DISCUSSION

2009 monthly flows were compared with historical monthly flows to find similar months for comparison. For months chosen, individual loads from both the historical month and the 2009 month were compared to see where loads had substantially deviated from the accepted premise that higher flows tend to yield higher loads.

For example, 2009 flow at Towanda was 10,244 cubic feet per second (cfs) for June 2009 and 10,638 CFS for June 1994. By looking closer at the daily flows of each month, the peak daily flow for June 1994 was 52,700 cfs and for June 2009 was 34,000 cfs. With June 2009 having both a 4 percent lower average monthly flow and a 35 percent lower average daily flow as compared to 1994, it would be expected that June 1994 would have higher loads if there had been no improvements or degradations during the time period. Further comparison of the two months showed that 2009 had 34 and 68 percent lower loads of TN and SS, respectively, which was expected.

In contradiction to what was expected, DP and DOP had 97 and 1,045 percent higher loads during June 2009, respectively. This shows a dramatic difference from what would be expected given the difference in flows. It could be inferred that TN and SS loads have been reduced from 1994 to 2009 and DP and DOP loads have increased over the time period at Towanda. Similarly, May 1994 was comparable to May 2009 with the flow difference being 1 percent more during 1994. TN and SS loads were 40 and 20 percent lower, respectively, during May 2009 while TP, DP, and DOP were 31, 53, and 93 percent higher, respectively, during May 2009 as compared to May 1994. Closer inspection of the flows indicate that the May 2009 peak daily average was 25 percent higher than the May 1994 peak daily average so the comparison may not be as strong.

Table 39 shows a condensation of monthly loads at all sites down to a percent variation that can be compared to the variation in monthly flow. To calculate these values, the percent difference between each monthly comparison was averaged together to get one value for each parameter and site and may be useful for identifying parameters for future in-depth study. The flow value corresponds to the percent difference between the comparison period and the 2009 period and does not specifically designate the 2009 flow as higher or lower than the comparison flow. Parameter percent values do indicate whether the values were lower or higher during 2009 as compared to other years. For example, the average flow difference for 2009 comparisons at Towanda was 5 percent while the average TN values for 2009 were 30 percent less, and the TP values were 20 percent greater than the comparison periods.

Towanda

2009 annual flow at Towanda was 85 percent of the LTM with June, August, and October rising above LTM values. This resulted in loads for all parameters, except DP and DOP, being largely below the LTM. These included TN, TP, and SS at 61, 78, and 24 percent of LTM, respectively. In contrast, DP and DOP both were above LTM at 126 and 184 percent, respectively, including the DOP average concentration being 215 percent of the LTM. Highest season flows and loads of all parameters were recorded during winter. Although spring had the next highest flow, fall had higher load values for TNH_3, DP, and DOP. Summer recorded the lowest flows and loads for all parameters.

March 2009 accounted for a high percentage of the nutrient load including 23, 25, and 45 percent of the TN, TP, and SS loads, respectively. A closer comparison of January and August at Towanda shows that although the flow was comparable at 8,315 and 8,437 cfs, respectively, there was a dramatic difference in SS, with 16 million pounds transported during January and 48 million pounds during August. This may indicate a difference in the amount of new erosion that was transported, as the ground was likely frozen during January, and may account for the dramatic decrease in SS load.

Also noteworthy is that although TP load increased 78 percent from January to August, DP and DOP only increased by 37 and 26 percent, respectively. During the same period, there was a 28 percent drop in TN loads. This may be due to higher volatilization and/or plant uptake increases during the summer versus winter. Drops were also found when comparing January and August in TNOx and TNH_3 with 55 percent and 43 percent, respectively.

Comparisons with baselines at Towanda showed that TP was higher than predicted by each method. Looking closer at seasonal baselines, all seasons showed that TP was higher than predicted by baseline comparisons. All other annual and seasonal baseline comparisons were below predicted values for 2009.

Trends for 1989 through 2009 at Towanda were decreasing for all parameters except flow, TP, DP, DOP, and DNH_3. DNH_3 had no significant trend due to 20 percent of the values BMDL, resulting in no significant trends. Flow, TP, and DP had no significant trends while DOP had an upward trend. This trend indicates that DOP flow-adjusted concentrations have increased by between 486 and 817 percent over the 20-year time period. Starting at the detection limit for DOP (0.01mg/L), this increase would result in values of about 0.06 mg/L today.

Danville

2009 flow at Danville was similar to Towanda including above LTM values during June, August, and October with annual flow at 90 percent of the LTM. Annual loads for all parameters were below LTM values except DP and DOP, with 119 and 165 percent of the LTM, respectively. DP and DOP average concentration values for 2009 were above the LTM by 131 and 183 percent, respectively. Seasonal load and flow values were highest during the winter and lowest during summer.

Comparable monthly flows at Danville were February to December and May to November but there were no large differences between TN, TP, and SS loads. As with Towanda, March had the highest flows and highest loads for these parameters. Interestingly, October had the third lowest monthly flow and the second highest SS load. As with Towanda, Danville had lowest flows and lowest loads of TN, TP, and SS during September.

2009 TN, TP, and SS yields at Danville were lower than all baseline values except for TP, when compared to the second half of the dataset. The predicted yield was 0.335 lbs/acre, and the actual 2009 yield was 0.357 lbs/acre. All seasonal yields for 2009 were below the initial five-year baseline yields. 2009 trends at Danville were the same as at Towanda with two exceptions: TP had a downward trend and DOP had no trends, as 20 percent of the values were BMDL.

Marietta

2009 flows at Marietta were 89 percent of the LTM with the same months as Towanda and Danville being above the LTM: June, August, and October. 2009 loads also were well below LTM values, including 73 percent for TN, 55 percent for TP, and 37 percent for SS. High seasonal flows occurred during winter followed by spring. Although winter had 2 percent higher flows for the period, it had 23 percent, 26 percent, and 36 percent higher loads of DN, DNOx, and DNH_3, respectively, and 17 percent less TOC. Comparison of monthly flows and loads for TN, TP, and SS show that January had 9 percent less flow than June, while the TN load during the time period was 23 percent greater than the TN load during June. This could account for the variation in DN, DNOx, and DNH_3 when comparing the winter and spring months. The lower January flow and higher than expected TN loads as compared to June could be a product of lower temperature and less rain during January, causing reductions in volatization and infiltration. The same situation was found when February was compared to May. Additionally, TP, DP, and DOP loads were slightly higher for the lower flow spring period. As with other mainstem sites, Marietta recorded lowest flows and loads of all parameters during the summer season.

Additional monthly comparisons, like those shown in Table 39, show that DP and DOP had large variations from expected conditions. Specific monthly comparisons with similar flow months that occurred prior to 2000 showed that DP and DOP loads have increased. When used to compare a similar flow month during the early to mid-2000s, the same comparison method shows the opposite for DP and DOP as values seem to be lower than expected during 2009. Past reports have also shown that the early to mid-2000s have shown increases in these two parameters at Marietta as well as several other sites. Specifically at Marietta, these increases have begun to somewhat reverse over the past few years while loads at Danville, Towanda, and Lewisburg have continued to show high values of both DP and DOP.

2009 annual and seasonal yields at Marietta were below baseline values for TN, TP, and SS for all comparisons. Apparently, some change had occurred from north to south on the mainstem regarding TP, as yields at Towanda were above all baseline predictions, while yields at Danville were above the baseline prediction using the second half of the dataset.

Changes in trends from Danville to Marietta included the addition of two downward trends for DNH_3 and DP. DOP had no trend due to concentration BMDL and there was no trend for flow. All other parameters had downward trends through 2009. Most dramatic reductions from 1987 to 2009 occurred for TON and DON, with 41-55 percent change in TON and 34-51 percent change in DON.

Lewisburg

2009 annual flow at Lewisburg was 86 percent of the LTM with August, October, and December being above the LTM. Subsequently, loads for all parameters except DP and DOP were well below LTM values. DP loads at Lewisburg were 105 percent of the LTM while the average concentration was 122 percent of the LTM. DOP loads were 178 percent of the LTM and average concentration was 207 percent of the LTM. Compared with DP and DOP values at Towanda, Danville, and Marietta, it seems that both DP and DOP recorded higher values in the middle and northern parts of the basin versus the southern portion. Comparisons with Newport and Conestoga indicated the same pattern as Newport recorded values of DP below the LTM and DOP at the LTM while Conestoga recorded lower than LTM values for both DP and DOP. Lewisburg recorded substantially lower than LTM values of SS at 28 percent of LTM for 2009.

No noticeable patterns were found when comparing seasonal loads at Lewisburg. The highest flow values and load values for all parameters were recorded during winter followed by fall, spring, and summer.

Monthly comparisons similar to those mentioned for Marietta show the same pattern. Specific comparisons of January and June show that June had 4 percent less flow than January, coupled with 34 percent less TN, 6 percent more TP, and 24 percent more SS. Comparison of May to October at Lewisburg shows a variation in flow of less than 1 percent coupled with higher values of both TP and SS during October, with 25 percent and 129 percent more loads of the constituents, respectively. October represents the beginning of the water year and typically consists of substantial rises in flows during the time period. Give that flow was essentially the same for both months, the increases in SS load could be attributed to increases in runoff versus infiltration due to the fall turnover of vegetation and crops. Higher sediment loads during October may have been influenced by low flows during September, which was not an issue during May 2009.

2009 annual baseline comparisons for Lewisburg were below all predicted values for TN, TP, and SS. Seasonal baseline comparisons were also below predicted values, except for TP during winter, which was at the predicted value. Most trends at Lewisburg were downward for 2009. Similar to Marietta, largest trend reductions from 1984 to 2009 were for TON and DON, with 52-66 percent and 45-59 percent reductions, respectively. DNH_3, DP, and DOP all had no trends due to concentrations BMDL. TOC and flow had no significant trends.

Newport

2009 annual flow at Newport was 85 percent of the LTM with monthly rises above the LTM during May, June, October, and December. Annual loads were also below LTM including SS being less than 50 percent of the LTM. Both DOP and TOC were at 100 percent of the LTM although flow values were 85 percent of the annual LTM. Seasonal flows were highest during spring at 5,708 cfs followed by fall at 4,717 cfs. High seasonal loads varied between the two seasons for different parameters with no substantial differences to note.

Relevant monthly comparisons at Newport include February, June, and October, which are evenly split through the year temporally. Moving from those months through the year, there was an increase in flow of 8 percent between February and June, a decrease of 6 percent between June and October, and a 1 percent increase between February and October. Through all of these changes, the differences in values of TN, TP, and SS between the same months increased by a substantial percentage beyond the smaller change in flow, with the exception of TN from February to June, which only changed 1 percent. June values of TP and SS were 152 percent and 230 percent higher, respectively, than February values. October values of TP and SS were 252 percent and 497 percent higher, respectively, than February values, although there was only a 1 percent difference in total monthly flow.

Baseline comparisons at Newport indicate that 2009 yield values were below predictions for TN, TP, and SS for all comparisons. The only exception was the seasonal comparison of TP during winter, which was slightly above the predicted initial baseline value. Trends at Newport were more variable than at the other sites. Both TNH_3 and DNH_3 had no trends due to BMDL, while both TNOx and DNOx had no significant trends. There were significant downward trends in TON and DON including reductions of 45-59 percent and 37-52 percent for each, respectively, since 1984. Apparently, these large reductions in TON and DON were enough to define a downward trend for both TN and DON, with 8-17 percent and 3-12 percent reductions, respectively, documented from 1984 through 2009. TP and DP had downward trends amounting in 27-46 percent and 27-45 percent reductions, respectively, over the time period. Interestingly, DOP continued a previous upward trend in spite of the downward TP and DP trends, including increases of 127-277 percent over the time period. Whereas the trend results indicate one direction over the entire time period, several monthly comparisons indicate a situation similar to Marietta in that comparisons of 2009 to the early and mid-2000s indicate less difference than comparisons with the 1980s and 1990s. Thus, the increases in DOP seem to have leveled off since the early to mid-2000s but still represent substantial increases since the beginning of the monitoring period in 1984.

Conestoga

2009 annual flows at Conestoga were 95 percent of the LTM representing the highest LTM flow percentage of all sites. Monthly flow values surpassed the LTM during seven of the 12 months including August through December. Conestoga continued to be the site with the highest yields and average concentrations for all parameters. However, when compared to previous years, 2009 values implied substantial reductions in several parameters. When comparing LTM load and concentration values, Conestoga had the lowest percentage of LTM values for TP, TON, DOP, DON, and TOC. Additionally, the 2009 SS average concentration was the lowest percentage of LTM average concentration of all sites at 26.5 percent.

Seasonal flows were highest during the fall followed by spring, summer, and winter. Due to the uncommon distribution of flows at Conestoga (with winter being the lowest flow period and summer having substantial flow), a few comparisons can be made. Comparison of spring and summer shows that summer had 40 percent less flow, which resulted in lower loads of most parameters ranging from 24 percent for TOC to 80 percent for DON, with TN and DN at 47 and 46 percent, respectively. The interesting comparison is that TP, DP, and DOP all increased from spring to summer with increases

of 4, 23, and 27 percent, respectively. Although trends analysis for DOP showed decreasing trends, this monthly comparison implied that DOP values were higher than expected. The cause of this observation may be similar to the cause of the increases in DOP found at other sites including Towanda, Danville, and Lewisburg.

Monthly comparisons similar to those shown in Table 39 indicate dramatic differences when March 2009 is compared to March 1985. Flow during 2009 was 8 percent lower than March 1985 flow while TN, DN, TON, DON, TNOx, and DNOx monthly loads during 2009 ranged from 45 to 67 percent lower than 1985 values. Other substantial reductions taken from this comparison include TP, DP, DOP, TOC, and SS at 365, 222, 189, 261, and 183 percent lower than March 1985 values, respectively. By far, the biggest change was for TNH_3 and DNH_3 at 1,293 and 1,192 percent, respectively, below the 1985 March values.

2009 annual and seasonal yields were below all baseline comparisons for TN, TP, and SS. The most substantial comparison involved SS with the 2009 yield being 292 and the baseline predictions ranging from 996 to 1,548 lbs/acre/year. Seasonal comparisons indicate that the lowest deviation from the baseline prediction occurred during fall for SS where the value for 2009 was 50 percent less that the baseline prediction.

Trends for 2009 at Conestoga were downward for all parameters except DN, TNOx, and DNOx, which had no significant trends. These downward trends included DOP which had been trending upward at most sites. As previously mentioned, in spite of the downward trend, DOP did show conditions that could be perceived as degrading when comparing the spring and summer seasons.

Table 39. Average of Monthly Changes from Historical Similar Flow Month

Site	Q	TN	DN	TON	DON	DNH3	TNH3	TNOx	DNOx	TP	DP	DIP	TOC	Sed
Towanda	5	-30	-28	-24	-20	-31	-48	-40	-38	20	58	360	-5	-26
Danville	3	-38	-33	-46	-31	-63	-55	-39	-39	-2	33	171	-16	-8
Lewisburg	7	-26	-22	-13	-1	-38	-47	-25	-24	4	37	233	3	-28
Newport	4	-9	-9	-6	-14	-26	-6	-9	-9	-15	-31	44	6	-7
Marietta	7	-19	-21	-21	-36	-16	-12	-17	-16	-27	-57	12	2	-7
Conestoga	4	-24	-23	-71	-65	-87	-100	-18	-19	-74	-38	-48	-31	-87