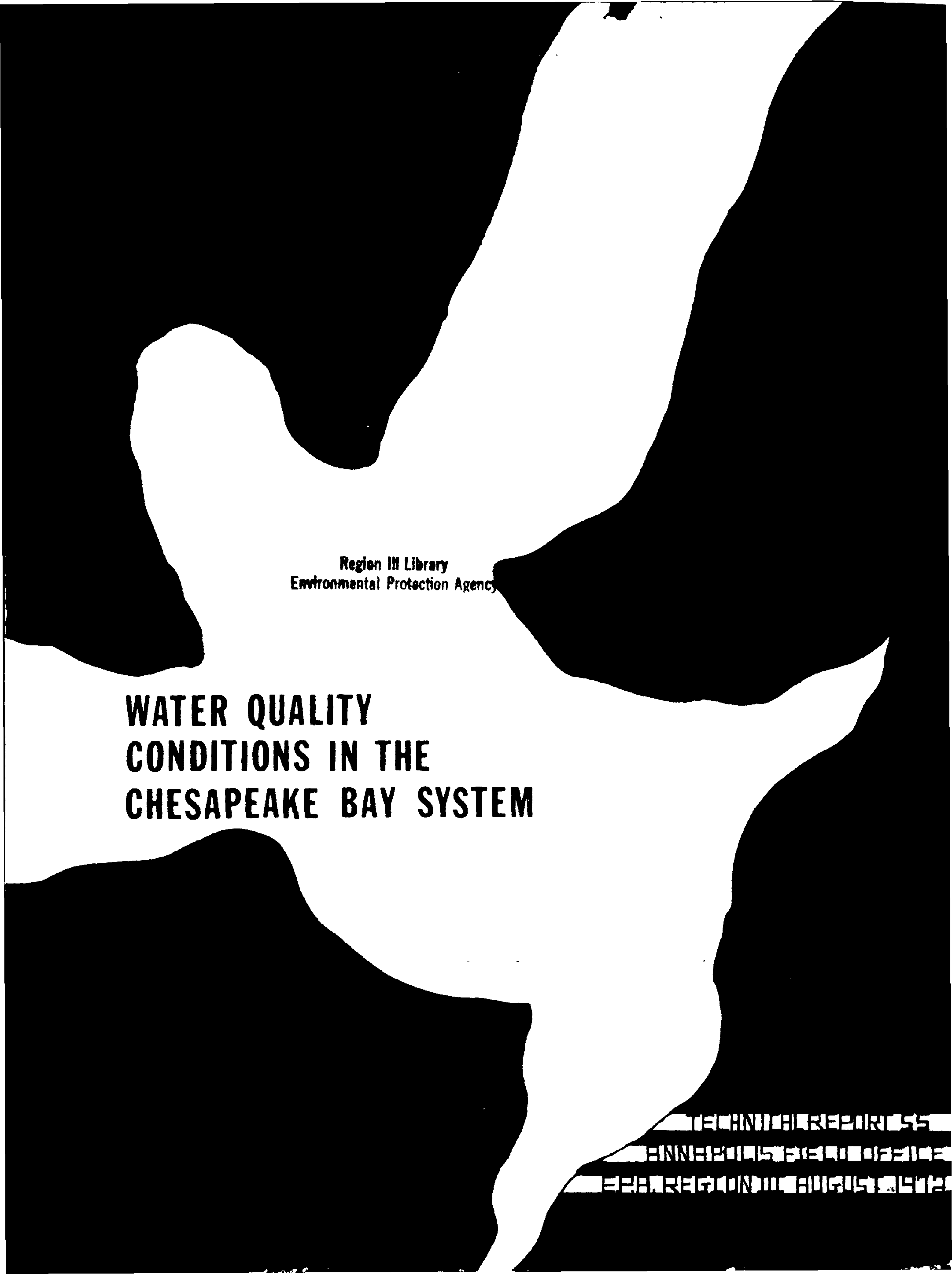


WATER QUALITY CONDITIONS IN THE CHESAPEAKE BAY SYSTEM

TECHNICAL REPORT 55
ANNAPOLIS FIELD OFFICE
EPA, REGION III, AUGUST 1972

Annapolis Field Office

Region III

Environmental Protection Agency

WATER QUALITY CONDITIONS

IN THE

CHESAPEAKE BAY SYSTEM

Technical Report 55

August 1972

Thomas H. Pheiffer*

Daniel K. Donnelly

Dorothy A. Possehl

* Currently represents the Environmental Studies Section, Environmental Planning Branch, Air and Water Division, Region III, EPA in the Chesapeake Bay Study.

PREFACE

The Annapolis Field Office, Region III, Environmental Protection Agency, makes data and other technical information available to all interested individuals. The data reported for the States of Maryland and Virginia and the District of Columbia were obtained through a cooperative effort with the Baltimore District, U. S. Army Corps of Engineers. The information contained in Technical Report No. 55 will also be published in the Corps of Engineers' report to the Congress covering the existing conditions of the Chesapeake Bay with regard to navigation, fisheries, flood control, control of noxious weeds, water pollution, water quality control, beach erosion, and recreation.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

List of Tables

List of Tables

List of Tables

List of Tables

List of Figures

List of Figures

List of Figures

List of Figures

CHAPTER I

INTRODUCTION

This report delineates existing water quality conditions in the Chesapeake Bay and its tidal tributaries and evaluates current water quality data and monitoring programs in the context of a Bay management program. Data sources for this report were the Annapolis Field Office, National Marine Fisheries Service, U. S. Geological Survey, Maryland Department of Water Resources, Maryland Department of Health, Maryland Environmental Service, University of Maryland, The Johns Hopkins University, Virginia Water Control Board, Virginia Institute of Marine Science, and the District of Columbia Department of Environmental Services.

The Bay is discussed in terms of study areas based on hydrological significance or geographical expediency. The study areas are as follows: Lower Susquehanna River, Upper Bay and Upper Eastern Shore, Upper Western Shore, Baltimore Harbor, Middle Western Shore, Middle Chesapeake Bay, Middle Eastern Shore, Lower Eastern Shore, Patuxent River, Potomac River, Rappahannock River, York River, James River, and Lower Chesapeake Bay Waters.

Chapter III sets forth the beneficial water uses for the study areas together with the water quality standards established for the support of these uses. Chapter IV contains a brief description of the study area followed by the identification of the data sources and the extent of current data available. The available water quality information is assessed for each study area, to the extent possible, with specific reference to the following parameters: bacterial densities, dissolved oxygen, nutrients, heavy metals, and pesticides. Where sufficient data exists, as in the case of the Potomac Estuary, water quality trends are identified and their significance discussed.

A discussion of inventories of industrial and municipal waste-water discharges is included in Chapter V as well as an evaluation of the available data base for the Bay. All of the existing data on each study area are not presented but will be generally available from the Environmental Protection Agency or the appropriate collection agency.

Chapter II presents a summary of the findings based on the information contained in Chapter IV, the body of the report. It is recognized that the report will be critized for not addressing the adopted water qualtiy standards only for the numbered parameters of dissolved oxygen, bacteria, pH, and temperature. The authors feel that the insidious parameters--nutrients, heavy metals, pesticides, and toxic chemicals--must be placed in proper perspective before such parameters manifest their presence in serious violations of existing water quality standards.

CHAPTER II

SUMMARY OF FINDINGS

1. Based on nutrient input studies of the major tributary watersheds of the Chesapeake Bay, the Annapolis Field Office finds the Susquehanna River to be the largest contributor of nutrients to the Bay. This is due to the fact that the Susquehanna River is the largest source of freshwater to the Bay, providing approximately 50 percent of its freshwater inflow. Its nutrient input to the Bay exceeds the combined input of the Potomac River and the James River, the second and third largest contributors of nutrients to the Bay, for all the various nutrient fractions measured.

2. Blooms of blue-green algae were first reported in upper Chesapeake Bay tributaries in late August 1968. The blooms occurred in the Sassafras River near Georgetown, Maryland, and the Elk River downstream from Elkton, Maryland. Since 1968, these blooms have gradually increased in size, density, and duration. In 1971, blooms became evident early in the summer. In June, the upper Sassafras River showed chlorophyll _a_ values of 121.5 μg/l; the Northeast River, values of 224.0 μg/l. In July, the Bohemia River had chlorophyll _a_ values of 110.0 μg/l. The major problem areas appear at the headwaters of each of the upper Bay tributaries.

3. Prior to 1966, 21 public bathing beaches in Baltimore County, located on the shores of Middle, Gunpowder, Back, and Bird Rivers, Chesapeake Bay, and Bear Creek, were open. The number of bathing beaches approved for operation by the Baltimore County Health Department has steadily declined since then, mainly due to bacterial pollution problems. Only six permits were issued to operate public bathing beaches for the 1971 summer season.

4. Major souces of pollution in Baltimore Harbor include wastes from the Baltimore City Patapsco Wastewater Treatment Plant, which discharges primary treated effluent directly into the Harbor, direct industrial discharges, sewage overflows and leaks into Harbor tributaries, urban runoff, and the occurrence of spills of hazardous substances from vessels and dockside facilities.

5. A December 1971 field investigation by the Annapolis Field Office of industrial discharges into Baltimore Harbor identified significant discharges of ethion, cyanide, phenol, nutrients, and various heavy metals into the Harbor.

6. A comparison of bottom sediment data from Baltimore Harbor with recent sediment data obtained in the vicinity of Tangier Island showed excessive amounts of volatile solids, chemical oxygen demand, and oil and greases in the bottom sediment from the Harbor. Tangier Island, located in the lower Chesapeake Bay off Pocomoke Sound, is considered a clean area with regard to pollutants in the bottom sediment surrounding the

island.

7. The dissolved oxygen standard of 5.0 mg/l is generally being maintained at the surface in the middle Western Shore tributaries (the Magothy, Severn, South, Rhode, and West Rivers). However, the DO level is occasionally depressed, below a depth of 5 feet, during late summer in the upper Severn and South Rivers. Fecal coliform concentrations are generally satisfactory in the Magothy and South Rivers, although 127 acres in the South River are closed to shellfish harvesting to safeguard against possible failure of a wastewater treatment plant in the upper portion of the river. Excessive fecal coliform densities in the Severn, Rhode, and West Rivers are attributed to wastewater treatment plants and defective septic systems discharging into these rivers. As a result, 1481 acres in the Severn River and 63 acres in the Rhode and West River system are now closed to shellfish harvesting. High nutrient concentrations have been recorded during the summer months of 1971 in the Severn and South Rivers, contributing to the algal "blooms" which have occurred in these areas as recently as December 1971. Occasional algal "blooms", with corresponding high total PO_4 values, have also been observed in the Magothy, Rhode, and West Rivers.

8. While dissolved oxygen and coliform concentrations in the Sandy Point area of Chesapeake Bay are generally quite satisfactory, nutrient concentrations have shown a trend to increase in the last three years. The concentration of total phosphate has nearly doubled since 1968, contributing to the alarming

rise in the chlorophyll a density during this time. A fourfold increase in the chlorophyll a density (from an average density of 36 μg/l in June 1968 to 153 μg/l in June 1971) indicates a serious threat to water quality conditions in this area. High nitrate-nitrogen concentrations noted in late winter and early spring, as compared to summer values, are attributed to increased loadings from the Susquehanna River during the winter and spring periods of high flow rates. In addition, operation of the Sandy Point wastewater treatment plant, with a planned ultimate capacity of 19.0 MGD, will tend to further increase the concentrations of nutrients in the Bay, possibly leading to hypereutrophic conditions in this area.

9. Very little has been done in the way of intensive bacteriological studies in the Chester River Basin, with the exception of the Radcliffe Creek area, where excessive coliform densities were found by Maryland Department of Water Resources surveys. Shellfish bed closings in the remainder of the basin are not widespread, and are confined to narrow portions of the Chester and Corsica Rivers and one small creek. The only samples indicating depressed dissolved oxygen conditions in the basin were taken in Radcliffe Creek on July 14, 1970. Samples taken under similar temperature conditions on August 24, 1971, did not show the low DO levels. Nutrient data are very limited in the Chester basin but some algal bloom conditions were noted in the upper section of the river in September of 1970. In December 1971, the reddish brown discoloration in this

area was tentatively identified as a dinoflagellate (Massartia rotundata).

10. Many small areas in the Eastern Bay region have been closed to shellfish harvesting due to bacterial pollution. Most of these areas are in narrow sections of creeks and rivers or along shorelines. The pollution can be attributed primarily to septic tank leaching. Dissolved oxygen in the basin generally meets standards with the exception of the St. Michaels Harbor area where DO readings below 4.0 mg/l have been reported. These oxygen depressions are probably due to poor flushing in the harbor. Conditions were favorable to algal growth in the late summer of both 1970 and 1971 with less growth in 1971 than in 1970. Total phosphate concentrations were high during some of the bloom conditions but there are insufficient nutrient data to establish any definite nutrient-phytoplankton relationships. A small section of the Miles River was the only area in the Eastern Bay region in which sampling was done. More intensive studies covering a broader area must be undertaken before an adequate evaluation of the water quality in the basin can be made.

11. Bacteriological conditions in the Choptank Basin are poor, with many violations of standards in both Group A and Group C waters. As a result of the bacterial pollution, the Choptank represents a great loss in natural resource potential. More than 5400 acres of shellfish beds have been closed to harvesting. Dissolved oxygen levels in the Choptank currently meet standards with concentra-

tions rarely dropping below 5 mg/l even during the summer months. Some high nutrient levels have been documented, particularly in the upper sections of the stream where excessive algal blooms have occurred. These blooms seemed to be associated with total Kjeldahl nitrogen (as N) concentrations greater than 0.9 mg/l and total phosphorus (as PO_4) concentrations greater than 0.3 mg/l. The most prolific blooms were recorded in the Denton area and were probably due to over-enrichment from sewage and industrial wastes. Metals analyses indicates that some concentrations were significantly above fish toxicity levels but that generally the water in the basin is relatively free from contamination by heavy metals.

12. The opening of 375 acres of shellfish beds in the Little Choptank River, which had previously been closed, indicates that bacteriological conditions have recently improved. The 875 acres now closed to shellfish harvesting are probably affected by leaching from septic tanks near the shoreline. The only known industry in the basin is the Madison Canning Company in Madison, which uses land disposal techniques; thus, there is no discharge to the Little Choptank River from this source. Intensive investigations in this river would be desirable to ascertain existing water quality conditions and to identify any trends.

13. Bacteriological conditions in the Nanticoke River have seriously degraded between 1967 and 1971. While only occasional violations of the 240 MPN/100 ml fecal coliform maximum were noted in 1967, violations of the fecal coliform standard were noted at most of the

stations sampled in July and August of 1971. Dissolved oxygen concentrations were generally good in 1971, ranging from 6 to 8 mg/l. However, an exception was noted in the Nanticoke Harbor area in August 1971, when depressed DO values were noted. At the same time, an algal bloom in the area was believed responsible for a fish kill involving large numbers of menhadden. Nutrient concentrations, in particular total phosphate and ammonia nitrogen, are low throughout most of the Nanticoke estuary. In 1971, the concentrations of zinc, mercury, copper, and cadmium were acceptable, but lead and chromium concentrations exceeded the maximum limits allowable for drinking water.

14. Poor bacteriological conditions in the Wicomico River and Sharps Creek have resulted in the closing of 22 acres in the lower Wicomico to shellfish harvesting. Coliform densities in Sharps Creek averaged 18,500 MPN/100 ml in 1971, while coliform densities near Salisbury ranged from 2,400 to 54,000 MPN/100 ml. Seepage from the Green Giant Company in Fruitland, septic tank leachings, and the discharge of inadequately treated waste from the overloaded Salisbury treatment plant are responsible for the high bacterial counts. Dissolved oxygen concentrations are generally adequate upstream from Salisbury, but an oxygen sag begins near Harbor Point and does not recover until White Haven. Nutrient concentrations, relatively low throughout most of the Wicomico River, increase near Harbor Point to 3 mg/l and 2.2 mg/l for TKN and TP,

respectively. Inefficient treatment of wastes by the Salisbury plant is responsible for both the oxygen sag and the high nutrient concentrations noted above.

15. Although very little information concerning water quality in the Manokin River is available, a few interpretations of the abstract information that is available can be made. In general, water quality conditions appear to be satisfactory. A 1967 Federal Water Pollution Control Administration (now EPA) report on immediate pollution control needs for the Eastern Shore made no mention of needs in the Manokin River. A further indication of satisfactory bacteriological conditions is the fact that no shellfish areas in the Manokin River have been closed. However, intensive sampling of this area is necessary to determine more exactly current water quality conditions and trends.

16. Bacteriological conditions in the Little and Big Annemessex Rivers are satisfactory in the designated shellfish areas. However, exceptions are noted in the Little Annemessex River near the two major discharges located in this area. Coliform counts of 240,000 MPN/100 ml and 46,000 MPN/100 ml were found in September 1968 near waste discharges from the town of Crisfield and from Mrs. Paul's Kitchens seafood packing plant, respectively. However, both waste sources are scheduled to receive secondary treatment in the future. Dissolved oxygen concentrations were found to be adequate in September 1970, although some depression of oxygen levels may occur in low-flow periods. Although total phosphate values are

low in the Annemessex Basin (ranging from .05 to .28 mg/l), TKN values were much higher, ranging from .80 to 1.20 mg/l in September 1970.

17. Bacteriological conditions in the Pocomoke River are generally poor, with many samples in 1971 having fecal coliform counts greatly in excess of the 240 MPN/100 ml standard set for this river. While bacterial quality in a major portion of the Pocomoke River remained unchanged between 1967 and 1971, a distinct improvement occurred downstream from Pocomoke City after a secondary treatment plant, treating both domestic and industrial waste, began operation. Violations of the coliform standard of 70 MPN/100 ml in Pocomoke Sound has resulted in the closing of shellfish beds in this area, including 1485 acres in Virginia waters. Nutrient concentrations are generally high in the Pocomoke River, with exceptionally high values found near Snow Hill, where Maryland Chicken Processors discharges inadequately treated poultry processing waste into the river. Also, in the summer of 1971, dissolved oxygen values in the Pocomoke River were low, with an oxygen sag occurring at Snow Hill. However, nutrient and DO concentrations are generally satisfactory in Pocomoke Sound.

18. In the Patuxent River, coliform densities are generally satisfactory; however, high coliform concentrations (21,000-24,000 MPN/100 ml) were noted in the vicinity of the large wastewater treatment plants located between Laurel and Bowie, Maryland. Dissolved oxygen concentrations appear to have degraded between

1968 and 1971 to a level approaching the average daily standard of 5.0 mg/l, particularly during the late summer and fall periods of low flow rates. The data also indicates that nutrient concentrations (NO_3 as N and total PO_4) have increased between 1967 and 1970, a probable cause of the several algal blooms which have recently occurred in the lower Patuxent River.

19. Since the first sanitary surveys in 1913, the water quality of the upper Potomac Estuary has deteriorated. This is attributed to the increased pollution originating in the Washington Metropolitan Area.

20. Since the summer of 1969, the high fecal coliform densities previously found near the waste discharge points in the upper Potomac Estuary have been reduced by continuous wastewater effluent chlorination. At present, the largest sources of bacterial pollution in the upper estuary are from sanitary and combined sewer overflows, where, at times, about 10 to 20 MGD of untreated sewage enters the estuary because of inadequate sewer and treatment plant capacities. In the vicinity of Roosevelt Island, high bacterial densities occur as a result of sewerage overflows along the Georgetown waterfront. Activation of the Potomac Pumping Station in May 1972 and the closure of the so-called "Georgetown Gap" in September 1972 will shift these overflows downstream. By 1973, expansion of the sewage treatment facilities at Blue Plains should abate the overflows.

21. Effluents from the 18 major wastewater treatment facilities

and combined sewer overflows, with a total flow of 325 MGD, contribute 450,000; 24,000; and 60,000 lbs/day of ultimate oxygen demand, phosphorus, and nitrogen, respectively, to the waters of the upper Potomac Estuary.

22. Historical data records show that dissolved oxygen levels in the upper Potomac Estuary have decreased. A slight upward trend occurred in the early 1960's due to a higher degree of wastewater treatment. However, with the increasing population, the amount of organic matter discharged increased to a record high in 1971, resulting in a critical dissolved oxygen stress in the receiving water. In recent years, dissolved oxygen concentrations of less than 1.0 mg/l have occurred during low-flow, high temperature periods.

23. The recent detection of heavy metals in bottom sediments of the Potomac Estuary has raised sufficient concern to include the accumulation of metals as a water quality problem requiring additional study and analysis. Significant concentrations of lead, cobalt, chromium, copper, nickel, barium, aluminum, iron, and lithium in the bottom sediment were measured in the vicinities of Woodrow Wilson Bridge, Possum Point, and Route 301 Bridge.

24. In recent years, large populations of blue-green algae, often forming thick mats, have been observed in the Potomac Estuary from the Potomac River Bridge (Route 301) upstream to the Woodrow Wilson Bridge during the months of June through October. In September of 1970, after a period of low stream flow and high

temperatures, the algal mats extended upstream beyond Hains Point and included a nuisance growth within the Tidal Basin. The District of Columbia Department of Environmental Services reported algae nuisance conditions in the Tidal Basin as early as 1966.

25. The effects of the massive blue-green blooms in the middle and upper portions of the Potomac Estuary are: (1) an increase of over 490,000 lbs/day in total oxygen demand, (2) an overall decrease in dissolved oxygen due to algal respiration in waters 12 feet and greater in depth, (3) creation of nuisance and aesthetically objectionable conditions, and (4) reduction in the feasibility of using the upper estuary as a potable water supply source because of potential toxin, taste, and odor problems.

26. In the saline portion of the Potomac Estuary, the algal populations are not as dense as in the freshwater portion. Nevertheless, at times large populations of marine phytoplankton, primarily the algae Gymnodinium sp., Massartia sp., and Amphidinium sp., occur, producing massive growths known as "red tides." On February 28 and 29, and March 1, 1972 extremely widespread "red tides" were observed in the lower Potomac Estuary.

27. Approximately 15,550 acres of oyster bars are closed to shellfish harvesting for direct market consumption in the lower Potomac Estuary because of bacterial pollution. Of the closures, approximately 15,162 and 398 acres are located in Virginia and Maryland estuaries, respectively.

28. Water quality conditions in the Rappahannock River, with a

few exceptions, are generally satisfactory. During 1971, fecal coliform counts in the Rappahannock River were less than 100/100 ml, except in a 5-mile reach directly downstream from the City of Fredericksburg. During low-flow periods, degraded bacteriological conditions occur downstream from Fredericksburg as a result of waste discharged by the city and by the FMC Corporation. Less than 3 percent of the available oyster bars in the Rappahannock River, 2363 acres, are now closed, out of a total of 69,008 shellfish acres. In the summer of 1971, dissolved oxygen concentrations ranged from 7.3 to 8.9 mg/l. However, in 1970, oxygen sags were noted at River Miles 100 and 80 during periods of low flow. Both nutrient concentrations (total phosphorus and nitrate-nitrogen) and pesticide concentrations (chlorinated hydrocarbon and phosphorus) remained low during 1970 and 1971. In addition, concentrations of heavy metals (mercury, lead, and arsenic) were usually less than the detectable limits for those metals.

29. Bacteriological standards in the York River are exceeded in the vicinity of West Point, at the confluence of the Mattaponi and Pamunkey Rivers, and near Yorktown. Elsewhere in the York River (from 4.5 miles below West Point to near Yorktown) bacteriological standards are being maintained. Industrial discharges, in particular that from the Chesapeake Corporation at West Point, and inadequately treated residential sewage have resulted in the closing of 5092 acres to shellfish harvesting in the York River. Although this represents 27 percent of the available oyster bars,

this is an improvement over 1967, when 39 percent of the available bars were closed. The dissolved oxygen standard of 5.0 mg/l was upheld during the summer of 1971 at all stations sampled. However, in July and August of 1970, DO values of 3.6 mg/l and 0.8 mg/l were noted immediately below the Chesapeake Corporation discharge output at West Point. Nutrient concentrations in the York River were low during 1970 (total phosphate: .10 mg/l or less, and nitrate-nitrogen: .19 mg/l or less). The following metals were found in the York River system, in most cases at levels near the minimum detectable level: chromium, zinc, copper, mercury, manganese, lead, and arsenic.

30. Contravention of bacterial standards for shellfish harvesting (70 MPN/100 ml) in the James River has resulted in the closing of approximately 50 percent of the total available shellfish beds. Approximately 46,727 acres of the 93,062 shellfish acres available have been closed due to degraded bacteriological conditions in the James River. The largest closure, 36,275 acres in the Hampton Roads area, is due to the numerous industrial and domestic waste discharges in this area.

31. In the fall of 1971 an intensive sampling survey by the Annapolis Field Office in the James River detected average fecal coliform counts of 24,300 MPN/100 ml and 65,900 MPN/100 ml, well above the fecal coliform standard for primary contact recreation (240 MPN/100 ml), at stations below Goode Creek and below the Richmond

Deepwater Terminal, respectively. The discharge of raw wastes from the City of Richmond to Goode Creek was the cause of the extremely high bacterial levels downstream from Richmond. Although this raw waste discharge has now been eliminated, periods of high storm runoff will result in the bypass of raw wastes from combined sewers to the estuary.

32. Dissolved oxygen concentrations in the James River, measured by the Virginia Water Control Board during the spring and summer of 1971, were generally greater than the 5.0 mg/l standard, with some exceptions noted during the July - August low flow period. Between June and December 1971, the Virginia Institute of Marine Science collected DO and BOD data during low water slack conditions. Three oxygen sags were noted: 1) downstream from the City of Richmond wastewater treatment plant discharge to the vicinity of Turkey Island (10 miles); 2) downstream from Hopewell to the mouth of the Chickahominy River (20 miles); and 3) downstream from Jamestown Island. The first sag, with DO values depressed to 3.0 mg/l, is the result of the high organic loading exerted by the Richmond STP: a 5-day BOD loading of approximately 38,364 lbs/day. A combination of poorly treated domestic wastes and a heavy organic industrial effluent from the Hopewell area contribute to the second DO sag. The Continental Can Company and the Hercules Powder Company, both discharging into Bailey Bay, contribute 5-day BOD loadings of approximately 39,840 lbs/day and 39,400 lbs/day, respectively. During 1971, DO concentrations of 0.0 mg/l were recorded on several

occasions at the Route 10 sampling station in Bailey Creek. BOD data for the James River, while not conclusive, did manifest maxima in the area of the oxygen sags downstream from Richmond, Hopewell, and Jamestown Island.

33. Nutrient concentrations in the James River have not appreciably changed between levels found in 1966 and in 1971. Highest concentrations were found in the late spring: in May 1971, ammonia-nitrogen varied from .030 to 3.900 mg/l, nitrate-nitrogen varied from .190 to .950 mg/l, and inorganic phosphorus (as P) varied from .010 to .140 mg/l. While phosphorus concentrations do not vary greatly throughout the James Estuary, nitrogen concentrations are greatest downstream from Richmond and Hopewell. The former increase is due to primary treated domestic waste from the City of Richmond, while the latter increase is due to organic industrial wastes discharged into Bailey Creek. Nutrient concentrations were excessively high in Bailey Creek in 1971: ammonia-nitrogen varied from 2.0 to 11.0 mg/l and TKN varied from 7.0 to 14.0 mg/l at the Route 10 Bridge, one-half mile from the confluence of Bailey Creek with the James River. While nutrient levels in the Estuary are sufficient to support excessive algal growths, no chlorophyll a data has been taken during periods of high nutrient concentrations.

34. Traces of both chlorinated hydrocarbon and thio-phosphate pesticides were detected in surface waters of the James Estuary during the late spring and early summer months of 1971 (May - July). In general, pesticides in the James Estuary were found at levels far

below the point at which they would constitute a hazard to health. The United States Public Health Service standards for public and municipal water supplies at the raw water intake were, at no time, contravened by any of the pesticides analyzed. Although the tidal James Estuary is not now used as a public or municipal water supply, studies are currently underway to determine the feasibility of such a water use for the upper Estuary.

35. Heavy metal concentrations--arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, and zinc-- in surface waters of the main stem of the James Estuary are not critical. The highest concentrations of metals were found between River Miles 77.44 and 98.34. High heavy metal concentrations of iron, manganese, and zinc were found at River Mile 0.65 in Bailey Creek, one-half mile from its confluence with the James Estuary at River Mile 77. A number of industries discharge significant quantities of wastes into Bailey Bay, including Continental Can Company, and Firestone Company.

36. The Elizabeth River, a tributary estuary of the James River, is an excessively utilized waterway with regard to waste assimilation. Five sewage treatment plants--Western Branch STP, Washington STP, Lamberts Point STP, Great Gridge STP, and Pinner Point STP-- operated by the Hampton Roads Sanitation District Commission, provide primary treatment only. Frequent overflows of untreated sewage to the Elizabeth River are the result of poor plant operation and/or

hydraulic overloads. In addition to domestic waste discharged by sewage treatment plants and toxic wastes discharged by a variety of industrial concerns, the area is plagued by frequent spills and waste discharges from the extensive shopyard and docking facilities in the area.

37. Current routine monitoring programs of the regulatory agencies are adequate to show contraventions in the adopted numerical water quality standards. More frequent routine monitoring for standards violations would be desirable.

38. A knowledge of water quality of the entire Chesapeake Bay is essential. Water quality sampling over an extended period of time and as frequently as possible is needed. Sampling in the tidal tributaries should occur at slack water tide with freshwater inflows recorded. Concurrent slack water boat runs up the entire main channel of the Bay would be a vital element of this program. The resulting data from the tidal tributaries would then be integrated with the slack water runs' data to give an overall picture of the water quality conditions of the Bay for the sample period.

CHAPTER III

WATER QUALITY STANDARDS

The following is a condensation of the pertinent sections of the Maryland, Virginia, and District of Columbia Water Quality Standards.

MARYLAND

Water Use Categories:

I - Shellfish Harvesting, II - Public or Municipal Water Supply, III - Water Contact Recreation, IV - Propagation of Fish, Other Aquatic Life and Wildlife, V - Agricultural Water Supply, and VI - Industrial Water Supply.

Bacteriological Standards:

For Group "A" Water Uses - Coliform organisms to be less than 70 per 100 ml (MPN) of sample (Shellfish Waters).

For Group "B" Water Uses - Monthly average values (either MPN or MF count) of coliform organisms not to exceed 5,000 per 100 ml of sample; nor to exceed this number in more than 20 percent of the samples examined during any month; nor to exceed 20,000 per 100 ml in more than 20 percent of the samples examined during any month; nor to exceed 20,000 per 100 ml in more than 5 percent of such samples (Public or Municipal Water Supply Uses).

Water Contact Recreation Uses - fecal coliform organism density not to exceed 240 per 100 ml (MPN).

For Group "C" Water Uses - Fecal coliform density not to exceed

240 per 100 ml (MPN).

Dissolved Oxygen Standards:

For all water use categories other than IV, DO concentrations must not be less than 4.0 mg per liter at any time, except where--and to the extent that--lower values occur naturally.

For Group "A, B and C" Water Uses - For the propagation of fish and other aquatic life (Water Use Category IV) in all other waters, the DO concentration must not be less than 4.0 mg per liter at any time, with a minimum monthly average of not less than 5.0 mg per liter, except where--and to the extent that--lower values occur naturally.

pH Standards:

For all water use categories other than IV, pH values must not be less than 5.0 nor greater than 9.0, except where--and to the extent that--pH values outside this range occur naturally.

For Group "A, B and C" Water Uses - Normal pH values for the waters of the zone must not be less than 6.0 nor greater than 8.5, except where--and to the extent that--pH values outside this range occur naturally.

Temperature Standards:

For all water use categories other than IV, there must be no temperature change that adversely affects fish, other aquatic life, or spawning success. There must be no thermal barriers to the passage of fish or other aquatic life. Maximum temperature must not exceed 100°F beyond 50 feet from any point of discharge.

For Group "A, B and C" Water Uses - For tidal waters used for the propagation of fish and other aquatic life (Water Use Category IV), temperature must not exceed 90°F beyond such distance from any point of discharge as specified by the Maryland Department of Water Resources as necessary for the protection of the water use. In addition, for all tidal waters, maximum temperature elevation is to be limited as follows:

> For natural water temperatures of 50°F or less, the temperature elevation must not exceed 20°F above the natural water temperature with a maximum temperature of 60°F.
>
> For natural water temperature greater than 50°F, the temperature elevation must not exceed 10°F above the natural water temperature with a maximum temperature of 90°F.

Any deviation, other than natural, from the above requirements is to be evaluated for risk to the propagation of fish and other aquatic life by the Potomac River Fisheries Commission in those waters of the Potomac River and its tributaries under the jurisdiction of the Fisheries Commission and by the Department of Chesapeake Bay Affairs with respect to all other tidal waters, and will be permitted or denied by the Department of Water Resources after consultation with such agency (also applies to pH and DO standards).

VIRGINIA

Water Uses Assigned:

A. Waters generally satisfactory for secondary contact recreation, propagation of fish, shellfish, and aquatic life, and other beneficial uses,

B. Waters generally satisfactory for primary contact recreation (prolonged intimate contact and considerable risk of ingestion), propagation of fish, shellfish, and other aquatic life, and other beneficial uses.

Bacteriological Standards:

For Class IIA and IIB Water Uses:

Shellfish Waters - The median MPN coliform organism density shall not exceed 70 per 100 ml, and not more than 10 percent of the samples ordinarily shall exceed an MPN of 230 per 100 ml for a 5-tube decimal dilution test (or 330 per 100 ml, where a 3-tube decimal dilution test is used) in those portions of the area most probably exposed to fecal contamination during the most unfavorable conditions.

Primary Contact Recreation Uses - Fecal coliform (multiple-tube fermentation of MF count) within a 30-day period not to exceed a long mean of 200 per 100 ml, and not more than 10 percent of samples within a 30-day period will exceed 400 per 100 ml.

Dissolved Oxygen Standards:

For Class II Water Uses - Minimum DO concentration of 4.0

mg per liter and a daily average of 5.0 mg per liter.

pH Standards:

For Class II Water Uses - Not less than 6.0 or greater than 8.5.

Temperature Standards:

For Class II Water Uses - 4.0°F rise above natural (September-May). 1.5°F rise above natural (June-August).

Additional Virginia Standards:

1. Free from substances attributable to sewage, industrial waste, or other waste that will settle to form sludge deposits that are unsightly, putrescent, or odorous, to such degree as to create a nuisance or to interfere directly or indirectly with specified uses of such waters;
2. Free from floating debris, oil, grease, scum, or other floating materials attributable to sewage, industrial waste, or other wastes that are unsightly to such degree as to create a nuisance or to interfere directly or indirectly with specified uses of such waters;
3. Free from materials attributable to sewage, industrial waste, or other waste which produce odor, or appreciably change the existing color or other conditions to such degree as to create a nuisance or interfere directly or indirectly with specified uses of such waters;
4. Free from high-temperature, toxic or other deleterious substances attributable to sewage, industrial waste, or other waste in concentrations or combinations which

interfere directly or indirectly with specified uses of such waters; and

5. There shall be no sudden temperature changes that may affect aquatic life. There shall be no thermal barriers to the passage of fish. Essential spawning areas shall not be affected.

The Maryland standards contain general or aesthetic criteria similar to the criteria set forth above.

DISTRICT OF COLUMBIA

The waters of the District of Columbia shall at all times be free from:

Substances attributable to sewage, industrial wastes, or other waste that will settle to form sludge deposits that are unsightly, putrescent or odorous to such degree as to create a nuisance, or that interfere directly or indirectly with water uses;

Floating debris, oil, grease, scum, and other floating materials attributable to sewage, industrial waste, or other waste in amounts sufficient to be unsightly to such a degree as to create a nuisance, or that interfere directly or indirectly with water uses;

Materials attributable to sewage, industrial waste, or other waste which produce taste, odor, or appreciably change the existing color or other physical and chemical conditions in the receiving stream to such degree as to create a nuisance, or that interfere directly or indirectly with water uses; and

High-temperature, toxic, corrosive or other deleterious substances attributable to sewage, industrial waste, or other waste in concentrations or combinations which interfere directly or indirectly with water uses, or which are harmful to human, animal, plant, or aquatic life.

Criteria shall apply to an entire stretch of the stream. However, reasonable allowance shall be made for the mixing and dispersion of approved discharges. Sampling frequency shall provide a sound basis for computations. Within the limits of field conditions, sampling point locations will be selected to permit the collection of representative samples. The following criteria shall apply to all stream flows equal to or exceeding the 7-day, 10-year minimum flow except where, and to the extent that, natural conditions prevent their attainment.

I. Potomac River: D.C. - Montgomery County line to vicinity of Key Bridge (including tributaries).

<u>Uses to be protected</u>

Recreational boating

Fish and wildlife propagation

Industrial water supply

Water contact recreation (Anticipated future use predicated on the delivery of water of a quality suitable for water contact recreation at the Maryland - District of Columbia boundary line. The District of Columbia will protect swimming as a use in suitable areas in the upper reaches of this portion of the Potomac River within the District of Columbia. The objective date for this use is 1975).

<u>Water Qualtiy Criteria</u>

Fecal Coliform - not to exceed 240 per 100 ml in 90 percent of the samples collected each month.*

Dissolved Oxygen - not less than 4 mg/l; daily average not less than 5 mg/l.

pH - 6.0 to 8.5.

Temperature - not to exceed 90°F. There shall be no sudden or localized temperature changes that may adversely affect aquatic life. No increase in natural water temperature caused by artificial heat inputs shall exceed 5°F after reasonable allowance for mixing.

II. Potomac River: Vicinity of Key Bridge to D.C. - Prince George's County line (including tributaries).

Uses to be protected

Maintenance of fish life

Recreational boating

Industrial water supply

Water Quality Criteria

Fecal Coliform - not to exceed a geometric mean of 1000 per 100 ml nor equal or exceed 2000 per 100 ml in more than 10 percent of the samples.*

Dissolved Oxygen - not less than 4 mg/l (daily average not less than 5 mg/l) from Key Bridge to Rochambeau Memorial Bridge. Not less than 3 mg/l (daily average not less than 4 mg/l) from Rochambeau Memorial Bridge to D.C. - Prince George's County line.

pH - 6.0 to 8.5.

Temperature - same as I.

Policy Statement

There are no waters within the District of Columbia whose existing quality is better than the quality indicated by the established standards. Accordingly, it is the policy of the District of Columbia to improve the quality of all its waters as reflected in the standards. All industrial, public, and private sources of pollution will be required to provide the degree of waste treatment necessary to meet the water quality standards. In implementing this policy, the Secretary of the Interior will be kept advised and will be provided with such information as he will need to discharge his responsibilities under the Federal Water Pollution Control Act, as amended.

*Not applicable during or immediately following periods of rainfall.

CHESAPEAKE BAY WATER QUALITY STANDARDS

River Area	Description	Criteria	Water Uses
Potomac River	Tidal Basin (D.C.) to St. Mary's County	(Md.) Group C	III, IV, VI
Upper Bay	Area bounded by Harford County, Kent County, Anne Arundel County, and a line extending one-half mile from Baltimore County Shore	(Md.) Group A	I, III, IV
	Area bounded by Baltimore County, Kent County, Cecil County, and Harford County Shore	(Md.) Group C	III, IV, VI
Susquehanna River	From Pennsylvania State Line to Chesapeake Bay	(Md.) Group B	II, III, IV, V, VI
Baltimore Harbor	Baltimore Harbor (tidal) and tributaries		
	Gwynn Falls - Headwaters to Baltimore Harbor	Group C	III, IV, V, VI
	Jones Falls - Lake Roland Dam to Baltimore Harbor	Group C	III, IV, VI
	Patapsco River - Confluence of South Branch with North Branch to tidal waters	Group C	III, IV, V, VI
	Patapsco River - Inner Harbor; from head to straight line between Hawkins Point and Sollers Point	Bacterial Standard No standard established DO - 1 ph - 1 Temp - 1	VI

River Area	Description	Criteria	Water Uses
James River	Lower James River and its tidal tributaries from Old Point Comfort--Fort Wool to Barrett Point (Buoy 64), except prohibited or spoil areas, unless otherwise designated	(Va.) Class IIB	Special Standards A
Middle Chesapeake Bay	Chesapeake Bay and its tidal tributaries from Thimble Shoal Channel (Longitude 76° 10' West to Cape Charles; Latitude 37° 07.4' North) and North to Virginia-Maryland State Line West of the east-west divide boundary on the Eastern Shore of Virginia and from Thimble Shoal Channel west to Longitude 76° 10' West and North to Virginia-Maryland State Line	(Va.) Class IIB	Special Standards A
Lower Chesapeake Bay	Chesapeake Bay from Old Point Comfort Tower (Latitude 37° 00' North; Longitude 76° 18.8' West) to Thimble Shoal Light (Latitude 37° 00.9' North; Longitude 76° 14.4' West) along the South side of Thimble Shoal Channel to Cape Henry Light (Latitude 36° 55.6' North; Longitude 76° 00.4' West).	(Va.) Class IIB	Special Standards A
Patuxent River	Swann Creek to Bridge on Maryland Route 381 (Prince Georges-Charles Counties)	(Md.) Group A	I, III, IV, VI
Upper Western Shore			
Bush River	Bush River to respective bridges on Maryland Route 7 - Harford County	(Md.) Group C	III, IV, VI
Gunpowder River	(Baltimore County) All forks of Bird River to respective bridges on U.S. Route 40	(Md.) Group C	III, IV, VI
Middle River	(Baltimore County) Headwaters to Chesapeake Bay	(Md.) Group C	III, IV, VI

River Area	Description	Criteria	Water Uses
Back River	(Baltimore County) Back River and Tidal tributaries - Headwaters to Chesapeake Bay	(Md.) Group C	III, IV, VI
Magothy River	(Anne Arundel and Calvert Counties) Magothy River and tributaries. Henderson Point to mouth	(Md.) Group A	I, III, IV
Middle Western Shore			
Severn River	(Anne Arundel and Calvert Counties) Severn River and tributaries - Mouth of Forked Creek to Bridge at Maryland Route 450	Group A	I, III, IV
	Bridge at Maryland Route 450 to mouth	Group A	I, III, IV, VI
South River	(Anne Arundel and Calvert Counties) South River and tributaries - Headwaters to Porter Point	Group C	III, IV
West River	(Anne Arundel and Calvert Counties) - Headwaters of tributaries to mouth of West River	Group A	I, III, IV
Lower Western Shore			
Great Wicomico River Rappahannock River Piankatank River Mobjack Bay York River Poquoson River Back Bay	Chesapeake Bay and its tidal tributaries from Thimble Shoal Channel (Longitude 76° 10' West to Cape Charles; Latitude 37° 07.4' North), and North to Virginia-Maryland State Line west of the east-west divide boundary on the Eastern Shore of Virginia and from Thimble Shoal Channel west to Longitude 76° 10' West and North to Virginia-Maryland State Line	(Va.) Class IIB	Special Standards A
Upper Eastern Shore			
Northeast River	(Cecil County) Northeast River (all forks) in the Town of North East, at the Dam north of Maryland Route 7; for all other forks at the respective bridges on Maryland Route 7	(Md.) Group B	II, III, IV, V, VI

River Area	Description	Criteria	Water Uses
Elk River	(Cecil County) Elk River and estuarine portions of creeks, coves, and tributaries in C & O Canal and Back Creek - mouth at Chesapeake Bay to non-estuarine boundaries and/or Delaware State Line	(Md.) Group C	III, IV, V
Bohemia River	(Cecil County) Elk River and estuarine portions of creeks, coves, and tributaries in C & O Canal and Back Creek - mouth at Chesapeake Bay to non-estuarine boundaries and/or Delaware State Line	(Md.) Group C	III, IV, V
Sassafras River	(Cecil-Kent County) Bridge on U.S. Route 301 - mouth at Chesapeake Bay to headwaters and/or Delaware line	(Md.) Group B	II, III, IV, V
Chester River	(Cecil-Kent-Queen Anne County) Chester River and estuarine portions of creeks, coves, and tributaries other than Piney Creek, Winchester Creek, and Corsica River mouth at Chesapeake Bay to U.S. Route 213 Bridge	(Md.) Group A	I, III, IV
<u>Middle Eastern Shore</u>			
Wye River	Wye East River - Mouth to a point 2-1/2 miles above Wye Landing	(Md.) Group A	I, III, IV
Miles River	Eastern Bay and estuarine (wide) portions of tributaries, coves, and creeks other than St. Michaels Harbor and Wye East River - mouth at Chesapeake Bay to non-estuarine boundaries		
Tred Avon River	Tred Avon River and estuarine (wide) portions of other than Town Creek	(Md.) Group A	I, III, IV
	Mouth at Choptank River to Easton Point and to non-estuarine portions of tributaries		

River Area	Description	Criteria	Water Uses
Choptank River	Choptank River and all tributaries from line extending below Low Knee Point to Wright Wharf to Delaware line or to all Maryland headwaters	(Md.) Group C	III, IV, V, VI
Little Choptank River	Little Choptank River including estuarine portions of creeks, coves, and tributaries	(Md.) Group A	I, III, IV
	From mouth (Line drawn between Hills Point and northern tip of Oyster Cove) to head all of estuarine portions		
Nanticoke River	Nanticoke River including estuarine portions of creeks, coves, and tributaries except Nanticoke Harbor	(Md.) Group A	I, III, IV
	From mouth (line drawn between Frog Point and Stump Point) to a line between mouth of Jacks Creek and Runaway Point		
Wicomico	Wicomico River including estuarine portions of creeks, coves, and tributaries	Group A	I, III, IV
	From mouth (line between Mollies Point and Wingate Point to point 1 (one) mile above Mt. Vernon Wharf)		
Manakin River	Manakin River including estuarine portions of creeks, coves, and tributaries	(Md.) Group A	I, III, IV
	(Mouth - Line between Pin Point and Hazard Point to Sharps Point)		
Big Annamessex	Big Annamessex River including estuarine portions of creeks, coves, and tributaries	(Md.) Group A	I, III, IV
	Mouth (Line between Pot Island and Flatcap Point) to bridge on River Road		

River Area	Description	Criteria	Water Uses
Lower Eastern Shore		(Va.) Class IIB	Special Standards A
Pocomoke River Pocomoke Sound	Chesapeake Bay and its tidal tributaries from Thimble Shoal Channel (Longitude 76° 10' West to Cape Charles; Latitude 37° 07.4' North) and North to Virginia-Maryland State Line West of the east-west divide boundary on the Eastern Shore of Virginia and from Thimble Shoal Channel West to Longitude 76° 10' West and North to Virginia-Maryland State Line		

CHAPTER IV

CHESAPEAKE BAY STUDY AREAS

A. LOWER SUSQUEHANNA RIVER AREA

The tidal reach of the Susquehanna River extends from Havre De Grace, Maryland, to the foot of Conowingo Dam, approximately 10 miles upstream. This stretch of the river is protected by Group B water quality standards. Beneficial uses include public or municipal water supply, water contact recreation, agricultural water supply, industrial water supply, and propagation of fish, other aquatic life, and wildlife.

According to the Maryland Department of Water Resources (MDWR), discharges of treated and untreated sewage from the communities of Octoraro and Port Deposit, along the lower main stem, have resulted in bacterial counts exceeding water quality standards. The great assimilative capacity of the River in this area prevents severe bacterial degradation. Also, during periods of severe drought, the intrusion of saline water from the Bay may render the lower few miles of the river temporarily unsuitable as a source of public water supply.

The dissolved oxygen (DO) standard of 5.0 mg/l has been contravened immediately below the Conowingo Dam during the critical summers following deep-water releases from the reservoir. Recent fish kills below the Conowingto Dam have been attributed to oxygen deficiencies in these waters. Dissolved oxygen concentrations of 3.0 mg/l were measured at mid-pool below the dam during the summer months of 1971. However, the DO level of the river recovers quickly downstream from the Conowingo Dam with no violations of standards.

The "Chesapeake Bay Nutrient Input Study," Technical Report Number 47, by the Annapolis Field Office, analyzed nutrient contributions to the Bay during the period June 1969 to August 1970. Major tributary watersheds of the Bay include the Susquehanna, Patuxent, Potomac, Rappahannock, Pamunkey, Mattaponi, James, and Chickahominy Rivers. The nutrient input to the Bay from the Susquehanna River is as follows:

Table IV-1

Parameter	Average Monthly Concentrations (mg/l)	Average Monthly Contribution (lbs/day)	Percent Input to Bay (lbs/day)
T. PO_4 as PO_4	0.18	33,000	49%
P (Inorganic)	0.12	20,000	54%
TKN as N	0.67	93,000	60%
NO_2 + NO_3 as N	0.91	153,000	66%
NH_3 as N	0.23	29,000	71%
TOC	3.64	513,000	51%

These nutrient contributions were based on average monthly flows for the 15-month study period, measured at Conowingo, Maryland. The above data, when compared with data from the other rivers in the study, show the Susquehanna River to be the largest contributor of nutrients to the Bay. This is due to the fact that the Susquehanna is the largest contributor of freshwater to the Bay (approximately 50 percent).

For an average month during the 15-month study period the flows for the three major nutrient contributors were: the Susquehanna River, 32,133 cfs, the Potomac River 9,634 cfs, and the James River 5,740 cfs. Detailed nutrient-flow relationships are contained in Technical Report Number 47.

As a result of accelerated eutrophication in the upper Chesapeake Bay tributaries and the significance of the Susquehanna River as a nutrient input to the Bay, a nutrient survey of the lower Susquehanna River Basin was initiated by AFO in June 1971 with the cooperation of the Commonwealth of Pennsylvania. This continuing survey is intended to accomplish the following: quantitatively delineate the contributory nutrient loadings (nitrogen and phosphorus) from critical sub-basins and specific major metropolitan area discharges; determine the relative contribution of nutrients from non-point sources, such as agricultural and other types of land runoff; permit a mass balance of the nutrient load over an annual cycle including the fate of such nutrients in the impoundments and establish the necessary treatment requirements to achieve allowable nutrient limits. In addition to water sampling, effluent samples from 26 wastewater treatment plants are being provided to the AFO on a monthly basis for analysis.

The AFO tested for heavy metals in the summer of 1971 in the pool below Conowingo Dam. In the water samples, mercury, lead, and zinc were detected at .0001, .001, and .057 ppm, respectively. The mercury and lead readings represent the minimum detectable limit for the laboratory procedure employed and, thus, the actual concentrations of the two metals might have been lower. The zinc concentrations are normally high and oftentimes measured at an order of magnitude similar to the various nutrient fractions.

The AFO ran heavy metal analysis on water samples obtained from the pool below Conowingo Dam again in February 1972 to determine the concentrations of various metals in water discharged from the impoundment. The results were as follows: iron .72 ppm, manganese .32 ppm, zinc < .02 ppm, copper < .03 ppm, chromium < .03 ppm, lead < .03 ppm, cadmium < .01 ppm, and nickel < .05 ppm.

The above metals reported as "less than" represent the lower levels of sensitivity of the instruments employed in the metals measurement. The source of iron and manganese could be upstream mine drainage. Pyrite would be a source of iron.

J. H. Carpenter of the Johns Hopkins University's Chesapeake Bay Institute (currently Director of Oceanography Section, National Science Foundation) analyzed water samples for the presence of iron, manganese, zinc, nickel, copper, cobalt, chromium, and cadmium in both the dissolved and suspended states. The water samples were collected at weekly intervals from April 1965 through August 1966 at Lapidium, Maryland, about 1 mile below the Conowingo Dam. Average concentrations of heavy metals associated with suspended sediment, for which data was available, were as follows:

Copper - 2 ppb, September 1965 through January 1966, and June 1966 through August 1966; 3 ppb, February 1966 through May 1966.

Nickel - 4 ppb, September 1965 through January 1966, and June 1966 through August 1966; 9 ppb, February 1966 through May 1966.

Zinc - 8 ppb, September 1965 through January 1966, and January 1966 through August 1966; 27 ppb, February 1966 through May 1966.

Manganese - 75 ppb, September 1965 through January 1966, and June 1966 through August 1966; 225 ppb, February 1966 through May 1966.

Iron - 400 ppb, September 1965 through January 1966, and June 1966 through August 1966; 1,500 ppb, February 1966 through May 1966.

The periods of high metal concentration were usually associated with high river flows and high concentrations of suspended sediment.

Carpenter's data will provide some of the needed background information to assess heavy metal contributions to the Bay from Susquehanna River Basin drainage.

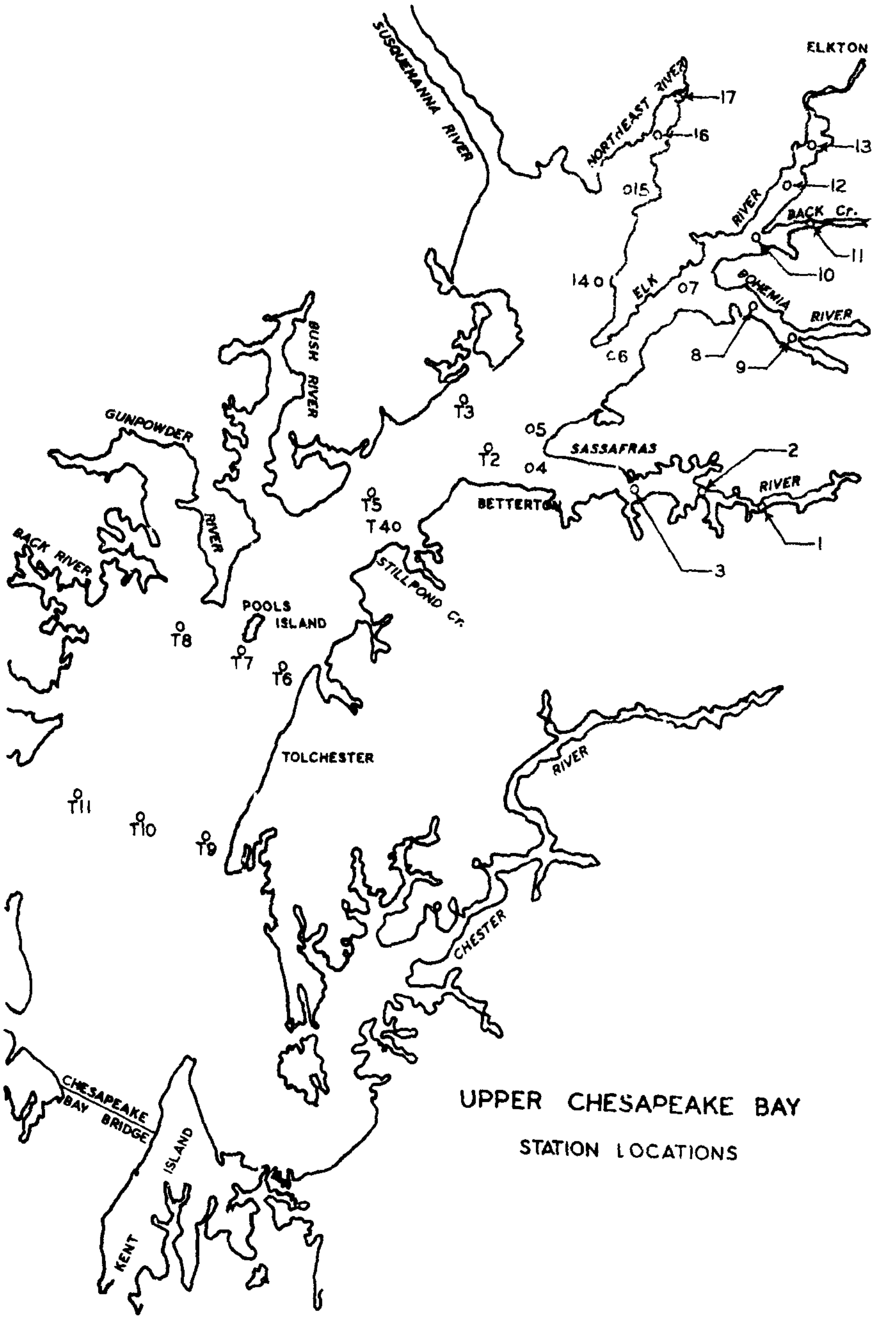
B. UPPER BAY AND UPPER EASTERN SHORE AREA

This area includes the Northeast, Elk, Bohemia, and Sassafras Rivers and the open Bay waters from Sparrows Point northward to the mouth of the Susquehanna River. Beneficial uses include municipal, industrial, and agricultural water supply; water contact recreation; propagation of fish, other aquatic life, and wildlife; and shellfish harvesting. Recent studies indicate that this is a critical spawning and nursery area for several species of fish. Specific uses for these estuaries and the criteria to support the uses are set forth in the water quality standards section of this chapter.

Sampling stations were established in the upper Bay in 1968 by the Annapolis Field Office and maintained during the subsequent summer sampling seasons. A map showing the station locations and brief descriptions of these stations can be found on the following pages. The Maryland Department of Water Resources also monitored the stations during the summer months of 1970 and 1971. The following measurements were taken by the Maryland Department of Water Resources in 1971: water temperature, pH, Secchi disc, conductivity, salinity, DO, total coliforms, fecal coliforms, $NO^2 + NO^3$ as N, total PO_4, organic PO_4, chlorophyll a, NH_3 as N, and TKN. The following discussions are based on the data obtained from this cooperative program.

BACTERIOLOGICAL CONDITIONS

The bacteriological quality of the estuaries is generally good except in areas where wastewater treatment facilities are inadequate.



UPPER CHESAPEAKE BAY
STATION LOCATIONS

Figure IV-1

Table IV - 2

Station Locations

1. Sassafras River, at Georgetown Bridge
2. Sassafras River, Nun Buoy "6"
3. Sassafras River, Can "3", Ordinary Point
4. Sassafras River, mouth, off Betterton
5. Chesapeake Bay, off Grove Point Buoy "1"
6. Elk River at Turkey Point, Buoy N "6"
7. Elk River at confluence with Bohemia River, Buoy N "10"
8. Bohemia River at Long Point, Buoy N "2"
9. Bohemia River at Georges Point
10. Elk River at confluence with C & D Canal, Buoy "19"
11. Chesapeake and Delaware Canal, Buoy N "26"
12. Elk River at Paddy Piddles Cove, Buoy N "6"
13. Elk River off Locust Point, Buoy N "14"
14. Northeast River channel off Rocky Point, Buoy R "2"
15. Northeast River off Roach Point, Buoy N "10"
16. Northeast River off Charlestown, Buoy N "8"
17. Northeast River at mouth of Northeast Creek

T1. Sassafras River, mouth, off Betterton (same as Station 4)
T2. Chesapeake Bay, off Sassafras River, north of channel between N "26" and N "2"
T3. Chesapeake Bay, Buoy N "2" at Spesutie Island channel
T4. Chesapeake Bay, Buoy N "22" off Still Pond Creek
T5. Chesapeake Bay, Buoy C "1" off Romney Creek
T6. Chesapeake Bay, Buoy "12" off Fairlee Creek
T7. Chesapeake Bay, Buoy C "3", lower tip Pooles Island
T8. Chesapeake Bay, Buoy S41B, off Gunpowder River
T9. Chesapeake Bay, Buoy R "6" above Swan Point
T10. Chesapeake Bay, between Buoy C "5" and S "18B"
T11. Chesapeake Bay, off Craighill channel light

The communities of Charlestown, North Chesapeake City, South Chesapeake City, Meadowview, and Northeast have been directed by the MDWR to construct or improve treatment facilities.

Sampling data of the MDWR obtained during June, July, and August of 1971 showed fecal coliform densities at all stations considerably less than the primary contact recreation standard of 240 MPN/100 ml. On October 18 and 19, 1971 the following densities were recorded.

Sampling Station	Date	Time	Fecal Coliform MPN/100 ml
1	10-19-71	1546	930
9	10-19-71	1232	230
12	10-19-71	1328	220
13	10-19-71	1333	430
17	10-18-71	1638	430

The pattern depicted above, showing high bacterial occurrences at various locations, could indicate extreme weather conditions and probable storm water impact.

DISSOLVED OXYGEN CONDITIONS

Data obtained by the MDWR and the AFO during the 1971 water quality surveys were reviewed for contraventions of the DO standard. No significant contraventions of the 5.0 mg/l daily average DO standard were recorded at the sampling stations. On June 6, 1971, surface-water DO measurements of 5.4, 5.0, and 5.1 were recorded at Stations 2, 3, and 4, respectively, in the Sassafras River. While on October 18, 1971, at

Stations 16 and 17 in the Northeast River surface-water DO concentrations were 5.8 and 5.4 respectively. It is expected that DO concentrations dip below the standard during the decay and respiratory phases of excessive algal blooms in the upper reaches of the tributaries in this study area.

NUTRIENTS

Background data on nutrient fractions are available for the summer seasons of 1968 through 1971. The MDWR analyzed approximately 185 samples for the various nutrient fractions in this study area during 1971. The AFO performed about 190 nutrient analyses in 1971.

WATER QUALITY TRENDS

Blooms of blue-green algae in the upper Bay tributaries have been associated with increased nutrient concentrations. In late August of 1968, excessive blooms of blue-green algae were first reported in the Sassafras River near Georgetown and in the Elk River downstream from Elkton. On August 27, 1968, when blooms were observed, chlorophyll a was measured at 257 micrograms per liter in the Sassafras River near Georgetown. In the Elk River, 140 micrograms per liter of chlorophyll a was measured on August 28, 1968. Total inorganic phosphorus concentrations were higher in the areas of the blooms when compared to concentrations measured below these areas.

In sussequent years, since 1968, these blooms have gradually increased in size, density and duration.

By 1969, all of the headwaters of the upper Bay tributaries were affected with the uppermost stations of the Sassafras, Elk, Bohemia, and Northeast showing September chlorophyll a values of 97.5, 120.75, 387.0, and 117.75 μg/l, respectively.

During the early summer of 1970 there was a great deal of rain and therefore, extensive blooms didn't occur until late in the season. August values in the upper two stations in the Elk were 213.8 and 151.5. All four stations in the Northeast were badly hit with chlorophyll a values of 165.0, 163.5, 287.3, and 315.0, respectively, from mouth to headwaters of the river. The Bohemia also had a large standing crop in August with chlorophyll a values of 141.0 and 180.0.

In 1971 blooms became evident early in the summer. In June the upper Sassafras was showing chlorophyll a values of 121.5; the Northeast values of 224.0; and in July, the Bohemia values of 110.0.

The major offending organisms found to be present in these blooms are Anabaena, Oscillatoria (two forms of filamentous blue-greens) and a coccoid blue-green Anacystis (the problem organism of the Potomac River). All three of the nuisance blue-greens were found in great abundance.

These blue-greens seem to be unsuitable as food for grazing zooplankton populations, and therefore, are not consumed until they reach huge standing crop proportions that are readily visible as floating masses in the water.

The major problem areas appear at the headwaters of each of the upper Bay tributaries. With each year, however, the area encompassed by the large algal standing crop increases, especially during the hot, low-flow months. Because of this large standing crop, there is a potential water quality problem.

In addition to this abundance of blue-green algae, there also seems to be a diverse but relatively small quantity of healthy green phytoplankton.

Although there is an imbalance in the phytoplankton community, the other trophic levels seem to be healthy. The bacteriological quality of these tributaries is basically good. The zooplankton and bottom communities seem to be diverse and healthy. Every spring this area is used by huge numbers of anadromous fish, such as striped bass, alewives, and several species of clupeids.

C. UPPER WESTERN SHORE AREA

The study area includes the Bush, Gunpowder, and Middle rivers. Back River is discussed in the section on Baltimore Harbor. Romney Creek and Swan Creek are included in this discussion as they are recipients of effluent from wastewater treatment plants in the northern portion of study area.

The tidal waters of Bush, Gunpowder, and Middle Rivers are classified in the Maryland water quality standards for water contact recreation, industrial water supply, and propagation of fish, other aquatic life and wildlife. No specific standards are assigned to Romney and Swan Creeks.

No current (1970-71) water quality surveys are available for this study area except for a Romney Creek study carried out by the Annapolis Field Office on June 11, 1970. Bathing beach reports of the Baltimore County Health Department concerning bacterial analyses were received for the period 1966 through 1971. Other water quality surveys reviewed for this report were a study encompassing the Bush River, Romney Creek, and Swan Creek conducted by the Annapolis Field Office during the period of October to December 1967, and a 1965 summer survey by Mr. John R. Longwell, Maryland Department of Water Resources, results of which are contained in a report entitled "Physical, Chemical and Bacteriological Water Quality in Gunpowder Falls and Little Gunpowder Falls."

Personnel of the Department of Water Resources report that little development has taken place in the study area since 1965 and that water quality remains generally good in the Bush, Gunpowder, and Middle Rivers. It was noted, however, that during December 1971 the presence of algae (Massartia) was reported for the first time in the Middle River. The following is a brief discussion of the available data mentioned above.

WATER QUALITY CONDITIONS

During the August 1965 water quality survey, the Maryland Department of Water Resources (MDWR) found that the median DO values in the Gunpowder River below the confluence of Gunpowder Falls and Little Gunpowder Falls ranged from 6.9 ppm to 9.0 ppm. The overall maximum DO value was 9.4 ppm and the minimum 5.8 ppm. The 1965 determinations for fecal coliforms (*E. coli*) showed minimum and maximum values of less than 3/100 ml and 230/100 ml (MPN).

The Department of Water Resources has not conducted recent water quality surveys in the Middle river. In December 1961, the MDWR received reports for the first time of algae in the Middle River. It was believed to be, at the time of observance, the phytoplankter *Massartia*.

Dissolved oxygen concentrations during the October to December 1967 survey ranged between 9.0 ppm and 11.0 ppm. With the exception of two sampling stations, fecal coliform densities were usually below 100/100 ml. At Stations 18 and 19, located near the Edgewood Arsenal, fecal coliform densities exceeded the contact recreation standard on two occasions.

The Edgewood Arsenal has taken steps to provide treatment to its waste. Wastewater treatment facilities are under construction and should be completed this year.

On June 11, 1970, the Annapolis Field Office conducted a 1-day water quality survey of Romney Creek. This limited survey indicated a high phytoplankton count. An algal bloom was found just downstream from the Sod Run wastewater treatment plant. High phosphorus and variable nitrogen readings were recorded during the survey. At the two stations located below the point of discharge, chlorophyll _a_ was measured at 192.0 and 210.0 micrograms per liter, indicative of the bloom conditions. Additional sampling data will be needed to identify the Sod Run plant as the primary cause of the algal blooms. Operating records from the Sod Run plant showed a BOD_5 removal of approximately 68 percent for the month of January 1972.

Swan Creek receives effluent discharges from the Aberdeen Proving Ground and from the Glenn Heights and Town of Aberdeen wastewater treatment plants, which discharge into Swan Creek above the Aberdeen Proving Ground's discharge. In the 1967 survey frequent high fecal coliform counts were found at a sampling station located downstream from the three discharges. It should be noted that the effect of tidal excursion makes the identification of bacterial sources difficult. In addition, high chlorophyll values were reported in the tidal headwaters of Swan Creek below these discharges. The high chlorophyll values coincided with the higher nutrient figures for phosphates and Kjeldahl nitrogen recorded during the 1967 survey.

Currently, the Aberdeen Proving Ground discharges untreated effluent from sedimentation tanks and backwash from filters at the water filtration plant into the headwaters of Swan Creek. Action has begun to alleviate the current situation by providing treatment of sludge and filter backwash at the main potable water treatment plant serving the Aberdeen Proving Ground area.

WATER QUALITY TRENDS

The insufficient data base precludes evaluations in terms of nutrient enrichment in the Bush, Gunpowder, and Middle Rivers. Romney and Swan Creeks receive nutrients from wastewater treatment plants in the area. These creeks appear to act as nutrient traps or settling basins for the nutrients. Localized algal blooms have occurred in these creeks.

The Baltimore County Department of Health conducts sanitary surveys and performs bacterial analyses of beach water as its basis for issuing permits to operate public bathing beaches. Prior to the 1966 summer surveys, 21 public beaches were located on the shores of Middle, Gunpowder, Back and Bird Rivers, Chesapeake Bay, and Bear Creek. The results of the 1966 summer surveys justified the closing of four beaches in Middle River, two in Bird River, two in Back River, and four in Bear Creek. The Health Department's 1967, 1968, and 1969 surveys showed no significant changes in water quality in the beach waters. Seven applications for permits to operate public bathing beaches for the 1970 season were received and approved by the Department of Health. They were: four beaches in Chesapeake Bay, two beaches in Middle River, and one beach in Gunpowder River. In 1971, seven applications were received and six permits issued.

Beaches are closed in Baltimore county when the 240/100 ml fecal coliform standard is frequently exceeded. In several instances the closures of beaches have been traced to failing individual sewage disposal systems surrounding the beaches. The Health Department surveys have also pointed out unsanitary conditions associated with the actual beach area, which included picnic grounds, dressing rooms, showers, and toilets.

In order to identify trends other than bacteriological, monitoring data should be sought for nutrients, pesticides, and heavy metals.

D. BALTIMORE HARBOR AREA

In February 1969, the Maryland Department of Water Resources, with Federal financial assistance under Section 3(c) of the Federal Water Pollution Control Act, initiated a 3-year study of Baltimore Harbor for the purpose of developing a comprehensive water quality management plan. Since that time the Maryland Environmental Service (MES) has taken over the responsibility for completing the project. The field work was completed in February 1972. The recommended management plan is expected later this year. The plan will include a detailed description of existing water quality conditions in Baltimore Harbor. Therefore, the following discussion is a brief review of water quality conditions in the Harbor, based on contacts with Mr. William Sloan, Baltimore Harbor Project Leader, MES, and current data from the files of the Annapolis Field Office.

Major sources of pollution in Baltimore Harbor include wastes from the Baltimore City Patapsco Wastewater Treatment Plant, which discharges primary treated effluent directly into the Harbor, direct industrial discharges, sewerage overflows and leaks into Harbor tributaries, urban runoff, and the occurrence of spills of hazardous substances from vessels and dockside facilities.

MUNICIPAL AND INDUSTRIAL DISCHARGES

The Patapsco Wastewater Treatment Plant currently discharges approximately 13 mgd of primary treated wastes into the Harbor in the vicinity of Wagners Point above the mouth of Curtis Bay. Expansion plans for the Patapsco Plant include secondary treatment facilities. In addition, the MES study may include a recommendation for nutrient removal at the Patapsco Plant. The Back River Plant, Baltimore City's major wastewater treatment plant, provides secondary treatment to approximately 158 mgd of wastewater, of which 38 mgd is discharged into the upper portion Back River. Highly eutrophic conditions, as indicated by a heavy algal standing crop, exist due to the discharge of treated wastewater containing large amounts of nutrients from the Back River Plant.

Bethlehem Steel (Sparrows Point Plant) purchases the remaining 120 mgd of secondary treatment effluent for use as process water. The process water, in turn, is discharged near the mouth of Bear Creek which has experienced extensive algal blooms during the summer months. The MES study included a point of discharge evaluation for the Bethlehem Steel wastewater outfall to determine if better dispersion would result from a discharge point in the main Harbor.

While some of the industries in the Baltimore area have been authorized to connect to the city's wastewater treatment system most major water-using industries discharge directly into the Harbor. Those industries that do not discharge into the city's system must obtain an industrial waste discharge permit under the 1899 Refuse Act.

In December 1971, the AFO conducted a field investigation of several of the major water-using industries known to be discharging significant quantities of wastes into Baltimore Harbor (see attached map).

Effluent samples were obtained as well as receiving water samples opposite the discharges. Quantities of wastes (lbs/day) were calculated from flows provided in applications submitted by the industries under the 1899 Refuse Act and based upon a single sample representative of the daily discharge. The following information is provided as an indication of industrial waste problems in Baltimore Harbor. It should be emphasized that the information presented does not include all of the parameters measured in the discharges.

The FMC Corporation discharges its waste into Stonehouse cove, a tributary of Curtis Bay. Ethion, an insecticide, was found in the discharges of two outfalls at concentrations of .028 mg/l and .661 mg/l, respectively. A water sample taken opposite the outfalls contained 1.118 mg/l ethion. Although no specific water quality criteria for ethion has been established for particular water use classification, ethion is known to be an acutely toxic insecticide.

Two discharges from Allied Chemical Corporation were found to contain 8.8 mg/l and 4.5 mg/l of chromium, respectively. This chromium input was calculated to be 37 lbs/day. The receiving water sample taken adjacent to the discharges contained .30 mg/l chromium. The U. S. Public Health Service (PHS) drinking water standard is .05 mg/l and the fish toxicity level for chromium is 2.0 mg/l. Phenol was also detected in the actual effluent at .180 mg/l (3 lbs/day). A water sample collected opposite this outfall contained the same concentration,

.180 mg/l of phenol, an amount greater than that specified in the PHS drinking water standards (0.001 mg/l).

The water quality criteria for fish and aquatic life cited in these discussions were obtained primarily from the publication Water Quality Criteria, Second Edition, by J. E. McKee and H. W. Wolf, The Resources Agency of California, State Water Resources Control Board, revised 1963. The Public Health Service drinking water criteria, as well as the fish and aquatic life criteria, are presented for comparison purposes only. For the most part, the constituents in the industrial wastes are not covered by numerical criteria in adopted water quality standards.

One outfall from the Amstar corporation was found to be discharging 36,962 lbs/day of total carbon, concentrated at 214.38 mg/l in the actual effluent. It is known that organic particulates (carbon) reduce dissolved oxygen in the water and form harmful sludge deposits. Significant discharges of phenol and sulfate were also detected at Amstar Corporation.

Effluent from the Glidden-Durkee Division of SCM Corporation contained 19,723 mg/l of sulfate (47,335 lbs/day). The receiving water sample near the outfall had 4,990 mg/l sulfate. Concentrations of 353 mg/l and 18.7 mg/l of total Kheldahl nitrogen and total phosphate, respectively, were present in one outfall discharge. This same discharge was found to be contributing 648 lbs/day of ammonia nitrogen (270 mg/l). For the purpose of comparison, this ammonia concentration, 270 mg/l, is approximately twentyfold greater than that contained in untreated domestic sewage.

American Smelting and Refining Company's discharge contained 6.5 mg/l of arsenic (108.5 lbs/day). The concentration of arsenic in the immediate receiving waters was close to the fish toxicity level of 1.0 mg/l. Copper was also present in the effluent at a concentration of 76 mg/l (1,200 lbs/day). Copper was detected in the receiving water sample at 12 mg/l. Fish toxicity levels and drinking water standards for copper are 0.15 mg/l and 1.0 mg/l, respectively. The actual effluent had a pH of 2.5 while the immediate receiving waters had a 3.5 pH. Fish tolerance levels range from 4.5 to 9.5 and the water quality standards assigned to the Baltimore Harbor by the State of Maryland are 5.0 to 9.0.

The December 1971 survey disclosed that the Bethlehem Steel Corporation at Sparrows Point was discharging cyanide into Baltimore Harbor. The cyanide concentration and loading from this critical discharge were found to be 16.1 mg/l and 193 lbs/day, respectively. Recommended maximum drinking water criteria and fish toxicity levels are 0.01 mg/l, and 0.1 mg/l, respectively. The receiving water sample taken opposite the discharge contained 14.0 mg/l of cyanide. Phenol was also detected in several of Bethlehem Steel's discharges. In the effluent of one particular discharge, phenol was concentrated at 23.5 mg/l (282 lbs/day). The receiving water sample had 21.0 mg/l of phenol. Drinking water standards for phenol are 0.001 mg/l, while the levels considered to be toxic or lethal to fish are 0.4 to 0.6 mg/l. A low pH of 2.1 was measured in the receiving waters opposite two of

Bethlehem Steel's discharges.

Critical concentrations of heavy metals in the actual effluents from Bethlehem Steel were found for the following: iron, zinc, lead, and copper. Iron was found being discharged at 888,000 plus lbs/day. Iron concentrations in water samples collected near several outfalls ranged from 1.2 to 70.0 mg/l. All concentrations are in excess of the PHS drinking water standards (0.3 mg/l) and fish toxicity levels (1.0 mg/l).

Over 50,000 lbs/day of zinc was being discharged by Bethlehem Steel during the December 1971 survey. The highest amount detected in a receiving water sample was 10 mg/l, which exceeds the PHS drinking water standard (5.0 mg/l), the fish toxicity level (0.15 mg/l), and the concentration (5.0 mg/l) at which zinc becomes aesthetically undesirable (causes a greasy and milky appearance in the water).

Lead and copper were discharged at rates of 6,335 and 127,000 lbs/day, respectively. Receiving water samples had concentrations of 2.0 and 27.0 mg/l for lead and copper, respectively. Small traces of lead are highly toxic to aquatic life, as lead is an accumulative poison. The fish toxicity level for copper is 0.15 mg/l. The drinking water standards for lead and copper are 0.05 mg/l. The drinking water standards for lead and copper are 0.05 and 1.0 mg/l, respectively.

Solids were discharged at the following rates: 32,600,000 lbs/day of total solids and 1,700,000 lbs/day of suspended solids. Both the drinking water standard of 500 mg/l and the 4,000 mg/l limit which renders water unfit for human consumption were exceeded by all of the receiving water samples.

The cumulative sulfate contribution from the major outfalls was 150,027,919 lbs/day. One particular discharge had a concentration of 118,196 mg/l and a loading of 135,132,243 lbs/day. The water sample taken opposite this critical outfall also contained 118,196 mg/l of sulfate. The recommended drinking water standard for sulfate is 250 mg/l.

The combined loadings from the major discharges for total carbon, phosphate, and ammonia were 182,492 lbs/day, + 23,000 lbs/day, and 17,860 lbs/day, respectively. Receiving water samples contained concentrations of phosphate ranging from 0.8 mg/l to 5.9 mg/l. For purposes of comparison, it should be noted that this discharge of phosphate, in excess of 23,000 lbs/day, is equivalent to approximately one-third of the phosphate load in the entire upper Potomac Estuary from the Washington Metropolitan Area. Its role as a nutrient in accelerating the eutrophication process is well documented.

The Maryland Environmental Service's comprehensive study of the Baltimore Harbor provided for a 1-year's study of the higher trophic levels of the fauna in the harbor. The study was carried out by the Chesapeake Biological Laboratory, Natural Resources Institute, University of Maryland. The study concludes that species showing reduction in numbers from the mouth of the Patapsco River to Fort McHenry are those which live in or on the bottom or are dependent on benthic species. Also, the fauna present in Bear Creek, Colgate Creek, Northwest Branch, Middle Branch, and Curtis Creek are species either adapted to a highly polluted environment or, if present, exhibit a detrimental physical condition as a result of the environment. The report contains several recommendations, one of which recommends that the biological potential of Baltimore Harbor could be improved if the addition of untreated industrial and domestic effluents into the tributaries and main Harbor were prevented by curtailment or treatment of present discharges of foreign material into these areas.

BOTTOM SEDIMENT

Analyses of bottom sediment in Baltimore Harbor were made during 1971 by the AFO as part of a continuing program. The maintenance of shipping channels in the Harbor requires periodic dredging and subsequent disposal of the dredged material. The dredged spoils were analyzed for potential pollutants in instances where the spoils were planned for deposition in healthy environs.

On several occasions in 1971, bottom sediments (upper 2 or 3 cm) from the Harbor were analyzed for total Kjeldahl nitrogen, chemical oxygen demand, volatile solids, mercury, lead, zinc, cadmium, chromium, copper, and oil and grease. Some of the high concentrations measured and respective sampling locations were as follows:

Volatile Solids - 143,300 ppm Northwest branch opposite Amstar Corporation; 149,500 ppm Curtis Bay near Thomas Point; 214,000 ppm Bear Creek at Long Point; 217,700 ppm Middle Branch at Buoy N6; 170,000 ppm Colgate Creek headwaters; 142,200 ppm right side of shipping channel off Sollers Point.

COD - 343,280 ppm Northwest Branch opposite Amstar Corporation; 666,980 ppm Bear Creek near Long Point; 552,920 ppm Middle

Branch at Buoy N6; 661,000 ppm Colgate Creek headwaters.

Oil and Grease - 17,510 ppm Northwest Branch off Amstar Corporation; 81,220 ppm Bear Creek at Lloyds Point; 38,150 ppm Middle Branch Buoy N6; 76,410 ppm lower portion of Northwest Branch.

TKN - 2,703 ppm Curtis Bay at Buoy 16; 3,993 ppm Sparrows Point Buoy N8; 6,220 ppm Bear Creek near Long Point; 5,811 ppm Middle Branch Buoy N6; 3,180 ppm right side of shipping channel off Sollers Point.

Mercury - 0.043 ppm Northwest Branch opposite Amstar Corporation; 0.026 ppm Curtis Bay both at Buoy 16 and at Thomas Point; 0.045 and 0.046 at two of the Northwest Branch sampling stations; 0.068 ppm opposite Hawkins Point and adjacent to the main shipping channel.

Lead - 3,271 ppm upper Northwest Branch and 1,673 ppm opposite Amstar Corporation in the Northwest Branch; 2,200 ppm Colgate Creek near Dundalk; 936 ppm Colgate Creek headwaters; 1,502 ppm right side of Shipping channel off Sollers Point.

Zinc - 4,710 ppm Bear Creek at Long Point; 2,828 ppm Colgate Creek near Dundalk; 3,324 ppm Colgate Creek headwaters; 2,589 ppm right side of shipping channel off Sollers Point.

Cadmium - Undetectable in many instances; 51 ppm Bear Creek near Long Point; 251 ppm Colgate Creek near Dundalk; 315 ppm and 192 ppm, middle of channel and right side of shipping channel, respectively, off Sollers Point.

Chromium - 9,425 ppm Bear Creek off Long Point, 2,654 ppm, 8,100 ppm, 6,763 ppm, and 5,681 ppm, respectively, for stations in the upper portion to the lower portion of Northwest Branch; 3,035 ppm right side of shipping channel off Sollers Point.

Copper - Not measured at several sampling locations; 502 and 518 ppm at two sampling locations in middle portion of Colgate Creek; 320 ppm right side of shipping channel off Sollers Point.

A comparison of Baltimore Harbor bottom sediment data with recent data obtained in the vicinity of Tangier Island is presented herein. Tangier Island, located in the lower Bay off Pocomoke Sound, is considered a clean area with regard to pollutants in the bottom sediment surrounding the island.

TKN values for bottom sediment near Tangier Island ranged from 140 to 770 ppm. Most TKN values in Baltimore Harbor ranged between 1,000 and 3,000 ppm.

With the exception of two sampling stations near the bulkhead at Dundalk Marine Terminal, COD in Baltimore Harbor was found to range from approximately 100,000 to 700,000 ppm. COD ranged from 2,390 to 10,540 ppm at Tangier Island.

Volatile solids in Tangier Island sediment samples ranged from 5,800 to 20,800 ppm. Baltimore Harbor sediment values of volatile solids ranged from 12,500 to 217,700 ppm; most samples were in excess of 100,000 ppm.

Oil and grease concentrations ranged from 140 to 460 ppm in bottom sediment adjacent to Tangier Island. The lowest value in Baltimore Harbor was 420 ppm, while the highest value was 81,220 ppm. Eight samples fell within a concentration range of 10,000-40,000 ppm. Of the 39 bottom sediment analyses of Baltimore Harbor reviewed for this section of the report, all but one exceeded the highest value (460 ppm) for oil and grease measured at Tangier Island.

Lead was detected in only two of six samples at Tangier Island at low concentrations (0.4 and 0.7 ppm). Eight of the Harbor samples contained lead in excess of 1,000 ppm.

Cadmium was also low in Tangier Island samples, averaging 0.23 ppm. Although undetectable in most Harbor samples, cadmium was measured in five samples at concentrations as follows: 35.6, 51.0, 192.3, 251.2, and 315.4 ppm

Concentrations of zinc in Tangier Island sediment were low: 8, 13, 12, 27, 12, and 11 ppm. The range for zinc in Baltimore Harbor was 27 to 4,710 ppm. At least half of the samples were in excess of 1,000 ppm.

BACTERIOLOGICAL PROBLEMS

The bacteriological conditions of tributaries to Baltimore Harbor are poor. Gwynn Falls and Jones Falls, tributaries to the Harbor area of the Patapsco River, are severely degraded by very high bacterial densities, due mainly to storm sewer drainage and sewerage system overflows and leaks, all of which enter these streams from the Baltimore Metropolitan Area.

The Baltimore County Department of Health, in a recent water quality study of Bear Creek, noted that the only public beaches available to the Dundalk community are located in Bear Creek and that these have been closed to swimming since 1966. The degradation of bacteriological conditions in Bear Creek is attributed to discharges of sewage and industrial wastes in the area, storm water drainage, and tidal action causing pollutants to flow into Bear Creek from Baltimore Harbor. As noted earlier, Bethlehem Steel has a major discharge located near the mouth of Bear Creek.

Likewise, bathing beaches in Back River have been closed since 1966 because of excessive bacterial counts. The major contributors of bacteria to Back River are its polluted tributaries. In 1965, the AFO conducted an extensive water pollution survey of Back River. In this study it was found that Herring Run was the source of almost 90 percent of both coliform and fecal coliform bacteria contributed by the five tributary streams and the Back River Wastewater Treatment Plant. Moores Run and Stemmers Run, together, provided about 10 percent of the total, while the contributions of the Back River Wastewater Treatment Plant effluent, Bread and Cheese Creek, and Redhouse Creek contributed about 1 percent or less.

NUTRIENTS

During the 1969, 1970, and 1971 summer months the Maryland

Environmental Service (MES) monitored the various nutrient fractions and measured chlorophyll a values in Baltimore Harbor in an attempt to assess the problem of algae in the Harbor. The table below presents nutrient data collected by MES at Harbor sampling stations on August 25, 1971, during an algal bloom (see attached location map). The samples were taken during daylight hours between 10:00 a.m. and 2:00 p.m. EST.

Table IV-3

August 25, 1971

Sta.	Temp. °C	DO mg/l	NH_3 as N mg/l	NO_2+NO_3 as N mg/l	Tot. PO_4 mg/l	Chloro. a μg/l	TKN mg/l
1	25.3	8.2	.11	.03	.41	111	1.25
1A	26.4	9.7	.40	.11	.21	108	1.35
2	26.1	9.1	.53	.11	.30	144	.93
3	27.2	13.7	.90	.16	.93	258	2.61
4	26.0	7.4	.43	.09	.26	144	1.49
4A	25.8	8.4	.70	.09	.30	144	2.01
4B	25.5	5.8	.53	.09	.30	51	1.17
5	25.8	7.6	.37	.09	.30	72	1.21
5A	27.2	14.1	.57	.11	.45	456	3.27
6A	26.4	2.4	.55	.05	.28	102	1.12
7A	25.4	5.4	.60	.12	.26	54	1.21

The above table shows chlorophyll a values measured during bloom stages of algae in late August 1971. At Stations 3 and 5A, where the highest chlorophyll a values were recorded, surface water oxygen saturation conditions also occurred, probably due to the high photosynthesis accompanying the algal processes. Stations 3 and 5A are located at the mouths of Colgate Creek and Bear Creek, respectively. High total phosphate values were recorded during the blooms. Ammonia and nitrite-nitrate nitrogen decreased with algal activity, while increases of total Kheldahl nitrogen indicated higher concentrations of organic matter in the water due to the by-products of algal production.

An examination of sampling data collected on July 8 and August 2, 1971, gives reason to believe that blooms of algae could have occurred during these periods. They did not, however, even though warm water temperatures were recorded together with nutrient concentrations in the water considered more than sufficient for the occurrence of algal blooms. Possibly the presence of toxic material inhibited algal growth. The question of possible algal poisoning will be addressed in the MES study report on Baltimore Harbor.

The earlier discussion of municipal and industrial discharges identified these discharges as significant contributors of nutrients in Baltimore Harbor.

DISSOLVED OXYGEN

Dissolved oxygen concentrations shall not be less than 4.0 mg/l in Baltimore Harbor according to water quality standards established by the State of Maryland. This standard was seldom contravened in surface waters during the 1971 surveys. More often, saturation conditions were observed during the daylight hours when algal photosynthesis occurs. Mr. William Sloan, MES, carried out diurnal studies (24 hours) of algal processes during 1970 and 1971 in an attempt to determine the effects of algal respiration on DO during hours of darkness. Mr. Sloan reports that his tentative findings are inconclusive. While DO showed no appreciable fluctuation in Bear Creek and Stony Creek, the studies showed significant fluctuations in DO in the Northwest Harbor and off Wagners Point. In the upper reach of Northwest Harbor, DO was observed to vary from high values of 9.0 and 12.0 ppm to low values of 0.6 and 4.0 ppm, respectively, on separate occasions during the early morning hours (darkness). The MES report is expected to expand the algal respiration studies.

Although surface waters generally meet the DO standard, subsurface waters at the 15-foot level are frequently depressed below the standard. During the summer of 1971, the lowest subsurface DO concentrations were observed in the Inner Harbor at sampling stations 6A and 7A. At depths greater than 15 feet, concentrations of DO are often quite low.

The Maryland Environmental Service's report will examine the DO problem as it relates to benthic demand, wastewater demand, algal demand, and reaeration.

GENERAL

The consulting firm of Arthur D. Little, Incorporated, was retained by the Maryland Environmental Service to investigate oil and chemical spill hazards; preventive measures in industrial plants in the Baltimore Metropolitan Area were recommended. Findings and recommendations of the Arthur D. Little report, "The Prevention of Spills of Oil and Chemicals into Baltimore Harbor and Environs," will be incorporated into the forthcoming water quality management plan of MES for Baltimore Harbor.

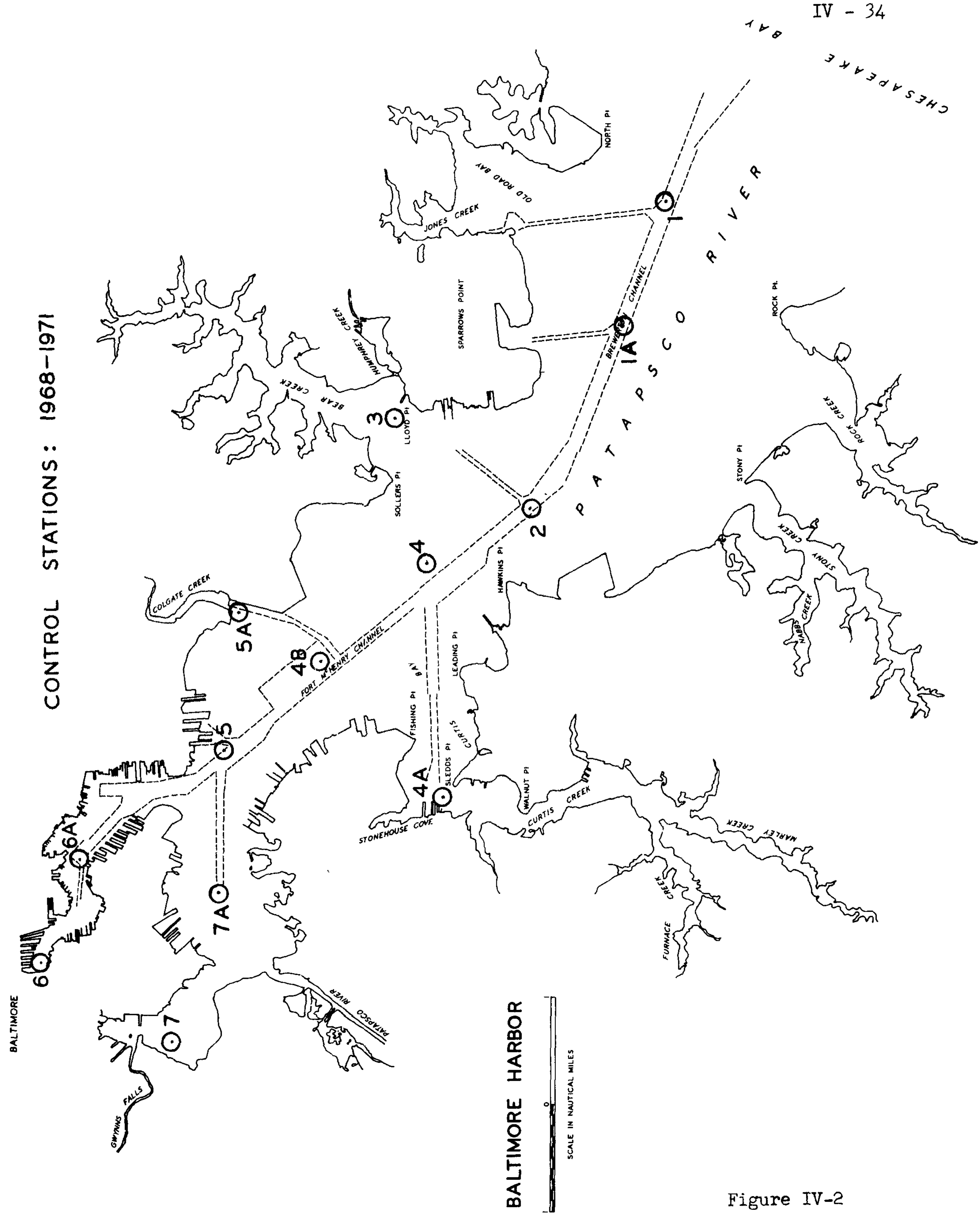

CONTROL STATIONS: 1968-1971
BALTIMORE HARBOR
SCALE IN NAUTICAL MILES
CHESAPEAKE BAY
PATAPSCO RIVER
NORTH Pt
OLD ROAD BAY
JONES CREEK
SPARROWS POINT
HUMPHREY CREEK
BEAR CREEK
LLOYD Pt
SOLLERS Pt
BREWERTON CHANNEL
FORT McHENRY CHANNEL
COLGATE CREEK
ROCK Pt
ROCK CREEK
STONY Pt
STONY CREEK
NABBS CREEK
HAWKINS Pt
LEADING Pt
FISHING Pt
BAY
SLEDDS Pt
CURTIS
STONEHOUSE COVE
WALNUT Pt
CURTIS CREEK
MARLEY CREEK
FURNACE CREEK
GWYNNS FALLS
BALTIMORE
1
1A
2
3
4
4A
4B
5
5A
6
6A
7
7A

Figure IV-2

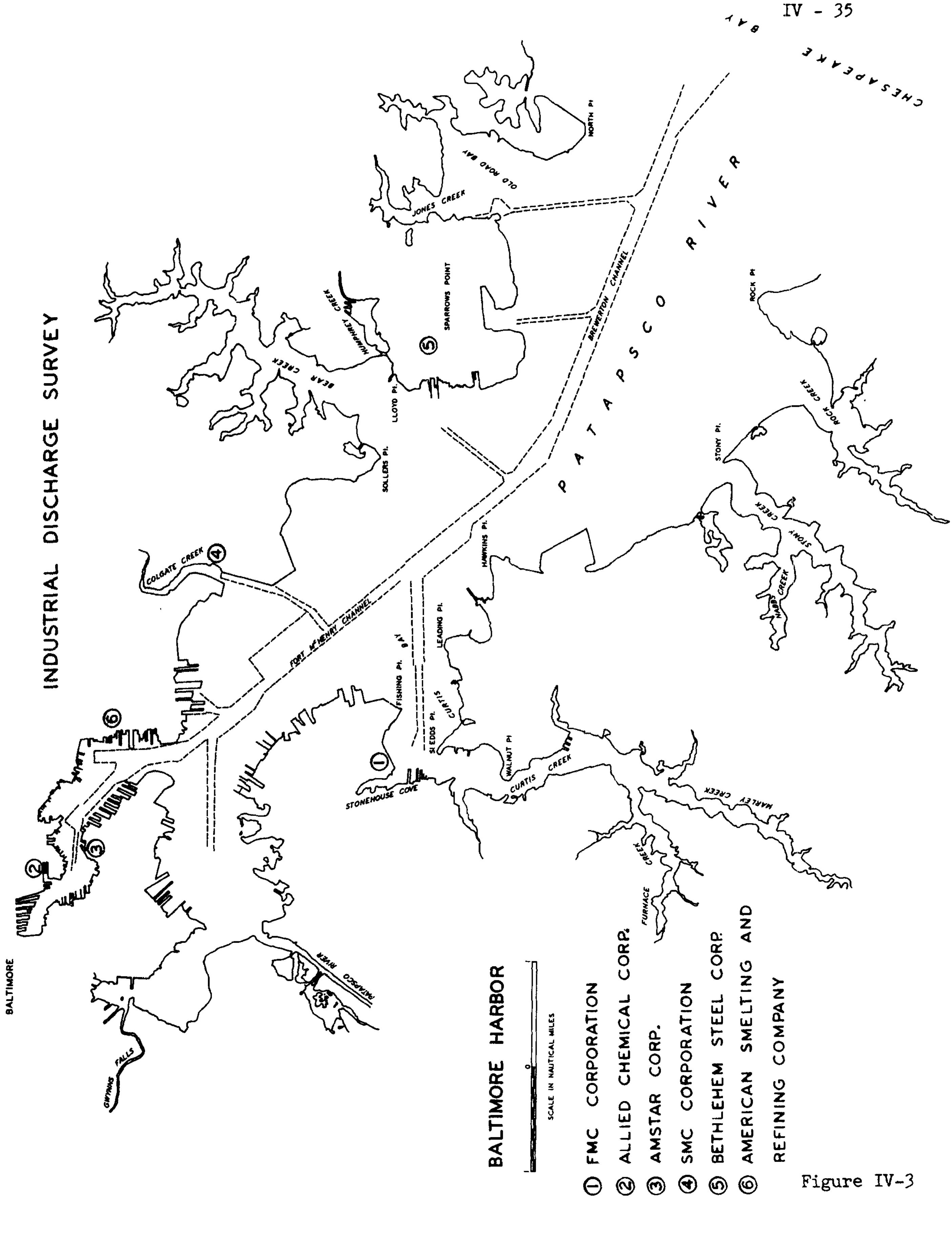

INDUSTRIAL DISCHARGE SURVEY
BALTIMORE HARBOR
SCALE IN NAUTICAL MILES
① FMC CORPORATION
② ALLIED CHEMICAL CORP.
③ AMSTAR CORP.
④ SMC CORPORATION
⑤ BETHLEHEM STEEL CORP.
⑥ AMERICAN SMELTING AND
REFINING COMPANY
BALTIMORE
CHESAPEAKE
BAY
PATAPSCO RIVER
BREWERTON CHANNEL
FORT McHENRY CHANNEL
OLD ROAD BAY
NORTH PT.
JONES CREEK
SPARROWS POINT
HUMPHREY CREEK
BEAR CREEK
LLOYD PT.
SOLLERS PT.
COLGATE CREEK
HAWKINS PT.
LEADING PT.
FISHING PT.
BAY
CURTIS
ST. EDDS PT.
STONEHOUSE COVE
WALNUT PT.
CURTIS CREEK
MARLEY CREEK
FURNACE CREEK
ROCK PT.
ROCK CREEK
STONY PT.
STONY CREEK
NABBS CREEK
PATAPSCO RIVER
GWYNNS FALLS

Figure IV-3

E. MIDDLE WESTERN SHORE AREA

The area covered in this section of the report is located just south of the Baltimore Metropolitan Area and includes the Annapolis Metropolitan Area. The Magothy, Severn, South, and West Rivers are the major drainage areas. The drainage area includes 270 square miles of land and over 190 miles of waterfront.

All the rivers mentioned above are protected by water quality standards to permit water contact recreation and propagation of fish, other aquatic life and wildlife. In addition, the Magothy, Severn, South, and West Rivers are designated as shellfish harvesting waters in the standards of the State of Maryland.

The Maryland Department of Water Resources conducted field surveys on the Severn and South Rivers during 1970 and 1971. No similar surveys by the Department were conducted for the Magothy or West Rivers. The 1970 and 1971 surveys included measurements of the following parameters: water temperature, pH, secchi disc, conductivity, salinity, DO, total coliforms, NO_2 + NO_3 as N, total PO_4, organic PO_4, chlorophyll a, NH_3 as N, and TKN.

The AFO, Environmental Protection Agency, conducted a water quality survey of the Annapolis Metropolitan Area during 1967. The data report from this survey covered the West, Rhode, Magothy, South, and Severn Rivers. In 1970 a survey was conducted on the Severn River on a 1-day basis in March and June by the AFO.

The Smithsonian Institute's Chesapeake Bay Center for En-

Table IV - 4

State of Maryland

Station Location List

Station Number	Location
SR0	Turkey Point - mid-channel
SR0W	Turkey Point - west side of channel, 10-foot depth contour
SR0E	Turkey Point - east side of channel, 10-foot depth contour
SR1	Mouth of Selby Bay
SR2	Cedar Point - mid-channel
SR2W	Cedar Point - west side, 10-foot depth contour
SR2E	Cedar Point - east side, 10-foot depth contour
SR3	Ferry Point - mid-channel
SR3W	North Point Almshouse Creek, 10-foot depth contour
SR3E	East side of channel, 10-foot depth contour, Ferry Point
PPT	Mid-channel - Poplar Point
SR4	Mid-channel - Boyds Point
SR5	Mouth of Broad Creek
SR6	Head of Broad Creek
SR7	Mouth of Granville Creek
SR8	Beards Point (Glen Isle)
SR9	Head of South River

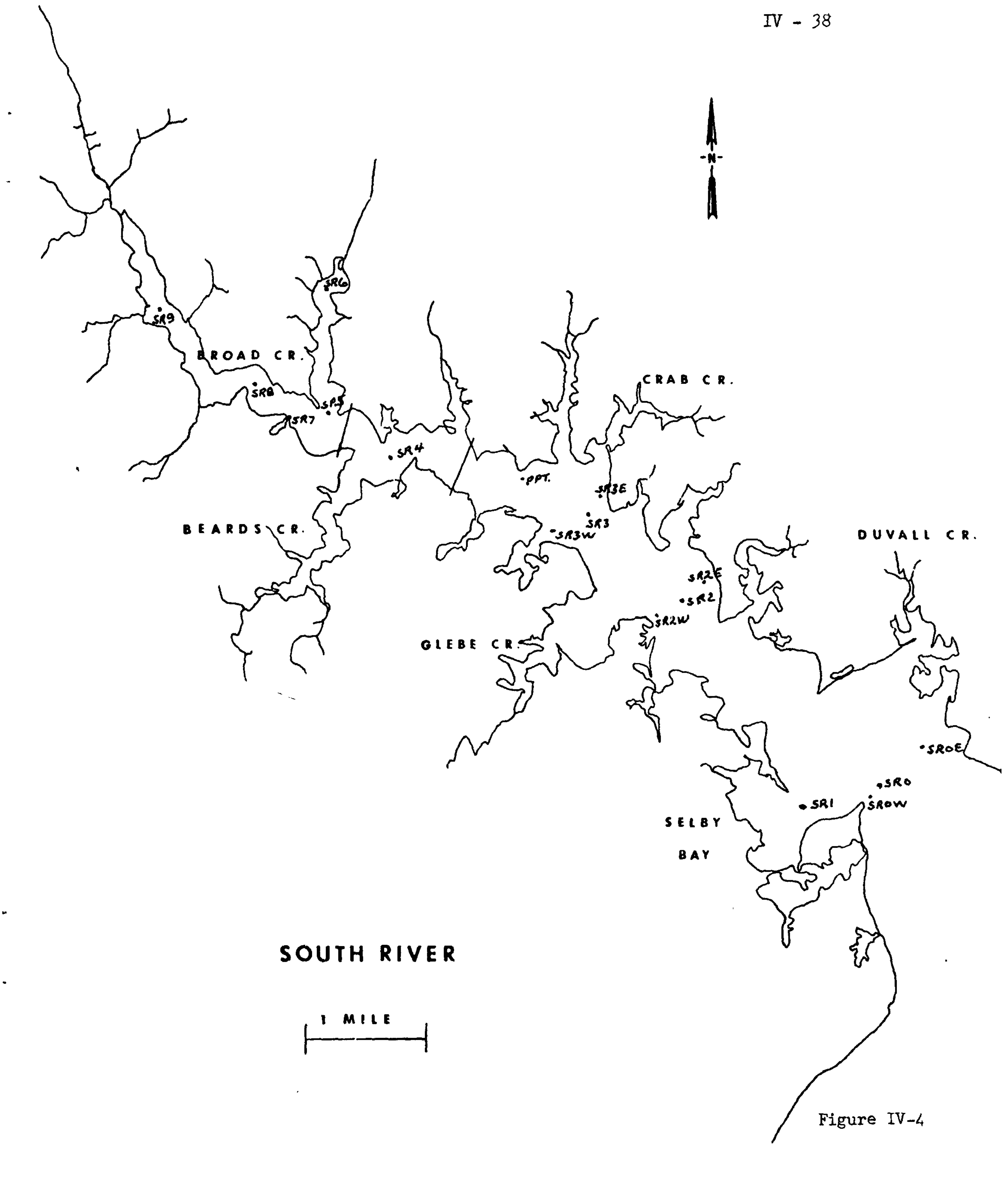

BROAD CR.
SR9
SR6
SR8
SR5
SR7
SR4
CRAB CR.
PPT.
SR3E
SR3
SR3W
BEARDS CR.
DUVALL CR.
SR2E
SR2
SR2W
GLEBE CR.
SR0E
SR0
SR1
SR0W
SELBY
BAY
SOUTH RIVER
1 MILE
N

Figure IV-4

Table IV - 5

State of Maryland

Station Location List

Station Number	Location
SVO	Mouth of Severn River, off Greenbury Point, Buoy R "8"
SVBC	Mouth of Back Creek
SVSC	Mouth of Spa Creek
SV1	Off of the Naval Academy Pier, Buoy C "17"
SVCC	Mouth of College Creek
SVWC	Mouth of Weems Creek
SV2	Approximately 200 yards upstream of the Route 50-301 bridge, 20-foot contour, mid-channel
SV3	Between Arnold Point and Brewer Point at Buoy "5"
SV4	Mouth of Little Round Bay off of St. Helena Island, 20-foot contour
SV5	Round Bay off of Eaglenest Point, 20-foot contour, mid-channel
SV6	Off of Carrollton Manor, mid-channel
SV7	Head of Severn River, Indian Landing, West Side
SVSC1	Spa Creek, mid-channel off Southgate Avenue
SVSC2	Head of Spa Creek

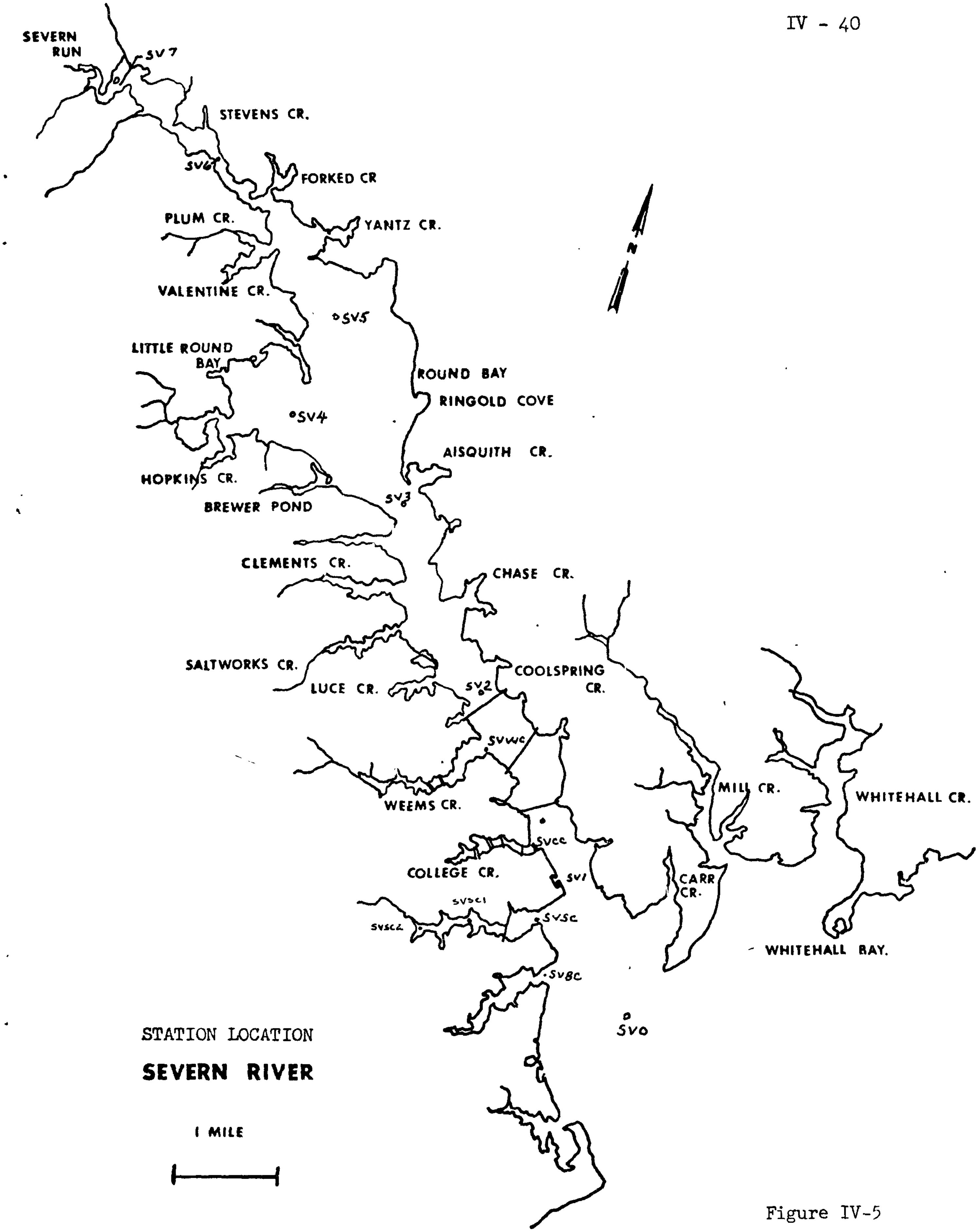

SEVERN RUN
SV7
STEVENS CR.
SV6
FORKED CR
PLUM CR.
YANTZ CR.
VALENTINE CR.
SV5
LITTLE ROUND BAY
ROUND BAY
RINGOLD COVE
SV4
AISQUITH CR.
HOPKINS CR.
BREWER POND
SV3
CLEMENTS CR.
CHASE CR.
SALTWORKS CR.
LUCE CR.
SV2
COOLSPRING CR.
SVWC
MILL CR.
WHITEHALL CR.
WEEMS CR.
SVCC
COLLEGE CR.
SV1
CARR CR.
SVSC
WHITEHALL BAY.
SVBC
SVO
N
STATION LOCATION
SEVERN RIVER
1 MILE

Figure IV-5

vironmental Studies supports an extensive estuarine research program in the Rhode River. One of these studies being investigated by R. L. Cory, U. S. Geological Survey, involves biological, chemical, and physical measurements of water quality in the Rhode River. Time limitations on this report did not permit a review of water quality related studies being carried out by the Chesapeake Bay Center for Environmental Studies.

The following discussions are based on data from the Maryland Departments of Water Resources and Health and Mental Hygiene and the Annapolis Field Office. Maps prepared by the MDWR are presented to show sampling station locations for the South and Severn Rivers.

BACTERIOLOGICAL CONDITIONS

The review of fecal coliform data for the 1971 sampling season showed only one violation of standards at one sampling location in the South River. During 1970, on July 21 and August 31, abnormally high fecal coliform densities were recorded in the upper South River. However, the high occurrence of bacteria was attributed to heavy rains occurring just prior to the surveys.

The Maryland Department of Health and Mental Hygiene reports that a total of 127 acres of oyster bars remain closed in the South River above Cedar and Melvin Points. This area remains closed to safeguard against possible failure of a package wastewater treatment plant located in the upper portion of the South River. The reach of the river below Cedar and Melvin Points was reopened to shellfish harvesting on February 26, 1968.

Water contact recreation standards were exceeded at several sampling stations in upper and lower Severn River, including Spa Creek, in 1971. Based on the available data, standards were contravened on the following dates: June 16, July 7, and October 13, 1971. The MDWR attributes the excessive fecal coliform densities in the Severn River to wastewater treatment plant discharges from the City of Annapolis, the United States Naval Academy, and defective septic systems. The City of Annapolis provides only primary treatment to its wastewater.

The entire Severn River is currently closed to shellfish harvesting. The closure involves approximately 1,481 acres of public bars. In addition to the sources of bacteria mentioned above, the construction of new housing with its concomitant erosion contributes to the coliform problem.

The Maryland Department of Water Resources reports that the bacterial quality of the Magothy is relatively good as a result of the correction of more than 100 septic tank and sewage violations. Shellfish areas formerly closed have been reopened.

In the Rhode and West River system, 63 acres of private oyster bars are closed. This includes bottom grounds in the West River above the county wharf, which was closed in December 1965, and all of Parish Creek, closed in April 1967. The MDWR reports that the bacterial degradation is caused primarily by defective septic systems.

DISSOLVED OXYGEN CONDITIONS

Dissolved oxygen measurements taken at water surfaces indicate that the DO standards are currently being maintained in the South and Severn Rivers. Contacts with personnel of the Maryland Department of Water Resources affirm that the DO concentrations in the Rhode, West, and Magothy Rivers are sufficient to support the beneficial uses assigned to these streams.

The MDWR reports that in the South River, dissolved oxygen is depressed below a depth of 5 feet in the months of July and August. Algal blooms have been observed during this period in the upper reach of the South River. Low dissolved oxygen concentrations below the 5-foot depth have also been recorded at stations in the upper Severn River during the summer months of 1971. It is expected that the respiration processes of algae coupled with low reaeration rates are affecting the oxygen-holding capacities of the water columns in the South and Severn Rivers.

NUTRIENTS

The most significant nutrient concentrations observed in the South River during the 1971 sampling surveys were measured on the July 6, 1971, survey at the following stations:

Table IV-6

Station	Temp. °C	NO_2+NO_3 as N mg/l	Chlorophyll a µg/l	T. Phosphorus as PO_4 mg/l	TKN mg/l
SR4	28.9	< .01	60	.54	1.20
SR5	28.9	< .01	54	.37	1.13
SR6	29.9	< .01	78	1.12	1.07
SR7	29.9	< .01	246	1.25	1.20
SR8	30.3	< .01	72	1.11	1.13
SR9	29.6	< .01	90	.99	1.27

The above concentrations of chlorophyll a and phosphates could be expected with algal growth processes. Blooms of algae, believed to be the plankton organism Massartia rotundata, have been observed in the South River during the summer months of 1971 and as recently as December 1971.

Abnormally high concentrations of chlorophyll a, total PO_4, and TKN were measured in the upper and the lower Severn River in the vicinity of Annapolis during the 1971 surveys by the MDWR. While the high concentrations were recorded in the upper Severn River stations on July 7, 1971, excessive concentrations were measured in Spa Creek at Annapolis on both the July 7 and the October 13, 1971, sampling surveys. Plankton blooms, identified as Massartia rotundata, were reported in the Severn River during 1971.

The 1967 surveys by the AFO included measurements of the various nutrient fractions. Occasional high concentrations of total dissolved PO_4 with accompanying significant chlorophyll a measurements were reported in the Magothy, West, and Rhode Rivers during the 1967 surveys. Current information is needed in order to identify water quality trends, especially in light of the recent algal blooms reported in these waters.

HEAVY METALS AND PESTICIDES

The MDWR analyzed water samples obtained from the Severn and South Rivers for copper during the 1971 sampling seasons. Concentrations were found to be less than 0.05 mg/l. The detectable limit in the laboratory is oftentimes 0.05 mg/l. Concentrations above this limit could be significant with respect to the ability of shellfish to concentrate heavy metals.

The MDWR did not analyze water samples for pesticides during the 1970 and 1971 sampling surveys, nor has the Annapolis Field Office monitored for pesticides in this study area.

WATER QUALITY TRENDS

Personnel of the MDWR conducted an aerial overflight of the middle portion of the Bay on December 14, 1971, to determine the persistence of algae in the Bay. The Department had received citizen reports of reddish-brown water in many of the tributaries to the Bay. The overflight showed plankton blooms persisting in the Magothy, Severn, South, and West Rivers. Biologists in the Maryland Department of Water Resources have tentatively identified the predominant organism in the bloom as *Massartia rotundata*, a dinoflagellate, which generally constitutes more than 90 percent of the total number of organisms present.

The algal blooms observed last summer (1971) in the South River were also observed during the December 14, 1971, aerial overflight. Algal blooms in the upper South River have been observed by residents in the area during the summer months since 1968.

The extent of the algal blooms in the Bay observed during the aerial overflight is discussed in the summary section of Chapter XI.

F. MIDDLE CHESAPEAKE BAY IN THE VICINITY OF SANDY POINT

The portion of the Chesapeake Bay covered herein includes the middle section of the Bay, from the vicinity of the Patapsco River southward to the Severn River area. Surveys taken by the Annapolis Field Office of EPA between 1968 and 1971 constitute the main basis of the information contained in this chapter. Twenty-two stations on eight transects in the Bay were monitored at regular intervals to ascertain existing water quality conditions. Table IV-7 lists these station locations. The two main purposes of the EPA surveys were: (1) to determine and identify any existing water quality trends in this area and (2) to determine baseline conditions in this area before the introduction of a wastewater treatment plant discharging directly into Bay waters in the vicinity of Sandy Point.

The proposed Sandy Point treatment plant will serve the 56.91 square mile Broad Neck Sewerage Service Area, located between Annapolis and Glen Burnie. This area is now served by individual septic tanks and, occasionally, raw sewage lines discharging into the surrounding water areas (the Magothy and Severn Rivers, and Chesapeake Bay). The proposed treatment plant will serve estimated populations of 70,000 by 1980 and 148,000 by the year 2000.

Construction of the Sandy Point plant, providing secondary treatment of all wastes, will be in two stages: the first stage, to be completed and in operation by late 1972, will have a capacity of 8.8 MGD;

the second stage, to be completed sometime before the year 2000, will have a capacity of 19.0 MGD.

In 1962, the Chesapeake Bay Institute conducted a 20-day continuous dye discharge study to determine the movement and dispersion of an introduced contaminant into the Bay waters off Sandy Point. The dye was released approximately 1,360 yards off the shoreline just north of Sandy Point, near the location of the future sewage outfall from the Sandy Point treatment plant. In this area of the Bay, tidal currents are quite strong: greater than 3 knots on the ebb current and up to 2 knots on the flood current. This causes dye (or waste effluent) to concentrate in a narrow north-south aligned plume offshore Sandy Point. During ebb tide, the plume will extend down the Bay towards the Bay Bridge; during flood tide, the plume will extend up the Bay. Observations of the dye confirmed this, and at no time was the dye plume observed to extend toward the shore at Sandy Point.

The total dissolved and suspended material in secondary treated waste effluent is approximately 100 ppm (parts per million) including 15 ppm inorganic phosphate and 25 ppm inorganic nitrogen. This effluent is considerably less dense than the surrounding Bay water, with an average salinity of 6.97 ppt (parts per thousand) at the surface and 14.70 ppt at a depth of 40 feet. There fore, from a bottom discharge point, the effluent will rise toward the surface, and thus some degree of initial dilution will occur. At the surface, the diluted effluent will then become aligned in the north-south plume described above.

Natural surface concentrations of inorganic phosphate ranged from

.043 to .089 mg/l near the future Sandy Point waste outfall during 1971. The natural surface concentrations of inorganic nitrogen ranged from .019 to .393 mg/l in the same area during 1971. High increases in nutrients (a 213 percent average greater inorganic phosphate density and a 162 percent average greater inorganic nitrogen density) are concentrated in a narrow plume, 100 yards wide and 600 yards long, located 1,200 yards offshore Sandy Point. Approximately 600 yards from shore, the average increases in nutrient densities reduce to 21 percent for inorganic phosphate and 16 percent for inorganic nitrogen.

Detrimental or harmful effects to Bay waters in the vicinity of Sandy Point, due to waste effluent from the future treatment plant, cannot be accurately predicted. High increases in nutrient concentrations will occur only in a relatively small area offshore Sandy Point. Elsewhere, a high degree of dilution, due to the strong tidal currents present, will reduce the relative increase in nutrients to an acceptable level, compared to the concentration of nutrients naturally present. However, the natural concentrations of nutrients are already high and have shown a trend to increase in the last few years. Also, operation of the wastewater treatment plant at the planned ultimate capacity of 19.0 MGD will greatly increase the percentage of nutrients in the effluent. It is not known how much of an increase in nutrients the Bay waters in this area can absorb before harmful effects occur, i.e., hypereutrophic conditions.

The above observations are based solely on the effects of increases in nutrient concentrations. It has been assumed that bacterial levels of the waste effluent will be below the level which would constitute a danger to health. While a sufficient dilution of the effluent nutrients is generally indicated, this may not be the case if high bacterial levels are found in the effluent. High bacterial levels would result in the closing of oyster bars in the area.

The greatest problem affecting general water quality in this portion of Chesapeake Bay is that of increasing nutrient concentrations. Both dissolved oxygen and coliform concentrations in this area are well within the prescribed safe limits (dissolved oxygen concentration greater than 5.0 mg/l and coliform density less than 70 MPN/100 ml). In addition, dissolved oxygen and coliform densities in the Sandy Point area have shown no trends either to increase or to decrease in the past three years. Dissolved oxygen concentrations have generally been between 6.0 and 7.0 mg/l while coliform densities have generally been below 20 MPN/100 ml during this time. The large volume of water present, its great assimilative capacity, and the strong tidal currents in this area are responsible for these conditions.

Nutrient concentrations have, however, greatly increased during the last 3 years. The concentration of nitrate-nitrogen (as N) remained stable between 1968 and 1971, but the concentration of total phosphate (as PO_4) increased nearly 100 percent during the same time. Concentrations of nitrate-nitrogen (as N) at the surface in the Sandy Point area averaged .609 mg/l and .461 mg/l during April and May of 1968, the months of highest concentrations of this nutrient. During

1971, concentrations of nitrate-nitrogen (as N) averaged .640 mg/l and .479 mg/l for the same months. It can be seen that nitrate-nitrogen (as N) concentrations have remained relatively constant between 1968 and 1971. However, the concentration of total phosphate (as PO_4) showed a nearly twofold increase. Concentrations of total phosphate (as PO_4) at the surface in the Sandy Point area averaged .122 mg/l and .104 mg/l during June and July of 1968, the months of highest phosphate (as PO_4) concentrations. In 1971, concentrations of total phosphate (as PO_4) averaged .227 mg/l and .217 mg/l for the same months. This near doubling of phosphate concentrations accounts, in part, for the alarming rise in the chlorophyll _a_ density during this time. Surface concentrations of chlorophyll _a_ averaged between 35.0 and 40.0 µg/l during the summer months of 1968, 1969, and 1970. However, in June 1971, chlorophyll _a_ concentrations averaged 153 µg/l, a nearly fourfold increase. In addition, isolated algae blooms have been observed in this area, as indicated by abnormally high chlorophyll _a_ concentrations. On June 14, 1971, a chlorophyll _a_ density of 682.5 µg/l was measured at Station 1, Transect G. This was attributed to a high level of nutrients, in particular phosphorus (.662 mg/l), at that time.

Average concentrations of nitrate-nitrogen (as N) in the Sandy Point area are generally greatest in late winter and early spring, and least during late summer. From a maximum average concentration in February 1970 of 1.055 mg/l, the average concentration of nitrate-nitrogen (as N) steadily decreased to a minimum of .007 mg/l in August

1970, a decrease of 1.048 mg/l in a 6-month period. The average concentration of inorganic phosphorus, however, remained constant during this period. The decrease in the nitrate-nitrogen (as N) concentration is partly the result of a decrease in the flow rate of the Susquehanna River between late winter and summer. The concentration of nitrate-nitrogen in the Susquehanna River is flow-dependent: a high flow rate will tend to generate a "flushing action" in the river causing large loadings of nitrate-nitrogen to enter the Bay. In February 1970, when a high concentration of nitrate-nitrogen was measured in the Sandy Point area, the flow rate of the Susquehanna River was 64,233 cfs at the Conowingo Dam. The flow rate of the Susquehanna River decreased to 17,850 cfs in August 1970, when a low concentration of nitrate-nitrogen was noted. In addition, utilization of nutrients by plankton accounts for part of the decrease in the concentration of nitrate-nitrogen during spring and summer.

Tables IV-8 and IV-9 summarize current nutrient and chlorophyll _a_ concentrations at the surface in the Sandy Point area during the spring months of highest concentrations in 1971.

Table IV-7

Transect	Station	
AA	1	Buoy RBC
	2	Buoy R 28 C
A	1	Off tower at Windmill Point
	2	Red Flasher "10C"
	3	Black and White buoy "13B"
B	1	Red Flasher "2" Magothy River
	2	Red Nun "4C"
	3	Black Flasher, bell "1"
C	1	Off house at Tydings-on-the-Bay
	2	Red Flasher, bell "2C"
	3	Edge of dumping grounds
D	1	Off Sandy Point
	2	Red Flasher, gong "8"
	3	South edge of dumping grounds
E	1	Off Hacketts Point
	2	Red Flasher, gong "4"
	3	Off Matapeake ferry slip
F	1	Tolly's Point, Buoy "33"
	2	Mid-Bay
	3	Brickhouse Bar, Buoy "20B"
G	1	Off Bembe Beach
	2	Bay Buoy (bell)

Table IV-8

April 1971

Station	NH_3-N mg/l	NO_2+NO_3-N mg/l	Inorganic P mg/l	Chlorophyll a µg/l	Organic N mg/l	Organic P mg/l
AA 1	.109	.661	.041	24.0	.254	.062
2	.471	.719	.047	51.8	.264	.137
A 1	.116	.661	.052	1.5	-	.027
2	.113	.669	.055	5.3	-	.025
3	.162	.621	.066	12.8	-	.051
B 1	.098	.705	.055	17.3	.439	.039
2	.127	.698	.054	7.5	-	.006
3	.173	.650	.038	12.0	.016	.035
C 1	.140	.664	.056	17.3	-	.043
2	.169	.693	.051	13.5	-	.054
3	.185	.641	.043	13.5	-	.032
D 1	.044	.571	.037	38.3	.206	.036
2	.069	.615	.045	19.5	.067	.023
3	.095	.573	.045	1.5	.215	.024
E 1	.055	.631	.044	20.3	.149	.023
2	.093	.619	.053	15.0	-	.027
3	.156	.552	.041	21.8	.563	.021
F 1	.089	.634	.039	23.3	.728	.021
2	.116	.622	.036	11.3	.058	.032
3	.124	.570	.041	38.3	.307	.056
G 1	.105	.657	.042	3.0	.183	.022
2	.060	.666	.046	18.8	.734	.030

Table IV-9

June 1971

Station	NH_3-N mg/l	NO_2+NO_3-N mg/l	Inorganic P mg/l	Chlorophyll a μg/l	Organic N mg/l	Organic P mg/l
AA 1	.141	.175	.032	77.3	.850	.133
2	.773	.146	.046	76.5	-	.151
A 1	.484	.188	.065	233.3	1.574	.324
2	.070	.189	.064	191.3	1.549	.274
3	.057	.106	.037	45.8	.526	.082
B 1	.036	.088	.049	99.8	1.114	.124
2	.225	.082	.068	-	1.644	.240
3	.186	.096	.058	156.8	1.108	.123
C 1	.093	.086	.069	180.8	2.389	.248
2	.230	.060	.072	234.0	2.100	.185
3	.145	.096	.042	150.0	1.731	.199
D 1	.001	.130	.048	146.3	.725	.141
2	.002	.089	.050	130.5	.762	.129
3	.001	.077	.051	105.0	.536	.097
E 1	.002	.010	.053	50.3	.437	.056
2	.001	.091	.074	198.0	1.172	.162
3	.003	.088	.041	27.8	.027	.036
F 1	.002	.078	.059	86.3	.649	.121
2	.004	.098	.063	131.3	.790	.128
3	.002	.010	.063	96.0	.581	.108
G 1	.003	.031	.143	682.5	4.022	.519
2	.001	.010	.059	132.0	.960	.129

G. MIDDLE EASTERN SHORE AREA

1. CHESTER RIVER AREA

The Chester is the largest of the rivers in the upper section of the Eastern Shore. The river forms the boundary between Kent and Queen Annes Counties as it flows from its headwaters in Delaware to the Bay. The Chester and its tributaries serve as the drainage system for a 360 square mile area which has a population of slightly less than 30,000.

Chestertown is the largest population center and has most of the significant waste discharges in the basin. The discharges are from the sewage treatment plant and the Vita Foods corporation plant to Radcliffe Creek and from the Campbell Soup and Tenneco Chemicals plants to Morgan Neck Creek.

Two other sewage treatment plants are located in the Chester basin. The Centreville plant dischages to the Corsica River and Millington discharges to the Chester River.

Three areas in the Chester basin are classified as Group A waters and should be suitable for shellfish harvesting, water contact recreation and propagation of fish, other aquatic life and wildlife. These areas are: (1) Chester River and estuarine portions of creeks, coves and tributaries (excluding Piney Creek, Winchester Creek and Corsica River) from the mouth at the Chesapeake Bay to U. S. Route 213 Bridge, (2) Piney Creek and estuarine portions of coves and tributaries from the mouth at the Chester River to the U. S. 50-301 crossing, and (3) Corsica River and estuarine portions of tributaries from the mouth at the Chester River to Earle Cove.

Three more areas are classified as Group C waters and should be suitable for water contact recreation and propagation of fish, other aquatic life and wildlife. These areas are: (1) Chester River and creeks, coves and tributaries from the U. S. Route 213 Bridge to the Maryland Route 313 Bridge, (2) Piney Creek and tributaries from U. S. Route 50-301 crossing to its headwaters, (3) Corsica River and tributaries from Earle Cove and from estuarine portions to its headwaters. The last two classification areas are the Chester River and triburaries from Maryland Route 313 Bridge to the Delaware State Line and headwaters classified as Group B, to be used for public or municipal water supply, water contact recreation and propagation of fish, other aquatic life and wildlife; and all of Winchester Creek and its tributaries classified as Group C water to be used for water contact recreation and industrial water supply.

Only two water quality surveys were available for the Chester River basin. One study conducted by the Annapolis Field Office (AFO) in 1970 consisted of four sets of samples at 9 stations located between the mouth of the Chester and Crumpton, Maryland. The second investigation was done by the Maryland Department of Water Resources (MDWR) and was apparently designed to study the effect of municipal and industrial effluents on the Chester River, Radcliffe Creek area. Station location lists for these studies appear in this report.

Another study currently in progress was instituted in November, 1971 as a joint effort of the Westinghouse Electric Corporation (Ocean Research Laboratory and Ocean Research and Engineering Center) and the Maryland Department of Natural Resources. This is intended to be a comprehensive regional study which will investigate the transport characteristics for pollutants as related to biological contamination in the basin.

BACTERIOLOGICAL CONDITIONS

The only bacteriological data available is in the area around Chestertown. The coliform densities in Radcliffe Creek are much greater than the densities found in the Chestertown sewage treatment lagoon effluents. Vita Foods Corporation also has a plant which discharges to Radcliffe Creek and may contribute to the coliform problem.

Three areas in the Chester Basin have been closed to direct shellfish harvesting due to bacterial pollution. The areas closed and their locations are as follows:

Area	Number of Acres Closed	Description of the Area
Chester River	108	All waters upstream from a line between Ashland Landing and Quaker Neck Landing
Corsica River	10	All waters upstream from a line between Ship Point and Wash Point
Queenstown Creek	-	entire creek

DISSOLVED OXYGEN CONDITIONS

Samples from two stations in the MDWR Radcliffe Creek area study showed DO less than the 4.0 mg/l allowable minimum. These samples were taken in July when the water temperature was around 23° C. Samples taken at these same two stations in August at about the same time of day when water temperature was 24° to 26° C had DO's of 7.7 and 7.4 mg/l. Due to the seemingly inconsistent data, no conclusive statement can be made as to whether or not there is a DO problem.

In the AFO study no violations of the 4.0 mg/l minimum were found in the surface or 20-foot depth samples but two were found at 40-foot depths in September when water temperatures were 25° C. No sampling was done in July and August during this study and low DO levels would be most likely to occur in these months.

NUTRIENTS

The AFO study was designed primarily as an investigation of nutrient-salinity relationships in the estuary. Unfortunately, sampling was suspended during the months of July and August when algal blooms are most likely to occur due to high nutrient loadings. In the September 4, 1970 sampling, the two uppermost stations at Possum Point and Crumpton had chlorophyll _a_ concentrations of 52.5 and 111.0 µg/l respectively. This would indicate that excessive bloom level algal problems may have existed during the summer. No nutrient parameters were run on the September samples, thus precluding the establishment of nutrient-phytoplankton correlations.

OTHER

During the AFO survey in 1970, pH values ranged between 6.0 and 7.6 and were within the prescribed limits set in the water quality standards. The samples taken in the MDWR investigation had significantly higher pH values (ranging from 6.5 to 8.7) and on May 18, 1971 3 samples taken in Radcliffe Creek exceeded the upper limit of the pH standard.

The Chester River cooperative study, mentioned previously, will focus on pesticides and polychlorinated biphenyls in the environment and will also produce some data on heavy metals.

WATER QUALITY TRENDS

In response to a number of telephone calls in December, 1971, the MDWR conducted an investigation of a reddish brown discoloration of water in the Chesapeake Bay tributaries. Some samples were taken from the western shore rivers and the discoloration was attributed to the presence of a dinoflagellate tentatively identified as Massartia Rotundata. This sampling led to aerial surveillance which disclosed similar discoloration in a number of areas north of the Patuxent. The Chester was the most severely affected river on the Eastern Shore but was not as heavily discolored as the areas on the western side of the Bay. Discoloration was recorded as far up the River as Cedar Point and although no sampling was done in the Chester, the discoloration was similar enough to assume that the plankton were probably the same as those found in samples on the western shore.

STATE OF MARYLAND

DEPARTMENT OF WATER RESOURCES

WATER QUALITY INVESTIGATION DIVISION

Chester River - Radcliffe & Morgan Creeks

Kent County

1971

Station Location List

Table IV-10

STATION NUMBER	LOCATION	NEAREST TOWN
CH40 (S, B)	Chester River. Red Num Buoy #40 near Chester River Country Club Dock	Chestertown
CH213 (S, B)	Chester River. Chestertown Bridge	Chestertown
RC1	Radcliffe Creek. At mouth-Flashing Light "41"	Chestertown
RC2	Radcliffe Creek. 50 yards from old sewage treatment plant, near old effluent line	Chestertown
RC3	Chester River. Radcliffe Creek-upstream of sewage treatment plant effluent	Chestertown
RC4	Chester River. Radcliffe Creek-Quaker Neck Road Bridge	Chestertown
E	Chestertown Lagoon effluent	Chestertown

NOTE: S= Surface sample
B= Bottom sample

Anapolis Field Office - EPA

Chester River

Station Location List

Table IV-11

Station Number	Location	Latitude	Longitude
1	Love Point - Bell Buoy	39° 04' 00"	76° 16' 24"
2	Long Point - Buoy 9	38° 59' 36"	76° 12' 48"
3	Boxes Point - Buoy 14	39° 02' 64"	76° 12' 06"
4	Nichols Run - Buoy 16	39° 05' 12"	76° 09' 54"
5	Corsica River - Buoy 4	39° 04' 54"	76° 06' 48"
6	Milton Point - Buoy 28	39° 08' 18"	76° 04' 24"
7	Chestertown Beacon	39° 12' 01"	76° 04' 07"
8	Possum Point - Buoy 44	39° 14' 27"	76° 00' 32"
9	Crumpton - Buoy 58	39° 14' 36"	76° 56' 41"

2. EASTERN BAY AREA

The Eastern Bay Area, a small drainage area (approximately 120 square miles) with a population of 11,500, consists of the Eastern Bay, Wye and Miles Rivers and a number of smaller bays and creeks. Most of the waters in this basin are estuarine, much of which are closed to shellfish harvesting.

According to the latest Maryland Department of Water Resources status report (November 1, 1970), the only waste discharges in the area are from S. E. W. Friel Company in Wye Mills, Harrison and Jarboe in St. Michaels and the St. Michael's sewage treatment plant. This report also stated that legal action had been taken against Roger Johnson for sediment pollution. Most of the sanitary waste in this basin is treated ineffectively in septic tank systems. A secondary level sewage treatment plant has been scheduled for construction at Grasonville to reduce septic tank leaching.

The waters of the Eastern Bay drainage area have been given two sets of use classification by the Maryland Department of Water Resources. Eastern Bay and estuarine portions of tributaries, coves and creeks (excluding St. Michaels Harbor and Wye East River) and the Wye East River from the mouth to a point 2 1/2 miles above Wye Landing are classified as group A waters to be used for shellfish harvesting, water contact recreation, and propagation of fish, other aquatic life and wildlife. All of the non-estuarine portions of Eastern Bay, St. Michaels Harbor and the Wye East River from a point 2 1/2 miles above Wye Landing to their headwaters are group C waters suitable for water contact recreation and propagation of fish, other aquatic life and wildlife.

The only parts of this area which have been adequately studied are Miles River and St. Michaels Harbor. Monthly sampling was conducted by the Department of Water Resources from April through August in both 1970 and 1971. Stations for these surveys were located in St. Michaels Harbor, Oak Creek and near the entrances to both the creek and the harbor. A station location list for these studies is included in this section.

BACTERIOLOGICAL CONDITIONS

Samples taken at the two stations located in the section of the Miles River open for shellfish harvesting showed most coliform densities ranging from about 3 to 10 mg/l with a few isolated samples having higher counts. In general, the results of the surveys support the suitability of the water quality for shellfish harvesting.

Likewise, the sampling done in Oak Creek and St. Michaels Harbor supports the conclusion that these waters are unfit for shellfish harvesting. An example of coliform densities in this area is given in table IV-12.

Table IV-12

Coliform Densities in Oak Creek and St. Michael's Harbor

	June 28, 1971		July 19, 1971		August 16,1971	
	Coliform MPN/100 ml	E. Coli MPN/100 ml	Coliform MPN/100 ml	E. Coli MPN/100 ml	Coliform MPN/100 ml	E. Coli MPN/100 ml
A	230	93	230	93	430	230
B	230	93	430	230	430	150
C	93	23	93	43	930	93
E	430	230	2300	430	2300	930
F	930	93	930	210	430	93
G	230	93	930	430	93	93

Station Locations

A, B, C - Oak Creek Transects E, F, G - St. Michaels Harbor Transects

The bacteria pollution in the Eastern Bay area is due primarily to septic tank failure and subsequent leaching. Most of the shellfish bed closings are in shoreline areas or narrow sections of the creeks and rivers. Following is a list of areas where shellfish harvesting is presently prohibited.

Table IV-13

Name of Area	Description of Closed Portion
Warehouse Creek	All
Thompson Creek	All
Cox Creek	All waters above confluence with Thompson Creek

Table IV-13 (Cont.)

Name of Area	Description of Closed Portion
Leeds Creek	All
St. Michaels Harbor	All
Spencer Creek	All
Little Neck Creek	All
Newcomb Creek-Oak Creek	All
Miles River	All above Red Buoy #10
Wye East River	All above line between Dividing Creek and Quarter Cove including tributaries
Kent Island Narrows	All shoreline area from Wells Cove to Long Point

DISSOLVED OXYGEN CONDITIONS

The section of the drainage basin sampled appeared to be relatively free from signs of oxygen depletion. Only a few samples taken in and near St. Michaels Harbor had dissolved oxygen levels below 4.0 mg/l. These oxygen depressions were probably due to discharges from the sewage treatment plant at St. Michaels coupled with poor transport characteristics in the Harbor.

NUTRIENTS

Sampling done in July and August of 1970 and 1971 indicates that an algal problem* did exist in the Oak Creek and St. Michaels Harbor areas. Many of the chlorophyll concentrations found in 1970 were between 50 and 100 μg/l with some values above 100 μg/l. In 1971, the severity of the algal problem (in terms of chlorophyll a concentration) in St. Michaels Harbor was significantly decreased from 1970 (69 μg/l was the highest chlorophyll value recorded) and no chlorophyll concentrations above 50 μg/l were recorded in Oak Creek.

There are not sufficient data to develop significant nutrient-phytoplankton relationships. Total phosphate concentrations associated with the algal blooms ranged from 0.2 to 2.5 mg/l and the nitrite plus nitrate concentrations were always less than 0.01 mg/l. No other nitrogen fractions were reported.

*Algal problem measured in terms of chlorophyll a concentrations with 50 μg/l as the max before occurence of excessive bloom conditions.

GENERAL

In viewing the nutrient-algal situation it appears that there may have been an improvement in water quality conditions but that the causes are not evident from the available data. More extensive work would be necessary to develop more definite relationships.

Investigative activity in the Eastern Bay Area was concentrated in only a small section of the Miles River. More work should be undertaken in the Eastern Bay, Wye River and the other bays and tributaries so that a better assessment of the overall basin conditions can be developed.

STATE OF MARYLAND

DEPARTMENT OF WATER RESOURCES

WATER QUALITY INVESTIGATION DIVISION

Miles River - Oak Creek Survey
Talbot County
August 3, 1970

Station Location List

Table IV-14

Station Number	Location
A1	North Shore, 1050 nautical yards above Maryland Route 33 bridge at mouth of Oak Creek.
A2	Mid-stream, 1050 nautical yards above Maryland Route 33 bridge at mouth of Oak Creek.
A3	South Shore, 1050 nautical yards above Maryland Route 33 bridge at mouth of Oak Creek.
B1	East Shore, 550 nautical yards above Maryland Route 33 bridge at mouth of Oak Creek.
B2	Mid-stream, 550 nautical yards above Maryland Route 33 bridge at mouth of Oak Creek.
B3	West Shore, 550 nautical yards above Maryland Route 33 bridge at mouth of Oak Creek.
C1	East Shore, 250 nautical yards above Maryland Route 33 bridge at mouth of Oak Creek.
C2	Mid-stream, 250 nautical yards above Maryland Route 33 bridge at mouth of Oak Creek.
C3	West Shore, 250 nautical yards above Maryland Route 33 bridge at mouth of Oak Creek.
7	Miles River, Flashing Light "7" off mouth of Oak Creek.

Table IV-14 (Cont.)

Station Number	Location
N4	Miles River, Nun Buoy "4" off St. Michaels Harbor.
E1	Southeast Shore, upper end of St. Michaels Harbor, 450 nautical yards from Flashing Light at mouth.
E2	Mid-harbor, upper end of St. Michaels Harbor, 450 nautical yards from flashing Light at mouth.
E3	Northwest Shore, upper end of St. Michaels Harbor, 450 nautical yards from Flashing Light at mouth.
F1	South Shore, middle St. Michaels Harbor, 425 nautical yards from Flahing Light at mouth.
F2	Mid-harbor, middle St. Michaels Harbor, 250 nautical yards from Flashing Light at mouth.
F3	North Shore, middle St. Michaels Harbor, 175 nautical yards from Flashing Light at mouth.
G1	Southeast Shore, mouth of St. Michaels Harbor, 300 nautical yards from Flashing Light at mouth.
G2	Mid-harbor, mouth of St. Michaels Harbor, 75 nautical yards from Flashing Light at mouth.
G3	Northwest Shore- mouth of St. Michaels Harbor, 250 nautical yards from Flashing Light at mouth.

3. CHOPTANK RIVER AREA

The Choptank is the largest river on the Eastern Shore draining portions of Kent County in Delaware, and Talbot, Caroline and Dorchester Counties in Maryland. The drainage area of the Choptank Basin is 795 square miles and has a population of 55,000 with two population centers at Cambridge (14,000) and Easton (11,000). The tidal portion of the river extends past Denton to a point slightly downstream from Greensboro, Maryland.

The two largest wastewater discharges in the basin are 3.8 MGD from a heavily overloaded primary treatment plant at Cambridge and a 2.5 MGD intermediate plant at Easton.

Other municipal treatment plants in the drainage area are primary plants at East New Market and Trappe, an intermediate plant at Oxford and secondary plants at Ridgely, Preston, Denton, Cambridge Sanitary District Number 1 and Dorchester County Sanitary District Number 1. The Denton plant provides no effluent chlorination and discharges directly into the Choptank. The other facilities discharge to tributaries of the Choptank.

The town of Greensboro has a population of 1300 and discharges raw sewage to the Choptank. The town of Secretary (population 600) is presently served by septic tanks.

There are a large number of industrial discharges to the Choptank basin many of which were reported as not being in compliance with the laws and regulations in the November 1, 1970 MDWR water quality status report. Detailed information about these discharges if available in the industrial inventory which is discussed in the Data Inventories section.

The estuarine portion of the Choptank River and its tributaries form a complicated network of water use classifications consisting of 11 zones employing four different sets of water use categories. Five of these zones are listed as Group A waters protected for shellfish harvesting, water contact recreation, and propagation of fish, other aquatic life and wildlife. These are:

1. The Choptank and estuarine portions of tributaries in Talbot County from the mouth at the Chesapeake Bay to a line extending from Bow Knee Point to Wright Wharf with the exception of Black Walnut Cove, San Domingo Creek and Tred Avon River, which are listed separately,
2. Black Walnut Cove from the mouth at the Chesapeake Bay to a line drawn from Battery Point to Bar Neck Point,
3. San Domingo Creek and estuarine portions of its tributaries from the mouth at Broad Creek to the mouth of the cove to St. Michaels and to non-estuarine boundaries,
4. Tred Avon River and estuarine portions of tributaries other than Town Creek from the mouth at the Choptank River to Easton Point and to non-estuarine portions of tributaries, and
5. The Choptank River, Lecompte Bay and all coves in Dorchester County portion from the mouth to a line drawn between Bow Knee Point and Wrights Wharf Road.

Another set of four zones are classified as Group C waters and can be used for water contact recreation and propagation of fish, other aquatic life, and wildlife. These zones are:

1. Black Walnut Cove from a line drawn between Battery Point and Bar Neck Point to all headwaters.
2. Cove of San Domingo Creek leading to St. Michaels from its mouth to all headwaters.
3. Tred Avon River and all portions of tributaries from Easton Point to all headwaters, and
4. Town Creek and all tributaries from the mouth at Tred Avon River to all headwaters.

The last two classifications in the Choptank Estuary are for Group C waters but with different water use specifications. All of the creeks and tributaries in Dorchester County should be acceptable for water contact recreation, propagation of fish, other aquatic life and wildlife and agricultural water supply. The Choptank River and all tributaries from a line extending between Bow Knee Point and Wright Wharf to the Delaware line or to all Maryland Headwaters should be acceptable for the three preceding uses and for industrial water supply.

A significant amount of water quality data has recently been gathered in the Choptank basin. The Maryland Department of Water Resources conducted studies in the upper Choptank in the spring, summer, and fall of both 1970 and 1971. The Annapolis Field Office (AFO), EPA, sampled on July 13-15, 1971, and again on August 5, 1971, as part of a survey studying the major rivers on the Eastern Shore. Another study was conducted cooperatively by AFO and the National Marine Fisheries

Services (NMFS) Laboratory in Oxford, Maryland, in August, September, and October of 1971. Station location lists for these studies are included at the end of this section.

BACTERIOLOGICAL CONDITIONS

The bacteriological standards imposed on the waters of the Choptank as a result of classifications in water use Groups A and C require a maximum coliform density of 70 MPN/100 ml for Group A and a maximum fecal coliform density of 240 MPN/100 ml for Group C. The number of standards violations, particularly in Group A waters, is reflected in the shellfish bed closings shown in the following table:

Table IV-15

Shellfish Bed Closings in the Choptank Basin

Name of Area	Acres Closed	Description of Area Closed
Choptank River	4962	All waters upstream from a line between Howell Pt. and Jenkins Creek.
San Domingo Creek	23	Both "branches" from point which is north of red day beacon "14"
Town Creek	4	Entire creek from mouth to all headwaters
Tred Avon River	149	All waters of Tred Avon and tributaries upstream from a line from Long Pt. to an unnamed cove on the opposite shore.
La Trappe Creek	58	Entire creek from mouth to all headwaters
Tilghman Island	234	Area surrounding Tilghman Island marked off by closure line buoys - includes Front Creek, Back Creek, Knapp Narrow, Pawpaw and Blackwalnut Coves and Dogwood Harbor.

No bacterial analysis was done on samples from the NMFS-AFO study and the MDWR studies were in the upper Choptank, above waters designated as Group A. The only available bacteriological data in Group A waters are from the AFO-1971 Eastern Shore Survey.

Data from both AFO and MDWR studies showed many exceeding the 240MPN/100 ml fecal coliform standard between Choptank and Greensboro where the water is classified as Group C. Excessive bacterial counts were observed consistently at stations near Greensboro and Denton. These results are not unexpected since waste from Greensboro receives no treatment at all and the effluent from the secondary plant at Denton is not chlorinated.

Much of the Group A water below Bow Knee Point is closed to the intended use of shellfish harvesting (Table IV-15). Examination of the bacterial data from the AFO survey corroborates the validity of the closings (Table IV-16). Stations 8, 9, 10, and 11 each show violations in at least 2 out of 3 samples. These stations all lie in the area between Bow Knee Point and Howell Point where the shellfish beds are presently closed. Samples taken at stations 12 (uppermost station in the section of the Choptank open to shellfish harvesting), 13 and 14 (located in the lower Tred Avon River which is currently open) indicated that bacteriological standards were being met and verified the acceptability of the area for its intended use.

Table IV-16

TOTAL COLIFORM DENSITIES AT STATIONS IN CHOPTANK WATERS PROTECTED FOR SHELLFISH HARVESTING (MAXIMUM ALLOWABLE COLIFORM DENSITY 70 MPN/100 ml)

Station Number	7/13/71 MPN/100 ml	7/14/71 MPN/100 ml	7/15/71 MPN/100 ml
AFO 8	330	50	490
AFO 9	80	80	20
AFO 10	330	130	330
AFO 11	790	80	No sample taken
AFO 12	60	20	"
AFO 13	20	20	"
AFO 14	20	20	"

DISSOLVED OXYGEN CONDITIONS

Dissolved oxygen levels in the Choptank estuary are quite high with many of the values from fall and spring samplings reported as being close to saturation. As would be expected, the DO levels in the summer are lower than in spring and fall but do remain well above the required 5.0 mg/l standard. Samples taken by MDWR on July 6 and 7, 1970 showed DO ranges from 5.5 to 8.2 mg/l and 5.4 to 9.8 mg/l respectively. On July 13, 1971 sampling was done independently by both AFO and MDWR. The following table lists the observed DO values, arranging the stations approximately according to the river profile.

Table IV-17

DISSOLVED OXYGEN VALUES IN THE CHOPTANK RIVER ON JULY 13, 1971

Station Number	D. O. Value (mg/l)
AFO 1	8.5
MDWR 11	7.3
AFO 2	6.6
AFO 3	8.0
MDWR 9A	7.1
MDWR 10	7.1
AFO 4	2.7
MDWR 9	7.1
MDWR 6	6.5
AFO 5	7.2
AFO 5A	7.6
MDWR 7	12.6
MDWR 5	3.7
AFO 6	8.9
MDWR 4	6.7
MDWR 3	7.4
AFO 7	7.5
MDWR 1	7.3
AFO 8	6.9
AFO 9	6.5
AFO 10	6.8
AFO 11	7.2

Table IV-17 (Cont.)

Station Number	D. O. Value (mg/l)
AFO 12	10.3
AFO 13	6.8
AFO 14	6.3

NUTRIENTS

Data from the AFO survey in July and August of 1971 indicate nuisance level algal blooms (measured as chlorophyll a concentrations) in the upper reaches of the Choptank, above the confluence with Hunting Creek. The blooms seem to be associated with total Kjeldahl nitrogen (TKN as N) concentrations above 0.9 mg/l and total phosphorus (TP as PO_4) concentrations above 0.3 mg/l (see table IV-18). The MDWR data also show high phosphorus concentrations in the same areas during the July sampling runs with only a few high concentrations occurring in the spring and fall studies.

The chlorophyll concentrations indicate that the most extensive algal blooms occurred in the Denton area probably as a result of enrichment from sewage and industrial waste. Samples from station 7 (below the Dover Bridge) consistently show TP and TKN concentrations higher than those at station 6 which is upstream from the bridge. This is due to the effluent from the Easton sewage lagoons which empty into an unnamed tributary 0.8 miles southwest of Dover Bridge. The nutrient increases are not inordinate and do not seem to influence the algae situation significantly.

Table IV-18

NUTRIENT - CHLOROPHYLL* RELATIONSHIPS IN CHOPTANK RIVER

Station	August 5, 1971			July 14, 1971		
	Chlorophyll *a* µg/l	TP mg/l	TKN mg/l	Chlorophyll *a* µg/l	TP mg/l	TKN mg/l
AFO 1	103	.510	1.49	150	.471	1.93
AFO 2	73	.519	1.68	171	.450	1.45
AFO 3	80	.373	1.33	121	.383	1.45
AFO 4	48	.361	.92	105	.326	1.54
AFO 5	28	.381	1.02	80	.310	1.58
AFO 5A	30	.410	.96	97	.313	1.13
AFO 6	28	.325	.76	73	.316	.95
AFO 7	22	.433	1.02	66	.333	1.34
AFO 8	33	.340	.56	35	.259	.87
AFO 9	14	.242	.40	17	.165	.66
AFO 10	38	.336	.94	15	.149	.52
AFO 11	17	.204	.41	48	.214	.66
AFO 12	10	.165	.75	30	.192	.92
AFO 13	13.5	.142	.33	16	.117	.54
AFO 14	11.3	.189	.52	13	.132	.92

*Chlorophyll *a* concentrations greater than 50 µg/l indicate nuisance level algal blooms.

METALS

Metals analyses were run on three of the sets of samples taken in 1971. Samples taken on July 13, 1971 during the AFO Eastern Shore survey were analyzed for zinc, lead, mercury, copper, chromium and cadmium. Samples taken on August 2 and August 17, 1971 during the AFO-NMFS cooperative study were analyzed for zinc, lead, cadmium, chromium and copper.

Due to equipment sensitivity problems, the copper, chromium and cadmium concentrations in the AFO samples were reported only as being less than 0.1 mg/l and the lead concentrations as being less than 0.5 mg/l. The zinc and mercury concentrations in these samples ranged from less than 0.005 mg/l to 0.014 mg/l and from less than 0/0005 μg/l to 0.0020 μg/l, respectively.

Almost all of the cadmium and chromium concentrations in the NMFS-AFO cooperative samples were reported at the lower detection limit (0.001 mg/l). Many of the lead, zinc and copper values were also reported as 0.001 mg/l. concentrations of lead, zinc and copper in the NMFS-AFO samples are shown in the accompanying tables.

In general, the waters of the Choptank are relatively free from contamination by heavy metals. Zinc concentrations significantly above the fish toxicity level of 0.15 mg/l were observed at stations N1, N2, N5, and N6 but only on one of the two days on which the sampling was done. The lead concentrations fall mostly at the lower detection limit (0.001 mg/l) with only 5 samples showing concentrations close to or in the fisn toxicity range of 0.1 - 0.2 mg/l. These isolated instances of high metals concentrations are not sufficient to indicate a metals problem.

Table IV-19

CHOPTANK RIVER

Metal Concentrations for NMFS-AFO Samples Taken August 2, 1971

Station	Depth (ft)	Zinc mg/l	Lead mg/l	Copper mg/l
N 1	1	.016	.156	.025
N 1	16	.299	.001	.050
N 2	1	.245	.001	.050
N 2	9	.245	.001	.050
N 3	1	.001	.001	.001
N 3	29	.160	.001	.050
N 4	1	.048	.001	.001
N 4	58	.140	.001	.001
N 5	1	.001	.001	.001
N 5	13	.129	.001	.001
N 6	1	.052	.078	.001
N 6	26	.106	.001	.050
N 7	1	.001	.001	.001
N 7	13	.158	.001	.050
N 8	1	.018	.078	.025
N 8	13	.074	.001	.050
N 9	1	.021	.001	.001
N 9	49	.066	.156	.025
N 10	1	.036	.001	.001
N 10	13	.093	.001	.025
Range		.001 - .299	.001 - .156	.001 - .050

Table IV-20

CHOPTANK RIVER

Metal Concentrations for NMFS-AFO Samples Taken August 17, 1971

Station	Depth (ft)	Zinc mg/l	Lead mg/l	Copper mg/l
N 1	1	.062	.001	.001
N 1	20	.026	.001	.001
N 2	1	.021	.001	.001
N 2	5	.018	.001	.001
N 3	1	.015	.001	.001
N 3	26	.007	.001	.001
N 4	1	.015	.001	.001
N 4	49	.016	.001	.001
N 5	1	.199	.001	.001
N 5	13	.120	.001	.001
N 6	1	.173	.001	.001
N 6	23	.092	.150	.001
N 7	1	.069	.001	.001
N 7	33	.130	.001	.001
N 8	1	.139	.001	.001
N 8	13	.066	.001	.001
N 10	1	.101	.104	.001
	Range	.007 - .199	.001 - .150	.001

Table IV-21

ANNAPOLIS FIELD OFFICE STATIONS

CHOPTANK RIVER

Station Number	Location
AFO 0	Headwaters of Choptank
AFO 1	Denton, Power Towers
AFO 2	Buoy 79
AFO 3	Buoy 70
AFO 4	Buoy 66
AFO 5	Mouth of Tuchahoe Creek
AFO 5A	Fixed Bridge, Tuckahoe Creek
AFO 6	Buoy 60
AFO 7	Buoy 55
AFO 8	Buoy 41
AFO 9	Buoy 36
AFO 10	Buoy 30
AFO 11	Buoy 24
AFO 12	Buoy 19
AFO 13	Buoy 11M
AFO 14	Channel, Tred Avon River, Oxford, Maryland

Determinations: Temperature,*pH,* Total Phosphate, Inorganic Phosphorous, Total Kjeldahl Nitrogen, Zinc, Nitrite + Nitrate, Ammonia, DO, Total Organic Carbon, Lead, Chlorophyll, Mercury, Coliform, Fecal Coliform, Copper, Chromium, Cadmium.

*Field Determinations

Table IV-22

NATIONAL MARINE FISHERIES LABORATORY STATIONS

CHOPTANK RIVER

Station Number	Location
N 1	Denton Bridge
N 2	Fowling Creek
N 3	Tuckahoe Creek at Bridge
N 4	Hunting Creek
N 5	Warwick River
N 6	Cambridge
N 7	Howell Point
N 8	Benoni Light
N 9	Cooks Point
N 10	Double Mills Point

Determinations: Inorganic Phosphorous, Nitrite & Nitrate, Ammonia, Total Organic Carbon, Zinc, Lead, Cadmium, Chromium and Copper.

Table IV-23

STATE OF MARYLAND

WATER QUALITY INVESTIGATION DIVISION STATIONS

Choptank River

1970

Station Location List

STATION NUMBER	LOCATION
MDWR 1	Bridge at mouth of Hunting Creek
MDWR 2	Bridge on Hunting Creek above Linchester Pond
MDWR EE1	Unnamed tributary receiving effluent from Easton sewage lagoons, 0.8 mile southwest of Dover Bridge
MDWR 3	Pier at boat basin in Choptank
MDWR 4 (S, B)	Dover Bridge on Maryland Route 331
MDWR 5 (S, B)	Choptank River at Ganey Wharf
MDWR 6 (S, B)	Tuckahoe Creek at mouth
MDWR 7	Tuckahoe Creek at bridge in Hillsboro
MDWR 8	Tuckahoe Creek at bridge on Maryland Route 404
MDWR 9 (S, B)	Choptank River below mouth of Fowling Creek
MDWR 9A (S, B)	Downstream of Denton lagoon effluent
MDWR 10 (S, B)	Choptank River at black day beacon, 1 mile downstream from Denton

Table IV-23 (Cont.)

STATION NUMBER	LOCATION
MDWR 11 (S, B)	Choptank River at Maryland Route 404 bridge in Denton
MDWR 12 (S, B)	Choptank River at railroad bridge upstream from Denton
MDWR 13	Bridge on River Road over Chicken Branch tributary just south of Brick Wall Landing
MDWR 14	Choptank River at Brick Wall Landing
MDWR 15	Forge Branch at bridge on Maryland Route 480
MDWR 16	Choptank River at launching ramp downstream from Greensboro
MDWR 17	Choptank River at bridge on Maryland Route 313 just north of Greensboro
MDWR 18	Oldtown Branch at bridge on Maryland Route 313
MDWR 19	Choptank River at bridge on Maryland Route 287 east of Goldsboro

NOTE: S = Surface Sample
B= Bottom Sample
Stations not designated S or B are Surface

Determinations: *DO, BOD, Turbidity, Color, Suspended Solids, Dissolved Solids, Total Solids, *Temperature, *pH, *Salinity, Chlorides, *Conductivity (non-tidal stations), Coliforms and *E. coli*, Nitrite, Nitrate, and Total Phosphate.

* Field Determinations

4. LITTLE CHOPTANK RIVER AREA

The Little Choptank River and its tributaries form a small predominately tidal basin south of the Choptank River. The total drainage area of the basin is less than 100 square miles and the population is approximately 5,800. Madison Canning Company in Madison is the only known industry in the basin and was listed as being in compliance with laws and regulations by the Maryland Department of Water Resources.

The Little Choptank has been divided into two use classifications. The river, including estuarine portions of creeks, coves, and tributaries, from the mouth (a line drawn between Hills Point and the northern tip of Oyster Cove) to the head of all estuarine portions is classified as Group A waters and may be used for shellfish harvesting, water contact recreation, and propagation of fish, other aquatic life, and wildlife. The Little Choptank River and its tributaries beyond the estuary are classified in Group C and may be used for water contact recreation and propagation of fish, other aquatic life, and wildlife.

General Water Quality Conditions

Data on water quality in this area is lacking but some pertinent information is available. As was stated before, Madison Canning Comapny is the only industry in the basin and reports the use of land waste disposal techniques, hence, no discharge to the water.

On February 21, 1972, the Maryland Environmental Health Administration opened approximately 30 percent of the 1,250 acres of shellfish beds which had been closed due to bacterial pollution. Now open for shellfish harvesting are "All of the waters of the Little Choptank River downstream from a line extending from McKeil Point to Cedar Point, with the exception of Hudson Creek." The waters which remain closed are probably affected by leaching from the septic tanks near the shoreline.

From the above information, it can be concluded that recently there has been a significant improvement in at least the bacterial quality of the water and that even through there is little pollution creating activity in the basin, some water quality investigative work would be desirable in this area.

5. NANTICOKE RIVER AREA

The drainage basin formed by the Nanticoke River and its major tributaries, Marshy Hope Creek and Broad Creek, serves an 815 square mile area in Delaware and Maryland. The estuarine section of the basin extends 35 miles from the mouth of the Nanticoke to Seaford, Delaware, and includes portions of both Marshy Hope and Broad Creeks. The total population of the basin is over 54,000 with the highest density areas being the Laurel-Delmar (10,500) and Seaford (16,200) census divisions.

Of the discharges to the estuary, those at Seaford, Delaware, and Federalsburg and Hurlock, Maryland are the most significant. At Seaford, wastewater from a population of 7,000 receives primary treatment only. This plant is scheduled for upgrading to secondary treatment in October, 1972, and will serve as the main plant for a new regional system. Secondary treatment is provided at Federalsburg but the plant is heavily overloaded by industrial waste, accounting for 70 percent of the flow and 85 percent of the BOD load to the plant. Plans have been made for expansion of this plant to accommodate the needs of the area. Hurlock has a secondary plant which is operating satisfactorily with an average daily flow of 1.0 MGD.

Other significant discharges to the Nanticoke are:

1. Raw sewage (0.1 MGD) from Sharptown, Maryland,
2. A large nylon manufacturing plant operated by Dupont at Seaford,
3. A secondary plant at Laurel which serves 2,500 people,
4. A secondary package plant at Vienna,
5. Delmarva Power and Light Company in Vienna,

6. Maryland Chicken Processors, Inc. in Nanticoke, and
7. H. B. Kennerly & Sons, Inc. in Nanticoke.

Waters in the Nanticoke estuary have been assigned four use classifications by the Maryland Department of Water Resources and the Delaware Department of Natural Resources and Environmental Control. The Nanticoke River from the mouth (a line between Frog Point and Stump Point) to a line between the mouth of Jacks Creek and Runaway Point, including estuarine portions of creeks, coves, and tributaries except Nanticoke Harbor is classified as Group A water and may be used for shellfish harvesting, water contact recreation, and propagation of fish, other aquatic life and wildlife. Nanticoke Harbor is classified as Group C waters and may be used for water contact recreation and propagation of fish, other aquatic life and wildlife. The Main stem of the Nanticoke from the Jacks Creek - Runaway Point line to the Maryland - Delaware boundary is classified as Group C waters and may be used for water contact recreation; propagation of fish, other aquatic life and wildlife; and agricultural water supply. The Nanticoke estuary in Delaware is a single zone with designated uses of industrial water supply after reasonable treatment, recreation, and maintenance and propagation of fish, aquatic life and wildlife.

A number of surveys have been conducted in this area by the Maryland Department of Water Resources and by the Annapolis Field Office. Sampling was done by the Maryland Department of Water Resources in May and August of both 1970 and 1971 and by AFO in the summers of

1967 and 1971. Station location lists for these surveys are included.

BACTERIOLOGICAL CONDITIONS

Surveys in 1967 by the Annapolis Field Office and in 1970 by the Maryland Department of Water Resources, Water Quality Investigation Division, both reported occasional violations of the 240 MPN/100 ml fecal coliform maximum allowed in Group C waters. Average values for fecal coliform counts in the Group C waters, however, were below the maximum level at most stations. The coliform counts in the Group A stations were above the maximum 70 MPN/100 ml value in almost all cases.

The same two agencies conducted surveys again in 1971 with sampling by the Maryland Department of Water Resources on May 24-25 and August 30-31 and by Annapolis Field Office on July 20-22 and August 10-12.

Sampling by the MDWR in May indicated high fecal coliform values in the Group C waters only near the Vienna Sewage Treatment Plant and the Delmarva Power and Light Company fly ash lagoon. The only available data on the Group A waters was obtained during this sampling run. Of the four samples taken in Group A waters, only one met the maximum allowable coliform count of 70 MPN/100 ml. No valid conclusions can be drawn regarding the suitability of the Group A waters for their prescribed use since the amount of data is so limited. Samples taken on August 30 and 31, 1971, showed violations of bacterial standards at almost all of the stations in both Group A and C waters in the basin.

The 1971 AFO study indicates an even more severe coliform problem than was seen in the MDWR 1971 study. Violations of the 240 MPN/100 ml fecal coliform maximum occur at all stations and the mean fecal coliform counts (based on six samples) at all but two of eight stations exceeded the maximum allowable level. The most significant incidents of bacterial pollution are mean fecal coliform counts of 7,383, 3,641, and 1,898 MPN/100 ml at stations 1 (upstream from Seaford), 8 (Broad Creek, Laurel, Delaware), and 5 (Broad Creek at Bethel, Delaware), respectively.

DISSOLVED OXYGEN CONDITIONS

Dissolved oxygen levels in the Nanticoke Basin are generally very good, with most values ranging from 6 to 8 mg/l. One exception is the Nanticoke Harbor area where oxygen depressions were documented at the end of August 1971. At this time, depressed values existed as far up the river as the confluence with Marshy Hope Creek. Also in this period, a fish kill involving a large number of menhadden was reported in the harbor. Representatives of the Maryland Department of Water Resources observed rich blooms of red algae upon which the menhadden were presumably feeding, and sampling in connection with the kill exposed the low DO values. No conclusive evidence has been found that would definitely establish the cause of the kill, hence, no damage suits could by instituted by the Maryland Department of Natural Resources. Discharges from Maryland Chicken Processors, Inc. and H. B. Kennerly & Sons, Inc. (an oyster processing plant) along with algae blooms and the poor transport characteristics of the harbor probably contributed to the low DO levels. Both of the above named companys have been put under orders by the MDWR to provide adequate treatment for their waste.

NUTRIENTS

Nutrient levels in the Nanticoke estuary remained quite low throughout areas sampled. Total phosphate and ammonia nitrogen were lowest with average concentrations ranging from .14 mg/l to .56 mg/l and .03 mg/l to .6 mg/l, respectively. Nitrite plus Nitrate and Total Kjeldahl Nitrogen (TKN) concentrations were slightly higher with some average values for TKN greater than 2 mg/l. MDWR reports high nutient concentrations at the Vienna STP, the confluence with Marshy Hope Creek, and near Quantico Creek where the shape of the river is severely constricted.

OTHER

THe pH values found in the Nanticoke all lie within the specified water quality standards range of 6.0 to 8.5 with most of the readings grouped between 6.5 and 7.5.

Samples collected by AFO on July 21, 1971, were analyzed for zinc, lead, mercury, copper, chromium and cadmium. The metal concentrations did not vary from station to station; measured values were: zinc - .005 mg/l; lead - .50 mg/l; mercury - .0005 mg/l; copper - .100 mg/l; chromium - .100 mg/l; and cadmium - .1C0 mg/l. The levels of zinc, mercury, copper and cadmium all meet Public Health Service Drinking Water Standards and are below the levels which have been found toxic to fish and aquatic life. The lead concentrations (.50 mg/l) were above the maximum allowed for drinking water (.05 mg/l) and the fish toxicity level (0.1 to 0.2 mg/l). Chromium also occurred in concentrations above the maximum allowable for drinking water (.05 mg/l).

Table IV-24

ANNAPOLIS FIELD OFFICE STATION LOCATIONS

NANTICOKE RIVER

STATION NUMBER	LOCATION
1	Upstream of Seaford, Delaware
2	Woodland Ferry, Delaware
3	Sharptown, Maryland
4	Vienna, Maryland
5	Broad Creek, Bethel, Delaware
6	Marshy Hope Creek, Brookview, Maryland
7	Marshy Hope Creek, Federalsburg, Rt. 318 Bridge
8	Broad Creek, Laurel, Delaware

Table IV-25

STATE OF MARYLAND

WATER QUALITY INVESTIGATION DIVISION STATION LOCATIONS

NANTICOKE RIVER

STATION NUMBER	STREAM CODE	MILES ABOVE MOUTH*	LOCATION
1S	NAN	32.5	Just west of Maryland - Delaware line on river bend at black Buoy #45
2S	NAN	29.1	1/2 mile upstream from Buoy #38 (Wicomico County)
3S	MAR	28.8	Marshyhope Creek at Walnut Landing, .5 miles above mouth of Marshyhope Creek (Dorchester County)
3AS	NAN	23.8	Nanticoke River at Delmarva Power and Light Company effluent (Dorchester County)
3BS	NAN	23.7	Nanticoke River at Vienna Sewage Treatment Plant (Dorchester County)
3CS	NAN	23.9	Nanticoke River at Delmarva fly ash lagoon effluent (Dorchester County)
4S	NAN	23.6	Bridge at Vienna (Dorchester County)
5AS	NAN	17.7	Athaloo Landing, Buoy #23 (Wicomico County)
5S	NAN	14.0	Penknife Point, Buoy #17 (Dorchester County)
6S	NAN	8.5	Off Tyaskin, Buoy #13 (Wicomico County)
7S	WET	8.1	Wetipquin Bridge, Wetipquin Creek, .8 mile above mouth (Wicomico County)
8S	NAN	6.2	Jackson Harbor at Bivalve (Wicomico County)
9S	NAN	2.3	Nanticoke Harbor (Dorchester County)

* Based on distance from confluence

6. WICOMICO RIVER - MONIE BAY AREA

Tidal action in the Wicomico River extends for 24 miles from the mouth of the river to dams at Salisbury, Maryland. The total drainage area of the basin is 239 square miles and the population is approximately 44,500, of which 70 percent is concentrated in the vicinity of Salisbury.

The largest discharge in the basin is from a heavily overloaded secondary treatment plant at Salisbury which treats both domestic (40 percent of volume) and industrial (60 percent of volume) waste. The plant's design parameters are 3.6 MGD flow and 187 mg/l BOD load; the actual loadings are 4.6 MGD flow and 411 mg/l BOD. BOD removal has been reduced to less than 70 percent because of the overloading problem. Another secondary plant is being built at Fruitland where 2,000 people are presently being served by septic tanks.

At Salisbury, Mardel Byproducts Corporation, with inadequate biological stabilization; and Petroleum Equipment Division of Dresser Industries discharge to Mitchell Pond and the Wicomico River, respectively. The Green Giant Company has a plant in Fruitland which employs land disposal methods and J. I. Wells in Quantico discharges inadequately treated waste into the Wicomico. Mardel Byproducts and J. I. Wells have been listed as not in compliance with Maryland laws and regulations by the Department of Water Resources in the November 1, 1970, status report.

Three sets of water use classifications have been accepted for this area. The Wicomico river from the mouth to a point 1 mile above

Mount Vernon wharf, and Monie Bay from the mouth to the head of the Bay 1/2 mile above Nail Point (both including estuarine portions of creek, coves, and tributaries) are classified as Group A waters with shellfish harvesting; water contact recreation, and propagation of fish, other aquatic life and wildlife as the protected water uses. Tributaries beyond both estuaries are Group C water with water contact recreation and propagation of fish, other aquatic life and wildlife as the protected water uses. The main stem Wicomico River and all tributaries, ponds and headwaters in Maryland from a point 1 mile above Mount Vernon Wharf to all headwaters or the Maryland-Delaware State Line is designated as Group C waters with water contact recreation; propagation of fish, other aquatic life and wildlife; and agricultural water supply as protected water uses.

Surveys by AFO in 1967 and 1971 and by the Maryland Department of Water Resources in 1970 and 1971 provide the basis for evaluation of the water quality conditions in this basin. Station Location lists for these surveys are included.

BACTERIOLOGICAL CONDITIONS

Bacterial pollution in the Wicomico River is widespread; at a majority of the stations sampled, coliform densities averaged an order of magnitute or more above the 240 MPN/100 ml standard set for the prescribed water uses in the Group C waters.

Samples taken is Sharps Creek produced the highest bacterial counts ranging from 16,090 MPN/100 ml to greater than 160,900 MPN/100 ml in 1967 and averaging 18,500 MPN/100 ml in 1971. This pollution may be a result of seepage and overflows from the Green Giant land disposal system and septic tank leachings.

Coliform count in Salisbury area generally run from 2,400 to 54,000 MPN/100 ml. These high values are due to inadequate treatment at the Salisbury treatment plant and a possible discharge from Mardel Byproducts.

The waters designated for shellfish harvesting must not have fecal coliform densities greater than 70 MPN/100 ml. Thus, the bacterial quality of the water is adequate for shellfish harvesting only below a point 750 yards south of Clara Road in the lower section of the river. According to a report by the Maryland Department of Water Resources, 22 acres in the Wicomico have been closed to shellfish harvesting.

No shellfish bed closings have been reported in Monie Bay, thus indicating satisfactory bacterial quality in those waters.

DISSOLVED OXYGEN CONDITIONS

Data from the 1967 AFO survey showed oxygen depressions in the Salisbury area and in Sharps Creek. Samples taken above Salisbury had more than adequate dissolved oxygen but an oxygen sag begins between the Nancy Point and Harbor Point stations. (The overloaded Salisbury treatment plant discharges between these stations). Further depression occurred at Gumbey Landing. Recovery is very gradual and DO levels averaging 5.0 mg/l are not reestablished until the White Haven station.

Samples taken from Sharps Creek near Fruitland indicated that severe depression of oxygen levels also existed in that area in 1967. Low DO levels in Sharps Creek may be attributable to the oxygen demanding waste entering the stream from the Green Giant land disposal system and septic tank leachings.

NUTRIENTS

Nutrient values in the Wicomico estuary show relatively low values throughout most of the basin. Samples at Harbor Point reflect the impact of the Salisbury treatment plant with TKN values from 2 to 3 mg/l and TP values from 1.2 to 2.2 mg/l. TKN and ammonia levels averaging 1.93 mg/l and .70 mg/l, respectively, are also considerably higher in Sharp's Creek than in the rest of the basin.

Other than the two exceptions mentioned, the trend is a decrease in nutrient concentrations at the stations downstream from Salisbury.

OTHER

Samples of shellfish from waters of the Wicomico and Monie Bay have been analyzed for copper, zinc, cadmium and mercury as part of a Maryland Department of Health and Mental Hygiene program. This program will alwo include pesticide analysis in the 1972 fiscal year.

Table IV-26

ANNAPOLIS FIELD OFFICE STATION LOCATIONS

WICOMICO RIVER

STATION NUMBER	LOCATION
1	Nancy Point
2	Harbor Point, Fl 57
3	Gumby Landing, Buoy 51
3A	Fl 47
4	Patricks Landing, Fl 45
5	Quantico Wharf
6	Collins Wharf, Buoy 30
7	White Haven, between Buoy 26 and 27
8	Webster Cove, Fl 18 and 19
9	Island Point, Nun 12
10	Wicomico Creek Ferry
11	Sharps Creek, River Road Bridge
12	Tonytank Creek Bridge
13	Beaverdam Creek, Shumaker Road Bridge
13A	Beaverdam Creek, Route 12
14	Naylor Mill Road, North of Salisbury, Md.

Table IV-27

STATE OF MARYLAND

DEPARTMENT OF WATER RESOURCES

Wicomico River Basin
Wicomico County
1970

Station Location List

STATION NUMBER	MILES ABOVE MOUTH	LOCATION	NEAREST TOWN
River Stations			
1	20.5	Nancy Point	Salisbury
2	19.7	Harbor Point, Buoy FL-57	Salisbury
3	18.7	Gumby Landing, Buoy FL-53	Fruitland
4	16.1	Patricks Landing, Buoy FL-45	Siloam
4A	14.1	Upper Ferry	Siloam
5	13.4	Quantico Wharf (off J. I. Wells effluent in the channel)	Quantico
5A	11.9	Kerod Landing	Quantico
6	8.9	Collins Wharf	Trinity
7	5.5	Whitehaven, Buoy FL-27	White Haven
8	2.1	Webster Cove, Buoy FL-18	Mt. Vernon
9	0.0	Island Point, Buoy FL-14	Mt. Vernon
Tributary Stations			
10	8.2 E 0.9	Wicomico Creek, bridge on Redden Ferry Road	Trinity
11	18.0 E 0.4	Sharps Creek, bridge on River Road	Fruitland
12	18.0 E 0.4	Tony Tank Creek, bridge on River Road	Fruitland

Table IV-27 (Cont.)

STATION NUMBER	MILES ABOVE MOUTH	LOCATION	NEAREST TOWN
Tributary Stations			
15	20.7 W 0.5	Mitchell Pond, bridge on Md. Rt. 349	Salisbury
13A	21.1 E 0.1	Beaverdam Creek, bridge on Riverside Drive just above confluence with Leonard Pond Run	Salisbury
13	21.1 E 2.5	Beaverdam Creek, bridge on Shumaker Road below Shumaker Pond	Salisbury
14A	21.1 N 0.0	Leonard Pond Run, bridge on East Main Street at the confluence with Beaverdam Creek	Salisbury
14B	21.1 N 0.5	Johnson Pond, in pond just above the dam on Md. Rt. 349	Salisbury
14C	21.1 N 2.2	Middle Neck Branch, bridge on U.S. Rt. 13	Salisbury
14D	21.1 N 3.0	Brewington Branch, bridge on U.S. Rt. 13	Salisbury
14	21.1 N 2.8	Leonard Pond Run, bridge on Naylor Mill Road	Salisbury
14E	21.1 N 5.0	Connelly Mill Branch, bridge on Jersey Road	Delmar
14F	21.1 N 4.8	Leonard Pond Run, bridge immediately downstream from Md. Rt. 13 bridge crossing Leonard Pond	Delmar
14G	21.1 E 5.0	Beaver Dam Creek, Mt. Hermon crossing	Mt. Hermon
14E1	21.1 N 1.0	Woods Creek, Jersey Road crossing	Delmar

7. MANOKIN RIVER AREA

The Manokin River drains a small wedge shaped area in the middle of Somerset County, Maryland. The drainage basin is approximately 60 square miles in area and has a population of 2900. The only known discharge to the Manokin is biologically treated domestic waste from a Somerset County Sanitary District Plant at Princess Anne.

The Manokin River has been divided into three zones for water use classifications. The Manokin River including estuarine portions of creeks, coves and tributaries from the mouth (a line between Pin Point and Hazard Point) to Sharps Point is designated as group A waters with shellfish harvesting; water contact recreation; and propagation of fish, other aquatic life and wildlife as the protected use classifications. Manokin River tributaries beyond the estuary (mouth of river to Sharps Point) are group C waters and are protected for water contact recreation; and propagation of fish, other aquatic life and wildlife. The main stem of the Manokin River and its tributaries from Sharps Point to all headwaters is also classified as group C waters and may be used for water contact recreation; propagation of fish, other aquatic life and wildlife; and agricultural water supply.

GENERAL WATER QUALITY CONDITIONS

The authors have no knowledge of any water quality investigative work done in this area and were able to find only abstract information regarding the water quality in the basin. Since no sampling data is available, any theories advanced in this section come solely from subjective interpretation of non-analytical information.

Below are listed a number of facts that give some insight into the water quality picture in the Manokin River.

1. The only discharge in the basin has adequate secondary level treatment (biological stabilization) and is reported as being in compliance with the laws and regulations of the Maryland Department of Water Resources.

2. None of the shellfish areas have been closed by the Maryland Department of Health and Mental Hygiene.

3. A 1967 EPA* report on immediate pollution control needs for the Eastern Shore made no mention of needs in the Manokin River Basin.

In view of the above statements the water quality in the Manokin River should be satisfactory. Some intensive sampling should be done in this area to measure the background levels of the most common water quality paramenters. Since part of this basin is classified for agricultural water supply use, pesticide sampling might also be informative.

* Then called FWPCA

8. ANNEMESSEX RIVERS AREA

The Little and Big Annemessex Rivers combine to form one of the smallest drainage basins on the Eastern Shore. The area drained by these rivers is between 35 and 40 square miles and has a population of about 5200. The two river systems, of which the Big Annemessex is the northern-most, are connected by the Annemessex Canal. On the Little Annemessex River there is a harbor at Crisfield which has been extensively developed with marina facilities.

The major discharges in this basin are located at Crisfield on the Little Annemessex River. Domestic waste from the town of Crisfield receives only primary treatment (secondary treatment scheduled to begin April, 1972) before discharge. Waste from Mrs. Paul's Kitchens seafood packing plant (which will connect to the sewage treatment plant in the future) presently receives only inadequate primary treatment.

Two water use classifications have been specified for this basin. The Big Annemessex River from the mouth to the bridge on River Road; the Little Annemessex, (along with Broad Creek and Daugherty Creek) from the mouth to a line drawn between channel markers #11 and N-10 to all estuarine headwaters; and Jenkins Creek from the mouth to the bridge on the road to Birdtown are all classified as Group A waters with shellfish harvesting; water contact recreation; and propagation of fish, other aquatic life and wildlife as water uses to be protected. These water use areas include estuarine portions of creeks, coves, and tributaries. All other waters in this basin are classified as Group C waters and may be used for water contact recreation and propagation of fish, other aquatic life and wildlife.

Relatively little investigative work has been done in the Annemessex basin. Two surveys conducted by the Department of Water Resources on September 3 - 4, 1968 and September 8, 1970 provide the only data which could be located. A station location list and map are included.

BACTERIOLOGICAL CONDITIONS

Only one station in these two studies was located in the shellfish harvesting area. Samples taken at this station in 1968 showed coliform counts of 430 and 93 MPN/100 ml but a sample taken in 1970 showed a value of only 15 MPN/100 ml which is well below the 70 MPN/100 ml maximum standard set for shellfish harvesting waters. Indications are that all of the designated shellfish beds remain suitable for use.

The group C waters were generally acceptable for the designated uses except near the two major discharges in the basin. The samples taken in 1968 indicated the following values:

Station Number	Sample Location	Date	Coliform MPN/100 ml	E. Coli MPN/100 ml
4	100 yards west of sewage treatment plant effluent, mouth of Hop point	9-3-68	240,000+	46,000
		9-4-68	2,300	2,300
7	Channel next to Mrs Paul's plant, below mouth of Somers Cove	9-3-68	4,300	430
		9-4-68	46,000	15,000

The sample taken September 8, 1970 showed decreases in Coliform to 430 MPN/100 ml and E. Coli to 150 MPN/100 ml at station 4 and decreases in Coliform to 15 MPN/100 ml and E. Coli to 7.3 MPN/100 ml at station 7. Since only one sample was taken at each station in 1970 any statement regarding an improvement in water quality would be considerably biased.

DISSOLVED OXYGEN CONDITIONS

Only one of the samples taken in the 1968 and 1970 surveys fell below the minimum DO value (4.0 mg/l). Since all of the sampling was done in September, some depression of oxygen levels in the July - August period may go un-noted, but the general quality of the water from the oxygen standpoint appears to be satisfactory. The standards for the group A and C water uses (minimum DO of 4.0 mg/l and average DO of 5.0 mg/l) are being met according to the data collected.

NUTRIENTS

Nutrient analyses were performed on the samples collected on September 8, 1970. Total phosphate values reported in the estuary were low, ranging from .05 to .28 mg/l, but high nitrogen levels were found. Total Kjeldahl Nitrogen values ranged from .80 to 1.20 mg/l with half of the samples showing levels above 1.00 mg/l.

OTHER CONDITIONS

No data on heavy metals or pesticides in this area is available.

Table IV-28

STATE OF MARYLAND

DEPARTMENT OF WATER RESOURCES

WATER QUALITY INVESTIGATION DIVISION

Crisfield Harbor - Little Annemessex River Survey
Somerset County
September, 1971

Station Location List

STATION NUMBER	LOCATION
1	Middle of Somers Cove
2	Mouth of Somers Cove
3	1/4 mile north of Flashing Light "13A" west of old brick icehouse
4	100 yards west of sewage treatment plant effluent, north of Hop Point
5	Mouth of Annemessex Canal, Beacon No. 18
6	Beacon No. 2
7	Channel next to Mrs. Paul's plant, below mouth of Somers Cove
8	Red Nun Buoy #12
9	Red Nun Buoy #8
*10	Annemessex Canal, approximately one mile north of Flashing Light "18"
*11	Annemessex Canal, approximately two miles north of Flashing Light "18"
*12	Mouth of Annemessex Canal, north end at Flashing Light "5"

Table IV-28 (Cont.)

STATION NUMBER	LOCATION
*13	Mouth of Acre Creek at Flashing Light "3"
*14	Mouth of Doughterty Creek at Big Annemessex River at Flashing Light "1"

* These stations were added for the 1970 survey.

CRISFIELD HARBOR
LITTLE ANNEMESSEX RIVER SURVEY
STATION LOCATIONS

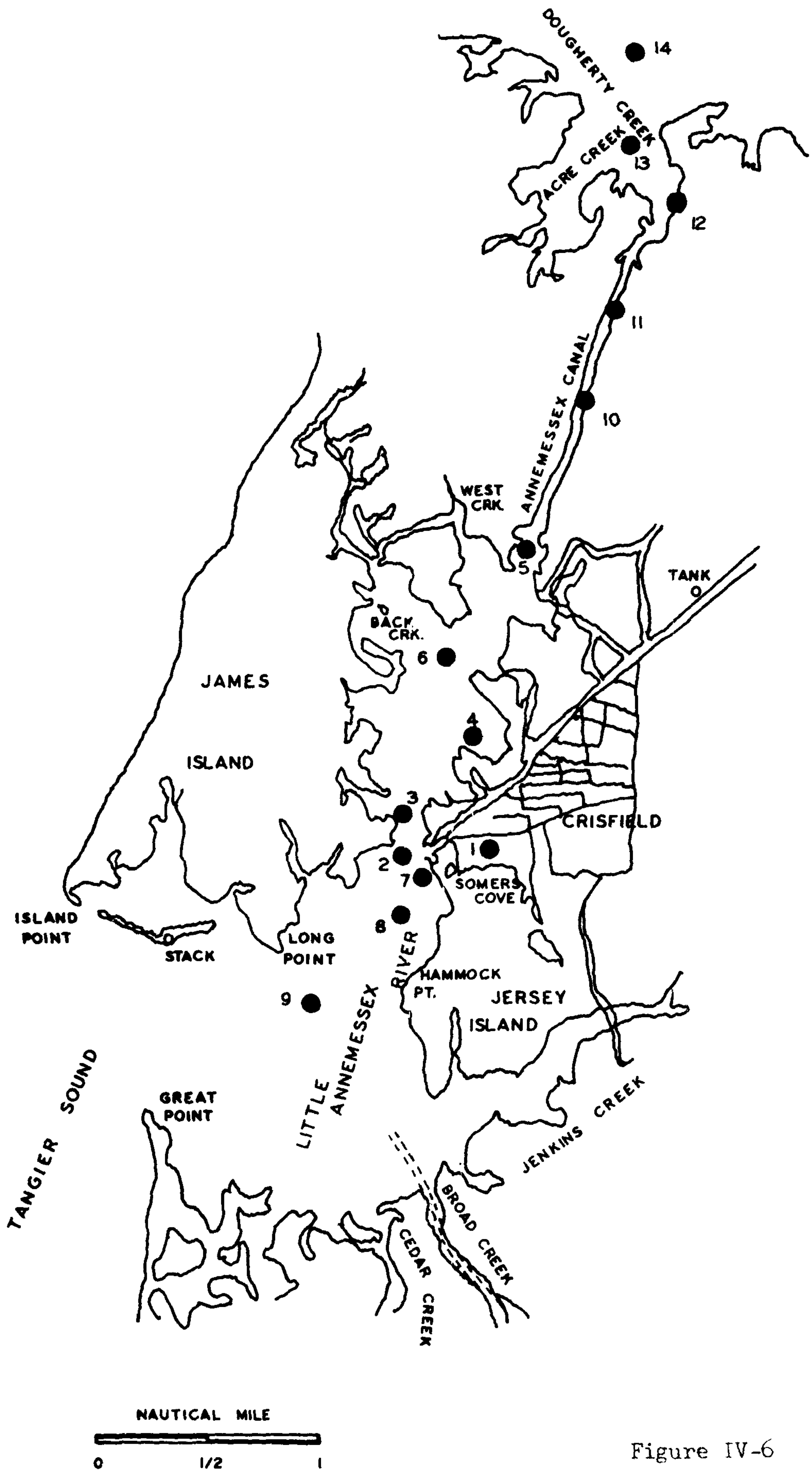


Figure IV-6

H. LOWER EASTERN SHORE AREA

(POCOMOKE RIVER)

The Pocomoke River is the primary drainage for a 488 square mile area located in a sparsely populated (population approximately 16,700) portion of the Delmarva Peninsula. The largest part of the Pocomoke drainage area lies in Maryland with the tidal influence extending 23 miles from Pocomoke Sound to a point slightly above Snow Hill, Maryland.

Major discharges to the Pocomoke River occur at the two population centers in the basin, Snow Hill and Pocomoke City, Maryland. Primary treated domestic waste from the town of Snow Hill, inadequately treated poultry processing waste from Maryland Chicken Processors, Incorporated, and inadequately treated vegetable canning waste from W. T. Onley Company are all discharged into the River at Snow Hill. Waste from Johnson Meat Products Company, Campbell Soup Comapny and Mason Canning Company, as well as domestic waste receive secondary treatment before being discharged at Pocomoke City.

Three water use classifications are specified for the Pocomoke estuary. The Virginia portion of Pocomoke Sound and the Virginia tributaries are classified as II-B waters and are generally satisfactory for use as public water supply; primary contact recreation; propagation of aquatic life; and other beneficial uses. The Maryland sector of Pocomoke Sound including estuarine portions of creeks, coves and tributaries (except Fair Island Canal) is included in group

A water with uses specified as shellfish harvesting; water contact recreation; and propagation of fish, other aquatic life and wildlife. The Pocomoke River and all its Maryland tributaries is classified as group C water with uses including water contact recreation; propagation of fish, other aquatic life and wildlife; agricultural water supply; and industrial water supply. Specific standards associated with the various water use classifications are discussed in the following sections.

Data from surveys by the Annapolis Field Office (1967 & 1971) and the Maryland Department of Water Resources (1971) were used in evaluating the water quality of this basin.

BACTERIOLOGICAL CONDITIONS

Bacterial water quality in the Pocomoke River is generally poor and examination of the data showed that many of the samples had fecal coliform values greatly in excess of the 240 MPN/100 ml standard set for waters in the C use classification. As would be expected, bacterial quality is at its worst immediately downstream from the population and industrial centers at Snow Hill and Pocomoke City.

Most of the fecal coliform values around Snow Hill range between 700 and 5400 MPN/100 ml with no apparent change in levels between 1967 and 1971. Bacterial pollution in this area is mainly attributable to the reduced effectiveness of chlorination when coupled with primary treatment and the inadequacy of treatment for poultry processing waste

In the case of Pocomoke City, a distinct improvement in bacterial quality occurred between 1967 and 1971. Eight (8) samples taken in 1967 showed most fecal coliform counts ranging from 2700 - 54000 MPN/100 ml with three of the samples having values greater than 10,000 MPN/100 ml. In 1971, six (6) samples produced counts of 490, 490, 2400, 2400, 70 and 9180 MPN/100 ml. This improvement is attributed to the secondary treatment plant in Pocomoke City which began operation in 1970 and treats part of the city's industrial waste as well as domestic waste.

The standards in Pocomoke Sound were established by both Virginia and Maryland to allow harvesting of shellfish in ths area. This requires that coliform counts <u>average</u> less than 70 MPN/100 ml (in Virginia no more than 10% can be greater than 230 MPN/100 ml) and additionally, in Virginia only, chloride concentrations must not exceed 800 mg/l. Due to violation of these standards shellfish beds have been closed in both Maryland and Virginia waters.

An improvement of the bacterial quality of the water led the Maryland Department of Health and Mental Hygiene to reopen shellfish harvesting beds from Tulls Point to and including Marumsco Creek in January, 1970. Beds from Marumsco Creek up the Sound to the end of the group A waters at the mouth of the Pocomoke River remained closed.

In November, 1971, shellfish areas in Marumsco Creek were closed, but areas further up the Sound were opened. The beds now open in Marumsco Creek area form a wedge bounded by a line between number 6 light and a point 500 feet west of Rumbley Point and a line between number 6 light and number 1 light.

As reported in Water Control Board Publications of 1967 and 1971, there has been no change in the Virginia area (1,485 acres) closed to shellfish harvesting. The data collected by AFO in 1967 and 1971 reinforces the decision of the Water Control Board in not opening any shellfish beds as no improvement in the bacterial quality of the water can be detected.

DISSOLVED OXYGEN CONDITIONS

A Maryland Department of Water Resources survey conducted April 19-21, 1971 showed DO levels in the River well above the 5.0 ppm average required for this water use classification.

However, sampling at the same stations from July 12-14, 1971 indicated a severe oxygen deficiency throughout the entire stream.

The data collected by AFO in July and August of 1967 showed a distinct oxygen sag starting at Snow Hill with partial recovery at Milburn Landing. At Pocomoke City waste loadings caused a further oxygen depletion and full recovery from the sag did not occur until Shelltown.

The 1971 study conducted in July, August and September by AFO further manifested the greater efficiency of the Pocomoke City treatment plant. The data shows an oxygen sag beginning at Snow Hill with little or no recovery at Milburn Landing. But, instead of a second sag farther downstream, significant recovery appears at the Pocomoke City station and almost total recovery is realized at Puncheon Landing.

Samples taken in Pocomoke Sound and its smaller tributaries all showed satisfactory DO levels with most values reported being well above 5.0 ppm.

NUTRIENTS

The Maryland Department of Water Resources reports above normal background values for nutrients in the River. Most of the yearly averages for Total Phosphate were approximately 1.00 mg/l and Total

Kjeldahl Nitrogen averages ranged from .80 mg/l to 1.5 mg/l. Nutrients were reported as being exceptionally high in the water near Maryland Chicken Processors, Incorporated, where yearly averages were: Ammonia - 7.52 mg/l; Total Phosphate - 30.0 mg/l; and Total Kjeldahl Nitrogen - 29.0 mg/l.

Data collected by AFO in 1971 indicated that Total Kjeldahl Nitrogen (TKN) was the only nutrient parameter which was slightly above normal in the Pocomoke Sound and its tributaries. About half of the samples collected in this area had TKN values greater than 1.00 mg/l. Total Phosphate levels rarely exceeded .500 mg/l and ammonia levels were predominantly below .100 mg/l.

OTHER

No data on metals or pesticides in the waters of the Pocomoke has been discovered, but some work has been done on metals in shell fish. The Maryland Department of Health and Mental Hygiene has established a program for monitoring copper, zinc, cadmium and mercury in shell fish with some of the work being done in Pocomoke Sound. This program is to be continued in conjunction with the administration of Maryland's food laws and is to be expanded to include pesticide analyses during fiscal 1972.

Table IV-29

STATE OF MARYLAND

DEPARTMENT OF WATER RESOURCES

WATER QUALITY INVESTIGATION DIVISION

Pocomoke River

Worcester County

Station Location List

STATION NUMBER	STREAM CODE	MILES ABOVE MOUTH*	LOCATION	NEAREST TOWN
1	POK	32.6	Pocomoke River at Hallet Heights (mouth of Purnell Branch)	Snow Hill
2	POK	31.2	Pocomoke River at W. T. Olney (just south of Md. 12 Bridge-Plant - effluent about 1/3 mile downstream of bridge)	Snow Hill
3	POK	31.6	Bridge on Maryland 12	Snow Hill
4	POK	31.0	Pocomoke River at Snow Hill Sewage Treatment Plant	Snow Hill
5	POK	30.9	Pocomoke River at Maryland Chicken Corporation	Snow Hill
6	POK	29.0	Pocomoke River at mouth of Nassawango Creek	Snow Hill
7	POK	26.5	Pocomoke River at mouth of Corker's Creek	Snow Hill
8	POK	23.0	Pocomoke River at Milburn Landing	Pocomoke City
9	POK	19.6	Pocomoke River at mouth of Dividing Creek	Pocomoke City
10	POK	17.5	Pocomoke River at Johnson's Meat Products	Pocomoke City

Table IV-29 (Cont.)

STATION NUMBER	STREAM CODE	MILES ABOVE MOUTH*	LOCATION	NEAREST TOWN
11	POK	17.1	Pocomoke River at Pocomoke Provision Company (between old and new bridge)	Pocomoke City
12	POK	16.6	Pocomoke River at Ralph Mason Company (water tower)	Pocomoke City
13	POK	16.5	Pocomoke River at the Campbell Soup Company (downstream of electric tower at big grey tank with yellow band)	Pocomoke City
14	POK	16.0	Pocomoke River at mouth of Union Branch	Pocomoke City
15	POK	14.6	Pocomoke River at Puncheon Landing	Pocomoke City
16	POK	11.8	Pocomoke River at 2.8 miles downstream of Puncheon Landing	Pocomoke City
17	POK	9.8	Pocomoke River at 4.8 miles downstream of Puncheon Landing	Pocomoke City
18	-	-	Hall Bridge, Cedarhall Wharf Road Crossing	St. James
19	-	-	Pitt's Creek, Colona Road Crossing	St. James
20	-	-	Town Bridge, Maryland 756 Crossing	Pocomoke City
21	-	-	Willow Grove Creek, U.S. 113 Crossing	Willow Grove
22	-	-	Mattapone Creek, U.S. 113 Crossing	Betheden Church
23	-	-	Corker's Creek, U.S. 113 Crossing	Betheden Church

Table IV-29 (Cont.)

STATION NUMBER	STREAM CODE	MILES ABOVE MOUTH*	LOCATION	NEAREST TOWN
24	-	-	Purnell Branch, U.S. 113 Crossing	Snow Hill
25	-	-	Pocomoke River, Porter's Crossing Road	Snow Hill
26	-	-	Dividing Creek, River Road Crossing	Pocomoke City
27	-	-	Dividing Creek, unnamed road crossing	Whiteburg
28	-	-	Pusey Bridge, Whiteburg Road Crossing	Whiteburg
29	-	-	Dividing Creek, Dentson Dam Road Crossing	Olivet Church
30	-	-	Nassawango Creek, Mt. Olive Road Crossing	Colburne
31	-	-	Nassawango Creek, Maryland 12 Crossing	Rolling Hills
32	-	-	Nassawango Creek, Old Furnace Road Crossing	Furnace
33	-	-	Nassawango Creek, Red House Road Crossing	Nassawango Creek
34	-	-	Nassawango Creek, Nassawango Road Crossing	Snow Hill
35	-	-	Pocomoke River, Whiton Crossing Road	Whiton
36	-	-	Pocomoke River, Maryland 374 Crossing	Burbage Crossing
37	-	-	Pocomoke River, Purnell Crossing Road	Purnell Crossing
38	-	-	Pocomoke River, Logtown Road Crossing	Mt. Pleasant

Table IV-29 (Cont.)

STATION NUMBER	STREAM CODE	MILES ABOVE MOUTH*	LOCATION	NEAREST TOWN
39	-	-	Pocomoke River, U.S. 50 Crossing	Willards
40	-	-	Pocomoke River, Sheppard Crossing Road	Bethel
Wicomico County				
41	-	-	Pocomoke River, North Folk, Bethel Road Crossing	Bethel
42	-	-	Burnt Mill Branch, U.S. 50 Crossing	Willards
43	-	-	Gordy's Bridge, unnamed crossing	Willards
44	-	-	Adleurs Pond, Maryland 350 Crossing	Powellville
45	-	-	Nassawango Creek, Mt. Herman Road Crossing (Maryland 350)	Wango
46	-	-	Wango Branch, Wango Road Crossing	Wango
47	-	-	Beaverdam Creek, Johnson's Road Crossing	Wango
48	-	-	Horsebridge Creek, Johnson's Road Crossing	Wango
Somerset County				
49	-	-	Marimisco Creek, Marimisco Road Crossing	Marimisco
50	-	-	East Creek, Tulls Road Crossing	Tulls Corner
51	-	-	Johnson's Creek, Phoenix Church Road Crossing	Bedsworth

Table IV-29 (Cont.)

STATION NUMBER	STREAM CODE	MILES ABOVE MOUTH*	LOCATION	NEAREST TOWN
52	-	-	Johnson's Creek, Maryland 667 Crossing	Hopewell
53	-	-	Pocomoke River, end of Wharf Shelltown	Shelltown

* Based on distance from confluence

Table IV-30

EASTERN SHORE STUDY - AFO

POCOMOKE RIVER

STATION NUMBER	LOCATION
1	Porters Crossing
2	Snow Hill
3	Milburn Landing
4	Pocomoke City
5	Puncheon Landing
6	Rehobeth
7	Cedar Hall Wharf
8	Shelltown, Maryland
9	East of Fair Island
10	Opposite Persimmon Point
11	Fair Island Channel
12	Robin Hood Bay
13	Rumbly Point
14	Marumsco Creek
15	Bullbegger Creek
16	Pitts Creek
17	Holdens Creek

I. PATUXENT RIVER AREA

The Patuxent River Basin covers an area of 963 square miles, stretching for 110 miles from the headwaters in upper Howard and Montgomery Counties, Maryland, to its mouth at Chesapeake Bay. Major tributaries of the Patuxent are the Little Patuxent and the Western Branch, with drainage areas of 160 and 110 square miles, respectively. The three regions of the Patuxent River are:

(1) Upper Patuxent - Frederick County line to Fall Line at Laurel; Little Patuxent Branch - Frederick County line to Savage,

(2) Middle Patuxent - Fall Line to Queen Anne's Bridge, and

(3) Lower Patuxent (tidal estuary) - Queen Anne's Bridge to mouth at Chesapeake Bay.

The upper region of the Patuxent River lies entirely in the Piedmont Plateau geological area, while the middle and lower regions, located below the Fall Line, lie in the Coastal Plain.

All areas of the Patuxent River are classified as Water Use III (water contact recreation) and Water Use IV areas (propagation of fish and aquatic life). In addition, the following areas are designated as Water Use II areas (municipal water supply): Patuxent River headwaters to Rocky Gorge Reservoir; middle Patuxent River and tributaries; and Little Patuxent River and tributaries. Also, the lower portion of the Patuxent River, from Deep Landing to the mouth of the Patuxent, is designated as Water Use I area (shellfish harvesting). The most stringent water quality standards in the Patuxent River, those for shellfish harvesting, call for an average daily dissolved oxygen concentration of 5.0 mg/l and a maximum coliform density of 70 MPN/100 ml.

BACTERIOLOGICAL CONDITIONS

At the present time, a severe lack of information exists concerning coliform bacteria concentrations in all areas of the Patuxent River. This shortage is especially serious in the lower Patuxent River region where careful monitoring of bacteriological conditions is essential. Below Deep Landing (River Mile 29.35), a shellfish harvesting area, a coliform density of 70 MPN/100 ml must not be exceeded. Table IV-31 summarizes the most recent coliform concentration data available.

Table IV-31

PATUXENT RIVER BACTERIOLOGICAL DATA

DECEMBER 15, 1970

RIVER MILE	COLIFORM MPN/100 ml
22.90	39
32.20	1,500
41.75	4,300
45.20	21,000
54.88	24,000
60.74	4,300
63.67	93
63.70	23
66.37	430
71.50	230
75.00	430
80.00	93

From the above data, it appears that the coliform density standard is upheld in the shellfish harvesting area. The coliform density tends to decrease as one moves downstream from maximum coliform densities found at approximately River Mile 50. The extremely high coliform densities at River Miles 45.20 and 54.88 can be attributed to the large wastewater outputs from treatment plants at Laurel Parkway (2.60 MGD), Bowie-Belair (1.90 MGD), and Fort Meade (2.10 MGD). However, 106 acres (5 public, 101 private acres) are now closed to oyster production out of a total of 14,804 acres available in the Patuxent River. The closed areas are located in the lower portion of the Patuxent River and include Back Creek, Mill Creek, and St. John Creek.

More surveys of the entire Patuxent River Basin need to be made to determine if current water quality standards are being maintained at the required levels.

DISSOLVED OXYGEN CONDITIONS

Dissolved oxygen concentrations in the Patuxent River, from River Mile 19.4 to 60.74, ranged from a high of 7.81 mg/l to a low of 4.54 mg/l on September 1, 1970. On September 5, 1968, dissolved oxygen values ranged from 9.4 mg/l to 5.5 mg/l in the same area. The low dissolved oxygen values noted in September 1970 are partly the result of a high nitrogenous oxygen demand (NOD) at this time. A maximum TKN value of 1.242 mg/l was found at River Mile 60.74, resulting in a NOD value of 5.6 mg/l. The dissolved oxygen concentration appears to have degraded between 1968 and 1970, although this may be the result of a low-flow rate during fall 1970. Insufficient information concerning flow rates exists in order to make a definite statement regarding dissolved oxygen concentration trends in the Patuxent River. Table IV-32 presents a more detailed summary of dissolved oxygen concentrations in the Patuxent River between 1968 and 1971.

It can be seen that dissolved oxygen values generally are lower in the upper region of the river, gradually increasing moving downstream. The higher dissolved oxygen concentrations observed in the spring, as compared to fall values, are attributed to greater flow rates in the spring than in the fall. Table IV-33 presents detailed dissolved oxygen concentration data during the late spring and summer months of 1970. Dissolved oxygen concentrations, with some exceptions, were generally greater than 5.0 mg/l. However, any degradation of water quality in the Patuxent River will result in the serious contravention of the dissolved oxygen standard of 5.0 mg/l.

Table IV-32

PATUXENT RIVER DISSOLVED OXYGEN CONCENTRATIONS
(mg/1)

River Mile	9/5/68	5/13/70	9/1/70	5/17/71
19.40	-	11.87	4.54	-
22.90	9.4	10.96	5.35	9.4
23.90	8.0	-	-	9.6
25.25	-	10.42	5.62	9.8
26.65	8.8	-	-	8.8
27.35	8.6	10.09	5.85	8.5
29.35	8.2	-	-	8.8
31.85	7.2	8.19	5.35	8.5
34.35	7.3	-	-	9.0
38.25	8.0	6.46	6.58	7.0
41.45	-	6.15	7.81	7.3
42.80	7.8	-	-	7.3
44.50	-	-	-	7.7
45.20	6.4	5.02	5.38	-
47.45	5.5	5.16	5.92	-
54.88	-	4.98	5.76	-
60.74	-	4.94	4.97	-

Table IV-33

PATUXEN RIVER DISSOLVED OXYGEN VALUES - 1970
(mg/l)

River Mile	6/11/70	6/29/70	7/27/70	9/1/70
19.4	9.63	8.13	10.10	4.54
22.9	9.92	3.34	9.11	5.35
25.0	9.59	9.35	12.63	5.62
27.3	9.27	8.36	8.05	5.85
28.5	10.71	8.91	8.54	5.03
31.9	7.82	7.89	8.28	5.35
32.2	6.27	7.73	6.48	6.37
38.4	7.11	10.22	6.62	6.58
41.75	8.23	9.27	6.89	7.81
45.20	5.27	4.91	3.84	5.38
47.45	4.75	5.58	4.94	5.92
48.60	5.64	5.96	5.42	5.57
52.50	5.58	6.19	5.96	6.11
54.88	5.40	6.44	5.88	5.76
60.74	4.58	6.35	5.66	4.97

NUTRIENTS

Recent data indicate that nutrient concentrations in the Patuxent River have greatly increased in the last few years. A summary of average nutrient concentrations in 1967 and 1970 is outlined in Table IV-34.

Table IV-34

PATUXENT RIVER NUTRIENT CONCENTRATIONS

River	$NO_2 + NO_3$ as N		T. Phosphorus as PO_4	
Mile	1967 (mg/l)	1970 (mg/l)	1967 (mg/l)	1970 (mg/l)
47.45	1.448	1.569	1.433	2.091
54.88	-	1.985	2.003	2.753
60.74	1.500	2.006	2.487	3.685

In the above region, nitrate-nitrogen (as N) concentrations have increased an average of 25 percent since 1967, while total phosphorus (as PO_4) concentrations have increased an average of 44 percent from 1967 to 1970. The proceeding observations are based on average nutrient concentration values obtained by mathematically averaging four to eight samples taken throughout each year (1967 and 1970).

Table IV-35 (nitrate-nitrogen) and Table IV-36 (total phosphorus as PO_4) detail nutrient concentration data in the Patuxent River during the year 1970. It can be seen that both nitrogen and phosphorus concentration levels are greater in the upper region of the river, and gradually decrease downstream. In general, nutrient values are highest

Table IV-35

PATUXENT RIVER

$NO_2 + NO_3$ as N

(mg/l)

River Mile	2/18/70	5/13/70	7/27/70	9/1/70	11/23/70
19.4	-	.065	.050	.001	-
22.9	.383	.071	.041	.001	.141
25.0	.512	.084	.041	.001	-
27.3	.584	.097	.041	.001	-
28.5	.819	.269	.090	.001	-
31.9	.841	.462	.162	.001	-
32.2	.973	.572	.314	.001	.623
38.4	.975	.654	.447	.001	.726
41.75	.959	.743	.521	.121	.942
45.20	.901	1.070	1.031	1.350	1.240
47.45	.907	1.420	1.186	2.160	1.240
48.60	.924	1.550	1.321	2.330	1.220
52.50	.911	1.490	1.748	2.550	1.270
54.88	.901	1.490	1.802	2.840	1.270
60.74	.891	1.410	1.928	2.680	1.270

Table IV-36

PATUXENT RIVER

Total Phosphorus as PO_4 (mg/l)

River Mile	2/18/70	5/13/70	7/27/70	9/1/70	11/23/70
19.4	-	.171	.272	.400	-
22.9	.175	.320	.272	.440	.229
25.0	.204	.371	.256	.462	-
27.3	.246	.519	.337	.490	-
28.5	.422	.582	.344	.427	-
31.9	.363	.489	.372	.416	-
32.2	.681	.542	.367	.394	.487
38.4	.795	.451	.506	.572	.853
41.75	1.120	.619	.711	.622	1.486
45.20	.173	1.297	1.467	1.783	2.422
47.45	1.540	1.643	1.111	3.765	1.783
48.60	1.570	1.989	1.270	3.248	1.872
52.50	1.660	2.259	1.889	3.963	2.202
54.88	1.660	2.141	1.556	4.128	2.367
60.74	1.980	2.649	2.444	5.119	3.160

during the fall months and least during the summer. Maximum values of 2.840 mg/l and 5.119 mg/l for nitrate-nitrogen (as N) and total phosphorus (as PO_4), respectively, were found on September 1, 1970. It appears that nutrient concentrations in the middle and upper regions of the Patuxent River greatly exceeded the recommended maximum concentrations of nitrogen (.5 mg/l) and phosphorus (.33 mg/l) during most of 1970 (Reference 4). These nutrient concentrations are far above the level that may stimulate excessive algal growth in the river.

Chlorophyll a concentrations provide one means of measuring the standing crop of algae in a water body. A chlorophyll a concentration greater than 50 µg/l indicates an algal standing crop of "bloom" proportions (Reference 4). In the upper region of the river, River Mile 45.20 to 60.74, chlorophyll a concentrations during 1970 ranged from 5.83 to 19.76 mg/l. The absence of excessive algal growths in the upper Patuxent River is attributed to excessive turbidity in this area. Large amounts of suspended material in the water limits light penetration, thereby limiting utilization of available nutrients and inhibiting the growth of algae. However, several algal blooms have occurred in the lower Patuxent River. If corrective measures are not taken, large-scale algal blooms, such as occur yearly in the Potomac River, could become a fact in the Patuxent River. The increasing nutrient concentrations should be checked by more efficient wastewater treatment methods in order to prevent nuisance algal growths. It has been estimated that by 1980, 95 percent of the nitrogen and 96 percent of the phosphorus will have to be removed from wastewater before discharge in order to meet water quality standards in the Patuxent River.

HEAVY METALS

No significant surveys of heavy metal concentrations in the Patuxent River have been conducted to data. However, present indications are that the amounts of most metals in the river are either slight or are comparable to levels in most major rivers in North America. The only known exception to this is found in the vicinity of Chalk Point (River Mile 25.0), near the site of the steam electric power plant which began operation in 1964. High copper concentrations and greening in oysters were found near the cooling water outfall at Eagle Harbor, 2 miles upstream from Chalk Point. These detrimental effects were greatest near the outfall, and steadily decreased downstream from Eagle Harbor. At times, copper levels in oysters taken from the economically important shellfish harvesting area just south of Chalk Point have exceeded the recommended limits for human consumption and have resulted in the loss of commercial oyster sales. The source of the high copper levels has been attributed to corroding condenser tubes in the power plant.

The information contained in this chapter has been obtained from the following sources:

1. Natural Resources Institute, "Patuxent Thermal Studies," Summary and Recommendations, January 1969.

2. Governor's Patuxent River Watershed Advisory Committee, "The Patuxent River, Maryland's Asset, Maryland's Responsibility," July 1968.

3. Flemer, D. A., Hamilton, D. H., Keefe, C. W., and Mihursky, J. A., Chesapeake Biological Laboratory, "The Effects of Thermal Loading and Water Quality on Estuarine Primary Production," December 1970.

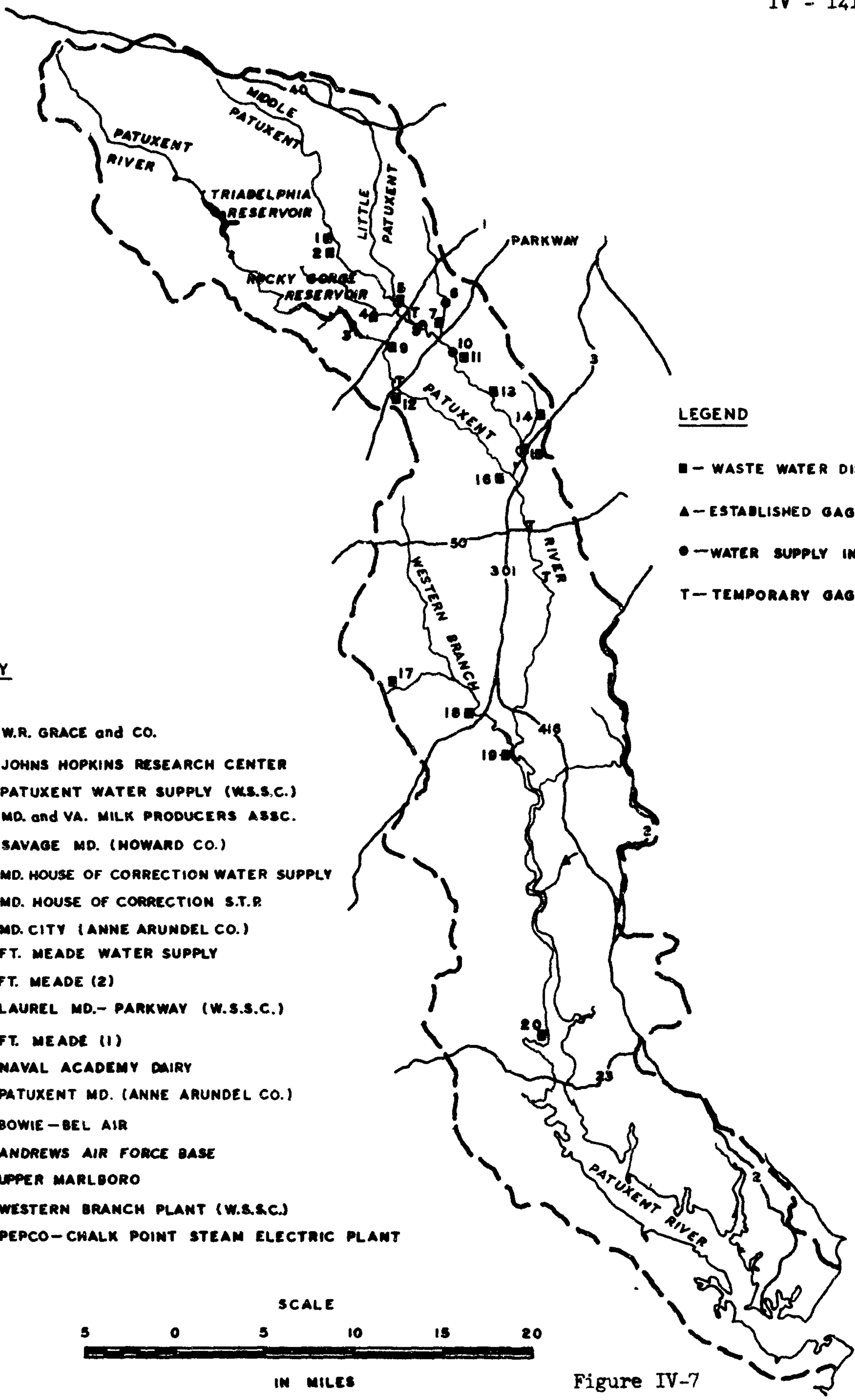
4. Federal Water Pollution Control Administration, "The Patuxent River, "Water Quality Management Technical Evaluation, September 1969.

5. Federal Water Pollution Control Administration, "Water Quality and Pollution Control Study, Patuxent River Basin," CB-SRBP Working Document No. 15, May 1967.

6. State of Maryland, Department of Water Resources, "Patuxent River Study," 1970-71.

7. "Patuxent Estuary Study," EPA, AFO, 1970, unpublished.

PATUXENT RIVER BASIN



LEGEND

■ — WASTE WATER DISCHARGES

▲ — ESTABLISHED GAGING STATIONS

● — WATER SUPPLY INTAKES

T — TEMPORARY GAGING STATIONS

KEY

1. W.R. GRACE and CO.
2. JOHNS HOPKINS RESEARCH CENTER
3. PATUXENT WATER SUPPLY (W.S.S.C.)
4. MD. and VA. MILK PRODUCERS ASSC.
5. SAVAGE MD. (HOWARD CO.)

6.-8. MD. HOUSE OF CORRECTION WATER SUPPLY

7. MD. HOUSE OF CORRECTION S.T.P.
9. MD. CITY (ANNE ARUNDEL CO.)
10. FT. MEADE WATER SUPPLY
11. FT. MEADE (2)
12. LAUREL MD.- PARKWAY (W.S.S.C.)
13. FT. MEADE (1)
14. NAVAL ACADEMY DAIRY
15. PATUXENT MD. (ANNE ARUNDEL CO.)
16. BOWIE—BEL AIR
17. ANDREWS AIR FORCE BASE
18. UPPER MARLBORO
19. WESTERN BRANCH PLANT (W.S.S.C.)
20. PEPCO—CHALK POINT STEAM ELECTRIC PLANT

SCALE

5 0 5 10 15 20

IN MILES

Figure IV-7

J. POTOMAC RIVER STUDY AREA

Existing water quality conditions in the Potomac River were determined for the tidal portion of the River which extends from Chain Bridge in Washington, D. C., 112 miles southeastward to the Chesapeake Bay. The tidal portion of the Potomac River is shown in figure IV-8.

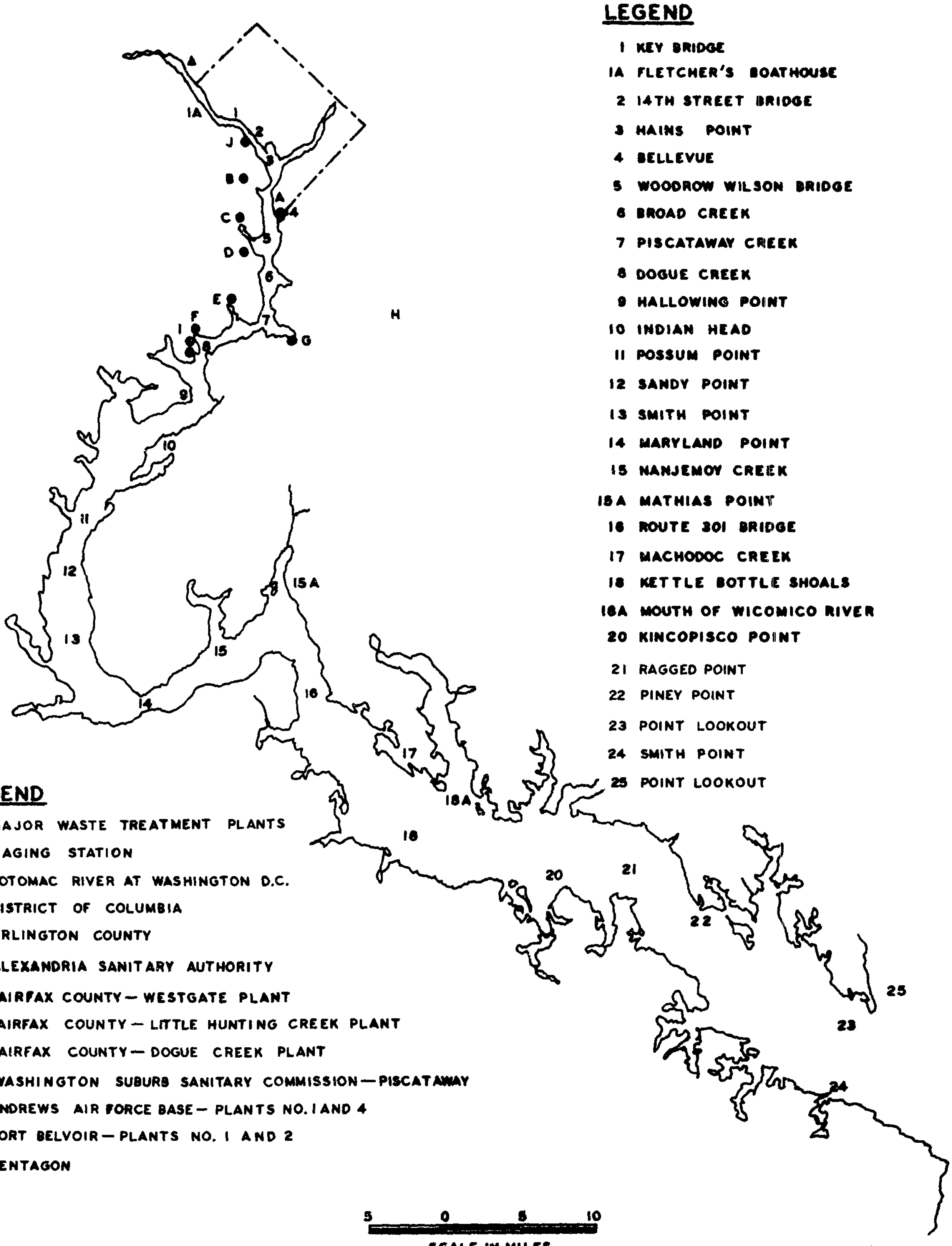
From the Key Bridge vicinity, below the Fall Line, downstream to the District of Columbia-Prince Georges County (Md.) line, water quality standards have been established to support the water uses of recreational boating, maintenance of fish life, and industrial water supply. From the District of Columbia-Prince Georges County line to Point Lookout, where the Potomac River discharges to the Bay, water contact recreation, propagation of fish, other aquatic life and wild-life, and industrial water supply uses are permitted. Shellfish harvesting is an allowable use of the Potomac Estuary from Upper Cedar Point to Point Lookout, except in areas where such use is prohibited by Maryland and Virginia health officials. The water quality criteria necessary to support the beneficial water uses in the Potomac Estuary are listed in Chapter III.

BACTERIOLOGICAL CONDITIONS

The highest fecal coliform densities in the Potomac Estuary are found in the upper portion of the estuary near Washington. The fecal coliform standard of 1,000 MPN/100 ml (geometric mean) established for

POTOMAC ESTUARY

SAMPLING STATIONS



LEGEND

1 KEY BRIDGE
1A FLETCHER'S BOATHOUSE
2 14TH STREET BRIDGE
3 HAINS POINT
4 BELLEVUE
5 WOODROW WILSON BRIDGE
6 BROAD CREEK
7 PISCATAWAY CREEK
8 DOGUE CREEK
9 HALLOWING POINT
10 INDIAN HEAD
11 POSSUM POINT
12 SANDY POINT
13 SMITH POINT
14 MARYLAND POINT
15 NANJEMOY CREEK
15A MATHIAS POINT
16 ROUTE 301 BRIDGE
17 MACHODOC CREEK
18 KETTLE BOTTLE SHOALS
18A MOUTH OF WICOMICO RIVER
20 KINCOPISCO POINT
21 RAGGED POINT
22 PINEY POINT
23 POINT LOOKOUT
24 SMITH POINT
25 POINT LOOKOUT

LEGEND

Δ MAJOR WASTE TREATMENT PLANTS
● GAGING STATION
POTOMAC RIVER AT WASHINGTON D.C.
A DISTRICT OF COLUMBIA
B ARLINGTON COUNTY
C ALEXANDRIA SANITARY AUTHORITY
D FAIRFAX COUNTY — WESTGATE PLANT
E FAIRFAX COUNTY — LITTLE HUNTING CREEK PLANT
F FAIRFAX COUNTY — DOGUE CREEK PLANT
G WASHINGTON SUBURB SANITARY COMMISSION — PISCATAWAY
H ANDREWS AIR FORCE BASE — PLANTS NO. 1 AND 4
I FORT BELVOIR — PLANTS NO. 1 AND 2
J PENTAGON

Figure IV-8

the Key Bridge to the D.C.-Prince Georges County (Md.) line segment was consistently contravened during 1971 according to sampling data of the Government of the District of Columbia, Department of Environmental Services. In the vicinity of Roosevelt Island, the results of samples taken during the summer months of June, July, and August reveal fecal coliform densities ranging form a low of 3,300 MPN/100 ml to a high of 350,000 MPN/100 ml, with a mean of about 150,000 MPN/100 ml. The high densities are attributed mainly to untreated sewage being discharged into the upper estuary as a result of inadequate sewerage and the exceeding of capacity at the District of Columbia Water Pollution Control Plant (Blue Plains).

Fecal coliform densities in the vicinity of Fort Washington show a decrease from the above figures. From Indian Head downstream to Maryland Point, the fecal coliform counts are within the standard of 240 MPN/100 ml established for the estuarine reach from the D.C. line to Upper Cedar Point.

From Upper Cedar Point to the Bay, the Potomac River and its estuaries are designated shellfish waters. There are currently about 29,000 acres of oyster beds in the Potomac Estuary and its embayments. For shellfish harvesting, the most probable number (MPN) of coliform organisms should be less than 70 per 100 ml of sample. Except for isolated areas, the bacterial quality of these waters remains within the above limits. These isolated areas are discussed below.

Areas currently closed to shellfish harvesting in Virginia estuaries of the Potomac are located in King George and Westmoreland Counties and include portions of Upper Machodoc, Monroe, and Mattox Creeks. Four of the condemned areas total approximately 1,868 acres of river bottom out of an approximate total of 15,162 acres. Inadequate waste-water treatment plants, marinas, subdivision build-up, and human activities are cited by the Virginia State Water Control Board as reasons for the closures.

The following oyster bars are prohibited for shellfish harvesting in St. Mary's County, Maryland:

Breton Bay - 55 acres public, 8 acres private. Order issued November 1, 1971.

St. Mary's River - 23 acres public. Order issued January 17, 1972.

Neale Sound - 2 acres private. Order issued August 1960.

Upper St. Catherine Sound - 39 acres public, 15 acres private. Order issued November 1, 1971.

Charleston Creek - Conditions not suitable for prior use as oyster storage area. Order issued November 1, 1971.

Head of St. Clement Bay - 120 acres public, 23 acres private. Order issued November 1, 1971.

Canoe Neck Creek - 19 acres private. Order issued November 1, 1971.

St. Patrick Creek - 83 acres private. Order issued November 1, 1971.

The November 1, 1971, closings can be attributed to faulty septic systems of individual dwellings and present management practices with regard to livestock. It should be noted, however, that on January 17, 1972, the acreage of oyster bars closed in St. Mary's River was reduced from 178 to 23 acres by the Maryland Department of Health and Mental Hygiene as a result of sewage violation corrections.

Bacterial densities in the Upper Potomac Estuary have been determined routinely by the District of Columbia, Department of Sanitary Engineering (now Department of Environmental Services), since 1938. While total coliform counts at Three Sisters Island, below the Fall Line, have remained fairly constant for the past 20 years at about 2,000 MPN/100 ml during the summer months, the total coliform density in the estuary increased to over 2,000,000 MPN/100 ml near the Blue Plains Wastewater Treatment Plant in 1966. When year-round chlorination began in 1970, the total coliform density decreased to less than 7,000 MPN/100 ml (Figure IV-9).

Bacterial densities, however, remain high in the estuary along the Georgetown waterfront due to the overflow of mixed sanitary and storm sewage from the overloaded sewage treatment system. Figure IV-10 indicates current fecal coliform densities in the vicinity of Roosevelt Island. Activations of the Potomac Pumping Station in May 1972 and the closure of the so called "Georgetown Gap" in September 1972 will shift these overflows downstream. By 1973, expansion of the sewage treatment facilities at Blue Plains should abate the overflows.

Although continuing interim construction will reduce the frequency of combined sewer overflows, they cannot be completely eliminated until

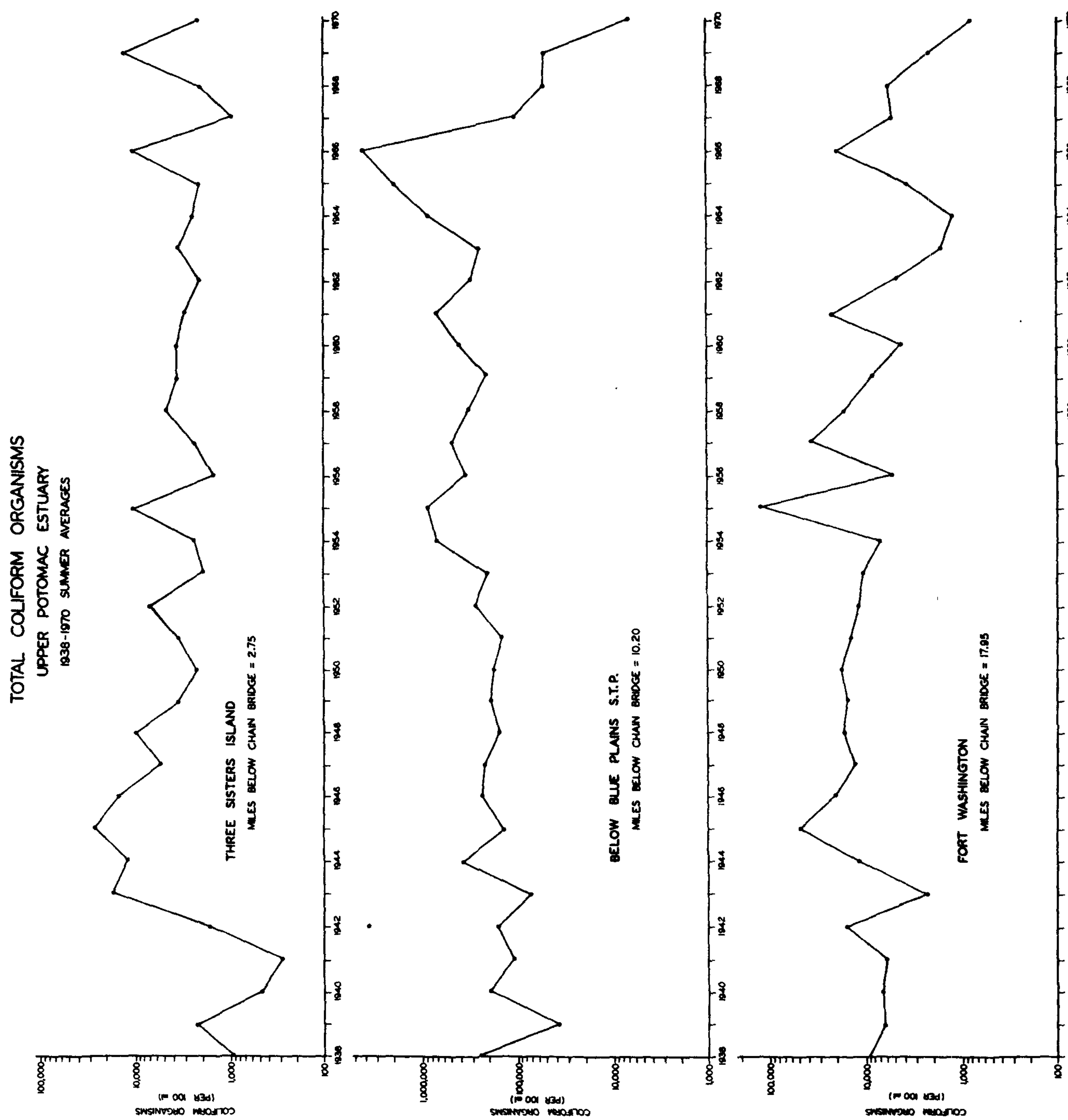

TOTAL COLIFORM ORGANISMS
UPPER POTOMAC ESTUARY
1938-1970 SUMMER AVERAGES
THREE SISTERS ISLAND
MILES BELOW CHAIN BRIDGE = 2.75
BELOW BLUE PLAINS S.T.P.
MILES BELOW CHAIN BRIDGE = 10.20
FORT WASHINGTON
MILES BELOW CHAIN BRIDGE = 17.95
COLIFORM ORGANISMS
(PER 100 ml)
100,000
10,000
1,000
100
1,000,000
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970

Figure IV-9

FECAL COLIFORM DENSITIES
ROOSEVELT ISLAND

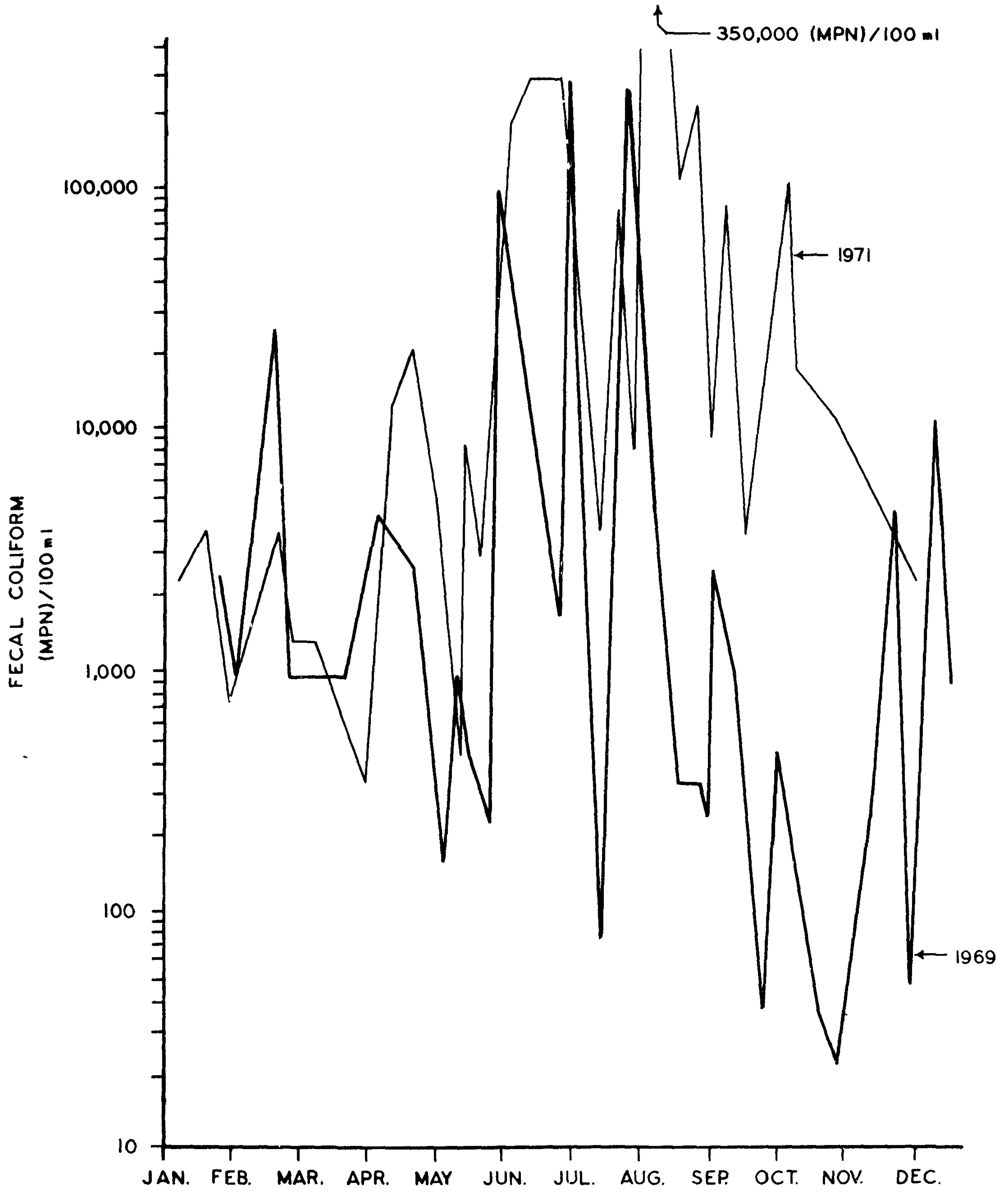


Figure IV-10

storm and sanitary sewers are separated, perhaps after the year 2000. A possible alternative to separation is the retention and treatment of combined system and separate system overflows.

DISSOLVED OXYGEN

The dissolved oxygen (DO) standard extablished for the Potomac Estuary requires a minimum DO concentration of 4.0 mg/l with a daily average of 5.0 mg/l. This standard is maintained in the middle and lower reaches of the estuary, but is contravened during the summer months in the upper estuary in the vicinity of the major waste discharges.

The following DO concentrations represent surface conditions at sampling stations in the middle and lower portions of the estuary. Dissolved oxygen concentrations are not seriously affected by waste discharges in this area.

Table IV-37

STATION	SAMPLING DATE	WATER TEMPERATURE °C	DO mg/l
Indian Head	6-29-71	28.5	7.43
(30.60 mi. below	7-29-71	27.3	4.51
Chain Bridge)	8-25-71	28.0	12.25
	9-28-71	23.1	6.61
Smith Point	6-29-71	27.8	4.15
(46.80 mi. below	8-25-71	26.5	8.50
Chain Bridge)	9-28-71	24.4	9.27
U.S. Route 301 Bridge	6-28-71	28.3	8.75
(67.40 mi. below	7-29-71	26.7	7.95
Chain Bridge)	8-25-71	27.6	8.74
	9-27-71	24.1	7.81
Piney Point	6-28-71	27.5	9.04
(99.20 mi. below	8-02-71	26.9	9.73
Chain Bridge)	8-24-71	27.2	7.53
	9-27-71	23.6	8.45

As indicated above, DO concentrations exceed, for the most part, the standard of 5.0 mg/l. Only at lower water depths, where reaeration is restricted by salinity stratification, are depressed oxygen concentrations observed.

In the upper reach from Chain Bridge to Indian Head, Maryland, a total domestic wastewater flow of approximately 325 MGD is discharged into the upper Potomac estuary. Eighteen facilities currently serve approximately 2.5 million people in the Washington Metropolitan Area with the largest facility being the Blue Plains plant of the District of Columbia (Table IV-38). Of the 325 MGD, 42, 23, and 35 percent come from Maryland, Virginia, and the District of Columbia, respectively.

An anlysis of loading trends since 1913 indicates that wastewater volumes have increased eightfold, from 42 to 325 MGD (Table IV-39). Of major significance has been the increase in ultimate oxygen demand (UOD) loadings. The carboaceous UOD increased from 84,000 lbs/day in 1913 to about 297,000 lbs/day in the late 1950's. With the construction of secondary treatment facilities, including completion of the Blue Plains plant of the District of Columbia, the carbonaceous loading was reduced to 110,000 lbs/day. The nitrogenous loading has increased steadily from 1913 to the present loading of 254,000 lbs/day which exceeds the current carbonacous loading of 204,000 lbs/day. This results in a total oxygen demand loading of over 450,000 lbs/day. The instream oxidation of this load results in low DO concentrations, often less than 1.0 mg/l during the summer (Figure IV-11). Interim chemical treatment to reduce the biochemical oxygen demand, suspended solids, and phosphorus in the Blue Plains effluent is scheduled to begin in June 1972.

As shown in Figures IV-11 and IV-12, the most seriously depressed oxygen concentrations occur in the vicinity of the Woodrow Wilson Bridge, 12.1 miles below Chain Bridge, downstream from the Blue Plains plant, the major waste discharge source in the upper estuary. Under varying flow conditions dissolved oxygen levels remain depressed, indicating that high water temperatures during the summer have a greater influence than freshwater inflow on the ability of the upper estuary to retain dissolved oxygen. While freswater inflows have been more uniform in recent summer months, the loadings requiring in-stream oxidation have increased each year. This is evident by the fact that since 1960 the increase in wastewater volumes and the continued increase in nitrogenous UOD have resulted in a total oxygen demanding load to the estuary similar to that which occurred before the secondary treatment facility was completed in the late 1950's.

There are 82 wastewater point source discharges into the middle and lower reaches of the Potomac Estuary and their tributaries. The estimated BOD, total phosphorus as P, and nitrogen as N are 4,000, 500, and 1,000 lbs/day, respectively. Although the discharges appear numerous, the dissolved oxygen standard is maintained in this portion of the estuary as manifested by the data set forth earlier in this report.

NUTRIENTS

While bacterial densities and dissolved oxygen concentrations

Table IV-38

WASTEWATER LOADINGS TO THE UPPER POTOMAC ESTUARY AND TRIBUTARIES
GREAT FALLS TO INDIAN HEAD 1970

Facility	Population Served	Flow	BOD_5		Suspended Solids		T. Phosphorus as P	TKN	$NO_2 + NO_3$
			Untreated	Treated	Untreated	Treated	Treated	Treated	Treated
		mgd	(lbs/day)	(lbs/day)	(lbs/day)	(lbs/day)	(lbs/day)	(lbs/day)	(lbs/day)
Pentagon	10,[illegible]00*	1.060	2,100	360	2,100	310	65	290	20
Arlington	247,000	19.390	33,[illegible]00	5,460	37,400	14,300	1,650	1,020	1,465
Sewer Overflows D. C. System	18,300**	2.516	3,740	3,740	[illegible],700	3,700	170	460	20
Naval Laboratory White Oaks, Md.	950*	0.095	25	7	32	12	7	25	1
District of Columbia	1,830,000	251. 60	373,700	103,800	369,900	102,000	17,300	46,200	2,000
Alexandria	190,000	23.300	28,000	13,000	36,200	12,[illegible]00	2,300	3,690	20
Fairfax-Westgate	124,400	11.570	11,500	10,900	9,600	8,200	1,280	1,830	4[illegible]
Piscataway, WSSC	55,000	5.810	6,300	540	7,300	1,310	320	630	100
Andrews AFB No. 1	8,200*	0.820	1,200	110	770	110	45	50	30
Andrews AFB No. 4	860*	0.086	104	16	80	10	[illegible]	3	3
Naval Comm. Station Cheltenham, Md.	670*	0.067	110	15	140	14	3	2	1
Fairfax-Hunting Cr.	25,000	3.260	4,060	1,390	5,880	1,130	380	620	15
Fairfax-Dogue Cr.	20,000	2.441	4,048	915	4,010	760	270	365	20
Fort Belvoir No. 1	3,600	0.600	1,100	120	110	70	30	25	25
Fort Belvoir No. 2	18,400	2.340	3,500	380	3,800	325	175	430	20
Fairfax-Lower Potomac****	-	-	-	-	-	-	-	-	-
Naval Ordnance Station Indian Head, Md.									
Site I	2,500*	0.250	155	90	200	160	12	25	1
Site II	3,600*	0.360	355	140	430	80	8	5	1
Site III	60*	0.006	2	1	2	1	1	1	1
Site IV	10*	0.001	2	1	2	1	1	1	1
TOTAL		325.632	483,501	140,985	479,656	145,093	24,022	[illegible]	[illegible],784

* Based on 100 gcpd
** Based on dry weather flow to wastewater facility
*** Under construction

Table IV-39

PRESENT WASTEWATER LOADINGS
WASHINGTON METROPOLITAN AREA

Facility	Average Waste Flow (mgd)	Population Served	Per Capita Waste Flow (gpd)	Untreated BOD_5 (lbs/day)	Per Capita BOD_5 Load (lbs/day)	Untreated TKN as N (lbs/day)	Per Capita TKN Load (lbs/day)	Untreated TPO_4 as PO_4 (lbs/day)	Per Capita TPO_4 Load (lbs/day)
Pentagon	1.060	10,600*	100	2,100	0.20	440	0.042	182	0.017
Arlington	19.390	247,000	79	33,500	0.14	4,800	0.019	4,575	0.018
Sewer Overflows-D. C.	2.516	18,300**	138	3,740	0.20	460	0.025	645	0.035
U. S. Naval Laboratory	0.095	950*	100	25	0.03	30	0.030	30	0.030
District of Columbia	251.660	1,830,000	138	373,700	0.20	46,000	0.025	64,539	0.035
Alexandria	23.300	190,000	123	38,000	0.20	4,580	0.024	6,060	0.031
Fairfax-Westgate	11.570	124,400	93	11,500	0.09	3,140	0.025	3,394	0.027
Piscataway	5.810	55,000	106	6,300	0.11	1,650	0.030	1,106	0.020
Andrews AFB No. 1	0.820	8,200*	100	1,200	0.15	70	0.008	152	0.018
Andrews AFB No. 4	0.086	860*	100	104	0.12	12	0.014	18	0.021
Naval Comm. Station	0.067	670*	100	110	0.16	15	0.020	15	0.020
Fairfax-Hunting Creek	3.260	25,000	130	4,060	0.16	720	0.029	833	0.033
Fairfax-Dogue Creek	2.441	20,000	122	4,048	0.20	465	0.023	606	0.030
Fort Belvoir No. 1	0.600	3,600	167	1,100	0.30	145	0.040	76	0.021
Fort Belvoir No. 2	2.340	18,400	127	3,500	0.19	960	0.052	394	0.021
Fairfax-Lower Potomac***	-	-	-	-	-	-	-	-	-
Naval Ordnance Station Indian Head									
Site I	0.250	2,500*	100	155	0.06	30	0.012	50	0.020
Site II	0.360	3,600*	100	355	0.10	10	0.003	30	0.008
Site III	0.006	60*	100	2	0.03	2	0.033	5	0.083
Site IV	0.001	10*	100	2	0.20	2	0.200	5	0.500
TOTALS	325.630	2,559,150		483,501		63,531		82,715	

* Based on 100 gpcpd
** Based on dry weather flow to wastewater facility
*** Under construction

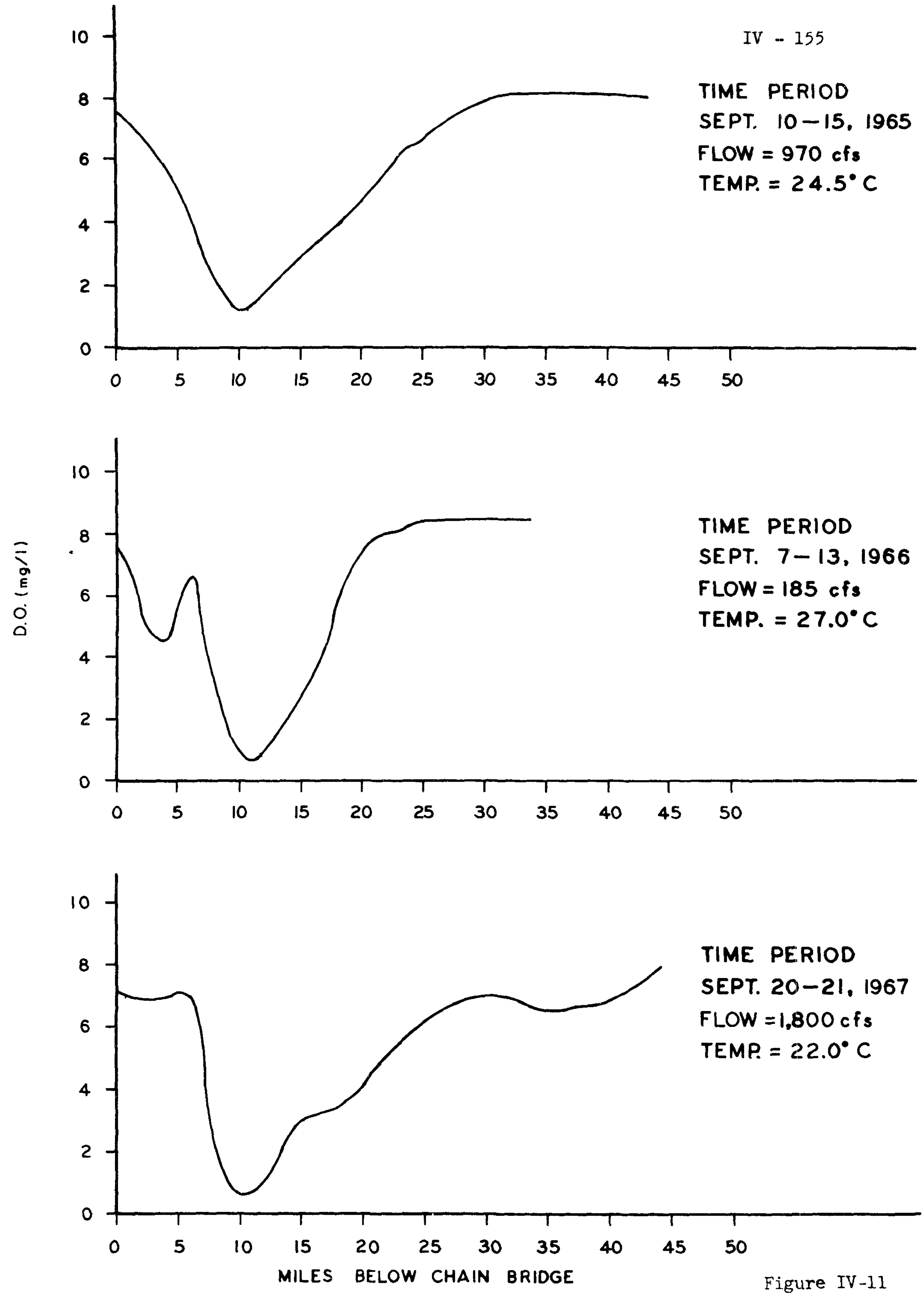

TIME PERIOD
SEPT. 10—15, 1965
FLOW = 970 cfs
TEMP. = 24.5° C
TIME PERIOD
SEPT. 7—13, 1966
FLOW = 185 cfs
TEMP. = 27.0° C
TIME PERIOD
SEPT. 20—21, 1967
FLOW = 1,800 cfs
TEMP. = 22.0° C
D.O. (mg/l)
MILES BELOW CHAIN BRIDGE
0 2 4 6 8 10
0 5 10 15 20 25 30 35 40 45 50

Figure IV-11

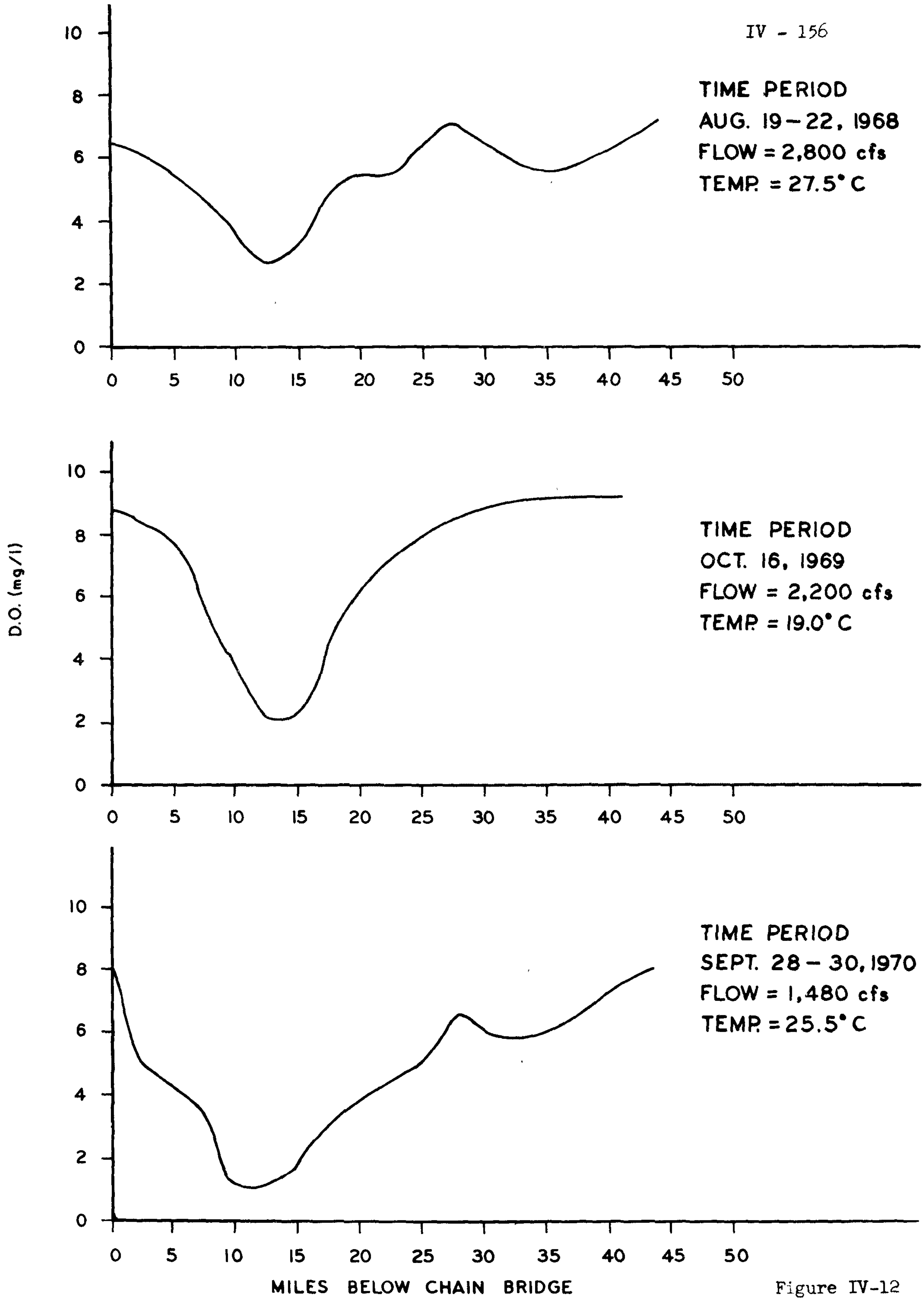

TIME PERIOD
AUG. 19-22, 1968
FLOW = 2,800 cfs
TEMP. = 27.5° C
TIME PERIOD
OCT. 16, 1969
FLOW = 2,200 cfs
TEMP. = 19.0° C
TIME PERIOD
SEPT. 28 - 30, 1970
FLOW = 1,480 cfs
TEMP. = 25.5° C
D.O. (mg/l)
0
2
4
6
8
10
0
5
10
15
20
25
30
35
40
45
50
MILES BELOW CHAIN BRIDGE

Figure IV-12

remain as water quality problems in the Potomac Estuary, nutrient inputs to the estuary are also incluencing a great portion of the estuary.

Detailed analyses of the freshwater inflow from the upper Potomac River Basin at Great Falls, Maryland, were conducted during the period from June 1969 to August 1970 to determine the nutrient contribution of the water entering the tidal system. Based on average monthly flows for the 15-month study period, the results were as follows:

Parameter	Monthly Average (lbs/day)	Percent Contribution to Bay (lbs/day)
TPO_4 as PO_4	23,000	33%
P (Inorganic)	9,900	27%
TKN as N	35,000	23%
$NO_2 + NO_3$ as N	57,000	25%
NH_3 as N	6,000	15%
TOC	267,000	27%

The percent of nutrient input to the Chesapeake Bay and its tidal estuaries by the Potomac River is based on a study of the nutrients contributed from the following rivers: Susquehanna, Rappahannock, Pamunkey, Mattaponi, James, and Chickahominy. The Potomac is the second largest contributor of nutrients to the Bay, outranked only by the Susquehanna River.

The major sources of nutrients in the Potomac Estuary are the Washington Metropolitan Area wastewater discharges. Under low-flow conditions, approximately 90 percent of the nitrogen and 96 percent of the phosphorus are from treated waste effluents. At median freshwater inflows, approximately 60 to 82 percent of the nitrogen and phosphorus, respectively, are from these wastewater discharges.

The total phosphorus from wastewater discharges has increased about 22-fold, from 1,100 lbs/day in 1913 to 24,000 lbs/day in 1970, while total nitrogen loadings have increased from 6,400 to 60,000 lbs/day. The greater increase of phosphorus reflects not only an increase in population but also the increased use of detergents. The current carbon loadings are about 100,000 lbs/day, approximately the same as they were in the mid-1940's.

The concentrations and forms of phosphorus and nitrogen in the Potomac Estuary area are a function of wastewater loadings, temperature, freshwater inflow, and biological activity. As shown in Figure IV-13, inorganic phosphorus concentrations varied considerably, at the six stations sampled, from March 1969 through September 1970. The concentration at Hains Point, located at the upper end of the tidal excursion of the major wastewater discharges, was fairly uniform, averaging about 0.3 mg/l during 1969 and 1970. The data for 1971 show an average of about 0.4 mg/l in this area. At Woodrow Wilson Bridge, located below the Blue Plains wastewater discharge, the inorganic phosphorus concentration increased appreciably with concentrations over 2.5 mg/l during periods of low flow such as those that occurred in the period July to October 1969 and September 1970. The remaining four downstream stations had inorganic phosphorus concentrations progressively smaller.

The total phosphorus concentration closely parallels that of inorganic phosphorus. In the upper reach, the ratio of total phosphorus

INORGANIC PHOSPHATE CONCENTRATION as PO_4
POTOMAC ESTUARY
1969 - 1970

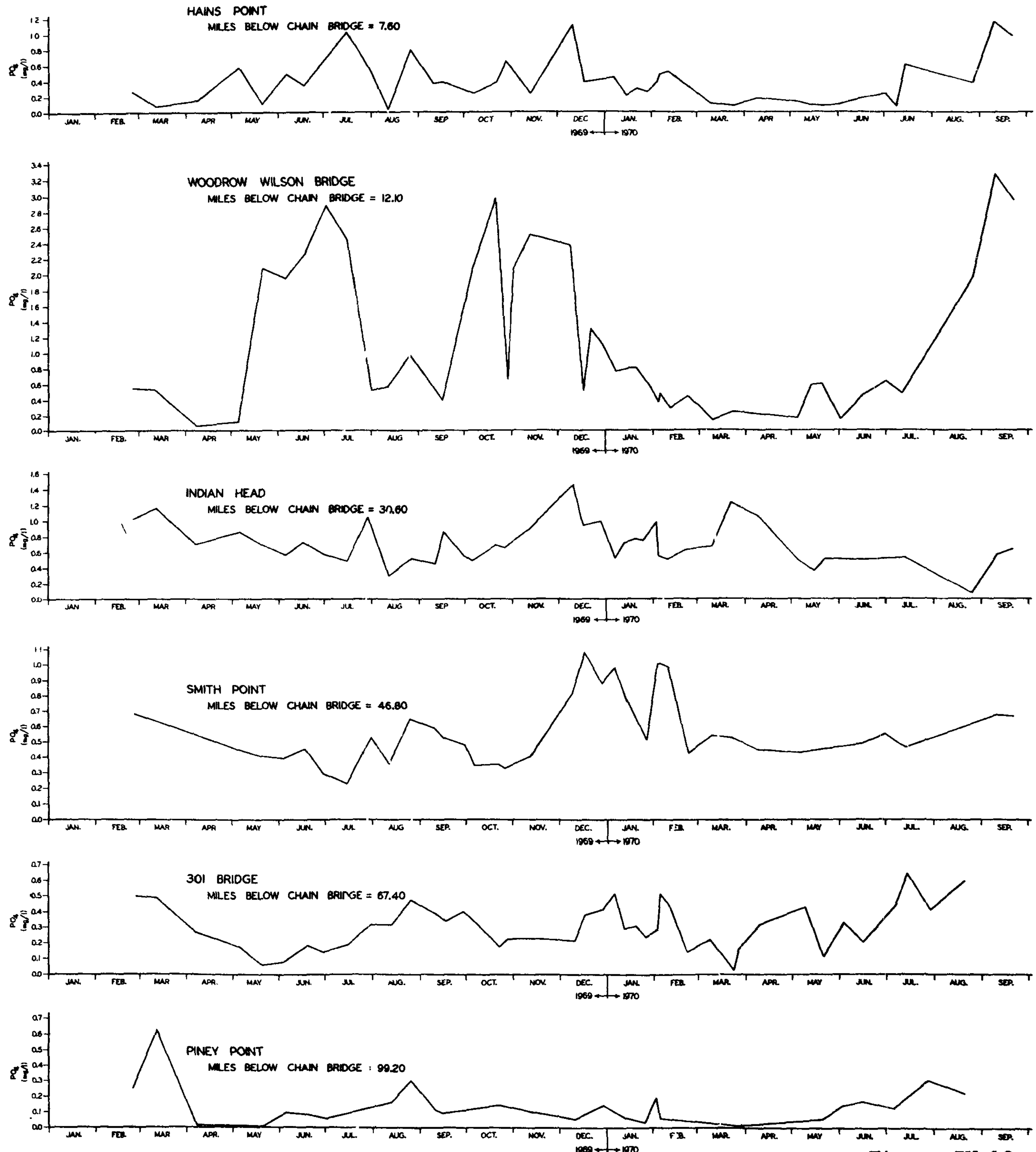


Figure IV-13

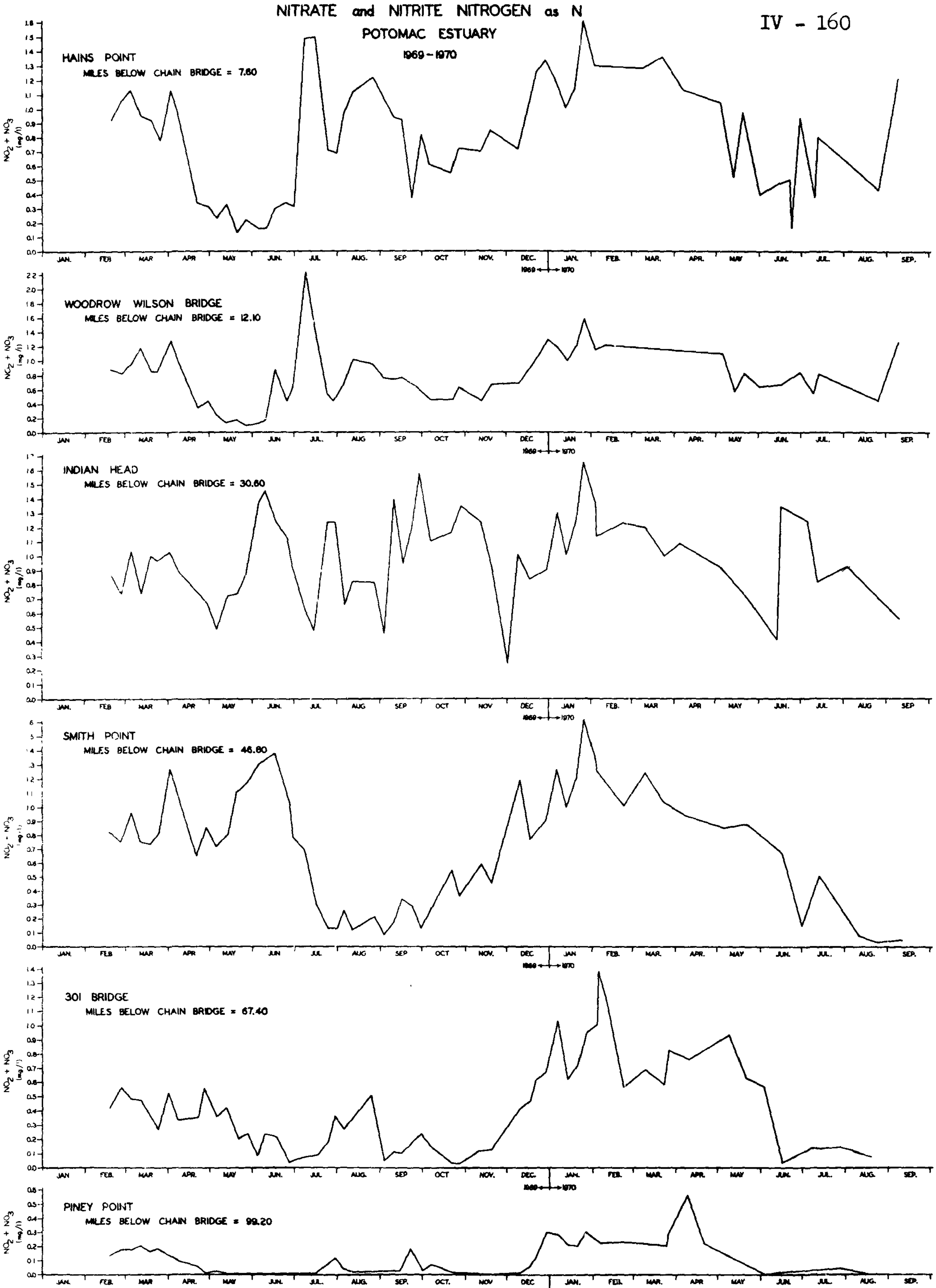

NITRATE and NITRITE NITROGEN as N
POTOMAC ESTUARY
1969 - 1970
HAINS POINT
MILES BELOW CHAIN BRIDGE = 7.60
WOODROW WILSON BRIDGE
MILES BELOW CHAIN BRIDGE = 12.10
INDIAN HEAD
MILES BELOW CHAIN BRIDGE = 30.60
SMITH POINT
MILES BELOW CHAIN BRIDGE = 46.80
301 BRIDGE
MILES BELOW CHAIN BRIDGE = 67.40
PINEY POINT
MILES BELOW CHAIN BRIDGE = 99.20
NO2 + NO3 (mg/l)
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP.
1969 1970

Figure IV-14

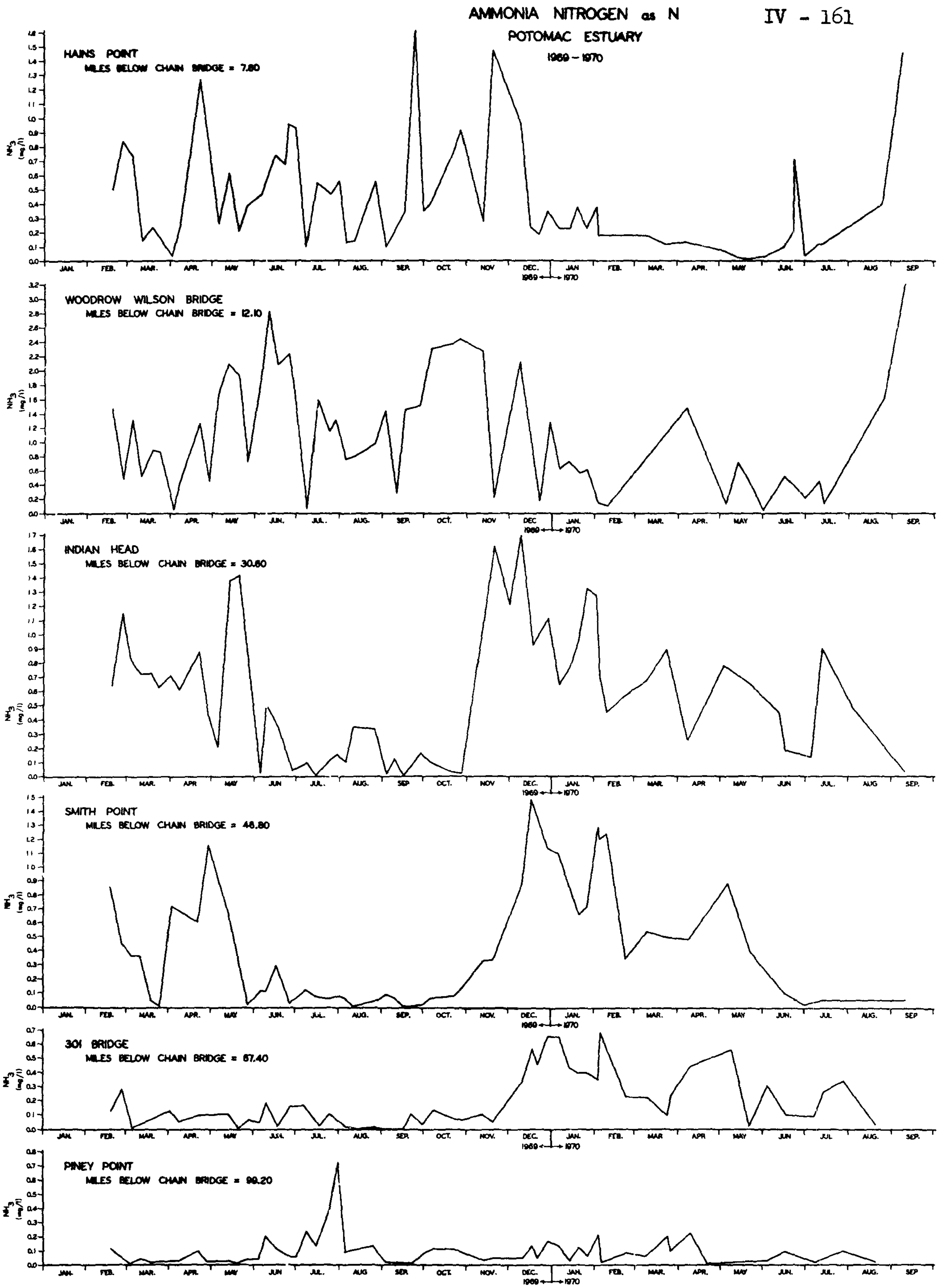

AMMONIA NITROGEN as N
POTOMAC ESTUARY
1969 – 1970
HAINS POINT
MILES BELOW CHAIN BRIDGE = 7.80
WOODROW WILSON BRIDGE
MILES BELOW CHAIN BRIDGE = 12.10
INDIAN HEAD
MILES BELOW CHAIN BRIDGE = 30.80
SMITH POINT
MILES BELOW CHAIN BRIDGE = 46.80
301 BRIDGE
MILES BELOW CHAIN BRIDGE = 67.40
PINEY POINT
MILES BELOW CHAIN BRIDGE = 99.20
NH3 (mg/l)
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP.
1969 ← → 1970

Figure IV-15

to inorganic phosphorus ranges from 1.1 to 1.5. The ratio is higher in the middle reach, normally varying from 1.5 to 2.0 with the ratio in the lower reach having a range of approximately 2.0 to 2.5.

The concentration of nitrite (NO_2) and nitrate (NO_3) nitrogen at Hains Point and Woodrow Wilson Bridge varies almost inversely with that of phosphorus (Figure IV-14). The NO_2+NO_3 concentration was highest in July and August 1969 and during the spring months of 1970. The increase of NO_2+NO_3 at Indian Head, as compared to Woodrow Wilson Bridge in May-June 1969, September-November 1969, and July 1970, was a result of the conversion of ammonia from the wastewater treatment plant discharges to NO_3. The extremely low concentrations of NO_2+NO_3 in the summer months at Smith Point was caused by uptake by algal cells. During winter months algal utilization is lower, thus the concentrations of nitrates are high, as in January and April 1970. At Piney Point, concentrations of NO_2+NO_3 were usually less than 0.1 mg/l during 1969, 1970, and 1971.

The concentration of ammonia nitrogen is also affected by flow and temperature conditions. Although large quantities of ammonia are discharged into the Potomac near Woodrow Wilson Bridge from wastewater treatment facilities, the ammonia at Indian Head during the summer months is low because of nitrification.

During the summer and early fall months, the average ranges of pH, alkalinity, and free dissolved CO_2 (measured by titration) for the five stations in the upper and middle reaches were:

Table IV-40

LOCATION	pH (units)	ALKALINITY (mg/l as $CaCO_3$)	FREE DISSOLVED CO_2 (mg/l)
Chain Bridge	7.5 - 8.0	80 - 100	2 - 4
W. Wilson Bridge	7.0 - 7.5	90 - 110	8 - 12
Indian Head	7.2 - 8.0	70 - 90	6 - 10
Maryland Point	7.5 - 8.2	60 - 85	2 - 8
Rte. 301 Bridge	7.5 - 8.0	65 - 85	7 - 8

In the vicinity of the Woodrow Wilson Bridge, the increase in both alkalinity and CO_2 with a corresponding decrease in pH is attributed to wastewater discharges. The decrease in both alkalinity and CO_2 with a corresponding increase in pH at the Indian Head and Maryland Point stations is due to algal growths. In the lower estuary, the increased alkalinity and CO_2 values and decreased pH values are caused by the smaller algal standing crops in this area.

HEAVY METALS

Recent detection of heavy metals in sediments of the Potomac River Estuary has raised sufficient concern to include the accumulation of metals as a water quality problem requiring additional study and analysis.

A cooperative program of the Annapolis Field Office and the U.S. Naval Ordnance Station laboratory in Indian Head, Maryland, was initiated to determine the occurrence of heavy metals in the Potomac Estuary and bottom sediment Sediment analyses were made during August and

September 1970, and again in April 1971. While small concentrations of zinc and manganese were detected in the overlying waters of the estuary, considerable amounts of various heavy metals were found in the sediment by acid extraction determination.

From the sediment analyses presented on the following pages it is evident that the concentrations of lead, cobalt, chromium, cadmium, copper, nickel, zinc, silver, barium, aluminum, iron, and lithium in the upper estuary in the area immediately above the Woodrow Wilson Bridge are greater than the metal concentrations measured above and below this area. Of the metals measured in April 1971, all showed increases in concentrations in this area but the concentrations were lower than those detected in August and December of 1970.

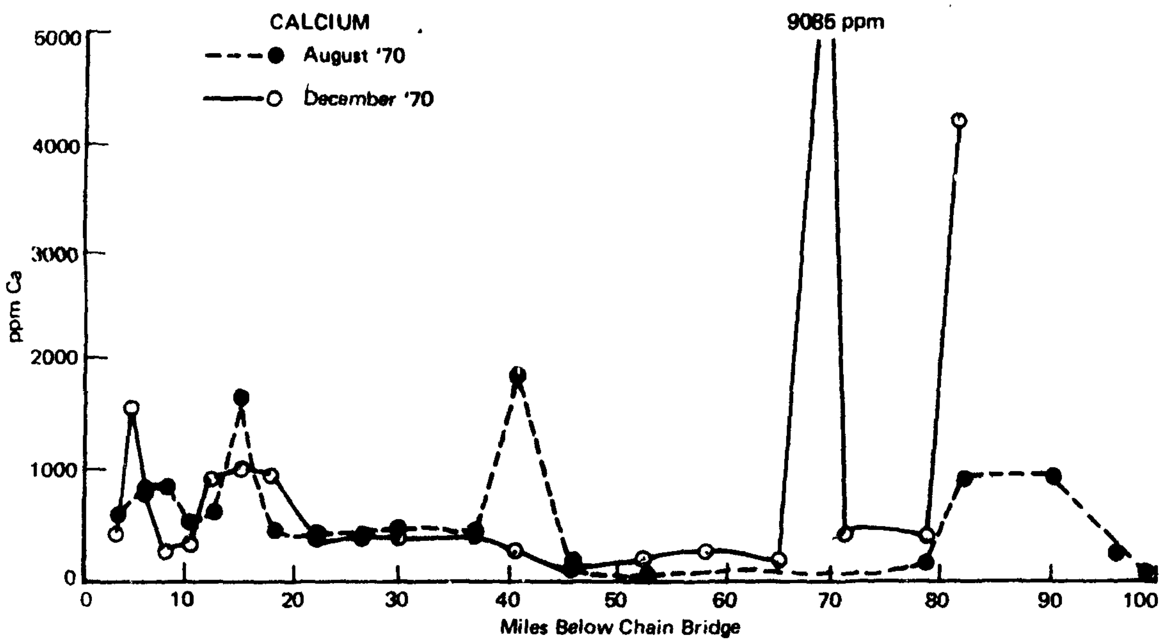
At Possum Point and the Route 301 Bridge, 38.0 and 67.4 miles below Chain Bridge, respectively, the incidence of metals in the sediment again increased significantly. While there were increases in the qualtities of most metals at the two sampling stations, the following showed the greatest increased concentrations when compared to the initial determinations made in August 1970: barium, lead, iron, strontium, lithium, cobalt, magnesium, chromium, nickel, and potassium. At the Route 301 Bridge sampling station, copper showed a sharp increase in April 1971, to 731 ppm, while at Possum Point the April 1971 amount was lower than that of December 1970.

Although mercury is not included in the data set forth at the end of this section, sediment samples were analyzed for mercury. The concentration of mercury was found to be below the detection limit in practically all samples analyzed. Exceptions were noted at Piscataway Creek, Hallowing Point, Indian Head, Possum Point, and Sandy Point during December 1970, at which time the concentrations measured were 26.2, 5.0, 5.0, 5.6, and 4.7 ppb, respectively.

Arsenic, antimony, boron, bismuth, lanthanum, molybdenum, selenium, tin, and zirconium were included in the list of metals to be measured. However, the concentration of these metals was found to be below the detection limit in all samples.

Heavy metals in the Potomac Estuary are chemically bound in bottom sediment and require heat and an acid-induced low pH in the laboratory procedure employed to extract them from the sediment samples. These metals, and the possibility of their remineralization into the overlying water, must be considered in the disposal of dredged spoil. Dredging operations involving deepening and widening of the channels near Washington, construction of piers and marinas, etc., disturb the sediments and require disposal of the dredged spoil. Should dredged material containing high concentrations of potentially toxic metals be deposited in open waters of the estuary during high-flow conditions, colloidal suspension of the fine clay sediments with adsorbed metals could be transported downstream to economically important shellfish growing areas. The metals could then be taken up by filter-feeding organisms which pump water through their digestive systems with probable accumulations of metals occurring in these organisms.

A more detailed report entitled "Heavy Metals Analyses of Bottom Sediment in the Potomac Estuary", which discusses possible sources of


CALCIUM
August '70
December '70
9086 ppm
5000
4000
3000
2000
1000
0
ppm Ca
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

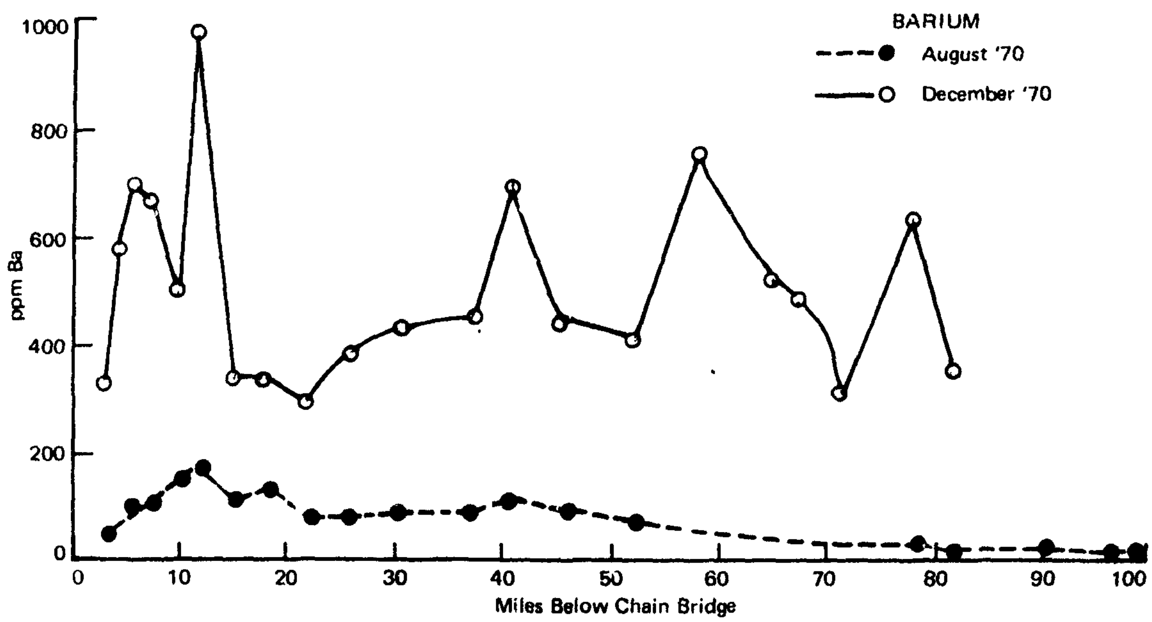
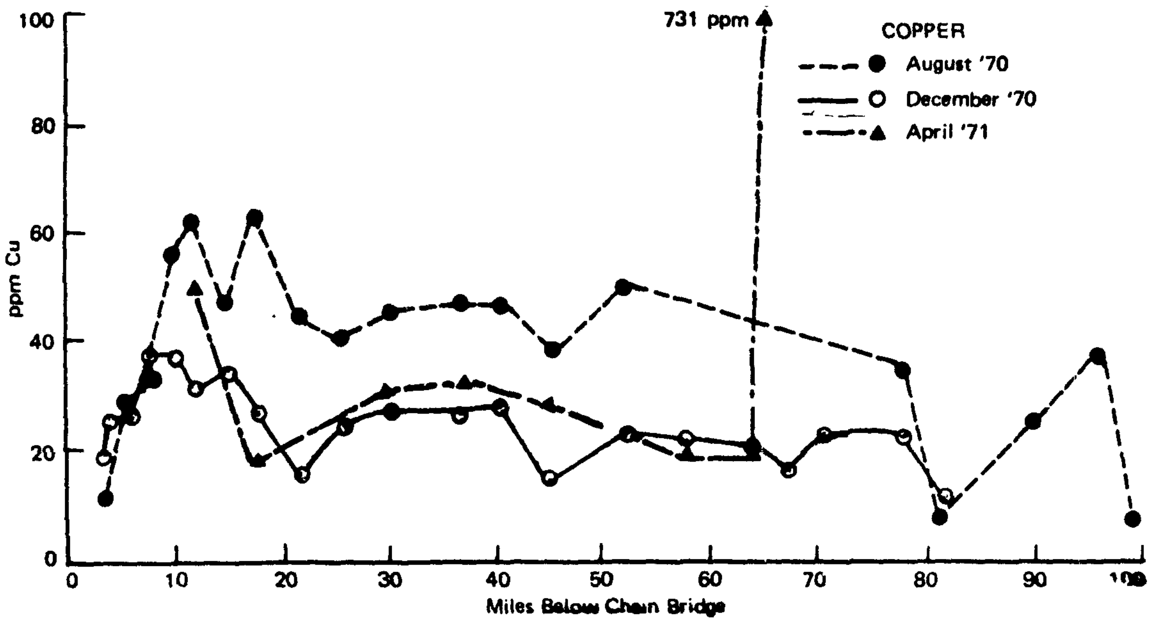

BARIUM
August '70
December '70
1000
800
600
400
200
0
ppm Ba
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

Figure IV-16


COPPER
August '70
December '70
April '71
731 ppm
ppm Cu
Miles Below Chain Bridge

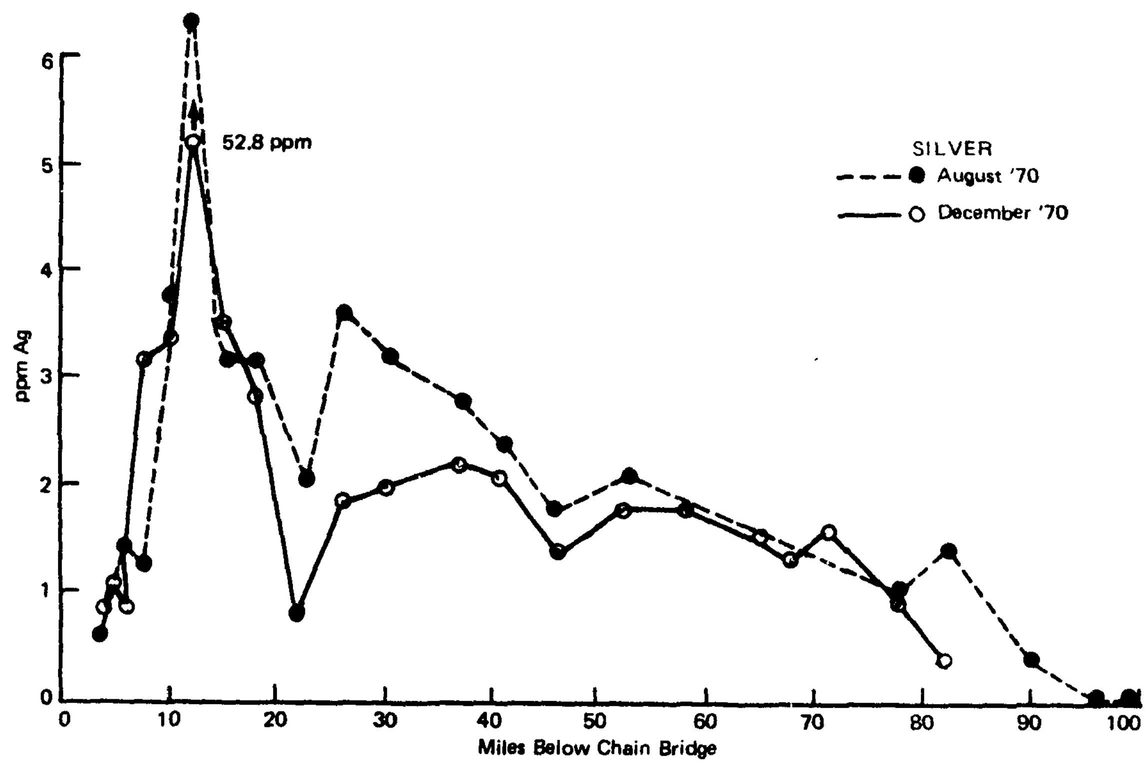
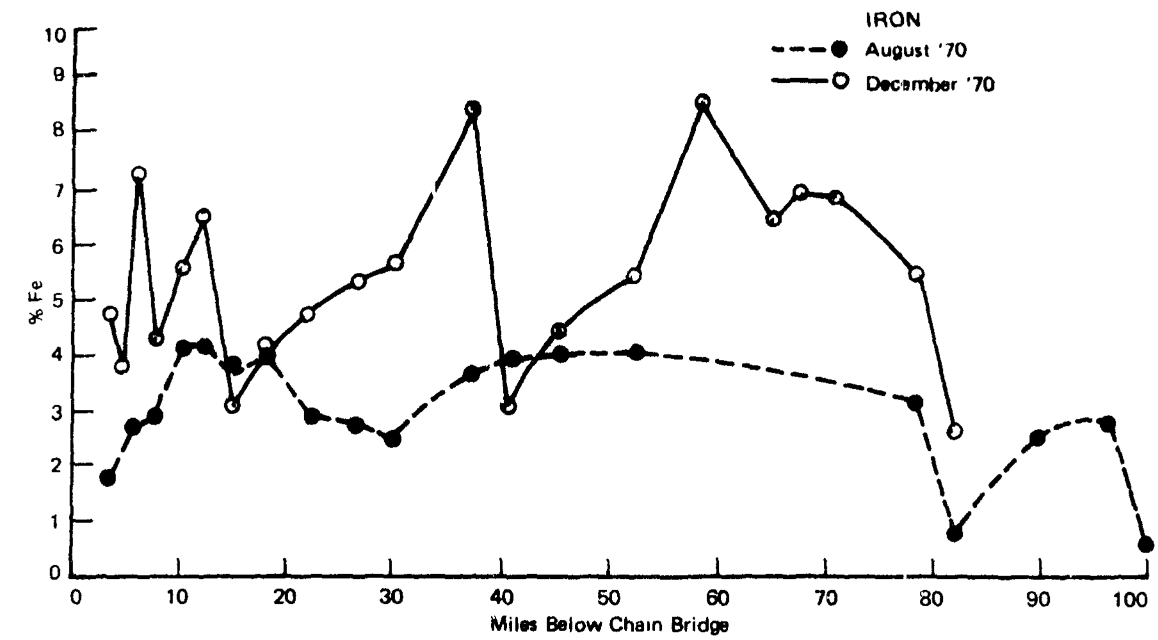

SILVER
August '70
December '70
52.8 ppm
ppm Ag
Miles Below Chain Bridge

Figure IV-17


IRON
August '70
December '70
% Fe
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

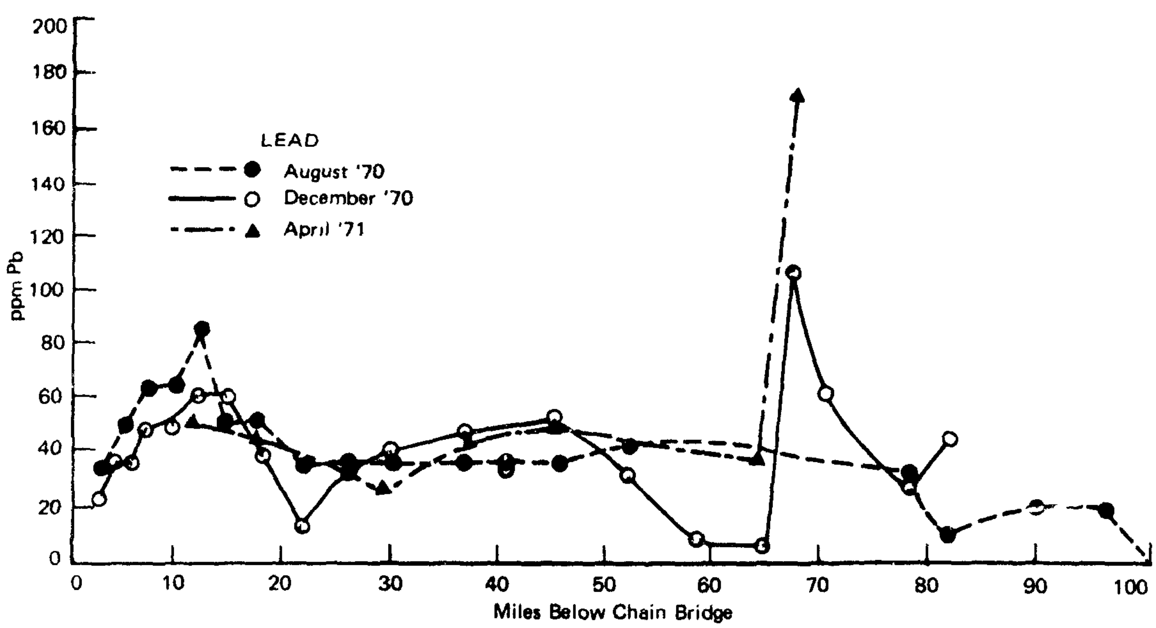
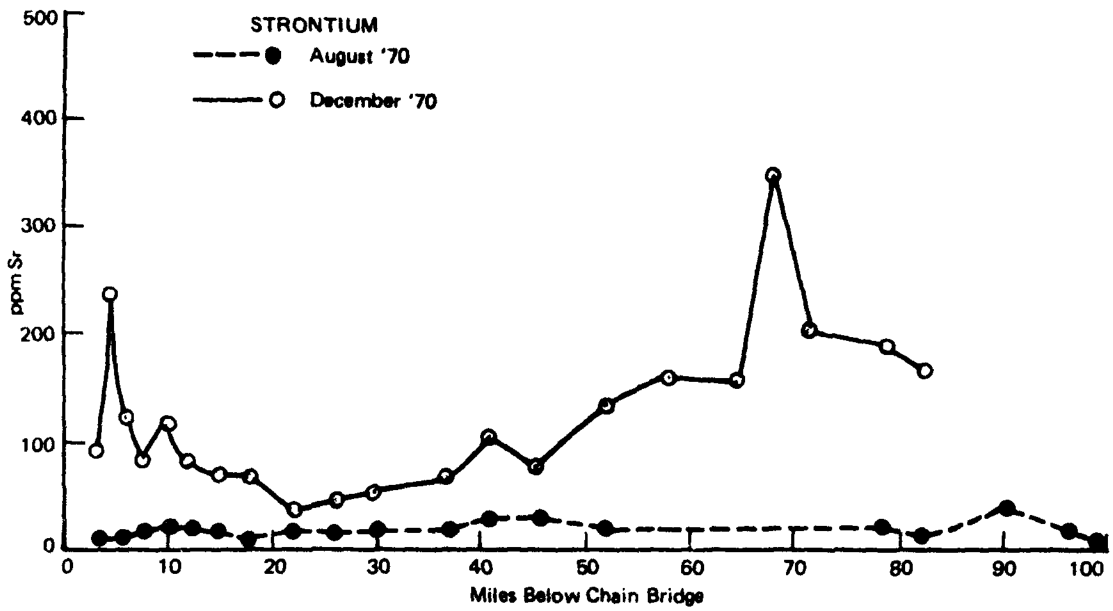

LEAD
August '70
December '70
April '71
ppm Pb
0
20
40
60
80
100
120
140
160
180
200
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

Figure IV-18


STRONTIUM
August '70
December '70
ppm Sr
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

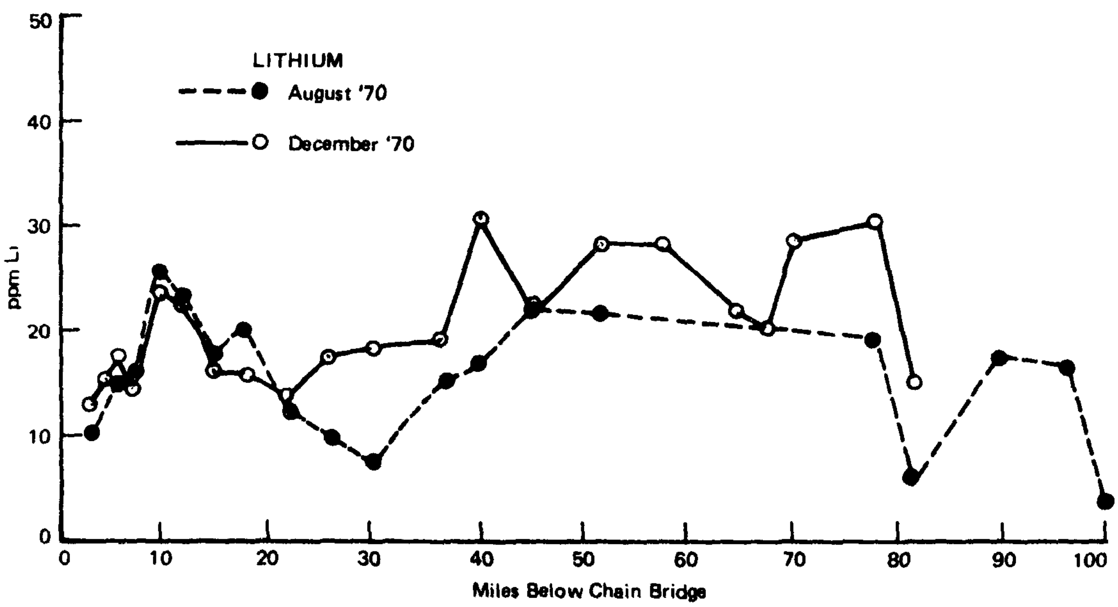
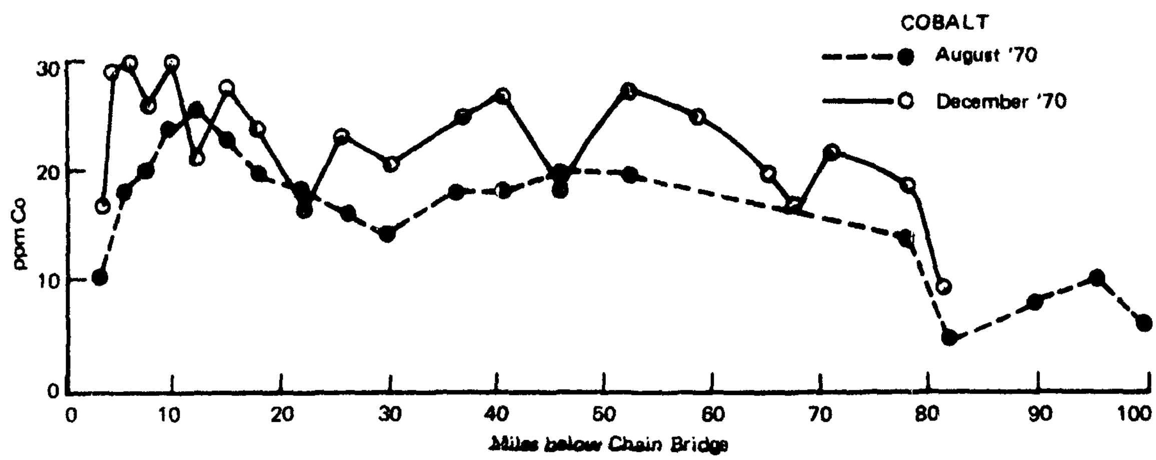

LITHIUM
August '70
December '70
ppm Li
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

Figure IV-19


COBALT
August '70
December '70
30
20
10
0
ppm Co
0
10
20
30
40
50
60
70
80
90
100
Miles below Chain Bridge

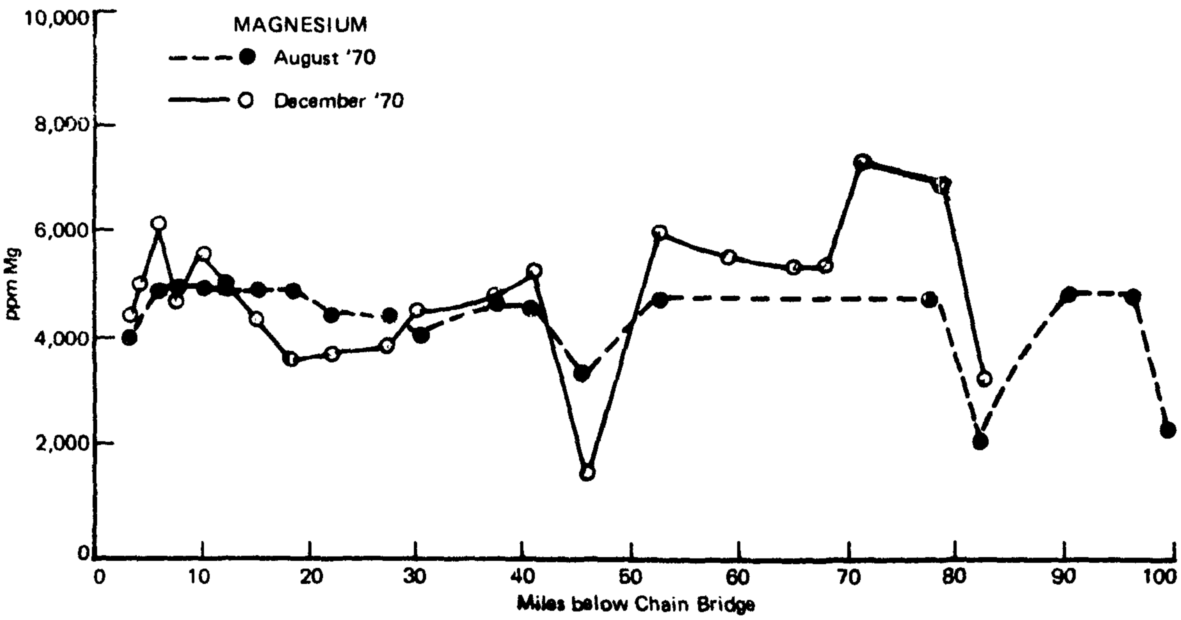

MAGNESIUM
August '70
December '70
10,000
8,000
6,000
4,000
2,000
0
ppm Mg
0
10
20
30
40
50
60
70
80
90
100
Miles below Chain Bridge

Figure IV-20

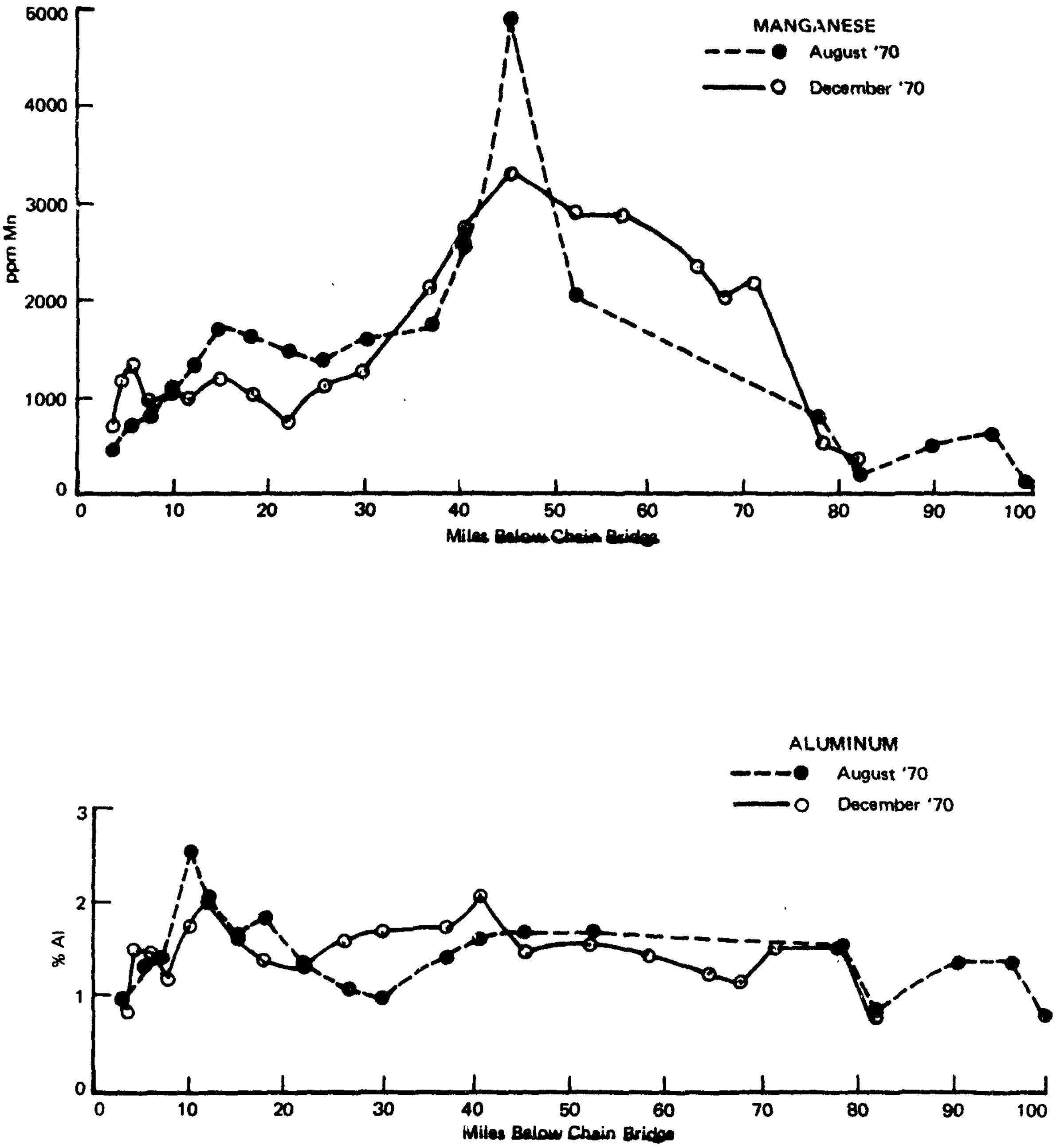
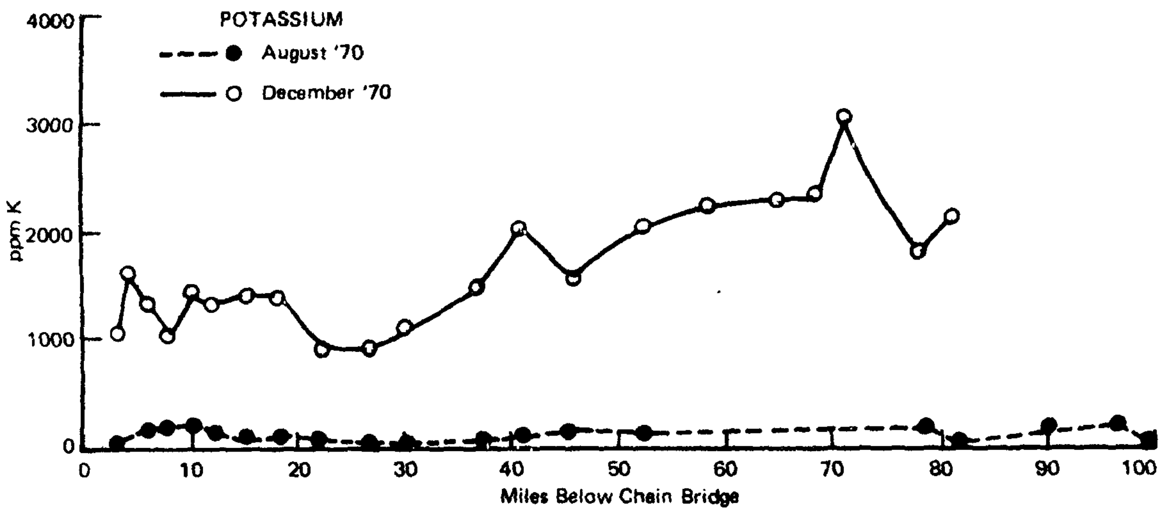

MANGANESE
August '70
December '70
ppm Mn
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge
ALUMINUM
August '70
December '70
% Al
3
2
1
0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

Figure IV-21


POTASSIUM
August '70
December '70
4000
3000
2000
1000
0
ppm K
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

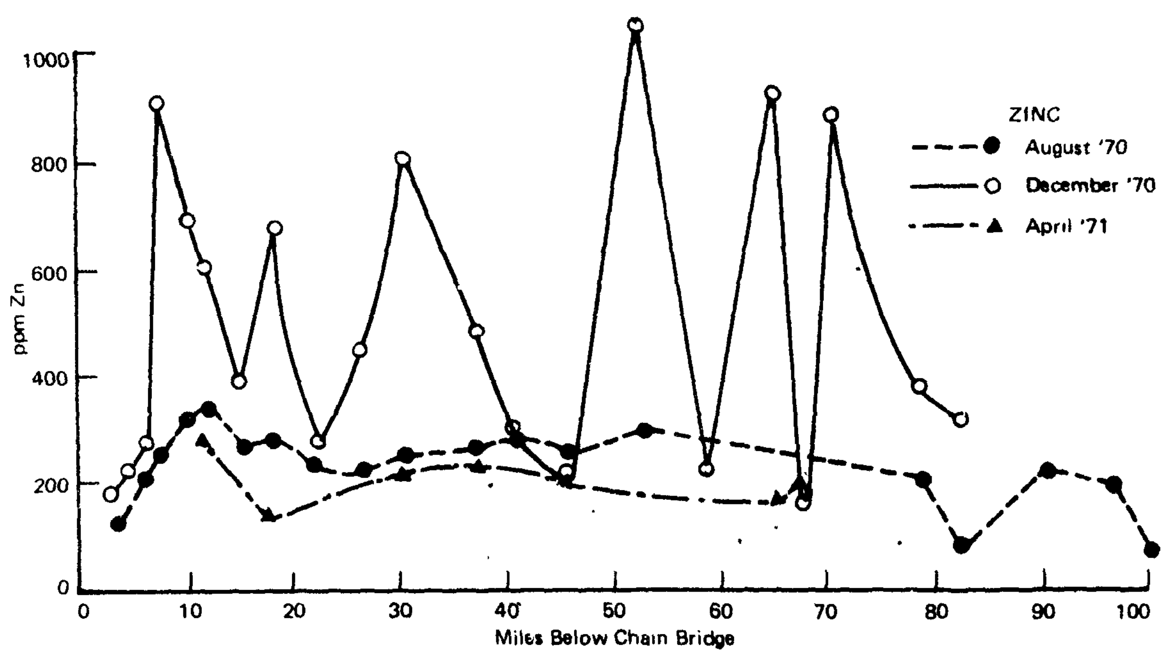
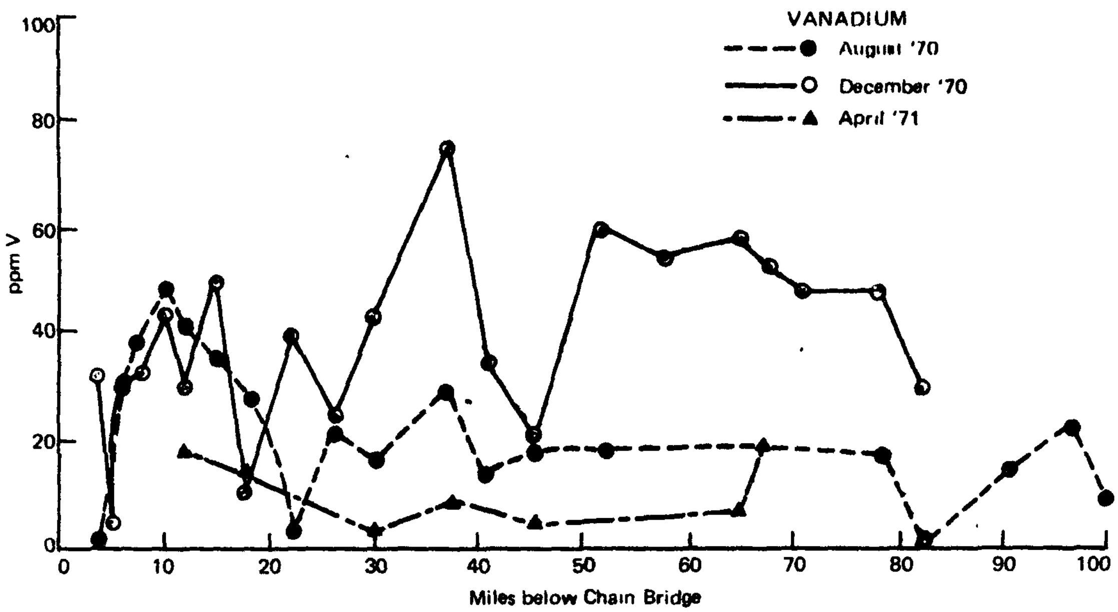

ZINC
August '70
December '70
April '71
1000
800
600
400
200
0
ppm Zn
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

Figure IV-22


VANADIUM
August '70
December '70
April '71
ppm V
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
Miles below Chain Bridge

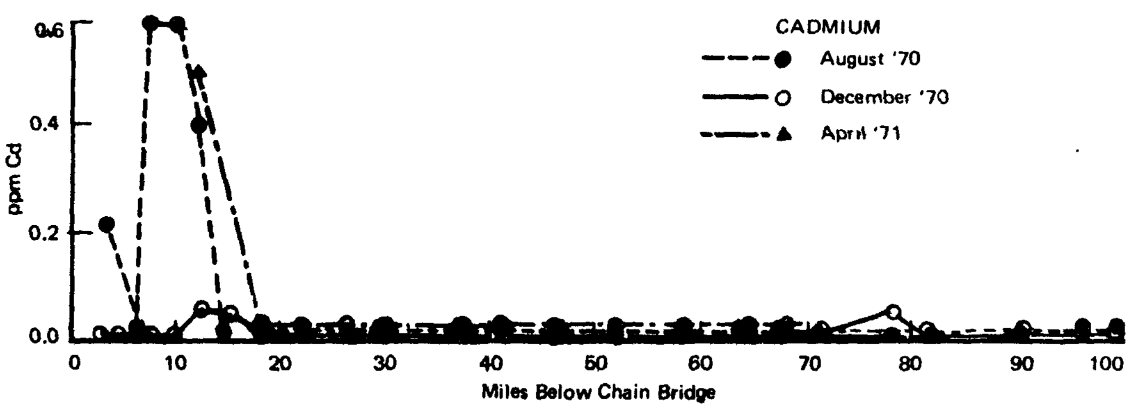
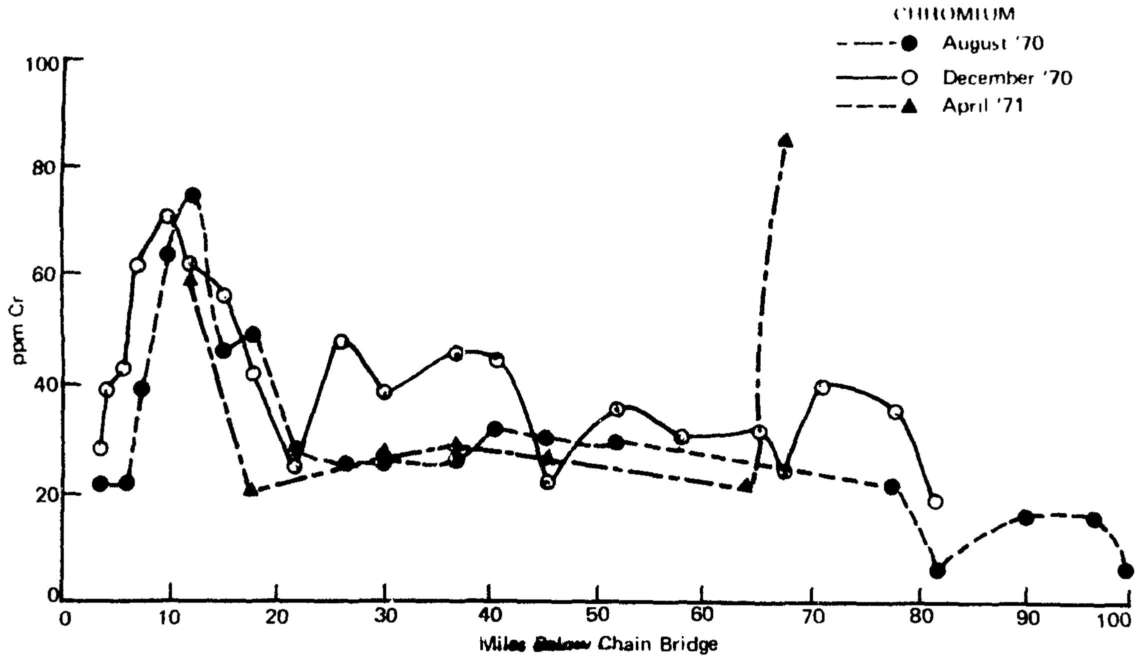

CADMIUM
August '70
December '70
April '71
ppm Cd
0.6
0.4
0.2
0.0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

Figure IV-23


CHROMIUM
August '70
December '70
April '71
ppm Cr
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

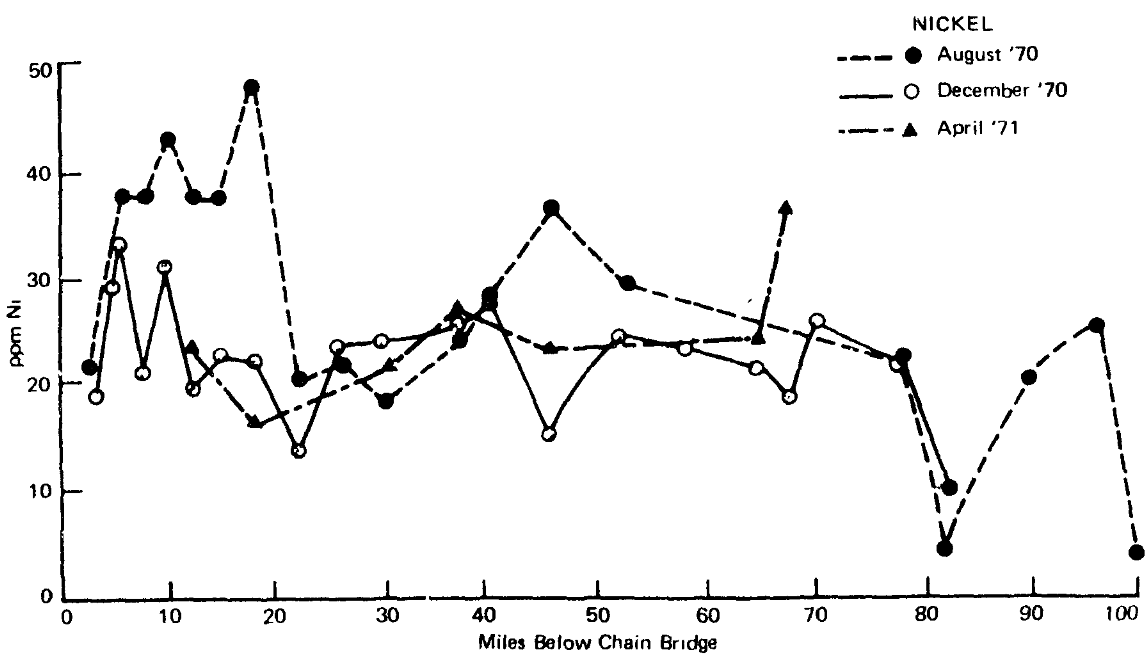

NICKEL
August '70
December '70
April '71
ppm Ni
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

Figure IV-24

heavy metals in the bottom sediment and recommends further studies, is available from the Annapolis Field Office of EPA, Annapolis, Maryland.

CHLORINATED HYDROCARBON PESTICIDES

During August 5 to 11, 1969, samples obtained from six stations in the Potomac Estuary and a 24-hour composite sample of the final effluent from the Blue Plains Wastewater Treatment Plant were analyzed for pesticides. The estuary stations sampled are as follows:

STATION	MILES FROM CHESAPEAKE BAY
Chain Bridge	106.5
Arlington Memorial Bridge	100.7
Woodrow Wilson Bridge	94.4
Piscataway	89.0
Indian Head	77.5
U. S. Route 301 Bridge	46.3

The pesticide compounds for which the samples were analyzed and the minimum detectable concentrations for each are presented in Table IV-41.

None of these compounds were detected in any of the six estuary samples or in the 24-hour composite of the final effluent from the Blue Plains facility.

Since there is considerable agricultural use of insecticides and herbicides within the Potomac River Basin at certain times of the year, and because of the limited data available, further surveys to include those seasons of use are needed.

Table IV-41

PESTICIDES ANALYZED AND

MINIMUM DETECTABLE LIMITS

COMPOUND	MINIMUM DETECTABLE CONCENTRATION ng/l*
Dieldrin	5
Endrin	5
DDT	10
DDE	5
Heptachlor	5
Heptachlor Epoxide	5
Aldrin	5
BHC	5
Endosulphan	5
Chlordane (Tech.)	25
Toxaphene	1,000
Methoxychlor	25

* ng/l = nanograms/liter

WATER QUALITY TRENDS

The Potomac tidal system is saline in the lower reach with the middle reach brackish and the upper reach fresh water. These differences in salinity as well as nutrient enrichment by wastewater discharges have a pronounced effect on the ecology of the estuary. Under summer and fall conditions, large populations of blue-green algae (a pollution tolerant phytoplankton), mainly Anacystis sp. are prevalent in the freshwater portion of the estuary. Large standing crops of this alga occur, especially during periods of low flow, forming green mats of cells. The blue-green algae are apparently not readily grazed by the higher trophic forms and therefore are often considered a "dead end" of the normal food chain.

The large populations of blue-green algae have been observed from Woodrow Wilson Bridge downstream to Potomac River Route 301 Bridge during the months of June through October. In September of 1970, after a period of low-stream flow and high temperatures, the algal mats extended upstream beyond Hains Point and included the first nuisance growth within the Tidal Basin. The effects of the algal blooms in the middle estuary are (1) an increase of over 490,000 lbs/day in total oxygen demand, (2) an overall decrease in dissolved oxygen due to algal respiration in waters 12 feet and greater in depth, (3) creation of nuisance and aesthetically objectionable conditions, and (4) reduction in the feasibility of using the upper estuary as a potable water supply source because of potential toxin, taste, and odor problems.

In the saline portion of the Potomac Estuary, the algal populations are not as dense as in the freshwater portion. Nevertheless, at times large populations of marine phytoplankton, primarily the algae *Gymnodinium* sp., *Massartia* sp., and *Amphidinium* sp., occur producing massive growths known as "red tides."

On February 28 and 29, and March 1, 1972, Dr. Donald Lear, Annapolis Field Office, observed extremely widespread "red tides" in the Lower Potomac Estuary. In Neale Sound, behind Cobb Island at the mouth of the Wicomico River, in Charleston Creek (a tributary to the Wicomico River), the Wicomico River itself, St. Catherine's Sound, Whites Neck Creek (tributary to St. Catherine's Sound), the Potomac River itself in this area, Dukeharts Channel, St. Clements Bay, St. Patrick Creek, Canoe Neck Creek, and the Potomac River in the vicinity of Piney Point (about 15 or 20 miles downstream) all showed evidence of red tide conditions. Dr. Lear reported that water temperature at the time of the observations was 10 to 12°C and that the causative organism was presumably due to the phytoplankter *Massartia*. This organism is not uncommonly encountered in the lower Bay in late summer and early fall, but is always associated with warm water conditions. In the winter of 1971, a few blooms of *Massartia* were recorded in the vicinity of Morgantown and in the reaches immediately adjacent to the Morgantown area. The 1971 blooms were few and remarkable because they had not been noted before.

The effect of the increases in nutrient loadings from wastewater since 1913 on the dominant plant forms in the upper estuary has been dramatic (Figure IV-25). Several nutrients and other growth factors have been implicated as stimulating this, with nitrogen and phosphorus showing promise of being the most manageable.

The historical plant life cycles in the upper Potomac Estuary can be inferred from several studies. Cumming [1] surveyed the estuary in 1913-1914 and noted the absence of plant life near the major waste outfalls with "normal" amounts of rooted aquatic plants on the flats or shoal areas below the urban area. No nuisance levels of rooted aquatic plants or phytoplankton blooms were noted.

In the 1920's, an infestation of water chestnut appeared in the waters of the Chesapeake Bay including the Potomac Estuary. This infestation was controlled by mechanical removal [2].

In September and October 1952, another survey of the reaches near the metropolitan area made by Bartsch [3] revealed that vegetation in the area was virtually nonexistent. No dense phytoplankton blooms were reported although the study did not include the downstream areas where they were subsequently found.

In August and September 1959, a survey of the area was made by Stotts and Longwell [4]. Blooms of the nuisance blue-green alga Anacystis were reported in the Anacostia and Potomac Rivers near Washington.

In 1958 a rooted aquatic plant, water milfoil, developed in the Potomac Estuary and created nuisance conditions. The growth increased

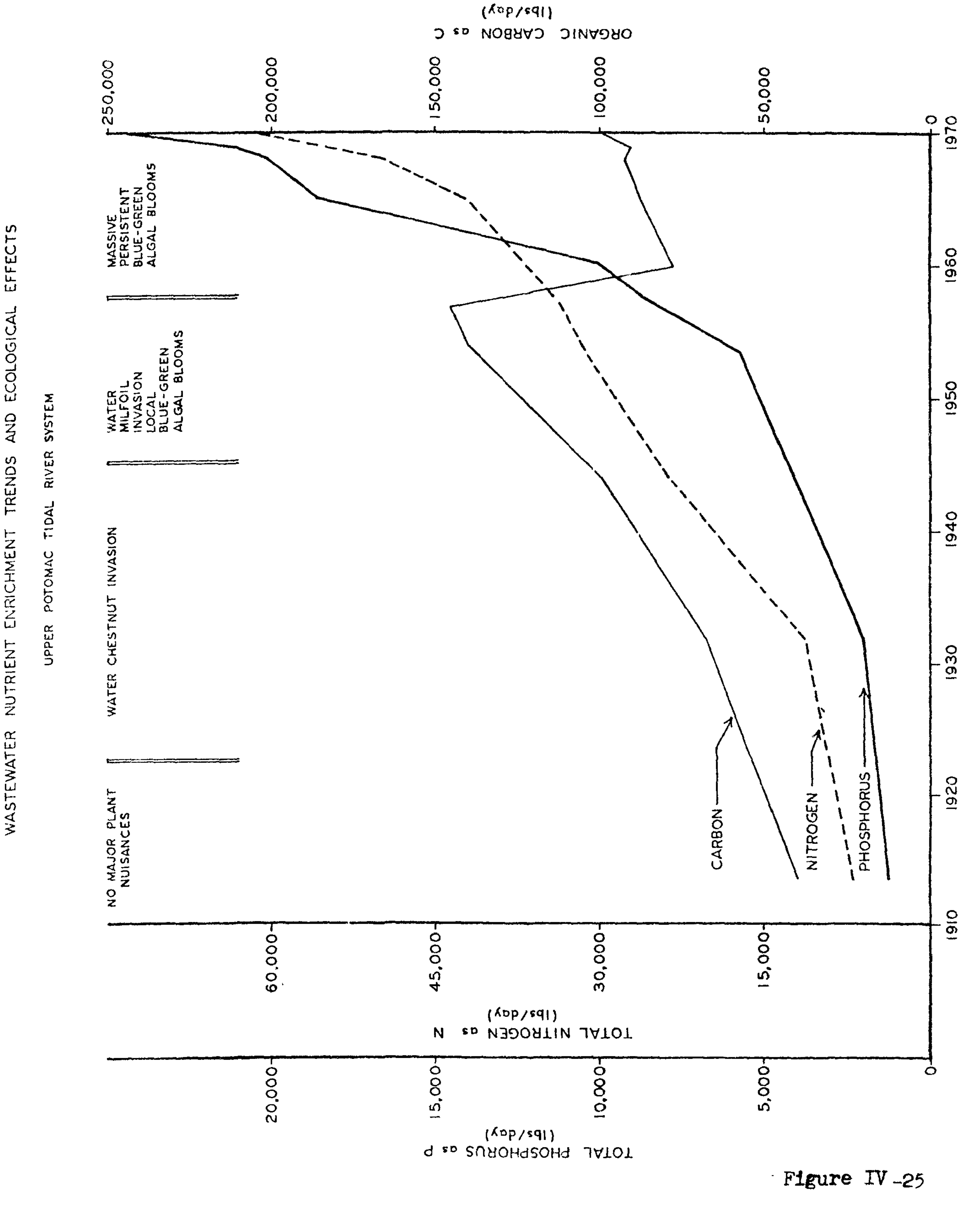

WASTEWATER NUTRIENT ENRICHMENT TRENDS AND ECOLOGICAL EFFECTS
UPPER POTOMAC TIDAL RIVER SYSTEM
NO MAJOR PLANT NUISANCES
WATER CHESTNUT INVASION
WATER MILFOIL INVASION LOCAL BLUE-GREEN ALGAL BLOOMS
MASSIVE PERSISTENT BLUE-GREEN ALGAL BLOOMS
ORGANIC CARBON as C (lbs/day)
250,000
200,000
150,000
100,000
50,000
0
TOTAL NITROGEN as N (lbs/day)
60,000
45,000
30,000
15,000
TOTAL PHOSPHORUS as P (lbs/day)
20,000
15,000
10,000
5,000
0
1910
1920
1930
1940
1950
1960
1970
CARBON
NITROGEN
PHOSPHORUS

Figure IV-25

to major proportions by 1963, especially in the embayments from Indian Head downstream [5].

These dense strands of rooted aquatic plants, which rapidly invaded the stream, dramatically disappeared in 1965 and 1966. The decrease was presumably due to a natural virus [6].

Subsequent and continuing observations by the Annapolis Field Office have confirmed persistent massive summer blooms of the blue-green alga Anacystis in nuisance concentrations of greater than 50 µg/l from the metropolitan area downstream at least as far as Maryland Point [7]. Chlorophyll a determinations (a gross measure of algal standing crop) in the upper reach and in the middle and lower reaches of the Potomac Estuary are presented in Figures IV-26 and IV-27, respectively.

Chlorophyll a at Indian Head and Smith Point for 1965-1966 and 1969-1970, as presented in Figures IV-26 and IV-27 respectively, indicate that algal populations have not only increased in density but have become more persistent over the annual cycle. At both stations, higher values of chlorophyll were measured during the 1969-1970 sampling cruises. The occurrence of a spring bloom of diatoms was observed in 1969 and 1970. This had not been observed during the 1965-1966 cruises.

These biological observations over the years appear to indicate a species succession. The initial response to a relatively light overenrichment [2] was the growth of water chestnut which, when removed, allowed the increasing nutrient load to be taken up into the rooted aquatic plant, water milfoil (Myriophyllum spicatum). The die-off of

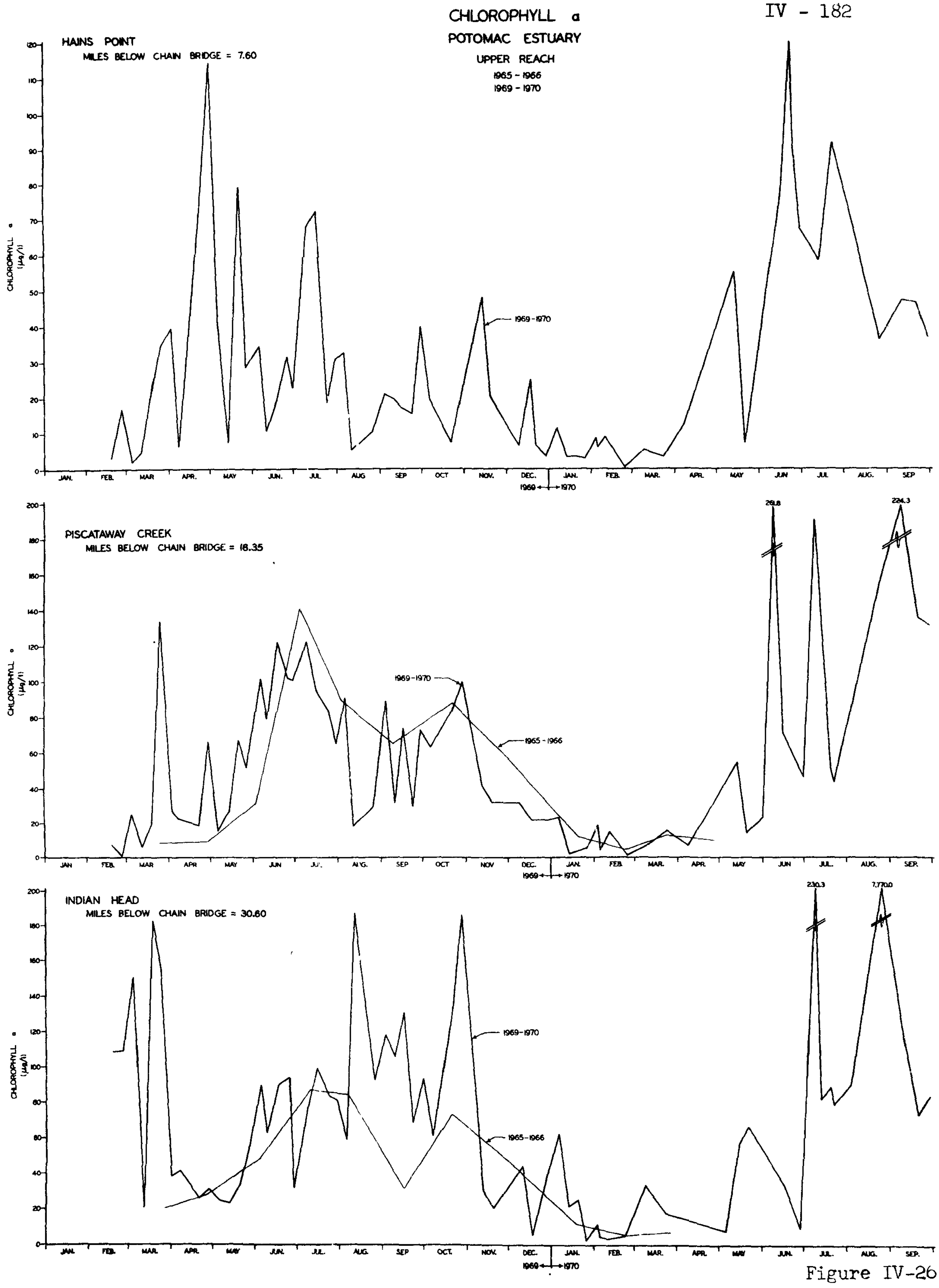
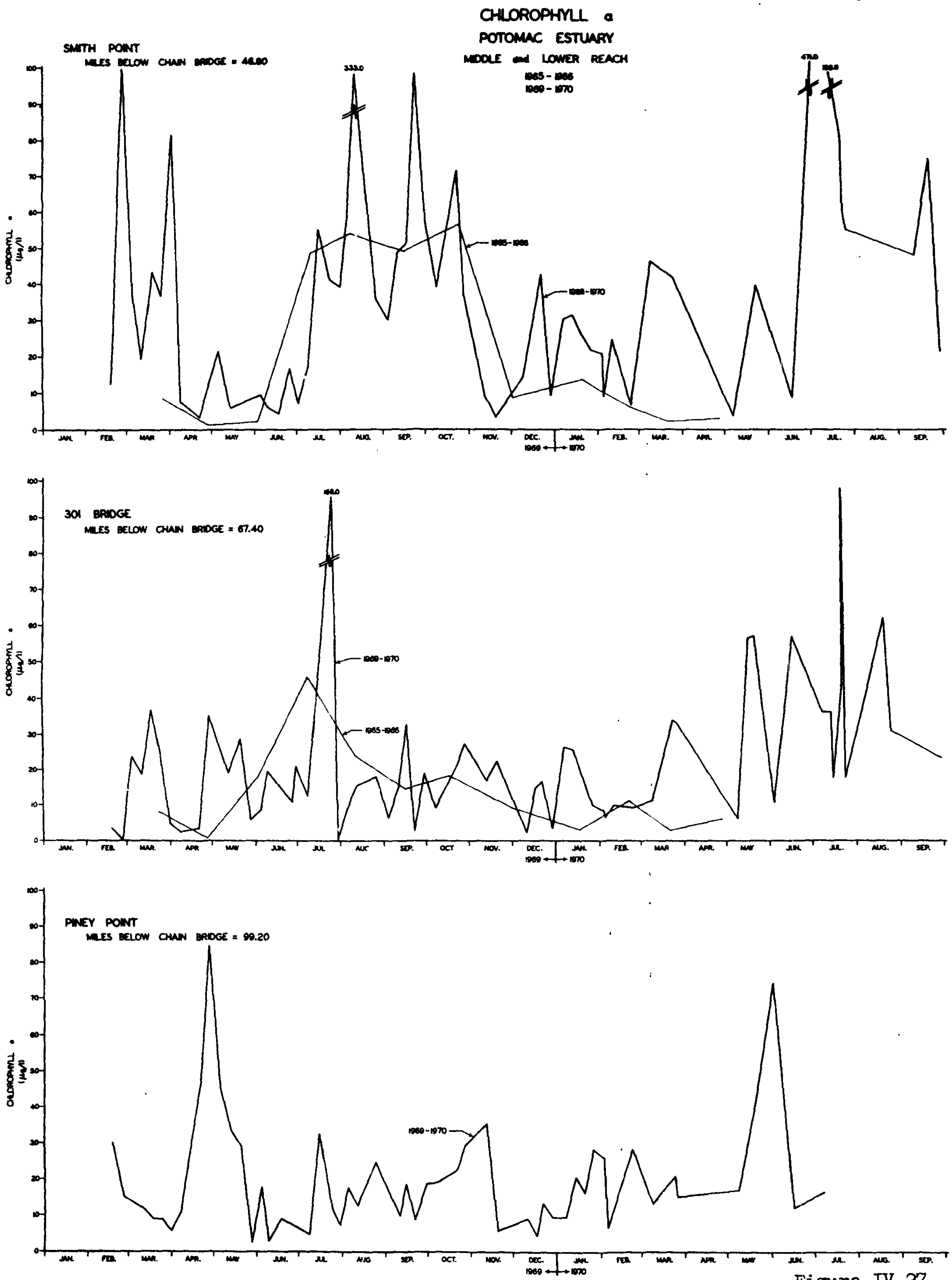

CHLOROPHYLL a
POTOMAC ESTUARY
UPPER REACH
1965 - 1966
1969 - 1970
HAINS POINT
MILES BELOW CHAIN BRIDGE = 7.60
CHLOROPHYLL a (μg/l)
1969-1970
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP.
1969 ← → 1970
PISCATAWAY CREEK
MILES BELOW CHAIN BRIDGE = 18.35
261.8
224.3
1969-1970
1965-1966
INDIAN HEAD
MILES BELOW CHAIN BRIDGE = 30.60
230.3
7,770.0
1969-1970
1965-1966

Figure IV-26



CHLOROPHYLL a
POTOMAC ESTUARY
MIDDLE and LOWER REACH
1965 - 1966
1969 - 1970
SMITH POINT
MILES BELOW CHAIN BRIDGE = 46.80
333.0
188.8
1965-1966
1969-1970
CHLOROPHYLL a (μg/l)
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP.
1969 ← → 1970
301 BRIDGE
MILES BELOW CHAIN BRIDGE = 67.40
168.0
1969-1970
1965-1966
PINEY POINT
MILES BELOW CHAIN BRIDGE = 99.20
1969-1970

Figure IV-27

water milfoil then allowed the nutrients to be competitively selected by the blue-green alga Anacystis. Since Anacystis is apparently not utilized in the normal food chain, huge mats and masses accumulate, die off, and decay.

From the above considerations, it would appear that nuisance conditions did not develop linearly with an increase in nutrients. Instead, the increase in nutrients appeared to favor the growth and thus the domination by a given species. As nutrients increased further, the species in turn was rapidly replaced by another dominant form. For example, water chestnut was replaced by water milfoil which in turn was replaced by Anacystis.

Figure IV-25 indicates that the massive blue-green algal blooms were associated with large phosphorus and nitrogen loading increases in the upper reaches of the Potomac River tidal system. The massive algal blooms have persisted since the early 1960's even though the amount of organic carbon from wastewater discharges has been reduced by almost 50 percent.

Laboratory and controlled field pond studies by Mulligan [8] have shown similar results. Ponds receiving low-nutrient additions (phosphorus and nitrogen) contained submerged aquatic weeds. Continuous blooms of algae appeared in the ponds having high nitrogen and phosphorus concentrations. An important observation in Mulligan's studies was that when the water quality was returned to its original state by reduction of nutrient concentrations, the ecosystem also reverted to its previous state. This observation was also supported by studies of Edmondson [9] on Lake Washington and Hasler on the Madison, Wisconsin lakes [10].

REFERENCES

1. U. S. Public Health Service, "Investigation of the Pollution and Sanitary Conditions of the Potomac Watershed," Hygienic Laboratory Bulletin No. 104, Treasury Department, February 1915.

2. Livermore, D. F. and W. E. Wanderlich, "Mechanical Removal of Organic Production from Waterways," Eutrophication: Causes, Consequences, Correctives," National Academy of Sciences, 1969.

3. Bartsch, A. F., "Bottom and Plankton Conditions in the Potomac River in the Washington Metropolitan Area," Appendix A, A report on water pollution in the Washington metropolitan area, Interstate Commission on the Potomac River Basin, 1954.

4. Stotts, V. D. and J. R. Longwell, "Potomac River Biological Investigation 1959," Supplement to technical appendix to Part VII of the report on the Potomac River Basin studies, U. S. Department of Health, Education and Welfare, 1962.

5. Elser, H. J., "Status of Aquatic Weed Problems in Tidewater Maryland," Spring 1965, Maryland Department of Chesapeake Bay Affairs, 8 pp mimeo, 1965.

6. Bayley, S. H. Rabin, and C. H. Southwick, "Recent Decline in the Distribution and Abundance of Eurasian Watermilfoil in Chesapeake Bay," Chesapeake Science, Vol. 9, No. 3, 1968.

7. Jaworski, N. A., D. W. Lear, Jr., and J. A. Aalto, "A Technical Assessment of Current Water Quality Conditions and Factors Affecting Water Quality in the Upper Potomac Estuary," CTSL, FWPCA, MAR, U. S. Department of the Interior, March 1969. (Now Annapolis Field Office, Region III, Environmental Protection Agency)

8. Mulligan, H. T., "Effects of Nutrient Enrichment on Aquatic Weeds and Algae," The Relationship of Agriculture to Soil and Water Pollution Conference Proceedings, Cornell University, January 1970.

9. Edmonson, W. T., "The Response of Lake Washington to Large Changes in its Nutrient Income," International Botanical Congress, 1969.

10. Hasler, A. D., "Culture Eutropnication is Reversible," Bioscience, Vol. 19, No. 5, May 1969.

K. RAPPAHANNOCK RIVER AREA

The tidal effects on the Rappahannock River extend for approximately 110 miles, up to the Fall Line, in the vicinity of Fredericksburg, Virginia. The total drainage area of the Basin is 2,715 square miles. The major industry in the tidal area is the American Viscose Division, FMC Corporation, at Fredericksburg.

Water uses assigned to the Rappahannock Estuary are primary contact recreation (prolonged intimate contact; considerable risk of ingestion); propagation of fish, shellfish, and other aquatic life; and other beneficial uses. The uses are protected by Class II standards, including bacteriological standards for primary contact recreation and shellfish uses. The standards are delineated in the appropriate section of this chapter.

BACTERIOLOGICAL CONDITIONS

Degradation of bacteriological conditions in the Rappahannock Estuary can occur downstream of the City of Fredericksburg during low-flow periods as a result of secondary treated wastes discharged by the City and the FMC Corporation. The bacterial quality varies with river flows and tides. For the lower range of flows (less than 500 cfs), when freshwater inflow is insufficient to overcome tidal effects, wastes accumulate in the estuary creating degraded bacterial and dissolved oxygen conditions. Sampling data of the Virginia Water Control Board obtained during June, July, and August of 1971 show a fecal coliform count range of less than 100/100 ml to 2100/100 ml in a reach extending from the Route 3 Bridge at Fredericksburg to a point about 5 miles downstream. From a total of nine samples taken during this period, four of the samples contained a fecal coliform density of less than 100/100 ml.

Except for the short stretch noted above the estuary below Fredericksburg is suitable to support primary contact recreation uses. Fecal coliform counts were less than 100/100 ml during the summer months of 1971.

The latest available report on shellfish growing areas by the Virginia State Water Control Board lists six areas in the Rappahannock River Basin condemned for the direct maketing of shellfish. The condemned areas total approximately 2,363 acres out of an estimated total of 69,008 acres, or roughly 3 percent, of the available oyster bars. The 2,363-acre figure represents an approximate increase of 1,254 acres, or 1 percent, over the 1967 figures. Jurisdiction for closing oyster bars lies with the Virginia State Department of Health.

Oyster beds currently condemned and the reasons for their condemnation are listed below:

Rappahannock River (1,045 acres): Windmill Creek - marina pollution, sewage treatment facilities, etc.; below Urbanna Creek - animal pollution, sewage treatment facilities, etc.

Carter's Creek (590 acres): industrial activity, marinas, residences, etc.

Urbanna Creek (297 acres): sewage treatment plant, marinas, commercial docks, etc.

Broad Creek (81 acres): marinas, commercial docks, residences, etc.

Eastern Branch of Corrotoman River (350 acres): lack of sewage treatment facilities.

DISSOLVED OXYGEN CONDITIONS

The Virginia Water Control Board reported that the DO concentrations during the summer of 1971 averaged 8.2 mg/l in the vicinity of the Route 3 Bridge at Fredericksburg. In this area the DO concentration averaged 7.4 mg/l during the summer of 1968. Below Fredericksburg at River Mile 105.3, based on the results of four surveys, the DO averaged 8.4 mg/l in the summer of 1971. In the same vicinity DO concentrations of 2.3 mg/l and 5.2 mg/l were recorded in the summers of 1965 and 1968, respectively.

From the Route 301 Bridge at Port Royal, Virginia, downstream to the Bay at Windmill Point, DO standards are maintained. A review of sampling data obtained in the summer of 1971 showed average DO concentrations of 8.9, 7.3, and 7.4 mg/l at River Miles 78, 56, and 43, respectively. The standard established for the Rappahannock Estuary requires a daily DO concentration average of 5.0 mg/l.

The Middle Atlantic Region, Federal Water Quality Administration (now Region III, EPA), conducted a field survey on the Rappahannock River in the vicinity of Fredericksburg, Virginia, from April through July 1970. The field survey was initiated to gather data in order to reevaluate the water quality aspects of the proposed Salem Church Reservoir of the U. S. Army Corps of Engineers. A total of 16 stations were sampled weekly from the Fall Line at Fredericksburg downstream to the Route 301 Bridge at Port Royal, Virginia. The following parameters were measured: water temperature, DO, BOD_5, and pH. The results of the dissolved oxygen determinations are briefly discussed below.

The limited amount of field data collected during the 1970 field survey showed depressed dissolved oxygen concentrations below the City of Fredericksburg, in the vicinity of Bernard Bar, and in the area of Route 301 Bridge, Port Royal, Virginia (see Figures IV-28 through IV-30). Although the City of Fredericksburg and the FMC Corporation provide secondary treatment to its sewage and process water, respectively, instream oxygen demand from the treated effluents apparently results in an oxygen sag in the vicinity of Bernard Bar, especially during the low-flow summer conditions. The mean monthly flows entering the estuary at Fredericksburg during June and July 1970 were 521 and 774 cfs, respectively, while the 1970 mean yearly flow was 1,360 cfs. In addition, the FMC Corporation discharges approximately 20 MGD of spent cooling water, which receives no treatment, upstream from Bernard Bar. The oxygen sag found 20 or 30 miles downstream from Fredericksburg (Figures IV-28 through IV-30) was not evaluated in the study.

NUTRIENTS

The Annapolis Field Office made a determination of the nutrient input from the freshwater portion of the Rappahannock River Basin

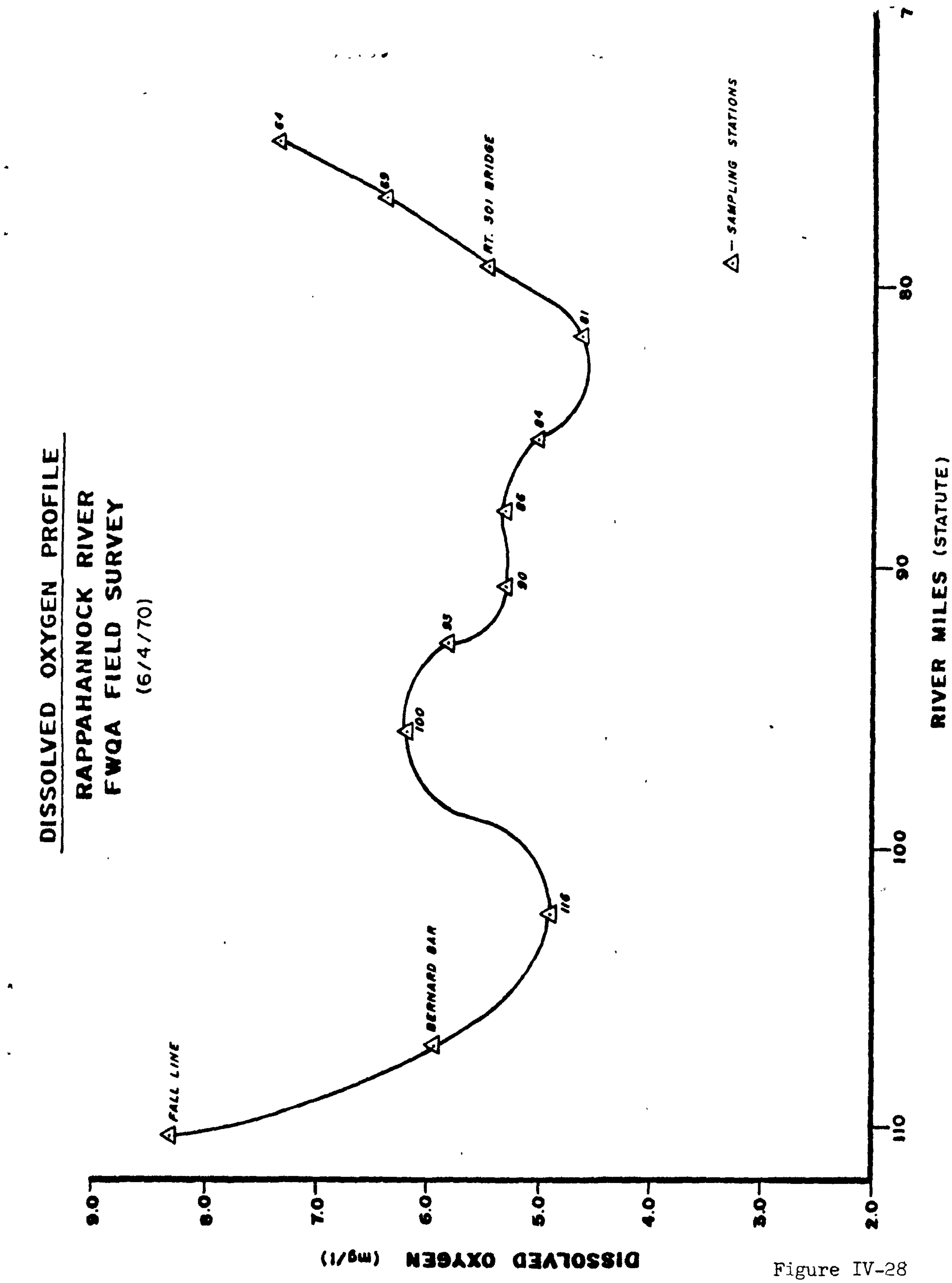

DISSOLVED OXYGEN PROFILE
RAPPAHANNOCK RIVER
FWQA FIELD SURVEY
(6/4/70)
64
69
RT. 301 BRIDGE
81
84
86
90
93
100
116
BERNARD BAR
FALL LINE
△ – SAMPLING STATIONS
80
90
100
110
RIVER MILES (STATUTE)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
DISSOLVED OXYGEN (mg/l)

Figure IV-28

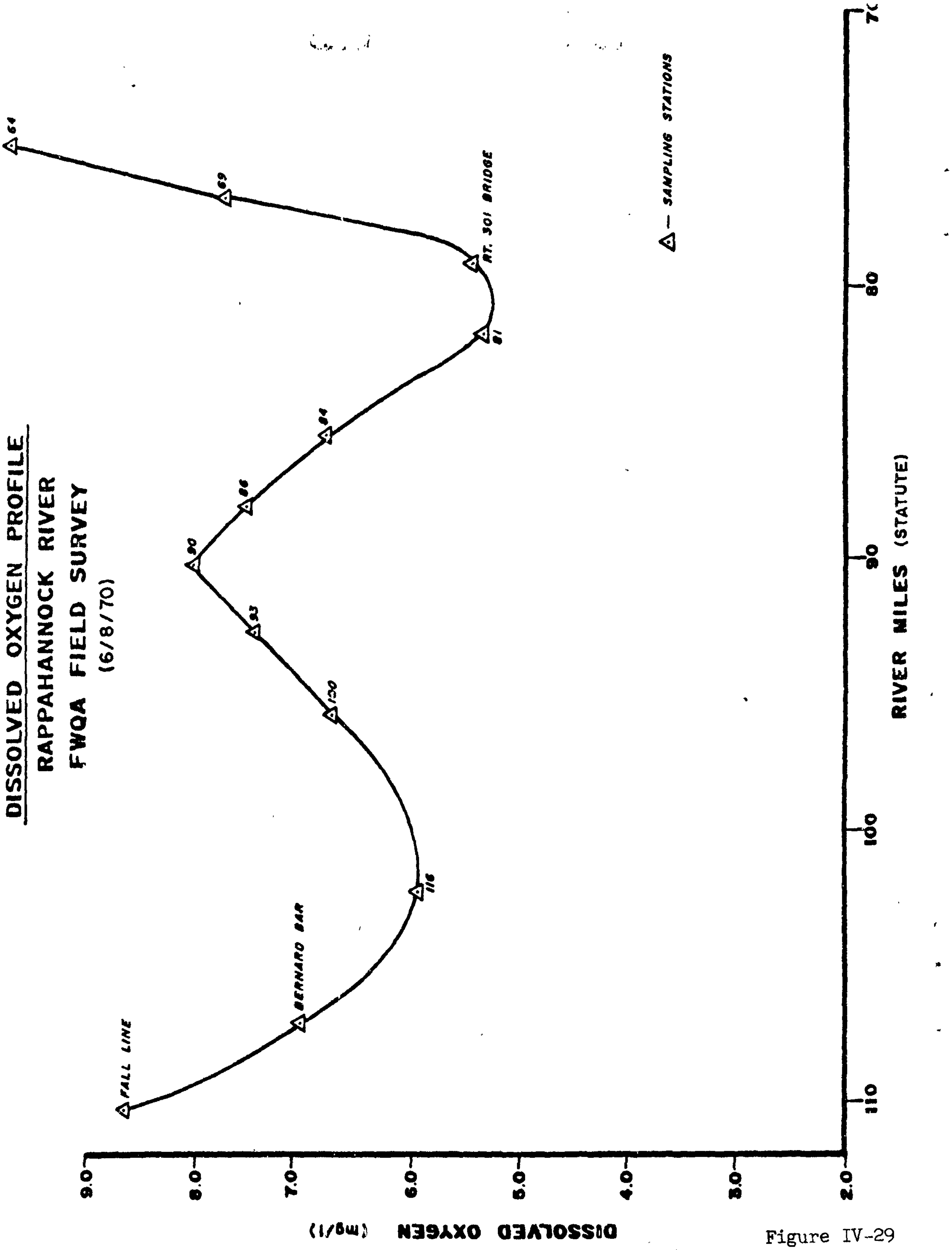

DISSOLVED OXYGEN PROFILE
RAPPAHANNOCK RIVER
FWQA FIELD SURVEY
(6/8/70)
△ — SAMPLING STATIONS
FALL LINE
BERNARD BAR
116
100
93
90
86
84
81
RT. 301 BRIDGE
69
64
DISSOLVED OXYGEN (mg/l)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
RIVER MILES (STATUTE)
110
100
90
80
70

Figure IV-29

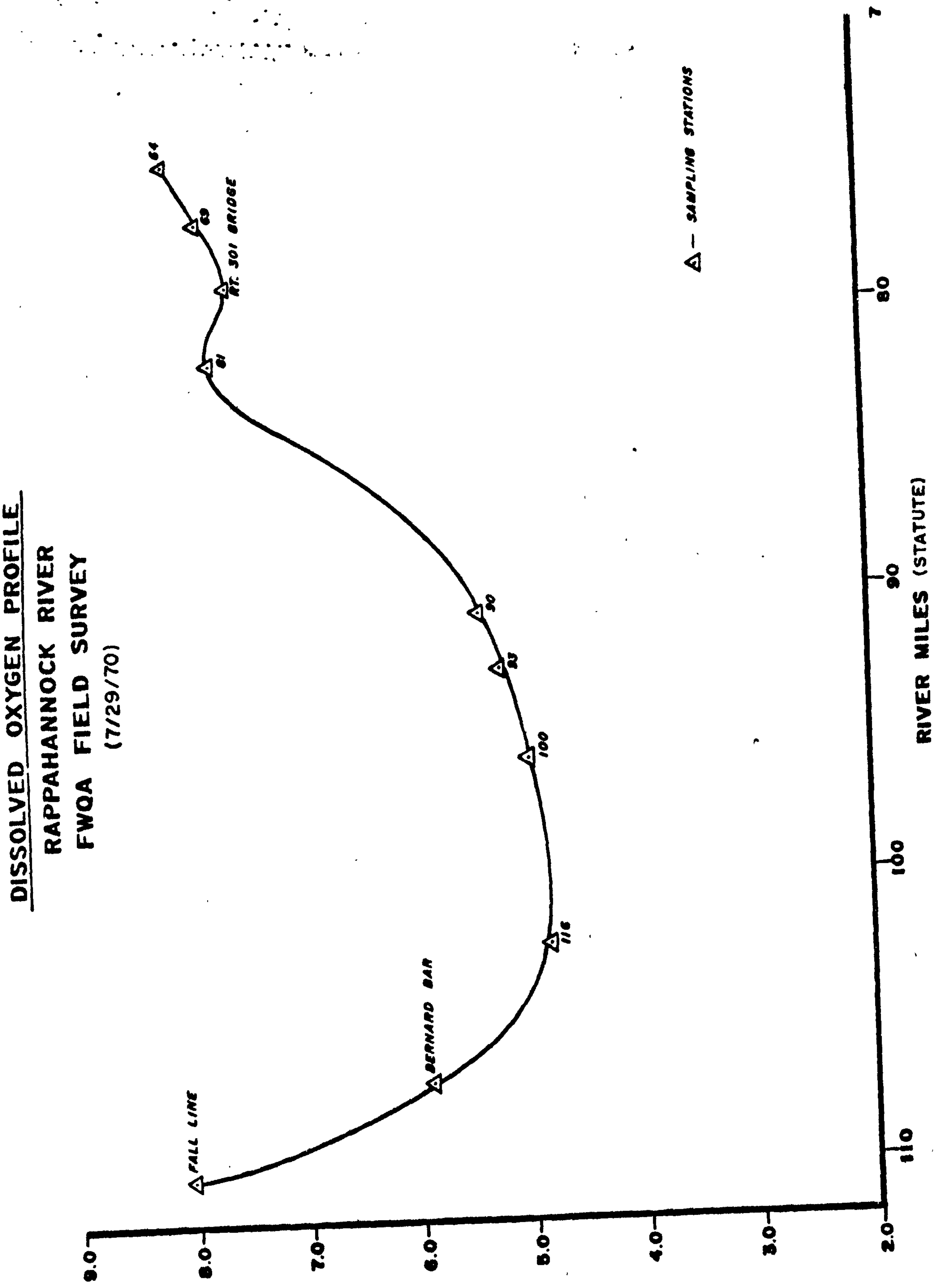

DISSOLVED OXYGEN PROFILE
RAPPAHANNOCK RIVER
FWQA FIELD SURVEY
(7/29/70)
△ — SAMPLING STATIONS
64
69
RT. 301 BRIDGE
81
90
93
100
116
BERNARD BAR
FALL LINE
RIVER MILES (STATUTE)
80
90
100
110
DISSOLVED OXYGEN (mg/l)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0

Figure IV-30

at the Fall Line (River Mile 110.3) for the period June 1969 to August 1970. Based on average monthly flows for the 15-month study period the results were as follows:

PARAMETER	AVERAGE MONTHLY CONTRIBUTION (lbs/day)	% INPUT TO BAY (lbs/day)
T. PO_4 as PO_4	1,600	2%
P (Inorganic)	900	2%
TKN as N	3,900	3%
NO_2 + NO_3 as N	3,600	1%
NH_3 as N	600	1%
TOC	29,000	3%

The following table of nutrient data is intended to show nutrient concentrations at several randomly selected sampling stations maintained by the Virginia Water Control Board. Valid conclusions cannot be drawn as the data is not sufficiently extensive, nor is it correlated with flow rates.

Table IV-42

STATION LOCATION (river mile)	DATE	TOTAL PHOSPHORUS AS P (mg/l)	NITRATE NITROGEN AS N (mg/l)
108	6-22-70	.1	.19
	7-26-70	.1	.53
	9-03-70	< .1	.07
	6-02-71	< .1	.78
	7-02-71	< .1	.39
	7-21-71	< .1	.24
	8-08-71	.1	.52
103	6-22-70	.18	.17
	9-03-70	< .1	.15
	6-02-71	< .1	.78
	7-02-71	< .1	.39
	7-21-71	< .1	.39
	8-08-71	.20	.45
78	4-13-70	< .05	.22
	5-27-70	< .05	.24
56	2-05-70	.05	.20
	4-13-70	.1	.35
	5-27-70	< .05	.01
43	4-13-70	< .05	.30
	5-27-70	.05	.03
29	4-13-70	.05	.50
	5-27-70	.50	.05
18	4-13-70	< .05	.01
	5-27-70	.05	.02
8	2-10-70	< .05	.12
	5-27-70	.05	.05
	9-28-70	.3	.05

The Virginia Water Control Board collected limited nutrient data during the 1960's and has provided summaries of the analyses of this data. At the Route 301 Bridge, Port Royal, Virginia (River Mile 79), the average minimum and maximum nitrate-nitrogen concentrations during 1962 were .02 and .28 mg/l, respectively, based on 10 sets of data. For most sampling stations, however, yearly concentration averages are obtained from very limited data. Phosphorus concentration data is reported for only three stations in the data summaries covering the 1960's.

HEAVY METALS

The Virginia Water Control Board sampled for mercury, lead, and arsenic during the summers of 1970 and 1971. For the most part, the data is limited to one set for either 1970 or 1971 and available only for the upper or middle reaches of the estuary. However, the concentrations measured in water samples were less than the detectable limits for the three metals in most samples. The concentrations most frequently observed were: less than .0005 ppm for mercury, less than .010 ppm for lead, and less than .005 ppm for arsenic.

Huggett et al. analyzed zinc, copper, and cadmium concentrations in a paper entitled "Utilizing Metal Concentration Relationships in the Eastern Oyster (*Crassostrea virginica*) to Detect Heavy Metal Pollution," VIMS Contribution number 431, Virginia Institute of Marine Science, October 1971. The study analyzed the distribution of zinc, copper, and cadmium in oysters from Virginia's major rivers. In the Rappahannock Estuary these metals were distributed in the oyster as follows:

Zinc: 400 - 800 ppm, Lowery Point (below Tappahannock, Va.) to Jones Point; 0 - 400 ppm, Jones Point to Bay.

Copper: 25 - 500 ppm, Lowery Point to Bowlers Wharf; 0 - 25 ppm, Bowlers Wharf to Bay.

Cadmium: 1.0 - 1.5 ppm, Totusky Creek to Bowlers Wharf; 0.6 - 1.0 ppm, Bowlers Wharf to Jones Point; (also Corrotoman River), < 0.6 ppm, Jones Point to Bay.

PESTICIDES

The Virginia Water Control Board analyzed water samples in June and July of 1971 in order to detect the presence of chlorinated hydrocarbon and phosphorus based pesticides. The chlorinated and thio-phosphate groups were measured at less than .1 ppm at all sampling stations selected for review. This recent data will provide some basis for detecting increases in pesticide concentrations.

WATER QUALITY TRENDS

Water quality remains generally good in the Rappahannock Estuary. Contributing factors to the maintenance of water quality standards are the apparent absence of intensive development within the basin drainage area and the provision of secondary treatment of wastewater at Fredericksburg, the major population center in the basin. However, a more sufficient data base must be established in order to identify any water quality trends. This will necessitate intensive and extensive monitoring of nutrients, pesticides, and heavy metals. Although the sparse data on metals and pesticides show concentrations in the water as negligible, bottom sediment data could show accumulations of greater significance. The remineralization of metals by disturbing bottom sediment is a growing concern where shellfish are economically important, as in the case of the Rappahannock Estuary.

L. YORK RIVER AREA

The York River is formed by the confluence of the Mattaponi and Pamunkey Rivers, its two principal tributaries, at West Point, approximately 35 miles from its mouth. The entire York River is tidal. The Pamunkey and Mattaponi Rivers are tidal from West Point for distances of about 51 and 37 miles, respectively. The major water-using industry in the study area is the Chesapeake corporation, located in the Town of West Point, which produces draft pulp, liner board, and draft paper.

Water uses assigned to the York River tidal system by the Commonwealth of Virginia include primary contact recreation; propagation of fish, shellfish and other aquatic life; and other beneficial uses. The uses are protected by Class II water quality standards, including bacteriological standards for primary contact recreation and shellfish harvesting uses.

The following discussions of existing water quality conditions in the York Estuary are based largely on data provided by the Virginia Water Control Board.

BACTERIOLOGICAL CONDITIONS

During the summer months of 1970 fecal coliform counts were found to be less than 100/100 ml in the York River from a point approximately 4.5 miles below West Point to its mouth. Monitoring stations were sampled on a frequency of once a month over a two-to three month period. The primary contact recreation standard prohibits a fecal coliform density in excess of a log mean of 200/100 ml (multiple-tube fermentation or MF count).

Currently, there are eight shellfish areas in the York River closed to harvesting by the Virginia State Department of Health. The condemned areas total approximately 5,092 acres out of an estimated total of 18,653 acres, or about 27 percent of the available oyster bars. The 27 percent figure reflects improved bacterial conditions, since nearly 39 percent of the available acreage was closed in 1967.

Of the estimated 5,092 acres closed, 4,675 acres are located in the main stem of the York River. These areas are in the vicinity of the Town of West Point, the Naval Warfare School, Gloucester Point, the City of Yorktown, and the Naval Weapons Station at Yorktown. The largest closure is located in waters adjacent to and below the Town of West Point. The reasons for condemnation of this area include industrial discharge, sewage discharges, marinas, and residential areas on the shoreline discharging raw and partially treated sewage. Industrial discharge from the Chesapeake Corporation constitutes the most significant pollution source affecting the closure of shellfish bars in the vicinity of West Point. The remaining closures are in Timberneck Creek (112 acres) and Sarah's Creek (305 acres).

DISSOLVED OXYGEN CONDITIONS

The following table gives the results of dissolved oxygen measurements for 1971.

Table IV-43

RIVER MILE (Statute Mile)	DATE	TIME	DO CONCENTRATION (mg/l)
31.48	6-28-71	1200	5.8
	8-01-71	1200	6.4
28.10	6-28-71	1220	6.2
	8-01-71	1210	7.4
	8-23-71	1320	5.8
11.14	6-28-71	1250	6.5
	8-01-71	1305	9.8
	8-23-71	1350	6.6
2.92	6-28-71	1340	6.0
	8-01-71	1325	7.0
	8-23-71	1440	8.1
1.88	8-01-71	1345	7.6
	8-23-71	1430	8.8

As shown by the available data, the DO standard of 5.0 mg/l was not contravened on the dates at the specific hours listed above. However, during the summer months of 1970 at River Mile 0.92 on the Pamunkey River, immediately below the Chesapeake Corporation discharge output, the following DO concenrations were measured: 3.6 mg/l (July 26), .80 mg/l (Aug. 12), and 5.0 mg/l (Aug. 24). No DO data was available at this sampling location for the summer months of 1971.

The Chesapeake Corporation at West Point discharges its effluent, which includes spent cooling water, to the Pamunkey River about 1-mile upstream from its confluence with the York River. The effluent, about 25 MGD, is characteristically high in BOD (30,000-35,000 lbs/day). The assimilative capacity of the upper York River has thus far precluded serious oxygen depletions except for the degradation in the Pamunkey River noted above. Increases in the strength of the current wastewater loadings could exceed the present capacity of the upper York River to assimilate this effluent.

The Chesapeake Corporation has constructed a small pilot plant to determine the most efficient method of treating its wastes. The Virginia Water Control Board has established a compliance date of October 1973 for the Chesapeake Corporation to provide adequate treatment of all its wastewater.

NUTRIENTS

The Pamunkey and Mattaponi Rivers were included in the detailed study by the Annapolis Field Office of the nutrient contribution to the Chesapeake Bay from its major tributary watersheds. These two rivers provide the most significant freshwater flows to the York River tidal system. The following table sets forth the average concentration of nutrients for the two rivers measured during the period of July 1969 to August 1970. The sampling stations were located above the Fall Lines in freshwater areas.

Table IV-44

	TPO_4 as PO_4 mg/l	Inorganic P mg/l	TKN as N mg/l	NO_2+NO_3 as N mg/l	NH_3 as N mg/l	TOC mg/l
Pamunkey River at Hanover, Va.	.18	.13	.53	.19	.12	6.15
Mattaponi River at Beaulahville, Virginia	.16	.13	.58	.11	.07	8.08

Nutrient data collected during 1970 and 1971 by the Virginia Water Control Board is presented below.

Table IV-45

STATION LOCATION (Statute river miles)	DATE	TOTAL PHOSPHATES AS P (mg/l)	NITRATE NITROGEN AS N (mg/l)
Mattaponi River - Mile 1.34	2-10-70	.05	.25
	3-19-70	1.00	.02
	4-17-70	.05	.34
	5-07-70	<.01	.01
	8-24-70	<.10	.03
	9-10-70	<.10	.18
	6-28-71	.10	.19
Pamunkey River - Mile 0.92	2-10-70	.05	.19
	3-19-70	.10	<.01
	4-17-70	.05	.17
	5-07-70	.05	.02
	8-12-70	.40	.06
York River - Mile 31.48	3-19-70	.10	.01
	4-14-70	.05	.01
	5-07-70	.05	.02
	8-24-70	.10	.02
	9-10-70	<.10	.05
	6-28-71	<.10	.19
York River - Mile 28.10	3-19-70	.05	.01
	4-17-70	.05	.05
	5-07-70	.05	.04
York River - Mile 11.14	3-19-70	.10	.01
	4-17-70	.05	.10
	5-07-70	.05	.02
York River - Mile 2.92	3-19-70	.10	.01
	5-07-70	.05	.01

The Mattaponi River and Pamunkey River data set forth above was obtained from sampling stations located on the two streams a short distance from their confluence with the York River.

As shown above, nutrient data was collected only at two of the monitoring locations during 1971 and only on one occasion. No nutrient data was reported for the York River stations for 1968 or 1969. Nutrient monitoring should continue on a more frequent basis to identify any nutrient trends in the York River Estuary.

HEAVY METALS

The following table indicates the concentrations of several heavy metals detected in water samples during 1970 and 1971. A blank space in the table indicates no measurement of that metal at the given location.

Table IV-46

Station Location	Date	Concentration in ppm (or mg/l)						
		Chromium	Zinc	Copper	Mercury	Manganese	Lead	Arsenic
Mattaponi River Mile 1.34	9-10-70	-	-	-	<.0005	-	-	-
	6-28-70	-	-	-	<.0005	-	.110	< .005
Pamunkey River Mile 0.92	3-19-70	.010	.010	.020	-	.150	-	-
	4-17-70	.030	.030	.020	-	.110	-	-
	5-07-70	.040	.010	.020	-	-	-	-
York River Mile 31.48	9-10-70	-	-	-	<.0005	-	-	-
	6-28-70	-	-	-	.0014	-	.010	.005
York River Mile 28.10	9-10-70	-	-	-	<.0005	-	-	-
York River Mile 11.14	9-10-70	-	-	-	<.0005	-	-	-
York River Mile 2.92	9-10-70	-	-	-	<.0005	-	-	-

Huggett, et al. analyzed oysters in 1971 from the York River to determine the distribution of zinc, copper, and cadmium in the oysters. (See Rappahannock River section of this chapter for further information.) Zinc was found to be uniformly distributed in the oysters in concentrations from 400 to 800 ppm from Terrapin Point, about 5 miles below West Point, to the mouth of the York. The highest concentrations of copper, 50 to 100 ppm, were detected in oysters collected between Terrapin Point and Mount Folly. Oysters containing from 1.5 to 2.0 ppm of cadmium were taken from Puritan Bay and the mouth of Queen Creek. These were the highest concentrations of copper and cadmium found in the York River, although both metals were found in oysters from other areas of the estuary. Further information on these studies can be obtained from the Virginia Institute of Marine Science.

PESTICIDES

Of the sampling stations reviewed for the York River study area, pesticide data was reported for two stations only. At River Mile 1.34 on the Mattaponi River, water samples collected June 28, 1971, contained concentrations of 1.00 ppm pesticides for both the chlorinated and thio-phosphate groups. Downstream at River Mile 31.48 on the York River, water samples contained less than .100 ppm for both pesticide groupings on June 28 and August 1, 1971. Continuous monitoring of pesticides should be included in ongoing sampling programs for the York River.

WATER QUALITY TRENDS

Although 27 percent of the available oyster bars are currently closed in the York River, this figure represents improved bacterial conditions since 1967. Sanitary surveys during 1967 resulted in the closure of nearly 39 percent of the available acreage. Compliance by the Chesapeake Corporation with pollution abatement order should further reduce the amount of oyster bars now closed downstream from the Town of West Point.

M. JAMES RIVER AREA

1. JAMES RIVER

The James River, the most southerly major tributary stream, is approximately 340 statute miles in length and provides 16 percent of the freshwater inflow to the Bay. There is a total fall of 988 feet from the headwaters near Iron Gate, Virginia to the fall line separating the Piedmont and Coastal Plain at lower Richmond, Virginia. From Richmond the James is a tidal estuary that joins the Bay at Hampton Roads, a distance of approximately 107 statute miles over which the fall in river level is negligible (less than 10 feet). The mean freshwater discharge is approximately 7,500 cfs with recorded extremes of 329 and 325,000 cfs.

Industry in the James Estuary is concentrated in three areas: Richmond, Hopewell, and the Norfolk-Newport News area. A thorough account of the historical, meteorological, economic, population, industrial, and transportation aspects of the James Estuary are contained in a recent report, "The Tidal James", by John B. Pleasants of the Virginia Institute of Marine Science.

The James Estuary, in Virginia water quality standards, is classified as Class IIB waters from the mouth at the Old Point Comfort-Fort Wool line to the fall line at Richmond. This includes the Chickahominy River to Walker's Dam and the tidal waters of the Appomattox River. These waters shall be satisfactory for primary contact recreation, the propagation of fish and other aquatic life, and other beneficial uses. In addition, the estuarine segment from the Old Point Comfort-

Fort Wool line to Barrets Point (mouth of Chickahominy River) is assigned the special bacteriological standard (70 MPN/100 ml coliforms) to protect the shellfish bars in this area, many of which, however, are condemned for direct marketing because of contravention of the standard.

The following discussions of existing water quality conditions are based on data provided by the Virginia Water Control Board, the Virginia Institute of Marine Science, and inhouse data of the Annapolis Field Office of EPA.

BACTERIOLOGICAL CONDITIONS

From October 14 through 30, 1969, the Federal Water Pollution Control Administration, Middle Atlantic Region (now, EPA, Region III) conducted an intensive water quality survey of the James Estuary between Richmond and Hopewell. Samples were collected each day at slack low tide and analyses were run for total coliform, fecal coliform, dissolved oxygen, temperature, biochemical oxygen demand, nutrients, chemical oxygen demand, total carbon, and metals. Figure IV-31 shows the 1969 sampling locations.

The bacteriological results of the October 1969 survey are presented in graphic form in Fig. IV-32. Results are given as the most probable number of bacteria (MPN). These data indicated that the fecal coliform levels in the James River were acceptable for all water uses during October at Boulevard Bridge and Mayo's Island. Immediately below these areas and downstream from the Richmond and Henrico County wastewater treatment plants the standard for primary contact (200 MF/100 ml fecal coliforms) recreation was contravened. Data of the Viginia State Water Control Board (VWCB) for the 1971 summer sampling season show that excessive bacterial counts still preclude contact recreation water uses in the upper estuary from the Richmond wastewater treatment plant outfall downstream to Bermuda Hundred less than two miles north of Hopewell.

From sampling Station 168 below Goode Creek, downstream to Duch Gap, a distance of approximately 10 miles, fecal coliform densities (MPN) averaging up to 80,000/100 ml were recorded on May 6, 1971. Fecal coliform densities averaged less than 5,000/100 ml on June 13, 1971, and tended to decrease on subsequent sampling runs, although bacterial counts still exceeded the standard for primary contact recreation. The Annapolis Field Office (AFO) recorded excessive fecal coliform counts in this same segment of the James River during the fall of 1971. At a station below Goode Creek on October 19 and November 2, 3, and 4, the densities were: 2,400/100ml, 2,100/100 ml, 91,800/100 ml, and 790/100 ml, respectively. Below the Richmond Deepwater Terminal the counts were 240,000/100 ml, 17,200/100 ml, 870/100 ml, and 5,400/100 ml on the respective sampling dates. During the October 1969 intensive survey fecal coliform densities averaged about 25,000/100 ml in this segment of the estuary.

The high fecal coliform densities described above were mainly due to discharges by the City of Richmond of raw wastes to Goode Creek which then entered the estuary. On February 28, 1972, an intercepting sewer was connected to the Richmond treatment plant which diverted 2 MGD of previously discharged raw wastes from the Goode Creek area. The VWCB advises that this recent hook-up eliminates the last raw discharge

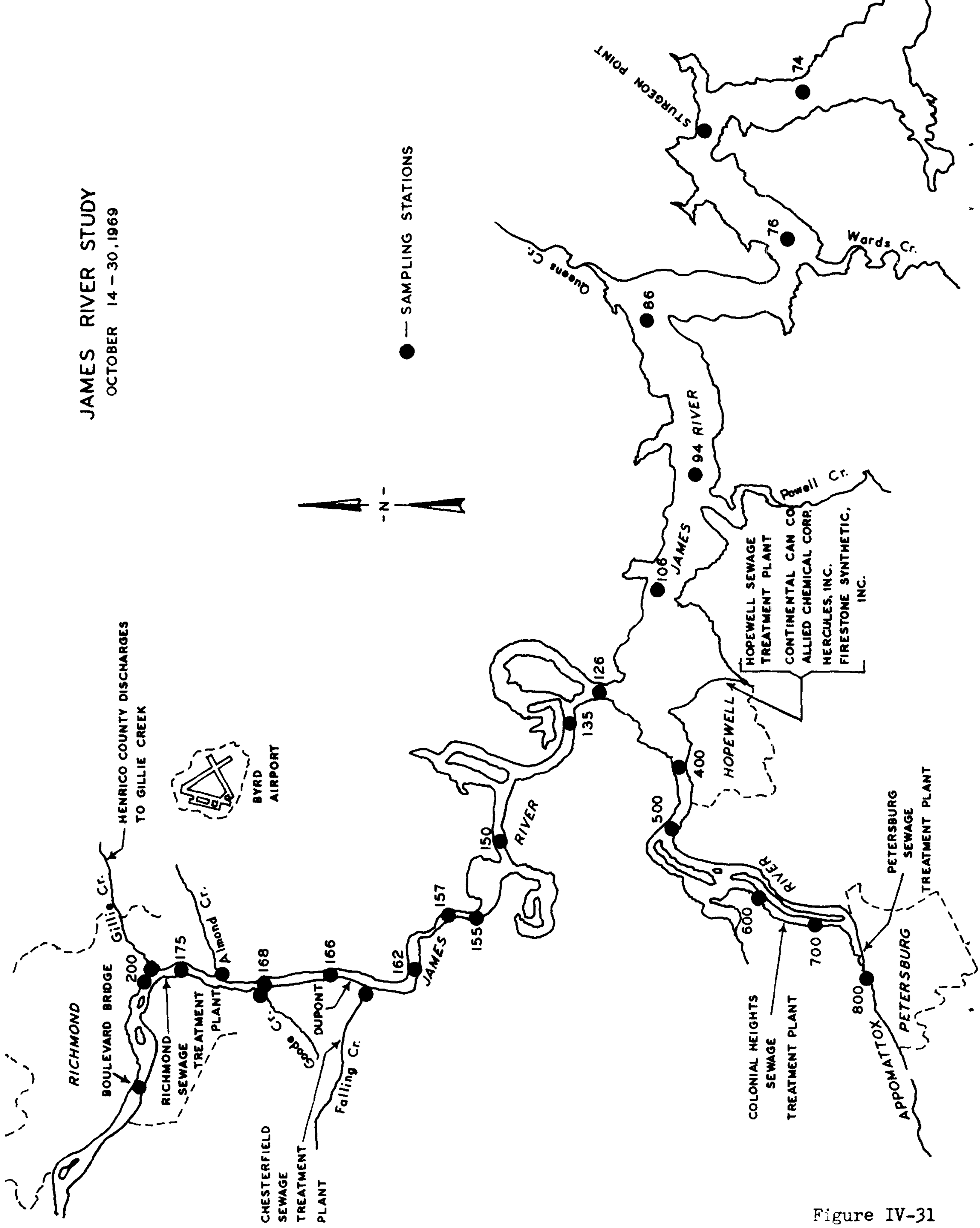

JAMES RIVER STUDY
OCTOBER 14 - 30, 1969
● — SAMPLING STATIONS
-N-
HENRICO COUNTY DISCHARGES TO GILLIE CREEK
BYRD AIRPORT
RICHMOND
BOULEVARD BRIDGE
RICHMOND SEWAGE TREATMENT PLANT
Gillie Cr.
Almond Cr.
Goode Cr.
DUPONT
Falling Cr.
CHESTERFIELD SEWAGE TREATMENT PLANT
JAMES
RIVER
200
175
168
166
162
157
155
150
135
126
106
94
86
76
74
Queens Cr.
Wards Cr.
Powell Cr.
STURGEON POINT
HOPEWELL SEWAGE TREATMENT PLANT
CONTINENTAL CAN CO.
ALLIED CHEMICAL CORP.
HERCULES, INC.
FIRESTONE SYNTHETIC, INC.
HOPEWELL
400
500
600
700
800
COLONIAL HEIGHTS SEWAGE TREATMENT PLANT
PETERSBURG SEWAGE TREATMENT PLANT
PETERSBURG
APPOMATTOX

Figure IV-31

FECAL COLIFORM DENSITIES VS RIVER MILE

OCTOBER 14 — 30, 1969

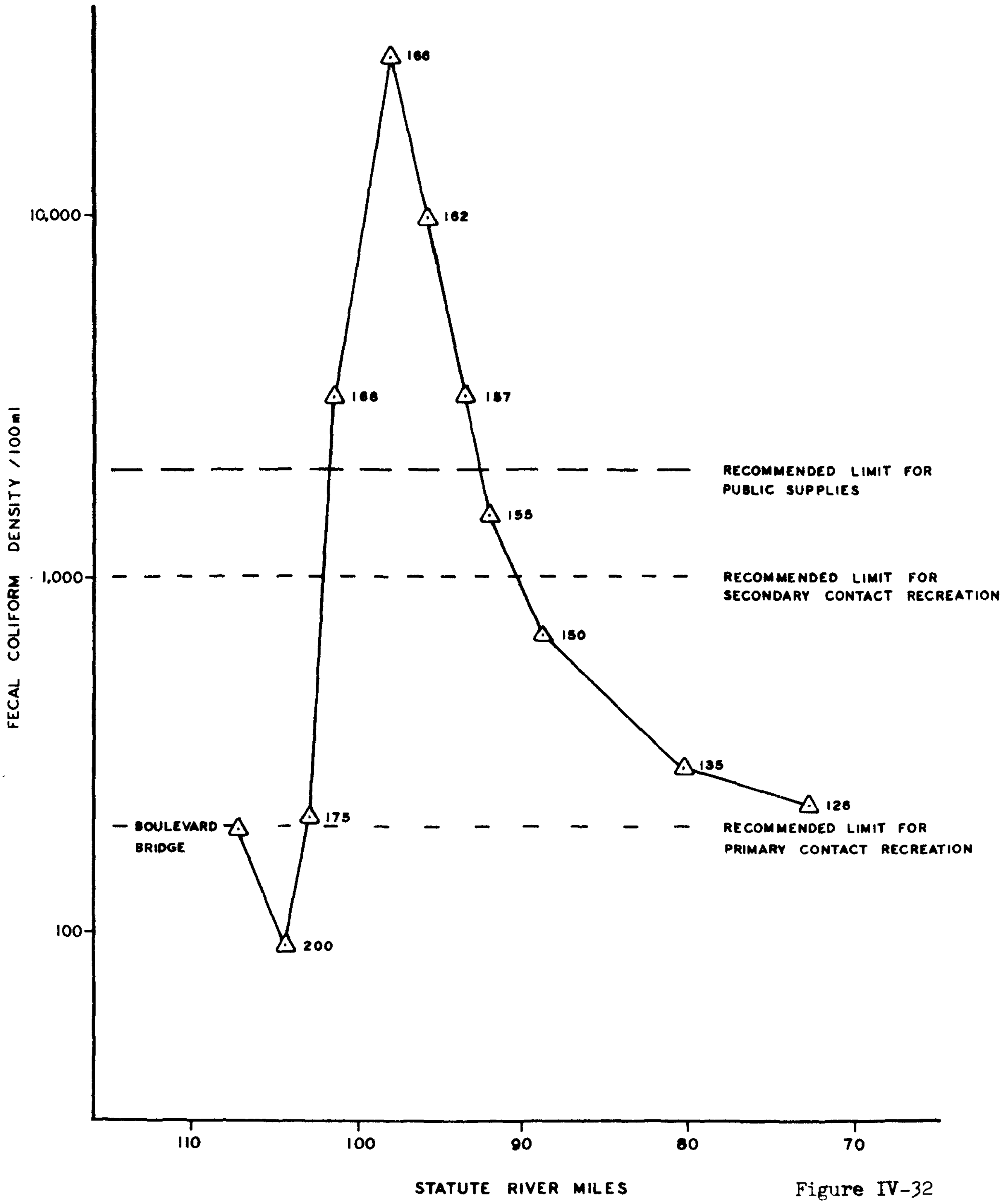


Figure IV-32

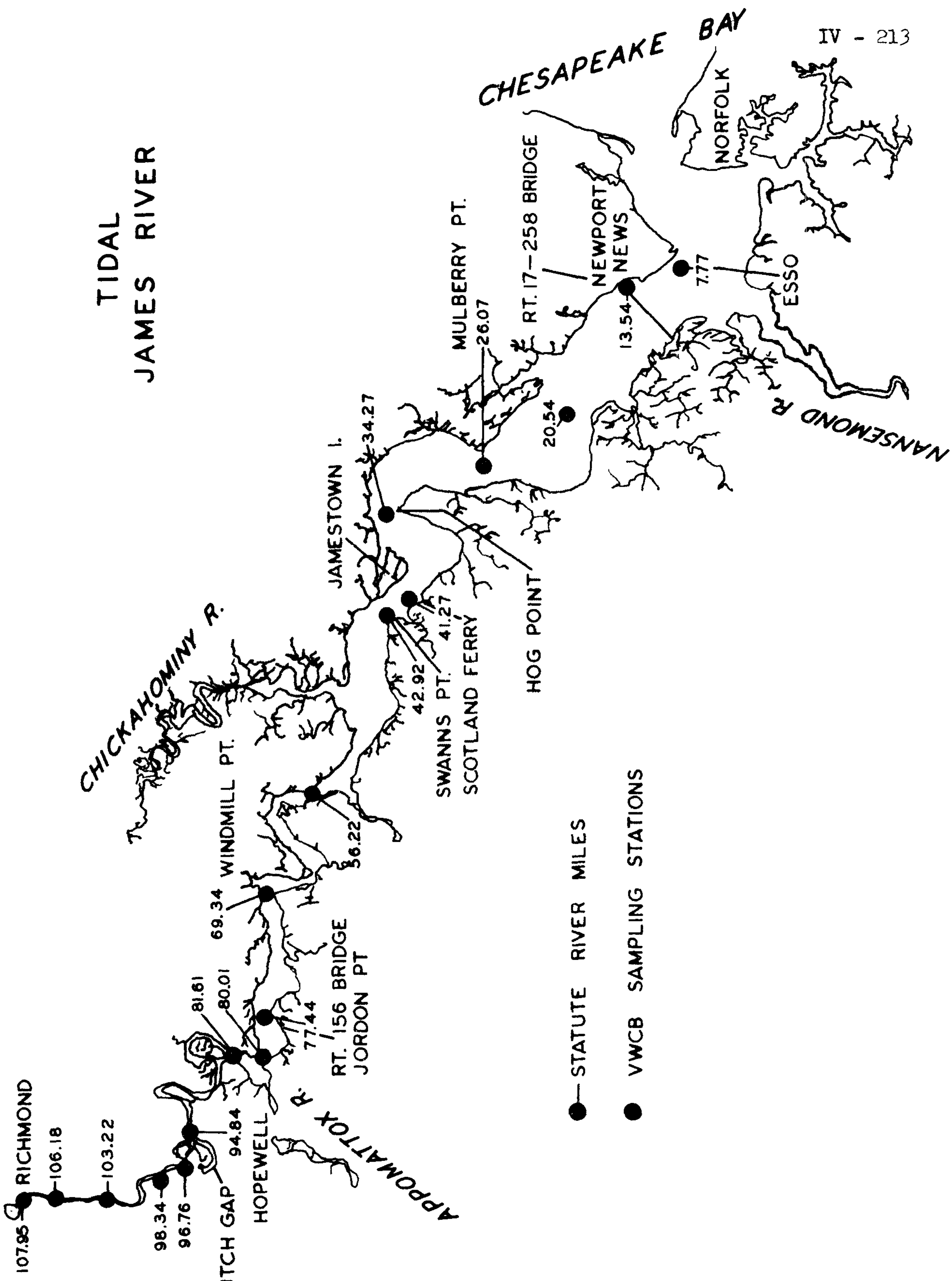

TIDAL
JAMES RIVER
CHESAPEAKE BAY
NORFOLK
RT. 17—258 BRIDGE
NEWPORT NEWS
MULBERRY PT.
26.07
13.54
7.77
ESSO
20.54
NANSEMOND R.
JAMESTOWN I.
34.27
HOG POINT
41.27
SCOTLAND FERRY
42.92
SWANNS PT.
CHICKAHOMINY R.
WINDMILL PT.
56.22
69.34
RT. 156 BRIDGE
JORDON PT
77.44
81.61
80.01
HOPEWELL
APPOMATTOX R.
94.84
DUTCH GAP
96.76
98.34
103.22
106.18
107.95
RICHMOND
STATUTE RIVER MILES
VWCB SAMPLING STATIONS

Figure IV-33

from the City of Richmond to the James River. It should be noted, however, that the existing combined sewers (sewers which carry both storm water and sewage) will still result in the bypass of raw wastes to the estuary during periods of high runoff following heavy rains when the sewage treatment plants' hydraulic capacities are exceeded. The extent of bacterial degradation in the James estuary at and below Richmond will have to be assessed during the 1972 sampling season.

From Turkey Point downstream to Windmill Point, a distance of approximately 12 statute miles, the bacterial levels steadily decrease. The great dilution capacity of the estuary at Hopewell and the absence of unchlorinated domestic waste in this reach appears to influence the bacterial recovery of the estuary.

The estuary from Windmill Point downstream to the ESSO pier at Newport News, a distance of approximately 62 statute miles, showed no serious bacterial degradation during the 1971 VWCB sampling runs. Sampling frequency amounted to one sampling run per month from May through September, except for July when two sampling runs were made. Except for occasional moderately high levels, fecal coliform densities were found to be less than 100/100 ml in this stretch of the estuary.

The most recent published report on shellfish growing areas by the Virginia Water Control Board lists eleven areas in the James River Basin condemned for the direct marketing of shellfish. The condemned areas total approximately 46,727 acres out of an estimated total of 93,062 acres available. Jurisdiction for closing shellfish areas lies with the Virginia State Department of Health.

The larger areas closed to direct marketing of shellfish are as follows: James River below Hog Island, 3,392 acres; Pagan River, 2,270 acres; Nansemond River, 1,980 acres; Willoughby Bay, 1205 acres; and the Hampton Roads area of the James River including the Elizabeth River, 36,275 acres. The large closures in the Hampton roads area are due to several reasons, including: the large population density, numerous marinas, dockage of naval vessels, industrial activities, and numerous wastewater treatment plant discharges. This latter problem is discussed in detail in the Elizabeth River section.

DISSOLVED OXYGEN CONDITIONS

Table IV-47 presents DO concentrations measured by the VWCB during the late spring and mid-summer months of 1971. Dissolved oxygen concentrations in the mainstem of the James River, with few exceptions, were greater than the standard which requires a daily average of 5.0 mg/l and a minimum of 4.0 mg/l. The highest DO concentrations were recorded during the May 11, 1971 sampling run when water temperatures were favorably low for DO maximum concentrations. In the 100 mile reach below Richmond the temperature averaged 18.9°C (66°F) during the sampling on May 11, 1971. Generally, the results of the July 23 and August 3, 1971 sampling runs show decreased oxygen concentrations. The average water temperature at the sampling stations on August 3, 1971 was 29.3°C (84.6°F) or 10.4°C (18.6°F) greater than the May 11, 1971 average temperature. The higher water temperatures would result in a decrease in the oxygen holding capacity of the water and an acceleration of biological activity relating to oxygen-consuming decomposition of organic wastes and detritus.

Table IV-47

SAMPLING STATION	DATE 1971	DO mg/l	TEMP °C
Esso Pier, Newport News	5-11	8.4	18.3
(Statute mile 7.77)	6-14	9.0	23.3
	7-05	7.8	24.4
	7-23	6.8	25.0
	8-03	3.8	25.6
Rt. 17-I-258 Bridge	5-11	8.6	18.9
(13.54)	6-14	8.0	25.0
	7-05	6.7	25.6
	7-23	7.2	25.6
	8-03	4.2	26.1
Byoy 12	5-11	8.8	20.0
(20.54)	6-14	6.6	25.6
	7-05	8.0	26.1
	7-23	8.2	26.1
	8-03	8.4	27.8
Buoy 24, Mulberry Point	5-11	10.0	18.9
(26.07)	6-14	7.0	26.7
	7-05	8.0	26.7
	7-23	6.4	26.1
	8-03	8.6	27.8

Table IV-47 (Cont.)

SAMPLING STATION	DATE 1971	DO mg/l	TEMP °C
Buoy 43, Hog Point	5-11	11.2	21.1
(34.27)	6-14	7.8	26.1
	7-05	8.0	26.1
	7-23	-	26.7
	8-03	8.4	28.3
Swann Point	5-11	10.0	21.7
(42.92)	6-14	7.2	26.7
	7-05	8.0	26.1
	7-23	7.0	25.6
	8-03	8.0	28.9
Buoy 74, Brandon Point	5-11	7.0	20.6
(56.22)	6-14	4.6	27.2
	7-05	5.8	28.9
	7-23	4.2	27.2
	8-03	6.4	30.0
Buoy 86, Windmill Point	5-11	9.8	21.1
(69.34)	6-14	7.4	27.8
	7-03	6.5	27.8
	7-23	7.4	27.8
	8-03	7.0	29.4

Table IV-47 (Cont.)

SAMPLING STATION	DATE 1971	DO mg/l	TEMP °C
Rt. 156 Bridge, Jordan	5-13	6.4	23.3
Point (77.44)	6-27	5.0	30.0
	7-05	7.8	30.6
	7-08	6.0	27.8
	7-23	8.0	27.8
	8-03	6.0	30.0
Buoy 118 Below American	5-06	10.2	16.7
Tobacco (80.01)	6-13	6.2	25.6
	7-05	7.4	28.9
	7-23	8.6	28.3
	8-03	6.8	30.0
Buoy 126	5-06	8.0	16.7
(81.61)	6-13	6.2	23.3
	7-05	6.0	27.8
	7-23	7.0	28.3
	8-03	9.0	30.6
Byoy 150, Dutch Gap	5-06	7.0	16.7
(94.84)	6-13	6.0	24.4
	7-05	8.0	27.8
	7-23	7.0	28.3
	8-03	5.0	30.6

Table IV-47 (Cont.)

SAMPLING STATION	DATE 1971	DO mg/l	TEMP °C
Buoy 155, Dutch Gap	5-06	9.2	17.2
(96.76)	6-13	6.5	23.9
	7-05	8.0	28.3
	7-23	7.0	28.3
	8-03	5.0	32.8
Buoy 157	5-06	6.2	17.2
(98.34)	6-13	6.0	28.3
	7-05	8.2	28.9
	7-23	4.0	28.3
	8-03	5.0	29.4
Buoy 166, Below Deep	5-06	7.8	17.2
Water Terminal (103.22)	6-13	8.0	23.3
	7.23	6.4	28.3
	8-03	6.0	30.6
Buoy 168, Below	5-06	10.0	17.2
Goode Creek	6-13	8.0	23.3
	7-23	6.6	28.3
	8-03	6.2	30.6

The Virginia Institute of Marine Science (VIMS) collected slack water samples at successive stations upstream from the mouth of the James Estuary on several occasions between June and December 1971. Dissolved oxygen measurements and 5-day BOD determinations were taken at the surface and at the bottom of the water column. The purpose of these field studies was to determine the existing water quality of the estuary below Richmond by evaluating the degree of deoxygenation caused by the biochemical breakdown of organic matter accompanying the waste discharges entering the estuary.

Figures IV-34, IV-35, and IV-36 show the results of low water slack runs made by VIMS on June 11, August 10, and September 8, 1971. Oxygen sags resulting from instream biological breakdown of waste are apparent from the graphs, and show a much more frequent contravention of the 4.0 mg/l standard than indicated in Table IV-47 above. The oxygen sags tend to become elongated due to the ebbing of the tide. The tidal influence appears more pronounced in the vicinity of Hopewell where the estuary widens. As expected, bottom waters tended to be lower in DO than surface waters; with a few noteworthy exceptions, the difference was only about 0.5 mg/l.

The initial oxygen sag begins about 5 miles below the discharge point of the City of Richmond's wastewater treatment plant, and extends approximately 12 nautical miles downstream to the vicinity of Turkey Island. During the August 10 and September 8, 1971 low water slack runs, DO was depressed to 3.0 mg/l near the confluence of Falling Creek

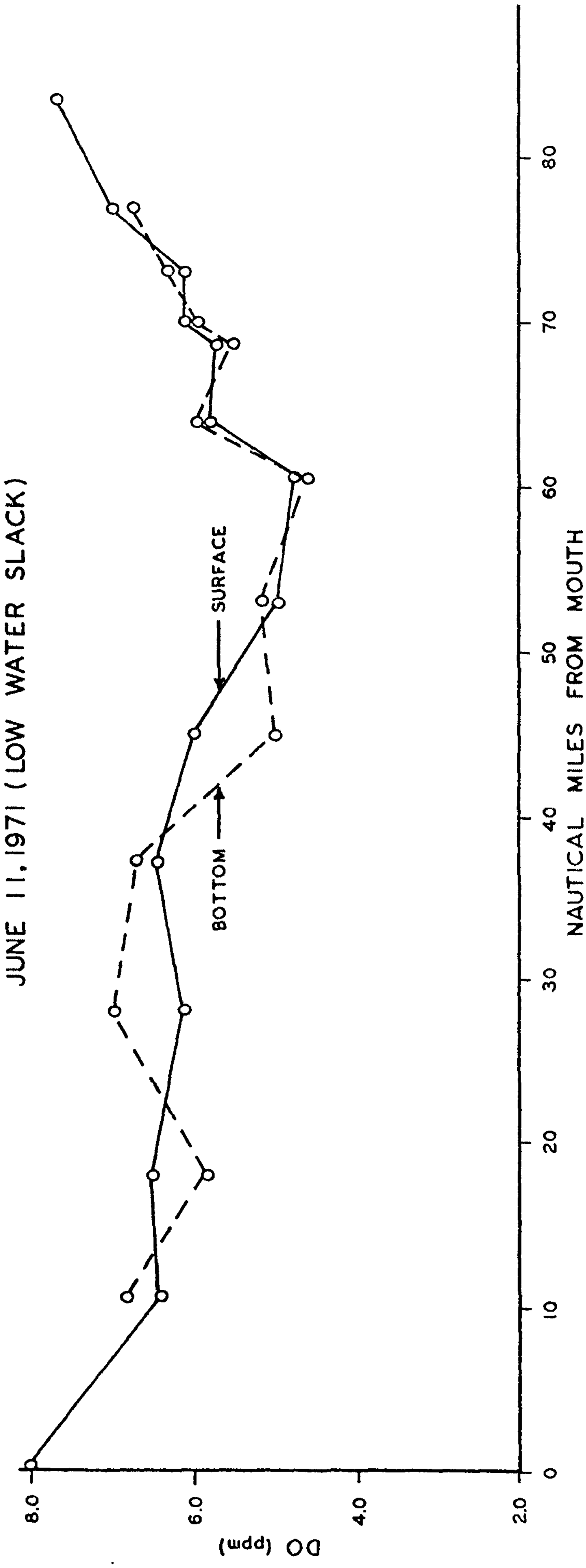

JUNE 11, 1971 (LOW WATER SLACK)
SURFACE
BOTTOM
NAUTICAL MILES FROM MOUTH
DO (ppm)
8.0
6.0
4.0
2.0
0
10
20
30
40
50
60
70
80

Figure IV-34

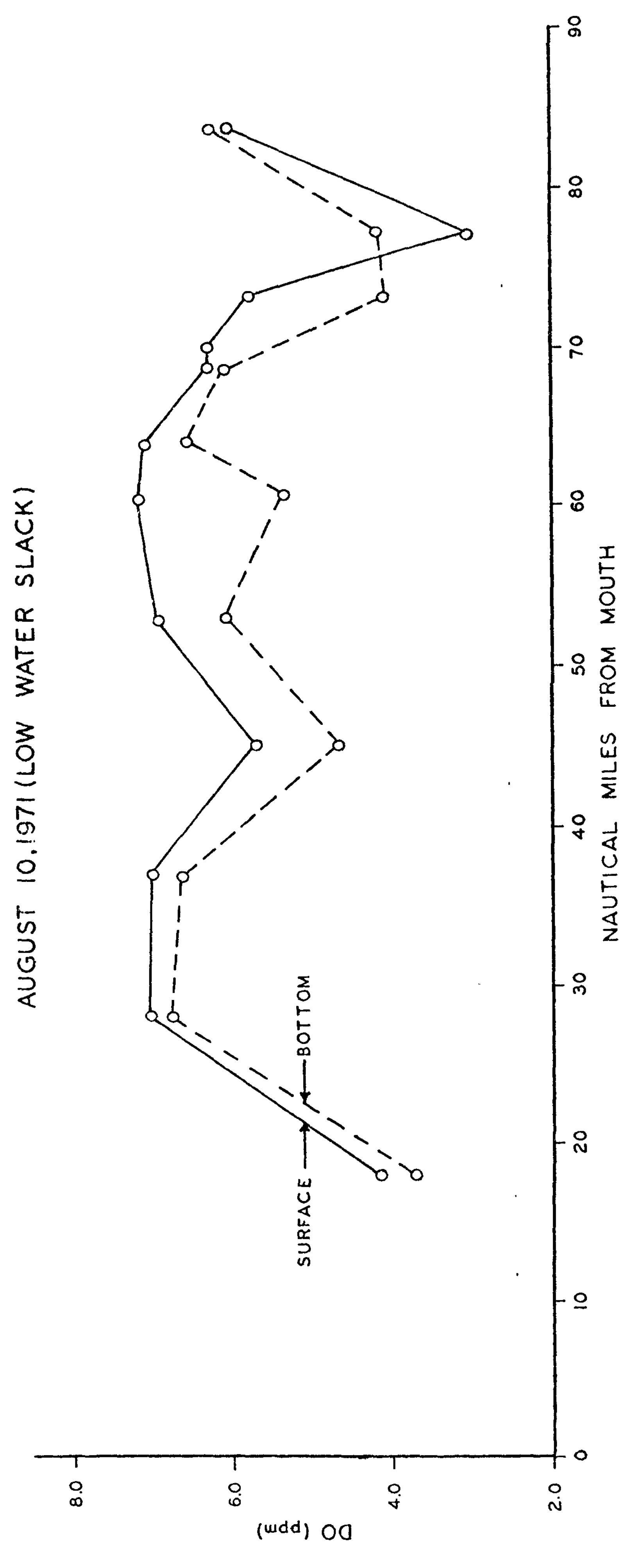

AUGUST 10,1971 (LOW WATER SLACK)
SURFACE
BOTTOM
NAUTICAL MILES FROM MOUTH
0
10
20
30
40
50
60
70
80
90
DO (ppm)
2.0
4.0
6.0
8.0

Figure IV-35

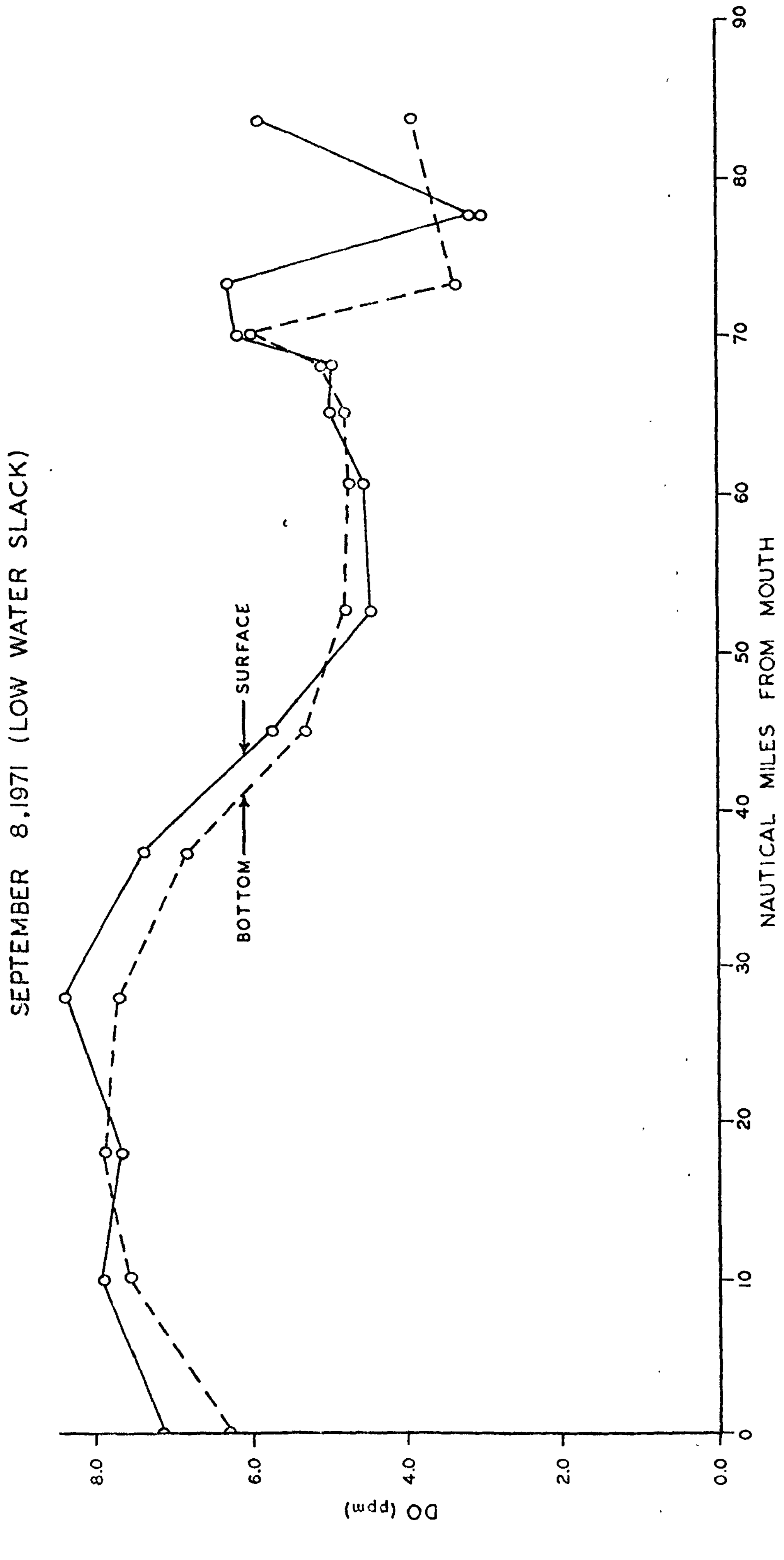

SEPTEMBER 8,1971 (LOW WATER SLACK)
SURFACE
BOTTOM
NAUTICAL MILES FROM MOUTH
DO (ppm)
0.0
2.0
4.0
6.0
8.0
0
10
20
30
40
50
60
70
80
90

Figure IV-36

with the estuary. Higher freshwater dilution flows and colder water temperatures prevented a significant DO depression during the June 11, 1971 run. Freshwater flows recorded at Richmond for the 3-day periods preceding the August and September runs averaged 5,728 and 7,689 cfs lower, respectively, than the average 3-day flow recorded prior to the June run.

Table IV-48 summarizes most of the significant sources of organic loadings to the James Estuary from Richmond to Hopewell. The most pronounced influence on the segment discussed above is the high organic loading exerted on the estuary by the Richmond Sewage Treatment Plant (STP). While secondary treatment facilities are slated for operation in October 1972, this facility currently provides only primary treatment to approximately 40 MGD of wastewater and exerts a 5-day BOD loading of 38,364 lbs/day. Even with secondary treatment, combined sewers in Richmond will result in the bypass of storm and sanitary wastes to the estuary following periods of heavy rainfall. Other sources of organic loadings above Turkey Island are the Henrico County STP, Richmond Deep Water Terminal STP, Chesterfield County's Falling Creek STP, and duPont Company's STP. The Henrico County STP provides secondary treatment and discharges to Gillies Creek just below Richmond.

From Turkey Island to several miles downstream, the estuary begins to recover from the oxygen sag downstream from the Richmond STP. However, as shown in Figures IV-34, IV-35, and IV-36, an elongated oxygen sag then occurs and extends from Hopewell downstream to the vicinity of the

Table IV-48

FACILITY	RECEIVING STREAM	TREATMENT	5-DAY BOD POUNDS PER DAY	REMARKS
Richmond City STP	James River	Primary	38,364	Secondary treatment by 8/72
Richmond Deep Water Terminal STP	James River	Primary	130	Approved plans for phasing out go to Richmond Secondary STP
DuPont Company	James River	Secondary equivalent	4,400	pH control, aerated lagoons, flyash ponds
Chesterfield Company Falling Creek STP	Falling Creek to James River	Secondary	857	Secondary treatment since 3/72
American Tobacco Company	James River	Settling lagoons	7,800	Future plans for equivalent of secondary treatment
Petersburg STP	Appomattox River	Primary	8,620	Overloaded, approved plans for secondary treatment 1974
Colonial Heights STP	Old Town Creek to Appomattox River	Primary	1,350	Plans for phasing out. Will go to Petersburg Secondary STP
Hopewell STP	Bailey Creek	Primary	3,000	Plans for regional secondary STP by 1975 to include Fort Lee and sanitary wastes (limited process wastes) from Firestone, Allied Chemical, Continental Can, and Hercules Powder (not to include cooling water treatment)
Fort Lee STP	Bailey Creek	Primary	2,000	
Firestone Company	Bailey Bay	None	1,280	
Allied Chemical Company	Gravelly Run to Bailey Bay	None	3,340	
Continental Can Company	Gravelly Run to Bailey Bay	Settling lagoons	39,840	
Hercules Powder Company	Bailey Bay	Settling lagoons	39,400	

entrance of the Chickahominy River, a distance of about 20 nautical miles. A combination of poorly treated domestic wastes from the Colonial Heights, Hopewell, and Petersburg areas and heavy organic industrial effluent from the Hopewell area contribute to this oxygen sag. As shown by Table IV-48, Colonial Heights, Petersburg, and Hopewell currently provide primary treatment only. The Petersburg Sewage Treatment Plant, which is overloaded by about 700,000 gallons per day, and the Colonial Heights STP discharge to the Appomattox River, while the Hopewell STP discharges to Bailey Creek. The Appomattox River in the vicinity of the Route 10 Bridge at Hopewell showed no serious DO depression during the 1971 sampling season; Bailey Creek, where it is traversed by Route 10, 0.6 mile upstream from its confluence with the James contained no DO at all except in cold weather.

Bailey Creek, in addition to recurring domestic wastes from Hopewell and Fort Lee, receives a heavy industrial effluent from several industries. These discharges enter the James River (Bailey Bay) below the Route 10 Bridge sampling station operated by the VWCB. The largest organic loadings to Bailey Bay are from Continental Can Company and Hercules Powder Company which discharge 39,840 and 39,400 lbs/day of 5-day BOD, respectively. The results of the 1971 monitoring by the VWCB at the Route 10 Bridge were as follows:

DATE	pH	TEMP °F	DO mg/l	BOD mg/l
1-18-71	10.0	44	4.0	250
2-14-71	5.5	39	6.0	146
3-13-71	>10.0	64	0.0	195
4-28-71	0.0	64	0.0	230
5-13-71	>10.0	77	0.0	-
6-27-71	8.2	98	0.0	380
7-08-71	6.7	82	-	-
8-02-71	8.9	90	0.0	200

The above data strongly demonstrate that the current industrial loadings to Bailey Bay are a significant factor in the depressed DO concentrations noted between Hopewell and the confluence of the Chickahominy River. Although not shown above, fecal coliform standards at this station were greatly exceeded, with values recorded in excess of 80,000 MPN/100 ml, indicating inadequacy of domestic sewage treatment.

The remaining oxygen sag, determined at low water slack, is downstream from Jamestown Island near the mouth of College Creek. The organic loadings from several small treatment plants in the Jamestown area and the treated wastes from Williamsburg which are discharged into College Creek could have influenced the lower DO concentrations in this section. The 1.82 MGD of wastewater from Williamsburg, previously treated at the College Creek plant, has recently been diverted to the newly constructed Hampton Roads Sanitation District's Williamsburg Plant, located near the Camp Wallace Military Reservation. Plans call for connecting the existing small plants in the Jamestown area to the new Williamsburg Plant.

The Virginia Institute of Marine Science also made runs at high water slack conditions, Figures IV-37, IV-38, and IV-39. The evidence of DO depression is similar to the low water slack runs discussed above, except that oxygen demanding material tends to become concentrated following high tide conditions. During flood tide, pollutants move upstream resulting in a backup and concentration of wastes rather than a dispersal. This effect is more pronounced in the upper estuary during low freshwater inflows. As with the low water slack runs, the lowest DO concentrations were recorded when flows were low and water temperatures high. The oxygen sag near Hopewell is closer to the waste outfalls following the flood tide.

Figures IV-40 and IV-41 show biochemical oxygen demand (BOD) data for bottom and surface water conditions obtained during high water slack. No BOD data were available for the low water slack runs. The Virginia Institute of Marine Science found these data to be inconclusive, as they often failed to coincide with DO deficits for the same sampling stations. However, BOD peaks were apparent below Richmond, Hopewell, and College Creek. The BOD surges at nautical River Miles 76 and 60 seem to manifest first, the high BOD discharge from the City of Richmond's primary plant and second, the heavy organic industrial loadings flowing from Bailey Bay at Hopewell.

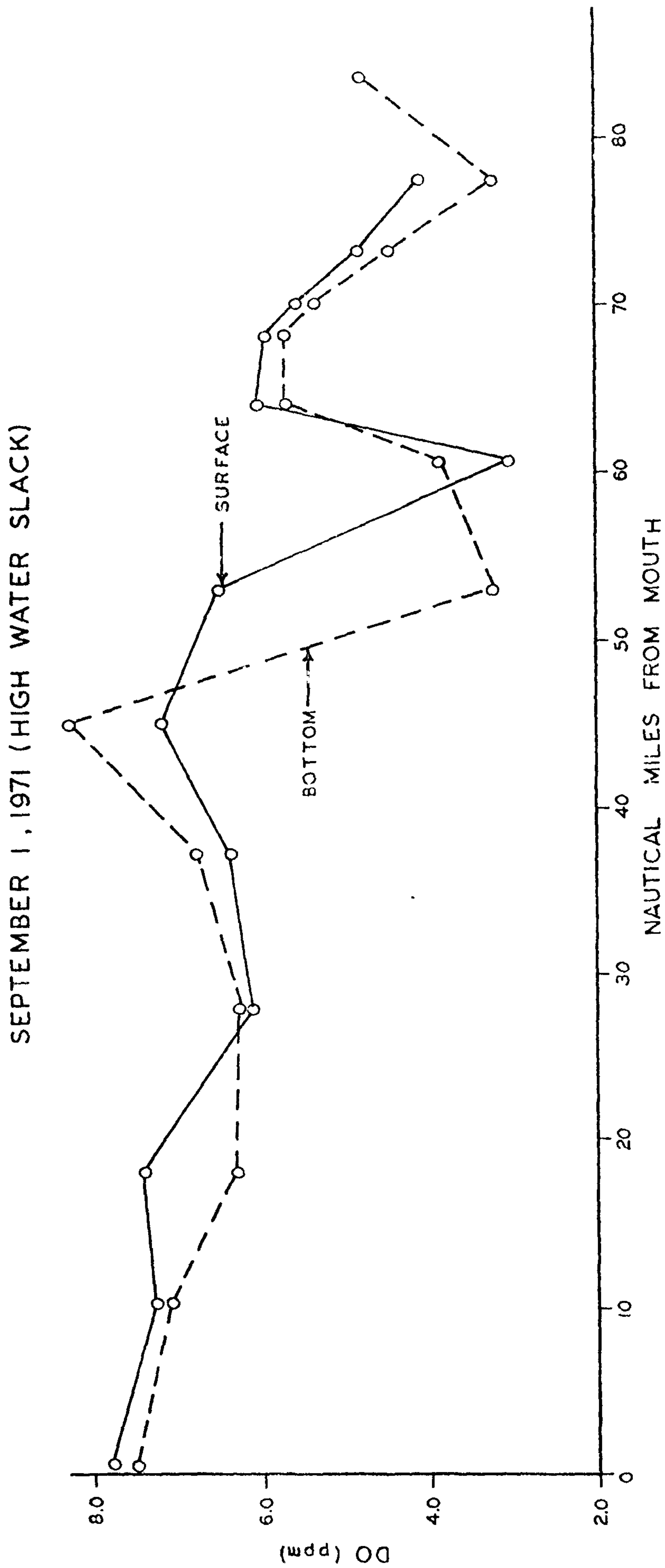

SEPTEMBER 1, 1971 (HIGH WATER SLACK)
SURFACE
BOTTOM
DO (ppm)
8.0
6.0
4.0
2.0
0
10
20
30
40
50
60
70
80
NAUTICAL MILES FROM MOUTH

Figure IV-37

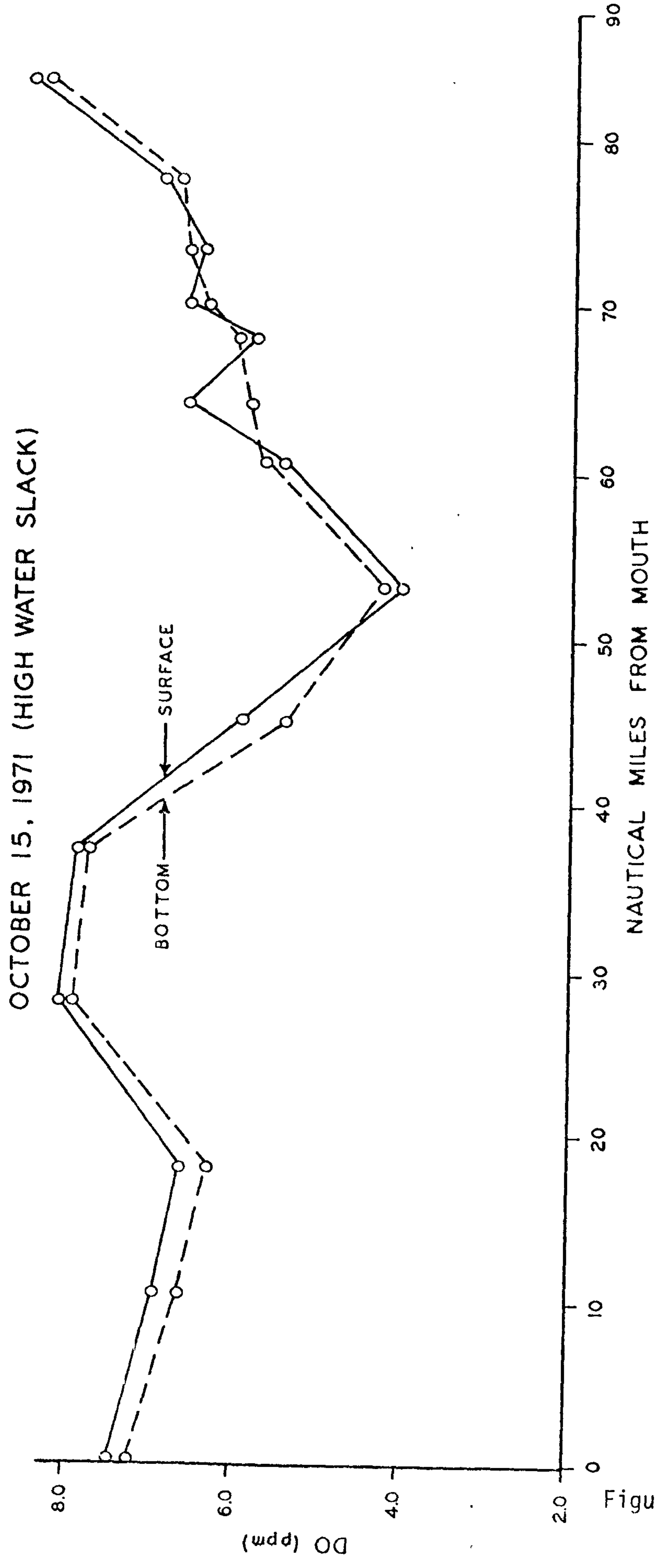

OCTOBER 15, 1971 (HIGH WATER SLACK)
SURFACE
BOTTOM
DO (ppm)
8.0
6.0
4.0
2.0
0
10
20
30
40
50
60
70
80
90
NAUTICAL MILES FROM MOUTH

Figure IV-38

OCTOBER 28, 1971 (HIGH WATER SLACK)

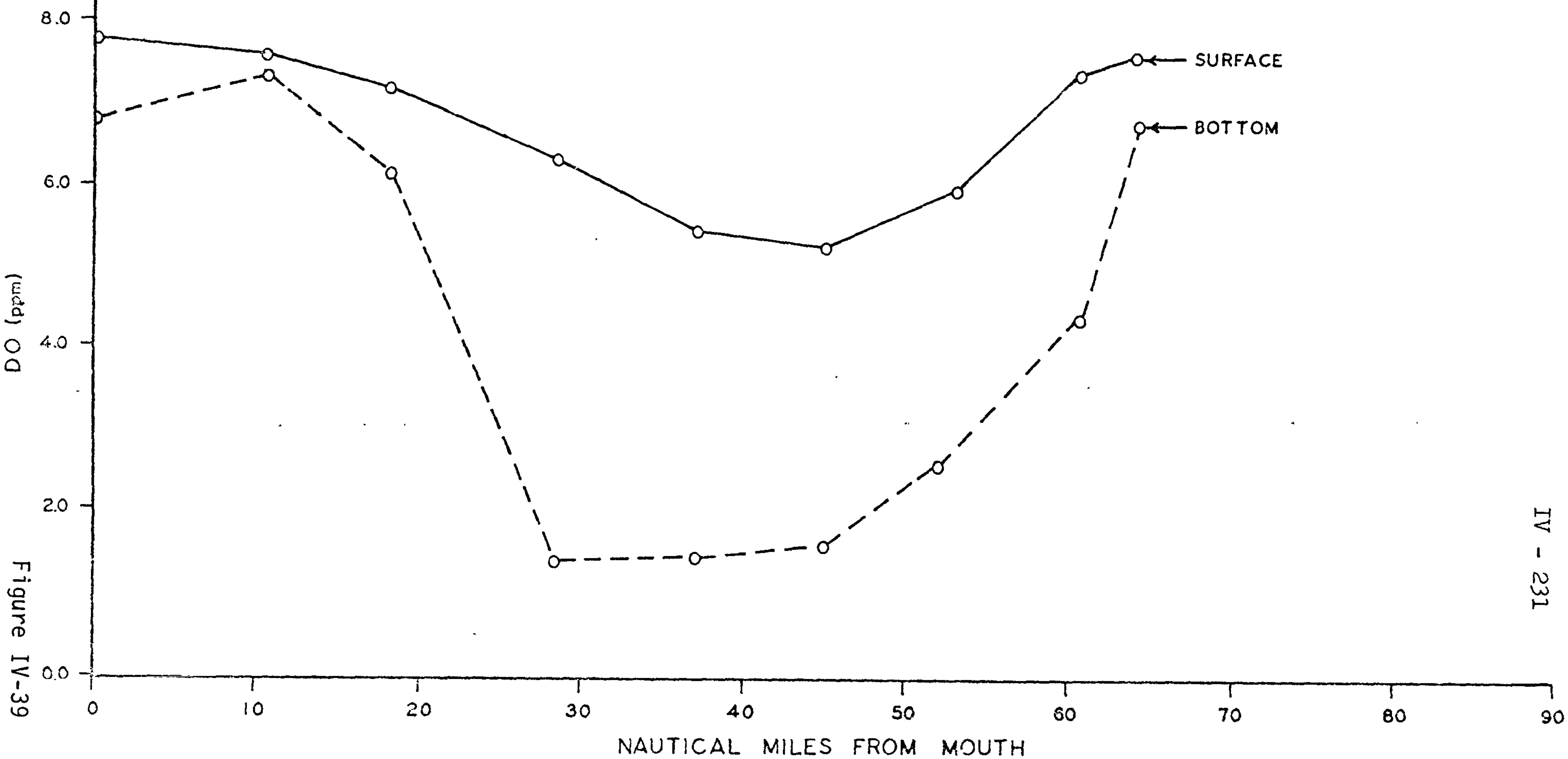


Figure IV-39

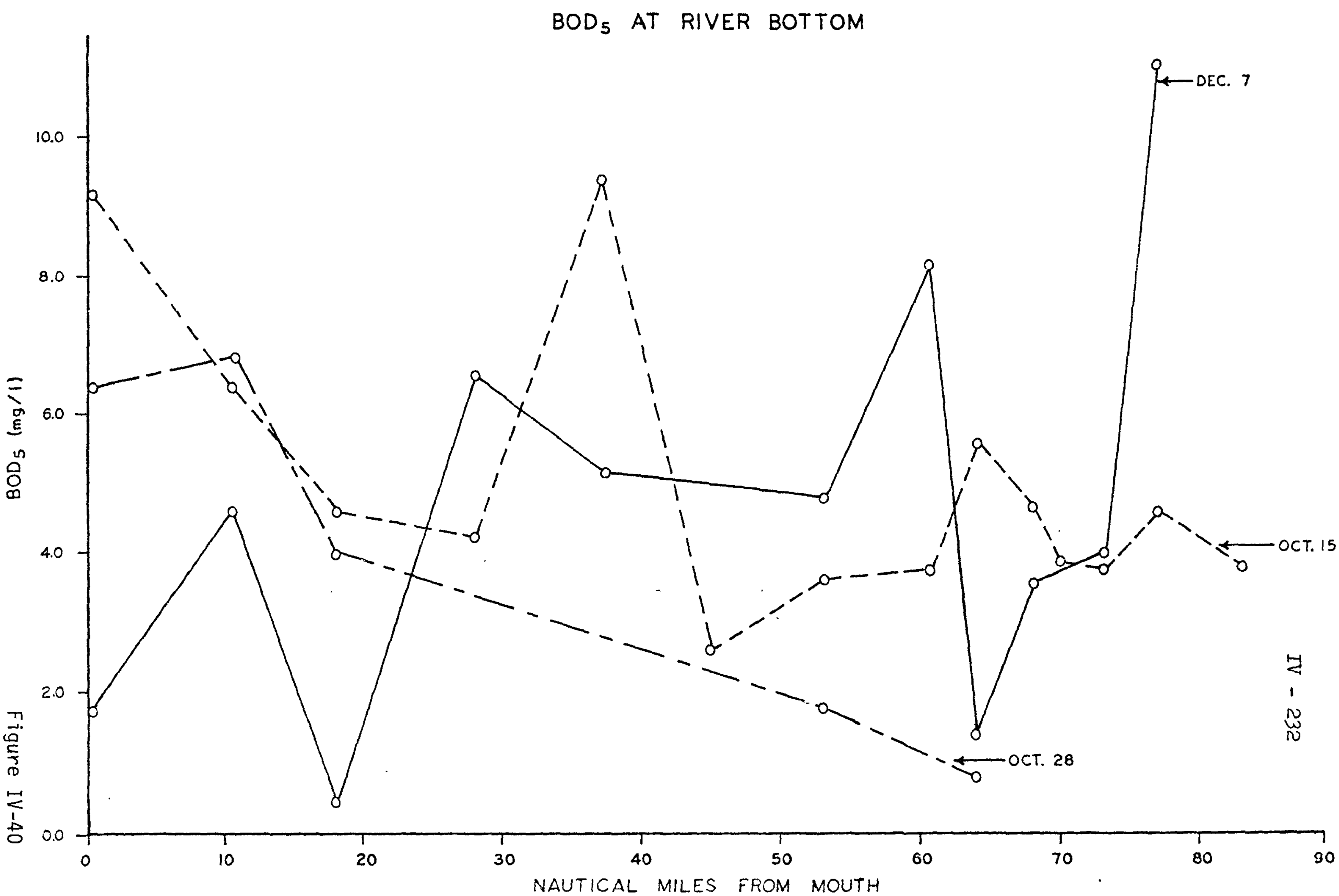

BOD5 AT RIVER BOTTOM
BOD5 (mg/l)
10.0
8.0
6.0
4.0
2.0
0.0
0
10
20
30
40
50
60
70
80
90
NAUTICAL MILES FROM MOUTH
DEC. 7
OCT. 15
OCT. 28

Figure IV-40

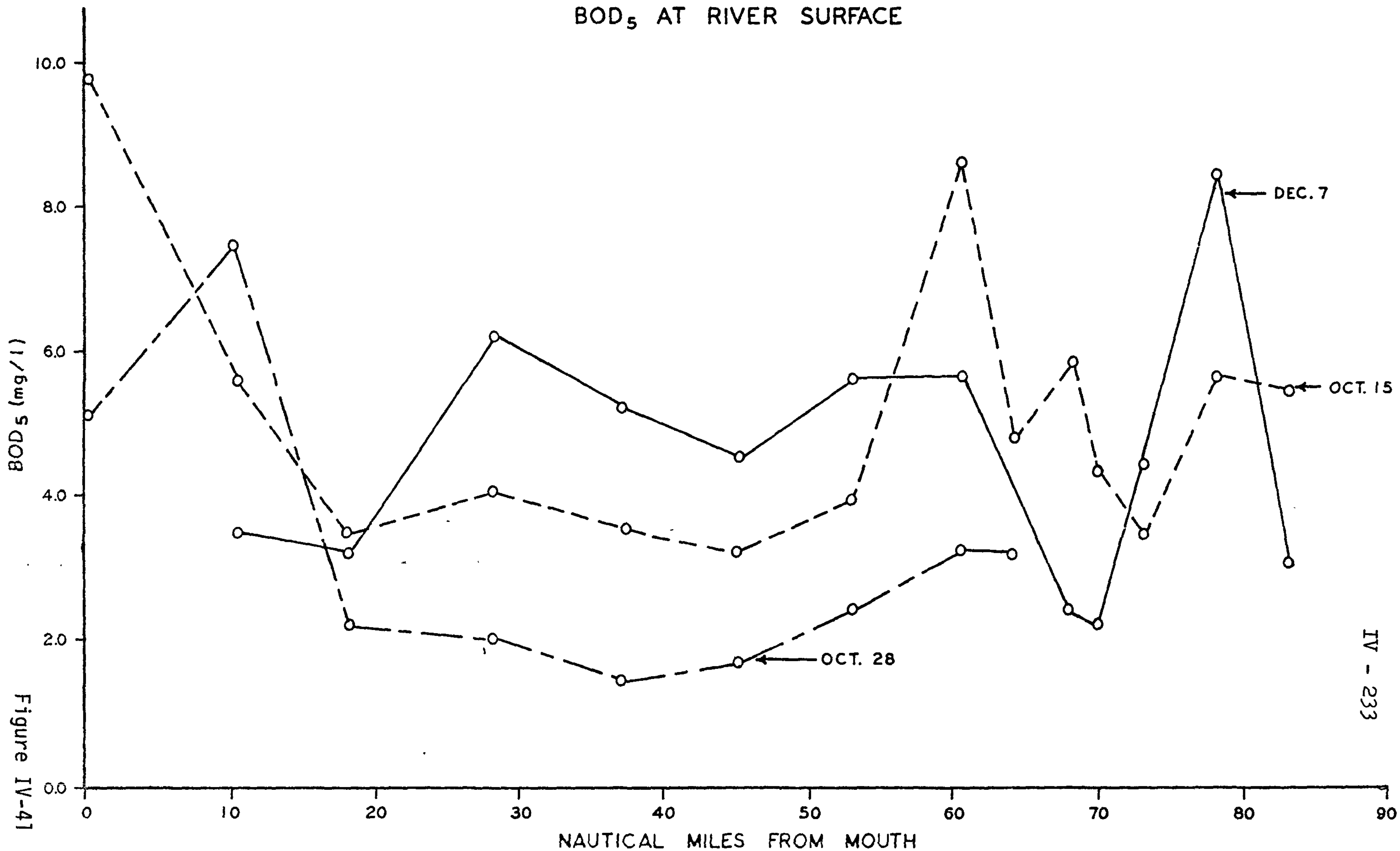

BOD5 AT RIVER SURFACE
BOD5 (mg/l)
10.0
8.0
6.0
4.0
2.0
0.0
0
10
20
30
40
50
60
70
80
90
NAUTICAL MILES FROM MOUTH
DEC. 7
OCT. 15
OCT. 28

Figure IV-41

NUTRIENTS

Surveys of the James Estuary were conducted during the spring and summer months of 1970 and 1971 by the Virginia Water Control Board and in November 1971 by the Annapolis Field Office (AFO) of EPA. The AFO carried out a detailed study of nutrient contributions to the Bay from the James and Chickahominy River as part of its "Chesapeake Bay Nutrient Input Study." The only other available data containing nutrient concentrations were taken by the Virginia Institute of Marine Science in an intensive study from 1965-1966. These sources constitute the basis of the information contained in this section.

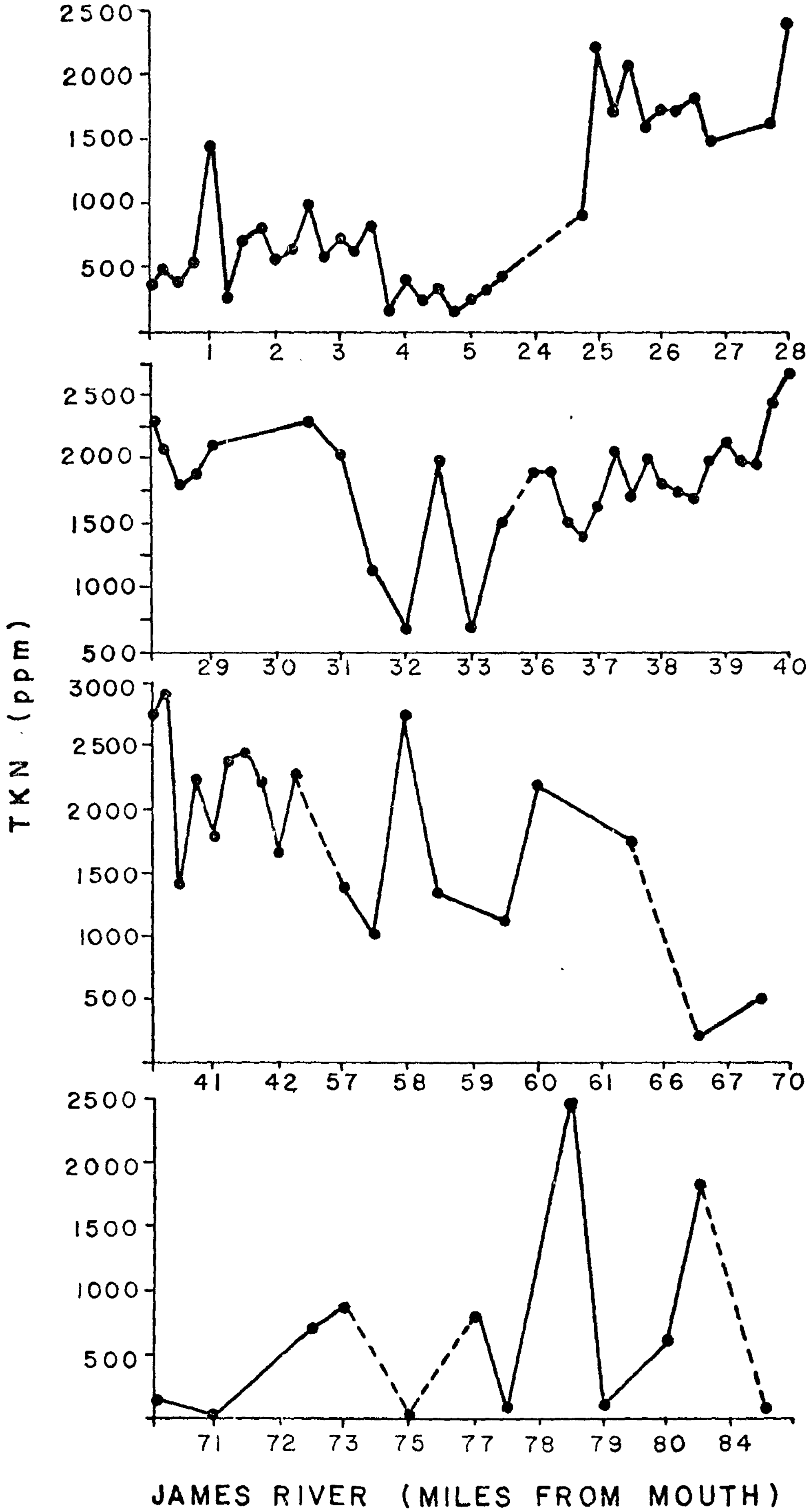
In September 1966, nitrate-nitrogen concentrations (as N) ranged from .028 to 1.246 mg/l between River Miles 13.54 and 98.34. The highest values, 1.078 and 1.246 mg/l, were found at River Miles 56.22 and 69.34, downstream from the industrial discharges at Hopewell (Statute River Mile 80.01). Inorganic phosphorus (as P) and organic phosphorus (as P) ranged from .016 to .372 mg/l and .031 to .271 mg/l, respectively, in the same area as above. The highest phosphorus values were recorded at River Mile 98.34. In addition, chlorophyll _a_ values of 92.0 and 86.0 μg/l were found at River Miles 69.34 and 98.34, respectively, well above the 25 μg/l level generally considered as acceptable. In terms of algal blooms, previous studies in the Potomac Estuary have shown that chlorophyll _a_ values in excess of 50 μg/l are indicative of nuisance conditions.

Nutrient data taken in August and November 1971 did not differ appreciably from concentrations found in September 1966. While the levels of nitrate-nitrogen were higher in August 1971 than in September 1966, the concentrations of both inorganic and organic phosphorus (as P) were lower than the September 1966 levels. However, the nitrate-nitrogen concentration decreased in November 1971 and the inorganic phosphorus (as P) level increased, as compared to September 1966 levels. Although chlorophyll a values were low in November 1971 (varying from 1.5 to 24.9 μg/l), no other recent chlorophyll a data exists. This precludes any statement concerning algal growth in the James Estuary during periods of high nutrient concentrations.

In 1971 nutrient concentrations were greatest during the late spring and early summer months, in particular the May-June period. Concentrations of both inorganic and organic nutrients in May 1971 are given in Table IV-50. The concentrations of ammonia-nitrogen and nitrate-nitrogen tended to increase downstream from Hopewell, while inorganic phosphorus (as P) levels increased downstream from Richmond (River Mile 107.95). The latter increase is due to primary treated domestic wastes from the City of Richmond, while the nitrogen increases are due to industrial wastes discharged into Bailey Creek, just downstream from Hopewell. During 1971, ammonia-nitrogen concentrations and total Kjeldahl nitrogen (TKN; includes ammonia) in Bailey Creek were excessively high, with NH_3 as N varying from a low of 2.00 mg/l to a high of 11.00 mg/l and TKN varying from 7.0 mg/l to 14.0 mg/l at the Rt. 10 bridge, 0.6 mile from the confluence of Bailey Creek with the James River. The high nitrate-nitrogen concentrations downstream from Hopewell could reflect the oxidation of NH_3 to nitrate-nitrogen due to the abundance of oxygen in the mainstem area. Discharges into the Appomattox River and from American Tobacco Company, directly into the James downstream from the mouth of the Appomattox, may account for the high nitrate-nitrogen levels in the James River downstream from River Mile 77.44. Insufficient data exist at this time to determine the impact of the Appomattox River on nutrient levels in the James River. Also, the high organic and inorganic phosphorus (as P) levels found in Bailey Creek are not reflected in increased values in the James River downstream from Hopewell. High dilution in this area could account for the lower P levels.

Nutrient concentrations in James River bottom sediment in the summer of 1971 are shown in Figures IV-42 and IV-43. (Note: All River Mile locations for sediments are given in nautical miles.) While TKN does not exhibit a definite pattern, total phosphorus concentration maxima occur at River Miles 5, 30, 37, and 40. No correlation between nutrient concentrations in surface water and bottom sediment of the James River can be found.

A lack of sufficient nutrient and chlorophyll a concentration data prevents making a definite statement regarding any related water quality problems in the James River. Chlorophyll a data taken during periods of high nutrient concentrations are essential in order to determine if any nuisance algal growths exist, as both nitrogen and phosphorus levels in the upper James River are present in amounts which could support excessive algal growths. In addition, the nutrient loadings originating from municipal and industrial sources should be determined.


2500
2000
1500
1000
500
1 2 3 4 5 24 25 26 27 28
2500
2000
1500
1000
500
29 30 31 32 33 36 37 38 39 40
3000
2500
2000
1500
1000
500
41 42 57 58 59 60 61 66 67 70
2500
2000
1500
1000
500
71 72 73 75 77 78 79 80 84
TKN (ppm)
JAMES RIVER (MILES FROM MOUTH)

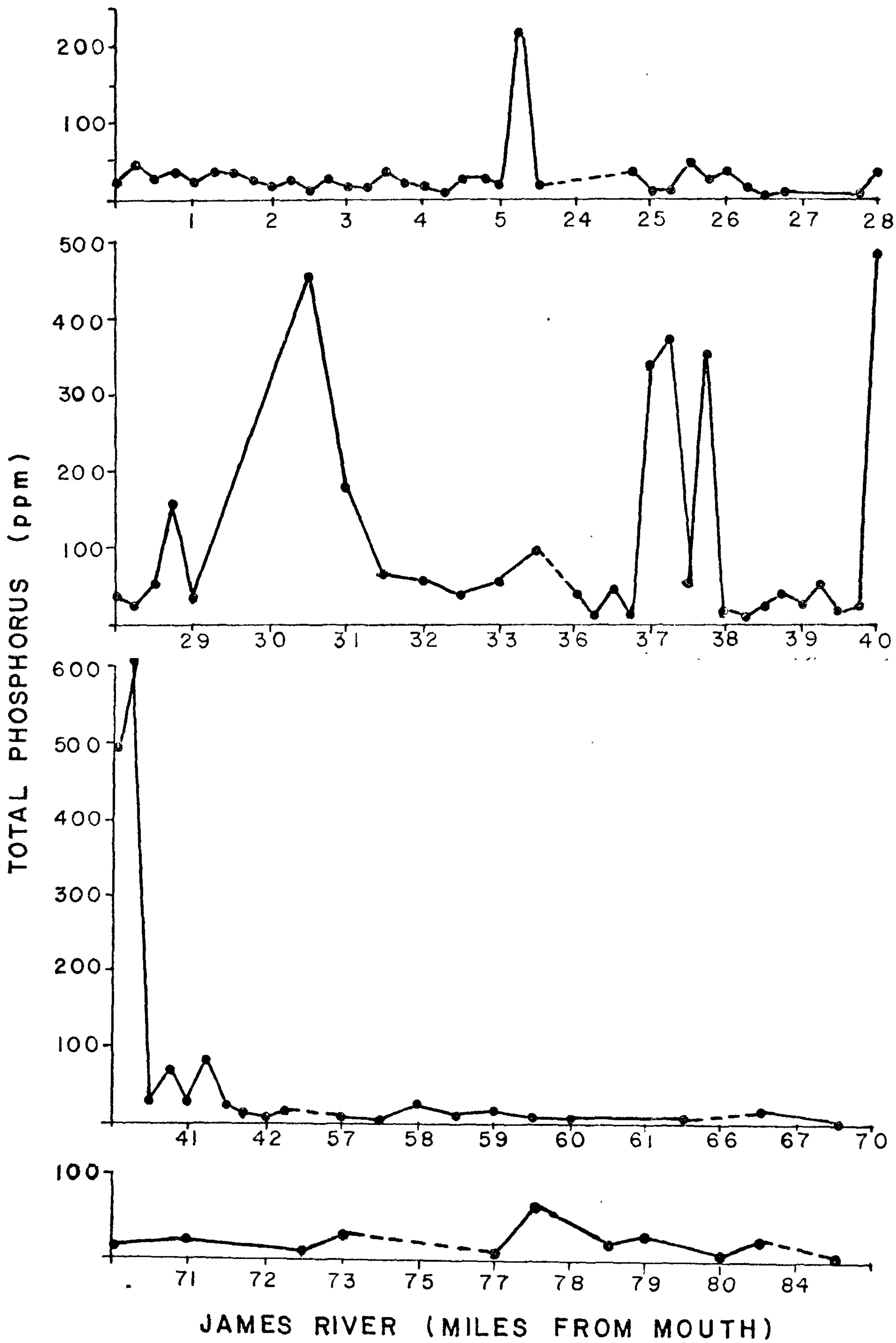

TOTAL PHOSPHORUS (ppm)
200
100
1
2
3
4
5
24
25
26
27
28
500
400
300
200
100
29
30
31
32
33
36
37
38
39
40
600
500
400
300
200
100
41
42
57
58
59
60
61
66
67
70
100
71
72
73
75
77
78
79
80
84
JAMES RIVER (MILES FROM MOUTH)

Figure IV-43

An initial step in determining nutrient sources to the James Estuary was taken by AFO during 1969-1970. Detailed analyses of the freshwater inflow from the James River at Route 147 Bridge (West Richmond) and from the Chickahominy River at Route 60 Bridge were conducted during the period from June 1969 to August 1970 to determine the nutrient contribution of the water entering the tidal system. The Appomattox River was not included in this intensive study. The following table presents the average concentration of nutrients based on average monthly flows for the two rivers measured during the 15-month period of June 1969 to August 1970.

Table IV-49

	TPO_4 AS PO_4 mg/l	INORGANIC P AS PO_4 mg/l	TKN AS N mg/l	NO_2+NO_3 AS N mg/l	NH_3 AS N mg/l	TOC mg/l
James River	.20	.13	.64	.66	.13	5.51
Chickahominy River	.57	.39	.73	.25	.07	10.53

Average monthly contributions in pounds per day for the two rivers can be found in the report "Chesapeake Bay Nutrient Input Study," Technical Report Number 47, by the Annapolis Field Office of EPA.

Table IV-50

James River

Nutrient Concentrations
May 1971

Statute River Mile	NH_3-N mg/l	NO_2+NO_3-N mg/l	Inorganic P as P mg/l	Organic N mg/l	Organic P mg/l
7.77	.600	.190	.060	-	.040
13.54	.500	.310	.010	-	.090
20.54	.300	.450	.010	-	.090
26.07	.070	.700	.010	.130	.090
34.27	.380	.800	.100	.420	.000
41.27	.060	.900	.060	.240	.040
42.92	.070	.850	.030	.230	.070
56.22	.310	.950	.030	.490	.070
69.34	.600	.650	.030	.400	.070
77.44	3.900	.600	.100	.700	.000
80.01	.620	.300	.070	.280	.030
81.61	.030	.500	.070	.570	.030
94.84	.600	.250	.100	.200	.000
96.76	.550	.400	.100	.050	.000
98.34	.600	.510	.140	.000	-
103.22	.500	.450	.140	.000	-
106.18	.400	.400	.100	.000	.000
107.95	.130	.350	.010	.070	.090

PESTICIDES

Both chlorinated hydrocarbon and thio-phosphate pesticides were found in surface waters of the James River during the late spring and summer months of 1971 (May-July). Total concentrations of each of the above general categories of pesticides were less than 0.100 μg/l, the minimum detectable laboratory limit for those parameters employed at the time the analyses were made. The chlorinated hydrocarbon pesticides Dieldrin, DDE, DDT, and Lindane were also monitored, with the following range of concentrations measured:

Dieldrin	.007 - .030 μg/l
DDE	<.020 - .030 μg/l
DDT	<.030 - .060 μg/l
Lindane	.030 - - μg/l

The United States Public Health Service standards for public and municipal water supplies at the raw water intake were, at no time, contravened by any of the above pesticides. The maximum allowable concentrations of these pesticides are:

Dieldrin	.017 mg/l
DDT	.042 mg/l
Lindane	.056 mg/l

Currently, no standard exists for DDE, although it appears that this pesticide is also present in only very small amounts.

In general, pesticides in the James River were found at levels far below the point at which they would constitute a hazard to health.

Although the tidal James Estuary is not now used as a public or municipal water supply, studies are currently underway to determine the feasibility of such a water use for the upper Estuary.

HEAVY METALS

The Virginia State Water Control Board monitored the following heavy metals in the James River during April, May, and September 1970, and June 1971: arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, and zinc. The range of concentrations of the above metals were found as follows:

Arsenic	< .005 mg/l
Cadmium	< .010 mg/l
Chromium	< .010 - .040 mg/l
Copper	< .010 - .140 mg/l
Iron	.600 mg/l
Lead	< .010 mg/l
Manganese	< .010 - .100 mg/l
Mercury	< .0005 - .0076 ppm
Zinc	< .010 - .080 mg/l

Concentrations of six of the above metals (arsenic, cadmium, chromium, copper, lead, and zinc) were, at all times, less than the standards the United States Public Health Service has set for the raw water intake of public and municipal water supplies. The water supply raw water intake standard was contravened in the case of iron and manganese, for which the standards are 0.3 mg/l and 0.05 mg/l, respectively. The standard for manganese was contravened four times out of a total of 16 samples, while the standard for iron was contravened on the only occasion this metal was monitored. In general, heavy metal concentrations in the main stem of the James Estuary are satisfactory, except between River Miles 77.44 and 98.34 where higher concentrations of some metals are found.

High heavy metal concentrations, in particular chromium, iron, manganese, and zinc, were found at Creek Mile 0.65 in Bailey Creek 0.6 mile from its confluence with the James Estuary at River Mile 77. The following heavy metal concentrations were found during 1970 and 1971 at River Mile 0.65 in Bailey Creek:

Arsenic	< .005 mg/l
Cadmium	< .010 mg/l
Chromium	< .010 - .060 mg/l
Copper	.010 - .050 mg/l
Iron	.900 - 1.700 mg/l
Lead	.020 - .030 mg/l
Manganese	.120 - .140 mg/l
Mercury	< .0005 ppm
Zinc	.070 - .340 mg/l

A number of industries discharge significant amounts of wastes into Bailey Bay, including Continental Can Co., Hercules Powder Co., Allied Chemical Co., and Firestone Co.

During the summer of 1971 concentrations of lead, mercury, and zinc in the bottom sediment of the main channel of the James River were monitored. This survey was conducted by the Virginia Institute of Marine Science in order to identify those dredging spoils which would violate water quality criteria for open water disposal. The following limits for heavy metal concentrations have been set by EPA for open water disposal of spoil materials:

Lead	50 ppm
Mercury	1 ppm
Zinc	50 ppm

Figures IV-44, IV-45, IV-46 delineate the concentrations of the above heavy metals in the bottom sediment of the James River (Note: River Mile locations in the remainder of this section are given in nautical miles). The criterion for lead was contravened at only one location, River Mile 82.0, about three miles below Richmond City's sewage treatment plant, where a concentration of 55 ppm was found. The concentration of mercury in the sediment was found to be satisfactory throughout the James River, never exceeding 1.0 ppm. However, the concentration of zinc in the James River sediment exceeded the spoil material disposal criterion in a large portion of the river, in particular between River Miles 25.0 (in Channel SW of Hog Island) and 64.0 (opposite Bailey Creek), and between River Miles 71.0 and 74.0 (in vicinity of Dutch Gap). Most zinc concentration values fell within a range between 50 and 240 ppm. At River Mile 72.0, a maximum concentration of 708 ppm of zinc was found in the James River sediment. In the paper "Utilizing Metal Concentration Relationships in the Eastern Oyster (Crassostrea virginica) to Detect Heavy Metal Pollution," VIMS no. 431, October 1971, oysters in the lower portion of the James River (below River Mile 25) were reported to contain concentrations of zinc ranging from 800 to 1600 ppm. However, no correlation between the levels of zinc in bottom sediment of the James River and the zinc levels in James River oysters has been found.

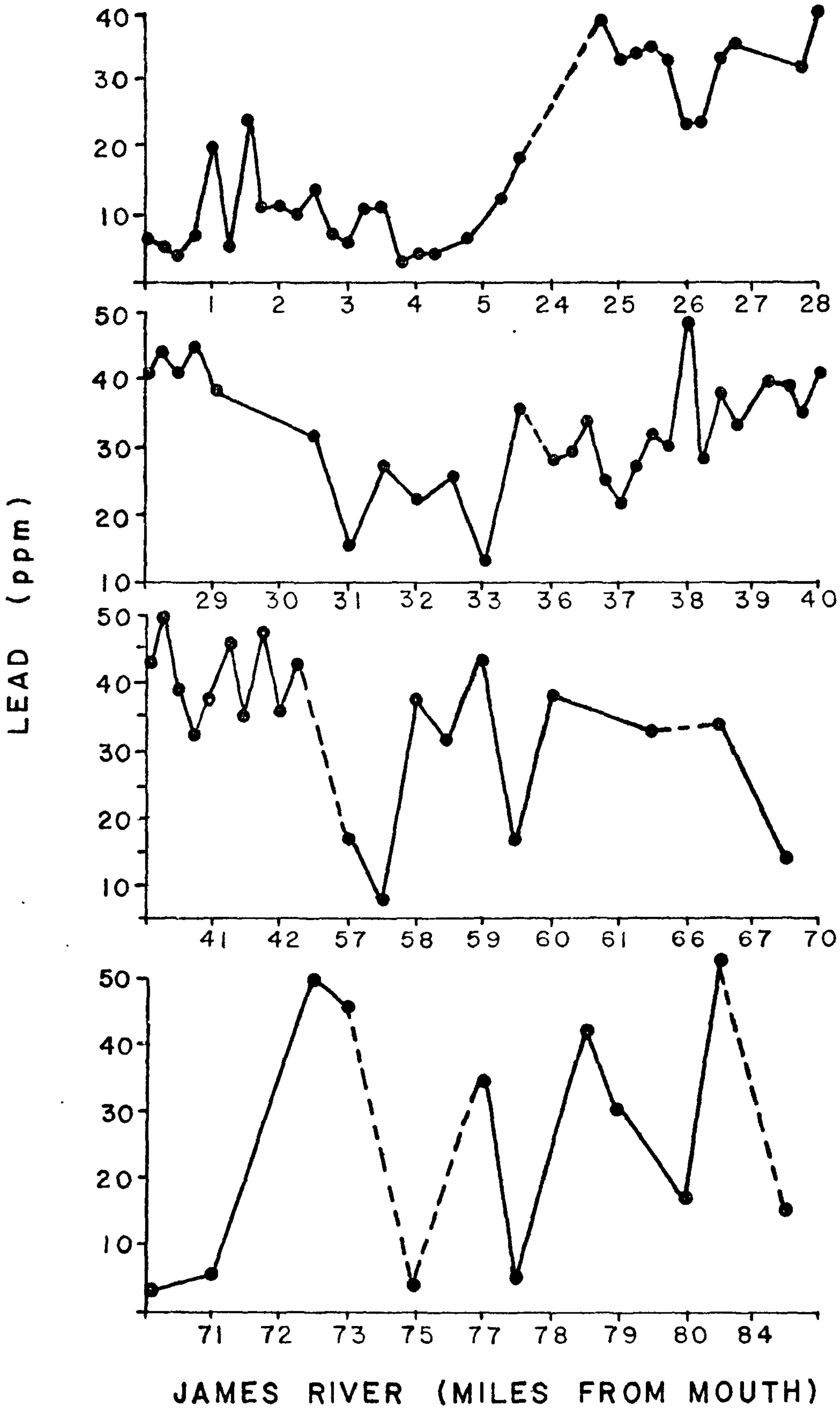

40
30
20
10
1
2
3
4
5
24
25
26
27
28
50
40
30
20
10
29
30
31
32
33
36
37
38
39
40
50
40
30
20
10
41
42
57
58
59
60
61
66
67
70
50
40
30
20
10
71
72
73
75
77
78
79
80
84
LEAD (ppm)
JAMES RIVER (MILES FROM MOUTH)

Figure IV-44

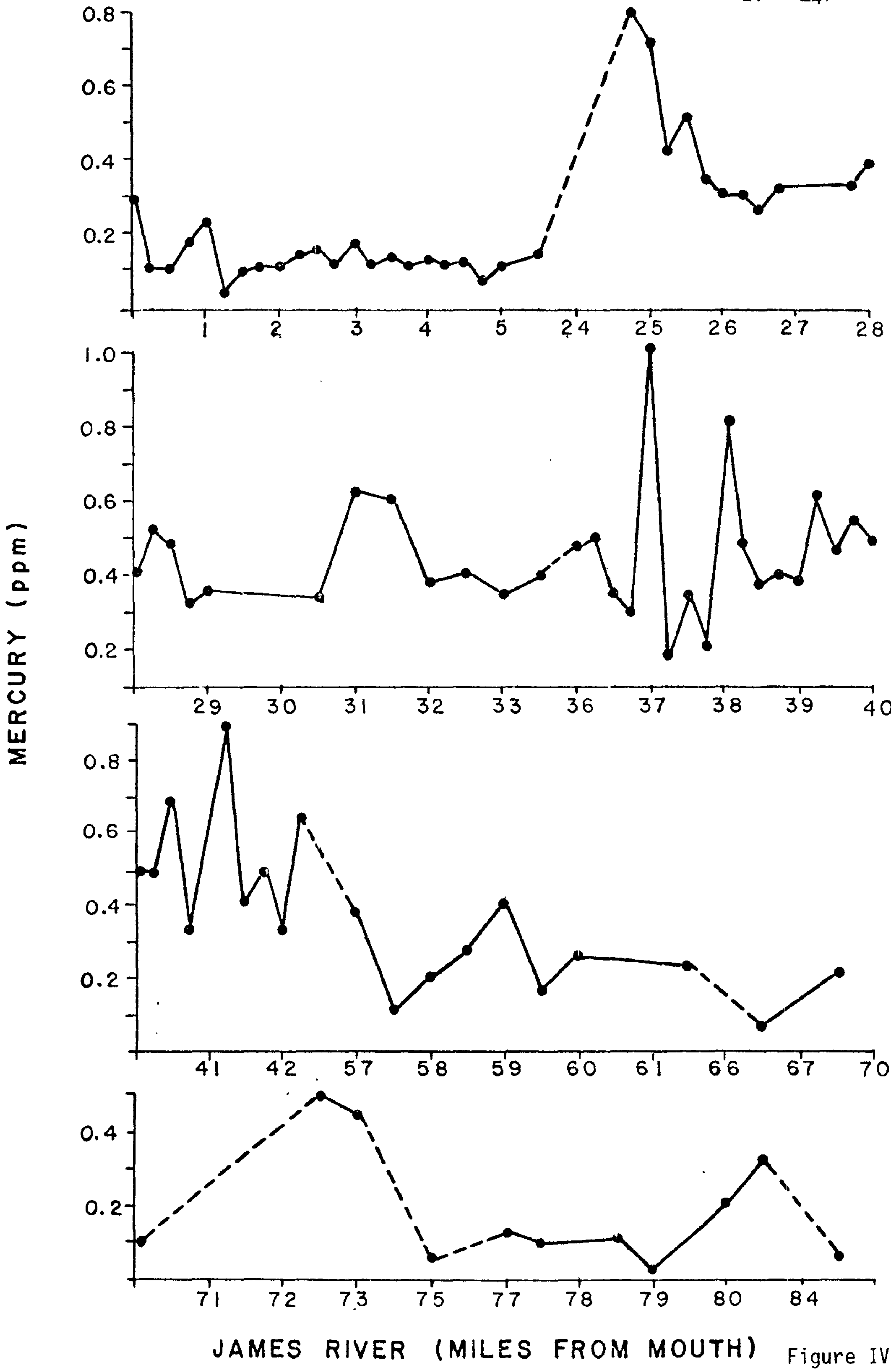

0.8
0.6
0.4
0.2
1 2 3 4 5 24 25 26 27 28
1.0
0.8
0.6
0.4
0.2
29 30 31 32 33 36 37 38 39 40
0.8
0.6
0.4
0.2
41 42 57 58 59 60 61 66 67 70
0.4
0.2
71 72 73 75 77 78 79 80 84
MERCURY (ppm)
JAMES RIVER (MILES FROM MOUTH)

Figure IV-45

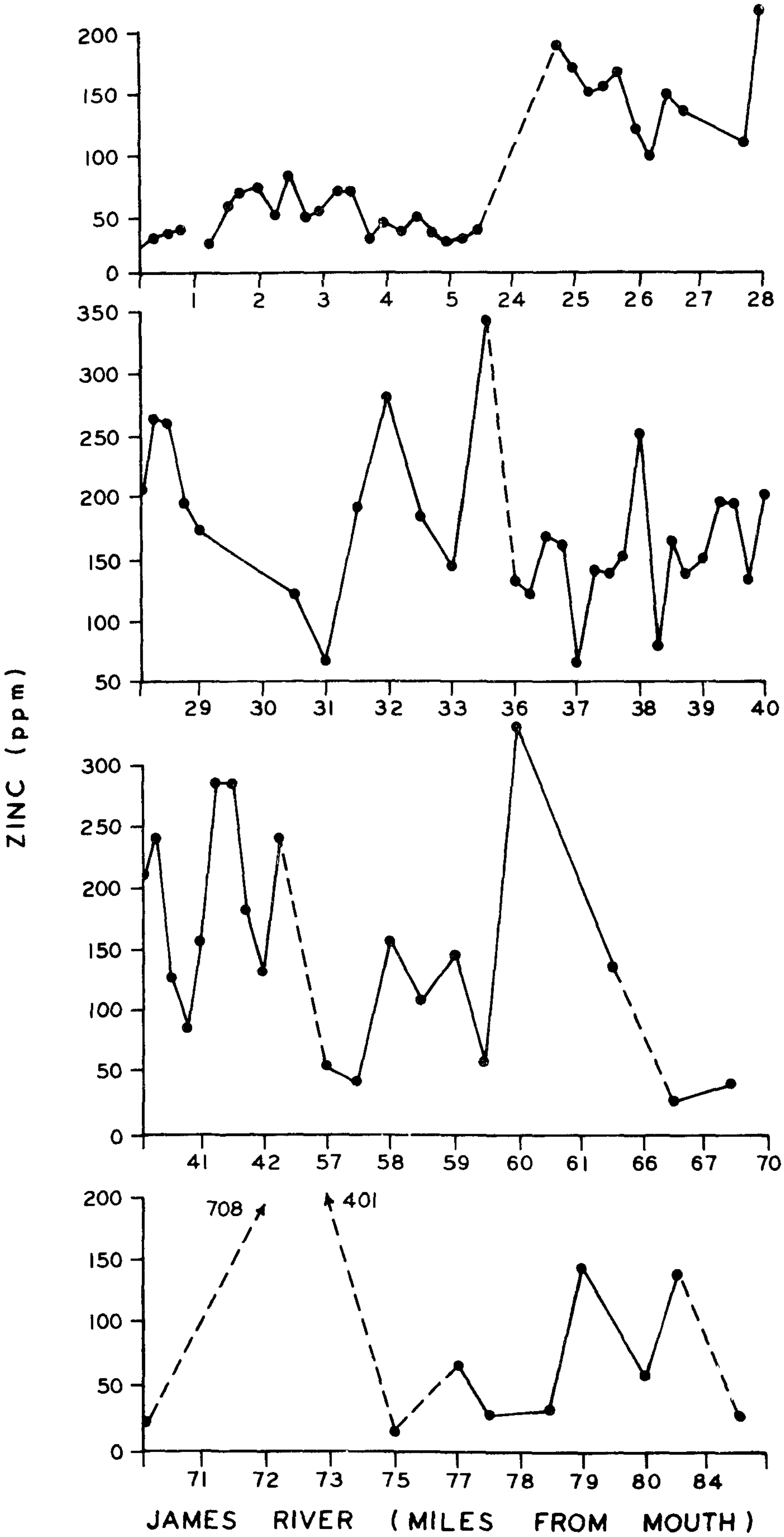

ZINC (ppm)
200
150
100
50
0
1 2 3 4 5 24 25 26 27 28
350
300
250
200
150
100
50
29 30 31 32 33 36 37 38 39 40
300
250
200
150
100
50
0
41 42 57 58 59 60 61 66 67 70
200
150
100
50
0
708
401
71 72 73 75 77 78 79 80 84
JAMES RIVER (MILES FROM MOUTH)

Figure IV-46

2. ELIZABETH RIVER

The Elizabeth River, an estuary with sluggish tidal cycles inhibiting the inflow of fresh water, is an example of an excessively utilized waterway in regard to waste assimilation. Due to (1) the relatively shallow nature of the Elizabeth River (2) low dispersion and transport characteristics and (3) intense industrial, commercial and domestic development, the Elizabeth River's ability to assimilate the diverse waste input from these sources is extremely limited.

The three main branches of the Elizabeth River - the Eastern Branch, Western Branch and Southern Branch - are characterized by heavy industrial, commercial and domestic pollution problems. In addition to domestic waste discharged by sewage treatment plants and toxic wastes discharged by a variety of industrial concerns, the area is plagued by frequent spills and waste discharges from the extensive shipyard and docking facilities therein.

On the Eastern Branch are located shopbuilding and drydock facilities, an automobile assembly plant, an electric power plant, and several shipping docks which contribute to the waste input of the river. The Southern Branch, the most industrialized and longest branch of the Elizabeth River, is characterized by a variety of industrial and commercial concerns: cement plants, creosote treatment plants, shipbuilding and drydock facilities, food processing plants, power plants, chemical plants, and U. S. Navy shipyards. On the Western Branch, the least industrialized branch of the Elizabeth River, are located a chemical manufacturing company and shipyards. The Main Branch houses shipping terminals, coal loading yards, an oil terminal, and sewage treatment plants.

INDUSTRIAL DISCHARGES

In March, 1972, the Annapolis Field Office conducted field investigations of major industries known to be discharging significant quantities of wastes into the Elizabeth River. Effluent samples and receiving water samples opposite the discharges were obtained. This information is presently being analyzed and will be published at some later time.

BACTERIOLOGICAL

In 1967 twelve areas in the James River Basin were condemned by the State Health Department for the direct marketing of shellfish. These condemned areas represented approximately 91% of the available shellfish harvesting acreage in the state of Virginia. The entire Elizabeth River was included as one of the original condemned areas for the location of oyster beds. Condemnation of these areas was based on several factors: high population density, sewerage system with 30 pump stations, heavy boat activities (commercial and military docks), numerous marinas, location of refineries and oyster processing plants, and heavy shipping activities.

Based on 1971 data the State Health Department has condemned eleven areas in the James River Basin for direct marketing of shellfish. These condemned areas total 46,727 acres as compared to 42,170 acres which were condemned in 1967. However, the condemned areas of 1971 represent approximately 50% of available acreage for shellfish harvesting on the James River Basin. This decrease in the percentage of condemned areas is not to be construed as a decrease in the amount of condemned acreage. It is, rather, due to an increase in the total available shellfish harvesting acreage from a 1967 level of 46,335 acres to a 1971 level of 93,062 acres.

Based on a water quality survey of the Elizabeth River during November, 1971 by AFO, fecal coliform counts (MPN) varied from 330/100 ml to 54,200/100 ml at station L-28 (Western Branch, Elizabeth River). The following table presents the total coliform and fecal coliform levels for the sampling period at stations in the Main Branch, Western Branch, Eastern Branch, and Southern Branch of the Elizabeth River.

Table IV-51

ELIZABETH RIVER

STATION NUMBER	STATION DESCRIPTION	DATE	COLIFORM MPN/100 ml	FECAL COLIFORM MPN/100 ml
L-28	Western Branch	11-02-71	1300	1300
	Elizabeth River	11-03-71	54200	54200
		11-04-71	490	330
	Norfolk Reach	11-02-71	5420	9180
L-29	Eastern Branch	11-03-71	2400	3480
	Elizabeth River	11-04-71	24000	9180
L-31	Eastern Branch	11-02-71	17200	17200
	at Pescara Creek	11-03-71	17200	10900
		11-04-71	34800	9180
L-33	Southern Branch	11-02-71	16090	16090
	at St. Helena	11-03-71	24000	24000
		11-04-71	17200	17200
L-34	Southern Branch	11-02-71	-	-
	Paradise Creek	11-03-71	9180	5420
		11-04-71	-	-

As can be seen in the preceding chart, extremely high total and fecal coliform counts were detected at every station. In every case the specific bacteriological water quality criteria assigned to shellfish areas was violated (i.e. 70 total coliform organisms MPN per 100 ml).

During 1969, 1970, and 1971 the VWCB monitored portions of the Eastern and Southern Branches of the Elizabeth River. The following table gives the coliform levels detected sporadically at three locations for the 1968, 1969, 1970, and 1971 sampling runs.

Table IV-52

EASTERN BRANCH, ELIZABETH RIVER

RIVER MILE	STATION DESCRIPTION	DATE	TOTAL COLIFORM MPN/100 ml	FECAL COLIFORM MPN/100 ml
		09-09-68	430	-
		02-03-69	-	4300
		07-24-69	43000	-
		04-21-70	230	-
0.07	Alternate Route 58-	05-05-70	4600	-
	460 Bridge	11-22-70	930	0
	Chesapeake, Virginia	05-11-71	930	700
		06-14-71	-	1300
		07-06-71	430	<100
		09-02-71	>11000	600
		06-28-68	30	-
		07-24-68	430	-
4.62	Route 13 Bridge			
		08-22-68	91	-
	Norfolk, Virginia			
		09-09-68	750	-
		02-03-69	23000	-
		04-28-69	930	-
		07-24--69	1500	-
		04-21-70	2400	-

Table IV-52 (Cont.)

RIVER MILE	STATION DESCRIPTION	DATE	TOTAL COLIFORM MPN/100 ml	FECAL COLIFORM MPN/100 ml
		05-05-70	11000	-
		11-22-70	4300	400
4.62	Route 13 Bridge	05-11-71	930	200
	Norfolk, Virginia	06-14-71	-	700
		07-06-71	430	300
		08-22-68	430	-
		09-09-68	230	-
		02-03-69	930	-
2.03	Beltline Railroad	04-21-70	930	-
	Bridge	05-05-70	11000	-
	Norfolk, Virginia	10-27-70	11000	-
	(Southern Branch)	11-22-70	930	0
		05-11-71	1500	100
		06-14-71	-	1600
		07-06-71	430	<100

MUNICIPAL DISCHARGES

The discharges emanating from two primary treatment plants on the Elizabeth River contribute to the widespread water quality problems associated with this river.

The Hampton Roads Sanitation District Commission operates several sewage treatment plants with nearly sixty pumping stations, the majority of which affect the water quality of the Elizabeth River. Occasionally these pumping stations overflow and raw untreated sewage enters the Elizabeth River. This situation contributes significantly to the high levels of coliform bacteria in the receiving waters.

A recurring eutrophication problem in the Elizabeth River is alledgedly the result of two plants - the Lamberts Point and Army District Sewage Treatment Plants. Quantities of algae rivaling those found in the upper Potoomac Estuary were evidenced in photographs of the Elizabeth River taken by a resident of the area.

The Hampton Roads Sanitiation District Lamberts Point Treatment Plant serves a population of 220,000 and has a design capacity of 24 MGD. At the present time this primary plant is utilized at a 25 MGD rate. Based on 1971 data the plant provides only 20% BOD removal and discharges approximately 24,000 lbs/day of BOD into the Elizabeth River.

The Hampton Roads Sanitation District Army Base Treatment Plant serves the James River north of the Lamberts Point Treatment Plant.

The plant has a design capacity of 11 MGD and is presently being utilized at a 12.3 MGD rate. Based on 1971 data the plant provides 28% BOD removal and discharges 11,300 lbs/day of BOD into the receiving waters.

Based on the Municipal Waste Quality Inventory and Waste Facilities Needs Data Report compiled by EPA in cooperation with the Virginia State Water Control Board the following TableIV-53 is a list of Hampton Roads Sanitation District Treatment Plants.

Two additional treatment plants not listed in the Municipal Waste Facility Inventory and Waste Facilities Needs Data Report are in operation on the Main Branch and Southern Branch of the Elizabeth River. A 15 MGD primary treatment plant is in operation at Pinner Point on the Main Branch. This plant is not well operated and, as a result, frequent overflows of untreated sewage into the Elizabeth River are not uncommon. A 2 MGD sewage treatment plant is in operation at Great Bridge (State Highway Number 168) on the Southern Branch of the Elizabeth River.

Table IV-53

HAMPTON ROADS SANITATION DISTRICT

Treatment Plants

Name	Discharge To	Population Served	Flow (MGD) Daily	Flow (MGD) Design	Type of Treatment	BOD (mg/l) Untreated	BOD (mg/l) Discharged
Deep Creek STP Chesapeake, Va.	Saint Julian Creek	1,800	0.149	0.410	Secondary**	196	17
Washington STP Chesapeake, Va.	Southern Branch of Elizabeth River	2,500	0.347 (2)*	0.500	Primary	205	91
Western Branch STP Chesapeake, Va.	Western Branch of Elizabeth River	12,000	1.131	2.000	Primary	171	106
Boat Harbor Plant Newport News, Va.	James River	109,000	18.000	12.000	Primary	147	119
James River STP Newport News City, Va.	Warwick River	150,000	3.910	5.000	Secondary	143	8
Lamberts Point STP Norfolk, Va.	Elizabeth River	220,000	25.000 (20 - 30)*	24.000	Primary	142	114
Army Base STP Norfolk, Va.	James River	-	12.300	11.000	Primary	152	110

*recent data

**series of lagoons

NUTRIENTS

The domestic and industrial waste input to the Elizabeth River contributes not only to high levels of coliform bacteria and toxic industrial wastes but also to progressive stream fertilization which ultimately leads to excessive algal growth. High nutrient levels, especially nitrogen and phosphorus, contribute to dense algal growth and resultant stream deterioration.

In November 1971 the Annapolis Field Office, EPA, Region III, conducted an intensive water quality survey of the James and Elizabeth Rivers. The data from this study are presented in the following table:

Table IV-54

ELIZABETH RIVER SURVEY
November, 1971

Annapolis Field Office

STATION	SECCHI DISK inches	DATE	pH	TEMP °C	T. PO_4 mg/l	Pi mg/l	TKN mg/l	NO_2+NO_3 mg/l
	36	11-02-71	7.30	22.87	0.404	0.408	0.790	0.390
L-26	42	11-03-71	7.20	23.30	0.352	0.332	0.610	0.371
	35	11-04-71	6.80	20.14	0.309	0.334	0.830	0.373
	44	11-02-71	7.10	22.78	0.409	0.337	0.840	0.360
L-27	40	11-03-71	7.20	23.07	0.403	0.290	0.670	0.328
	36	11-04-71	6.70	20.90	0.241	0.306	0.870	0.348
	36	11-02-71	7.15	23.2	0.373	0.354	0.960	0.336
L-28	30	11-03-71	7.10	23.2	0.341	0.252	0.920	0.302
	24	11-04-71	6.70	20.64	0.276	0.244	1.200	0.354
	42	11-02-71	7.15	23.03	0.459	0.435	1.010	0.334
L-29	48	11-03-71	7.20	23.04	0.386	0.326	0.800	0.300
	40	11-04-71	6.65	21.06	0.451	0.354	0.980	0.327
	42	11-02-71	7.10	23.12	0.440	0.406	1.080	0.315
L-30	30	11-03-71	7.20	23.15	0.481	0.364	0.830	0.319
	34	11-04-71	6.55	21.31	0.528	0.371	1.010	0.331
	36	11-02-71	7.25	23.18	0.438	0.427	1.060	0.303
L-31	36	11-03-71	7.00	23.10	0.462	0.354	0.890	0.309
	36	11-04-71	6.60	21.50	0.418	0.365	1.120	0.324
	30	11-02-71	7.20	23.30	0.404	0.392	1.120	0.291
L-32	34	11-03-71	7.00	23.40	0.425	0.355	0.940	0.308
	24	11-04-71	6.55	21.00	0.574	0.346	1.060	0.327
	36	11-02-71	7.10	23.73	0.432	0.470	1.100	0.290
L-33	36	11-03-71	6.90	23.72	0.366	0.336	1.210	0.315
	30	11-04-71	6.60	21.70	0.462	0.363	1.000	0.310
	27	11-02-71	7.00	24.00	0.462	0.418	1.130	0.290
L-34	48	11-03-71	6.80	23.67	0.405	0.332	1.030	0.302
	27	11-04-71	6.80	22.04	0.561	0.413	1.100	0.314

Table IV-54 (Cont.)

ELIZABETH RIVER SURVEY
November, 1971

Annapolis Field Office

STATION	NH_3 mg/l	DO mg/l	BOD_5 mg/l	TOC mg/l	TC mg/l	CHLOROPHYL µg/l	CONDUCTIVITY µ mhos	SALINITY ppt
	0.343	6.23	1.48	5.49	20.04	6.0	18.35	11.60
L-26	0.396	6.69	1.19	7.12	21.13	-	19.18	12.06
	0.378	7.28	1.28	9.49	23.50	-	18.65	12.45
	0.343	5.29	-	5.41	19.62	7.5	19.28	12.18
L-27	0.348	6.48	-	6.72	20.35	-	19.40	12.30
	0.652	6.56	-	10.39	24.24	-	20.00	13.30
	0.516	5.87	1.60	6.29	20.04	9.8	17.82	11.24
L-28	0.512	6.09	1.41	8.22	21.61	-	18.40	11.90
	0.594	6.77	1.96	12.30	25.54	-	18.14	12.00
	0.520	5.03	1.56	8.01	22.42	4.5	19.22	12.10
L-29	0.427	1.33	-	8.26	22.17	-	20.15	12.74
	0.537	6.25	1.12	11.41	25.24	-	20.14	13.20
	0.506	4.77	-	11.27	23.96	8.3	19.45	12.24
L-30	0.463	-	-	10.02	24.64	-	20.25	12.85
	0.598	5.30	-	14.74	27.65	-	19.93	13.10
	0.598	4.33	1.50	12.76	25.72	3.0	19.34	12.12
L-31	0.463	-	0.74	11.60	26.10	-	19.75	12.55
	0.517	5.71	0.94	15.21	28.01	-	19.40	12.66
	0.702	4.23	-	10.42	23.83	6.8	18.20	11.44
L-32	0.515	5.02	-	4.43	23.60	-	19.20	12.00
	0.755	5.30	-	23.07	33.84	-	17.70	11.58
	0.506	4.52	1.68	15.30	26.94	12.0	19.34	12.00
L-33	0.488	5.02	1.49	7.36	25.15	-	19.76	12.33
	0.494	6.31	1.13	19.42	31.12	-	20.00	12.88
	0.500	4.27	-	17.99	28.83	6.8	18.18	11.24
L-34	0.441	4.76	1.41	10.03	27.35	-	18.50	11.50
	0.502	5.01	-	22.41	33.45	-	18.53	11.90

During 1969, 1970 and 1971 the VWCB monitored portions of the Eastern and Southern Branches of the Elizabeth River. Sporadically high nutrient levels were detected at three stations. The following table presents the nutrient data collected by the VWCB.

Table IV-55

VIRGINIA WATER CONTROL BOARD

Elizabeth River - Eastern Branch

River Mile	Station Description	Date	TKN mg/l	NH_3 mg/l	$NO_2 + NO_3$ mg/l	Inorganic Phosphate mg/l	Total Phosphate mg/l
		04-21-70	.200	.120	<.060	.030	<.050
		05-05-70	1.100	1.800	.060	.080	.250
		10-27-70	1.100	1.600	.050	.210	.100
.07	Alternate Route 58 - 460 Bridge Chesapeake City, Virginia	11-22-70	.400	1.000	.300	.060	<.100
		05-11-71	.600	.500	.220	.080	.100
		06-14-71	1.100	1.000	.150	.100	.200
		07-06-71	2.700	1.200	.030	.330	.500
		10-26-68	1.800	.350	<.060	.440	-
		02-03-69	1.480	.510	.220	.250	-
		04-28-69	1.500	.520	<.030	.470	-
		07-24-69	4.850	.680	.230	1.000	-
		03-23-70	.400	.230	<.110	.060	.200
		04-21-70	.700	.700	.070	.050	.050
4.62	Route 13 Bridge Norfolk, Virginia	05-05-70	1.000	.400	.030	.060	.350
		10-27-70	1.100	1.800	.430	.190	.200
		11-22-70	1.000	1.000	.300	.130	.100
		05-11-71	.700	.520	.060	.140	.100
		06-14-71	1.300	.700	.070	.100	.200
		07-06-71	1.800	1.000	.150	.300	.400
		04-21-70	1.500	1.550	.110	.130	.150
		05-05-70	1.600	2.100	.050	.150	.350
		06-17-70	1.500	1.900	.250	.700	.750
		07-01-70	1.500	1.200	.240	.300	.350
2.03	Beltline Railroad Bridge Norfolk, Virginia	10-27-70	1.300	1.700	.270	.270	.200
		11-22-70	1.000	1.250	.600	.190	.200
		05-11-71	.700	.390	.090	.130	.100
		06-14-71	1.100	.900	.200	.100	.200
		07-06-71	1.300	.640	.080	.140	.300

Sediment data for the Elizabeth River beginning off Craney Island in the Elizabeth River Channel and extending down the Southern Branch of the Elizabeth River is presented in Figure IV-47. Although these data, collected by the Virginia Institute of Marine Science in the summer of 1971, are not extensive they do illustrate some areas where high concentrations of total Kjeldahl nitrogen, COD, volatile solids and total phosphorus have been detected.

Total Kjeldahl nitrogen concentrations in the sediment vary from 1000 ppm near Craney Island to nearly 35,000 ppm (3.5%) at nautical mile 14 in the Southern Branch of the Elizabeth River (Intracoastal Waterway in the vicinity of State Highway 168). Organic loadings from treatment plant effluents are indicated by high total Kjeldahl nitrogen concentrations. High TKN concentrations in sediment may be indicative of the direct influence of the six treatment plants on the Elizabeth River.

The chemical oxygen demand and volatile solids percentage in the sediment increase nearly uniformly from mile zero (at Craney Island) to mile 14 (Southern Branch - Intracoastal Waterway). This steady increase from Craney Island Reach to the Southern Branch (State Route 168) is indicative of the buildup of biologically resistant matter. The intense industrial development and corresponding deposition of toxic matter into the Elizabeth River is no doubt a contributing factor to the condition illustrated in Figure IV-47.

Total phosphorus concentration in the sediment varies from

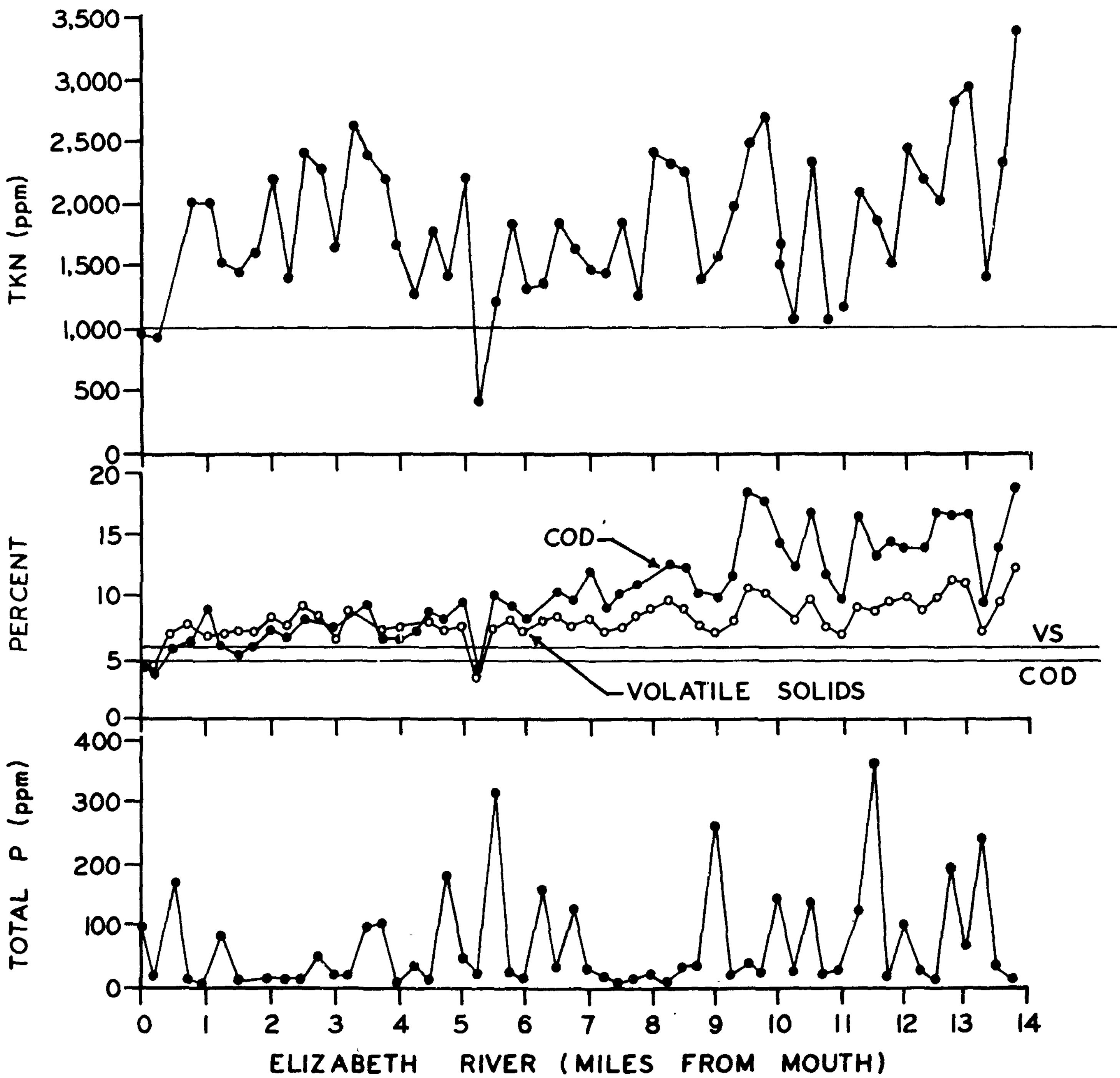

3,500
3,000
2,500
2,000
1,500
1,000
500
0
TKN (ppm)
20
15
10
5
0
PERCENT
COD
VS
COD
VOLATILE SOLIDS
400
300
200
100
0
TOTAL P (ppm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
ELIZABETH RIVER (MILES FROM MOUTH)

Figure IV-47

approximately 10 ppm to 300 ppm. Peak values were detected at numerous stations in the Elizabeth River.

Lead, mercury, zinc and copper concentrations in the sediment are illustrated in figure IV-48. Due to sluggish tidal cycles which inhibit the fresh water inflow, the suspended matter introduced into the waterway via natural conditions and heavy industrial loading renders the bottom sediment toxic. High levels of mercury (3 ppm), lead (500 ppm), zinc (1200 ppm) and copper (300 ppm) were detected by the Virginia Institute of Marine Science.

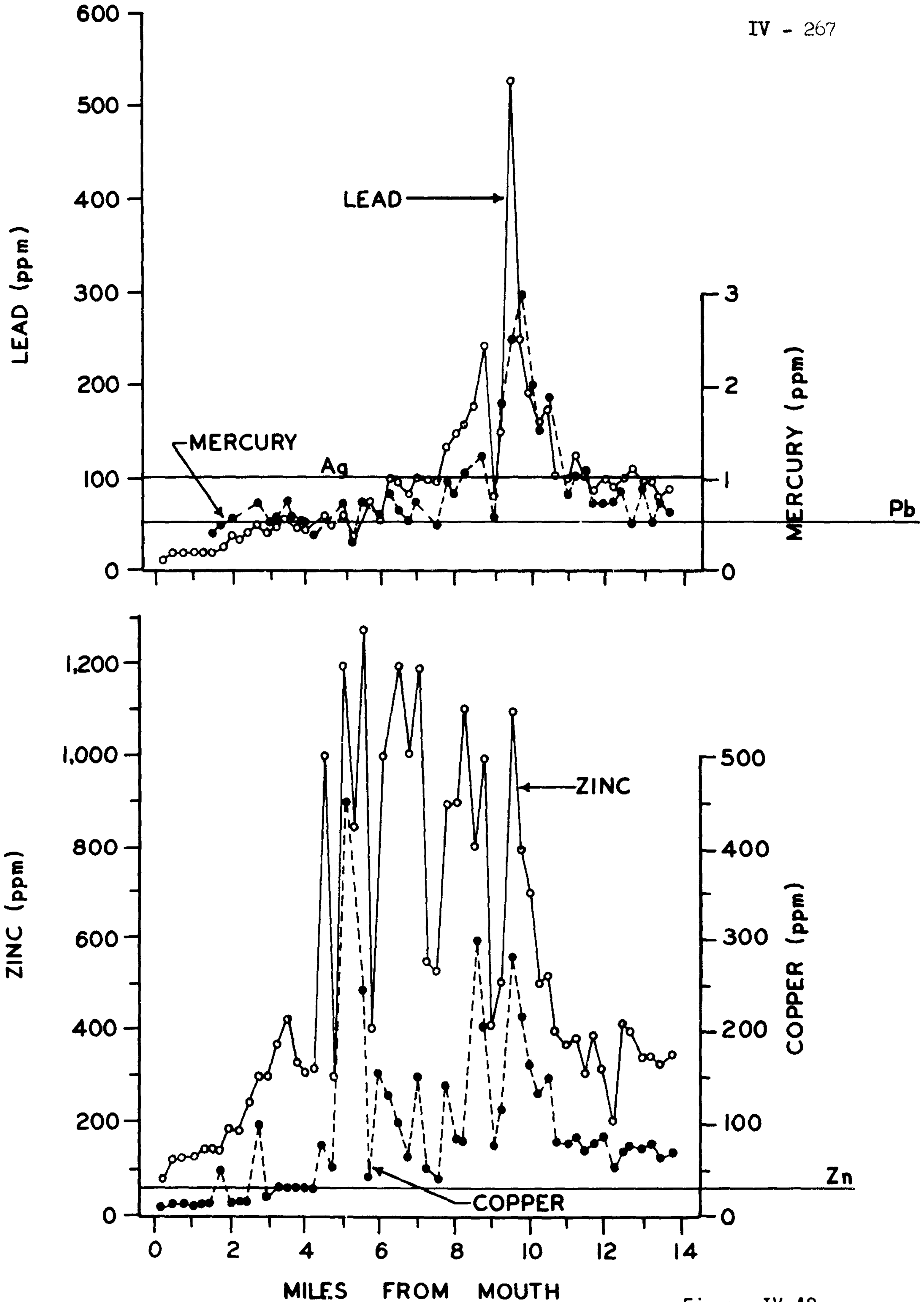

LEAD (ppm)
MERCURY (ppm)
LEAD
MERCURY
Ag
Pb
ZINC (ppm)
COPPER (ppm)
ZINC
COPPER
Zn
MILES FROM MOUTH

Figure IV-48

N. LOWER CHESAPEAKE BAY

For the puposes of this discussion, the lower Bay area includes all open waters of the Bay from Smith Island seaward to the Atlantic Ocean.

Whaley et al., Chesapeake Bay Institute, The Johns Hopkins University, conducted 24 surveys of the upper Chesapeake Bay and several of its tributary rivers during 1964, 1965, and 1966. The primary purpose of this study was to inventory the distributions of the various forms of phosphorus and nitrogen. The results of this study were recently reported by Dr. Donald W. Pritchard, Director of the Chesapeake Bay Institute (CBI Contribution Number 154).

The Bay sampling stations, in the study mentioned above, extended from the mouth of the Susquehanna River seaward to a point in the Bay just below the mouth of the Potomac River. Some of these earlier studies are compared with more recent data discussed in the upper Bay and Sandy Point sections of this report.

The Chesapeake Bay Institute has conducted more recent studies which included surveys of nutrient distribution throughout the entire length of the Bay. These surveys were conducted on a monthly basis from April 1969 through May 1971. The samples are still being analyzed with results expected during fall of 1972. Once interpreted, this data should provide a general picture of nutrient distribution in the lower Bay, heretofore not known, as well as a basis for determining changes in nutrient concentration in the middle and upper Bay.

CHAPTER V

DATA EVALUATION AND INVENTORIES

A. DATA EVALUATION

It is estimated that approximately 50 institutions and federal and state agencies are involved in data collection and analysis in the Chesapeake Bay or its tidal tributaries.

The nature of this report and the resources available to the authors precluded a comprehensive inventory of all sources of "water quality" data. Major emphasis was placed on obtaining current data from the regulatory agencies involved in monitoring programs to assure compliance with water quality standards. Those agencies were: the Annapolis Field Office, EPA; the Virginia Water Control Board; the Maryland Department of Water Resources; the District of Columbia Department of Environmental Services; and the Maryland Department of Health, which monitors shellfish waters. Other sources of data, collected by various institutions, were utilized in attempts to identify possible water quality trends for a particular estuarine area and as a supplementary nature where data were limited. Flow data from the U. S. Geological Survey were sought to relate, for example, depressed dissolved oxygen concentrations under low-flow conditions.

Monitoring data of the regulatory agencies of the District of Columbia, Maryland, Virginia, and the Environmental Protection Agency showed contraventions in numerical water qualtiy standards for the particular time the sample was taken. Standards for which numerical criteria were adopted are: pH, temperature, dissolved oxygen, and bacteria (fecal and/or total coliform). Monitoring, for the most part, was conducted during the critical high temperature periods. Two to three sets of data usually were available for the summer months of June, July, August, and September. Although attempts are made to collect data at slack water tide (high or low), the limited manpower and resources of the agencies did not always permit the correlation of data collection with tidal stages. Where data collection was correlated with tidal stage and freshwater flows, it is limited to a sub-estuary of the Bay, for example, the upper Potomac Estuary.

Parameters for which there are no required numerical stream or effluent standards, but are considered essential for predicting water quality effects on the Bay are discussed below. The following discussion pertains to data from the regulatory agencies.

Pesticides:

The Virginia Water Control Board (VWCB) began sampling for pesticides in the Rappahannock, York, and James Estuaries in its routine survey during the 1970 sampling season. Detection and identification of pesticides is generally by the two major categories, chlorinated hydrocarbons and thio-phosphates. However, specific chlorinated-hydrocarbon compounds were isolated for the James River. The Maryland Department of Water Resources (MDWR) does not currently monitor pesticides in its routine surveys. The Maryland State Department of Health (MDH) checks shellfish for pesticide content when contamination is expected.

The District of Columbia Department of Environmental Services (DCDES) does not monitor pesticides in the Washington area of the Potomac River.

The Annapolis Field Office (AFO) of EPA now has an in-house capability for pesticide analysis and will begin inclusion of pesticide monitoring during intensive surveys of water quality problem areas. Prior to this, pesticide samples were sent to the Beltsville Laboratory for analysis.

There is a need for expansion of current pesticide detection programs, especially in the economically important shellfish areas. Polychlorination biphenyl (PCB) should also be monitored. The VWCB did include PCB's in its James River surveys. Intensive surveys should be carried out to establish background levels for pesticides and PCB's, followed by routine monitoring to detect changes in concentrations and significant sources.

Heavy Metals:

The MDWR samples for metals in special studies, such as power plant effluent effects and proposed sites for power plants. In the case of the Calvert Cliff plant, radiation levels were measured off-shore of the construction site. With few exceptions, metals are not routinely monitored by MDWR. The MDH analyzed shellfish for metal content when contamination was expected. The VWCB began monitoring for metals during 1970. In 1970, the following metals were sampled in the James Estuary: arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, and zinc. The AFO has a metals analysis capability and has recently increased its monitoring of metals in both water and bottom sediment. The DCDES does not sample for metals.

There is a need for intensive surveys to ascertain background levels of metals, especially in shellfish waters. This should be followed up by periodic monitoring to note any buildup of metals.

Nutrients:

All the agencies discussed herein routinely monitor for the various nutrient fractions of nitrogen and phosphorus. Only MDWR and AFO include measurements of chlorophyll a to determine standing crops of phytoplankton.

There is a critical need to establish nutrient-phytoplankton relationships in areas, such as the upper Chesapeake Bay and the Potomac Estuary, where organic pollution is believed to be causing accelerated eutrophication with its accompanying dissolved oxygen depletions. Currently, nutrient monitoring is neither intensive nor extensive. Nutrient data obtained in the various tidal tributaries are not correlated with the net inflow at the mouth of the Bay, which is required to assess the effects of nutrients on the Bay proper.

Data Needs:

As previously mentioned, data collection and analysis is estimated to be scattered among some 50 institutions and federal and state agencies. The intricate patterns of tides and currents have historically restricted investigators to small areas of more manageable proportions. In some instances, such as the upper Potomac Estuary, enough data were collected and interpreted to allow simulation studies of the effects of waste discharges on the receiving waters. Studies have been limited, however, to predictions of water quality in defined areas of tidal tributaries to the Bay. The conspicuous absence of historical data throughout the Bay on a systematic basis prevents the prediction of the effects of wastes discharged in a particular estuary or Susquehanna River contributary loadings on other segments of the Bay.

A knowledge of water quality of the entire Bay is essential. Water quality sampling over an extended period of time, and as frequently as possible, is needed for all tidal tributaries of the Bay and the Bay itself. Sampling in the tidal tributaries should occur at slack water tide with freshwater inflows recorded. Concurrent slack water sampling boat runs up the entire main channel of the Bay would be a vital element of this program. The resulting data from the tidal tributaries would then be integrated, with the slack water runs data, to give an overall picture of the water quality conditions of the Bay for the sample period.

B. DATA INVENTORIES

Two basic types of data were used in the formulation of this report: 1) water quality monitoring data (including reports interpreting data), and 2) inventories of waste discharges (including data from waste discharge sampling). Since the volume of information acquired and used was extensive, it was impractical to include all of the data in the report. Therefore, it was determined that this data should be compiled and made easily accessible to those interested in further or more detailed examination of the water quality in the Bay. In order to provide this access, a computerized data storage and retrieval system (STORET), developed by the Environmental Protection Agency and its predecessor agencies, will be utilized. As well as serving as a repository for the data collected during this study, STORET will serve as the source for much of the information collected in future studies.

The following paragraphs are intended to give the reader a brief description of the types of data available in, and the capabilites of, the STORET system. Anyone desiring a more detailed knowledge of STORET or wishing to obtain copies of available data may contact the Surveillance Branch of the EPA Region III Office, 6th and Walnut Streets, Philadelphia, Pennsylvania 19106.

Water Quality Data

The STORET system was originally conceived as a method for central storage of water quality data. Hence, this is the most sophisticated of the subsystems that comprise STORET. Water quality data collected by

EPA, U. S. Geological Survey, and state and other participating agencies has been stored over the last few years and was available for interpretation during this study. The data which was gathered by the authors from sources cited throughout the text will also be computerized in STORET as soon as possible, manpower and resources permitting.

Water quality data is stored in the STORET system by unique station number which is identified by either mileage from the mouth of the river (River Mile Indexing) or latitude and longitude. Within the station designation, data is stored by date, time and depth to further identify its origin. The samples are characterized by physical, chemical and radiological parameters which are virtually limitless and number more than 500. There has been some difficulty in classifying biological parameters for use with the system but work in this area will continue.

The Virginia Water Control Board also operated a computerized data storage and retrieval system which handles all of the data collected in Virginia. The Maryland Department of Water Resources is presently working on a system for computerizing their water quality data.

Municipal Waste Inventory

The Municipal Waste Inventory became the second subsystem in STORET based on the Public Health Service inventory of 1968. A continuous updating procedure has since been developed by EPA and the various states to keep the inventory as current as possible and to include information on future waste treatment needs. The states initially provided a listing of all present or planned sewage treatment plants and now periodically update the information carried in each waste facility record. EPA has taken responsibility for the computerization of the data and for providing it to interested parties as well as to the states.

Information about each plant is stored under a unique identification number which represents the plant by state, city and facility codes. Data is stored in three separate sections for each plant. The first section contains identification data and shows, among other things, the county and community in which the plant is located, receiving waters, latitude and longitude of the outfall, and census statistics. The second section describes the physical plant and includes the type of sewer system employed, population served by the plant, type of treatment, actual and design flows and loads, percentage removals of organics and nutrients, and the kinds of equipment used in the treatment process. The third section is entitled "Waste Facilities Needs Data" and contains information on cost and type of new construction required and schedules for completion of new projects.

Industrial Waste Inventory

The industrial inventory was the last of the subsystems added to STORET and was primarily designed to store information on implementation of new facility construction by industries. Since this inventory listed only industries with construction needs, it did not meet the requirements of this study. The basic format of this inventory was modified and the inventory was expanded to include all of the industries which have filed for permits to discharge with the Corps of Engineers. The existing record format contained information on the county and city where the plant is located, the receiving waters, schedules of new construction, waste discharge flows, and latitude and longitude of discharges. The modifications were instituted to acquire the flexibility to include information on the type of waste being discharged and the type of treatment presently employed.

A more elaborate waste inventory system (RAPP) based totally on the Corps of Engineers permit applications is currently being developed. When this new inventory is completed (probably January 1973) the modified inventory developed for this report will be obsolete and will be replaced by the RAPP system.

ACKNOWLEDGMENTS

The authors, Thomas H. Pheiffer, Daniel K. Donnelly, and Dorothy A. Possehl of the Annapolis Field Office, Region III, EPA, wish to express their appreciation to those who assisted in the preparation of the report.

Special thanks go to Michael E. Bender, Virginia Institute of Marine Science: A. W. Hadder, Virginia State Water Control Board; William M. Sloan, Maryland Environmental Services; John R. Longwell, Maryland Department of Water Resources; Samuel Fowler, Maryland Department of Health and Mental Hygiene; and Carol Feister, The Johns Hopkins University.

The authors also wish to acknowledge the assistance of all staff members of the water chemistry laboratories of the institutions and federal and state agencies who contributed data for this report. Without their analysis of water samples, data would not be available for presentation.