Final

environmental statement

related to operation of

SURRY POWER STATION UNIT 1

VIRGINA ELECTRIC AND POWER COMPANY

DOCKET NO. 50-280

May 1972

UNITED STATES ATOMIC ENERGY COMMISSION

DIRECTORATE OF LICENSING

SUMMARY AND CONCLUSIONS

This Final Detailed Environmental Statement was prepared by the U. S. Atomic Energy Commission, Directorate of Licensing. It relates to the proposed issuance of an operating license to the Virginia Electric and Power Company for the start-up and operation of Surry Power Station Unit 1, located in Surry County, Virginia (Docket No. 50-280), but considers the environmental impact of both Units 1 and 2. The issuance of an operating license for Unit 2 (Docket No. 50-281) is under consideration for a later date.

1. This action is administrative.

2. The Surry Power Station will have two units. Each unit has a pressurized-water reactor designed for a power output of 2,441 megawatts thermal (MWt), which will be used to produce a warranted gross output per unit of 822.5 megawatts electrical (MWe). However, the maximum gross capacities of each unit are expected to be 2,546 MWt and 855 MWe. The waste heat, amounting to 3,400 MWt (12 billion Btu per hour) during full-power operation of both units, will be dissipated by pumping cooling water from the James River through the station's steam condensers and back to the river.

3. The environmental impact of the station, including both adverse and beneficial effects, is as follows:

   - 840 acres of forested land have been converted to industrial use. The cleared area now comprises a corridor across Gravel Neck which isolates Hog Island Waterfowl Refuge from the mainland, except for an access road across the site. Two 350-ft-wide rights-of-way were also cleared for transmission lines from the station to a division point 11 miles to the south; however, this land will serve as habitat for wildlife and some of it may be used for agriculture.

   - Salty water from the James River will be heated about 14°F during its passage through the condensers at the rate of 1,680,000 gallons per minute during full-power operation. In order to minimize thermal effects upon oyster seed beds near the downstream side of the station, the heated cooling water will be discharged about 5.7 miles upstream from the intake.

   - Fish will be lost on the screens at the cooling water intake and plankton that are entrained in the cooling water will be killed during passage through the condensers. Species such as the striped bass and blue crab will also decrease in the immediate area. The losses are likely to be small relative to the total population and standing crops, but cannot be estimated quantitatively because of the lack of preoperational information.

- Minor quantities of chemical waste will be discharged into the James River, resulting in a small increase in the total dissolved solids content. The damage to aquatic life will be little or none.
- Radioactive gaseous and liquid effluents will be released in negligible quantities.
- Addition of these electrical generating facilities to the area served by the applicant's power system will provide needed reserve capacity and electrical energy.

4. The principal alternatives considered were:

- Abandonment of the facility
- Use of fossil fuel at another site
- Modification of the present heat dissipation system
- Heat dissipation into a cooling pond
- Heat dissipation with cooling towers

5. Comments on the initial Draft Detailed Environmental Statement (issued March 22, 1971) were received from the following agencies and have been considered in this statement:

Council on Environmental Quality
Department of Agriculture
Department of the Army (Corps of Engineers)
Department of Commerce
Department of Health, Education, and Welfare
Department of Housing and Urban Development
Department of the Interior
Department of Transportation (Coast Guard)
Environmental Protection Agency
Federal Power Commission
Surry County Board of Supervisors
Virginia Water Control Board
Virginia Council on the Environment

6. The agencies listed above, plus the Advisory Council on Historic Preservation and the Virginia Department of Health, were also asked to comment on the revised Draft Detailed Environmental Statement (issued in March 1972). Comments have been received from the following agencies and incorporated in this Final Statement:

Department of Agriculture
Department of the Army (Corps of Engineers)
Department of Commerce
Department of the Interior
Department of Transportation (Coast Guard)
Environmental Protection Agency
Federal Power Commission

7. This statement is being made available to the public, to the Council on Environmental Quality, and to the other specified agencies in May 1972.

8. On the basis of the analysis and evaluation set forth in this statement, after weighing the environmental, economic, technical and other benefits of the Surry Power Station against environmental costs and considering available alternatives, it is concluded that the action called for is the issuance of an operating license for Unit 1 subject to the following conditions for protection of the environment:

   a. The incorporation of a non-radiological, as well as a radiological, environmental monitoring program in the Technical Specifications appended to the operating license. The applicant will be required to conduct the monitoring program to determine:

      1) The relationship between the thermal discharge and the physical-chemical characteristics of the water mass within the 10-mile tidal segment of the James River centered at Hog Island.

      2) The planktonic, nektonic, and benthic characteristics of this segment.

      3) The effects of the operation of the Surry Power Station on the physical, chemical, and biological variables of the James River Estuary.

   The monitoring program will continue for three years after Unit 2 is licensed to operate or, if significant impact is demonstrated, as long as is required to interpret the impact.

   b. The requirement that the applicant monitor the numbers and species of fish mortalities attributed to operation of the station and its auxiliary facilities and report on such mortalities to the Commission.

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FOREWORD

This is a detailed statement on environmental considerations related to the proposed operation of Surry Power Station Unit 1 (Docket No. 50-280) and Unit 2 (Docket No. 50-281). The statement has been prepared by the Directorate of Licensing (the staff) of the U. S. Atomic Energy Commission (AEC) in accordance with the Commission's regulations implementing the requirements of the National Environmental Policy Act of 1969 (NEPA), as set forth in revised Appendix D of 10 CFR Part 50.

NEPA requires that all agencies of the Federal Government report on major Federal actions significantly affecting the quality of the environment. These agencies are required to prepare a detailed statement which includes evaluation of the following specific items set forth in Section 102(2)(C) of the Act:

i. The environmental impact of the proposed action,

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

iii. the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity,

iv. any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented, and

v. alternatives to the proposed action.

This statement addresses the above points and includes further consideration of the positive and negative impacts of plant construction and operation. The principal sources of information used for assessments contained in this statement are the Virginia Electric and Power Company (Vepco) Environmental Report, dated December 1970, and the Supplement dated December 1971; the Final Safety Analysis Report (FSAR) on Surry Units 1 and 2; the Preliminary Safety Analysis Report (PSAR) on Surry Units 1 and 2; and Safety Evaluations, dated May 2, 1968. Copies of these documents are available in the AEC Public Document Room, 1717 H Street, N.W., Washington, D.C. 20006, and in the Local Public Document Room, Library of the College of William and Mary, Williamsburg, Virginia.

In addition, some of the information used by the staff was gained from a visit to the Surry Power Station site and surrounding areas on December 20-21,

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1971 by several AEC regulatory staff members. Independent calculations were also made and used by the staff in their assessment of environmental effects.

The present statement takes into account the comments previously received from Federal, State and local agencies concerning the Commission's Draft Detailed Statement on Environmental Considerations issued on March 22, 1971 (prior to the revision of Appendix D) and the responses by the applicant. In consideration of subsequent revisions of Appendix D, the Virginia Electric and Power Company (applicant) submitted the Environmental Report Supplement dated December 1971, copies of which were distributed to the specified agencies. Comments by these agencies concerning the Draft Detailed Statement have been received and are considered in this Final Environmental Statement.

I. INTRODUCTION

On March 20, 1967, the Virginia Electric and Power Company filed an application with the AEC for construction permits and operating licenses for Surry Power Station Units 1 and 2. Construction Permits No. CPPR-43 and No. CPPR-44 were issued accordingly on June 25, 1968, following reviews by the AEC regulatory staff and its Advisory Committee on Reactor Safeguards, and a public hearing before an Atomic Safety and Licensing Board in Williamsburg, Virginia on May 28, 1968.

Construction of Unit 1 is nearly complete and the reactor is expected to be ready for loading fuel in May, 1972. Unit 2 is expected to be ready for fuel loading about six months later.

With regard to the proposed issuance of a full-power operating license for Unit 1, the Commission published in the Federal Register of November 24, 1971, a Notice of Hearing concerning matters of radiological safety. An opportunity to expand the scope of the hearing to environmental issues was subsequently provided by means of a supplementary Notice of Hearing which was published in the Federal Register on December 30, 1971.

On December 14, 1971, the applicant filed a motion pursuant to 10 CFR 50.57(c) and paragraph D.2 of 10 CFR Part 50, Appendix D, requesting the issuance of a license authorizing the loading of fuel in Unit 1 and limited operation of Unit 1 up to 20 percent of full power during the period of on-going environmental review by the AEC. This motion was withdrawn on March 8, 1972.

Although individual operating licenses are contemplated for Surry Units 1 and 2, this statement necessarily deals with the impact of both units because they share many common facilities. Inasmuch as the construction effects have already occurred, the staff assessments contained herein are primarily concerned with the effects of operation.

A. SITE SELECTION

Selection of the Surry County site on Gravel Neck peninsula on the south side of the James River in Virginia was made after considerable study of its suitability to the environment, including thermal effects on the James River.[1] Although the site is opposite Jamestown Island, a location of historic and scenic importance, the applicant determined that the adjacent game preserve would partially screen the station and lowering the height of station structures would minimize their impact when seen from across the river. The use of fossil fuel at this site was not seriously considered because the stacks associated with such a plant would have detracted from the view from Jamestown and normal stack emissions would further increase objections.

Another site on the James River in Prince George County was considered, but the physical arrangement of the land would have required construction of the station within full view of several historic plantations. In addition, the land that would have to be acquired to meet AEC requirements included one of these historic buildings.

Some consideration was given to locating additional capacity in the coal fields in or near the far western part of the Vepco system, but this would have required construction of an extensive transmission system to the eastern part of the service area where a significant gap between load and generating capability was developing.

Additions to two existing stations on the Portsmouth-Hampton Roads area were considered but were eliminated because sufficient space was not available at either to construct a unit of the size contemplated. Two other new sites in the eastern area of the system appeared to have merit. One of these is on Currituck Sound in northeastern North Carolina, but it did not have sufficient water for once-through cooling purposes. The other new site, at Pig Point just west of Portsmouth, has sufficient water for once-through cooling and was considered satisfactory for a fossil-fueled plant. Because of its proximity to large populations, however, it was not suitable for a nuclear installation under existing siting rules.

The choice finally came down to selecting Pig Point for a fossil-fueled plant or Gravel Neck for a nuclear station. Selection between these two possibilities was based primarily on economic benefits: evaluation indicated levelized annual savings of $4.5 million in favor of the nuclear alternative.

B. APPLICATIONS AND APPROVALS

The following applications and approvals have been issued pertaining to construction and operation of the Surry Power Station:

1. Preliminary Safety Analysis Report and License Application by Vepco to the U. S. Atomic Commission, March 20, 1967, with Amendments No. 1 dated June 21, 1967 through No. 33 dated April 18, 1972.

2. Application to the Commonwealth of Virginia Department of Highways for the construction of a detour on State Highway 617. Authorization for Project 0617-090-124 (Industrial Access Road) granted December 12, 1966.

3. Application to the State Corporation Commission, Commonwealth of Virginia, to authorize the construction and operation of proposed transmission lines and other facilities in Surry County, including a proposed nuclear generating station, March 20, 1967. Certificate No. ET-138 issued on March 27, 1967.

4. Application to the U. S. Army Corps of Engineers to permit dredging circulating water intake, discharge canals, etc., June 16, 1967. Authorization permit granted August 21, 1967.

5. Application for a Certificate of Assurance for Discharges to the Commonwealth of Virginia, State Water Control Board, September 11, 1967. Certificate No. 1843 issued by the State Water Control Board, December 15, 1967.

6. Application to the U. S. Army Corps of Engineers for a permit to install and maintain seven timber pile channel markers in the James River to mark the intake channel at Surry Power Station, February 5, 1968. Permit was issued February 12, 1968.

7. Application to the U. S. Coast Guard for authorization to establish Surry Power Station daybeacons to mark station intake channel, March 15, 1968. Authorization was granted March 18, 1969.

8. USAEC Provision Construction Permits No. CPPR-43 and CPPR-44, issued June 25, 1968.

9. Approval of the Surry County Health Department for construction of the sewage disposal system for Surry Power Station, February 27, 1969.

10. Application to the U. S. Army Corps of Engineers for a permit to construct and temporarily maintain seven instrument towers in the James River, July 5, 1969. Permit issued July 16, 1969.

11. Application CG-2554 to the U. S. Coast Guard to establish seven lighted instrument towers in the James River, August 25, 1969. Approval granted September 2, 1969.

12. Application to the U. S. Coast Guard for the installation of lights to mark the stone groins along the discharge channel for the Surry Power Station, February 18, 1970. Approval was granted February 24, 1970.

13. USAEC Byproduct Material License No. 45-13670-01, May 20, 1970, with amendments.

14. USAEC Material License SNM-1191, August 11, 1970, with amendments.

15. Application to the U. S. Army Corps of Engineers for a permit to discharge wastes from the Surry Power Station, Section I, June 29, 1971, Section II, October 22, 1971. (Not yet received.)

16. Letter of Assurance by the Commonwealth of Virginia State Water Control Board, dated January 28, 1972, certifying there is reasonable assurance that the proposed operation of Surry Power Station Units 1 and 2 will not violate any applicable water standards.

II. THE SITE

A. LOCATION OF THE STATION

The two units of the Surry Station are being constructed on a small peninsula in Surry County, Virginia, that protrudes into the James River 25 miles upstream from the junction of this river and Chesapeake Bay (Fig. 2.1). The site selected for the station is on 840 acres of land owned by the Virginia Electric and Power Company at the tip of Gravel Neck Peninsula. This land is flat, low-lying, and heavily wooded. Before acquisition by the applicant, it was used in timbering operations.

The site extends completely across the peninsula (Fig. 2.2); the eastern and western site boundaries are steep bluffs 20 to 25 ft high that drop into the James River with little or no passable beach frontage. The northern boundary also is a sharp drop in elevation; this drop is the southern limit of Hog Island, which is a collection of 4285 acres of sand spits and marshes that appear as an extension of the peninsula. During excavation for the station, including the cooling-water canals, the excess dirt was transported to various sites on Hog Island for development of levees and roads by the State of Virginia in an effort to prevent intrusion of saline water into the multitude of fresh-water ponds. The State of Virginia has designated Hog Island as a bird sanctuary and is converting the usable land into corn and rice fields for the thousands of migrants that stop there.

State highway 650 connects the remainder of Surry County to Gravel Neck and Hog Island and crosses the applicant's property approximately 200 feet west of the station. A bridge has been built by the applicant to enable this road to cross the discharge canal. Inasmuch as the intake and discharge canals and the reactor containment buildings, turbine-generator buildings, etc., are enclosed by security fences, this bridge (which is also fenced along the sides) affords the only means for reaching Hog Island by land.

The applicant has built an attractive visitors' center on the north bank of the outlet canal. Sufficient trees have been removed to permit an unobstructed view of the station from this center, and the interior of the center contains both a lecture hall and rooms devoted to nuclear- and electric-generating displays.

A total of approximately 453 acres has been cleared for the construction of the station; the remainder of the applicant's property, as well as the southern portion of Gravel Neck peninsula, is wooded except for the transmission line rights-of-way. These rights-of-way are available for agricultural usage consistent with certain conditions imposed by the applicant for safety reasons. The minimum distance from the site boundaries to the reactor containment structures is presently 1650 ft, and the boundaries are posted.

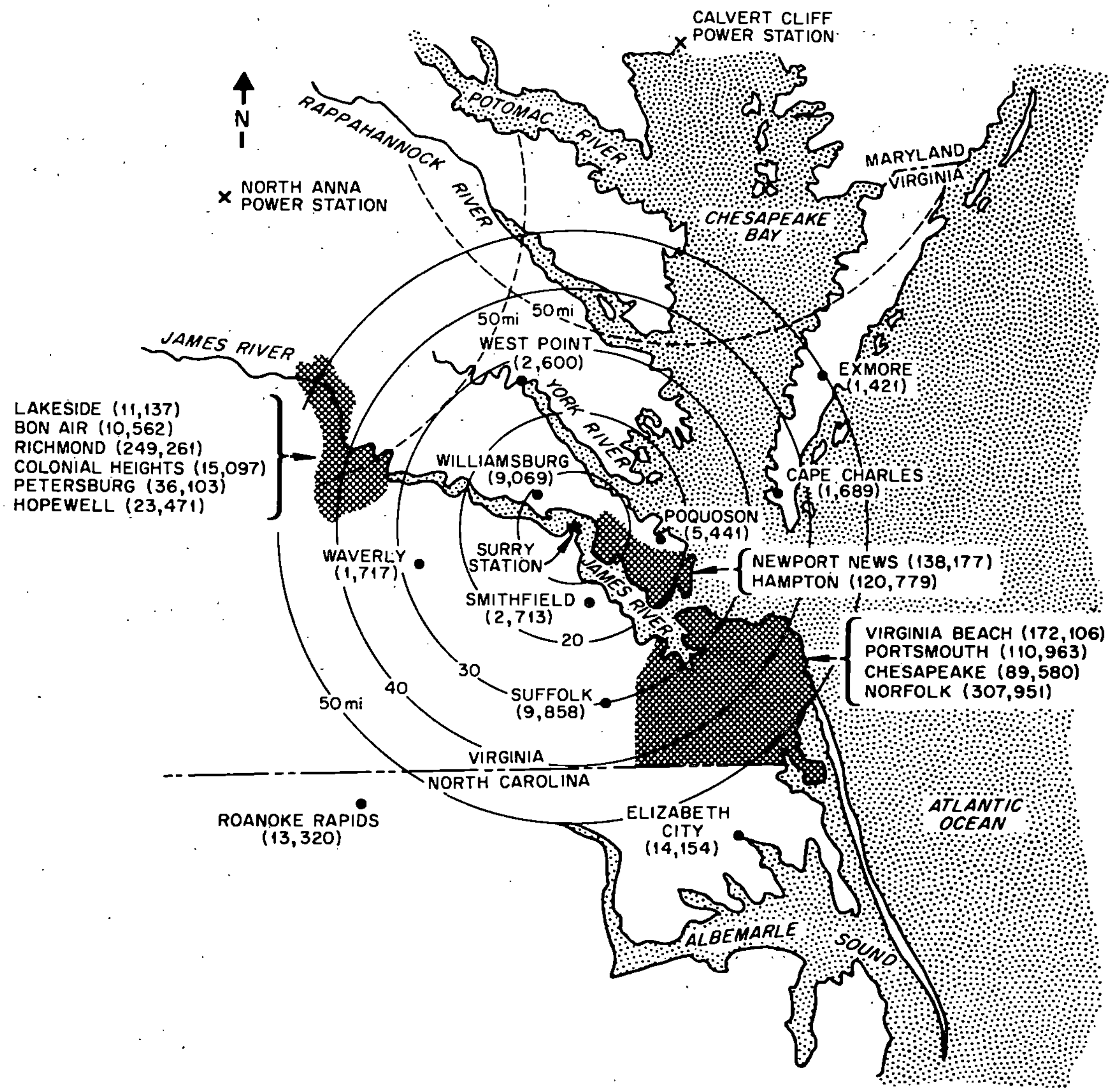


Fig. 2.1. Location of the Surry Power Station.

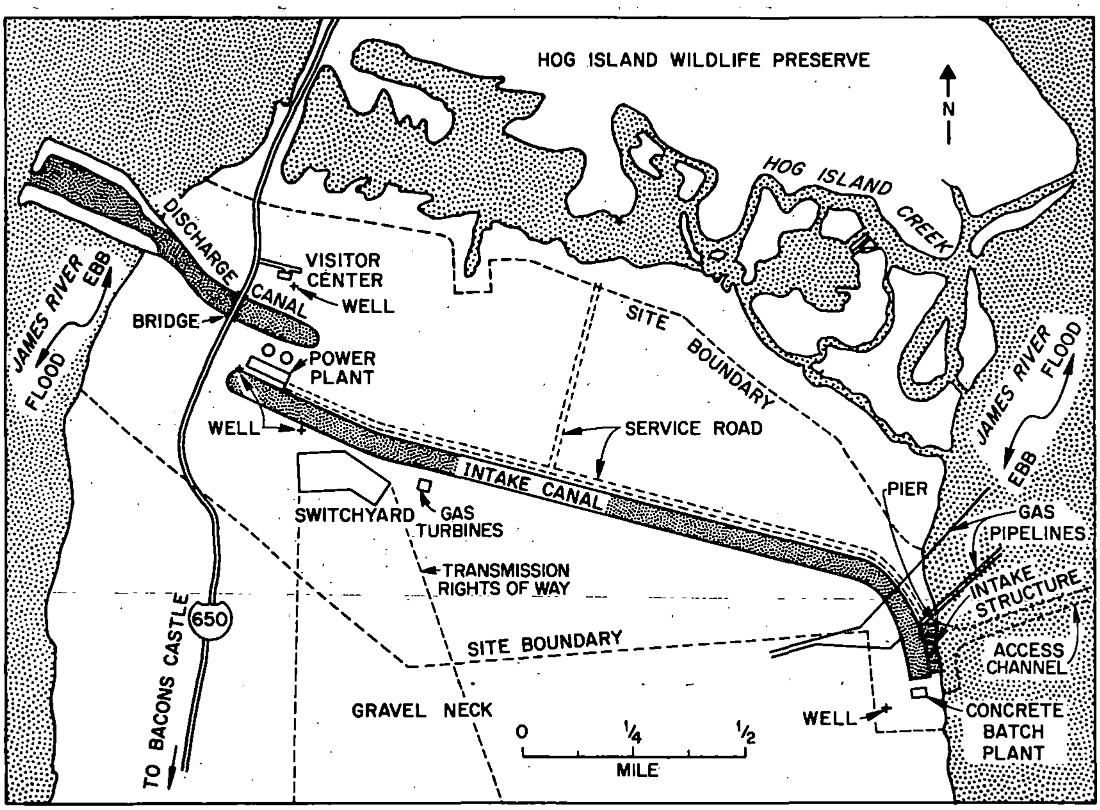


Fig. 2.2. Site plan of Surry Power Station.

Natural gas lines belonging to two utilities (Commonwealth Natural Gas Corporation and Colonial Pipeline Company) cross the extreme eastern portion of the applicant's property. These pipelines were relocated to pass under the inlet canal near the intake pumping station.

In the vicinity of the Surry Station the James River is three miles wide. Hog Island represents the approximate limit of salt-water incursion, thus dividing the James River into a tidal river upstream and an estuary downstream. A 25-ft channel has been dredged in the river by the U. S. Army Corps of Engineers, so that ocean-going vessels can proceed upstream as far as Hopewell. A section of the James to the east of Gravel Neck is used as an anchorage for a U.S. Navy "mothballed" fleet. The northern end of this anchorage is close to a channel that was dredged from the main channel to the west shore to permit the shipment of equipment by water to a pier adjacent to the intake pump house during construction of the Surry Station.

B. HISTORICAL SIGNIFICANCE

Because of the role of this section of Virginia during the colonial and Civil War eras, there are numerous natural and man-made historical sites near the Surry Station, although there does not appear to be anything of historical interest within the boundaries of the station site itself.[1] Although Hog Island once was a part of the Jamestown Settlement, no relic from this colony remains today, so this area is now important only as a wildlife preserve. Another preserve for birds, the Heron Rookery Natural Area, has recently been established by the State of Virginia in southwestern Surry County about 15 miles from the station site.[2] Also within Surry County are several well preserved colonial homes and buildings which have become the nucleus of a thriving tourist industry.[3] Among these are four that are listed in the National Register of Historic Places (Bacon's Castle - a national historic landmark, Chippokes Plantation, Smith's Fort, and Four Mile Tree).[4] Chippokes Plantation is the closest (2 miles) to the Surry site.

The peninsula formed by the York and James Rivers represents the "Cradle of America" and contains a large number of historical sites and features such as colonial homes, plantations, and battlefields. The greatest concentration is within the Colonial Historic Park and Williamsburg in York and James City Counties. There are many additional places of historical interest, especially related to the Revolutionary and Civil Wars, in the vicinity of Petersburg, Richmond, and Hampton Roads.

Some of the geologic formations underlying the Surry site are highly fossiliferous, but are typical of estuarine deposits and not considered to be of significant importance.[5]

C. REGIONAL DEMOGRAPHY AND LAND USE

Although it was the first part of the New World to be colonized by the British, much of this area of Virginia has retained an agricultural economy. Its rural character is evident in all directions from the Surry site, especially south of the James where the population density remains low for at least 20 miles (Surry County, 21 per sq mile;; Isle of Wight County, 58 per sq mile; Sussex County, 23 per sq mile; and Southampton, 31 per sq mile). Figure 2.1 shows the population distribution in the urban areas within 50 miles of the Surry site.[6]

1. Surry County

Surry County has a population of 5882, with a total of 1000 people in the three incorporated towns of Surry, Dendron, and Claremont. The economy of the county is based on agriculture, primarily soy beans, peanuts, general crops, and hogs, along with one meat products company and one dairy near Bacon's Castle four miles south of the Surry Station.[2] Beef cattle are grazed on the extensive open fields within Chippokes Plantation State Park two to three miles south of the plant site (Fig. 2.3). The county is served by two state highways: No. 10 leading to Hopewell and Suffolk; and No. 31 leading to the northern bank of the James by means of a ferry between Scotland and Jamestown. The only other means of crossing the James is by the bridges at Hopewell and Newport News. Surry County does not have railroad or airline service.

As the result of poor communications and a stagnant economy (per capita income is only 50% of the Virginia average), the population of Surry County has either remained constant or undergone decreases during various periods of the last 30 years.[2] Efforts are now being made to improve this situation through cooperative economic planning with surrounding counties and stimulation of tourism.[3] The Chippokes Plantation State Park is being developed for summer recreation, and an active campaign is being waged to advertise several historical sites relating to the colonial era.[7] There are 200 summer residents who have homes on the southern bank of the James River west of the Surry site, and several bathing beaches and marinas are also in the same area. The closest of these summer homes is 0.6 miles southwest of the plant site. The nearest permanent resident is the caretaker of Hog Island. Schools with a total enrollment of 1400 students are scattered throughout Surry County. Since there is no hospital in the county, the residents usually use the facilities at Hopewell or Williamsburg.

2. James City and York Counties

The middle of the James River is approximately the boundary between Surry County and James City County to the north. York County is between James City County and the York River. Although these counties have also been rural throughout most of their history, considerable changes are now evolving due to the proximity of the industrial Hampton Roads area and because of the very large tourist industry that has been built around the colonial historical sites in both counties.

James City County is still 67% wooded, but its current population (26,922 including Williamsburg City) (180 per sq-mile) is 47% greater than in 1960.[8]

In addition to the historical sites, the Williamsburg area contains The College of William and Mary, The Eastern State Mental Hospital, a nursing home, a city hospital, and a U.S. military weapons station. Jamestown Island, the Jamestown Festival Park, and the Williamsburg Historic Area, all within 10 miles of the Surry plant site, attract a total of more than one million visitors each year. A new state park is being constructed on a 2500-acre site adjacent to the York river and 15 miles northwest of the Gravel Neck peninsula. At present, there is little manufacturing other than lumber, millwork products, and synthetic fibers. However, a large brewery has recently been built and will eventually have an associated recreational area (Busch Gardens) immediately across the James from the tip of Hog Island.[8]

Of the 33,203 inhabitants of York County, less than 25% live in urban areas, and most of the 129 square miles inside this county are within the Colonial National Historic Park (including the town of Yorktown and the Yorktown battlefield) and several military reservations. These historical sites are connected to Williamsburg and Jamestown by the Colonial Parkway, a scenic highway within a Federally-controlled corridor. Most of the work force either are associated with governmental activities or commute to the cities of Hampton and Newport News; however, there does exist a small agriculturally based economy (dairy cattle, seafood, and lumber).[9]

Three major highways (Interstate 64, U.S. 60, and U.S. 17) pass through York and James City Counties, joining the Richmond and the Hampton Roads regions, as well as carrying tourist traffic between Florida and the Washington and New York areas (Fig. 2.3).

3. Hampton Roads Metropolitan Area

The eastern bank of the James, across from the Surry Station site, is the northwestern city limit of Newport News and the beginning of an urbanized area of more than one million people who live in six contiguous cities surrounding Hampton Roads. A military reservation (Fort Eustis) with 20,000 permanent and 5,000 transient personnel occupies the northwest corner of the city of Newport News. The most densely populated sections of both Newport News and Hampton lie at the tip of the peninsula formed by the York and James rivers approximately 10 to 20 miles southeast of the Surry Station. The population of these two cities has increased 25% during the last decade because of a strong economy based primarily on shipbuilding and other marine activities.[10]

On the southern side of the lower portion of the James (Hampton Roads) and encompassing a large area that is delineated by the Atlantic Ocean on the east, the North Carolina border on the south, and the Dismal Swamp on the west, is a megalopolis consisting of the cities of Norfolk, Portsmouth, Chesapeake, and Virginia Beach. In addition to the permanent residents of these cities, there is a large transient and temporary population related to the major military installations and summer recreational activities.[11]

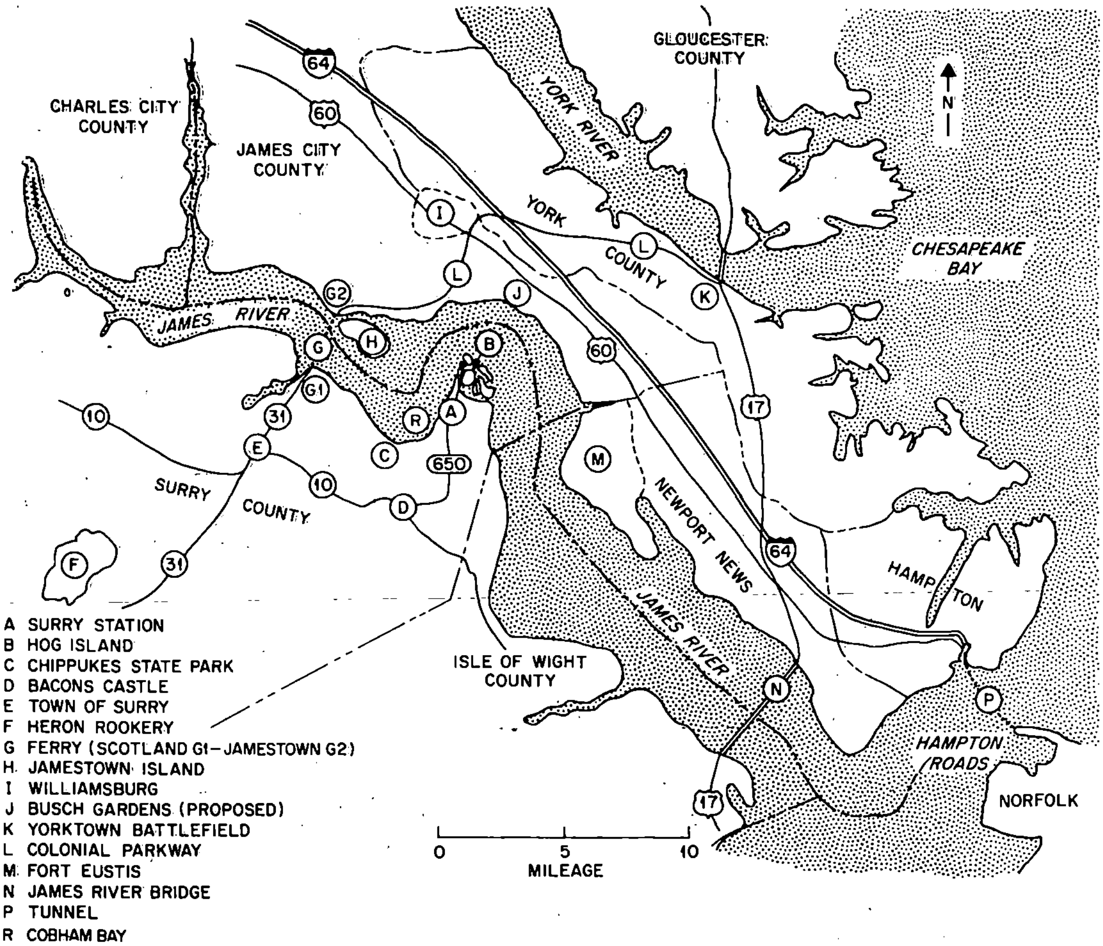


Fig. 2.3. Environs of Surry Power Station.

4. Proximity of Other Nuclear Power Stations

Approximately 30 to 50 miles to the west of the Surry Station site is the north-south urban corridor that encompasses Hopewell, Petersburg, Colonial Heights and Richmond, with a total population of 500,000 people. The northern portion of this corridor, including the city of Richmond, will also be within 50 miles of the North Anna Nuclear Station that is to be constructed near Mineral, Virginia, 90 miles northwest of the Surry Station (Fig. 2.1).

Inasmuch as the Calvert Cliffs Nuclear Plant in Maryland is approximately 85 miles north of the Surry Station, there will be portions of Essex County (pop. 7099), Lancaster County (pop. 9126), and Richmond County (pop. 5841) that lie within 50 miles of both nuclear power stations.

D. ENVIRONMENTAL FEATURES

1. Geology

The site is in the Coastal Plain, some 25 miles inland from Cape Henry, and some 50 miles east of Richmond, which is on the Fall Line. The Fall Line marks the boundary between the Piedmont to the west and the Coastal Plain. The Piedmont is underlain by a complex of hard igneous and metamorphic rocks formed during the Precambrian and Paleozoic eras and worn down during the Triassic and Jurassic periods of the Mesozoic era to a nearly flat and gently sloping peneplain. This peneplain was uplifted west of the Fall Line during late Mesozoic time (230+ million years) and tilted to the east and southeast. With continued erosion in the uplifted lands to the west, there was deposition on the lower part of the peneplain to the east, first of a thick layer of Cretaceous (63 million years) sand and clay, and, with more tipping, of still more sediments during the Tertiary period. At the site there are some 1300 ft of sediments resting on bedrock.[12]

The youngest formation of importance at the site is the Norfolk, an estuarine deposit of Pleistocene age (two million years).[13] It is 50 to 80 feet thick, with its bottom ranging from 16 to 47 feet below mean sea level (Fig. 2.4).

The upper 20 to 35 feet of the Norfolk formation consists of layers of brown and mottled brown sand, silty sand, and silt and clay. Some of the sand beds are, in part, firmly cemented with iron oxide. The lower part of the formation consists of layers of gray sand, silty sand, and silt and clay, containing some decayed vegetation and shell fragments. These deposits were probably formed in a swamp or in shallow water. The Norfolk formation is not regarded as a good setting for the foundations of heavy structures. Consequently, some of the cleaner fine sands were excavated and replaced with better compacted materials before construction of the Surry Station was initiated.

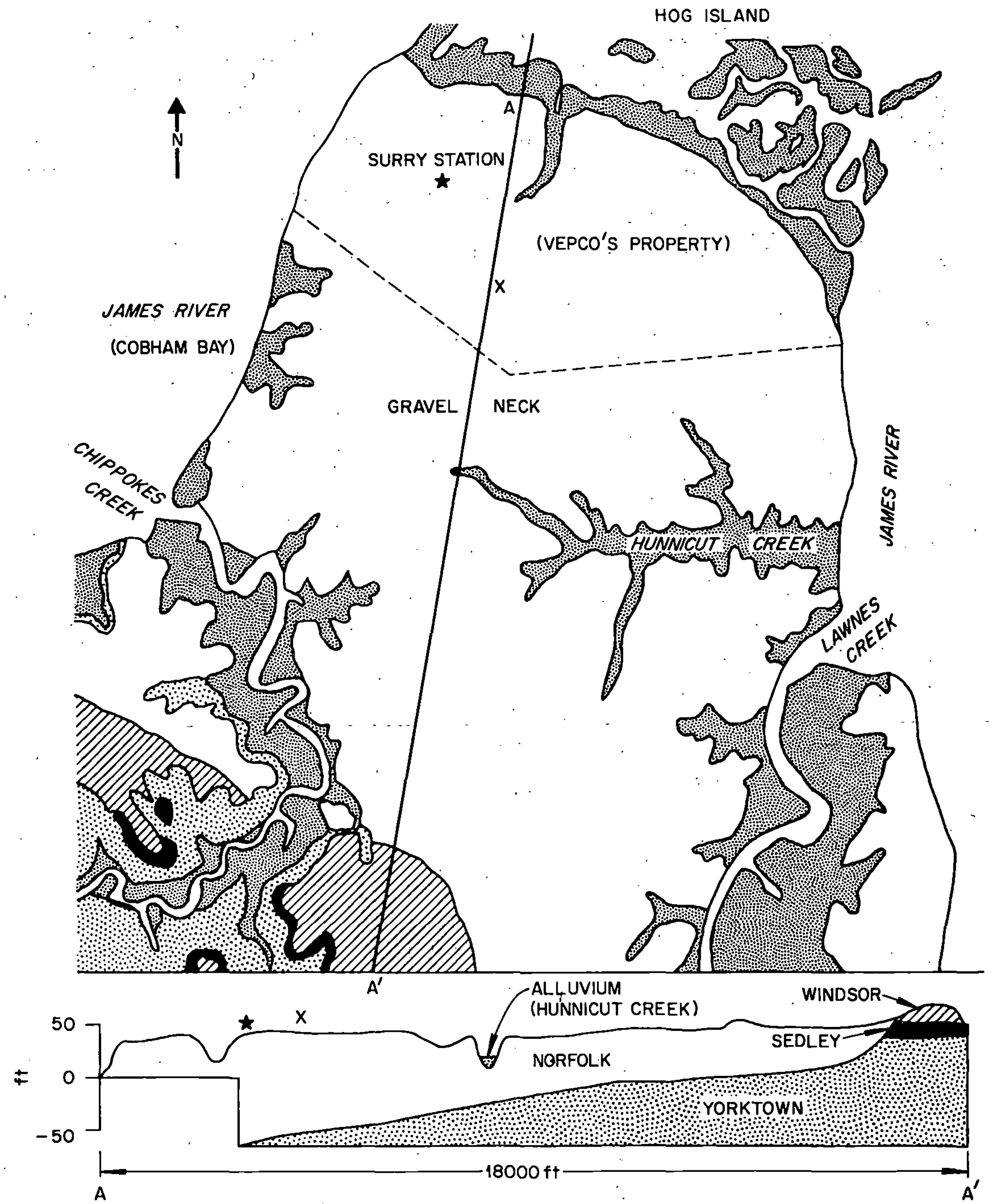


Fig. 2.4. Geologic map of Gravel Neck.

The Norfolk formation is underlain by the Chesapeake Group of formations of Miocene age (13 million years), as the Pliocene formations have been removed by erosion in the area.[13] The Chesapeake Group comprises three formations: the Yorktown, the St. Mary's, and the Calvert. The Chesapeake in the site area consists of compact, very stiff, tough clays that are green to dark gray in color, along with scattered compact sand and silt members. This material is strong and stable with moderate to high shearing strength. Underlying the Miocene sediments are 45 ft of Eocene sediments (46 million years), 55 ft of Paleocene sediments, and 800 ft of Cretaceous sediments for a total of about 1300 ft.

The foundations for the heavier Surry Station buildings were constructed by sinking pilings down to the stiff clay of the Chesapeake Group 70 ft below sea level. A few minor structures were founded on the surface sands.

All of the formations dip very gently to the southeast. There are no faults or other structures in the 1300 ft of sediments. Faults do exist in the hard rocks of the Piedmont 50 miles or more away, and from time to time these have been the epicenters for earthquakes. None of these quakes has been very large, so that ground motion has never been very intense, perhaps no more than an intensity of VII MM (Modified Mercalli Scale) near the epicenter and much less at the station site. It is possible, however, that there might be faulting in the bedrock deep below the site that could cause earthquakes with a surface intensity of motion of VII MM. The operating basis earthquake was therefore set with a ground acceleration of 0.07 g, and the design basis earthquake with a ground acceleration of 0.15 g.

The applicant gave considerable thought and attention to the possibility that an earthquake might cause the liquefaction of some of the sand beds in the Norfolk formation, which would be a more serious problem if it should take place than the actual shaking of the reactor structure. Although the possibility of liquefaction was considered unlikely, the more susceptible of the sand layers were dug out and replaced with better compacted materials under the heavier structures.

2. Hydrology

a. James River

The James River rises in extreme West Central Virginia some 300 miles west of the site and drains one-fourth of Virginia's land area as it cuts across the state on an average latitude of 37-1/2°.[12] The lower 60 miles of the river are tidal, although only the section downstream of Gravel Neck is estuarine and saline.

The flow of the river at the site is complex and is composed of three components. In order of the volumes involved, these flows are (1) the back-and-forth flow of the tide, (2) an upstream flow of more highly saline water near the bottom and a downstream flow of less saline water near the top, and (3) the outflow of water from the runoff of the watershed of the James. These three flows are superimposed one on the other; the most obvious result being that the outflowing tide, at least at the surface, lasts longer than the inflowing tide.

The total drainage area of the James River above the site is 9517 square miles (Fig. 2.5). The river runoff at the site is quite variable, ranging from a mean monthly low of 857 cfs in October 1942 to 36,185 cfs in January 1937. The mean monthly discharge has exceeded 857 cfs 100% of the time, 2660 cfs 90% of the time, 4370 cfs 75% of the time, 7860 cfs 50% of the time, 14,366 cfs 25% of the time, and 20,225 cfs 10% of the time. (The cooling system of the Surry Station will require 3750 cfs of water from the James River.) The maximum flood on the James was 234,000 cfs, at which time the level of the river was raised about one foot. The valley of the James at the site is so wide and flat that even a much larger flood would not raise the river level significantly higher.[14]

A more realistic cause for high water at the site is a hurricane. With a large hurricane arriving under the proper conditions, the water level at Surry could be raised some 21 feet for a matter of several hours. Such waves would produce an additional runup of 7.7 feet. The maximum possible height of water above normal sea level is therefore 28.7 feet as compared with a station grade of 26.5 feet. However, the station site is somewhat protected from the full force of the waves that would be built up on the eastern side of Gravel Neck.

There are two tidal cycles per day. At Hog Point the mean tidal level is +1.0 foot, while the mean range and spring range are 2.1 and 2.5 feet, respectively. During flood tides, the average velocity of the water near the surface is 1.9 fps and the maximum current during spring tides is 2.8 fps.[15] During ebb tides the average rate of flow downstream is 2.2 fps and the maximum rate of flow during spring tides is 3.2 fps. These are strong currents, with velocities that vary from bank to bank and from surface to bottom, that tend to mix the water of the estuary. Mixing is reduced somewhat by the tendency of the more saline and heavier water to remain in the lower levels; however, gradual dilution of this saline water occurs as it moves upstream so that it returns in the ebb flow near the surface of the river, thereby achieving further mixing. At times the boundary between these counterflows becomes strongly sloped so that the seaward (dilute) component extends to all depths on the south side of the estuary and the upstream (saline) component extends from bottom to surface on the north side.

The James is used primarily for navigation and sewage disposal. Because of the high degree of pollution from the Richmond and Hopewell areas, no water is drawn from the James for human consumption. Although the water becomes less polluted downstream, no water supplies are removed in the relatively rural section upstream of the salinity boundary. In the vicinity of the Surry

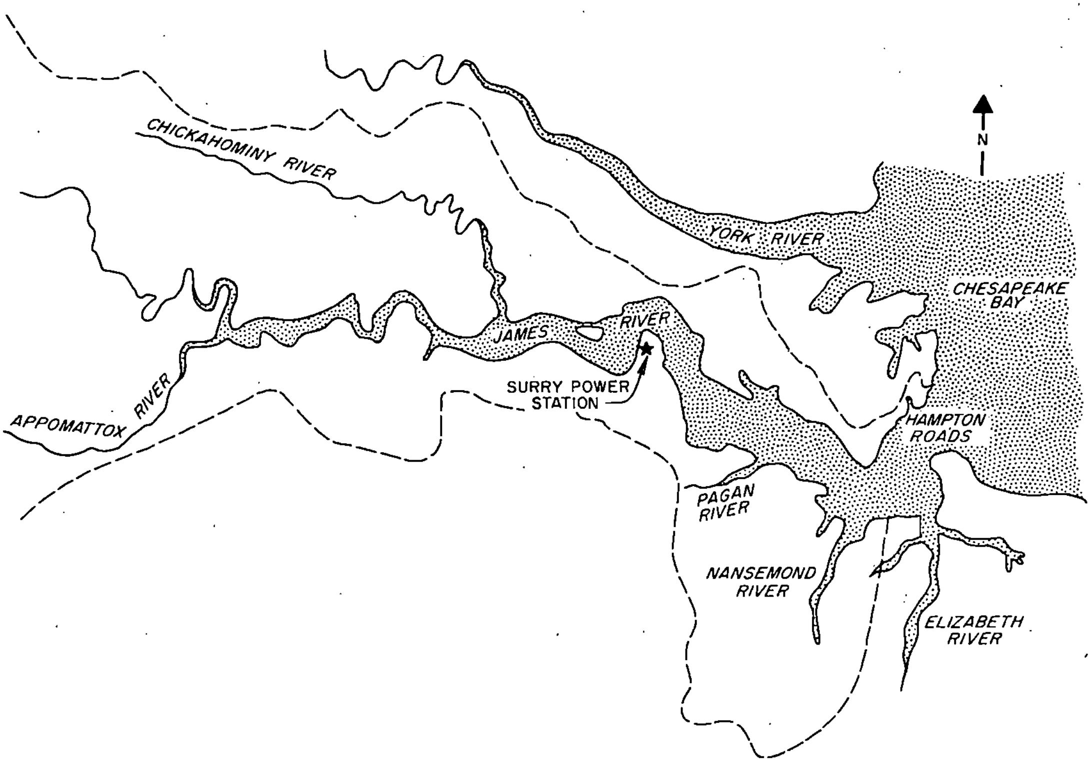


Fig. 2.5. James River Basin, Coastal Plains section.

site, the river again becomes the receptacle for sewage, from the James City County and Williamsburg disposal plants and from chemical plants on Skiffs Creek north of Fort Eustis. A new brewery, immediately across the river from Hog Island, will soon begin to empty its waste water into the James between the discharge and intake of the Surry Station.

There is a considerable amount of sports fishing in the James, but very little commercial fishing in the vicinity of Gravel Neck. The oyster industry is steadily moving seaward because of problems relating to salinity and pollution; the largest oyster beds are now in the vicinity of Newport News. Other types of commercial fishing occur in the more saline waters of Hampton Roads.

b. Groundwater

Because of extensive marine and estuarine sediments east of the Fall Line, the groundwater supply of the Coastal Plains region is much more extensive than in the mountainous and Piedmont regions of Virginia.[2,16] At the Surry site, the Norfolk formation, while saturated with the water table a foot or two above sea level, is not a good aquifer because the sediments are too fine. However, thousands of shallow wells in this formation provide small amounts of water to the rural population. There are 11 wells within a radius of five miles of the site at small farms and private homes. Water from these wells ranges from moderately-hard to hard in quality, and these shallow wells are subject to salt water intrusion if overpumped.[2,12]

The Chesapeake Group of formations yields no water at all because it is composed of solid clay and marl. Along with the underlying Chickahomeny clay, the formations of this group play an important role as an aquiclude and protect the underlying aquifers from invasion by saline water.[12] They would also act as seals against radioactive contamination of the lower-lying aquifers due to percolation of surface water in the event of leakage around the site. These deeper formations, ranging from Eocene to Cretaceous, contain many beds of medium to coarse sand that have provided wells with outputs of several hundred gallons per minute. There are several such wells in Surry County, including four on the Surry Station site (about 400 ft deep and with yields of 75 to 200 gpm) which supply water for makeup and domestic use of the plant, for the visitors' center, and for the concrete batch plant. Water from the Cretaceous formations is very soft near the Fall Line, but contains much bicarbonate in wells near the site. In some localities the water also contains excessive concentrations of fluoride and/or ferric ions.[2,8] These deep aquifers are also tapped as auxiliary municipal supplies for Fort Eustis, Williamsburg, Norfolk, Portsmouth, and Virginia Beach. Some reduction in artesian pressure is becoming evident because of these large withdrawals.[12]

3. Meteorology

The station site lies in a region of temperate climate where the weather synthesized over the continental mass is considerably modified by the proximity of the Atlantic Ocean.[12] Consequently, the Coastal Plains tend to be wetter and warmer than inland regions and are subject to abnormal conditions that are formed over the open ocean.

The average temperatures in the area of the site are 42°F in January and 79° in July, with annual extremes of approximately 5°F low and 105°F high (Table 2.1). The length of the growing season is 254 days, considerably longer

Table 2.1. Monthly temperature (°F) averages, 1931–1960 (from Ref. 12)

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	High	Low	Years of record
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
Richmond	38.7	40.1	46.6	57.0	66.4	74.4	77.9	76.2	70.2	58.9	48.4	39.5	59.9	104	−12	31

than those in the mountainous and Piedmont regions of Virginia. Snows melt rapidly, and ice that persists for more than a week or two is rare. The James freezes over from bank to bank every few years in the neighborhood of the station site; however, the ice layer is neither thick nor long-lasting. The Surry area has an average of 46 inches of precipitation per year, of which 1 to 2 inches falls in the form of 10 to 20 inches of snow. Rainfall averages between 3 to 4 inches from December through May, achieves a maximum of 5 to 6 inches per month during the season of summer storms, then drops to a low of 2 to 3 inches in October and November. The tidewater region of Virginia undergoes periodic seasons of drought of varying intensity (Table 2.2); the most extreme siege was in 1930-31, when the rainfall was 20 inches below normal. This region is very flat; the maximum elevations in Surry County are less than 150 feet. Consequently, this area is very humid during the long summer season.

The prevailing winds over the site are predominantly westerly (NW, W, SW) with a stronger northerly component at ground level. Wind speeds rarely (∿0.5%) exceed 23 mph. Wind roses taken from the applicant's FSAR are included as Appendix C of this Statement. These data were obtained at a tower on the station site at an elevation of 150 feet and at a 20-ft-high station on Hog Island.

Table 2.2. Precipitation in tidewater Virginia (1929–1965)[a]

	Numerical index[b] values by month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1929	−0.30	0.95	−0.80	−0.46	−0.99	1.45	−0.34	−0.96	−1.17	0.92	1.05	−0.28
1930	−0.13	−0.74	−1.74	−1.78	−2.15	−1.31	−2.19	−3.34	−4.36	−4.60	−5.23	−5.19
1931	−5.62	−5.94	−5.13	−4.44	−3.33	−2.82	−2.71	−1.91	−1.90	−2.26	−3.27	−3.85
1932	−3.32	−3.55	−2.63	−2.53	−2.27	−2.16	−2.56	−3.56	−4.06	0.65	0.77	1.27
1933	1.25	1.00	0.25	0.65	0.72	0.01	0.05	1.48	−0.56	−1.16	−1.67	−2.10
1934	−2.59	0.83	1.59	0.98	1.91	1.53	1.84	1.52	2.75	1.95	1.93	1.53
1935	1.76	1.46	0.95	1.71	1.69	1.65	1.94	2.03	3.33	2.69	2.83	2.64
1936	4.02	4.21	3.97	3.87	−0.98	−0.82	−1.20	−1.96	−2.25	−2.37	−3.04	0.55
1937	2.53	2.15	1.50	2.54	2.26	2.56	2.57	2.72	2.55	3.19	3.79	3.00
1938	2.62	1.86	1.49	1.33	1.49	3.05	3.85	2.67	3.51	3.08	2.86	2.43
1939	2.22	2.80	2.62	2.61	1.52	1.55	2.08	2.58	−0.90	0.60	0.72	−0.46
1940	−0.59	−0.58	−0.86	0.84	−0.03	−0.64	−0.89	−0.35	−0.65	−0.81	−0.09	−0.54
1941	−0.70	−0.99	−1.25	−1.26	−2.02	−1.85	−1.68	−2.26	−3.26	−4.15	−5.02	−5.16
1942	−5.14	−5.20	−3.82	−4.64	−5.06	−4.95	−4.96	0.76	0.96	2.16	1.50	1.77
1943	−0.23	−0.43	−0.38	−0.45	−0.24	−0.43	−0.65	−1.71	−1.65	−1.14	−1.48	−1.83
1944	0.23	1.06	2.14	2.14	−1.08	−2.08	−2.40	−2.70	−1.98	−1.88	−1.44	−1.33
1945	−1.40	−0.80	−2.25	−2.43	0.15	0.87	3.45	2.83	2.98	2.46	2.36	3.76
1946	3.09	2.71	1.56	1.35	2.45	2.58	2.32	2.33	−0.06	−0.26	−0.57	−1.07
1947	−0.60	−1.10	−1.24	−1.47	−1.64	−1.02	−1.21	2.02	−1.65	−2.12	0.54	0.23
1948	0.63	0.55	0.23	0.81	1.80	1.70	1.14	1.40	1.07	0.99	2.02	2.69
1949	−0.45	−0.26	−0.77	−1.16	0.49	0.44	0.27	0.98	−0.01	−0.20	−0.07	−0.38
1950	−1.00	−1.53	−1.42	−1.73	−1.49	−1.85	0.82	0.70	0.97	−0.33	−0.66	−0.68
1951	−1.28	−1.62	−1.58	−1.60	−1.71	−0.70	−0.98	−1.06	−1.78	−1.98	−1.68	0.92
1952	1.62	1.86	2.21	0.04	−0.17	−0.81	−1.62	−1.78	−2.20	−2.38	−1.70	−1.34
1953	−1.51	−1.37	−1.21	−0.87	−1.03	−0.87	−1.89	−1.65	−1.48	−2.10	−2.46	−2.54
1954	−1.76	−2.23	−1.94	−2.26	−1.37	−2.19	−2.45	−2.74	−3.34	−3.59	−3.93	−3.83
1955	−4.19	−3.62	−3.33	−3.46	−3.64	−2.75	−3.14	−1.28	2.22	2.06	0.03	−0.38
1956	−0.64	−0.04	−0.18	−0.05	−0.17	−0.45	0.64	0.34	0.45	1.54	1.55	1.46
1957	1.53	2.04	2.24	−0.65	−1.17	−1.19	−2.20	0.01	0.10	0.80	1.66	2.62
1958	2.64	2.81	3.71	3.79	4.25	4.70	3.96	4.84	3.62	3.82	3.31	3.65
1959	−0.54	−0.95	−0.88	−0.24	−0.98	−1.60	0.89	−0.87	−1.14	0.95	1.28	1.12
1960	0.91	1.36	0.04	−0.61	0.80	0.59	1.07	1.30	2.38	2.61	1.93	1.79
1961	1.79	2.55	2.47	2.14	3.05	3.81	2.79	2.20	1.23	1.89	1.30	2.11
1962	2.71	2.63	2.77	2.92	2.17	2.77	2.74	2.09	1.95	1.34	2.18	2.32
1963	2.03	1.98	2.16	−1.14	−1.28	1.76	−0.94	−1.75	−1.25	−2.10	0.47	0.55
1964	0.88	1.68	−0.48	−0.29	−1.00	−1.23	−1.46	−1.45	0.89	1.72	−0.24	0.33
1965	−0.27	−0.58	−0.35	−0.50	−1.48	0.38	0.71	−0.77	−1.50[c]	−2.20[c]		

[a]Excerpted from *James River Basin Comprehensive Water Resources Plan – Hydrologic Analysis,* Vol. III, Virginia Department of Conservation and Economic Development–Division of Water Resources, Richmond, Virginia, 1970.

[b]Explanation of W. C. Palmer's index for wet and dry periods:

Monthly index value	Class
4.00	extremely wet
3.00 to 3.99	very wet
2.00 to 2.99	moderately wet
1.00 to 1.99	slightly wet
0.50 to 0.99	incipient wet spell
0.49 to −0.49	near normal
−0.50 to −0.99	incipient drought
−1.00 to −1.99	mild drought
−2.00 to −2.99	moderate drought
−3.00 to −3.99	severe drought
−4.00	extreme drought

[c]Provisional data.

The site lies within the path of severe thunderstorms, especially in the summer, and also within a region that experiences tornadoes periodically. The applicant has calculated the probability of a tornado striking within a 35-mile radius of the station to be 4.74×10^{-5} per year.[5] The tidewater region is subjected to the effects of tropical storms that form in the warm regions of the Atlantic, and several hurricanes have passed near the James estuary during the last 100 years. During one of the most recent, hurricane Camille, 31 inches of rain fell on some parts of the James river basin on August 19, 1969. The effects of the resulting flood are still being studied.

E. ECOLOGY OF THE SITE AND ENVIRONS

1. Terrestrial Biota

The Atlantic Coastal Plain is crossed by many meandering streams in shallow valleys, which usually terminate in estuaries along the coast. Proceeding from the coast toward the interior are several diverse, natural plant associations from salt marshes to forests (Fig. 2.6). The terrestrial ecosystem of the Surry Power Station site and the surrounding region contains communities similar to those of the majority of the Virginia and North Carolina Coastal Plain.[17]

Tidal flats and salt marshes of the region contain several distinct associations, depending on salinity of the water and substrate. Along creeks and at the edge of the estuary are communities of giant cordgrass (*Spartina cynosuroides*), sometimes covering areas of considerable width, which grade into zones of rush (*Juncus* spp.) toward the inland side of the cordgrass community. Near the upper limits of brackish water along streams are almost pure stands of cattail (*Typha latifolia*). At the inner-most edge of the salt marsh, on higher sites, are several important dicots, marsh elder (*Iva frutescens*), groundsel tree (*Baccharis halimifolia*), partridge pea (*Cassia fasiculata*) and bush clover (*Lespedeza capitata*).

Much of the lower portions of the peninsula were previously affected by tidal inundations. By means of dikes and water control structures a portion of that area (Hog Island State Waterfowl Refuge) is drained each spring and planted in millet to increase waterfowl usage of the lower one-third of the James River.[18] The remainder is undisturbed and is used as a major feeding area during winter. Additional acreage is cultivated to provide winter food for waterfowl. Those undisturbed areas of salt-marsh communities are very important as feeding areas, since the tidal waters do not freeze as quickly as the controlled areas. Hog Island Refuge presently supports both resident and migratory bird populations. Estimates of waterfowl, primarily geese and ducks, suggest peak populations which exceed 25,000.[18] In addition, the tidal flats and marshlands provide habitat for numerous species of shore and wading birds. The presence of the Southern bald eagle (*Haliaeetus leucocephalus leucocephalus*) and the American peregrine falcon (*Falco peregrinus anatum*) have been noted near the Surry Station site.[19] Both of these species are on the Department of Interior list of endangered species.[20] No actual census data are available for the marsh communities. Bird species recorded as present in the area or whose range includes the area surrounding the site are identified in Appendix E.

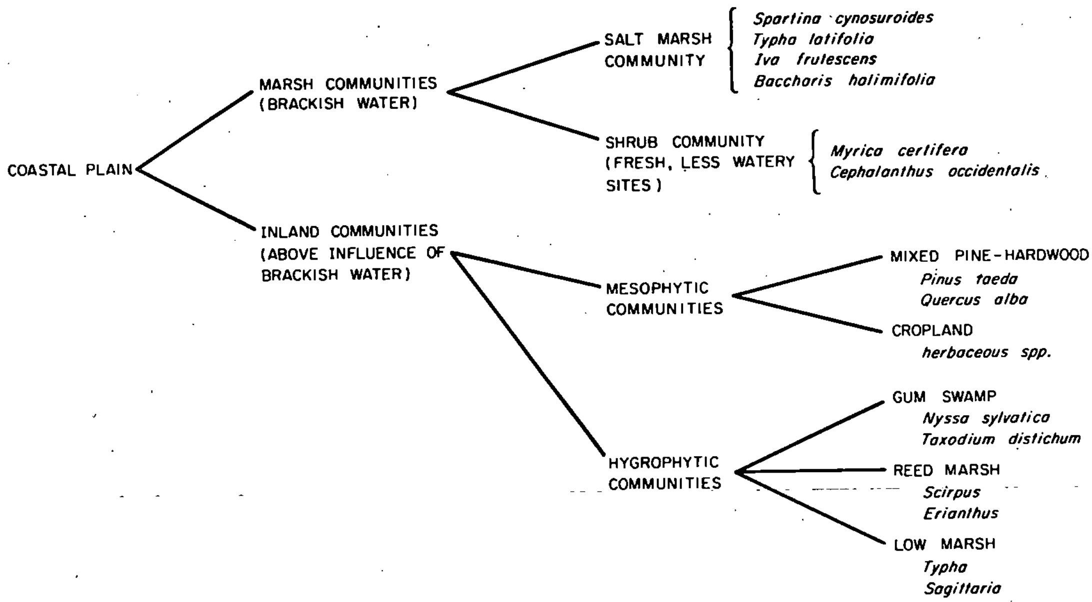


Fig. 2.6. Important plant communities and dominant species in the area of the Surry Power Station site and the surrounding region.

The marshlands provide additional habitat for numerous amphibians, frogs and toads being the most abundant. An annotated checklist for Surry County suggests the presence of 34 amphibious species, in either the brackish or the freshwater marshes (Appendix E). Similar habitats support populations of turtles. Most reptiles (snakes and lizards) inhabit the more inland areas of forest and swamp communities. A total of 43 species of reptiles are considered to occur or range within the area (Appendix E).

The transition between low marshlands and higher, terrestrial communities is dominated by wax myrtle (Myrica certifera) and buttonwood (Cephalanthus occidentalis). This zone is important as habitat for many species of birds and small mammals. The white-tailed deer, a large herbivore of the station site, is an important species to sport hunting on the Hog Island Refuge[18] and adjacent wooded or crop lands. This zone of shrubby vegetation constitutes an important food base as browse during winter seasons.

Other plant associations of importance, dominated by herbaceous and woody species (Appendix D), are located inland. Those occupying higher, well drained sites consist of dryland forest communities, while adjacent moist areas support palustrine forest or fresh-water marsh communities. Forest typical of Surry County is characterized as loblolly-shortleaf pine, consisting of 50% coniferous species with oaks, hickory, and gum as broadleaf associates.[21] Mixed pine-hardwood communities dominate the site. Loblolly pine (Pinus taeda) and white oak (Quercus alba) are identified as dominant canopy species, with dogwood (Cornus florida) and sourwood (Oxydendrum arboreum) as important understory species.[17,19]

Forest communities provide major habitat for numerous wildlife species. Most important is the white-tailed deer, foraging on the mast (nut) crop of oaks (Quercus) and browsing numerous species within the understory layer. During periods when food base fluctuates, deer are usually unrestricted and seek more productive areas. Such movements probably existed between the nearby forests and cultivated cropland communities and Hog Island Refuge. Predators of the forest include the gray fox and the skunk. Small mammals, especially rodents, occupy the more open, edge habitats, as do birds of prey (hawks and owls). A total of 37 mammalian species have been identified as present, or as those whose range might include the site area (Appendix E). Actual records of abundance are not available.

Forest communities provide additional ecological niches for reptiles (Appendix E) and many species of songbirds. Bird species recorded in the area, or whose range includes the area surrounding the station site, illustrate the diversity of habitats. A total of 194 species, the majority of which are associated with forest or forest edge communities, are identified in an annotated checklist (Appendix E).

Of minor importance in the adjacent region are palustrine forests with swamp communities dominated by black gum (Nyssa sylvatica) and bald cypress (Taxodium distichum), with ash (Fraxinus), elm (Ulmus), and red cedar (Juniperus virginiana) as common associates. Reed-marsh communities, freshwater, often occur at the edge of hygrophilous forests, dominated by bullrush (Scirpus) and plume grass (Erianthus). Along streams and rivers, above the influence of brackish waters, are cattail (Typha) and arrowhead (Sagittaris) communities.

Major orders of invertebrates are represented in the region. Tabulation of species is not available, except for specific notation[19] of those identified as pests to man (spiders, chiggers, mosquitos, ticks, and flies). These are identified in Appendix E.

2. Ecology of the Aquatic Environs

The James River at the site of the Surry Power Station is characteristic of a tidal estuary, with typical brackish water and portions of shoreline being composed of swamps and marshes. The area is in the transition zone between salt water and fresh water. The salinity ranges from 0 to 18 parts per thousand, the wide variations depending on the influx of fresh water from upstream.[19]

Although the James River is badly polluted between Richmond and Hopewell (approximately 35 miles upstream from the site), natural processes make the water relatively clean by the time it reaches the Hog Island area.[19]

Because of the extreme variation in salinity in this transition zone of the estuary where the station is located, the number of species is less than in both the freshwater section upstream and the brackish water section downstream in which the salinity gradient is much less. Although species diversity is relatively low in this zone, densities of certain euryhaline species are very high, due probably to the lack of interspecific competition for food and space. The effect of this wide range in salinity is expressed by the low species diversity values obtained from preoperational studies by the applicant, which compare the number of species to the total number of organisms. The values for benthic invertebrates range from 0 to 2.8, and these are much lower than values usually found in the more saline portions of estuaries. Mean seasonal diversity values over a period of 2-1/2 years are shown in Fig. 2.7.[22]

The primary producers (green plants) use solar energy to synthesize organic matter from inorganic raw materials (carbon dioxide, water, and minerals). The majority of the primary production in an aquatic system is carried on by the phytoplankton (Fig. 2.8). These microscopic organisms are the major food source for most of the zooplankton and for many fish.[23,24] They therefore serve as a basic food supply for aquatic consumers.

The decomposer community, composed primarily of bacteria, is a fundamental unit of a biological system. These organisms break down organic materials, thus preventing the loss of elemental nutrients from the system and returning them in a form available for use by the primary producers.[25]

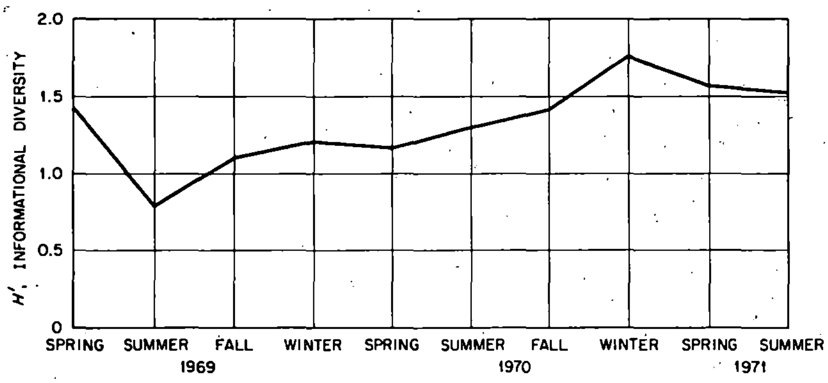


Fig. 2.7. Mean seasonal species diversity of benthic invertebrates in the James River estuary adjacent to the Surry Power station (ref. 22).

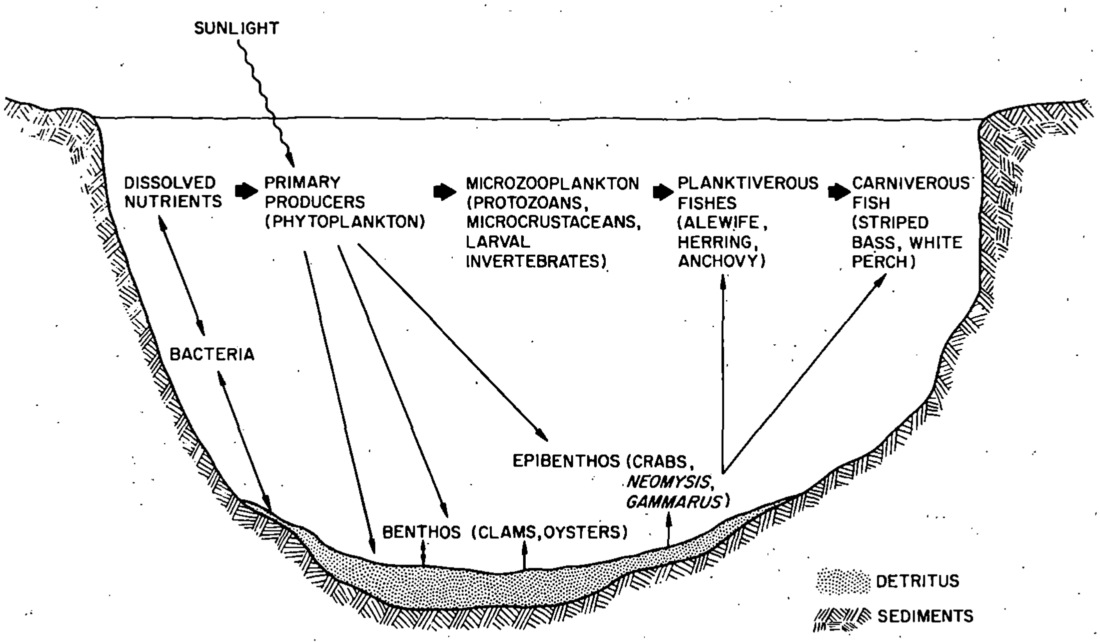


Fig. 2.8. Simplified aquatic food web for the James River at Hog Island.

In addition to providing raw materials for the producers, bacteria serve as food for many zooplanktonic organisms.[25] By contributing nutrients to both the primary producers and the primary consumers, the decomposers form the basis of the aquatic food web and supply nutritive material to all other trophic levels (Fig. 2.8). There are no data available with which to evaluate the bacterial populations of the Surry site.

Odum and de la Cruz,[26] however, found that in Georgia estuaries the major energy pathway from autotrophs (green plants capable of making their own food) to heterotrophs (organisms requiring a supply of organic material from the environment) was through the detritus food chain, with little grazing on live vegetation. They found that detritus particles composed more than 90% of the total seston and that they were rich in protein. Darnell[27] defines detritus as "all types of biogenic material in various states of decomposition which represent potential energy sources for consumer species." It thus includes dead organisms in addition to the by-products of living organisms, such as egested, excreted, and secreted matter. Functional, energy-yielding detritus, however, also includes the bacteria and various microbes living in association with them. Darnell[28] cites research which indicates that the most estuarine consumers ingest large quantities of detritus. Even the most carnivorous consumers take in some detritus.[29,30] Richman[31] and Smirnov[32] have shown that laboratory cultures of cladocerans grow and reproduce on a diet of detritus particles. It is therefore possible that organic detritus may form an important part of the estuarine food chain in the Hog Island Area.

The consumers in an aquatic system include microscopic zooplankton, macroinvertebrates, and fishes. The zooplankton feed on particulate organic material, which includes phytoplankton, bacteria, and detritus which they convert into a form usable by larger consumers (Fig. 2.8). The macroinvertebrates of the benthic community include both attached and mobile forms which live in or on the bottom of a body of water.

The large invertebrates comprising the benthic community are thought to be the best indices for measuring environmental stress on an aquatic system. Because they have a much longer generation time than the smaller planktonic species and may reproduce only once a year, benthic organisms are not able to recover rapidly from population reductions caused by changes in the environment. The sedentary habits of these organisms do not allow them to escape harmful conditions in the area, in contrast to the planktonic forms which are carried by the current.[33]

The community association of an invertebrate is not rigid, since the developmental states of an organism may be members of different communities. For example, the free-swimming larval and juvenile stages of many macroinvertebrates that are benthic as adults are classed as zooplankton, or specifically meroplankton. These include barnacles, molluscs, and crabs. Also classed as meroplankton are the larval and juvenile fishes. Some adult organisms, such as the amphipod Gammarus, can appear in all three communities, occurring in the plankton, but entering attached and benthic habitats to feed. Many of the organisms at the Surry location can thus be members of more than one ecological community.

The aquatic species found in the vicinity are listed in Appendices F and G.

a. Producers

Vascular Plants. According to the applicant, there are few submergent or emergent plants growing in the immediate area. Widgeon grass and eelgrass grow in the more saline water downstream. In the less brackish marshes upstream, there is other vegetation, including arum, cordgrass, and cattails.[19]

Phytoplankton in the area is scarce due to high turbidity caused by the large quantities of suspended sediments carried by the river. This limits the amount of light available for photosynthesis. A method often used to estimate the biomass of primary producers is the measurement of chlorophyll content. Preliminary data furnished by the applicant show that standing crops in the vicinity of Hog Island reach a maximum in October, with about 10 μg chlor "a" per liter, and a minimum in spring, with about 3 μg per liter (Fig. 2.9). The area upstream near Richmond is 3 to 5 times as productive, due to the organic waste load the river receives.

Species composition data show that the plankton in the Surry vicinity is dominated by diatoms during the year, with diatoms comprising about 95%, dinoflagellates 4%, and green algae 1% of the total (averages of three sampling dates: February 24, March 19, and August 9, 1971.[19] Preliminary sampling indicated no blue-green algae. The dominant algal species in any aquatic system change seasonally, but no data from the Surry site have been made available with which this can be evaluated.

b. Consumers

Zooplankton. The applicant's report indicates that zooplankton is sparse in the area of the Surry Station.[34] The majority of the organisms occur during the spawning of anadromous fishes in April, May, and June. Gammarus was found to be the most abundant species, with other amphipods, copepods, and a few shrimp being found.

The quantity of fish and macroinvertebrate larvae (meroplankton) has also been small. The organisms found have included the eggs and larvae of fish and the larval stages of crabs, barnacles, and oysters.[19]

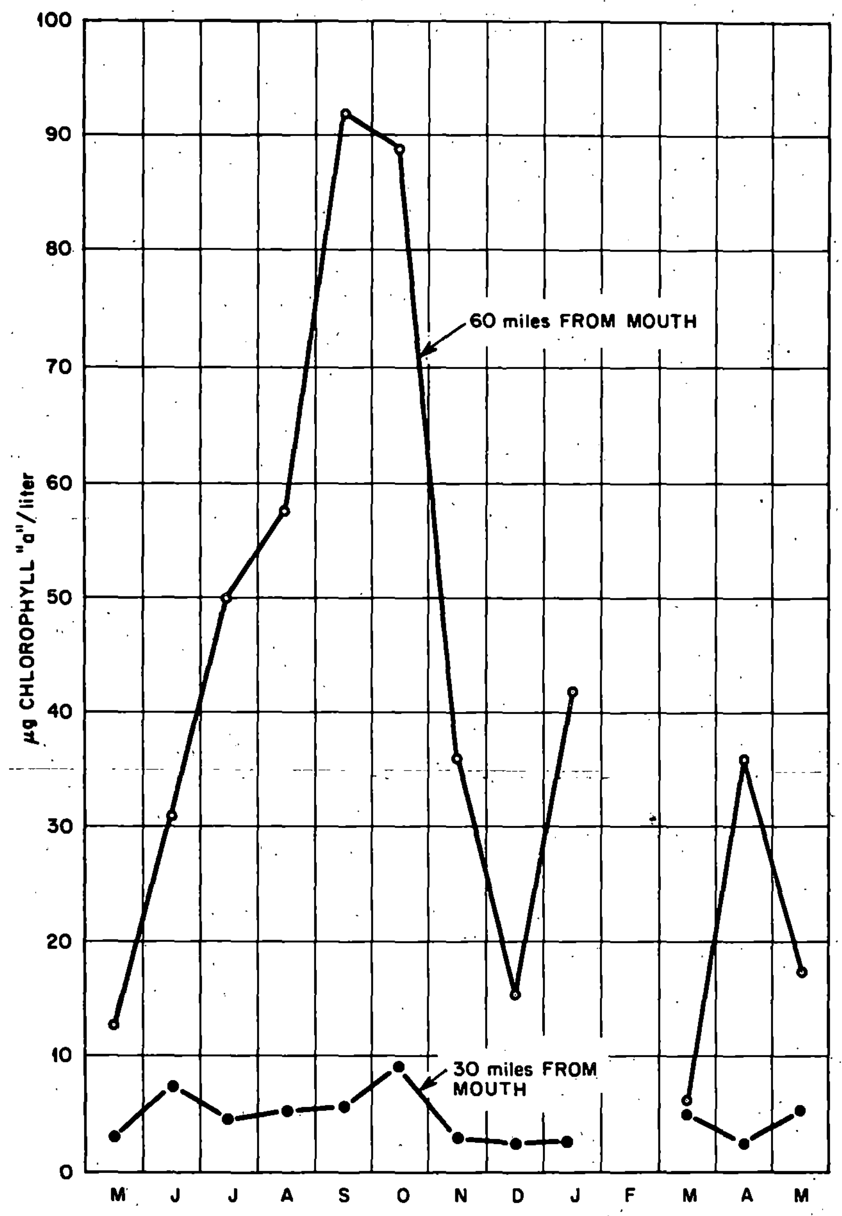


Fig. 2.9. Phytoplankton standing crops (expressed as μg chlorophyll "a" per liter) in two sections of the James River. The upstream station is near Hopewell and the downstream station is in the area of Hog Island (ref. 34).

Macroinvertebrates. As stated above, the species diversity of the macroinvertebrates was found to be low compared with that in more saline areas of the James estuary.

The organism which has been most frequently encountered in preoperational studies is the marsh clam, Rangia cuneata, a species capable of tolerating wide ranges of salinity and temperature. The applicant has determined that it comprises more than 90% of the total invertebrate biomass (with an average weight of 1.6 kg/m^2) and averages 70 individuals/m^2 (refs. 21,22). Maximum densities of over 600 individuals/m^2 have occurred at Tribell Shoals and the Thorofare Deep (Fig. 2.10).[22] The Virginia Institute of Marine Science studied the marketing possibilities of the clam and concluded that, although it exists in commercial quantities in isolated areas, it is not probable that high yields could be maintained on a regular basis.[22]

Neomysis, the opposum shrimp, forms a major portion of the diet of juvenile striped bass in other rivers, but preoperational studies indicate that it may be scarce in the station area.[22] It has been suggested that the marsh clam may limit the food source of the shrimp by reducing the quantity of detritus in the river.[19] Markle and Grant found no Neomysis in stomach samples of striped bass from the James River.[35] Their sampling was done, however, during a period of low salinity, when Neomysis would not have been expected.

The polychaete Scoleocolepides viridis is the second most commonly encountered benthic invertebrate in the area. A maximum density of 900 individuals/m^2 has occurred during the time of spring spawning. George found that fertilization did not occur at salinities of less than 5 parts per thousand.[36] The organisms at the site thus reproduce infrequently, the population being sustained by the import of juveniles from areas of higher salinity downstream. S. viridis can withstand wide variations in salinity and is often found in the upper reaches of esuaries in association with the burrowing isopod Cyathura polita, whose density was found to vary both spatially and seasonally (maximum found was 150/m^2) (ref. 22). Both organisms are detritus feeders, and both are permanent residents of the Surry location.

The blue crab, Callinectes sapidus, is present in commercial quantities in this area and is considered by the applicant to be the most abundant seasonal macroinvertebrate. The presence of other various species depends on the salinity. Dipteran larvae enter the area when the salinity decreases, while Macoma mitchilli, Laeonereis culveri, and Balanus occur when the salinity is high. In sampling conducted by the Virginia Institute of Marine Science, it has been found that B. improvisus, Corophium (amphipod), and Bowerbankia (ectoproct) comprise 90% or more of the attached organisms in the vicinity.[22]

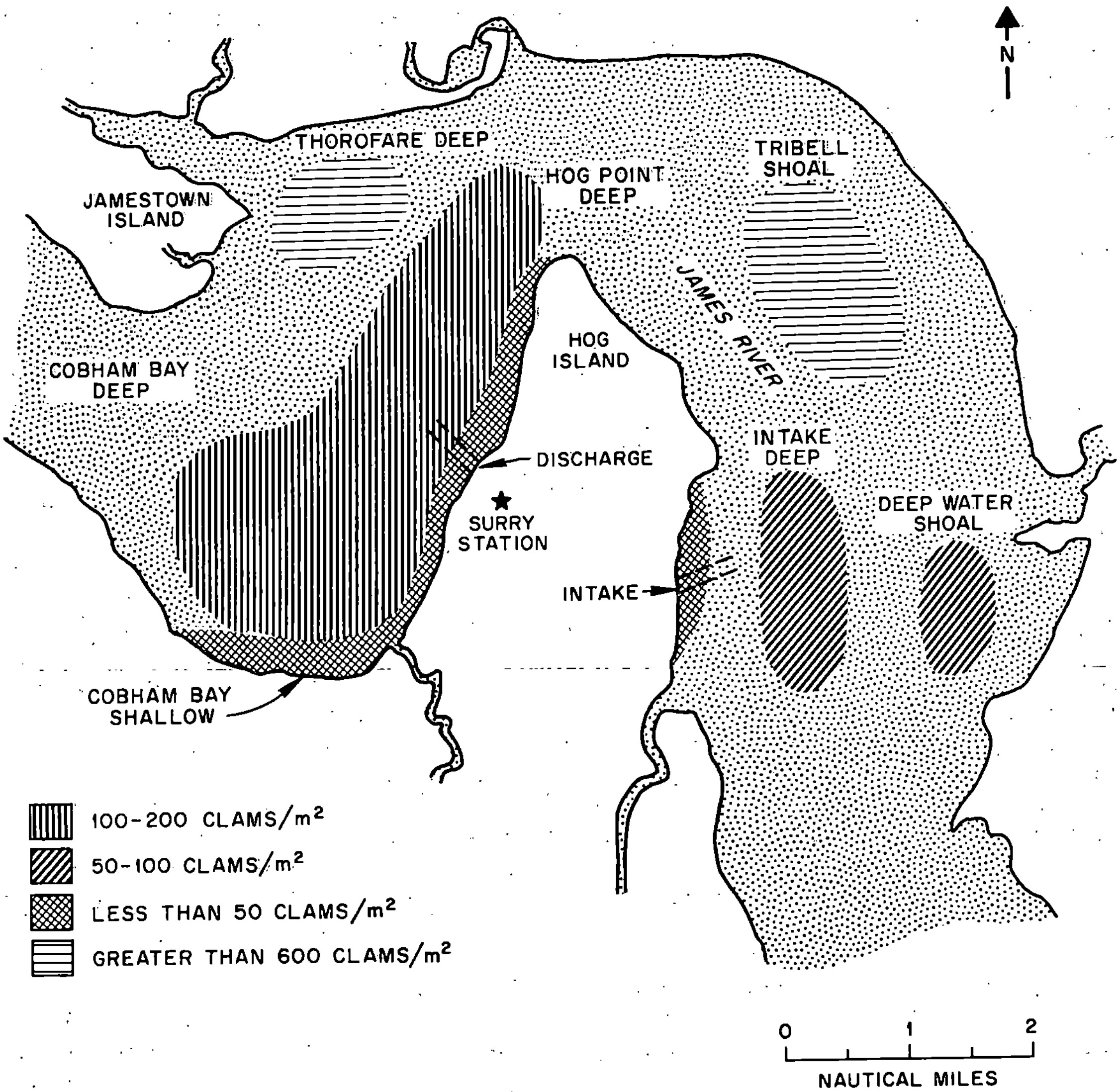


Fig. 2.10. Densities of the clam *Rangia cuneata* in the James River around Hog Island (ref. 22).

Oyster larvae, Crassostrea virginica, occur in the meroplankton, but set adults have rarely been encountered in the immediate area during preliminary studies. The range of the species is dependent on salinity, and adults are usually killed by heavy fresh water flow from upstream during the spring.(37) The nearest quantities of commercial importance occur about 5 miles downstream on the south shore and on the north shore in Deep Water Shoal across from the intake. The lower James River, downstream from this area to Chesapeake Bay, contains seedbeds and is one of the few oyster grounds of the world still operated as a free fishery. Most of the setting in the James occurs after August 1, with a peak around September 1.(38) Temperature increases influence the oyster populations by decreasing the resistance of oysters to a pathogenic protozoan, Minchinia nelsoni ("MSX").(39-42)

Fishes. The fishes are the top consumers in the river. The applicant found the population to be composed of a few permanent residents, which include brown bullhead (Ictalurus nebulosus), white catfish (I. catus, white perch (Marone americana), and hogchoker (Trinectes maculatus). Striped killifish (Fundulus majalis) and mummichog (F. heteroclitus) are permanent shoreline species. Various migratory species appear temporarily as they pass through the vicinity. Anadromous species (striped bass, herring, shad) can be found in the area during the spring and fall as they travel to and from spawning grounds upstream. The American eel, a catadromous fish, migrates downstream to spawn in the ocean, after spending much of its life in the river near the Surry site.(19)

The area serves as a nursery ground for the larvae and juveniles of species such as the spot, Atlantic croaker, white perch, striped bass, shad, and herring.(21,43) The major factor affecting distribution of larvae is salinity. Most of the young croakers in the river have been found in areas of intermediate salinities (trace to 18 parts per thousand).(44) This also happens to be the range of salinities in the Surry Station vicinity. The most concentrated shad spawning takes place near Hopewell, about 35 miles upstream from the site. Massmann and Bailey observed little spawning before the temperature reached 55°F.(45)

Most of the James River is fished commercially for both finfish and shellfish from Hopewell to Newport News. There is also a sport fishery in the James River over the same area. The most important species are the catfish and bullheads, oyster, clams, spot, shad, and menhaden (Table 2.3). The oyster bars are located downstream from the Surry Station. Oyster production in the James River was once very high but has declined due to pollution and closing of commercial harvesting because of organic pollution.

TABLE 2.3

Annual Commercial Catch of Finfish and Shellfish in the James River in 1970.[46] Seed and Shucking Oyster Data for Public and Private Grounds in Fiscal Year 1970-71.[47]

Species	Pounds	Value
Alewives	730,000	$ 14,304
Bluefish	31,300	2,840
Butterfish	50,400	5,392
Black Bonita	500	63
Carp	5,700	145
Catfish & Bullheads	394,900	59,987
Croakers	11,000	1,341
Eels	237,700	37,258
Fluke	3,400	824
Gizzard Shad	3,400	102
Harvestfish	2,300	350
Hickory Shad	3,500	246
King Whiting	500	57
Menhaden	1,116,400	22,893
Pigfish	2,100	63
Sea Bass	9,500	2,415
Sea Trout Grey	25,000	2,765
Sea Trout Spotted	7,800	2,289
Shad	1,119,200	82,027
Grey Fish	200	7
Spot	720,100	57,600
Stripped Bass	99,700	21,405
Swell Fish	17,000	413
Tautog	100	5
White Perch	27,300	4,038
Unclassified for food	1,000	100
Unclassified for bait	724,000	13,962
Pompano	300	150
Total Fish Catch in Pounds	5,344,500	$ 333,041
Oysters (meat)	1,171,800	749,952
Clams (meat)	494,232	316,308
Snapping Turtles	47,000	10,814

Oysters:	
Total Seed Oysters	458,637 bushels
Total Shucking Oysters	170,844 bushels

III. THE STATION

A. EXTERNAL APPEARANCE

Photographs of the Surry Power Station are shown in Figs. 3.1 to 3.4. These photographs show clearly the relationship of the cooling water intake and discharge structures to the reactor and steam generating facilities. The two domed structures, designated as the reactor containment buildings, enclose the nuclear steam supply systems of the two Surry units. The large box-shaped building south of and adjacent to the reactor containment buildings houses the turbine-generators, auxiliary equipment, and offices. The station is bordered on the north by the circulating-water discharge canal and on the south by the high-level water intake canal. Located on the north side of the discharge canal is the visitors center.

State Highway 650, which leads to the Hog Island Waterfowl Refuge, crosses the applicant's property approximately 200 feet west of the station. The entire station is therefore visible from this highway and from the James River near the discharge canal.

During a site visit, the AEC staff confirmed that the applicant has constructed a facility that blends well with the landscape. The concrete foundations were constructed 50 feet below grade so as to lower the tops of the dull-gray concrete domes and minimize their effect on the skyline, as seen from the Colonial Parkway on the northern shore of the James River and from the ferry that crosses the river between Jamestown and Scotland. Blue-green siding on the turbine building helps to blend the structure into the forest background, and trees on both sides of the discharge canal partially screen the station from the river.

B. TRANSMISSION LINES

A substation (switchyard in Fig. 2.2) has been built immediately south of the water intake canal to tie the two nuclear units into the applicant's power transmission system. Also located at the switchyard are two gas-turbine generating units which are operated independently of the nuclear plant to provide up to 140 MWe during peak loads on the power system.

The applicant has chosen to make all of its interconnects south of the James River. Two 350-ft rights-of-way have been cleared through the woods of Surry County to permit the construction of transmission lines from the Surry Station to a division point 11 miles to the south. One of these rights-of-way has one 500-kV line and three double-circuit 230-kV lines; the other has two 500-kV lines and one double-circuit 230-kV line. At the division point the lines will go in four directions (generally east and west) in rights-of-way of 120 to 350-ft width.

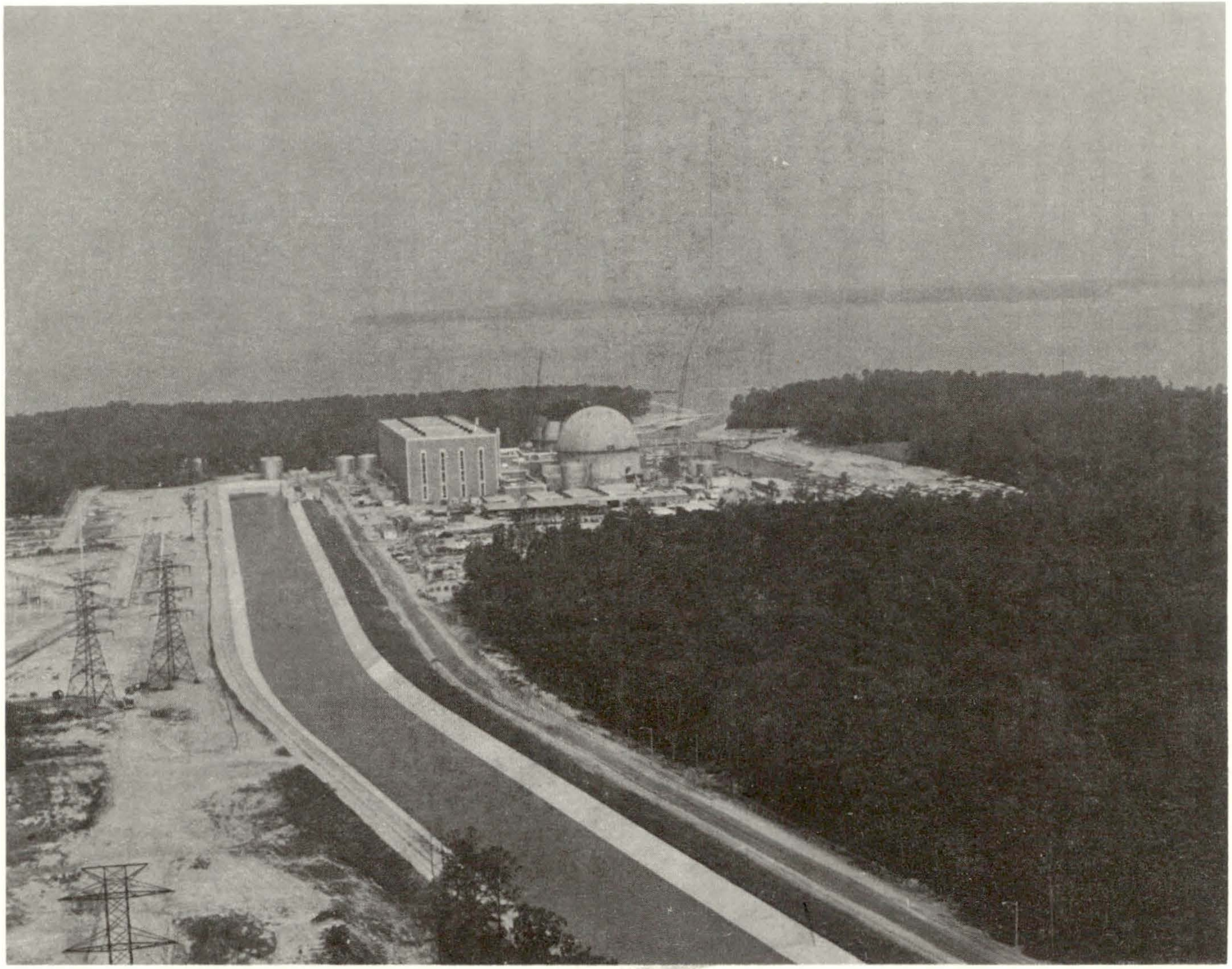


Fig. 3.1. Aerial view of the Surry Power Station, showing intake and discharge canals.

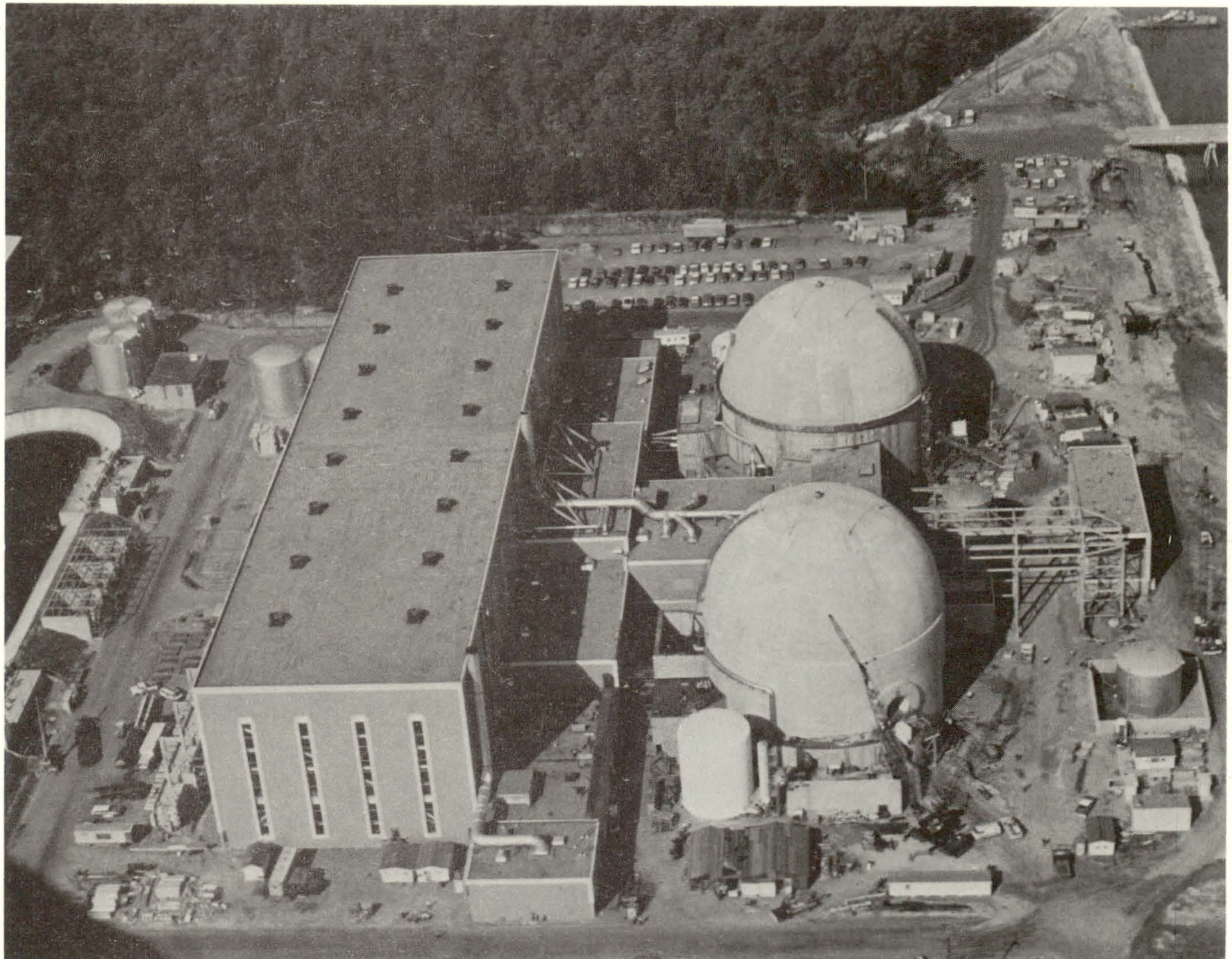


Fig. 3.2. Aerial view of Surry Power Station Units 1 and 2 (Unit 2 is in the foreground).

Fig. 3.3. Cooling water intake structure, Surry Power Station.

Fig. 3.4. Cooling water discharge canal, showing rock groin.

The applicant has purchased 4420 acres of land for these rights-of-way, of which 3543 acres have been cleared of all timber and brush. The corridors will be maintained free of woody growth either through seeding by the landowner or chemical treatment every three years by the applicant. The land within these corridors may be used by the landowner for any agricultural application that is consistent with the applicant's easement.

To reduce the visual impact of the transmission towers, the applicant has used a special type of steel that oxidizes to a russet color.

C. REACTOR AND STEAM ELECTRIC SYSTEM

The Surry Power Station will generate electricity from the operation of twin nuclear power units. Each unit will consist of a closed-cycle, pressurized, light-water-moderated nuclear steam supply system, a turbine-generator, and auxiliary equipment. The nuclear steam supply system for each unit was designed and supplied by Westinghouse Electric Corporation; the remainder of the station was designed by the applicant or its architect-engineer, Stone and Webster Engineering Corporation. The design power ratings of each unit are 2441 MWt and 822.5 MWe gross output (788 MWe net), with an ultimate predicted capability of 2546 MWt and electrical output of 855.2 MWe (820 MWe net).

Each of the two reactors will be fueled with slightly enriched uranium dioxide pellets enclosed within Zircaloy-clad tubes. The reactor core will contain 157 fuel assemblies, each fuel assembly consisting of 204 fuel rods arranged in a square array. Reactor operation will be controlled by silver-indium-cadmium control assemblies, fixed burnable poison rods (borosilicate glass in stainless steel tubes), and boric acid dissolved in the reactor coolant.

The heat generated by each reactor will be transferred through three separate, closed-cycle loops (the primary coolant system) to three steam generators (Fig. 3.5). The steam generators will in turn utilize the heat from the primary system to produce steam at 700 psig. The steam will be transferred through closed-cycle secondary coolant loops to the steam turbines, which will drive generators to produce electricity. After passing through the turbines, the spent steam will be condensed and returned to the steam generators to repeat the cycle.

D. EFFLUENT SYSTEMS

1. Thermal

The Surry Power Station will utilize a once-through cooling system to dissipate waste heat from the turbine condensers (into the cooling water) and from the plant service water system to the environment. A flow diagram

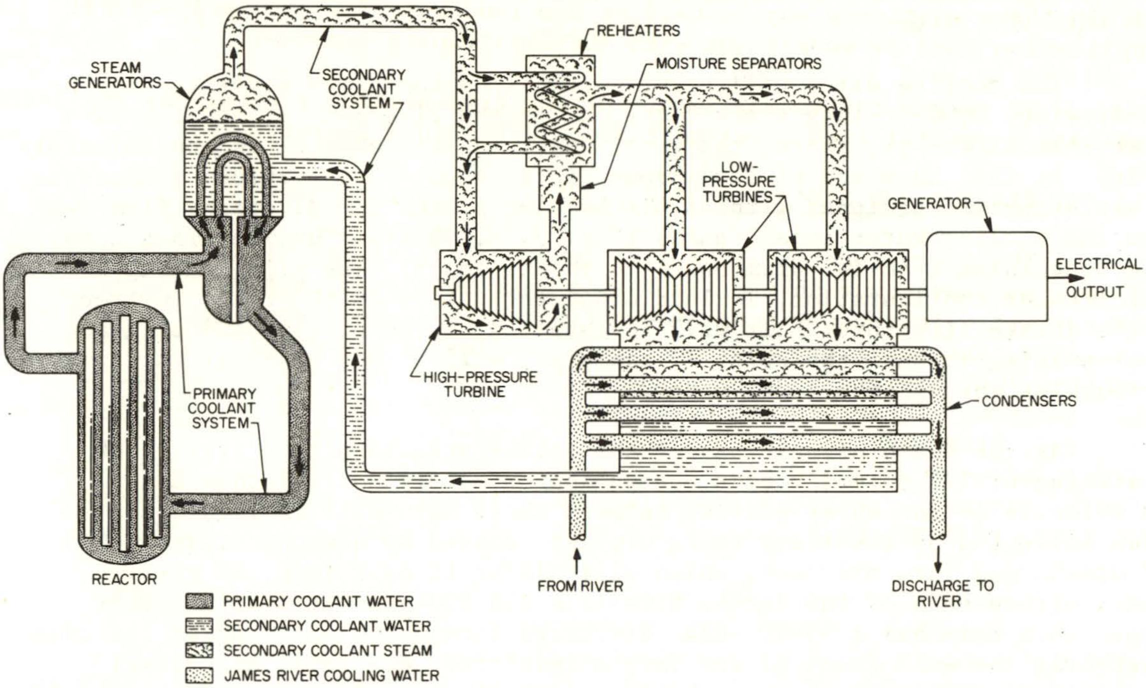


Fig. 3.5. Simplified flow diagram of the steam-electric system, Surry Power Station Unit 1.

of this once-through system is shown in Fig. 3.6. Water will be pumped from the James River at a flow rate of approximately 1,680,000 gallons per minute (840,000 gpm per unit), circulated through the turbine condensers and plant auxiliary cooling systems, and returned to the James River at a point nearly 6 miles upstream of the intake. At the planned operating level of 2441 MWt, the cooling water will be warmed approximately 14°F before being discharged back into the river.

The cooling water will be withdrawn from the James River through a 150-ft-wide, 5000-ft-long channel dredged in the riverbed between the main river channel and the shore; the water depth in this channel is approximately 13 ft. At the shore end of the channel is an eight-bay, reinforced-concrete intake structure equipped with an air bubbler system for diverting fish away from the cooling water intake pumps (Fig. 3.7). The air bubbler is a 2-in. pipe containing 1/16-in.-diam holes, 4 inches apart. The pipe, having a semicircular configuration, is laid along the bottom of the river in front of the intake structure. Air will be supplied to the pipe at 100 psig and, after passing through the holes in the pipe, will form a vertical curtain of air bubbles through the river water.

At the mouth of each bay of the intake structure is a trash rack consisting of 1/2-in.-wide bars spaced approximately 3-1/2 inches apart. The velocity of the water passing between these bars will be 1.03 fps. Trash collected by the trash racks will be removed by a mechanical rake and discharged into a trough, which will sluice it back into the river. Housed within each of the intake bays is a 210,000-gpm circulating water pump. Each pump has a 95-in.-dia. discharge line which will convey the river water over the embankment of and into a reinforced concrete, high-level intake canal. This canal has a bottom width of about 32 feet and an overall length of 1.7 miles. It will maintain a minimum of 45,000,000 gallons of cooling water.

The cooling water will flow by gravity the entire length of the high-level intake canal into two high-level, four-bay intake structures; each structure serves one power station unit. Each of the high-level intake bays contains a trash rack, a traveling screen, and an inlet to a 96-in.-dia. condenser intake pipe. The 1/2-in.-wide trash rack bars are spaced approximately 3.5 inches apart. The traveling screens, constructed of 14 gage wire with 3/8-in. clear openings, are designed to move once every 24 hours or when a pressure differential of 6 inches of water exists across the screens. Debris and fish will be removed from the screens by wash water supplied by two 850-gpm pumps and will be collected in wire baskets.

The cooling water will flow by gravity from each intake bay through a 96-in.-dia. pipe to the turbine steam condensers. Service water used for auxiliary cooling systems will be withdrawn from the system before the circulating water enters the condensers. (Each condenser is equipped with an Amertap condenser tube cleaning system, which circulates sponge-rubber balls

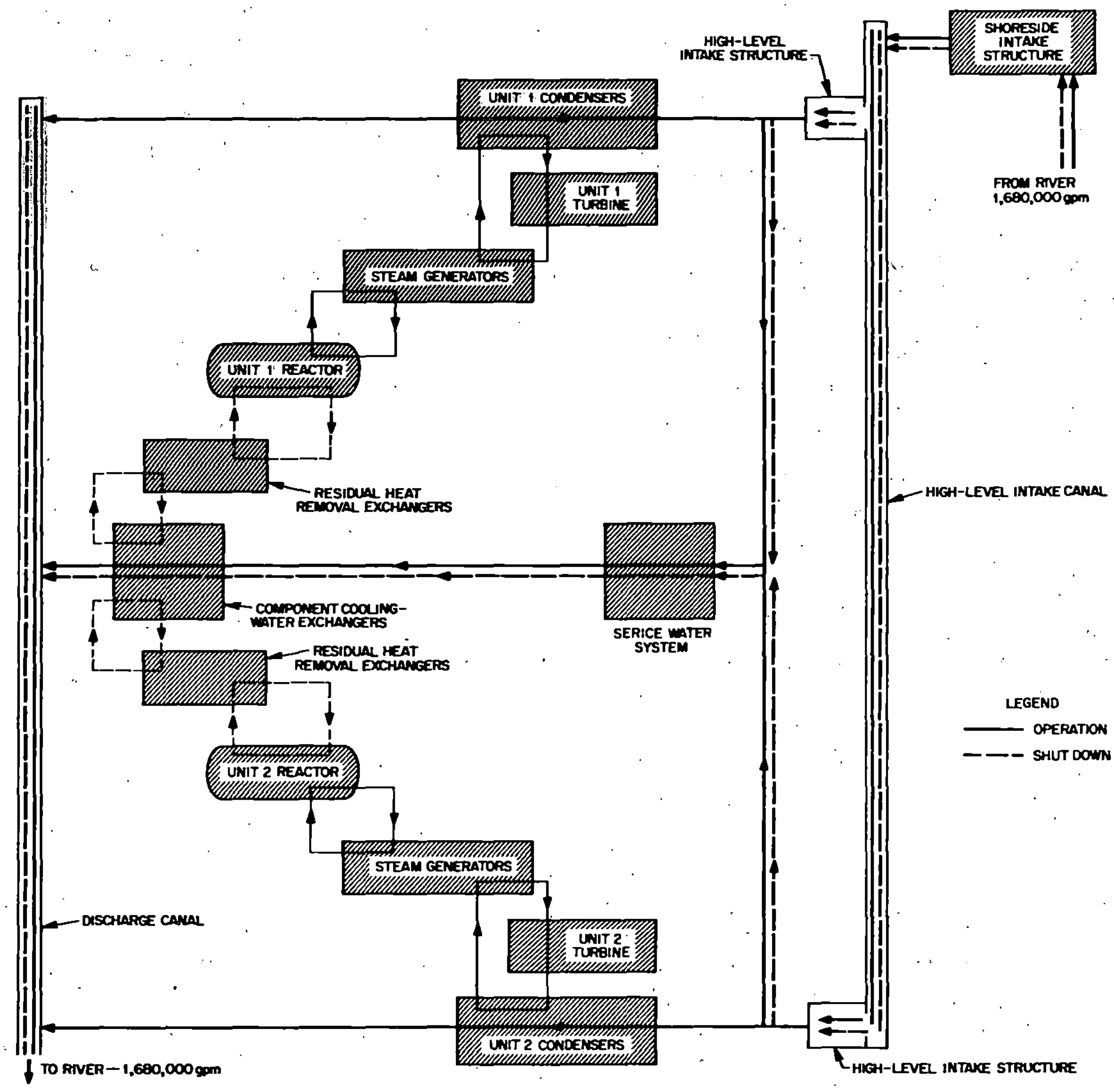


Fig. 3.6. Flow diagram of the heat dissipation system, Surry Power Station.

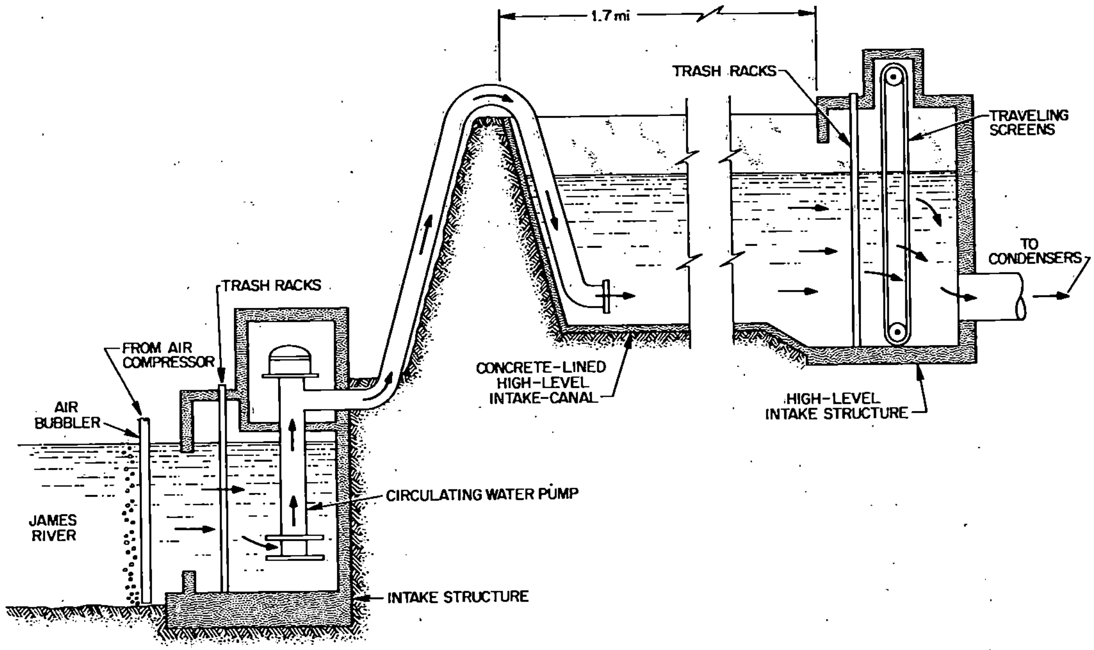


Fig. 3.7. Schematic of water intake system, Surry Power Station (not to scale).

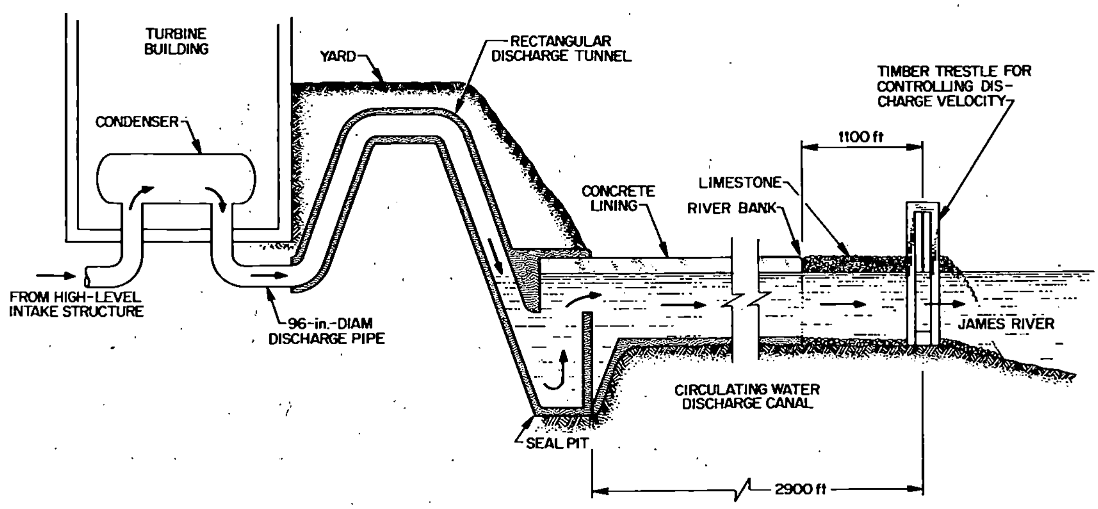


Fig. 3.8. Schematic of water discharge system, Surry Power Station (not to scale).

through the condenser tubes to prevent accumulation of deposits, and should eliminate the need for chemical cleaning of the condenser tubes.)

After passing through the condensers, the warmed cooling water will empty into a 12.5-ft by 12.5-ft rectangular discharge tunnel and subsequently flow into a common circulating water discharge canal which will convey the water from both units (including the service water discharge) to the James River (Fig. 3.8). The discharge canal ranges in width from 20 feet to 65 feet and has an overall length of about 2900 feet. The 1800-ft section of the canal that extends from the power station units to the river shoreline is lined with concrete, while the 1100-ft section that extends into the river is lined with and enclosed by limestone rocks.

The velocity of the water flowing through the discharge canal will be approximately 2.2 fps, but the terminal discharge velocity will be maintained at 6 fps by a velocity control structure at the end of the discharge canal. This control structure, consisting of a timber trestle containing five 10-ft-wide bays in which timber gates may be placed, extends about halfway across the opening of the discharge canal. In the event that flow through the discharge canal is reduced (as in the case of shutdown of one of the units), the timber gates will be installed to reduce the net area available for water flow and thus maintain the optimum 6-fps discharge velocity. The time required for water to travel from the shoreline intake structure to the exit of the discharge canal will be approximately 61 min., of which the residence time from the inlet of the condensers to the exit of the discharge canal will be about 28 minutes.

During periods of shutdown, heat will be transferred from the primary coolant system through the residual heat removal exchangers to the component cooling water system. The component cooling water heat exchangers will then transfer the waste heat to the service water system, which will discharge it to the James River via the circulating-water discharge canal. Each Surry unit has its own residual heat removal system, but the component cooling water system and the service water system are shared by both units.

<u>Thermal Effluent Dispersion</u>

In full-power operation the Surry Station will discharge 11.9×10^9 Btu/hr into the James River estuary by way of cooling water discharged into Cobham Bay. Dissipation of the thermal plume produced by the warmed water discharge will be dependent upon prevailing estuarine and meteorological conditions. The various flow regimes of the estuary, their associated densities and temperatures, wind velocities, ambient air temperatures and relative humidities will affect the size, shape, and rate of dissipation of the plume.

a. <u>Site Features Pertinent to Heat Dissipation</u>

The topography of the James River in the vicinity of Hog Island is shown in Fig. 3.9. The width of the river from the condenser outlet directly across toward Jamestown Island is approximately 2.6 miles. At its narrowest, opposite Hog Point, the river is 1.5 miles wide, and becomes 3-3/4 miles wide at a point opposite the condenser inlet.

Flow velocities at Hog Point are primarily of tidal origin. The mean tidal vertical range is 2.1 feet. Figure 3.10 illustrates how the central channel surface velocity varies over one tidal cycle.[1] It should be noted that the maximum ebb velocity exceeds the maximum flood velocity (2.5 ft/sec vs 1.6 ft/sec) and ebb duration exceeds that of flood (6.7 hrs vs 6.1 hrs).[2] Flow rates associated with the tidal motion are in excess of 130,000 cfs.[2]

In comparison to the total tidal flows, fresh river water flows are far lower. Records of the mean monthly discharge in the river at 372 monthly periods from 1934 to 1965 were obtained by Pritchard and Carpenter.[2] These data are listed in Table 3.1. The minimum mean monthly discharge of 857 cfs occurred in 1942. The median monthly fresh water discharge is 7860 cfs.

Table 3.1. Mean monthly fresh water flows of the James River at Hog Point

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

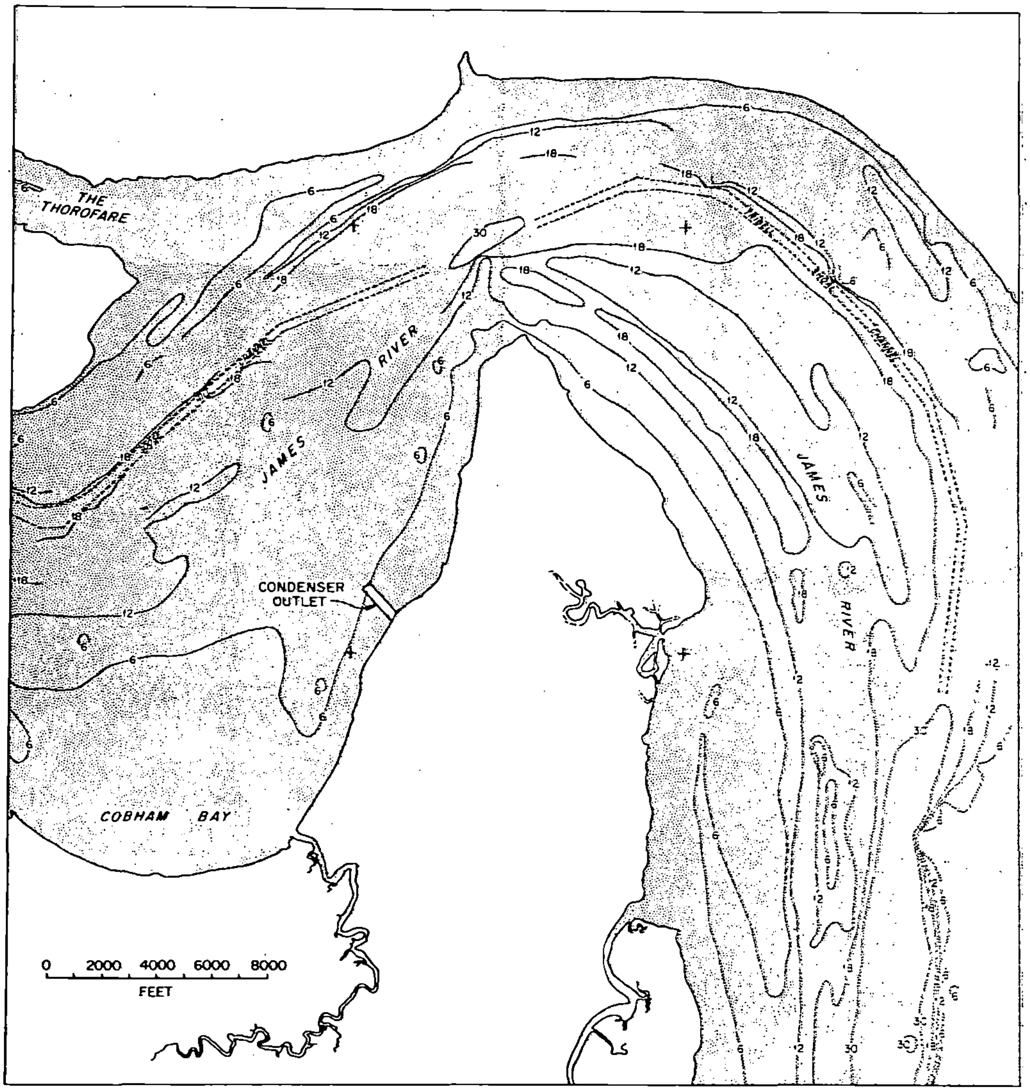


Fig. 3.9. The topography of the James River in the vicinity of Hog Island.

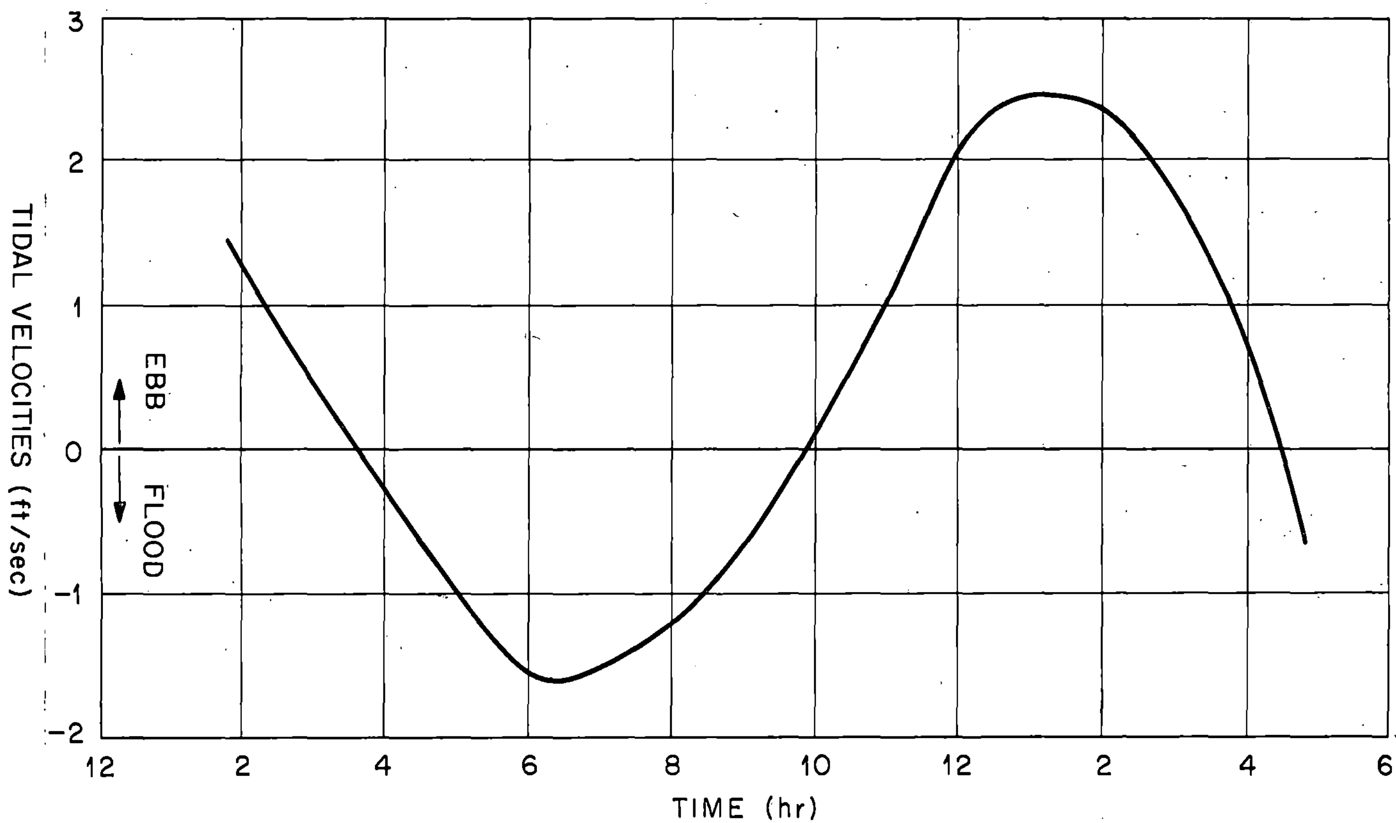


Fig. 3.10. Central channel surface velocity over one tidal cycle.

Hog Point is in the region of transition between the fresh tidal river and the estuary proper; therefore, salt concentrations in this region of the river vary not only over a tidal cycle, but also with variation in the fresh water river flow. When river flows are less than 10,000 cfs, salt water extends upstream of the Surry discharge canal,[2] and the entire Hog Point region thus becomes a part of the "partially mixed estuary." In such an estuary the salinity decreases in more or less a regular manner from the mouth toward the head while it increases in depth. At some intermediate depth there is a region where the salt gradient is higher than either above or below. This is the demarcation between the lower layer flow which is directed inland, on the average, over a tidal cycle and the upper layer seaward flow. The shearing stress resulting from the interaction of these two flows induces mixing of the salt water with the upper layer of fresh water, thus producing a circulatory flow pattern as shown in Fig. 3.11. (It should be emphasized that the indicated net flow directions are superimposed upon a primarily oscillatory tidal flow.) The magnitude of the total upper-layer flow, $Q_R + Q_M$, can thus be described as the sum of the fresh water river flow, Q_R, and the saline "mixing flow," Q_M. The existence of this "non-tidal circulatory flow" in the James River estuary has been demonstrated by salinity gradient measurements taken near Hog Point and in physical model studies performed for the applicant by Pritchard-Carpenter Consultants.[3] From these studies the consultant concluded that the total upper-layer flow of the estuary at Hog Point remains rather constant at 25,000 cfs in the range of fresh water river flows from 2000 cfs to 6000 cfs. There is some question as to the magnitude of this flow for fresh water river flows outside this range, especially between 14,000 cfs and 25,000 cfs.

The cooling rate of the water surface, which is of significance in the determination of the thermal plume areas bounded by the lower excess temperature isotherm (less than 3°F), depends upon the meteorological conditions at the site.

Since the heat storage capacity of the river system is extremely large (approximately equal to that for the water volume of a tidal excursion), the system as a whole, particularly as regards the lower temperature isotherms, should be resistant to variations induced by short term changes in weather conditions. Hence, it is proper to use monthly average conditions at the site for determination of the surface cooling coefficient.

The average wind velocity and temperature in the vicinity of Hog Point for the months of December and August are listed in Table 3.2.[4] This table also shows values for the surface loss coefficient as calculated from three

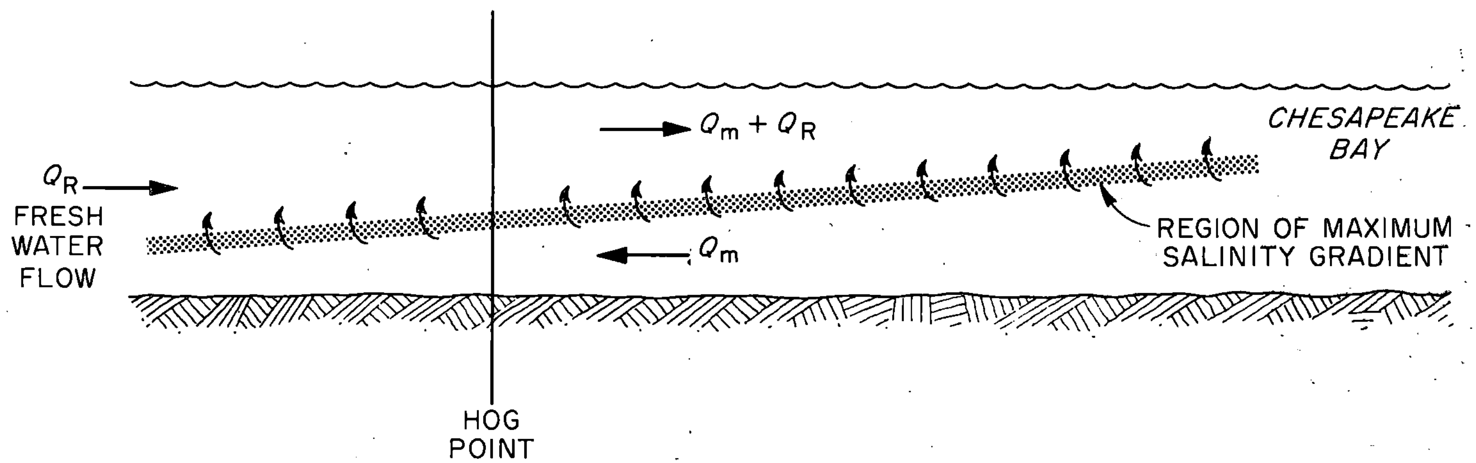


Fig. 3.11. Illustration of total surface and density current flow. Indicated velocity directions are for average over tidal cycle.

correlations[5] for each of the two months considered. These values range from 3.3 to 4.5 Btu/ft^2-hr-°F for December, in good agreement with a value of 3.4 Btu/ft^2-hr-°F used by Pritchard-Carpenter Consultants. Hence, it appears that for winter conditions, when heat loss coefficients are lowest, the surface cooling rate of the James River in the vicinity of the Surry Power Station has been conservatively estimated.

Table 3.2. Heat loss coefficients in the vicinity of the Surry Station for December and August

	December	August
Average temperature, °F (ref. 4)	45	77
Average wind velocity, mph (ref. 4)	10	8
Surface loss coefficient from ref. 5, Btu/(hr ft^2 °F)		
Lake Hefner correlation	3.3	5.4
Lake Colorado City correlation	4.5	7.7
Meyer's correlation	4.0	7.5
Values assumed by Pritchard-Carpenter	3.4	6.9

b. Qualitative Description of Plume Behavior

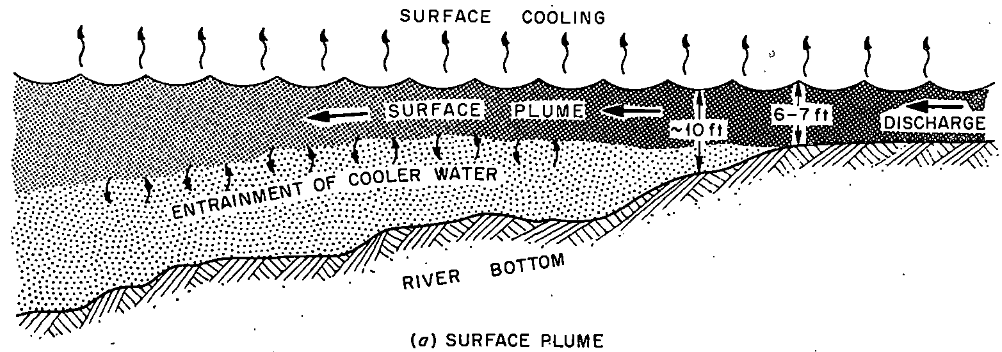
The cooling water discharge from the Surry Station will enter the James River some 1100 feet from the shoreline, where it will tend to dissipate homogeneously throughout the shallow, near-shore waters of the estuary (depths less than 10 feet). When the momentum of the effluent carries it into deeper waters, the resulting thermal plume will, depending upon its density, stratify in one of three regions of the estuary--on the surface, on the bottom, or somewhere between the surface and the bottom (Fig. 3.12). Since the cooling water intake is about six miles downstream from the discharge, and since the salinity of the estuary in the vicinity of Hog Point varies longitudinally along the estuary (as discussed in the previous section), the density of the heated cooling water effluent is unpredictable, as is the stratification level of the plume. It is most probable, however, that the discharge will, on occasions, be more dense than the receiving waters of the James River; therefore, both interflow and underflow sinking plumes, as well as the surface plume, will occur.

The direction in which the plume dissipates will be determined primarily by the actions of the tide. Figure 3.13, depicted by D. W. Pritchard,[3] describes the expected plume behavior over a tidal cycle. According to this figure, the plume will extend upstream during the period of slack before ebb tide, will begin to move downstream during the period of mid-ebb tide, and will reach a maximum downstream distance during late ebb tide. The reversal of the tide (flood tide) will then cause the plume to again shift upstream of the discharge. As is evident from Fig. 3.13, the superimposition of the river flow upon the tidal flow will cause the plume to extend a greater distance from the discharge during ebb tide than during flood tide.

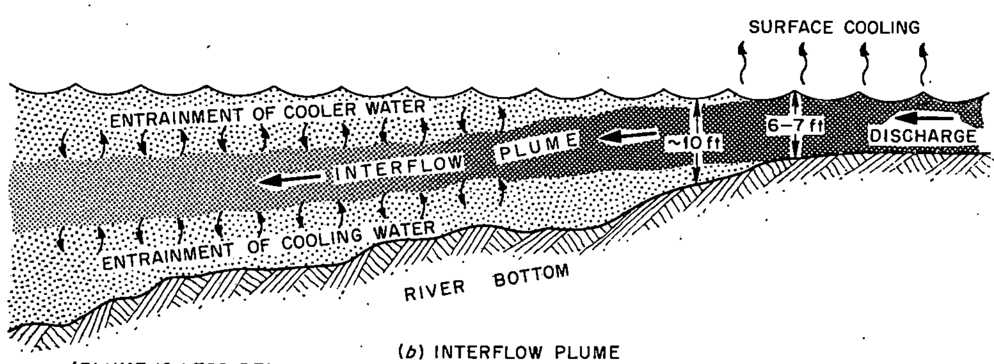
The dissipation of heat from the plume will occur via three main processes-by entrainment of surrounding cooler water, by surface heat exchange to the atmosphere, and by natural diffusion of the heated water into the receiving water (Figure 3.12). Although all of these cooling processes will, to some extent, occur simultaneously, the entrainment process should be the dominant method of heat dissipation within the area of the plume bounded by the 3°F excess isotherm, while surface cooling and natural diffusion should dominate beyond this region. The rate of heat dissipation within the 3°F excess isotherm will then depend primarily upon the rate of mixing with cooler water, while the rate of heat dissipation from the region of the plume beyond the 3°F excess isotherm will depend primarily upon the ambient diffusivity of the estuary, the wind velocity, the ambient air temperature, and the relative humidity.

c. Quantitative Discussion of Thermal Plume Behavior

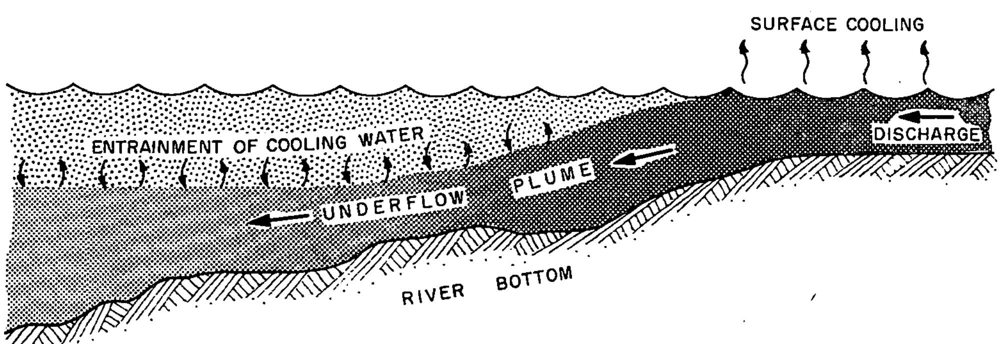
As discussed in previous sections, the region of the James River estuary in the vicinity of the Surry Nuclear Power Station is a complex system of interrelated and ever-changing flows, temperatures, and densities.



(*a*) SURFACE PLUME
(PLUME IS LESS DENSE THAN RECEIVING WATER)



(*b*) INTERFLOW PLUME
(PLUME IS LESS DENSE THAN BOTTOM WATER AND MORE DENSE THAN SURFACE WATER)



(*c*) UNDERFLOW PLUME
(PLUME IS MORE DENSE THAN RECEIVING WATER)

Fig. 3.12.

Fig. 3.13. Thermal plumes for Surry Power Station over a Tidal Cycle (summer operation), as predicted by Pritchard's physical model. Perimeter of cross-hatched area indicates 3.6°F excess isotherm.

Since the methodology for prediction of thermal plume dispersion into estuarine waters has not yet advanced sufficiently to incorporate all of these complexities, various simplifying assumptions must be made if one is to assess the probable behavior of the water plume discharged from the Surry Station.

The first Surry thermal plume study was conducted by D. W. Pritchard in 1967.[3] It consisted of the operation of a physical model of the Surry system at the U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. Pritchard utilized this model to study the behavior of the Surry plume under the influence of two different river flow rates (2000 cfs and 6000 cfs) for plant operation during the summer. The data obtained from the operation of this model proved adequate for qualitative prediction of the behavior of the plume and, within the limitations of any physical model, provided adequate approximations of expected plume sizes for the two cases studied. The results of this study are shown in Fig. 3.13.

Two later studies of the Surry thermal plume, both of which were conducted by Pritchard, consisted of analytical determinations of plume sizes for both winter and summer operation.[6,7] Since the physical model study indicated that the largest plume will result during the period of late ebb tide, only ebb tide plumes were predicted in each of these studies. As in the physical model study, hydrologic data corresponding to river flows ranging from 2000 cfs to 6000 cfs were used. All three of Pritchard's studies predicted values for plume areas, widths and lengths as well as closure temperatures. (The closure temperature was defined as the maximum value of the minimum excess temperature that will occur along the far shore in some specific cross-section of the estuary.[3])

In an assessment of the results of the three Pritchard studies, the Oak Ridge National Laboratory conducted an independent analytical thermal plume study for the AEC using the same river flows that were used by Pritchard. This study utilized a "jet entrainment model"[8] which provided area and length values for an assumed surface plume. No closure temperatures were determined. However, since Pritchard's closure temperature calculations assumed the extreme condition of complete lateral mixing of the cooling water effluent with the estuary, it is believed that his studies predicted the highest closure temperature that could exist in the range of river flows studied. As shown in Table 3.3, the studies conducted by the regulatory staff predicted smaller plumes than did any of Pritchard's studies. It is therefore concluded that, for river flows ranging from 2000 cfs to 6000 cfs, the size of the thermal plume and the closure temperature to be produced by operation of the Surry Station at full power should fall within the predictions made by Pritchard.

Table 3.3. Comparison of results of thermal plume studies for the Surry Station[a]

	Isotherm (°F)	Distance from discharge that isotherm will exist (ft)	Area bounded by isotherm (acres)	Closure temperature (°F)
Pritchard's physical model, summer operation	5 3	15,600 49,700	615 1900	1.44
Pritchard's analytical model, summer operation	5 3	12,900 33,100	630 4200	1.40
AEC Regulatory Staff's analytical model, summer operation	5 3	9,100 24,000	415 3000	
Pritchard's analytical model, winter operation	5 3	17,100 47,500	1100 8600	1.63
AEC Regulatory Staff's analytical model, winter operation	5 3	9,300 26,780	430 3850	

[a]All plume predictions listed are for the period of late ebb tide.

The relative sizes of the largest thermal plumes that are likely to occur at the Surry Station during those ebb tide periods when river flows range between 2000 cfs and 6000 cfs, as determined by Pritchard, for both summer and winter operation, are shown in Fig. 3.14. It should be recognized that these worst-case predictions represent plumes that will occur only about 1.5 hours each tidal cycle (3 hours each day). The remainer of the tidal cycle should produce smaller plumes with no closure temperature.

It is evident from Fig. 3.14 that a portion of the discharged heat will be recirculated during the late ebb and slack before flood periods of the tidal cycle. It is estimated that approximately 14% recirculation will occur during this 1.5 hour time interval - this is equivalent to 2% recirculation averaged over a complete tidal cycle. The effect of this recirculation should be virtually nil for reasons that become evident by following the course of events of one tidal cycle in the following way:

Recirculated water enters the intake structure during the 1.5 hour time interval around low water slack. This water is discharged 8 miles upstream one hour later, which is well into the beginning of flood tide. The recirculated water then becomes well mixed with the flood tide flow, thus producing some additional temperature increase in the plume produced during this phase of the tidal cycle; however, plumes produced during this tidal phase appear to be small in comparison with flood time plumes. The intake of recirculated water should cease during early flood tide and the discharge should thus become thoroughly mixed with the tidal flow before high water

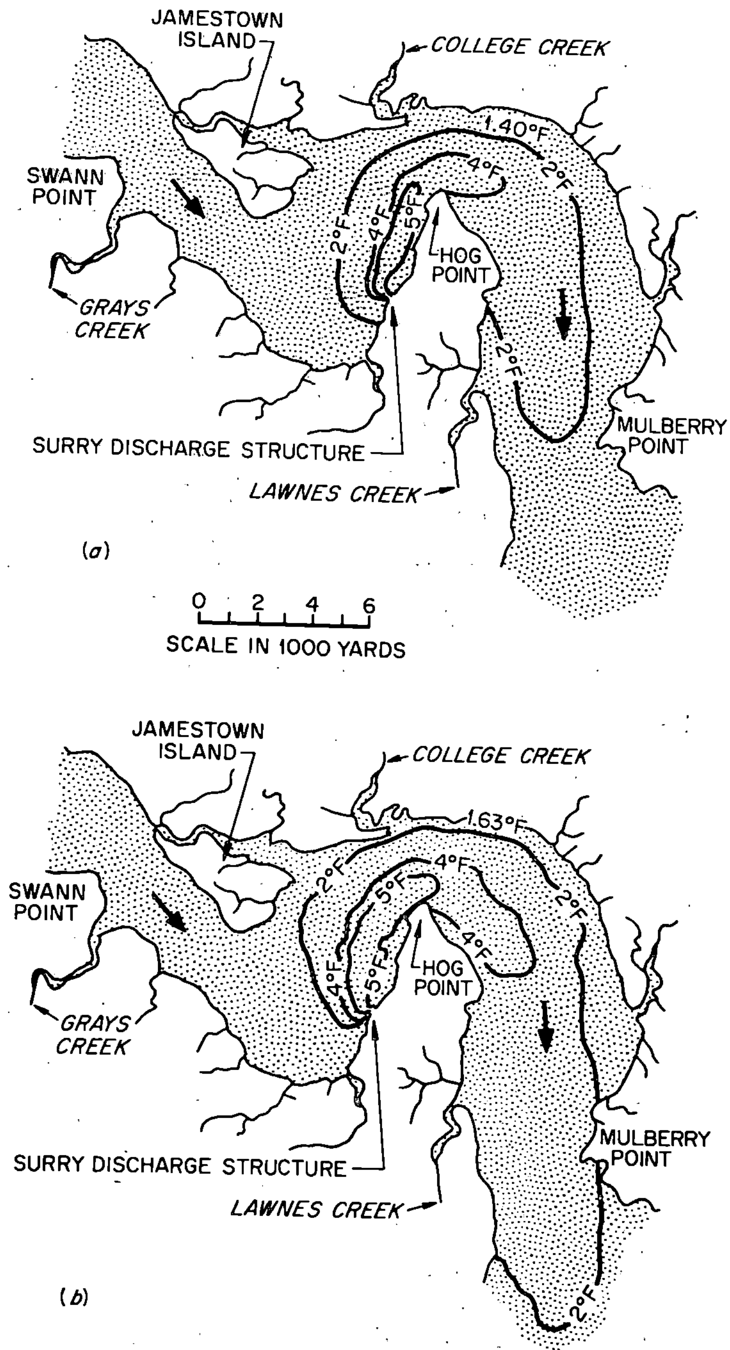


Fig. 3.14. Predicted thermal plumes for Surry Power Station during ebb tide periods for (a) summer operation, and (b) winter operation.

slack occurs, about four hours later. It will then be another six hours before this water again approaches the recirculation zone during late flood tide, by which time it will be completely indistinguishable from the tidal flows. Hence, there is no likelihood of continual temperature rise due to repeated recirculation of the same water. The net effect of the recirculated water would then be equivalent to reducing the condenser flow by about 2%, resulting in an average temperature increase across the condensers of 0.3°F.

Among the assumptions employed in the current assessments of the mode of dispersion of thermal plumes from the Surry Station is that it is valid to conclude that the predictions at river flows of 2000 and 6000 cfs indicate no more adverse conditions would occur at higher or lower flow rates. It is questionable whether some of the assumptions involved in predictions of the plume dimensions for 2000 and 6000 cfs river flows are equally valid for much higher or lower river flow rates.

Another assumption used in all of the aforementioned studies was that the entire cooling water flow will enter the estuary through the designed exit of the discharge canal. Further investigations have revealed, however, that the rock groins that enclose the discharge canal may allow for outflow of the heated discharge.[9] However, since the amount of such outflow is unknown, no determination has been made as to its effect on the existing thermal plume predictions.

2. Radioactive Wastes

In the operation of nuclear power reactors, radioactive material is produced by fission and by neutron-activation reactions of metals and material in the reactor system. Small amounts of gaseous and liquid radioactive wastes enter the waste streams from the primary and secondary systems which are monitored and processed within the plant to minimize the amounts of radioactive nuclides that are released to the atmosphere and to the James River.

The radioactive waste systems of the Surry Power Station are designed to collect and process the liquid, gaseous, and solid wastes that are byproducts of station operation and that might contain radioactive materials. The system is designed to accommodate the wastes produced during simultaneous operation of both Unit 1 and Unit 2 and is common to both units. It is sized on the assumption that both units are operating on a daily load-following cycle between 100% and 50% of power, using boric acid to adjust for reactivity changes in the core. The radioactivity that may be released during operation of both Units 1 and 2 at full power will be in accordance with AEC regulations, as set forth in 10 CFR Part 20 and 10 CFR Part 50. The limits established in 10 CFR Part 20 apply to the combined releases from Units 1 and 2.

a. Liquid Waste System

The liquid radioactive waste treatment system consists of the tanks, piping, pumps, evaporators, process equipment, and instrumentation necessary to collect, process, store, analyze, monitor, and discharge potentially radioactive wastes from the plant. Treated liquid wastes will be handled on a batch-basis as required to permit optimum control and reduce the chance for an inadvertent release of radioactive liquid. Prior to release of any treated liquid wastes, samples will be analyzed to determine the type and amount of radioactivity in a batch to assure conformance with release limits. Radiation monitors will automatically terminate liquid waste discharges if the high radiation levels are detected in the discharge line.

The liquid waste treatment system is divided into three parts: the chemical and volume control system, the boron recovery system, and the liquid waste disposal system. The interrelations of these systems and their interaction with other components of the station are shown in Fig. 3.15.

The chemical and volume control system (CVCS) is intended primarily to maintain the proper concentration of boron in the primary coolant for reactivity control and to treat and degas the primary coolant. The liquid from the primary loop will be cooled, passed through a mixed-bed demineralizer, filtered, sent to the volume control tank and returned to the primary loop. Excess liquid in the volume control tank will be sent to the boron recovery system. There is a separate CVCS system for each unit (reactor) of the station. The spent demineralizer resins and filter cartridges will be disposed of as solid radioactive waste.

The boron recovery system, which is common to both units, will process excess liquid from the chemical and volume control system to recover boric acid and purify water for reuse within the station. The liquid entering from the chemical and volume control system will be passed through a gas stripper, filtered, and sent to an evaporator. The condensate from the evaporator is accumulated and kept in storage tanks for use as makeup water for the primary loop or released through the liquid waste disposal system. The evaporator concentrates (sludge containing boric acid) may be reused or disposed of as solid radioactive waste. Our estimates of anticipated annual releases from the boron recovery system are based on the assumption that 8% of this water will be released each year after processing. Other conditions assumed include 0.25% leaking fuel, a 10^4 decontamination factor (D.F.) for the evaporator and a D.F. of 10 for the mixed bed demineralizer. Exceptions to the decontamination factors for specific isotopes have been taken; for example, a tritium D.F. of 1 is used for both evaporation and demineralization. No removal by ion exchange was considered for yttrium, molybdenum and cesium. A D.F. of 10^3 was used for the evaporation of iodines.

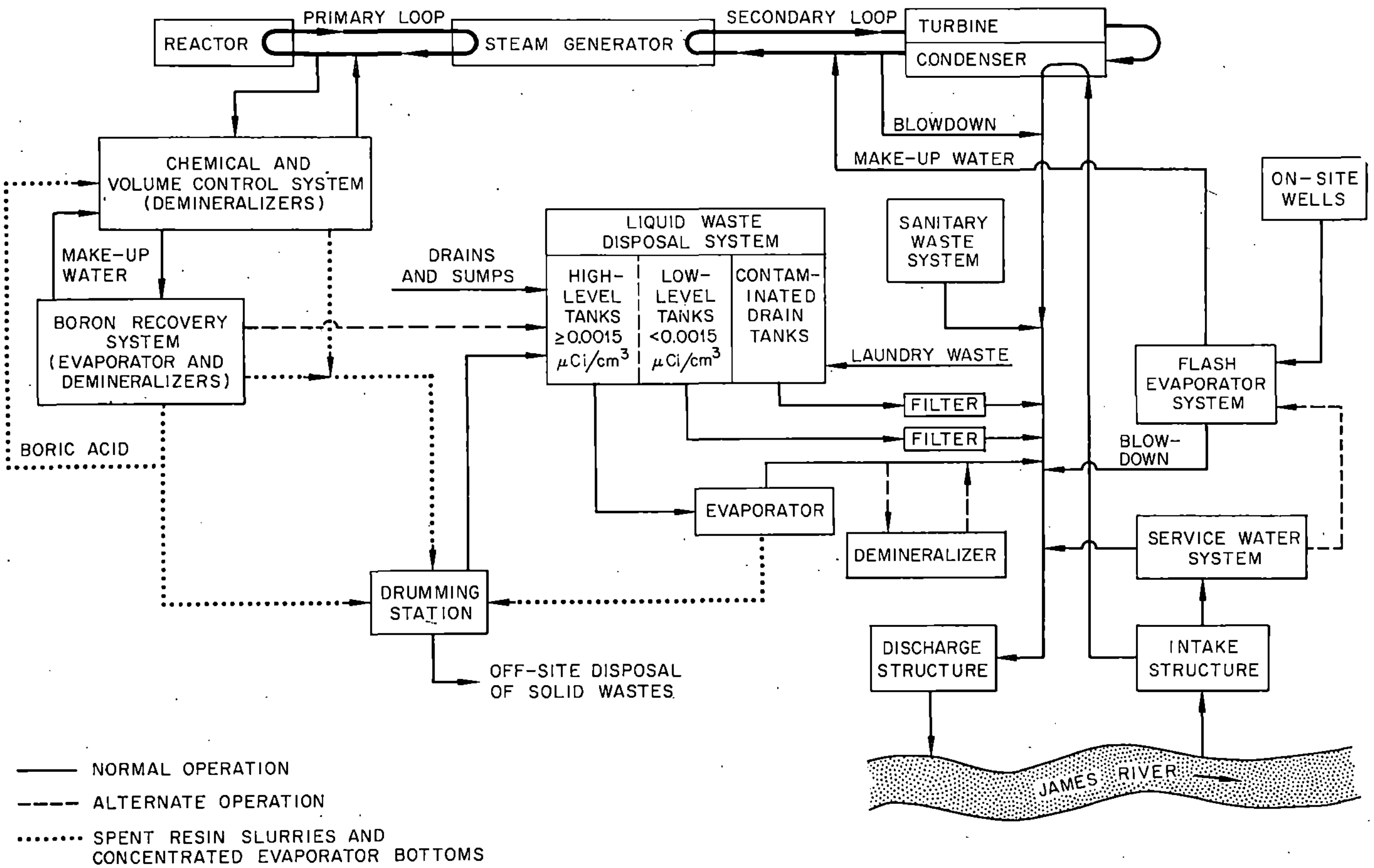


Fig. 3.15. Liquid waste disposal system, Surry Power Station.

The discharges from various equipment drains and floor sumps will be processed in the liquid waste disposal system. Liquids entering this system are accumulated in three pairs of drain tanks: the low-level drain tanks, the high-level drain tanks, and the contaminated drain tanks which receive liquid waste from the laundry and the personnel change area drains. Contents of the low-level drain tanks and the contaminated drain tanks will be filtered and discharged into the circulating water discharge canal, whereas the contents of the high-level drain tanks will be sent to an evaporator. The condensate from the evaporator is monitored and released to the discharge canal, while the concentrates from the evaporator will be disposed of as solid radioactive waste. The liquid waste disposal system is common to both units.

Our estimates of anticipated annual releases from the liquid waste disposal system are based on the assumption that the waste disposal system processes about two million gallons per year of liquid waste at an average concentration of about 6% of the primary coolant activity. The primary coolant activity is based on the assumption of 0.25% leaking fuel. The waste evaporator is considered to have a 10^4 D.F. except for iodines which have a 10^3 D.F.

Another more significant source of radioactive releases is the liquids from the steam generator blowdown will contain radioactivity if there is primary to secondary system leakage. Table 3.4 presents a summary which indicates that the blowdown from the steam generator is the source of most of the liquid radioactive discharge. These estimates are based on a 20-gallon per day primary to secondary leak rate in each unit and 0.25% leaking fuel. If the radioactivity in the blowdown reaches a concentration of 3.5×10^{-3} μCi/ml, the blowdown will be diverted to the liquid waste disposal system. The waste disposal system can only be temporary, since the normal blowdown flow (22 gpm for each reactor) cannot be processed in the liquid waste disposal system evaporator (6 gpm capacity).

b. Gaseous Waste

During power operation of the facilities, radioactive materials released to the atmosphere in gaseous effluents include low concentrations of fission product noble gases (krypton and xenon), halogens (mostly iodines), tritium contained in water vapor, and particulate material including both fission products and activated corrosion products.

The primary source of gaseous radioactive waste is from the degassing of the reactor coolant. This is principally from the exhaust of cover gases from waste holdup tanks and from chemical and volume control system equipment

Table 3.4. Estimate of liquid radioactive discharges with both Units 1 and 2 in operation.

Nuclide	Half-life	Concentration in primary coolant (μCi/cm^3)	Activity released to discharge canal (Ci/year)				Concentration in discharge canal (μCi/cm^3)	Ratio to MPC
			Steam generator blowdown	Boron recovery system	Liquid waste disposal system	Total		
^{86}Rb	18.66 days	0.000724	0.0383	0.000017	0.000028	0.0383	1.24×10^{-11}	6.2×10^{-7}
^{89}Sr	50.8 days	0.000661	0.0360	0.000016	0.000029	0.0360	1.17×10^{-11}	3.9×10^{-6}
^{90}Sr	28.9 years	0.0000214	0.00118	*g*	*g*	0.00118	3.83×10^{-13}	1.3×10^{-6}
^{90}Y	64.0 hr	0.0000104	0.000434	0.0000023	*g*	0.000436	1.41×10^{-13}	7.0×10^{-9}
^{91}Y	58.8 days	0.000785	0.0428	0.000190	0.000034	0.0430	1.40×10^{-11}	4.7×10^{-7}
^{95}Zr	65.5 days	0.000108	0.00590	0.0000026	0.0000047	0.00591	1.92×10^{-12}	3.2×10^{-8}
^{95}Nb	35.1 days	0.000105	0.00567	0.0000025	0.0000044	0.00568	1.84×10^{-12}	1.8×10^{-8}
^{97}Zr	16.8 hr	0.0000593	0.00149	*g*	*g*	0.00149	4.83×10^{-13}	2.4×10^{-8}
^{99}Mo	66.6 hr	0.458	19.46	0.100	0.00553	19.57	6.34×10^{-9}	1.6×10^{-4}
^{103}Ru	39.8 days	0.0000808	0.00438	0.0000019	0.0000034	0.00439	1.42×10^{-12}	1.8×10^{-8}
^{105}Rh	35.5 hr	0.0000420	0.00148	*g*	*g*	0.00148	4.80×10^{-13}	4.8×10^{-9}
^{106}Ru	368 days	0.0000206	0.00114	*g*	*g*	0.00114	3.70×10^{-13}	3.7×10^{-8}
^{127}Sb	3.80 days	0.00000394	0.000179	*g*	*g*	0.000179	5.80×10^{-14}	1.9×10^{-8}
^{129m}Te	34.1 days	0.00531	0.287	0.000128	0.000221	0.287	9.32×10^{-11}	4.7×10^{-6}
^{131m}Te	30 hr	0.00398	0.132	0.0000768	0.0000093	0.132	4.28×10^{-11}	1.1×10^{-6}
^{131}I	8.065 days	0.477	23.90	0.112	0.139	24.15	7.83×10^{-9}	2.6×10^{-2}
^{132}Te	78 hr	0.0470	2.07	0.00104	0.000691	2.07	6.72×10^{-10}	3.4×10^{-5}
^{132}I	2.284 hr	0.140	0.791	0.00164	*g*	0.793	2.57×10^{-10}	3.2×10^{-5}
^{133}I	20.8 hr	0.606	17.05	0.106	0.00376	17.16	5.56×10^{-9}	5.6×10^{-3}
^{134}Cs	2.06 years	0.299	16.52	0.0726	0.0138	16.61	5.38×10^{-9}	6.0×10^{-4}
^{135}I	6.7 hr	0.287	3.97	0.0248	*g*	3.99	1.30×10^{-9}	3.2×10^{-4}
^{136}Cs	13 days	0.105	5.46	0.0250	0.00366	5.49	1.78×10^{-9}	3.0×10^{-5}
^{137}Cs	30.2 years	0.239	13.22	0.0581	0.0111	13.29	4.31×10^{-9}	2.2×10^{-4}
^{140}Ba	12.8 days	0.000798	0.0414	0.0000190	0.0000277	0.0414	1.34×10^{-11}	6.7×10^{-7}
^{141}Ce	32.53 days	0.000119	0.00642	0.0000029	0.0000049	0.00643	2.08×10^{-12}	2.3×10^{-8}
^{143}Ce	33.0 hr	0.0000743	0.00256	0.0000015	*g*	0.00256	8.31×10^{-13}	2.1×10^{-8}
^{144}Ce	284.4 days	0.0000667	0.00368	0.0000016	0.0000031	0.00368	1.19×10^{-12}	1.2×10^{-7}
^{147}Nd	11.06 days	0.0000435	0.00224	0.0000010	0.0000014	0.00224	7.27×10^{-13}	1.2×10^{-8}
^{147}Pm	2.6234 years	0.00000695	0.000382	*g*	*g*	0.000382	1.24×10^{-13}	6.2×10^{-10}
^{149}Pm	53.1 hr	0.0000261	0.00105	*g*	*g*	0.00105	3.40×10^{-13}	8.5×10^{-9}
^{151}Pm	28.4 hr	0.00000779	0.000252	*g*	*g*	0.000252	8.17×10^{-14}	2.7×10^{-8}
^{153}Sm	46.8 hr	0.0000144	0.000555	*g*	*g*	0.000555	1.80×10^{-13}	2.2×10^{-9}
^{51}Cr	27.8 days	0.00093	0.0499	0.0000224	0.0000378	0.0500	1.62×10^{-11}	8.1×10^{-9}
^{54}Mn	313 days	0.00077	0.0425	0.0000187	0.0000354	0.0426	1.38×10^{-11}	1.4×10^{-7}
^{56}Mn	2.582 hr	0.029	0.183	0.0000481	*g*	0.183	5.94×10^{-11}	5.9×10^{-7}
^{58}Co	71.4 days	0.025	1.37	0.000605	0.00110	1.37	4.45×10^{-10}	4.9×10^{-6}
^{60}Co	5.258 years	0.00074	0.0409	0.0000180	0.0000343	0.0410	1.33×10^{-11}	4.4×10^{-7}
^{55}Fe	2.7 years	0.0017	0.0939	0.0000413	0.0000787	0.0940	3.05×10^{-11}	3.8×10^{-8}
^{59}Fe	45 days	0.0010	0.0543	0.0000241	0.0000428	0.0544	1.76×10^{-11}	3.5×10^{-7}
Total		2.73	104.89	0.502	0.179	105.57	3.42×10^{-8}	
^{3}H	12.6 years					2,000	6.49×10^{-7}	2.2×10^{-4}
Total								3.3×10^{-2}

[g]Less than 10^{-6}.

vents. Additional sources of gaseous waste activity include the auxiliary building exhaust, the vents from the steam generator blowdown tanks, the turbine building exhausts, the reactor building containment purging, and the main condenser air ejectors. Figure 3.16 is a schematic representation of these systems.

The gaseous waste disposal system will process the fission product gases from contaminated reactor coolant fluids resulting from the operation of both units. Gaseous wastes, primarily hydrogen, nitrogen, and small quantities of fission product gases, will be removed from the reactor coolant letdown by the gas stripper in the boron recovery system. These gases are held for decay in the gaseous waste disposal system, together with those collected by the various vents throughout the plant and from the evaporator in the liquid waste disposal system. To reduce the volume of gases which must be stored in the gas decay tanks, the system has been provided with catalytic hydrogen recombiners, the operation of which reduces the volume of gas to be handled by approximately a factor of 10.

Table 3.5, which is a summary of calculated annual radioactive gaseous releases, is based on a holdup time of 60 days for the gas processing system. Indicated in the table are the anticipated annual releases of radioactive materials in gaseous effluent for both units, based on the radwaste systems described in the applicant's Final Safety Analysis Report. Operation was assumed with 0.25% leaking fuel and a 20-gallon-per-day primary to secondary system leak rate.

Table 3.5. Calculated annual resease of radioactive nuclides in gaseous effluent from Surry Station, Units 1 and 2

0.25% failed fuel

Isotope	Annual release (Ci)			Steam generator leak (no delay)	
	Containment purge	Auxiliary Bldg.	Gas processing system (60 days delay)	Air ejector	Blowdown tank vent
^{85}Kr	36	1.6	1442	6	0
^{87}Kr	0	2.0	0	7	0
^{88}Kr	1	6.0	0	23	0
^{131m}Xe	26	2.5	50	9.4	0
^{133}Xe	2680	475	104	1818	0
^{135}Xe	1	2.0	0	8	0
^{138}Xe	0	1.5	0	5	0
^{131}I	0.04	10.4	0	0.44[b]	1.62[b]
^{133}I	0.04	–	0	0.22	0.88

[b]Limited by Technical Specifications to 0.9 Ci. $\chi/Q = 5.5 \times 10^{-6}$.

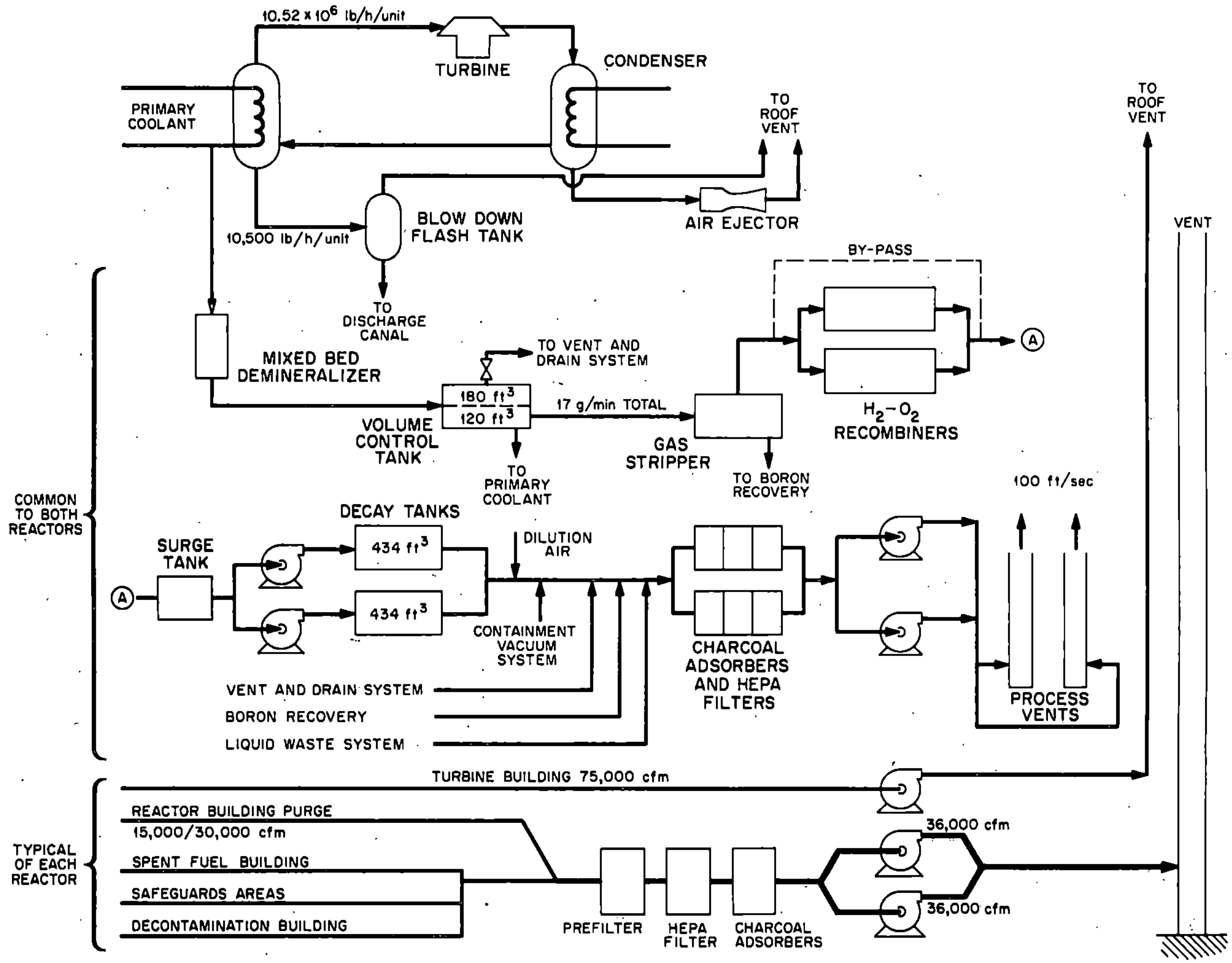


Fig. 3.16. Radioactive gaseous waste system, Surry Power Station.

The auxiliary building is maintained at a slightly negative pressure with respect to outside pressure. The exhaust air from potentially contaminated areas may be filtered through high efficiency filters and charcoal absorbers prior to being discharged through the auxiliary building vent stack. This filtering system is common to the fuel building ventilation system and the containment purge system.

Following power operation, it may be necessary to use the containment treatment system prior to purging the containment. This system draws contaminated air across a filter assembly which consists of a roughing filter, a high efficiency particulate filter, and a charcoal absorber, passes through the system fan, and is then returned to the containment. The containment purge system uses the common high efficiency particulate filters and charcoal absorbers and discharges to the atmosphere through the plant vent.

Turbine building ventilation exhaust is discharged to the atmosphere without treatment through roof-mounted exhaust fans. Off-gases from the steam generator blowdown and the condenser air ejector are vented to the atmosphere without treatment.

c. Solid Waste

Solid wastes will include concentrated 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 solid waste disposal system provides holdup, packaging, and storage facilities for solid wastes. Loaded solid waste containers will be monitored and stored in an appropriate area prior to shipment offsite for disposal. No solid wastes will be permanently stored at the Surry site. All solid waste will be packaged and shipped to a licensed burial ground (at Maxey Flats, Fleming County, Kentucky) in accordance with AEC and DOT regulations. Based on plants presently in operation, it is expected that approximately 100 to 200 drums of solid waste will be transported offsite each year.

3. Chemical and Sanitary Wastes

The chemical discharges from the station will be low, since a mechanical method will be used to clean the turbine condenser tubes and no chemical additions to the condenser cooling water will be required. In addition, the use of a once-through cooling system will provide a large volume of water for dilution of the chemical discharges.

The chemical discharges from the station with both Units 1 and 2 in operation are summarized in Table 3.6. These are the amounts and concentrations which will be added to any normal amount occurring in the cooling water.

Table 3.6. Maximum chemical discharges

	Amount (lb/year)	Concentration in discharge canal (ppm)
	Primary coolant	
B	2,700	4.0×10^{-4}
Li	2	3.0×10^{-7}
	Steam generator blowdown	
PO_4	1,100	1.6×10^{-4}
Cyclohexylamine	190	2.8×10^{-5}
Hydrazine	*a*	*a*
	Flash evaporator system	
SO_4	350,000	5.1×10^{-2} [b]
Na	1,080	1.6×10^{-4} [b]
	Sanitary waste system	
Free chlorine	20	2.9×10^{-6}
	Laundry	
Detergent[c]	400	5.9×10^{-5}

[a]Normally, hydrazine is reacted chemically and is not discharged.

[b]The values given are on an annual average basis. Discharge of polishing demineralizer regenerants occurs approximately once every 30 days. During discharge, concentrations in the discharge canal will be 0.49 ppm SO_4 and 0.34 ppm Na.

[c]A biodegradable nonphosphate detergent will be used.

Each unit (reactor) utilizes a flash evaporator to provide pure makeup water for the secondary loop. The chemical discharges from this system shown in Table 3.6 arise from the use of sulfuric acid for scale control and sodium hydroxide and sulfuric acid for regeneration of the polishing demineralizer.

Sanitary wastes from the station and the information center receive treatment provided by septic tanks. The liquid from the septic tanks passes through a subterranean sand filter to a level control tank, where it is chlorinated, sent to a holdup tank, and finally discharged into the discharge canal. The discharge into the canal is at the rate of 3250 gal/day and contains a maximum of 2 ppm residual chlorine.

During construction of the station, cleaning solutions used in cleaning the secondary loop are collected in a pit near the head of the discharge canal. The liquid in the pit will eventually evaporate and the pit will be back-filled with earth. The applicant estimates that the following amounts of chemicals will be discharged into the pit: disodium phosphate, 800 lb; trisodium phosphate, 1800 lb; nonionic detergent, 400 lb; antifoam agent, 40 lb.

The applicant states in its Environmental Report (p. 45) and Environmental Report Supplement (p. 281) that chlorine will not be used as a biocide in the condenser cooling water. However, in the "Application for Permit, Surry Power Station" (dated Sept. 11, 1967) to the Virginia State Water Control Board, the applicant makes the following statement in regard to the condenser cooling 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." On the basis of this application, the applicant was issued Certificate No. 1843 from the Virginia State Water Control Board on December 12, 1967. It would thus appear that the applicant could use intermittent chlorination as a treatment for the condenser circulating water. This chemical discharge is not included in Table 3.6.

4. Other Wastes

Nonradioactive trash such as paper, shop debris, etc., will be disposed of on site by burning.

Trash from the intake traveling screens will be buried on site.

The station has two package boilers used only for startup steam and building heating. Each boiler is rated at 80,000 lb of steam per hour and is designed to burn No. 2 commercial grade fuel oil with a maximum sulfur content of 0.75%. The applicant estimates that the discharge from each of these units will contain 0.8 lb SO_2 and 0.1 lb particulates per million Btu heat input for each hour of operation and that the opacity will be well below Ringelmann 2.

IV. ENVIRONMENTAL IMPACT OF SITE PREPARATION AND STATION CONSTRUCTION

Site preparation for the Surry Power Station began in 1967 and construction was started in 1968. Unit 1 will be ready for fuel loading by May and completion of Unit 2 is also planned before the end of 1972. The major environmental impact of these activities, therefore, have already occurred.

A. AREA INVOLVED

During construction of the Surry Station considerable modification of the landscape has occurred, especially at the northern end of Gravel Neck Peninsula and the adjacent swampy area of Hog Island. Of the 840 acres owned by the applicant, a total of 453 acres was cleared and all of the major components are within this area (see Fig. 2.2 on p.15). As construction progressed, the cleared land was subjected to further excavation for the inlet and outlet canals and foundations of the major buildings. Over 1.5 million cubic yards of earth was removed, and most of this was transferred to various sections of Hog Island to improve the barriers against salt water intrusion. The State of Virginia is still in the process of converting this earth to levees and roads.

The western bank of Gravel Neck has been modified over a stretch of approximately 200 yards by the excavation of an exit of the outlet canal and the discharge groin. Inasmuch as the profile of the outlet canal is low, and the site is isolated, the visual impact of this alteration is not great.

A new channel was dredged in the James to connect the shipping channel to the east bank of Gravel Neck to permit transporting equipment to the site by water. This access channel will continue to be used as part of the water intake system; however, additional dredging is not foreseen unless additional units are constructed at the Surry site. A pier was constructed at the approximate location of the intake system.

In addition to the land needed for the Surry Station, 3543 acres were cleared for transmission line rights-of-way, principally in Surry, Isle of Wight, and Prince George Counties. Most of the clearing operations were performed by the former owners, who achieved a financial return of nearly $50,000 on the timber that was cut.(1)

Minor modifications were made in the route of Highway 650, a state road that originally connected Bacon's Castle and Hog Island. This road was reoriented slightly so that it remains outside the exclusion area and passes about 200 feet west of the main components of the station. A new bridge had to be built over the outlet canal to permit this road to continue on to Hog Island. The road has been upgraded and is now paved with asphalt as far as the northern boundary of the Surry Site, where it then continues to the northern tip of Hog Island over a new earthen levee that has been constructed as a barrier on the western side of Hog Island.

B. MANPOWER EFFECTS

Very little social impact has been caused by the construction of the Surry Station. As of January 1, 1972, the work force was about 1450, down from a maximum of 2000. Most of these workers commute from the more populated centers to the east and southeast, and the predominantly agricultural labor force of Surry County is not involved. There have been no significant increases in demand for county services such as schools. Most of the construction crew will depart when the station is completed in 1972.

No relocation of residents from the site was needed, since no persons were living on the plant site initially. No apparent damage has been done to nearby property as a result of construction.

C. EFFECTS ON LAND USE AND WATER QUALITY

The only important impact on the use of the land involved with the Surry Station is the removal of trees from 453 acres of Gravel Neck and 3543 acres in counties south of the James River. The loss of this timber land is not considered unreasonable, however, because this section of Virginia is heavily wooded and is in no foreseeable danger of being over-harvested. Surry County contained approximately 135,687 acres of commercial forest land in 1966 and all but 1100 acres were in private holdings.[2] All species groups present were growing faster than they were being cut. The amount of commercial forest in Planning District 19, which includes the areas of Surry Power Station and its associated transmission lines, increased from 871,300 acres in 1957 to 894,000 acres in 1965.[3] In this coastal plain area, the average basal area is approximately 65.8 sq. ft/acre, of which 15.1 sq. ft/acre is composed of rough and rotten trees. This indicates that clearing for the power station and transmission line corridors has had little impact on the timber industry in this area. Most of the cleared land that makes up the transmission line corridors will be available for agricultural use.

Clearing and construction activities have caused some localized and temporary erosion and sedimentation at the Surry Site and in transmission line corridors. Eroded areas were revegetated after transmission line construction so erosion and sedimentation were controlled. Planting of the station site with native species will help to stabilize soils and prevent erosion once construction of the station is completed. A plan for landscaping the station site is described in the applicant's environmental report supplement.[1]

The earth that was transferred from excavations on the site to Hog Island was given to the State of Virginia to make extensive improvements to Hog Island Waterfowl Refuge.

During dredging activities related to the access channel there was considerable disturbance of the river environs; however, these impacts were localized to a relatively small area. Inasmuch as the water from this section of the James was not withdrawn for any use, the greatest impact fell on the aquatic life--especially benthic organisms. These insults ended soon after dredging was discontinued. The impact of this disturbance on aquatic organisms is unknown, but considering the high turbidity of the James River, the impact was probably negligible.

There has been no impact on the quality of potable water in this area. Gravel Neck represents an isolated geological entity; water from wells on the site comes from deep aquifers that were in no way affected by excavations performed on the site.

The waste pit used for disposal of cleaning solutions during construction should be filled as soon as possible. Since evaporation rates in this area are low due to the high humidity and rainfall, an alternative disposal method should be investigated, such as containing and trucking the material off site to an approved waste disposal plant.

D. AESTHETIC EFFECTS

Most of the activity involved in the preparation and construction of the Surry Station remained hidden because of the width of the James and the isolation of Gravel Neck from the remainder of Surry County. Although the excavation and transport of dirt was considerable, the low profile of both Gravel Neck and Hog Island permitted the dense forests to act as an effective screen. Consequently, other than the conversion of a remote sylvan area into a remote beehive of human activity, no aesthetic insult was incurred.

The removal of trees from the transmission line rights-of-way apparently did not cause any great alarm, probably because the corridors were cut through sparsely populated sections wherever possible. The applicant has initiated a program to seed the cleared areas for erosion control as well as aesthetic reasons.

Landscaping with native shrubs and grasses will enhance the appearance of the Surry Station site and reduce the water erosion of cleared areas. Removal of construction debris and temporary facilities after completion of construction also will enhance the appearance of the site.

V. ENVIRONMENTAL IMPACTS OF STATION OPERATION

A. IMPACT ON LAND USE

The only potential impact of Surry Station operation on land use will be due to localized icing and fogging around the discharge canal and on the bridge which spans the discharge canal. During spring and fall, when fog frequencies are greater, fogging will be increased in the localized area of the discharge canal due to the warm cooling water discharged from the Surry Station. Icing on the bridge in winter may be a problem to drivers on Highway 650. This highway provides access through the applicant's property to Hog Island and to the visitors' center which was constructed by the applicant on the north side of the discharge canal (Figure 2.2).

B. IMPACT ON WATER USE

Once-through cooling of the Surry Station should have no thermal effect on local ground water, but it will produce a thermal plume in the James River. As discussed in Section III, the plume will extend the greatest distance upstream during late flood tide and will extend the greatest distance downstream during late ebb tide. Although the plume produced during ebb tide should have no direct effect on man's use of the river, the 4°F to 5°F excess isotherms of the flood tide plume may reach the swimming areas of Cobham Bay; during the summer the waters of Cobham Bay may rise to a temperature in excess of 90°F.

The increased temperature of the estuary will tend to increase the frequency of fogging over the river. However, no determination has been made by the applicant as to the magnitude of this increase, and such a determination by the AEC regulatory staff is not presently feasible.

The effect of the Surry Station on the James River water budget will be minimal. By assuming all heat will be dissipated from the river to the atmosphere through evaporation, it was determined that the water losses would amount to approximately 50 cfs. The actual amount that will be lost due to evaporation will be less than this, however, since some heat will be lost through other methods of heat transfer, such as radiation.

The water intake structure is located at the shoreline of the James River, on the downstream side of the station. The low velocity of the water entering this structure (1 fps) should have no effect on water activities in the immediate area.

The discharge canal extends about 1100 feet into the river. The terminal discharge velocity (6 fps) was selected to provide for maximum mixing of the effluent with the river without being detrimental to the operation of small boats.[1] Although swimming in the immediate area of the discharge is not expected, a sign warning of the dangers involved would further reduce the probability.

The major impact of the discharge structure on man's use of the James River will probably be the presence of the 1100-ft rock discharge groin that extends into the river. It may prove somewhat of a hazard to pleasure boaters; however, since the river is approximately 2.7 miles wide at this point, the discharge canal could be avoided with a minimum of inconvenience. Lights on the discharge structure and warning signs in the water surrounding the canal should reduce this potential hazard to a minimum.

Since the end of the discharge canal is approximately 1.7 miles from the navigation channel of the river, no impact on commercial navigation should be realized.

C. IMPACT ON THE TERRESTRIAL ENVIRONMENT

The sources of impact on the terrestrial environment include (1) radiation effects resulting from gaseous releases of radionuclides to the atmosphere or from semi-aquatic animals (ducks, muskrat, etc.) consuming aquatic plants contaminated with radionuclides from liquid releases, and (2) potential effects on terrestrial communities resulting from both clearing and herbicide use for brush control on transmission-line corridors. (Radiation effects are discussed in Section V. E.)

A total of 3543 acres of wood land was cleared for the Surry project transmission lines, resulting in a temporary displacement of wildlife. Effects on plant life also resulted from the conversion from forest to field and thicket habitats; however, invasion of new species (grasses and forbs) and sprouting from stumps quickly establishes a transition between fields and forests.

Maintenance for the control of brush, trees, and broadleaf plants in the rights-of-way will include the use of selective herbicides listed in Table 5.1.[2] These chemicals will be applied by foliar spraying at rates recommended for brush control[3] in accordance with suggested precautions through label registration with the EPA and the USDA, as regulated by the Virginia Department of Agriculture. However, this does not preclude the possibility that there will be no adverse effects on the biota.[4]

Herbicide treatments will be performed on a three-year application cycle, supplemented by occasional cutting. Application by private contractor will be regulated in accordance with specifications for chemical control of brush on rights-of-way (Vepco Specification No. 71-1, Ref. 7).

Agricultural use of transmission line corridors should be encouraged through leases, fertilizer and seed subsidy, or other means of promoting use of these lands. This will minimize the quantity and frequency of herbicide application needed to control vegetation on these transmission-line corridors.

Table 5.1 Herbicides, application rates, and types of vegetation control to be used by Vepco on transmission rights-of-way (Ref. 2)

Herbicide	Rate	Type of control
Tordon 101 (Picloram)	2 gal of concentrate (½ lb Picloram, 2 lb acid equivalent 2,4-D) to 50 gal water, applied to 1 acre	Pines and other resistant species
Silvex	1½ gal of concentrate [6 lb acid equiv. 2-(2,4,5-trichlorophenoxy)Propionic acid] to 50 gal water, applied to 1 acre	Oaks and other intermediate species
2,4,5-T	1½ gal of concentrate (6 lb. acid equiv. 2,4,5-trichlorophenoxyacetic acid) to 50 gal water, applied to 1 acre	General broadleaf species

D. IMPACT ON AQUATIC ECOSYSTEMS

1. Sources of Impact

In general, the sources of potential impact on the aquatic environment are associated with the alternation of water quality or alteration of water flow in the James River through (1) releases of radionuclides to the river (discussed in Section V. E.), (2) releases of chemicals, (3) addition of large quantities of heat from cooling water, (4) physical effects associated with scouring, increased turbidity, and alteration of salinity and density flow patterns in the area of Hog Island, and (5) entrainment and impingement effects on biota in the James River from pumping planktonic and nektonic (free-swimming) species into the intake canal. The larger organisms are prevented by screens from entering the condensers, while smaller organisms are passed through the condensers and exposed to a thermal shock before being discharged back to the river.

a. Chemicals

Several chemicals will be used in the Surry Station and will be discharged to the James River via the cooling water discharge canal. The estimated concentrations (see Table 3.6 on page 66) of all these materials in the discharge canal are well below those for which measurable effects on aquatic organisms have been found. Additional dilution with James River water will reduce the concentration of chemicals released from the station to levels well below those known to produce toxic effects on aquatic organisms.

As described in Section III, the applicant will not use chlorine, except in the sanitary waste system. However, approval has been granted by the Virginia State Water Control Board[15] for chlorine use as a biocide if necessary in the condenser cooling system. In those cases, according to the applicant, chlorination would be limited to 0.5 ppm residual chlorine for 30 minutes each 8 hours.

Chlorine is an extremely toxic material to aquatic organisms at concentrations of less than 0.1 ppm. Merkens[6] found that, at a pH of 7.0, 0.08 pm of residual chlorine killed half of his test fish in seven days. Zillich[7] found chlorinated sewage effluent to be toxic to fathead minnows at residual chlorine concentrations of 0.04 to 0.05 ppm, and Basch[8] found that 50% of a population of rainbow trout could tolerate 0.23 ppm for only 96 hours. Arthur and Eaton[9] found that half of a population of the invertebrate, Gammarus pseudolimnaeus, survived 96 hours at a concentration of 0.22 ppm and that reproduction was reduced when chronic concentrations (for 15 weeks) were maintained at 0.0034 ppm. They also found that the highest concentration that produced no effect on the life cycle of the fathead minnow was 0.016 ppm. Sprague and Drury[10] showed an avoidance response by rainbow trout to free chlorine levels of 0.001 ppm.

In view of the extreme toxicity of chlorine at these low concentrations, the 0.5 ppm residual chlorine in the condenser cooling water is considered excessive. Under low flow conditions, dilution with James River water may not reduce residual chlorine to below toxic levels. Organisms entrained in the thermal plume may be exposed to toxic levels of chlorine for several hours. Thus, if biocide treatment of the condenser cooling system becomes necessary, chlorination levels will be reduced to below 0.5 ppm residual chlorine or an alternative biocide or cleaning method should be used. Chlorination, if it becomes necessary, will be regulated according to the technical specifications for operation of the station.

b. Dissolved Oxygen

Increasing the temperature of cooling water by 14°F, as predicted for Surry Station, will theoretically result in a decrease in dissolved oxygen concentrations in the cooling water. If oxygen levels were reduced to certain critical levels, effects on the biota in the James River would result.

Once the heated cooling water from the Surry Station has entered the James River, the oxygen demand of materials in river water will be increased as a result of the increased temperature. In waters containing a high BOD (biochemical oxygen demand), this increased demand could exceed the rate of reoxygenation from surface diffusion and photosynthetic production, thus resulting in a decrease in oxygen levels below those normally expected.

Dissolved-oxygen analyses of samples taken by Alabaster and Downing[11] showed that most unheated water was not saturated, that there was either a slight rise or little change in oxygen concentration in the heated water discharged from the condensers, and that, as a result, the effluent was supersaturated with respect to oxygen (and other gases). These authors made the further (very pertinent) observation that the changes were generally small compared with those occurring in most natural waters through plant photosynthesis and respiration and through the oxidation of organic effluents.

Adams has reported similar analyses at California power stations.[12] Measurements of dissolved oxygen at intake and outfall points showed that dissolved-oxygen concentrations were not decreased in passing through the cooling water system. Rather, the water merely became supersaturated with oxygen. As the temperature of the effluent dropped in the mixing zone, saturation values dropped correspondingly, with little loss of dissolved oxygen.

Oxygen concentrations in the area of Hog Island are generally near air-saturation levels, with a minimum of 6.2 ppm and a maximum of 12.0 ppm.[13] In addition, the BOD in this area is relatively low compared with upstream sections of the James River at Hopewell and Richmond, Virginia. The average BOD (5-day BOD at 20°C) near Hog Island was found to be 1.1 mg/liter with a maximum of 2.2 and a minimum of 0.2 mg/liter.[13]

It is likely that oxygen supersaturation will occur in water passing through the condensers and that there will be loss of oxygen in the dishcarge canal until saturation is reached. Under maximum summer temperatures of 30.5°C (87°F), oxygen saturation levels will be about 7.4 mg/l. With the 7.8°C (14°F) increase resulting from passage through the condensers of the Surry Power Station, the oxygen saturation level in water will decrease to 6.7 mg/l. Because of turbulent flow in the discharge canal and at the discharge groin, it is not likely that oxygen levels would decrease helium saturation levels. This decrease in oxygen concentration should have no effect on biota in the James River since oxygen concentrations are not considered limiting to estuarine species until levels drop to 4.0 mg/l or below. Both Virginia state[14] and federal[15] water quality standards recommend that dissolved oxygen concentrations in estuaries and tidal tributaries should not be less than 4.0 mg/l at any time or place.

c. Turbidity

Discharge of cooling water to the James River will cause some scouring in the area of the discharge canal, resulting in some localized increase in turbidity in this area. Preoperational water samples collected in the area of Hog Island showed an average turbidity of 18 ppm (Jackson Candle units) with a maximum and minimum of 20 and 15 ppm, respectively.[13] Since the James River already has a high turbidity, the effect of this localized increase on biota in the James River will be negligible. After a period of operation, the loose sediments will probably be scoured away and the turbidity readings will probably stabilize.

d. Salinity

At full operational flow of 3740 cfs and low summertime fresh water discharge, the Surry Station will cause some changes in the salt distribution of the river. The magnitude of the change and the extent of the region which may be affected are presently unknown. The most probable alteration would be destruction of the density stratification upstream from the intake point, which would cause this portion to behave like a well-mixed estuary.

The potential for significant alterations of the natural salt transport scheme in this portion of the estuary can be illustrated using data provided by the applicant. In September of 1965 during a period of fresh water discharge of about 1450 cfs, the salinity on the upstream side of the power plant was 6.9 ppt. To maintain this concentration, sufficient ocean-derived salt must move upstream to mix with the fresh water. This process requires an upstream transport of salt water from the downstream side of the power plant site at a rate of 1300 cfs. This is equivalent to 1175 lb of salt per second. By comparison, plant operation at 3740 cfs would move about 3310 lb/sec salt upstream.

Because of the importance of density stratification and density flow to estuarine species, any alteration of the natural salt transport and salinity stratification scheme in this estuary could result in a significant impact on the biota in the James River. However, until more data are available, a quantitative assessment of this potential impact cannot be made.

e. Temperature

Temperature is an important variable governing both physical and biological parameters and processes in the aquatic environment. Organisms are known to have upper and lower thermal tolerance limits, optimum growth temperatures, preferred temperatures in gradients, and restricted temperature limits for migration, spawning, and development. Temperature governs the occurrence, behavior, and metabolism of aquatic organisms and can modify the species composition of a community or ecosystem. Temperature also affects various physical parameters, including viscosity, specific gravity, and solubility of gases, thus indirectly affecting biological processes.

Generally, marine organisms are more stenothermal (able to tolerate only a narrow range of temperatures) than freshwater or estuarine species[16] Naylor[17] noted that estuarine species were more tolerant of heated effluents than marine forms and concluded that some cold-water stenothermal species may be eliminated by heated discharges while eurythermal species (able to tolerate a wide range of temperatures) may be increased.

Planktonic forms are most susceptible to temperature fluctuations resulting from power plant operations, since they are dependent upon water currents for much of their movement. Larger, motile organisms are usually able to find and remain in areas near their preferred temperature, unless trapped in shallow or enclosed areas or forced to migrate through thermally altered zones. Many organisms have restricted ranges of temperature within which they can reproduce successfully. Larval development also requires narrow ranges of temperature. For these reasons, many species may exist in excessively heated areas only by continued recruitment from the outside. In such areas, fish may be absent during warm summer months and present in cold winter months. In some locations, populations of widely heat-tolerant species may replace stenothermal species.

As described in Section III, large amounts of heat will be discharged to the James River during operation of the Surry Station. Cooling water with a 14°F Δt will be discharged to the river at a rate of 3740 cfs. The ambient temperatures may be as high as 87°F at mid-depth in the summer[13] and probably higher than this at the surface. Discharge temperatures during summer thus may exceed 100°F. Preoperational temperature data for one year and estimated discharge temperatures of cooling water are shown in Fig. 5.1. During summer periods when ambient water temperatures are above 80°F, many aquatic organisms in the James River may be living near their upper lethal temperature limits and probably above their thermal range of metabolic insensitivity. Additions of large quantities of heat to the James River at these times could result in changes in the biotic community. Such changes might not be readily apparent, especially if they involve planktonic crustaceans or algae. However, secondary effects from such changes would be are manifested only after a considerable period of operation.

State water quality standards for tidal estuaries in the coastal zone of Virginia[14] limit the temperature rise at the edge of the mixing zone of

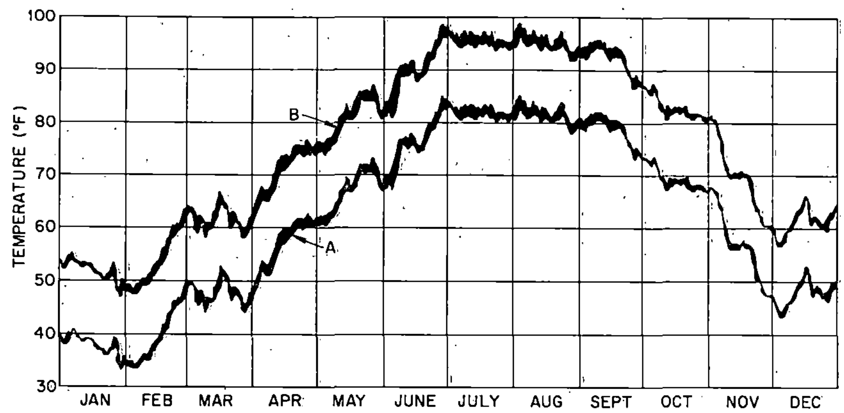


Fig. 5.1. (A) Maximum and minimum water temperatures at mid-depth in the James River in Cobham Bay during 1969 and (B) calculated discharge temperatures from the Surry Power Station, assuming a 14°F Δt across the condenser.

the thermal plume to 1.5°F during the June-August period. During the remainder of the year, the rise may not exceed 4.0°F. The mixing zone criterion is not defined but is determined on a case-by-case basis. The only restriction is that the mixing zone "shall occupy as small an area and length as possible and shall not prevent free passage of fish or cause fish mortality."(14)

Plume studies described in Section III showed that excess temperature (temperature above ambient) of 9°F (5°C) will cover an area of about 67 acres during summer conditions. Thermal plume size in winter, however, will be much larger than during the summer. During winter, the maximum closure temperature was estimated to be 1.63°F at the northern shore of the James River opposite Hog Island. The Virginia State Water Control Board has approved the thermal discharge specifications based on the physical model for Surry Power Station (Appendix I). The mixing zone criterion should not be violated since the maximum closure temperature was calculated to be 1.4°F during the June-August period.

Table 5.2 shows the relative amounts of water and the organisms therein which will be exposed to the given excess temperatures (Δt) at various net downstream flows of the James River. At low flows, nearly every organism in the area of the discharge will be exposed to an excess temperature of 5°F or greater. Since planktonic organisms may pass the discharge area several times as a result of tidal action, exposure times for these organisms will be greater than for nektonic species which can avoid exposure. As net downstream flow increases, the volume of water and organisms exposed to the given excess temperatures decreases.

Table 5.2. The ratio of the volume of water needed to dilute thermal discharges for given Δt's to the net downstream flow. Values of 1 or greater indicate that the entire net downstream flow will be exposed to the given Δt.

Net downstream flow (cfs)	Ratio			
	Δt = 14°F	Δt = 10°F	Δt = 5°F	Δt = 3°F
500	0.882	1.234	2.469	4.116
1000	0.789	1.104	2.209	3.682
1500	0.713	0.999	1.998	3.330
2000	0.651	0.912	1.824	3.040
2500	0.599	0.839	1.678	2.797
3000	0.554	0.776	1.553	2.589
3500	0.516	0.723	1.446	2.410
4000	0.483	0.676	1.352	2.254
4500	0.453	0.635	1.270	2.118
5000	0.427	0.599	1.198	1.996
5500	0.404	0.566	1.133	1.888
6000	0.383	0.537	1.075	1.791
6500	0.365	0.511	1.022	1.704
7000	0.348	0.487	0.975	1.625
7500	0.332	0.465	0.931	1.552
8000	0.318	0.445	0.891	1.486
8500	0.305	0.427	0.855	1.425
9000	0.293	0.410	0.821	1.369
9500	0.282	0.395	0.790	1.318
10000	0.272	0.381	0.762	1.270
10500	0.262	0.367	0.735	1.225
11000	0.253	0.355	0.710	1.184
11500	0.245	0.343	0.687	1.145
12000	0.237	0.332	0.665	1.108
12500	0.230	0.322	0.644	1.074
13000	0.223	0.312	0.625	1.042
13500	0.216	0.303	0.607	1.012
14000	0.210	0.295	0.590	0.983
14500	0.205	0.287	0.574	0.956
15000	0.199	0.279	0.558	0.931
15500	0.194	0.272	0.544	0.907
16000	0.189	0.265	0.530	0.884
16500	0.184	0.258	0.517	0.862
17000	0.180	0.252	0.504	0.841
17500	0.176	0.246	0.493	0.821
18000	0.172	0.240	0.481	0.802
18500	0.168	0.235	0.470	0.784
19000	0.164	0.230	0.460	0.767
19500	0.160	0.225	0.450	0.751
20000	0.157	0.220	0.441	0.735
20500	0.154	0.216	0.432	0.720
21000	0.151	0.211	0.423	0.705
21500	0.148	0.207	0.414	0.691
22000	0.145	0.203	0.406	0.678
22500	0.142	0.199	0.399	0.665
23000	0.139	0.195	0.391	0.652
23500	0.137	0.192	0.384	0.640
24000	0.134	0.188	0.377	0.629
24500	0.132	0.185	0.370	0.618
25000	0.130	0.182	0.364	0.607

The duration of exposure, as well as the excess temperature of exposure, is very important in determining possible effects on the organisms so affected. Once the thermal plume reaches the surface, the rate of mixing will rapidly decrease. The duration of exposure to the increased temperature can be roughly estimated from the configuration of the thermal plume and the flow rates of the James River. Preliminary calculations show that if an organism were entrained in the thermal plume near the discharge groin, exposure times to some excess temperatures could last for hours. For example, exposure to an excess temperature of 7°F or greater could last for over 1 hr, while exposure to an excess temperature of 2°F or greater could last for over 10 hr. In view of the high ambient river temperatures in summer, the low temperature tolerance of many of the species, and the high probability of exposure to elevated temperatures, some thermal effects are anticipated.

f. Entrainment and Impingement

Every power plant using once-through cooling entrains a portion of the planktonic biota with the cooling water which passes through the condensers and is subsequently discharged back into the environment. During this process, organisms are susceptible to thermal and mechanical injury and often to changes in the chemical composition of their surroundings. Larger organisms can become impinged on intake screens and trash racks, and injured or killed as a result of physical damage or fatigue in attempting to escape from the screens. The importance of entrainment and impingement is related to the relative quantity of organisms withdrawn, the degree to which these organisms are affected, the ecological role of these organisms, and the reproductive strategies of the species involved. The relative importance of these factors is related to the location of the power plant, the design of the cooling water system, and the ambient conditions of the body of water used for cooling.

(1) Entrainment at Surry

With both units operating at full flow, an unknown proportion of the planktonic biota in the James River near Hog Island will have passed through the condensers. The actual proportion will vary as the result of changes in the fresh water runoff. This proportion can be estimated using Equation (1) below. Estimates obtained in this manner require that the organisms be randomly distributed. In many cases, these estimates must be modified to account for the behavior of the species and the salt-induced density currents which are a part of the estuarine flow. However, Eq. (1) can be used as a first approximation of the magnitude of the entrainment problem and is applicable for many species:

$$P = \frac{F_c}{F_c + F_d}, \qquad (1)$$

where

P = fraction of plankton which has passed through the condensers,

F_c = flow through the condenser, in cfs,

F_d = dilution flow, in cfs.

During periods when saline water is not present at the intake, the dilution flow will be equivalent to the fresh water discharge of the James River above Hog Island. However, during periods of salt water intrusion, the dilution flow will include ocean-derived water. If the salinity is known, a conservative estimate of the dilution flow can be made using Eq. (2) at times when upstream and downstream salt transport are equal:

$$F_d = F + \frac{F(S)}{S_m - S}, \qquad (2)$$

where

F = fresh water flow, in cfs,

S = salinity, in parts per thousand,

S_m = salinity at the mouth of the estuary (30 parts per thousand).

This equation was applied to salinity and flow data collected from the Patuxent Estuary at the Chalk Point Plant. The average salinity near the plant intake was about 11.5 ppt, while the average salinity downstream approached 16 ppt.[85] Cronin[86] indicated that the 1114 cfs condenser flow at this plant was about 50% greater than the average freshwater runoff above the plant, which would therefore be about 750 cfs. Using this information in equation (2),

$$F_d = 750 \text{ cfs} + \frac{(750)(11.5)}{(16 - 11.5)} = 3214 \text{ cfs}$$

Pritchard[87] has estimated the dilution flow (F_d) at this plant using three techniques. By using the observed salinity distribution he computed the dilution flow at the plant site to be about 3160 cfs. By observing the concentration of a dye released at a constant rate over a period of nine days, the dilution flow was estimated to be 4160 cfs. Computations using temperature data provided an additional estimate of 3180 cfs. Pritchard also concluded that the dye study overestimated the dilution flow.[87] Thus, the dilution flow calculated by equation (2) agrees well with the dilution flow determined by other techniques.

Because of the intake-discharge arrangement at Surry, the dilution flow will often be less near the discharge than it is near the intake. For this reason, the fraction of water which has passed through the condensers will be greater on the upstream side of Gravel Neck than on the downstream side. The probability that a particular organism (e.g., a larval fish passively migrating downstream) will pass through the condenser will be equal to the fraction of water which has passed through the condensers on the downstream side of Hog Point. Using Eq.(1), these values were computed for various dilution flows (Table 5.3). Without accurate, comprehensive flow and salinity measurements, the precise relationship between dilution flow and fresh water discharge cannot be ascertained. However, it is apparent from the relatively frequent low level of fresh water discharge that the dilution flows may often be quite low and that, at minimum summer fresh water discharge and a full 3740-cfs flow through the station, over 50% of the plankton between the discharge and the intake will have passed through the plant.

Table 5.3. Probability of entrainment for plankton near the intake of the Surry Station

Dilution flow (cfs)	Probability of entrainment		Dilution flow (cfs)	Probability of entrainment	
	Two units operating	One unit operating		Two units operating	One unit operating
500	0.882	0.789	13,000	0.223	0.125
1,000	0.789	0.651	13,500	0.216	0.121
1,500	0.713	0.554	14,000	0.210	0.117
2,000	0.651	0.483	14,500	0.205	0.114
2,500	0.599	0.427	15,000	0.199	0.110
3,000	0.554	0.383	15,500	0.194	0.107
3,500	0.516	0.348	16,000	0.189	0.104
4,000	0.483	0.318	16,500	0.184	0.101
4,500	0.453	0.293	17,000	0.180	0.099
5,000	0.427	0.272	17,500	0.176	0.096
5,500	0.404	0.253	18,000	0.172	0.094
6,000	0.383	0.237	18,500	0.168	0.091
6,500	0.365	0.223	19,000	0.164	0.089
7,000	0.348	0.210	19,500	0.160	0.087
7,500	0.332	0.199	20,000	0.157	0.085
8,000	0.318	0.189	20,500	0.154	0.083
8,500	0.305	0.180	21,000	0.151	0.081
9,000	0.293	0.172	21,500	0.148	0.080
9,500	0.282	0.164	22,000	0.145	0.078
10,000	0.272	0.157	22,500	0.142	0.076
10,500	0.262	0.151	23,000	0.139	0.075
11,000	0.253	0.145	23,500	0.137	0.073
11,500	0.245	0.139	24,000	0.134	0.072
12,000	0.237	0.134	24,500	0.132	0.070
12,500	0.230	0.130	25,000	0.130	0.069

The level of entrainment which is anticipated as the result of station operation is sufficient to warrant further consideration. Some mortality of entrained organisms may result from mechanical damage, thermal shock, and osmotic stresses resulting from rapid salinity changes as the plume mixes with less saline water upstream. In addition, sublethal effects of condenser passage may reduce the growth rate or reproductive potential of entrained organisms.

For the situation which will exist at Surry, the effects will be determined by the accumulation of exposure to temperatures above the limit (i.e., a dose response of time and temperature). The temperature dose which organisms receive can be determined by integrating thermal exposure through time. Thus, in order to predict the thermal dose which an organism receives, it is necessary to know both the magnitude of the temperature increase and the duration of exposure at each level above the critical limit. This information can be derived from the temperature of the cooling water plotted against time (i.e., a time-temperature profile).

The time-temperature, profile of the condenser cooling water at Surry is presented in Fig. 5.2. Exposure durations are for both units operating with a 14°F temperature increase in the condensers and a full 3740-cfs flow. At this flow rate the cooling water will remain in the canal about 30 minutes, during which the temperature will remain about 14°F above ambient. The 30-min retention time within the canal may vary 20% or more, depending upon the stage of the tide. However, with one unit operating and 1870-cfs flow, the retention time may be doubled.

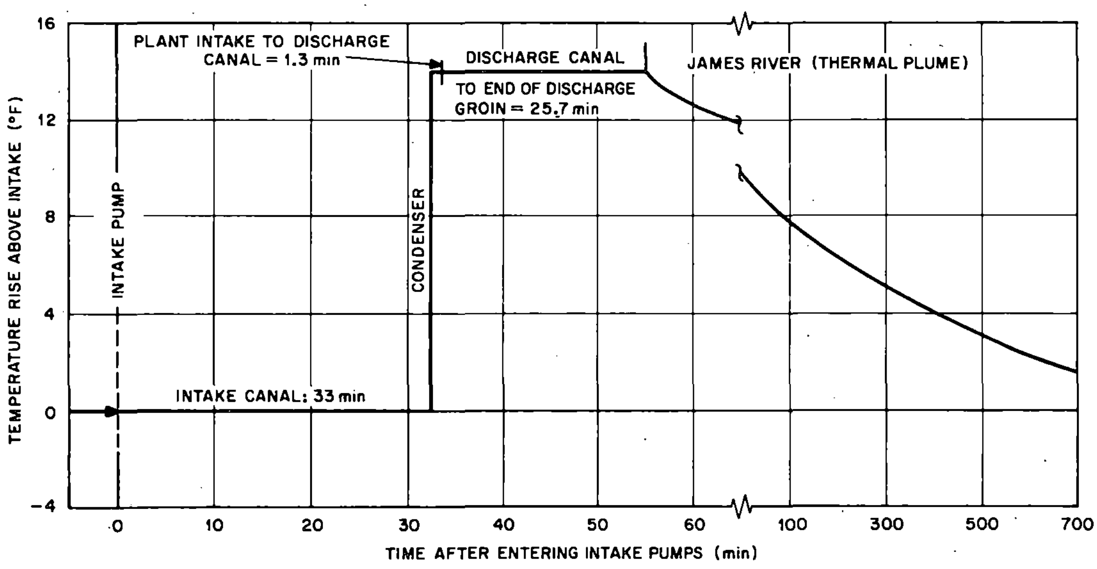


Fig. 5.2. Time-course (left to right) of temperature change in cooling water at the Surry Power Station (estimated from references cited in the text).

Once the water is discharged into the James River, the temperature begins to fall more rapidly as a result of mixing with the cooler water in the river. The length of time spent at levels in excess of various temperatures was calculated from the surface temperature isotherms predicted by the physical model (See Section III). All heat loss was assumed to be the result of mixing and the average depths of the 9°F, 7.2°F, 5.4°F, 3.6°F, and 1.8°F isotherms were 4 ft, 5 ft, 6 ft, 7 ft, and 7 ft respectively. These assumptions provide only a first approximation and probably underestimate the duration of exposure at lower levels above ambient.

As mentioned in Section III, mixing of the plume may be different from that predicted if water flows through openings if water flows through openings in the rock groin instead of through the opening at the end of the groin (See Fig. 2.2). If a significant fraction of the cooling water excaped through the side of the groin, mixing would be decreased and the time-temperature curve would be different from that shown in Fig. 5.2. The net result would be an increase in the thermal dose to entrained organisms since retention time in the canal and exposure to various excess temperatures in the plume would be greater because of the reduced exit velocity and reduced mixing with water in the James River.

The entrainment problem may be further compounded by alterations of the non-tidal density flow. Destruction of the density flow between the discharge and the intake would increase greatly the proportion of larval organisms which may be entrained as they migrate upstream in the deeper water.

(2) Impingement

A major problem encountered during the operation of some power plants has been that of fish mortality resulting from impingement on the fine-mesh screens used to filter out debris that could cause damage to the circulating water system. The problem has occurred at the Indian Point plant on the Hudson River, where fish have been killed on the intake screens.[18,19]

The most important contributing factor is the capturing capacity of the large volume of water withdrawn from the river at high velocities. The only action that really seems to reduce the level of mortality is a reduction in the intake velocity. With intake velocities less than about 1 fps, the rate that fish were killed on the intake screen was significantly lower than with the intake velocities in excess of that amount (Fig. 5.3). Intake velocities through the trash racks at the Surry Power Station will be slightly greater than 1 fps.

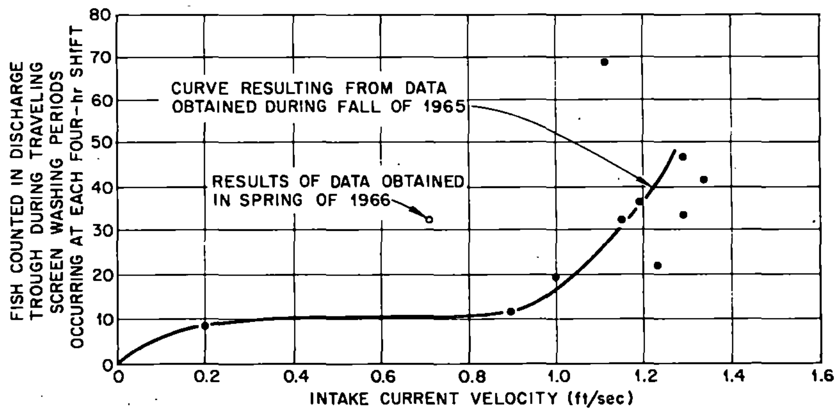


Fig. 5.3 Fish count per screen vs average current velocity (ref. 18).

The cooling water system of the Surry Power Station will almost certainly withdraw fish with the cooling water. With no screening to keep fish away from the intake openings of the pumps, fish will move through the trash racks and will be pumped into the canal. Since there is no exit from the canal except through the condensers, fish will be effectively removed from the estuary. In all likelihood, the fish so withdrawn would be killed initially by the pump or later by impingement on the traveling screens at the condenser intake. During test operations of the circulating water system, fish were collected on the intake screens, and additional fish were collected later by seining the intake canal.

Installation of traveling screens at the intake structure on the river might reduce the number of large fish killed, but it is likely that small fish would still be killed. Tests are presently under way to determine the effectiveness of air bubble curtains to scare fish away from the intake. If an air bubble screen is not effective, a possible alternative is a by-pass canal from the intake canal back to the James River. This alternative is under consideration by the applicant.

2. Effects on the Aquatic Biota

A comprehensive quantitative assessment of the biological impacts of plant operation on aquatic organisms and populations in the James River is difficult because of the nature of station design and operation, the complex tidal flow in the estuary, the diverse biota of an estuarine environment with species having complex and varied life histories, and the lack of quantitative data on biota in the James River. However, an attempt has been made to assess the potential biological impact of plant operation on those species and groups of organisms that were considered to be most vulnerable to the important sources of impact.

a. Operational Effects on Decomposers

The increase in temperature in the James River due to discharge of heat by the Surry Station would be expected to favor increased bacterial growth[20] during most of the year only if the carrying capacity of the food supply was greater than the standing crop of the bacteria. The low BOD levels in this area of the James River indicate that the carrying capacity of the bacterial food supply would become limiting before bacterial standing crops increase significantly. However, if, in addition to the increased temperature, there is an associated increase in available organic material (e.g., fish or other organisms killed by plant operation), standing crops of bacteria might increase. Bacterial counts in the influent and effluent water of a power plant on the Patuxent River estuary when there was a rapid heat change (but no chlorination) were found to remain constant.[21]

Entrainment and passage through the condensers are not expected to seriously affect decomposer populations. Data on bacterial populations in estuarine environments are inadequate to assess the long-term effects of plant operation on this component; but, based on operating experience of plants in similar estuaries, no serious effects are likely to occur from normal operation.

b. Operational Effects on Primary Producers

Temperature is recognized as one of the principal controlling factors of growth and composition of algal communities. Each species in nature has its own range of temperature tolerance and its range of optimum growth, photosynthesis, and reproduction.[22] In general, the diatoms are represented by the largest number of species with relatively low temperature tolerances, namely, to temperatures below 86°F. The tolerances of the green algae cover a wide temperature span. The blue-green algae include more species that are tolerant of very high temperatures. There are some species in all groups, however, that tolerate an unusual extreme for their group. Under normal seasonal conditions, there is a succession of species on the same substrate. This succession is largely the result of changes in water temperature and light intensity through the optima for the various species. As the temperature increases or decreases, one species replaces another as the dominant organism. There are also many other pressures upon a species, including interspecies competition and grazing. Figure 5.4 indicates the most commonly observed type of population shift. The population shift exhibited in this figure has been generally accepted, although, as Coutant[22] pointed out, it is a generalized pattern, which is not always followed by algal populations in the field.

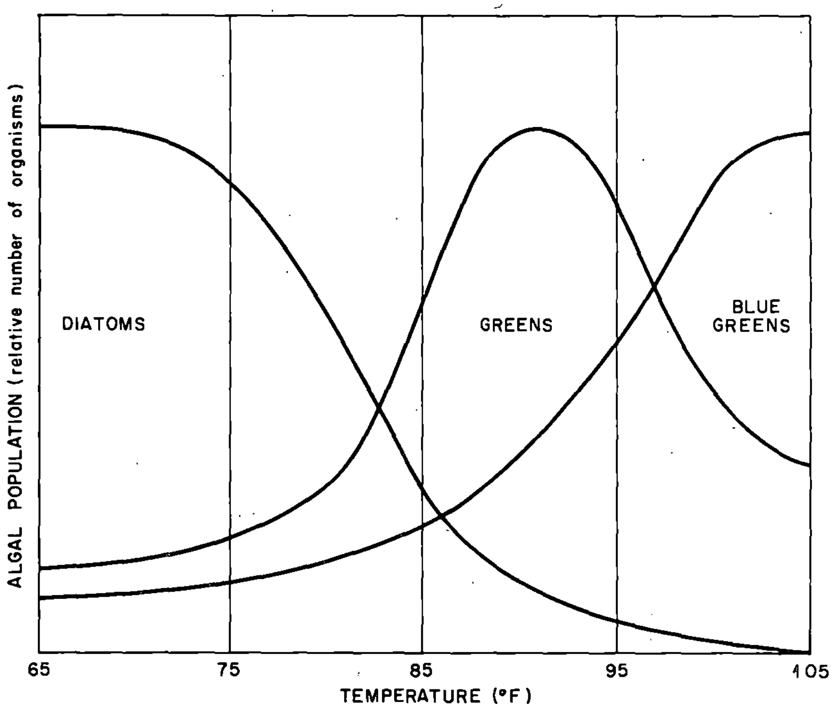


Fig. 5.4 Population changes among algal groups with change in temperature (adapted from ref. 25).

Reports of field studies of the biota associated with discharge canals of power plants, where the water temperature is still essentially as high as it was when it left the condensers, have noted dominance of the periphyton community by heat-tolerant blue-green algae when water temperatures exceed about 86°F. Reports by Trembley[23] indicate that the periphyton grown on glass slides was dominated more completely by blue-green algal species in the discharge canal of the Martin's Creek Power Plant on the Delaware River when the temperature exceeded 94.1°F. There were fewer species on the slides than when the water was cooler, but those remaining were represented by a larger number of individuals. This condition is generally recognized as an indication of an abnormal community structure. It is difficult to determine, however, how much of the alteration of community structure was due to chlorination of the cooling water.[22]

Foerster[35] discussed the apparent early arrival of spring seasonal successions in periphyton of the discharge canal of the Yankee Atomic Power Plant on the Connecticut River. Buck[(24)] reported a noticeable shift from diatoms to blue-green algae in plankton in the area of thermal effluent. These planktonic forms were presumably derived from the peri-phyton populations of the mile-long canal, although a detailed report of this study has not yet been published. Similar changes in the species composition of plankton in cooling water were reported by Beer and Pipes,[(26)] who described a shift from diatom dominance in the inlet to dominance by unicellular green algae in the effluent canal of the Dresden Station on the Illinois River.

In a September survey, Oscillatoria (a blue-green filamentous alga) covered all bottom materials in shallow water of the discharge canal and the river bed close to the confluence of the discharge from the John Seview Steam Plant (Tennessee Valley Authority) with the Holston River, in Tennessee.[(22)] No large-scale replacement of cold-water marine algae by warm-water-tolerant forms was found by North[(27)] at the Morro Bay discharge canal, however. The entire algal flora was simply depleted at the warmer temperature. In the area of the thermal discharge at the Chalk Point Power Plant on the Patuxent estuary, the diversity of green algae and diatoms was changed to one composed chiefly of Chlorella.[(88)]

The lethal temperature of the algae varies with the species. For most of the algal species studied to date, the lethal temperature is in the range from 91.5°F to 113°F, with the majority being near 111°F. Diatoms that require cooler temperatures (stenotherms) are generally most sensitive to temperature change and can withstand only an 18°F temperature change. Diatoms suited to warmer temperatures can tolerate temperature changes of from 27°F to 36°F. These temperature changes are far greater than the 14°F Δt at the Surry Power Station. The more important question, however, is the duration of exposure to the excess temperatures in the discharge canal and the James River.

The low incidence of observed effect of waste heat discharge on phytoplankton populations appears to be due to a number of factors, perhaps the most important being exposure time. In most situations, phytoplankters in the area of thermal discharge from power stations experienced temperature elevations as high as 5.4°F (3°C) above ambient for no more than 1/2 hr, a relatively short time compared with the 8 or more hours required for algal cells to divide.

Nearly all phytoplankton passing the discharge area of the Surry Station will be exposed to some excess temperature during the year. During low flow conditions, the entire net downstream flow and the planktonic organisms therein will be entrained in the thermal plume (Table 5.3). For organisms entrained in the plume near the discharge groin, exposure times may last for hours. Preliminary estimates of exposure to elevated temperatures indicate that some changes in species composition could occur during the summer period, when ambient water temperatures are maximum. It is likely, however, that dominance of some diatoms will decrease and green and blue-green algae will increase in abundance in some areas covered by the thermal plume during the summer period, as at the Chalk Point plant on the Patuxent estuary.

Attached algal growths on the walls of discharge canals, rubble, and other fixed substrates near the mouths of the discharge groin are most apt to experience shifts in dominance, because they will be almost continually exposed to the temperature elevation of 14°F (7.8°C). At the Surry Station, the surface area so affected is very small, and any algal cells which break off and enter the James River plankton would represent an extremely small fraction of the total algal productivity in the system.

Death of algal cells is not easily recognized, and recent studies have measured photosynthesis, or the formation of new organic matter, to determine thermal effects. A number of investigators have found that photosynthesis rate is affected by temperature.[28] In temperate climates, photosynthesis by the entire phytoplankton community is inhibited, since water temperatures frequently are less than optimal for photosynthesis during most of the year. During late summer, ambient temperatures may approach or exceed the optimum. An optimum temperature for photosynthesis of about 86.9°F (30.5°C) has been reported by investigators who have been careful to distinguish between thermal and chlorination effects at power plants.[29]

Production rates (Fig. 5.5) and standing crops (Fig. 2.9) of phytoplankton are low in the James River in the area of Hog Island, probably because of the high turbidity, which limits light penetration. With a shallow photic zone, photosynthesis is confined to a shallow surface layer, while respiration occurs at all depths. Increased respiration resulting from increased temperature could then result in a decrease in net production of phytoplankton unless there was a corresponding increase in primary production rate. During winter months, when temperatures are below the optimum for photosynthesis, primary production rate may increase. During the summer, however, temperatures may exceed the photosynthetic optimum and primary production would decrease, particularly in the area covered by the thermal plume where temperatures may exceed 100°F.

The effects of entrainment on algal populations during the operation of other power plants have been determined by examining the ability of the algae to produce organic matter. Using this method in studies on the York River, in Virginia, Warinner and Brehmer[30] showed that the responses of phytoplankton to entrainment depended on the ambient stream temperature as well as on the change of temperature imposed by the condensers. At winter temperatures (32 to 50°F), elevated temperatures increased production. During the summer (temperatures 59 to 70°F), slight additional temperature increases increased production, but larger increases (greater than 10°F) depressed it. The greater the temperature rise in summer, the greater was the depression of the affected plankton's ability to photosynthesize.

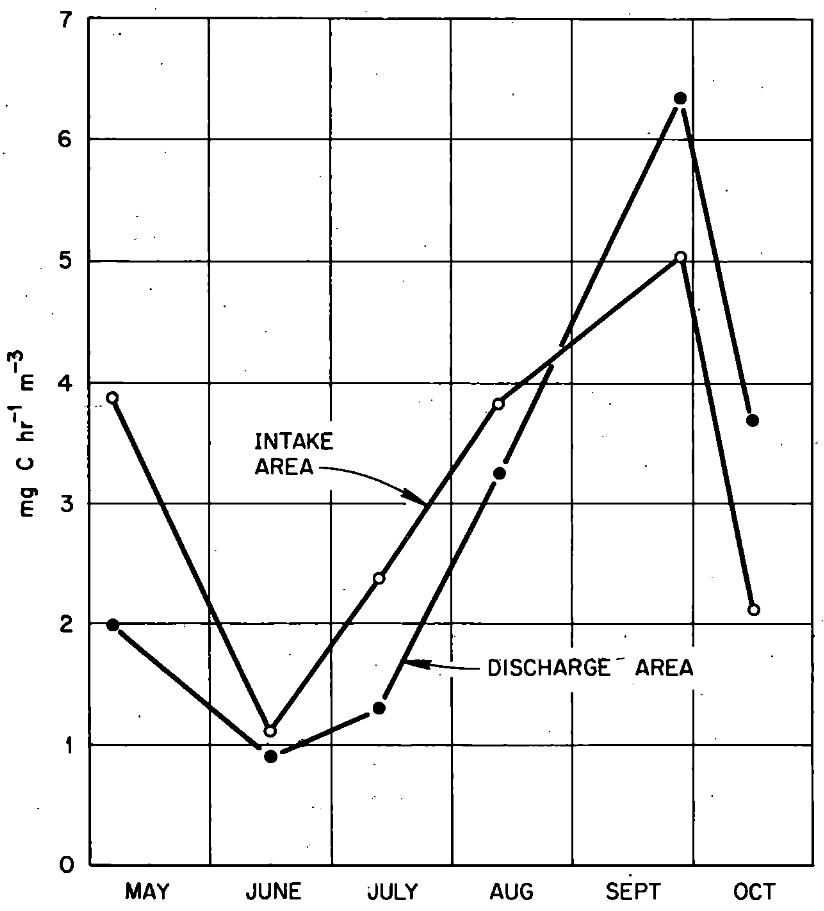


Fig. 5.5. Production rates of phytoplankton in the James River near the intake and discharge areas of the Surry Power Station (ref. 31).

Similar results were shown by Morgan and Stross[32] for the Chalk Point Plant on the Patuxent estuary off Chesapeake Bay; temperature rises of about 14.5°F stimulated photosynthesis when ambient water temperatures were 60°F or cooler and inhibited photosynthesis when temperatures were 68°F or warmer. Passage through the condensers at times, however, contributed additional damage (perhaps mechanical or chemical) that nullified stimulation by temperature rise at cool temperatures and increased inhibition at warmer ambient levels. Phytoplankton returned to the cool temperatures of the mixed estuary at the end of the discharge canal did not recover their photosynthetic ability. In relating the observed changes in productivity to the entire estuary, the authors noted that real reductions in productivity might occur only if the rate of photosynthesis is not nutrient limited. They concluded that since Stottlemeyer[33] found that nutrient limitation was only a sporadic occurrence, reduction in photosynthesis by another factor (the power plant) must, therefore, reduce the amount of material available for passage through the food chain.

In contrast, another study showed rates of photosynthesis that were similar for power plant intake and effluent water when incubated at the prevailing temperature for each source, although some differences were significant.[21] Algae in heated water had a higher rate of photo-synthesis than algae incubated at ambient temperatures. The highest rates of photosynthesis occurred at temperatures between 80.6° and 91.4°F. The highest rate observed was for effluent water incubated at 86.9°F. No consistent reduction of photosynthesis was observed in the vicinity of the discharge canal during field studies.

These studies reveal the uncertainty surrounding predictions related to the effects of entrainment on planktonic algal populations. Because of the large proportion of the phytoplankton which will be exposed to elevated temperatures during condenser passage, the composition of the phytoplankton community around Gravel Neck may change toward more heat-tolerant forms. Such impacts should be indicated by the monitoring program described in section V.F. and established in technical specifications in the operating licenses.

c. Operational Effects on Consumers

There is a diverse consumer fauna in this area of the James River, consisting of epibenthic and attached benthic organisms, planktonic and nektonic species such as zooplankton, egg and larval stages of species which are planktonic (meroplankton), zooplankton (primarily crustaceans), and resident as well as transient fish species. To assess the potential impact of plant operation on consumer organisms from thermal discharges, entrainment in cooling water, impingement on intake screens, and other physical factors, the following three major categories of consumers were considered, based on their distribution and life history patterns: (1) zooplankton, (2) benthos, and (3) fish.

A critical factor in evaluating the affects of plant operation is knowing the response of consumer organisms to alteration of environmental variables such as temperature and salinity. The physiology of the aquatic fauna, for example, is directly affected by temperature. Changes in the temperature may cause increases in metabolism, changes in food conversion abilities, changes in reproductive capacity, changes in behavior, or even thermalldeath. Fry et al. described the thermal responses of fish and divided the total range of temperature experience of an organism into several zones.[34] They discerned an upper and a lower zone of thermal resistance and a central zone of thermal tolerance, bounded respectively above and below by an upper and a lower lethal temperature. The lethal temperature is defined as that temperature which, when a fish is brought rapidly to it from a different temperature, will kill a stated fraction of the population (generally 50%) within an indefinitely prolonged exposure. In the zones of thermal resistance an organism can survive for a definite period of time that becomes longer as the temperature approaches the lethal temperature.

Previous thermal history profoundly affects the lethal temperature, this history being referred to as acclimation temperature. In general, a history of cold temperatures results in a low lethal temperature, while a history of warm temperatures produces an elevated lethal temperature.

There is accumulating evidence that many cold-blooded (poikilothermic) species are capable of considerable adjustment of their metabolic activities to a wide range of temperatures. This adjustment to warmer temperatures is evidenced by increased upper and lower lethal temperatures. The range of adjustment may be considerable, as, for example, in the goldfish, which has an upper lethal temperature that varies from approximately 78.8°F to 104°F. This hardy species may be one of the extreme cases in this respect.[22]

Elevation of lethal temperature is not directly proportional to elevation of acclimation temperature, but rather some fraction of it. The result is that the acclimation temperature and the upper lethal temperature tend to converge upon the ultimate upper lethal temperature, at which both the acclimation and the lethal temperature are the same.[22] The time necessary for thermal acclimation varies among species.[22] Adjustment to higher temperatures is generally fairly rapid; data of Alabaster and Downing[11] indicate an elevation of about 1.8°F per day for the roach; Sprague[35] found that acclimation temperatures could be raised 4.5°F to 9°F per day for several crustaceans. Once acquired, tolerance to high temperatures may persist for considerable periods after return of the fish to a lower temperature.[22] Heat exposure during acclimation need not be continuous. An intermittent exposure to a different temperature for sufficient hours per day can produce the same acclimation temperature as a continuous exposure.[22] According to several authors,[22] acclimation to low temperature usually tends to shift the lower thermal limits downward, and acclimation to high temperatures tends to shift the lower limits upward. Since inter-mittent brief exposure to high temperatures can result in markedly increased resistance to heat which is not readily lost during subsequent exposure to low temperatures, possible increased susceptibility to reduced temperatures may result in areas where organisms regularly encounter thermal plumes.

By testing species in the laboratory, Brett[36] noted that a slow rate of decrease in environmental temperature is of greater importance for maintaining life than a slow rate of increase. Thus, lethal cold can be more important than lethal heat as a factor affecting survival of some species exposed to thermal plumes. Deaths resulting from the inability of fish to rapidly acclimate to lowering temperatures have been reported by several authors.[37,38]

Upon exposure to altered temperatures, the duration of the exposure, the size of the fish, and its thermal history are extremely important in determining its survival. Eggs and larvae are extremely exacting in their temperature requirements, while subjuveniles and juveniles appear to be more eurythermal, and adults tend to be broadly stenothermal.[39]

Based upon the few data on upper lethal temperatures reported in the literature, larvae of temperate marine fishes have lower upper lethal limits than the adults have.[16,39] The experimentally derived median upper temperature for temperate species is 78.8°F for larvae and 86°F for the adults.[50] Although the upper limits for larvae and adults differ, the absolute ranges of temperatures tolerated are approximately identical.[39]

The eggs of some species may be especially sensitive to fluctuations of temperature. For instance, one of the most important effects noted in the study on eggs of the American smelt (Osmerus mordax) in Maine was the large increases in mortality during fluctuations in daily water temperature of as much as 12.6°F as observed by Rothschild.[40] In contrast, striped bass eggs (Morone saxatilis) were found to survive in water whose temperature varied from 55° to 75°F daily.[41]

In predicting responses to increased temperature, it is important to note that a temperature need not kill the organisms directly to produce profound effects on a population. For instance, brook trout were found to be comparatively slow in catching minnows at 63°F and virtually incapable of catching them at 69.8°F. This caused the trout to virtually starve to death.[22] Many other types of sublethal effects on populations are known to occur.

Rates of metabolism and activity of organisms increase with increasing temperatures over most of the tolerated temperature range and then often drop suddenly near the upper lethal temperature. Such rates vary with different species, processes, and levels or ranges of temperature and may be modified by salinity and oxygen factors. It is often considered that the effects of elevated temperatures on a bio-logical system increase the rate of biochemical reactions within the system by 100% to 600% for each 18°F increase,[42] although this rate does not necessarily hold for extreme temperatures. By applying this concept, it is apparent that even a slight temperature increase may have far-reaching effects, because a number of metabolic functions will be accelerated with a temperature increase even though the organism may not be killed outright. Fortunately, as Coutant[22] pointed out, the actual metabolic increases upon exposure to elevated temperatures are often less than would be anticipated from strictly thermodynamic considerations, where metabolic rate would typically vary directly with temperature. If their oxidative processes are independent of temperature (thermally insensitive), then the rate of oxygen utilization would be relatively constant over a wide temperature range. Studies involving many species of invertebrates indicate that over certain parts of a temperature range in which they can be held for prolonged periods, animals tend to be metabolically independent. This kind of response is intermediate between the two extremes. In general, this thermal range of metabolic insensitivity coincides with the temperature regime of the animal's habitat. For such species, slight changes in their thermal environment would have little effect as long as such changes remained within the zone of metabolic insensitivity. However, changes which exceeded this zone could have a pronounced effect.

The temperature requirements for reproduction in many species are confined to narrower ranges than for other physiological functions.[39,42] Most aquatic animals have restricted temperatures for breeding. Photo-period effects and rising temperatures in the spring induce development of the gonads, and actual spawning takes place when a certain temperature level is reached. This value varies for different species, and in some species the whole process may be reversed.[16]

A temperature stimulus of some kind is often required for inducing sexual activity in aquatic animals. This threshold is often quite critical and may occur with a temperature rise of only 1 or 2°C.[36] Brandhorst[38] believed that spawning activity in herring was induced by the suddenness of the temperature change rather than by the magnitude of the change <u>per se</u>. Generally, low temperatures during pre-spawning periods delay spawning, and higher temperatures hasten it.[36,39]

Fish attracted to discharge canals and in residence there for several months may be induced by higher temperatures to spawn earlier than might otherwise be expected.[22] Premature spawning can be speculated to have many repercussions in the receiving water, ranging from loss of progeny due to lack of proper food to species changes brought about by the overly dominant large warm-water fry. The problem is not unique to discharge canals but occurs in cooling ponds and mixed water bodies wherever the water temperature is elevated.[22]

Few of the theoretically predicted changes in reproductive schedules have been studied at power plants, and observations are generally limited to evidence that premature spawning can and does occur. For instance, white suckers (Catostomus commersonni) spawned prematurely in the discharge canal of the Martin's Creed Power Plant on the Delaware River.[43] Spawning activities were observed earlier there than elsewhere (times not given). Young-of-the-year were active in the spring in the canal and apparently left the warmer water as the temperature rose in summer. Very small fry of several other species (rearing determined them to be principally minnow species) were found in the canal prior to normal spawning times. They probably were spawned in the canal instead of having passed through the condensers, although it was not certain.[22]

The attraction of fish to warm areas associated with thermal discharges may cause additional problems. For instance, fish attracted to warm discharge canals of power plants, and forced by their own temperature selection behavior to remain there, subject themselves to speeded metabolic rates compared with their seasonal norm in other parts of their environment.

At the Connecticut Yankee Atomic Power Company's plant on the Connecticut River, Merriman et al.[44] have identified "skinny fish" in the winter accumulations of brown bullheads (Ictalurus nebulosus) and white catfish (I. catus) in the discharge canal. The weight-length ratio, or "condition factor," exhibited significant declines throughout the winter months. Fish tagged early in the winter of 1968-69 and recaptured four months later had lost an average of 20% of their weight, some having lost 60%. Comparisons of tagged and untagged fish in weekly collections indicated that this marked weight loss was not the result of the tagging but was indicative of the resident canal population as a whole. Populations in the cooler river water outside the canal also showed some condition loss, but at a much slower rate. The poorer condition was also identifiable in these two species of fish caught in the canal in the summer. Channel catfish (I. punctatus), on the other hand, showed no such decline in condition at any season.

Significance of the weight losses for ultimate survival of the populations in the Connecticut River has yet to be established, but the persistence of the effect beyond the winter was demonstrated through tagging and recovery studies.[22] Early fall returns from fish tagged in the canal the previou winter revealed that these fish had not made up their past winter's weight loss over the summer.

As a corollary to feeding rate and quantity of food consumed, the effect of temperature upon the growth of fish is an important factor in considering the effects of heated effluents but is one which has been studied essentially using freshwater fishes in the laboratory. In general, reduction in growth rate can be expected with increasing temperature above optimum for the species, especially if the availability of food does not increase.[36,45] This situation is the result of reduced food conversion efficiency, which in some cases may be intensified by behaviorial changes such as reduced effectiveness as a predator or reduced appetite.

1. Zooplankton. Very little is known of the zooplankton fauna of the lower James River, although preliminary data show a relative paucity of zooplankters in the area of Hog Island. Samples collected in this area showed amphipods (Gammarus sp.), copepods (Acartia sp., Cyclops sp., Eurytemora sp., Diaptomus sp.) mysids (Neomysis sp.), decapods (Rhithropanopeus sp. zoea), harpacticoids (Ectionosoma sp.), and various rotifers to be present.[13,31]

Zooplankters play a critical role in the trophic structure of estuarine systems, since juvenile fish of many anadromous and estuarine spawning species rely on these organisms for their first food source when feeding begins after yolk sac absorption. In some estuaries, zooplankton densities have been shown to decrease during the downstream movement of juvenile fish, the result of intensive feeding on this component of the estuarine fauna. A reduction in zooplankton in the James River would thus have a critical impact on the stability and productivity of this tidal estuary and on fish populations relying on this estuary as a nursery, feeding, and spawning ground.

The most important group of zooplankters in the Chesapeake Bay system appears to be copepods, in particular Acartia sp., which is found in the James River. Copepods account for 75 to 80% of the zooplankton in the Chesapeake Bay.[46]

The effects of elevating the temperature of natural waters on zooplankton populations are not well defined at present. Patalas[47] found that the production of zooplankters doubled after a lake in Poland was heated by thermal effluents. In the Patuxent estuary, Acartia tonsa, a copepod, suffered no reduction in standing crop in the vicinity of a thermal discharge from a power plant.[48] In Lake Ontario, the standing crops of Bosmina sp. and Daphnia sp. increased 123.8 and 2.4 times, respectively, adjacent to the thermal outfall from the Nine Mile Point power plant.[49]

The upper thermal tolerance levels of some epibenthic crustacean zooplankters which migrate vertically (amphipods and mysids) and smaller zooplankters (copepods) are shown in Table 5.4. Temperature tolerance values for

Table 5.4. Upper temperature limits of attached and epibenthic invertebrates and zooplankton found in the James River in the area of the Surry Power Station. Values based on laboratory studies.[48-51]

Species	Acclimation temp (°F)	Upper Critical temp (°F)	Criterion
Neomysis americana	33.8–77	59–82.4	24-hr LD_{50}
Gammarus faciatus	59–61	87.8	24-hr LD_{50}
Crangon septemspinosa	59	81.5	24-hr LD_{50}
Monoculodes sp.	59	84.2	24-hr LD_{50}
Palaemonetes vulgaris	37	102	LD_{50}
Callinectes sapidus			
Adults	40	105.7	LD_{50}
	76	106	LD_{50}
	42.8–86	101.7	48-hr TL_m
Juveniles	42.8–86	102.2	48-hr TL_m
Acartia tonsa	41–77	87.8	100% lethal in 2 hr
	–	91.4	Lethal in 4 days

species such as Acartia, Neomysis, the opossum shrimp, and Gammarus indicate that during summer, when ambient river temperatures are maximum, these species will be severely affected by entrainment in the thermal plume from the Surry Station. As previously mentioned, exposure times for planktonic organisms entrained near the discharge groin will amount to several hours, and during low flow periods the entire net downstream flow and the organisms therein will be exposed to the thermal plume. Also, since the plume will not stratify at depths less than 10 ft (see Section III), the excess temperature will contact the bottom. This will eliminate much habitat used by epibenthic zooplankters (Neomysis, Gammarus, etc.) since, even though these species are not killed directly, they will avoid the higher temperatures. Thus it is likely that a large area of the river in the vicinity of Hog Island and upstream in Cobham Bay will be lost as habitat to many epibenthic zooplankton species.

The available data suggest that zooplankton production in the area is very low and that recruitment from upstream probably plays a critical role in maintaining zooplankton densities. A reduction in zooplankton densities from exposure to the thermal plume would reduce recruitment to populations further down the estuary. In addition, zooplankters which survive passage through the plume will be vulnerable to entrainment in cooling water.

Heinle[46] found that the growth rate and production rate of Acartia tonsa increased with increasing temperature up to about 80.6°F (27°C) and then decreased above this temperature. With upper thermal limits for survival of about 87°F and reduced growth and production rates at this temperature, a significant decrease in productivity of estuarine copepods in the area of the James River around Hog Island and probably farther downstream will likely occur during the summer periods when temperatures are maximum. Assuming that other estuarine zooplankters have similar thermal tolerance limits to survival, growth, and productivity, reductions in other zooplankton species also are likely. It is doubtful that zooplankton populations could compensate for the increased mortality and decreased growth rate by increasing turnover rates of biomass during this time of year, since food supply probably is limiting in this area, judging from the low primary production rates (see Fig. 5.5). Thus, for a period beginning in June and extending into late September, zooplankton productivity in the James River is likely to be significantly decreased as a result of exposure to the thermal plume produced by the Surry Station.

The net effects of this, both on zooplankton production and on the ecology throughout the year of the James River, cannot be assessed until quantitative data on zooplankton composition through the year are available.

As discussed earlier in this section, a large proportion of the plankton between the discharge and intake area will be entrained in condenser cooling water. This will represent a second source of impact to those species which survived exposure to the thermal plume.

The effects of entrainment on planktonic consumers should include an estimate of the mortality incurred during condenser passage under all combinations of temperature, salinity, and plankton composition which naturally occur at the site. In order to fully understand the ecological consequence of the mortality which does occur, it is important to determine the potential of the populations of the affected species to compensate for the increased mortality.

Such an analysis was carried out in May 1964 at the Paradise Generating Station at Green River, Kentucky.[52] Biologists of the Tennessee Valley Authority found that the volume of zooplankton was drastically reduced during passage through the single-pass cooling system of the plant. However, microcrustaceans that bypassed the plant were found to reproduce at an accelerated pace in water that was warmed by mixing with the thermal discharge, 16°F above an ambient of 82°F. Coutant[22] observed that decreases in zooplankton volume could not be attributable to thermal shock effects alone. Other factors might include mechanical destruction in the condenser or piping system and predation upon carcasses and weakened individuals at or near the plant discharge. The Green River reports shed no light on these processes.[22]

Heinle[53] conducted an extensive series of laboratory and field experiments to determine the effect of condenser passage on zooplankton in the brackish Patuxent estuary in the vicinity of the Chalk Point Power Station of Potomac Electric Power Company. Instead of examining survival alone, he observed the reproductive success in subsequent laboratory culture of populations that had experienced the thermal, mechanical, and chemical shocks of condenser passage. Entrained populations of some copepods were generally not as fit for reproduction as control groups, even when the exposure temperatures were below the laboratory-determined lethal temperatures. He attributed part of this effect to chlorination of cooling water as a normal operating routine at the plant. While effects of condenser passage were identified by this research, the methodology and the lack of control over such variables as chlorination yielded results of uncertain predictive utility. As previously mentioned, population densities of the zooplankton organisms remained high within the estuary, despite high rates of natural predation and the additional losses attributable to the power plant. Certainly, the reproductive potential of the entire population exceeded the effects of the condenser passage.

Normandeau[54] identified clear effects of condenser passage on summer zooplankton and phytoplankton at the Merrimack Generating Station. Samples taken above the inlet and in the discharge canal indicated a reduction in population density of nearly all zooplankton and diatoms after passing through the power plant. These effects were definitely related to absolute temperature, being discernible principally when the condenser cooling water was elevated in July to temperatures above 100°F. The increase in temperature by itself was not the apparent causative factor; rather, mortality was evidenced when the maximum temperature attained exceeded the tolerance limits of the species. The zooplankton population depressions were also evident in the mixing zone in the

Merrimack River downstream of the plant, although cooling water was a small percentage of the total river flow at this point.(54)

Dressel(55) conducted thermal shock tests on Acartia tonsa thermally acclimated at 68 to 77°F. After 96 hours, no adverse effects were found following a 14.4°F thermal shock for 5 minutes and then returning slowly to ambient temperature within 20 minutes of exposure. This laboratory study, however, did not duplicate the thermal exposure to which zooplankters in the Surry Station cooling water will be exposed. (See Fig. 5.2.) At Surry, exposure to the 14°F Δt will last for at least 27 minutes and, under certain tidal conditions, may last over 30 minutes. The organisms will not be returned to ambient river temperatures in 20 minutes, as in the laboratory study, but rather only after several hours in the plume. The thermal exposure for entrained zooplankters at Surry thus will be significantly greater than that used in the laboratory exposure. Without duplicating the thermal dose (temperature increase and time of exposure) which zooplankton will encounter at the Surry Station, effects on survival cannot be predicted. Based on thermal tolerance levels of zooplankton species, it is likely that during the summer period (June-September) a large proportion of zooplankters entrained in cooling water will be killed as indicated by Table 5.4. This, combined with the effects from exposure to the thermal plume, may have a significant impact on fish larvae which use this region of the river as a nursery ground. The growth of other fish species, which feed on zooplankton, may also be affected.

(2) Benthos

The benthic invertebrate fauna in the area of the James River around Hog Island is represented by about 23 species consisting of four phyla, Arthropoda, Mollusca, Annelida, and Nemertea (Appendix D). The benthos can be divided into two major categories based on differences in the distribution and behavioral patterns of the species.

Attached benthos are benthic species living on or in the substrate and are relatively sedentary, in some cases attached, throughout most or all of their life history. Certain life history stages may be mobile as plankton and/or nekton but are stationary as adults. This group is represented by the clams, oysters, barnacles, mussels, sandworms, etc.

Species with planktonic larval stages will be vulnerable to both entrainment in cooling water of the Surry Power Station and exposure to the thermal plume. Sedentary and attached adults in the area will be exposed to excess temperatures in the thermal plume.

The dominant species representing this group of benthic organisms in the area of Hog Island is the brackish water clam (see Section II). This organism is a euryhaline species which is presently of little commercial value even though it is edible and is available in commercial quantities in this area.

In terms of commercial value, the most important benthic species in this area of the James River is the oyster. The nearest commercial oyster beds to the Surry Power Station are located across the river from the intake structure at Deep Water Shoal and downstream in Burwell Bay (Fig. 5.6). Oysters have been collected upstream from these areas but no oyster beds of size sufficient for commercial exploitation have developed, apparently due to the low success of setting in the lower-salinity waters.

Other attached benthic species include barnacles (Balanus spp.) which also have planktonic larvae, sandworms, and burrowing isopods. Some of these species are permanent residents in this area of Hog Island, while others are temporary, depending on life history stages and salinity changes.

The epibenthic fauna consists of organisms which live on or near the bottom but do not remain sedentary. This group is represented by shrimp, crab (blue crab), mysids (Neomysis sp.), and amphipods (Gammarus sp.).

Both the adult and larval stages of these species will be exposed to the thermal plume. In addition, the larval stages, as well as adults of smaller species, will be vulnerable to entrainment. The blue crab is considered to be the most important seasonal macroinvertebrate, and an extensive seasonal crab pot fishery which lasts 1 to 2 months a year exists in the vicinity of Hog Island.[13] Part of the fishery is in the area that will be exposed to the thermal plume from the Surry Station. Spawning occurs in the lower estuary, and the young blue crab are transported upstream by the higher salinity density currents. Withdrawal of high-salinity water from the bottom of the estuary for cooling water will thus entrain small blue crab and other small epibenthic species moving up the estuary where they develop. The planktonic larvae that are not entrained will likely be exposed to excess temperatures from the thermal discharge. Other species that will be vulnerable to the same factors are shrimp, mysids, and amphipods.

Because of the tidal flow and varying discharge, the degree and duration of exposure to elevated temperatures will vary. Plume model studies (see Section III) indicate that exposure of benthic species to maximum elevated temperatures will occur in the immediate area of the discharge groin and for a considerable distance upstream in Cobham Bay and downstream along both the western and the eastern side of Hog Island.

Plume dissipation studies also indicate that excess temperatures will not stratify at depths less than 10 ft. Thus, benthic species in water 10 feet deep or less will be exposed to excess temperatures. A contour map of this area shows that this will represent a substantial portion of the benthic area on the west side of Hog Island (Fig. 5.6). Because of the tidal flow, the duration of exposure to these excess temperatures will be considerable, particularly in the area adjacent to the discharge groin. The size of the area affected will vary seasonally, with the maximum area covered by the plume occurring in winter when ambient temperatures are minimum.

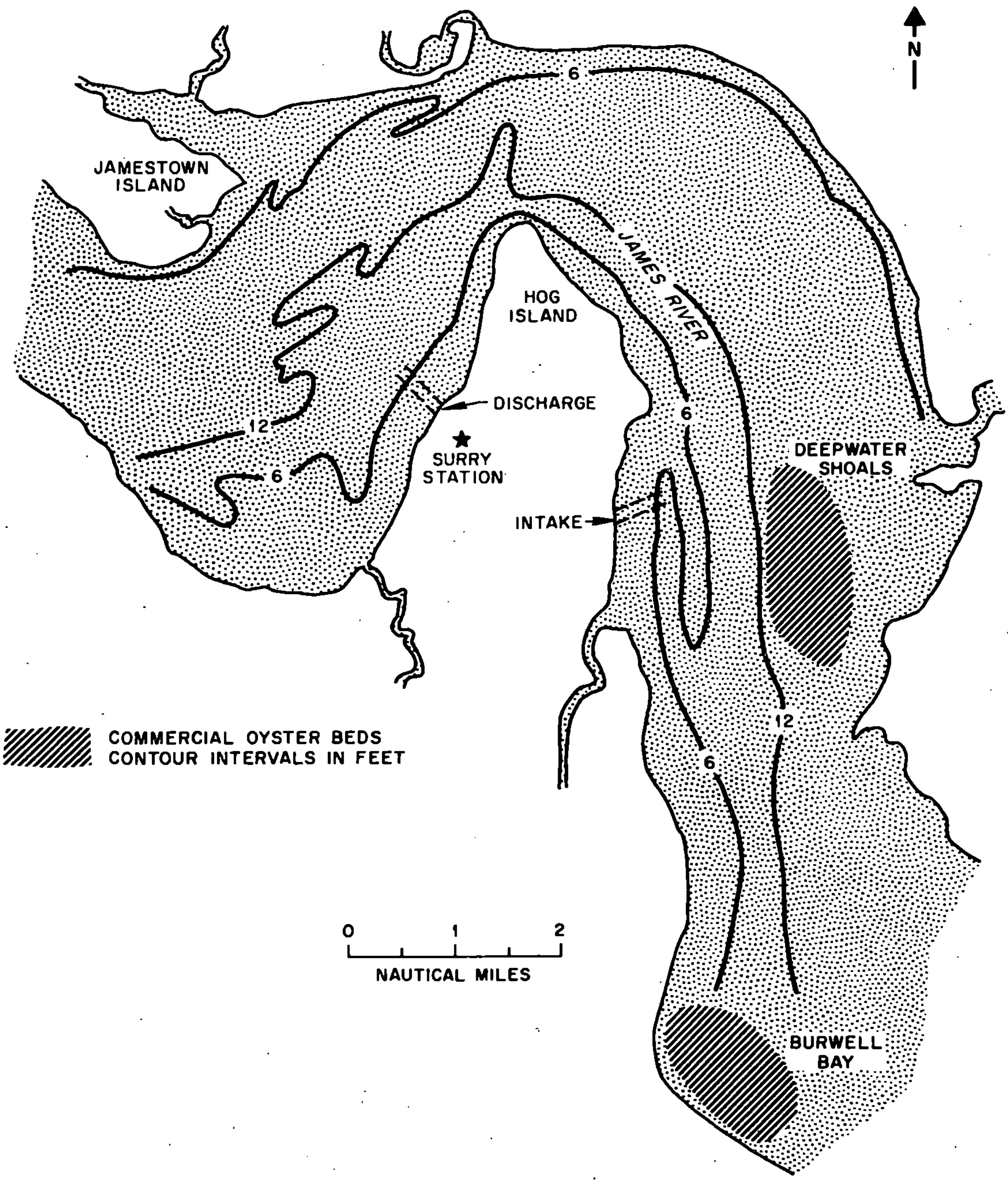


Fig. 5.6. Contour map of the James River in the vicinity of Hog Island showing locations of the nearest commercial oyster beds.

With the high discharge velocity (6 fps) at the discharge groin, severe scouring will probably eliminate all benthic species in this immediate area. The affected area will, however, be relatively small compared with the total benthic habitat in the James River estuary.

The combined salinity changes and thermal effects are likely to produce more profound changes in the benthic fauna in this area, particularly in Cobham Bay and along the western shore of Hog Island in the shallower waters, where the thermal plume will contact the bottom.

The effects of thermal discharges on benthic communities have been reviewed by Stewart.[56] In general, the number and distribution of bottom organisms decrease as water temperatures increase, with a tolerance limit close to 90°F for a "balanced" population structure. Studies of particular species of macroinvertebrates have shown that lethal temperatures vary considerably with the type of organism (Table 5.4). In some cases a particular species may be stenothermal for one developmental stage and eurythermal for another. Thus, a large number of species are able to tolerate higher temperatures than those at which they can reproduce. In a study on the York River, in Virginia, Warinner and Brehmer[30] found that the community composition and abundance of marine benthic invertebrates in the river were affected by thermal discharge over a distance of 300 to 400 meters from the discharge outfall, and they concluded that during the months of high normal river temperatures there was clear evidence of biological stress.

At power plants where benthic communities are destroyed in summer, the reverse is often the case in winter.[56] Massengill[57] reported not only colonization, but also a 10 to 40% increase in standing crop in the discharge canal at the Connecticut Yankee Atomic Power Plant, as compared with stations in the Connecticut River.

At the Surry Station, maximum summer temperatures are likely to eliminate benthic species over a considerable area contacted by the plume. Attached benthic species probably will be killed where temperatures exceed 90°F, and epibenthic species such as the blue crab will avoid these areas.[84] Alteration of blue crab distribution may have some effects on the crab pot fishery in this area. Unless there is sufficient suitable habitat available outside of the affected area for this species, a decrease in abundance and yield (commercial catch) of this species will probably occur.

In addition, small blue crab and other small benthic invertebrates will be entrained and killed from physical damage or thermal shock as they pass through the condenser cooling system. Tagatz[51] found that the thermal tolerance limit (48-hr TLμ) for juvenile blue crab ranged from 88.5 to 99°F when acclimation temperatures were 42.8 to 86°F. Exposures to near lethal temperatures cause equilibrium loss and erratic behavior patterns. At acclimation temperatures above 73°F, the upper lethal temperature for juveniles was relatively constant at about 100°F.[51] This species will likely suffer significant mortalities from entrainment during the summer period (June-September) when ambient river temperatures are maximum.

Thermal shock tests on oyster larvae showed that an 18°F temperature increase affected survival but did not affect growth or setting success.[58] It is likely that oyster larvae would be killed by low salinity in the area of the discharge even if they survive the thermal and physical effects of entrainment. Hog Island is approximately the upstream limit of oyster distribution in the James River.

Data available on the thermal tolerance of Rangia embryos and larvae are difficult to extrapolate to the thermal exposure which entrained organisms will encounter at the Surry Station because of the short exposure times. A 14°F thermal shock for 5 seconds had no significant effect on survival of developing embryos.[31] However, a combined thermal and salinity shock (salinity drop from 5 to 1 ppt) caused complete mortality. Survival of larvae exposed to the salinity shock only was not affected, while the combined temperature-salinity shock produced a 50% mortality.[31] The salinity shock which will be encountered by entrained organisms at the Surry Station cannot be determined because of uncertainties in salinity distribution and effects of plant discharge on density flow. The thermal exposure, however, will be much greater, since the organisms will be exposed to the 14°F Δt for 27 minutes or longer. With the combined salinity-thermal shock, it is likely that complete mortality of Rangia larvae will occur.

No data are available on the thermal tolerance of Rangia adults which will be exposed to the thermal plume. Published reports indicate that bivalves are tolerant of high temperatures. Adams[12] reported that the discharge canal of the Humboldt Bay Nuclear Plant on the California coast was a favorable site for natural setting for native oysters (Ostrea lurida), cockles (Cardium corbis), littleneck clams (Protothaca staminae), butter clams (Saxidomus giganteus), gaper clams (Tresus nuttalli), and about half a dozen other bivalves.

3. Fish

Estuaries such as the James River typically have diverse and varying fish faunas. The species composition varies seasonally due to variations in salinity and movement of species into, out of, and through the estuary during spawning. Egg, larval, and juvenile stages of some species move through various parts of the estuary during development.

In the area of Gravel Neck where the Surry Station is located, the fish fauna is composed of both resident and transient species. Since Gravel Neck is located in the transition zone between fresh and brackish water, freshwater fish species move into the area when salinity drops to zero. The exact location of the interface between fresh and brackish water is largely dependent on freshwater inflow from upstream. As flow increases, the interface moves downstream, thus allowing freshwater species to extend their downstream distribution. Adults of freshwater species have been collected on both the eastern and the western side of Hog Island.[13]

In April, May, and June, anadromous fish species move through the estuary during the upstream spawning migration. Species such as striped bass, shad, and herring spawn in freshwater upstream and move back downstream into low-salinity nursery areas as eggs, larvae, and juveniles.

Other fish species are estuarine residents or marine species which spend a portion of their life history in the estuary. Some of these species are dependent on the estuary as a nursery ground, while others utilize it for feeding but are not absolutely dependent on it.

Fish species in the James River, including the tidal estuary, can be classified into one of four major categories based on their life history and distribution patterns: (1) freshwater spawners - sea migrants (anadromous); (2) freshwater spawners - estuarine and freshwater residents; (3) estuarine spawners; (4) marine spawners.

(1) Freshwater spawners - sea migrants (anadromous) (Fig. 5.7).

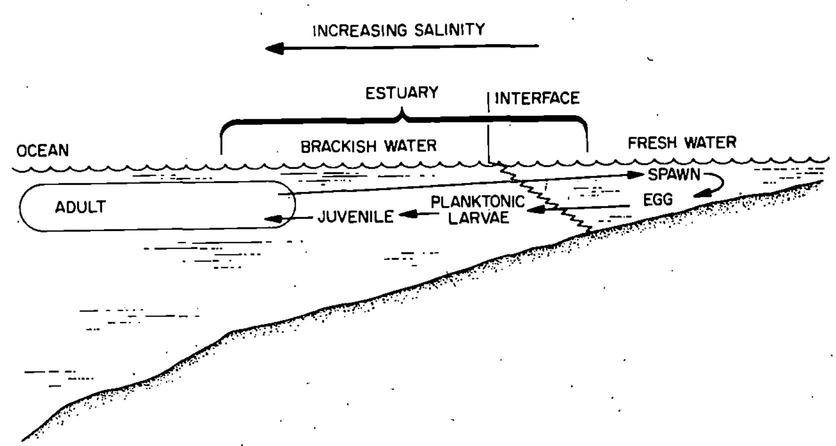


Fig. 5.7. Schematic diagram of the life history and distribution pattern of a "freshwater spawning - sea migrant" fish species.

These are species which migrate up the tidal estuary to spawn and hatch in fresh water. The larvae are planktonic (referred to as meroplankton or icthyoplankton) and are carried by currents into low-salinity nursery areas of the upper estuary, where they develop and begin active feeding. After a period of development, depending on the species, they migrate back to sea. Some of these species remain in certain parts of the estuary as residents. In the James River, this group is represented by the herring (blueback, alewife, and American shad), white perch, and striped bass. These species spawn above the Hog Island area but utilize this area as a nursery ground.(13)

Nearly all life history stages of species in this group will be subjected to potential impact from operation of the Surry Power Station. Adults may be subjected to thermal stress on both the upstream and the downstream movement to and from the spawning areas, as well as being vulnerable to both being pumped into the canal and impingement on the intake screens. Planktonic larvae and nektonic juveniles will be exposed to the thermal plume, in addition to being vulnerable to entrainment in the cooling water. Planktonic eggs of certain species, such as the herring, will also be exposed to the same conditions as the larvae and juveniles if they are carried downstream by currents into the area of the Surry Station.

(2) Freshwater spawners - estuarine and freshwater residents (Fig. 5.8).

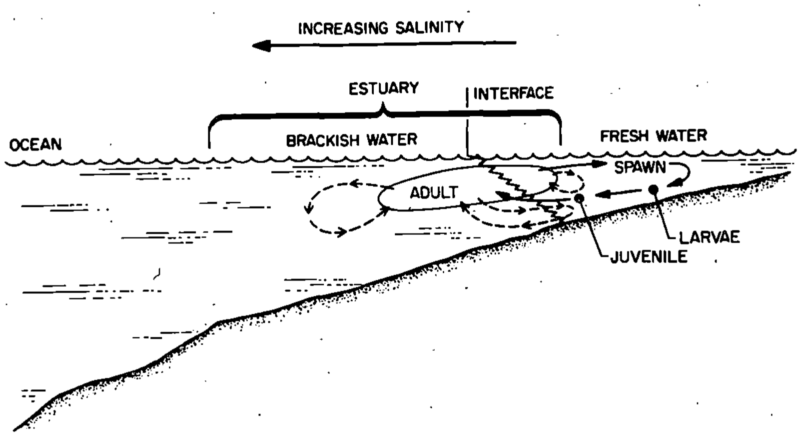


Fig. 5.8. Schematic diagram of the life history and distribution patterns of a "fresh water spawning — estuarine and fresh water resident" fish species in a tidal estuary. Dashed lines indicate the distribution and movement patterns of adults of different species.

These are species which live in various parts of the estuary or in the freshwater areas above the estuary and spawn and hatch in fresh water. Many of these species can tolerate salinity changes and thus are able to move in and out of the tidal estuary, while others are restricted to freshwater. This group is represented by the various Centrarchids (sunfish, bass, etc.), carp, brown bullhead, channel catfish, and white catfish. Various forage fish are also included in this group (shiners, darters, etc.).

Only the adult and juvenile stages of this group will be subjected to the sources of impact from operation of the Surry Station, since egg and larval development of these species occur upstream in fresh water. The eggs of these species usually are not planktonic.

(3) Estuarine spawners (Fig. 5.9). These are species which spawn, mature, and live their entire life history in brackish water or at the edge of the estuary. Some species remain in relatively the same area in which they were spawned (silverside), while others move to low-salinity nursery grounds upstream (hogchoker, bay anchovy). The hogchoker exhibits annual cyclic movement within the estuary. After hatching, juveniles move to low-salinity areas upstream in July and August, followed by a downstream movement to an area of higher salinity the following spring. This cycle is repeated every year for the first four years of life. Important bait fish which live in the shore zone, such as the mummichog and striped killifish, also will be vulnerable to entrainment and the thermal plume.

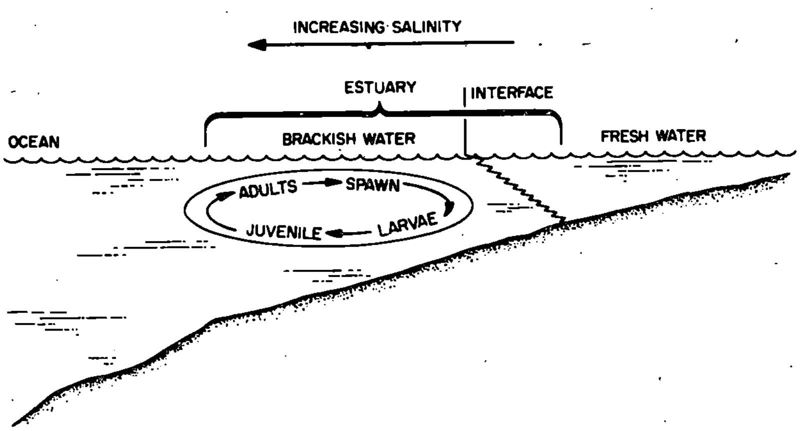


Fig. 5.9. Schematic diagram of the life history and distribution of an "estuarine spawning" fish species.

All life history stages, except the eggs of some species, of this group of fish will be subjected to some impacts from operation of the Surry Power Station. The extent of impact will depend on the spawning areas within the estuary, location of nursery grounds, degree of movement of juvenile and adult stages, and thermal tolerance of the species.

(4) Marine spawners (Fig. 5.10). These are species which spawn in the marine environment or at the edge of the estuary but rely on the estuary to varying degrees as a nursery or feeding area. Some species return as permanent residents. In the James River, this group is represented by the Atlantic croaker, Atlantic menhaden, spot, and American eel.

This group of fish species will have the adult and, in some cases, juvenile stages subjected to the sources of impact from operation of the Surry Power Station. Adults will be vulnerable to impingement on the intake screen and will be exposed to the thermal plume. Those species which also use the estuary as a nursery area, such as the Atlantic menhaden, croaker, and spot, will probably experience some entrainment of the small larval and post-larval stages.

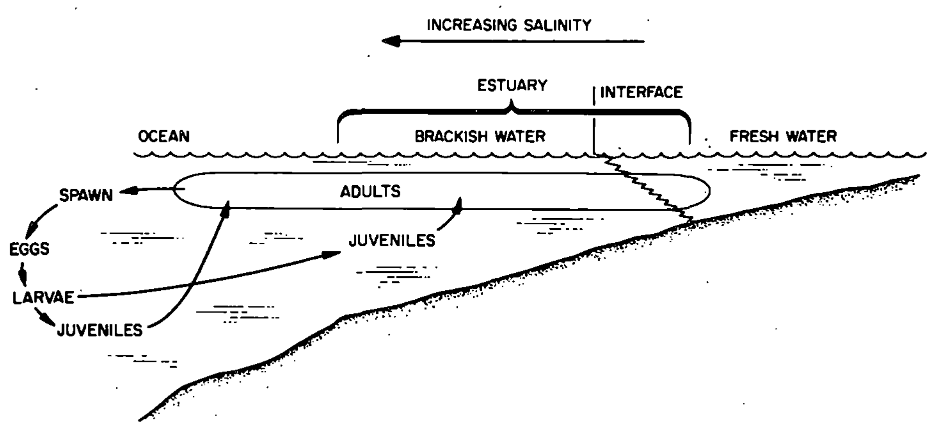


Fig. 5.10. Schematic diagram of the life history and distribution patterns of a marine spawning fish species which also utilizes various parts of an estuary.

The potential impacts of plant operation, including thermal, entrainment, and impingement effects on fish species and fish populations, can be evaluated only by identifying the various life history stages which would be in the area of the Surry Station and thus vulnerable to the sources of impact. Unfortunately, fish populations in the lower James River have not been studied extensively, and data are presently not available to document the actual occurence of life history stages of all species in the area of Gravel Neck. Life history and distribution data of the same species from other estuaries can be used, however, for predicting the distribution of the fish species in the James River and thus the relative vulnerability to sources of potential impact (Table 5.5). Anadromous species, such as striped bass, herring, and shad, spawn above the section of river on which the Surry Station is located. Thus, their eggs are not likely to be exposed to the thermal plume or vulnerable to entrainment. The larvae and post-larval stages will be vulnerable to these sources, however, since this section of the James River is used as a nursery ground by these species.

Table 5.5. Life stages of fish species in the James River which will be vulnerable[a] to the thermal discharge, entrainment in condenser cooling water, and impingement on intake screens at the Surry Power Station

Species	Thermal			Entrainment			Impingement
	Egg	Larva	Post-larva	Egg	Larva	Post-larva	Post-larva
Blueback herring	*	*	*	*	*	*	*
Alewife	*	*	*	*	*	*	*
Gizzard shad	–	*	*	–	*	*	*
Striped bass	–	*	*	–	*	*	*
White perch	–	*	*	–	*	*	*
American eel	–	–	*	–	–	*	*
Atlantic croaker	–	*	*	–	*	*	*
Hogchoker	–	*	*	–	*	*	*
Bay anchovy	*	*	*	–	*	*	*
Spot	–	*	*	–	*	*	*
Atlantic menhaden	–	*	*	–	*	*	*
Silverside	*	*	*	–	*	*	*
Striped killifish	*	*	*	–	*	*	*
Mummichog	*	*	*	–	*	*	*
Catfish	–	–	*	–	–	*	*
Bullhead	–	–	*	–	–	*	*
Largemouth bass	–	–	*	–	–	*	*
Sunfish	–	–	*	–	–	*	*
Shiner	–	–	*	–	–	*	*

[a]* = vulnerable; – = not vulnerable.

Eggs of fish species which spawn in this area of the James River, such as the silverside, bay anchovy, hogchoker, mummichog, and banded killifish, will be vulnerable to the thermal plume. If the eggs are pelagic (e.g., bay anchovy, hogchoker) they also will be entrained.

A quantitative assessment of thermal impact on fish populations requires data on thermal sensitivity of all life history stages. Adults are able to avoid temperatures which cause stress, but planktonic larval stages will be carried into the plume by currents and thus are not able to avoid temperatures that may be critical for development and survival. At low flow, all organisms moving through the area of the discharge will be exposed to some excess temperatures above ambient. During the summer period of maximum temperatures, adults of most fish species will probably avoid the area of the discharge groin where temperatures may exceed 100°F. In winter, certain species may congregate in the area of the discharge.

Larval or egg stages of fish entrained in the plume in summer will receive a thermal exposure, the degree of which depends on where entrainment in the plume occurs. Although direct mortality may not result from the thermal exposure, there will be indirect effects such as increased metabolism, accelerated rate of development, increased vulnerability to disease and predation, etc. At present too little is known about sublethal effects of fish to predict the impact of sublethal exposures on species exposed to the thermal plume from the Surry Station.

Based on preliminary calculations of thermal dose, it is likely that during the summer period, fish entrained in the plume where the excess temperature is 9°F or greater will suffer significant mortality. In some cases the mortality may approach 100%, depending on the thermal tolerance of the species and where entrainment in the plume occurs, which determines the thermal dose received. The upper tolerance limit of several estuarine fish species is shown in Table 5.6.

At the higher acclimation temperatures, the upper lethal temperature for most species is about 90°F or above. During the summer period, discharge temperatures (see Fig. 5.1) will be above the upper critical temperature for many of these species. Critical exposure temperatures may cover an area sufficient to produce a lethal thermal dose to organisms entrained in the plume near the discharge groin. Exposure to temperatures above the upper critical level could last for several minutes.

Assuming that the 9°F excess isotherm is the critical temperature increase during the summer period, nearly all of the net downstream flow will be required to dilute excess temperatures of the cooling water from 14°F to 9°F (Table 5.2). Under these conditions, most of the water moving through the area between the intake and discharge, and organisms therein, will have had to pass through lethal temperatures. Preliminary estimates indicate that for a river discharge of 2000 cfs, this will be approximately 80% of the water. For river discharges of 2000 cfs or less, the mortality of fish larvae or other life stages entrained in the plume will thus be approximately 80% or greater during the summer period. Since larval stages of species such as striped bass depend on this area as a nursery ground during the period, there likely will be high mortality rates of the larval stages which cannot avoid these exposure conditions.

In addition to exposure to the thermal plume, eggs, larvae, and adult fish will also be subjected to impingement on intake screens and entrainment in cooling water. Based on experience at other power plants, this source

Table 5.6. Upper temperature limits of fish species found in the James River. Values based on field observations and laboratory studies.[16, 39, 49, 50]

Species	Acclimation temp (°F)	Upper critical temp (°F)	Criterion
Atlantic silverside	72.5	98.4	LD_{50}
	77.0	98.9	LD_{50}
	–	90.5	72-hr TL_m
	44.6–82.4	72.5–90.5	48-hr TL_m
Alewife	59	73.4	T[a]
	–	88.5	T
	–	80.1–90.0	T
Striped bass			
Adult	53	89	LD_{50}
	60.5	92.5	LD_{50}
	77	99	LD_{50}
	–	89.6	T
	–	77–80.6	Field observation
	39.9	75	8-hr LD_{50}
Juveniles	–	95	T
White perch	79.8	99.6	LD_{50}
	77.4	99.8	LD_{50}
Mummichog	38	102.7	LD_{50}
	79	107.5	LD_{50}
	45	98.6	8-hr LD_{50}
	–	104	T
	82.4	98.6	T
Striped killifish	75	101.7	LD_{50}

[a]T = maximum tolerated temperature.

of impact will likely be more significant to fish than exposure to the thermal plume.

Proffitt found, for example, that after the passage of minnows through condensers of a power plant, several hundred were seen dead and dying along the banks of the effluent canal.(59) In another study, preliminary observations obtained at the Connecticut Yankee Atomic Power Plant on the Connecticut River indicated that larval river herring (Alosa spp.) were able to successfully pass through condensers in July in which the temperature was raised to 93°F. All larvae were judged to be in good condition following the rapid thermal shock and collection by plankton net in the plant's discharge canal.(60) However, more detailed studies(61) at this site found that no larval or juvenile fish of the nine species which were entrained in the condenser cooling-water system of the plant survived when the temperature of the canal water exceeded 86°F. Among these species were several that are found at the Surry site, including alewives, blueback herring, white perch, and American eels.

Mihursky and McErlean(62) found a maximum survival of 11.7% for striped bass eggs that had passed through condensers of the Vienna, Maryland, power plant. In several cases, there was no survival. This mortality was attributed to either damage of eggs passing through the plant or injury from the method used in sampling the eggs at the plant inlet and discharge.

In contrast to these findings, Kerr(63) found that juvenile striped bass and Chinook salmon that passed through the condenser system of a power plant had generally high survival. Kerr acknowledged the fact that the small striped bass would "readily go into a state of shock" during the experiments.

In connection with Kerr's observation that the juvenile striped bass would go into a state of shock, it is important to recognize that considerable mortality may result from such shock which would not cause death from physiological causes and would consequently not be observed in laboratory studies. Thermal death, with an end point such as (for fish) cessation of beating of the opercula as is often used in laboratory studies, may not be the most pertinent ecological effect of acute thermal shock to organisms exposed to elevated temperatures. Heat death of cold-blooded organisms has been observed to follow a common pattern which includes, in sequence, loss of equilibrium, coma, and physiological death. These observations have been made with several species of fish and with amphibians and reptiles. They probably hold, in essence, for lower forms as well. The early stages of heat death, while not "death" in themselves, may lead to death through immobilization in the area of adverse temperature (which may prolong exposure until death results) or through stimulation of predatory activity upon the heat-injured organism. Both results have been observed in the field and in laboratory experiments.(22)

A concept of a critical exposure to heat, which causes equilibrium loss, similar to that proposed by Cowels and Bogert(64) would seem to be of paramount significance in understanding the relations of aquatic populations to thermal shock in condenser cooling water of a power station, as was noted by Mihursky and Kennedy.[49] It is increasingly recognized that the demise of animal populations is not absolutely dependent upon the physiological death limits of individuals, but involves broad ecological considerations such as breeding densities and predator-prey relationships. Equilibrium loss in the natural environment is a critical occurrence for the survival of an organism, because it greatly increases the organism's susceptibility to predation.

The effect of equilibrium loss in providing stimulatory cues to predators may be a particularly important feature in fish and other animals shocked by condenser cooling water. Mossman[65] cites several points of evidence that suggest release of predator attack by any behavior associated with weakness. Coutant[22] has specifically studied the effects of acute thermal shock and found that the vulnerability of thermally shocked juvenile salmonids to predation by larger fish increased. When both shocked and control fish were offered simultaneously under laboratory conditions, the shocked fish were found to be selectively preyed upon by larger fish. Relative vulnerability of shocked fish to predation increased with duration of sublethal exposure to lethal temperatures. Effects were also shown well below doses causing equilibrium losses.

Confirmation of the potential importance of predation on shocked organisms in the field situations of thermal discharges can be found in the many references to predators being attracted to points of thermal discharge.[22] Although preference for a particular temperature range may be the predominant attractant for some organisms, it hardly would apply to concentrations of fish-eating gulls.[66] Neill[67] reported intensive feeding by fish on entrained zooplankton in the outfall area of a power plant on Lake Monona. Young-of-the-year bluegills congregated at the periphery of the discharge plume and fed on zooplankton. Several large long-nose gar, their stomachs distended by an abundance of zooplankton, were taken in and near the discharge. Bigmouth buffalo, yellow bass, bluegills, black crappies, and brook silversides caught near the outfalls were suspected of feeding heavily on zooplankton, although confirming data were not collected. Abundant zooplankton was entrained by this plant in cooling water taken from 100 meters offshore and 5.2 meters below the water surface. Apparently, the effects of condenser passage killed or debilitated the zooplankton sufficiently that predation upon them was easier than it was in the unheated water of the lake.

Obviously, it is impossible to make absolute statements concerning the mortality of organisms which will be drawn through any given plant. The probability is high, however, that a large fraction of the organisms entrained at the Surry Station will be killed or damaged by the entrainment.

As previously mentioned, fish and other organisms also will be pumped into the intake canal and impinged on traveling screens at the high-level intakes. The magnitude of this potential effect is as yet unknown, but pumping tests followed by seining of the canal should indicate the relative quantities of fish which will be lost through this source.

Based on this preliminary analysis, the overall impact on fish in the James River from all of the sources previously discussed will be to stress fish populations in the area of Hog Island. Standing crops and recruitment of several species may be reduced. Species such as the striped bass will be vulnerable to significant impact from both entrainment of larvae in the plume and entrainment in cooling water at the intake. Many species will avoid the area of the discharge during summer, whereas, during winter, some species may congregate in this area. The overall impact of station operation on fish populations in the James River cannot be quantified because of the lack of information on population dynamics and distribution patterns for species in this estuary.

E. RADIOLOGICAL IMPACT OF ROUTINE OPERATION

Radioactive nuclides will be released to the air and to the water from the Surry Station only under controlled conditions. Release of these effluents will be conducted in accordance with the AEC Regulations set forth in 10 CFR Part 20,[68] and with the objective of limiting such releases to the "lowest practicable level" as set forth in 10 CFR 50.36a.[69] No detectable effects on man are expected to result from releases of radionuclides meeting the 10 CFR Part 50 limitations.

Compliance with 10 CFR Part 20 can be ascertained by monitoring the environs both before and after plant operations have begun. It should be noted that the limitations set forth in 10 CFR Part 20 were based upon recommendations of recognized national and international radiation protection groups which represent the consensus of informed and responsible scientific judgment in the world today. Operating experience with similar power plants has shown that actual releases of radionuclides from these plants have generally been small fractions of the limits set forth in 10 CFR Part 20.

1. Radiation Doses to Man

Individuals and population groups could be irradiated by the released radionuclides via numerous pathways and modes of exposure. The irradiation occurs as a result of external and internal exposure to the radionuclides present in the reactor effluents. External exposure results from the absorption in the human body of emissions from radioactive nuclides located outside the body. If the radioactive nuclide is introduced into the body, whether by breathing, drinking, or eating, the emissions cause internal exposure. The modes of external exposure for which dose estimates are presented are (a) immersion in a cloud of radioactive gaseous effluent, (b) submersion in a body of water having radionuclides present, and (c) exposure from a contaminated land surface. Pathways of internal exposure for which dose estimates are presented are (a) intake of air, (b) intake of water, (c) intake of milk, and (d) intake of fish. Other exposure pathways, such as contaminated food crops, were considered but are not presented because the estimated doses were insignificant compared with those treated here.

Throughout the discussion of radiological impact to man, use of the term "dose" should be understood to include "dose commitment" whenever internal exposure modes are involved. The dose commitment due to an intake of radioactivity is the total dose an individual will accrue within his lifetime as a result of that intake. Internal dose may be calculated for any body organ, and that organ may be identified as the "reference organ." All of our dose estimates were calculated using dosimetric parameters applicable to adults (i.e., the population was assumed to be composed entirely of adults) except those for the thyroid. Dosimetric parameters applicable to a child were used for thyroid exposure resulting from the intake of milk since it is most critical. We have limited the other calculations to the adult population because of the uncertainties in the values of many parameters that have a direct bearing on the magnitude of the eventual radiation dose estimates (e.g., source of radioactivity, initial distribution in the environment, and subsequent redistribution along the exposure pathways to man).

The initial dispersion and dilution of radionuclides transported in the air has been estimated using a computer code by Reeves et al.(70) The calculated radionuclide intakes were converted to dose estimates using the INREM internal dose code.(71) The external concentrations of radionuclides were converted to dose estimates using the EXREM external dose

Table 5.7. Summary of estimated doses (millirem) to the total body of individuals near the site boundary and to the total population (year 1970) within 50 miles of the site in man-rem per year of discharge

Exposure mode	Dose due to gaseous effluent		Dose due to liquid effluents[a]	
	Individual (millirem)	Population (man-rem)	Individual (millirem)	Population (man-rem)
Air immersion	0.11	0.07		
Inhalation	0.0085	0.0077		
Land surface	0.23	0.124		
Ingestion				
Fish			0.88	72
Shellfish			0.088	18
Water			0.314	
Milk	0.0086[b]			
Water submersion			0.0048	0.075
Individual total				
Gaseous	0.36			
Liquid			2.52	
Population total		0.20		90.075

[a] Zero dilution was used for ingestion of water and submersion; a dilution factor of 5 was used for ingestion of fish.

[b] Dose at the nearest dairy herd.

code.[72] The dose calculations for the various exposure pathways and modes are discussed in some detail in succeeding sections, and the resulting estimates of dose for total body are presented in Table 5.7. All dose calculations are based on the calculated releases for normal operation listed in Tables 3.4 and 3.5.

a. Gaseous Effluents

In assessing the possible radiological impact to man for gaseous effluents, we have assumed average meteorological conditions based on site specific data from the FSAR. The highest estimated dose to individuals at the exclusion radius (503 m) occurs in the southeast direction.

(1) Immersion in a Radioactive Cloud

The internal dose contributions due to exposure to inert gas radionuclides are negligible and therefore only external exposure from a cloud of radioactive noble gases is considered. The concentrations of airborne effluents at ground level were obtained for each of sixteen 22.5° sectors from 1 to 50 miles from the reactor using an atmospheric diffusion model given by Reeves et al.[70] The maximum total body dose per year of effluent release for an individual via this exposure pathway is .11 mrem, assuming that the individual continuously occupies his designated location at the boundary (503 m in the southeast direction). Xenon-133 contributed 84% of this dose. Table 5.8 shows the average annual dose for cumulative population groups at various distances from the reactor site.

Table 5.8. Cumulative Dose and Average Annual Dose from ground-level air concentration

Radial Distance in Miles	Cumulative population	Cumulative dose (man-rem/yr)	Average annual dose for cumulative population (millirem/year)
1	4	0.0001	0.0328
2	36	0.0003	0.0090
3	121	0.0005	0.0038
4	265	0.0006	0.0022
5	1,169	0.0011	0.00094
10	66,630	0.024	0.00037
20	247,700	0.045	0.00018
30	524,100	0.055	0.00010
40	1,112,000	0.066	0.00006
50	1,550,000	0.070	0.00004

(2) Exposure to a Contaminated Land Surface

Assuming an effective deposition velocity of 1 cm/sec for elemental iodine, the average radionuclide concentration on the ground was estimated in each of sixteen 22.5° sectors at various distances. Continuous occupancy at a designated location by the exposed individual was also assumed. The maximum total-body dose per year of effluent release for an individual via this exposure pathway is 0.23 mrem at 503 m in the southeast direction.

Iodine is the major dose contributor for this exposure pathway, even though the exposure is external. Iodine-131 contributes 31% and ^{133}I contributes 65% of the estimated dose.

(3) Milk Consumption

The doses to individuals from the intake of milk produced by cows raised near the reactor was also estimated. The average radionuclide contration deposited on the pasture was determined assuming an effective deposition velocity of 1 cm/sec for I_2. We used a general environmental model to estimate the radionuclide concentration in milk produced by cows grazing on the contaminated pasture.(73) Since no cows graze at the site boundary, the dose was determined at the nearest dairy heard, which is about 3.5 miles from the site. The maximum total-body dose per year of release from this pathway for an adult individual, who drinks 0.6 liters of milk per day, is 0.0086 mrem. A population dose was not estimated for this exposure pathway because the Surry site is not a dairying region. There are only three dairy farms in Surry County.

Dose estimates for the thyroid are desirable for this exposure pathway because ^{131}I is the major dose-contributing radionuclide. The thyroid dose for a child who drinks 0.6 liters of milk per day from the nearest dairy herd is about 48 mrem per year.

(4) Inhalation

Air inhalation doses were estimated for an inhalation rate of 2×10^7 cm^3/day(74) for man. Assuming the individual resides at the southeast boundary continuously, the maximum total-body dose per year of release to an individual via inhalation of the airborne effluent is less than 0.01 mrem. However, ^{131}I is an important dose contributor to the thyroid for this exposure pathway; the estimated dose for that reference organ is .33 mrem (all due to ^{131}I).

b. Liquid Effluents

(1) Drinking Water

The estimates of maximum dose via drinking water are based on the assumption that an adult drinks 1200 cm^3/day (4.38×10^5 cm^3/year)(74) and that the water is taken from the point of Surry discharge with zero dilution in the James River. Using the anticipated activity release from the liquid radioactive waste system, we find a whole body dose of 0.31 mrem per year of release for the radionuclides listed in Table 3.4 (p. 62). There are no public drinking water supplies taken from the James River downstream from the site at present, due to the high salinity of the water.

(2) Fish Consumption

The estimates of the dose received from fish consumption are based on the assumption that an adult consumes 20 g/day of fish (7.3×10^3 g/yr)[75] that are living in the liquid radioactive waste effluent. The radionuclide concentrations in the seafood are assumed to be in equilibrium with the radionuclide concentrations in the effluent where reconcentration in the flesh of the organism has been considered. Using the radionuclides listed in Table 3.4, the total-body dose to the individual is 0.88 mrem per year of release. Most of that dose is attributable to ^{137}Cs and ^{134}Cs. The dose to the thyroid is 2.0 mrem/year, most of which is due to ^{131}I.

A similar calculation was done for shellfish consumption. The daily intake was assumed to be 10 g/day and resulted in a total body dose of 0.088 mrem per year of release. The thyroid dose was about 5 mrem per year of release.

(3) Submersion in Water

Estimates were made of submersion doses for a man swimming in the liquid radioactive waste effluent with zero dilution. If one assumes that the individual swims in this undiluted effluent 1% of the year (1 hr/day for 3 summer months) the estimated total-body dose is 0.0048 mrem per year of release. In this case the dose estimate for ^{136}Cs constitutes 33% of the total, while ^{131}I contributes 12% and ^{136}Cs contributes 16%.

2. Dose to the Regional Population

The man-rem or total population dose is defined to be the sum of the whole-body doses to all individual members of a given population. The population doses which result from the operation of the Surry Station for all significant pathways are listed in Table 5.9. Based on 1970 census figures, the total dose from air-immersion to the people living within a 50-mile radius of the Surry Station is 0.07 man-rem per year of reactor operation, while the dose from exposure to the contaminated land surface is 0.124 man-rem. The inhalation dose for the same population is 0.008 man-rem. Assuming that 1% of the people within a 50-mile radius of the site swim in the undiluted effluent, the total dose would be 0.075 man-rem. The transportation of radioactive materials to and from the Surry Station results in a population dose of 2.1 man-rem (See Section 6). The total edible catch[76] of fish and shellfish was 873,000 and 1,679,000 lbs, respectively. The catch of sport fish was assumed to be an additional amount equal to one-half the commercial catch. Thus, the population dose for these pathways was 72 and 18 man-rem, respectively.

TABLE 5.9
TOTAL ANNUAL DOSE TO THE GENERAL POPULATION FROM THE OPERATION OF THE SURRY STATION

Pathway	People Exposed	Annual Man-Rem Dose
Air immersion	1,550,000	0.07
Air inhalation	1,550,000	0.008
Contaminated Land Surface	1,550,000	0.124
Fish Consumption	54,000	72
Shellfish Consumption	209,000	18
Water Immersion (Swimming)	15,500	0.075
Transportation of Irradiated Fuel	150,000	1.3
Transportation of Radioactive Waste	150,000	0.8
		92.377

Thus, based on our estimates, the population dose from all pathways as a result of the operation of the Surry Station is about 92.4 man-rem. By comparison, the natural background dose of about 0.1 rem per year per person results in a population dose of 155,000 man-rem. Thus, operation of the Surry Station will add only an extremely small increment to the dose that results from natural background radiation and is in itself immeasurable.

3. Radiation Doses to Aquatic Organisms

The ability of aquatic organisms to concentrate radionuclides presents a potential radiological hazard to species living in the contaminated water. In order to assess the potential impact of liquid releases to James River biota, radiation doses to aquatic plants (algae, etc.), invertebrates, and fish were calculated. Dose calculations were based on the assumption that the organisms live continuously in effluent water containing radionuclides in concentrations equal to those at the point of discharge from the Surry Station. This pathway of exposure was used in order to estimate maximum doses. Organisms which live in the estuary will receive a lower dose as radionuclide concentrations become diluted with James River water.

Total doses were computed as the sum of the internal and external (immersion) doses. The internal dose to aquatic organisms as listed in Table 5.10 results from intake of radionuclides through either ingestion (food chain), direct absorption from water, or both. Immersion dose (Table 5.11) results from immersion of the organism in the contaminated water and, as calculated by the computer code EXREM,(71,72) is insignificant compared to the internal dose.

Table 5.10. Internal dose to aquatic plants (algae), invertebrates, and fish growing in liquid effluent from the Surry Station and concentration factors (from refs. 12–14) used in the dose calculations

Radionuclide	Dose (millirads/year)		
	Plants	Invertebrates	Fish
^{86}Rb	0.16	0.32	0.32
^{89}Sr	0.36	0.48	0.018
^{90}Sr	0.022	0.03	0.0011
^{90}Y	0.024	0.0024	2.4×10^{-4}
^{91}Y	1.50	0.15	0.015
^{95}Zr	0.059	0.0059	3.9×10^{-4}
^{95}Nb	0.018	0.0018	1.8×10^{-4}
^{97}Zr	0.028	0.0028	1.9×10^{-4}
^{99}Mo	6.40	6.40	6.40
^{103}Ru	0.023	0.023	0.0012
^{106}Ru	0.019	0.019	9.7×10^{-4}
^{129m}Te	0.19	0.048	0.77
^{131m}Te	0.13	0.032	0.51
^{131}I	0.13	0.64	3.2
^{132}Te	2.4	0.60	9.6
^{133}I	170	87.0	44.0
^{134}Cs	2800	1200	1100
^{135}I	6.3	32	1.6
^{136}Cs	540	240	210
^{137}Cs	1200	520	450
^{140}Ba	0.29	0.12	0.0058
^{141}Ce	0.082	0.0083	8.2×10^{-4}
^{143}Ce	0.15	0.015	0.0015
^{144}Ce	0.29	0.029	0.0029
^{147}Nd	0.054	0.0054	5.4×10^{-4}
^{127}Sb	0.11	0.018	4.4×10^{-5}
^{51}Cr	7.6×10^{-4}	3.8×10^{-4}	0.0015
^{54}Mn	4.6	18	0.0033
^{58}Co	13	7.6	2.5
^{60}Co	0.93	0.56	0.19
^{55}Fe	0.019	0.012	0.0011
^{59}Fe	1.3	0.85	0.080
^{3}H	12.0	12.0	12.0
Total	4600.0	2200.0	1800.0

Table 5.11. Immersion dose (beta + gamma) to plants, invertebrates, and fish living continuously in liquid effluent from the Surry Station

Radionuclide	Immersion dose (millirads/year)
^{86}Rb	3.0×10^{-5}
^{89}Sr	6.1×10^{-5}
^{90}Sr	3.7×10^{-6}
^{90}Y	1.2×10^{-6}
^{91}Y	7.7×10^{-5}
^{95}Zr	5.6×10^{-5}
^{95}Nb	2.7×10^{-5}
^{97}Zr	1.9×10^{-5}
^{99}Mo	0.055
^{103}Ru	1.4×10^{-5}
^{106}Ru	7.1×10^{-6}
^{129m}Te	6.1×10^{-4}
^{131m}Te	2.1×10^{-3}
^{131}I	0.073
^{132}Te	0.034
^{133}I	8.7×10^{-2}
^{134}Cs	0.17
^{135}I	0.081
^{136}Cs	0.081
^{137}Cs	0.057
^{140}Ba	7.7×10^{-4}
^{141}Ce	6.1×10^{-6}
^{143}Ce	1.5×10^{-5}
^{144}Ce	1.5×10^{-5}
^{147}Nd	4.5×10^{-6}
^{127}Sb	9.1×10^{-7}
^{51}Cr	9.1×10^{-6}
^{54}Mn	2.2×10^{-4}
^{58}Co	3.2×10^{-3}
^{60}Co	6.0×10^{-4}
^{55}Fe	5.6×10^{-6}
^{59}Fe	4.2×10^{-4}
^{3}H	0.039
Total	0.69

Internal dose D_i (millirad/year), for radionuclide "i" was computed from the following equation:

$$D_i = 1.87 \times 10^7 W_i C_i E_i,$$

where 1.87×10^7 is a constant to convert μCi per gram of organism to millirad/year, W_i is the concentration (μCi/ml) of the radionuclide in the liquid effluent of the Surry Station, C_i is the bioaccumulation factor[77,78,79] of the radionuclide in the biota of interest, and E_i is the effective absorbed energy (Mev) of the radionuclide (the largest effective absorbed energy listed in Report No. 2 of the International Commission for Radiation Protection was selected).[74]

The dose calculations assume steady state conditions (i.e., the radionuclide concentrations in water remain constant). The computed internal doses are maximized, since the maximum effective absorbed energies (E_i) in man were used in the calculation. For small organisms such as single-celled phytoplankton, zooplankton and benthic invertebrates, the internal dose will tend to be overestimated because these organisms will absorb less than the maximum effective energy.

Bioaccumulation factors (C_i) used in the calculation of internal dose (Table 5.12) were experimentally determined values obtained from the literature, since there were no data on bioaccumulation factors specifically for the James River ecosystem. Because factors vary in different environments due to various physical, chemical, and biological conditions, the maximum values for aquatic ecosystems obtained from the literature were used in most of the calculations.

The estimated total doses for aquaticplants, invertebrates, and fishes living in the discharge canal are 4.6, 2.2 and 1.8 rads/year, respectively, and results are primarily from internal exposure (<1% from immersion). The radiocesiums contribute most of the internal dose in plants, invertebrates, and fish.

The doses to organisms living in the discharge canal are well below those at which demonstrable radiation effects have been found. Since the assumptions used to estimate the dose to aquatic organisms near the Surry Station tend to maximize the dose, there should be no discernible effects to these organisms as a result of the low-level releases.

4. Radiation Doses to Terrestrial Organisms

Because of the many potential modes and pathways of radiation exposure to terrestrial organisms near the Surry Station, a single pathway was selected which would most likely result in the maximum radiation dose to an organism in the surrounding terrestrial ecosystem. The pathway of

TABLE 5.12 BIOACCUMULATION FACTORS (FROM REFS. 77, 78, 79) USED IN CALCULATING THE DOSE TO AQUATIC PLANTS, INVERTEBRATES, AND FISH

Radionuclide	Plants	Invertebrates	Fish
^{86}Rb	1,000	2,200	2,200
^{89}Sr	3,000	4,000	150
^{90}Sr	3,000	4,000	150
^{90}Y	10,000	1,000	100
^{91}Y	10,000	1,000	100
^{96}Zr	1,500	150	10
^{95}Nb	1,000	100	10
^{97}Zr	15,000	150	10
^{99}Mo	100	100	100
^{103}Ru	2,000	2,000	100
^{106}Ru	2,000	2,000	100
^{129m}T	100	25	400
^{131m}T	100	25	400
^{131}I	200	1,000	50
^{132}Te	100	25	400
^{133}I	200	1,000	50
^{134}Cs	25,000	11,000	9,500
^{135}I	200	1,000	50
^{136}Cs	25,000	11,000	9,500
^{197}Cs	25,000	11,000	9,500
^{140}Ba	500	200	10
^{141}Ce	10,000	1,000	100
^{143}Ce	10,000	1,000	100
^{144}Ce	10,000	1,000	100
^{147}Nd	10,000	1,000	100
^{127}Sb	100,000	16,000	40
^{51}Cr	100	50	200
^{54}Mn	35,000	140,000	25
^{58}Co	2,500	1,500	500
^{60}Co	2,500	1,500	500
^{55}Fe	5,000	3,200	300
^{59}Fe	5,000	3,200	300
^{3}H	1	1	1

maximum exposure would be for an animal such as a duck or raccoon, which consumes aquatic plants (algae, etc.) that grow in the water near the point of discharge of liquid radioactive effluents. Although other pathways were considered, this one was selected for assessment based on the following considerations: (1) The estimated dose to man from submersion in air (external dose), ground contamination (external dose), and inhalation (internal dose) resulted in a total dose of less than 1 millirem/year based on the worst-case condition (Table 5.9). The dose to these terrestrial animals would be approximately the same for this pathway. (2) If an internal dose from ingestion of contaminated terrestrial plants is added, the dose to the animal is raised only slightly. (3) Since aquatic plants concentrate most radionuclides by factors ranging from approximately 10 to 10^5 (Table 5.12) relative to the concentrations in water, the internal radiation dose to a wild animal from consuming algae is probably much greater than other food chain pathways.

To assess the potential effect on terrestrial animals, the internal dose to the whole body was estimated for a mammal or bird eating algae as its only source of food. The ratio of daily intake (grams of algae consumed) to total body weight (grams of animal) was set equal to 0.1, and the animal was assumed to be in equilibrium with the algae (i.e., the animal had attained an equilibrium body burden of radionuclides such that the rate of excretion equaled the rate of assimilation). Concentrations of radionuclides in the algae were computed as the product of the radionuclide concentration in the discharge water (see Table 3.4) and the bioaccumulation factor [equilibrium radionuclide concentration per gram of animal (wet) weight divided by radionuclide concentration (μCi/cc) in water] for that nuclide as listed in Table 5.12.

The internal dose, D_i (millirad/year), for radionuclide "i" to an animal consuming aquatic plants was computed from the following equation:

$$D_i = \frac{1.87 \times 10^7 X_i^{eq} E_i}{m} ,$$

where 1.87×10^7 is a constant to convert μCi per gram of animal to millirad/year, X_i^{eq} is the body burden of the radionuclide (μCi) at equilibrium in an animal consuming 100 g of algae per day, E_i is the effective absorbed energy (Mev) of the radionuclide for a 10-cm-diam cylindrical animal, and m is the mass of the animal (1000 g). The body burden, X_i^{eq} (μCi), of the radionuclide at equilibrium in the total body of the animal was computed from the following expression:

$$X_i^{eq} = 1.4\ T_i W_i C_i g\ \ f_i ,$$

where T_i is the effective half-time (days) of the radionuclide in the whole body of the animal, W_i is the concentration (μCi/ml) of the radionuclide in the liquid effluent of the Surry Station (Table 3.4), C_i is the bioaccumulation factor of the radionuclide in algae or other aquatic vegetation (dimensionless), g is the mass (grams) of algae consumed per day (100 g/day) by the animal, and f_i is the fraction of the ingested quantity of radionuclide "i" that is assimilated by the tissues of the animal (dimensionless).

Table 5.13. Internal dose to a terrestrial animal consuming only aquatic plants growing in effluent water from the Surry Station

Radionuclide	Dose (millirads/year)
^{86}Rb	0.29
^{89}Sr	0.78
^{90}Sr	5.50
^{90}Y	9.1×10^{-7}
^{91}Y	1.3×10^{-3}
^{95}Zr	2.5×10^{-5}
^{95}Nb	3.0×10^{-5}
^{97}Zr	2.2×10^{-7}
^{99}Mo	1.2
^{103}Ru	3.8×10^{-4}
^{106}Ru	6.0×10^{-4}
^{129m}Te	5.2×10^{-2}
^{131m}Te	3.2×10^{-3}
^{131}I	9.6
^{132}Te	0.13
^{133}I	1.7
^{134}Cs	13,000
^{135}I	0.15
^{136}Cs	460
^{137}Cs	8,300
^{140}Ba	0.014
^{141}Ce	3.0×10^{-5}
^{143}Ce	2.5×10^{-6}
^{144}Ce	8.0×10^{-4}
^{147}Nd	7.0×10^{-6}
^{127}Sb	1.4×10^{-3}
^{51}Cr	8.1×10^{-6}
^{54}Mn	0.17
^{58}Co	2.2
^{60}Co	0.18
^{55}Fe	0.12
^{59}Fe	0.42
^{3}H	0.12
Total	22,000

The estimated total internal dose to an animal from the given pathway of exposure was 2.2 rad/year or approximately 6 millirad/day (Table 5.13). Strontium-90, ^{134}Cs, and ^{137}Cs contributed over 98% of this dose.

The literature on the effects of chronic low-level radiation on terrestrial biota is not extensive; however, the available information indicates that a detectable radiation effect would not be found at a dose rate of 2.2 rad/year for terrestrial animals.[80]

It must be emphasized that doses to these animals represent extreme conditions. If foods other than aquatic plants are consumed or the animals feed in other areas where radionuclide concentrations are lower, the doses will decrease correspondingly. Also, it is highly unlikely that a mammal or bird would feed only in this one location for a period of time sufficient to attain equilibrium with radionuclides in aquatic plants. The maximized dose estimate to birds and animals in the James River Estuary is still far lower than the dose required to produce a detectable radiation effect.

F. ENVIRONMENTAL MONITORING PROGRAM

An environmental monitoring program, comprised of ecological and radiological surveys in the vicinity of the Surry Station, was initiated more than two years ago and will continue after station operation has begun, with modifications stated in the Technical Specifications. The ecological surveys have been conducted partly by the applicant and partly by the Virginia Institute of Marine Sciences,[76] to determine the impact of the operation on the ecology of the James River estuary. The program has consisted of the following:

1. Thermal and Salinity Monitoring

A system of seven temperature monitors is installed on instrument towers in the James River near the Surry site (Fig. 5.11). Towers 3, 5, 6, and 7 measure temperature at mid-depth and bottom; towers 1, 2, and 4 monitor temperature at mid-depth only.

Salinity monitors are located at towers 1 and 7. A mid-depth temperature and salinity monitor will be installed at the Surry Station intake prior to operation of the Station.

2. Biological Survey and Biological Monitoring

A preoperational survey of the James River in the vicinity of Hog Island was begun in 1968. The survey and monitoring program is being conducted by the applicant and by the Virginia Institute of Marine Science in Gloucester Point, Virginia. The biological monitoring covers phytoplankton, including primary production measurements, zooplankton, attached and epibenthic organisms, and fish. Laboratory studies are also being conducted on certain important species, to determine the effects of temperature and salinity on growth, survival, and reproduction:

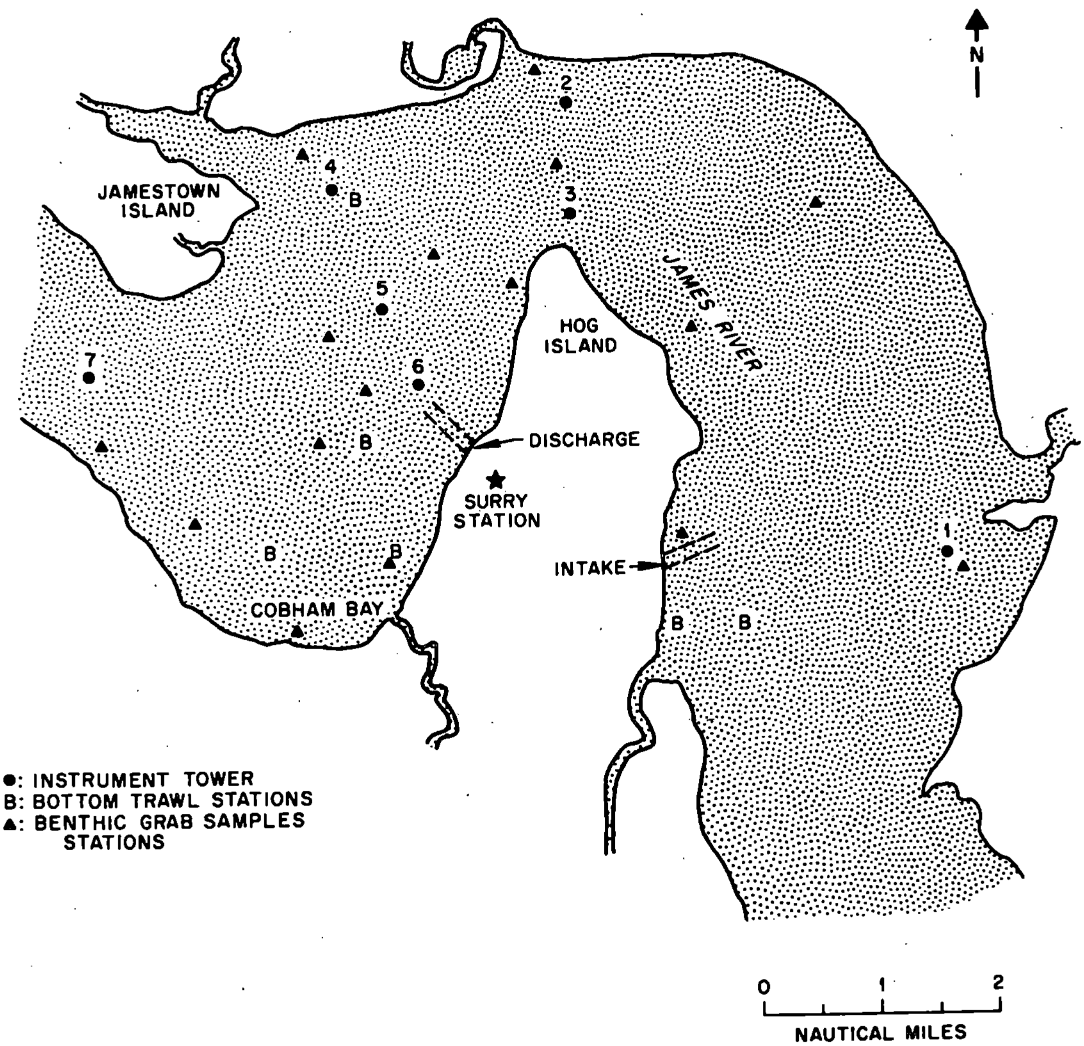


Fig. 5.11. Location of seven instrument towers for temperature and salinity monitoring and biological sampling stations in the James River near the Surry site.

a. Phytoplankton samples are being collected at monthly intervals in the intake canal and at instrument towers 4 and 6. One-liter water samples are collected from mid-depth, preserved, and analyzed for species composition and abundance. The sampling program was begun in January, 1971 and will continue through the postoperational study phase.

b. Zooplankton studies are being taken monthly at the intake canal and at instrument towers 4 and 6. These samples consist of 3 vertical tows at each location using a 30-mesh net with a 1/3-m opening. The samples are preserved and analyzed for species composition.

c. Fouling plates consisting of 125 mm x 75 mm asbestos plates are suspended 1 m above the bottom at instrument towers 1, 4 and 6. Two vertical and two horizontal plates are suspended at each location. One of each pair is left in place for one year to study the succession and development of the attached benthos community, consisting of barnacles, etc. At bimonthly intervals, the other plates are removed and replaced. The plates are frozen and analyzed for species composition.

d. Bottom trawls for sampling epibenthic species, bottom fish, etc., are collected at monthly intervals using a benthic sled with a 2-mm mesh bag. The sled is towed for 5 minutes in shallow and deep water near the intake, in deep water near the discharge, in deep water near instrument 4, and in shallow and deep water in Cobham Bay. The samples are preserved and analyzed for species composition.

e. Primary production rates are measured at 6-week intervals using the ^{14}C method. Water samples are collected from the upper 0.3 meters at instrument towers 4 and 6 and at the intake canal. These are then incubated aboard ship for 4 hours. The water samples are also analyzed for pH, alkalinity, salinity, and temperature at the time of collection.

f. Benthic grab samples are being collected four times a year to survey the benthic and epibenthic invertebrates. Two replicate samples are taken at 16 locations shown in Fig. 5.11. Samples are collected with a 0.07-sq-meter Van Veen grab and preserved, and the organisms are identified and counted.

g. The brackish water clam, Rangia cuneata, the dominant benthic invertebrate in this area of the James River, is the subject of detailed field and laboratory studies being conducted by the Virginia Institute of Marine Science. Marked clams were planted in July, 1971, at several locations in the James River in the vicinity of Hog Island (Fig. 5.12). These clams will be harvested one year later to determine the effects of salinity and substrate on clam growth.

The condition index (clam tissue volume/volume of clam shell cavity) of clams collected at monthly intervals from the same locations as the growth studies (Fig. 5.12) is also being measured. This index

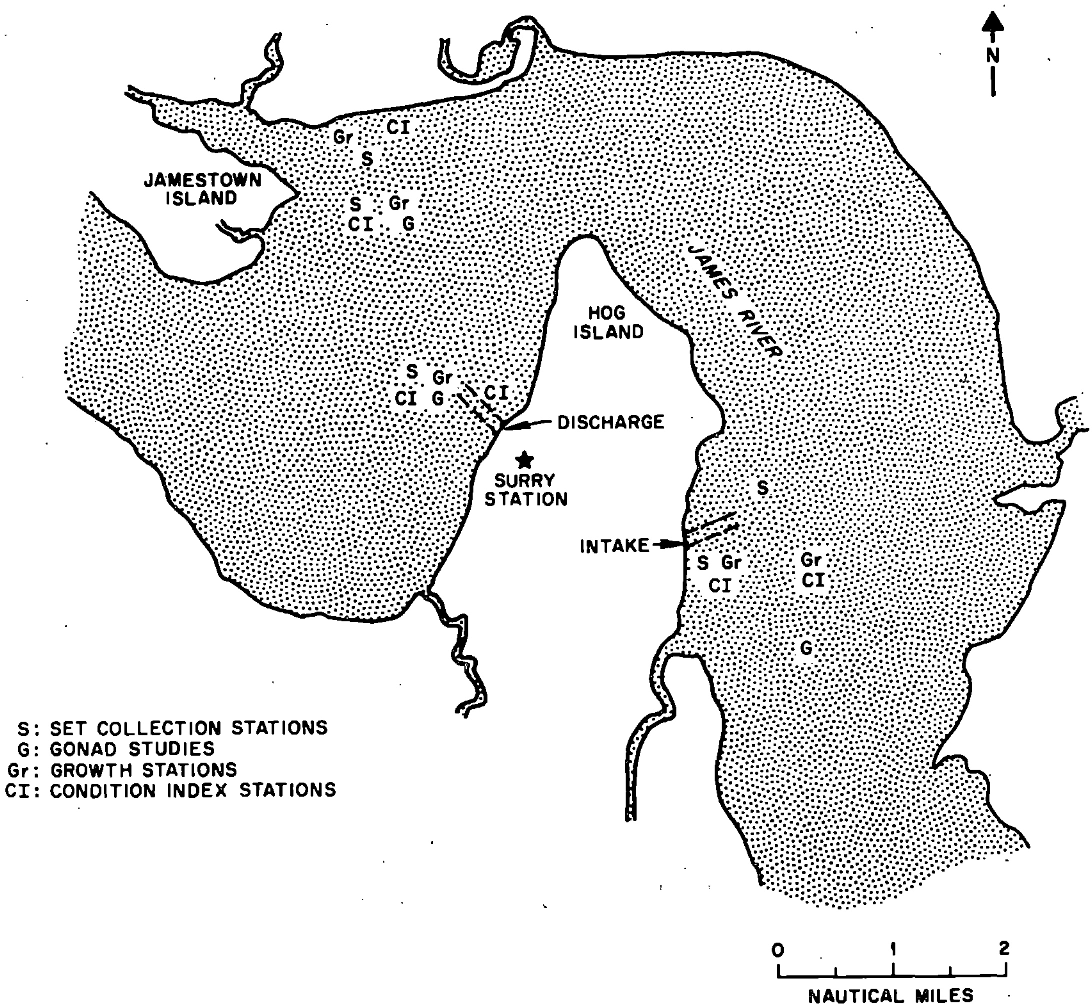


Fig. 5.12. Locations of set collection stations, gonad studies, growth stations, and condition index stations in the James River in the vicinity of Hog Island.

reflects the stored energy over and above that required for maintenance and physiological activities of the organism. A low condition index, for example, would indicate an increased energy demand for maintenance and less energy available for storage. Environmental factors which affect metabolism could significantly alter the condition index if the organisms metabolism and maintenance requirement increased as a result of increased water temperature.

To determine the relationship between environmental changes and gonad development and spawning of Rangia, histological examination of clam gonads is being made. Clams 30 to 40 mm long are collected every two weeks at the intake, the discharge, instrument tower 4, and the mouth of the Chickahominy River (Figs. 2.5 and 5.12). Histological slides of the gonads are made from 20 clams collected at each site, to determine the relationships between the initiation of gonad development and spawning of Rangia and temperature and salinity in the James River.

Set collectors at the same locations described above are sampled every two weeks, in order to determine when swimming larvae of Rangia settle to the bottom and begin adult development. These data can be used as a check on the histological data on gonad development, as well as measure the setting and recruitment patterns of this species at the different locations.

Laboratory studies are also being conducted to determine the best growth and survival of Rangia at 16 different combinations of temperature and salinity. The effects of expected thermal and salinity shock on organisms including oyster and clam larvae are also being measured.

3. Radiological Monitoring

The applicant began a preoperational radiological monitoring program in 1968 to determine background levels in the area of the Surrey Station. A detailed description of the preoperational program and data derived from the program is presented in Appendix C of the applicant's Environmental Report Supplement. Samples of water (river, well, surface), rain, air crops, fowl, oysters, clams, crab, fish, silt, milk and soil have been analyzed. Water samples were analyzed for gross alpha, gross beta, and ^{3}H; air, samples for gross alpha and beta activities; rain for gross beta and ^{3}H; crops, biota, silt and soil for gross beta and gamma spectra; and milk for ^{90}Sr, ^{137}Cs, ^{131}I, and calcium. Ambient gamma background radiation was measured with thermoluminescent dosimeters. The air sampling network was established using average meteorological conditions along with current and projected population densities as criteria for sampling station locations. Water samples and associated biota were collected from locations beginning 11 miles above the station and extending as far as Newport News.

The radiological surveillance program will continue, once the station has begun operations, in the same manner as in the preoperational program, with

Table 5.14. Surry operational environmental radiological monitoring program

Collection frequency:
BW Biweekly
M Monthly
BM Bimonthly
Q Quarterly
SA Semiannually
A Annually

	Air particulates	Ambient external gamma radiation	Precipitation	Milk	Well water	Crops	Surface water	Fowl (coat)	Soil	James River water	Silt	Oysters	Clams	Crabs	Fish
Land-based stations															
1 Surry Station	BW	Q	M		SA				SA						
2 Hog Island Reserve	BW	Q			SA			SA							
3 Bacon's Castle	BW	Q		BM(2)	SA	A(3)			SA						
4 Chippokes Creek							SA								
5 Alliance	BW	Q							SA						
6 Colonial Parkway	BW	Q		BM					SA						
7 Williamsburg							SA								
8 Jamestown					SA										
9 Dow	BW	Q		BM					SA						
10 Fort Eustis	BW	Q							SA						
11 Newport News	BW	Q	M				SA								
12 Smithfield		Q		BM			SA								
13 Richmond															
James River sampling stations															
1 Chickahominy										BM	SA		BM		
2 Cobham Bay										BM					
3 Station discharge										BM	SA		BM		SA
4 Jamestown													BM		
5 Hog Island Point											SA		BM		
6 Station intake										BM	SA				SA
7 Lawnes Creek													BM		
8 Deep Water Shoals												BM		A	
9 Point of Shoals										BM	SA	BM		A	
10 Newport News										BM	SA	BM			

the exception that more detailed analyses by gamma spectrometry will be performed on a number of sample media. A summary of the program, as it is expected to be conducted during this period, is given in Table 5.14.

4. Adequacy of the Monitoring Program

The monitoring program thus far conducted for the Surry Station is adequate for detecting impacts of station operation on most components of the biota in the James River in the area of Hog Island. Some aspects of preoperational sampling and monitoring, however, have been overlooked and should be included in order to measure the potential sources of impact. The following requirements are included in the operating license Technical Specifications:

a. A program for routinely monitoring the quantities of organisms (meroplankton, phytoplankton, zooplankton) entrained in the cooling water system. This program is designed to measure both the physical effects of pumping into the intake canal and the thermal effects of passage through the condensers and out through the discharge canal. These data will be useful in assessing the long-term effects of entraining planktonic organisms, including larvae of fish, clams, oysters, etc., on aquatic populations, which depend on the James River as a feeding, spawning, and nursery area.

b. Pumping tests for cooling water have demonstrated that larger fish will be pumped into the intake canal from the river. Once in the canal, these fish are lost from the estuary, since they are too large to pass through the traveling screens at the plant. Fish killed on the traveling screens or by other operating effects of the station will be identified, counted and reported.

c. Preliminary model studies of thermal plume dispersion from the Surry Station show that, during flood tide, the plume will move upstream into Cobham Bay. All instrument towers for thermal and salinity monitoring are downstream from Cobham Bay, except for tower 7, upstream from Cobham Bay (Fig. 5.11). An instrument tower for thermal and salinity monitoring will be placed in Cobham Bay so that temperature and salinity data for this area will be available should any biological changes occur.

d. In view of the potential for destroying the density flow in this area of the James River by pumping more salt across Gravel Neck than would normally flow around it by density flow, the density flow will be monitored at locations throughout this estuarine segment, particularly during periods when it will be most pronounced (i.e., low flow summer conditions). Since many species rely on the density flow for dispersal to nursery areas (e.g., blue crab), any disruption or alteration of density flows could result in significant impacts on these species.

e. The lack of quantitative data on fish distribution in the vicinity of Hog Island prevents a detailed quantitative assessment of potential impacts of plant operation on fish populations which live in, pass through, or utilize temporarily this area. Potentially, long-term delayed effects on populations of fish in James which utilize this section for a nursery area (e.g., striped bass) may be produced as a result of operation of the Surry Power Station. Therefore, a program will be initiated for determining the seasonal and spatial distribution of fish (eggs, larvae, juveniles, and adults) in this section of the James River. Many of the monitoring programs previously described (e.g., bottom sled) will sample some of these components, but a specific effort will be made to sample over an annual cycle the adult, larval, and egg stages of fish.

f. Should the applicant use chlorination as a biocide treatment of the condenser cooling system, a chlorine monitoring program will be established prior to use. Monitoring will include chlorine demand in the intake water, as well as residual chlorine levels at various locations in the discharge canal. The amounts of chlorine used will also be recorded.

G. TRANSPORTATION OF NUCLEAR FUEL AND SOLID RADIOACTIVE WASTE

The nuclear fuel for the two reactors at Gravel Neck in Surry County, Virginia is slightly enriched uranium in the form of sintered uranium oxide pellets encapsulated in zircaloy fuel rods. Each year, with both reactors in normal operation, about 50 metric tons of fuel will be replaced.

The applicant has indicated that cold (new) fuel for the reactor will be transported about 400 miles by truck from Columbia, South Carolina, to the plant site. Irradiated (used) fuel will be transported by truck to Barnwell, South Carolina, a distance of about 500 miles; the solid radioactive wastes will be shipped to Morehead, Kentucky, for disposal, a distance of about 500 miles. The applicant has indicated the cold fuel will be transported from Columbia, South Carolina to Surry via routes U.S. 76/378, I-95, U.S. 40, Va. 10 and Va. 650. The irradiated fuel will be transported to Barnwell, South Carolina via routes Va. 650, Va. 10, I-95 and S.C. 64, avoiding heavily populated and congested areas wherever possible. Solid wastes will be transported to Morehead, Kentucky via routes Va. 650, Va. 10, I-95, I-64, I-81, I-77 and I-64.

1. Transport of Cold (New) Fuel

The applicant has indicated that cold fuel will be shipped in Westinghouse Model RCC or RCC-1 shipping containers approved for use under DOT Special Permit #5450. Each container holds two fuel elements. Eight truckloads of 7 containers each will be required each year.

2. Transport of Irradiated Fuel

Fuel elements removed from the reactor will be unchanged in appearance and will contain some of the original U-235 (which is recoverable). As a result of the irradiation and fissioning of the uranium, the fuel element will contain large amounts of fission products and some plutonium. As the radioactivity decays, it produces radiation and "decay heat." The amount of radioactivity remaining in the fuel varies according to the length of time after discharge from the reactor. After discharge from a reactor, the fuel elements are placed under water in a storage pool for cooling prior to being loaded into a cask for transport.

Although the specific cask design has not been identified, the applicant states that the irradiated fuel elements will be shipped, after 4 or 5 months cooling period, in approved casks designed for transport by truck. The cask will weigh perhaps 30 tons and carry 1 fuel element. To transport the irradiated fuel, the applicant estimates 104 truckload shipments per year. An equal number of shipments will be required to return the empty casks.

3. Transport of Solid Radioactive Wastes

The solid wastes generated by the two units will be shipped in 55-gallon drums or other packages approved for transport of the activities involved. The applicant has estimated that about 60 truckloads will be required to ship the solid wastes to the burial grounds each year from both reactors. About one-half of the shipments will be drums of evaporator bottoms and low level rubbish, one-third will be filter assembly casks and one-sixth will be resins in shielded casks.

4. Principles of Safety in Transport

Protection of the public and transport workers from radiation during the shipment of nuclear fuel and waste is achieved by a combination of limitations on the contents (according to the quantities and types of radioactivity), the package design, and the external radiation levels. Shipments move in routine commerce and on conventional transportation equipment. Shipments are therefore subject to normal accident environments, just like other nonradioactive cargo, and the shipper has essentially no control over the likelihood of an accident. Safety in routine transportation does not depend on special routing.

Packaging and transport of radioactive materials are regulated at the Federal level by both the Atomic Energy Commission (AEC) and the Department of Transportation (DOT). In addition, certain aspects, such as limitations on gross weight of trucks, are regulated by the States.

The probability of accidental releases of low level contaminated material is sufficiently small that, considering the form of the waste, the likelihood of significant exposure is extremely small. Packaging for these materials is designed to remain leakproof under normal transport conditions of temperature, pressure, vibration, rough handling, exposure to rain, etc. The packaging may release its contents in an accident.

For larger quantities of radioactive materials, the packaging design (Type B packaging) must be capable of withstanding, without loss of contents or shielding, the damage which might result from a severe accident. Test conditions for packaging are specified in the regulations and include tests for high-speed impact, puncture, fire, and immersion in water.[81]

In addition, the packaging must provide adequate radiation shielding to limit the exposure of transport workers and the general public. For irradiated fuel, the package must have heat-dissipation characteristics to protect against overheating from radioactive decay heat. For fresh and irradiated fuel, the design must also provide nuclear criticality safety under both normal and accident damage conditions.

Each package in transport is identified with a distinctive radiation label on two sides, and by warning signs on the transport vehicle.

Based on the truck accident statistics for 1969,[82] a shipment of fuel or waste from a reactor may be expected to be involved in an accident about once every six years. In case of an accident, procedures which carriers are required[83] to follow will reduce the consequences of an accident in many cases. The procedures include segregation of damaged and leaking packages from people, and notification of the shipper and the Department of Transportation. Radiological assistance teams are available through an inter-Governmental program to provide equipped and trained personnel. These teams, dispatched in response to calls for emergency assistance, can mitigate the consequences of an accident.

5. Exposures During Normal (No Accident) Conditions

a. Cold Fuel

Since the nuclear radiations and heat emitted by cold fuel are small, there will be essentially no effect on the environment during transport under normal conditions. Exposure of individual transport workers is estimated to be less than 1 millirem (mrem) per shipment. For the 7 shipments, with two drivers for each vehicle, the total dose would be about 0.01 man-rem* per year. The radiation level associated with each truckload of cold fuel will be less than 0.1 mrem/hr at 6 feet from the truck. A member of the general public who spends 3 minutes at an average distance of 3 feet from the truck might receive a dose of about 0.005 mrem per shipment. The dose to other persons along the shipping route would be extremely small.

b. Irradiated Fuel

Based on actual radiation levels associated with shipments of irradiated fuel elements, we estimate the radiation level at 3 feet from the truck

*Man-rem is an expression for the summation of whole body doses to individuals in a group. In some cases, the dose may be fairly uniform and received by only a few persons (e.g., drivers and brakemen) or, in other cases, the dose may vary and be received by a large number of people (e.g., 105 persons along the shipping route).

will be about 25 mrem/hr. The individual truck driver would be unlikely to receive more than about 30 millirem in the 500-mile shipment. For the 104 shipments by truck during the year with 2 drivers on each vehicle, the total dose would be about 6 man-rem per year.

A member of the general public, who spends 3 minutes at an average distance of 3 feet from the truck, might receive a dose of as much as 1.3 mrem. If 10 persons were so exposed per shipment, the total annual dose for the 104 shipments by truck would be about 1.4 man-rem. Approximately 150,000 persons who reside along the 500-mile route over which the irradiated fuel is transported might receive an annual dose of about 1.3 man-rem. The regulatory radiation level limit of 10 mrem/hr at a distance of 6 feet from the vehicle was used to calculate the integrated dose to persons in an area between 100 feet and 1/2 mile on both sides of the shipping route. It was assumed that the shipment would travel 200 miles per day and the population density would average 330 persons per square mile along the route.

The amount of heat released to the air from each cask will be about 30,000 Btu's/hr. For comparison, 35,000 Btu's/hr is about equal to the heat released from an air conditioner in an average size home. Although the temperature of the air which contacts the loaded cask may be increased a few degrees, because the amount of heat is small and is being released over the entire transportation route, no appreciable thermal effects on the environment will result.

c. Solid Radioactive Wastes

About 60 truckloads of solid radioactive wastes will be shipped to a disposal site each year. Under normal conditions, the individual truck driver might receive as much as 15 mrem per shipment. If the same driver were to drive 25 truckloads in a year, he could receive an estimated dose of about 400 mrem during the year. A total dose to all drivers for the year, assuming 2 drivers per vehicle, might be about 1.8 man-rem.

A member of the general public who spends 3 minutes at an average distance of 3 feet from the truck might receive a dose of as much as 1.3 mrem. If 10 persons were so exposed per shipment, the total annual dose for the 60 shipments by truck would be about 0.8 man-rem. Approximately 150,000 persons who reside along the 500-mile route over which the solid radioactive waste is transported might receive an annual dose of about 0.8 man-rem. These doses were calculated for persons in an area between 100 feet and 1/2 mile on either side of the shipping route, assuming 330 persons per square mile, 10 mrem/hr at 6 feet from the vehicle, and the shipment traveling 200 miles per day.

VI ENVIRONMENTAL IMPACT OF POSTULATED ACCIDENTS

A. PLANT ACCIDENTS

A high degree of protection against the occurrence of postulated accidents at the Surry Power Station, Units 1 and 2, is provided through correct design, manufacture, and operation, and the quality assurance program used to establish the necessary high integrity of the reactor system, as considered in the Commission's Safety Evaluation dated February 23, 1972. Deviations from established operating parameters that may occur are handled by protective systems to place and hold the plant in a safe condition. Notwithstanding this, the conservative postulate is made that serious accidents might occur, in spite of the fact that they are extremely unlikely. Engineered safety features are installed to mitigate the consequences of these postulated events and proper operation of this equipment is assumed in the analysis of accident consequences.

The probability of occurrence of accidents and the spectrum of their consequences to be considered from an environmental effects standpoint have been analyzed using best estimates of probabilities and realistic fission product release and transport assumptions. For site evaluation in the Commission's safety review, extremely conservative assumptions were used for the purpose of comparing calculated doses resulting from a hypothetical release of fission products from the fuel, against the 10 CFR Part 100 siting guidelines. The computed doses that would be received by the population and environment from actual accidents will be significantly less than those presented in the Safety Evaluation.

The Commission issued guidance to applicants on September 1, 1971, requiring the consideration of a spectrum of accidents with assumptions as realistic as the state of knowledge permits. The applicant's response was contained in Applicant's Environmental Report Supplement Volume 1, dated December 1, 1971.

The applicant's report has been evaluated using the standard accident assumptions and guidance issued as a proposed annex to Appendix D to 10 CFR Part 50 by the Commission on December 1, 1971. Nine classes of postulated accidents and occurrences ranging in severity from trivial to very serious were identified by the Commission. In general, accidents in the high potential consequence end of the spectrum have a low occurrence rate and those on the low potential consequence end have a higher occurrence rate. The examples selected by the applicant for these cases are shown in Table 6.1. The examples selected are reasonable homogeneous in terms of probability within each class, although we consider the steam generator tube rupture as more appropriately in Class 5. Certain assumptions made by the applicant do not exactly agree with those in the proposed annex to Appendix D, but the use of alternative assumptions does not significantly affect overall environmental risk.

Commission estimates of the dose which might be received by an assumed individual standing at the site boundary in the downwind direction, using the assumptions in the proposed annex to Appendix D, are presented in Table 6.2. Estimates of the integrated exposure that might be delivered to the population within fifty miles of the site are also presented in Table 6.2. The man-rem estimate was based on the projected population around the site for the year 1980.

To rigorously establish a realistic annual risk, the calculated doses in Table 6.2 would have to be multiplied by estimated probabilities. The events in Classes 1 and 2 represent occurrences which are anticipated during plant operation and their consequences, which are very small, are considered within the framework of routine effluents from the plant. Except for a limited amount of fuel failures and some steam generator leakage, the events in Classes 3 through 5 are not anticipated during plant operation but events of this type could occur sometime during the 40 year plant lifetime. Accidents in Classes 6 and 7 and small accidents in Class 8 are of similar or lower probability than accidents in Classes 3 through 5 but are still possible. The probability of occurrence of large Class 8 accidents is very small. Therefore, when the consequences indicated in Table 6.2 are weighted by probabilities, the environmental risk is very low. The postulated occurrences in Class 9 involve sequences of successive failures more severe than those required to be considered in the design basis of protective systems and engineered safety features. Their consequences could be severe. However, the probability of their occurrence is so small that their environmental risk is extremely low. Defense in depth (multiple physical barriers), quality assurance for design, manufacture and operation, continued surveillance and testing, and conservative design are all applied to provide and maintain the required high degree of assurance that potential accidents in this class are, and will remain, sufficiently small in probability that the environmental risk is extremely low.

Table 6.2 indicates that the realistically estimated radiological consequences of the postulated accidents would result in exposures of an assumed individual at the site boundary to concentrations of radioactive materials within the Maximum Permissible Concentrations (MPC) of Appendix B, Table II, 10 CFR Part 20. Table 6.2 also shows that the estimated integrated exposure of the population within fifty miles of the plant from each postulated accident would be orders of magnitude smaller than that from naturally occurring radioactivity, which corresponds to approximately 190,000 man-rem per year, based on a natural background of 100 mrem per year. When considered with the probability of occurrence, the annual potential radiation exposure of the population from all postulated accidents is an even smaller fraction of the exposure from natural background radiation and, in fact, is well within the naturally occurring variations in the natural background. It is concluded from the results of this analysis that the environmental risks due to postulated radiological accidents are exceedingly small.

TABLE 6.1

CLASSIFICATION OF POSTULATED ACCIDENTS AND OCCURRENCES

Class	AEC Description	Applicant's Example(s)
1.0	Trivial incidents	Small spills, small leaks inside containment
2.0	Small releases outside containment	Spills, leaks, and pipe breaks
3.0	Radwaste system failures	Equipment failure, serious malfunction, or human error
4.0	Fission products to Primary System (BWR)	Fuel failures during normal operation, transients outside expected range of variables
5.0	Fission products to Primary and Secondary Systems (PWR)	Fuel failure during normal operation, transients outside expected range of variables, and heat exchanger leak
6.0	Refueling accident	Dropped fuel element, dropped heavy object onto fuel, mechanical malfunction or loss of cooling in transfer tube
7.0	Spent fuel handling accident	Dropped fuel element, dropped heavy object onto fuel, dropped shielding cask, loss of cooling to cask, transportation incident onsite
8.0	Accident initiation events considered in design basis evaluation in the SAR	Reactivity transient, rupture of primary piping, flow decrease, steam line break, steam generator tube rupture
9.0	Hypothetical sequence of failures more severe than Class 8	Successive failures of multiple barriers normally provided and maintained

TABLE 6.2

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

Class	Event	Estimated fraction of 10 CFR Part 20[1] at site boundary	Estimated dose to population in 50 mile radius, man-rem
1.0	Trivial incidents	2/	2/
2.0	Small releases outside containment	2/	2/
3.0	Radwaste system failures		
3.1	Equipment leakage or malfunction	0.1	4.2
3.2	Release of waste gas storage tank contents	0.4	17
3.3	Release of liquid waste contents	0.011	0.46
4.0	Fission products to primary system (BWR)	N.A.	N.A.
5.0	Fission products to primary and secondary systems (PWR)		
5.1	Fuel cladding defects and steam generator leaks	2/	2/
5.2	Off-design transients that induce fuel failure above those expected and steam generator leak	0.002	0.1
5.3	Steam generator tube rupture	0.13	5.5

1/ Represents the calculated fraction of a whole body dose of 500 mrem or the equivalent dose to an organ.

2/ The releases are expected to be in accord with proposed Appendix I for routine effluents (i.e., 5 mrem per year to an individual from all sources).

TABLE 6.2 (cont'd)

Class	Event	Estimated fraction of 10 CFR Part 20 limit at site boundary[1/]	Estimated dose to population in 50-mile radius, man-rem
6.0	Refueling accidents		
6.1	Fuel bundle drop	0.022	0.88
6.2	Heavy object drop onto fuel in core	0.37	15
7.0	Spent fuel handling accident		
7.1	Fuel assembly drop in fuel rack	0.013	0.55
7.2	Heavy object drop onto fuel rack	0.054	2.2
7.3	Fuel cask drop	N.A.	N.A.
8.0	Accident initiation events considered in design bases analysis report SAR		
8.1	Loss-of Coolant Accidents		
	Small break	0.22	17
	Large break	0.071	5.5
8.1(a)	Break in instrument line from primary system that penetrates the containment	N.A.	N.A.
8.2(a)	Rod injection accident (PWR)	0.007	0.55
8.2(b)	Rod drop accident (BWR)	N.A.	N.A.
8.3(a)	Steam line breaks (PWR's outside containment)		
	Small break	<0.001	<0.1
	Large break	0.001	<0.1
8.3(b)	Steam line break (BWR)	N.A.	N.A.

B. TRANSPORTATION ACCIDENTS

1. Cold (New) Fuel Exposures

The cold fuel has been described in Section V.G.1. Under accident conditions other than accidental criticality, the pelletized form of the nuclear fuel, its encapsulation, and the low specific activity of the fuel, limit the radiological impact on the environment to negligible levels.

The packaging is designed to prevent criticality under normal and severe accident conditions. To release a number of fuel assemblies under conditions that could lead to accidental criticality would require severe damage or destruction of more than one package, which is unlikely to happen in other than an extremely severe accident.

The probability that an accident could occur under conditions that could result in accidental criticality is extremely remote. If criticality were to occur in transport, persons within a radius of about 100 feet from the accident might receive a serious exposure but beyond that distance, no detectable radiation effects would be likely. Persons within a few feet of the accident could receive fatal or near-fatal exposures unless shielded by intervening material. Although there would be no nuclear explosion, heat generated in the reaction would probably separate the fuel elements so that the reaction would stop. The reaction would not be expected to continue for more than a few seconds and normally would not recur. Residual radiation levels due to induced radioactivity in the fuel elements might reach a few roentgens per hour at 3 feet. There would be very little dispersion of radioactive material.

2. Irradiated Fuel Exposures

Effects on the environment from accidental releases of radioactive materials during shipment of irradiated fuel (see Section V.G.2) have been estimated for the situation where contaminated coolant is released and the situation where gases and coolant are released.

a. Leakage of contaminated coolant resulting from improper closing of the cask is possible as a result of human error, even though the shipper is required to follow specific procedures which include tests and examination of the closed container prior to each shipment. Such an accident is highly unlikely during the 40-year life of the plant.

Leakage of liquid at a rate of 0.001 cc per second or about 80 drops/hour is about the smallest amount of leakage that can be detected by visual observation of a large container. If undetected leakage of contaminated liquid coolant were to occur, the amount would be so small that the individual exposure would not exceed a few mrem and only a very few people would receive such exposures.

b. Release of gases and coolant is an extremely remote possibility. In the improbable event that a cask is involved in an extremely severe accident such that the cask containment is breached and the cladding of the fuel assemblies penetrated, some of the coolant and some of the noble gases might be released from the cask.

In such an accident, the amount of radioactive material released would be limited to the available fraction of the noble gases in the void spaces in the fuel pins and some fraction of the low level contamination in the coolant. Persons would not be expected to remain near the accident due to the severe conditions which would be involved, including a major fire. If releases occurred, they would be expected to take place in a short period of time. Only a limited area would be affected. Persons in the downwind region and within 100 feet or so of the accident might receive doses as high as a few hundred millirem. Under average weather conditions, a few hundred square feet might be contaminated to the extent that it would require decontamination (that is, Range I contamination levels) according to the standards[1] of the Environmental Protection Agency.

3. Solid Radioactive Waste Exposures

It is highly unlikely that a shipment of solid radioactive waste will be involved in a severe accident during the 40-year life of the plant. If a shipment of low-level waste (in drums) becomes involved in a severe accident, some release of waste might occur but the specific activity of the waste will be so low that the exposure of personnel would not be expected to be significant. Other solid radioactive wastes will be shipped in Type B packages. The probability of release from a Type B package, in even a very severe accident, is sufficiently small that, considering the solid form of the waste and the very remote probability that a shipment of such waste would be involved in a very severe accident, the likelihood of significant exposure would be extremely small.

In either case, spread of the contamination beyond the immediate area is unlikely and, although local clean-up might be required, no significant exposure to the general public would be expected to result.

4. Severity of Postulated Transportation Accidents

The events postulated in this analysis are unlikely but possible. More severe accidents than those analyzed can be postulated and their consequences could be severe. Quality assurance for design, manufacture, and use of the packages, continued surveillance and testing of packages and transport conditions, and conservative design of packages ensure that the probability of accidents of this latter potential is sufficiently small that the environmental risk is extremely low. For those reasons, more severe accidents have not been included in the analysis.

5. Alternatives to Normal Transportation Procedures

Alternatives, such as special routing of shipments, providing escorts in separate vehicles, adding shielding to the containers, and constructing a fuel recovery and fabrication plant on the site rather than shipping fuel to and from the station, have been examined. The impact on the environment of transportation under normal or postulated accident conditions is not considered to be sufficient to justify the additional effort required to implement any of the alternatives.

VII. ADVERSE EFFECTS WHICH CANNOT BE AVOIDED

Essentially all of the impacts resulting from operation of the Surry Power Station will be borne by the local aquatic ecosystems in the James River.

In order to minimize thermal effects on oyster seedbeds downstream, the condenser cooling water system for the station was constructed so as to discharge heated water 5.7 miles upstream from the intake. This arrangement will increase the mortality of both large and small forms of aquatic life because some of them will be cycled more than once through the plant. However, at a dilution flow of 20,000 cfs expected as the minimum, the probability of entrainment is less than 16% when both units are operating (Table 5.3). This amount of loss is not likely to seriously diminish the food chain in the overall estuary. Nevertheless, the applicant will be required to conduct an extensive monitoring program to verify the predictions and to modify plant operation if its impact is found unacceptable.

Some adult fish will be pumped into the intake canal and will be lost through impingement on the intake screens. If the air-bubble diversion scheme being tested at the river intake proves unsuccessful in minimizing this impact, a fish by-pass arrangement from the intake canal to the river can be constructed.

It is likely that commercially important species such as the striped bass and blue crab will be affected by plant operation, resulting in a decrease in local populations of these species. Other species may also be affected either as a result of direct mortality or indirectly through alteration of species productivity by alteration of food chain components. Alteration or destruction of the density flow in the area extending from the intake to the discharge, causing this portion to behave as a well-mixed estuary, would be reflected in a decrease in several ecologically and economically important species including the oyster, blue crab, striped bass, croaker, spot, and hogchoker. The oyster ground at Deep Water Shoal also is likely to experience some damage if the density flow and salinity distribution is altered or destroyed, since oyster larvae rely on this flow as an essential means of dispersion as they seek the optimal salinity for growth and development.

The effects of cumulative and repetitive impacts due to thermal stresses and possible alteration of salinity distribution patterns cannot be predicted accurately or quantified due to the lack of sufficient baseline data. As a result, the impact of the Surry Station on the aquatic environment will not be fully known until operational experience has developed.

Any adverse effects on the terrestrial environment have largely occurred during construction of the station and its associated transmission facilities.

Even though the applicant reduced the height of the station structures in an attempt to minimize the profile of the station above the treetops, the reactor containment vessels remain visible from the Colonial Parkway and Jamestown Island on the north side of the James River and also from the Scotland-Jamestown Ferry. It is our opinion that this exposure is inoffensive and will not disturb tourists who are on the north bank of the James River.

Land cleared for transmission lines will be available for agricultural uses such as cattle grazing or crops that are compatible with the safety requirements set by the applicant; however, applications of broad-spectrum herbicides for control of woody vegetation may discourage the use of right-of-way as habitats by animals. An effort is being made to minimize the visual impact of the transmission towers by the use of steel that oxidizes to a russet color. The applicant is aware of the preferred criteria for siting transmission lines(1) and has kept them away from scenic and historic sites.

VIII. SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The environs of the Surry Power Station have been altered principally through the excavation of the intake and discharge canals and the foundations for larger buildings. The tip of Gravel Neck Peninsula has been effectively converted into an extension of Hog Island through the use of the excavated dirt to build up a protective levee that also serves as a road to the far end of Hog Island. These modifications are considered to be permanent, but are beneficial to the establishment of Hog Island as a waterfowl refuge.

The land on which the station is being built was previously part of a privately owned tract that was harvested for pulpwood and lumber. Consequently, the acreage available for timbering use has been decreased; however, this loss does not appear to be significant to the economy of Surry County where there are currently 136,000 acres of forest land. Because of the low demand and the poor quality of these forests, lumbering activities remain at a low level (four companies employ less than a total of 100 people with combined incomes of about $100,000 per year).[1] Similarly, the loss of trees within the 3543 acres of transmission line rights-of-way in Surry, Isle of Wight, Sussex and Prince George counties will represent a small fraction of the 600,000 acres of forest in these counties. Some improvement in the quality of these forests may be achieved through the applicant's policy of contributing $25 per acre to a landowner for the reforestation of pineland equivalent to the acreage removed from production because of clearing for transmission line rights-of-way.[2] Since these corridors remain the property of the individual landowners, they may use the land for any agricultural endeavor that is compatible with safety requirements set by the applicant. Another incentive payment ($75 to $100 per acre) is offered by the applicant to landowners who will remove the stumps from the right-of-way on their property and convert this land from brush growth to seed crops so as to provide a cover that will keep out woody growth and prevent erosion.[2] These corridors will act as fire lands in thickly forested sections and afford additional "edge growth" for small animals.

The applicant has drilled four wells into the cretaceous artesian aquifers approximately 400 feet below the surface of the plant site. One of these wells is being used on a temporary basis at the concrete batch plant; the others will be used permanently to furnish water for the visitors' center and makeup water for the station. This extensive aquifer supplies water to both municipal and industrial users throughout the tidewater area. The amount withdrawn daily at the Surry Station will be very small in comparison with some of the industrial wells nearby and will not have any appreciable influence on the total output of this aquifer.

Approximately 400 acres of Gravel Neck have been cleared for the various components of the Surry Station, and the upper portion of the peninsula has been effectively severed by the intake and discharge canals. Although minor erosion of the exposed land has occurred, this problem is being controlled by seeding cleared areas and by forming concrete sidings and floors for the canals so that long-range deterioration will be essentially nil. The canals may have diverted the course of some groundwater that moved toward Hog Island through the Norfolk formation; however, because of the relatively narrow width (2 miles) of Gravel Neck, this groundwater is also free to flow east or west into the James River. There have been no impacts on the land or water resources of Gravel Neck south of the site boundary.

The canals and their protective fences will limit movement between Hog Island Waterfowl Refuge and the mainland, since passage for both man and animals is possible only by means of the bridge over the discharge canal. This impediment is not considered important, except that the existing ecological balance may be altered, especially as regards such land animals as deer and rabbits.

The recreational value of Cobham Bay and the riverfront west of Gravel Neck is based primarily on swimming, boating, and fishing. The outflow of cooling water from the Surry Station will cause a 4 to 5°F rise in the temperature of the water in this region. Consequently, in this limited area, the temperature of the James will be 70°F or higher from early in May until late September or early October, thereby extending the recreational season. This effect may benefit the plans of the State of Virginia to construct water recreation facilities as part of the new Chippokes Plantation State Park.[3]

Consideration must be given to the effect of the Surry Station on the budding tourist industry of Surry County and the well-established and rapidly growing tourism in James City and York Counties. Most of the interest and income is generated by the authentic colonial sites that have been well preserved or carefully restored and are displayed in a manner that is both educational and pleasing. The site of the Surry Station is separated by at least two miles of forest from the closest tourist site (Chippokes Plantation) in Surry County, and the station is not visible more than 1000 yards away from the exclusion area.

There is no indication that the Surry Station will have any detrimental short-term or long-term effect on the industrialization of Surry County or the counties on the north bank of the James River or upon the use of the river itself. It is evident that the additional tax revenue will be the greatest impact of the Surry Station on Surry County. This additional income should permit the people of Surry County to accomplish many things that could never be achieved under their current depressed agricultural economy.

Although the applicant has not drawn up plans for doing so, the site of the Surry Power Station could be returned to a natural setting at the end of the station's useful life. Plans for this type of reconversion will require that necessary precautions be taken to remove all radioactive materials, including the earth itself, or that alternative plans be made to isolate all contaminated material.

IX. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

A large quantity of concrete, various metals, and other construction material was used to build the Surry Power Station. When the station is decommissioned, much of this material might be recovered; however, the reactor vessels and adjacent shields would be irretrievable for several decades because of activation of long half-life materials during operation. Most of the buildings could be used for industrial purposes and the surrounding land could be restored to agricultural use.

The life of the station is estimated to be 30 years. During this period, assuming a fuel with 3.1% enrichment, the applicant estimates that 15,900 kg of uranium and 9100 kg of plutonium will be consumed (if plutonium is not recycled). Of the more valuable strategic metals, 200 lb of cadmium, 22,000 lb of nickel, and 370,000 lb of zirconium will also be used in fuel elements and other components of the core.[1]

Small losses of aquatic biota are expected as a result of station operation, but cannot be quantified at this time due to lack of data. Areas cleared for transmission lines may enhance wildlife resources rather than remove it, since ecologists have found that ecotones develop along rights-of-way. The trees removed were of low quality and constitute less than 1% of the commercial forest in Dinwiddie, Greenville, Prince George, Surry and Sussex Counties.

X. NEED FOR THE SURRY POWER STATION

Virginia Electric and Power Company (Vepco) is a state-and federally-regulated utility engaged in the generation and distribution of electric energy as needed by the people and industry of an area comprising the most populated portions of Virginia, the northeast corner of North Carolina, and a small segment of West Virginia, as shown in Fig. 10.1. Vepco generates about 99% of the electric power in this area,[1] which is designated by the Federal Power Commission (FPC) as Power Supply Area No. 18 (PSA-18) of the Southeast Region (Region III).[2] The area served by the applicant includes a population of about 3.5 million and major industrial complexes involved with tobacco products, chemical products, textiles, wood and paper pulp, electrical and mechanical equipment, petroleum products, shipbuilding, and food products. In addition to direct sales to individual consumers, the applicant distributes electric energy for resale to 21 municipal systems and 19 cooperatives.[3]

A. PAST GROWTH OF THE POWER SYSTEM

The growth of the Vepco system is shown in Table 10.1 for the years 1960 to 1972.[1] This table shows that the power consumption and peak load in the Vepco service area have almost tripled in 11 years. The doubling time is barely over seven years, which indicates an average annual growth rate of about 10%, as compared with the national power consumption growth rate of 8%.[4] The higher growth rate for the Vepco System is a reflection of the 17.2% population growth rate of Virginia, compared with the national population growth rate of 13.3% for the decade 1960 to 1970.

The applicant serves 75% of the population of Virginia, including the urban corridor shown in Fig. 10.1 which contains about 59% of the state's population.[5] Our analysis of the 1970 population[6] indicates that the population growth in Virginia was concentrated in the following general areas:

a. West and south of Alexandria: the counties of Arlington, Fairfax, Loudoun, Prince William, and Stafford and the cities of Alexandria and Fairfax, had a combined population growth rate of 47.5% during the decade.

b. Urban area around Richmond and Petersburg: the counties of Chesterfield, Hanover, Henrico, and Prince George, and the cities of Richmond, Petersburg, and Hopewell had a combined population growth rate of 16%.

c. Peninsula northwest of Hampton: the counties of James City and York and the cities of Hampton, Newport News, and Williamsburg had a combined population growth of nearly 24%.

d. The cities of Norfolk, Portsmouth, Virginia Beach, and Chesapeake had a combined population growth of 17.6%.

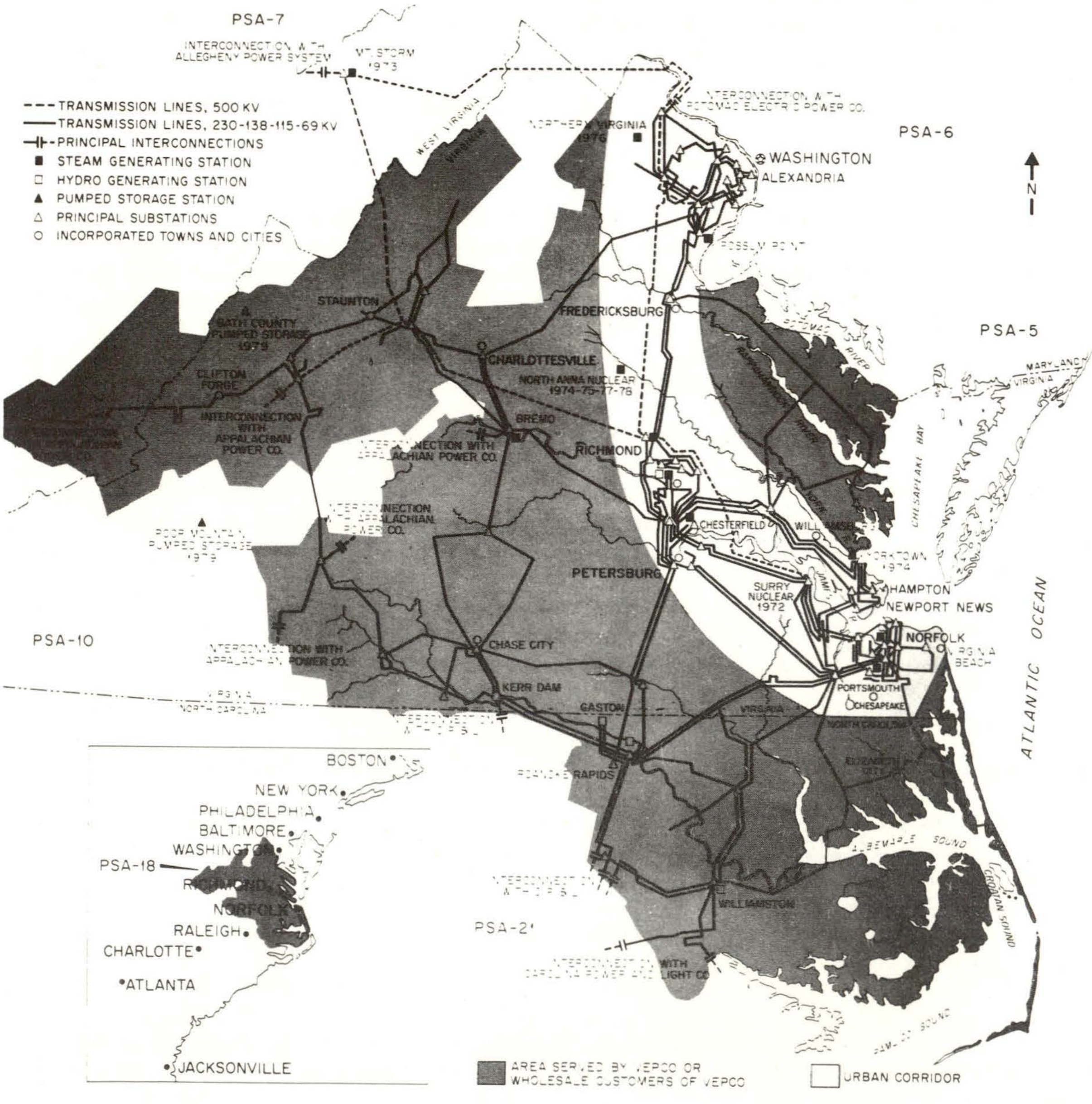


Fig. 10.1. Virginia Electric and Power Company service area map, showing existing and planned generating stations, transmission routes, and interconnections with other utilities.

The population growth in the remainder of the Vepco service area can be characterized as follows:

a. Counties having established industrial communities generally increased in population, as illustrated by the county of Albemarle and the city of Charlottesville.

b. Counties without an industrial base declined in population, as illustrated by the fact that outside of the urban corridor the majority of counties declined in population.

The annual growth rates of power distributed and peak load exhibit wide variations which are attributed to daily, seasonal, and yearly variations in weather conditions and/or economic parameters. However, the primary conclusion to be derived from analysis of these figures is that a fixed average annual growth rate can be used to determine power supply needs for five to ten years in the future, but decisions relating to power needs of the more immediate future need to take into consideration the possibility of weather conditions and business cycles that create unusually high peak demand. Such an event occurred in the applicant's service area during the "hot" summer of 1968, when a 21.5% increase in peak demand was observed over that of 1967. In view of the 1971 increase of 9.1% during a "cool" summer, the applicant's forecast of a 19% increase for the 1972 summer peak may be a prudent precaution.

Of crucial importance to an electric utility is the amount of generating reserve capacity. This is the generating capability or power available in excess of the peak load. Except for 1961, the applicant maintained an adequate reserve capacity from 1960 through 1967 by timely additions to existing fossil-fueled plants at the Portsmouth Station (1962) and the Possum Point Station (1962), supplemented by installation of gas-turbine generator peaking facilities, and by the construction of the coal mine-mouth Mt. Storm Station in West Virginia (1966). However, beginning with 1968 when the unusual increase occurred in the peak load, the applicant has experienced increasing difficulty in meeting the power demand of its service area. Although an addition to the Chesterfield power plant in 1969 temporarily helped the situation, the utility has since been forced to increase its purchases of power from other utilities each succeeding year, in order to be assured of having sufficient reserve capacity in case of forced outages of generating equipment or unpredictable high power demand.

It can be seen from Table 10.1 that, in recent years, the reserve capacity of the power system has been less than the quantity of power purchased. This is an undesirable situation for a power supply system for the following reasons:

a. Purchased power is less reliable due to the greater number of interconnecting relay stations and exposure of transmission lines between the generating stations and the load.

Table 10.1 Virginia Electric and Power Company generating capability, power interchange, power demand, and reserve capacity at peak load since 1960.

Year	Vepco generating capacity [MW(e)]	Actual purchase (or sale) [MW(e)]	Total power available [MW(e)] (*a*)	Peak load [MW(e)] (*b*)	Annual growth of peak load (%)	Reserve capacity		Power distributed in service area for year (billions of kilowatt-hours)	Annual growth of power distributed (%)
						MW(e) (*a* – *b*)	Percent of peak load		
1960	1978	109	2087	1772		315	17.8	9.05	
1961	1922	127	2049	1925	8.6	124	6.4	9.88	9.2
1962	2362	127	2489	2081	8.1	408	19.6	10.83	9.6
1963	2584	127	2711	2316	11.3	395	17.0	11.88	9.8
1964	2899	127	3026	2510	8.4	516	20.6	13.12	10.4
1965	3159	131	3290	2900	15.5	390	13.4	14.64	11.6
1966	3961	131	4092	3320	14.5	772	23.2	16.42	12.1
1967	4040	(78)	3962	3499	5.4	463	13.2	17.82	8.5
1968	4131	200	4331	4253	21.5	78	1.8	20.47	14.9
1969	4910	(34)	4876	4639	9.1	237	5.1	22.73	11.0
1970	4998	325	5323	4852	4.6	471	9.7	25.07	10.3
1971	5051	881	5932	5295	9.1	637	12.0	27.01	7.7

b. The generating units providing the purchased power are subject to demands by the controlling utility.

c. Purchased power generally costs the utility more than power generated within its own power system.

B. NEW GENERATING CAPACITY

The applicant in order to reduce its reliance on other utilities, embarked several years ago on a massive construction program to reestablish sufficient reserve capacity within its own system. These additions (completed or under construction) are shown in Table 10.2 for the years 1971 to 1975.(7) In doubling the system capability by 1976, the goal of the applicant is to acquire and maintain 15 to 18% reserve over peak demand. This much reserve capacity is considered necessary by the applicant to allow for simultaneous system maintenance, forced outage of the largest generating unit, emergency aid to neighboring utilities, and inaccurate estimates of service area demand. Successful completion of the construction on schedule will increase Vepco's reserve capacity to about 20%, assuming a continued 10% annual growth rate. This amount of reserve capacity is considered advisable by the FPC.(8)

Table 10.2 Recent and future generating additions

Location	Expected date in operation	Nominal generating capacity [MW(e)]	Nominal system capacity [MW(e)]
(gas-turbine)	1971	140	5,188
Surry Station Unit No. 1	June 1972	800	5,960[a]
Surry Station Unit No. 2	Dec. 1972	800	6,760
2nd addition to Mt. Storm (coal)	Mar. 1973	555	7,315
North Anna Unit No. 1	Mar. 1974	940	8,255
2nd addition to Yorktown (oil)	Mar. 1974	845	9,100
North Anna Unit No. 2	Mar. 1975	940	10,040

[a]Bremo Station Units Nos. 1 and 2 [28 MW(e)] scheduled for retirement.

C. IMMEDIATE NEEDS OF THE POWER SYSTEM

For the immediate future, the applicant must rely on purchases of large blocks of power from other utilities in order to satisfy the peak power demands of its customers. The expected power purchases and reserve capacity at 1972 peak load for the applicant's power system with and without the 788 MWe net capability of Surry No. 1 are given in Table 10.3. The reserve capacity indicated was calculated on the basis of a 6300 MWe peak load forecast by Vepco from the long-term growth pattern of its power system.

TABLE 10.3 Power purchases and reserve capacity at 6300 MWe 1972 forecast peak load with and without Surry Unit 1

Condition	Firm power from power pool (MWe)	Firm power due to individual contracts (MWe)	Power capacity of system (MWe)	Reserve capacity of system	
				MWe	Percent of peak load
Surry Unit 1 operating	144	952	7074	774	12.3
Surry Unit 1 not operating	685	952	6827	527	8.4

The applicant was a member of the Carolinas-Virginia (CARVA) Power Pool and is obligated to fulfill its requirements until April 30, 1973. A basic requirement of this power pool arrangement is that all participants maintain the same percentage level of reserve capacity as the power pool combined reserve. Since the applicant presently has a shortage of reserve capacity (its percentage reserve capacity is lower than the percentage reserve capacity of the power pool), it has a contractual obligation to purchase power from the other participants. The amount of power purchased will, therefore, be dependent on whether Surry Power Station is operational or not. The applicant also has contracts with adjacent utilities on an individual basis to purchase up to 952 MWe,[9] as needed to meet the demands of its service area. Not all of the 952 MWe capacity may be available on demand since it is supplied by several specific generating units, any of which may be out of service.

With Surry Unit 1 in operation this summer at full capacity, the firm power purchased from the power pool will be 144 MWe.[9] In this case, Vepco's reserve capacity will be about 774 MWe, which is 12.3% over the forecast peak load. Without Surry Unit 1, the firm power purchases from the power pool in 1972 would increase to 685 MWe, and the reserve capacity would be reduced to 527 MWe, which is about 8.4% reserve capacity.

According to FPC's estimate of the power supply situation this summer,[10] the Virginia-Carolinas Subregion (VACAR) would have only 12.2% reserve margin with both Surry Unit 1 and Oconee Unit 1 in operation. With Oconee Unit 1 no longer expected in operation this summer due to damage during recent tests, VACAR's reserve will be reduced. If the additions of Duke Power Company's 591 MWe Cliffside Unit 5 and South Carolina Public Service Authority's 40 MWe of gas turbine capacity occur as scheduled in July, and with Surry Unit 1 in full operation, the VACAR reserve will be about 11% of the estimated peak load.[11]

Whether Surry Unit 1 will be needed to meet Vepco's peak power demand in the summer of 1972 depends primarily on whether the system peak demand is as high as forecast, and to a lesser extent on whether Oconee Unit 1 is in operation. However, operation of Surry Unit 1 by then would lessen the power drain from the power pool to the applicant and place the power pool in a better position to provide emergency aid to its participants or to other power systems in the Southeast.

The applicant's power situation could be even more critical during the summer of 1973 despite the addition of a new coal-fired unit at Mt. Storm next spring. As shown in Table 10.4 the applicant's reserve will be 13.5% if both Surry Units are operating, 2.3% if only one Surry unit is operating, and a negative 9.0% if neither is operating. This is due to a cessation of the power pool reserve sharing arrangement and a decline in firm power commitments from other utilities. Thus, the applicant's need for both Surry units becomes even more urgent in 1973.

Table 10.4 Power purchases and reserve capacity at 7010 MWe 1973 forecast peak load with and without Surry Units 1 and 2

Condition	Firm power from power pool (MWe)	Firm power due to individual contracts (MWe)	Power capactiy of system[a] (MWe)	Reserve capacity of system	
				MWe	Percent of peak load
Both Surry units operating	0	660	7958	948	13.5
One Surry unit operating	0	660	7170	160	2.3
No Surry unit	0	660	6382	(628)	(9.0)

[a] Includes 532 MWe from a new unit at Mt. Storm.

XI. ALTERNATIVES TO THE PROPOSED ACTION AND COST-BENEFIT ANALYSIS OF THEIR ENVIRONMENTAL EFFECTS

The applicant has provided a discussion of alternatives and a cost-benefit analysis in its Environmental Report Supplement,(1) which includes a description of power system requirements anticipated for 1971-1973 and the alternatives considered to meet those requirements when they were studied during the period 1964-1967. A summary of the site considerations is contained in Section I of this statement.

A. ALTERNATIVES TO THE PROPOSED ACTION

The need for additional power resources in the applicant's service area is discussed in Section X, where it was pointed out that serious power shortages could occur during the 1972 and 1973 summer peak demand periods unless new base-load capacity is placed in operation. Failure to provide power is not considered a feasible alternative in view of the applicant's obligation under its charter from the State Corporation Commission to serve its customers.

1. Purchasing Power

Purchasing additional capacity and energy does not represent a satisfactory solution to the applicant's need for base-load generation. Neighboring utilities will not have sufficient excess capacity, as discussed in Section X, and must give priority to their own requirements. Thus, the applicant would not have sufficient control over such a source of power.

2. Conversion to Fossil Fuel

Conversion of the Surry Power Station to a fossil-fueled steam-electric power plant is not practical. The steam-electric cycle of the existing facility uses a turbine-generator combination that is matched to the temperature and pressure characteristics of the steam produced by the combination of the nuclear reactor and steam generator. Consequently, converting the plant to fossil-fueled steam generation would also require changing the turbine-generator to obtain the maximum efficiency and lowest fuel cost and to minimize the environmental impact.

This alternative would require dismantling most of the existing plant and rebuilding. The capital costs of the alteration and the future operating costs, including power purchases, for the power system would be about the same as for abandoning the Surry site and rebuilding elsewhere.

3. Alternative Means of Generation

Unit 1 of the Surry Station is almost ready for low-power testing, and Unit 2 is nearing completion. Consequently, abandonment would mean a loss of more than $300 million invested so far, plus contract severance and shutdown costs, and most of the natural resources used on the construction.

Replacement of these needed generating units could only be accomplished by construction of similar size units at another site, and by securing increased capacity to meet the demand growth during the construction period. Environmental impacts at other plant sites would probably be similar to the impact at the Surry site. If the replacement plant were a fossil-fueled facility, the initial investment would be slightly less, but the environmental impact could be significantly greater as a result of the following problems associated with fossil-fueled power plants:

(1) contamination of the terrestrial system, the aquatic system, or both by leaching of contaminants from the coal storage yard or by spilling of oil,

(2) air pollution by unrecovered waste from the fuel-burning process, such as sulfur dioxide and oxides of nitrogen,

(3) greater aesthetic impact of coal storage yards or oil storage tanks and the high smokestacks associated with fossil-fueled power plants.

In the interim, from 1972 to 1976, replacement of this lost generating capacity during peak loads would have to be made by additional firm power purchases from other utilities at a cost of at least $68 million.(1) Purchased peak power, if available, adds another incremental cost to the power consumer, since purchased peak power is almost always more expensive. This is because the power sold is generated by the less efficient units of the other utilities.

Construction of an oil-fired generating station at Pig Point, just west of Portsmouth, is the most likely alternative means of providing sufficient base-load generation to replace the Surry Station. A coal-fired station at this location was considered during the 1964-1967 studies by the applicant, as mentioned in Section X; any new fossil-fired station would have to be designed to use low-sulfur, low-ash-content oil in order to meet anticipated air pollution standards.(1)

Table 11.1 presents a comparison made by the applicant of the direct costs of the Surry Station vs. those of an equivalent capacity oil-fired plant that could be built at Pig Point. 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 excluded. 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 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. As shown in the table, the capital costs remaining to be

TABLE 11.1[1]

DIRECT COSTS OF ELECTRICITY FROM SURRY POWER STATION vs AN OIL-FIRED PLANT OF THE SAME SIZE AT PIG POINT

	Surry-Nuclear (including Capital Costs expended)	Pig Point Oil-Fired
Plant capital cost (millions)		
Expended	\$305	\$244[2]
Remaining	65	
New site capital cost	——	10[3]
Total (million)	\$370[1]	\$254
Capital cost (\$/Kw)	226	155
Cost per Kwh (Mills):		
(a) Capital (5000 hrs/yr)[4]	5.81	3.97
(b) Operating & Maintenance[5]	0.50	0.50
(c) Special Insurance[6]	0.20	--
(d) Fuel	2.33[7]	6.18[8]
Total	8.84	10.59
Annual cost (million)	\$72.4	\$86.9

(1) Total estimated cost for the project in 1971 prices.

(2) Cost of 1976 oil-fired station, reflected in 1971 prices.

(3) Base unit used for costs in (2) 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.

(4) Capitalization rate, 12.8%, 30-year life.

(5) Includes normal insurance.

(6) Additional liability insurance cost for nuclear plants.

(7) Fuel cost (levelized) including carrying charges.

(8) 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.

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.

The fuel costs per kilowatt-hour of energy generated also are to the advantage of the nuclear plant. Over the useful life of a 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 on oil supply could be expected to aggravate pressure for increases in oil prices.

An oil-fired plant would burn about 13 billion barrels of oil per year. If oil containing 1% sulfur could be made available in this quantity, about 44,000 tons of sulfur dioxide would be emitted each year. Emission of particulates would amount to about 4,800 tons per year.

Compared with the nuclear plant, an oil-fired plant would discharge approximately two-thirds as much heat to the water body because of its higher thermal efficiency and because of its discharge of some heat to the air through the smokestack.

4. Alternative Cooling Systems

Waste heat from the steam supply systems in the Surry Station will be dissipated by using the once-through cooling method, described in Section III, which will draw water from the river and pass it through the condensers, then return it to the river at a higher temperature. This selection of once-through cooling was based on site characteristics, water availability, aesthetics, initial costs, and environmental effects, as discussed in Appendix H of this statement. Our review of the applicant's evaluation supports his judgment. However, if the once-through cooling system is found to have a significantly adverse long-term effect on the aquatic ecology of the James River, further consideration should be given to the following alternatives:

a. Modification of the Once-Through Cooling System

The present cooling system can be modified to change operational parameters. Approximate costs of various possibilities are given in Table 11.2. They are discussed more fully as follows:

(1) If the air-bubble screen at the riverfront water intake (see Section 3) is only partially effective in discouraging the entry of fish into the intake bays, a bypass from the intake canal to the James River could be constructed to permit free-swimming fish to escape from the intake canal without passing through the condensers. This could consist of an overflow from the canal (at the extreme west end) into a lower-level pool that would drain into the river by means of a buried pipe approximately 2 ft in diameter. Such

a bypass would permit fish to escape from the intake canal without being subjected to the thermal shock of the discharge canal. The staff estimates the cost of this alternative to be $100,000.

(2) If the air-bubble screen is totally ineffective, the applicant could install traveling screens at the riverfront water intake structure. This would eliminate the fish kill at the pump impellers and keep fish out of the intake canal. Fish kills on the traveling screens at the river would be limited to a small portion of the juvenile population, since the larger fish can successfully swim against the water velocity of 1 fps expected at the screens. The applicant has estimated the cost of this alternative as $600,000.

(3) The discharge canal exit gate structure could be modified to achieve exit velocities greater than 6 fps if future ecological monitoring programs indicate that higher velocities would enhance the protection of the aquatic environment. Since we estimate that an increase in the exit velocity from 6 to 12 fps would only reduce the area enclosed by the 5°F excess isotherm from 630 acres to 520 acres, it is doubtful whether such a modification would provide a significant reduction of environmental impact. In addition, the 12 fps velocity might be a safety hazard to swimmers or boaters in front of the discharge. This alternative was estimated by the staff to cost $100,000.

(4) The water temperature at the discharge to the river could be lowered by adding more water intake pumps and a condenser bypass canal with automatically controlled gates. A decrease of about 5°F could be obtained by adding four pumps similar to the existing pumps. At 6 fps discharge velocity, we estimate that this decrease in the exit temperature of the cooling water would reduce the area enclosed by the 5°F excess isotherm from 630 acres to about 100 acres, thus providing a significant reduction in the potential environmental impact. However, this alternative would increase the water flow by 50%; there is also a potential environmental impact in the movement of these large quantities of water from the downstream side of the peninsula to the upstream side, since the salinity of the James River would be altered in the areas of the intake and discharge structures (see Section V). Using figures from Appendix H, the staff estimates this alternative would cost $6,000,000.

(5) The water temperature at the discharge to the river could be lowered by placing sparger (power spray) units in the discharge canal. By increasing the width of the discharge canal to about 200 ft to gain greater surface area and space for sufficient power spray units, a 5°F reduction in discharge temperature might be obtained. This would reduce the 5°F excess isotherm even more than the preceding alternative, since about one-third of the waste heat of the plant would now be dissipated to the air. The applicant expects to gain experience with sparger units in a fresh-water discharge at the Chesterfield Station near Richmond in the near future. However, the saline water at Surry might cause difficult corrosion problems with the sparger units. Also, some salt might be carried by spray to the surrounding land areas, leading to corrosion of buildings and equipment or to an impact on local terrestrial

TABLE 11.2

COMPARISON OF INVESTMENT COSTS AND ENVIRONMENTAL BENEFITS OF ALTERNATIVE MODIFICATIONS OF THE ONCE-THROUGH COOLING SYSTEM

Alternative	Investment cost (dollars)	Environmental benefit
Fish-saving bypass canal	100,000	Permit fish to go from in-canal to Cobham Bay
Traveling screens at intake structure	600,000	Positively bar entry of fish into intake bays
Modify discharge exit gate structure	100,000	Reduce thermal plume area by about 20% at 5°F excess isotherm
Add four dilution pumps, intake structure, and automatic condenser bypass control	6,000,000	Reduce thermal plume area by 80% at 5°F excess isotherm; reduce discharge canal temperature about 5°F
Cooling ponds	22,000,000	Practically eliminate thermal plume and entrainment of fish and plankton
Offshore submerged discharge	10,000,000	Reduce thermal plume area by 75% at 5°F excess isotherm
Mechanical-draft cooling tower	42,500,000	Practically eliminate thermal plume and entrainment of fish and plankton
Natural-draft cooling tower	70,000,000	Practically eliminate plume and entrainment of fish and plankton
Mechanical-draft cooling tower (half capacity) in combination with once-through cooling	25,000,000	Minimize thermal plume; control environmental impact based on river conditions (temperature and fresh water flow)

plant life. This alternative was also estimated to cost $6,000,000 using figures from Appendix H.

(6) A submerged offshore discharge structure could be installed in the river where the water depth is about 10 ft. About a mile of 20-ft-diameter pipe would be installed from the condenser discharge plenum to the submerged discharge structure. The area enclosed by the 5°F excess isotherm would be significantly reduced, but the quantitative evaluation depends on the type of discharge structure and the velocity of the discharge. Including additional pumps, the staff estimates this alternative would cost $10,000,000.

If the modifications suggested for the present once-through cooling system still do not provide for adequate protection of the aquatic environment, closed-cycle systems must be considered. These would involve cooling ponds or cooling towers.

b. Cooling Ponds

Cooling ponds are large shallow ponds constructed to provide ample surface area for evaporation of water, and thus for heat dissipation, to the atmosphere. For the dissipation of about 3400 MW(t) (12×10^9 Btu/hr) of excess thermal energy, as would be necessary for the two units of the Surry Power Station, the applicant estimates that at least 4000 acres of cooling ponds would be needed (Appendix H). The cooling ponds would be concentrated in a compact area.

The clearing of a compact area of 4000 acres of mostly forest land would constitute an impact on the terrestrial environment much greater than that associated with the transmission line corridors. In this case, the land would be removed from both agricultural and wildlife production; it would then be necessary to regard the land use as a long-term loss of a natural resource. Furthermore, the saline water in the cooling ponds could eventually pollute the underground potable water supply.

c. Cooling Towers

There are four basic types of cooling towers used to dissipate large amounts of excess thermal energy from cooling water systems. They are (1) wet (evaporative), induced draft, (2) wet (evaporative), natural draft, (3) dry, induced draft, (4) dry, natural draft.

The appearance of the cooling towers and, therefore, the aesthetic impact are controlled primarily by the choice between induced- and natural-draft cooling. The induced-draft tower has a relatively low profile,[2] and its aesthetic impact may be minimized by proper landscaping techniques. The natural-draft tower, which may be more than 300 ft high,[2] cannot be hidden. However, the cleanness of the design and the hyperbolic shape of its external surface may be more pleasing to the viewer than most high towers, such as smokestacks.

The environmental impact of the operation of cooling towers is greater for wet than for dry cooling towers. In addition to the vapor leaving the wet cooling tower, a small percentage (0.05 to 0.2%) of the cooling water is lost by drift, which consists of water droplets entrained by the air flow. These droplets of water also contain any chemicals dissolved in the cooling water. The water droplets return to the ground in the immediate area of the cooling tower. Thus there is a potential impact due to excess chemical additions to the soil. In the case of a power plant that uses saline water in the cooling system, the chemical impact is serious, since the salt concentration (10 to 30 ppt) may be ten to a hundred times the concentration of all other dissolved chemicals. The applicant was aware of this problem and of the fact that no wet cooling tower of the size required at the Surry Power Station had ever been built and operated with saline water.[2] However, if the once-through cooling system is found to have a significantly adverse long-term effect on the aquatic ecology of the James River, the wet cooling tower alternative should be reconsidered as the technology improves. Cooling tower designers and fabricators can reduce the entrainment of water droplets in the air flow through the cooling tower at additional cost.[2]

Since the cooling water is completely contained when a dry cooling tower is used, there is no problem with entrainment of water droplets in the air flow and no problem with chemical deposition on the soil around the cooling tower. Thus, the environmental impact would be significantly less than with wet cooling towers. However, no dry cooling towers of the size required for the Surry Power Station have yet been built.[2,3]

A cooling tower option that is not mentioned by the applicant is a combination of once-through cooling with a cooling tower. An induced-draft cooling tower with a cooling capacity equal to the waste thermal energy of one nuclear unit could be located on the site in a manner that would have minimal aesthetic impact. This cooling tower could be connected to the condenser discharge plenum for both units and used to lower the temperature of the water discharged to the river, decrease the volume of water discharged to the river, or both. Thus, the applicant would have a means of reducing the size of the thermal plume and the thermal shock to the aquatic fauna.

The cooling tower costs were presented in the Applicant's Environment Report Supplement and are considered reasonable.

5. 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. Introduction of elemental chlorine into the circulating water reduces biomass build-up by destroying the organisms as they pass through the condensers. At Surry a mechanical system is employed at an approximate installed cost of $507,000 per unit; a biocide system could have been installed for approximately $54,000 per 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. The applicant has thus installed a much more expensive alternate system so as to reduce the overall environmental impact.

6. Alternatives to Normal Transportation Procedures

Alternatives such as special routing of shipments, providing escorts in separate vehicles, adding shielding to the containers, and constructing a fuel recovery and fabrication plant on the site rather than shipping fuel to and from the station have been examined. The impact of transportation on the environment under normal or postulated accident conditions is not considered to be sufficient to justify the additional effort required to implement any of the alternatives.

B. SUMMARY OF BENEFIT-COST ANALYSIS

1. Benefits

The primary benefit of the Surry Power Station is the availability of a dependable source of needed electrical energy. Secondary benefits to the local area include increased employment and tax revenue.

2. Environmental Costs

a. Land Use

The development at the station has caused a reassignment of 840 acres of forest land, although only 453 acres have been cleared for the plant. A visitors' center is included in this land use. The applicant has estimated that about 45,000 visitors will use the center per year.

Transmission line rights-of-way required 4,420 acres, of which 3,540 acres were cleared of trees. The applicant will permit use of the rights-of-way for agriculture. Land not used for agriculture will serve as habitats for wildlife. Erosion control will be implemented in the rights-of-way.

b. Water Use

The station will use estuarine water for cooling purposes and return it to the James River, except for evaporation of about 15,000 gpm. When operating at full power, the condenser cooling water (1.68×10^6 gpm) will be heated to about 14°F. In summer the 5°F ΔT will cover a range from 540 to 630 acres (flood to ebb tide). In winter this range will be from 970 to 1100 acres.

The discharge of chemicals to the river is quite small, maximum concentrations ranging from 3.0×10^{-7} ppm (lithium) to 5.1×10^{-2} ppm (sulfate). This discharge is not expected to have an effect on water quality.

c. Radiological Impact

The annual whole-body dose to the populations residing in the vicinity of the plant is estimated to be about 92.4 man-rem, which is less than 0.06% of natural background in the area.

d. Biological Impact

Operation of the plant is not expected to have a serious effect on the biota of the area. However, a surveillance program has been initiated to determine any effects and their magnitude during plant operation. If seriously adverse effects are found, remedial measures may be necessary. Of particular concern is the impingement of fish on water intake structures and entrainment of organisms, especially planktonic forms, in the condenser cooling water.

2. Cost-Benefit Balance

The plant as designed is expected to have but a small impact on the environment. The alternatives do not have advantages with regard to environmental impacts over the proposed design. A cost-benefit summary of the present design is given in Table 11.3.

The staff has analyzed the known identifiable and potential benefits and costs. On balance, our conclusion is that the benefits exceed the costs.

TABLE 11.3

BENEFIT-COST SUMMARY OF PRESENT DESIGN OF THE SURRY POWER STATION

Benefits	
Primary benefits:	
Electric energy to be supplied	More than 8 billion kilowatt-hours per year
Electric capacity contributing to reliability of power supply in Virginia-Carolinas subregion	1,600,000 kilowatts
Secondary local benefits:	
Employment of operating staff	135 persons
Taxes paid to Surry County	$1,000,000 per year
Nuclear Information Center	45,000 visitors per year
Environmental Costs	
Land Use:	
Forest land for station	840 acres purchased and 453 acres cleared
Forest land in rights-of-way for transmission lines	4,420 acres purchased and 3,540 acres cleared
Fogging and icing	Some increase around discharge canal and bridge over it.
Water use:	
Cooling water flow	1,680,000 gallons per minute (water evaporated - 15,000 gpm)
River area enclosed by 5°F excess isotherm:	
Summer	540-630 acres
Winter	970-1100 acres
Chemicals discharged to river	Negligible (see Table 3.6)

TABLE 11.3 (Cont.)

Radiological impact:	
Routine operation:	
Cumulative dose from operation of Units 1 & 2	92.4 man-rem/yr (less than 0.06% of natural background)
Whole-body dose to individual at site boundary	0.36 mrem/yr (less than 0.4% of natural background)
Accidents during operation or transportation	Annual potential radiation exposure of population from all postulated accidents is small fraction of natural background.
Biological impact:	Small fraction of biota in James River around Hog Island, including some commercial fish and shellfish, adversely affected by water intake system and thermal discharge.

XII. DISCUSSION OF COMMENTS RECEIVED ON THE DRAFT DETAILED STATEMENT ON ENVIRONMENTAL CONSIDERATIONS

Pursuant to Appendix D to 10 CFR Part 50, the draft detailed statement was transmitted in March 1972, with a request for comment, to the Federal, State and local agencies listed in the Summary at the beginning of this final statement. In addition, comments were requested from interested persons by means of a notice published in the Federal Register on March 28, 1972.

Comments in response to these requests were received from the Department of Agriculture, Department of the Army (Corps of Engineers), Department of Commerce, Department of the Interior, Department of Transportation (Coast Guard), The Environmental Protection Agency and the Federal Power Commission. Their comments are reproduced in Appendix J. Extensive responses[1,2] to these agency comments have been received from the applicant and are available for reading at the AEC docket rooms in Washington, D. C. (1717 H Street) and Williamsburg, Virginia (The College of William and Mary library). Portions of the applicant's responses appear in this section.

Our consideration of comments received is reflected in part by text revisions in other sections of the statement, which are listed by subject at the end of this section, and by the following discussion.

A. RADIOLOGICAL TOPICS

1. Primary-to-Secondary Steam Generator Leakage

Several comments questioned the adequacy of the liquid radioactive waste treatment system to handle steam generator blowdown diverted to it in the event of primary-to-secondary steam generator leakage. The staff analysis of the impact from the release of untreated steam generator blowdown, as discussed in Section V.E., indicates it will not be excessive. Our evaluation is based on fission product releases from the fuel into the primary coolant and thence to the secondary system via steam generator tube leakage. The Technical Specifications establish the limits for such releases. Methods available to the applicant to reduce this source include reducing the blowdown rate, reducing the reactor power, isolating the leaking generator, or shutting the reactor down and repairing the leak.

The applicant's response includes the following statement:

"The applicant has checked several operating PWR reactors and feels that the Surry Power Station liquid radioactive waste treatment system compares favorably with similar plants which are in operation or will be in operation in the near future. In addition to the waste disposal system evaporator, the boron recovery system contains two 20-gallon-per-minute evaporators, cesium removal ion exchangers, mixed-bed ion exchangers, and more than 120,000 gallons of associated tankage. The boron recovery system is expected to process approximately 8 x 10^6 gallons per year of reactor coolant letdown, of which approximately 92% will be recycled to the primary grade water system for reuse. Radioactivity removed from the process streams of this system will be drummed for shipment offsite. The 6 gallon-per-minute waste disposal evaporator and associated tankage are sufficient to process the expected remaining waste disposal system influents."

The sources of activity considered in this statement as a result of primary-to-secondary leakage include some 100 Ci/yr in liquid wastes, 2000 Ci/yr of noble gas and substantial quantities of airborne radioiodine. We believe that sources we have not considered would not significantly increase these releases. For additional information, refer to the applicant's Environmental Report Supplement (pages 284-308 and Appendix I). An error in Table 3.5 of the Draft Environmental Statement has been corrected to conform with technical specification limits of I-131 releases only to 0.9 Ci/yr. Due to expected isotopic distribution of iodine, I-133 releases will be limited to about 0.4 Ci/yr.

2. Particulate Filters

The applicant has confirmed that HEPA filters are shown in Fig. 5.3.1-1 of the FSAR and adds the following comments:

"Although adequate to process the exhaust filtering requirements from any one space, these filters are not capable of processing simultaneously the containment, auxiliary building, safeguards area, fuel building, and decontamination building exhausts.

"The initial containment purge after reactor cooldown will be passed through the HEPA filters and charcoal adsorbers to reduce containment activity, as necessary, to permit access for refueling operations. Exhausts from other spaces will be filtered if activity levels prior to release so warrant."

3. Decontamination Factor for Liquid Waste System Evaporator

The basis for assuming 10,000 as the decontamination factor (DF), with which the staff concurs, is provided by the following response from the applicant:

"The basic reason for the difference between the waste disposal evaporator decontamination factor reported from operating plants and those projected by the Applicant for Surry is that the design is significantly different.

"Operating decontamination factors less than 100 have been experienced for two similar designs of evaporators. These decontamination factors are the result of foaming or carryover in a compact evaporator which operates at a varying vacuum, has a high heat flux per unit area from a submerged bundle, and which has marginal provisions for disengaging space and vapor velocity.

"The Surry design is much larger and allows ample disengagement space as well as a centrifugal separator to decrease entrainment. The heat flux is applied in such a manner as to flash only about 1% of the circulated flow. It should also be recognized that one of the best ways to combat foaming is to increase temperature. The Surry evaporator will operate at 250°F instead of 166°F, and at a pressure instead of a vacuum.

"A vapor entrainment of about .06% was based upon the curves of Cessna[1]; the frequency distribution of droplets from boiling was assumed Gaussian with cutoffs at 0 and about 100 microns. This was evaluated to give a centrifugal separator capability of about 99.9% removal, or, for a factor of 133 concentrations between feed and bottoms, a total decontamination factor of about 10,000."

"Ref: 1 - Cessna & Badger 'Industrial Engineering and Chemistry,' Vol. 26, p. 485, 1934."

4. <u>60-Day Holdup of Radioactive Gases</u>

Page 64 of the Draft Environmental Statement contained an error which has been corrected in Section III.D.2.b. to verify the 60-day holdup time. Technical Specification 3.11 states that, "During normal conditions of plant operation, radioactive gaseous wastes shall be provided a minimum holdup of 60 days except for low radioactivity gaseous waste resulting from purge and fill operations associated with refueling and reactor startup." This requirement is consistent with the "as low as practicable" provision of 10 CFR 50.36a.

5. <u>Steam Generator Blowdown Vent</u>

The applicant has indicated to us that he is actively engaged in the design and evaluation of a blowdown tank heat exchanger that would substantially reduce this source of iodine releases.

6. <u>Radioactive Releases</u>

The applicant will be required to limit radioactive effluents to levels consistent with the Commission's final formulation of Appendix I to 10 CFR Part 50. These requirements will be incorporated in technical specifications which are part of the operating license. Specification 3.11 for the Surry Station has been revised to satisfy the intent of proposed Appendix I. However, the methods by which this is done are the responsibility of the applicant. AEC personnel will make periodic visits to the station to verify compliance with the specifications.

7. Diffusion of Gaseous Releases

The direction of prevailing winds given as from the Atlantic Ocean in the Draft Environmental Statement was in error and has been corrected to agree with the wind roses in Appendix C. This error does not affect the validity of any dispersion (X/Q) calculation. The applicant's response contains these additional remarks:

"In calculating maximum annual individual dose at the site boundary from radioactive gases, the assumption of annual average meteorological conditions and equal distribution of radioactive gases among the referenced sixteen 22.5° sectors is realistic for gases released from the blowdown tank vent and the air ejector. The calculations presented in the draft detailed statement assumed a constant failed fuel percentage of 0.25% and constant steam generator leakage of 20 gallons per day. With these assumptions, the release of radioactive gases from the air ejector and the blowdown tank vent would approximate a constant rate over an entire year. Thus, the use of an average annual meteorological dispersion factor is justified for these sources. For calculating average annual distribution of gases, from the aforementioned sources, among the sixteen sectors, a weighting factor that accounts for annual average wind direction should be utilized; however, as can be ascertained from the annual wind direction roses presented in Appendix C of the draft statement, the assumption of equal distribution among the sixteen sectors approximates the actual expected distribution.

"By Table 3.5 of the draft statement, the blowdown tank vent and the air ejector, which, as stated above, can be assumed to have constant releases rates over a year, account for 98% of the iodine-131 released, 96% of the iodine-133 released, and 39% of the xenon-133 released. The remaining significant quantities of gas are released from either the containment purge or the gas processing system. Of this, the most significant is xenon-133 from containment purges.

"The gas processing system, with the recombiner operating, has sufficient capability to hold radioactive gases for in excess of three hundred days. With this capability, releases can be accomplished, as required by the activity to be released, during favorable meteorological conditions. Thus, with this capability, even though releases may be confined to one or several sectors, the concentrations of radioactive gases within these sectors may be held to a minumum.

"The containment for the Surry Units are of sub-atmospheric design. Containment 'purges' during normal operation will be conducted only when the containment is at atmospheric pressure; the containment will be at atmospheric pressure only when the reactor is not operating. It is anticipated that a 'purge' of a containment will normally be conducted only once per year just prior to commencement of refueling. Although the gases released during these once-per-year-unit purges may be diffused only through one or several sectors, the total activity of gases dispersed in these sectors will not be significant. These once-per-year 'purges' should result, as shown in Table 3.5 of the draft statement, in the release of approximately thirty-six (36) curies of krypton-85. With once-per-year purges, xenon-133 would reach an equilibrium value in the containment in approximately 30 days and radioactive decay would limit the xenon-133 total activity in the containment. Thus, with once-per-year 'purges,' the xenon-133 curies released should be less than twice the released activity of krypton-85. "The only other gas discharges that could originate from the containment would be discharges required to maintain the sub-atmospheric condition with inleakage. The maximum air leakage into the containment is 1.2 scfm. Discharges required to remove this inleakage would contribute, when compared to 'purges,' insignificantly to the anticipated annual release total calculated from other sources."

8. <u>Direct Radiation Exposure</u>

A comment was received which raised the possibility of a direct line of exposure from the boron recovery tanks to the visitors center. The applicant's response indicates that "the direct radiation exposure has been considered and is considered to be negligible. During plant operations, if the direct radiation exposure proves to be a problem, shielding will be added as necessary."

9. <u>Doses to Specific Organs</u>

A comment was received which implied that doses to specific organs should be given in tabular form. The staff does not agree with the comment. Since the total body dose is the genetically significant dose and therefore involves the general population, it has been included in the Table 5.7 for all pathways. While individual organ doses may be higher than the total body dose, the corresponding limits in ICRP Report No. II are also higher. It is therefore felt necessary to point out only organ doses which are substantially higher than those for total body. The dose to a child's thyroid from milk consumption at the nearest dairy is one of those. While it is a factor of 10 larger than the doses to the general population, it is only received by a few individuals who may drink milk from this dairy. It therefore does not contribute significantly to the general population dose and should not be considered as such.

The applicant's Environmental Report Supplement presents, on page H-34 of Appendix H, the doses to critical organs from shellfish ingestion. The applicant's response also points out that "the tabulation of all doses in one table may be misleading since it implies that the effect of a unit of radiation is the same, independent of the affected part of the body. In addition, such a tabulation may imply that doses to various organs can be summed to give a dose to all organs."

10. <u>Doses from Consumption of Fish and Shellfish</u>

Tables 5.7 and 5.9 have been modified to indicate doses to individuals and the regional population from consumption of fish and shellfish.

11. Radiological Monitoring

The in-plant radiation monitoring system is described in Sections 11.3 and 12.5 of the FSAR. The radiological environmental monitoring program to be conducted during operation of the plant is prescribed by Technical Specification 4.9 which will be a requirement of the operating license. It is essentially the same as the preoperational program described in Appendix C of the applicant's Environmental Report Supplement.

Regarding the comment that aquatic plants should be included, the applicant's response indicates that attempts have been made to sample such plants but they are virtually nonexistent in the area of the discharge canal. Rooted plants being sampled on land are corn, peanuts and soybeans. The staff presently feels that the wide spectrum of biota, soil and water samples being taken are sufficient to indicate any radionuclide accumulation.

12. Accidental Radiation Releases to Water

A comment suggested that "many of the accidents described in Table 6.2 could result in releases to water and should be evaluated." The doses calculated as consequences of the postulated accidents are based on airborne transport of radioactive materials, resulting in both a direct and an inhalation dose. Our evaluation of the accident doses assumes that the applicant's environmental monitoring program and appropriate additional monitoring (which could be initiated subsequent to an incident detected by in-plant monitoring) would detect the presence of radioactivity in the environment in a timely manner such that remedial action could be taken if necessary to limit exposure from other potential pathways to man. The small quantities of dispersed radioactive material which might enter the food chain would not be significant in terms of endangering aquatic life.

13. Solid Wastes Burial

The applicant's response indicates that all drummed solid waste shipped from the station will be buried at the Nuclear Engineering Company's facility at Maxey Flats, Fleming County, Kentucky. This facility has been licensed by the Kentucky Department of Health, under authority granted by the USAEC.

B. NON-RADIOLOGICAL TOPICS

1. Rejection of the Currituck Sound Site

The applicant's response to a comment from the Department of Interior is that salt-water cooling tower technology had not developed in 1966, when the Surry Station site was selected, sufficiently to consider it a viable alternative to once-through cooling; nor were cooling ponds feasible along Currituck Sound, where the land is too flat to permit enconomic development of an impoundment.

2. Finfish and Shellfish

Table 2.3 has been added to Section II of the statement to provide data on the commercial catch of finfish and shellfish. Included is data on seed oysters and shucking oysters. The radiological doses expected from consumption of these biota have been added to Section V.E.

3. Transmission Lines

In its Environmental Report Supplement, the applicant discussed in detail the costs and impacts associated with line location, construction and maintenance. It also appears that the applicant used guidelines such as those advocated by the Department of Agriculture and Department of Interior in formulating its designs and routing of rights-of-way. The applicant's practices in disposing of waste vegetation are also covered in its Report. Timber cleared from the rights-of-way was considered of poor quality and was less than 1% of forest land in the area. The applicant's response indicates that vegetation control will encourage the growth of grasses and other low-growing species which will prevent soil movement. The cleared areas should also enhance rather reduce wildlife resources by providing increased feeding grounds for terrestorial animals which do not find adequate feed in timbered areas.

4. Chlorination of Condensers

The applicant has stated clearly that it intends to rely upon mechanical cleaning of condenser tubes by sponge rubber balls and that no chlorination equipment has been installed for this purpose. Should circumstances force the applicant to use chlorination, the Virginia State Water Use Permit imposes a limit of 0.5 ppm at the condenser outlet, which should result in a concentration of 0.1 ppm or less at the exit end of the discharge canal because of the residence time of 30 minutes in the canal and the chlorine demand in the water. Technical specifications associated with the operating license will require appropriate monitoring. The applicant indicates that "dechlorination equipment has not been considered since it is felt unnecessary and the addition of the reducing agent, sulfur dioxide or sodium bisulfite, introduces further unwanted chemicals to the environment."

5. Disposal of Wastes

The applicant's response provides the following discussion of its methods:

"A septic tand-sand filter-post chlorination system represents the most feasible method for treating the small volume of sanitary wastes generated at a relatively remote generating station. The system will yield the equivalent of secondary treatment without risking the loading and mechanical problems associated with the alternative - an extended aeration package type unit.

"A representative of the Virginia State Department of Health routinely checks the outfall from the septic systems for the presence of harmful bacteria and free chlorine residual. Station personnel also routinely check and log the free chlorine residual in this outfall. To date, no complaints have been made on any problems pertaining to operation of this system.

"The maximum calculated input to each septic system is 3250 gallons per day. The systems are presently in use and all receiving inputs that are representative of the demands that will be placed on them during station operation. Experience with each system indicates that the effluent at the outfall is considerably less than the 3250 gallons per day calculated input. The effluent from these systems, which is exceedingly small when compared to the two unit discharge canal flow of approximately 2.4×10^9 gallons per day which dilutes this effluent, is not expected to cause any adverse environmental effects.

"When necessary, a septic tank cleaning contractor will be used to remove and dispose of any sludge accumulation that could affect operation of the sanitary waste disposal systems. The sludge removed during routine maintenance operations will be disposed of in compliance with methods approved by the State Health Department.

"Construction materials and miscellaneous solid station wastes are presently buried in a designated pit at the site. Bulky materials, such as cardboard boxes, may be burned in the pit prior to burial.

"Applicant has initiated a program to comply with the March 17, 1972, State 'Regulations for the Control and Abatement of Air Pollution,' Section 4.01.00, which applies to open burning. No items such as rubber tires, crankcase oil, or similar materials, and no animals or animal waste are burned. Further, in conjunction with the State Air Pollution Control Board, Applicant is investigating the use of air pollution control devices to be used with open pit burning of solid wastes at its power station sites, in compliance with Section 4.01.03 of the Regulations.

"After completion of Unit 2 at Surry, disposal of construction materials will no longer be necessary. Applicant has formulated no definite plans for disposal of station solid wastes beyond that time, but is investigating having them hauled to the Surry County waste disposal facility.

"Trash from the intake traveling screens will be buried on site. The burial area is located in a wooded area adjacent to the intake canal. The trash is topped with sufficient ground cover to reduce offensive odors. The burial area is located in a relative isolated area and if any slight odor develops, it would be dispersed before reaching an area where it would be considered offensive."

6. Oil Spill Counter Measures

The applicant's response indicates that it is fully cognizant of its responsibility to maintain water quality by preventing, containing, or mitigating the consequences of spills of oil or other non-radioactive substances at the Surry Power Station. It is not expected that water quality will be degraded by spills for these reasons:

1. relative small quantities of oil products are maintained on site,

2. oil and hazardous substances are stored in engineered containers,

3. we comply with the Occupational Safety and Hazards Act (OSHA) for oil storage facilities,

4. soil conditions prevent contamination of lower-lying aquifiers, and

5. operating techniques guard against potential spills.

The reporting system which will be used to alert responsible management and appropriate legal authorities for the Surry Power Station is the same as for other generating facilities. If a spill is detected, it is reported to supervisory personnel on site, who notify the Station Manager or senior supervisor on site if the Manager is unavailable. The Station Manager or his designee has the responsibility to notify the Water Quality Office of the Environmental Protection Agency in Charlottesville, Virginia, and also the U. S. Coast Guard in Portsmouth, Virginia. Similarly he contacts the Superintendent-Production Operations in the general office of Vepco.

The plot plans which describe the location of these preventive facilities and the oil storage tank is incorporated in Section 15 of the Final Safety Analysis Report.

7. State Water Quality Standards

The Virginia water quality standards for estuaries limit the temperature rise at the edge of the mixing zone to 1.5°F during the June-August period and to 4°F for the rest of the year. It further states that the mixing zone, which is determined on a case by case basis, shall occupy as small an area and length as possible and shall not present free passage of fish. Figure 3-14A depicts the summer plume with its closure temperature of 1.4°F and Figure 3-14B depicts the winter plume with its closure temperature of 1.63°F. Both are maximum closure temperatures which occur 1-1/2 hours of each tidal cycle and allow for passage of fish through a region outside of the defined mining zone.

8. River Water Losses and Induced Fog

The applicant's reponse indicates the following:

"At a full load station heat rejection rate of 12×10^9 BTU/hr, the maximum river water loss, by evaporation alone, would be on the order of 50 cfs. Since the transfer mechanisms of radiation and convection will also contribute to the heat exchange process, however, this evaporation rate is expected to be substantially lower. In view of the fact that there is no limitation on the amount of replacement water available at Hog Point, this small loss will have no effect.

"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 significant. 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."

9. <u>Beneficial Use of Heated Water</u>

The applicant's response indicates that potential beneficial uses of the rejected heat from the Surry Nuclear Facility were considered but were not considered feasible.

"Mariculture was the first possible beneficial use of the thermally enriched waters investigated. After a review of the seasonal instability of the salinity characteristics of the tidal segment encompassing Hog Point, the effluents were considered unsuitable for the culture of either estuarine or freshwater species of fish or shellfish. The site is located in the most environmentally compatible reach of the James tidal system. The intake and discharge are upstream from the commercially important clam and oyster beds and downstream from the spawning areas of striped bass, white perch, and the anadromous <u>Alosid</u> species of fish. The factors which contribute to the environmental compatibility destroy the potential use of the area for mariculture."

10. <u>Analysis of the Thermal Plume</u>

We concur with the EPA's observation that the complex geometry and tidal effects of the James River around Hog Point render the analysis of thermal plume sizes extremely difficult. Hence, the results from the physical model studies are likely more significant than those from any of the analytical models. We also concur that the physical model study could profitably be extended to include flow regimes where more adverse thermal conditions are anticipated. These would most probably occur when fresh water flow rates range from 6000 cfs to 25,000 cfs. In view of the time required to perform such a study, it would not be feasible to utilize a hydraulic model as that located at Vicksburg, Mississippi. However, the station Technical Specifications will require the applicant to incorporate an extensive continuous monitoring program to determine the behavior of the thermal plume under all conditions.

EPA commented that at high fresh water river flows the phenomenon of a sinking plume is mostly likely to occur, and thus should be examined by physical model studies. Actually, a sinking plume is more likely to occur at lower river flows when the longitudinal gradient of salinity is greater. Therefore, since the physical model employed by Pritchard incorporated both salinity and thermal parameters for the 2000 cfs flow, the results should refect the consequences of the sinking plume more so than studies at higher flow rates. The rate of dissipation of the plume during periods of high river flows (14,000 cfs - 25,000 cfs) may be less due to the reduction of available dilution water.

The complex system of interrelated and ever-changing flows, temperatures, and densities of the James River in the vicinity of Hog Point render impossible the task of analytically predicting three-dimensional temperature distributions.

Vertical temperature distributions are also difficult to physically model in a distorted hydraulic model. However, vertical as well as horizontal temperature distributions will be monitored by the applicant when the plant is in operation.

It is evident from Figure 3.14 that a portion of the plant effluent will be recirculated during the late ebb and slack before flood periods of the tidal cycle. Approximately 14% recirculation will occur during this 1.5 hour time interval - this is equivalent to 2% recirculation averaged over a complete tidal cycle. The effect of this recirculation should be virtually nil for reasons that become evident by following the course of events of one tidal cycle, as described in Section III.D.1.c of this Statement.

11. <u>Use of Minimum River Flows</u>

A comment suggested that the assessments contained in this statement be based upon the minimum 7-day flow of 440 cfs during 1930. The applicant's response states, "The commenting agency has apparently misinterpreted Page E-4 of the Applicant's Environmental Report Supplement.

"The Surry Station discharge is located at a point approximately 30 nautical miles upstream from the mouth (Fort Wool) of the James River. The referenced gaging station is located above the fall line (the head of Tidewater) at approximately Mile 95. An additional volume of approximately 20 percent enters the system through tributary streams downstream from the Richmond and the Richmond and Kanawa Canal gaging stations.

"At extreme low freshwater discharge periods, the <u>time of passage</u> from the fall line to the Surry site is approximately 40 days. During this time the highs and lows in the hydrograph tend to integrate, thus rendering the monthly mean value as the most valid figure available.

"The commenting agency should be made aware of the relationship between the freshwater inflow and the 'net available new water' at the site. Dr. D. W. Pritchard has indicated that as the freshwater inflow decreases the 'net available new water' volume increases. Although no salinity data are available on which to base calculations for the referenced minimum 7-day low flow, the 'net available new water' at the site probably exceeded 100,000 cfs during the period."

12. Effects on Aquatic Biota

Several comments raised questions regarding the effects of entrainment, altering salinity distribution, destruction of density flow, combined thermal-salinity stress on estuarine species, and the long-term impact of station operation on the James River estuary. Additional discussion of these aspects is included in Section V.D. of this statement. However, due to lack of adequate baseline data, the AEC recognizes that quantification of these effects cannot be determined more fully without extensive monitoring during operation of the station. Such a monitoring program will be required in the Technical Specifications appended to the operating license.

13. Air Bubble Curtain

The applicant's commitment to evaluate the effectiveness of the bubbler system in diverting fish away from the cooling water intake structure and to install additional protective measures, if needed, is documented on p. 263 of the Applicant's Environmental Report Supplement. Slots and supports for traveling screens have been provided on the structure. A bypass from the intake canal to the river is another possible modification (see Section XI.A.4 of this Statement).

14. Alternative Closed-Cycle Cooling System

Based on information in Appendix H and in the applicant's response to the Agency comments, the staff estimates the initial investment cost of a closed-cycle system of canals and spray modules at close to $40 million for Surry Units 1 and 2. This would utilize the excess of 300 acres and 600 spray modules. The land used would consume most of the remainder of the applicant's property on the Gravel Neck peninsula. Maintenance of the spray modules and associated plumbing would be a significant operational problem, in addition to an added cost of producing power.

The 7000-acre cooling pond area cited in the Draft Statement was based on information supplied by the applicant (Appendix H). However, the staff reviewed the use of cooling ponds for other power plants, and found that from one to two acres of pond surface were required per MWe. In one case, about 2000 acres of cooling pond were required for a 600 MWe nuclear-fueled power station in Michigan. Extrapolation to the power capacity of Surry indicates that 5500 acres would be needed at Surry. Considering the higher average temperature and humidity, the 7000-acre estimate is probably reasonable.

In the applicant's response to the Agency comments, a value of 4000 acres minimum is stated. In either case, a very large percentage of the 6400 acres of land within three miles of the plant would have to be converted to water surface.

The applicant estimated that cooling ponds may cost in excess of $22 million. This information has been included in Table 11.2.

15. Recreational Potential of Gravel Neck Peninsula

The applicant has provided the following response to the comment suggesting that the long-term effect of the station's operation should be considered in relation to coordinated planning for recreational development of Gravel Neck:

"The Applicant has consulted with the appropriate State and Federal agencies having responsibilities relative to land use and recreation. The comments of these agencies are included in Appendix G of the Applicant's Environmental Report Supplement. The State agencies' comments were transmitted through the Governors Council on the Environment (G-23).

"Upper estuarine areas have a low potential for aquatic and shore recreation. The bottom materials consist primarily of soft mud and beach areas are minimal. The Surry Site is in the area of the 'turbidity maximum' zone of the estuary and the high suspended solids levels make the water undesirable for contact recreation."

C. LOCATION OF PRINCIPAL CHANGES IN RESPONSE TO COMMENTS

Topic Commented Upon	Section Where Topic is Addressed
Rejection of Currituck Sound	XI, XII
Need for Power	X
Misnomer of Historical Sites	II.B
Correction of Wind Direction	II.D.3
Thunderstorms and Tornadoes	II.D.3
Species Affected by Salinity	II.E.2
Commercial Catch of Fish and Shellfish	II.E.2
Transmission Line Right-of-Way	III.B, IV.C, VII, and XII
Thermal Plume Behavior	III.D.1, XII
Disposal of Sanitary Wastes	III.D.3, XII

Chlorination of Condensers	III.D.3, V.D.1.a, XII
Loss of Timber Production	IV.C, XII
Fog and Evaporation	V.B, XII
State Water Quality Standards	V.D.1.e, XII
Oil Spill Counter-Measures	XII
Beneficial Use of Heated Water	XII
Entrainment	V.D.1.f, XII
Use of Minimum River Flows	XII
Air Bubble Curtain	V.D.1.f, XII
Effects on Aquatic Biota	V.D.2, XII
Land Animals	VIII
Loss of Fish and Wildlife	IX
Quantification of Adverse Effects	VII, XII (also see Monitoring, V.F)
Alternative Cooling Methods and Cost-Benefits	XI, XII
Recreational Development of Gravel Neck	XII
Radioactive Steam Generator Leakage	XII
Evaporator Decontamination Factor	XII
Sixty-Day Holdup of Gases	III.D.2.b, XII
Radioactive Releases	XII
Direct Radiation Exposure	XII
Doses to Specific Organs	XII
Doses from Consumption of Fish and Shellfish	V.E., XII
Radiological Monitoring	XII

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9. Letter from Stanley Ragone, Virginia Electric and Power Company, to E. L. Bloch, Acting Deputy Director for Reactor Projects, Directorate of Licensing, USAEC, May 12, 1972.

10. Letter from T. A. Phillips, Chief, Bureau of Power, Federal Power Commission, to L. Manning Muntzing, Director of Regulation, USAEC, January 18, 1972, with enclosure entitled, "Adequacy of Electric Generating Capacity in Areas with Pending Nuclear Plant Operating Licenses."

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1. Virginia Electric and Power Company, Environmental Report Supplement, December 1971.

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Section XII

1. Letter from Stanley Ragone, Virginia Electric and Power Company, to Dr. Peter A. Morris, Director, Division of Reactor Licensing, USAEC, April 28, 1972.

2. Letters from Stanley Ragone, Virginia Electric and Power Company, to Mr. E. L. Bloch, Acting Director of Licensing, USAEC, May 10, and May 12, 1972.

APPENDIX A

CORRESPONDENCE FROM THE VIRGINIA HISTORIC

LANDMARKS COMMISSION

COMMONWEALTH OF VIRGINIA

VIRGINIA HISTORIC LANDMARKS COMMISSION
ROOM 1106
NINTH STREET STATE OFFICE BUILDING
RICHMOND, VIRGINIA 23219
TELEPHONE: 770-3143

January 10, 1972

Mr. W. J. Ross
Oak Ridge National Laboratories
Oak Ridge, Tennessee

Dear Mr. Ross: Re: Surry Power Station, Virginia

We have studied our records and find that the Surry Power Station will not have an adverse effect on any landmark - architectural or archaeological. However, I cannot refrain from noting that this seems a strange time to be conducting such an investigation in view of the fact that the plant is nearly ready for operation. What would the practical effect of your report be if it were found that the project has a devastating effect on a number of significant sites? In other words, what good would it do?

The possible adverse effect of the project on the view across the James River from Jamestown was taken into consideration by Vepco and I understand they buried as much of the structure as possible so as to make use of the screening trees.

Sincerely yours,

James W. Moody, Jr.
Executive Director

JWM/bb

APPENDIX B

CORRESPONDENCE FROM THE VIRGINIA DEPARTMENT

OF CONSERVATION AND ECONOMIC DEVELOPMENT AND

COMMONWEALTH OF VIRGINIA

RANDOLPH W. CHURCH
State Librarian
RAY O. HUMMEL, JR.
Assistant Librarian

VIRGINIA STATE LIBRARY
RICHMOND
23219

LIBRARY DIVISION
General Library Branch
Extension Branch
ARCHIVES DIVISION
Archives Branch
Publications Branch
LIBRARY SERVICES DIVISION
Administrative Offices
Records Management Section
Photographic Laboratory

January 24, 1972

Mr. W. J. Ross
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

Dear Mr. Ross:

I'm sorry I was not here to speak with you last week when you telephoned me. I hope the information I provide here is what you want and need.

Since my field is archeology, rather than Paleontology, I am unable to answer authoritatively your query concerning possible damage to fossil deposits underlying the VEPCO Nuclear Power Plant in Surry County, Virginia. Since the deposits are widespread marine beds, I doubt if any harm could result to them. However, to obtain an authoritative opinion, may I suggest that you write or call Dr. James L. Calver, Director, Division of Mineral Resources, Department of Conservation and Economic Development, Charlottesville, Virginia 22903.

I did look over the area involved in the construction, and I found no historical or prehistoric site of importance involved.

If you have further questions on this, please let me know.

Sincerely yours,

Howard A MacCord, Sr.
Howard A. MacCord, Sr.
Archeologist

HAM:A

COMMONWEALTH OF VIRGINIA

DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES
NATURAL RESOURCES BUILDING
BOX 3667, CHARLOTTESVILLE, VA 22903
JAMES L. CALVER, STATE GEOLOGIST

January 19, 1972

Mr. W. J. Ross
Oak Ridge National Laboratory
Union Carbide Corporation
P. O. Box X
Oak Ridge, Tennessee 37830

Dear Mr. Ross:

In reply to your letter of January 11, 1972, the Division completed geologic mapping studies in the Gravel Neck and Hog Island areas with the publication of Report of Investigations 18, "Geology of the Williamsburg, Hog Island, and Bacons Castle Quadrangles." Currently, we have disengaged our interest and only when specialized studies become necessary would the area need to be revisited. We have no concern about present construction, and anticipate there would be sufficient material exposed for future investigations. Flooding of land surfaces and urban developments pose problems only if we are unable to make geologic surveys before completion of such projects. So far as scientific studies related to remains of past human life and activities, this matter is in the provinces of the State archaelogist. You may use the foregoing information as a reference in the specific report referred to in your letter of January 11, 1972.

Very truly yours,

Bruce Hobbs

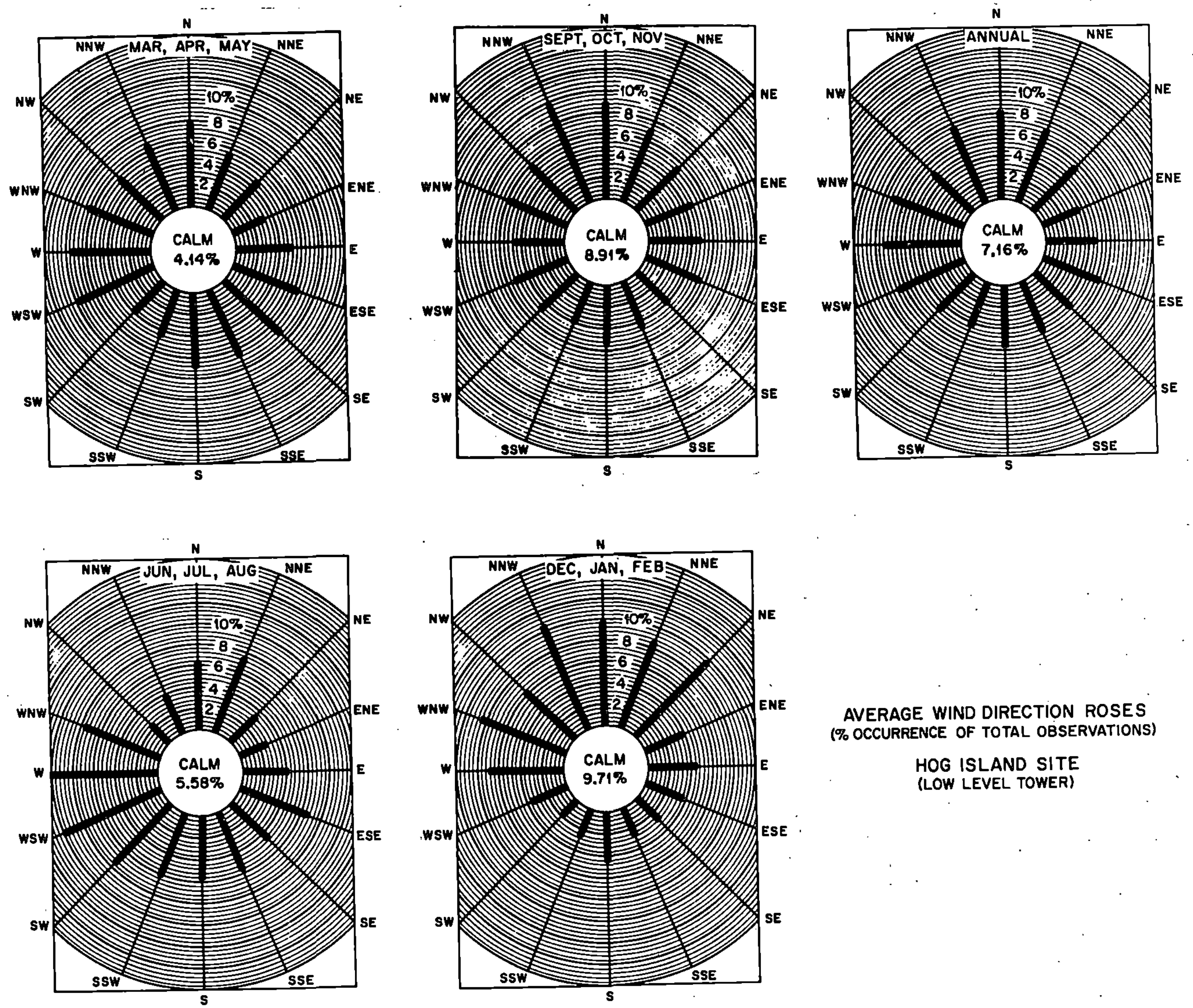
Bruce Hobbs
Assistant State Geologist

BH/kr

You Are Welcome in Virginia — Birthplace of the Nation

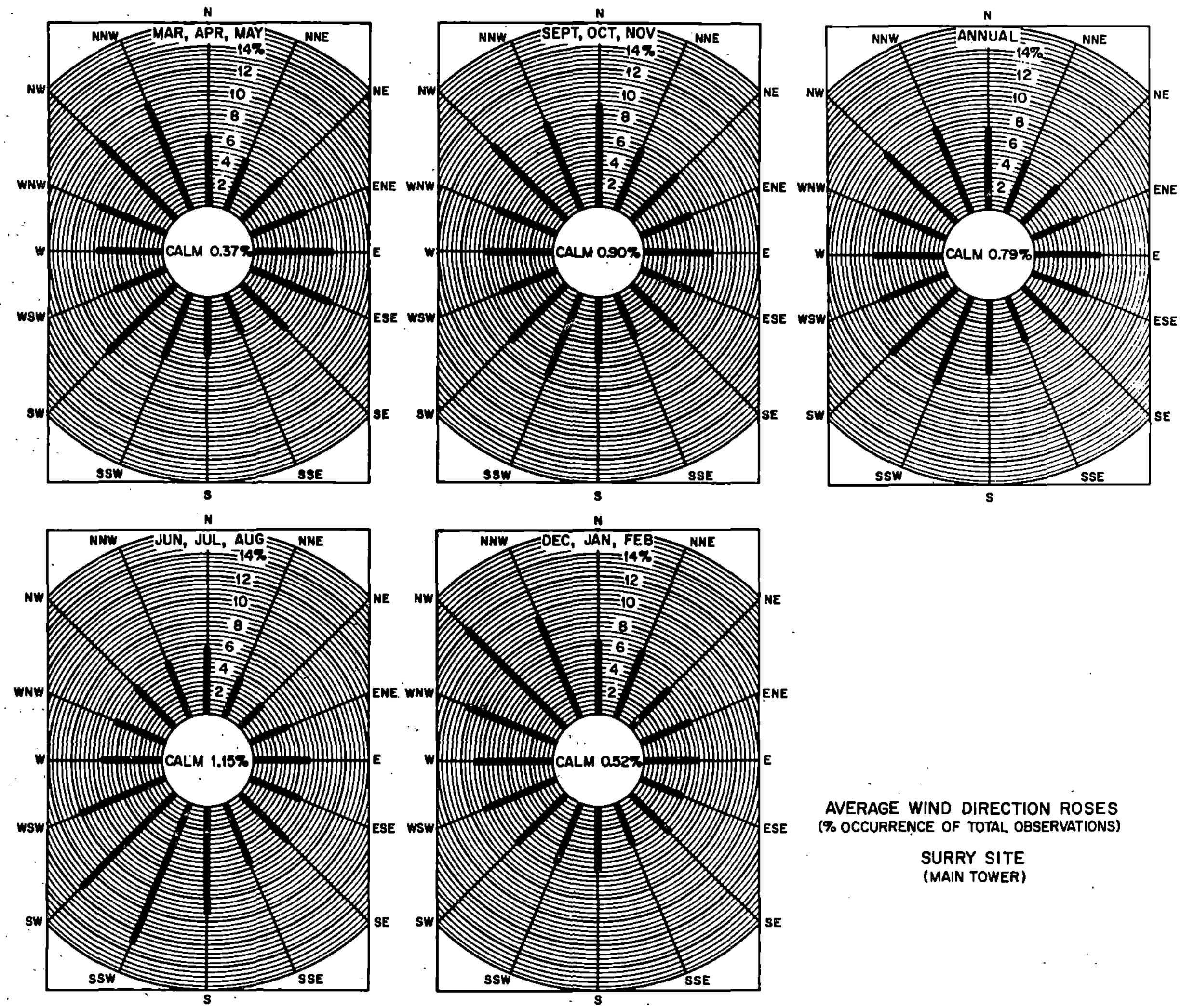
APPENDIX C

AVERAGE WIND DIRECTION ROSES AT HOG ISLAND AND SURRY SITES



AVERAGE WIND DIRECTION ROSES
(% OCCURRENCE OF TOTAL OBSERVATIONS)

HOG ISLAND SITE
(LOW LEVEL TOWER)



AVERAGE WIND DIRECTION ROSES
(% OCCURRENCE OF TOTAL OBSERVATIONS)

SURRY SITE
(MAIN TOWER)

APPENDIX D

TERRESTRIAL FLORA IN THE VICINITY

OF THE SURRY POWER STATION

Iva frutescens (marsh elder)
Baccharis halimifolia (groundsel tree)
Cassia fasciculata (partridge pea)
Lespedeza capitata (bush clover)
Myrica certifera (wax myrtle)
Cephalanthus occidentalis (buttonwood)
Pinus taeda (loblolly pine)
Pinus virginiana (Virginia pine)
Pinus echinata (shortleaf pine)
Quercus alba (white oak)
Quercus stellata (post oak)
Quercus rubra (red oak)
Quercus coccinea (scarlet oak)
Carya sp. (hickory)
Nyssa sylvatica (black gum)
Liquidambar styraciflua (red gum)
Acer rubrum (red maple)
Cornus florida (dogwood)
Oxydendrum arboreum (sourwood)
Vaccinum arboreum (farkleberry)
Ilex opaca (American holly)
Juniperus virginiana (red cedar)
Fraxinus pensylvanica (red ash)
Ulmus sp. (elm)
Taxodium distichum (cypress)

APPENDIX E

TERRESTRIAL FAUNA IN THE VICINITY

OF THE SURRY POWER STATION

Mammals

Odocoileus virginianus virginianus (white tailed deer)
Ursus americanus americanus (black bear)
Lynx rufus (bobcat)
Lutra canadensis lataxina (otter)
Mustela vison mink (mink)
Memphitis memphitis nigra (skunk)
Mustela frenata noveboracensis (weasel)
Urocyon cinereoargenteus cinereoargenteus (gray fox)
Vulpes fulva (red fox)
Didelphis virginiana virginiana (opossum)
Procyon lotor lotor (raccoon)
Marmota monax monax (woodchuck)
Sciurus carolinensis carolinensis (gray squirrel)
Glaucomys volans volans (southern flying squirrel)
Castor canadensis canadensis (beaver)
Sylvilagus floridanus mallurus (eastern cottontail rabbit)

Peromyscus leucopus leucopus (white-footed mouse)
Oryzomys palustris palustris (rice rat)
Peromyscus nutalli nutalli (golden mouse)
Microtus pennsylvanicus nigrans (meadow mouse)
Pitymys pinetorum pinetorum (pine mouse)
Ondrata zibethica macrodon (muskrat)

Rattus rattus alexandrinus (roof rat)
R. norvegicus (house rat)
Mus mustulus (house mouse)
Zapus hudsonius americanus (meadow jumping mouse)

Scalopus aquaticus aquaticus (common mole)
Condylura cristata cristata (star-nosed mole)

Sorex longirostris longirostris (long-nosed shrew)
Cryptotis parva parva (least shrew)
Blarina brevicauda (short-tailed shrew)

Myotis lucifugus lucifugus (brown bat)
M. keenii septentrionalis (long-eared bat)
Lasionycteris noctivagons (silver-hearied bat)
Nycticeius humeralis (evening bat)
Pipistrellus subflavus subflavus (pipistrelle)
Lasiurus borealis borealis (red bat)

Birds

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
Northern Virginia rail
Sora
Eastern American oystercatcher
Eastern piping plover
Black-bellied plover
Wilson's common snipe
Eastern solitary sandpiper
Western willet
Greater yellowlegs
American know
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
Least sandpiper
Sanderling
American herring gull
Laughing gull
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 cormorant
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
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

Northern common tern
Caspian tern
Common dovekie
Eastern mourning dove
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
Eastern American goldfinch
Red-eyed Eastern towhee
Eastern savannah sparrow
Labrador savannah sparrow
Sharp-tailed sparrow
Northern slate-colored junco
Eastern yellow-billed cuckoo
Southern screech owl
Northern barred owl
North American barn 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
Eastern song sparrow
Mississippi song sparrow
Atlantic song sparrow
White-throated sparrow
Southern swamp sparrow
Eastern snow bunting

Annotated list from Murray, J. A., A Checklist of the Birds of Virginia, Virginia Society of Ornithology, 1952.

Reptiles

Common snapping turtle
Eastern mud turtle
Eastern box turtle
Eastern painted turtle
Red-bellied turtle
Six-lined race runner
Five-lined skink
Southeastern five-lined skink
Brown water snake
Northern water snake
Glossy water snake
Northern red-bellied snake
Rough earth snake
Eastern hognose snake
Eastern worm snake
Rough green snake
Black rat snake
Eastern king snake
Coastal Plain milk snake
Southeastern scarlet snake
Eastern cottonmouth
Canebrake rattlesnake
Stinkpot
Spotted turtle
Northern diamondback terrapin
River cooter
Northern fence lizard
Ground skink
Broad-headed skink
Eastern slender glass lizard
Red-bellied water snake
Queen snake
Northern brown snake
Eastern garter snake
Eastern earth snake
Southern ringneck snake
Northern black racer
Corn snake
Northern pine snake
Eastern milk snake
Mole snake
Northern copperhead
Timber rattlesnake

Annotated list from "A Checklist of Virginia's Mammals, Birds, Reptiles, and Amphibians," Virginia Wildlife 1959, Commission of Game and Inland Fisheries, Richmond, Va.

Insects

Collembola (springtails)
Thysanura (silverfish)
Odonata (dragonflies)
Hemiptera (cicadas, aphids)
Coleoptera (beetles)
Siphonaptera (fleas)
Lepidoptera (moths, butterflies)
Isoptera (termites)
Orthoptera (grasshoppers, crickets, mantids, and cockroaches)
- Periplaneta americana (American cockroach)
- Blatella germanica (German cockroach)
- Blatta orientalis (oriental cockroach)

Hymenoptera (wasps, bees, ants)
3 orders of lice
Diptera (flies, mosquitos)
- Musca domestica (common house fly)
- Culicoides sp. (sand fly)
- Black flies (family Simuliidae)
- Horse flies (family Tabanidae)
- Marsh flies (family Sciomyzidae)
- Others

  Aedes sollicitans
  A. taeniorhynchus
  + others

Arachnids

Spiders - including Latrodetus mactans (black widow) and Loxosceles reclusa (brown recluse)

Eutrombicula alfreddugesi (chigger)

Ticks - including Dermacentor variabilis (American dog tick or Wood tick), Rhipicephalus sanguinius (brown dog tick), and Amblyomma americanum (lone star tick)

Amphibians

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 (Desmognathus 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)

Annotated list from "A Checklist of Virginia's Mammals, Birds, Reptiles, and Amphibians," Virginia Wildlife 1959, Commission of Game and Inland Fisheries, Richmond, Va.

APPENDIX F

AQUATIC FLORA IN THE VICINITY OF THE SURRY POWER STATION

Araceae

Peltandra virginica (arrow arum)

Ruppiaceae

Ruppia maritima (eidgeon grass)

Typhaceae

Typha angustifolia (narrow-leaved cattail)
T. latifolia (common cattail)
Spartina cynosuroides (giant cordgrass)

Zosteraceae

Zostera marina (eelgrass)

APPENDIX G

AQUATIC FAUNA IN THE VICINITY OF THE SURRY POWER STATION

Platyhelminthes

Stylochus ellipticus

Nemertea

Tubulanus pellucidus

Rotifera

Unidentified species

Annelida

Polychaeta

capitellid (unidentified)
Heteromastus filiformis
Laeonereis culveri
Lysippides grayi (?)
Nereis succinea
Scoleocolepides viridis

Oligochaeta

Unidentified species

Mollusca

Brachidontes recurvus (mussel)
Congeria leucophaeta (mussel)
Crassostrea virginica (oyster)
Macoma balthica (clam)
M. mitchilli (clam)
M. phenax (clam)
Polymesoda caroliniana (Bosc) (clam)
Rangia cuneata (marsh clam)

Arthropoda

Crustacea

Copepoda

Acartia sp.
Cyclops sp.
Diaptomus sp.
Ectinosoma sp.
Eurytemora sp.

Isopoda

Chiridotea almyra
Cyathura polita
Edotea triloba

Amphipoda

Corophium lacustre
Gammarus sp.
Lepidactylus dytiscus
Leptocheirus plumulosus
Monoculodes edwardsi

Cladocera

Leptodora sp.

Cirripedia

Balanus eburneus
B. improvisus

Mysidacea

Neomysis americanus (opossum shrimp)

Cumacea

Diastylis sp.

Decapoda

Callinectes sapidus (blue crab)
Crangon septemspinosus (sand shrimp)
Palaemonetes pugio (shrimp)
Penaeus sp. (shrimp)
Rhithopanopeus horrisii

Insecta

Tendipedidae (larvae) - dipterans

Ectoprocta

Bowerbankia
Membranipora tenuis

Chordata

Osteichthyes

Acipenseridae

Acipenser oxyrhynchus (Atlantic sturgeon)

Anguillidae

Anguilla rostrata (American eel)

Antherinidae

Menidia beryllina (tidewater, or glassy, silverside)
M. menidia (Atlantic silverside)

Belonidae

Strongylura marina (Atlantic needlefish)

Blennidae

Chasmodes bosquianus (striped blenny)

Carangidae

Caranx hippos (crevalle jack)

Centrarchidae

Lepomis gibbosus (pumpkinseed)
Lepomis sp. (sunfish)
Micropterus salmoides (largemouth bass)

Clupediae

Alosa aestivalis (blueback herring)
A.pseudoharengus (alewife)
A.mediocris (hickory shad)
A.sapidissima (American shad)
Brevoortia tyrannus (Atlantic menhaden)
Dorosoma cepedianum (gizzard shad)
Pomolobus aestivalis (glut herring)

Cyprinidae

Cyprinus carpio (carp)
Notemigonus crysoleucas (golden shiner)
Notropis bifrenatus (bridle shiner)
N. hudsonius (spottail shiner)

Cyprinodontidae

Fundulus diaphanus (banded killifish)
F. heteroclitus (mummichog)
F. majalis (striped killifish)

Engraulidae

Anchoa mitchilli (bay anchovy)

Gobiidae

Gobiosoma bosci (naked goby)

Ictaluridae

Ictalurus catus (white catfish)
I. nubulosus (brown bullhead)
I. punctatus (channel catfish)

Percidae

Etheostoma olmstedi (tessellated darter)
Perca flavescens (yellow perch)

Pleuronectidae

Paralichthys dentatus (summer flounder)

Pomatomidae

Pomatomus saltatrix (bluefish)

Poeciliidae

Gambusia affinis (mosquitofish)

Sciaenidae

Bairdella chrysura (silver perch)
Cynoscion regalis (weakfish)
Leiostomus xanthurus (spot)
Micropogon undulatus (Atlantic croaker)

Serranidae

Morone americanus (white perch)
M. saxatilis (striped bass)

Soleidae

Trinectes maculatus (hogchoker)

Umbridae

Umbra pygmaea (eastern mudminnow)

REFERENCES FOR APPENDIX G

1. J. D. Andrews and Catherine Cook, "Range and Habitat of the Clam Polymesoda caroliniana (Bosc) in Virginia (Family Cycladidae)," Ecology 32(4), 758-760 (1951).

2. W. H. Massmann, "Relative Abundance of Young Fishes in Virginia Estuaries," Technical sessions, Eighteenth North American Wildlife Conference, pp. 439-449.

3. W. H. Massman, "Marine Fishes in Fresh and Brackish Waters of Virginia Rivers," Ecology 35(1), 75-78 (1954).

4. Virginia Electric and Power Company, Applicant's Environmental Report Supplement, Operating License Stage, Surry Power Station (1971).

5. Virginia Institute of Marine Science, A Study of the Flora and Fauna in the Oligohaline Zone of the James River, Virginia. Preoperational Report, Vepco Surry (1971).

APPENDIX H

Virginia Electric and Power Company Analysis of Alternate Cooling Methods for the Surry Power Station

Several types of cooling systems have been considered for providing condenser cooling water at Surry. These include once-through cooling, once-through cooling with additional dilution, cooling lagoons, spray systems, and cooling towers. The selection of once-through cooling was based upon site characteristics, water availability, aesthetics, initial costs, and environmental effects. This method provided an efficient system with minimum operating and maintenance costs, and its impact on the river ecology was anticipated to be minimal. Other reasons influencing this decision are discussed below.

1. Design Basis

In the interest of accuracy, all costs where possible are based on real costs of equipment and construction within the Vepco system purchased subsequent to the design of the Surry cooling system. Maintenance costs were not included in any of the estimates because of the difficulty in obtaining an accurate cost figure. Operational costs are based upon an expected 30-year life. All costs are based upon the full power requirements of both Surry units.

The following values were used to determine the size and operating cost of the various alternate cooling systems:

Cooling Water Flow	-	1,546,000 gpm (both Units)
Range	-	13.9°F
Approach	-	10° F
Max. Summer WBT	-	78° F

The range is the temperature span over which the water is cooled by the cooling system. In this evaluation the range equals the temperature rise of the water passing through the condenser; thus the evaluation is applicable either to an open or to a closed condenser cooling water system. WBT is wet bulb temperature, representing the lowest temperature that the cooling water can reach by evaporative means for given ambient conditions.

The approach is the smallest differential temperature above the WBT that a given cooling system can attain. These values constitute the minimum conditions which can be tolerated without a decrease in station performance during summer operation.

.2. Alternate Systems

a. Dilution

Dilution of the cooling water effluent would require additional expenditures for pumping excess water into the cooling water system. For example, in order to achieve half the temperature rise that is presently incorporated in the system design, the station would require an additional set of circulating water pumps with the same capacity as those presently installed, and a dilution water bypass canal with automatic gates and flow control equipment. The section of the inlet canal upstream of the condenser would have to hold enough water to allow the station to come off load in the event of total circulating water pump failure without causing damage to critical station components. Therefore, automatic flow control gates would be required to shut off the bypass canal under these conditions to prevent draining of the inlet canal.

The estimated cost for a dilution system would be:

Pumps	$1,460,000
Canal, gates, and control system	4,900,000
Operating Cost (30 Yr. Life)	1,966,000
Total	$8,326,000

This means of reducing the temperature of the water leaving the station does not reduce the temperature rise of the water passing through the condensers, nor does it reduce the heat load to the river.

b. Reservoir, Lagoons, Cooling Ponds

A cooling reservoir would have been the most difficult cooling method to employ at the Surry site since the topography of the area does not lend itself to this application.

As may be seen from Figure I.A-2 on p. 4 of the Environmental Report Supplement, the land area within a three-mile radius from the Unit 1 containment is small. The total amount within this radius, including the wildlife refuge, is about 10 square miles, or 6400 acres. Our calculations indicate that a closed reservoir sized for the two Surry units would have to contain 50,000 acre-feet of water (7000 acres, averaging seven feet deep).

It is clear that this type of facility would have to be constructed inland, remote from the power station, and that considerable expenditures would be required for dikes, canals, and make-up water pumps.

The land near Surry sells for approximately $330 per acre, which would result in a cost of $2,310,000 to buy the required 7,000 acres. Clearing costs, at $350 per acre, would add an additional $2,450,000. The dams and dikes required to enclose the reservoir and provide an average depth of seven feet would cost approximately $8,500,000 and the dikes and canals needed to divide the reservoir into cooling lagoons would cost another $7,500,000. The pumping station required for filling and make-up would cost $1,500,000. Thus the total cost for installing a reservoir cooling system would amount to $22,260,000, not including costs of canals and other modifications required to provide an interface with the present cooling system.

c. Spray Systems

At the time that the design for the Surry cooling system was being completed, no suitable spray systems were commercially available. Presently available power spray modules in the development phase have experienced high maintenance costs. The cost for a power spray installation would have been approximately $12,000,000. A more extensive canal system would have been required to allow sufficient treatment time. On the basis of the cost of the existing canals, the additional canals would have cost $1,000,000. The operating cost of a spray system over a 30 year life is expected to be $3,920,000. Thus the cost of an adequate power spray system would be $16,920,000, in addition to the amount spent on the existing system, which is still required.

Installation of spray systems in the present discharge system, because of the low initial ΔT of 14F and the volume of water involved, would result in only a 1-2F reduction in ΔT at the discharge groin. Such expenditure to achieve this minimal result is not economically feasible or justifiable.

d. 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 utilizing once-through cooling. Topographic maps of the James River around the peninsula indicated that adequate river surface area and water volume were available to 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, alternate techniques for providing cooling were not believed necessary.

Even so, initial thought and design consideration were given to the installation of cooling towers. Further study indicated, however, that they were not feasible at Surry. There are no operational salt-water towers of the size required for the Surry installation. Preliminary estimates were that two cooling towers would have been required for each unit, and that the size of each tower would have been 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 features 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 aesthetically undesirable by many.

The cooling towers would have to operate on saline river water which contains sea salt concentrations approaching 20,000 ppm during certain portions of the year. In 1967 there were no utilities in this country operating a cooling tower on brackish water, and those industrial towers which were operating under this condition were experiencing severe maintenance problems. One small unit in England (45 MW per tower) was in operation. A portion of these salts would be carried into the vapor plume, and this saline "drift" or "mist" could possibly have a deleterious effect on plant life and on the environment of the area. With a high deposition rate, the offsite 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.

Make-up requirements for cooling towers can be extreme. Typical values are 2 percent for natural draft towers and 5-10 percent for mechanical draft cooling towers. In cases of unusual temperature conditions and drift problems, much larger values have been experienced.

The installed prices for cooling towers would have been $69,600,000 for natural draft cooling towers and $42,500,000 for mechanical draft cooling towers. These costs include (in addition to the structure) pumps, piping, canals, and control and monitoring equipment. The operating costs over a 30-year life would be $2,400,000 and $4,800,000, respectively.

Mechanical draft cooling towers would have been a poor choice at this location despite the lower cost. The total cost for natural draft cooling towers would thus have been $72,000,000 over and above the cost of the system presently installed, since similar equipment would still be necessary.

3. Conclusion

The above discussion indicates that alternate cooling methods were excluded primarily on the basis of initial cost. Other considerations, however, were difficulty of installation, anticipation of extensive maintenance costs with relatively new systems (spargers, large cooling towers), aesthetic values, and environmental costs.

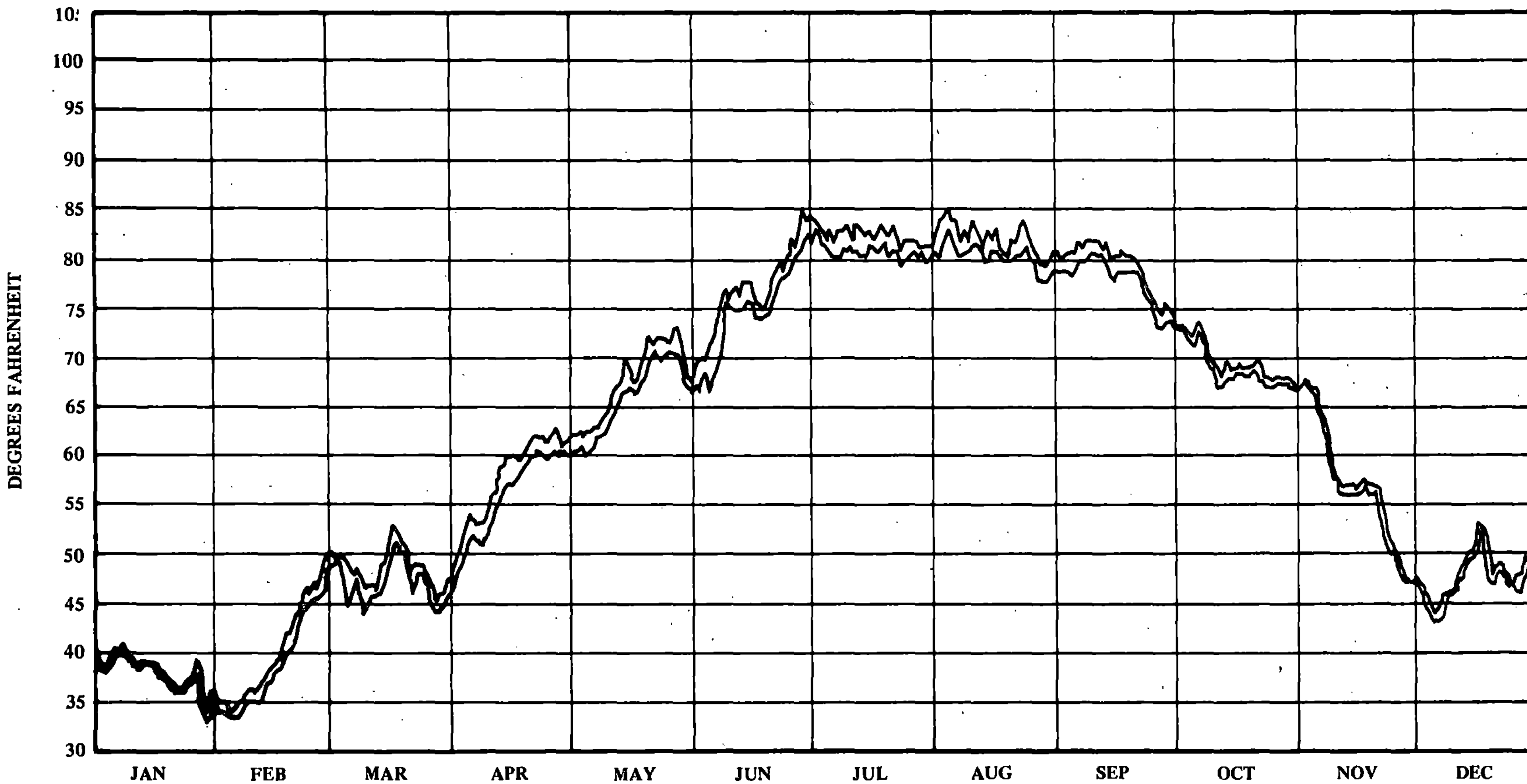
With regard to environmental costs, each alternate system would require additional treatment of the water and thus could have potentially adverse effects upon marine organisms. For example, organisms in the makeup water to cooling towers or lagoons would be totally removed from the river ecosystem.

It is evident that each of the cooling methods discussed would have some adverse effects on the marine environment. Thus, since the presently installed once-through cooling system is expected to have a very limited effect on the river ecology, the rationale for installing one of the alternate systems is questionable.

A consideration of the costs involved indicates that each alternate system would have required great additional expense and would have produced a questionable improvement if any, in environmental protection. Since these alternate cooling systems would not have materially improved the cost-benefit balance for Surry Power Station, Applicant did not feel that they should have been installed initially, and is of the same opinion at this time.

JAMES RIVER STUDY – SURRY

CBN MID MAX & MIN TEMP. 1971



Commonwealth of Virginia

STATE WATER CONTROL BOARD

P. O. Box 11143, 4010 W. Broad St., Richmond, Virginia 23230 · (703) 770-2241

A. H. Paessler, Executive Secretary

APPENDIX I

CERTIFICATE OF ASSURANCE

NO. CA-1843

ISSUED TO

Virginia Electric and Power Company
Surry Nuclear Power Station
Box 315
Surry, Virginia 23833

January 28, 1972

The State Water Control Board hereby certifies that there is reasonable assurance that the wastewater discharge certified in the attached Certificate No. 1843 dated December 12, 1967, and subject to the conditions and restrictions enumerated therein will not cause any violation of applicable water quality standards.

By: A H Paessler
A. H. Paessler, Executive Secretary

COMMONWEALTH OF VIRGINIA STATE WATER CONTROL BOARD

P. O. BOX 11143 - RICHMOND, VIRGINIA 23230 - (703) 770-2241

APPENDIX I

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 25, 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.

APPENDIX I

STATE WATER CONTROL BOARD

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, CHAIRMAN

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

50 - 280
50 - 281

April 17, 1972

RECEIVED
APR 18 1972
U.S. ATOMIC ENERGY COMMISSION
Regulatory
Mail Section

Mr. Lester Rogers, Director
Division of Radiological and
Environmental Protection
U. S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Rogers:

We have had AEC's draft environmental statement for the Surry Station Units 1 and 2 of the Virginia Electric and Power Company reviewed in the relevant agencies of the Department of Agriculture and comments from Forest Service and Economic Research Service, both agencies of the Department, are enclosed.

Sincerely,

T C Byerly

T. C. BYERLY
Coordinator, Environmental
Quality Activities

Enclosures

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

re: Virginia Electric and Power Company

The two units of the Surry Station are being constructed on a small peninsula in Surry County, Virginia, that protrudes into the James River 25 miles upstream from the junction of this river and Chesapeake Bay. The statement indicates that 453 acres of woodland have been cleared for the construction of the station and 3,543 acres cleared for project transmission lines. The statement relates loss of woodland only to a temporary displacement of wildlife. Other adverse impacts of woodland clearing, which should be added to the statement, include loss of a timber inventory base and its annual growth and an increase in soil movement and sediment production.

The statement would be strengthened if it would discuss criteria that was employed in locating transmission lines to assure adequate consideration of involved environmental values. If possible, costs that are associated with environmental protection in line location, construction, and maintenance should be made known. Also the statement might report the company's policy in respect to utilization of non-air polluting practices in disposal of waste vegetation.

In regard to gaseous radioactive wastes which would be held for decay in the waste disposal system before discharged into the atmosphere, the statement might give consideration to the amount and the contents of the discharged gases and discuss any effects they would have on the environment.

ERS Comments on the Draft Detailed Environmental Statement for the Surry Nuclear Power Station, Virginia

The statement conforms, in general, with the NEP Act criteria for content. The cost-benefit summary table (p. 159) indicates certain advantages of the proposed action that cannot presently be expressed in money amounts. An example is the estimated number of jobs provided by the operation of the proposed nuclear power alternative. We believe that the statement would be more effective if the expected favorable and adverse aspects of all of the various alternatives considered were presented together in a comparative type of summary.

DEPARTMENT OF THE ARMY
NORFOLK DISTRICT, CORPS OF ENGINEERS
FORT NORFOLK, 803 FRONT STREET
NORFOLK, VIRGINIA 23510

IN REPLY REFER TO

NAOEN-R

13 April 1972

50-280
50-281

Mr. Lester Rogers
Director
Division of Radiological and
Environmental Protection
Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Rogers:

With regard to your Draft Detailed Statement on Environmental Considerations related to the Proposed Issuance of Operating Licenses to the Virginia Electric and Power Company for Surry Power Station Units 1 and 2, we have no comment.

Sincerely yours,

for W. H. TAMM
Chief, Engineering Division

50-280
50-281

April 14, 1972

RECEIVED
APR 17 1972
U.S. ATOMIC ENERGY COMMISSION
Regulatory Mail Section

Mr. Lester Rogers, Director
Division of Radiological and
Environmental Protection
U.S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

The Draft Detailed Statement by the U.S. Atomic Energy Commission on Environmental Considerations Related to the Proposed Issuance of Operating Licenses to the Virginia Electric and Power Company for Surry Power Station, Units 1 and 2, Surry County, Virginia, Docket Numbers 50-280 and 50-281, which accompanied your letter, has been received by the Department of Commerce for review and comment.

In order to give you the benefit of the Department's analysis, the following comments are offered for your consideration.

We have reviewed the statement on the Surry Power Station and consider that it gives objective consideration to the probable impact and potential adverse effects that the operation of this facility will impose upon the environment and associated aquatic biota in the James River estuary. To further strengthen the statement, we offer the following comments and suggestions for possible inclusion.

With regard to Section III, the Station, apparently no research facilities, ponds, tanks, or raceways were considered on the site for experiments concerning the beneficial use of heated water for aquaculture. Perhaps the applicant has given, or will give some consideration to aquaculture research; if so, discussion of this topic could be included.

A quantitative discussion of thermal plume behavior appears on pages 54-59. Based on figures 2.10, 3.13, and 3.14 (pp. 35, 56 and 59), it appears that heated water will be recycled through the plant during ebb and slack tide. Although we realize that this possibility must have been considered during studies of the Surry thermal plume, there does not seem to be any mention of it in the statement. If heated water is recycled through the plant, it would seem that the discharge temperature would be higher than 14°F above ambient. However, if the heated water drawn into the intake cools to ambient before being reheated, the increase in temperature would be unaffected. Some discussion of this matter would eliminate confusion or misinterpretation of the information that is presented.

On page 67, it is stated that approximately 100 to 200 drums of solid wastes will be transported offsite for burial each year. The location of the burial grounds, particularly in relation to proximity to water and aquatic resources should be specified.

It is stated (page 67) that ".... a mechanical system will be used to clean the condenser tubes and no chemical additions to the cooling water will be required." However, on page 75, the possibility of using chlorine as a biocide is introduced. Chlorine has been found to be extremely toxic to aquatic organisms (as pointed out in this section of the statement). On the other hand, the mechanical system that has been installed has been found to be not entirely satisfactory elsewhere (as noted, for example, in the statement on the Enrico Fermi plant). Some discussion of the efficacy of the installed system in comparison with other mechanical systems could be presented, in conjunction with an evaluation of the feasibility of replacing the installed system with another system, if necessary, to protect aquatic life.

Under Section V, Environmental Impacts of Station Operation, Aquatic Ecosystems, on pages 78-79, it is stated that "State water quality standards for tidal estuaries in the coastal zone of Virginia limit the temperature rise at the edge of the mixing zone of the thermal plume to 1.5°F during the June-August period. It is further stated that "....the mixing zone shall occupy as small an area and length as possible and shall not prevent free passage of fish." We do not understand how the power plant will be able to comply with these standards and restrictions, based on the predicted thermal plumes shown in Fig. 3.14 (page 59). On page 86, first paragraph, it is stated that "Intake velocities through the trash racks at the Surry Power Station will be slightly greater than 1 fps." Based on Fig. 5.3, slightly greater flow than 1 fps (for example, 1.2fps) can cause serious fish kills.

On page 86, last paragraph, it is concluded that the technique of using air bubble curtains to scare fish away from the intake ....,"may not perform adequately." In view of the uncertain effectiveness of this method, the statement should indicate that alternative methods for preventing or curtailing impingement of fish will be tested and evaluated. Possible modifications are mentioned on page 153 in the section on "modifications of the once-through cooling system." Reference to this section might be made at the bottom of page 86.

The effects of the discharge of heated water on the aquatic biota are covered thoroughly on pages 87-114, and it is apparent that heav mortalities will occur. Yet on page 145, it is stated that ".... the total impact on the environment from operation of the Surry Power Station will constitute a moderately adverse effect....." The term "moderately" should be better defined.

In the section on "Adequacy of the Environmental Monitoring Program" on page 130, several recommendations are made for improving the program. We presume the applicant will give them favorable consideration in view of the likelihood that the results will provide valuable information on the effects of operation of this power plant on aquatic biota. In addition to the proposed studies, monitoring of trends in commercial fish and shellfish landings might reveal a subtle long-term impact that may not otherwise be noticed.

The liquid radioactive effluent release expected from this power station is substantially greater than that expected from nuclear power stations of similar type and power rating. Other than the steam generator blowdown, the total release expected is relatively low; however, the release from this blowdown is substantial (104.9 Ci/yr) for the assumptions used in generating table 3.4. Of this steam generator blowdown, the most serious radionuclide is probably 131_I for which 23.90 Ci/yr release is expected.

While it is stated that if the radioactivity in the blowdown reaches a concentration of 3.5×10^{-3} μCi/ml, the blowdown will be diverted to the liquid waste disposal system, it is also noted that the liquid waste disposal system evaporator would only be able to handle a small fraction (less than 14%) of the blowdown volume. Thus the proposed action is essentially meaningless.

Similarly, while the release of most gaseous effluents are quite reasonable in general, the expected release of gaseous radioactive iodines resulting from the steam generator blowdown operation are substantial, amounting to a total of 2.06 Ci/yr of ^{131}I and 1.10 Ci/yr of ^{133}I. It is noted in table 3.5 that these latter releases will be limited by the Technical Specifications to 0.9 Ci/yr; however, there is no discussion of how this will be accomplished.

The draft statement should contain specific reference to how the expected effluents compare to the Proposed Appendix I to 10 CFR 50. It is also proposed that as an alternative, the draft statement should contain a discussion of actions which would substantially reduce radioactive emissions resulting from the steam generator blowdown.

The discussion of Section V.D.1 regarding radiological impact of routine operations may be misleading, although technically correct. On page 115 it is stated that: "The dose calculations for the various exposure pathways and modes are discussed in some detail in succeeding sections, and the resulting estimates of dose for total body are presented in table 5.7."

While it is true that table 5.7 summarizes the total body dose as stated, there is no similar tabulation for dose to specific organs. Thus the estimate that "The thyroid dose for a child who drinks 0.6 liters of milk per day from the nearest dairy herd is about 48 mrem per year," is not given in tabular form even though this is more than a factor of 10 larger than any other single contribution to general population dose. Similarly the thyroid dose from air inhalation at the site boundary is not included in any tabular form.

Here again the relation of the expected population exposure to the proposed Appendix I of 10 CFR should be discussed. (We note that reference to proposed Appendix I of 10 CFR 50 is mentioned on page 140 during the discussion of postulated accidents.)

The discussion on page 125 regarding the environmental monitoring program states that this program was initiated more than two years ago, and that the ecological surveys are scheduled to continue through the first two years after station operation. There is no discussion of the future of monitoring programs after this period. It is also suggested that discussion of the in-plant radiation monitoring program in this draft statement would be helpful.

Our computation of a mean annual diffusion rate of 7×10^{-6} sec m^{-3} at the 500 m distance is in close agreement with the AEC's value of 5.5×10^{-6} sec m^{-3}. However, this diffusion rate is only applicable provided the release was at a uniform rate and spread throughout the entire year.

We are unable to assess the radiological impact of postulated accidents since the assumptions used by the AEC in computing downwind doses are described as "assumptions in the proposed annex to Appendix D," a document not available to us.

The plant will utilize a once-through cooling system taking 3740 cubic feet per sec (cfs) of water from the James River. At the plant's planned operating level, this cooling water will be heated 14°F and then discharged back into the river at a point 6 miles upstream of the intake. Comparing this amount of warming with a median monthly mean river flow of 7,860 cfs, the resultant river warming is estimated to be at least 5°F in a 1000 acre area of the river during the winter months. The effective warming over that of the normal river temperature could possibly be even greater when we consider that the intake lies downstream of this thermal discharge and some of this warmer water would be recycled into the plant. Based on this relatively large heat and moisture source, some consideration should have been given to the following possible inadvertent climatic modifications:

(a) the increased river water dissipation by evaporation and the subsequent addition of sensible heat and water vapor to the atmosphere, and

(b) the potential for greater frequency and intensity of steam fog over and downwind of the river and the resultant impact on river and nearby road traffic.

On page 24, reference is made to the wind roses obtained from the towers at the proposed site. The statement is made that the prevailing winds are from the Atlantic Ocean. The wind roses show that the prevailing winds are from directions of SW, W and NW, rather than off the Atlantic Ocean.

On the top of page 26 the statement is made that "farther inland severe thunderstorms and tornadoes are experienced each year." The implication is that severe thunderstorms and tornadoes do not occur in the immediate area. The annual point probability of a tornado in the area of the site is .00037 and severe thunderstorms are not unusual in the area of the Surry Power Station.

With regard to Table 10.3 on page 159, does employment payroll refer to number of employees or to dollars? The summary might also contain an estimate of the loss of commercial fish and shellfish (see pages 103, 107 and 145).

We hope these comments will be of assistance to you in the preparation of the final statement.

Sincerely,

Sidney R. Galler

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

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U.S. ATOMIC ENERGY COMMISSION
Regulatory Mail Section

MAY 1 1972

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Dear Mr. Muntzing:

This is in response to Mr. Rogers' letter of March 1972 requesting our comments on the Atomic Energy Commission's draft statement, dated March 1972, on environmental considerations for Surry Power Station Units 1 and 2, Surry County, Virginia.

Site Selection

The last paragraph on page 8 appears to show evidence of the applicant's restricting its siting possibilities to accommodate a nuclear power plant using once-through cooling. We do not think that lack of sufficient water for once-through cooling is an adequate reason for rejection of the Currituck Sound site in northeastern North Carolina. This reasoning is contrary to the requirements of NEPA.

Since the project area will ultimately involve approximately 4,285 acres of sand pits, marshes and segments of the James River and is in the vicinity of outdoor recreation resources of Hog Island Wildlife Management Refuge, the Chippokes Plantation State Park and historic Jamestown Island, we suggest that the applicant coordinate planning efforts with the State agencies involved in preservation of natural resources. Among these are the Virginia Division of State Parks, Division of Forestry, and the Commission of Game and Inland Fisheries.

Historic Significance

Bacon's Castle, Chippokes Plantation, Smith's Fort and Four Mile Tree are identified errroneously as national monuments. They should be identified as properties on the National Register of Historic Places.

Thermal Effects

Based on records for the period 1934 to 1965, the applicant determined that the minimum mean-monthly fresh-water

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discharge for the James River at the site was 857 cfs. However, an interpretation of upstream records indicates that mean flow during the period August through October 1930 was less than 700 cfs, with a minimum mean-monthly flow of about 600 cfs. During this drought the flow was about 440 cfs for seven consecutive days. We suggest that this discussion use as its basis the minimum 7-day flow since significant damage to aquatic life will likely occur as a result of minimum instantaneous flows rather than minimum monthly flows.

Radioactive Waste

The statement indicates that solid radioactive waste will be packaged and shipped to a licensed burial ground in accordance with AEC and DOT regulations. The location of these licensed burial grounds should be identified and included in the final environmental statement.

Chemical and Sanitary Wastes

According to pages 67 and 75, a mechanical method will be used to clean the condenser tubes, thus hopefully obviating the need for biocides. However, there is still a possibility of the need for a biocide and the applicant has obtained approval from the Virginia State Water Control Board for the use of chlorine. The applicant plans to limit chlorination to 0.5 ppm residual chlorine for 30 minutes each eight hours.

The AEC has expressed concern for this level of concentration since organisms entrained in the thermal plume may be exposed to toxic levels of chlorine for several hours. We suggest that careful monitoring of the effects of chlorine used as a biocide be required by AEC and if the impacts are significant, appropriate action be required to alleviate the effects by appropriate methods such as aeration devices or holding ponds.

Nonradioactive trash such as paper and shop debris will be burned. We suggest that the statement explain how the burning will be accomplished to control smoke and fly ash and the method of disposal of the residue.

According to page 68, trash from the intake screens will be buried on site. We suggest that the statement describe the criteria for burial and possible environmental impacts. Since fish and other aquatic life killed on the screens will be buried with the trash, offensive odors could occur if the cover is thin or if the groundwater rises as a result of rainy periods.

Impact on Aquatic Ecosystems

The temperature effects have been estimated on the basis of a physical model and analytical analysis. However, due to the rather complex flow conditions existing in the vicinity of the cooling water intake and discharge canals, it is unlikely that sufficient evidence would be available to suggest that an alternative cooling method be used at this time. Thus, post-operational studies of the temperatures and possible ecological effects must eventually dictate whether or not remedial measures will be necessary.

It is stated that the project would alter the natural salt transport and salinity stratification regime in this area and this could result in a significant impact on the biota of the James River upstream from the project. AEC recognizes the importance of density stratification and density flow to estuarine species on page 77, but concludes that a quantitative assessment of this potential impact cannot be made until more data are available. We suggest that AEC require the applicant to collect relevant data needed to make a quantitative assessment of this potential impact prior to plant operation.

It is stated on page 89 that dominance of some diatoms will decrease and green and blue-green algae will increase in abundance in some areas covered by the thermal plume during the summer period. It was also stated on page 92 that since a large proportion of the phytoplankton will be exposed to elevated temperatures during condenser passage, the composition of the phytoplankton community around Gravel Neck may change toward more heat-tolerant forms. However, the statement does not identify the types of blue-green algae expected as a result of elevated temperature or the adverse environmental consequences which may result.

These consequences should include the possibility of a reduction in primary productivity in the James River estuary, the loss of photosynthetic capacity of planktonic forms exposed to elevated temperatures and the reduction in the amount of material available as the base for the food chains of many animals. The discussion should also cover any anticipated adverse impacts upon the intermediate food-chain organisms as a result of phytoplankton-community structure alteration.

The discussion on pages 97 - 100 indicates, the critical role that the zooplankton play in the trophic structure of estuarine systems and the likelihood that a large area of the river will be lost as habitat to many zooplankton species. However, according to the statement, the net effects on zooplankton production and on the ecology throughout the year of the James River, cannot be assessed until quantitative data on zooplankton composition throughout the year are available. We think that an assessment or a postulation of the effect should be included in the final environmental statement. We also think that the assessment or postulation should be compared to post-operation assessments of the effects.

The statement indicates that blue crabs are expected to avoid areas where the water temperature is above 90°F and Rangia embryos and larvae drawn through the condenser and exposed to the combined salinity-thermal shock are likely to result in complete mortality. The environmental statement should include a quantitative analysis of the impact of all project-related decrease in abundance and yield of blue crabs. Both long and short range ecological consequences of the loss of zooplankton and benthos should be addressed.

Although the statement adequately describes the expected mortality of adult fish, eggs, and larvae to thermal shock, entrainment and impingement, it does not assess the potential adverse effects on sport and commercial fishing which are likely to occur as a result of these losses. The statement on page 114 that "the overall impact on fish in the James River from all of the sources previously discussed will be to stress fish populations in the area of Hog Island" is not an adequate quantitative evaluation.

The possibility of affecting migrating fish which in turn would affect upstream and downstream fisheries is evident. The expected quantity of fish resources and their habitats which are affected should be described. Expected short and long term impacts on the commercial harvest, sport and recreational harvest, resident and anadromous fish population structure and diversity, anadromous fish migrations and juvenile rearing areas, and the degree to which standing crops of various species will be affected should be evaluated.

Radiological Impact of Routine Operation

Aquatic plants should be included in the sampling program. Some type of rooted plant should be sampled as an indicator for the presence of certain radionuclides, particularly those elements which are accumulated by surface absorption.

Adequacy of the Monitoring Program

It appears that AEC has done an adequate job of evaluating the applicant's monitoring program and suggesting programs for post-operation monitoring; however, the statement shows what AEC thinks should be done rather than what AEC requires. We suggest that since AEC believes that the data discussed on pages 130 - 132 are needed, it should make the acquiring of this data a part of the license requirements and should list them as requirements in the final environmental statement.

Accidents

Section VI, Environmental Impact of Postulated Accidents, gives an adequate evaluation of impacts resulting from postulated accidents through Class 8 for air borne emissions. However, the environmental effects of releases to water is lacking. Many of the accidents described in Table 6.2 could result in releases to the water and should be evaluated.

We also think that Class 9 accidents resulting in both air and water releases should be described and the impact on human life and the remaining environment discussed as long as there is any possibility of occurrence. The consequences of an accident of this severity could have far-reaching effects on the land and water bodies and could last for centuries.

We suggest that the applicant develop emergency procedures for maximum containment of waste and minimum personnel contamination, which would be used if a severe transportation accident caused a spill of low-level solid wastes. This procedure should be included in the final environmental statement.

Adverse Effects Which Cannot be Avoided

This section is superficial and does not present the magnitude of resource losses which are expected to occur as a result of the plant. A more quantitative description of the adverse effects of the project and the expected associated degradation is needed.

Short Term Uses and Long Term Productivity

Mention is made on page 148 of the recreational use of Cobham Bay and the riverfront west of Gravel Neck; however, an adequate discussion of the extent and type of impact on the water and land resources of the peninsula and adjacent areas is not given. The statement should discuss the long term effect of the station's operation in relation to coordinated planning for recreational development of Gravel Neck Peninsula.

The statement that "Hog Island has no particular value as a habitat for land animals" is not correct. The area provides valuable habitat for a variety of upland game species, including white-tailed deer and an abundance of small animals. At various times, Hog Island has been used as a study area for research projects on rabbits. We think that the last sentence on page 147 should read as follows:

> "This impediment is not considered important, except that the existing ecological balance may be altered."

Irreversible and Irretrievable Commitment of Resources

This section should describe the annual production of fish and wildlife resources that will be lost due to the construction and operation of the project. Wildlife resources reduction within the area to be cleared for transmission lines and plant facilities and losses of aquatic biota due to channel dredging and plant operation should be included.

Alternatives

Many of the Department of the Interior's concerns and the Atomic Energy Commission's concerns expressed in the statement could be eliminated or significantly reduced by the use of alternative cooling methods such as cooling towers or cooling ponds. However, we note that AEC's review of the applicant's evaluation supports his judgment. Several possible modifications of the once-through cooling system are described on pages 153 and 154 and could be used if post-operational monitoring shows that such modifications are needed.

It is stated on page 154 that if the modifications suggested for the once-through cooling system do not provide for adequate protection of the aquatic environment closed-cycle systems must be considered. We suggest that the language be changed to state that if the once-through cooling system does not provide for adequate protection of the aquatic environment, AEC will require the applicant to use a closed-cycle cooling system. The similar statement in item 6 on page ii should be likewise changed.

Summary of Cost-Benefit Analysis

We think that the cost-benefit summary presented in Table 10.3 is inadequate. It appears that the transmission and distribution cost is not included in the monetary evaluation. The taxes paid to Surry County should not be included since this money is first paid by the applicant's customers as part of the electric utility bill and is therefore simply a transfer of funds.

The biological impact should be expanded to include damage to fish and other aquatic life. The word "moderate" is not an adequate evaluation.

We suggest that the water consumed through induced evaporation of about 15,000 gpm be included under water use.

We hope these comments will be useful to you in the preparation of the final environmental statement.

Sincerely yours,

J. J. Lyon

Deputy Assistant Secretary of the Interior

Mr. L. Manning Muntzing
Director of Regulation
U.S. Atomic Energy Commission
Washington, D.C. 20545

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

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U.S. ATOMIC ENERGY COMMISSION
Regulatory

Mr. Lester Rogers, Director
Division of Radiological
and Environmental Protection
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

This is in response to your letter of early March addressed to Mr. Herbert F. DeSimone, Assistant Secretary for Environment and Urban Systems, Department of Transportation, concerning the environmental impact statement, environmental report and other pertinent papers for the Surry Power Station Units 1 and 2 presently under construction at Gravel Neck, James River in Surry County, Virginia.

The concerned operating administrations and staff of the Department of Transportation have reviewed the material submitted for this project.

Noted in the review of the Office of Hazardous Materials is the following:

> "We have no specific comments to offer on this report. We find no statement or information regarding the transport of radioactive material which are inconsistent with existing DOT or AEC regulatory requirements. We were especially impressed with the coverage and detail provided in the Surry Report."

Reference is made to the Department's previous review of the project as indicated in our letter to Mr. Harold L. Price dated 4 May 1971. In the previous review this Department had certain concerns regarding low flows. It appears that the revised environmental impact statement more than adequately covers this particular concern.

The Department of Transportation has no other comment to offer concerning the information submitted for the Surry Project. It is pleased to note, however, the extensive treatment given to the transportation aspects of this nuclear facility. This Department has no objection to the draft statement and we have no objection to the issuance of an operating license for the Surry Project.

The opportunity to review and comment on the Surry Power Station Units 1 and 2 is appreciated.

Sincerely,

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W. L. BENKERT
Rear Admiral, U. S. Coast Guard
Chief, Office of Marine Environment
and Systems

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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U.S. ATOMIC ENERGY COMMISSION
Regulatory Mail Section

14 APR 1972

Mr. Manning L. Muntzing
Director of Regulation
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Muntzing:

The Environmental Protection Agency has reviewed the draft environmental impact statement for the Surry Power Station Units 1 and 2.

We appreciate the difficult circumstances and time restrictions under which the Atomic Energy Commission must prepare a series of complex impact statements. We also recognize the difficulty in determining the appropriate degree to which an agency should go in developing and providing data to support conclusions reached in the impact statement. It is our judgment, however, that this statement should contain additional information in order to evaluate fully the environmental impact of operating the Surry Power Station. We, therefore, recommend that the final impact statement contain the additional information outlined in our detailed comments which are enclosed.

The major environmental impact of the Surry Power Station will result from the operation of the once-through cooling system. In order to determine the requirements for alternative cooling, we need the information requested in our detailed comments as well as thermal data generated by a comprehensive monitoring system while only unit one is operational.

In addition to thermal effects, sufficient saline water from the coolant discharge will be moved upstream to change the natural salinity patterns. Since the impact on biota could be quite significant, additional information on the synergistic effects of the concurrent saltwater/freshwater interchange and temperature increases should be included in the final statement.

With respect to the facility itself, the capacity of the liquid radioactive waste treatment system appears inadequate to handle the volumes of liquid wastes which are expected to be generated. Relative to other PWR plants of similar power output, the Surry liquid radwaste treatment system possesses only limited storage and processing capability. This may be of particular concern because of the commercial shellfishing and seasonal crab pot fishery in the immediate area of the Surry Power Station.

We will be pleased to discuss our comments with you or members of your staff.

Sincerely yours,

Sheldon Meyers
Director
Office of Federal Activities

Enclosure

ENVIRONMENTAL PROTECTION AGENCY

Washington, D.C. 20460

EPA-D-AEC-00044-14

APRIL 1972

ENVIRONMENTAL IMPACT STATEMENT COMMENTS

Surry Power Station Units 1 and 2

INTRODUCTION AND CONCLUSIONS

The Environmental Protection Agency has reviewed the draft environmental impact statement for the Surry Power Station Units 1 and 2 prepared by the U.S. Atomic Energy Commission and issued on March 13, 1972. Our conclusions are as follows:

1. It is our opinion that the present once-through cooling system may not provide adequate protection for the aquatic environment, and additional consideration should be given to the use of alternative cooling systems. Since naturally occurring water temperatures are high during the summer months (maximum surface temperature measured was 92.8°F, and 87°F occurs frequently at mid-depth), much of the biota is already under thermal stress. Even slight increases above these natural temperatures can cause far reaching effects for some species. In addition, the state water quality standards with regard to temperature may be exceeded at various times during the year and the 1.5°F isotherm will cover a major portion of the river on a routine basis.

2. The capacity of the liquid radioactive waste treatment system appears inadequate to handle the volumes of liquid wastes which are expected to be generated at this facility.

3. The final statement should include an assessment of the potential radiation dose to both individuals and the population resulting from the consumption of shellfish grown in the area waters that may have reconcentrated radionuclides discharged from the facility. This dose should be considered when developing liquid radioactive waste discharge limits for the Surry Station.

4. The AEC has done a commendable job of describing the ecology of a tidal estuarine area. There, is however, a need for additional baseline data on the local biota in order to more fully assess the environmental impact of plant operations. The needed data is specified in our detailed comments.

5. The environmental consequences of the concurrent saltwater/freshwater interchange and temperature increases induced by the Surry plant are not clearly understood. Additional information on this synergistic effect should be included in the final statement.

6. Two radiological issues require further analysis and evaluation--transportation accidents and accidents involving reactor systems. These issues are common to all nuclear power plants and it is appropriate that they be handled on a general basis. The AEC is currently studying the probability and consequences of such accidents and will apply their results to all licensed facilities. EPA is working closely with the AEC in the conduct of this work.

RADIOLOGICAL ASPECTS

Radioactive Waste Management

It was not clear from the impact statement that a minimum of 60 days holdup will be provided in the waste gas system, thus assuring that releases from this system will be essentially composed of Kr-85. According to the applicant, radioactive gases could be held up for as long as 300 days prior to release even when both units are being operated on a rigorous load following schedule. In order to be consistent with the "as low as practicable" provision of 10 CFR 50.36a, it would appear both prudent and practicable to achieve a minimum holdup of 60 days for radioactive gases in the Surry gaseous waste treatment system.

Experience at other nuclear power stations has shown that the gaseous waste system may not be the largest source of radioactive gaseous effluents. A delineation of the secondary sources is given in the draft statement although release estimates are provided for only a few. During primary-to-secondary leakage conditions, radioactive gases from the air ejector and blowdown flash tank vent will be released directly to the atmosphere without treatment. As shown in Table 3.5 of the draft detailed statement, the blowdown tank can be a large contributor to radioiodine releases. Since alternatives exist for treating or eliminating such releases, the feasibility of each alternative should be considered in the final statement. For example, a heat exchanger might be installed prior to the blowdown flash tank to control flashing and, consequently, partitioning of radioiodines into the gaseous phase. Alternatively, steam released in the blowdown flash tank might be routed back to the main condenser, or filters could be installed on the air ejector and blowdown flash tank vent to reduce releases of particulates and radioiodines.

The containment treatment system should be used in a manner consistent with keeping releases, especially radioiodines, as low as practicable. Particulate and charcoal filters are available for use in the auxiliary building, safeguards area, fuel building, and decontamination building, but may be by-passed. Although the draft detailed statement designates these particulate filters as HEPA filters, Figure 5.3.1-1 of the FSAR would indicate that they are not of such quality. Confirmation should be provided that these particulate filters are HEPA filters and that these filter systems are used to minimize gaseous and particulate releases.

The liquid radioactive waste treatment system, as described in the applicant's environmental report and the draft detailed statement, is inadequate when compared to other PWR plants of similar power output. As indicated in the draft detailed statement, the liquid waste disposal system is not capable of handling radioactive wastes generated during primary-to-secondary leakage. This limitation is a result of the low evaporator capacity (6 gpm) and limited liquid waste tank capacity. Other PWR plants of similar power output have evaporator capacities several times the capacity of the Surry Power Station waste evaporator, while tankage capacities are generally greater by at least a factor of two.

Consideration of the proposed treatment of radioactive steam generator blowdown appears to be inconsistent with keeping the radioactivity in effluents "as low as practicable." It is proposed to treat steam generator blowdown only when its concentration would cause the discharge canal concentration to exceed the applicable 10 CFR 20 concentration for an unidentified mixture of radionuclides in water. As shown in the draft statement, the magnitude of radioactivity in steam generator blowdown during periods of primary-to-secondary leakage, if untreated, may be far greater than any other source of liquid wastes. Since PWR operating experience has shown that primary-to-secondary leakage is not an uncommon event, steam generator blowdown should be treated whenever contaminated by such leakage, in order to keep radioactive effluents at the lowest practicable level.

Experience gained at other PWRs has shown that the magnitude of leakage from the secondary system is comparable to steam generator blowdown. During periods of primary-to-secondary leakage, secondary system leakage will also be contaminated. The draft detailed statement, however, does not provide an estimate of the volume or radionuclide concentrations associated with this leakage. Further, it is not clear from the FSAR or the environmental report whether secondary system leakage can be routed to the waste treatment system. The final detailed statement should provide complete estimates of liquid and gaseous sources of radioactivity from secondary system leakage during primary-to-secondary leakage conditions.

As indicated in the applicant's environmental report and the draft detailed statement, only the steam generator blowdown (22 gpm) would be diverted to the waste treatment system. Available tank capacity, however, could only contain a few hours of flow at this rate. Further, in the event of primary-to-secondary leakage much larger blowdown volumes can be expected; thus, because of the limited evaporator size, the system would be overloaded resulting in the discharge of contaminated liquids. This situation would be further aggravated by the addition of contaminated secondary system leakage to the liquid waste treatment system.

The capacity of the liquid radioactive waste treatment system thus appears inadequate to handle the volumes of liquid wastes which are expected to be generated at this facility. In order to maintain radioactivity releases "as low as practicable," the AEC should consider the need for installation of additional liquid radioactive waste processing capacity at the Surry Power Station.

The draft detailed statement indicates that radioactivity releases will be in accordance with AEC regulations as set forth in 10 CFR 20 and 10 CFR 50. It is noted that proposed technical specifications presented in the FSAR only require adherence to 10 CFR 20 regulations, without indicating the requirement to utilize the waste management equipment to maintain discharges as low as practicable in accordance with the provisions of 10 CFR 50.36a. In developing release limits for liquids, consideration should be given to potential reconcentration of radionuclides by shellfish, particulary iodine -131.

Dose Assessment

Except for fish and shellfish, the major pathways of individual and population doses are considered in the draft detailed statement. It was indicated that no population dose estimates for fish consumption were made because there are no commercial fishing grounds in the James River. There is, however, a considerable amount of sport fishing in the James River in the vicinity of the Surry Power Station. The final statement should clarify this point and provide a population dose assessment for fish consumption in light of the extensive sport fishing.

It also appears that the draft detailed statement has not considered shellfish in its dose assessment. Based on data in the draft detailed statement our analysis indicates that, relative to the proposed Appendix I guidelines, significant exposures may result from the ingestion of shellfish. Therefore, the final statement should provide both an individual and a population dose assessment for the shellfish pathway. We recognize that large uncertainties accompany each factor used in such a dose assessment. For example, the actual amount of dilution water available is unknown; concentration factors may vary by many orders of magnitude, and the assumed 20 g/day (16 lb/yr) individual intake may not be conservative.

In calculating the maximum annual individual dose at the site boundary in the detailed statement, it appears that the radioactive gas effluent was considered as being distributed among all sixteen 22.5° sectors around the Surry site according to annual average meteorological conditions. The applicant's proposed waste gas system cycle, however, will involve only a ten day release period per year. Containment purges of limited duration will also occur at various times during the year. For such short release periods only a few of the sixteen sectors may receive the radioactive gases released. Therefore, the maximum annual individual dose at the site boundary should be reevaluated taking into account meteorological conditions over appropriately short release periods.

Transportation and Reactor Accidents

In its review of nuclear power plants, EPA has identified a need for additional information on two types of accidents which could result in radiation exposure to the public; (1) those involving transportation of spent fuel and radioactive wastes and (2) in-plant accidents involving reactor systems.

Since each nuclear power reactor site may possess unique characteristics, these should be assessed individually relative to any potential significance during accident situations. The Surry cooling water intake structure is designed differently from other facilities. Water must be pumped up and into the intake canal, as shown on page 46 of the draft detailed statement. Consideration should be given to the implications of this unique arrangement during postulated accident situations where an uninterrupted supply of cooling water is required. Results of such an analysis could then be presented in the accident section of the final statement.

Many of the factors in accident analysis, however, are common to all nuclear power plants; the environmental risk for each type of accident is therefore amenable to a general analysis. Although the AEC has done considerable work for a number of years on the safety aspects of such accidents, we believe that a thorough analysis of the probabilities of occurrence and the expected consequences of such accidents is necessary. A general study would result in a better understanding of the environmental risks than would a less-detailed examination of the questions on a case-by-case basis. An understanding has been reached with the AEC that they will conduct such analyses, with EPA participation, concurrent with reviews of impact statements for individual facilities and will make the results public in the near future. We believe that any changes in equipment or operating procedures for individual plants, required as a result of these analyses, could be included without appreciably changing the overall plant design. If major redesign of the plants to include engineering changes were expected, or if an immediate public or environmental risk were being taken while these two issues were being resolved, we will, of course, make our concerns known, and an updated impact statement may be necessary.

The statement concludes "...that the environmental risks due to postulated radiological accidents are exceedingly small." This conclusion is based on the standard accident assumptions and guidance issued by the AEC for light-water-cooled reactors as a proposed amendment to Appendix D of 10 CFR Part 50 on December 1, 1971. EPA commented on this proposed amendment in a letter to the Commission on January 13, 1972, indicating the necessity for a detailed discussion of the technical bases of the assumptions involved in determining the various classes of accidents and expected consequences. We believe that the general analysis of accidents mentioned above will be adequate to resolve these points and that the AEC will apply the results to all licensed facilities.

NON-RADIOLOGICAL ASPECTS

Water Quality and Thermal Effects

Thermal Effects

The once-through cooling system proposed for the Surry Power Station will raise the temperature of the cooling water about 14°F at full power operation. This appears to be an excessive heat release to the river and means that the applicable federally-approved state water quality standards could be exceeded during the summer months. The standards call for a maximum rise of 1.5°F in the James River estuary in June, July, and August. Although a small mixing zone might be acceptable, the average closing excess temperature over the tidal cycle is nearly 1.5°F.

In addition, the more complex thermal activity of the Surry discharge plume is difficult to evaluate due to some major inadequacies in the supportive modeling studies. For example, the James River estuary is a tide-dominated system with density variations associated with temperature and salinity variations. We believe that for this complex system, since numerical models are presently inadequate, only a physical model can predict the effect of thermal discharges.

Apparently the physical model was run only under summer conditions. In order to complete the study, however, modeling should be performed for other seasons. Although this need for additional studies was recognized in the draft statement, EPA would like to emphasize the importance of these studies and predictions, and recommend that they be instituted as soon as practical. Such additional thermal predictions are needed for more varied and extreme conditions. For example, a unique set of problems can occur under high flow winter conditions in the James River. During these periods the upstream thermal discharge may cause the creation of a plume of warm saline water in a body of essentially fresh water. This plume may submerge resulting in a larger area being occupied than if it were on the surface. The probability of such a submerged plume forming should be studied, and its impact on the biota should be assessed.

There is some question regarding wind velocity measurements used in the predictive studies. We believe that the use of 5 mph for summer and 10 mph for winter conditions is too high and therefore these studies tend to underestimate the size of the thermal plume. In addition, it appears that the monthly average wind velocity for only one year was considered. The use of one year's data is not adequate for establishing a baseline wind velocity, especially considering the 40 year lifetime of the plant. The reevaluation of the thermal plume using more representative wind velocities and both significantly lower and higher wind velocities is recommended.

Our evaluation of plume behavior and effects is also hampered by the lack of certain needed information which makes it difficult to verify the accuracy of the predicted thermal plumes. This information, describing the characteristics of the thermal plume, should be presented in support of Figure 3.13 and should include a description of the depth of the heated zone, indicate the minimum temperature isotherm with which the plume is being defined, and show the 1.5°F isotherm for summer conditions.

The draft impact statement indicates that the non-tidal circulatory flow in the upper layer remains essentially steady at 25,000 cfs for fresh water flows between 2,000 cfs and 6,000 cfs. According to the applicant's environmental report, however, when the fresh water flow at Hog Point was approximately 6,000 cfs, the net non-tidal flow in the upper layer at Deep Water Shoals was 18,000 cfs. This upper layer flow is somewhat less than the stated 25,000 cfs non-tidal circulatory flow. The final statement should clarify this point. Also, the magnitude of the non-tidal circulatory flow should be given for fresh-water inflows outside of the 2,000 cfs-6,000 cfs range, especially for low flow conditions. Such flows are significantly greater than the 7 day-10 year low flow of 650 cfs at Richmond. Variations in the magnitude of the non-tidal circulatory flow will vary the size and shape of the predicted thermal plume. Therefore, the additional predictions and studies should be based on flows which produce the most critical conditions.

The conditions discussed above combine to question the environmental acceptability of proposed once-through cooling. We feel, therefore, that additional environmental assurances are needed. We believe 'hese assurances should include the provision of the additional information requested in our detailed comments, and careful monitoring during the period when only unit one is operational in order to validate the predictive thermal data. These actions should clarify the thermal issue and permit a determination of the acceptability of once-through cooling.

Salinity Effects

Sufficient saline water from the coolant discharge will be moved upstream to change the density stratification and result in a well-mixed estuary. The impact upon biota could be quite significant and adequate data to make a judgement is not presented. An alternate cooling system could be a means of avoiding this effect and should be considered. It was indicated in the draft statement that "when flows are less than 14,000 cfs, salt water extends upstream of the Surry discharge canal..." This information is in conflict with that given in Appendix E of the applicant's environmental report. Specifically, page E-10 states that "at a river discharge of 10,000 cfs, the area from Hog Point upstream is in the freshwater tidal river." In addition to clarifying this information, more data concerning the natural salinity of the area around Hog Point should be given. Also, a table should be included which summarizes variations in the natural salinities at Cobham Bay, Hog Point, and Deep Water Shoals for various fresh water flows. This is necessary to evaluate the impact of discharges that have a higher salinity than the receiving waters. The expected changes in the natural salinity patterns should be given, as the impact on biota could be quite significant. The National Technical Advisory Committee recommends that changes in the salinity patterns be not more than $\pm$ 10% of the natural variation.

Chemical and Other Discharges

Although a mechanical system is provided for cleaning the condensers, there is the possibility that a chlorine condenser wash may be required occasionally. Although EPA recommends that no chlorine be used, if the use of this biocide becomes essential, it should be employed so that residuals at discharge measure less than 0.1mg/l. Further, since the discharge of chlorine or other biocides could have adverse effects on the biota of the James River, the methods and conditions under which it will be used should be discussed in the final statement. In addition, the use of dechlorination techniques to avoid the discharge of excessive amounts of residual chlorine should be explored.

Biological Effects

The effects of thermal effluents on biological systems are the subject of extensive research at the present time. Of particular concern are the biota of the transition zones between fresh and saline waters. Indications are that thermal alterations coupled with varying saline concentrations can have a variety of adverse effects on living organisms and aquatic systems. The James River, in the vicinity of the Surry plant, is such a transition zone. Consequently, the potential adverse impact of the synergistic effects of temperature and salinity in these waters are of considerable concern to EPA. These effects, coupled with the mechanical damage of entrainment in the cooling system create a significant potential hazard for the aquatic biota of the James River.

Although, in general, the draft EIS presented a good background summary of the potential effects of plant operations on the biota of a tidal estuary, important additional information in several areas is needed. For example, the Surry plant is located on a hydrodynamically, and therefore ecologically, significant portion of the James River. This stretch of the river has a wide range of salinities, from 0 to 13 parts per thousand (ppt), and has been described as having an "escalator" type of flow pattern (a salt water wedge moving upstream along the bottom with a seaward surface flow of fresher, less saline water). This interaction could provide a method of upstream movement for several planktonic species. The basic problems which should be considered in the final statement are the potential combined effects of the thermal effluent, the salinity density change, and the effluent from the new sewage treatment plant upon the aquatic system. The statement should address the potential change of the area from an "escalator" system to a well-mixed estuary.

For example, the effect this situation will have on planktonic movements up and down the James River at Hog Island should be discussed. The final statement should also discuss the impact of the new sewage treatment plant (located across the James River from the power plant site) on river water quality and on the ability of the Surry plant to meet water quality standards. We understand this new sewage plant has a capacity of 9.8 mgd. Presently 2 mgd is being contributed by the Busch brewery and an additional 2 mgd will come from the Williamsburg sewage system in the near future. These sources are expected to expand to 8.5 mgd within ten years. As designed, the sewage treatment plant will be capable of 90% BOD removal, but will not remove nitrogen or phosphorus.

An evaluation of the consequences of these three conditions (thermal pollution, salinity density change; new sewage treatment plant) cannot be made without data on the species which inhabit the immediate area. Thus, the final statement should contain additional information on the quantitative distribution of larval forms in the area, current fish populations, and the extent and distribution of natural nursery areas in the river and the marsh area.

The problem of entrainment needs clarification with respect to changes in the James River due to plant operation. The potential for recirculation due to temperature and density changes should be discussed in greater detail with respect to the planktonic organisms.

Alternative Cooling Methods

Although a number of cooling system alternatives were discussed in the draft statement, the scope of these discussions was, in some cases, not sufficiently broad to permit a thorough environmental assessment. We note the following:

1) The use of a closed-cycle system of canals and spray modules should be given further consideration. This type of facility used in conjunction with a return canal to the intake could eliminate the salinity gradient and provide additional cooling. The final statement should contain an expanded analysis of this cooling alternative.

2) Cooling ponds are not evaluated adequately in the draft statement. Based on our calculations, the area requirement cited in the report (7000 acres) is over-estimated--(possibly by a factor of two.) The final statement should again estimate the cooling pond size that would be required for the Surry plant and indicate the costs, benefits, and general feasibility of this alternative.

3) In the draft statement cooling towers have been evaluated only in a non-quantitative manner.

For example, although the argument against the use of cooling towers is based on the potential for salt water drift, only qualitative and unsubstantiated statements are used to support this argument. It is stated that the drift droplets "return to the ground in the immediate area of the cooling tower" and the resulting "chemical impact is serious." Since the Surry station is located on a peninsula, however, much of the area nearby is water surface, and would not be affected by drift.

Further, a review of the salinity data contained in the environmental report indicates that the salinity near the plant (upstream from Hog Point) is essentially zero, i.e., no sea water intrusion, at river flows greater than 10,000 cfs. Thus, 40 percent of the time the river could be used for makeup water in towers with no concern for salt water drift. For median river flows (7500-8000 cfs) the salinity upstream of Hog Point is less than 1 ppt. In fact, only during long periods of low river flow will the salinity reach values as high as 20 ppt and for these periods alternate sources for providing water may be possible. The final statement should address the consequences of cooling towers in a quantitative manner - estimating the possible rates of deposition of salt on land surfaces under various conditions, describing the availability of make-up water for periods of high river salinity, and indicating the probable environmental effects that could result. These aspects should be investigated before cooling towers are rejected as a feasible alternative.

MONITORING AND SURVEILLANCE

A comprehensive monitoring and surveillance program should be developed for the environment affected by the Surry Power Station to ensure compliance with existing standards. EPA will be pleased to work with Federal and state agencies in developing general guidelines which can be used by the applicant in preparing a comprehensive plan.

The following specific areas should be considered in developing the Surry Power Station monitoring and surveillance plan:

1. Radioactive effluent monitoring. This sampling and analysis program should include specific analysis for those radionuclides which are the major potential dose contributors.

2. Water temperature and salinity monitoring. Several monitoring stations will be required to document compliance with state water quality standards. The data from these stations could also help to determine the applicability of the various models used to predict the thermal effects of the Surry Power Station.

3. Chemical monitoring. The monitoring program should include those chemicals and chemical characteristics that are important factors in meeting state water quality standards. The method of operational monitoring of chlorine, heavy metals, and herbicides should also be included.

4. Dissolved oxygen monitoring. This is necessary to ensure that receiving waters remain within applicable standards.

5. Biological monitoring. The development of this plan will depend on established base-line biological data and demonstrated needs as determined by information generated by other elements of the monitoring program.

COST/BENEFIT

The applicant has clearly demonstrated the demand for electricity; such observations as the purchase of 881 megawatts in 1971 and the minimal reserve margin to be attained even with the Surry Unit 1 on line by summer are symptomatic of this need.

The cost-benefit analysis, however, should be expanded in the final statement to include a detailed evaluation of all alternatives, including those not presently considered. Monetary estimates should be explained in detail so that gross figures cited can be verified. Comparison with a fossil-fuel alternative is demonstrated to result in selection of the nuclear plant. This comparison, however, is marred by the omission of consideration of the lower thermal discharge by the fossil fuel plant. Thus, a low-profile mechanical cooling tower for the Surry plant, used as a helper system with the once-through cooling, might merit consideration in view of the large heat output.

In the discussion of the impact on air quality from the alternative oil plant at Pig Point, no attempt was made to determine the effect of emissions on ambient air quality. Since the location seems to provide good ventilation and since appropriate Federal new source performance standards would have to be met, it seems unlikely that the oil plant would deteriorate the ambient air quality to a point where a standard would be violated. It is concluded, therefore, that cost-benefit analyses of cooling system alternatives should be discussed in greater detail in order to support assertions made on the undesirable impact or cost of alternatives.

The sale of electricity produced by Surry should be of considerably greater return than given in the cost-benefit summary, assuming normal operation of the plant. The price to consumers ($1,340,000,000), however, should not be used as a benefit, since this price includes distribution costs, taxes, and other overhead costs. The cost of generating power by the least cost alternative should be used. Also, taxes should not be included as a benefit to the nation, although they may benefit the local community. The benefits of taxes paid and employment payroll have already been "covered" or "paid for" in the market value of power produced.

SITE SELECTION

The James River in the vicinity of the Surry site is the fresh and saline water interface of the tidal estuary. Tidal flow in the area is extremely complex and the biota of the area, particularly the benthic forms, are subject to considerable osmotic stress.

Because of this high-stress level situation, and the reduced species mix it causes, the aquatic biota is less stable, less strongly established and less capable of surviving additional burdens than are the biota of purely freshwater or saltwater systems. The Surry plant will be adding a thermal stress component with unpredictable consequences to this already stressed system.

In addition, saline water taken in on the east side of the point and discharged into the less-saline water (west side) may well produce a change in the salinity gradient causing a partially-mixed estuary to develop into a well-mixed estuary. This situation (considering the paucity of data on the variety and distribution of the river's lifeforms) will also have essentially unpredictable consequences.

This plant site is felt to be less than ideal, and biological effects of plant operation could be significantly greater for a given amount of energy produced than had the plant been sited in a non-estuarine area. EPA is concerned about the uniformity and adequacy of this site selection survey as well as site selection surveys in general. We believe that proper site selection can do a great deal to mitigate a particular plant's environmental impact. We therefore suggest that future impact statements more thoroughly consider the following factors:

soil types and disposition, local topography, surface and subsurface hydrology, existing vegetation, wildlife, human population levels and distribution, and unusual environmental conditions (as in the case of the James River estuary).

In regard to the Surry site, additional material should have been included on the specific surveys, both for the selected site and for the most likely alternative sites. We realize that a consideration of this material may appear to be "after the fact", due to the status of construction; however, should alternate methods of cooling be needed or future power demands require an expansion of the power plant, these factors would have to be considered.

ADDITIONAL COMMENTS

During our review we noted that in certain instances the statement does not present sufficient information to substantiate the conclusions presented. We recognize that much of this information is not of major importance in evaluating the environmental impact of the Surry Power Station. The cumulative effect, however, could be significant. It would, therefore, be helpful in determining the impact of the plant if the following information were included in the final statement.

Radiological

1. Field measurements at operating nuclear power plants indicate that a source of potential radiation exposure to persons in the vicinity of the plant may be direct radiation exposure. It appears that a direct line of exposure could exist between the boron recovery tanks and the visitor's center. An evaluation should be made at the Surry site of the potential for this type of exposure to individuals at the visitor's center and in the vicinity of the site boundary.

2. In estimating radioactivity releases from the liquid waste disposal system, a decontamination factor (DF) of 10,000 for all radionuclides is assumed for the waste evaporator. Actual experience, however, has shown much lower DFs. The bases for such a high DF should be presented in the final statement.

3. Operating experience at other PWRs has shown the presence of noble gases and C-14 in significant quantities in the liquid effluent; tritium and C-14 have been observed in containment purge discharges. Release estimates for these radionuclides should be provided in the final detailed statement so that an assessment of the total potential radiological impact of liquid and gaseous discharges from the Surry Power Station may be made.

4. Some points require clarification relative to the dose assessment presented in the draft detailed statement. A human intake of 20 g/day of fish is assumed; it is not clear, however, how this intake is distributed between fin fish and shellfish. Also, on page 118 it is stated that the fish live in the liquid radioactive waste effluent; Table 5.7 has a footnote indicating that a dilution factor of 10 was applied to the liquid effluents for the ingestion of fish.

Non-Radiological

1. The use of septic tanks for the disposal of sanitary wastes is not high quality treatment. Possible problems of operating this system, together with the disposal of sludge should be more fully discussed.

2. Recognizing that water quality is affected by spills of oil and hazardous non-radioactive substances, a spill prevention, containment and countermeasure plan should be prepared for this facility. The plan should include:

a) a description of the reporting system which will be used to alert responsible management and appropriate legal authorities.

b) a description of preventive facilities (including overall facility plot) which prevent, contain or treat spills and unplanned discharges.

c) a list of all oil and hazardous materials which may be spilled at this facility.

3. A discussion on the possible recycling of cooling water and the resulting buildup of pollutants in the river between the intake and discharge structure should be included in the final statement.

4. Solid waste, whether generated from facility construction or routine operation, should not be burned unless provision is made for incineration with adequate air pollution control facilities. Land disposal is an acceptable alternative if a satisfactory method of sanitary landfilling is employed. Once the facility is in operation, generated solid waste quantities will be relatively small and can probably be handled economically by local contractors. Care should be taken, however, to insure that the solid waste is disposed of in a properly-operated sanitary landfill, or through incineration in a state Air Pollution Control Board-approved facility. The Bureau of Solid Waste and Vector Control, Virginia State Department of Health, can provide necessary information as to disposal site acceptability.

5. Although the alternative of no new power plant was discussed, it was found to be an unacceptable alternative because Virginia's regulations on power companies compel power producers to meet all anticipated energy demands. Although this discussion seems to satisfy the requirements of the National Environmental Policy Act, no mention is made of how pricing policy and VEPCO's advertising has stimulated the increase in demand for power.

6. The statement does not contain adequate information to perform a thorough assessment of the facility's impact on local air quality. Consideration should be given to the quantity of ozone produced by high voltage lines. Additional information should be provided relative to the gas turbine generating units, including the type of fuel, sulfur content, and annual fuel consumption. Also, annual fuel consumption for the station's auxiliary boilers should be provided. Although the meteorological data presented seems to be complete, the prevailing wind direction from the Atlantic, according to page 24 of the draft statement, seems to be contradicted by the wind roses of Appendix C. The Appendix C data, as well as U.S. Weather Bureau data from adjacent stations, seems to indicate a prevailing wind from the southwest.

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426
April 20, 1972

IN REPLY REFER TO:
PWR-ER

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APR 25 1972
U.S. ATOMIC ENERGY COMMISSION
Regulatory
Mail Section

50-280
50-281

Mr. Lester Rogers
Director, Division of Radiological
and Environmental Protection
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

This is in response to your letter requesting the comments of the Federal Power Commission on the Draft Detailed Statement on the Environmental Considerations Related to the Proposed Issuance of Operating Licenses to the Virginia Electric and Power Company (VEPCO) for Surry Power Station Units 1 and 2, dated March 1972.

The Federal Power Commission has previously commented on the need for the Surry Units 1 and 2 in a letter dated June 4, 1971, but these comments were based on the then scheduled commercial service dates of February 1972 for Unit 1 and June 1972 for Unit 2.

The commercial service dates for these units have recently been revised and current target dates are August 1972 and October 1972 respectively. The following comments are a revision of our June 4, 1971 comments, and are based on latest available estimates of load, power resources and reserve margin in our files relating to the Applicant's system and to the Virginia-Carolina Subregion (VACAR) of the Southeastern Electric Reliability Council.

These comments also reflect later information than some of that relating to the Virginia-Carolina Subregion contained in our letter of January 18, 1972, addressed to the Director of Regulation, U. S. Atomic Energy Commission and cited as reference (9) in the Draft Detailed Statement. The estimate of reserve margin in that reference was based on the availability of Oconee No. 1 unit of the Duke Power Company. It is now evident that the Oconee No. 1 unit will not be available for the summer 1972 peak season because of damage sustained during recent tests.

The Federal Power Commission's Bureau of Power staff is currently evaluating the electric load-supply situation within the contiguous United States as it might obtain for the summer 1972 load period, based upon the information submitted to the Commission by the industry on Power System Statements FPC Form 12-E. Information available to the staff through April 1, 1972 is included.

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For summer peaking utilities, the probability is that the summer peak will occur in the months of June, July or August. For those utilities in the VACAR region, where the effect of hot weather on the load is significant, there is an historical probability that the one hour which proves to be the peak will occur in August, but there is an almost certain likelihood that a number of hours in the preceding June and July will be of almost equal magnitude. The staff of the Bureau of Power, therefore, elects June 1 as the base point for its evaluations.

VEPCO estimates its net dependable resources as of June 1, 1972, with which to meet its summer load will be 6,589 megawatts, comprised of 5,190 megawatts of generation now in service and 1,399 megawatts of firm purchases. It expects no further addition to its resources during the summer other than the Surry No. 1 unit. The summer peak is estimated to be 6,300 megawatts, resulting in a reserve margin of 289 megawatts, or 4.6 percent of peak load. Included in VEPCO's generation now in service are six steam-electric units with name plate ratings between 240 megawatts and 694 megawatts. The forced outage of any one of these units during peak load periods could possibly necessitate a load curtailment.

The VACAR area as a whole, including VEPCO, is not significantly in a better condition to withstand a major contingency without an adverse effect upon the adequacy and reliability of electric service. As of June 1, it estimates its net dependable capacity to be 19,880 megawatts of generation now in service, plus the 420-megawatt Sutton No. 3 unit, 60 megawatts of gas turbine capacity expected to be in operation before June 1, and 1,813 megawatts of net firm purchases, for a total of 22,173 megawatts. The estimated summer peak is 20,818 megawatts, resulting in a reserve margin of 1,355 megawatts or 5.5 percent of peak load. Included in the steam-electric generation now in service are units with name plate ratings of 570, 570, 650, 650, and 694 megawatts. The forced outage of any two of these units during peak load periods could possibly necessitate a load curtailment. Other than the Surry No. 1 unit previously noted, the only other VACAR area generation expected to be in service after June 1, but during the summer is Duke Power Company's 591-megawatt Cliffside No. 5 unit and 40 megawatts of gas turbine capacity on the South Carolina Public Service Authority's system, all in July.

The staff of the Bureau of Power concludes that any output from the Surry No. 1 unit that can be made available during the summer 1972 load period discussed above will be of great benefit to the VACAR area in improving the reserve margin situation to better withstand the reasonable

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contingencies which are inherent in electric system operations, and possibly avoid potential curtailments of service. Further, although the Surry 2 unit cannot be available to assist in meeting the summer 1972 peak loads, and the reserve margin for the VACAR region in the winter of 1972-73 with both Surry 1 and Oconee 1 at full capacity will be in excess of 20 percent, it will be beneficial for Surry 2 to achieve commercial operation as early as possible to permit conduct of maintenance work deferred because of deficiencies in generating capacity in the past.

Very truly yours,

T. A. Phillips
Chief, Bureau of Power