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Trends and Status of Flow, Nutrients, and Sediments for Selected Nontidal Sites in the Chesapeake Bay Watershed, 1985-98

By Michael J. Langland, U.S. Geological Survey,
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CONTENTS

ILLUSTRATIONS

TABLES

Trends and Status of Flow, Nutrients, and Sediments for Selected Nontidal Sites in the Chesapeake Bay Watershed, 1985-98

by Michael J. Langland, U.S. Geological Survey, Joel D. Blomquist, U.S. Geological Survey, Lori A. Sprague, U.S. Geological Survey, and Robert E. Edwards, Susquehanna River Basin Commission

ABSTRACT

Data from 30 stream sites in nontidal portions of the Chesapeake Bay Watershed were analyzed to document annual nutrient and sediment loads and trends for the period 1985 through 1998 as part of an annual water-quality update for the Chesapeake Bay Program. Annual loads were estimated by use of the U.S. Geological Survey ESTIMATOR model and are available upon request. Trends were estimated by use of either linear regression, Seasonal Kendall, or Kendall-Theil tests. Trends were reported for monthly-mean flow, monthly load, flow-adjusted concentration, and flow-weighted concentration. Mean yields and median concentrations were calculated to help assess current water-quality status and to facilitate comparisons between basins. The trend in flow was upward at 12 of the 30 sites. Trends of nutrient and sediment load were upward at these same 12 sites. Trends in flow–adjusted and flow-weighted concentrations varied by species. Trends in flow-weighted concentrations were generally upward or not significant for the nitrogen species and parallel or not significant for phosphorus species. Trends in flow-adjusted concentrations were downward at nearly all sites for sediment and dissolved solids in the Susquehanna and Potomac River Basins and generally were not significant in the Virginia river basins.

INTRODUCTION

The ecosystem of the Chesapeake Bay has been adversely affected by nutrient enrichment. The Chesapeake Bay Program (CBP), a multi-jurisdictional restoration effort, established a goal to reduce controllable nutrient loads into the estuary by 40 percent by the year 2000. Results from the CBP watershed and water-quality models indicated that water quality would be sufficiently improved to support living resources if the 40-percent nutrient-reduction goal was met. Individual nutrient-reduction goals and associated strategies were established for the major rivers delivering nutrients to the Bay. Progress toward these reduction goals have been reevaluated by use of the watershed and water-quality models. Additionally, water-quality and living-resource data are compiled and analyzed to assess the response of the watershed to nutrient-reduction efforts. The 1998 data-analysis effort is part of an annual effort to document changes in water quality and living resources in response to Nutrient Reduction Strategies (NRS) in the Chesapeake Bay Watershed.

Two programs, the River Input Monitoring and Multi-Agency Nontidal Programs, provide information about water-quality conditions in the nontidal areas of the Bay. As part of the River Input Monitoring Program, water-quality and streamflow data are collected at nine stations near the Fall Line (fig. 1). Through the Multi-Agency Nontidal Program, water-quality and streamflow data are collected by several agencies at 21 sites upstream from the River Input Program sites in the nontidal watershed (fig. 1). The water-quality and streamflow data are used to determine trends in streamflow and in concentration and load of nutrients. At 15 of the 21 sites, trend calculations were completed by the U.S. Geological Survey (USGS) in cooperation with Maryland Department of Natural Resources (MdDNR), Virginia Department of Environmental Quality (VaDEQ), and Washington, D.C., Council of Governments (WashCOG); and at 6 sites by the Susquehanna River Basin Commission (SRBC) as part of the Susquehanna Nutrient Assessment Program.

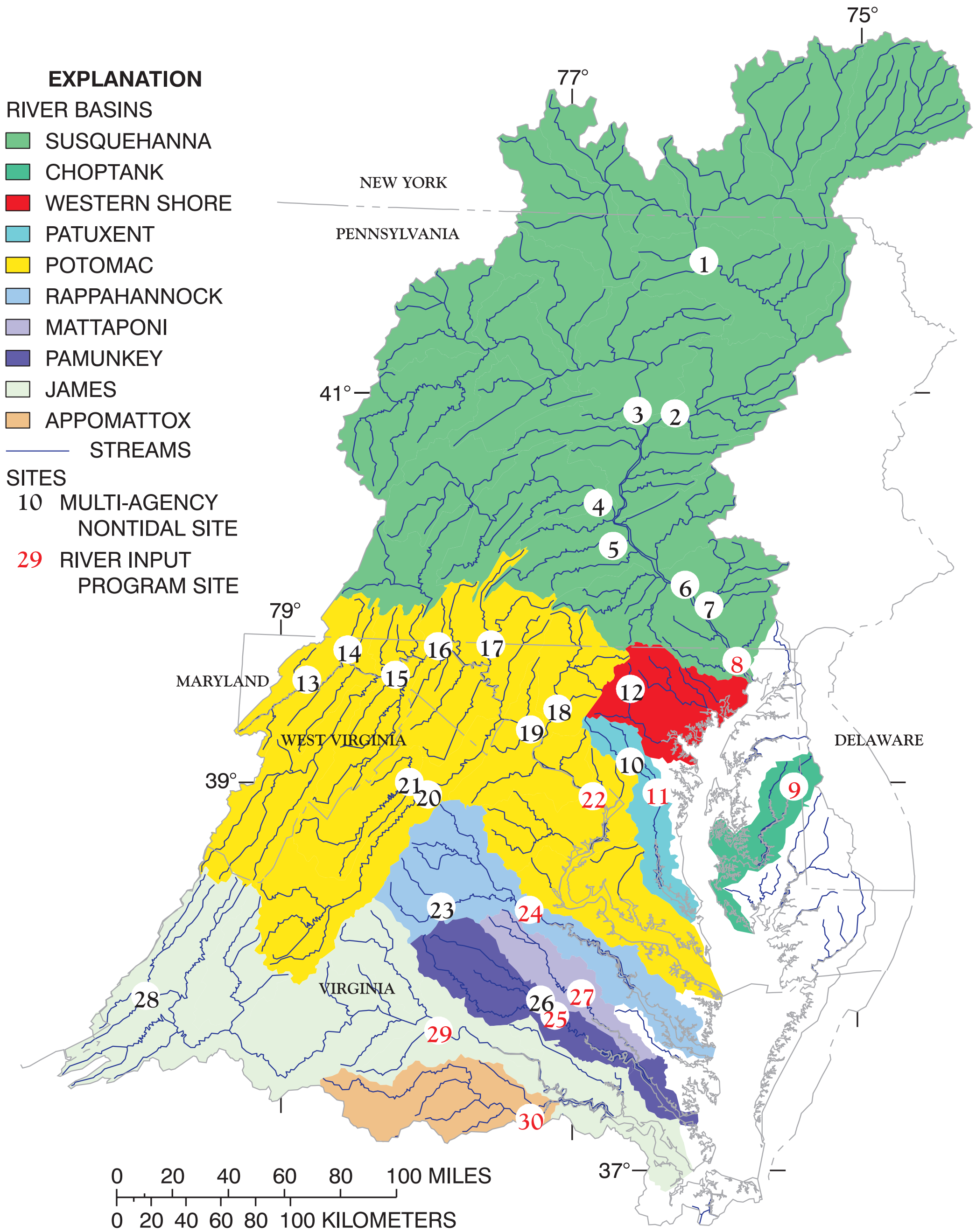

Figure 1. Location and site number for the 30 sites used in this study.

PURPOSE

This report documents the methods used to estimate trends and status in flow and nutrient and sediment concentrations and loads and presents trends in flow and nutrient and sediment water-quality data from 1985 to 1998 from nontidal sites in the Chesapeake Bay Watershed. Water-quality and biological data from the tidal portions of the Bay will be used to assess changes in water quality in response to natural conditions and implementation of nutrient-reduction strategies.

STUDY METHODS

The methods section discusses how the data sets were constructed and describes the statistical tests used to interpret trends. Water-quality constituent loads were estimated by use of a multi-parameter regression model. Trends were estimated by use of both parametric and nonparametric tests.

Data Set Construction

The following section describes the sources of the water-quality and flow data, selection of constituents, record length, and estimation of missing constituents used in calculations of annual loads and trends.

Water-quality concentration and streamflow data were retrieved and compiled from the following agencies: the USGS, the U.S. Environmental Protection Agency (USEPA), the Pennsylvania Department of Environmental Protection (PaDEP), the MdDNR, the VaDEQ, the SRBC, the Interstate Commission on the Potomac River Basin (ICPRB), and the WashCOG. This effort was undertaken to update the nontidal water-quality database to include 1997 and 1998 data at the 30 sites. This database originally consisted of data from 1972 through 1992 (Langland and others, 1995) and was updated through 1996 (Langland and others, 1998). The 30 sites analyzed as part of the 1998 Chesapeake Bay Program water-quality update are listed in table 1.

Data for a total of 38 physical, biological, and chemical water-quality constituents (table 2) were retrieved, if available, and updated for the 30 sites in table 1. These constituents include 14 nutrient species, suspended sediment, and total suspended solids. Continuous daily streamflow data were retrieved from the USGS National Water Information System (NWIS) database. The updated water-quality database and the USGS streamflow database provided the input data files to estimate annual loads and trends. Constituent concentration data were quality assured by use of a statistical program that identified suspect remark codes (such as less than detection or greater-than values), missing dates and / or missing times associated with the sample before they were added to the database. Additionally, the raw and residual data were visually examined before their use in the various trend and load analysis programs.

The following nitrogen, phosphorus, and sediment / solids species were tested for trend and have estimated annual loads where applicable. Because of analytical differences between SED and TSS determinations, SED concentrations tend to be higher and more variable than TSS concentrations (Kammerer and others, 1998). Therefore, caution should be used when comparing the two.

Nitrogen species:	
Total nitrogen	TN
Dissolved Kjeldahl nitrogen	DKN
Total Kjeldahl nitrogen	TKN
Total ammonia	TNH_3
Dissolved ammonia	DNH_3
Total or dissolved nitrate, or total or dissolved nitrite plus nitrate	NOx
Phosphorus species:	
Total phosphorus	TP
Dissolved phosphorus	DP
Dissolved inorganic phosphorus	DIP
Suspended sediment	SED
Total suspended solids	TSS

In some data sets, water-quality records were missing for some constituents. Where possible, the concentration of missing constituents was calculated from the reported species of the constituent. For example, if the concentration of total nitrogen was missing, an estimated value was obtained by adding total Kjeldahl (total organic nitrogen plus total ammonia) and total nitrite plus nitrate. If total nitrite plus nitrate was missing, the sum of the total nitrite and total nitrate was used if available. If more than one of the nitrogen species used in calculating total nitrogen was below the detection limit, the estimated value was not determined or reported as less than the combined minimum reporting limit. In some data sets, total nitrogen and total phosphorus are calculated as the sum of the particulate and dissolved constituents. The concentration of missing constituents was estimated ONLY for input data files used to calculate loads and trends. Missing values in the statistical database were not populated.

Table 1. *Streamflow and water-quality station numbers for the 9 River Input Program and 21 Multi-Agency Nontidal Program sites*

Streamflow station	Water-quality station	Latitude	Longitude	Map ID	Drainage area (square miles)	Station name
			River Input Program Sites			
01491000	01491000	385950	754710	9	113	Choptank River near Greensboro, Md.
01578310	01578310	393928	761029	8	27,100	Susquehanna River at Conowingo, Md.
01594440	01594440	385721	764136	11	348	Patuxent River near Bowie, Md.
01646580	PR01	385546	770701	22	11,600	Potomac River at Chain Bridge, Md.
01668000	01668000	381920	773105	24	1,596	Rappahannock River near Fredericksburg, Va.
01673000	01673000	374603	771957	25	1,081	Pamunkey River near Hanover, Va.
01674500	01674500	375316	770948	27	601	Mattaponi River near Beulahville, Va.
02035000	02035000	374015	780510	29	6,257	James River at Cartersville, Va.
02041650	02041650	371330	772832	30	1,344	Appomattox River at Matoaca, Va.
			Multi-Agency Nontidal Program Sites			
01531500	01531500	414555	762628	1	7,797	Susquehanna River at Towanda, Pa.
01540500	01540500	405729	763710	2	11,220	Susquehanna River at Danville, Pa.
01553500	01553500	405803	765236	3	6,859	West Branch Susquehanna River at Lewisburg, Pa.
01567000	01567000	402842	770746	4	3,354	Juniata River at Newport, Pa.
01570000	01570000	401508	770117	5	470	Conodoguinet Creek near Hogestown, Pa.
01576000	01576000	400316	763152	6	25,990	Susquehanna River at Marietta, Pa.
01576754	01576754	395647	762205	7	470	Conestoga River at Conestoga, Pa.
01586000	NPA0165	393000	765300	12	56.6	North Branch Patapsco River at Cederhurst, Md.
01592500	PXT0809	390700	765231	10	132	Patuxent River at Laurel, Md.
01599000	GEO0009	392936	790242	13	47	Georges Creek near Franklin, Md.
01601500	WIL0013	393941	784650	14	247	Wills Creek near Cumberland, Md.
01610000	POT2766	393218	782717	15	3,109	Potomac River at Paw Paw, W. Va.
01613000	POT2386	394149	781036	16	4,073	Potomac River at Hancock, Md.
01614500	CON0180	394256	774931	17	501	Conococheague Creek at Fairview, Md.
01643000	MON0155	392313	772158	18	817	Monocacy River at Reels Mill Road, Md.
01638500	POT1595	391624	773238	19	9,651	Potomac River at Point of Rocks, Md.
01631000	1BSSF003.56	385449	781240	20	1,642	South Fork Shenandoah River at Front Royal, Va.
01634000	1BNFS010.34	385836	782011	21	768	North Fork Shenandoah River near Strasburg, Va.
01666500	3-ROB001.90	381930	780545	23	179	Robinson River near Locust Dale, Va.
01671020	8-NAR005.42	375100	772541	26	463	North Anna River at Hart Corner near Doswell, Va.
02013100	2-JKS023.61	374719	800003	28	614	Jackson River below Dunlap Creek at Covington, Va.

Table 2. *List of constituents in U.S. Geological Survey Chesapeake Bay nontidal water-quality database*

[ft^3/s, cubic feet per second; mg/L, milligrams per liter; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; C, carbon; $CaCO_3$, calcium carbonate; g/m^2, grams per square meter]

Constituent code	Data description	Constituent code	Data description
STAID	Station number	00618	Dissolved nitrate as N, in mg/L
SNAME	Station name	00620	Total nitrate as N, in mg/L
AGENCY	Collection agency code	00623	Dissolved ammonia plus organic nitrogen as N, in mg/L
DATE	Date of sample collection	00625	Total ammonia plus organic nitrogen as N, in mg/L
TIME	Time of sample collection	00630	Total nitrate plus nitrite as N, in mg/L
LAT	Latitude	00631	Dissolved nitrate plus nitrite as N, in mg/L
LONG	Longitude	00665	Total phosphorus as P, in mg/L
HUC	Hydrologic unit code	00671	Dissolved inorganic phosphorus as P, in mg/L
00010	Water temperature, in degrees Celsius	00680	Total organic carbon as C, in mg/L
00060	Daily mean discharge, in ft^3/s	00681	Dissolved organic carbon as C, in mg/L
00061	Instantaneous discharge, in ft^3/s	00900	Hardness as $CaCO_3$, in mg/L
00065	Stream stage, in feet	00915	Dissolved calcium as Ca, in mg/L
00076	Turbidity, in NTU	00925	Dissolved magnesium as Mg, in mg/L
00095	Specific conductance, in microsiemens per centimeter	00930	Dissolved sodium as Na, in mg/L
00300	Dissolved oxygen, in mg/L	00935	Dissolved potassium as K, in mg/L
00400	pH, in pH units	00940	Dissolved chlorine as Cl, in mg/L
00410	Total alkalinity as $CaCO_3$, in mg/L	00945	Dissolved sulfate as SO_4, in mg/L
00530	Total suspended solids at 105 degrees Celsius, in mg/L	00955	Dissolved silica as SiO_2, in mg/L
00600	Total nitrogen as N, in mg/L	32211	Chlorophyll *a,* in µg/L
00608	Dissolved ammonia as N, in mg/L	32231	Chlorophyll *b,* in µg/L
00610	Total ammonia as N, in mg/L	32232	Chlorophyll *c,* in µg/L
00613	Dissolved nitrite as N, in mg/L	49954	Periphyton algal dry mass, in g/m^2
00615	Total nitrite as N, in mg/L	80154	Total suspended sediment, in mg/L

For trend results to be most useful for the 1998 water-quality update, the time series would ideally begin in January 1985 and end in December 1998. Shorter time-series data are acceptable, however, if they meet certain criteria. For both the ESTIMATOR model and any trend test, the data set must contain a minimum of 10 years and 100 "monthly" samples, or a mixture of monthly and quarterly data with at least 10 years and 75 samples with no date gaps greater than 3 months. Loads and trends were estimated on data sets for any time periods of 10 years or greater starting between January 1985 and January 1989 and continuing through December 1998.

Data Analysis

A brief description of the model used to estimate loads (ESTIMATOR), the statistical tests used to compute trends (linear regression, Seasonal Kendall, and Kendall-Theil), and procedures used with censored data are presented below.

ESTIMATOR Model

The loads of nutrients, suspended sediment, and total solids were estimated by use of the USGS 7-para-meter, log-linear regression model (ESTIMATOR) developed by Cohn and others (1989). The model uses the Minimum Variance Unbiased Estimator (MVUE) developed by Bradu and Mundlak (1970) to correct for retransformation bias associated with log-linear regression. The adjusted maximum likelihood estimator (AMLE) (Cohn, 1988) is used to assign concentrations to censored data, which are data below a detectable limit. The model is of the form:

$$ln[C] = \beta_o + \beta_1 ln[Q/\bar{Q}] + \beta_2\{ln[Q/\bar{Q}]\}^2 + \beta_3[T - \bar{T}] + \beta_4[T - \bar{T}]^2 + \beta_5 \sin[2\pi T] + \beta_6 \cos[2\pi T] + \varepsilon,$$

where ln is the natural logarithm function;

C is measured concentration, in milligrams per liter;

Q is measured streamflow, in cubic feet per second;

T is time, measured in decimal years;

$\bar{Q}$ and $\bar{T}$ are centering variables for streamflow and time;

β_x are parameters estimated by ordinary least squares (non-censored data) and minimum variance (censored data); and

β_0 is a constant;

β_1 and β_2 describe the relation between concentration and flow;

β_3 and β_4 describe the trend in concentration data;

β_5 and β_6 describe seasonal variation in concentration data; and

ε is combined independent random error, assumed to be normally distributed with zero mean and variance σ_ε^2.

Linear Regression

Linear regression is a parametric test that approximates the relation between two continuous variables. A linear trend is estimated by regressing a response variable (for example, flow or load) as a function of an explanatory variable (such as time). It is important that residual plots meet the assumptions of normality, constant variance, linearity, and independence. In most cases, data must be log-transformed in order to improve linearity. If this transformation is used, the residual plots again must be checked for normality, constant variance, linearity, and independence. When the assumptions are met, a null hypothesis of zero slope over time is tested. If the slope is significantly greater than zero, the null hypothesis is rejected, and the conclusion is that a linear trend over time has occurred. Because the regression model does not account for the error and dependence in the estimates, a conservative p-value of 0.01 or less was considered significant. The magnitude (percentage change over time) was estimated from the equation $[e^{(b*t)}-1]$ *100 where b is the slope and t is the time, in years. The upper and lower bounds, representing the 95-percent confidence interval around the magnitude, also were calculated. Helsel and Hirsch (1992) provide additional discussion for applying regression techniques to surface-water data.

Seasonal Kendall Test

The Seasonal Kendall (SK) test (Hirsch and others, 1982) is a nonparametric test for a monotonic linear trend that is resistant to outliers and is not dependent on the normality of the data set. By comparing only the data from similar seasons (monthly data used in the study), the test also reduces seasonal effects on concentrations when testing for trend. If the later value in time is larger, then a plus is recorded; if the later value in time is smaller, then a minus is recorded. The test statistic is computed as the difference between the total number of pluses (increases in time) and the number of minuses (decreases in time). If the test statistic is 0, then there is no change (no trend) in time. As the test statistic increases or decreases from 0, the probability of a seasonal trend also increases. A p-value of 0.05 or less was considered significant.

Kendall-Theil Trend Analysis

The Kendall-Theil (KT) analysis is also a nonparametric test for a monotonic linear trend by use of pairwise comparison and a Kendall's tau test for significance, similar to the SK test. The KT analysis differs from the SK test, however, in how it adjusts for seasonality. The SK test accounts for seasonality by calculating pairwise slopes on data within the same season; the overall trend slope is computed from the median of these seasonal slopes. The KT analysis accounts for seasonality by first obtaining residuals from an MVUE regression that includes seasonality terms. The trend slope is then determined by calculating pairwise slopes on the residual data for the entire period of study and computing the overall median of these slopes (Helsel and Hirsch, 1992). This approach allows increased power in the slope estimate for the KT test over the SK test. Flow-adjusted and season-adjusted residuals from the ESTIMATOR model (with date terms B_3 and B_4 removed) were used as input to the KT analysis to estimate an adjusted trend in concentration. For 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 (Helsel and Hirsch, 1992). The magnitude was computed from the formula [bn / C-(bn / 2)], where b is the slope, n is the number of data points, and C is the intercept (predicted concentration at center of flow) (Cohn and others, 1989). The upper and lower error bounds were calculated from the ranked slopes that correspond to the 95-percent confidence level. A p-value of 0.05 or less was considered significant.

Detection and Trend Reporting of Censored Data

The presence of a large number of censored values (values reported below the detection limit) in a data set can adversely affect the estimation of load and trend slope by not allowing for corrections because of variations in streamflow. In the ESTIMATOR model, values were assigned to the censored data by use of the AMLE (Cohn and others, 1989).

The following decisions were presented to the Data Analysis Work Group (DAWG), a workgroup of the Monitoring Subcommittee of the Chesapeake Bay Program, and approved for use with the tests for trend. These decisions are based on current USGS computer program analysis (Shertz and others, 1991) and work by Helsel and Hirsch (1992).

- <5 percent censored data – censored values will be assigned one half of the detection limit. For all trend tests, the p-value, the slope estimate, and the magnitude (percentage change over time) will be reported.
- Between 5 and 20 percent censored data – three separate trend analysis tests of the data will be performed. First, on the raw data file with censored data set to half the detection limit (both KT and SK); second, all censored data set to 0 (KT only); and third, all censored data set to the detection limit (KT only). In these instances, the highest p-value, the range in slope estimate, and a range in the magnitude of the trend will be reported.
- >20 percent censored data – trend results will not be reported.

TRENDS IN FLOW AND WATER-QUALITY CONDITIONS

Trends in water quality were estimated by use of parametric and nonparametric statistical tests described earlier in this report. The parametric test involved a regression of nontransformed and transformed data with time. Nonparametric tests used nontransformed data and included the SK and KT. The SK test was used to estimate trends in streamflow and loads and was used to compare with linear regression trends. Analysis for trend was performed on the following:

- monthly-mean flow
- monthly load
- flow-weighted concentrations (FWC), and
- flow-adjusted concentrations (FAC)

Each of the above trends provide a unique perspective on the changes in water quality within the Chesapeake Bay Watershed. These trends can be used to help document water-quality changes as a result of both natural and human-induced influences and can be used as indicators of improvement or lack of improvement of that quality within the Bay Watershed.

Monthly-Mean Streamflow

Trends in monthly-mean flows indicate the changes in hydrology (streamflow) over time. Fluctuations in streamflow affect the observed concentrations of nutrients and the average loads and concentrations of these constituents delivered to the tidal estuaries. Changes in streamflow also affect water quality and living-resource responses in the estuary. The trend in flow was calculated by use of a regression (log flow) with time. Trends were reported only for those sites where the residuals of the model met the assumptions of normality, constant variance, linearity, and independence.

Significant upward trends in streamflow (fig. 2 and Appendix 1) occurred at 12 sites. The sites are concentrated in the middle and lower areas of the Potomac River Basin, where significant flooding occurred in 3 of the last 4 years. None of the 30 sites in the basin showed a downward trend in streamflow. For comparison, the SK test (monthly) also was performed at all sites, and where trends were significant by use of the SK, trends also were significant by use of the regression model. However, because parametric tests tend to have more power to detect trends than do nonparametric tests, some sites had not-significant trends by use of SK where the parametric test indicated a significant trend. In no cases did the results indicate trends in opposing directions.

Monthly Load

The constituent load is highly related to and dependent on flow. The load represents the amount of a given constituent transported and delivered downstream, eventually reaching the tidal estuaries. A trend in load will aid in explaining water-quality and living-resource changes in the tidal estuaries and assessing the effectiveness of Nutrient Reduction Strategies. Linear regression of log-transformed monthly loads from ESTIMATOR as a function of time was used to test for trend. In most cases, the regression produced normally distributed residuals.

For nearly all constituents, load increased with flow. Where flow increased significantly, significant upward trends in TN load occurred at 6 of the 12 sites (fig. 3) and NOx load trends were upward at 7 of the 12 sites (Appendix 1). The only downward trends in TN and NOx loads occurred at the Patuxent River Input site (site 11 on fig. 1). Significant upward trends in TP load occurred at 4 of the 12 sites having upward trends in flow and, similar to the nitrogen, a downward trend in TP load occurred at the Patuxent River Input site (fig. 3). Results for DP loads, however, indicate downward trends at seven of the eight Susquehanna River sites (Appendix 1). In general, loads for TN and TP entering the Bay from the River Input Monitoring sites have increased from 1985 to 1998.

In an average flow year, the three largest rivers draining to the Bay (the Susquehanna, the Potomac, and the James) deliver about 87 percent of the streamflow and about 96 percent of the nitrogen, 91 percent of the phosphorus, and 93 percent of the suspended sediment or total solids loads into the Chesapeake Bay (Langland and others, 1995). During the period of study, flow for 3 of the last 4 years has exceeded the long-term average flow at the three largest rivers (fig. 4).

Flow-Weighted Concentrations

A trend in monthly flow-weighted concentrations represents a trend that is NOT adjusted for the effects of streamflow. This approach can be useful in comparing trends from nontidal sites to sites in the tidal tributaries and mainstem of the Bay. Monthly flow-weighted concentrations are calcu-

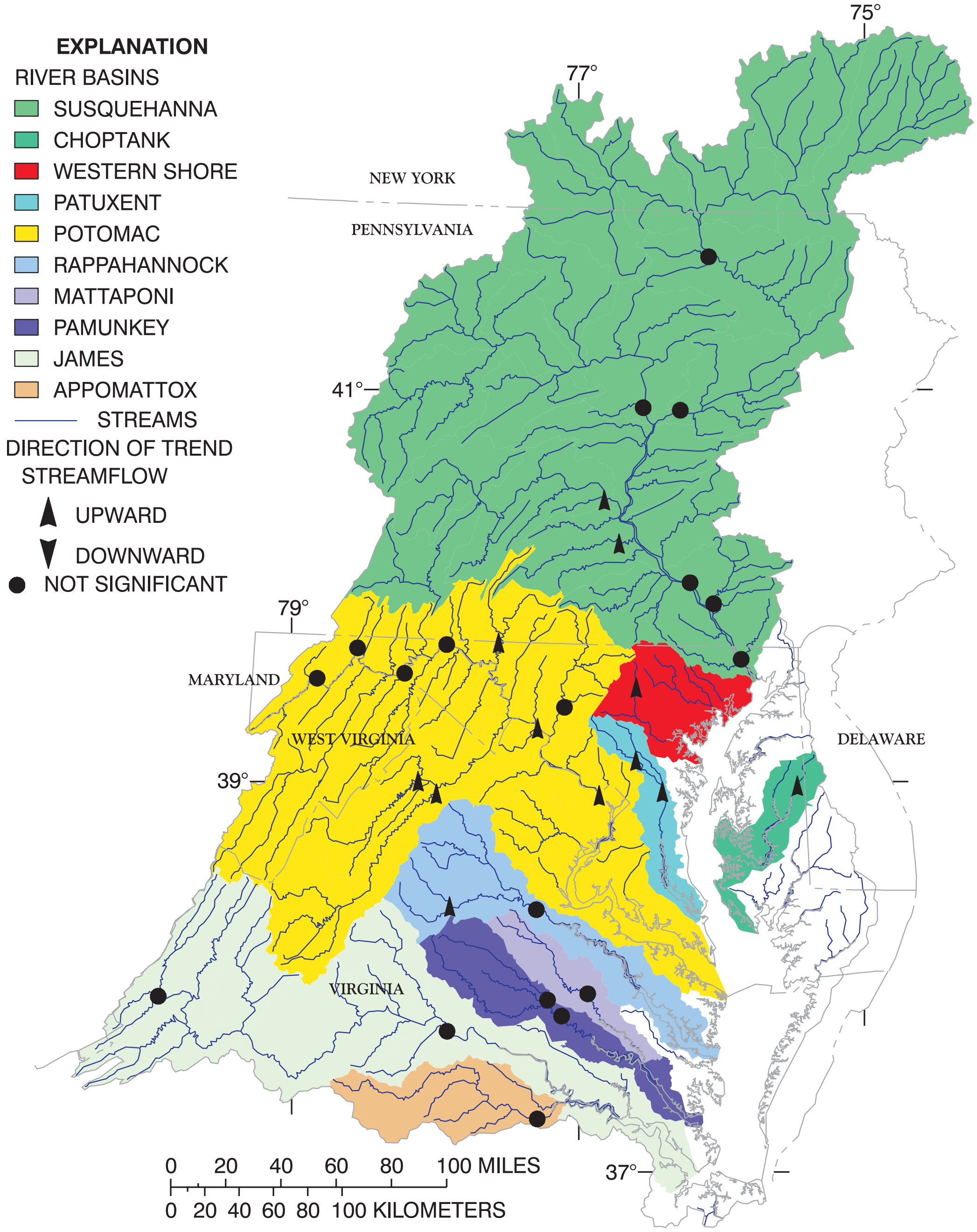

Figure 2. Trends in streamflow, 1985-98.

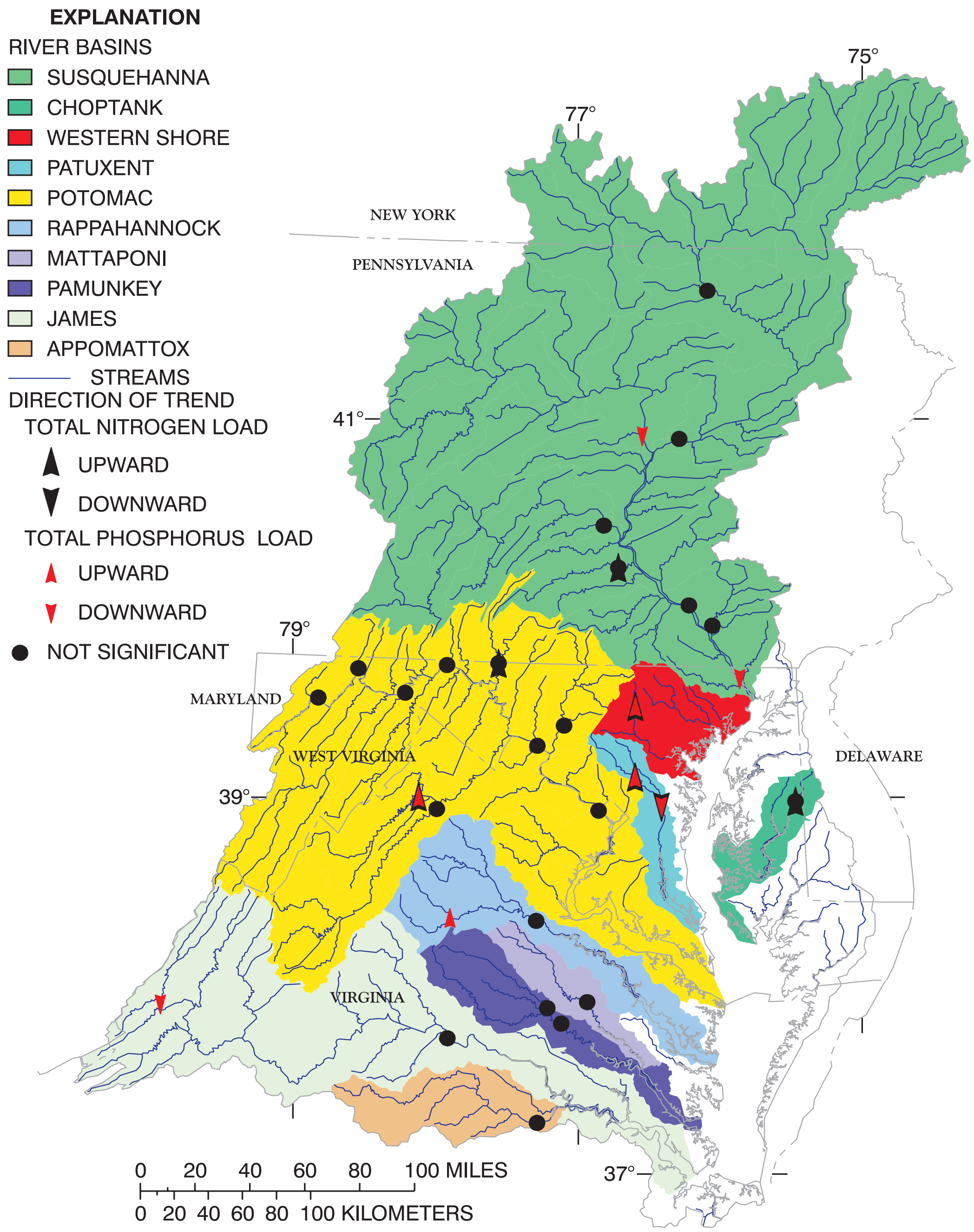

Figure 3. Trends in load for total nitrogen and total phosphorus.

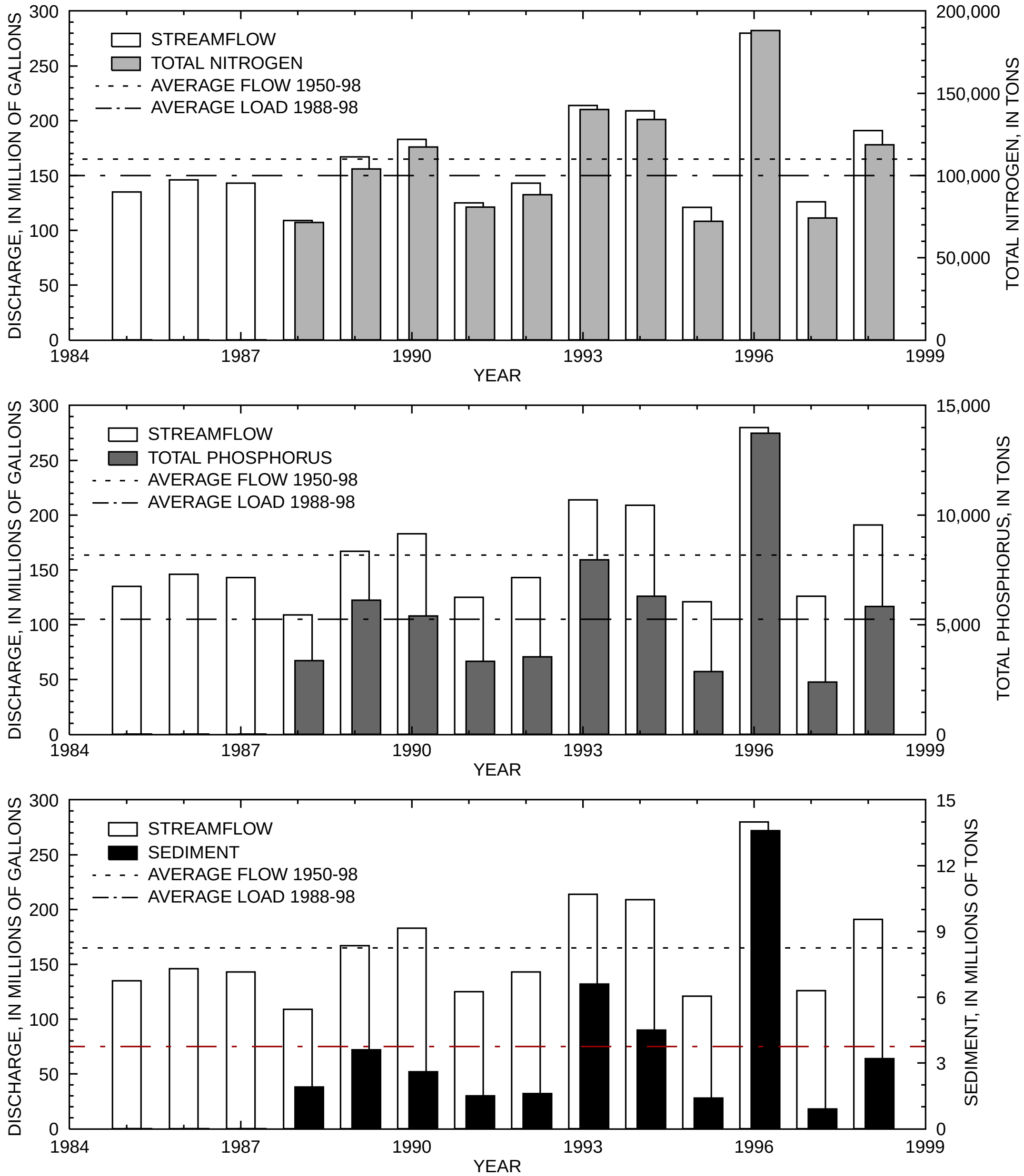

Figure 4. Combined annual flow and loads from the three largest rivers (Susquehanna, Potomac, and James) draining into the Chesapeake Bay Watershed for 1988-98 compared to long-term average flow (1950-98) and the average load (1988-98).

lated by dividing the total monthly load (from ESTIMATOR) by the monthly streamflow. Because ESTIMATOR uses the daily streamflow record, a daily concentration can be estimated and summed between sampling dates, and used to represent a "flow-weighted" monthly concentration, which may be more representative of the true monthly mean concentration. For example, in figure 5, the observed concentration of total nitrogen is 1.0 mg/L, not weighted for flow. This is based on the one sample collected per month. When weighted for streamflow, however, the concentration (from ESTIMATOR) increases to 2.2 mg/L. It is important to account for the flow variability because the volume of flow occurring in short periods between sample intervals is likely to have a more pronounced and long-lived effect on average concentrations in the tidal estuaries and other mixed receiving areas. Therefore, a flow-weighted concentration should provide a more accurate estimate of the monthly mean concentration and may correlate better with trends in estuarine concentrations. Monthly flow-weighted concentrations were tested for trend by use of linear regressions. In most cases, the regression produced normally distributed residuals. In some cases, the trend was significant, with non-normal residuals. This precludes the use of linear regression. In these cases, the KT test was used ("Test" column in Appendix 2).

Trends for flow-weighted TN concentrations were downward at 13 sites distributed in nearly all 10 major drainage basins (fig. 6 and Appendix 2). Trends for flow-weighted NOx concentrations were downward at five sites and were upward at six sites (Appendix 2). At only one of the six NOx sites with upward trends was the TN trend also upward. Trends in flow-weighted TP concentrations were downward at 16 sites (fig. 6). Data for one site, on the North Fork Shenandoah River, indicated an upward trend in TP. For TSS or SED, trends were upward at only two sites, one in the Patuxent River Basin, the other in the Potomac River Basin (Appendix 2).

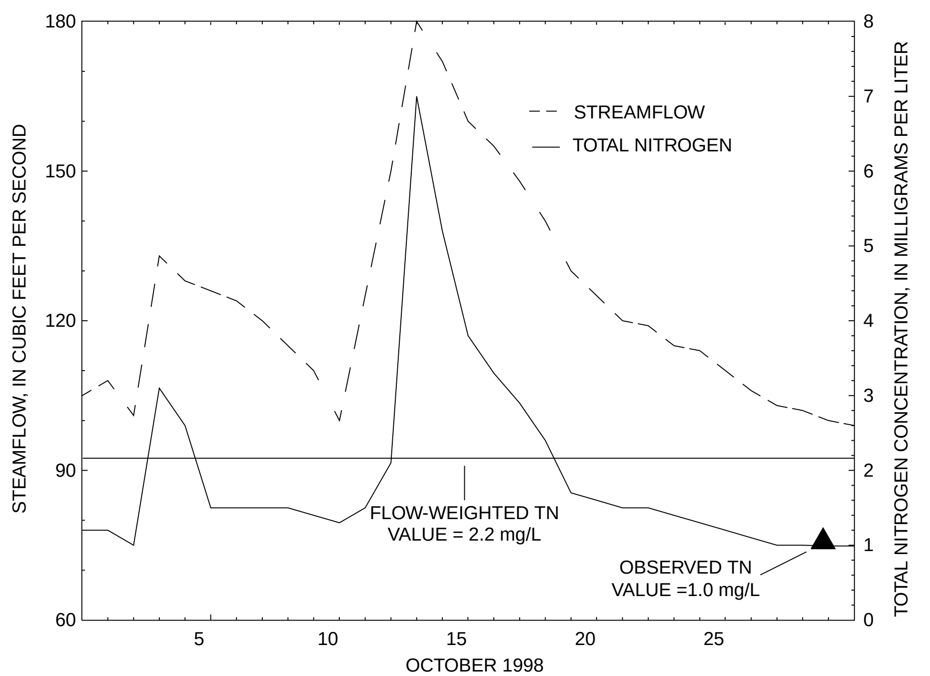

Figure 5. Comparison between observed monthly concentration and a flow-weighted monthly concentration of total nitrogen.

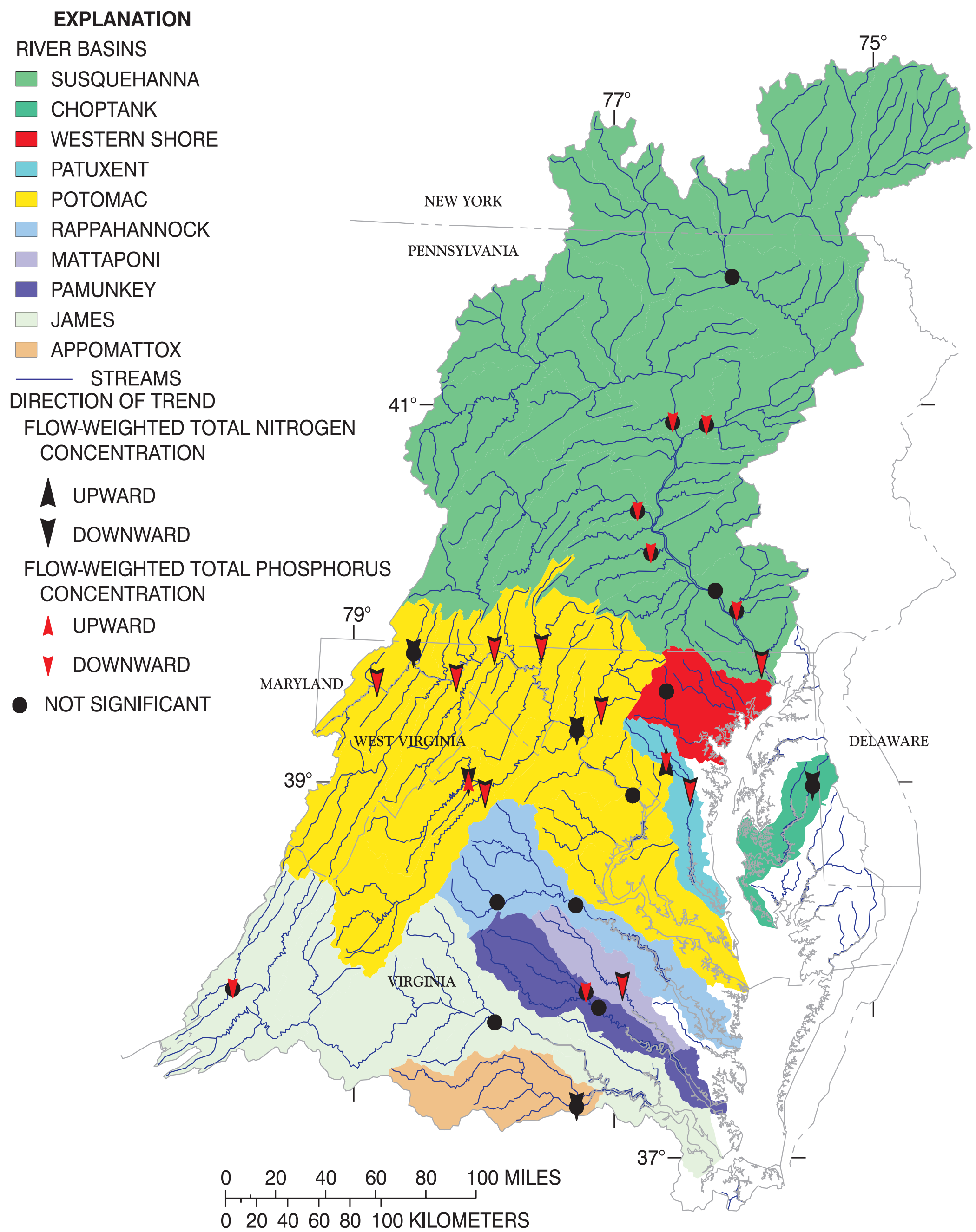

Figure 6. Trends in flow-weighted concentrations for total nitrogen and total phosphorus.

Flow-Adjusted Concentrations

Concentrations of water-quality constituents are commonly correlated with streamflow. The cause of this relation varies between the constituent and the individual basin. For example, in point-source dominated basins, the input of many constituents is relatively constant. Increases in basin streamflow will most likely result in decreasing concentrations of these constituents as a result of dilution. In contrast, in nonpoint-source dominated basins, constituent concentrations entering the stream from overland flow will most likely increase as streamflow increases (Shertz and others, 1991). This flow-related variability must be removed to obtain flow independent water-quality concentrations that allow for examination of changes in water quality resulting from human activities. Flow-adjusted trends are the best indicator of human-induced changes affecting water quality within a watershed. To determine the trend in flow-adjusted concentration, observed concentration data were adjusted for season and streamflow by use of a 5-parameter ESTIMATOR model. This model is identical to the 7-parameter load model except the date and date-squared terms are removed. Values for multiple samples collected on the same day were averaged, and the resulting residual data set was input into the KT test.

Results from the KT test indicate trends in TN and NOx concentration adjusted for flow were downward at 19 and 12 of the 30 sites, respectively, occurring in nearly all major Chesapeake Bay drainage basins (fig. 7 and Appendix 3). While only two sites had upward trends in TN, seven sites had upward trends in NOx. Trends in flow-adjusted TP concentrations were downward at 21 of the sites, with only 1 site showing an increase. The only significant upward trend for TSS or SED was in the Patuxent River Basin; trends were downward at five sites in Maryland and Virginia. As a result of flow and adjustment, an additional five TN and six TP sites indicated significant trends in concentration.

In investigations from previous years (Langland and others, 1998), trends in flow-adjusted concentration were estimated by use of the date coefficient from the 7-parameter ESTIMATOR model. This method has been questioned because of perceived log-transformation bias. As a result of testing and comparing to other methods, the ESTIMATOR does appear to be valid for quantifying trends (although trend results from ESTIMATOR were not used in this report). The percentage differences between statistically significant trend magnitudes by use of the ESTIMATOR and KT are shown in figure 8. The median difference (absolute values) is about 7 percent for TN, 21 percent for NOx, 20 percent for TP, 12 percent for DP, and 25 percent for SED / TSS. A total of 126 trend results were compared; 114 agreed in both significance and direction. There were no cases of opposing significant trends.

STATUS OF FLOW AND WATER-QUALITY CONDITIONS

Status is a measure of current water-quality conditions. In order to help facilitate comparison of current water-quality conditions among basins in the Chesapeake Bay Watershed, a mean annual yield (based on annual loads from ESTIMATOR divided by the drainage area) and a median flow-weighted concentration were calculated at each of the 30 stations presented in this report.

Mean Yield

The “status” of current yields was assessed by station and constituent at the 30 sites in this study. As requested by DAWG, this “status” assessment was based on a 3-year mean of annual yield for the years 1996, 1997, and 1998 (if not available, then the last 3 years of record) and was determined as follows:

1. Compile the 3-year yield data by station and constituent,
2. Determine the 5^{th}- and 95^{th}-percentile for each constituent by use of available data from the 30 sites,
3. Subtract the 95^{th}-percentile value from each status yield for each constituent,
4. Subtract the 5^{th}- and 95^{th}-percentile values for each constituent, and
5. Divide the result from (3) by the result from (4) and multiply by 100.

The above procedure transforms the status yields of each constituent at the 30 sites into percentages between 0 and 100. The percentages were subtracted from 100 to allow a simple comparison between basins, because the lower the percentage, the lower the yield. Status yields and percentage for the 30 sites are presented in Appendix 1. As previously reported (Langland, 1995), the areas

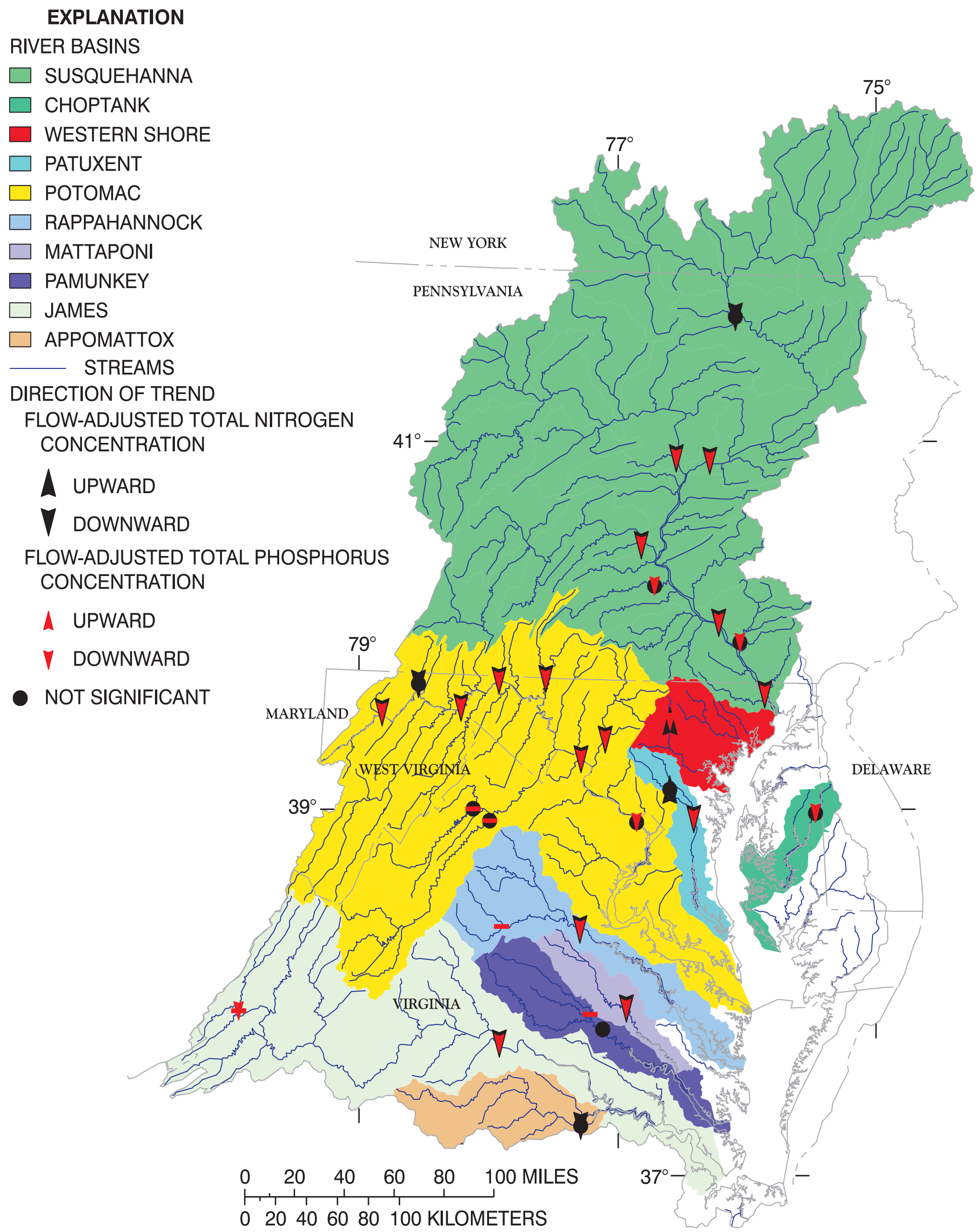

Figure 7. Trends in flow-adjusted concentrations for total nitrogen and total phosphorus.

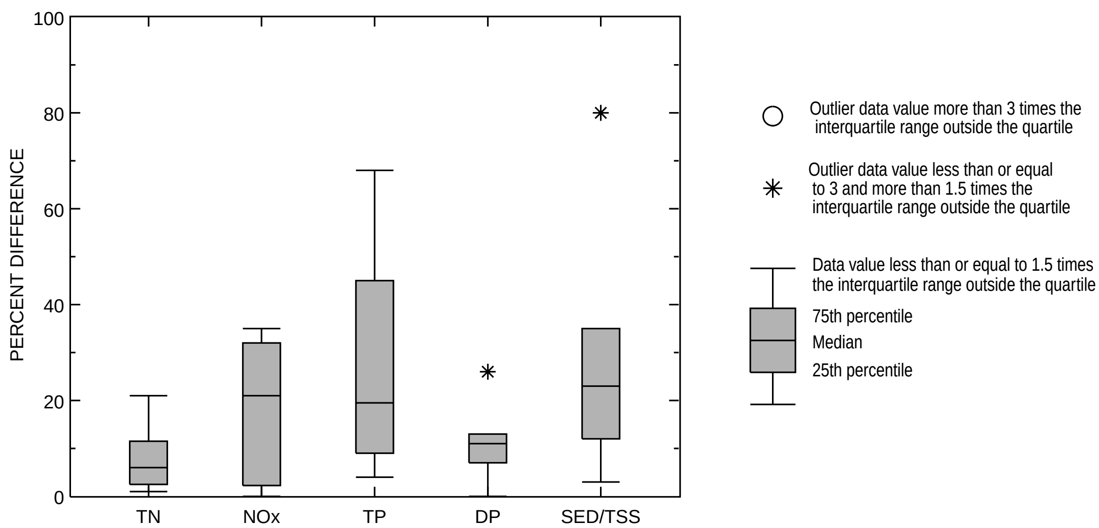

Figure 8. Percentage difference in statistically significant trends between the ESTIMATOR model and the Kendall-Theil test by use of absolute values.

with the highest nitrogen yields also contain higher percentages of land in agriculture with some association to carbonate rock type; lower yields coincide with higher percentages of forest land.

Median Concentration

The "status" of current water-quality concentrations was determined by station and constituent at the 30 sites. This status was based on the median concentration for the period 1996-98 or the last 3 years of record. The same procedure discussed above for status yields was used to compare median concentration. The status of the concentrations and percentages for the 30 sites are presented in Appendixes 2 and 3. Similar to the yields, the areas having the highest nitrogen concentrations also have higher percentages of land in agriculture; lower concentrations coincide with higher percentages of forest land.

SUMMARY

Nutrient and sediment data from 30 stream sites in nontidal portions of the Chesapeake Bay Watershed were analyzed to document annual loads and trends for the period 1985 through 1998, as part of an annual water-quality assessment for the Chesapeake Bay Program. Annual loads were estimated by use of the USGS ESTIMATOR model. Trends were estimated by use of log-transformed regressions, the Seasonal Kendall, or Kendall-Theil tests. Trends were reported for monthly-mean flow, monthly load, flow-weighted concentration, and flow-adjusted concentration. Mean yields and median flow-weighted concentrations based on the last 3 years of record were calculated to determine the status of recent water-quality conditions and help facilitate comparisons between basins. A significant upward trend in flow occurred at 12 of the 30 sites. Increases in some nutrient and sediment loads and trends occurred at these same 12 sites. Throughout the Bay watershed, trends in flow-adjusted and flow-weighted concentrations were generally downward or not significant for total nitrogen, not significant for nitrite plus nitrate nitrogen, and downward or not significant for phosphorus species. Flow-adjusted trends in concentration were downward at nearly all sites for sediment and dissolved solids in the Susquehanna and Potomac River Basins and were generally not significant in the Virginia river basins.

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Appendix 1—Trends in streamflow and load data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed

Parameters: Q, streamflow; TN, total nitrogen; DNH, dissolved ammonia; TNH, total ammonia; NOx, total or dissolved nitrate, or, nitrite plus nitrate; DKN, dissolved ammonia plus organic nitrogen; TKN, total ammonia plus organic nitrogen; TP, total phosphorus; DP, dissolved phosphorus; DIP, dissolved inorganic phosphorus; TSS, total suspended solids; SED, suspended sediment.

Station: flow, USGS streamflow site number; WQ, water-quality site number.

Statistics: POR, time period used in test; test, regression (Reg), Kendall Theil (KT); log transformed; yes (Y) or no (N); p-value, measure of significance of regressor at 0.01; slope, regression slope; base median, median of first 2 years of record; status median, median of last 3 years of record; magnitude, minimum (min) and maximum (max) percentage change in trend for indicated period of record; tend direction, UP, down (DN), or not significant (NS); relative rank, each individual status yield (pound per acre) compared to all others of the same parameter; shaded areas are significant at 99-percent confidence level; —, not applicable or insufficient data.

Appendix 1. *Trends in streamflow and load data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station: Flow	Station: WQ	POR	Test	Log transformation	p-value	Base-median yields	Status-median yields	Magnitude: Minimum	Magnitude: Maximum	Trend direction	Relative rank
RIVER INPUT SITES												
01491000 - Choptank River near Greensboro, Md. (map ID site #9)												
Q	01491000	01491000	Jan85-Dec98	Reg	Y	0.0004	95.8	—	40	108	UP	—
TN	01491000	01491000	Jan85-Dec98	Reg	Y	.0026	2.66	6.47	25	179	UP	23
TKN	01491000	01491000	Jan85-Dec98	Reg	Y	.3251	—	—	-23	117	NS	—
NOx	01491000	01491000	Jan85-Dec98	Reg	Y	.0001	1.60	3.60	51	201	UP	18
TP	01491000	01491000	Jan85-Dec98	Reg	Y	.0375	.086	.253	4	223	NS	17
DP	01491000	01491000	Jan85-Dec98	Reg	Y	.0001	.024	.124	79	433	UP	22
DIP	01491000	01491000	Jan85-Dec98	Reg	Y	.0001	.020	.106	103	479	UP	35
SED	01491000	01491000	Jan85-Dec98	Reg	Y	.2553	9.87	31.8	-52	274	NS	0
01578310 - Susquehanna River at Conowingo, Md. (map ID site #8)												
Q	01578310	01578310	Jan85-Dec98	Reg	Y	.5522	29,700	—	-20	52	NS	—
TN	01578310	01578310	Jan85-Dec98	Reg	Y	.4515	6.88	6.99	-37	22	NS	25
TKN	01578310	01578310	Jan85-Dec98	Reg	Y	.0001	—	—	-31	-65	DN	—
NOx	01578310	01578310	Jan85-Dec98	Reg	Y	.4414	4.23	5.94	-18	59	NS	32
TP	01578310	01578310	Jan85-Dec98	Reg	Y	.0058	.205	.117	-17	-66	DN	0
DP	01578310	01578310	Jan85-Dec98	Reg	Y	.0005	.087	.051	-29	-69	DN	0
DIP	01578310	01578310	Jan85-Dec98	Reg	Y	.6533	.036	.050	-30	77	NS	10
SED	01578310	01578310	Jan85-Dec98	Reg	Y	.2673	47.0	55.1	-23	157	NS	4
01594440 - Patuxent River near Bowie, Md. (map ID site #11)												
Q	01594440	01594440	Jan85-Dec98	Reg	Y	.0001	305	—	39	136	UP	—
TN	01594440	01594440	Jan85-Dec98	Reg	Y	.0001	8.52	8.31	-24	-49	DN	32
TKN	01594440	01594440	Jan85-Dec98	Reg	Y	.0001	—	—	-25	-57	DN	—
NOx	01594440	01594440	Jan85-Dec98	Reg	Y	.0001	5.63	5.30	-25	-46	DN	28
TP	01594440	01594440	Jan85-Dec98	Reg	Y	.0001	.564	.487	-36	-66	DN	47
DP	01594440	01594440	Jan85-Dec98	Reg	Y	.0001	.247	.152	-72	-78	DN	30
DIP	01594440	01594440	Jan85-Dec98	Reg	Y	.0097	.185	.156	-7	-38	DN	57
SED	01594440	01594440	Jan85-Dec98	Reg	Y	.7021	75.2	175	-51	61	NS	44

Appendix 1. *Trends in streamflow and load data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics						Magnitude			
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median yields	Status-median yields	Minimum	Maximum	Trend direction	Relative rank
01646580 - Potomac River at Chain Bridge, Md. (map ID site #28)												
Q	01646580	PR01	Jan85-Dec98	Reg	Y	0.008	8,840	—	16	154	UP	—
TN	01646580	PR01	Jan85-Dec98	Reg	Y	.0170	3.28	11.0	12	197	NS	44
TKN	01646580	PR01	Jan85-Dec98	Reg	Y	.3638	—	—	-25	123	NS	—
NOx	01646580	PR01	Jan85-Dec98	Reg	Y	.0002	1.71	8.87	59	158	UP	48
TP	01646580	PR01	Jan85-Dec98	Reg	Y	.1957	.155	.402	-21	213	NS	36
DP	01646580	PR01	Jan85-Dec98	Reg	Y	.6746	.090	.167	-35	96	NS	34
DIP	01646580	PR01	Jan85-Dec98	Reg	Y	.2682	.047	.128	-22	143	NS	45
SED	01646580	PR01	Jan85-Dec98	Reg	Y	.6131	49.2	125	-70	-19	NS	28
01668000 - Rappahannock River near Fredericksburg, Va. (map ID site #24)												
Q	01668000	01668000	Jan88-Dec98	Reg	Y	.1314	—	—	-11	140	NS	—
TN	01668000	01668000	Jan88-Dec98	Reg	Y	.6653	1.98	4.53	-44	147	NS	14
NOx	01668000	01668000	Jan88-Dec98	Reg	Y	.9210	1.04	2.50	-56	150	NS	29
TP	01668000	01668000	Jan88-Dec98	Reg	Y	.7623	.144	.383	-58	225	NS	12
DIP	01668000	01668000	Jan88-Dec98	Reg	Y	.3115	.024	.068	-29	194	NS	18
TSS	01668000	01668000	Jan88-Dec98	Reg	Y	.7115	60.7	187	-70	490	NS	100
01673000 - Pamunkey River near Hanover, Va. (map ID site #25)												
Q	01673000	01673000	Jan89-Dec98	Reg	Y	.6040	—	—	-31	190	NS	—
TN	01673000	01673000	Jan89-Dec98	Reg	Y	.6918	2.14	2.23	-36	96	NS	4
NOx	01673000	01673000	Jan89-Dec98	Reg	Y	.0877	.647	1.02	-5	49	NS	9
TP	01673000	01673000	Jan89-Dec98	Reg	Y	.7414	.206	.214	-40	103	NS	3
DIP	01673000	01673000	Jan89-Dec98	Reg	Y	.0001	.044	.070	54	233	UP	19
TSS	01673000	01673000	Jan89-Dec98	Reg	Y	.6871	81.9	78.3	-72	132	NS	35
01674500 - Mattaponi River near Beulahville, Va. (map ID site #27)												
Q	01674500	01674500	Jan89-Dec98	Reg	Y	.1075	—	—	-9	60	NS	—
TN	01674500	01674500	Jan89-Dec98	Reg	Y	.5434	2.24	1.70	-56	55	NS	1
NOx	01674500	01674500	Jan89-Dec98	Reg	Y	.3916	.383	.376	-53	34	NS	0
TP	01674500	01674500	Jan89-Dec98	Reg	Y	.3736	.113	.161	-61	42	NS	0
DIP	01674500	01674500	Jan89-Dec98	Reg	Y	.0907	.029	.056	-7	171	NS	12
TSS	01674500	01674500	Jan89-Dec98	Reg	Y	.9901	11.6	33.2	-59	140	NS	6

Appendix 1. *Trends in streamflow and load data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics						Magnitude			
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median yields	Status-median yields	Minimum	Maximum	Trend direction	Relative rank
02035000 - James River at Cartersville, Va. (map ID site #29)												
Q	02035000	02035000	Jan88-Dec98	Reg	Y	0.3386	—	—	-17	72	NS	—
TN	02035000	02035000	Jan88-Dec98	Reg	Y	.8483	1.66	1.93	-45	64	NS	2
NOx	02035000	02035000	Jan88-Dec98	Reg	Y	.5389	.630	.758	-53	49	NS	5
TP	02035000	02035000	Jan88-Dec98	Reg	Y	.0611	.358	.291	-65	2	NS	2
DIP	02035000	02035000	Jan88-Dec98	Reg	Y	.0001	.258	.118	-50	-68	DN	40
TSS	02035000	02035000	Jan88-Dec98	Reg	Y	.9823	41.6	122	-67	193	NS	64
02041650 - Appomattox River at Matoaca, Va. (map ID site #30)												
Q	02041650	02041650	Jan89-Dec98	Reg	Y	.6742	—	—	-42	43	NS	—
TN	02041650	02041650	Jan89-Dec98	Reg	Y	.2361	1.50	1.49	-55	21	NS	0
NOx	02041650	02041650	Jan89-Dec98	Reg	Y	.3779	.376	.401	-44	24	NS	0
TP	02041650	02041650	Jan89-Dec98	Reg	Y	.6605	.106	.138	-52	58	NS	0
DIP	02041650	02041650	Jan89-Dec98	Reg	Y	.5865	.029	.035	-28	79	NS	3
TSS	02041650	02041650	Jan89-Dec98	Reg	Y	.6403	22.8	27.3	-64	86	NS	2
MULTI-AGENCY SITES												
01531500 - Susquehanna River at Towanda, Pa. (map ID site #1)												
Q	01531500	TOW	Jan89-Dec98	Reg	N	.9172	6,520	9,860	-35	62	NS	—
TN	01531500	TOW	Jan89-Dec98	Reg	Y	.0626	7.29	4.65	-61	2	NS	15
NOx	01531500	TOW	Jan89-Dec98	Reg	Y	.0303	4.41	2.61	-64	-6	NS	13
TP	01531500	TOW	Jan89-Dec98	Reg	Y	.0238	.357	.230	-72	-9	NS	14
DP	01531500	TOW	Jan89-Dec98	Reg	Y	.0001	.161	.082	-39	-76	DN	9
DIP	01531500	TOW	Jan89-Dec98	Reg	Y	.0300	.055	.029	-61	-5	NS	0
SED	01531500	TOW	Jan89-Dec98	Reg	Y	.2346	349	205	-77	43	NS	54
01540500 - Susquehanna River at Danville, Pa. (map ID site #2)												
Q	01540500	DAN	Jan85-Dec98	Reg	N	.1750	11,000	14,600	-10	79	NS	—
TN	01540500	DAN	Jan85-Dec98	Reg	Y	.3286	5.70	4.77	-43	20	NS	15
NOx	01540500	DAN	Jan85-Dec98	Reg	Y	.6540	2.79	2.99	-24	56	NS	15
TP	01540500	DAN	Jan85-Dec98	Reg	Y	.0309	.338	.197	-63	-5	NS	10
DP	01540500	DAN	Jan85-Dec98	Reg	Y	.0001	.102	.055	-46	-80	DN	1
DIP	01540500	DAN	Jan85-Dec98	Reg	Y	.0870	.048	.031	-55	5	NS	1
SED	01540500	DAN	Jan85-Dec98	Reg	Y	.4657	193	119	-122	228	NS	26

Appendix 1. *Trends in streamflow and load data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics									
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median yields	Status-median yields	Magnitude		Trend direction	Relative rank
									Minimum	Maximum		
01553500 - West Branch Susquehanna River at Lewisburg, Pa. (map ID site #3)												
Q	01553500	LEW	Jan85-Dec98	Reg	Y	0.5050	8,160	10,500	-20	59	NS	—
TN	01553500	LEW	Jan85-Dec98	Reg	Y	.0875	5.85	4.13	-49	5	NS	12
NOx	01553500	LEW	Jan85-Dec98	Reg	Y	.5225	2.98	2.86	-35	25	NS	14
TP	01553500	LEW	Jan85-Dec98	Reg	Y	.0008	.204	.094	-30	-73	DN	0
DP	01553500	LEW	Jan85-Dec98	Reg	Y	.0001	.129	.051	-52	-77	DN	0
DIP	01553500	LEW	Jan85-Dec98	Reg	Y	.0693	.049	.027	-47	2	NS	0
SED	01553500	LEW	Jan85-Dec98	Reg	Y	.7331	123	56.8	-66	359	NS	5
01567000 - Juniata River at Newport, Pa. (map ID site #4)												
Q	01567000	JUN	Jan85-Dec98	Reg	Y	.0033	2,420	5,070	19	131	UP	—
TN	01567000	JUN	Jan85-Dec98	Reg	Y	.4520	4.29	7.56	-22	74	NS	28
NOx	01567000	JUN	Jan85-Dec98	Reg	Y	.1696	2.85	5.54	-11	93	NS	29
TP	01567000	JUN	Jan85-Dec98	Reg	Y	.0486	.196	.284	-59	-1	NS	21
DP	01567000	JUN	Jan85-Dec98	Reg	Y	.0015	.105	.115	-60	-20	DN	19
DIP	01567000	JUN	Jan85-Dec98	Reg	Y	.0246	.118	.061	-64	-7	NS	15
SED	01567000	JUN	Jan85-Dec98	Reg	Y	.4987	80.1	208	-62	210	NS	55
01576000 - Susquehanna River at Marietta, Pa. (map ID site #6)												
Q	01576000	MAR	Jan85-Dec98	Reg	Y	.1388	25,500	40,000	-8	88	NS	—
TN	01576000	MAR	Jan85-Dec98	Reg	Y	.4052	4.96	6.27	-45	27	NS	22
NOx	01576000	MAR	Jan85-Dec98	Reg	Y	.9718	3.25	4.81	-34	49	NS	25
TP	01576000	MAR	Jan85-Dec98	Reg	Y	.1047	.196	.200	-73	-12	NS	10
DP	01576000	MAR	Jan85-Dec98	Reg	Y	.0008	.095	.080	-26	-66	DN	9
DIP	01576000	MAR	Jan85-Dec98	Reg	Y	.0121	.021	.039	15	187	NS	5
SED	01576000	MAR	Jan85-Dec98	Reg	Y	.6001	84.0	117	-93	168	NS	25

Appendix 1. *Trends in streamflow and load data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics									
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median yields	Status-median yields	Magnitude		Trend direction	Relative rank
									Minimum	Maximum		
01576754 - Conestoga River at Conestoga, Pa. (map ID site #7)												
Q	01576754	CON	Jan85-Dec98	Reg	Y	0.0529	451	747	0	69	NS	—
TN	01576754	CON	Jan85-Dec98	Reg	Y	.5246	26.7	37.5	-16	40	NS	100
NOx	01576754	CON	Jan85-Dec98	Reg	Y	.2683	19.7	30.5	-10	44	NS	100
TP	01576754	CON	Jan85-Dec98	SK	N	.2305	1.67	1.45	-61	-7	NS	100
DP	01576754	CON	Jan85-Dec98	Reg	Y	.0001	.955	.608	-40	-69	DN	100
DIP	01576754	CON	Jan85-Dec98	Reg	Y	.0001	.905	.536	-39	-69	DN	100
SED	01576754	CON	Jan85-Dec98	Reg	Y	.5241	337	452	-138	57	NS	100
01570000 - Conodoguinet Creek near Hogestown, Pa. (map ID site #5)												
Q	01570000	WQN0213	Jan85-Dec98	Reg	Y	.0001	—	—	59	207	UP	—
TN	01570000	WQN0213	Jan85-Dec98	Reg	Y	.0001	7.44	20.1	84	239	UP	85
NOx	01570000	WQN0213	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TP	01570000	WQN0213	Jan85-Dec98	Reg	Y	.4076	.047	.251	-70	63	NS	17
DP	01570000	WQN0213	Jan85-Dec98	Reg	Y	.0015	.034	.088	-72	-93	DN	11
DIP	01570000	WQN0213	Jan85-Dec98	Reg	Y	.0001	.224	.066	-60	-90	DN	17
TSS	01570000	WQN0213	Jan85-Dec98	—	—	—	—	—	—	—	—	—
01586000 - North Branch Patapsco River at Cedarhurst, Md. (map ID site #12)												
Q	01586000	NPA0165	Jan85-Dec98	Reg	Y	.0001	—	—	30	115	UP	—
TN	01586000	NPA0165	Jan85-Dec98	Reg	Y	.0001	8.69	22.5	75	175	UP	96
TKN	01586000	NPA0165	Jan85-Dec98	Reg	Y	.6894	—	—	-45	48	NS	—
NOx	01586000	NPA0165	Jan85-Dec98	Reg	Y	.0001	7.24	16.5	60	144	UP	92
TP	01586000	NPA0165	Jan85-Dec98	Reg	Y	.7424	.120	.236	-55	141	NS	15
DP	01586000	NPA0165	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01586000	NPA0165	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01586000	NPA0165	Jan85-Dec98	Reg	Y	.0672	17.6	72.7	-7	824	NS	32

Appendix 1. *Trends in streamflow and load data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics									
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median yields	Status-median yields	Magnitude		Trend direction	Relative rank
									Minimum	Maximum		
01592500 - Patuxent River near Laurel, Md. (map ID site #10)												
Q	01592500	PXT0809	Jan85-Dec98	Reg	Y	0.0039	—	—	26	222	UP	—
TN	01592500	PXT0809	Jan85-Dec98	Reg	Y	.0006	0.622	6.68	49	306	UP	24
TKN	01592500	PXT0809	Jan85-Dec98	Reg	Y	.0018	—	—	35	225	UP	—
NOx	01592500	PXT0809	Jan85-Dec98	Reg	Y	.0008	.352	4.02	46	303	UP	21
TP	01592500	PXT0809	Jan85-Dec98	Reg	Y	.0079	.023	.122	-6	-7	UP	0
DP	01592500	PXT0809	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01592500	PXT0809	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01592500	PXT0809	Jan85-Dec98	Reg	Y	.0001	3.27	32.1	139	516	UP	5
01599000 - Georges Creek near Franklin, Md. (map ID site #13)												
Q	01599000	GEO0009	Jan85-Dec98	Reg	Y	.1633	—	—	-11	104	NS	—
TN	01599000	GEO0009	Jan85-Dec98	Reg	Y	.6263	3.65	5.08	-40	35	NS	17
TKN	01599000	GEO0009	Jan85-Dec98	Reg	Y	.2113	—	—	-52	18	NS	—
NOx	01599000	GEO0009	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TP	01599000	GEO0009	Jan85-Dec98	Reg	Y	.1684	.178	.214	-48	12	NS	12
DP	01599000	GEO0009	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01599000	GEO0009	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01599000	GEO0009	Jan85-Dec98	Reg	Y	.0491	45.9	165	1	226	NS	92
01601500 - Wills Creek near Cumberland, Md. (map ID site #14)												
Q	01601500	WIL0013	Jan85-Dec98	Reg	Y	.0178	—	—	-17	98	NS	—
TN	01601500	WIL0013	Jan85-Dec98	Reg	Y	.4155	3.84	5.37	-57	42	NS	18
DNH	01601500	WIL0013	Jan85-Dec98	Reg	Y	.0105	—	—	19	242	NS	—
TKN	01601500	WIL0013	Jan85-Dec98	Reg	Y	.1659	—	—	-60	17	NS	—
NOx	01601500	WIL0013	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TP	01601500	WIL0013	Jan85-Dec98	Reg	Y	.2805	.077	.195	-14	47	NS	10
DP	01601500	WIL0013	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01601500	WIL0013	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01601500	WIL0013	Jan85-Dec98	Reg	Y	.2999	31.4	76.3	-32	55	NS	34

Appendix 1. *Trends in streamflow and load data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics						Magnitude			
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median yields	Status-median yields	Minimum	Maximum	Trend direction	Relative rank
01610000 - Potomac River at Paw Paw, W. Va. (map ID site #15)												
Q	01610000	POT2766	Jan85-Dec98	Reg	Y	0.2156	—	—	-12	80	NS	—
TN	01610000	POT2766	Jan85-Dec98	Reg	Y	.6821	2.89	4.14	-28	65	NS	12
DNH	01610000	POT2766	Jan85-Dec98	Reg	Y	.001	—	—	-17	-51	DN	—
TKN	01610000	POT2766	Jan85-Dec98	Reg	Y	.3641	—	—	-49	28	NS	—
NOx	01610000	POT2766	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TP	01610000	POT2766	Jan85-Dec98	Reg	Y	.4333	.145	.169	-56	42	NS	6
DP	01610000	POT2766	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01610000	POT2766	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01610000	POT2766	Jan85-Dec98	Reg	Y	.7989	30.2	82.3	-52	162	NS	38
01613000 - Potomac River at Hancock, Md. (map ID site #16)												
Q	01613000	POT2386	Jan85-Dec98	Reg	Y	.1999	—	—	-12	81	NS	—
TN	01613000	POT2386	Jan85-Dec98	Reg	Y	.3762	3.11	4.04	-46	26	NS	12
TNH	01613000	POT2386	Jan85-Dec98	Reg	Y	.8974	—	—	-42	61	NS	—
TKN	01613000	POT2386	Jan85-Dec98	Reg	Y	.0262	—	—	-59	-6	NS	—
NOx	01613000	POT2386	Jan85-Dec98	Reg	Y	.487	1.68	2.38	-49	37	NS	11
TP	01613000	POT2386	Jan85-Dec98	Reg	Y	.2826	.133	.188	-57	28	NS	9
DP	01613000	POT2386	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01613000	POT2386	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01613000	POT2386	Jan85-Dec98	Reg	Y	.1449	27.4	94.9	-21	416	NS	46
01614500 - Conococheague Creek at Fairview, Md. (map ID site #17)												
Q	01614500	CON0180	Jan85-Dec98	Reg	Y	.0001	—	—	44	194	UP	—
TN	01614500	CON0180	Jan85-Dec98	Reg	Y	.0021	8.64	24.1	22	141	UP	100
DNH	01614500	CON0180	Jan85-Dec98	Reg	Y	.8734	—	—	-37	72	NS	—
TKN	01614500	CON0180	Jan85-Dec98	Reg	Y	.5315	—	—	-26	79	NS	—
NOx	01614500	CON0180	Jan85-Dec98	Reg	Y	.0052	7.43	19.2	16	125	UP	100
TP	01614500	CON0180	Jan85-Dec98	Reg	Y	.8049	.332	.524	-26	49	—	51
DP	01614500	CON0180	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01614500	CON0180	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01614500	CON0180	Jan85-Dec98	Reg	Y	.0064	17.0	175	42	695	UP	99

Appendix 1. *Trends in streamflow and load data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics						Magnitude			
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median yields	Status-median yields	Minimum	Maximum	Trend direction	Relative rank
01638500 - Potomac River at Point of Rocks, Md. (map ID site #19)												
Q	01638500	POT1595	Jan85-Dec98	Reg	Y	0.0073	—	—	14	128	UP	—
TN	01638500	POT1595	Jan85-Dec98	Reg	Y	.0893	4.38	8.60	-4	93	NS	33
DNH	01638500	POT1595	Jan85-Dec98	Reg	Y	.7494	—	—	-46	57	NS	—
TKN	01638500	POT1595	Jan85-Dec98	Reg	Y	.9512	—	—	-35	57	NS	—
NOx	01638500	POT1595	Jan85-Dec98	Reg	Y	.0666	2.72	5.89	-2	99	NS	31
TP	01638500	POT1595	Jan85-Dec98	Reg	Y	.8323	.165	.293	-40	87	NS	22
DP	01638500	POT1595	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01638500	POT1595	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01638500	POT1595	Jan85-Dec98	Reg	Y	.0616	27.0	117	-4	485	NS	61
01643000 - Monocacy River at Reels Mill Road, Md. (map ID site #18)												
Q	01643000	MON0528	Jan85-Dec98	Reg	Y	.0121	—	—	12	142	NS	—
TN	01643000	MON0528	Jan85-Dec98	Reg	Y	.5954	5.45	11.0	-5	291	NS	44
DNH	01643000	MON0528	Jan85-Dec98	Reg	Y	.5601	—	—	-41	166	NS	—
TKN	01643000	MON0528	Jan85-Dec98	Reg	Y	.5604	—	—	-47	41	NS	—
NOx	01643000	MON0528	Jan85-Dec98	Reg	Y	.0265	2.53	3.68	-75	-9	NS	19
TP	01643000	MON0528	Jan85-Dec98	Reg	Y	.6093	.285	.524	-49	48	NS	51
DP	01643000	MON0528	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01643000	MON0528	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01643000	MON0528	Jan85-Dec98	Reg	Y	.0728	18.9	82.7	-5	291	NS	38
01631000 - S. Fork Shenandoah River near Front Royal, Va. (map ID site #20)												
Q	01631000	1BSSF003.56	Jan85-Dec98	Reg	Y	.0006	—	—	32	163	UP	—
TN	01631000	1BSSF003.56	Jan85-Dec98	Reg	Y	.9501	2.21	4.41	-41	64	NS	14
TNH	01631000	1BSSF003.56	Jan85-Dec98	Reg	Y	.3919	—	—	-57	40	NS	—
TKN	01631000	1BSSF003.56	Jan85-Dec98	Reg	Y	.0169	—	—	-70	-12	NS	—
NOx	01631000	1BSSF003.56	Jan85-Dec98	Reg	Y	.002	1.48	4.92	31	220	UP	26
TP	01631000	1BSSF003.56	Jan85-Dec98	Reg	Y	.3178	.361	.599	-19	92	NS	61
DP	01631000	1BSSF003.56	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01631000	1BSSF003.56	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01631000	1BSSF003.56	Jan85-Dec98	—	—	—	—	—	—	—	—	—

Appendix 1. *Trends in streamflow and load data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics									
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median yields	Status-median yields	Magnitude		Trend direction	Relative rank
									Minimum	Maximum		
01634000 - N. Fork Shenandoah River near Strasburg, Va. (map ID site #21)												
Q	01634000	1BNFS010.34	Jan85-Dec98	Reg	Y	0.0003	—	—	43	220	UP	—
TN	01634000	1BNFS010.34	Jan85-Dec98	Reg	Y	.0001	1.55	7.48	96	414	UP	28
TNH	01634000	1BNFS010.34	Jan85-Dec98	Reg	Y	.1249	—	—	-13	218	NS	—
TKN	01634000	1BNFS010.34	Jan85-Dec98	Reg	Y	.563	—	—	-35	123	NS	—
NOx	01634000	1BNFS010.34	Jan85-Dec98	Reg	Y	.0001	1.15	7.61	142	660	UP	41
TP	01634000	1BNFS010.34	Jan85-Dec98	Reg	Y	.0001	.143	.540	169	497	UP	53
DP	01634000	1BNFS010.34	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01634000	1BNFS010.34	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01634000	1BNFS010.34	Jan85-Dec98	Reg	Y	.0107	5.19	38.7	48	1676	NS	9
01666500 - Robinson River near Locust Dale, Va. (map ID site #23)												
Q	01666500	3-ROB001.90	Jan85-Dec98	Reg	Y	.0004	—	—	40	202	UP	—
TN	01666500	3-ROB001.90	Jan85-Dec98	Reg	Y	.22	1.45	3.11	-18	136	NS	8
TNH	01666500	3-ROB001.90	Jan85-Dec98	Reg	Y	.2349	—	—	-66	30	NS	—
TKN	01666500	3-ROB001.90	Jan85-Dec98	Reg	Y	.4427	—	—	-33	150	NS	—
NOx	01666500	3-ROB001.90	Jan85-Dec98	Reg	Y	.0583	1.16	2.79	-1	134	NS	14
TP	01666500	3-ROB001.90	Jan85-Dec98	Reg	Y	.0014	.191	.505	39	283	UP	49
DP	01666500	3-ROB001.90	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01666500	3-ROB001.90	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01666500	3-ROB001.90	Jan85-Dec98	Reg	Y	.0014	12.4	95.3			UP	47
01671020 - North Anna River at Hart Corner near Doswell, Va. (map ID site #26)												
Q	01671020	8-NAR005.42	Jan85-Dec98	Reg	Y	.0456	—	—	1	129	NS	—
TN	01671020	8-NAR005.42	Jan85-Dec98	Reg	Y	.4572	.434	1.34	-2	515	NS	0
TNH	01671020	8-NAR005.42	Jan85-Dec98	Reg	Y	.4189	—	—	-29	126	NS	—
TKN	01671020	8-NAR005.42	Jan85-Dec98	Reg	Y	.7159	—	—	-43	47	NS	—
NOx	01671020	8-NAR005.42	Jan85-Dec98	Reg	Y	.1975	.243	.623	-18	162	NS	1
TP	01671020	8-NAR005.42	Jan85-Dec98	Reg	Y	.661	.178	.205	-43	43	NS	11
DP	01671020	8-NAR005.42	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01671020	8-NAR005.42	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01671020	8-NAR005.42	Jan85-Dec98	Reg	Y	.0573	5.77	22.8	-2	515	NS	0

Appendix 1. *Trends in streamflow and load data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics									
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median yields	Status-median yields	Magnitude		Trend direction	Relative rank
									Minimum	Maximum		
02013100 - Jackson River below Dunlap Creek at Covington, Va. (map ID site #28)												
Q	02013100	2-JKS023.61	Jan85-Dec98	Reg	Y	0.1632	—	—	-8	61	NS	—
TN	02013100	2-JKS023.61	Jan85-Dec98	Reg	Y	.4438	0.916	1.36	-15	45	NS	0
TNH	02013100	2-JKS023.61	Jan85-Dec98	Reg	Y	.0073	—	—	9	71	UP	—
TKN	02013100	2-JKS023.61	Jan85-Dec98	Reg	Y	.0659	—	—	-35	1	NS	—
NOx	02013100	2-JKS023.61	Jan85-Dec98	Reg	Y	.0466	.257	.815	1	127	NS	2
TP	02013100	2-JKS023.61	Jan85-Dec98	Reg	Y	.0001	5.18	1.16	-83	-85	DN	100
DP	02013100	2-JKS023.61	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	02013100	2-JKS023.61	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	02013100	2-JKS023.61	Jan85-Dec98	Reg	Y	.1306	13.2	24.5	-9	113	NS	0

Appendix 2—Trends in Flow-Weighted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed

Parameters: TN, total nitrogen; DNH, dissolved ammonia; TNH, total ammonia; NOx, total or dissolved nitrate, or, nitrite plus nitrate; DKN, dissolved ammonia plus organic nitrogen; TKN, total ammonia plus organic nitrogen; TP, total phosphorus; DP, dissolved phosphorus; DIP, dissolved inorganic phosphorus; TSS, total suspended solids; SED, suspended sediment.

Station: flow, USGS discharge site number; WQ, water-quality site number.

Statistics: POR, time period used in test; test, regression (Reg), Kendall Theil (KT); log transformed; yes (Y) or no (N); p-value, measure of significance of regressor at 0.01; slope, regression slope; base median, median of first 2 years of record; status median, median of last 3 years of record; magnitude, minimum (min) and maximum (max) percentage change in trend for indicated period of record; tend direction, UP, down (DN), or not significant (NS); relative rank, each individual status concentration (milligrams per liter) compared to all others of the same parameter; shaded areas are significant at 99-percent confidence level; —, not applicable or insufficient data.

Appendix 2. *Trends in flow-weighted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics									
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median concentration	Status-median concentration	Magnitude		Trend direction	Relative rank
									Minimum	Maximum		
RIVER INPUT SITE DATA												
01491000 - Choptank River near Greensboro, Md. (map ID site #9)												
TN	01491000	01491000	Jan85-Dec98	KT	Y	0.0001	1.72	1.56	-6	-9	DN	28
NOx	01491000	01491000	Jan85-Dec98	Reg	N	.5678	1.01	.965	-6	11	NS	26
TKN	01491000	01491000	Jan85-Dec98	Reg	Y	.0001	—	—	-29	-45	DN	—
TP	01491000	01491000	Jan85-Dec98	Reg	Y	.1702	.056	.057	-26	5	NS	15
DP	01491000	01491000	Jan85-Dec98	Reg	Y	.0001	.019	.029	27	75	UP	30
DIP	01491000	01491000	Jan85-Dec98	Reg	Y	.0001	.014	.024	42	91	UP	34
SED	01491000	01491000	Jan85-Dec98	Reg	Y	.0784	6.02	9.02	-48	3	NS	0
01578310 - Susquehanna River at Conowingo, Md. (map ID site #8)												
TN	01578310	01578310	Jan85-Dec98	Reg	N	.0001	1.93	1.62	-19	-21	DN	29
NOx	01578310	01578310	Jan85-Dec98	Reg	N	.0454	1.19	1.21	1	7	NS	34
TKN	01578310	01578310	Jan85-Dec98	Reg	Y	.0001	—	—	-52	-58	DN	—
TP	01578310	01578310	Jan85-Dec98	KT	Y	.0001	.060	.032	-57	-75	DN	1
DP	01578310	01578310	Jan85-Dec98	Reg	Y	.0001	.024	.012	-53	-61	DN	3
DIP	01578310	01578310	Jan85-Dec98	Reg	N	.6223	.009	.009	-14	18	NS	4
SED	01578310	01578310	Jan85-Dec98	Reg	Y	.1155	13.4	13.6	-6	73	NS	4
01594440 - Patuxent River near Bowie, Md. (map ID site #11)												
TN	01594440	01594440	Jan85-Dec98	Reg	Y	.0001	4.76	1.77	-63	-68	DN	34
NOx	01594440	01594440	Jan85-Dec98	Reg	Y	.0001	3.24	1.21	-61	-68	DN	34
TKN	01594440	01594440	Jan85-Dec98	Reg	Y	.0001	—	—	-67	-70	DN	—
TP	01594440	01594440	Jan85-Dec98	Reg	Y	.0001	.329	.114	-72	-76	DN	46
DP	01594440	01594440	Jan85-Dec98	Reg	Y	.0001	.143	.041	-72	-78	DN	50
DIP	01594440	01594440	Jan85-Dec98	Reg	Y	.0001	.105	.042	-50	-65	DN	72
SED	01594440	01594440	Jan85-Dec98	Reg	Y	.0001	45.6	38.0	-31	-65	DN	45

Appendix 2. *Trends in flow-weighted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics									
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median concentration	Status-median concentration	Magnitude		Trend direction	Relative rank
									Minimum	Maximum		
01646580 - Potomac River at Chain Bridge, Md. (map ID site #28)												
TN	01646580	PR01	Jan85-Dec98	Reg	Y	0.2125	1.79	2.09	-4	18	NS	42
NOx	01646580	PR01	Jan85-Dec98	Reg	N	.0001	.978	1.48	28	58	UP	42
TKN	01646580	PR01	Jan85-Dec98	Reg	Y	.0036	—	—	-9	-38	NS	—
TP	01646580	PR01	Jan85-Dec98	Reg	Y	.6033	.099	.100	-33	26	NS	38
DP	01646580	PR01	Jan85-Dec98	Reg	Y	.0001	.054	.041	-22	-45	DN	50
DIP	01646580	PR01	Jan85-Dec98	Reg	Y	.0165	.030	.025	-32	-4	NS	38
SED	01646580	PR01	Jan85-Dec98	Reg	Y	.0080	32.3	34.8	-19	-74	DN	39
01668000 - Rappahannock River near Fredericksburg, Va. (map ID site #24)												
TSS	01668000	01668000	Jan88-Dec98	Reg	Y	.8476	25.8	41.6	-67	150	NS	100
TN	01668000	01668000	Jan88-Dec98	Reg	Y	.0934	.959	.999	-38	4	NS	14
NOx	01668000	01668000	Jan88-Dec98	Reg	N	.0570	.544	.498	-36	1	NS	29
TP	01668000	01668000	Jan88-Dec98	Reg	Y	.4219	.068	.080	-54	38	NS	11
DIP	01668000	01668000	Jan88-Dec98	Reg	Y	.9006	.012	.014	-21	23	NS	13
01673000 - Pamunkey River near Hanover, Va. (map ID site #25)												
TSS	01673000	01673000	Jan89-Dec98	Reg	Y	.2302	28.9	25.4	-60	25	NS	55
TN	01673000	01673000	Jan89-Dec98	Reg	Y	.5426	.740	.697	-8	5	NS	6
NOx	01673000	01673000	Jan89-Dec98	Reg	N	.0001	.236	.305	26	38	UP	13
TP	01673000	01673000	Jan89-Dec98	Reg	Y	.5659	.075	.067	-13	8	NS	5
DIP	01673000	01673000	Jan89-Dec98	Reg	Y	.0001	.016	.025	74	125	UP	38
01674500 - Mattaponi River near Beulahville, Va. (map ID site #27)												
TSS	01674500	01674500	Jan89-Dec98	Reg	N	.7662	8.10	9.69	-22	29	NS	5
TN	01674500	01674500	Jan89-Dec98	Reg	Y	.0001	.841	.521	-22	-34	DN	1
NOx	01674500	01674500	Jan89-Dec98	Reg	N	.0001	.201	.127	-28	-41	DN	0
TP	01674500	01674500	Jan89-Dec98	KT	N	.0001	.082	.045	-31	-45	DN	0
DIP	01674500	01674500	Jan89-Dec98	Reg	N	.0001	.020	.017	23	39	UP	21

Appendix 2. *Trends in flow-weighted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics									
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median concentration	Status-median concentration	Magnitude		Trend direction	Relative rank
									Minimum	Maximum		
02035000 - James River at Cartersville, Va. (map ID site #29)												
TSS	02035000	02035000	Jan88-Dec98	Reg	Y	0.6124	15.5	34.0	-60	72	NS	82
TN	02035000	02035000	Jan88-Dec98	Reg	Y	.0169	.624	.587	-34	-4	NS	3
NOx	02035000	02035000	Jan88-Dec98	Reg	Y	.0031	.239	.227	-12	-45	DN	7
TP	02035000	02035000	Jan88-Dec98	KT	N	.0000	.154	.088	-48	-61	DN	3
DIP	02035000	02035000	Jan88-Dec98	Reg	Y	.0001	.098	.035	-60	-72	DN	58
02041650 - Appomattox River at Matoaca, Va. (map ID site #30)												
TSS	02041650	02041650	Jan89-Dec98	Reg	Y	.6085	9.19	9.18	-38	32	NS	3
TN	02041650	02041650	Jan89-Dec98	Reg	Y	.0001	.594	.500	-14	-22	DN	1
NOx	02041650	02041650	Jan89-Dec98	Reg	Y	.0817	.171	.162	-16	1	NS	2
TP	02041650	02041650	Jan89-Dec98	Reg	Y	.6620	.043	.046	-18	13	NS	1
DIP	02041650	02041650	Jan89-Dec98	Reg	N	.0001	.011	.013	20	29	UP	12
MULTI-AGENCY SITE DATA												
01531500 - Susquehanna River at Towanda, Pa. (map ID site #1)												
TN	01531500	TOW	Jan89-Dec98	Reg	Y	.1364	2.45	.965	-68	16	NS	13
NOx	01531500	TOW	Jan89-Dec98	Reg	Y	.0858	1.55	.531	-70	8	NS	12
TP	01531500	TOW	Jan89-Dec98	Reg	Y	.0551	.135	.050	-76	1	NS	11
DP	01531500	TOW	Jan89-Dec98	Reg	Y	.0026	.062	.019	-30	-80	DN	14
DIP	01531500	TOW	Jan89-Dec98	Reg	Y	.1012	.020	.007	-68	10	NS	0
SED	01531500	TOW	Jan89-Dec98	Reg	Y	.2516	137	46.0	-79	50	NS	58
01540500 - Susquehanna River at Danville, Pa. (map ID site #2)												
TN	01540500	DAN	Jan85-Dec98	Reg	Y	.0870	2.00	1.16	-60	6	NS	18
NOx	01540500	DAN	Jan85-Dec98	Reg	Y	.5176	1.08	.707	-47	37	NS	18
TP	01540500	DAN	Jan85-Dec98	Reg	Y	.0082	.117	.053	-18	-73	DN	13
DP	01540500	DAN	Jan85-Dec98	Reg	Y	.0001	.038	.013	-46	-80	DN	3
DIP	01540500	DAN	Jan85-Dec98	Reg	Y	.0245	.019	.008	-68	-8	NS	0
SED	01540500	DAN	Jan85-Dec98	Reg	Y	.2094	82.4	27.7	-74	34	NS	28

Appendix 2. *Trends in flow-weighted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics									
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median concentration	Status-median concentration	Magnitude Minimum	Magnitude Maximum	Trend direction	Relative rank
01553500 - West Branch Susquehanna River at Lewisburg, Pa. (map ID site #3)												
TN	01553500	LEW	Jan85-Dec98	Reg	Y	0.0608	1.16	0.99	-59	2	NS	13
NOx	01553500	LEW	Jan85-Dec98	Reg	Y	.3050	.612	.562	-48	23	NS	13
TP	01553500	LEW	Jan85-Dec98	Reg	Y	.0007	.047	.026	-34	-77	DN	0
DP	01553500	LEW	Jan85-Dec98	Reg	Y	.0001	.025	.010	-54	-81	DN	0
DIP	01553500	LEW	Jan85-Dec98	Reg	Y	.0670	.011	.007	-58	3	NS	0
SED	01553500	LEW	Jan85-Dec98	Reg	Y	.5425	25.5	15.5	-67	79	NS	7
01567000 - Juniata River at Newport, Pa. (map ID site #4)												
TN	01567000	JUN	Jan85-Dec98	Reg	Y	.1431	1.94	1.18	-56	12	NS	18
NOx	01567000	JUN	Jan85-Dec98	Reg	Y	.3235	1.24	.911	-50	26	NS	24
TP	01567000	JUN	Jan85-Dec98	Reg	Y	.0003	.078	.036	-36	-77	DN	3
DP	01567000	JUN	Jan85-Dec98	Reg	Y	.0001	.046	.018	-47	-78	DN	12
DIP	01567000	JUN	Jan85-Dec98	Reg	Y	.0001	.042	.014	-42	-79	DN	14
SED	01567000	JUN	Jan85-Dec98	Reg	Y	.5377	40.2	28.3	-64	69	NS	29
01576000 - Susquehanna River at Marietta, Pa. (map ID site #6)												
TN	01576000	MAR	Jan85-Dec98	Reg	Y	.0794	2.15	1.04	-61	5	NS	15
NOx	01576000	MAR	Jan85-Dec98	Reg	Y	.2664	1.29	.813	-54	25	NS	21
TP	01576000	MAR	Jan85-Dec98	Reg	Y	.0186	.084	.035	-73	-12	NS	3
DP	01576000	MAR	Jan85-Dec98	Reg	Y	.0001	.040	.014	-38	-76	DN	6
DIP	01576000	MAR	Jan85-Dec98	Reg	Y	.2360	.008	.008	-19	130	NS	1
SED	01576000	MAR	Jan85-Dec98	Reg	Y	.2564	35.1	23.0	-74	43	NS	20
01576754 - Conestoga River at Conestoga, Pa. (map ID site #7)												
TN	01576754	CON	Jan85-Dec98	Reg	Y	.2686	10.1	5.76	-39	15	NS	100
NOx	01576754	CON	Jan85-Dec98	Reg	Y	.3912	7.14	4.67	-35	8	NS	100
TP	01576754	CON	Jan85-Dec98	Reg	Y	.0013	.690	.237	-27	-71	DN	100
DP	01576754	CON	Jan85-Dec98	Reg	Y	.0001	.343	.101	-52	-77	DN	100
DIP	01576754	CON	Jan85-Dec98	Reg	Y	.0001	.321	.095	-52	-77	DN	100
SED	01576754	CON	Jan85-Dec98	Reg	Y	.1896	124	92.1	-72	28	NS	100

Appendix 2. *Trends in flow-weighted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics									
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median concentration	Status-median concentration	Magnitude		Trend direction	Relative rank
									Minimum	Maximum		
01570000 - Conodoguinet Creek near Hogestown, Pa. (map ID site #5)												
TN	01570000	WQN0213	Jan85-Dec98	Reg	N	0.5412	2.38	2.65	-36	68	NS	56
NOx	01570000	WQN0213	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TP	01570000	WQN0213	Jan85-Dec98	Reg	Y	.0045	.078	.028	-34	-88	DN	0
DP	01570000	WQN0213	Jan85-Dec98	Reg	Y	.0001	.046	.012	-72	-93	DN	1
DIP	01570000	WQN0213	Jan85-Dec98	Reg	N	.0001	.104	.009	-69	-79	DN	4
TSS	01570000	WQN0213	Jan85-Dec98	—	—	—	—	—	—	—	—	—
01586000 - North Branch Patapsco River at Cedarhurst, Md. (map ID site #12)												
TN	01586000	NPA0165	Jan85-Dec98	Reg	Y	.2419	3.57	4.51	25	38	NS	100
NOx	01586000	NPA0165	Jan85-Dec98	Reg	N	.0001	2.96	3.37	10	25	UP	100
TP	01586000	NPA0165	Jan85-Dec98	Reg	Y	.143	.066	.047	-67	17	NS	9
DP	01586000	NPA0165	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01586000	NPA0165	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01586000	NPA0165	Jan85-Dec98	Reg	Y	.2419	10.2	17.7	-31	—	NS	31
01592500 - Patuxent River near Laurel, Md. (map ID site #10)												
TN	01592500	PXT0809	Jan85-Dec98	Reg	N	.0001	1.55	1.92	18	26	UP	37
NOx	01592500	PXT0809	Jan85-Dec98	Reg	N	.0001	.942	1.15	16	27	UP	32
TP	01592500	PXT0809	Jan85-Dec98	Reg	N	.0001	.045	.043	-4	-8	DN	7
DP	01592500	PXT0809	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01592500	PXT0809	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01592500	PXT0809	Jan85-Dec98	Reg	Y	.0001	6.88	12.0	87	94	UP	12
01599000 - Georges Creek near Franklin, Md. (map ID site #13)												
TN	01599000	GEO0009	Jan85-Dec98	Reg	N	.0001	2.00	1.37	-31	-35	DN	23
NOx	01599000	GEO0009	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TP	01599000	GEO0009	Jan85-Dec98	Reg	Y	.0001	.112	.063	-36	-50	DN	18
DP	01599000	GEO0009	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01599000	GEO0009	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01599000	GEO0009	Jan85-Dec98	Reg	Y	.0012	29.9	39.1	13	61	UP	99

Appendix 2. *Trends in flow-weighted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics									
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median concentration	Status-median concentration	Magnitude		Trend direction	Relative rank
									Minimum	Maximum		
01601500 - Wills Creek near Cumberland, Md. (map ID site #14)												
TN	01601500	WIL0013	Jan85-Dec98	Reg	Y	0.0001	1.71	1.20	-28	-49	DN	19
NOx	01601500	WIL0013	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TP	01601500	WIL0013	Jan85-Dec98	Reg	N	.2579	.038	.043	-22	82	NS	7
DP	01601500	WIL0013	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01601500	WIL0013	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01601500	WIL0013	Jan85-Dec98	Reg	Y	.3966	14.0	18.9	-22	87	NS	34
01610000 - Potomac River at Paw Paw, W. Va. (map ID site #15)												
TN	01610000	POT2766	Jan85-Dec98	Reg	Y	.0001	1.17	1.08	-8	-18	DN	16
NOx	01610000	POT2766	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TP	01610000	POT2766	Jan85-Dec98	Reg	Y	.0011	.078	.052	-21	-52	DN	12
DP	01610000	POT2766	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01610000	POT2766	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01610000	POT2766	Jan85-Dec98	Reg	Y	.6483	13.0	19.4	-46	48	NS	36
01613000 - Potomac River at Hancock, Md. (map ID site #16)												
TN	01613000	POT2386	Jan85-Dec98	Reg	Y	.0001	1.37	1.05	-30	-40	DN	15
NOx	01613000	POT2386	Jan85-Dec98	Reg	Y	.0001	.721	.565	-21	-45	DN	13
TP	01613000	POT2386	Jan85-Dec98	Reg	N	.0001	.077	.047	-18	-69	DN	9
DP	01613000	POT2386	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01613000	POT2386	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01613000	POT2386	Jan85-Dec98	Reg	Y	.1246	12.0	22.9	-12	190	NS	47
01614500 - Conococheague Creek at Fairview, Md. (map ID site #17)												
TN	01614500	CON0180	Jan85-Dec98	Reg	N	.0001	4.72	4.16	-12	-20	DN	95
NOx	01614500	CON0180	Jan85-Dec98	Reg	N	.0001	3.79	3.27	-14	-26	DN	98
TP	01614500	CON0180	Jan85-Dec98	Reg	N	.0001	.182	.118	-43	-62	DN	48
DP	01614500	CON0180	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01614500	CON0180	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01614500	CON0180	Jan85-Dec98	Reg	N	.0395	13.8	26.5	7	220	NS	58

Appendix 2. *Trends in flow-weighted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics									
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median concentration	Status-median concentration	Magnitude Minimum	Magnitude Maximum	Trend direction	Relative rank
01638500 - Potomac River at Point of Rocks, Md. (map ID site #19)												
TN	01638500	POT1595	Jan85-Dec98	Reg	Y	0.0001	2.14	1.89	-11	-18	DN	37
NOx	01638500	POT1595	Jan85-Dec98	Reg	N	.0061	1.28	1.22	-4	-20	DN	34
TP	01638500	POT1595	Jan85-Dec98	Reg	Y	.0012	.108	.079	-16	-49	NS	27
DP	01638500	POT1595	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01638500	POT1595	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01638500	POT1595	Jan85-Dec98	Reg	Y	.1856	13.7	32.6	-17	160	NS	78
01643000 - Monocacy River at Reels Mill Road, Md. (map ID site #18)												
TN	01643000	MON0528	Jan85-Dec98	Reg	Y	.0001	2.80	1.84	-37	-53	DN	35
NOx	01643000	MON0528	Jan85-Dec98	Reg	N	.0001	1.27	.614	-37	-80	DN	15
TP	01643000	MON0528	Jan85-Dec98	Reg	N	.0001	.219	.126	-32	-62	DN	52
DP	01643000	MON0528	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01643000	MON0528	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01643000	MON0528	Jan85-Dec98	Reg	Y	.3846	15.6	18.8	-18	66	NS	34
01631000 - S. Fork Shenandoah River near Front Royal, Va. (map ID site #20)												
TN	01631000	1BSSF003.56	Jan85-Dec98	Reg	Y	.0001	1.23	1.09	-16	-37	DN	16
NOx	01631000	1BSSF003.56	Jan85-Dec98	Reg	Y	.0001	.758	1.21	62	33	UP	34
TP	01631000	1BSSF003.56	Jan85-Dec98	Reg	Y	.0001	.215	.182	-11	-28	DN	83
DP	01631000	1BSSF003.56	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01631000	1BSSF003.56	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01631000	1BSSF003.56	Jan85-Dec98	—	—	—	—	—	—	—	—	—
01634000 - N. Fork Shenandoah River near Strasburg, Va. (map ID site #21)												
TN	01634000	1BNFS010.34	Jan85-Dec98	Reg	N	.0001	1.20	1.73	19	52	UP	33
NOx	01634000	1BNFS010.34	Jan85-Dec98	Reg	N	.0001	.838	1.79	92	153	UP	52
TP	01634000	1BNFS010.34	Jan85-Dec98	Reg	Y	.0001	.116	.184	72	104	UP	84
DP	01634000	1BNFS010.34	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01634000	1BNFS010.34	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01634000	1BNFS010.34	Jan85-Dec98	Reg	Y	.0466	4.24	10.1	2	470	NS	6

Appendix 2. *Trends in flow-weighted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics									
	Flow	WQ	POR	Test	Log transformation	p-value	Base-median concentration	Status-median concentration	Magnitude		Trend direction	Relative rank
									Minimum	Maximum		
01666500 - Robinson River near Locust Dale, Va. (map ID site #23)												
TN	01666500	3-ROB001.90	Jan85-Dec98	Reg	Y	0.0468	.675	.735	-27	0	NS	7
NOx	01666500	3-ROB001.90	Jan85-Dec98	Reg	Y	.0032	.560	.535	-4	-16	DN	12
TP	01666500	3-ROB001.90	Jan85-Dec98	Reg	Y	.0001	.093	.132	15	54	UP	56
DP	01666500	3-ROB001.90	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01666500	3-ROB001.90	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01666500	3-ROB001.90	Jan85-Dec98	Reg	Y	.0071	5.56	28.4	55	130	UP	65
01671020 - North Anna River at Hart Corner near Doswell, Va. (map ID site #26)												
TN	01671020	8-NAR005.42	Jan85-Dec98	Reg	Y	.2247	.272	.341	-37	11	NS	0
NOx	01671020	8-NAR005.42	Jan85-Dec98	Reg	Y	.7326	.161	.164	-21	18	NS	1
TP	01671020	8-NAR005.42	Jan85-Dec98	Reg	Y	.0001	.110	.065	-50	-30	DN	19
DP	01671020	8-NAR005.42	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	01671020	8-NAR005.42	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	01671020	8-NAR005.42	Jan85-Dec98	Reg	Y	.0739	3.90	7.86	-4	171	NS	0
02013100 - Jackson River below Dunlap Creek at Covington, Va. (map ID site #28)												
TN	02013100	2-JKS023.61	Jan85-Dec98	Reg	Y	.3602	.438	.448	-19	8	NS	2
NOx	02013100	2-JKS023.61	Jan85-Dec98	Reg	Y	.0041	.130	.226	13	54	UP	3
TP	02013100	2-JKS023.61	Jan85-Dec98	Reg	Y	.0001	2.29	.399	-84	-89	DN	100
DP	02013100	2-JKS023.61	Jan85-Dec98	—	—	—	—	—	—	—	—	—
DIP	02013100	2-JKS023.61	Jan85-Dec98	—	—	—	—	—	—	—	—	—
TSS	02013100	2-JKS023.61	Jan85-Dec98	Reg	Y	.0965	7.03	8.16	-2	37	NS	2

APPENDIX 3—TRENDS IN FLOW-ADJUSTED CONCENTRATION DATA FOR 9 RIVER INPUT MONITORING PROGRAM SITES AND 21 MULTI-AGENCY NONTIDAL PROGRAM SITES IN THE CHESAPEAKE BAY WATERSHED

Parameters: TN, total nitrogen; DNH, dissolved ammonia; TNH, total ammonia; NOx, total or dissolved nitrate, or, nitrite plus nitrate; DKN, dissolved ammonia plus organic nitrogen; TKN, total ammonia plus organic nitrogen; TP, total phosphorus; DP, dissolved phosphorus; DIP, dissolved inorganic phosphorus; TSS, total suspended solids; SED, suspended sediment.

Station: flow, USGS discharge site number; WQ, water-quality site number.

Statistics: POR, time period used in test; percentage less than detect, percentage of samples reported at less than the detection limit; test, regression (Reg), Kendall Theil (KT); log transformed; yes (Y) or no (N); p-value, measure of significance of regressor at 0.05; slope, regression slope; base median, median of first 2 years of record; status median, median of last 3 years of record; magnitude, minimum (min) and maximum (max) percentage change in trend for indicated period of record; tend direction, UP, down (DN), or not significant (NS); relative rank, each individual status concentration (milligrams per liter) compared to all others of the same parameter; shaded areas are significant at 95-percent confidence level; —, not applicable or insufficient data.

Appendix 3. *Trends in flow-adjusted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics								
	Flow	WQ	POR	Percentage less than detect	Test	p-value 0.05	Base-median concentration	Status-median concentration	Magnitude Minimum	Magnitude Maximum	Trend direction
01491000 - Choptank River near Greensboro, Md. (map ID site #9)											
TN	01491000	01491000	Jan85-Dec98	0	KT	0.0963	—	—	-14	1	NS
TKN	01491000	01491000	Jan85-Dec98	0	KT	.0000	—	—	-41	-58	DN
NOx	01491000	01491000	Jan85-Dec98	.3	KT	.0000	—	—	17	45	UP
TP	01491000	01491000	Jan85-Dec98	1.8	KT	.0006	—	—	-13	-39	DN
DP	01491000	01491000	Jan85-Dec98	3.2	KT	.5628	—	—	-15	36	NS
DIP	01491000	01491000	Jan85-Dec98	4.4	KT	.0634	—	—	0	69	NS
SED	01491000	01491000	Jan85-Dec98	0	KT	.0000	—	—	-33	-69	DN
01578310 - Susquehanna River at Conowingo, Md. (map ID site #8)											
TN	01578310	01578310	Jan85-Dec98	0	KT	.0000	—	—	-13	-25	DN
TKN	01578310	01578310	Jan85-Dec98	0	KT	.0000	—	—	-56	-71	DN
NOx	01578310	01578310	Jan85-Dec98	0	KT	.5513	—	—	-6	12	NS
TP	01578310	01578310	Jan85-Dec98	2.8	KT	.0000	—	—	-36	-60	DN
DP	01578310	01578310	Jan85-Dec98	3.5	KT	.0000	—	—	-51	-22	DN
DIP	01578310	01578310	Jan85-Dec98	16.1	KT	.9190	—	—	-60	32	NS
SED	01578310	01578310	Jan85-Dec98	0	KT	.0069	—	—	-8	-42	DN
01594440 - Patuxent River near Bowie, Md. (map ID site #11)											
TN	01594440	01594440	Jan85-Dec98	0	KT	.0000	—	—	-60	-70	DN
TKN	01594440	01594440	Jan85-Dec98	0	KT	.0000	—	—	-68	-78	DN
NOx	01594440	01594440	Jan85-Dec98	0	KT	.0000	—	—	-58	-70	DN
TP	01594440	01594440	Jan85-Dec98	.2	KT	.0000	—	—	-78	-90	DN
DP	01594440	01594440	Jan85-Dec98	3.5	KT	.0000	—	—	-74	-93	DN
DIP	01594440	01594440	Jan85-Dec98	4.1	KT	.0000	—	—	-60	-85	DN
SED	01594440	01594440	Jan85-Dec98	0	KT	.0000	—	—	-52	-72	DN

Appendix 3. *Trends in flow-adjusted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics						Magnitude		
	Flow	WQ	POR	Percentage less than detect	Test	p-value 0.05	Base-median concentration	Status-median concentration	Minimum	Maximum	Trend direction
01646580 - Potomac River at Chain Bridge, Md. (map ID site #28)											
TN	01646580	PR01	Jan85-Dec98	0	KT	0.2020	—	—	0	15	NS
TKN	01646580	PR01	Jan85-Dec98	0	KT	.0000	—	—	-49	-65	DN
NOx	01646580	PR01	Jan85-Dec98	.5	KT	.0059	—	—	23	47	UP
TP	01646580	PR01	Jan85-Dec98	2.8	KT	.0000	—	—	-60	-40	DN
DP	01646580	PR01	Jan85-Dec98	10.4	KT	.0000	—	—	-68	-40	DN
DIP	01646580	PR01	Jan85-Dec98	22	KT	—	—	—	—	—	—
SED	01646580	PR01	Jan85-Dec98	0	KT	.0000	—	—	-47	-95	DN
01668000 - Rappahannock River near Fredericksburg, Va. (map ID site #24)											
TN	01668000	01668000	Jan88-Dec98	0	KT	.0000	—	—	-21	-41	DN
NOx	01668000	01668000	Jan88-Dec98	7	KT	.0196	—	—	-3	-30	DN
TP	01668000	01668000	Jan88-Dec98	2	KT	.0000	—	—	-41	-76	DN
DIP	01668000	01668000	Jan88-Dec98	13	KT	.8286	—	—	-29	47	NS
TSS	01668000	01668000	Jan88-Dec98	18	KT	.0043	—	—	-22	-93	DN
01673000 - Pamunkey River near Hanover, Va. (map ID site #25)											
TN	01673000	01673000	Jan89-Dec98	0	KT	.7790	—	—	-12	10	NS
NOx	01673000	01673000	Jan89-Dec98	0	KT	.0000	—	—	20	53	UP
TP	01673000	01673000	Jan89-Dec98	0	KT	.2891	—	—	-23	8	NS
DIP	01673000	01673000	Jan89-Dec98	11	KT	.0000	—	—	69	262	UP
TSS	01673000	01673000	Jan89-Dec98	10	KT	.7230	—	—	-37	36	NS
01674500 - Mattaponi River near Beulahville, Va. (map ID site #27)											
TN	01674500	01674500	Jan89-Dec98	0	KT	.0000	—	—	-21	-37	DN
NOx	01674500	01674500	Jan89-Dec98	2	KT	.0088	—	—	-6	-35	DN
TP	01674500	01674500	Jan89-Dec98	0	KT	.0000	—	—	-25	-42	DN
DIP	01674500	01674500	Jan89-Dec98	14	KT	.0092	—	—	0	93	UP
TSS	01674500	01674500	Jan89-Dec98	18	KT	.3314	—	—	-41	16	NS

Appendix 3. *Trends in flow-adjusted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics								
	Flow	WQ	POR	Percentage less than detect	Test	p-value 0.05	Base-median concentration	Status-median concentration	Magnitude		Trend direction
									Minimum	Maximum	
02035000 - James River at Cartersville, Va. (map ID site #29)											
TN	02035000	02035000	Jan88-Dec98	0	KT	0.0084	—	—	-30	-5	DN
NOx	02035000	02035000	Jan88-Dec98	2	KT	.2672	—	—	-15	4	NS
TP	02035000	02035000	Jan88-Dec98	0	KT	.0000	—	—	-69	-44	DN
DIP	02035000	02035000	Jan88-Dec98	2	KT	.0000	—	—	-83	-65	DN
TSS	02035000	02035000	Jan88-Dec98	12	KT	.9290	—	—	-26	49	NS
02041650 - Appomattox River at Matoaca, Va. (map ID site #30)											
TN	02041650	02041650	Jan89-Dec98	0	KT	.0000	—	—	-27	-11	DN
NOx	02041650	02041650	Jan89-Dec98	3	KT	.0337	—	—	-39	-2	DN
TP	02041650	02041650	Jan89-Dec98	0	KT	.0931	—	—	-31	0	NS
DIP	02041650	02041650	Jan89-Dec98	17	KT	.7426	—	—	0	118	NS
TSS	02041650	02041650	Jan89-Dec98	16	KT	.5398	—	—	-15	60	NS
MULTI-AGENCY SITES											
01531500 - Susquehanna River at Towanda, Pa. (map ID site #1)											
TN	01531500	TOW	Jan89-Dec98	0	KT	.0000	1.35	1.01	-22	-43	DN
NOx	01531500	TOW	Jan89-Dec98	0	KT	.0000	.744	.631	-21	-42	DN
TP	01531500	TOW	Jan89-Dec98	.4	KT	.5226	.048	.056	-45	35	NS
DP	01531500	TOW	Jan89-Dec98	1.1	KT	.0000	.031	.024	-37	-65	DN
DIP	01531500	TOW	Jan89-Dec98	2.6	KT	.0114	.008	.005	-76	0	DN
SED	01531500	TOW	Jan89-Dec98	0	KT	.4562	.8	4.2	-21	-68	NS
01540500 - Susquehanna River at Danville, Pa. (map ID site #2)											
TN	01540500	DAN	Jan85-Dec98	0	KT	.0000	1.51	1.18	-22	-36	DN
NOx	01540500	DAN	Jan85-Dec98	0	KT	.0526	.796	.786	-17	0	NS
TP	01540500	DAN	Jan85-Dec98	.5	KT	.0000	.075	.034	-30	-60	DN
DP	01540500	DAN	Jan85-Dec98	3.3	KT	.0000	.027	.012	-54	-70	DN
DIP	01540500	DAN	Jan85-Dec98	20.4	—	—	.019	.008	—	—	—
SED	01540500	DAN	Jan85-Dec98	.5	KT	.0012	36.6	23.5	-25	-74	DN

Appendix 3. *Trends in flow-adjusted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics								
	Flow	WQ	POR	Percentage less than detect	Test	p-value 0.05	Base-median concentration	Status-median concentration	Magnitude Minimum	Magnitude Maximum	Trend direction
01553500 - West Branch Susquehanna River at Lewisburg, Pa. (map ID site #3)											
TN	01553500	LEW	Jan85-Dec98	0	KT	0.0000	1.17	0.89	-16	-31	DN
NOx	01553500	LEW	Jan85-Dec98	0	KT	.1109	.655	.581	-16	2	NS
TP	01553500	LEW	Jan85-Dec98	.3	KT	.0000	.034	.01	-51	-79	DN
DP	01553500	LEW	Jan85-Dec98	10.6	KT	.0000	.02	.008	-63	-81	DN
DIP	01553500	LEW	Jan85-Dec98	29.9	—	—	.011	.007	—	—	—
SED	01553500	LEW	Jan85-Dec98	.9	KT	.9293	11.2	12.8	-53	98	NS
01567000 - Juniata River at Newport, Pa. (map ID site #4)											
TN	01567000	JUN	Jan85-Dec98	0	KT	.0000	1.99	1.52	-19	-29	DN
NOx	01567000	JUN	Jan85-Dec98	0	KT	.0000	1.53	1.2	-13	-23	DN
TP	01567000	JUN	Jan85-Dec98	0	KT	.0000	.073	.038	-39	-62	DN
DP	01567000	JUN	Jan85-Dec98	1.2	KT	.0000	.043	.018	-47	-65	DN
DIP	01567000	JUN	Jan85-Dec98	12.2	KT	.0000	.017	.014	-53	-90	DN
SED	01567000	JUN	Jan85-Dec98	.9	KT	.0015	23.3	10.6	-25	-73	DN
01576000 - Susquehanna River at Marietta, Pa. (map ID site #6)											
TN	01576000	MAR	Jan85-Dec98	0	KT	.0000	1.62	1.34	-25	-41	DN
NOx	01576000	MAR	Jan85-Dec98	0	KT	.0342	1.03	1.02	-1	-21	DN
TP	01576000	MAR	Jan85-Dec98	.3	KT	.0000	.084	.043	-46	-71	DN
DP	01576000	MAR	Jan85-Dec98	2.4	KT	.0000	.031	.016	-49	-66	DN
DIP	01576000	MAR	Jan85-Dec98	23.8	—	—	.008	.008	—	—	—
SED	01576000	MAR	Jan85-Dec98	1.2	KT	.0013	39.7	24.5	-24	-73	DN
01576754 - Conestoga River at Conestoga, Pa. (map ID site #7)											
TN	01576754	CON	Jan85-Dec98	0	KT	.3555	8.74	8.86	-12	5	NS
NOx	01576754	CON	Jan85-Dec98	0	KT	.3276	6.26	6.84	-5	18	NS
TP	01576754	CON	Jan85-Dec98	0	KT	.0000	.382	.139	-44	-67	DN
DP	01576754	CON	Jan85-Dec98	0	KT	.0000	.247	.112	-55	-73	DN
DIP	01576754	CON	Jan85-Dec98	.5	KT	.0000	.178	.063	-60	-83	DN
SED	01576754	CON	Jan85-Dec98	.9	KT	.0060	56	55.9	-13	-64	DN

Appendix 3. *Trends in flow-adjusted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics						Magnitude		Trend direction
	Flow	WQ	POR	Percentage less than detect	Test	p-value 0.05	Base-median concentration	Status-median concentration	Minimum	Maximum	
01570000 - Conodoguinet Creek near Hogestown, Pa. (map ID site #5)											
TN	01570000	WQN0213	Jan85-Dec98	12	KT	0.1915	—	—	-21	-50	NS
NOx	01570000	WQN0213	Jan85-Dec98	—	—	—	—	—	—	—	—
TP	01570000	WQN0213	Jan85-Dec98	13	KT	.0000	—	—	-69	-95	DN
DP	01570000	WQN0213	Jan85-Dec98	20	KT	.0000	—	—	-85	-110	DN
DIP	01570000	WQN0213	Jan85-Dec98	—	—	—	—	—	—	—	—
TSS	01570000	WQN0213	Jan85-Dec98	—	—	—	—	—	—	—	—
01586000 - North Branch Patapsco River at Cedarhurst, Md. (map ID site #12)											
TN	01586000	NPA0165	Jan85-Dec98	0	KT	.0000	—	—	27	31	UP
NOx	01586000	NPA0165	Jan85-Dec98	0	KT	.0000	—	—	46	53	UP
TP	01586000	NPA0165	Jan85-Dec98	7.6	KT	.0000	—	—	-75	-82	DN
DIP	01586000	NPA0165	Jan85-Dec98	—	—	—	—	—	—	—	—
TSS	01586000	NPA0165	Jan85-Dec98	4.8	KT	.0015	—	—	-70	-61	DN
01592500 - Patuxent River near Laurel, Md. (map ID site #10)											
TN	01592500	PXT0809	Jan85-Dec98	0	KT	.0010	—	—	14	17	UP
NOx	01592500	PXT0809	Jan85-Dec98	0	KT	.0385	—	—	14	21	UP
TP	01592500	PXT0809	Jan85-Dec98	2.4	KT	.8396	—	—	-8	0	NS
DIP	01592500	PXT0809	Jan85-Dec98	—	—	—	—	—	—	—	—
TSS	01592500	PXT0809	Jan85-Dec98	2.4	KT	.0238	—	—	52	76	UP
01599000 - Georges Creek near Franklin, Md. (map ID site #13)											
TN	01599000	GEO0009	Jan85-Dec98	0	KT	.0000	—	—	-31	-35	DN
NOx	01599000	GEO0009	Jan85-Dec98	0	KT	.0328	—	—	69	222	UP
TP	01599000	GEO0009	Jan85-Dec98	2.4	KT	.0000	—	—	-73	-75	DN
DIP	01599000	GEO0009	Jan85-Dec98	—	—	—	—	—	—	—	—
TSS	01599000	GEO0009	Jan85-Dec98	.6	KT	.7241	—	—	-13	0	NS

Appendix 3. *Trends in flow-adjusted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics						Magnitude		
	Flow	WQ	POR	Percentage less than detect	Test	p-value 0.05	Base-median concentration	Status-median concentration	Minimum	Maximum	Trend direction
01601500 - Wills Creek near Cumberland, Md. (map ID site #14)											
TN	01601500	WIL0013	Jan85-Dec98	0	KT	0.0000	—	—	-43	-47	DN
NOx	01601500	WIL0013	Jan85-Dec98	0	KT	.8709	—	—	8	112	NS
TP	01601500	WIL0013	Jan85-Dec98	17	KT	.6495	—	—	-29	0	NS
DIP	01601500	WIL0013	Jan85-Dec98	—	—	—	—	—	—	—	—
TSS	01601500	WIL0013	Jan85-Dec98	8.5	KT	.5798	—	—	-10	-73	NS
01610000 - Potomac River at Paw Paw, W. Va. (map ID site #15)											
TN	01610000	POT2766	Jan85-Dec98	0	KT	.0007	—	—	-19	-23	DN
NOx	01610000	POT2766	Jan85-Dec98	0	KT	.0010	—	—	277	794	UP
TP	01610000	POT2766	Jan85-Dec98	3.9	KT	.0004	—	—	-50	-57	DN
DIP	01610000	POT2766	Jan85-Dec98	—	—	—	—	—	—	—	—
TSS	01610000	POT2766	Jan85-Dec98	6	KT	.0233	—	—	-43	-55	DN
01613000 - Potomac River at Hancock, Md. (map ID site #16)											
TN	01613000	POT2386	Jan85-Dec98	0	KT	.0000	—	—	-33	-126	DN
NOx	01613000	POT2386	Jan85-Dec98	0	KT	.9278	—	—	-12	8	NS
TP	01613000	POT2386	Jan85-Dec98	3.8	KT	.0000	—	—	-53	-58	DN
DIP	01613000	POT2386	Jan85-Dec98	—	—	—	—	—	—	—	—
TSS	01613000	POT2386	Jan85-Dec98	6.7	KT	.0639	—	—	-43	-82	NS
01614500 - Conococheague Creek at Fairview, Md. (map ID site #17)											
TN	01614500	CON0180	Jan85-Dec98	0	KT	.0003	—	—	-15	-18	DN
NOx	01614500	CON0180	Jan85-Dec98	0	KT	.0611	—	—	10	16	NS
TP	01614500	CON0180	Jan85-Dec98	.6	KT	.0000	—	—	-53	4	DN
DIP	01614500	CON0180	Jan85-Dec98	—	—	—	—	—	—	—	—
TSS	01614500	CON0180	Jan85-Dec98	5.5	KT	.0015	—	—	-42	-50	DN

Appendix 3. Trends in flow-adjusted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued

Parameter	Station		Statistics								
	Flow	WQ	POR	Percentage less than detect	Test	p-value 0.05	Base-median concentration	Status-median concentration	Magnitude Minimum	Magnitude Maximum	Trend direction
01638500 - Potomac River at Point of Rocks, Md. (map ID site #19)											
TN	01638500	POT1595	Jan85-Dec98	0	KT	0.0009	—	—	-17	-20	DN
NOx	01638500	POT1595	Jan85-Dec98	0	—	.0158	—	—	20	28	DN
TP	01638500	POT1595	Jan85-Dec98	.6	KT	.0000	—	—	-57	-62	DN
DIP	01638500	POT1595	Jan85-Dec98	—	—	—	—	—	—	—	—
TSS	01638500	POT1595	Jan85-Dec98	3.6	KT	.0069	—	—	-37	-45	DN
01643000 - Monocacy River at Reels Mill Road, Md. (map ID site #18)											
TN	01643000	MON0528	Jan85-Dec98	0	KT	.0000	—	—	-49	-53	DN
NOx	01643000	MON0528	Jan85-Dec98	0	KT	.5638	—	—	-7	-85	NS
TP	01643000	MON0528	Jan85-Dec98	0	KT	.0000	—	—	-56	-62	DN
DIP	01643000	MON0528	Jan85-Dec98	—	—	—	—	—	—	—	—
TSS	01643000	MON0528	Jan85-Dec98	0	KT	.3766	—	—	-16	-30	NS
01631000 - S. Fork Shenandoah River near Front Royal, Va. (map ID site #20)											
TN	01631000	1BSSF003.56	Jan85-Dec98	36	—	—	—	—	—	—	—
NOx	01631000	1BSSF003.56	Jan85-Dec98	.8	KT	.3420	—	—	2	5	NS
TP	01631000	1BSSF003.56	Jan85-Dec98	20	KT	.0676	—	—	—	—	NS
DP	01631000	1BSSF003.56	Jan85-Dec98	—	—	—	—	—	—	—	—
DIP	01631000	1BSSF003.56	Jan85-Dec98	—	—	—	—	—	—	—	—
TSS	01631000	1BSSF003.56	Jan85-Dec98	41	—	—	—	—	—	—	—
01634000 - N. Fork Shenandoah River near Strasburg, Va. (map ID site #21)											
TN	01634000	1BNFS010.34	Jan85-Dec98	20	KT	.3035	—	—	7	17	NS
NOx	01634000	1BNFS010.34	Jan85-Dec98	3.2	KT	.0514	—	—	23	35	NS
TP	01634000	1BNFS010.34	Jan85-Dec98	31	—	—	—	—	—	—	—
DP	01634000	1BNFS010.34	Jan85-Dec98	—	—	—	—	—	—	—	—
DIP	01634000	1BNFS010.34	Jan85-Dec98	—	—	—	—	—	—	—	—
TSS	01634000	1BNFS010.34	Jan85-Dec98	53	—	—	—	—	—	—	—

Appendix 3. *Trends in flow-adjusted concentration data for 9 River Input Monitoring Program sites and 21 Multi-Agency Nontidal Program sites in the Chesapeake Bay Watershed—Continued*

Parameter	Station		Statistics								
	Flow	WQ	POR	Percentage less than detect	Test	p-value 0.05	Base-median concentration	Status-median concentration	Magnitude		Trend direction
									Minimum	Maximum	
01666500 - Robinson River near Locust Dale, Va. (map ID site #23)											
TN	01666500	3-ROB001.90	Jan85-Dec98	43	—	—	—	—	—	—	
NOx	01666500	3-ROB001.90	Jan85-Dec98	0	KT	0.0060	—	—	-17	-23	DN
TP	01666500	3-ROB001.90	Jan85-Dec98	56	—	—	—	—	—	—	—
DP	01666500	3-ROB001.90	Jan85-Dec98	—	—	—	—	—	—	—	—
DIP	01666500	3-ROB001.90	Jan85-Dec98	—	—	—	—	—	—	—	—
TSS	01666500	3-ROB001.90	Jan85-Dec98	23	—	—	—	—	—	—	—
01671020 - North Anna River at Hart Corner near Doswell, Va. (map ID site #26)											
TN	01671020	8-NAR005.42	Jan85-Dec98	62	—	—	—	—	—	—	—
NOx	01671020	8-NAR005.42	Jan85-Dec98	20	KT	.6587	—	—	-7	0	NS
TP	01671020	8-NAR005.42	Jan85-Dec98	35	—	—	—	—	—	—	—
DP	01671020	8-NAR005.42	Jan85-Dec98	—	—	—	—	—	—	—	—
DIP	01671020	8-NAR005.42	Jan85-Dec98	—	—	—	—	—	—	—	—
TSS	01671020	8-NAR005.42	Jan85-Dec98	57	—	—	—	—	—	—	—
02013100 - Jackson River below Dunlap Creek at Covington, Va. (map ID site #28)											
TN	02013100	2-JKS023.61	Jan85-Dec98	46	—	—	—	—	—	—	—
NOx	02013100	2-JKS023.61	Jan85-Dec98	5.7	KT	.4423	—	—	4	10	NS
TP	02013100	2-JKS023.61	Jan85-Dec98	2.1	KT	.0000	—	—	-119	-124	DN
DP	02013100	2-JKS023.61	Jan85-Dec98	—	—	—	—	—	—	—	—
DIP	02013100	2-JKS023.61	Jan85-Dec98	—	—	—	—	—	—	—	—
TSS	02013100	2-JKS023.61	Jan85-Dec98	9.9	KT	.1102	—	—	-28	16	NS