DISCHARGE, NUTRIENT, AND SUSPENDED-SEDIMENT TRENDS

Flow Adjusted Concentration (FAC) trend analyses of water quality and flow data collected at the six Group A monitoring sites were completed for the period January 1985 through December 2008. Trends were estimated based on the USGS water year, October 1 to September 30, using the USGS 7-parameter, log-linear regression model (ESTIMATOR) developed by Cohn and others (1989) and described in Langland and others (1999). This estimator relates the constituent concentration to water discharge, seasonal effects, and long-term trends, and computes the best-fit regression equation. These tests were used to estimate the direction and magnitude of trends for discharge, SS, TOC, and several forms of nitrogen and phosphorus. Slope, p-value and sigma (error) values are taken directly from ESTIMATOR output. These values are then used to calculate flow adjusted trends using the following equations:

Trend =
100*(exp(Slope *(end yr – begin yr)) – 1)

Trend minimum =
100*(exp((Slope – (1.96*sigma)) *(end yr – begin yr)) – 1)

Trend maximum =
100*(exp((Slope + (1.96*sigma)) *(end yr – begin yr)) – 1)

The computer application S-Plus with the USGS ESTREND library addition was used to conduct Seasonal Kendall trend analysis on flows (Schertz and others, 1991). Trend 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 overland 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 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 down for improving trends and up for degrading trends. When a time series for a particular parameter had greater than 20 percent of its observations BMDL, a trend analysis could not be completed and it was listed as BMDL.

Table 33. Trend Statistics for the Susquehanna River at Towanda, Pa., October 1988 Through September 2008

Parameter	STORET Code	Time Series/Test	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	65.84	0.1324	-	-	-	NS
TN	600	FAC	-0.0250	<0.0001	-42.59	-39.35	-35.93	Down
DN	602	FAC	-0.0214	<0.0001	-38.54	-34.82	-30.87	Down
TON	605	FAC	-0.0302	<0.0001	-51.78	-45.34	-38.03	Down
DON	607	FAC	-0.0208	<0.0001	-42.04	-34.03	-24.92	Down
DNH_3	608	FAC	-0.0150	0.0004	-37.41	-25.92	-12.32	BMDL
TNH_3	610	FAC	-0.0247	<0.0001	-48.85	-38.98	-27.21	Down
DKN	623	FAC	-0.0200	<0.0001	-40.64	-32.97	-24.31	Down
TKN	625	FAC	-0.0298	<0.0001	-50.82	-44.90	-38.27	Down
TNOx	630	FAC	-0.0205	<0.0001	-37.91	-33.63	-29.06	Down
DNOx	631	FAC	-0.0203	<0.0001	-37.91	-33.37	-28.50	Down
TP	665	FAC	-0.0004	0.9123	-13.85	-0.80	14.24	NS
DP	666	FAC	-0.0021	0.5671	-17.38	-4.11	11.29	NS
DOP	671	FAC	0.1002	<0.0001	486.38	641.87	838.58	Up
TOC	680	FAC	-0.0034	0.0205	-11.91	-6.57	-0.92	Down
SS	80154	FAC	-0.0191	0.0009	-43.95	-30.43	-13.66	Down

Down = downward/improving trend
Up = Upward/degrading trend
BMDL = Greater than 20% of values were Below Method Detection Limit
NS = No significant trend

Table 34. Trend Statistics for the Susquehanna River at Danville, Pa., October 1984 Through September 2008

Parameter	STORET Code	Time Series/Test	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	104.32	0.0597	-	-	-	NS
TN	600	FAC	-0.0257	<0.0001	-49.23	-46.03	-42.63	Down
DN	602	FAC	-0.0209	<0.0001	-43.04	-39.44	-35.63	Down
TON	605	FAC	-0.0338	<0.0001	-60.68	-55.57	-49.79	Down
DON	607	FAC	-0.0266	<0.0001	-53.49	-47.19	-40.03	Down
DNH_3	608	FAC	-0.0243	<0.0001	-53.32	-44.19	-33.27	BMDL
TNH_3	610	FAC	-0.0297	<0.0001	-58.61	-50.97	-41.93	Down
DKN	623	FAC	-0.0253	<0.0001	-51.79	-45.51	-38.42	Down
TKN	625	FAC	-0.0343	<0.0001	-60.78	-56.10	-50.85	Down
TNOx	630	FAC	-0.0190	<0.0001	-40.66	-36.62	-32.30	Down
DNOx	631	FAC	-0.0190	<0.0001	-40.94	-36.62	-31.98	Down
TP	665	FAC	-0.0136	<0.0001	-37.64	-27.85	-16.52	Down
DP	666	FAC	-0.0043	0.1977	-23.14	-9.81	5.84	NS
DOP	671	FAC	0.0866	<0.0001	516.99	699.17	935.14	BMDL
TOC	680	FAC	-0.0088	<0.0001	-23.48	-19.04	-14.34	Down
SS	80154	FAC	-0.0333	<0.0001	-62.57	-55.03	-45.98	Down

Down = downward/improving trend
Up = Upward/degrading trend
BMDL = Greater than 20% of values were Below Method Detection Limit
NS = No significant trend

Table 35. Trend Statistics for the West Branch Susquehanna River at Lewisburg, Pa., October 1984 Through September 2008

Parameter	STORET Code	Time Series/Test	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	-16.91	0.6862	-	-	-	NS
TN	600	FAC	-0.0164	<0.0001	-37.13	-32.54	-27.61	Down
DN	602	FAC	-0.0133	<0.0001	-31.96	-27.33	-22.38	Down
TON	605	FAC	-0.0387	<0.0001	-66.65	-60.50	-53.21	Down
DON	607	FAC	-0.0309	<0.0001	-59.02	-52.36	-44.63	Down
DNH_3	608	FAC	-0.0113	0.0026	-36.23	-23.75	-8.83	BMDL
TNH_3	610	FAC	-0.0167	<0.0001	-44.25	-33.02	-19.53	Down
DKN	623	FAC	-0.0247	<0.0001	-52.45	-44.72	-35.74	Down
TKN	625	FAC	-0.0323	<0.0001	-60.56	-53.94	-46.20	Down
TNOx	630	FAC	-0.0055	<0.0001	-17.95	-12.37	-6.40	Down
DNOx	631	FAC	-0.0056	<0.0001	-18.15	-12.58	-6.62	Down
TP	665	FAC	-0.0153	<0.0001	-42.07	-30.73	-17.18	Down
DP	666	FAC	-0.0258	<0.0001	-55.61	-46.16	-34.71	BMDL
DOP	671	FAC	0.0737	<0.0001	335.99	486.38	688.65	BMDL
TOC	680	FAC	0.0026	0.1135	-1.74	6.44	15.30	NS
SS	80154	FAC	-0.0166	0.0066	-47.18	-32.86	-14.66	Down

Down = downward/improving trend
Up = Upward/degrading trend
BMDL = Greater than 20% of values were Below Method Detection Limit
NS = No significant trend

Table 36. Trend Statistics for the Juniata River at Newport, Pa., October 1984 Through September 2008

Parameter	STORET Code	Time Series/Test	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	5.45	0.6639	-	-	-	NS
TN	600	FAC	-0.0055	0.0000	-16.79	-12.37	-7.71	Down
DN	602	FAC	-0.0029	0.0048	-11.01	-6.72	-2.23	Down
TON	605	FAC	-0.0307	<0.0001	-59.40	-52.14	-43.57	Down
DON	607	FAC	-0.0248	<0.0001	-51.89	-44.85	-36.79	Down
DNH_3	608	FAC	-0.0162	<0.0001	-43.57	-32.21	-18.56	BMDL
TNH_3	610	FAC	-0.0173	<0.0001	-44.79	-33.98	-21.06	BMDL
DKN	623	FAC	-0.0248	<0.0001	-52.56	-44.85	-35.90	Down
TKN	625	FAC	-0.0270	<0.0001	-55.00	-47.69	-39.19	Down
TNOx	630	FAC	0.0012	0.2752	-2.27	2.92	8.39	NS
DNOx	631	FAC	0.0024	0.0346	0.12	5.93	12.08	NS
TP	665	FAC	-0.0189	<0.0001	-45.60	-36.47	-25.80	Down
DP	666	FAC	-0.0170	<0.0001	-42.79	-33.50	-22.70	Down
DOP	671	FAC	0.0498	<0.0001	152.71	230.42	332.03	Up
TOC	680	FAC	-0.0077	<0.0001	-23.62	-16.87	-9.53	Down
SS	80154	FAC	-0.0206	0.0001	-52.02	-39.01	-22.47	Down

Down = downward/improving trend
Up = Upward/degrading trend
BMDL = Greater than 20% of values were Below Method Detection Limit
NS = No significant trend

Table 37. Trend Statistics for the Susquehanna River at Marietta, Pa., October 1986 Through September 2008

Parameter	STORET Code	Time Series/Test	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	6.89	0.9513	-	-	-	NS
TN	600	FAC	-0.0148	<0.0001	-32.02	-27.79	-23.30	Down
DN	602	FAC	-0.0214	<0.0001	-41.46	-37.55	-33.38	Down
TON	605	FAC	-0.0306	<0.0001	-55.95	-48.99	-40.94	Down
DON	607	FAC	-0.0244	<0.0001	-49.73	-41.54	-32.01	Down
DNH_3	608	FAC	-0.0111	0.0040	-33.79	-21.67	-7.32	Down
TNH_3	610	FAC	-0.0140	0.0003	-37.88	-26.51	-13.05	Down
DKN	623	FAC	-0.0228	<0.0001	-47.70	-39.44	-29.88	Down
TKN	625	FAC	-0.0286	<0.0001	-53.17	-46.70	-39.34	Down
TNOx	630	FAC	-0.0064	0.0001	-18.92	-13.13	-6.93	Down
DNOx	631	FAC	-0.0064	0.0001	-18.92	-13.13	-6.93	Down
TP	665	FAC	-0.0123	0.0001	-33.25	-23.71	-12.80	Down
DP	666	FAC	-0.0158	<0.0001	-38.73	-29.36	-18.56	Down
DOP	671	FAC	0.0999	<0.0001	598.24	800.52	1061.40	BMDL
TOC	680	FAC	-0.0070	<0.0001	-19.64	-14.27	-8.54	Down
SS	80154	FAC	-0.0239	<0.0001	-51.74	-40.89	-27.61	Down

Down = downward/improving trend
Up = Upward/degrading trend
BMDL = Greater than 20% of values were Below Method Detection Limit
NS = No significant trend

Table 38. Trend Statistics for the Conestoga River at Conestoga, Pa., October 1984 Through September 2008

Parameter	STORET Code	Time Series/Test	Slope	P-Value	Slope Magnitude (%)			Trend Direction
					Minimum	Trend	Maximum	
FLOW	60	SK	2.79	0.2756	-	-	-	NS
TN	600	FAC	-0.0093	<0.0001	-23.68	-20.00	-16.15	Down
DN	602	FAC	-0.0010	0.3378	-6.86	-2.37	2.33	NS
TON	605	FAC	-0.0306	<0.0001	-58.14	-52.02	-45.01	Down
DON	607	FAC	-0.0014	0.5903	-14.84	-3.30	9.79	NS
DNH_3	608	FAC	-0.0597	<0.0001	-79.76	-76.14	-71.87	Down
TNH_3	610	FAC	-0.0614	<0.0001	-80.57	-77.09	-72.99	Down
DKN	623	FAC	-0.0128	<0.0001	-34.61	-26.45	-17.27	Down
TKN	625	FAC	-0.0359	<0.0001	-62.62	-57.75	-52.26	Down
TNOx	630	FAC	0.0005	0.6824	-4.80	1.21	7.59	NS
DNOx	631	FAC	0.0011	0.3969	-3.42	2.68	9.15	NS
TP	665	FAC	-0.0299	<0.0001	-57.23	-51.21	-44.34	Down
DP	666	FAC	-0.0246	<0.0001	-49.33	-44.59	-39.41	Down
DOP	671	FAC	-0.0096	0.0013	-31.03	-20.58	-8.54	Down
TOC	680	FAC	-0.0269	<0.0001	-51.82	-47.57	-42.93	Down
SS	80154	FAC	-0.0514	<0.0001	-76.43	-70.88	-64.01	Down

Down = downward/improving trend
Up = Upward/degrading trend
BMDL = Greater than 20% of values were Below Method Detection Limit
NS = No significant trend