Summary of and follow up comments on Sept 6 presentation to the Nutrient Monitoring Council regarding alternative methods of calculating nitrate loads

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Summary

Different methods of calculating nitrate-N load estimates for the Illinois River at Valley City and Florence were compared. Load estimates in the Illinois Nutrient Loss Reduction Strategy were calculated by linear interpolation of nitrate concentrations measured by width and depth integrated samples collected about 12 times per year. Loads calculated by this method were compared to loads calculated from continuous in-stream probe concentration measurements and compared to the results of the USGS application of the LoadEst Adjusted Maximum Likelihood Estimation (AMLE) method. Average differences between methods as large as 13% were presented; analyses attempting to isolate factors contributing to the differences were also presented. Nitrate concentrations measured by the continuous probe were on average between 8% and 9% greater than point concentrations measured by lab analysis of point collected samples at Florence depending on whether the probe measurement was a daily average concentration or an instantaneous concentration matched to within 10 minutes of the point sample collection. Daily average probe measured concentrations were also 6% greater than lab measurements in width and depth integrated samples.

Daily nitrate loads calculated from continuous probe concentration measurements and daily average discharge values averaged about 13% greater than loads calculated from linear interpolation of width and depth integrated samples. When aggregated to water year loads (2012-16), those based on continuous probe measured concentrations were 10% greater than linear interpolation between width and depth integrated samples.

Based on these results, it seems a large proportion of the differences in estimated load stem from differences in concentration values. The concentration values used to develop the presentation were sent to Paul Terrio to check their accuracy. Some additional difference in load estimation methods may also be due to the continuous probe better representing variation in concentration during high flow and high concentration events that did not undergo width and depth sampling. The infrequent nature of width and depth sampling generally leads to infrequent sampling of high flow events which also frequently have high concentrations and loads. Consequently, loads estimated by linear interpolation may underestimate the actual load.

There may also be differences in the point concentration measurement by the continuous probe, and width and depth integrated sample concentrations. USGS has procedures in place to adjust load estimates for these differences.

The LoadEst AMLE method produced monthly and annual load estimates that were about 3% greater than the values calculated by linear interpolation between width and depth integrated samples. For individual months, differences between Loadest AMLE and linear interpolation estimates are often on the order of 50%.

Different approaches to estimating nutrient loads lead to different estimates of load. Assessing changes in load over time should be based on consistent methods and/or some valid harmonization of old and new methods.

Finally, it was reported that the five year average loads in the Illinois River have been as much as 31% below the baseline average during the dry period of 1985-89, when average water flow was 23% below the baseline. Thus, five year averages need to be interpreted in light of changes in water flow. But, nNw that we have more than 34 years of data at most, if not all, of the major stations, it might make more sense to compare the 17 year baseline load averages to the most recent 17 year period because there will be less variation in water flow over 17 years. The 17 year moving average nitrate load in the Illinois River was presented. Some follow up information on this point is provided below based on statewide nitrate-N load and waterflow data.

During the discussion, one or two committee members raised questions about the 72% increase in nitrate load in the Rock River. Some follow up info on this is also provided below.

The value of 17 year average loads vs 5 year averages

The estimated annual flow of nitrate-N out of the state varied between 200 and 710 million lb N during the baseline period of 1980-96. The average load during the baseline period was 406 million lb N per year. The five year moving average (red dashed line in Figure 1) varied from less than 300 to nearly 500 million lb N per year, and the variation corresponds to periods of high and low flow. The 17 year average load (blue dashed line in Figure 1) has been relatively more stable. The 1999-2015 average nitrate N load is 4% less than the baseline average, while water flow is 0.4% above the baseline value. Comparing the most recent 17 years to 1980-1996 loads provides a more stable “apples to apples” comparison.

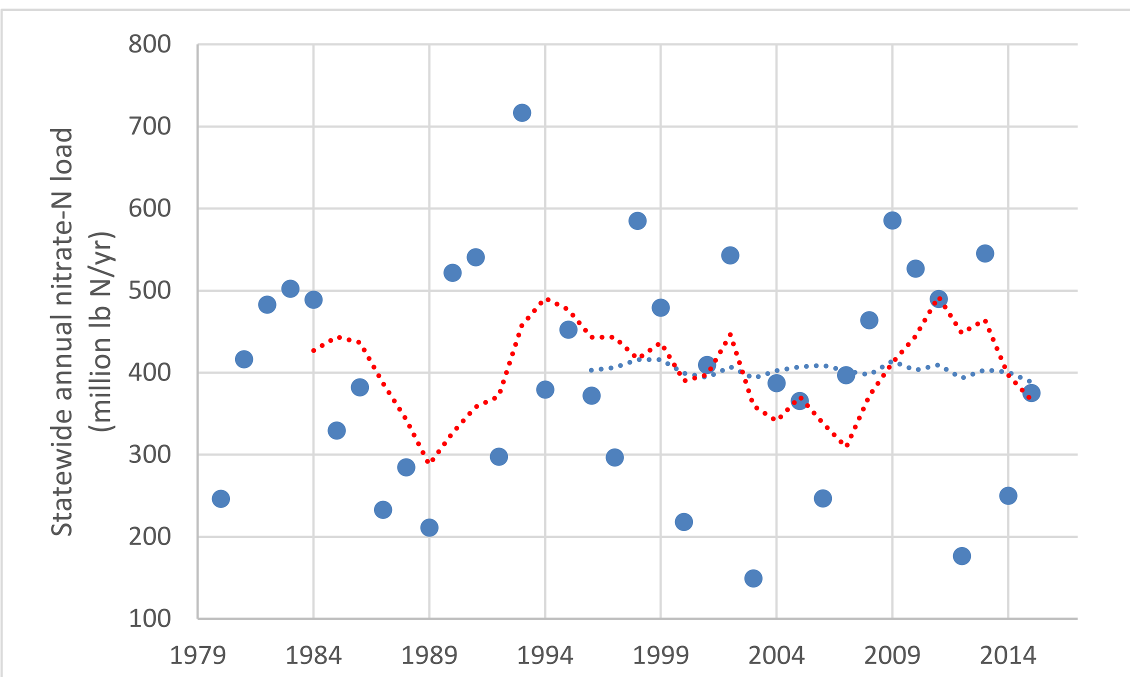

Figure 1. Estimated annual nitrate-N loads in the eight rivers leaving the state (blue dots), five year moving average (red dashed line) and 17 year moving average (blue dashed line).

Increased Nitrate Load in the Rock River between Rockton and Joslin

Nitrate-N loads for the Illinois portion of the Rock River were estimated by subtracting the estimated loads at Rockton from the loads estimated at Joslin. Five year average loads at Rockton fluctuated between 10 and 20 thousand metric tons per year (22 and 44 million lb N per year) (Figure 2). Average load for 2011-15 was 14,500 Mg N/yr (32 million lb N/yr) which is 22% less than the baseline period load of 18,600 Mg N/yr (40 million lb N/yr).

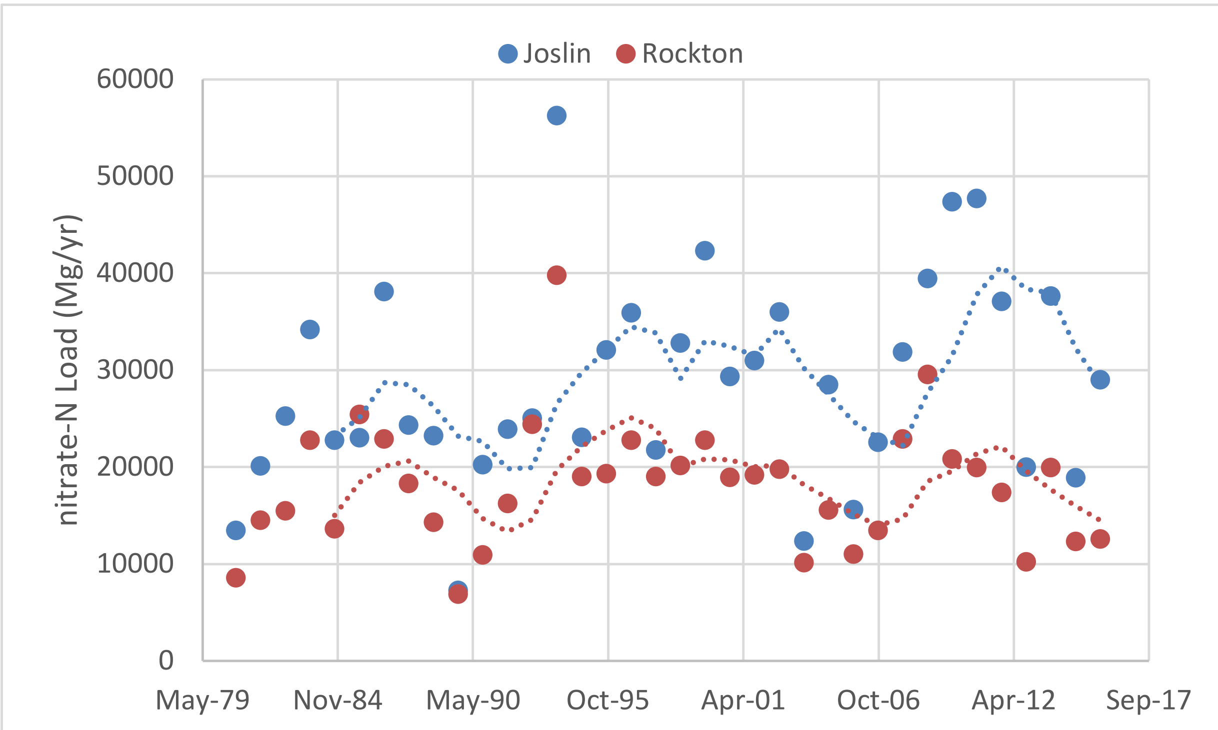

Figure 2. Annual nitrate-N loads in the Rock River at Rockton and Joslin with the five year moving averages shown in the dashed lines.

At Joslin, five year average nitrate-N loads fluctuated 30,000 and 40,000 Mg N/yr (66 and 88 million lb N per year), with the highest averages occurring between about 2007 and 2012. The 2011-15 average load at Joslin (which includes the contribution from Wisconsin) was 6% above the baseline load, while the five year average flow was only 1% above the baseline period.

The average difference between the two stations during the baseline period was 7,800 Mg N/yr (17 million lb N/yr), but for the 2011-15 period this had increased 72% to 13,500 Mg N/yr (30 million lb N/yr). The percentage increase is large, but the magnitude of the increase (13 million lb N/yr) is a relatively small portion (~3.5%) of the approximately 367 million lb N load leaving the state each year between 2011 and 2015.

During the baseline period, the difference between nitrate loads at Joslin and Rockton were near zero for 1985, 1989 and 1992 (Figure 3). The load difference for 1985 was actually less than zero. This may be a consequence of inaccuracies in the annual load estimation method. In 1985 there was one large flow event in early March, which was sampled at both Rockton and Joslin. The nitrate concentration measured prior to the event at Rockton was unusually high (6.5 mg N/L), and concentrations remained relatively high during (5.5 mg N/L) and after (5.2 mg N/L) the event. At Joslin, the concentration measured prior to the event was above average but not unusual for the site (4.7 mg N/L) and the values during (2.8 mg N/L) and after (2.5 mg N/L) the event were below average for the site. Nitrate concentration can change significantly during a high flow event and it is possible that the 1985 load calculation at Rockton was overestimated and load at Joslin was underestimated due to timing of the sample collection, which would contribute to an underestimate of the load entering between Joslin and Rockton. These low load values were not associated with unusually low sampling frequency or average discharge at sampling being lower than the annual average discharge. While load estimation accuracy may be a factor, I did not find compelling evidence to support this explanation. There are a series of small dams along the Rock River and it is possible that the impoundments behind these dams promote significant quantities of nitrate removal through denitrification during low flow periods. Flow into the Rock River between Rockton and Joslin was well below average in 1989 and 1992 (Figure 4). In general, nitrate concentrations averaged over 20 sampling events at Rockton tended to be greater than at Joslin during the baseline period. After about 1995, concentrations at Rockton decline and became similar to the concentrations at Joslin.

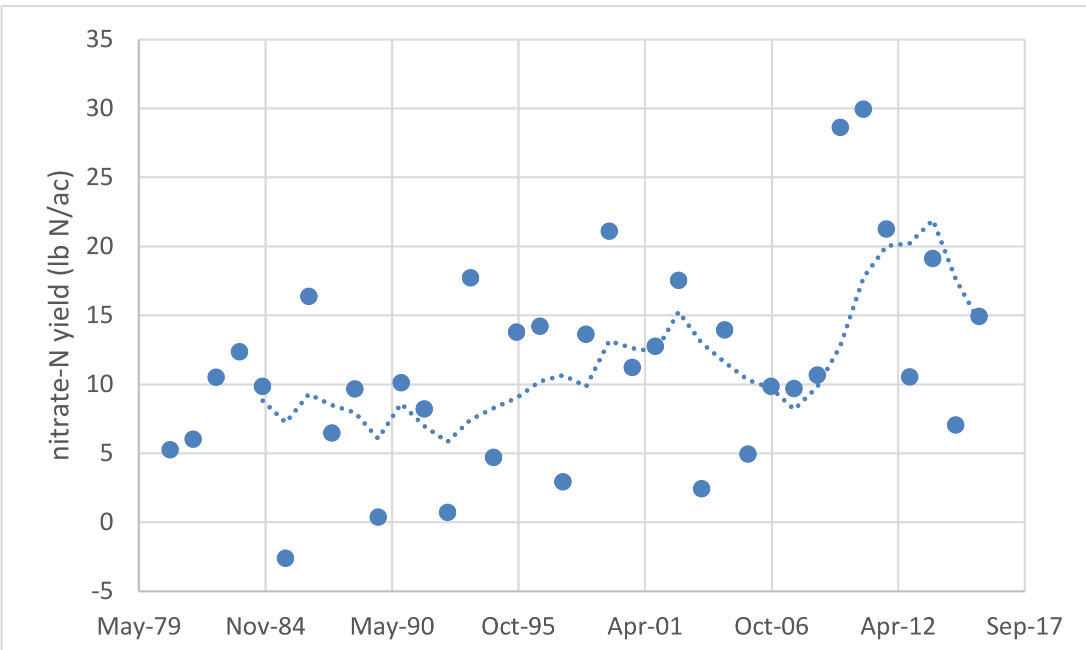

Figure 3. Estimated annual Nitrate-N yield from the Rock River watershed between Rockton and Joslin. The dashed line is the 5 year moving average.

There are no obvious sudden changes in the raw concentration data at either Rockton or Joslin. There was a gradual increase in annual flow weighted average concentrations between about 1996 and 2002 (Figure 5). This flow weighted average concentration was calculated from the difference between loads and flows at Joslin and Rockton and represents the flow weighted average concentration of the water flowing past Joslin that had entered the Rock River between Rockton and Joslin. This suggests that the change that increased nitrate-N loads in the Rock River between Rockton and Joslin may have occurred during the late 1990s and early 2000s. Increased tile drainage is a possible cause; but would it occur more intensively on the Illinois side of the watershed? Perhaps if the soils and topography in Wisconsin are less conducive to tile drainage. There are two ethanol plants in the watershed (ADM Grain in

Ashford and CHS Ethanol in Rochelle). I would expect increased discharge of N and P from these plants as production ramped up, but the P load in the river has not changed. If the additional nitrate was delivered through deep groundwater flow paths, then the source of the additional nitrate may be older than the late 1990s.

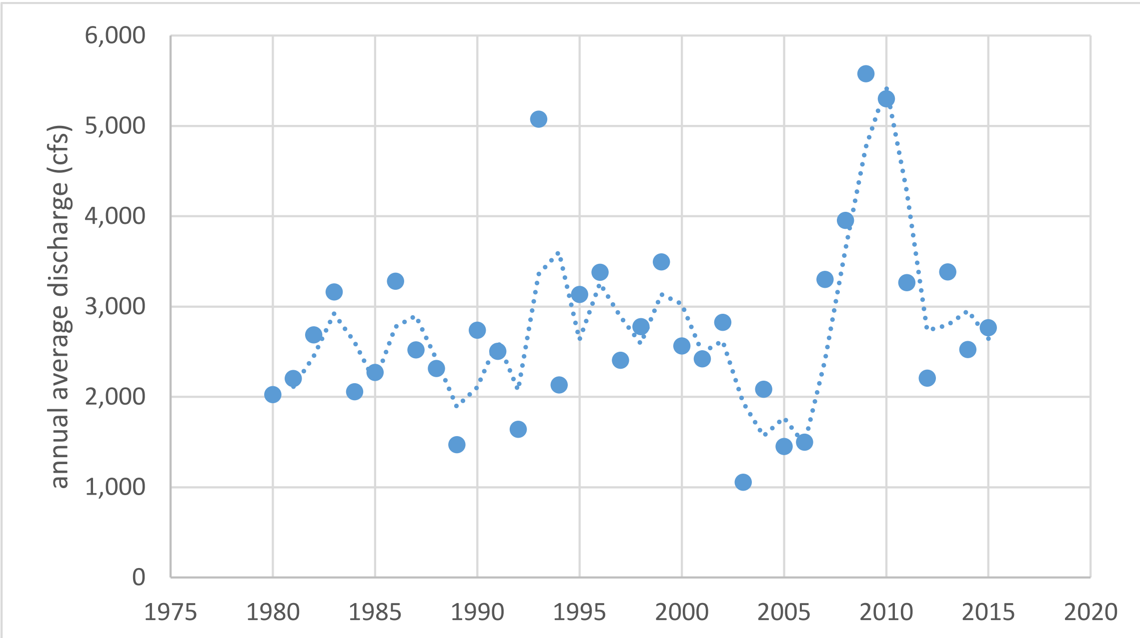

Figure 4. Annual average discharge in the Rock River between Rockton and Joslin. Dashed line is the 5 year moving average.

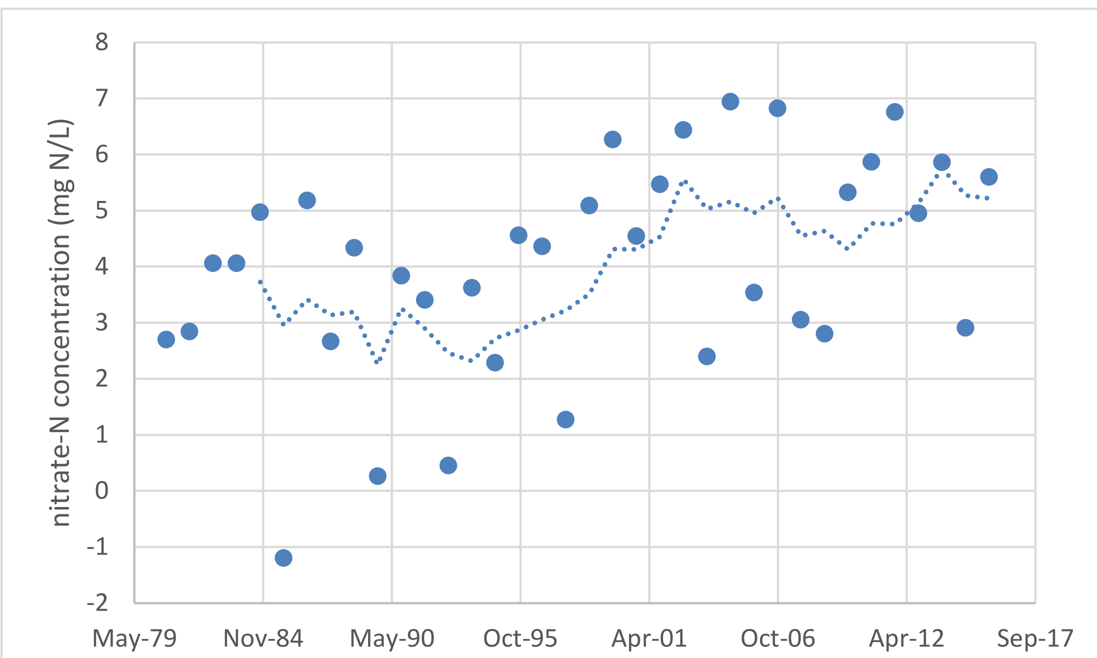

Figure 5. Flow weighted average annual nitrate-N concentrations based on the difference in nitrate-N loads and discharge between Rockton and Joslin.

The area planted to corn in the Illinois counties (Boone, De Kalb, Lee, Ogle, Whiteside and Winnebago) increased about 11% from the baseline period, while acres planted to corn in the Wisconsin counties (Dane, Dodd, Jefferson and Rock) remained steady or decreased a few percentage points (Figure 6). This may be one of several causal factors, although it should be noted that the area planted to corn for the state as a whole increased about 13% while the statewide nitrate load decreased 10%. Unfortunately there are no data to available to easily and accurately assess changes in the intensity of tile drainage over time. Unless a point source can be identified, I would speculate that the increase in nitrate N load in the Rock River between Rockton and Joslin may be due to increased tile drainage and corn acres. Additional investigation on this could be very informative.

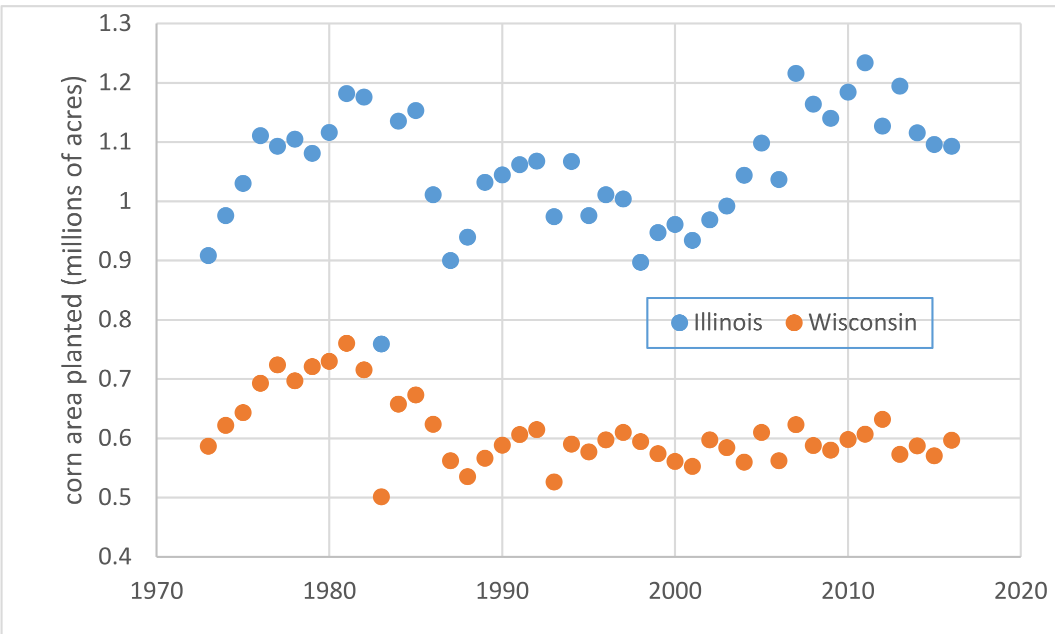

Figure 6. Area planted to corn in the Illinois and Wisconsin counties in the Rock River Watershed.