NUTRIENTS AND SUSPENDED SEDIMENT TRANSPORTED IN THE SUSQUEHANNA RIVER BASIN, 2004, AND TRENDS, JANUARY 1985 THROUGH DECEMBER 2004

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NUTRIENTS AND SUSPENDED SEDIMENT TRANSPORTED IN THE SUSQUEHANNA RIVER BASIN, 2004, AND TRENDS, JANUARY 1985 THROUGH DECEMBER 2004

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ABSTRACT

Nutrient and suspended-sediment (SS) samples were collected under base flow and stormflow conditions during calendar year 2004 for Group A sites listed in Table 2. Fixed date samples also were collected at these sites. Additionally, fixed date samples were collected during the fourth quarter of 2004 at Group B sites listed in Table 2. All samples were analyzed for nitrogen and phosphorus species, total organic carbon (TOC), and SS.

Precipitation for 2004 was above average for all Group A sites. Highest departures from the long-term precipitation averages were recorded at Newport with 14.3 inches above the long-term mean (LTM). Highest departure from LTM in discharge was 157.9 percent above LTM at Conestoga. Lowest departure from the mean was at Towanda for rainfall, 9.16 inches above LTM and at Danville for flow at 127.7 percent of the LTM. Precipitation and flows were above LTM largely due to high flows caused by Tropical Storm Ivan in September.

This report utilizes four methods to analyze nutrient and SS loads and yields: (1) comparison with the LTM; (2) comparison with initial 5-year baseline yields; (3) comparison with baseline data from the beginning of program through 2004 (full program baseline); and (4) flow adjusted trend analysis through 2004.

Comparison with the LTM showed increases in flow, total phosphorus (TP), and SS for all sites except for SS at Lewisburg. Increases in total nitrogen (TN) were shown at Newport and Marietta when compared to the LTMs. Baseline comparisons showed increases in TN at Newport, increases in TP at all sites except Conestoga, and increases in SS at all sites except Conestoga and Lewisburg, when compared to the initial 5-year baselines. When compared to the full program baseline, Newport showed increases in all three parameters, Marietta and Danville showed increases in TP, and all sites except Conestoga and Lewisburg showed increases in SS. Trends in flow-adjusted concentrations (FACs) were found to be decreasing for TN, TP, and SS at all sites except for TP at Marietta, which showed no significant trends. No significant trends were found for flow.

INTRODUCTION

Nutrients and SS entering the Chesapeake Bay (Bay) from the Susquehanna River Basin contribute to nutrient enrichment problems in the Bay (USEPA, 1982). The Pennsylvania Department of Environmental Protection (PADEP) Bureau of Laboratories, the U.S. Environmental Protection Agency (USEPA), the U.S. Geological Survey (USGS), and the Susquehanna River Basin Commission (SRBC) conducted a 5-year intensive study at 12 sites from 1985-89 to quantify nutrient and SS transported to the Bay via the Susquehanna River Basin. In 1990, the number of sampling sites was reduced to five long-term monitoring stations. An additional site was included in 1994.

In October 2004, 13 additional sites, (two in New York and 11 in Pennsylvania), were added as part of the Chesapeake Bay Program's Non-tidal Water Quality Monitoring Network. This project involves effort conducted by all six Bay state jurisdictions, the USEPA, USGS, and SRBC to create a uniform non-tidal monitoring network for the entire Bay watershed.

Purpose of Report

The purpose of this report is to present basic information on annual and seasonal loads and yields of nutrients and SS measured during calendar year 2004. Comparisons are made to LTM, similar flow years, baseline data calculated from the 1985-89 study, and baseline data calculated from the entire duration of the program. Seasonal and annual variations in loads are discussed, as well as the results of flow adjusted trend analyses for the period January 1985 through December 2004 for various forms of nitrogen and phosphorus, SS, TOC, and water discharge.

DESCRIPTION OF THE SUSQUEHANNA RIVER BASIN

The Susquehanna River (Figure 1) drains an area of 27,510 square miles (Susquehanna River Basin Study Coordination Committee, 1970), and is the largest tributary to the Bay. The Susquehanna River originates in the Appalachian Plateau of southcentral New York, flows into the Valley and Ridge and Piedmont Provinces of Pennsylvania and Maryland, and joins the Bay at Havre de Grace, Md. The climate in the Susquehanna River Basin varies considerably from the low lands adjacent to the Bay in Maryland to the high elevations, above 2,000 feet, of the northern headwaters in central New York State. The annual mean temperature ranges from 53^{o} F (degrees Fahrenheit) near the Pennsylvania-Maryland border to 45^{o} F in the northern part of the basin. Annual precipitation in the basin averages 39.15 inches and is fairly well distributed throughout the year.

Land use in the Susquehanna River Basin, shown in Table 1, is predominantly rural with woodland accounting for 69 percent; agriculture, 21 percent; and urban, 7 percent. Woodland occupies the higher elevations of the northern and western parts of the basin and much of the mountain and ridge land in the Juniata and Lower Susquehanna Subbasins. Woods and grasslands occupy areas in the lower part of the basin that are unsuitable for cultivation because the slopes are too steep, the soils are too stony, or the soils are poorly drained. The Lower Susquehanna Subbasin contains the highest density of agriculture within the watershed. However, extensive areas are cultivated along the river valleys in southern New York and along the West Branch Susquehanna River from Northumberland, Pa., to Lock Haven, Pa., including the Bald Eagle Creek Valley.

Major urban areas in the Lower Susquehanna Subbasin include York, Lancaster, Harrisburg, and Sunbury, Pa. Most of the urban areas in the northern part of the basin are located along river valleys, and they include Binghamton, Elmira, and Corning, N.Y. Urban areas in the Middle Susquehanna include Scranton and Wilkes-Barre, Pa. The major urban areas in the West Branch Susquehanna Subbasin are Williamsport, Renovo, and Clearfield. Lewistown and Altoona are the major urban areas within the Juniata Subbasin.

NUTRIENT MONITORING SITES

Data were collected from five sites on the Susquehanna River, three sites on the West Branch Susquehanna River, and 11 from smaller tributaries in the basin. These 19 sites, selected for long-term monitoring of nutrient and SS transport in the basin are listed in Table 2, and their general locations are shown in Figure 2. In October 2005, four additional sites will be added to the existing monitoring network, three in New York and one in Maryland.

SAMPLE COLLECTION AND ANALYSIS

Samples were collected to measure nutrient and SS concentrations during various flows in 2004. For Group A sites, two samples were collected per month: one near the twelfth of the month and one during monthly base flow conditions. Additionally, at least four high flow events were sampled, targeting one per season. When possible, a second high flow event was sampled in accordance with spring planting in the basin. During high flow sampling events, samples were collected daily during the rise and fall of the hydrograph. The goal was to gather a minimum of three samples on the rise and three samples on the fall, with one sample as close to peak flow as possible. Sampling continued until flows returned to pre-storm levels.

Figure 1. The Susquehanna River Basin, Subbasins, and Population Centers

Table 1. 2000 Land Use Percentages for the Susquehanna River Basin and Selected Tributaries

Site	Waterbody	Urban	Agricultural			Forested	Other
			Row Crops	Pasture/Hay	Total		
Towanda	Susquehanna	3	17	5	22	71	4
Danville	Susquehanna	9	16	4	20	68	3
Lewisburg	West Branch Susquehanna River	3	9	2	11	83	3
Newport	Juniata	6	14	4	18	74	2
Marietta	Susquehanna	12	17	19	36	47	5
Conestoga	Conestoga	21	12	36	48	26	5
Wilkes-Barre	Susquehanna	3	16	5	21	71	5
Karthaus	West Branch Susquehanna River	2	11	1	12	80	6
Castanea	Bald Eagle	3	11	3	14	76	7
Jersey Shore	West Branch Susquehanna River	2	6	1	7	87	4
Penns Creek	Penns	2	16	4	20	75	3
Saxton	Raystown Branch Juniata	3	18	5	23	71	3
Dromgold	Shermans	2	15	6	21	74	3
Hogestown	Conodoguinet	7	38	6	44	43	6
Hershey	Swatara	8	18	10	28	56	8
Manchester	West Conewago	9	12	36	48	36	7
Martic Forge	Pequea	9	12	48	60	25	6
Smithboro, NY	Susquehanna	3	17	5	22	71	4
Chemung, NY	Chemung	3	15	5	20	74	3
Entire Basin	Susquehanna River Basin	7	14	7	21	69	3

Table 2. Data Collection Sites and Their Drainage Areas

USGS ID Number	Original Sites (Group A)	Subbasin	Short Name	Drainage Area (Sq Mi)
01531500	Susquehanna River at Towanda, Pa.	Middle Susquehanna	Towanda	7,797
01540500	Susquehanna River at Danville, Pa.	Middle Susquehanna	Danville	11,220
01553500	West Branch Susquehanna River at Lewisburg, Pa.	W Branch Susquehanna	Lewisburg	6,847
01567000	Juniata River at Newport, Pa.	Juniata	Newport	3,354
01576000	Susquehanna River at Marietta, Pa.	Lower Susquehanna	Marietta	25,990
01576754	Conestoga River at Conestoga, Pa.	Lower Susquehanna	Conestoga	470
	Enhanced Sites (Group B)			
01515000	Susquehanna River at Smithboro, NY	Upper Susquehanna	Smithboro	4,631
01531000	Chemung River at Chemung, NY	Chemung	Chemung	2,506
01536500	Susquehanna River near Wilkes-Barre, Pa	Middle Susquehanna	Wilkes-Barre	9,960
01542500	West Branch Susquehanna River near Karthaus, Pa	W Branch Susquehanna	Karthaus	1,462
01548085	Bald Eagle Creek near Castanea, Pa	W Branch Susquehanna	Castanea	420
01549760	West Branch Susquehanna River near Jersey Shore, Pa	W Branch Susquehanna	Jersey Shore	5,225
01555000	Penns Creek at Penns Creek, Pa	Lower Susquehanna	Penns Creek	301
01562000	Raystown Branch Juniata River at Saxton, Pa	Juniata	Saxton	756
01568000	Shermans Creek near Dromgold, Pa	Lower Susquehanna	Dromgold	200
01570000	Conodoquinet Creek near Hogestown, Pa	Lower Susquehanna	Hogestown	470
01573560	Swatara Creek near Hershey, Pa	Lower Susquehanna	Hershey	483
01574000	West Conewago Creek near Manchester, Pa	Lower Susquehanna	Manchester	510
01576787	Pequea Creek near Martic Forge, Pa	Lower Susquehanna	Pequea	155

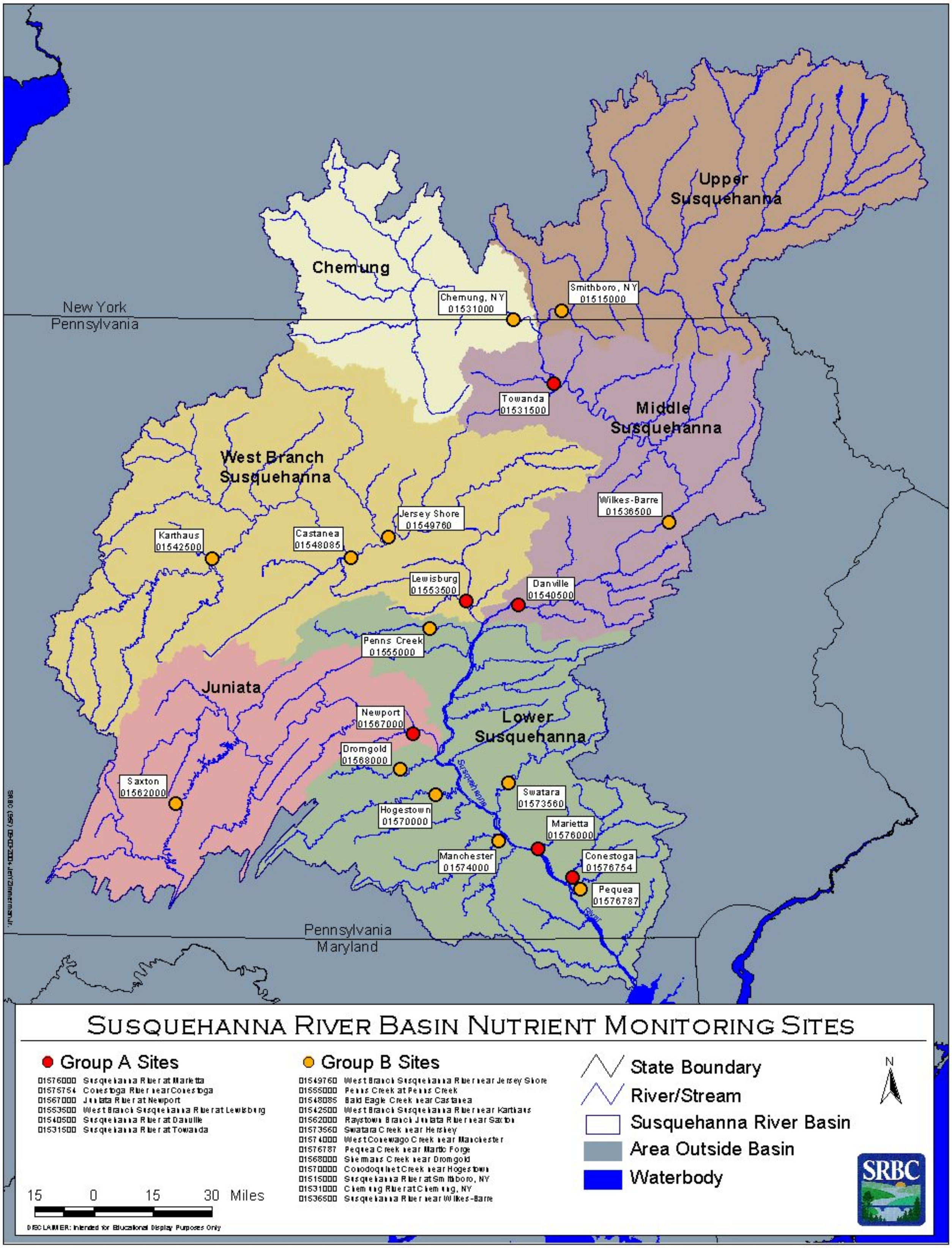


Figure 2. Locations of Sampling Sites Within the Susquehanna River Basin

For Group B sites, sampling started in October 2004. Fixed date monthly samples were collected during the middle of each month for the last quarter of 2004. All samples were collected by hand with USGS depth integrating samplers. Samples were collected using the same protocol as Group A sites. At each site between 3- and 10-depth integrated verticals were collected across the water column and then composited to obtain a representative sample of the entire waterbody.

Whole water samples were collected to be analyzed for TN species, TP species, TOC, and SS. For Group B sites, SS samples were only collected during storm events. Additionally, filtered samples were collected to analyze for dissolved nitrogen (DN) and dissolved phosphorus (DP) species. All Pennsylvania samples were delivered to the PADEP Laboratory in Harrisburg to be analyzed the following workday. New York samples were sent to Columbia Analytical Services in Rochester, N.Y., for analysis the following workday. SS concentrations for Group A sites were completed at SRBC and for Group B sites at the USGS sediment laboratory in Kentucky. The parameters and laboratory methods used are listed in Table 3.

PRECIPITATION

Precipitation data were obtained from long-term monitoring stations operated by the U.S. Department of Commerce. The data are published as Climatological Data—Pennsylvania, and as Climatological Data—New York by the National Oceanic and Atmospheric Administration (NOAA) at the National Climatic Data Center in Asheville, North Carolina. Quarterly and annual data from these sources were compiled across the

Table 3. Water Quality Parameters, Laboratory Methods, and Detection Limits

Parameter	Laboratory	Methodology	Detection Limit (mg/l)	References
Total Ammonia (TNH4)	PADEP	Colorimetry	0.020	USEPA 350.1
	CAS*	Colorimetry	0.050	USEPA 350.1
Dissolved Ammonia (DNH4)	PADEP	Block Digest, Colorimetry	0.020	USEPA 350.1
	CAS*	Block Digest, Colorimetry	0.050	USEPA 350.1
Total Nitrogen (TN)	PADEP	Persulfate Digestion for TN	0.040	Standard Methods #4500-N_{org}-D
Dissolved Nitrogen (DN)	PADEP	Persulfate Digestion	0.040	Standard Methods #4500-N_{org}-D
Total Kjeldahl Nitrogen (TKN)	CAS*	Block Digest, Flow Injection	0.050	USEPA 351.2
Dissolved Kjeldahl Nitrogen (DKN)	CAS*	Block Digest, Flow Injection	0.050	USEPA 351.2
Total Nitrite plus Nitrate (TNO23)	PADEP	Cd-reduction, Colorimetry	0.010	USEPA 353.2
	CAS*	Colorimetric by LACHAT	0.002	USEPA 353.2
Dissolved Nitrite plus Nitrate (DNO23)	PADEP	Cd-reduction, Colorimetry	0.010	USEPA 353.2
	CAS*	Colorimetric by LACHAT	0.002	USEPA 353.2
Dissolved Orthophosphate (DOP)	PADEP	Colorimetry	0.002	USEPA 365.1
	CAS*	Colorimetric Determination	0.002	USEPA 365.1
Dissolved Phosphorus (DP)	PADEP	Block Digest, Colorimetry	0.010	USEPA 365.1
	CAS*	Colorimetric Determination	0.002	USEPA 365.1
Total Phosphorus (TP)	PADEP	Persulfate Digest, Colorimetry	0.010	USEPA 365.1
	CAS*	Colorimetric Determination	0.002	USEPA 365.1
Total Organic Carbon (TOC)	PADEP	Combustion/Oxidation	0.50	SM 5310D
	CAS*	Chemical Oxidation	0.05	GEN 415.1/9060
Suspended Sediment (total)	SRBC	**		
	USGS	**		

* Columbia Analytical Services, Rochester, NY (New York sites only)
** TWRI Book 3, Chapter C2 and Book 5, Chapter C1, Laboratory Theory and Methods for Sediment Analysis (Guy and others, 1969)

subbasins of the Susquehanna River Basin and are reported in Table 4 for Group A sites. Average rainfall values for October through December for Group B sites are reported in Table 20. Due to high rainfalls in the summer (mostly from Tropical Storm Ivan), precipitation totals exceeded the LTM at all Group A sites for 2004.

WATER DISCHARGE

Water discharge data were obtained from the USGS and are listed in Table 5. Water discharges were above the LTM at all Group A sites ranging from 127.7 percent of the LTM at Danville to 157.9 percent at Conestoga. These values were a direct effect of Tropical Storm Ivan during September 2004. High flows for September ranged from 10 percent of the annual flow at Conestoga to 19 percent of the annual flow at Newport. Figure 3 compares the 2004 discharges with the LTM discharges for each site.

Table 4. Summary for Annual Precipitation for Selected Areas in the Susquehanna River Basin, Calendar Year 2004

River Location	Season	Calendar Year 2004 Precipitation inches	Average Long-term Precipitation inches	Departure From Long-term inches
Susquehanna River above Towanda, Pa.	January-March	6.36	7.20	-0.84
	April-June	11.96	10.60	+1.36
	July-September	20.01	11.23	+8.78
	October-December	8.57	8.72	-0.15
	Yearly Total	**46.90**	**37.75**	**+9.15**
Susquehanna River above Danville, Pa.	January-March	6.31	7.25	-0.94
	April-June	12.18	10.70	+1.48
	July-September	20.19	11.48	+8.71
	October-December	8.85	8.80	+0.05
	Yearly Total	**47.53**	**38.23**	**+9.30**
West Branch Susquehanna River above Lewisburg, Pa.	January-March	8.67	8.06	+0.61
	April-June	13.29	11.23	+2.06
	July-September	24.59	12.66	+11.93
	October-December	8.46	9.38	-0.92
	Yearly Total	**55.01**	**41.33**	**+13.68**
Juniata River above Newport, Pa.	January-March	7.80	7.66	+0.14
	April-June	13.29	9.66	+3.63
	July-September	21.78	10.15	+11.63
	October-December	7.77	8.80	-1.03
	Yearly Total	**50.64**	**36.27**	**+14.37**
Susquehanna River above Marietta, Pa.	January-March	7.22	7.94	-0.72
	April-June	13.65	10.80	+2.85
	July-September	21.87	11.71	+10.16
	October-December	8.77	9.10	-0.33
	Yearly Total	**51.51**	**39.55**	**+11.96**
Conestoga River above Conestoga, Pa.	January-March	7.45	8.83	-1.38
	April-June	15.77	10.55	+5.22
	July-September	19.75	12.82	+6.93
	October-December	9.28	10.06	-0.78
	Yearly Total	**52.25**	**42.26**	**+9.99**

Table 5. Annual Water Discharge, Calendar Year 2004

Site	Years of Record	Long-term Annual Mean cfs[1]	2004 Mean cfs	2004 Percent of LTM[2]
Towanda	16	11,635	15,337	131.8
Danville	20	17,091	21,823	127.7
Lewisburg	20	11,356	16,530	145.6
Newport	20	4,773	6,862	143.8
Marietta	18	40,336	56,169	139.3
Conestoga	20	666	1,052	158

[1] Cubic feet per second
[2] Long-term mean

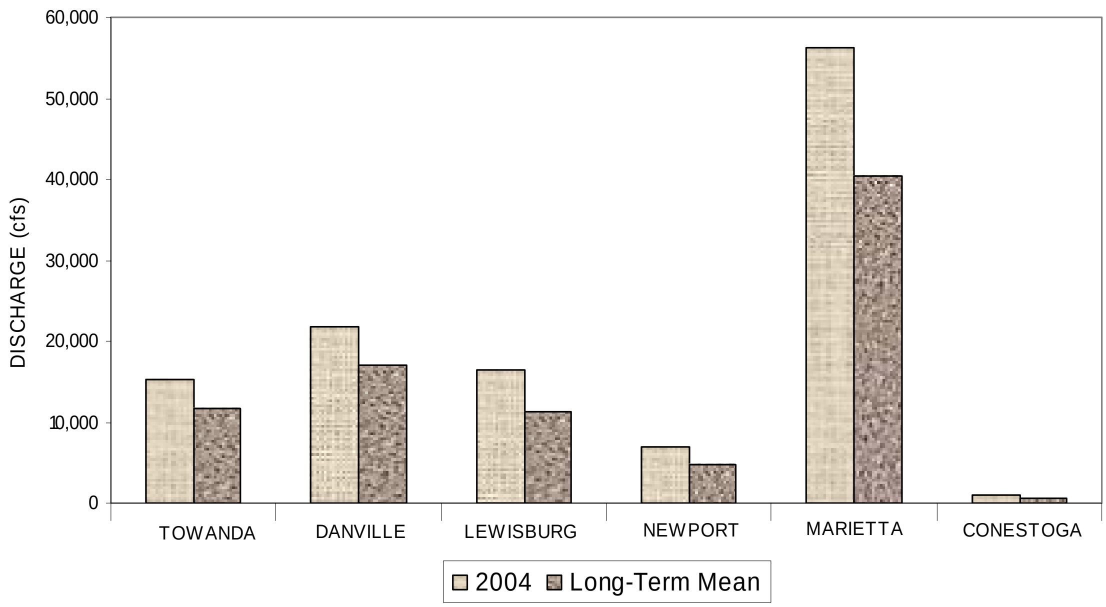


Figure 3. Annual and Long-Term Discharges at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa.

ANNUAL NUTRIENT AND SUSPENDED-SEDIMENT LOADS AND YIELDS

Loads and yields represent two methods for describing nutrient and SS amounts within a basin. Loads refer to the actual amount of the constituent being transported in the water column past a given point over a specific duration of time and are expressed in pounds. Yields compare the transported load with the acreage of the watershed and are expressed in lbs/acre. This allows for easy watershed comparisons. This project reports loads and yields for the constituents listed in Table 6 as computed by the Minimum Variance Unbiased Estimator (MVUE) described by Cohn and others (1989). This estimator relates the constituent concentration to water discharge, seasonal effects, and long-term trends, and computes the best-fit regression equation. Daily loads of the constituents were then calculated from the daily mean water discharge records. The loads were reported along with the estimates of accuracy.

Identifying sites where the percentage of LTM for a constituent was higher than the percentage of LTM for discharge may show potential areas where improvements or degradations have occurred for that particular constituent. One item to note is that nutrients and SS increase with increased flow (Ott and others, 1991; Takita, 1996, 1998). In 2004, this became an issue due to Tropical Storm Ivan in September where flows were 528 percent above the LTM at Marietta. During events such as this, sediment and nutrients (mostly phosphorous) that are trapped in the beds of streams and rivers are reintroduced into the water column and transported downstream. The high values that were found in 2004 were mostly due to this scouring process and can be seen when comparing annual loads to seasonal loads (including monthly loads for September alone).

Tables 7-19 show the loads and yields for the six monitoring stations in Group A, as well as an associated error value. They also show the average annual concentration for each constituent. Comparisons have been made to the LTMs for all constituents. Figures 4A-6B show graphs of 2004 loads and yields versus LTMs. Table 20 shows summary statistics for the Group B sites consisting of average concentrations of the various parameters for the 3-month period that the sites were sampled. Table 21 shows monthly loads for TN, TP, and SS and monthly flow for Group A sites. As a general note, nutrient and SS loads increase with increasing discharge. Many of the values are high due to unusually high flows during September, specifically from Tropical Storm Ivan.

Table 6. List of Analyzed Parameters, Abbreviations, and STORET Codes

Parameter	Abbreviation	STORET Code
Total Nitrogen as N	TN	00600
Dissolved Nitrogen as N	DN	00602
Total Organic Nitrogen as N	TON	00605
Dissolved Organic Nitrogen as N	DON	00607
Total Ammonia as N	TNH_3	00610
Dissolved Ammonia as N	DNH_3	00608
Total Nitrate + Nitrite as N	TNOx	00630
Dissolved Nitrate + Nitrite as N	DNOx	00631
Total Phosphorus as P	TP	00665
Dissolved Phosphorus as P	DP	00666
Dissolved Orthophosphate as P	DOP	00671
Total Organic Carbon	TOC	00680
Suspended Sediment	SS	80154

Table 7. Annual Water Discharges, Annual Loads, Yields, and Average Concentration of Total Nitrogen, Calendar Year 2004

Site	2004 Discharge cfs	Discharge % of LTM	2004 Load thousands of lbs	Load % of LTM	Prediction Error percent	2004 Avg. Conc. mg/l	LTM Conc. mg/l	2004 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,337	131.8	31,220	107.7	5.6	1.03	1.27	6.26	5.81
Danville	21,823	127.7	45,613	100.3	6.0	1.06	1.35	6.35	6.33
Lewisburg	16,530	145.6	33,427	136.7	7.4	1.03	1.09	7.63	5.58
Newport	6,862	143.8	26,608	160.2	5.4	1.97	1.77	12.40	7.74
Marietta	56,169	139.3	179,472	144.2	6.3	1.62	1.57	10.79	7.48
Conestoga	1,052	158	15,116	143.4	5.5	7.30	8.03	50.25	35.04

Table 8. Annual Water Discharges and Annual Loads and Yields of Total Phosphorus, Calendar Year 2004

Site	2004 Discharge cfs	Discharge % of LTM	2004 Load thousands of lbs	Load % of LTM	Prediction Error percent	2004 Avg. Conc. mg/l	LTM Conc. mg/l	2004 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,337	131.8	3,233	146.6	24.9	0.1071	0.0963	0.648	0.442
Danville	21,823	127.7	5,623	169.3	26.0	0.1309	0.0987	0.783	0.463
Lewisburg	16,530	145.6	2,164	172.9	31.5	0.0665	0.0560	0.494	0.286
Newport	6,862	143.8	1,575	188.6	23.1	0.1166	0.0888	0.734	0.389
Marietta	56,169	139.3	15,804	206.2	24.8	0.1429	0.0965	0.950	0.461
Conestoga	1,052	158	1,125	164.0	35.4	0.5431	0.5227	3.739	2.280

Table 9. Annual Water Discharges and Annual Loads and Yields of Total Suspended Sediment, Calendar Year 2004

Site	2004 Discharge cfs	Discharge % of LTM	2004 Load thousands of lbs	Load % of LTM	Prediction Error percent	2004 Avg. Conc. mg/l	LTM Conc. mg/l	2004 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,337	131.8	5,409,886	220.6	62.5	179.17	107.07	1,084.1	491.5
Danville	21,823	127.7	6,004,331	224.8	56.4	139.75	79.38	836.2	372.0
Lewisburg	16,530	145.6	831,642	84.8	78.1	25.56	43.88	189.8	223.9
Newport	6,862	143.8	1,182,830	231.9	61.0	87.56	54.28	551.0	237.6
Marietta	56,169	139.3	15,887,154	285.0	60.6	143.67	70.21	955.1	335.2
Conestoga	1,052	158	537,074	165.6	110	259.32	247.19	1,785.5	1078.0

Table 10. Annual Water Discharges and Annual Loads and Yields of Total Ammonia, Calendar Year 2004

Site	2004 Discharge cfs	Discharge % of LTM	2004 Load thousands of lbs	Load % of LTM	Prediction Error Percent	2004 Avg. Conc. mg/l	LTM Conc. mg/l	2004 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,337	131.8	1,444	94.7	23.52	0.0453	0.0630	0.274	0.289
Danville	21,823	127.7	2,350	81.1	26.15	0.0547	0.0862	0.327	0.404
Lewisburg	16,530	145.6	1,280	122.6	24.60	0.0393	0.0467	0.292	0.238
Newport	6,862	143.8	682	162.9	30.5	0.0505	0.0446	0.318	0.195
Marietta	56,169	139.3	7,222	164.1	28.1	0.0653	0.0554	0.434	0.265
Conestoga	1,052	158	240	85.2	38.0	0.1158	0.2147	0.798	0.936

Table 11. Annual Water Discharges and Annual Loads and Yields of Total NO_{23} Nitrogen, Calendar Year 2004

Site	2004 Discharge cfs	Discharge % of LTM	2004 Load thousands of lbs	Load % of LTM	Prediction Error Percent	2004 Avg. Conc. mg/l	LTM Conc. mg/l	2004 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,337	131.8	31,220	179.9	5.55	1.034	0.7576	6.26	3.48
Danville	21,823	127.7	30,188	114.4	6.69	0.703	0.7844	4.20	3.68
Lewisburg	16,530	145.6	24,918	161.1	6.71	0.766	0.6918	5.69	3.53
Newport	6,862	143.8	22,271	176.8	5.28	1.6485	1.3408	10.38	5.87
Marietta	56,169	139.3	142,935	166.6	6.80	1.293	1.0803	8.59	5.16
Conestoga	1,052	158	13,109	155.0	8.08	6.3293	6.4456	43.58	28.11

Table 12. Annual Water Discharges and Annual Loads and Yields of Total Organic Nitrogen, Calendar Year 2004

Site	2004 Discharge cfs	Discharge % of LTM	2004 Load thousands of lbs	Load % of LTM	Prediction Error Percent	2004 Avg. Conc. mg/l	LTM Conc. mg/l	2004 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,337	131.8	11,067	88.0	11.75	0.229	0.48	1.95	2.22
Danville	21,823	127.7	14,705	84.5	12.58	0.342	0.52	2.05	2.42
Lewisburg	16,530	145.6	8,537	105.7	20.44	0.262	0.36	1.95	1.84
Newport	6,862	143.8	4,280	103.6	19.58	0.317	0.44	1.99	1.92
Marietta	56,169	139.3	33,500	88.7	14.49	0.303	0.476	2.01	2.27
Conestoga	1,052	158	2,294	116.8	24.75	1.108	1.50	7.63	6.53

Table 13. Annual Water Discharges and Annual Loads and Yields of Dissolved Phosphorus, Calendar Year 2004

Site	2004 Discharge cfs	Discharge % of LTM	2004 Load thousands of lbs	Load % of LTM	Prediction Error Percent	2004 Avg. Conc. mg/l	LTM Conc. mg/l	2004 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,337	131.8	929	121.9	18.89	0.0308	0.033	0.186	0.153
Danville	21,823	127.7	1,505	163.3	21.53	0.0350	0.027	0.210	0.128
Lewisburg	16,530	145.6	651	141.1	20.85	0.0200	0.020	0.149	0.105
Newport	6,862	143.8	672	161.0	19.61	0.0498	0.045	0.313	0.195
Marietta	56,169	139.3	3,566	151.1	17.56	0.0323	0.030	0.214	0.142
Conestoga	1,052	158	414	154.0	15.58	0.1997	0.205	1.375	0.893

Table 14. Annual Water Discharges and Annual Loads and Yields of Dissolved Orthophosphate, Calendar Year 2004

Site	2004 Discharge cfs	Discharge % of LTM	2004 Load thousands of lbs	Load % of LTM	Prediction Error Percent	2004 Avg. Conc. mg/l	LTM Conc. mg/l	2004 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,337	131.8	636	160.3	22.88	0.0211	0.017	0.128	0.080
Danville	21,823	127.7	1,067	228.9	24.94	0.0248	0.014	0.149	0.065
Lewisburg	16,530	145.6	433	229.9	31.91	0.0133	0.008	0.099	0.043
Newport	6,862	143.8	553	173.7	26.02	0.0410	0.034	0.258	0.148
Marietta	56,169	139.3	2,757	169.6	23.32	0.0249	0.021	0.166	0.098
Conestoga	1,052	158	383	173.6	21.67	0.1847	0.168	1.272	0.733

Table 15. Annual Water Discharges and Annual Loads and Yields of Dissolved Ammonia, Calendar Year 2004

Site	2004 Discharge cfs	Discharge % of LTM	2004 Load thousands of lbs	Load % of LTM	Prediction Error Percent	2004 Avg. Conc. mg/l	LTM Conc. mg/l	2004 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,337	131.8	1,346	115.8	18.46	0.0446	0.051	0.270	0.233
Danville	21,823	127.7	2,167	123.4	19.43	0.0504	0.052	0.302	0.244
Lewisburg	16,530	145.6	1,299	117.6	17.51	0.0399	0.049	0.296	0.252
Newport	6,862	143.8	619	170.3	19.30	0.0458	0.039	0.288	0.169
Marietta	56,169	139.3	6,113	161.3	19.43	0.0553	0.048	0.368	0.228
Conestoga	1,052	158	219	111.2	33.00	0.1056	0.15	0.727	0.654

Table 16. Annual Water Discharges and Annual Loads and Yields of Dissolved Nitrogen, Calendar Year 2004

Site	2004 Discharge cfs	Discharge % of LTM	2004 Load thousands of lbs	Load % of LTM	Prediction Error Percent	2004 Avg. Conc. mg/l	LTM Conc. mg/l	2004 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,337	131.8	27,868	117.9	5.79	0.923	1.032	5.585	4.739
Danville	21,823	127.7	39,966	107.7	6.12	0.930	1.103	5.566	5.168
Lewisburg	16,530	145.6	28,866	119.1	6.49	0.887	1.084	6.587	5.532
Newport	6,862	143.8	24,264	158.8	4.87	1.796	1.626	11.304	7.117
Marietta	56,169	139.3	161,236	165.8	6.43	1.458	1.225	9.693	5.847
Conestoga	1,052	158	14,573	151.6	6.22	7.037	7.326	48.448	31.949

Table 17. Annual Water Discharges and Annual Loads and Yields of Dissolved NO_{23} Nitrogen, Calendar Year 2004

Site	2004 Discharge cfs	Discharge % of LTM	2004 Load thousands of lbs	Load % of LTM	Prediction Error Percent	2004 Avg. Conc. mg/l	LTM Conc. mg/l	2004 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,337	131.8	21,023	137.1	6.67	0.697	0.670	4.213	3.074
Danville	21,823	127.7	29,985	119.4	6.76	0.698	0.746	4.176	3.497
Lewisburg	16,530	145.6	24,732	142.6	6.68	0.760	0.776	5.644	3.959
Newport	6,862	143.8	22,142	174.6	5.28	1.639	1.350	10.315	5.907
Marietta	56,169	139.3	140,328	208.8	6.90	1.269	0.846	8.436	4.040
Conestoga	1,052	158	12,944	154.7	7.67	6.250	6.379	43.030	27.820

Table 18. Annual Water Discharges and Annual Loads and Yields of Dissolved Organic Nitrogen, Calendar Year 2004

Site	2004 Discharge cfs	Discharge % of LTM	2004 Load thousands of lbs	Load % of LTM	Prediction Error Percent	2004 Avg. Conc. mg/l	LTM Conc. mg/l	2004 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,337	131.8	6,910	85.4	10.94	0.229	0.353	1.385	1.621
Danville	21,823	127.7	9,676	88.4	10.74	0.225	0.326	1.347	1.525
Lewisburg	16,530	145.6	4,838	91.7	15.73	0.149	0.236	1.104	1.204
Newport	6,862	143.8	2,699	96.0	11.15	0.200	0.299	1.257	1.310
Marietta	56,169	139.3	19,979	75.1	16.73	0.181	0.335	1.201	1.599
Conestoga	1,052	158	1,804	170.5	24.34	0.871	0.806	5.997	3.517

Table 19. Annual Water Discharges and Annual Loads and Yields of Total Organic Carbon, Calendar Year 2004

Site	2004 Discharge cfs	Discharge % of LTM	2004 Load thousands of lbs	Load % of LTM	Prediction Error Percent	2004 Avg. Conc. mg/l	LTM Conc. mg/l	2004 Yield lbs/ac/yr	LTM Yield lb/ac/yr
Towanda	15,337	131.8	111,601	135.6	4.90	3.696	3.594	22.365	16.498
Danville	21,823	127.7	157,771	143.7	4.54	3.672	3.262	21.971	15.285
Lewisburg	16,530	145.6	76,688	168.1	7.95	2.357	2.041	17.500	10.412
Newport	6,862	143.8	40,436	129.9	7.27	2.993	3.312	18.838	14.497
Marietta	56,169	139.3	335,726	148.6	5.74	3.036	2.846	20.184	13.585
Conestoga	1,052	158	10,296	124.3	10.47	4.971	6.316	34.229	27.546

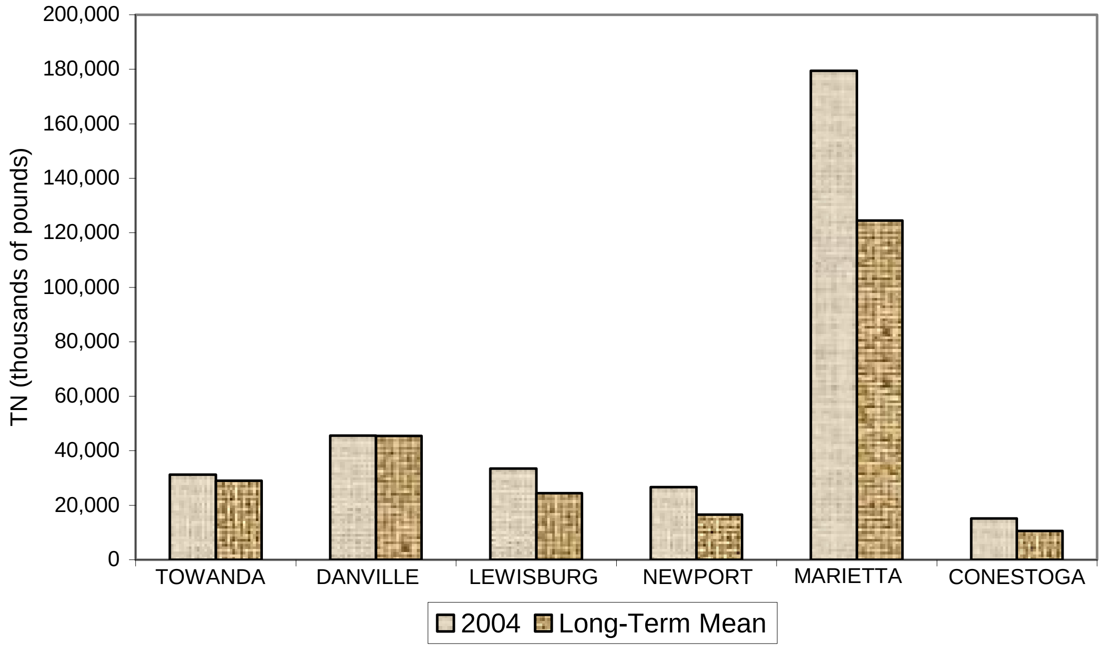


Figure 4A. ***Annual Loads of Total Nitrogen (TN) at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2004***

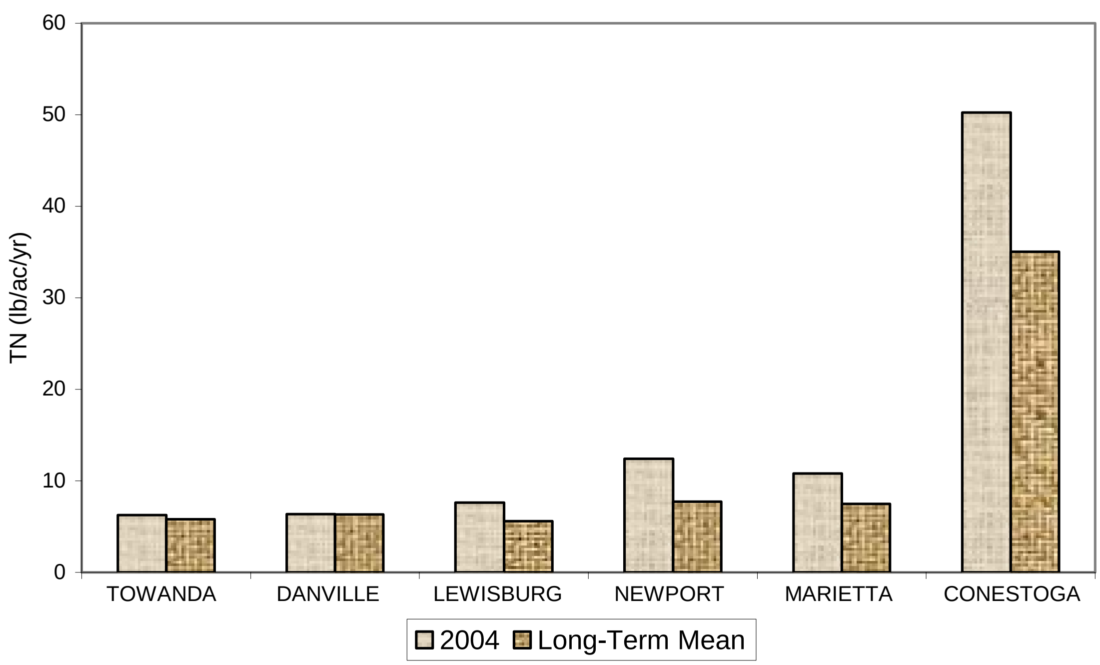


Figure 4B. ***Total Nitrogen (TN) Yields at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2004***

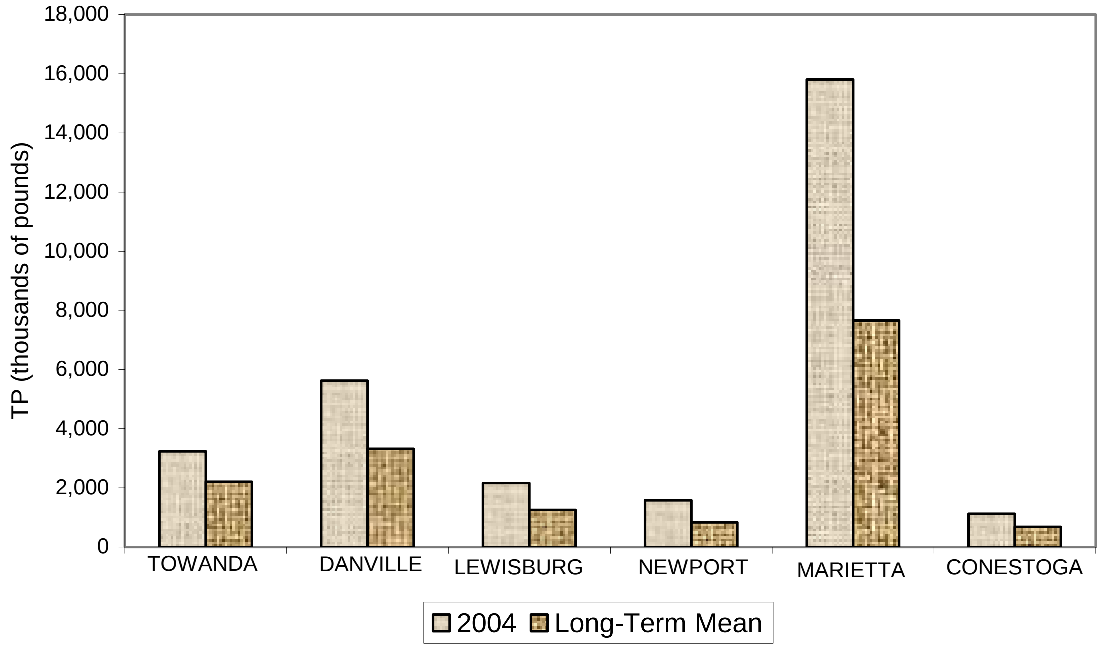


Figure 5A. Annual Loads of Total Phosphorus (TP) at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2004

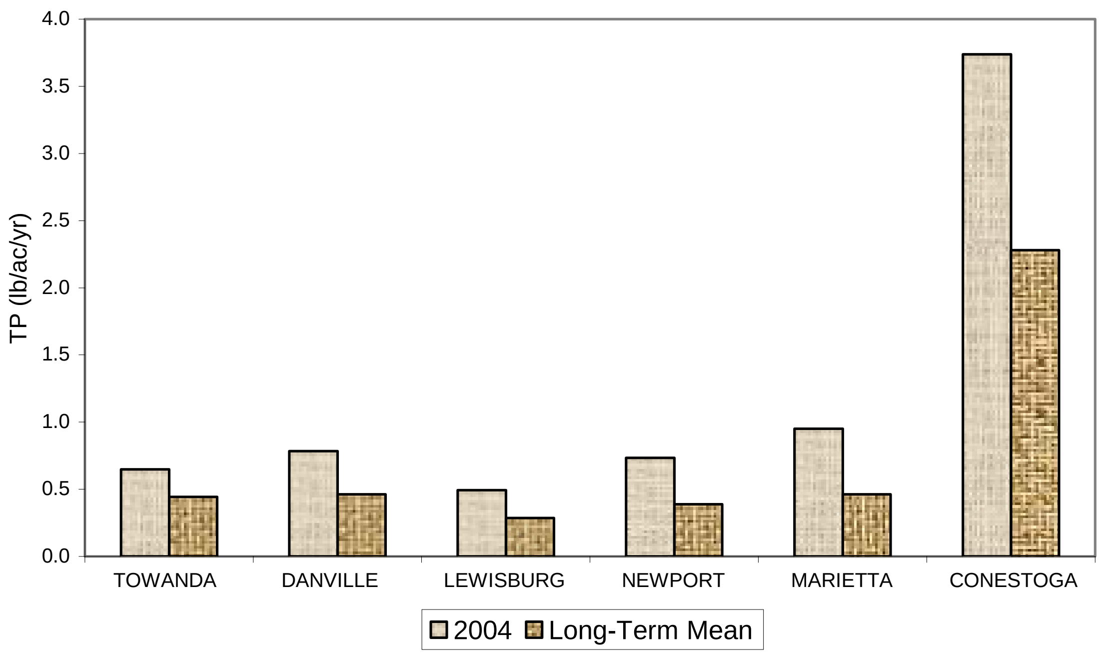


Figure 5B. Total Phosphorus (TP) Yields at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2004

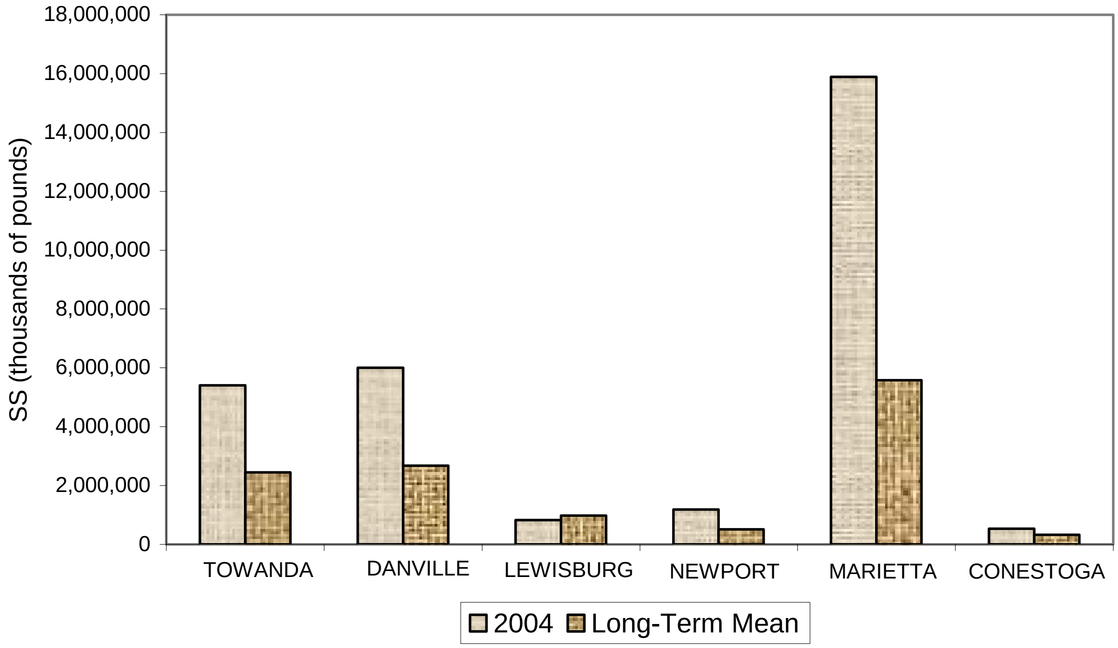


Figure 6A. Annual Loads of Suspended Sediment (SS) at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2004

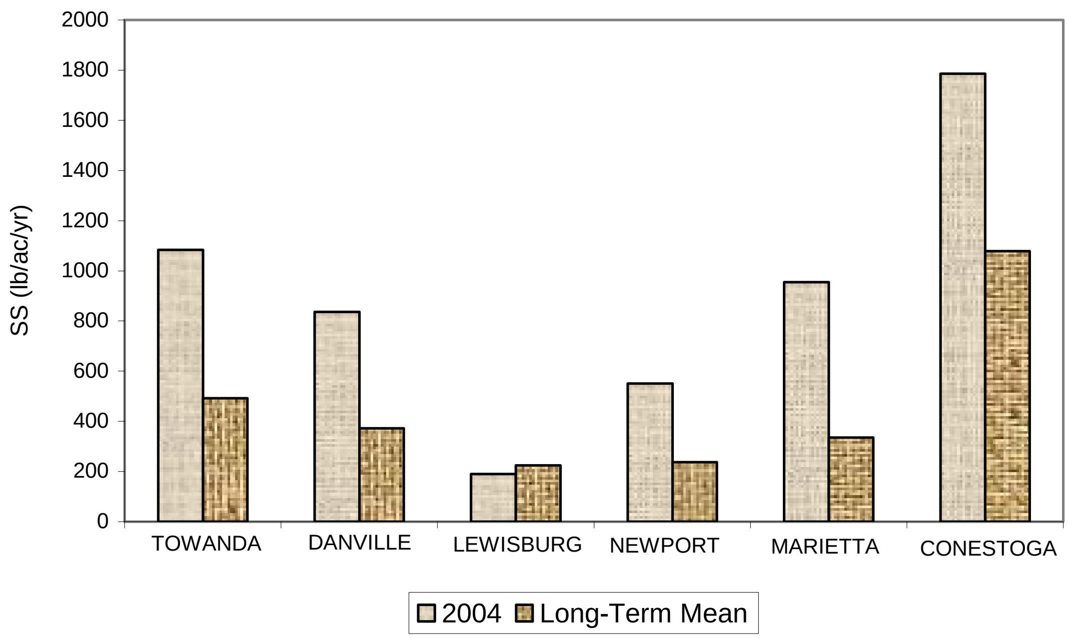


Figure 6B. Suspended Sediment (SS) Yields at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2004

Table 20. Enhanced Monitoring Station Average Concentration Data for Fall 2004

Station	Avg. Flow	Precip	Temp	Cond	pH	TN	DN	TNH_4	DNH_4	TNOx	DNOx	TP	DP	DOP	TOC	TSS
	cfs	inches	C°			mg/l										
Smithboro	16,470	9.71	7.17	181	7.28	1.15	0.90	0.102	0.034	0.628	0.502	0.039	0.025	0.019	3.74	16.1
Chemung	4,553	7.72	7.40	256	7.58	1.55	1.36	0.024	0.023	1.085	0.889	0.039	0.020	0.016	3.77	13.2
Wilkes-Barre	26,570	10.22	8.87	236	7.27	0.92	0.83	0.027	0.027	0.553	0.547	0.052	0.043	0.014	3.07	32.0
Karthaus	2,502	8.40	7.03	387	5.87	0.59	0.56	0.043	0.043	0.400	0.397	0.014	0.012	0.011	1.46	2.0
Castanea	-	8.50	7.27	261	7.35	1.66	1.66	0.037	0.030	1.393	1.393	0.024	0.013	0.013	2.01	4.7
Jersey Shore	9,775	8.74	7.47	214	6.98	0.84	0.80	0.023	0.023	0.677	0.660	0.032	0.025	0.025	1.25	4.0
Penns Creek	633	11.61	7.37	213	8.10	1.59	1.58	0.020	0.020	1.377	1.380	0.044	0.038	0.033	1.74	4.7
Saxton	1,265	7.16	10.97	253	7.57	2.24	2.25	0.020	0.023	2.080	2.077	0.013	0.010	0.010	2.03	8.0
Dromgold	411	9.99	10.57	169	7.03	2.13	2.08	0.030	0.030	1.947	1.883	0.014	0.011	0.011	1.74	4.7
Hogestown	699	8.86	12.00	417	7.77	4.70	4.70	0.020	0.020	4.553	4.307	0.015	0.011	0.011	1.71	2.0
Hershey	931	10.66	11.77	296	7.10	4.94	4.91	0.027	0.027	4.597	4.573	0.030	0.019	0.018	1.65	5.3
Manchester	518	8.64	11.23	269	7.63	2.84	2.81	0.023	0.023	2.540	2.480	0.055	0.042	0.038	3.29	4.0
Martic Forge	-	10.93	12.40	494	7.77	9.56	9.57	0.027	0.027	8.467	7.853	0.062	0.046	0.043	1.82	4.0

Table 21.   2004 Monthly Flow (Q) in Cubic Feet per Second and TN, TP, and SS in Thousands of Pounds

Site	Parameter	January	February	March	April	May	June	July	August	September	October	November	December	Annual*
Towanda	Q	11,506	4,708	27,475	20,507	16,106	6,701	12,642	14,384	27,943	6,894	10,413	23,774	15,254
	TN	2,333	866	5,394	3,502	2,549	943	1,805	2,037	4,241	1,104	1,824	4,621	31,219
	TP	115	25	381	206	150	56	283	227	1,170	78	149	393	3,233
	SS	41,183	2,768	359,747	138,529	71,952	17,993	465,651	156,322	3,761,733	18,229	93,254	282,524	5,409,885
Danville	Q	19,152	7,373	34,873	27,973	23,716	10,630	13,784	19,722	40,628	12,380	14,498	35,803	21,711
	TN	4,194	1,388	7,040	4,858	3,793	1,464	1,912	2,810	6,165	2,047	2,629	7,314	45,614
	TP	269	45	550	337	283	101	309	377	2,075	190	274	814	5,624
	SS	97,532	5,299	332,148	160,243	118,811	28,766	282,270	200,197	4,165,133	50,161	135,019	428,752	6,004,331
Lewisburg	Q	17,575	5,183	27,414	20,213	18,735	6,983	12,261	12,513	34,921	8,523	10,614	22,367	16,442
	TN	3,569	1,029	4,948	3,147	2,731	986	1,717	1,781	5,429	1,519	2,030	4,541	33,427
	TP	200	25	267	137	125	34	125	105	730	69	95	252	2,164
	SS	65,611	1,938	92,251	34,376	30,316	4,220	49,281	25,360	452,754	8,562	14,279	52,695	831,643
Newport	Q	7,045	2,798	11,733	12,202	5,873	2,808	2,996	3,532	15,957	3,503	4,928	8,718	6,841
	TN	2,559	801	3,742	3,555	1,686	716	850	1,080	5,246	1,226	1,785	3,362	26,608
	TP	107	25	180	192	83	38	52	66	554	58	77	140	1,572
	SS	44,813	3,525	100,319	115,976	27,791	8,135	14,712	19,046	771,129	11,205	20,313	45,865	1,182,829
Marietta	Q	52,316	25,634	84,797	75,837	58,368	29,360	33,416	46,894	110,893	33,890	35,943	83,871	55,935
	TN	16,765	6,539	22,386	17,549	13,013	5,943	7,506	11,550	29,501	10,023	10,992	27,705	179,472
	TP	879	176	1,414	1,037	745	304	686	938	6,897	522	515	1,693	15,806
	SS	425,658	33,275	868,732	550,453	336,233	98,848	480,247	510,837	11,500,093	159,268	163,702	759,807	15,887,153
Conestoga	Q	724	1,399	676	964	747	804	1,693	1,730	1,222	79	756	1,173	997
	TN	1,024	1,620	913	1,173	930	922	1,775	1,903	1,350	957	975	1,572	15,114
	TP	31	147	26	46	34	48	276	222	149	39	42	64	1,124
	SS	7,117	112,506	6,267	17,666	8,574	16,248	163,924	107,325	64,839	5,911	9,714	16,983	537,074

*Annual flow is average for the year
*Annual loads are total for the year

SEASONAL WATER DISCHARGES AND NUTRIENT AND SUSPENDED-SEDIMENT LOADS AND YIELDS

Seasonal loads for all parameters and all sites are listed in Table 22 for loads and Table 23 for percentages (high values in boldface type). Figures 7-16 show graphs of TN, TP, and SS for each season at each site. For the purposes of this project, January through March is winter, April through June is spring, July through September is summer, and October through December is fall. As a general note, nutrient and SS levels increase with increases in flow.

Table 22. Seasonal Mean Water Discharges and Loads of Nutrients and Suspended Sediment, Calendar Year 2004

Station	Season	Mean Water Discharge	Total Nitrogen as N	Dissolved Nitrogen as N	Total Ammonia as N	Dissolved Ammonia as N	Total Organic Nitrogen as N	Dissolved Organic Nitrogen as N	Total Nitrate Plus Nitrite as N	Dissolved Nitrate Plus Nitrite as N	Total Phosphorus as P	Dissolved Phosphorus as P	Dissolved Ortho-Phosphate as P	Total Organic Carbon	Suspended Sediment
		cfs	thousands of pounds												
Towanda	Winter	14,944	**8,592**	**8,065**	661	644	2,138	1,672	**9,214**	**9,245**	521	199	147	20,233	403,698
	Spring	14,456	6,994	6,350	372	409	2,039	1,530	6,638	6,633	412	159	112	21,297	228,474
	Summer	**18,218**	8,083	6,544	531	441	**3,782**	**2,325**	5,831	5,688	**1,680**	**321**	**212**	**46,618**	**4,383,707**
	Fall	13,729	7,550	6,909	**786**	**673**	1,816	1,383	8,505	8,419	619	250	166	23,453	394,007
Danville	Winter	20,984	**12,621**	**11,908**	687	770	3,142	2,459	11,029	**11,022**	864	322	246	27,851	434,979
	Spring	20,806	10,115	8,942	380	470	3,194	2,223	7,929	7,868	720	257	195	30,109	307,820
	Summer	**24,538**	10,887	8,380	187	200	**5,325**	**2,789**	3,384	3,304	**2,761**	**468**	312	**63,025**	**4,647,599**
	Fall	20,963	11,989	10,737	**829**	**812**	3,044	2,205	**11,098**	10,917	1,278	458	**313**	36,786	915,735
Lewisburg	Winter	17,166	**9,547**	**8,484**	**422**	**409**	2,355	**1,486**	**7,006**	**6,983**	492	165	107	15,747	159,800
	Spring	15,348	6,863	6,144	228	260	1,601	1,084	5,215	5,190	297	115	76	13,227	68,911
	Summer	**19,735**	8,927	6,988	248	276	**3,066**	1,303	5,917	5,807	**960**	**187**	**134**	**33,160**	**527,396**
	Fall	13,870	8,099	7,249	383	354	1,515	965	6,780	6,751	415	184	116	14,553	75,536
Newport	Winter	7,370	7,102	**6,624**	150	146	1,095	748	**6,004**	**5,983**	312	145	119	9,035	148,658
	Spring	6,949	5,958	5,428	139	137	1,039	644	4,909	4,881	314	136	107	8,808	151,902
	Summer	**7,403**	**7,175**	6,147	**247**	**197**	**1,493**	**780**	5,444	5,387	**673**	**234**	**205**	**14,636**	**804,887**
	Fall	5,725	6,374	6,064	146	139	653	527	5,913	5,891	275	157	123	7,957	77,383
Marietta	Winter	55,488	45,689	42,980	2,015	1,785	7,952	5,102	37,950	37,401	2,468	767	625	63,029	1,327,665
	Spring	54,564	36,505	33,107	1,133	1,140	6,709	4,122	29,225	28,716	2,086	702	528	64,652	985,534
	Summer	**63,222**	48,558	39,718	1,835	1,370	**11,865**	**6,410**	33,252	32,468	**8,520**	**1232**	**948**	**136,340**	**12,491,178**
	Fall	51,401	**48,720**	**45,430**	**2,239**	**1,818**	6,974	4,346	**42,508**	**41,743**	2,730	866	657	71,706	1,082,778
Conestoga	Winter	933	3,557	3,409	57	54	639	507	2,865	2,861	204	69	53	2,049	159,889
	Spring	837	3,026	2,958	32	31	417	364	2,704	2,665	128	58	53	1,763	42,488
	Summer	**1,551**	**5,029**	**4,706**	**103**	**89**	**820**	**548**	**4,395**	**4,292**	**647**	**201**	**200**	**4,589**	**336,089**
	Fall	888	3,505	3,500	48	45	418	384	3,145	3,126	145	85	78	1,895	32,608

Table 23. Seasonal Mean Water Discharge and Load Percentages of Nutrients and Suspended Sediment, Calendar year 2004

Station	Season	Mean Water Discharge	Total Nitrogen as N	Dissolved Nitrogen as N	Total Ammonia as N	Dissolved Ammonia as N	Total Organic Nitrogen as N	Dissolved Organic Nitrogen as N	Total Nitrate Plus Nitrite as N	Dissolved Nitrate Plus Nitrite as N	Total Phosphorus as P	Dissolved Phosphorus as P	Dissolved Ortho-Phosphate as P	Total Organic Carbon	Suspended Sediment
		cfs	thousands of pounds												
Towanda	Winter	24	**28**	**29**	28	30	22	24	**31**	**31**	16	21	23	18	7
	Spring	24	22	23	16	19	21	22	22	22	13	17	18	19	4
	Summer	**30**	26	23	23	20	**38**	**34**	19	19	**52**	**35**	**33**	**42**	**82**
	Fall	22	24	25	**33**	**31**	19	20	28	28	19	27	26	21	7
Danville	Winter	24	**28**	**30**	33	34	21	25	33	**33**	15	21	23	18	7
	Spring	24	22	22	18	21	22	23	24	24	13	17	18	19	5
	Summer	**28**	24	21	9	9	**36**	**29**	10	10	**49**	**32**	29	**40**	**73**
	Fall	24	26	27	**40**	**36**	21	23	**33**	33	23	30	**30**	23	15
Lewisburg	Winter	26	**28**	**30**	**33**	**32**	28	**31**	**28**	**29**	23	25	25	21	19
	Spring	23	21	21	18	20	19	22	21	21	14	18	18	17	8
	Summer	**30**	27	24	19	21	**35**	27	24	23	**44**	**29**	**30**	**43**	**64**
	Fall	21	24	25	30	27	18	20	27	27	19	28	27	19	9
Newport	Winter	27	27	**28**	22	24	26	28	**27**	**27**	20	22	21	22	13
	Spring	25	22	22	20	22	24	24	22	22	20	20	19	22	13
	Summer	**27**	**27**	25	**37**	**32**	**35**	**28**	24	24	**43**	**35**	**38**	**36**	**67**
	Fall	21	24	25	21	22	15	20	27	27	17	23	22	20	7
Marietta	Winter	25	25	26	**28**	29	24	26	27	27	16	22	23	19	8
	Spring	24	20	21	16	19	20	21	20	20	13	20	19	19	6
	Summer	**28**	27	25	25	22	**35**	**31**	23	23	**54**	**34**	**34**	**41**	**79**
	Fall	23	**28**	**28**	31	**30**	21	22	**30**	**30**	17	24	24	21	7
Conestoga	Winter	22	24	23	24	25	28	28	22	22	18	17	14	20	28
	Spring	20	20	20	13	14	18	20	21	21	11	14	14	17	7
	Summer	**37**	**33**	**33**	**43**	**40**	**36**	**31**	**33**	**33**	**58**	**48**	**52**	**45**	**59**
	Fall	21	23	24	20	21	18	21	24	24	13	21	20	18	6

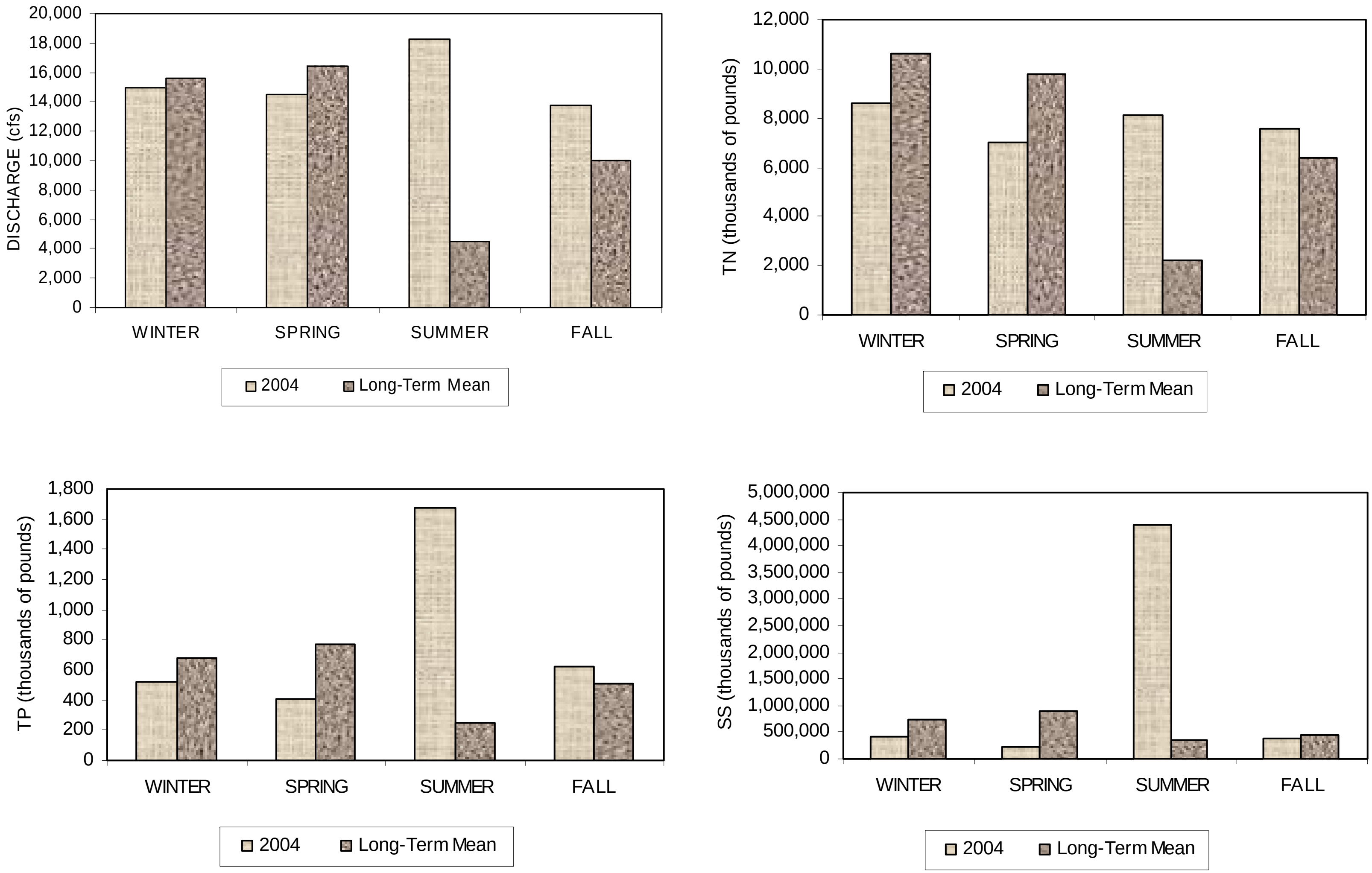


Figure 7. Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), Suspended Sediment (SS) at Towanda, Pa., Calendar Year 2004

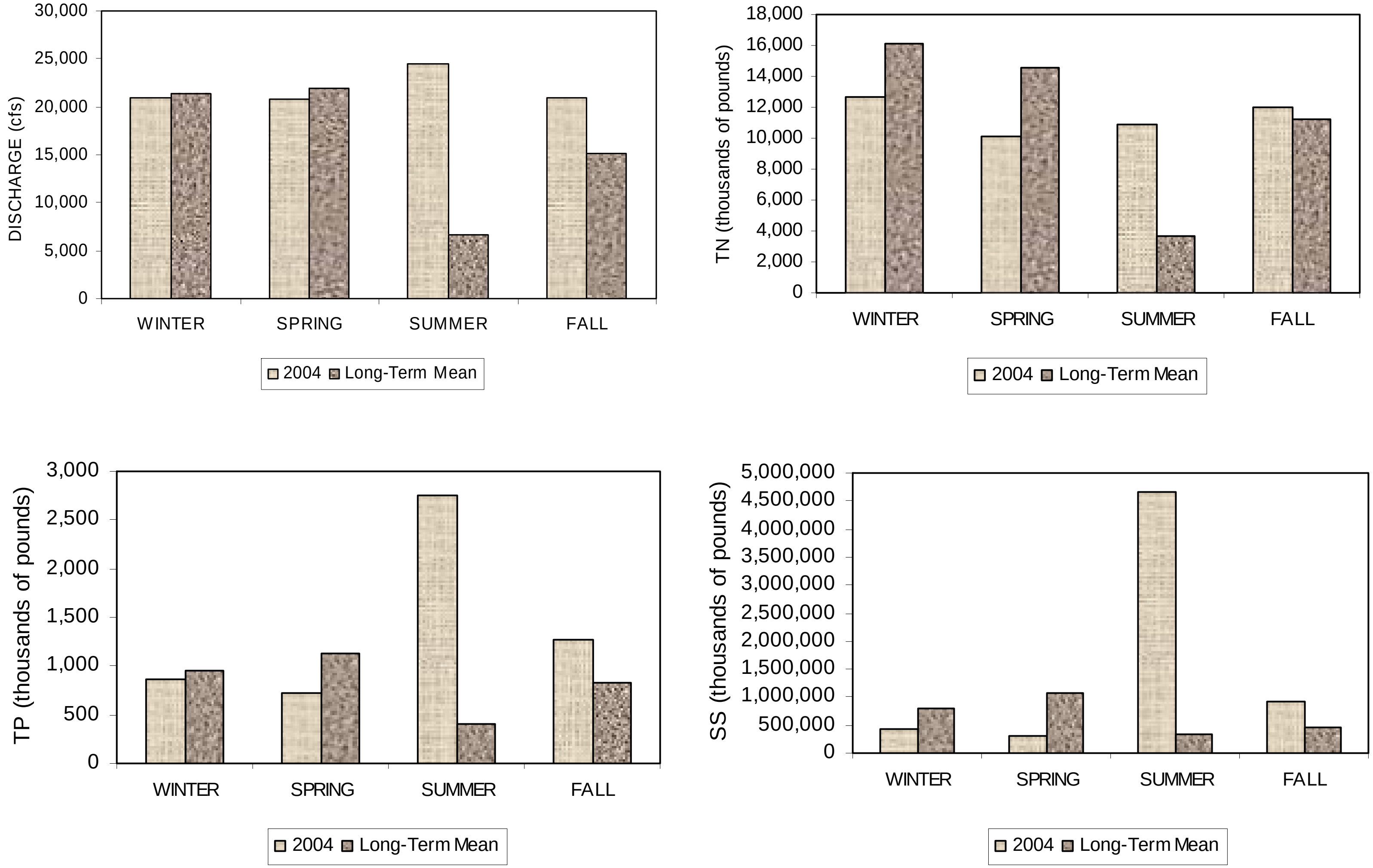


Figure 8. Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), Suspended Sediment (SS) at Danville, Pa., Calendar Year 2004

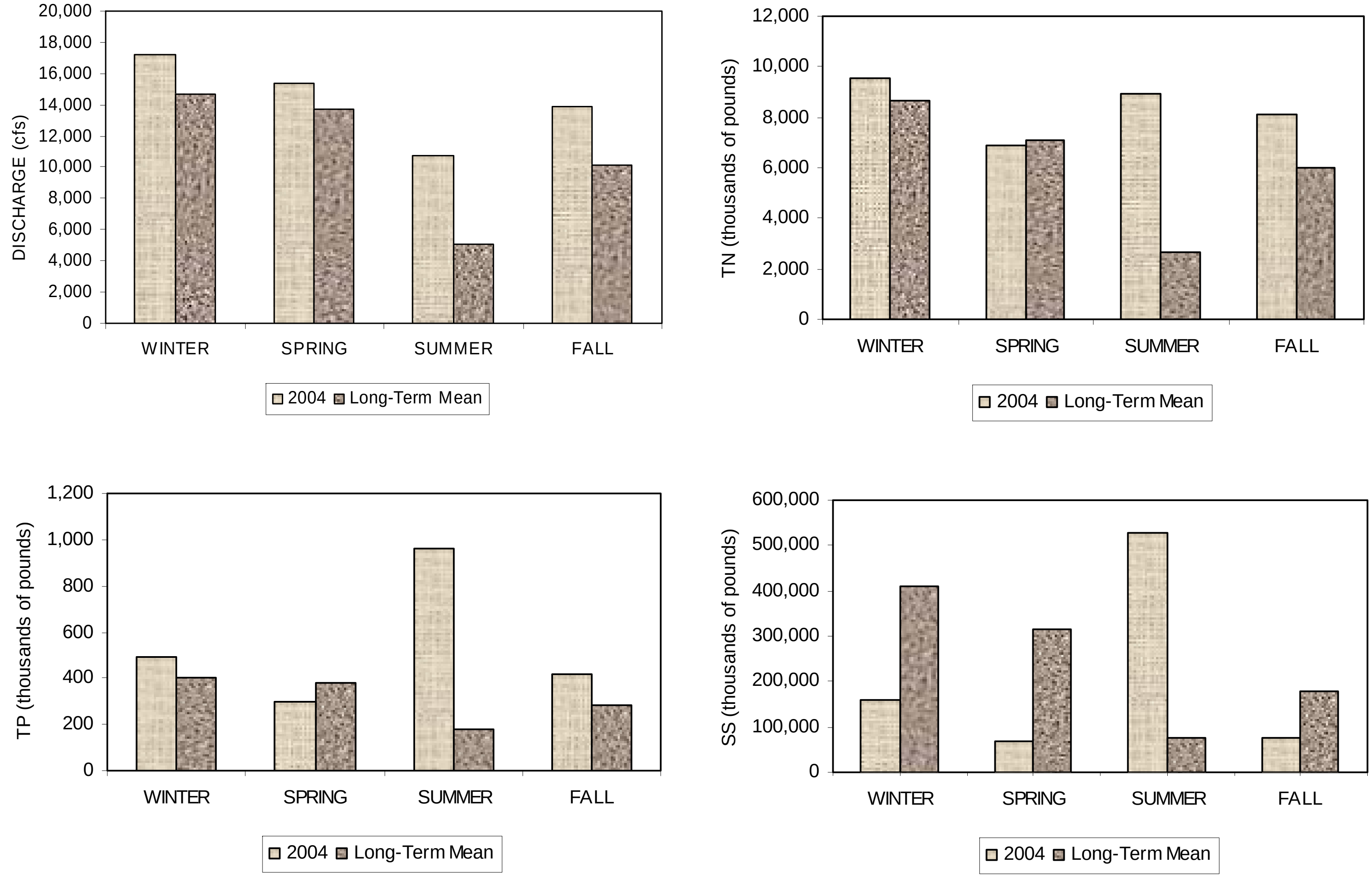


Figure 9. Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), Suspended Sediment (SS) at Lewisburg, Pa., Calendar Year 2004

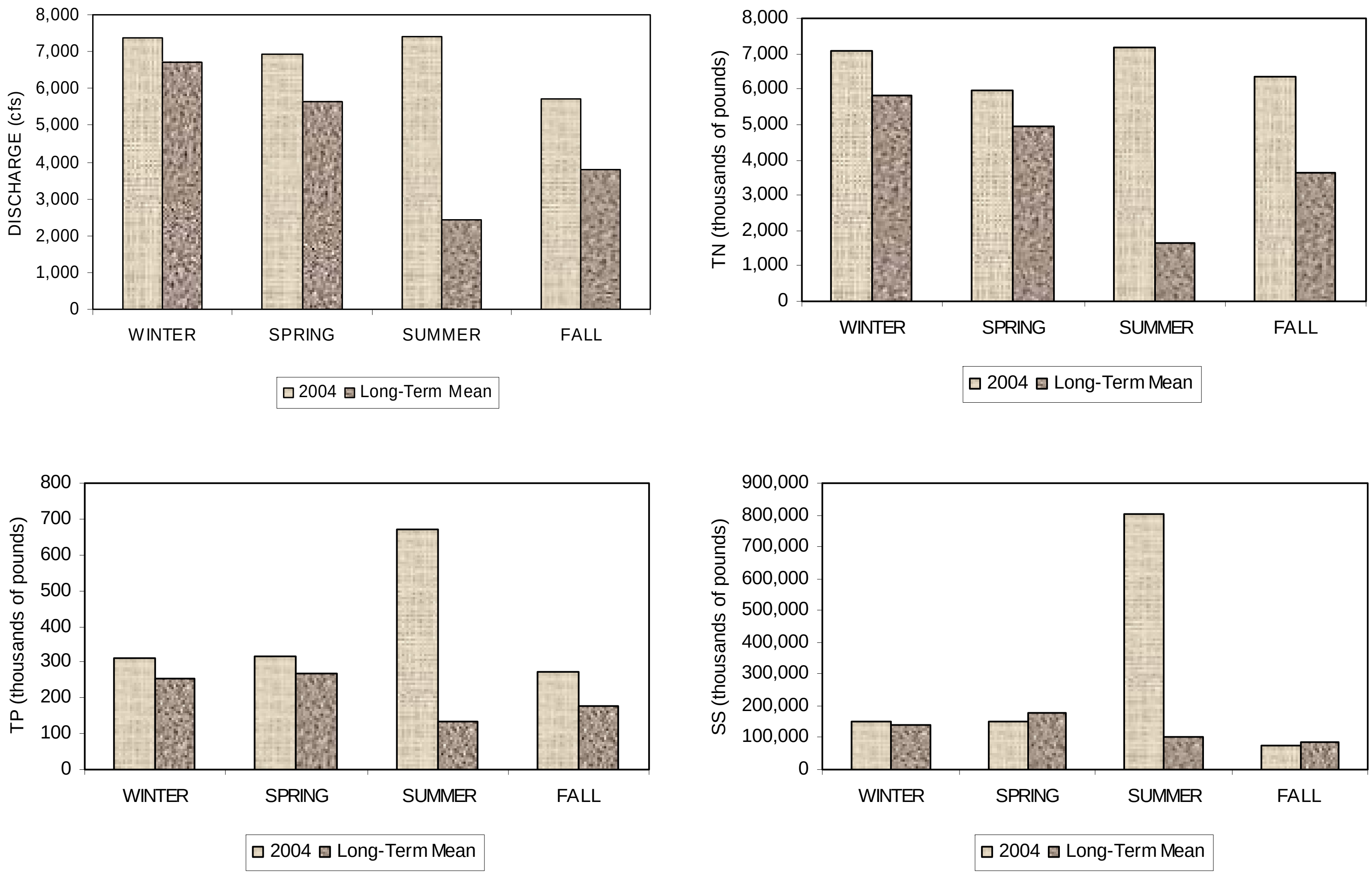


Figure 10. Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), Suspended Sediment (SS) at Newport, Pa., Calendar Year 2004

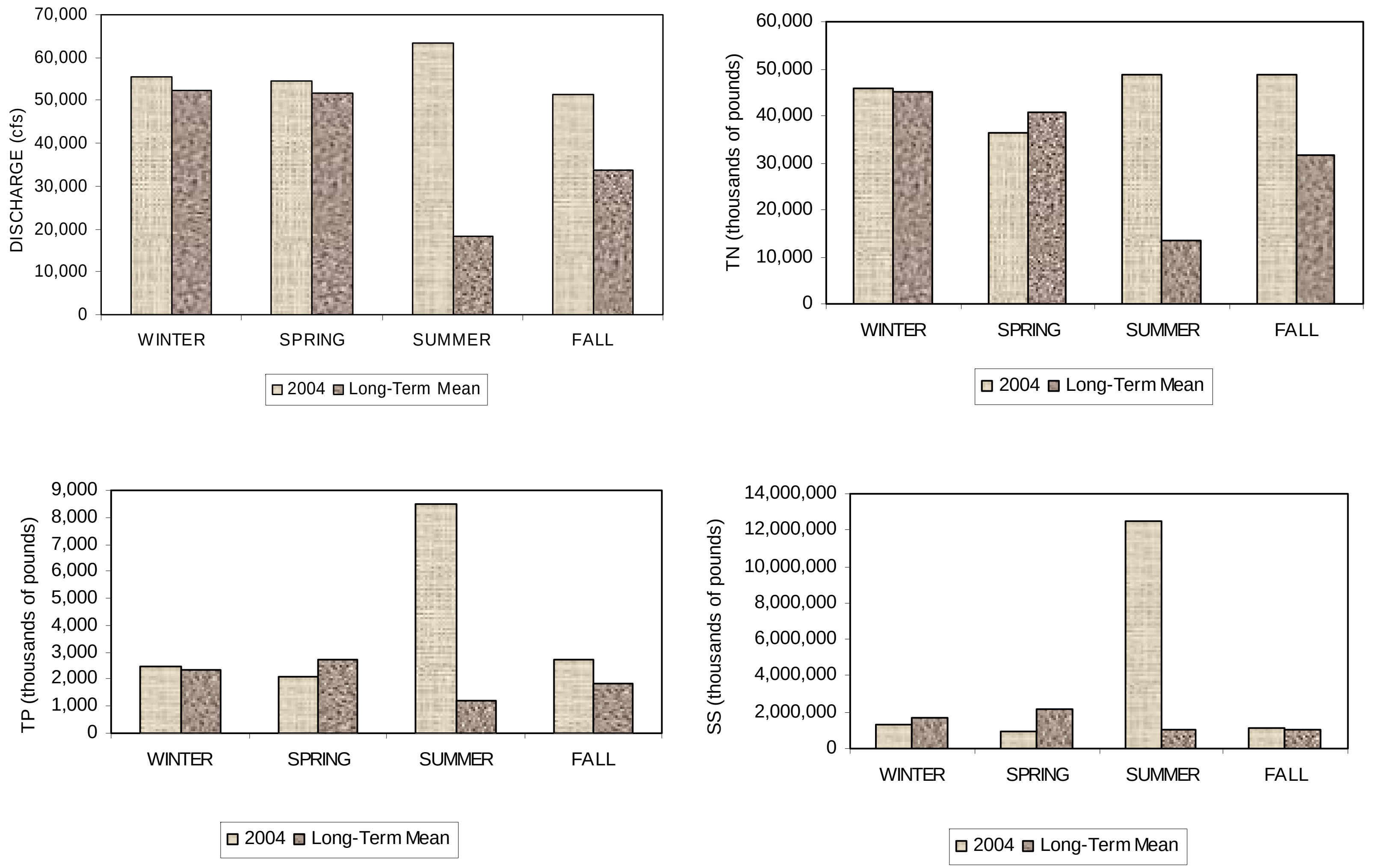


Figure 11. ***Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), Suspended Sediment (SS) at Marietta, Pa., Calendar Year 2004***

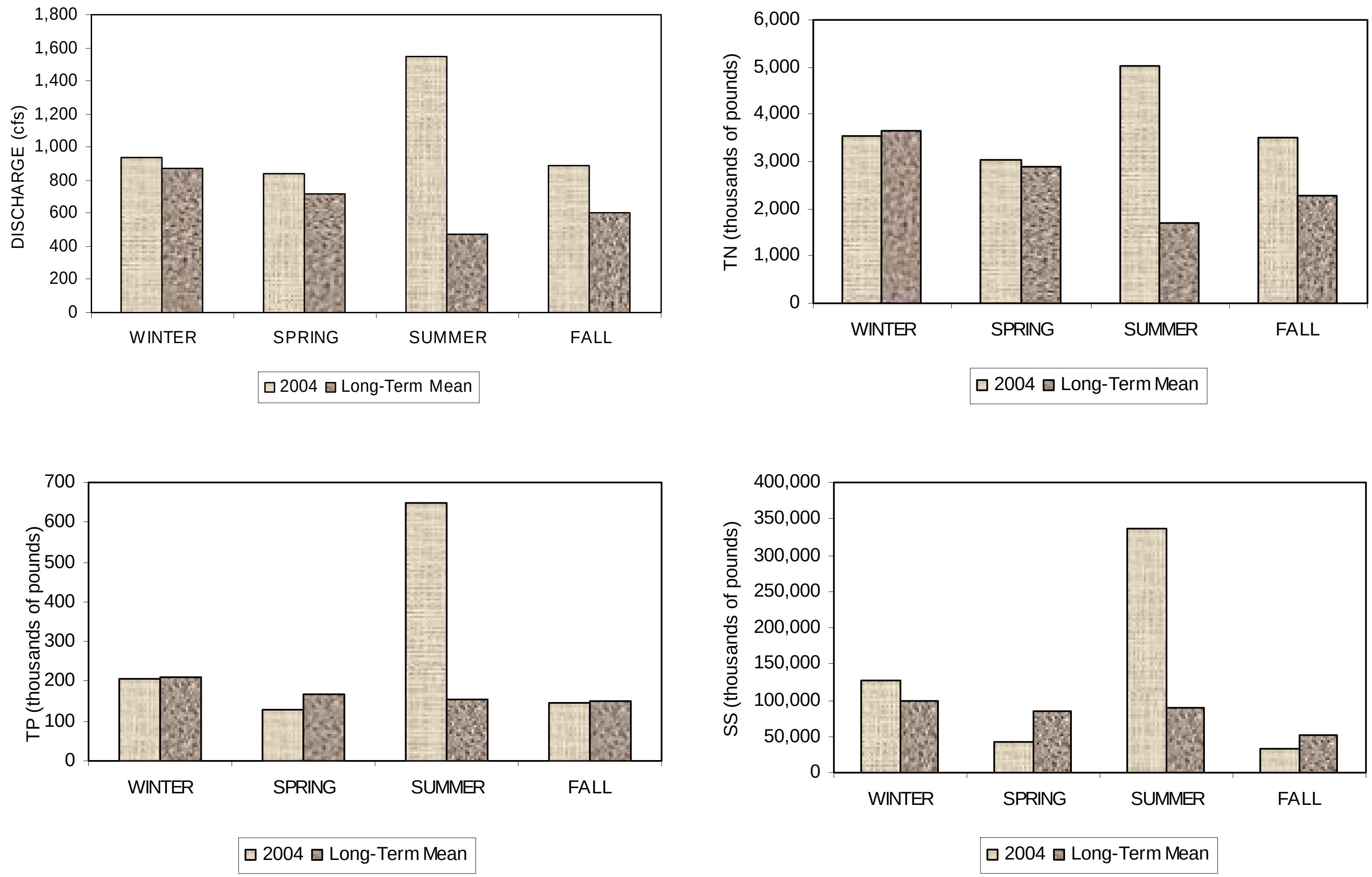
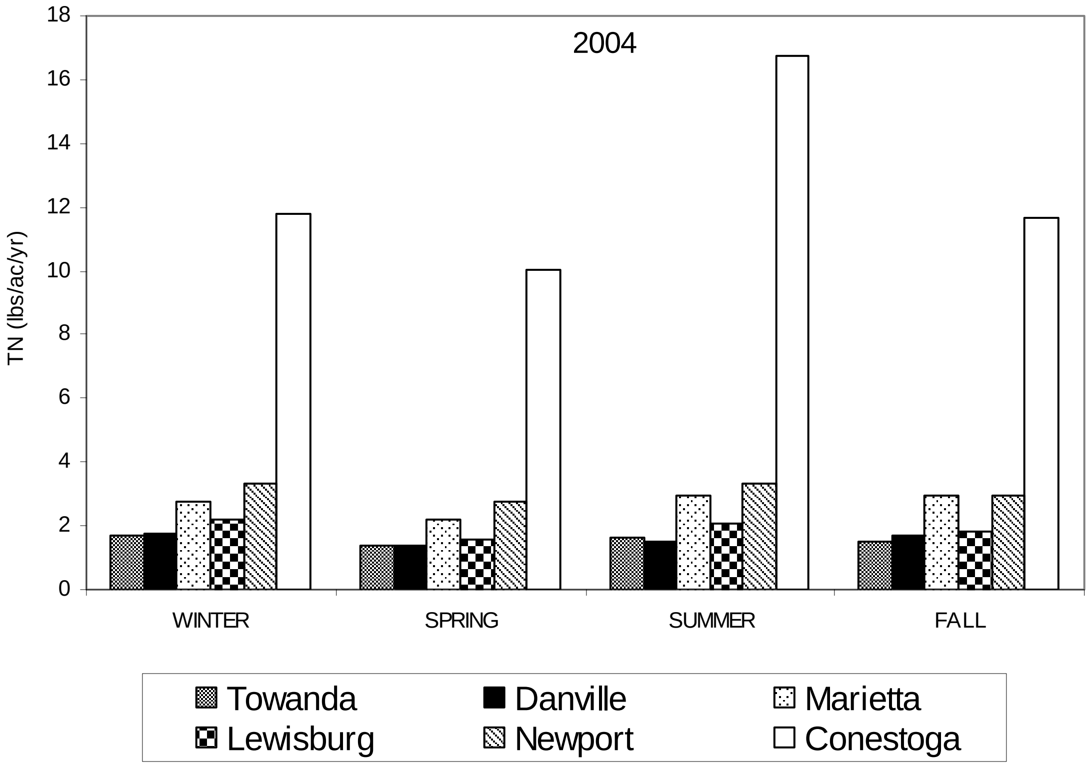


Figure 12. ***Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), Suspended Sediment (SS) at Conestoga, Pa., Calendar Year 2004***



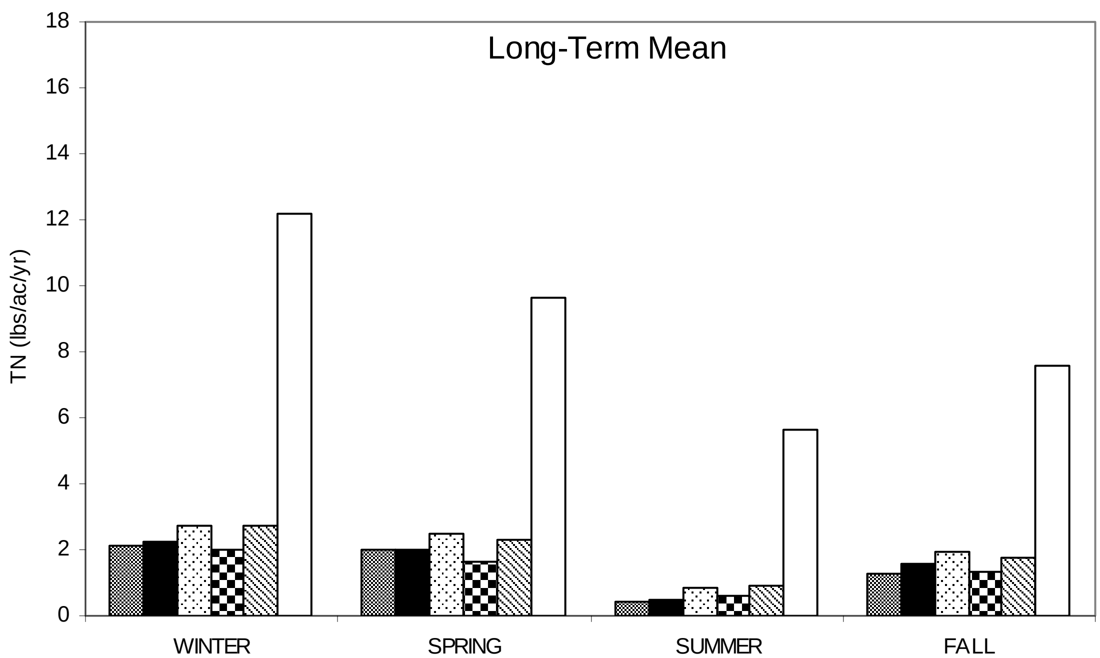


Figure 13. ***Comparison of Seasonal Yields of Total Nitrogen (TN) at Towanda, Danville, Marietta, Lewisburg, Newport, and Conestoga, Pa.***

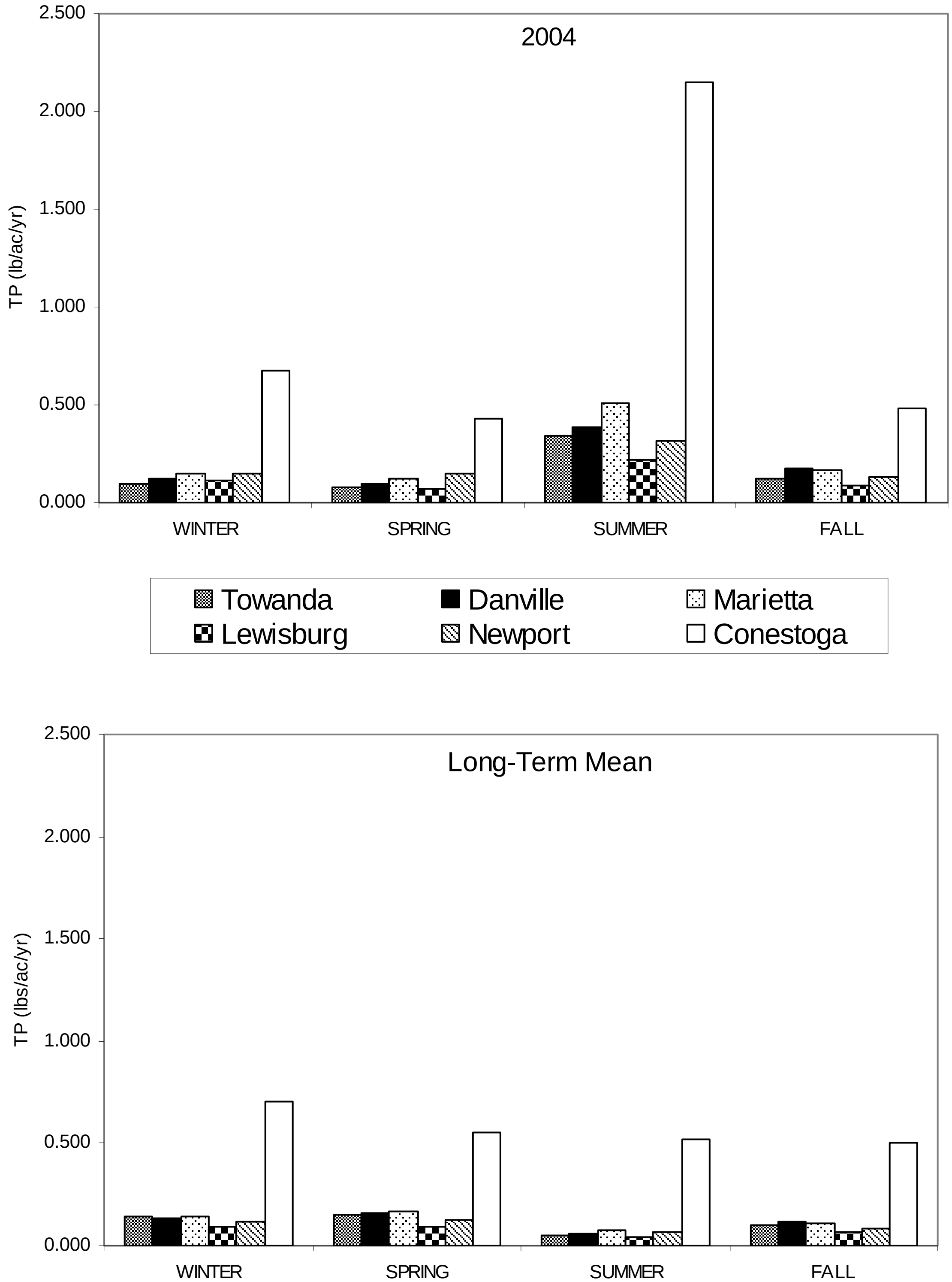


Figure 14. ***Comparison of Seasonal Yields of Total Phosphorus (TP) at Towanda, Danville, Marietta, Lewisburg, Newport, and Conestoga, Pa.***

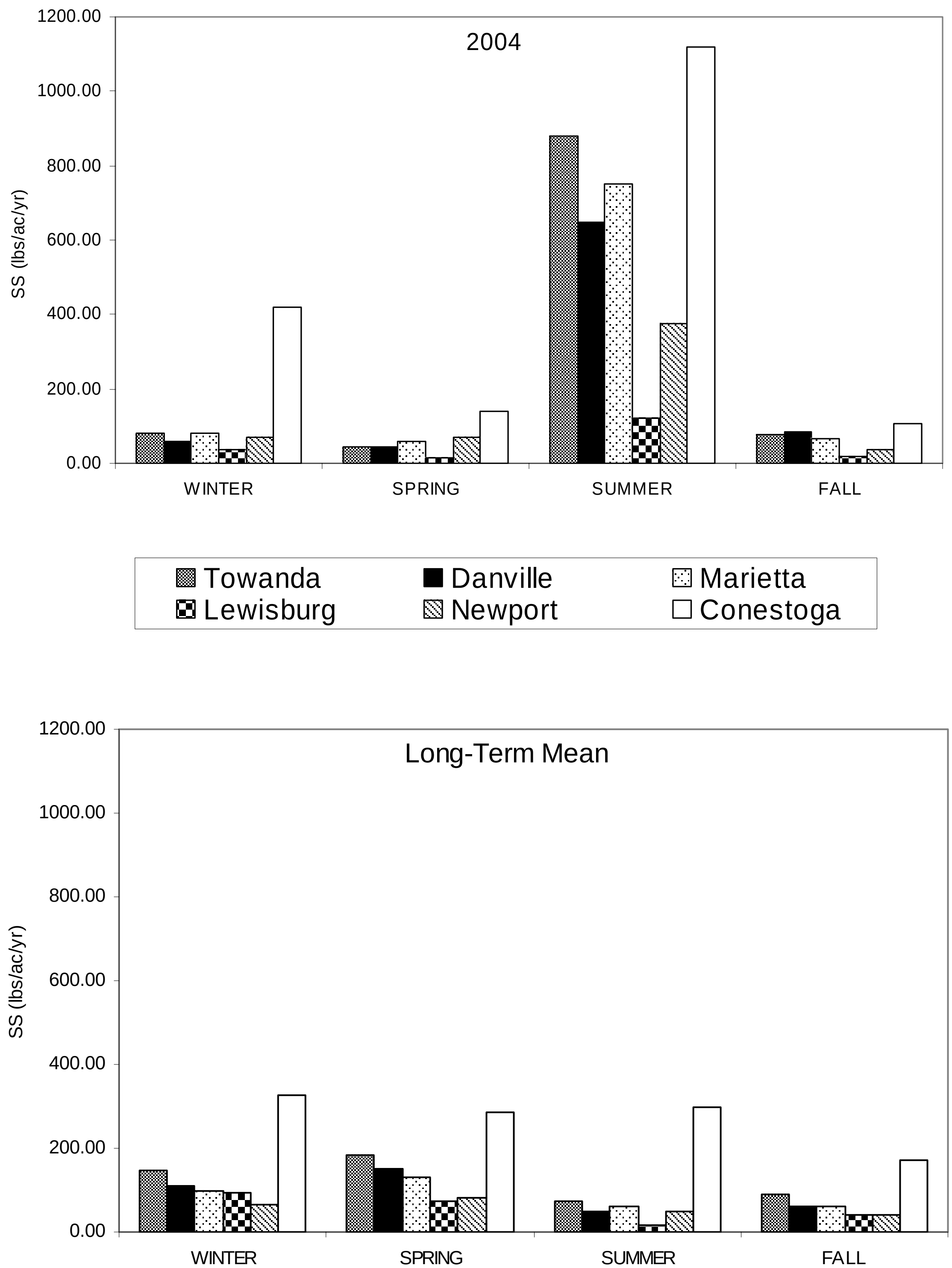


Figure 15. ***Comparison of Seasonal Yields of Suspended Sediment (SS) at Towanda, Danville, Marietta, Lewisburg, Newport, and Conestoga, Pa.***

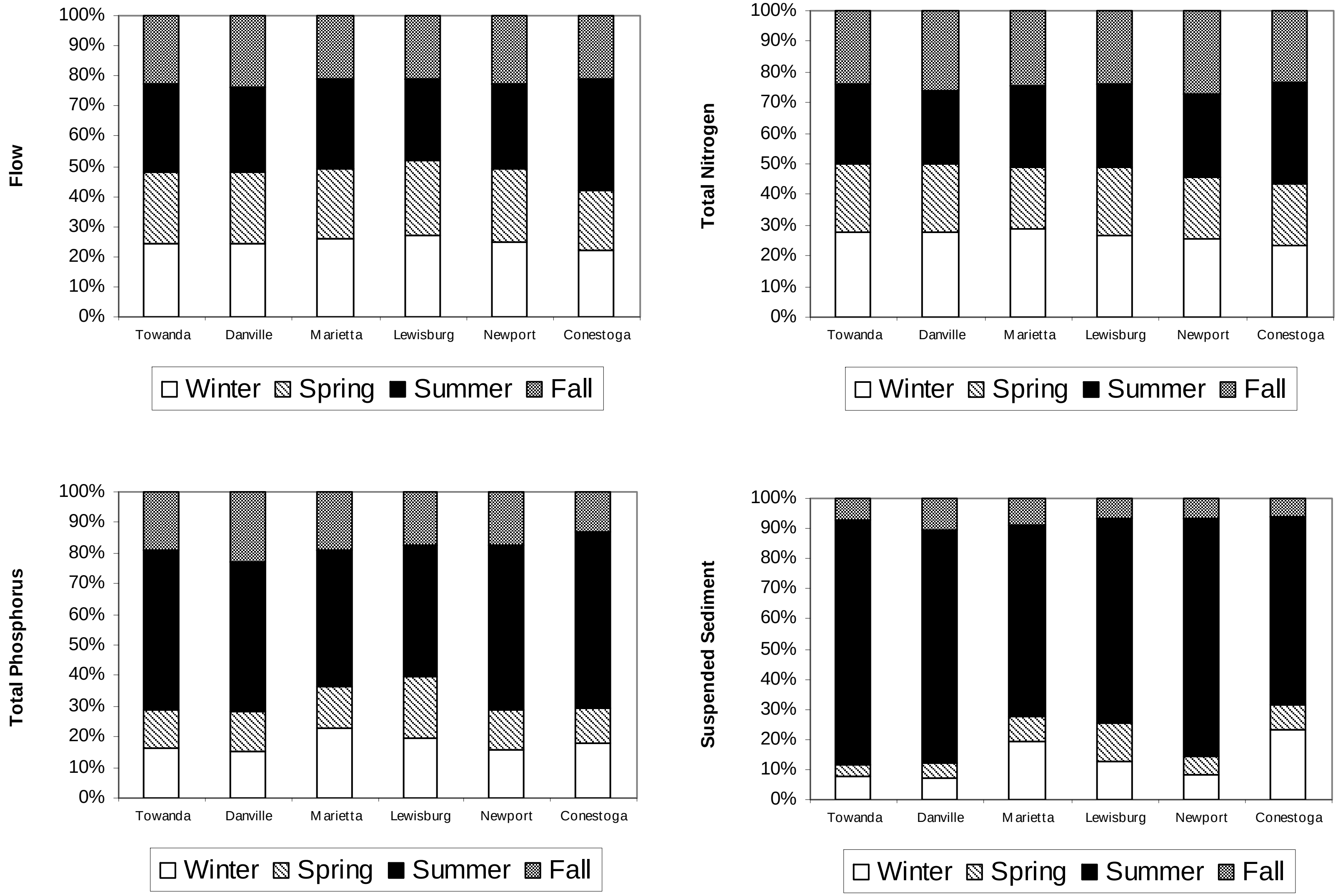


Figure 16. ***Seasonal Percent of Annual Load of Total Nitrogen, Total Phosphorus, and Suspended Sediment at Towanda, Danville, Marietta, Lewisburg, Newport, and Conestoga, Pa., Calendar Year 2004.***

COMPARISON OF THE 2004 LOADS AND YIELDS OF TOTAL NITROGEN, TOTAL PHOSPHORUS, AND SUSPENDED SEDIMENT WITH THE BASELINES

Annual fluctuations of nutrient and SS loads and water discharge create difficulties in determining whether the changes observed were related to land use, nutrient availability, or simply annual water discharge. Ott and others (1991) used the relationship between annual loads and annual water discharge to provide a method to reduce the variability of loadings due to discharge. This was accomplished by plotting the annual yields against the water-discharge ratio. This water-discharge ratio is the ratio of the annual mean discharge to the LTM discharge. Data from the initial 5-year study (1985-89) were used to provide a best-fit linear regression line to be used as the baseline relationship between annual yields and water discharge. It was hypothesized that, as future yields and water-discharge ratios were plotted against the baseline, any significant deviation from the baseline would indicate that some change in the annual yield had occurred, and that further evaluations to determine the reason for the change were warranted. The data collected in 2004 were compared with the 1985-89 baselines, where possible. Monitoring at some of the stations was started after 1987; therefore, a baseline was established for the 5-year period following the start of monitoring. 2004 yield values also were plotted against a baseline developed with data from the beginning of each dataset (usually 1985) through 2004. Figures 17-28 display the baseline graphs and the 2004 yields.

Susquehanna River at Towanda, Pa.

The baselines for TN, TP, and SS for the Susquehanna River at Towanda are shown in Figures 17 and 18 with the 2004 annual yield. Actual 2004 and baseline yields are listed in Table 24 along with the discharge ratio. Best-fit lines were drawn through the data sets using the following equations:

Initial 5-year Baseline;

Total Nitrogen (TN)

TN Yield = 0.0642 + 6.6451x $R^2 = 0.86$

Total Phosphorus (TP)

TP Yield = -0.1375 + 0.5399x $R^2 = 0.53$

Suspended Sediment (SS)

SS Yield = -620.42 + 1006.5x $R^2 = 0.43$

Where x = water-discharge ratio and R2 = correlation coefficient

2004 Baselines;

Total Nitrogen (TN)

TN Yield = 0.6019 + 5.2078x $R^2 = 0.75$

Total Phosphorus (TP)

TP Yield = -0.1606 + 0.6027x $R^2 = 0.70$

Suspended Sediment (SS)

SS Yield = -701.9 + 1193.4x $R^2 = 0.60$

Table 24. Comparison of 2004 TN, TP, and SS Yields with Baseline Yields at Towanda, Pa.

Parameter	Discharge Ratio	1989 – 1993 Baseline lb/ac/yr	1989 - 2004 Baseline lb/ac/yr	2004 lb/ac/yr
TN	1.427	9.547	8.033	6.256
TP	1.427	0.633	0.699	0.648
SS	1.427	815.856	1000.92	1084.13

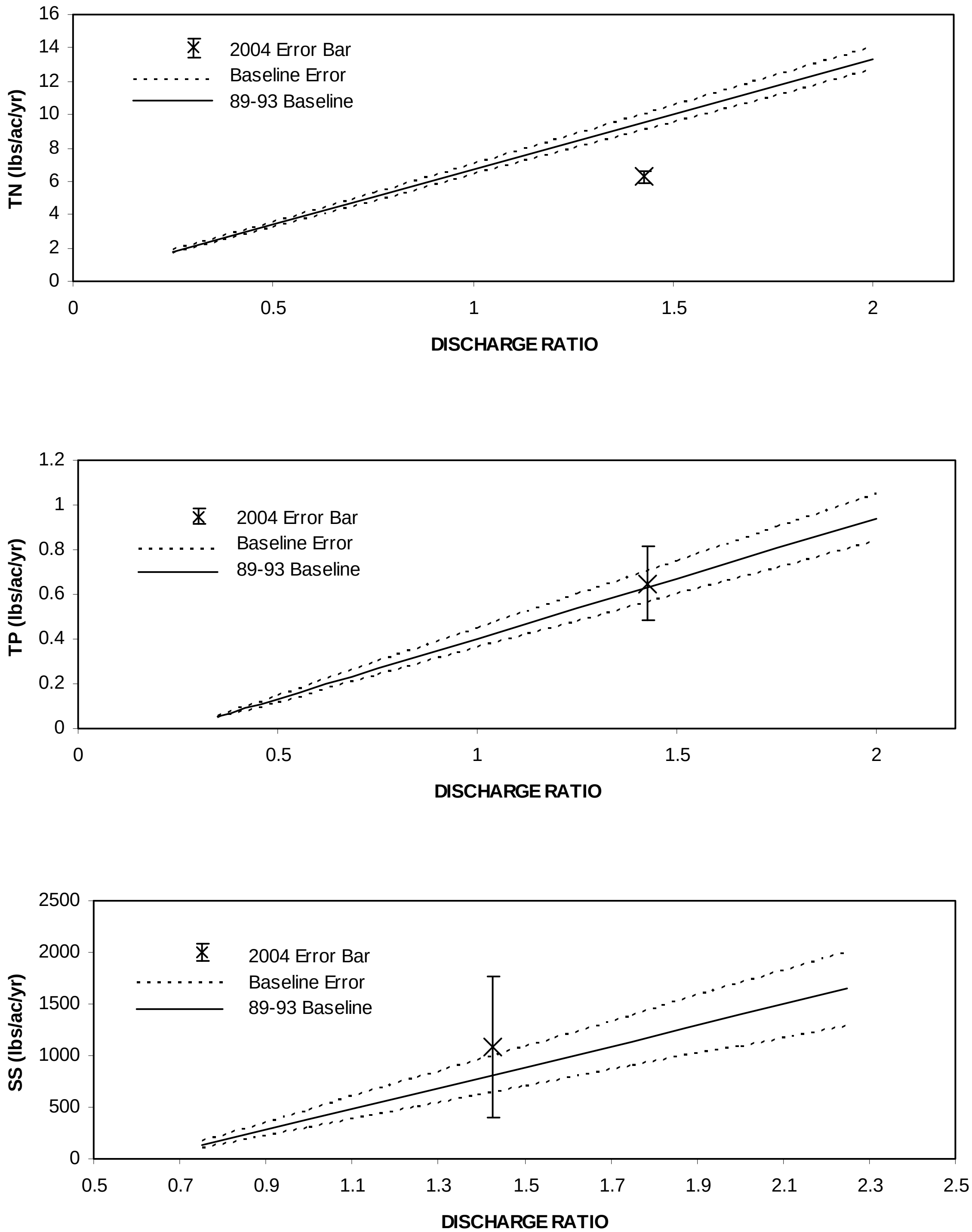


Figure 17. Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Susquehanna River at Towanda, Pa., 2004 Yield Compared to 1989-1993 Baseline

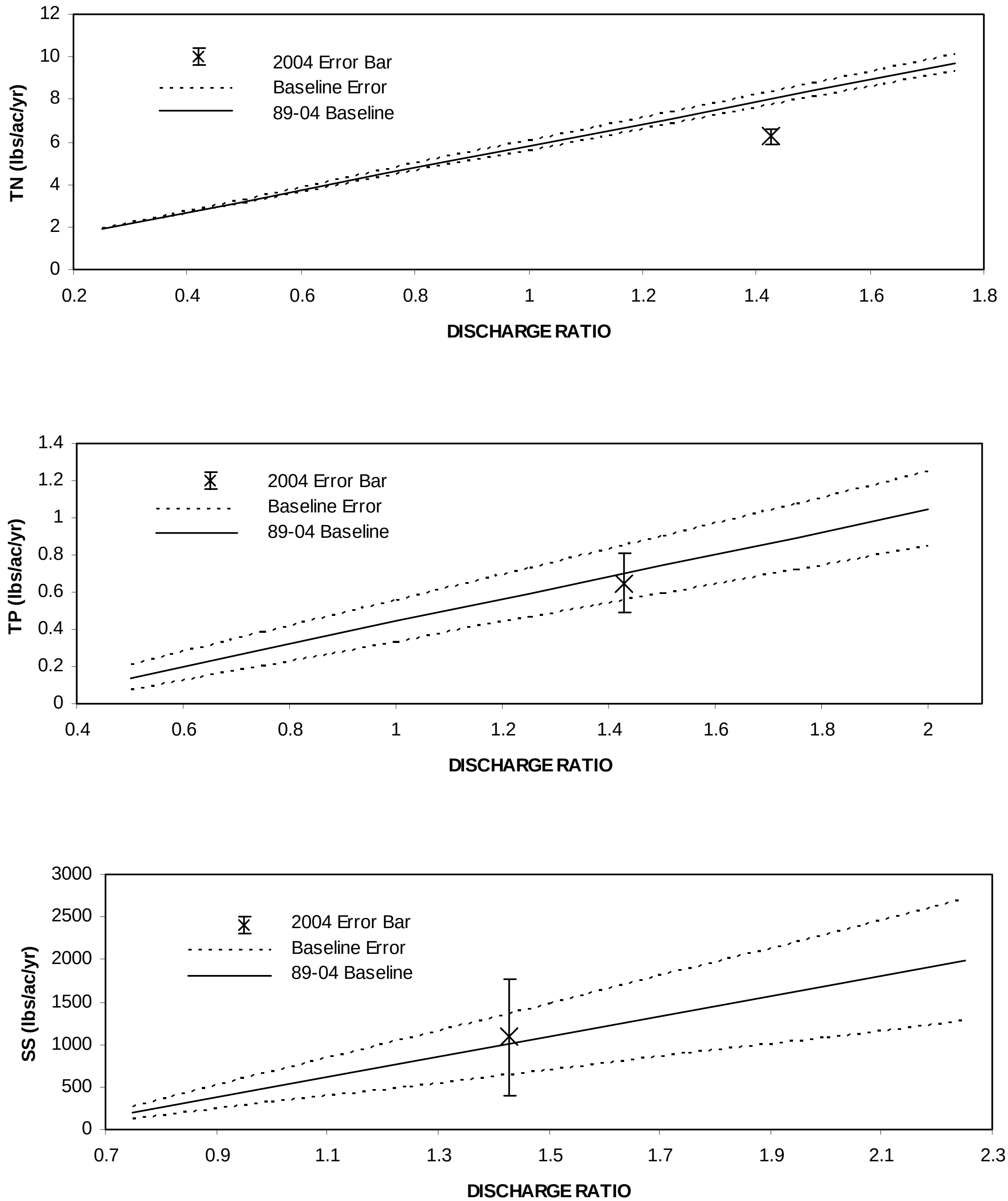


Figure 18. ***Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Susquehanna River at Towanda, Pa., 2004 Yield Compared to 1989-2004 Baseline***

Susquehanna River at Danville, Pa.

The baselines for TN, TP, and SS for the Susquehanna River at Danville are shown in Figures 19 and 20 with the 2004 annual yield. Actual 2004 and baseline yields are listed in Table 25 along with the discharge ratio. Best-fit lines were drawn through the data sets using the following equations:

Initial 5-year Baseline;

Total Nitrogen (TN)

TN Yield = -0.2303 + 6.4302x $R^2 = 0.85$

Total Phosphorus (TP)

TP Yield = -0.1583 + 0.583x $R^2 = 0.95$

Suspended Sediment (SS)

SS Yield = -480.64 + 762.56x $R^2 = 0.99$

2004 Baselines;

Total Nitrogen (TN)

TN Yield = 1.4799 + 4.8508x $R^2 = 0.64$

Total Phosphorus (TP)

TP Yield = -0.1619 + 0.6245x $R^2 = 0.75$

Suspended Sediment (SS)

SS Yield = -461.88 + 833.83x $R^2 = 0.66$

West Branch Susquehanna River at Lewisburg, Pa.

The baselines for TN, TP, and SS for the West Branch of the Susquehanna River at Lewisburg are shown in Figures 21 and 22 with the 2004 annual yield. Actual 2004 and baseline yields are listed in Table 26 along with the discharge ratio. Best-fit lines were drawn through the data sets using the following equations:

Initial-5 year Baseline;

Total Nitrogen (TN)

TN Yield = -1.4234 + 7.1513x $R^2 = 0.73$

Total Phosphorus (TP)

TP Yield = 0.0255 + 0.2498x $R^2 = 0.53$

Suspended Sediment (SS)

SS Yield = -157.34 + 316.17x $R^2 = 0.67$

2004 Baselines;

Total Nitrogen (TN)

TN Yield = 0.0207 + 5.5594x $R^2 = 0.86$

Total Phosphorus (TP)

TP Yield = -0.1145 + 0.4001x $R^2 = 0.74$

Suspended Sediment (SS)

SS Yield = -284.27 + 508.12x $R^2 = 0.43$

Table 25. Comparison of 2004 TN, TP, and SS Yields with Baseline Yields at Danville, Pa.

Parameter	Discharge Ratio	1985 – 1989 Baseline lb/ac/yr	1985 - 2004 Baseline lb/ac/yr	2004 lb/ac/yr
TN	1.415	8.868	8.344	6.352
TP	1.415	0.667	0.722	0.783
SS	1.415	751.37	717.989	836.165

Table 26. Comparison of 2004 Total Nitrogen, Total Phosphorus, and Suspended-Sediment Yields With Baseline Yields at Lewisburg, Pa.

Parameter	Discharge Ratio	1985 – 1989 Baseline lb/ac/yr	1985 - 2004 Baseline lb/ac/yr	2004 lb/ac/yr
TN	1.501	10.30	8.365	7.22
TP	1.501	0.435	0.486	0.39
SS	1.501	317.231	478.448	189.783

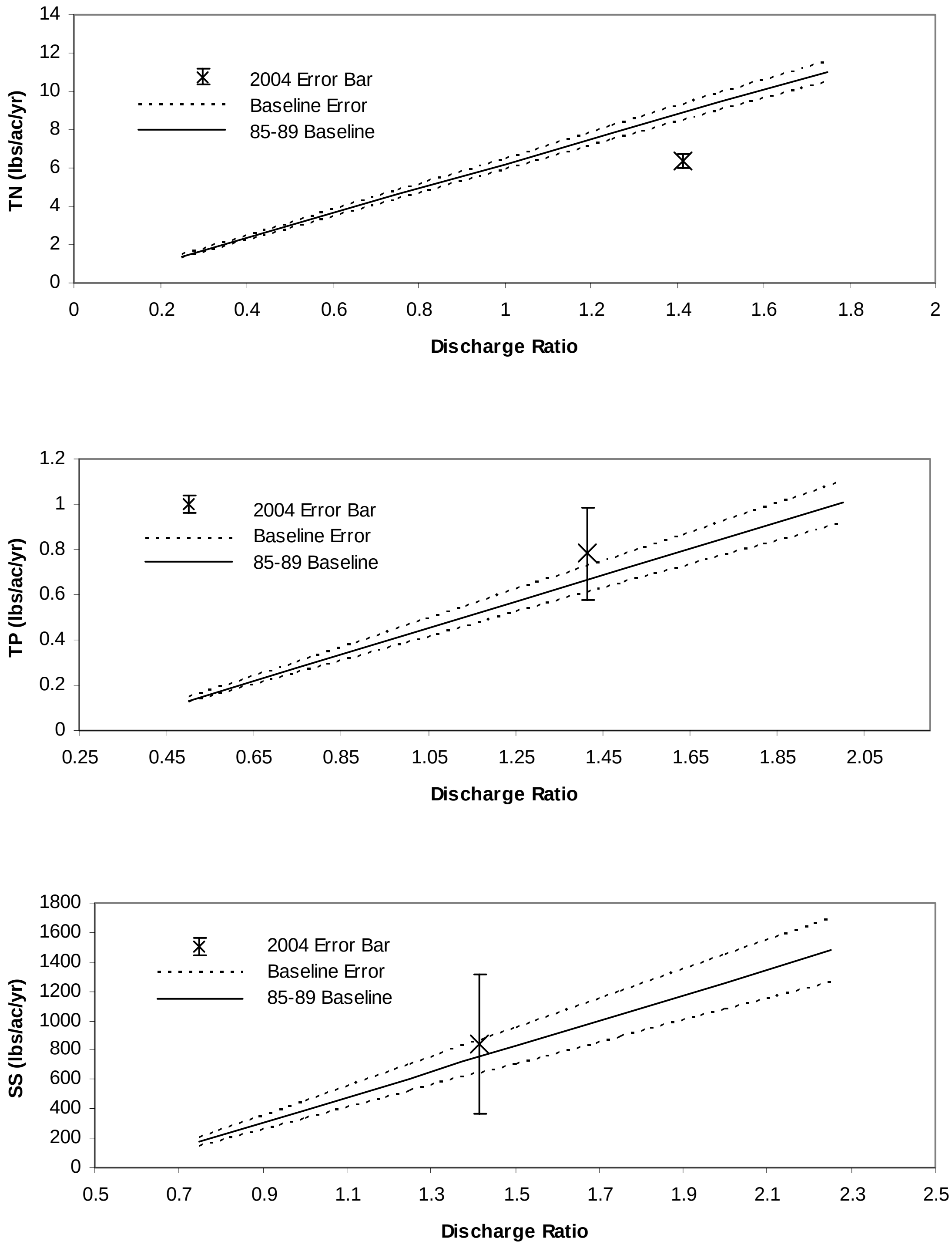
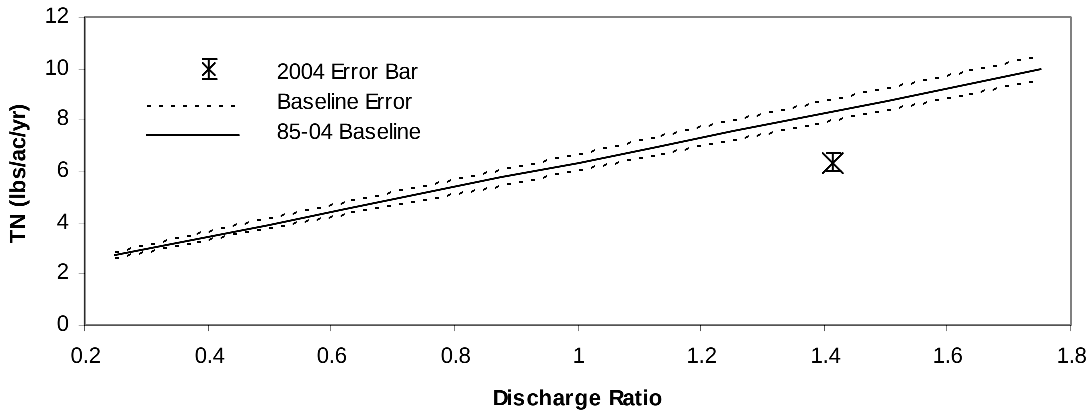
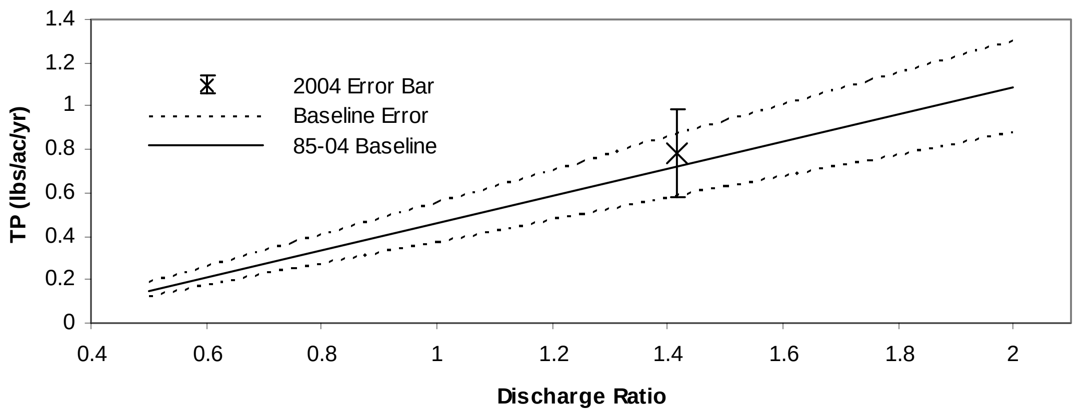


Figure 19. Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Susquehanna River at Danville, Pa., 2004 Yield Compared to 1985-1989 Baseline





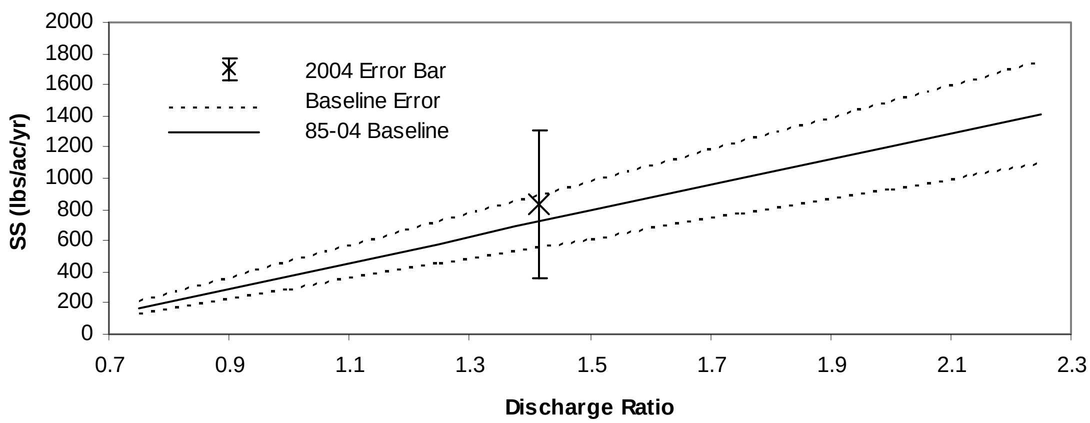


Figure 20. Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Susquehanna River at Danville, Pa., 2004 Yield Compared to 1985-2004 Baseline

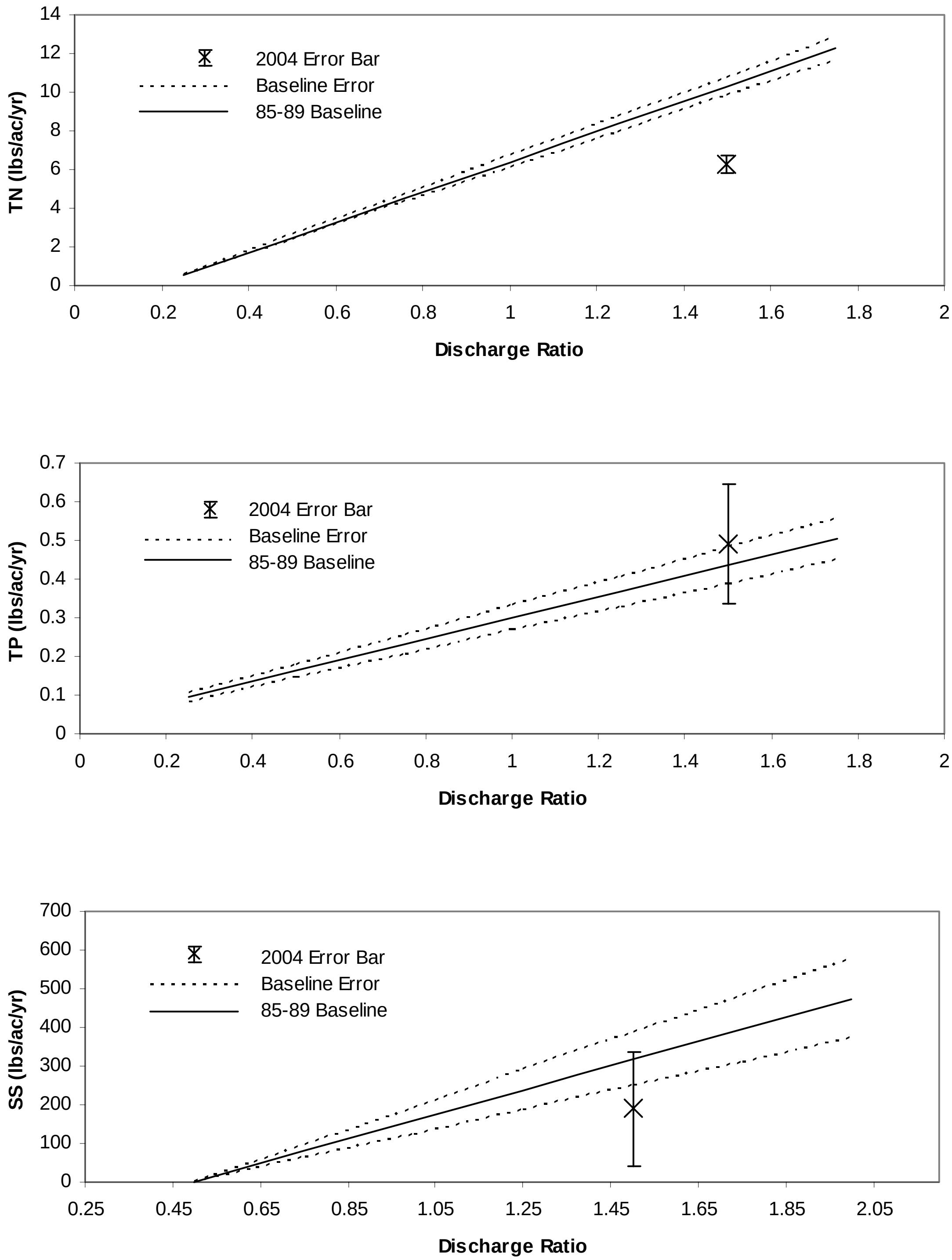
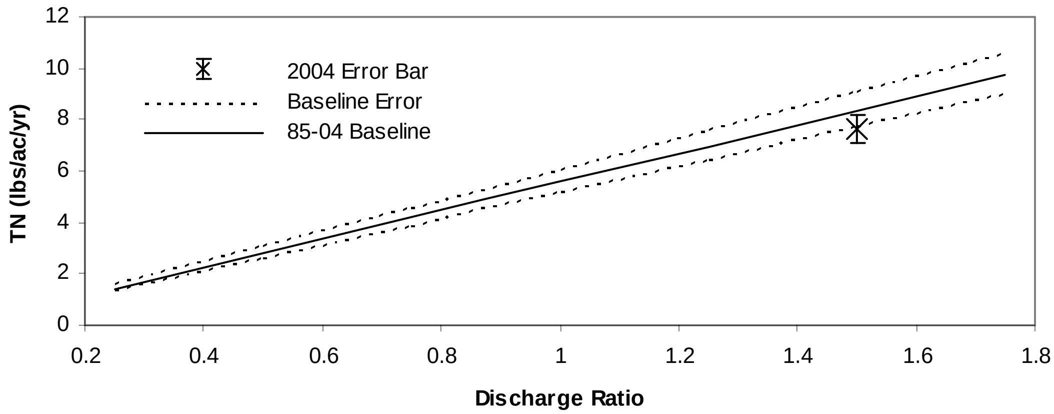
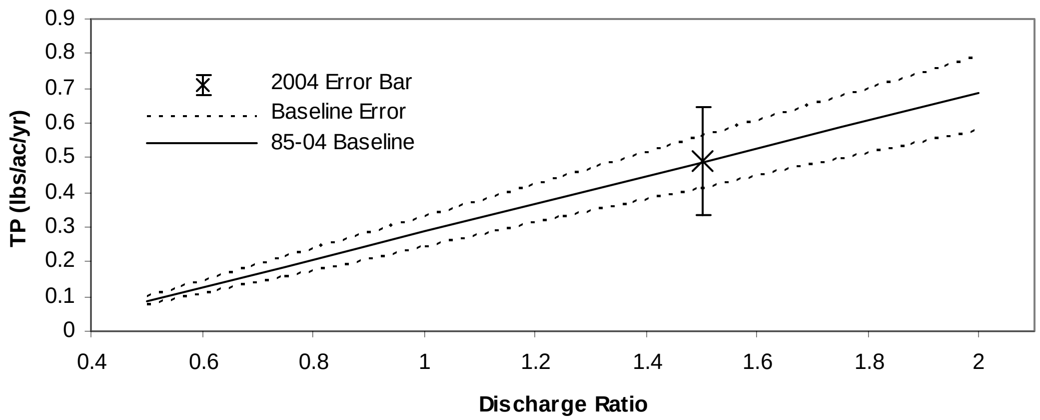


Figure 21. ***Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, West Branch Susquehanna River at Lewisburg, Pa., 2004 Yield Compared to 1985-1989 Baseline***





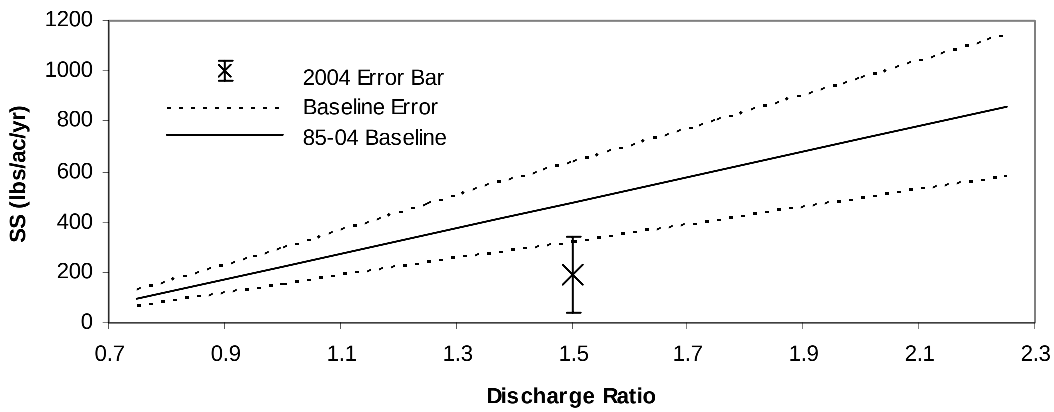


Figure 22. ***Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, West Branch Susquehanna River at Lewisburg, Pa., 2004 Yield Compared to 1985-2004 Baseline***

Juniata River at Newport, Pa.

The baselines for TN, TP, and SS for the Juniata River at Newport are shown in Figures 23 and 24 with the 2004 annual yield. Actual 2004 and baseline yields are listed in Table 27 along with the discharge ratio. Best-fit lines were drawn through the data sets using the following equations:

Initial 5-year Baseline;

Total Nitrogen (TN)

TN Yield = -0.2997 + 7.7349x $R^2 = 0.80$

Total Phosphorus (TP)

TP Yield = -0.0762 + 0.4462x $R^2 = 0.96$

Suspended Sediment (SS)

SS Yield = -294.17 + 490.39x $R^2 = 0.89$

2004 Baselines;

Total Nitrogen (TN)

TN Yield = -0.2985 + 8.0374x $R^2 = 0.95$

Total Phosphorus (TP)

TP Yield = -0.0064 + 0.3953x $R^2 = 0.67$

Suspended Sediment (SS)

SS Yield = -149.52 + 387.12x $R^2 = 0.81$

Susquehanna River at Marietta, Pa.

The baselines for TN, TP, and SS for the Susquehanna River at Marietta are shown in Figures 25 and 26 with the 2004 annual yield. Actual 2004 and baseline yields are listed in Table 28 along with the discharge ratio. Best-fit lines were drawn through the data sets using the following equations:

Initial 5-year Baseline;

Total Nitrogen (TN)

TN Yield = -0.8251 + 8.3195x $R^2 = 0.99$

Total Phosphorus (TP)

TP Yield = 0.1393 + 0.2102x $R^2 = 0.27$

Suspended Sediment (SS)

SS Yield = -97.695 + 344.91x $R^2 = 0.48$

2004 Baselines;

Total Nitrogen (TN)

TN Yield = -0.3534 + 8.2514x $R^2 = 0.92$

Total Phosphorus (TP)

TP Yield = -0.2151 + 0.7015x $R^2 = 0.78$

Suspended Sediment (SS)

SS Yield = -328.92 + 682.71x $R^2 = 0.76$

Table 27. Comparison of 2004 TN, TP, and SS Yields With Baseline Yields at Newport, Pa.

Parameter	Discharge Ratio	1985 – 1989 Baseline lb/ac/yr	1985 - 2004 Baseline lb/ac/yr	2004 lb/ac/yr
TN	1.48	11.148	11.597	12.4
TP	1.48	0.584	0.579	0.73
SS	1.48	431.607	423.418	551.04

Table 28. Comparison of 2004 TN, TP, and SS Yields With Baseline Yields at Marietta, Pa.

Parameter	Discharge Ratio	1987 – 1991 Baseline lb/ac/yr	1987 - 2004 Baseline lb/ac/yr	2004 lb/ac/yr
TN	1.497	11.629	12.0	10.79
TP	1.497	0.454	0.835	0.95
SS	1.497	418.635	693.097	955.12

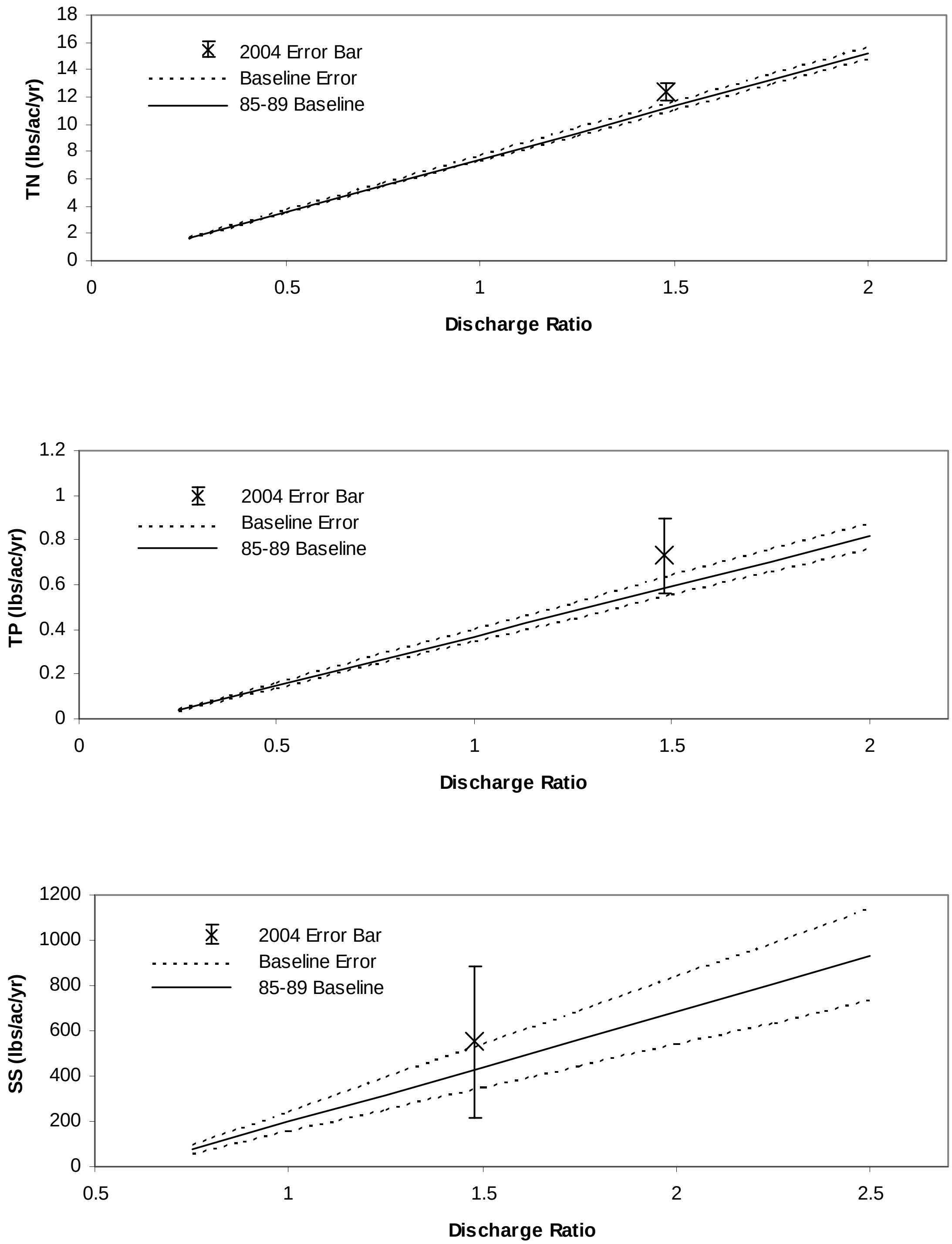


Figure 23. ***Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Juniata River at Newport, Pa., 2004 Yield Compared to 1985-1989 Baseline***

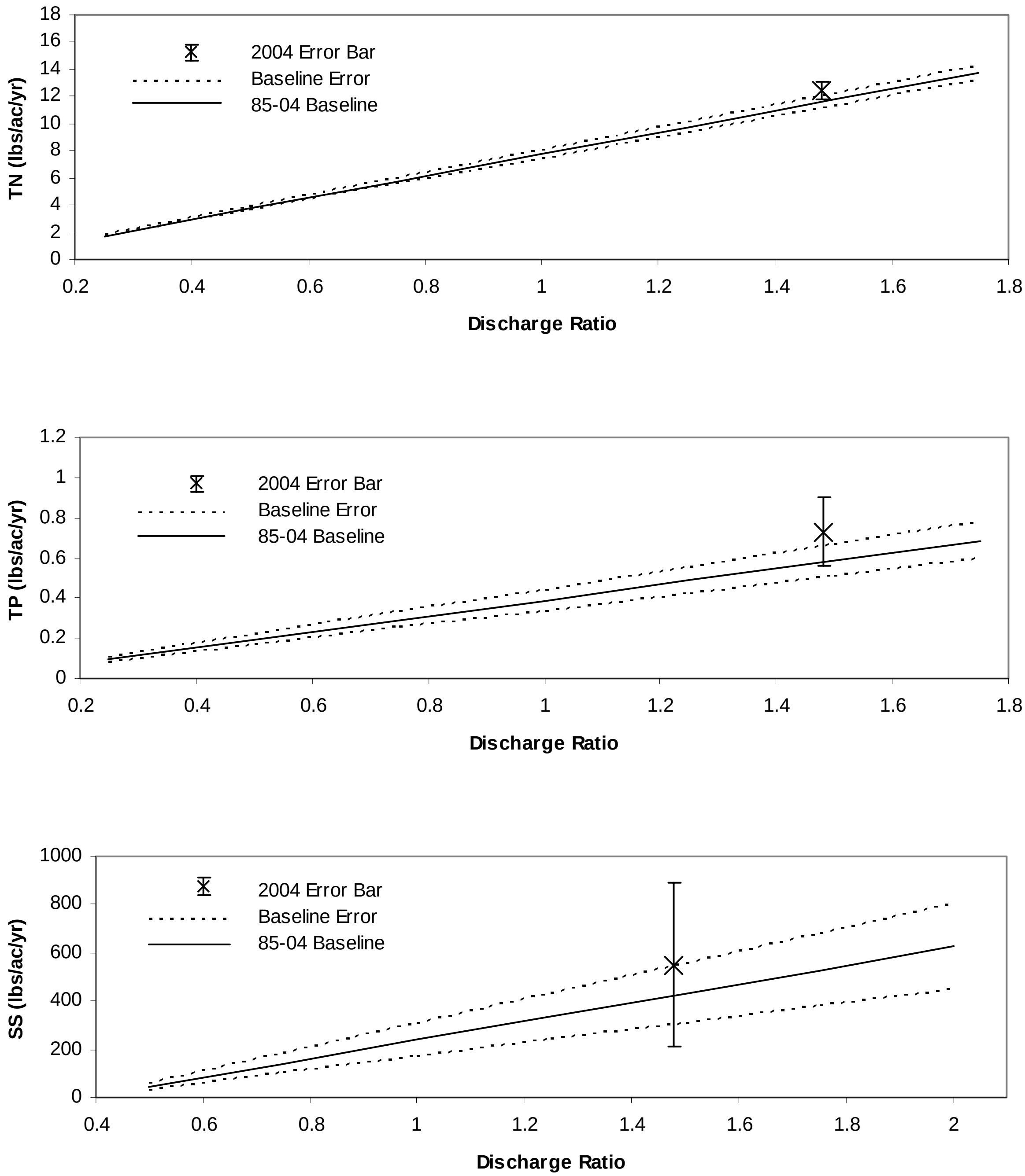


Figure 24. ***Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Juniata River at Newport, Pa., 2004 Yield Compared to 1985-2004 Baseline***

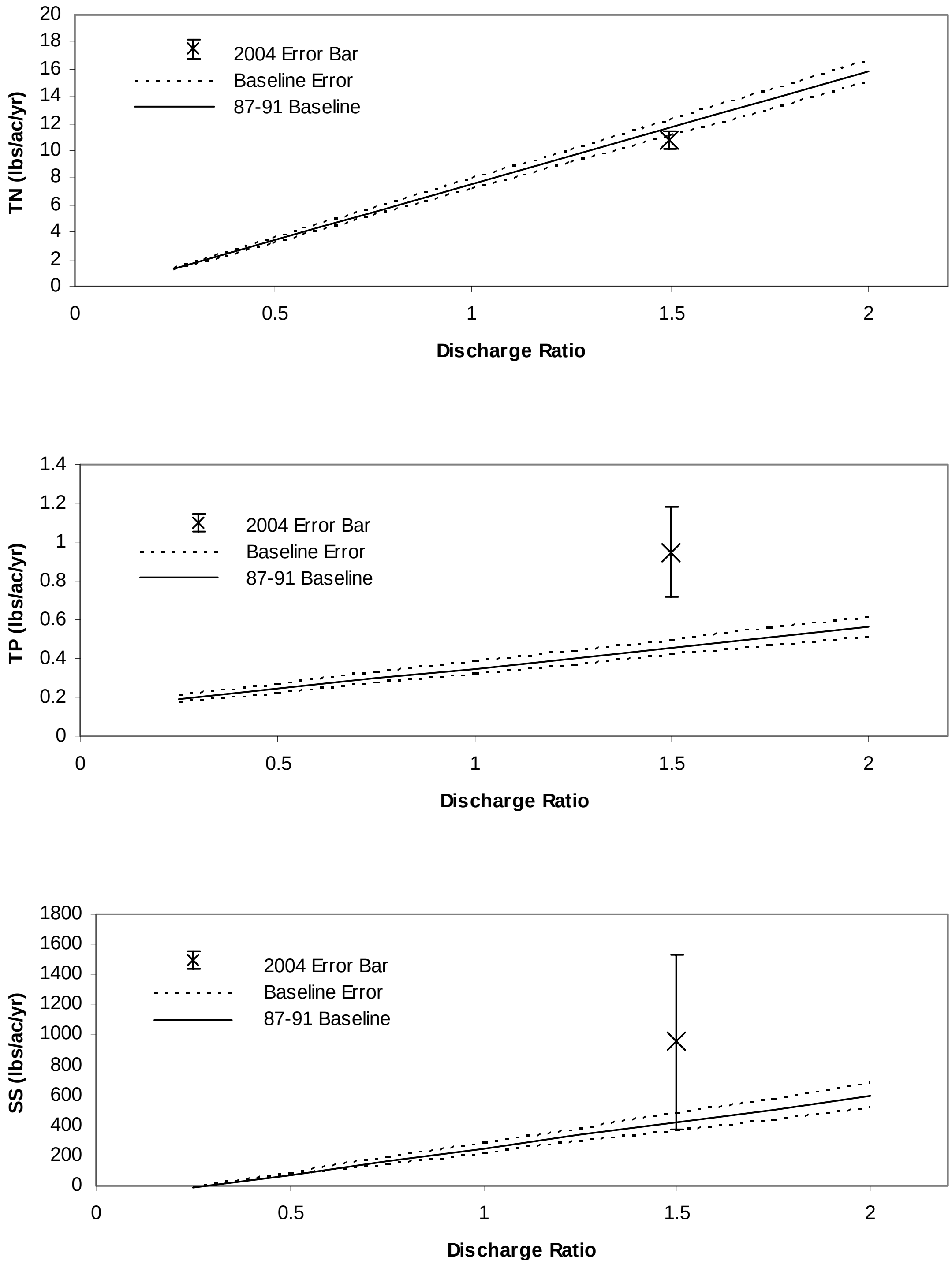


Figure 25. Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Susquehanna River at Marietta, Pa., 2004 Yield Compared to 1987-1991 Baseline

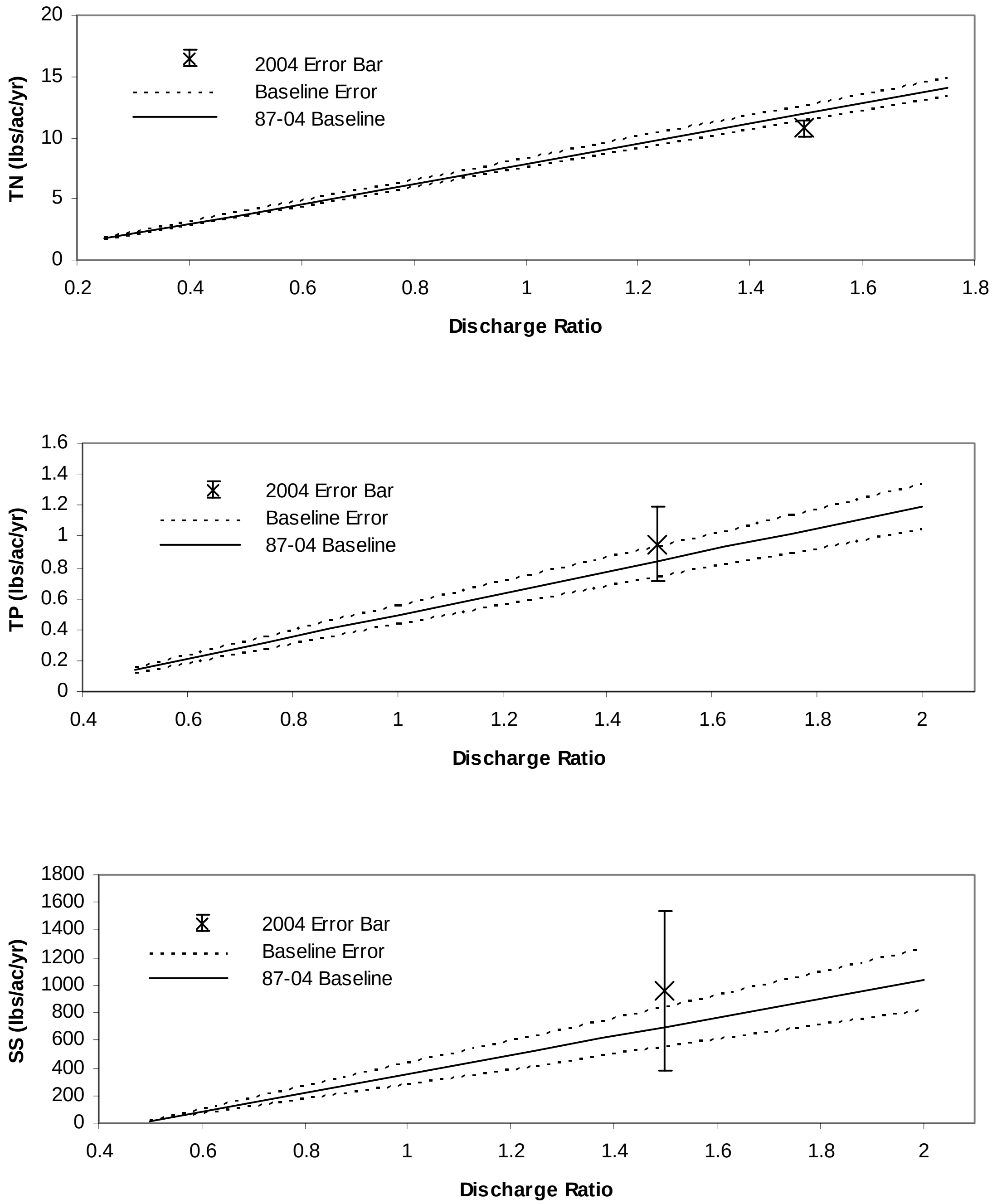


Figure 26. Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Susquehanna River at Marietta, Pa., 2004 Yield Compared to 1987-2004 Baseline

Conestoga River at Conestoga, Pa.

The baselines for TN, TP, and SS for the Susquehanna River at Towanda are shown in Figures 27 and 28 with the 2004 annual yield. Actual 2004 and baseline yields are listed in Table 29 along with the discharge ratio. Best-fit lines were drawn through the data sets using the following equations:

Initial 5-year Baseline;

Total Nitrogen (TN)

TN Yield = 2.1988 + 33.479x $R^2 = 0.97$

Total Phosphorus (TP)

TP Yield = 0.4272 + 1.9976x $R^2 = 0.67$

Suspended Sediment (SS)

SS Yield = -614.08 + 1864.17x $R^2 = 0.72$

2004 Baselines;

Total Nitrogen (TN)

TN Yield = 3.594 + 31.44x $R^2 = 0.96$

Total Phosphorus (TP)

TP Yield = -0.6628 + 2.9425x $R^2 = 0.80$

Suspended Sediment (SS)

SS Yield = -604.68 + 1682.7x $R^2 = 0.76$

Table 29. Comparison of 2004 TN, TP, and SS Yields With Baseline Yields at Conestoga, Pa.

Parameter	Discharge Ratio	1985 – 1989 Baseline lb/ac/yr	1985 - 2004 Baseline lb/ac/yr	2004 lb/ac/yr
TN	1.761	61.155	58.959	56.98
TP	1.761	3.945	4.519	3.51
SS	1.761	2,451.29	2,358.56	1,868.2

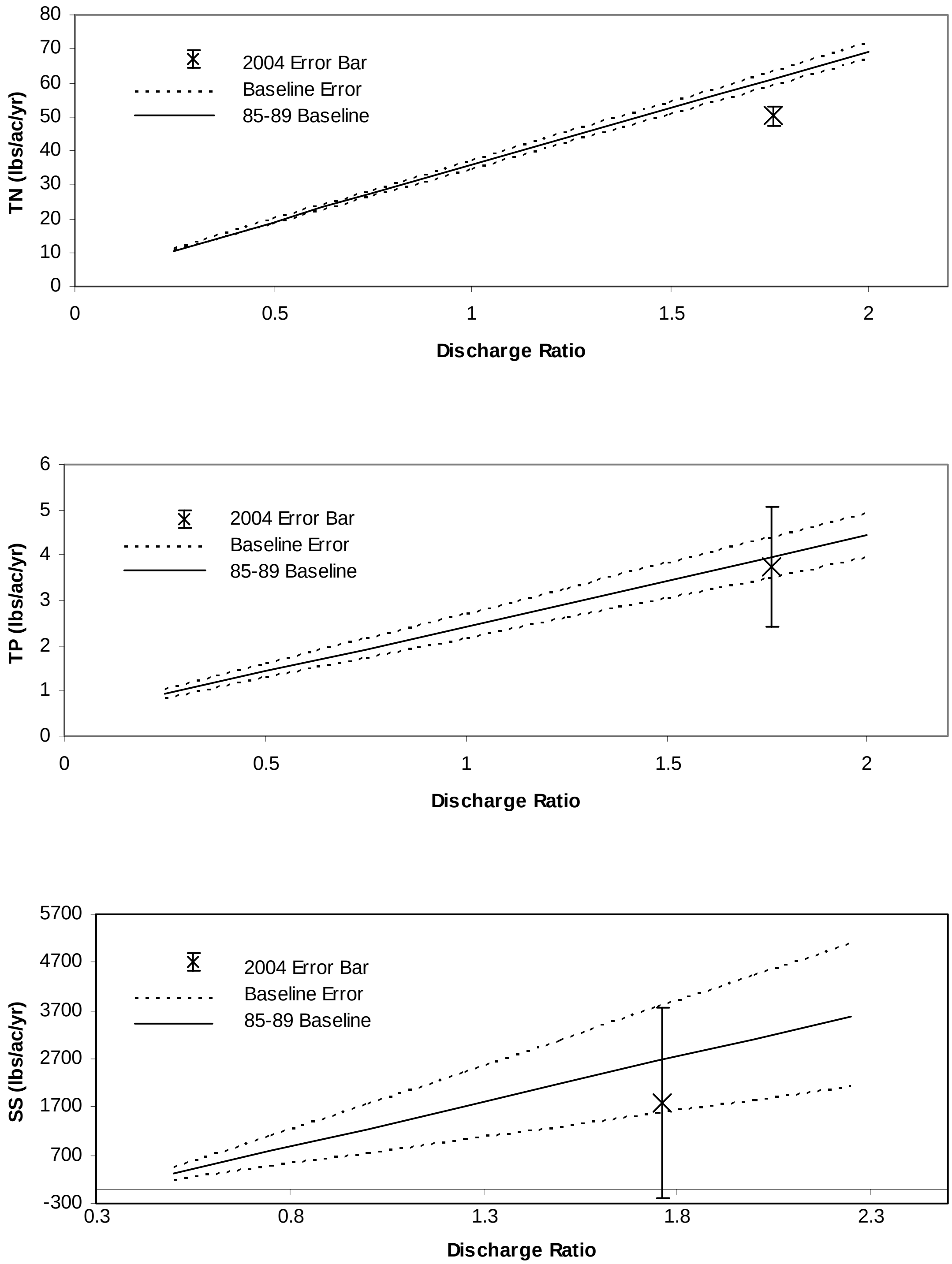


Figure 27. ***Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Conestoga River at Conestoga, Pa., 2004 Yield Compared to 1985-1989 Baseline***

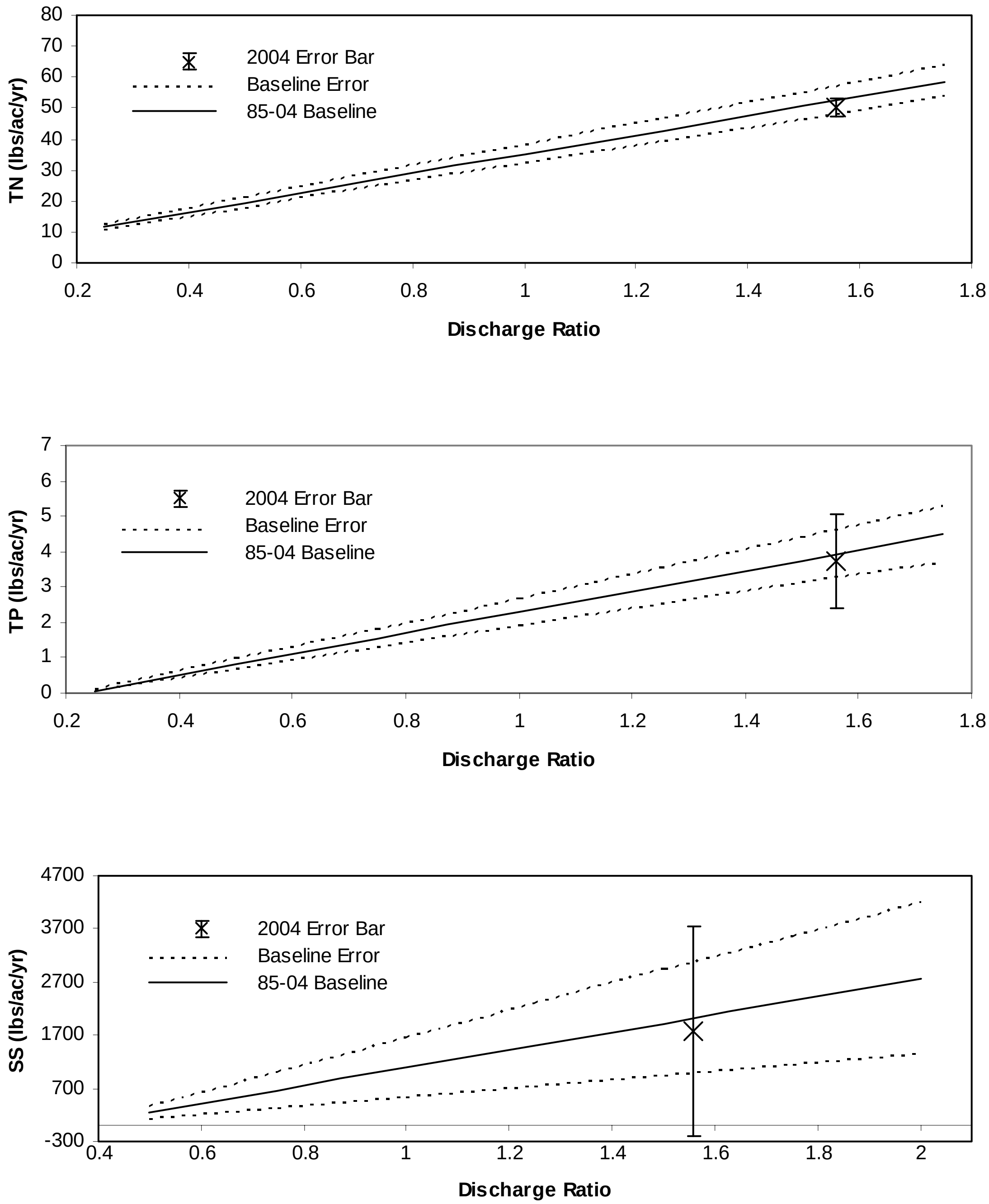


Figure 28. ***Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Conestoga River at Conestoga, Pa., 2004 Yield Compared to 1985-2004 Baseline***

DISCHARGE, NUTRIENT, AND SUSPENDED-SEDIMENT TRENDS

Trend analyses of water quality and flow data collected at the six Group A monitoring sites were completed for the period January 1985 through December 2004. FAC trends were estimated using the USGS 7-parameter, log-linear regression model (ESTIMATOR) developed by Cohn and others (1989) and described in Langland and others (1999). This estimator relates the constituent concentration to water discharge, seasonal effects, and long-term trends, and computes the best-fit regression equation. These tests were used to estimate the direction and magnitude of trends for discharge, SS, TOC, and several forms of nitrogen and phosphorus. Trends in FAC are directly taken from ESTIMATOR output. Trends in flow are calculated using S-Plus with the USGS ESTREND library addition (Shertz and others, 1991). Results were reported for monthly mean discharge (FLOW) and FAC.

Trends in FLOW indicate the natural changes in hydrology. Changes in flow and the cumulative sources of flow (base flow and over land runoff) affect the observed concentrations and the estimated loads of nutrients and SS. The FAC is the concentration after the effects of flow are removed from the concentration time series. Trends in FAC indicate that changes have occurred in the processes that deliver constituents to the stream system. After the effects of flow are removed, this is the concentration that relates to the effects of nutrient-reduction activities and other actions taking place in the watershed. A description of the methodology is included in Langland and others (1999).

Trend results for each monitoring site are presented in Tables 30 through 35. Each table lists the results for flow, the various nitrogen and phosphorus species, TOC, and SS. The level of significance was set by the p-value of 0.05 for FAC (Langland and others, 1999). The magnitude of the slope incorporates a confidence interval and was reported as a range (minimum and maximum). The slope direction was reported as not significant (NS) or, when significant, as improving or degrading. When a time series had greater than 20 percent of its observations below the method detection level (BMDL), a trend analysis could not be completed.

Table 30. Trend Statistics for the Susquehanna River at Towanda, Pa., January 1989 Through December 2004

Parameter	STORET Code	Time Series	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	FLOW	66.209	0.5812	-	-	-	NS
TN	600	FAC	-0.0248	0.0000	-37	-33	-29	IMPROVING
DN	602	FAC	-0.0173	0.0000	-29	-24	-20	IMPROVING
TON	605	FAC	-0.0291	0.0000	-45	-37	-29	IMPROVING
DON	607	FAC	-0.0135	0.0014	-29	-19	-8	IMPROVING
DNH_3	608	FAC	-0.0129	0.0175	-32	-19	-3	IMPROVING
TNH_3	610	FAC	-0.0374	0.0000	-54	-45	-34	IMPROVING
DKN	623	FAC	-0.0231	0.0000	-40	-31	-20	IMPROVING
TKN	625	FAC	-0.0313	0.0000	-47	-39	-31	IMPROVING
TNOx	630	FAC	-0.0172	0.0000	-29	-24	-19	IMPROVING
DNOx	631	FAC	-0.0166	0.0000	-28	-23	-18	IMPROVING
TP	665	FAC	-0.0135	0.0053	-31	-19	-6	IMPROVING
DP	666	FAC	-0.0226	0.0000	-40	-30	-19	IMPROVING
DOP	671	FAC	0.1024	0.0000	304	414	554	DEGRADING
TOC	680	FAC	-0.0066	0.0003	-15	-10	-5	IMPROVING
SS	80154	FAC	-0.0264	0.0006	-49	-34	-16	IMPROVING

Table 31. Trend Statistics for the Susquehanna River at Danville, Pa., January 1985 Through December 2004

Parameter	STORET Code	Time Series/Test	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	FLOW	151.34	0.2695	-	-	-	NS
TN	600	FAC	-0.0243	0.0000	-42	-38	-34	IMPROVING
DN	602	FAC	-0.0173	0.0000	-34	-29	-25	IMPROVING
TON	605	FAC	-0.0345	0.0000	-56	-50	-43	IMPROVING
DON	607	FAC	-0.0192	0.0000	-40	-32	-22	IMPROVING
DNH_3	608	FAC	-0.0275	0.0000	-51	-42	-31	IMPROVING
TNH_3	610	FAC	-0.0428	0.0000	-65	-57	-49	IMPROVING
DKN	623	FAC	-0.0278	0.0000	-50	-43	-34	IMPROVING
TKN	625	FAC	-0.0344	0.0000	-55	-50	-43	IMPROVING
TNOx	630	FAC	-0.0124	0.0000	-27	-22	-17	IMPROVING
DNOx	631	FAC	-0.0125	0.0000	-27	-22	-17	IMPROVING
TP	665	FAC	-0.0249	0.0000	-48	-39	-29	IMPROVING
DP	666	FAC	-0.0235	0.0000	-46	-37	-27	IMPROVING
DOP	671	FAC	0.0848	0.0000	329	445	592	DEGRADING
TOC	680	FAC	-0.0125	0.0000	-27	-22	-17	IMPROVING
SS	80154	FAC	-0.0450	0.0000	-67	-59	-50	IMPROVING

Table 32. Trend Statistics for the West Branch Susquehanna River at Lewisburg, Pa., January 1985 Through December 2004

Parameter	STORET Code	Time Series	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	FLOW	25.15	0.7625	-	-	-	NS
TN	600	FAC	-0.0150	0.0000	-31	-26	-20	IMPROVING
DN	602	FAC	-0.0115	0.0000	-25	-21	-15	IMPROVING
TON	605	FAC	-0.0300	0.0000	-54	-45	-35	IMPROVING
DON	607	FAC	-0.0249	0.0000	-47	-39	-30	IMPROVING
DNH_3	608	FAC	-0.0067	0.1150	-26	-13	4	NS
TNH_3	610	FAC	-0.0258	0.0000	-51	-40	-27	BMDL
DKN	623	FAC	-0.0300	0.0000	-54	-45	-35	BMDL
TKN	625	FAC	-0.0254	0.0000	-49	-40	-29	IMPROVING
TNOx	630	FAC	-0.0051	0.0048	-16	-10	-3	IMPROVING
DNOx	631	FAC	-0.0050	0.0056	-16	-10	-3	IMPROVING
TP	665	FAC	-0.0231	0.0000	-48	-37	-24	IMPROVING
DP	666	FAC	-0.0374	0.0000	-60	-53	-44	IMPROVING
DOP	671	FAC	0.0736	0.0000	230	335	475	BMDL
TOC	680	FAC	0.0007	0.7373	-7	1	10	NS
SS	80154	FAC	-0.0520	0.0000	-74	-65	-53	IMPROVING

Table 33. Trend Statistics for the Juniata River at Newport, Pa., January 1989 Through December 2004

Parameter	STORET Code	Time Series	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	FLOW	31.56	0.3726	-	-	-	NS
TN	600	FAC	-0.0059	0.0000	-16	-11	-6	IMPROVING
DN	602	FAC	-0.0026	0.0277	-9	-5	0	IMPROVING
TON	605	FAC	-0.0253	0.0000	-48	-40	-29	IMPROVING
DON	607	FAC	-0.0184	0.0000	-40	-31	-21	IMPROVING
DNH_3	608	FAC	-0.0179	0.0000	-41	-30	-17	IMPROVING
TNH_3	610	FAC	-0.0334	0.0000	-58	-49	-38	BMDL
DKN	623	FAC	-0.0279	0.0000	-51	-43	-33	BMDL
TKN	625	FAC	-0.0228	0.0000	-45	-37	-27	IMPROVING
TNOx	630	FAC	0.0006	0.6322	-4	1	6	NS
DNOx	631	FAC	0.0017	0.2059	-2	3	9	NS
TP	665	FAC	-0.0131	0.0006	-34	-23	-11	IMPROVING
DP	666	FAC	-0.0092	0.0139	-28	-17	-3	IMPROVING
DOP	671	FAC	0.0710	0.0000	219	313	435	DEGRADING
TOC	680	FAC	-0.0144	0.0000	-31	-25	-18	IMPROVING
SS	80154	FAC	-0.0166	0.0058	-43	-28	-9	IMPROVING

Table 34. Trend Statistics for the Susquehanna River at Marietta, Pa., January 1987 Through December 2004

Parameter	STORET Code	Time Series	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	FLOW	-102.3	0.6849	-	-	-	NS
TN	600	FAC	-0.0149	0.0000	-28	-24	-19	IMPROVING
DN	602	FAC	-0.0082	0.0000	-19	-14	-8	IMPROVING
TON	605	FAC	-0.0202	0.0000	-41	-30	-18	IMPROVING
DON	607	FAC	0.0041	0.4713	-12	8	32	NS
DNH_3	608	FAC	-0.0122	0.0072	-32	-20	-6	IMPROVING
TNH_3	610	FAC	-0.0260	0.0000	-48	-37	-25	IMPROVING
DKN	623	FAC	-0.0191	0.0000	-39	-29	-18	IMPROVING
TKN	625	FAC	-0.0267	0.0000	-46	-38	-29	IMPROVING
TNOx	630	FAC	-0.0054	0.0065	-15	-9	-3	IMPROVING
DNOx	631	FAC	-0.0052	0.0091	-15	-9	-2	IMPROVING
TP	665	FAC	-0.0027	0.4998	-17	-5	10	NS
DP	666	FAC	0.0003	0.9347	-12	1	15	NS
DOP	671	FAC	0.1448	0.0000	953	1253	1638	DEGRADING
TOC	680	FAC	-0.0076	0.0000	-18	-13	-7	IMPROVING
SS	80154	FAC	-0.0194	0.0015	-43	-29	-13	IMPROVING

Table 35. Trend Statistics for the Conestoga River at Conestoga, Pa., January 1985 Through December 2004

Parameter	STORET Code	Time Series	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	FLOW	3.571	0.6145	-	-	-	NS
TN	600	FAC	-0.0089	0.0000	-20	-16	-13	IMPROVING
DN	602	FAC	0.0000	0.9722	-5	0	5	NS
TON	605	FAC	-0.0267	0.0000	-48	-41	-33	IMPROVING
DON	607	FAC	0.0007	0.8278	-11	1	15	NS
DNH_3	608	FAC	-0.0645	0.0000	-76	-72	-68	IMPROVING
TNH_3	610	FAC	-0.0700	0.0000	-79	-75	-71	IMPROVING
DKN	623	FAC	-0.0171	0.0000	-37	-29	-20	IMPROVING
TKN	625	FAC	-0.0333	0.0000	-54	-49	-42	IMPROVING
TNOx	630	FAC	0.0020	0.1808	-2	4	10	NS
DNOx	631	FAC	0.0029	0.0543	0	6	12	NS
TP	665	FAC	-0.0219	0.0000	-43	-35	-27	IMPROVING
DP	666	FAC	-0.0215	0.0000	-40	-35	-29	IMPROVING
DOP	671	FAC	-0.0072	0.0173	-23	-13	-3	IMPROVING
TOC	680	FAC	-0.0300	0.0000	-49	-45	-40	IMPROVING
SS	80154	FAC	-0.0423	0.0000	-65	-57	-48	IMPROVING

DISCUSSION

2004 was a significant year for loads in the Susquehanna River Basin. Unusually high flows during the summer months, specifically from Tropical Storm Ivan, led to high TP and SS values for the season. September flows ranged from 247 percent of the LTM at Conestoga to 608 percent of the LTM at Towanda. Annual flows ranged from 127.7 percent of the LTM at Danville to 157.9 percent of the LTM at Conestoga due to above average rainfall throughout the basin.

The average daily high flow for September 2004 was 497,000 cubic feet per second (cfs) at Marietta on September 20, 2004. Flows that are greater than 400,000 cfs constitute a scour event, which means that sediment that is currently deposited in the river is reintroduced into the water column due to the high flow and turbulence (Langland, 2000). Prior to 2004, the last scour event occurred on January 21, 1996, and had an average daily high of 556,000 cfs. One comparison worth noting is that prior to 1996, the previous scour event took place only three years earlier on April 3, 1993, with an average daily flow of 431,000 cfs. This means that there were three years for nutrients and sediment to accumulate in the streams and rivers before being scoured again in 1996. After 1996, there were eight years until the next scout event in 2004, increasing the length of time for nutrients and sediment to accumulate. The difference between these three dates can be seen in Table 36. In comparison, the TN values are significantly lower for September 2004, even though it had the second highest average daily flow. Part of this is due to the lower average monthly flow as compared to 1996 and 1993.

When looking at TP and SS, higher than expected values are found as compared to 1996. This may be due to the time difference between scour events. Had the 1993 scour event not happened, the TP and SS values for 1996 might be higher than the 2004 scour event. The differences between 2004 and 1993 also are worth noting. The scouring event prior to 1993 was in 1983, (10 years prior) creating a good comparison to 2004. Table 37 shows a more in-depth analysis of 2004 versus 1993. Since flow directly influences the levels of nutrients and SS, it is not only necessary to look at the annual flow but also to look at the mean daily high flow for the year. When comparing the annual flows from two years, as a percentage, to the percentages of nutrients and SS for those years, improvements that might have occurred can be investigated. For example, at Marietta, the 2004 annual flow and daily mean high are approximately 114.5 percent of those for 1993. Therefore, the percentages for TN, TP, and SS for these years should be roughly the same if water quality has neither improved nor degraded. However, TN in 2004 was only 95 percent of the TN in 1993 even though the flow in 2004 was greater. TP and SS both increased above the 114.5 percent flow values.

Table 38 lists the data analyses that were completed at the six Group A sites in the Susquehanna River Basin. 2004 loads for TN, TNH3, DNH3, DN, and DNO23 were all lower than the LTMs at Towanda, Danville, Lewisburg, and Conestoga. Values for 2004 were lower than the LTM at all sites for TON and DON (except for DON at Conestoga). Newport and Marietta showed increases in 2004 as compared to the LTMs for all parameters except TON and DON. 2004 values of TOC were lower than the LTM at Newport and Conestoga. SS for 2004 increased over the LTMs at all sites except Lewisburg, which is a heavily forested watershed. Additionally, there were increases at all six sites in TP and DOP as compared to the LTM.

The highest flow season was summer for all sites due, to Tropical Storm Ivan. This caused all parameters to be highest during the summer months at Conestoga. This was the only site where TN was highest during the high flow season. For Towanda, Danville, and Lewisburg, the high TN season was winter, which was the second highest flow season for these sites. DN also was highest during winter at these sites, as well as at Newport. DNO23 followed this same trend. Another interesting point is that at Marietta the highest season for TN, DN, TNH3, DNH3, TNO23, and DNO23 was fall, which was the lowest flow season. TOC, TP, and SS were all highest during the highest flow months.

Comparison with the initial 5-year baselines showed improvements in TN at Towanda, Danville, Lewisburg, and Conestoga. Towanda and Danville also showed improvements in TN, when compared to the full program baselines. Lewisburg showed improvements in SS yields for both comparisons. Newport showed slight increases in TN and TP for both comparisons, while showing no change in SS yields. Marietta showed increases in TP and SS when compared to the initial 5-year baseline but showed no significant deviations from the predicted values for the full program baseline.

2004 showed no trend in flow at any of the six long-term sites. TN, TP, and SS showed decreasing trends at all sites except Marietta, which had no significant trends for TP. Towanda and Danville had decreasing trends for all parameters except DOP, which showed increasing trends at Towanda, Danville, Newport, and Marietta.

The places where improvements or degradations are likely occurring are where most of these analyses agree, shown in Table 38. TN showed improvements for all analyses at Towanda, Danville, Lewisburg, and Conestoga, which has a high concentration of urban and agricultural land uses. Marietta and Danville showed TP degradation for several of the analyses with the exception of trends. Danville trends showed TP to be decreasing while Marietta showed no trends for TP. SS analyses showed potential degradations for all comparisons except the trends in FACs at Towanda, Danville, Newport, and Marietta. Since most of the results were a direct result of Tropical Storm Ivan, the best analysis was likely the trends analysis as it removed the effects of flow. Trends for all parameters, shown in Table 39, were improving except for TP at Marietta. The only exceptions to this were the DOP trends for Towanda, Danville, Newport, and Marietta, which were all degrading.

Table 36. Storm Events at Marietta with High Average Daily Flows Greater Than 400,000 cfs

Month of Storm Event	Average Monthly Flow	High Daily Average Flow	Monthly TN	Monthly TP	Monthly SS
February-84	109,341	446,000	-	-	-
April-93	235,133	431,000	68,743,015	7,259,275	12,371,847,860
January-96	116,852	556,000	40,092,507	4,162,444	6,333,728,265
September-04	110,893	497,000	32,748,690	6,257,286	9,908,945,265

Table 37. Comparison of 2004 and 1993 Flows and Loads of TN, TP, and SS

Site	Parameter	2004	1993	% Difference **
Towanda	Annual Q (cfs)	15,337	13,555	113
	Avg. High Q (cfs) *	127,000	149,000	85
	TN (1000's Lbs)	31,219	35,926	87
	TP (1000's Lbs)	3,233	3,232	100
	SS (1000's Lbs)	5,409,886	4,567,110	118
Danville	Annual Q (cfs)	21,823	19,823	110
	Avg. High Q (cfs) *	205,000	186,000	110
	TN (1000's Lbs)	45,613	60,290	76
	TP (1000's Lbs)	5,622	4,932	114
	SS (1000's Lbs)	6,004,330	6,903,900	87
Lewisburg	Annual Q (cfs)	16,530	14,410	115
	Avg. High Q (cfs) *	190,000	143,000	133
	TN (1000's Lbs)	33,427	32,650	102
	TP (1000's Lbs)	2,164	1,800	120
	SS (1000's Lbs)	831,642	2,013,460	41
Newport	Annual Q (cfs)	6,862	5,952	115
	Avg. High Q (cfs) *	85,100	48,500	175
	TN (1000's Lbs)	26,608	22,312	119
	TP (1000's Lbs)	1,574	1,099	143
	SS (1000's Lbs)	1,182,830	653,740	181
Marietta	Annual Q (cfs)	56,169	49,393	114
	Avg. High Q (cfs) *	497,000	431,000	115
	TN (1000's Lbs)	179,471	188,700	95
	TP (1000's Lbs)	15,804	12,500	126
	SS (1000's Lbs)	15,887,153	10,410,900	153
Conestoga	Annual Q (cfs)	1,052	885	119
	Avg. High Q (cfs) *	10,400	9,480	110
	TN (1000's Lbs)	15,115	14,210	106
	TP (1000's Lbs)	1,124	970	116
	SS (1000's Lbs)	537,074	419,230	128

* Avg. High Q equals the average daily value that was highest for the year
** % Difference equals 2004 value divided by 1993 value

Table 38. Summary of 2004 Data Comparison to Percentage of LTM, Initial 5-Year Baseline, and Full Program Baseline, and Trends in Flow-Adjusted Concentration for TN, TP, and SS

Parameter	Site	LTM %	Baseline 89	Baseline 04	Trend
FLOW	Towanda	**INC**	N/A	N/A	None
	Danville	**INC**	N/A	N/A	None
	Lewisburg	**INC**	N/A	N/A	None
	Newport	**INC**	N/A	N/A	None
	Marietta	**INC**	N/A	N/A	None
	Conestoga	**INC**	N/A	N/A	None
TN	Towanda	DEC	DEC	DEC	DEC
	Danville	DEC	DEC	DEC	DEC
	Lewisburg	DEC	DEC	DEC	DEC
	Newport	**INC**	**INC**	**INC**	DEC
	Marietta	**INC**	DEC	DEC	DEC
	Conestoga	DEC	DEC	DEC	DEC
TP	Towanda	**INC**	**INC**	DEC	DEC
	Danville	**INC**	**INC**	**INC**	DEC
	Lewisburg	**INC**	DEC	DEC	DEC
	Newport	**INC**	**INC**	**INC**	DEC
	Marietta	**INC**	**INC**	**INC**	**NS**
	Conestoga	**INC**	DEC	DEC	DEC
SS	Towanda	**INC**	**INC**	**INC**	DEC
	Danville	**INC**	**INC**	**INC**	DEC
	Lewisburg	DEC	DEC	DEC	DEC
	Newport	**INC**	**INC**	**INC**	DEC
	Marietta	**INC**	**INC**	**INC**	DEC
	Conestoga	**INC**	DEC	DEC	DEC

INC = Increasing Trends DEC = Decreasing Trends N/A = Not Applicable NS = Not Significant

Table 39. Summary of 2004 Flow-Adjusted Concentration Trends at all Sites

Parameter	Towanda	Danville	Lewisburg	Newport	Marietta	Conestoga
TN	DEC	DEC	DEC	DEC	DEC	DEC
DN	DEC	DEC	DEC	DEC	DEC	NS
TON	DEC	DEC	DEC	DEC	DEC	DEC
DON	DEC	DEC	DEC	DEC	NS	NS
DNH	DEC	DEC	NS	DEC	DEC	DEC
TNH	DEC	DEC	BMDL	BMDL	DEC	DEC
DKN	DEC	DEC	BMDL	BMDL	DEC	DEC
TKN	DEC	DEC	DEC	DEC	DEC	DEC
TNOX	DEC	DEC	DEC	NS	DEC	NS
DNOX	DEC	DEC	DEC	NS	DEC	NS
TP	DEC	DEC	DEC	DEC	NS	DEC
DP	DEC	DEC	DEC	DEC	NS	DEC
DOP	**INC**	**INC**	BMDL	**INC**	**INC**	DEC
TOC	DEC	DEC	NS	DEC	DEC	DEC
SS	DEC	DEC	DEC	DEC	DEC	DEC

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