NUTRIENTS AND SUSPENDED SEDIMENT TRANSPORTED IN THE SUSQUEHANNA RIVER BASIN, 2003, AND TRENDS, JANUARY 1985 THROUGH DECEMBER 2003

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SUSQUEHANNA RIVER BASIN COMMISSION

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**Statutory Citations: Federal - Pub. L. 91-575, 84 Stat. 1509 (December 1970); Maryland - Natural Resources Sec. 8-301 (Michie 1974); New York - ECL Sec. 21-1301 (McKinney 1973); and Pennsylvania - 32 P.S. 820.1 (Supp. 1976).*

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ABSTRACT

Nutrient and suspended-sediment (SS) samples were collected under base flow and stormflow conditions during calendar year 2003. The samples were collected from the Susquehanna River at Towanda, Danville, and Marietta; the West Branch Susquehanna River at Lewisburg; the Juniata River at Newport; and the Conestoga River at Conestoga, Pennsylvania, and analyzed for nitrogen and phosphorus species and SS.

Precipitation for 2003 was above average for all sites. Highest departures from the long-term averages were recorded at Conestoga with 14.68 inches above the long-term mean (LTM) leading to the highest flow at 176.2 percent of the LTM. Lowest departure from the mean was at Danville for rainfall, 1.54 above LTM, and at Lewisburg for flow at 147.3 percent of the LTM. No trends were found for flow.

This report utilizes five methods to determine whether nutrient and SS loads and yields are improving: (1) comparison with similar water year 1996; (2) comparison with initial 5-year baseline yields; (3) comparison with baseline data from beginning of program through 2002 (full program baseline); (4) comparison with the LTM; and (5) trend analysis through 2003.

Comparison with the year 1996 showed increases at Newport for total nitrogen (TN) and total phosphorus (TP) and increases for flow and TN at Conestoga. Baseline comparisons showed increases in TN and TP at Newport and an increase in TP at Marietta when compared to the initial 5-year baselines, and an increase in all three at Newport and an increase in TP for Marietta when compared to the full program baseline.

Comparison with the LTM showed increases at Newport for TN, TP, and SS, increase in flow at Conestoga, and an increase in TP at Marietta. Trends in flow-adjusted concentrations (FACs) were found to be decreasing at Newport for TN and TP and no significant trend at Marietta for TP. TN, TP, and SS were shown to be decreasing at all other sites for all analysis methods.

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's (PADEP) Bureau of Laboratories, the U.S. Environmental Protection Agency (USEPA), and the Susquehanna River Basin Commission (SRBC) cooperated in a study to quantify nutrient and SS transported to the Bay via the Susquehanna River Basin.

Background

Given that the lower Susquehanna River Basin is a significant source of SS to the Bay, SRBC, in cooperation with the PADEP, USEPA, and the U.S. Geological Survey (USGS), conducted a 5-year intensive study at 14 sites from 1985-89. In 1990, the number of sampling sites was reduced to five long-term monitoring stations. An additional site was included in 1994, and sampling at these six sites has continued to the present day. Calculated annual loads and yields of nutrient and SS showed year-to-year variability that was highly correlated with the variability of the annual water discharge (Ott and others, 1991; Takita, 1996, 1998). These studies also reinforced the indications from earlier studies that the highest nutrient yields come from the lower basin.

The existing Susquehanna River sediment and nutrient sites are important in documenting Pennsylvania's real progress in the Bay cleanup effort. These sites have been used to keep track of trends in water quality improvement. With 50 percent of the Bay's total freshwater inflow coming from the Susquehanna River, these sites are critical calibration sites for the Chesapeake Bay Model, which is being used as a major tool in planning the restoration effort.

Objective of the Study

The objective of SRBC's monitoring program is to collect monthly base flow and daily, or more frequent, samples during selected storms from the six long-term monitoring sites in the Susquehanna River Basin. The data are then used to compute annual nutrient and SS loads and trends to evaluate the results of nutrient reduction efforts.

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 2003, and to compare the TN, TP, and SS loads with the baseline established from the 1985-89 study and baselines established for the entire span of the program. Seasonal and annual variations in loads are discussed, as well as the results of statistical trend analysis for the period January 1985 through December 2003 for various forms of nitrogen and phosphorus, SS, total organic carbon (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 and central Pennsylvania, 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. Precipitation in the basin averages 39.15 inches per year, 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 70 percent; agriculture, 22 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 contains the highest density of agriculture within the basin. 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., and Scranton and Wilkes-Barre, Pa. The major urban areas in the West Branch Susquehanna Subbasin are Williamsport, Renovo, and Clearfield. Lewisburg and Altoona are the major urban areas within the Juniata Subbasin.

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

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

Site	Urban	Agricultural	Forested	Other
Towanda	4	23	72	1
Danville	9	22	67	2
Lewisburg	4	11	84	1
Newport	6	19	74	1
Marietta	12	37	49	2
Conestoga	21	49	29	1
Susquehanna River Basin	7	22	70	1

NUTRIENT MONITORING SITES

Data were collected from three sites on the Susquehanna River and three major tributaries in the basin. These six 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.

The Susquehanna River at Towanda, Pa., was selected because it represents the contribution from New York State, although the drainage area does include the Tioga River Watershed in northern Pennsylvania and an area along the northern tier counties of eastern Pennsylvania. The drainage area at Towanda is 7,797 square miles, of which 6,262 square miles lie in New York.

The Susquehanna River at Danville, Pa., has a drainage area of 11,220 square miles, and includes part of northcentral Pennsylvania (the Tioga River Watershed) and much of southcentral New York. Data collected at Danville represent the loadings from tributaries between Towanda and Danville.

Data collected from the West Branch Susquehanna River at Lewisburg, Pa., represent the loadings from this major tributary to the mainstem. The West Branch includes much of northcentral Pennsylvania and has a drainage area of 6,847 square miles. The combined drainage areas above Lewisburg and Danville represent 65.7 percent of the total Susquehanna River Basin.

The Juniata River, a major tributary to the mainstem, includes much of southcentral Pennsylvania, and has a drainage area, above Newport, Pa., of 3,354 square miles. This station represents the loadings from the Juniata River. The combined drainage areas at Danville, Lewisburg, and Newport represent 77.9 percent of the Susquehanna River Basin.

The Susquehanna River at Marietta, Pa., is the southern-most sampling site upstream from the reservoirs on the lower Susquehanna River, and represents the inflow to the reservoirs from its 25,990-square-mile drainage area. This drainage area represents 94.5 percent of the total Susquehanna River Basin.

Table 2. Data Collection Sites and Their Drainage Areas

USGS Identification Number	Original Sites	Short Name	Drainage Area (square mile)
01531500	Susquehanna River at Towanda, Pa.	Towanda	7,797
01540500	Susquehanna River at Danville, Pa.	Danville	11,220
01553500	West Branch Susquehanna River at Lewisburg, Pa.	Lewisburg	6,847
01567000	Juniata River at Newport, Pa.	Newport	3,354
01576000	Susquehanna River at Marietta, Pa.	Marietta	25,990
01576754	Conestoga River at Conestoga, Pa.	Conestoga	470

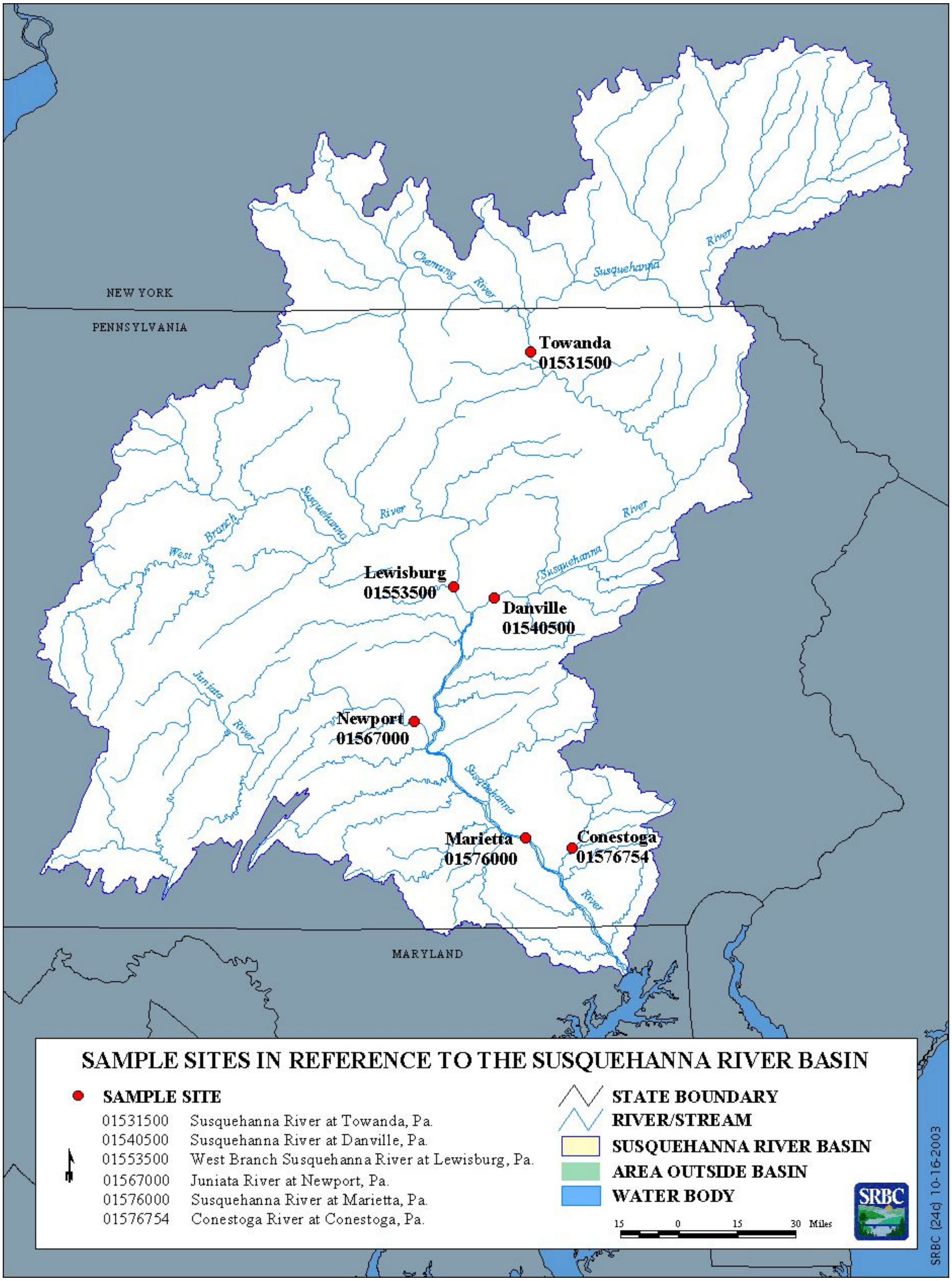


Figure 2. Locations of Sampling Sites within the Susquehanna River Basin

Data collected from the Conestoga River at Conestoga, Pa., provide loadings from a major tributary watershed that is actively farmed and is experiencing an increase in agricultural nutrient management programs. Additionally, this watershed is experiencing an increase in development. The drainage area of this basin above the sampling site is 470 square miles.

SAMPLE COLLECTION AND ANALYSIS

Samples were collected to measure nutrient and SS concentrations during various flows. Generally, two samples were collected per month; one near the twelfth of the month and one during monthly base flow conditions. Additionally, a minimum of 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 prestorm levels. All low flow and random samples were collected by hand with USGS depth-integrating samplers. Multiple vertical samples were taken at each site and then composited so that a representative sample was obtained. Winch operated depth-integrating samplers were used during high flow events to insure that the full water column was sampled.

Whole water samples were collected to be analyzed for TN species, TP species, TOC, and SS. Additionally, filtered samples were collected to analyze for dissolved nitrogen (DN) and dissolved phosphorus (DP) species. All samples were delivered to the PADEP Laboratory in Harrisburg to be analyzed the following workday. The parameters and laboratory methods used are listed in Table 3. SS samples were analyzed at SRBC.

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 subbasins of the Susquehanna River Basin and are reported in Table 4. Due to high rainfalls in the spring and fall, precipitation totals exceeded the LTM at all sites for 2003.

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

Parameter	Laboratory	Methodology	Detection Limit (mg/l)	References
Ammonia (total)	PADEP	Colorimetry	0.020	USEPA 350.1
Ammonia (dissolved)	PADEP	Block Digest, Colorimetry	0.020	USEPA 350.1
Nitrogen (total)	PADEP	Persulfate Digestion for TN	0.040	Standard Methods #4500-N_{org}-D
Nitrogen (dissolved)	PADEP	Persulfate Digestion	0.040	Standard Methods #4500-N_{org}-D
Nitrite plus Nitrate (total)	PADEP	Cd-reduction, Colorimetry	0.010	USEPA 353.2
Nitrite plus Nitrate (dissolved)	PADEP	Cd-reduction, Colorimetry	0.010	USEPA 353.2
Orthophosphate (dissolved)	PADEP	Colorimetry	0.002	USEPA 365.1
Phosphorus (dissolved)	PADEP	Block Digest, Colorimetry	0.010	USEPA 365.1
Phosphorus (total)	PADEP	Persulfate Digest, Colorimetry	0.010	USEPA 365.1
Organic Carbon (total)	PADEP	Combustion/Oxidation	0.50	SM 5310D

Table 4. Summary for Annual Precipitation for Selected Areas in the Susquehanna River Basin, Calendar Year 2003

River Location	Season	Calendar Year 2003 Precipitation inches	Average Long-term Precipitation inches	Departure From Long Term inches
Susquehanna River above Towanda, Pa	January-March	6.58	7.94	-1.36
	April-June	8.77	10.02	-1.25
	July-September	15.06	10.25	+4.81
	October-December	9.71	8.73	+0.98
	Yearly Total	**40.12**	**36.94**	**+3.18**
Susquehanna River above Danville, Pa.	January-March	6.13	7.87	-1.74
	April-June	9.13	10.11	-0.99
	July-September	13.97	10.39	+3.58
	October-December	9.43	8.75	+0.68
	Yearly Total	**38.66**	**37.12**	**+1.54**
West Branch Susquehanna River above Lewisburg, Pa.	January-March	8.38	8.87	-0.49
	April-June	11.55	11.43	+0.12
	July-September	21.25	11.61	+9.64
	October-December	12.18	9.44	+2.74
	Yearly Total	**53.36**	**41.35**	**+12.01**
Juniata River above Newport, Pa.	January-March	8.57	8.79	-0.22
	April-June	13.09	11.01	+2.08
	July-September	16.21	10.89	+5.32
	October-December	10.57	9.13	+1.44
	Yearly Total	**48.44**	**39.82**	**+8.62**
Susquehanna River above Marietta, Pa.	January-March	7.99	8.49	-0.50
	April-June	11.68	10.71	+0.97
	July-September	16.21	10.79	+5.42
	October-December	10.88	9.06	+1.81
	Yearly Total	**46.76**	**39.05**	**+7.71**
Conestoga River above Conestoga, Pa.	January-March	10.19	8.57	+1.62
	April-June	14.16	10.85	+3.31
	July-September	16.96	11.79	+5.17
	October-December	14.09	9.50	+4.59
	Yearly Total	**55.40**	**40.71**	**+14.69**

WATER DISCHARGE

Water discharge data were obtained from the USGS and are listed in Table 5. Lewisburg recorded the second highest rainfall for the year but also recorded the lowest percent of flow above the LTM. This could be due to the watershed being mostly forested and thus allowing for less runoff. Water discharges were above the LTM at all sites ranging from 147.3 percent of the LTM at Lewisburg to 176.2 percent at Conestoga. Figure 3 compares the 2003 discharges with the LTM discharges for each site.

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. Tables 7-19 show the loads and yields for the six monitoring stations, 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. As a general note, nutrient and SS loads increase with increasing discharge.

Table 5. Annual Water Discharge, Calendar Year 2003

Site	Years of Record	Long-term Annual Mean cfs[1]	2003	
			Mean cfs	Percent of LTM[2]
Towanda	90	10,700	16,290	152.2
Danville	99	15,359	24,050	156.6
Lewisburg	64	10,924	16,095	147.3
Newport	104	4,564	8,029	175.9
Marietta	72	37,290	59,234	158.8
Conestoga	19	655	1,154	176.2

[1] Cubic feet per second
[2] Long-Term Mean

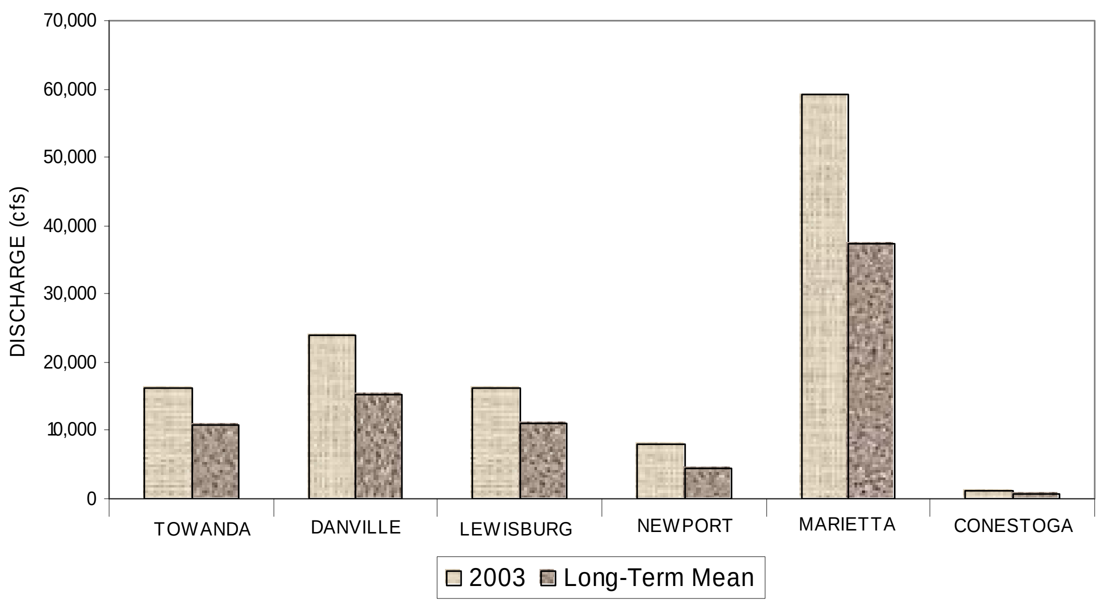


Figure 3. Annual and Long-Term Discharges at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa.

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 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	N Load % of LTM	Prediction Error percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	32,621	113.1	5.4	1.37	1.02	5.78	6.54
Danville	24,050	156.6	50,184	110.4	6.0	1.50	1.06	6.33	6.99
Lewisburg	16,095	147.3	31,644	132.0	7.9	1.12	1.0	5.47	7.22
Newport	8,029	175.9	31,282	194.5	5.1	1.79	1.98	7.49	14.57
Marietta	59,234	158.8	193,078	150.2	6.3	1.75	1.66	7.73	11.61
Conestoga	1,154	176.2	17,139	166.4	5.3	7.98	7.54	34.24	56.98

Table 8. Annual Water Discharges and Annual Loads and Yields of Total Phosphorus, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	P Load % of LTM	Prediction Error percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	2,677	125.2	21.5	0.1015	0.0835	0.428	0.54
Danville	24,050	156.6	4,691	146.5	20.7	0.1059	0.0991	0.446	0.65
Lewisburg	16,095	147.3	1,712	142.2	27.1	0.0560	0.0540	0.275	0.39
Newport	8,029	175.9	1,949	244.8	20.4	0.0886	0.1233	0.371	0.91
Marietta	59,234	158.8	15,013	196.6	19.0	0.1040	0.1287	0.459	0.90
Conestoga	1,154	176.2	1,055	159.1	31.0	0.5139	0.4644	2.202	3.51

Table 9. Annual Water Discharges and Annual Loads and Yields of Total Suspended Sediment, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	SS Load % of LTM	Prediction Error percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	2,399,772	106.4	45.5	107.06	74.83	452.0	480.9
Danville	24,050	156.6	2,855,630	114.4	38.0	82.53	60.31	347.5	397.7
Lewisburg	16,095	147.3	555,487	56.2	63.1	45.98	17.53	225.7	126.8
Newport	8,029	175.9	1,059,614	223.3	46.0	52.82	67.03	221.1	493.6
Marietta	59,234	158.8	8,041,920	151.8	33.9	72.15	68.96	318.4	483.5
Conestoga	1,154	176.2	561,962	179.5	94.1	242.78	247.35	1040.8	1,868.2

Table 10. Annual Water Discharges and Annual Loads and Yields of Total Ammonia, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	1,319	90.0	22.26	0.0688	0.0411	0.29	0.26
Danville	24,050	156.6	2,083	95.0	25.35	0.0721	0.0440	0.30	0.29
Lewisburg	16,095	147.3	1,032	100.0	24.46	0.0480	0.0326	0.24	0.24
Newport	8,029	175.9	587	146.4	25.21	0.0447	0.0371	0.19	0.27
Marietta	59,234	158.8	6,391	142.2	27.91	0.0612	0.0548	0.27	0.38
Conestoga	1,154	176.2	257	90.5	37.54	0.2200	0.1131	0.94	0.86

Table 11. Annual Water Discharges and Annual Loads and Yields of Total NO_{23} Nitrogen, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	22,055	134	7.41	0.7799	0.688	3.29	4.42
Danville	24,050	156.6	33,440	128	6.68	0.8663	0.706	3.65	4.66
Lewisburg	16,095	147.3	23,174	155	6.72	0.6960	0.731	3.42	5.29
Newport	8,029	175.9	25,091	210	5.20	1.3304	1.587	5.57	11.69
Marietta	59,234	158.8	146,915	168	7.02	1.1915	1.260	5.26	8.83
Conestoga	1,154	176.2	14,852	181	6.88	6.37	6.537	27.30	49.37

Table 12. Annual Water Discharges and Annual Loads and Yields of Total Organic Nitrogen, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	10,019	90	11.20	0.53	0.312	2.24	2.01
Danville	24,050	156.6	16,175	922	12.98	0.58	0.342	2.44	2.25
Lewisburg	16,095	147.3	8,894	110	21.23	0.375	0.281	1.84	2.03
Newport	8,029	175.9	6,092	148	14.13	0.458	0.385	1.92	2.84
Marietta	59,234	158.8	35,348	0.88	14.76	0.548	0.303	2.42	2.13
Conestoga	1,154	176.2	2,798	144	25.84	1.51	1.232	6.47	9.3

Table 13. Annual Water Discharges and Annual Loads and Yields of Dissolved Phosphorus, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	905	121	19.03	0.0356	0.0282	0.15	0.18
Danville	24,050	156.6	1,348	151	19.52	0.029	0.0285	0.12	0.19
Lewisburg	16,095	147.3	584	129	19.03	0.021	0.0184	0.10	0.13
Newport	8,029	175.9	905	225	18.22	0.045	0.0573	0.19	0.42
Marietta	59,234	158.8	4,667	192	16.27	0.033	0.0400	0.15	0.28
Conestoga	1,154	176.2	448	172	14.16	0.20	0.1972	0.87	1.49

Table 14. Annual Water Discharges and Annual Loads and Yields of Dissolved Orthophosphate, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	703	1.85	24.10	0.018	0.0219	0.076	0.14
Danville	24,050	156.6	1,004	231	24.25	0.014	0.0212	0.061	0.14
Lewisburg	16,095	147.3	364	2.08	30.20	0.008	0.0115	0.04	0.08
Newport	8,029	175.9	873	288	28.22	0.034	0.0552	0.14	0.41
Marietta	59,234	158.8	4,358	263	24.94	0.023	0.0374	0.10	0.26
Conestoga	1,154	176.2	414	195	19.37	0.16	0.1822	0.70	1.38

Table 15. Annual Water Discharges and Annual Loads and Yields of Dissolved Ammonia, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	1,461	128	19.72	0.054	0.0456	0.23	0.29
Danville	24,050	156.6	2,252	131	19.86	0.057	0.0476	0.24	0.31
Lewisburg	16,095	147.3	1,238	114	18.14	0.05	0.0391	0.25	0.28
Newport	8,029	175.9	612	181	16.70	0.038	0.0387	0.16	0.28
Marietta	59,234	158.8	5,946	151	19.65	0.05	0.0510	0.24	0.36
Conestoga	1,154	176.2	242	124	31.26	0.15	0.1065	0.65	0.29

Table 16. Annual Water Discharges and Annual Loads and Yields of Dissolved Nitrogen, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	30,225	133	5.67	1.08	0.942	4.57	6.06
Danville	24,050	156.6	44,867	123	6.54	1.208	0.948	5.09	6.25
Lewisburg	16,095	147.3	28,206	121	6.57	1.08	0.890	5.32	6.44
Newport	8,029	175.9	28,640	212	4.71	1.50	1.812	6.28	13.34
Marietta	59,234	158.8	173,772	167	6.58	1.42	1.490	6.25	10.45
Conestoga	1,154	176.2	16,363	190	6.14	6.68	7.202	28.65	54.40

Table 17. Annual Water Discharges and Annual Loads and Yields of Dissolved NO_{23} Nitrogen, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	21,878	154	7.38	0.67	0.682	2.85	4.38
Danville	24,050	156.6	33,112	137	6.72	0.80	0.699	3.36	4.61
Lewisburg	16,095	147.3	23,002	145	6.57	0.74	0.726	3.62	5.25
Newport	8,029	175.9	24,956	231	5.21	1.20	1.579	5.03	11.63
Marietta	59,234	158.8	145,701	221	7.16	0.90	1.249	3.97	8.76
Conestoga	1,154	176.2	14,800	199	6.88	5.78	6.514	24.78	49.20

Table 18. Annual Water Discharges and Annual Loads and Yields of Dissolved Organic Nitrogen, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	8,541	104	10.70	0.39	0.266	1.64	1.71
Danville	24,050	156.6	11,893	108	10.76	0.36	0.251	1.54	1.66
Lewisburg	16,095	147.3	5,566	105	15.88	0.25	0.176	1.21	1.27
Newport	8,029	175.9	4,017	142	11.59	0.31	0.254	1.31	1.87
Marietta	59,234	158.8	23,113	80	18.47	0.39	0.198	1.73	1.39
Conestoga	1,154	176.2	2,157	213	25.76	0.79	0.949	3.37	7.17

Table 19. Annual Water Discharges and Annual Loads and Yields of Total Organic Carbon, Calendar Year 2003

Site	Annual Discharge cfs	Discharge % of LTM	Annual Load thousand lbs	Load % of LTM	Prediction Error Percent	LTM Conc. mg/l	2003 Ave. Conc. mg/l	LTM Yield lb/ac/yr	Annual Yield lbs/ac/yr
Towanda	16,290	152.2	112,146	141	4.45	3.77	3.497	15.91	22.47
Danville	24,050	156.6	166,362	156	4.28	3.52	3.514	14.81	23.17
Lewisburg	16,095	147.3	73,227	169	7.31	2.02	2.311	9.91	16.71
Newport	8,029	175.9	50,402	167	6.68	3.36	3.189	14.06	23.48
Marietta	59,234	158.8	356,712	151	5.10	3.21	3.059	14.17	21.45
Conestoga	1,154	176.2	11,153	137	9.50	6.31	4.909	27.07	37.08

Identifying sites where the percentage of LTM for a constituent was higher than the percentage of LTM for discharge may show potential areas where degradation was occurring for that particular constituent. For example, the flow for 2003 was 175.9 percent of the LTM at Newport while TN was 194.5 percent, TP was 244.8 percent, and SS was 223.3 percent of the long term means. This implies an increase in these constituents that has come from more than increased flow. Newport also showed higher average annual concentrations for TN, TP, and SS during 2003 as compared with the LTMs. As a general note for 2003, when higher percentages of LTM were found, so were higher average concentrations. Marietta showed an increased TP load and concentration value when compared to the LTM. All yield values for 2003 for TN, TP, and SS were higher than the LTMs for all sites except for SS at Lewisburg. Lewisburg also showed a lower average annual concentration as compared to the LTM. The higher yields were most likely due to increased flow during 2003.

While TN was shown to be decreasing at all sites, DN showed higher than LTM values at Newport, Marietta, and Conestoga. Much of this DN value was contained in dissolved NO23 which was higher than the LTM at Newport, Marietta, and Conestoga. Dissolved ammonia was also higher than the LTM at Newport. DP was higher than LTMs at Newport and Marietta and dissolved orthophosphate (DOP) was higher than LTMs at all sites. Dissolved organic nitrogen showed higher than LTMs at Conestoga. Lewisburg was the only site to show higher than LTMs for TOC. This could be due to leaf litter from the mostly forested watershed. Figures 4-6 show loads and yields of TN, TP, and SS in comparison with the LTM for each site.

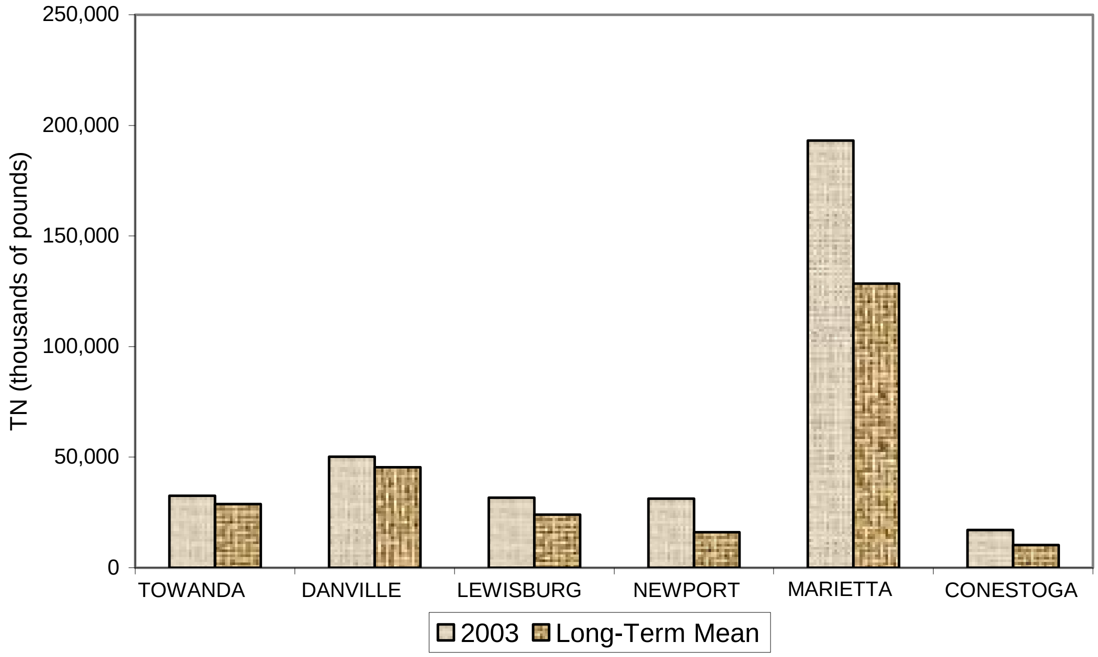


Figure 4A. ***Annual Loads of Total Nitrogen (TN) at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2003***

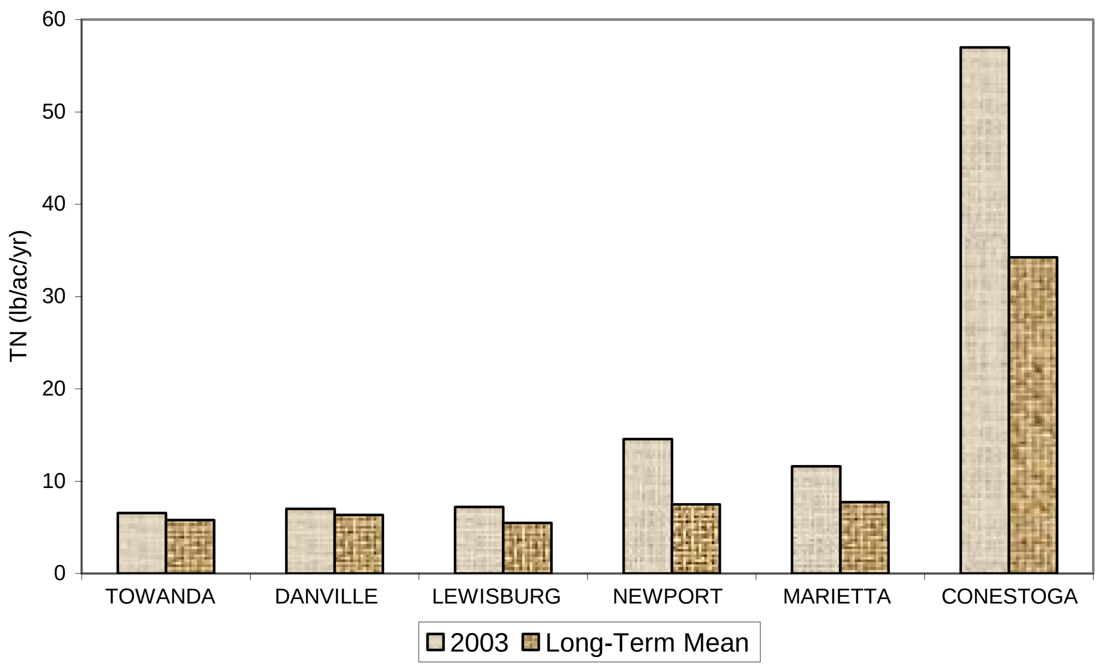


Figure 4B. ***Total Nitrogen (TN) Yields at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2003***

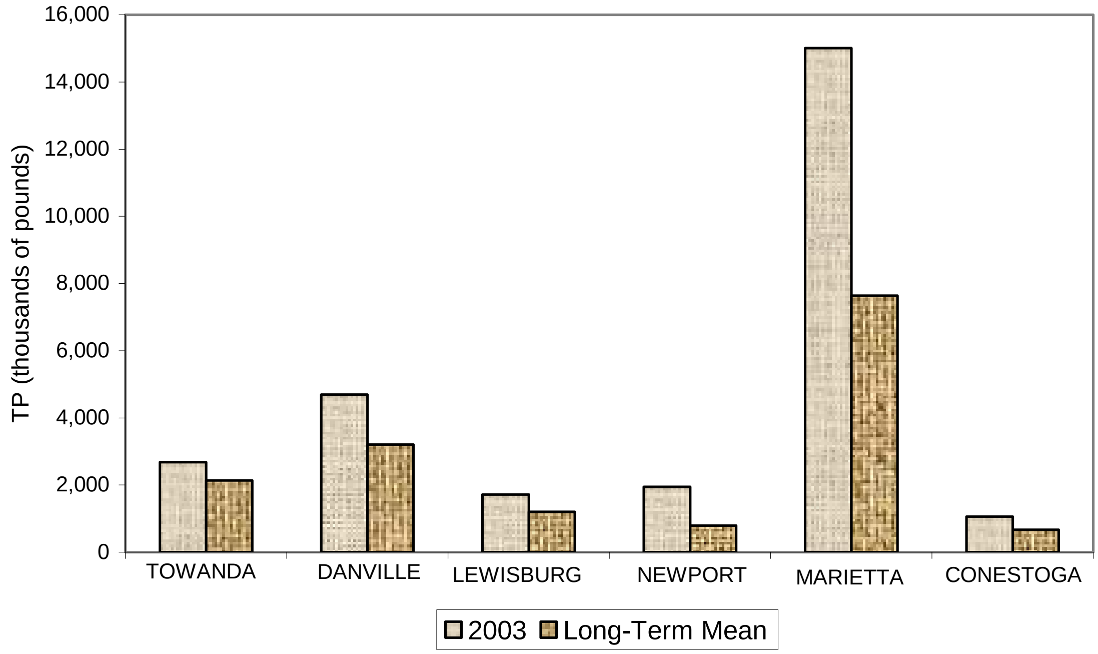


Figure 5A. ***Annual Loads of Total Phosphorus (TP) at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2003***

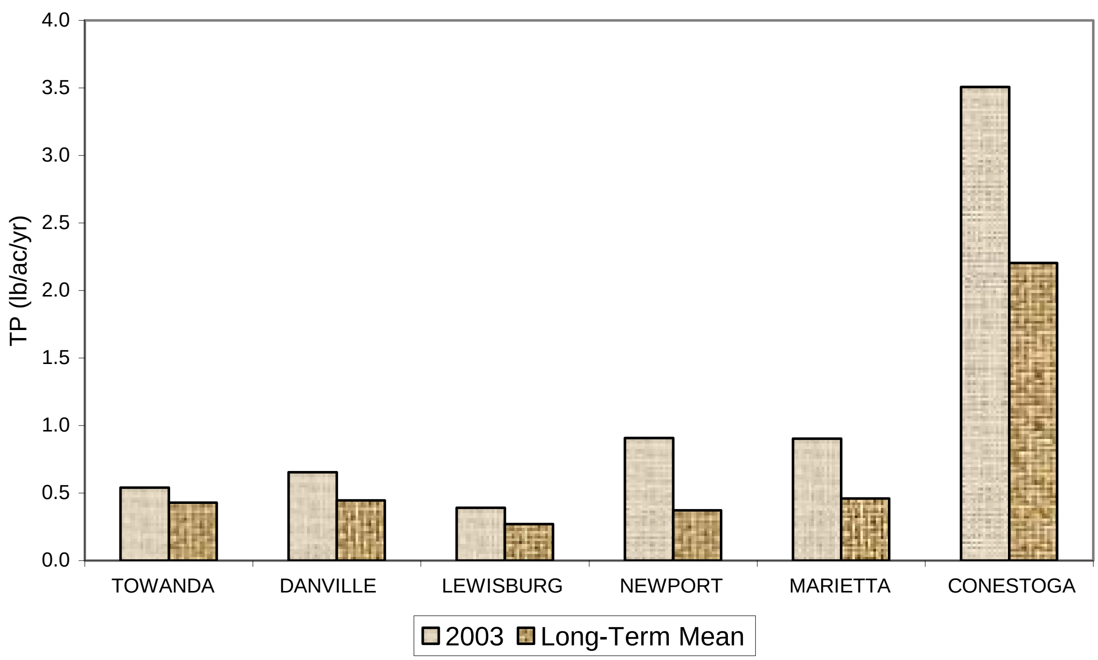


Figure 5B. ***Total Phosphorus (TP) Yields at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2003***

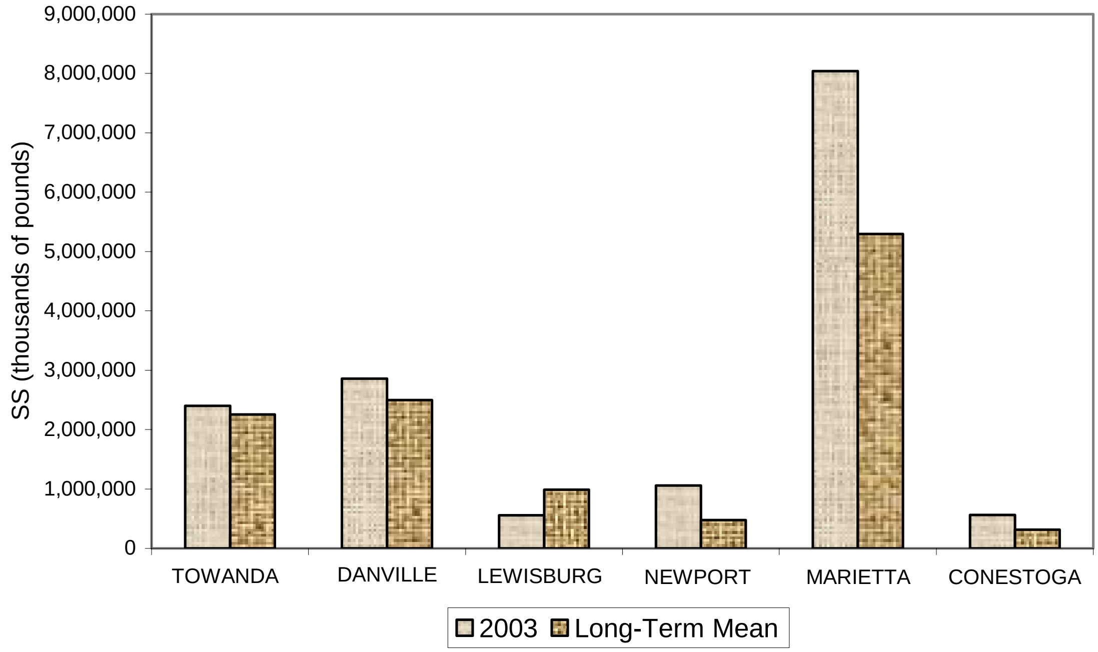


Figure 6A. ***Annual Loads of Suspended Sediment (SS) at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2003***

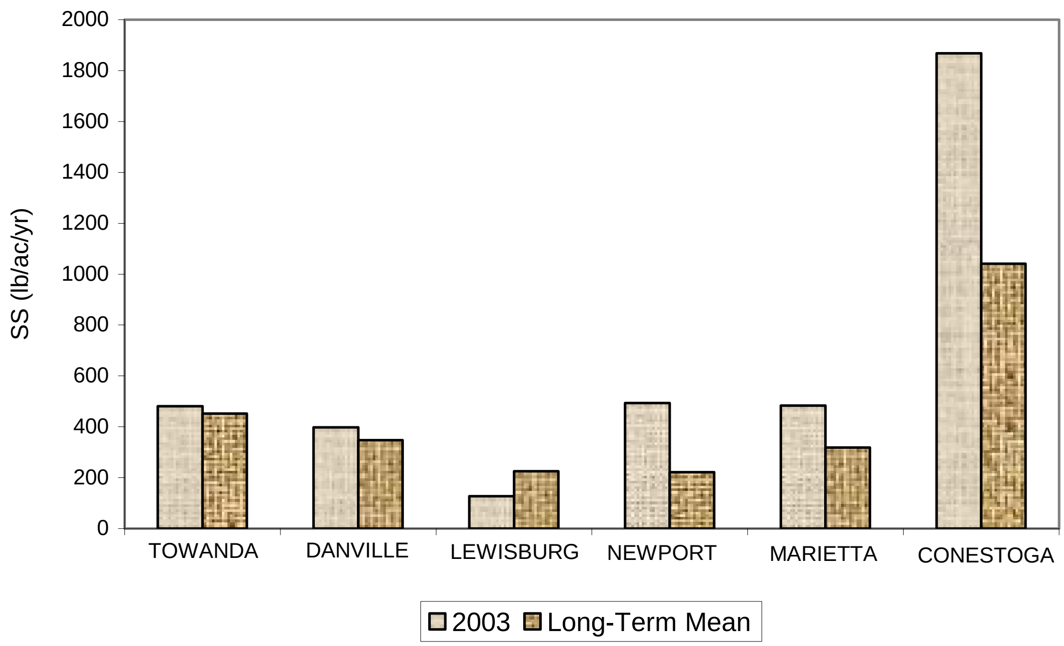


Figure 6B. ***Suspended Sediment (SS) Yields at Towanda, Danville, Lewisburg, Newport, Marietta, and Conestoga, Pa., Calendar Year 2003***

When looking at constituent loads, it can be difficult to determine whether improvements are being made due to the variations in flow. Because of this, it is useful to compare the loads from years that had similar amounts of flow. Table 20 lists the flow and TN, TP, and SS loads for 1996 and 2003. The fact that constituent loads tend to be higher during higher flow years suggests that the loads for TN, TP, and SS should be higher for all sites except Conestoga during 1996. This was the case for TN, TP, and SS at all sites except Newport, which showed higher percent loads as compared to the 1996 values for TN and TP.

Tables 21–24 show seasonal comparisons of years 1996 and 2003. Newport showed higher percentages than 1996 for TN and TP for all seasons, including doubling the 1996 spring value. SS at Conestoga was four times the 1996 value, while the TP value was only 43.27 percent of the 1996 value. This indicates less sediment bound phosphorous was being transported. Summer sampling results showed increased percentages as compared to 1996 in TP and SS at Towanda, Danville, Conestoga, and Marietta. TN was higher in the fall at Newport, Conestoga, and Marietta.

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

Seasonal loads for all parameters and all sites are listed in Table 25 for loads and Table 26 for percentages (high values in boldface type). 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. This was observed at all sites for TN except at Towanda. TP, DP and DOP were highest during the fall for all sites except for TP at Conestoga. This matched the highest flow season for Towanda, Danville, Lewisburg, and Marietta.

For Newport, fall was actually the lowest flow season while it was the highest for TP, DP, DOP, and the second highest for TN, DN, total nitrate plus nitrite (TNOx), dissolved nitrate plus nitrite (DNOx), total ammonia (TNH3), dissolved ammonia (DNH3), and TOC. Winter at Newport constituted 36.5 percent of the annual flow and 26.54 percent of the SS annual load while fall represented 13.73 percent of the flow and 24.28 percent of the SS. SS was highest during the winter at Towanda, Danville, Lewisburg, and Marietta even though the season was the second highest for flow at each of the four sites. Conestoga had the highest SS loads during the spring, which was the third highest flow season for the site. Flow at Conestoga for spring was 25.41 percent of the annual flow and 38.26 percent of the annual SS load.

When compared to the seasonal LTMs, Towanda and Danville showed higher than the LTMs for spring flow and lower than the LTMs in TN and TP, with large reductions shown in SS. Spring flows at Lewisburg for 2003 were equal to the LTM while similar reductions in TN, TP, and SS were found at Lewisburg as at the northern sites. Newport showed above LTM values for all seasons for flow, TN, TP, and SS. Marietta had a higher spring flow than the LTM while also showing a lower SS value. Conestoga had all flow values higher than the LTM and a much larger SS value as compared to the LTM during the spring. Figures 7-12 show graphs of discharge, TN, TP and SS as compared to the LTM.

Newport showed an increase in TN yields during the winter and spring when compared to the LTM yields, while Marietta showed higher TN yields in the fall as compared to the LTM yield. Towanda, Danville, and Marietta showed increasing TP yields downstream for 2003, which matched the same trend in LTM yields. Marietta and Newport both showed significant increases in yield values during the summer and fall months as compared to the LTMs. Increases over the LTMs also were apparent during those seasons at all other sites. SS showed a generally decreasing trend in the long term when moving downstream on the Susquehanna. 2003 yields roughly followed the same pattern during winter and fall but showed increasing yields during the spring and summer. When comparing the seasonal percentages, spring had the highest percent of TP, SS, and flow at all sites. Figures 13-16 show the seasonal yields for each site.

Table 20. Comparison of 2003 Loads with 1996 Loads for Flow, TN, TP, and SS

Site	Discharge (cfs)			TN thousands (lbs)			TP thousand (lbs)			SS thousands (lbs)		
	1996	2003	% Change	1996	2003	% Change	1996	2003	% Change	1996	2003	% Change
Towanda	17,000	16,290	95.82	43,400	32,621	75.16	4,800	2,677	55.77	8,690,000	2,399,772	27.62
Danville	24,800	24,050	96.98	64,600	50,184	77.68	6,890	4,691	68.08	7,450,000	2,855,630	38.33
Lewisburg	17,100	16,095	94.12	40,800	31,644	77.56	2,810	1,712	60.93	4,560,000	555,487	12.18
Newport	8,660	8,029	92.71	30,500	31,282	102.56	1,270	1,949	153.46	1,270,000	1,059,614	83.43
Marietta	63,600	59,234	93.14	221,000	193,078	87.37	16,200	15,013	92.67	14,000,000	8,041,920	57.44
Conestoga	1,120	1,154	103.04	16,300	17,139	105.15	1,580	1,055	66.77	759,000	561,962	74.04

Table 21. Comparison of 2003 Loads with 1996 Loads for Flow, TN, TP, and SS During Winter

Site	Discharge (cfs)			TN thousands (lbs)			TP thousand (lbs)			SS thousands (lbs)		
	1996	2003	% Change	1996	2003	% Change	1996	2003	% Change	1996	2003	% Change
Towanda	20,600	18,888	91.69	14,300	10,475	73.25	1,590	830	52.20	2,930,000	966,671	32.99
Danville	30,600	26,795	87.57	21,700	15,774	72.69	2,200	1,281	58.23	2,650,000	966,803	36.48
Lewisburg	24,200	16,344	67.54	16,800	8,870	52.80	1,260	505	40.08	2,690,000	229,980	8.55
Newport	12,700	10,186	80.20	11,600	9,857	84.97	618	515	83.33	496,000	281,229	56.70
Marietta	96,600	62,987	65.20	86,300	51,639	59.84	6,460	3,784	58.58	5,750,000	2,442,463	42.48
Conestoga	1,410	1,337	94.82	5,390	5,179	96.09	520	225	43.27	25,900	126,788	489.53

Table 22. Comparison of 2003 Loads with 1996 Loads for Flow, TN, TP, and SS During Spring

Site	Discharge (cfs)			TN thousands (lbs)			TP thousand (lbs)			SS thousands (lbs)		
	1996	2003	% Change	1996	2003	% Change	1996	2003	% Change	1996	2003	% Change
Towanda	20,900	17,454	83.51	12,500	8,096	64.77	1,160	538	46.38	2,310,000	400,918	17.36
Danville	29,200	26,696	91.42	17,400	12,502	71.85	1,620	1,029	63.52	2,020,000	663,111	32.83
Lewisburg	14,800	15,462	104.47	7,540	6,638	88.04	419	281	67.06	413,000	69,222	16.76
Newport	6,260	8,935	142.73	5,030	7,680	152.68	190	525	276.32	172,000	351,206	204.19
Marietta	62,000	64,682	104.33	44,200	44,306	100.24	2,770	3,446	124.40	2,220,000	1,880,303	84.70
Conestoga	1,010	1,172	116.04	3,720	4,162	111.88	277	297	107.22	122,000	214,999	176.23

Table 23. Comparison of 2003 Loads with 1996 Loads for Flow, TN, TP, and SS During Summer

Site	Discharge (cfs)			TN thousands (lbs)			TP thousand (lbs)			SS thousands (lbs)		
	1996	2003	% Change	1996	2003	% Change	1996	2003	% Change	1996	2003	% Change
Towanda	4,740	9,454	199.45	2,320	3,916	168.79	183	380	207.65	83,500	274,906	329.23
Danville	7,380	14,255	193.16	3,640	5,954	163.57	307	657	214.01	106,000	309,983	292.44
Lewisburg	7,790	13,634	175.02	3,610	5,649	156.48	210	299	142.38	135,000	79,585	58.95
Newport	6,470	4,948	76.48	6,020	4,831	80.25	300	363	121.00	462,000	169,942	36.78
Marietta	27,000	40,352	149.45	18,900	30,556	161.67	1,210	2,663	220.08	745,000	1,332,297	178.83
Conestoga	563	810	143.87	1,950	2,835	145.38	151	264	174.83	50,100	123,607	246.72

Table 24. Comparison of 2003 Loads with 1996 Loads for Flow, TN, TP, and SS During Fall

Site	Discharge (cfs)			TN thousands (lbs)			TP thousand (lbs)			SS thousands (lbs)		
	1996	2003	% Change	1996	2003	% Change	1996	2003	% Change	1996	2003	% Change
Towanda	21,700	19,363	89.23	14,200	10,134	71.37	1,860	928	49.89	3,250,000	747,276	22.99
Danville	31,900	28,456	89.20	21,800	15,955	73.19	2,730	1,723	63.11	2,670,000	915,735	34.30
Lewisburg	21,800	18,940	86.88	12,900	10,488	81.30	927	627	67.64	1,320,000	176,699	13.39
Newport	9,210	3,830	41.59	7,900	8,915	112.85	162	546	337.04	138,000	257,267	186.43
Marietta	79,100	68,913	87.12	71,800	66,577	92.73	5,740	5,120	89.20	5,310,000	2,386,857	44.95
Conestoga	1,490	1,294	86.85	5,270	4,963	94.17	635	268	42.20	327,000	96,568	29.53

Table 25. Seasonal Mean Water Discharges and Loads of Nutrients and Suspended Sediment, Calendar year 2003

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	18,888	**10,475**	**9,768**	414	476	**3,106**	**2,548**	7,138	**7,113**	830	248	184	27,711	**966,671**
	Spring	17,454	8,096	7,477	247	280	2,580	2,194	5,418	5,434	538	178	136	27,771	400,918
	Summer	9,454	3,916	3,466	143	142	1,549	1,310	2,330	2,300	380	136	116	20,758	284,906
	Fall	**19,363**	10,134	9,513	**514**	**563**	2,784	2,489	**7,170**	7,031	**928**	**344**	**267**	**35,906**	747,276
Danville	Winter	26,795	15,774	14,430	687	770	**4,656**	3,464	11,029	**11,022**	1,281	353	269	38,853	**966,803**
	Spring	26,696	12,502	10,894	380	470	4,510	3,136	7,929	7,868	1,029	278	213	43,525	663,111
	Summer	14,255	5,954	5,008	187	200	2,498	1,747	3,384	3,304	657	190	148	30,363	309,983
	Fall	**28,456**	**15,955**	**14,565**	**829**	**812**	4,511	**3,546**	**11,098**	10,917	**1,723**	**528**	**374**	**53,621**	915,735
Lewisburg	Winter	16,344	8,870	7,753	339	382	**2,770**	1,617	6,027	6,028	505	146	95	15,889	**229,980**
	Spring	15,462	6,638	5,994	180	250	1,801	1,245	4,840	4,809	281	104	60	14,882	69,222
	Summer	13,634	5,649	5,118	134	181	1,615	1,085	4,248	4,172	299	114	74	18,700	79,585
	Fall	**18,940**	**10,488**	**9,341**	**378**	**425**	2,708	**1,620**	**8,060**	**7,992**	**627**	**219**	**135**	**23,757**	176,699
Newport	Winter	**10,186**	**9,857**	**9,099**	**175**	**182**	**1,903**	**1,304**	**7,904**	**7,875**	515	238	229	**14,119**	281,229
	Spring	8,935	7,680	6,919	146	157	1,761	1,118	5,927	5,891	525	217	200	13,378	**351,206**
	Summer	4,948	4,831	4,373	95	99	992	642	3,781	3,754	363	178	180	9,313	169,942
	Fall	3,830	8,915	8,248	171	173	1,436	954	7,479	7,436	**546**	**272**	**264**	13,592	257,267
Marietta	Winter	62,987	51,639	47,366	2,102	1,910	**10,460**	**7,152**	39,371	39,095	3,784	1,079	1,007	81,725	**2,442,463**
	Spring	64,682	44,306	39,263	1,072	1,148	9,049	5,751	32,581	32,151	3,446	1,100	972	90,966	1,880,303
	Summer	40,352	30,556	26,569	633	665	6,009	3,890	21,928	21,715	2,663	918	883	73,517	1,332,297
	Fall	**68,913**	**66,577**	**60,573**	**2,584**	**2,232**	9,830	6,320	**53,034**	**52,740**	**5,120**	**1,570**	**1,497**	**110,504**	2,386,857
Conestoga	Winter	**1,337**	**5,179**	**4,937**	77	**77**	**952**	**750**	4,313	4,275	225	98	80	2,883	126,788
	Spring	1,172	4,162	3,929	57	51	714	544	3,569	3,550	**297**	100	95	2,887	**214,999**
	Summer	810	2,835	2,694	44	38	420	308	2,541	2,543	264	107	111	2,246	123,607
	Fall	1,294	4,963	4,803	**80**	76	711	554	**4,428**	**4,432**	268	**143**	**128**	**3,137**	96,568

Table 26. Seasonal Mean Water Discharge and Load Percentages of Nutrients and Suspended Sediment, Calendar year 2003

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	28.99%	**32.11**%	**32.32**%	31.41%	32.58%	**31.00**%	**29.83**%	32.36%	**32.51**%	31.02%	27.37%	26.17%	24.71%	**40.28**%
	Spring	26.79%	24.82%	24.74%	18.74%	19.16%	25.75%	25.69%	24.56%	24.84%	20.10%	19.65%	19.35%	24.76%	16.71%
	Summer	14.51%	12.00%	11.47%	10.85%	9.72%	15.46%	15.34%	10.56%	10.51%	14.20%	15.01%	16.50%	18.51%	11.87%
	Fall	**29.72**%	31.07%	31.47%	**39.00**%	**38.54**%	27.79%	29.14%	**32.51**%	32.14%	**34.68**%	**37.97**%	**37.98**%	**32.02**%	31.14%
Danville	Winter	27.85%	31.43%	32.14%	32.98%	34.19%	**28.79**%	29.13%	32.98%	**33.29**%	27.31%	26.17%	26.79%	23.35%	**33.86**%
	Spring	27.75%	24.91%	24.26%	18.24%	20..87%	27.88%	26.37%	23.71%	23.76%	21.94%	20.61%	21.22%	26.16%	23.22%
	Summer	14.82%	11.86%	11.15%	8.98%	8.88%	15.44%	14.69%	10.12%	9.98%	14.01%	14.08%	14.74%	18.25%	10.86%
	Fall	**29.58**%	**31.79**%	**32.44**%	**39.80**%	**36.06**%	27.89%	**29.82**%	**33.19**%	32.97%	**36.74**%	39.14%	**37.25**%	**32.23**%	32.07%
Lewisburg	Winter	25.39%	28.03%	27.19%	32.88%	30.86%	**31.14**%	29.05%	26.01%	26.21%	29.50%	25.04%	26.10%	21.70%	**41.40**%
	Spring	24.02%	20.98%	21.25%	17.46%	20.19%	20.25%	22.36%	20.88%	20.91%	16.41%	17.84%	16.48%	20.32%	12.46%
	Summer	21.18%%	17.85%	18.15%	13.00%	14.62%	18.16%	19.49%	18.33%	18.14%	17.46%	19.55%	20.33%	25.54%	14.33%
	Fall	**29.42**%	**33.14**%	**33.12**%	**36.66**%	**34.33**%	30.45%	**29.10**%	**34.78**%	**34.75**%	**36.62**%	**37.56**%	**37.09**%	**32.44**%	31.81%
Newport	Winter	**36.51**%	**31.51**%	**31.77**%	**29.81**%	**29.79**%	**31.24**%	**32.45**%	**31.50**%	**31.56**%	26.42%	26.30%	26.23%	**28.01**%	26.54%
	Spring	32.03%	24.55%	24.16%	24.87%	25.70%	28.91%	27.82%	23.62%	23.61%	26.94%	23.98%	22.91%	26.54%	**33.14**%
	Summer	17.74%	15.44%	15.27%	16.18%	16.20%	16.28%	15.98%	15.07%	15.04%	18.62%	19.67%	20.62%	18.48%	16.04%
	Fall	13.73%	28.50%	28.80%	29.13%	28.31%	23.57%	23.74%	29.81%	29.80%	**28.01**%	**30.06**%	**30.24**%	26.97%	24.28%
Marietta	Winter	26.58%	26.75%	27.26%	32.89%	32.07%	**29.59**%	**30.94**%	26.80%	26.83%	25.20%	23.12%	23.10%	22.91%	**30.37**%
	Spring	27.30%	22.95%	22.59%	16.77%	19.28%	25.60%	24.88%	22.18%	22.07%	22.95%	23.57%	22.30%	25.50%	23.38%
	Summer	17.03%	15.83%	15.29%	9.90%	11.17%	17.00%	16.83%	14.93%	14.90%	17.74%	19.67%	20.26%	20.61%	16.57%
	Fall	**29.09**%	**34.48**%	**34.86**%	**40.43**%	**37.48**%	27.81%	27.34%	**36.10**%	**36.20**%	**34.10**%	**33.64**%	**34.34**%	**30.98**%	29.68%
Conestoga	Winter	**28.98**%	**30.22**%	**30.17**%	29.84%	**31.82**%	**34.04**%	**34.79**%	29.04%	28.89%	21.35%	21.88%	19.32%	25.85%	22.56%
	Spring	25.41%	24.28%	24.01%	22.09%	21.07%	25.53%	25.23%	24.03%	23.99%	**28.18**%	22.32%	22.95%	25.89%	**38.26**%
	Summer	17.56%	16.54%	16.46%	17.05%	15.70%	15.02%	14.29%	17.11%	17.18%	25.05%	23.88%	26.81%	20.14%	22.00%
	Fall	28.05%	28.96%	29.35%	**31.01**%	31.40%	25.42%	25.70%	**29.82**%	**29.95**%	25.43%	**31.92**%	**30.92**%	**28.13**%	17.18%

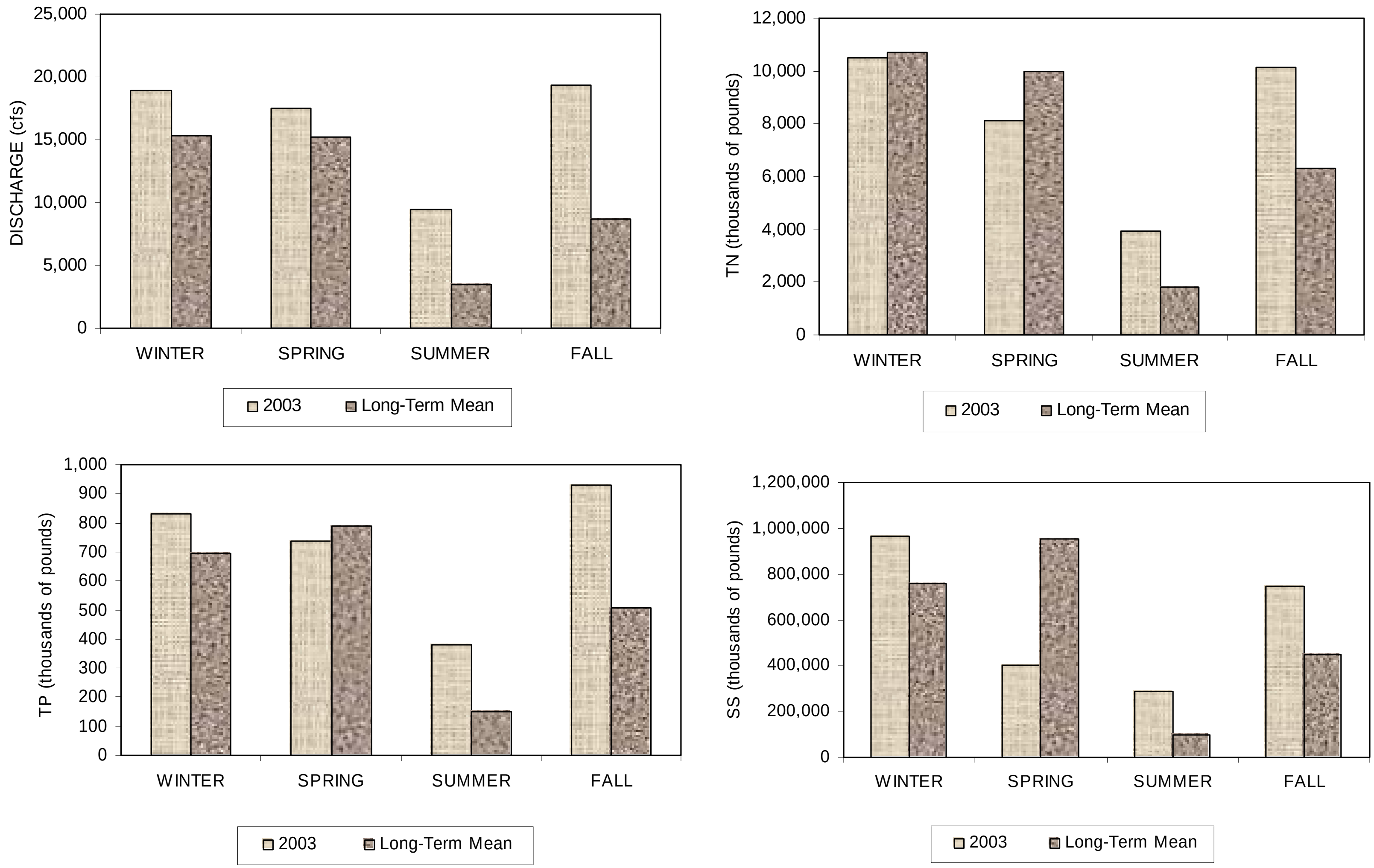


Figure 7. Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), Suspended Sediment (SS) at Towanda, Pa., Calendar Year 2003

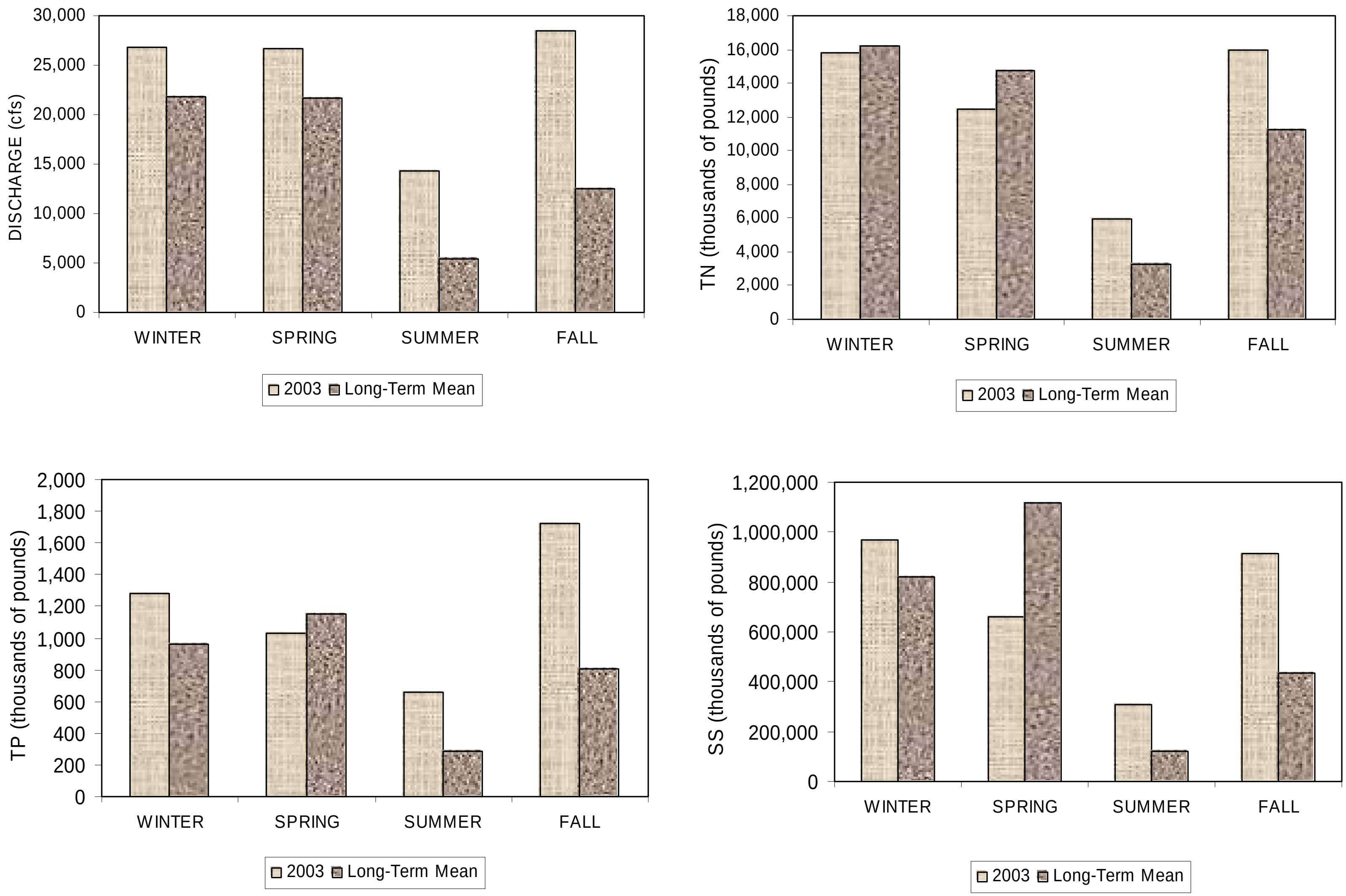


Figure 8. Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), Suspended Sediment (SS) at Danville, Pa., Calendar Year 2003

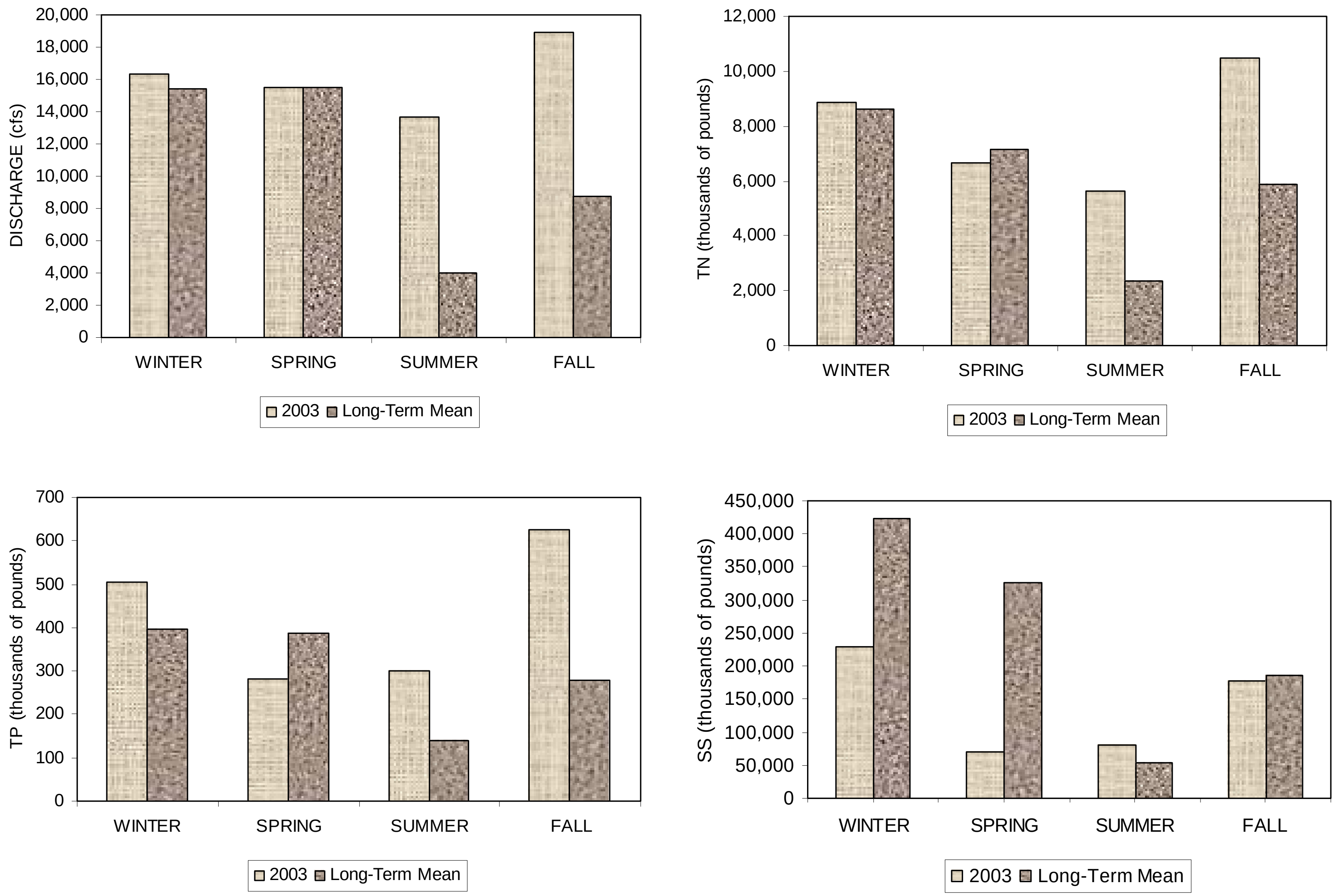


Figure 9. ***Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), Suspended Sediment (SS) at Lewisburg, Pa., Calendar Year 2003***

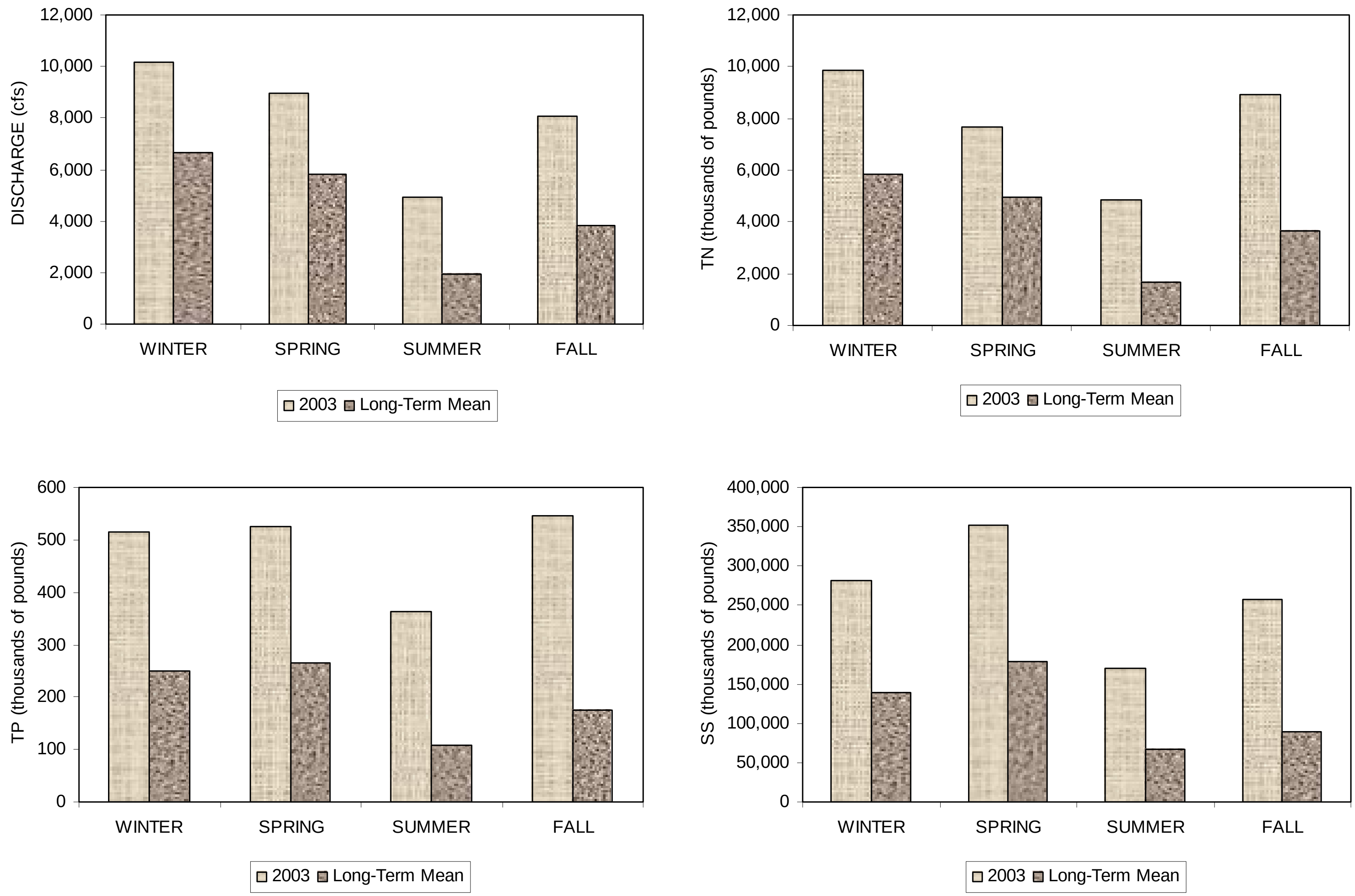


Figure 10. ***Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), Suspended Sediment (SS) at Newport, Pa., Calendar Year 2003***

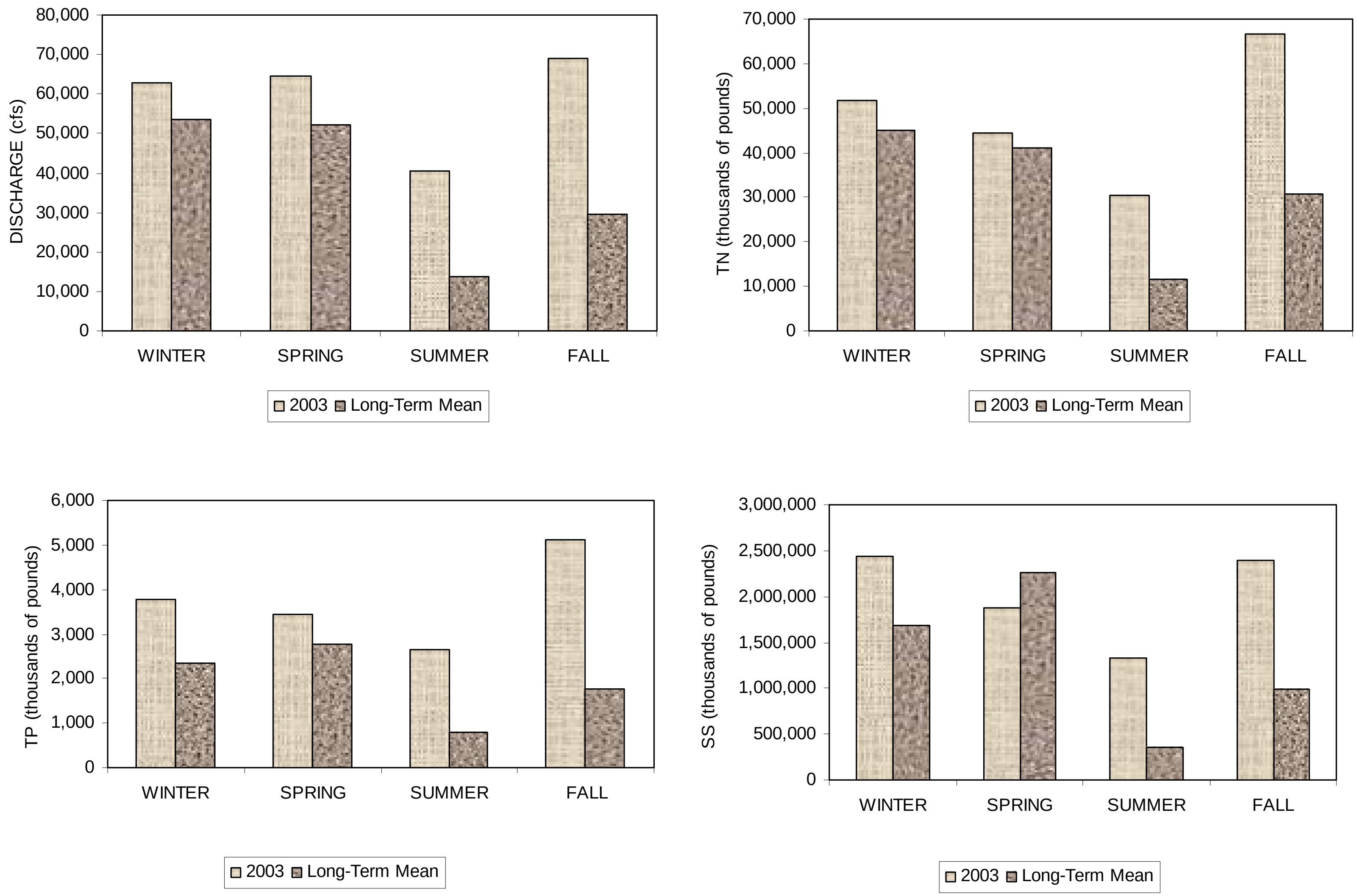


Figure 11. ***Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), Suspended Sediment (SS) at Marietta, Pa., Calendar Year 2003***

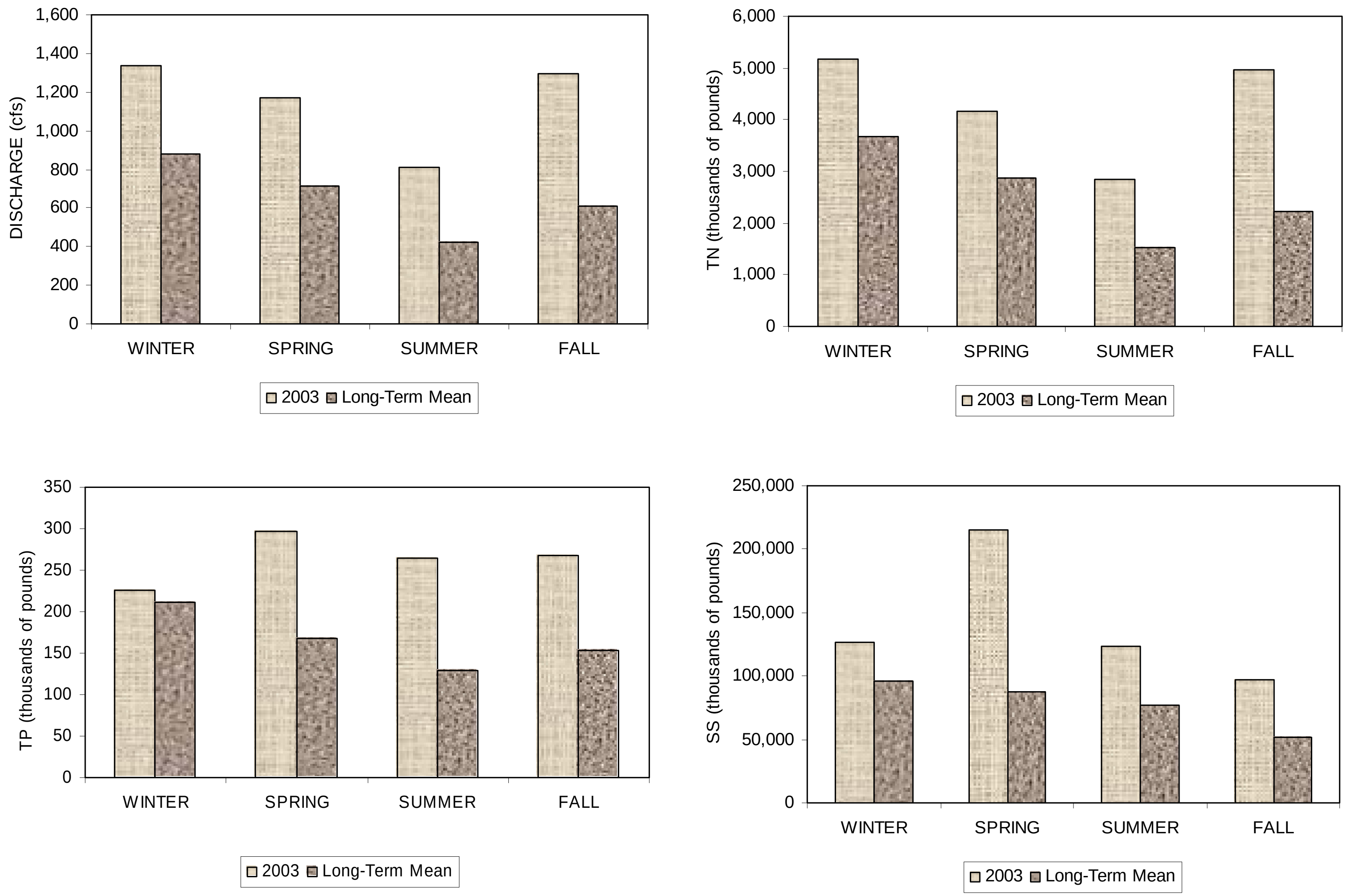


Figure 12. ***Seasonal Discharges and Loads of Total Nitrogen (TN), Total Phosphorus (TP), Suspended Sediment (SS) at Conestoga, Pa., Calendar Year 2003***

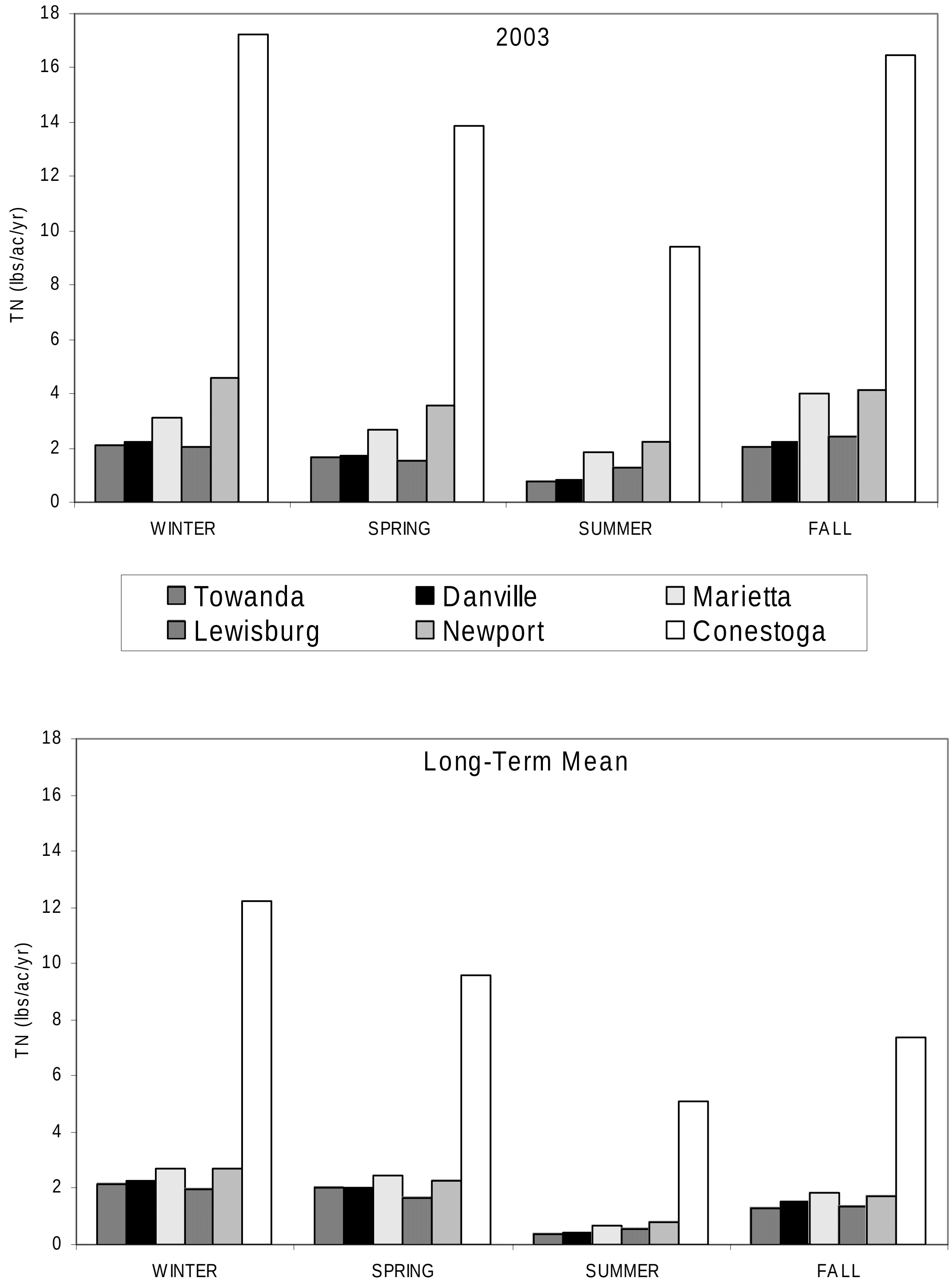
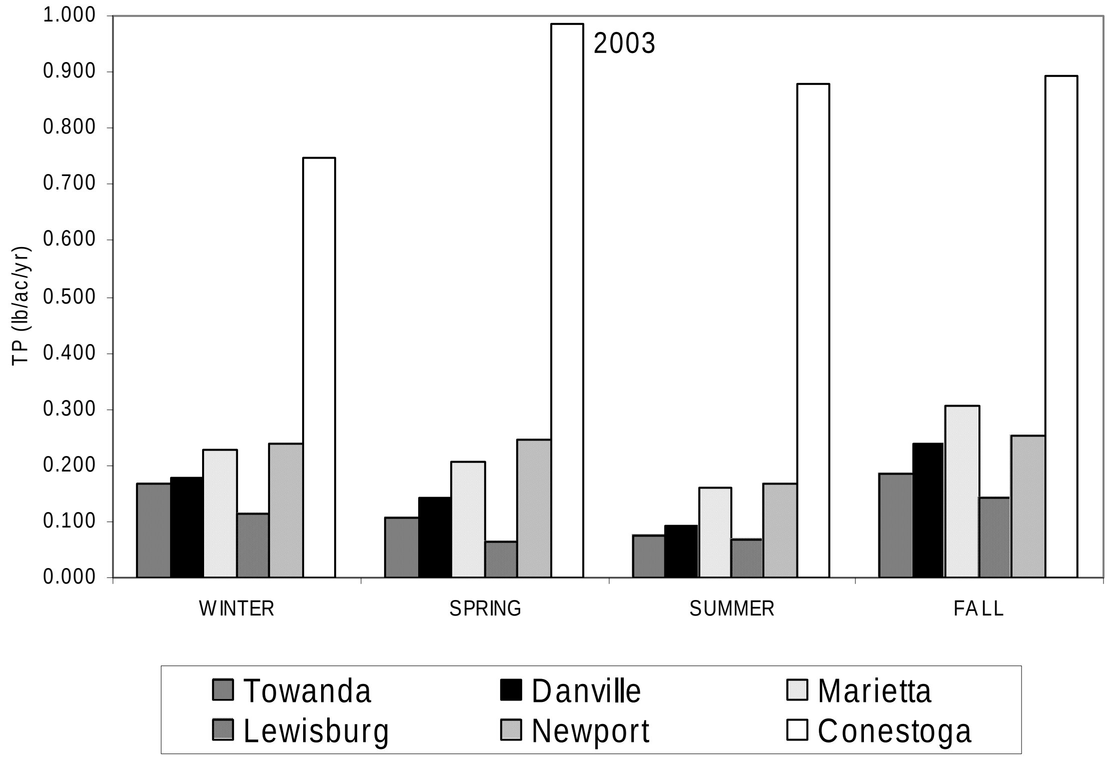


Figure 13. ***Comparison of Seasonal Yields of Total Nitrogen (TN) at Towanda, Danville, Marietta, Lewisburg, Newport, and Conestoga, Pa.***



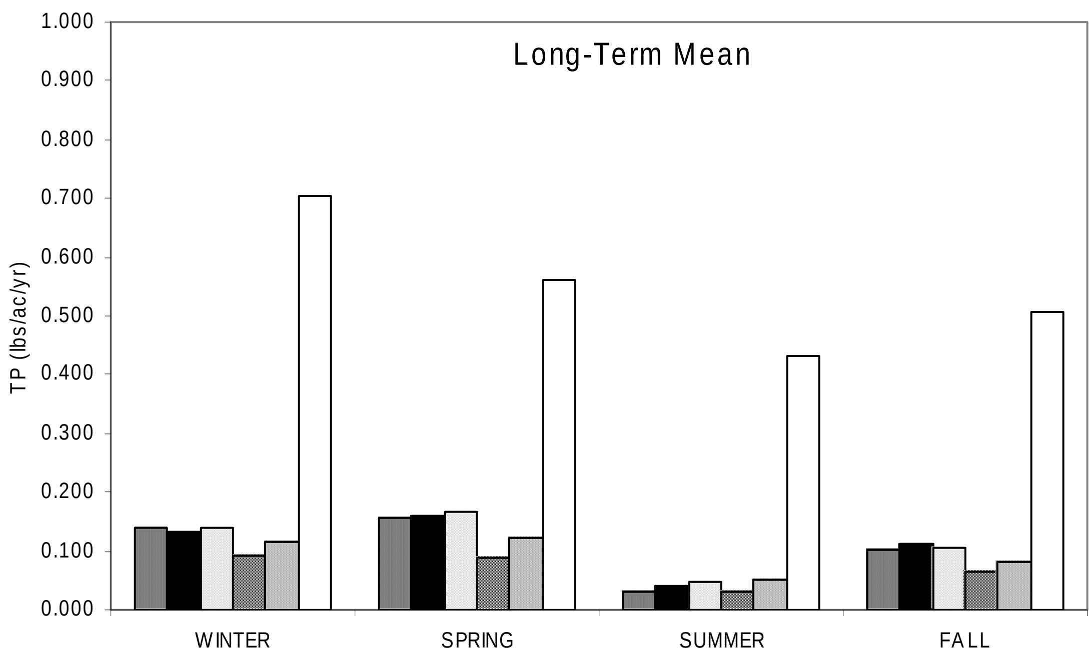


Figure 14. Comparison of Seasonal Yields of Total Phosphorus (TP) at Towanda, Danville, Marietta, Lewisburg, Newport, and Conestoga, Pa.

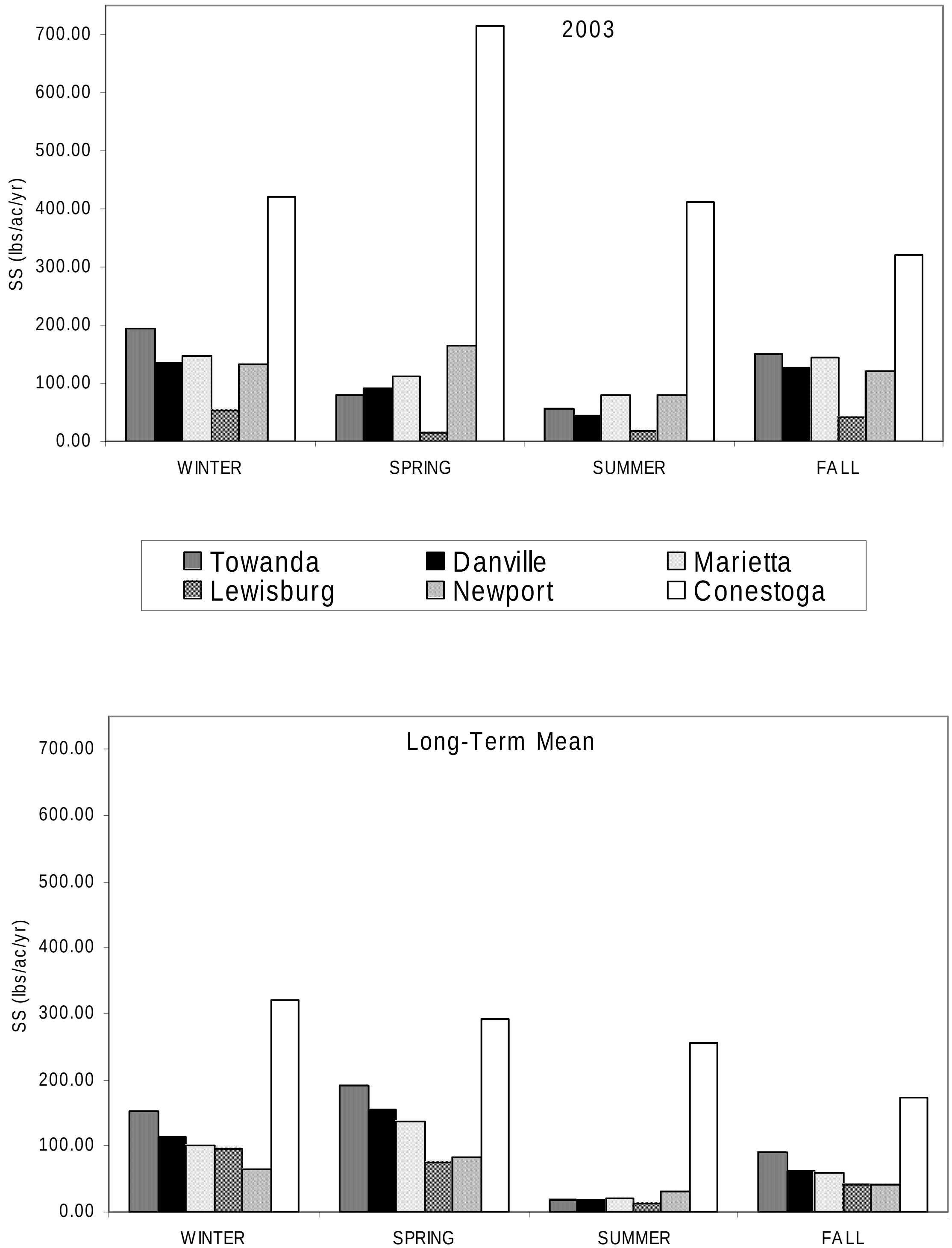


Figure 15. ***Comparison of Seasonal Yields of Suspended Sediment (SS) at Towanda, Danville, Marietta, Lewisburg, Newport, and Conestoga, Pa.***

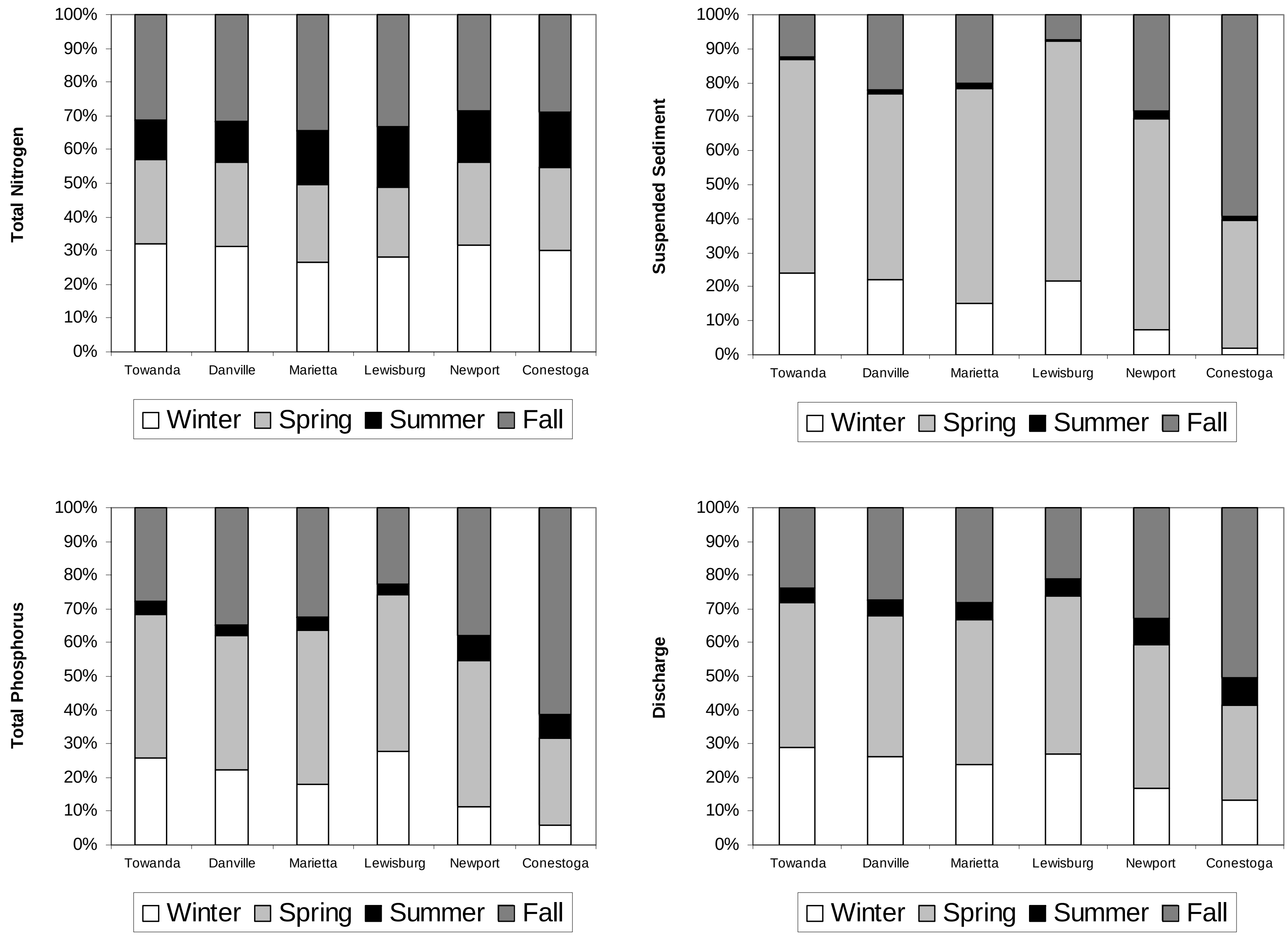


Figure 16. Seasonal Percent of Annual Load of Total Nitrogen, Total Phosphorus, and Suspended Sediment at Towanda, Danville, Marietta, Lewisburg, Newport, and Conestoga, Pa.

COMPARISON OF THE 2003 LOADS AND YIELDS OF TOTAL NITROGEN, TOTAL PHOSPHORUS, AND SUSPENDED SEDIMENT WITH THE BASELINES

The annual fluctuations of nutrient and SS loads and water discharge make it difficult to determine whether the changes were related to land use, nutrient availability, or simply annual water discharge. Ott and others (1991) used the functional 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 loads or 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 loads and water discharge. It was hypothesized that, as future loads and water-discharge ratios were plotted against the baseline, any significant deviation from the baseline would indicate that some change in the annual load had occurred, and that further evaluations to determine the reason for the change were warranted. The data collected in 2003 were compared with the 1985-89 baseline, 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. 2003 yields values also were plotted against a baseline developed with data from the beginning of each dataset (usually 1985) through 2002. Figures 17-28 display the baseline graphs and the 2003 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 2003 annual yield. Actual 2003 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 = .0642 + 6.0358x $R^2 = 0.86$

Total Phosphorus (TP)

TP Yield = -0.1375 + 0.4909x $R^2 = 0.53$

Suspended Sediment (SS)

SS Yield = -620.42 + 914.21x $R^2 = 0.43$

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

2002 Baselines;

Total Nitrogen (TN)

TN Yield = 0.3397 + 5.8545x $R^2 = 0.87$

Total Phosphorus (TP)

TP Yield = -0.2163 + 0.6148x $R^2 = 0.71$

Suspended Sediment (SS)

SS Yield = -833.1 + 1238.3x $R^2 = 0.67$

Table 27. Comparison of 2003 TN, TP, and SS Yields with Baseline Yields at Towanda, Pa.

Parameter	Discharge Ratio	1989 – 1993 Baseline lb/ac/yr	1989 - 2002 Baseline lb/ac/yr	2003 lb/ac/yr
TN	1.522	9.25	9.25	6.54
TP	1.522	0.6096	0.7194	0.54
SS	1.522	771.008	1051.59	480.91

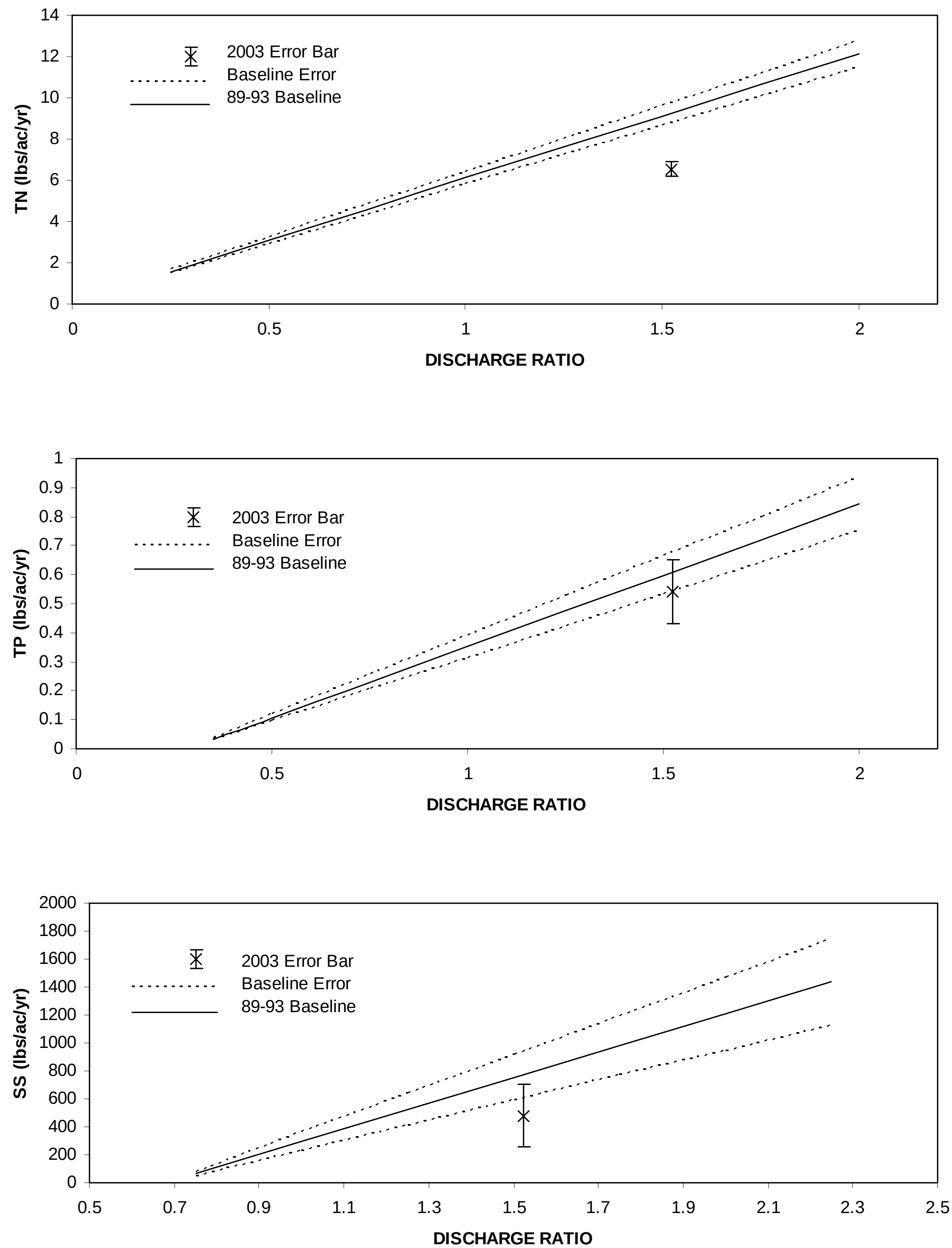


Figure 17. ***Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Susquehanna River at Towanda, Pa., 1989-1993 and 2003***

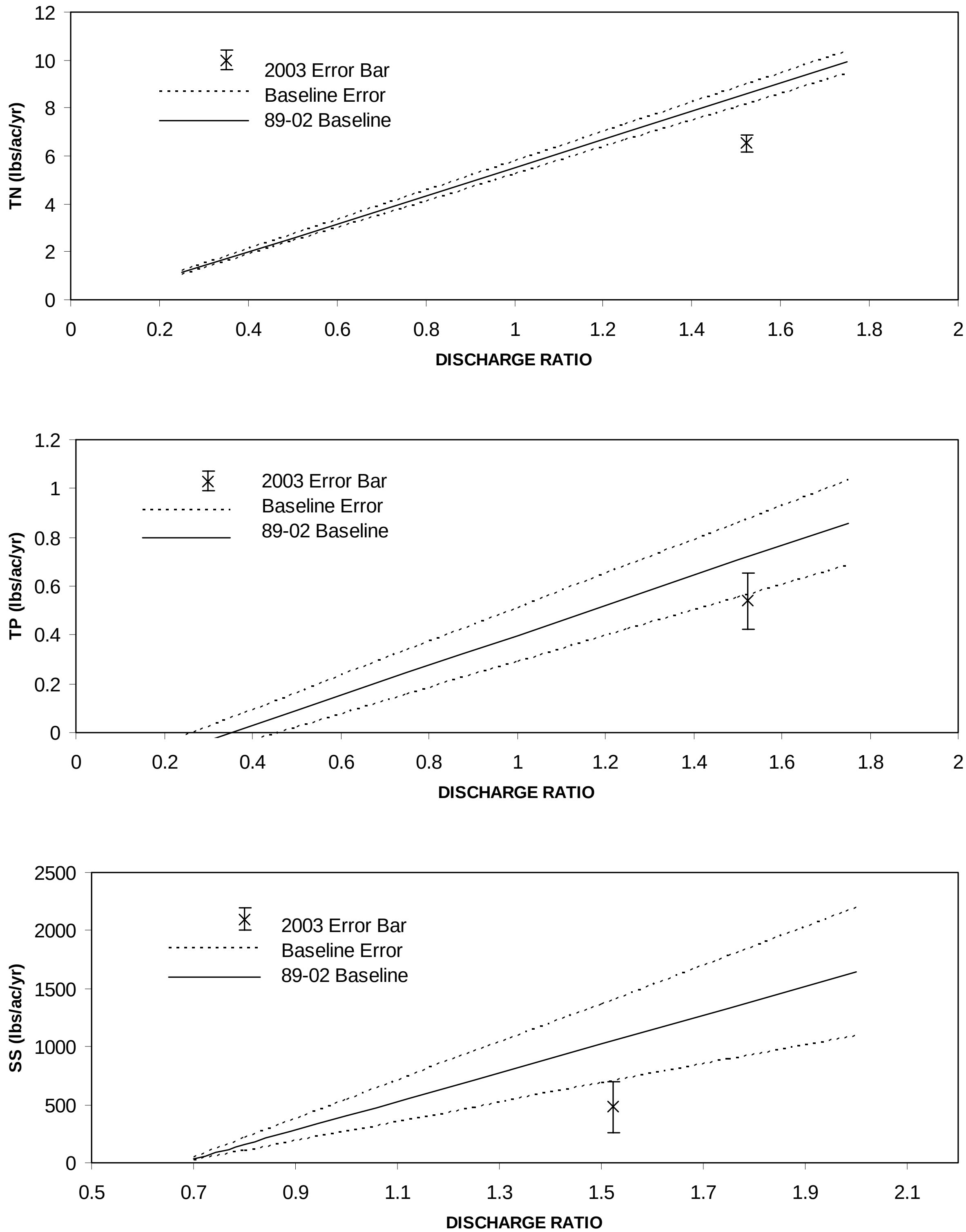


Figure 18. ***Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Susquehanna River at Towanda, Pa., 1989-2002 and 2003***

Susquehanna River at Danville, Pa.

Figures 19-20 shows the baselines for TN, TP, and SS and the 2003 yields for the Susquehanna River at Danville. Actual 2003 and baseline yields are listed in Table 28 along with the discharge ratio. The regression equations used to establish the baselines were:

Initial 5-year baseline;

Total Nitrogen (TN)

TN Yield = -0.2303 + 7.3419x R^2 = 0.85

Total Phosphorus (TP)

TP Yield = -0.1583 + 0.6657x R^2 = 0.95

Suspended Sediment (SS)

SS Yield = -480.64 + 870.684x R^2 = 0.99

2002 Baselines;

Total Nitrogen (TN)

TN Yield = 0.3994 + 5.7997x R^2 = 0.78

Total Phosphorus (TP)

TP Yield = -0.1748 + 0.5993x R^2 = 0.73

Suspended Sediment (SS)

SS Yield = -557.19 + 887.57x R^2 = 0.7446

West Branch Susquehanna River at Lewisburg, Pa.

The baselines and the 2003 yields for TN, TP, and SS are shown in Figures 21-22. Actual 2003 and baseline yields are listed in Table 29 along with the discharge ratio. The baselines were defined by the following equations:

Initial 5-year baseline;

Total Nitrogen (TN)

TN Yield = -1.4234 + 7.8108x R^2 = 0.73

Total Phosphorus (TP)

TP Yield = 0.0255 + 0.2728x R^2 = 0.53

Suspended Sediment (SS)

SS Yield = -157.34 + 345.33x R^2 = 0.67

2002 Baselines;

Total Nitrogen (TN)

TN Yield = -0.5775 + 6.1956xR^2 = 0.88

Total Phosphorus (TP)

TP Yield = -0.1392 + 0.424x R^2 = 0.72

Suspended Sediment (SS)

SS Yield = -507.09 + 768.37x R^2 = 0.72

Table 28. Comparison of 2003 TN, TP, and SS Yields with Baseline Yields at Danville, Pa.

Parameter	Discharge Ratio	1985 – 1989 Baseline lb/ac/yr	1985 - 2002 Baseline lb/ac/yr	2003 lb/ac/yr
TN	1.566	11.27	9.482	6.99
TP	1.566	0.8842	0.7637	0.65
SS	1.566	882.851	832.745	397.68

Table 29. Comparison of 2003 Total Nitrogen, Total Phosphorus, and Suspended-Sediment Yields With Baseline Yields at Lewisburg, Pa.

Parameter	Discharge Ratio	1985 – 1989 Baseline lb/ac/yr	1985 - 2002 Baseline lb/ac/yr	2003 lb/ac/yr
TN	1.473	10.082	8.549	7.22
TP	1.473	0.4273	0.4854	0.39
SS	1.473	351.331	624.719	126.76

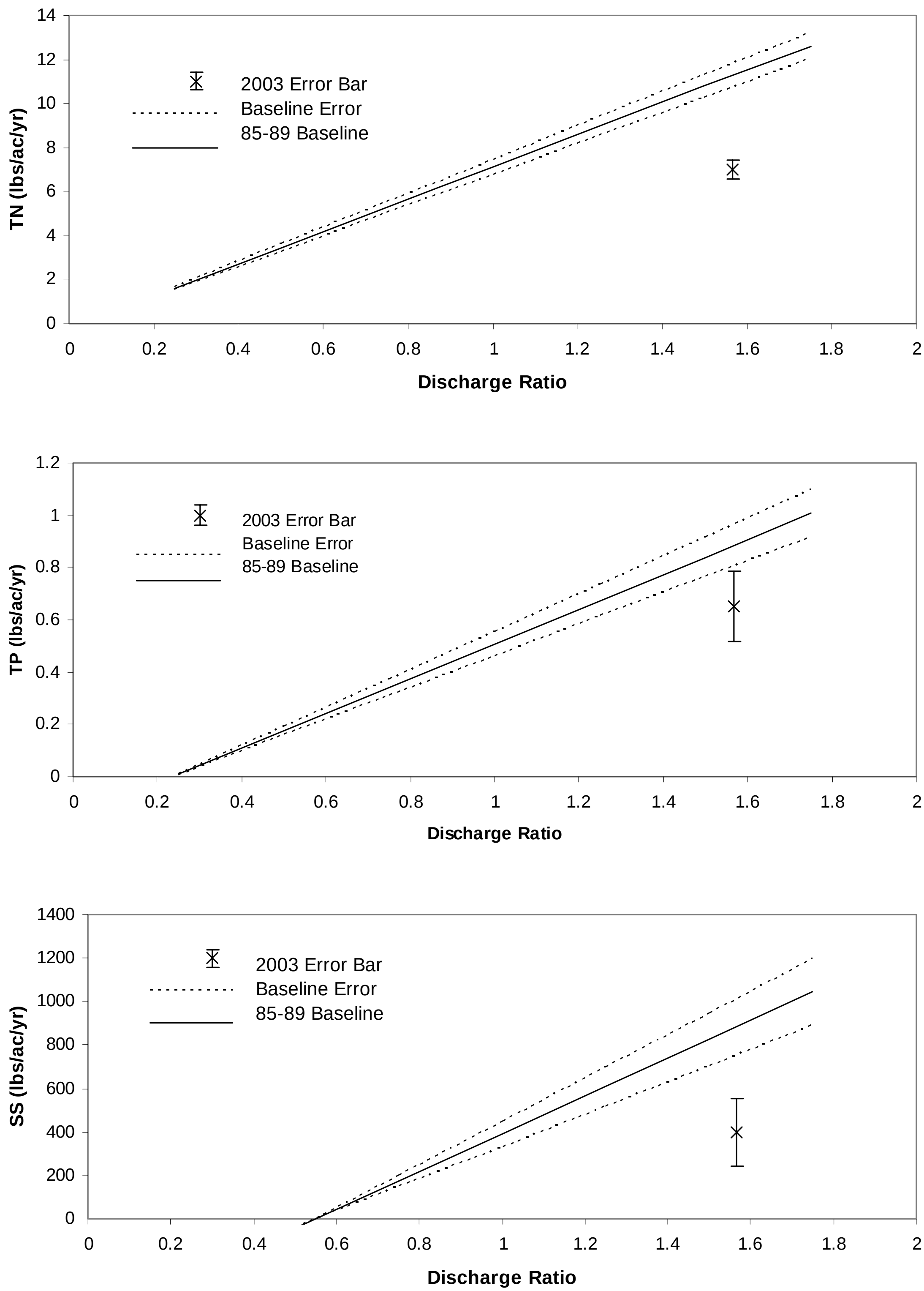


Figure 19. Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Susquehanna River at Danville, Pa., 1985-1989 and 2003

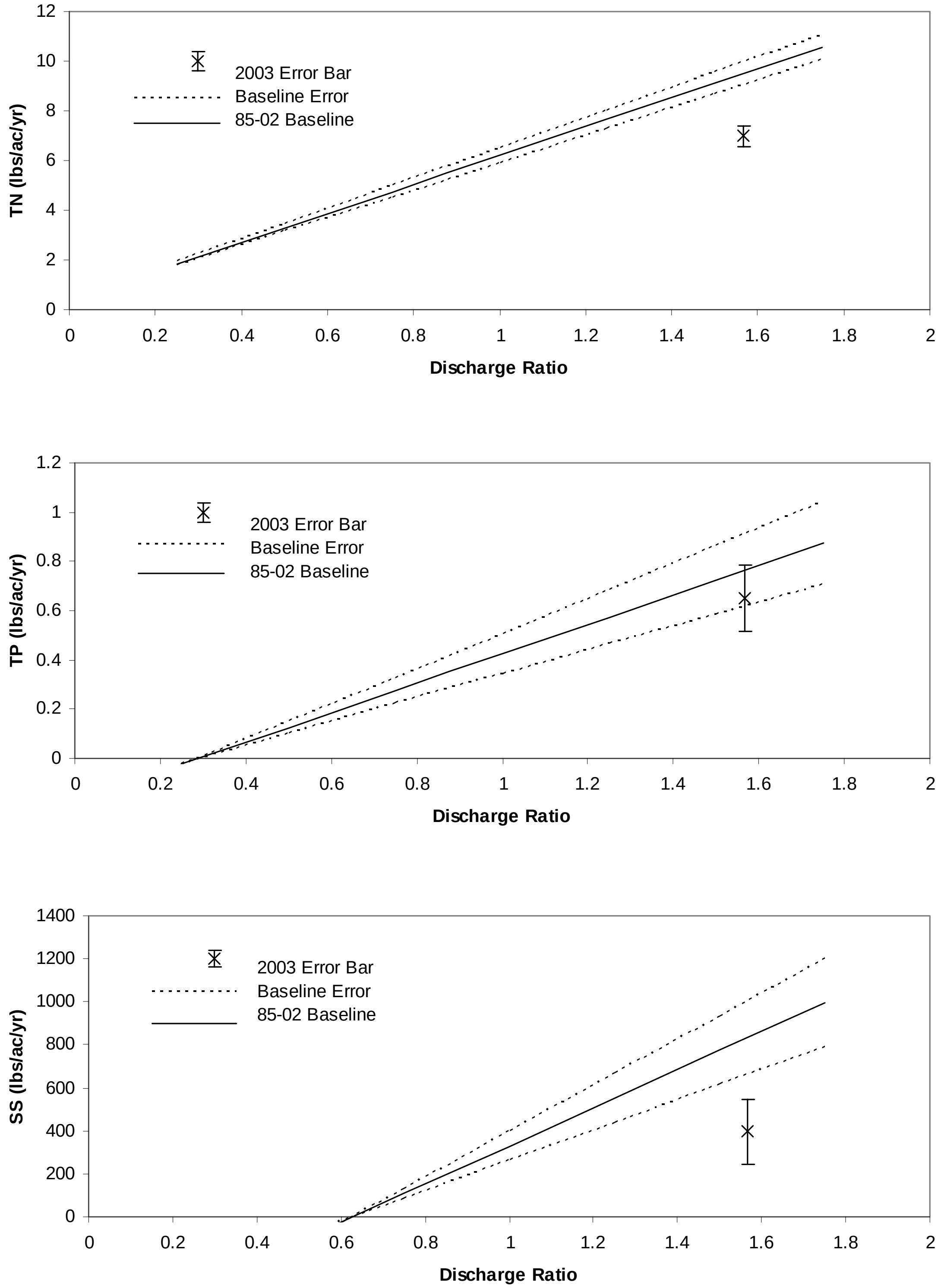


Figure 20. ***Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Susquehanna River at Danville, Pa., 1985-2002 and 2003***

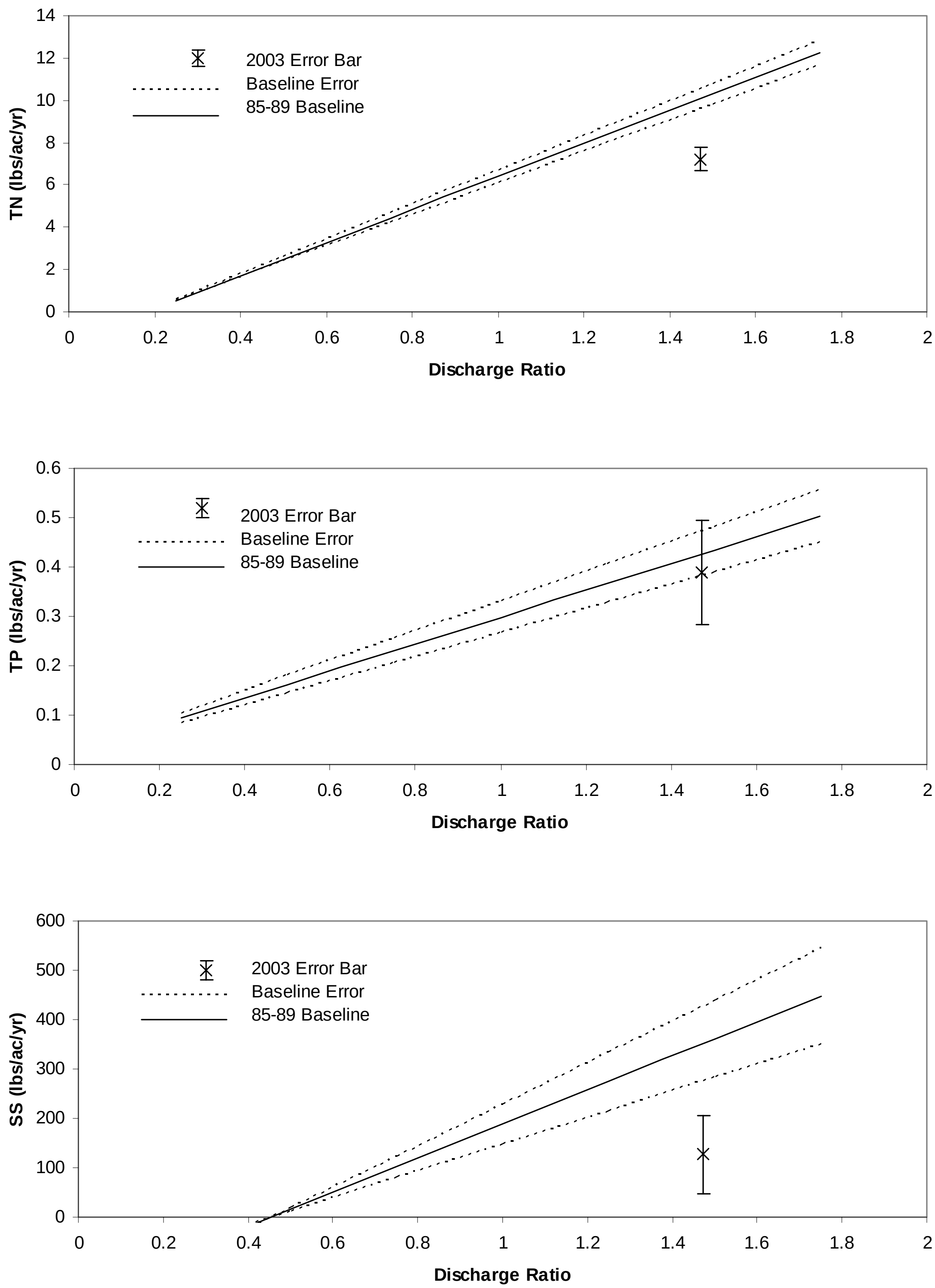


Figure 21. ***Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, West Branch Susquehanna River at Lewisburg, Pa., 1985-1989 and 2003***

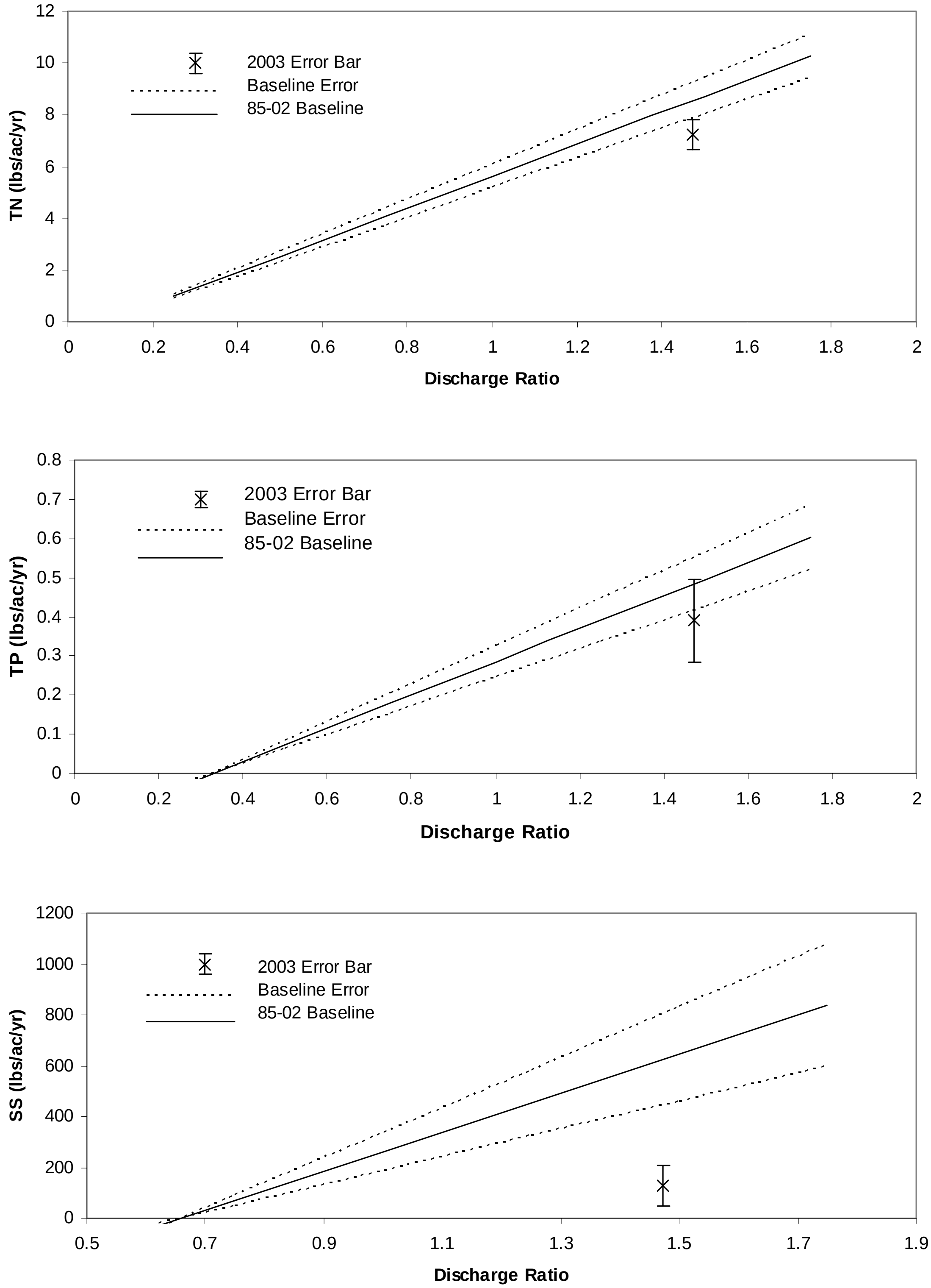


Figure 22. Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, West Branch Susquehanna River at Lewisburg, Pa., 1985-2002 and 2003

Juniata River at Newport, Pa.

The baselines and 2003 yields for TN, TP, and SS at Newport, are shown in Figures 23-24. Actual 2003 and baseline yields are listed in Table 30 along with the discharge ratio. The baselines were defined by the following equations:

Initial 5-year baseline;

Total Nitrogen (TN)

TN Yield = -0.2997 + 8.3964x R^2 = 0.80

Total Phosphorus (TP)

TP Yield = -0.0762 + 0.4844x R^2 = 0.96

Suspended Sediment (SS)

SS Yield = -294.17 + 532.33x R^2 = 0.89

2002 Baselines;

Total Nitrogen (TN)

TN Yield = 0.0697 + 7.4075x R^2 = 0.93

Total Phosphorus (TP)

TP Yield = 0.1038 + 0.2498x R^2 = 0.54

Suspended Sediment (SS)

SS Yield = -131.86 + 355.03x R^2 = 0.80

Susquehanna River at Marietta, Pa.

The Figure 25-26 shows the TN, TP, and SS baselines and 2003 yield. Actual 2003 and baseline yields are listed in Table 31 along with the discharge ratio. The baselines were defined by the following equations:

Initial 5-year baseline;

Total Nitrogen (TN)

TN Yield = -0.8251 + 9.1855x R^2 = 0.99

Total Phosphorus (TP)

TP Yield = 0.1393 + 0.2321x R^2 = 0.27

Suspended Sediment (SS)

SS Yield = -97.695 + 380.81x R^2 = 0.48

2002 Baselines;

Total Nitrogen (TN)

TN Yield = -0.8488 + 8.449x R^2 = 0.92

Total Phosphorus (TP)

TP Yield = -0.1479 + 0.5872x R^2 = 0.69

Suspended Sediment (SS)

SS Yield = -320.71 + 637.48x R^2 = 0.83

Table 30. Comparison of 2003 TN, TP, and SS Yields with Baseline Yields at Newport, Pa.

Parameter	Discharge Ratio	1985 – 1989 Baseline lb/ac/yr	1985 - 2002 Baseline lb/ac/yr	2003 lb/ac/yr
TN	1.59	13.051	11.848	14.57
TP	1.59	0.6939	0.501	0.91
SS	1.59	552.235	432.637	493.63

Table 31. Comparison of 2003 TN, TP, and SS Yields with Baseline Yields at Marietta, Pa.

Parameter	Discharge Ratio	1987 – 1991 Baseline lb/ac/yr	1987 - 2002 Baseline lb/ac/yr	2003 lb/ac/yr
TN	1.759	15.332	14.013	11.61
TP	1.759	0.5476	0.885	0.9
SS	1.759	572.15	800.617	483.47

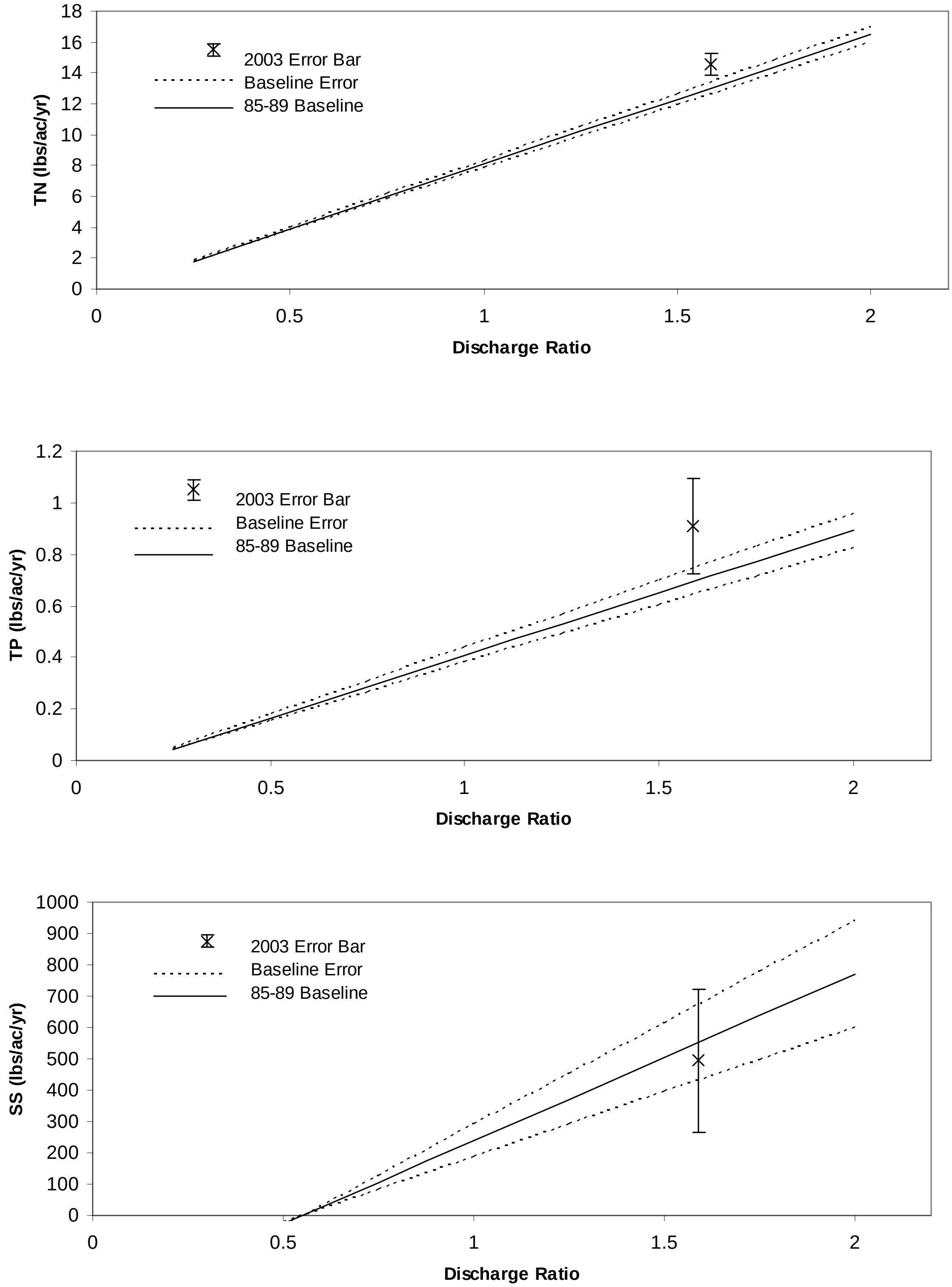
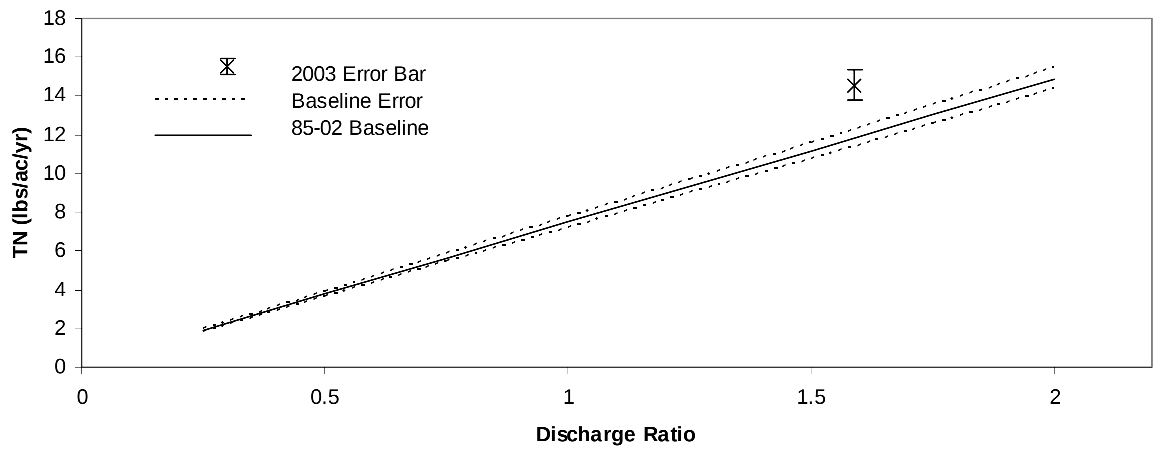
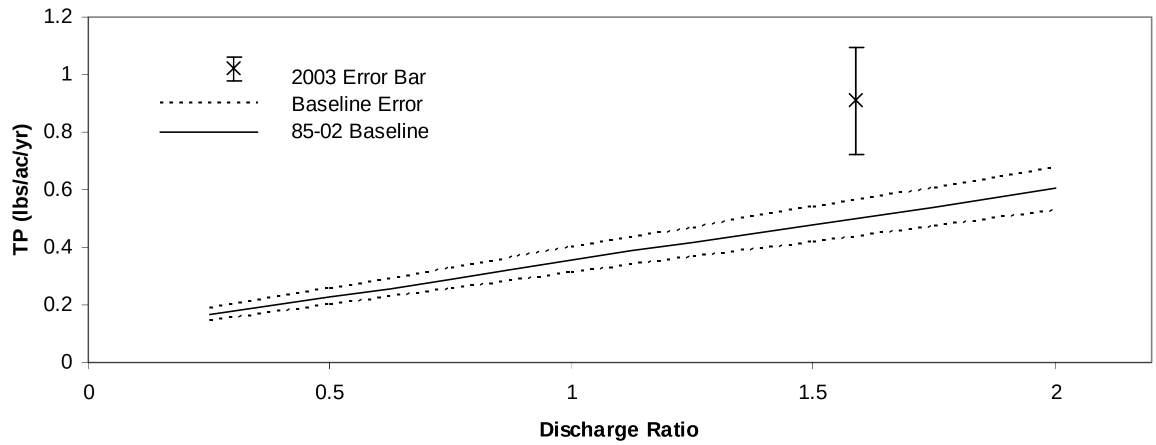


Figure 23. Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Juniata River at Newport, Pa., 1985-1989 and 2003





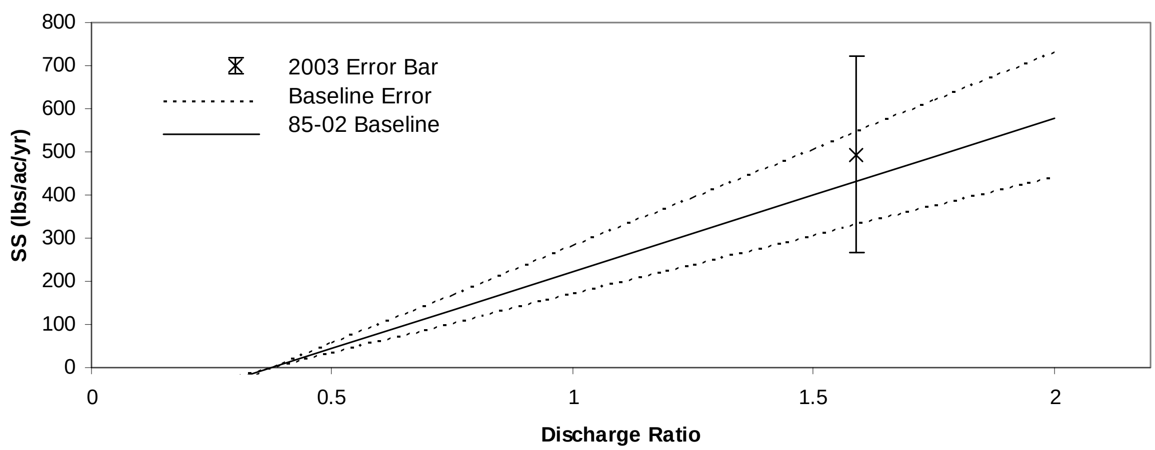


Figure 24. ***Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Juniata River at Newport, Pa., 1985-2002 and 2003***

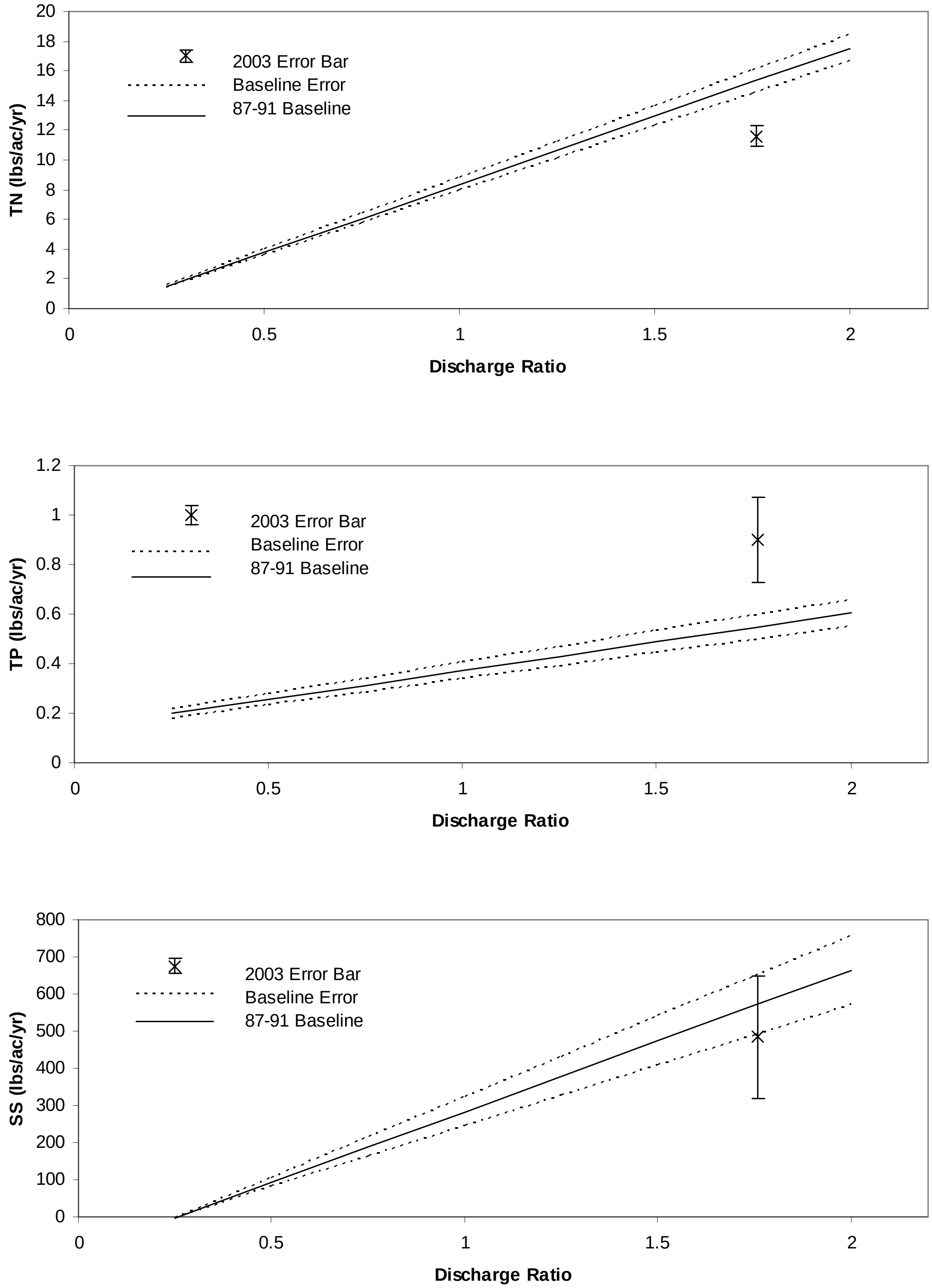
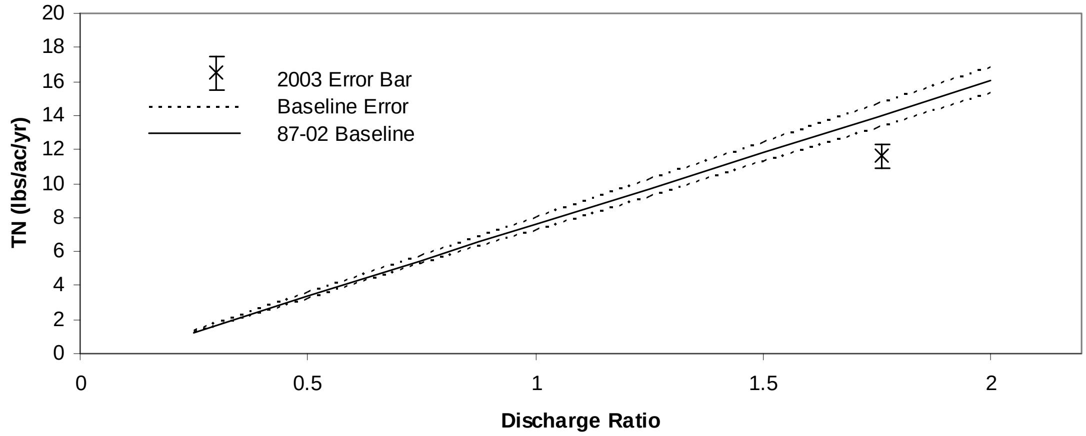
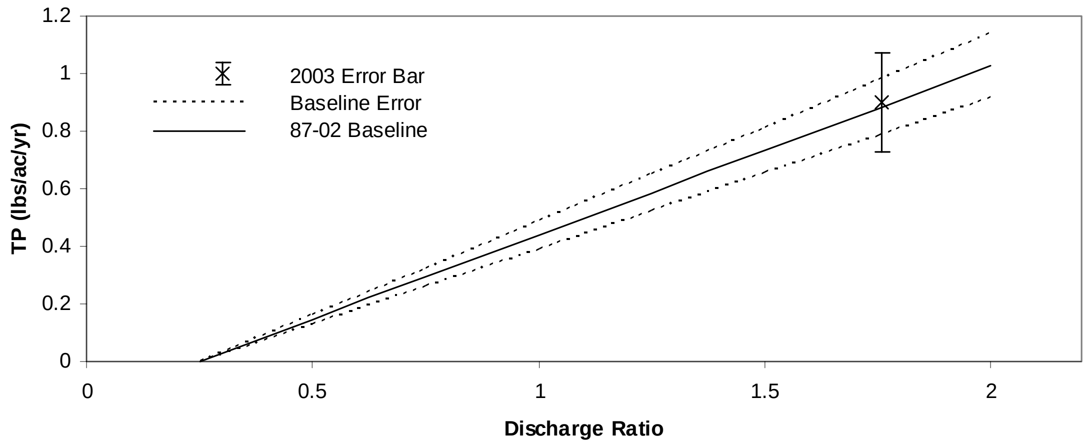


Figure 25. Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Susquehanna River at Marietta, Pa., 1987-1991 and 2003





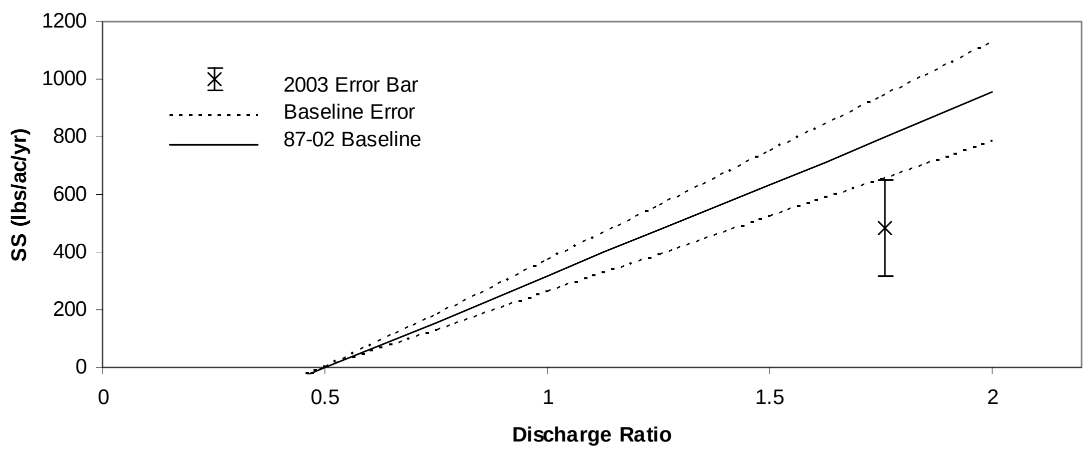


Figure 26. Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Susquehanna River at Marietta, Pa., 1987-2002 and 2003

Conestoga River at Conestoga, Pa.

Figure 27-28 shows the TN, TP, and SS baselines and 2003 yields. Actual 2003 and baseline yields are listed in Table 32 along with the discharge ratio. The baselines were defined by the following equations:

Initial 5-year baseline;

Total Nitrogen (TN)

TN Yield = 2.1988 + 31.264x R^2 = 0.97

Total Phosphorus (TP)

TP Yield = 0.4272 + 1.8654x R^2 = 0.67

Suspended Sediment (SS)

SS Yield = -614.08 + 1740.7x R^2 = 0.72

2002 Baselines;

Total Nitrogen (TN)

TN Yield = 2.347 + 32.262x R^2 = 0.95

Total Phosphorus (TP)

TP Yield = -1.1218 + 3.4263x R^2 = 0.82

Suspended Sediment (SS)

SS Yield = -871.82 + 1966.6x R^2 = 0.77

Table 32. Comparison of 2003 TN, TP, and SS Yields with Baseline Yields at Conestoga, Pa.

Parameter	Discharge Ratio	1985 – 1989 Baseline lb/ac/yr	1985 - 2002 Baseline lb/ac/yr	2003 lb/ac/yr
TN	1.761	57.255	59.16	56.98
TP	1.761	3.712	6.034	3.51
SS	1.761	2,451.29	2,591.36	1868.2

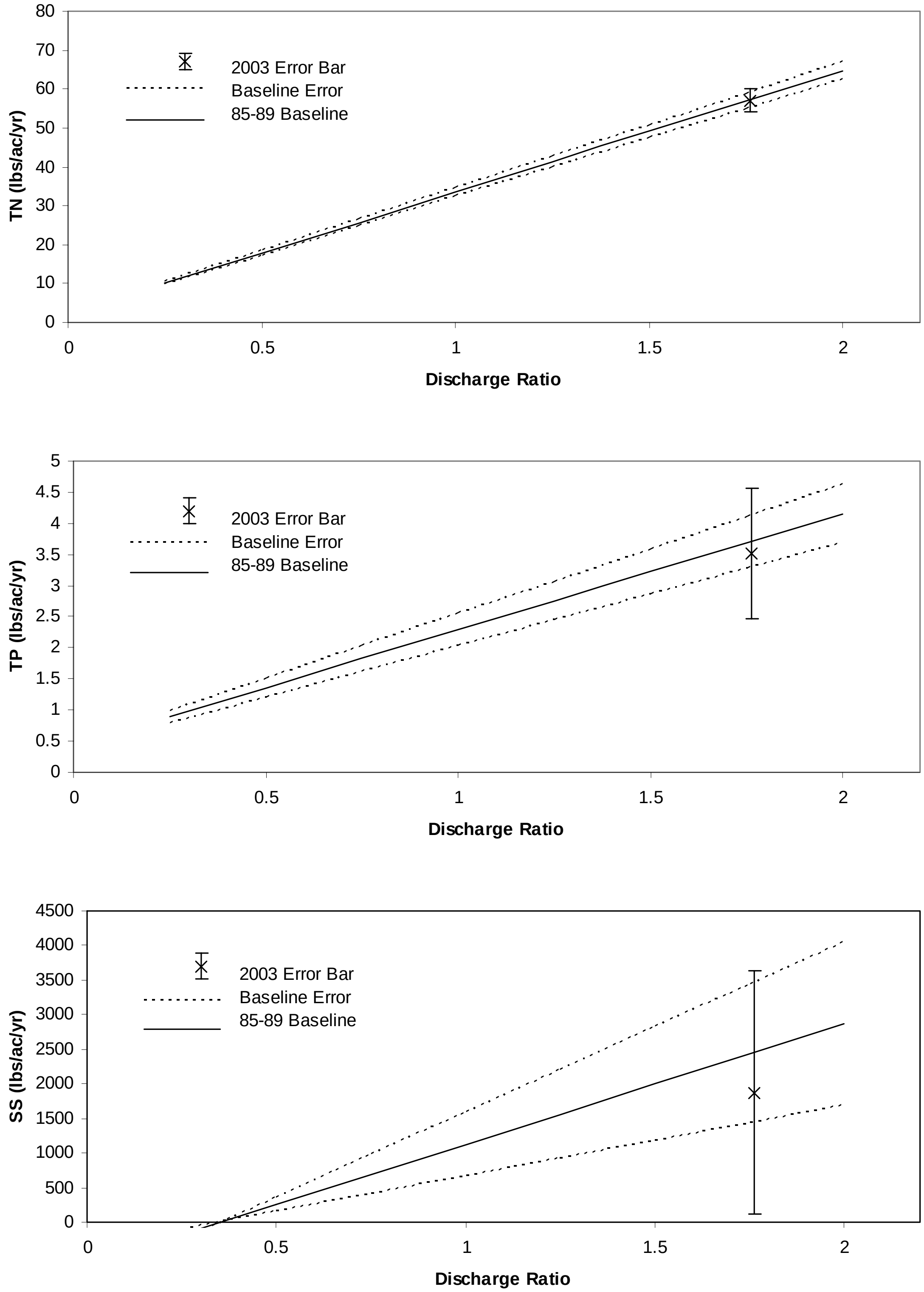


Figure 27. Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Conestoga River at Conestoga, Pa., 1985-1989 and 2003

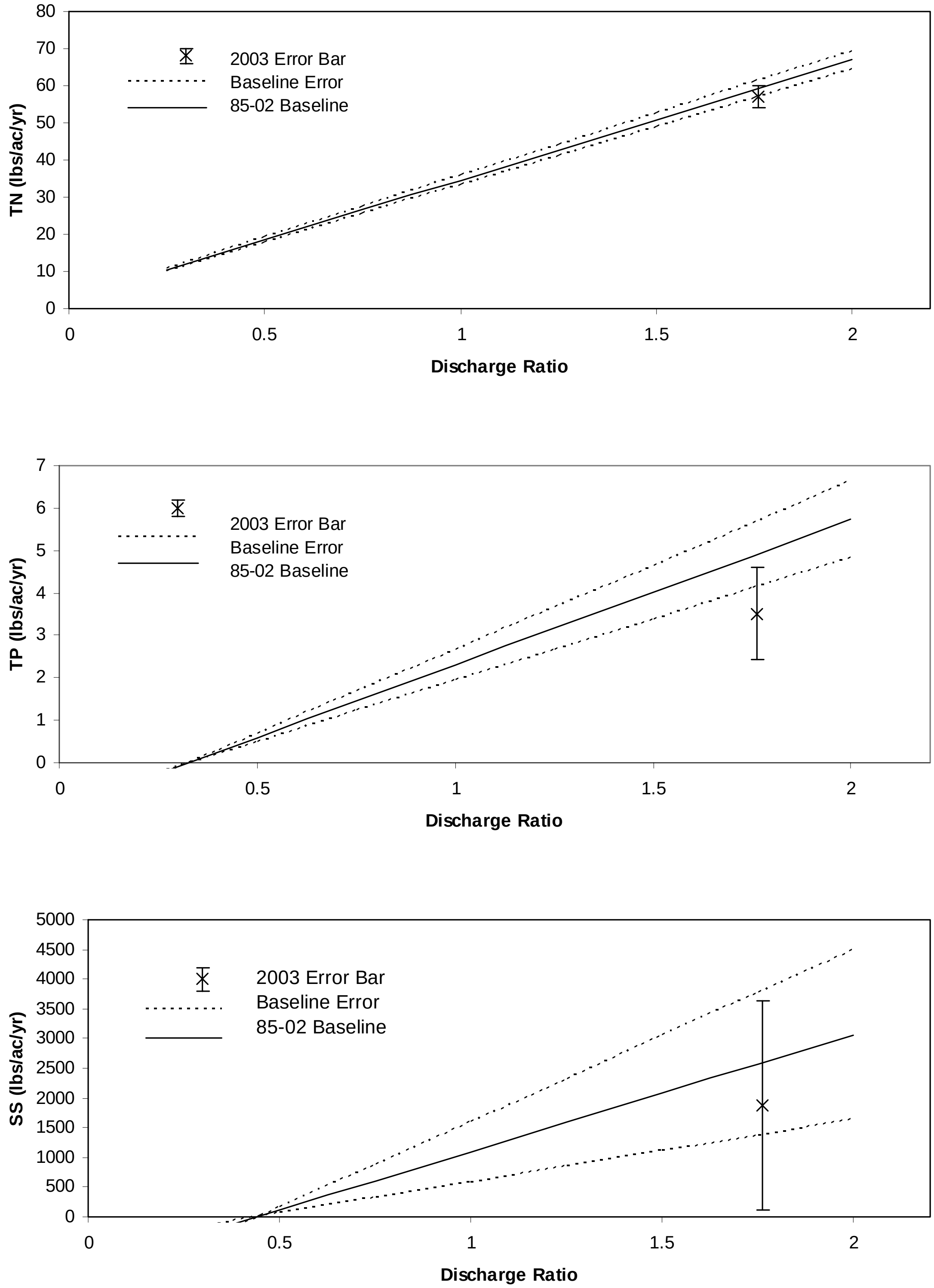


Figure 28. ***Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Conestoga River at Conestoga, Pa., 1985-2002 and 2003***

DISCHARGE, NUTRIENT, AND SUSPENDED-SEDIMENT TRENDS

Trend analyses of water quality and flow data collected at the six monitoring sites were completed for the period January 1985 through December 2002. Trends were estimated using linear regression techniques and the USGS estimator model (Cohn and others, 1989). These tests were used to estimate the direction and magnitude of trends for discharge, SS, TOC, and several forms of nitrogen and phosphorus. 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 33 through 38. 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.

Improving trends were found at all sites for all nitrogen constituents except DON at Marietta and Conestoga. Increasing trends in DOP were found at all sites except Lewisburg and Conestoga, which recorded a BMDL and decreasing trend, respectively. All parameters showed improving trends at Towanda and Danville except for DOP. No significant trends were found at Marietta for TON, DP and TP, Conestoga for DN and DNOx, Newport for TNOx and DNOx, and Lewisburg for TOC. These results support the previous load data. All other parameters had decreasing trends for 2003.

Table 33. Trend Statistics for the Susquehanna River at Towanda, Pa., January 1989 through December 2003

Parameter	Storet Code	Time Series	P-Value	Slope Magnitude (%)		Trend Direction
				Minimum	Maximum	
FLOW	60	FAC	0.5380			NS
TN	600	FAC	0.0000	-39	-31	IMPROVING
DN	602	FAC	0.0000	-30	-20	IMPROVING
TON	605	FAC	0.0000	-45	-28	IMPROVING
DON	607	FAC	0.0158	-27	-3	IMPROVING
DNH_3	608	FAC	0.0014	-38	-11	IMPROVING
TNH_3	610	FAC	0.0000	-57	-37	IMPROVING
DKN	623	FAC	0.0000	-37	-16	IMPROVING
TKN	625	FAC	0.0000	-48	-32	IMPROVING
TNOx	630	FAC	0.0000	-32	-21	IMPROVING
DNOx	631	FAC	0.0000	-32	-21	IMPROVING
TP	665	FAC	0.0005	-35	-12	IMPROVING
DP	666	FAC	0.0000	-45	-26	IMPROVING
DOP	671	FAC	0.0000	236	458	DEGRADING
TOC	680	FAC	0.0050	-13	-2	IMPROVING
SS	80154	FAC	0.0005	-51	-18	IMPROVING

Table 34. Trend Statistics for the Susquehanna River at Danville, Pa., January 1985 through December 2003

Parameter	Storet Code	Time Series	P-Value	Slope Magnitude (%)		Trend Direction
				Minimum	Maximum	
FLOW	60	FLOW	0.9743			NS
TN	600	FAC	0.0000	-42	-34	IMPROVING
DN	602	FAC	0.0000	-34	-25	IMPROVING
TON	605	FAC	0.0000	-55	-41	IMPROVING
DON	607	FAC	0.0000	-34	-15	IMPROVING
DNH_3	608	FAC	0.0000	-58	-39	IMPROVING
TNH_3	610	FAC	0.0000	-70	-55	IMPROVING
DKN	623	FAC	0.0000	-51	-35	IMPROVING
TKN	625	FAC	0.0000	-56	-43	IMPROVING
TNOx	630	FAC	0.0000	-28	-17	IMPROVING
DNOx	631	FAC	0.0000	-28	-18	IMPROVING
TP	665	FAC	0.0000	-52	-34	IMPROVING
DP	666	FAC	0.0000	-54	-37	IMPROVING
DOP	671	FAC	0.0000	230	447	DEGRADING
TOC	680	FAC	0.0000	-27	-17	IMPROVING
SS	80154	FAC	0.0000	-70	-54	IMPROVING

Table 35. Trend Statistics for the West Branch Susquehanna River at Lewisburg, Pa., January 1985 through December 2003

Parameter	Storet Code	Time Series	P-Value	Slope Magnitude (%)		Trend Direction
				Minimum	Maximum	
FLOW	60	FLOW	0.2402			NS
TN	600	FAC	0.0000	-33	-22	IMPROVING
DN	602	FAC	0.0000	-26	-16	IMPROVING
TON	605	FAC	0.0000	-52	-32	IMPROVING
DON	607	FAC	0.0000	-42	-22	IMPROVING
DNH_3	608	FAC	0.0193	-33	-3	IMPROVING
TNH_3	610	FAC	0.0000	-57	-34	BMDL
DKN	623	FAC	0.0000	-51	-30	BMDL
TKN	625	FAC	0.0000	-49	-28	IMPROVING
TNOx	630	FAC	0.0030	-19	-4	IMPROVING
DNOx	631	FAC	0.0045	-18	-3	IMPROVING
TP	665	FAC	0.0000	-52	-48	IMPROVING
DP	666	FAC	0.0000	-63	-48	IMPROVING
DOP	671	FAC	0.0000	150	347	BMDL
TOC	680	FAC	0.4214	-5	13	NS
SS	80154	FAC	0.0000	-71	-47	IMPROVING

Table 36. Trend Statistics for the Juniata River at Newport, Pa., January 1989 through December 2003

Parameter	Storet Code	Time Series	P-Value	Slope Magnitude (%)		Trend Direction
				Minimum	Maximum	
FLOW	60	FLOW	0.5889			NS
TN	600	FAC	0.0000	-18	-8	IMPROVING
DN	602	FAC	0.0018	-12	-3	IMPROVING
TON	605	FAC	0.0000	-39	-20	IMPROVING
DON	607	FAC	0.0022	-29	-7	IMPROVING
DNH_3	608	FAC	0.0000	-48	-27	IMPROVING
TNH_3	610	FAC	0.0000	-63	-46	BMDL
DKN	623	FAC	0.0000	-46	-26	BMDL
TKN	625	FAC	0.0000	-40	-21	IMPROVING
TNOx	630	FAC	0.2430	-10	3	NS
DNOx	631	FAC	0.6061	-8	5	NS
TP	665	FAC	0.0014	-33	-9	IMPROVING
DP	666	FAC	0.0261	-27	-2	IMPROVING
DOP	671	FAC	0.0000	191	394	DEGRADING
TOC	680	FAC	0.0000	-29	-13	IMPROVING
SS	80154	FAC	0.0198	-42	-4	IMPROVING

Table 37. Trend Statistics for the Susquehanna River at Marietta, Pa., January 1987 through December 2003

Parameter	Storet Code	Time Series	P-Value	Slope Magnitude (%)		Trend Direction
				Minimum	Maximum	
FLOW	60	FLOW	0.5963			NS
TN	600	FAC	0.0000	-27	-15	IMPROVING
DN	602	FAC	0.0013	-18	-5	IMPROVING
TON	605	FAC	0.0985	-30	3	NS
DON	607	FAC	0.0116	7	73	DEGRADING
DNH_3	608	FAC	0.0002	-39	-14	IMPROVING
TNH_3	610	FAC	0.0000	-56	-30	IMPROVING
DKN	623	FAC	0.0002	-36	-13	IMPROVING
TKN	625	FAC	0.0000	-41	-20	IMPROVING
TNOx	630	FAC	0.0187	-17	-2	IMPROVING
DNOx	631	FAC	0.0359	-16	-1	IMPROVING
TP	665	FAC	0.9110	-16	17	NS
DP	666	FAC	0.4869	-9	21	NS
DOP	671	FAC	0.0000	924	1610	DEGRADING
TOC	680	FAC	0.0013	-15	-4	IMPROVING
SS	80154	FAC	0.0022	-43	-11	IMPROVING

Table 38. Trend Statistics for the Conestoga River at Conestoga, Pa., January 1985 through December 2003

Parameter	Storet Code	Time Series	P-Value	Slope Magnitude (%)		Trend Direction
				Minimum	Maximum	
FLOW	60	FLOW	0.3388			NS
TN	600	FAC	0.0000	-18	-8	IMPROVING
DN	602	FAC	0.6072	-4	7	NS
TON	605	FAC	0.0000	-46	-25	IMPROVING
DON	607	FAC	0.7957	-13	20	DEGRADING
DNH_3	608	FAC	0.0000	-81	-70	IMPROVING
TNH_3	610	FAC	0.0000	-84	-75	IMPROVING
DKN	623	FAC	0.0000	-40	-19	IMPROVING
TKN	625	FAC	0.0000	-52	-36	IMPROVING
TNOx	630	FAC	0.4859	-5	12	IMPROVING
DNOx	631	FAC	0.2927	-4	13	NS
TP	665	FAC	0.0000	-46	-24	IMPROVING
DP	666	FAC	0.0000	-39	-25	IMPROVING
DOP	671	FAC	0.0309	-28	-1	IMPROVING
TOC	680	FAC	0.0000	-49	-38	IMPROVING
SS	80154	FAC	0.0000	-61	-36	IMPROVING

SUMMARY

Bimonthly and stormflow samples were collected during 2003 from the Susquehanna River at Towanda, Danville, and Marietta; the West Branch Susquehanna River at Lewisburg; the Juniata River at Newport; and the Conestoga River at Conestoga, Pa. Collected samples were analyzed for various nitrogen and phosphorus species and SS.

Precipitation for 2003 was above average for all sites. Highest departures from the long-term averages were recorded at Conestoga with 14.68 inches above the LTM leading to the highest flow at 176.2 percent of the LTM. Lowest departure from the mean was at Danville for rainfall, 1.54 inches above LTM, and at Lewisburg for flow at 147.3 percent of the LTM. No trends were found for flow.

2003 data were analyzed in five ways: comparison with LTMs; comparison with similar water year data (1996); comparison with initial 5-year baselines; comparison with full program baselines; and analysis of FAC trends. Results of these methods are shown in Table 39. For LTM comparisons, this chart shows the percentages of LTM as compared to the percentages of the LTM for discharge. Strongest evidence for improvements or degradation was shown where all methods agree. This was the case for TN at all sites except Newport where loads were shown to be higher for 4-of-5 methods and Conestoga, which showed higher load values as compared to the 1996 loads. All other sites showed improving TN conditions for all analysis methods. This was also the case for TP at Towanda, Danville, Lewisburg, and Conestoga. Newport showed degrading signs for TP in 4 of the 5 analysis methods and Marietta showed degrading trends for 3 of the 5 for TP. SS showed improving signs at all sites except Newport, which had degrading signs when compared to the LTM percentage and the full program baseline.

Table 40 shows the FAC trends for 2003. Increasing trends were shown for DON at Conestoga and Marietta while Towanda, Danville, Marietta, and Newport all showed increasing trends in DOP. All other trends were either decreasing or not significant. Lewisburg and Newport also showed total kjedahl nitrogen (TKN) and dissolved kjedahl nitrogen (DKN) as below method detection limit meaning that more than 20 percent of the data was BMDL and a trend could not be reported. This also occurred at Lewisburg for DOP.

The percentages of LTM have shown that the dissolved fractions of nitrogen and phosphorus were degrading. Newport showed the most degrading constituents including TN, DN, DNH3, TNO23, DNO23, TP, DP and DOP. Marietta showed degrading conditions in TNO23, DNO23, DN, TP, DP, and DOP. All six sites showed degrading conditions when compared to the percentages of LTM for DOP. Conestoga showed degrading conditions in TNO23, DNO23, DN, and DON. Lewisburg showed degrading conditions in TNO23 and TOC which could be due to the leaf drop from the mostly forested watershed.

Table 39. Summary of 2003 Data Comparison to Percentage of LTM, 1996 Loads, Initial 5-Year Baseline, and Full Program Baseline, and Trends in Flow-Adjusted Concentration for TN, TP, and SS

Parameter	Site	LTM %	1996	Basline 89	Baseline 0	Trend
FLOW	Towanda	**INC**	DEC	N/A	N/A	None
	Danville	**INC**	DEC	N/A	N/A	None
	Lewisburg	**INC**	DEC	N/A	N/A	None
	Newport	**INC**	DEC	N/A	N/A	None
	Marietta	**INC**	DEC	N/A	N/A	None
	Conestoga	**INC**	**INC**	N/A	N/A	None
TN	Towanda	DEC	DEC	DEC	DEC	DEC
	Danville	DEC	DEC	DEC	DEC	DEC
	Lewisburg	DEC	DEC	DEC	DEC	DEC
	Newport	**INC**	**INC**	**INC**	**INC**	DEC
	Marietta	DEC	DEC	DEC	DEC	DEC
	Conestoga	DEC	**INC**	DEC	DEC	DEC
TP	Towanda	DEC	DEC	DEC	DEC	DEC
	Danville	DEC	DEC	DEC	DEC	DEC
	Lewisburg	DEC	DEC	DEC	DEC	DEC
	Newport	**INC**	**INC**	**INC**	**INC**	DEC
	Marietta	**INC**	DEC	**INC**	**INC**	**NS**
	Conestoga	DEC	DEC	DEC	DEC	DEC
SS	Towanda	DEC	DEC	DEC	DEC	DEC
	Danville	DEC	DEC	DEC	DEC	DEC
	Lewisburg	DEC	DEC	DEC	DEC	DEC
	Newport	**INC**	DEC	DEC	**INC**	DEC
	Marietta	DEC	DEC	DEC	DEC	DEC
	Conestoga	DEC	DEC	DEC	DEC	DEC

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

Table 40. Summary of 2003 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	NS	DEC
DON	DEC	DEC	DEC	DEC	**INC**	**INC**
DNH	DEC	DEC	DEC	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	DEC
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

REFERENCES

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APPENDIX A

2003 Storm Sampling Concentrations of Total Nitrogen, Total Phosphorus, and Suspended Sediment

2003 Storms

2003 ended as one of the wettest years on record. As part of this program, four storms were sampled targeting one per season. An additional storm was sampled during the spring. Figures 1 through 30 show the concentrations of total nitrogen, total phosphorus, and suspended sediment throughout the storm, plotted against the flow for the day of sample collection.

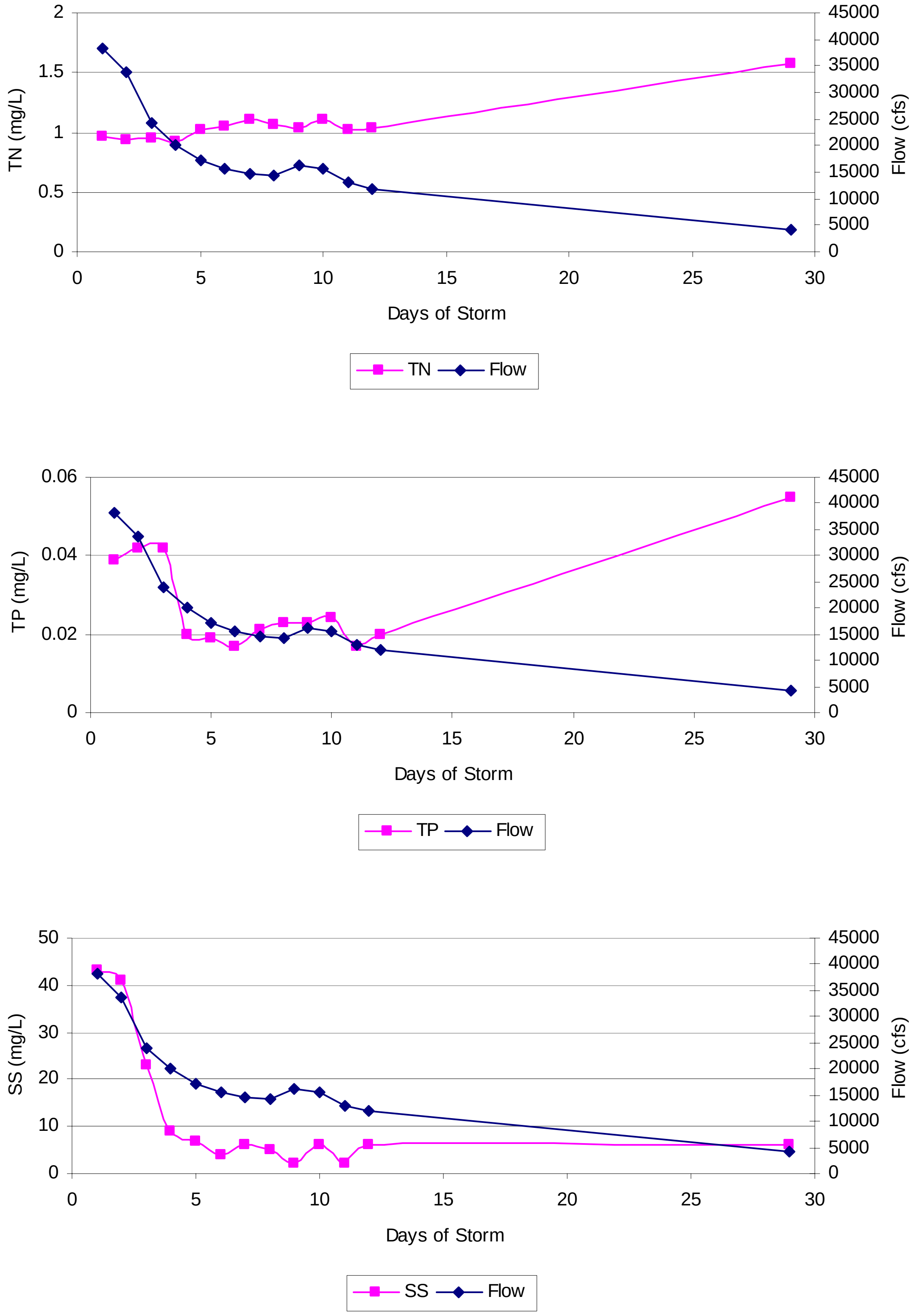


Figure 1. January 2-30, 2003, Storm at Towanda

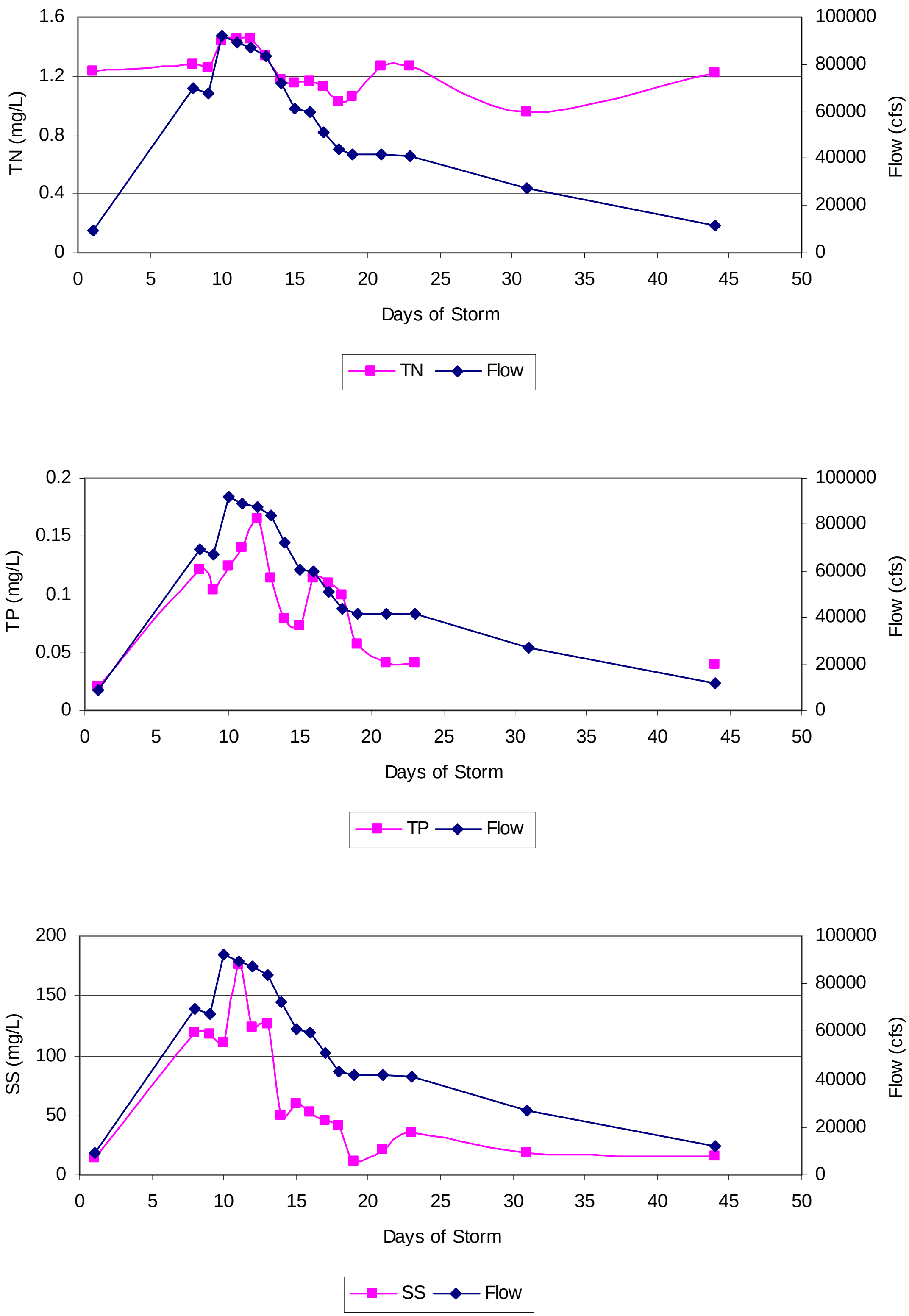


Figure 2. March 12-April 24, 2003, Storm at Towanda

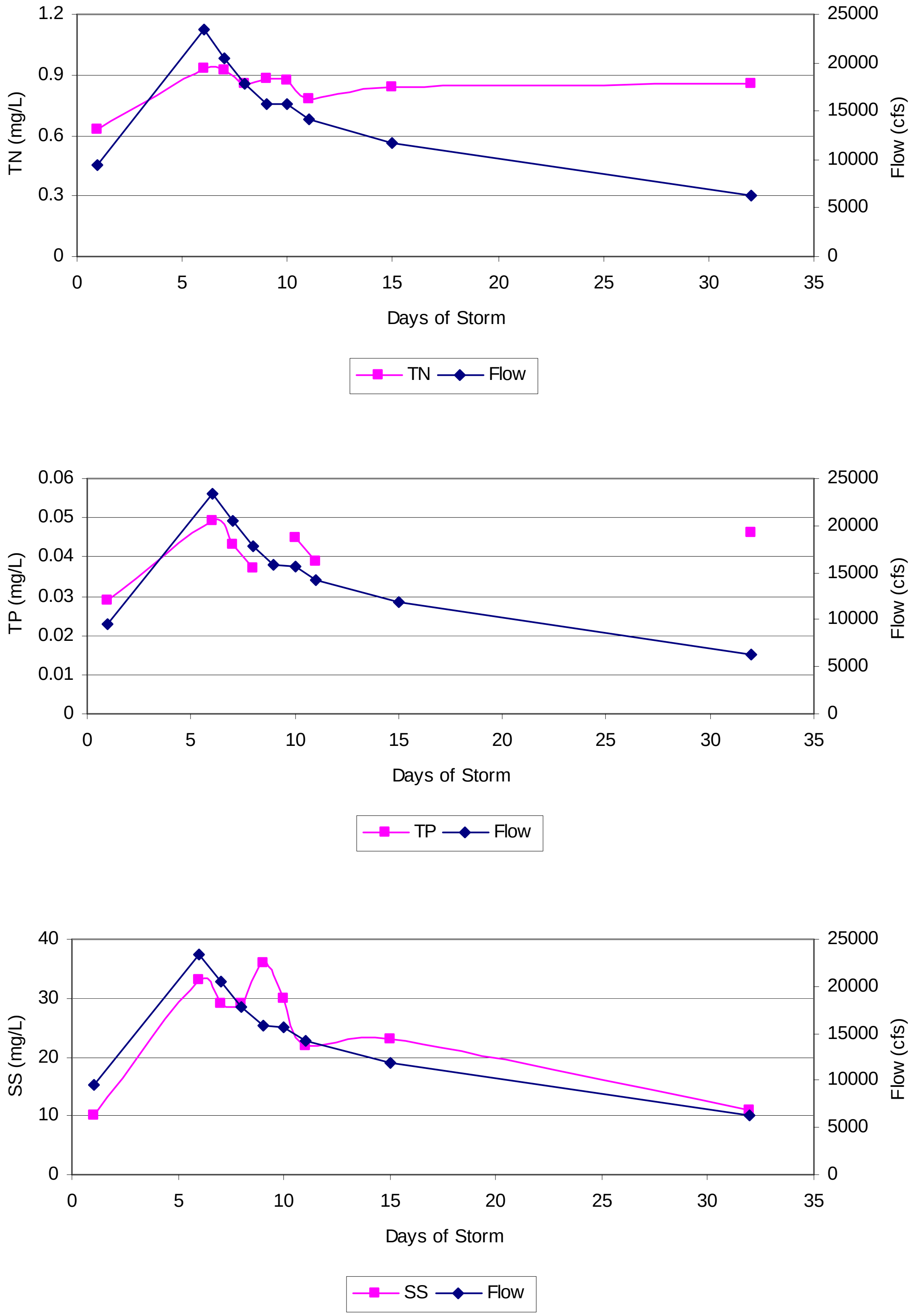


Figure 3. May 30-June 30, 2003, Storm at Towanda

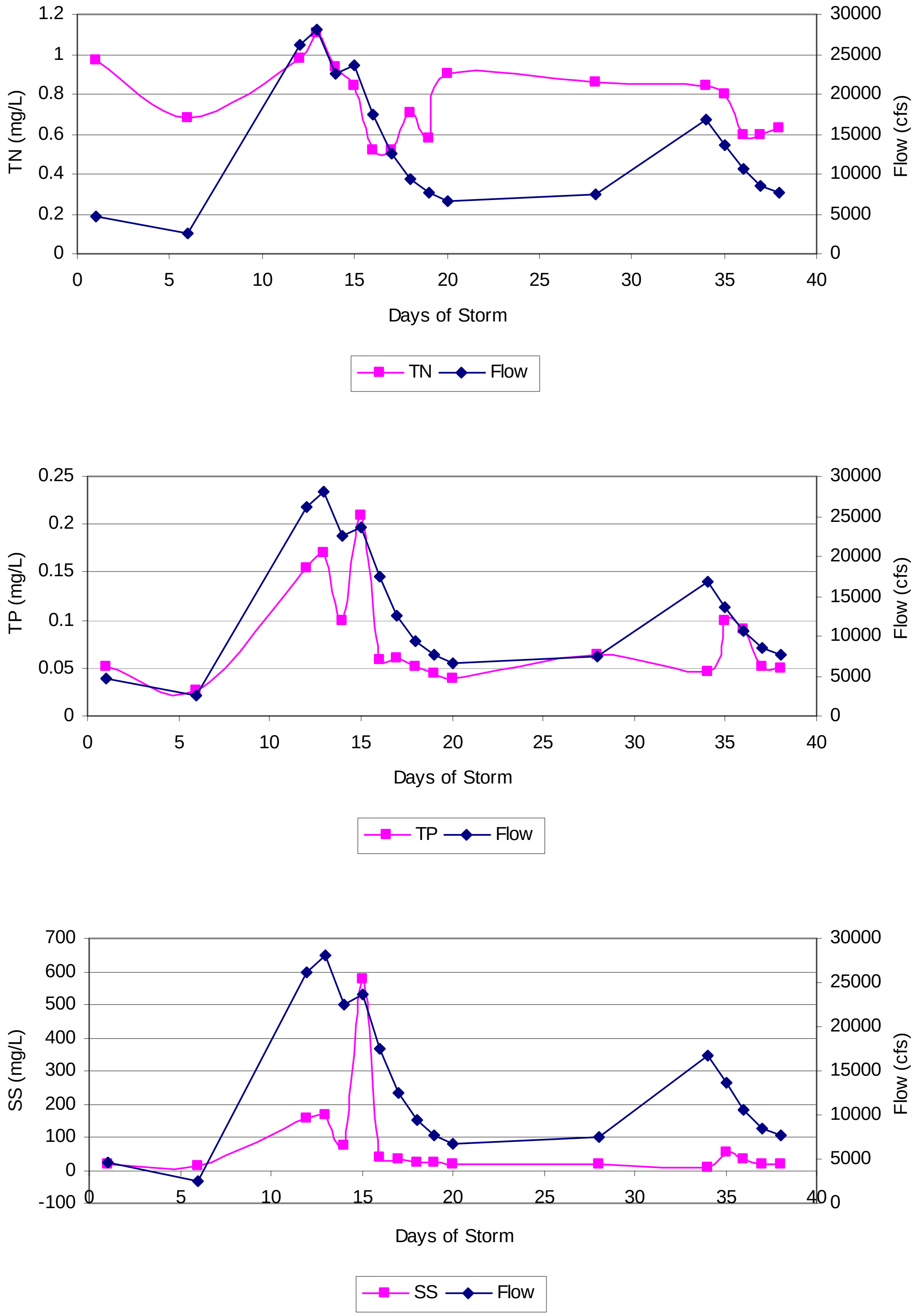
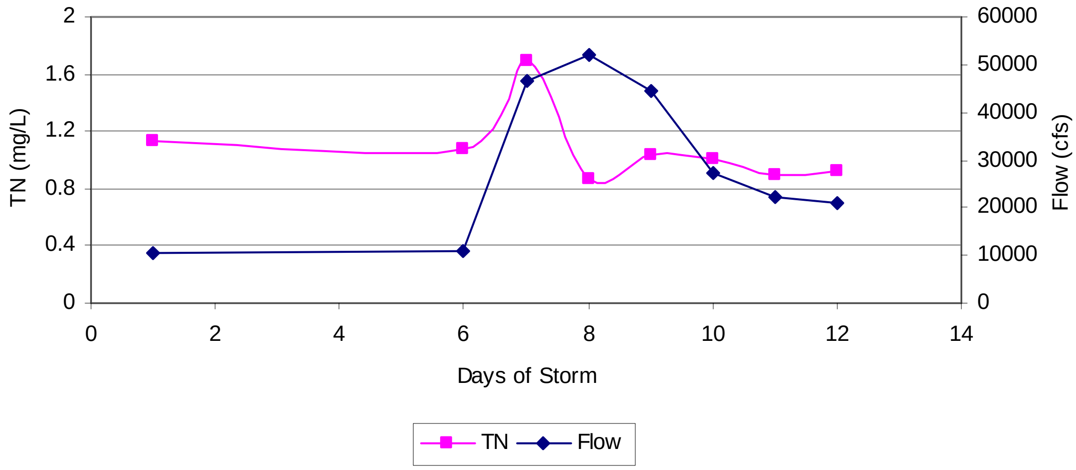
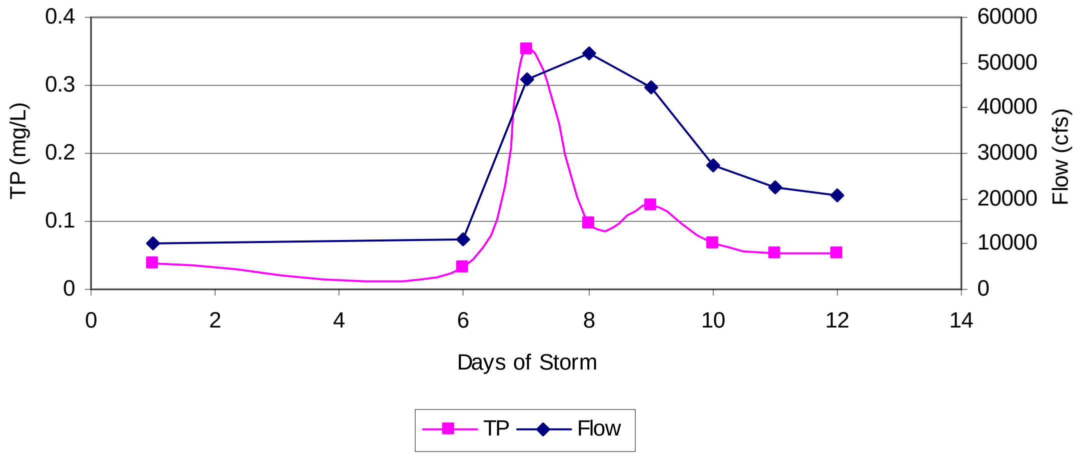


Figure 4. August 21-September 28, 2003, Storm at Towanda





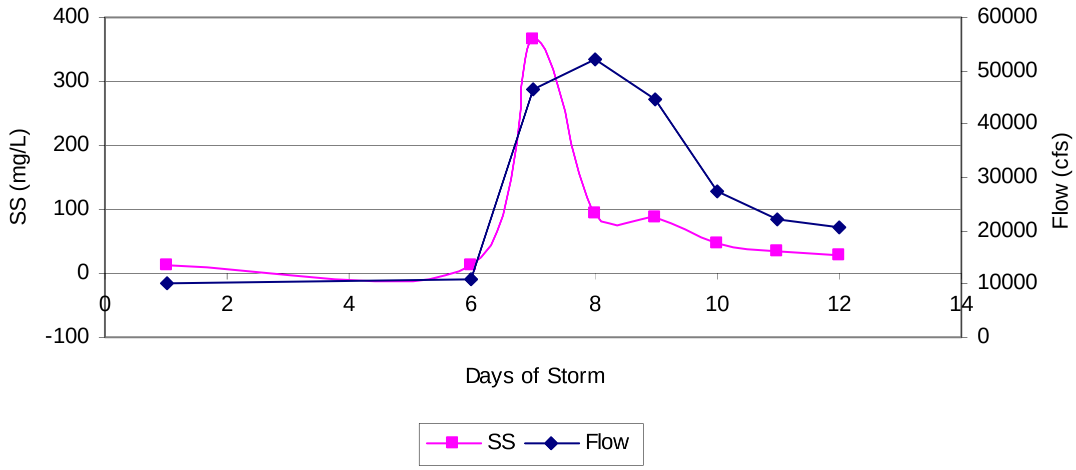


Figure 5.   November 14-25, 2003, Storm at Towanda

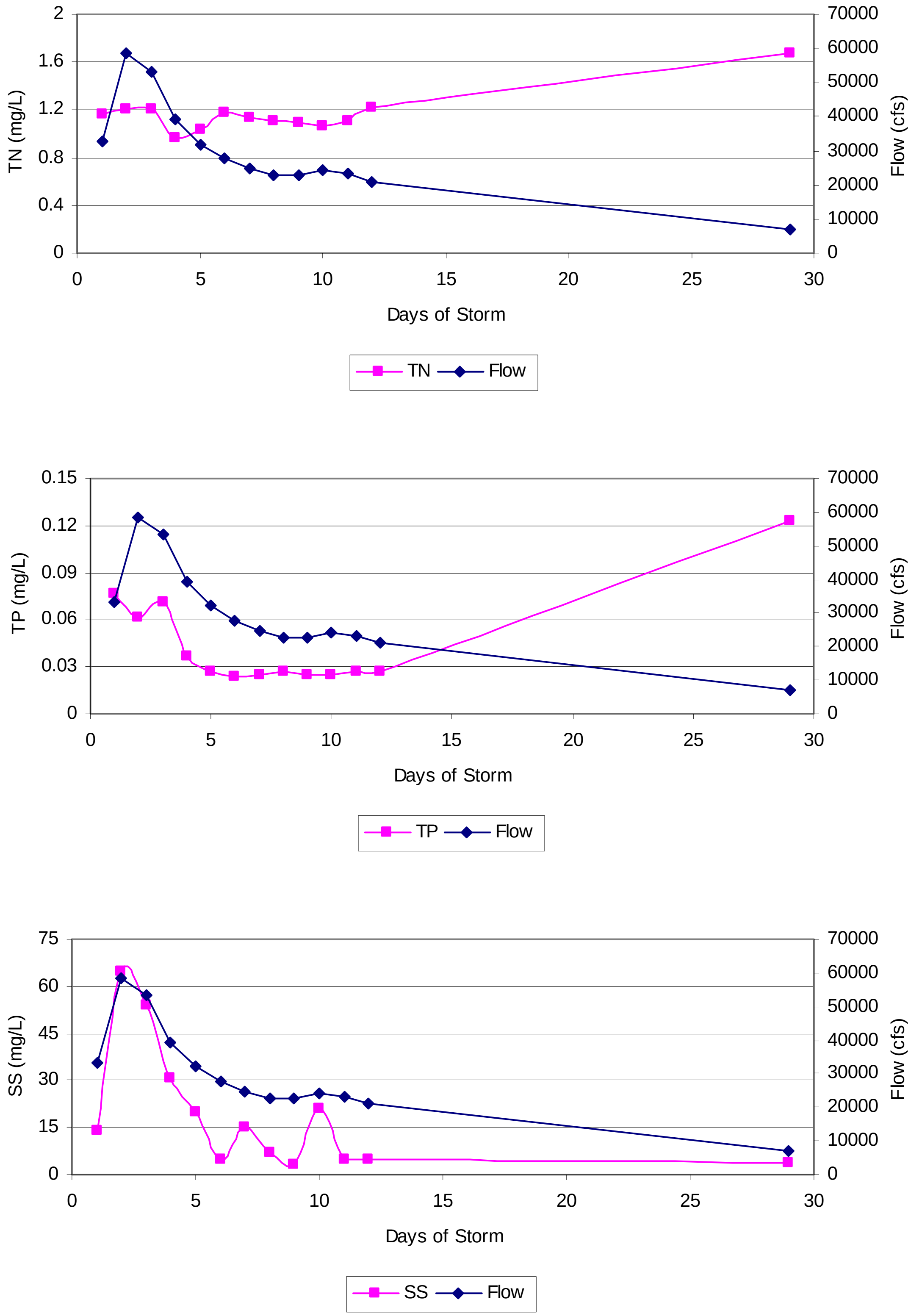
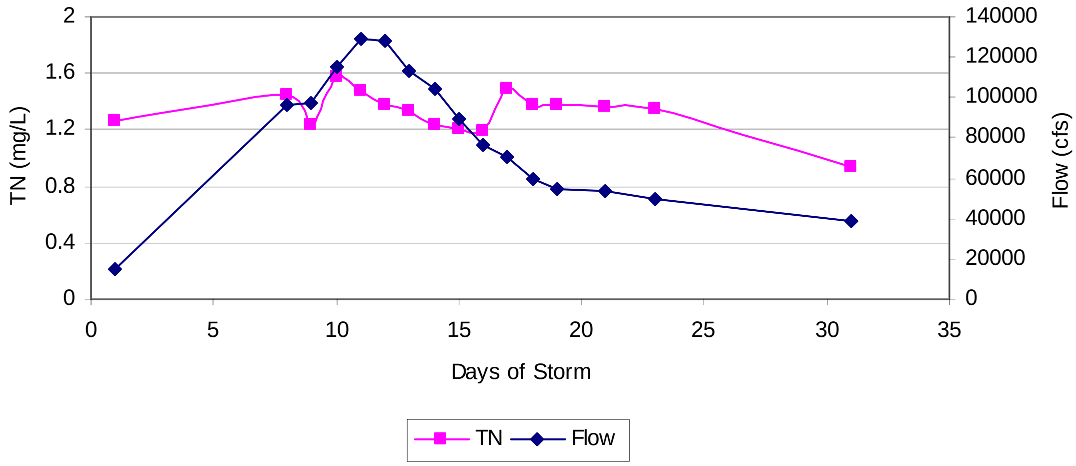
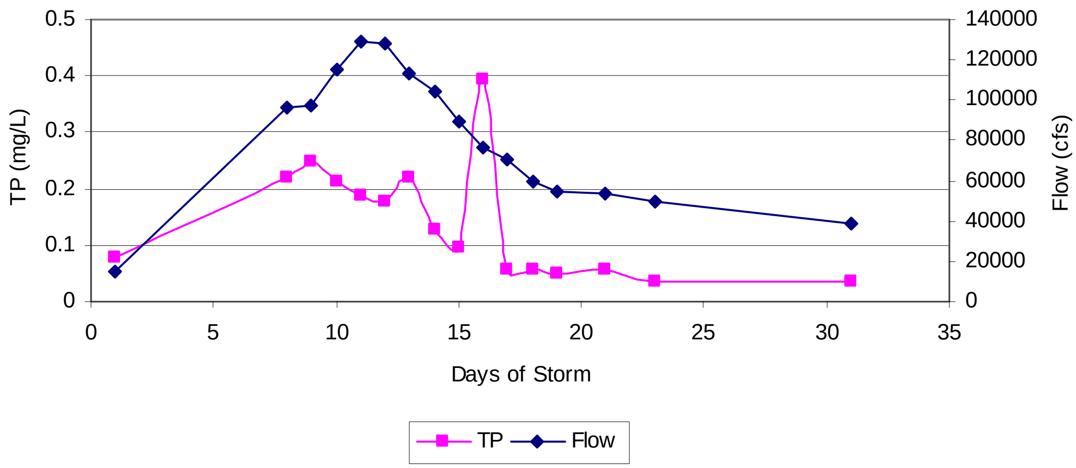


Figure 6. January 2-30, 2003, Storm at Danville





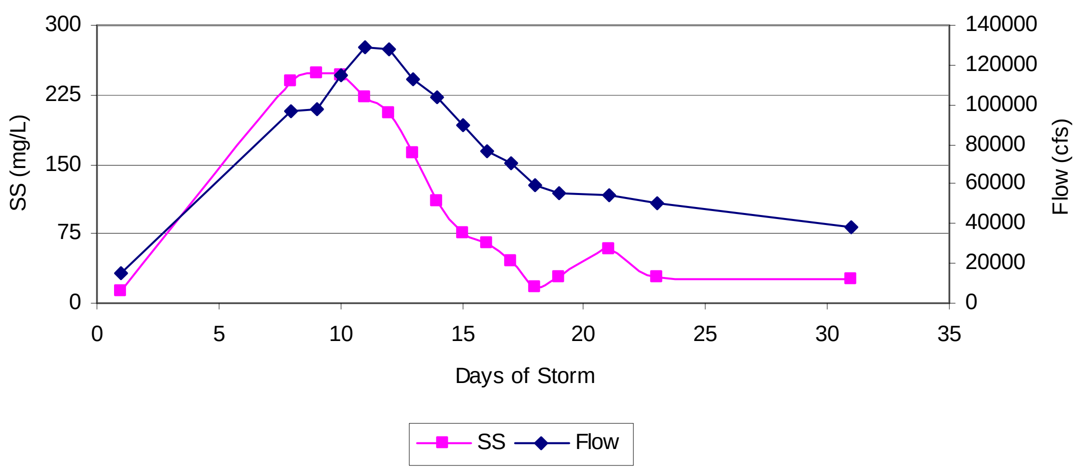
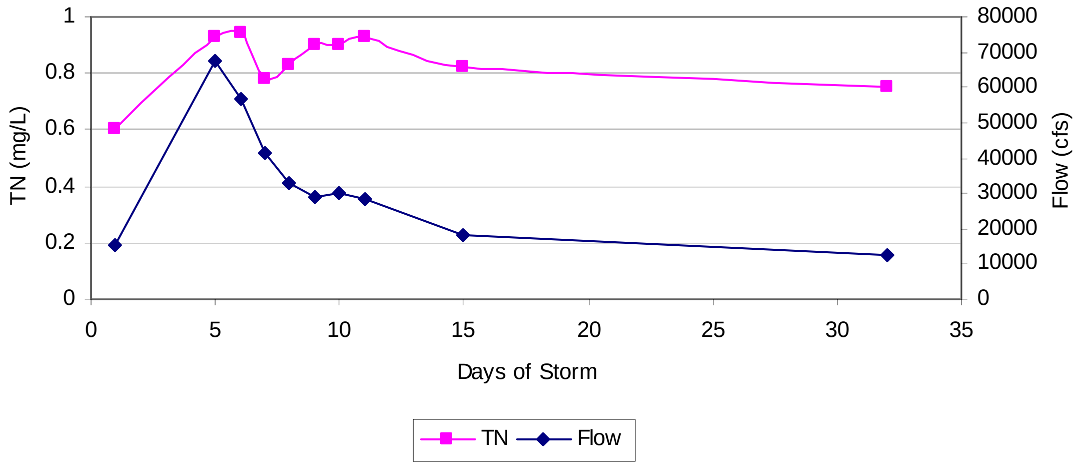
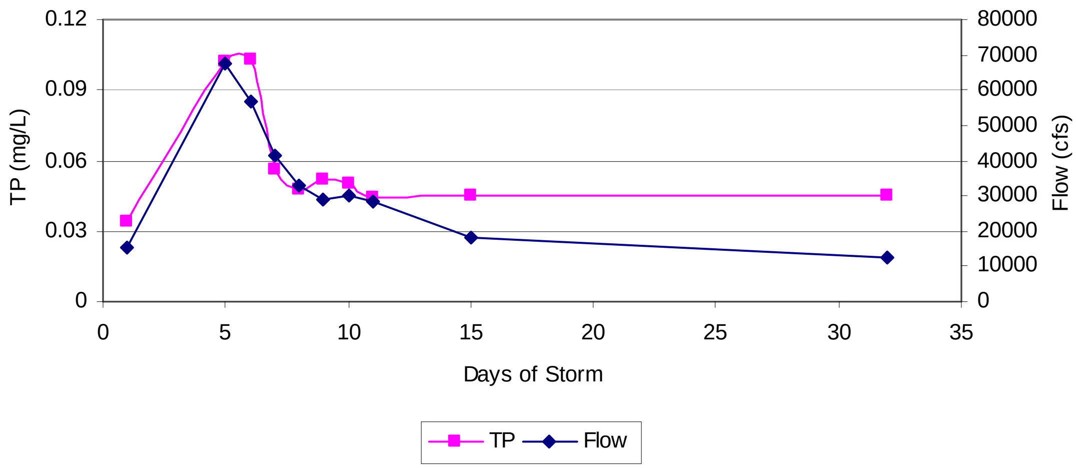


Figure 7. March 12-April 11, 2003, Storm at Danville





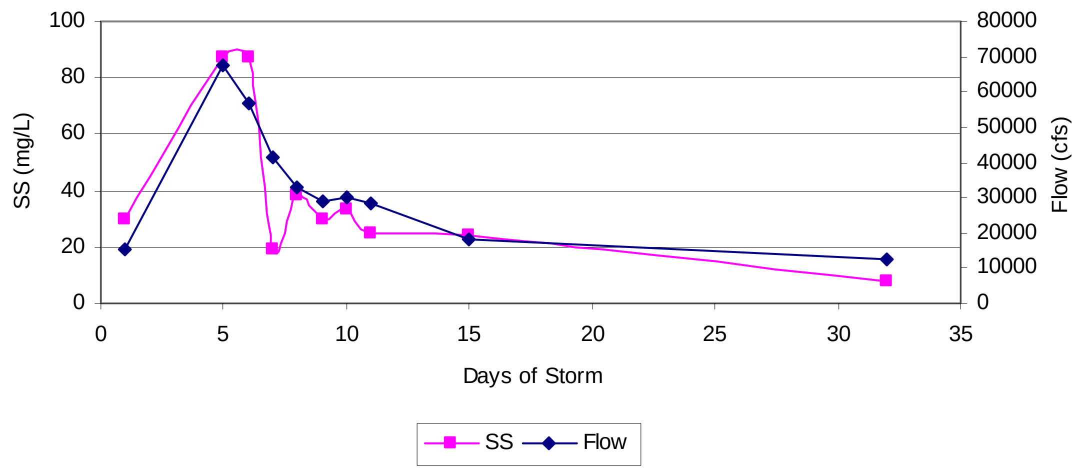
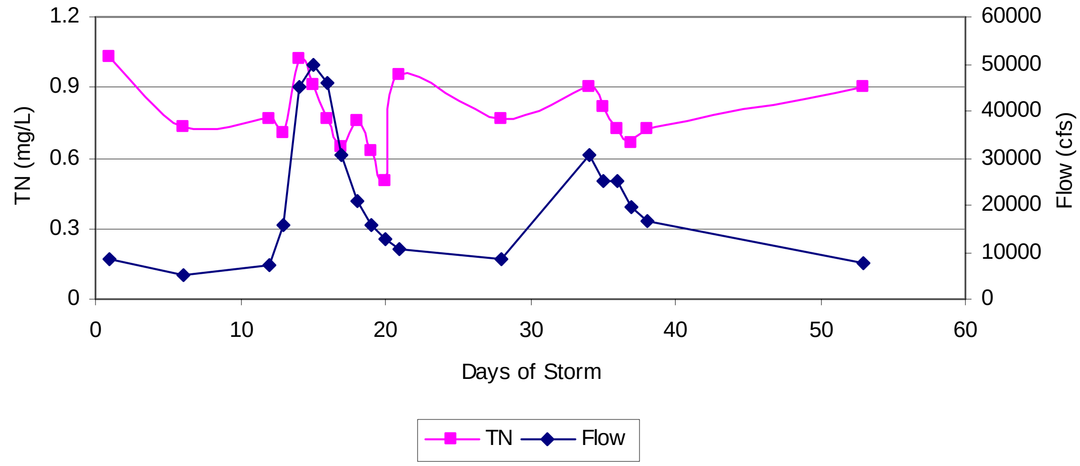
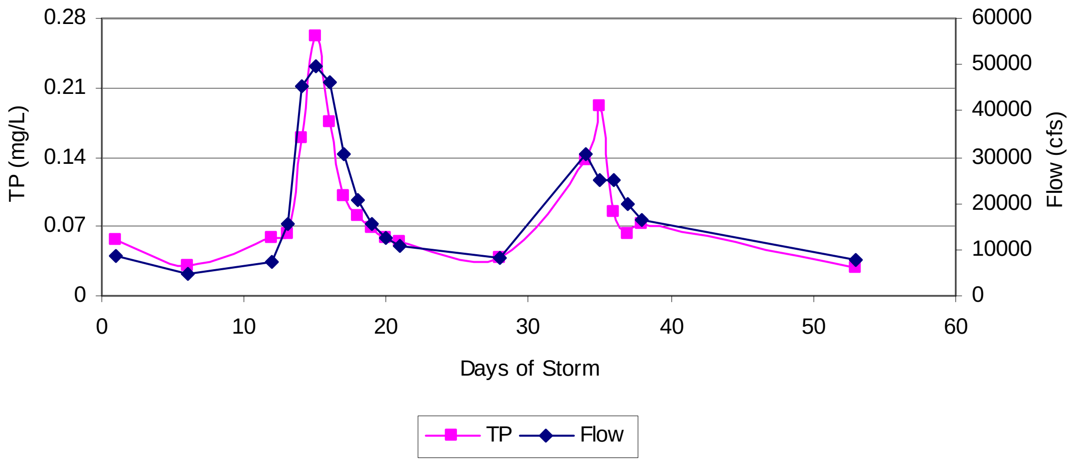


Figure 8. May 30-June 30, 2003, Storm at Danville





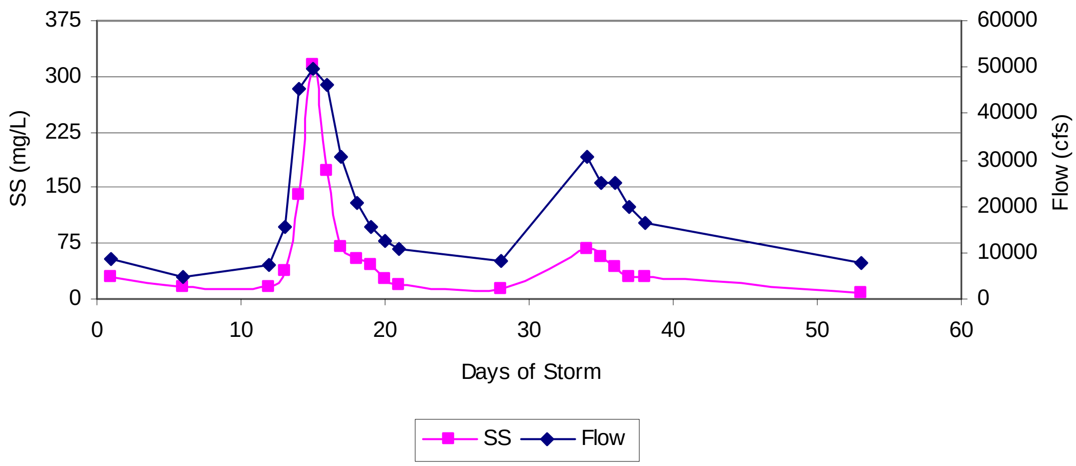


Figure 9. August 21-October 13, 2003, Storm at Danville

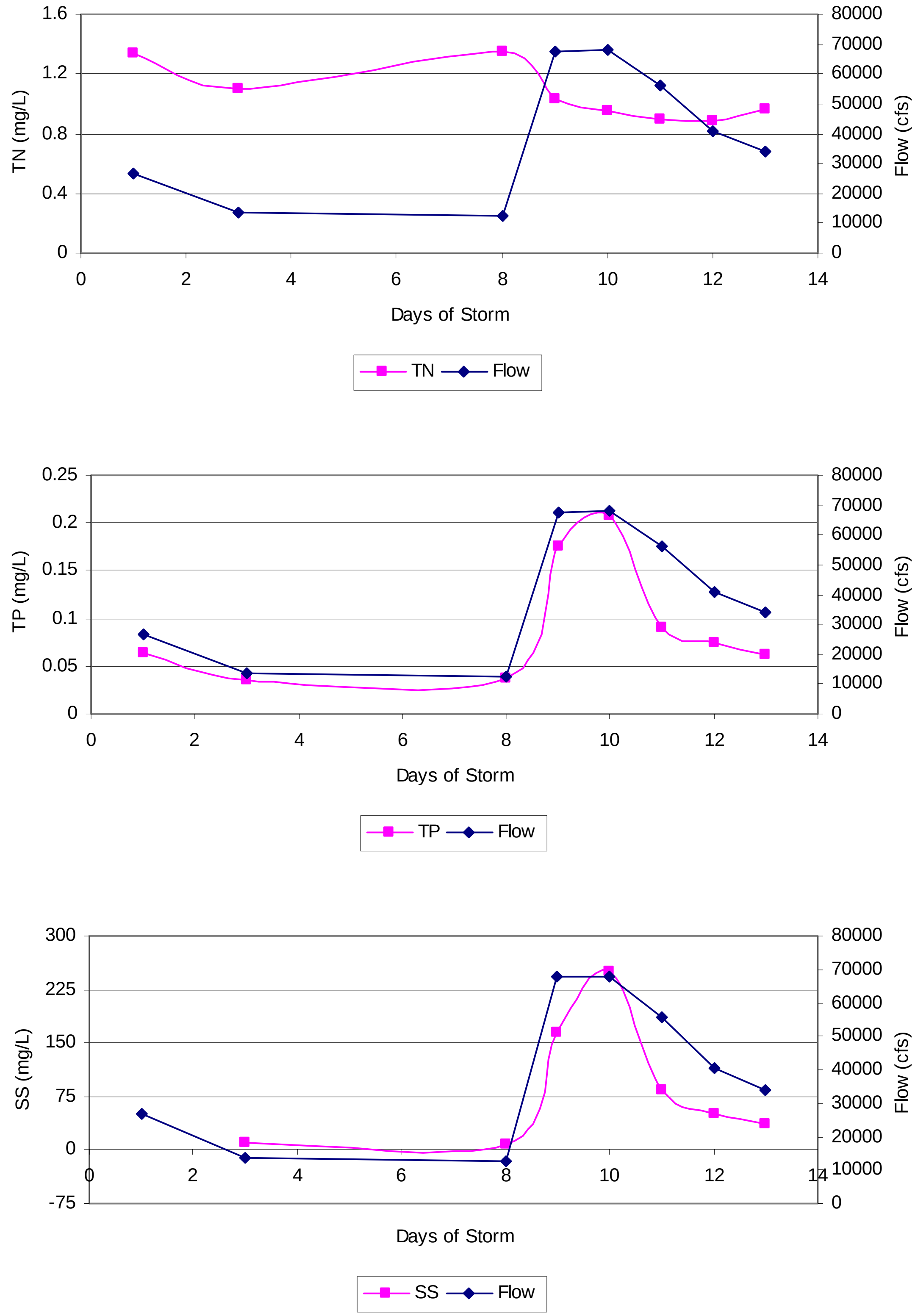


Figure 10. November 12-25, 2003, Storm at Danville

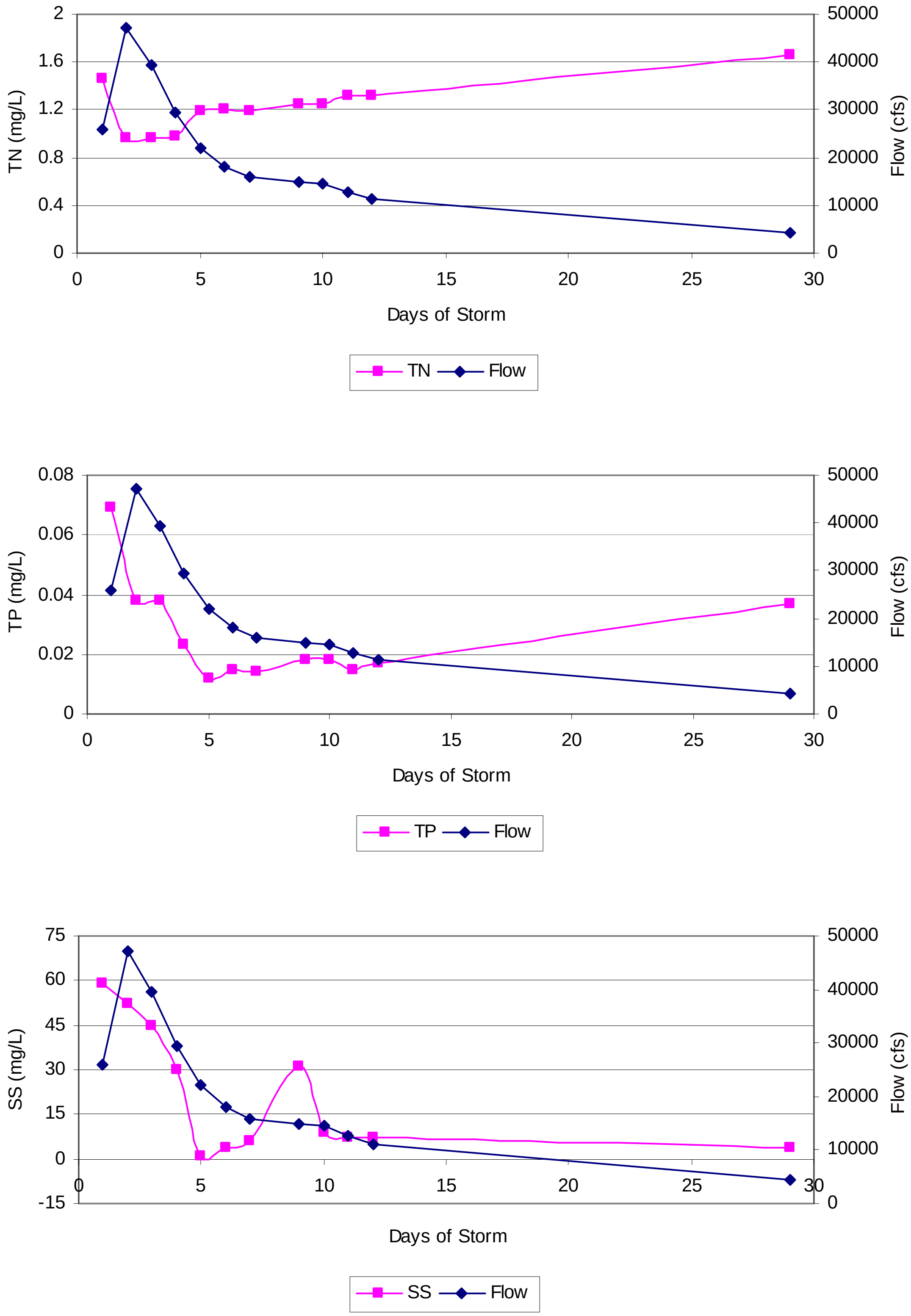
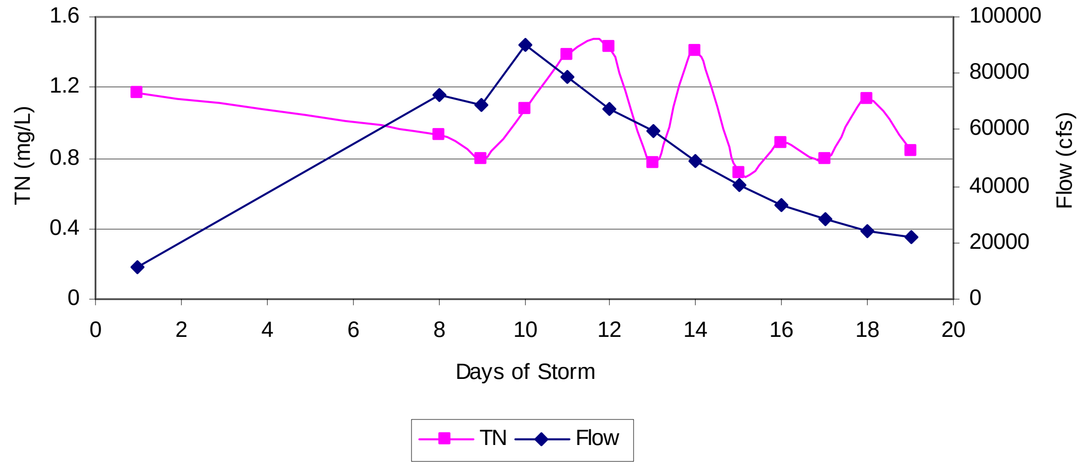
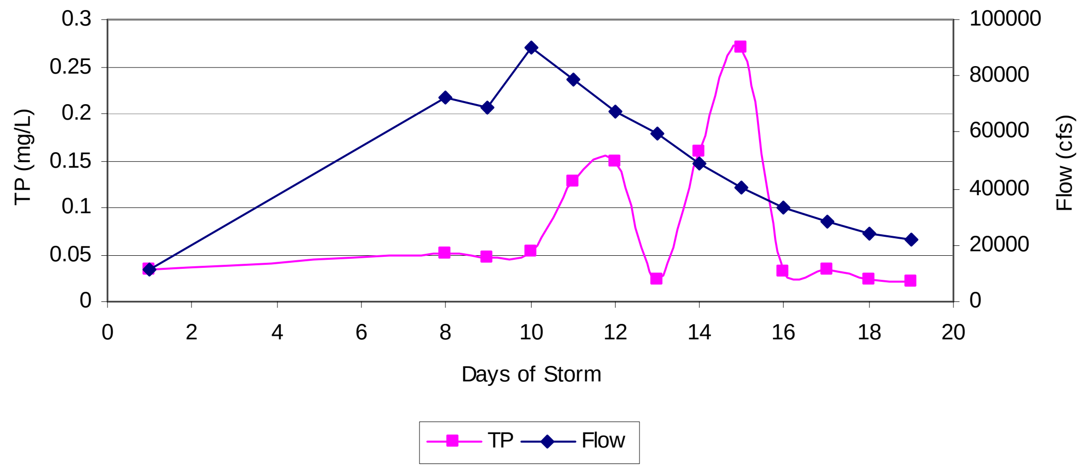


Figure 11. January 2-30, 2003, Storm at Lewisburg





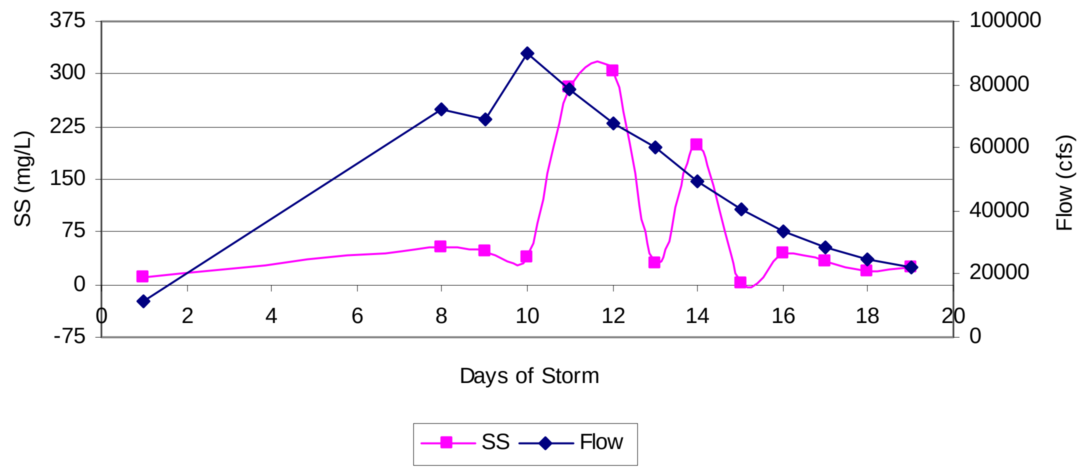


Figure 12. March 12-30, 2003, Storm at Lewisburg

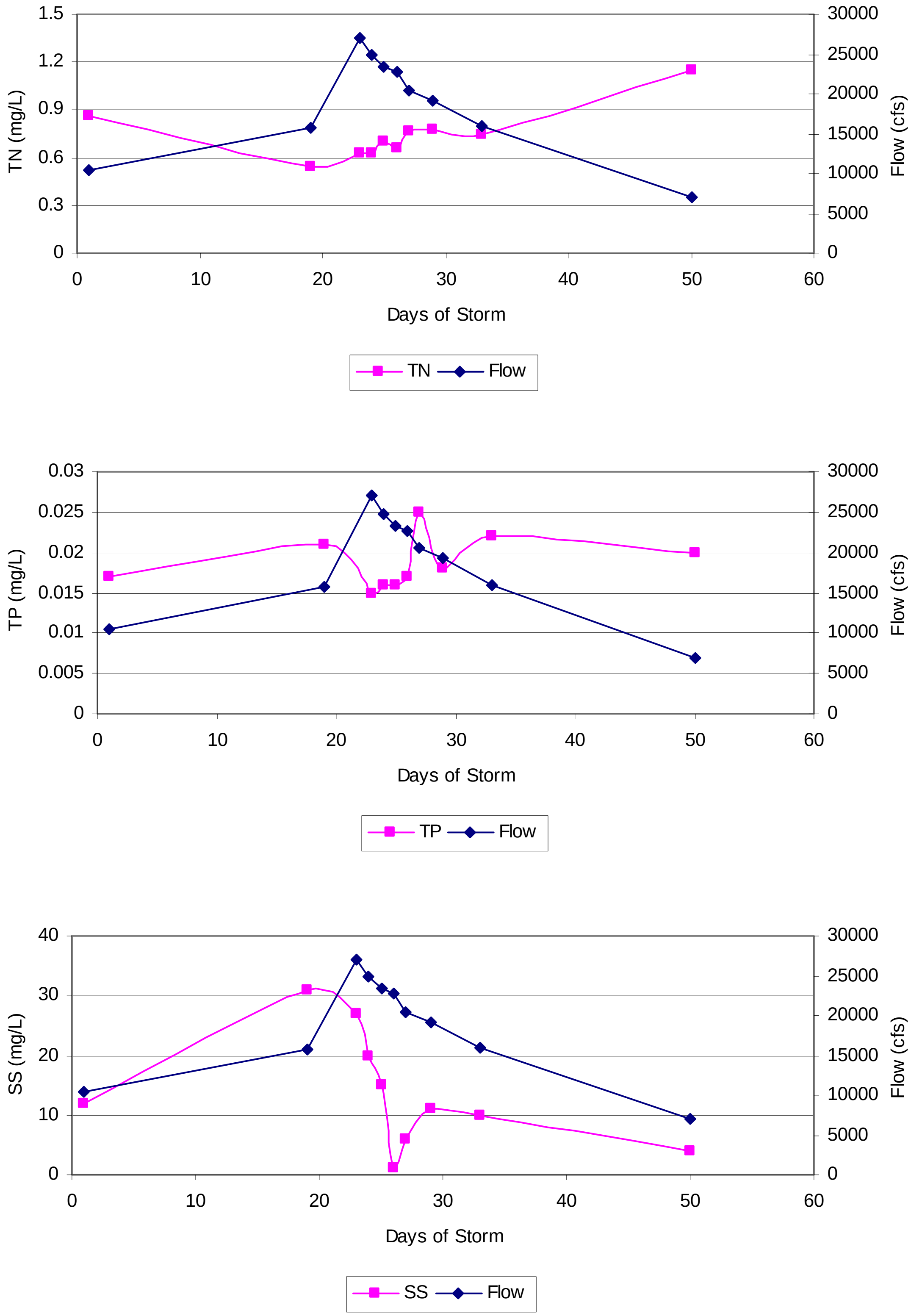


Figure 13. ***May 12-June 30, 2003, Storm at Lewisburg***

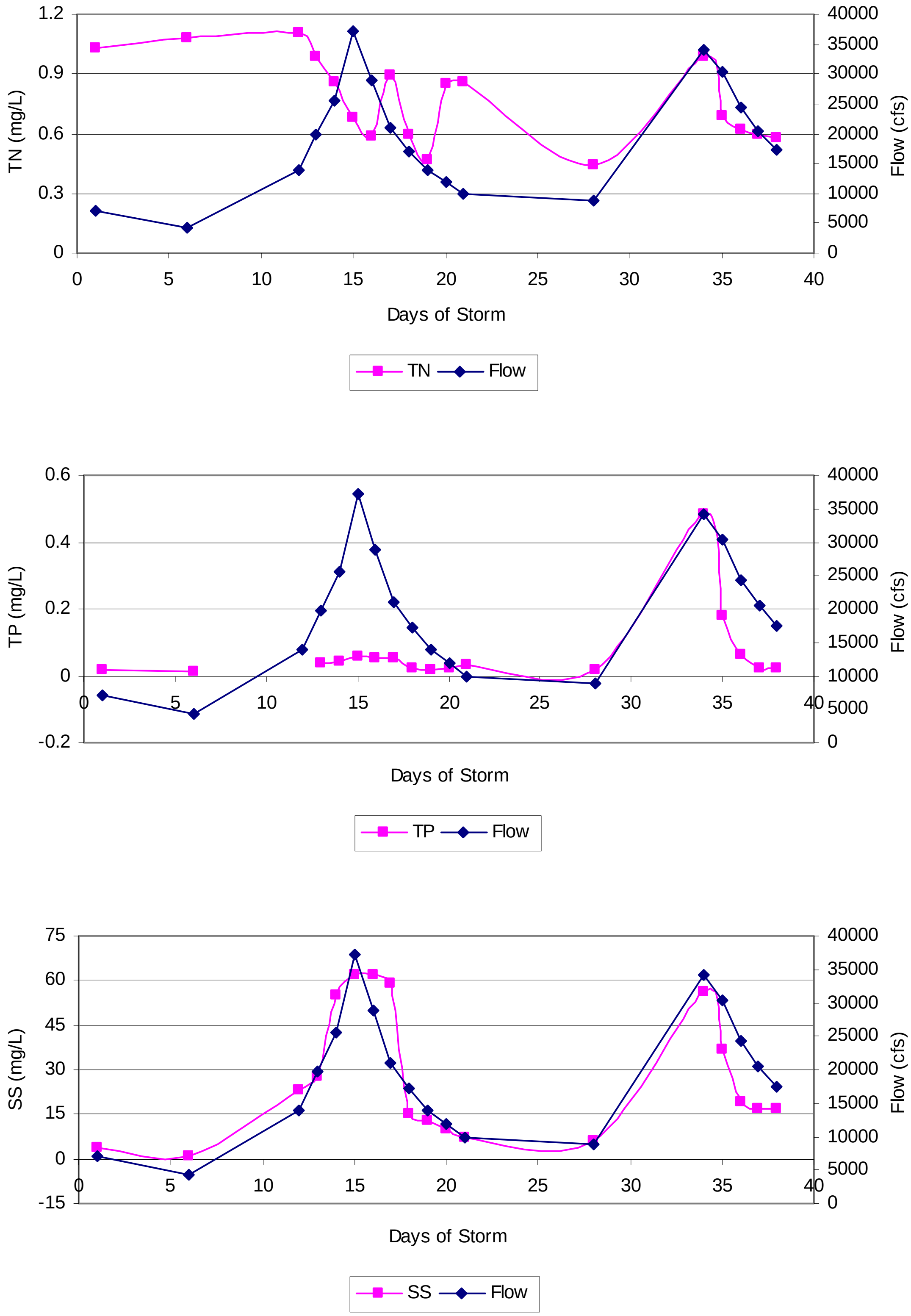


Figure 14. August 21-September 28, 2003, Storm at Lewisburg

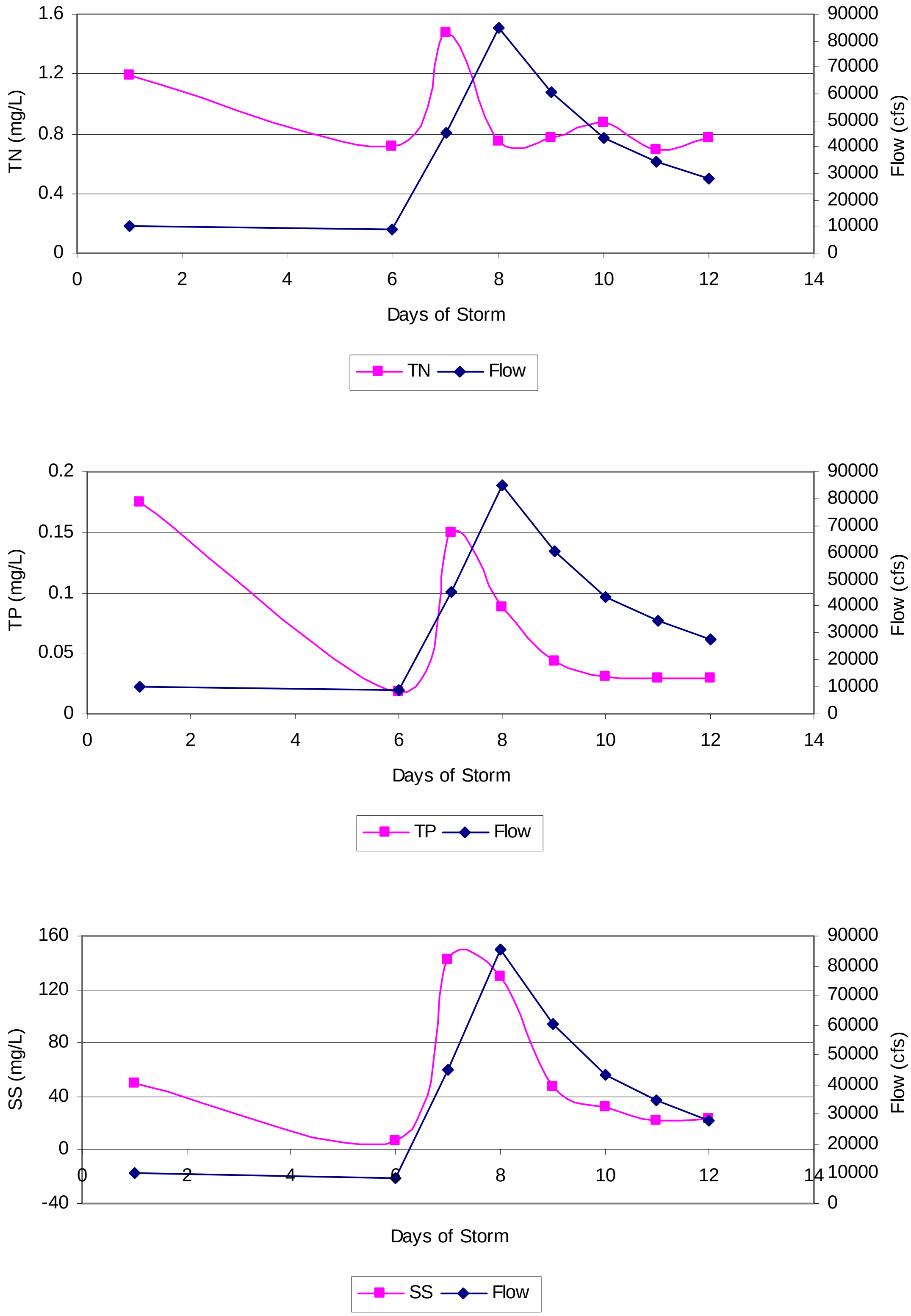


Figure 15. November 14-25, 2003, Storm at Lewisburg

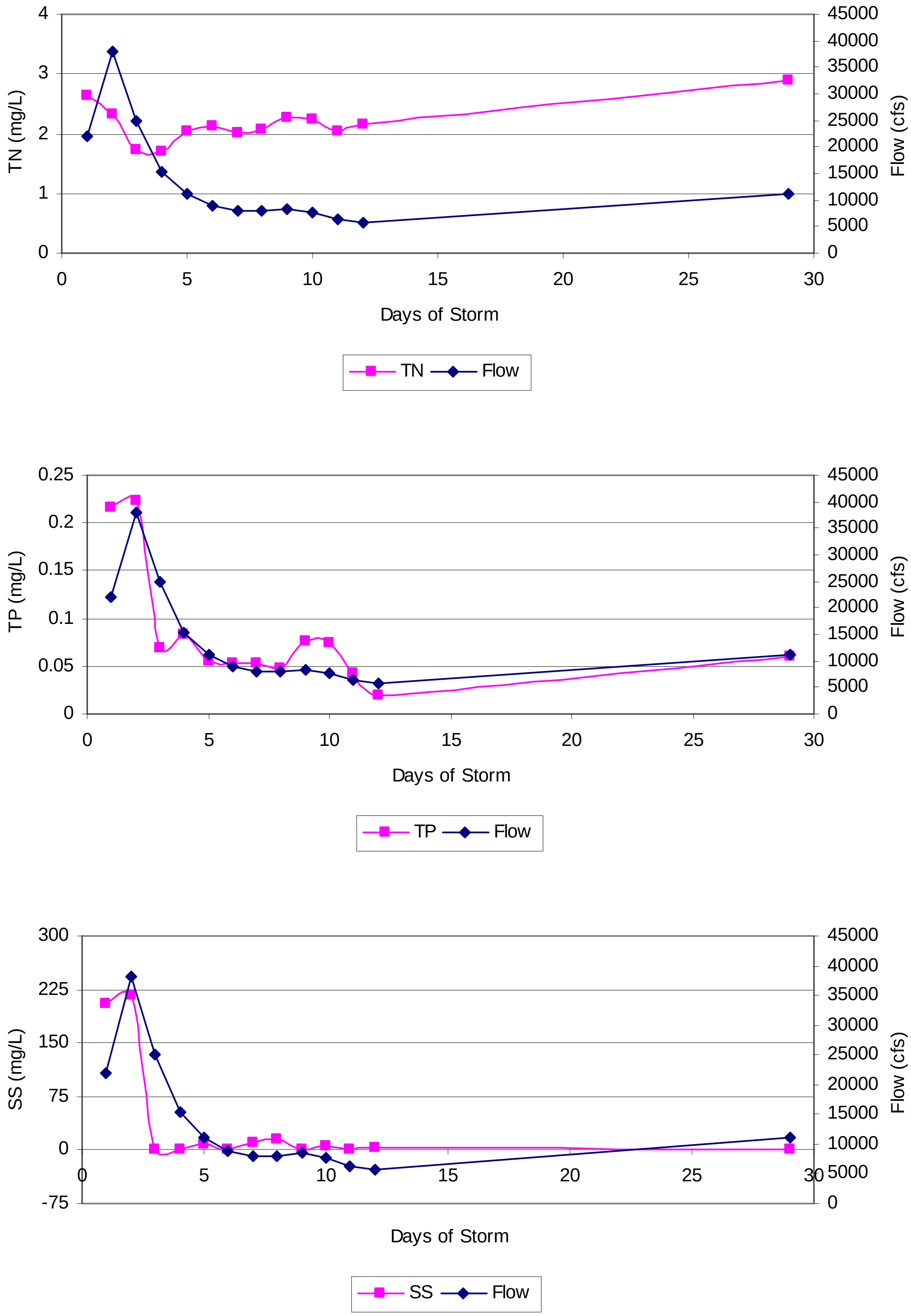
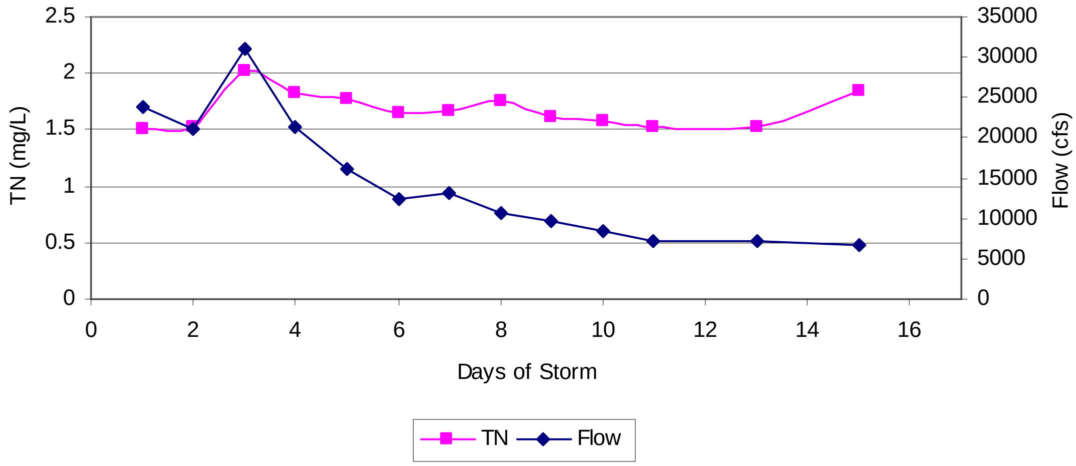
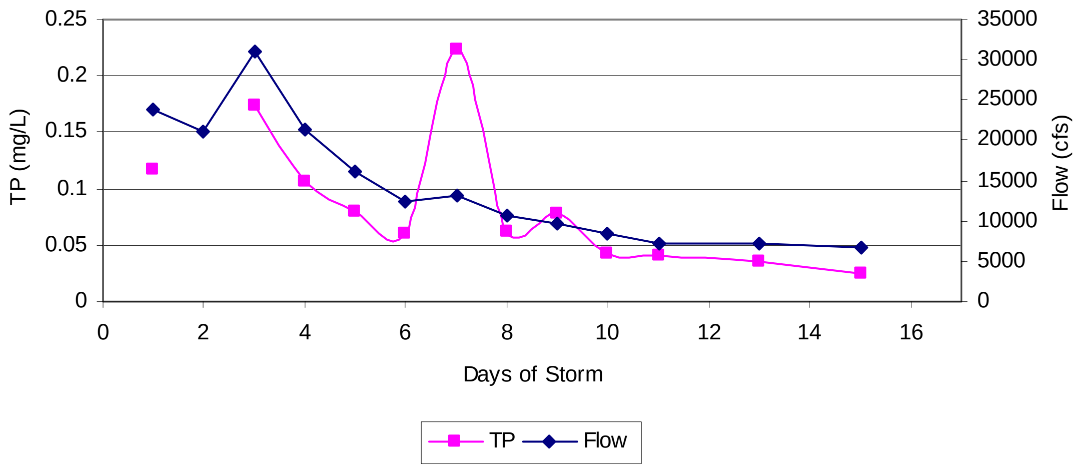


Figure 16. January 2-30, 2003, Storm at Newport





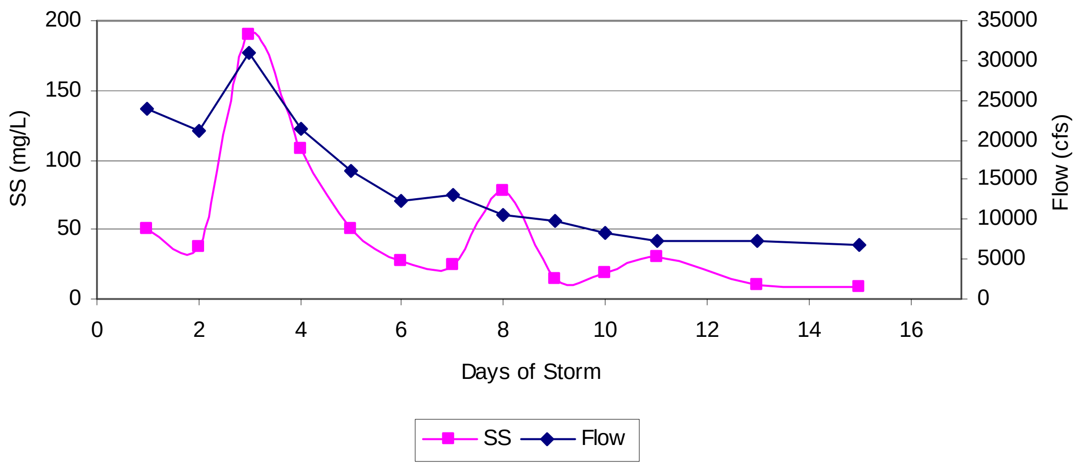


Figure 17. March 19-April 2, 2003, Storm at Newport

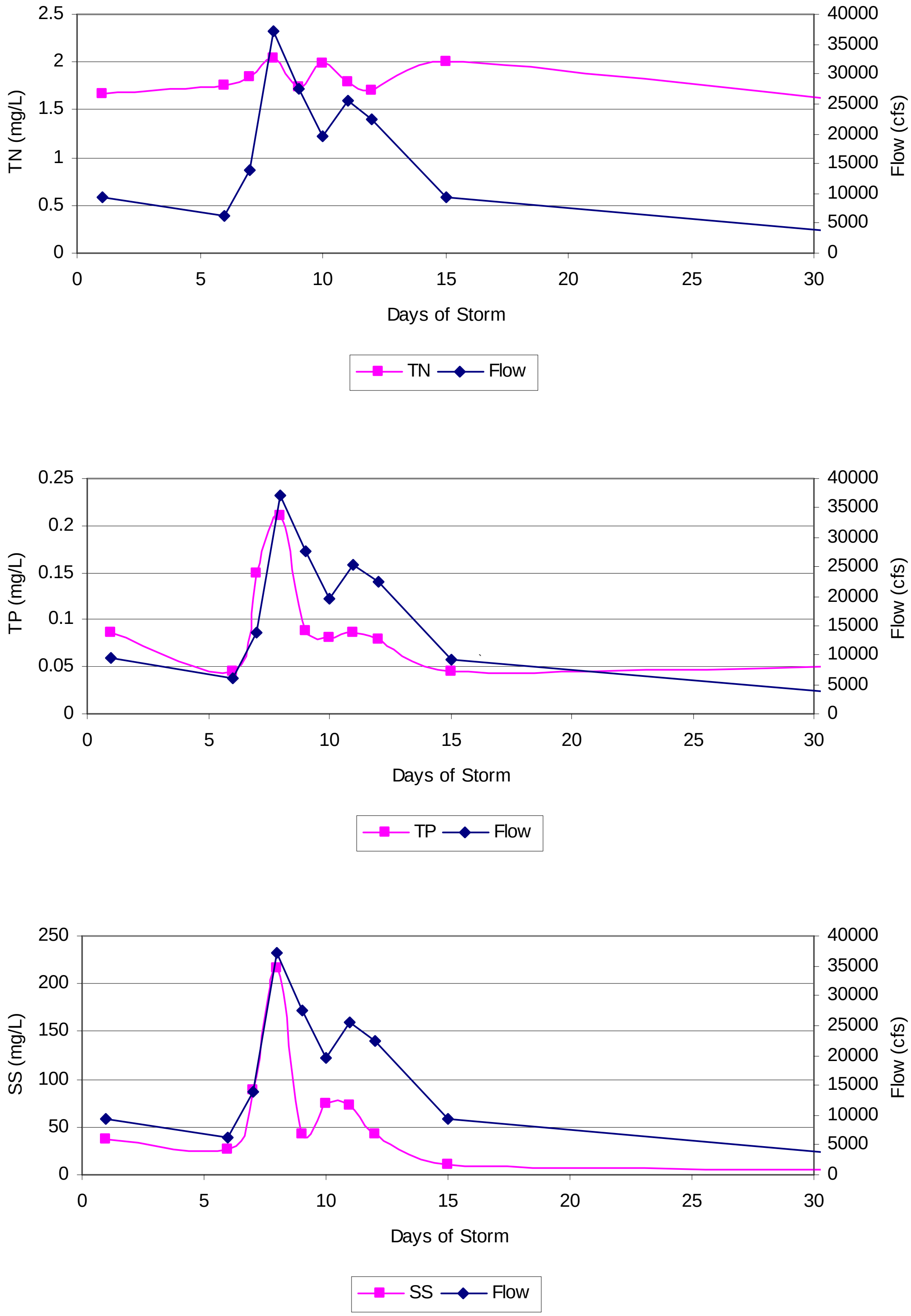


Figure 18. May 29-June 30, 2003, Storm at Newport

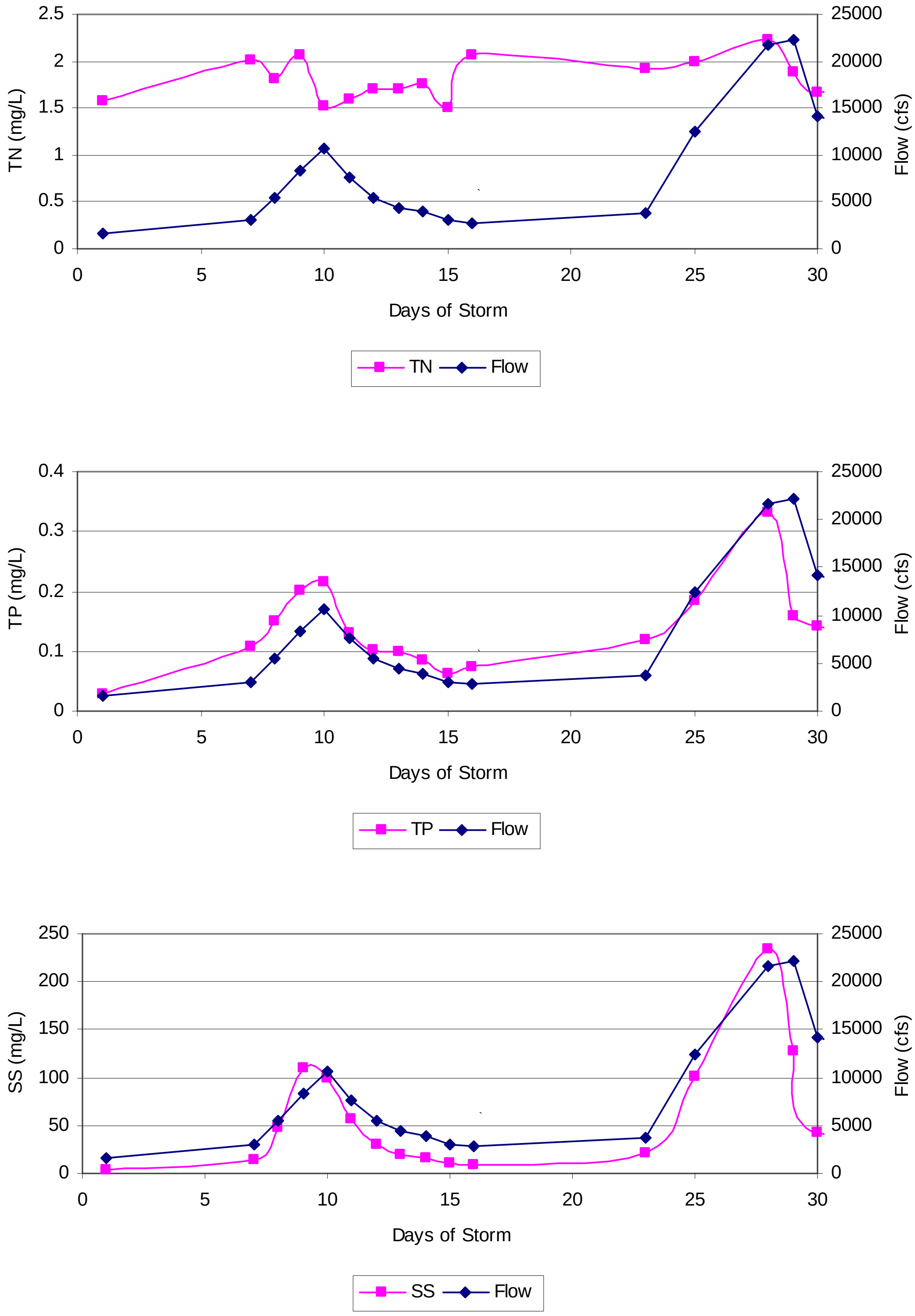
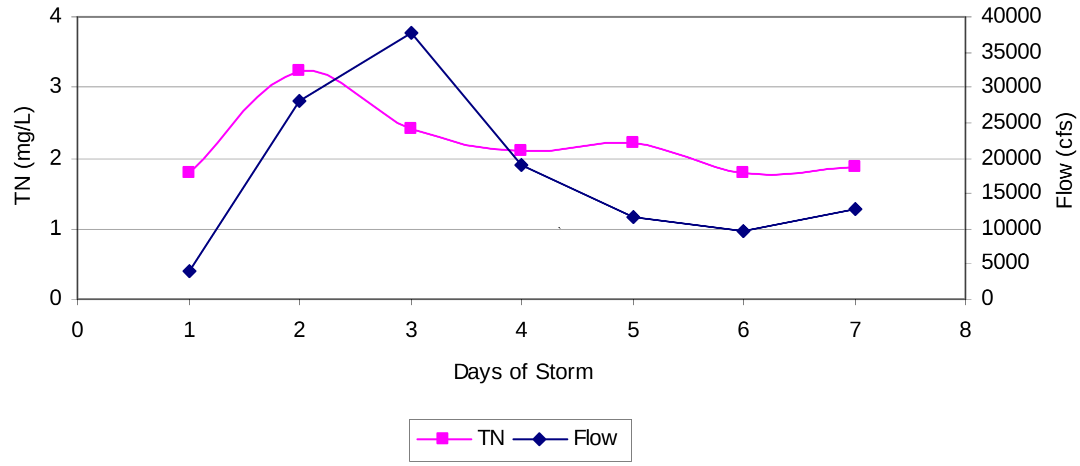
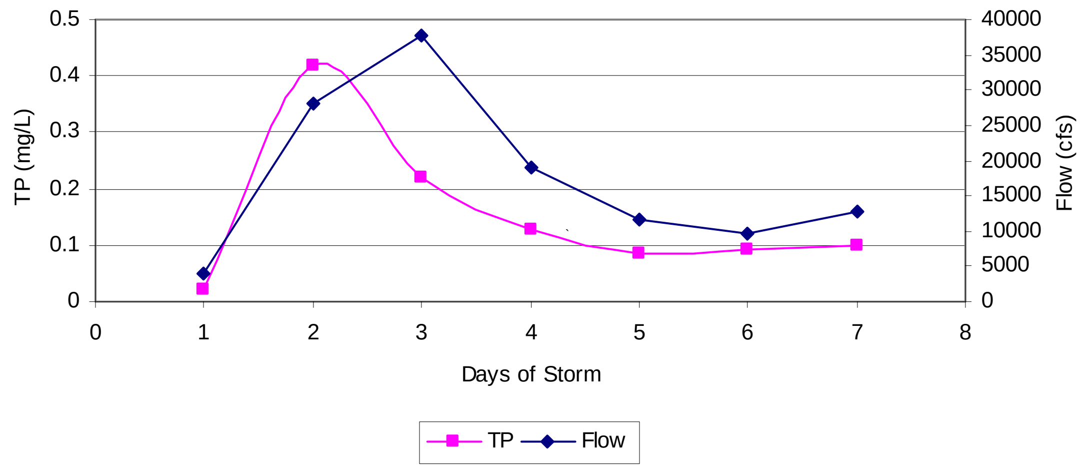


Figure 19. ***August 27-October 13, 2003, Storm at Newport***





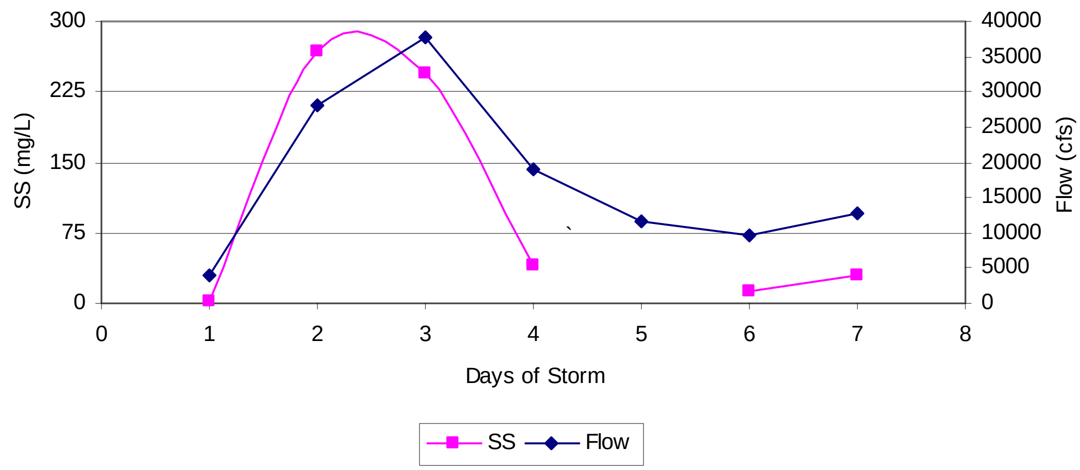


Figure 20. November 19-25, 2003, Storm at Newport

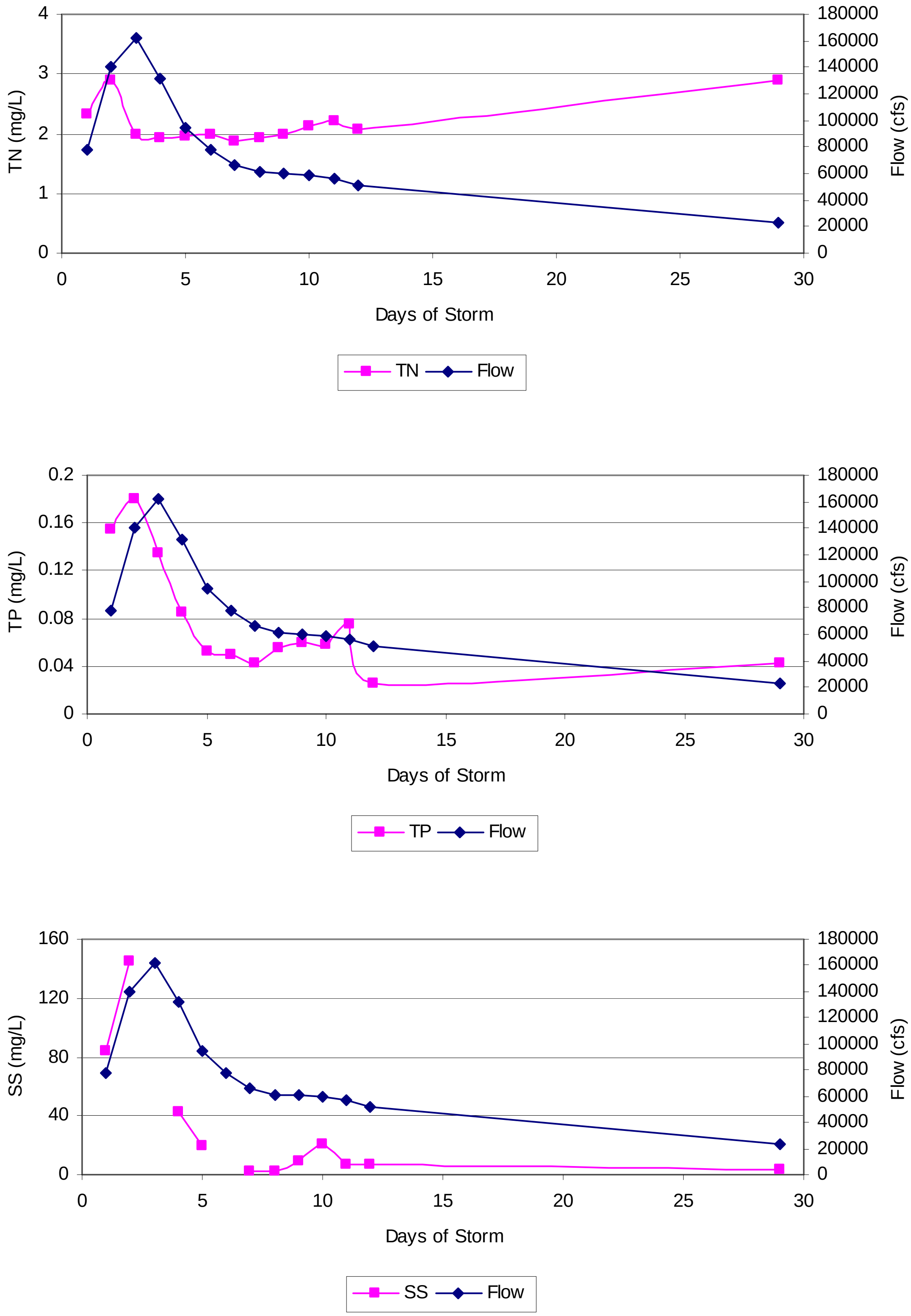
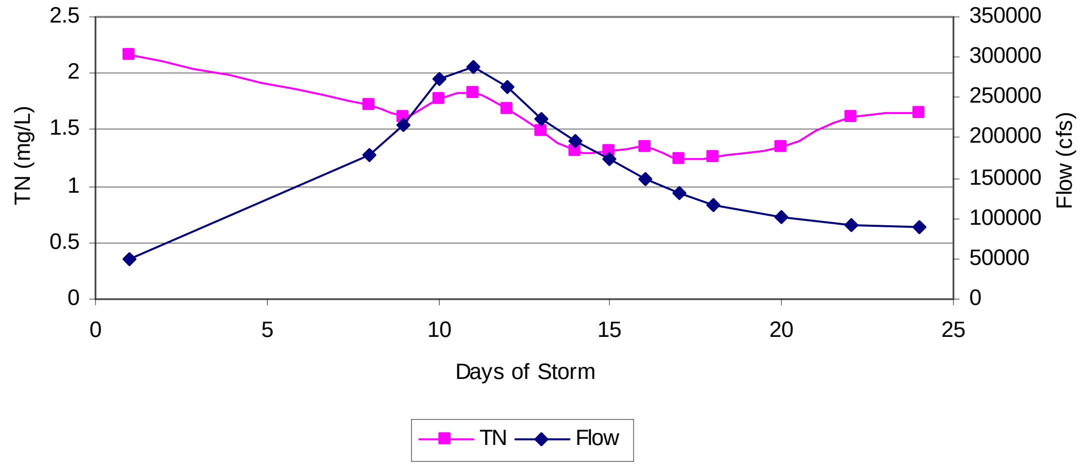
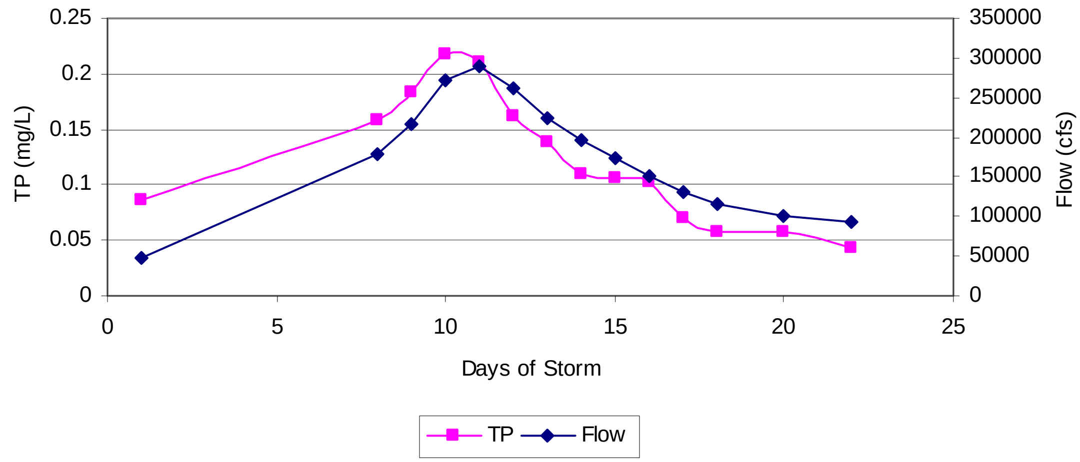


Figure 21. January 2-30, 2003, Storm at Marietta





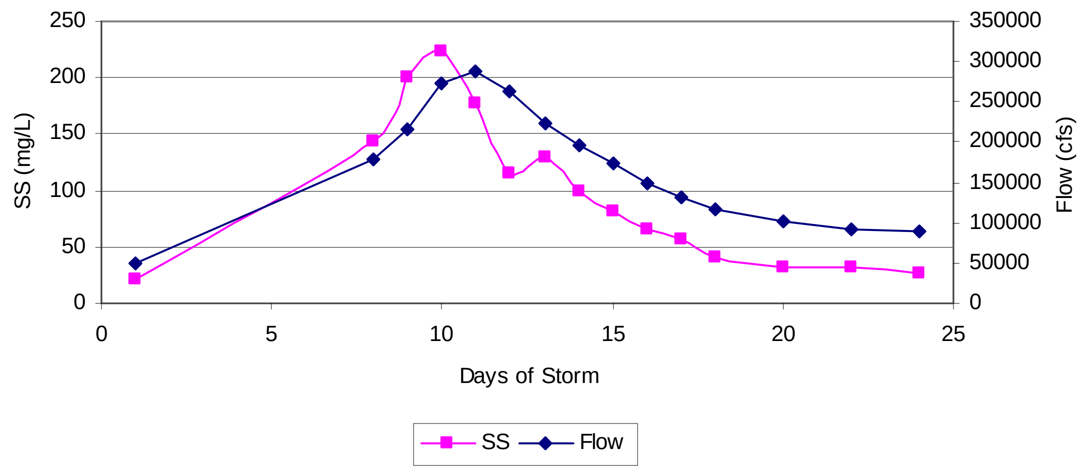
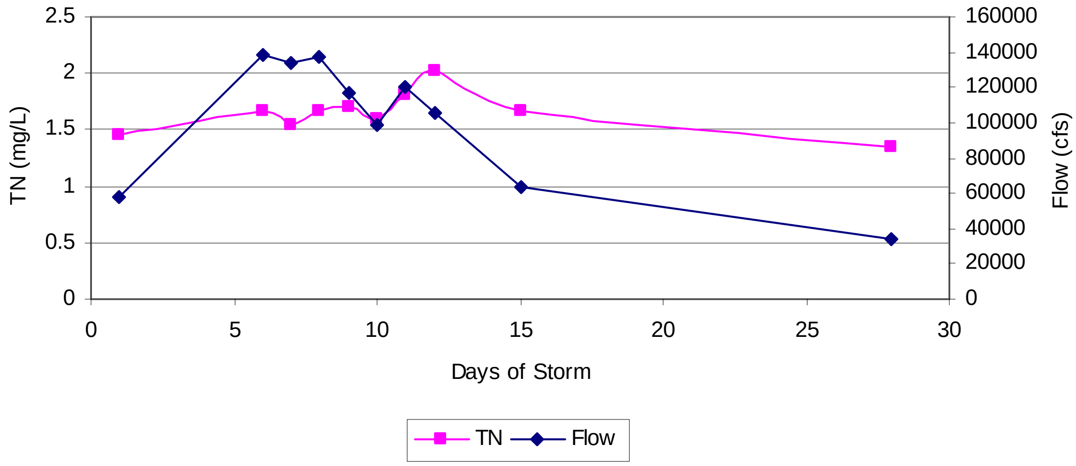
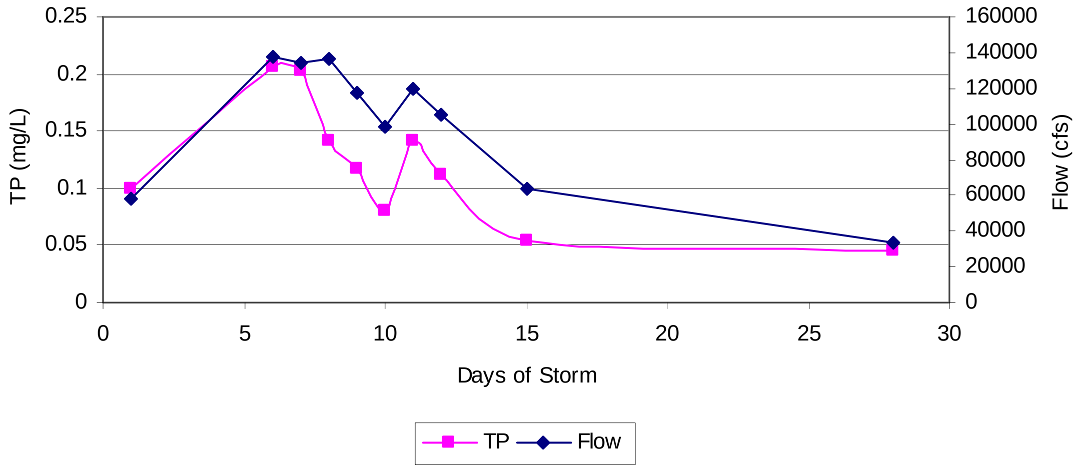


Figure 22. March 12-April 4, 2003, Storm at Marietta





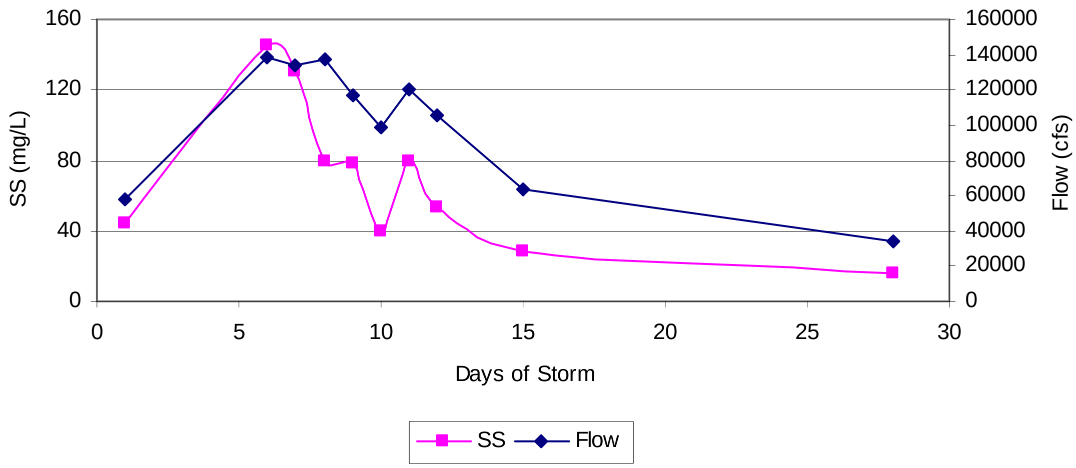


Figure 23. May 12-June 33, 2003, Storm at Marietta

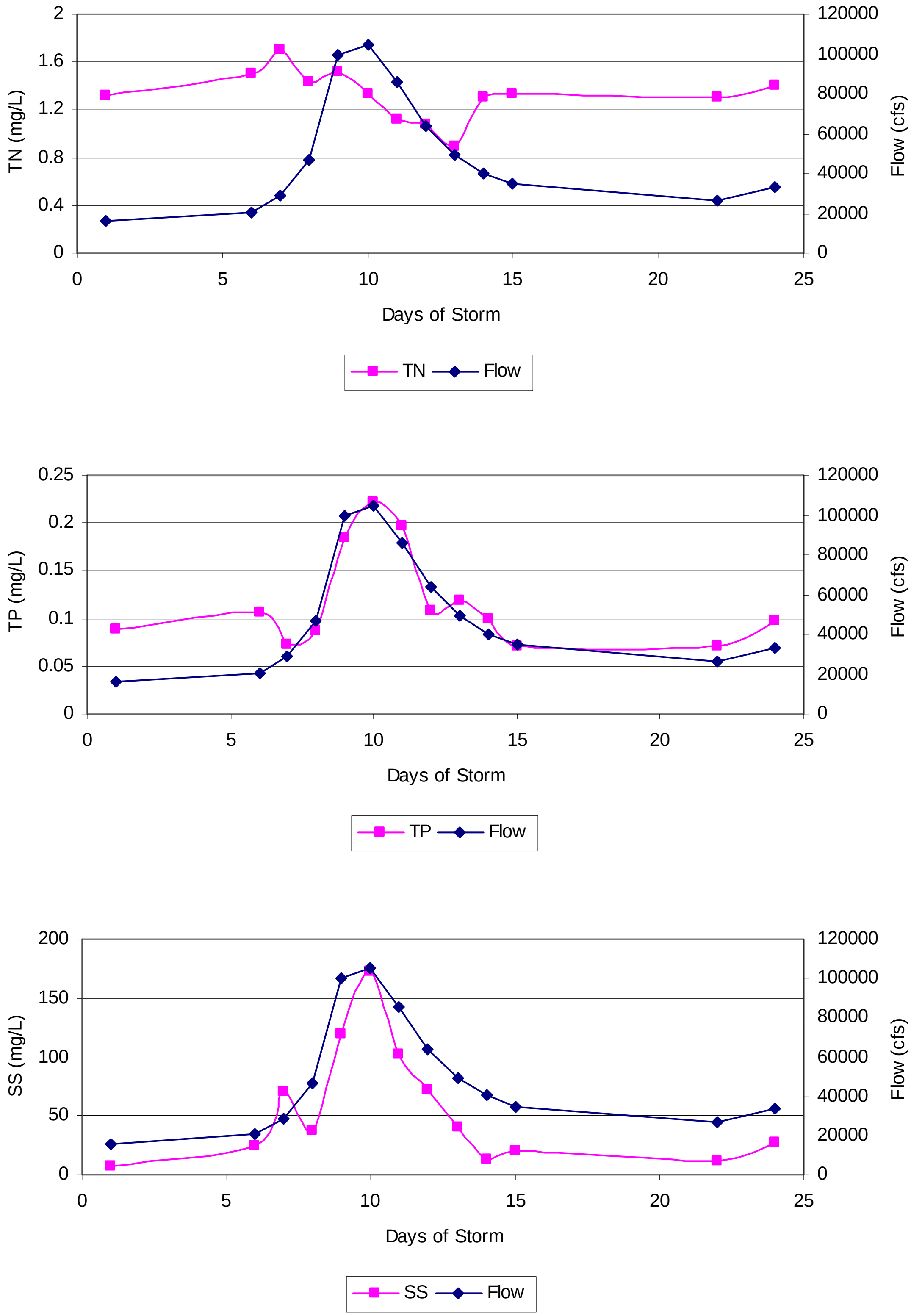


Figure 24. August 28-September 20, 2003, Storm at Marietta

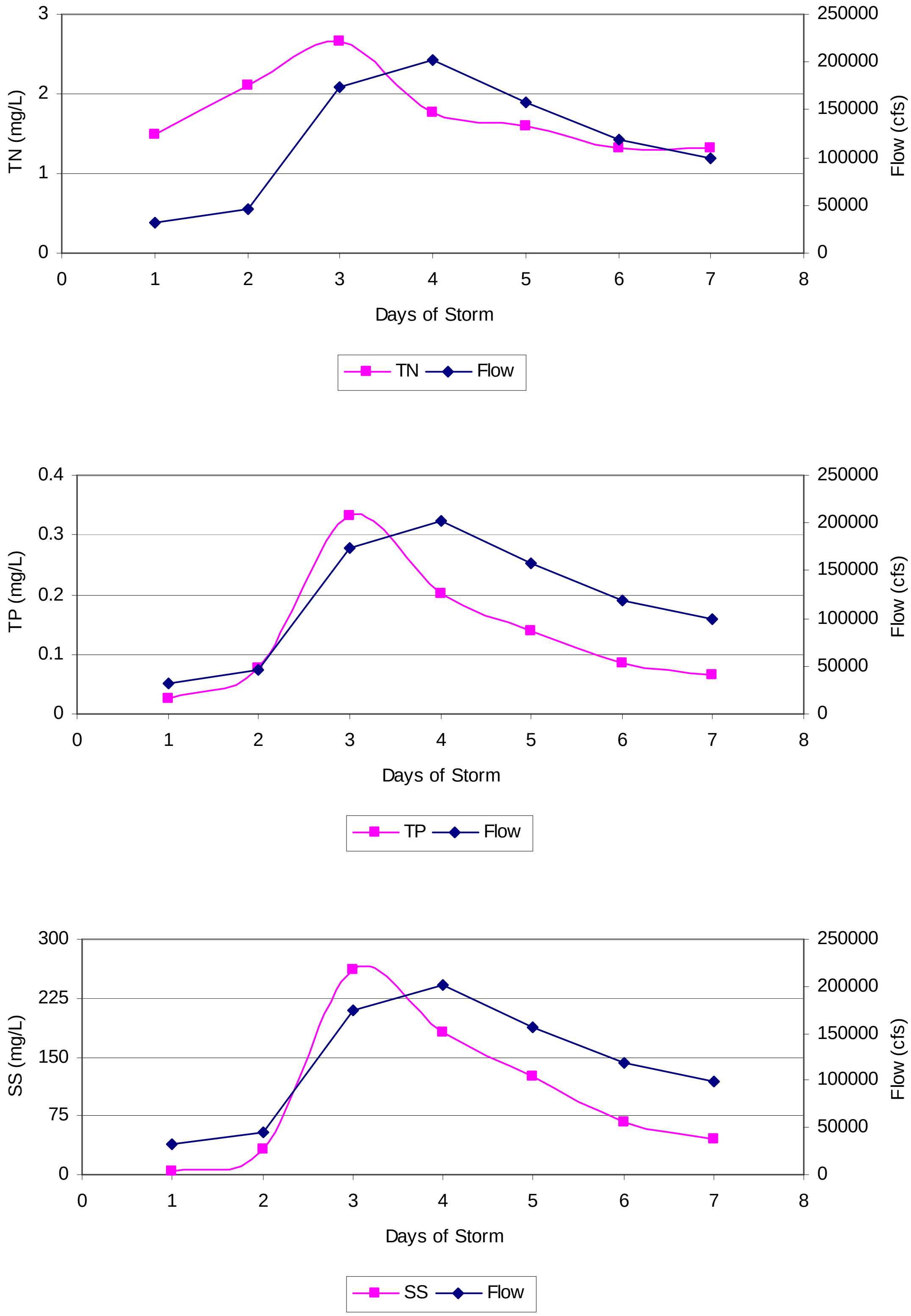
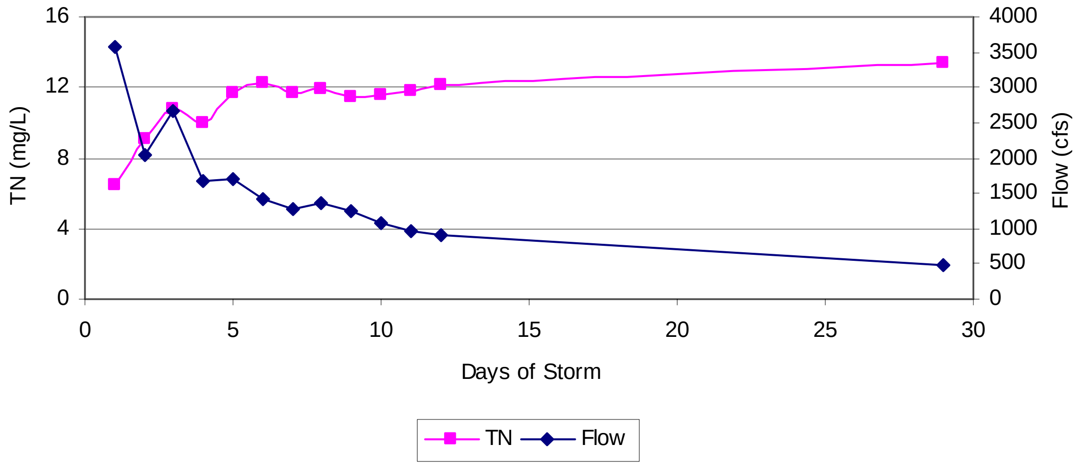
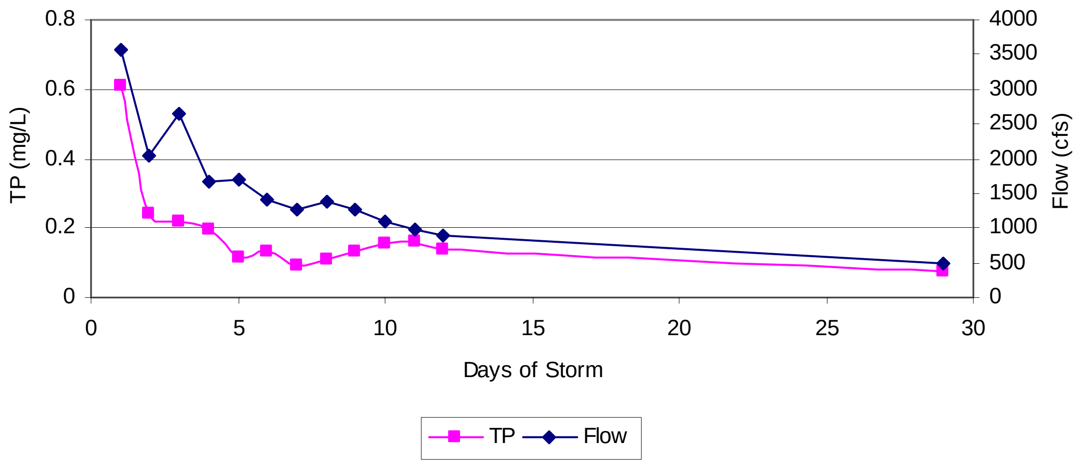


Figure 25. ***November 19-25, 2003, Storm at Marietta***





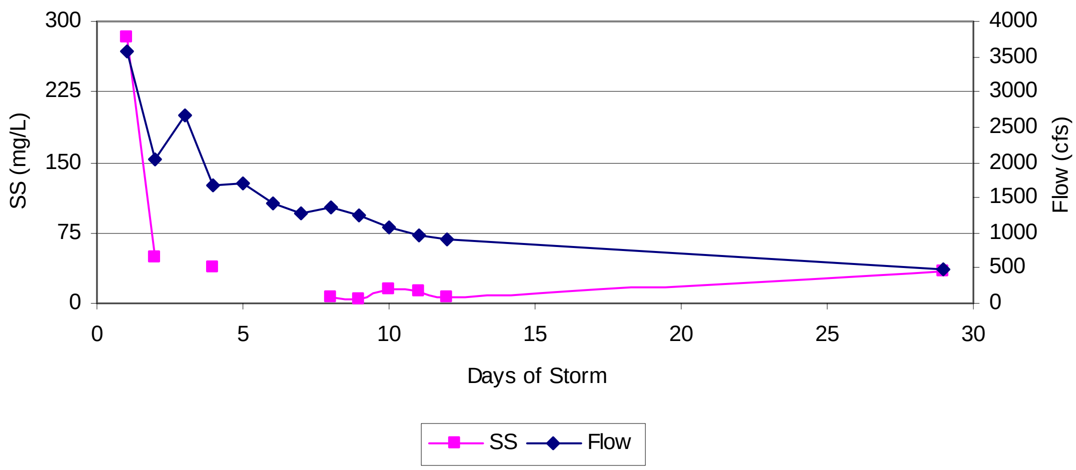
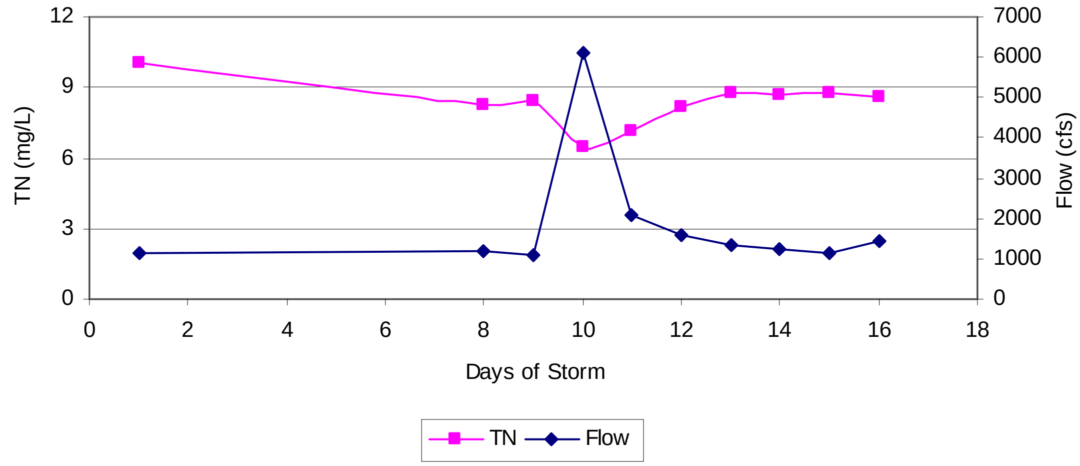
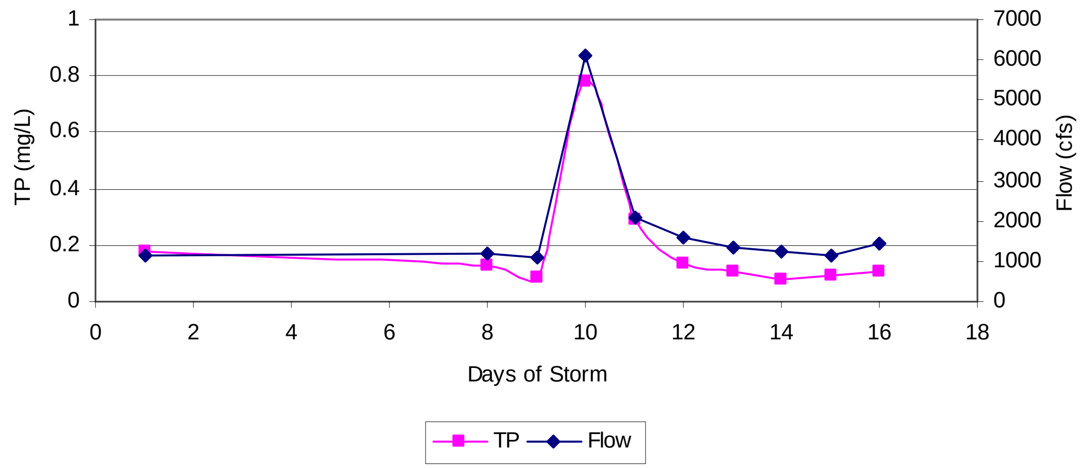


Figure 26. January 2-30, 2003, Storm at Conestoga





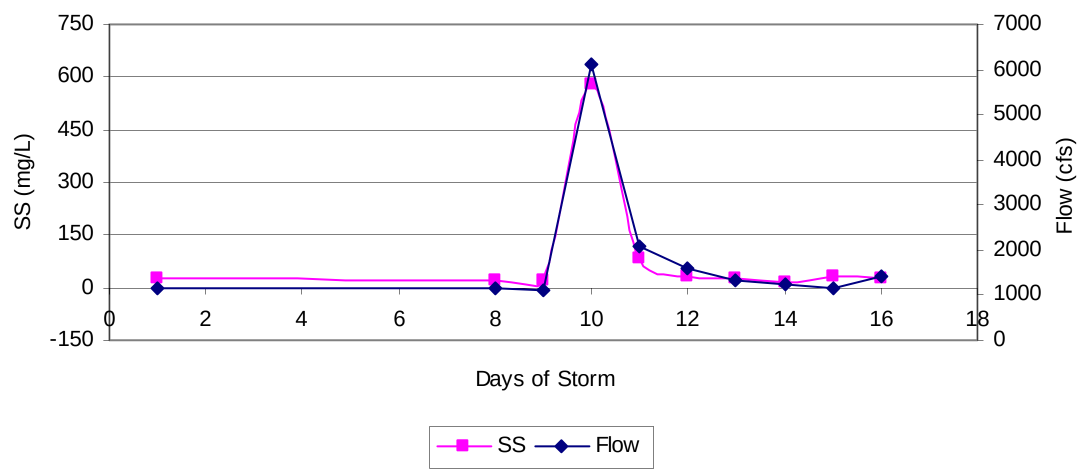


Figure 27. March 12-27, 2003, Storm at Conestoga

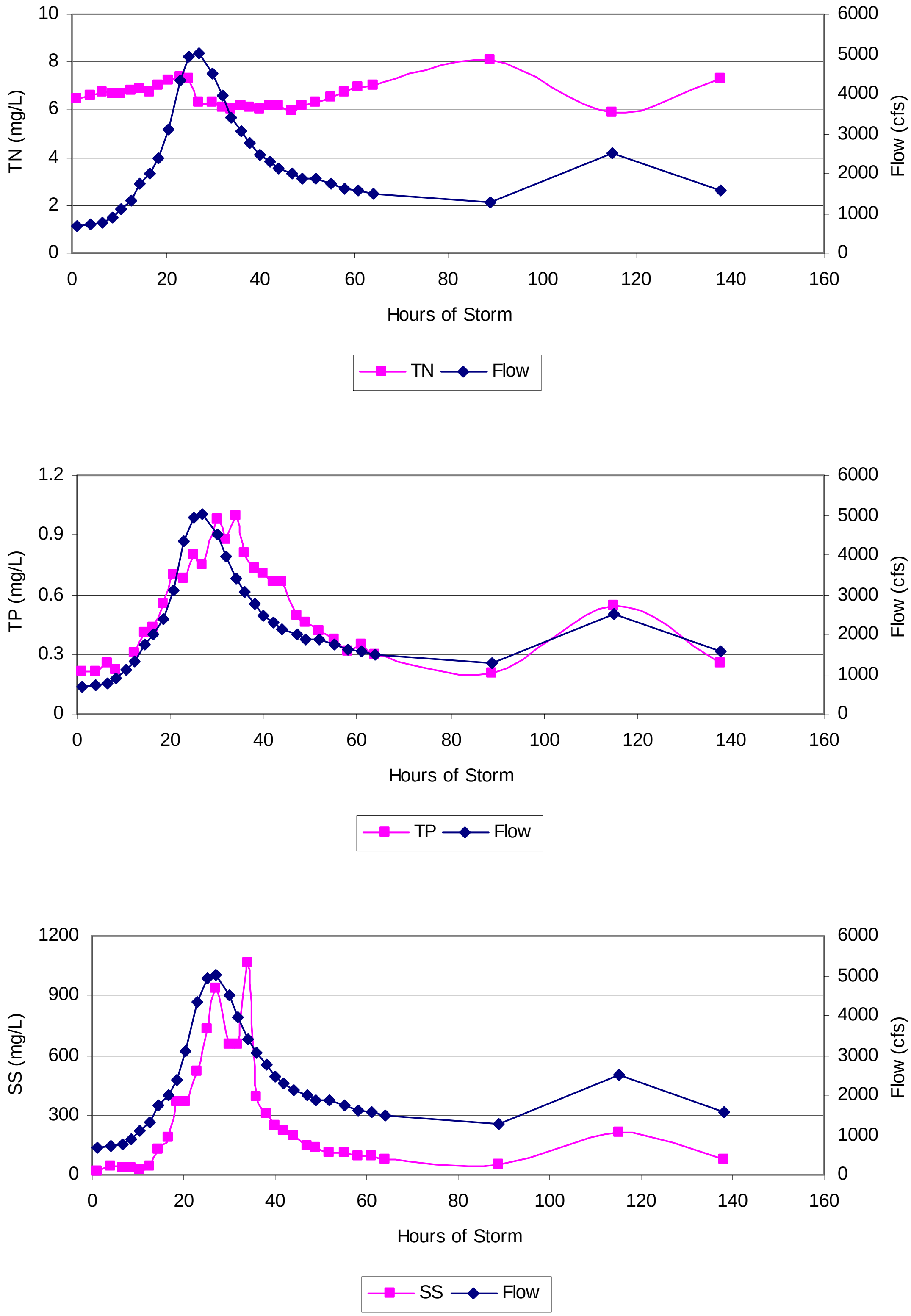
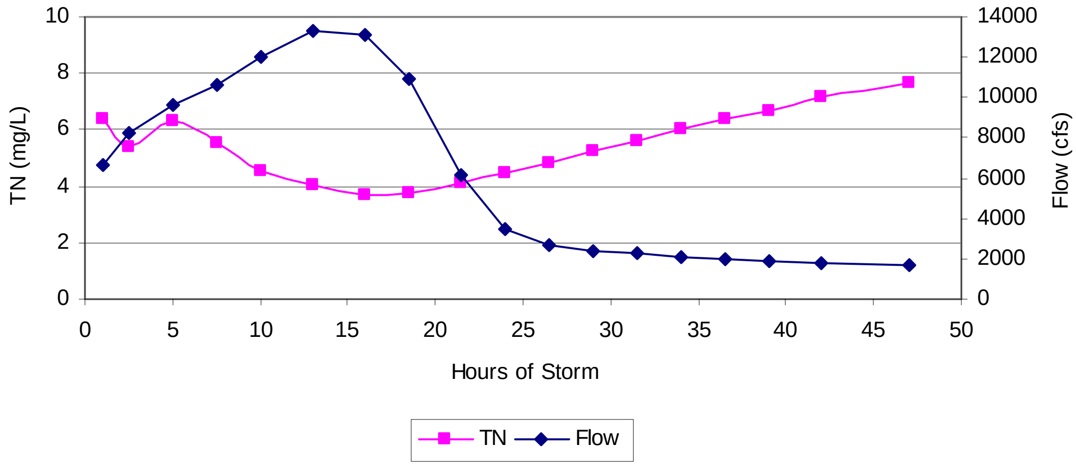
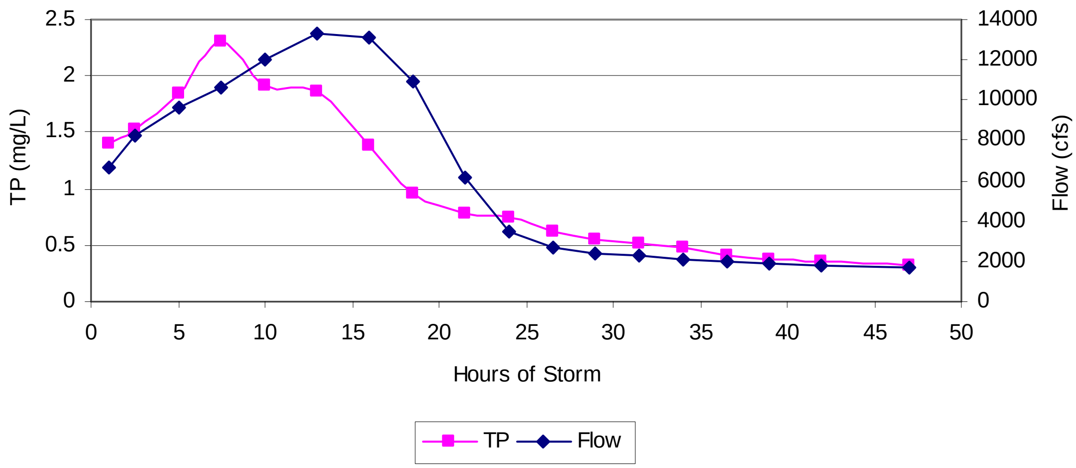


Figure 28. June 3-9, 2003, Storm at Conestoga





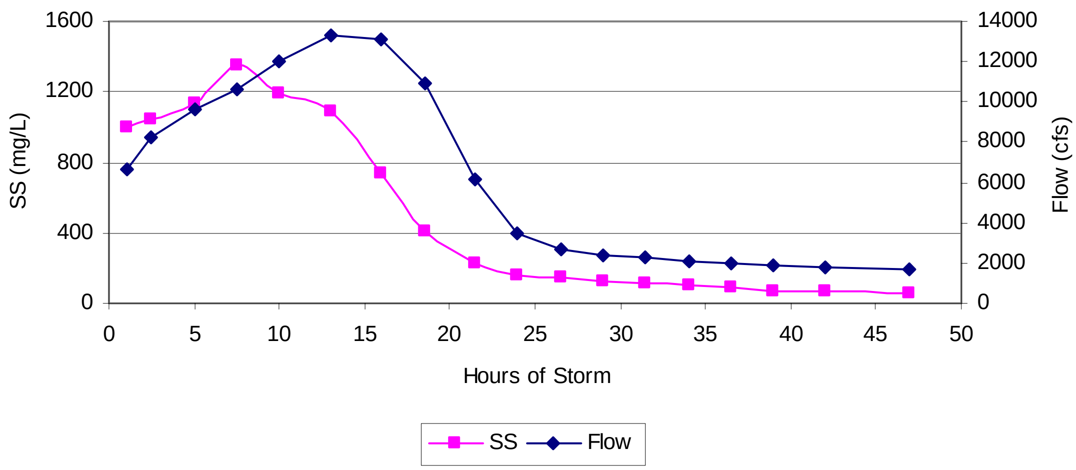


Figure 29. September 23-25, 2003, Storm at Conestoga

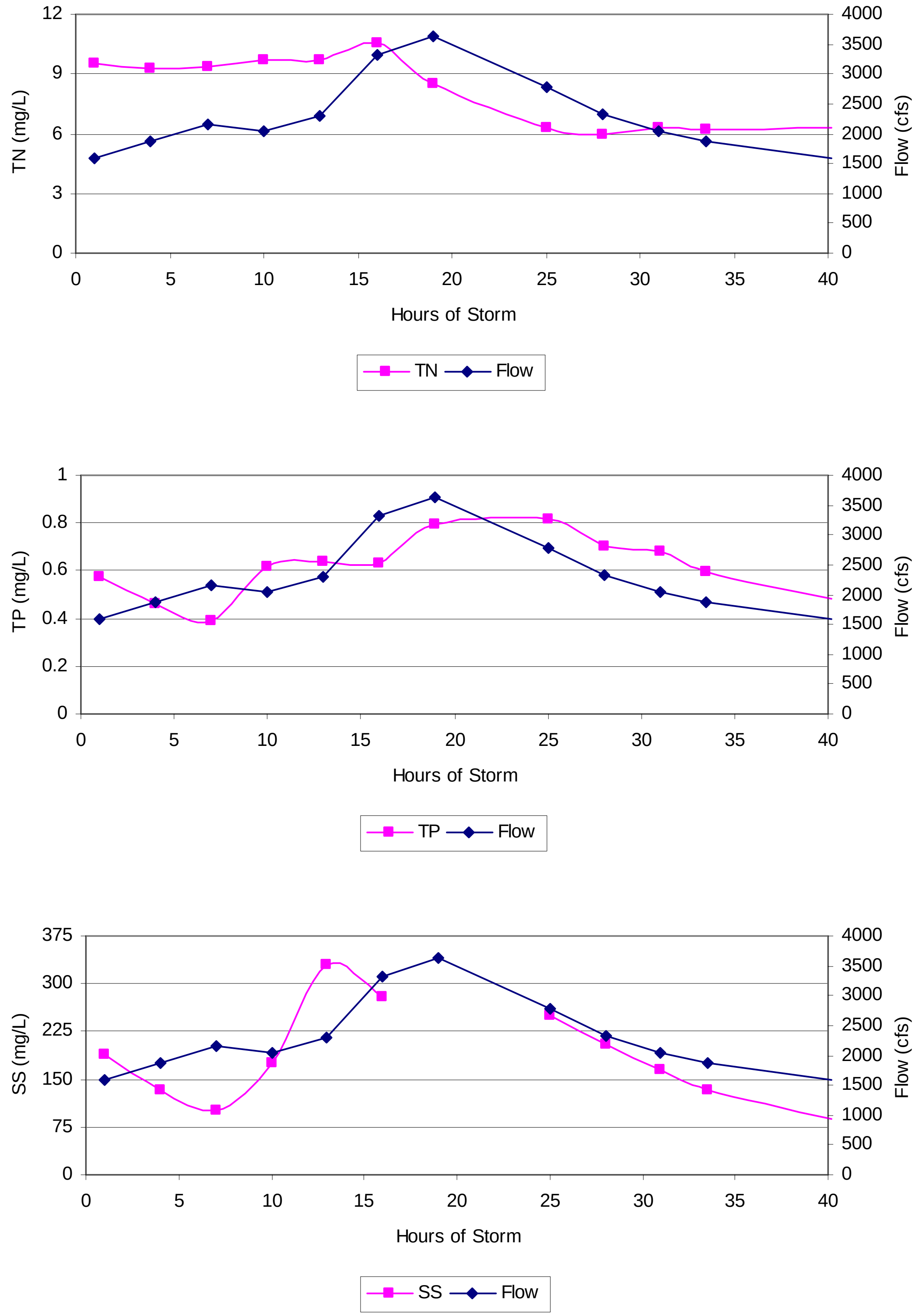


Figure 30. November 19-21, 2003, Storm at Conestoga