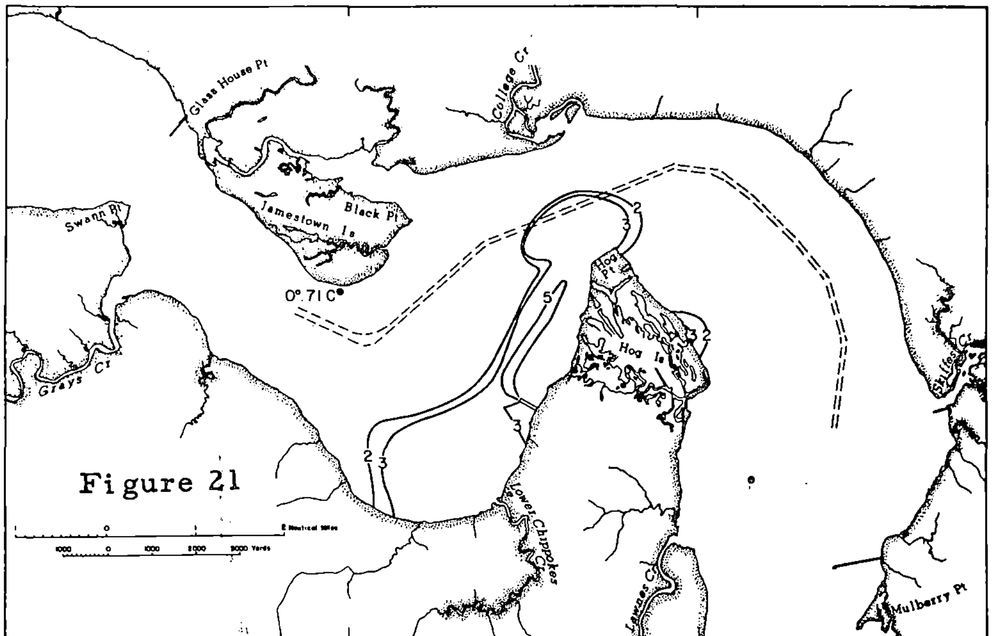


Figure 21

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24 X 10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 3

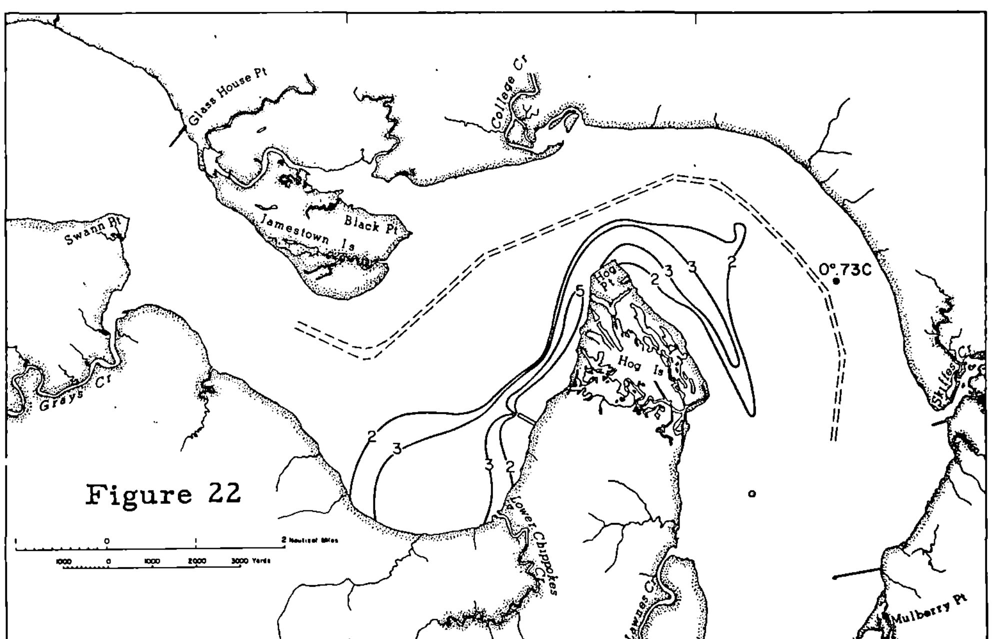


Figure 22

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24 X 10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 4½

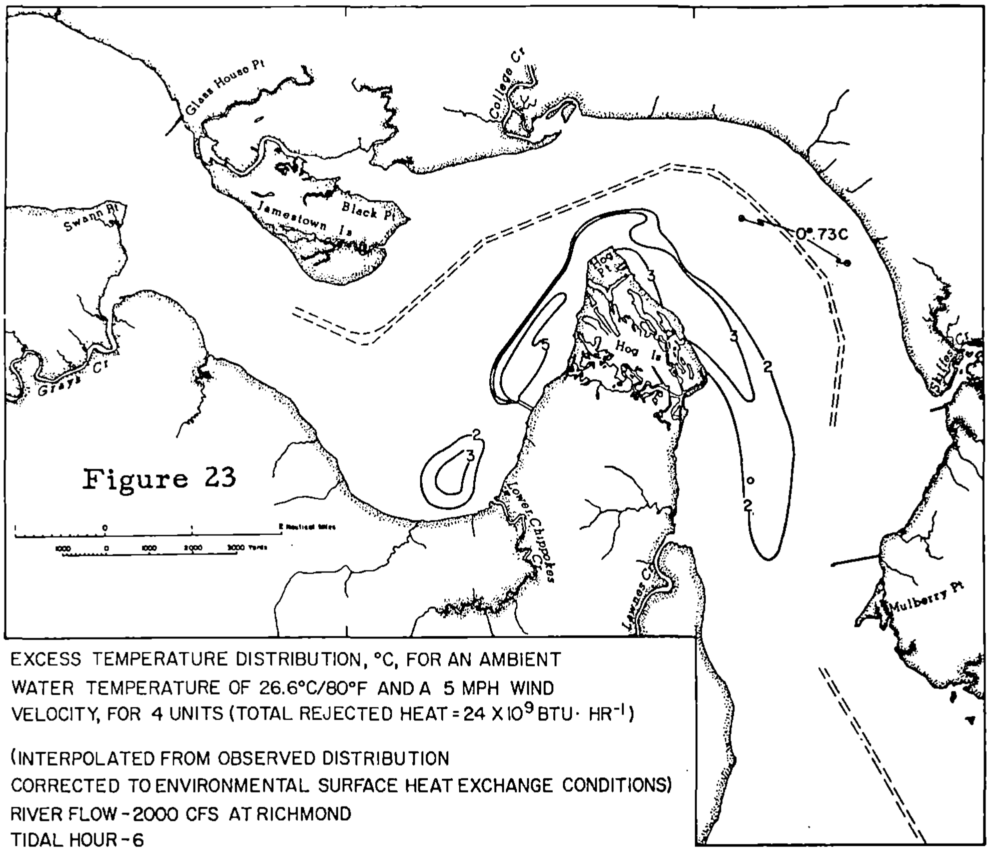


Figure 23

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24 X 10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 6

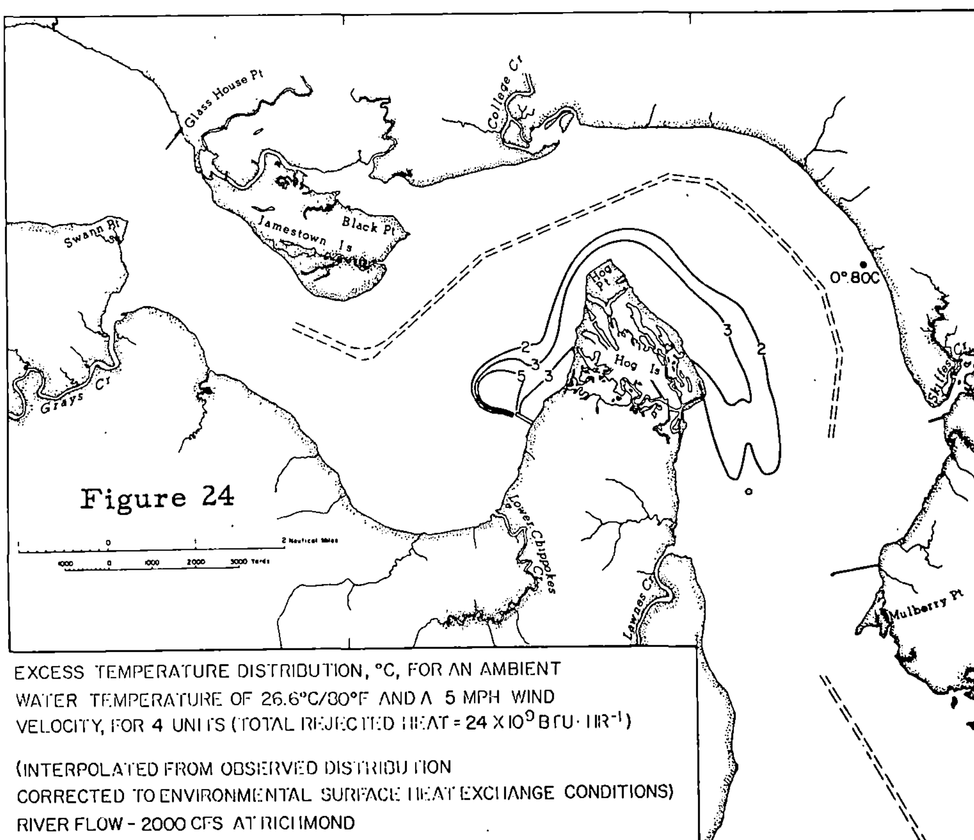


Figure 24

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24 X 10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 7½

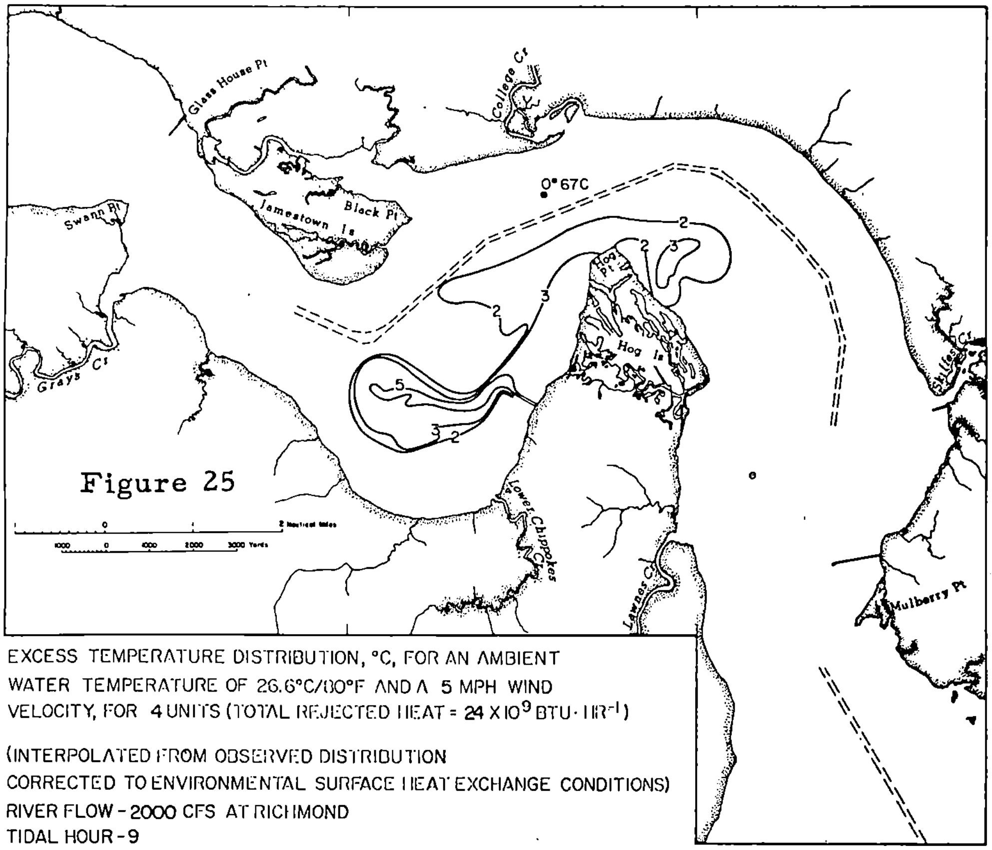


Figure 25

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24 X 10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 9

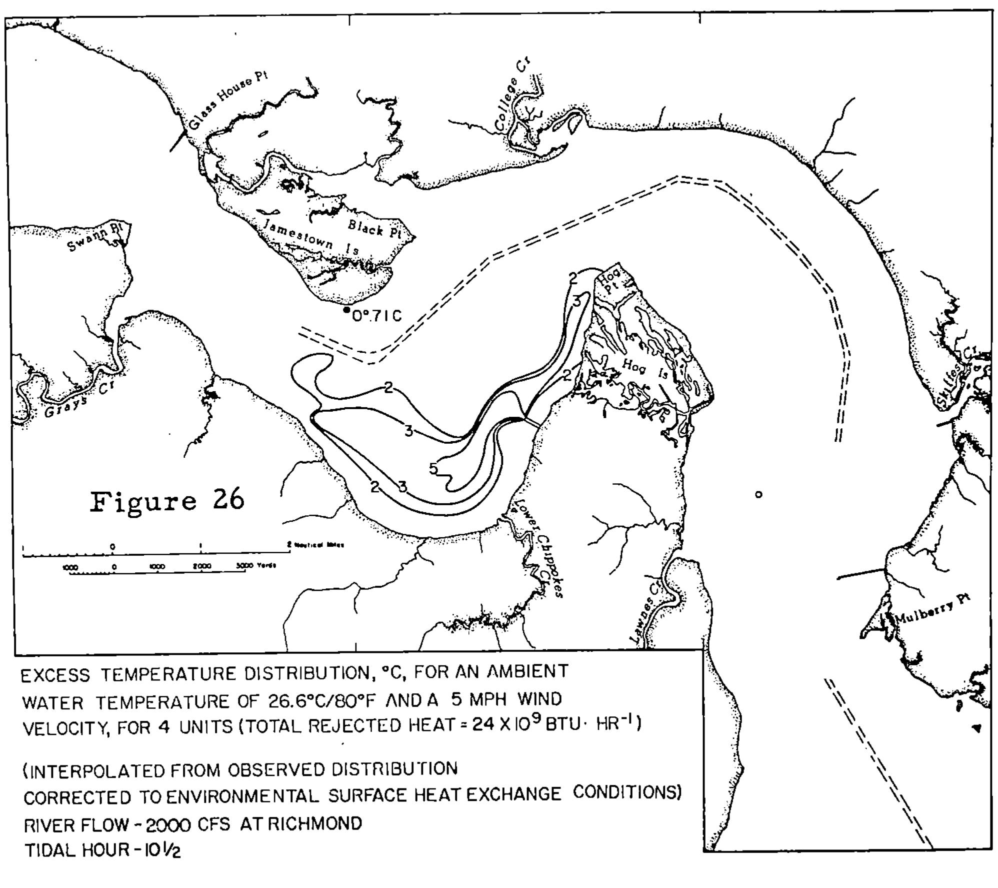


Figure 26

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24 X 10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 10½

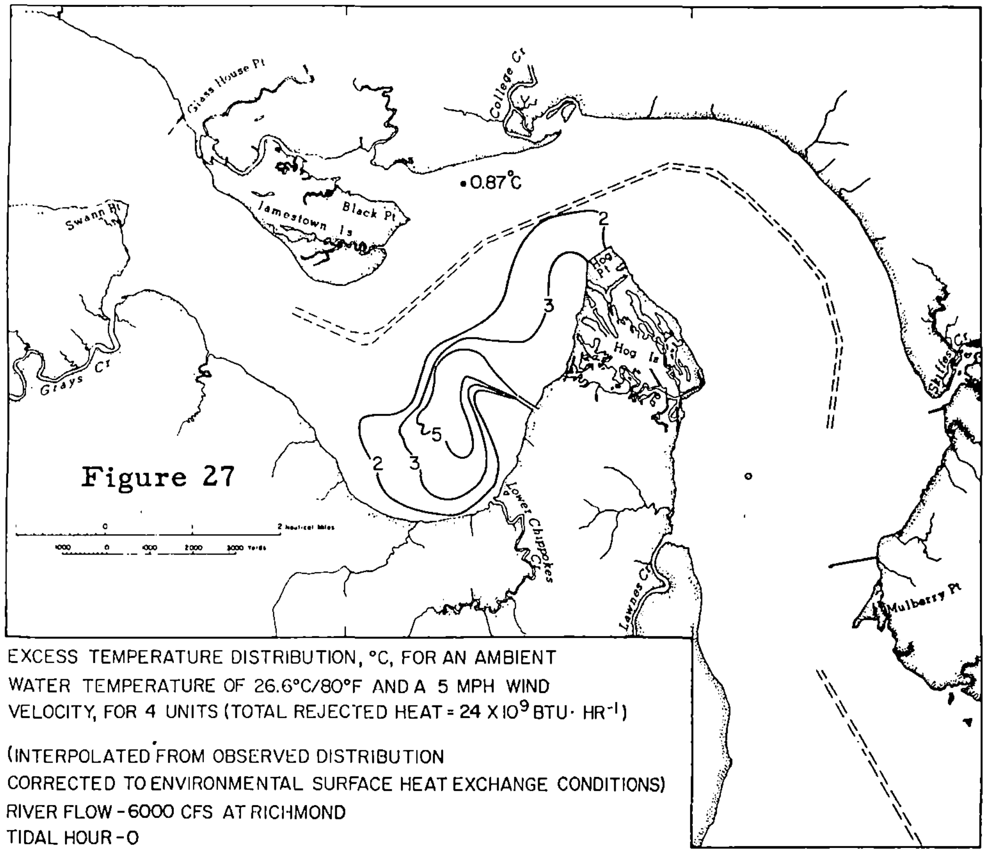


Figure 27

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24 X 10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 0

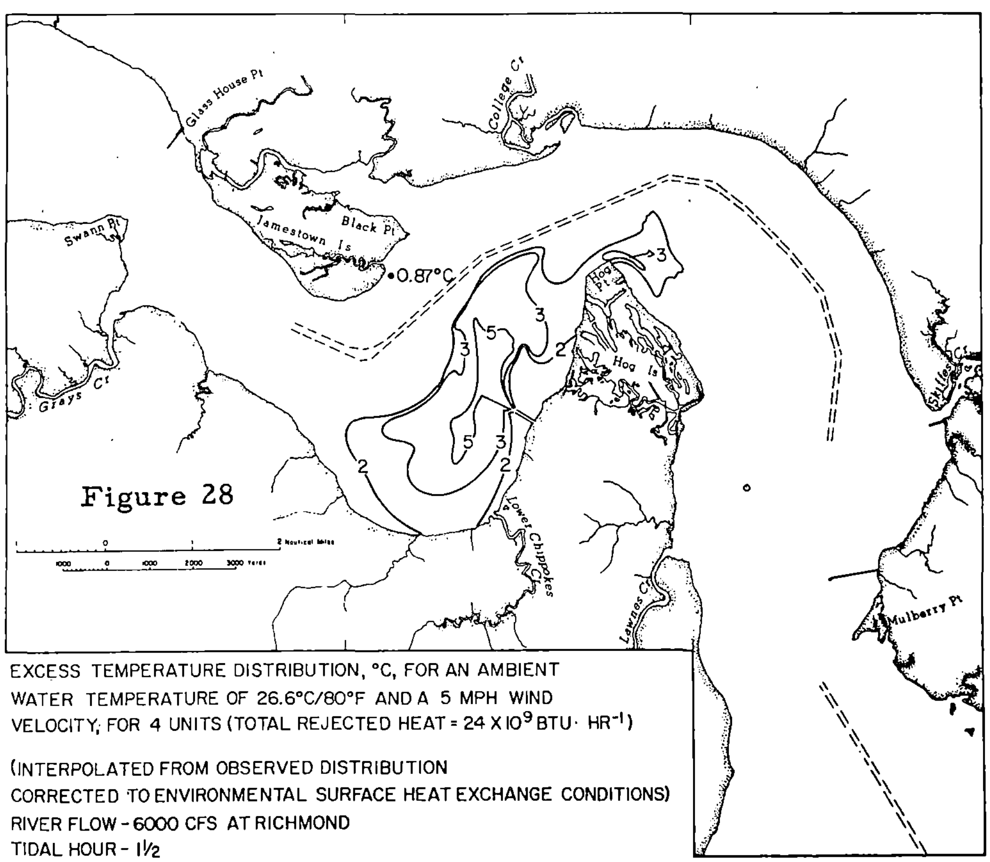


Figure 28

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24 X 10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 1½

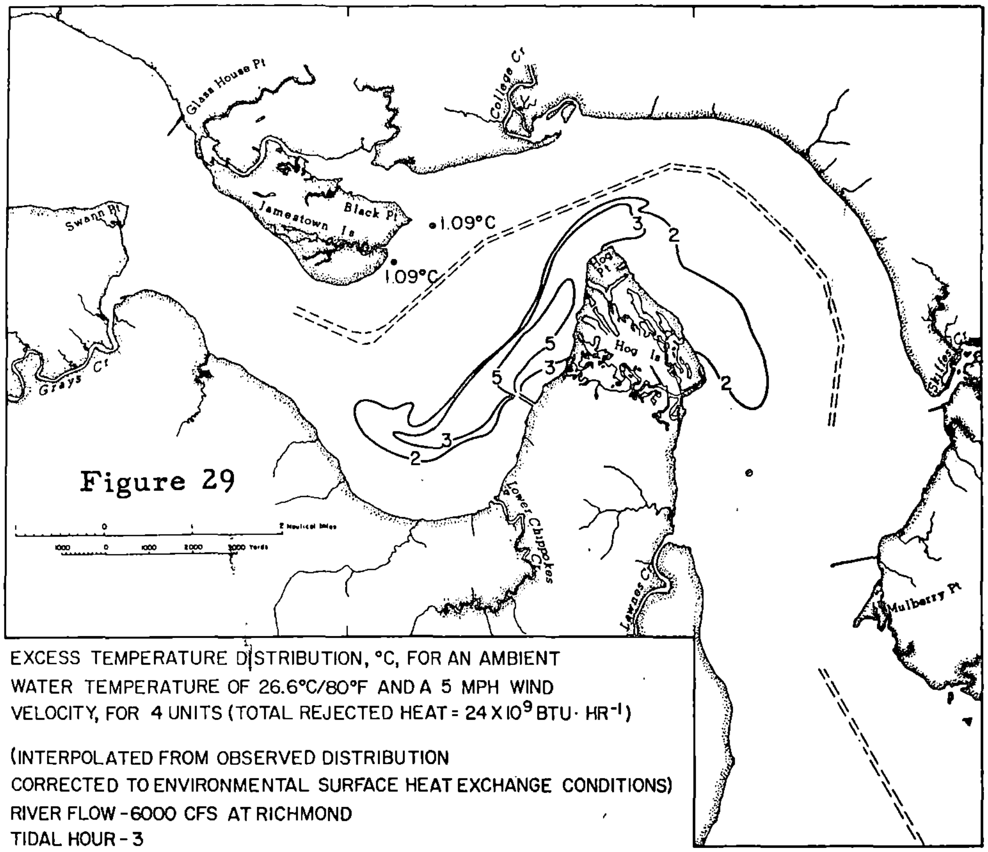


Figure 29

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 3

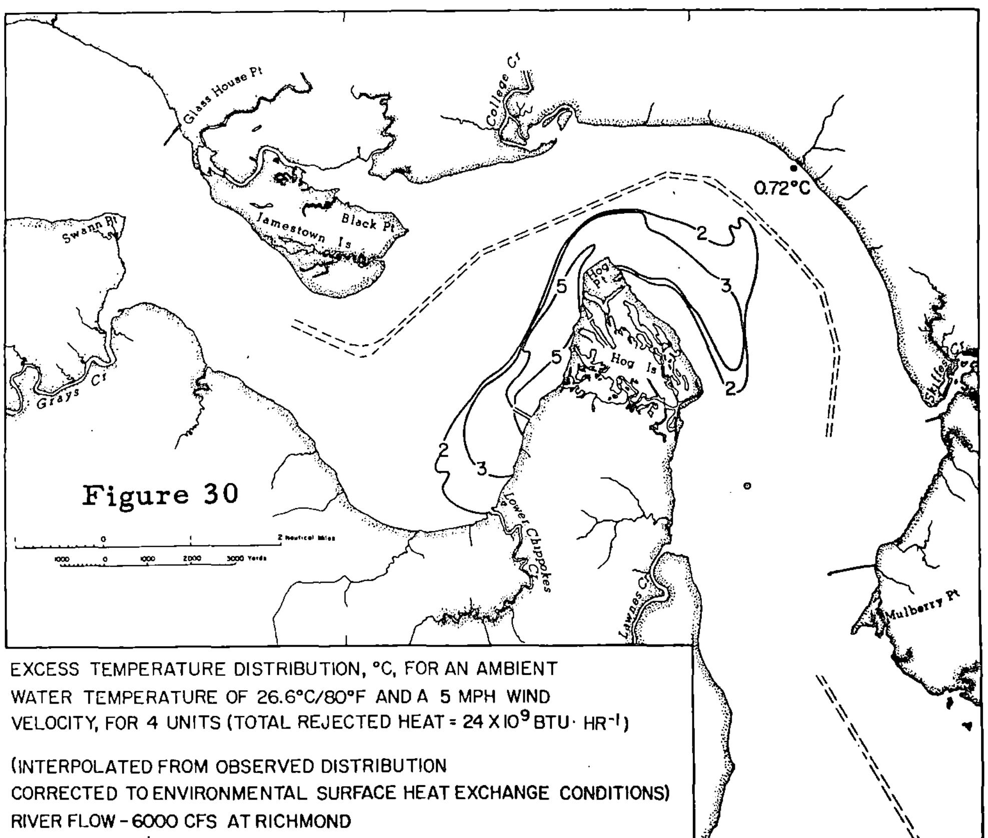


Figure 30

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 4 1/2

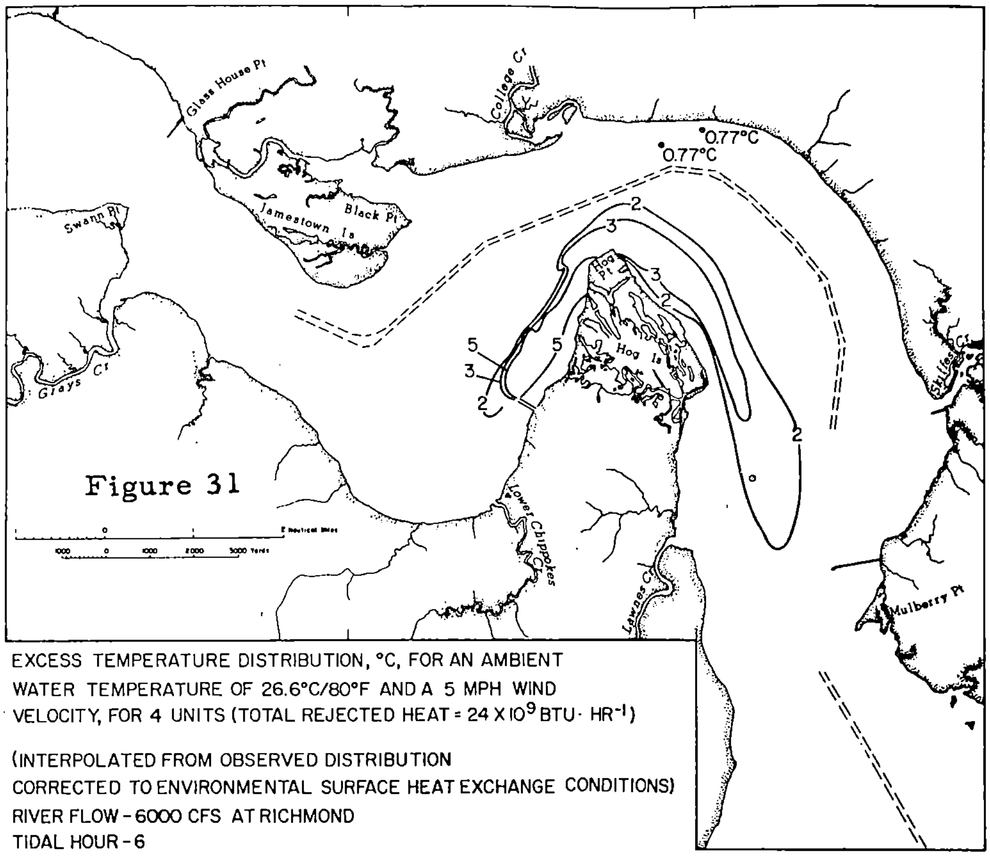


Figure 31

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24 X 10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 6

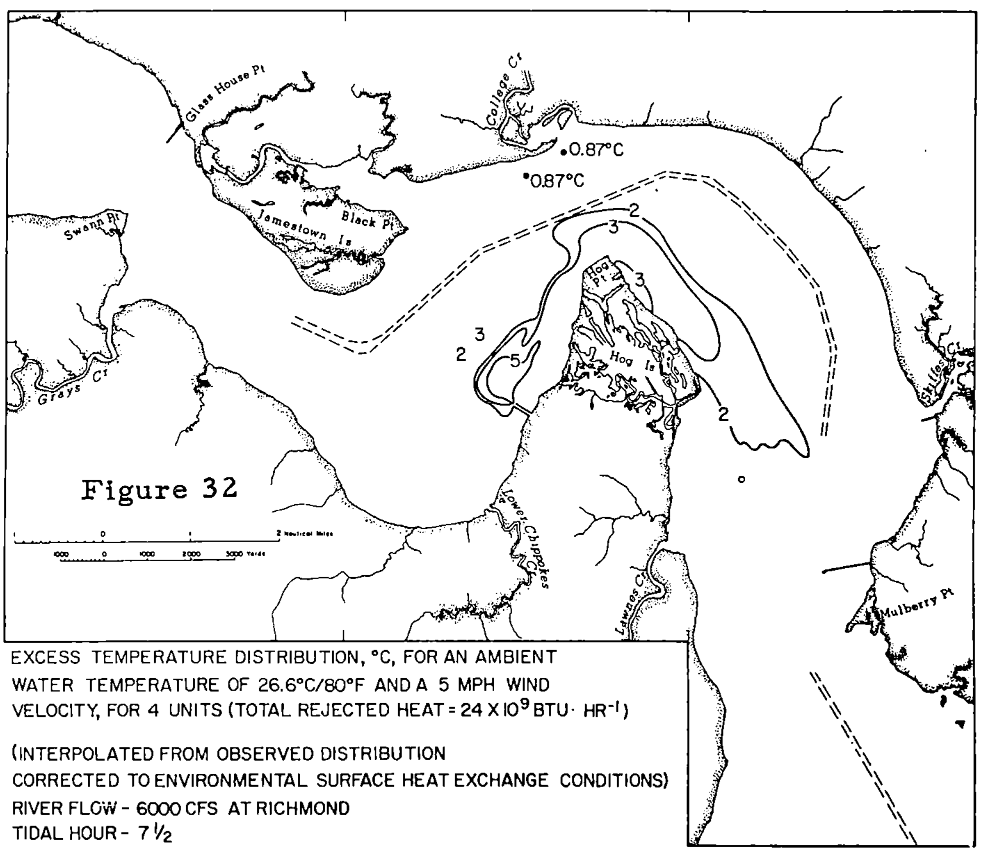
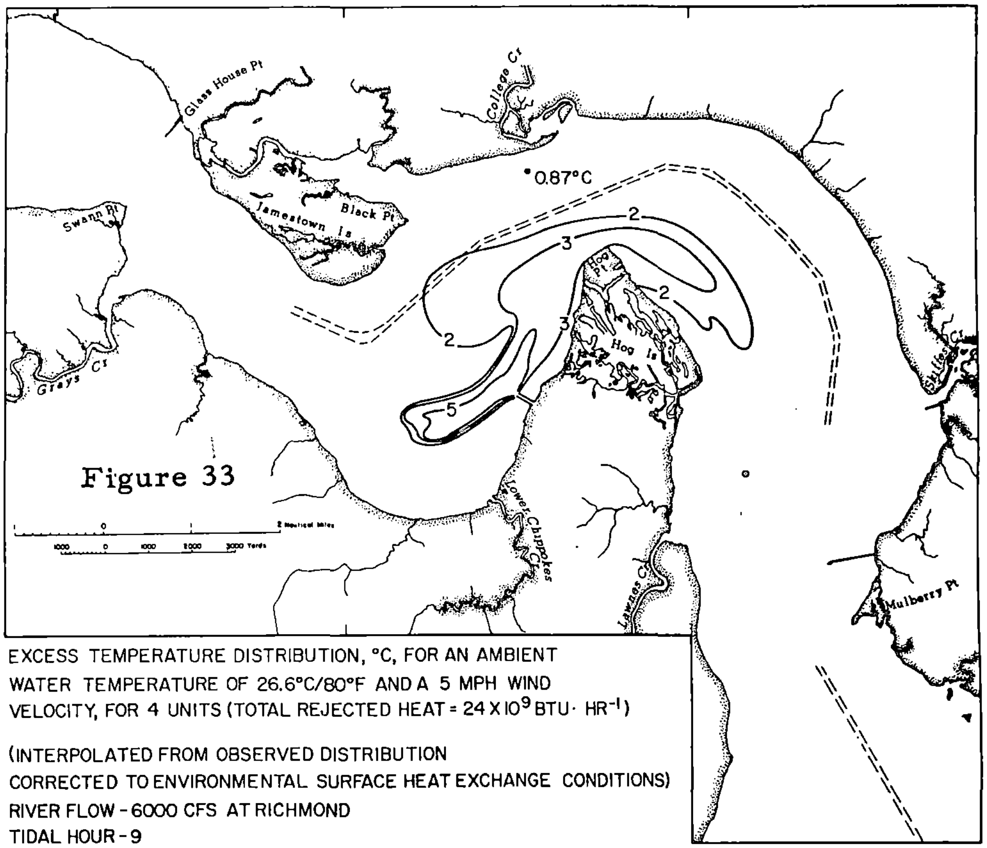


Figure 32

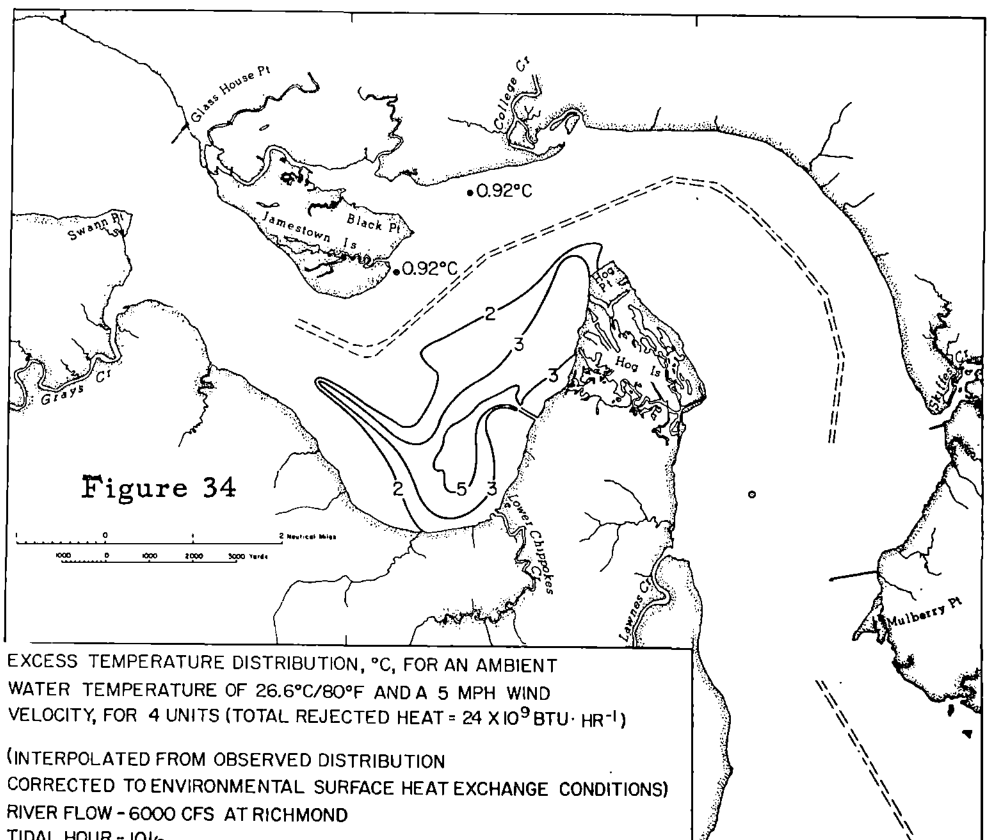
EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24 X 10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 7 1/2



EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24 X 10^9 BTU· HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 9



EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 26.6°C/80°F AND A 5 MPH WIND VELOCITY, FOR 4 UNITS (TOTAL REJECTED HEAT = 24 X 10^9 BTU· HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 6000 CFS AT RICHMOND
TIDAL HOUR - 10½

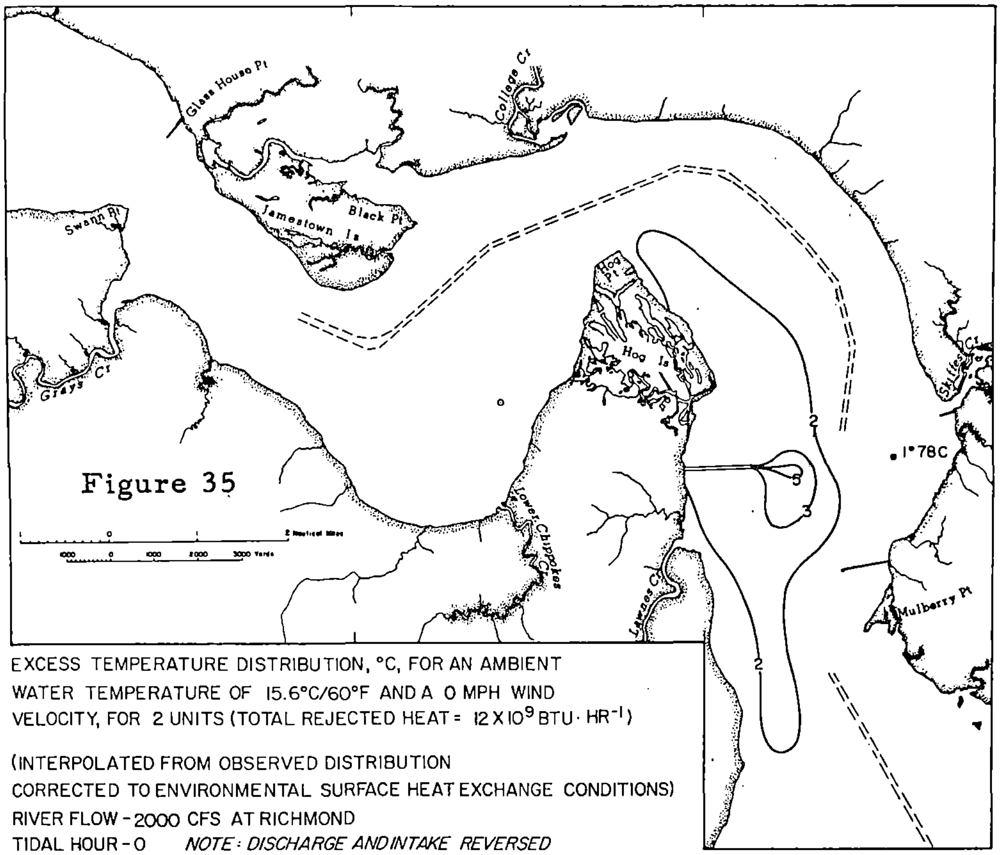


Figure 35

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 15.6°C/60°F AND A 0 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 0 *NOTE: DISCHARGE AND INTAKE REVERSED*

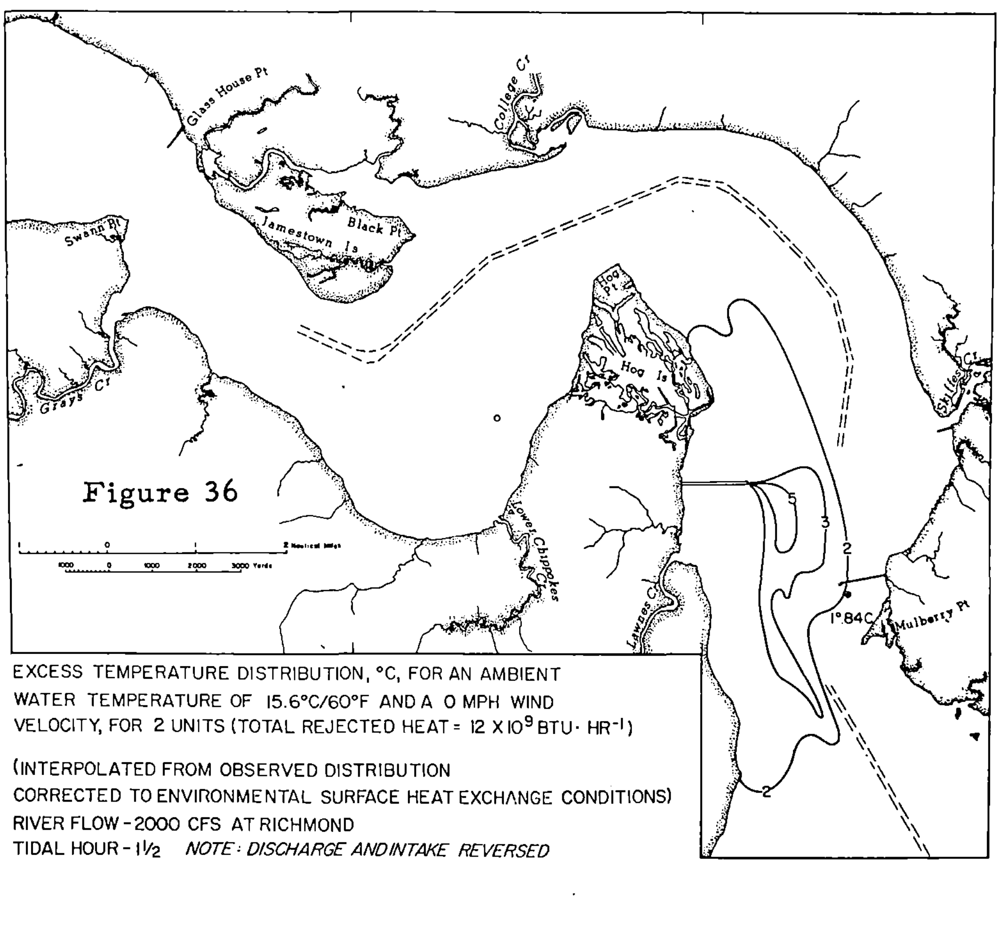


Figure 36

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 15.6°C/60°F AND A 0 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 1½ *NOTE: DISCHARGE AND INTAKE REVERSED*

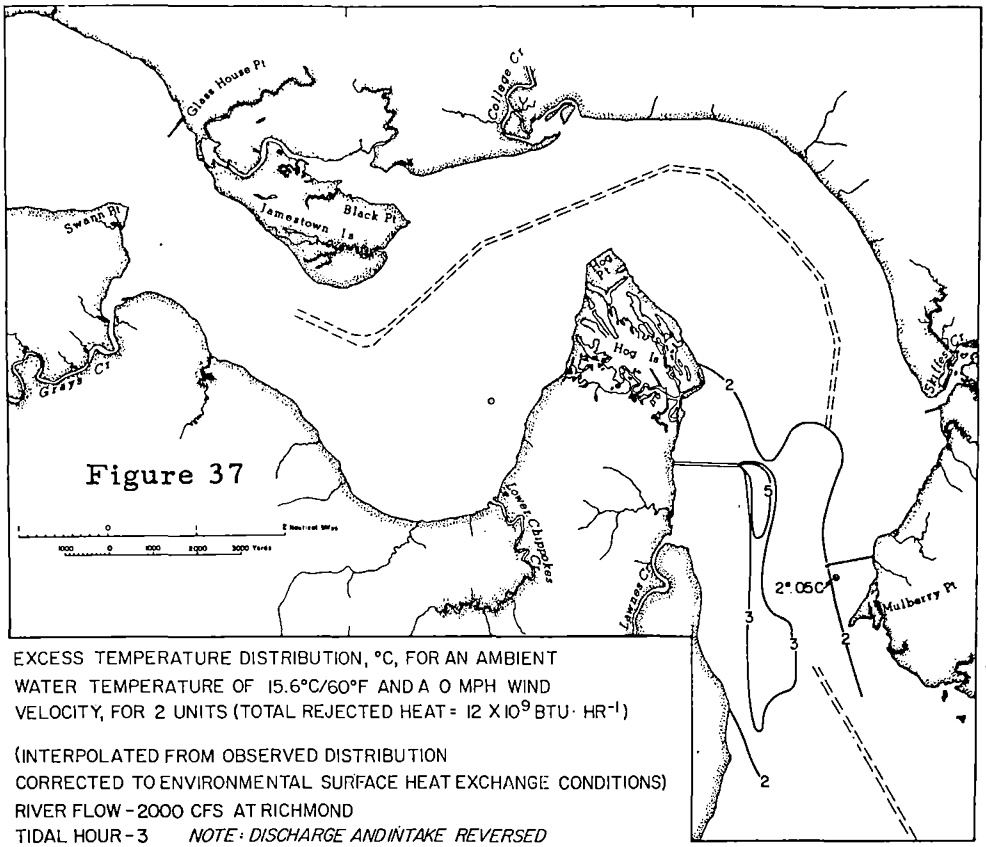


Figure 37

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 15.6°C/60°F AND A 0 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION
CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 3 *NOTE: DISCHARGE AND INTAKE REVERSED*

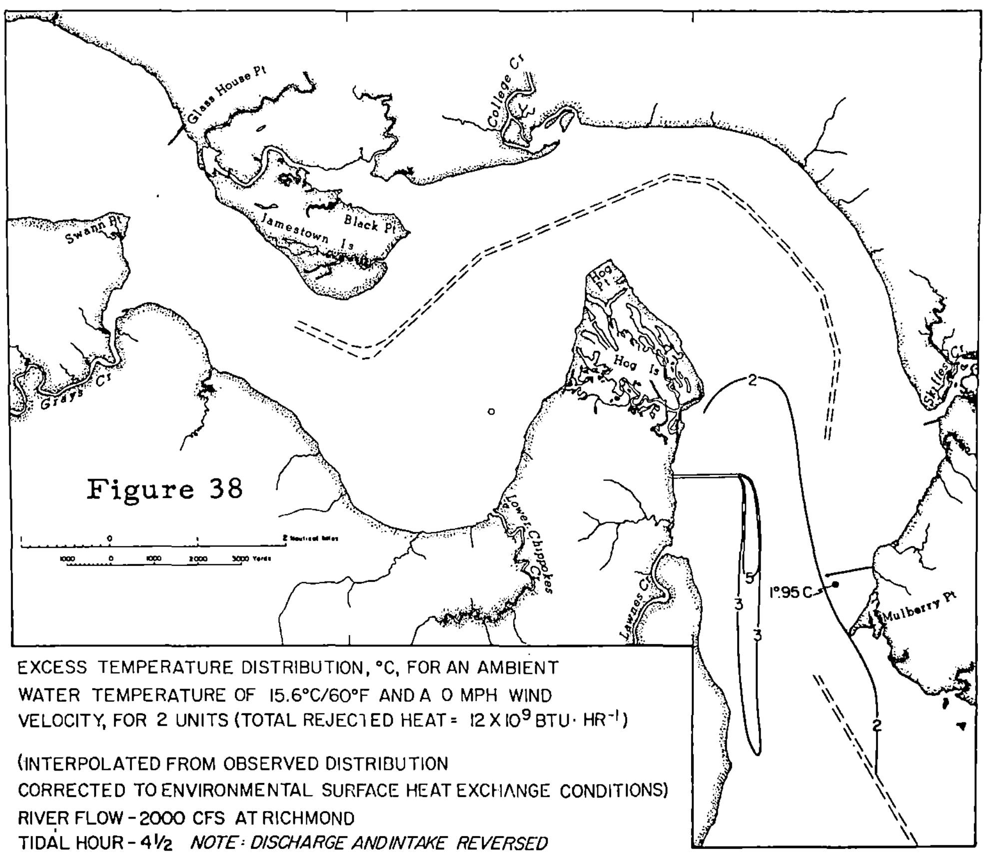


Figure 38

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 15.6°C/60°F AND A 0 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION
CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 4½ *NOTE: DISCHARGE AND INTAKE REVERSED*

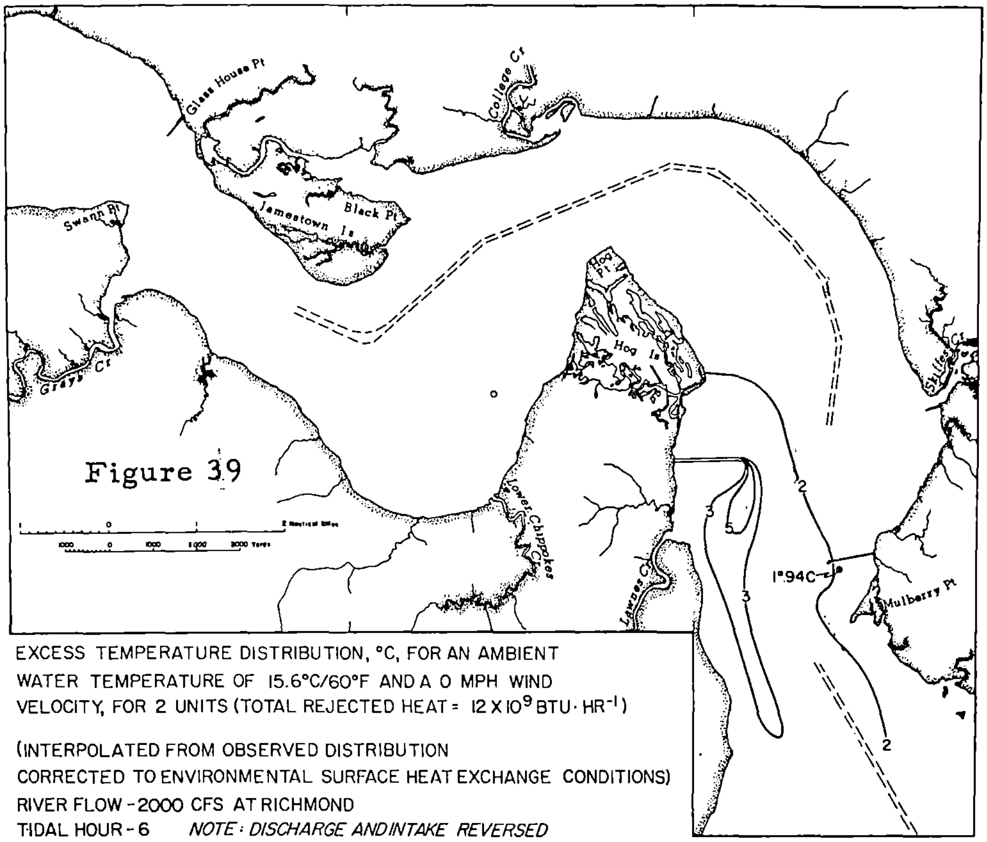


Figure 39

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 15.6°C/60°F AND A 0 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 6 *NOTE: DISCHARGE AND INTAKE REVERSED*

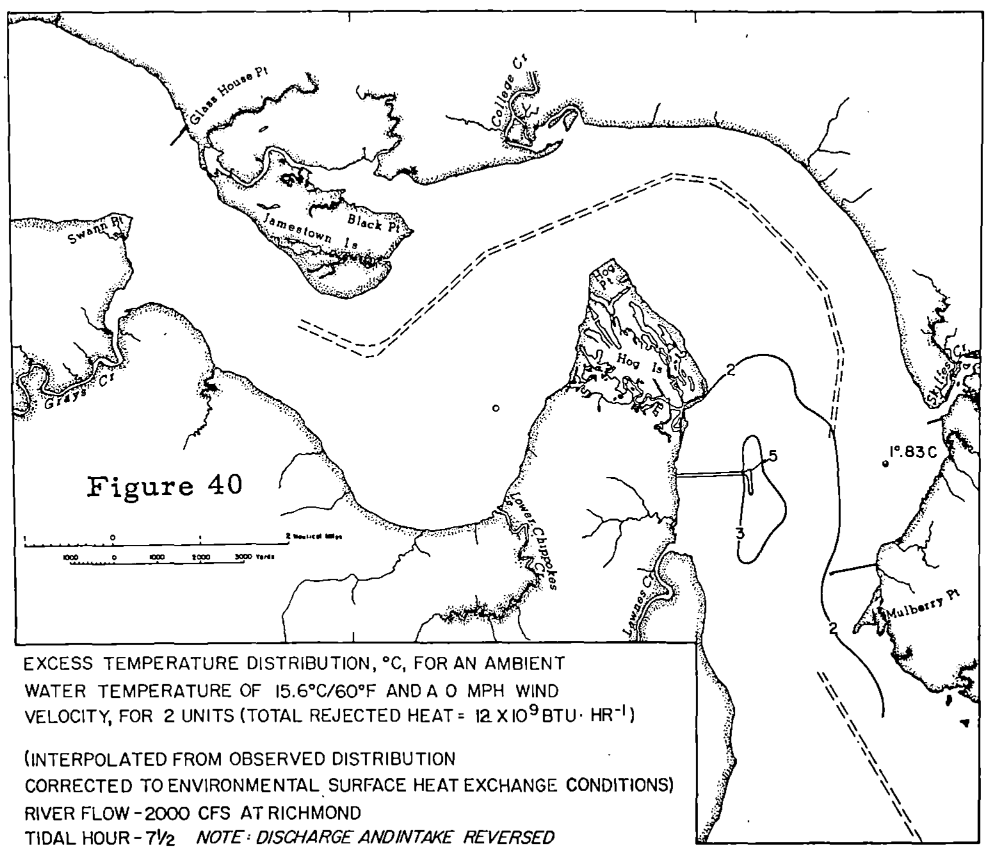


Figure 40

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 15.6°C/60°F AND A 0 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU · HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 7½ *NOTE: DISCHARGE AND INTAKE REVERSED*

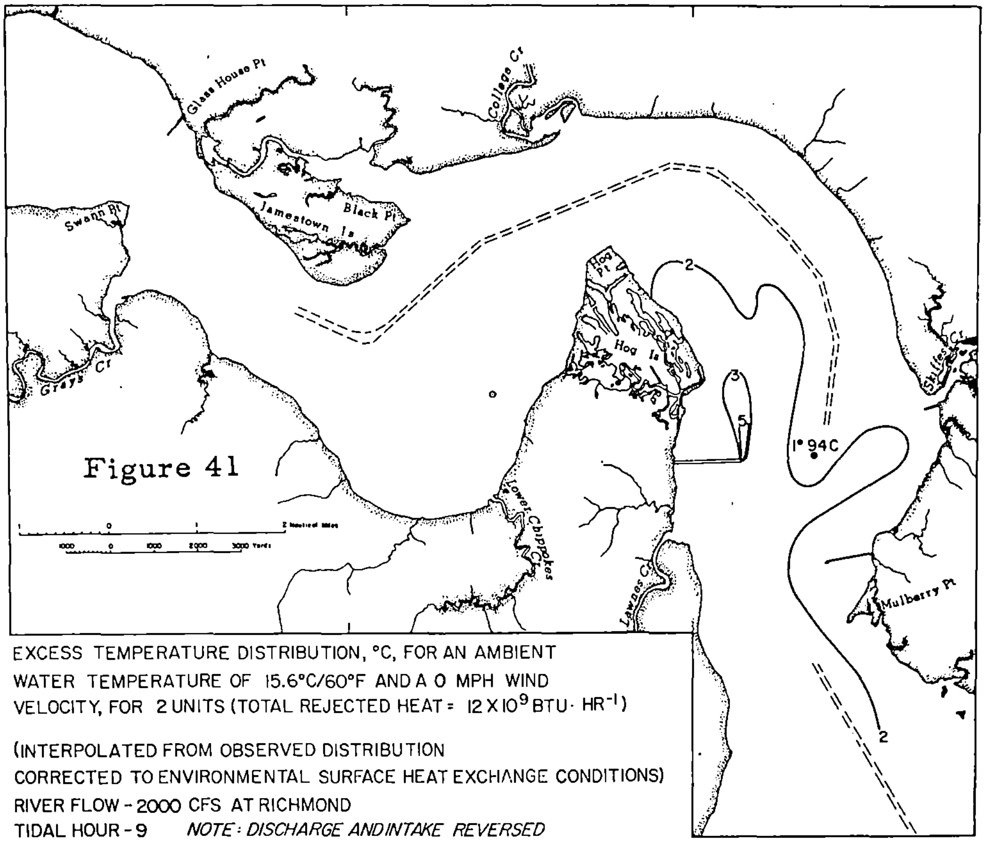


Figure 41

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 15.6°C/60°F AND A 0 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU· HR^{-1})

(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 9 *NOTE: DISCHARGE AND INTAKE REVERSED*

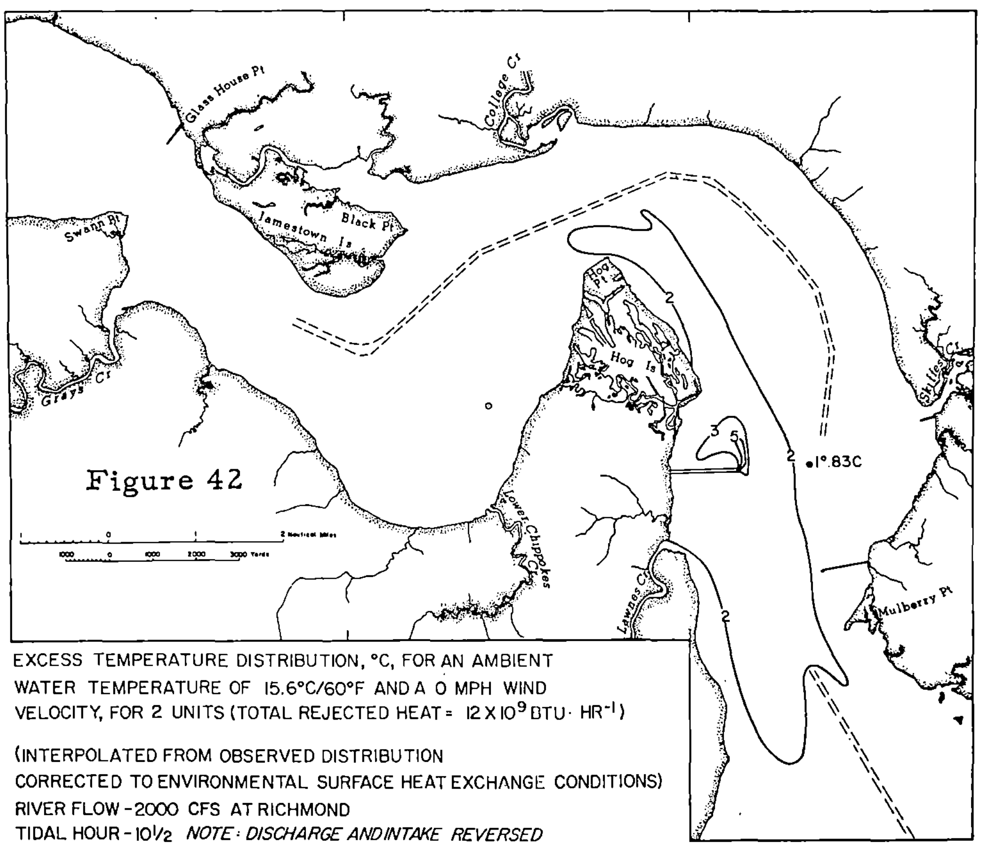


Figure 42

EXCESS TEMPERATURE DISTRIBUTION, °C, FOR AN AMBIENT WATER TEMPERATURE OF 15.6°C/60°F AND A 0 MPH WIND VELOCITY, FOR 2 UNITS (TOTAL REJECTED HEAT = 12×10^9 BTU· HR^{-1})

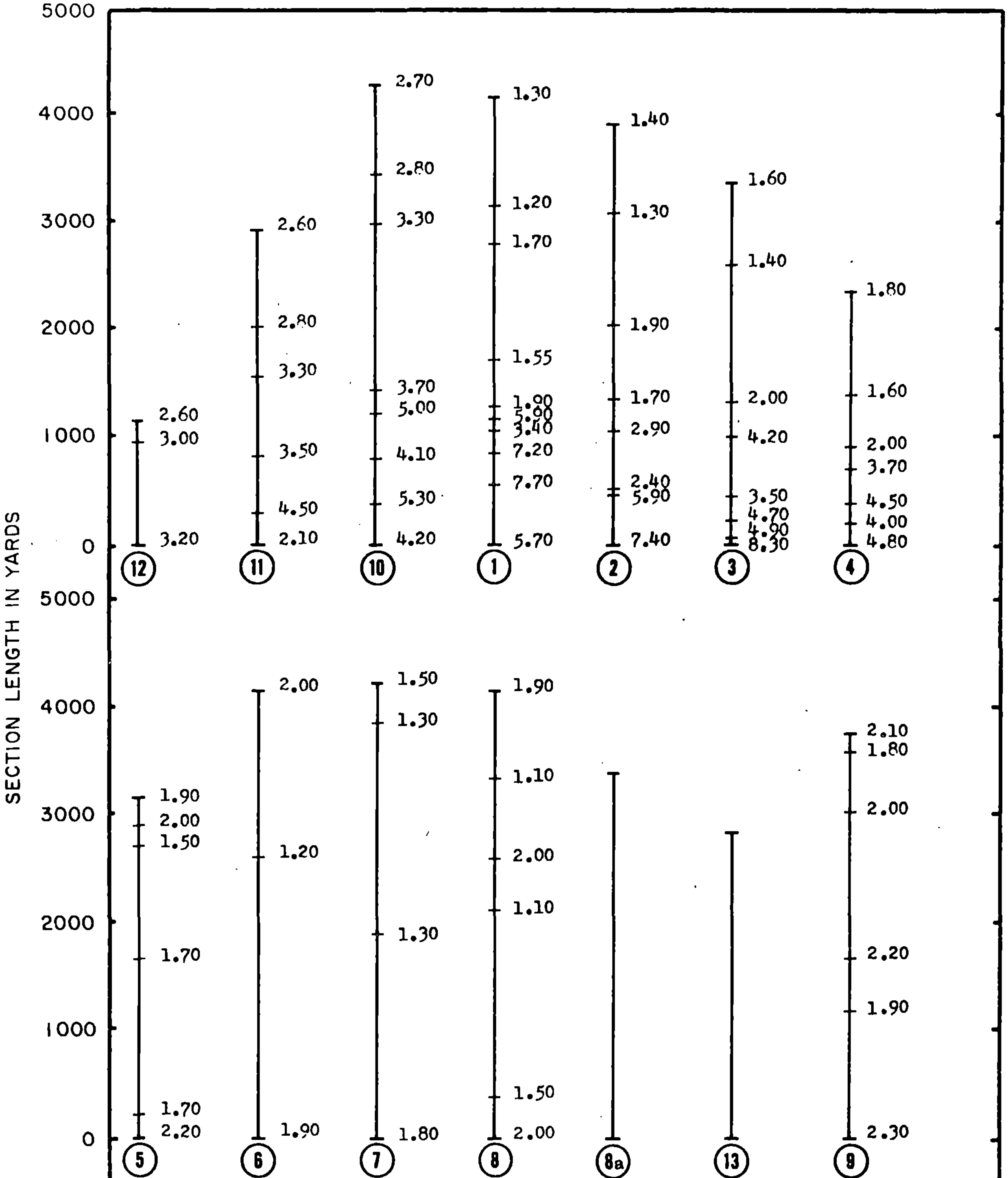
(INTERPOLATED FROM OBSERVED DISTRIBUTION CORRECTED TO ENVIRONMENTAL SURFACE HEAT EXCHANGE CONDITIONS)
RIVER FLOW - 2000 CFS AT RICHMOND
TIDAL HOUR - 10½ *NOTE: DISCHARGE AND INTAKE REVERSED*

APPENDIX

To The Report

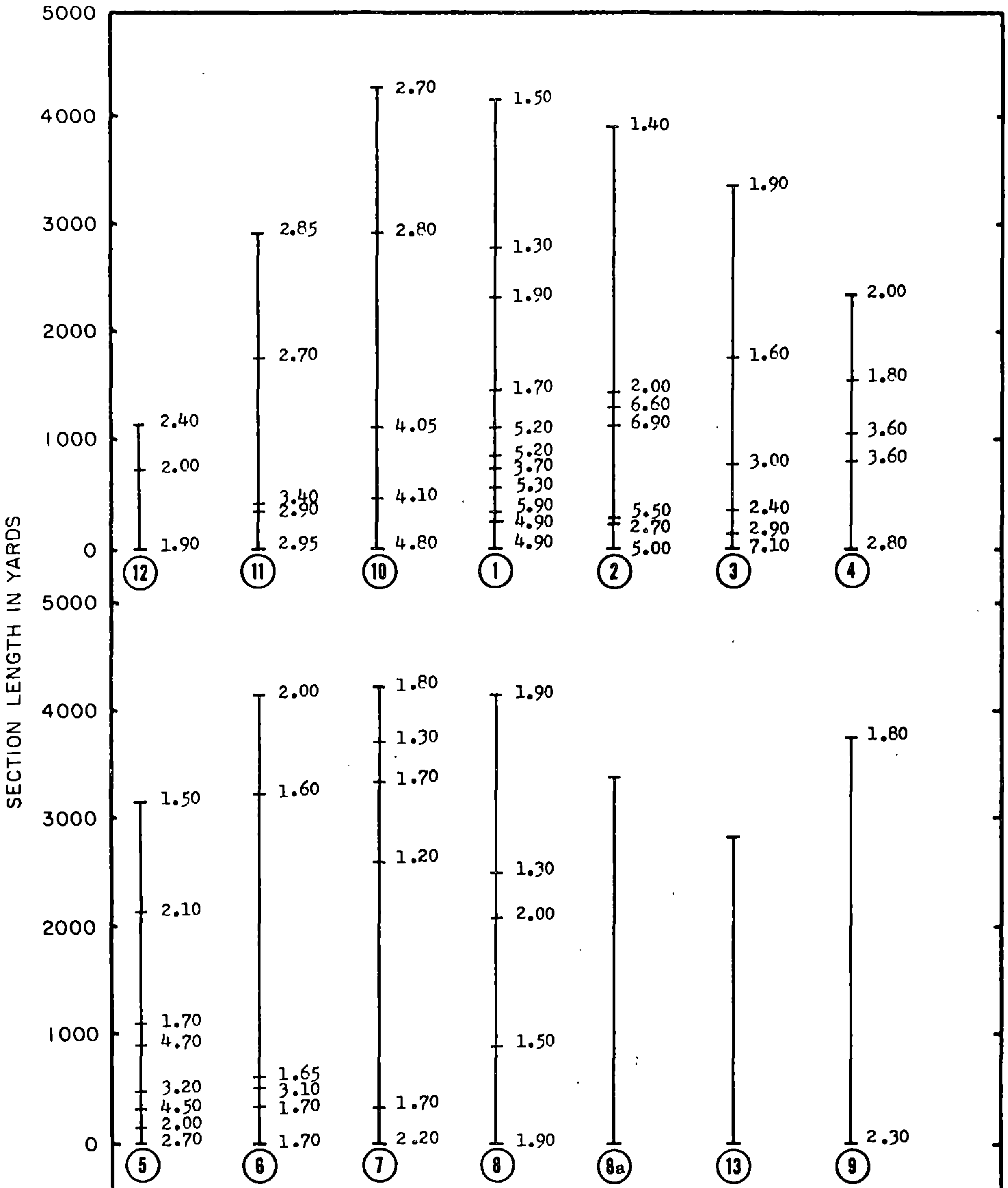
Temperature Distribution in the James River Estuary
Which Will Result From the Discharge of Waste Heat
From the Surry Nuclear Power Station

Observed Excess Temperatures
from the
October 1966 Tests Carried Out in
The James River Estuary Model



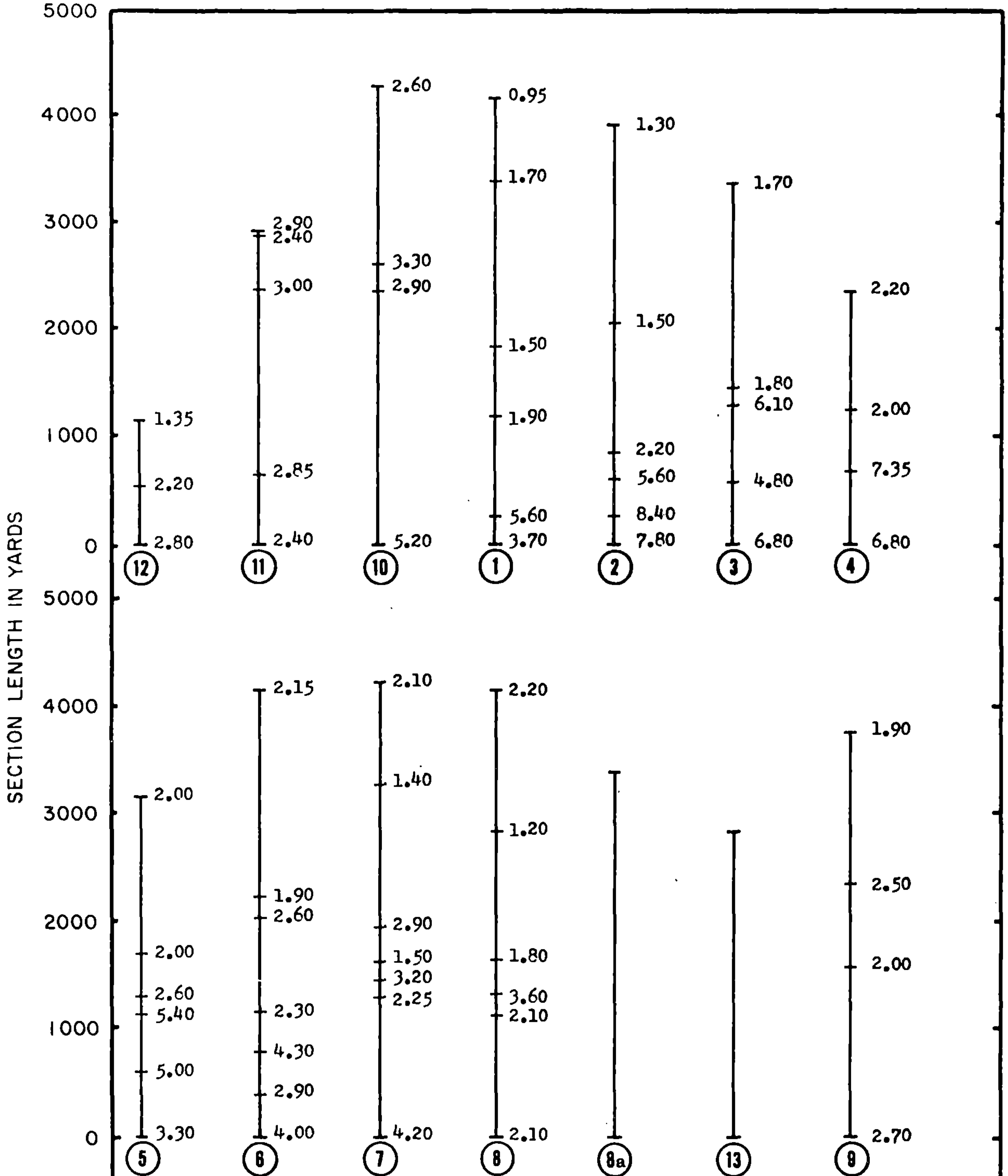
OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR

RIVER FLOW = 2000 cfs
REJECTED HEAT = 12×10^9 BTU/HR.
TIDAL HOUR = 0

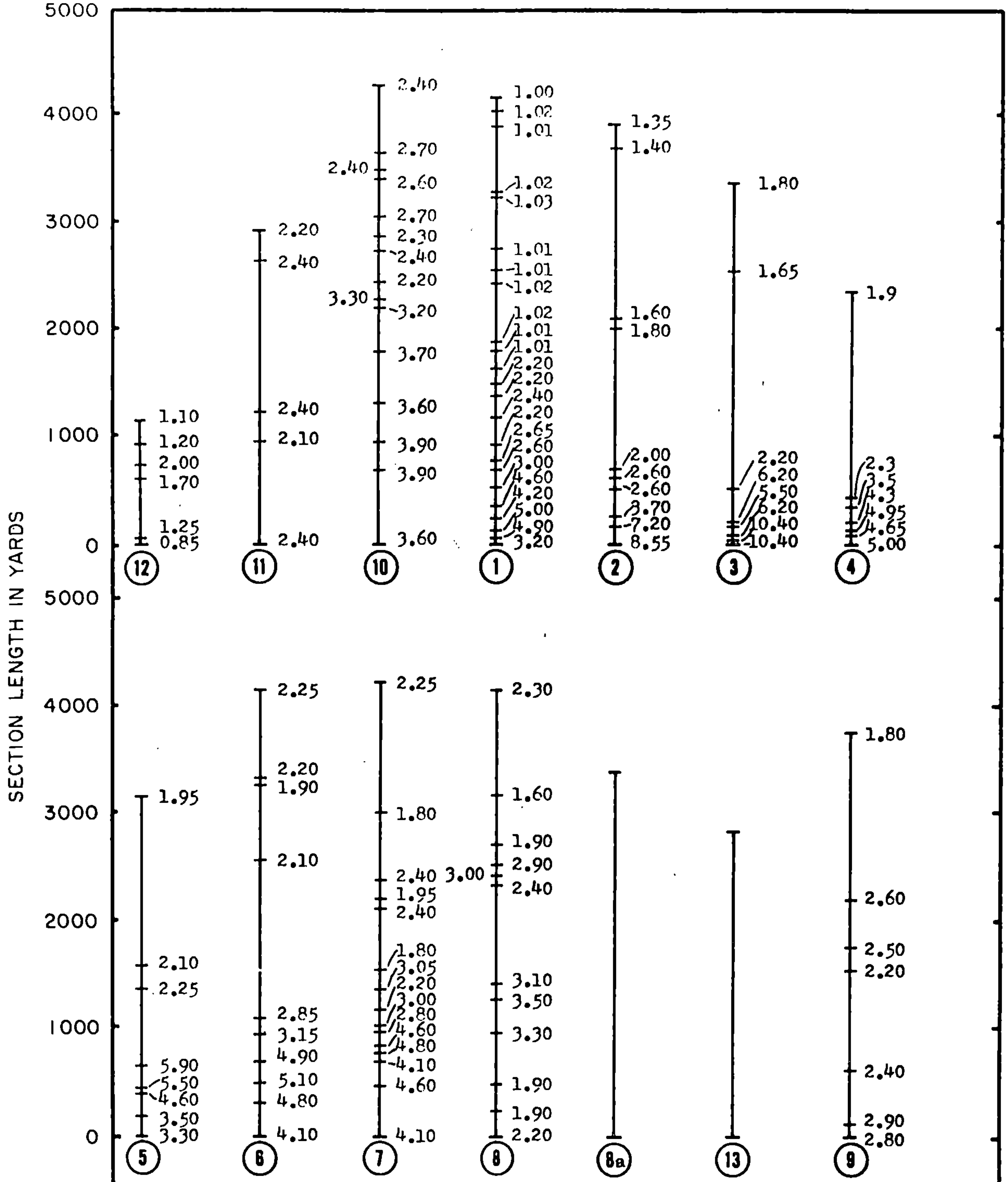


OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR

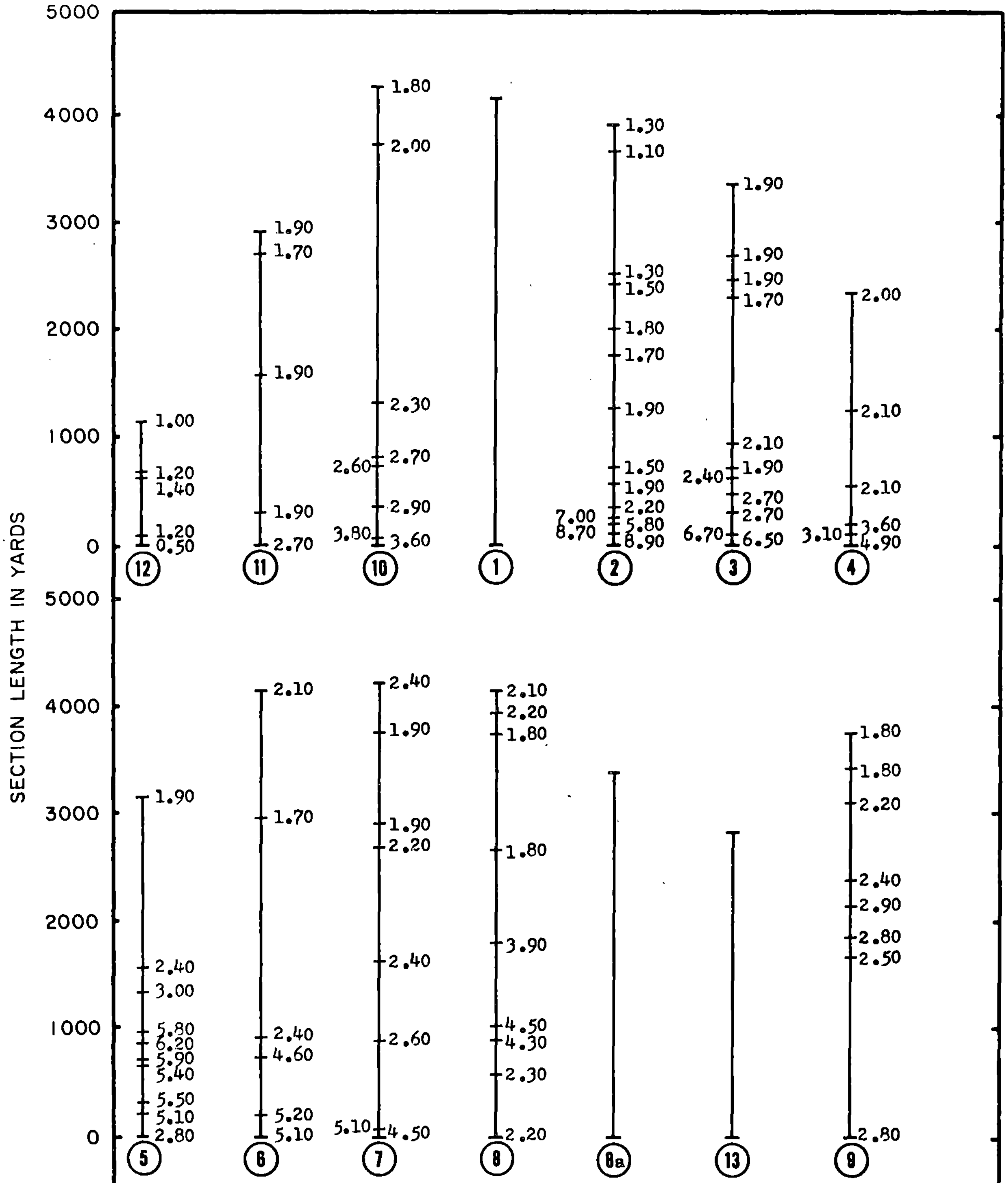
RIVER FLOW = 2000 cfs
REJECTED HEAT = 12×10^9 BTU/HR.
TIDAL HOUR = 1 1/2



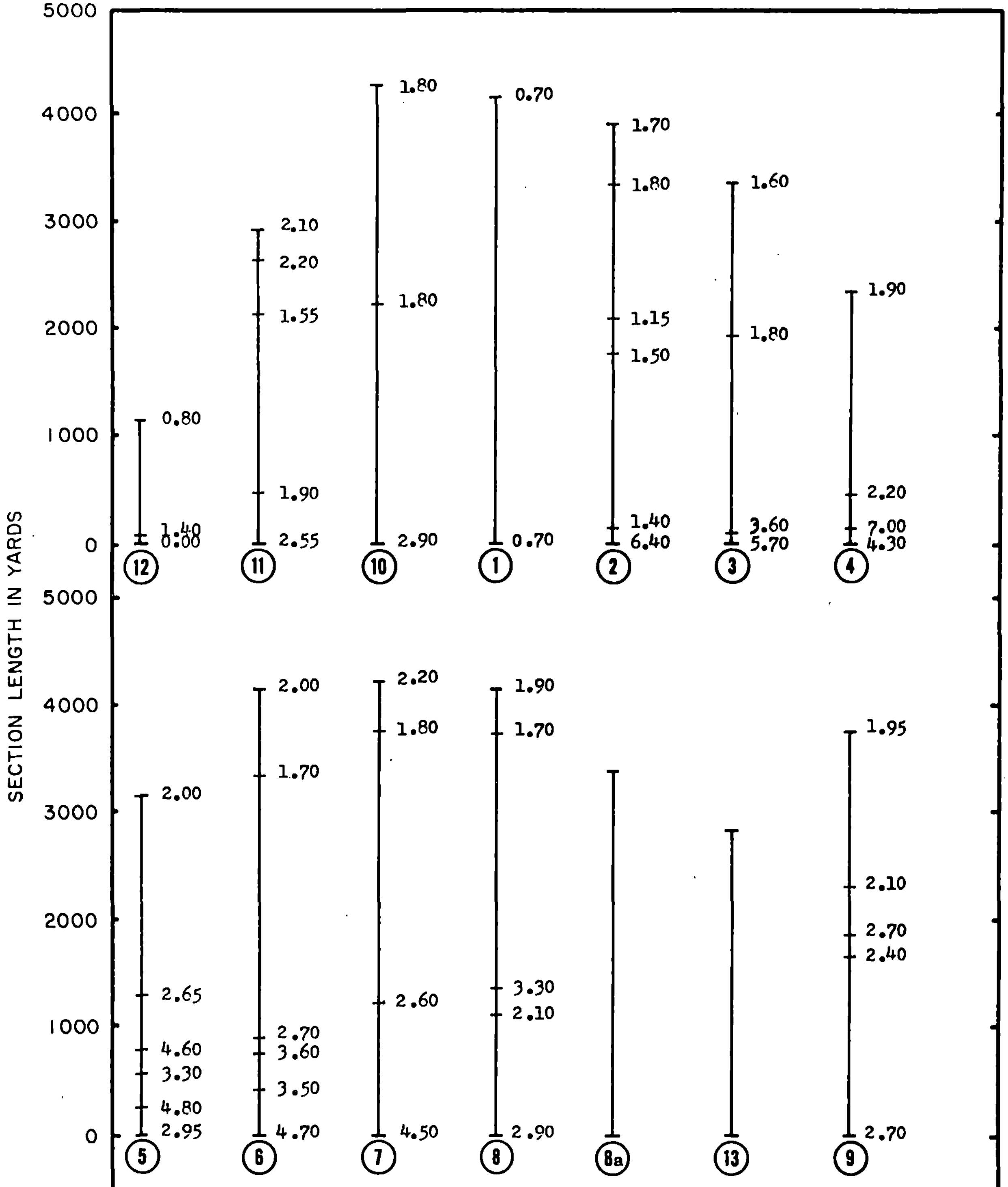
OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 2000 cfs
REJECTED HEAT = 12×10^9 BTU / HR.
TIDAL HOUR = 3



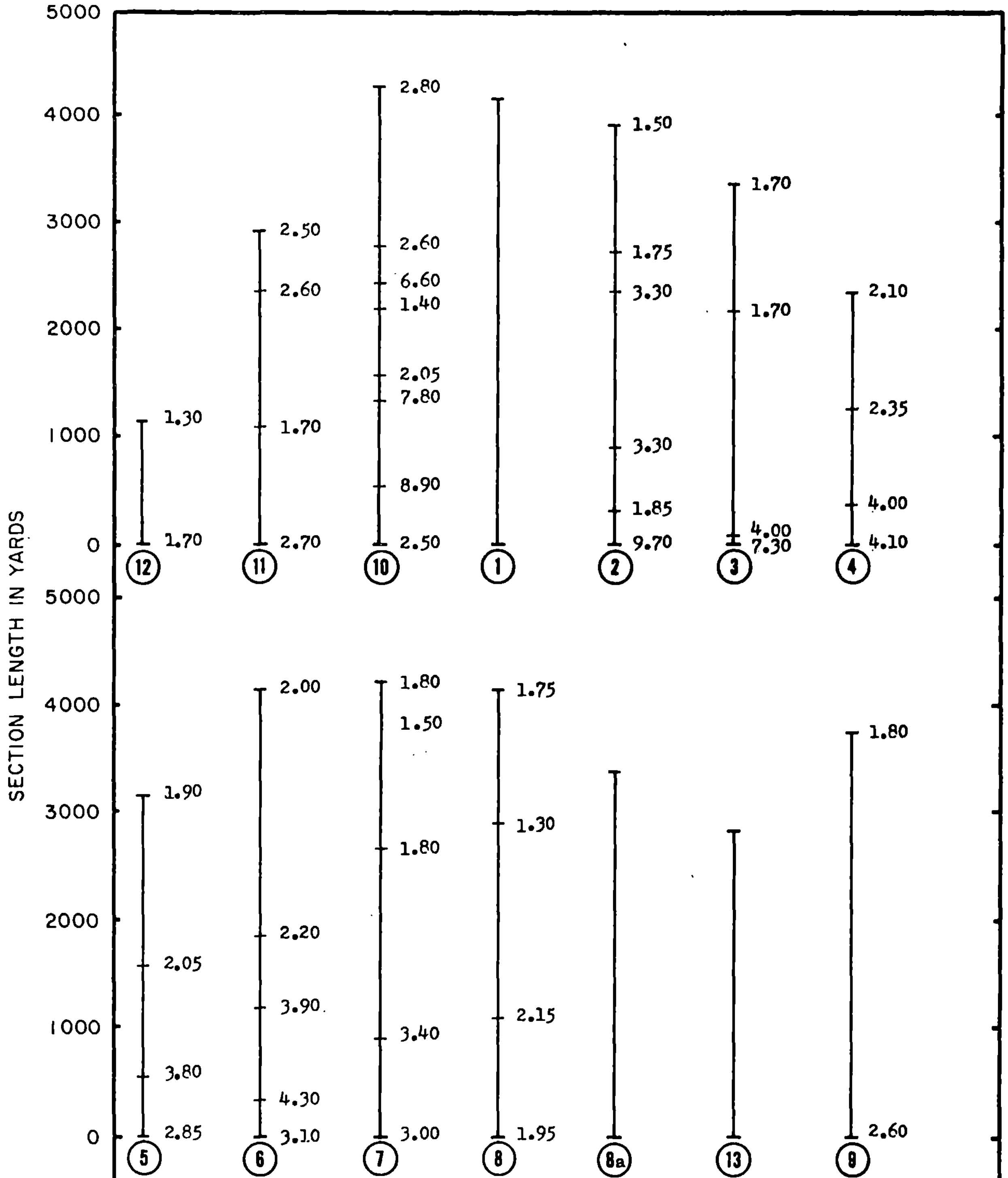
OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 2000 cfs
REJECTED HEAT = 12×10^9 BTU / HR.
TIDAL HOUR = 4 1/2



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 2000 cfs
REJECTED HEAT = 12×10^9 BTU / HR.
TIDAL HOUR = 6

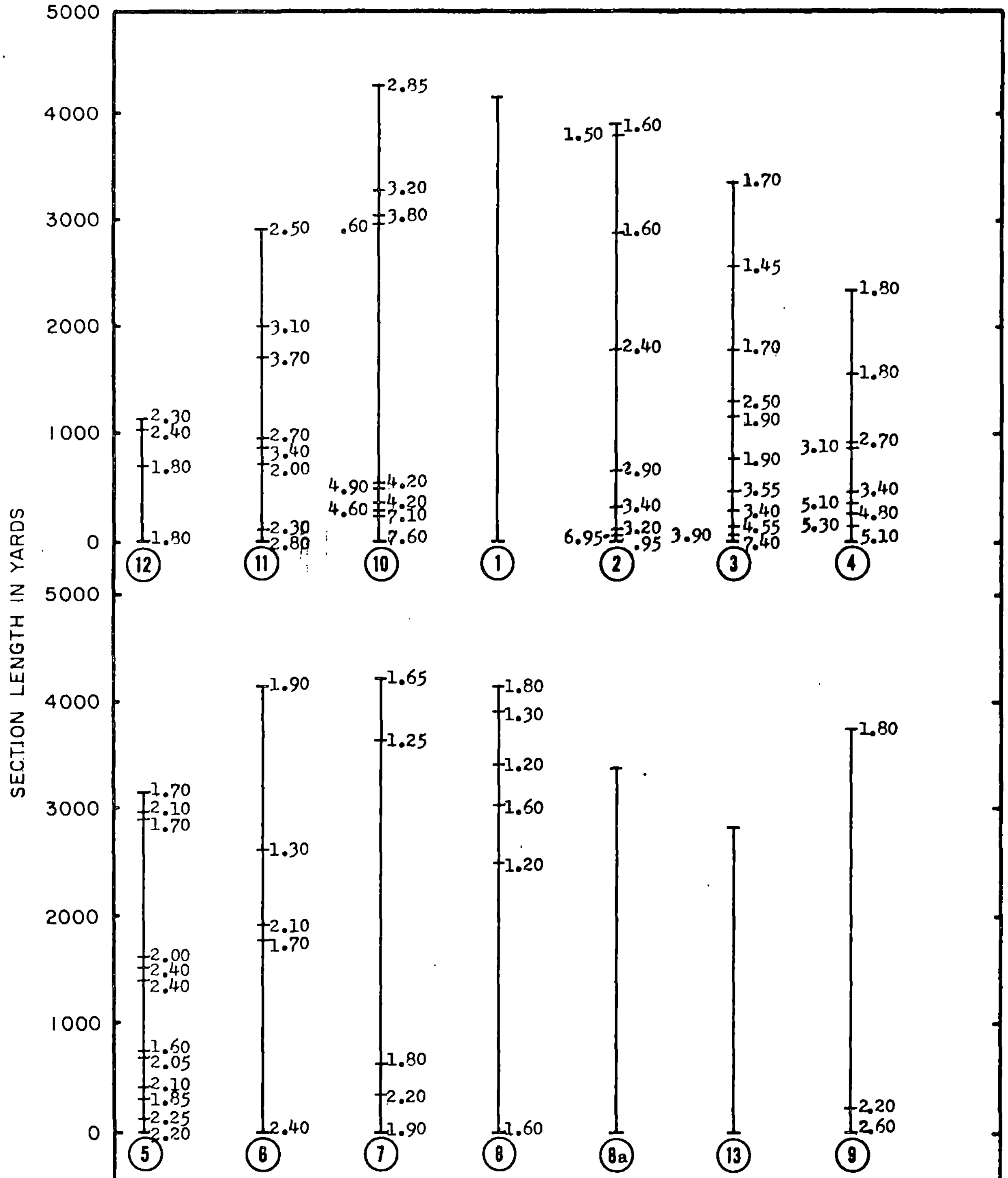


OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 2000 cfs
REJECTED HEAT = 12×10^9 BTU / HR.
TIDAL HOUR = 7 1/2

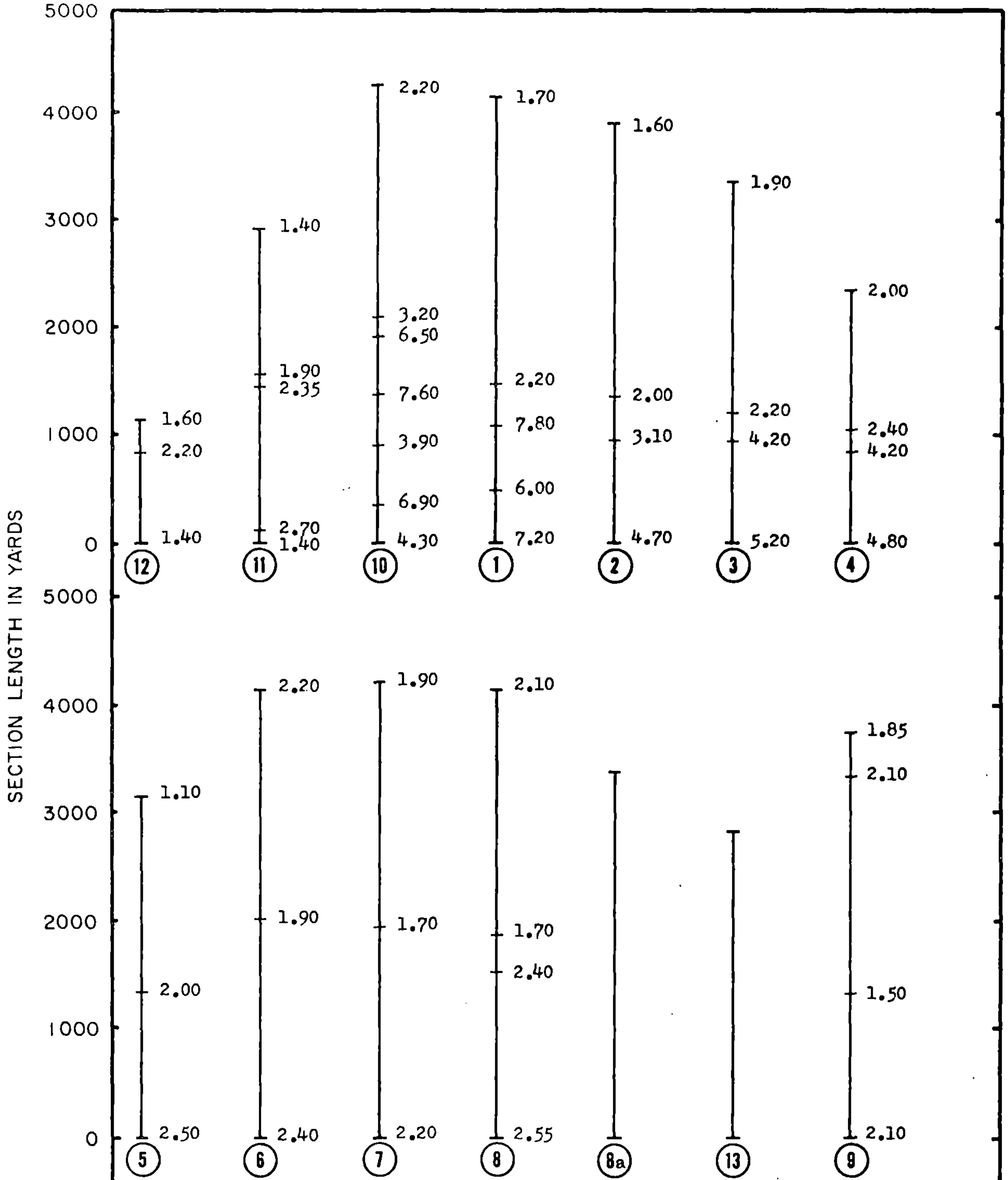


OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR

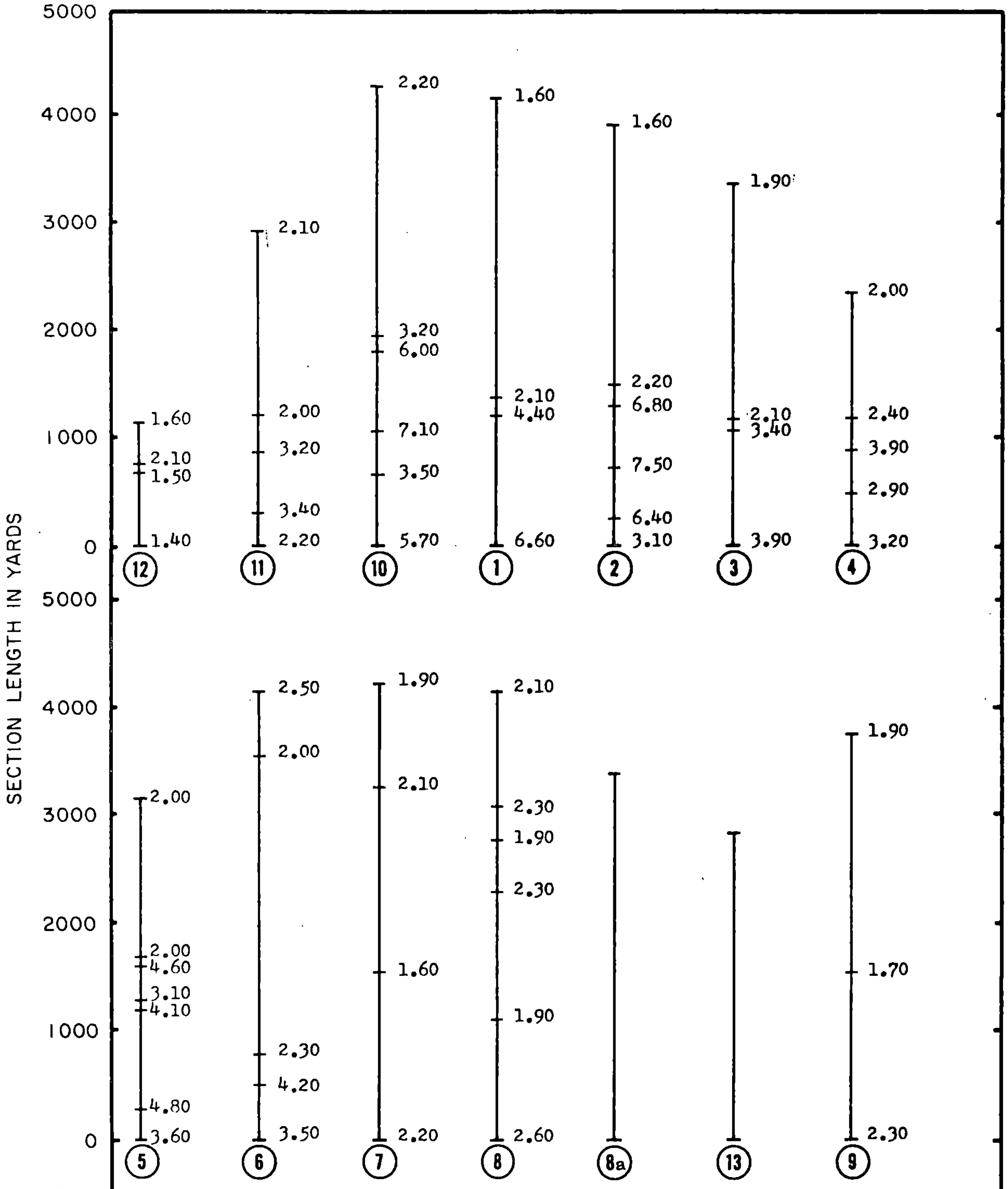
RIVER FLOW = 2000 cfs
REJECTED HEAT = 12×10^9 BTU / HR.
TIDAL HOUR = 9



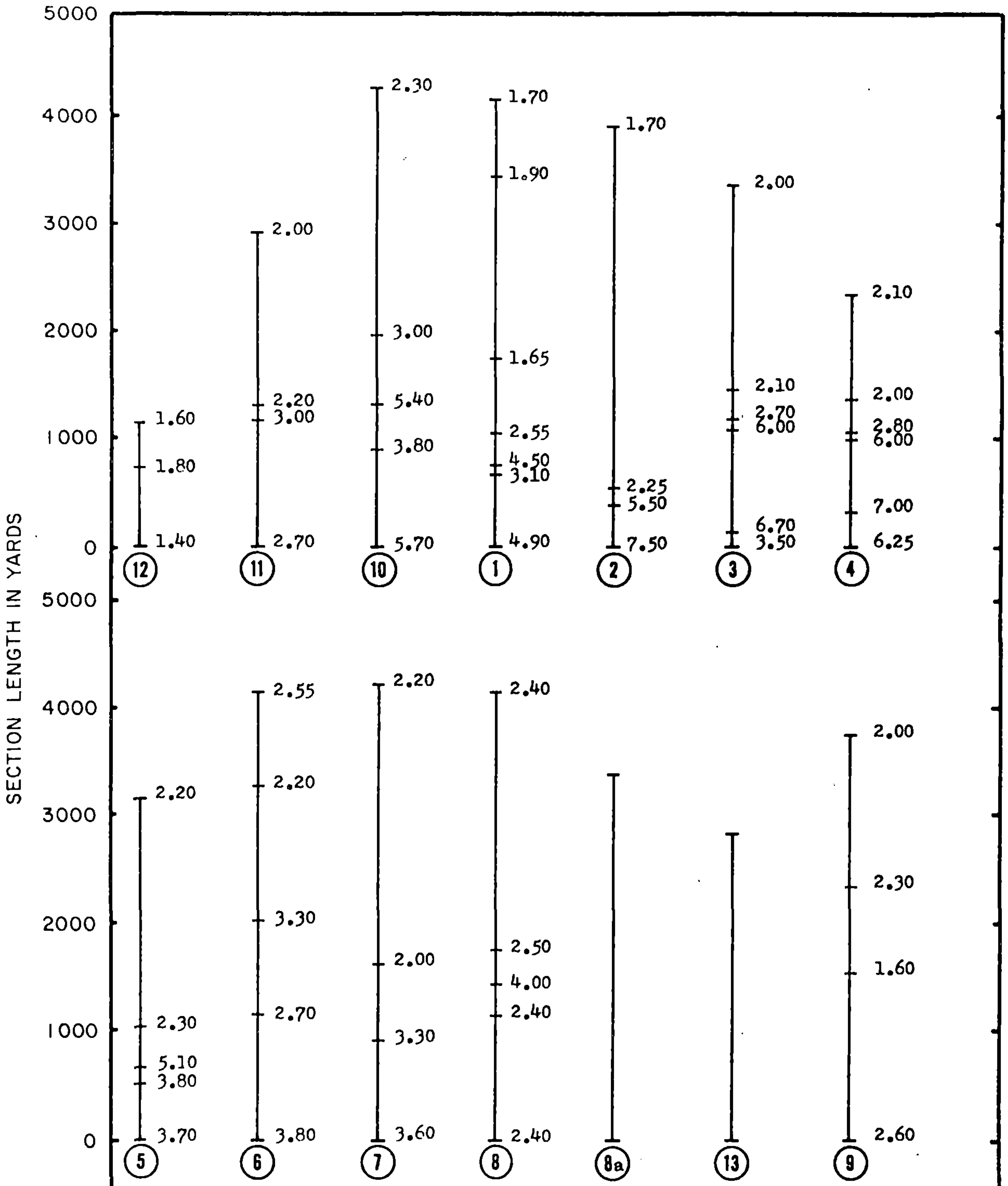
OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 2000 cfs
REJECTED HEAT = 12 x 10^9 BTU / HR.
TIDAL HOUR = 10 1/2



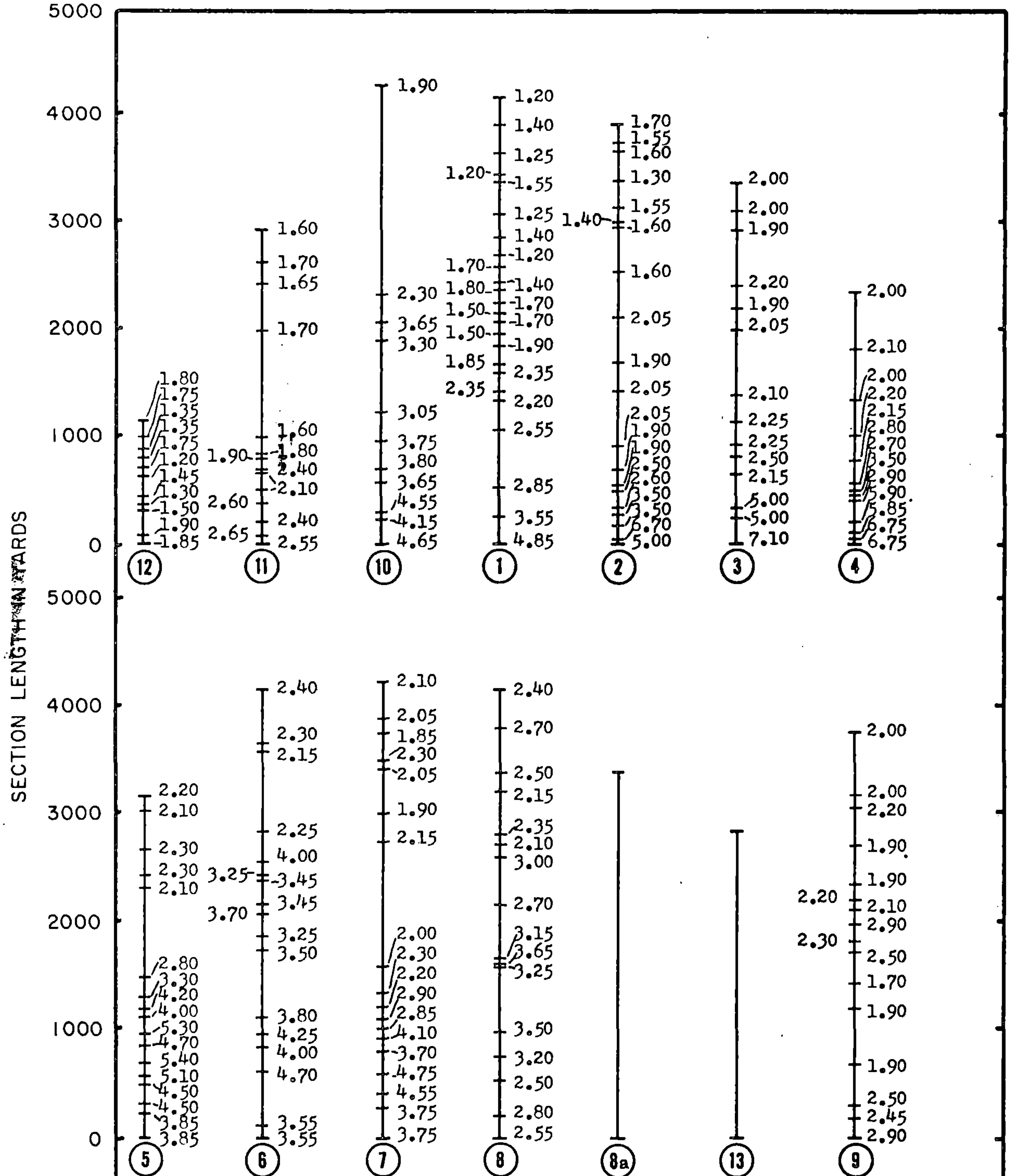
OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 6000 cfs
REJECTED HEAT = 12×10^9 BTU / HR.
TIDAL HOUR = 0



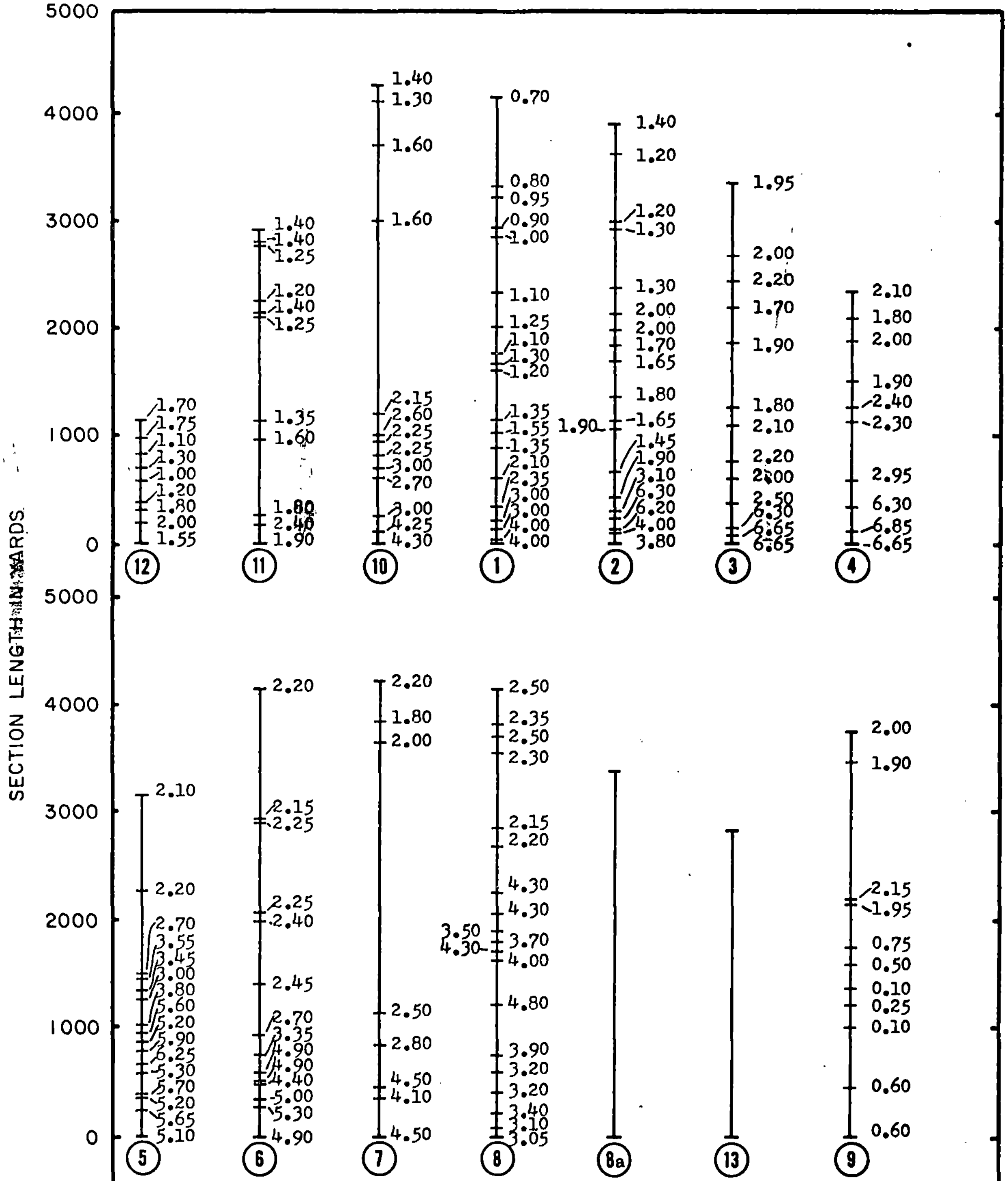
OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 6000 cfs
REJECTED HEAT = 12×10^9 BTU / HR.
TIDAL HOUR = 1 1/2



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 6000 cfs
REJECTED HEAT = 12×10^9 BTU/HR.
TIDAL HOUR = 3

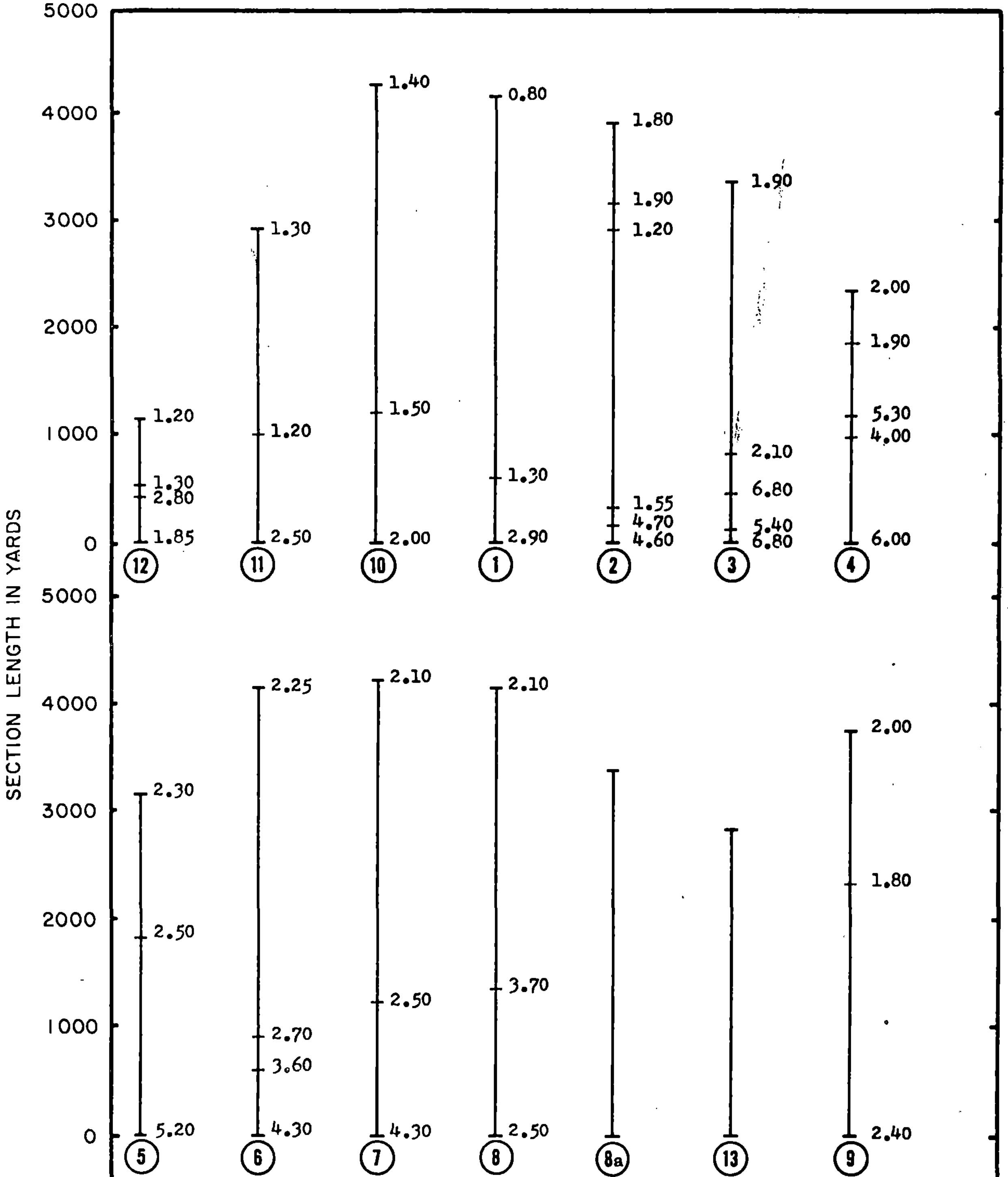


OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 6000 cfs
REJECTED HEAT = 12×10^9 BTU / HR.
TIDAL HOUR = 4 1/2

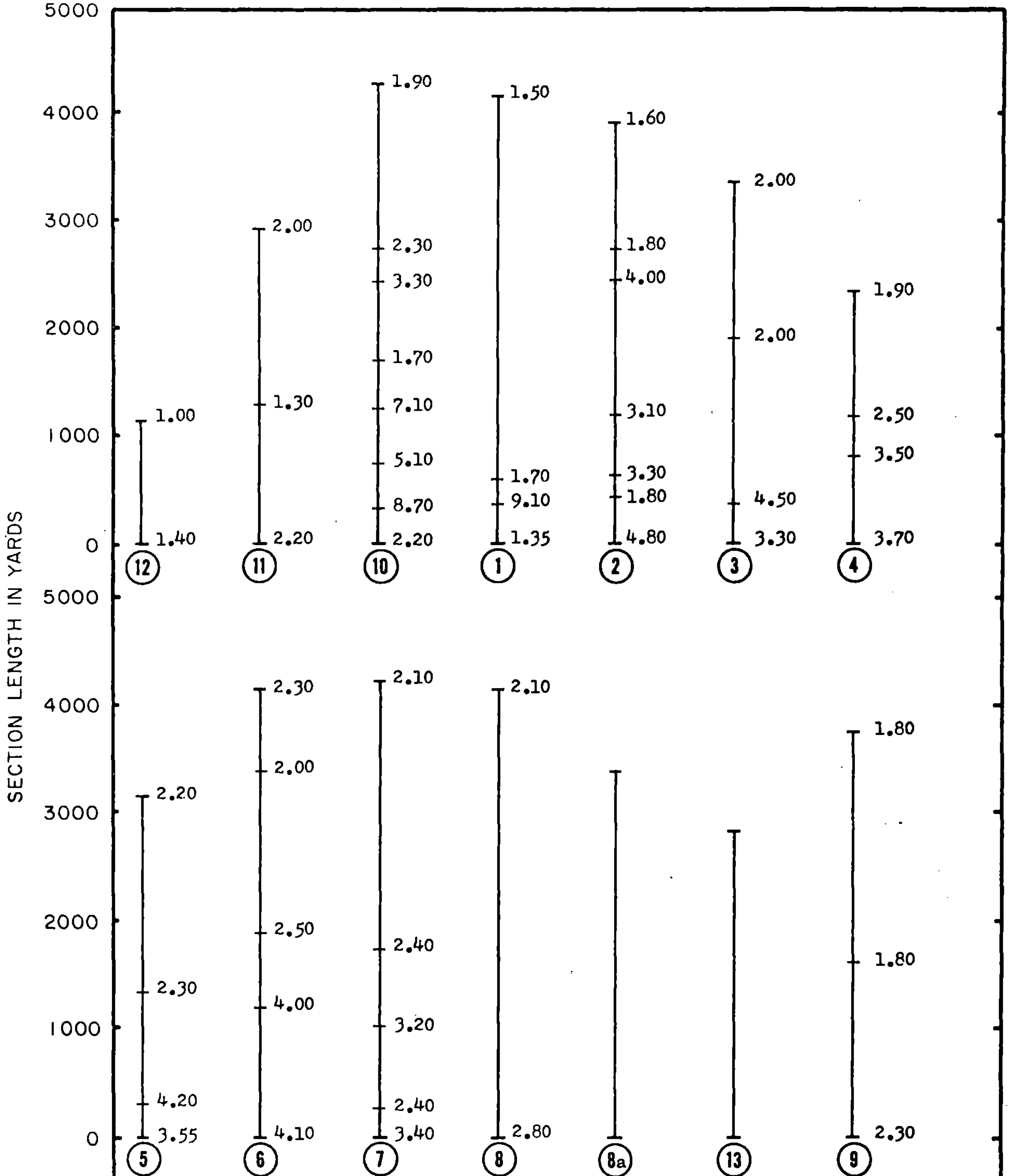


OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR

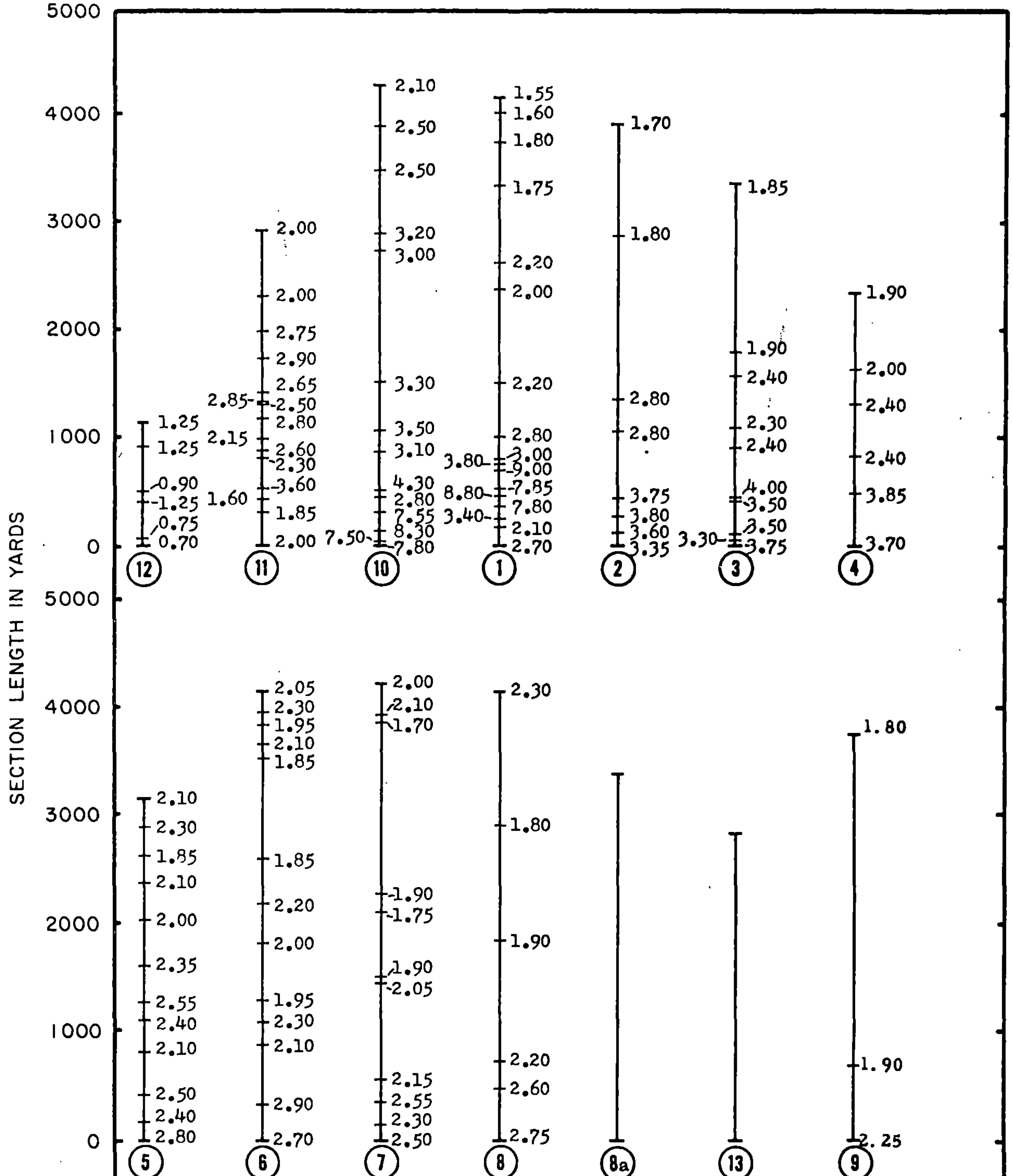
RIVER FLOW = 6000 cfs
REJECTED HEAT = 12 x 10^9 BTU / HR.
TIDAL HOUR = 6



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 6000 cfs
REJECTED HEAT = 12×10^9 BTU / HR.
TIDAL HOUR = 7 1/2

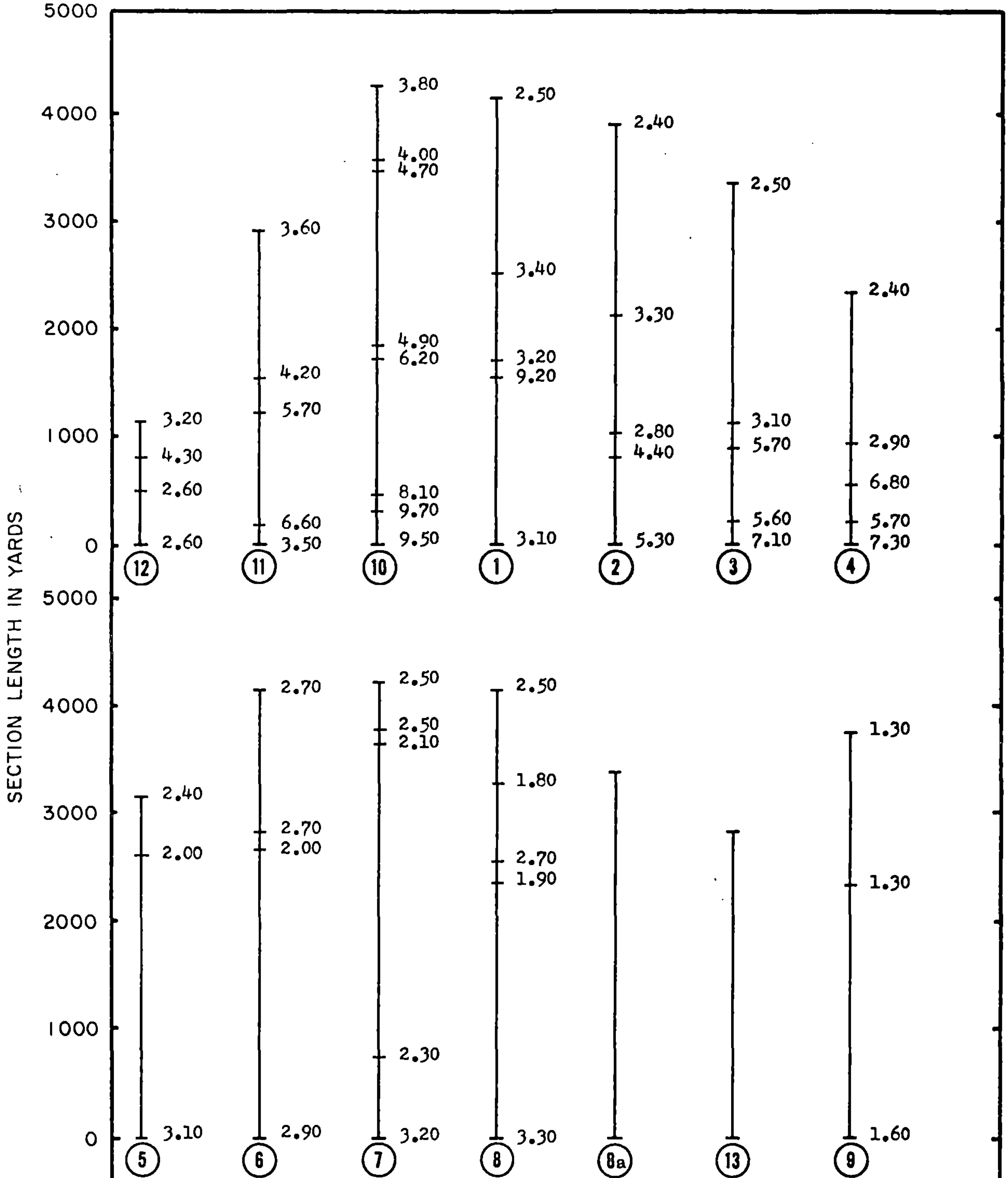


OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 6000 cfs
REJECTED HEAT = 12×10^9 BTU/HR.
TIDAL HOUR = 9

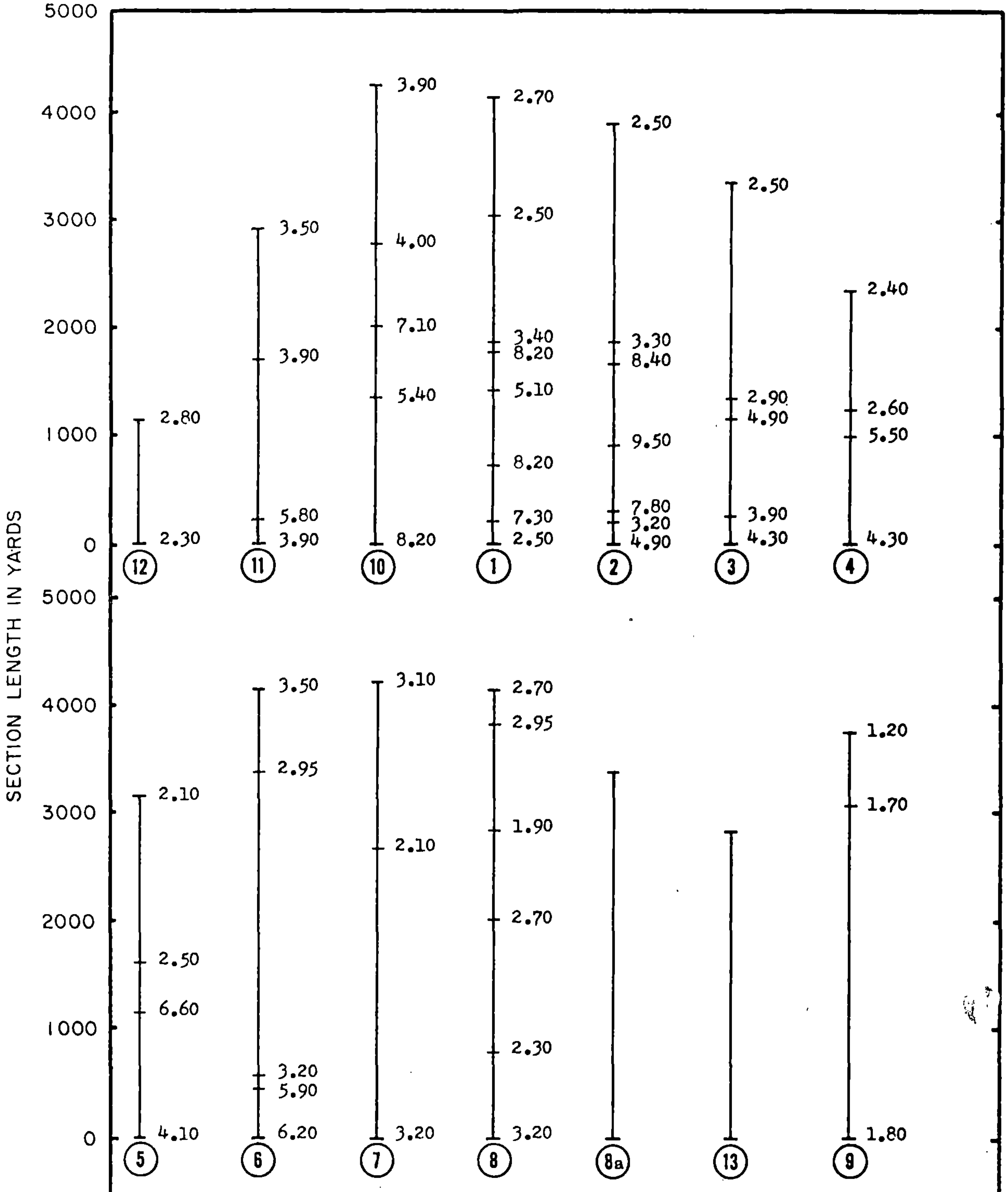


OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR

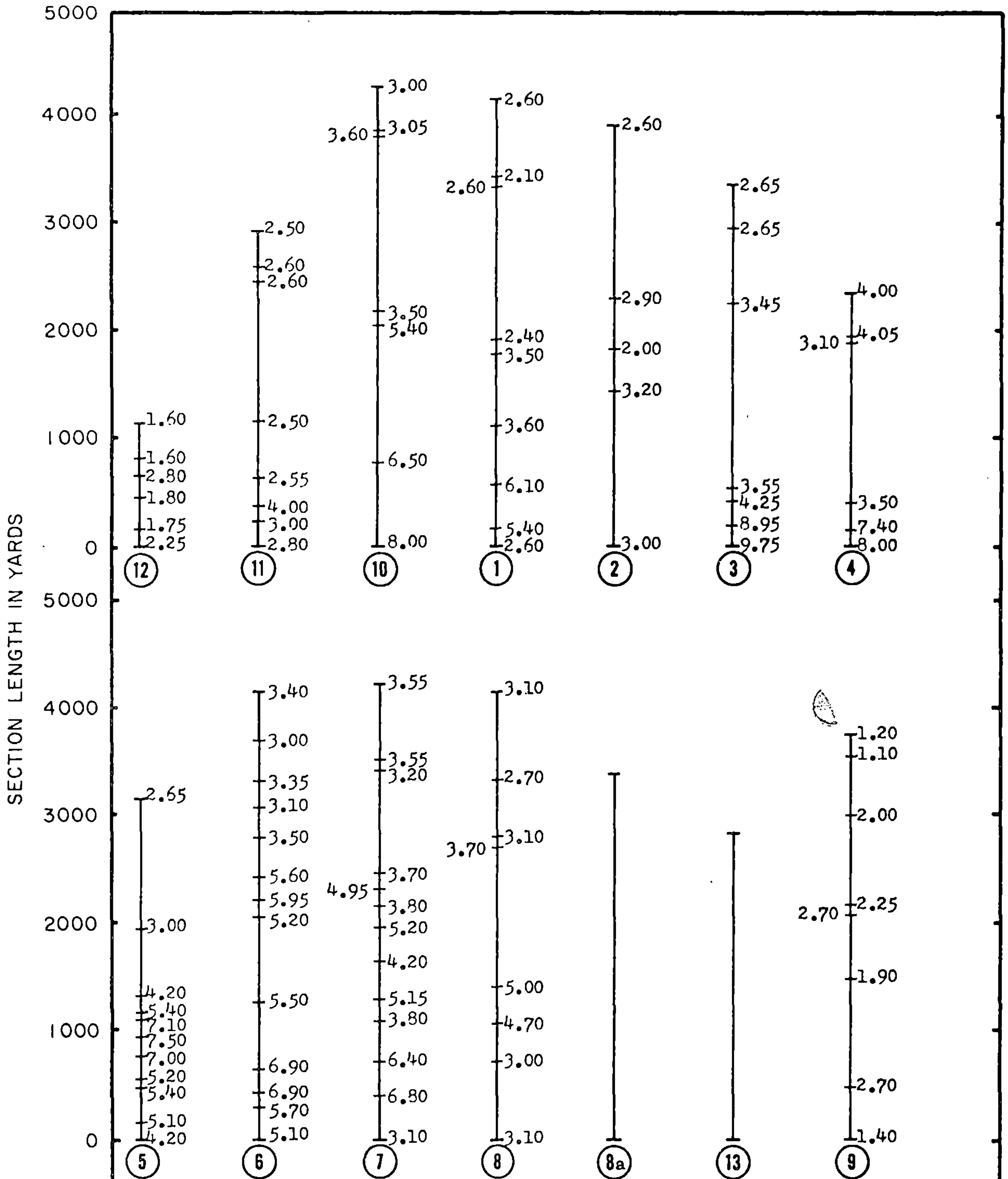
RIVER FLOW = 6000 cfs
REJECTED HEAT = 12×10^9 BTU/HR.
TIDAL HOUR = 10 1/2



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 2000 cfs
REJECTED HEAT = 24×10^9 BTU / HR.
TIDAL HOUR = 0

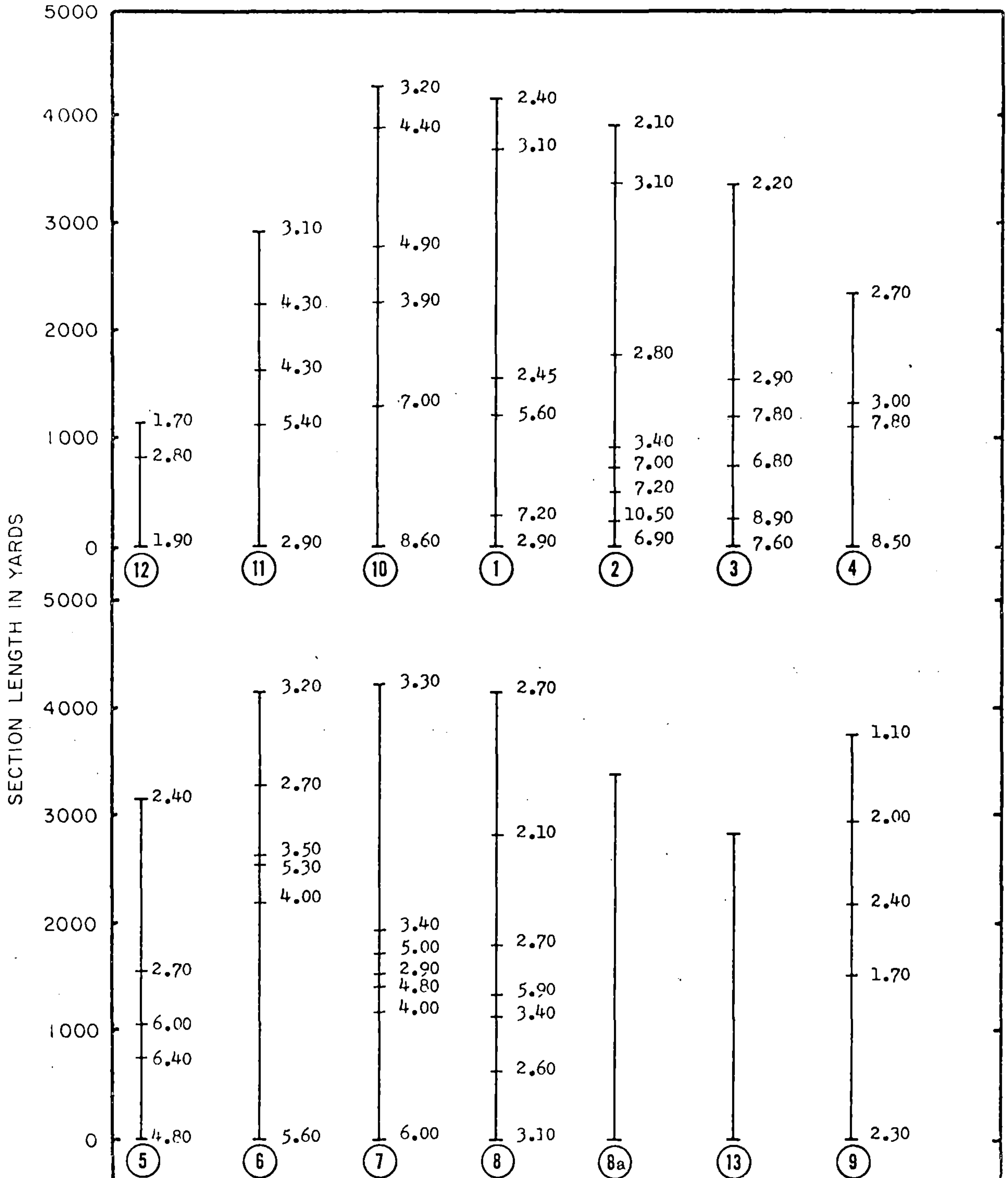


OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 2000 cfs
REJECTED HEAT = 24×10^9 BTU / HR.
TIDAL HOUR = 1 1/2



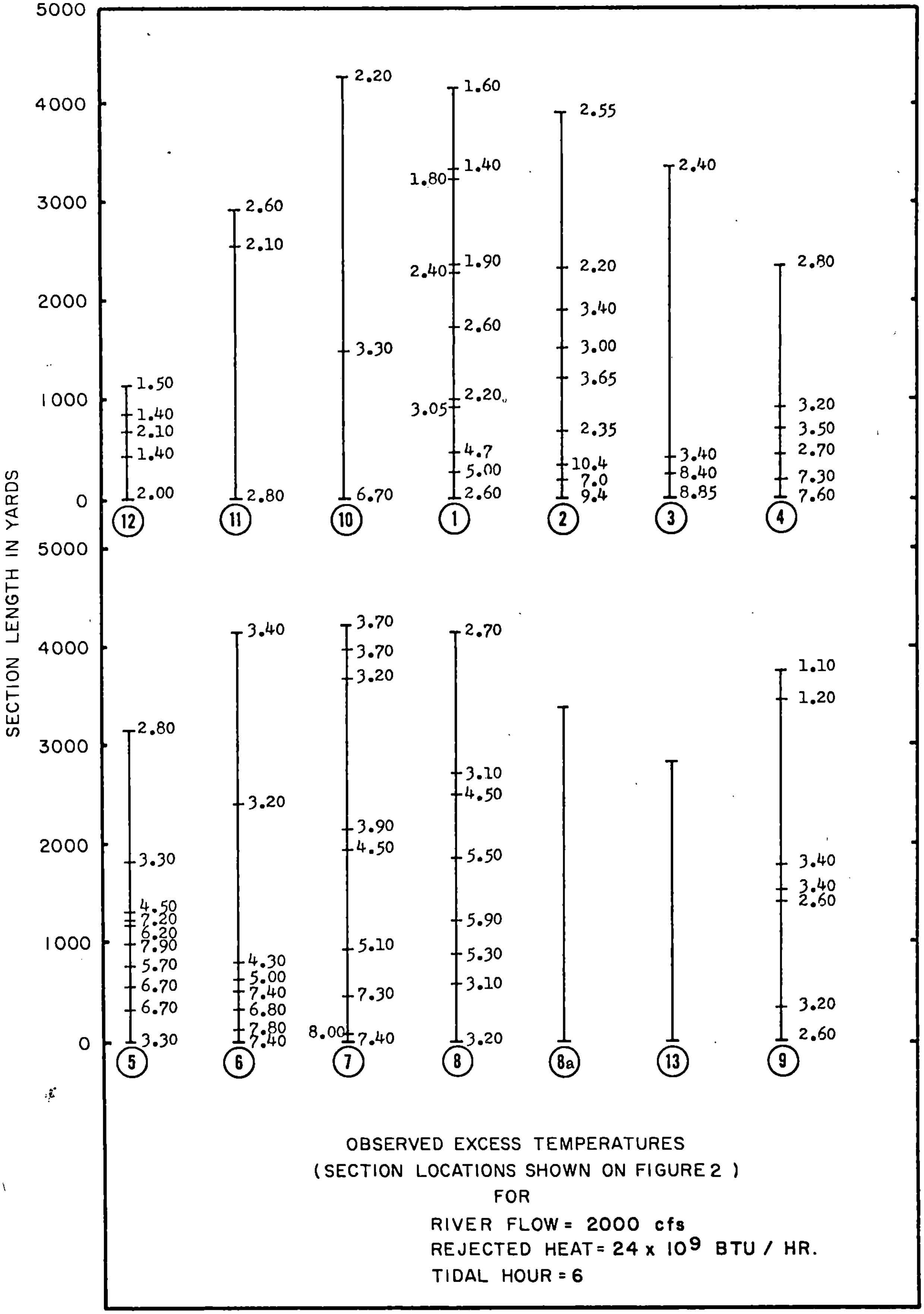
OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR

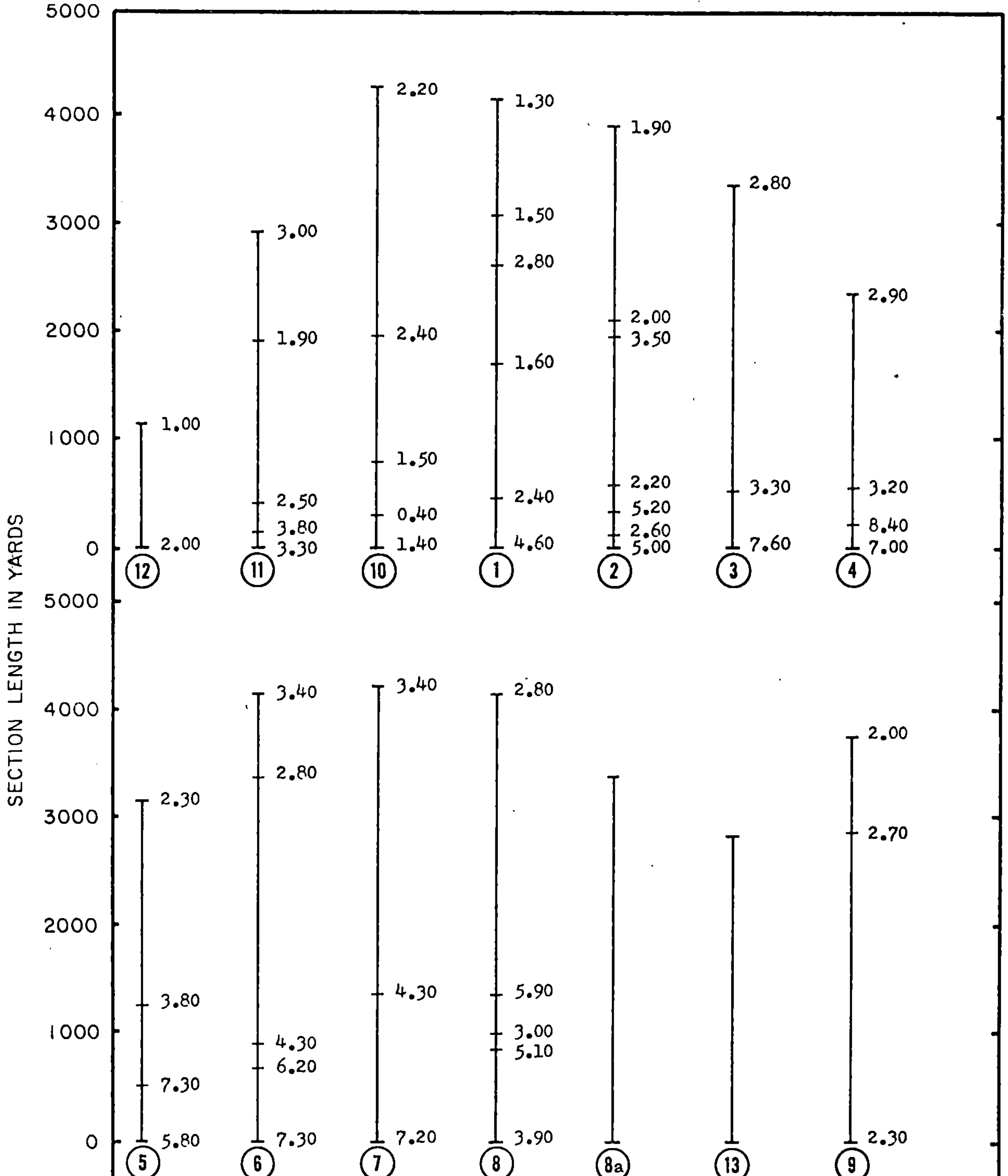
RIVER FLOW = 2000 cfs
REJECTED HEAT = 24 x 10^9 BTU/HR.
TIDAL HOUR = 4 1/2



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR

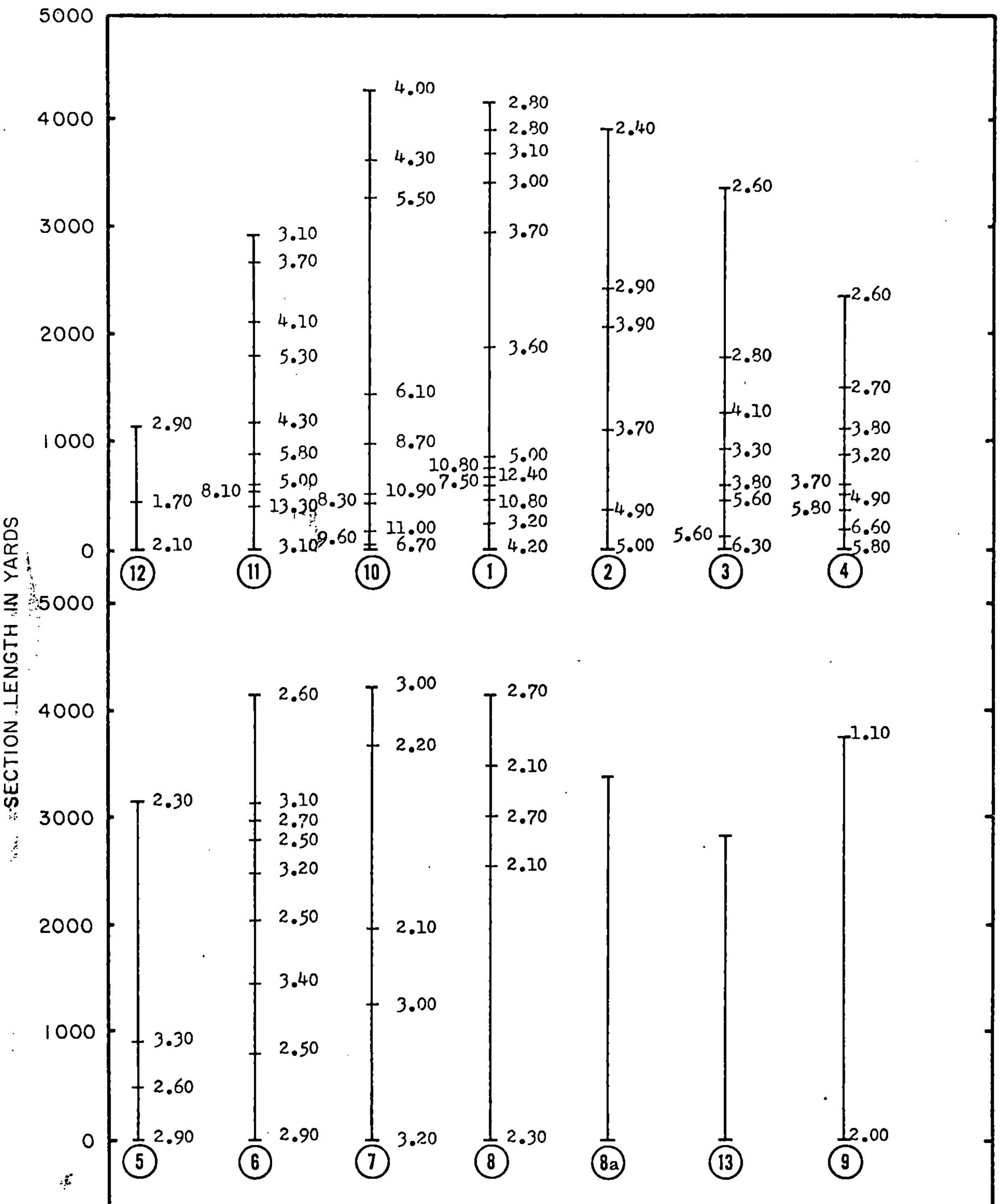
RIVER FLOW = 2000 cfs
REJECTED HEAT = 24 x 10^9 BTU/HR.
TIDAL HOUR = 3


SECTION LENGTH IN YARDS
5000
4000
3000
2000
1000
0
12
11
10
1
2
3
4
5
6
7
8
8a
13
9
OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 2000 cfs
REJECTED HEAT = 24 x 10^9 BTU / HR.
TIDAL HOUR = 6

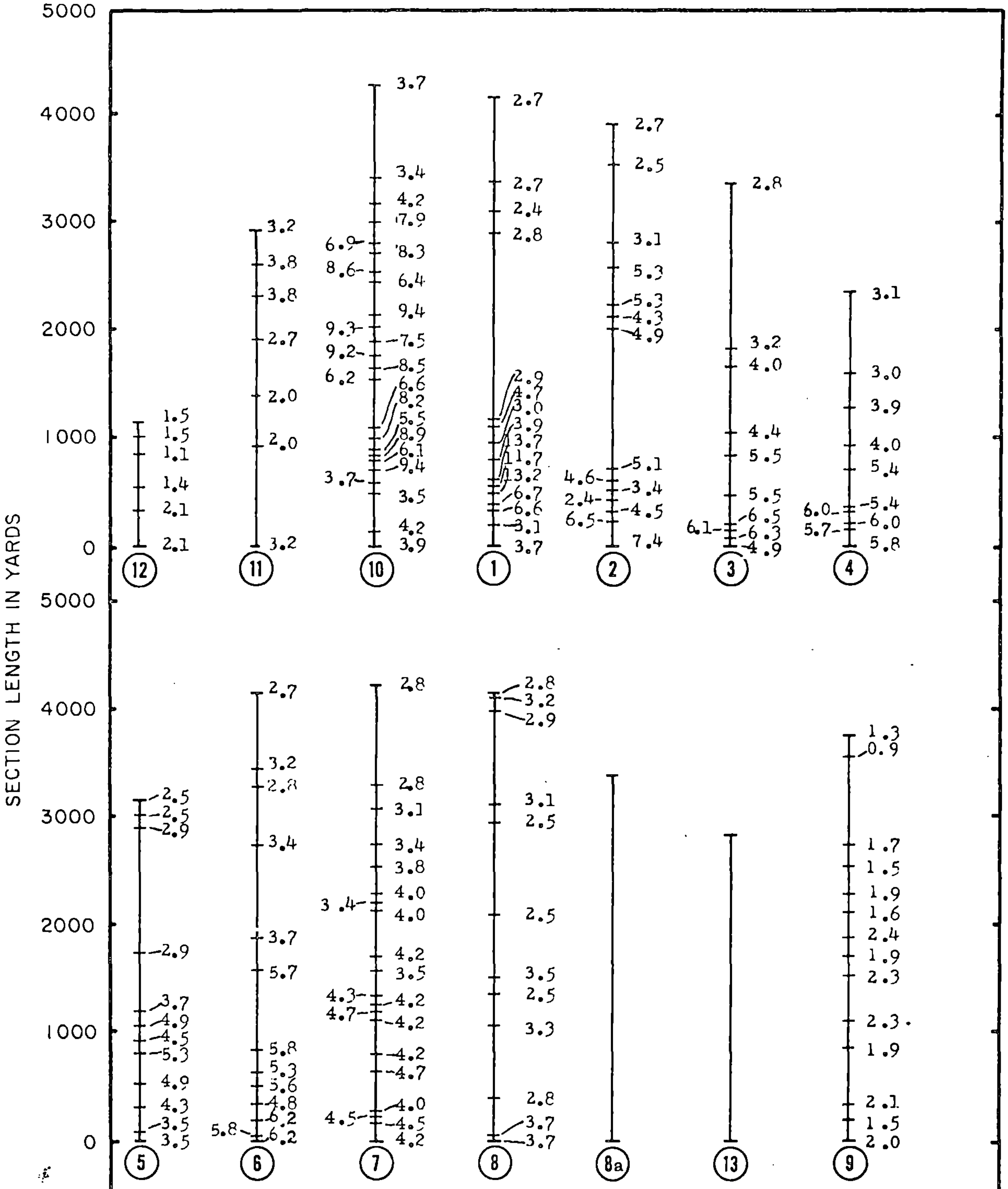


OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR

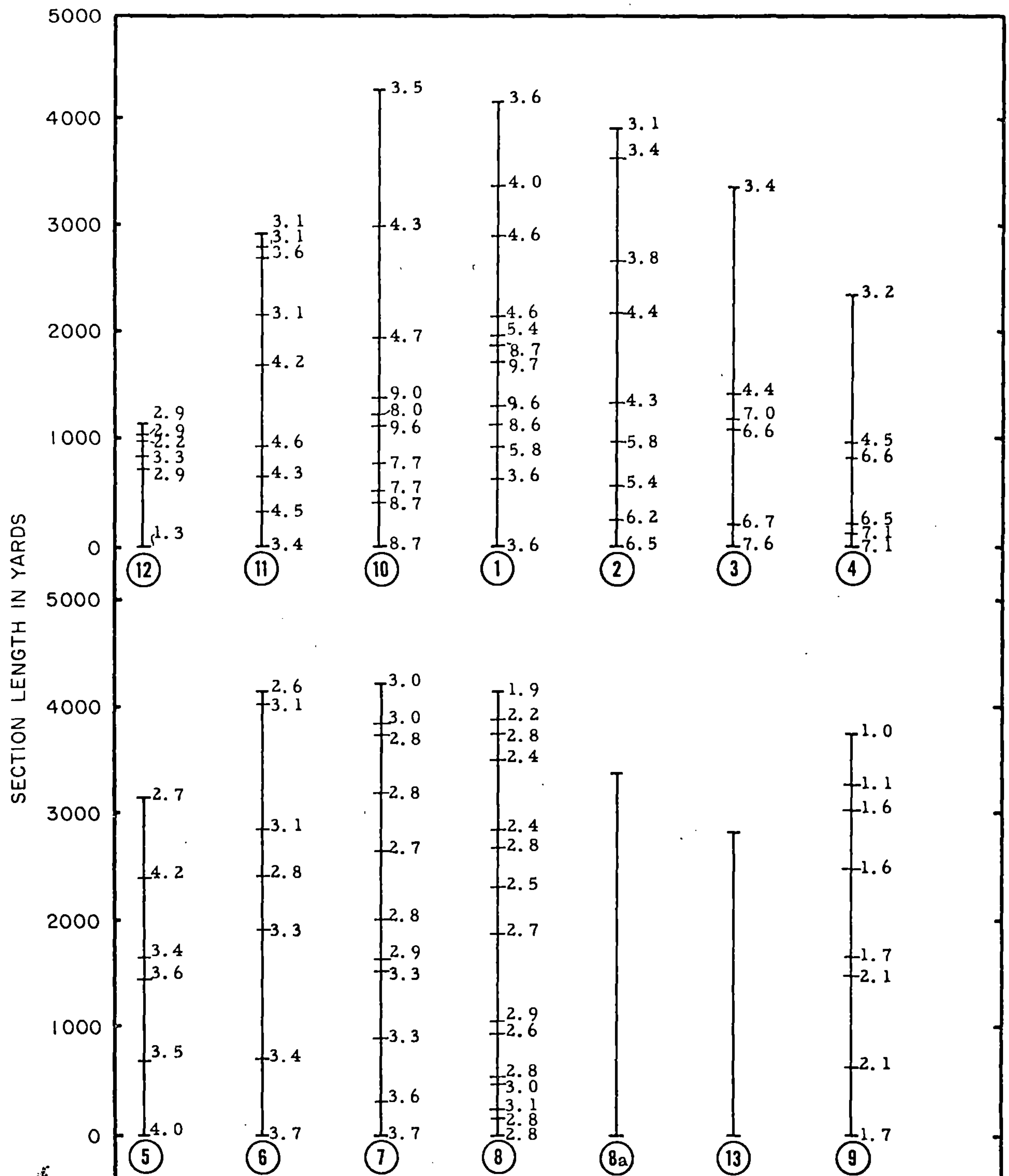
RIVER FLOW = 2000 cfs
REJECTED HEAT = 24×10^9 BTU/HR.
TIDAL HOUR = 7 1/2



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 2000 cfs
REJECTED HEAT = 24 x 10^9 BTU / HR.
TIDAL HOUR = 10 1/2



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 2000 cfs
REJECTED HEAT = 24 x 10^9 BTU / HR.
TIDAL HOUR = 9



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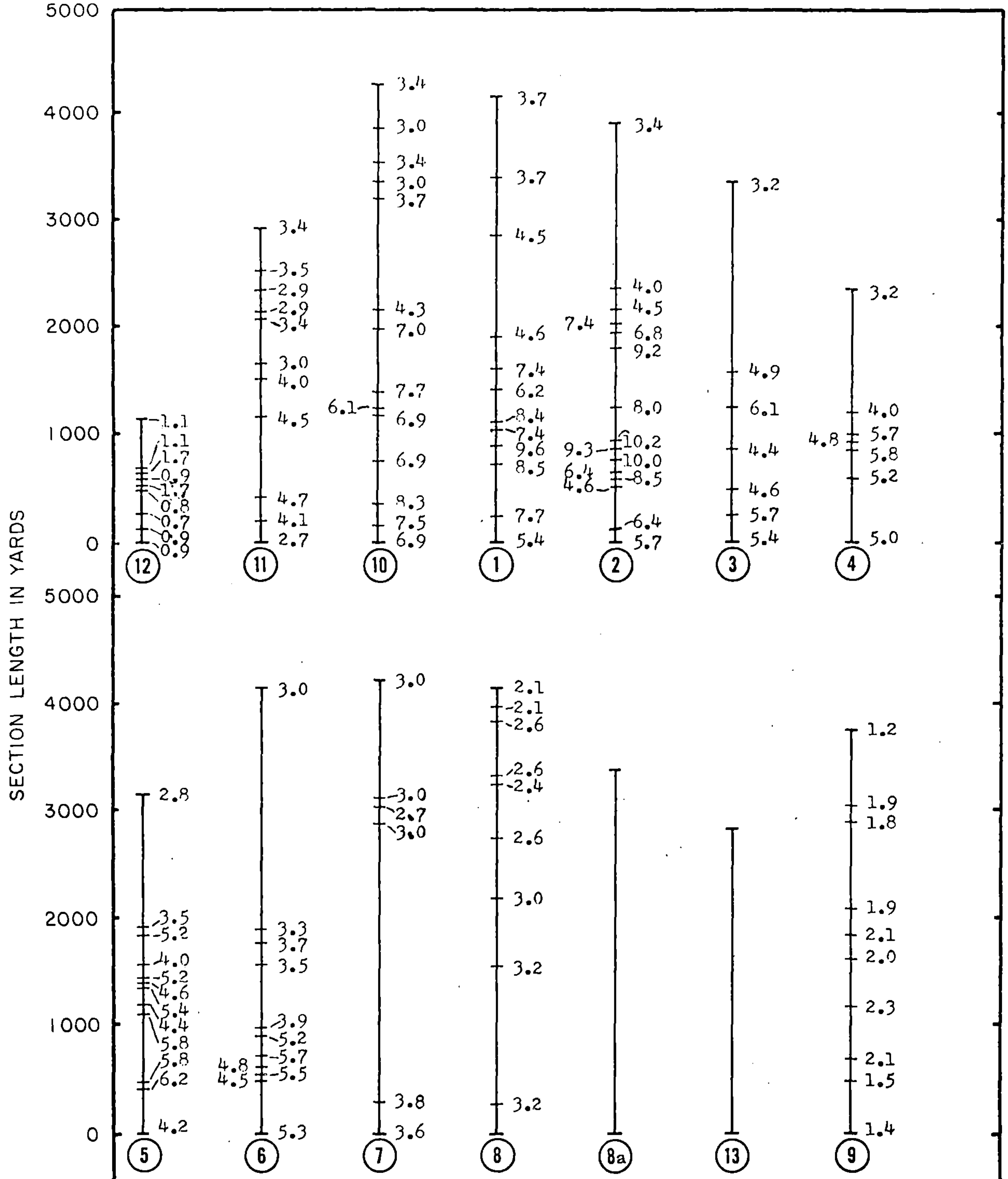

OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
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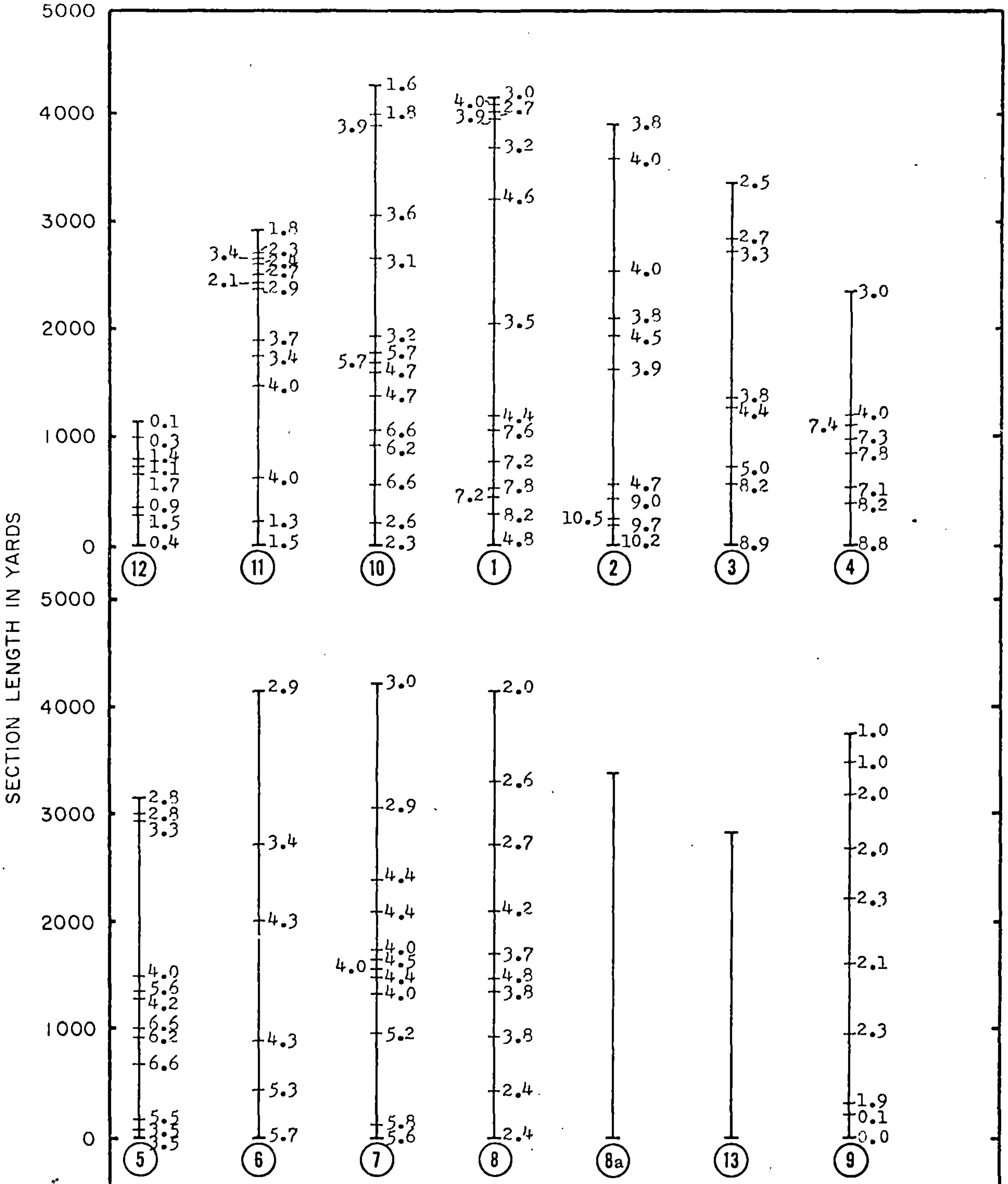
REJECTED HEAT = 24 x 10^9 BTU/HR.
TIDAL HOUR = 1 1/2



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
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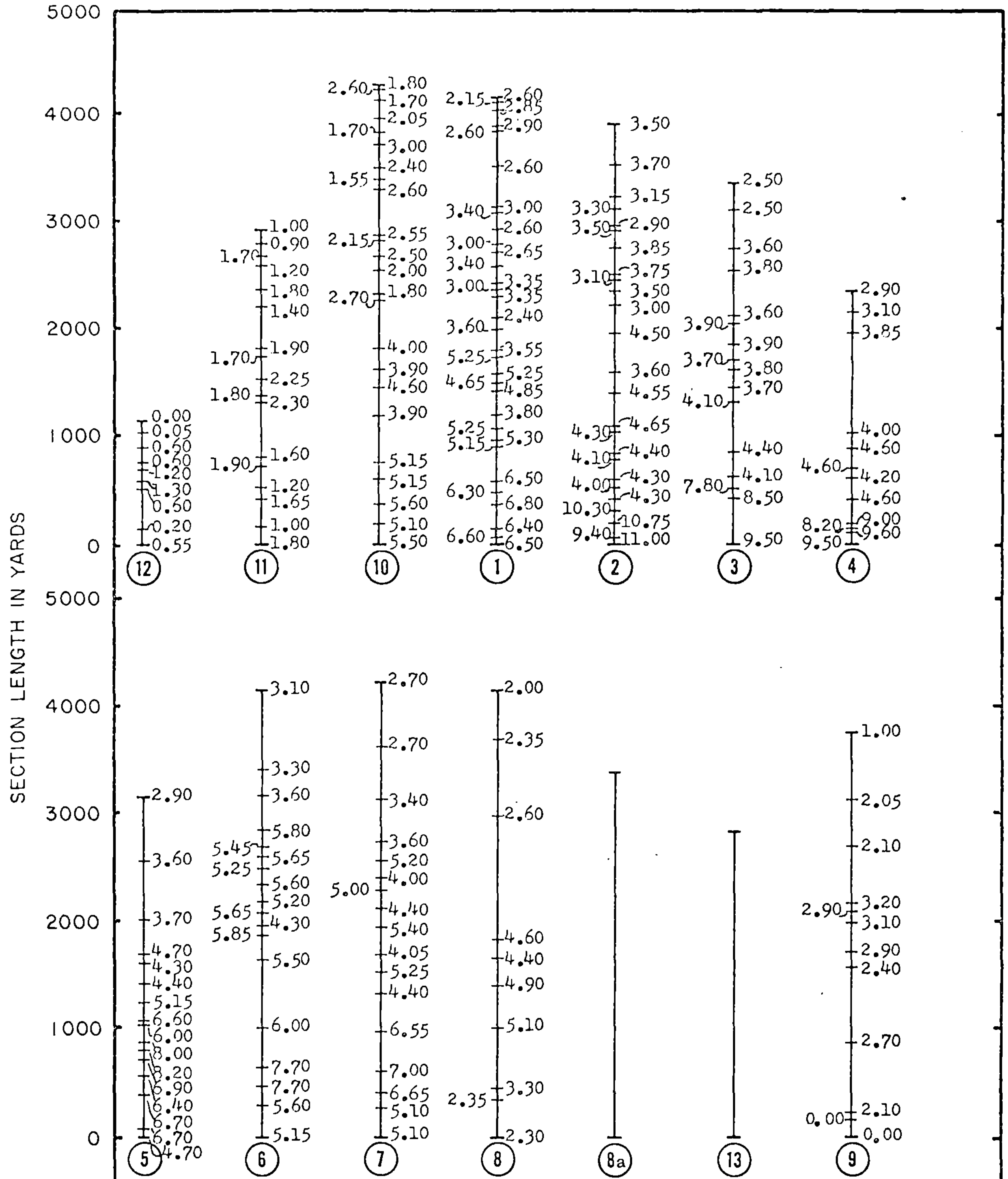
REJECTED HEAT = 24×10^9 BTU/HR.
TIDAL HOUR = 3



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(SECTION LOCATIONS SHOWN ON FIGURE 2)
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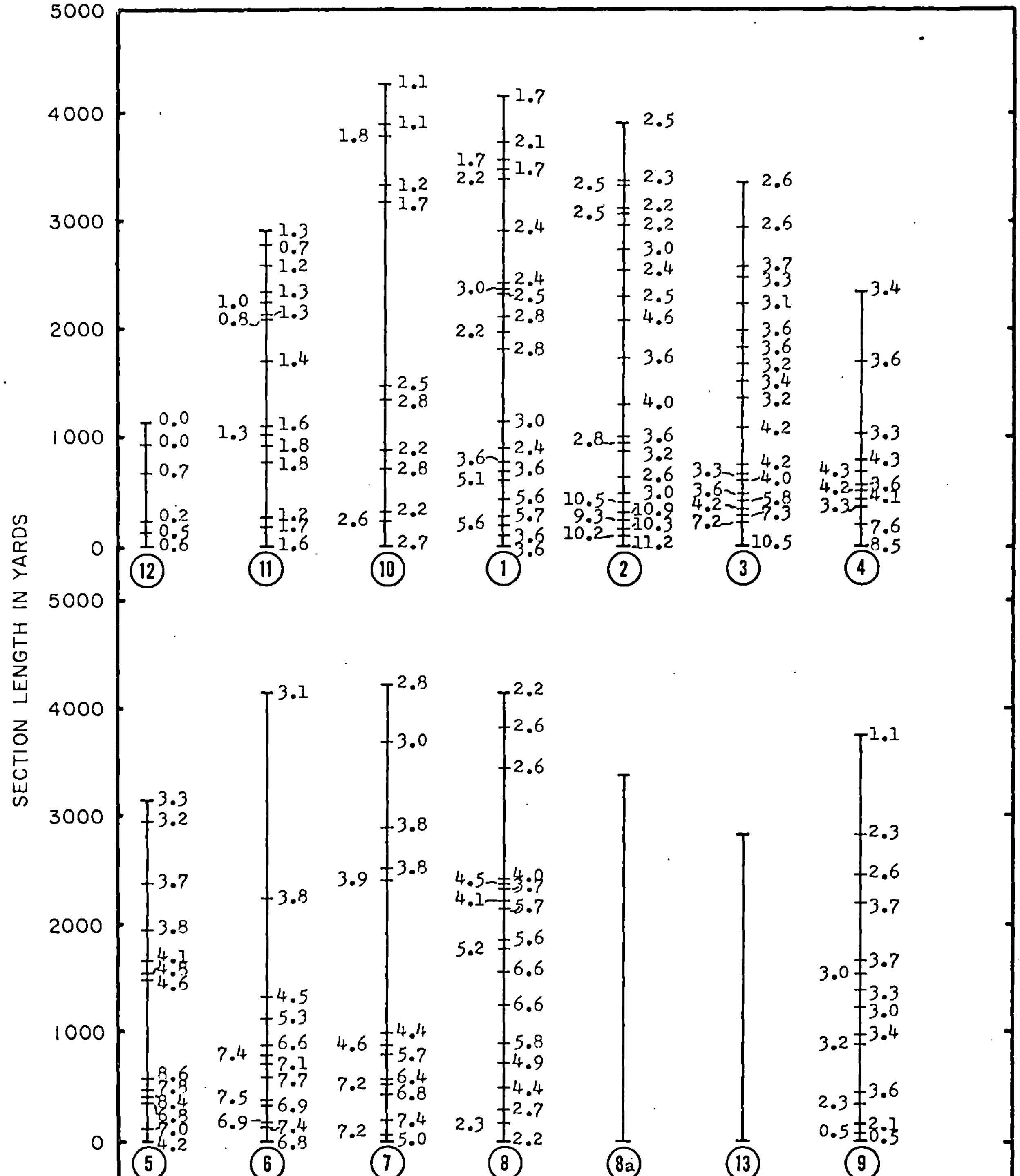
REJECTED HEAT = 24 x 10^9 BTU / HR.
TIDAL HOUR = 4 1/2



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
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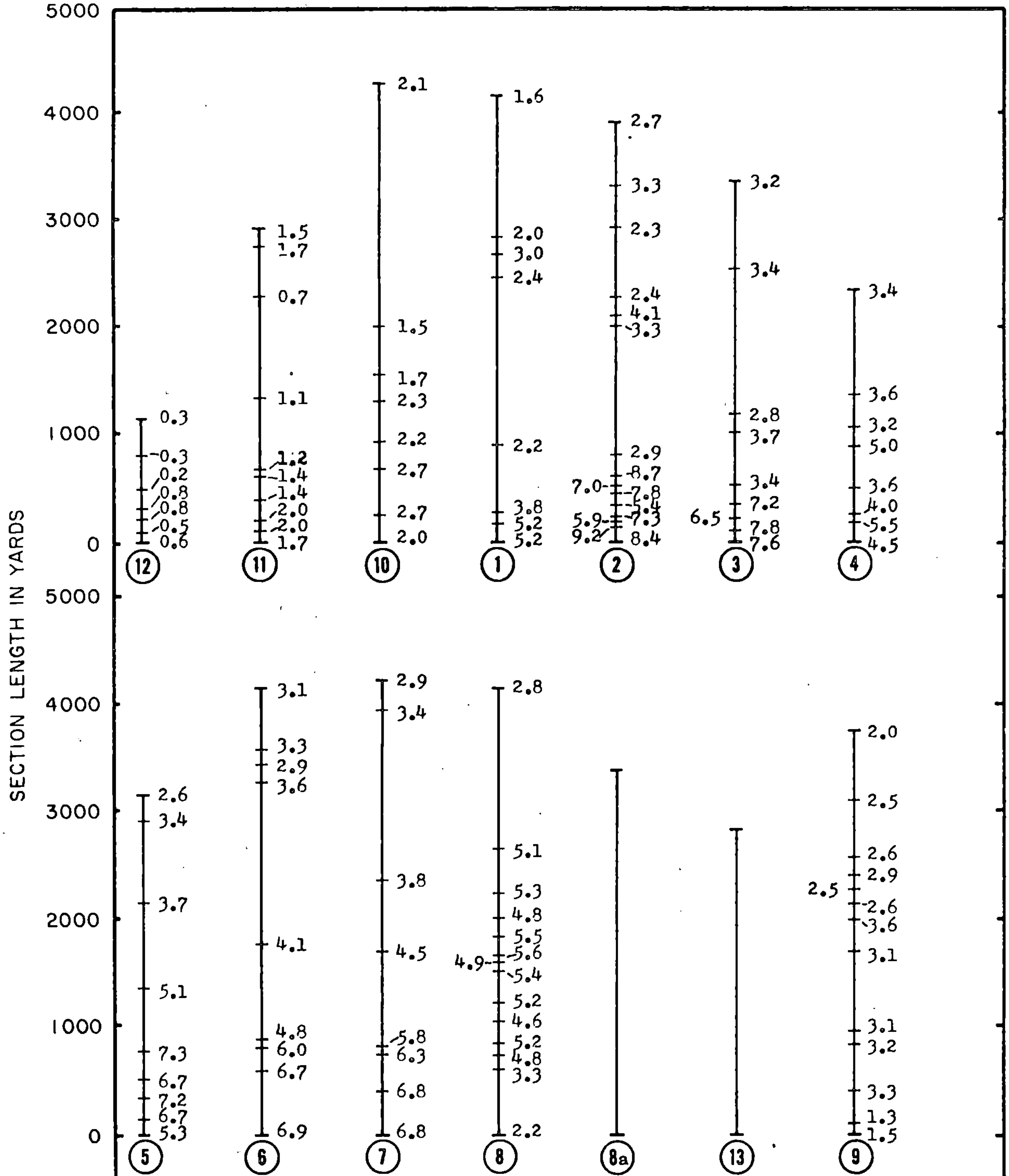
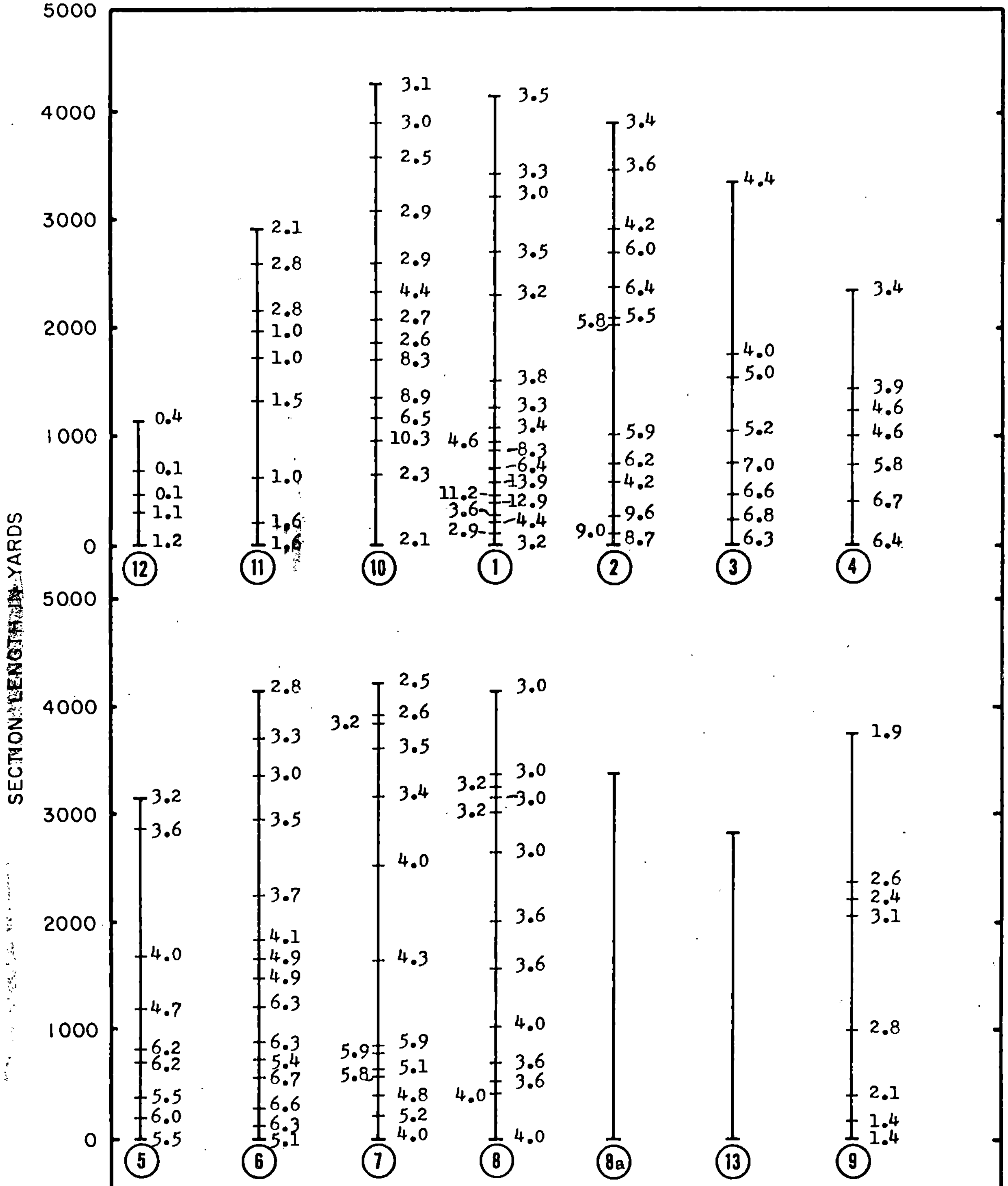
REJECTED HEAT = 24 x 10^9 BTU / HR.
TIDAL HOUR = 6



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 6000 cfs
REJECTED HEAT = 24 x 10^9 BTU / HR.
TIDAL HOUR = 7 1/2



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(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
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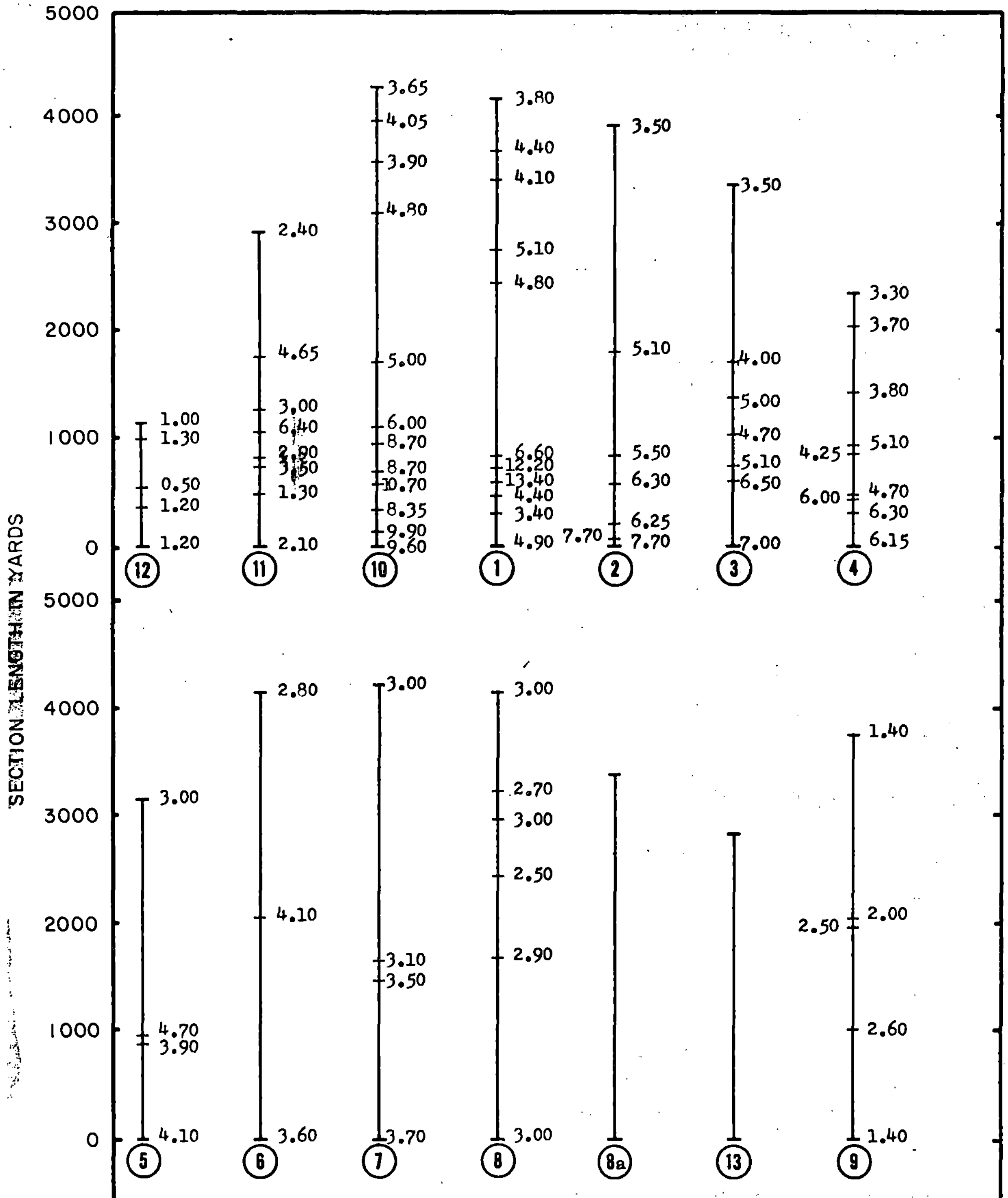
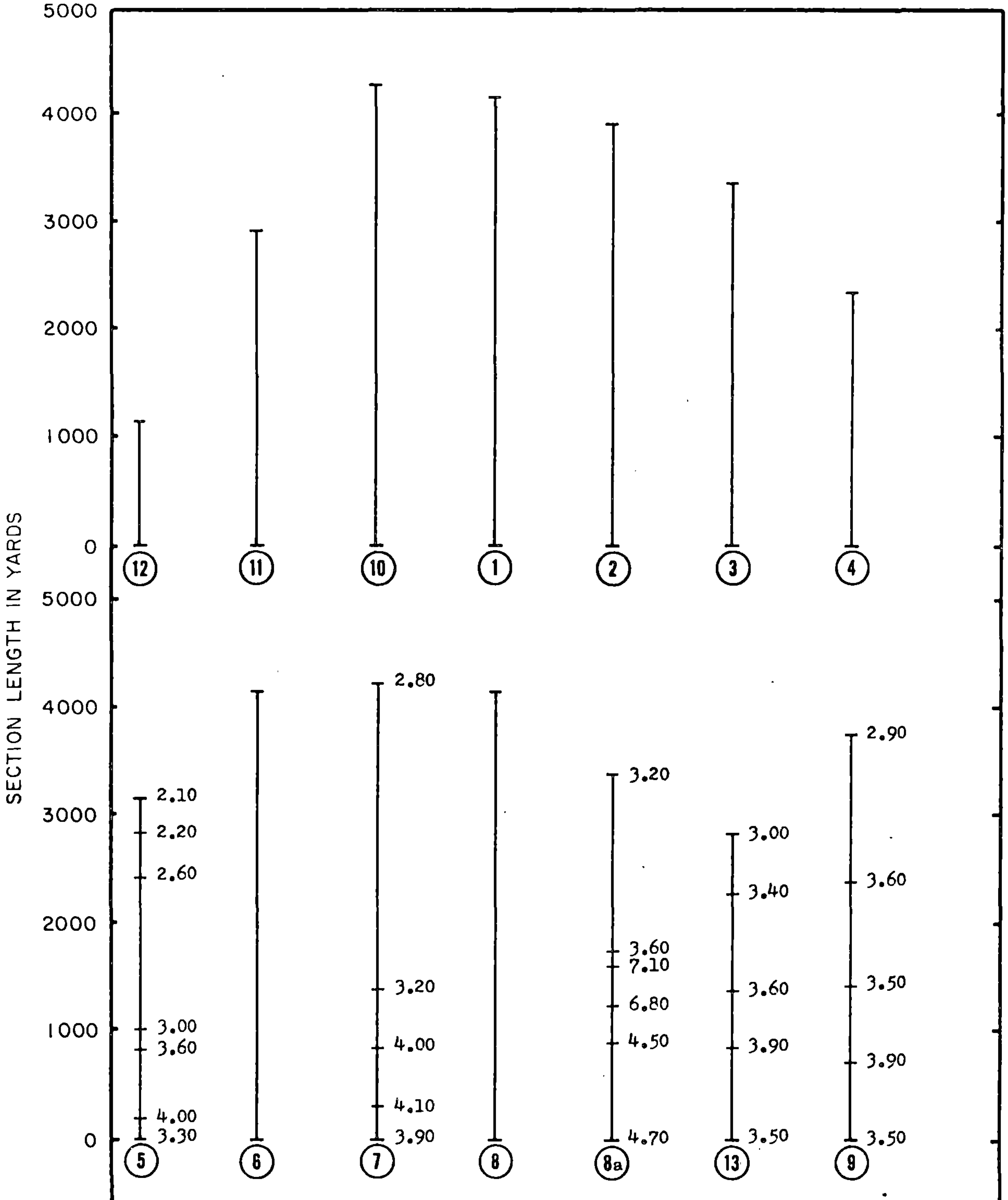
REJECTED HEAT = 24×10^9 BTU / HR.
TIDAL HOUR = 9



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 6000 cfs
REJECTED HEAT = 24 x 10^9 BTU/HR.
TIDAL HOUR = 10 1/2



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR

DISCHARGE AND INTAKE REVERSED

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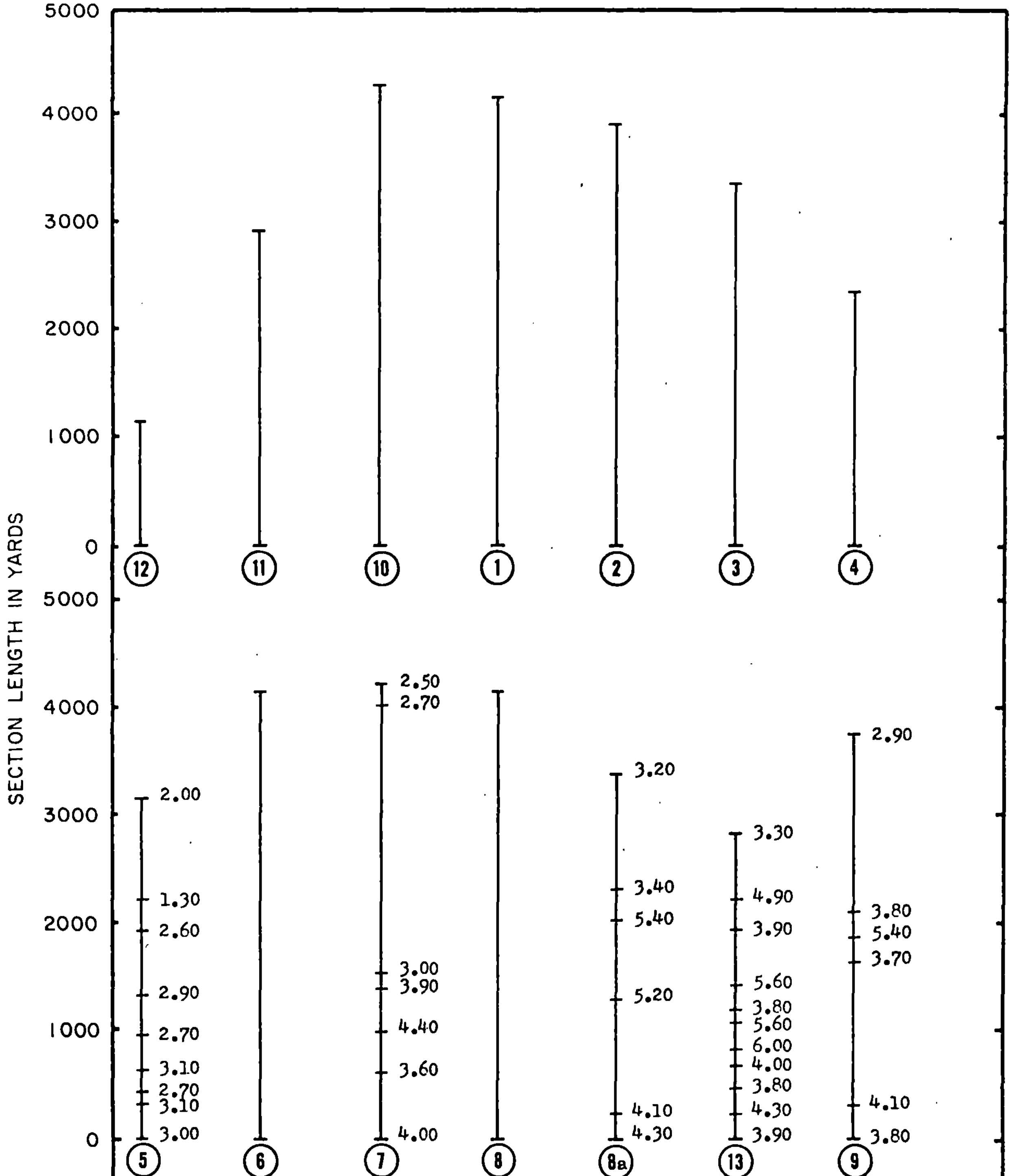
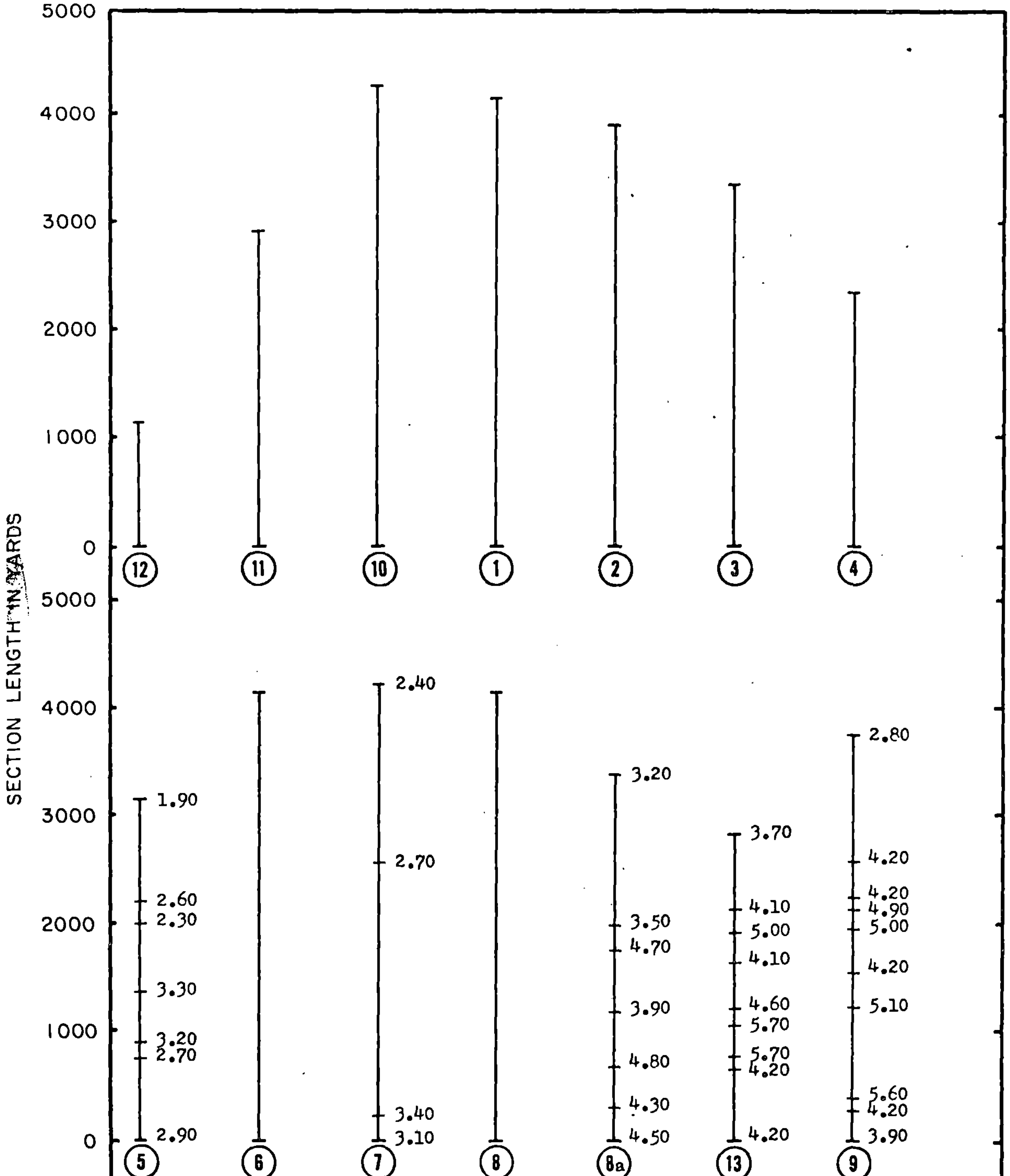
REJECTED HEAT = 12×10^9 BTU / HR.
TIDAL HOUR = 0



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR

DISCHARGE AND INTAKE REVERSED

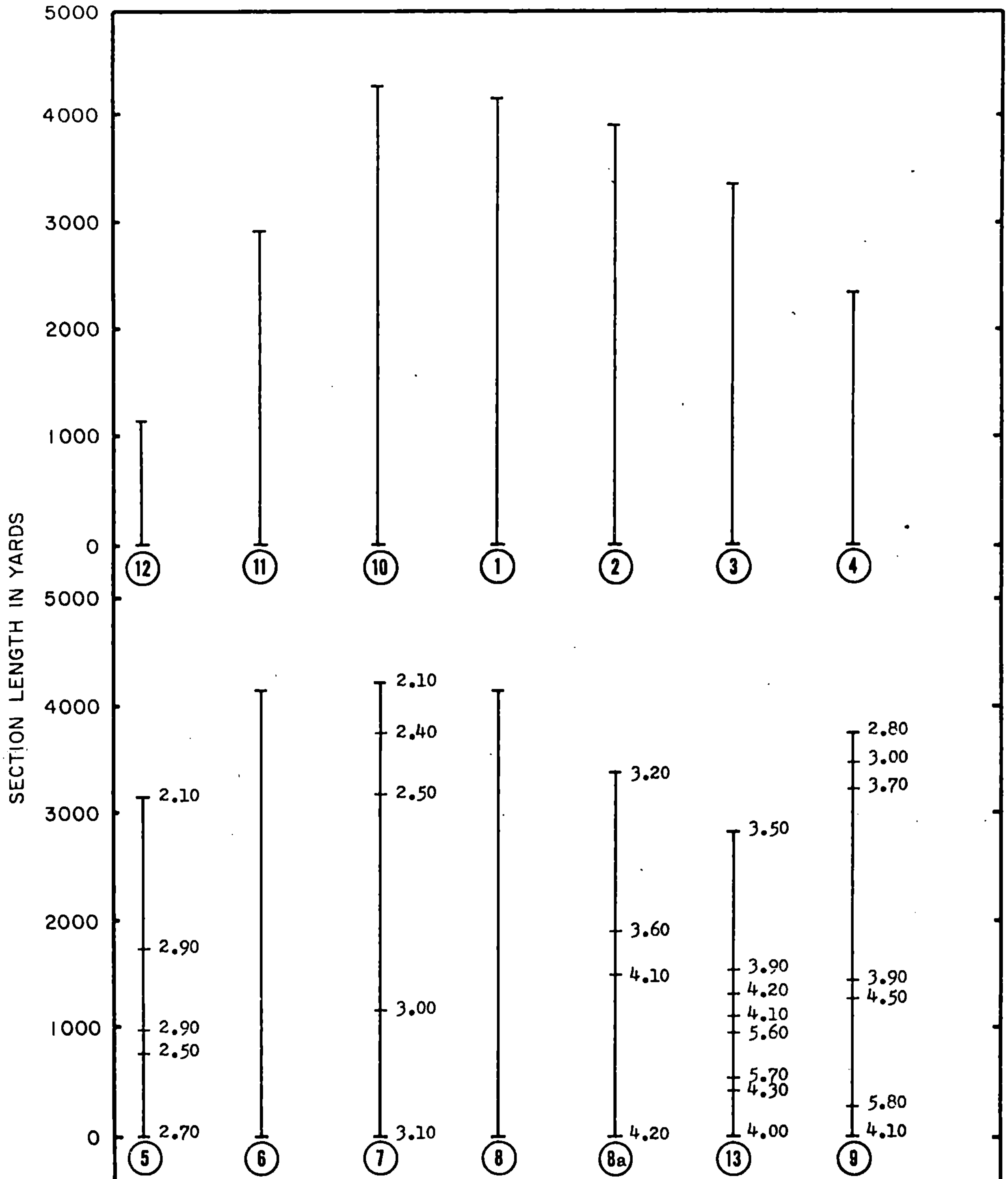
RIVER FLOW = 2000 cfs
REJECTED HEAT = 12×10^9 BTU / HR.
TIDAL HOUR = 1 1/2



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR

DISCHARGE AND INTAKE REVERSED

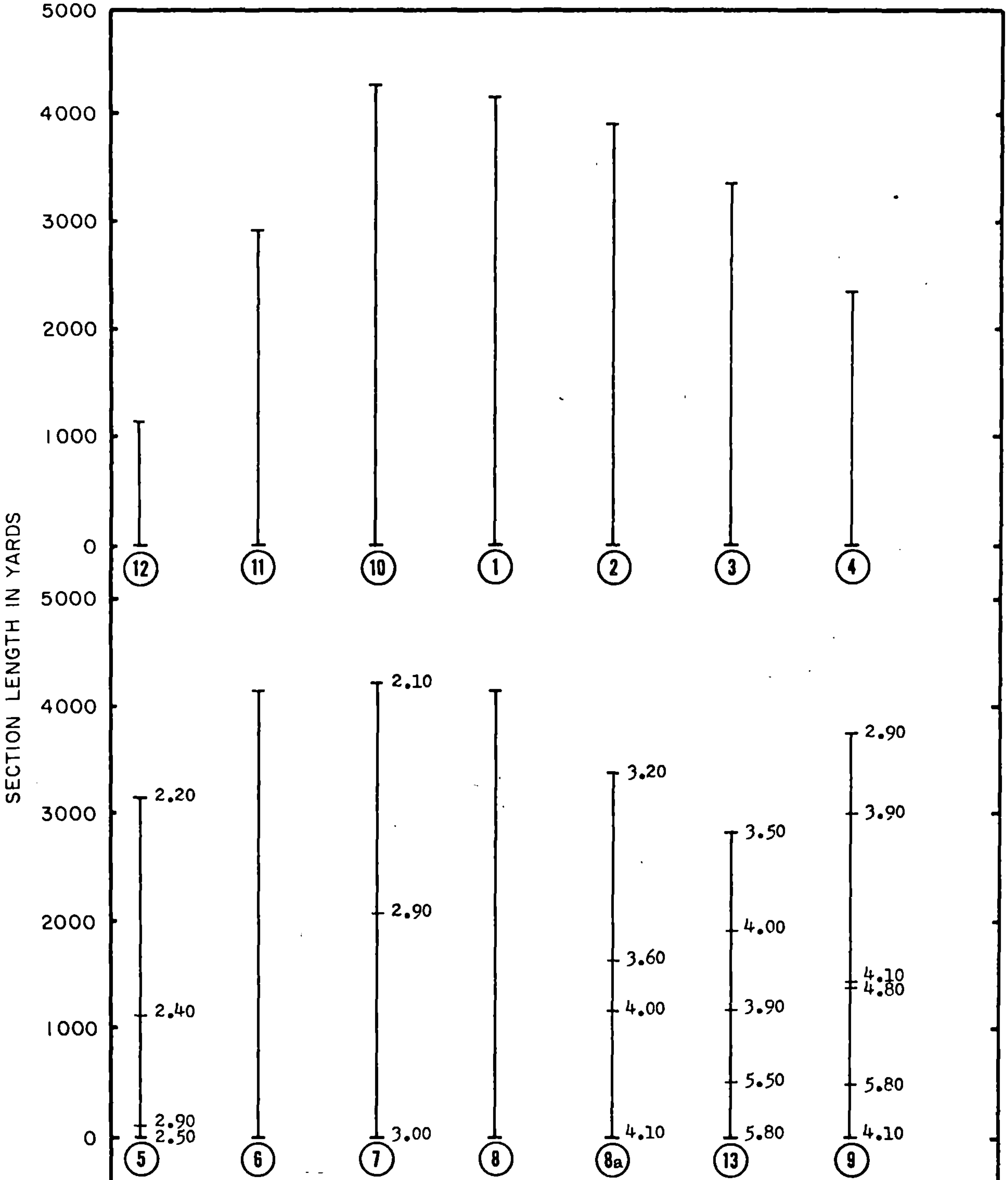
RIVER FLOW = 2000 cfs
REJECTED HEAT = 12×10^9 BTU / HR.
TIDAL HOUR = 3



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR

DISCHARGE AND INTAKE REVERSED

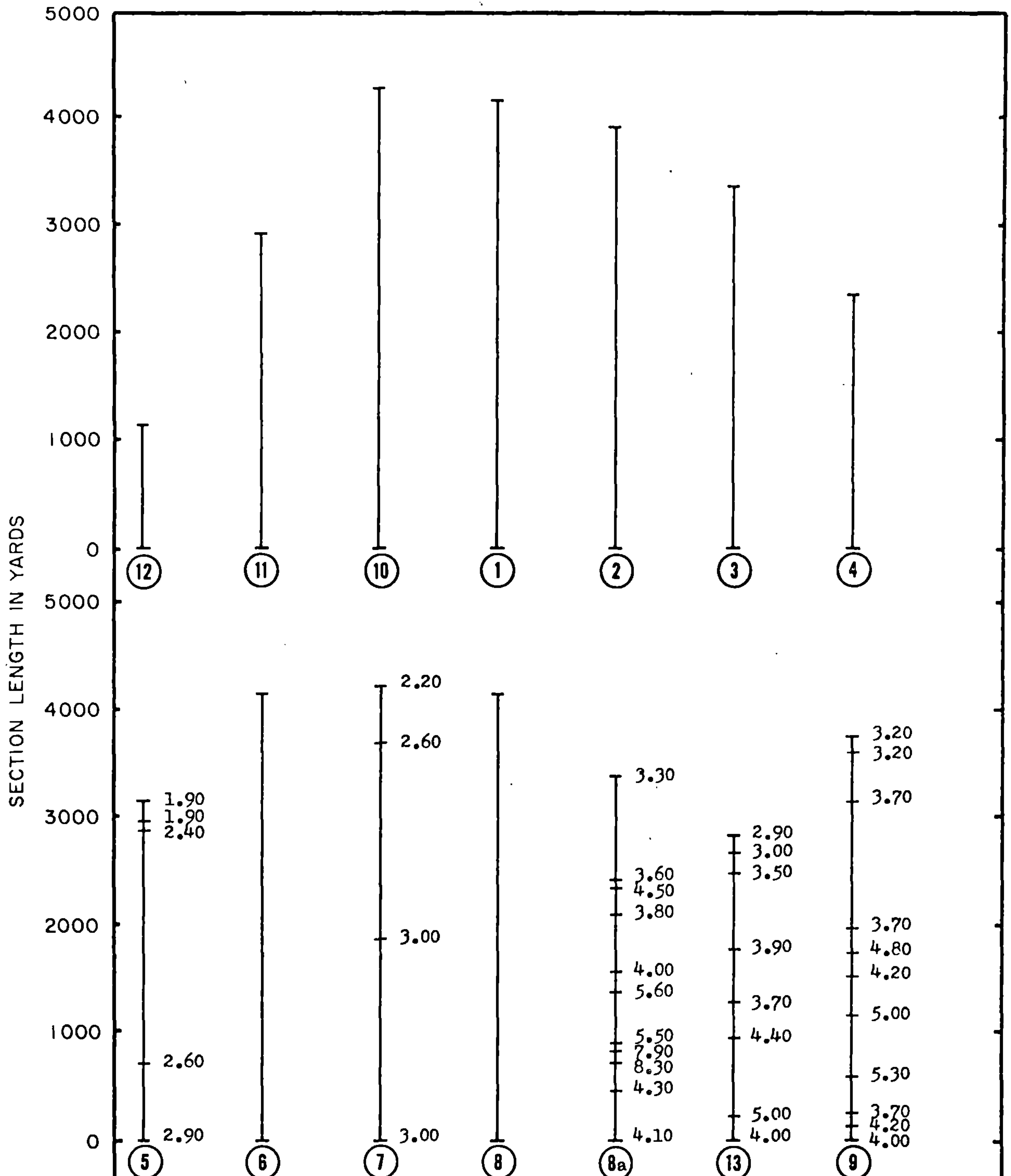
RIVER FLOW = 2000 cfs
REJECTED HEAT = 12×10^9 BTU / HR.
TIDAL HOUR = 4 1/2



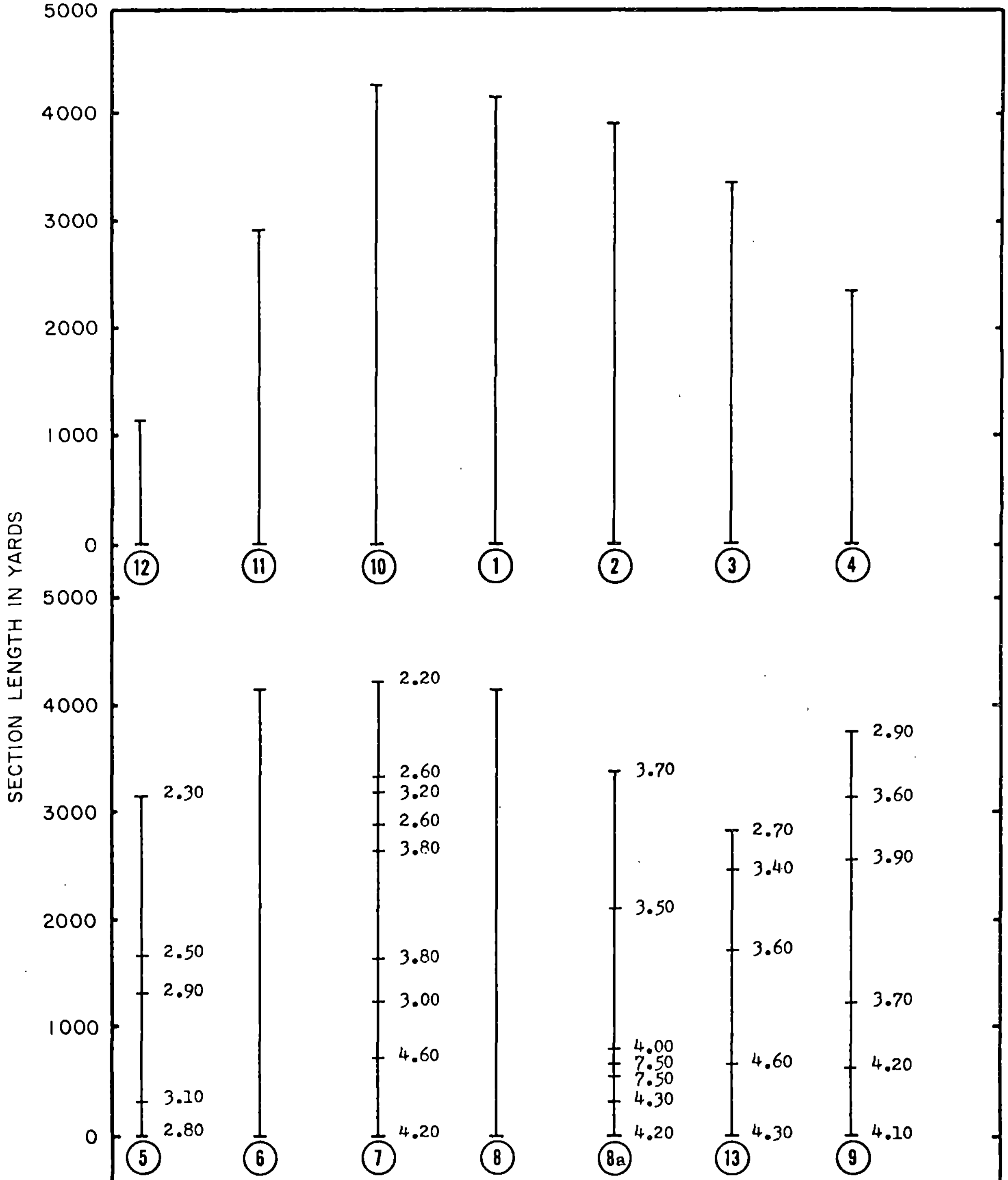
OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR

DISCHARGE AND INTAKE REVERSED

RIVER FLOW = 2000 cfs
REJECTED HEAT = 12 x 10^9 BTU / HR.
TIDAL HOUR = 6



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 2000 cfs
REJECTED HEAT = 12×10^9 BTU / HR.
TIDAL HOUR = 7 1/2



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
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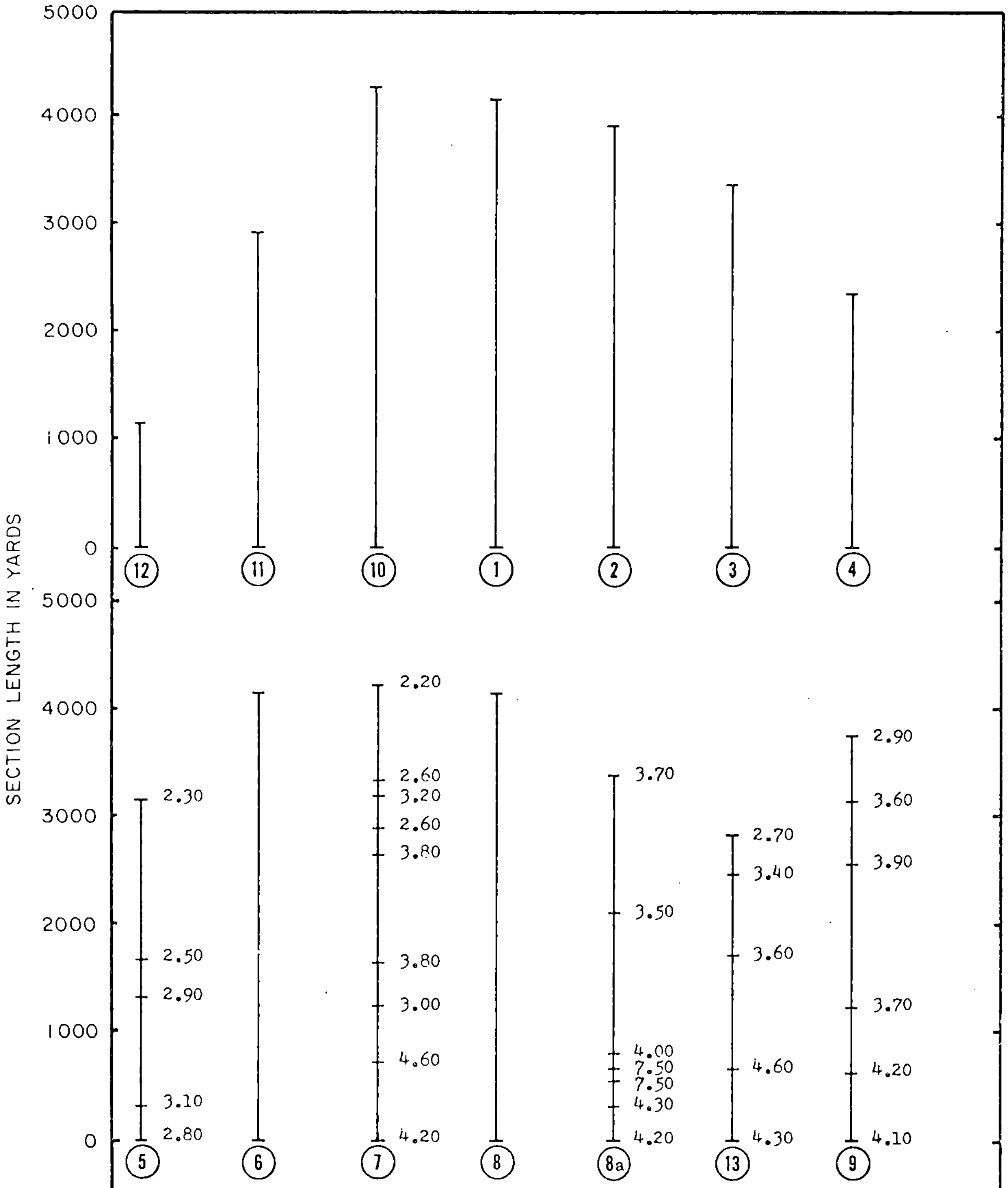
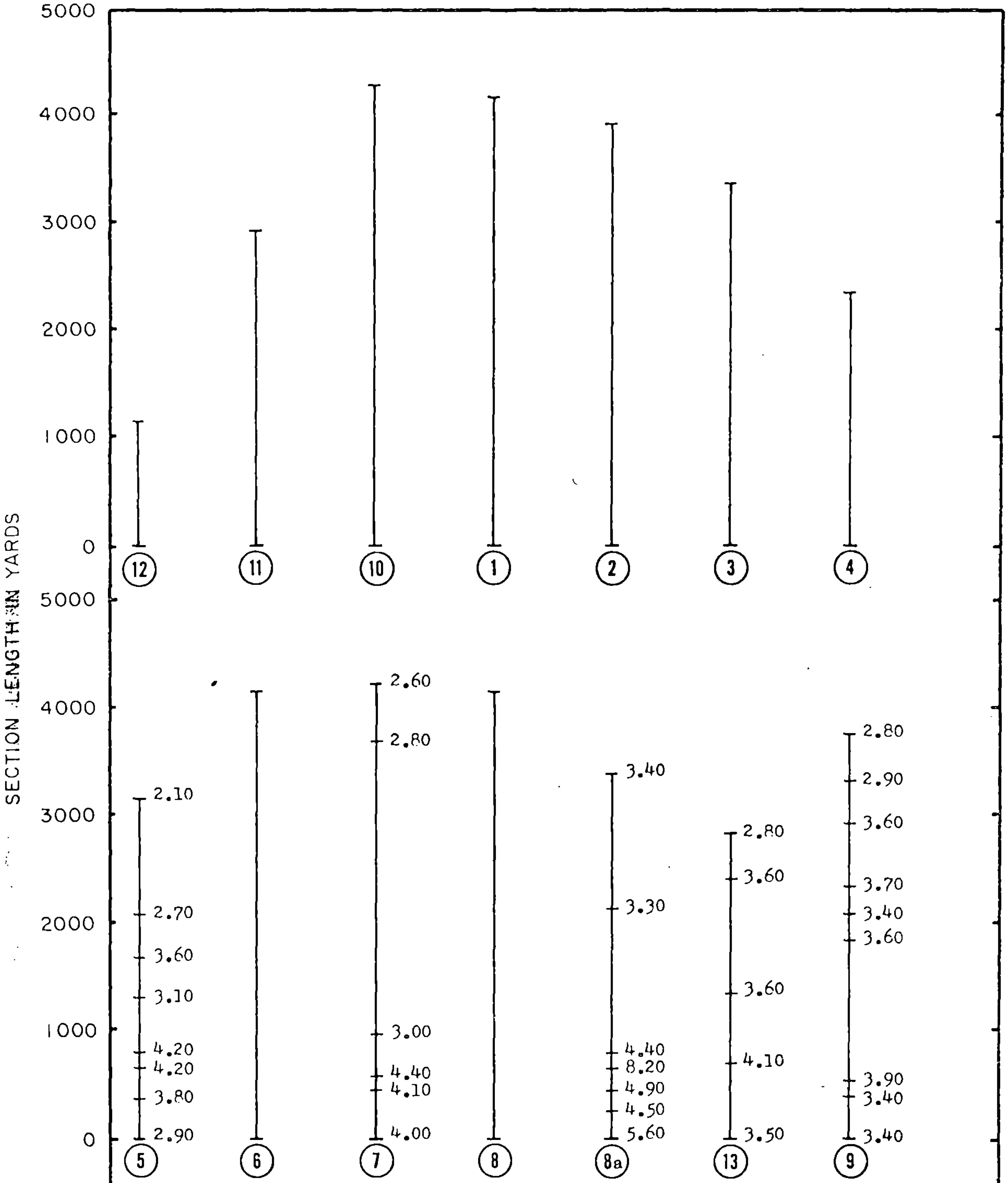
REJECTED HEAT = 12×10^9 BTU / HR.
TIDAL HOUR = 9

DISCHARGE AND INTAKE REVERSED



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR
RIVER FLOW = 2000 cfs
REJECTED HEAT = 12×10^9 BTU / HR
TIDAL HOUR = 9

DISCHARGE AND INTAKE REVERSED



OBSERVED EXCESS TEMPERATURES
(SECTION LOCATIONS SHOWN ON FIGURE 2)
FOR

DISCHARGE AND INTAKE REVERSED

RIVER FLOW = 2000 cfs
REJECTED HEAT = 12 x 10^9 BTU / HR.
TIDAL HOUR = 10 1/2

PRITCHARD-CARPENTER, CONSULTANTS
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The Johns Hopkins University
Baltimore, Maryland 21218

DISTRIBUTION OF EXCESS TEMPERATURE IN THE JAMES RIVER ESTUARY ADJACENT TO THE SURRY NUCLEAR POWER STATION FOR WINTER CONDITIONS

A Report to
Virginia Electric and Power Company

Previous reports (November, 1966; August, 1967; September, 1970) have described the hydrography of the James River Estuary in the vicinity of the site of the Surry Nuclear Power Station, and the distribution of excess temperature in the James River estuary adjacent to the plant site in the summer season. The purpose of this report is to present the probable distribution of excess temperature to be expected in winter.

The distribution of excess temperature in the thermal plume which extends in the downcurrent direction from the discharge orifice during each ebb and flood period of the tide depends upon: (1) the momentum entrainment of dilution water into the plume due to the excess momentum of the high speed thermal discharge; (2) natural turbulent mixing of the heated effluent and the receiving waters; (3) the background excess temperature of the receiving water entrained into and mixed with the thermal plume; and (4) the loss of excess heat from the water surface to the atmosphere due to surface cooling. The background excess temperature is in turn dependent upon the net new "dilution" water made available to the tidal segment adjacent to the plant site, and surface cooling which occurs over the area of the tidal segments upstream and downstream from the discharge orifice.

At any given phase of the tide, the excess temperature in any cross-section across the thermal plume increases from the shoreline on the side of the estuary on which the plant is located to a maximum value along the axis of the thermal plume, and then decreases as the far shore of the estuary is approached. At a specific phase of the tide, the minimum excess temperature which occurs along the far shore in some specific cross-section will be greater than for any other cross-section, and for any other phase of the tide. This maximum value of the minimum excess temperature in the specific cross-section is called the closure temperature. Both hydraulic and numerical model studies indicate that the closure temperature occurs at the end of ebb tidal flow, along the north side of the James River estuary approximately opposite the tip of the Hog Island peninsula.

With given discharge orifice dimensions, volume rate of flow of condenser cooling water, and temperature rise across the condensers, dilution of the thermal effluent by momentum entrainment will be independent of season. The energy for turbulent mixing of the thermal effluent and the receiving estuarine waters is provided by the tidal currents, which vary slightly with the phase of the moon and the relative position of earth, sun and moon but do not vary in a regular seasonal cycle. Thus the dilution of the thermal effluent by turbulent mixing is also independent of season.

The net new water available to the tidal segment adjacent to the plant site for dilution was shown in our November 1966 report to be relatively independent of river flow, and hence of season, and to equal about 25,000 $ft \cdot sec^{-1}$.

The only process which might lead to a seasonal difference in the distribution of excess temperature in the thermal plume, of the background excess temperature, and of the closure excess temperature, is then possible seasonal variations in the rate of loss of heat from the water to the atmosphere; that is, in season variations in the surface cooling coefficient.

The surface cooling coefficient increases with increasing wind speed and with increasing ambient temperature. Average wind speeds are somewhat higher in winter than in summer, and so on the average this factor should lead to a higher rate of heat loss in winter than in summer. However, ambient temperatures are greater in summer than in winter, and consequently this factor would result in higher rates of heat loss in summer than in winter. Since the higher winter wind speeds cannot always be counted on, the comparison between summer and winter conditions will here be made assuming the same wind speed for both seasons.

In our report of September 1970 use was made of surface cooling coefficients corresponding to a wind speed of 10 mph and an ambient temperature of 80°F. In this computation of the distribution of excess temperature in winter conditions, surface cooling coefficients corresponding to a wind speed of 10 mph and an ambient temperature of 40°F have been used.

Table 1 gives the length, width and area contained within specific isotherms of excess temperature for winter conditions, resulting from the discharge of a condenser cooling water flow of 3500 cfs with a temperature rise across the condensers of 14°F from the Surry Nuclear Power Station with two units at rated capacity. The discharge velocity is assumed to be $6 \text{ ft} \cdot \text{sec}^{-1}$, and the computations apply to the end of the period of ebb tidal flow, which has previously been shown to be the most critical period with respect to closure temperatures.

This computed horizontal distribution of excess temperature for winter conditions is shown schematically in Figure 1. The closure temperature is also entered on this figure at a position just off the north shore of the estuary, across from the tip of Hog Island peninsula.

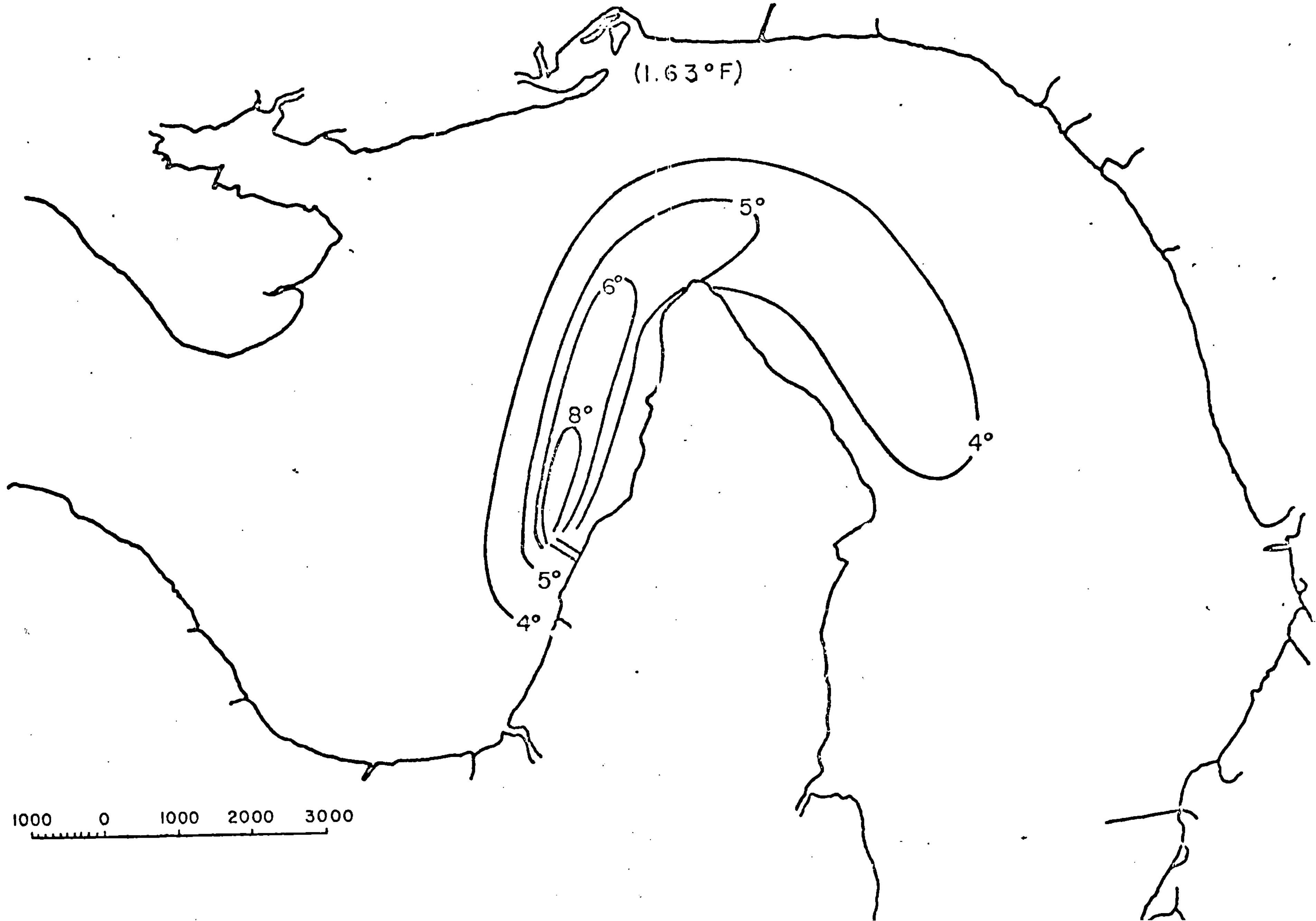
Figure 1 of this report should be compared to Figure 1 of our report of September 1970. Note that the areas contained within given isotherms of excess temperature for winter conditions are about 1.8 times as long as for summer conditions (the length of these areas in winter is, however, only about 1.4 times as long as for summer).

Table 1

Length, ℓ_θ, Width, b_θ, and Area, A_θ, of Specified Isotherms of Excess Temperature, θ, in James River Estuary in Thermal Plume from Surry Nuclear Power Plant for Winter Conditions. Two Units, Discharging 3500 cfs Condenser Cooling Water Flow at Temperature Rise Across Condensers of 14°F, at a Discharge Velocity of 6 ft $\cdot$ sec^{-1}.

θ(°F)	ℓ_θ(ft)	b_θ(ft)	A_θ(Acres)
12	6.57×10^2	1.10×10^2	1.6
10	1.57×10^3	2.62×10^2	9.4
8	4.59×10^3	7.65×10^2	80.3
6	1.09×10^4	1.82×10^3	4.50×10^2
5	1.71×10^4	2.85×10^3	1.12×10^3
4	3.04×10^4	5.07×10^3	3.51×10^3
3	4.75×10^4	7.91×10^3	8.63×10^3
2	6.86×10^4	1.14×10^4	1.80×10^4

Figure 1. Horizontal Distribution of Excess Temperature in James River Estuary for End of Ebb Tidal Flow, for Winter Conditions. Surry Nuclear Power Plant, Two Units, Temperature Rise at Condensers 14°F, Discharge Velocity 6 ft.sec^{-1}. Closure Temperature 1.63°F.



The closure excess temperature for summer conditions, as shown in Figure 1 of our report of September 1970, is 1.40°F. The closure excess temperature for winter conditions is, as shown on Figure 1 of this report, 1.63°F. The reason for this relatively small difference can be seen from a consideration of the processes which control the closure temperature.

The closure excess temperature can be considered to be determined primarily by two processes: (1) dilution of the excess heat discharged in the condenser cooling water by the "new" water available for dilution in the tidal segment adjacent to the plant site; and (2) surface cooling from the water surface area of the tidal segment adjacent to the plant site. For both summer and winter conditions the total new dilution water flow rate to the tidal segment adjacent to the plant site has been shown to be approximately 25,000 cfs. The closure excess temperature due to dilution alone is then

$$\theta'_c = \theta_o \times \frac{Q_c}{Q_D} = 14° \times \frac{3500}{25,000} = 1.96°F$$

and is the same for summer and winter conditions. The closure excess temperature corrected for surface cooling is given by:

$$\theta_c = \theta'_c \left\{ \frac{Q_h}{Q_h + \mu\, \theta'_c\, \Delta A} \right\}$$

where Q_h is the rate of rejection of excess heat at the condensers (11.0×10^9 BTU · hr^{-1}); μ is the surface cooling coefficient in BTU · ft^{-2} · (°F)$^{-1}$ · hr^{-1}, and ΔA is the surface area of the tidal segment adjacent to the plant site (3.4×10^8 ft^2). For summer conditions the appropriate value of the surface cooling coefficient μ is 6.9 BTU · ft^{-2} · (°F)$^{-1}$ · hr^{-1}, while for winter conditions this coefficient is about 3.4 BTU · ft^{-2} · (°F)$^{-1}$ · hr^{-1}. Substituting these values into the above equation gives the closure temperatures already quoted.

Note that even though the surface cooling rate per unit area in winter is only about one-half that for summer conditions, the dilution process, which is essentially the same both summer and winter, is so much more important than the cooling process, that the closure excess temperatures under winter conditions (1.63°F) is only slightly higher than under summer conditions (1.40°F).

D. W. Pritchard
Consultant

Reference List

(1) Pritchard - Carpenter, Consultants. Hydrology of the James River Estuary with Emphasis on the Ten-Mile Segment Centered on Hog Point, Virginia. A report prepared for the Virginia Electric and Power Company, Richmond, Virginia. November, 1966.

(2) Pritchard - Carpenter, Consultants. Temperature Distribution in the James River Estuary Which Will Result From the Discharge of Waste Heat From the Surry Nuclear Power Station. A report prepared for the Virginia Electric and Power Company, Richmond, Virginia. August 30, 1967.

(3) Pritchard-Carpenter, Consultants. Predicted Distribution of Excess Temperature in the James River Estuary Adjacent to the Surry Nuclear Power Station for Several Different Discharge Structure Configurations. September, 1970.

APPENDIX C

ENVIRONMENTAL RADIATION SURVEILLANCE PROGRAM

INTRODUCTION

The Surry Power Station was designed to operate safely without any adverse impact on the environment. The release of small quantities of radioactive gases and liquids may be expected but will be kept at levels well below the limits specified in the Code of Federal Regulations, Title 10, Chapter I, Part 20 (10 CFR 20). Levels of release will be kept as low as practicable, consistent with AEC policy on implementation of the National Environmental Policy Act of 1969.

Although no adverse effect on the environment is expected from the operation of the Surry Power Station, an environmental monitoring surveillance program has been established to measure changes in the background radiation and contamination levels around the facility.

This report covers work performed by Eberline Instrument Corporation (EIC) for the Virginia Electric and Power Company (VEPCO) in the vicinity of the Surry Nuclear Power Station.

Data has been acquired since 1968 concerning the radioactivity content of the environment around the station site. Only the data obtained for all four quarters of 1970 and the first two quarters of 1971 are included in this report since the more recent data and sampling program reflect more closely the anticipated post operational environment sampling program.

Air Particulate

Samples of air particulate are collected on glass fiber filters from nine (9) locations shown in Table C-1 and Figure I. Air samplers are on for two (2) hours and then off one (1) hour. The filters are exchanged weekly and are analyzed after decay of radon daughters for gross beta with a Nuclear-Chicago low background beta counter. These initial gross beta measurements are performed by VEPCO on-site and the results are confirmed by sending nine (9) samples per month (one from each location) to EIC where they are analyzed for gross beta with a Beckman Wide Beta I or Beckman Wide Beta II low background beta counter. Sensitivity is 0.05 pCi/m^3 for one-hundred (100) cubic meter (m^3) volume. (Table C-2)

Radiogas

Inert gases, primarily isotopes of krypton and xenon, may be released in low concentrations and may cause a slight increase in the background radiation level. The millirem dose (beta plus gamma) per month is measured using five 1/8" x 1/8" x 0.035" solid Li F thermoluminescent dosimeters double sealed in plastic bags. These dosimeters are placed at locations shown in Table C-1 and Figure I. Prior to May 1970, a single dosimeter was placed at each station, but subsequent measurements were based on five dosimeters at each station. Each dosimeter was read out using the Eberline Model TLR-5 reader. The combined thickness of both plastic bags is approximately 40 mg/cm^2. (Table C-3)

Water

Water samples are collected bi-monthly from the James River, locations 1, 3, 6, 9, and 10 in Figure 2. These samples are analyzed for gross beta. Due to the salinity of this water, an oxalate precipitation is performed and the precipitate counted. A chemical recovery adjustment is made on sample before reporting results. Each river water sample is analyzed for tritium by liquid scintillation counting. (Table C-4)

Water from two deep wells (Surry Station and Hog Island Reserve) and two shallow wells (Bacon's Castle and Jamestown) are collected semi-annually. An aliquot of each sample is evaporated on a metal planchet and analyzed for gross alpha and gross beta with a Beckman Wide Beta I proportional counter (alpha and beta measured separately). (Table C-5)

Surface water is collected semi-annually from Chippokes Creek, Williamsburg Reservoir, Newport News Reservoir, and Smithfield. An aliquot of each sample is evaporated on a metal planchet and analyzed for gross alpha and gross beta with a Beckman Wide Beta I proportional counter. (Table C-6)

Precipitation samples are collected at the site and at Newport News. A composite sample from each location is analyzed for tritium by liquid scintillation counting and for gross beta by the procedure described above for surface and well water samples. (Table C-7)

Biota

Corn, peanuts, and soybeans are sampled at Bacon's Castle annually. The samples are analyzed for major gamma emitters by gamma spectrometry. The sample is then dried, ground, and blended. An aliquot is wet ashed and dissolved in acid. An aliquot of the solution is analyzed for potassium with an EEL Model 140 Atomic Absorption Spectrophotometer. The remaining solution is transferred to a metal planchet with acid, evaporated to dryness, and beta counted with a Beckman Wide Beta I or Beckman Wide Beta II low background beta counter. Results for crop samples are reported as pCi/g (dry). (Table C-8)

Fowl samples are collected semi-annually at Hog Island Reserve. Combined muscle and tissue are analyzed for gross beta and K-40 by a procedure similar to that described for crop samples and results expressed in pCi/g (wet) weight. Bone samples are analyzed for gross beta, K-40, and Sr-90. Results for bone are reported as pCi/g (dry) weight. Thyroid samples are analyzed for I-131 by gamma spectrometry and the results are reported in pCi/g (wet) weight. (Table C-9)

Oyster samples are collected bi-monthly from locations 8, 9, and 10 in Figure 2. The edible portion (tissue) is analyzed for major gamma emitters by gamma spectrometry. The sample is dried, ashed, and analyzed for K-40 and gross beta as described for crop samples. Results are reported as pCi/g (wet) weight. (Table C-10) Clam samples are collected bi-monthly from locations 1, 2, 4, 5, and 7 in Figure 2. These samples are analyzed the same as described for oysters. (Table C-10) Crab samples are collected during the summer months from Deep Water Shoals and Point of Shoals. These are analyzed the same as described for oysters. (Table C-11)

Silt

Samples of silt are collected at locations 1, 3, 5, 6, 9, and 10 in Figure 2. Each sample is analyzed for major gamma emitters, gross beta, and K-40 using procedures similar to those described for biota samples. Results are reported as pCi/g (dry) weight. (Table C-12)

Soil

Soil samples are collected semi-annually at the station site and five additional locations away from the site as shown in Table 1. They are analyzed for Gross Beta, K-40 and Gamma Scanned. (Table C-13)

Milk

Samples of milk are collected bi-monthly from four locations near the site (locations 3, 6, 9, and 12 in Figure 1) with two samples from location number 3. Each sample is analyzed for Sr-90, Cs-137, and stable calcium. I-131 analysis is performed by gamma spectrometry of a one liter sample in a Marinelli beaker. Sr-90 is separated from the milk with cation exchange resin, eluted from the resin and analyzed. Stable cesium is determined and reported. (Table C-14)

The Surry Environemntal Sampling Program, with the type of analysis and frequency for the samples taken, is shown in the following exhibit: SURRY NUCLEAR STATION - ENVIRONMENTAL SAMPLING PROGRAM.

SURRY NUCLEAR STATION

ENVIRONMENTAL SAMPLING PROGRAM

SAMPLE TYPE	FREQUENCY		TYPE OF ANALYSIS
I. WATERS			
A. James River	Bi-Monthly		Gross Beta, Tritium
1. Chickahominy			
2. Station Intake			
3. Station Discharge			
4. Point of Shoals			
5. Newport News			
B. Wells	Semi-Annual		Gross Alpha, Gross Beta
1. Surry Station (Deep)			
2. Hog Island Reserve (Deep)			
3. Bacon's Castle (Shallow)			
4. Jamestown (Shallow)			
C. Surface Water	Semi-Annual	Soluble Insoluble	Gross Alpha, Gross Beta Gross Alpha, Gross Beta
1. Chippokes Creek			
2. Williamsburg Reservoir			
3. Newport News Reservoir			
4. Smithfield			
D. Precipitation	Monthly Semi-Annual (composite)		Gross Beta Tritium
1. Surry Station			
2. Newport News			
II. Air			
A. Particulates	Weekly Monthly		Gross Beta Gross Alpha
1. Richmond			
2. Surry Station			
3. Hog Island Reserve			

SAMPLE TYPE	FREQUENCY		TYPE OF ANALYSIS
A. Particulates (Cont'd)			
4. Bacon's Castle			
5. Alliance			
6. Colonial Parkway			
7. Dow			
8. Fort Eustis			
9. Newport News			
B. Radiogas	Monthly	TLD	mR exposure
1-9. Same as II-A			
10. Smithfield			
III. BIOTA			
A. Crops	Annual	Corn, Peanut & Soybean	Gross Beta, K-40, Gamma Scan
1. Bacon's Castle			
B. Fowl (Coot)	Semi-Annual	Muscle & Tissue Bone Thyroid	Gross Beta, K-40 Gross Beta, K-40, Sr-90 I-131
1. Hog Island Reserve			
C. Oyster	Bi-Monthly	Tissue	Gross Beta, K-40, Gamma Scan
1. Deep Water Shoals			
2. Point of Shoals			
3. Newport News			
D. Clam	Bi-Monthly	Tissue	Gross Beta, K-40, Gamma Scan
1. Chickahominy			
2. Chippokes Creek			
3. Hog Island Point			
4. Lawnes Creek			
5. Station Discharge			

SAMPLE TYPE	FREQUENCY		TYPE OF ANALYSIS
III. BIOTA (Cont'd.)			
E. Crab	Summer Months	Tissue	Gross Beta, K-40, Gamma Scan
1. Hog Island Point to James River Bridge			
F. Fish (White Perch and Catfish)	Semi-Annual	Tissue	Gross Beta, K-40, Gamma Scan
1. Intake and Discharge			
IV. SILT	Bi-Monthly		Gross Beta, K-40, Gamma Scan
1. Chickahominy			
2. Station Discharge			
3. Hog Island Point			
4. Station Intake			
5. Point of Shoals			
6. Newport News			
V. MILK	Bi-Monthly		Sr-90, Cs-137, I-131, & Calcium
1. Bacon's Castle (Epps)			
2. Bacon's Castle (Judkins)			
3. Dow Dairy (Ross)			
4. Smithfield (Barlow)			
5. Colonial Parkway Dairy (Smith)			
VI. SOIL	Semi-Annual		Gross Beta, K-40, Gamma Scan
1. Alliance			
2. Bacon's Castle			
3. Colonial Parkway			
4. Dow			
5. Fort Eustis			
6. Surry Station			

TABLE C-1
SURRY POWER STATION
ENVIRONMENTAL SAMPLING PROGRAM

LAND BASED SAMPLING STATIONS

STATION NUMBER (See Figure 1)

Sample Medium**	1	2	3	4	5	6	7	8	9	10	11	12
Air Particulate	X	X	X	-	X	X	-	-	X	X	X	-
Radiogas	X	X	X	-	X	X	-	-	X	X	X	X
Precipitation	X	-	-	-	-	-	-	-	-	-	X	-
Milk	-	-	X (2)	-	-	X	-	-	X	-	-	X
Well Water	X	X	X	-	-	-	-	X	-	-	-	-
Crop	-	-	X	-	-	-	-	-	-	-	-	-
Surface Water	-	-	-	X	-	-	X	-	-	-	X	X
Fowl (Coot)	-	X	-	-	-	-	-	-	-	-	-	-
Soil	X	-	X	-	X	X	-	-	X	X	-	-

No. 1 - Surry Station (0) ***
No. 2 - Hog Island Reserve (19)
No. 3 - Bacon's Castle (4.6)
No. 4 - Chippokes Creek (4.4)
No. 5 - Alliance (5.0)
No. 6 - Colonial Parkway (4.0)
No. 7 - Williamsburg (9.5)
No. 8 - Jamestown (6.5)
No. 9 - Dow (5.0)
No. 10 - Fort Eustis (4.8)
No. 11 - Newport News (19.0)
No. 12 - Smithfield (13.0)

JAMES RIVER SAMPLING STATIONS

STATION NUMBER (See Figure 2)

Sample Medium**	1	2	3	4	5	6	7	8	9	10
James River Water	X	-	X	-	-	X	-	-	X	X
Silt	X	-	X	-	X	X	-	-	X	X
Oyster	-	-	-	-	-	-	-	X	X	X
Clam	X	X	-	X	X	-	X	-	-	-
Crab *	-	-	-	-	-	-	-	-	-	-
Fish *	-	-	-	-	-	-	-	-	-	-

No. 1 - Chickahominy (10.9)
No. 2 - Cobham Bay (1.5)
No. 3 - Station Discharge (0.8)
No. 4 - Jamestown (3.8)
No. 5 - Hog Island (3.8)
No. 6 - Station Intake (6.9)
No. 7 - Lawnes Creek (8.0)
No. 8 - Deep Water Shoals (8.4)
No. 9 - Point of Shoals (13.3)
No. 10 - Newport News (23.6)

*Sampled in the vicinity of station- usually at intake structure
**Intertidal vegetation sampled when available from discharge canal area.
*** Approximate distance in miles from the station

TABLE C-2

AIR PARTICULATE

QUARTERLY AVERAGES

STATION	pCi/m^3/QUARTER 1st Qt., 1970	pCi/m^3/QUARTER 2nd Qt., 1970	pCi/m^3/QUARTER 3rd Qt., 1970
Richmond	0.10 ± 0.03	0.34 ± 0.11	0.22 ± 0.10
Surry Station	0.10 ± 0.04	0.32 ± 0.09	0.20 ± 0.09
Hog Island Reserve	0.15 ± 0.03	0.32 ± 0.09	0.20 ± 0.10
Bacon's Castle	0.16 ± 0.05	0.53 ± 0.17	0.31 ± 0.15
Alliance	0.17 ± 0.10	0.49 ± 0.15	0.26 ± 0.14
Colonial Parkway	0.11 ± 0.03	0.35 ± 0.10	0.22 ± 0.10
Dow	0.11 ± 0.03	0.36 ± 0.11	0.22 ± 0.09
Fort Eustis	0.10 ± 0.03	0.31 ± 0.10	0.17 ± 0.07
Newport News	0.11 ± 0.04	0.34 ± 0.09	0.22 ± 0.10

STATION	pCi/m^3/QUARTER 4th Qt., 1970	pCi/m^3/QUARTER 1st Qt., 1971	pCi/m^3/QUARTER 2nd Qt., 1971
Richmond	0.18 ± 0.09	0.03 ± 0.02	0.40 ± 0.12
Surry Station	0.12 ± 0.05	0.13 ± 0.06	0.41 ± 0.12
Hog Island Reserve	0.12 ± 0.06	0.13 ± 0.06	0.56 ± 0.16
Bacon's Castle	0.17 ± 0.10	0.19 ± 0.08	0.47 ± 0.29
Alliance	0.14 ± 0.08	0.17 ± 0.08	0.38 ± 0.11
Colonial Parkway	0.14 ± 0.05	0.14 ± 0.05	0.42 ± 0.13
Dow	0.14 ± 0.07	0.15 ± 0.07	0.41 ± 0.12
Fort Eustis	0.13 ± 0.07	0.13 ± 0.07	0.42 ± 0.12
Newport News	0.14 ± 0.07	0.15 ± 0.07	0.42 ± 0.12

TABLE C-3

AREA MONITORS - TLD

(Dose for Period - mrem)*

STATION	JANUARY 1970	FEBRUARY 1970	MARCH 1970	APRIL 1970 03-30 to 05-11	MAY 1970 05-11 to 06-01
Control	5	0	28	52	20
Richmond	10	5	33	61	20
Surry Station	5	6	35	50	11
Hog Island Reserve	7	9	33	57	15
Bacon's Castle	6	4	34	51	14
Alliance	7	5	34	46	16
Colonial Parkway	5	4	28	60	14
Dow	8	8	28	63	15
Fort Eustis	6	13	40	43	17
Newport News	7	7	32	50	19
Smithfield	8	3	31	50	16

STATION	JUNE 1970 06-01 to 07-20	JULY 1970 07-20 to 08-18	AUGUST 1970 08-18 to 09-08	SEPTEMBER 1970 09-08 to 09-29
Control	19	15	10	15
Richmond	18	15	10	15
Surry Station	15	12	10	15
Hog Island Reserve	15	15	9	15
Bacon's Castle	13	14	8	12
Alliance	12	12	9	12
Colonial Parkway	17	15	10	13
Dow	19	14	9	13
Fort Eustis	16	13	10	13
Newport News	14	16	9	13
Smithfield	18	14	10	14

TABLE C-3

AREA MONITORS - TLD (Cont'd)

(Dose for Period - mrem)*

STATION	APRIL, 1971 04-01 to 05-11	MAY, 1971 05-11 to 06-01	JUNE, 1971 06-02 to 07-06
Control	13	7	18
Richmond	+	+	23
Surry Station	12	7	22
Hog Island Reserve	13	7	25
Bacon's Castle	11	8	**
Alliance	12	7	17
Colonial Parkway	11	8	16
Dow	13	7	16
Fort Eustis	12	7	19
Newport News	13	8	19
Smithfield	16	11	20
Scotland Wharf	11	8	18
Jamestown	11	7	16
Lee Hall	15	10	21
Route 10 and 676	12	7	15

*Control not subtracted from dosimeter readings.
**Reading not available.

TABLE C-4

JAMES RIVER WATER

(Gross Beta & Tritium)

STATION	COLLECTION DATE	BETA pCi/l	COMPOSITE H-3 pCi/ml
Newport News	12-09-69	3 ± 1	6 ± 2
Point of Shoals	12-09-69	5 ± 1	6 ± 2
Station Intake	12-09-69	3 ± 1	5 ± 1
Cobham Bay	12-09-69	2 ± 1	6 ± 2
Newport News	01-27-70	0 ± 2	
Point of Shoals	01-27-70	3 ± 2	
Station Intake	01-27-70	8 ± 3	
Cobham Bay	01-27-70	4 ± 3	
Chickohominy	01-27-70	3 ± 2	
James River Bridge	03-19-70	8 ± 2	7 ± 2
Point of Shoals	03-19-70	6 ± 2	11 ± 2
Station Intake	03-19-70	6 ± 2	7 ± 2
Station Discharge	03-19-70	10 ± 2	9 ± 2
Chickohominy	03-19-70	12 ± 2	7 ± 2
Newport News	05-20-70	2 ± 1	0 ± 2
Point of Shoals	05-20-70	5 ± 1	2 ± 1
Chickohominy	05-20-70	6 ± 2	0 ± 2
Station Intake	05-20-70	2 ± 1	2 ± 1
Station Discharge	05-20-70	7 ± 1	2 ± 1
Newport News	07-02-70	7 ± 2	
Point of Shoals	07-02-70	7 ± 2	
Station Intake	07-02-70	5 ± 1	
Station Discharge	07-02-70	5 ± 1	
Chickohominy	07-02-70	10 ± 2	

JAMES RIVER WATER (Cont'd)

(Gross Beta & Tritium)

STATION	COLLECTION DATE	BETA pCi/l	COMPOSITE H-3 pCi/ml
Newport News	09-02-70	2 ± 1	0 ± 2
Point of Shoals	09-02-70	2 ± 1	0 ± 2
Station Intake	09-02-70	2 ± 1	0 ± 2
Station Discharge	09-02-70	6 ± 2	0 ± 2
Chickohominy	09-02-70	2 ± 1	0 ± 2

TABLE C-4

JAMES RIVER WATER (Cont'd)

(Gross Beta & Tritium)

STATION	COLLECTION DATE	BETA pCi/1	COMPOSITE H-3 pCi/ml
Newport News	11-19-70	6 ± 1	0 ± 1
Point of Shoals	11-19-70	5 ± 1	0 ± 2
Station Intake	11-19-70	4 ± 1	0 ± 2
Station Discharge	11-18-70	4 ± 1	0 ± 2
Chickohominy	11-20-70	0 ± 2	0 ± 2
Newport News	01-14-71	0 ± 2	
Point of Shoals	01-14-71	7 ± 1	
Station Intake	01-13-71	3 ± 1	
Station Discharge	01-13-71	10 ± 2	
Chickohominy	01-13-71	3 ± 1	
Newport News	03-10-71	3 ± 1	0 ± 1
Point of Shoals	03-10-71	9 ± 2	0 ± 1
Station Intake	03-10-71	5 ± 1	0 ± 1
Station Discharge	03-10-71	9 ± 2	0 ± 1
Chickohominy	03-10-71	6 ± 1	0 ± 1
Newport News	05-19-71	6 ± 1	0 ± 1
Point of Shoals	05-19-71	7 ± 1	0 ± 1
Station Intake	05-20-71	4 ± 1	0 ± 1
Station Discharge	05-20-71	9 ± 2	0 ± 1
Chickohominy	05-21-71	9 ± 2	0 ± 1

TABLE C-5

WELL WATER

(Gross Alpha & Beta)

STATION	COLLECTION DATE	ALPHA pCi/1	BETA pCi/1
Bacon's Castle	04-14-70	0.0 ± 2.5	16 ± 2.0
Hog Island Reserve	04-14-70	0.0 ± 2.5	5.[illegible] ± 1.5
Jamestown	04-14-70	3.4 ± 1.0	16 ± 2.0
Surry Station	04-14-70	0.0 ± 2.5	4.7 ± 1.5
Bacon's Castle	09-29-70	0.0 ± 2.5	10 ± 2.0
Hog Island Reserve	09-29-70	0.0 ± 2.5	0.0 ± 2.0
Jamestown	09-29-70	0.0 ± 2.5	3.2 ± 0.7
Surry Station	09-29-70	0.0 ± 2.5	0.0 ± 2.0
Bacon's Castle	04-05-71	0 ± 2	9 ± 2
Hog Island Reserve	04-05-71	0 ± 2	3 ± 1
Jamestown	04-05-71	0 ± 2	8 ± 1
Surry Station	04-05-71	0 ± 2	2 ± 1

TABLE C-6

SURFACE WATER

(Gross Alpha & Beta)

STATION	COLLECTION DATE	DISSOLVED ALPHA pCi/l	DISSOLVED BETA pCi/l	SUSPENDED ALPHA pCi/l	SUSPENDED BETA pCi/l
Chippokes Creek	04-13-70	6 ± 1	7 ± 2	5 ± 2	10 ± 2
Newport News	04-13-70	0 ± 2	3 ± 1	3 ± 1	7 ± 1
Smithfield	04-13-70	0 ± 2	0 ± 2	5 ± 2	10 ± 2
Williamsburg	04-13-70	0 ± 2	2 ± 1	4 ± 1	7 ± 1
Chippokes Creek	09-29-70	0 ± 2	3 ± 1	0 ± 2	3 ± 1
Newport News	09-29-70	0 ± 2	3 ± 1	0 ± 2	0 ± 2
Smithfield	09-29-70	0 ± 2	2 ± 1	0 ± 2	3 ± 1
Williamsburg	09-29-70	0 ± 2	5 ± 1	0 ± 2	0 ± 2
Chippokes Creek	04-05-71	0 ± 2	3 ± 1	0 ± 2	0 ± 1
Newport News	04-05-71	0 ± 2	3 ± 1	0 ± 2	0 ± 1
Smithfield	04-05-71	0 ± 2	6 ± 1	0 ± 2	0 ± 1
Williamsburg	04-05-71	0 ± 2	4 ± 1	0 ± 2	0 ± 1

TABLE C-7

RAIN WATER COMPOSITE

(Gross Beta & Tritium)

Station	Date Collected	Beta pCi/1	H-3 pCi/ml
Newport News	Jan.-March 1970	26±5	7±2
Surry Station		28±4	8±2
Newport News	April-Sept. 1970	14±2	0±2
Surry Station		20±3	0±2
Newport News	Oct.-Dec. 1970	41±4	0±2
Surry Station		41±4	0±2
Newport News	Jan.-June 1971	8.72±1.11	0±1
Surry Station		8.61±1.21	0±1

TABLE C-8

CROP SAMPLES

(Cross Beta, K-40, & Gamma Scan)

STATION	COLLECTION DATE	SAMPLE TYPE	WET WT. (g)	DRY WT. (g)	BETA pCi/g (DRY)	K-40 pCi/g (DRY)	GAMMA SCAN pCi/g (DRY)
Bacon's Castle	10/69	Corn	223	200	3.96 ± 0.34	2.49	*
Bacon's Castle	12/69	Soybean	185	141	9.32 ± 0.16	2.99	*
Bacon's Castle	12/69	Peanut	186	183	3.99 ± 0.11	1.99	*
Bacon's Castle	10-05-70	Corn	360	334	1.65 ± 0.15	0.84	*
Bacon's Castle	10-05-70	Peanut	325	310	9.76 ± 0.48	5.74	*
Bacon's Castle	11-23-70	Soybean	1666	1300	13.7 ± 1.3	9.57	*

* Gamma Scan indicated <5 pCi/total sample for Fe-59, Co-60, Zr-95, Ru-106, and Cs-137.

TABLE C-9

FOWL SAMPLES

COOT

Collection Date 04-24-70

Hog Island Reserve

(Gross Beta, K-40, Sr-90, & I-131)

TISSUE TYPE	WET WT. (g)	DRY WT. (g)	BETA pCi/g(WET)	BETA pCi/g(DRY)	K-40 pCi/g(WET)	K-40 pCi/g(DRY)	Sr-90 pCi/g(DRY)	I-131 pCi/g(WET)
Bone	90.7	59.9		5.53 ± 0.67		1.33	1.34 ± 0.13	
Muscle	476	155	0.84 ± 0.10		0.14			
Thyroid	3.50							5

CLAPPER RAIL

Collection Date 03-13-70

Hog Island Reserve

(Gross Beta, K-40, Sr-90)

TISSUE TYPE	WET. WT. (g)	DRY WT. (g)	BETA pCi/g(WET)	BETA pCi/g(DRY)	K-40 pCi/g(WET)	K-40 pCi/g(DRY)	Sr-90 pCi/g(DRY)	I-131 pCi/g(WET)
Bone	90	30.0		3.23 ± 0.13		4.70	0.55 ± 0.24	
Muscle	120	32.5	0.99 ± 0.03		1.41			
Bone	108	38.0		2.82 ± 0.11		3.71	0.41 ± 0.18	
Muscle	137	34.5	0.93 ± 0.03		1.45			

TABLE C-9

Collection Date 01-12-71 (Cont'd)

Hog Island Reserve

(Gross Beta, K-40, Sr-90, & I-131)

TISSUE TYPE	WET WT. (g)	DRY WT. (g)	BETA pCi/g(WET)	BETA pCi/g(DRY)	K-40 pCi/g(WET)	K-40 pCi/g(DRY)	Sr-90 pCi/g(DRY)	I-131 pCi/g(WE
Bone	40	26.5		6.63 ± 0.78		4.59	3.00 ± 0.27	
Muscle	388	128	1.67 ± 0.20		0.76			
Thyroid	2.5							5

TABLE C-10

OYSTER AND CLAM SAMPLES

(Gross Beta, K-40, & Gamma Scan)

STATION	COLLECTION DATE	SAMPLE TYPE	WET WT. (g)	DRY WT. (g)	BETA pCi/g(WET)	K-40 pCi/g(WET)	GAMMA SCAN pCi/g(WET)
Newport News	12-09-69	Oyster	178	14.5	0.30 ± 0.06	0.17	*
Deep Water Shoals	12-09-69	Oyster	209	16.0	0.25 ± 0.04	0.11	*
Point of Shoals	12-09-69	Oyster	259	25.0	0.30 ± 0.06	0.15	*
Lawnes Creek	12-12-69	Clam	309	39.5	0.35 ± 0.08	0.15	*
Chippokes Creek	12-12-69	Clam	156	15.5	0.29 ± 0.06	0.12	*
Jamestown	12-12-69	Clam	124	16.0	0.26 ± 0.08	0.13	*
Newport News	01-27-70	Oyster	128	12.5	0.22 ± 0.06	0.21	*
Deep Water Shoals	01-27-70	Oyster	143	11.9	0.22 ± 0.04	0.11	*
Point of Shoals	01-27-70	Oyster	172	18.8	0.37 ± 0.06	0.12	*
Lawnes Creek	01-17-70	Clam	222	36.1	0.46 ± 0.10	0.16	*
Chippokes Creek	01-27-70	Clam	244	30.4	0.26 ± 0.06	0.11	*
Hog Island Point	01-27-70	Clam	200	18.6	0.21 ± 0.06	0.11	*
Jamestown	01-28-70	Clam	176	11.1	0.10 ± 0.04	0.05	*
Chickohominy	01-28-70	Clam	91	9.1	0.12 ± 0.02	0.07	*
Deep Water Shoals	03-19-70	Oyster	210	18.0	0.43 ± 0.07	0.10	*
Point of Shoals	03-17-70	Oyster	173	16.5	0.34 ± 0.08	0.29	*
Lawnes Creek	03-19-70	Clam	199	25.0	0.37 ± 0.07	0.11	*
Chippokes Creek	03-19-70	Clam	150	14.0	0.17 ± 0.05	0.14	*
Hog Island Point	03-19-70	Clam	108	11.0	0.44 ± 0.06	0.12	*

TABLE C-10

OYSTER AND CLAM SAMPLES (Cont'd)

(Gross Beta, K-40, & Gamma Scan)

STATION	COLLECTION DATE	SAMPLE TYPE	WET WT. (g)	DRY WT. (g)	BETA pCi/g(WET)	K-40 pCi/g(WET)	GAMMA SCAN pCi/g(WET)
Jamestown	03-19-70	Clam	162	22.0	0.43 ± 0.02	0.27	*
Chickohominy	03-19-70	Clam	121	7.0	0.19 ± 0.05	0.05	*
James River Bridge	03-17-70	Oyster	159	15.0	0.94 ± 0.10	0.94	*

TABLE C-10

OYSTER AND CLAM SAMPLES (Cont'd)

(Gross Beta, K-40, & Gamma Scan)

STATION	COLLECTION DATE	SAMPLE TYPE	WET WT. (g)	DRY WT. (g)	BETA pCi/g(WET)	K-40 pCi/g(WET)	GAMMA SCAN pCi/g(WET)
Deep Water Shoals	05-20-70	Oyster	225	19.0	0.48 ± 0.06	0.26	*
Newport News	05-20-70	Oyster	230	14.0	0.28 ± 0.04	0.19	*
Point of Shoals	05-20-70	Oyster	183	23.0	0.77 ± 0.08	0.38	*
Chickohominy	05-20-70	Clam	154	11.0	0.35 ± 0.05	0.13	*
Hog Island Point	05-20-70	Clam	111	15.5	0.91 ± 0.11	0.43	*
Jamestown	05-20-70	Clam	96.5	10.0	0.26 ± 0.05	0.25	*
Lawnes Creek	05-20-70	Clam	118	13.0	0.44 ± 0.06	0.28	*
Station Discharge	05-20-70	Clam	113	11.5	0.39 ± 0.06	*	
Newport News	07-02-70	Oyster	214	19.0	1.20 ± 0.13	1.19	*
Deep Water Shoals	07-02-70	Oyster	234	21.0	0.93 ± 0.11	0.86	*
Point of Shoals	07-02-70	Oyster	235	23.0	1.43 ± 0.14	1.31	*
Lawnes Creek	07-02-70	Clam	190	33.0	1.56 ± 0.22	1.67	*
Chippokes Creek	07-02-70	Clam	236	14.0	0.43 ± 0.05	0.34	*
Hog Island Point	07-02-70	Clam	244	19.0	0.81 ± 0.09	0.74	*
Jamestown	07-02-70	Clam	173	21.0	1.00 ± 0.13	0.93	*
Chickohominy	07-02-70	Clam	180	10.0	0.23 ± 0.04	0.21	*
Newport News	09-02-70	Oyster	146	21.0	0.91 ± 0.10	0.55	*
Deep Water Shoals	09-23-70	Oyster	244	30.0	1.11 ± 0.15	0.96	*
Lawnes Creek	09-23-70	Clam	378	49.0	0.90 ± 0.12	0.75	*

TABLE C-10

OYSTER AND CLAM SAMPLES (Cont'd)

(Gross Beta, K-40, & Gamma Scan)

STATION	COLLECTION DATE	SAMPLE TYPE	WET WT. (g)	DRY WT. (g)	BETA pCi/g(WET)	K-40 pCi/g(WET)	GAMMA SCAN pCi/g(WET)
Hog Island Point	09-23-70	Clam	150	18.0	0.83 ± 0.11	0.47	*
Station Discharge	09-23-70	Clam	160	16.0	1.05 ± 0.15	0.96	*
Chickohominy	09-23-70	Clam	169	14.0	0.31 ± 0.04	0.16	*

TABLE C-10

OYSTER AND CLAM SAMPLES (Cont'd)

(Gross Beta, K-40, & Gamma Scan)

STATION	COLLECTION DATE	SAMPLE TYPE	WET WT. (g)	DRY WT. (g)	BETA pCi/g(WET)	K-40 pCi/g(WET)	GAMMA SCAN pCi/g(WET)
Newport News	11-19-70	Oyster	278	22	1.74 ± 0.21	1.77	*
Deep Water Shoals	11-18-70	Oyster	352	30	0.42 ± 0.07	0.27	*
Point of Shoals	11-19-70	Oyster	322	26	0.60 ± 0.08	0.46	*
Lawnes Creek	11-19-70	Clam	346	45	0.58 ± 0.07	0.25	*
Hog Island Point	11-18-70	Clam	340	43	0.42 ± 0.06	0.24	*
Station Discharge	11-18-70	Clam	400	38	0.58 ± 0.08	0.54	*
Jamestown	11-18-70	Clam	356	47	0.67 ± 0.10	0.51	*
Chickohominy	11-20-70	Clam	242	12	0.23 ± 0.04	0.18	*
Newport News	01-14-71	Oyster	230	24	0.83 ± 0.11	0.54	ND
Deep Water Shoals	01-14-71	Oyster	333	24	0.66 ± 0.08	0.44	ND
Point of Shoals	01-14-71	Oyster	227	18	0.71 ± 0.08	0.46	ND
Lawnes Creek	01-14-71	Clam	336	18	0.27 ± 0.04	0.16	ND
Hog Island Point	01-13-71	Clam	333	16	0.27 ± 0.04	0.15	ND
Station Discharge	01-13-71	Clam	298	12	0.12 ± 0.02	0.09	ND
Jamestown	01-13-71	Clam	282	16	0.25 ± 0.04	0.14	ND
Chickohominy	01-13-71	Clam	328	10	0.17 ± 0.02	0.08	ND
Newport News	03-11-71	Oyster	330	25	0.87 ± 0.09	0.51	ND
Deep Water Shoals	03-11-71	Oyster	312	30	0.58 ± 0.08	0.36	ND
Point of Shoals	03-11-71	Oyster	328	31	0.80 ± 0.10	0.49	ND

TABLE C-10

OYSTER AND CLAM SAMPLES (Cont'd)

(Gross Beta, K-40, & Gamma Scan)

STATION	COLLECTION DATE	SAMPLE TYPE	WET WT. (g)	DRY WT. (g)	BETA pCi/g (WET)	K-40 pCi/g (WET)	GAMMA SCAN pCi/g (WET)
Lawnes Creek	03-10-71	Clam	216	28	0.40 ± 0.06	0.18	ND
Hog Island Point	03-10-71	Clam	368	36	0.39 ± 0.06	0.15	ND
Station Discharge	03-10-71	Clam	310	32	0.34 ± 0.05	0.16	ND
Jamestown	03-10-71	Clam	368	28	0.88 ± 0.08	0.13	ND
Chickohominy	03-11-71	Clam	269	17	0.20 ± 0.03	0.06	ND

ND = No detectable activity above background and system sensitivity other than naturally occurring uranium, thorium, and potassium.

TABLE C-10

OYSTER AND CLAM SAMPLES (Cont'd)

(Gross Beta, K-40, & Gamma Scan)

STATION	COLLECTION DATE	SAMPLE TYPE	WET WT. (g)	DRY WT. (g)	BETA pCi/g(WET)	K-40 pCi/g(WET)	GAMMA SCAN pCi/g(WET)
Newport News	05-19-71	Oyster	298	20	0.58 ± 0.06	0.32	ND
Deep Water Shoals	05-20-71	Oyster	277	30	0.26 ± 0.04	0.12	ND
Point of Shoals	05-19-71	Oyster	320	37	0.67 ± 0.09	0.35	ND
Lawnes Creek	05-20-71	Clam	324	114	1.11 ± 0.17	0.40	ND
Hog Island Point	05-20-71	Clam	246	60	0.61 ± 0.11	0.31	ND
Station Discharge	05-20-71	Clam	192	40	0.56 ± 0.10	0.23	ND
Jamestown	05-21-71	Clam	165	32	0.63 ± 0.09	0.22	ND
Chickohominy	05-21-71	Clam	116	14	0.43 ± 0.05	0.13	ND

ND = No detectable activity above background and system sensitivity other than naturally occurring uranium, thorium, and potassium.

*Gamma Scan indicated <5 pCi/total sample for Fe-59, Co-60, Zr-95, Ru-106, and Cs-137.

TABLE C-11

CRAB SAMPLE

(Gross Beta, K-40, & Gamma Scan)

STATION	COLLECTION DATE	WET WT. (g)	DRY WT. (g)	BETA pCi/g (WET)	K-40 pCi/g (WET)	GAMMA SCAN pCi/g (WET)
Station Discharge	07-02-70	130	29	2.49 ± 0.35	2.59	*
Station Intake	09-03-70	135	29	1.47 ± 0.18	1.24	*

*Gamma Scan indicated <5 pCi/total sample for Fe-59, Co-60, Zr-95, Ru-106, and Cs-137.

TABLE C-12
SILT SAMPLES

(Gross Beta, K-40, & Gamma Scan)

STATION	COLLECTION DATE	WET WT. (g)	DRY WT. (g)	BETA pCi/g (DRY)	K-40 pCi/g (DRY)	GAMMA SCAN pCi/g (DRY)
Newport News	12-09-69	333	183	5.29 ± 0.42	1.24	*
Point of Shoals	12-09-69	307	78.5	3.47 ± 0.62	1.35	*
Station Intake	12-12-69	408	173	2.77 ± 0.58	1.29	*
Hog Island Point	12-12-69	320	96.0	4.13 ± 0.64	1.29	*
Station Discharge	12-12-69	402	239	2.08 ± 0.54	0.44	*
Newport News	01-28-70	200	69.4	2.61 ± 0.56	1.65	*
Point of Shoals	01-28-70	409	175	2.62 ± 0.56	1.85	*
Station Intake	01-28-70	455	261	1.22 ± 0.48	0.86	*
Hog Island Point	01-28-70	265	105	2.38 ± 0.54	1.07	*
Station Discharge	01-28-70	353	146	1.71 ± 0.50	1.15	*
Chickohominy	01-28-70	290	167	0.86 ± 0.46	0.84	*
Point of Shoals	03-17-70	228	90.5	4.46 ± 0.64	1.99	*
Station Intake	03-19-70	277	125	2.65 ± 0.56	1.23	*
Hog Island Point	03-19-70	319	148	2.88 ± 0.56	1.23	*
Station Discharge	03-19-70	234	89.0	3.56 ± 0.60	1.23	*
Chickohominy	03-19-70	261	84.0	1.36 ± 0.48	1.07	*
James River Bridge	03-17-70	268	88.0	5.03 ± 0.66	2.83	*

TABLE C-12

SILT SAMPLES (Cont'd)

(Gross Beta, K-40, & Gamma Scan)

STATION	COLLECTION DATE	WET WT. (g)	DRY WT. (g)	BETA pCi/g (DRY)	K-40 pCi/g (DRY)	GAMMA SCAN pCi/g (DRY)
Chickohominy	05-20-70	220	102	3.32 ± 0.50	1.84	*
Hog Island Point	05-20-70	246	116	4.07 ± 0.57	1.23	*
Newport News	05-20-70	254	125	3.91 ± 0.50	1.76	*
Point of Shoals	05-20-70	220	146	4.39 ± 0.60	1.53	*
Station Intake	05-20-70	295	173	3.24 ± 0.50	1.15	*
Station Discharge	05-20-70	155	106	3.39 ± 0.51	1.68	*
Newport News	07-02-70	238	137	8.76 ± 1.39	9.59	*
Point of Shoals	07-02-70	203	74	12.8 ± 1.4	9.59	*
Station Intake	07-02-70	198	100	7.55 ± 1.03	5.77	*
Hog Island Point	07-02-70	225	102	8.22 ± 1.20	7.66	*
Station Discharge	07-02-70	204	76	4.23 ± 0.62	1.94	*
Chickohominy	07-02-70	172	70	2.54 ± 0.44	1.31	*
Newport News	09-02-70	374	196	5.82 ± 0.89	5.74	*
Point of Shoals	09-02-70	342	174	4.65 ± 0.69	3.83	*
Station Intake	09-02-70	351	188	3.13 ± 0.49	1.91	*
Hog Island Point	09-02-70	372	161	2.10 ± 0.35	0.77	*
Station Discharge	09-02-70	334	133	5.13 ± 0.70	3.83	*
Chickohominy	09-02-70	347	130	4.19 ± 0.67	3.83	*

TABLE C-12

SILT SAMPLES (Cont'd)

(Gross Beta, K-40, & Gamma Scan)

STATION	COLLECTION DATE	WET WT. (g)	DRY WT. (g)	BETA pCi/g (DRY)	K-40 pCi/g (DRY)	GAMMA SCAN pCi/g (DRY)
Newport News	11-19-70	478	161	7.54 ±0.91	3.83	*
Point of Shoals	11-19-70	554	209	4.99 ± 0.80	3.83	*
Station Intake	11-19-70	546	324	7.53 ± 1.02	5.74	*
Hog Island Point	11-18-70	606	324	5.24 ± 0.74	1.91	*
Station Discharge	11-18-70	612	304	6.11 ± 0.85	3.83	*
Chickohominy	11-20-70	483	133	6.51 ± 0.77	1.91	*
Newport News	01-14-71	529	184	9.80 ± 0.95	2.78	ND
Point of Shoals	01-14-71	651	228	4.32 ± 0.59	1.08	ND
Station Intake	01-14-71	672	356	7.30 ± 0.78	1.08	ND
Hog Island Point	01-13-71	664	308	4.13 ± 0.56	0.76	ND
Station Discharge	01-13-71	578	201	5.67 ± 0.70	1.54	ND
Chickohominy	01-13-71	600	398	4.01 ± 0.53	0.31	ND
Newport News	03-11-71	659	442	2.31 ± 0.40	0.77	ND
Point of Shoals	03-11-71	526	182	5.51 ± 0.69	1.15	ND
Station Intake	03-10-71	655	297	4.10 ± 0.57	0.77	ND
Hog Island Point	03-10-71	558	292	4.49 ± 0.60	0.77	ND
Station Discharge	03-10-71	576	268	3.79 ± 0.54	0.77	ND
Chickohominy	03-11-71	632	308	3.03 ± 0.49	0.92	ND

TABLE C-12

SILT SAMPLES (Cont'd)

(Gross Beta, K-40, & Gamma Scan)

STATION	COLLECTION DATE	WET WT. (g)	DRY WT. (g)	BETA pCi/g (DRY)	K-40 pCi/g (DRY)	GAMMA SCAN pCi/g (DRY)
Newport News	05-19-71	508	172	6.21 ± 0.77	1.76	ND
Point of Shoals	05-19-71	474	162	8.01 ± 0.87	1.84	ND
Station Intake	05-20-71	440	171	6.03 ± 0.71	0.77	ND
Hog Island Point	05-20-71	598	308	2.93	0.77	ND
Station Discharge	05-20-71	484	244	5.00 ± 0.84	0.77	ND
Chickohominy	05-21-71	526	158	4.94 ± 0.62	1.15	ND

*Gamma Scan indicated <5 pCi/total sample for Fe-59, Co-60, Zr-95, Ru-106, and Cs-137.

ND = No detectable activity above background and system sensitivity other than naturally occurring uranium, thorium, and potassium.

TABLE C-13

SOIL SAMPLES

(Gross Beta)

STATION	COLLECTION DATE	WET WT. (g)	DRY WT. (g)	BETA pCi/g (DRY)	K-40 pCi/g (DRY)	GAMMA SCAN pCi/g (DRY)
Alliance	04-13-70	636	536	1.05 ± 0.23	---	ND
Bacon's Castle	04-13-70	742	716	1.10 ± 0.24	---	ND
Colonial Parkway	04-13-70	504	418	1.63 ± 0.25	---	ND
Dow	04-13-70	746	647	3.84 ± 0.30	---	ND
Fort Eustis	04-13-70	668	615	0.90 ± 0.23	---	ND
Surry Station	04-13-70	725	540	2.48 ± 0.27	---	ND
Alliance	09-29-70	594	526	1.67 ± 0.32	---	ND
Bacon's Castle	09-29-70	534	478	2.34 ± 0.40	---	ND
Colonial Parkway	09-29-70	501	421	3.74 ± 0.54	---	ND
Dow	09-29-70	660	512	5.01 ± 0.64	---	ND
Fort Eustis	09-29-70	506	412	4.27 ± 0.58	---	ND
Surry Station	09-29-70	559	474	3.11 ± 0.48	---	ND
Alliance	04-05-71	550	522	1.39 ± 0.26	0.23	ND
Bacon's Castle	04-05-71	507	372	3.25 ± 0.46	0.23	ND
Colonial Parkway	04-05-71	582	484	3.47 ± 0.48	0.04	ND
Dow	04-05-71	473	398	3.11 ± 0.46	0.32	ND
Fort Eustis	04-05-71	493	420	2.74 ± 0.43	0.36	ND
Surry Station	04-05-71	450	350	2.28 ± 0.38	0.45	ND

ND = No detectable activity above background and system sensitivity other than naturally occurring uranium, thorium, and potassium, and a trace of cesium-137 from worldwide fallout.

TABLE C-[illegible]

MILK SAMPLES

(Sr-90, Calcium, Cs-137, & 1-131)

STATION	COLLECTION DATE	Sr-90 pCi/1	pCi Sr-90/g Ca	CALCIUM g/1	Cs-137 pCi/1	1-131 pCi/1
Smith Dairy	02-23-70	Lost	---	---	---	---
Ross Dairy	02-23-70	10.6 ± 1.6	12.7 ± 1.0	0.84	5.76 ± 0.28	<15
Epps Dairy	02-24-70	11.6 ± 1.8	11.6 ± 1.8	1.00	6.75 ± 0.24	<15
Jenkins Dairy	02-24-70	18.3 ± 2.2	18.0 ± 1.1	1.02	4.23 ± 0.22	<15
Barlow Dairy	02-24-70	11.2 ± 1.8	9.4 ± 0.8	1.20	5.92 ± 0.30	<15
Epps Dairy	04-04-70	9.39 ± 0.56	11.2 ± 0.7	0.84	4.84 ± 0.30	<15
Barlow Dairy	04-04-70	12.0 ± 1.0	9.94 ± 0.80	1.20	5.13 ± 0.18	<15
Ross Dairy	04-28-70	9.69 ± 0.34	9.30 ± 0.33	1.04	5.84 ± 0.18	<15
Judkins Dairy	04-28-70	18.5 ± 0.9	20.1 ± 1.0	0.92	7.72 ± 0.18	<15
Smith Dairy	04-28-70	14.7 ± 0.7	15.0 ± 0.7	0.98	5.25 ± 0.30	<15
Epps Dairy	06-09-70	6.74 ± 1.48	4.41 ± 0.97	1.53	12.9 ± 0.8	<15
Barlow Dairy	06-09-70	2.61 ± 0.57	2.12 ± 0.46	1.23	6.77 ± 0.20	<15
Ross Dairy	06-09-70	1.37 ± 0.30	0.98 ± 0.21	1.40	5.76 ± 0.24	<15
Judkins Dairy	06-09-70	3.90 ± 0.86	5.13 ± 1.13	0.76	10.1 ± 0.2	<15
North Shore Dairy	06-09-70	2.35 ± 0.52	1.72 ± 0.38	1.37	7.63 ± 0.22	<15
Epps Dairy	08-18-70	14.3 ± 0.9	15.0 ± 0.9	0.95	5.14 ± 0.19	<15
Barlow Dairy	08-18-70	8.56 ± 0.68	7.64 ± 0.61	1.12	3.59 ± 0.22	<15
Ross Dairy	08-11-70	9.91 ± 0.49	16.8 ± 0.8	0.59	2.39 ± 0.17	<15
Judkins Dairy	08-18-70	18.4 ± 0.9	16.5 ± 0.8	1.11	2.22 ± 0.13	<15
Smith Dairy	08-11-70	11.0 ± 0.9	11.2 ± 0.9	0.98	4.65 ± 0.15	<15

TABLE C-14

MILK SAMPLES (Cont'd)

(Sr-90, Calcium, Cs-137, & I-131)

STATION	COLLECTION DATE	Sr-90 pCi/l	pCi Sr-90/g Ca	CALCIUM g/l	Cs-137 pCi/l	I-131 pCi/l
Epps Dairy	04-05-71	7.21 ± 1.30	13.8 ± 2.50	0.52	<10	<10
Barlow Dairy	04-05-71	9.73 ± 0.78	16.2 ± 1.30	0.60	<10	<10
Judkins Dairy	04-05-71	18.8 ± 1.90	26.0 ± 2.60	0.72	<10	<10
Smith Dairy	04-15-71	10.5 ± 1.90	11.4 ± 2.10	0.92	<10	<10
Ross Dairy	04-15-71	13.1 ± 1.30	13.1 ± 1.30	1.00	<10	<10
Epps Dairy	06-14-71	5.59 ± 1.23	9.31 ± 2.05	0.60	<10	<10
Barlow Dairy	06-14-71	8.26 ± 1.82	12.9 ± 2.80	0.64	<10	<10
Judkins Dairy	06-14-71	6.07 ± 1.34	9.46 ± 2.08	0.64	<10	<10
Smith Dairy	06-01-71	6.74 ± 1.08	10.5 ± 1.70	0.64	<10	<10
Ross Dairy	06-01-71	8.49 ± 1.36	14.1 ± 2.30	0.60	<10	<10

FIGURE 1
SURRY NUCLEAR STATION
LAND BASED SAMPLING STATIONS

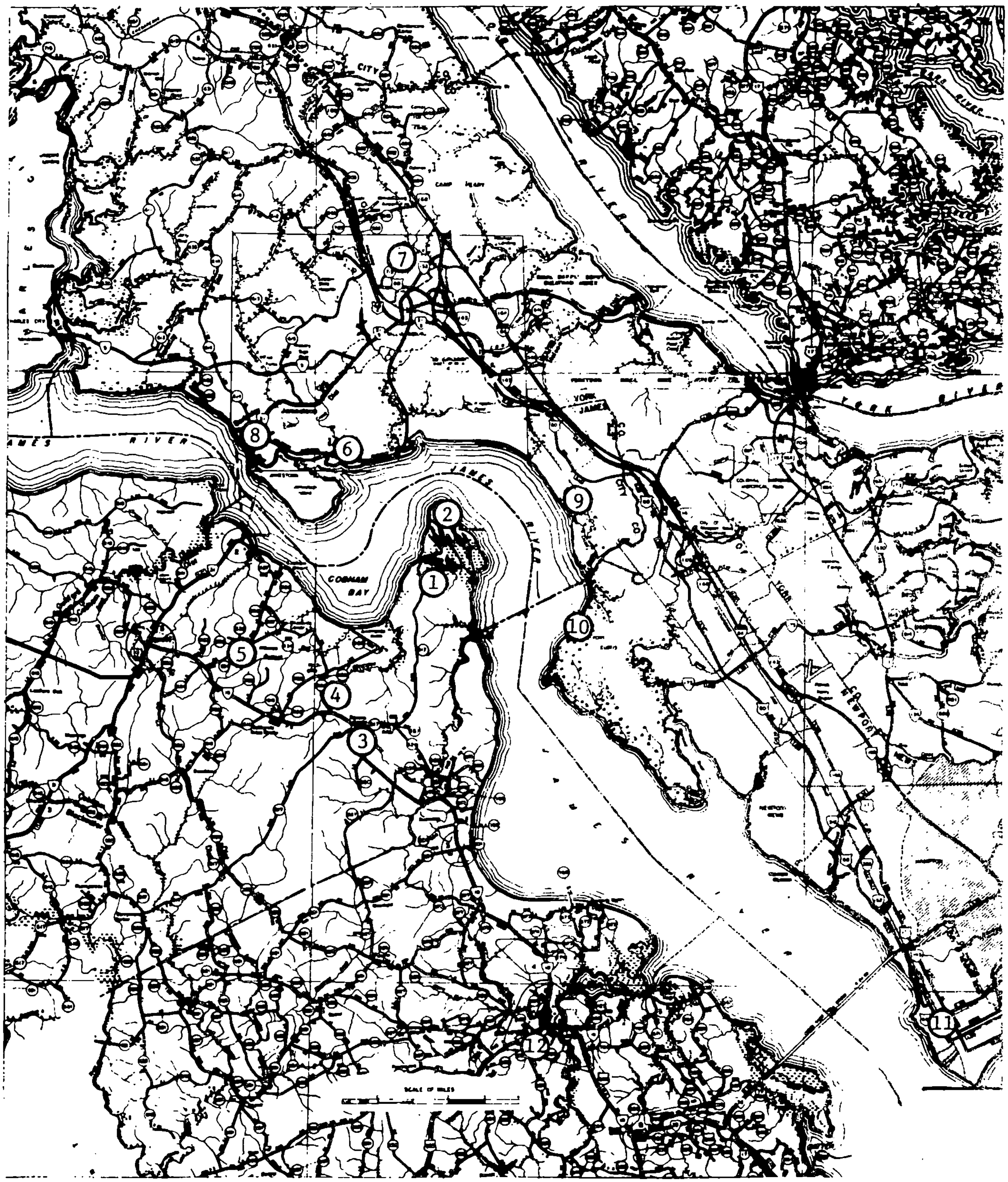
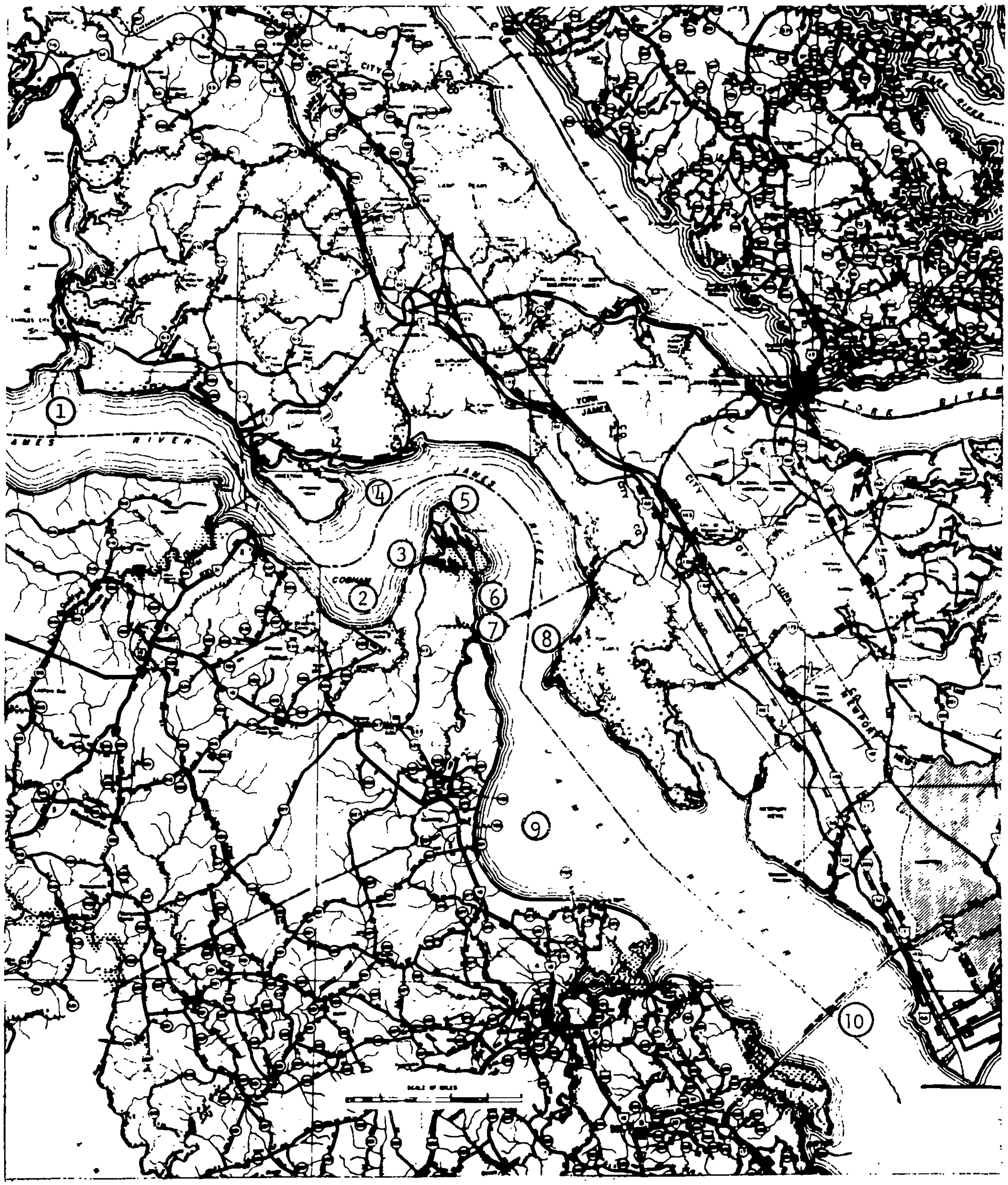


FIGURE 2
SURRY NUCLEAR STATION
JAMES RIVER SAMPLING STATIONS



APPENDIX D

SURRY COUNTY DATA SUMMARY

DATA SUMMARY

Surry County

August, 1971
71–26

DIVISION OF STATE PLANNING & COMMUNITY AFFAIRS
1010 James Madison Building / Richmond, Virginia 23219

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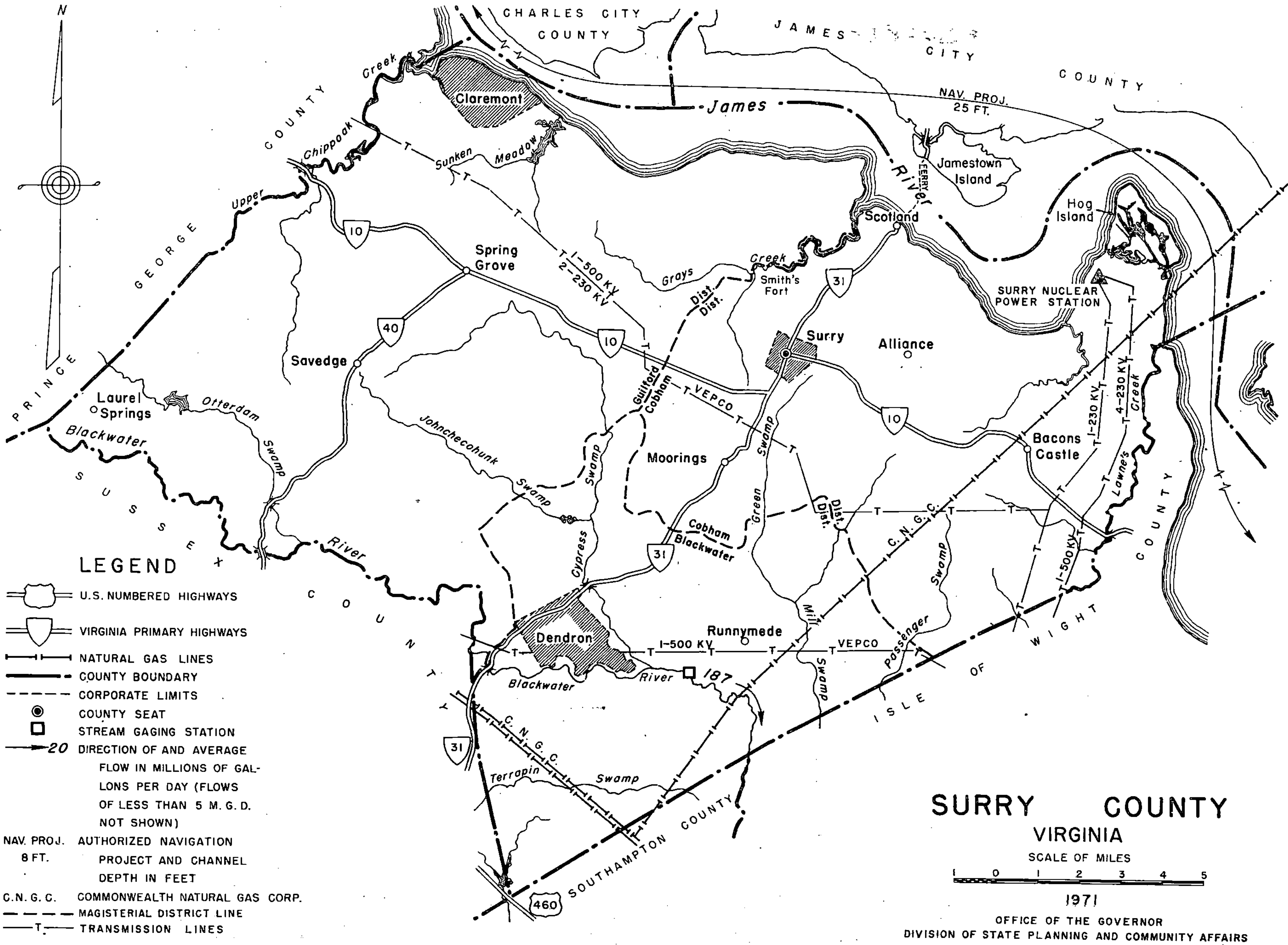
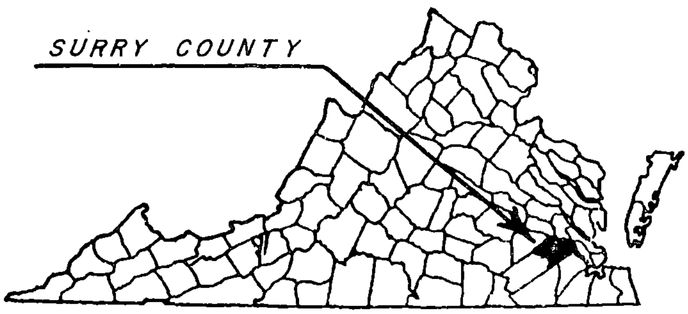
Revised - August, 1971

This report is one of a series made for all counties and independent cities in Virginia. The reports are revised every two years by the Office of Research and Information, Division of State Planning and Community Affairs. The cooperation of local citizens, chambers of commerce, and state, local and federal government agencies is gratefully acknowledged. Research Assistant, Patricia Webb, was primarily responsible for the writing and organization of this report. The material in this publication is not copyrighted and may be quoted; however, it would be appreciated if credit were given to the Division of State Planning and Community Affairs.


SURRY COUNTY
VIRGINIA
SCALE OF MILES
1 0 1 2 3 4 5
1971
OFFICE OF THE GOVERNOR
DIVISION OF STATE PLANNING AND COMMUNITY AFFAIRS
LEGEND
U.S. NUMBERED HIGHWAYS
VIRGINIA PRIMARY HIGHWAYS
NATURAL GAS LINES
COUNTY BOUNDARY
CORPORATE LIMITS
COUNTY SEAT
STREAM GAGING STATION
20 DIRECTION OF AND AVERAGE FLOW IN MILLIONS OF GALLONS PER DAY (FLOWS OF LESS THAN 5 M. G. D. NOT SHOWN)
NAV. PROJ. 8 FT. AUTHORIZED NAVIGATION PROJECT AND CHANNEL DEPTH IN FEET
C. N. G. C. COMMONWEALTH NATURAL GAS CORP.
MAGISTERIAL DISTRICT LINE
T TRANSMISSION LINES
N
CHARLES CITY COUNTY
JAMES CITY COUNTY
PRINCE GEORGE COUNTY
SUSSEX COUNTY
SOUTHAMPTON COUNTY
ISLE OF WIGHT COUNTY
James River
NAV. PROJ. 25 FT.
FERRY
Jamestown Island
Hog Island
SURRY NUCLEAR POWER STATION
Claremont
Scotland
Smith's Fort
Spring Grove
Savedge
Laurel Springs
Surry
Alliance
Moorings
Bacons Castle
Dendron
Runnymede
Upper Chippoak Creek
Sunken Meadow
Grays Creek
Otterdam Swamp
Blackwater River
Johnchecohunk Swamp
Cypress Swamp
Green Swamp
Mill Swamp
Passenger Swamp
Lawne's Creek
Terrapin Swamp
Guilford
Cobham
Blackwater
Dist.
1-500 KV
2-230 KV
4-230 KV
1-230 KV
VEPCO
C. N. G. C.
10
31
40
460
187

SECTION I - INTRODUCTION



INDEX TO COUNTY LOCATION

Surry County was formed in 1652 from James City County, the county where Jamestown, the first permanent English settlement, is located. Surry was named for Surrey County in England, although the "e" was dropped in the spelling of the American county. Surry lies just across the James River from Jamestown and was explored and settled early by the colonists. In 1609 Captain John Smith build a fort, Smith's Fort, on Gray's Creek, just north of the town of Surry. By 1623 there were 64 settlers living in Surry County - 31 of these were living on Hog Island, a peninsula of the county which juts into the James River.

Surry County has many old homes of historical significance, some of which are open to the public. The land around Smith's Fort was a gift from the Indian Chief Powhatan to Thomas Rolfe, the son of his daughter Pocahontas. In 1652 Thomas Warren built a house on this land, which still stands today and is known as the Rolf-Warren House. This house is open to the public. Another of the very old homes in Surry is Chippokes Plantation, one of the original land grant plantations, which still retains its original boundaries. Although this plantation has become a state park, it is still a working plantation and there are cows, sheep, soybeans and other crops raised here. Chippokes was named for an Indian, Chippoke, who was a great help to the early settlers of the county. Bacon's Castle, a privately owned home, was built around 1660 by Arthur Allen. Its name comes from Nathaniel Bacon, leader of Bacon's Rebellion, although he probably never saw the house. Other historic places are Claremont Manor, now a private school, the Glebe House in Southwark Parish, the ruins of Southwark Church and Pleasant Point.

Surry County lies in the Costal Plain bordering the James River. Its area consists of 280 sq. mi. of land (179,200 acres) and 26 sq. mi. of inland water. The surface is gently rolling or quite level, with some high points that rise about 93 feet above sea level in the eastern part of the county and about 120 feet in the western part of the county. Temperature averages 41^{o} in January, 78^{o} in July. Precipitation amounts to about 43 inches annually and is well distributed. About 76 percent of the land area is wooded, and production of pulpwood and lumber is an important business in Surry. Marl, clay, sand and gravel are the only significant mineral resources. In 1970 the population of Surry County was 5,882. The State Division of Planning and Community Affairs has predicted that the county's population will decrease at an average annual rate of 0.5 percent and will each 5,600 by 1980.

This is a rural county and agriculture is the principal industry. The sandy loam soil is well adapted to general crops. In particular, Surry is known for its peanuts and ranked sixth among Virginia's peanut-producing counties in 1970. In recent years hog production has increased and the county ranks sixth among Virginia counties in value of farm income from hogs. There is a ready market in the meat-packing houses of neighboring counties in this famous "Virginia ham" country. Soybeans and corn are also raised in rather large quantities. Some farms specialize in poultry, hogs, and cattle.

The only manufacturing concerns are a meat products company and several sawmills and planning mills.

In the extreme northeastern corner of Surry County is Hog Island Waterfowl Refuge, a 2,485 acre tract on the James River, set aside as a winter home for Canada geese and other migratory fowl. On Blackwater River northeast of Dendron is the Heron Rookery Natural Area, a new sanctuary, recently donated to the state as a heron preserve. It is their natural nesting place.

A nuclear powered steam generating station which will house two 800,000 kilowatt units is under construction by the Virginia Electric and Power Company at Hog Island. This station is scheduled to open in 1972 for commercial service and will serve approximately 400,000 households.

SECTION II - POPULATION

Table 1.--Selected Population Statistics

	1940	1950	1960	1970 a/
Surry County	6,193	6,220	6,220	5,882
Town of Surry	254	248	288	269
Town of Claremont	380	374	377	383
Town of Dendron	465	476	403	336

	Surry County		Virginia	
	1960	1970	1960	1970
Median age	24.1	n.a.	27.1	n.a.
Age distribution:				
Percent of total population				
0 to 4	13.1	10.0	11.6	8.4
5 to 17	29.6	29.0	25.4	25.8
18 to 20	4.0	4.7	4.7	5.8
21 to 44	25.0	24.7	32.9	32.5
45 to 64	18.5	21.0	18.2	19.6
65 and over	10.0	10.8	7.1	7.9
Race distribution:				
Percent of total population				
White	35.3	34.8	79.2	80.8
Negro	64.7	65.2	20.6	18.6
Other race	0.0	0.0	0.2	0.6
Percent of family heads which are male	n.a.	75.1	n.a.	88.7
Percent of family heads which are female	n.a.	10.0	n.a.	11.3
Percent of total population of 14 year olds and over in the labor force	50.2	n.a.	55.7	n.a.
Median school years completed by persons 25 years and over	7.5	n.a.	9.9	n.a.

a/ Population in 1970 by magisterial districts was Blackwater District 1,440, Cobham District 2,704 and Guilford District 1,738.

n.a. - not available

Note: Details may not add to totals due to rounding.

Sources: U.S. Bureau of the Census, Census of Population, 1960, Vol. I, Characteristics of the Population, Part 48, Virginia, (Washington: Government Printing Office, 1963); U.S. Bureau of the Census, 1970 Census of Population, PC(V2)-48, General Population Characteristics, Virginia, (Washington: Government Printing Office, February, 1971).

SECTION III - HOUSING

Table 2.--Selected Housing Statistics for Surry County, 1970

Item	Surry County	Virginia	Percent of State
All housing units..................	2,041	1,491,663	0.1
Year around housing units........	1,906	1,483,026	0.1
Vacant-seasonal and migratory....	135	8,637	1.6
Persons per unit occupied..........	3.7	3.2	115.6
Ownership........................	3.5	3.3	106.1
Rental...........................	4.2	3.0	140.0
Units in structure:			
One unit.........................	1,745	1,110,016	0.2
Two units or more................	61	326,496	0.0
Mobile home or trailer...........	100	46,514	0.2

Source: U. S. Bureau of the Census, 1970 Census of Housing, HC(V1)-48, General Housing Characteristics, Virginia, (Washington: Government Printing Office, February, 1971).

Table 3.--Tenure, Race, Value, and Contract Rent in Surry County, 1970

Item	Number of Housing Units: Surry County	Number of Housing Units: Virginia	Percent Distribution of Housing Units: Surry County	Percent Distribution of Housing Units: Virginia
Tenure and Race:				
Owner Occupied..............	1,073	861,867	100.0	100.0
White..................	548	746,619	51.1	86.6
Negro..................	525	113,126	49.0	13.1
Other race.............	0	2,122	0.0	0.2
Renter Occupied...........	507	528,360	100.0	100.0
White..................	202	417,603	39.8	79.0
Negro..................	305	106,941	60.2	20.2
Other race.............	0	3,816	0.0	0.7
Value: Specified Owner Occupied				
Less than $5,000	151	49,590	27.3	7.1
$5,000 to $9,999	174	103,276	31.5	14.8
$10,000 to $14,999	107	136,571	19.3	19.6
$15,000 to $19,999	64	129,246	11.6	18.5
$20,000 to $24,999	35	90,874	6.3	13.0
$25,000 to $34,999	16	99,608	2.9	14.3
$35,000 to $49,999	5	62,585	1.0	9.0
$50,000 or more	1	25,454	0.2	3.6
Total	553	697,204	100.0	100.0
Contract Rent: Specified Renter Occupied				
Less than $40	116	50,923	41.1	10.5
$40 to $59	29	65,425	10.3	13.4
$60 to $79	16	70,971	5.7	14.6
$80 to $99	14	56,543	5.0	11.6
$100 to $119	6	48,437	2.1	10.0
$120 to $149	13	73,074	4.6	15.0
$150 to $199	2	59,828	0.7	12.3
$200 or more	0	22,239	0.0	4.6
No cash rent	86	38,857	30.5	8.0
Total	282	486,297	100.0	100.0

Note: Details may not add to totals due to rounding.

Source: U. S. Bureau of the Census, 1970 Census of Housing, HC(V1)-48, General Housing Characteristics, Virginia, (Washington: Government Printing Office, February, 1971).

SECTION IV - INCOME

Table 4 .--Income Measures

	Surry County	Virginia
Total personal income:		
1960 ($000)........................	$ 8,138	$ 7,339,300
1967 ($000)........................	13,224	$12,778,000
Per capita income:		
1960...............................	$ 1,308	$ 1,856
Ratio to state average...........	.70	1.00
1967...............................	$ 2,214	$ 2,777
Ratio to state average...........	.80	1.00
1959 family income:		
Median.............................	$ 2,694	$ 4,964
Ratio to state average...........	.54	1.00
Percent less than $3,000...........	55.4	27.9
Percent $10,000 and over...........	2.4	13.2

Sources: U. S. Bureau of the Census, Census of Population, 1960, Vol. I, Characteristics of the Population, Part 48, Virginia (Washington: Government Printing Office, 1963); University of Virginia, Bureau of Population and Economic Research, Personal Income of Virginia Counties and Cities, 1960, 1965, and 1967, (Charlottesville: University of Virginia, 1969), Tables I and II.

Table 5.--Adjusted Gross Taxable Income for Surry County, 1969[a/]

Item	Surry County
Source of income:	
Gross wages	$8,788,637
Dividends[b/]	965,224
Business gain or loss	251,814
Capital gain[c/]	417,304
Net farm	824,742
Adjusted gross taxable income	$11,247,721
Income per tax return	$ 5,384
Income per tax return as a percent of the state average of $6,802	79.2

Note: Details may not add to totals due to rounding.

a/ Adjusted gross taxable income refers to adjusted gross income for state tax purposes as defined by the Virginia state tax law. There is a distinction between adjusted gross taxable income and total personal income. Not included in adjusted gross taxable income but in total personal income are military income of non-Virginia residents, income in kind, unreported income under $1,000, transfer payments, other labor income (which is workmen's compensation and military reservist's pay minus personal contributions for social insurance and private pensions). Adjusted gross taxable income includes capital gains, but total personal income does not.

b/ Includes dividends, interest, rents and royalties, annuities or pensions, and the income from partnerships, estates and trusts.

c/ Capital gain is the net gain (or loss) incurred from the sale or exchange of real estate, stocks, bonds and other personalty.

Source: Commonwealth of Virginia, Department of Taxation, Income of Resident and Nonresident Individuals and Fiduciaries for the Taxable Year 1969, (unpublished tables).

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Source: Commonwealth of Virginia, Department of Taxation, Income of Resident and Nonresident Individuals and Fiduciaries for the Taxable Year 1969, (unpublished tables).

SECTION V - LABOR RESOURCES

WORK FORCE

Table 6.--Work Force Data for Surry County[a/]

Item	March 1960	March 1970	Percent Change 1960-70
Population	6,220	5,882	-5.4
Civilian work force	1,789	3,487	94.9
Percent of population	28.8	59.3	...
Unemployment	130	54	-58.5
Percent of work force	7.3	1.5	...
Employment	1,659	3,433	107.0
Nonagricultural employment	729	2,839	289.4
Manufacturing	68	54	-20.6
Nonmanufacturing	367	2,318	531.6
Contract construction	*	1,828	...
Trans. & public utilities	*	36	...
Wholesale and retail trade	100	121	21.0
Finance, insurance & real estate	*	11	...
Service	40	*	...
Government	202	241	19.3
All other nonmanufacturing	25	81	224.0
All other nonagricultural[b/]	294	467	58.8
Agricultural	930	594	-36.1

*Figures withheld to avoid disclosure of individual operations.

a/ Employment data are based on place of work rather than place of residence.

b/ Includes self-employed, unpaid family workers, and domestic workers in private households.

Source: Virginia employment Commission, Division of Research, Statistics, and Information.

Table 7.--Average Number of Establishments, Average Employment, Total Wages, and Average Wage Per Employee for the Twelve Month Period Ending January 1, 1971[a]

Item	Construction	Manufacturing	Trade	Services	Total [b]
Surry County					
Average no. of establishments	4	3	11	*	18
Average employment	1,867	52	96	*	2,015
Total wages	$26,138,040	$258,122	$347,319	$*	$26,743,481
Average wage per employee	$ 14,000	$ 4,964	$ 3,618	$*	13,272
Percent of county to state average wage	187.7	75.3	67.7	*	211.1
State average wage per employee	7,457	$ 6,595	$ 5,346	$5,414	$ 6,287

*Figures withheld to avoid disclosure of individual operations.

a/ Coverage includes nonagricultural employers having four or more workers for 20 weeks within a calendar year. It excludes government, railroad, self-employed, domestic service, unpaid family workers, and some nonprofit organizations.

b/ Total includes other employment sectors in addition to those shown.

Source: Virginia Employment Commission, Covered Employment and Wages, (selected quarters).

WORK-RESIDENCE INFORMATION

Table 8.--Work Residence Information for Surry County, April, 1960

	Number	Percent of Total
Total resident workers reporting a place of work a/	1,852	100.0
Places of work reported:		
Surry County	1,334	72.0
Out-Commuters from Surry County		
Newport News-Hampton Cities	110	6.0
Norfolk-Portsmouth Cities	11	0.6
Richmond City	11	0.6
Isle of Wight County	164	8.9
Southampton County	7	0.4
Sussex County	81	4.4
Prince George County	32	1.7
Petersburg City	7	0.4
Hopewell City	47	2.5
Elsewhere	48	2.6
Total	518	28.1

In-Commuters to Surry County

Residence	Number
Southampton County	15
Sussex County	14
Prince George County	11
Isle of Wight	12
Total	52

Total out-Commuters = 518
Total in-Commuters = 52
Net out-Commuters = 466

Note: Details may not add to totals due to rounding.

a/ Resident workers not reporting a place of work totaled 26.

Source: U.S. Bureau of the Census, Census of Population: 1960, (unpublished tabulations based on a 25 percent sample).

SECTION VI - MAJOR EMPLOYMENT SECTORS

MANUFACTURING

Table 9.--Measures of Manufacturing in 1967

Item	Surry County	Virginia	Percent of State
Number of establishments:			
Total	6	4,938	0.1
With 20 or more employees	1	1,620	0.1
All employees:			
Total number (000)	*	339.8	...
Payroll (million dollars)	*	$1,905.1	...
Production workers:			
Total number (000)	*	268.2	...
Man-hours (millions)	*	535.0	...
Wages (million dollars)	*	$1,296.1	...
Average wage/hour	*	$2.42	...
Value added by manufacture (million dollars)	*	$4,067.7	...
Capital expenditures, new (million dollars)	*	$347.0	...

*Figures withheld to avoid disclosure of individual operations.

Sources: U.S. Bureau of the Census, 1967 Census of Manufactures, Virginia, MC67(3)-47, (Washington: U.S. Government Printing Office, 1970), Table 4.

MANUFACTURING

Table 10.--Major Manufacturing Establishments in Surry County

Name	Location	Product	Approximate Employment[a/] March, 1970
S. Wallace Edwards & Son	Surry	Meat Products	1-19
Joseph Moore	Surry County	Logging	1-19
Seward Lumber Company	Claremont	Lumber	20-49

Sources: Virginia Employment Commission; Virginia State Chamber of Commerce, Industrial Directory of Manufacturing in Virginia, (Richmond: Virginia State Chamber of Commerce, 1969); Commonwealth of Virginia, Division of Industrial Development, unpublished material.

RETAIL TRADE

Table 11.--Measures of Retail Trade in 1967

Item	Surry County	Virginia	Percent of State
No. of establishments	37	32,315	0.1
Sales:			
Total sales ($000)	$2,846	$6,150,202	0.0
Per capita sales a/	$ 48	$ 1,323	3.6
Total payroll ($000)	$ 219	$ 709,339	0.0

Item	1967 Total Sales ($000) Surry County
Lumber, building materials, and hardware	*
General merchandise	238
Food	834
Automotive	*
Gasoline stations	205
Apparel	0
Home furnishings & equipment	*
Drugs and sundries	*
All other	1,569
Total	2,846

* Withheld to avoid disclosure of individual operations and included in "all other."

a/ The population figure used in determining per capita sales is the 1970 Census of Population figure.

Sources: U. S. Bureau of the Census, 1967 Census of Business, Retail Trade, Virginia, BC67-RA48, (Washington: U. S. Government Printing Office, 1969), Table 3; U. S. Bureau of the Census, 1970 Census of Population, PC(V1)-48, Final Population Counts, Virginia, (Washington: Government Printing Office, December, 1970).

Table 12 .--Taxable Sales for the Twelve Months Ending March 31, 1971 [a/]

Item	Surry County	Virginia
Average number of registered dealers:		
12 months ending March 31, 1971.......	102	74,377
Percent of state average..............	0.1	100.0
Total taxable sales:		
12 months ending March 31, 1971.......	$2,993,574	$7,293,469,510
Percent of state total................	0.0	100.0
Per capita sales[b/]:		
12 months ending March 31, 1971.......	$ 508	$1,569
Percent of state average..............	32.4	100.0

a/ Taxable sales and retail sales differ. Included in taxable sales but not in retail sales are equipment rentals; repairs; sales made by hotels, motels, and tourist camps; and a use tax on items which are purchased outside the state but brought into the state for final use. Included in retail sales but not in taxable sales are gasoline; automobiles; ABC store sales; sales to any branch of government or to certain state-franchised public utilities; certain sales to interstate airlines and shiplines; and sales by daily or periodic publications.

b/ The population figure used in determining per capita sales is the 1970 Census of Population figure.

Sources: Virginia Department of Taxation, Taxable Sales, Quarterly Report, (Richmond: Commonwealth of Virginia), selected quarters; U. S. Bureau of the Census, 1970 Census of Population, PC(V1)-48, Final Population Counts, Virginia, (Washington: Government Printing Office, December, 1970).

WHOLESALE TRADE

Table 13.--Measures of Wholesale Trade in 1967

Item	Surry County	Virginia	Percent of State
No. of establishments	3	4,577	0.1
Total sales ($000)	$512	$6,162,254	0.0
Total payroll ($000)	$ 84	$ 339,005	0.0

Source: U. S. Bureau of the Census, 1967 Census of Business, Wholesale Trade, Virginia, BC67-WA48, (Washington: U. S. Government Printing Office, 1969), Table 4.

SELECTED SERVICES

Table 14.--Measures of Selected Services in 1967[a/]

Item	Surry County	Virginia	Percent of State
No. of establishments	10	19,986	0.1
Receipts:			
Total receipts($000)	$93	$835,314	0.0
Per capita receipts[b/]	$ 2	$ 180	1.1
Total payroll ($000)	$16	$273,615	...

a/ Selected services cover hotels, motels, camps, trailer parks, personal services, miscellaneous business services, automobile repair and services, and garages. Also included are miscellaneous repair services, motion pictures, and amusement and recreation services. Nonprofit membership recreational services are excluded.

b/ The population figure used in determining per capita receipts is the 1970 Census of Population figure.

Sources: U. S. Bureau of the Census, 1967 Census of Business, Selected Services, Virginia, BC67-SA48, (Washington: Government Printing Office, 1967), Table 3; U. S. Bureau of the Census, 1970 Census of Population, PC(V1)-48, Final Population Counts, Virginia, (Washington: Government Printing Office, December, 1970).

AGRICULTURE

Table 15.--Selected Measures of Agriculture in Surry County

Item	1959		1964	
Number of farms	538		396	
Commercial farms	363		307	
Tenant farms	107		74	
Percent of land area in farms	43.8		39.3	
Average size of farms	146.0	acres	177.7	acres
Value of all farm products sold	$3,332,064		$3,646,662	
Land in farms	78,554	acres	70,373	acres
Cropland	31,825	acres	34,253	acres
Woodland on farms	42,160	acres	32,830	acres
Pasture[a/]	2,058	acres	1,616	acres
Other land on farms	2,511	acres	1,674	acres

Value of farm products sold, 1964	Number of farms		Percent Distribution of farms	
	County	Virginia	County	Virginia
Under $500	36	20,001	10.0	24.9
$500 to $999	24	10,952	6.1	13.6
$1,000 to $1,999	51	12,630	12.9	15.7
$2,000 to $4,999	91	16,555	23.0	20.6
$5,000 to $7,499	42	6,361	10.6	7.9
$7,500 to $9,999	35	3,529	8.8	4.4
$10,000 to $14,999	44	3,665	11.1	4.6
$15,000 and over	73	6,661	18.4	8.3
Total	396	80,354	100.0	100.0

Principal sources of county farm income in 1964 were:

$2,600,462 from field crops other than vegetables, fruits or nuts.
784,794 from livestock and livestock products, other than poultry and dairy.
107,020 from forest products and horticultural speciality products.
76,430 from poultry and poultry products.

Note: Details may not add to totals due to rounding.

a/ Excludes woodland pasture.

Sources: U. S. Bureau of the Census, 1964 Census of Agriculture, Virginia, Volume 1, Part 24, (Washington: U. S. Government Printing Office, 1967), Tables 1 and 6; 1959 Census of Agriculture, Virginia, Volume 1, Part 24, (Washington: U. S. Government Printing Office, 1961), Tables 1 and 6.

SECTION VII - GOVERNMENT

TYPE

Surry County is currently in the process of redistricting the county's magisterial districts in order to comply with the principle of one-man one-vote. The three old magisterial districts will be retained for tax purposes. Pending the approval of the U.S. Attorney General the county will be divided, politically, into five election districts, which will become effective January 1, 1972. From each of these a representative, or supervisor, is elected to serve for four years on the board of supervisors; the county's governing body. These supervisors have no election district functions, but are individually responsible to their electorate. Collectively the board serves as the legislative and policy making branch of the county government. They meet once a month, or more often if necessary, at the court house in Surry. Meetings are open to the public. Other elected officials of the county are chosen by the electorate of the entire county including the towns which are politically a part of the county and district in which they are located.

Claremont, Dendron and Surry are incorporated towns. Each is governed by a town council, composed of either five or six men, and a mayor who is elected by the voters of the respective towns. Since towns are part of the county, the ordinances and regulations of the county are effective in them and since the residents of the towns are affected by two governments--both town and county--the qualified voters of the towns vote for officials of the two governing bodies. However, county residents do not vote for, or come under the government of the town officials.

PLANNING ACTIVITIES

Surry County is a member of the 19th District Planning Commission, headquartered in Petersburg, which is staffed and operating and includes, also, the counties of Dinwiddie, Sussex, Prince George and Greensville and the cities of Emporia, Hopewell, Petersburg and Colonial Heights. Surry County also has a local planning commission and subdivision regulation. The county also sponsors an industrial development commission, which is endeavoring to bring new industry into Surry County.

The town of Claremont has subdivision regulations.

PUBLIC SAFETY

Police protection - Surry County receives police protection from the county sheriff and his deputies and from the police officers of Claremont and Dendron There is now a central radio station with 24-hour dispatcher service to notify these men when they are needed. Troopers of the Virginia State Police provide highway supervision and aid local police officers when needed. All of these law enforcement units have radio cars.

Fire protection - Volunteer fire companies are maintained at Claremont, Dendron and Surry. These companies are equipped with modern fire-fighting trucks and many of the members are trained in first-aid and rescue work as well as in the control of fire. These companies serve wherever and whenever they are needed.

<u>Rescue Squads</u> - There is an active county volunteer rescue squad which operates out of the town of Surry.

SECTION VIII - LOCAL FINANCES

FISCAL STATEMENT FOR COUNTY OF SURRY

Table 16.--Consolidated Statement of Fund Accounts for the Year Ended June 30, 1970

Description	Amount	Percent of Total Credits
Adjusted Balance July 1, 1969	$ 183,256	...
Credits		
Revenue:[a]		
From local sources	351,493	39.6
From the commonwealth	395,394	44.5
From the federal government	140,862	15.9
Total revenue	887,749	99.9
Nonrevenue[b,c]	580	0.1
Total credits	$ 888,329	100.0
Total credits and balance	$1,071,585	

Description	Amount	Percent of Total Debits
Debits		
Government operating expenses	$ 205,437	23.1
School operating expenses	648,589	73.0
Capital outlays	13,329	1.5
Interest and other debt costs	7,533	0.8
Redemption of debt[c]	14,100	1.6
Total debits	$ 888,988	100.0
Balance, June 30, 1970	$ 182,597	

Note: Details may not add to totals due to rounding.

a/ The annual or periodic collection of taxes and appropriations from the state and federal governments and sums from other sources which increase the cash of a fund but do not increase a liability or a reserve of the fund.

b/ Nonrevenue includes the additions to cash other than those from revenue sources such as receipts from the sale of assets or bonds and the recovery of expenditures. Proceeds of temporary loans made for operating purposes are not included.

c/ In contrast to state fiscal statements where borrowing and debt redemption are not treated as revenues and expenditures, borrowing is here treated as a current credit (nonrevenue), and the redemption of debt as a current expenditure.

Source: Auditor of Public Accounts, Richmond, Virginia, County of Surry, Virginia: Report on Audit, Year Ended June 30, 1970, (V. Lee Parker and Company, Certified Public Accountants, Petersburg, Virginia, December, 1970).

ASSESSED VALUE AND NET DEBT

Table 17.--Total Assessed Value and Net Debt in Surry County

1969 Total Assessed Value a/	1969 Net Debt b/	Percent of Net Debt to Total Assessed Value
$12,318,042	$253,200	2.1

a/ Total assessed value of all locally taxable property for the tax year 1969.

b/ Net debt as of June 30, 1969.

Sources: Department of Taxation, Report of the Department of Taxation to the Governor of Virginia for the Fiscal Year Ending June 30, 1970, (Richmond; October, 1970); Auditor of Public Accounts, Report of the Auditor of Public Accounts of the Commonwealth of Virginia on the Comparative Cost of Local Government for the Fiscal Year Ended June 30, 1969, (Richmond: 1971), Exhibit C.

TOTAL TAX LEVIES

Table 18 .--Total Assessed Value and Total Levies Collected from All Locally Taxable Property in Surry County, 1969

Type of Tax	Assessed Value, 1969	Local Levies 1969 a/
Real estate	$ 6,259,150	$143,960
Tangible personal property	2,506,890	57,658
Public service corporations b/	3,220,022	74,061
Machinery and tools	147,470	3,392
Merchants' capital	184,510	4,244
Total	$12,318,042	$283,315

a/ Town levies imposed by incorporated towns for town purposes are not included.

b/ Public service corporations are taxed on real estate and tangible personal property.

Source: Department of Taxation, Report of the Department of Taxation to the Governor of Virginia for the Fiscal Year Ending June 30, 1970, (Richmond: October, 1970).

REAL ESTATE

Table 19.--Real Estate Assessment Ratios and Property Tax Rates

Area	1971 Nominal Tax Rate Per $100	1971 Assessment Ratio	Effective True Tax Rate Per $100
Surry County	$2.00	.20	$.40
Towns			
Claremont	.60	...	...
Dendron	None	...	...
Surry	None	...	...

a/ Levies are for town purposes only and are in addition to the basic county levy.

Sources: County Commissioner of the Revenue; Town Treasurer.

MACHINERY AND TOOLS

Table 20.--Tax Rates and Assessment Ratios for Machinery and Tools

Area	1971 Nominal Tax Rate Per $100	1971 Assessment Ratio a/	Effective True Tax Rate Per $100
Surry County	$2.00	.50	$1.00
Towns b/			
Claremont	.60	...	...
Dendron	None	...	...
Surry	None	...	...

a/ Assessed as ratio to cost in the county, ratio to fair market value in town.

b/ Levies are for town purposes only and are in addition to the basic county levy.

Sources: County Commissioner of the Revenue; Town Treasurer.

TANGIBLE PERSONAL PROPERTY

Table 21.--Tangible Personal Property Tax[a/]

Area	1971 Nominal Tax Rate Per $100	1971 Assessment Ratio[b/]	Effective True Tax Rate Per $100
Surry County	$2.00	.50	$1.00
Towns[c/]			
Claremont	.60	...	...
Dendron	None	...	...
Surry	None	...	...

a/ Tangible personal property includes motor vehicles, boats and motors, trailers, farm machinery and tools, livestock and business furniture and fixtures. The tangible personal property of manufacturing establishments such as office furniture and fixtures, trucks, and company cars are not taxed locally. A manufacturer is taxed on these items at the state rate of 30¢ per $100 book value.

b/ Assessed as ratio to fair market value.

c/ Levies are for town purposes only and are in addition to the basic county levy.

Source: County Commissioner of the Revenue; Town Treasurer.

MERCHANTS' CAPITAL TAX

Table 22.--Merchants' Capital Tax [a/]

Area	1971 Nominal Tax Rate Per $100	1971 Assessment Ratio [b/]	Effective True Tax Rate Per $100
Surry County	$2.00	.50	$1.00
Towns[c/]			
Claremont	.60	...	...
Dendron	None	...	...
Surry	None	...	...

a/ Merchants' capital is defined as inventory of stock on hand, the excess of bills and accounts receivable over bills and accounts payable, and all other taxable personal property not offered for sale as merchandise. (This tax applies mainly to retailers and wholesalers. A manufacturer is taxed on these items at the state rate of 30¢ per $100 of book value.)

b/ Assessed as ratio to inventory in county, ratio to fair market value in town.

c/ Levies are for town purposes only and are in addition to the basic county levy.

Sources: County Commissioner of the Revenue; Town Treasurer.

OTHER TAXES

Surry County does not levy either a merchants' license or a professional-occupational license tax. The town of Claremont levys both merchants' license and professional-occupational license taxes.

The town of Claremont charges a utility tax for both electrical service and telephone service.

An additional source of revenue for both town and county comes from the sale of motor vehicle license tags. Surry County charges $10.00 for auto tags, $10.00 up, based on weight, for truck tags and $5.00 for motorcycle tags. The town of Claremont charges $6.25 for auto and pickup truck tags and $3.00 for motorcycle tags.

SECTION IX - TRANSPORTATION

HIGHWAY

State Highway Route 10 gives access to Hopewell, Petersburg and Richmond to the northwest and Norfolk and the Hampton Roads area to the southeast. Other state roads connect this highway with all parts of the county and with arterial routes north and south in adjacent counties.

Trucking - Freight transportation is available from six carriers authorized to provide interstate service in the area. Three of these companies also provide intrastate service.

Bus - Passenger service is provided by Trailways Bus Line on the route between Richmond and Norfolk. Connections to distant points are made at these cities. Greyhound Bus Line service is available in Sussex County close to the Surry County line.

RAILWAY

There are no railroads in the county, but the Norfolk and Western Railway in adjoining Sussex County provides freight service for the area. This railway and connecting lines at Petersburg, Norfolk and Richmond offer nationwide freight and passenger services.

LICENSED PUBLIC AIRPORTS

There are no licensed airports in Surry County but in adjacent Sussex County not far from the county line there are two airfields suitable for business and pleasure flying. The Waverly Municipal Airport has two sod runways, one 4,400 feet and the other 2,000 feet long. The field is unattended. The Wakefield Municipal Airport (app. 3 miles from the Surry County line) has a paved runway, with markers, 4,000 feet long. The field is attended during the day and food and lodging are available nearby. Hopewell Airport, about 15 miles northwest of the county line, has three runways, one of which is hard surfaced and 2,418 feet in length. The two sod runways are 2,000 and 2,400 feet long, respectively.

The field is attended during the day, has hangars, unicom, and IFR approach. Fuel, surface transportation, repairs, charter service, flight instruction and snacks are available. Food and lodging are available nearby. The nearest airport offering commercial airline service is Richard E. Byrd International Airport near Richmond which is served by five airlines with direct flights to many points and world-wide connections. This field is about 50 miles from Surry County and it is a major airport offering many flights a day via commercial airlines. Charter flights, surface transportation, food, lodging, and many other services are available. Residents of the eastern end of the county are nearer either the Norfolk Municipal Airport in Norfolk or Patrick Henry Airport in Newport News, both very large airfields, which offer about the same facilities that are available at Byrd Airport.

SECTION X - UTILITIES

WATERWORKS SYSTEMS

A privately owned system supplies water to the town of Claremont. The water is pumped from three wells into a concrete reservoir thence to the distribution and storage system. The estimated capacity of the wells and pumps is 100,000 gallons per day and the water production is estimated as 50,000 gallons per day.

At Surry a privately owned system obtains water from two wells, one equipped with a 50 gallon per minute pump, the other a 10 gallon per minute pump which deliver the water to pressure tanks and the distribution system. The daily water usage is estimated as 30,000 gallons and hardness of the water is 0.5 grains per gallon.

The town of Dendron has a water supply system under consideration.

There are four privately owned water systems in the county which supply well water to subdivisions or summer cottages. Another supply is under consideration.

SEWERAGE SYSTEMS

Two schools provide secondary treatment for their sewage. There are no other sewerage systems in the County.

Source: Virginia Department of Health.

WATER AND SEWERAGE RATES

Water Rates

Claremont - Flat monthly charge of $2.00 for all users.

Surry - Monthly rates are $2.00 for the first 4,000 gallons and 50¢ per 1,000 gallons for all additional.

SEWER RATES

Neither Claremont or Surry have sewerage systems.

ELECTRICITY

The towns and communities of Surry County are supplied with electricity by the Virginia Electric and Power Company, which has its main offices in Richmond. This is the state's largest electric system. The greatest part of the county receives its power from the Prince George Electric Cooperative, which has offices in Waverly and receives its power from Virginia Electric and Power Company.

Under construction, now, at Hog Island in Surry County is a $349 million nuclear power plant. Virginia Electric and Power Company plans to have this plant in operation by 1972. There will be two nuclear powered reactors to supply the power to electric generators, which will supply approximately 1,600,000 kilowatts of electricity. The station will serve about 400,000 families in an area of about 32,000 square miles. This area involves not only Virginia, but, also, northeastern North Carolina and eastern West Virginia. The power plant has an information center, which is open daily Monday-Sunday and gives interesting information not only about the power plant, but, also, about the history of electricity.

NATURAL GAS

An 8-inch pipeline of the Commonwealth Natural Gas Corporation crosses the eastern edge of Surry County to York County to supply the pipelines of the Virginia Electric and Power Company there. Commonwealth Natural Gas Corporation's twelve-inch transmission pipelines pass through Sussex County just south of the Surry County line and cross the southern corner of Surry County not far from Dendron. The county itself has no natural gas service at this time.

SECTION XI - EDUCATION

Public Schools

Table 23.--Selected Public School Information

Item	Surry County	Virginia
Number of children in 1970, Ages 7-19	1,623	1,192,883
Enrollment, 1969-70[a/]	1,311	1,128,921
Gross average daily attendance, 1969-70[b/]	1,126	1,002,961
Cost of operation per pupil in gross average daily attendance, 1969-70[c/]	$ 536	$ 644
Pupil-teacher ratio, 1969-70[d/]	23.2	22.5
Average annual teacher salary, 1969-70[e/]	$6,553	$8,070
High school enrollment, 1969-70[f/]	397	398,349
High school graduates, 1969-70	45	56,006
High school dropouts, 1969-70[g/]	17	17,872
Percent of high school graduates going to college, 1970	24.0	59.0
Percent of high school graduates continuing education in other than college, 1970	16.0	10.0

a/ Total number of pupils admitted to the school system; state figure adjusted to exclude double counting for transfers from one school system to another.

b/ Average daily attendance (ADA) of all schools in the county, plus ADA of pupils for whom the area pays tuition, minus ADA of pupils for whom tuition is received.

c/ Debt service and capital outlay excluded. The state figure is a weighted mean.

d/ Average number of day school pupils per classroom teaching position.

e/ Classroom teaching position (excludes supervisors, principals and head teachers).

f/ State figure adjusted to exclude double counting for transfers from one school system to another.

g/ Pupils who drop out during the school term; summer dropouts are not included.

Sources: State Board of Education, Superintendent of Public Instruction, Annual Report, 1969-1970, (Richmond: State Board of Education, December, 1970); State Department of Education, Division of Educational Research and Statistics, Virginia High School Dropouts, 1969-1970, (Richmond: State Department of Education, October, 1970); State Department of Education, Facing Up: Statistical Data on Virginia's Public Schools, No. 5, (Richmond: State Department of Education, January, 1971); U. S. Bureau of the Census, 1970 Census of Population, PC(V2)-48, General Population Characteristics, Virginia, (Washington: Government Printing Office, February, 1971).

PRIVATE SCHOOLS

Surry County has two private schools in the county. Surry Academy offers both primary and secondary classes and has an enrollment of about 250. In the town of Claremont is Claremont Academy, which is a Catholic school going up to the ninth grade at the present time. This school is in one of the historical old houses in the county, Claremont Manor.

VOCATIONAL-TECHNICAL SCHOOLS

There are no vocational-technical schools in Surry County, but facilities are available in the nearby cities and counties. In the nearby city of Petersburg there are apprenticeship classes offered in the city's high schools. These classes are open to Surry County residents. Surry also falls in the Chesterfield Area for community colleges and county residents can attend John Tyler Community College in Chester.

HIGHER EDUCATION

Although Surry County has no colleges in the county itself, there are several within a short distance of the county. The College of William and Mary, across the James River in Williamsburg, is the nearest college to Surry County. William and Mary is the second oldest college in the nation and the oldest in Virginia. If offers courses in arts and sciences, law and business administration. Tidewater Community College near Portsmouth is one of the many community colleges being developed in Virginia and it offers 2-year degrees in a number of fields. At Petersburg, less than 40 miles from the county, are Richard Bland College, a two-year college and Virginia State College, a four-year liberal arts college. John Tyler Community College in Chester offers associate (2-year) degrees in a number of areas, from engineering to nursing, or credits gained here may be transferred to a four-year institution of higher learning. The many colleges of Norfolk, Portsmouth and Richmond are also available to Surry county residents and are in easy driving distance of the county.

SECTION XII - RECREATION

The wide tidal portion of the James River forms the northern boundary of Surry County offering opportunities for water sports and recreation. There are several beaches in this area and two of them have boat launching ramps. Grays Creek near the town of Surry also has a boat launching ramp. Chippokes Plantation State Park will offer a number of opportunities for different types of recreation. Chippokes Plantation is now open to the public and there is a large recreational area now under construction that will offer boating, swimming, camping and other outdoor activities.

Fishing is good in the county and a number of fishing areas have been stocked with different species of fish. Sunken Meadow Pond near Claremont has been stocked with largemouth bass, crappie, bream and pickeral. There are boats available here. Grays Creek and the Blackwater River have been stocked with largemouth bass and bream and Chippoke Creek with these species and with crappie.

Surry County is a rural area and this being the case most of the county's recreational activities are sponsored by its schools, churches, 4-H Clubs or civic organizations. The county has a number of old homes, some open to the public, and is, also, just across the James River from Jamestown Island, site of the first permanent English settlement in America.

Surry County residents are also near Hopewell, Petersburg, Richmond, Hampton, Newport News, Norfolk and Portsmouth and can enjoy the opportunities for entertainment offered by these cities.

SECTION XIII - OTHER COMMUNITY FACILITIES

FINANCIAL

Table 24.--Bank Deposits for Banks Within Surry County, June 30, 1971

Bank	Location	Total Deposits
The Bank of Surry, Inc.	Town of Surry	$4,724,992

a/ Includes deposits of branches not physically located in the county.

Sources: R. L. Polk and Co., Polk's World Bank Directory, (Nashville, Tennessee, R. L. Polk and Company, March, 1970); State Corporation Commission.

Table 24.--Federal Deposit Insurance Corporation Listings for Total Accounts and Deposits, June 30, 1970 a/

	Surry County
Total number of accounts....................	3,003
Deposits:	
Total..................................	$4,113
Per capita b/..............................	$ 70

a/ Only deposits and accounts of banks and branches physically located in the county are shown.

b/ Population figure used in determining per capita deposits is the 1970 Census of Population figure.

Source: Federal Deposit Insurance Corporation, Summary of Accounts and Deposits in All Commercial Banks, Richmond Region, June 30, 1970, (Washington: Federal Deposit Insurance Corporation, 1971); U. S. Bureau of the Census, 1970 Census of Population, PC(V1)-48, Final Population Counts, Virginia, (Washington: Government Printing Office, December, 1970).

RELIGIOUS

There are about 17 churches representing several Protestant denominations in Surry County. Catholic services are held in Claremont. The nearest Catholic Church is in Hopewell and the nearest Jewish synagogue is in Petersburg. Most of the churches maintain Sunday schools, youth programs and other activities that make a valuable contribution to community life.

MEDICAL

There are no hospitals in Surry County, but there are a number of excellent facilities in the surrounding counties, which are available to Surry residents. The John Randolph Hospital in Hopewell is a very short distance from the county. Norfolk General Hospital in Norfolk, Petersburg General Hospital in Petersburg, Louise Obici Memorial Hospital in Suffolk, Portsmouth General Hospital in Portsmouth and the excellent medical facilities of Newport News and Richmond are all within easy driving distance of Surry County. The county public health department is in the town of Surry and has a staff of nurses, sanitarians and a health director. The town of Surry, also, has a general practitioner and a drug store.

LIBRARIES

There are no libraries in Surry County, but there a number of facilities close to the county. The Walter Cecil Rawls Library and Museum is in neighboring Southampton County in Franklin City. The cities of Petersburg, Hopewell and Richmond all have good library facilities. Norfolk, Portsmouth and Newport News, also, offer good facilities.

SECTION XIV - NATURAL RESOURCES

MINERALS

Surry County is in the Coastal Plain province and is underlain primarily by sand, gravel, clay, and marl strata. No commercial rock or mineral production was reported in the county during 1969.

In the past, sand and gravel have been produced at several localities for building purposes and for use in highway construction and maintenance. Calcareous marl occurs in the county and was formerly produced at sites near Claremont and marketed for agricultural use. Clay materials at selected localities in the county have been tested and found potentially suitable for use in the manufacture of face brick, flue tile and garden pottery products.

Source: Virginia Division of Mineral Resources.

GROUND WATER

Surry County is in the Coastal Plain Province and is underlain by unconsolidated sediments consisting of sand, gravel, clay, marl and shell strata that dip and thicken to the east. These strata are underlain by bedrock that is present at a depth of approximately 600 feet near Laurel Spring in the west and 1,400 feet at Hog Island in the east.

Ground water occurs under both artesian and water-table conditions in the county. The artesian aquifers are by far the most important and occur in two principal zones. The upper artesian aquifer is composed of shell, marl and thin-sand strata and is encountered at depths between 50 and 300 feet in the west and 80 and 400 feet in the east. Yields of up to 100 gallons per minute are usually possible from this aquifer. Higher yields have been recorded along the James River where several wells have had natural flows. A 420 feet deep well owned by VEPCO at Hog Island had an initial yield of 200 gallons per minute.

The lower artesian aquifer consists mainly of coarse sands and gravels and extends to bedrock from a depth of about 300 feet in the west and about 400 feet in the east. There has been very little development of this aquifer in the county, although the potential should be excellent. An 800 foot deep well at Bacon's Castle was formerly test pumped at a rate of 940 gallons per minute and wells have produced over a thousand gallons per minute from this aquifer elsewhere in the Coastal Plain. It is likely that sustained yields of up to 500 gallons per minute could be produced in most places from this aquifer.

The county probably has some of the best potential for future development of ground water in the state. The artesian head has not been lowered appreciably in this area due to heavy pumping as has been the case in other parts of the Coastal Plain. It is estimated that four wells per square mile with yields of about 500 gallons per minute could be developed in the aretsian aquifers without creating adverse effects on existing wells. This would mean a total production of almost three million gallons of water per day per square mile if the wells are pumped continuously. Careful attention would have to be given to well spacing to insure optimum production.

In the artesian aquifers total hardness decreases from 200 mg/1 (milligrams per liter) in the west to less than 100 mg/1 in the eastern part of the county. The flouride content in the eastern part may require treatment and the iron content of water from the upper aquifer in the west may be high. Water used in boilers may need treatment for sodium carbonate. The chloride content is low but there is a danger of saline water encroachment if heavy pumping occurs in the northeast portion of the county.

Domestic supplies of water are usually obtained from wells 15 to 80 feet deep in the sand and gravel deposits in the water table zone. The water is moderately hard, usually contains excessive quantities of of iron, and is often acidic. The presence of nitrates in the water indicates the possibility of surface contamination. Springs yield low to moderate supplies of hard calcium bicarbonate water and are seldom used except for stock purposes.

Source: Virginia Division of Water Resources. (More detailed information may be obtained upon request.)

SURFACE WATER

The James River forms the northern boundary of Surry County. This is a major stream and contains a large supply of water; however, the James River is affected by the tide and the salinity of the water is quite high. There are a few small creeks in the northern part of the county which feed into the James River. The central and the southern part of the county is in the watershed of Blackwater River. A gaging station has been maintained for a number of years on the Blackwater River near Dendron and the average stream flow is 187 million gallons a day. Records at this point indicate a good flow except during droughts when the flow gets very low. Flow duration and high-and low-flow sequence data are available for the gage on Blackwater River near Dendron. Records of temperature and water quality data are available for this gage.

There are a few millponds which might furnish water supplies, especially if these ponds could be augmented. In general, reservoirs would be needed in order to furnish dependable sources of water during dry periods.

Source: Virginia Division of Water Resources. (More detailed information may be obtained upon request.)

FORESTS

According to the 1966 Forest Survey, Surry County contains approximately 135,687 acres of commercial forest land. This is an increase of 800 acres of forest land since 1957.

The ownership of commercial forest land in Surry County is all in private holdings but 1,100 acres.

In 1969 hardwood sawtimber was being cut slightly faster than it was growing. Other species groups in sawtimber sizes were growing faster than they were being cut. When considering total growing stock all species groups were growing faster than they were being cut. A gradual build up in volume of growing stock has taken place during the past 10 years. Much of the area cut for sawtimber during the past 10 years has reseeded and now is in the seedling and sapling size class with an increase in total acreage of this size class and a corresponding decrease in the acreage of sawtimber size timber.

Forest product markets are excellent in this county. Growth for this county is above average. The major forest management needs are for continued thinnings in pole size stands and release of desirable seedlings in the seedling and sapling stands.

Source: 1966 Forest Survey. Virginia Division of Forestry.

Table 26.--Selected Forestry Information

Forest Types	1966 Acres
Lobolly pine	49,215
Shortleaf pine	3,190
Virginia pine	2,850
Oak-pine	26,333
Oak-hickory	36,665
Oak-gum-cypress	17,434
Total	135,687

Stand Size Classes	1966 Acres
Sawtimber	70,596
Pole size timber	36,973
Seedlings and saplings	28,118
Total	135,687

Inventory, 1969

Species Groups	Sawtimber[a/] (million board feet)	Growing Stock[b/] (thousand cords)
Softwoods	340.0	1,348
Soft hardwoods	119.3	563
Hard hardwoods	137.0	718
Total	596.3	2,629

Estimated Current Annual Net Growth and Cut, 1969

Species Groups	Sawtimber (million board feet) Growth	Sawtimber (million board feet) Cut	Growing Stock (thousand cords) Growth	Growing Stock (thousand cords) Cut
Softwoods	14.9	7.7	56	41
Soft hardwoods	4.5	3.9	20	16
Hard hardwoods	5.5	5.9	28	23
Total	24.9	17.5	104	80

a/ Softwoods 9" DBH and over; hardwoods 11" DBH and over. DBH refers to diameter at breast height. The stem diameter is measured in inches and covers the outside bark measured at 4½ feet above the ground.

b/ Growing stock, all merchantable trees 5" or over DHB.

Source: Department of Conservation and Economic Development, Division of Forestry.

APPENDIX E

HYDROLOGY OF THE JAMES RIVER ESTUARY WITH EMPHASIS UPON THE TEN-MILE SEGMENT CENTERED ON HOG POINT, VIRGINIA

Hydrology of the James River Estuary with Emphasis upon the Ten-Mile Segment Centered on Hog Point, Virginia

A Report Prepared for
Virginia Electric and Power Company
Richmond, Virginia
As Supporting Material for
The Preliminary Safety Analysis Report
Surry Nuclear Power Station

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General Hydrology, James River Estuary

The Surry Nuclear Power Station site is located on the James River approximately 30 miles above the river mouth at Old Point Comfort and 55 miles below Richmond, Virginia. This 85-mile stretch of the river is subjected to tidal motion, and hence is a tidal estuary. According to one classification system (1), that part of the tidal waterway between the mouth and the point of most upstream intrusion of measurable ocean salt is called the estuary proper, while the fresh water segment above that point up to the head of tide is called the tidal river.

Hog Point is the northernmost point of a peninsula formed by a large bend in the James River estuary, as shown in Figure 1. The Surry Nuclear Power Station site extends across the central portion of the peninsula, the river forming both the eastern and western boundaries of the site. The peninsula to the north of the site is a low lying area of tidal marshes, tidal channels, and islands which serve as a wild fowl refuge, and terminates at Hog Point.

The eastern boundary of the site, which borders the river along the downstream side of the peninsula, is approximately opposite Deep Water Shoals. The western boundary borders the river on the upstream side of the peninsula at the northeastern end of Cobham Bay. In the following frequent reference will be made to Deep Water Shoals, or downstream, side, and to Cobham Bay, or upstream, side of the site.

Hog Point is in the region of transition between the fresh tidal river and the estuary proper. Under conditions of very high river flow fresh water extends downstream of Deep Water Shoals. During periods of moderately high river flow, brackish water extends past Deep Water Shoals to the vicinity of Hog Point, while the Cobham Bay side of the site remains in the fresh water tidal river. Under flow conditions characteristic of most of the year the upper boundary of the estuary proper is located upstream from the Cobham Bay side of the site. The distribution of salinity in the estuary under various regimes of river flow will be discussed in a later section of this report.

Under all but the most extreme river flow conditions, the oscillatory ebb and flood of the tide constitute the dominant motion in both estuary proper and the tidal river. The net downstream flow required to discharge the fresh water seaward through any cross section represents but a small fraction of the tidal flows.

The James River estuary has been classified in the literature as a partially mixed estuary (2, 3). In such an estuary the salinity decreases in a more or less regular manner from the mouth toward the head. The salinity also increases with depth at any location. There usually occurs a layer near mid-depth in which the salinity increases more rapidly with depth than is the case in the overlying fresher layer or in the deeper, more saline layer. However, this layer of maximum vertical salinity gradient does not constitute a sharp interface as is the case in the classical salt-wedge estuary.

The upper, less saline, layer has a net non-tidal motion directed toward the mouth of the estuary, while the lower, more saline, layer has a net non-tidal motion directed toward the head of the estuary. The boundary between these layers is generally sloped across the estuary so that the seaward moving surface layer extends to greater depths on the right side of the estuary (looking seaward) than on the left. Under some conditions, particularly in the wider sections of the estuary, the boundary between the counter-flowing layers intercepts the surface, so that there is a net seaward flow surface to bottom on the right side of the estuary (looking seaward) and a net flow toward the head of the estuary on the left side of the estuary.

This net non-tidal circulation pattern involves flow volumes large compared to the river discharge, but still small compared to the oscillatory tidal flow. For example, measurements made in July 1950, at a time when the fresh water discharge at Hog Point was approximately 6000 cfs, showed a net non-tidal, seaward directed flow in the surface layers at Deep Water Shoals of 18,000 cfs, and a counter-flow in the deeper layers of approximately 12,000 cfs (note that the difference in non-tidal flow of the surface and deep layers must equal the river discharge). By comparison, the average volume rate of up-river directed flow during the flood-tide period, and of seaward directed flow during the ebb-tide period amounted to some 130,000 cfs through the Deep Water Shoals section.

At the time of the above described flow measurements, the salinity at the surface at Deep Water Shoals was about 4.2‰, and at the bottom about 6.1‰. At a point farther down the estuary, where the surface and bottom salinities were, respectively, about 11.0‰ and 14.5‰, the net non-tidal seaward-directed flow in the surface layers was observed to be about 24,000 cfs, or some 4 times the fresh water river discharge. In general, the volume rate of flow of the net non-tidal circulation increases toward the mouth of the estuary.

As the river flow decreases, the salinity distribution moves up the estuary, so that at any location the salinity increases with decreasing river flow. Also, in general, the higher the salinity, the larger the ratio of the net non-tidal flow to the river flow. Thus, within the estuary proper, the water available for dilution of an introduced waste material at a given section does not decrease in direct proportion to the decrease in river flow.

James River Discharge at Hog Point

The farthest downstream gaging station on the main stem of the James River is located near Richmond, Virginia, just above the upstream limit of tidal influence. The drainage area above this gage amounts to 6757 square miles. Some flow is diverted around this gage for use as condenser cooling water and returned to the river below the gage. Daily records of this diversion have been maintained, so that the adjusted flow at the Richmond gage can be compiled.

Between the Richmond gage and Hog Point, an additional 2760 mi^2 drain into the James River. Gaging stations on tributary streams which enter the James in this stretch of the river provide flow data for 1638 mi^2, leaving 1122 mi^2 of ungaged drainage area. In order to determine the probable fresh water discharge at Hog Point, it has been assumed here that the observed discharge for the 1638 mi^2 of gaged tributary flow below Richmond is representative of the runoff for the 1122 mi^2 of ungaged drainage area. Therefore the discharge at Hog Point has been computed by adding to the adjusted flow at Richmond the drainage from the combined gaged and ungaged area between Richmond and Hog Point computed from the following relationship:

$$(1) \qquad [\text{Discharge from the gaged area}] \times \frac{[\text{Total, gaged plus ungaged area}]}{[\text{gaged area}]}$$

In compiling the river discharge data monthly mean flows have been used, rather than daily mean flows. This choice was made for the following reasons. In the fifty miles or so of tidal river below Richmond the cross-sectional area of the waterway increases significantly compared to the stream above Richmond, and there is a somewhat irregular but significant increase in cross-sectional area with distance downstream. The mean travel time for a flow of 14,000 cfs (a flow which is exceeded only 25% of the time) from Richmond to Hog Point exceeds 20 days. Therefore it is probable that short period fluctuations in discharge at Richmond are considerably smoothed at Hog Point. Further, within the estuary proper there is considerable inertia in the response of the salinity pattern and the net non-tidal circulation to rapid variations in river discharge.

Table I lists the gaging stations used to determine the mean monthly flows for Hog Point. Estimates of the flow in Kanawha Canal, which diverts an average of 875 cfs around the Richmond gage on the James River, were used to adjust the gaged discharge for the period October 1934 to September 1935, when direct measurements of the diversion were not made. In estimating the additional runoff for the 2760 square miles of drainage area between the Richmond gage and Hog Point, discharge from the gages on the Appomattox near Petersburg, the Chickahominy near Providence Forge, and Falling Creek near

Dreury's Bluff were combined and used in equation (1) for the period September 1942 through September 1956, and August 1957 through June 1964 when data from all three gages were available. The total gaged area covered by these three gages is 1638 mi^2. During the periods January through August 1942, October 1956 through July 1957, and July 1964 through September 1965, data were not available for the Falling Creek gage, leaving a gaged drainage area of 1584 mi^2. Between October 1934 and August 1942 discharge data from only the Appomattox River gage were available, thus providing a gaged drainage area for that period of 1335 mi^2.

Table II gives the monthly mean discharge of the James River at Hog Point for the water years 1935 through 1965 (i.e., from October 1934 through September 1965). The following statistics are derived from these 372 monthly mean discharges.

Minimum monthly mean discharge.	857 cfs
90% of monthly mean discharges greater than	2,660 cfs
75% of monthly mean discharges greater than	4,370 cfs
Median monthly mean discharge	7,860 cfs
Mean monthly mean discharge	9,952 cfs
25% of monthly mean discharges greater than	14,366 cfs
10% of monthly mean discharges greater than	20,225 cfs
Maximum monthly mean discharge.	39,778 cfs

For comparison, for the period 1935 through 1965, the estimated minimum daily discharge at Hog Point is 680 cfs, and the maximum instantaneous discharge is estimated to be 175,000 cfs. Further discussion of high discharges is given under the section on Floods.

Tidal Characteristics of Waterway

The astronomical tide along the Atlantic coastline of the United States is predominantly a semi-diurnal tide, with two high waters and two low waters each lunar day (24.84 hrs). There are differences between each of two high waters and between each of the two low waters each day, but the differences are not sufficient to classify the tide as a mixed tide. This periodic rise and fall of water surface elevation at the entrance to the Chesapeake Bay proceeds up the Bay and its tributaries as a progressive wave. This wave is attenuated as it proceeds, and is also reflected from the head of tide in the Bay and the tributaries, and also from prominences along the length of the Bay and tributaries. A progressive wave which proceeds up a closed channel without energy loss, and is fully reflected, would produce a standing wave in the waterway. Because of the attenuation of tidal energy along the estuary, the combination of the incoming progressive wave with the complex reflected wave has characteristics intermediate between those of a progressive wave and those of a standing wave.

In a progressive tidal wave maximum flood current occurs at the same time as high water, while in a standing wave maximum flood current precedes high water by approximately 3 hours. At Hog Point in the James River maximum flood current precedes high water by about 50 minutes. Thus the tide has characteristics intermediate between a progressive and a standing wave, but slightly more like a progressive wave.

The datum plane for Coast and Geodetic Charts of the James River estuary is mean low water. On this datum, mean tide level at Hog Point is +1.0 foot, mean tidal range is 2.1 feet, and mean spring tide range is 2.5 feet.

The U. S. Coast and Geodetic Tidal Current Tables show that off Hog Point the ebb current is longer and stronger than the flood current. The average maximum ebb current is 1.3 knots (2.2 ft. sec^{-1}) and the average maximum flood current is 1.1 knots (1.9 ft. sec^{-1}). During spring tides the ebb currents reach a maximum of 1.9 knots (3.2 ft. sec^{-1}) and the flood currents a maximum of 1.6 knots (2.8 ft. sec^{-1}). During the typical tidal period of 12 hours 25 minutes, the current, on the average, will ebb for 7 hours and 5 minutes, and flood for 5 hours and 20 minutes. It should be pointed out that the data used to compile the USC+GS tables are based on near surface observations, and correspond to approximately mean river discharge. The predominance of ebb flow over flood flow will decrease with decreasing river discharge. Also, particularly when the boundary between the estuary proper and the tidal river is upstream of Hog Point (that is, when measurable concentrations of ocean salinity extend upstream from Hog Point), the strength and duration of the ebb directed flow decreases with increasing depth, while the strength and duration of the flood directed flow increases with depth. Thus in the deep waters of the channel the flood current will frequently be stronger and of longer duration than the ebb current.

Probability of Flooding of the James River in the Vicinity of Hog Point

Data on the magnitude and frequency of exceptionally high discharges (floods) of the James River at Richmond, and of several tributary streams which enter the James between Richmond and Hog Point, have been analyzed in order to determine the probability of flooding in the vicinity of Hog Point resulting from high river discharges. The estimate of the magnitude and frequency of flood flows at Hog Point is not amenable to a simple, straightforward procedure. Maximum discharges of the main stem at Richmond seldom occur simultaneously with maximum inflow from the downstream tributaries. Also, as pointed out previously, the relatively large cross-section of the tidal river over much of the 55 miles between Richmond and Hog Point results in some smoothing of short term fluctuations in river discharge. Even at very high river flows the discharge at Hog Point will reflect an average of the discharge at the upstream gaging stations over a period of at least several days.

Several methods were employed, on a trial basis, to combine the data on the magnitude and frequency of floods on the James River at Richmond with data for the gaged tributaries downstream from Richmond, taking into account the smoothing features of the stretch of tidal river between Richmond and Hog Point. These trials led to the conclusion that the magnitude and frequency of flood discharges at Hog Point would not exceed those for the Richmond gage, and to a first approximation the statistics available for the James River at Richmond could be used for the James River at Hog Point. Even if no smoothing occurred in the tidal river, maximum discharges at Hog Point would not exceed those at Richmond by more than about 20%, and, as will be shown below, high river discharge is not likely to significantly increase in water level in the vicinity of Hog Point in any case.

The mean annual flood (that is, the flood with a probable recurrence interval of 2.33 yrs) for the James River at Richmond is 68,000 cfs. Based on the method outlined in the U. S. Geological Survey Water Supply Paper 1673, "Magnitude and Frequency of Floods in the United States", the following statistics have been derived for the James River at Hog Point.

Recurrence Interval (years)	Ratio of Discharge to Mean Annual Flood	Discharge (cfs)
1.1	0.40	27,200
2	0.90	61,200
5	1.46	99.280
10	1.90	129,200
20	2.40	163,200
50	3.42	232,560

There are no *a priori* methods whereby the rise in water level associated with these maximum river discharges can be directly computed. However, some probable bounds on the effect these flows would have on the water at Hog Point can be made.

A comparison of these fresh water discharges with the volume rate of flow through the cross section at Hog Point associated with the normal ebb and flood of the tide provides one means of estimating the effects of high river discharge on water level. During each tidal cycle, approximately 190,000 cfs flow first upstream for approximately 6 hours and then downstream for approximately 6 hours. During spring tides this figure is increased to nearly 270,000 cfs averaged over each half tide. This oscillatory discharge through the section is associated with a periodic rise and fall of the water surface of 2.1 ft on the average, and 2.5 ft for spring tides. Of more significance, this flow during each half tidal cycle is associated with a longitudinal slope of the water surface along the estuary of less than 1×10^{-5} (i.e., 1 ft in 30 miles).

Another approach to the problem is to consider the slope required to maintain a steady discharge equal to, say, the flood which has a recurrence interval of once in 50 years, using the classical Chézy equation for open channel flow. Such a computation also gives a slope of about 1×10^{-5}. Since the mean level of the Chesapeake Bay outside the mouth of the James is unlikely to be effected by such discharges from the James, a discharge of some 230,000 cfs could be maintained if the mean water level at Hog Point stood 1 foot above the normal mean water level.

Any surge associated with the transient nature of such flood discharges would have the same wave characteristics as the tide, since both must travel as long waves in such a relatively shallow channel as the James. Consequently the maximum rise in water level which might be associated with a flood of the magnitude of 230,000 cfs would not exceed the tidal range of 2.5 feet, and would likely be closer to the minimum estimate of 1 foot above normal mean water level.

Of considerably greater consequence with respect to water level are meteorological tides caused by a combination of wind and atmospheric pressure differences. The phenomena sometimes called storm surges fall in this category of meteorological tides. Storm surges caused by hurricanes have caused the largest increase in water level along coasts and within estuaries.

No long term records have been located which give adequate statistics on the probable influence of meteorological tides in the vicinity of Hog Point on the James River. However, on the basis of other tributaries to the Chesapeake Bay, meteorological tides of up to 6 feet might be expected to occur at a frequency of once every two to three years, and an extreme meteorological tide of +12 feet above mean low water must be considered as possible at this location, with a recurrence interval of perhaps 50 years.

<u>Salinity Distribution, James River Estuary in the Vicinity of Hog Point</u>

Since 1942 some 3150 salinity measurements have been made in the ten-mile stretch of the James River centered on Hog Point by personnel of the Virginia Institute of Marine Science (formerly the Virginia Fisheries Laboratory) and of the Chesapeake Bay Institute of The Johns Hopkins University. These data are recorded on punch cards at the Virginia Institute of Marine

Science and on punch cards and magnetic tape at The Johns Hopkins University.

As pointed out in the section on the general feature of the hydrology of the James River estuary, Hog Point is located in the transition region between the tidal river and the estuary proper. The area upstream and downstream of Hog Point is subject to a wide range of salt concentration, dependent primarily on river discharge. The "fresh" water of the tidal river has a dissolved solids concentration of about 100 ppm (0.10 ‰). This salinity is readily distinguished from that resulting from the intrusion of ocean derived salts, since the ratios of the major ions are very different in the river as compared to the ocean. The river salts are quite low in chloride ion, which is less than 10% of the total dissolved solids in the fresh water segment of the James River. Chloride ion constitutes over 50% of the dissolved solids in sea water. Thus, when the chloride ion exceeds 0.05‰, the "salinity" is about 0.1‰ or greater, and the dissolved solids result primarily from an admixture of ocean water with the river water, even though the river water would in this case constitute over 99% of the mixture. For the purposes of this discussion, a salinity of 0.1‰ will be taken as a measure of the upstream limit of sea salt intrusion.

At median river flows (about 7500 to 8000 cfs discharge) the upstream limit of measurable ocean salt concentrations is located at about Swann Point just upstream from Jamestown Island. The salinity off the upstream, or Cobham Bay, side of the power plant site at this flow range is about 0.5‰ (parts per thousand); off Hog Point about 2‰, and off the downstream, or Deep Water Shoal, side of the power plant site about 3.5‰.

At a river discharge of 10,000 cfs, the area from Hog Point upstream is in the fresh water tidal river. The salinity in the vicinity of Deep Water Shoals for this flow is about 1‰.

The boundary between the fresh water tidal river and the estuary proper moves downstream of Deep Water Shoals for river discharges of 14,000 cfs and greater.

Referring to the data on river discharge, it is seen that salinities exceeding 0.1‰ occur off the downstream side of the power plant site approximately 75% of the time, while the upper limit of ocean salt intrusion extends above the upstream side of the power plant site something over 50% of the time.

High river discharge for the most part occurs during the colder months. During the late spring, summer and early fall months, both sides of the power plant site will be seaward of the upstream limit of sea salt intrusion. During the low flow periods of late summer and early fall, salinities in the vicinity of Hog Point can attain relatively high values. Thus in September of 1965, after several months of discharge less than 2000 cfs, the salinity at the surface off the downstream side of the power plant site was observed to be 13.5‰; off Hog Point 10.0‰; and off the upstream side of the power plant site 6.9‰.

The salinity generally increases with depth, being from 1 to 4‰ greater on the bottom in the channel than on the surface. Thus, the observations discussed above for September 1965 showed salinities at a depth of 24 feet off the Deep Water Shoals side of the power plant site of 14.6‰; off Hog Point at 8 feet in depth a salinity of 10.6‰ was observed; and at the same depth off the upstream side of the power plant site a salinity of 8.7‰ was found.

These are not the highest salinities which have been observed at these sites. Listed below are the observed ranges in salinity in the vicinity of the power plant site. Note that a salinity of 0.0 means no measurable sea derived salt.

Observed Salinity Range

Off the downstream side of the power plant site:	Surface -	0.0 to 16.95‰
	at 25 feet -	0.0 to 21.13‰
Off Hog Point:	Surface -	0.0 to 12.20‰
	at 20 feet -	0.0 to 14.20‰
Off the upstream side of the power plant site:	Surface -	0.0 to 9.19‰
	at 20 feet -	0.0 to 11.16‰

For comparison, the ocean salinity off the mouth of the Chesapeake Bay is approximately 33‰. The bottom salinity off the downstream side of the power plant site thus has, under prolonged low flow conditions, attained values nearly two-thirds that of the ocean water source.

Temperature Distribution, James River Estuary

Some 3000 water temperature measurements have been made in the ten-mile stretch of the James River centered on Hog Point since 1942 by personnel of the Virginia Institute of Marine Science (formerly the Virginia Fisheries Laboratory) and of the Chesapeake Bay Institute, The Johns Hopkins University. These data are recorded on punch cards at the Virginia Institute of Marine Science and on punch cards and magnetic tape at The Johns Hopkins University.

Surface water temperature in the James River estuary in the vicinity of the power plant site closely follows the mean daily air temperature, except for a slight lag during the spring period of rapid heating and the fall period of rapid cooling.

The maximum surface water temperature which has been observed in this area of the James River estuary is 33.8°C (92.8°F) and the minimum observed temperature 1.8°C (35.2°F). Since the observations are strongly biased toward the warm season, somewhat lower winter temperatures than the probable 1.8°C occasionally occur. The majority of summer surface water temperatures fall in the range 26°C to 28°C (78.8°F to 82.4°F), but temperatures exceeding 30°C (86°F) are not uncommon.

Water temperature in the estuary decreases with depth during spring and summer. The vertical gradient is largest during the spring period of rapid heating, about 4°C over 20 feet of water depth. In summer the temperature decrease over the same depth interval is 1°C to 2°C. During the fall period of cooling water temperatures are usually uniform with depth, while in winter there is frequently a slight increase in temperature with depth.

Movement, Mixing and Diffusion of Introduced Waste Products in the James River Estuary

The processes of movement, mixing and diffusion of an introduced substance or property (i.e., excess heat) will differ somewhat in the fresh water tidal river segment of the waterway as compared to the estuary proper. At sufficiently high river discharges (i.e., in excess of about 10,000 cfs) discharges from the upstream side of the power plant site would be made into the fresh water tidal river. The introduced material will be initially advected away from the source by the oscillatory motion of the tide, moving upstream on the flood tide and downstream on the ebb tide. The upstream length of the flood excursion is about 4 miles, and the downstream length of the ebb excursion is about 6 miles. Thus on each tidal cycle there is a net seaward movement of the introduced material. The rate of this seaward movement will in a specific case depend upon the river discharge.

The tidal velocities at peak of ebb and flood flow are on the order of 2 ft. sec^{-1}. Such flows in a waterway such as the James River estuary produce significant turbulent fluctuations which in turn provide for rapid turbulent mixing and diffusion of an introduced substance. Vertical mixing in the fresh water of the tidal river is very rapid, since the density stratification is very weak. Horizontal dispersion is enhanced by vertical and lateral shear in the mean velocity field, and large scale eddies lead to a spread of any introduced material across the width of the waterway within a few tidal cycles after release of the material to the waterway.

Within the tidal river, maximum dilution of a continuously discharged material will be that provided by the volume rate of fresh water discharge through the section of the waterway.

Under river discharge conditions which occur about 60% of the time the upstream limit of measurable ocean derived salinity will occur above the power plant site. The fate of an introduced material will be modified, as compared to a discharge into the tidal river, both as a result of the vertical stratification associated with the vertical distribution of salinity, and as a result of the net non-tidal circulation pattern involving an augmented seaward flow of the upper layers and a contrary net non-tidal flow of the lower layers. Vertical mixing is in this case somewhat inhibited by the vertical stability. In addition to the movement associated with oscillatory motion of the tidal currents, material in the upper layers will be advected seaward, while material in the deeper layers will be advected up the estuary. The amount of water available for dilution of an introduced material in the surface layers will exceed, frequently by severalfold, the volume rate of river discharge past the section. Further, the upstream directed flow of the deeper layers will lead to a spread of an introduced material upstream to the upper limit of salt intrusion. As in the case of discharge to the tidal river, turbulent diffusion will be effective in dilution and spread of the introduced material, both vertically and horizontally.

Both empirical and theoretical studies of turbulent diffusion of an introduced contaminant in tidal waterways have been carried out by the Chesapeake Bay Institute of The Johns Hopkins University. A number of field studies involving both continuous and instantaneous discharges of tracer fluorescent dyes have been carried out in tidal estuaries of the Chesapeake Bay system. These field studies have been used to test theoretical relationships, particularly those developed by Okubo (4, 5, 6).

Work is now underway to select the diffusion experiments which have been completed in tidal waterways closely similar to the James River in the vicinity of Hog Point, for a direct estimate of the diffusion characteristics of the estuarine environment adjacent to the power plant site. Theoretical studies are also underway using the theoretical relationships which have proven most successful in matching the observed distribution from field studies.

Studies of the distribution of excess temperature from the condenser discharge have been made using the James River estuary hydraulic model at the U. S. Army Waterways Experiment Station, Vicksburg, Mississippi. The results of these tests, which are now being analyzed, will provide valuable information on the dispersion of a contaminant introduced with the condenser cooling water discharge.

The concentration of an introduced contaminant at a given point in the estuary or at a given time after discharge depends upon the manner of introduction (i. e., as a local, high concentration source or premised into a large volume discharge; as a continuous discharge or as a nearly instantaneous release), as well as on the inherent diffusion characteristics of the receiving waters. Therefore numerical statements respecting movement and diffusion of an introduced substance, as distinct from the qualitative description given above, can only be made for specific cases where the source term is adequately described.

The work now underway will treat the following specific cases: (i) the continuous discharge of very low level liquid wastes premixed into the condenser cooling water discharge; (ii) an accidental pulse release of activity into the condenser cooling water discharge; (iii) the distribution of activity in the estuary resulting from the washout of material accidentally released to the atmosphere.

Summary

The 85-mile stretch of the James River between Richmond, Virginia, and the mouth of the river at Old Point Comfort is subjected to tidal motion and is hence a tidal estuary. The Surray Nuclear Power Station site, located some 30 miles above the mouth of the estuary, is in the transition region between the fresh water tidal river and the saline waters of the estuary proper. At river discharges exceeding about 10,000 cfs the upstream limit of measurable ocean derived salt intrusion will be at or below Hog Point. Water adjacent to the power plant site will be fresh, but still subjected to the oscillatory tidal motion. For river discharges less than 10,000 cfs (a condition occurring approximately 60% of the time) the water adjacent to the power plant site will have varying concentrations of ocean derived salts, dependent on river discharge.

The oscillatory ebb and flood of the tide constitute the dominant motion in the waterway in the vicinity of the power plant site. The net downstream flow required to discharge the fresh water seaward through any cross-section represents but a small fraction of the tidal flows.

Within the estuary proper the salinity decreases in a more or less uniform manner from the mouth toward the head, and at any location also increases with depth. Superimposed upon the oscillatory tide there is a net non-tidal circulation in which the upper, less saline, layers move seaward, while the deeper, more saline, layers move up the estuary. The net non-tidal seaward directed flow is stronger and extends to greater depths on the right side of the estuary (looking downstream) than on the left. At times the boundary between these two counterflows becomes strongly sloped so that the

seaward flow extends to all depths on the right side of the estuary, and the flow directed up the estuary occurs from bottom to surface on the left side of the estuary.

The volume rate of flow associated with this net non-tidal circulation pattern, while small compared to the oscillatory tidal flows, is severalfold larger than the volume rate of river discharge. In general, the higher the salinity, the larger the ratio of the ratio of the volume rate of seaward flow in the surface layers to the river discharge. Consequently, since at any given section, the salinity increases with decreasing river discharge, the volume rate of flow associated with the net non-tidal circulation does not decrease directly as the river discharge.

The drainage area of the James River above Hog Point is 9517 square miles. The drainage area above the nearest gage on the main stem of the James River near Richmond, Virginia, is 6757 square miles. An additional 1638 mi^2 of drainage area on tributaries between Richmond and Hog Point is gaged, leaving 1122 mi^2 ungaged. Discharge records for the gaged tributaries below Richmond have been used to estimate the discharge for the ungaged area, and the monthly discharges for the James River at Richmond, and for the gaged and ungaged areas below Richmond, have been combined to provide estimates of the river discharge at Hog Point. Table II gives values for the monthly discharge, in cfs, for the period October 1934 to September 1965. The following statistics are derived from these 372 monthly values:

Minimum monthly mean discharge	857 cfs
90% of monthly mean discharges greater than	2660 cfs
75% of monthly mean discharges greater than	4370 cfs
Median monthly mean discharge	7860 cfs
Mean monthly mean discharge	9952 cfs
25% of monthly mean discharges greater than	14,366 cfs
10% of monthly mean discharges greater than	20,225 cfs
Maximum monthly mean discharge	39,778 cfs

TABLE I

Gaging Stations Used in Compiling James River
Discharge at Hog Point

Location	Drainage Area (mi^2)	Annual Mean Discharge (cfs)	Period of Record
Kanewha Canal near Richmond	Diversion around Richmond Gage	866 (29 yrs)	Sept. 1935 to present
James River near Richmond	6,757	7,351 (Adjusted) (31 yrs)	Oct. 1934 to present
Falling Creek near Dreury's Bluff	54	57 (20 yrs)	Sept. 1942 to July 1964
Appomattox River near Petersburg	1,335	1,165 (39yrs)	Oct. 1926 to present
Chickahominy River near Providence Forge	294	271 (23 yrs)	Jan. 1942 to present

TABLE II

Mean Monthly Discharge in cfs, James River at Hog Point,

For Water Years 1935 through 1965

(i.e., Oct. 1935 through Sept. 1965)

Note: Total Drainage Area is 9517 mi^2, of which 8395 mi^2 is gaged. Figures in this Table include estimates of the runoff for the 1122 mi^2 of ungaged Drainage Area.

Water Year \ Month	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Year (Aver.)
1935	5191	5011	20951	22488	14827	20490	32045	8304	7830	6402	5298	19092	13965
1936	3145	8324	10336	39778	25806	34620	20763	6702	4631	2849	3154	2157	13504
1937	5711	2765	9137	36185	19862	10693	27926	13040	6674	5289	9281	10836	13331
1938	24819	11887	8764	12364	9991	13118	9179	6437	15797	17190	12997	3581	12217
1939	2914	4934	9071	8997	26181	19751	10359	5953	4666	7200	9128	3005	9247
1940	3096	4911	3552	5544	18319	9215	18959	10018	16688	7203	34397	7616	11559
1941	3447	7722	7832	11332	6493	9135	22105	3919	3527	8708	1971	1258	6537
1942	857	1415	3828	4510	6329	9306	5227	13840	8358	3896	15167	4836	6501
1943	18256	7319	12771	14106	21118	17614	14073	11788	7860	6649	2073	1508	11221
1944	1436	2971	2659	6547	10068	25264	14366	9823	3221	2312	2972	18310	8053
1945	7251	4645	9886	13750	12804	12297	8909	10432	4178	10654	4616	12058	9280
1946	4294	5330	14988	19225	18498	13666	10892	19707	8209	6974	3846	2744	10676

TABLE 1. (continued)

Water Year \ Month	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Year (Aver.)
1947	2890	3455	4224	17046	6243	15376	13026	6250	5107	4614	2686	3883	7082
1948	4804	14363	6476	9311	21776	21299	25582	14626	7700	4667	12522	3051	12124
1949	7967	13880	34608	26306	19211	16643	17181	15402	8626	13777	9774	6254	15814
1950	4734	13681	8509	7858	17805	13292	7655	15239	8790	6295	3895	13268	10012
1951	5073	4843	17373	7512	17023	15945	21682	8258	13726	5190	3246	2419	10165
1952	1827	5862	14255	20225	19364	26030	18012	14376	4884	4090	5870	6439	11760
1953	2759	10568	8983	16907	17642	24795	14829	10005	5264	2842	1753	1618	9785
1954	1483	2203	5868	9705	7580	15852	10258	10487	4231	2631	1486	954	6066
1955	5197	6395	9880	8058	12374	25728	12307	5252	4733	3335	20886	4665	9996
1956	5551	3459	2867	2992	11632	10921	11667	4617	4176	3175	2259	2260	5432
1957	4270	8815	7461	7923	22606	16307	18739	6662	6310	2116	1591	5050	8872
1958	4659	8761	17261	16549	17213	20480	26168	20890	6557	4537	6597	2652	12675
1959	2897	2949	6019	9769	6379	8496	18616	6081	7729	4543	3874	2791	6665
1960	10816	9065	11290	10307	23161	17069	25301	14660	7471	2971	4371	6735	11870
1961	3169	3113	3700	5533	21475	16639	19391	14579	10072	4955	4776	4125	9194
1962	15220	7049	20882	19484	15443	32186	22042	9135	9339	6809	3624	2621	13677
1963	2552	8733	5498	13541	9076	31513	6740	4762	4410	1690	1139	1037	7567
1964	1133	2662	4340	14509	16992	15649	9580	5522	2179	2071	1421	1630	6437
1965	2834	3106	6777	11066	18268	18779	11588	6452	3123	2521	1482	1433	7223

The tide in the James River is a semi-diurnal tide, with two high waters and two low waters each lunar day of 24.84 hours. The datum plane for U. S. Coast and Geodetic Survey charts of the James River is mean low water. On this datum, mean tide level at Hog Point is +1.0 foot, mean tidal range is 2.1 feet, and mean spring tidal range is 2.5 feet.

The ebb current at the surface in the vicinity of Hog Point is of longer duration and is stronger than the flood current. The average maximum ebb current is 1.3 knots (2.2 $ft \cdot sec^{-1}$), and the average maximum flood current is 1.1 knots (1.9 $ft \cdot sec^{-1}$). During spring tides the ebb currents reach a maximum of 1.9 knots (3.2 $ft \cdot sec^{-1}$)and the flood currents a maximum of 1.6 knots (2.8 $ft \cdot sec^{-1}$). During the typical tidal period of 12 hours 25 minutes, the current, on the average, will ebb for 7 hours and 5 minutes, and flood for 5 hours and 20 minutes. The predominance of ebb flow over flood flow will decrease with decreasing river discharge, and also with depth. When measurable concentrations of ocean salinity extend upstream from Hog Point, the flood current will usually be stronger and of longer duration than the ebb current in the deeper layers of the channel.

Data on the magnitude and frequency of exceptionally high discharges(floods) of the James River at Richmond and of the several tributary streams which enter the James between Richmond and Hog Point have been analyzed in order to determine the probability of flooding in the vicinity of Hog Point resulting from such high river discharges. It is concluded that the mean annual flood (that is, the flood with a recurrence interval of 2.33 yrs) is 68,000 cfs. On the basis of this mean annual flood, the following statistics are derived for flood discharges at Hog Point:

Recurrence Interval (years)	Ratio of Discharge to Mean Annual Flood	Discharge (cfs)
1.1	0.40	27,200
2	0.90	61,200
5	1.46	99,280
10	1.90	129,200
20	2.40	163,200
50	3.42	232,560

An analysis of the probable rise in mean water level at Hog Point associated with these flood discharges indicates that even for the flood discharge having a recurrence interval of only once in 50 years, the water level at Hog Point would rise no more than 1 foot above normal mean water level.

Of considerably greater consequence with respect to water level are meteorological tides caused by a combination of wind and atmospheric pressure difference. It is estimated that meteorological tides of up to 6 feet might be expected to occur at a frequency of once every two to three years, and an extreme meteorological tide of +12 feet above mean low water level must be considered as possible at Hog Point with a recurrence interval of once in 50 years.

From the standpoint of the salinity distribution, Hog Point is located in a transition region. The area upstream and downstream from Hog Point is subject to wide range of salt concentration, dependent primarily on river discharge. At median river flows (about 7500 to 8000 cfs discharge) the upstream limit of measurable ocean salt concentrations is located at about Swann Point just upstream from Jamestown Island. The salinity off the upstream side of the plant site at this flow range is about 0.5‰ (parts per thousand), off Hog Point about 2‰, and at Deep Water Shoals about 3.5‰. At a river discharge of 10,000 cfs, the area upstream from Hog Point is in the fresh water tidal river, and the salinity in the vicinity of Deep Water Shoals is about 1‰. The boundary between the fresh water tidal river and the estuary proper moves downstream of Deep Water Shoals for river discharges of 14,000 cfs and greater.

Salinities exceeding 0.1‰ occur off the downstream side of the power plant site approximately 75% of the time, while the upper limit of ocean salt intrusion extends above the upstream side of the power plant site something over 50% of the time. During the low flow periods of late summer and early fall, salinities in the vicinity of Hog Point can attain relatively high values. Listed below are the observed ranges of salinity in the vicinity of the power plant site. Note that a salinity of 0.0‰ means no measurable sea derived salt.

Observed Salinity Range

Off the downstream side of the power plant site:	Surface -	0.0 to 16.95‰
	at 25 feet -	0.0 to 21.13‰
Off Hog Point:	Surface -	0.0 to 12.20‰
	at 20 feet -	0.0 to 14.20‰
Off the upstream side of the power plant site:	Surface -	0.0 to 9.19‰
	at 20 feet -	0.0 to 11.16‰

From these figures it is seen that the salinity in the deeper waters off the downstream side of the power plant site has, under conditions of prolonged low river discharge, attained values nearly two-thirds that of the ocean water source.

Surface water temperatures in the James River estuary in the vicinity of the power plant site closely follow the daily mean air temperature, except for a slight lag during the spring period of rapid heating and the fall period of rapid cooling.

The maximum surface water temperature which has been observed in this area of the James River estuary is 33.8°C (92.8°F) and the minimum observed temperature 1.8°C (35.2°F). The majority of summer surface water temperatures fall in the range 26°C to 28°C (78.8°F to 82.4°F), but temperatures exceeding 30°C (86°F) are not uncommon.

Water temperatures decrease with depth during spring (about 4°C decrease in 20 feet) and during summer (about 1° to 2°C decrease in 20 feet). During the fall period water temperatures are usually uniform with depth, while in winter there is frequently a slight increase with depth.

The processes of movement, mixing and diffusion of an introduced substance or property will differ somewhat under those river flow conditions such that the power plant site is in the fresh water tidal river as compared to conditions when the boundary of the estuary proper extends upstream from the power plant site.

In both cases the introduced material will be advected back and forth past the site by the oscillatory motion of the tide. Also, in both cases horizontal turbulent mixing will be effective in spreading any introduced material across the width of the estuary within a few tidal cycles after release to the waterway.

Within the tidal river vertical mixing will also be fairly rapid. During each tidal cycle, the introduced material will move upstream on the flood tide about 4 miles, and downstream about 6 miles, thus showing a net seaward advection which will in a specific case depend on the magnitude of the river discharge. Maximum dilution of a continuous discharged material will be that provided by the volume rate of fresh water discharge through the section of the waterway.

Within the estuary proper, the vertical stability associated with the vertical increase in salinity will inhibit the degree of vertical mixing somewhat. The net non-tidal circulation pattern will result in an augmented seaward advection of material in the upper layers and a net movement up the estuary of material in the deeper layers. The amount of water available for dilution of an introduced material in the surface layers will exceed, frequently by severalfold, the volume rate of river discharge past the section.

The concentration of an introduced contaminant at a given point in the estuary or at a given time after release to the waterway depends upon the manner of introduction as well as on the inherent diffusion characteristics of the receiving waters. Both empirical and theoretical studies of turbulent diffusion of an introduced contaminant in the tidal waterways of the Chesapeake Bay estuarine system have been carried out by the Chesapeake Bay Institute of The Johns Hopkins University. Work is now underway in which these studies are being used in the treatment of the following specific cases of discharge of a contaminant into the James River off the power plant site: (i) the continuous discharge of very low level liquid wastes premixed into the condenser cooling water discharge; (ii) an accidental pulse release of activity into the condenser cooling discharge; (iii) the distribution of activity in the estuary resulting from the washout of material accidentally released to the atmosphere.

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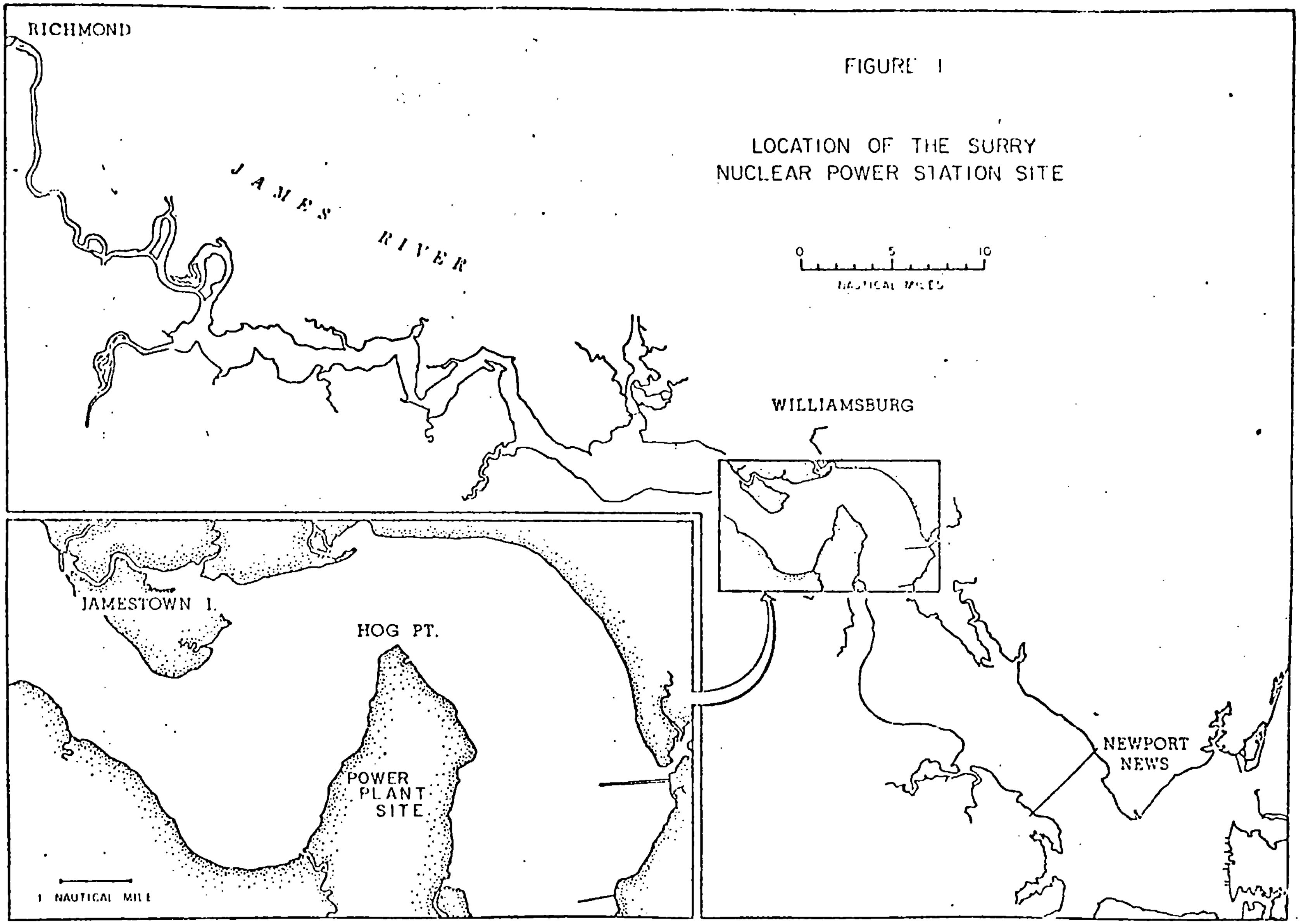
RICHMOND
FIGURE 1
LOCATION OF THE SURRY
NUCLEAR POWER STATION SITE
JAMES RIVER
0
5
10
NAUTICAL MILES
WILLIAMSBURG
JAMESTOWN I.
HOG PT.
POWER
PLANT
SITE
1 NAUTICAL MILE
NEWPORT
NEWS

APPENDIX F

SUMMARY OF RECENT, ONGOING AND FUTURE STUDIES

CONDUCTED IN THE

OLIGOHALINE SECTION OF THE JAMES RIVER ESTUARY

SUMMARY OF RECENT, ONGOING AND FUTURE STUDIES CONDUCTED IN THE OLIGOHALINE SECTION OF THE JAMES RIVER ESTUARY

Introduction

The following report has been prepared in an attempt to summarize the relevant environmental studies which: (1) have been recently completed; (2) are presently being conducted; and (3) are planned in the vicinity of the Surry Nuclear Power Plant. Many of the studies have only a few stations located in the vicinity of the Hog Island plant site, e.g. oyster studies which are limited to the rock at Deep Water Shoals, while others, e.g. benthic populations, are being sampled intensively in the area.

Table 1 shows the major studies conducted in the area and the years in which actual data were collected, along with an identification number. The references or projects corresponding to these identification numbers are tabulated in Table 2.

Surry Plant

In 1968 cooperative studies funded by VEPCO and VIMS were begun on the Hog Island plant site. These studies included both pre and post operational field programs and also laboratory studies on the possible effects of thermal shocks to both oyster and clam larvae.

The following is a brief summary of the biological research which is being done by VIMS under the cooperative program with VEPCO. In referring to sampling locations, the locations of the instrument towers are shown in Figure 1.

Phytoplankton

Collections are made monthly in the intake canal and at towers CBN and CBS. A one liter whole water sample is collected from mid-depth with a Kemmerer Bottle and preserved in modified Lugol's solution. Samples are being analyzed for species composition and abundance. Collections were begun in January of 1971 and will continue thru the post operational study phase.

Zooplankton

Collections have been made monthly since January 1971 in the intake canal and at towers CBN and CBS. A sample consists of 3 vertical tows with a 1/3 meter net of number 30 mesh. Samples are preserved in buffered formalin and are being analyzed for species composition. Collections will continue thru the post operational study period.

Fouling Plates

Fouling plates consist of 125 mm by 75 mm asbestos plates suspended 1 m above the bottom at towers DWS, CBN and CBS. There are two vertical and two horizontal plates at each station. One of each pair is left in place for a year to study succession and community development. The other plates are removed and replaced at bi-monthly intervals. These plates are frozen and later examined for species composition. These studies will continue thru the post operational study period.

Shrimp and Small Fish

Monthly samples are collected using a benthic sled with an opening of 1' by 2 1/2' and a 2 mm mesh bag. The sled is towed for 5 minutes in shallow and deep water (sand and mud bottoms) near the intake, in deep water (mud bottom) near the outfall, in deep water (mud bottom) near tower CBN and in shallow and deep water (sand and mud bottoms) in Cobham Bay. The location of the stations is shown in Figure 2. Organisms are removed from the net and preserved in buffered formalin. Collections have been made since January 1971 and will continue after the plant becomes operable.

Primary Productivity

Productivity measurements using a modified C^{14} procedure are being made at towers CBN, CBS and at the intake canal. Samples are taken from the upper 0.3 m of water and incubated shipboard for 4 hours. Samples are also analyzed for pH, alkalinity, salinity and temperature at the time of collection. The productivity studies were initiated in the spring of 1971 and will be continued at 6 week intervals throughout the field phase of the study.

Benthic Studies

Benthic grab samples have been taken in the spring, summer, fall and winter since June 1969. Two replicates are taken at each of 16 stations from Jamestown Island to Deep Water Shoals (Figure 3). Samples are collected with a 0.07 m^2 Van Veen grab, washed through a 1 mm screen and preserved in buffered formalin. In the lab, samples are sorted, organisms are identified to species and counted. Total biomass in each replicate is determined. This sampling has shown that the benthos is overwhelmingly dominated by the brackish water clam Rangia cuneata. Therefore, more detailed work with this species is being carried out.

Growth of Rangia cuneata

A study is underway on the effects of salinity and substrate on the growth of Rangia. Clams were collected in Cobham Bay, returned to the lab and weighed and length and width measured. Then a number was painted on each clam for later identification. These clams were planted in a sand and a mud bottom near the intake, outfall, tower CBN and the mouth of the Chickahominy River (Figure 4). The clams planted at each station were from 30 mm to 60 mm long, except near tower CBN where clams from 3 mm to 60 mm were planted. They will be left one year and growth determined. The clams were put out in July 1971.

Condition Index of Rangia Cuneata

Condition index compares clam tissues to their theoretical maximum size, that is, the volume of the shell cavity. In general it reflects stored energy over and above that required for the animal's maintenance and physiological activities. In this sense condition index may be considered to reflect the overall appearance of the environment to the organism. Condition index is determined monthly for 20 clams from 40 mm to 50 mm long, collected from the same locations as the growth studies (Figure 4). Collections have been made since July 1970.

Gonads and Set Collections

Rangia clams are being collected every two weeks at the intake, outfall, tower CBN and the mouth of the Chickahominy River (Figure 4). Twenty clams 30-40 mm long from each station are shucked and histological slides are made of their gonads. Temperature and salinity data are taken at the time of collection to correlate changes in environmental factors with initiation of gonad development and subsequent spawning. Approximately two years of data have been collected.

Set collectors are placed at the same locations as above and sampled every two weeks (Figure 4). Set collectors indicate when the swimming larvae settle to the bottom and take on the appearance of adults. This information will serve as a check on the gonadal studies and also indicate setting and recruitment patterns at the different stations. This study was started in the spring of 1970.

Laboratory Experiments

Rangia - Adult Rangia have been spawned in the laboratory and work on the developing embryos and larvae has been carried out. Embryos and straight hinge larvae have been placed in a factorial experiment to determine the best survival and growth at 16 different combinations of temperature and salinity. Another factorial experiment dealt with the effects of the expected thermal and salinity shocks from the power plant on survival and growth of embryos and larvae.

Crassostrea and Mulinia - The effects of thermal shocks of 5, 10, 15 and 20°C has been determined on larvae of the oyster, *Crassostrea virginica* and the clam, *Mulinia lateralis*. Oyster larvae were acclimated at 25 ± 1°C and at a salinity of 20 ± 2 °/00, while the clam larvae were acclimated at 20 ± 1°C and 20 ± 2 °/00 salinity. The larvae received a 5 second thermal shock and were then allowed 30 minutes to return to ambient. All larvae were maintained under controlled conditions and after the thermal shock were fed equal amounts of food, a pure *Monochrysis* algae culture. Control groups were run with each set of shocked larvae. The effects of the thermal shock were assessed in terms of growth, mortality and setting success.

RECENT AND ONGOING STUDIES IN THE OLIGOHALINE SECTION OF THE JAMES RIVER ESTUARY

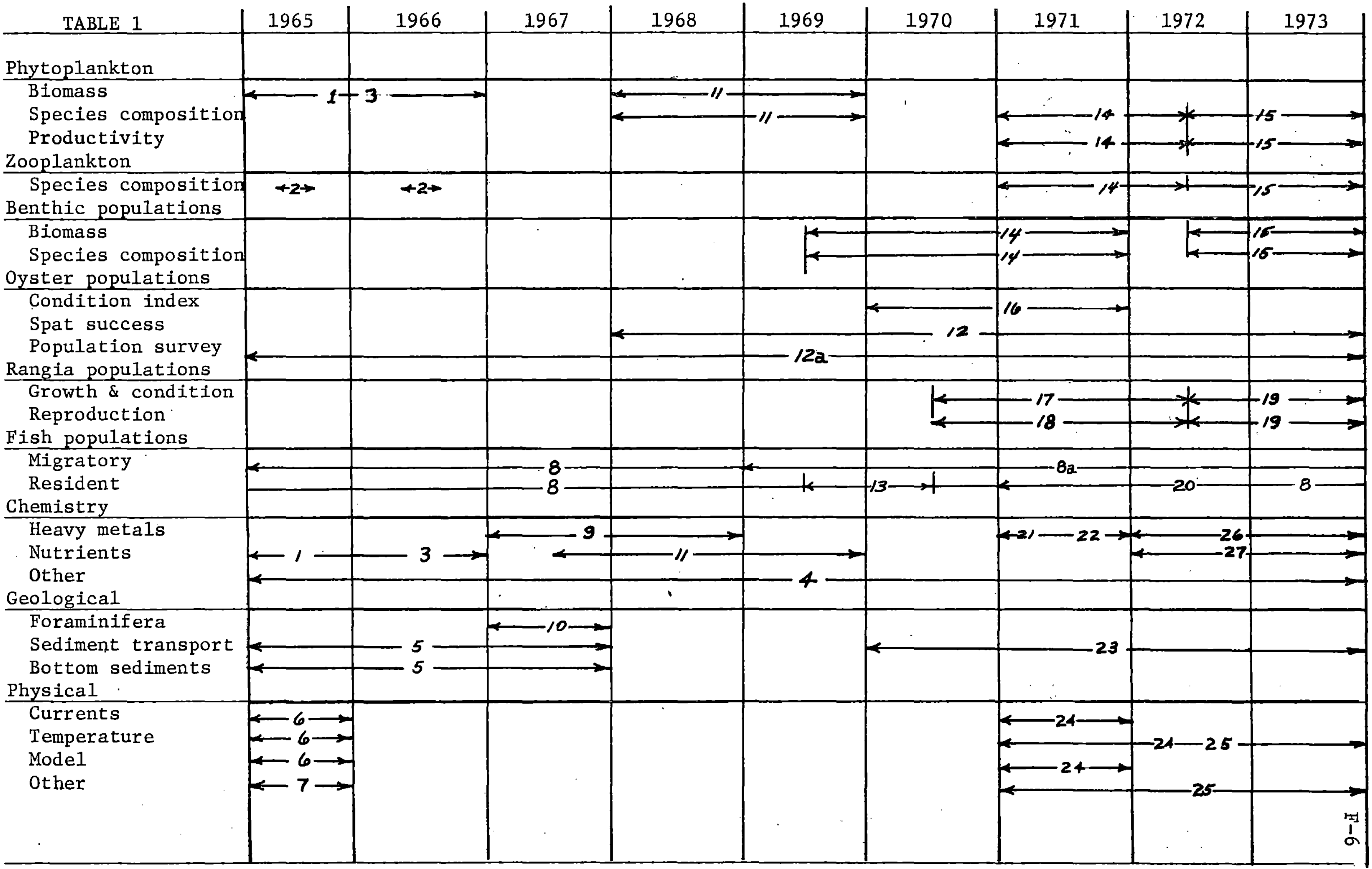

Table 2

1. Brehmer, M. L. and S. O. Haltiwnager, 1966. A biological and chemical study of the tidal James River. Final Contract Report (FWPCA-PH 86-65-86).

2. Calder, D. R. and V. G. Burrell, Jr. 1967. Occurrence of Moerisia lyonsi (Limnomedusae, Moerisiidae) in North America. Amer. Midl. Natur. 78: 540-541.

3. Brehmer, M. L. 1967. Nutrient assimilation in a Virginia tidal system. P. 218-249. In: Proceedings of National Symposium on Estuarine Pollution, P. L. McCarty and R. Kennedy (Eds.) Stanford Univ. Press.

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5. Nichols, M. (in press). Sediments of the James Estuary. Geological Society of Amer. Mem. #133

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9. Brehmer, M. L. 1967 & 68. Data report - heavy metals in shellfish. VIMS.

10. Nichols, M. and W. Norton. 1969. Foramineferal populations in a coastal plain estuary. Palaeogography, Palaeoclimatology and Palaeoecology 6: 197-213.

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12. Haven, D. S. 1968 to date. Oyster spat success - Marine Resources Bull. VIMS.

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17. Peddicord, R. 1970-72. Factors influencing the growth and survival of the brackish water clam (Rangia cuneata) Ph.D. thesis.

18. Cain, T. 1970-72. Reproduction and development of the brackish water clam (Rangia cuneata). Ph.D. thesis.

19. Post-operation studies on the growth, reproduction and survival of the brackish water clam (Rangia cuneata).

20. Ichthyology Dept. - various beach seining studies.

21. Huggett, R., M. Bender and H. D. Slone. 1971. Utilizing metal concentration relationships in the eastern oyster (Crassostrea virginica) to detect heavy metal pollution.

22. Slone, H. D., R. J. Huggett and M. E. Bender. 1971. Nutrients and heavy metals in James River sediments. VIMS.

23. Nichols, M. M. 1970 to date. Remote sensing and on site studies of sediment transport in the James Estuary. VIMS.

24. Fang, F. and E. Ruzecki. 1971. Hydrographic survey of the James Estuary, VIMS.

25. Fang, F. 1971-1973. Thermal distribution off Hog Point. AEC Contract.

26. Uptake of metals by Rangia - Intake and outfall - post-operational studies. VIMS - VEPCO.

27. Dynamics of phosphorus and nitrogen in the James River. VIMS and State Water Control Board.

Figure 1. VEPCO Instrument Towers

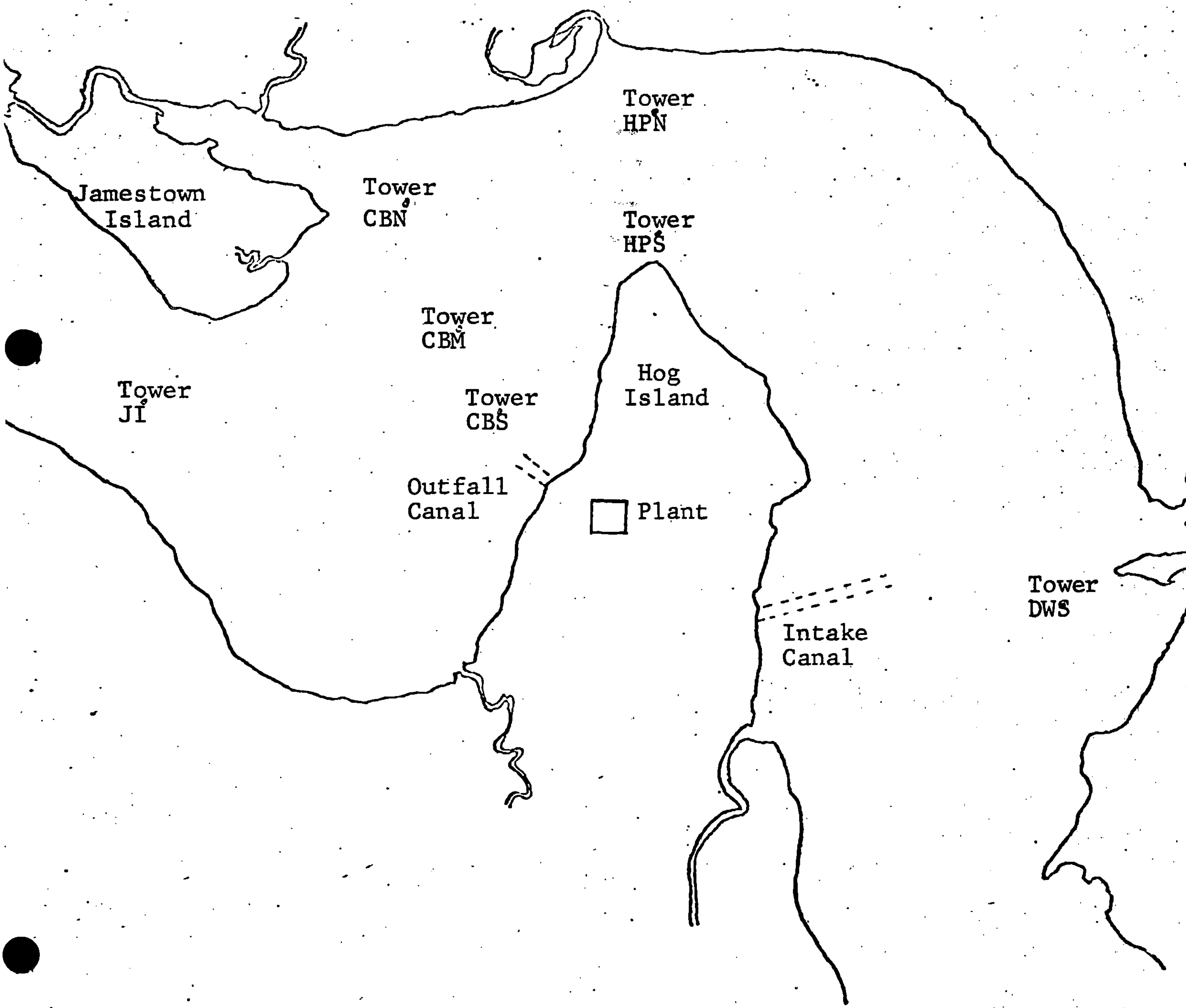


Figure 2. Bottom Trawl Stations

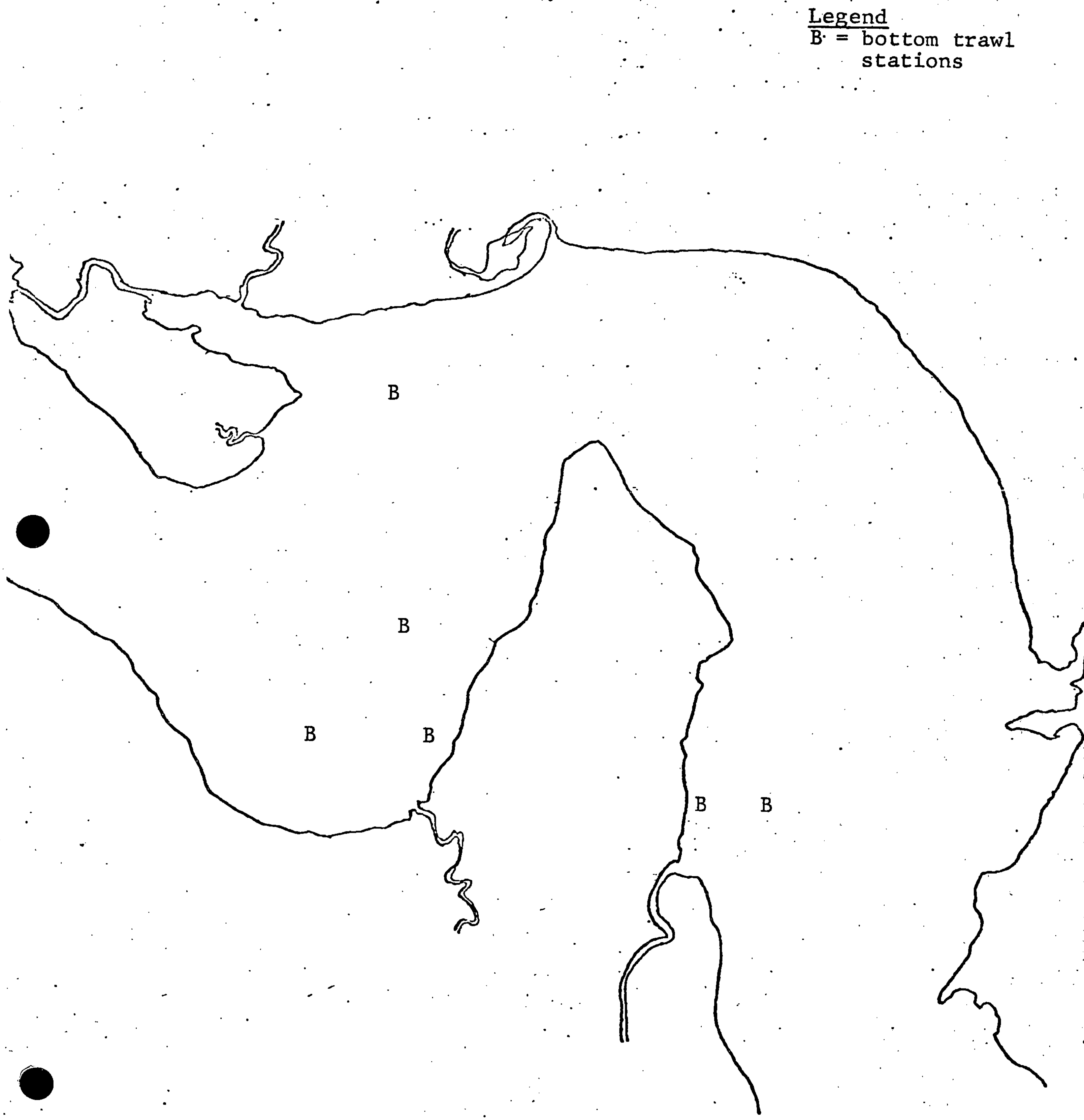


Figure 3. Benthic locations in James River

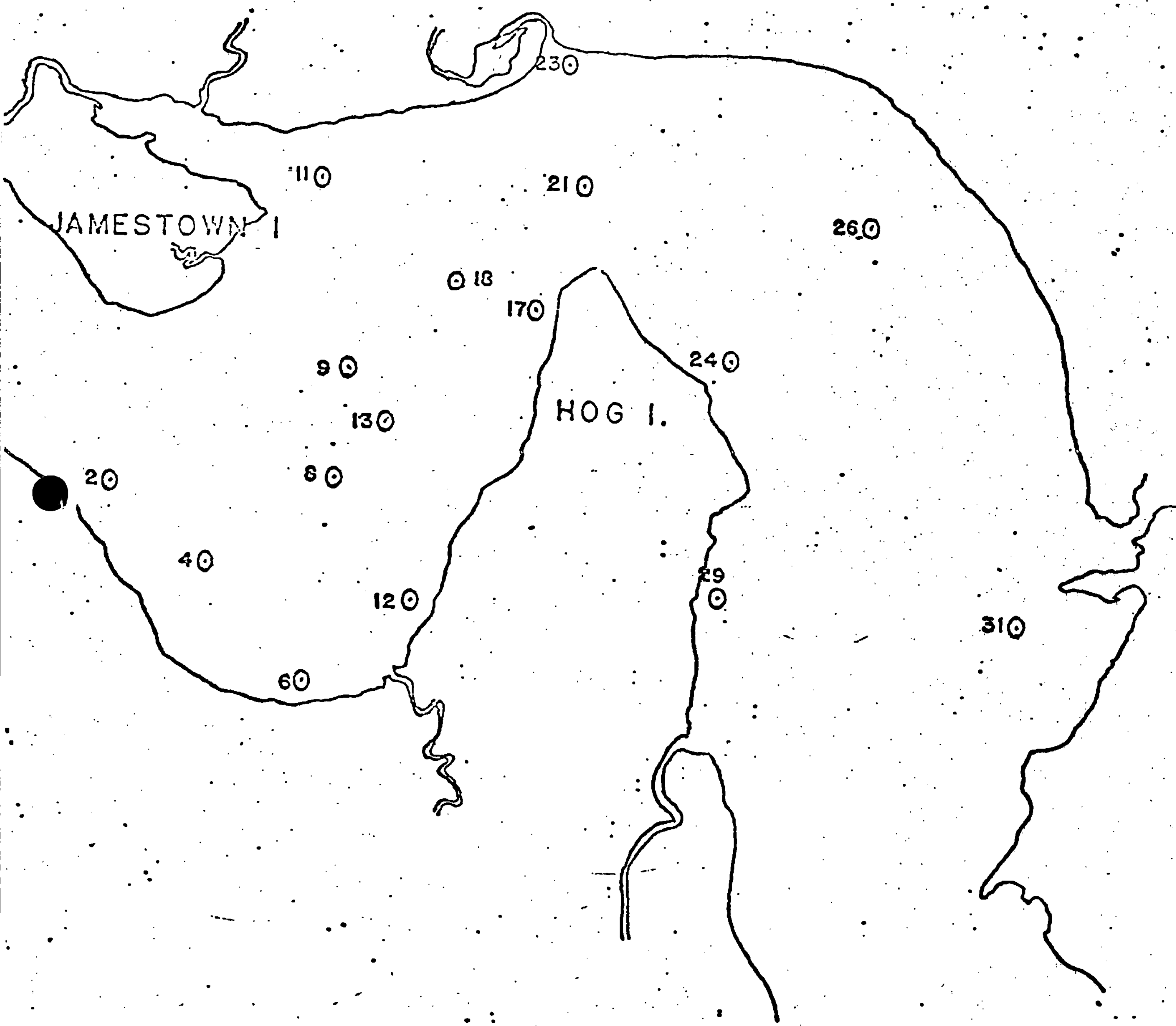
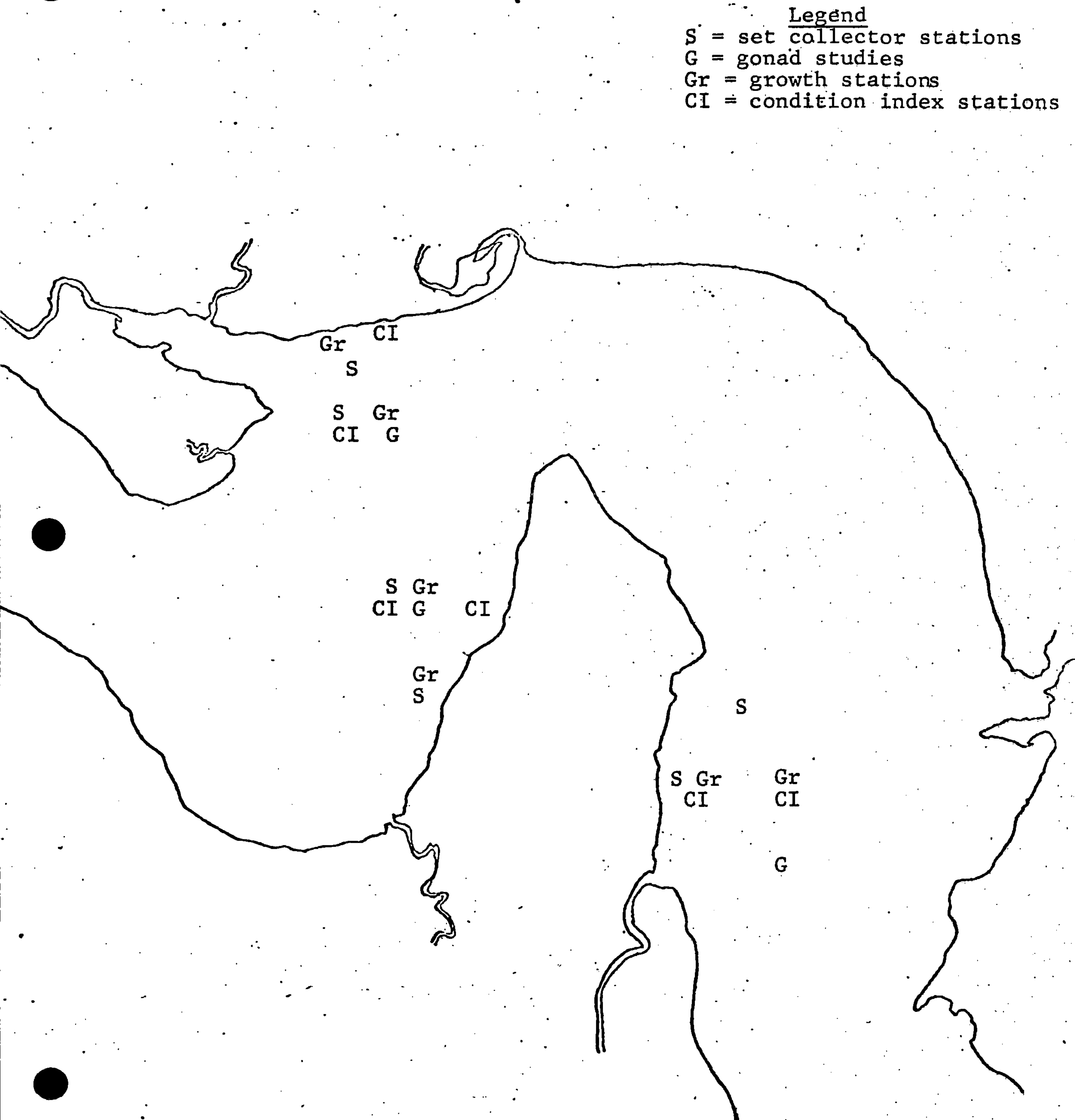


Figure 4. Rangia Sampling Stations



APPENDIX G

ENVIRONMENTAL APPROVALS AND CONSULTATIONS

UNITED STATES ATOMIC ENERGY COMMISSION

DOCKET NOS. 50-280 AND 50-281

VIRGINIA ELECTRIC AND POWER COMPANY

NOTICE OF ISSUANCE OF PROVISIONAL CONSTRUCTION PERMITS

Notice is hereby given that, pursuant to the Initial Decision of the Atomic Safety and Licensing Board, dated June 25, 1968, the Director of the Division of Reactor Licensing has issued Provisional Construction Permits Nos. CPPR-43 and CPPR-44 to Virginia Electric and Power Company for the construction of two pressurized water nuclear reactors at the Company's site in Surry County, Virginia. The reactors, known as the Surry Power Station Units 1 and 2, are each designed for initial operation at approximately 2441 thermal megawatts with a net electrical output of approximately 780 megawatts each.

A copy of the Initial Decision is on file in the Commission's Public Document Room, 1717 H Street, N.W., Washington, D. C.

FOR THE ATOMIC ENERGY COMMISSION

Peter A. Morris

Peter A. Morris, Director
Division of Reactor Licensing

Dated at Bethesda, Maryland
this day of June, 1968.
JUN 25 1968

VIRGINIA ELECTRIC AND POWER COMPANY

DOCKET NO. 50-280

ORDER EXTENDING COMPLETION DATE

Virginia Electric and Power Company has filed a request dated May 18, 1971, for an extension of the latest completion date specified in Provisional Construction Permit No. CPPR-43, for construction of a 2441 megawatts (thermal) pressurized water nuclear reactor, designated as the Surry Power Station Unit No. 1, at the applicant's site in Surry County, Virginia.

Good cause having been shown for extension of said date pursuant to Section 185 of the Atomic Energy Act of 1954, as amended, and Section 50.55(b) of 10 CFR Part 50 of the Commission's regulations, IT IS HEREBY ORDERED THAT the latest completion date is extended from July 1, 1971 to July 1, 1972.

FOR THE ATOMIC ENERGY COMMISSION

Peter A. Morris, Director
Division of Reactor Licensing

Date of Issuance:
JUN 24 1971

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

VIRGINIA ELECTRIC AND POWER COMPANY

(SURRY POWER STATION, UNIT NO. 1)

DOCKET NO. 50-280

PROVISIONAL CONSTRUCTION PERMIT

Construction Permit No. CPPR-43

1. Pursuant to Section 104(b) of the Atomic Energy Act of 1954, as amended (the Act), and Title 10, Chapter 1, Code of Federal Regulations, Part 50, "Licensing of Production and Utilization Facilities," and pursuant to the order of the Atomic Safety and Licensing Board, the Atomic Energy Commission (the Commission) hereby issues a provisional construction permit to Virginia Electric and Power Company (the applicant), for a utilization facility (the facility), designed to operate at 2441 megawatts (thermal), described in the application and amendments thereto (the application) filed in this matter by the applicant and as more fully described in the evidence received at the public hearing upon that application. The facility, known as Surry Power Station, Unit No. 1, will be located at the applicant's Surry County, Virginia site fourteen miles northwest of Newport News, Virginia.

2. This permit shall be deemed to contain and be subject to the conditions specified in Sections 50.54 and 50.55 of said regulations; is subject to all applicable provisions of the Act, and rules, regulations and orders of the Commission now or hereafter in effect; and is subject to the conditions specified or incorporated below:

   A. The earliest date for the completion of the facility is July 1, 1970, and the latest date for completion of the facility is July 1, 1971.

   B. The facility shall be constructed and located at the site as described in the application, northwest of Newport News, Virginia.

   C. This construction permit authorizes the applicant to construct the facility described in the application and the hearing record in accordance with the principal architectural and engineering criteria set forth therein.

3. This permit is provisional to the extent that a license authorizing operation of the facility will not be issued by the Commission unless (a) the applicant submits to the Commission, by amendment to the application, the complete final safety analysis report, portions of which may be submitted

and evaluated from time to time; (b) the Commission finds that the final design provides reasonable assurance that the health and safety of the public will not be endangered by the operation of the facility in accordance with procedures approved by it in connection with the issuance of said license; and (c) the applicant submits proof of financial protection and the execution of an indemnity agreement as required by Section 170 of the Act.

FOR THE ATOMIC ENERGY COMMISSION

Peter A. Morris

Peter A. Morris, Director
Division of Reactor Licensing

Date of Issuance: JUN 25 1968

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

VIRGINIA ELECTRIC AND POWER COMPANY

(SURRY POWER STATION, UNIT NO. 2)

DOCKET NO. 50-281

PROVISIONAL CONSTRUCTION PERMIT

Construction Permit No. CPPR-44

1. Pursuant to Section 104(b) of the Atomic Energy Act of 1954, as amended (the Act), and Title 10, Chapter 1, Code of Federal Regulations, Part 50, "Licensing of Production and Utilization Facilities," and pursuant to the order of the Atomic Safety and Licensing Board, the Atomic Energy Commission (the Commission) hereby issues a provisional construction permit to Virginia Electric and Power Company (the applicant), for a utilization facility (the facility), designed to operate at 2441 megawatts (thermal), described in the application and amendments thereto (the application) filed in this matter by the applicant and as more fully described in the evidence received at the public hearing upon that application. The facility, known as Surry Power Station, Unit No. 2, will be located at the applicant's Surry County, Virginia site northwest of Newport News, Virginia.

2. This permit shall be deemed to contain and be subject to the conditions specified in Sections 50.54 and 50.55 of said regulations; is subject to all applicable provisions of the Act, and rules, regulations and orders of the Commission now or hereafter in effect; and is subject to the conditions specified or incorporated below:

   A. The earliest date for the completion of the facility is July 1, 1971, and the latest date for completion of the facility is July 1, 1972.

   B. The facility shall be constructed and located at the site as described in the application, northwest of Newport News, Virginia.

   C. This construction permit authorizes the applicant to construct the facility described in the application and the hearing record in accordance with the principal architectural and engineering criteria set forth therein.

3. This permit is provisional to the extent that a license authorizing operation of the facility will not be issued by the Commission unless (a) the applicant submits to the Commission, by amendment to the application, the complete final safety analysis report, portions of which may be submitted and evaluated from time to time; (b) the Commission finds that the final design provides reasonable assurance that the health and safety of the public will not

be endangered by the operation of the facility in accordance with procedures approved by it in connection with the issuance of said license; and (c) the applicant submits proof of financial protection and the execution of an indemnity agreement as required by Section 170 of the Act.

FOR THE ATOMIC ENERGY COMMISSION

Peter A. Morris

Peter A. Morris, Director
Division of Reactor Licensing

Date of Issuance: JUN 25 1968

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

MATERIAL LICENSE

Pursuant to the Atomic Energy Act of 1954, as amended, and Title 10, Code of Federal Regulations, Chapter 1, Part 30 and Part 70, a license is hereby issued authorizing the licensee to receive and possess the materials designated below; use such materials for the purposes and at the place designated below; to transfer such material to persons authorized to receive it in accordance with the regulations in said Parts. This license shall be deemed to contain the conditions as specified in Section 70.32(a) of said regulations, and is subject to all applicable rules, regulations, and orders of the Atomic Energy Commission now or hereafter in effect and to any conditions as specified below.

1. Licensee

   Virginia Electric and Power Company

2. Address

   700 East Franklin Street
   Richmond, Virginia 23209

3. License No.

   SNM-1191

4. Docket No.

   70-1249

5. Materials

   Plutonium, uranium enriched U-235 isotope, and byproduct material

6. Expiration Date

   December 31, 1971, or upon conversion of Construction Permit CPPR-43 to an operating license, whichever is earlier

7. Maximum quantity of material licensee may possess at any one time under the license.

   a. 1863 kilograms U-235 as reactor fuel assemblies
   b. two polonium-beryllium neutron sources not to exceed a nominal value of 250 curies each
   c. two plutonium-beryllium boron analyzer neutron sources not to exceed a nominal value of 5 curies each
   d. 1 source assembly equivalent to those described in item (b) above
   e. 80 milligrams of enriched uranium contained in up to 20 incore monitoring system detectors

License Number SNM-1191

MATERIAL LICENSE

Supplementary Sheet

G-2 (2)

f. cesium-137, 1 sealed source, 5 millicuries
g. cesium-137, 40 sealed sources, 10 microcuries each
h. chlorine-36, 25 sealed sources, 10 microcuries each
i. any byproduct material, any form, 25 millicuries total
j. cesium-137, 1 sealed source, 100 millicuries
k. cobalt-60, 1 sealed source, 1000 millicuries

8. Authorized Use

For use in accordance with the statements, representations and conditions specified in the licensee's application dated 5 May 1970. The enriched uranium contained in the fuel assemblies may be received, inspected and stored only. The other materials are authorized for receipt and storage only.

9. Authorized Place of Storage

The temporary fuel storage facility located at the Surry Power Station site, Surry County, Virginia. The licensee is hereby exempted from the requirements of Section 70.24, 10 CFR 70, to the extent that the section applies to the material covered by this license.

Date AUG 11 1970

For the U. S. Atomic Energy Commission

Donald A. Nussbaumer

by Donald A. Nussbaumer

Division of Materials Licensing
Washington, D. C. 20545

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

DML:JCD
70-1249

AMENDMENT NO. 3 TO AEC MATERIAL
LICENSE SNM-1191

Pursuant to Title 10, Code of Federal Regulations, Parts 30, 40 and 70, Items 6, 7, 8 and 9 of Materials License SNM-1191 are hereby amended and Item 10 is added to read as follows:

6. Expiration Date

December 31, 1972, or upon conversion of Construction Permit No. CPPR-43 to an operating license, whichever is earlier.

7. Maximum Quantities of Material Licensee May Possess at Any One Time Under This License

a. 1863 kilograms U-235 in reactor fuel assemblies for Surry Unit No. 1
b. 80 milligrams of U-235 contained in incore monitoring system detectors
c. two Pu-Be boron analyzer neutron sources not to exceed a nominal value of 5 curies each.
d. one source assembly equivalent to those described in Item (c) above
e. cesium-137, one sealed source, 5 millicuries
f. cesium-137, 40 sealed sources, 10 microcuries each
g. chlorine-36, 25 sealed sources, 10 microcuries each
h. any byproduct material, any form, 25 millicuries total
i. cesium-137, 1 sealed source, 100 millicuries
j. cobalt-60, 1 sealed source, 1 curie
k. four dosimeter capsules containing a total of 18×10^{-3} microcuries of U-238 and 50 microcuries of Np-237.

8. Authorized Use

For receipt, inspection, possession, storage, transfer between the permanent Fuel Building and the temporary fuel storage facility, and packaging for transport of fuel in accordance with conditions specified in the licensee's application dated May 5, 1970, and supplement dated June 11, 1971. The neutron source described in Item 7d may be used as described in the licensee's January 27, 1971 supplement.

AMENDMENT NO. 3 to AEC MATERIAL
LICENSE SNM-1191

9. Authorized Place of Use

The licensee's permanent Fuel Building and the temporary fuel storage facility located at the Surry Power Station site, Surry County, Virginia.

10. The licensee is hereby exempted from the requirements of Section 70.24, 10 CFR 70, to the extent that this section applies to material covered under this license.

All other conditions of this license shall remain the same.

FOR THE U.S. ATOMIC ENERGY COMMISSION

DATE AUG 20 1971

for [signature]
Donald A. Nussbaumer
Division of Materials Licensing

UNITED STATES
ATOMIC ENERGY COMMISSION
MATERIAL LICENSE

Pursuant to the Atomic Energy Act of 1954, as amended, and Title 10, Code of Federal Regulations, Chapter 1, Parts 30, 40 and 70, a license is hereby issued authorizing the licensee to receive and possess the materials designated below; and to transfer such materials to persons authorized to receive them in accordance with the regulations in said Parts. This license shall be deemed to contain the conditions as specified in Section 70.32(a) of said regulations, and is subject to all applicable rules, regulations, and orders of the Atomic Energy Commission now or hereafter in effect and to any conditions as specified below.

1. Licensee

   Virginia Electric and Power Company

2. Address

   Richmond, Virginia 23209

3. License No.

   SNM-1264

4. Docket No.

   70-1295

5. Expiration Date

   December 31, 1972, or upon conversion of Construction Permit CPPR-44 to an operating license, whichever is earlier.

6. Materials

   Plutonium, uranium enriched in the U-235 isotope, source material and byproduct material.

7. Maximum Quantities of Materials Licensee May Possess at Any One Time Under This License

   a. 1820 kilograms of U-235 contained in fuel assemblies for Surry Unit No. 2
   b. 80 milligrams U-235 contained in incore detectors
   c. 200 curies of Pu-238 as sealed Pu-Be neutron sources
   d. four dosimeter capsules containing a total of 16×10^{-3} microcuries of U-238 and 50 microcuries of Np-237.

8. Authorized Use

   For receipt, inspection, possession, storage, transfer between the permanent Fuel Building and the temporary fuel storage facility, and packaging for transport of fuel in accordance with the statements, representations and conditions specified in the licensee's application dated June 11, 1971.

Licensee: Virginia Electric and Power Company

License No: SNM-1264

Docket No: 70-1295

9. Authorized Place of Use

The licensee's permanent Fuel Building and the temporary fuel storage facility located at the Surry Power Station site, Surry County, Virginia.

10. The licensee is hereby exempted from the requirements of Section 70.24, 10 CFR 70, to the extent that this section applies to material covered under this license.

FOR THE U.S. ATOMIC ENERGY COMMISSION

Date AUG 20 1971

Donald A. Nussbaumer, Chief
Division of Materials Licensing

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

AUG 2 1971

DML:JCD
70-1249
SNM-1191, Amendment No. 4

Virginia Electric and Power Company
ATTN: Mr. Stanley Ragone
Vice President
P.O. Box 26666
Richmond, Virginia 23209

Gentlemen:

Pursuant to Title 10, Code of Federal Regulations, Part 70, Item 7.1. is added to Materials License No. SNM-1191 as follows:

7.1. 200 curies of Pu-238 as sealed Pu-Be neutron sources.

All other conditions of this license shall remain the same.

FOR THE ATOMIC ENERGY COMMISSION

Donald A. Nussbaumer

Donald A. Nussbaumer, Chief
Fuel Fabrication and
Transportation Branch
Division of Materials Licensing

FORM AEC-374
(7-66)
10 CFR 30

This Copy Is For Your Files

U. S. ATOMIC ENERGY COMMISSION

BYPRODUCT MATERIAL LICENSE

Pursuant to the Atomic Energy Act of 1954 and Title 10, Code of Federal Regulations, Chapter 1, Parts 30, 32, 33, 34, and 35, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, own, possess, transfer and import byproduct material listed below; and to use such byproduct material for the purpose(s) and at the place(s) designated below. This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, and is subject to all applicable rules, regulations, and orders of the Atomic Energy Commission now or hereafter in effect and to any conditions specified below.

Licensee	
1. Virginia Electric & Power Company	3. License number 45-13670-01
2. 7th & Franklin Streets P. O. Box 1194 Richmond, Virginia 23209	4. Expiration date See condition 15. below
	5. Reference No.

6. Byproduct material (element and mass number)	7. Chemical and/or physical form	8. Maximum amount of radioactivity which licensee may possess at any one time
A. Cobalt 60	A. Sealed source	A. 21,000 millicuries
B. Cesium 137	B. Sealed source	B. 5 millicuries
C. Cesium 137	C. Sealed source	C. 100 millicuries
D. Cesium 137	D. Sealed sources	D. 0.4 millicurie total, Maximum Activity per Source, 10 microcuries
E. Chlorine 36	E. Sealed sources	E. 0.25 millicurie total, Maximum Activity per Source, 10 microcuries
F. Any byproduct material with Atomic Numbers between 3 to 83, inclusive	F. Any	F. 25 millicuries total
G. Polonium 210	G. Sealed sources (Po-Be neutron)	G. 500 curies total, Maximum Activity per Source, 250 curies
H. HYDROGEN 3	H. ANY	H 5 MILLICURIES

FORM AEC-374A
(2-65)
10 CFR 30

U. S. ATOMIC ENERGY COMMISSION
BYPRODUCT MATERIAL LICENSE
Supplementary Sheet

License Number 45-13670-01

9. Authorized use

A. through C. Instrument calibration.
D. through E. Check sources.
F. Radiochemical analyses and instrument calibration.
G. Storage only-reactor start-up source.

CONDITIONS

10. Byproduct material may only be used at Surry Power Station, Surry, Virginia.

11. The licensee shall comply with the provisions of Title 10, Chapter 1, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation."

12. Byproduct material shall be used by, or under the supervision of, W. W. Cameron, E. M. Sweeny, P. R. Beament, J. W. Martin, B. R. Sylvia, J. Horhutz, Jr., J. E. Massey, P.P. Nottingham or R. D. Terry.

13.A.(1) Each sealed source containing byproduct material, other than Hydrogen 3, with a half-life greater than thirty days and in any form other than gas shall be tested for leakage and/or contamination at intervals not to exceed six months. In the absence of a certificate from a transferor indicating that a test has been made within six months prior to the transfer, the sealed source shall not be put into use until tested.

(2) Notwithstanding the periodic leak test required by the preceding paragraph, any licensed sealed source containing byproduct material is exempted from periodic leak tests provided the quantity of byproduct material contained in the source does not exceed ten times the quantity specified for the byproduct material in Column II, Schedule A, Section 31.100, 10 CFR 31.

(3) The periodic leak test required by this condition does not apply to sealed sources that are stored and not being used. The sources excepted from this test shall be tested for leakage prior to any use or transfer to another person unless they have been leak tested within six months prior to the date of use or transfer.

13. continued

B. The test shall be capable of detecting the presence of 0.005 microcurie of radioactive material on the test sample. The test sample shall be taken from the sealed source or from the surfaces of the device in which the sealed source is permanently mounted or stored on which one might expect contamination to accumulate. Records of leak test results shall be kept in units of microcuries and maintained for inspection by the Commission.

C. If the test reveals the presence of 0.005 microcurie or more of removable contamination, the licensee shall immediately withdraw the sealed source from use and shall cause it to be decontaminated and repaired or to be disposed of in accordance with Commission regulations. A report shall be filed within 5 days of the test with the Director, Division of Materials Licensing, U. S. Atomic Energy Commission, Washington, D. C., 20545, describing the equipment involved, the test results, and the corrective action taken. A copy of such report shall also be sent to the Director, Region II, Division of Compliance, USAEC, Suite 818, 230 Peachtree Street, Northwest, Atlanta, Georgia, 30303.

D. Tests for leakage and/or contamination shall be performed by W. W. Cameron or by other persons specifically authorized by the Commission or an Agreement State to perform such services.

14. Except as specifically provided otherwise by this license, the licensee shall possess and use byproduct material described in Items 6, 7, and 8 of this license in accordance with statements, representations, and procedures contained in the licensee's application dated April 29, 1970.

15. This license shall expire May 31, 1971, or upon conversion of Construction Permit CPPR-43 to an operating license, whichever is earlier.

For the U. S. Atomic Energy Commission

Date MAY 20 1970

by Materials Branch

Division of Materials Licensing
Washington, D. C. 20545

FORM AEC-374A
(2-65)
10 CFR 30

U. S. ATOMIC ENERGY COMMISSION
BYPRODUCT MATERIAL LICENSE
Supplementary Sheet

G-3 (4)

License Number 45-13670-01

Amendment No. 02

NOTED APR 26 1971 E.A.BAUM

Virginia Electric and Power
Company
7th and Franklin Streets
P. O. Box 1194
Richmond, Virginia 23209

In accordance with application dated April 1, 1971, License Number 45-13670-01 is amended as follows:

Subitem 8.A. is amended to read:

8.A. 2 curies

Condition 15. is amended to read:

15. This license shall expire May 31, 1974, or upon conversion of Construction Permit CPPR-43 to an operating license, whichever is earlier.

For the U. S. Atomic Energy Commission

Date APR 14 1971

by Original Signed by Robert E. Brinkman
~~Materials Branch~~ Division of Materials Licensing
Washington, D. C. 20545

5

June 29, 1971

District Engineer
U. S. Army Corps of Engineers
Norfolk District
803 Front Street
Norfolk, Virginia 23510

Gentlemen:

Enclosed is Section I of an application by the Virginia Electric and Power Company to discharge waste from their Surry Power Station in Surry County, Virginia under § 407 of the Rivers and Harbors Act of 1899. A check for $350.00 is also enclosed to cover the fees associated with this application as is a copy of a Permit from the State Water Control Board of the Commonwealth of Virginia covering this facility.

Due to the short time alloted to complete this application the necessary drawings and analytical work have not been completed for all discharges. Please do not process this application until the completed Section II forms are received. These forms should be completed by August 1, 1971.

All discharges except roof drains, some yard drains and wash water from the inlet circulating water traveling screens have been included in the application. These discharges were omitted after consultation with the Corps of Engineers.

This application is filed under general protest including, but not limited to, the following specific reservations:

The Rivers and Harbors Act of 1899 does not confer Federal jurisdiction over discharges or deposits to either intrastate or interstate navigable waters where such discharges or deposits do not constitute an impediment to navigation or to interstate commerce. Insofar as it attempts to do so, the Act is unconstitutional.

Insofar as the regulations published in 33 C.F.R. § 209.131 are applied to navigable waters other than those considered navigable under 33 C.F.R. § 209.260 as interpreted by the Corps administrative practice in the past, or to the extent that such regulations are applied to any tributary of a navigable stream other than "any tributary of any navigable water from which [refuse matters] shall float or be washed into such navigable water," the regulations are unauthorized by statute and unconstitutional.

[The Corps of Engineers has no jurisdiction over thermal discharges since discharges of heated water are not "refuse matter" under the Act.]

[The Corps of Engineers has no jurisdiction over radioactive discharges from a nuclear power station subject to the jurisdiction of the Atomic Energy Commission.]

The delegation in 33 C.F.R. § 209.131 to the Environmental Protection Agency (EPA) of the authority and discretion vested exclusively in the Corps of Engineers by Congress to issue permits under the Rivers and Harbors Act of 1899 is invalid, being both unauthorized by statute and unconstitutional.

The state certification of reasonable assurance required in some cases by § 21(b) of the Water Quality Improvement Act of 1970 is conclusive as to the effect of the discharge of pollutants on water quality standards and is likewise conclusive on the question whether or not a Corps permit should be issued under the Rivers and Harbors Act of 1899. Where a state certification is not required, no letter from state regulatory officials, such as that proposed in 33 C.F.R. § 209.131(h)(3), can lawfully be required.

Neither EPA nor the Corps of Engineers has jurisdiction to impose so-called "base levels of treatment" criteria or any other effluent limitation in the course of its implementation of the permit system.

The points of discharge required by the Corps to be specified in the application are properly the point of discharge from any discharge canal, private waste treatment facility, lagoon, reservoir or any other waste treatment facility. Any attempt to exercise jurisdiction over discharges into any of the facilities just mentioned is unconstitutional and is unauthorized by statute. In filing applications we have, therefore, designated what we believe to be the proper points of discharge in addition to those which we have been instructed to use by Corps representatives. See discharge serial number 001A of plot plan.

Section 1(d) of the form of permit proposed in the Corps Book of Instructions is unauthorized by statute.

No provision of the Refuse Act authorizes a filing fee to be imposed.

[Subject to the provisions of 33 C.F.R. § 209.131(n)(1) Virginia Electric and Power Company requests that the permit for the plant be granted for the remaining useful life of this plant, estimated as but not limited to, 41 years. A permit which must be revalidated every five years may create serious financing problems for the Company in raising additional private capital.]

Nothing in this letter or this application shall prejudice or shall be construed in any way as a waiver, either in part or in full, of any or all legal rights which the Company has to contest in part or in full the constitutionality, interpretation, validity or applicability of any statutes or regulations pursuant to which it is filed.

Subject to the reservations outlined above and any others which it may later assert Virginia Electric and Power Company intends to cooperate with the Corps of Engineers and with the Environmental Protection Agency in the smooth functioning of this permit system. If we can be of assistance to you in furnishing further information or in clarifying any of the responses provided to date, please feel free to contact us.

Very truly yours,

E. B. Crutchfield

cc: State Water Control Board
Commonwealth of Virginia

bc: Messrs: Stanley Ragone
Harrison Hubard
J. D. Ristroph
T. T. Smith
E. M. Sweeney, Jr.

BJP/PG

October 22, 1971

District Engineer
U.S. Army Corps of Engineers
Norfolk District
803 Front Street
Norfolk, Virginia 23510

Gentlemen:

Enclosed is Section II and Part B of Eng Form 4345-1 covering discharges from our Surry Nuclear Power Station in Surry County, Virginia.

This station has been assigned application number 2SD 0XZ 3 000217.

Since Unit #1 at this station is not scheduled to go into operation until mid 1972 and the #2 Unit in late 1972 only design data with estimated maximum and minimum data is employed in completing the application.

Detail drawings for discharge serial numbers 001 and 006 are on a common drawing. The original is attached to the application for 001 with only copies attached to 006.

Detail drawings for discharge serial numbers 002, 003, 004 and 005 are on a common drawing. The original is attached to the application for 002 with copies attached to 003, 004 and 005.

Very truly yours,

Orig signed by
E. B. Crutchfield

E. B. Crutchfield BP

cc: Mr. A. H. Paessler
State Water Control Board
Commonwealth of Virginia

bc: Mr. Stanley Ragone
Mr. J. D. Ristroph
Mr. T. T. Smith, Jr.
Mr. E. M. Sweeney, Jr.

BJP/PG

DEPARTMENT OF THE ARMY
NORFOLK DISTRICT CORPS OF ENGINEERS
FORT NORFOLK 803 FRONT STREET
NORFOLK VIRGINIA 23510

IN REPLY REFER TO

NAOOP-P(James River) 12 February 1968

Virginia Electric and Power Company
Richmond, Virginia 23209

ATTN: Mr. W. M. Wills, Director
Power Station Design

Gentlemen:

In response to your request of 5 February 1968, enclosed is an Army Department permit authorizing you to install and maintain seven timber pile channel markers in the James River to mark the intake channel at your Surry Power Station, Hog Island, Surry County, Virginia.

If any material change in the plan of work is found necessary, a revised plan should be promptly submitted to this office for approval prior to any work involving such change.

Your attention is invited to the conditions of the permit, including Condition (i) which requires that you notify this office of certain dates in connection with the work.

If you have not already done so, it is necessary that you apply to the Commander, Fifth Coast Guard District, Federal Building, 431 Crawford Street, Portsmouth, Virginia 23705, for his authorization of the markers.

Sincerely yours,

C. E. Adams, Jr.

C. E. ADAMS, JR.
Colonel, Corps of Engineers
District Engineer

1 Encl
Permit, 12 Feb 68

Copy furnished:
Commander, O-2, Fifth CG Dist,
Portsmouth, w/dwg

U. S. C. & G. S., Norfolk, w/dwg

DEPARTMENT OF THE ARMY

NOTE.—It is to be understood that this instrument does not give any property rights either in real estate or material, or any exclusive privileges; and that it does not authorize any injury to private property or invasion of private rights, or any infringement of Federal, State, or local laws or regulations, nor does it obviate the necessity of obtaining *State assent* to the work authorized. ~~IT MERELY EXPRESSES THE ASSENT OF THE FEDERAL GOVERNMENT SO FAR AS CONCERNS THE PUBLIC RIGHTS OF NAVIGATION.~~ (See *Cummings* v. *Chicago*, 188 U. S., 410.) 16—13168-2

PERMIT

U. S. Army Engineer District,
Norfolk, Corps of Engineers.

12 February, 1968.

Virginia Electric and Power Company
Richmond, Virginia 23209

ATTN: Mr. W. M. Wills, Director
Power Station Design

Gentlemen:

Referring to written request dated 5 February 1968

I have to inform you that, upon the recommendation of the Chief of Engineers, and under the provisions of Section 10 of the Act of Congress approved March 3, 1899, entitled "An act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," you are hereby authorized by the Secretary of the Army.

to install and maintain seven timber pile channel markers (the structures to be maintained in good repair or completely removed from the waterway; the markers to have the characteristics specified by the U. S. Coast Guard)
(Here describe the proposed structure or work.)

in the James River, (Here tc be named the river, harbor, or waterway concerned.)

to mark the intake channel

at your Surry Power Station, Hog Island, Surry County, Virginia,
(Here to be named the nearest well-known locality—preferably a town or city—and the distance in miles and tenths from some definite point in the same, stating whether above or below or giving direction by points of compass.)

in accordance with the plans shown on the drawing/attached hereto in 2 sheets, marked: "Day Markers for Intake Channel Surry Power Station Stone & Webster Engineering Corp. 11-17-67 FSK-42 Sheet 2 of 2 REVISED 12-28-67",
(Or drawings; give file number or other definite identification marks.)

subject to the following conditions:

(*a*) That the work shall be subject to the supervision and approval of the District Engineer, Corps of Engineers, in charge of the locality, who may temporarily suspend the work at any time, if in his judgment the interests of navigation so require.

(*b*) That any material dredged in the prosecution of the work herein authorized shall be removed evenly and no large refuse piles, ridges across the bed of the waterway, or deep holes that may have a tendency to cause injury to navigable channels or to the banks of the waterway shall be left. If any pipe, wire, or cable hereby authorized is laid in a trench, the formation of permanent ridges across the bed of the waterway shall be avoided and the back filling shall be so done as not to increase the cost of future dredging for navigation. Any material to be deposited or dumped under this authorization, either in the waterway or on shore above high-water mark, shall be deposited or dumped at the locality shown on the drawing hereto attached, and, if so prescribed thereon, within or behind a good and substantial bulkhead or bulkheads, such as will prevent escape of the material in the waterway. If the material is to be deposited in the harbor of New York, or in its adjacent or tributary waters, or in Long Island Sound, a permit therefor must be previously obtained from the Supervisor of New York Harbor, New York City.

(*c*) That there shall be no unreasonable interference with navigation by the work herein authorized.

(*d*) That if inspections or any other operations by the United States are necessary in the interest of navigation, all expenses connected therewith shall be borne by the permittee.

(*e*) That no attempt shall be made by the permittee or the owner to forbid the full and free use by the public of all navigable waters at or adjacent to the work or structure.

(*f*) That if future operations by the United States require an alteration in the position of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army, it shall cause unreasonable obstruction to the free navigation of said water, the owner will be required upon due notice from the Secretary of the Army, to remove or alter the structural work or obstructions caused thereby without expense to the United States, so as to render navigation reasonably free, easy, and unobstructed; and if, upon the expiration or revocation of this permit, the structure, fill, excavation, or other modification of the watercourse hereby authorized shall not be completed, the owners shall, without expense to the United States, and to such extent and in such time and manner as the Secretary of the Army may require, remove all or any portion of the uncompleted structure or fill and restore to its former condition the navigable capacity of the watercourse. No claim shall be made against the United States on account of any such removal or alteration.

(*g*) That the United States shall in no case be liable for any damage or injury to the structure or work herein authorized which may be caused by or result from future operations undertaken by the Government for the conservation or improvement of navigation, or for other purposes, and no claim or right to compensation shall accrue from any such damage.

(*h*) That if the display of lights and signals on any work hereby authorized is not otherwise provided for by law, such lights and signals as may be prescribed by the U. S. Coast Guard, shall be installed and maintained by and at the expense of the owner.

(*i*) That the permittee shall notify the said district engineer at what time the work will be commenced, and as far in advance of the time of commencement as the said district engineer may specify, and shall also notify him promptly, in writing, of the commencement of work, suspension of work, if for a period of more than one week, resumption of work, and its completion.

(*j*) That if the structure or work herein authorized is not completed on or before the thirty-first day of December, 19 69, this permit, if not previously revoked or specifically extended, shall cease and be null and void.

By authority of the Secretary of the Army:

C. E. Adams, Jr.

Plan attached

C. E. ADAMS, JR.
Colonel, Corps of Engineers
District Engineer

ENG FORM 1 SEP 48 1721 (Civil) This form supersedes ED Form 96, dated 1 Apr 48, which may be used until exhausted.

EM 1145-2-303

U. S. GOVERNMENT PRINTING OFFICE 16—13168-5

DEPARTMENT OF THE ARMY
NORFOLK DISTRICT, CORPS OF ENGINEERS
FORT NORFOLK, 803 FRONT STREET
NORFOLK, VIRGINIA 23510

IN REPLY REFER TO
NAOOP-P (James River)

16 July 1969

Virginia Electric and Power Company
P. O. Box 1194
Richmond, Virginia 23209

ATTN: Mr. W. M. Wills, Director, Power Station Design

Gentlemen:

Regarding your request of 5 June 1969, enclosed is an Army Department permit authorizing you to construct and temporarily maintain seven instrument towers in the James River near Hog Island, Surry County, Virginia.

If any material change in the plan of the work is found necessary, revised plans must be submitted for our approval prior to any work involving such change.

Your attention is invited to the conditions of the permit including Condition (i) requiring you to notify this office of certain dates in connection with the work.

Your attention is also invited to the fact that the towers must be provided with lights, the characteristics of which must be as prescribed by Commander, Fifth Coast Guard District (o-2), Federal Building, 431 Crawford Street, Portsmouth, Virginia 23705; and that all of the structures must be removed from the water not later than 31 March 1975.

Sincerely yours,

C. E. ADAMS, JR.
Colonel, Corps of Engineers
District Engineer

1 Encl
Permit, 16 Jul 69

Copy furnished:
U.S.C.&G.S., Norfolk, w/drawing
Va. Institute of Marine Science, Gloucester Pt., w/cy permit
Commander, Fifth Coast Guard District, w/cy permit
Chairman, Board of Supervisors, Surry County, w/drawing
Virginia Marine Resources Commission, Newport News, Va. w/drawing

DEPARTMENT OF THE ARMY

NOTE.—It is to be understood that this instrument does not give any property rights either in real estate or material, or any exclusive privileges; and that it does not authorize any injury to private property or invasion of private rights, or any infringement of Federal, State, or local laws or regulations, nor does it obviate the necessity of obtaining *State assent* to the work authorized. IT MERELY EXPRESSES THE ASSENT OF THE FEDERAL GOVERNMENT SO FAR AS CONCERNS THE PUBLIC RIGHTS OF NAVIGATION. (See *Cummings* v. *Chicago*, 188 U. S., 410.) 16—13168-2

PERMIT

Norfolk District, Corps of Engineers.

Virginia Electric & Power Company
P. O. Box 1194
Richmond, Virginia 23209

16 July, 1969

ATTN: Mr. W. M. Wills, Director, Power Station Design

Gentlemen:

Referring to written request dated 5 June 1969,

I have to inform you that, upon the recommendation of the Chief of Engineers, and under the provisions of Section 10 of the Act of Congress approved March 3, 1899, entitled "An act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," you are hereby authorized by the Secretary of the Army.

to install and temporarily maintain 3-pile instrument towers (the structures to
(Here describe the proposed structure or work.)
be at least 15 feet above mean high water; each structure to carry night lighting, the characteristics of which are to be prescribed by Commander, Fifth Coast Guard District; each structure to be maintained in a condition satisfactory to District Engineer, or be completely removed from the waterway; each structure to be completely removed from the river not later than 31 March 1975),

in James River,
(Here to be named the river, harbor, or waterway concerned.)

~~at~~ near Hog Island, Surry County, Virginia,
(Here to be named the nearest well-known locality—preferably a town or city—and the distance in miles and tenths from some definite point in the same, stating whether above or below or giving direction by points of compass.)

in accordance with the plans shown on the drawing attached hereto marked: "Proposed
(Or drawings; give file number or other definite identification marks.)
Instrument Towers in James River near Hog Island, Virginia, Application by Virginia Electric and Power Company, June 1969",

subject to the following conditions:

(*a*) That the work shall be subject to the supervision and approval of the District Engineer, Corps of Engineers, in charge of the locality, who may temporarily suspend the work at any time, if in his judgment the interests of navigation so require.

(*b*) That any material dredged in the prosecution of the work herein authorized shall be removed evenly and no large refuse piles, ridges across the bed of the waterway, or deep holes that may have a tendency to cause injury to navigable channels or to the banks of the waterway shall be left. If any pipe, wire, or cable hereby authorized is laid in a trench, the formation of permanent ridges across the bed of the waterway shall be avoided and the back filling shall be so done as not to increase the cost of future dredging for navigation. Any material to be deposited or dumped under this authorization, either in the waterway or on shore above high-water mark, shall be deposited or dumped at the locality shown on the drawing hereto attached, and, if so prescribed thereon, within or behind a good and substantial bulkhead or bulkheads, such as will prevent escape of the material in the waterway. If the material is to be deposited in the harbor of New York, or in its adjacent or tributary waters, or in Long Island Sound, a permit therefor must be previously obtained from the Supervisor of New York Harbor, New York City.

(*c*) That there shall be no unreasonable interference with navigation by the work herein authorized.

(*d*) That if inspections or any other operations by the United States are necessary in the interest of navigation, all expenses connected therewith shall be borne by the permittee.

(*e*) That no attempt shall be made by the permittee or the owner to forbid the full and free use by the public of all navigable waters at or adjacent to the work or structure.

(*f*) That if future operations by the United States require an alteration in the position of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army, it shall cause unreasonable obstruction to the free navigation of said water, the owner will be required upon due notice from the Secretary of the Army, to remove or alter the structural work or obstructions caused thereby without expense to the United States, so as to render navigation reasonably free, easy, and unobstructed; and if, upon the expiration or revocation of this permit, the structure, fill, excavation, or other modification of the watercourse hereby authorized shall not be completed, the owners shall, without expense to the United States, and to such extent and in such time and manner as the Secretary of the Army may require, remove all or any portion of the uncompleted structure or fill and restore to its former condition the navigable capacity of the watercourse. No claim shall be made against the United States on account of any such removal or alteration.

(*g*) That the United States shall in no case be liable for any damage or injury to the structure or work herein authorized which may be caused by or result from future operations undertaken by the Government for the conservation or improvement of navigation, or for other purposes, and no claim or right to compensation shall accrue from any such damage.

(*h*) That if the display of lights and signals on any work hereby authorized is not otherwise provided for by law, such lights and signals as may be prescribed by the U. S. Coast Guard, shall be installed and maintained by and at the expense of the owner.

(*i*) That the permittee shall notify the said district engineer at what time the work will be commenced, and as far in advance of the time of commencement as the said district engineer may specify, and shall also notify him promptly, in writing, of the commencement of work, suspension of work, if for a period of more than one week, resumption of work, and its completion.

(*j*) That if the structure or work herein authorized is not completed on or before the thirty-first day of March, 1975, this permit, if not previously revoked or specifically extended, shall cease and be null and void.

By authority of the Secretary of the Army:

Plan Attached

C. E. ADAMS, JR.
Colonel, Corps of Engineers
District Engineer

DEPARTMENT OF THE ARMY
NORFOLK DISTRICT CORPS OF ENGINEERS
FORT NORFOLK 803 FRONT STREET
NORFOLK VIRGINIA 23510

IN REPLY REFER TO NAOOP-P

21 August 1967

Virginia Electric and Power Company
Richmond, Virginia 23209

Attn: Mr. W. M. Wills, Director Power Station Design

Gentlemen:

Referring to your application dated 16 June 1967, enclosed is an Army Department permit authorizing you to dredge circulating water intake and discharge channels, to install a screen well, steel sheet-pile bulkhead dock and temporary open-pile timber dock, and to install groins along the discharge channel in the James River at Hog Island, Surry County, Virginia.

You are cautioned that if for any reason any material change in the location or plan of the work is found necessary, revised plans should be submitted promptly to this office in order that they may receive the approval required by law before any work involving such change is begun.

Your attention is invited to the various conditions of the permit, including Conditions (h) and (i), relative to the marking of the groins and to notifying this office of certain dates in connection with the work.

It is necessary that you communicate directly with Commander, Fifth Coast Guard District, Portsmouth, Va. (Aids to Navigation Branch) telephone 393-6081, extension 226, in order to determine the characteristics of the markers required on the groins.

Very sincerely yours,

C. E. Adams, Jr.

C. E. ADAMS, JR.
Colonel, Corps of Engineers
District Engineer

1 Encl
Permit, 21 Aug 67

Copy furnished:
Commander, 5th C.G. District
Attn: Aids to Navigation Branch, w/dwg

U.S.C.&G.S., Norfolk, w/dwg

Chairman, Bd. of Supervisors,
Surry County, w/dwg

DEPARTMENT OF THE ARMY

NOTE.—It is to be understood that this instrument does not give any property rights either in real estate or material, or any exclusive privileges; and that it does not authorize any injury to private property or invasion of private rights, or any infringement of Federal, State, or local laws or regulations, nor does it obviate the necessity of obtaining *State assent* to the work authorized. [redacted]. (See *Cummings* v. *Chicago*, 188 U. S., 410.) 16—13168-2

PERMIT

U. S. Army Engineer District,
Norfolk, Corps of Engineers.

21 August, 1967.

Virginia Electric and Power Company
Richmond, Virginia 23209
Attn: Mr. W. M. Wills
Director Power Station Design

Gentlemen:

Referring to written request dated 16 June 1967,

I have to inform you that, upon the recommendation of the Chief of Engineers, and under the provisions of Section 10 of the Act of Congress approved March 3, 1899, entitled "An act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," you are hereby authorized by the Secretary of the Army,

to dredge circulating water intake and discharge channels (the dredged material, approximately 395,000 cubic yards, to be deposited on shore in such manner that it will not return to navigable waters), to install a screen well, steel sheet pile bulkhead dock and temporary open-pile timber dock, and to install stone groins along the discharge channel (the structures to be maintained in good condition or to be completely removed from the waterway, except that the temporary dock will be completely removed when its use is no longer required)

(Here describe the proposed structure or work.)

in the James River

(Here to be named the river, harbor, or waterway concerned.)

at Hog Island, Surry County, Virginia,

(Here to be named the nearest well-known locality—preferably a town or city—and the distance in miles and tenths from some definite point in the same, stating whether above or below or giving direction by points of compass.)

in accordance with the plans shown on the drawing attached hereto, marked "Proposed Water Front Construction Near Hog Island in James River at Surry, Virginia . . . ,".

(Or drawings; give file number or other definite identification marks.)

subject to the following conditions:

(*a*) That the work shall be subject to the supervision and approval of the District Engineer, Corps of Engineers, in charge of the locality, who may temporarily suspend the work at any time, if in his judgment the interests of navigation so require.

(*b*) That any material dredged in the prosecution of the work herein authorized shall be removed evenly and no large refuse piles, ridges across the bed of the waterway, or deep holes that may have a tendency to cause injury to navigable channels or to the banks of the waterway shall be left. If any pipe, wire, or cable hereby authorized is laid in a trench, the formation of permanent ridges across the bed of the waterway shall be avoided and the back filling shall be so done as not to increase the cost of future dredging for navigation. Any material to be deposited or dumped under this authorization, either in the waterway or on shore above high-water mark, shall be deposited or dumped at the locality shown on the drawing hereto attached, and, if so prescribed thereon, within or behind a good and substantial bulkhead or bulkheads, such as will prevent escape of the material in the waterway. If the material is to be deposited in the harbor of New York, or in its adjacent or tributary waters, or in Long Island Sound, a permit therefor must be previously obtained from the Supervisor of New York Harbor, New York City.

(*c*) That there shall be no unreasonable interference with navigation by the work herein authorized.

(*d*) That if inspections or any other operations by the United States are necessary in the interest of navigation, all expenses connected therewith shall be borne by the permittee.

(*e*) That no attempt shall be made by the permittee or the owner to forbid the full and free use by the public of all navigable waters at or adjacent to the work or structure.

(*f*) That if future operations by the United States require an alteration in the position of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army, it shall cause unreasonable obstruction to the free navigation of said water, the owner will be required upon due notice from the Secretary of the Army, to remove or alter the structural work or obstructions caused thereby without expense to the United States, so as to render navigation reasonably free, easy, and unobstructed; and if, upon the expiration or revocation of this permit, the structure, fill, excavation, or other modification of the watercourse hereby authorized shall not be completed, the owners shall, without expense to the United States, and to such extent and in such time and manner as the Secretary of the Army may require, remove all or any portion of the uncompleted structure or fill and restore to its former condition the navigable capacity of the watercourse. No claim shall be made against the United States on account of any such removal or alteration.

(*g*) That the United States shall in no case be liable for any damage or injury to the structure or work herein authorized which may be caused by or result from future operations undertaken by the Government for the conservation or improvement of navigation, or for other purposes, and no claim or right to compensation shall accrue from any such damage.

(*h*) That if the display of lights and signals on any work hereby authorized is not otherwise provided for by law, such lights and signals as may be prescribed by the U. S. Coast Guard, shall be installed and maintained by and at the expense of the owner.

(*i*) That the permittee shall notify the said district engineer at what time the work will be commenced, and as far in advance of the time of commencement as the said district engineer may specify, and shall also notify him promptly, in writing, of the commencement of work, suspension of work, if for a period of more than one week, resumption of work, and its completion.

(*j*) That if the structure or work herein authorized is not completed on or before the thirty-first day of December, 1970, this permit, if not previously revoked or specifically extended, shall cease and be null and void.

(k) That the permittee shall comply promptly with any regulations, conditions, or instructions affecting the work hereby authorized if and when issued by the Federal Water Pollution Control Administration and/or the State water pollution control agency having jurisdiction to abate or prevent water pollution. Such regulations, conditions, or instructions in effect or prescribed by the Federal Water Pollution Control Administration or State agency are hereby made a condition of this permit.

By authority of the Secretary of the Army:

C. E. Adams

Plan attached

C. E. ADAMS, JR.
Colonel, Corps of Engineers
District Engineer

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Address reply to:
COMMANDER (o-2)
Fifth Coast Guard District
Federal Bldg.
431 Crawford St.
Portsmouth, Va. 23705

3264
18 March 1968

Mr. W. M. Wills, Director
Power Station Design
Post Office Box 1194
Richmond, Virginia 23209

Dear Mr. Wills:

Returned herewith as enclosure (1) is an approved copy of your Private Aids to Navigation Application Form CG-2554 which authorizes the establishment of Surry Power Station Daybeacons 1, 2, 3, 5, 7, 9, and 11 to mark the Virginia Electric Power Company's intake channel in the James River at Hog Island, Surry County, Virginia.

Please advise this office when these aids have been placed on station so that the information may be published in this district's Local Notice to Mariners. A Coast Guard inspection will be scheduled at that time.

Sincerely yours,

John A. Dearden
JOHN A. DEARDEN
Commander, U. S. Coast Guard
Chief, Aids to Navigation Branch
By direction of the Commander
Fifth Coast Guard District

Encl: (1) Approved CG-2554

DEPARTMENT OF TRANSPORTATION U. S. COAST GUARD CG-2554 (Rev. 4-67)	**PRIVATE AIDS TO NAVIGATION APPLICATION** *(See attached instructions and copy of Code of Fed. Reg., Title 33, Chap. 1, Sec. 66)*	Form approved Budget Bureau No. 48-R379.1

1. ACTION REQUESTED FOR PRIVATE AIDS TO NAVIGATION: A. [X] ESTABLISH AND MAINTAIN B. [ ] DISCONTINUE C. [ ] CHANGE D. [ ] CHANGE OWNERSHIP

2. DATE ACTION TO START: March 1, 1968

3. AIDS WILL BE OPERATED: A. [X] THROUGHOUT YEAR B. [ ] TEMPORARILY UNTIL ______ C. [ ] ANNUALLY FROM ______ TO ______

4. NECESSITY FOR AID *(Continue in Block 8)*: Guide shipping thru dredged channel

5. GENERAL LOCALITY: James River-Hog Island

6. CORPS OF ENGINEERS AUTHORIZED THIS STRUCTURE OR BUOY BY [X] PERMIT OR [ ] LETTER *(file and date)*: NAOOP-P (James River) 12 February, 1968

FOR DISTRICT COMMANDERS ONLY — 7. APPLICANT WILL FILL IN APPLICABLE REMAINING COLUMNS

LIGHT LIST NUMBER OR PAGE (1)	NAME OF AID (2a)	NO. OR LTR. (2b)	LIGHT PER. (2c)	LIGHT FLASH LGTH. (2d)	LIGHT COLOR (2e)	POSITION (3a)	DEPTH OF WATER (3b)	CANDLE-POWER (4)	HGHT. ABOVE WATER (5)	STRUCTURE TYPE, COLOR, and HEIGHT ABOVE GROUND (6)	REMARKS *(See Instructions)* (7)
						BEARING DISTANCE FROM SHORE LINE					
LLP 332	Surry Pwr. Sta. Dbns.	1				N69-30'-00"E 2000 yds	12.0		10.0	Single Pile	Black Rectangle
		2				N69-30'-00"E 2000 yds	12.0		10.0	Single Pile	Red Triangle
		3				N69-30'-00"E 1525 yds	4.0		10.0	Single Pile	Black Rectangle
		5				N69-30'-00"E 1050 yds	4.0		10.0	Single Pile	" "
		7				N69-30'-00"E 575 yds	4.0		10.0	Single Pile	" "
		9				N69-30'-00"E 100 yds	2.6		10.0	Single Pile	" "
		11				S 00-00'-00"E 250 yds from steel bulkhead dock or No. 9 marker	1.2		10.0	Single Pile	" "
						(See Reverse)					

RCV'D MAILROOM FIFTH CG DISTRICT PORTSMOUTH, VIRGINIA 18 MAR 68 08 31

8. ADDITIONAL COMMENTS

Protect oyster beds adjacent to channel by confining shipping to dredged area.

G-8 (2)

9a. NAME AND ADDRESS OF PERSON IN DIRECT CHARGE OF AID: Mr. W. M. Wills, Director Power Station Design P. O. Box 1194, Richmond, Va. 23209

9b. TELEPHONE NO.: 771-3271

10a. NAME AND ADDRESS OF PERSON OR CORPORATION AT WHOSE EXPENSE AID IS MAINTAINED: Virginia Electric and Power Company

10b. THE APPLICANT AGREES TO SAVE THE COAST GUARD HARMLESS WITH RESPECT TO ANY CLAIM OR CLAIMS THAT MAY RESULT ARISING FROM THE ALLEGED NEGLIGENCE OF THE MAINTENANCE OR OPERATION OF THE APPROVED AID(s).

10c. DATE: 3-1-68

10d. SIGNATURE AND TITLE OF OFFICIAL SIGNING: W. M. Wills, Director-Power Sta. Design

Reverse of CG-2554 (Rev. 4-67)

11. FIRST ENDORSEMENT FOR USE BY DISTRICT COMMANDER					SERIAL NO.
A. TO: Commandant (OAN)			B. FROM: Commander, Fifth Coast Guard District		
	YES	NO	F. CHARTS AFFECTED 529		G. CLASSIFICATION OF AIDS Class II
C. Approval is recommended	X				
D. Notice to Mariners will be issued	X		H. DATE 3/8/68	SIGNATURE (By direction) R. E. PHELPS	
E. Light List should be corrected	X				

12. FOR USE BY COMMANDANT (OAN)								
RECD.			L.N.M.			L/L		
CHART			W.N.M.			FILE		

13. SECOND ENDORSEMENT			
A. TO: Commander 5th Coast Guard District			B. FROM: Commandant (OAN)
C. Approved		F. DATE	G. SIGNATURE (By direction)
D. Approved as corrected	X	MAR 15 1968	J. A. GRANGER
E. See Remarks			

REMARKS: DISTRICT COMMENT: Charted positions to be:

D/B No. 1 - 37°09'43" N, 76°39'06" W

No. 2 - 37°09'47" N, 76°39'06" W

No. 3 - 37°09'38" N, 76°39'19" W

No. 5 - 37°09'33" N, 76°39'37" W

No. 7 - 37°09'28" N, 76°39'54" W

No. 9 - 37°09'24" N, 76°40'10" W

[redacted]1 - 37°09'16" N, 76°40'10" W

11

DATE	REFERENCE	ACTION AND REMARKS

	J	F	M	A	M	J	J	A	S	O	N	D

NAME OF AID	LIGHT LIST NO.	PAGE

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Address reply to:
COMMANDER(o-2)
Fifth Coast Guard District
Federal Bldg.
431 Crawford St.
Portsmouth, Va. 23705

3267
24 February 1970

Mr. W. M. Wills, Director
Power Station Design
Virginia Electric And Power Company
Post Office Box 1194
Richmond, Virginia 23219

Dear Mr. Wills:

Returned herewith is an approved copy of your application for the installation of lights to mark the stone groins along the discharge channel for your Surry Power Station in the James River.

As indicated on the cover sheet of the application form, it is necessary for you to advise this office when the lights are placed in operation so that the information may be published in this district's Local Notice to Mariners to apprise traffic in that area of the purposeful existence of these two lights.

Sincerely,

John A. Dearden

JOHN A. DEARDEN
Commander, U. S. Coast Guard
Chief, Aids to Navigation Branch
By direction of the Commander
Fifth Coast Guard District

Encl: (1) Approved Appl.

DEPARTMENT OF TRANSPORTATION
U. S. COAST GUARD
CG-2554 (Rev. 4-67)

PRIVATE AIDS TO NAVIGATION APPLICATION

(See attached instructions and copy of Code of Fed. Reg., Title 33, Chap. 1, Sec. 66)

Form approved Budget Bureau No. 48-R379.1

1. ACTION REQUESTED FOR PRIVATE AIDS TO NAVIGATION: A. [X] ESTABLISH AND MAINTAIN B. [ ] DISCONTINUE C. [ ] CHANGE D. [ ] CHANGE OWNERSHIP

2. DATE ACTION TO START: Approx. June 15, 1970

3. AIDS WILL BE OPERATED: A. [X] THROUGHOUT YEAR B. [ ] TEMPORARILY UNTIL ______ C. [ ] ANNUALLY FROM ______ TO ______

4. NECESSITY FOR AID (*Continue in Block 8*): Mark Stone Groins Along Discharge Channel

5. GENERAL LOCALITY: James River - Hog Island

6. CORPS OF ENGINEERS AUTHORIZED THIS STRUCTURE OR BUOY BY: [X] PERMIT OR [ ] LETTER (*file and date*) NAOOP-P 21 August 1967

FOR DISTRICT COMMANDERS ONLY

7. APPLICANT WILL FILL IN APPLICABLE REMAINING COLUMNS

LIGHT LIST NUMBER OR PAGE (1)	NAME OF AID (2a)	NO. OR LTR. (2b)	LIGHT PER. (2c)	FLASH LGTH. (2d)	COLOR (2e)	POSITION (3a) (Note 1.)	DEPTH OF WATER (3b)	CANDLE-POWER (4)	HGHT. ABOVE WATER (5)	STRUCTURE TYPE, COLOR, and HEIGHT ABOVE GROUND (6)	REMARKS (*See Instructions*) (7)
3080.30	VEPCO GROIN LT	A	1.0 (Qk	0.3 Fl)	R	E 2, 522, 704 N 310, 434 37° 10' 20" N 76° 42' 21" W	N.A.	15	20.2	Single light support pole; light 15' above top of stone groin	
3080.31	VEPCO GROIN LT	B	1.0 (Qk	0.3 Fl)	R	E 2, 522, 492 N 309, 975 37° 10' 16" N 76° 42' 24.5" W	N.A.	15	20.2	"	

8. ADDITIONAL COMMENTS

Note 1. Virginia Plane Grid Coordinates, South Zone

9a. NAME AND ADDRESS OF PERSON IN DIRECT CHARGE OF AID
Mr. E. M. Sweeney
Va. Electric & Power Co.
P. O. Box 315
Surry, Va. 23883

9b. TELEPHONE NO.
(703) 353-3184

10a. NAME AND ADDRESS OF PERSON OR CORPORATION AT WHOSE EXPENSE AID IS MAINTAINED
Virginia Electric & Power Co.
P. O. Box 1194
Richmond, Virginia 23219

10b. THE APPLICANT AGREES TO SAVE THE COAST GUARD HARMLESS WITH RESPECT TO ANY CLAIM OR CLAIMS THAT MAY RESULT ARISING FROM THE ALLEGED NEGLIGENCE OF THE MAINTENANCE OR OPERATION OF THE APPROVED AID(s).

10c. DATE
Jan. 29, 1970

10d. SIGNATURE AND TITLE OF OFFICIAL SIGNING
W. M. Wills
W. M. Wills, Dir.-Pwr. Sta. Design

Reverse of CG-2554 (Rev. 4-67)

11. FIRST ENDORSEMENT FOR USE BY DISTRICT COMMANDER SERIAL NO. 05-04-70-D

~~XXXXXXXXXXXXXXXXXX~~ FROM: Commander, Fifth Coast Guard District

	YES	NO
C. Approval is recommended	X	
D. Notice to Mariners will be issued	X	
E. Light List should be corrected	X	

F. CHARTS AFFECTED: 529

G. CLASSIFICATION OF AIDS: Class I

H. DATE: FEB 18 1970

SIGNATURE (By direction) E. H. BURT, JR.

~~XXXXXXXXXXXXXXXXXXXXXXXXXX~~

RECD.			L.N.M.			L/L		
CHART			W.N.M.			FILE		

~~XXXXXXXXXXXXXXXXXXXX~~

~~XXXXXXXXXXXXX~~ ~~XXXXXXXXXXXXXX~~ ~~XXXXXXXXXXXXXXXXXXXX~~

C. Approved	✓
D. Approved as corrected	
E. See Remarks	

F. DATE: FEB 18 1970

G. SIGNATURE (By direction) S. G. CARKEEK

REMARKS:

DATE	REFERENCE	ACTION AND REMARKS

J	F	M	A	M	J	J	A	S	O	N	D

NAME OF AID: VEPCO GROIN LTS A & B-CLASS I Assigned Norfolk Station

LIGHT LIST NO. 3080.30 3080.31

PAGE 342

G-10 (1)

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Address reply to:
COMMANDER (o-2)
Fifth Coast Guard District
Federal Bldg.
431 Crawford St.
Portsmouth, Va. 23705

3264
2 September 1969

Virginia Electric and Power Company
Richmond,
Virginia 23209

Attention: Mr. Kenny Moore

Dear Mr. Moore:

Enclosed herewith is an approved copy of your Private Aids to Navigation Application Form CG-2554 which authorizes the establishment of seven (7) lighted instrument towers in the James River near Hog Island.

It will be appreciated if you continue to report to this office by telephone as each light is established, confirming by letter upon completion of all seven towers.

Sincerely yours,

John A. Dearden

JOHN A. DEARDEN
Commander, U. S. Coast Guard
Chief, Aids to Navigation Branch
By direction of the Commander
Fifth Coast Guard District

Encl: (1) Approved copy of CG-2554

DEPARTMENT OF TRANSPORTATION
U. S. COAST GUARD
CG-2554 (Rev. 4-67)

PRIVATE AIDS TO NAVIGATION APPLICATION

(See attached instructions and copy of Code of Fed. Reg., Title 33, Chap. 1, Sec. 66)

Form approved Budget Bureau No. 48-R379.1

1. ACTION REQUESTED FOR PRIVATE AIDS TO NAVIGATION: A. [x] ESTABLISH AND MAINTAIN B. [ ] DISCONTINUE C. [ ] CHANGE D. [ ] CHANGE OWNERSHIP

2. DATE ACTION TO START: July 1, 1969

3. AIDS WILL BE OPERATED: A. [x] THROUGHOUT YEAR B. [x] TEMPORARILY UNTIL March 31, 1975 C. [ ] ANNUALLY FROM ______ TO ______

4. NECESSITY FOR AID *(Continue in Block 8)*: Environmental Survey Equipment Platform

5. GENERAL LOCALITY: James River-Hog Island

6. CORPS OF ENGINEERS AUTHORIZED THIS STRUCTURE BY: NAOOP-P (James River) [x] PERMIT OR [ ] LETTER *(file and date)* 16 July 1969

FOR DISTRICT COMMANDERS ONLY — 7. APPLICANT WILL FILL IN APPLICABLE REMAINING COLUMNS

LIGHT LIST NUMBER OR PAGE (1)	NAME OF AID (2a)	NO. OR LTR. (2b)	LIGHT PER. (2c)	FLASH LGTH. (2d)	COLOR (2e)	POSITION (3a)	DEPTH OF WATER (3b)	CANDLE-POWER (4)	HGHT. ABOVE WATER (5)	STRUCTURE TYPE, COLOR, and HEIGHT ABOVE GROUND (6)	REMARKS *(See Instructions)* (7)
3068.10	VEPCO INSTRUMENT TOWER LIGHTS	[redacted] A	1.0	0.3	W	37° -09'-25" N 76° -37'-30" W	5.5	15	15	single light support pile & 3 battered guard piles	DWG. FSK-506 DWG. FSK-507
3078.10		[redacted] B	1.0	0.3	W	37° -12'-52" N 76° - 41'-14" W	22.0	15	15	" " "	" " "
3079.10		[redacted] C	1.0	0.3	W	37° -12'-00" N 76° -41'-10" W	16.0	15	15	" " "	" " "
3079.20		[redacted] D	1.0	0.3	W	37° -12'-20" N 76° -43'-15" W	7.0	15	15	" " "	" " "
3080.10		[redacted] E	1.0	0.3	[illegible]	37° -11'-25" N 76° -42'-47" W	10.0	15	15	" " "	" " "
3080.20		[redacted] F	1.0	0.3	W	37° -10'-45" N 76° -42'-28" W	11.0	15	15	" " "	" " "
3085.10		[redacted] G	1.0	0.3	[illegible]	37° -11'-00" N 76° -45'-52" W	25.0	15	15	" " "	" " "

8. ADDITIONAL COMMENTS

9a. NAME AND ADDRESS OF PERSON IN DIRECT CHARGE OF AID

Mr. B. J. Peters
Virginia Electric & Pwr.Co.
P. O. Box 1194
Richmond, Virginia 23209

9b. TELEPHONE NO.
771-3336

10a. NAME AND ADDRESS OF PERSON OR CORPORATION AT WHOSE EXPENSE AID IS MAINTAINED

Virginia Electric and Power Company

10b. THE APPLICANT AGREES TO SAVE THE COAST GUARD HARMLESS WITH RESPECT TO ANY CLAIM OR CLAIMS THAT MAY RESULT ARISING FROM THE ALLEGED NEGLIGENCE OF THE MAINTENANCE OR OPERATION OF THE APPROVED AID(s).

10c. DATE: July 18, 1969

10d. SIGNATURE AND TITLE OF OFFICIAL SIGNING: W. M. Wills Director - Pwr. Sta.Design

G-10 (2)

FIRST ENDORSEMENT FOR USE BY DISTRICT COMMANDER — SERIAL NO.

A. TO: Commandant (OAN)

B. FROM: Commander Fifth Coast Guard District

	YES	NO
C. Approval is recommended	X	
D. Notice to Mariners will be issued	X	
E. Light List should be corrected	X	

F. CHARTS AFFECTED: 529

G. CLASSIFICATION OF AIDS: Class I

H. DATE: 7/31/69

SIGNATURE (By direction): R. E. PHELPS

12. FOR USE BY COMMANDANT (OAN)

8/6

RECD.	AUG 5 1969		L.N.M.			L/L	
CHART	529(1)		W.N.M.			FILE	

13. SECOND ENDORSEMENT

A. TO: Commander 5TH Coast Guard District

B. FROM: Commandant (OAN)

C. Approved	X
D. Approved as corrected	
E. See Remarks	

F. DATE: AUG 25 1969

G. SIGNATURE (By direction): J. A. GRANGER

REMARKS:

DATE	REFERENCE	ACTION AND REMARKS

	J	F	M	A	M	J	J	A	S	O	N	D

NAME OF AID | LIGHT LIST NO. | PAGE

COMMONWEALTH OF VIRGINIA

STATE CORPORATION COMMISSION

—0—

CERTIFICATE NO. ET-138

—0—

VIRGINIA ELECTRIC AND POWER COMPANY

by this Certificate of Public Convenience and Necessity is hereby authorized under the Utility Facilities Act to

~~XXXXX~~ ~~XXXXXXXXX~~

construct and operate proposed transmission lines and other facilities in Surry County, including a proposed nuclear generating station, the locations being shown by dashed blue and red lines, etc.,

as outlined - - -

on the attached map stamped—Received March 20, 1967

Dated at Richmond, Va. March 27, 1967.

STATE CORPORATION COMMISSION

By [signature]

Commissioner

COMMONWEALTH OF VIRGINIA

STATE CORPORATION COMMISSION

—0—

CERTIFICATE NO. ET-138a

—0—

VIRGINIA ELECTRIC AND POWER COMPANY

by this Certificate of Public Convenience and Necessity is hereby authorized under the Utility Facilities Act to

XXXXX XXXXXXXX

operate present transmission lines and facilities in Surry County, and to construct and operate transmission lines and facilities, previously approved but not constructed, and to construct and operate proposed transmission lines and facilities, including a proposed generating unit No. 2 at the Surry Power Station, as shown

(Note: This Certificate No. ET-138a cancels and replaces Certificate No. ET-138, issued on March 27, 1967.)

XXXXXXXX

on the attached map stamped—Received June 17, 1968.

Dated at Richmond, Va. July 16, 1968.

STATE CORPORATION COMMISSION

By _______________
Commissioner

SURRY COUNTY HEALTH DEPARTMENT
SURRY, VIRGINIA 23883

G-12 (1)

27 February 1969

OPERATION WITH THE
..TE DEPARTMENT OF HEALTH

NOTED MAR 0 3 1969 W.M.W.

Mr. W. M. Wills
Director, Power Station Design
Virginia Electric and Power Company
Richmond, Virginia 23209

Re: Plan of Sewage Disposal System
Vepco Power Station - Surry

Dear Mr. Wills:

The plans and specifications of the sewage disposal system for the Vepco Power Station have been reviewed by this department.

This is to notify you that the plans have been approved and construction may begin.

Sincerely,

R.P. Ostergard

R. P. Ostergard, M. D.,
Assistant Director, Surry Health Dept.

Gordon Berryman

Gordon C. Berryman III, Sanitarian
Surry Health Department

RPO:b

COMMONWEALTH OF VIRGINIA

DOUGLAS B. FUGATE, COMMISSIONER
L. BAUGHAN, LURAY, VA.
RANSDELL CHILTON, LANCASTER, VA.
S. S. FLYTHE, MARTINSVILLE, VA.
R. S. HOLLAND, VIRGINIA BEACH, VA.
GEORGE C. LANDRITH, ALEXANDRIA, VA.
LAWRENCE H. MCWANE, LYNCHBURG, VA.
W. M. SCLATER, JR., MARION, VA.
ROBERT S. WEAVER, JR., VICTORIA, VA.

DEPARTMENT OF HIGHWAYS
RICHMOND, VA. 23219

~~JOHN E. HARWOOD,~~
DEPUTY COMMISSIONER & CHIEF ENGINEER
A. B. EURE, DIRECTOR OF ADMINISTRATION
D. N. HUDDLE, DIRECTOR OF ENGINEERING
J. V. CLARKE, DIRECTOR OF OPERATIONS
W. S. G. BRITTON,
DIRECTOR OF PROGRAMMING AND PLANNING

CHARLES P. JOHNSTON
DISTRICT ENGINEER

IN REPLY PLEASE REFER TO
Route 617 - Proj.0617-090-124
Industrial Access Road

OFFICE OF DISTRICT ENGINEER
SUFFOLK, VA. 23434

Waverly, Virginia
December 12, 1966

Mr. E. V. Crutchfield, Vice President
Virginia Electric and Power Company
Richmond, Virginia 23209

Dear Mr. Crutchfield:

This is to acknowledge your letter of December 9, in which you wish to get permission to construct your detour as soon as possible. Insofar as this office is concerned, and I am sure that Mr. Blundon will agree, it is satisfactory for you to start construction on this detour at your earliest convenience.

I do not have a set of the plans for the road in this office. By copy of this letter to Mr. H. G. Blundon, I am requesting him to furnish you this information as soon as possible.

We appreciate your interest in getting this road in as soon as possible.

Yours very truly,

Frank Robinson

W. Frank Robinson
Resident Engineer

WFR/rc
cc: Mr. H. G. Blundon

NOTED DEC 13 1966 E.B.C.

December 9, 1966

Mr. W. F. Robinson
Resident Engineer
Virginia Department of Highways
Waverly, Virginia 23890

Dear Mr. Robinson:

As you know, Company personnel have discussed with you and Mr. H. G. Blunden, Engineer in Secondary Roads, of the Highway Department, the changes in State Route 617 that will be necessary in order to permit the Company to construct its $200,000,000 nuclear power plant in Surry County. In those discussions, in addition to improvements to be made by the State Highway Department in the portions of Route 617 leading to our property, with industrial access funds, we have also discussed with you the necessity of relocating the portion of that highway that presently bisects the proposed plant site.

In these discussions both you and Mr. Blunden have advised us that the State Highway Department will consent to the required relocation of Route 617 in the plant site area. You have assured us that the necessary conveyances will be executed by the Highway Department upon our completion, at our expense, of an alternate route through our property, meeting GS-3 standards except for one curve, not to exceed 16 degrees, as shown on attached sketch F. SK. No. 3, "Proposed Relocation of Virginia Highway Route 617". Please advise us in the near future as to the connection points at our property boundaries, and we will determine the exact location of the route through our property.

Meanwhile, as you know, we are most anxious to begin site preparation work as soon as possible and you have advised us that upon written request you will grant us permission to close that portion of the road through the plant site, provided we construct a detour to assure continued use of the route. We understand that this detour need not meet all of the GS-3 requirements.

We would appreciate your consent to this detour as soon as possible so as not to delay our schedule for construction of the plant.

We would also appreciate your advising as soon as possible as to the permanent connecting points referred to above. As soon as we receive definitive word from you on this we will be able to proceed immediately with the design and construction of the relocated portion of Route 617 through our property.

We would appreciate your confirmation of this understanding.

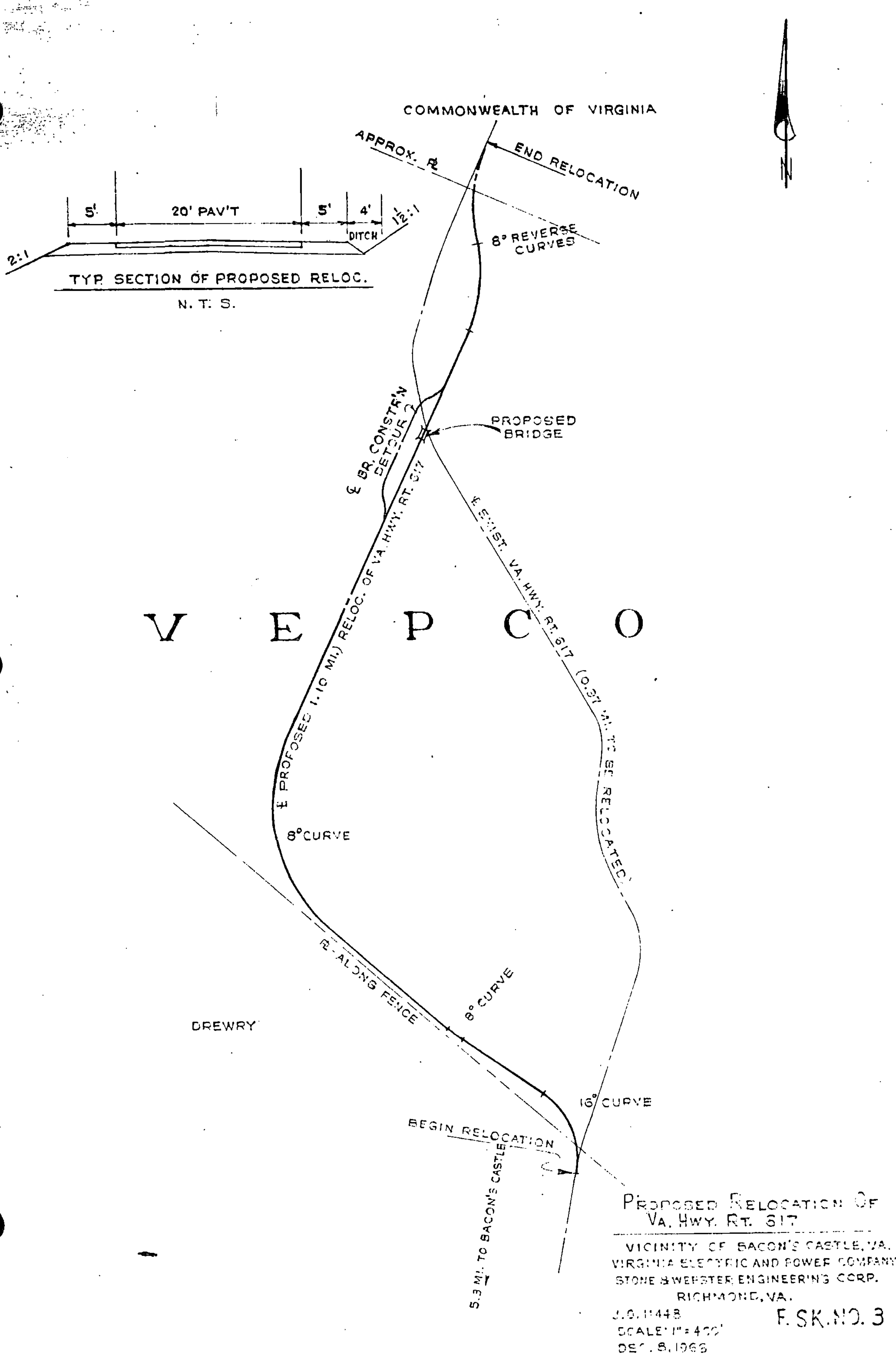
Sincerely yours,

Virginia Electric and Power Company

By J D Ristroph for
E. B. Crutchfield
Vice President

cc: Mr. H. G. Blunden

bc: Mr. J. D. Ristroph
Mr. Miles Cary
Mr. W. M. Wills


COMMONWEALTH OF VIRGINIA
APPROX. ℄
END RELOCATION
N
8° REVERSE CURVES
5'
20' PAV'T
5'
4'
DITCH
2:1
TYP. SECTION OF PROPOSED RELOC.
N. T. S.
PROPOSED BRIDGE
℄ BR. CONST'N DETOUR
℄ EXIST. VA. HWY. RT. 617 (0.37 MI. TO BE RELOCATED)
℄ PROPOSED (1.10 MI.) RELOC. OF VA. HWY. RT. 617
V E P C O
8° CURVE
℄ ALONG FENCE
8° CURVE
DREWRY
16° CURVE
BEGIN RELOCATION
5.3 MI. TO BACON'S CASTLE
PROPOSED RELOCATION OF VA. HWY. RT. 617
VICINITY OF BACON'S CASTLE, VA.
VIRGINIA ELECTRIC AND POWER COMPANY
STONE & WEBSTER ENGINEERING CORP.
RICHMOND, VA.
J.O. 11448
SCALE: 1"=400'
F. SK. NO. 3

COMMONWEALTH OF VIRGINIA **STATE WATER CONTROL BOARD**

P. O. BOX 11143 - RICHMOND, VIRGINIA 23230 - (703) 770-2241

BOARD MEMBERS
W. P. GRIFFIN
HENRY S. HOLLAND, III
W. H. SINGLETON
ROSS H. WALKER
E. BLACKBURN MOORE
CHAIRMAN

December 15, 1967

Mr. J. D. Ristroph, Manager
Power Production
Virginia Electric and Power Company
Surry Power Station
Surry, Virginia

Dear Mr. Ristroph:

Enclosed is the original and two copies of Certificate No. 1843. Would you please sign the copy in the space indicated and return it to this office at your earliest convenience.

Please note that Paragraph 5 pertains to the quality of your effluent and its effect upon the receiving State waters. Water quality standards have been established by the Board for Section 26 of the Lower James River into which your effluent is discharged.

With reference to the standards which have been established, it is important that adequate analytical data concerning plant effluent and the receiving stream be obtained. It will be your responsibility to keep the records as referred to in Paragraphs 13 and 14 of the certificate.

We would like to confer with you later about the information which these reports should contain.

If you have any questions, or if we can be of any assistance to you, please do not hestitate to contact us.

Very truly yours,

Charles E. Cooley

C. E. Cooley, Director
Pollution Abatement Division

CEC/mjs
Enclosures (3)
cc: State Corporation Commission

CLEAN STREAMS PROVIDE HEALTH WEALTH AND RECREATION

COMMONWEALTH OF VIRGINIA **STATE WATER CONTROL BOARD**

P. O. BOX 11143 - RICHMOND, VIRGINIA 23230 - (703) 770-2241

BOARD MEMBERS
W. P. GRIFFIN
HENRY S. HOLLAND, III
W. H. SINGLETON
ROSS H. WALKER
E. BLACKBURN MOORE
CHAIRMAN

CERTIFICATE NO. 1843

Issued on December 12, 1967 in accordance with the
State Water Control Law
Chapter 2, Title 62, Code of Virginia, 1950

to

Virginia Electric and Power Company
(of Richmond, Virginia)
Surry Power Station
Surry, Virginia

an "owner" as defined in the Law, to discharge industrial wastes waters into the James River (Section 26, Lower James River Basin), in accordance with the following conditions:

1. Manufacturing operations and industrial wastes resulting therefrom shall be in accordance with a letter and report dated September 11, 1967, from Mr. J. D. Ristroph, Manager - Power Production.

2. This certificate is in accordance with an action taken by the Board in Minute 31 of its meeting of November 28, 1967, at which time the Board approved the report described in (1) above.

3. All industrial wastes from the owner's establishment shall be treated in the facilities, or in such other manner as referred to in (1) above.

4. The industrial wastes referred to in this certificate shall be maintained at all times of such quality that, upon adequate mixing with the receiving State waters and in combination with any other waste discharges certificated by the Board, the standards of quality established by the Board shall be maintained in the receiving State waters.

5. In issuing this certificate, the Board has relied upon the statements and representations made by the owner in its application and other correspondence or communications.

6. In issuing this certificate, the Board has not taken into consideration the structural stability of any of the units or parts thereof.

CLEAN STREAMS PROVIDE HEALTH WEALTH AND RECREATION

NOTED DEC 22 1967 J.D.R.

7. When the construction referred to in (1) above has been completed, a statement shall be submitted by the owner certifying that construction has been in accordance with (1) above.

8. Operations involving the discharge of industrial wastes to State waters shall not be begun until the facilities referred to in (1) above have been completed.

9. Sufficient maintenance shall be practiced on the facilities referred to in (1) above at all times to insure effluent quality in accordance with the terms of this certificate.

10. Removal of any solids from the waste treatment facilities referred to in (1) above shall be under such conditions that they do not subsequently reach State waters.

11. This certificate shall become void should the establishment here certificated be closed for a period in excess of six months.

12. Reports on the receiving stream and such other State waters as are or may be potentially affected as a result of the waste discharge referred to in (1) above shall be kept by the owner and subject to inspection by the Board's authorized representatives and shall be submitted with such frequency and in such detail as to be satisfactory to the Board and its staff.

13. Reports on the operation of the facilities referred to in (1) above and the quantity and quality of effluent from such facilities shall be kept by the owner and subject to inspection by the Board's authorized representatives and shall be submitted with such frequency and in such detail as to be satisfactory to the Board and its staff.

14. This certificate cannot be transferred or assigned. Any new owner or successor in interest to the above owner must make application for a new certificate prior to assuming ownership and commencing operations.

15. The Board may amend or revoke this certificate for good cause and after proper hearing.

E. Blackburn Moore

E. BLACKBURN MOORE, CHAIRMAN

CEC/mjs
Enc. (3)

June 29, 1971

State Water Control Board
Commonwealth of Virginia
4010 West Broad Street
Richmond, Virginia 23230

Attention: Mr. A. H. Paessler

Gentlemen:

We request that the State Water Control Board, on the basis of our Certificate No. 1843, the information supplied in the application therefor and any other information on file with your Board, issue a Certificate of Assurance for discharges from our Surry Power Station, as required by § 21(b) of the Water Quality Improvement Act. If the staff needs any data other than that already on file, please feel free to contact us.

Very truly yours,

J. D. Ristroph
J. D. Ristroph
Executive Director
Environmental Control

JDR/db

bc: Mr. E. B. Crutchfield
Mr. Stanley Ragone
Mr. T. T. Smith

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

June 15, 1971

Mr. Harold L. Price
Director of Regulation
Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Price;

The attached draft environmental impact statement on considerations related to the proposed operation of VEPCO's Surry Power Station Units 1 and 2 has been reviewed in the relevant agencies of the Department of Agriculture and we have no comments to make.

Sincerely,

T. C. Byerly

T. C. BYERLY
Coordinator, Environmental
Quality Activities

Enclosure

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20315

IN REPLY REFER TO

ENGCW-ON

9 June 1971

Mr. Harold L. Price
Director of Regulation
Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Price:

The draft statement on environmental considerati s related to the proposed operation of Surry Power Station Units and 2 by the Virginia Electric and Power Company, Docket Numb 50-280 and 50-281, issued 22 March 1971 has been reviewed with resp t to the Civil Functions of the U. S. Army Corps of Engineers and no comm ts are offered.

Sincerely yo s,

Paul C. Driscoll LTC CE

for J. B. NEWMAN
Colonel, Cor of Engineers
Executive Di ctor of Civil Works

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

G-17 (1)

JUN 21 1971

Dear Mr. Price:

On March 31 you requested our comments on your draft detailed statement and the environmental report submitted by the Virginia Electric and Power Company for the AEC (Docket Nos. 50-280 and 50-281.) The report was furnished in accordance with Section 102(2)(C) of the National Environmental Policy Act of 1969 in conjunction with a request for an operating license for Surry Power Station, Units 1 and 2, Surry County, Virginia.

This report has been reviewed by various units of this Department having special expertise in fields covered by the draft statement and their comments are included below for your consideration. Unit 1 is scheduled for commercial operation in late 1972. Unit 2 is scheduled for operation in the 2nd quarter of 1972.

Overall the applicant has prepared a good environmental statement. The Company has complied with the various laws which are applicable. Our concern is that the Company comply not only with the law but with the intent so that the environment can be fully protected if not enhanced.

Thermal Effects--The James River estuary, just below this plant, is the major seed oyster producing area in Virginia. To avoid any thermal impact on these oyster beds, condenser cooling water is to be taken from the James River on the east side or downstream of the site and, after being heated, discharged on the west side or upstream. Cooling water would be circulated at a rate of 3,444 cfs (cubic feet per second) for the two units. Based on records for the period October 1934 to September 1965, the applicant determined that the minimum mean-monthly fresh-water discharge for the James River at the site has been 857 cfs. But during the period August through October 1930, an interpretation of upstream records indicates that mean flow was less than 700 cfs with the lowest mean monthly flow being about 600 cfs. During this drought the flow was about 440 cfs for 7 consecutive days.

2678

As in most estuaries, the oscillatory tidal flow is much greater than the fresh-water flow. Being oscillatory, such flow flushes contaminants out of the estuary only by dispersion--since most of the same water moving seaward on the ebb tide returns upstream on the flood tide. Dispersive flushing may be a very slow process, especially where tidal range in stage is small, such as in the James River estuary.

Superimposed upon the oscillatory tidal flows and the fresh-water flows, there is a net nontidal circulation caused by intrusion of saline water within the estuary. The applicant states that this circulatory flow is several-fold larger than the fresh-water discharge. Of the tidal, fresh-water, and circulatory discharges, convective transport of contaminants by the last two may be the most important.

The applicant has utilized a physical model to aid in designing the cooling water intake and discharge systems and to evaluate temperature effects in the estuary near the plant site. The design of the station discharge is intended to cause the water, which has been heated by 14°F, to mix and thereby become reduced rapidly in temperature. Based on these model tests, the applicant states that a maximum temperature rise of 1.4°F may be realized at the far shore under summer conditions. However, it is becoming generally recognized (Harleman and others, 1966) that the results of dispersion studies, such as the movement of heated water and radionuclides, may be invalid when based on physical models.

The reliance on a physical model for evaluating temperature effects, the failure to consider the worst low fresh-water flow conditions, and the possible overestimation of the ability of tidal discharges to flush contaminants from the estuary make the applicant's evaluation of the thermal effect questionable. Post-operational measurement of temperatures is desirable and may dictate that remedial measures be taken if the present design does not meet the new water-quality standards of the Virginia State Water Control Board. Information on measures the company feels it could take if, for example, temperature standards were not met should be added to the statement.

Harleman, D. R. F., E. R. Holley, and W. C. Huber, Interpretation of Water Pollution data from tidal estuary models: Proc., Third International Conf. on Water Pollution Research, 1966.

Aquatic Resources--The environmental statement is inadequate because of failure to include provisions that the company will make modifications in equipment or operations to correct any damages noted during preoperational and/or postoperational investigations or through accidental discharge from the plant.

Compliance with the above considerations will assure protection of the indigenous fish and wildlife resources and other aquatic resources of the project area.

We note with satisfaction the cooperative efforts of the applicant with the Virginia State Game and Inland Fisheries Commission to stabilize the reservoir of food by providing 400,000 cubic yards of surplus material for constructing and improving dikes surrounding the game management area and preventing "washing" from salt water causing sudden changes in the salinity of the marsh water.

Monitoring--The environmental surveillance program set forth in the draft environmental statements of the Atomic Energy Commission and Virginia Electric and Power Company appears to have only minor deficiencies.

Fish and aquatic vegetation should be sampled. We are concerned with the possibility of damages to finfish and aquatic life. Radiological monitoring sampling should include species of carnivorous and herbivorous fishes and aquatic vegetation collected within 500 feet of the discharge.

We do not believe it necessary to select samples of all fish or aquatic plant species. A few representative species should provide an indication of radionuclide accumulation, if any. The inclusion of such samples in the environmental surveillance program would require little additional effort.

Geologic and Hydrologic Safety--The Geological Survey has reviewed geologic and hydrologic aspects of the site for the Atomic Energy Commission, Division of Regulations, in connection with the construction applications for both Units 1 and 2 (see attachments dated April 25, 1967, and March 18, 1968). At AEC's request, this review pertained to safety aspects of the site such as faulting, earthquake effects, foundation conditions, and flood protection.

There is little geologic information in the draft statement with which to make an evaluation of the impact of the operation of the plant on the geologic environment.

Historical and Archeological---The Jamestown National Historic Site and Chippokes Plantation (a National Register property) are located slightly upstream but in close proximity to the station. Operation of the nuclear power station should have negligible, if any, direct adverse effect on the esthetic qualities of these two areas. There could be considerable indirect impact on the esthetics of this area of the James River. As pointed out above, model studies may not reflect actual operation. A statement should be included indicating the Company will modify equipment or operations to protect the area if continuing monitoring discloses environmental degradation not revealed during the planning and construction.

We are not aware of and the statement does not discuss any significant archeological remains on the site. The statement should reflect the Company's awareness of the importance of reporting and protecting archeological finds so that they might receive proper study and recognition.

We appreciate the opportunity of commenting upon this proposal.

Sincerely yours,

Jack O. Horton

Deputy Assistant Secretary of the Interior

Mr. Harold L. Price
Director of Regulation
U.S. Atomic Energy Commission
Washington, D.C. 20545

Enclosure

Vepco Response

Applicant has considered all points commented upon in the letter from the U.S. Department of the Interior. All comments are directed toward possible improvements in Applicant's environmental protection program, rather than to specific omissions or errors. The Department states that "...Applicant has prepared a good environmental statement..." but that the primary concern is for "...the Company [to] comply not only with the law but with the intent so that the environment can be fully protected if not enhanced. Vepco responses to specific items are given below:

a. Thermal effects: Four studies of the James River Estuary hydrology in the vicinity of Surry Power Station have been conducted by Pritchard-Carpenter, Consultants, of the Chesapeake Bay Institute, for the Applicant. Their studies, over the period of November 1966 to January 1971, have utilized mathematical modeling techniques and represent extensions of Applicant's original work with the physical model. Factors considered in addition to net dilution water flow for mixing purposes are wind and ambient temperature conditions, as related to the air/water heat exchange capabilities. (See Appendix B)

Results of the studies, some of which are on record in summary form with the State Water Control Board, we believe provide reasonable assurance that the proposed operation of Surry Units 1 and 2, as presently designed, will be acceptable by applicable water quality standards.

As noted in Section I.D.1, Applicant has applied to the Corps of Engineers for a use permit, under 1899 Refuse Act, and is currently awaiting the outcome of that review. (See Appendix G-4)

b. Aquatic resources: Applicant is unaware of any significant damages to aquatic resources which have been or will be caused by Surry Power Station; furthermore, Applicant is willing to cooperate in efforts to monitor the effects of the power station on these resources, in order that should significant adverse effects be detected, remedies may be considered and evaluated.

c. Monitoring: Applicant has been conducting an ecological monitoring program for several years to determine pre-operational environmental conditions and construction effects. This program includes a representative sampling of fish and aquatic vegetation found in the vicinity of the station. Applicant is willing to consider the white perch for monitoring purposes but it has been unsuccessful in locating this fish on a periodic sample basis in the vicinity of the station canal discharge. (See Appendix F).

d. Geologic and Hydrologic Safety: Applicant has conducted extensive studies of these effects upon the station as presently designed. These studies are a matter of public record in Sections 2.3, 2.4, and 2.5 of the Safety Analysis Report. Where results of the studies have indicated the need for corrective work, this work is now in progress.

Radiological effects on site hydrology may be classified as consequences of radiological releases and will be discussed as such in the revised Environmental Report. Since expected maximum releases are as low as practicable, however, any effects on site hydrology will be minimal.

e. Historical and Archaeological: Applicant's environmental monitoring program will point out those effects, including the effect upon local esthetics, which may need to be reduced or corrected to preserve environmental quality.

Applicant acknowledges the importance of archaeological finds to society and is most willing to cooperate in their protection. One such find, which was believed to have been the site of an old church, was excavated under Applicant's funding; however, nothing of significant importance was discovered.

f. Summary: Additional discussions of each topic above may be found elsewhere in this report. Pertinent sections are as follows:

1. Thermal effects: Section II.I.C.2 and Appendix B*
2. Aquatic resources: Section I.C.2. and Appendix C
3. Monitoring: Appendix C
4. Geologic and Hydrologic: Section I.C.
5. Historical and Archaeological: Section I.C.1.

*Information relative to river flows can be found in Appendix B.

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

OCT 21 1971

Docket No. 50-280
and 50-281

Virginia Electric and Power Company
ATTN: Mr. Stanley Ragone
Vice President
P. O. Box 1194
Richmond, Virginia 23209

Gentlemen:

During our review of your application for an operating license for Surry Power Station, Units 1 and 2, we requested the comments and recommendations of the U. S. Department of the Interior, Fish and Wildlife Service. A copy of the Fish and Wildlife Service's report, containing comments and recommendations on environmental effects associated with the proposed construction and operation of the Surry Power Station, is enclosed for your information. Copies of the report are also being sent to the appropriate State and local officials. The information and recommendations in the report will be considered in our overall evaluation of the Surry Power Station.

We concur with the Department of the Interior's comments and recommendations and therefore request that you implement them, including continuing to cooperate with appropriate Federal and State agencies in developing the necessary program for the preoperational and post-operational environmental monitoring surveys. Twenty copies of the results of your preoperational surveillance program should be submitted to us as soon as it is availabl

Please inform us in detail how you intend to implement each of the Department of Interior's comments and recommendations.

Sincerely,

Peter A. Morris, Director
Division of Reactor Licensing

Enclosure:
Fish & Wildlife Service Report
dated 10/4/71

cc: (see next page)

ADDRESS ONLY THE DIRECTOR
BUREAU OF SPORT FISHERIES
AND WILDLIFE

United States Department of the Interior
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
WASHINGTON, D.C. 20240

OCT 4 1971

Mr. Harold L. Price
Director of Regulation
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Price:

This letter contains our Bureau's comments on the Virginia Electric and Power Company's application for an operating license for the Surry Power Station, Units 1 and 2, James River, Virginia, AEC Docket Nos. 50-280 and 50-281. The Final Safety Analysis Report and all subsequent amendments through No. 22 also were reviewed in conjunction with the application. The comments of the Mid-Atlantic Coastal Fisheries Research Center, NMFS, Department of Commerce, were obtained and are included in this review.

Former Acting Commissioner Pancochar's letter of comment on the construction permit, dated September 8, 1967, described the physical features of the project, discussed the fish and wildlife resources that would be affected, and recommended measures to protect these resources from significant damage. Former Commissioner Pautzke's letters of February 12 and April 9, 1968, provided additional comments. The construction permit was issued on June 25, 1968. We understand that construction of the project is substantially complete and fuel loading is scheduled for January 1972.

The preoperational radiological monitoring program initiated in 1968 is generally satisfactory. However, it should be expanded to include representative species of carnivorous and herbivorous fishes and aquatic vegetation collected within 500 feet of the discharge point. With these additions, the radiological monitoring program would be satisfactory insofar as the fish and wildlife resources are concerned. It will be necessary to conduct postoperational radiological monitoring surveys to determine the extent of radioactivity buildup, if any, in the aquatic and terrestrial organisms.

Operation of the project has the potential of affecting the aquatic resources of the James River estuary adversely. We are concerned that damage to aquatic life may result from the release of heated condenser cooling water and that a significant number of aquatic organisms may become entrained in the cooling water intake structure and destroyed.

4 E R E

Based on records for the period from October 1934 to September 1965, the applicant determined that the minimum mean-monthly fresh-water discharge for the James River at the project site was 657 cfs. During the period August through October 1930, an interpretation of upstream records indicates that mean flow was less than 700 cfs with the lowest mean monthly flow being about 600 cfs. During this drought, the flow was about 440 cfs for seven consecutive days.

As in most estuaries, the oscillatory tidal flow is much greater than the fresh-water flow. Being oscillatory, such flow flushes contaminants out of the estuary only by dispersion--since most of the same water moving seaward on the ebbtide returns upstream in the flood tide. Dispersive flushing may be a very slow process, especially where tidal range in stage is small, such as in the James River estuary.

Superimposed upon the oscillatory tidal flows and the fresh-water flows, there is a net nontidal circulation caused by intrusion of saline water within the estuary. The applicant states that this circulatory flow is several-fold larger than the fresh-water discharge. Of the tidal, fresh-water, and circulatory discharges, convective transport of contaminants by the last two may be the most important.

The applicant used a physical model to aid in designing the cooling water intake and discharge systems and to evaluate temperature effects in the estuary near the plant site. The design of the station discharge is intended to cause the water, which has been heated by 14° F, to mix and thereby become reduced rapidly in temperature. Based on these model tests, the applicant states that a maximum temperature rise of 1.4° F may be realized at the far shore under summer conditions.

A paper entitled "Interpretation of Water Pollution Data from Tidal Estuary Models" by D. R. F. Harleman, E. R. Holley Jr., and W. C. Huber, published in the Third International Conference on Water Pollution Research, Vol. 3, 1966, indicates that the results of dispersion studies, such as the movement of heated water and radionuclides, may be invalid when based on physical models.

The reliance on a physical model for evaluating temperature effects, the failure to consider the worst low fresh-water flow conditions, and the possible overestimation of the ability of tidal discharges to flush contaminants from the estuary appears to make the applicant's evaluation of the thermal effect questionable.

In view of the above, postoperational monitoring of water temperatures will be necessary to determine the impact of the heated effluent on aquatic resources. The company has expressed assurance that the problem referenced above will be resolved satisfactorily. Therefore, we would have no objection to the issuance of the operating license. However, we recommend that prior to issuance of the operating license, the applicant provide assurance that the project will be operated in a manner which will not reduce the quality of the water or affect the fish and wildlife resources and the environment of the James River estuary adversely.

We further recommend that the Virginia Electric and Power Company:

1. Continue to cooperate with the Bureau of Sport Fisheries and Wildlife, other concerned Federal agencies, and the appropriate State agencies in the development of the radiological and ecological monitoring programs and other studies.

2. Continue to conduct preoperational radiological and ecological surveys developed in cooperation with the above-named agencies. Prepare reports of these surveys, and provide six copies of each to the Director, Bureau of Sport Fisheries and Wildlife, for evaluation prior to project operation.

3. Meet regularly with the above-named agencies to discuss any new or modified plans, the progress of the radiological and ecological surveys, and other studies.

4. Conduct postoperational radiological and ecological surveys in accordance with plans developed under recommendation No. 1 and as may be modified under recommendation No. 3 above. Prepare reports annually or until it has been conclusively demonstrated that no significant adverse conditions exist, and submit six copies of these reports to the Director, Bureau of Sport Fisheries and Wildlife, for evaluation.

5. Maintain adequate flexibility of plan design to permit such modifications in project structures and operations, including facilities to reduce the temperature of the effluent water and installation of fish protective devices at the intake structure as may be determined necessary as a result of the preoperational and postoperational surveys and other studies to protect the fish and wildlife resources and the environment.

The opportunity for providing our comments is appreciated.

Sincerely yours,

Willis King

Assistant Director

Vepco Response

Concerns stated in the Fish and Wildlife Service letter (October 4, 1971) are almost identical to those expressed above in G-17 and G-17a. Applicant has already submitted the required number of copies of the material requested by the AEC letter (October 26, 1971) in its FSAR Amendment 16 of December 1, 1970 in answer to supplemental question 11.4.

ADVISORY COUNCIL
ON
HISTORIC PRESERVATION

WASHINGTON, D.C. [illegible]

April 13, 1970

Mr. Peter A. Morris, Director
Division of Reactor Licensing
Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Morris:

In response to your request of March 9, 1970, for the comments of the Advisory Council on Historic Preservation concerning the location of the Surry Power Station in Surry County, Virginia, in relation to the Chippokes Plantation, the Council has considered the effect of this undertaking upon the National Register property.

In accordance with its procedures the Council has received an evaluation of the effect of the power station at the construction site and has reached the conclusion that the probable effect upon the Chippokes Plantation cannot be judged to be sufficiently adverse to warrant Council comment.

Sincerely yours,

Robert R. Garvey, Jr.

Robert R. Garvey, Jr.
Executive Secretary

cc: Dr. Edward P. Alexander, State Liaison Officer for Historic Preservation, Room 1106, State Ninth Street Office Building, Richmond, Virginia 23219

THE COUNCIL is charged by the Act of October 15, 1966, with advising the President and Congress in the field of Historic Preservation, recommending measures to coordinate governmental with private activities, advising on the dissemination of information, encouraging public interest and participation, recommending the conduct of special studies, advising in the preparation of legislation, and encouraging specialized training and education. The Council also has the responsibility to comment on Federal or Federally-assisted undertakings that have an effect on cultural property listed in the National Register.

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Address reply to:
COMMANDANT (AWL)
U.S. COAST GUARD
WASHINGTON, D.C. 20591

RECEIVED
MAY 1971
U.S. ATOMIC ENERGY COMMISSION
Regulatory
Mail Section

MAY 1971

Mr. Harold L. Price
Director of Regulation
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Price:

This is in response to your letter of 31 March 1971 addressed to Mr. Michael S. Cafferty, Acting Assistant Secretary for Environment and Urban Systems, Department of Transportation, concerning your draft environmental statement and Virginia Electric and Power Company's environmental report for the Surry Power Station Units 1 and 2, presently under construction at Gravel Neck, James River in Surry County, Virginia.

The concerned operating administration and staff of the Department of Transportation have reviewed both the draft statement and environmental report. It is the determination of the Department that the impact of this project upon transportation is minimal.

Although this Department recommends issuance of the license and early completion of the project we are concerned greatly with section 3.3 "Heat Dissipation", page 9 of the draft report.

The James River is considered a navigable waterway and as such this Department is vitally interested in any environmental aspect affecting the river. Noted in the staff review of the impact statement was the fact that the design of the cooling water system indicates a potential for build-up of heated water in the river which could produce severe environmental and ecological effects particularly during periods of low flow. From a practical standpoint it can be assumed that the periods of low flow will be during the summer months which also happen to be the periods when the plants will be operating at fairly high peaks with each unit requiring 840,000 gpm of river water to supply condensing and service water needs. This issue certainly requires further discussion in more detail. This Department defers to the reviews of the Fish and Wildlife Service and the Environmental Protection Agency which appear to be essential in this case.

The opportunity offered the Department of Transportation to review and comment on the environmental statement and the environment report for Surry Power Station Units 1 and 2 is appreciated.

Sincerely,

R. Y. EDWARDS
Rear Admiral, U. S. Coast Guard
Chief, Office of Public and International Affairs

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

G-21 (1)

JUN 4 1971

Mr. Harold L. Price
Director of Regulation
U. S. Atomic Energy Commission
Washington, D. C. 20545

50-280
50-281

Dear Mr. Price:

This is in reference to your letter of March 31, 1971, requesting comments of the Federal Power Commission on the Draft Detailed Statement on Environmental Considerations by the U. S. Atomic Energy Commission related to the Proposed Operation of Surry Power Station Units 1 and 2 by the Virginia Electric and Power Company, Docket Nos. 50-280 and 50-281.

These comments are in accordance with the National Environmental Policy Act of 1969 and the guidelines of the President's Council on Environmental Quality dated April 23, 1971. Our comments take into account the fact that this project is in an advanced stage of construction and that the applicant is expecting the first unit to go into commercial service in February 1972 and the second unit in June 1972.

The Need for Power

The Surry nuclear power station is located on the James River in Surry County, Virginia, 25 miles northwest from Norfolk on a point of land called Gravel Neck. According to the applicant's environmental report, the Company's system reserve capacity during the coming summer of 1971 when augmented by firm purchases is expected to be 11.8 percent and that of the summer of 1972 to be 14.8 percent. The Company also states that without the 800-megawatt capacity of each of the Surry nuclear units, the power supply of its system would remain vulnerable to massive interruptions. Furthermore, according to the Company's report, this vulnerability could not be remedied by importation of power from neighboring utility systems because of a lack of existing transmission line capacity and because excess capacity in amounts sufficient to displace the capacity of the Surry units was not available in its region.

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JUN 7 1971
U.S. ATOMIC ENERGY COMMISSION
Regulatory
Mail Section

2654

Rec'd Off. Dir. of Reg.
Date 6/7/71
Time 1:30

A review of the information available in this office, based on the applicant's Monthly Power Statement, FPC Form 12-E and the April 1, 1971, report of the Virginia-Carolinas Subregion of the Southeastern Electric Reliability Council, confirms the precarious supply-demand situation which is expected to develop during the summer of 1972 and the general low-reserve situation of the utility systems who are members of the Virginia-Carolinas Subregion.

The following table summarizes data available from the reports which have been cited, but does not include capacity available from firm purchases:

	Virginia Electric Power Company Summer 1972	SECR Virginia-Carolinas Subregion Summer 1972	Southeastern Electric Reliability Council Summer 1972
Not Including Surry Units No. 1 and 2			
Capacity MW	5,188	22,304	75,197
Peak Load MW	6,440	20,980	64,746
Reserve MW	-1,252	1,324	10,451
Percent	-19.4	6.3	16.1
Including Surry Units No. 1 and 2			
Capacity MW	6,764	23,943	76,836
Peak Load MW	6,440	20,980	64,746
Reserve MW	324	2,963	12,090
Percent	5.0	14.1	18.7

It will be noted that based on the capacity owned by the applicant and without taking into account the capacity of the Surry units, the Company would have been entering the 1972 summer peaking season with a capacity of 1,252 megawatts less than the current projected summer peak load. When account is taken of the Surry units, the Company's reserve situation improves to 5.0 percent. Thus, even when the Surry units are available, the Company will find it necessary to continue to depend on firm purchases from neighboring utilities to maintain reliable services. While the reserve capacity of the Virginia-Carolinas Subregion, with and without the Surry units, is somewhat higher, these reserves are not high enough to assure full confidence in a troubleless summer of 1972.

Mr. Harold L. Price

In general the Commission's Bureau of Power regards a reserve capacity of about 20 percent as essential under many present utility system operating conditions. During the past several years, there have been many delays in availability of new power system facilities, particularly with large new generating units. When the reserve margins of any system, in a theoretical determination such as we have made based on data available to us, tends to approach or fall below the 15 percent level, the Commission's Bureau of Power feels that there should be ample cause for apprehension.

Alternates to Proposed Action

Since the construction of the Surry units is in its final stage with the scheduled date for commercial operation less than one year away, there are no practical alternatives to the project which could provide the needed capacity by the summer of 1972. The applicant is unable to rely on capacity elsewhere in the Virginia-Carolinas Sub-region. Importation from the Pennsylvania-New Jersey-Maryland Inter-connection to the north similarly cannot be counted upon because of the general low-reserve situation among the electric utility systems of the Eastern seaboard. A lack of sufficient transmission capacity to the west precludes hope of support from that direction. There is not sufficient time, moreover, to consider a fossil fuel substitute plant. For the same reason a hydroelectric installation cannot be regarded as a practical substitute.

Sincerely,

John N. Nassikas

John N. Nassikas
Chairman

G-22 (1)

ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

EPA-80

OFFICE OF THE ADMINISTRATOR

AUG 16 1971

RECEIVED
AUG 17 1971
U.S. ATOMIC ENERGY COMMISSION
Regulatory
Mail Section

Mr. Harold L. Price
Director of Regulation
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Price:

Thank you for your letter of March 31, 1971, requesting comments on your draft detailed statement for the Surry Power Station Units 1 and 2. We are pleased to provide the enclosed report which summarizes our evaluation of the potential environmental effects of operating the proposed facility. The report represents a compilation of comments developed by our Office of Radiation Programs and Office of Water Programs.

Our most important conclusions are relative to potential shellfish contamination, gaseous waste holdup, and a population dose assessment. As detailed in our report, technical specifications proposed by the applicant would permit substantial quantities of iodine-131 to be discharged per year. Our analysis indicates that discharges of iodine-131 should be restricted to less than two curies of iodine-131 per year if the potential dose to an individual due to shellfish consumption is to be within applicable regulations.

With respect to gaseous effluents from the plant, it is our view that reduction of environmental exposure justifies longer holdup time than indicated. Although a recombiner has been incorporated into the gas handling system, thus allowing a longer feed time into a decay tank and fewer releases per year, only a 20-day holdup is proposed. It is believed that it is reasonable to control the gaseous releases from the plant such that they are comprised essentially of Kr-85 only (about 95% of the mixture). An effective holdup time of about 60 days would normally be required to meet this criterion for typical estimates of PWR fission product production.

A dose assessment of the population at risk is significant in evaluating the overall potential impact of the plant. It is suggested that such an analysis be presented in the final environmental statement for the facility taking into account the final design of the waste treatment facilities.

We appreciate the opportunity to review and comment on the potential environmental impact of the Surry Power Station Units 1 and 2. If we can assist you further in this matter, please let us know.

Sincerely,

George Marienthal

George Marienthal
Acting Director
Office of Federal Activities

Enclosure

Vepco Response

Concerns of the Environmental Protection Agency (EPA) focus on three areas: potential shellfish contamination from radionuclide releases, gaseous waste holdup durations, and population dose assessment. Their recommendations are summarized below.

(a) Shellfish contamination. "...Our analysis indicated that discharge of Iodine-131 should be restricted to less than two curies of Iodine -131 per year if the potential dose to an individual due to shellfish consumption is to be within applicable regulations."

(b) Gaseous waste holdup. "...It is believed that it is reasonable to control the gaseous releases from the plant such that they are comprised essentially of Kr-85 only (about 95% of the mixture). An effective holdup time of about 60 days would normally be required to meet this criterion for typical estimates of PWR fission production."

(c) Population dose assessment. "It is suggested that such an analysis be presented in the final environmental statement for the facility taking into account the final design of the waste treatment facilities."

Vepco response. In reply to the EPA review of the Draft Environmental Statement for Surry Power Station, the following comments represent a summary of Applicant's portion on the three items of concern.

(a) In determining the allowable release rate of I-131, the Environmental Protection Agency used a concentration factor of 10,000 for I-131 in shellfish based on C. L. Weaver's article, "A Proposed Radioactivity Concentration Guide for Shellfish", which appeared in the September 1967 edition of Radiological Health Data and Reports. Vepco is of the opinion that a concentration factor of 50 is a more realistic value for shellfish, based upon UCRL Report 50564 by

W. H. Chapman and others titled, "Concentration Factors of Chemical Elements in Edible Aquatic Organisms" dated December 1968.

It should be noted that Weaver's article lists concentration factors for I-131 in shellfish which may vary between 100 and 10,000 and which were "not used in deriving the guides but are presented as one of the considerations for selection of the radionuclides" to be used as radiological guides. Inasmuch as UCRL-50564 is based on recent experimental evidence, Applicant feels that a shellfish reconcentration factor of 50 is more realistic. Since the EPA figure of 1.8 Ci/yr for a concentration factor of 10,0-0 is equivalent to 360 Ci/yr for a concentration factor of 50, the maximum design releases of 26.5* Ci/yr (expected releases are about 5.4 Ci/yr based on a realistic estimate of 0.2% failed fuel) are well within limitations.

The oyster beds below the station site are extensive but are mainly a source of seed oysters, to be taken and replanted in other waters and then retaken, in most cases after one year. The beds are in a tidal estuarine environment which increases the dilution water available from the fresh water flow above the bed significantly.

(b) With respect to gaseous waste discharges, all gas accumulated in the treatment system after the feed period will be held for at least 60 days to ensure that the total mixture is essentially Kr-85. This is in agreement with

---

*The figure of 26.5 Ci/yr differs from the 14 Ci/yr given in the Vepco Request to Continue Construction. The figure of 26.5 Ci/yr reflects primarily blowdown from both reactor units with steam generator leakage in both units, whereas the figure of 14 Ci/yr resulted from blowdown of only one reactor unit.

EPA recommendations.

(c) The Environmental Protection Agency noted that for gaseous releases of halogen and particulate isotopes with half lives greater than 8 days, the maximum permissible concentration limits should be reduced by a factor of 700. This concentration limit reduction was incorporated into the Technical Specifications as Item TS-3.11.B.1 on May 31, 1971.

(d) Applicant's Environmental Report contained analyses of the net gaseous and liquid releases. A population dose assessment, as such, was not included. Applicant has recently conducted a population dose analysis which estimates the exposures resulting from maximum expected radioactive liquid and gaseous releases. Results of this study are given in Appendix H.

G-23 (1)

COMMONWEALTH OF VIRGINIA
GOVERNOR'S OFFICE
COUNCIL ON THE ENVIRONMENT
EIGHTH STREET OFFICE BUILDING
RICHMOND 23219

LINWOOD HOLTON
GOVERNOR

GERALD P. MCCARTHY
EXECUTIVE DIRECTOR

August 25, 1971

RECEIVED
AUG 30 1971
U.S. ATOMIC ENERGY COMMISSION
Regulatory
Mail Section

Dr. Peter A. Morris, Director
Division of Reactor Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Surry Nuclear Power Station
Docket Nos. 50-280 and 50-281

Dear Dr. Morris:

Before replying to your letter of March 26, 1971 and the notice published in the Federal Register on December 4, 1970, this office wanted to circulate the draft detailed statement and a copy of the environmental report submitted to the Atomic Energy Commission by Virginia Electric and Power Company to the environmentally related state agencies, including the Department of Health, the Department of Conservation and Economic Development, the Commission of Outdoor Recreation, Commission of Game and Inland Fisheries and the State Corporation Commission, requesting their review and comments. In addition, I noticed that copies of the draft detailed statement were also forwarded to the Executive Director of the State Water Control Board.

On behalf of each of these agencies and the State Water Control Board, this will advise you that none of the state agencies has reported unfavorably; to the contrary, most agencies were favorably impressed with the environmental report, and are of the view that the impact of this project on the environment will be minimized. These state agencies will, of course, continue to review the project and exercise their appropriate jurisdiction.

Sincerely,

Gerald P. McCarthy

Gerald P. McCarthy

GPMcC/fo

3858

Wakefield, Virginia
July 19, 1966

Mr. A. H. McDowell, President
Virginia Electric and Power Company
7th and Franklin Streets
Richmond, Virginia

NOTED JUL 21 1966 A.H.McD.

NOTED JUL 22 1966 R.M.H.

Dear Mr. McDowell:

At the regular meeting of the Thomas Rolfe Branch, Association for the Preservation of Virginia Antiquities, at the Rolfe-Warren House, Surry, Virginia, on Monday, July 18, 1966, the members voted that I express to you and your fine organization their delight in having the new nuclear plant locate at Hog Island.

Their feeling was one of a warm welcome to the many who will come to Surry, either temporarily or as permanent residents.

As indicated at the meeting, this plant represents the many wonders of the twentieth century. In contrast, the Rolfe-Warren House built in 1652 and located near Smith's Fort built in 1609, shows the tastes and permanency of building that the early English settlers of our country had. With undaunted courage, they carved out of trees, brick, mortar and land a place that was to become the great country that we live in and enjoy today.

Surry County is rightfully spoken of as the "Mother of Counties", for one historian has stated that one-eighth of the counties of Virginia were carved from its boundaries. It has several places of unusual historical significance.

The citizens look forward to the new era with interest, and at the same time, reflect on the rich heritage the county has.

Cordially,

Lucile R. Munford

(MRS. GEORGE L. MUNFORD)
THOMAS ROLFE BRANCH, A.P.V.A.
Directress

EDWARD PORTER ALEXANDER
JAMES GEDDY HOUSE
WILLIAMSBURG, VIRGINIA

September 9, 1966

Mr. Eugene B. Crutchfield
Vice President
Virginia Electric and Power Company
7th and Franklin Streets
Richmond, Virginia

Dear Mr. Crutchfield:

It was a great pleasure to meet you the other day and to hear of your plans for the new Surry atomic plant. I have had a chance to discuss them since with my fellow members of the Virginia Historic Landmarks Commission.

We are, of course, greatly interested in seeing that such a development does not affect adversely important historic landmarks such as Bacon's Castle, Chippokes Plantation, Jamestown, or Carter's Grove.

Your plans to achieve a low profile for the main building of the plant, to avoid if at all possible a high stack, to screen the plant and its canal with plentiful timber, and to keep the power lines themselves at a distance from Bacon's Castle and Chippokes and screened as much as they can be are greatly to be commended.

I see every reason to hope that wise industrial progress can be achieved with proper regard for the historical landmarks of this great Commonwealth and I appreciate your cooperative and understanding attitude.

Sincerely,

Edward P. Alexander

Edward P. Alexander
Chairman, Virginia Historic
Landmarks Commission

APPENDIX H

EVALUATION OF DOSES FROM ESTIMATED RADIOACTIVE EFFLUENTS AT THE SURRY NUCLEAR POWER STATION

NUS-816

EVALUATION OF THE DOSES FROM ESTIMATED RADIOACTIVE EFFLUENTS AT THE SURRY POWER STATION

Prepared For

VIRGINIA ELECTRIC AND POWER COMPANY

By

F. Kantor

November 1971

ENVIRONMENTAL SAFEGUARDS DIVISION

NUS CORPORATION
4 Research Place
Rockville, Maryland 20850

Approved:

A. W. De Agazio, Manager
Nuclear Power Projects

M. I. Goldman, Sc.D.
Vice President and
General Manager

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I. INTRODUCTION

The Surry Power Station consists of two virtually identical pressurized water reactors, each designed to be capable of attaining a maximum capacity of 2546 MWt, corresponding to a gross electrical output of 855 MWe. The Surry Station is located on a point of land projecting into the James River approximately 25 miles northwest of Norfolk, Virginia, and 46 miles southeast of Richmond, Virginia. During the normal operation of the station, small quantities of radioactive materials will be released on a controlled basis to the environment. The releases may consist of both gaseous and liquid discharges. These discharges will be limited by Title 10, Part 20 of the Code of Federal Regulations (10 CFR 20) and in conformance with the Surry Technical Specifications.

The radioactive materials, both gaseous and liquid, are assumed to impose a very low but theoretically calculable radiation exposure on the local population. The purpose of this study is to quantify and assess the potential radiation exposure to the public resulting from operation of the Surry Power Station. This evaluation considers the total dose to the population within a 50 mile radius of the plant as well as the per capita dose. The study includes the dose to a hypothetical "maximum" individual who resides full-time at the site boundary, consumes seafood raised in the discharge canal, drinks discharge canal water, and as a child, drinks milk from cows which graze at the site boundary, all during a period of activity release from the plant under an assumed set of "worst case" conditions. The significant environmental pathways by which the activity released from the plant could conceivably reach the public have been evaluated in detail.

Since the applicable regulations are based on a consideration of average annual dose, this study is directed at determining the maximum doses averaged over a year. The estimated doses to individuals and the population are compared to existing dose guidelines and to normal background radiation doses.

II. SUMMARY AND CONCLUSIONS

The radiation exposure to the public resulting from operation of the Surry Power Station is evaluated in this report. The quantities of the radioactive gaseous and liquid effluents released from the plant were obtained for an assumed combination of plant operating conditions which would provide maximum discharges. These assumptions included 1% fuel defects and steam generator tube leaks in both reactor units. In addition, very pessimistic environmental dilution and concentration factors were assumed so that the annual average doses calculated in this study are the maximum values which could reasonably be expected to occur.

A. Source Terms

The most significant gaseous constituents are the fission product noble gases. A much smaller quantity of radioactive iodines are released. A total of 16,220 Ci/yr of gaseous effluents are projected to be released from the plant.

The liquid activity released, with 1% fuel defects and steam generator leaks, is estimated to total 1057 Ci/yr of which 942 Ci is tritium. The total concentration of activity in the discharge canal with a canal flow rate of 1.55×10^6 gpm is 3.43×10^{-7} μCi/cc. The dilution water flow rate in the James River adjacent to the station site, based on the mean monthly discharge rate, is approximately 4.5×10^6 gpm. This results in a dilution factor of about 4.

B. Exposure Pathways

The radiation doses to humans calculated for the Surry Station indicate that the most significant exposure pathways are external exposure to the noble gas discharges, and internal exposure due to the ingestion of seafood in which the nuclide activities in the liquid discharges have been reconcentrated. Other exposure pathways which were considered and found to be minor contributors to the dose were (1) inhalation of radioactive gas, (2) noble gas particulate daughter nuclides in the food chain, (3) ingestion of drinking water, (4) swimming in the James River, (5) lying along the shore of the James River (sunbathing), and (6) a child drinking milk from cows grazing at the site boundary.

C. Doses

The maximum annual average whole body dose to the projected 1980 population within 50 miles of the Surry site is 87.6 man-rem/year from both gaseous and liquid discharges. This includes an external population dose of 5.93 man-rem/year from the noble gases and an internal population dose of 81.7 man-rem/year from the ingestion of seafood. The ingestion dose was based on the assumptions that the entire commercial harvest of edible seafood landed in the James River plus an estimated sport catch was raised in waters with activity concentrations equal to that of the river adjacent to the discharge canal and consumed by the population within 50 miles of the site.

The maximum annual average per capita dose within 50 miles of the plant from both gaseous and liquid discharges is 0.0689 man-rem/year.

This can be compared to the average dose from natural background sources of about 125 mrem/year to obtain an estimate of the impact of plant operations on the general population in the area.

The external whole body dose from design basis gaseous discharges to an individual who resides full time at the site boundary is 8.87 mrem/year.

A hypothetical individual who consumes 50 grams per day of seafood which has been raised in undiluted discharge canal water would receive an internal whole body dose of 4.98 mrem/year. The corresponding dose from seafood raised in the James River adjacent to the site is 1.28 mrem/year.

Critical organ doses of 5.39 mrem/year to the thyroid, muscle, liver, and spleen result from the consumption of 50 gm/day of seafood raised in the James River. If the seafood was assumed to be raised in the discharge canal, the critical organ doses would be about a factor of 4 higher.

There are no public drinking water supplies taken from the James River downstream from the site. However, for the purpose of this report, it was calculated that an individual who received his entire drinking water supply from the discharge canal would receive a dose of 0.287 mrem/year.

A person who swam 200 hours/year in the James River could receive a whole body dose of 3.82×10^{-3} mrem/yr. A sunbather who lies on the shore of the James River adjacent to the site 200 hours/year could receive a whole body dose of 0.482 mrem/year from radioactive materials accumulated on the shoreline sand.

The hypothetical "maximum" individual who resides full time at the downwind site boundary, eats 50 grams/day of seafood raised in the discharge canal, obtains his entire supply of drinking water from the discharge canal, swims 200 hours/year in the James River, and sunbathes 200 hours/year on the shore adjacent to the site would receive an annual average whole body dose of 14.6 mrem/year.

Comparison of Surry derived doses with Federal standards (10 CFR 20) and natural background radiation indicate that:

1. The maximum whole body dose to the average individual within 50 miles of the Surry Plant from gaseous and liquid discharges is 0.041% of the 10 CFR 20 limit (170 mrem/year) and about 0.055% of the natural background.

2. The hypothetical "maximum" individual would receive 2.92% of the 10 CFR 20 limit (500 mrem/year) and about 12.0% of natural background.

D. Conclusions

Consideration of the per capita dose in the vicinity of the Surry Plant from gaseous and liquid discharges indicates that the Federal limit for permissible dose (170 mrem/year) would not be remotely approached.

The "maximum" individual at the site boundary receives from all exposure pathways for the gaseous and liquid discharges less than 3% of the Federal limit for permissible dose (500 mrem/year).

It is concluded that operation of the Surry Power Station even with the maximum design basis conditions assumed for this study will not impose a significant radiation risk on either individuals or the general public as a whole.

III. POPULATION EXPOSURE FROM GASEOUS EFFLUENTS

There are a number of potential pathways through which local populations may be exposed to the radioactive effluents from nuclear operations. These are illustrated in Figure 1. Three general pathways may be identified for the gaseous effluents: (1) direct radiation exposure, (2) inhalation exposure and (3) exposure to particulates through food chains. The importance of these individual pathways is determined by the quantity and nature of the radionuclide constituents in the gaseous effluent. Thus, the first step in estimating population exposure is a quantitative identification of the constituents in the projected gaseous effluents.

A. Projected Gaseous Effluents

The estimated maximum quantities of gaseous radioactivity released from the Surry Power Station on an annual basis are shown in Table I. These values are based on the assumptions that 1% of the fuel elements in both units have defective cladding and that there is a 330-day fill, 60-day decay, and 10-day bleed cycle for the waste gas decay tanks. Under these conditions, the maximum gaseous activity release is estimated to be 16,220 Ci per year.

The conservatism of the assumptions employed in estimating the gaseous activity release is illustrated by comparison with the gaseous activities which have been released from operating pressurized water reactors to date. The annual average release rate experience[1] is summarized in Table II. Based on this experience (with the exception of the first year of Ginna experience which is atypical), the Surry extrapolated release rate would range from a minimum of 22 Ci/yr to a maximum of 2680 Ci/yr,

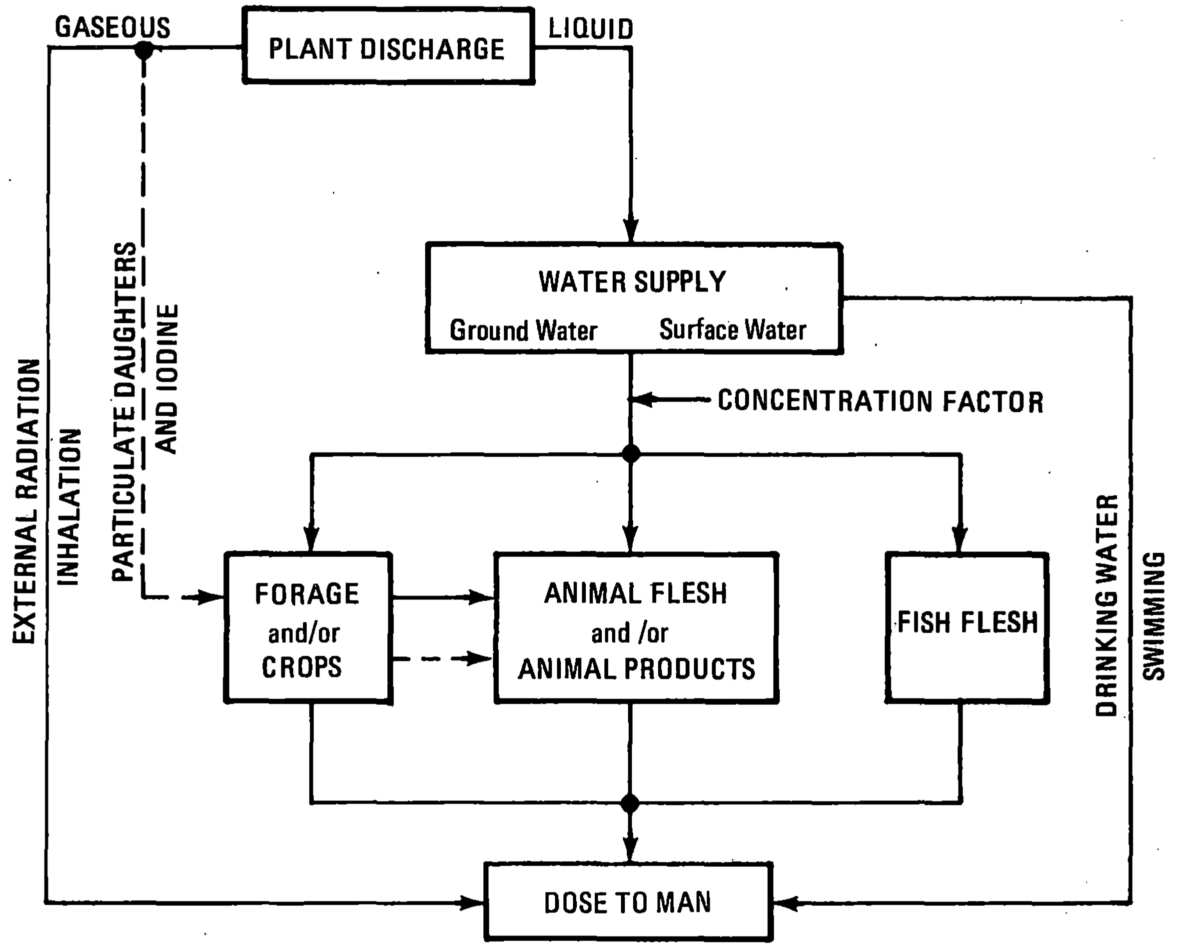


Figure 1 EXPOSURE PATHWAYS

TABLE I

MAXIMUM GASEOUS RELEASES FROM

THE SURRY POWER STATION

Nuclide	Annual Gaseous Activity Release Curies
Kr-85	16,200
Xe-131m	4.48
Xe-133m	2.02×10^{-6}
Xe-133	12.0
Xe-135	3.41×10^{-47}
I-129	1.32×10^{-8}
I-131	1.06×10^{-4}
I-133	1.42×10^{-24}

Gaseous Releases Based Upon·

(1) Two units, 2546 MWt each
(2) One percent failed fuel
(3) 330 day feed, 60 day decay, and 10 day bleed cycle for the waste gas decay tanks.

TABLE II

PWR WASTE GAS RELEASE EXPERIENCE (1)

Plant	Annual Average Release Rate (μCi/sec)/ 1000 MWe-hr	Extrapolated Expected Surry Release Rate* Ci/yr
Indian Point #1 (265 MWe)	1.2×10^{-2} (1963-1970)	2,680 (Maximum)
Yankee Rowe (175 MWe)	1.0×10^{-4} (1964-1970)	22 (Minimum)
San Onofre (430 MWe)	5.0×10^{-3} (1967-1970)	1,120
Connecticut Yankee (600 MWe)	3.0×10^{-3} (1967-1970)	671
Ginna (420MWe)	1.4×10^{-1} (1970)	31,300 (Atypical Maximum)

NOTE: Surry design basis annual average gaseous release rate = 16,220 Ci/yr

*Based on a total of 7.10×10^{6} MWe-hr per year from both units operating in a load following mode at 65 percent of full power and an annual load factor of 80 percent assuming a total of 7.10×10^6 MWe-hr per year from the two Surry units. The activity release rate used in this study is 16,220 Ci/yr. Another factor which should be noted is that the plants listed in Table II do not provide for the extended decay period made possible by the recombiners in the Surry gaseous waste disposal system. With recombiners operating, the release rates at the existing stations would be expected to be less than those shown and, consequently, the extrapolated expected release rate for the Surry Plant would be reduced even further below 2680 Ci/yr.

B. Doses From Gaseous Effluents

1. Noble Gas Dose

As has been mentioned earlier, there are three general pathways by which humans may be exposed to the gaseous radioactivity released from a nuclear plant. The importance of each of the pathways is determined by the quantity and chemical nature of the gases released. It may be observed in Table I that the primary constituents in the gaseous effluent are the noble gases, krypton and xenon. Since the noble gases do not react chemically with other substances under normal conditions, there is no physical basis for either transport through food chains or reconcentration within the human body for these gases.

In terms of inhalation and absorption in the body, both krypton and xenon may be present in physical solution, chiefly in the body water and fat[2]. Several human exposure experiments revealed that inhalation of relatively large amounts of radioactive noble gases resulted in very low tissue exposures.[3,4] In general, it may be estimated that the internal dose from radioactive noble gases dissolved in body tissue following inhalation from a cloud is negligible, i.e., less than 1% of the associated external whole body dose.[5] The resultant doses from exposure to noble gases, therefore, are considered to be external whole body doses only.

Although external doses are the only concern from the parent noble gases, there is one particulate daughter product (Cs-135) from the parent noble gas nuclide Xe-135 which is theoretically available for food chain transport. The external exposure and food chain transport routes of exposure for the noble gases are considered in the following paragraphs.

a. External cloud dose

The external doses were calculated using the ICRP[6] "infinite semispherical cloud" model; that is, the exposed individual is assumed to be located at the center of an infinitely large semispherical cloud of uniform radioactivity concentration equal to that of the centerline, or maximum, concentration level of the plume at the specified distance.

The ICRP method for calculating whole body dose assumes that beta radiation with a maximum energy of 0.1 MeV or greater is considered as contributing to the external whole body dose to the same extent as gamma radiation. This is a conservative assumption and in the case of nuclides, which are primarily beta emitters such as Kr-85 (the major contributor to the dose from the Surry gaseous effluents), results in a substantial overestimate of the genetically significant dose.[5]

Since the dose calculations include atmospheric diffusion parameters, meteorological information was required. Data was obtained from the Hog

Island Weather Station, which was located approximately two miles north-northeast of the reactor site. One year of Hog Island data (2/1/68-2/1/69) was reduced and summarized using the NUS computer program, WINDVANE. Based on this data, the highest annual average χ/Q value (8.8×10^{-6} sec/m^3) was found to occur at the north site boundary.

The annual average radiation dose was calculated for each of the population ring sectors shown in Figures 2.1-4 and 2.1-5 of the FSAR.[7] The population dose (in man-rem/year) was calculated by multiplying the average dose for a sector by the number of people projected for the year 1980 for that sector, and summing over all sectors out to 50 miles from the site. The average per capita dose was calculated by dividing the population dose by the total 1980 population. A detailed summary of the computational model is described in Appendix A.

The annual average whole body doses from exposure to the noble gases are presented in Table III for an individual at the site boundary (8.87 mrem/year) and for the population within 50 miles of the plant (5.93 man-rem/year). The doses were calculated for the maximum annual average release for the plant with 1% fuel defects. The doses were also calculated for the high and low extrapolated expected Surry releases, based on the releases per unit energy generated at operating U.S. PWR stations (Table II). Included for comparison are the individual and population doses estimated to result from natural background radiation.

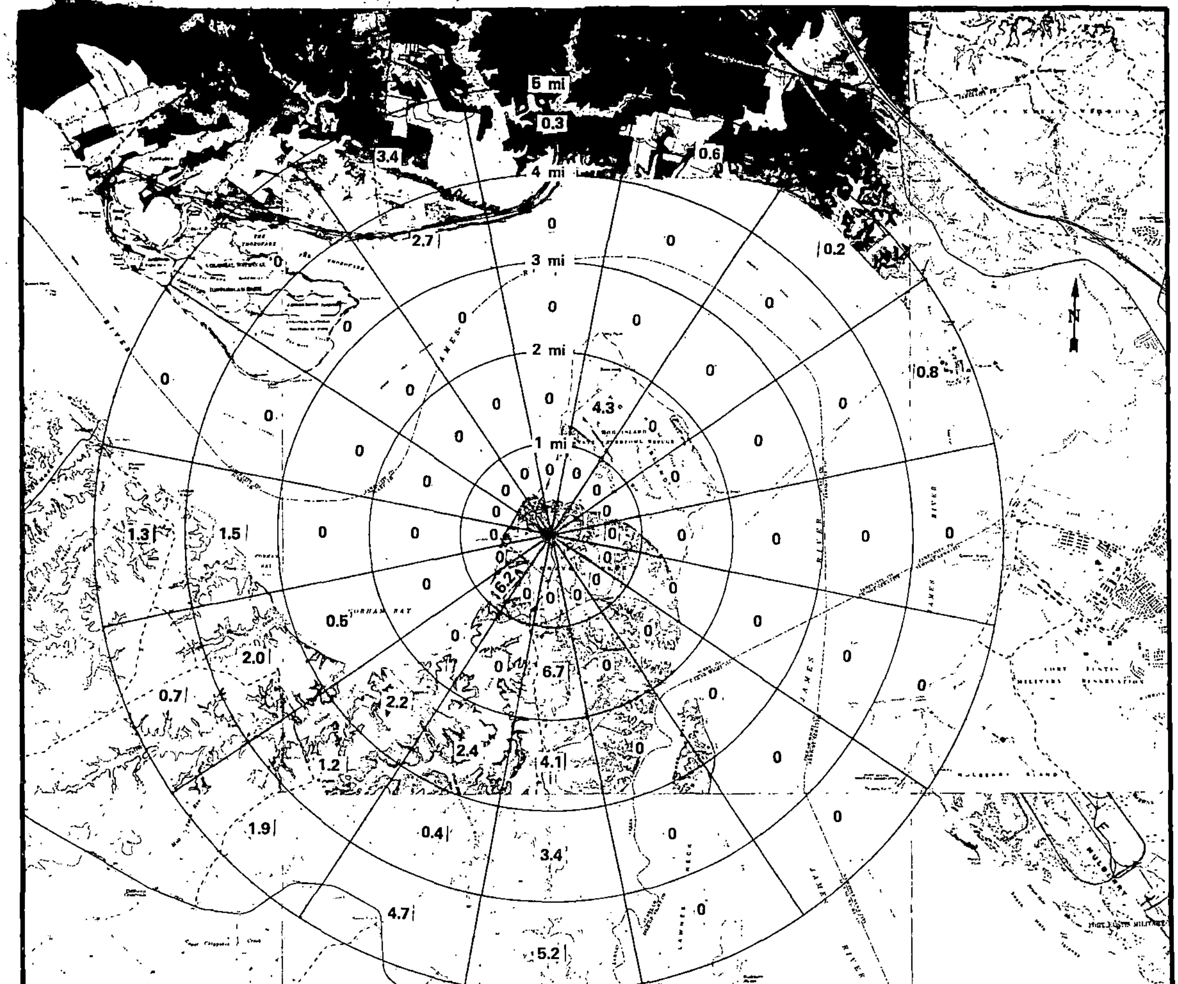
Figures 2 and 3 show the population doses for each sector from 0 to 5 miles and from 5 to 50 miles, respectively. The annual average dose isopleths (mrem/year) out to 50 miles are shown in Figure 4.

TABLE III

ANNUAL WHOLE BODY RADIATION DOSES FROM SURRY GASEOUS RELEASES

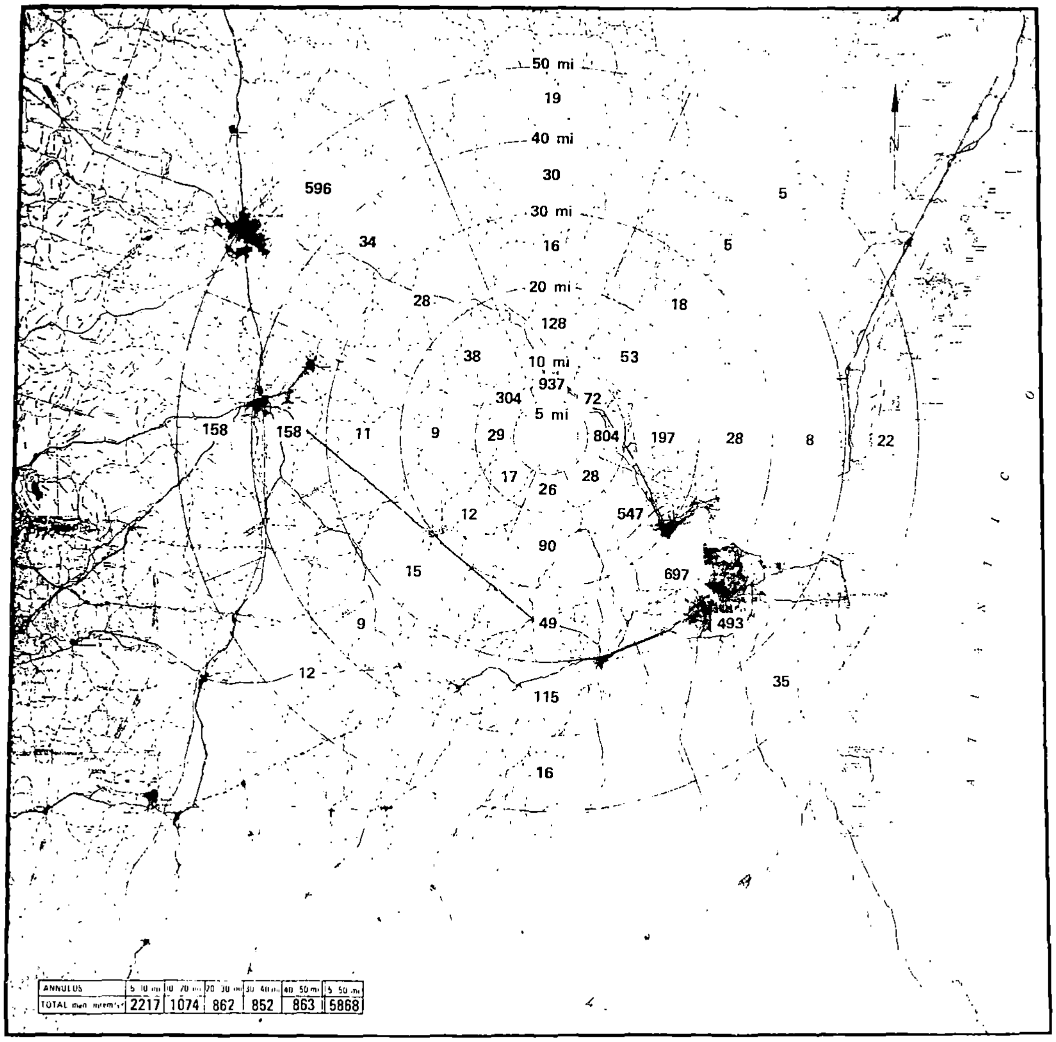
Type of Dose	Maximum Dose Based on Release with 1% Fuel Defects	Dose Based on Expected Releases Extrapolated from Previous Operating Experience	
		Maximum	Minimum
1. INDIVIDUAL DOSE, PLANT ORIGIN			
Dose rate (mrem/year) at site Boundary	8.87	1.46	1.22×10^{-2}
2. NATURAL BACKGROUND DOSE (mrem/year)	125	125	125
3. POPULATION DOSE* WITHIN 50 MILES OF THE PLANT			
a. Total Plant derived dose (man-rem/year)	5.93	0.978	8.18×10^{-3}
b. Average annual per capita dose (mrem/year)	3.03×10^{-3}	4.99×10^{-4}	4.18×10^{-6}
c. Total natural background dose (man-rem/year)	2.45×10^{5}	2.45×10^{5}	2.45×10^{5}

*Based on a projected 1980 population of 1,959,000 within 50 miles of the Surry Power Station



Annulus	0–1 mi	1–2 mi	2–3 mi	3–4 mi	4–5 mi	0–5 mi
TOTAL man–mrem/yr	6.2	11	9.2	11	19	57

FIGURE 2 – SURRY POWER STATION POPULATION DOSE FROM GASEOUS RELEASE IN MAN–MREM/YR, 0–5 miles



ANNULUS	5-10 mi	10-20 mi	20-30 mi	30-40 mi	40-50 mi	5-50 mi
TOTAL man-mrem/yr	2217	1074	862	852	863	5868

FIGURE 3 – SURRY POWER STATION POPULATION DOSE FROM GASEOUS RELEASE IN MAN-MREM/YR, 5–50 miles

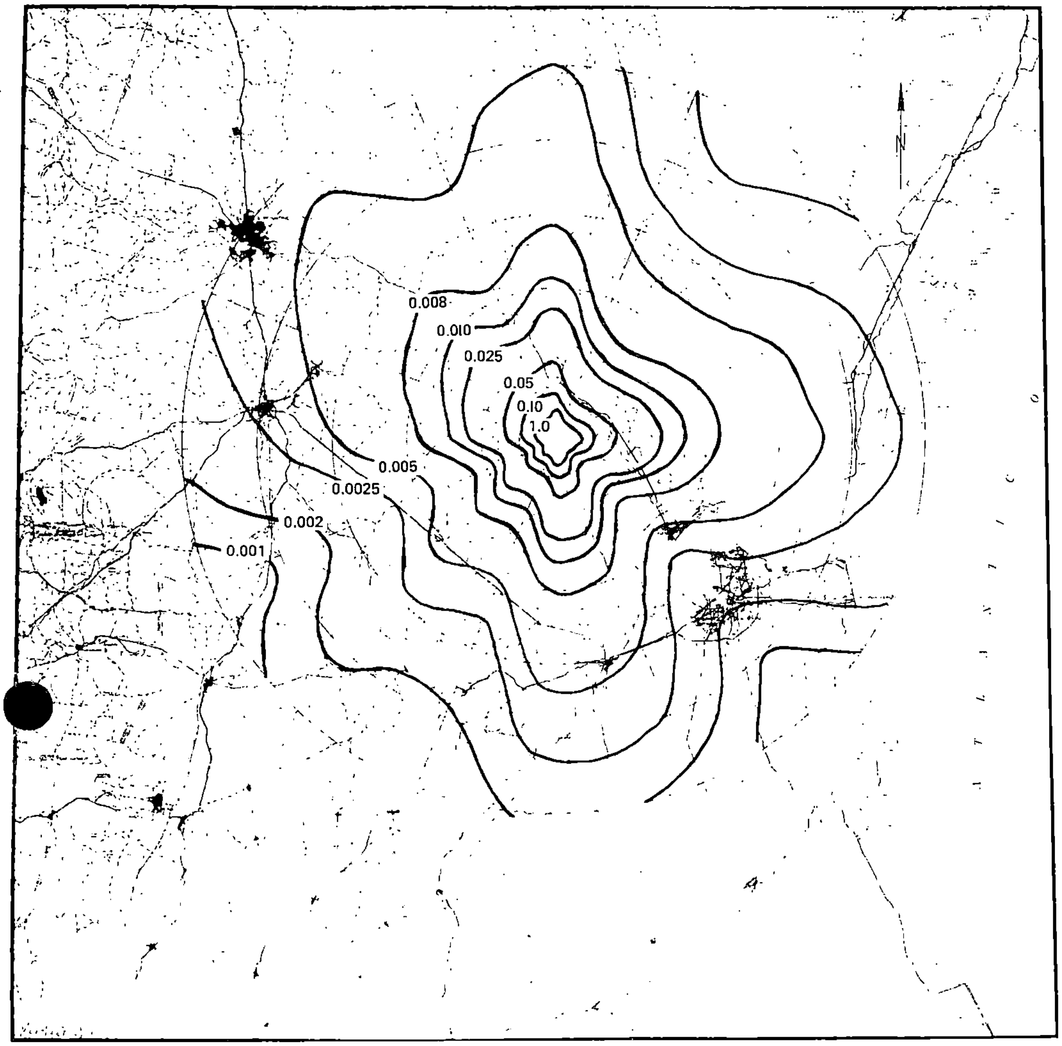


FIGURE 4 – SURRY POWER STATION
ANNUAL WHOLE BODY DOSE ISOPLETHS
FROM GASEOUS RELEASE mrem/year

b. Food chain transport

One of the gaseous radionuclides has a particulate daughter (Cs-135) which can enter the food chain and be transported to man. The decay chain of interest is:(8)

$$^{135}Xe \xrightarrow[\text{hour}]{9.2} {}^{135}Cs \xrightarrow[\text{year}]{2 \times 10^{6}} {}^{135}Ba$$

The amount of Xe-135 estimated to be released from the Surry Station, as shown in Table I, is extremely small, 3.41×10^{-47} Ci/year. Assuming that all of this activity decayed immediately to Cs-135, the potential dose contribution from this route of exposure was evaluated and found to be insignificant.

2. Radioiodine Doses

A small amount of radioactive iodine in addition to the noble gases will be released with the gases from the Surry Plant. Iodine is an insignificant contributor to the external whole body dose but may produce potentially significant internal doses due to the preferential concentration of iodine in the human thyroid gland. Iodine may enter the body either through inhalation or by ingestion. The most critical pathway for environmental transport of the routine releases of radioiodine is the pasture-cow-milk-man pathway.

a. Thyroid ingestion dose

Iodine-131 has been identified as the principal iodine nuclide of concern due to the relatively greater amount released and its long half-life compared to the other iodine nuclides. The critical exposure pathway is through deposition on pasture which is ingested by grazing cows, transferred to the milk and subsequently ingested by man. The most sensitive receptor in the population (in terms of total thyroid dose per unit intake) has been determined to be a young child six months to one year of age. This is due to the child's smaller thyroid mass and greater radiosensitivity.

The child thyroid dose for the Surry Station was calculated by assuming that the grazing cows were located at the site boundary. In this case the south boundary of the site was selected as the point of reference because the north side of the site is completely bounded by the Hog Island State Waterfowl Refuge, a State game preserve. Dose conversion parameters recommended by the ICRP[6] and the Federal Radiation Council (FRC)[8]* were utilized. The cows were assumed to be grazing continuously through the 10-day vent period as the activity builds up on the pasture and through the period following the cessation of venting as the activity on the pasture decayed. The effect of delay between the production and consumption of the milk was not included nor was the effect of dilution by other milk supplies. The child thyroid dose model is shown in detail in Appendix A.

Using this conservative child dose model, the maximum annual thyroid dose was calculated to be 0.0289 mrem/year. The thyroid dose to an adult would be at least a factor of 10 less than this based primarily on the difference in size between the adult and child thyroid glands.

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* The functions of the Federal Radiation Council were incorporated into the Environmental Protection Agency in December, 1970.

One of the conservatisms applied in calculating the child thyroid dose was the assumption that cows were grazing at the site boundary. In fact, there are no cows grazing at the site boundary and the nearest dairy herd is estimated to be about 3.5 miles from the site. Only three dairy farms are located in Surry County. The additional atmospheric dilution to the nearest dairy herd would reduce the child thyroid dose to 8.63×10^{-4} mrem/year.

b. Thyroid inhalation dose

The adult thyroid dose at the site boundary resulting from inhalation of the released radioiodines was calculated for the Surry Plant. The dose was determined to be 3.19×10^{-4} mrem/year. The method utilized to calculate the thyroid inhalation dose is given in Appendix A.

3. Dose at Visitor's Center

The whole body dose and the thyroid inhalation dose were calculated at the Surry Visitor's Center. The Visitor's Center is located approximately 900 feet north of the reactor site. The whole body dose at the Center was determined to be 0.378 mrem based on a four hour visit at the Center during the period when gaseous activity was being vented to the atmosphere.

The thyroid inhalation dose was calculated to be 1.36×10^{-5} mrem for a four hour visit. No credit was taken in any of the calculations for the shielding effect of the Center building itself.

IV. POPULATION EXPOSURE FROM LIQUID EFFLUENTS

This section of the report is directed at estimating the internal radiation doses to man resulting from the ingestion of the small quantities of radioactive materials discharged from the Surry Plant. Since there is no public water supplied from the James River downstream of Hopewell, Virginia, approximately 40 river miles upstream from the site, and no irrigation activities, the exposure pathway of concern is that from edible marine organisms harvested from the James River. External exposure pathways considered were swimming in the James River adjacent to the site and sunbathing along the shore.

A. Projected Liquid Effluents

Table IV shows the estimated maximum annual liquid releases from the Surry Station. These estimated values are based on the conservative assumptions that in both units 1% of the fuel elements will have cladding defects, equilibrium corrosion products will exist in the primary coolant, and the steam generators will leak at the rate of one liter/hour per unit. The nuclide concentrations in the discharge canal are based upon the release of liquid wastes from both reactor units with a circulating water flow rate of 1.55×10^6 gpm.

The segment of the James River adjacent to the Surry Plant is a tidal estuary and subject to tidal motion. The site is in the transitional region of the estuary between the fresh water tidal river and the saline waters. The oscillatory ebb and flood of the tide constitutes the dominant motion in the waterway in the vicinity of the site. It has been established that

TABLE IV

MAXIMUM CONCENTRATION OF RADIONUCLIDES
IN SURRY POWER STATION LIQUID DISCHARGES
AND IN JAMES RIVER ADJACENT TO THE SITE

Nuclide	Annual Activity Release[a] Ci	Concentration in Discharge Canal[b] C_W (μCi/cc)	Concentration in James River[c] C'_W (μCi/cc)
H-3	9.42 (+2)	3.06 (-7)	7.89 (-8)
Cr-51	1.18 (-2)	3.83 (-12)	9.88 (-13)
Mn-54	9.96 (-3)	3.24 (-12)	8.36 (-13)
Mn-56	4.27 (-2)	1.39 (-11)	3.59 (-12)
Co-58	3.17 (-1)	1.03 (-10)	2.66 (-11)
Fe-59	1.32 (-2)	4.27 (-12)	1.10 (-12)
Co-60	9.59 (-3)	3.12 (-12)	8.05 (-13)
Sr-89	4.81 (-2)	1.56 (-11)	4.02 (-12)
Sr-90	1.48 (-3)	4.80 (-13)	1.24 (-13)
Sr-91	7.42 (-3)	2.41 (-12)	6.22 (-13)
Y-90	1.70 (-3)	5.51 (-13)	1.42 (-13)
Y-91	8.62 (-3)	2.80 (-12)	7.22 (-13)
Y-92	2.35 (-3)	7.63 (-13)	1.97 (-13)
Zr-95	9.30 (-3)	3.02 (-12)	7.79 (-13)
Nb-95	9.36 (-3)	3.04 (-12)	7.84 (-13)
Mo-99	3.05 (+1)	9.90 (-9)	2.55 (-9)
I-131	2.65 (+1)	8.61 (-9)	2.22 (-9)
I-132	3.44 (+0)	1.12 (-9)	2.89 (-10)
I-133	2.45 (+1)	7.95 (-9)	2.05 (-9)
I-134	2.92 (-1)	9.50 (-11)	2.45 (-11)
I-135	6.27 (+0)	2.04 (-9)	5.26 (-10)
Te-132	2.58 (+0)	8.38 (-10)	2.16 (-10)
Cs-134	3.10 (+0)	1.01 (-9)	2.61 (-10)
Cs-136	2.81 (-1)	9.14 (-11)	2.36 (-11)
Cs-137	1.72 (+1)	5.58 (-9)	1.44 (-9)
Ba-140	2.61 (-3)	8.49 (-13)	2.19 (-13)
La-140	1.59 (-2)	5.15 (-12)	1.33 (-12)
Ce-144	3.64 (-2)	1.18 (-11)	3.04 (-12)
TOTAL	1.06 (+3)	3.43 (-7)	8.85 (-8)
TOTAL (non tritium)	1.15 (+2)	3.74 (-8)	9.65 (-9)

TABLE IV (Continued)

± Numbers are powers of 10

a. Activities based on the following assumptions:
   1. two units, 2546 MWt each
   2. one percent failed fuel and equilibrium corrosion products in each unit
   3. steam generator tube leakage of 1 liter/hour per unit.

b. Discharge canal flow rate = 1.55×10^6 gpm

c. Minimum volume rate of fresh water flow available for dilution assumed to be 9,952 cfs the average monthly discharge rate of fresh water flow seaward in the tidal segment centered at the site and, hence, the average amount of "new" water available for dilution of the discharged nuclides, is about 4.5×10^6 gpm (9,952 cfs).[9] This results in a dilution factor of approximately 4 which was applied to the activities in the discharge canal to obtain the maximum nuclide concentrations in the James River adjacent to the site, shown in Table IV.

B. Doses from Liquid Effluents

Since the James River contains productive shellfishing grounds and commercial and sport fishing are significant enterprises in the lower James River and Chesapeake Bay, the potential exposure from ingestion of seafood affected by the Surry Station discharge must be considered in any evaluation of the radiation doses to humans. The dose from ingestion of drinking water is not of concern; however the maximum possible dose from drinking discharge canal water has been calculated for this report.

1. Internal Dose from Ingestion of Seafood

A number of factors are required to compute the internal doses from ingestion of seafood which might conceivably contain radioactivity from the plant liquid effluents. In addition to the activity concentrations in the waters of interest, the concentration of the activity in the seafood and the amount consumed must be established.

Marine organisms through biological processes have the ability to concentrate the radionuclides released from the plant. This concentration of activity in seafood which is in turn ingested by man must be considered in determining the possible dose to man. The ratio of the concentration of a radionuclide in a marine organism to that in its ambient water is known as the concentration factor (CF). The concentration factor varies among the different species of marine life and, for a given species, varies with the different radionuclides. Also, the concentration may very considerably between different organs of an organism. For the dose calculations in this report, appropriate concentration factors were used for the edible portions of the fish and shellfish,[10] shown in Table V. Another variable is the difference in concentration factors between fresh water and seawater. For the purpose of this study, whenever there were different concentration factors given in the reference for fresh water and seawater, the most conservative value, i.e., the highest concentration factor; was selected.

In order to determine the dose to humans, the quantity of seafood eaten must be estimated. The dose model used postulates that the maximum individual consumes 50 grams of shellfish flesh every day. This is about equal to the seafood consumption reported for commercial fisherman[11] and about four times the annual per capita consumption of seafood in the United Stated.[12] A consumption of 50 gm/day of shellfish results in a slightly higher dose than a consumption of 50 gm/day of fish.

The dose to an individual from ingestion of seafood containing radioactivity is determined from the rate of intake of each component radionuclide and the application of the computational model of the ICRP[6] which is presented in Appendix B. The ICRP dose conversion values used were those for the whole body and for a chronic exposure period of 168 hours per week.

TABLE V

INDIVIDUAL WHOLE BODY DOSE FROM INGESTION OF SEAFOOD

Isotope	$(MPC)_W$ Whole Body 168 hr/Wk μCi/cc	Concentration Factor[a] C_F cc/gm	Max. Whole Body Dose[b] mrem/yr	Highest Expected Whole Body Dose[c] mrem/yr
H-3	5.0 (-2)	9.3 (-1)	7.08 (-4)	1.83 (-4)
Cr-51	2.0 (-1)	2.0 (+1)	4.79 (-6)	1.24 (-6)
Mn-54	8.0 (-3)	5.0 (+3)	2.53 (-4)	6.53 (-5)
Mn-56	3.0 (-1)	5.0 (+3)	2.89 (-5)	7.46 (-6)
Co-58	4.0 (-3)	1.5 (+2)	4.83 (-3)	1.25 (-3)
Fe-59	2.0 (-3)	2.0 (+4)	5.34 (-3)	1.38 (-3)
Co-60	1.0 (-3)	1.5 (+2)	5.85 (-4)	1.51 (-4)
Sr-89	7.0 (-4)	1.0 (+2)	2.78 (-4)	7.17 (-5)
Sr-90	4.0 (-6)	1.0 (+2)	1.50 (-3)	3.87 (-4)
Sr-91	2.0 (-2)	1.0 (+2)	1.51 (-6)	3.90 (-7)
Y-90	3.0 (+1)	1.0 (+3)	2.30 (-9)	5.93 (-10)
Y-91	2.0 (+0)	1.0 (+3)	1.75 (-7)	4.52 (-8)
Y-92	3.0 (+2)	1.0 (+3)	3.18 (-10)	8.20 (-11)
Zr-95	1.0 (+0)	1.0 (+3)	3.77 (-7)	9.73 (-8)
Nb-95	4.0 (+0)	1.0 (+2)	9.49 (-9)	2.45 (-9)
Mo-99	8.0 (-3)	1.0 (+2)	1.55 (-2)	4.00 (-3)
I-131	2.0 (-3)	5.0 (+1)	2.70 (-2)	6.97 (-3)
I-132	4.0 (-2)	5.0 (+1)	1.75 (-4)	4.52 (-5)
I-133	9.0 (-3)	5.0 (+1)	5.52 (-3)	1.42 (-3)
I-134	1.0 (-1)	5.0 (+1)	5.94 (-6)	1.53 (-6)
I-135	2.0 (-2)	5.0 (+1)	6.38 (-4)	1.65 (-4)
Te-132	5.0 (-3)	1.0 (+2)	2.09 (-3)	5.39 (-4)
Cs-134	9.0 (-5)	1.0 (+3)	1.41 (+0)	3.64 (-1)
Cs-136	9.0 (-4)	1.0 (+3)	1.27 (-2)	3.28 (-3)
Cs-137	2.0 (-4)	1.0 (+3)	3.49 (+0)	9.00 (-1)
Ba-140	5.0 (-3)	2.0 (+2)	4.25 (-6)	1.10 (-6)
La-140	2.0 (+1)	1.0 (+3)	3.22 (-8)	8.31 (-9)
Ce-144	3.0 (-1)	1.0 (+3)	4.92 (-6)	1.27 (-6)
		TOTAL	4.98 mrem/yr	1.28 mrem/yr

± Numbers denote powers of 10.

a Concentration factors obtained from reference (10) with the following exceptions:
1. Concentration factor for Sr obtained from S. Thompson, Lawrence Radiation Lab, Univ. of Calf., to be published.
2. Concentration factor for Te obtained from A. M. Freke, Health Physics, Vol. 13, 1967.

b Maximum whole body dose from ingestion of seafood raised in water at the maximum concentrations estimated for the discharge canal.

c Highest expected whole body dose from ingestion of seafood raised in water at the maximum concentrations estimated for the James River adjacent to the site.

The maximum whole body doses shown in Table V were calculated by assuming that an individual consumed 50 grams of shellfish per day for 365 days of the year which had been raised in water with activity concentrations equal to that of the discharge canal. The highest expected whole body dose, also shown in Table V, assumed that the 50 grams of shellfish consumed daily has been raised in the James River adjacent to the site in which the discharge water had been diluted to the concentrations shown in Table IV. In both cases, no credit was taken for depletion by radioactive decay or deposition once the material left the plant. In addition, the calculated doses include a factor of a 10% increase to account for any recirculation effects due to the fact that the discharge for the Surry Plant is located upstream from the intake. The recirculation effect could vary from 0% at flood tide to an estimated maximum of 15% at ebb tide and a recirculation factor of 10% is considered to be conservative.[13]

The dose rate to specific organs of the human body from ingestion of seafood was calculated for the critical organs which concentrate certain radionuclides. Table VI shows the dose to critical organs for an individual who consumes 50 gm/day of shellfish raised in water with activity concentrations equal to those shown in Table IV for the discharge canal and for the James River adjacent to the Surry Station (with a 10% increase to account for possible recirculation effects). The highest doses were found for I-131 in the thyroid and Cs-137 in the liver, spleen, and muscle.

To estimate the maximum population dose, it was assumed that the entire commercial harvest of edible fish and shellfish taken from the James River plus an estimated sport catch was raised in water at the maximum activity concentrations computed for the James River adjacent to the discharge canal

TABLE VI

DOSES TO CRITICAL ORGANS FROM SHELLFISH INGESTION

Critical Organ[6]	Radionuclides Considered	Dose mrem/year At Discharge Canal Concentrations	Dose mrem/year At James River Concentrations
Muscle	Cs-137	20.9	5.39
Spleen	Cs-137, Fe-59	20.9	5.39
Liver	Cs-137, Mn-54, Ce-144	20.9	5.39
Bone	Sr-89, Sr-90, Y-91, Ba-140	.0446	0.0115
Kidney	Mo-99	.186	0.0480
Lower Large Intestine	Sr-91, Y-90, Sr-90, Mn-54, Y-91, Fe-59, Zr-95, Nb-95, Mo-99, Te-132, Ba-140, La-140, Co-60, Co-58, Mn-56, Cr-51	.545	0.141
Upper Large Intestine	Y-92	4.77×10^{-6}	1.23×10^{-6}
Thyroid	I-131, I-132, I-133, I-134, I-135	20.9	5.39

and was consumed by the population within 50 miles of the site.

A detailed description of the commercial fishery landings from the James River was obtained from the National Marine Fisheries Service for the year 1969,[14] the latest year for which complete data was available. The seafood was divided into two categories, fish and shellfish, because of their differing tendencies for reconcentration of radioactive materials.

The sport fishing catch was estimated to be 25 to 50% of the commercial catch, excluding the alewives and menhaden,[15] with the upper value of 50% being selected for this tabulation. For fish, it is estimated that only about one-third of the gross (landed) weight is utilized for food.[16] Therefore, the total edible amount of fish was obtained by multiplying the gross pounds of edible fish by this conversion factor. For the shellfish category it was estimated that the sport catch was 10% of the commercial catch.[15] The edible amount of hard crabs was obtained by multiplying the gross weights by the conversion factor of 15% (soft crabs were considered to be completely edible).[16] The landed weights for the mollusks (clams and oysters) are reported in pounds of meat, therefore, it was not necessary to convert these weights.

The total gross weights for seafood from the James River and the edible amounts used to determine the population seafood dose were as follows:

	Gross Pounds Per Year	Edible Pounds Per Year
Fish	2,493,000	873,000
Shellfish	3,137,000	1,690,000

Two species of fish which are found in the James River and in quantity make up a large part of the commercial catch were not included in the seafood tabulation. These species, alewives and menhaden, are not normally used for human food but rather are processed into fish meal or oil or are used for bait.

The total population whole body dose was 81.7 man-rem/year and the per capita whole body dose 0.0659 mrem/year from seafood (based on a 1960 population of 1,240,000 to maximize the per capita dose). A more detailed description of the computational model is given in Appendix B.

2. Internal Dose from Ingestion of Drinking Water

Although there are no public water supplies taken from the James River downstream of the Surry site because of the water salinity, a calculation was performed to estimate the maximum dose to an individual from ingestion of drinking water containing radioactive nuclides discharged from the plant. The assumption was made that an individual drank 2200 cc/day of water with a concentration of activity equal to that shown in Table IV for the discharge canal. The 2200 cc/day is the daily consumption of water in the diet recommended by the ICRP as representative of the standard man.(6) The whole body dose from ingestion of this water was calculated to be 0.287 mrem/year, shown in Table VII.

3. External Dose to Swimmers

The direct irradiation of humans while swimming presents only a minor exposure pathway. It is postulated that an external dose is derived from

TABLE VII

WHOLE BODY DOSE FROM THE INGESTION OF WATER

Isotope	Maximum Individual Dose* mrem/year
H-3	3.37 (-2)
Cr-51	1.05 (-7)
Mn-54	2.23 (-6)
Mn-56	2.55 (-7)
Co-58	1.42 (-4)
Fe-59	1.17 (-5)
Co-60	1.72 (-5)
Sr-89	1.23 (-4)
Sr-90	6.60 (-4)
Sr-91	6.63 (-7)
Y-90	1.01 (-10)
Y-91	7.70 (-9)
Y-92	1.40 (-11)
Zr-95	1.66 (-8)
Nb-95	4.18 (-9)
Mo-99	6.81 (-3)
I-131	2.37 (-2)
I-132	1.54 (-4)
I-133	4.86 (-3)
I-134	5.23 (-6)
I-135	5.61 (-4)
Te-132	9.22 (-4)
Cs-134	6.17 (-2)
Cs-136	5.59 (-4)
Cs-137	1.53 (-1)
Ba-140	9.34 (-7)
La-140	1.42 (-9)
Ce-144	2.16 (-7)
TOTAL	0.287 mrem/year

± Numbers denote powers of 10

* Maximum dose assumes individual's entire supply of drinking water obtained from discharge canal

the discharge liquid effluents by swimming in the James River adjacent to the site.

The exposure to swimmers may be conservatively estimated by assuming that the swimmer is completely immersed in an infinite medium of uniform concentration and receives the same dose as the water itself. The expression for the dose rate is given by:

$$D\left(\frac{\text{rem}}{\text{hour}}\right) = \left(C'w\ \frac{\mu\text{Ci}}{\text{cc}_w}\right)\left(1.0\ \frac{\text{cc}}{\text{gm}}\right)\left(E\ \frac{\text{MeV}}{\text{dis}}\right)\left(3600\ \frac{\text{sec}}{\text{hr}}\right)\left(3.7 \times 10^4\ \frac{\text{dis}}{\text{sec-}\mu\text{Ci}}\right)$$

$$\left(1.6 \times 10^{-8}\ \frac{\text{gm-rem}}{\text{MeV}}\right)$$

where C'w, the concentration of the radionuclides in the James River, is given in Table IV, and E is the energy per disintegration. This relationship applies only to an infinite medium where the energy released per unit volume by the radionuclides is equal to the energy absorbed per unit volume of the medium. It is a conservative calculation and will tend to overestimate the dose.

The results of this calculation for the various nuclides discharged into the James River are shown in Table VIII. Only the nucludes which contribute significantly to the dose are shown. The James River activity concentrations include a factor of a 10% increase to account for the possible effects of recirculation.

TABLE VIII

IMMERSION DOSE FROM SWIMMING

Isotope	James River Concentration μCi/cc	Energy Mev/dis	Dose Rate mrem/hr
H-3	8.68(-8)	0.01	1.85(-6)
Mo-99	2.81(-9)	0.5	3.23(-6)
I-131	2.44(-9)	0.6	2.96(-6)
I-132	3.17(-10)	2.9	1.96(-6)
I-133	2.25(-9)	1.0	4.79(-6)
I-134	2.70(-11)	2.6	1.50(-7)
I-135	5.78(-10)	2.1	2.59(-6)
Te-132	2.38(-10)	0.3	1.57(-7)
Cs-134	2.86(-10)	1.0	6.09(-7)
Cs-136	2.59(-11)	2.4	1.32(-7)
Cs-137	1.58(-9)	0.2	6.40(-7)
		TOTAL	1.91(-5) mrem/hr

4. External Dose to Sunbathers

The radionuclides in the liquid wastes discharged to the James River from the Surry Station can be expected to accumulate to some degree on the bottom sediments and the shoreline sand. A potential external exposure pathway exists for persons sunbathing or walking along the river's edge. The affected area would be limited to approximately the area of the beach between the low and high water marks.

The concentrations of the radionuclides on the shore are influenced by the dilution that occurs in the river, the chemical composition of the effluent as well as the marine environment, and the sorptive capacity of the shoreline soil which is usually expressed as a concentration factor between water and soil. The ability of soils to concentrate radioactive materials differs widely from one element to another. Radionuclides are removed from solution primarily by adsorption and ion exchange. Generally, the fine grained bottom sediments are more effective sorbers of radionuclides than are the coarser grained sands.

The largest discharges of radioactive liquids to the environment are made from the Windscale site in England and at Hanford in the United States. Smaller discharges have been made from the Oak Ridge National Laboratory into the Clinch River and from the Savannah River Plant. At Windscale, where the principal radioactive effluents are fission products derived from the processing of spent fuel elements, the discharges are made directly to the marine environment whereas the Hanford wastes are discharged to the Columbia River some several hundred miles from the Pacific Ocean. An extensive environmental monitoring program at Windscale has resulted in the development of concentration factors for several radionuclides on shoreline sand[17] with the highest concentration factor reported for the Windscale studies being 1000.[18]

The Windscale concentration factors were utilized in the Surry study to obtain an estimate of the significance of the sunbathing route of exposure.

It was assumed that an individual lying on the shore would receive half the dose that he would receive if he were completely immersed in the sand. A calculation similar to the swimming dose calculation with sand as the infinite medium and with the concentration factors applied results in a whole body dose of 2.41×10^{-3} mrem/hr. Assuming an exposure period of 200 hours per year, the annual dose to a sunbather from the Surry Station would be 0.48 mrem.

V. TOTAL DOSES AND COMPARISON WITH FEDERAL REGULATIONS AND NATURAL BACKGROUND

A summary of the maximum annual average whole body doses resulting from the gaseous and liquid effluents discharged from the Surry Station is given in Table IX. The table includes all of the exposure pathways which are considered significant contributors to the whole body dose; the genetically significant dose. The whole body doses from gaseous and liquid discharges can be added directly to obtain the total whole body dose either to an individual at the site boundary or to an average member of the population within a 50 mile radius of the plant. Table IX also includes the dose from natural background sources for comparison.

Under the very pessimistic plant and environmental conditions assumed, i.e., maximum activity release and minimum dilution, the maximum annual average whole body dose to the population resulting from both gaseous and liquid emissions is 87.6 man-rem/year and the maximum per capita dose is 0.0689 mrem/year. This amounts to 0.041% of the per capita dose permitted by Federal regulations and 0.055% of the per capita natural background dose, as shown in Table X.

TABLE IX

MAXIMUM ANNUAL AVERAGE WHOLE BODY DOSES FROM GASEOUS AND LIQUID EFFLUENTS OF THE SURRY POWER STATION

	DOSE
1. INDIVIDUAL DOSE	
A. External Whole Body Dose (mrem/year)	
From noble gas discharge at site boundary	8.87
From swimming	3.82×10^{-3}
From sunbathing	0.482
B. Internal Whole Body Dose (mrem/year)	
From ingestion of seafood	4.98
From ingestion of water	0.287
C. Natural Background Dose (mrem/year)	125
2. POPULATION DOSE WITHIN 50 MILE RADIUS	
A. External Whole Body Dose From Noble Gas Discharge (man-rem/year)	5.93
B. Internal Whole Body Dose From ingestion of seafood (man-rem/year)	81.7
TOTAL POPULATION DOSE	87.6
C. Total Natural Background Dose (man-rem/year)	2.45×10^{5}
D. Annual Average Per Capita Dose (mrem/year)	.0689

TABLE X

COMPARISON OF MAXIMUM ANNUAL AVERAGE DOSES
TO FEDERAL REGULATIONS AND NATURAL BACKGROUND

$$\text{Fractional Dose} = \left(\frac{\text{Surry Dose}}{\text{Dose From Other Sources}}\right)$$

	10 CFR 20 Levels (0.500 Rem/Yr)	10 CFR 20 Levels (0.170 Rem/Yr)	Natural Background (0.125 Rem/Yr)
1. INDIVIDUAL DOSE RATIO			
A. External Whole Body Dose			
From noble gas discharge	1.77×10^{-2}	--	7.10×10^{-2}
From swimming	7.64×10^{-6}	--	3.06×10^{-5}
From sunbathing	9.64×10^{-4}	--	3.86×10^{-3}
B. Internal Whole Body Dose			
From ingestion of seafood	9.96×10^{-3}	--	3.98×10^{-2}
From Ingestion of water	5.74×10^{-4}	--	2.30×10^{-3}
2. POPULATION DOSE RATIO			
Annual Average per Capita Dose	--	4.05×10^{-4}	5.51×10^{-4}

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APPENDIX A

COMPUTATIONAL METHODS FOR DOSES RESULTING FROM GASEOUS EFFLUENTS

A. Whole Body Dose

As indicated in Table I, the gaseous radioactive effluents consist primarily of the noble gases krypton-85 and xenon-133. Exposure of a man to an atmosphere contaminated with these radionuclides results only in an external, whole body dose, from submersion in the radioactive cloud. Since these radionuclides are not incorporated into the human body to a significant degree, there are no resultant internal doses.

The external, whole body, population dose within a sector "s" resulting from the release of Q_i curies of the i^{th} radionuclide per year from the Surry Power Station was computed by means of the following equation:

(1) $D_{s,i}$ (man-rem/year) =

$$\frac{1}{2}\left[P_s \times \chi/Q \times Q_i \times 10^{-6} \times 10^{6} \times 3.7 \times 10^{4} \times E_i \times 1.6 \times 10^{-6} \times 1.13 \times \frac{1}{1.293 \times 10^{-3}} \times \frac{1}{10^{2}}\right]$$

where:

1/2	=	Geometry factor. The body is assumed to be irradiated from half the solid angle by the radioactive cloud of large volume, that is, it is assumed to be surrounded by an infinite, semispherical radioactive cloud.
P_s	=	Estimated number of persons living within sector "s".
$(X/Q)_s$	=	Factor computed from atmospheric dispersion equations for the distance of the midpoint of sector "s" from the station, and expressed in units of sec/meter^3.
Q_i	=	Number of curies of the i^{th} radionuclide released from the station per year.
10^{-6}	=	m^3/cc
10^6	=	μCi/Ci
3.7×10^4	=	dis/sec-μCi
E_i	=	Effective energy (of β's and γ's) per disintegration of the i^{th} radionuclide, in MeV.
1.13	=	Stopping power of tissue relative to air, for β's and secondary electrons produced by x- and γ-radiation.[1]

1.293×10^{-3} = Density of air, gm/cm^3.

10^2 = ergs/gm-rem.

It should be noted that for the gaseous radionuclides Kr-85, Xe-131m, Xe-133m, and Xe-133, the biological factors for converting rads to rem (the Quality Factor QF and the relative damage factor "n") are taken to be unity. Therefore, the ratio of rem to rads is unity and the dose equation given above may be expressed in units or either rad or rem.

To facilitate the calculations, the terms in the above equation were grouped as follows:

(2) $D_{s,i}$ (man-rem/yr) = $F_s \times F_i$

where:

F_s = $(P_s)\,(X/Q)_s$

F_i = $(0.26)\,(Q_i)\,(E_i)$

As such, F_s is a function of population, direction, and distance from the station; and F_i is a function of a specific radionuclide.

Values for P_s were estimated for the year 1980 population data presented in Figures 2.1-4 and 2.1-5 of the Surry FSAR. In these figures, ten concentric circles of varying radii are drawn about the Surry site, forming annuli, and population data are given for each annulus by compass sectors. All values of P_s used in these dose calculations were estimated values for the year 1980.

The average value of (χ/Q) for a specific sector was taken to be that for the distance of the midpoint of that sector from the station. For example, the average χ/Q for a sector 10-20 miles in a given direction was taken to be that for a distance of 15 miles from the station in the given direction. The numerical values for χ/Q used in this evaluation were obtained using the NUS computer code WINDVANE. The Q_i values used in the dose calculations are given in Table 1 in the body of the report. These gaseous releases are based on assumed one percent fuel defects.

The remaining factor in the dose equation is E_i, the effective energy (β's and γ's) per disintegration of the i^{th} radionuclide. The value of E_i for each radionuclide of interest was obtained from ICRP Publication 2[1] and entered in Table A-1.

Values for the factors, F_s of equation (2) were computed for each sector of each annulus, summed and entered in Table A-2. Similarly, the values for the factor, F_i, were computed for the four radionuclides concerned and summed to obtain $\sum F_i$ as shown in Tables A-1 and A-2. Using equation (2), the value of $D_{s,i}$ (man-rem/year) was computed and entered in Table A-2.

The population dose (man-rem/year) within the entire area (considered to be within a 50-mile radius of the station) resulting from the release of the radionuclides is given by the equation:

TABLE A-1

CALCULATION SHEET FOR WHOLE BODY DOSES FROM NOBLE GASES

Gases Considered	Curies/Year	E_i Mev/Disintegration	Unit Dose rem/Ci-sec/m^3	F_i Whole Body Dose/Exposure rem-m^3/sec-yr
Kr^{85}	16,200	0.24	0.062	1010
Xe^{131m}	4.48	0.16	0.041	0.186
Xe^{133m}	2.02×10^{-6}	0.23*	0.060	2.79×10^{-8}
Xe^{133}	12.0	0.19	0.049	0.591
TOTAL	17,443			$\sum F_i \cong 1011$

* The value of E_i for Xe^{133m} is not listed in ICRP II. Value obtained from the Radiological Health Handbook of the Public Health Service, dated January 1970.

TABLE A-2

NOBLE GASES EMISSION DOSE

Population Basis	F_a Weighted Unit Exposure man-sec/m^3	$\sum F_i$ Whole Body Dose/Exposure rem-m^3/sec-yr	D_Σ Population Whole Body Dose man-rem/yr	D Average Whole Body Dose rem/yr
1,959,000 (1980)	5.89×10^{-3}	1011	5.93	3.03×10^{-3}

Site Boundary $\chi/Q = 8.8 \times 10^{-6}$ sec/m^3 (FSAR p. 2.2.3-2)

Site Boundary Whole Body Dose = (8.8×10^{-6}) (1011) = 8.87 mrem/year

(3) $$D = \sum_{s=1}^{n} D_{s,i}$$

where "n" is equal to the total number of sectors.

The following equation was used to compute $\overline{D}$, the average annual dose per person living within the entire area of interest.

(4) $$\overline{D} = {}^{D}\textstyle\sum \Big/ \displaystyle\sum_{s=1}^{n} P_s$$

where $\sum_{s=1}^{n} P_s$ is the total population within 50 miles of the site.

The results of computations carried out using the above equations are presented in Table A-2.

The dose rate in mrem/year, at the site boundary due to the radiogases released, was also computed. This value is included in Table A-2 for comparison purposes. For a continuous one-year occupancy at the site boundary, a person would receive a dose of 8.9 mrem from exposure to the four noble gases released.

The computed dose and dose rate values entered in Table A-2 are based on the estimated maximum releases of radiogases listed in Table 1 in the body of the report. However, significantly lower releases would be expected based on experience in operating PWR plants (see Table 2). The lower expected releases from the normal operating conditions of the Surry station result in proportionately lower doses and dose rates, and provide a basis for calculating a range of expected doses. These lower values may be computed directly by multiplying the dose values in Table A-2 by the ratio of the expected release to the assumed release based on 1% fuel defects, shown in Table 2. Thus, the values in Table A-2 may be multiplied by the following factors to yield maximum and minimum expected doses:

(a) 0.165 - to obtain the maximum expected values
(b) 0.00138 - to obtain the minimum expected values

B. Thyroid Inhalation Dose

A small amount of radioactive iodine, principally I-131, is released from the Surry plant during normal operation. The external whole body dose resulting from submersion in a cloud of radioactive iodine is negligible, however, iodine which is taken into the body produces an internal dose as the iodine is preferentially concentrated in the thyroid gland. The thyroid dose was calculated by the following equation:

(5) $\overline{D}$ (rem/yr) = $Q \times X/Q \times BR \times DCF$

where (X/Q) and Q_i are the same as defined previously and:

BR = Breathing rate, 2.31×10^{-4} m^3/sec for the "standard man."
DCF = Dose coversion factor, 1.48×10^6 rad/curie I-131 inhaled[2]

C. Child Thyroid Milk Ingestion Dose Model

A small amount of gaseous radioiodines will be released from the Surry plant in addition to the noble gases. The critical pathway for iodine ingestion is the pasture-cow-milk-man pathway with the thyroid being the critical organ. The most sensitive receptor in the population in terms of a thyroid dose from milk ingestion is a young child six months to one year old. The following model[3,4] was used to compute the child thyroid milk dose from the radioiodine of concern, I-131:

$$D = \frac{0.01 \times 8.64 \times 10^4 \times 0.09 \times \chi/Q \times Q \times 1.0 \times 3.7 \times 10^4 \times 0.35 \times 0.18}{2.0 \times 0.139 \times 0.116 \times 6.24 \times 10^5 \times 100}$$

where:

0.01	=	Deposition velocity of iodine onto pasture,[5] m/sec
8.64×10^4	=	sec/day
0.09	=	Milk-to-grass ratio,[5] μCi/l milk per μCi/m^2 pasture
χ/Q	=	Atmospheric dilution factor at the site boundary, sec/m^3
Q	=	Number of curies of I-131 released, μCi/yr
1.0	=	Child milk intake,[6] l/day
3.7×10^4	=	Disintegrations/sec-μCi

0.35	=	Fraction of Iodine ingested which reaches thyroid[7]
0.18	=	Effective energy deposited in the thyroid, MeV[7]
2.0	=	Mass of child's thyroid,[6] gm
0.139	=	Decay constant for iodine on pasture,[5] day^{-1}
0.116	=	Effective decay constant for iodine in child's thyroid,[5] day^{-1}
6.24×10^5	=	MeV/erg
100	=	ergs/gm-rad

Since the quality factor and relative damage factor are taken to be unity for I-131, the ratio of rem to rad is unity and the dose equation given above may be expressed in units of either rem or rad.

APPENDIX A

REFERENCES

1. ICRP Publication 2: "Report of Committee II on Permissible Dose for Internal Radiation," International Commission on Radiological Protection, Pergamon Press, 1959.

2. Di Nunno, J. J., et. al. "Calculation of Distance Factors for Power and Test Reactor Sites," TID-14844, USAEC, 1962.

3. Hull, A. P., "Comments on a Derivation of the 'Factor of 700' for I-131," Health Physics, Vol. 19, No. 5, November, 1970.

4. George, K. D., "I-131 Reconcentration Factor," Health Physics, Volume 19, No. 5, November, 1970.

5. Burnett, J. J., "A Derivation of the 'Factor of 700' for I-131," Health Physics, Vol. 18, No. 1, January, 1970.

6. "Background Material for the Development of Radiation Protection Standards," Federal Radiation Council, Report No. 5, July, 1964.

7. Bryant, P. M., "Data for Assessments Concerning Controlled and Accidental Releases of I-131 and Cs-137 to Atmosphere," Health Physics, Vol. 17, No. 1, July 1969.

APPENDIX B

COMPUTATIONAL METHODS FOR DOSES RESULTING FROM LIQUID EFFLUENTS

A. Whole Body Doses From Seafood

The annual whole body dose (rem/year) received by a person who consumes 50 grams daily of seafood of type "a" grown in waters contaminated with radionuclide "i" can be determined from the following equations:

$$D_i = \frac{\text{Daily intake of "i" via seafood}}{\text{Daily intake of "i" resulting in 5 rem/year}} \times 5 \text{ (rem/year)}$$

$$(1)\quad D_{a,i} \left(\text{rem/year}\right) = \frac{50\ (g_a/\text{day}) \times C_w\ (\mu Ci/cc_w)_i \times CF\left(\dfrac{\mu Ci/g_a}{\mu Ci/cc_w}\right)_i}{(MPC)_w\ (\mu Ci/cc_w)_i \times 2200\ (cc_w/\text{day})} \times 5 \left(\text{rem/year}\right)$$

where:

C_w = Concentration of radionuclide "i" in the ambient waters of the organisms.

CF = Concentration factor for the edible part of the marine organisms concerned. Values compiled by the Lawrence Radiation Laboratory were used in these calculations.[1]

$(MPC)_w$ = ICRP - derived value[2] for the maximum permissible concentration of radionuclide "i" in potable water, applicable to chronic intake (168 hr/week) and for the whole body as the organ of reference.

2200 cc/day = Intake of water by standard man.[2]

5 rem/year = Whole body dose resulting from continuous daily intake (by ingestion) of $\left[(MPC)_w\ (\mu Ci/cc) \times 2200\ (cc/day)\right]$ μCi of radionuclide "i".

For the radionuclides of interest, the Q_f (Quality Factor) and the relative damage factor "n" are both taken to be unity. Hence, the ratio of rems to rads is unity and the dose equations in the Appendix may be expressed in units of either rads or rem.

When the seafood is contaminated with "n" radionuclides, the total, annual whole body dose is:

$$(2)\quad D_a\ (\text{rem/year}) = \sum_{i=1}^{n} D_{a,i}$$

The nuclide concentrations listed in Table IV for the James River, with an increase of 10% to account for the possible occurrence of recirculation of the discharged effluents through the plant, were considered for these calculations. The results are shown in Table

The general population doses resulting from the ingestion of seafood raised in the liquid effluents discharged to the James River were calculated as follows:

The average amount of seafood consumed annually per person within 50 miles of the plant, assuming that all of the seafood harvested in Virginia is eaten within 50 miles of the plant is:

$$(3)\quad \overline{A}_a\,(\text{gm/yr}) = \frac{A_a\,(\text{gross lbs/yr}) \times f_a\,\dfrac{\text{edible lbs}}{\text{gross lbs}} \times 454\,(\text{gm/lb})}{P\,(\text{population within 50 miles})}$$

where:

$\overline{A}_a$ = Gross pounds per year of fish and shellfish

f_a = 0.35 for fish

= 0.15 for hard crabs

= 1.0 for soft crabs, all mollusks

P = Population within 50 miles of the plant, based on 1960 population of 1,240,000 to maximize per capita dose.

The whole body dose received by an individual in the population who consumes an annual average of $\overline{A}_a$ grams of seafood of type "a" can be determined by the expression:

$$\overline{D}_a = \frac{\text{Yearly intake of seafood "a"}}{\text{Yearly intake of "a" resulting in } D_a\,(\text{rem/yr})} \times D_a\,(\text{rem/yr})$$

$$(4)\quad \overline{D}_a\,(\text{rem/yr}) = \frac{\overline{A}_a\,(\text{gm/yr})}{50\,(\text{gm / day})(365\text{ day/yr})} \times D_a\,(\text{rem/yr})$$

where D_a is determined by equations (1) and (2) for the activity concentrations computed for the James River adjacent to the plant (with a 10% increase for recirculation of the effluents).

The total population dose (man-rem/yr) is the average individual dose multiplied by the 1960 population within 50 miles of the plant:

(5) D_{Σ} (man-rem/yr) = $\sum_a$ P (persons within 50 miles) x $\bar{D}_a$ (rem/yr)

The calculated doses are shown below:

Type of Seafood	$\bar{A}_a$ (gm/yr)	Per Capita Dose $\bar{D}_a$ (rem/yr/person)	Population Dose D_{Σ} (man-rem/yr)
Fish	320	2.24×10^{-5}	27.8
Shellfish	619	4.35×10^{-5}	53.9
		TOTAL	81.7

B. Whole Body Dose From Drinking Water

The annual whole body dose (rem/year) received by a person who consumes his total daily water intake (2200 cc) contaminated with radionuclides "i" can be calculated from the following equations:

$$D_i = \frac{\text{Concentration of "i" in drinking water}}{\text{Concentration of "i" resulting in 5 rem/yr}} \times 5 \text{ (rem/yr)}$$

(6) $$D_i \text{ (rem/yr)} = \frac{C_W\ (\mu Ci/cc_W)i}{(MPC)_W\ (\mu Ci/cc_W)i} \times 5 \text{ (rem/yr)}$$

Here, C_w and MPC_w are defined the same as on page B-1 and are numerically equal to their respective values in Table IV of the text.

When the water is contaminated with "n" radionuclides, the total annual whole body dose is:

$$(7) \quad D\ (\text{rem/year}) = \sum_{i=1}^{n} D_i$$

REFERENCES

1. Chapman, W. H., et. al., "Concentration Factors of Chemical Elements in Edible Aquatic Organisms," UCRL-50564, December 1968.

2. ICRP Publication 2, "Report of Committee II on Permissible Dose For Internal Radiation", International Commission on Radiological Protection, Pergamon Press, New York, 1959.

APPENDIX I

RESPONSES TO QUESTIONS

FROM

U.S. ATOMIC ENERGY COMMISSION

DIVISION OF RADIOLOGICAL AND ENVIRONMENTAL PROTECTION

APPENDIX I

TABLE OF CONTENTS

SECTION ONE
NEED FOR POWER

Q1. What is the composition of Vepco's projected load growth for the next five years by major categories?

ANSWER

The applicant projects only its total peak loads; a projection relating the contribution of each category or type of load to the total peak load is not attempted. The Applicant does, however, project its energy sales by major categories. Table 1-1. "Peak Loads and Sales, 1972-1976," lists for 1972-1976, the latest projections for energy sales, by major categories, and the latest projections for peak load.

TABLE I-1
VIRGINIA ELECTRIC AND POWER COMPANY
PEAK LOADS AND SALES
1972 - 1976

A. MEGAWATTS AND KILOWATT HOURS

YEAR	PEAK LOAD (MW)	SALES-KWH (MILLIONS) TOTAL	RES'DL	COM'RL	INDUST'L	ST LGT.	PUBLIC AUTHORITIES	SALES FOR RESALE	OTHERS
1972	6300	28198	9460	6845	5064	124	3704	2994	7
1973	7010	31360	10505	7671	5432	131	4141	3456	24
1974	7790	34809	11624	8594	5827	138	4634	3992	
1975	8660	38650	12817	9627	6250	146	5190	4620	
1976	9610								

B. PERCENTAGES

YEAR	~~GROWTH ANNUAL~~ PERCENT PEAK LOAD	TOTAL SALES	PERCENT ANNUAL SALES RES'DL	COM'RL	INDUST'L	ST.LGT.	PUBLIC AUTHORITIES	SALES FOR RESALE	OTHER
1972	19.0	14.3	33.6	24.3	18.0	0.4	13.1	10.6	0
1973	11.3	11.2	33.5	24.5	17.3	0.4	13.2	11.0	0.1
1974	11.1	11.0	33.4	24.7	16.7	0.4	13.3	11.5	0
1975	11.2	11.0	33.2	24.9	16.2	0.4	13.4	11.9	0
1976	11.0								

NOTE: OFFICIAL SALES FORECAST EXTENDS ONLY THROUGH 1975.

Q2. Why is the load growth rate for 1972 so much greater than for other years? (19% according to Fig. I.E.1-1 on P. 161 of the Environmental Report Supplement Volume 1)

ANSWER

Over the past several years the Applicant has experienced wide variations in its rate of load growth. These variations have an apparent direct relationship to specific weather conditions. The following table lists the Applicant's peak load growth from 1964 to 1971 and provides a descriptive weather evaluation for the summers of these years.

	Summer Peak		
Year	Load-MW	Increase Over Previous Year - %	Weather (1) Evaluation
1963	2316		
1964	2510	8.4	Mild
1965	2900	15.5	Average
1966	3320	14.5	Hot
1967	3499	5.4	Mild
1968	4253	21.5	Hot
1969	4639	9.1	Average
1970	4852	4.6	Average
1971	5295	9.1	Very Mild

(1) Descriptive weather evaluation term applied to each year was based on review of weather statistics collected at the Applicant's three major load centers.

With the exception of 1970 and 1971, the impact of weather sensitive loads is apparent: a hot or average summer following a mild summer produces a much larger than average increase in peak load; a hot summer following an average summer produces an above average increase; an average year following a hot year produces a slightly smaller than average increase.

The apparent discrepancies in this review appear in 1970 and 1971. The 4.6% increase in load in 1970 from an average summer to an average summer is very low while the 1971 increase of 9.1% from an average to a very mild summer is exceedingly high. The reason for this apparent discrepancy is that actual data in 1970 does not reflect the true conditions existing at the time of the system peak. Because of a generation shortage on its system as well as on the entire eastern seaboard, the Applicant had been forced to institute three measures to curtail its load at the time of its 1970 summer peak load. It is estimated that the 1970 peak load was curtailed by 290 MW by taking the following steps:

(1) 5% voltage reduction - 120 MW

(2) Telephone appeal to selected commercial and industrial customers - 70 MW

(3) Radio - television appeal to all customers - 100 MW.

Without this load curtailment the Applicant would have experienced a much higher 1970 load which would have produced the peak loads and percentage increases shown in the following table:

Summer Peak

Year	Load-MW	Increase Over Previous Year - %	Weather Evaluation
1969	4639		
1970	5142	10.8	Average
1971	5295	3.0	Very Mild

Using the above adjusted 1970 load, the load increase from an average summer in 1969 to an average summer in 1970 was at the estimated percentage rate of growth. For the very mild summer following the average summer, the 3.0% increase is approximately what would be expected.

Evaluation of the pattern of percentage load increases for varying weather conditions indicates that, for the return to average summer conditions following a very mild summer, the Applicant must anticipate an abnormally large load growth. Furthermore, the two years unrealized growth in weather sensitive loads (unrealized in 1970 because of load reduction and in 1971 because of mild weather) should, with a return to average summer weather, be realized in 1972. The Applicant believes that a 19% increase in load in 1972 is not inconsistent with past experience and data. The average percent growth per year for the period from 1968 to and including the estimated 1972 load, is 10.32%, which is consistent with Vepco's historical load growth for the past ten years.

Q3. What types of agreement does Vepco have relating to reliability of service and curtailment of power?

ANSWER

The Applicant has agreements with the Southeastern Power Administration, the Pennsylvania, New Jersey, Maryland Interconnection, The Appalachian Power Company, The Alleghany Power System (through two of its member companies) and the Carolina Power & Light Company. In general, these agreements provide for parallel operation of electric systems and for capacity and energy transactions between the parties. Every agreement includes a clause relating to emergency capacity and energy which each party will make available to the other if the need arises and if the capacity or energy is available.

The Applicant is a signatory to the VACAR Reliability Agreement and to the Southeastern Electric Reliability Council Agreement. These agreements are specifically directed to the augmentation of reliability of the bulk power supply of the member companies.

Through the Applicant's membership in VACAR, it is a party to an Inter-Area Reliability Agreement signed by the VACAR group, the East Central Area Reliability Group, and the Mid-Atlantic Area Co-ordination Group. This agreement provides for inter-regional cooperation to augment reliability of bulk power supply of the member companies.

Through the Applicant's membership in the Southeastern Electric Reliability Council, it is a member of the National Electric Reliability Council which was formed to augment the reliability of bulk power supply in the electric utility systems of North America.

The Applicant has no contractual obligation to curtail power. However, under the provisions of the VACAR Reliability Agreement, the VACAR members have established principles of operation to be followed when there is a generation shortage on one or more of the participating systems. In general, these principles outline the cooperative efforts of all the members to prevent loss of load by any member, but when all possible cooperation does not eliminate the generation shortage, those companies short of generation are required to drop load until their generation is equal to their load.

The Applicant, by operating its systems in parallel with other systems, has implicitly agreed to conform to good operating practices and to cooperate with neighboring companies during periods of generation shortage. Should a condition occur where the Applicant has more load than resources and no other company can provide assistance, the Applicant would immediately begin load curtailment to restore a proper balance between generation and load.

The Applicant has, in conjunction with other companies, but not under any contract, instituted an automatic load shedding program designed to drop approximately 30% of the Applicant's total load in three steps during times of decaying frequency.

Q4. Does Vepco plan to retire any generating units from service during the next five year? If so, please state the reasons.

ANSWER

The Applicant plans to retire two small generating units at its Bremo Power Station in December, 1972, and one small unit at its Balcony Falls hydro facility in April, 1972.

The units at the Bremo Power Station, with a combined nameplate rating of 30 MW, were placed in service in 1931. These units have been in cold reserve for several years and have been used only during extreme system emergencies. Because of the age of the units and because of the cost of making these units comply with federal and state emission standards, it is not economically feasible to continue their operation and the Applicant has committed itself to their removal by the end of 1972 if Surry 1 and 2 are available.

The unit at Balcony Falls has a nameplate rating of 675 KW. Because the fixed and operating costs of this unit exceed the revenue derived from its operation, the unit is being shutdown.

SECTION TWO
SITE AND SITE SELECTION

Q1. What was the previous use of the site land? What fraction of the 840 acres will be used for plant buildings, auxiliary components, substation and transmission? What total area was cleared for construction?

ANSWER

The 840 acres of the site were purchased from the Halifax Timber Company which used the land for timber production. Presently the following acreage on the site is utilized for

Main Plant Site	12.5 Acres
Discharge Canal	21.1 Acres
Intake Canal	59.2 Acres
Switchyard	13.3 Acres
On Site Transmission	76.6 Acres
TOTAL	182.7 Acres

An additional 28.1 acres were also cleared for construction related activities. In all, approximately 210.8 acres of the 840 acres on site were cleared.

Q2. What restrictions and easements will be in force relative to passage through the site and use of the shorelines? Will hunting be permitted?

ANSWER

State Route 650, which crosses the site west of the main plant structures, provides unrestricted access across the site. Any restrictions on use of this road would be imposed by the State of Virginia and would probably only be vehicular weight restrictions intended to preserve the road.

For security reasons, the intake canal, major site structures, and discharge canal will be enclosed by a chain link fence. The periphery of the site will be unfenced but will be posted with "No Trespassing" signs. Hunting will not be permitted on the site.

Q3. Are there any problems that might be caused by the proximity of the cooling water intake system to the gas pipelines on the eastern side of Gravel Neck?

ANSWER

The subject gas pipelines are situated inside protective sleeves well below grade level. The proximity of these gaslines to the cooling water intake system will present no problems.

Q4. Will future dredging of the inlet channel be necessary?

ANSWER

It is the Applicant's belief that future dredging of the inlet channel will not be necessary.

Q5. Was an upstream (non-estuarine) site considered?

ANSWER

An upstream site at Weyenoke, located on a peninsula of the James River in Charles City County was considered. The site was determined to be unattractive because of low level marshes and because of the site's proximity to historical homes and plantations. The site was disposed of prior to consideration of the Surry site. Additional information pertaining to this site and site selection is presented on pages 56 and 57 of the Surry Power Station Environmental Report submitted to the Atomic Energy Commission on December 31, 1970.

SECTION THREE
ECOLOGICAL IMPACT

Q1. What data are available pertaining to the standing crops of organisms-benthic, nektonic (adult fish, fish eggs and larve) and planktonic species in the area of the intake and discharge structures?

ANSWER

The tidal segment encompassing Hog Point is ecologically classified as the "gradient zone" of the James River tidal system. This zone is characterized by the greatest fluctuations in salinity both within and between years of any area within the system. For example, during the study period from May, 1965 through May, 1966, the salinity measured at slack before flood tide ranged from fresh water to 16.20 parts per thousand (ppt) at a channel station off the intake and 11.24 ppt at a channel station off the discharge of the Surry facility. This natural variation within seasons severely limits infauna and epifauna populations to those species which can tolerate a wide range of salinity levels. During the pre-operational study conducted by the Virginia Institute of Marine Science for the Applicant, only 23 species of benthic invertebrates representing the Phyla Arthropoda, Mollusca, Annelida, and Nemertea were collected from the Hog Point area. The dominant organism in the area in terms of both numbers and biomass is the clam *Rangia cuneata*. This clam has a clumped distribution and the associated variation both within and between stations is high. In the shallow areas of both the upstream and downstream side of Hog Point, the average clam population was less than $50/m^2$. The average weight of the clams is dependent upon the year class represented in the population. Table 2 of the pre-operational report entitled, "A Study of the Flora and Fauna in the Oligohaline Zone of the James River, Virginia" is reproduced herein as Table I-2. Figure I-1 identifies

TABLE I-2

SPECIES, NUMBER OF INDIVIDUALS
AND TOTAL WET WEIGHT IN GRAMS
PER 0.14 M^2 AT EACH STATION

Spring 1969

SPECIES	STATIONS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gammarus sp.																
Dipteran larvae																
Corophium lacustre														2	13	1
Cyathura polita							2									
Laeonereis culveri			1													
Congeria leucophaeta	8								4	178						
Macoma mitchelli												1			1	
M. balthica																
Brachidontes recurvus	1									4						
Lepidactylus dytiscus			6									4				
Monoculodes edwardsi				1												
Tubulanus pellucidus									1				1			
Heteromastus filiformis																
Leptocheirus plumulosus			1	5			22	1					4		30	
Edotea triloba																
Nereis succinea																
Chiridotea almyra																
Mya arenaria																
Lysippides grayi																
Unid. oligochaetes																
Unid. capitellids																
Rangia cuneata	26	23	5	13	2	7	18	51	12	157	13	2	18	4	5	1
Scolecolepides viridis			5	6		1	8	1	18	1	3	3	15	1	6	2
Biomass	305	221	134	200	15	112	299	613	161	2001	431	101	236	161	142	20

TABLE I-2

SPECIES, NUMBER OF INDIVIDUALS
AND TOTAL WET WEIGHT IN GRAMS
PER 0.14 M^2 AT EACH STATION

Spring 1969

SPECIES	STATIONS 17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Gammarus sp.		2														
Dipteran larvae																
Corophium lacustre	5	55	4										2	2		
Cyathura polita	2	15	1		1		6			2		3	2	1	4	
Laeonereis culveri							14		2				1			
Congeria leucophaeta	37	105	2		3							1				
Macoma mitchelli				1	3	1	2	2					1		5	
M. balthica													3	3		
Brachidontes recurvus	2	13			4							2			1	
Lepidactylus dytiscus																
Monoculodes edwardsi				1												
Tubulanus pellucidus			1	1		1						2		2		
Heteromastus filiformis																
Leptocheirus plumulosus			1	15			27	1		1	1	8	2	5	27	
Edotea triloba												2				
Nereis succinea																
Chiridotea almyra																
Mya arenaria																
Lysippides grayi																
Unid. oligochaetes																
Unid. capitellids								2								
Rangia cuneata	3	73	2	4	21	58	23	9	119	7	67	8	2	4		
Scolecolepides viridis	4	3	5	11	15	2	18	1	1		1			4	6	
Biomass	82	936	36	143	352	659	675	177	1395	113	986	100	90	68	6	

TABLE I-2

SPECIES, NUMBER OF INDIVIDUALS
AND TOTAL WET WEIGHT IN GRAMS
PER 0.14 M^2 AT EACH STATION

Summer 1969

SPECIES	STATIONS 3	9	11	14	17	22	26	30								
Gammarus sp.																
Dipteran larvae																
Corophium lacustre																
Cyathura polita																
Laeonereis culveri	2			4	5											
Congeria leucophaeta																
Macoma mitchelli		2	1					2								
M. balthica																
Brachidontes recurvus																
Lepidactylus dytiscus					1											
Monoculodes edwardsi																
Tubulanus pellucidus.																
Heteromastus filiformis																
Leptocheirus plumulosus.																
Edotea triloba																
Nereis succinea																
Chiridotea almyra																
Mya arenaria																
Lysippides grayi																
Unid. oligochaetes																
Unid. capitellids																
Rangia cuneata	9		43		1	14	159	5								
Scolecolepides viridis	4	2		6	9			1								
Biomass	297	5	500	0	38	153	1502	74								

TABLE I-2

SPECIES, NUMBER OF INDIVIDUALS
AND TOTAL WET WEIGHT IN GRAMS
PER 0.14 M^2 AT EACH STATION

Fall 1970

SPECIES	STATIONS 2	4	6	8	9	11	12	13	17	18	21	23	24	26	29	31
Gammarus sp.	380	184	9	216	124	53	10	233	18	118	182	19	227	35	52	55
Dipteran larvae	3					8										
Corophium lacustre																
Cyathura polita			1	2	6		1	5		3	21	1		2	1	7
Laeonereis culveri	27		24		6	6	28					4	13	3	17	4
Congeria leucophaeta																
Macoma mitchelli	5		7	3		2	1	14		6		23	12		8	1
M. balthica																
Brachidontes recurvus																
Lepidactylus dytiscus																
Monoculodes edwardsi																
Tubulanus pellucidus										1				1	3	
Heteromastus filiformis																
Leptocheirus plumulosus																
Edotea triloba		1			2					2				2		
Nereis succinea																
Chiridotea almyra																
Mya arenaria																
Lysippides grayi																
Unid. oligochaetes	4	7			2		6			1	43	3		1	10	1
Unid. capitellids																
Rangia cuneata	3	28	3	83	2	12	9	5	3	4	16	5	7	90	2	8
Scolecolepides viridis	39	1	54	6	4	6	10	10	7		82	23	6	2	18	2
Biomass	35	249	68	963	29	142	390	69	87	96	272	168	189	891	90	308

TABLE I-2

SPECIES, NUMBER OF INDIVIDUALS
AND TOTAL WET WEIGHT IN GRAMS
PER 0.14 M^2 AT EACH STATION

Spring 1971

SPECIES	STATIONS 2	4	6	8	9	11	12	13	17	18	21	23	24	26	29	31
Gammarus sp.		8	5		6	9	7	14	29	7	2	22	85	5	12	10
Dipteran larvae	7	5	1							3	1	1				1
Corophium lacustre				1			1					3			2	
Cyathura polita								2			3	1				6
Laeonereis culveri			1										1			
Congeria leucophaeta																
Macoma mitchelli													1	1	2	5
M. balthica																
Brachidontes recurvus											2					
Lepidactylus dytiscus																
Monoculodes edwardsi			2				3		1				1			
Tubulanus pellucidus		3		1										1	4	2
Heteromastus filiformis																
Leptocheirus plumulosus			25				17									
Edotea triloba																
Nereis succinea																
Chiridotea almyra			2				1			6	3					
Mya arenaria																
Lysippides grayi						1	1									
Unid. oligochaetes															17	
Unid. capitellids																
Rangia cuneata	71	20	1	22	22	34		5	14		12	7	6	36		3
Scolecolepides viridis			32	25	25	5	5	12	7			25	9		6	4
Biomass	1120	178	23	307	403	638	1	88	469	1	245	373	207	356	1	116

TABLE I-2

SPECIES, NUMBER OF INDIVIDUALS
AND TOTAL WET WEIGHT IN GRAMS
PER 0.14 M^2 AT EACH STATION

Summer 1971

SPECIES	STATIONS 2	4	6	8	9	11	12	13	17	18	21	23	24	26	29	31
Gammarus sp.		37	2	4		11	1	4	8		42	11	10	1	13	21
Dipteran larvae								1			1	2	1			
Corophium lacustre	2		1		3					109			1			1
Cyathura polita											3	1			1	
Laeonereis culveri			2				1		2			2	8			
Congeria leucophaeta										1						
Macoma mitchelli								1					1	1	1	6
M. balthica																
Brachidontes recurvus																
Lepidactylus dytiscus			18				5	30								
Monoculodes edwardsi					3			1					1			
Tubulanus pellucidus		1		1	1								3		1	1
Heteromastus filiformis																
Leptocheirus plumulosus																
Edotea triloba																
Nereis succinea																
Chiridotea almyra																
Mya arenaria																
Lysippides grayi											4	4				
Unid. oligochaetes							5				2	2	3		4	
Unid. capitellids			1													
Rangia cuneata	91	13	5	44	25	42	4	2	1	6	127	2	10	95	3	7
Scolecolepides viridis	2	1	3		16	7	3	2	2	3	5	14	7	3	1	2
Biomass	1533	264	241	655	469	847	239	33	32	96	2347	2	226	1027	39	80

TABLE I-2

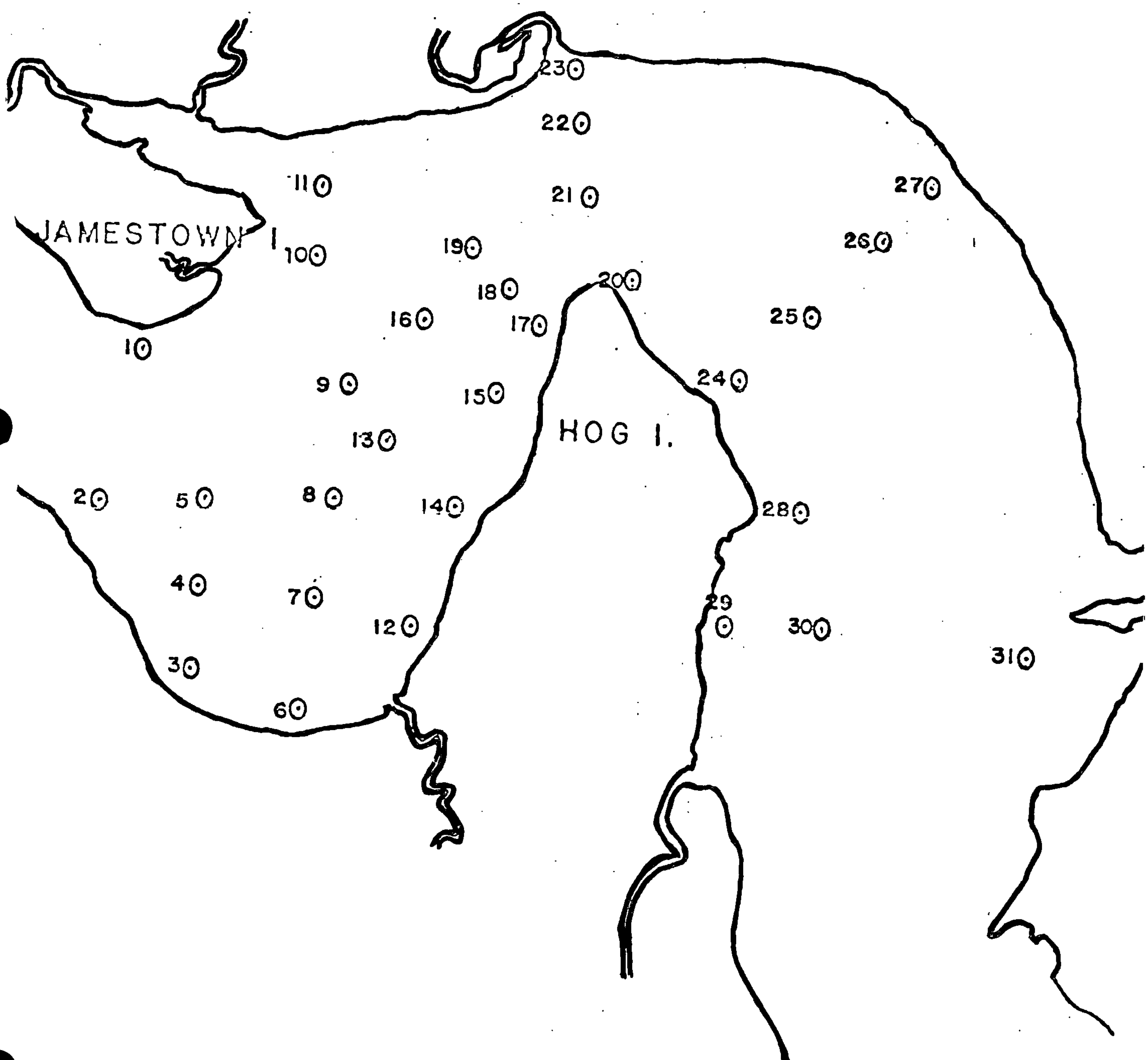
SPECIES, NUMBER OF INDIVIDUALS
AND TOTAL WET WEIGHT IN GRAMS
PER 0.14 M^2 AT EACH STATION

Winter 1971

SPECIES	STATIONS 2	4	6	8	9	11	12	13	17	18	21	23	24	26	29	31
Gammarus sp.		18		3				1	1			1		1	67	34
Dipteran larvae		4	3				3	6			2	32	15	1	6	
Corophium lacustre		2		2	7		6	14	1	17	1	2	1	2	1	16
Cyathura polita				2	4	1		2		6	1	2				8
Laeonereis culveri												13	5		3	
Congeria leucophaeta																
Macoma mitchelli								1				6	3		20	18
M. balthica										3					5	
Brachidontes recurvus																
Lepidactylus dytiscus																
Monoculodes edwardsi																
Tubulanus pellucidus											1			1		
Heteromastus filiformis																
Leptocheirus plumulosus			32				5		41				1			
Edotea triloba											1					
Nereis succinea		2	23				4			1			2			1
Chiridotea almyra								1							1	
Mya arenaria															1	
Lysippides grayi																
Unid. oligochaetes					1				1				1			4
Unid. capitellids							1								10	
Rangia cuneata	29	8	1	6	9	9	6	3	11	5	11	8	10	145		10
Scolecolepides viridis	5	2	12	15	13			4	1	2		3	1		7	
Biomass	333	140	1	107	173	106	288	20	308	46	179	459	249	1436	3	385

FIGURE I-1

SAMPLING STATION NUMBERS
AND
LOCATION IN THE JAMES RIVER



the sample locations used in the table.

The total number of nektonic species found in this tidal segment during a part of each year is very high (See Section I.C.2(a) of Applicant's Environmental Report Supplement Volume I). Population characteristics at a given time, however, are dependent upon the season (water temperature) and the salinity. Because of the high degree of associated variation, neither the applicant and its contractors nor the competent state estuarine research organization has attempted to describe the higher nekton populations in terms of biomass.

The tidal segment adjacent to the Surry facility is not utilized as a spawning area for the recreationally or commercially important species of fish. The Anodromous Alosids spawn upstream in the freshwater tidal reach and upper tributaries and the young remain in the tidal river until Fall. The "estuarine" Serranids spawn upstream of Jamestown Island and the young move downstream as they develop.

Certain forage species such as Silversides and Gobies utilize the oligohaline reach as a spawning area, but no data are available relative to the standing crops present at a given time.

Several studies have evaluated the phytoplankton standing crop (as measured by chlorophyll "a" levels) in the oligohaline reach of the James River. These include references 1, 2, and 3.

The following chlorophyll "a" data for the period May, 1965 to June, 1966 are from Reference 1.

Month	Chlorophyll "a" (μgm/l)	
	Intake	Discharge
May 65	2.8	3.5
June 65	3.9	7.3

Month	Chlorophyll "a" (μgm/l)	
	Intake	Discharge
July 65	4.7	4.4
August 65	3.3	5.4
September 65	4.5	5.8
October 65	45.9*	8.9
November 65	7.4	3.0
December 65	14.0	2.8
January 66	5.4	2.7
February 66	3.9	4.8
March 66	3.8	2.3
April 66	4.0	5.0

* This value is in question.

The data from the pre-operational report (manuscript) indicate that primary productivity values in the area are very low.

Date	mg C/(hr m^3)	
	Intake	Discharge
May 71	3.884	2.014
June 71	1.127	0.942
July 71	2.370	1.292
August 71	3.848	3.260
September 71	5.077	6.373
October 71	2.096	3.712

The low chlorophyll "a" and primary productivity levels measured in this tidal segment result from a physical characteristic of the oligohaline zone known as the turbidity maximum. In this reach, the inorganic settleable solids load is in the highest of any location within the estuary (see reference 1, also Nichols, M. M. and G. Poor, 1967. "Sediment transport in a coastal plain estuary," Am. Soc. Civil Engrs. 93 (WW4): 83-95). This phenomona is attributed to the physical interaction between the sediments transported upstream from the meso - and polyhaline reaches and those transported downstream from the tidal river and to the peptizing of previously flocculated material in the predominantly uni-valent ionic environment of the reach.

The high suspended solids levels not only decrease the depth of light penetration thus limiting primary productivity, but upon re-flocculation mechanically entrap phytoplankton organisms and in the process of sedimentation, remove them from the water column.

Therefore, the tidal segment adjacent to Hog Point is characterized by high turbidity levels, low phytoplankton biomass, and low primary productivity levels.

References

1. Brehmer, M. L. and S. O. Haltiwanger, 1966, "A biological and chemical study of the tidal James River." Final Contract Report, Contract No. Ph 86-65-86, FWPCA (mimeo)

2. Brehmer, M. L. 1967, "Nutrient assimilation in a Virginia tidal system," p. 218-249. In: P. L. McCarty and R. Kennedy, [ed], Proceedings of National Symposium on Estuarine Pollution, Stanford University, California, August 23-25, 1967.

3. Brehmer, M. L. 1972, "Biological and Chemical Study of Virginia's Estuaries" (in press)

Q2. What recent data have been acquired by Vepco's monitoring system pertaining to temperature, dissolved oxygen, biochemical oxygen demand, and salinity regimes of the James River?

ANSWER

Figure I-2 shows the maximum and minimum James River temperature data collected at instrument tower 4 shown on Environmental Report Supplement Figure II.I.A.2-1. These data are representative of temperature data collected at the remaining Vepco instrument towers.

At present, significant salinity data is unavailable because of the poor performance of the installed salinity measuring instrumentation. The Applicant is continuing its efforts to collect this salinity data. Historical salinity data is available.

Dissolved oxygen data is not being collected since considerable historical data is available. Biochemical oxygen demand data is not being collected since it is the Applicant's belief that such data are not relevant to any preoperational or postoperational environmental considerations at the Surry Power Plant.

FIGURE I-2 (SH. 1 of 2)

JAMES RIVER STUDY
COBHAM BAY NORTH
SAMPLE STATION FOUR
MAXIMUM AND MINIMUM WATER
TEMPERATURE AT MID-DEPTH
1970

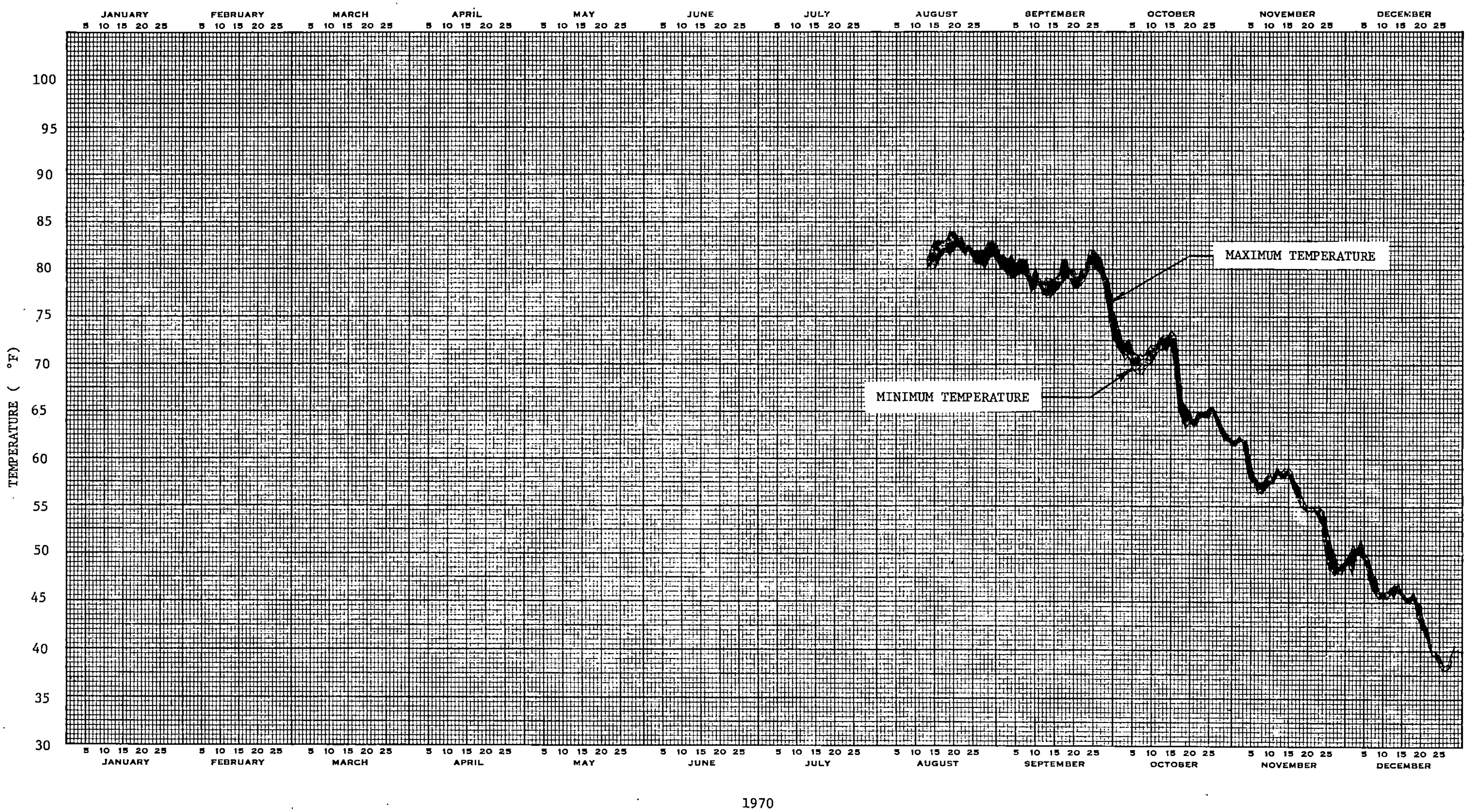
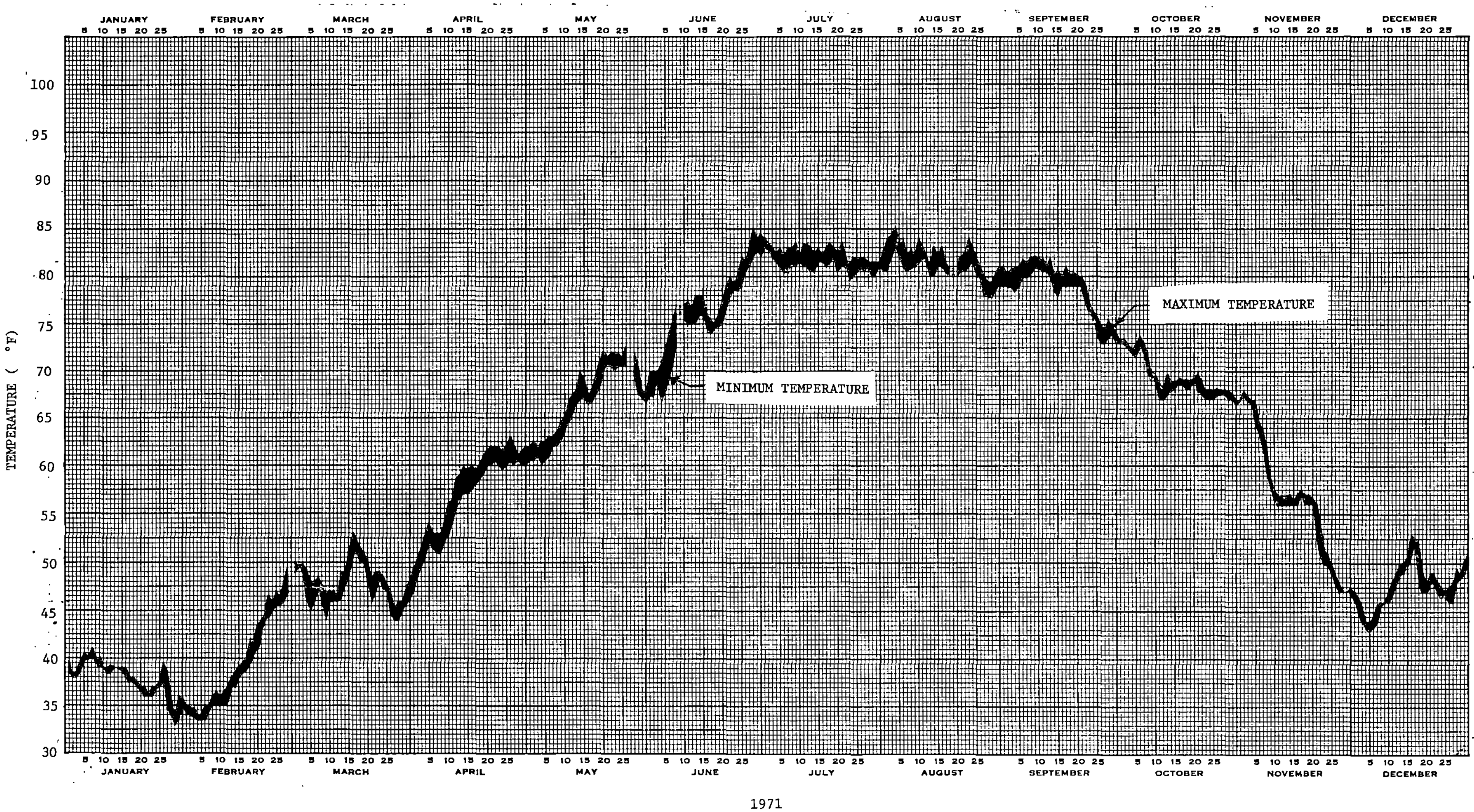


FIGURE I-2 (SH. 2 of 2)

JAMES RIVER STUDY
COBHAM BAY NORTH
SAMPLE STATION FOUR
MAXIMUM AND MINIMUM WATER
TEMPERATURE AT MID-DEPTH
1971



Q3. What are the maximum and average free chlorine concentrations in the sanitary waste system discharges? Are both the discharge canal and a drainage field used?

ANSWER

At the Surry Power Station there are two identical sewage disposal systems. One system serves the Surry Information Center exclusively and the other system serves the station. Each system is sized to process 5000 gallons per day; the maximum expected input to either is 3250 gallons per day.

Sewage flowing into these systems passes first into a septic tank and then through a subsurface sand filter. Liquid effluent from the sand filter then passes into a contact tank, where it is chlorine treated, and then is discharged into the discharge canal where it is mixed with the circulating water flow of approximately 778,000 gallons per minute with one unit operation.

The contact tank and associated components in each system are sized to be able to provide a 2 ppm chlorine residual concentration with 30 minutes retention. In operation of the systems, measured residual chlorine concentrations in the sewage system effluents, prior to dilution in the discharge canal have been: for the Information Center System-2.0 ppm maximum with an average of 0.4 ppm; for the system servicing the station-1.3 ppm maximum with an average of 0.57 ppm.

Q4. What is the estimated total area of land corridors off site required for transmission lines built because of the Surry Project? Please provide Vepco system maps with and without the station and sketches or photographs showing the transmission line structures.

ANSWER

Prior to consideration of the Surry Power Station site, additional transmission circuits were planned to reinforce connections between the Norfolk load area and the central portion of the Vepco system. After the Surry Power Station site was selected, these plans were modified to make provision for connecting this power station into the Vepco transmission system. Figure I-3 shows the rights of way directly associated with the Surry Power Station. Figure I-4 shows the system additions planned before the Surry site was selected. Comparison of these figures indicate that an additional 688 acres of rights of way were acquired as a result of Surry Power Station.

Figures I-5 through I-7 are sketches of the various transmission line structures being utilized in these corridors.

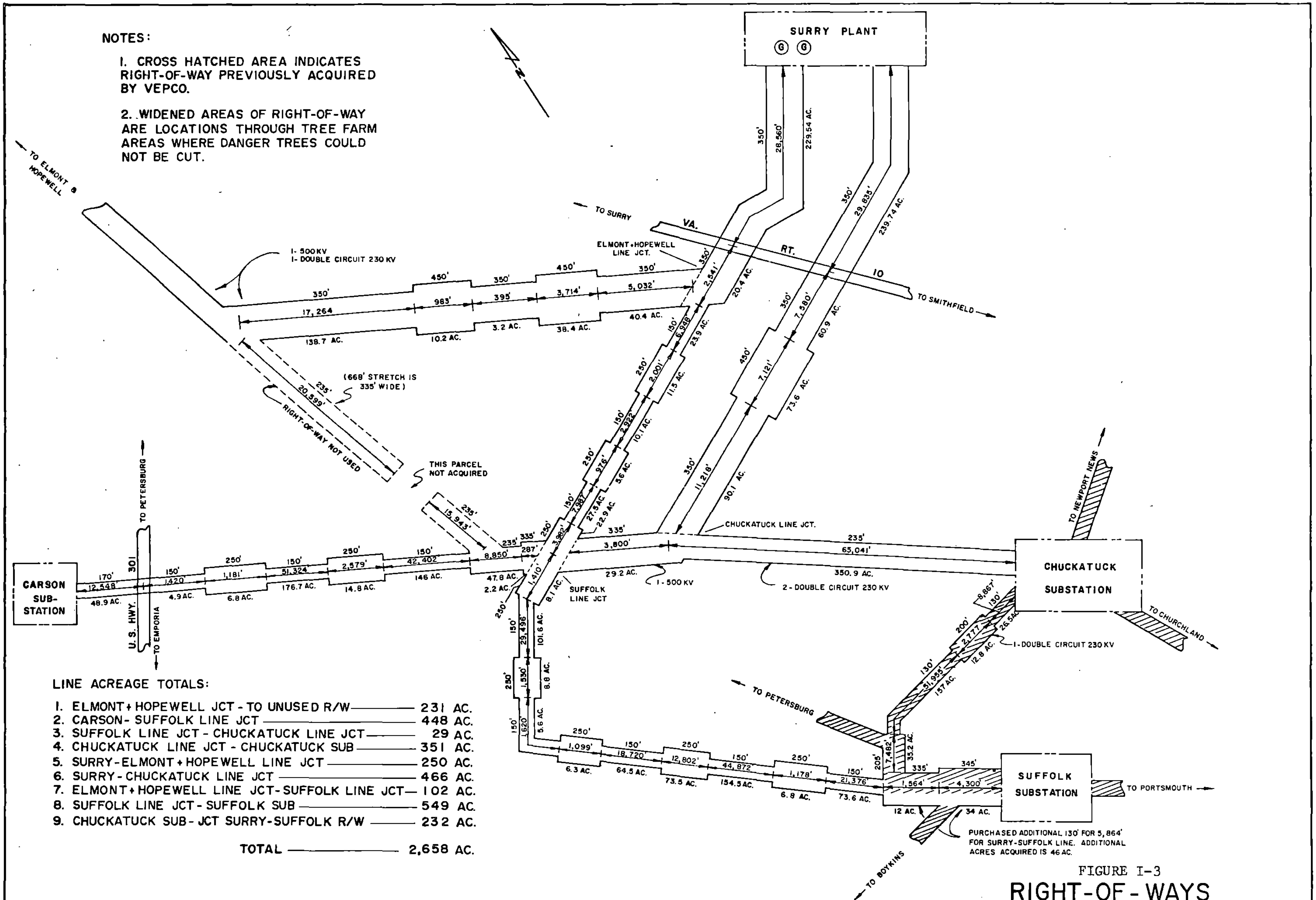
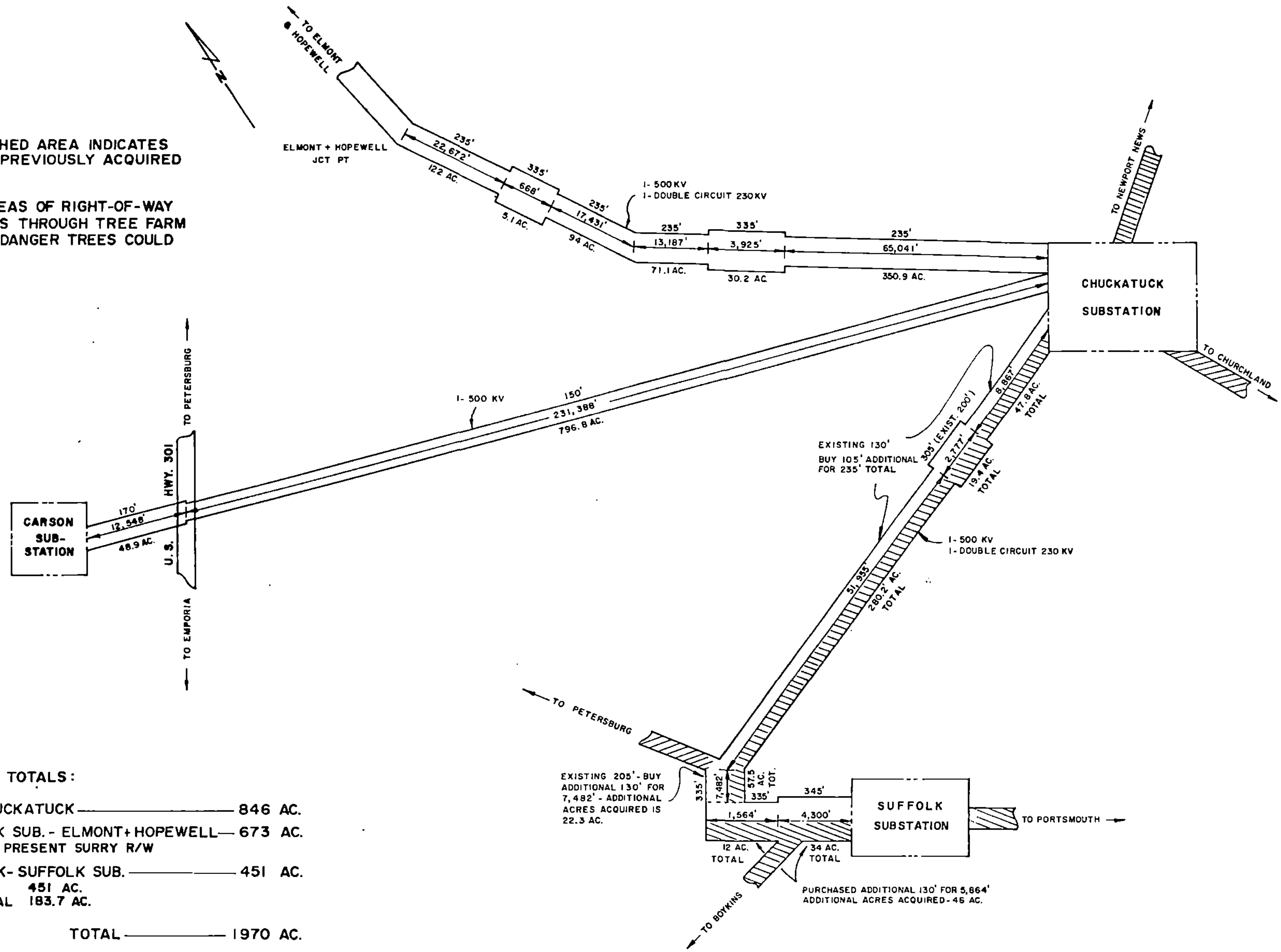


FIGURE I-3
RIGHT-OF-WAYS
SURRY POWER STATION AREA
(DIMENSIONS IN FEET - AREA IN ACRES)
(688 ADDITIONAL ACRES)

NOTES:

1. CROSS HATCHED AREA INDICATES RIGHT-OF-WAY PREVIOUSLY ACQUIRED BY VEPCO.

2. WIDENED AREAS OF RIGHT-OF-WAY ARE LOCATIONS THROUGH TREE FARM AREAS WHERE DANGER TREES COULD NOT BE CUT.



LINE ACREAGE TOTALS:

1. CARSON-CHUCKATUCK ——— 846 AC.
2. CHUCKATUCK SUB. - ELMONT+HOPEWELL ——— 673 AC.
   JCT WITH PRESENT SURRY R/W
3. CHUCKATUCK-SUFFOLK SUB. ——— 451 AC.
   TOTAL 451 AC.
   ADDITIONAL 183.7 AC.

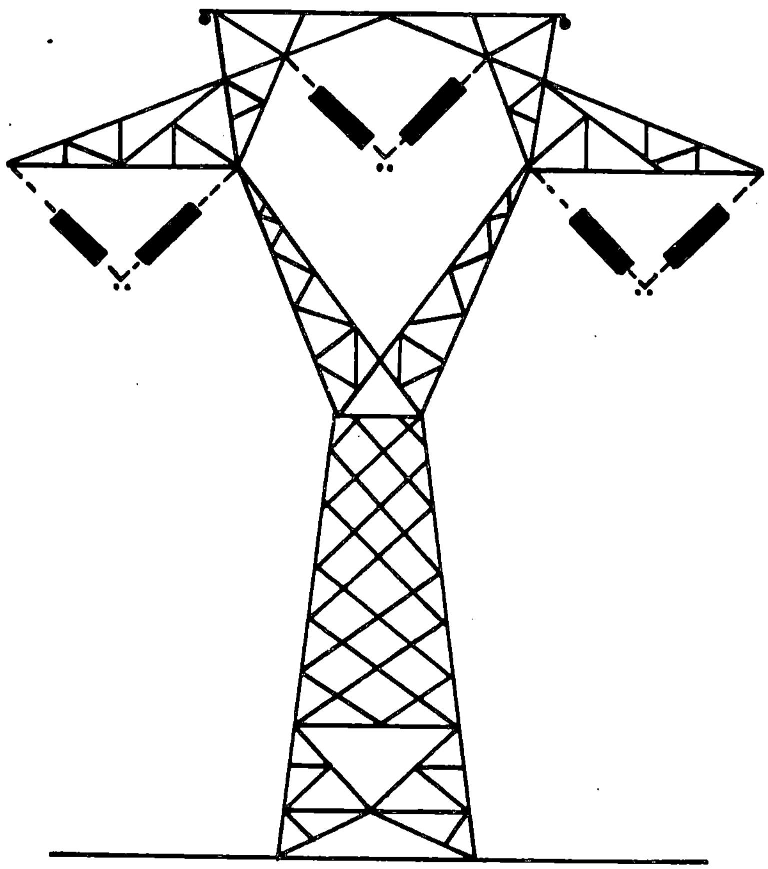
TOTAL ——— 1970 AC.

FIGURE I-4

RIGHT-OF-WAYS SURRY AREA

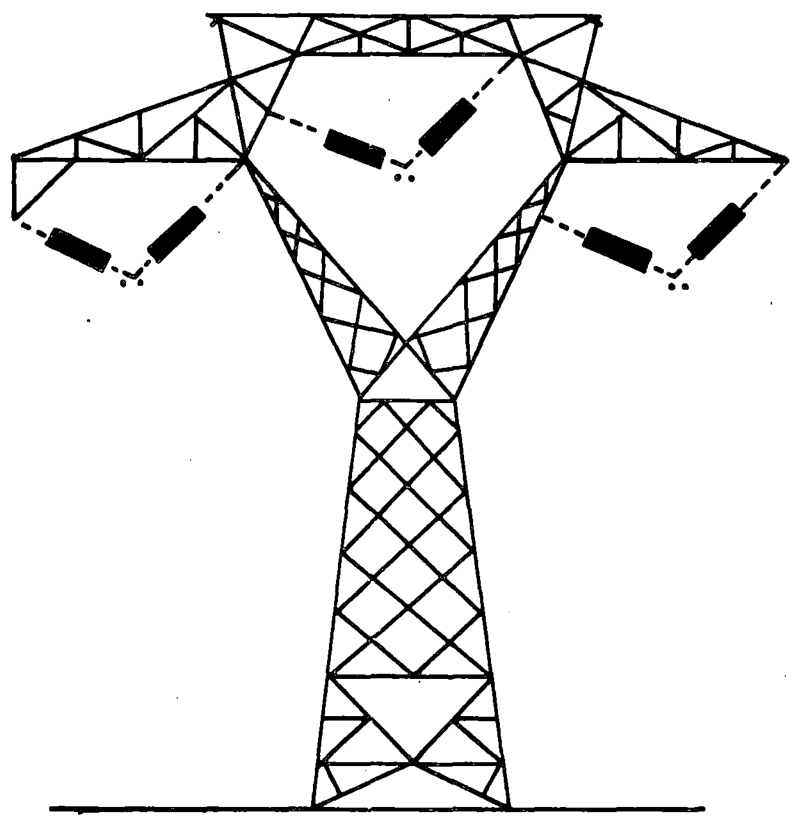
WITH NO SURRY POWER STATION
(DIMENSIONS IN FEET - AREA IN ACRES)

FIGURE I-5



SURRY—ELMONT 500 KV
TRANSMISSON TOWER
TYPES 5LT, 5MT, 5HT

FIGURE I-6

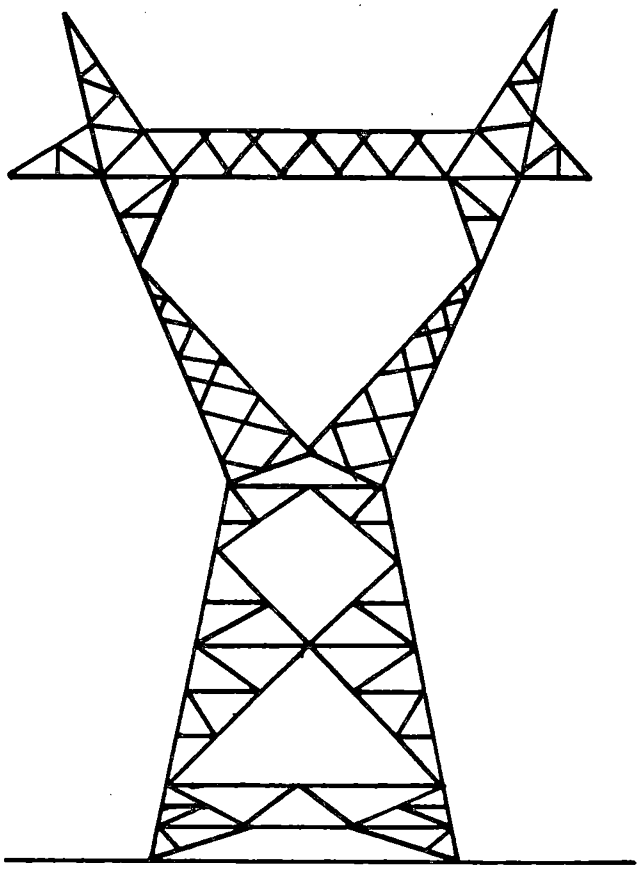


SURRY—ELMONT 500 KV

TRANSMISSON TOWER

TYPES 5LA ,5MA

FIGURE I-7



SURRY—ELMONT 500 KV
TRANSMISSON TOWER
TYPES 5HA, 5DE

NOTE: THIS IS A DEADEND TOWER AND CONDUCTOR SUPPORTS ARE NOT SHOWN ON THIS VIEW

Q5. What chemicals will be used to control the growth of Deciduous species in the transmission line corridors? What are expected rates of application?

ANSWER

Chemicals used to control woody growth on transmission line corridors are Tordon 101, 2,4,5-T and Silvex. These materials are registered with the U. S. Department of Agriculture, the Environmental Protection Agency and the Virginia Department of Agriculture, and are approved for woody brush control. The particular chemical used would depend upon the species present on the right of way.

Normally, 2,4,5-T is used for mixed stands of brush. This chemical is applied at the rate of six pounds acid equivalent per acre. The material is mixed at the rate of 1 1/2 gallons of concentrate to 50 gallons of water, and is applied to an acre of brush. Tordon 101 would be used when the right of way is heavily infested with pine and Red Maple. Tordon 101 would be used at the rate of two gallons of concentrate in 50 gallons of water applied to an acre of brush. Silvex would be applied at the rate of six pounds acid equivalent to an acre and would be used if the predominant species on the right of way were oak. Silvex would be mixed at the rate of 1 1/2 gallons of concentrate in 50 gallons of water, and this mixture would be applied to an acre of brush.

The interval between treatment is usually three years. If brush control is satisfactory, a cutting project is usually substituted after the second application. In this way, two applications and one cutting project are performed during a ten year period.

SECTION FOUR
HEAT DISSIPATION SYSTEM

Q1. What will be the velocity of the cooling water as it passes through the trash racks at the shore intake structure? What size bars are used for the trash racks and what is the spacing between them? What are the transit times for passage of water through the intake canal, through the condenser, from the point of discharge to the end of the rock-filled groin? (Please provide schematic drawings of the water intake system and the discharge system)

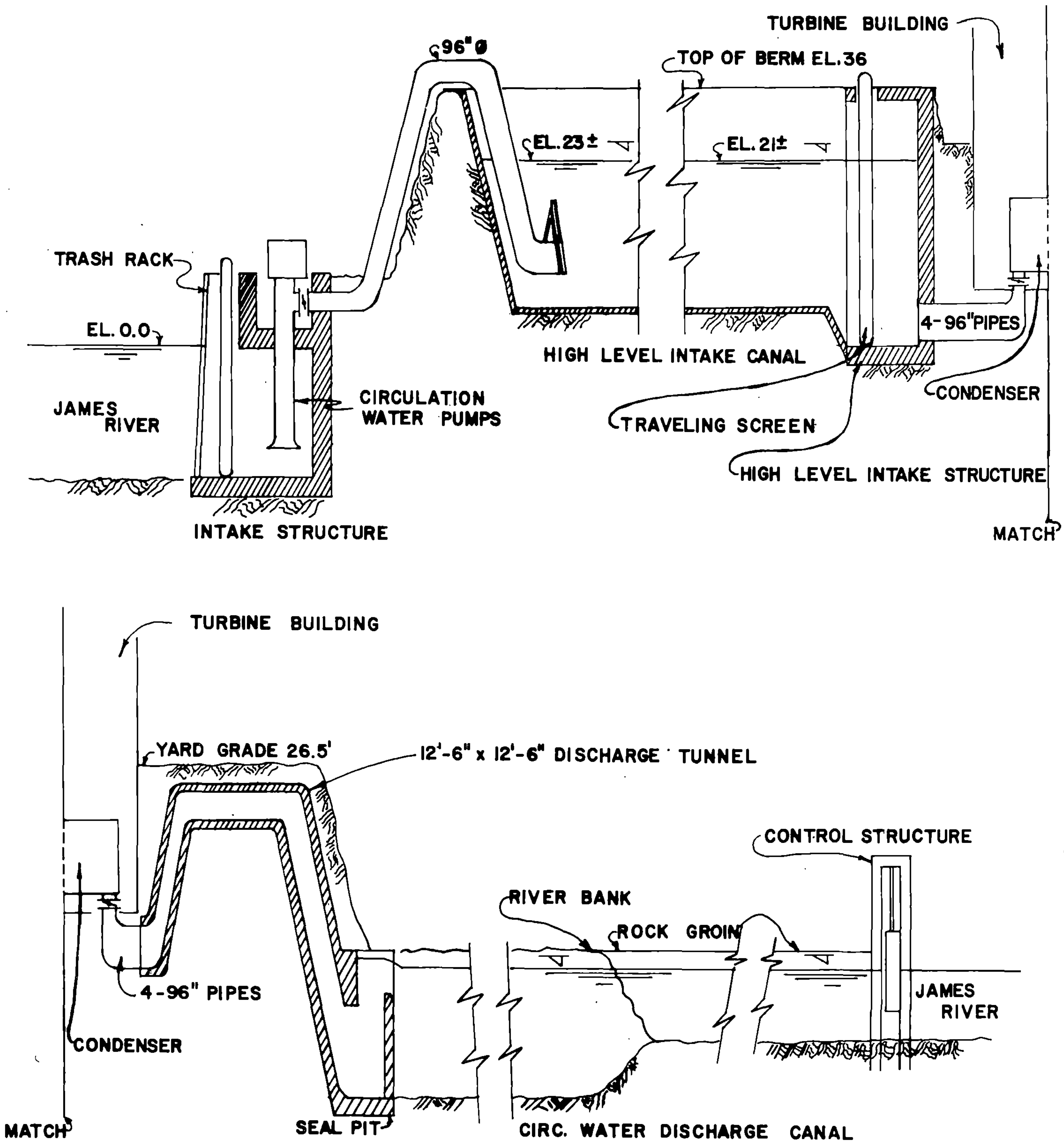
ANSWER

The velocity of the cooling water at the face of and between the bars of the trash racks is dependent on tide level as follows:

Tide Level	Velocity at Face, fps	Velocity Through Bars, fps
Mean High Water	0.92	1.05
Mean Tide Level	0.97	1.10
Mean Low Water	1.02	1.16

The bars of the trash racks are of ½" thickness and are 4" wide. The spacings of the bars are 4 inches between centerlines.

The time of transit for passage of water from the river intake to the high level intake structure is about 33 minutes, if it is assumed both units are in operation. The transit time through the piping system and condenser is about 1.5 minutes and the time of residence in the discharge canal system to the end of the rock groin is about 28 minutes. The transit time through the entire system is thus about 1 hour. Figure I - 8 gives a schematic profile of the Surry Power Station Circulating Water System.



CIRCULATING WATER SYSTEM
SURRY POWER STATION
VIRGINIA ELECTRIC AND POWER COMPANY

FIGURE I-8

Q2. What would be the cost of adding traveling screens to the shoreline intake structure?

ANSWER

To add traveling water screens to the shoreline structure, it is estimated that, assuming such a project would commence in 1972, the cost for Surry Unit 1 would be $280,000 and the cost for Surry Unit 2 would be $295,000. The total combined cost would be $595,000.

Q3. Why was 6 feet per second chosen as the discharge velocity?

ANSWER

The discharge velocity at the outlet was selected to achieve sufficient mixing of the station effluent with the residual water in the James River, but at the same time to minimize the effects of the station plume on small boating and on bed scour.

Q4. Would more dredging of the discharge canal and the shoreline canal in the riverbed be necessary for operation of four units?

ANSWER

If it were decided that two additional units would be installed at the Surry Power Station, the discharge canal, if it were utilized for the additional two units, and the shoreline canal in the riverbed would require enlargement.

SECTION FIVE
CHEMICAL AND RADIOACTIVE DISCHARGES

INTRODUCTION

Radioactive releases presented in this section were calculated on an expected fuel failure rate of 0.20%, instead of the requested 0.25%, to retain consistency with the calculations presented in the Environmental Report Supplement. It is also the Applicant's belief that based on realistic operating data from operating Westinghouse pressurized water reactors, the assumption of 0.20% failed fuel is more realistic than the assumption of 0.25%.

Q1. What quantity of radioactive gas bypasses the waste gas decay system as indicated in Fig. 11.2.5-2 of the FSAR? Please give the volume in cfm and activity in the same units as from the gas decay system.

ANSWER

The most significant sources of activity that bypass the waste gas decay system as indicated in Fig. 11.2.5-2 of the FSAR are from:

A. Containment Purge System

B. Boron Recovery System

C. Liquid Waste System

A. Containment Purge System - During reactor containment subatmospheric operation, there will be some inleakage into the containment. This inleakage, if the containment leaked at the design rate of .1% of contained volume in 24 hours, would amount to approximately 1.2 scfm. The containment purge system is equipped with two, 5 scfm mechanical vacuum pumps for removal of this inleakage. These mechanical vacuum pumps discharge to the suction of the process vent blowers, as shown on FSAR Figure 11.2.5-2. The radionuclide release rates from this system are shown on Table I-3. The following assumptions were used in the calculations:

(1) 0.2% Failed Fuel

(2) Free volume of containment equals 1.75×10^6 ft^3.

(3) Containment activity based on 330 days buildup from a 1 liter/hr Primary to Containment leak rate.

(4) Activity lost from containment leakage considered negligible during

the 330 days buildup (therefore, the release rates are maximum release rates).

(5) Iodine plates out, or is removed by the Iodine removal filters in the containment or by the waste gas filters.

(6) 5 scfm flowrate through the purge system.

(7) 5 scfm flowrate is diluted with 300 scfm flow generated by process blowers and is then discharged through process vents.

B. Boron Recovery System - The source of activity from this system is from the decay of Iodine in the hold up tanks. The release rates listed in Table I-3 were calculated using the following assumptions:

(1) 0.2% Failed Fuel

(2) 17 gpm letdown rate (average for load follow).

(3) Load Follow Operation.

(4) Volume of Boron Recovery Tank = 127,000 gal.

(5) 95% of Xenon supplied to the Evaporator is retained in the evaporator distillate.

(6) With processing through the evaporator, .0025% of the Xenon in the holdup tanks is released to the atmosphere via the Distillate Tank.

(7) 0.08% of the Xenon in the Boron Recovery Tank is released.

C. High Level Liquid Waste System - Iodine decay is also the source of noble gas release for this system. The release rates listed in Table I-3 were calculated using the following assumptions:

(1) 0.2% Failed Fuel

(2) Activities from liquid waste estimates for

a. Sample Sinks

b. Lab Wastes

c. Primary Coolant System Leakage

d. Spent Resin Flush

(3) Volume of Liquid Waste Tank - 2000 gal.

(4) 95% of Xenon supplied to the Liquid Waste Evaporator is retained in evaporator distillate.

(5) With processing through the evaporator, 0.0025% of the Xenon in the Waste Tank is released to the atmosphere via the Distillate Tank.

(6) 0.08% of the Xenon in the Waste Tank is vented to atmosphere.

TABLE I-3

RELEASE RATES (Ci/sec)

Isotope	Containment Purge	Boron Recovery Sys.	High Level Waste
Kr 85 m	9.04×10^{-11}	-	-
Kr 85	2.67×10^{-7}	-	-
Kr 87	1.55×10^{-11}	-	-
Kr 88	1.01×10^{-10}	-	-
Xe 131m	2.38×10^{-8}	3.96×10^{-8}	2.09×10^{-10}
Xe 133m	1.81×10^{-9}	1.14×10^{-9}	6.66×10^{-12}
Xe 133	3.56×10^{-7}	2.92×10^{-8}	1.65×10^{-10}
Xe 135m	2.13×10^{-10}	7.61×10^{-12}	4.44×10^{-14}
Xe 135	1.25×10^{-9}	4.12×10^{-10}	2.41×10^{-12}

Q2. What partition factor is claimed for iodine in the steam generator, at the condenser air ejector, and for the steam and water from the blowdown? What quantity of radioactive iodine is expected to be released to the atmosphere from the air ejector and the blowdown vents when the activity level in the discharge canal is equal to the MPC? Give the blowdown rate used in gpm and/or cfm, average or maximum.

ANSWER

The following partition factors were used in calculating the radioactive iodine released to the atmosphere from the air ejector and blowdown tank vents:

$$\frac{\mu Ci/gm\ H_2O}{\mu Ci/gm\ Steam} = 10 \quad \text{(Steam Generator)}$$

$$\frac{\mu Ci/gm\ Steam}{\mu Ci/cc\ Air} = 10^4 \quad \text{(Condenser)}$$

$$\frac{\mu Ci/sec\ into\ blowdown\ tank}{\mu Ci/sec\ out\ tank\ vent} = 42$$

Table I-4 lists the radioactive iodine released to the atmosphere from the air ejector and blowdown tank vents, and is based on the above partition factors and the following assumptions:

(1) Primary to secondary leak rate equals 20 gpd (3.15 liter/hr).

(2) 0.2% Failed Fuel.

(3) Steam Generator volume equals $47.6 m^3$ each.

(4) Steam Generator blowdown rate equals 22 gpm/reactor unit (maximum)

(5) Air Ejector flow equals 12.5 scfm.

TABLE I-4

Ci/sec
Two Unit Operation

Isotope	Blowdown Tank	Air Ejector
I 131	1.24×10^{-8}	2.84×10^{-11}
I 132	1.64×10^{-9}	3.74×10^{-12}
I 133	1.13×10^{-8}	2.6×10^{-11}
I 134	1.30×10^{-10}	2.98×10^{-13}
I 135	3.0×10^{-9}	6.88×10^{-12}

If the mixture of isotopes in the Discharge Canal listed in the Liquid Waste Estimates were at MPC, the above releases from the blowdown tank vent and the air ejector would increase by a factor of approximately 41.

Q3. Is the expected average holdup time for radioactive gas in the recombiner and decay tanks equal to or greater than 60 days?

ANSWER

The expected average holdup time for radioactive gas in the recombiner and waste gas decay tanks is greater than 60 days. The typical steps involved in a waste gas cycle, during which decay of gases would occur, are listed below. These steps were assumed for calculation of waste gas releases presented in Environmental Report Supplement Table II.1.C.2-5.

Typical Steps Involved In Processing of Waste Gas

1. Waste radioactive gas stripped from primary coolant letdown water is fed to a waste gas decay tank during a 330 day filling period with the recombiner operating.
2. Upon completion of the filling period, the contents of a waste gas decay tank are held up for an additional 60 days.
3. Upon completion of the holdup period, the contents of a waste gas decay tank are bled to the atmosphere over a 10 day period.

Q4. Please explain the difference in equilibrium coolant activity shown on Table 9.1-5 of the FSAR and Table 11.2.2-1 on page B-16 of the original Applicant's Environmental Report.

ANSWER

The activities for FSAR Tables 11.2.2-1 and 11.2.2-2 presented on pages B-16 and B-17 of the Surry Power Station Environmental Report, submitted December 31, 1970, were calculated assuming 100% power operation with a load follow operation value for boron recovery annual average letdown of 17 gpm. These assumptions provide a conservative approach to the waste gas release calculation.

The activities presented in Table 9.1-5 of the FSAR were calculated assuming base loaded operation. If the calculational techniques used in generation of Table 11.2.2-1 were used, considering 100% power and a base load letdown of 1.2 gpm, activities would be generated that would be in close agreement with the activities presented in Table 9.1-5.

Q5. What quantity of radioactive gas and radioiodine is contributed by the various vacuum systems and by the various leaks in the turbine steam loop?

ANSWER

An estimate of the radioiodine released via the air ejector is given in Table I-4, in answer to question 2 of Section Five.

All radioactive gases due to a primary to secondary leak are assumed to exit from the secondary system via the air ejector. Table I-5 below lists the air ejector radioactive gas release rates based on the following assumptions:

(1) Primary to secondary leak rate equals 20 gpd

(2) 0.2% Failed Fuel

(3) No credit for decay

TABLE I-5

Ci/sec. Releases
Two Unit Operation

Isotope	Air Ejector Release Rate
Xe 133	6.52×10^{-5}
Xe 133m	7.22×10^{-7}
Xe 135	1.42×10^{-6}
Kr 85 m	4.88×10^{-7}
Kr 85	1.18×10^{-6}
Kr 87	2.42×10^{-7}
Kr 88	8.52×10^{-7}

The iodine release rates due to leakage in the turbine steam loop are based on the following general assumptions:

(1) Equilibrium Steam Generator Activity Based On:

(a) 0.2% Failed Fuel

(b) Each Steam Generator Volume equals $47.6 m^3$

(c) Blowdown equals 22 gpm/unit

(d) Steam generator leakage rate equal to 20 gpd

(2) Partition Factors:

(a) Steam Generator

$$10 \ \frac{\mu Ci/gm\ H_2O}{\mu Ci/gm\ Steam}$$

(b) Condensers

$$10^4 \ \frac{\mu Ci/gm\ Steam}{\mu Ci/cc\ Air}$$

(3) The sources and estimates of steam plant leakage are as listed in Table I-6.

TABLE I-6

Sources Of Leakage

Sources	Steam/Vapor Leaks (Per Unit)	Steam Reflashing (Total)	Water Leaks (Per Unit)
Auxiliary Steam Drain Receiver	-	1100 #/hr	-
Containment Spray Pump Turbine	0.1 #/hr	-	-
Auxiliary Feed Pump Turbine	0.1 #/hr	-	-
Chilled Water Air Ejector Condenser Vent	2.5 scfm	-	-
Gland Steam Condenser Vent	18 scfm	-	-
Valve Steam Leaks	100 #/hr	-	0.2 gpm
Pump Seal Water (Condensate)	-	-	10.0 gpm
Building Heaters Condensate Receivers	-	600 #/hr	-

From the estimates listed in Table I-6, it can be concluded that the four basic sources of Iodine release in the turbine steam loop are from:

(1) Direct Steam Leakage:

(a) 100.2 #/hr - unit = 200.4 #/hr Total

(b) No decay or plate out (all Iodine in steam is released to atmosphere).

(2) Vapor Leakage From Chilled Water and Gland Steam Condenser Vents:

(a) 20.5 scfm/unit = 41 scfm Total

(b) Steam Generator and Condenser Partition Factors Considered

(3) Vapor from Condensate Leakage

(a) 10 gpm/unit = 20 gpm Total

(b) Condenser Plate Out Factor Equals 10

(c) 2.4% of Iodines in Condensate is Released to Atmosphere.

(4) Leaks From Reflashed Steam:

(a) 3% of liquid in the Condensate receiver flashes, therefore, 0.24% of the iodine in the 40 gpm of Condensate is released to the atmosphere.

(b) 13% of the liquid in the Auxiliary Steam Drain Receiver flashes, therefore, 1.04% of the iodine from 17 gpm of Condensate is released to the atmosphere.

(c) 30% of the liquid valve steam leakage flashes, therefore, 2.4% of the iodine in this leakage is released to the atmosphere.

(d) Plate Out Factor in the Condensate and Auxiliary Steam Drain Receivers equals 10.

Table I-7 below lists the total radioactive iodine released from the turbine steam loop calculated with the above source assumptions. These iodine release rates are predicted on conservative assumptions regarding plate out factors and mass flow rates of various leak paths. Field data has not been definite in this concentration range, but iodine deposition in the system is believed to be significally greater than predicted in this analysis.

TABLE I-7

Iodine Release Rates (Ci/sec)
Two Unit Operation

Isotope	Direct Steam Leakage	Chilled H_2O & Gland Steam Condensers	Reflashed Steam	Condensate Leakage
I 131	6.04×10^{-10}	4.64×10^{-11}	4.17×10^{-11}	7.26×10^{-11}
I 132	8.00×10^{-11}	6.14×10^{-12}	5.53×10^{-12}	9.62×10^{-12}
I 133	5.54×10^{-10}	4.25×10^{-11}	3.83×10^{-11}	6.66×10^{-11}
I 134	6.36×10^{-12}	4.88×10^{-13}	4.40×10^{-13}	7.64×10^{-13}
I 135	1.47×10^{-10}	1.13×10^{-11}	1.02×10^{-11}	1.76×10^{-11}

Q6. What would be the leak rate at which activity in the steam generator blowdown would equal 3.5×10^{-3} μCi/cc, if a steam generator leak occurred while the reactor operated with 0.20% failed fuel? Does the applicant intend to engage in a maintenance program that will keep the leakage rate below that figure?

ANSWER

A continuous leak rate of approximately 13 liters/hour (0.057 gpm) would be required to increase the blowdown equilibrium activity to 3.5×10^{-3} μCi/cc if the following assumptions are made:

(1) 0.2% Failed Fuel

(2) Volume of each steam generator equals $47.6 m^3$

(3) Blowdown rate from each steam generator equals 22 gpm/unit.

If steam generator leakage increased such that, with a 22 gpm blowdown per unit, the blowdown activity increased to 3.5×10^{-3} μCi/cc, blowdown would be diverted to the liquid waste disposal system or continuous blowdown from the effected steam generator would be terminated. If, in this condition, the capability of the liquid waste disposal system limited continuous blowdown or intermittent blowdown of the effected steam generator to such an extent that steam generator chemistry specifications were exceeded, repairs to the leaking steam generator would be conducted. With the capability provided by the reactor coolant loop isolation valves, the leaking steam generator could be isolated and the reactor operated with only two loops in service, until repairs could be made to the leaking steam generator.

Q7. Please confirm that the discharges given on pages 288 and 291 of the Environmental Report Supplement are based on the following flow rates (gal/yr).

steam generator blowdown	2.29×10^7
laundry	2.50×10^5
sampling system	2.76×10^4
boron recovery letdown	6.40×10^5
spent resin flush	3.16×10^4
laboratory wastes	4.03×10^4
primary coolant system leakage	3.23×10^3

ANSWER

The above listed flowrates were utilized in calculating the radionuclide releases presented on pages 288 and 291 of the Environmental Report Supplement.

Q8. Vepco's Application for Permit for Surry Power Station to the State Water Control Board dated September 1967, contains the following statement relative to the condenser circulating water: "No chlorination will be used; however, should intermittent chlorination become necessary, it would be limited to 0.5 ppm residual Cl for 30 minutes each 8 hours." This statement permits the Applicant to chlorinate as indicated and, in so doing, cause an impact on the environment. Will the Applicant stipulate the conditions under which he would exercise the option allowed by the permit?

ANSWER

The Applicant would utilize intermittent chlorination of circulating water only when the mechanical condenser tube cleaning system is inoperative or ineffective in removing marine growth. If the unit's performance is effected to such extent that electrical output is reduced then chlorination treatment will be considered.

With the Applicant's experience with mechanical condenser tube cleaning systems similar to the system installed at Surry, the Applicant does not expect intermittent chlorination to be necessary.

Q9. The Environmental Report Supplement (p. 183) discusses an artificial lagoon used for the disposal of certain chemicals during construction. Please confirm the following estimate of the amounts discharged to the lagoon

disodium phosphate	800 lbs.
trisodium phosphate	1800 lbs.
non-ionic detergent	400 lbs.
anti-foam agent	40 lbs.

Please also indicate whether this lagoon will be used following the completion of Units 1 and 2.

ANSWER

As of January, 1972, an updated analysis of the lagoon indicates that, because of additional cleaning of secondary systems, the amounts of chemicals discharged to the treatment lagoon have increased to an estimated 3900 pounds of trisodium phosphate, 3370 pounds of disodium phosphate, 600 pounds of non-ionic detergent, and 60 pounds of anti-foam agent.

Use of the lagoon after completion of construction of Units 1 and 2 is not contemplated at this time. However, if operational cleaning of the secondary systems is required at some future date, this lagoon or one of comparable size would have to be provided.

Q10. What will be the amount and nature of the detergents used in the onsite laundry?

ANSWER

The laundry detergent scheduled to be used at the Surry Power Station is a non-phosphate, no enzyme, bio-degradable detergent which has a ph of 11.0 in an average use concentration (0.1%). The amount of detergent to be used is estimated to be less than one half pound per day.

Q11. Please confirm the following figures for boron concentration in the discharge canal: average 9.27×10^{-6} ppm; maximum, 4.05×10^{-4} ppm.

ANSWER

Assuming a circulating water flow of 7.75×10^{5} gpm, the maximum plausible boron concentration in the discharge canal resulting from station operation, is calculated to be 5.3×10^{-4} ppm. This calculation assumes that the full ouput of the boron evaporators, 40 gpm, with a 10 ppm boron concentration, is discharged to the discharge canal.

Assuming a 500 ppm reactor coolant boron concentration is equivalent to the average reactor coolant boron concentration, the average boron concentration in the discharge canal attributable to station operation, is calculated to be 9.27×10^{-6} ppm.

Q12. Do the activities given in the Table on page 291 of the Environmental Report Supplement for the following nuclides include the contributions from parent nuclides shown in parentheses?

Y-90	(Sr-90)
Y-91	(Sr-91)
Nb-95	(Zr-95)
X-132	(To-132)
La-140	(Ba-140)

ANSWER

The contributions from the parent nuclides shown above in parentheses are included in the liquid waste estimate calculations.

Q13. Why are the following nuclides not given in the Table mentioned above? They should be in equilibrium with the parent nuclides shown in parentheses.

Tc-99m	(mo-99)
Ba-137m	(Ca-137)
Pr-144	(Ce-144)

ANSWER

The basis for isotope selection for the liquid waste estimates was the list of isotopes in Table 9.1-5 of the FSAR, excluding isotopes with half lives less than 2 hours and/or isotopes which are biologically insignificant compared to the reported parents or daughters.

Tc-99m (T 1/2 = 6 hr) was considered biologically insignificant compared to its parent, Mo-99 (T 1/2 = 66.6 hr). The discharge in curies per year of Tc-99m (MPC = 3×10^{-3} μCi/ml) is equal to approximately 82% of the discharge of Mo-99 (MPC = 4×10^{-5} μCi/ml). When considering MPC's and the above discharge ratio, Tc-99m is approximately 90 times less significant than Mo-99.

Since the Ba-137m (T 1/2 = 2.55 min) and Pr-144 (T 1/2 = 17.3 min) are not listed in Appendix B of 10CFR20, and because of their short half lives, they were considered relatively insignificant.

Q14. Why are Te-129m and its daughter Te-129 not listed? Please give the activities for these and also for Ru-103, Ru-106, Nb-93m, and Te-127m.

ANSWER

The basis for isotope selection for the liquid waste estimates was the list of isotopes presented in Table 9.1-5 of the FSAR, excluding isotopes with half lives less than 2 hours and/or isotopes which are biologically insignificant compared to the reported parents or daughters.

Te-129m was not listed in Table 9.1-5. Te-129 was not listed in the liquid waste estimates, although its reactor coolant activity of 4.6×10^{-3} μCi/cc is listed in Table 9.1-5, because of its short half life of 69 minutes.

Table I-8 below presents the reactor coolant activities for Te-127m, Te-129m, Ru-103, Ru-106 and Nb-93m, for 0.2% failed fuel. The table also presents the steam generator activity and annual curie releases calculated utilizing the following assumptions:

(1) 0.2% failed fuel

(2) Base load operation

(3) Steam generator volume equals $47.6 m^3$ each

(4) Primary to secondary leak rate equals 1 liter/hr.

Table 1-8

Isotope	Reactor Coolant Activity (μCi/cc)	Steam Generator Activity (μCi/cc)	Ci/yr* Discharged
Te 127m	3.20×10^{-4}	6.40×10^{-8}	5.60×10^{-3}
Te 129m	3.20×10^{-3}	6.20×10^{-7}	5.40×10^{-2}
Ru 103	5.60×10^{-5}	1.10×10^{-8}	9.60×10^{-4}
Ru 106	7.20×10^{-6}	1.44×10^{-9}	1.26×10^{-4}
Nb 93m	1.20×10^{-4}	2.40×10^{-8}	2.20×10^{-3}

* From steam generator blowdown activity. Two unit operation assumed.

SECTION SIX
RADIOLOGICAL IMPACT

Q1. The information presented in the tables on pages C-6 through C-9 figures 1 and 2 on pages C-37 and C-38 of the applicant's Environmental Report Supplement, Vol. 2, Appendix C (Environmental Radiation Surveillance Program) appear to be out of date and an inconsistency with the text exists regarding sample station location numbers. Please provide updated tables and figures which reflect current plans as to sampling location and distance from station, sample types, sampling frequency, and types of analysis to be performed on the respective samples.

ANSWER

Revision One of pages C-2, C-5, C-6, and C-9 and Figure 2 on page C-38 corrected the inconsistencies in Appendix C of the Environmental Report Supplement. Appendix C, with the above revised pages, accurately represents the Radiation Surveillance Program through December, 1971.

In 1972, with the availability of Ge (Li) detectors, the surveillance program is placing more emphasis on gamma isotopic analysis on selected media and less emphasis on gross beta counted for a large number of samples. Table I-9 details this updated surveillance program.

Revision One to page C-9 provided the information requested on distance of sampling locations from the station.

TABLE I-9
SURRY POWER STATION
ENVIRONMENTAL SAMPLING PROGRAM

SAMPLE TYPE	FREQUENCY	TYPE OF ANALYSIS
1. WATERS		
A. James River	Bi-Monthly Semi-Annual	Tritium Gamma Isotopic & Tritium*
Chickahominy Station Intake Station Discharge Point of Shoals Newport News		
B. Wells	Semi-Annual	Gross Alpha, Gross Beta, Tritium
Surry Station (Deep) Hog Island Reserve (Deep) Bacon's Castle (Shallow) Jamestown (Shallow)		
C. Surface Water	Semi-Annual	Gross Alpha, Gross Beta, & Tritium
Chippokes Creek Williamsburg Reservoir Newport News Reservoir Smithfield		
D. Precipitation	Monthly Semi-Annual**	Gross Beta & Tritium Gross Beta & Tritium
Surry Station Newport News		

* Composits of Bi-Monthly samples from Chickahominy & Newport News Stations

** Composits of Monthly samples

TABLE 1-9 (CONT.)

SAMPLE TYPE	FREQUENCY		TYPE OF ANALYSIS
II. AIR			
A. Particulates			
	Monthly		Gross Beta
	Quarterly***		Gamma Isotopic
Surry Station			
Hog Island Reserve			
Bacon's Castle			
Alliance			
Colonial Parkway			
Dow			
Fort Eustis			
Newport News			
B. Radiogas	Quarterly	TLD	mrem exposure
Surry Station			
Hog Island Reserve			
Bacon's Castle			
Alliance			
Colonial Parkway			
Dow			
Fort Eustis			
Newport News			
Smithfield			

*** Composits of Bi-Weekly samples. Stations 1 and 2 analyzed as one sample. Station 3, 5, 6, 9, and 10 analyzed as one sample. Station 11 analyzed as one sample.

TABLE I-9 (CONT.)

SAMPLE TYPE	FREQUENCY		TYPE OF ANALYSIS
III. BIOTA			
A. Crops	Annual	Corn, Peanut, & Soybean	Gamma Isotopic and Sr-90
Bacon's Castle			
B. Fowl	Semi-Annual		Gamma Isotopic
Hog Island Reserve			
C. Oyster	Bi-Monthly	Tissue	Gamma Isotopic
Deep Water Shoals Point of Shoals Newport News			
D. Clam	Bi-Monthly	Tissue	Gamma Isotopic
Chickahominy Chippokes Creek Hog Island Point Lawnes Creek Station Discharge Jamestown			
E. Crab	Twice per season	Tissue	Gamma Isotopic
In Vicinity of Station			
F. Fish (Catfish and white perch or eel)	Semi-Annual		Gamma Isotopic
Vicinity of Station			

TABLE I-9 (CONT.)

SAMPLE TYPE	FREQUENCY	TYPE OF ANALYSIS
IV. SILT	Semi-Annual	Gamma Isotopic
Chickahominy		
Station Discharge		
Hog Island Point		
Station Intake		
Point of Shoals		
Newport News		
V. MILK	Bi-Monthly	Sr-90, Calcium, and Gamma Scan for I-131 and C_s-137
Bacon's Castle (Epps)		
Bacon's Castle (Judkins)		
Dow (Ross)		
Smithfield (Barlow)		
Colonial Parkway (Smith)		
VI. SOIL	Annual	Gamma Isotopic
Alliance		
Bacon's Castle		
Colonial Parkway		
Dow		
Fort Eustis		
Surry Station		

SECTION SEVEN
DECOMMISSIONING

Q1. What plans if any, have been made and which alternates were considered for decommissioning the plant, site clearance, and handling radioactive materials upon termination of plant operation?

ANSWER

Decommissioning of the station should not occur in the immediate future since the life of the station is estimated to be 30 years. Because of the unpredictability of conditions which might exist at the time of decommissioning, no definite plans have been formulated for such an undertaking. However, a preliminary estimate of the costs associated with decommissioning of the station has been conducted and the Applicant is confident that the financial requirements necessary for such an undertaking can be met. In determining its revenue requirements for the future, the Applicant has made provisions for financing decommissioning. In addition to satisfying financial requirements, it is expected that decommissioning could be accomplished in accordance with any regulations applicable at that time.

Q2. What components will be significantly radioactive upon termination of operation to require AEC licenses for continued use or possession?

ANSWER

At the present time, it is unknown what components will be significantly radioactive upon termination of operation to require AEC licenses for continued use or possession. It is anticipated that some portions or components of the reactor coolant system may be significantly radioactive upon completion of operation to require AEC licenses. For these items or other items significantly radioactive, the Applicant will obtain the required AEC licenses.

Q3. Over the plant life, what is the expected consumption of fissionable materials and strategic metals such as nickel, cadmium and zirconium?

ANSWER

Estimates of the maximum amounts of fissile materials and strategic metals to be consumed in a reactor core over the life of the Surry Station are presented in Tables I - 10 and I - 11. The following assumptions were made in calculating these quantities:

(1) Plant life will be thirty years

(2) Reload batches of fuel will have an enrichment of 3.1%

(3) Plutonium will not be recycled

If recycle of plutonium was assumed, the amount of uranium consumed would be decreased but this would be compensated for by an increase in the amount of plutonium consumed.

Among the materials considered to be strategic are cadmium, nickel and zirconium. Cadmium is used in the core as a neutron absorber in the 53 control rod assemblies. It is not anticipated that the initial control rods will have to be replaced over the life of the plant.

Nickel is present in the core in stainless steel and inconel. Stainless steel is used in cladding of control rods and burnable poison assemblies, and in components of the fuel assemblies. Inconel is also used in the fuel assemblies. Approximately 1500 fuel assemblies will be irradiated over the life of the plant. The burnable poison assemblies will be removed from the core at the first refueling.

Zirconium is contained in the Zircaloy -4 clad of the fuel rods. Each fuel assembly has approximately 250 pounds of cladding.

The analysis of the fissile material consumed by each reactor includes the consumption of fissile material produced in the core during operation. The computer program LEOPARD was used to predict the rate of fissile consumption of various isotopes in the reactor. These rates and the total consumption of these isotopes during plant life are presented in Table 1-12. After initial core loading, it was assumed that 23 tonnes of uranium is loaded into the core each year.

TABLE I-10

STATION CONSUMPTION OF FISSILE MATERIAL
ONE REACTOR CORE

Uranium	15,900 KG
Plutonium	9,100 KG

TABLE I-11

STATION CONSUMPTION OF STRATEGIC METALS
ONE REACTOR CORE

Material	Amount Consumed (lbs)
Cadmium	200
Nickel	22,000
Zirconium	375,000

TABLE I-12

UNIT CONSUMPTION RATES OF CERTAIN FISSILE MATERIALS

ISOTOPE	FISSION RATE (Kg/tonne U. feed)	TOTAL LOSS-ONE UNIT CONSUMPTION (Kg)
U^{235}	19.2700	14200
U^{236}	0.0120	9
U^{238}	2.2664	1700
Pu^{239}	10.3846	8000
Pu^{240}	0.0139	10
Pu^{241}	1.5567	1100
Pu^{242}	0.0016	1