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STATUS AND TRENDS IN WATER QUALITY AND LIVING RESOURCES IN THE VIRGINIA CHESAPEAKE BAY: YORK RIVER (1985-2001)

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Principal Investigators:

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Submitted to:

Mr. Frederick J. Hoffman
Virginia Department of Environmental Quality
629 East Main Street
Richmond, Virginia 23230

February 24, 2003

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Notice

During the mid-1990's the Chesapeake Bay Program's (CBP) Analytical Methods and Quality Assurance Workgroup recommended that the CBP adopt new and more accurate analytical methods for measuring total nitrogen, dissolved inorganic nitrogen, total phosphorus and dissolved inorganic phosphorus. An recent examination of scatterplots of these parameters suggested that the adoption of these news methods in 1994 may have resulted in step trends in concentrations of these parameters. Since the presence of a step trend in the data would adversely affect the ability to detect long-term trends, the CBP's Tidal Monitoring and Assessment Workgroup (TMAW) recommended a statistical protocol that could be used to identify and correct step trends caused by the method changes in these parameters. This procedure would serve as a "stop-gap" protocol until more robust statistical techniques could be developed and adopted for general use by the CBP for long term-trend detection in such cases.

This report presents long-term trend results on nutrient data using TMAW's "stop-gap" protocol (see in Chapter III). Subsequent examinations of the results of these analyses by the TMAW indicate that, in some cases, the method correction protocols may not have performed with the desired validity. As a result, caution should be used in interpreting the long-term water quality trends conducted on the method-corrected nutrient data provided in this report.

Results for dissolved inorganic nitrogen in tidal fresh and oligohaline segments indicated there were no method change effects (see Table 3-1:Chapter III) and, as a result, long-term trend analyses performed on these parameters within these salinity regimes should be valid. In addition, all long term trends (1985 to 2001) presented for chlorophyll *a*, total suspended solids, secchi depth, dissolved oxygen, salinity and temperature were not subjected to method correction protocols and can be considered valid. All trends presented on data collected from 1995 through 2001 are valid. A new method for assessing long term trends on data subjected to analytical method changes will be used in all subsequent reports.

Preface

This material in this report was produced for the Virginia Department of Environmental Qaulity in order to summarize patterns of status and trends in water quality, phytoplankton, primary productivity, zooplankton and benthos collected as part of the Virginia Chesapeake Bay Program. There are three reports, referred to as basin summaries, one each for the James River, the York River and the Rappahannock River. These basin summaries are intended to be electronic reports that will be periodically updated and they were intended for an audience already knowledgeable of the history and rationale of the program; design of the program; field and laboratory methods; specialized parameters, e.g. the Benthic Index of Biotic Integrity; status and trends analytical methods, etc.

In order to create a record of past patterns in status and trends and to make these data more widely available, a printed version of each basin summary was produced. To make the information more interpretable we have added an introduction and a methods section. However, this report is a data report and is not a comprehensive, interpretive report. Therefore, there is no discussion section to this report.

All three basin summaries and appendices are available at the Old Dominion University Chesapeake Bay Program website <www.chesapeakebay.odu.edu> under "Reports." The James River Report includes the Elizabeth River, the Chickahominy River and the Appomattox River. The York River Report includes the tidal Pamunkey River and Mattaponi River. The Rappahannock River Report includes the Corrotoman River. Also available at this website are appendices that include (1) tables of status for all parameters measured at all stations sampled by each program, (2) tables of all parameters and metrics for which there was a significant trend, and (3) scatter plots of all parameters over time. There are five appendices: water quality, phytoplankton, primary productivity, zooplankton and benthos.

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Summary

This summary includes materials provided by Rick Hoffman of the Chesapeake Bay Program of the Virginia Department of Environmental Quality. Environmental information regarding other important conditions in Chesapeake Bay (e.g. submerged aquatic vegetation, fisheries, chemical contaminants) has been reported previously (*Chesapeake Bay and its Tributaries: Results of Monitoring Programs And Status of Resources; 2002 Biennial Report of the Secretary of Natural Resources to The Virginia General Assembly*).

The Virginia Chesapeake Bay and its tidal tributaries continue to show some environmental trends indicating progress toward restoration of a more balanced and healthy ecosystem. However, the Bay system remains degraded and some areas and indicators show continuing degradation. Progress in reducing nutrient inputs has made demonstrable improvements and we expect that continued progress toward nutrient reduction goals, along with appropriate fisheries management and chemical contaminant controls, will result in additional improvements to the Bay. Findings from the last 17 years of the monitoring programs are highlighted below. Patterns of nutrient and sediment loads are summarized in Table 1.

- Nonpoint source loads (estimates of controllable and uncontrollable) of phosphorus, nitrogen, and sediment as calculated by the Bay Program Watershed Model, decreased by 7%, 9%, and 11%, respectively, compared to the 1985 baseline loads.

- Point source nutrient loads were reduced by 57% for phosphorus and 25% for nitrogen, compared to the 1985 baseline loads. This decrease in discharge may be partly due to ongoing drought conditions in Virginia.

- Combined nutrient loads were reduced by 26% for phosphorus and 15% for nitrogen, compared to the 1985 baseline loads.

- For phosphorus, there were improving trends at the river input stations of the James River, Mattaponi River and Rapphannock River with a degrading trend in the Pamunkey River. The improving trends are indicative of both point and nonpoint source nutrient reductions over the last 17 years. Although some improving trends were detected in tidal waters, many degrading trends in phosphorus were detected. Overall, there were 12 areas with improving trends and 19 areas with degrading trends in this parameter.

- For nitrogen, there were improving trends in the Mattaponi River and the Potomac River and a degrading trend in the Pamunkey River. Nitrogen levels showed improving trends in much of the tidal Potomac River and Elizabeth River. Degrading trends occurred in much of the tidal York River and lower James River. Overall, there were 9 areas showing improving trends and 10 areas showing degrading trends for nitrogen.

- Because of improvements made in analytical techniques instituted in 1995, a second set of trend analyses on data from 1995 through the present were preformed in order to use the most consistent data record. Both phosphorus and nitrogen show many improving conditions throughout the Virginia Chesapeake Bay when these most recent seven years are examined. These improvements are probably related to the management actions to reduce nutrient inputs as well as the generally decreased river flow that has occurred in recent years.

- Chlorophyll levels are moderately high throughout much of the tidal waters. Degrading trends were widespread geographically and indicative of detrimentally high nutrient levels. Overall, nine areas showed degrading trends in chlorophyll *a* while only one area showed an improving trend.

- Levels of dissolved oxygen are improving in geographically widespread areas of the tidal rivers. However, conditions for dissolved oxygen still remain only fair in much of the Virginia Chesapeake Bay and a few of the river segments near the Bay. The Corrotoman River and Tangier Sound are the only areas with degrading trends in dissolved oxygen. Overall, there were 13 areas showing improving trends and two areas showing degrading trends for dissolved oxygen conditions.

- Water clarity, a very important environmental parameter, was generally poor and degrading trends were detected in many areas near and in the Virginia Chesapeake Bay. This is probably related to high and scattered increasing levels of suspended solids. These degrading conditions in the Virginia Chesapeake Bay may result in degradation of zooplankton populations and are a major impediment to restoration of submerged aquatic vegetation (SAV). Overall, there were no areas showing improving trends and 13 areas showing degrading trends in water clarity.

- With regard to algal levels, there are widespread increases in cyanobacterial abundance and biomass and also concern about the poor status of dinoflagellates. However, there are widespread improvements in rates of primary productivity.

- Zooplankton community diversity showed generally improving trends in upstream regions but degrading trends at the mouths of all three rivers. These degrading trends are possibly related to degrading trends in nitrogen, phosphorus, and water clarity indicators, and a decreasing trend in salinity.

- Benthic community patterns differed greatly between the rivers. In the James River there strong improving trends upstream and continued good status down stream. In the Elizabeth River there was a strong improving trend although the status of the benthic communities remains poor. In the York River and the Rappahannock River there are degrading trends in the middle reaches.

Table 1. Nutrient and Sediment Loads for Virginia (2001). **Modified from data provided by the Virginia Department of Environmental Quality. Phosphorous and nitrogen loads are in kg/year and sediment loads are metric tons/year. Percent change compares 2001 data to 1985 data. Nonpoint source loads are results based on the Year 2000 Progress Run of Phase 4.3 of the Chesapeake Bay Watershed Model and calculated reductions for calendar year 2001 Best Management Practices (BMPs) as monitored by the Department of Conservation and Recreation.**

River Basin	2001 Phosphorus Load	Percent Change in Phosphorus	2001 Nitrogen Load	Percent Change in Nitrogen	2001 Sediment Load	Percent Change in Sediment
A. Nonpoint Loads						
Potomac	749,527	-10.5%	6,305,959	-10.1%	650,655	-13.4%
Rappahannock	396,532	-19.5%	3,372,686	-19.9%	297,812	-21.4%
York	297,250	-13.4%	3,089,427	-13.3%	126,172	-12.2%
James	2,037,523	- 0.8%	10,316,677	- 2.7%	1,085,925	- 5.4%
Coastal	88,295	-14.2%	943,327	- 5.0%	17,581	-17.2%
Totals	3,569,127	- 7%	24,028,077	- 9%	2,178,145	-11%
B. Point Source Loads. In parentheses is the number of significant point source discharges.						
Potomac (40)	251,218	-28%	5,336,045	+8%		
Rappahannock (14)	21,850	-74%	247,132	+11%		
York (9)	83,000	-59%	501,573	-20%		
James (30)	619,655	-62%	6,138,200	-44%		
Coastal (8)	66,482	-56%	826,527	+40%		
Totals	1,042,205	-57%	13,049,477	-25%		
C. Total Loads. All river basins combined.						
Nonpoint Source	3,569,127	-7%	24,028,077	-9%	2,178,145	-10.8%
Point Source	1,042,205	-57%	13,049,477	-25%		
Combined Loads	4,611,332	-26%	37,077,555	-15%	2,178,145	-10.8%

Chapter 1. Introduction

A marked decline in the water quality of the Chesapeake Bay has occurred over the past several decades. The disappearance of submerged aquatic vegetation in certain regions of the Bay, declines in the abundance of some commercially and recreationally important species, increases in the incidence of low dissolved oxygen events, changes in the Bay's food web, and other ecological problems have been related to the deteriorating water quality. The results of concentrated research efforts in the late 1970s and early 1980s stimulated the establishment of Federal and state directives to better manage the Chesapeake Bay watershed. By way of the Chesapeake Bay Agreements of 1983, the State of Maryland, the Commonwealths of Virginia and Pennsylvania, and the District of Columbia, agreed to share the responsibility for improving environmental conditions in the Chesapeake Bay. As part of this agreement, a long-term monitoring program in the Chesapeake Bay was established in order to: 1) track long-term trends in water quality and living resource conditions over time, 2) assess current water quality and living resource conditions, and 3) establish linkages between water quality and living resources communities. By tracking long-term trends in water quality and living resources, managers may be able to determine if changes in water quality and living resource conditions have occurred over time and if those changes are a reflection of management actions. Assessments of current status may allow managers to identify regions of concern that could benefit from the implementation of pollution abatement or management strategies. By identifying linkages between water quality and living resources it may be possible for managers to determine the impact of water quality management practices on living resource communities.

Water quality and living resource monitoring in the Virginia Mainstem and tributaries began in 1985 and has continued for 16 years. Detailed assessments of the status and long-term trends in water quality and living resources in Chesapeake Bay and its tributaries have been previously conducted (Alden et al., 1991,1992; Carpenter and Lane, 1998; Dauer, 1997; Dauer et al., 1998a,1998b, 2002; Lane et al.,1998; Marshall, 1994,1996; Marshall and Burchardt, 1998; Marshall et al., 1998). An attempt was made to determine if there was concordance in current conditions of, and long-term changes, in water quality and living resources. The purpose of this project was to reassess the results of these studies by re-conducting the analyses after adding data collected during 2001. This report describes the status of water quality and living resource conditions for the Virginia Mainstem and tributaries, summarizes major long-term trends in water quality and measures of living resource community health.

Chapter 2. Monitoring Program Descriptions

I. Water Quality

A. Sampling Locations and Procedures

As part of the U. S. Geological Survey's River Input Program, water quality data have been collected at five stations near the fall line and three stations above the fall line in Virginia. Samples were taken at base-flow twice a month and during high flows whenever possible between 1988 and 2001. Water quality data have also been collected by the Virginia Department of Environmental Quality at three additional stations upstream of these River Input sites (Figure 2-1). These stations had a minimum of three consecutive years of samples taken between 1985 and 1996 with sampling occurring on at least a monthly basis.

Water quality conditions were regularly monitored at 28 sites in the Bay Mainstem beginning in July, 1985. From 1985 until 1995 eight stations were sampled by Old Dominion University (ODU) and 20 stations were sampled by the Virginia Institute of Marine Science (VIMS). From 1995 through the present, Mainstem water quality monitoring was conducted by ODU. Tributary water quality monitoring was conducted by the Department of Environmental Quality at 28 sites in the James, York (including Mattaponi and Pamunkey) and Rappahannock rivers (Figure 2). In addition, six permanent water quality monitoring sites were established in the Elizabeth River/Hampton Roads Harbor by ODU in February, 1989 (Figure 2-2).

The temporal sampling scheme for the water quality monitoring program changed several times over the 14 year period (varying from 20 to 12 sampling events per year) as a result of changes in the monitoring program budget. In general, Mainstem sampling cruises were conducted semi-monthly from March through October and monthly from November through February. Tributary sampling by the Virginia Department of Environmental Quality was generally conducted 20 times per year. The Elizabeth River stations were sampled monthly. Field sampling procedures used for ODU and VIMS water quality collections are described in detail by Alden et al., 1992a. Field sampling procedures for DEQ water quality collections are described in detail in DEQ's Quality Assurance Project Plan for the Chesapeake Bay Program (Applied Marine Research Laboratory, 1998).

B. Laboratory sample processing

Descriptions of laboratory sample processing and standard operating procedures for all water quality parameters are found in the Chesapeake Bay Program Quality Assurance Project Plans (QAPjPs) prepared by each of the participating laboratories (Applied Marine Research Laboratory, 1998). Copies of the QAPjPs can be obtained by contacting EPA's Chesapeake Bay Program Quality Assurance Officer.

II. Phytoplankton

A. Sampling Locations and Procedures

Seven stations were established in Chesapeake Bay in July 1985. These were CB6.1, CB6.4, CB7.3E, CB7.4, LE5.5, WE4.2, and LE3.6 (Figure 3). From July, 1985 through September, 1990, phytoplankton collections were taken from these stations twice a month from March through October, and monthly November through February. From October, 1990, monthly samples were taken at all Bay stations. Monthly sample collections and analysis in the James (TF5.5, RET5.2),
York (RET4.1, RET4.3), and Rappahannock (TF3.3, RET3.1) rivers began in March, 1986. In March, 1987, station RET4.1 in the Pamunkey River was replaced by station TF4.2, and in February, 1989, monthly collections began at two stations (SBE2, SBE5) in the Elizabeth River. Picoplankton analysis was included at several trial stations in January, 1989, and was expanded to include all stations in July, 1989. Primary production analysis was added to all Bay and tributary stations in July 1989.

At each station, two vertical sets of three liter water samples were taken at five equidistant depths above the pycnocline and placed in two separate carboys. The process was repeated at five depths below the pycnocline. The water in each carboy was carefully mixed and replicate 500 ml sub-samples were removed from each carboy, and fixed with Lugol's solution. A second set of 125 ml sub-samples were also taken above and below the pycnocline, preserved with glutaraldehyde and placed in a cooler. These samples were taken to determine the concentrations of the autotrophic picoplankton population. An additional replicate set was also taken from the same carboy set taken above the pycnocline for primary productivity measurements.

B. Laboratory Sample Processing

Samples for phytoplankton analyses were passed through a series of settling and siphoning steps to produce a concentrate (or fraction of the concentrate) that was examined using a modified Utermöhl method with an inverted plankton microscope (Marshall and Alden, 1990). The analysis procedure attained an estimated precision of 85% (Venrick, 1978). The autotrophic picoplankton were processed through a protocol that included their collection on a 0.2 µ nucleopore filter, with subsequent analysis using an epifluorescent microscope, under oil at 1000x magnification, with a "green" and “blue” filter sets (Marshall, 1995). Supplemental analysis with a scanning electron microscope was used in several of the species identifications. Methodology for the productivity measurements is given in Marshall and Nesius (1996). Appropriate quality assurance/quality control practices in sample collection, analysis, and data entry were employed throughout this period.

III. Zooplankton

A. Sampling Locations and Procedures

Microzooplankton communities were monitored monthly at seven sites in the Mainstem and six sites in the Virginia tributaries beginning in January, 1993 (Figure 3-3). Whole water samples were collected at all stations. Before sampling, 10 ml of modified Lugol's solution was placed into two liter (L) bottles designated for each station. The water was sampled through the use of a battery powered pump attached to a hose. Two composite water samples, each totaling 15 L, were taken from five equidistant depths above the pycnocline and collected in two carboys. Each carboy was thoroughly mixed and 1 L taken from each (Samples A and B for each station).

Mesozooplankton communities were monitored monthly at seven sites in the Mainstem beginning in July, 1985 (Figure 3-3). Monthly mesozooplankton monitoring was conducted at six sites in the major Virginia tributaries (Rappahannock, York/Pamunkey, and James rivers) beginning in March, 1986 (one site on the Pamunkey was originally sampled at RET4.1 but relocated to TF4.2 in February, 1987). In 1986 a new sampling regime began that increased frequency to two samples per month during April, May, July, and August at all the tidal freshwater stations (TF3.3, TF4.2, TF5.5). At the same time, sampling frequency was increased to twice per month for July and August also at stations RET3.1, RET4.3, RET5.2, LE5.5, and SBE5 in order to allow better characterization of zooplankton communities during spawning periods of commercially important fish species in these areas.

Single mesozooplankton tows were conducted at each site using a bongo apparatus with 202 µ mesh nets. The nets were towed obliquely from the surface to 1 m above the bottom and back to the surface over a period of approximately five minutes. A calibrated flowmeter was attached to each net and flowmeter readings were recorded just prior to net deployment and immediately upon net retrieval. Once onboard the research vessel, the nets were "washed down" and the contents of the cod-ends were decanted into pre-labeled one liter sample containers and preserved with 7% buffered formalin. All sample numbers were recorded on a sample chain-of-custody form before departing the site.

B. Laboratory Sample Processing

The whole water samples taken for microzooplankton (<200µ) analysis were processed through a screen, plus a series of settling and siphoning procedures (Park and Marshall, 1993). These steps removed the larger zooplankters and debris to provide 3 sub-sets based on size to be analyzed. This method insured the collection and analysis of the small non-loricated ciliates to be included in the count.

The mesozooplankton samples were processed according to the coefficient of variation stabilizing (CVS) method described by Alden et al. (1982). This method has numerous advantages over other zooplankton enumeration techniques. The CVS method provides abundance estimates with equitable coefficients of variation for species of interest in zooplankton subsamples. It is particularly useful in increasing the precision of the estimates of numbers of large species of relatively low abundance that may be important due to their biomass, their trophic position, or their economic significance. The investigator can be quite confident that the precision of the abundance estimates is at least at the pre-determined level for all species processed by the CVS method. The method also has the advantage of allowing the investigator to set a level of precision that is consistent with cost, manpower, or time constraints. Finally, the size class data produced by the CVS method may provide information of intrinsic ecological significance.

Briefly, the CVS method involves the sieve fractionation of the samples into size classes of 2000µ, 850µ, 650µ, 300µ, and 200µ. This series was found useful for Bay mesozooplankton communities. An additional sieve size fraction between 200µ and 63µ was collected and analyzed beginning in 1998. This fraction was added to allow greater comparability with the mesozooplankton data collected in Maryland. However, these data are incomplete and the results from this additional sieve-size fraction will be reported beginning with the 1999 data set. The size classes appropriate for whole counts were transferred to labeled vials containing 7% buffered formalin and temporarily stored until counted. The size class aliquots in which the organisms were too numerous to count in their entirety were split with a Folsom plankton splitter until an appropriate sample size was achieved for statistically valid counts of the dominant species. A level of sampling error of 30% requires that each species of interest be counted to achieve a range of between 30 and 56 organisms counted in any given split. During the splitting process, reserve splits were labeled, preserved in formalin and retained until the counting procedure was completed. Those species observed in the final split were counted in the reserved splits until all had achieved the range for the 30% error level (see Alden et al., 1982 for details of CVS methodology). However, if commercially important species (e.g., blue crab zoea) were encountered, they were counted to achieve the 30% error level for the statistical models. The samples were counted under a dissecting microscope in custom-designed counting trays (60 mm tissue culture dishes). Taxonomic identifications were made under compound or inverted microscopes and reference collections and/or photographs were maintained for each taxon for documentation and QA/QC purposes.

IV. Benthos

A. Fixed Location Sampling

Sixteen stations in the lower Chesapeake Bay were sampled quarterly (March, June, September, December) from March 1985 through December 1995 as part of the Benthic Biological Monitoring Program of the Chesapeake Bay Program. Beginning in 1996 sampling at the fixed stations occurred only in June and September and a stratified random sampling element was added to the program. Power and robustness analyses indicated that sampling during June and September would be sufficient for detecting long-term trends at the fixed locations while at the same time, allow funding resources to be reallocated to the probability-based random sampling regime (Alden et al., 1997). Stations were located within the mainstem of the bay and the major tributaries - the James, York and Rappahannock rivers (Figure 3). In the tributaries, stations were located within the tidal freshwater zone (TF5.5, TF4.2, TF3.3), turbidity maximum (transitional) zone (RET5.2, RET4.3, RET3.1), lower estuarine mesohaline muds (LE5.2, LE4.1,

LE3.2) and lower estuarine polyhaline silty-sands (LE5.4, LE4.3). The tidal freshwater station within the York River estuary was located in the Pamunkey River. In the Mainstem of the Bay three stations were located off the mouths of the major tributaries (CB8.1, CB6.4, CB6.1) and two stations in the deeper channels near the bay mouth (CB7.3E) and above the Rappahannock River near the Virginia-Maryland border (CB5.4).
In 1989, five additional stations were added to the program: two stations in the Southern Branch of the Elizabeth River (SBE2, SBE5) in regions exposed to contaminated sediments, a station in the transitional region of the James River (LE5.1), a station in the lower York River exposed to low dissolved oxygen events (LE4.3B), and a station in the lower Rappahannock River exposed to low dissolved oxygen events (LE3.4).

For the fixed point stations three replicate box core samples were collected for benthic community analysis. Each replicate had a surface area of 184 cm^2, a minimum depth of penetration to 25 cm within the sediment, was sieved on a 0.5 mm screen, relaxed in dilute isopropyl alcohol and preserved with a buffered formalin-rose bengal solution.

At each station on each collection date a 50g subsample of the surface sediment was taken for sediment analysis. Salinity and temperature were measured using a Beckman RS5-3 conductive salinometer and bottom dissolved oxygen was measured using a YSI Model 57 oxygen meter. For the original 16 stations see Dauer et al. (1992) for a summary of the pattern of bottom oxygen values, Dauer et al. (1993) for a summary of the distribution of contaminants in the sediments and Dauer (1993) for a summary of salinity, water depth, and sedimentary parameters.

B. Probability-based Sampling

In 1996 a probability-based sampling program was added to estimate the area of the Virginia Chesapeake Bay and its tributaries that met the Benthic Restoration Goals as indicated by the B-IBI (Ranasinghe et al., 1994; Weisberg et al., 1997; Alden et al., 2002). Four strata were defined and each stratum was sampled by 25 randomly allocated sites. The four strata were: 1) the James River; 2) the York River (including the Pamunkey and Mattaponi rivers); 3) the Rappahannock River; and 4) the Mainstem of the Chesapeake Bay. Each year a new set of 25 random sites was selected for each stratum.

Probability-based sampling within strata supplements data collected at fixed-point stations. Sampling design and methods for probability-based sampling are based upon those developed by EPA's Environmental Monitoring and Assessment Program (EMAP, Weisberg et al., 1993) and allow unbiased comparisons of conditions between strata (e.g., tributaries) of the Chesapeake Bay within the same collection year and within tributaries for between different years. The consistency of sampling design and methodologies for probability-based sampling between the Virginia and Maryland benthic monitoring programs allows bay-wide characterizations of the condition of the benthos for the Chesapeake Bay (Dauer 1999; Dauer and Rodi 1998a, 1998b, 1999, 2001, 2002).

Within each probability-based stratum, 25 random locations were sampled using a 0.04 m^2 Young grab. At each station one grab sample was taken for macrobenthic community analysis and a second grab sample for sediment particle size analysis and the determination of total volatile solids. All sampling processing for probability-based sampling stations were identical to those for the fixed stations. Physico-chemical measurements were also made at the random locations.

C. Laboratory Sample Processing

In the laboratory, each replicate was sorted and all the individuals identified to the lowest possible taxon and enumerated. Biomass was estimated for each taxon as ash-free dry weight (AFDW) by drying to constant weight at 60 °C and ashing at 550 °C for four hours. Biomass was expressed as the difference between the dry and ashed weight.

The sand fraction of each sediment sample was dry sieved and the silt-clay fraction was quantified by a pipette analysis using the techniques of Folk (1974). Total volatile solids for each sediment sample was determined as the AFDW weight of the sediment divided by the dry weight of the sediment, expressed as a percentage.

V. Statistical Analyses

In order to ensure that long-term trends in water quality and living resource data are correctly interpreted, a unified approach for conducting the statistical analyses and interpreting their results was developed. Statistical analytical procedures used in this study were based on guidelines developed by the CBP Monitoring Subcommittee's Tidal Monitoring and Assessment Workgroup.
For both status and trend analyses, the stations were grouped into segments based on the segmentation scheme developed by the Data Analysis Workgroup (Figure 2-2). Status and trend analyses were conducted for different seasonal time periods as defined for each monitoring component in Table 2-1.

A. Status Assessments

For the tidal water quality stations, status analyses were conducted using surface and bottom water quality measurements for six parameters: total nitrogen, dissolved inorganic nitrogen, total phosphorus, dissolved inorganic phosphorus, chlorophyll *a*, and total suspended solids. Status analyses were also performed on secchi depth and bottom dissolved oxygen. All analyses were conducted using water quality data collected from all of the Chesapeake Bay Mainstem and tributary collection stations from the January 1999 through December of 2001 except for bottom dissolved oxygen for which analyses were conducted using data collected only during the summer months of June through September.

The relative status of each station and segment was determined by comparison to a benchmark data set comprised of all data collected from 1985 to 1990 by both the Virginia and Maryland monitoring programs. Each station was rated as poor, fair, or good relative to the benchmark data. The ratings are obtained for data collected within each salinity zone with salinity zones being assigned using the Venice classification system (Symposium on the Classification of Brackish Waters, 1958). For each parameter in the benchmark data set, a transformation was chosen that yields a distribution that was symmetric and approximated by the logistic cumulative distribution function (CDF). In most cases, the logarithmic transformation was selected. A logistic CDF based on the mean and variance of each parameter of the benchmark data set was used to perform a probability integral transform on all data collected during the period of January, 1998 through December, 2001. This resulted in data in the interval (0,1) that follow a uniform distribution. The three year median of these transformed data was computed as an indicator of status for the period specified. The median of n observations taken from a uniform distribution follows a Beta distribution with parameters (m,m) where:

$$m = (n+1)/2$$

and n is the number of observations.

The transformed three year medians were compared to the Beta density distribution and status was determined by the placement of the transformed medians along the distribution. If the median was in the upper third of the distribution (where upper is chosen as the end of the distribution that is ecologically desirable) then the status rating is good, while a median in the middle third was rated fair, and a median in the lower third was rated poor. In most cases, serial dependence of the raw data resulted in greater than expected variance in the Beta density of the medians. To adjust for this, the variance of the Beta density was increased by a function of the ratio of among station variance to within station variance.

Because sampling regimes between monitoring programs varied with respect to the number of collection events within a given month and the number of replicate samples collected at each station varied, a uniform calculation protocol was adopted for use by both states to insure that the calculations were not inadvertently biased by these discrepancies. First, replicate values were combined by calculating a median for each station date and layer combination. Median values for each station month and year combination were calculated to combine separate cruises per month. Finally, station specific or segment specific median scores were calculated that were compared to the benchmark scale.

Status for phytoplankton, microzooplankton and mesozooplankton involved the calculation of relative status using the same technique as described for water quality relative status assessments.

For phytoplankton communities the following indicators were assessed: total phytoplankton community abundance, total phytoplankton community biomass, diatom abundance, dinoflagellate abundance, cyanobacteria abundance, picoplankton abundance, and primary productivity (carbon fixation). Benchmarks for picoplankton abundance were made using data collected only in Virginia since sampling protocols for the Maryland program did not include counts of epifluorescent picoplankton. Microzooplankton parameters assessed included total microzooplankton abundance, copepod nauplii abundance and rotifer abundance. Mesozooplankton parameters assessed included the Margalef diversity index, the Shannon-Weiner diversity index, and total mesozooplankton abundance. Note that the benchmarks for mesozooplankton data were made using data collected only in Virginia since the sampling protocols for the Maryland program does not include counts of epifluorescent picoplankton. A change in laboratory sample processing for the mesozooplankton

program occurred in 2000 and as a result only data collected through 1999 were used in both status and trend analyses for the mesozooplankton.

Status of benthic communities at each station was characterized using the three-year mean value (1999-2001) of the B-IBI (Weisberg et al., 1997). The B-IBI indicates whether the macrobenthic community meets the restoration goals developed for benthic habitats of the Chesapeake Bay. An index value that exceeds or equals 3.0 indicates that the macrobenthic community meets or exceeds the restoration goals developed for that habitat type while a value below 3.0 indicates that the macrobenthic community does not meet the restoration goals. Status of the benthic community was classified into four levels based on the B-IBI. Values less than or equal to 2 were classified as severely degraded, values from 2.0 to 2.6 were classified as degraded, values greater than 2.6 but less than 3.0 were classified as marginal, and values of 3.0 or more were classified as meeting goals.

Water quality data were assessed to determine if the SAV habitat requirements were met for the following parameters: light attenuation (KD), percentage of required light at the leaf surface (PLL) (0.5 and 1.0 m), total suspended solids, chlorophyll *a*, dissolved inorganic nitrogen, and dissolved inorganic phosphorus. Three year medians for the SAV growing season were compared to the SAV habitat requirement values (see Table 2-2) using a Mann-Whitney U-test. If the median values were significantly higher (lower for PLL) than the habitat requirement for that parameter then the parameter was considered to have failed to met the SAV habitat requirements and if the values were significantly lower (higher for PLL) than the habitat requirement then the parameter was to considered to have met the SAV habitat requirement. If there was no significant difference between the habitat requirements or there were insufficient data to conduct the analysis, the parameter was considered borderline.

B. Long-term Trend Analyses

1. Non-tidal water quality

Trend analyses were conducted on data collected at nine stations at and above the fall-line in the Virginia tributaries. Concentrations of water-quality constituents are often correlated with streamflow. Removal of natural flow variability allows examination of changes in water quality resulting from human activities. Flow-adjusted concentration trends were determined with a non-parametric Kendall-Theil analysis. The trend slope was the overall median of the pairwise slopes of residuals from a log-linear-regression model incorporating flow and season terms. For data sets with greater than five percent censored data, a range in slope and magnitude was defined by twice computing the median slope - first, with censored data equal to zero and second, with censored data equal to the maximum detection limit. For data sets with greater than twenty percent censored data, no results were reported. A p-value of 0.05 or less was considered significant for this analysis.

When considering the health of living resources, it is necessary to examine trends in concentrations that may be both flow- and human-induced. These concentrations were weighted, but not adjusted, for flow. The flow-weighting resulted in a more representative monthly concentration than the one point per month typical of many observed data sets. The volume of flow occurring between these infrequent sample dates is likely to have a pronounced effect on average concentrations in the tidal estuaries and other mixed receiving areas. Therefore trends in flow-weighted concentrations may correlate better with trends in estuarine concentrations. The linear trend in flow-weighted concentration was estimated by regressing flow-weighted concentrations with time. In most cases, the data was log-transformed in order to meet the assumptions of normality, constant variance, and linearity. A p-value of 0.01 or less was considered significant for this analysis.

2. Tidal water quality

The statistical tests used for the trend analyses were the Seasonal Kendall test for monotonic trends and the Van Belle and Hughes (Gilbert, 1987) tests for homogeneity of trends between stations, seasons, and station-season combinations. A p value of 0.05 was chosen as the statistical test criterion for all trend analyses. Recent studies on representative data sets from the Chesapeake Bay monitoring program have indicated that these tests are very powerful and robust, even when data violate most of the assumptions of parametric statistics (Alden et al., 1991; Alden et al., 1992b; Alden et al., 1994; Alden and Lane, 1996).

Trend analyses were conducted on the same suite of water quality parameters used for the status assessments and salinity and water temperature. Prior to the trend analyses, data were reduced to a single observation for each station month and layer combination by first calculating the median of all replicates for each layer by station and date and then calculating the median between all dates for a given station within each month. For all applicable water quality parameters, any values less then the highest detection limit were set to one half of the highest detection limit. For calculated parameters, each constituent parameter that was below the detection limit was set to one half of the detection limit and the parameter was then calculated.

Increasing trends in total nitrogen, dissolved inorganic nitrogen, total phosphorus, dissolved inorganic phosphorus, chlorophyll *a* and total suspended solids should indicate increased eutrophication and as a result positive slopes in these parameters indicate degrading conditions while negative slopes indicate improving water quality conditions. Increasing trends in secchi depth and bottom dissolved oxygen indicate increasing water clarity and reduced eutrophication, respectively and, as a result, indicate improving water quality conditions. Decreasing trends in these two parameters indicate degrading conditions.

3. Tidal water quality method corrections

In 1994, changes in analytical methods for estimating concentrations of total nitrogen, dissolved inorganic nitrogen, total phosphorus and dissolved inorganic phosphorus were implemented by the Department of Environmental Quality in order to improve the accuracy of concentration estimates. Procedural changes involved the implementation of automated sample processing on a Scalar auto-analyzer for nitrites (NO2F), nitrates-nitrites (NO23F), ammonia (NH4F) and orthophosphate (PO4F). In addition, particulate nitrogen(PN), total dissolved nitrogen (TDN), particulate phosphorus (PHOSP) and total dissolved phosphorus (TDP) were added to the suite of parameters measured via auto-analyzer while total Kjeldahl nitrogen (fixed and whole) and direct measurements of total phosphorus (TP) were discontinued. These changes resulted in step trends in the data for these parameters that must be accounted for prior to conducting trend analyses.

Data were corrected for method changes by conducting a multiple regression analysis on log transformed water quality data with the following terms: 1) a linear trend term (Time); 2) a non-linear trend term (Time^2); 3) a month term to control for the effect of seasonal cycles; 4) a station term to control for the effect of differences due to station location and; 5) a dummy variable term that accounts for the effect of any changes in methods (0=prior to method change, 1=after method change). Analyses were conducted by salinity regime. For parameter/salinity regime combinations with a significant method change effect (p. <0.05), coefficients for this model term were used as correction factors that were applied to the original data. The resulting "method corrected" data were analyzed for long-term trends using the seasonal Kendall trend test. A comparison was made between the method corrected trends and trends conducted on the original data to assess the effect of the method correction analysis on trend analysis results. For the Elizabeth River all segments except the Elizabeth River Mouth segment used the newer analytical methods from the inception of this program in 1989. Therefore, method corrections were only applied to the Elizabeth River Mouth segment.

4. Living resources

Trend analyses for phytoplankton communities were conducted on the following phytoplankton community indices: the phytoplankton IBI, total phytoplankton abundance (excluding picoplankton); total phytoplankton biomass (excluding picoplankton); the Margalef species diversity index, and C^{14} productivity. In addition, trend analyses were conducted on abundance and biomass values for the following taxonomic groups: diatoms; dinoflagellates; cyanobacteria; cryptomonads; chlorophytes; bloom producing species; and toxic bloom producing species.

The Margalef species diversity index was calculated as follows:

$$D = \frac{S - 1}{\log_2 N}$$

where *S* is the number of taxa in the sample and *N* is the number of individuals (Margalef, 1958).

Trend analyses were conducted by station using monthly medians of microzooplankton and mesozooplankton data collected from the beginning of the respective monitoring programs through December of 2001 and December of 1999 for microzooplankton and mesozooplankton, respectively.

Microzooplankton bioindicators used for the trend analyses included: total microzooplankton abundance; rotifer abundance; copepod nauplii abundance; oligotrich abundance; tintinnid abundance; sarcodinia abundance; and microzooplankton cladoceran abundance. Mesozooplankton bioindicators used for these analyses were: total mesozooplankton abundance (excluding copepod nauplii); holoplankton abundance; meroplankton abundance; indices of mesozooplankton community species diversity (including the total number of species collected, the Shannon-Weiner index, the Margalef diversity index, and Pielou's evenness); calanoid copepod abundance; cladoceran abundance; cyclopoid copepod abundance; *Acartia tonsa* abundance; *Bosmina longirostris* abundance; *Eurytemora spp.* abundance; and crab zoea abundance.

The Shannon Weiner diversity index (H') was calculated as follows:

$$H' = -\sum_{i=1}^{s} p_i \log_2 p_i$$

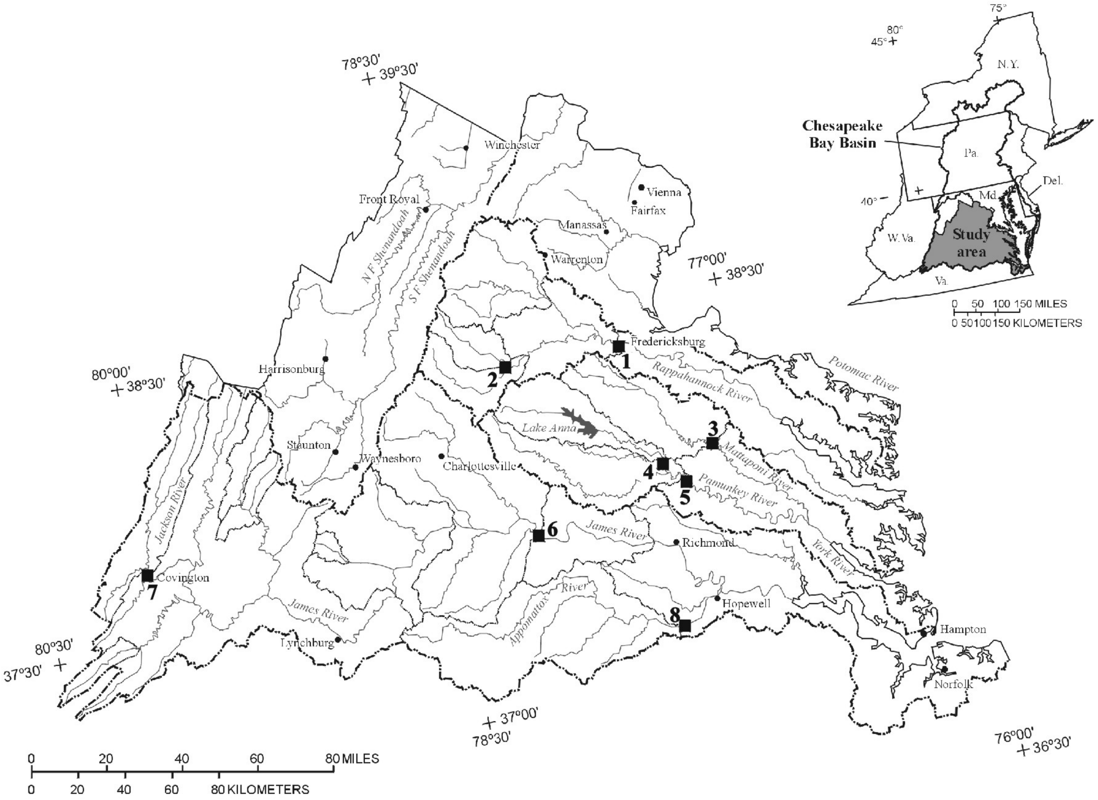
where p_i is the proportion of the ith species and S is the number of species.

Pielou's evenness index (J) was calculated using the equation:

$$J = \frac{H'}{\log_2 S}$$

where H' is the diversity index and S is the total number of species collected. Increasing trends in mesozooplankton abundance, holoplankton abundance, merozooplankton abundance and measures of species diversity indicate improving conditions while negative slopes indicate degrading conditions.

Trend analyses for benthic communities were conducted using the B-IBI (Ranasinghe et al., 1994; Weisberg et al., 1997) and on selected metrics of the B-IBI. Benthic restoration goals were developed for benthic habitats of the Chesapeake Bay based upon reference sites that were minimally impacted by low dissolved oxygen events and sediment contaminants. Goals were developed based upon data from an index period of July 15 through September 30. Therefore trends in the value of the B-IBI were based upon September cruise values for the 14 year period of 1985-1998. Selected benthic metrics were species diversity (H'), community abundance, community biomass, pollution-indicative species abundance, pollution-indicative species biomass, pollution-sensitive species abundance, and pollution-sensitive species biomass. See Weisberg et al. (1997) for a list of pollution-indicative and pollution-sensitive taxa.



1 Station 01668000 - Rappahannock River near Fredericksburg
2 Station 01666500 - Robinson River
3 Station 01674500 - Mattaponi River near Beulahville
4 Station 01671020 - North Anna River near Doswell
5 Station 01673000 - Pamunkey River near Hanover
6 Station 02035000 - James River at Cartersville
7 Station 02013100 - Jackson River at Covington
8 Station 02041650 - Appomattox River

Figure 2-1. Locations of the USGS sampling stations at and above the fall-line in each of the Virginia tributaries.

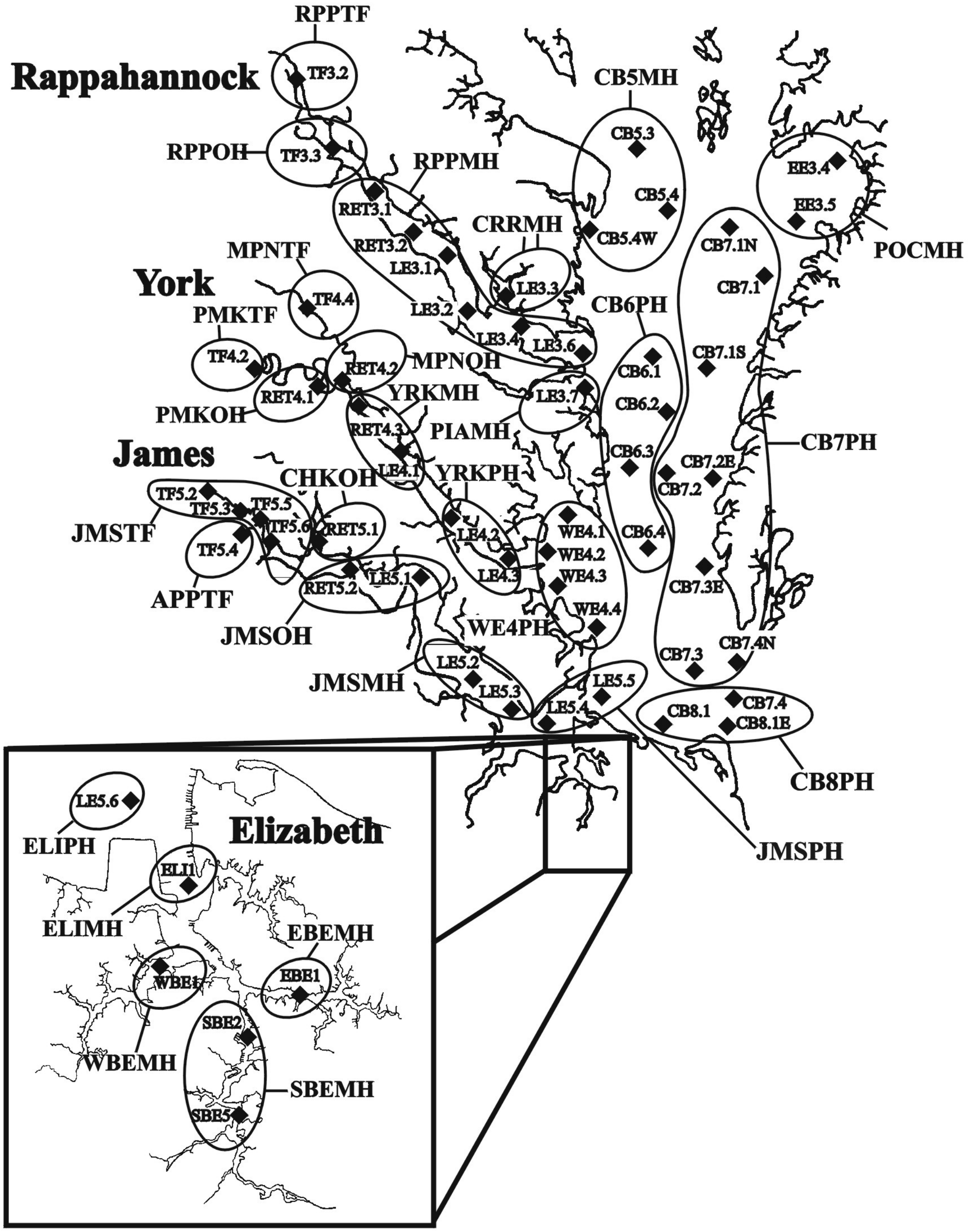


Figure 2-2. Map showing the locations of the water quality monitoring stations in the Virginia tributaries and the Lower Chesapeake Bay Mainstem used in the statistical analyses. Also shown are ellipses that delineate the Chesapeake Bay Program segmentation scheme.

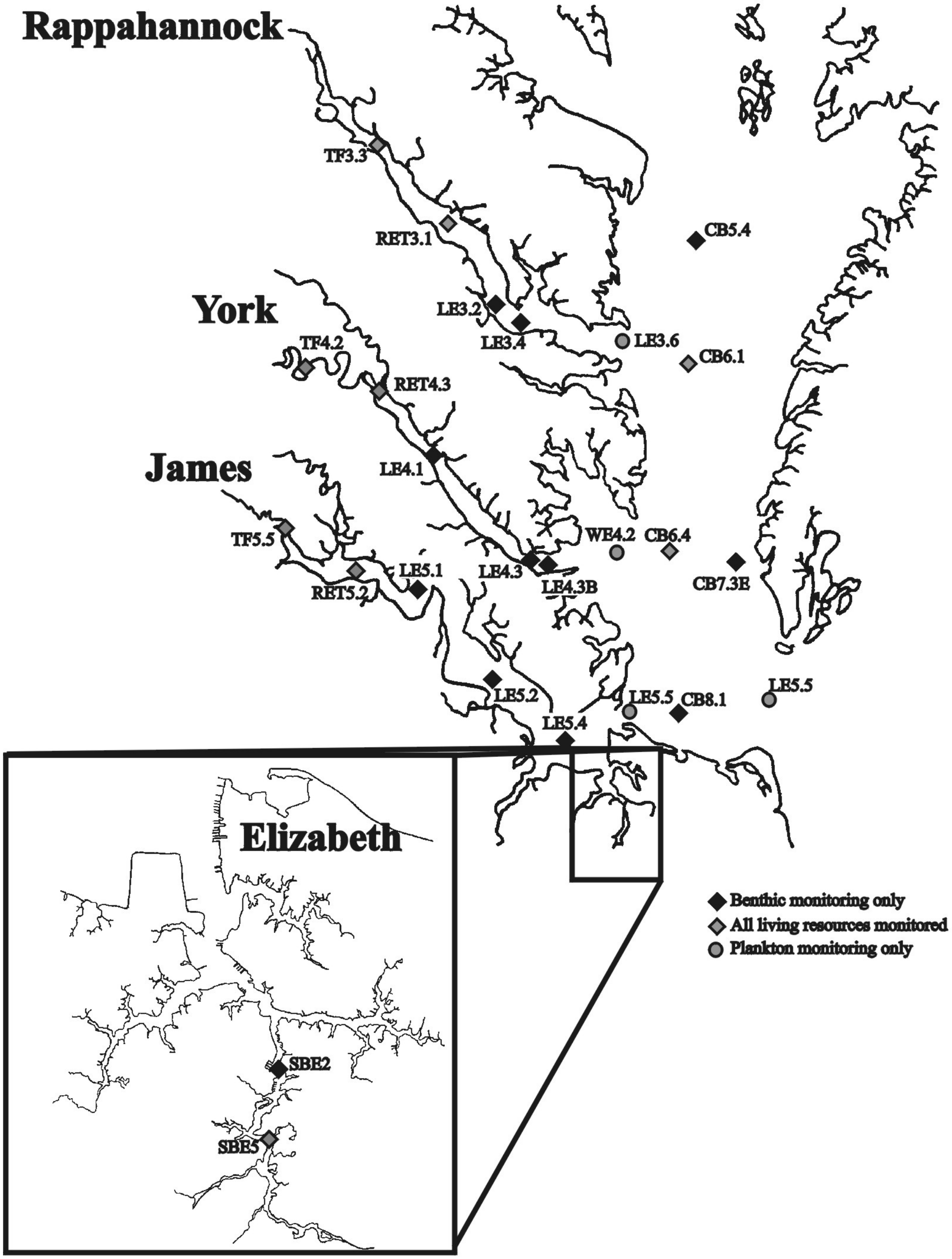


Figure 2-3. Location of living resource monitoring stations in the Virginia tributaries and the Lower Chesapeake Bay Mainstem.

Table 2-1. **Definitions of seasonal time periods for status and trend analyses conducted for of the tidal monitoring programs. A "x" indicates the analysis was conducted for the season and parameter group combination while a "-" indicates that no analysis was conducted. Note that benthic status and trend analyses were conducted on data collected from June 15 through September 30.**

		Water Quality			Plankton		Benthos	
Season	**Definition**	**Status**	**Trend**	**SAV Goals**	**Status**	**Trend**	**Status**	**Trend**
Annual	Entire year	x	x	-	x	x	-	-
SAV1	March through May and September through November	x	x	x	x	x	-	-
SAV2	April through October	x	x	-	x	x	-	-
Summer1	June through September	x	x	-	x	x	x*	x*
Summer2	July through September	x	x	-	x	x	-	-
Spring1	March through May	x	x	-	x	x	-	-
Spring2	April through June	x	x	-	x	x	-	-
Fall	October through December	-	x	-	x	x	-	-
Winter	January and February	-	x	-	x	x	-	-

Table 2-2. **Habitat requirements for growth and survival of SAV (from Batuik el al., 1992; 2000).**

Salinity Regime	**SAV Growth Season**	**Percent Light at Leaf**	**Total Suspended Solids (mg/l)**	**Chlorophyll *a* (µg/l)**	**Dissolved Inorganic Nitrogen (mg/l)**	**Dissolved Inorganic Phosphorus (mg/l)**
Tidal Freshwater	Apr.-Oct.	<2	<15	<15	none	<0.02
Oligohaline	Apr.- Oct.	<2	<15	<15	none	<0.02
Mesohaline	Apr.-Oct.	<1.5	<15	<15	<0.15	<0.01
Polyhaline	Mar.-May,	<1.5	<15	<15	<0.15	<0.01

Chapter 3. Water Quality Method Correction Analyses

I. Method Change Effects

This chapter summarizes the effects of the changes in analytical methods for estimating concentrations of total nitrogen, dissolved inorganic nitrogen, total phosphorus and dissolved inorganic phosphorus implemented by the Department of Environmental Quality in 1994. Significant method effects were detected for both total nitrogen and total phosphorus in all salinity regimes. Correction factors for total nitrogen and total phosphorus indicate that the changes in analytical methods for these two parameters resulted in data that were lower in all salinity regimes after 1994. Significant method change effects were detected for dissolved inorganic nitrogen in the mesohaline (an increase in concentration after 1994) and the polyhaline (a decrease after 1994) salinity regimes. Significant method change effects were detected for dissolved inorganic phosphorus in all salinity regimes. Correction factors for this parameter indicate that the changes in analytical methods resulted in data that were lower in the tidal freshwater and oligohaline salinity regimes and higher in the mesohaline and polyhaline salinity regimes after 1994 (Table 3-1).

II. Trend Analysis Comparison

A. James River

Previous investigations using data collected through 2000 indicated widespread decreasing trends throughout the James River. However, addition of data collected in 2001 and application of method corrections for this parameter resulted in either the disappearance or reversal of the majority of these trends. The only improving trends which persisted in the corrected data set were detected in the Upper James River (JMSTF, surface and bottom) and the Chickahominy River (CHKOH, surface only) (Table 3-2).

In contrast to total nitrogen, trends in dissolved inorganic nitrogen for the "corrected" data were similar to those previously detected with the exception of the disappearance of two improving trends in the Lower James River (JMSMH) (Table 3-2).

Nearly all of the previously detected improving trends in total phosphorus disappeared or were reversed after application of the method corrections and addition of the data collected in 2001. In addition, degrading trends in "corrected" total phosphorus were detected in the Middle James River (JMSOH) and the Chickahominy River (CHKOH). The improving trends in both surface and bottom total phosphorus persisted in the Upper James River (JMSTF) despite the method correction and addition of the data collected in 2001 (Table 3-3).

The direction or absence of trends in dissolved inorganic phosphorus persisted within all tidal freshwater and oligohaline segments. However, in the Lower James River (JMSMH) and James River Mouth (JMSPH) previously detected improving trends reversed and disappeared, respectively, as a result of additional data from 2001 and application of the method corrections (Table 3-2).

B. Elizabeth River

For the majority of segments, no method corrections were applied and as a result few changes in pattern were observed. However, in the Elizabeth River Mouth previously detected improving trends reversed or disappeared (Table 3-3).

C. York River

As a result of the method corrections and addition of data collected in 2001, most of the previously detected improving trends in total nitrogen in the York River either reversed or disappeared. In addition, degrading trends in both surface and bottom total nitrogen appeared in the Lower Pamunkey River (segment PMKOH) and the Lower Mattaponi River (segment MPNOH) while degrading trends in bottom total nitrogen appeared in the Middle York River (segment YRKPH) and Lower York River (segment YRKPH) (Table 3-4).

Few trends in dissolved inorganic nitrogen were detected in the York River through 2000. This pattern persisted despite the addition of data for 2001 and the application of the method corrections.
Two improving trends in dissolved inorganic nitrogen were previously detected but both disappeared in the method “corrected” data (Table 3-4).

As a result of the addition of data collected in 2001 and the application of the method corrections, degrading trends in total phosphorus appeared in nearly all segments of the York River and a previously detected improving trend in the Lower York River was reversed (Table 3-4).

In contrast, previously detected degrading trends in dissolved inorganic phosphorus in the Pamunkey and Mattaponi Rivers disappeared as a result of the addition of data collected in 2001 and the application of the method corrections. Two degrading trends in dissolved inorganic phosphorus appeared in the Middle York River (segment JMSOH) (Table 3-4).

D. Rappahannock River

As a result of the addition of the data collected in 2001 and the application of the method corrections, nearly all improving trends in total nitrogen in the Rappahannock River either disappeared or were reversed. In addition, two degrading trends in bottom total nitrogen appeared in the Middle Rappahannock River (segment RPPOH) and the Corrotoman River (CRRMH) (Table 3-5).

Previously detected improving trends in dissolved inorganic nitrogen in the Middle Rappahannock River (segment RPPOH) disappeared after addition of the data collected in 2001 and the application of the method corrections. A degrading trend in bottom dissolved inorganic nitrogen appeared in the Upper Rappahannock River (segment JMSTF) (Table 3-5).

Although few trends in total phosphorus were detected in the data collected through 2000, the addition of the data collected in 2001 and the application of the method corrections resulted in the appearance of widespread degrading trends in both surface and bottom total phosphorus (Table 3-5).

There were no changes in trend analysis results for dissolved inorganic phosphorus as a result of the addition of the data collected in 2001 and the application of the method corrections (Table 3-5).

Table 3-1. Method change correction factors for each salinity regime. An “ns” indicates the method change effect was not significant (p>0.05). A “-“ indicates that no method change analysis was performed for the parameter indicated. In the salinity regime column, an TF =Tidal freshwater, O =Oligohaline, M=Mesohaline, and P=Polyhaline.

Salinity Zone	Total Nitrogen	Dissolved Inorganic Nitrogen	Dissolved Inorganic Phosphorus	Total Phosphorus
TF	0.8894	ns	1.3748	0.8000
O	0.7999	ns	1.0661	0.7821
M	0.8231	1.1003	0.8131	0.8424
P	0.7342	0.8209	0.6004	0.7115

Table 3-2. Changes in the pattern of water quality trends between 2001 and 2000 analyses for the James River. Dark shading indicates a previously improving trend that changes to a degrading trend. Light shading indicates either (1) a previous improving trend that changes to no trend (Disappearance improving), (2) or a previous no trend changing to a degrading trend (Appearance degrading).

	Appomattox	Upper James	Chickahominy	Middle James	Lower James	River Mouth
STN	Disappearance Improving	Same Improving	Same Improving	Disappearance Improving	Reversal Degrading	Reversal Degrading
BTN	Disappearance Improving	Same Improving	Disappearance Improving	Reversal Degrading	Reversal Degrading	Appearance Degrading
SDIN	Same NS	Same Improving	Same NS	Same Improving	Disappearance Improving	Same NS
BDIN	Same NS	Same Improving	Same NS	Same Improving	Disappearance Improving	Same NS
STP	Disappearance Improving	Same Improving	Appearance Degrading	Appearance Degrading	Reversal Degrading	Disappearance Improving
BTP	Reversal Degrading	Same Improving	Appearance Degrading	Appearance Degrading	Appearance Degrading	Disappearance Improving
SDIP	Same Improving	Same Improving	Same NS	Same NS	Reversal Degrading	Disappearance Improving
BDIP	Same Improving	Same Improving	Same NS	Same NS	Reversal Degrading	Disappearance Improving

Table 3-3. Changes in the pattern of water quality trends between 2001 and 2000 analyses for the Elizabeth River. See Table III-2 for shading explanation.

	Western Branch	Southern Branch	Eastern Branch	Elizabeth River Mainstem NStem	Elizabeth River Mouth
STN	Same Improving	Same Improving	Same Improving	Appearance Improving	Reversal Degrading
BTN	Same Improving	Appearance Improving	Same Improving	Appearance Improving	Reversal Degrading
SDIN	Same Improving	Same Improving	Same Improving	Same Improving	Disappearance Improving
BDIN	Same Improving	Same Improving	Same Improving	Same Improving	Disappearance Improving
STP	Same Improving	Same Improving	Same Improving	Same Improving	Reversal Degrading
BTP	Same Improving	Same Improving	Same Improving	Same Improving	Reversal Degrading
SDIP	Same Improving	Same Improving	Same Improving	Same Improving	Disappearance Improving
BDIP	Same Improving	Same Improving	Same Improving	Same Improving	Disappearance Improving

Table 3-4. Changes in the pattern of water quality trends between 2001 and 2000 analyses for the York River. See Table III-2 for shading explanation.

	Upper Pamunkey	Lower Pamunkey	Upper Mattaponi	Lower Mattaponi	Middle York	Lower York	Mobjack Bay
STN	Disappearance Improving	Appearance Degrading	Disappearance Improving	Appearance Degrading	Reversal Degrading	Reversal Degrading	Disappearance Improving
BTN	Disappearance Improving	Appearance Degrading	Same Improving	Appearance Degrading	Appearance Degrading	Appearance Degrading	Reversal Degrading
SDIN	Same NS	Same NS	Same NS	Same NS	Disappearance Improving	Same NS	Same NS
BDIN	Same NS	Same NS	Same NS	Same NS	Same NS	Same NS	Disappearance Improving
STP	Appearance Degrading	Appearance Degrading	Appearance Degrading	Appearance Degrading	Appearance Degrading	Appearance Degrading	Appearance Degrading
BTP	Appearance Degrading	Appearance Degrading	Appearance Degrading	Appearance Degrading	Same Degrading	Reversal Degrading	Same NS
SDIP	Disappearance Degrading	Disappearance Degrading	Disappearance Degrading	Disappearance Degrading	Appearance Degrading	Same NS	Same NS
BDIP	Disappearance Degrading	Same NS	Disappearance Degrading	Disappearance Degrading	Appearance Degrading	Same NS	Same NS

Table 3-5. Changes in the pattern of water quality trends between 2001 and 2000 analyses for the Rappahannock River. See Table III-2 for shading explanation.

	Upper Rappahannock	Middle Rappahannock	Lower Rappahannock	Corrotoman
STN	Disappearance Improving	Disappearance Improving	Disappearance Improving	Reversal Degrading
BTN	Same Improving	Appearance Degrading	Disappearance Improving	Appearance Degrading
SDIN	Same NS	Disappearance Improving	Same NS	Same NS
BDIN	Appearance Degrading	Disappearance Improving	Same NS	Same NS
STP	Same NS	Appearance Degrading	Appearance Degrading	Appearance Degrading
BTP	Disappearance Improving	Appearance Degrading	Appearance Degrading	Same Degrading
SDIP	Same NS	Same NS	Same NS	Same NS
BDIP	Same NS	Same NS	Same NS	Same NS

Chapter 4. York River Basin

I. Executive Summary

A. Summary of Basin Characteristics

The York River watershed consists of approximately 8,468 km^2. Forested and agricultural lands are the most abundant in the watershed accounting for nearly 61% and 21% of the total land cover in the basin, respectively. All other land use types each account for less than 10% of the remaining land in the basin. Approximately 6,062 km of the over 16,117 km of streambanks and shoreline within the watershed has a 30 m minimum riparian forest buffer. The York River watershed has an estimated human population of 372,488 with an overall population density of 47.63 individuals per km^2. Major population centers within the watershed include Ashland, Gloucester Point, Hampton, and West Point.

In 1999, agricultural non-point sources accounted for 1,446,051 kg/yr (37%) of total nitrogen loadings to the York River while urban non-point, mixed open non-point and point sources in combination account for 1,677,837 kg/yr (42%) in approximately equal proportions. Agricultural non-point sources accounted for 144,696 kg/yr (40%) of total phosphorus loadings while mixed open and point sources accounted for 153,768 kg/yr (42%). With the exception of one year, point source loadings of total nitrogen increased every year from 1987 through 1999. Although total phosphorus loadings substantially decreased immediately following the phosphate ban, loadings increased every year from 1993 to 1999.

Daily freshwater flow at the fall-line in the Mattaponi ranged from a minimum of 0.02 m^3/sec to a maximum of 220.31 m^3/sec for the period of January 1, 1985 through December 31, 2001. Grand mean flow at the fall-line was 14.22 m^3/sec. Daily freshwater flow at the fall-line in the Pamunkey was higher ranging from a minimum of 1.33 m^3/sec to a maximum of 577.66 m^3/sec and with an grand mean flow of 27.78 m^3/sec. Figures 4-1 to 4-9 provide summary information of basin characteristics of the York River.

B. Summary of Status and Long Term Trends

Figures 4-10 to 4-13 provide summaries of water quality status and trend analyses for the York River. Status of surface and bottom total and dissolved inorganic nitrogen was either good or fair in every segment of the York River. Status of surface and bottom total and dissolved inorganic phosphorus was either poor or fair in all segments except for (1) surface and bottom total phosphorus in the Upper Pamunkey River, (2) the Upper Mattaponi River (segments PMKTF and MPNTF) and for bottom dissolved inorganic Mobjack Bay (MOBPH). Status for surface chlorophyll *a*, surface and bottom total suspended solids and secchi depth was fair or poor in most segments. Status for bottom dissolved oxygen was good in all segments of the York River (Figures V9-V10). In the Pamunkey River and the Mattaponi River segments, the majority of parameters either did not meet the SAV habitat requirement or were borderline. In the Middle York River (YRKMH) only dissolved inorganic nitrogen met the SAV habitat requirements. In contrast, in the Lower York River (YRKPH) and Mobjack Bay (MOBPH) nearly all parameters met the

SAV criteria.

Widespread degrading trends were detected in "method corrected" surface and bottom total nitrogen and total phosphorus in the York River. Degrading trends in total suspended solids and/or water clarity (secchi depth) were detected in the Middle York River (YRKMH), Lower York River (YRKPH) and Mobjack Bay (MOBPH). Improving trends in dissolved oxygen were detected in the Lower Mattaponi River (MPNOH), the Middle York River (YRKMH) and Mobjack Bay (MOBPH). Degrading trends in surface chlorophyll *a* were detected in the Lower Pamunkey River and Mattaponi River (segments PMKOH and MPNOH) and the Middle York River (Figures V9-V10).

For data collected after the method correction (1995-2001), degrading trends in surface and bottom total nitrogen were detected in the Upper and Lower Pamunkey River, respectively. Degrading trends in surface or bottom total phosphorus were detected in the Upper Pamunkey River (PMKTF), the Upper Mattaponi River (MPNTF), the Middle York River (YRKMH) and the Lower York River (YRKPH). Improving trends in surface total nitrogen and surface and bottom total phosphorus were detected in Mobjack Bay (MOBPH). Degrading trends in total suspended solids and/or water clarity (secchi depth) were detected in the Upper Pamunkey River, the Upper Mattaponi River, the Middle York River and Lower York River.

Figures 4-14 to 4-17 provide summaries of living resource status and trend analyses for the York River. There are numerous degrading phytoplankton trends in the tidal regions of the York River. Total phytoplankton abundance and biomass are increasing, with negative trends in the abundance and biomass of the cyanobacteria at all phytoplankton stations. In addition, the status of dinoflagellate biomass is poor, with no significant trends for this category at this time. The diatom status at the tidal freshwater station is also poor, with no significant trend indicated at that site, but with favorable trends for diatom biomass present downstream. Favorable status (fair to good) and trends are present in the river for productivity, chlorophyte biomass, autotrophic picoplankton biomass, and cryptophyte biomass. No significant change is indicated for the cell biomass to cell abundance ratio (although with poor status), and the prokaryote to eukaryote ratio (with the status of good). Of concern are also the number of seasonal blooms of dinoflagellates occurring in the lower reaches of this river, which in the past have included toxin producing species.

Degrading trends in rotifer abundance were detected in the mesohaline York River (YRKMH) and polyhaline York River (YRKPH). Status of rotifer abundance was poor in both of these segments but good in the tidal freshwater Pamunkey (PMKTF). There was another degrading trend in the polyhaline segment, that of copepod nauplii abundance. Status of this parameter ranged from poor fair in the tidal freshwater Pamunkey River (PMKTF) to poor in the Mobjack Bay (MOBPH) and good in the mesohaline York River (YRKMH).

In the tidal freshwater Pamunkey River (PMKTF) benthic community status was good with improving trends in species diversity, abundance and biomass. In the mesohaline York River (YRKMH), benthic community status varied from good to degraded and degrading trends in the B-IBI, species diversity, and pollution sensitive species were detected at both stations. In the Lower York River (YRKPH), benthic community status ranged from degraded at station LE4.3B to good at station LE4.3. The degraded status at station LE4.3B was related to the short-term hypoxic events that occur at this station.

C. Summary of Major Issues in the Basin

With respect to nutrients, the major problem in the York River appears to be the status of all phosphorus parameters which was poor or fair in the majority of segments. Poor status was coupled with degrading trends in total phosphorus but it is unclear whether these trends were the result of a real change in concentration or an artifact of the method correction procedure. Scatterplots of total phosphorus concentrations in most segments appear to suggest that the statistical method correction procedure functioned properly. The degrading trends in total phosphorus detected in the data after the method change (1995-2001) also appear to support this observation.

Water clarity also appears to be a widespread problem in the York River as was indicated by the fair and poor status of this parameter throughout the tributary. In addition, several water clarity parameters either did not meet SAV habitat requirements or were borderline in many segments in this river, particularly in the upper reaches of the estuary. Although the status of water clarity was good and SAV habitat requirements for water clarity parameters were met in the Lower York River and Mobjack Bay, degrading trends in total suspended solids and/or water clarity (secchi depth) were detected in these segments.

Improving trends in dissolved oxygen were detected in the Lower Mattaponi River (MPNOH), the Middle York River (YRKMH) and Mobjack Bay (MOBPH). Degrading trends in surface chlorophyll *a* were detected in the Lower Pamunkey River and Mattaponi River (segments PMKOH and MPNOH) and the Middle York River (YRKMH).

Continued trends of increased cyanobacteria abundance and biomass present an unfavorable pattern along with the poor status of dinoflagellates and their frequent bloom development in the lower river segment; however, favorable diatom populations remain dominant in the river basin, although signs of unfavorable status and conditions are present at the tidal freshwater site. Degrading trends in rotifer abundance were detected in Mobjack Bay and the mesohaline York River. These degrading trends are possibly related to degrading trends in nitrogen, phosphorus, and water clarity indicators, and a decreasing trend in salinity. Both benthic monitoring stations in the mesohaline York River showed degrading trends in the B-IBI. Status of benthic communities in the deep water areas of the polyhaline York River (YRKPH) was degraded primarily as a result of periodic hypoxic events.

II. Management Recommendations

The cause of the poor status and trends in phosphorus is uncertain. It seems likely that these problems are related at least in part due to the increase in recent years of point source phosphorus loadings in both the

Pamunkey and Mattaponi Rivers. The source of water clarity problem is unclear. It may be the result of increased sediment input from a variety of sources. Alternatively, the decrease in water clarity may be caused by an increase in the abundance of phytoplankton in the water column. Chlorophyll *a* levels in the mesohaline York River are the highest of all Virginia's tidal waters. Degrading (increasing) trends in cyanobacterial abundance were detected at all stations monitored in the York River and degrading trends in surface chlorophyll *a* concentrations were also detected in two segments of the York River. The increases in point source nitrogen and phosphorus loads observed in the Pamunkey and Mattaponi rivers could contribute to potential increases in phytoplankton. It is recommended that additional point source controls be initiated in these two tributaries to alleviate this potential problem.

Freshwater input to both the Pamunkey and Mattaponi was lower during the past three years than in previous years. Low flows could also adversely affect both nutrient levels and water clarity by reducing the flushing rates in the river such that nutrient, sediment and/or phytoplankton concentrations increase as a result.

A more thorough investigation of existing data sets may help to identify potential sources of the water clarity problems. An analysis of trends in both the fixed and volatile components of total suspended solids along with a statistical analysis of potential relationships between secchi depth and various environmental factors such as suspend solids concentrations, flow regime and phytoplankton concentrations is recommended. Nutrient and water clarity problems in the York River may explain the degrading trends in microzooplankton and mesozooplankton indicators.

With respect to benthic communities problems were located in the mesohaline and polyhaline York River. In the mesohaline York River benthic community status was either degraded or marginal (at stations RET4.3 and LE4.1, respectively) or evidence suggests that benthic communities are degrading as evidenced by degrading trends in the B-IBI and other indicators at station RET4.3. Additional information is required before conclusions regarding management actions related to the benthos can be made. In the polyhaline York River degraded benthic communities were found at station LE4.3B where short-term hypoxic events occur on a regular basis. The cause of anoxic events at this station may be related excessive decomposition of organic material by bacteria, high respiration by phytoplankton, stratification of the water column due to salinity or temperature effects or a combination of these factors.

III. Overview of Basin Characteristics

The York River watershed consists of approximately 8,468 km^2 and extends 225 km from the headwaters of the Pamunkey and Mattaponi rivers in Orange and Louisa counties to Yorktown, Virginia where it empties into Chesapeake Bay. Human population in the York River watershed increased from 324,036 individuals in 1990 to 372,488 in 2000 (Figure 4-1a) and is projected to reach over 450,000 by 2020. Overall population density was 47.63 individuals per km^2. Population density within the York River watershed ranged from 20.59 individuals per km^2 within the Mattaponi sub-watersheds to over 500 individuals per km^2 in the Poquoson (lower portion of the York River) sub-watershed (Figure 4-1b). Major population centers within the watershed include Ashland, Gloucester Point, Hampton, and West Point.

Forested and agricultural lands are the most abundant land-use types in the watershed accounting for nearly 61% and 21% of the total land cover in the basin, respectively. All other land use types each account for less than 10% of the remaining land in the basin. Approximately 6,062 km of the over 16,117 km of streambanks and shoreline within the watershed has a 30 m minimum riparian forest buffer. Forested land decreases substantial moving downstream from the Pamunkey and Mattaponi rivers both in terms of total area and percent of the total area within the sub-watersheds while urban land increases downstream (Figures 4-2a-b).

Agricultural non-point sources accounted for 1,446,051 kg/yr (37%) of total nitrogen loadings to the York River while urban non-point, mixed open non-point and point sources in combination account for 1,677,837 kg/yr (42%) in approximately equal proportions (Figure 4-3a). Agricultural non-point sources accounted for 144,696 kg/yr (40%) of total phosphorus loadings while mixed open and point sources accounted for 153,768 kg/yr (42%) in nearly equal amounts (Figure 4-3b). In 1999, the primary source of sediment loads to the York River is non-point run-off from agricultural and forest lands which account for 63,503,300 kg/yr (54%) and 29,937,270 kg/yr (25%) of the total load, respectively. The remaining potential sources of sediment loads contribute little or no amount to the total load (Figure 4-3c).

With the exception of one year, point source loadings of total nitrogen increased every year from 1987 through 1999. Although total phosphorus loadings substantially decreased immediately following the phosphate ban, loadings increased every year from 1993 to 1999 (Figure 4-4a-b). In 1999, point source loads of both total nitrogen and total phosphorus were concentrated in the Pamunkey River, Mattaponi River,and Poquoson sub-watersheds (Figure 4-5a-b). Point source total nitrogen loads to these three sub-watersheds showed a fairly consistent increase from 1987 to 1999 (Figure 4-6). Following the phosphate ban, point source total phosphorus loads to the Mobjack Bay and Poquoson sub-watersheds declined substantially and have remained at consistently low levels since 1989. In contrast, total phosphorus loads in the Pamunkey and Mattaponi rivers showed and initial decline following the ban followed by a increase beginning in 1993 (Figure 4-7).

Daily freshwater flow at the fall-line in the Mattaponi ranged from a minimum of 0.02 m^3/sec to a maximum of 220.31 m^3/sec for the period of January 1, 1985 through December 31, 2001. Grand mean flow at the fall-line was 14.22 m^3/sec. Daily freshwater flow at the fall-line in the Pamunkey was higher ranging from a minimum of 1.33 m^3/sec to a maximum of 577.66 m^3/sec and with a grand mean of 27.78 m^3/sec. Peaks in monthly mean freshwater flow for the last three years in both the Pamunkey and Mattaponi rivers were less than previous years peaks (Figure 8a-b). Annual mean flow during the last three years in both the Pamunkey and Mattaponi rivers was lower than the grand mean flow for each of these tributaries (Figure 9a-b).

IV. Overview of Monitoring Results

Status of surface and bottom total and dissolved inorganic nitrogen was either good or fair in every segment of the York River. Status of surface and bottom total and dissolved inorganic phosphorus was either poor or fair in all segments except for surface and bottom total phosphorus and dissolved inorganic phosphorus was either poor or fair in all segments except for surface and bottom total phosphorus in the Upper Pamunkey River and the Upper Mattaponi River (segments PMKTF and MPNTF) and for surface and bottom dissolved inorganic Mobjack Bay (MOBPH). Status for surface chlorophyll *a*, surface and bottom total suspended solids and secchi depth was fair or poor in most segments (Figure 4-10 and 4-11). Status for bottom dissolved oxygen was good in all segments of the York River. In the Pamunkey River and the Mattaponi River segments the majority of parameters either did not meet the SAV habitat requirement or were borderline. In the Middle York River (YRKMH) only dissolved inorganic nitrogen met the SAV habitat requirements. In contrast, in the Lower York River (YRKPH) and Mobjack Bay (MOBPH) nearly all parameters met the SAV criteria.

Degrading trends in total suspended solids and/or water clarity (secchi depth) were detected in the Middle York River (YRKMH), Lower York River (YRKPH) and Mobjack Bay (MOBPH). Improving trends in dissolved oxygen were detected in the Lower Mattaponi River (MPNOH), the Middle York River (YRKMH) and Mobjack Bay (MOBPH). Degrading trends in surface chlorophyll *a* were detected in the Lower Pamunkey River and Mattaponi River (segments PMKOH and MPNOH) and the Middle York River. Widespread degrading trends were detected in “method corrected” surface and bottom total nitrogen and total phosphorus in the York River (Figure 4-10 and 4-11).

For data collected after the method correction (1995-2001), degrading trends in surface and bottom total nitrogen were detected in the Upper and Lower Pamunkey River, respectively. Degrading trends in surface or bottom total phosphorus were detected in the Upper Pamunkey River (PMKTF), the Upper Mattaponi River (MPNTF), the Middle York River (YRKMH) and the Lower York River (YRKPH). Improving trends in surface total nitrogen and surface and bottom total phosphorus were detected in Mobjack Bay (MOBPH). Degrading trends in total suspended solids and/or water clarity (secchi depth) were detected in the Upper Pamunkey River, the Upper Mattaponi River, the Middle York River and Lower York River (Figure 4-12 and 4-13).

A major concern regarding the phytoplankton composition is the poor status prevailing with the dinoflagellates and the increasing trends associated with cyanobacteria abundance and biomass. This condition is associated with the frequent summer blooms of dinoflagellates in the lower river segment (Figure 4-14). The dominant phytoplankton throughout the river are the diatoms, chlorophytes, and cryptophytes, which are also associated with increased presence of the cyanobacteria. Downstream the freshwater diatoms are replaced by estuarine diatoms and dinoflagellates that are common to the Bay waters.

Microzooplankton monitoring results indicate a continued degradation in the middle York and mouth in terms of increasing rotifer abundance. These degrading trends are associated with degrading nutrient and water clarity trends and decreasing salinity. In addition, a degrading trend in copepod nauplii abundance that disappeared last year but was evident in previous years, reappeared this year indicating continued water quality problems in Mobjack Bay (Figure 4-15). A change in methodology prevents a critical review of the status and trends in the mesozooplankton monitoring results. However, plots of raw data indicate that relative abundances and numbers of species of mesozooplankton are mostly unchanged from last year. The related water quality trends (mostly secchi depth and salinity) have not changed substantially from last year and therefore it is likely that the general mesozooplankton status and trends (Figure 4-16) have not changed much from last year. Therefore, it is likely that mesozooplankton diversity continues to decline in the lower part of the basin while the upper part of the basin should have continued improving trends.

In the tidal freshwater Pamunkey River (PMKTF) benthic community status was good with improving trends in species diversity, abundance and biomass. In the mesohaline York River (YRKMH), benthic community status varied from good to degraded and degrading trends in the B-IBI, species diversity, and pollution sensitive species were detected at both stations. In the Lower York River (YRKPH), benthic community status ranged from degraded at station LE4.3B to good at station LE4.3. The degraded status at station LE4.3B was related to the short-term hypoxic events that occur at this station (Figure 4-17).

V. Detailed Overview of Status and Trends

A. Fall-Line

In the Pamunkey River at Hanover, degrading trends in flow adjusted and flow weighted concentrations total nitrogen, nitrates-nitrites (fixed), total phosphorus, and dissolved inorganic phosphorus. Degrading trends were also detected in loadings of dissolved inorganic phosphorus and total suspended solids at this station (Table 4-1). A decreasing trend in freshwater flow were detected at this station (Table 4-1).

In the Mattaponi River near Beulahville, improving trends in flow adjusted concentrations, flow weighted concentrations and loadings of total nitrogen, nitrates-nitrites, and total phosphorus were detected. Improving trends were also detected in loadings of dissolved inorganic phosphorus and in flow weighted concentrations and loadings of total suspended solids at this station (Table 4-1). In the North Anna River at Doswell, improving trends in flow adjusted concentrations, flow weighted concentrations and loadings of ammonia and flow weighted concentrations and loadings of nitrates-nitrites and nitrates were detected at this station. Improving trends in flow adjusted concentrations, flow weighted concentrations and loadings of total phosphorus were detected at this station. Degrading trends in flow adjusted and flow weighted concentrations of total Kjeldahl nitrogen and flow adjusted total suspended solids (Table 4-1).

B. Mobjack Bay (MOBPH)

1. Water quality for living resources

Status was fair to good for all but one of the water quality parameters in Mobjack Bay (Table 4-2). Status was good for surface total nitrogen and bottom total phosphorus, surface and bottom dissolved inorganic nitrogen and dissolved inorganic phosphorus, surface chlorophyll *a*, bottom total suspended solids, and bottom dissolved oxygen. Status was fair for bottom total nitrogen and surface total phosphorus, and surface total suspended solids. Status was poor for secchi depth. There were no significant trends for most parameters (Table 4-3), but degrading trends were detected for bottom total nitrogen, surface total phosphorus, surface total suspended solids, and secchi depth. Bottom dissolved oxygen showed an improving trend. Surface and bottom water salinities showed an decreasing trend.

2. Water quality for SAV

Relative status of most parameters was good except for surface total suspended solids and secchi depth for which the relative status was fair and good, respectively. All parameters either failed to meet the SAV habitat requirements or were borderline (Table 4-4). Degrading trends were detected in surface total phosphorus, total suspended solids, secchi depth, and the percentage of light at the leaf surface at 1.0 meters (Table 4-5).

3. Water quality trends for 1995-2001

Improving trends in bottom total nitrogen, surface and bottom total phosphorus, and surface and bottom total suspended solids were detected in this segment. Decreasing trends in bottom water temperature and bottom salinity were also detected in this segment (Figure 4-12 and 4-13).

4. Living resources

The total phytoplankton biomass, species diversity, and biomass to cell abundance ratio status were poor, with none having any trends. No trends were also associated with total phytoplankton abundance, although there were increasing biomass trends present for diatom and chlorophyte biomass. In contrast, the autotrophic picoplankton biomass trend was favorably decreasing. There were specific degrading trends in cyanobacteria biomass and abundance, along with poor status (but no trend) for dinoflagellate biomass. Also, the prokaryote to eukaryote cell biomass ratio did not show a trend even with the increase in cyanobacteria abundance. In general, there are numerous degrading trends in this region that are accompanied by seasonal blooms of dinoflagellates (Figure 4-14). Past dinoflagellate blooms have included toxic species, but these have not resulted in any major toxic event to date.

Degrading annual trends are evident in microzooplankton parameters as an increase in rotifer abundance and a decrease in copepod nauplii abundance. These parameters also had poor status. This is likely associated with poor nutrient and water clarity parameters and declining salinity (Figure 4-15).

Benthic monitoring is not conducted within this segment and it is recommended that monitoring of benthic communities be conducted within this segment (Figure 4-17).

C. Polyhaline York River (YRKPH- Lower York)

1. Water quality for living resources

Status was poor for many of the water quality parameters in the Lower York segment (Table 4-6): surface and bottom total phosphorus, surface and bottom dissolved inorganic phosphorus, surface chlorophyll *a*, bottom total suspended solids, and secchi depth. Status was fair for bottom total nitrogen, surface total suspended solids, and bottom dissolved oxygen. Status was good for surface total nitrogen, and surface and bottom dissolved inorganic nitrogen. There were no significant trends for most parameters in the Lower York segment (Table 4-7), but degrading trends were detected for surface and bottom total nitrogen and total phosphorus, bottom total suspended solids, and secchi depth. No parameters showed an improving trend.

2. Water quality for SAV

Relative status was good for surface total nitrogen and dissolved inorganic nitrogen, fair for surface total suspended solids and chlorophyll *a*, and poor for surface total phosphorus, dissolved inorganic phosphorus and secchi depth. Most parameters met the SAV habitat requirements or were borderline except for the percentage of light at the leaf surface at 1.0 meters (Table 4-8). Degrading trends were detected in surface total nitrogen, total phosphorus, secchi depth, and the percentage of light at the leaf surface at both 0.5 and 1.0 meters (Table 4-9).

3. Water quality trends for 1995-2001

Degrading trends in surface total phosphorus and secchi depth were detected in this segment along with an increasing trend in surface salinity (Figure 4-12 and 4-13).

4. Living resources

Phytoplankton and zooplankton monitoring is not conducted within this segment.

Benthic community status was degraded. The degraded status was found at the station in the channel subjected to short-term hypoxia (LE4.3B)while the station with good status was located on the shoal (LE4.3) (Figure 4-17).

D. Mesohaline York River (YRKMH - Middle York)

1. Water quality for living resources

Status was poor for most of the water quality parameters in the Middle York segment (Table 4-10): surface and bottom total phosphorus, surface and bottom dissolved inorganic phosphorus, surface chlorophyll *a*, surface and bottom total suspended solids, and secchi depth. Status was fair for bottom total nitrogen. Status was good for surface total nitrogen, surface and bottom dissolved inorganic nitrogen, and bottom dissolved oxygen. There were degrading trends for most parameters in the Middle York segment (Table 4-11): surface and bottom total nitrogen and total phosphorus, surface and bottom dissolved inorganic phosphorus, surface chlorophyll *a*, and bottom total suspended solids. Only bottom dissolved oxygen showed an improving trend.

2. Water quality for SAV

Relative status was good for surface total nitrogen and dissolved inorganic nitrogen but poor for all other parameters. Most parameters either failed to meet the SAV habitat requirements or were borderline except for surface dissolved inorganic nitrogen (Table 4-12). Degrading trends in surface total nitrogen, total phosphorus, dissolved inorganic phosphorus, and chlorophyll *a* were detected in this segment while improving trends were detected in the percentage of light at the leaf surface at both 0.5 and 1.0 meters (Table 4-13).

3. Water quality trends for 1995-2001

Degrading trends in bottom total phosphorus, surface and bottom dissolved inorganic phosphorus, surface chlorophyll *a* and surface total suspended solids. Increasing trends in surface and bottom salinity were also detected in this segment (Figures 4-12 and 4-13).

4. Living resources

The total phytoplankton biomass and abundance have increasing trends with biomass and the biomass to cell abundance ratio, both considered poor, with fair status for species diversity. Favorable status and trends are associated with diatom, chlorophyte, and cryptophyte biomass. Autotrophic picoplankton status is also good, with a favorable decreasing trend in biomass. In contrast, dinoflagellate status is poor (with no trend) and cyanobacteria biomass (status poor) and abundance showing degrading trends (Figure 4-14). Indications that these relationships have not yet greatly influenced the trophic phytoplankton status is the good status and lack of a trend in the prokaryote to eukaryote cell ratio.

Annual trends are degrading for microzooplankton as seen in an increase in rotifer abundance and poor rotifer abundance status. However, copepod nauplii abundance status continues to be good with no reappearance of a degradging trend, indicating some improvement for this region (Figure 4-15).

Benthic community status varied from marginal to degraded and both benthic monitoring stations showed degrading trends in the B-IBI, species diversity and pollution sensitive species (Figure 4-17).

E. Oligohaline Pamunkey River (PMKOH - Lower Pamunkey)

1. Water quality for living resources

Status was poor for about half of the water quality parameters in the Lower Pamunkey segment (Table 4-14): bottom total phosphorus, surface and bottom dissolved inorganic phosphorus, and surface and bottom total suspended solids. Status was good for surface and bottom total nitrogen, surface and bottom dissolved inorganic nitrogen, and bottom dissolved oxygen. Status was fair for surface total phosphorus, surface chlorophyll *a*, and secchi depth. There were no significant trends for most parameters in the Lower Pamunkey segment (Table 4-15): surface and bottom dissolved inorganic nitrogen and dissolved inorganic phosphorus, surface and bottom total suspended solids, secchi depth, bottom dissolved oxygen, and surface and bottom water temperature. Degrading trends were observed for surface and bottom total nitrogen and total phosphorus, and surface chlorophyll *a*. No parameters showed an improving trend. Surface and bottom water salinity showed an increasing trend.

2. Water quality for SAV

Degrading trends in surface total nitrogen, dissolved inorganic nitrogen, total phosphorus, dissolved inorganic phosphorus, and chlorophyll *a* were detected in this segment (Table 4-16). Relative status was good for surface total nitrogen, dissolved inorganic nitrogen and chlorophyll *a*, fair for total phosphorus and secchi depth and poor for dissolved inorganic phosphorus and total suspended solids. All parameters either failed to meet the SAV habitat requirements or were borderline (Table 4-17).

3. Water quality trends for 1995-2001

A degrading trend in bottom total nitrogen was detected in this segment. No other significant trends were detected (Figures 4-12 and 4-13).

4. Living resources

Living resource monitoring is not conducted within this segment.

F. Tidal Freshwater Pamunkey River (PMKTF - Upper Pamunkey)

1. Water quality for living resources

Status was good for most of the water quality parameters in the Upper Pamunkey segment (Table 4-18): surface and bottom total nitrogen and total phosphorus, surface and bottom dissolved inorganic nitrogen, surface chlorophyll *a*, bottom total suspended solids, and bottom dissolved oxygen. Status was fair for surface and bottom dissolved inorganic phosphorus, and secchi depth. Status was poor for surface total suspended solids. There were no significant trends for most parameters in the Upper Pamunkey segment (Table 4-19): surface and bottom total nitrogen, surface and bottom dissolved inorganic nitrogen and dissolved inorganic phosphorus, surface chlorophyll a, surface total suspended solids, secchi depth, and bottom dissolved oxygen, and surface and bottom water salinity. Degrading trends were observed for surface and bottom total phosphorus. Only bottom total suspended solids showed an improving trend. Surface and bottom water temperature showed an increasing trend.

2. Water quality for SAV

Relative status was good for surface total nitrogen, dissolved inorganic nitrogen, total phosphorus, and chlorophyll *a*, fair for dissolved inorganic phosphorus and secchi depth and poor for total suspended solids. Most parameters either failed to meet the SAV habitat requirements or were borderline with the exception of chlorophyll *a* for which the SAV habitat requirement was met (Table 4-20). A degrading trend in surface total phosphorus was detected in this segment (Table 4-21).

3. Water quality trends for 1995-2001

Degrading trends in surface total nitrogen, bottom total phosphorus, surface total suspended solids, and secchi depth (Figure 4-12 and 4-13).

4. Living resources

Several degrading associations are found at this station. Total phytoplankton abundance and biomass are increasing, with the present status of total biomass and the ratio between total biomass and cell abundance poor. The status of diatoms and dinoflagellates are also poor, with no trends associated in these categories. In addition, both cyanobacteria abundance and biomass have degrading (increasing) trends. Favorable trends are present with the increasing biomass of cryptophytes and chlorophytes, and decreasing biomass of the autotrophic picoplankton (Figure 4-14) . At this station, and in the downstream region of the York, exist numerous degrading trends among the phytoplankton categories that if they continue will impact the trophic status within the river.

No significant annual trends in microzooplankton were evident for this region, as in the past few years.

Rotifer abundance status is good while copepod nauplii abundance status changed from poor to fair indicating some improvement (Figure 4-15).

Benthic community status was good with improving trends in species diversity, abundance and biomass (Figure 4-17).

G. Oligohaline Mattaponi River (MPNOH - Lower Mattaponi)

1. Water quality for living resources

In the Lower Mattaponi segment, status was good for surface and bottom total nitrogen,and for surface and bottom dissolved inorganic nitrogen (Table 4-22). Status was fair for surface and bottom total phosphorus, surface chlorophyll *a*, secchi depth, and bottom dissolved oxygen. Status was poor for surface and bottom dissolved inorganic phosphorus, and surface and bottom total suspended solids. There were no significant trends for most parameters in the Lower Mattaponi segment (Table 4-23): surface and bottom dissolved inorganic nitrogen and dissolved inorganic phosphorus, surface and bottom total suspended solids, and secchi depth. Only bottom dissolved oxygen showed an improving trend. Degrading trends were observed for surface and bottom total nitrogen and total phosphorus, and surface chlorophyll *a*. Surface and bottom water salinity showed an increasing trend.

2. Water quality for SAV

Degrading trends in surface total nitrogen, dissolved inorganic nitrogen, total phosphorus, dissolved inorganic phosphorus, chlorophyll *a*, and total suspended solids were detected in this segment (Table 4-24). Relative status was good for surface total nitrogen, dissolved inorganic nitrogen and chlorophyll *a*, fair for total phosphorus and secchi depth and poor for dissolved inorganic phosphorus and total suspended solids. Most parameters either failed to meet the SAV habitat requirements or were borderline with the exception of chlorophyll *a* for which the SAV habitat requirement was met (Table 4-25).

3. Water quality trends for 1995-2001

An improving trend in bottom dissolved oxygen was detected in this segment along with increasing trends in surface and bottom salinity (Figure 4-12 and 4-13).

4. Living resources

Living resource monitoring is not conducted within this segment.

H. Tidal Freshwater Mattaponi River (MPNTF - Upper Mattaponi)

1. Water quality for living resources

In the Upper Mattaponi segment, status was good for almost all water quality parameters (Table 4-25): surface and bottom total nitrogen and total phosphorus, surface and bottom dissolved inorganic nitrogen, surface chlorophyll *a*, surface and bottom total suspended solids, secchi depth, and bottom dissolved oxygen. Status was fair for surface and bottom dissolved inorganic phosphorus. There were no significant trends for most parameters in the Upper Mattaponi segment (Table 4-24): surface total nitrogen, surface and bottom dissolved inorganic nitrogen and dissolved inorganic phosphorus, surface chlorophyll *a*, surface and bottom total suspended solids, secchi depth, and bottom dissolved oxygen. An improving trend was observed for bottom total nitrogen, and degrading trends were observed for surface and bottom total phosphorus. Surface and bottom water temperature showed an increasing trend.

2. Water quality for SAV

Degrading trends in surface total nitrogen, dissolved inorganic nitrogen, total phosphorus, dissolved inorganic phosphorus, chlorophyll *a*, and total suspended solids were detected in this segment (Table 4-28). Relative status was good or fair for all parameters. SAV habitat requirements were met for chlorophyll *a* and total suspended solids; however the percentage of light at the leaf surface at 1.0 meters failed to met the requirement and the remaining parameters were borderline (Table 4-29).

3. Water quality trends for 1995-2001

Degrading trends in bottom total phosphorus, bottom total suspended solids and secchi depth were detected in this segment (Figures 4-12 and 4-13).

4. Living resources

Living resource monitoring is not conducted within this segment.

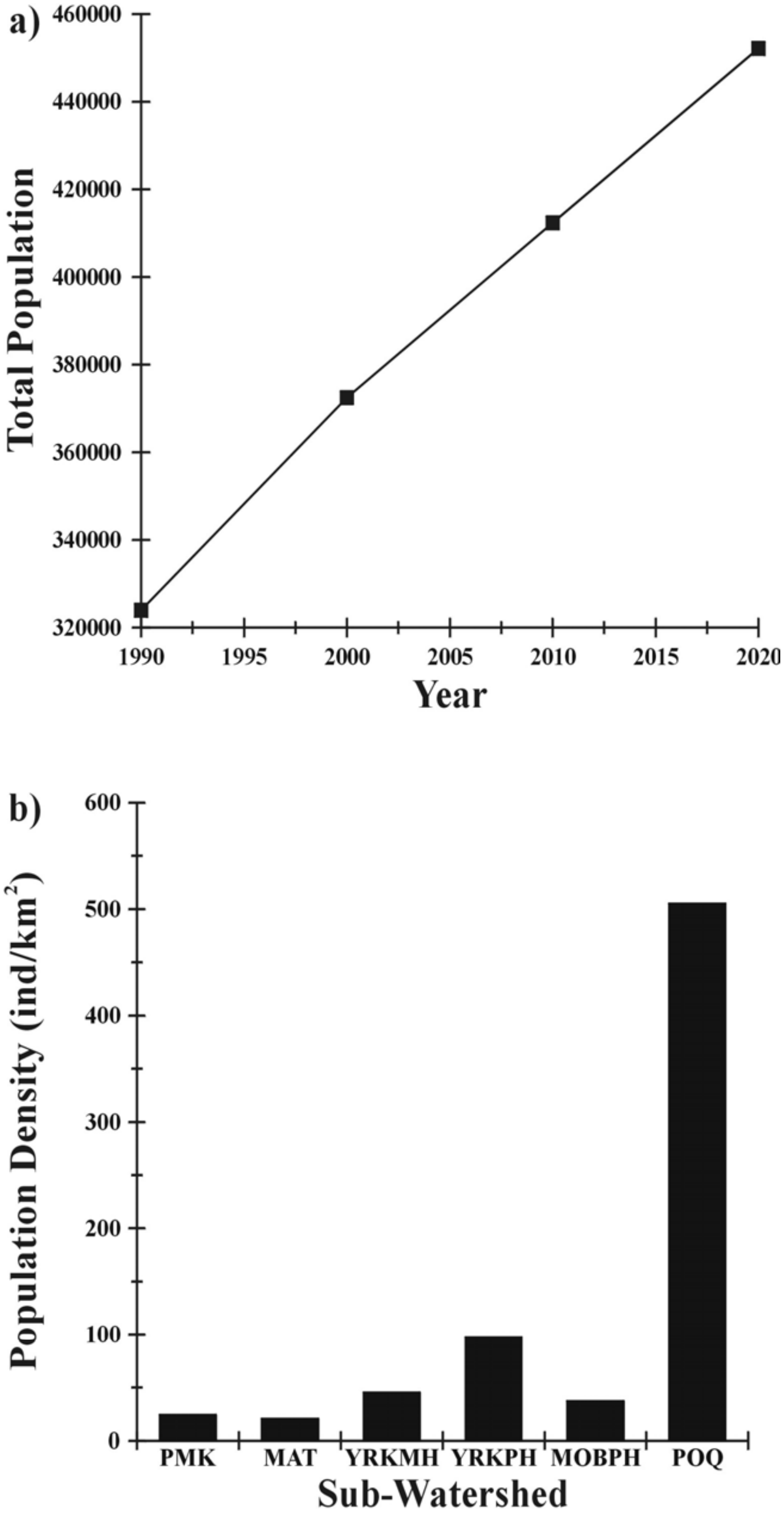


Figure 4-1. Patterns in a) total and projected total watershed population over time and b) population density between sub-watersheds within the York River basin.

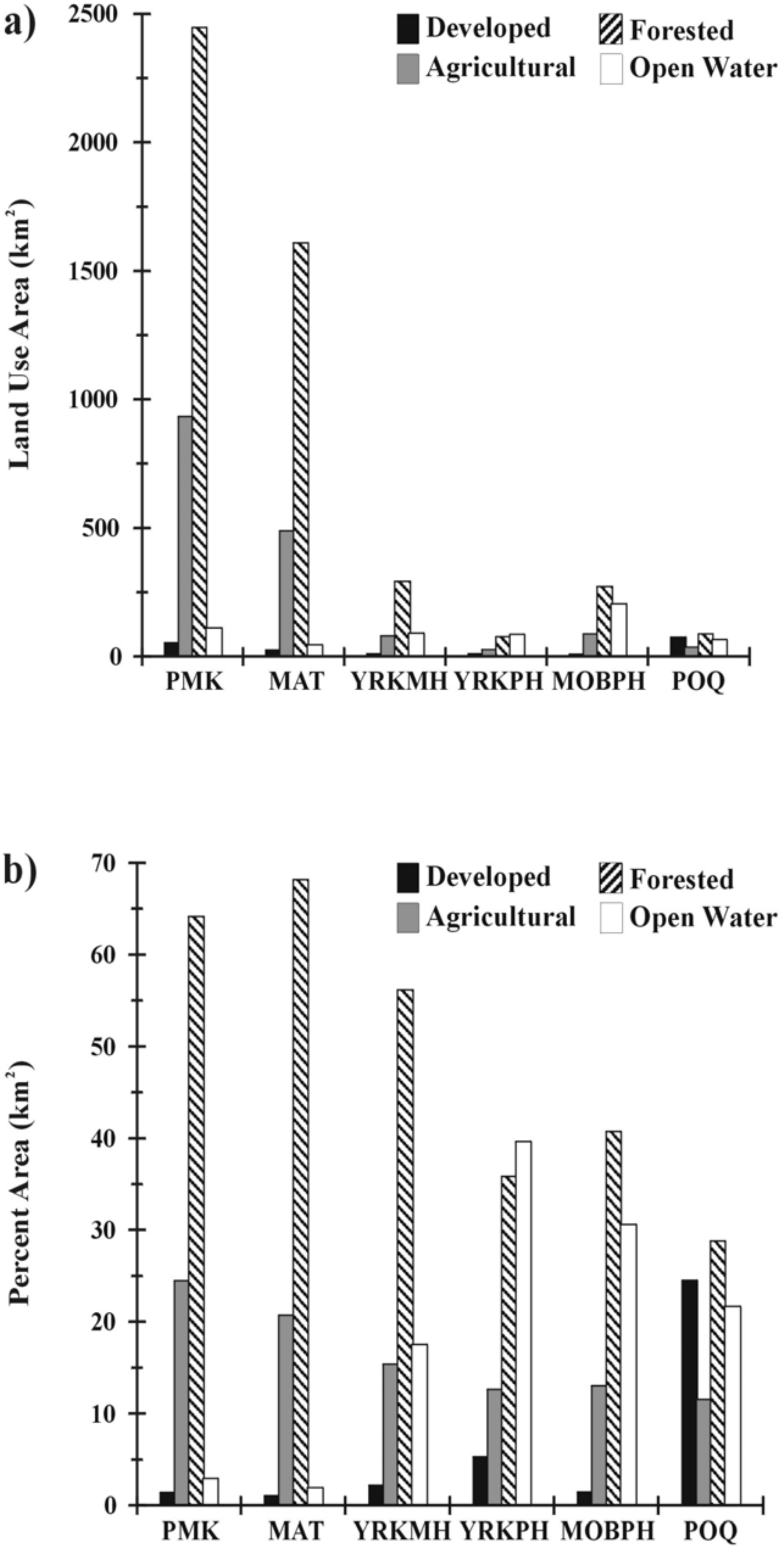


Figure 4-2. Differences in a) total area and b) percentages of land-use types between sub-watersheds of the York River for 1999. Data presented were provided by the USEPA, Chesapeake Bay Program Office.

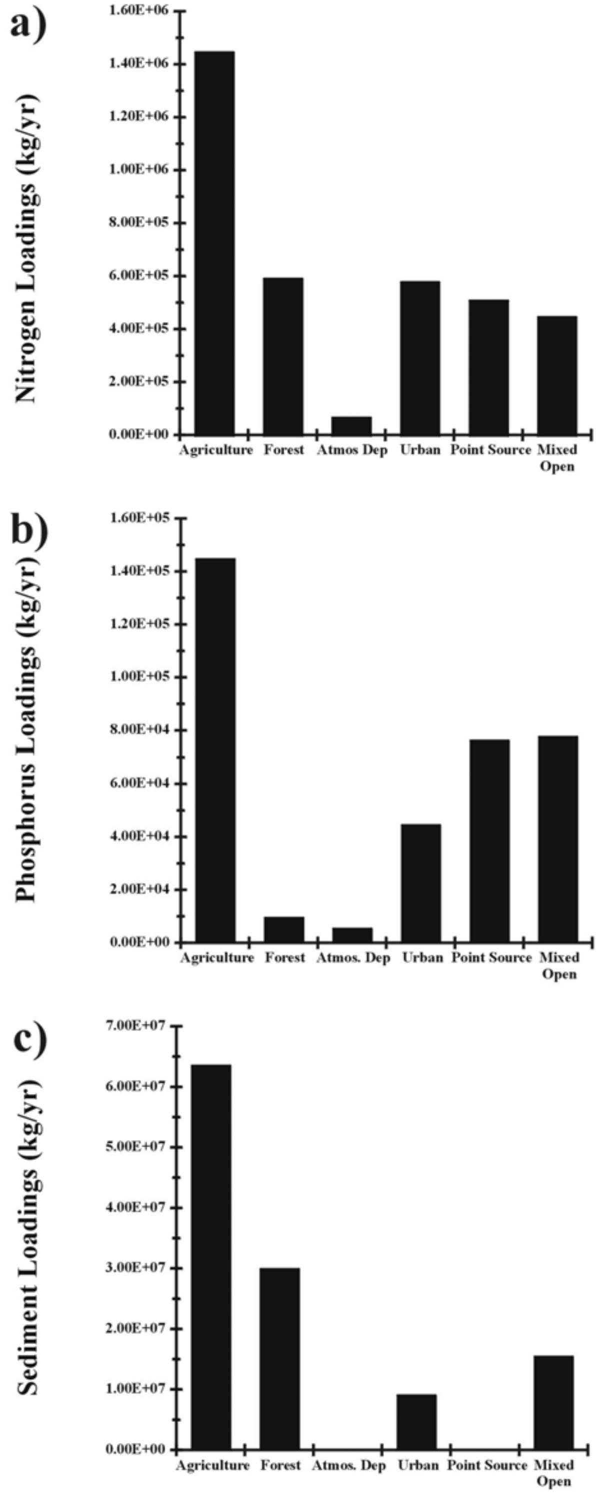


Figure 4-3. Non-point source loadings of a) nitrogen, b) phosphorus, and c) sediments by source for the York River in 2000. Data generated using the USEPA Chesapeake Bay Watershed Model.

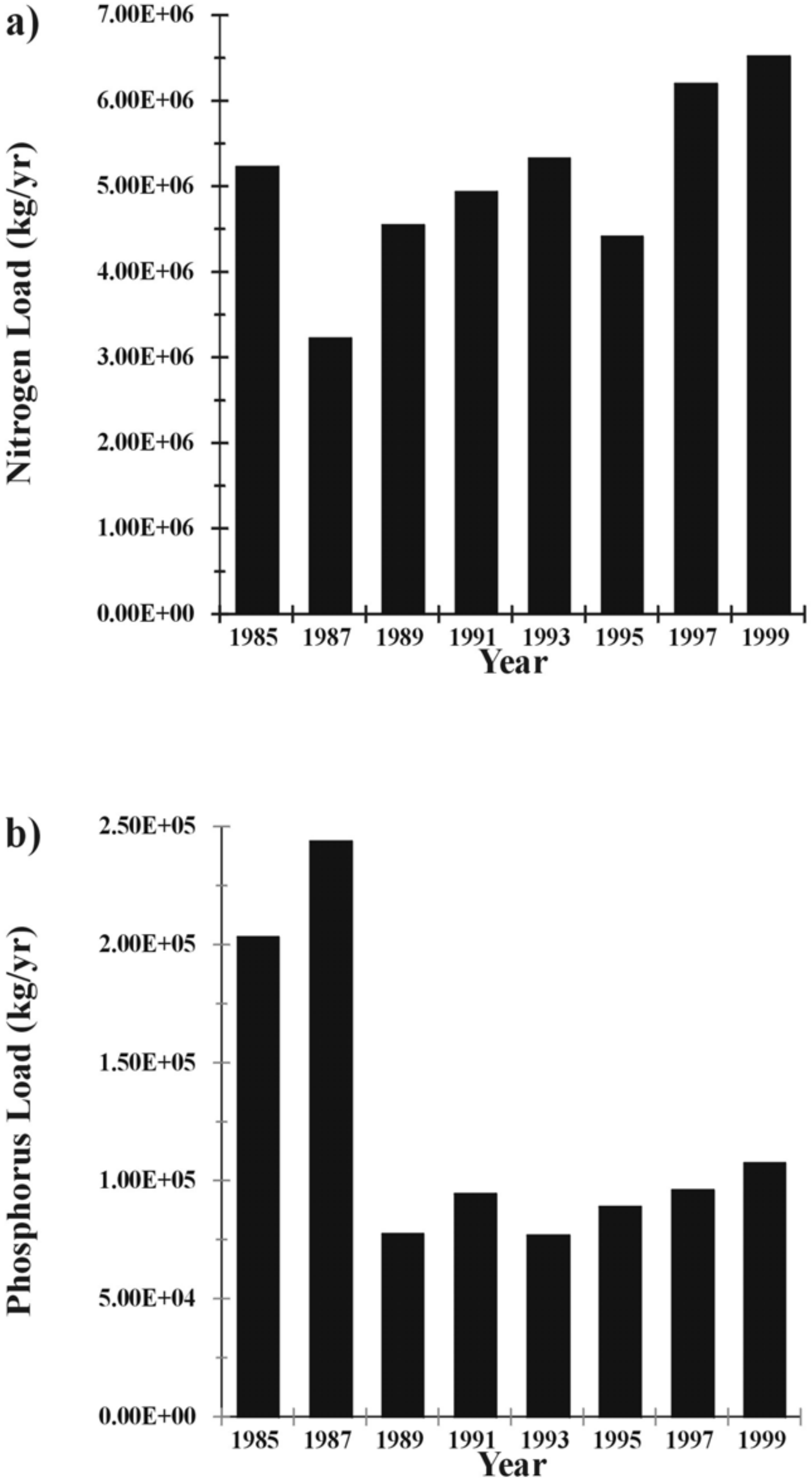


Figure 4-4. Long-term trends in point source a) nitrogen loadings and b) phosphorus loadings in the York River.

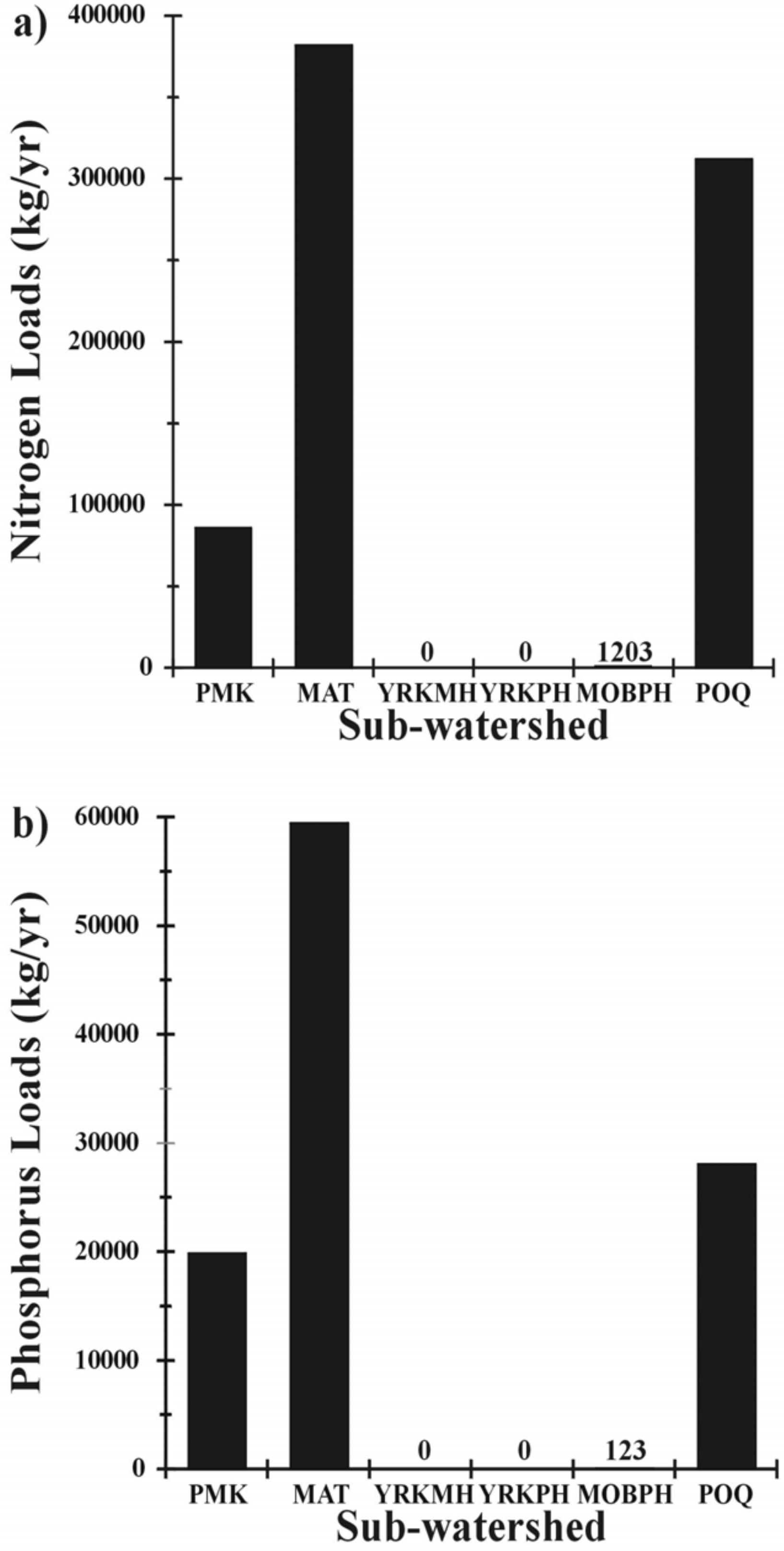


Figure 4-5. Spatial patterns in point source a) nitrogen and b) phosphorus loadings in the York River for 1999. PMK=Pamunkey, MAT=Mattaponi, POQ=Poquoson sub-watersheds.

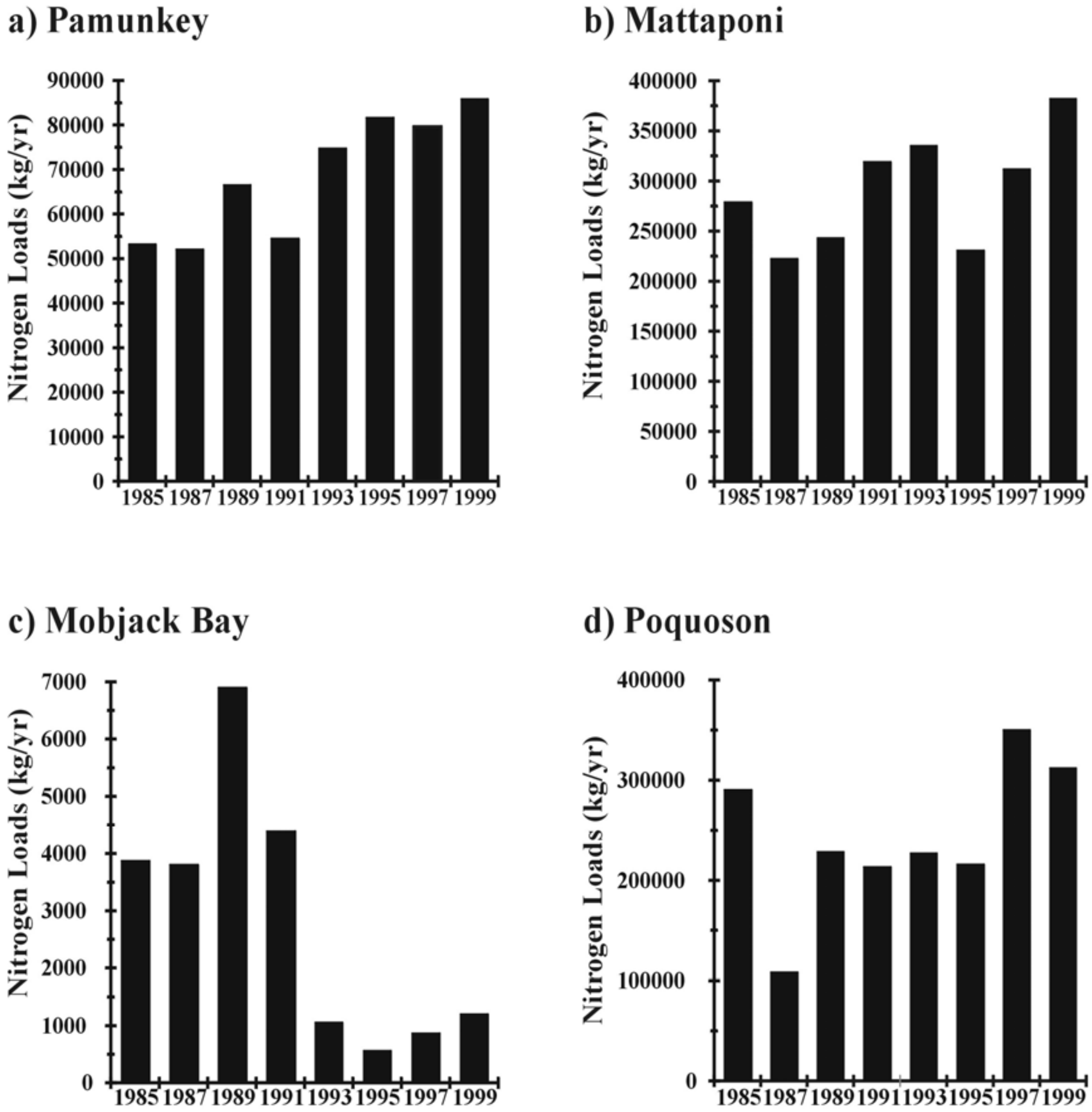
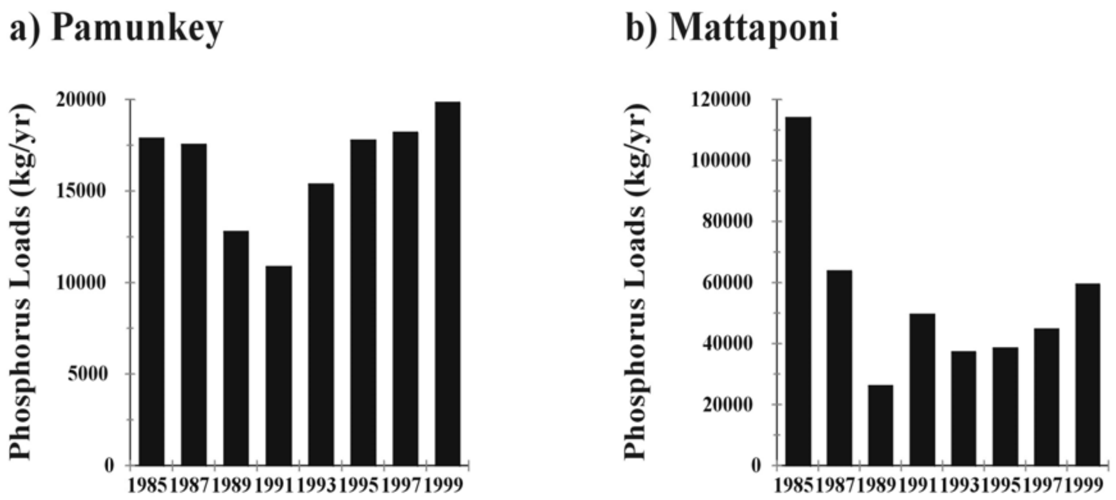


Figure 4-6. Change in point source nitrogen in the a) Pamunkey, b) Mattaponi, c) Mobjack Bay, and d) Poquoson sub-watersheds of the York River from 1985 to 1999.



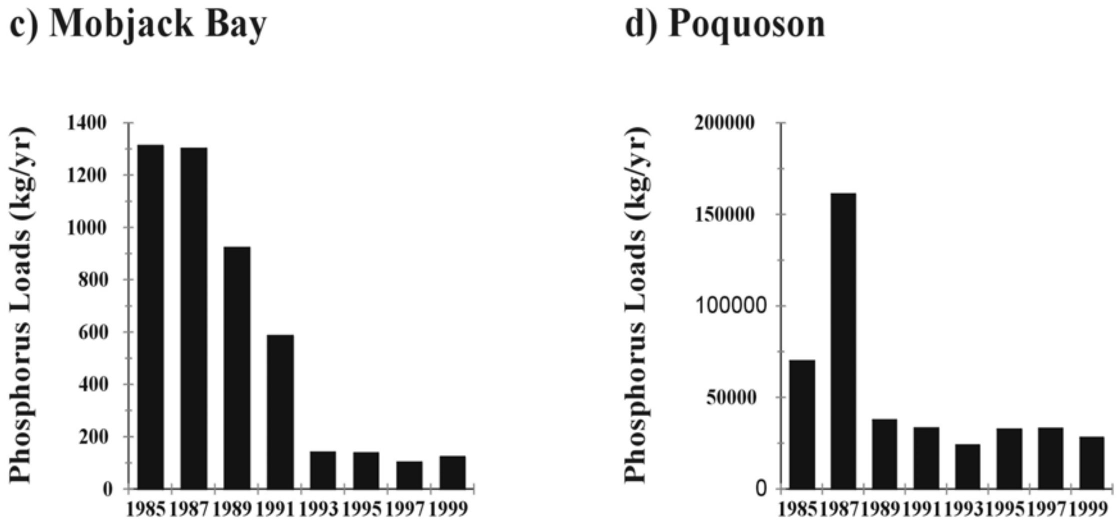
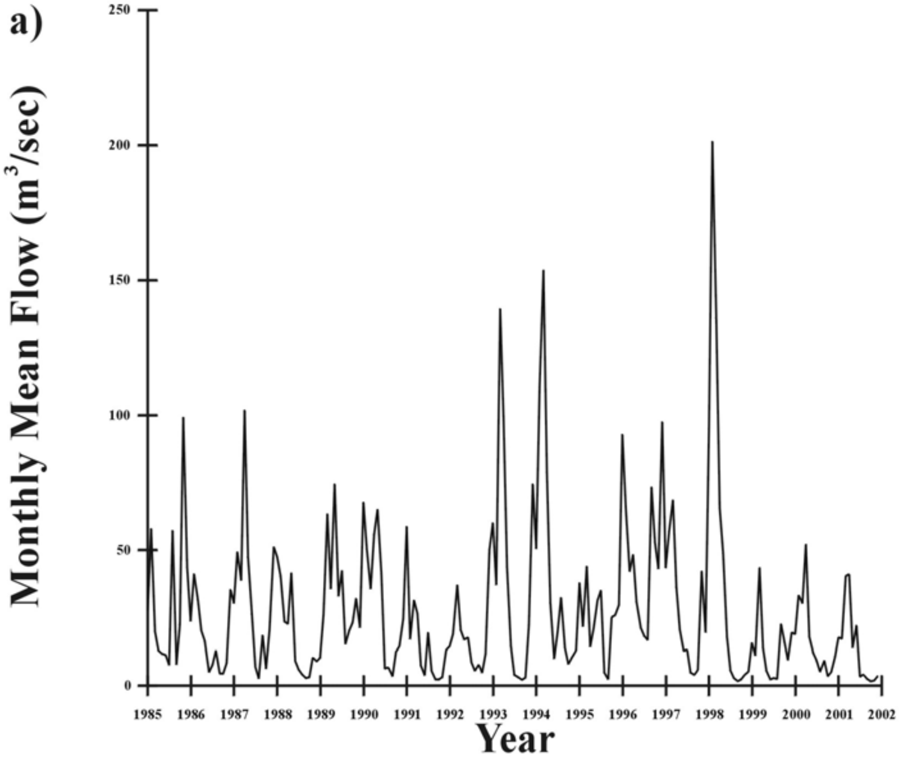


Figure 4-7. Change in point source phosphorus in the a) Pamunkey, b) Mattaponi, c) Mobjack Bay, and d) Poquoson sub-watersheds of the York River from 1985 to 1999.



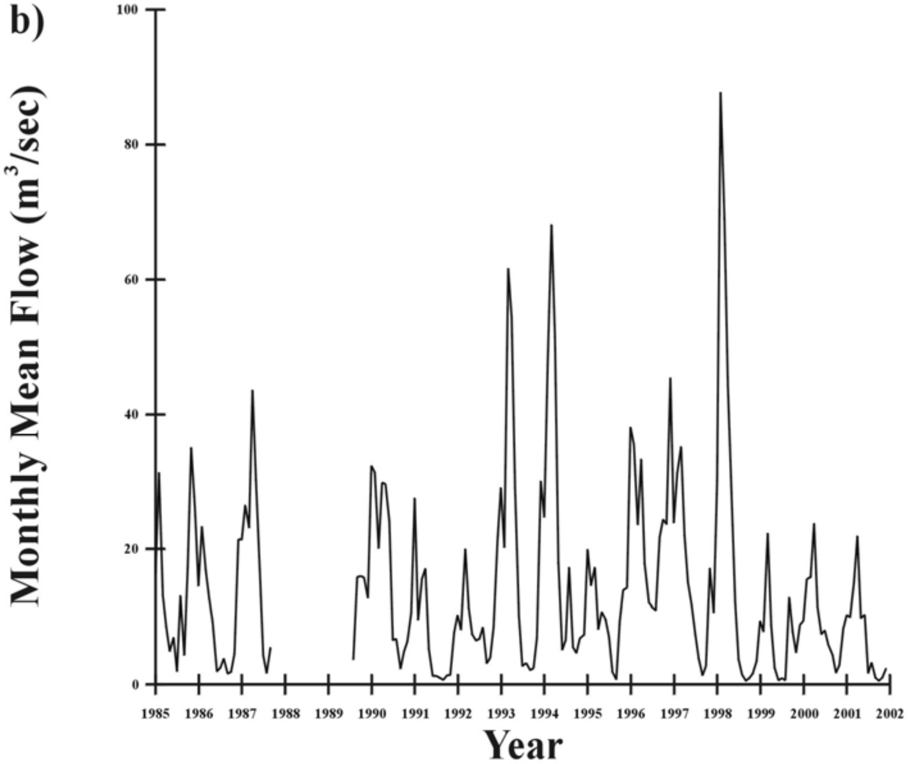


Figure 4-8. Plot of monthly mean flow at the a) Pamunkey River fall-line and b) the Mattaponi River fall-line for the period of 1985 to 2001.

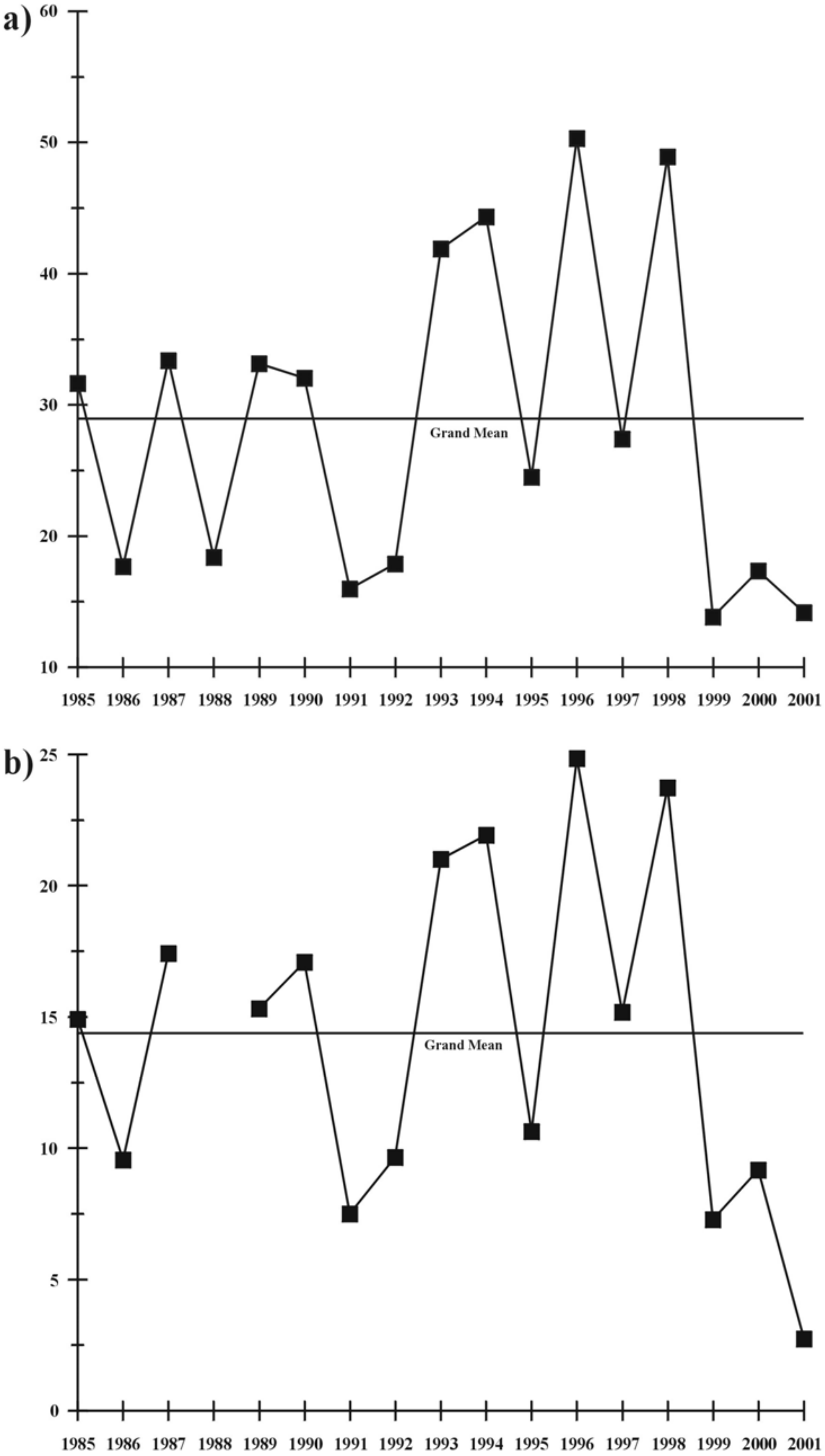
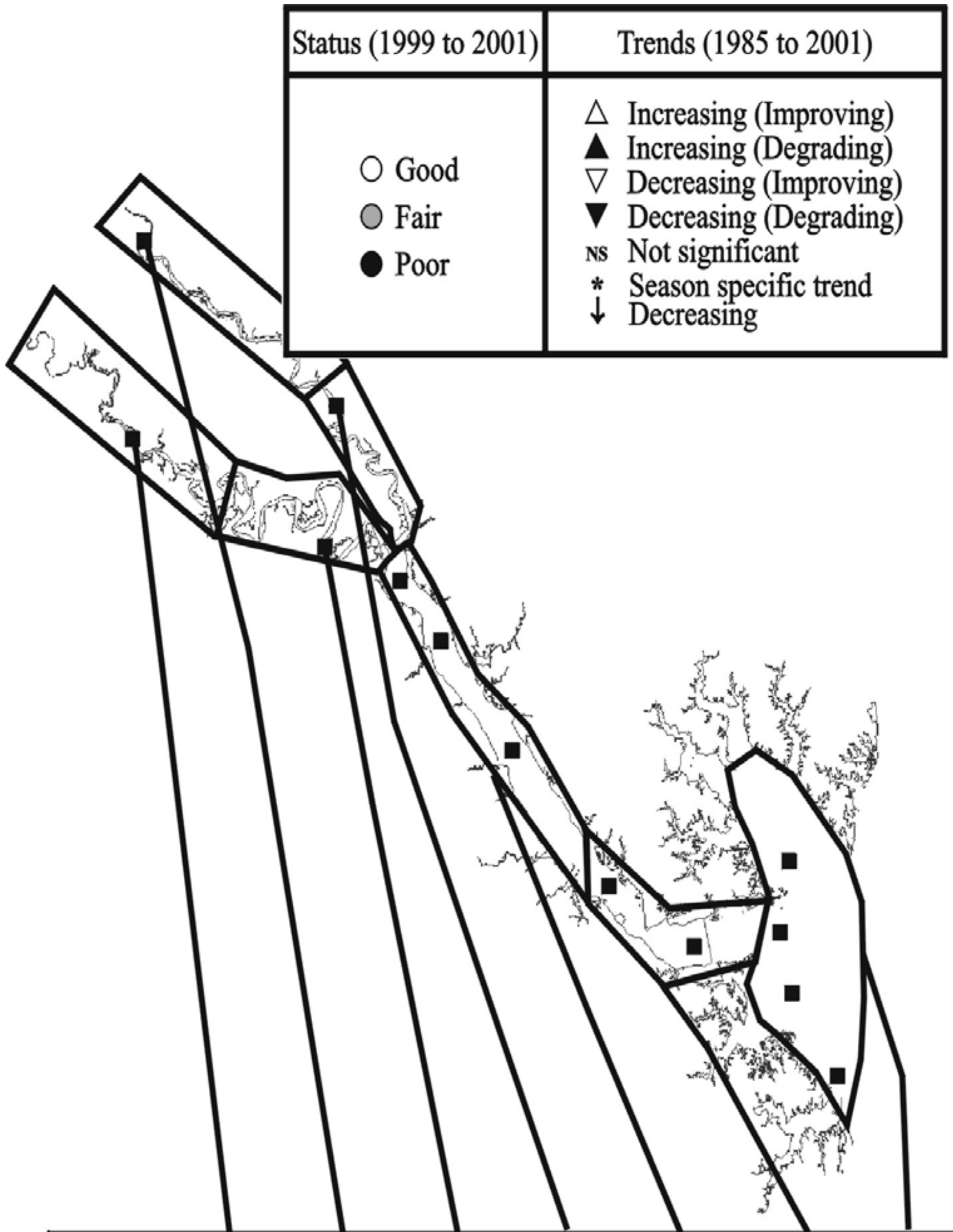
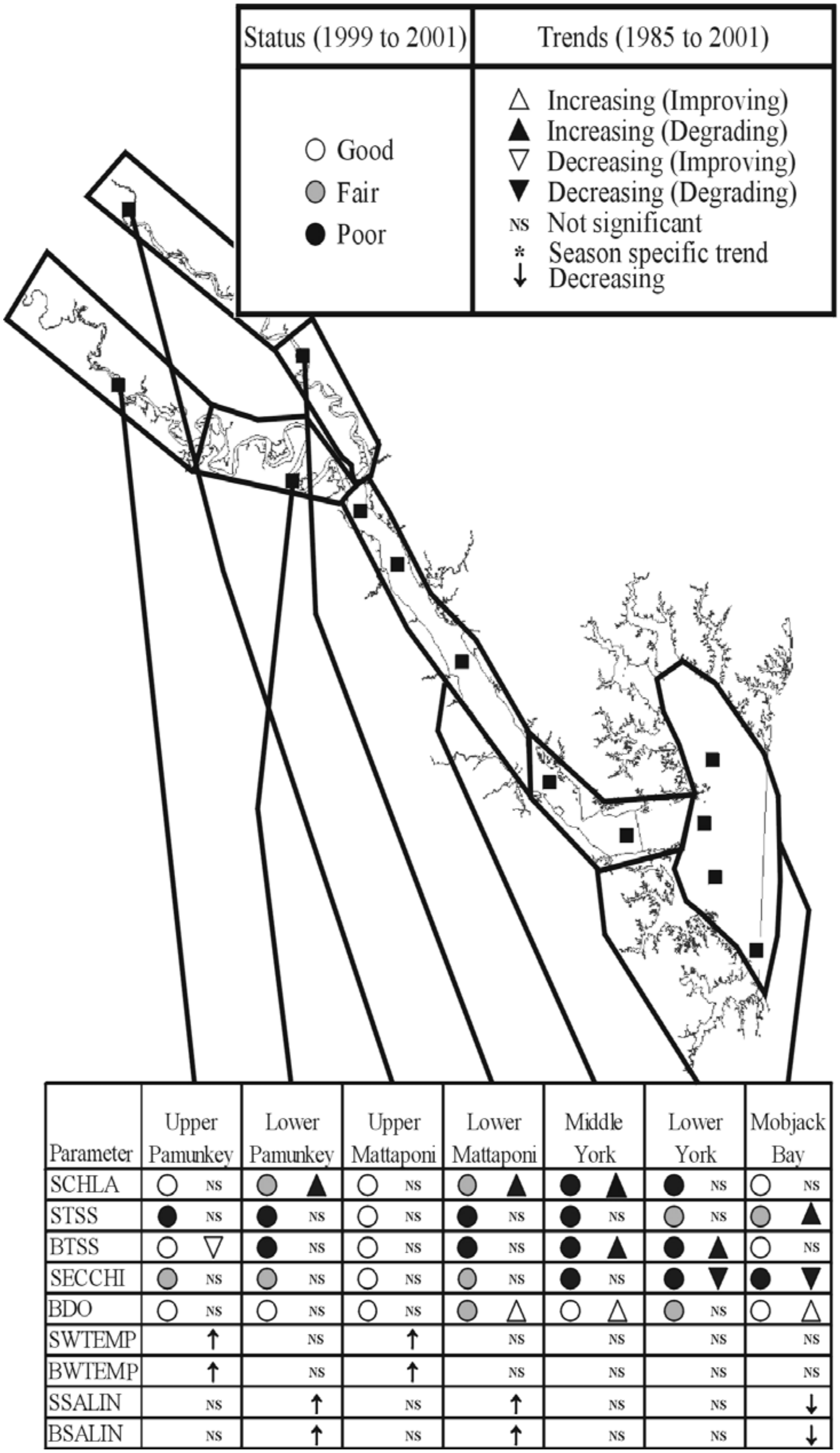


Figure 4-9. Plot of annual mean flow at the a) Pamunkey River fall-line and b) the Mattaponi River fall-line for the period of 1985 to 2001.



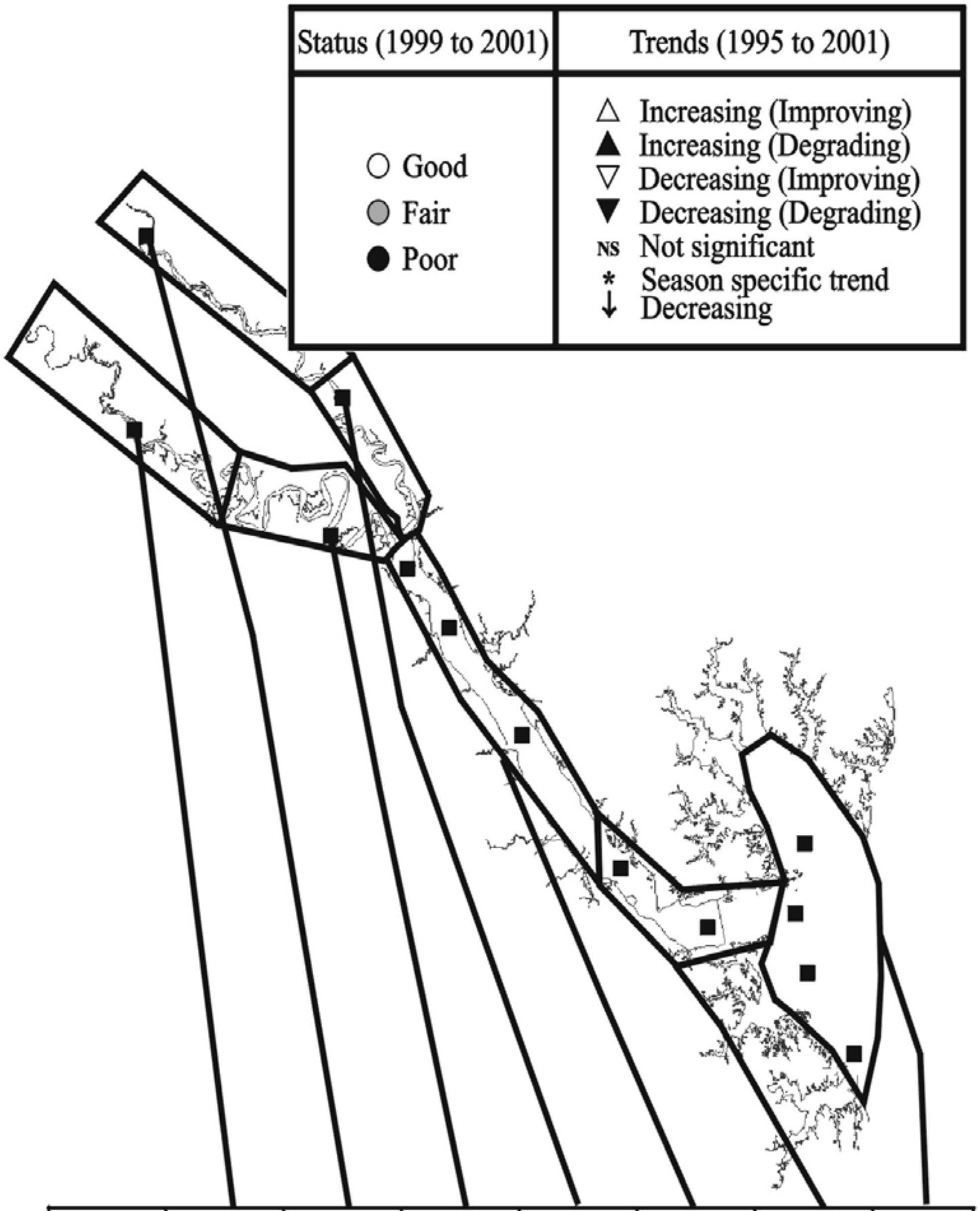
Parameter	Upper Pamunkey	Lower Pamunkey	Upper Mattaponi	Lower Mattaponi	Middle York	Lower York	Mobjack Bay
STN	○ NS	○ ▲	○ NS	○ ▲	○ ▲	○ ▲	○ NS
BTN	○ NS	○ ▲	○ ▽	○ ▲	◍ ▲	◍ ▲	◍ ▲
SDIN	○ NS	○ NS	○ NS	○ NS	○ NS	○ NS	○ NS
BDIN	○ NS	○ NS	○ NS	○ NS	○ NS	○ NS	○ NS
STP	○ ▲	◍ ▲	○ ▲	◍ ▲	● ▲	● ▲	◍ ▲
BTP	○ ▲	● ▲	○ ▲	◍ ▲	● ▲	● ▲	○ NS
SDIP	◍ NS	● NS	◍ NS	● NS	● ▲	● NS	○ NS
BDIP	◍ NS	● NS	◍ NS	● NS	● ▲	● NS	○ NS

Figure 4-10. Map of the York River basin showing summaries of the status and trend analyses for each segment. Abbreviations for each parameter are: TN= total nitrogen; DIN=dissolved inorganic nitrogen; TP=total phosphorus; DIP=dissolved inorganic phosphorus. The prefixes S and B refer to surface and bottom measurements, respectively. All parameters shown were corrected for potential method effects associated with changes to analytical techniques that occurred in 1994.



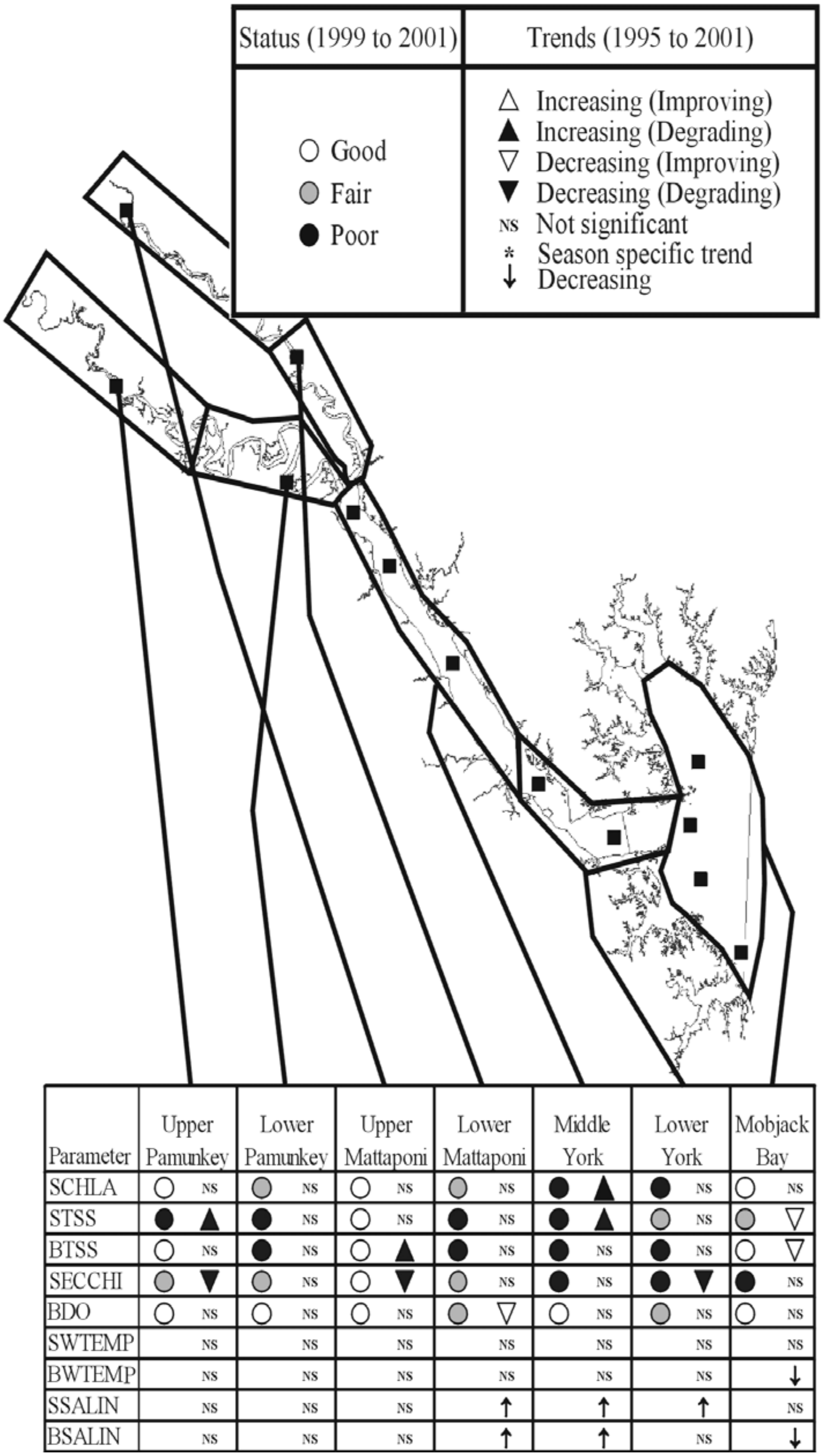
Parameter	Upper Pamunkey	Lower Pamunkey	Upper Mattaponi	Lower Mattaponi	Middle York	Lower York	Mobjack Bay
SCHLA	○ NS	◍ ▲	○ NS	◍ ▲	● ▲	● NS	○ NS
STSS	● NS	● NS	○ NS	● NS	● NS	◍ NS	◍ ▲
BTSS	○ ▽	● NS	○ NS	● NS	● ▲	● ▲	○ NS
SECCHI	◍ NS	◍ NS	○ NS	◍ NS	● NS	● ▼	● ▼
BDO	○ NS	○ NS	○ NS	◍ △	○ △	◍ NS	○ △
SWTEMP	↑	NS	↑	NS	NS	NS	NS
BWTEMP	↑	NS	↑	NS	NS	NS	NS
SSALIN	NS	↑	NS	↑	NS	NS	↓
BSALIN	NS	↑	NS	↑	NS	NS	↓

Figure 4-11. Map of the York River basin showing summaries of the status and trend analyses for each segment. Abbreviations for each parameter are:CHLA=chlorophyll a; TSS=total suspended solids; SECCHI=secchi depth; DO=dissolved oxygen; WTEMP=water temperature; SALIN=salinity. The prefixes S and B refer to surface and bottom measurements, respectively.



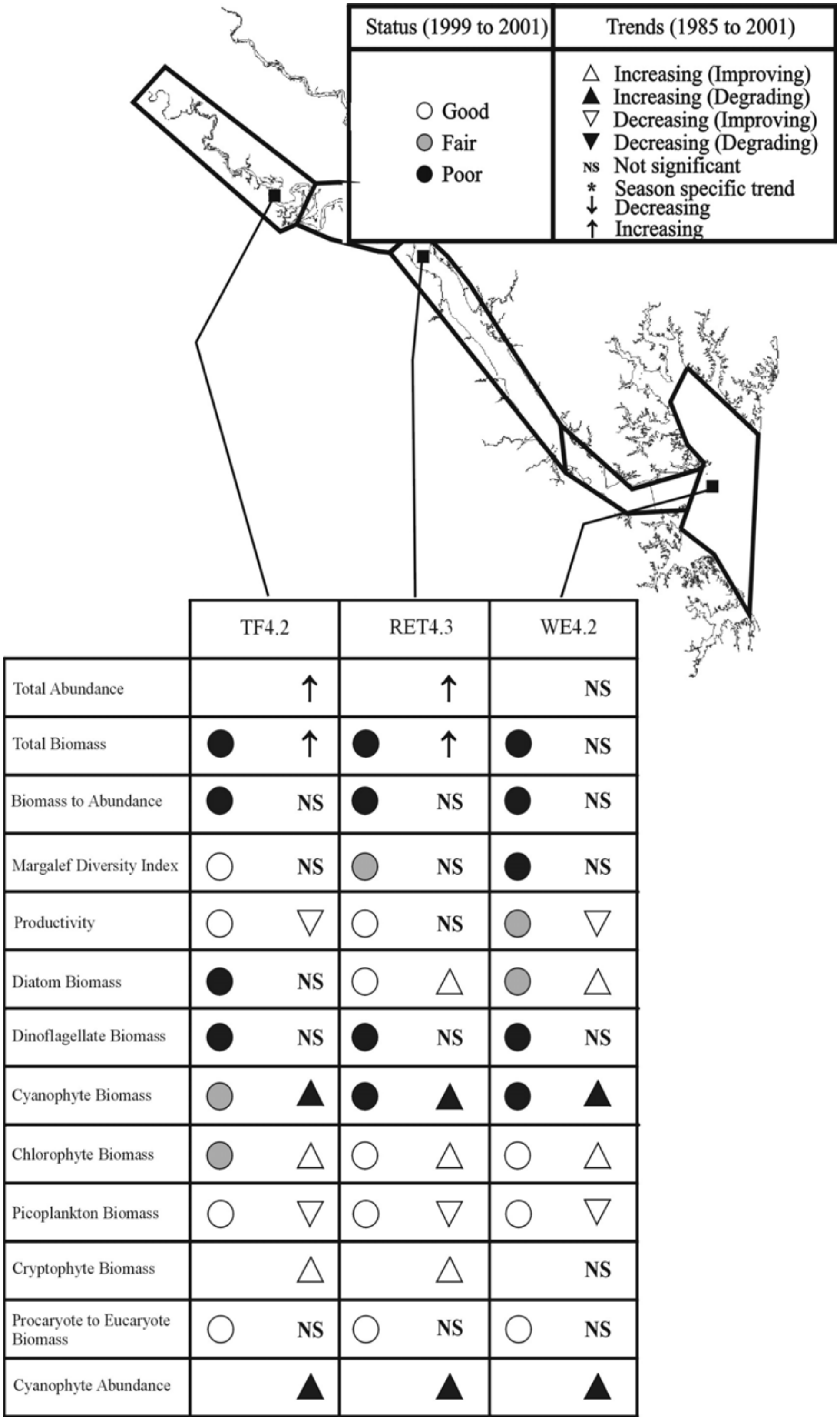
Parameter	Upper Pamunkey	Lower Pamunkey	Upper Mattaponi	Lower Mattaponi	Middle York	Lower York	Mobjack Bay
STN	○ ▲	○ NS	○ NS	○ NS	○ NS	○ NS	○ NS
BTN	○ NS	○ ▲	○ NS	○ NS	◍ NS	◍ NS	◍ ▽
SDIN	○ NS	○ NS	○ NS	○ NS	○ NS	○ NS	○ NS
BDIN	○ NS	○ NS	○ NS	○ NS	○ NS	○ NS	○ NS
STP	○ NS	◍ NS	○ NS	◍ NS	● NS	● ▲	◍ ▽
BTP	○ ▲	● NS	○ ▲	◍ NS	● ▲	● NS	○ ▽
SDIP	◍ NS	● NS	◍ NS	● NS	● ▲	● NS	○ NS
BDIP	◍ NS	● NS	◍ NS	● NS	● ▲	● NS	○ NS

Figure 4-12 Map of the York River basin showing summaries of the status and trend analyses for each segment for the period after the method corrections were initiated (1995-2001). Abbreviations for each parameter are: TN=total nitrogen; DIN=dissolved inorganic nitrogen; TP=total phosphorus; DIP=dissolved inorganic phosphorus. The prefixes S and B refer to surface and bottom measurements, respectively.



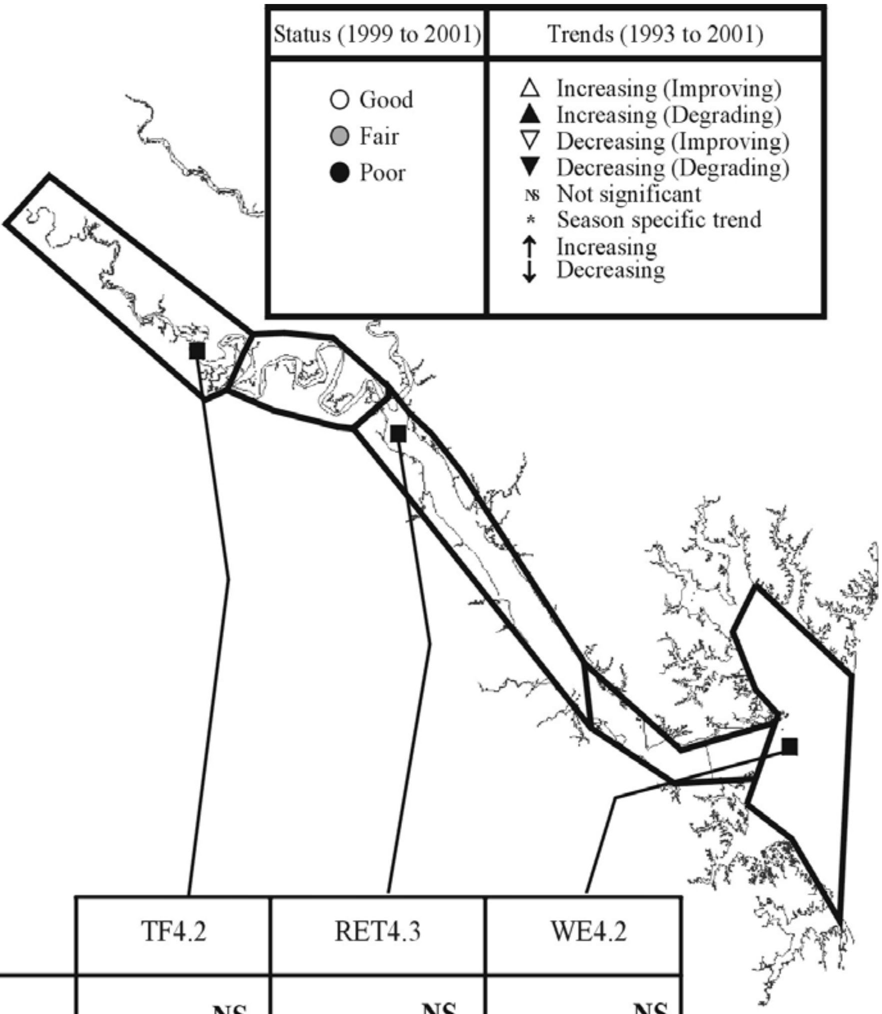
Parameter	Upper Pamunkey	Lower Pamunkey	Upper Mattaponi	Lower Mattaponi	Middle York	Lower York	Mobjack Bay
SCHLA	○ NS	◐ NS	○ NS	◐ NS	● ▲	● NS	○ NS
STSS	● ▲	● NS	○ NS	● NS	● ▲	◐ NS	◐ ▽
BTSS	○ NS	● NS	○ ▲	● NS	● NS	● NS	○ ▽
SECCHI	◐ ▼	◐ NS	○ ▼	◐ NS	● NS	● ▼	● NS
BDO	○ NS	○ NS	○ NS	◐ ▽	○ NS	◐ NS	○ NS
SWTEMP	NS	NS	NS	NS	NS	NS	NS
BWTEMP	NS	NS	NS	NS	NS	NS	↓
SSALIN	NS	NS	NS	↑	↑	↑	NS
BSALIN	NS	NS	NS	↑	↑	NS	↓

Figure 4-13. Map of the York River basin showing summaries of the status and trend analyses for each segment for the period after the method corrections were initiated (1995-2001). Abbreviations for each parameter are:CHLA=chlorophyll a; TSS=total suspended solids; SECCHI=secchi depth; DO=dissolved oxygen; WTEMP=water temperature; SALIN=salinity. The prefixes S and B refer to surface and bottom measurements, respectively.



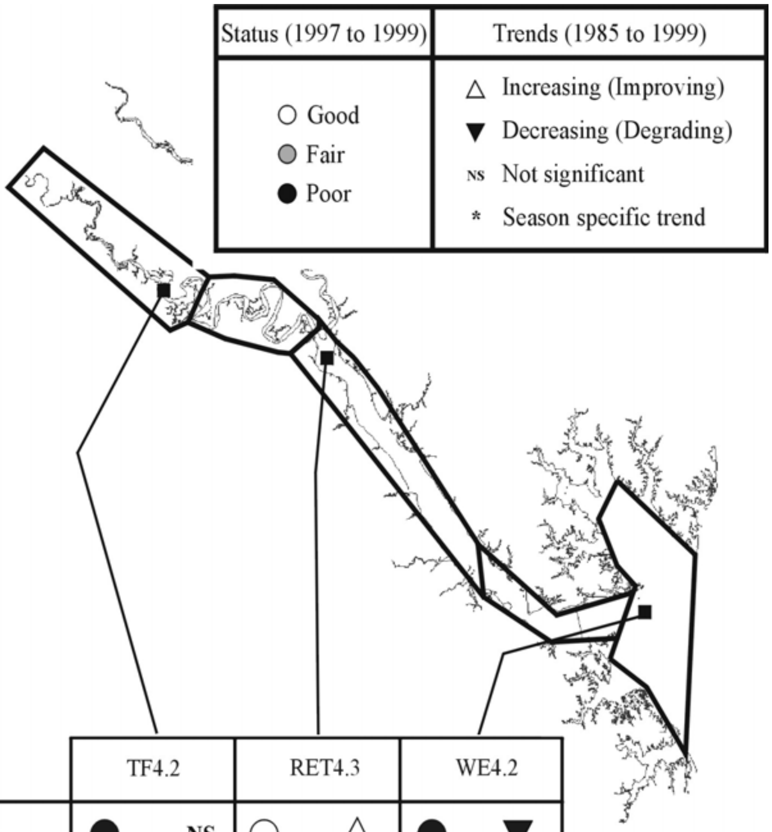
	TF4.2	RET4.3	WE4.2
Total Abundance	↑	↑	NS
Total Biomass	● ↑	● ↑	● NS
Biomass to Abundance	● NS	● NS	● NS
Margalef Diversity Index	○ NS	◍ NS	● NS
Productivity	○ ▽	○ NS	◍ ▽
Diatom Biomass	● NS	○ △	◍ △
Dinoflagellate Biomass	● NS	● NS	● NS
Cyanophyte Biomass	◍ ▲	● ▲	● ▲
Chlorophyte Biomass	◍ △	○ △	○ △
Picoplankton Biomass	○ ▽	○ ▽	○ ▽
Cryptophyte Biomass	△	△	NS
Procaryote to Eucaryote Biomass	○ NS	○ NS	○ NS
Cyanophyte Abundance	▲	▲	▲

Figure 4-14. Map of the York River basin showing summaries of the status and trend analyses for phytoplankton bioindicators for each segment.



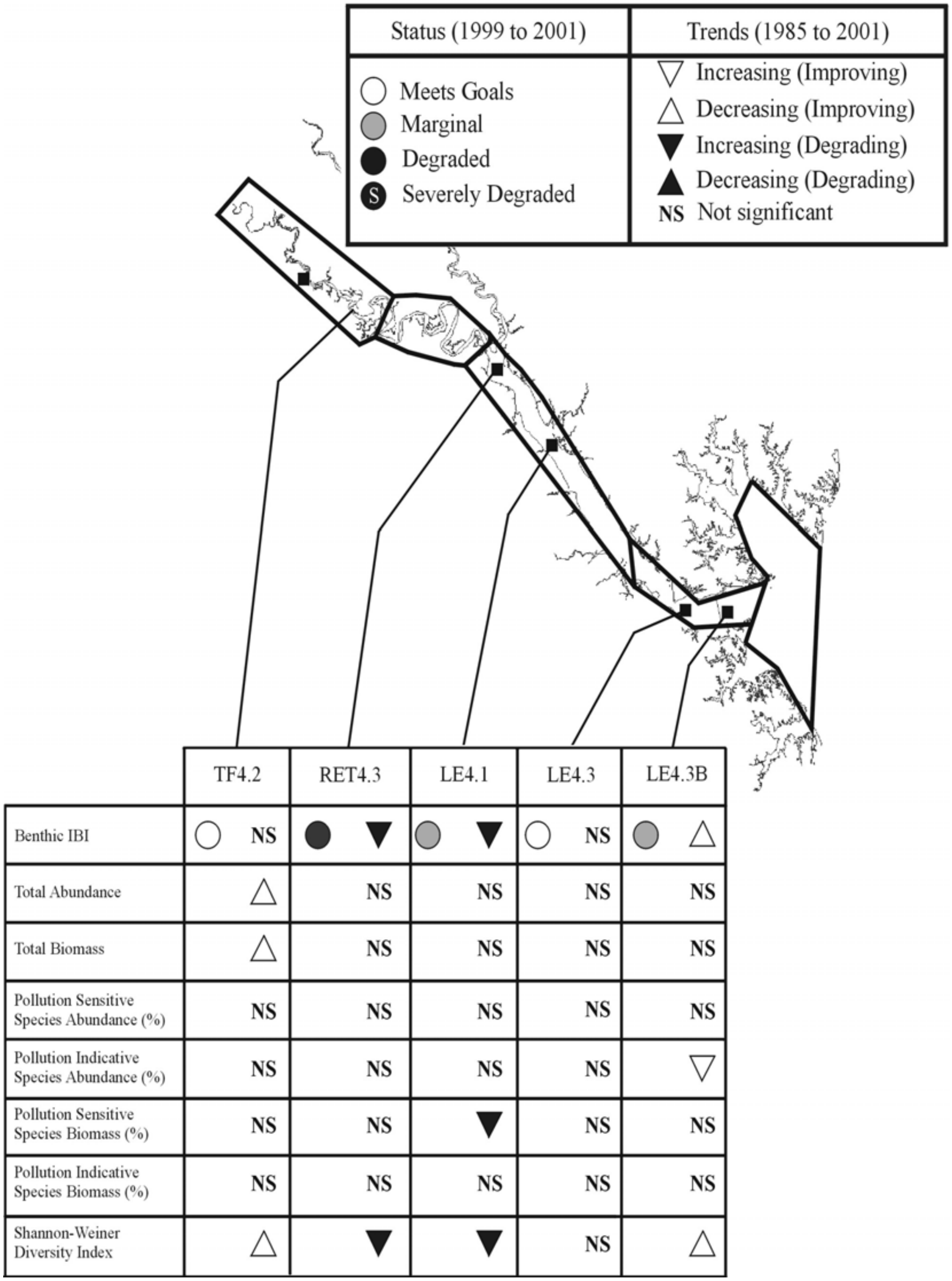
	TF4.2	RET4.3	WE4.2
Total Abundance	NS	NS	NS
Total Biomass	NS	NS	NS
Copepod Nauplii Abundance	◍ NS	○ NS	● ▼
Rotifer Abundance	○ NS	● ▲	● ▲
Oligotrich Abundance	NS	NS	NS
Cladoceran Abundance	↓	NS	NS
Tintinnid Abundance	NS	NS	↓
Polychaeta Larvae Abundance	NS	NS	↓

Figure 4-15. Map of the York River basin showing summaries of the status and trend analyses for microzooplankton bioindicators for each segment.



	TF4.2		RET4.3		WE4.2	
Total Abundance	●	NS	○	△	●	▼
Margalef Diversity Index	○	△	○	△	◍	NS
Shannon Wiener Index	○	△	○	△	◍	▼
Holoplankton Abundance		NS		△		▼
Meroplankton Abundance		NS		△*		▼
Calanoid Abundance		NS		△		▼
Cyclopoid Abundance		NS		NS		NS
Cladoceran Abundance		NS		△		▼*
Crab Zoea Abundance		NS		NS		NS
Acartia tonsa		▼		NS		▼
Eurytemora spp.		▼		NS		NS
Bosmina longirostis		NS		△		NS

Figure 4-16. Map of the York River basin showing summaries of the status and trend analyses for mesozooplankton bioindicators for each segment.



	TF4.2	RET4.3	LE4.1	LE4.3	LE4.3B
Benthic IBI	○ NS	● ▼	◍ ▼	○ NS	◍ △
Total Abundance	△	NS	NS	NS	NS
Total Biomass	△	NS	NS	NS	NS
Pollution Sensitive Species Abundance (%)	NS	NS	NS	NS	NS
Pollution Indicative Species Abundance (%)	NS	NS	NS	NS	▽
Pollution Sensitive Species Biomass (%)	NS	NS	▼	NS	NS
Pollution Indicative Species Biomass (%)	NS	NS	NS	NS	NS
Shannon-Weiner Diversity Index	△	▼	▼	NS	△

Figure 4-17. Map of the York River basin showing summaries of the status and trend analyses for benthic bioindicators for each segment.

Table 4-1. Water quality trends at York RIM stations 1674500 (Mattaponi River near Beulahville), 1673000 (Pamunkey River at Hanover), and 1671020 (North Anna River at Doswell).

River	Station	Parameter	DataType	Status	Slope	pValue	Direction
Pamunkey River at Hanover	1673000	FLOW	FLOW	411.95000	-0.0446	0.0259	DECREASING
Pamunkey River at Hanover	1673000	TN	FAC	-	0.0118	0.0008	DEGRADING
Pamunkey River at Hanover	1673000	TN	FWC	1.69300	0.0114	0.0001	DEGRADING
Pamunkey River at Hanover	1673000	NO23F	FAC	-	0.0186	0.0002	DEGRADING
Pamunkey River at Hanover	1673000	NO23F	FWC	0.66856	0.0259	0.0001	DEGRADING
Pamunkey River at Hanover	1673000	TP	FAC	-	0.0335	0.0000	DEGRADING
Pamunkey River at Hanover	1673000	TP	FWC	0.24365	0.0343	0.0001	DEGRADING
Pamunkey River at Hanover	1673000	PO4F	FAC	-	0.0662	0.0000	DEGRADING
Pamunkey River at Hanover	1673000	PO4F	FWC	0.08181	0.0802	0.0001	DEGRADING
Pamunkey River at Hanover	1673000	PO4F	LOAD	0.04245	0.0356	0.0134	DEGRADING
Pamunkey River at Hanover	1673000	TSS	FAC	-	0.0342	0.0027	DEGRADING
Mattaponi River at Beulahville	1674500	FLOW	FLOW	280.40000	-0.0415	0.0423	IMPROVING
Mattaponi River at Beulahville	1674500	TN	FAC	-	-0.0104	0.0007	IMPROVING
Mattaponi River at Beulahville	1674500	TN	FWC	1.20481	-0.0096	0.0019	IMPROVING
Mattaponi River at Beulahville	1674500	TN	LOAD	0.79420	-0.0511	0.0229	IMPROVING
Mattaponi River at Beulahville	1674500	NO23F	FAC	-	-0.0238	0.0006	IMPROVING
Mattaponi River at Beulahville	1674500	NO23F	FWC	0.33318	-0.0155	0.0001	IMPROVING
Mattaponi River at Beulahville	1674500	NO23F	LOAD	0.19853	-0.0570	0.0025	IMPROVING
Mattaponi River at Beulahville	1674500	TP	FAC	-	-0.0097	0.0428	IMPROVING
Mattaponi River at Beulahville	1674500	TP	FWC	0.11819	-0.0131	0.0010	IMPROVING
Mattaponi River at Beulahville	1674500	TP	LOAD	0.07509	-0.0546	0.0186	IMPROVING
Mattaponi River at Beulahville	1674500	PO4F	LOAD	0.01785	-0.0424	0.0428	IMPROVING
Mattaponi River at Beulahville	1674500	TSS	FWC	17.05876	-0.0304	0.0324	IMPROVING
Mattaponi River at Beulahville	1674500	TSS	LOAD	11.19490	-0.0718	0.0336	IMPROVING
North Anna River at Doswell	1671020	FLOW	FLOW	112.85000	-0.0236	0.0413	DECREASING
North Anna River at Doswell	1671020	TNH4	FAC	-	-0.0134	0.0000	IMPROVING
North Anna River at Doswell	1671020	TNH4	FWC	0.03651	-0.0136	0.0001	IMPROVING
North Anna River at Doswell	1671020	TNH4	LOAD	0.03091	-0.0372	0.0022	IMPROVING
North Anna River at Doswell	1671020	TKN	FAC	-	0.0124	0.0097	DEGRADING
North Anna River at Doswell	1671020	TKN	FWC	0.27016	0.0082	0.0001	DEGRADING
North Anna River at Doswell	1671020	NO23W	FWC	0.10002	-0.0144	0.0006	IMPROVING
North Anna River at Doswell	1671020	NO23W	LOAD	0.08126	-0.0380	0.0126	IMPROVING
North Anna River at Doswell	1671020	NO3W	FWC	0.09393	-0.0128	0.0045	IMPROVING
North Anna River at Doswell	1671020	NO3W	LOAD	0.07602	-0.0364	0.0184	IMPROVING
North Anna River at Doswell	1671020	TP	FAC	-	-0.1083	0.0000	IMPROVING
North Anna River at Doswell	1671020	TP	FWC	0.01588	-0.1109	0.0001	IMPROVING
North Anna River at Doswell	1671020	TP	LOAD	0.01355	-0.1345	0.0001	IMPROVING
North Anna River at Doswell	1671020	TSS	FAC	-	0.0283	0.0012	DEGRADING

Table 4-2. **Water quality status in segment MOBPH (value is the median concentration, secchi in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).**

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
MOBPH	TN	Annual	0.387	32.6	GOOD	0.397	40.3	FAIR
MOBPH	TN	Spring1	0.350	21.1	GOOD	0.354	30.8	GOOD
MOBPH	TN	Spring2	0.382	35.2	GOOD	0.397	46.2	FAIR
MOBPH	TN	Summer1	0.482	55.2	FAIR	0.484	55.4	FAIR
MOBPH	TN	Summer2	0.490	55.6	FAIR	0.486	51.2	FAIR
MOBPH	DIN	Annual	0.010	9.4	GOOD	0.013	7.0	GOOD
MOBPH	DIN	Spring1	0.006	5.9	GOOD	0.008	8.0	GOOD
MOBPH	DIN	Spring2	0.008	11.9	GOOD	0.009	8.6	GOOD
MOBPH	DIN	Summer1	0.012	23.0	GOOD	0.027	10.1	GOOD
MOBPH	DIN	Summer2	0.012	20.8	GOOD	0.028	6.9	GOOD
MOBPH	TP	Annual	0.026	38.4	FAIR	0.029	24.8	GOOD
MOBPH	TP	Spring1	0.020	34.7	GOOD	0.026	19.9	GOOD
MOBPH	TP	Spring2	0.023	45.3	FAIR	0.029	35.7	GOOD
MOBPH	TP	Summer1	0.040	58.6	FAIR	0.046	34.9	GOOD
MOBPH	TP	Summer2	0.040	55.5	FAIR	0.047	27.9	GOOD
MOBPH	DIP	Annual	0.001	8.9	GOOD	0.002	9.0	GOOD
MOBPH	DIP	Spring1	0.001	1.2	GOOD	0.001	1.9	GOOD
MOBPH	DIP	Spring2	0.001	6.2	GOOD	0.001	6.4	GOOD
MOBPH	DIP	Summer1	0.003	24.0	GOOD	0.005	10.2	GOOD
MOBPH	DIP	Summer2	0.004	27.5	GOOD	0.005	9.7	GOOD
MOBPH	CHLA	Annual	4.873	34.3	GOOD	-	-	-
MOBPH	CHLA	Spring1	3.538	15.5	GOOD	-	-	-
MOBPH	CHLA	Spring2	4.873	33.2	GOOD	-	-	-
MOBPH	CHLA	Summer1	9.618	74.1	POOR	-	-	-
MOBPH	CHLA	Summer2	9.999	77.5	POOR	-	-	-
MOBPH	TSS	Annual	9.200	51.1	FAIR	13.075	36.6	GOOD
MOBPH	TSS	Spring1	7.963	46.5	FAIR	12.848	42.3	GOOD
MOBPH	TSS	Spring2	8.485	58.4	POOR	13.433	51.4	FAIR
MOBPH	TSS	Summer1	12.845	66.9	POOR	20.855	54.3	FAIR
MOBPH	TSS	Summer2	13.113	69.2	POOR	21.804	56.5	FAIR
MOBPH	SECCHI	Annual	1.250	24.4	POOR	-	-	-
MOBPH	SECCHI	Spring1	1.350	28.6	POOR	-	-	-
MOBPH	SECCHI	Spring2	1.300	22.3	POOR	-	-	-
MOBPH	SECCHI	Summer1	1.088	15.7	POOR	-	-	-
MOBPH	SECCHI	Summer2	1.000	14.1	POOR	-	-	-
MOBPH	DO	Spring1	-	-	-	9.665	-	GOOD
MOBPH	DO	Spring2	-	-	-	8.795	-	GOOD
MOBPH	DO	Summer1	-	-	-	6.709	-	GOOD
MOBPH	DO	Summer2	-	-	-	6.708	-	GOOD

Table 4-3. Water quality trends in segment MOBPH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
MOBPH	TN*	Annual	B	0.596	0.0139	32.67	0.00	0.0393	DEGRADING
MOBPH	TN*	Spring1	B	0.545	0.0371	95.24	0.00	0.0227	DEGRADING
MOBPH	TN*	Spring2	B	0.563	0.0382	94.95	0.00	0.0008	DEGRADING
MOBPH	DIN*	Summer1	B	0.087	-0.0062	-99.79	1.79	0.0398	IMPROVING
MOBPH	TP*	Annual	S	0.034	0.0014	58.37	1.80	0.0257	DEGRADING
MOBPH	TP*	Spring2	S	0.028	0.0023	115.65	0.00	0.0126	DEGRADING
MOBPH	TSS*	Annual	S	13.84	0.626	76.89	0.00	0.0028	DEGRADING
MOBPH	TSS*	Spring1	S	11.88	0.556	79.48	0.00	0.0153	DEGRADING
MOBPH	TSS*	Fall	S	8.22	1.252	258.86	0.00	0.0466	DEGRADING
MOBPH	TSS*	Spring2	S	11.27	0.723	109.03	0.00	0.0016	DEGRADING
MOBPH	SECCHI	Annual	S	1.50	-0.01	-15.41	0.00	0.0040	DEGRADING
MOBPH	SECCHI	Summer1	S	1.20	-0.01	-15.44	0.00	0.0340	DEGRADING
MOBPH	SECCHI	Summer2	S	1.20	-0.01	-16.29	0.00	0.0300	DEGRADING
MOBPH	DO	Spring1	B	8.70	0.06	11.57	0.00	0.0360	IMPROVING
MOBPH	DO	Summer1	B	6.20	0.05	13.71	0.00	0.0010	IMPROVING
MOBPH	SALIN	Annual	S	21.98	-0.07	-5.47	0.00	0.0340	DECREASING
MOBPH	SALIN	Summer1	S	22.78	-0.15	-11.24	0.00	0.0040	DECREASING
MOBPH	SALIN	Summer2	S	22.78	-0.13	-9.99	0.00	0.0210	DECREASING
MOBPH	SALIN	Annual	B	22.76	-0.08	-6.12	0.00	0.0080	DECREASING
MOBPH	SALIN	Summer1	B	23.10	-0.14	-10.07	0.00	0.0030	DECREASING
MOBPH	SALIN	Summer2	B	23.10	-0.12	-8.74	0.00	0.0320	DECREASING
MOBPH	PLL10	Annual	S	0.20	-0.002	-18.70	0.00	0.0180	DEGRADING
MOBPH	PLL10	Summer2	S	0.10	-0.003	-42.50	0.00	0.0410	DEGRADING

Table 4-4. SAV season water quality status in segment MOBPH (value is the median concentration; secchi in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
MOBPH	TN	0.378	25.8	**Good**	-	-
MOBPH	DIN	0.009	4.6	**Good**	0.0112	**Pass**
MOBPH	TP	0.023	31.5	**Good**	-	-
MOBPH	DIP	0.001	6.8	**Good**	0.0025	**Pass**
MOBPH	CHLA	4.92	37.4	**Good**	8.3	**Pass**
MOBPH	TSS	8.84	51.2	**Fair**	11.0	**Pass**
MOBPH	SECCHI	1.30	21.8	**Poor**	-	-
MOBPH	KD	-	-	-	1.30	**Pass**
MOBPH	PLL05	-	-	-	0.283	**Pass**
MOBPH	PLL10	-	-	-	0.147	**Borderline**

Table 4-5. SAV Season Water quality trends in segment MOBPH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
MOBPH	TP*	SAV1	S	0.036	0.0019	73.36	0.00	0.0191	**DEGRADING**
MOBPH	TP*	SAV2	S	0.030	0.0016	73.93	1.19	0.0461	**DEGRADING**
MOBPH	TSS*	SAV1	S	13.98	0.767	93.23	0.00	0.0026	**DEGRADING**
MOBPH	TSS*	SAV2	S	11.57	0.774	113.80	0.00	0.0024	**DEGRADING**
MOBPH	SECCHI	SAV2	S	1.80	-0.02	-20.21	0.00	0.0080	**DEGRADING**
MOBPH	PLL10	SAV2	S	0.30	-0.004	-20.40	0.00	0.0220	**DEGRADING**

Table 4-6. Water quality status in segment YRKPH (value is the median concentration, secchi in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
YRKPH	TN	Annual	0.427	37.5	GOOD	0.477	51.9	FAIR
YRKPH	TN	Spring1	0.407	30.6	GOOD	0.454	49.1	FAIR
YRKPH	TN	Spring2	0.407	31.1	GOOD	0.461	54.1	FAIR
YRKPH	TN	Summer1	0.486	48.5	FAIR	0.544	60.4	POOR
YRKPH	TN	Summer2	0.492	50.9	FAIR	0.551	67.2	POOR
YRKPH	DIN	Annual	0.031	32.3	GOOD	0.045	34.0	GOOD
YRKPH	DIN	Spring1	0.017	11.2	GOOD	0.018	24.5	GOOD
YRKPH	DIN	Spring2	0.023	39.2	GOOD	0.030	38.3	GOOD
YRKPH	DIN	Summer1	0.044	71.4	POOR	0.076	49.4	FAIR
YRKPH	DIN	Summer2	0.044	63.5	POOR	0.096	51.7	FAIR
YRKPH	TP	Annual	0.051	85.8	POOR	0.073	84.8	POOR
YRKPH	TP	Spring1	0.040	84.1	POOR	0.050	81.9	POOR
YRKPH	TP	Spring2	0.044	88.1	POOR	0.070	86.1	POOR
YRKPH	TP	Summer1	0.074	92.3	POOR	0.087	88.9	POOR
YRKPH	TP	Summer2	0.082	91.8	POOR	0.091	87.6	POOR
YRKPH	DIP	Annual	0.014	80.5	POOR	0.017	75.3	POOR
YRKPH	DIP	Spring1	0.007	74.6	POOR	0.008	74.4	POOR
YRKPH	DIP	Spring2	0.008	77.3	POOR	0.010	76.8	POOR
YRKPH	DIP	Summer1	0.022	82.7	POOR	0.030	76.0	POOR
YRKPH	DIP	Summer2	0.025	86.7	POOR	0.032	80.2	POOR
YRKPH	CHLA	Annual	8.840	62.4	POOR	-	-	-
YRKPH	CHLA	Spring1	6.700	45.6	FAIR	-	-	-
YRKPH	CHLA	Spring2	8.950	57.0	POOR	-	-	-
YRKPH	CHLA	Summer1	10.123	76.5	POOR	-	-	-
YRKPH	CHLA	Summer2	10.340	80.7	POOR	-	-	-
YRKPH	TSS	Annual	12.000	49.9	FAIR	24.250	73.7	POOR
YRKPH	TSS	Spring1	16.125	70.4	POOR	29.000	78.4	POOR
YRKPH	TSS	Spring2	16.125	78.6	POOR	38.000	91.4	POOR
YRKPH	TSS	Summer1	10.250	48.1	FAIR	22.250	71.5	POOR
YRKPH	TSS	Summer2	10.000	36.3	GOOD	20.500	61.4	POOR
YRKPH	SECCHI	Annual	1.150	12.9	POOR	-	-	-
YRKPH	SECCHI	Spring1	0.900	6.6	POOR	-	-	-
YRKPH	SECCHI	Spring2	0.900	5.0	POOR	-	-	-
YRKPH	SECCHI	Summer1	1.050	10.7	POOR	-	-	-
YRKPH	SECCHI	Summer2	1.050	14.2	POOR	-	-	-
YRKPH	DO	Spring1	-	-	-	8.735	-	GOOD
YRKPH	DO	Spring2	-	-	-	7.185	-	GOOD
YRKPH	DO	Summer1	-	-	-	4.328	-	FAIR
YRKPH	DO	Summer2	-	-	-	4.155	-	FAIR

Table 4-7. Water quality trends in segment YRKPH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
YRKPH	TN*	Annual	S	0.414	0.0110	45.22	0.00	0.0017	DEGRADING
YRKPH	TN*	Spring1	S	0.411	0.0170	70.79	0.00	0.0299	DEGRADING
YRKPH	TN*	Summer1	S	0.409	0.0170	72.31	0.00	0.0156	DEGRADING
YRKPH	TN*	Fall	S	0.416	0.0120	48.68	0.00	0.0186	DEGRADING
YRKPH	TN*	Spring2	S	0.397	0.0180	78.73	0.00	0.0065	DEGRADING
YRKPH	TN*	Summer2	S	0.437	0.0160	63.00	0.00	0.0341	DEGRADING
YRKPH	TN*	Annual	B	0.427	0.0200	80.36	0.00	<0.0001	DEGRADING
YRKPH	TN*	Spring1	B	0.411	0.0310	128.77	0.00	0.0076	DEGRADING
YRKPH	TN*	Summer1	B	0.440	0.0320	121.80	0.00	0.0003	DEGRADING
YRKPH	TN*	Fall	B	0.408	0.0190	79.54	0.00	0.0068	DEGRADING
YRKPH	TN*	Spring2	B	0.434	0.0320	125.86	0.00	0.0004	DEGRADING
YRKPH	TN*	Summer2	B	0.455	0.0330	124.45	0.00	0.0046	DEGRADING
YRKPH	TP*	Annual	S	0.037	0.0020	96.06	0.00	<0.0001	DEGRADING
YRKPH	TP*	Spring1	S	0.030	0.0020	101.74	0.00	0.0027	DEGRADING
YRKPH	TP*	Summer1	S	0.043	0.0020	71.11	0.00	0.0103	DEGRADING
YRKPH	TP*	Fall	S	0.039	0.0040	158.46	0.00	0.0023	DEGRADING
YRKPH	TP*	Spring2	S	0.029	0.0020	140.18	0.00	0.0002	DEGRADING
YRKPH	TP*	Annual	B	0.042	0.0030	101.35	0.00	<0.0001	DEGRADING
YRKPH	TP*	Spring1	B	0.046	0.0020	88.91	0.00	0.0239	DEGRADING
YRKPH	TP*	Summer1	B	0.042	0.0030	108.73	0.00	0.0002	DEGRADING
YRKPH	TP*	Fall	B	0.038	0.0030	126.23	0.00	0.0019	DEGRADING
YRKPH	TP*	Winter	B	0.034	0.0020	88.99	0.00	0.0141	DEGRADING
YRKPH	TP*	Spring2	B	0.042	0.0030	101.25	0.00	0.0053	DEGRADING
YRKPH	TP*	Summer2	B	0.045	0.0030	105.14	0.00	0.0005	DEGRADING
YRKPH	PO4F*	Summer1	S	0.011	0.0010	177.99	5.56	0.0042	DEGRADING
YRKPH	PO4F*	Summer2	S	0.012	0.0010	160.76	0.00	0.0205	DEGRADING
YRKPH	CHLA*	Summer1	S	8.30	0.161	32.98	0.00	0.0390	DEGRADING
YRKPH	TSS	Spring2	S	6.00	0.569	161.16	0.04	0.0200	DEGRADING
YRKPH	TSS	Annual	B	20.00	0.539	45.81	0.01	0.0440	DEGRADING
YRKPH	SECCHI	Annual	S	1.30	-0.01	-9.94	0.00	0.0380	DEGRADING
YRKPH	SECCHI	Spring1	S	1.30	-0.02	-27.98	0.00	0.0200	DEGRADING
YRKPH	SALIN	Summer1	S	22.78	-0.20	-14.92	0.00	0.0030	DECREASING
YRKPH	SALIN	Summer2	S	22.94	-0.21	-15.44	0.00	0.0050	DECREASING
YRKPH	SALIN	Summer1	B	23.94	-0.14	-10.17	0.00	0.0120	DECREASING
YRKPH	SALIN	Summer2	B	24.14	-0.10	-7.35	0.00	0.0480	DECREASING
YRKPH	WTEMP	Spring2	B	18.76	-0.10	-9.40	0.00	0.0210	DECREASING
YRKPH	PLL05	Spring1	S	0.40	-0.016	-68.43	0.00	<0.0001	DEGRADING
YRKPH	PLL05	Spring2	S	0.50	-0.014	-47.60	0.00	0.0010	DEGRADING
YRKPH	PLL10	Spring1	S	0.30	-0.011	-62.90	0.00	<0.0001	DEGRADING
YRKPH	PLL10	Spring2	S	0.30	-0.010	-56.67	0.00	0.0010	DEGRADING

Table 4-8. **SAV season water quality status in segment YRKPH (value is the median concentration; secchi in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).**

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
YRKPH	TN	0.438	39.6	**Good**	-	-
YRKPH	DIN	0.036	30.0	**Good**	0.0375	**Pass**
YRKPH	TP	0.049	86.9	**Poor**	-	-
YRKPH	DIP	0.012	70.6	**Poor**	0.0170	**Borderline**
YRKPH	CHLA	6.61	52.8	**Fair**	9.1	**Pass**
YRKPH	TSS	11.25	51.7	**Fair**	9.7	**Pass**
YRKPH	SECCHI	1.08	11.5	**Poor**	-	-
YRKPH	KD	-	-	-	1.50	**Borderline**
YRKPH	PLL05	-	-	-	0.195	**Pass**
YRKPH	PLL10	-	-	-	0.097	**Fails**

Table 4-9. **SAV Season Water quality trends in segment YRKPH (only significant trends are displayed).**

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
YRKPH	TN*	SAV1	S	0.422	0.0170	70.12	0.00	0.0003	**DEGRADING**
YRKPH	TN*	SAV2	S	0.418	0.0170	67.13	0.00	0.0001	**DEGRADING**
YRKPH	TP*	SAV1	S	0.039	0.0020	79.12	0.00	<0.0001	**DEGRADING**
YRKPH	TP*	SAV2	S	0.039	0.0020	90.41	0.00	<0.0001	**DEGRADING**
YRKPH	SECCHI	SAV2	S	1.30	-0.02	-21.84	0.00	0.0060	**DEGRADING**
YRKPH	PLL05	SAV2	S	0.30	-0.006	-36.27	0.00	0.0420	**DEGRADING**
YRKPH	PLL10	SAV2	S	0.20	-0.004	-34.85	0.00	0.0340	**DEGRADING**

Table 4-10. Water quality status in segment YRKMH (value is the median concentration, secchi in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
YRKMH	TN	Annual	0.633	28.7	GOOD	0.796	51.7	FAIR
YRKMH	TN	Spring1	0.732	27.6	GOOD	0.827	51.8	FAIR
YRKMH	TN	Spring2	0.732	31.2	GOOD	0.821	57.5	FAIR
YRKMH	TN	Summer1	0.623	25.7	GOOD	0.736	51.3	FAIR
YRKMH	TN	Summer2	0.628	29.8	GOOD	0.729	53.8	FAIR
YRKMH	DIN	Annual	0.084	33.7	GOOD	0.075	18.1	GOOD
YRKMH	DIN	Spring1	0.063	7.5	GOOD	0.041	2.4	GOOD
YRKMH	DIN	Spring2	0.062	22.1	GOOD	0.049	9.8	GOOD
YRKMH	DIN	Summer1	0.090	62.4	POOR	0.099	26.6	GOOD
YRKMH	DIN	Summer2	0.090	62.4	POOR	0.099	28.0	GOOD
YRKMH	TP	Annual	0.092	88.7	POOR	0.123	93.7	POOR
YRKMH	TP	Spring1	0.101	94.3	POOR	0.125	95.7	POOR
YRKMH	TP	Spring2	0.097	91.5	POOR	0.127	95.5	POOR
YRKMH	TP	Summer1	0.089	82.5	POOR	0.125	91.4	POOR
YRKMH	TP	Summer2	0.104	80.5	POOR	0.124	89.9	POOR
YRKMH	DIP	Annual	0.018	91.1	POOR	0.017	82.7	POOR
YRKMH	DIP	Spring1	0.009	82.1	POOR	0.010	83.7	POOR
YRKMH	DIP	Spring2	0.011	86.0	POOR	0.011	84.0	POOR
YRKMH	DIP	Summer1	0.031	93.0	POOR	0.028	77.7	POOR
YRKMH	DIP	Summer2	0.035	93.7	POOR	0.033	80.5	POOR
YRKMH	CHLA	Annual	15.713	76.1	POOR	-	-	-
YRKMH	CHLA	Spring1	17.090	80.4	POOR	-	-	-
YRKMH	CHLA	Spring2	13.915	71.9	POOR	-	-	-
YRKMH	CHLA	Summer1	16.708	68.0	POOR	-	-	-
YRKMH	CHLA	Summer2	17.440	67.4	POOR	-	-	-
YRKMH	TSS	Annual	27.000	92.2	POOR	64.000	95.3	POOR
YRKMH	TSS	Spring1	55.500	97.9	POOR	90.000	97.6	POOR
YRKMH	TSS	Spring2	60.000	98.3	POOR	88.500	97.5	POOR
YRKMH	TSS	Summer1	26.500	92.1	POOR	55.500	95.4	POOR
YRKMH	TSS	Summer2	26.000	89.9	POOR	42.500	93.1	POOR
YRKMH	SECCHI	Annual	0.550	4.8	POOR	-	-	-
YRKMH	SECCHI	Spring1	0.400	3.6	POOR	-	-	-
YRKMH	SECCHI	Spring2	0.400	3.2	POOR	-	-	-
YRKMH	SECCHI	Summer1	0.500	5.2	POOR	-	-	-
YRKMH	SECCHI	Summer2	0.500	5.2	POOR	-	-	-
YRKMH	DO	Spring1	-	-	-	8.235	-	GOOD
YRKMH	DO	Spring2	-	-	-	6.425	-	GOOD
YRKMH	DO	Summer1	-	-	-	5.273	-	GOOD
YRKMH	DO	Summer2	-	-	-	5.238	-	GOOD

Table 4-11. Water quality trends in segment YRKMH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
YRKMH	TN*	Annual	S	0.574	0.0190	55.98	0.00	0.0003	**DEGRADING**
YRKMH	TN*	Spring1	S	0.596	0.0180	50.74	0.00	0.0302	**DEGRADING**
YRKMH	TN*	Summer1	S	0.544	0.0290	91.94	0.00	0.0067	**DEGRADING**
YRKMH	TN*	Fall	S	0.534	0.0190	58.91	0.00	0.0363	**DEGRADING**
YRKMH	TN*	Spring2	S	0.528	0.0230	73.42	0.00	0.0026	**DEGRADING**
YRKMH	TN*	Summer2	S	0.572	0.0300	89.48	0.00	0.0115	**DEGRADING**
YRKMH	TN*	Annual	B	0.621	0.0240	64.85	0.00	<0.0001	**DEGRADING**
YRKMH	TN*	Summer1	B	0.602	0.0310	88.63	0.00	0.0048	**DEGRADING**
YRKMH	TN*	Fall	B	0.562	0.0190	58.33	0.00	0.0059	**DEGRADING**
YRKMH	TN*	Spring2	B	0.544	0.0230	71.90	0.00	0.0115	**DEGRADING**
YRKMH	TN*	Summer2	B	0.630	0.0340	91.20	0.00	0.0076	**DEGRADING**
YRKMH	DIN*	Spring1	S	0.148	0.0170	193.58	7.41	0.0217	**DEGRADING**
YRKMH	DIN*	Spring1	B	0.115	0.0180	260.11	7.41	0.0115	**DEGRADING**
YRKMH	DIN*	Spring2	B	0.100	0.0120	206.17	14.81	0.0256	**DEGRADING**
YRKMH	TP*	Annual	S	0.060	0.0040	119.80	0.00	<0.0001	**DEGRADING**
YRKMH	TP*	Spring1	S	0.066	0.0030	64.32	0.00	0.0385	**DEGRADING**
YRKMH	TP*	Summer1	S	0.060	0.0060	158.61	0.00	0.0009	**DEGRADING**
YRKMH	TP*	Fall	S	0.049	0.0050	182.60	0.00	<0.0001	**DEGRADING**
YRKMH	TP*	Winter	S	0.058	0.0040	124.03	0.00	0.0413	**DEGRADING**
YRKMH	TP*	Spring2	S	0.054	0.0030	97.23	0.00	0.0124	**DEGRADING**
YRKMH	TP*	Summer2	S	0.062	0.0060	163.25	0.00	0.0030	**DEGRADING**
YRKMH	TP*	Annual	B	0.072	0.0060	148.40	0.00	<0.0001	**DEGRADING**
YRKMH	TP*	Summer1	B	0.070	0.0070	157.84	0.00	0.0059	**DEGRADING**
YRKMH	TP*	Fall	B	0.059	0.0070	210.45	0.00	<0.0001	**DEGRADING**
YRKMH	TP*	Winter	B	0.061	0.0060	175.36	0.00	0.0424	**DEGRADING**
YRKMH	TP*	Summer2	B	0.072	0.0080	177.56	0.00	0.0047	**DEGRADING**
YRKMH	PO4F*	Annual	S	0.013	0.0010	93.14	19.05	<0.0001	**DEGRADING**
YRKMH	PO4F*	Summer1	S	0.017	0.0020	232.15	0.00	0.0009	**DEGRADING**
YRKMH	PO4F*	Fall	S	0.021	0.0010	112.27	3.85	0.0191	**DEGRADING**
YRKMH	PO4F*	Summer2	S	0.017	0.0030	293.17	0.00	0.0002	**DEGRADING**
YRKMH	PO4F*	Annual	B	0.014	0.0010	99.58	19.23	<0.0001	**DEGRADING**
YRKMH	PO4F*	Summer1	B	0.017	0.0020	203.22	2.78	0.0011	**DEGRADING**
YRKMH	PO4F*	Fall	B	0.023	0.0020	149.79	0.00	0.0057	**DEGRADING**
YRKMH	PO4F*	Summer2	B	0.018	0.0020	225.53	0.00	0.0012	**DEGRADING**
YRKMH	CHLA*	Annual	S	9.50	0.257	45.95	0.04	0.0050	**DEGRADING**
YRKMH	TSS	Annual	B	42.10	1.561	63.02	0.00	0.0110	**DEGRADING**
YRKMH	DO	Summer1	B	5.10	0.03	10.63	0.00	0.0450	**IMPROVING**
YRKMH	SALIN	Summer1	B	16.51	-0.16	-16.80	0.00	0.0170	**DECREASING**
YRKMH	SALIN	Summer2	B	16.83	-0.16	-16.10	0.00	0.0450	**DECREASING**
YRKMH	PLL05	Annual	S	0.00	0.001	0.00	0.00	0.0110	**IMPROVING**
YRKMH	PLL10	Annual	S	0.00	0.001	0.00	0.00	0.0260	**IMPROVING**

Table 4-12. **SAV season water quality status in segment YRKMH (value is the median concentration; secchi in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).**

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
YRKMH	TN	0.628	27.8	**Good**	-	-
YRKMH	DIN	0.075	39.0	**Good**	0.0880	**Pass**
YRKMH	TP	0.091	86.7	**Poor**	-	-
YRKMH	DIP	0.021	90.8	**Poor**	0.0205	**Fails**
YRKMH	CHLA	13.92	69.5	**Poor**	15.2	**Borderline**
YRKMH	TSS	27.00	92.8	**Poor**	28.0	**Fails**
YRKMH	SECCHI	0.50	5.3	**Poor**	-	-
YRKMH	KD	-	-	-	2.90	**Fails**
YRKMH	PLL05	-	-	-	0.048	**Fails**
YRKMH	PLL10	-	-	-	0.012	**Fails**

Table 4-13. **SAV Season Waterquality trends in segment YRKMH (only significant trends are displayed).**

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
YRKMH	TN*	SAV1	S	0.546	0.0280	86.19	0.00	<0.0001	**DEGRADING**
YRKMH	TN*	SAV2	S	0.567	0.0230	70.20	0.00	0.0003	**DEGRADING**
YRKMH	TP*	SAV1	S	0.057	0.0050	157.14	0.00	<0.0001	**DEGRADING**
YRKMH	TP*	SAV2	S	0.062	0.0040	114.71	0.00	<0.0001	**DEGRADING**
YRKMH	PO4F*	SAV1	S	0.014	0.0010	141.75	9.52	0.0001	**DEGRADING**
YRKMH	PO4F*	SAV2	S	0.011	0.0010	119.48	18.87	0.0001	**DEGRADING**
YRKMH	CHLA*	SAV1	S	9.50	0.257	45.95	0.00	0.0410	**DEGRADING**
YRKMH	PLL05	SAV1	S	0.00	0.001	0.00	0.00	0.0360	**IMPROVING**
YRKMH	PLL10	SAV1	S	0.00	0.000	0.00	0.00	0.0460	**IMPROVING**

Table 4-14. Water quality status in segment PMKOH (value is the median concentration, secchi in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
PMKOH	TN	Annual	0.767	11.1	**GOOD**	1.199	32.1	**GOOD**
PMKOH	TN	Spring1	0.940	13.0	**GOOD**	1.719	46.6	**FAIR**
PMKOH	TN	Spring2	0.934	17.2	**GOOD**	1.420	40.8	**FAIR**
PMKOH	TN	Summer1	0.688	12.6	**GOOD**	1.034	34.0	**GOOD**
PMKOH	TN	Summer2	0.680	13.4	**GOOD**	1.014	35.6	**GOOD**
PMKOH	DIN	Annual	0.217	23.3	**GOOD**	0.208	21.3	**GOOD**
PMKOH	DIN	Spring1	0.297	12.4	**GOOD**	0.294	11.8	**GOOD**
PMKOH	DIN	Spring2	0.250	19.3	**GOOD**	0.240	17.7	**GOOD**
PMKOH	DIN	Summer1	0.164	38.2	**GOOD**	0.163	36.1	**GOOD**
PMKOH	DIN	Summer2	0.124	34.9	**GOOD**	0.144	37.7	**GOOD**
PMKOH	TP	Annual	0.092	48.5	**FAIR**	0.199	79.6	**POOR**
PMKOH	TP	Spring1	0.144	73.6	**POOR**	0.294	89.9	**POOR**
PMKOH	TP	Spring2	0.143	74.0	**POOR**	0.272	87.8	**POOR**
PMKOH	TP	Summer1	0.095	46.9	**FAIR**	0.199	77.0	**POOR**
PMKOH	TP	Summer2	0.090	42.2	**FAIR**	0.191	74.8	**POOR**
PMKOH	DIP	Annual	0.022	74.8	**POOR**	0.023	74.7	**POOR**
PMKOH	DIP	Spring1	0.017	70.5	**POOR**	0.018	70.3	**POOR**
PMKOH	DIP	Spring2	0.018	67.7	**POOR**	0.018	66.8	**POOR**
PMKOH	DIP	Summer1	0.023	72.3	**POOR**	0.023	69.4	**POOR**
PMKOH	DIP	Summer2	0.023	74.0	**POOR**	0.024	70.7	**POOR**
PMKOH	CHLA	Annual	9.235	44.4	**FAIR**	-	-	-
PMKOH	CHLA	Spring1	5.015	21.0	**GOOD**	-	-	-
PMKOH	CHLA	Spring2	9.180	39.9	**GOOD**	-	-	-
PMKOH	CHLA	Summer1	12.405	41.7	**FAIR**	-	-	-
PMKOH	CHLA	Summer2	19.970	58.8	**POOR**	-	-	-
PMKOH	TSS	Annual	58.000	88.6	**POOR**	122.000	91.7	**POOR**
PMKOH	TSS	Spring1	85.000	93.5	**POOR**	159.000	93.2	**POOR**
PMKOH	TSS	Spring2	82.000	94.6	**POOR**	161.000	94.1	**POOR**
PMKOH	TSS	Summer1	46.500	84.8	**POOR**	124.000	92.9	**POOR**
PMKOH	TSS	Summer2	35.000	78.3	**POOR**	122.000	92.5	**POOR**
PMKOH	SECCHI	Annual	0.400	44.7	**FAIR**	-	-	-
PMKOH	SECCHI	Spring1	0.200	9.6	**POOR**	-	-	-
PMKOH	SECCHI	Spring2	0.200	6.6	**POOR**	-	-	-
PMKOH	SECCHI	Summer1	0.450	48.1	**FAIR**	-	-	-
PMKOH	SECCHI	Summer2	0.500	54.0	**FAIR**	-	-	-
PMKOH	DO	Spring1	-	-	-	8.395	-	**GOOD**
PMKOH	DO	Spring2	-	-	-	6.070	-	**GOOD**
PMKOH	DO	Summer1	-	-	-	5.180	-	**GOOD**
PMKOH	DO	Summer2	-	-	-	4.930	-	**FAIR**

Table 4-15. Water quality trends in segment PMKOH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
PMKOH	TN*	Annual	S	0.636	0.0250	65.49	0.00	0.0002	**DEGRADING**
PMKOH	TN*	Summer1	S	0.601	0.0300	83.46	0.00	0.0002	**DEGRADING**
PMKOH	TN*	Fall	S	0.585	0.0280	81.36	0.00	0.0402	**DEGRADING**
PMKOH	TN*	Spring2	S	0.586	0.0340	97.75	0.00	0.0348	**DEGRADING**
PMKOH	TN*	Summer2	S	0.612	0.0260	71.08	0.00	0.0007	**DEGRADING**
PMKOH	TN*	Annual	B	0.787	0.0410	87.93	0.00	0.0005	**DEGRADING**
PMKOH	TN*	Summer1	B	0.705	0.0430	104.38	0.00	0.0128	**DEGRADING**
PMKOH	TN*	Fall	B	0.775	0.0410	90.13	0.00	0.0092	**DEGRADING**
PMKOH	TN*	Summer2	B	0.702	0.0480	116.65	0.00	0.0161	**DEGRADING**
PMKOH	DIN*	Spring1	S	0.270	0.0080	47.22	0.00	0.0155	**DEGRADING**
PMKOH	DIN*	Winter	S	0.545	-0.0130	-38.99	0.00	0.0449	**IMPROVING**
PMKOH	DIN*	Spring2	S	0.170	0.0140	144.39	7.41	0.0044	**DEGRADING**
PMKOH	TP*	Annual	S	0.077	0.0050	110.92	0.00	0.0004	**DEGRADING**
PMKOH	TP*	Spring1	S	0.073	0.0070	163.22	0.00	0.0115	**DEGRADING**
PMKOH	TP*	Fall	S	0.065	0.0080	204.63	0.00	0.0114	**DEGRADING**
PMKOH	TP*	Summer2	S	0.079	0.0050	99.17	0.00	0.0458	**DEGRADING**
PMKOH	TP*	Annual	B	0.102	0.0140	228.05	0.00	0.0002	**DEGRADING**
PMKOH	TP*	Spring1	B	0.081	0.0210	438.37	0.00	0.0039	**DEGRADING**
PMKOH	TP*	Fall	B	0.104	0.0160	254.33	0.00	0.0159	**DEGRADING**
PMKOH	TP*	Spring2	B	0.086	0.0160	308.28	0.00	0.0250	**DEGRADING**
PMKOH	PO4F*	Summer1	S	0.013	0.0030	365.31	8.33	0.0014	**DEGRADING**
PMKOH	PO4F*	Summer2	S	0.010	0.0030	578.84	11.11	0.0001	**DEGRADING**
PMKOH	PO4F*	Summer2	B	0.008	0.0030	598.44	14.81	0.0024	**DEGRADING**
PMKOH	CHLA*	Annual	S	6.40	0.103	27.41	0.23	0.0020	**DEGRADING**
PMKOH	CHLA*	Summer1	S	9.50	0.379	67.79	0.03	0.0210	**DEGRADING**
PMKOH	SALIN	Annual	S	3.49	0.06	27.62	0.00	0.0210	**INCREASING**
PMKOH	SALIN	Annual	B	4.31	0.06	25.32	0.00	0.0410	**INCREASING**

Table 4-16. SAV season water quality status in segment PMKOH (value is the median concentration; secchi in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
PMKOH	TN	0.732	12.6	**Good**	-	-
PMKOH	DIN	0.203	32.9	**Good**	0.2030	-
PMKOH	TP	0.101	51.9	**Fair**	-	-
PMKOH	DIP	0.023	75.2	**Poor**	0.0230	**Borderline**
PMKOH	CHLA	10.54	38.3	**Good**	10.5	**Borderline**
PMKOH	TSS	58.00	90.5	**Poor**	58.0	**Fails**
PMKOH	SECCHI	0.40	42.6	**Fair**	-	-
PMKOH	KD	-	-	-	3.60	**Fails**
PMKOH	PLL05	-	-	-	0.009	**Fails**
PMKOH	PLL10	-	-	-	0.001	**Fails**

Table 4-17. SAV Season Water quality trends in segment PMKOH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
PMKOH	TN*	SAV1	S	0.590	0.0310	89.54	0.00	<0.0001	**DEGRADING**
PMKOH	TN*	SAV2	S	0.604	0.0310	87.29	0.00	0.0004	**DEGRADING**
PMKOH	DIN*	SAV1	S	0.134	0.0080	99.17	11.11	0.0246	**DEGRADING**
PMKOH	DIN*	SAV2	S	0.205	0.0060	51.35	7.69	0.0481	**DEGRADING**
PMKOH	TP*	SAV1	S	0.072	0.0050	117.59	0.00	0.0020	**DEGRADING**
PMKOH	TP*	SAV2	S	0.068	0.0070	182.87	0.00	0.0001	**DEGRADING**
PMKOH	PO4F*	SAV1	S	0.012	0.0020	274.93	12.70	0.0001	**DEGRADING**
PMKOH	PO4F*	SAV2	S	0.011	0.0010	207.30	26.92	0.0058	**DEGRADING**
PMKOH	CHLA*	SAV1	S	7.50	0.228	51.77	0.08	0.0320	**DEGRADING**

Table 4-18. Water quality status in segment PMKTF (value is the median concentration, secchi in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
PMKTF	TN	Annual	0.751	9.9	GOOD	0.787	7.7	GOOD
PMKTF	TN	Spring1	0.735	10.3	GOOD	0.752	8.0	GOOD
PMKTF	TN	Spring2	0.824	13.5	GOOD	0.763	7.5	GOOD
PMKTF	TN	Summer1	0.638	5.2	GOOD	0.646	3.1	GOOD
PMKTF	TN	Summer2	0.618	4.5	GOOD	0.645	3.1	GOOD
PMKTF	DIN	Annual	0.336	18.3	GOOD	0.309	14.0	GOOD
PMKTF	DIN	Spring1	0.369	13.6	GOOD	0.362	11.0	GOOD
PMKTF	DIN	Spring2	0.368	16.7	GOOD	0.362	12.9	GOOD
PMKTF	DIN	Summer1	0.127	6.8	GOOD	0.128	6.5	GOOD
PMKTF	DIN	Summer2	0.126	8.5	GOOD	0.115	7.6	GOOD
PMKTF	TP	Annual	0.073	33.0	GOOD	0.078	28.0	GOOD
PMKTF	TP	Spring1	0.076	41.6	FAIR	0.083	38.8	GOOD
PMKTF	TP	Spring2	0.085	44.3	FAIR	0.091	38.0	GOOD
PMKTF	TP	Summer1	0.076	25.5	GOOD	0.081	23.5	GOOD
PMKTF	TP	Summer2	0.069	17.9	GOOD	0.073	16.9	GOOD
PMKTF	DIP	Annual	0.020	44.0	FAIR	0.020	52.1	FAIR
PMKTF	DIP	Spring1	0.023	54.5	FAIR	0.023	62.9	POOR
PMKTF	DIP	Spring2	0.032	68.5	POOR	0.026	66.5	POOR
PMKTF	DIP	Summer1	0.019	42.0	FAIR	0.019	49.1	FAIR
PMKTF	DIP	Summer2	0.019	42.2	FAIR	0.018	48.9	FAIR
PMKTF	CHLA	Annual	2.785	19.7	GOOD	-	-	-
PMKTF	CHLA	Spring1	2.710	17.7	GOOD	-	-	-
PMKTF	CHLA	Spring2	2.850	14.5	GOOD	-	-	-
PMKTF	CHLA	Summer1	6.745	25.1	GOOD	-	-	-
PMKTF	CHLA	Summer2	7.385	25.3	GOOD	-	-	-
PMKTF	TSS	Annual	17.500	59.6	POOR	20.000	31.8	GOOD
PMKTF	TSS	Spring1	20.000	62.9	POOR	24.000	40.2	GOOD
PMKTF	TSS	Spring2	20.000	60.7	POOR	24.000	33.9	GOOD
PMKTF	TSS	Summer1	20.500	67.2	POOR	21.000	28.4	GOOD
PMKTF	TSS	Summer2	22.000	71.2	POOR	21.000	29.0	GOOD
PMKTF	SECCHI	Annual	0.600	60.6	FAIR	-	-	-
PMKTF	SECCHI	Spring1	0.600	59.6	GOOD	-	-	-
PMKTF	SECCHI	Spring2	0.600	60.7	GOOD	-	-	-
PMKTF	SECCHI	Summer1	0.600	58.8	FAIR	-	-	-
PMKTF	SECCHI	Summer2	0.600	58.0	FAIR	-	-	-
PMKTF	DO	Spring1	-	-	-	8.245	-	GOOD
PMKTF	DO	Spring2	-	-	-	6.600	-	GOOD
PMKTF	DO	Summer1	-	-	-	5.280	-	GOOD
PMKTF	DO	Summer2	-	-	-	5.080	-	GOOD

Table 4-19. Water quality trends in segment PMKTF (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
PMKTF	TP*	Annual	S	0.054	0.0020	62.60	0.00	0.0004	**DEGRADING**
PMKTF	TP*	Spring1	S	0.040	0.0020	85.00	0.00	0.0123	**DEGRADING**
PMKTF	TP*	Fall	S	0.046	0.0030	107.84	0.00	0.0149	**DEGRADING**
PMKTF	TP*	Spring2	S	0.051	0.0020	67.10	0.00	0.0239	**DEGRADING**
PMKTF	TP*	Annual	B	0.057	0.0030	100.67	0.00	<0.0001	**DEGRADING**
PMKTF	TP*	Spring1	B	0.041	0.0040	164.51	0.00	0.0014	**DEGRADING**
PMKTF	TP*	Summer1	B	0.074	0.0040	91.32	0.00	0.0401	**DEGRADING**
PMKTF	TP*	Fall	B	0.052	0.0030	88.27	0.00	0.0127	**DEGRADING**
PMKTF	TP*	Spring2	B	0.053	0.0030	98.81	0.00	0.0053	**DEGRADING**
PMKTF	PO4F*	Summer1	S	0.029	-0.0020	-125.03	25.00	0.0293	**IMPROVING**
PMKTF	PO4F*	Fall	B	0.026	-0.0020	-109.68	36.00	0.0245	**IMPROVING**
PMKTF	TSS	Annual	B	20.50	-0.500	-41.46	0.01	0.0130	**IMPROVING**
PMKTF	WTEMP	Annual	S	18.00	0.06	5.39	0.00	0.0480	**INCREASING**
PMKTF	WTEMP	Summer1	S	25.50	0.11	7.53	0.00	0.0130	**INCREASING**
PMKTF	WTEMP	Summer2	S	25.50	0.17	11.04	0.00	0.0010	**INCREASING**
PMKTF	WTEMP	Annual	B	19.10	0.08	7.02	0.00	0.0260	**INCREASING**
PMKTF	WTEMP	Summer2	B	26.00	0.15	9.81	0.00	0.0020	**INCREASING**

Table 4-20. **SAV season water quality status in segment PMKTF (value is the median concentration; secchi in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).**

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
PMKTF	TN	0.674	7.2	**Good**	-	-
PMKTF	DIN	0.233	14.0	**Good**	0.2330	-
PMKTF	TP	0.076	29.9	**Good**	-	-
PMKTF	DIP	0.023	51.2	**Fair**	0.0230	**Borderline**
PMKTF	CHLA	3.47	15.4	**Good**	3.5	**Pass**
PMKTF	TSS	19.00	61.5	**Poor**	19.0	**Borderline**
PMKTF	SECCHI	0.60	58.9	**Fair**	-	-
PMKTF	KD	-	-	-	2.40	**Fails**
PMKTF	PLL05	-	-	-	0.076	**Borderline**
PMKTF	PLL10	-	-	-	0.026	**Fails**

Table 4-21. **SAV Season Water quality trends in segment PMKTF (only significant trends are displayed).**

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
PMKTF	TP*	SAV1	S	0.059	0.0020	57.21	0.00	0.0105	**DEGRADING**
PMKTF	TP*	SAV2	S	0.046	0.0020	73.76	0.00	0.0051	**DEGRADING**

Table 4-22. Water quality status in segment MPNOH (value is the median concentration, secchi in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
MPNOH	TN	Annual	0.760	10.8	GOOD	0.844	12.9	GOOD
MPNOH	TN	Spring1	0.904	11.6	GOOD	0.834	7.1	GOOD
MPNOH	TN	Spring2	0.830	12.6	GOOD	0.834	10.3	GOOD
MPNOH	TN	Summer1	0.727	14.9	GOOD	1.032	33.9	GOOD
MPNOH	TN	Summer2	0.727	16.5	GOOD	1.123	44.6	FAIR
MPNOH	DIN	Annual	0.176	18.5	GOOD	0.160	15.6	GOOD
MPNOH	DIN	Spring1	0.200	6.3	GOOD	0.184	5.1	GOOD
MPNOH	DIN	Spring2	0.194	13.7	GOOD	0.189	12.6	GOOD
MPNOH	DIN	Summer1	0.159	37.4	GOOD	0.158	35.0	GOOD
MPNOH	DIN	Summer2	0.159	43.3	FAIR	0.157	40.7	FAIR
MPNOH	TP	Annual	0.102	55.9	FAIR	0.126	54.1	FAIR
MPNOH	TP	Spring1	0.147	74.7	POOR	0.120	45.5	FAIR
MPNOH	TP	Spring2	0.118	61.1	POOR	0.158	60.8	POOR
MPNOH	TP	Summer1	0.108	56.9	FAIR	0.192	75.1	POOR
MPNOH	TP	Summer2	0.113	60.3	FAIR	0.192	75.0	POOR
MPNOH	DIP	Annual	0.020	70.4	POOR	0.019	68.0	POOR
MPNOH	DIP	Spring1	0.013	59.0	FAIR	0.015	62.9	POOR
MPNOH	DIP	Spring2	0.019	69.9	POOR	0.017	64.5	POOR
MPNOH	DIP	Summer1	0.024	73.7	POOR	0.025	72.1	POOR
MPNOH	DIP	Summer2	0.030	81.9	POOR	0.027	74.6	POOR
MPNOH	CHLA	Annual	9.080	43.7	FAIR	-	-	-
MPNOH	CHLA	Spring1	5.230	22.2	GOOD	-	-	-
MPNOH	CHLA	Spring2	6.980	29.5	GOOD	-	-	-
MPNOH	CHLA	Summer1	12.650	42.7	FAIR	-	-	-
MPNOH	CHLA	Summer2	12.820	39.5	GOOD	-	-	-
MPNOH	TSS	Annual	32.500	68.4	POOR	61.000	74.0	POOR
MPNOH	TSS	Spring1	56.000	83.9	POOR	62.000	68.9	POOR
MPNOH	TSS	Spring2	41.000	73.0	POOR	70.000	73.3	POOR
MPNOH	TSS	Summer1	30.000	68.1	POOR	75.000	80.5	POOR
MPNOH	TSS	Summer2	30.000	70.5	POOR	80.000	82.8	POOR
MPNOH	SECCHI	Annual	0.400	44.7	FAIR	-	-	-
MPNOH	SECCHI	Spring1	0.300	35.6	POOR	-	-	-
MPNOH	SECCHI	Spring2	0.300	29.3	POOR	-	-	-
MPNOH	SECCHI	Summer1	0.400	37.5	POOR	-	-	-
MPNOH	SECCHI	Summer2	0.400	33.5	POOR	-	-	-
MPNOH	DO	Spring1	-	-	-	8.230	-	GOOD
MPNOH	DO	Spring2	-	-	-	7.060	-	GOOD
MPNOH	DO	Summer1	-	-	-	4.985	-	FAIR
MPNOH	DO	Summer2	-	-	-	4.540	-	FAIR

Table 4-23. Water quality trends in segment MPNOH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
MPNOH	TN*	Annual	S	0.539	0.0220	69.74	0.00	<0.0001	**DEGRADING**
MPNOH	TN*	Spring1	S	0.553	0.0200	59.98	0.00	0.0077	**DEGRADING**
MPNOH	TN*	Summer1	S	0.514	0.0270	90.26	0.00	0.0004	**DEGRADING**
MPNOH	TN*	Fall	S	0.506	0.0260	86.64	0.00	0.0078	**DEGRADING**
MPNOH	TN*	Spring2	S	0.519	0.0230	76.67	0.00	0.0066	**DEGRADING**
MPNOH	TN*	Summer2	S	0.513	0.0330	110.77	0.00	0.0001	**DEGRADING**
MPNOH	TN*	Annual	B	0.736	0.0190	43.68	0.00	0.0132	**DEGRADING**
MPNOH	TN*	Fall	B	0.623	0.0250	67.10	0.00	0.0073	**DEGRADING**
MPNOH	DIN*	Spring1	S	0.189	0.0110	100.03	3.70	0.0112	**DEGRADING**
MPNOH	DIN*	Spring2	S	0.133	0.0130	171.04	3.70	0.0016	**DEGRADING**
MPNOH	DIN*	Spring1	B	0.199	0.0110	91.57	3.70	0.0095	**DEGRADING**
MPNOH	DIN*	Spring2	B	0.130	0.0130	166.80	7.41	0.0046	**DEGRADING**
MPNOH	TP*	Annual	S	0.053	0.0050	143.31	0.00	<0.0001	**DEGRADING**
MPNOH	TP*	Spring1	S	0.052	0.0070	224.12	0.00	0.0002	**DEGRADING**
MPNOH	TP*	Summer1	S	0.045	0.0040	145.85	0.00	0.0013	**DEGRADING**
MPNOH	TP*	Fall	S	0.053	0.0050	165.11	0.00	0.0230	**DEGRADING**
MPNOH	TP*	Spring2	S	0.047	0.0060	226.16	0.00	0.0001	**DEGRADING**
MPNOH	TP*	Summer2	S	0.046	0.0040	145.33	0.00	0.0107	**DEGRADING**
MPNOH	TP*	Annual	B	0.089	0.0050	93.20	0.00	0.0012	**DEGRADING**
MPNOH	TP*	Spring1	B	0.076	0.0070	160.07	0.00	0.0187	**DEGRADING**
MPNOH	TP*	Spring2	B	0.079	0.0070	155.73	0.00	0.0217	**DEGRADING**
MPNOH	PO4F*	Summer1	S	0.010	0.0020	321.47	13.89	0.0105	**DEGRADING**
MPNOH	PO4F*	Summer2	S	0.007	0.0030	676.56	18.52	0.0009	**DEGRADING**
MPNOH	PO4F*	Summer1	B	0.010	0.0020	321.47	11.11	0.0111	**DEGRADING**
MPNOH	PO4F*	Summer2	B	0.007	0.0030	626.45	14.81	0.0009	**DEGRADING**
MPNOH	CHLA*	Annual	S	3.90	0.091	39.80	0.31	<0.0001	**DEGRADING**
MPNOH	CHLA*	Spring1	S	1.60	0.000	0.00	0.46	0.0300	**DEGRADING**
MPNOH	TSS	Summer1	B	40.00	2.500	106.25	0.00	0.0170	**DEGRADING**
MPNOH	TSS	Summer2	B	36.00	3.036	143.35	0.00	0.0220	**DEGRADING**
MPNOH	DO	Summer1	B	5.10	0.05	16.30	0.00	0.0260	**IMPROVING**
MPNOH	SALIN	Annual	S	3.38	0.12	59.85	0.00	0.0020	**INCREASING**
MPNOH	SALIN	Annual	B	4.31	0.12	46.03	0.00	0.0100	**INCREASING**
MPNOH	WTEMP	Summer2	S	26.58	0.08	4.80	0.00	0.0200	**INCREASING**
MPNOH	PLL10	Summer2	S	0.00	-0.001	0.00	0.00	0.0390	**DEGRADING**

Table 4-24. **SAV season water quality status in segment MPNOH (value is the median concentration; secchi in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).**

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
MPNOH	TN	0.742	13.1	Good	-	-
MPNOH	DIN	0.159	26.1	Good	0.1590	-
MPNOH	TP	0.113	60.7	Fair	-	-
MPNOH	DIP	0.021	72.0	Poor	0.0210	Borderline
MPNOH	CHLA	10.04	36.4	Good	10.0	Pass
MPNOH	TSS	37.00	75.4	Poor	37.0	Fails
MPNOH	SECCHI	0.40	42.6	Fair	-	-
MPNOH	KD	-	-	-	3.60	Fails
MPNOH	PLL05	-	-	-	0.014	Fails
MPNOH	PLL10	-	-	-	0.003	Fails

Table 4-25. **SAV Season Water quality trends in segment MPNOH (only significant trends are displayed).**

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
MPNOH	TN*	SAV1	S	0.509	0.0300	98.62	0.00	<0.0001	DEGRADING
MPNOH	TN*	SAV2	S	0.533	0.0250	79.46	0.00	<0.0001	DEGRADING
MPNOH	DIN*	SAV1	S	0.098	0.0100	174.19	14.29	0.0079	DEGRADING
MPNOH	DIN*	SAV2	S	0.137	0.0090	112.92	13.21	0.0222	DEGRADING
MPNOH	TP*	SAV1	S	0.046	0.0050	193.71	0.00	<0.0001	DEGRADING
MPNOH	TP*	SAV2	S	0.051	0.0050	171.85	0.00	<0.0001	DEGRADING
MPNOH	PO4F*	SAV1	S	0.010	0.0010	195.26	19.05	0.0106	DEGRADING
MPNOH	CHLA*	SAV1	S	7.40	0.175	40.20	0.14	0.0070	DEGRADING
MPNOH	TSS	SAV1	S	19.00	0.556	49.71	0.01	0.0490	DEGRADING

Table 4-26. **Water quality status in segment MPNTF (value is the median concentration, secchi in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).**

Segment	**Parameter**	**Season**	**SValue**	**SScore**	**SStatus**	**BValue**	**BScore**	**BStatus**
MPNTF	TN	Annual	0.562	4.2	**GOOD**	0.632	3.6	**GOOD**
MPNTF	TN	Spring1	0.601	5.6	**GOOD**	0.662	5.2	**GOOD**
MPNTF	TN	Spring2	0.655	6.7	**GOOD**	0.688	5.2	**GOOD**
MPNTF	TN	Summer1	0.597	4.2	**GOOD**	0.632	2.8	**GOOD**
MPNTF	TN	Summer2	0.543	2.9	**GOOD**	0.560	1.7	**GOOD**
MPNTF	DIN	Annual	0.196	7.8	**GOOD**	0.188	5.8	**GOOD**
MPNTF	DIN	Spring1	0.206	4.1	**GOOD**	0.201	2.9	**GOOD**
MPNTF	DIN	Spring2	0.206	5.2	**GOOD**	0.204	3.4	**GOOD**
MPNTF	DIN	Summer1	0.108	5.3	**GOOD**	0.106	4.8	**GOOD**
MPNTF	DIN	Summer2	0.101	6.1	**GOOD**	0.099	6.1	**GOOD**
MPNTF	TP	Annual	0.067	27.9	**GOOD**	0.074	24.8	**GOOD**
MPNTF	TP	Spring1	0.061	27.0	**GOOD**	0.065	22.4	**GOOD**
MPNTF	TP	Spring2	0.072	30.6	**GOOD**	0.077	25.6	**GOOD**
MPNTF	TP	Summer1	0.077	26.6	**GOOD**	0.081	23.5	**GOOD**
MPNTF	TP	Summer2	0.082	28.6	**GOOD**	0.078	20.3	**GOOD**
MPNTF	DIP	Annual	0.020	45.1	**FAIR**	0.020	52.1	**FAIR**
MPNTF	DIP	Spring1	0.020	47.8	**FAIR**	0.025	66.7	**POOR**
MPNTF	DIP	Spring2	0.029	64.2	**POOR**	0.033	76.0	**POOR**
MPNTF	DIP	Summer1	0.022	45.9	**FAIR**	0.022	54.3	**FAIR**
MPNTF	DIP	Summer2	0.014	30.9	**GOOD**	0.016	44.0	**FAIR**
MPNTF	CHLA	Annual	2.190	14.6	**GOOD**	-	-	-
MPNTF	CHLA	Spring1	1.850	9.2	**GOOD**	-	-	-
MPNTF	CHLA	Spring2	1.900	7.6	**GOOD**	-	-	-
MPNTF	CHLA	Summer1	5.920	21.3	**GOOD**	-	-	-
MPNTF	CHLA	Summer2	6.840	23.0	**GOOD**	-	-	-
MPNTF	TSS	Annual	10.000	30.4	**GOOD**	9.000	7.0	**GOOD**
MPNTF	TSS	Spring1	10.000	21.4	**GOOD**	12.000	11.3	**GOOD**
MPNTF	TSS	Spring2	8.000	11.0	**GOOD**	8.000	3.0	**GOOD**
MPNTF	TSS	Summer1	7.500	12.8	**GOOD**	8.000	3.4	**GOOD**
MPNTF	TSS	Summer2	7.000	12.0	**GOOD**	8.000	3.7	**GOOD**
MPNTF	SECCHI	Annual	0.700	73.1	**GOOD**	-	-	-
MPNTF	SECCHI	Spring1	0.900	86.3	**GOOD**	-	-	-
MPNTF	SECCHI	Spring2	0.700	73.8	**GOOD**	-	-	-
MPNTF	SECCHI	Summer1	0.700	72.6	**GOOD**	-	-	-
MPNTF	SECCHI	Summer2	0.700	71.6	**GOOD**	-	-	-
MPNTF	DO	Spring1	-	-	-	8.370	-	**GOOD**
MPNTF	DO	Spring2	-	-	-	7.150	-	**GOOD**
MPNTF	DO	Summer1	-	-	-	5.740	-	**GOOD**
MPNTF	DO	Summer2	-	-	-	5.330	-	**GOOD**

Table 4-27. Water quality trends in segment MPNTF (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
MPNTF	TN*	Spring1	S	0.588	0.0090	25.74	0.00	0.0067	**DEGRADING**
MPNTF	TN*	Spring2	S	0.601	0.0120	35.09	0.00	0.0222	**DEGRADING**
MPNTF	TN*	Summer2	S	0.770	-0.0250	-55.82	0.00	0.0081	**IMPROVING**
MPNTF	TN*	Annual	B	0.702	-0.0100	-24.22	0.00	0.0269	**IMPROVING**
MPNTF	DIN*	Spring2	S	0.175	0.0100	92.07	0.00	0.0215	**DEGRADING**
MPNTF	TP*	Annual	S	0.050	0.0010	43.82	0.00	0.0001	**DEGRADING**
MPNTF	TP*	Spring1	S	0.037	0.0020	68.86	0.00	0.0130	**DEGRADING**
MPNTF	TP*	Spring2	S	0.049	0.0010	41.92	0.00	0.0120	**DEGRADING**
MPNTF	TP*	Annual	B	0.104	0.0010	16.38	0.00	0.0252	**DEGRADING**
MPNTF	WTEMP	Annual	S	17.50	0.10	9.71	0.00	0.0140	**INCREASING**
MPNTF	WTEMP	Summer1	S	25.63	0.19	12.72	0.00	0.0030	**INCREASING**
MPNTF	WTEMP	Summer2	S	25.63	0.21	13.87	0.00	<0.0001	**INCREASING**
MPNTF	WTEMP	Annual	B	18.58	0.12	10.62	0.00	0.0040	**INCREASING**
MPNTF	WTEMP	Summer1	B	26.50	0.17	10.61	0.00	0.0090	**INCREASING**
MPNTF	WTEMP	Summer2	B	26.50	0.21	13.42	0.00	<0.0001	**INCREASING**
MPNTF	PLL05	Annual	S	0.10	-0.004	-74.80	0.00	0.0130	**DEGRADING**
MPNTF	PLL05	Summer1	S	0.10	-0.006	-95.20	0.00	0.0370	**DEGRADING**
MPNTF	PLL10	Annual	S	0.10	-0.002	-37.40	0.00	0.0180	**DEGRADING**
MPNTF	PLL10	Summer1	S	0.10	-0.004	-61.20	0.00	0.0320	**DEGRADING**

Table 4-28. **SAV season water quality status in segment MPNTF (value is the median concentration; secchi in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).**

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
MPNTF	TN	0.599	5.0	Good	-	-
MPNTF	DIN	0.142	6.3	Good	0.1420	-
MPNTF	TP	0.071	25.1	Good	-	-
MPNTF	DIP	0.027	58.1	Fair	0.0270	Borderline
MPNTF	CHLA	2.92	12.2	Good	2.9	Pass
MPNTF	TSS	7.00	11.7	Good	7.0	Pass
MPNTF	SECCHI	0.80	81.3	Good	-	-
MPNTF	KD	-	-	-	1.80	Borderline
MPNTF	PLL05	-	-	-	0.086	Borderline
MPNTF	PLL10	-	-	-	0.037	Fails

Table 4-29. **SAV Season Water quality trends in segment MPNTF (only significant trends are displayed).**

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
MPNTF	DIN*	SAV1	S	0.127	0.0080	100.56	6.35	0.0245	DEGRADING
MPNTF	TP*	SAV1	S	0.057	0.0010	32.72	0.00	0.0071	DEGRADING
MPNTF	TP*	SAV2	S	0.049	0.0010	38.48	0.00	0.0205	DEGRADING
MPNTF	WTEMP	SAV1	S	23.38	0.12	8.49	0.00	0.0330	INCREASING

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Glossary of Important Terms

Anoxic - condition in which the water column is characterized by a complete absence of oxygen. Anoxic conditions typically result from excessive decomposition of organic material by bacteria, high respiration by phytoplankton, stratification of the water column due to salinity or temperature effects or a combination of these factors. Anoxic conditions can result in fish kills or localized extinction of benthic communities.

Anthropogenic - resulting from or generated by human activities.

Benthos - refers to organisms that dwell on or within the bottom. Includes both hard substratum habitats (e.g. oyster reefs) and sedimentary habitats (sand and mud bottoms).

B-IBI - the benthic index of biotic integrity of Weisberg et al. (1997). The B-IBI is a multi-metric index that compares the condition of a benthic community to reference conditions.

Biological Nutrient Removal (BNR) - A temperature dependent process in which the ammonia nitrogen present in wastewater is converted by bacteria first to nitrate nitrogen and then to nitrogen gas. This technique is used to reduce the concentration of nitrogen in sewage treatment plant effluents.

Biomass - a quantitative estimate of the total mass of organisms for a particular population or community within a given area at a given time. Biomass for phytoplankton is measured as the total carbon within a liter of water. Biomass for the benthos is measured as the total ash-free dry weight per square meter of sediment habitat.

Chlorophyll *a* - a green pigment found in plant cells that functions as the receptor for energy in the form of sunlight. This energy is used in the production of cellular materials for growth and reproduction in plants. Chlorophyll *a* concentrations are measured in µg/L and are used as estimate of the total biomass of phytoplankton cells in the water column. In general, high levels of chlorophyll *a* concentrations are believed to be indicative of excessive growth of phytoplankton resulting from excess nutrients such as nitrogen and phosphorus in the water column.

Calanoid copepod - crustaceans of the subclass Copepoda and order Calanoida that are the dominant group of the mesozooplankton in marine systems. Copepods in this group (e.g. *Acartia tonsa*) are one of the most important consumers of phytoplankton in estuarine systems.

Chlorophytes - algae belonging to the division Chlorophyta often referred to as true “green algae.” Chlorophytes occur in unicellular, colonial and filamentous forms and are generally more common in tidal freshwater and oligohaline portions of estuaries.

Cladocerans - crustaceans of the class Branchipoda and class Cladocera commonly referred to as “water fleas.” Although cladocerans are primarily found in tidal freshwater areas in estuaries, blooms of marine cladocerans periodically occur in higher salinity areas. Some smaller species such as *Bosmina longirostris* are believed to be indicators of poor water quality conditions.

Cryptomonads -algae belonging to the division Cryptophyta that have accessory pigments in addition to chlorophyll *a* which give these small flagellated cells a red, brown or yellow color.

Cyanobacteria - algae belonging to the division Cyanophycea that are procaryotic and that occur in single-celled , filamentous and colonial forms. In general, high concentrations of cyanobacteria are considered to be indicative of poor water quality.

Cyclopoid copepod - crustaceans of the subclass Copepoda and order Cyclopoida that are the dominant group of the mesozooplankton in marine systems. Copepods in this group (e.g. *Mesocyclops edax*) are one of the most important consumers of phytoplankton in estuarine systems.

Diatoms - algae belonging to the division Bacillariophyta that have a cell wall that is composed primarily of silica and that consists of two separate halves. Most diatoms are single-celled but some are colonial and filamentous forms. Diatoms are generally considered to be indicative of good water quality and are considered to be appropriate food for many zooplankton.

Dinoflagellates - biflagellated, predominately unicellular protists which are capable of performing photosynthesis. Many dinoflagellates are covered with cellulose plates or with a series of membranes. Some dinoflagellates periodically reproduce in large numbers causing blooms that are often referred to as "red tides." Certain species produce toxins and blooms of these forms have been implicated in fish kills. High concentrations of dinoflagellates are generally considered to be indicative of poor water quality.

Dissolved oxygen (DO) - the concentration of oxygen in solution in the water column, measured in mg/L. Most organisms rely on oxygen for cellular metabolism and as a result low levels of dissolved oxygen adversely affect important living resources such as fish and the benthos. In general, dissolved oxygen levels decrease with increasing pollution.

Dissolved inorganic nitrogen (DIN) - the concentration of inorganic nitrogen compounds including ammonia (NH_4), nitrates (NO_3) and nitrites (NO_2) in the water column measured in mg/L. These dissolved inorganic forms of nitrogen are directly available for uptake by phytoplankton by diffusion without first undergoing the process of decomposition. High concentrations of dissolved inorganic nitrogen can result in excessive growth of phytoplankton which in turn can adversely effect other living resources.

Dissolved inorganic phosphorus (PO4F) - the concentration of inorganic phosphorus compounds consisting primarily of orthophosphates (PO_4), The dissolved inorganic forms of phosphorus are directly available for uptake by phytoplankton by diffusion without first undergoing the process of decomposition. High concentrations of dissolved inorganic phosphorus can result in excessive growth of phytoplankton which in turn can adversely effect other living resources.

Estuary - A semi-enclosed body of water that has a free connection with the open sea and within which seawater is diluted measurably with freshwater derived from land drainage.

Eucaryote - organisms the cells of which have discrete organelles and a nucleus separated from the cytoplasm by a membrane.

Fall-line - location of the maximum upstream extent of tidal influence in an estuary typically characterized by a waterfall.

Fixed Point Stations - stations for long-term trend analysis whose location is unchanged over time.

Flow adjusted concentration (FAC) - concentration value which has been recalculated to remove the variation caused by freshwater flow into a stream. By removing variation caused by flow, the effects of other factors such as nutrient management strategies can be assessed.

Holoplankton - zooplankton such as copepods or cladocerans that spend their entire life cycle within the water column.

Habitat - a local environment that has a community distinct from other such habitat types. For the B-IBI of Chesapeake Bay seven habitat types were defined as combinations of salinity and sedimentary types - tidal freshwater, oligohaline, low mesohaline, high mesohaline sand, high mesohaline mud, polyhaline sand and polyhaline mud.

Hypoxic - condition in which the water column is characterized by dissolved oxygen concentrations less than 2 mg/L but greater than 0 mg/L. Hypoxic conditions typically result from excessive decomposition of organic material by bacteria, high respiration by phytoplankton, stratification of the water column due to salinity or temperature effects or a combination of these factors. Hypoxic conditions can result in fish kills or localized extinction of benthic communities.

Light attenuation (KD) - Absorption, scattering, or reflection of light by dissolved or suspended material in the water column expressed as the change in light extinction per meter of depth. Light attenuation reduces the amount of light available to submerged aquatic vegetation.

Loading - the total mass of contaminant or nutrient added to a stream or river generally expressed in lbs/yr.

Macrobenthos - a size category of benthic organisms that are retained on a mesh of 0.5 mm.

Meroplankton - temporary zooplankton consisting of the larval stages of organisms whose adult stages are not planktonic.

Mesohaline - refers to waters with salinity values ranging between 0.5 and 18.0 ppt.

Mesozooplankton - zooplankton with a maximum dimension ranging between 63 µm and 2000 µm. This size category consists primarily of adults stages of copepods, cladocerans, mysid shrimp, and chaetognaths, as well as, the larval stages of a variety of invertebrates and fish.

Metric - a parameter or measurement of community structure (e.g., abundance, biomass, species diversity).

Microzooplankton - zooplankton with a maximum dimension ranging between 2 µm and 63 µm. This size category consists primarily of single-celled protozoans, rotifers and the larval stages of copepods, cladocerans and other invertebrates.

Nauplii - earliest crustacean larval stage characterized by a single simple eye and three pairs of appendages.

Non-point source - a source of pollution that is distributed widely across the landscape surrounding a water body instead of being at a fixed location (e.g. run-off from residential and agricultural land).

Oligohaline - refers to waters with salinity values ranging between 0.5 and 5.0 ppt.

Oligotrich - protists of the phylum Ciliophora and order Oligotricha. These ciliates are important predators of small phytoplankton in marine systems.

Percent of light at the leaf surface (PLL) - the percentage of light at the surface of the water column that reaches the surface of the leaves of submerged aquatic vegetation generally estimated for depths of 0.5 m and 1.0 m. Without sufficient light at the leaf surface, submerged aquatic plants cannot perform photosynthesis and hence cannot grow or reproduce.

Phytoplankton - that portion of the plankton capable of producing its own food by photosynthesis. Typical members of the phytoplankton include diatoms, dinoflagellates and chlorophytes.

Picoplankton - phytoplankton with a diameter between 0.2 and 2.0 µm in diameter. Picoplankton consists primarily of cyanobacteria and high concentrations of picoplankton are generally considered to be indicative of poor water quality conditions.

Pielou's evenness - an estimate of the distribution of proportional abundances of individual species within a community. Evenness (J) is calculated as follows: $J=H'/\ln S$ where H' is the Shannon - Weiner diversity index and S is the number of species.

Plankton - aquatic organisms that drift within and that are incapable of movement against water currents. Some plankton have limited locomotor ability that allows them to change their vertical position in the water column.

Point source - a source of pollution that is concentrated at a specific location such as the outfall of a sewage treatment plant or factory.

Polyhaline - refers to waters with salinity values ranging between 18.0 and 30 ppt.

Primary productivity - the rate of production of living material through the process of photosynthesis that for phytoplankton is typically expressed in grams of carbon per liter of water per hour. High rates of primary productivity are generally considered to be related to excessive concentrations of nutrients such as nitrogen and phosphorus in the water column.

Probability based sampling - all locations within a stratum have an equal chance of being sampled. Allows estimation of the percent of the stratum meeting or failing the benthic restoration goals.

Procaryote - organisms the cells of which do not have discrete organelles or a nucleus (e.g. Cyanobacteria).

Pycnocline - a rapid change in salinity in the water column indicating stratification of water with depth resulting from either changes in salinity or water temperature.

Random Station - a station selected randomly within a stratum. In every succeeding sampling event new random locations are selected.

Recruitment - The successful dispersal settlement and development of larval forms of plants or animal to a reproducing adult.

Reference condition - the structure of benthic communities at reference sites.

Reference sites - sites determined to be minimally impacted by anthropogenic stress. Conditions at theses sites are considered to represent goals for restoration of impacted benthic communities. Reference sites were selected by Weisberg et al. (1997) as those outside highly developed watersheds, distant from any point-source discharge, with no sediment contaminant effect, with no low dissolved oxygen effect and with a low level of organic matter in the sediment.

Restoration Goal - refers to obtaining an average B-IBI value of 3.0 for a benthic community indicating that values for metrics approximate the reference condition.

Riparian Buffer - An area of trees and shrubs a minium of 100 feet wide located up gradient, adjacent, and parallel to the edge of a water feature which serves to: 1) reduce excess amounts of sediment, organic matter, nutrients, and other pollutants in surface runoff, 2) reduce soluble pollutants in shallow ground water flow, 3) create shade along water bodies to lower aquatic temperatures, 4) provide a source of detritus and large woody debris aquatic organisms, 5) provide riparian habitat and corridors for wildlife, and 6) reduce erosion of streambanks and shorelines

Rotifer - small multicellular planktonic animal of phylum Rotifera. These organisms are a major component of the microzooplankton and are major consumers of phytoplankton. High densities of rotifers are believed to be indicative of high densities of small phytoplankton such as cyanobacteria and as such are believed to be indicative of poor water quality.

Salinity - the concentration of dissolved salts in the water column measured in mg/L, ppt or psu. The composition and distribution of plant and animal communities is directly affected by salinity in estuarine systems. The effects of salinity on living resources must be taken into consideration when interpreting the potential effects of human activities on living resources.

Sarcodinians - single celled protists of the subphylum Sarcodina which includes amoeba and similar forms, characterized by possession of pseudopodia. Planktonic forms of sarcodinians typically have a external shell or test constructed of detrital or sedimentary particles and are important consumers of phytoplankton.

Secchi depth - the depth of light penetration expressed in meters as measured using a secchi disk. Light penetration depth directly affects the growth and recruitment of submerge aquatic vegetation.

Shannon Weiner diversity index - a measure of the number of species within a community and the relative abundances of each species. The Shannon Weiner index is calculated as follows:

$$H' = -\sum_{i=1}^{S} p_i \log_2 p_i$$

where p_i is the proportion of the *i*th species and S is the number of species.

Stratum - a geographic region of unique ecological condition or managerial interest.

Submerged aquatic vegetation (SAV) - rooted vascular plants (e.g. eelgrass, widgeon grass, sago pondweed) that grow in shallow water areas . SAV are important in marine environments because they serve as major food source, provide refuge for juvenile crabs and fish, stabilize sediments preventing shoreline erosion and excessive suspended materials in the water column, and produce oxygen in the water column.

Threshold - a value of a metric that determines the B-IBI scoring. For all metrics except abundance and biomass, two thresholds are used - the lower 5th percentile and the 50th percentile (median) of the distribution of values at reference sites. Samples with metric values less than the lower 5th percentile are scored as a 1. Samples with values between the 5th and 50th metrics are scored as 3 and values greater than the 50th percentile are scored as 5. For abundance and biomass, values below the 5th and above the 95th percentile are scored as 1, values between the 5th and 25th and the 75th and 95th percentiles are scored as 3 and values between the 25th and 75th percentiles are scored as 5.

Tidal freshwater - refers to waters with salinity values ranging between 0 and 0.5 ppt which are located in the upper reaches of the estuary at or just below the maximum upstream extent of tidal influence.

Tintinnid - protists of phylum Ciliophora and order Oligotricha. These ciliates are important predators of small phytoplankton in marine systems. Tintinnids are distinguished from other members of this group because they create an exoskeleton or test made of foreign particles that have been cemented together.

Total nitrogen (TN) - the concentration of both inorganic and organic compounds in the water column which contain nitrogen measured in mg/L. Nitrogen is a required nutrient for protein synthesis. Inorganic forms of nitrogen are directly available for uptake by phytoplankton while organic compounds must first be decomposed by bacteria prior to being available for use for other organisms. High levels of total nitrogen are considered to be detrimental to living resources either as a source of nutrients for excessive phytoplankton growth or as a source of excessive bacterial decomposition that can increase the incidence and extent of anoxic or hypoxic events.

Total phosphorus (TP) - the concentration of both inorganic and organic compounds in the water column which contain phosphorus measured in mg/L. Phosphorus is a required nutrient for cellular metabolism and for the production of cell membranes. Inorganic forms of phosphorus are directly available for uptake by phytoplankton while organic compounds must first be decomposed by bacteria prior to being available for use for other organisms. High levels of total nitrogen are considered to be detrimental to living resources either as a source of nutrients for excessive phytoplankton growth or as a source of excessive bacterial decomposition that can increase the incidence and extent of anoxic or hypoxic events.

Total suspended solids (TSS) - the concentration of suspended particles in the water column, measured in mg/L. The composition of total suspended solids includes both inorganic (fixed) and organic (volatile) compounds. The fixed suspended solids component is comprised of sediment particles while the volatile suspended solids component is comprised of detrital particles and planktonic organisms. The concentration of total suspended solids directly affects water clarity which in turn affects the development and growth of submerged aquatic vegetation.

Zoea - last planktonic larval stage of crustaceans such as crabs and shrimp. Numbers of crab zoea may reflect the recruitment success of adult crabs.

Zooplankton - the animal component of the plankton which typically includes copepods, cladocerans, jellyfish and many other forms.