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FINAL

BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CONTRACT TASK ORDER 0252

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ACRONYMS

AFETA Camp Peary	Armed Forces Experimental Training Activity Camp Peary, Williamsburg, Virginia
Baker	Baker Environmental, Inc.
BTAG	U.S. Environmental Protection Agency, Region III Biological Technical Assistance Group
CBP	Chesapeake Bay Program
CLP	Contract Laboratory Program
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DO	Dissolved Oxygen
EMAP	Environmental Monitoring and Assessment Program
LANTDIV	Atlantic Division, Naval Facilities Engineering Command
mg/L	milligram per liter
ng/kg	nanogram per kilogram
ng/L	nanogram per liter
NOAA	National Oceanic and Atmospheric Administration
ODU	Old Dominion University
PCP	Pentachlorophenol
PAH	Polyaromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
ppm	parts per million
ppt	parts per thousand
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SAV	Submerged Aquatic Vegetation
SSA	Site Screening Area
TBT	Tributyltin
μg/L	microgram per liter
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
VDEQ	Virginia Department of Environmental Quality
VIMS	Virginia Institute of Marine Science

1.0 INTRODUCTION

The technical approach for the Remedial Investigation/Feasibility Study (RI/FS) and Site Screening Area (SSA) activities at WPNSTA Yorktown includes conducting an ecological risk assessment of the terrestrial and aquatic ecosystems at each of the RI/FS sites. The ecological significance of the risks characterized at the sites will consider the types and magnitudes of the risks as well as the natural variability of the spatial and temporal patterns inherent in these ecosystems. To determine this natural variability in these ecosystems, background or reference stations will be evaluated and the results will be used in evaluating the spatial and temporal patterns observed at the RI/FS sites.

The basic requirements for a background station include:

- The station must represent an area not influenced by RI/FS sites or SSAs at WPNSTA Yorktown or by similar sources of contamination off site.

- The station must be representative of regional environmental conditions.

Evaluation of data collected during previous investigations indicate that background stations for the on-site small freshwater streams (headwaters of King Creek, Felgates Creek, Indian Field Creek, and Ballard Creek) meet the basic requirements of a background station, and will provide data on the variability of constituent concentrations in the surface water, sediments, and selected biota communities. However, there are no identified on-site reference tidal freshwater streams or freshwater pond systems (lower reaches of King Creek, Felgates Creek, Indian Field Creek, Ballard Creek and Lee Pond,Roosevelt Pond, Pond No. 11, and Pond No. 12, respectively) that are not impacted by any site or SSA activity. Therefore, off-site background data must be used to evaluate the tidal freshwater streams and freshwater pond ecosystems.

This literature review was performed to compile the existing surface water, sediment, benthic macroinvertebrate, and fish population data of tidal freshwater streams and freshwater ponds representative of the WPNSTA Yorktown area.

2.0 REGIONAL BACKGROUND

WPNSTA Yorktown is situated on the Virginia Peninsula in York and James City Counties and the City of Newport News. WPNSTA Yorktown is bounded on the northwest by the Naval Supply Center Cheatham Annex, the Virginia Emergency Fuel Farm, and the future community of Whittaker's Mill; on the northeast by the York River (a main tributary to the Chesapeake Bay) and the Colonial National Historic Parkway; on the southwest by Route 143 and Interstate 64; and on the southeast by Route 238 and the community of Lackey.

2.1 Chesapeake Bay

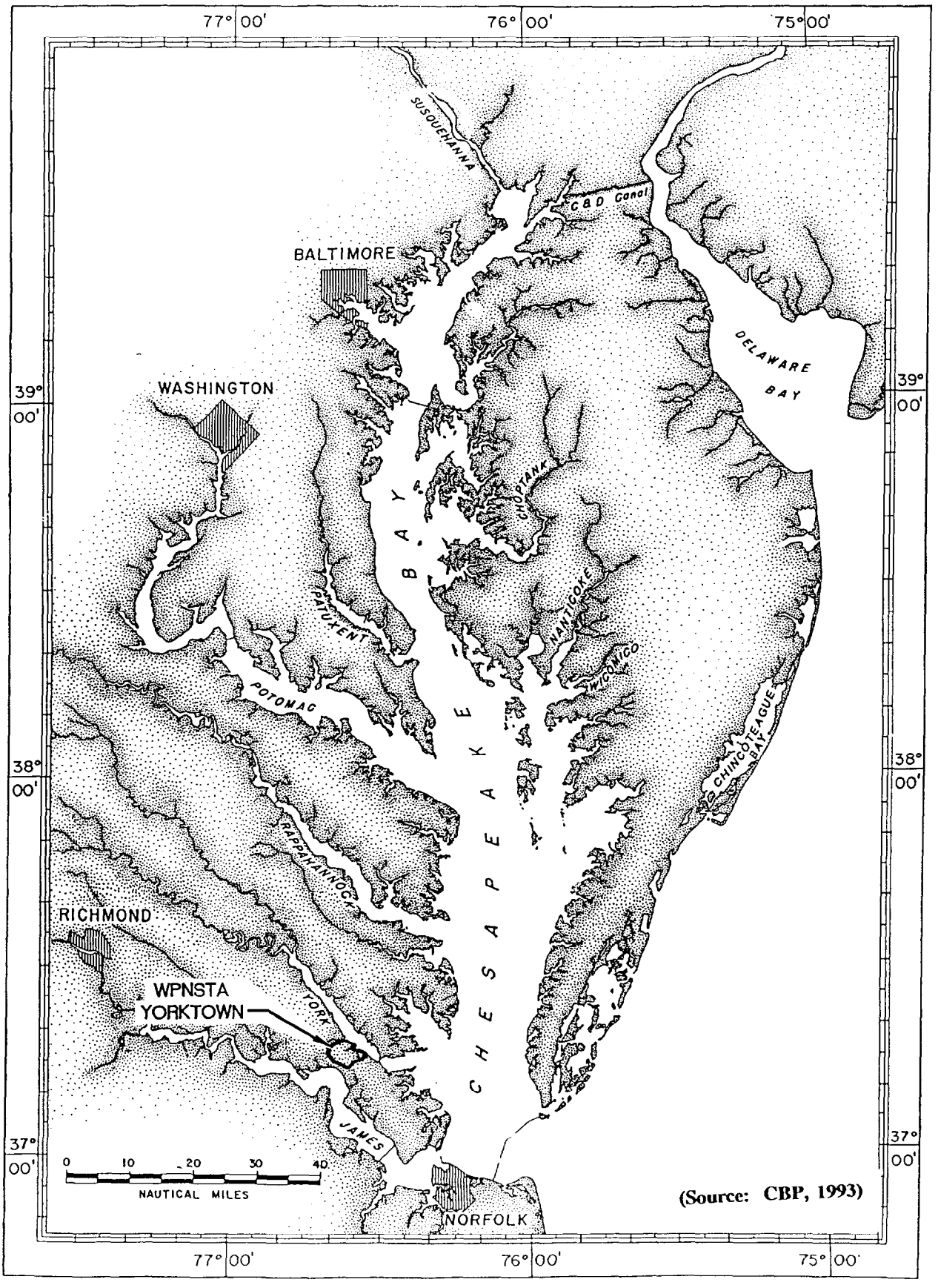
Figure 2-1 depicts the Chesapeake Bay area and the main tributaries to the Bay. The Chesapeake watershed that drains into the Chesapeake estuary contains approximately 64,000 square miles in several states including New York, Central Pennsylvania, Maryland, Delaware, Virginia, West Virginia, and the District of Columbia. The western watershed originates in the mountainous Appalachian Mountain Chain, and flows through the rolling Piedmont Plateau to the estuary which lies in the Coastal Plain. The eastern watershed is contained wholly within the Coastal Plain (Tetra Tech, 1986).

The drainage basin for the Chesapeake Bay consists of 150 rivers, creeks, and streams, with approximately 50 considered to be major tributaries. Six major rivers account for 90 percent of the freshwater diluting the Chesapeake Bay. The largest river, the Susquehanna, drains nearly 43 percent of the basin and contributes an average of 51 percent of the inflow. The York, Rappahannock, and the James Rivers drain nearly 25 percent of the basin and contribute three, four, and fourteen percent, respectively, of the inflow. The Patuxent River is the smallest of the major rivers draining only a little over one percent of the basin and contributing one and a half percent to the inflow (Tetra Tech, 1986).

The upper western shore and the eastern shore basins of the Chesapeake Bay are composed of several streams and rivers, all of which have small discharges of freshwater. The larger rivers on the upper western shore collectively drain two and a half percent of the basin and contribute two and a half percent of the inflow. The flat, low discharge streams of the eastern shore collectively drain six percent of the basin and contribute six percent of the inflow.

The shores of the Chesapeake Bay generally are composed of unconsolidated Miocene sands; therefore, the shores are subject to erosion. The few rocky outcrops are fossiliferous beds. The mainstem of the Chesapeake Bay trends north to south, and essentially has a shallow (e.g., 20 to 30 feet) sandy or silty

FIGURE 2-1
CHESAPEAKE BAY SITE MAP
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



(Source: CBP, 1993)

bottom, except in the reach from the Chesapeake Bay Bridge to the mouth of the Rappahannock, where a deep (e.g., 80 to 100 feet) trench runs down the axis.

The salinity zones within the Chesapeake Bay vary greatly, influenced by freshwater discharge, tide, weather, and water depth. The Chesapeake Bay is composed of the following salinity zones: tidal fresh, oligohaline, mesohaline, and polyhaline. Tidal freshwater areas have salinity ranges of less than 0.5 parts per thousand (ppt) and includes the upper tidal reaches of all the Chesapeake Bay tributaries and the area of the Chesapeake Bay known as the Susquehanna Flats. Tidal freshwater areas are critical spawning grounds for anadromous finfish, but mainly support freshwater species of finfish, invertebrates, and plankton. Oligohaline zones have salinity ranges of 0.5 to 5.0 ppt. The middle reaches of tidal tributaries and a portion of the upper mainstem of the Chesapeake Bay are oligohaline waters. Oligohaline areas support fresh and brackish water species of aquatic vegetation and are important nursery grounds for anadromous finfish and spawning grounds for estuarine finfish (CBP, 1988b). Table 2-1 presents the known living resources that are indicators of ecological health, which reside in the various salinity zones of the Chesapeake Bay and its tributaries.

The mesohaline zone is the most common salinity zone in the Chesapeake Bay. The salinity of mesohaline water ranges from 5.0 to 18.0 ppt. The mesohaline zone includes the mainstem Chesapeake Bay from the mouth of the Patapsco River to the area south of the mouth of the Potomac River. In addition, the lower reaches of the major tributaries to the Chesapeake Bay are also mesohaline. The mesohaline zone is inhabited by species of finfish, shellfish, and benthic organisms, along with euryhaline (i.e., tolerant of a wide range of salinities) marine species. The polyhaline regions of the Chesapeake Bay have salinities ranging from 18.0 to 32.0 ppt. Polyhaline zones are located in the Virginia portion of the mainstem of the Chesapeake Bay. The lower reaches of the York and James Rivers are also polyhaline waters (CBP, 1988b).

2.2 York River

The York River Basin is situated in the central and eastern section of Virginia. The Rappahannock River Basin is located to the north and the James River Basin is located to the south of the York River Basin. The headwaters of the York River Basin are situated in Orange County and flow approximately 220 miles in a southeasterly direction into the Chesapeake Bay, draining 2,661 square miles. The width of the basin ranges from five miles at the headwaters of the York River to 40 miles at the mouth of the river. The York River is formed approximately 30 miles from its mouth by the confluence of two of its tributaries, the Pamunkey and Mattaponi Rivers (VSWCB, 1990a). The entire length of the York River is tidal. The

TABLE 2-1
LIVING RESOURCES INDICATIVE OF THE ECOLOGICAL CONDITION OF THE CHESAPEAKE BAY
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

REPRESENTATIVE LIVING RESOURCES

The following list of species or species associations was developed by the Living Resources Task Force to serve as an indicator of the Bay's ecological condition. Not all species are indicators of recovery; rather, the abundance of some are reflective of poor habitat conditions for less tolerant species. The list includes species of commercial and recreational importance and species which, due to their abundance, productivity, or distribution, are important in the flow and accumulation of energy through various trophic levels of the Chesapeake Bay ecosystem.

PHYTOPLANKTON ASSOCIATIONS:

Oligohaline

Winter/Spring
Cyclotella striata
Melosira granulata
Melosira islandica
Katodinium rotundatum
Cyclotella meneghiniana
Skeletonema costatum

Summer/Fall
Cyclotella striata
Merismopedia spp.
Microcystis aeruginosa
Gymnodinium spp.
Argetoceros spp.
Skeletonema costatum

Mesohaline

Winter/Spring
Skeletonema costatum
Cyclotella striata
Heterocapsa triquetra
Certaulina pelagica
Asterionella glacialis
Asterionella japonica

Summer/Fall
Cyclotella striata
Cryptomonas spp.
Skeletonema costatum

(Source: CBP, 1988b)

TABLE 2-1 (continued)
LIVING RESOURCES INDICATIVE OF THE ECOLOGICAL CONDITION OF THE CHESAPEAKE BAY
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Summer/Fall (continued)
Leptocylindrus minimus

Polyhaline

Winter/Spring
Skeletonema costatum
Leptocylindrus danicus
Asterionella glacialis
Cerataulina pelagica
Thalassiosira nordenskioldii
Thalassiosira rotula

Summer/Fall
Prorocentrum micans
Prorocentrum minimum
Heterocapsa triquetra
Cryptomonas spp.
Skeletonema costatum

ZOOPLANKTON ASSOCIATIONS:

Tidal fresh to oligohaline

Bosmina longirostris (Cladoceran)
Leptodora kindtii
Cyclops spp.
Mesocyclops edax
Diaptomus spp.
Tintinnids

Mesohaline to polyhaline

Winter
Cyanea capillata (lion's mane jellyfish)
Eurytemora affinis (copepod)
Acartia clausi (copepod)
Pseudocalanus spp.
Centropages hamatus
Temora longicornis
Neomysis americana
Sagitta elegans
Oithona spp.

Summer
Chrysaora quinquecirrha (sea nettle)
Mnemiopsis leidyi (ctenophore)
Podon polyphemoidese (cladoceran)
Evadne tergestina
Acartia tonsa (copepod)
Pseudodiaptomus coronatus
Labidocera aestiva
Parvocalanus crassirostris
Neomysis americana

(Source: CBP, 1988b)

TABLE 2-1 (continued)
LIVING RESOURCES INDICATIVE OF THE ECOLOGICAL CONDITION OF THE CHESAPEAKE BAY
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Summer (continued)
Sagitta tenius
Scottolana canadenis (meiobenthic copepod)
Ectinosonia centicorne (meiobenthic copepod)

SUBMERGED AQUATIC VEGETATION SPECIES:

Ruppia maritima (widgeongrass)
Zostera marina (eelgrass)
Vallisneria americana (wild celery)
Potamogeton pectinatus (sago pondweed)
Potamogeton perfoliatus (redhead grass)

EMERGENT AQUATIC VEGETATION SPECIES:

Spartina alterniflora (salt marsh cordgrass)
Spartina cynosuroides (big cordgrass)
Spartina patens (salt meadow cordgrass)
Juncus roemerianus

BENTHIC ASSOCIATIONS:

Tidal fresh

Tubificidae (Limnodrilidae)
Chironomidae
Corbicula manilensis (Asian clam)

Oligohaline

Rangia cuneata (brackish water clam)
Scolecolepides viridis (polychaete worm)

Mesohaline

Macoma balthica (Baltic clam)
Heteromastus filiformis (polychaete worm)
Streblospio benedicti (polychaete worm)
Leptocheirus plumulosus (amphipod)
Mya arenaria (soft-shelled clam)

Polyhaline

Loimia medusa
Mulinia lateralis
Asabellides oculata
Sphiophanes bombyx
Mercenaria mercenaria (hard clam)
Maldanids
Tellinids
Nephtyiids
Phoxocephalids
Haustoriids

(Source: CBP, 1988b)

TABLE 2-1 (continued)
LIVING RESOURCES INDICATIVE OF THE ECOLOGICAL CONDITION OF THE CHESAPEAKE BAY
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Euryhaline
Callinectes sapidus (blue crab)

Motile epifauna
Palaemonetes pugio (grass shrimp)
Gammarus gammarus (amphipod)
Crangon
Corophium
Mysidacea

Sessile epifauna
Balanus improvisus (barnacle)
Mytilis edulis
Molgula spp.
Bryozoa
Crassostrea virginica (American oyster)
Anemones

FINFISH SPECIES:

Freshwater and Estuarine Spawners

Alosa sapidissima (American shad)
Alosa pseudoharengus (alewife)
Alosa aestivalis (blueback herring)
Alosa mediocris (hickory shad)
Anchoa mitchilli (Bay anchovy)
Menidia menidia (Atlantic silverside)
Morone saxatilis (striped bass)
Morone americana (white perch)
Perca flavescens (yellow perch)
Acipenser oxyrynchus (Atlantic sturgeon)
Acipenser brevirostrum (shortnose sturgeon)
Fundulus heteroclitus (mummichog)
Micropterus salmoides (largemouth bass)
Pseudopleuronectes americanus (winter flounder)
Trinectes maculatus (hogchoker)
Cynoscion regalis (weakfish)
Cynoscion nebulosus (spotted seatrout)
Pogonias cromis (black drum)

Ocean Spawners

Brevoortia tyrannus (menhaden)
Leiostomus xanthurus (spot)
Micropogonias undulatus (Atlantic croaker)
Sciaenops ocellatus (red drum)
Centropristis striata (black sea bass)
Paralichthys dentatus (summer flounder)
Pomatomus saltatrix (bluefish)
Anguilla rostrata (eel)

(Source: CBP, 1988b)

TABLE 2-1 (continued)
LIVING RESOURCES INDICATIVE OF THE ECOLOGICAL CONDITION OF THE CHESAPEAKE BAY
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

WATERFOWL AND OTHER AQUATIC BIRD SPECIES:

Anas platyrhynchos (mallard)
Anas rubripes (black duck)
Aythya valisneria (canvasback)
Aythya americana (redhead duck)
Aix sponsa (wood duck)
Ardea herodias (great blue heron)
Florida caerulea (little blue heron)
Butorides striatus (green-backed heron)
Casmerodius albus (American egret)
Egretta thula (snowy egret)
Pandion haliaetus (osprey)
Haliaeetus leucocephalus (bald eagle)
Clangula heimalis (old squaw)
Melanitta deglandi (white-winged scoter)
Olor columbianus (tundra swan)
Megaceryle alcyon (kingfisher)
Anas acuta (northern pintail)
Anas strepera (gadwall)
Anas americana (American widgeon)
Branta canadensis (Canada goose)
Sterna albifrons (least tern)
Haematopus palliatus (oystercatcher)
Rynchops niger (black skimmer)
Limnodromus spp. (dowitcher)
Arenaria interpres (ruddy turnstone)
Actitis macularia (spotted sandpiper)

OTHER VERTEBRATE SPECIES:

Mustela vison (mink)
Lutra canadensis (river otter)
Ondatra zibethica (muskrat)
Castorcanadensis (beaver)
Caretta caretta (Atlantic loggerhead turtle)
Lepidochelys kempi (Atlantic ridley turtle)
Malaclemys terrapin (diamondback terrapin)

(Source: CBP, 1988b)

salinity structure of the York River is influenced by the interaction of freshwater discharge and tidal flux. The salinity gradients between surface and bottom waters tend to increase with increasing freshwater discharge in the spring and to decrease in the summer and fall. However, the salinity gradient in the lower York River appears to be controlled by tidal forces (Bender, 1987).

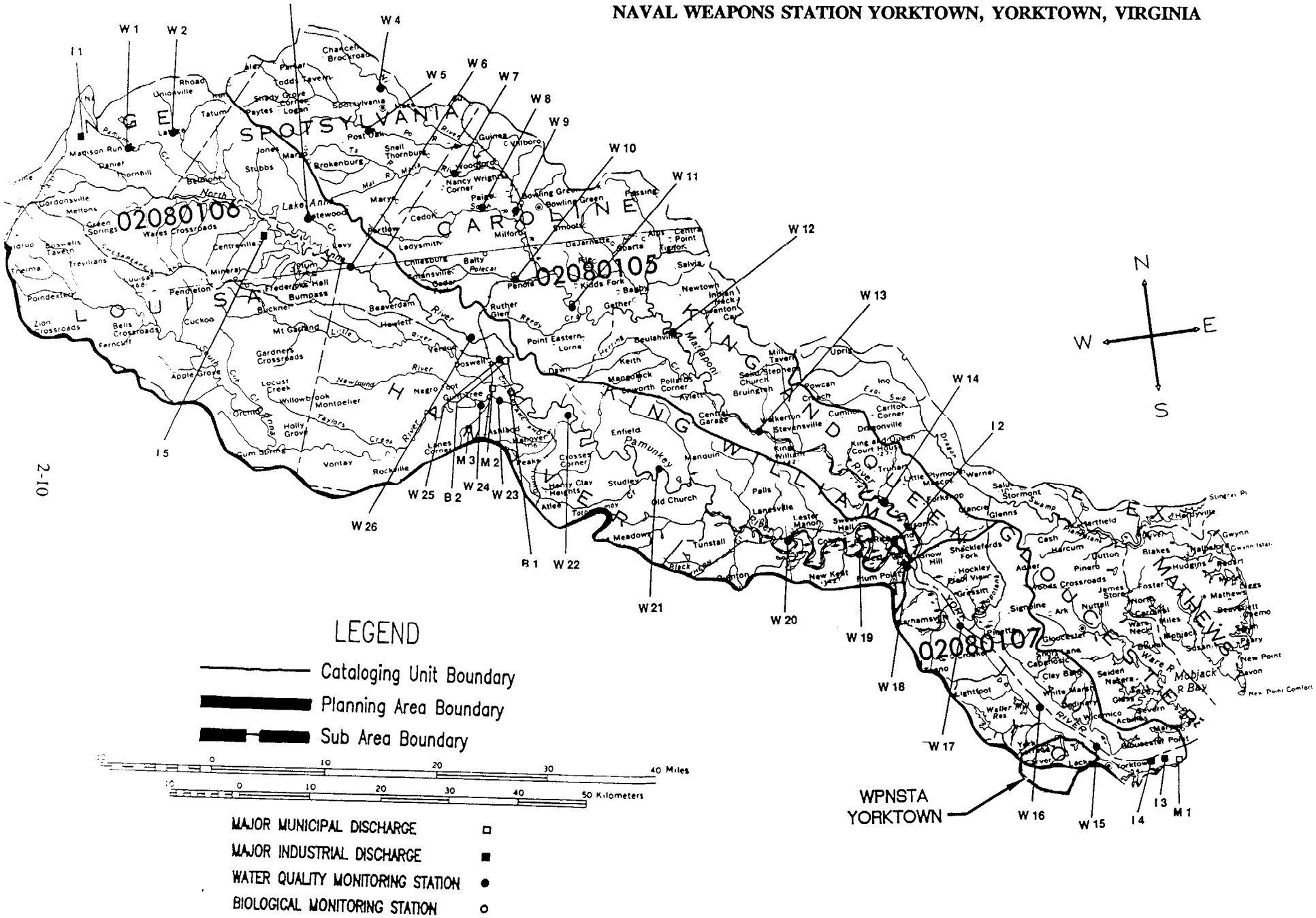
Figure 2-2 displays the mainstem and the major tributaries to the York River. The York River Basin is divided into three United States Geological Survey (USGS) Hydrologic Units from northwest to southeast: the Pamunkey River Subbasin, the Mattaponi River Watershed, and the York River estuary and tributaries from the headwaters at West Point, Virginia, to the confluence with the Chesapeake Bay. The segment incorporates Goalders Creek, Philbates Creek, Bakers Creek, Hockley Creek, Ware Creek, Poropotank River, and all surrounding tributaries (VSWCB, 1990a).

The York River Basin is situated in the Piedmont and Coastal Plain Physiographic Provinces. The topography of the basin ranges from rolling hills in the far western portion of the watershed to gently sloping hills and flat farmland near the mouth. The average precipitation over the basin varies from 41 to 47 inches per year. The coastal areas are subject to extreme weather conditions produced by hurricanes, and the entire basin is exposed to thunderstorms, hailstorms, tornadoes, and ice storms (VSWCB, 1990a).

The majority of the land use within the York River Basin is rural. Approximately 70 percent of the basin is forest and another 22 percent is cropland and pasture. Less than two percent of the land area is classified as urban (VSWCB, 1990a). The tidal amplitude of approximately 2.2 feet creates a relatively large tidal prism. The tidal prism results in turbulent mixing and flushing of the estuary. The mixing and flushing assist in removing pollutants, as well as oxygenating the bottom waters. The salinity in this area ranges from 7 to 13 ppt (Tetra Tech, 1986).

The 15 mile reach of the lower York River estuary has five military installations situated on its southern shore. The WPNSTA Yorktown is located on 10,624 acres in York and James City Counties on the Virginia peninsula. In addition to WPNSTA Yorktown, the other four military bases lining the York River are Langley Air Force Base (situated between the York and the James Rivers), Cheatham Annex (situated on the peninsula formed by the York and James Rivers), the U.S. Armed Forces Experimental Training Activity - Camp Peary (situated on the York River), and the Naval Supply Center - Yorktown Fuels Division (situated on Wormley Creek).

FIGURE 2-2
YORK RIVER BASIN SITE MAP
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



(Source: VSWCB, 1990a)

3.0 METHODOLOGY

This literature review was initiated by developing a core set of contacts consisting of government agencies, Chesapeake Bay Program employees, and other technical experts. This core set of contacts was created from recommendations from the United States Environmental Protection Agency (USEPA), Region III - Biological Technical Assistance Group (BTAG) and previously established Baker Environmental, Inc. (Baker) contacts. As contact calls were conducted, the original contact list was expanded into a network of contacts. Table 3-1 presents the contact list formulated during the literature review. Appendix A presents the contact reports prepared during the literature review.

3.1 Institutions

The majority of the information collected for the WPNSTA Yorktown literature review was obtained from the Chesapeake Bay Program (CBP), Old Dominion University (ODU), and the College of William and Mary, Virginia Institute of Marine Science (VIMS).

3.3.1 Chesapeake Bay Program

The CBP main office is located in Annapolis, Maryland. CBP is a unique, regional, Federal-state-local partnership that was developed in the 1983 Chesapeake Bay Agreement. In the 1970s, research conducted in the Chesapeake Bay indicated a need for a regional restoration effort and identified three areas requiring immediate attention: nutrient over-enrichment, decreasing submerged aquatic vegetation, and toxic pollution. The CBP was developed as a means to restore the Chesapeake Bay. Virginia, Maryland, Pennsylvania, the District of Columbia, and the USEPA established a formal agreement for a cooperative effort to address the Chesapeake Bay's water quality problems and provide long-term resource management.

The CBP monitoring program includes routine monitoring of 19 directly measured water quality parameters at 49 stations in the mainstem of the Chesapeake Bay. The Chesapeake Bay monitoring programs includes the monitoring of water quality, physiochemical, biological, and living resources at various stations throughout the Chesapeake Bay and its tributaries. Appendix A, Tables A-1 through A-17 display the monitoring stations of the Commonwealth of Virginia for the various CBP monitoring programs. As a part of the CBP monitoring program, the VDEQ contracts out benthic macroinvertebrate, fish, and surface water monitoring to ODU and VIMS.

TABLE 3-1

LIST OF CONTACTS
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

ORGANIZATION/AGENCY/INSTITUTION	CONTACT	AREA OF EXPERTISE
Baker Environmental - Richmond, VA	Robert Siegfreid	Fisheries Management
Chesapeake Bay Program Office - Annapolis, MD	Richard Batiuk	Toxic Substances
	Karen Bisland	Living Resources Coordinator
	Joseph Macknis	Monitoring Program Coordinator
	Louis Linker	Soils/Sediment
	William Matuszeski	Program Director
Fish and Wildlife Service - Gloucester, VA	Gary Swihart	Fisheries Management
NOAA - Annapolis, MD	Ann Lang	Program Director
	John Jacobs	Intern
Old Dominion University - Norfolk, VA	Daniel Dauer	Department of Biological Sciences
	Bud Rodi	Department of Biological Sciences - Data Management
	Ray Aldon	Marine Research Library
State of Delaware Water - Dover, DE	John Maxted	Water Quality
USEPA - Region III - Annapolis, MD	Leo Clark	Field Sampling
	Jon Capacasa	Chesapeake Bay Program
Virginia Department of Environmental Quality - Chesapeake Bay Program Office	John Kennedy	Water Quality
	Mark Bushing	Water Quality
Virginia Department of Environmental Quality - Tidewater Regional Office	Michelle Fults	Water Quality
	Traycie West	Data Management
Virginia Department of Environmental Quality - Richmond, VA	Ronald Gregary	Water Quality
	Louis Seivard	Freshwater Ponds
	Charles Morgan	Data Management
Virginia Institute of Marine Science - College of William and Mary, Gloucester, VA	Robert Diaz	Department of Coastal and Marine Ecology
	Linda Schafner	Department of Coastal and Marine Ecology
	Herbert Austin	Fisheries
	Robert Unger	Organic Chemist
	James Perry	Flora
	Carl Hershner	Wetlands
	Chris Bonzek	Fisheries Data Management
	Mo Lynch	NERRS Program
York River State Park	Russell Johnston	Park Director
EMAP - Estuaries Virginia Province	Norman Rubinstein	Estuaries Virginian Province Manager
	Elise Petrocolli	Data Management - Virginia
Virginia Department of Game and Inland Fisheries - Planning Division	Becky Wajda	Data Management

3.1.2 Old Dominion University

ODU is located in Norfolk, Virginia. ODU-Applied Marine Research Laboratory has an active marine and estuarine research program which includes monitoring/studying the lower Chesapeake Bay. ODU-Applied Marine Research Laboratory is under contract with the VDEQ to conduct water quality, phytoplankton, zooplankton, and benthic macroinvertebrate investigations in the mainstem of the York River. The various station locations for these studies are included in Appendix A. A description of the type of benthic macroinvertebrate data collected by ODU on a quarterly basis is presented in Section 4.1.4.1.

3.1.3 College of William and Mary - Virginia Institute of Marine Science (VIMS)

VIMS is located in Gloucester, Virginia, and is affiliated with the College of William and Mary. VIMS conducts extensive marine research in the lower segment of the Chesapeake Bay. VIMS is under contract with the VDEQ to conduct various CBP monitoring programs in the mainstem of the York River. These monitoring programs include: water quality, submerged aquatic vegetation (SAV), bacteriological, phytoplankton, benthic macroinvertebrate, oyster bar surveys, oyster disease surveys, juvenile blue crab population surveys, and fish population surveys. The VIMS' CBP station locations for the above-mentioned monitoring programs are presented in Appendix B.

3.2 Requested Information

The following information, as available, was compiled from the contacts listed in Table 3-1 for tidally influenced creeks and freshwater ponds:

- **Surface Water/Sediment** - Contract Laboratory Program (CLP) analytical data for volatile organic compounds, semivolatile organic compounds, metals, pesticides, polychlorinated biphenyl compounds (PCBs); dissolved oxygen; pH; grain size; hardness; total organic carbon; nitrate-nitrite nitrogen; ammonia-nitrogen; total organic nitrogen; and sediment oxygen demand

- **Benthic Macroinvertebrates** - population and tissue data

- **Fish/Shellfish** - population and tissue data

- **Flora** - submerged aquatic vegetation and wetlands

The above-mentioned information was requested for tidally influenced creeks and marshes with a salinity gradient ranging from 0 to 25 ppt. In addition to tidally influenced creeks, freshwater pond data was also requested. It was originally anticipated that background data could be obtained from a tributary to any of the main tributaries from the eastern or western shore of the Chesapeake Bay. However, upon consulting with several ecological experts at the CBP Office and ODU, it was determined that the different river basins are not comparable (Bisland, 1994; Dauer, 1994; Macknis, 1994). The York River Basin is hydrodynamically and ecologically different from the Rhappahannock and James River Basins (Bisland, 1994; Dauer, 1994).

The eastern shore of the Chesapeake Bay was also originally considered in the selection of reference stations; however, the eastern shore was determined to have its own contamination problems (i.e., agricultural run-off) (Bisland, 1994; Dauer, 1994, Diaz, 1994). Therefore, it was determined that the background data should be limited to data collected only within the York River Basin in order to be ecologically comparable to the study creeks and ponds at WPNSTA Yorktown.

3.3 Database Information

In addition to the preparation of a core contact list, information databases were also identified and accessed. These databases were reviewed and downloaded where appropriate for this investigation. However, a portion of the requested information was not available in electronic format and not all of the expected data had arrived at the time of this report due to the quick turnaround time requested for this investigation.

3.3.1 Environmental Monitoring and Assessment Program Data

The Environmental Monitoring and Assessment Program (EMAP)-Estuaries Virginian Province data was accessed from the EMAP database by EMAP personnel. The data received included the following information for the years of 1990 and 1991 for stations located adjacent to the mouths of the York River, James River, and Rhappahannock River, in addition to stations located within the mainstem of the York River (see Appendix B Tables B-18 and B-19):

- Vertical profiles of water column salinity, temperature, dissolved oxygen (DO) concentrations, fluorescence, pH, and photosynthetically active radiation (i.e., a measure of the intensity of light in the range of wavelengths used by algae in photosynthesis).

- Biotic condition indicators - measurements that quantify the integrated response of ecological resources to individual stressors. These measurements included frequency of tumors observed in fish, populations of benthic and fish species, benthic biomass, benthic and fish community composition and diversity.

- Hydrolab continual water quality monitoring including temperature, salinity, and DO concentrations.

- Benthic species composition, abundance, and biomass estimated from sediment grab samples.

- Grain size distribution estimated from benthic species sediment grab samples.

- Surface sediments collected and analyzed for the following: 15 major and trace elements, 24 individual polyaromatic hydrocarbon (PAH) compounds, the pesticide DDT and its metabolites, 9 pesticides other than DDT, 18 individual PCB congeners, total organic carbon, and mono-, di-, and tributyltin.

- Sediment toxicity data.

- Fish species composition and abundance data collected from trawl sampling.

- Fish gross external pathology data, including fin erosion, somatic ulcers, cataracts and axial skeletal abnormalities.

It should be noted that the above-mentioned data sets were not available for all the stations requested. In addition, although the data contained within the EMAP databases have been funded wholly or in part by the USEPA through its EMAP Estuaries Program, it has not been subjected to USEPA review, and therefore does not necessarily reflect the view of the USEPA and no official endorsement should be inferred.

3.3.2 STORET Database

STORET is the USEPA computer system for the storage and retrieval of water quality data. Data are entered into the STORET system by various Federal, state, and inter-state agencies responsible for monitoring water quality. Funding for the collection and entry into the STORET data base is provided by various sections of the Clean Water Act.

The STORET database was accessed by various institutions. STORET data information is presented in the surface water and sediment discussions in Section 4.1.1 and Section 4.1.2, respectively.

4.0 RESULTS

This literature review was conducted to research existing data and determine the usability of the data as background station information. The study area is presented on Figure 4-1. The information collected from various databases, agencies, institutions, and other contacts was compiled. The following sections present a discussion of the type and amount of accumulated information.

4.1 Tidal Freshwater Creek Data

4.1.1 Surface Water Quality

The VDEQ as part of the water quality inventory program [305(b) report] assessed freshwater tidal creek tributaries to the York River. The Virginia 305(b) report describes water quality conditions throughout the Commonwealth of Virginia. All waters of Virginia are classified and managed to at least support Federal Clean Water Act goals of fishable/swimmable waters. Many waters are managed to maintain water quality substantially higher than the minimum required goals of the Clean Water Act (VSWCB, 1990a).

The freshwater tidal creeks in the York River are monitored in coordination with the CBP. Twenty-eight stations have been established by the VDEQ in the main tributaries to the Chesapeake Bay. The water quality at these stations are measured 20 times per year for the following parameters: Secchi disc depth, temperature, salinity, chlorophyll, DO, nitrogen, phosphorus, carbon, and silica (VSWCB, 1990a).

The Tidewater Regional Office (STORET, 1994) collected surface water quality data at sampling stations Queens Creek and Philbates Creek. In addition, the VDEQ has collected surface water quality information from King Creek.

4.1.1.1 Queens Creek

Water quality data were collected from the Route 132 bridge in York County, Virginia along Queens Creek. Fifteen water samples were collected from this location: two samples, dated November and December 1992; eleven samples, one each month - from February through December 1993; and two samples, dated February and March 1994. Metals were analyzed in only one water sample monitored in May 1993 (STORET, 1994). Various water quality parameters were measured in the other samples. Queens Creek water quality data are presented in Appendix C on Table C-1.

1 0 .5 1
1 centimeter = 1 kilometer

Topographic Map Symbols

- Primary highway, hard surface
- Secondary highway, hard surface
- Light duty road, principal street, hard or improved surface
- Other road or street; trail
- Route marker: Interstate; U.S.; State
- Railroad: standard gage; narrow gage
- Bridge; overpass; underpass
- Tunnel: road; railroad
- Built up area; locality; elevation
- Airport; landing field; landing strip
- National boundary
- State boundary
- County boundary
- National or State reservation boundary
- Land grant boundary
- U.S. public lands survey: range, township; section
- Range, township; section line: protracted
- Power transmission line; pipeline
- Dam; dam with lock
- Cemetery; building
- Windmill; water well; spring
- Mine shaft; adit or cave; mine, quarry; gravel pit
- Campground; picnic area; U.S. location monument
- Ruins; cliff dwelling
- Distorted surface: strip mine, lava; sand
- Contours: index; intermediate; supplementary
- Bathymetric contours: index; intermediate
- Stream, lake: perennial; intermittent
- Rapids, large and small; falls, large and small
- Area to be submerged; marsh, swamp
- Land subject to controlled inundation; woodland
- Scrub; mangrove
- Orchard; vineyard

25250IIE

FIGURE 4-1
STUDY AREA

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

4.1.1.2 Philbates Creek

Water quality data were collected from Route 600 at the dam in New Kent, Virginia along Philbates Creek. Fifteen water samples were collected from this location: three samples, from August to November 1990; three samples, dated February, May, and August 1991; four samples, dated February, May, August, and November 1992; four samples, dated February, May, August and November 1993; and one sample, collected from February 1994. Nine water samples were analyzed for metals. Various water quality parameters were measured in the other samples collected (STORET, 1994). The Philbates Creek data are presented in Appendix C on Table C-2.

4.1.1.3 King Creek

Water quality data were collected from one station along King Creek: the Colonial Parkway at the confluence with Whitman Swamp, York, Virginia. Fourteen water samples were collected from this location, six samples from July through December 1992 and eight samples from January through August 1993. One water sample was analyzed for metals. Various water quality parameters were measured in the other samples collected (STORET, 1994). All of the surface water data collected from King Creek is presented in Appendix C on Table C-3.

4.1.1.4 Other Creeks

In addition to the water quality monitoring data collected from Queens Creek, Philbates Creek, and King Creek; Severn Creek and Back Creek were monitored for a specific contaminant in 1987. A study (Hall, 1988) conducted on organotin compounds included sampling in the Chesapeake Bay for the presence of tributyltin (TBT). The study was conducted because of the widespread use of TBT containing anti-fouling boat paints. The lower Chesapeake Bay area is potentially affected by the use of TBT paints due to both recreational and commercial boat use. TBT has been found to be toxic to many aquatic organisms. The surface water results from this study are presented in Appendix C on Table C-4.

The surface water quality information is limited to the above-mentioned studies. Although these studies were conducted in tributaries to the York River, they lacked analyses for the CLP parameters of concern.

4.1.2 Sediment Quality

The VDEQ collected sediment quality data at sampling stations in Queens Creek, Philbates Creek, and King Creek (STORET, 1994). In Queens Creek, one sediment sample was collected in June 1993 and analyzed for pentachlorophenol (PCP), PCB congeners, and selected pesticides. In Philbates Creek, one sediment sample was collected in July 1992 and also analyzed for PCP, PCB congeners, and selected pesticides. One sediment sample was collected in June 1993 in King Creek and analyzed for metals, pesticides, and PCB congeners. The results of the sediment studies conducted in Queens Creek, Philbates Creek, and King Creek are presented in Appendix D on Table D-1.

Appendix D, Table D-2 presents results from a sediment study performed by VIMS (Huggett et al., 1988) for selected compounds in the Chesapeake Bay from 1979 through 1986. The sampling stations are located along the western shore of the Chesapeake Bay, with one sample location adjacent to the mouth of the York River.

Specific contaminant studies on sediments were conducted in Severn Creek and Back Creek. TBT was analyzed in the sediment samples collected from these areas (Hall, 1988). TBT has been widely used in recreational and commercial boat paints. TBT has been proven to be toxic to many aquatic organisms. Appendix D, Table D-3 presents the TBT sediment results from this study.

4.1.3 Flora

Wetlands within the Chesapeake Bay watershed lie within the transition areas between well drained, rarely flooded uplands and permanently flooded, deep waters of streams, rivers, ponds, lakes, and coastal embayments. Two basic types of wetlands, coastal and inland, occupy approximately three percent of the Chesapeake Bay drainage area or 1.2 million acres. Over 80 percent of these wetlands are inland and the remainder are coastal wetlands. Coastal wetlands are composed of tidal marshes and mud flats found along the margins of tidal rivers and saltwater embayments. These areas are periodically flooded by salt or brackish water. Inland wetlands within this area are predominantly forested, followed by shrub and emergent wetlands, most of which are nontidal or not affected by ocean-driven tides (CBP, 1988a).

The types of plants and animals that populate the tidal wetlands of the Chesapeake Bay are determined by the salinity and the frequency of tidal flooding. Appendix E, Table E-1 presents the differences between the physical and biological characteristics of tidal freshwater marshes and salt marshes (Odum et al., 1984).

4.1.3.1 Vegetation and Wetlands

Typical east coast marshes are dominated by a combination of annuals and perennials, the majority of which are common to freshwater wetlands throughout North America. Tidal freshwater marsh flora most likely consist of the following plants (Odum et al., 1984):

- Broad-leaved emergent perennial macrophytes [spatterdock (*Nuphar lutecum*), arrowarum (*Peltandra virginica*), pickerel weed (*Pontederia cordata*), and arrowheads]

- Herbaceous annuals [smartweeds (*Polygonum* spp.), tear-thumbs (*Polygonum sagittatum*), burmarigolds (*Bidens laevis*), jewelweed (*Impatiens capensis*), giant ragweed, water-hemp (*Amaranthus cannaabinus*), water-dock (*Rumex verticillatus*)]

- Annual and perennial sedges, rushes, and grasses [bulrushes, spike-rushes (*Eleocharis quadrangulata*), umbrella-sedges (*Cyperus* spp.), rice cutgrass (*Leersia oryzoides*), wild rice (*Zizania aquatica*), giant cutgrass (*Zizaniopsis miliacea*)]

- Grasslike plants or shrub herbs [sweetflag (*Acorus calamus*), cattail (*Typha* spp.), rosemallow (*Hibiscus moscheutos*), water parsnip (*Sium suave*)]

- Hydrophtyic shrubs [bottom bush, wax-myrtle (*Myrica cerifera*), swamp rose (*Rosa palustris*)]

The saltmarshes of the lower and mid-Bay are dominated by meadow cordgrass, saltgrass, and saltmarsh cordgrass (*Spartina alterniflora*). The irregularly flooded salt marshes have the fewest plant species and are dominated by needlerush (CBP, 1988b).

The wetlands along the York River shoreline from Carter Creek to Queens Creek are primarily composed of Spartina communities. The intertidal area is primarily vegetated by a narrow band of saltmarsh cordgrass. Higher elevations are dominated by big cordgrass. In several areas along the York River shoreline, the saltmarsh cordgrass has eroded away, exposing large blocks of peat in the intertidal zones and overhanging margins of peat near the mean high tide line (Silberhorn, 1981).

Queens Creek marsh is the largest marsh creek in York County. The Queens Creek marsh is primarily dominated by grass with abundant stands of saltmarsh cordgrass throughout the lower half of the marsh system. In the lower saline portions and at higher elevations, big cordgrass, marsh elder, salt bushes (*Iva frutescens*), and groundsel tree (*Baccharis halimifolia*) predominate. The upper reaches of Queens Creek are dominated by arrow arum (Silberhorn, 1981).

Portions of King Creek, Felgates Creek, and Indian Field Creek are located on WPNSTA Yorktown. The King Creek marsh is a brackish water marsh with no one dominant plant species. At the mouth of the creek, where more saline conditions exist, saltmarsh cordgrass predominates. The Felgates Creek area is dominated by saltmarsh cordgrass, along with big cordgrass, cattails, sedge, and saltmarsh rush. The marsh areas in the area between Indian Field Creek and Yorktown Creek are dominated by saltmarsh cordgrass. Yorktown Creek is classified as a brackish water marsh dominated by cattails. The Wormley Creek area, another tributary to the York River, is considered to be highly valued as a detritus contributor to the marine food web and a deterrent to erosion. The Wormley Creek area is dominated by saltmarsh cordgrass (Silberhorn, 1981).

The majority of Goodwin Island marshes (a polyhaline marsh area) is vegetated with pine and other upland vegetation. The intertidal areas of Goodwin Island and the associated marsh islands are vegetated primarily with tall forms of saltmarsh cordgrass (Silberhorn, 1981) and saltgrass (Perry et al., 1990). The shoreline margins of Claxton Creek are lined with saltmarsh cordgrass and the higher areas of the marsh are dominated by black needlerush (*Juncus roemerianus*) and associated patches of saltgrass meadow (saltmeadow hay-saltgrass). The marsh of Back Creek is mostly vegetated with highly productive saltmarsh cordgrass, which is a highly valued marsh type (Silberhorn, 1981). The Catlett Islands marsh area (a mesohaline marsh area) is dominated by saltmarsh cordgrass and saltgrass. Taskinas Creek (an oligohaline area) is dominated by saltmeadow hay (*Spartina patens*) and saltgrass. Sweet Hall Marsh is dominated by the following species in descending order by abundance: arrow arum, erect sedge (*Carex stricta*), rice cutgrass, and smart weed (Perry et al., 1990).

The Poquoson River area is divided into three sections: Chisman Creek, Poquoson River Proper, and Bennett Creek area. Bay Tree Creek Marsh is the largest marsh within the Chisman Creek area and is dominated by black needlerush communities. Adjacent to Bay Tree Creek Marsh is Cabin Creek which is also dominated by needlerush. The wetlands of Poquoson River Proper are dominated by saltmarsh cordgrass. Three creeks in this area, Hodges Cove, Moores Creek, and Lambs Creek, are stressed from

development. Creeks within the Bennett Creek area, especially Roberts Creek and Whitehouse Creek, have been destroyed by development (Silberhorn, 1981).

The Plum Tree Island Marsh is the largest saline marsh in the lower Chesapeake Bay (Silberhorn, 1981). Saltmarsh cordgrass dominates the broad intertidal zone that surrounds the more elevated portions of this marsh. Most of the shoreline, except for the mouths of various creeks, is dominated by sand beach. The interior portions of the marsh are dominated by meadows (saltmeadow hay-saltgrass) and black needlerush. Several relic beach ridges form elongated pine hummocks, typically fringed with salt-bushes. Old spoil banks along dredged canals support extensive stands of salt bushes (Silberhorn, 1981).

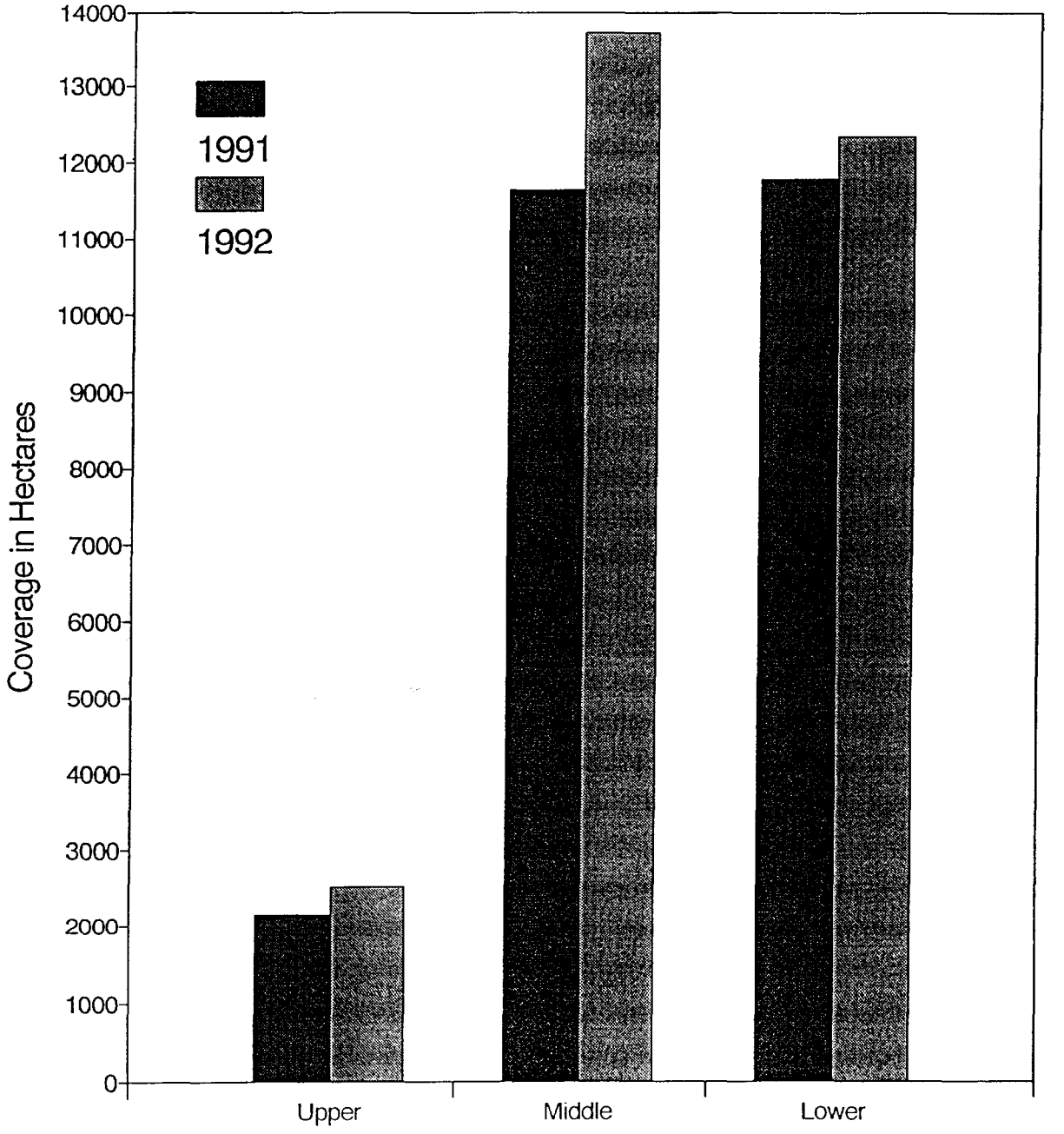
The Back River (Northwestern Branch) and Brick Kiln Creek are characterized mainly as meadow or brackish water mixed community types. The vegetation at the very end of Brick Kiln Creek is highly diverse; however, its species composition is not typical of a tidal freshwater marsh (Silberhorn, 1981). This area is dominated by spike rush, mock bishop's weed (*Ptilimnium capillaceum*), marsh mallow, and marsh hibiscus (*Hibiscus mosheutos*) (Silberhorn, 1981).

4.1.3.2 Submerged Aquatic Vegetation

There are 15 species of SAV that are typically located in the Chesapeake Bay and its tidal tributaries. Appendix E, Table E-2 displays a listing of the SAV species present in the Chesapeake Bay. The species distributions of SAVs are typically determined by their salinity tolerances. The presence of toxics such as herbicides, heavy metals, and petroleum products in a water system deter the growth of SAV. The production of SAV is closely related to the following water quality conditions: dissolved inorganic nitrogen, dissolved inorganic phosphorus, total suspended solids, chlorophyll-*a*, Secchi depth, and light attenuation. Baywide decline in SAV has been attributed to reduced light availability from excessive water turbidity and biofouling of the plants caused by excessive nutrient and sediment loading (CRC, 1991). Decline in the SAV areal coverage began in upstream areas of the York River and have progressed downstream (Bender, 1987).

Figure 4-2 displays the total hectares of SAV by region within the Chesapeake Bay. In 1985, a biweekly sampling program was initiated by VDEQ in conjunction with CBP to monitor SAV in the shallow water habitats of the York River (VDEQ, 1990).

FIGURE 4-2
HECTARES OF SUBMERGED AQUATIC VEGETATION IN EACH ZONE OF THE CHESAPEAKE BAY, 1991-1992
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



(Source: CBP, 1993)

There were 830 hectares of SAV detected in the York River during a 1992 study compared to 804 hectares reported in a 1991 study (Orth et al., 1993). In the York River, 82.8 percent of the SAV beds can be classified as dense beds, while 3.0 percent were moderately dense, 10.7 percent were sparse, and 3.5 percent were very sparse. The dense beds, primarily consisting of *Zostera marina* and *Ruppia martima*, were located mainly from Gloucester Point to the mouth of the York River.

4.1.4 Aquatic Fauna

The type and abundance of species present in an aquatic system are largely dependent on the ecological condition of the water body. Both benthic macroinvertebrate and fish species are influenced by their environment.

The distribution of benthic macroinvertebrate species is likely to respond to changes in water and sediment quality. Benthic macroinvertebrate responses to changes in their habitat tend to be region specific. Many benthic organisms exist for one to two years or longer; therefore, benthic communities are excellent indicators of an environment's short-term and long-term trends in environmental quality (CBP, 1988b). Benthic species tend to be either: (1) deep living, cryptic, retractile, not susceptible to predation, and abundant; or (2) surface dwelling, exposed, susceptible to predation and uncommon or only sporadically abundant (Virnstein, 1979). The latter species are most heavily preyed upon in the natural environment.

The fish community existing in specific areas is controlled by water and sediment quality. Polluted water bodies tend to contain a less diverse and less stable fish community than unpolluted sites and are dominated by pollution-tolerant species, such as carp and mummichog species.

4.1.4.1 Benthic Macroinvertebrates

The temporal and spatial distribution of benthic macroinvertebrate communities is heavily influenced by chemical and physical factors (e.g., salinity, depth, substrata, DO concentrations, and temperature) (Diaz et al., 1990). In low salinity environments, suspension-feeding bivalves dominate (e.g., *Corbicula fluminea* and *Macoma* spp.). In higher salinity environments, other suspension feeding organisms (especially the polychaete *Chaetopterus variopedatus* and the tunicate *Molgula manhattensis*) dominate along with suspension-feeding bivalves (e.g., *Ensis directus* and *Mytilus edulis*) and a variety of other feeding types.

Benthic macroinvertebrate communities are monitored by ODU, under contract with the VDEQ, four times a year at the 19 CBP main tributary stations to the Chesapeake Bay. This benthic macroinvertebrate database has been furnished electronically by ODU for the York River stations from the years 1985 through 1992. The information is composed of benthic macroinvertebrate abundance and biomass by species for the various York River stations. This data is not presented in the appendices because the study area included only mainstem York River stations.

Numerous studies have been conducted in various segments of the Chesapeake Bay to determine what types of species exist. One study (Dauer et al., 1993) was conducted to evaluate biological criteria for defining water quality and the presence of acceptable levels of benthic macroinvertebrate resources in the lower Chesapeake Bay. Appendix F, Table F-1 presents a list distinguishing between species found in "healthy" aquatic environments (i.e., equilibrium) and species typically found in "stressed" aquatic environments (i.e., opportunistic).

Equilibrium taxa are characterized by large, relatively long-lived taxa. Equilibrium taxa tend to dominate undisturbed or unstressed habitats. Whereas, opportunistic taxa are characterized by relatively short-lived, tolerant taxa with relatively high reproductive and recruitment potential. Opportunistic taxa often dominate disturbed or stressed habitats. The larger taxa live deep within the bottom sediments and the smaller taxa live within one or two centimeters from the sediment/water interface. Mature benthic macroinvertebrate communities typically contain a diverse set of feeding guilds, including carnivores, deposit feeders, and suspension feeders. Disturbed communities are often dominated by a single feeding group, such as surficial interface feeders (Dauer et al., 1993).

In another study conducted by Dauer et al. (1987), the percent of individuals and the percent biomass of benthic communities in six different estuarine environments were determined. The study environments represented include: tidal freshwater sites, transitional sites, mesohaline mud sites, polyhaline silty-sand sites, mainstem mud sites, and silty-sand sites. Appendix F, Table F-2 displays the percent biomass and percent individuals detected in each of the estuarine environments in the lower Chesapeake Bay.

Appendix F, Table F-3 displays the type and biomass of the benthic macroinvertebrate species collected in a study (Ewing et al., 1982) of a tidal creek area of the lower Chesapeake Bay (e.g., Old Plantation Creek, King Creek, and Cherrystone Inlet). Another benthic population study was conducted by VIMS on the dominant macrofaunal groups detected in the major habitats of the Chesapeake Bay (Diaz et al., 1990). Appendix F, Table F-4 displays the organisms collected in the specific estuarine habitats presented

in this study. The habitats, macrofaunal characteristics, and densities from this study are displayed in Appendix F on Table F-5.

VIMS has conducted studies only in the main tributaries to the Chesapeake Bay. Studies to the tributaries of these main tributaries are expected to begin in the spring of 1995 and continue for one to two years. In addition to VIMS, ODU has performed an extensive amount of studies in the Chesapeake Bay; however, these studies have also been limited to the main tributaries (Dauer, 1994). At the present time, there are limited data existing for benthic macroinvertebrate studies conducted in the tributaries to the York River (Diaz, 1994).

Although benthic macroinvertebrate studies have not been specifically conducted in the tributaries to the York River, certain inferences and trends can be made as to the type and quantity of organisms expected in a "healthy" environment in the lower portion of the Chesapeake Bay. A study conducted by Dauer et al. (1993) concluded that most organisms exhibit a large recruitment pulse in the spring, a smaller recruitment pulse in the fall, and reductions in the summer and winter. Adverse effects of contaminants are greatest during the summer because of low dilution flows and high temperatures. In addition, episodic low oxygen events, identified as a major factor affecting the occurrence of depressed living resources in the Chesapeake Bay, occur in the summer months.

A study (Kemp et al., 1981) conducted in a mesohaline area near the Patuxent River found the maximum biomass of benthic macroinvertebrates was detected in June, while the number of individuals was highest in the spring. The summer population of benthic macroinvertebrates appears to be limited by predation at three meter (sandy) and six meter (transitional, sandy-mud) contours. In addition, the summer population of benthic macroinvertebrates at depths of nine meters (mud) or greater appear to be limited by low oxygen levels.

In addition to seasonal effects on the benthic macroinvertebrate community, salinity also determines the type and density of benthic macroinvertebrate species residing in a particular stream section (Dauer, 1993). Benthic macroinvertebrate studies conducted in the York River demonstrated biomass values of species increased from lowest values at the tidal freshwater region to highest values in the mesohaline zone of the York River. The mesohaline stations were dominated by the bivalve, *Macoma balthica*. The polyhaline station at the mouth of the York River, was dominated by the maldanid polychaete, *Clymenella torquata*; the bivalves, *Anadara transversa*, *Mercenaria mercenaria* (hard shell clam); *Mya arenarea* (soft shell clam); and the polychaete, *Loimia medusa*.

The lowest biomass and number of individuals were observed at the tidal freshwater region and the highest values were observed in the polyhaline zone at the mouth of the York River (Dauer, 1993). The percent biomass consisting of opportunistic species declined from high values in the tidal freshwater region, dominated by *limnodrilid oligochaetes*, to values of less than 10 percent for the remainder of the estuarine gradient.

In the tidal freshwater areas there were temporal trends of increasing biomass, increasing species diversity, increasing abundance and a decline in opportunistic biomass in the month of September. A decline in the opportunistic biomass may be due to large increases in insect larvae, which were not classified as either opportunistic or equilibrium species (Dauer, 1993b).

In summary, it is expected that benthic macroinvertebrate sampling in the tidal freshwater regions at WPNSTA Yorktown in the summer months would most likely result in an abundant species population and low biomass. As mentioned above, previous studies conducted in the tidal freshwater streams found the benthic macroinvertebrate community to be dominated by opportunistic species.

4.1.4.2 Fish

Tidal freshwater fish communities are complex and have a seasonally variable mixture of freshwater species tolerant of low salinity conditions. The community consists of four major categories: (1) estuarine residents, those which spawn and remain in the York River System; (2) anadromous species, those which utilize the freshwater portion of the river as a spawning and nursery area and migrate from the system as juveniles or young adults; (3) catadromous species, those which spawn offshore but utilize the river as a nursery area and feeding ground and (4) strays, those species which occasionally enter the York River (Bender, 1987).

Appendix G, Table G-1 displays the fish species typically found in the Chesapeake Bay and in the tributaries to the Chesapeake Bay. Finfish represent the majority of the fish species existing in the Chesapeake Bay. There are two main spawning behaviors of the finfish in the Chesapeake Bay: ocean-spawning fish [spot (*Leiostomus xanthurus*), croaker (*Micropognias undulatus*), menhaden (*Brevoortia tyrannus*)] and freshwater estuarine-spawning fish [striped bass (*Morone saxatilis*), blueback herrings (*Alosa aestivalis*), and shad (*Alosa sapidissima*)]. The estuarine resident fish spawn during the spring in the tidal freshwater areas, as the low salinity waters serve as nursery areas (CBP, 1988b).

The anadromous marine shad, hickory shad (*Alosa mediocris*), blueback herring, and alewife (*Alosa pseudoharengus*) spend their adult lives in the marine environment, but return to freshwater portions of the estuary to spawn. Some marine spawning fish (e.g., menhaden, croaker, and weakfish) spawn in the marine environment, but utilize portions of the estuary as nurseries (Tetra Tech, 1986).

The finfish in the Chesapeake Bay initially feed on zooplankton and later turn to larger prey (CBP, 1988b). Studies indicate that the highest survival rate for finfish larvae are positively correlated to the highest zooplankton densities. Therefore, the success of finfish using the Chesapeake Bay as nursery grounds is dependent on the availability of certain types of plankton.

Factors that control the species composition and abundance of estuarine fish communities are complex and not well understood (EMAP, 1994). Most fish ecologists agree that the assemblage of fish that occurs in a specific area is controlled by water and sediment quality parameters. For example, polluted areas tend to contain less diverse and less stable fish communities than unpolluted sites and are dominated by pollution-tolerant species, such as mummichogs (*Fundulus heteroclitus*) and carp (*Cyprinus carpio*).

In addition to water and sediment quality regulating fish habitats, the following factors regulate the fish diversity in estuaries (Cain et al., 1976):

- Variety of niches
- Size of niches and niche overlap
- Stability of environment or climate
- Rigorousness of environment
- Succession
- Productivity
- Biomass accumulation
- Competition
- Space
- Length of food chains
- Body size

Numerous fish population studies have been conducted in the Chesapeake Bay and the tributaries to the Chesapeake Bay. Fish were collected in three marsh stream sections (e.g., headwater, main creek, and

river) for a four month period differentiating between night and day catches. The type and weight of the species collected in this marsh stream study are detailed below (Rozas et al., 1987a):

Species	HEADWATER		MAIN CREEK		RIVER	
	No.	Wt.	No.	Wt.	No.	Wt.
Grass Shrimp	7,923	1,274	5,472	913	5,698	966
Mummichog	1,392	737	552	330	451	350
Banded killifish	917	425	636	320	98	121
Inland silverside	132	76	143	67	243	158
Blue crab	134	3,779	115	2,684	205	3,403
Spottail shiner	112	517	52	166	27	126
Pumpkinseed	107	1,549	49	497	32	724

No. - number of species
Wt. - total weight of species collected in grams

Appendix G, Table G-2 displays the results of an intertidal creek (North Inlet Estuary) study performed from October 21, 1974 to February 22, 1975 (Bozeman et al., 1980). Spot was the most abundant species detected, followed by pinfish, menhaden, Atlantic croaker, and the speckled worm eel. Appendix G, Table G-3 displays the fish and macrocrustaceans collected in SAV in a study conducted from mid-June through October 1985 in a tidal freshwater creek in the Parsons Island marsh on the Chickahominy River (Rozas et al., 1987a). The grass shrimp was the most abundant macrocrustacean species collected and the banded killifish was the most abundant fish species collected, followed by the mummichog.

Another fish population study, Rozas et al. (1987b), determined that 95.8 percent of the fish collected in a tidal freshwater marsh (Parsons Island marsh) consisted of grass shrimp, mummichogs, branded killifish, inland siversides, and blue crabs. The grass shrimp, mummichog, and the blue crab made up the majority of the total biomass. The majority of the shrimp and mud crabs collected were adults, while the majority of blue crabs and fish collected were juveniles. Freshwater species accounted for most of the organisms collected in this tidal freshwater marsh, followed by estuarine, diadromous, and marine species. The study concluded that all fish do not use tidal freshwater marshes to the same degree. Marshes located at the upper reaches of the tidal creeks support greater densities of fish than marshes further downstream.

Spot were found to be the most successful species in tidal creeks, especially in mesohaline marshes (Weinstein et al., 1983). Spot are bottom-feeding fish which enter the estuary in late spring and generally return to the ocean in the late fall. Smaller individuals may remain over the winter in deeper channels of

the estuaries (Van Veld et al., 1990). The number of species residing in marshes is highly seasonal with the greatest number of species typically collected in the summer (Rozas et al., 1984).

A study (Weinstein et al., 1983) conducted in a tidal creek and an adjacent seagrass meadow of the Vaucluse Shores, Virginia, included monthly trawl sampling to detect the fish population occupying the study area. Appendix G, Table G-4 presents the fish population detected in the grassbed of the study area. Spot was the most frequently detected species in the marsh, as well as upstream and downstream of the marsh.

VIMS conducts juvenile fish population studies in the mainstem of the York River on a monthly basis. These population studies are located in mid-channel stations of the York River at five mile intervals using a trawl sampler. The species collected in the VIMS population study include: Atlantic croaker, channel catfish, silver perch, spot, striped bass, summer flounder, weakfish, white catfish, and white perch. These data are not presented in the appendices because the study area included only mainstem York River stations, rather than any data specific to tributaries to the York River.

Besides finfish and crabs, there are many shellfish beds located in the York River Basin. However, there appears to be a vast amount of contamination of these beds. The upper segment of the York River (to the confluence with the Mattaponi and Pamunkey Rivers) contains 3,602 acres of closed shellfish beds, while the Poropotank River has 446 acres and Adams Creek has 76 acres of condemned beds. The closing of the oyster beds appears to be influenced by nonpoint sources. The nonpoint sources in the area include residential, urban, and/or agricultural runoff, failing/inadequate septic systems, natural conditions/drainage, and boat pollution from public and private boat slips. In addition to nonpoint sources, the oyster beds have been adversely influenced in recent years by two diseases: MSX and Dermo. The lower portion of the York River (from the Chesapeake Bay at Sandy Point and Tue Point to the confluence with Taskinas Creek and Adams Creek) contains approximately 4,664 acres of condemned shellfish grounds (VSWCB, 1990a).

In summary, a fish population study conducted in any of the tributaries to the York River near WPNSTA Yorktown would most likely result in the collection of spot, mummichog, striped bass, bay anchovy, white perch, yellow perch, and herring. The crustaceans collected would include the grass shrimp and the blue and mud crabs.

4.2 Freshwater Pond Data

4.2.1 Surface Water

The VDEQ Lake Monitoring Program (revised in 1985) consists of a five year cycle of lake monitoring for each non-Federally owned public lake in excess of 25 acres in size within the Commonwealth. There are currently 247 publicly accessible lakes in the Commonwealth. These lakes are monitored for the following water quality parameters: DO depth profiles; temperature depth profiles; Secchi depth; pH; complete nitrogen series (total kjeldahl nitrogen, ammonia-nitrogen, nitrate, and nitrite); low range total phosphorus, fecal coliform, chlorophyll-a, and preserved algae. For public lakes greater than 25 acres in size, the following parameters are also monitored every five years: alkalinity, hardness, specific conductance, ortho-phosphate, total organic carbon, limited metals (water and sediment), and limited pesticides/herbicides (water and sediment) (VSWCB, 1990a).

Unfortunately, an extensive amount of data on freshwater ponds does not exist, especially for sediment, flora, and fauna. Any extensive studies conducted beyond basic water quality parameters were conducted due to contamination problems within the ponds; therefore, these ponds could not be used for background reference stations in the York River Basin (Seivard, 1994).

The VDEQ recommended Hardwood Mill Pond and Waller Mill Reservoir as pond systems that would be representative of freshwater impoundments of the York River Basin (Seivard, 1994). The following chemical analyses have been performed for Hardwood Mill Reservoir in the Summer of 1988: DO, temperature, Secchi depth, pH, hardness, total suspended solids, suspended volatile solids, suspended fixed solids, total kjedahl nitrogen, ammonia, nitrate, nitrite, total phosphorus, ortho-phosphate, fecal coliform, alkalinity, hardness, conductivity, salinity, aldrin, endrin, heptachlor epoxide, iron, manganese, and chlorophyll. In addition to surface water analyses, the algal species were also identified.

Chemical measurements were performed by the VDEQ in one other pond in the York River Basin, Waller Mill Reservoir. The surface water of Waller Mill Reservoir was analyzed in 1980 and 1990 for the same parameters mentioned above for the Hardwood Mill Reservoir, except for aldrin, endrin, and heptachlor epoxide (STORET, 1994).

4.2.2 Sediment

The following parameters were analyzed in the sediments collected from the Hardwood Mill Pond study: PCB congeners, pentachlorophenol, dieldrin, total chlordane, DDT, DDE, DDD, endrin, toxaphene, heptachlor, heptachlor epoxide, arsenic, cadmium, chromium, copper, lead, mercury, zinc, and nickel (STORET, 1994). No sediment data for Waller Mill Reservoir were available.

4.2.3 Benthic Macroinvertebrates

There are no known existing benthic macroinvertebrate data collected from freshwater ponds in the York River Basin.

4.2.4 Fish

Reportedly, there is a lack of fish population data collected from freshwater ponds in the York River Basin (Seivard, 1994).

A limited fish population study has been conducted at the Armed Forces Experimental Training Activity Camp Peary (AFETA Camp Peary) in Williamsburg, Virginia. The fish survey included a qualitative population study of fish species collected from two on-base freshwater ponds. The following fish species were collected from the study ponds: largemouth bass, channel catfish, blue catfish, white catfish, flat bullhead catfish, blue gill, black crappie, white perch, gizzard shad, American eel, redear sunfish, golden shiner, and pumpkin seed.

A focused biological fish tissue sampling program (Baker Environmental, Inc. et al., 1993) was conducted at WPNSTA Yorktown that included fish tissue analyses of species collected from Lee Pond and Roosevelt Pond. The study was conducted in areas suspected of receiving contaminant loading. The fish samples were analyzed for CLP semivolatile organic compounds, metals, pesticides, and PCBs.

5.0 CONCLUSIONS

There is a significant amount of information available for studies performed in the York River; however, at the present time there is a lack of data collected from the tributaries to the York River. It cannot be assumed that the tributaries to the York River and the York River are similar. However, various assumptions concerning what types of benthic macroinvertebrate and fish species will inhabit the tidally influenced creeks during various months of the year can be made.

One difficulty encountered in conducting this literature review was finding an extensively sampled, pristine, tidally influenced creek or freshwater pond. Any extensive studies performed (i.e. analysis for CLP parameters in surface water and sediment) were most likely conducted in potentially affected or heavily polluted waters in the mainstem of the York River.

It should be emphasized that upon interviewing many of the technical experts, it was stated that sampling of the tributaries is planned in the near future. Diaz (1994) indicated that VIMS will begin benthic macroinvertebrate sampling of tributaries to the York River in the Spring of 1995. Dauer (1994) indicated that ODU will be expanding their research into the tributaries of the York River in the near future. Swihart (1994) of the Fish and Wildlife Service (White Marsh Region, Gloucester, VA) discussed plans to begin conducting fish studies in the York River within the next year. CBP will also be expanding monitoring into the tributaries of the main tributaries of the Chesapeake Bay (Capatanza, 1994). Therefore, in a two or three year period a much larger database of benthic macroinvertebrate and fish data collected from tributaries to the York River will exist.

5.1 Tidal Freshwater Reference Summary

5.1.1 Surface Water/Sediment

There does not appear to be sufficient information for background surface water and sediment stations, particularly for surface water and sediment data collected from relatively "pristine" environments. The VDEQ water quality data for Queens Creek, King Creek, and Philbates Creek do contain general water quality parameters including select metals and some sediment pesticide and PCB monitoring. However, the existing data do not contain the extensive CLP monitoring of surface water and sediment that is required to constitute a WPNSTA Yorktown background station.

The VDEQ Bioaccumulation Initiative Study for the coastal management zones of Virginia conducted CLP monitoring of surface water and sediment for various streams and ponds located at Federally-owned facilities, private industries, and sanitary treatment plants. However, the sites chosen for this investigation were from areas of potential concern of bioaccumulatable compounds. As mentioned in Section 1.0, the criteria for a good reference station includes selection of a site that is not influenced by sites or similar sources of contaminants. As such, it will be necessary to collect/analyze tidal freshwater background surface water and sediment samples to obtain appropriate reference data to compare with data collected from the streams/creeks at WPNSTA Yorktown.

5.1.2 Benthic Macroinvertebrates

The existing benthic macroinvertebrate information for the mainstem area of the York River may be used to predict the type of species expected according to salinity and substrata type of the sampling area. However, it should be noted that the majority of the data collected for the mainstem areas of the York River are in relatively deep waters compared to the shallow depths of most of the tributaries. The depth of the water does affect the resident benthic macroinvertebrate species present to a certain degree. Therefore, it may be appropriate to collect benthic macroinvertebrate samples to confirm that the species predicted to exist in the area represent actual shallow freshwater stream conditions.

5.1.3 Fish

The marshes consist of unconsolidated sediments with dense vegetation; therefore, most fish studies are confined to mainstem trawl studies (Odum et al., 1984). The existing fish population data collected for the mainstem of the York River and several tributaries will also be representative of the tributaries to the York River. However, limited sampling of the tidal freshwater streams may be considered to confirm this historical data.

5.2 Freshwater Pond Reference Summary

5.2.1 Surface Water/Sediment

There does not appear to be a sufficient amount of existing freshwater pond data for the York River basin. The data provided by the VDEQ for Waller Mill Reservoir and Hardwood Mill Pond do not contain the extensive CLP monitoring data that is required to constitute a WPNSTA background station.

The VDEQ Bioconcentration Initiative Study for the coastal management zones of Virginia conducted CLP monitoring of surface water and sediment for various streams and ponds located at Federally-owned facilities, private industries, and sanitary treatment plants. However the sites chosen for this investigation were from areas of potential concern of bioaccumulatable compounds. As mentioned in Section 1.0, the criteria for a good reference station includes selection of a site that is not influenced by WPNSTA facilities or any other known point sources of contaminants. As such, it will also be necessary to collect freshwater pond background surface water and sediment samples to obtain appropriate reference data to compare with data collected from the freshwater ponds located at WPNSTA Yorktown.

5.2.2 Benthic Macroinvertebrate

An adequate database for benthic macroinvertebrate species in freshwater ponds within the York River Basin was not located. Therefore, it is necessary to collect background freshwater pond benthic macroinvertebrate samples to obtain reference data to compare with the benthic macroinvertebrate freshwater pond samples collected from WPNSTA Yorktown.

5.2.3 Fish

A fish survey (Baker, 1994) has been conducted at the Armed Forces Experimental Training Activity, Camp Peary in Williamsburg, Virginia. The fish survey included a limited population study of fish species collected from two on-base freshwater ponds. Similar to the surface water/sediment and benthic macroinvertebrate data, the existing fish population database for freshwater ponds is also insufficient to qualify as background. Fish data collected from background freshwater ponds are necessary to compare with those freshwater pond fish data obtained from WPNSTA Yorktown.

6.0 RECOMMENDATIONS

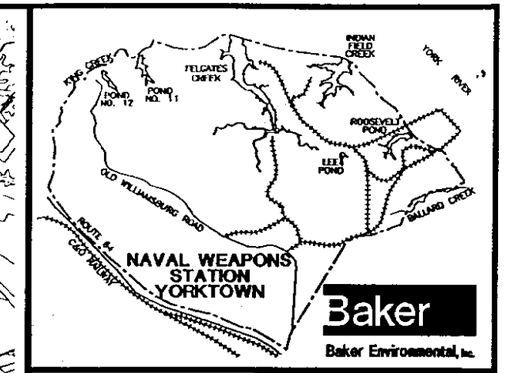
The following tidal freshwater streams and freshwater ponds in the York River Basin have been recommended to be representative of background information based on the following: a review of the literature; discussions with environmental professionals familiar with the region and the York River Basin; and, by comparing hydrological and ecological characteristics of the recommended waterbodies to the on-site waterbodies. In order to minimize variations in sampling results, the selected background locations will be sampled using the same field methodologies and procedures as the on-site locations. The recommended waterbodies are presented on Figure 6-1.

6.1 Recommended Tidal Freshwater Background Station

The ponds and creeks presented below are recommended as potentially unimpacted areas. Two of the recommended tidal freshwater creeks from this list will be selected to conduct background station sampling of surface water/sediment, benthic macroinvertebrate communities, and limited fish population studies. Selection of the background streams will be made after a field reconnaissance has been conducted during the onset of the field ecological sampling event at WPNSTA Yorktown slated to begin July 18, 1994.

Timberneck Creek

- Advantages:
  - Approximately the same channel width as Felgates Creek and Indian Field Creek
  - No apparent adverse impacts from surrounding land-use
  - The creek has a slightly smaller drainage area than Felgates Creek
  - This creek has been recognized by the National Estuarine Research Reserve program as a good control site for the area
  - Located at the same river mile as WPNSTA Yorktown
- Disadvantages:
  - Wetlands are located at the confluence with the York River, but not along the mainstem
  - The creek has a much larger drainage area than Indian Field Creek
  - Located across the York River from WPNSTA Yorktown



1 0 .5 1

1 centimeter = 1 kilometer

Topographic Map Symbols

- Primary highway, hard surface
- Secondary highway, hard surface
- Light duty road, principal street, hard or improved surface
- Other road or street; trail
- Route marker: Interstate; U.S.; State
- Railroad: standard gage; narrow gage
- Bridge; overpass; underpass
- Tunnel: road; railroad
- Built up area; locality; elevation
- Airport; landing field; landing strip
- National boundary
- State boundary
- County boundary
- National or State reservation boundary
- Land grant boundary
- U.S. public lands survey: range, township; section
- Range, township; section line: protracted
- Power transmission line; pipeline
- Dam; dam with lock
- Cemetery; building
- Windmill; water well; spring
- Mine shaft; adit or cave; mine, quarry; gravel pit
- Campground; picnic area; U.S. location monument
- Ruins; cliff dwelling
- Distorted surface: strip mine, lava; sand
- Contours: index; intermediate; supplementary
- Bathymetric contours: index; intermediate
- Stream, lake: perennial; intermittent
- Rapids, large and small; falls, large and small
- Area to be submerged; marsh, swamp
- Land subject to controlled inundation; woodland
- Scrub; mangrove
- Orchard; vineyard

25250DEF

FIGURE 6-1
PROPOSED BACKGROUND STATION LOCATIONS

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Poropotank Creek

- Advantages:
  - The entire creek is surrounded by wetlands
  - No apparent adverse impacts from surrounding land-use
- Disadvantages:
  - The "bay" is much wider than Felgates Creek and Indian Field Creek, but the actual channel width is smaller
  - Located across the York River from WPNSTA Yorktown
  - Located 10 miles upstream from WPNSTA Yorktown

Adams Creek

- Advantages:
  - No apparent impacts from surrounding land-use
  - The entire creek is surrounded by wetlands
  - The creek has a slightly smaller drainage area than Felgates Creek
- Disadvantages:
  - The creek has a much smaller channel width than Felgates Creek and Indian Field Creek
  - The creek has a much larger drainage area than Indian Field Creek
  - Located across the York River from WPNSTA Yorktown
  - Located 10 miles upstream from WPNSTA Yorktown

6.2 Proposed Freshwater Pond Reference Station

The following freshwater ponds within the York River Basin have been recommended by the VDEQ as representative background impoundments in the York River Basin. Two of the recommended ponds from this list will be selected to conduct background station sampling of surface water and sediments, benthic macroinvertebrates, and fish population studies. Selection of the two background ponds will be made after a field reconnaissance has been conducted. The following ponds are being considered:

Woodstock Pond

- Advantages:
  - Approximately the same size as the ponds on WPNSTA Yorktown
  - No apparent adverse impacts from surrounding land-use
  - Close proximity to a recommended background tidal freshwater stream: Taskinas Creek (located adjacent to the pond in the York River State Park)
  - Close proximity to the other recommended pond background stations: Skimino and Powell Ponds (located adjacent to the York River State Park at AFETA Camp Peary)
  - Located on the same side of the York River as WPNSTA Yorktown
- Disadvantages:
  - Located 10 miles upstream from WPNSTA Yorktown

Skimino and Powell Ponds

- Advantages:
  - Approximately the same size as the ponds on WPNSTA Yorktown
  - Data from previously conducted investigation in Skimino Pond can be used to supplement study data
  - Close proximity to a recommended background tidal freshwater stream (Taskinas Creek) and freshwater pond (Woodstock Pond)
  - Located on the same side of the York River as WPNSTA Yorktown
- Disadvantages:
  - May have adverse impact from AFETA Camp Peary activities
  - Located 8 miles upstream from WPNSTA Yorktown

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Cedarbush Creek

- Advantages:
  - Approximately the same channel width as Felgates Creek and Indian Field Creek
  - No apparent adverse impacts from surrounding land-use
  - This creek has been recognized by the National Estuarine Research Reserve program as a good control site for the area
  - Located at the same river mile as WPNSTA Yorktown
- Disadvantages:
  - Wetlands are located at the confluence with the York River, but not along the mainstem
  - The creek has a smaller drainage area than Felgates Creek and a much larger drainage area than Indian Field Creek
  - Located across the York River from WPNSTA Yorktown

Taskinas Creek

- Advantages:
  - Close proximity to the recommended pond background stations: Woodstock Pond (located adjacent to Taskinas Creek in York River State Park), Skimino and Powell Ponds (located adjacent to the York River State Park at AFETA Camp Peary)
  - No apparent adverse impacts from surrounding land-use
  - The creek has a slightly smaller drainage area than Felgates Creek
  - This creek has been recognized by the National Estuarine Research Reserve program as a good control site for the area
  - The entire creek is surrounded by wetlands
  - Located on the same side of the York River as WPNSTA Yorktown
- Disadvantages:
  - The creek has a much smaller channel width than Felgates Creek and Indian Field Creek
  - The creek has a much larger drainage area than Indian Field Creek
  - Located 10 miles upstream from WPNSTA Yorktown

APPENDIX A

CONTACT REPORTS

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 03-29-94

TO: John Maxted

FROM: Thomas Biksey/Jodi Golden

REPRESENTS: State of Delaware - Water Quality Division

REPRESENTS: Baker Environmental

PHONE NUMBER: (302) 739-4590

PHONE NUMBER: (412) 269-6000

SUBJECT:

He conducted Rapid Bioassessment Protocols for Coastal Streams.

He is sending a draft SOP for benthic macroinvertebrate sampling in nontidal streams, but requested that we not use these protocols on tidal streams.

He recommended contacting Lou Seivard of the VDEQ for freshwater pond information.

He recommended contacting EMAP for estuarine data in the York River.

He cannot provide any reference information because the variability may be to great between Virginia and Delaware ecological systems. He is currently conducting a study between states to determine this variability and formulate reference stations, but this information is not available at the present time. The study will be complete in a year.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 03-30-94

TO: Daniel Dauer

FROM: Thomas Biksey/Jodi Golden

REPRESENTS: Old Dominion University - Department of Biological Sciences

REPRESENTS: Baker Environmental

PHONE NUMBER: (302) 739-4590

PHONE NUMBER: (412) 269-6000

SUBJECT:

Old Dominion University (ODU) benthic macroinvertebrate data collected from stations in the York River are available in the SAS computer system. This data can also be accessed off of the STORET database system.

ODU benthic macroinvertebrate sampling stations are located in the mainstem of the York River.

Bud Rodi from his laboratory will supply us with the benthic macroinvertebrate station data in electronic format for the York River.

ODU has used eastern shore as background locations, but no longer finds the area to be ecological comparable to the western shore.

For benthic macroinvertebrate data in the York River, he recommended contact with Robert Diaz from VIMS.

He recommended limiting our reference station to the York River Basin because the other river basins within the eastern shore of the Chesapeake Bay are hydrodynamically different, which may affect the ecology of the basins.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 03-28-94 and 05-05-94

TO: Richard Batiuk

FROM: Thomas Biksey/Jodi Golden

REPRESENTS: Chesapeake Bay Program Office - Toxic Substances

REPRESENTS: Baker Environmental

PHONE NUMBER: (302) 739-4590 and interview

PHONE NUMBER: (412) 269-6000

SUBJECT:

Recommended contacting Ray Aldon of ODU and Lenwood Hall of the University of Maryland Y Research and Education Center for vegetation data.

Recommended contacting Mike Unger and Rob Hale of VIMS for surface water and sediment data.

Recommended contacting Bob Diaz and Linda Schaffner of VIMS for benthic macroinvertebrate data in the York River.

Recommended contacting Ken Moore, Robert Orth, and Bruce Nielson at VIMs for nutrient and general water quality data in the York River.

Recommended contacting Becky Dickett of VIMS if we are interested in atmospheric deposition between the York River and the Rappahannock River.

He will circulate our request for data from tributaries to the York River and he will collect data relevant to the project.

He will provide us with a report of benthic macroinvertebrate restoration goals for the Chesapeake Bay for 1993.

Stated that nutrients is a hot topic right now in the Chesapeake Bay.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 03-29-94

TO: Ray Aldon

FROM: Thomas Biksey/Jodi Golden

REPRESENTS: Old Dominion University - Marine Research Library

REPRESENTS: Baker Environmental

PHONE NUMBER: (804) 683-5582

PHONE NUMBER: (412) 269-6000

SUBJECT:

Toxicologist - he has performed extensive studies in the lower Chesapeake Bay.

Recommends Poropotank River (20 miles from Gloucester Point up the river) as a pristine area free of contamination.

Lack of information available for smaller tributaries due to a lack in funding from agencies.

He has performed a majority of his work on the Eastern shore - sediment toxicity studies, but no heavy chemistry work. The areas he has studied (e.g., Chisholm Creek) he does not recommend as representative background locations.

He has conducted studies on eastern shore tidal creeks pertaining to sediment toxicity - effects of particle size on benthic macroinvertebrates.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 04-05-94

TO: John Jacobs/Ann Lang

FROM: Tom Biksey/Jodi Golden

REPRESENTS: NOAA - Annapolis, MD

REPRESENTS: Baker Environmental

PHONE NUMBER: interview

PHONE NUMBER: (412) 269-6000

SUBJECT:

NOAA does not have any data from the tributaries to the York River.

He recommended contacting Joe Losh and Herb Austin of VIMS to obtain fish data for the York River area.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 03-31-94

TO: Michelle Fults/Traycie West

FROM: Jodi Golden

REPRESENTS: Virginia Department of Environmental Quality - Tidewater Region

REPRESENTS: Baker Environmental

PHONE NUMBER: (804) 552-1142

PHONE NUMBER: (412) 269-6000

SUBJECT:

Water quality and a limited amounted of sediment quality information is available for Felgates Creek, King Creek, Queen Creek, and Philbates Creek.

She is sending water and sediment quality data for King Creek, Queen Creek, and Philbates Creek.

She does not have any benthic macroinvertebrate or fish data for the York River.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 03-31-94

TO: Charles Morgan

FROM: Thomas Biksey/Jodi Golden

REPRESENTS: Virginia Department of Environmental Quality Data Management

REPRESENTS: Baker Environmental

PHONE NUMBER: (804) 762-4473

Phone Number: (412) 269-6000

SUBJECT:

He will provide water quality data and a limited amount of sediment quality data for Queen Creek, King Creek, and Felgates Creek.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown	CTO NUMBER: 252
LOCATION: Yorktown, Virginia	DATE: 04-04-94
TO: Bob Siegfried	FROM: Jodi Golden
REPRESENTS: Baker Environmental - Richmond, VA	REPRESENTS: Baker Environmental
PHONE NUMBER: (804) 282-1821	PHONE NUMBER: (412) 269-6000

SUBJECT:

He recommended contacting Rob Hale, Linda Schaffner, and Chris Bonzek of VIMS.

He recommended Taskinas Creek as a good reference station.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 04-04-94

TO: Chris Bonzek

FROM: Jodi Golden

REPRESENTS: Virginia Institute of Marine Science - Fisheries Management

REPRESENTS: Baker Environmental

PHONE NUMBER: (804) 642-7291

PHONE NUMBER: (412) 269-6000

SUBJECT: Fisheries Data

He is sending population data (monthly trawl studies) for the York River, but no fish tissue information.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 04-05-94

TO: Joe Macknis

FROM: Thomas Biksey/Jodi Golden

REPRESENTS: Chesapeake Bay Program - Water Quality Monitoring Program

REPRESENTS: Baker Environmental

PHONE NUMBER: interview

PHONE NUMBER: (412) 269-6000

SUBJECT:

His study data is for phytoplankton, zooplankton, and benthic macroinvertebrates. This data is written up by the researchers under separate covers.

He mentioned Habitat Restoration Goals established for the Chesapeake Bay.

He recommended contacting Robert Huggett of VIMS for finfish population data, Bruce Nielson of VIMS for DO studies.

He recommended contacting Greg Allen of the EPA Field Auditing Office.

He thinks the York River, Rappahannock River, and the Eastern Shore are the most pristine areas in the Chesapeake Bay.

He recommended staying in the York River to obtain a good reference station. Any tributary to the York River can be used to characterize the other tributaries to the York River.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 04-05-94

TO: Louis Linker

FROM: Thomas Biksey/Jodi Golden

REPRESENTS: Chesapeake Bay Program - Soils/Sediment

REPRESENTS: Baker Environmental

PHONE NUMBER: interview

PHONE NUMBER: (412) 269-6000

SUBJECT:

He does not have any sediment data for the York River.

He stated that there have not been any sediment oxygen demand studies in the lower Chesapeake Bay

He recommended contacting the University of Maryland to look into their B.E.S.T. and N.A.S.A.R. studies.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 04-06-94

TO: Robert Diaz

FROM: Thomas Biksey/Jodi Golden

REPRESENTS: Virginia Institute of Marine Science - Department of Coastal and Marine Ecology

REPRESENTS: Baker Environmental

PHONE NUMBER: interview

PHONE NUMBER: (412) 269-6000

SUBJECT:

He was unsure of the variability of using tributaries to other mainstems of the Chesapeake Bay as reference stations instead of tributaries off of the York River. The tributaries may be more ecological similar than the main tributaries to the Chesapeake Bay.

He doesn't think we can find a "clean" tributary to the York River because of the refineries in the area and the history of hydrocarbon contamination in the area. There are a good number of point sources entering the York River from hot water power plants, oil refineries, pulp mill, and naval activities.

He does not conduct studies in shallow waters. His students mainly conduct studies in deep waters.

He suggested researching the works of Michael Bender, David Yazzo, Mark La Salle, Priscilla Hinde, Amanda Daly, Michael Weinstien, Bob Huggett at the VIMS library.

The further you move away from Cheatham Annex the greater the variability in the ecological environments due to salinity variations.

He plans to begin a 1 to 2-year study in the marsh areas of the York River. This data (benthic macroinvertebrate studies) will not be published for another 2 or 3 years.

He feels any tributary to the York River would make a good reference station, but he cannot recommend any because we are eliminating station on a chemical constituent basis.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 04-07-04

TO: Gary Swihart

FROM: Thomas Biksey/Jodi Golden

REPRESENTS: U.S. Fish and Wildlife Service - White Marsh Region

REPRESENTS: Baker Environmental

PHONE NUMBER: interview

PHONE NUMBER: (412) 269-6000

SUBJECT:

He is involved with military recreational fisheries as "support", but he has not conducted work on WPNSTA Yorktown.

He does not know of any good reference stations in the area.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 04-13-94

TO: Lou Sievard

FROM: Thomas Biksey/Jodi Golden

REPRESENTS: Virginia Department of Environmental Quality - Freshwater Ponds

REPRESENTS: Baker Environmental

PHONE NUMBER: (804) 537-5267

PHONE NUMBER: (412) 269-6000

SUBJECT:

He will look into representative background freshwater ponds located in the York River Basin.

The VDEQ monitors 250 ponds in Virginia on a five-year schedule. The ponds are monitored for pH, DO profiles, and nutrients.

Recommended the following ponds as good reference freshwater ponds representative of the York River Basin: Hardwood Mill Pond, Waller Mill Reservoir, Bigler Mill Pond, Jones Mill Pond, Cheatham Lake, and Skimino Pond.,

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 04-14-94

TO: Becky Wajda

FROM: Thomas Biksey/Jodi Golden

REPRESENTS: VA Game Commission - Department of Inland Fisheries Planning Division

REPRESENTS: Baker Environmental

PHONE NUMBER: (804) 367-8351

PHONE NUMBER: (412) 269-6000

SUBJECT:

She will provide us with existing fish population data in the York River Basin for a fee.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 04-14-94

TO: Mo Lynch

FROM: Thomas Biksey/Jodi Golden

REPRESENTS: Virginia Institute of Marine Science - NERRS Program

REPRESENTS: Baker Environmental

PHONE NUMBER: (804) 642-7144

PHONE NUMBER: (412) 269-6000

SUBJECT:

He recommended using one of the NERRS research creeks as a background location. If we use NERRS creeks, a permit is required.

NERRS research areas include: Goodwin Islands, Catlett Islands, Taskinas Creek, and Sweethall Marsh.

He suggested reviewing a Mike Bender report published by the American Petroleum Institute in 1987.

He recommended contacting Dr. Jeff Shields - Manager of the NERRS Program at VIMS

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 04-05-94

TO: Karen Bisland

FROM: Thomas Biksey/Jodi Golden

REPRESENTS: Chesapeake Bay Program Office - Living Resource Coordinator

REPRESENTS: Baker Environmental

PHONE NUMBER: interview

PHONE NUMBER: (412) 269-6000

SUBJECT:

She conducts zooplankton studies twice a month in the tributaries to the Chesapeake Bay.

She thinks we should limit the background reference station to data from tributaries to the York River because the other tributaries to the Chesapeake Bay are more dominated by the ocean; therefore, have different ecosystems than the York River.

Virginia is beginning to develop a tributary strategy.

Recommended contacting Price Smith, Ann Lang, or John Jacobs from NOAA.

Recommended contacting Becky Wajda from the Inland Fisheries Department to obtain available fish data.

Recommended contacting Carl Hershner of VIMS for wetland ecology data.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 04-06-94

TO: Herbert Austin

FROM: Thomas Biksey

REPRESENTS: Virginia Institute of Marine Science - Fisheries

REPRESENTS: Baker Environmental

PHONE NUMBER: interview

PHONE NUMBER: (412) 269-6000

SUBJECT:

Recommended contacting Carl Hershner of VIMS for Kings Creek fish information.

Recommended reviewing Mike Bender report on oil contamination in the York River.

VIMS performs mainstem trawl surveys in the York River.

Recommended reviewing Jimmy Hoff's thesis.

Recommended the Poropotank River as a potentially good background creek in the York River. He stated that Poropotank River is heavily forested.

Mobojack Bay and Severn Bay were used as control creeks for studies conducted in the York River.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 04-06-94

TO: James Perry

FROM: Thomas Biksey

REPRESENTS: Virginia Institute of Marine Science - Flora

REPRESENTS: Baker Environmental

PHONE NUMBER: interview

PHONE NUMBER: (412) 269-6000

SUBJECT:

Recommended reviewing studies conducted by William Odum

He recommended the following creeks as good reference creeks based on ecological condition and access to the water: Poropotank River and Taskinas Creek.

He recommended avoiding the Mobojack Bay area.

He conducts the majority of his work in plant diversity.

He recommended contacting Bland Crowder of the NERRS program at VIMS.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 04-06-94

TO: Robert Hale

FROM: Thomas Biksey

REPRESENTS: Virginia Institute of Marine Science

REPRESENTS: Baker Environmental

PHONE NUMBER: interview

PHONE NUMBER: (412) 269-6000

SUBJECT:

Recommended reviewing a study by Pete Van Veld on sediment PAH levels from the York River to the Elizabeth River.

Recommended contacting Mike Unger at VIMS.

The York River has been proposed to NOAA to use as a model system - contact Bob Burn (Director of research).

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 04-06-94

TO: Michael Unger

FROM: Thomas Biksey

REPRESENTS: Virginia Institute of Marine Science - Organic Chemist

REPRESENTS: Baker Environmental

PHONE NUMBER: interview

PHONE NUMBER: (412) 269-6000

SUBJECT:

Recommended Timberneck Creek, Carter Creek, and Cedarbush Creek as a good reference creeks for the York River Basin due to the residential and agricultural surrounding landuses.

Recommended contacting Denis Briaton of the University of Maryland for information on explosives toxicity.

Clean sites in the York River are not well characterized, but on the whole the York River is fairly clean.

Recommended staying away from marine activities.

He stated that a mummichog study has been conducted in Timberneck creek the information is available for $100.00. The information consists of station identification, date, chemical, concentration, detection limit. The data is limited to a certain set of compounds. This data is not available in a DBase compatible format. The data is limited to a certain set of compounds.

A sediment study conducted in the Catltett Islands for PAHs has not been published.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 04-19-94

TO: Leo Clark

FROM: Jodi Golden

REPRESENTS: EPA Region III - Field Sampling

REPRESENTS: Baker Environmental

PHONE NUMBER: (410) 224-0941

PHONE NUMBER: (412) 269-6000

SUBJECT:

There are no on-going ambient water quality monitoring programs being conducted in the tributaries to the York River.

EPA has not conducted sampling in the York River since 1970.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE: 06-07-94

TO: Dave Dowling

FROM: Jodi Golden

REPRESENTS: Virginia Office of Fisheries - Williamsburg Office

REPRESENTS: Baker Environmental

PHONE NUMBER: (804) 253-4172

PHONE NUMBER: (412) 269-6000

SUBJECT:

Recommended using Woodstock Pond that runs through the York River State Park as a reference station.

Does not recommend using Hardwood Mill Reservoir because the ecology of this water body has been changed by chemicals added to the water, which is used as a drinking supply.

He does not know of any public ponds that would be good reference station, probably the best ponds are privately owned.

He does pond management for large ponds.

BAKER ENVIRONMENTAL, INC.
CONTACT REPORT

PROJECT: WPNSTA Yorktown

CTO NUMBER: 252

LOCATION: Yorktown, Virginia

DATE:

TO:

FROM: Thomas Biksey
/Jodi Golden

REPRESENTS:

REPRESENTS: Baker Environmental

PHONE NUMBER:

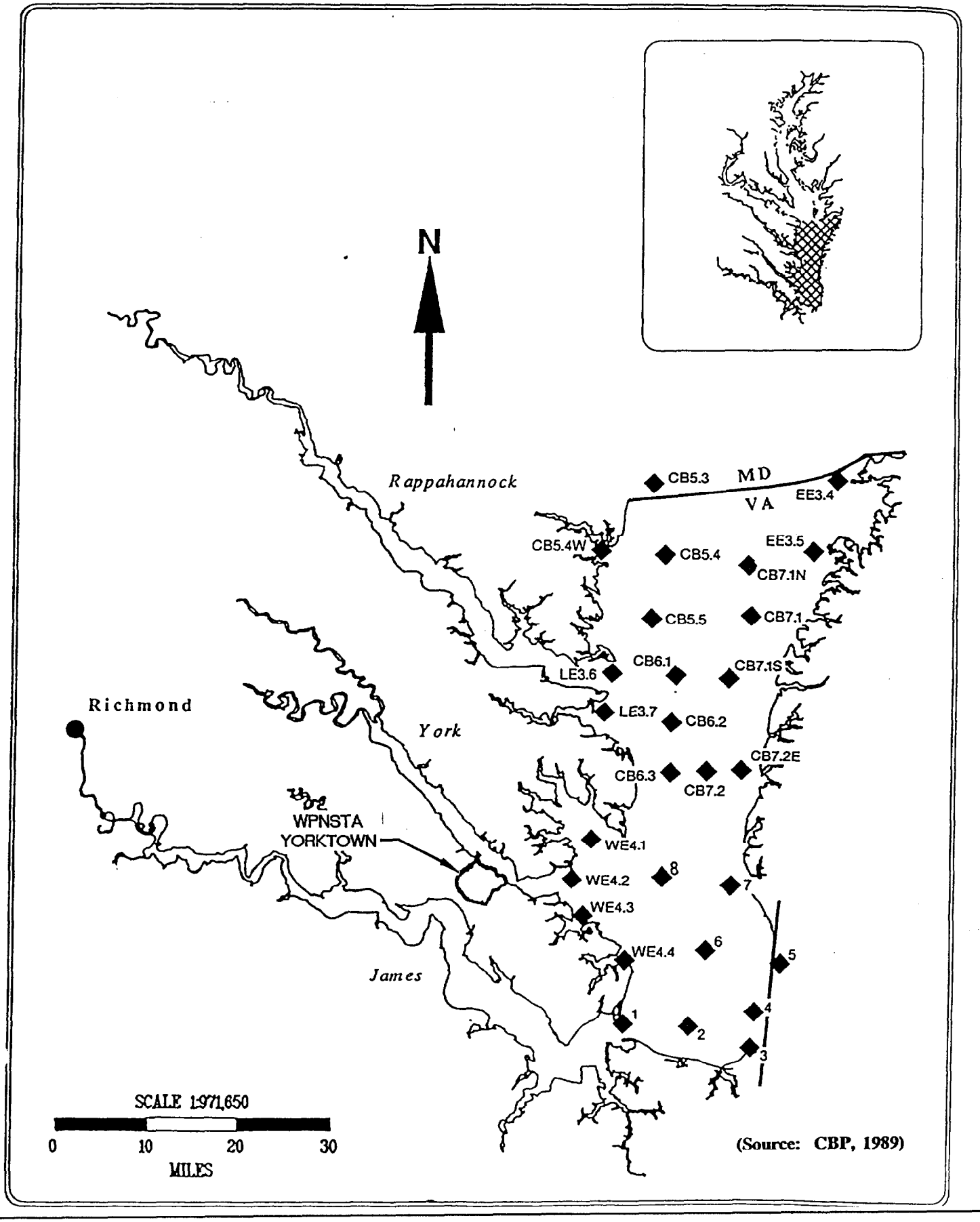
PHONE NUMBER: (412) 269-6000

SUBJECT:

APPENDIX B

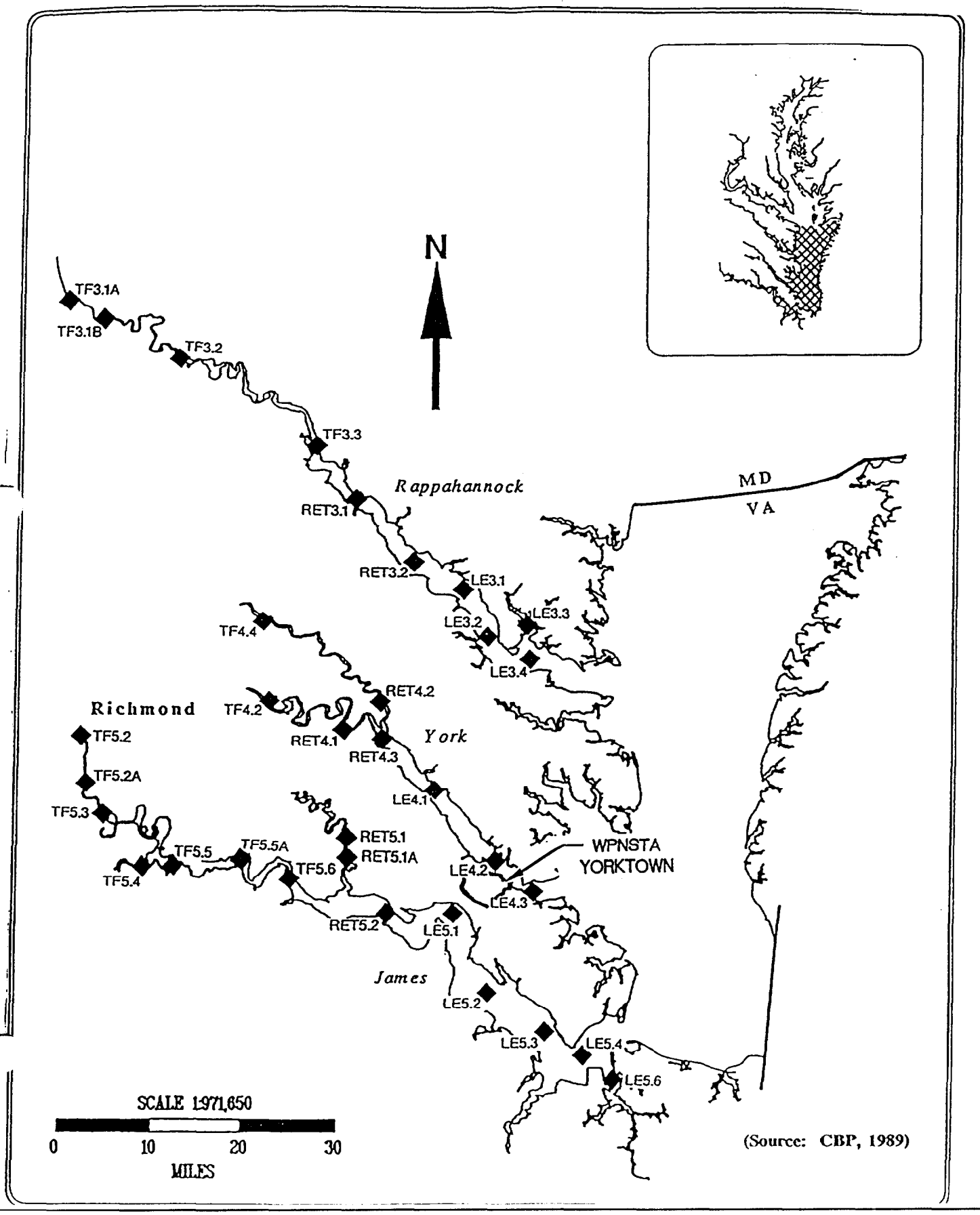
MONITORING STATION LOCATIONS

FIGURE B-1
CHESAPEAKE BAY WATER QUALITY MONITORING STATIONS -
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



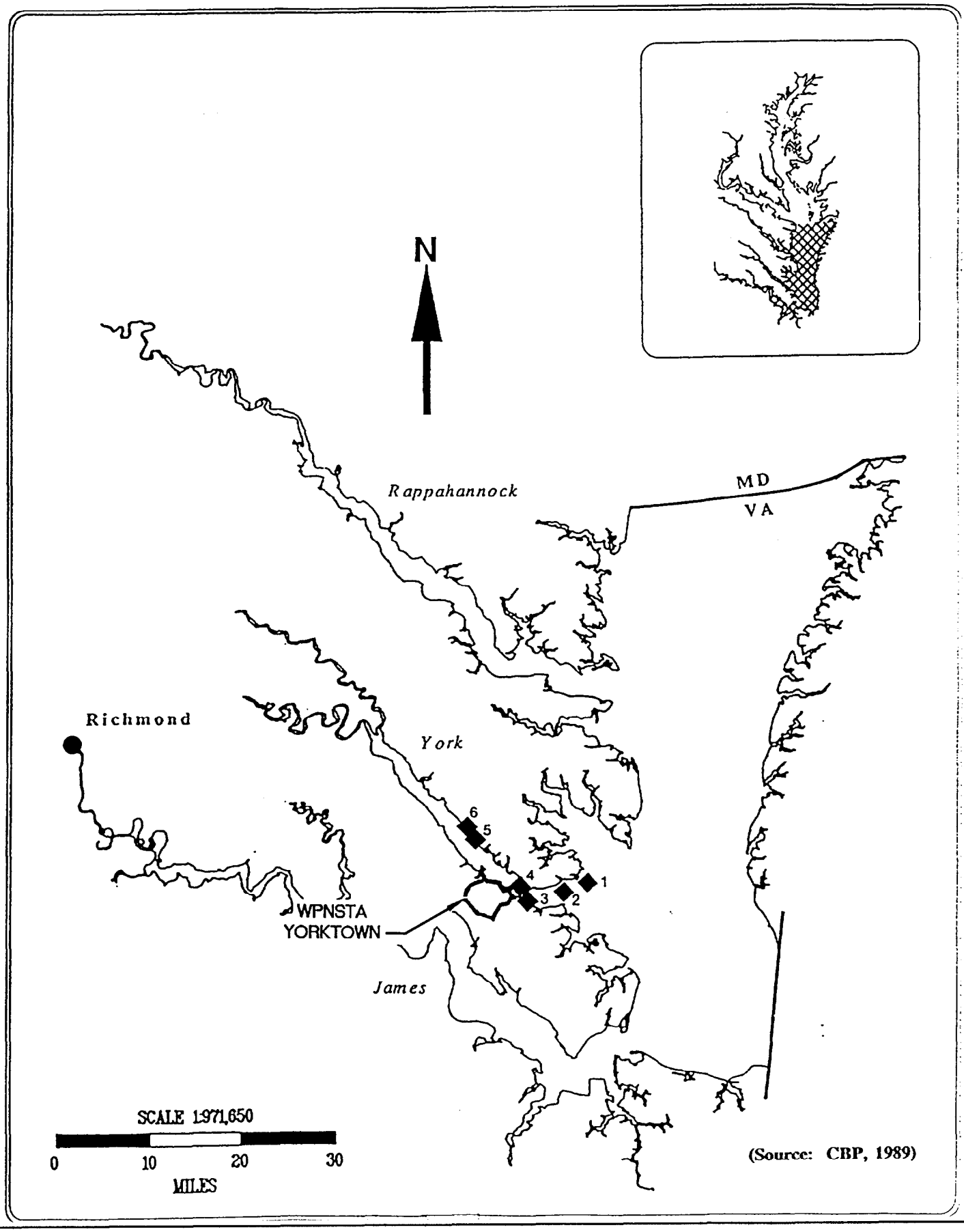
(Source: CBP, 1989)

FIGURE B-2
CHESAPEAKE BAY TIDAL TRIBUTARY
WATER QUALITY MONITORING STATIONS -
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



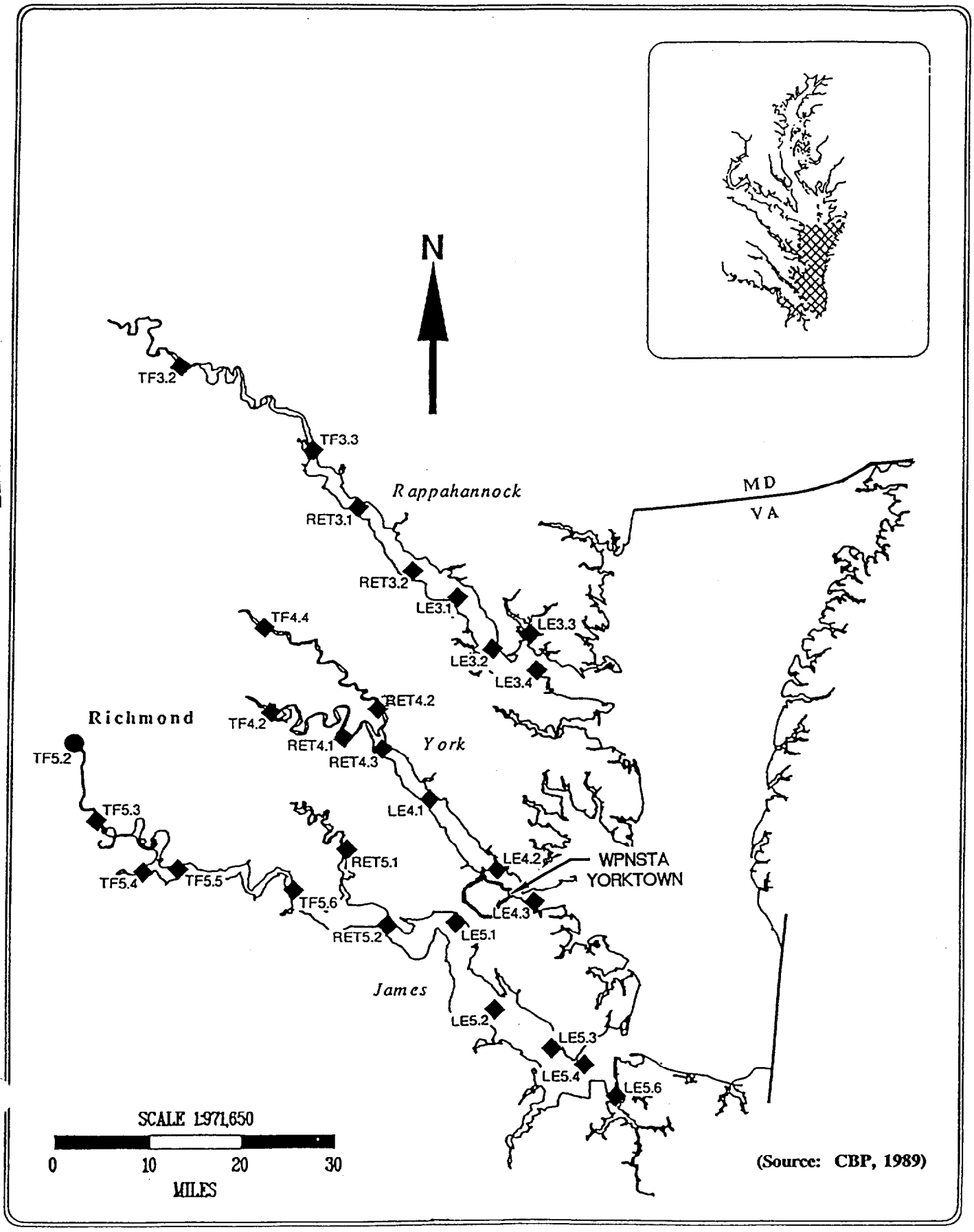
(Source: CBP, 1989)

FIGURE B-3
NEARSHORE SUBMERGED AQUATIC VEGETATION
HABITAT MONITORING STATIONS
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



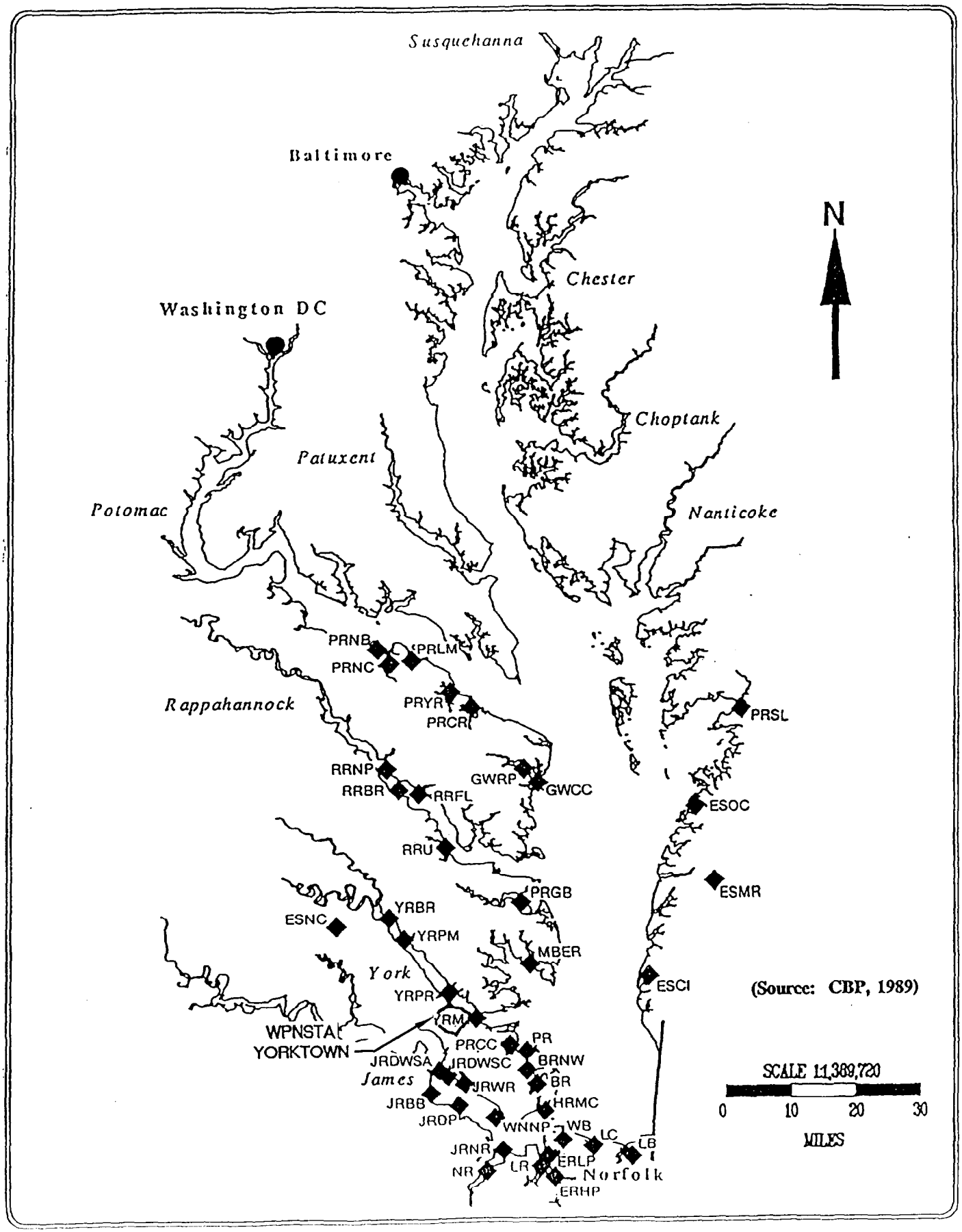
(Source: CBP, 1989)

FIGURE B-4
VIRGINIA CHESAPEAKE BAY TRIBUTARY SEDIMENT MONITORING STATIONS
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



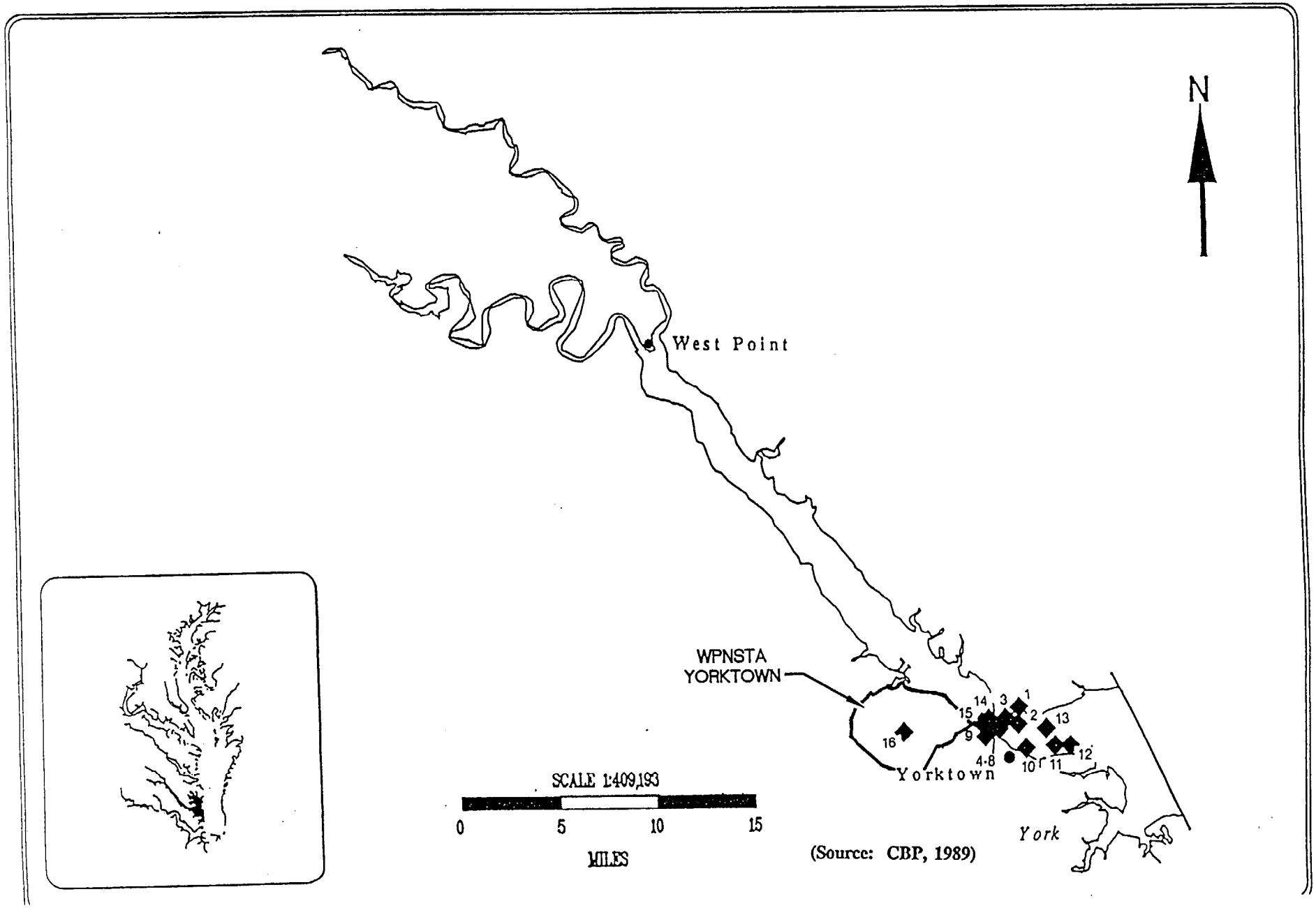
(Source: CBP, 1989)

FIGURE B-5
VIRGINIA SHELLFISH SURVEILLANCE STATIONS
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



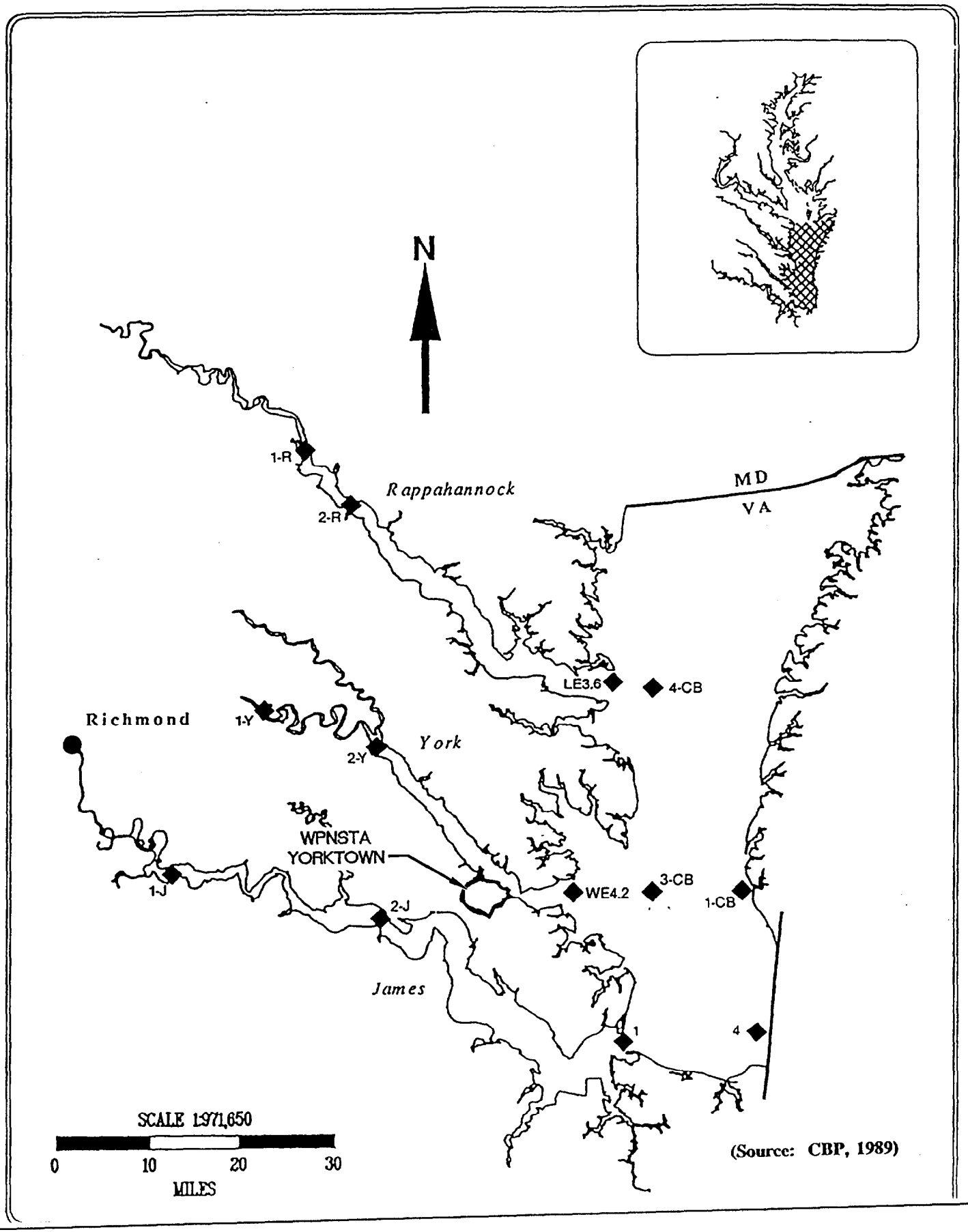
FIGURE

LOWER YORK RIVER BACTERIOLOGICAL MONITORING STATIONS
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



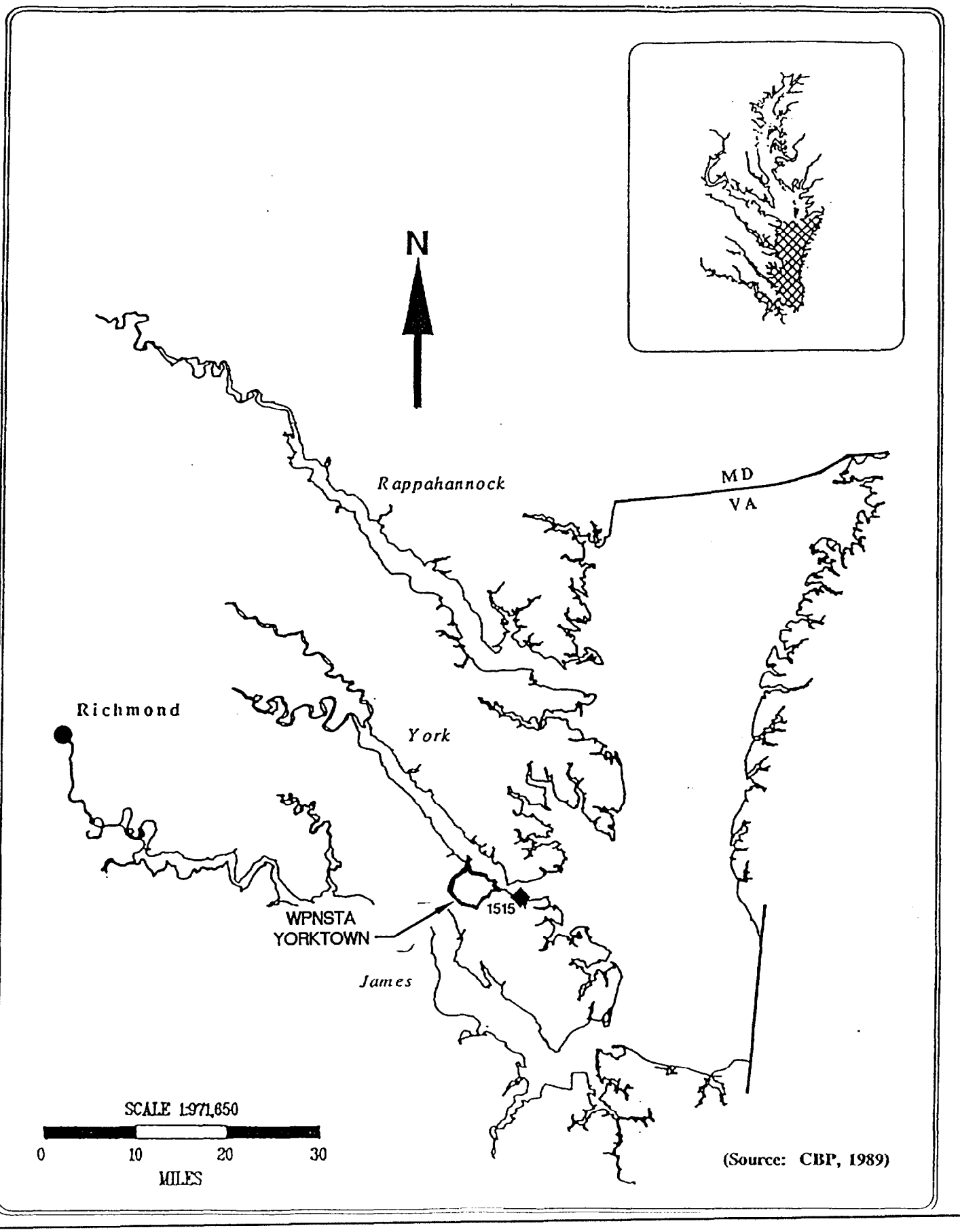
(Source: CBP, 1989)

FIGURE B-7
VIRGINIA PHYTOPLANKTON MONITORING STATIONS (VDEQ AND ODU)
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



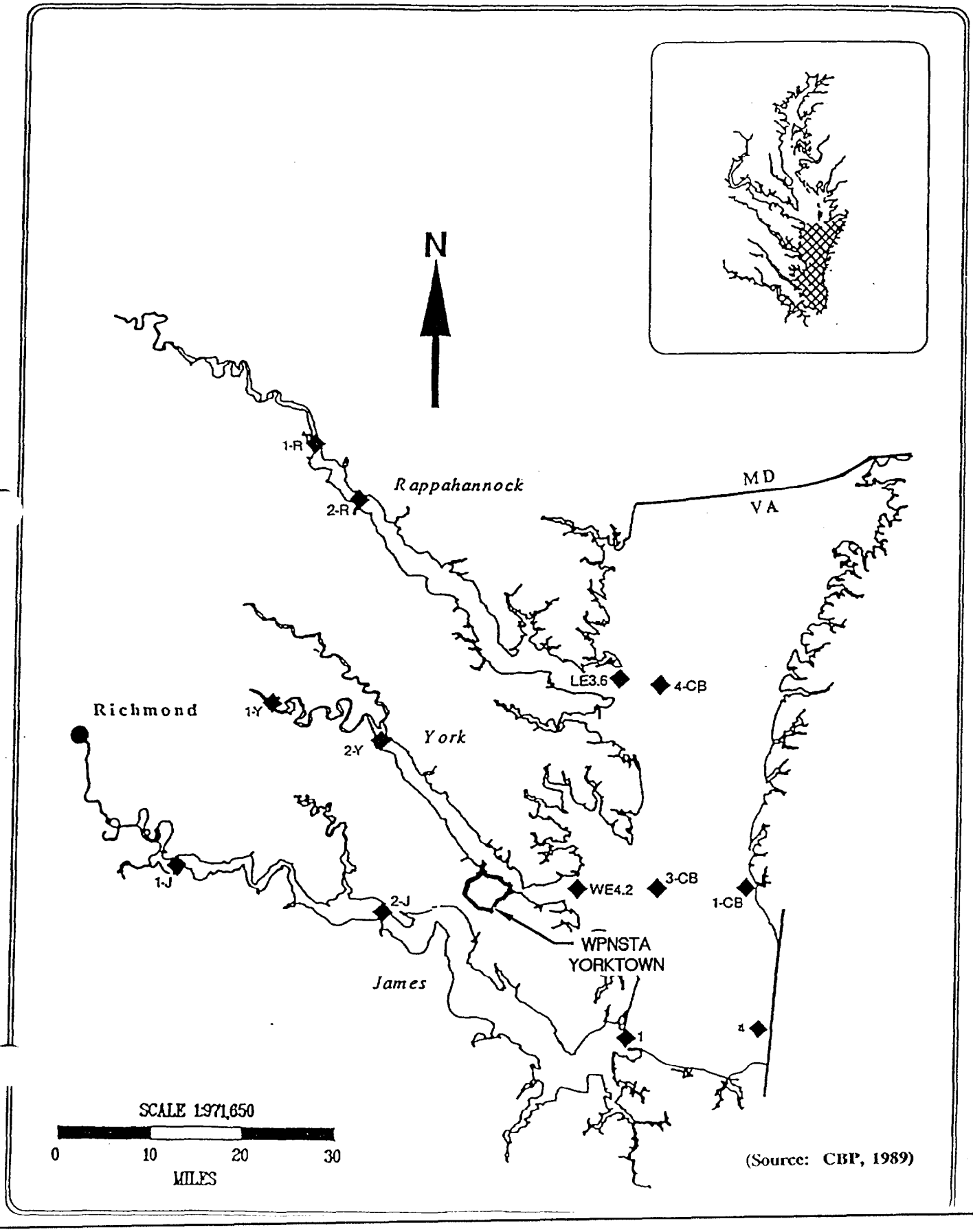
(Source: CBP, 1989)

FIGURE B-8
VIRGINIA PHYTOPLANKTON MONITORING STATIONS (VIMS)
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



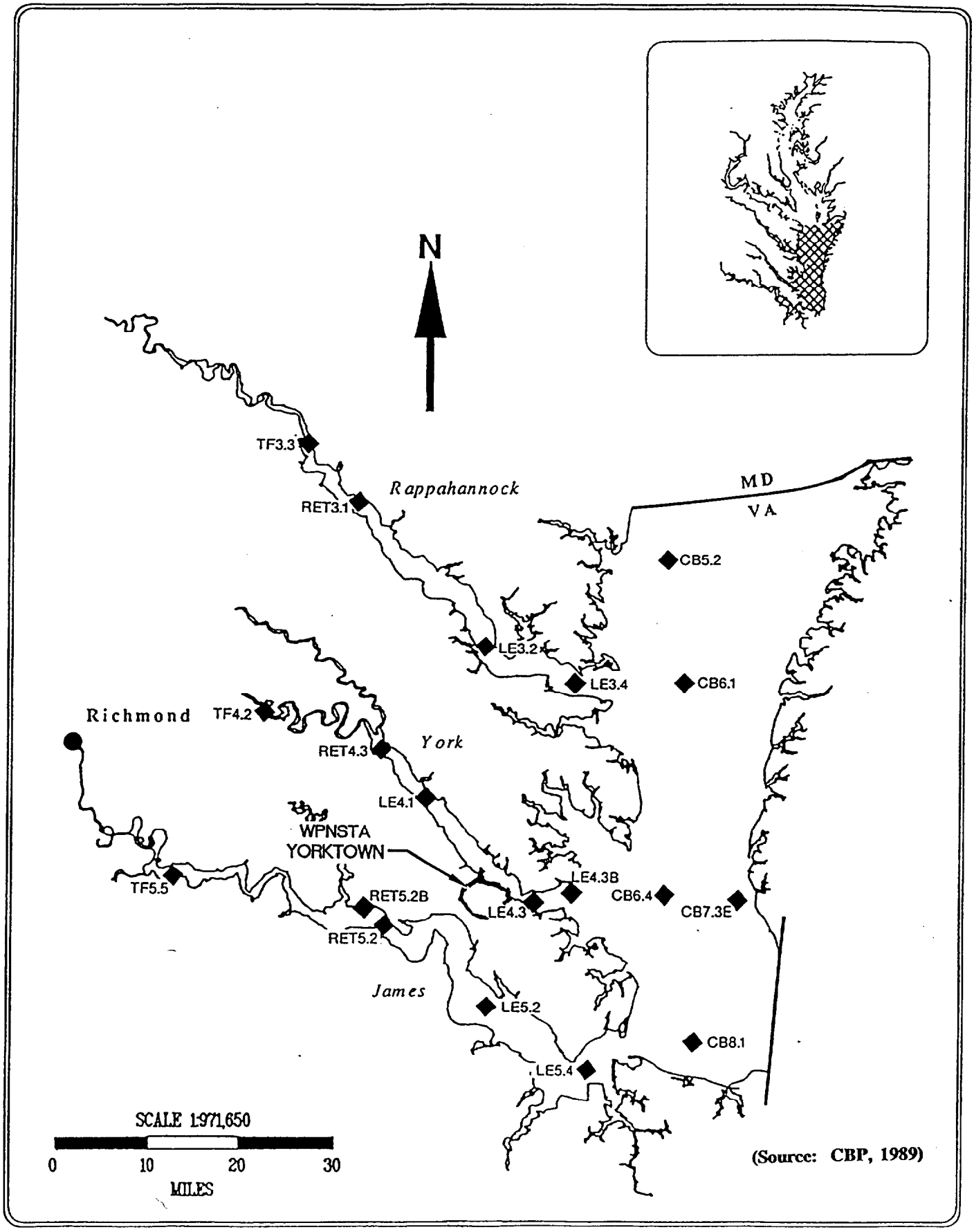
(Source: CBP, 1989)

FIGURE B-9
VIRGINIA ZOOPLANKTON MONITORING STATIONS
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



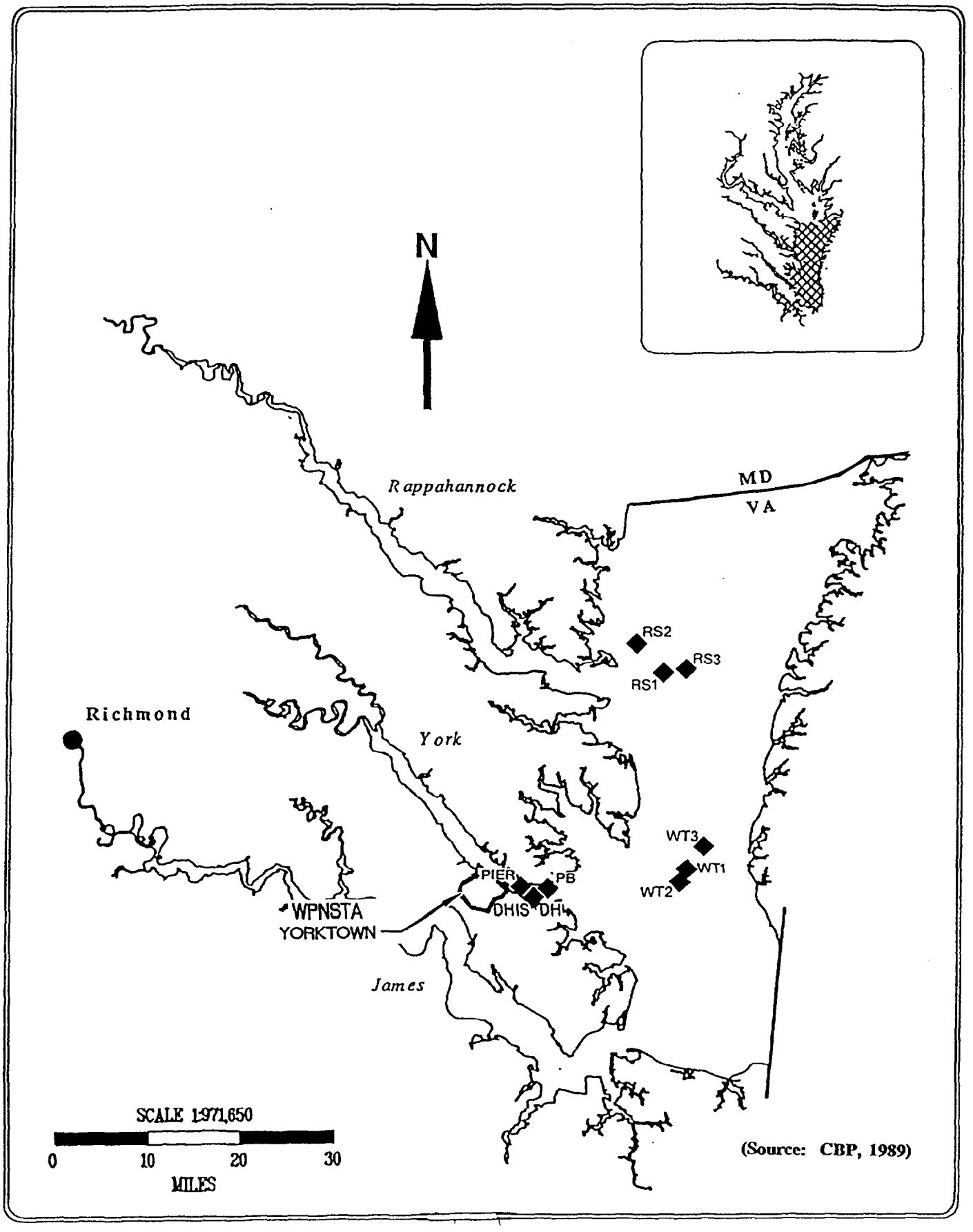
(Source: CBP, 1989)

FIGURE B-10
VIRGINIA BENTHIC MONITORING STATIONS (VDEQ AND ODU)
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



(Source: CBP, 1989)

FIGURE B-11
ZOOPLANKTON MONITORING STATIONS
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



(Source: CBP, 1989)

FIGURE B-12
VIRGINIA OYSTER SPAT SURVEY STATIONS
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

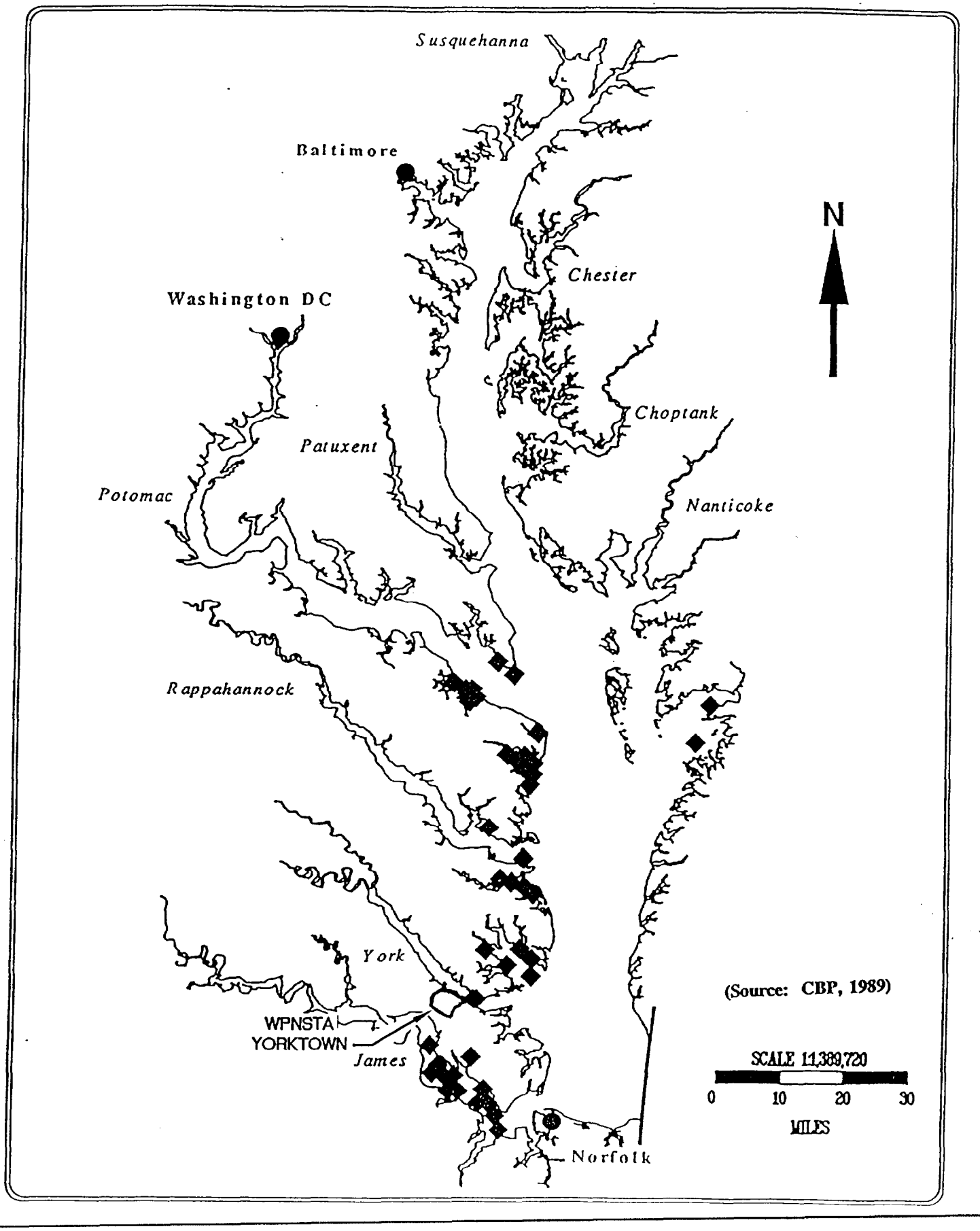
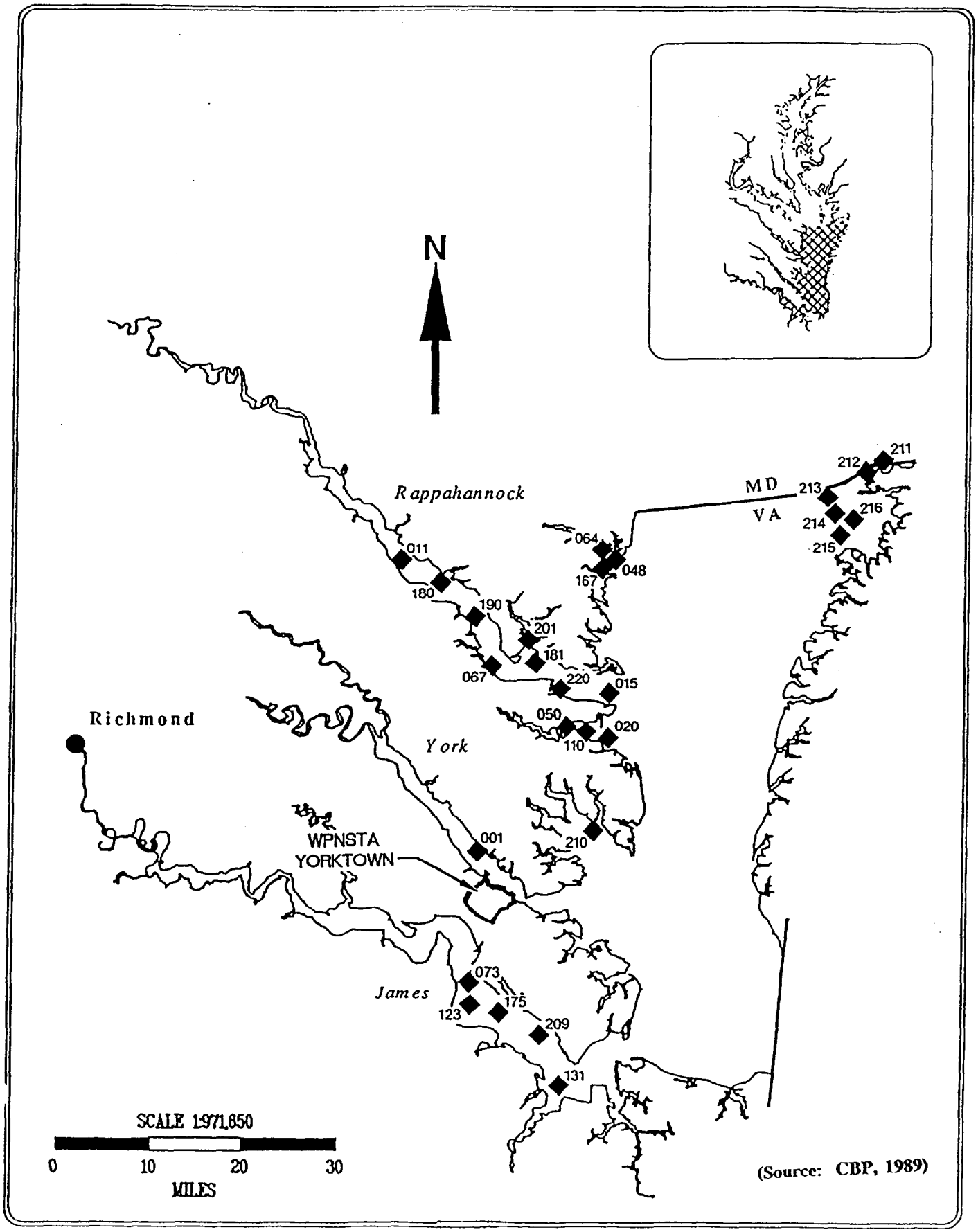


FIGURE B-13
VIRGINIA SPRING/FALL OYSTER BAR SURVEY STATIONS
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



(Source: CBP, 1989)

FIGURE B-14
VIRGINIA OYSTER DISEASE SURVEY STATIONS
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

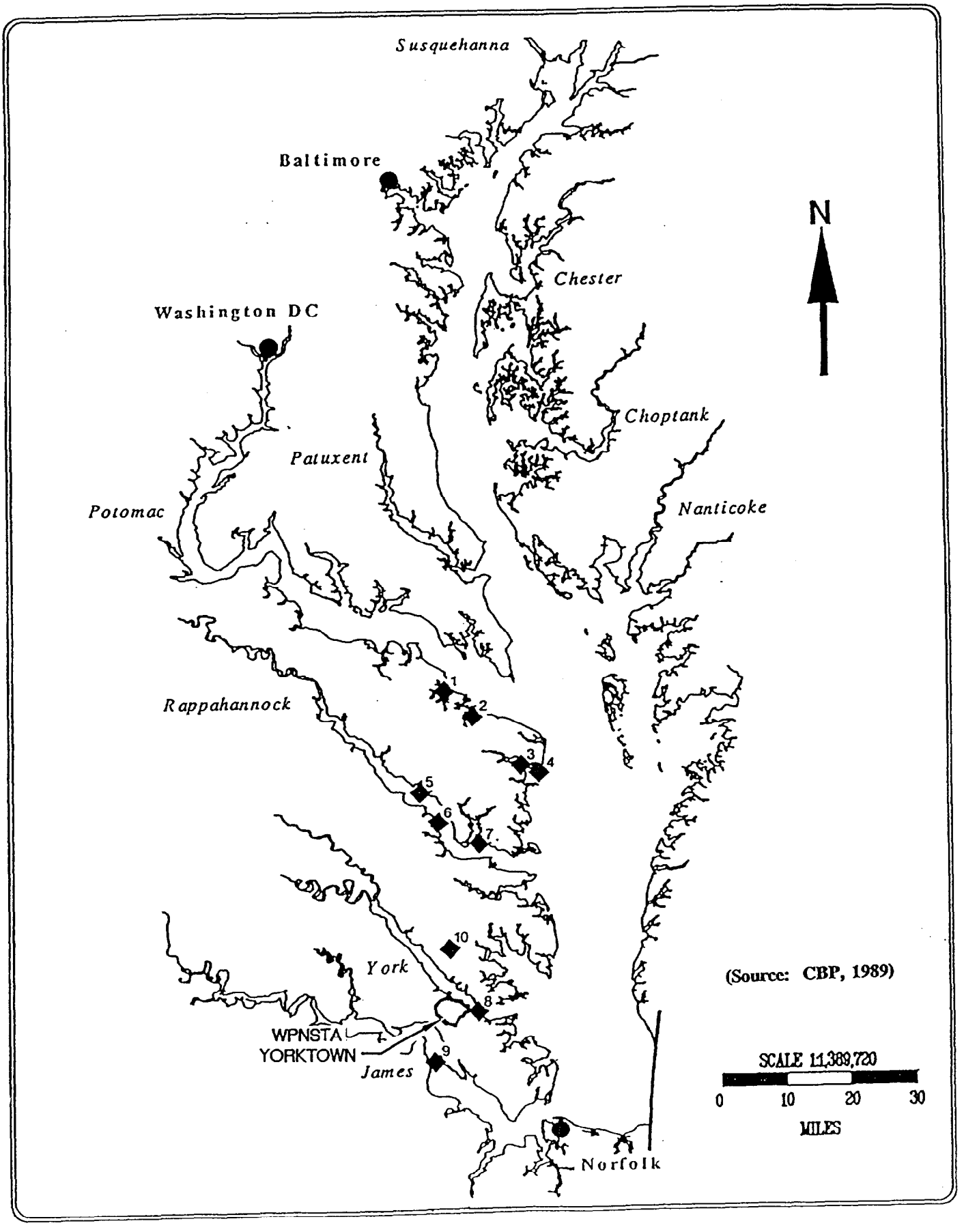
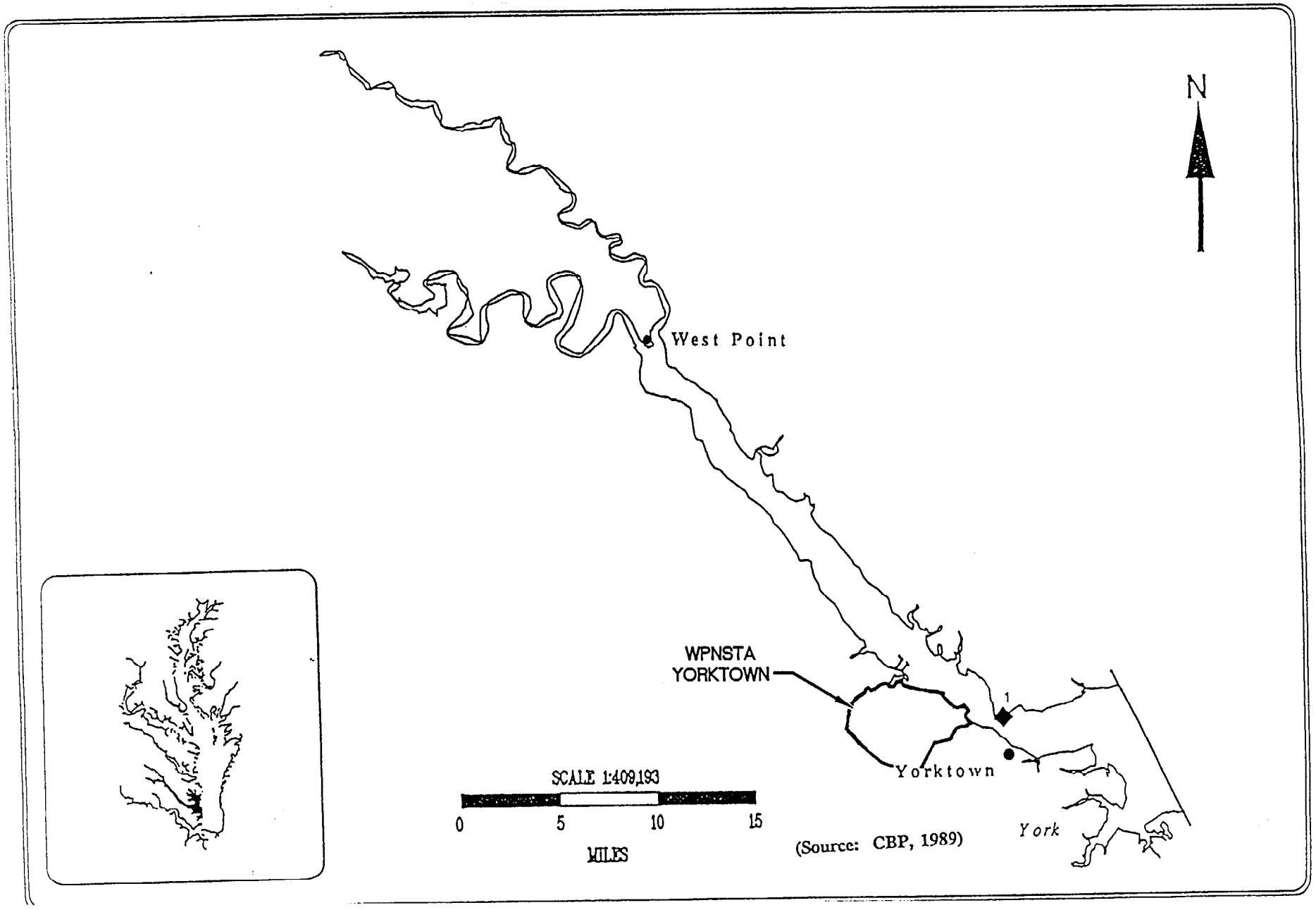
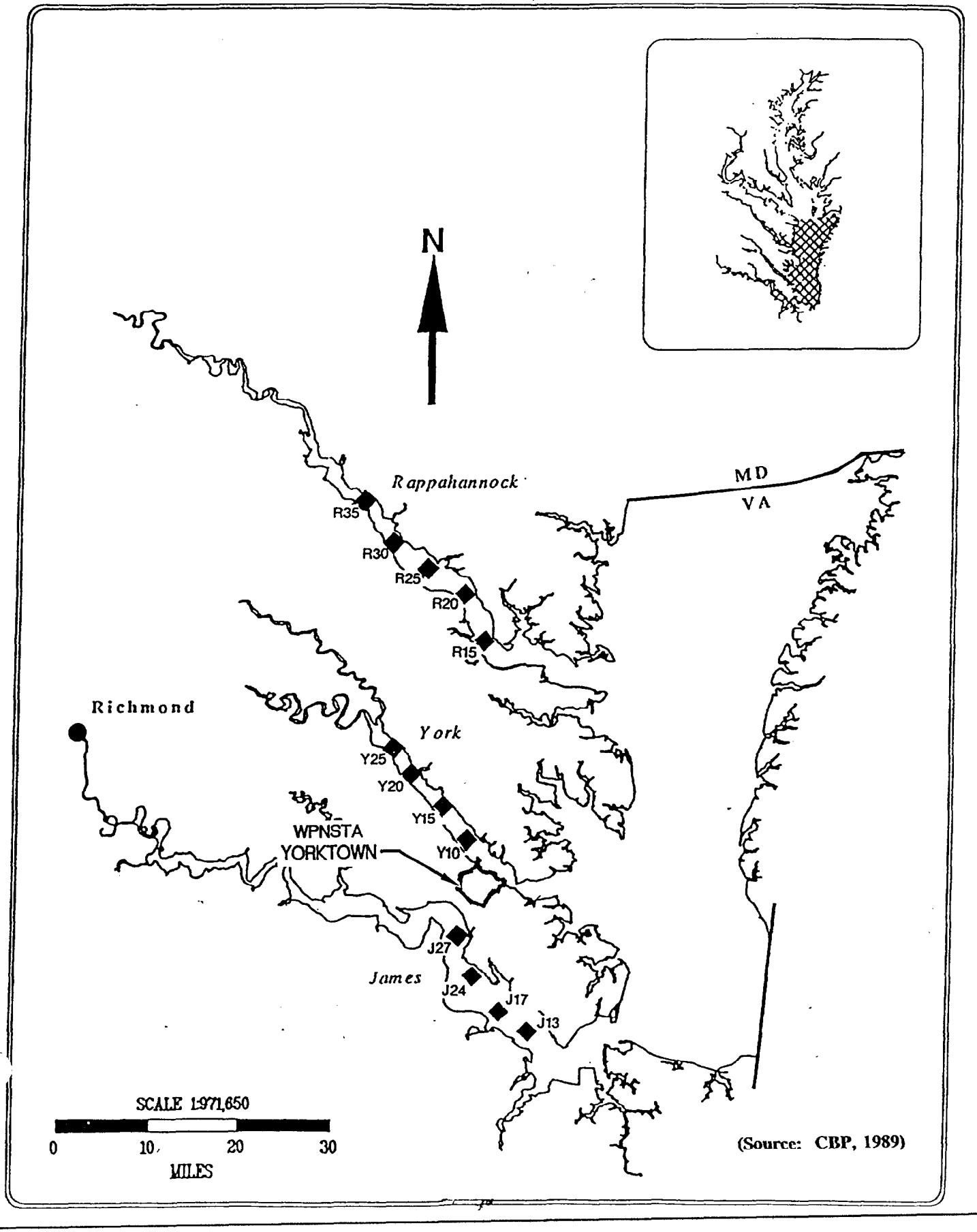


FIGURE B-15
VIRGINIA BLUE CRAB MEGALOPAE MONITORING STATIONS
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



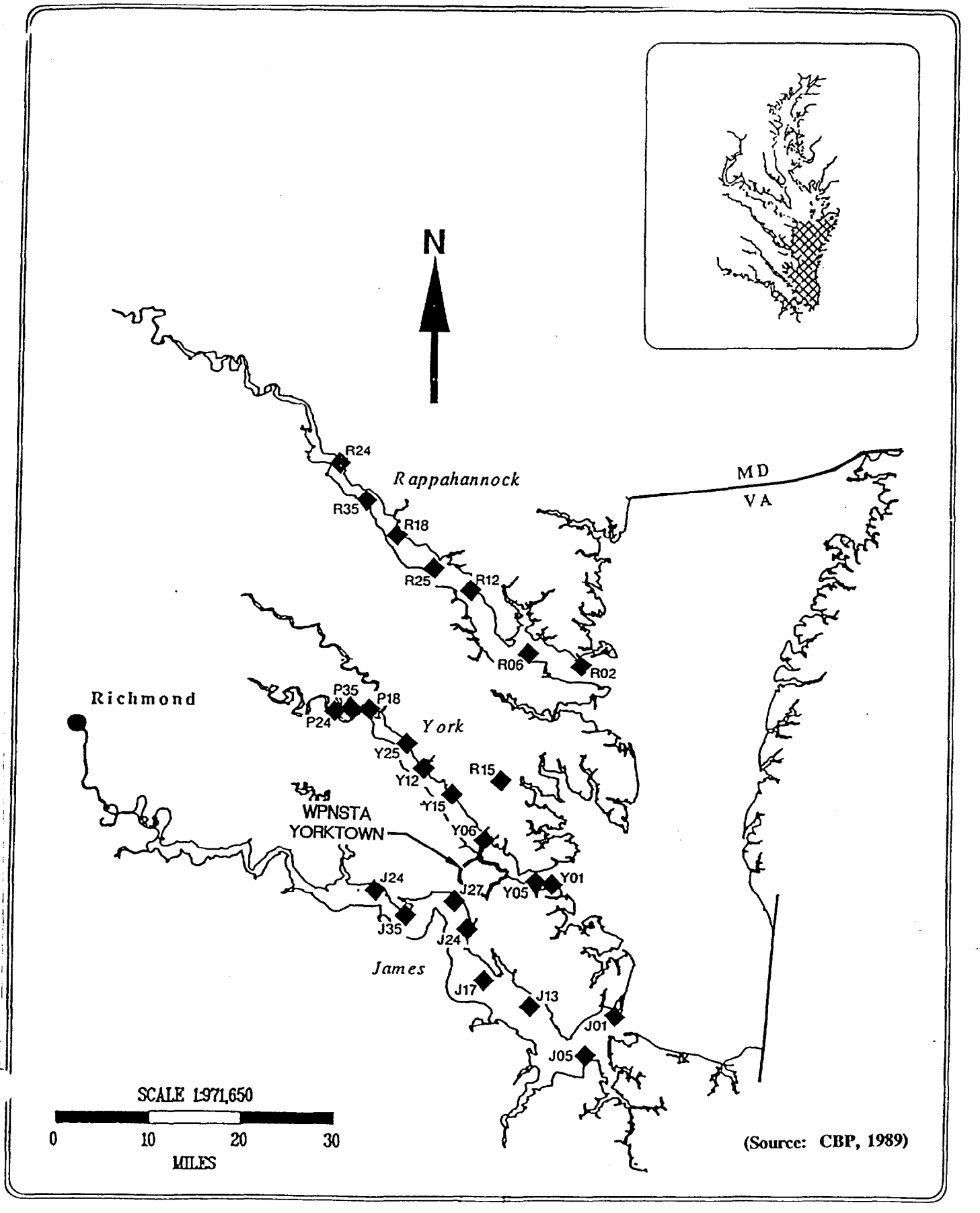
(Source: CBP, 1989)

FIGURE B-16
VIRGINIA JUVENILE BLUE CRAB MONITORING STATIONS
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



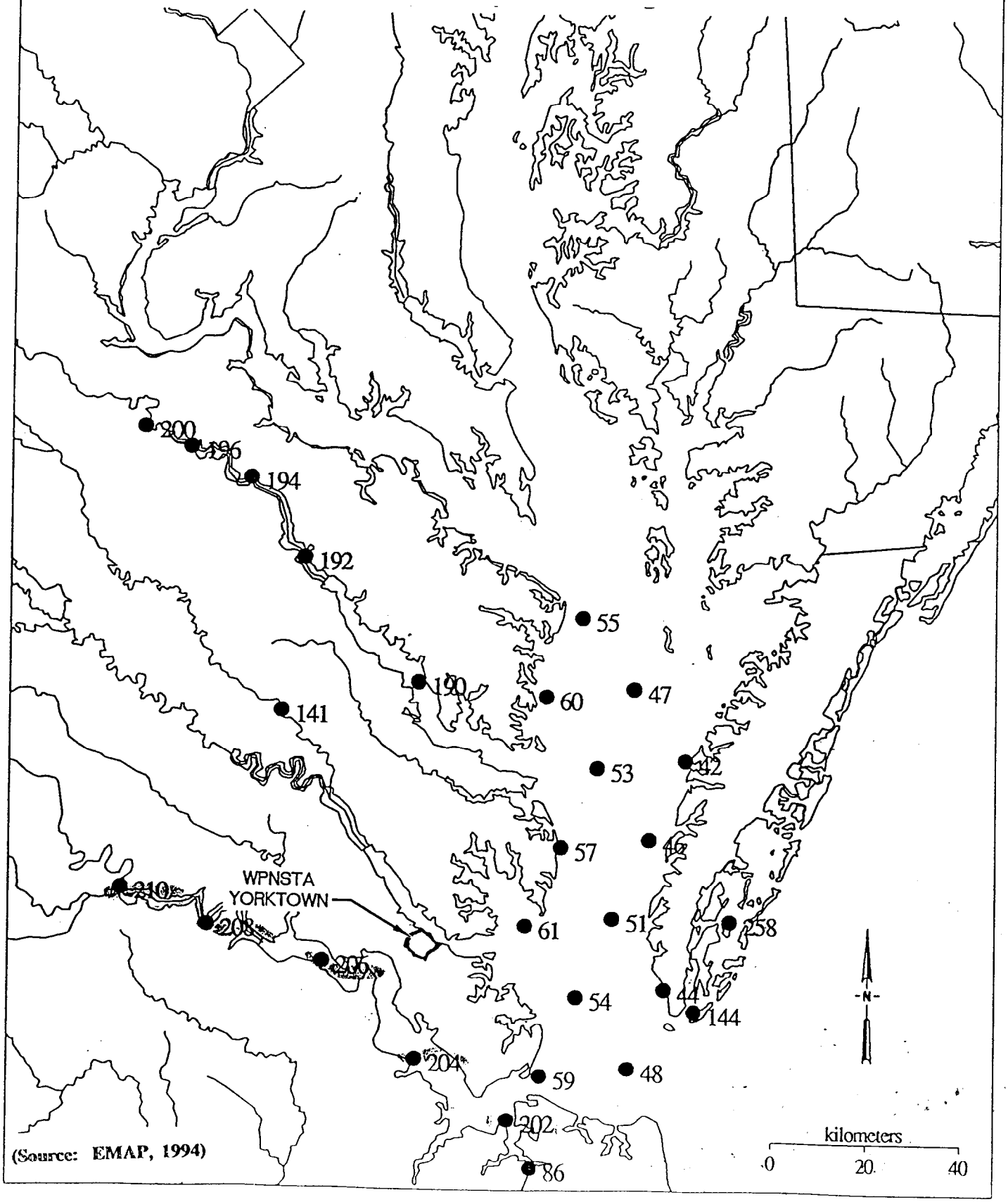
(Source: CBP, 1989)

FIGURE B-17
VIRGINIA JUVENILE BLUE CRAB MONITORING STATIONS
CHESAPEAKE BAY MONITORING PROGRAM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



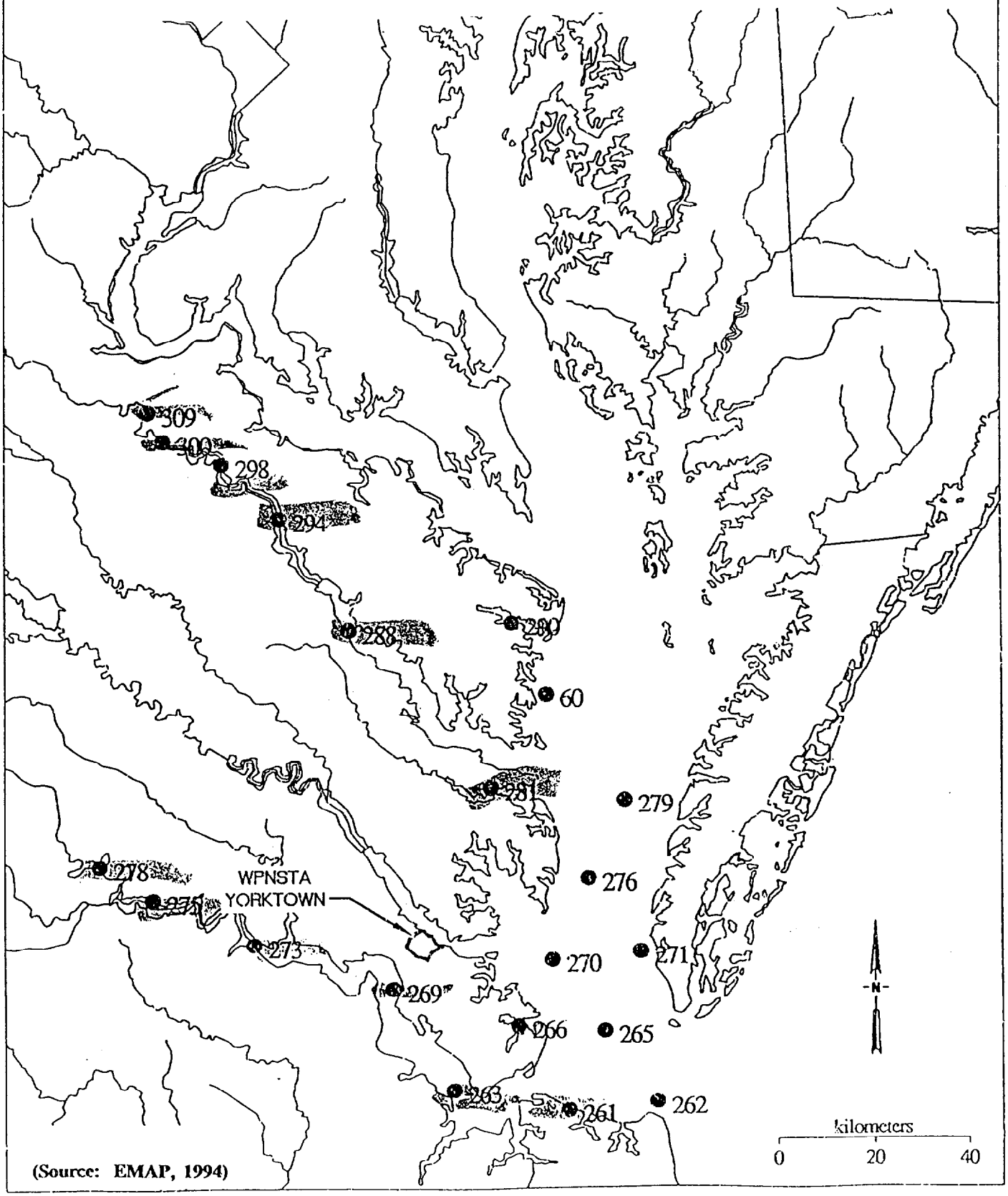
(Source: CBP, 1989)

FIGURE B-18
ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM
MONITORING STATION LOCATIONS - 1990
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



(Source: EMAP, 1994)

FIGURE B-19
ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM
MONITORING STATION LOCATIONS - 1991
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA



(Source: EMAP, 1994)

APPENDIX C

SURFACE WATER DATA

TABLE C-1
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER QUALITY: QUEENS CREEK
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

ITIAL DATA		11/5/92	12/07/92	02/10/93	03/03/93	04/14/93	05/12/93	06/17/93	07/13/93	08/25/93	09/22/93	10/13/93	11/09/93	12/08/93	02/17/94	03/22/94
ITIAL TIME		1330	1320	1415	1500	1055	1230	1330	1225	1345	1205	1300	1235	1330	1220	1220
EDIUM		WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
RAMETER	UNIT															
ater Temperature	degrees C	17.1	7	6.4	8.8	14.4	23.9	27.2	30	28.3	21.6	14.8	7.8	9.3	5.1	11.3
lor	color units	173	23	NA	27	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ld Conductivity	micromho	1900	3850	8500	1050	600	800	950	4000	12000	10500	15000	3900	7070	1400	450
ssolved Oxygen (probe)	mg/L	5.2	9.9	11.4	10.3	7.2	6.2	8.9	5.9	7.2	7.1	5.9	7.7	8.5	11.7	8.2
D (5 day)	mg/L	4	1	2	4	2	6	7	4	2	3	2	1	1	1	NA
D	mg/L	20	29	0	15	14	30	22	11	NA	0	0	0	0	14	19
	SU	7.8	7	7.98	8.11	7.46	7.65	7.71	7.9	7.78	7.91	7.73	7.48	7.37	7.78	7.74
(lab)	SU	8	8.2	8.3	8.3	8.3	8.6	8.3	7.8	8.2	8	7.8	8.1	8.2	8.3	NA
tal Alkalinity (CaCO3)	mg/L	150	192	133	152	143	168	176	227	250	224	195	206	214	183	NA
tal Nitrogen (NH3-NH4)	mg/L	0.4 U	0.17	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.04 U	0.04 U	0.04	NA	0.06	0.04 U	0.07	NA
ionized Ammonia-Nitrogen	mg/L	0.0008	0.0002	0.0005	0.0009	0.0003	0.0009	0.001	0.002	0.002	0.001	NA	0.0003	0.0002	0.0005	NA
tal Nitrite-Nitrogen	mg/L	0.02	0.01	0.01 U	0.01 U	0.01 U	0.01 U	0.01	0.01	0.01 U	0.01 U	NA	0.01 U	0.01	0.01	NA
ionized Ammonia*	mg/L	0.001	0.0003	0.0006	0.001	0.0004	0.001	0.002	0.003	0.002	0.002	NA	0.0003	0.0002	0.0006	NA
tal Nitrate-Nitrogen	mg/L	0.04 U	0.05	0.04 U	0.06	0.04	0.04 U	0.04 U	0.04 U	0.07	0.09	NA	0.04 U	0.04 U	0.14	NA
tal Kjedel Nitrogen	mg/L	0.6	0.5	0.6	0.5	0.4	0.7	1.8	1.9	1.4	1.6	NA	0.7	0.5	0.5	NA
tal Phosphorus	mg/L	0.2	0.1 U	0.1	0.1 U	0.1	0.2	0.2	0.3	0.2	0.2	NA	0.1 U	0.1 U	0.1 U	NA
tal Organic Carbon	mg/L	11.3	5.6	9.1	6.3	4.4	5.7	7.8	4.3	NA	5.3	6.2	4.4	5.2	3.2	4.9
tal Hardness (CaCO3)	mg/L	290	755	1480	NA	170	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
tal Chloride	mg/L	648	1940	4310	390	142	129	149	980	3444	3478	0	1837	1813	613	NA
tal Sulfate	mg/L	82	265	585	60	22	14	17	90	403	402	0	187	223	71	NA
tal Fluoride	mg/L	0.5 U	0.5 U	NA	0.1 U	0.51	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ssolved Silica	mg/L	6.1	7.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
tal Arsenic	ug/L	NA	NA	NA	NA	NA	10 U	NA	NA	NA	NA	NA	NA	NA	NA	NA
tal Cadmium	ug/L	NA	NA	NA	NA	NA	10 U	NA	NA	NA	NA	NA	NA	NA	NA	NA
tal Chromium	ug/L	NA	NA	NA	NA	NA	10 U	NA	NA	NA	NA	NA	NA	NA	NA	NA
tal Copper	ug/L	NA	NA	NA	NA	NA	10 U	NA	NA	NA	NA	NA	NA	NA	NA	NA
tal Iron	ug/L	NA	NA	NA	NA	NA	455	NA	NA	NA	NA	NA	NA	NA	NA	NA
tal Lead	ug/L	NA	NA	NA	NA	NA	10 U	NA	NA	NA	NA	NA	NA	NA	NA	NA
tal Manganese	ug/L	NA	NA	NA	NA	NA	216.3	NA	NA	NA	NA	NA	NA	NA	NA	NA
tal Mercury	ug/L	NA	NA	NA	NA	NA	0.3 U	NA	NA	NA	NA	NA	NA	NA	NA	NA
tal Nickel	ug/L	NA	NA	NA	NA	NA	10 U	NA	NA	NA	NA	NA	NA	NA	NA	NA
tal Zinc	ug/L	NA	NA	NA	NA	NA	10 U	NA	NA	NA	NA	NA	NA	NA	NA	NA
tal Selenium	ug/L	NA	NA	NA	NA	NA	20 U	NA	NA	NA	NA	NA	NA	NA	NA	NA
ream Flow Severity		3	3	3	3	3	3	3	3	2	3	3	3	3	3	3
cal Coliform	/100 ml	1600 L	1600 L	7	120	110	330	1600 L	1600	240	920	1600 L	1600 L	540	33	170
rbidity	NTU	16.5	25	7.5	6.9	7.5	7.3	18	20	10.6	10.8	11.6	11.5	9.9	4.6	NA

- Value automatically calculated by the STORET system
A - Parameter not analyzed
- Actual value is known to be greater than value given
- Sampled, but analysis lost or not performed
- Indicates material was analyzed, but not detected
ream flow severity: 2 - low; 3 - normal

BOD - Biochemical Oxygen Demand
COD - Chemical Oxygen Demand
SU - Standard Unit
NTU - Nephelometric Turbidity Units
mg/L - milligram per liter
ug/L - microgram per liter

TABLE C-2
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER QUALITY: PHILBATES CREEK
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

SAMPLE DATE		08/14/90	09/25/90	11/28/90	02/05/91	05/08/91	08/05/91	02/18/92	05/11/92	08/17/92	11/03/92	02/01/93	05/04/93	08/26/93	11/02/93	02/10/94
SAMPLE TIME		1538	1105	1430	1420	1352	1600	1445	1305	1401	1442	1343	1221	1045	1322	1414
MEDIUM		WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
PARAMETER	UNIT															
Water Temperature	degrees C	NA	19.7	13.2	9.4	24.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Color	color units	NA	NA	NA	70	41	NA	24	31	75	75	57	NA	NA	NA	NA
Field Conductivity	Micromho	NA	NA	103	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dissolved Oxygen (probe)	mg/L	7.5	NA	10	12	6.8	9.4	12.6	8.7	3.8	NA	NA	NA	NA	NA	NA
BOD (5 day)	mg/L	NA	2	2	1	2	3	2	2	1	4	3	3	NA	2	0 Q
COD	mg/L	NA	25	12	15	17	27	15	27	29	25	122	17	NA	NA	15
pH	SU	NA	7.8	6.92	6.92	6.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
pH (lab)	SU	NA	7.1	6.8	6.7	7	6.9	7.3	6.8	7.2	7	7.4	7.7	NA	6.6	7.1
Total Alkalinity (CaCO3)	mg/L	NA	36	31	21	34	23	28	34	30	33	26	27	NA	32	26
Total Nitrogen (NH3-NH4)	mg/L	NA	0.04 K	0.06	0.04 U	0.05	0.04 U	0.04 U	0.04 U	0.08	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U
Unionized Ammonia-Nitrogen*	mg/L	NA	0.001	0.0001	0.00006	0.0001	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Nitrite-Nitrogen	mg/L	NA	0.01	0.01	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.02	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Unionized Ammonia*	mg/L	NA	0.001	0.0001	7E-05	0.0002	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Nitrate-Nitrogen	mg/L	NA	0.04 K	0.13	0.23	0.48	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.32
Total Kjedel Nitrogen	mg/L	NA	0.7	0.4	0.4	0.6	0.8	0.5	0.7	1.1	0.7	0.6	0.7	1	0.8	0.3
Total Phosphorus	mg/L	NA	0.1	0.1 U	0.1	0.1	0.1 U	0.1	0.1 U	0.07	0.06	0.05	0.04	0.08	0.06	0.04
Dissolved Phosphorus (ortho)	mg/L	NA	0.01	NA	0.02	0.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	NA	5.6	4.3	3.7	5.7	6.1	2.7	6.2	11.1	6.7	7.7	6.3	NA	NA	4
Total Hardness (CaCO3)	mg/L	NA	54	40	39	52	64	40	40	42	48	38	38	NA	NA	34
Total Chloride	mg/L	NA	8	9	6	6	9	9	NA	NA	7	7	8	NA	10	8
Total Sulfate	mg/L	NA	3	4	5	13	3	5	NA	NA	3	5	4	NA	3	5
Total Fluoride	mg/L	NA	0.05 U	0.1 U	0.1 U	0.11	NA	NA	NA	0.1 U	0.5 U	0.5 U	NA	NA	NA	NA
Dissolved Silica	mg/L	NA	12	9.9	6.8	7.9	NA	5.9	4.8	8.6	9	5.4	NA	NA	NA	NA
Total Arsenic	ug/L	10 K	NA	10 U	10 U	10 U	10 U	10 U	NA	10 U	NA	10 U	10 U	NA	NA	NA
Total Beryllium	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	10 U	NA	10 U	NA	NA	NA	NA
Total Cadmium	ug/L	10 K	NA	10 U	10 U	10 U	10 U	10 U	NA	10 U	NA	10 U	10 U	NA	NA	NA
Total Chromium	ug/L	10 K	NA	10 U	10 U	10 U	10 U	10 U	NA	10 U	NA	10 U	10 U	NA	NA	NA
Total Copper	ug/L	10 K	NA	10 U	10 U	10 U	10 U	10 U	NA	10 U	NA	10 U	10 U	NA	NA	NA
Total Iron	ug/L	700	NA	490	490	60 U	505	306	NA	1033	NA	531	418	NA	NA	NA
Total Lead	ug/L	10 K	NA	10 U	10 U	10 U	10 U	10 U	NA	10 U	NA	10 U	10 U	NA	NA	NA
Total Magnesium	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	1290	NA	1360	NA	NA	NA	NA
Total Manganese	ug/L	110	NA	35	117	88	101.4	12.8	NA	186.5	NA	18.5	58	NA	NA	NA
Total Mercury	ug/L	0.3 K	NA	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	NA	0.3 U	NA	0.3 U	0.3 U	NA	NA	NA
Total Nickel	ug/L	10 K	NA	10 U	10 U	10 U	10 U	10 U	NA	10 U	NA	10 U	10 U	NA	NA	NA
Totla Thallium	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	20 U	NA	20 U	NA	NA	NA	NA
Total Zinc	ug/L	10 K	NA	10 U	10 U	10 U	10 U	10 U	NA	16	NA	10 U	10 U	NA	NA	NA
Total Selenium	ug/L	10 K	NA	20 U	20 U	10 U	20 U	20 U	NA	20 U	NA	20 U	20 U	NA	NA	NA
Fecal Coliform	/100 ml	NA	100	NA	100 K	100 K	NA	100 U	100 U	400	100 U	100 U	100 U	100 U	200	NA
Turbidity	NTU	NA	NA	NA	NA	NA	6.9	1.8	4.6	7.1	6.2	7.9	2.6	NA	7.4	2.6

* - Value automatically calculated by the STORET system
NA - Parameter not analyzed for
K - Actual value is known to be less than value given
L - Actual value is known to be greater than value given
O - Sampled, but analysis lost or not performed
Q - Sample held beyond normal holding time
U - Indicates material was analyzed for but not detected

BOD - Biochemical Oxygen Demand
COD - Chemical Oxygen Demand
SU - Standard Unit
NTU - Nephelometric Turbidity Units
mg/L - milligram per liter
ug/L - microgram per liter

TABLE C-3
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER QUALITY - KING CREEK
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION, YORKTOWN, YORKTOWN, VIRGINIA

INITIAL DATA		07/14/92	08/10/92	09/10/92	10/05/92	11/05/92	12/07/92	01/13/93	02/10/93	03/03/93	04/14/93	05/12/93	06/17/93	07/13/93	08/25/93
INITIAL TIME		1040	1145	1235	1135	1110	950	1205	1210	1240	920	1005	1100	1040	1055
MEDIUM		WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
PARAMETER	UNIT														
Water Temperature	degrees C	29.3	27.1	27.9	16.8	16.8	4.3	8.3	6.7	8.3	13.5	23.9	27.2	31.1	26.8
Color	color units	51	178	78	40	56	9	NA	NA	25	NA	NA	NA	NA	NA
Field Conductivity	MICROMHO	29000	4700	10000	19000	13000	12000	7500	15000	4800	4600	2250	9000	20000	25000
Dissolved Oxygen (probe)	mg/L	5.7	4.5	5.6	6.2	5.4	10.2	9.2	10.7	10	6.2	6.6	6.5	5.5	5.4
BOD (5 day)	mg/L	1	3	6	2	1	1	1	1	2	1	3	6	4	2
COD	mg/L	0 O	17	0 O	0	0 O	0 O	0 O	0 O	0 O	0 O	0 O	0	0 O	NA
pH	SU	7.69	7.74	7.86	8.22	7.69	7.94	7.59	8.22	8.23	7.5	7.75	7.61	7.83	7.53
pH (lab)	SU	7.8	7.8	7.8	7.7	7.9	8	8.2	8	8.2	8.2	8.4	8.1	7.5	8
Total Alkalinity (CaCO3)	mg/L	114	111	164	116	141	138	116	101	171	163	176	159	143	161
Total Nitrogen (NH3-NH4)	mg/L	0.04 U	0.05	0.04 U	0.04 U	0.12	0.09	0.09	0.04 U	0.04	0.08	0.04 U	0.04 U	0.04 U	0.04 U
Unionized Ammonia-Nitrogen*	mg/L	0.001	0.002	0.002	0.002	0.002	0.0009	0.0006	0.0009	0.001	0.0006	0.001	0.001	0.002	0.0009
Total Nitrite-Nitrogen	mg/L	0.01	0.03	0.01	0.01	0.02	0.01	0.01 U	0.01 U	0.01 U	0.01	0.01	0.01	0.01	0.01 U
Unionized Ammonia*	mg/L	0.002	0.002	0.002	0.002	0.002	0.001	0.0007	0.001	0.001	0.0007	0.001	0.001	0.003	0.001
Total Nitrate-Nitrogen	mg/L	0.04	0.06	0.04 U	0.04 U	0.05	0.04 U	0.06	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U
Total Kjedel Nitorgen	mg/L	1	1.2	1.2	0.7	0.7	0.3	0.5	0.5	0.6	0.6	0.7	1.3	1.8	1.6
Total Phosphorus	mg/L	0.3	0.4	0.4	0.1	0.2	0.1 U	0.1	0.1 U	0.1	0.2	0.2	0.3	0.4	0.3
Total Organic Carbon	mg/L	5.8	7.5	6.3	6.8	39.1	6.5	7.9	7.1	10.3	9.2	5.3	8	6.8	NA
Total Hardness (CaCO3)	mg/L	3300	510	1020	2800	1850	2350	NA	2700	NA	NA	NA	NA	NA	NA
Total Chloride	mg/L	10005	1376	3040	8200	5360	8760	1950	8620	2462	1785	714	2580	6170	9341
Total Sulfate	mg/L	1312	180	391	1100	720	1200	227	1180	324	240	95	337	810	1233
Total Fluoride	mg/L	NA	0.1 U	0.76	0.1 U	0.1 U	0.5 U	NA	NA	0.1 U	NA	NA	NA	NA	NA
Dissolved Silica	mg/L	8.1	7.5	10.6	4.3	6.2	5.8	NA	NA	NA	NA	NA	NA	NA	NA
Total Arsenic	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10 U	NA	NA	NA
Total Cadmium	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10 U	NA	NA	NA
Total Chromium	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10 U	NA	NA	NA
Total Copper	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10 U	NA	NA	NA
Total Iron	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	706	NA	NA	NA
Total Lead	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10 U	NA	NA	NA
Total Manganese	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	90.7	NA	NA	NA
Total Mercury	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.3 U	NA	NA	NA
Total Nickel	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10 U	NA	NA	NA
Total Thallium	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Zinc	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10 U	NA	NA	NA
Total Selenium	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	20 U	NA	NA	NA
Stream Flow Severity		3	3	3	5	3	3	3	3	3	3	3	3	3	2
Fecal Coliform	/100 ml	130	920	1600	1600 L	1600	920	1600 L	2 U	22	70	110	1600 U	540	110
Turbidity	NTU	17	56	15	22	13.1	13	14	9.8	10.7	16	10.3	18.5	19.5	20

* - VALUE AUTOMATICALLY CALCULATED BY THE STORET SYSTEM
NA - PARAMETER NOT ANALYZED FOR
L - ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
O - SAMPLED, BUT ANALYSIS LOST OR NOT PERFORMED
U - INDICATES MATERIAL WAS ANALYZED FOR BUT NOT DETECTED
STREAM FLOW SEVERITY - 2 - LOW; 3 - NORMAL

BOD - Biochemical Oxygen Demand
COD - Chemical Oxygen Demand
SU - Standard Unit
NTU - Nephelometric Turbidity Units
mg/L - milligram per liter
ug/L - microgram per liter

TABLE C-4
TRIBUTYLTIN CONCENTRATIONS IN ENVIRONMENTAL SAMPLES COLLECTED IN THE CHESAPEAKE BAY
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Type of Sample	Results	Location	Reference
Microlayer	Mean concentrations ranged from 54–310 ng l^{-1} in four marinas after monthly sampling during a 12 month study. Three TBT concentrations ranging 1049–1171 ng l^{-1} were reported in the marinas. TBT concentrations of 41 and 29 ng l^{-1} were detected in the Chesapeake and Delaware Canal during May and June.	Eight sampling stations in Maryland including 4 marinas, a large harbour, 2 major river systems and a heavily used shipping channel	Hall *et al.*, 1987a
Water Column	Mean TBT concentrations (monthly sampling 12 months) ranged 51–408 ng l^{-1} in 4 marinas. Peak concentrations were reported in May and June in the marinas. A maximum value of 998 ng l^{-1} was reported. TBT concentrations of 20–24 ng l^{-1} were reported in the Potomac River.		
Water Column	Maximum TBT concentrations of 1171 and 1801 ng l^{-1} were reported in 2 marinas. Mean concentrations of 435 and 291 ng l^{-1} were reported in the 2 marinas after bi-weekly sampling for 4 months. Peak TBT concentrations occurred in early spring followed by significant reductions during the summer and early fall. The highest concentration of TBT reported in the receiving system (Severn River) was 48 ng l^{-1}. Mean concentrations in the Severn River was 22 ng l^{-1}	Seven stations in the Back Creek/ Severn River area of Maryland	Hall *et al.*, 1987b
Centrifuged and uncentrifuged water column samples	No differences in concentration of TBT in centrifuged and uncentrifuged samples were reported. Thus suggesting TBTs are primarily associated with dissolved fractions of estuarine water.	Three stations in the Back Creek area of Maryland waters	Johnson *et al.*, 1987
Microlayer	TBT concentrations of 4568 ng l^{-1} were reported in Baltimore Harbor.	Baltimore Harbor and an Annapolis marina in Maryland	Matthias *et al.*, 1986
Water column	TBT concentrations of 71 ng l^{-1} were reported in an Annapolis marina.		
Microlayer	TBT concentrations of 4130 ng l^{-1} were reported in a marina in a July 1987 sample. The mean concentration of 6 stations in Back Creek was 971 ng l^{-1}. A TBT concentration of 60 ng l^{-1} was reported in the Severn River.	Seven stations in the Back Creek/ Severn River area of Maryland	Matthias *et al.*, in press
Water column	TBT concentrations ranging 142–367 ng l^{-1} were reported in Back Creek. TBT concentrations of 34 ng l^{-1} were reported in the Severn River.		
Sediment	TBT concentrations ranging from 140–1390 µg kg^{-1} (dry weight) were reported from 6 stations in Back Creek. A TBT concentration of 50 µg kg^{-1} was reported from the Severn River.		
Water column	20 week average TBT concentrations were 99, 121, 47, and 22 ng l^{-1} at 4 stations located equidistantly away from a marina area. A maximum TBT concentration of 530 ng l^{-1} was reported.	Spa Creek, Annapolis, MD	Batiuk, 1987
	20 week average TBT concentrations were 52, 47, 21, 19 ng l^{-1} at 4 stations located equidistantly away from a marina area. A maximum TBT concentration of 170 ng l^{-1} was reported.	Solomons on Back Creek and Patuxent River, MD	
	20 week average TBT concentration were 34, 30, 23, and 24 ng l^{-1} at 4 stations located equidistantly away from a marina. A maximum TBT concentration of 60 ng l^{-1} was reported.	Oxford adjacent to Trend Avon River, MD	
	20 week average TBT concentrations were 18, 29, 28, and 16 ng l^{-1} at 4 stations located in the Trend Avon River (non marinas). A maximum TBT concentration of 91 ng l^{-1} was reported.	Plain Dealing Creek, near Oxford, MD	
Water column	TBT concentrations ranged < 1–98 ng l^{-1} in Sarah Creek which contained several recreational marinas. TBT concentrations ranging from 10–100 ng l^{-1} were reported in various marinas. TBT concentrations of approximately 52 and 67 ng l^{-1} were reported in the Elizabeth River.	Sara Creek and Elizabeth River area of Virginia	Huggett *et al.*, 1986
Water column	TBT concentrations ranging from non-detectable to 76 ng l^{-1} were reported in Sarah Creek during June–Sept. TBT concentrations ranged 4–670 ng l^{-1} in the Hampton River. TBT concentrations during June–Sept ranged from non-detectable to 920 ng l^{-1} in the Hampton Roads–James River–Elizabeth River System.	Sarah Creek and Hampton Roads–James River–Elizabeth River system, VA	Westbrook *et al.*, 1986
Sediment	TBT concentrations ranging 920–1300 µg kg^{-1} were reported in Sarah Creek.		
Sediment	TBT (wet weight) ranged 6.1–74 µg kg^{-1}; dry weight concentrations ranged 23–290 µg kg^{-1}.	Sarah Creek and Kings Creek in Virginia	Rice *et al.*, in press
Oyster (*Crassostrea virginica*) tissue	A mean concentration of 834 ± 430 µg kg^{-1} wet weight was reported from Sarah Creek. A maximum concentration of 1570 µg kg^{-1} was reported. A mean concentration of 9 ± 2 µg kg^{-1} wet weight was reported from Kings Creek.		
Water column	TBT concentrations of 2.5–6.3 ng l^{-1} were reported in the Patapsco River. A TBT concentration of 61 ng l^{-1} was reported in an Annapolis marina. TBT concentrations in the Hampton Roads–Elizabeth River area of Virginia ranged from 16–66 ng l^{-1}. TBT concentrations in the open Bay ranged 2.3–9.1 ng l^{-1}.	Patapsco River, Annapolis marina open Bay in Maryland; Hampton Roads–Elizabeth River areas of Virginia	Olson & Brinkman, 1986

(Source: Hall, 1988)

APPENDIX D

SEDIMENT DATA

TABLE D-1
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY
SEDIMENT QUALITY: QUEENS CREEK, PHILBATES CREEK AND KING CREEK
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

		QUEENS CREEK	PHILBATES CREEK	KING CREEK
SAMPLE DATE		06/17/93	07/21/92	06/17/93
SAMPLE TIME		1330	1430	1100
MEDIUM		SEDIMENT	SEDIMENT	SEDIMENT
PARAMETER	UNIT			
Arsenic	mg/kg	NA	NA	5 U
Beryllium	mg/kg	NA	NA	5 U
Cadmium	mg/kg	NA	NA	5 U
Chromium	mg/kg	NA	NA	26
Copper	mg/kg	NA	NA	21
Lead	mg/kg	NA	NA	71
Mercury	mg/kg	NA	NA	0.3 U
Nickel	mg/kg	NA	NA	13
Silver	mg/kg	NA	NA	5 U
Thallium	mg/kg	NA	NA	5 U
Zinc	mg/kg	NA	NA	79
Selenium	mg/kg	NA	NA	1 U
PCP	ug/kg	50 U	50	50 U
Aldrin	ug/kg	100 U	100	100 U
DDD	ug/kg	100 U	100	100 U
DDE	ug/kg	100 U	100	100 U
DDT	ug/kg	100 U	100	100 U
Dieldrin	ug/kg	100 U	100	100 U
Endrin	ug/kg	100 U	100	100 U
Toxaphene	ug/kg	1000 U	1	1000 U
Heptachlor	ug/kg	100 U	0.1	100 U
Total PCBs	ug/kg	480	500	500 U
Heptachlor Epoxide	ug/kg	100 U	100	100 U
Dicofol	ug/kg	100 U	100	100 U

NA - PARAMETER NOT ANALYZED FOR
U - INDICATES MATERIAL WAS ANALYZED FOR BUT NOT DETECTED
DDD - DICHLORODIPHENYLDICHLOROETHANE
DDE - DICHLORODIPHENYLDICHLOROETHYLENE
DDT - DICHLORODIPHENYLTRICHLOROETHANE
PCB - Polychlorinated Biphenyls
ug/kg - microgram per kilogram

TABLE D-2
CHESAPEAKE BAY CONCENTRATIONS OF SELECTED COMPOUNDS FOR ECOLOGICAL INVESTIGATION
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

	Station and Year														
	LE5.5					WE4.2					LE3.6				
Compound	79S*	79F†	84	85‡	86	79S	79F	84	85	86	79S	79F	84	85	86
Phenanthrene	11	47	22	100	25	5	8	26	32	28	10	24	28	29	27
Fluoranthene	29	52	51	410	54	26	16	54	58	60	16	59	63	56	51
Pyrene	34	46	40	380	52	21	18	49	67	57	12	58	64	55	48
Benzo(a)fluorene	13	25	16	130	23	7	4	13	13	21	3	13	24	15	18
Benzo(a)anthracene	18	30	21	140	19	12	9	28	17	23	5	30 –	29	16	20
Chrysene/triphenylene	37	47	35	170	31	18	16	39	34	37	7	39	44	29	34
Benzo(e)pyrene	2	1	23	93	16	2	11	25	17	24	5	2	27	17	23
Benzo(a)pyrene	22	18	23	130	19	18	12	26	19	33	4	35	33	19	31
Pyrene	26	8	42	36	9	21	22	44	34	38	11	39	46	21	42
Benzo(g,h,i)perylene	15	6	18	46	9	15	8	31	23	20	3	17	28	12	26

	Station and Year															
	LE2.3				CB5.1				CB4.3C				CB3.3C			
Compound	79S	79F	84	86	79S	79F	84	86	79S	79F	84	86	79S	79F	84	86
Phenanthrene	19	42	54	64	17	49	47	50	44	68	26	11	280	220	300	240
Fluoranthene	34	70	89	88	35	81	85	74	60	82	42	14	370	220	370	300
Pyrene	29	57	72	87	33	73	79	66	43	70	38	4	360	220	370	290
Benzo(a)fluorene	10	16	24	34	10	27	24	23	11	38	13	2	120	98	150	77
Benzo(a)anthracene	10	23	28	25	10	32	26	20	8	25	16	>1	100	92	120	94
Chrysene/tripherylene	14	35	51	48	15	46	51	39	12	41	96	13	150	140	210	150
Benzo(e)pyrene	9	13	31	27	8	3	35	24	5	2	19	3	3	89	150	99
Benzo(a)pyrene	8	13	39	37	7	33	36	27	1	31	20	3	64	100	150	110
Pyrene	9	14	43	46	5	37	59	51	9	65	260	150	110	220	220	140
Benzo(g,h,i)perylene	7	5	27	21	5	18	35	19	4	21	21	10	38	56	96	79

*S = Spring †F = Fall ‡Northern Chesapeake Bay not sampled in 1985.

Note: Station LE5.5 is located at the mouth of the James River
Station WE4.2 is located at the mouth of the York River
Station LE3.6 is located at the mouth of the Rhappahannock
Stations CB5.1, CB4.3C, and CB3.3C are located in the mainstem of the Chesapeake Bay

(Source: Huggett et al., 1988)

TABLE D-3
TRIBUTYLTIN CONCENTRATIONS IN ENVIRONMENTAL SAMPLES COLLECTED IN THE CHESAPEAKE BAY
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Type of Sample	Results	Location	Reference
Microlayer	Mean concentrations ranged from 54–310 ng l^{-1} in four marinas after monthly sampling during a 12 month study. Three TBT concentrations ranging 1049–1171 ng l^{-1} were reported in the marinas. TBT concentrations of 41 and 29 ng l^{-1} were detected in the Chesapeake and Delaware Canal during May and June.	Eight sampling stations in Maryland including 4 marinas, a large harbour, 2 major river systems and a heavily used shipping channel	Hall *et al.*, 1987a
Water Column	Mean TBT concentrations (monthly sampling 12 months) ranged 51–408 ng l^{-1} in 4 marinas. Peak concentrations were reported in May and June in the marinas. A maximum value of 998 ng l^{-1} was reported. TBT concentrations of 20–24 ng l^{-1} were reported in the Potomac River.		
Water Column	Maximum TBT concentrations of 1171 and 1801 ng l^{-1} were reported in 2 marinas. Mean concentrations of 435 and 291 ng l^{-1} were reported in the 2 marinas after bi-weekly sampling for 4 months. Peak TBT concentrations occurred in early spring followed by significant reductions during the summer and early fall. The highest concentration of TBT reported in the receiving system (Severn River) was 48 ng l^{-1}. Mean concentrations in the Severn River was 22 ng l^{-1}	Seven stations in the Back Creek/ Severn River area of Maryland	Hall *et al.*, 1987b
Centrifuged and uncentrifuged water column samples	No differences in concentration of TBT in centrifuged and uncentrifuged samples were reported. Thus suggesting TBTs are primarily associated with dissolved fractions of estuarine water.	Three stations in the Back Creek area of Maryland waters	Johnson *et al.*, 1987
Microlayer	TBT concentrations of 4568 ng l^{-1} were reported in Baltimore Harbor.	Baltimore Harbor and an Annapolis marina in Maryland	Matthias *et al.*, 1986
Water column	TBT concentrations of 71 ng l^{-1} were reported in an Annapolis marina.		
Microlayer	TBT concentrations of 4130 ng l^{-1} were reported in a marina in a July 1987 sample. The mean concentration of 6 stations in Back Creek was 971 ng l^{-1}. A TBT concentration of 60 ng l^{-1} was reported in the Severn River.	Seven stations in the Back Creek/ Severn River area of Maryland	Matthias *et al.*, in press
Water column	TBT concentrations ranging 142–367 ng l^{-1} were reported in Back Creek. TBT concentrations of 34 ng l^{-1} were reported in the Severn River.		
Sediment	TBT concentrations ranging from 140–1390 μg kg^{-1} (dry weight) were reported from 6 stations in Back Creek. A TBT concentration of 50 μg kg^{-1} was reported from the Severn River.		
Water column	20 week average TBT concentrations were 99, 121, 47, and 22 ng l^{-1} at 4 stations located equidistantly away from a marina area. A maximum TBT concentration of 530 ng l^{-1} was reported.	Spa Creek, Annapolis, MD	Batiuk, 1987
	20 week average TBT concentrations were 52, 47, 21, 19 ng l^{-1} at 4 stations located equidistantly away from a marina area. A maximum TBT concentration of 170 ng l^{-1} was reported.	Solomons on Back Creek and Patuxent River, MD	
	20 week average TBT concentration were 34, 30, 23, and 24 ng l^{-1} at 4 stations located equidistantly away from a marina. A maximum TBT concentration of 60 ng l^{-1} was reported.	Oxford adjacent to Trend Avon River, MD	
	20 week average TBT concentrations were 18, 29, 28, and 16 ng l^{-1} at 4 stations located in the Trend Avon River (non marinas). A maximum TBT concentration of 91 ng l^{-1} was reported.	Plain Dealing Creek, near Oxford, MD	
Water column	TBT concentrations ranged < 1–98 ng l^{-1} in Sarah Creek which contained several recreational marinas. TBT concentrations ranging from 10–100 ng l^{-1} were reported in various marinas. TBT concentrations of approximately 52 and 67 ng l^{-1} were reported in the Elizabeth River.	Sara Creek and Elizabeth River area of Virginia	Huggett *et al.*, 1986
Water column	TBT concentrations ranging from non-detectable to 76 ng l^{-1} were reported in Sarah Creek during June–Sept. TBT concentrations ranged 4–670 ng l^{-1} in the Hampton River. TBT concentrations during June–Sept ranged from non-detectable to 920 ng l^{-1} in the Hampton Roads–James River–Elizabeth River System.	Sarah Creek and Hampton Roads–James River–Elizabeth River system, VA	Westbrook *et al.*, 1986
Sediment	TBT concentrations ranging 920–1300 μg kg^{-1} were reported in Sarah Creek.		
Sediment	TBT (wet weight) ranged 6.1–74 μg kg^{-1}; dry weight concentrations ranged 23–290 μg kg^{-1}.	Sarah Creek and Kings Creek in Virginia	Rice *et al.*, in press
Oyster (*Crassostrea virginica*) tissue	A mean concentration of 834 ± 430 μg kg^{-1} wet weight was reported from Sarah Creek. A maximum concentration of 1570 μg kg^{-1} was reported. A mean concentration of 9 ± 2 μg kg^{-1} wet weight was reported from Kings Creek.		
Water column	TBT concentrations of 2.5–6.3 ng l^{-1} were reported in the Patapsco River. A TBT concentration of 61 ng l^{-1} was reported in an Annapolis marina. TBT concentrations in the Hampton Roads–Elizabeth River area of Virginia ranged from 16–66 ng l^{-1}. TBT concentrations in the open Bay ranged 2.3–9.1 ng l^{-1}.	Patapsco River, Annapolis marina open Bay in Maryland; Hampton Roads–Elizabeth River areas of Virginia	Olson & Brinkman, 1986

(Source: Hall, 1988)

APPENDIX E

FLORA DATA

TABLE E-1
COMPARISON OF PHYSICAL AND BIOLOGICAL DIFFERENCES BETWEEN TIDAL FRESHWATER AND SALTWATER MARSHES BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Characteristics	Tidal freshwater marsh	Salt marsh
Physical		
Location	Head of estuary (above oligohaline zone)	Mid and lower estuary
Salinity	Average below 0.5 ppt	Average above 8.0 ppt and below 35 ppt (approx.)
Hydrology	Riverine influence and tidal influence	Largely tidal influence
Sediments	Silt-clay, high organic content, low root and peat content	More sand, lower organic content, higher peat and root content
Sediment redox potential	Moderate-strongly reducing (redox pairs unkown)	Strongly reducing, (due to sulfur reduction)
Sediment erodability	High erodability (particularly in the low marsh)	Generally lower erodability
Streambank morphology	Low gradient, little undercutting	Steeper gradient, more undercutting
Stream channel morphology	Low senuosity	Moderate to high sinuosity
Dissolved oxygen (water column)	Very low (summer)	Low (summer)
Dissolved sulfur	Trace (1 ppm)	Very high (2500 ppm)
Biological		
Macrophytes	Freshwater species	Marine and estuarine species
Macrophyte diversity	High species diversity	Low species diversity
Macrophyte zonation	Present, but not always distinct	Pronounced
Seasonal sequence of dominant macrophytes	Pronounced	Absent or minor
Macrophyte root/shoot	Low (generally below 2.0)	High (generally above 5.0)

(continued)

(Source: Odum et al., 1984)

TABLE E-1 (continued)
COMPARISON OF PHYSICAL AND BIOLOGICAL DIFFERENCES BETWEEN TIDAL FRESHWATER AND SALTWATER MARSHES BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Characteristics	Tidal freshwater marsh	Salt marsh
Biological		
Above-ground annual primary production	Comparable (?)	
Benthic algal production	Very low (less than 1% of Net community primary production)	Moderate (may be as High as 30% of net community primary production)
Phytoplankton	Comparable (?)	
Decomposition rate of intertidal vascular	Low marsh plants = extremely rapid, high marsh plants = moderate to slow	Moderate to slow for all plants
Anaerobic decomposition	Methanogenesis and fermentation probably predominate	Sulfur reduction predominates
Nutrient cycles	Pronounced spring uptake of NO, NO, PO large autumn release of reduced compounds	More even processing and release (conversion from oxidized to reduced forms throughout the year)
Sewage assimilative capacity	Low	Moderate
Primary consumers	Larval and adult insects, oligochaetes, amphipods	Adult insects, crustaceans, polychaetes, mollusks
Direct grazing	Variable (5-15%), higher on Hibiscus	Low (5%)
Detritus quality	High (low C/N ratio low crude fiber)	Low to moderate (higher C/N ratio, high crude fiber)
Invertebrates (other than insects)	Low species diversity, freshwater species	Moderate species diversity, estuarine and marine species
Insects	Both aquatic larval insects and terrestrial species	Mostly adult terrestrial species
Fishes	Freshwater and oligohaline species, and larvae, juveniles, and spawning adults of anadromous species	Marine and estuarine species

(continued)

(Source: Odum et al., 1984)

TABLE E-1 (continued)
COMPARISON OF PHYSICAL AND BIOLOGICAL DIFFERENCES BETWEEN TIDAL FRESHWATER AND SALTWATER MARSHES BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Characteristics	Tidal freshwater marsh	Salt marsh
Biological		
Reptiles and amphibians	High species diversity	Low species diversity
Waterfowl	High species diversity, high but spotty densities	Low to moderate species diversity, moderate densities
Furbearers	High species diversity, moderate densities	Low to moderate species diversity, moderate densities

(Source: Odum et al., 1984)

TABLE E-2
SUBMERGED AQUATIC VEGETATION
CHESAPEAKE BAY
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

COMMON NAME	SCIENTIFIC NAME
Eelgrass	*Zostera marina*
Grassleaf pondweed	*Potamogeton pusillus*
Horned pondweed	*Zannichellia palustris*
Muskgrass	*Chara spp.*
Naiad	*Najas spp.*
Naiad, southern	*Najas guadalupensis*
Nutall waterweed	*Elodea nuttallii*
Pondweed	*Potamogeton spp.*
Redhead grass	*Potamogeton perfoliatus*
Ribbonleaf pondweed	*Potamogeton epihydrus*
Sago pondweed	*Potamogeton pectinatus*
Shoal grass	*Halodule beaudettei*
Southern naiad	*Najas guadalupensis*
Water milfoil	*Myriophyllum spp.*
Waterweed	*Elodea canadensis*
Widgeon grass	*Ruppia maritima*
Wild celery	*Vallisneria americana*

(Source: CBP, 1993)

APPENDIX F

BENTHIC MACROINVERTEBRATE DATA

TABLE F-1
OPPORTUNISTIC AND EQUILIBRIUM BENTHIC MACROINVERTEBRATE SPECIES
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION, YORKTOWN, YORKTOWN, VIRGINIA

A. Opportunistic Species Group
Annelida: Polychaeta
Asabellides oculata
Eteone heteropoda
Glycinde solitaria
Leitoscoloplos fragilis
Mediomastus ambiseta
Nereis succinea
Paraprionospio pinnata
Polydora ligni
Streblospio benedicti
Annelida: Oligochaeta
Limmodrilus spp.
Molusca: Bivalvia
Mulina lateralis

B. Equilibrium Species Group
Cnidaria: Anthozoa
Cerianthus americanus
Annelida: Polychaeta
Asychis elongata
Clymenella torquata
Diopatra cuprea
Macroclymene zonalis
Mollusca: Bivalvia
Anadara ovalis
Anadara transversa
Cyrtopleura costata
Macoma balthica
Mercenaria mercenaria
Mya arenaria
Rangia cuneata
Tagelus divisus
Echinodermata: Ophiuroidea
Microphiopholis atra

Source: Dauer et al., 1993

TABLE F-2

PERCENT INDIVIDUAL AND PERCENT BIOMASS OF BENTHIC MACROINVERTEBRATE SPECIES
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION, YORKTOWN, YORKTOWN, VIRGINIA

Cumulative Percentage with Depth for Total Individuals

Depth Interval (centimeter)	Site Group					
	I	II	III	IV	V	VI
0 - 2	69.9	60.9	69.1	73.4	55.5	44.7
2 - 5	92.2	87.9	87.7	89.4	81.5	66.5
5 - 10	98.3	94.8	95.5	95.6	92.9	80.9
10 - 15	99.3	98	98.4	98.8	96.8	90.7
15 - 20	99.6	98.6	99.6	99.6	97.7	96.2
20 - 25	100	100	100	100	100	100

Cumulative Percentages with Depth for Total Biomass and Biomass with Bivalves Excluded (in parentheses)

Depth Interval (centimeters)	Site Group					
	I	II	III	IV	V	VI
0 - 2	99	15.2	54.2	97	33.3	6.9
	(53.2)	(74.5)	(69.1)	(40.6)		
2 - 5	99.8	25.5	57.9	98.3	50.9	15.4
	(79.2)	(89.3)	(89.6)	(66.6)		
5 - 10	99.9	50.5	67.4	98.9	74.5	48.2
	(93.5)	(96.0)	(94.4)	(77.8)		
10 - 15	99.9	81.6	92.8	99.3	81.1	70.3
	(97.4)	(98.0)	(97.1)	(86.6)		
15 - 20	99.9	99.6	99.8	99.9	87.6	80.7
	(98.7)	(98.7)	(99.2)	(97.8)		
20 - 25	100	100	100	100	100	100

I - Tidal Freshwater Sites
II - Transitional Sites
III - Mesohaline Mud Sites
IV - Polyhaline Silty-Sand Sites
V - Mainstem Mud Sites
VI - Mainstem Silty-Sand Sites

(Source: Dauer et al. 1987)

TABLE F-3
BENTHIC MACROINVERTEBRATE SPECIES, OLD PLANTATION CREEK, KING CREEK, CHERRYSTONE INLET
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION, YORKTOWN, YORKTOWN, VIRGINIA

Rank Analysis Dominants	Biological* Index	Constancy (%)	Fidelity (%)	Mean Density/Site (no./m2)
Streblospio benedicti	224	100	98	4,655
Mediomastus ambiseta	128	94	79	771
Tubificoides	121	83	82	890
Heteromastus filiformis	103	86	98	550
Leitoscoloplos fragilis	92	89	90	460
Polydora ligni	84	86	95	705
Caulleriella	67	75	43	613
Eteone heteropoda	46	83	98	182
Nereis succinea	33	89	99	119
Gemma gemma	33	28	2	14

* Total possible BIV = 240 pts.

Other characteristic taxa:
Gammarus mucronatus
Glycinde solitaria
Macoma balthica
Paraprionospio pinnata
Scolecolepides viridis

(Source: Ewing et al., 1982)

DOMINANT BENTHIC MAC[illegible]VERTEBRATE SPECIES
DETECTED IN THE [illegible]ESAPEAKE BAY
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Taxon	TF		OL		LM		HM-M		HM-MX		HM-S		P-M		P-MX		P-S		PE-MX		PE-S	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Oligochaeta (esp. *Limnodrilus* spp.)	*	-	+	-																		
Chironimidae (In)	+	-																				
Corbicula fluminea (B)	+	-																				
Rangia cuneata (B)			+	*																		
Leptocheirus plumulosus (Am)			+	-	*	-	+	-														
Marenzellaria (Scolecolepides) viridis (A)			+	+	+	-					+	-										
Gammarus spp. (Am)	-	-	-	-	+	-																
Streblospio benedicti (A)					+	-	+	-	+	-	+	-										
Heteromastus filiformis (A)					+	-	-	-	-	-	+	-										
Tubificoides spp. (A)	-	-	+	-	+	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Nereis succinea (A)			-	-	+	-	+	-	+	-	+	-	-	-	-	-						
Cyathura spp. (Is)			-	-	+	-	-	-	-	-	-	-										
Macoma balthica (B)			-	-	+	+	+	*	+	-	+	*	-	-	-	-						
Mya arenaria (B)					+	-	-	-	-	-	+	-										
Gemma gemma (B)					-	-	+	-	-	-	*	-										
Crassostrea virginica [1](B)					-	-	-	-	-	-	-	-										
Leucon americanus (C)							+	-	+	-			-	-								
Mulinia lateralis (B)			-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Paraprionospio pinnata (A)					-	-	+	-	+	-	-	-	+	-	+	-	-	-	+	-		
Mediomastus ambiseta (A)							+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Glycinde solitaria (A)									-	-	+	-			-	-						
Glycera spp. (A)							-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pseudeurythoe paucibranchiata (A)							-	-	+	-	-	-	+	-	+	-	+	-	-	-	-	-
Actéocina canaliculata (G)							-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-
Pectinaria gouldii (A)							-	-	-	-	-	-	+	-	+	-	+	-	-	-	-	-
Loimia medusa (A)							-	-					-	-	-	-	-	-	-	-	-	-
Ampelisca spp. (Am)									-	-			-	-	-	-	+	-	-	-	-	-
Molgula manhattensis (Ur)							-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sigambra tentaculata (A)													+	-	+	-	-	-	+	-	-	-
Nephtys spp. (A)													-	-	+	-	-	-	+	-	-	-
Macroclymene zonalis (A)													-	-	+	+	-	-	+	+	-	-
Bhawania heteroseta (A)													-	-		+	-	-	+	-	-	-
Notomastus latericeus (A)													-	-	+	-	-	-	-	-	-	-
Chaetopterus variopedatus (A)													-	-	-	+	-	-	-	-	-	-
Clymenella torquata (A)													-	-	-	+	-	-	+	+	-	-
Phoronis spp. (Ph)													-	-	-	-	+	-	-	-	-	-
Mercenaria mercenaria [1](B)													-	-	-	-	-	-	-	-	-	-
Tellina agilis (B)																	-	-	+	-	+	-
Ensis directus (B)															-	-	+	-	-	-	+	+
Amastigos caperatus (A)																			-	-	+	-
Haustoriidae (Am)																					+	-
Spiophanes bombyx (A)																	-	-	-	-	+	-
Mytilus edulis (B)															-	-	-	-	-	-	-	-

(Source: Diaz et al., 1999)

TABLE F-4 (Continued)
DOMINANT BENTHIC MACROINVERTEBRATE SPECIES
DETECTED IN THE CHESAPEAKE BAY
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Key:

TF - Tidal Freshwater
OL - Oligohaline
LM - Low Mesohaline
HM - High Mesohaline
P - Polyhaline
PE - Poly-Euhaline
M - Mud
MX - Mixed
S - Sand

A - Number of Individuals per Square Meter
(-) - less than 100
(+) - 100 to 1,000
(*) - greater than 1,000

B - ash-free dry weight per square meter
(-) - less than 1
(+) - 1 to 20
(*) - greater than 20

Taxonomic Categories:
A - *Annelida*
Am - *Amphipoda*
B - *Bivalvia*
C - *Cumacea*
G - *Gastropoda*
In - *Insecta*
Ph - *Phoronida*
Is - *Isopoda*
Ur - *Urochordata*

(Source: Diaz et al., 1990)

TABLE F-5
CHARACTERISTICS OF MAJOR BENTHIC HABITATS
IN THE CHESAPEAKE BAY ESTUARINE SYSTEM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Habitat type	Physical characteristics	Macrobenthic community characteristics	Macrofauna density	Macrofauna biomass
Tidal freshwater				
Shoals	Shallow depths Mud to sand sediments Wave-and tide-dominated High turbidity allochthonous carbon) Low to moderate light penetration	Stenohaline, otherwise eurytopic fauna Deposit and suspension feeders Moderate diversity	Low	Bivalves high Others low
Channels	Intermediate depths Mud to sand sediments Fluid mud possible Tide-dominated High turbidity (allochthonous carbon) No light penetration Occasional low oxygen	Stenohaline, otherwise eurytopic fauna Deposit and suspension feeders Moderate diversity	Low	Bivalves high Others low
Oligohaline				
Shoals	Shallow depths Mud to sand sediments Wave- and tide-dominated High deposition (allochthonous carbon) Low to moderate light penetration	Euryhaline, eurytopic fauna Deposit and suspension feeders Low diversity	Low to high	Bivalves high Others low
Channels	Moderate depths Mud sediments Fluid mud possible Tide-dominated High deposition (allochthonous carbon) No light penetration Occasional low oxygen	Euryhaline, eurytopic fauna Deposit and suspension feeders Low diversity	Low to high	Bivalves high Others low
Mesohaline				
Shoals	Shallow depths Sand sediments Wave- and tide-dominated Low to moderate turbidity Moderate light penetration Occasional low oxygen	Euryhaline, eurytopic fauna All feeding types Moderate diversity*	Moderate to high*	Bivalves high Others moderate
Channels	Intermediate to deep depths Mud sediments Fluid mud possible Tide-dominated High turbidity No light penetration Seasonal low oxygen	Euryhaline, eurytopic fauna All feeding types Moderate diversity*	Moderate to high*	Bivalves high* Others moderate*
Polyhaline				
Shoals	Shallow depths Sand sediments Wave- and tide-dominated Low turbidity High light penetration	Stenohaline, eury- to stenotopic fauna All feeding types Moderate diversity	Low to moderate	Low to moderate

ource: Diaz et al.,1990)

TABLE F-5 (continued)
CHARACTERISTICS OF MAJOR BENTHIC HABITATS
IN THE CHESAPEAKE BAY ESTUARINE SYSTEM
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Habitat type	Physical characteristics	Macrobenthic community characteristics	Macrofauna density	Macrofauna biomass
Basin	Intermediate depths Silt and fine sand sediments Tide-dominated Low turbidity Seasonal light penetration Occasional low oxygen	Stenohaline, eury- to stenotopic fauna All feeding types High diversity	Moderate	Moderate to high
Channels	Moderate to deep depths Mud to sand sediments Tide-dominated Moderate turbidity No light penetration Occasional low oxygen	Stenohaline, eury- to stenotopic fauna All feeding types Moderate to high diversity	Moderate	Low to high
Poly-euhaline				
Shoals	Shallow depths Sand sediments Wave- and tide-dominated Low turbidity High light penetration	Stenohaline, stenotopic fauna All feeding types Moderate to high diversity	Low to moderate	Low to moderate
Basin	Intermediate depths Silt and fine sand sediments Tide-dominated Low turbidity Seasonal light penetration	Stenotopic fauna All feeding types High diversity	Moderate	Moderate to high
Channels	Moderate to deep depths Mud to sand sediments Tide-dominated Low turbidity Seasonal light penetration	Stenotopic fauna All feeding types High diversity	Moderate	Low to high

* Except when low oxygen conditions prevail

(Source: Diaz et al.,1990)

APPENDIX G

FISH POPULATION DATA

TABLE G-1
FISH SPECIES IN THE CHESAPEAKE BAY
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Eastern oyster - The Eastern oyster is well adapted to an estuarine environment. It tolerates wide fluctuations in temperature, salinity, suspended sediments, and has a tremendous capacity to reproduce if habitat conditions and brood stock are adequate.

Soft shell clam - Soft shell crabs are most abundant in mesohaline waters of the Bay with coarse or sandy substrate. In polyhaline waters, predators limit the survival of the clams. This species is a widely distributed marine and estuarine bivalves.

Hard clam - The hard clam is limited to salinities greater than 12 ppt and is most abundant with salinities greater than 18 ppt. In the Chesapeake Bay, the hard clams are primarily located in the Pocomoke and Tangier Sounds and in subestuarine river systems in Virginia greater than 5 meters deep, with high densities in the lower Yorks and James Rivers.

Blue crab - Blue crab are tolerant to fluctuating environmental conditions and is ubiquitous during its peak summer abundance period. The Bay population of the blue crab is controlled by the return of postlarval crabs from coastal waters. Crabs prefer to reside in near shore and creek waters, SAV beds, and deeper water in the winter.

Atlantic menhaden - One of the most abundant species in the estuarine and coastal waters. This fish is a coastal ocean spawner, although minor spawns do occur in the lower Bay. Menhaden consume plankton and detritus, consuming zooplankton as young larvae and maturing into filter-feeding on phytoplankton and detritus. Menhaden are important prey to many fish and birds in the Bay.

Bay anchovy - Bay anchovy is the most abundant finfish residing in the Bay. They occur throughout the year. Bay anchovies consume zooplankton and they in turn are consumed by fish, terns, and jellyfish.

American shad (eastern distribution) or hickory shad (southern distribution) - The shad are large anadromous herring that spawn in the Bay during the spring. American shad populations in the Bay peak in April, while the populations of the hickory shad peak in May. Shad are zooplankton feeders that in turn, are consumed by fish.

TABLE G-1 (continued)
FISH SPECIES IN THE CHESAPEAKE BAY
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Alewife and blueback herring - These species are small anadromous species occurring in all of the tributaries to the Bay, but in reduced numbers. The herring are zooplankton, insect, and fish egg feeders who are in turn, consumed by coastal piscivores, mammals, amphibians, and aquatic birds.

Spot - Spot is an abundant bottom foraging species to all areas of the Bay except in the winter months. Spot are tolerant of a wide range of environmental conditions, but prefer brackish to saline waters above mud substrates. The spot consume shallow benthic macroinvertebrates and zooplankton (larvae consumes), and in turn, are consumed by predatory fish. Spot are short-lived coastal spawners with a high reproduction rate.

White perch - White perch are semi-anadromous estuarine species found in all major tributaries to the Bay, with each river system maintaining its own separate population. Peak spawning period for white perch is from April to May. The juvenile perch feed on zooplankton, larvae, insects, and anthripods; adults are also piscivous but also feed on benthos. Perch are preyed on by small invertebrates and higher piscivoruous predators.

Yellow Perch - The yellow perch is a freshwater species that has adapted to a semi-anadromous existence in the Bay. Yellow perch spawns in mid-February and March. Larvae feed on zooplankton; juveniles feed on benthos and larvae yellow perch; and adults feed on anchovies, killifish, and silversides.

Striped bass (rock fish) - A large anadromous species that spawns in the tributaries to the Bay in April and May in tidal freshwater above the salt wedge. Larvae bass feed on zooplankton; juveniles feed on fish larvae, insects, worms, mysids, and amphipods; while adults feed on bay anchovy, spot, menhaden, herring, shad, white perch, and yellow perch. Bass eggs and larvae are consumed by higher predators.

(Source: CRC et al., 1991)

TABLE G-2
NUMBER AND BIOMASS OF FISH SPECIES
COLLECTED FROM THE NORTH INLET ESTUARY
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Rank	Species	Oct 21	Nov 2	Dec 14 (D)	Jan 4 (D)	Jan 7	Jan 16	Jan 30	Feb 22
1	*Leiostomus*	5	—	—	120	1,863	2,120	6,144	88,100
	xanthurus	0.1 g	—	—	12.6 g	190.0 g	233.2 g	694.2 g	13,831.7 g
2	*Lagodon*	—	6	—	109	210	448	1,482	172,000
	rhomboides	—	0.1 g	—	2.9 g	5.6 g	12.2 g	44.5 g	2,071.3 g
3	*Brevoortia*	—	4	—	28	13	8	342	2,200
	tyrannus	—	0.1 g	—	1.2 g	0.8 g	0.4 g	42.2 g	303.2 g
4	*Micropogon*	2,532	166	92	4	3,425	10	2,187	323
	undulatus	31.4 g	2.5 g	1.9 g	0.1 g	92.4 g	0.4 g	67.7 g	12.2 g
5	*Myrophis*	—	—	77	306	212	44	146	1,750
	punctatus	—	—	17.0 g	73.5 g	45.9 g	10.5 g	32.2 g	423.5 g
6	*Anchoa*	64	14	—	—	—	—	—	—
	mitchilli	8.8 g	1.9 g	—	—	—	—	—	—
7	*Mugil*	—	—	18	86	123	42	314	—
	cephalus	—	—	2.5 g	12.2 g	17.2 g	6.1 g	46.1 g	—
8	*Anchoa*	7	9	2	—	—	—	—	—
	hepsetus	0.9 g	1.3 g	0.3 g	—	—	—	—	—
9	*Paralichthys*	—	—	—	—	124	86	238	—
	dentatus	—	—	—	—	5.8 g	4.2 g	9.9 g	—
10	*Centropristis*	120	34	—	—	—	—	—	—
	striata	3.6 g	1.2 g	—	—	—	—	—	—
11	*Mugil*	—	—	4	—	16	27	—	—
	curema	—	—	0.6 g	—	2.3 g	3.9 g	—	—
12	*Rissola*	40	16	—	—	—	—	—	—
	marginata	5.6 g	2.6 g	—	—	—	—	—	—
13	*Paralichthys*	—	—	—	3	16	—	34	—
	lethostigma								
	Paralichthys	—	—	—	0.1 g	0.6 g	—	—	—
	albigutta								
14	*Prionotus*	26	11	3	—	—	—	—	—
	tribulus	8.4 g	3.3 g	1.2 g	—	—	—	—	—
15	*Symphurus*	17	8	1	—	—	—	—	—
	plagiusa	0.5 g	0.3 g	—	—	—	—	—	—
16	*Syngnathus*	12	3	7	—	—	—	—	—
	louisianae	5.5 g	1.4 g	3.1 g	—	—	—	—	—
	Totals	2,823	271	204	656	6,002	2,785	10,887	264,373
		64.8 g	14.7 g	26.6 g	102.6 g	360.6 g	270.9 g	936.8 g	16,641.9 g

D = Daytime samples.

(Source: Bozeman et al., 1980)

TABLE G-3
NUMBER, BIOMASS AND PERCENT JUVENILE FISH SPECIES COLLECTED FROM PARSONS ISLAND MARSH
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Family, common name, species	Total no.	Total biomass (g)	Percent juveniles
Fishes			
Anguillidae			
American eel *Anguilla rostrata* (Lesueur)	70	109.7	100
Cyprinidae			
Golden shiner *Notemigonus crysoleucas* (Mitchill)	3	15.6	33
Bridle shiner *Notropis bifrenatus* (Cope)	6	2.6	17
Spot-tail shiner *Notropis hudsonius* (Clinton)	4	12.1	50
Ictaluridae			
Yellow bullhead *Ictalurus natalis* (Lesueur)	7	1.3	100
Brown bullhead *Ictalurus nebulosus* (Lesueur)	139	72.6	100
Channel catfish *Ictalurus punctatus* (Rafinesque)	1	0.1	100
Tadpole madtom *Notorus gyrinus* (Mitchill)	22	11.2	59
Cyprinodontidae			
Banded killifish *Fundulus diaphanus* (Lesueur)	4145	1077.8	98
Mummichog *Fundulus heteroclitus* (Linnaeus)	1364	899.3	83
Poeciliidae			
Mosquitofish *Gambusia affinis* (Baird & Girard)	110	19.4	54
Atherinidae			
Inland silverside *Menidia beryllina* (Cope)	42	0.3	100
Centrarchidae			
Bluespotted sunfish *Enneacanthus gloriosus* (Holbrook)	873	522.0	97
Pumpkinseed *Lepomis gibbosus* (Linnaeus)	29	194.4	100
Bluegill *Lepomis macrochirus* Rafinesque	5	84.1	60
Largemouth bass *Micropterus salmoides* (Lacepede)	1	0.3	100
Percidae			
Tessellated darter *Etheostoma olmstedi* Storer	36	35.1	28
Yellow perch *Perca flavescens* (Mitchill)	1	4.5	100
Gobiidae			
Naked goby *Gobiosoma bosci* (Lacepede)	60	5.3	95
Macrocrustaceans			
Palaemonidae			
Grass shrimp *Palaemonetes pugio* Holthuis	11 699	1214.0	75
Portunidae			
Blue crab *Callinectes sapidus* Rathbun	38	326.2	97
Xanthidae			
Mud crab *Rhithropanopeus harrisii* (Gould)	299	36.5	16

(Source: Rozas et al, 1987a)

TABLE G-4
NUMBER AND RANK OF FISH SPECIES
COLLECTED IN A GRASSBED AND MARSH AT VAUCLUSE SHORES, VIRGINIA
BACKGROUND LITERATURE REVIEW FOR ECOLOGICAL INVESTIGATIONS
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Zostera Species	No.	%
Leiostomus xanthurus	3794	61.7
Callinectes sapidus	1004	16.3
Syngnathus fuscus	753	12.2
Anchoa mitchilli	139	2.3
Bairdiella chrysoura	123	2.0
Apeltes quadracus	105	1.7
Paralichthys dentatus	71	1.2
Ophidion marginata	36	0.6
Hypsoblennius hentzi	19	0.3
Opsanus tau	15	0.2
Urophycis regia	13	0.2
Tautoga onitis	13	0.2
Eucinostomus argenteus	12	0.2
Centropristis striata	8	0.1
Orthopristis chrysoptera	7	0.1
Sphoeroides maculatus	7	0.1
Gobiesox strumosus	6	0.1
Stenotomus chrysops	5	0.1
Lagodon rhomboides	4	0.1
Hippocampus erectus	3	<0.1
Anguilla rostrata	3	<0.1
Membras martinica	3	<0.1
Gobiosoma bosci	2	<0.1
Syngnathus floridae	2	<0.1
Chilomycterus schoepfi	2	<0.1
Chasmodes bosquianus	2	<0.1
Trinectes maculatus	2	<0.1
Total	6153	

Ruppia Species	No.	%
Leiostomus xanthurus	3270	53.8
Callinectes sapidus	1409	23.2
Syngnathus fuscus	871	14.3
Anchoa mitchilli	104	1.7
Bairdiella chrysoura	64	1.1
Paralichthys dentatus	58	1.0
Hypsoblennius hentzi	53	0.9
Ophidion marginata	46	0.8
Opsanus tau	45	0.7
Centropristis striata	33	0.5
Chasmodes bosquianus	16	0.3
Urophycis regia	10	0.2
Gobiesox strumosus	10	0.2
Lagodon rhomboides	9	0.1
Eucinostomus argenteus	8	0.1
Stenotomus chrysops	8	0.1
Tautoga onitis	7	0.1
Anguilla rostrata	6	0.1
Trinectes maculatus	6	0.1
Orthopristis chrysoptera	6	0.1
Chilomycterus schoepfi	5	0.1
Chaetodon ocellatus	5	0.1
Conger oceanicus	5	0.1
Brevoortia tyrannus	3	<0.1
Syngnathus floridae	3	<0.1
Apeltes quadracus	2	<0.1
Membras martinica	2	<0.1
Cynoscion nebulosus	2	<0.1
Hippocampus erectus	2	<0.1
Sphoeroides maculatus	2	<0.1
Micropogonias undulatus	1	<0.1
Diplodus holbrooki	1	<0.1
Astroscopus guttata	1	<0.1
Alosa aestivalis	1	<0.1
Gobiosoma ginsburgi	1	<0.1
Total	6075	

Marsh Upstream Species	No.	%
Leiostomus xanthurus	11307	89.5
Callinectes sapidus	661	5.2
Brevoortia tyrannus	390	3.1
Anchoa mitchilli	183	1.4
Gobiosoma bosci	29	0.2
Bairdiella chrysoura	16	0.1
Trinectes maculatus	16	0.1
Gobiosoma ginsburgi	9	0.1
Anguilla rostrata	7	0.1
Micropogonias undulatus	6	<0.1
Mugil cephalus	5	<0.1
Paralichthys dentatus	5	<0.1
Opsanus tau	1	<0.1
Total	12634	

Marsh Downstream Species	No.	%
Leiostomus xanthurus	14354	90.1
Callinectes sapidus	1282	8.0
Anchoa mitchilli	69	0.4
Paralichthys dentatus	68	0.4
Trinectes maculatus	48	0.3
Brevoortia tyrannus	38	0.2
Anguilla rostrata	36	0.2
Bairdiella chrysoura	11	0.1
Syngnathus fuscus	8	0.1
Gobisoma bosci	7	<0.1
Opsanus tau	6	<0.1
Anchoa hepsetus	2	<0.1
Gobiosoma ginsburgi	2	<0.1
Cynoscion regalis	1	<0.1
Total	15932	

(Source: Weinstein et al., 1983)