

Conestoga River at Conestoga, Pa.

Figure 22 shows the TN, TP, and SS baselines. Actual 2002 and baseline yields are listed in Table 27 along with the discharge ratio. The baselines were defined by the following equations:

Total Nitrogen (TN)

$$\text{TN Yield} = 2.3343 + 35.3217x \quad R^2 = 0.97$$

Total Phosphorus (TP)

$$\text{TP Yield} = -1.4013 + 3.3216x \quad R^2 = 0.92$$

Suspended Sediment (SS)

$$\text{SS Yield} = -617.301 + 1978.075x \quad R^2 = 0.72$$

Table 27. Comparison of 2002 TN, TP, and SS Yields With Baseline Yields at Conestoga, Pa.

Parameter	Discharge Ratio	Baseline lb/ac/yr	2002 lb/ac/yr
TN	0.57	22.47	17.03
TP	0.57	0.49	1.436
SS	0.57	510.2	509.76

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), monthly load (LOAD), flow-weighted concentration (FWC), and flow-adjusted concentration (FAC).

Trends in FLOW indicate the natural changes in hydrology. Changes in flow and the cumulative sources of flow (baseflow and over land runoff) affect the observed concentrations and the estimated loads of nutrients and SS.

The LOAD represents the amount of a given constituent transported past a given point over a set duration of time. Trends in LOAD indicate the flux of constituents through the system or rates of output. When loads are expressed as yields (load per unit area), the rates of output among watersheds can be compared. The FWC is the result of the LOAD divided by the monthly flow. Trends in FWC indicate changes in stream quality over the period being investigated.

The FWC is an average monthly concentration, rather than a single observed concentration, and is more representative of monthly stream quality conditions. This is the concentration that affects the biological processes of the stream. 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).

Trends in FLOW, LOAD, FWC, and FAC represent four diverse approaches to evaluating stream quality. While each trend will not reveal the specific cause of water quality changes, the combined information can improve understanding of the causes influencing water quality trends.

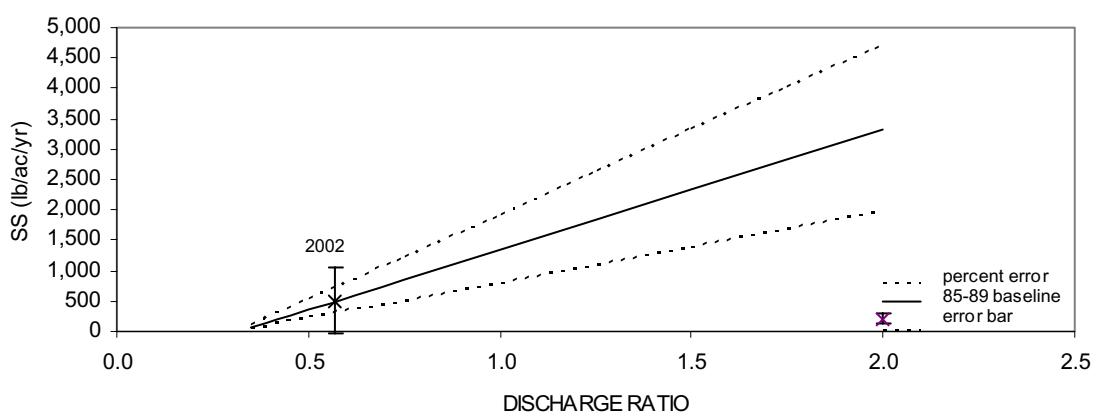
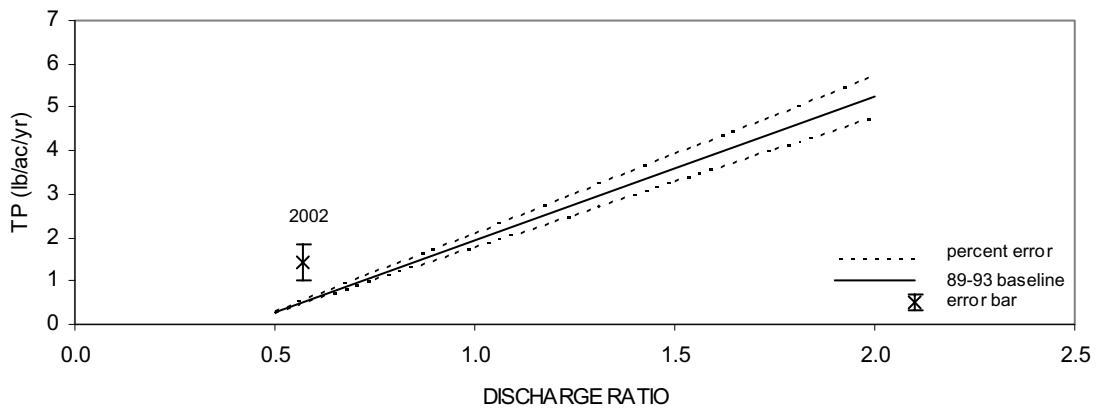
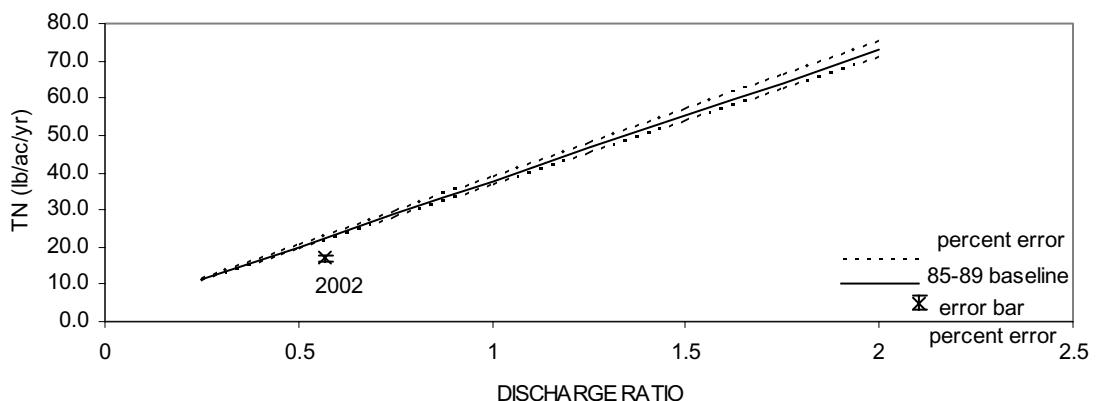


Figure 22. Total Nitrogen (TN), Total Phosphorus (TP), and Suspended-Sediment (SS) Yields, Conestoga River at Conestoga, Pa., 1985-1989 and 2002

Table 28 lists the constituents that showed the same trend results for all three analysis's making them the strongest trends for 2002. Trend results for each monitoring site are presented in Tables 29 through 34. Each table lists the results for flow (Q), the various nitrogen and phosphorus species, TOC, and SS. The level of significance was set by the p-value of 0.01 for LOAD and FWC, and a 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.

TN and DN showed improving trends for all sites for FACs which suggests that management actions taking place in the watersheds have led to improvements in nitrogen concentrations. These improving trends were likely due to the very strong improving trends in FAC, FWC, and LOAD analysis for TNH₃ and total Kjeldahl

nitrogen (TKN) at all sites. The dissolved fractions of these two constituents also recorded significant improving trends at four of six sites. All sites also recorded improving trends for at least one analysis method for TNOx and DNOx. TP showed improving trends in all three analytical methods at Danville, Lewisburg, Newport, and Conestoga. This is interesting to note in that three of these four are tributaries to the Susquehanna River. The actual mainstem of the Susquehanna recorded improving TP trends for all three analyses at Danville while showing no trends at Marietta or Towanda. Strong improving trends were apparent for DP at all sites except Marietta. A highly important trend is apparent when looking at DOP. Even though TP and DP were shown to be improving at most sites, DOP recorded degrading trends for all three analyses at Towanda, Danville, Newport, and Marietta. This indicated that the dissolved fraction of phosphorus was becoming more dominated by inorganic phosphorus. Danville, Lewisburg, and Conestoga each recorded improving trends for SS for all three analyses.

Table 28. List of Parameters Recording the Same Trend Result for Flow Adjusted Concentration, Flow Weighted Concentration, and LOAD

Parameter	Towanda	Danville	Lewisburg	Newport	Marietta	Conestoga
TN	Improving	Improving	Improving		Improving	
TON		Improving				Improving
DON					Degrading	
TNH ₃	Improving	Improving	Improving		Improving	Improving
DNH ₃		Improving		Improving	Improving	Improving
TKN	Improving	Improving	Improving	Improving	Improving	Improving
DKN	NS	Improving				Improving
TNOx	Improving				Improving	
DNOx	Improving				Improving	
TP	NS	Improving	Improving	Improving	NS	Improving
DP	Improving	Improving	Improving	Improving	NS	Improving
DOP	Degrading	Degrading		Degrading	Degrading	
TOC	NS		NS		NS	Improving
SS		Improving	Improving	NS	NS	Improving

Table 29. Trend Statistics for the Susquehanna River at Towanda, Pa., January 1989 through December 2002

Parameter	Storet Code	Time Series	P-Value	Slope Magnitude (%)		Trend Direction
				Minimum	Maximum	
Q	60	FLOW	0.19	-49	10	NS
TN	600	FAC	0.0000	-37	-27	IMPROVING
TN	600	FWC	0.0000	-27	-27	IMPROVING
TN	600	LOAD	0.0000	-58	-30	IMPROVING
DN	602	FAC	0.0000	-29	-18	IMPROVING
DN	602	FWC	0.0155	-34	-5	NS
DN	602	LOAD	0.0081	-58	-13	IMPROVING
TON	605	FAC	0.0018	-33	-9	IMPROVING
TON	605	FWC	0.030	-32	-2	NS
TON	605	LOAD	0.0159	-57	-9	NS
DON	607	FAC	0.2863	-7	26	NS
DON	607	FWC	.0111	-3	38	NS
DON	607	LOAD	0.5116	-39	28	NS
DNH ₃	608	FAC	0.2764	-27	10	NS
DNH ₃	608	FWC	0.12	-20	2	NS
DNH ₃	608	LOAD	0.01	-48	-7	IMPROVING
TNH ₃	610	FAC	0.002	-43	-11	IMPROVING
TNH ₃	610	FWC	0.0000	-26	-26	IMPROVING
TNH ₃	610	LOAD	0.0000	-60	-27	IMPROVING
DKN	623	FAC	0.8916	-12	16	NS
DKN	623	FWC	0.6	3	3	NS
DKN	623	LOAD	0.07	-40	2	NS
TKN	625	FAC	0.0024	-29	-7	IMPROVING
TKN	625	FWC	0.01	-26	-5	IMPROVING
TKN	625	LOAD	0.0000	-51	-16	IMPROVING
TNOx	630	FAC	0.0000	-40	-29	IMPROVING
TNOx	630	FWC	0.0000	-29	-29	IMPROVING
TNOx	630	LOAD	0.0000	-59	-33	IMPROVING
DNOx	631	FAC	0.0000	-41	-30	IMPROVING
DNOx	631	FWC	0.0000	-29	-29	IMPROVING
DNOx	631	LOAD	0.0000	-60	-33	IMPROVING
TP	665	FAC	0.4523	-22	11	NS
TP	665	FWC	0.28	-17	6	NS
TP	665	LOAD	0.03	-48	-3	NS
DP	666	FAC	0.002	-35	-9	IMPROVING
DP	666	FWC	0.01	-28	-4	IMPROVING
DP	666	LOAD	0.0000	-50	-20	IMPROVING
DOP	671	FAC	0.0000	228	486	Degrading
DOP	671	FWC	0.0000	262	425	Degrading
DOP	671	LOAD	0.0000	161	324	Degrading
TOC	680	FAC	0.3871	-9	4	NS
TOC	680	FWC	0.6815	-18	13	NS
TOC	680	LOAD	0.1448	-51	11	NS
SS	80154	FAC	0.2281	-38	12	NS
SS	80154	FWC	0.0000	-50	-13	IMPROVING
SS	80154	LOAD	0.02	-72	-11	NS

Table 30. Trend Statistics for the Susquehanna River at Danville, Pa., January 1985 through December 2002

Parameter	Storet Code	Time Series	P-Value	Slope Magnitude (%)		Trend Direction
				Minimum	Maximum	
Q	60	FLOW	0.38	-42	23	NS
TN	600	FAC	0.00	-39	-28	IMPROVING
TN	600	FWC	0.00	-24	-24	IMPROVING
TN	600	LOAD	0.01	-54	-13	IMPROVING
DN	602	FAC	0.00	-29	-18	IMPROVING
DN	602	FWC	0.0098	-28	-5	IMPROVING
DN	602	LOAD	0.0315	-49	-4	NS
TON	605	FAC	0.00	-48	-29	IMPROVING
TON	605	FWC	0.0001	-39	-20	IMPROVING
TON	605	LOAD	0.0015	-57	-19	IMPROVING
DON	607	FAC	0.0293	-25	-2	IMPROVING
DON	607	FWC	0.3637	-19	8	NS
DON	607	LOAD	0.1444	-42	8	NS
DNH ₃	608	FAC	0.00	-57	-35	IMPROVING
DNH ₃	608	FWC	0.00	-56	-39	IMPROVING
DNH ₃	608	LOAD	0.00	-69	-38	IMPROVING
TNH ₃	610	FAC	0.00	-65	-46	IMPROVING
TNH ₃	610	FWC	0.00	-58	-46	IMPROVING
TNH ₃	610	LOAD	0.00	-72	-43	IMPROVING
DKN	623	FAC	0.00	-36	-16	IMPROVING
DKN	623	FWC	0.00	-22	-22	IMPROVING
DKN	623	LOAD	0.00	-52	-10	IMPROVING
TKN	625	FAC	0.00	-47	-30	IMPROVING
TKN	625	FWC	0.00	-31	-31	IMPROVING
TKN	625	LOAD	0.00	-58	-20	IMPROVING
TNOx	630	FAC	0.08	-28	-15	NS
TNOx	630	FWC	0.06	-12	-12	NS
TNOx	630	LOAD	0.00	-47	1	IMPROVING
DNOx	631	FAC	0.06	-28	-16	NS
DNOx	631	FWC	0.05	-13	-13	NS
DNOx	631	LOAD	0.00	-47	-1	IMPROVING
TP	665	FAC	0.00	-50	-29	IMPROVING
TP	665	FWC	0.01	-41	-24	IMPROVING
TP	665	LOAD	0.00	-62	-16	IMPROVING
DP	666	FAC	0.00	-53	-34	IMPROVING
DP	666	FWC	0.00	-40	-40	IMPROVING
DP	666	LOAD	0.00	-63	-29	IMPROVING
DOP	671	FAC	0.00	178	385	Degrading
DOP	671	FWC	0.00	121	257	Degrading
DOP	671	LOAD	0.00	63	244	Degrading
TOC	680	FAC	0.00	-29	-18	IMPROVING
TOC	680	FWC	0.0077	-27	-5	IMPROVING
TOC	680	LOAD	0.0337	-49	-3	NS
SS	80154	FAC	0.00	-66	-45	IMPROVING
SS	80154	FWC	0.00	-65	-36	IMPROVING
SS	80154	LOAD	0.01	-79	-23	IMPROVING

Table 31. Trend Statistics for the West Branch Susquehanna River at Lewisburg, Pa., January 1985 through December 2002

Parameter	Storet Code	Time Series	P-Value	Slope Magnitude (%)		Trend Direction
				Minimum	Maximum	
Q	60	FLOW	0.0105	-46	-8	DOWN
TN	600	FAC	0.0000	-32	-19	IMPROVING
TN	600	FWC	0.0001	-20	-20	IMPROVING
TN	600	LOAD	0.0001	-54	-31	IMPROVING
DN	602	FAC	0.0000	-25	-14	IMPROVING
DN	602	FWC	0.1410	-26	4	NS
DN	602	LOAD	0.0081	-58	-13	IMPROVING
TON	605	FAC	0.0000	-49	-25	IMPROVING
TON	605	FWC	0.0001	-47	-28	IMPROVING
TON	605	LOAD	0.0159	-57	-9	NS
DON	607	FAC	0.0006	-35	-11	IMPROVING
DON	607	FWC	0.0157	-17	-17	NS
DON	607	LOAD	0.5116	-39	28	NS
DNH ₃	608	FAC	0.2940	-27	10	NS
DNH ₃	608	FWC	0.0129	-14	-14	NS
DNH ₃	608	LOAD	0.0001	-49	-25	IMPROVING
TNH ₃	610	FAC	0.0066	-42	-8	IMPROVING
TNH ₃	610	FWC	0.0001	-27	-27	IMPROVING
TNH ₃	610	LOAD	0.0001	-56	-35	IMPROVING
DKN	623	FAC	0.0016	-36	-10	BMDL
DKN	623	FWC	0.0001	-25	-25	IMPROVING
DKN	623	LOAD	0.0001	-56	-34	IMPROVING
TKN	625	FAC	0.0001	-41	-16	IMPROVING
TKN	625	FWC	0.0001	-37	-22	IMPROVING
TKN	625	LOAD	0.0001	-61	-38	IMPROVING
TNOx	630	FAC	0.0000	-25	-12	IMPROVING
TNOx	630	FWC	0.1358	-9	-9	NS
TNOx	630	LOAD	0.0001	-46	-23	IMPROVING
DNOx	631	FAC	0.0000	-25	-13	IMPROVING
DNOx	631	FWC	0.1002	-9	-9	NS
DNOx	631	LOAD	0.0001	-47	-23	IMPROVING
TP	665	FAC	0.0001	-47	-19	IMPROVING
TP	665	FWC	0.0001	-38	-25	IMPROVING
TP	665	LOAD	0.0001	-62	-39	IMPROVING
DP	666	FAC	0.0000	-62	-45	IMPROVING
DP	666	FWC	0.0001	-53	-53	IMPROVING
DP	666	LOAD	0.0001	-71	-58	IMPROVING
DOP	671	FAC	0.0000	118	311	BMDL
DOP	671	FWC	0.0001	120	227	Degrading
DOP	671	LOAD	0.0001	59	123	Degrading
TOC	680	FAC	0.2552	-4	17	NS
TOC	680	FWC	0.5156	-9	21	NS
TOC	680	LOAD	0.1448	-51	11	NS
SS	80154	FAC	0.0179	-49	-6	IMPROVING
SS	80154	FWC	0.0001	-52.588	-28.332	IMPROVING
SS	80154	LOAD	0.0001	-73.964	-35.557	IMPROVING

Table 32. Trend Statistics for the Juniata River at Newport, Pa., January 1989 through December 2002

Parameter	Storet Code	Time Series	P-Value	Slope Magnitude (%)		Trend Direction
				Minimum	Maximum	
Q	60	FLOW	0.21	-37	10	NS
TN	600	FAC	0.0000	-17	-6	IMPROVING
TN	600	FWC	0.10	-7	-7	NS
TN	600	LOAD	0.03	-39	-3	NS
DN	602	FAC	0.0135	-12	-1	IMPROVING
DN	602	FWC	0.7077	-16	13	NS
DN	602	LOAD	0.2095	-41	12	NS
TON	605	FAC	0.0095	-32	-5	IMPROVING
TON	605	FWC	0.0472	-29	-1	NS
TON	605	LOAD	0.0373	-49	-2	NS
DON	607	FAC	0.6929	-15	11	NS
DON	607	FWC	0.6766	-13	24	NS
DON	607	LOAD	0.3518	-35	16	NS
DNH ₃	608	FAC	0.0012	-41	-12	IMPROVING
DNH ₃	608	FWC	0.00	-36	-18	IMPROVING
DNH ₃	608	LOAD	0.00	-53	-23	IMPROVING
TNH ₃	610	FAC	0.0000	-56	-30	BDML
TNH ₃	610	FWC	0.00	-48	-36	IMPROVING
TNH ₃	610	LOAD	0.00	-62	-38	IMPROVING
DKN	623	FAC	0.0072	-30	-5	BMDL
DKN	623	FWC	0.00	-17	-17	IMPROVING
DKN	623	LOAD	0.00	-43	-13	IMPROVING
TKN	625	FAC	0.0135	-28	-4	IMPROVING
TKN	625	FWC	0.00	-25	-5	IMPROVING
TKN	625	LOAD	0.00	-44	-11	IMPROVING
TNOx	630	FAC	0.0053	-14	-3	IMPROVING
TNOx	630	FWC	0.57	-3	-3	NS
TNOx	630	LOAD	0.06	-36	1	NS
DNOx	631	FAC	0.0242	-13	-1	IMPROVING
DNOx	631	FWC	0.84	-1	-1	NS
DNOx	631	LOAD	0.08	-35	3	NS
TP	665	FAC	0.0036	-34	-8	IMPROVING
TP	665	FWC	0.00	-29	-11	IMPROVING
TP	665	LOAD	0.00	-48	-14	IMPROVING
DP	666	FAC	0.0184	-31	-3	IMPROVING
DP	666	FWC	0.02	-25	-3	NS
DP	666	LOAD	0.00	-42	-13	IMPROVING
DOP	671	FAC	0.0000	135	334	Degrading
DOP	671	FWC	0.00	132	246	Degrading
DOP	671	LOAD	0.00	87	202	Degrading
TOC	680	FAC	0.0003	-25	-8	IMPROVING
TOC	680	FWC	0.0921	-27	2	NS
TOC	680	LOAD	0.0389	-47	-2	NS
SS	80154	FAC	0.5227	-30	20	NS
SS	80154	FWC	0.03	-32	-2	NS
SS	80154	LOAD	0.08	-55	5	NS

Table 33. Trend Statistics for the Susquehanna River at Marietta, Pa., January 1987 through December 2002

Parameter	Storet Code	Time Series	P-Value	Slope Magnitude (%)		Trend Direction
				Minimum	Maximum	
Q	60	FLOW	0.48	-30	18	NS
TN	600	FAC	0.0000	-29	-17	IMPROVING
TN	600	FWC	0.00	-25	-25	IMPROVING
TN	600	LOAD	0.00	-47	-16	IMPROVING
DN	602	FAC	0.0000	-22	-10	IMPROVING
DN	602	FWC	0.0013	-30	-9	IMPROVING
DN	602	LOAD	0.0520	-47	0	NS
TON	605	FAC	0.2576	-8	38	NS
TON	605	FWC	0.1288	-3	25	NS
TON	605	LOAD	0.9805	-30	44	NS
DON	607	FAC	0.0000	47	135	Degrading
DON	607	FWC	0.0001	54	108	Degrading
DON	607	LOAD	0.0054	16	128	Degrading
DNH ₃	608	FAC	0.0059	-36	-7	IMPROVING
DNH ₃	608	FWC	0.00	-33	-17	IMPROVING
DNH ₃	608	LOAD	0.00	-46	-15	IMPROVING
TNH ₃	610	FAC	0.0000	-49	-22	IMPROVING
TNH ₃	610	FWC	0.00	-43	-31	IMPROVING
TNH ₃	610	LOAD	0.00	-55	-28	IMPROVING
DKN	623	FAC	0.1069	-25	3	NS
DKN	623	FWC	0.00	-14	-14	IMPROVING
DKN	623	LOAD	0.02	-37	-4	NS
TKN	625	FAC	0.0004	-36	-12	IMPROVING
TKN	625	FWC	0.00	-26	-26	IMPROVING
TKN	625	LOAD	0.00	-47	-14	IMPROVING
TNOx	630	FAC	0.0000	-25	-11	IMPROVING
TNOx	630	FWC	0.00	-21	-21	IMPROVING
TNOx	630	LOAD	0.00	-45	-11	IMPROVING
DNOx	631	FAC	0.0000	-25	-11	IMPROVING
DNOx	631	FWC	0.00	-21	-21	IMPROVING
DNOx	631	LOAD	0.00	-45	-11	IMPROVING
TP	665	FAC	0.3103	-8	29	NS
TP	665	FWC	0.88	-10	10	NS
TP	665	LOAD	0.50	-33	21	NS
DP	666	FAC	0.1417	-4	32	NS
DP	666	FWC	0.14	8	8	NS
DP	666	LOAD	0.78	-22	20	NS
DOP	671	FAC	0.0000	868	1645	Degrading
DOP	671	FWC	0.00	755	1068	Degrading
DOP	671	LOAD	0.00	602	1078	Degrading
TOC	680	FAC	0.2909	-10	3	NS
TOC	680	FWC	0.2768	-19	6	NS
TOC	680	LOAD	0.3038	-39	16	NS
SS	80154	FAC	0.6180	-27	20	NS
SS	80154	FWC	0.05	-34	-1	NS
SS	80154	LOAD	0.18	-53	15	NS

Table 34. Trend Statistics for the Conestoga River at Conestoga, Pa., January 1985 through December 2002

Parameter	Storet Code	Time Series	P-Value	Slope Magnitude (%)		Trend Direction
				Minimum	Maximum	
Q	60	FLOW	0.00	-50	-13	Down
TN	600	FAC	0.0000	-25	-17	IMPROVING
TN	600	FWC	0.06	-25	0	NS
TN	600	LOAD	0.00	-50	-31	IMPROVING
DN	602	FAC	0.0051	-13	-3	IMPROVING
DN	602	FWC	0.9751	-21	27	NS
DN	602	LOAD	0.0003	-47	-34	IMPROVING
TON	605	FAC	0.0000	-44	-23	IMPROVING
TON	605	FWC	0.0001	-37	-15	IMPROVING
TON	605	LOAD	0.0001	-71	-47	IMPROVING
DON	607	FAC	0.6266	-17	12	NS
DON	607	FWC	0.4923	-12	30	NS
DON	607	LOAD	0.0118	-46	-8	NS
DNH ₃	608	FAC	0.0000	-75	-62	IMPROVING
DNH ₃	608	FWC	0.00	-72	-65	IMPROVING
DNH ₃	608	LOAD	0.00	-84	-74	IMPROVING
TNH ₃	610	FAC	0.0000	-77	-65	IMPROVING
TNH ₃	610	FWC	0.00	-74	-68	IMPROVING
TNH ₃	610	LOAD	0.00	-74	-68	IMPROVING
DKN	623	FAC	0.0000	-46	-28	IMPROVING
DKN	623	FWC	0.00	-41	-24	IMPROVING
DKN	623	LOAD	0.00	-64	-46	IMPROVING
TKN	625	FAC	0.0000	-52	-35	IMPROVING
TKN	625	FWC	0.00	-48	-36	IMPROVING
TKN	625	LOAD	0.00	-70	-51	IMPROVING
TNOx	630	FAC	0.0782	-13	1	NS
TNOx	630	FWC	0.84	-10	13	NS
TNOx	630	LOAD	0.00	-41	-20	IMPROVING
DNOx	631	FAC	0.092	-13	1	NS
DNOx	631	FWC	0.75	-10	15	NS
DNOx	631	LOAD	0.00	-40	-19	IMPROVING
TP	665	FAC	0.0365	-29	-1	IMPROVING
TP	665	FWC	0.00	-25	-8	IMPROVING
TP	665	LOAD	0.00	-58	-30	IMPROVING
DP	666	FAC	0.0000	-35	-20	IMPROVING
DP	666	FWC	0.01	-30	-6	IMPROVING
DP	666	LOAD	0.00	-55	-36	IMPROVING
DOP	671	FAC	0.0959	-25	3	NS
DOP	671	FWC	0.49	-19	11	NS
DOP	671	LOAD	0.00	-48	-26	IMPROVING
TOC	680	FAC	0.0000	-48	-35	IMPROVING
TOC	680	FWC	0.0001	-50	-28	IMPROVING
TOC	680	LOAD	0.0001	-71	-47	IMPROVING
SS	80154	FAC	0.0004	-50	-18	IMPROVING
SS	80154	FWC	0.00	-68	-49	IMPROVING
SS	80154	LOAD	0.00	-84	-57	IMPROVING