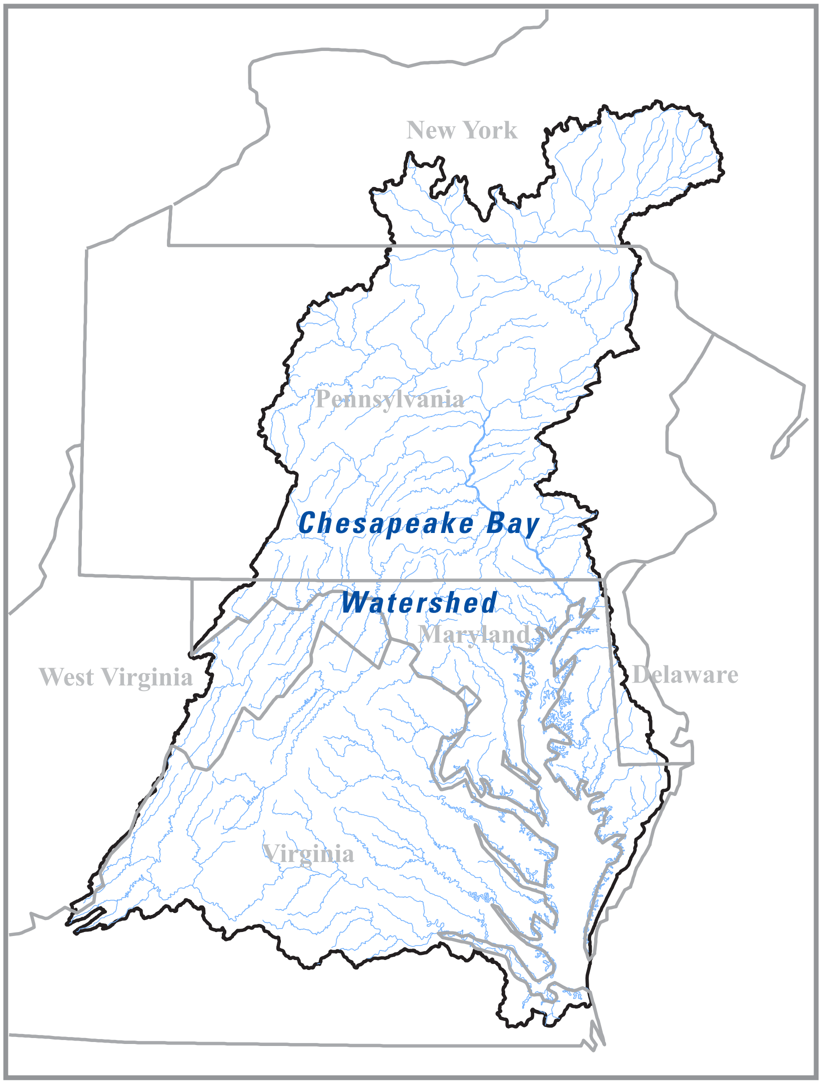
Total Nutrient and Sediment Loads, Trends, Yields, and Nontidal Water-Quality Indicators for Selected Nontidal Stations, Chesapeake Bay Watershed, 1985–2011



Open-File Report 2013–1052

U.S. Department of the Interior
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Total Nutrient and Sediment Loads, Trends, Yields, and Nontidal Water-Quality Indicators for Selected Nontidal Stations, Chesapeake Bay Watershed, 1985–2011

By Michael J. Langland, Joel D. Blomquist, Douglas L. Moyer, Kenneth E. Hyer, and Jeffrey G. Chanat

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Abstract

The U.S. Geological Survey, in cooperation with Chesapeake Bay Program (CBP) partners, routinely reports long-term concentration trends and monthly and annual constituent loads for stream water-quality monitoring stations across the Chesapeake Bay watershed. This report documents flow-adjusted trends in sediment and total nitrogen and phosphorus concentrations for 31 stations in the years 1985-2011 and for 32 stations in the years 2002-2011. Sediment and total nitrogen and phosphorus yields for 65 stations are presented for the years 2006-2011. A combined nontidal water-quality indicator (based on both trends and yields) indicates there are more stations classified as "improving water-quality trend and a low yield" than "degrading water-quality trend and a high yield" for total nitrogen. The same type of 2-way classification for total phosphorus and sediment results in equal numbers of stations in each indicator class.

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Introduction

The Chesapeake Bay has been adversely affected by nutrient and sediment enrichment. In 2010, the U.S. Environmental Protection Agency (USEPA) established a Total Maximum Daily Load (TMDL) requiring all jurisdictions in the Bay watershed to develop and implement Watershed Implementation Plans (WIPs) to reduce the loads of nutrients and sediment entering the Bay to established levels by 2025.

To consistently monitor and track loads, the Chesapeake Bay Program (CBP) partners formalized the CBP Nontidal Water-Quality Network (U.S. Environmental Protection Agency, 2004). Common sampling frequencies, protocols, and constituent analyses were established for all surface-water (stream) stations in the network. The U.S. Geological Survey in cooperation with the USEPA; and the States of New York, Pennsylvania, Maryland, Delaware, Virginia, and West Virginia; river basin commissions; and other partners, have expanded from 35 stations in 2004 to the current network of 120 stations in 2012.

To help track progress in meeting load-reduction goals, the USGS routinely reports long-term concentration trends and monthly and annual constituent loads for stream water-quality monitoring stations across the Chesapeake Bay watershed.

Purpose and Scope

This report presents updated results of load and trend analyses for nutrients and sediment at stream stations in the Chesapeake Bay Nontidal Water-Quality Network (CB-NTN) for multiple time periods. Loads and trends in flow-adjusted concentrations were estimated for the long-term (1985-2011) and 10-year (2002-2011) periods; loads were estimated for the 5-year (2006-2011) period. Yields were estimated for the 5-year period and combined with trend results from the 10-year period to develop nontidal water-quality indicators.

Methods

In 2004, new analytical techniques were developed based on the USGS ESTIMATOR model (Cohn and others, 1989) and since that time have been used to estimate trends in streamflow, load, and flow-adjusted concentration (Langland and others, 2006). In 2012, additional changes were incorporated into the model to obtain results for 1985-2010 (Langland and others, 2012).

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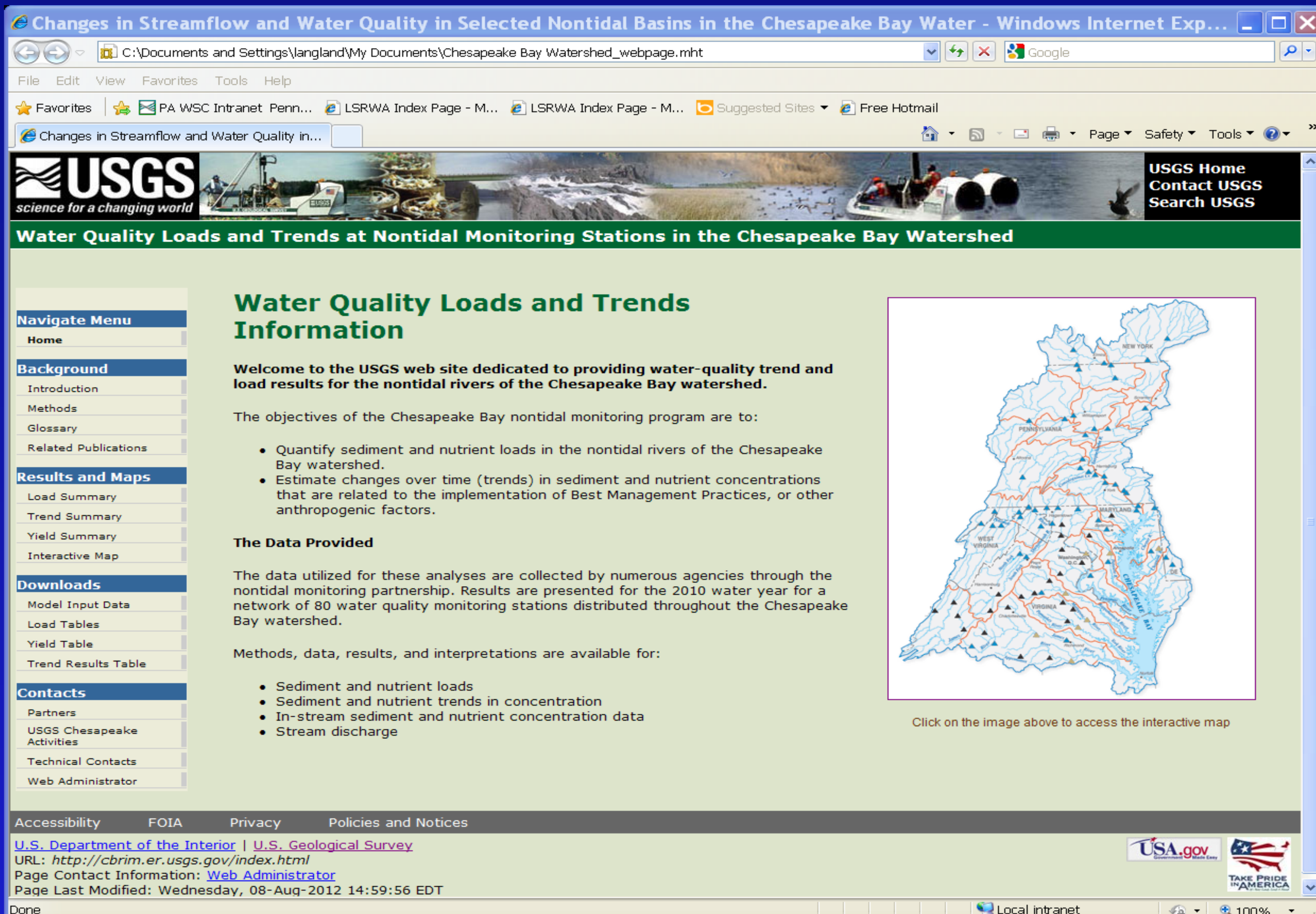
All data and results available at

http://cbrim.er.usgs.gov/



Monitoring Program Station Selection

Table 1. Description of data for the Chesapeake Bay Watershed.

[Primary (P) stations were sampled monthly and during eight targeted storms per year (since 2006). Secondary (S) stations were sampled monthly]

Time period	Length of record	Type/analysis	Number of stations (running total)
1985-2011	27 years	P -loads/trends/yields	31
2002-2011	10 years	P - load/trends/yields	1 (32)
2007-2011	5 years	P- loads/yields	33 (65)
2002-2011	10 years	S - trends	16 (81)

Why are we examining multiple time periods?

- Align with current and historical data collection efforts (long-term and 10-year loads and trends, 5-year loads)
- Examine changes over shorter time frames (since early 2000's)
- Provide additional data for indicators and measures of change

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Long-Term Monitoring Stations

The USGS is currently updating load and trend data at 31 long-term (generally 1985-2011) stations in the Bay watershed (fig. 1). The 31 stations consist of :

9 monitoring stations (red circles) at or near the most downstream nontidal areas of many large river basins and are termed "River Input Monitoring (RIM) Stations."

22 upstream stations (black circles) operated by multiple agencies

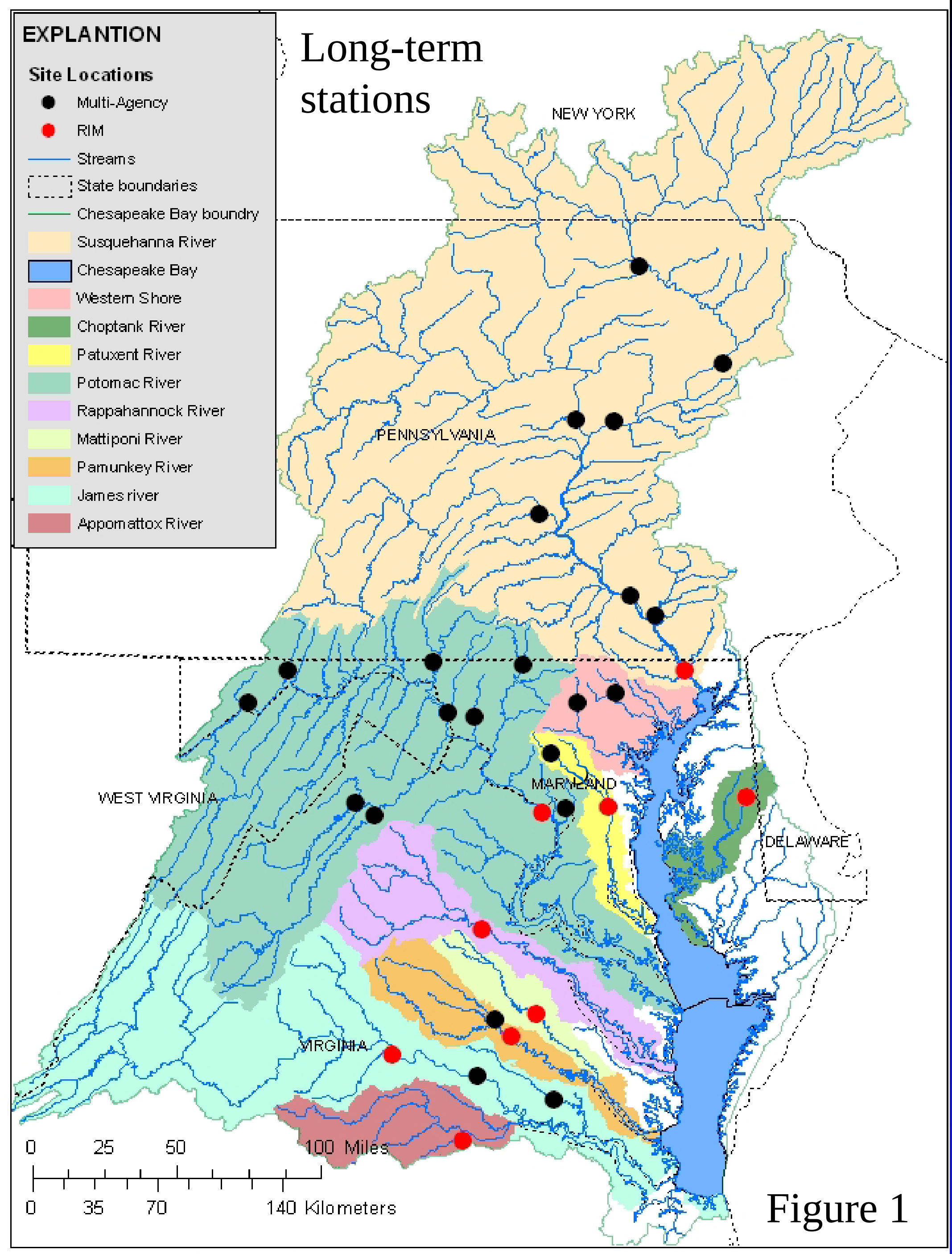


Figure 1

Monitoring Stations

The locations of all 81 stations evaluated for loads and (or) trends in 2011 are shown in figure 2.

- The red and black circles represent the 31 long-term monitoring stations.
- The yellow circle represents the one new site with 10 or more years of record added in 2011.
- The 33 blue circles represent stations with 5-9 years of record.
- The 16 brown squares represent secondary stations with 10 years of record.

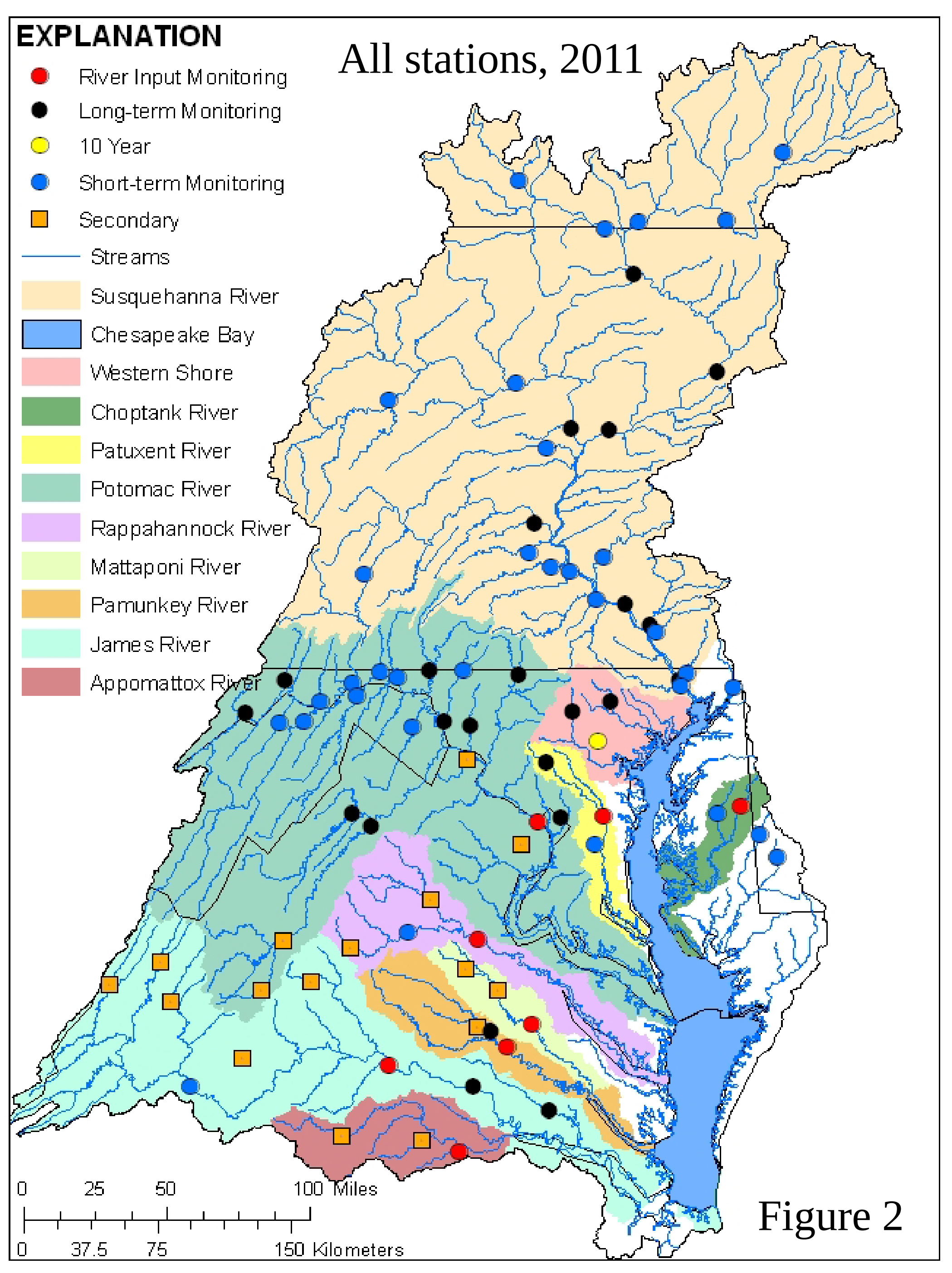


Figure 2

Table 2. Station information for the 81 stations in the Chesapeake Bay Nontidal Monitoring Network.

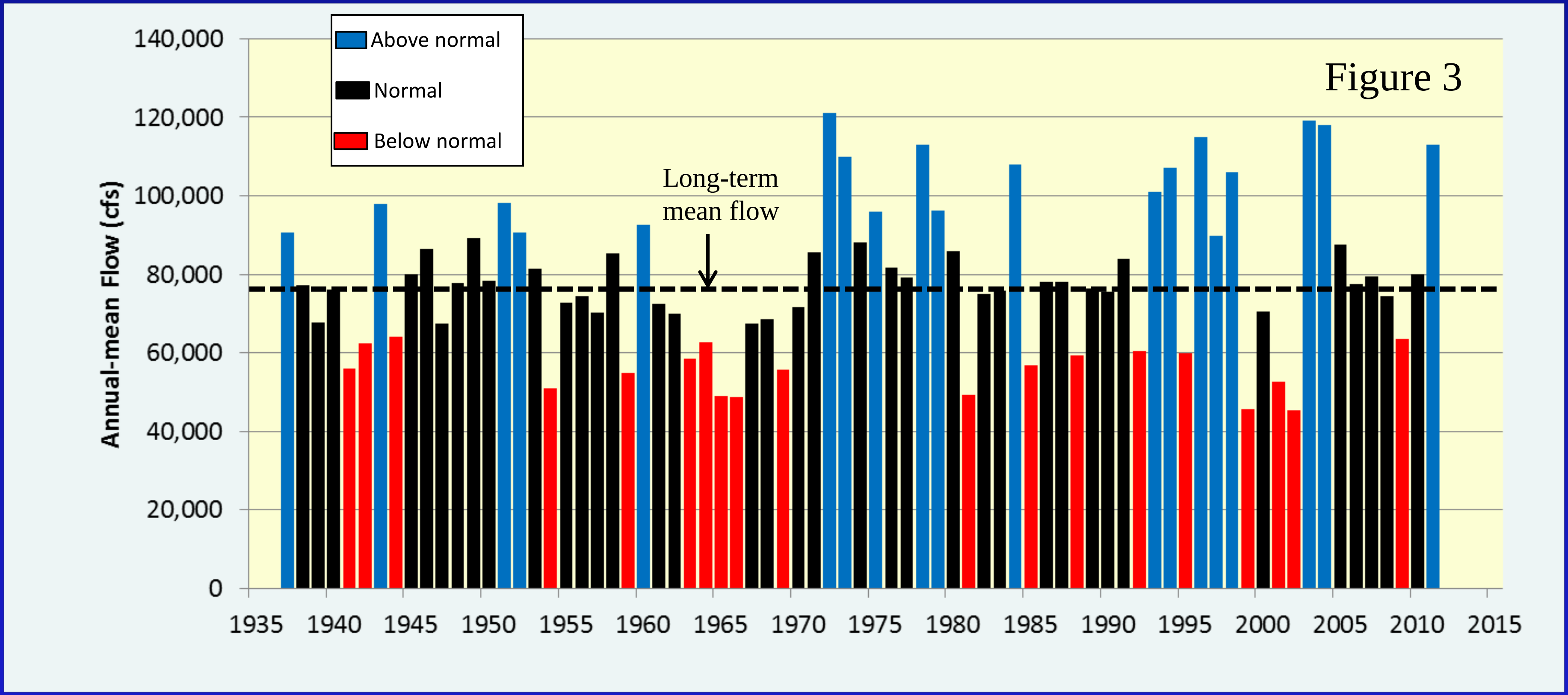
USGS GAGE	Multi-collector station name	Station Name	Years active	Drainage Area (square miles)	Latitude	Longitude
These 31 indicator stations have trends for long-term, 10 years, and 5 year yields						
01531500	WQN0305	Susquehanna River at Towanda, Pa.	27	7,797	414555	762628
01536500	WQN0302	Susquehanna River at Wilkes-Barre, Pa.	27	9,960	411503	755252
01540500	WQN0301	Susquehanna River at Danville, Pa.	27	11,220	405729	763710
01553500	WQN0401	West Branch Susquehanna River at Lewisburg, Pa.	27	6,859	405803	765236
01567000	WQN0214	Juniata River at Newport, Pa.	27	3,354	402842	770746
01576000	WQN0201	Susquehanna River at Marietta, Pa.	25	25,990	400316	763152
01576754	WQN0273	Conestoga River at Conestoga, Pa.	27	470	395647	762205
01578310	01578310	Susquehanna River at Conowingo, Md.	27	27,100	393928	761029
01491000	01491000	Choptank River near Greensboro, Md.	27	113	385950	754710
01582500	GUN0258	Gunpowder Falls at Glencoe, Md	27	160	393302	763809
01586000	NPA0165	North Branch Patapsco River at Cedarhurst, Md.	27	56.6	393000	765300
01591000	PXT0972	Patuxent River near Unity, Md	27	34.8	391418	770321
01594440	01594440	Patuxent River near Bowie, Md.	27	348	385721	764136
01599000	GEO0009	Georges Creek near Franklin, Md.	27	72.4	392938	790241
01601500	WIL0013	Wills Creek near Cumberland, Md.	27	247	393941	784650
01614500	CONO0180 / WQN0501	Conococheague Creek at Fairview, Md.	27	501	394256	774931
01619500	ANT0044, ANT0047	Antietem Creek near Sharpsburg, Md.	27	281	392701	774352
01631000	1BSSF003.56	S F Shenandoah River at Front Royal, Va.	27	1,642	385449	781240
01634000	1BNFS010.34	N F Shenandoah River near Strasburg, Va.	27	768	385836	782011
01637500	CAC0148	Catoctin Creek near Middletown, Md	27	66.9	392538	773322
01639000	MON0528 / MON0546	Monocacy River at Bridgeport, Md.	27	173	394043	771406
01646580	01646580	Potomac River at Chain Bridge, Md.	27	11,600	385546	770701
01651000	ANA0082, A4	NW Branch Anaacostia River nr Hyattsville, Md.	27	49.4	385708	765778
01668000	-	Rappahannock River near Fredericksburg, Va.	24	1,596	381920	773105
01671020	8-NAR005.42	North Anna at Hart Corner near Doswel, Va.	27	463	375100	772541
01673000	-	Pamunkey River near Hanover, Va.	24	1,081	374603	771957
01674500	-	Mattaponi River near Beulahville, Va.	24	601	375316	770948
02035000	-	James River at Cartersville, Va.	25	6,257	374015	780510
02037500	2-JMS117.35 / 2-JMS113.20	James River at Richmond, Va.	27	6,758	373347	773250
02041650	-	Appomattox River at Matoaca, Va.	24	1,344	371330	772832
02042500	2-CHK035.26	Chickahominy River near Providence Forge, Va	27	252	372610	770340
This 1 indicator stations has trends for 10 years and yields for 5 years						
01589300	GWN0115	Gwynns Falls at Villa Nova, Md	27	32.5	392045	764359
These 33 indicator stations have 5 year yields						
01515000	01515000	Susquehanna River near Waverly, NY	6	4,773	415905	763005
01531000	01531000	Chemaung River at Chemung, NY	6	2,506	420008	763806
01542500	01542500	WB Susquehanna River at Karthaus, Pa	6	1,462	410703	780633
01555000	WQN0229	Penns Creek at Penns Creek, Pa	6	301	405200	770255
01562000	WQN0223	Raystown Branch Juniata River at Saxton, Pa	6	756	401257	781556
01568000	WQN0243	Sherman Creek at Shermans Dale, Pa	6	200	401924	771009
01570000	WQN0271	Conodoguinet Creek near Hogestown, Pa	6	470	401508	770117
01571500	WQN0212 / 01571505	Yellow Breeches Creek near Camp Hill, Pa	6	216	401329	765354
01573560	WQN0272	Swatara Creek near Hershey, Pa	6	483	401754	764005
01574000	WQN0210	West Coneago Creek near Manchester, Pa	6	510	400456	764313
01576787	WQN0204	Pequea Creek near MarticForge, Pa	6	148	395421	791943
01667500	3-RAP030.21 / 01667500	Rapidan River near Culpeper, Va	6	472	382132	775824
01487000	-	Nanticoke River Near Bridgeville, De	6	75.4	384345	753341

Table 2. Station information for the 81 stations in the Chesapeake Bay Nontidal Monitoring Network. – Continued

USGS GAGE	Multi-collector station name	Station Name	Years active	Drainage Area (square miles)	Latitude	Longitude
01491500	TUK0181	Tuckahoe Creek Near Ruthsburg, Md	6	85.2	385802	755635
01495000	BEL0053	Big Elk Creek At Elk Mills, Md	6	52.6	393644	754901
01502500	-	Unadilla River At Rockdale, NY	6	520	422240	752423
01503000	-	Susquehanna River At Conklin, NY	6	2232	420207	754812
01529500	-	Cohocton River Near Campbell NY	6	470	421509	771301
01549760	WQN0410	West Branch Susquehanna River Near Jersey Shore	6	5225	411659	771920
01578475	WQN0263	Octoraro Creek At Richardsmere, Md	6	177	394125	760741
01580520	DER0015	Deer Creek Near Darlington, Md	6	164	393725	760953
01594526	TF1.2	Western Branch At Upper Marlboro. Md	6	89.7	384851	764503
01604500	-	Patterson Creek Near Headsville, Wv	6	221	392635	784920
01608500	-	South Branch Potomac River Near Springfield, Wva	6	1461	392649	783916
01610155	WQN0512	Sideling Hill Creek Near Bellegrove, Md	6	102	393858	782039
01611500	-	Cacapon River Near Great Cacapon, Wva	6	675	393456	781836
01613095	WQN0510	Tonoloway Creek Near Hancock, Md	6	111	394223	780910
01613525	WQN0509	Licking Creek Near Pectonville, Md	6	193	394040	780212
01616500	-	Opequon Creek Near Martinsburg, Wva	6	272	392525	775620
01619000	WQN0511	Antietam Creek Near Waynesboro, Pa	6	93.5	394260	773629
02024752	2-JMS279.41	James River At Blue Ridge Pkwy Bridge Nr Big Island, Va	6	3076	373320	792201
01609000	WQN0513	Town Creek Near Oldtown, Md	6	148	393312	783318
These 16 Secondary stations have 10 year trends						
01626000	1BSTH027.85	South River neat Waynesboro, Va	10+	127	300327	785430
01628500	1BSSF100.10	South Fork Shenandoah River near Dooms, Va	10+	1083	300519	785238
01638480	1ACAX004.57	Catoctin Cr. at Taylorstown, Va	10+	89.5	391518	773436
01654000	1AACO014.57	Accotink Cr. near Annandale, Va	10+	23.9	384846	771343
01664000	3-RPP147.10	Rappahannock River at Remington, Va	10+	252	383150	774850
01665500	3-RAP066.54	Rapidan River at Ruckersville, Va	10+	115	381650	782025
01671100	8-LTL009.54	Little River near Doswell, Va	10+	107	375221	773048
01673800	8-POR008.97	Po River near Spotsylvania, Va	10+	77.6	381017	773542
01674000	8-MPN094.79	Mattaponi River near Bowling Green, Va	10+	256	380342	772310
02011500	2-BCC004.71	Back Cr. near Mountain Grove, Va	10+	134	380410	795350
02015700	2-BLP000.79	Bullpasture River at Williamsville, Va	10+	110	381143	793414
02020500	2-CFP004.67	Calfpasture River above Mill Cr. at Goshen, Va	10+	141	375916	792938
02027500	2-PNY005.29	Piney River At Piney River, Va	10+	49.4	374208	790140
02031000	2-MCM005.12	Mechums River near White Hall, Va	10+	95.3	380609	783535
02039500	2-APP110.93	Appomattox River at Farmville, Va	10+	303	371825	772320
02041000	2-DPC005.20	Deep Cr. near Mannboro, Va	10+	177	371659	775212

Streamflow – Total Flow to the Chesapeake Bay

The annual mean streamflow to the Bay for 2011 was 113,000 cubic feet per second (ft^3s) which was approximately 40 percent greater than the long-term annual mean flow from 1937 to 2011 of 78,740 and greater than flow in 2010 as shown in figure 3 (methods from Bue, 1968). Total flow entering the Bay in 2011 was the fifth highest since the beginning of the record in 1937, resulting in increased annual-mean streamflows at 17 of the 31 long-term stations monitored since 1985, predominately located in the Susquehanna and Potomac River Basins.



Streamflow – Individual Site Data

Graphics produced for each of the 31 long-term monitoring stations show annual and seasonal streamflow relative to selected flow statistics. Differences between streamflows in 2011 and 2010 were spatially variable. Annual mean streamflow in 2011 was more than 100 percent greater than flow in 2010 at 5 of the 17 stations located mostly in Pennsylvania and northern Maryland (Susquehanna Basin). In contrast, annual mean streamflow was less in 2011 than in 2010 at 9 of 13 Virginia stations; at 6 other stations in the Potomac basin, streamflow was higher by 50 percent or more in 2011 compared to flow 2010 (fig. 4). The 90-percent increase in streamflow for the Susquehanna River and 1-percent increase for the Potomac River more than offset the decrease in streamflow from the other seven RIM stations in 2011.

For the period 1985 through 2011, significant upward trends in streamflow were indicated at 2 stations (Susquehanna River at Wilkes-Barre, Pa. and Susquehanna River at Danville, Pa.), and no significant trends in streamflow were indicated at the remaining 29 stations.

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Streamflow – Individual Site Data

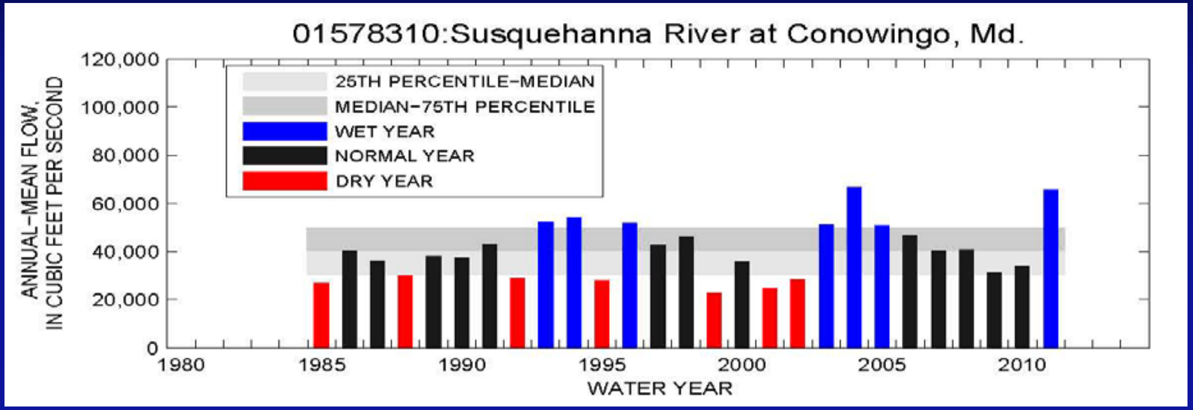
Annual streamflow plots were produced for all 31 long-term stations.

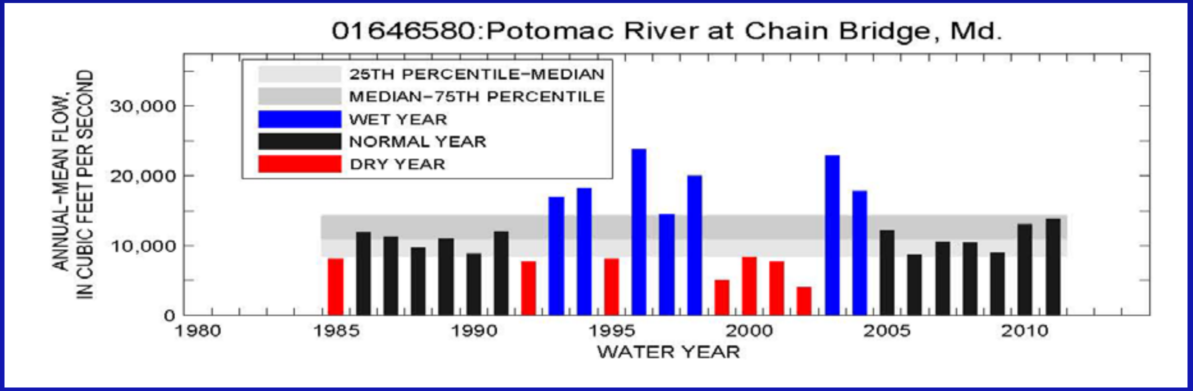
(Susquehanna River at Conowingo, Md. presented as an example)

Seasonal plots produced, but not shown.

Streamflow Generalities in 2011

- Susquehanna Basin much greater than normal (shown as black bars)
- Potomac Basin slightly greater than normal
- James Basin was less than normal





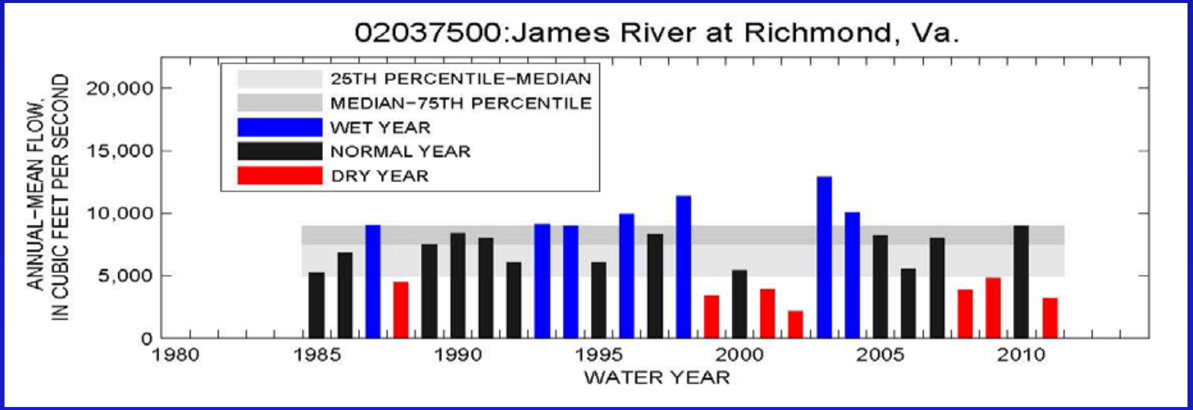


Figure 4

Annual Combined Total Nitrogen Load for the Chesapeake Bay River Input Monitoring (RIM) stations

In 2011, the annual combined estimated total nitrogen (TN) load for the nine RIM stations was 314 million pounds (Mlbs), 103 Mlbs more than the long-term average of 211 Mlbs (dashed line in fig. 5) for 1990 to 2011, the common time period used for the RIM program. The combined TN load for the RIM program stations increased by nearly 128 Mlbs to 314 Mlbs (69 percent) from 2010 to 2011, producing the second-highest delivered TN load since 1990. The Susquehanna River contributed about 77 percent of the combined TN load in 2011. The high correspondence (positive correlation) between annual streamflow and the TN combined load is apparent in figure 5.

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Annual Combined Total Nitrogen Load and Mean Streamflow for the Chesapeake Bay River Input Monitoring (RIM) stations, 1990-2011

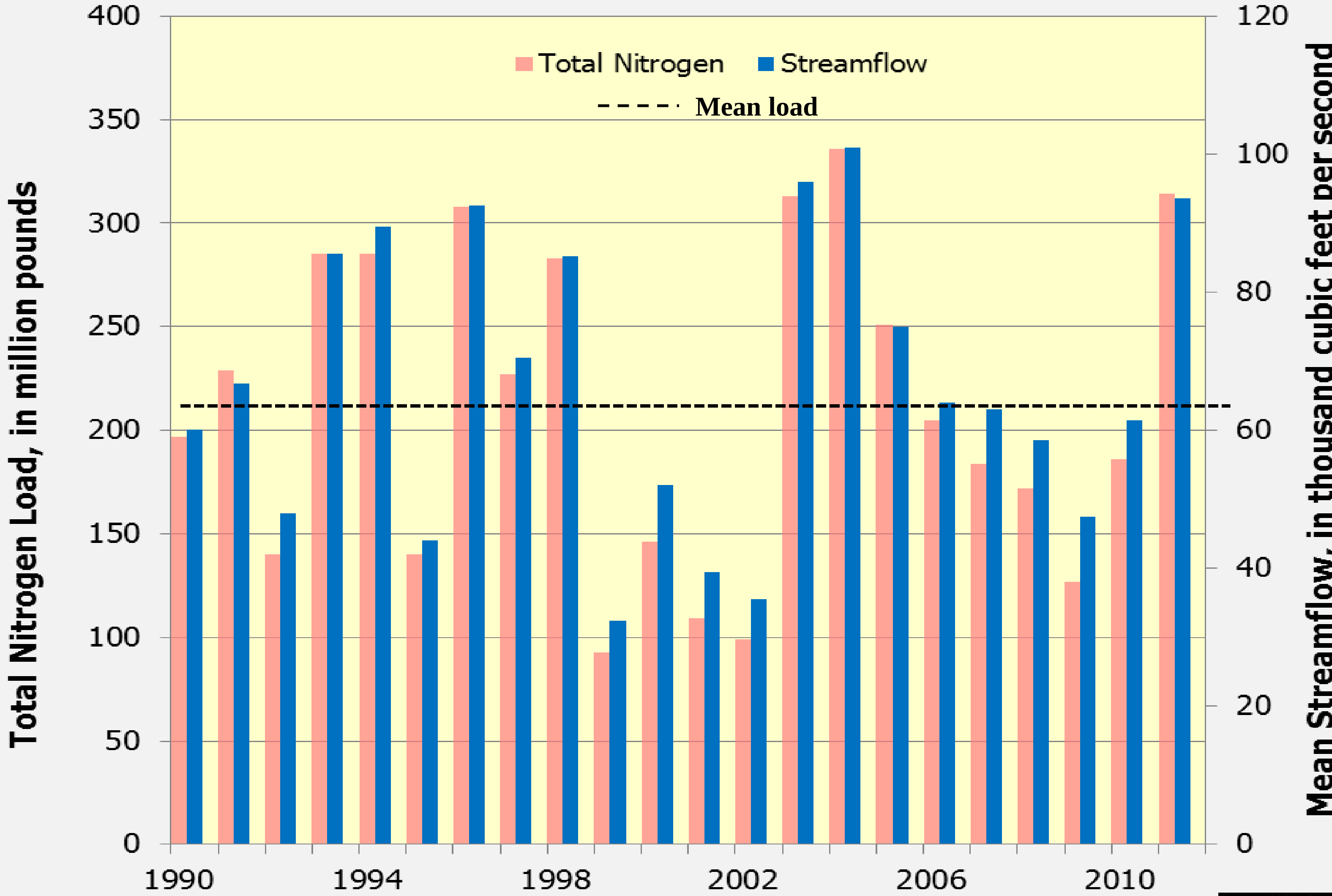

Figure 5

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Annual Combined Total Phosphorus Load for the Chesapeake Bay River Input Monitoring (RIM) stations

In 2011, the annual combined total phosphorus (TP) load (35.1 million pounds, Mlbs) exceeded (and was 160 percent greater than) the long-term average of 13.3 Mlbs (dashed line in fig. 6). The increases in streamflow and concentrations from 2010 to 2011 resulted in an estimated TP load increase of 22 Mlbs to 35.1 Mlbs and produced the highest delivered load since the record began in 1990. Similar to TN, the Susquehanna River delivered about 75 percent of the combined TP load in 2011. Annual variability in the combined TP load is moderately correlated related with the variability in streamflow.

Annual Combined Total Phosphorus Load and Mean Streamflow for the Chesapeake Bay River Input Monitoring (RIM) stations, 1990-2011

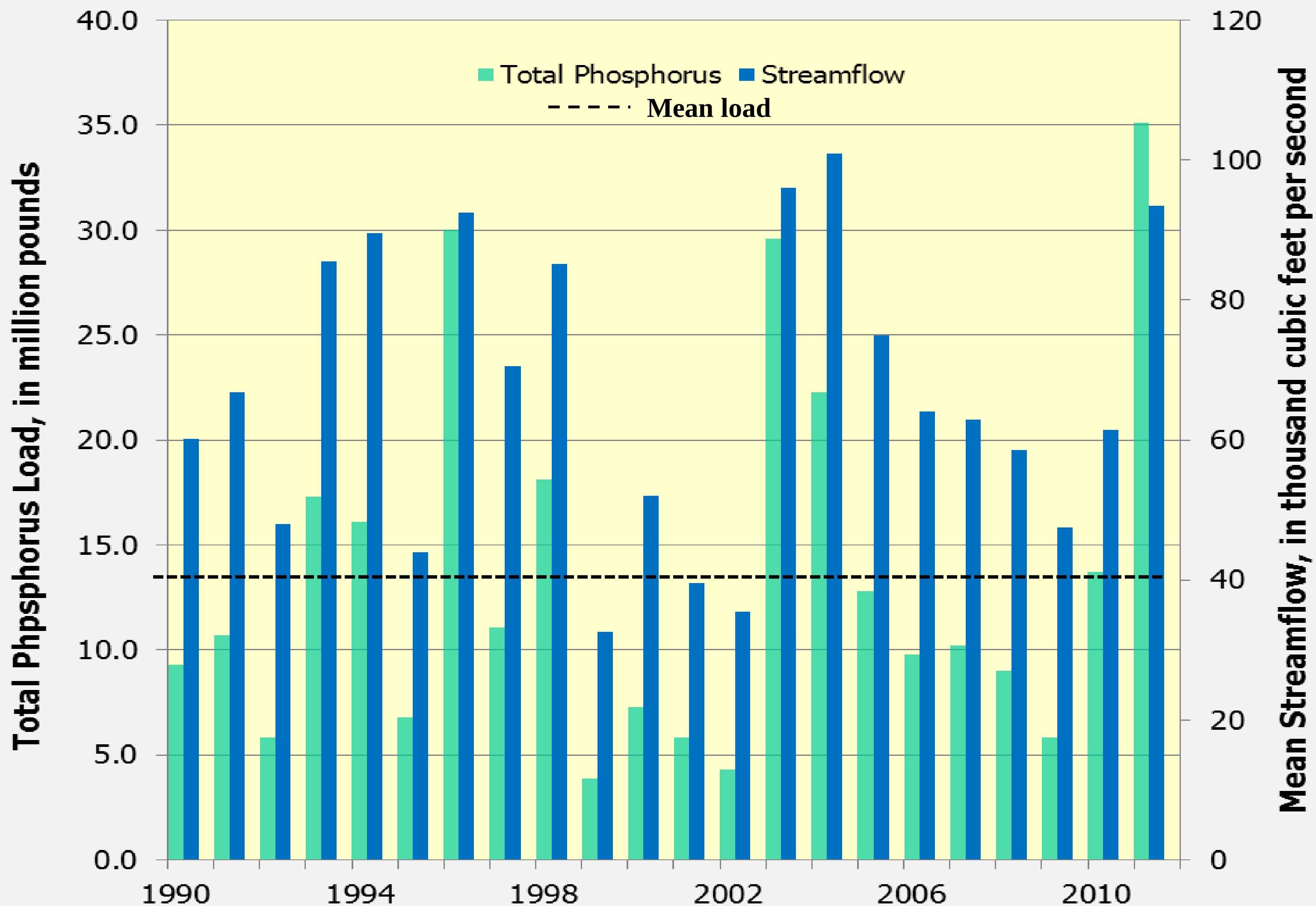

Figure 6

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Annual Combined Sediment Load for the Chesapeake Bay River Input Monitoring (RIM) stations

In 2011, the annual combined sediment load at the RIM stations, 51,700 million pounds (Mlbs), was the highest since the record began in 1990 and nearly 5 times the long-term average of 10,600 Mlbs (fig. 7). The increase in sediment loads from 2010 to 2011was caused in large part by two major storms in the Susquehanna River Basin which together contributed about 75 percent of the combined sediment load. Since 1990, the Susquehanna contributes on average about 39 percent of the sediment entering the Bay from the tributaries. The annual combined estimated sediment load increased from 38,000 Mlbs to 51,700 Mlbs, a 36-percent increase, from 2010 to 2011.

Annual Combined Sediment Load and Mean Streamflow for the Chesapeake Bay River Input Monitoring (RIM) stations, 1990-2011

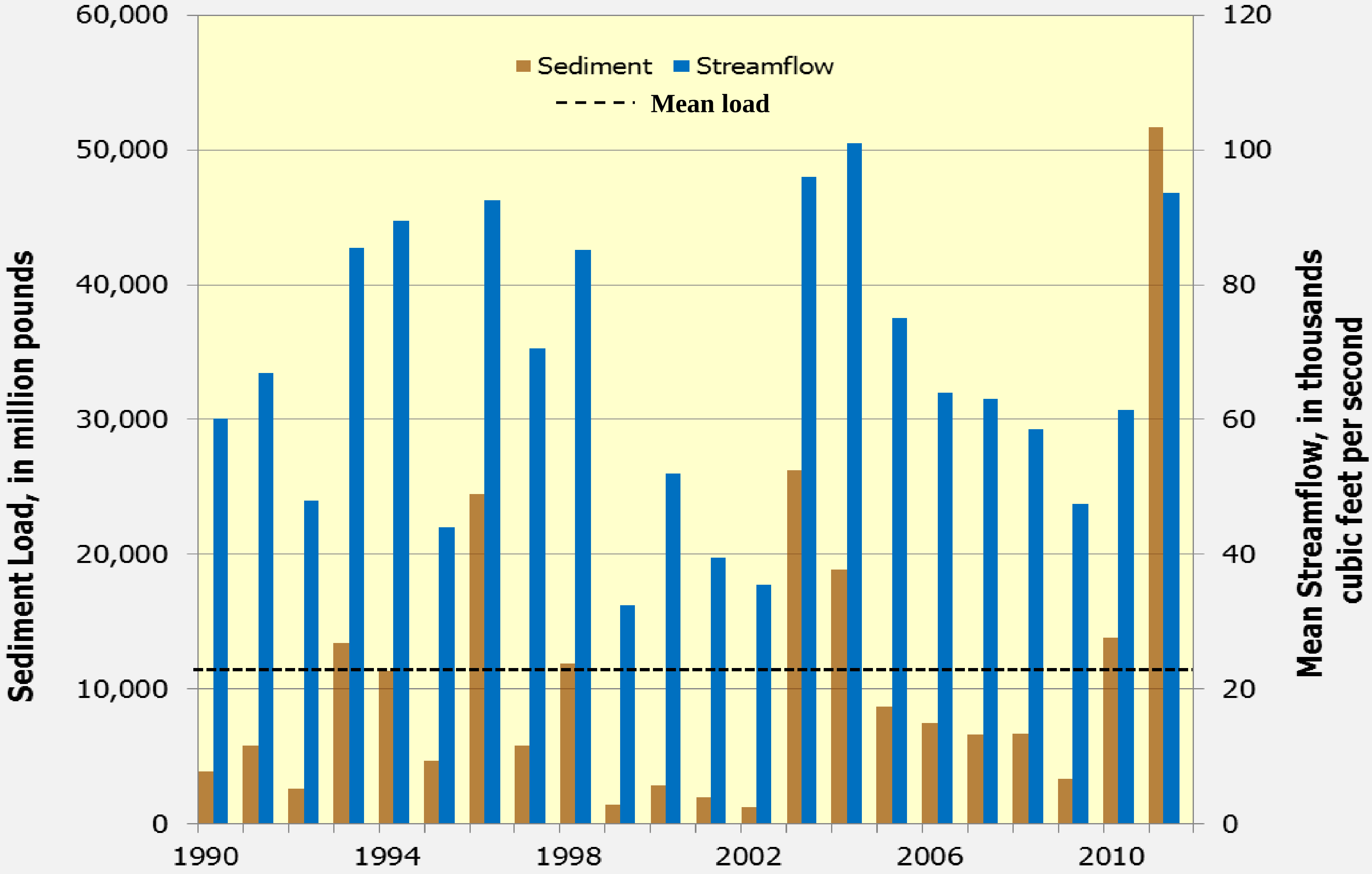

Figure 7

Flow-adjusted Concentrations (FAC)

USGS program ESTIMATOR (Cohn and others, 1989), estimates trends over given time period for total nitrogen (TN), total phosphorus (TP), and sediment (SED) for 2 time periods, 1985 to 2011 and 2002 to 2011

- Uses the slope coefficient (b), time (t), and time (t^2) for non-linearity flow adjusted trend,
- A total of 95 individual model runs were completed for each time period for TN, TP, and SED.

These trends are useful:

- For examining effects of management actions,
- Helps to adjust for the “effects” of hydrology and season.

Trends in Flow-adjusted Concentrations (1985-2011)

Total Nitrogen (TN) – For the RIM monitoring stations, the three largest monitored rivers (Susquehanna, Potomac, and James) and the Patuxent River had statistically significant downward (improving) trends in TN flow-adjusted concentration (FAC) (supplemental data and fig. 8). Only the Pamunkey and Choptank RIM stations had statistically significant upward (degrading) TN trends. No significant trends were indicated at the remaining RIM stations (Rappahannock, Mattaponi, and Appomattox).

In the 31-site long-term network, 21 stations had improving trends, 3 stations had degrading trends, and 7 stations had no trend. All eight stations in the Susquehanna River Basin, including the RIM site, had improving trends in TN FAC over the study period. Of the 11 stations in the Potomac River Basin, 9 had improving trends in TN FAC and 2 had no statistically significant trend. Three stations in the lower Virginia basins had significantly improving trends in TN FAC, one site had an degrading trend, and three stations had no statistically significant trend (fig. 8).

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Total Nitrogen

Trends in Flow-adjusted Concentration

(1985-2011)

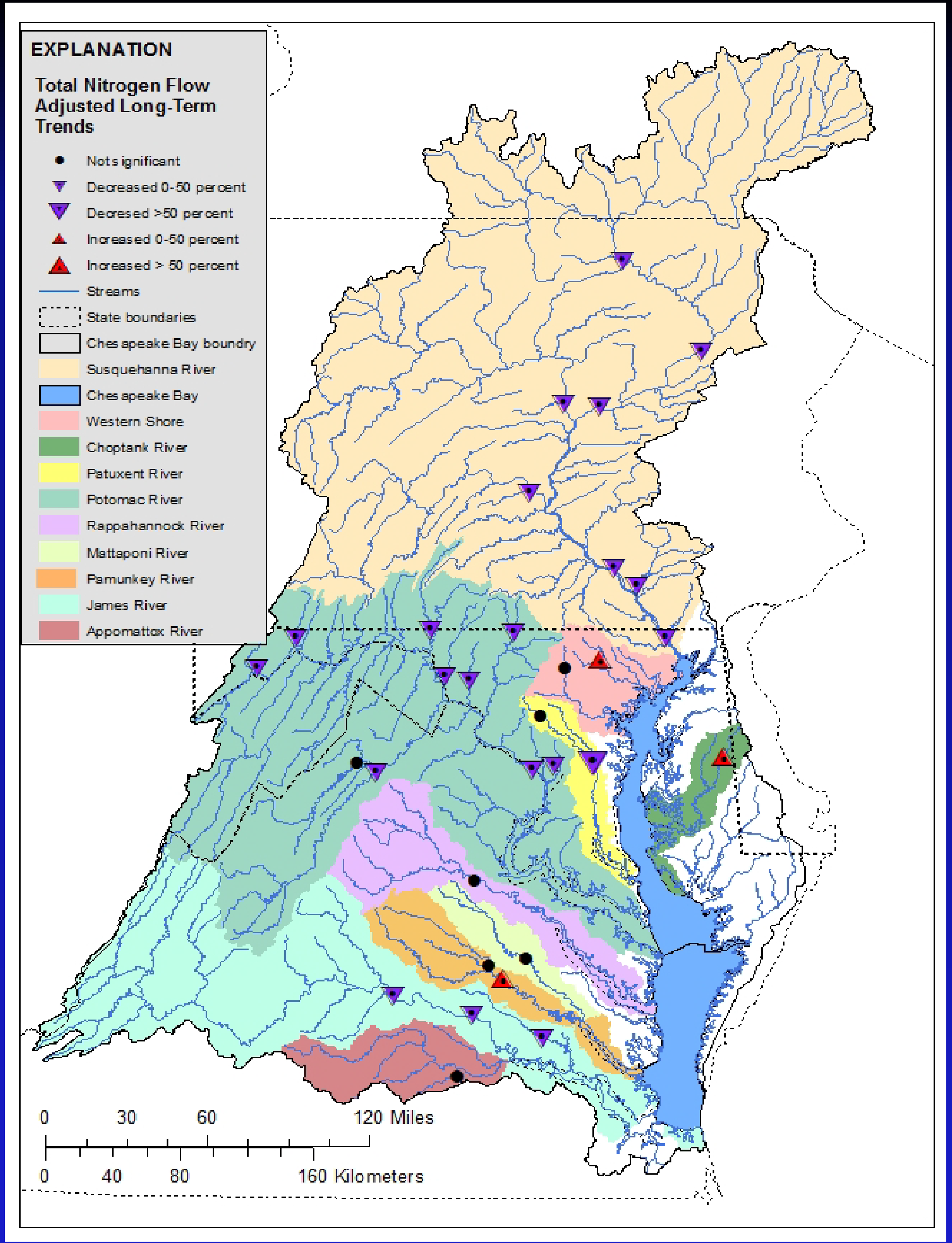

Figure 8

Trends in Flow-adjusted Concentrations (1985-2011)

Total Phosphorus (TP) – With respect to TP flow-adjusted concentrations (FAC), the Patuxent, Potomac, and James River Input Monitoring (RIM) stations had statistically significant improving trends, whereas the Choptank, Pamunkey, and Appomattox River RIM stations had statistically significant degrading trends. The RIM site on the Susquehanna River indicates a non-significant trend in TP FAC (fig. 9).

In the nontidal monitoring network, TP trends in FAC were improving significantly at 22 of the 31 stations and degrading significantly at 4 stations. Five stations did not have statistically significant trends. Improving trends were observed at seven of the eight stations in the Susquehanna River Basin. In the Potomac River Basin, nine stations showed improving trends and one site showed no statistically significant trend. In the James River Basin, two stations had improving trends and one site had no significant trend. In the entire Chesapeake Bay Watershed, 10 of 31 stations had improving trends with a magnitude greater than 50 percent, whereas 2 stations had degrading trends greater than 50 percent (fig. 9).

Total Phosphorus

Trends in Flow-adjusted Concentration

(1985-2011)

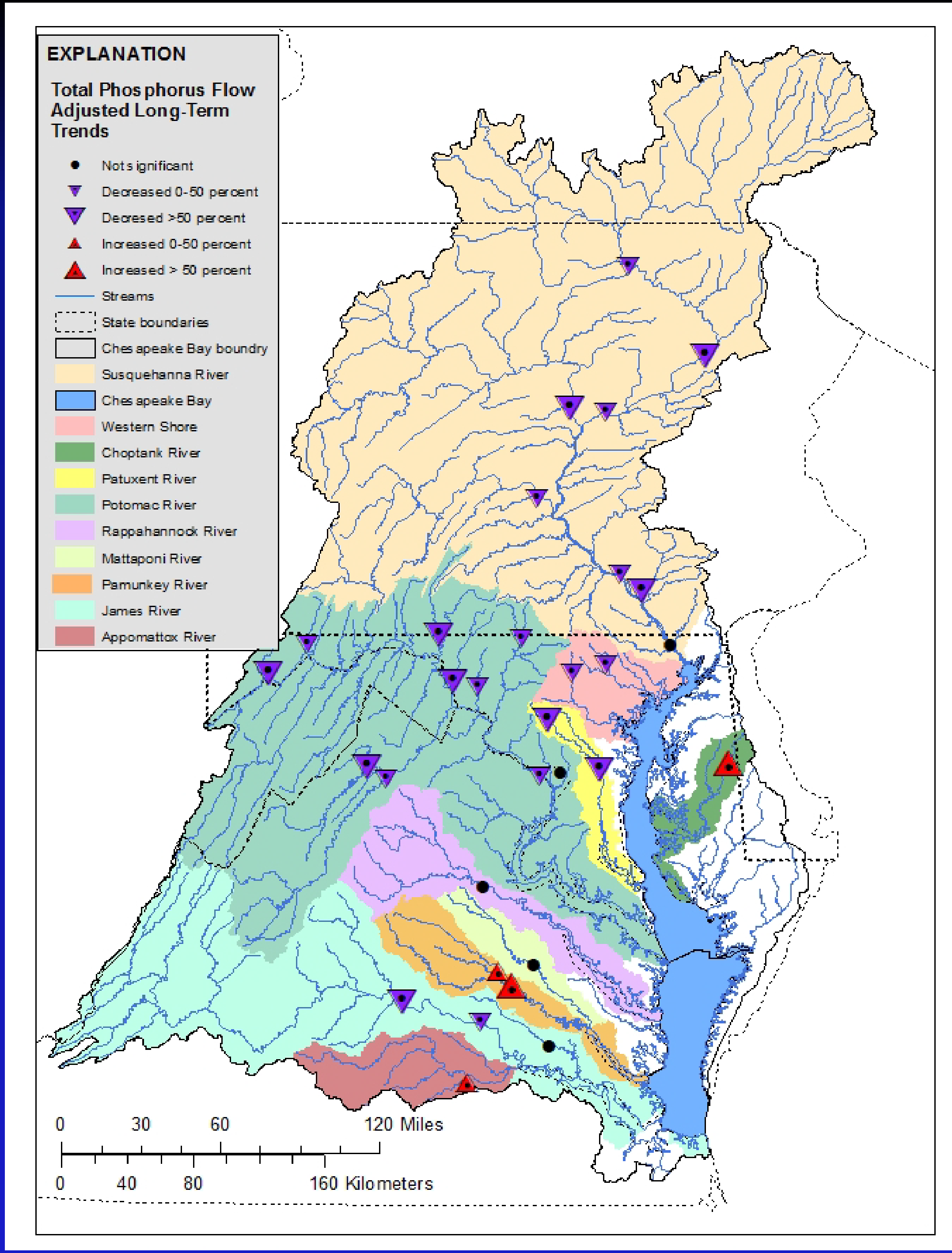

Figure 9

Trends in Flow-adjusted Concentrations (1985-2011)

Sediment – Statistically significant improving trends in sediment flow-adjusted concentrations (FAC) were observed for the Potomac, Patuxent, and Choptank River Input Monitoring (RIM) stations (fig. 10). The Pamunkey and Appomattox RIM stations had statistically significant degrading trends in sediment FAC. The Susquehanna, James, Rappahannock, and Mattaponi RIM stations had no trends.

Statistically significant improving trends in sediment FAC were indicated at 9 of the 31 stations and degrading trends at 8 stations. Changes in trend magnitude greater than 50 percent were indicated at three of the nine improving-trend stations and six of the eight degrading-trend stations (fig. 10). In the Susquehanna River Basin, improving trends were indicated for five stations. Results for the Potomac River Basin indicate an equal number of stations (two) with significant improving and degrading trends; no significantly detectable trends were apparent for seven stations. In the lower Virginia River basins, five stations had significantly degrading trends, and three stations had no detectable significant trend.

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Sediment

Trends in Flow-adjusted Concentration

(1985-2011)

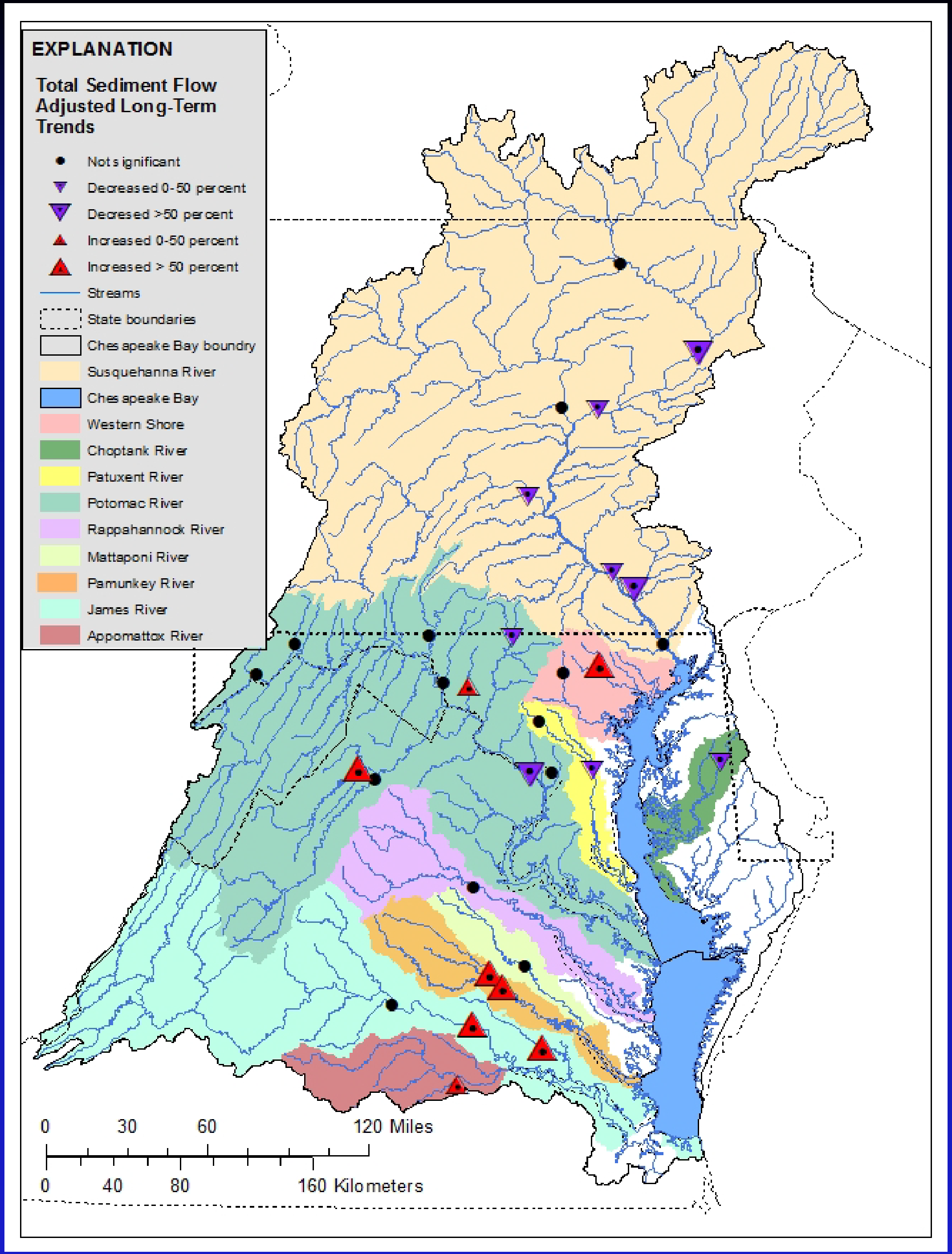

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Figure 10

Comparison of Flow-adjusted Concentrations for Long-term and 10-year Trends in Concentration for 31 Stations

	1985-2011 (long-term)	2002-2011 (10-year)	Difference
Total nitrogen	19 Improving 3 Degrading 9 No trend	12 Improving 1 Degrading 18 No trend	7 fewer improving stations, 2 fewer degrading stations, 9 more non-significant stations
Total phosphorus	22 Improving 4 Degrading 5 No trend	11 Improving 4 Degrading 16 No trend	11 fewer improving stations, 11 more non-significant stations
Sediment	9 Improving 8 Degrading 14 No trend	2 Improving 11 Degrading 18 No trend	7 fewer improving stations, 3 more degrading stations, 4 more non-significant stations

- There were 24 fewer statistically significant trends in concentration in the 10-year period compared to the long-term period.
- 25 of the 50 improving trends for 1985 to 2011 became either degrading or not significant for 2002 to 2011.

(Available on the web at *http://cbrim.er.usgs.gov/.)*

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Comparison of 10-year Concentration Trends and 5-year Average Yields

Trends in flow-adjusted concentrations (FAC) for total nitrogen (TN), total phosphorus (TP), and sediment were estimated for two time periods, 1985-2011 (long-term) and 2002-2011 (10-year), as discussed previously, and shown with yields (figs. 11-13). Average annual yields for TN, TP, and sediment were estimated from the most recent 5 years (2006-2011) and reported in tons per square mile. Data for all trends in FAC and yields can be found at the end of the report in the section “Supplemental Data.”

For the purposes of assessing relative magnitude of water-quality problems, yields were categorized as “High,” Medium,” or “Low” by dividing the range of yield data into thirds.

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Range Categories of Average Annual Yields for 65 Monitoring Stations in Chesapeake Bay Basin (2006-2011)

Range Category	Total Nitrogen (tons/mi^2)	Total Phosphorus (tons/mi^2)	Sediment (tons/mi^2)
High	>2.5 to 10.5	>0.20 to 0.62	>196 to 458
Medium	>1.5 to 2.5	>0.11 to 0.20	>82 to 196
Low	0.3 to 1.5	0.04 to 0.11	38 to 82

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Spatial Distribution of 5-year Average TN, TP, and Sediment Yields

Generally, higher yields for TN (fig. 11) were prevalent in the middle of the Bay watershed, areas that coincide with large areas of urban and agricultural land uses. The lowest yields were generally in the Virginia watersheds.

Generally, higher yields for TP (fig. 12) were prevalent in the middle of the Bay watershed, areas that coincide with large urban and agricultural land uses. The lowest yields were generally in the western areas of the Bay watershed, an area dominated by forests.

Generally, spatial patterns are less discernible for sediment yields (fig. 13) than for TN and TP except for higher yields in the middle of the watershed, areas where TN and TP were also highest. The lowest yields were generally in the western areas of the Bay watershed, an area dominated by forests, and the flat topography of the Eastern Shore of Maryland and Delaware.

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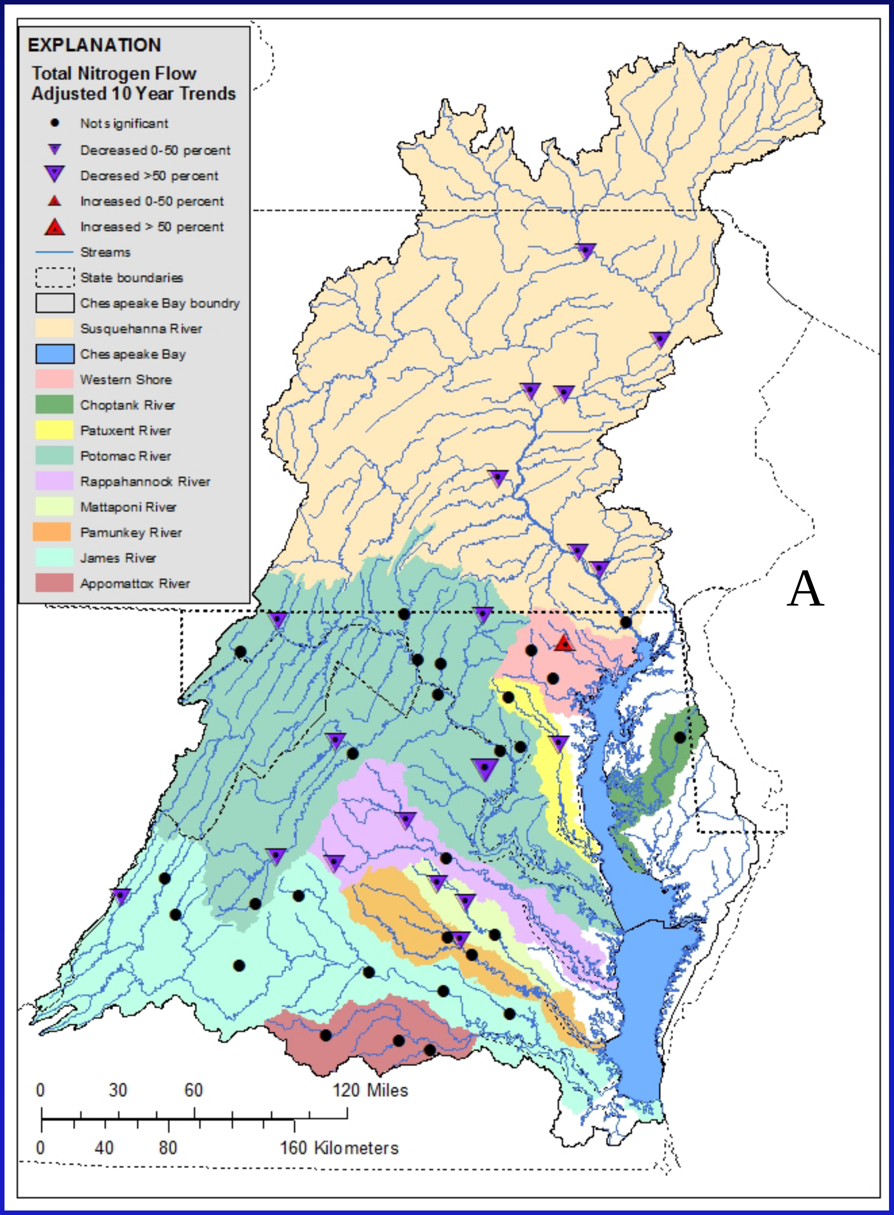
Figure 11. Total nitrogen 10-year concentration trends (A) and 5-year yields (B).



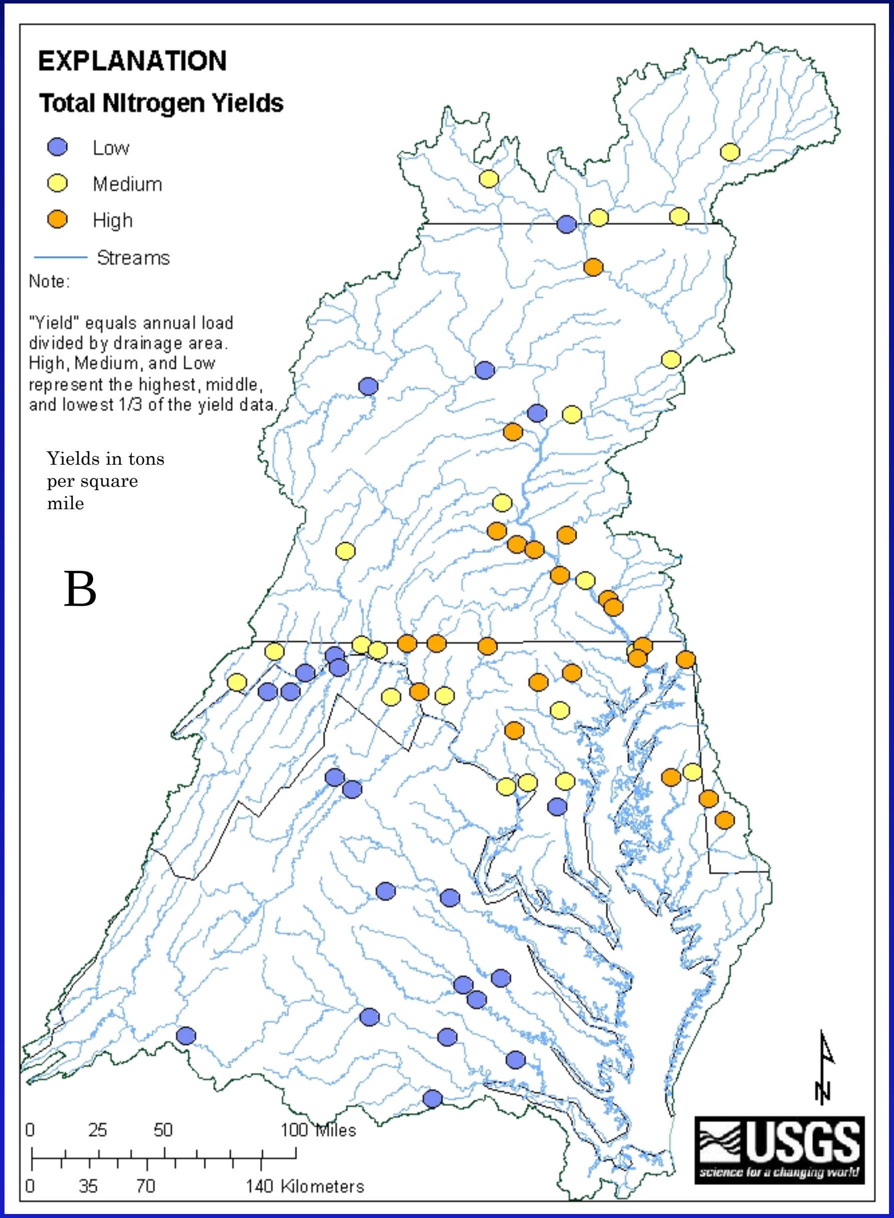
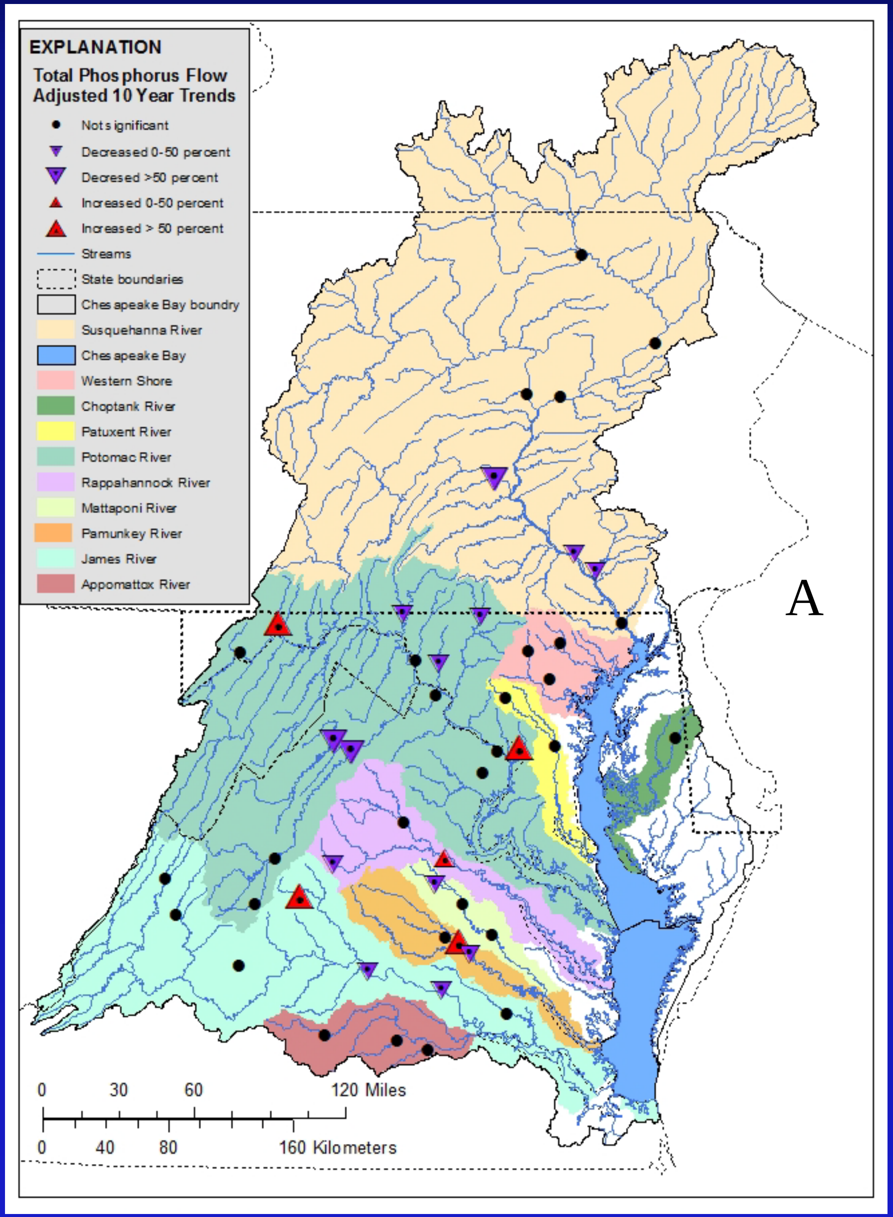


Figure 12. Total phosphorus 10-year concentration trends (A) and 5-year yields (B).



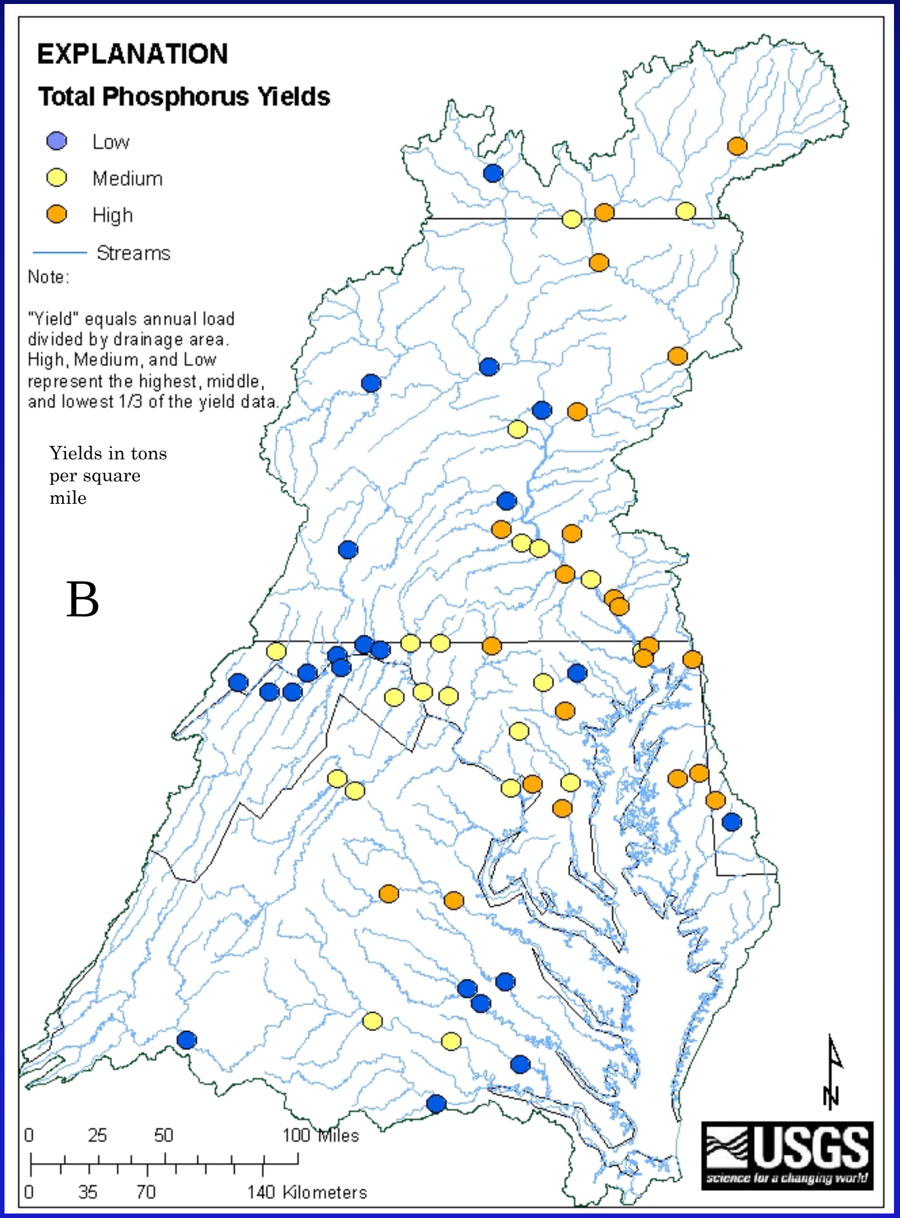
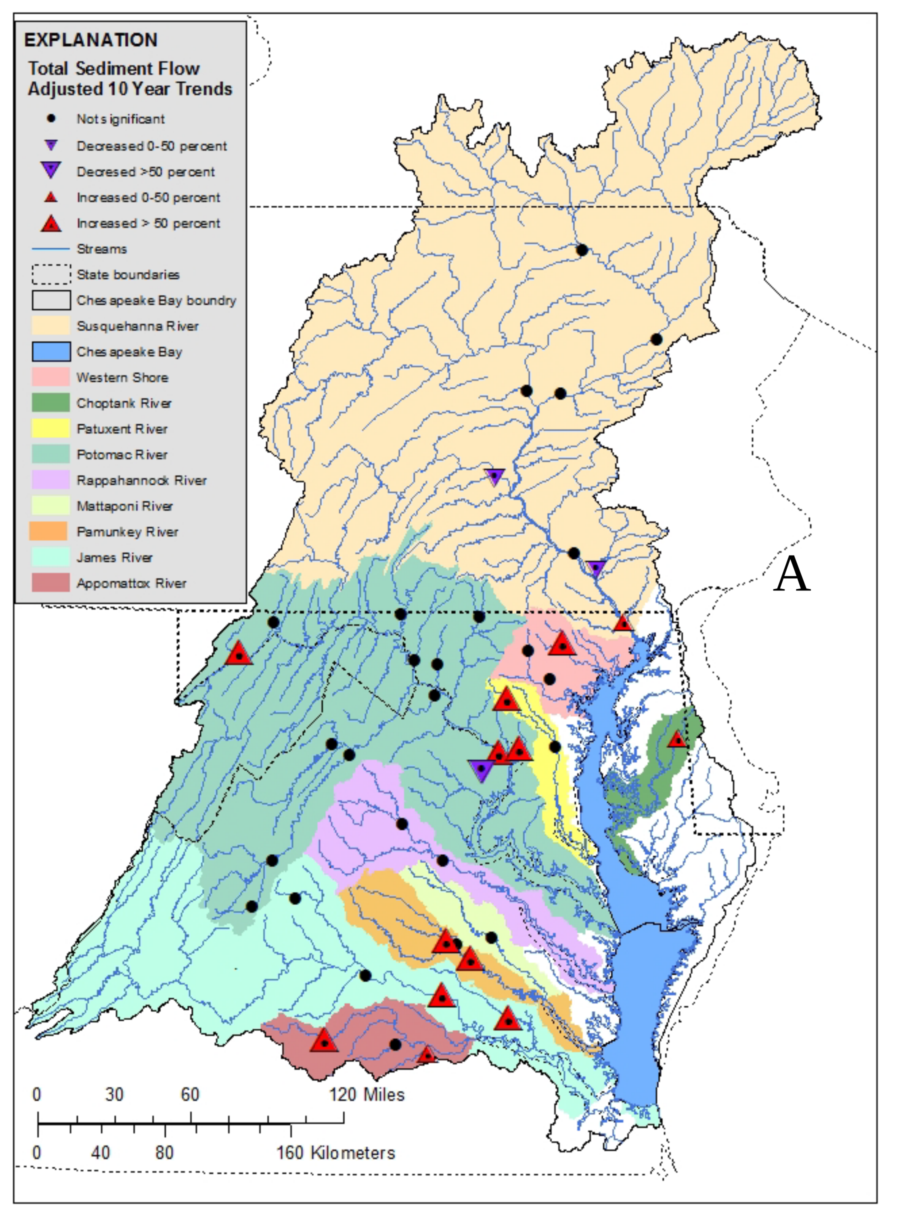
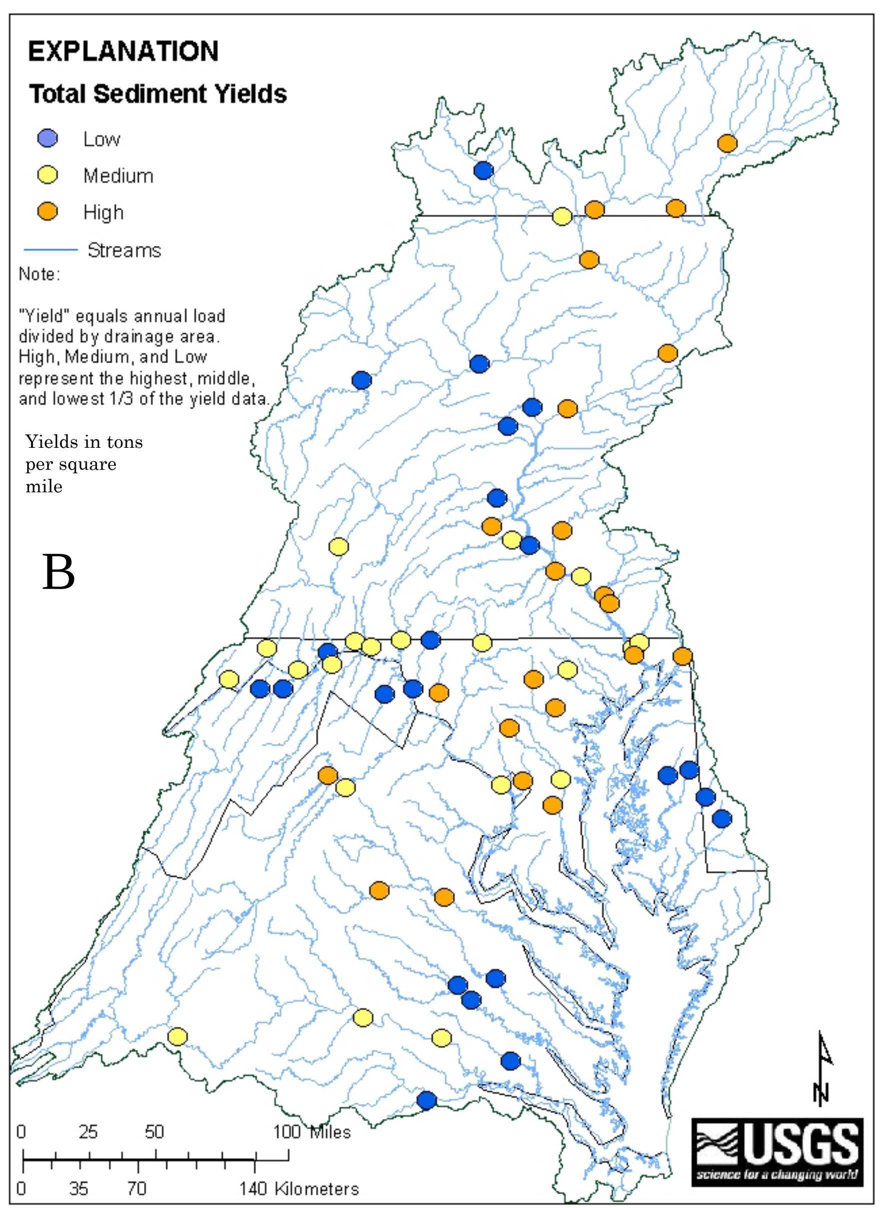


Figure 13. Sediment concentration 10-year trends (A) and 5-year yields (B).





Combined Water-Quality Indicator

The USGS, working with Chesapeake Bay Program partners, developed a new water-quality indicator in 2010 to interpret monitoring data for total nitrogen, total phosphorus, and sediment. The indicator combines the results of the 10-year trend analysis for flow-adjusted concentrations (32 stations) with results of average yields estimated from 5 years of data for a greater number of stations (65 primary stations). The same is true for total phosphorus and sediment. Four classifications for 10-year trends (arrows, dashes) were combined with 5-year annual yields (grouped into thirds and color coded) to produce a classification system consisting of 12 categories.

The combined indicator figures (figs. 14 and 15) show decreasing concentrations of total nitrogen and phosphorus in areas of the watershed that have relatively high nutrient yields. The combined indicator figure for sediment (fig. 16) shows less decreasing concentrations in areas with relatively high yields. These results support the idea that progress has been made in response to efforts to reduce inputs of nutrients, but perhaps less so for sediment, from the watershed to the Bay.

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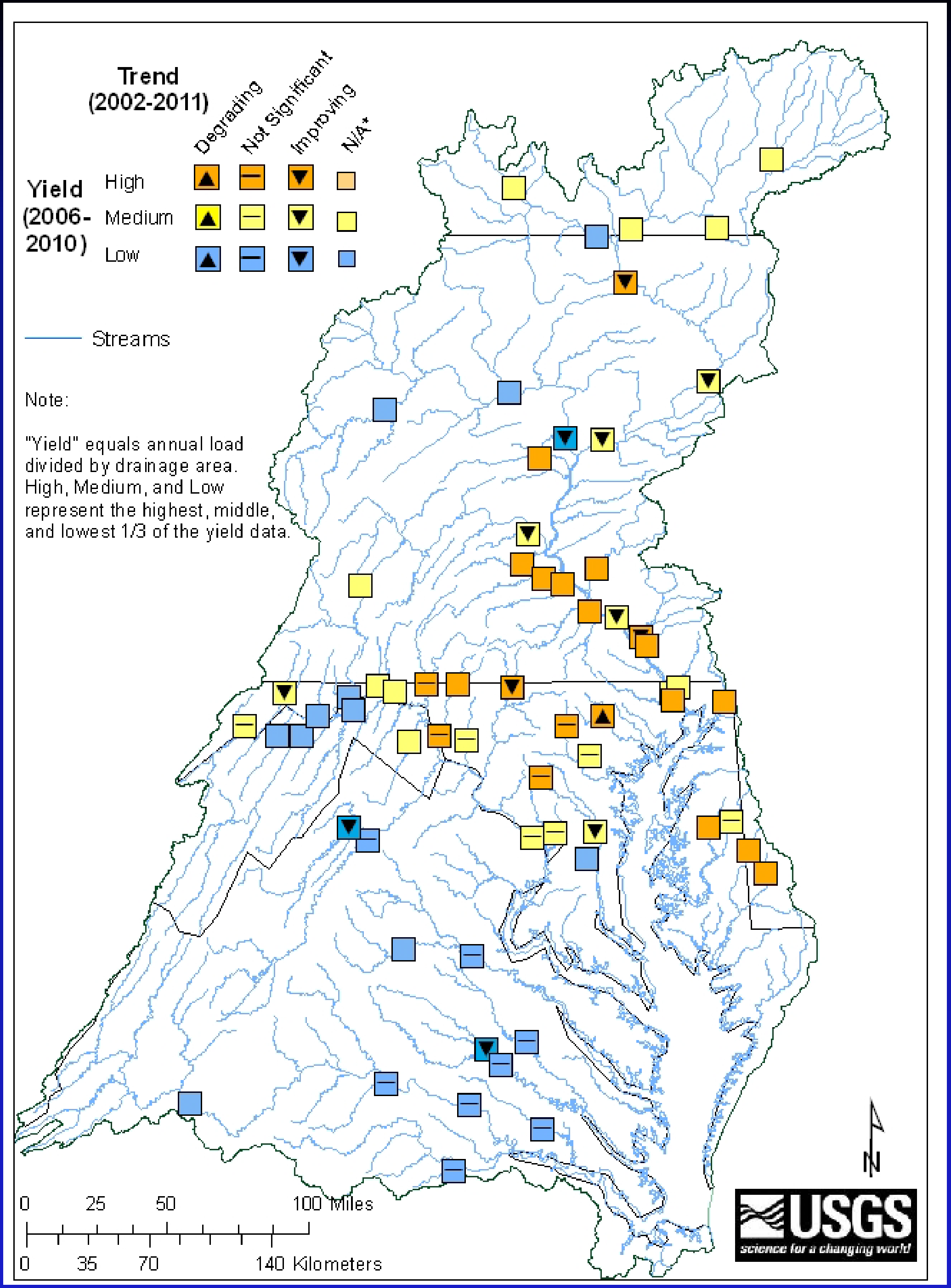
Total Nitrogen (TN) Combined Indicator

Twelve of the 32 stations had improving trends in TN flow-adjusted concentrations. Spatially, higher yields are distributed in the middle of Bay watershed whereas lower yields predominate in southern areas Bay watershed.

The results indicate that progress has been made in response to recent efforts to reduce inputs of nitrogen to the Bay from the watershed.

Figure 14



Total Phosphorus (TP) Combined Indicator

Twelve of the 32 stations had improving trends in TP concentrations, with 9 of the 12 stations in areas of relatively high total phosphorus yields. Spatially, no distribution is apparent, except for lower yields in the western Potomac River Basin (black arrow).

The combined figure indicates that progress has been made in response to recent efforts to reduce inputs of phosphorus to the Bay from the watershed.

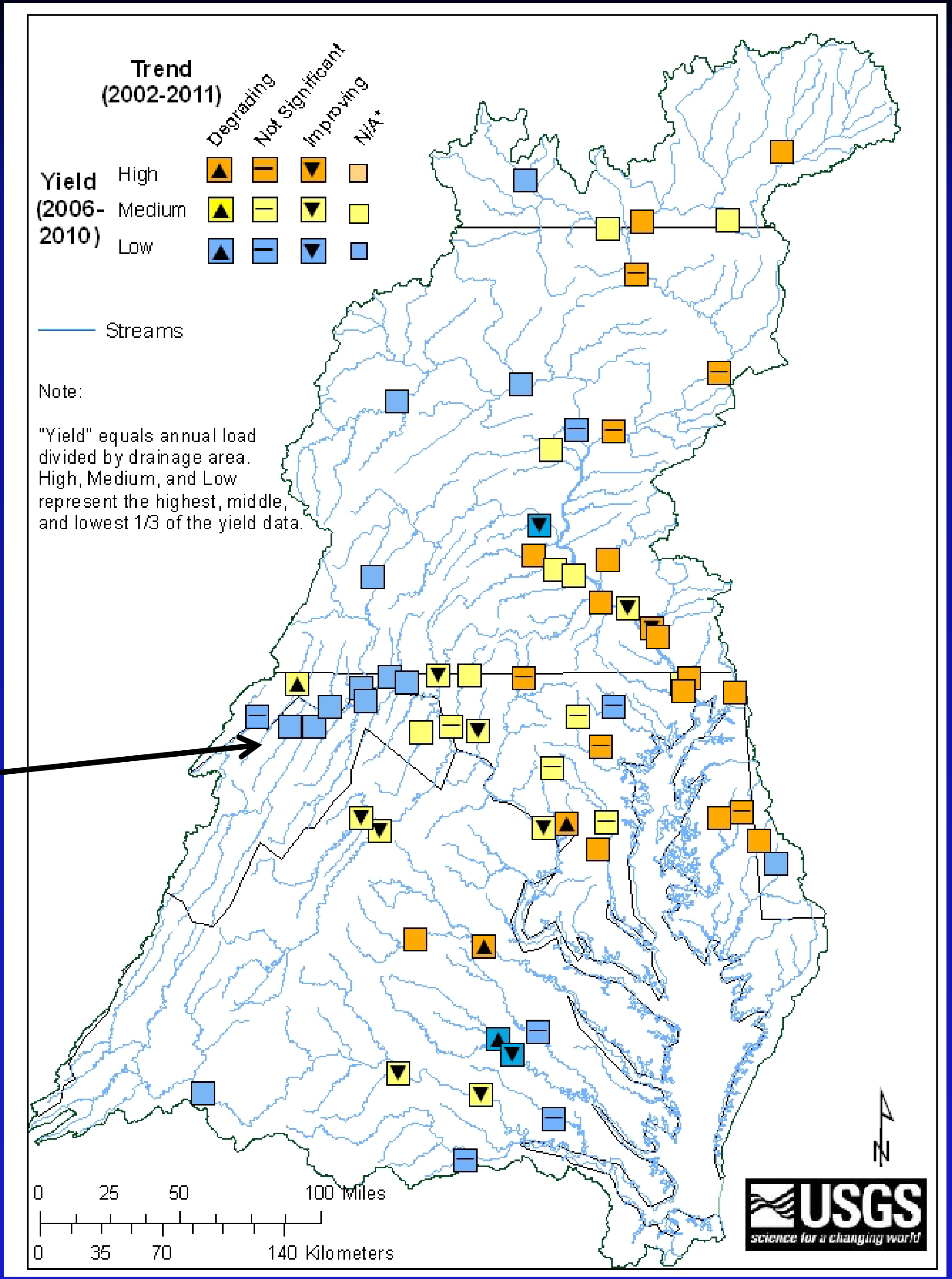


Figure 15

Sediment Combined Indicator

Three of the 31 stations had improving trends in sediment concentrations. In contrast, nine stations indicate degrading trends and all these stations were in the southern half of the watershed in areas of variable (low, medium, and high) sediment yields. Spatially, no distribution is apparent, except perhaps lower yields for the Eastern Shore of Maryland and Delaware (black arrow) and predominately forested areas.

The combined figure indicates that less progress (compared to that for nitrogen and phosphorus) has been made in response to recent efforts to reduce inputs of sediment to the Bay from the watershed.

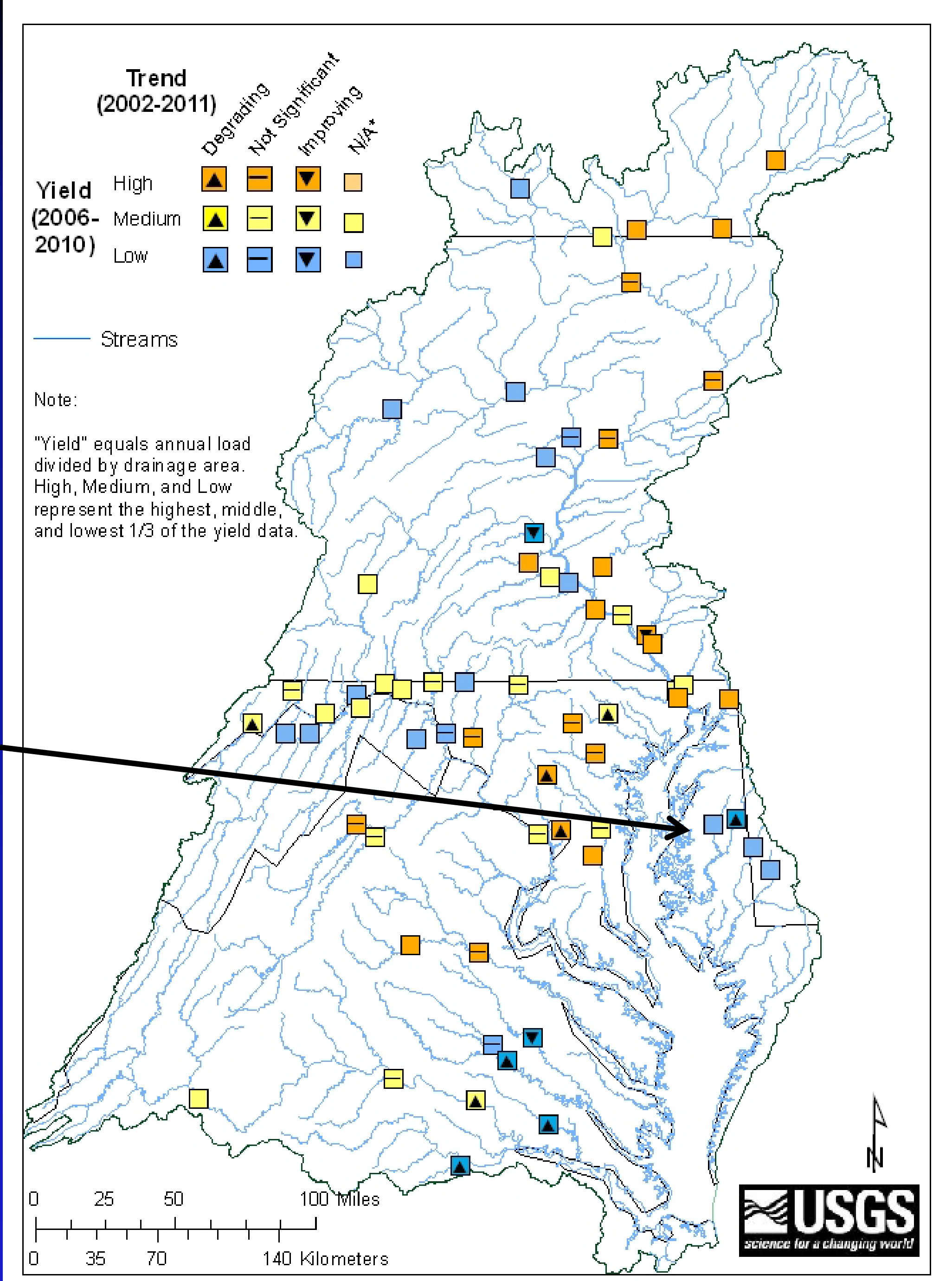


Figure 16

Water-Quality Indicator Summary

The water-quality indicator table summary (table 3) provides managers and scientists with combinations of trends and yields. A degrading water-quality trend and a high yield at a station might be considered a “poor” (red) combination. In contrast, an improving water-quality trend and a low yield might be considered a “good” (blue) combination – the goal for all stations. Of the 31 stations, 5 would be classified as “poor” (16 percent) and 7 stations would be classified as “good” (22 percent) for TN, TP, and sediment. If managers and scientists wanted to consider stations near the middle of the range (improving or not-significant trends and medium yields) for economic or environmental feasibility reasons, then 34 out of 96 trend/yield combinations could be classified as “fair” (35 percent) for TN, TP, and sediment.

For nutrients and sediment, more “good” areas generally are located in parts of the upper and western Susquehanna and western Potomac River Basins, and many locations in Virginia. In contrast, “poor” areas tend to be located in the middle of the Chesapeake Bay Watershed. Locations classified as “good” tend to be dominated by forested land, whereas those classified as “poor” tend to be dominated by urban and agricultural land uses.

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Table 3. Water-quality indicator summary.

		10-year flow-adjusted concentration trend for 32 stations (2002-2011)			
Total Nitrogen 5-year Yields (2006-2011)	Yield	Degrading (upward)	Not significant	Improving (downward)	Trends not available
	high	**1**	4	3	14
	medium	0	7	6	10
	low	0	8	**3**	9
Total Phosphorus 5-year Yields (2006-2011)	Yield	Degrading (upward)	Not significant	Improving (downward)	Trends not available
	high	**2**	6	1	12
	medium	1	5	8	8
	low	1	6	**2**	13
Sediment 5-year Yields (2006-2011)	Yield	Degrading (upward)	Not significant	Improving (downward)	Trends not available
	high	**2**	8	1	11
	medium	3	8	0	9
	low	5	3	**2**	13

33 stations currently are classified as “trends not available,” of which 13 and 20 stations are expected to have trends in 2013 and 2014, respectively.

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Summary

- The number of Primary stations increased from 64 in 2010 to 65 in 2011, one site was dropped and 2 stations were added.
- Annual mean streamflow to the Chesapeake Bay in 2011 was 40 percent greater than the long-term mean (1937-2011) and also as compared to 2010.
- Two of the 31 long-term monitoring stations (both in the Susquehanna River Basin) had statistically significant increasing trends indicating increase in streamflow (1985-2011).
- Trends in flow-adjusted concentration at the long-term stations showed improving conditions for total nitrogen (21 stations) and total phosphorus (22 stations) and an equal number of improving and degrading conditions (9 stations) for sediment from 1985-2011.
- For total nitrogen, yields estimated from 2006-2011 data were relatively higher in the middle of the Bay watershed and lower in the southern part of the Bay watershed.

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Summary – Continued

- For total phosphorus, the spatial distribution of yields was similar to total nitrogen; highest in the central and eastern areas of the watershed and generally lowest in the western Potomac River Basin
- For sediment, no discernible spatial pattern in yield was indicated, except lower yields in the coastal plain of Maryland and Delaware and predominately forested areas of the watershed.
- There were fewer stations with significantly degrading trends and more stations with no significant change in the 10-year time period compared to the long-term time period (1985-2011)
- Using a combined nontidal water-quality indicator (based on both trends and yields) approach, there are more “good” than “poor” station classifications for total nitrogen whereas total phosphorus and sediment are equal
- Evaluation of monitoring data using the combined indicator approach suggests that progress has been made in response to efforts to reduce inputs of nutrients, but perhaps not sediment, from the watershed to the Bay.

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Appendix 1. Supplemental Data – Long-term Trends

Flow-adjusted trends in total nitrogen concentrations, 1985-2011 for 31 long-term stations.

STATION	Station Name	Constituent	Trend in percent	Significance
01491000	Choptank River Near Greensboro, Md.	Total Nitrogen	7.3	DEGRADING
01531500	Susquehanna River At Towanda, Pa	Total Nitrogen	-45.7	IMPROVING
01536500	Susquehanna River At Wilkes-Barre, Pa	Total Nitrogen	-41.4	IMPROVING
01540500	Susquehanna River At Danville, Pa	Total Nitrogen	-44.8	IMPROVING
01553500	West Branch Susquehanna River At Lewisburg, Pa	Total Nitrogen	-31.7	IMPROVING
01567000	Juniata River At Newport, Pa	Total Nitrogen	-15.1	IMPROVING
01576000	Susquehanna River At Marietta, Pa	Total Nitrogen	-26.7	IMPROVING
01576754	Conestoga River At Conestoga, Pa	Total Nitrogen	-22.5	IMPROVING
01578310	Susquehanna River At Conowingo, Md	Total Nitrogen	-20.5	IMPROVING
01582500	Gunpowder Falls At Glencoe, Md	Total Nitrogen	5.6	DEGRADING
01586000	North Branch Patapsco River At Cedarhurst, Md	Total Nitrogen	1.9	not significant
01591000	Patuxent River Near Unity, Md	Total Nitrogen	6.7	not significant
01594440	Patuxent River At Bowie, Md	Total Nitrogen	-56.5	IMPROVING
01599000	Georges Creek At Franklin, Md	Total Nitrogen	-44.9	IMPROVING
01601500	Wills Creek Near Cumberland, Md	Total Nitrogen	-46.1	IMPROVING
01614500	Conococheague Creek At Fairview, Md	Total Nitrogen	-10.9	IMPROVING
01619500	Antietam Creek Near Sharpsburg, Md	Total Nitrogen	-23.7	IMPROVING
01631000	S F Shenandoah River At Front Royal, Va	Total Nitrogen	-37.4	IMPROVING
01634000	N F Shenandoah River Near Strasburg, Va	Total Nitrogen	-2.1	not significant
01637500	Catoctin Creek Near Middletown, Md	Total Nitrogen	-28.1	IMPROVING
01639000	Monocacy River At Bridgeport, Md	Total Nitrogen	-29.3	IMPROVING
01646580	Potomac River At Chain Bridge, Md	Total Nitrogen	-24.6	IMPROVING
01651000	Nw Branch Anacostia River Near Hyattsville, Md	Total Nitrogen	-20.7	IMPROVING
01668000	Rappahannock River Near Fredericksburg, Va	Total Nitrogen	-8.9	not significant
01671020	North Anna River At Hart Corner Near Doswell, Va	Total Nitrogen	3.6	not significant
01673000	Pamunkey River Near Hanover, Va	Total Nitrogen	21.1	DEGRADING
01674500	Mattaponi River Near Beulahville, Va	Total Nitrogen	1.9	not significant
02035000	James River At Cartersville, Va	Total Nitrogen	-15.5	IMPROVING
02037500	James River Near Richmond, Va	Total Nitrogen	-16.2	IMPROVING
02041650	Appomattox River At Matoaca, Va	Total Nitrogen	6.3	not significant
02042500	Chichamominy River Near Providence Forge, Va	Total Nitrogen	-20.2	IMPROVING

Appendix 1. Supplemental Data – Long-term Trends

Flow-adjusted trends in total phosphorus concentrations, 1985-2011 for 31 long-term stations.

STATION	Station Name	Constituent	Trend in percent	Significance
01531500	Susquehanna River At Towanda, Pa	Total Phosphorus	-22.7	IMPROVING
01536500	Susquehanna River At Wilkes-Barre, Pa	Total Phosphorus	-57.1	IMPROVING
01540500	Susquehanna River At Danville, Pa	Total Phosphorus	-32.8	IMPROVING
01553500	West Branch Susquehanna River At Lewisburg, Pa	Total Phosphorus	-50.8	IMPROVING
01567000	Juniata River At Newport, Pa	Total Phosphorus	-48.5	IMPROVING
01576000	Susquehanna River At Marietta, Pa	Total Phosphorus	-32.3	IMPROVING
01576754	Conestoga River At Conestoga, Pa	Total Phosphorus	-62.2	IMPROVING
01578310	Susquehanna River At Conowingo, Md	Total Phosphorus	2	not significant
01582500	Gunpowder Falls At Glencoe, Md	Total Phosphorus	-43.9	IMPROVING
01586000	North Branch Patapsco River At Cedarhurst, Md	Total Phosphorus	-47.8	IMPROVING
01591000	Patuxent River Near Unity, Md	Total Phosphorus	-71.6	IMPROVING
01594440	Patuxent River At Bowie, Md	Total Phosphorus	-55.7	IMPROVING
01599000	Georges Creek At Franklin, Md	Total Phosphorus	-52.7	IMPROVING
01601500	Wills Creek Near Cumberland, Md	Total Phosphorus	-36.3	IMPROVING
01614500	Conococheague Creek At Fairview, Md	Total Phosphorus	-71.1	IMPROVING
01619500	Antietam Creek Near Sharpsburg, Md	Total Phosphorus	-65.2	IMPROVING
01631000	S F Shenandoah River At Front Royal, Va	Total Phosphorus	-48	IMPROVING
01634000	N F Shenandoah River Near Strasburg, Va	Total Phosphorus	-62.7	IMPROVING
01637500	Catoctin Creek Near Middletown, Md	Total Phosphorus	-45.3	IMPROVING
01639000	Monocacy River At Bridgeport, Md	Total Phosphorus	-27.3	IMPROVING
01646580	Potomac River At Chain Bridge, Md	Total Phosphorus	-15.2	IMPROVING
01651000	Nw Branch Anacostia River Near Hyattsville, Md	Total Phosphorus	-16.9	not significant
01668000	Rappahannock River Near Fredericksburg, Va	Total Phosphorus	-6.1	not significant
01671020	North Anna River At Hart Corner Near Doswell, Va	Total Phosphorus	42.8	DEGRADING
01673000	Pamunkey River Near Hanover, Va	Total Phosphorus	102.8	DEGRADING
01674500	Mattaponi River Near Beulahville, Va	Total Phosphorus	-6.1	not significant
02035000	James River At Cartersville, Va	Total Phosphorus	-61.2	IMPROVING
02037500	James River Near Richmond, Va	Total Phosphorus	-40.4	IMPROVING
02041650	Appomattox River At Matoaca, Va	Total Phosphorus	27	DEGRADING
02042500	Chichamominy River Near Providence Forge, Va	Total Phosphorus	-11.2	not significant

Appendix 1. Supplemental Data – Long-term Trends

Flow-adjusted trends in sediment concentration, 1985-2011 for 31 long-term stations.

STATION	Station Name	Constituent	Trend in percent	Significance
01491000	Choptank River Near Greensboro, Md.	Total Suspended Sediment	-30.9	IMPROVING
01531500	Susquehanna River At Towanda, Pa	Total Suspended Sediment	-12.1	not significant
01536500	Susquehanna River At Wilkes-Barre, Pa	Total Suspended Solids	-60.3	IMPROVING
01540500	Susquehanna River At Danville, Pa	Total Suspended Sediment	-33.7	IMPROVING
01553500	West Branch Susquehanna River At Lewisburg, Pa	Total Suspended Sediment	-7.2	not significant
01567000	Juniata River At Newport, Pa	Total Suspended Sediment	-28.4	IMPROVING
01576000	Susquehanna River At Marietta, Pa	Total Suspended Sediment	-37.4	IMPROVING
01576754	Conestoga River At Conestoga, Pa	Total Suspended Sediment	-73.8	IMPROVING
01578310	Susquehanna River At Conowingo, Md	Total Suspended Sediment	-9.3	not significant
01582500	Gunpowder Falls At Glencoe, Md	Total Suspended Solids	60.1	DEGRADING
01586000	North Branch Patapsco River At Cedarhurst, Md	Total Suspended Solids	-24.5	not significant
01591000	Patuxent River Near Unity, Md	Total Suspended Solids	14	not significant
01594440	Patuxent River At Bowie, Md	Total Suspended Sediment	-41.8	IMPROVING
01599000	Georges Creek At Franklin, Md	Total Suspended Solids	26.4	not significant
01601500	Wills Creek Near Cumberland, Md	Total Suspended Solids	16.6	not significant
01614500	Conococheague Creek At Fairview, Md	Total Suspended Solids	20.2	not significant
01619500	Antietam Creek Near Sharpsburg, Md	Total Suspended Solids	-18.7	not significant
01631000	S F Shenandoah River At Front Royal, Va	Total Suspended Solids	18.4	not significant
01634000	N F Shenandoah River Near Strasburg, Va	Total Suspended Solids	57.8	DEGRADING
01637500	Catoctin Creek Near Middletown, Md	Total Suspended Solids	48.5	DEGRADING
01639000	Monocacy River At Bridgeport, Md	Total Suspended Solids	-43.6	IMPROVING
01646580	Potomac River At Chain Bridge, Md	Total Suspended Sediment	-57.5	IMPROVING
01651000	Nw Branch Anacostia River Near Hyattsville, Md	Total Suspended Solids	6.9	not significant
01668000	Rappahannock River Near Fredericksburg, Va	Total Suspended Solids	-2	not significant
01671020	North Anna River At Hart Corner Near Doswell, Va	Total Suspended Solids	273.8	DEGRADING
01673000	Pamunkey River Near Hanover, Va	Total Suspended Solids	143.7	DEGRADING
01674500	Mattaponi River Near Beulahville, Va	Total Suspended Solids	4.5	not significant
02035000	James River At Cartersville, Va	Total Suspended Solids	3.4	not significant
02037500	James River Near Richmond, Va	Total Suspended Solids	51.6	DEGRADING
02041650	Appomattox River At Matoaca, Va	Total Suspended Solids	28.6	DEGRADING
02042500	Chichamominy River Near Providence Forge, Va	Total Suspended Solids	72.5	DEGRADING

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Appendix 2. Supplemental Data – 10-year Trends

Flow-adjusted trends in total nitrogen concentrations, 2002-2011 for 32 stations.

STATION	Station Name	Constituent	FA trend in percent	Significance
01531500	Susquehanna River At Towanda, Pa	Total Nitrogen	-17.9	IMPROVING
01536500	Susquehanna River At Wilkes-Barre, Pa	Total Nitrogen	-27.3	IMPROVING
01540500	Susquehanna River At Danville, Pa	Total Nitrogen	-8.7	IMPROVING
01553500	West Branch Susquehanna River At Lewisburg, Pa	Total Nitrogen	-18.2	IMPROVING
01567000	Juniata River At Newport, Pa	Total Nitrogen	-13.3	IMPROVING
01576000	Susquehanna River At Marietta, Pa	Total Nitrogen	-22.9	IMPROVING
01576754	Conestoga River At Conestoga, Pa	Total Nitrogen	-16.1	IMPROVING
01578310	Susquehanna River At Conowingo, Md	Total Nitrogen	5.3	not significant
01491000	Choptank River Near Greensboro, Md.	Total Nitrogen	6	not significant
01582500	Gunpowder Falls At Glencoe, Md	Total Nitrogen	12.1	DEGRADING
01586000	North Branch Patapsco River At Cedarhurst, Md	Total Nitrogen	2.1	not significant
01591000	Patuxent River Near Unity, Md	Total Nitrogen	5.5	not significant
01594440	Patuxent River At Bowie, Md	Total Nitrogen	-18.1	IMPROVING
01599000	Georges Creek At Franklin, Md	Total Nitrogen	-11.2	not significant
01601500	Wills Creek Near Cumberland, Md	Total Nitrogen	-38.6	IMPROVING
01614500	Conococheague Creek At Fairview, Md	Total Nitrogen	-1.9	not significant
01619500	Antietam Creek Near Sharpsburg, Md	Total Nitrogen	1	not significant
01631000	S F Shenandoah River At Front Royal, Va	Total Nitrogen	5.9	not significant
01634000	N F Shenandoah River Near Strasburg, Va	Total Nitrogen	-15.5	IMPROVING
01637500	Catoctin Creek Near Middletown, Md	Total Nitrogen	-5.1	not significant
01639000	Monocacy River At Bridgeport, Md	Total Nitrogen	-33.8	IMPROVING
01646580	Potomac River At Chain Bridge, Md	Total Nitrogen	-1.5	not significant
01651000	Nw Branch Anacostia River Near Hyattsville, Md	Total Nitrogen	17.8	not significant
01668000	Rappahannock River Near Fredericksburg, Va	Total Nitrogen	-5.6	not significant
01671020	North Anna River At Hart Corner Near Doswell, Va	Total Nitrogen	-21.7	IMPROVING
01673000	Pamunkey River Near Hanover, Va	Total Nitrogen	1.3	not significant
01674500	Mattaponi River Near Beulahville, Va	Total Nitrogen	-4.1	not significant
02035000	James River At Cartersville, Va	Total Nitrogen	3.3	not significant
02037500	James River Near Richmond, Va	Total Nitrogen	-0.8	not significant
02041650	Appomattox River At Matoaca, Va	Total Nitrogen	4.7	not significant
02042500	Chickahominy River Near Providence Forge, Va	Total Nitrogen	-29.8	not significant
01589300	Gwynn Falls At Villa Nova, Md	Total Nitrogen	-4.2	not significant

Appendix 2. Supplemental Data – 10-year Trends

Flow-adjusted trends in total phosphorus concentrations, 2002-2011 for 32 stations.

STATION	Station Name	Constituent	FA trend in percent	Significance
01531500	Susquehanna River At Towanda, Pa	Total Phosphorus	11	not significant
01536500	Susquehanna River At Wilkes-Barre, Pa	Total Phosphorus	-24.1	not significant
01540500	Susquehanna River At Danville, Pa	Total Phosphorus	12.3	not significant
01553500	West Branch Susquehanna River At Lewisburg, Pa	Total Phosphorus	-2.9	not significant
01567000	Juniata River At Newport, Pa	Total Phosphorus	-51.8	IMPROVING
01576000	Susquehanna River At Marietta, Pa	Total Phosphorus	-39.2	IMPROVING
01576754	Conestoga River At Conestoga, Pa	Total Phosphorus	-47.8	IMPROVING
01578310	Susquehanna River At Conowingo, Md	Total Phosphorus	15.2	not significant
01491000	Choptank River Near Greensboro, Md.	Total Phosphorus	-0.9	not significant
01582500	Gunpowder Falls At Glencoe, Md	Total Phosphorus	12.1	not significant
01586000	North Branch Patapsco River At Cedarhurst, Md	Total Phosphorus	9.7	not significant
01591000	Patuxent River Near Unity, Md	Total Phosphorus	13.3	not significant
01594440	Patuxent River At Bowie, Md	Total Phosphorus	-9.8	not significant
01599000	Georges Creek At Franklin, Md	Total Phosphorus	8.3	not significant
01601500	Wills Creek Near Cumberland, Md	Total Phosphorus	65.4	DEGRADING
01614500	Conococheague Creek At Fairview, Md	Total Phosphorus	-49.3	IMPROVING
01619500	Antietam Creek Near Sharpsburg, Md	Total Phosphorus	3	not significant
01631000	S F Shenandoah River At Front Royal, Va	Total Phosphorus	-61	IMPROVING
01634000	N F Shenandoah River Near Strasburg, Va	Total Phosphorus	-86.4	IMPROVING
01637500	Catoctin Creek Near Middletown, Md	Total Phosphorus	-49.8	IMPROVING
01639000	Monocacy River At Bridgeport, Md	Total Phosphorus	-20.9	IMPROVING
01646580	Potomac River At Chain Bridge, Md	Total Phosphorus	-15.1	not significant
01651000	Nw Branch Anacostia River Near Hyattsville, Md	Total Phosphorus	55.4	DEGRADING
01668000	Rappahannock River Near Fredericksburg, Va	Total Phosphorus	42.6	DEGRADING
01671020	North Anna River At Hart Corner Near Doswell, Va	Total Phosphorus	84.9	DEGRADING
01673000	Pamunkey River Near Hanover, Va	Total Phosphorus	-22.3	IMPROVING
01674500	Mattaponi River Near Beulahville, Va	Total Phosphorus	9.6	not significant
02035000	James River At Cartersville, Va	Total Phosphorus	-43.7	IMPROVING
02037500	James River Near Richmond, Va	Total Phosphorus	-42.8	IMPROVING
02041650	Appomattox River At Matoaca, Va	Total Phosphorus	18.9	not significant
02042500	Chickahominy River Near Providence Forge, Va	Total Phosphorus	-36.2	not significant
01589300	Gwynn Falls At Villa Nova, Md	Total Phosphorus	10	not significant

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Appendix 2. Supplemental Data – 10-year Trends

Flow-adjusted trends in sediment concentrations, 2002-2011 for 32 stations.

STATION	Station Name	Constituent	FA trend in percent	Significance
01531500	Susquehanna River At Towanda, Pa	Sediment	4.8	not significant
01536500	Susquehanna River At Wilkes-Barre, Pa	Sediment	30.7	not significant
01540500	Susquehanna River At Danville, Pa	Sediment	-2.7	not significant
01553500	West Branch Susquehanna River At Lewisburg, Pa	Sediment	-2.4	not significant
01567000	Juniata River At Newport, Pa	Sediment	-43.5	IMPROVING
01576000	Susquehanna River At Marietta, Pa	Sediment	-5.6	not significant
01576754	Conestoga River At Conestoga, Pa	Sediment	-39.7	IMPROVING
01578310	Susquehanna River At Conowingo, Md	Sediment	44	DEGRADING
01491000	Choptank River Near Greensboro, Md.	Sediment	46.2	DEGRADING
01582500	Gunpowder Falls At Glencoe, Md	Sediment	115.6	DEGRADING
01586000	North Branch Patapsco River At Cedarhurst, Md	Sediment	67.4	not significant
01591000	Patuxent River Near Unity, Md	Sediment	138	DEGRADING
01594440	Patuxent River At Bowie, Md	Sediment	40.2	not significant
01599000	Georges Creek At Franklin, Md	Sediment	157.4	DEGRADING
01601500	Wills Creek Near Cumberland, Md	Sediment	73.9	not significant
01614500	Conococheague Creek At Fairview, Md	Sediment	-19.5	not significant
01619500	Antietam Creek Near Sharpsburg, Md	Sediment	20.6	not significant
01631000	S F Shenandoah River At Front Royal, Va	Sediment	-8.3	not significant
01634000	N F Shenandoah River Near Strasburg, Va	Sediment	21.3	not significant
01637500	Catoctin Creek Near Middletown, Md	Sediment	39.9	not significant
01639000	Monocacy River At Bridgeport, Md	Sediment	-5.6	not significant
01646580	Potomac River At Chain Bridge, Md	Sediment	56.5	DEGRADING
01651000	Nw Branch Anacostia River Near Hyattsville, Md	Sediment	236.2	DEGRADING
01668000	Rappahannock River Near Fredericksburg, Va	Sediment	18.2	not significant
01671020	North Anna River At Hart Corner Near Doswell, Va	Sediment	46.4	not significant
01673000	Pamunkey River Near Hanover, Va	Sediment	73.7	DEGRADING
01674500	Mattaponi River Near Beulahville, Va	Sediment	-20.3	not significant
02035000	James River At Cartersville, Va	Sediment	20.7	not significant
02037500	James River Near Richmond, Va	Sediment	57.4	DEGRADING
02041650	Appomattox River At Matoaca, Va	Sediment	44.8	DEGRADING
02042500	Chickahominy River Near Providence Forge, Va	Sediment	679.3	DEGRADING
01589300	Gwynn Falls At Villa Nova, Md	Sediment	65.3	not significant

Appendix 3. Supplemental Data – 5-year Annual-Average Yields

Yields in tons per square mile (tons/mi2) 2006-2011, for 65 stations

STATION	Station Name	Total nitrogen mean yield [tons/mi^2]	Total phosphorus mean yield [tons/mi^2]	Sediment mean yield [tons/mi^2]
01531500	SUSQUEHANNA RIVER AT TOWANDA, PA	4.76	0.508	764.7
01536500	SUSQUEHANNA RIVER AT WILKES-BARRE, PA	1.57	0.261	2061.0
01540500	SUSQUEHANNA RIVER AT DANVILLE, PA	1.77	0.196	196.5
01553500	WEST BRANCH SUSQUEHANNA RIVER AT LEWISBURG, PA	1.41	0.072	62.1
01567000	JUNIATA RIVER AT NEWPORT, PA	2.32	0.085	56.8
01576000	SUSQUEHANNA RIVER AT MARIETTA, PA	2.31	0.159	187.6
01576754	CONESTOGA RIVER AT CONESTOGA, PA	10.48	0.616	457.9
01578310	SUSQUEHANNA RIVER AT CONOWINGO DAM, MD	2.51	0.157	170.2
01491000	CHOPTANK RIVER NEAR GREENSBORO, MD	2.49	0.238	38.8
01582500	GUNPOWDER FALLS AT GLENCOE,MD	3.35	0.066	97.1
01586000	NORTH BRANCH PATAPSCO AT CEDARHURST, MD	4.43	0.144	322.4
01591000	PATUXENT RIVER NEAR UNITY, MD	3.16	0.124	316.5
01594440	PATUXENT RIVER NEAR BOWIE, MD	1.81	0.176	111.0
01599000	GEORGES CREEK AT GLENCOE, MD	1.89	0.096	108.8
01601500	WILLS CREEK NEAR CUMBERLAND, MD	1.97	0.111	196.0
01614500	CONOCOCHEAGUE CREEK AT FAIRVIEW, MD	5.85	0.153	99.7
01619500	ANTIETAM CREEK NEAR SHARPSBURG, MD	4.64	0.144	54.8
01631000	SF SHENANDOAH RIVER AT FRONT ROYAL, VA	1.38	0.156	130.6
01634000	NF SHENANDOAH RIVER NEAR STRASBURG, VA	1.48	0.115	323.2
01637500	CATOCTIN CREEK NEAR MIDDLETOWN, MD	2.20	0.145	210.1
01639000	MONOCACY RIVER AT BRIDGPORT, MD	3.47	0.324	113.2
01646580	POTOMAC RIVER AT CHAIN BRIDGE	1.88	0.143	184.0
01651000	NW BRANCH ANACOSTIA RIVER NEAR HYATTSVILLE, MD.	2.21	0.277	477.5
01668000	RAPPAHANNOCK RIVER NEAR FREDERICKSBURG, VA	1.14	0.242	317.5
01671020	NORTH ANNA RIVER AT HART CORNER NEAR DOSWELL, VA	0.37	0.039	38.2
01673000	PAMUNKEY RIVER NEAR HANOVER, VA	0.55	0.074	50.5
01674500	MATTAPONI RIVER NEAR BEULAHVILLE, VA	0.54	0.048	13.2
02035000	JAMES RIVER AT CARTERSVILLE, VA	0.72	0.128	136.4
02037500	JAMES RIVER AT RICHMOND, VA	0.70	0.153	154.3
02041650	APPOMATTOX RIVER AT MATOACA, VA	0.46	0.045	13.4
02042500	CHICKAHOMINY RIVER NEAR PROVIDEN FORGE, VA	0.70	0.109	32.7
01589300	GWYNNS FALLS AT VILLA NOVA, MD	2.15	0.206	618.1
01515000	SUSQUEHANNA RIVER NEAR WAVERLY, NY	1.94	0.218	259.8
01531000	CHEMUNG RIVER AT CHEMUNG, NY	1.36	0.152	163.8

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Appendix 3. Supplemental Data – 5-year Annual-Average Yields

Yields in tons per square mile (tons/mi2) 2006-2011, for 65 stations

STATION	Station Name	Total nitrogen mean yield [tons/mi^2]	Total phosphorus mean yield [tons/mi^2]	Sediment mean yield [tons/mi^2]
01542500	WB SUSQUEHANNA RIVER AT KARTHAUS, PA	1.11	0.050	53.0
01555000	PENNS CREEK AT PENNS CREEK, PA	2.53	0.115	56.5
01562000	RAYSTOWN BRANCH JUNIATA RIVER AT SAXTON, PA	2.45	0.095	102.2
01568000	SHERMAN CREEK AT SHERMANS DALE, PA	6.09	0.505	269.0
01570000	CONODOGUINET CREEK NEAR HOGESTOWN, PA	5.50	0.109	97.3
01571500	YELLOW BREECHES CREEK NR CAMP HILL, PA	3.41	0.123	76.8
01573560	SWATARA CREEK NEAR HERSHEY, PA	6.85	1.065	1381.4
01574000	WEST CONEWAGO CREEK NEAR MANCHESTER, PA	4.05	0.527	425.4
01576787	PEQUEA CREEK NEAR MARTIC FORGE, PA	9.81	0.590	315.4
01667500	RAPIDAN RIVER NEAR CULPEPPER, VA	1.52	0.437	535.1
01487000	NANTICOKE RIVER NEAR BRIDGEVILLE, DE	7.12	0.097	12.0
01488500	MARSHYHOPE CREEK NEAR ADAMSVILLE, DE	4.22	0.287	34.8
01491500	Tuckahoe Creek near Ruthsburg, MD	4.71	0.233	28.2
01495000	Big Elk Creek at Elk Mills, MD	5.87	0.446	840.0
01502500	UNADILLA RIVER AT ROCKDALE, NY	2.09	0.196	269.9
01503000	SUSQUEHANNA RIVER AT CONKLIN, NY	1.73	0.195	214.4
01529500	COHOCTON RIVER NEAR CAMPBELL NY	1.89	0.097	37.6
01549760	WEST BRANCH SUSQUEHANNA RIVER NEAR JERSEY SHORE	1.04	0.059	43.8
01578475	OCTORARO CREEK AT RICHARDSMERE, MD	8.56	0.255	89.8
01580520	Deer Creek near Darlington, MD	4.98	0.219	298.9
01594526	WESTERN BRANCH AT UPPER MARLBORO. MD	1.48	0.409	812.1
01604500	PATTERSON CREEK NEAR HEADSVILLE, WV	0.93	0.057	69.7
01608500	SOUTH BRANCH POTOMAC RIVER NEAR SPRINGFIELD, WV	0.96	0.083	70.8
01610155	SIDELING HILL CREEK NEAR BELLEGROVE, MD	1.27	0.034	78.6
01611500	CACAPON RIVER NEAR GREAT CACAPON, WV	0.93	0.065	99.9
01613095	Tonoloway Creek near Hancock, MD	1.90	0.062	110.9
01613525	LICKING CREEK NEAR PECTONVILLE, MD	1.87	0.076	154.2
01616500	OPEQUON CREEK NEAR MARTINSBURG, WV	2.13	0.181	72.5
01619000	ANTIETAM CREEK NEAR WAYNESBORO, PA	4.73	0.190	76.8
02024752	JAMES RIVER AT BLUE RIDGE PKWY BRIDGE NR BIG ISLAND, VA	0.63	0.092	88.7
01609000	Town Creek near Oldtown, MD	0.91	0.043	125.3

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Langland and others—**Total Nutrient and Sediment Loads, Trends, Yields, and Nontidal Water-Quality Indicators, Chesapeake Bay Watershed, 1985–2011**—Open-File Report 2013–1052