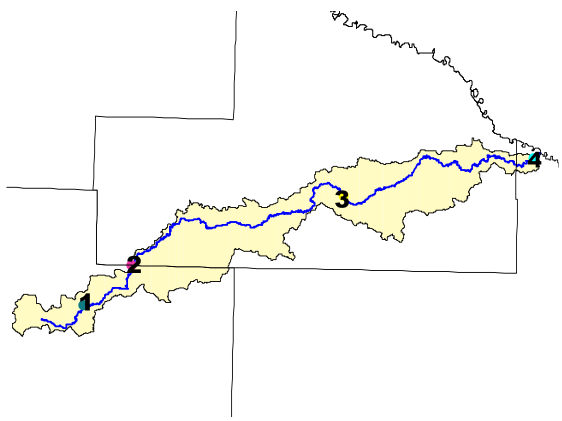
Chapter 5 Results & Discussion

Diagnostic Study Results and Discussion

Water Quality Monitoring

Water quality monitoring on the LCR focused on suspended sediments, nutrients and bacteria. Values represent grab samples taken from four sites on the main stem of the LCR. Parameters include: total suspended solids (TSS), nitrate-nitrogen (No3-N), total phosphorus (TP), Ortho phosphorus (PO_4), and Fecal Coliform bacteria. Other parameters can be found in tabular format (Appendix L). Those include fecal strep, dissolved oxygen, temperature, transparency, and conductivity.

The results listed in the tables include samples taken from the monitoring period of the diagnostic study. Those years include 1998, 1999, and 2000. 1996 and 1997, which were not part of the diagnostic study, were included for added sample size and comparison purposes.



Map 17: Index map showing site locations relative to watershed

Total Suspended Sediment

Total suspended sediment measurement in water refer to particles of soil and organic matter including algae cells that are suspended in solution. For reference it is estimated that pre-settlement monthly mean TSS levels were less than 10-100mg/l[1]. Total suspended sediment concentrations varied widely in the Little Cottonwood over the study period. A table of statistics representing the grab sample concentrations can be found in table 24. Also included, figure 13, is a graph of the fluctuating TSS concentrations on a log scale over time. In general TSS levels increase from site 1 to site 4 as more runoff, natural erosion, and bed scour accumulate throughout the system. The lower sites (3 & 4) consistently experienced higher levels of TSS. Over 50% of the time the LCR was sampled, concentrations were above set limits and ecoregion values. Ecoregion values

[1] Basin Information Document, MPCA.1997.

are taken from reference streams which are felt to be representative and reflect expected water quality for a particular region. (See McCollar and Heiskary, 1993 for additional details) During storms of 1” or more typically TSS levels rise from below 100 to 250 or even more. Maximum values were seen as high as 3055 mg/l in site 2 during a spring runoff event in April 1999. Typically sites 1, 2 and 4 cleared to levels below 30-40 mg/l during low flow/non-runoff conditions. However, site 3 stayed consistently turbid and kept a range of concentrations between 60-80 mg/l even during stable flows. Median concentrations found between the sites for TSS range from 19-76 mg/l with an interquartile range of 8-167 mg/l.

During storm events suspended sediment increased substantially in the LCR watershed. An automatic sampler was installed at site 2 in 1999 to further document changes in nutrient and sediment concentrations. The sampler was programmed to take samples from the river every two hours for 24 hours soon after a major storm event. Typical of suspended sediment and phosphors concentrations, TSS levels in the LCR reach a maximum when the stream discharge is at or near the peak. Figure 8 shows a typical TSS response found during storm**. 1.6 inches over two days.**

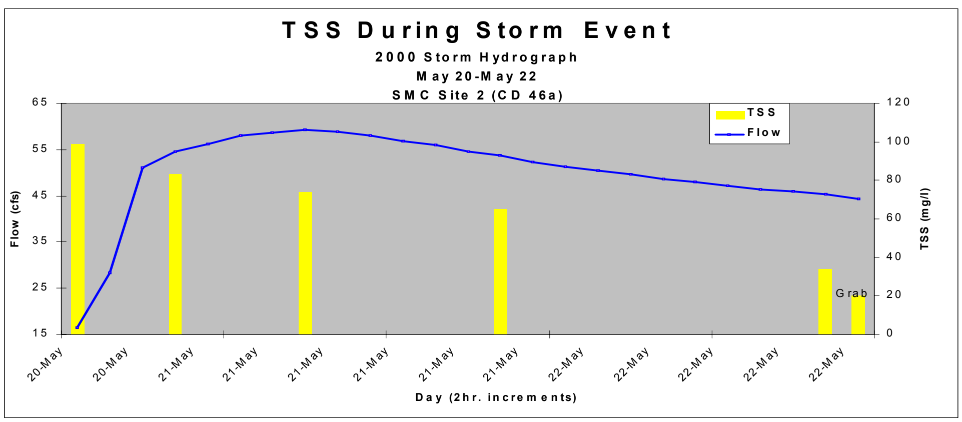


Figure 8: TSS and Storm Hydrograph

Nutrients

Nutrients are necessary for growth and maintenance of all life forms. However, nutrients can cause problems in aquatic systems when they are present in quantities that greatly exceed the amounts normally needed to sustain organisms living in the system. A process of nutrient enrichment (eutrophication) can cause production of algae and other aquatic plants to exceed desirable levels.[2]This study investigated two nutrients, phosphorus and nitrogen, which have been frequently identified as contributors to eutrophication when present in high quantities, and which in the case of un-ionized ammonia and nitrate, can be toxic. Besides being a concern for the Little Cottonwood elevated nutrient levels raise issue downstream. Within the past decade research and clean up efforts have concentrated on the MN River since it has been designated by the EPA as a heavily impaired water resource. High nutrient levels from tributaries have been identified as a major source for the water quality impairments. In addition, from a global perspective, recent concern over the “dead zone” (hypoxic zone-low oxygen levels) in the Gulf of

[2] Minnesota River Assesment Report, Physical and Chemical Assessment. January 1994

Mexico has drawn attention to contributing areas of the Upper Midwest such as the MN River Valley.

Nitrogen

Water samples were collected and analyzed for nitrogen in the form of Nitrate-Nitrogen. Nitrate in drinking water may cause methemoglominemia (Blue Baby Syndrome) in young children and a maximum nitrate concentration of 10 mg/l has been adopted to protect public health (MPCA, 1990). This level is also used as reference for surface waters. In the Little Cottonwood most of the total flow is derived from overland runoff. However, at times flow is sustained primarily through groundwater (e.g. baseflow and tile water). In certain areas where there is fractured bedrock (Sioux Quartzite near the headwaters) the opposite is true. Surface water may actually contribute to groundwater. Figure 13 represents the concentrations of nitrate found in the LCR at various locations as it makes its way to the MN River. Average concentrations range from 6 to 13 mg/l with an interquartile range of 2.2-18 mg/l. Nitrate levels are highest near the headwaters, and decrease as the river moves to the MN River. Unlike phosphorus, nitrate is water-soluble so as more water is added to the system from the upper waters to the mouth nitrate is diluted. Nitrate concentrations tended to decline during August through late fall (figure 13) when stream discharge declined, and crops were at full canopy. During this time period evapo-transpiration is at its highest, runoff at its lowest, and crops are utilizing as much nitrogen from organic sources (e.g. organic matter in the soil) and inorganic sources such as commercially applied fertilizers. Nitrate concentrations peaked at 13 to 21mg/l moving from the mouth to the upper portion of the watershed in mid-spring time and early summer. High levels near the headwaters (site 1) indicate a portion of commercially applied fertilizers are leaching away from the root zone and into subsurface drainage and eventually the river. Subsurface drainage is more prevalent in certain areas above site 3. Nitrogen concentration and response is very typical to many other MN River Basins as noted from the Minnesota River Assessment Report (1994). Examination of data form multiple samples collected through automatic samplers during runoff periods showed that nitrate concentrations, unlike suspended sediment concentrations, reach a maximum after the stream discharge has peaked. (Figure 9)

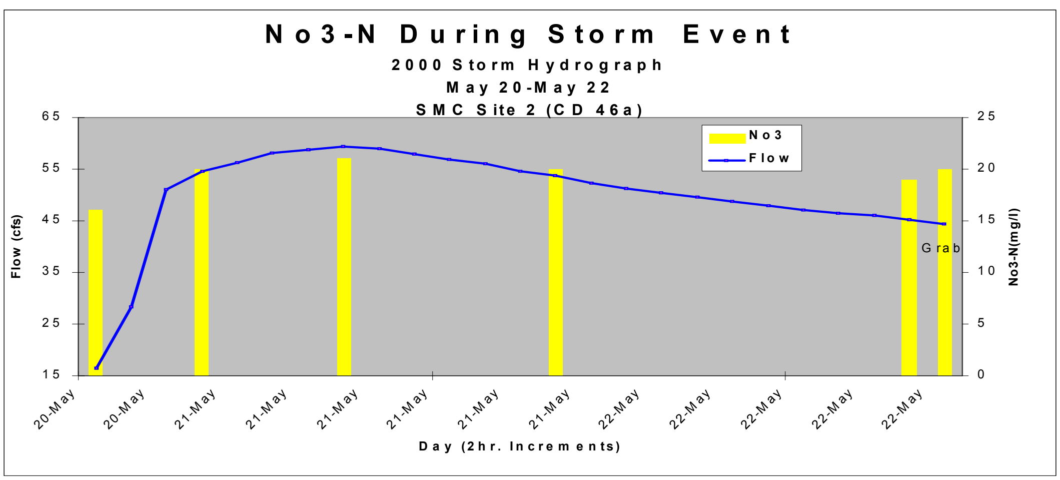


Figure 9: Nitrate and Storm Hydrograph

Stream discharge during this part of the runoff is predominantly derived from subsurface drainage water by ditches and tiles. This suggests that much of the nitrate is reaching the river through a shallow subsurface pathway. Randall (1986) and Montgomery (1999 Red Top Farms Demonstration Project) reported average nitrate concentrations that ranged from 16 to 172 mg/l in tiles draining shallow ground water at agricultural experiment stations located in the Minnesota River Basin[3]. Other sources of nitrate include failing septics, runoff from feedlots, and natural derived sources.

Phosphorus

Water samples were analyzed for both dissolved and particulate forms of phosphorus. Dissolved ortho-phosphorus (Po_4) is regarded as problematic because it is in a readily available form utilized by algae. Phosphorus in the particulate form also can be problematic because it can be transported as part of the suspended load, potentially affecting aquatic systems located further downstream. The combined amounts of dissolved and particulate phosphorus are termed total phosphorus. Ortho- Phosphorus and total phosphorus concentrations found on the main-stem of the LCR can be found in figures 14 and 15. Due to the tornado of 1998, lab analysis of ortho-phosphorus was discontinued in 1998. For reference levels of phosphorus present in streams and rivers of the MN River basin before European settlement were likely in the range of .110 mg/l or less (McCollor and Heiskary). Today median values for the MN River have been documented at .220 mg/l for total phosphorus.

Total phosphorus average concentrations ranged from .155 to .238 mg/l on the LCR. The interquartile range was .098-.295 mg/l. The highest level of total phosphorus was found to be .626 mg/l at site 2.

Average concentrations found for ortho-phosphorus ranged from .038 and .058 mg/l between all four monitoring sites. The inter-quartile range for dissolved ortho-phosphorus was .016-.101 mg/l. Dissolved ortho-phosphorus comprised at least 23% -36% of the total phosphorus in the 30 samples from 1996-2000.

As in the case of TSS, phosphorus concentrations increased during runoff periods. Due to its chemical nature, phosphorus binds to exchange sites on soil particles. Therefore TSS levels and total phosphorus levels have a positive relationship. That is, as erosion of soil into a water body increases, so too does total phosphorus. This response is shown by the changes of total phosphorus levels during a storm event at site 2 in 1999 (figures 10 and 11). The sampler was triggered by a rise of greater than .3-foot rise in stage from a 2.5" rain. In this particular example, TP concentration reached its peak just before the rising portion of the storm discharge hydrograph. During runoff, TP concentrations were about two times greater than the median value. Ortho-phosphorus levels were about 10 times higher than median values during major runoff events (Figure 8). This suggests the higher concentrations of phosphorus witnessed during storms are not only from soil, but can also be attributed to "fresh" sources such as manure, sewage, and fertilizers.

Bacteria

During the diagnostic study Fecal Coliform, Fecal Streptococci ,and Total Coliform were tested. The presence of coliform bacteria may indicate that human and/or animal wastes are entering the river along with the possibility pathogenic organisms. The potential presence of disease-causing organisms sometimes found with coliform bacteria limit the

[3] Red Top Farms Demo Site Synopsis, MN Department of Agriculture, 1999.

overall recreational suitability of the water for health and safety related reasons. Listed in Table 28 are fecal coliform levels found from 1996-2000. For reference a public beach is closed if fecal coliform levels exceed a geometric mean of 200-col/100 ml with no less than 5 samples per month. 18-19 samples were utilized in the statistics for table 28. Median concentrations for all three monitoring sites on the LCR range from 170-500 col./100 ml. Quartile ranges were 20-700 col./100ml. The highest levels were all found at site 3. This correlates with size/number of feedlots and numerous cattle access sites near the river in this particular area. 37-74 % of the samples exceeded the Western Corn Belt Plain Ecoregion Average at all four sites. At site 3 the samples exceeded the WCBP ecoregion average 74% of the time. The geometric mean was 129, 127, 266, and 125 for sites 1 through 4 respectively.

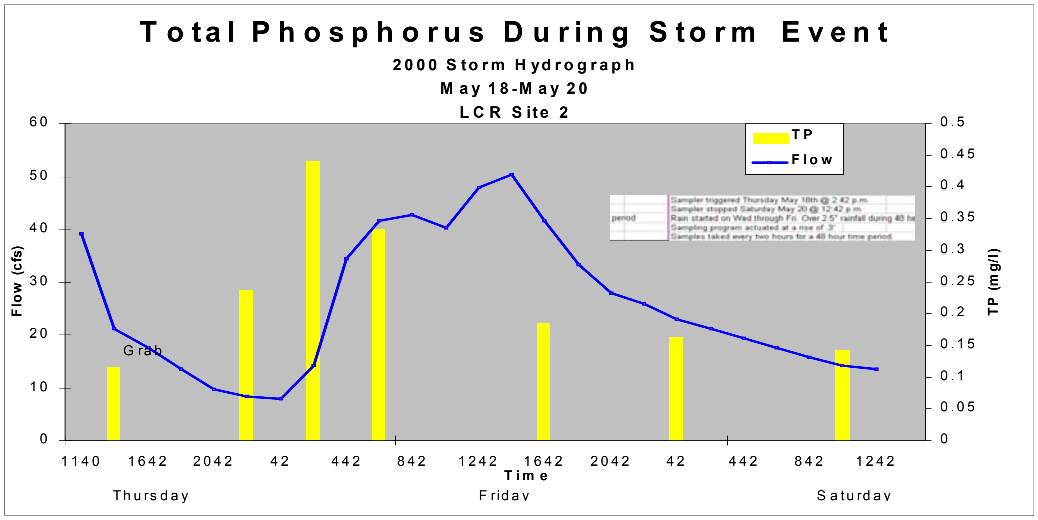


Figure 10: Total phosphorus and storm hydrograph

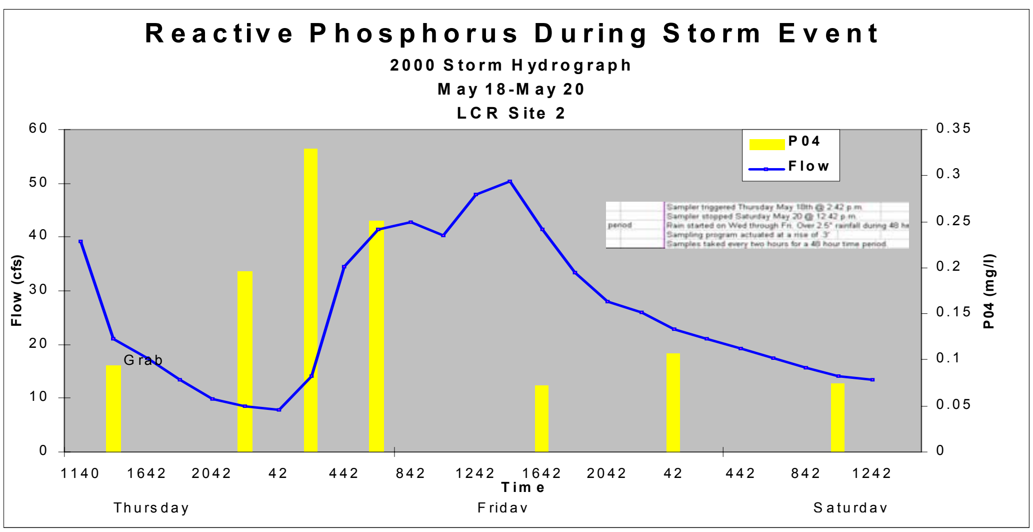


Figure 11: Ortho-phosphorus and storm hydrograph

Table 24

Total Suspended Solids (TSS, mg/L)

Site	Mean (mg/l)	Median (mg/l)	Max (mg/l)	Min (mg/l)	25%[1] (mg/l)	75%[1] (mg/l)	% of Samples Exceeding Limits[2]	% of samples Exceeding WCBP Ecoregion Average[3]	Count
Site 1	102	27	1708	2	9	71	46	39	41
Site 2	111	19	3055	2	8	33	28	15	40
Site 3	86	52	379	6	23	124	68	55	40
Site 4	164	76	1177	2	21	167	73	66	41

[1] Inter-quartile ranges determined by sorting the lower 25 percentile values and higher 75 percentile values

[2]Limit of 30 mg/l (reference applied to permitted point source discharges)

[3] Mean 1970-1992 Annual Western Corn Belt Plains Ecoregion Average based on 45.3 mg/l

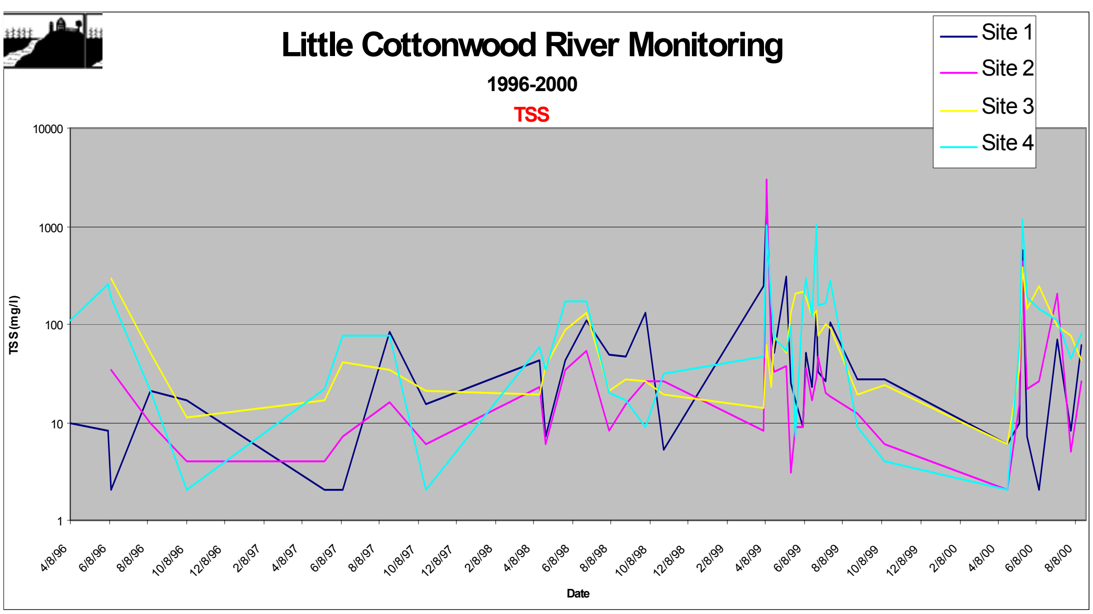


Figure 12: TSS Concentrations

Table 25

Nitrate Nitrogen

Site	Mean (Mg/l)	Median (Mg/l)	Max (Mg/l)	Min (Mg/l)	25%[1] (Mg/l)	75%[1] (Mg/l)	% of Samples Exceeding Limits/Standards[2]	% of samples Exceeding WCBP Ecoregion Average[3]	Count
Site 1	13.2	15.9	21.0	.5	8.3	18	73	85	41
Site 2	10.8	11.6	18.1	.05	8.1	14.3	58	83	40
Site 3	6.3	6.9	14.1	.13	2.7	10.0	25	60	40
Site 4	6.5	7.6	13.6	.09	2.2	9.7	22	61	41

[1] Inter-quartile ranges determined by sorting the lower 25 percentile values and higher percentile values

[2]Limit based on 10 mg/l

[3] Mean 1970-1992 Annual Western Corn Belt Plains Ecoregion Average based on 4.8 mg/l

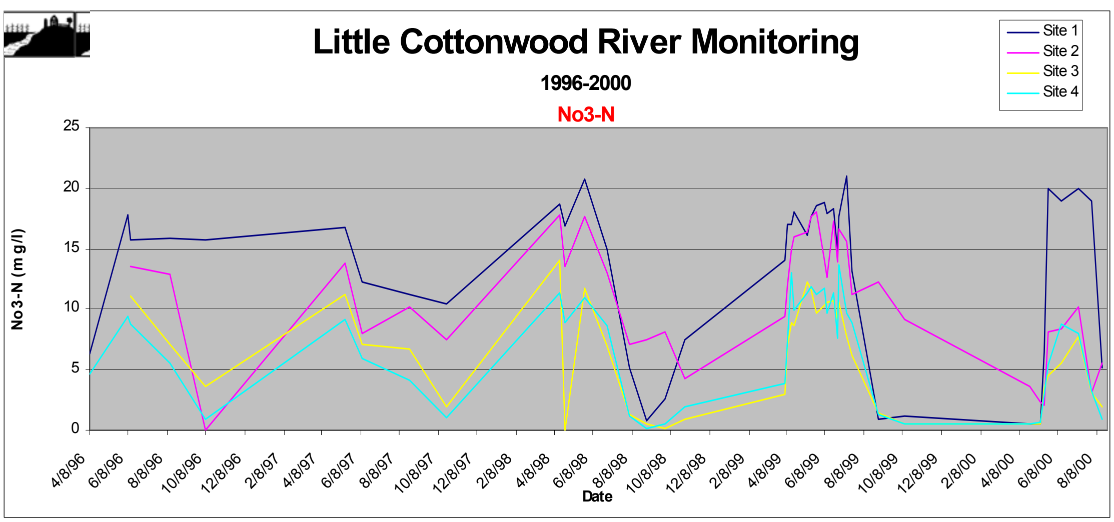


Figure 13: Nitrate Concentrations

Table 26

Total Phosphorus

Site	Mean (mg/L)	Median (mg/L)	Max (mg/L)	Min (mg/L)	25%[1]	75%[1]	% of samples Exceeding WCBP Ecoregion Average[2]	Count
Site 1	.191	.161	.626	.054	.110	.241	15	41
Site 2	.155	.136	.489	.039	.098	.186	8	40
Site 3	.238	.220	.427	.068	.166	.295	33	40
Site 4	.218	.202	.541	.059	.145	.274	22	41

[1] Inter-quartile ranges determined by sorting the lower 25 percentile values and higher 75 percentile values

[2] Mean 1970-1992 Annual Western Corn Belt Plains Ecoregion Average based on .280 mg/l

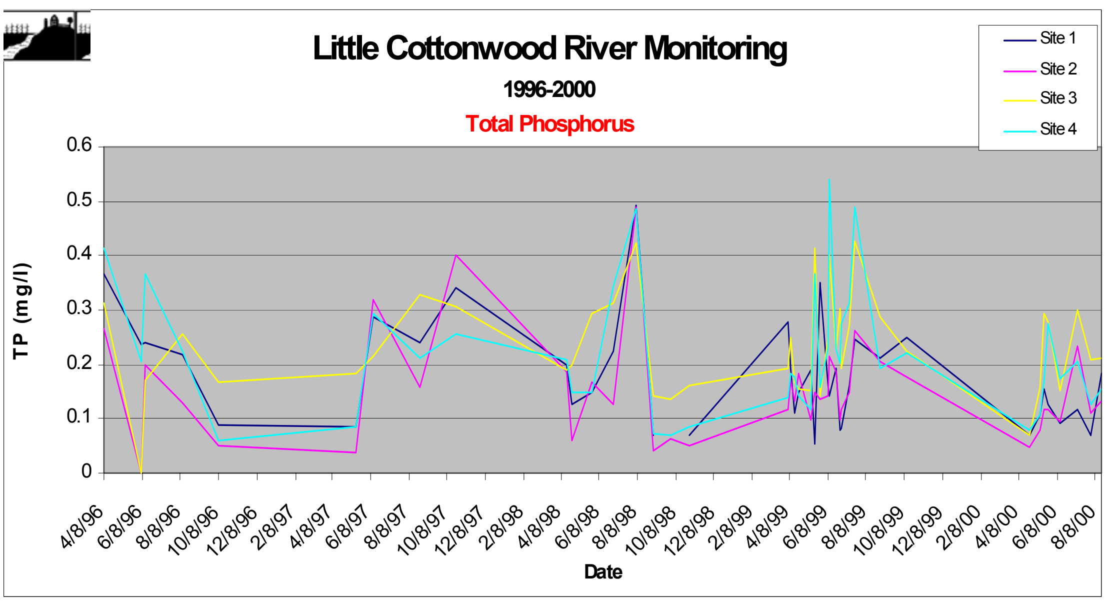


Figure 14: Total Phosphorus Concentrations

Table 27
Ortho-Phosphorus

Site	Mean (mg/L)	Median (mg/L)	Max (mg/L)	Min (mg/L)	25%[1]	75%[1]	% of Samples Exceeding Limits/Standards	% of samples Exceeding WCBP Ecoregion Average	Count
Site 1	.054	.034	.234	.003	.019	.077	Na	Na	36
Site 2	.038	.028	.173	.003	.016	.047	Na	Na	35
Site 3	.080	.065	.290	.003	.033	.094	Na	Na	35
Site 4	.080	.057	.251	.003	.031	.101	Na	Na	36

[1] Inter-quartile ranges determined by sorting the lower 25 percentile values and higher 75 percentile values

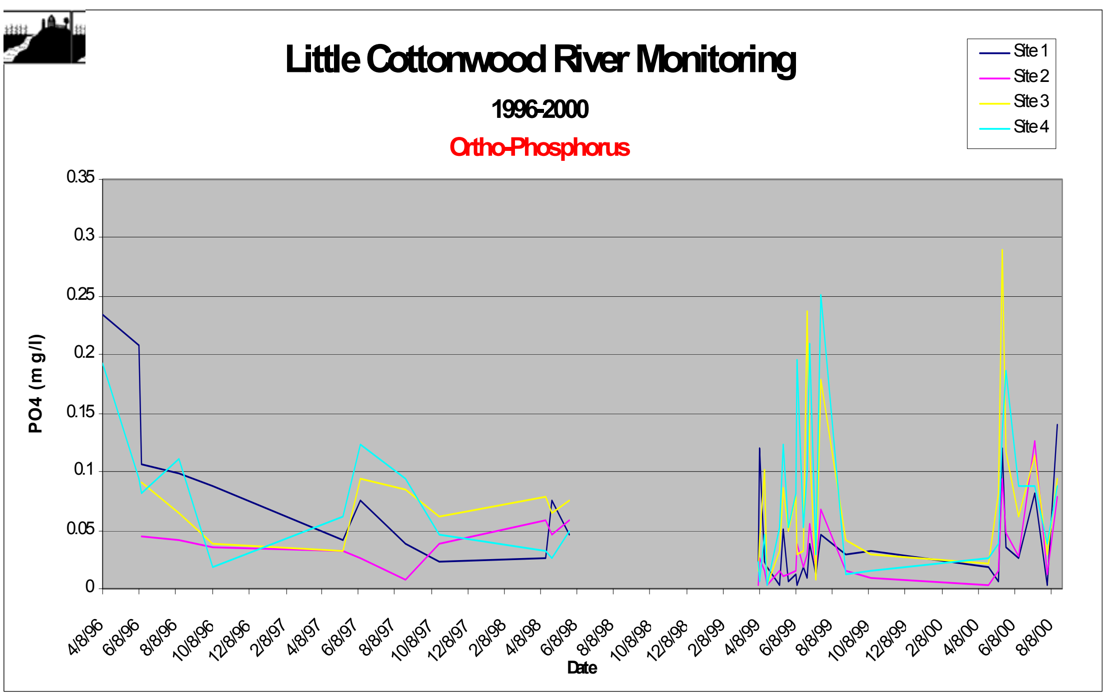


Figure 15: Ortho-phosphorus

Table 28

Fecal Colifrom Bacteria

Site	Mean (col./100ml)	Median (col./100ml)	Max (col./100ml)	Min (col./100ml)	25%[1] (col./100ml)	75%[1] (col./100ml)	% of Samples Exceeding Limits[2]	% of samples Exceeding WCBP Ecoregion Average[3]	Geometric Mean	Count
Site 1	388	280	1500	1	40	475	0	56	129	18
Site 2	1428	170	16000	1	20	385	11	37	127	19
Site 3	1887	500	17200	1	190	700	11	74	266	19
Site 4	734	170	6200	1	40	450	11	47	125	19

[1] Inter-quartile ranges determined by sorting the lower 25 percentile values and higher percentile values

[2]Limit based on 2000 col/100ml

[3] Mean 1970-1992 Annual Western Corn Belt Plains Ecoregion Average based on 230 col/100ml

Hydrology

Below are the flow conditions over the monitoring period expressed in cubic feet per second for 3 of the 4 water quality-monitoring sites. Site 1 did not have flow-recording equipment installed during the study. Site 3 did not have flow-recording equipment for the 2000 season. Also shown, figures 16-18, is the time in which a grab sample was taken in relation to the flow conditions. Where available, daily rainfall amounts are also included. A summary of the flow conditions can be found in tables 29 and 30.

During low flow events the river is sustained by baseflow or groundwater springs. Evidence of this was made apparent during near drought conditions in the 2000 spring season. (Photos 1) Near the mouth several springs were discovered adjacent and within the main channel. The upwelling of groundwater into the stream was tested on occasion. The samples tested very high in Iron (3.1mg/l) and contained <1 mg/l of nitrate.

Photo 1: Spring development near and in Little Cottonwood River. Picture on the left shows iron rich groundwater flowing out of the banks. The dissolved oxygen probe on the right shows the location of a developed spring near the edge of LCR (near water quality site 4)during low flow conditions in 2000.

According to USGS Water Resources Data for the permanent gaging station south of Courtland (site 4), average runoff values during the 25-year flow record have been 6.02 inches[4]. For water year 1998 and 1999 water runoff values were 5.13, and 4.95 inches respectively. This suggests that during the monitoring period the LCR was actually experiencing below normal flow conditions. This should be considered when evaluating the water quality during those two years. Below normal runoff conditions during a water quality monitoring study may also lead to below normal concentrations due to less chemical, and sediment transport from non-point sources.

In general the hydrographs show site 2 is flashy in nature. Generally during a storm event the river rises quickly and recedes just as fast. Unlike site 2, the flow downstream is much more gradual and peak flows continue for a much longer time period. The topography of the river course and nature of the flood plain help to reason for the gradual increase and decrease of river flows in this part of the watershed.

Table 29

1998 flow stats

Site	Mean (cfs)	Max (cfs)	Month of Max Occurrence	Min (cfs))	Month of Min Occurrence	Total Runoff
Site 2[1]	12	92	April	0	August	3.59
Site 3[2]	32	123	June	0	August	1.87
Site 4[1]	96	811	April	3	September	3.68

[1] April through October

[2] NOTE: Missing month of April (May through October)

Table 30

1999 flow stats

Site	Mean (cfs)	Max (cfs)	Month of Max Occurrence	Min (cfs))	Month of Min Occurrence	Total Runoff
Site 2[1]	12	114	July	0	September	4.39
Site 3[1]	32	170	July	0	September	2.7
Site 4[2]	96	479	July	4.2	September	3.86

[1] April through October

[2] NOTE: Missing month of October (April through September)

[4] **Water Resources Data, Water Year, USGS. Water Data Report MN99-1. 1999**

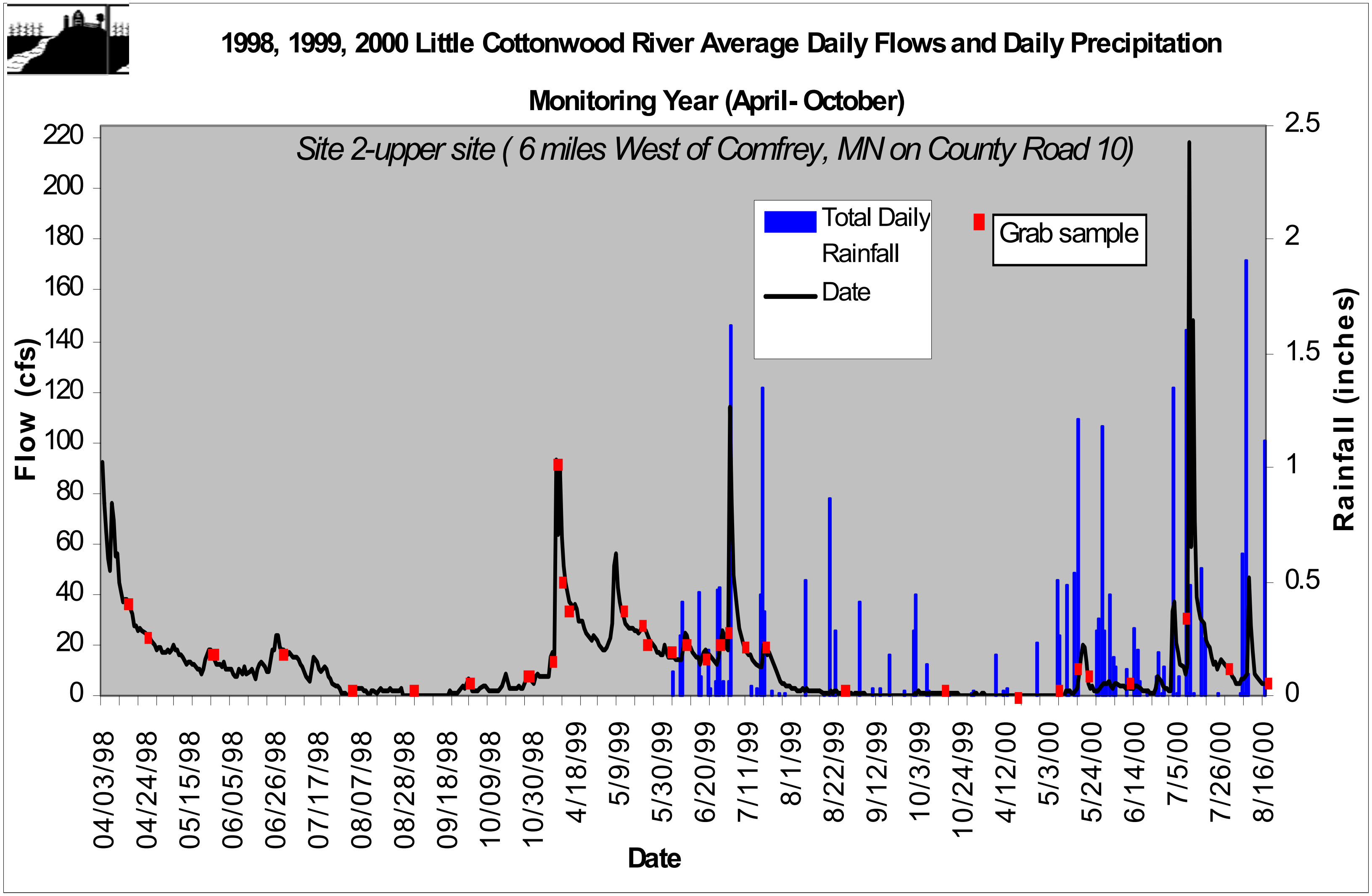


Figure 16: Site 2 hydrograph

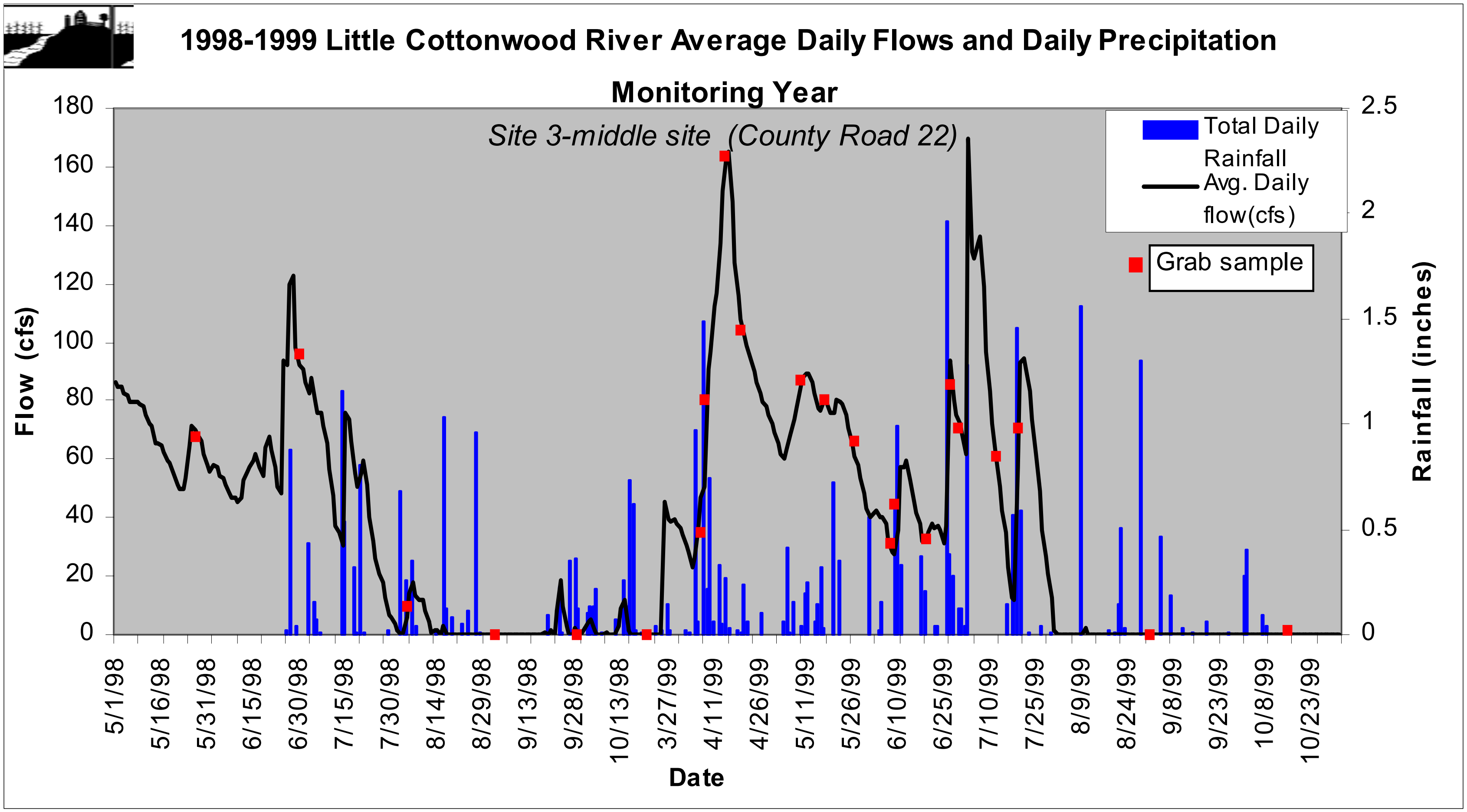


Figure 17: Site 3 hydrograph

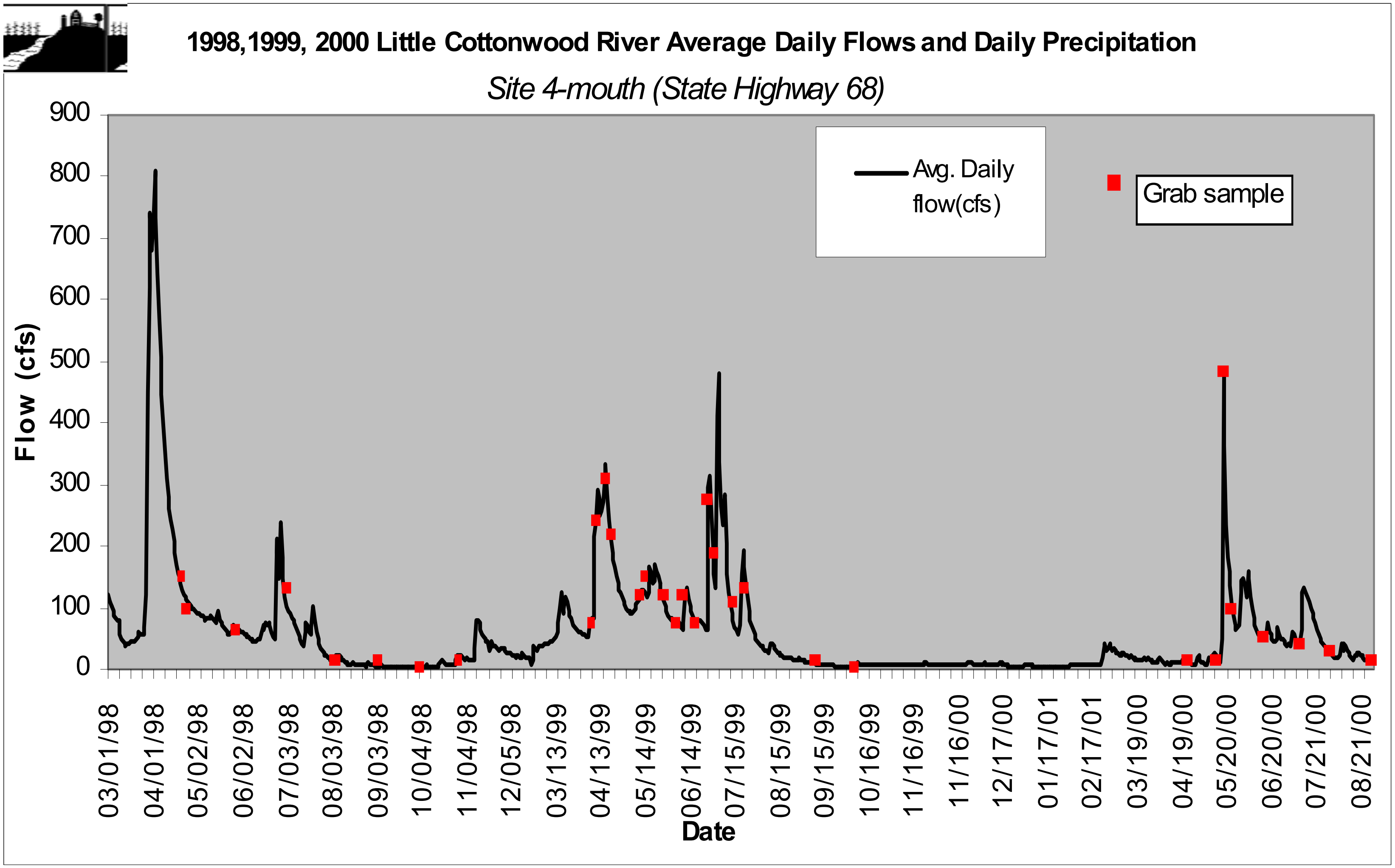


Figure 18: Site 4 hydrograph

Photo 2: Spring snow melt conditions near site 3 in Seven Mile Park. High flow conditions during spring snow-melt April 7, 2001.

Pollutant Loading Estimates

FLUX - - Flow Weighted Mean Concentrations and Yields

Below in tables 31-39 are the estimates of flow weighted mean concentrations (FWMC) and yields by year for selected nutrients and suspended sediments. In this diagnostic study four basic parameters were estimated for yields and average concentrations through a statistical computer-modeling program called FLUX. Total Suspended Sediments, Nitrate Nitrogen, Total Phosphorus, and Ortho Phosphorus were run through the program by BNC staff soon after the monitoring season. In 1998 ortho-phosphorus was not tested due to project setbacks from the tornado. The FLUX values for 1998 and 1999 represent the water quality of the Little Cottonwood River during the time period of April through October. The Flux values for 2000 represent the time period from April through August.

Further detail in regards to statistical modeling method used, and coefficient of variance for respected analytes can be cross-referenced in section M of the Appendix.

As reported earlier, the 1998, 1999, 2000 sampling seasons were different in terms of rainfall, flow, and amount of samples taken. Consequently, loading estimates will very considerably between monitoring years (figures 19-22). In addition to climatic differences and therefore overall runoff, the timing of grab sampling can sometimes overestimate or underestimate the amount of a particular water parameter of concern. As can be seen from the hydrographs the red dots indicate when the samples were taken in terms of water flow conditions. Ideally, grab samples should be taken during a variety flow conditions. The hydrographs show a few events in the early spring of 1998, July of 1999 and July of 2000 where very high flows were not captured with a sample. Consequently yields and concentrations are most likely slightly underestimated. For example, in 1998, 8 samples were taken with a majority of samples taken during low to moderate flow conditions. The characteristics of this type of monitoring most likely underestimates the loading rates for the LCR since a large number of runoff events and therefore higher flows, were not captured. However, in 1999, 16 samples were taken with a majority of samples taken during moderate to high flows to help compensate for 1998. Consequently, 1999 loads and FWMC are very representative of the monitoring year. Due to major project setbacks from the tornado in 1998, the project was extended into 2000. Monitoring continued in 2000 with a total of 8 samples utilized for estimates in FLUX. In 2000 a mixture of very low baseflow events with a near record peak flow at the mouth were sampled. A combination of three years worth of data with a greater number of samples taken during a wide variety of flow, groundwater/base flow and runoff dominated conditions will result in a more accurate portrayal of the chemical and physical makeup of the LCR resource during the study.

Relative Water Quality in the Watershed for 1999 Monitoring Season

Spatial Representation of Water Quality

In addition to the tables listing the respected average concentrations and yields for each site, maps were created for the 1999 season to show relative water quality impairments along stretches of the LCR. The 1999 Monitoring season is the only season represented by maps. 1999 was chosen since it most closely represents the water quality of the watershed. The maps help determine areas of the watershed where water quality is better or worse. Methods for selecting the three impairment categories can be found in the approach and methods chapter.

Concentration Maps 18, 19, 20

The first set of 9 maps graphically portray average concentrations found for TSS, TP, and NO3 at sites 2, 3 and 4. Site 1 values are not listed since flows were not retrieved at that site during the study.

Yield Maps 21, 22, 23

The second set of maps consists of yield values expressed on a lb./acre basis. Yield is simply defined as:

Yield = Total amount passing through monitoring station/Watershed Area

The first three yield maps are cumulative. In other words the yield values found at the mouth of the watershed (Site 4) represent the status of the watershed as a whole. While the yield values for site 3 is everything above site 3 , and so on…

Isolated Yield Maps 24, 25, 26

The second set of yield maps represent isolated values. The corresponding values represent the water quality ***between*** each of the monitoring sites. For example the contribution upstream of site 2 was subtracted from the yield value at site 3. The result is a yield between sites 2 and 3. The significance of displaying data this way is that it helps in determining what kind of voluntary BMPs to implement and where to put the BMPs in effort to maximize cost share dollars and water quality improvements.

Maps 23 and 26 are not color-coded. Impairment categories are still being developed for nitrogen yields.

1998

Table 31

Flow Weighted Mean Concentrations (mg/l)

Site	TSS	No3	TP	Po4
Site 2	22.0	14.0	.170	NA
Site 3	100.4	8.4	.303	NA
Site 4	90.2	9.3	.226	NA

Table 32

Accumulated Yield (lbs/acre)

Site	TSS	No3	TP	Po4
Site 2	18.2	11.5	.141	NA
Site 3	42.6	3.6	.129	NA
Site 4	98.6	10.2	.247	NA

Table 33

Isolated Yield(lbs./acre)

Site	TSS	No3	TP	Po4
Site 2	18.2	11.5	.141	NA
Site 3	49.5	1.3	.125	NA
Site 4	218.2	24.3	.500	NA

1999

Table 34

Flow Weighted Mean Concentrations (mg/l)

Site	TSS	No3	TP	Po4
Site 2	35.0	14.2	.156	.023
Site 3	83.8	9.0	.248	.082
Site 4	263.1	10.1	.244	.087

Table 35

:Accumulated Yield (lbs./acre)

Site	TSS	No3	TP	Po4
Site 2	34.9	14.2	.156	.023
Site 3	52.7	5.7	.158	.052
Site 4	262.6	10.1	.244	.087

Table 36

Isolated Yield (lbs./acre)

Site	TSS	No3	TP	Po4
Site 2	34.9	14.2	.156	.023
Site 3	57.7	3.3	.159	.060
Site 4	710.4	19.5	.430	.161

2000

Table 37

Flow Weighted Mean Concentrations (mg/l)

Site	TSS	No3	TP	Po4
Site 2	237	6.6	.125	.086
Site 3	NA	NA	NA	NA
Site 4	254.4	5.2	.182	.069

Table 38

Accumulated Yield (lbs/acre)

Site	TSS	No3	TP	Po4
Site 2	104.1	2.9	.055	.038
Site 3	NA	NA	NA	NA
Site 4	98.3	2.0	.070	.047

Table 39

Isolated Yield(lbs./acre)

Site	TSS	No3	TP	Po4
Site 2	104.1	2.9	.055	.038
Site 3	NA	NA	NA	NA
Site 4	83	1.6	.062	.042

Table 40

Average FWMC for 1998-2000 (mg/l)

Site	TSS	NO3	TP	Po4*
Site 2	98	11.6	.150	.055
Site 3**	92	8.7	.276	.082
Site 4	203	8.2	.217	.078

* Average does not include 1998

**Average does not include 2000

Mean 1970-1992 Annual Western Corn Belt Plains Ecoregion Average for:

TSS = 45.3 mg/l

Nitrate = 4.8 mg/l

TP = .280

Table 41

Average Accumulated Yield for 1998-2000 (lbs/acre)

Site	TSS	NO3	TP	Po4*
Site 2	52	9.5	.117	.030
Site 3**	48	4.7	.144	.052
Site 4	153	7.4	.331	.102

* Average does not include 1998

**Average does not include 2000

Table 42

Average Isolated Yield for 1998-2000 (lbs/acre)

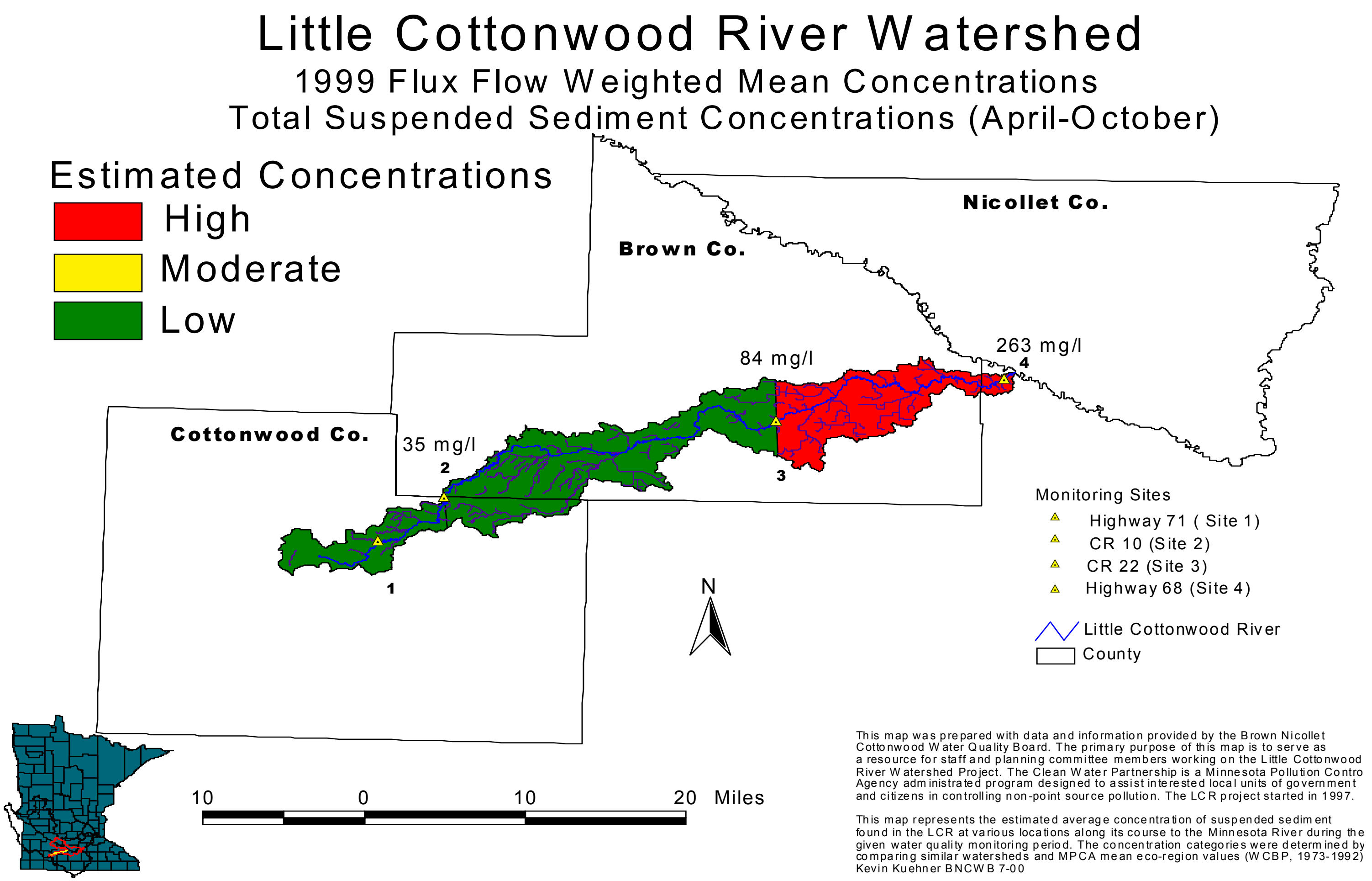
Site	TSS	NO3	TP	Po4*
Site 2	52	9.5	.117	.030
Site 3**	54	2.3	.142	.060
Site 4	337	15.1	.331	.102

* Average does not include 1998

** Average does not include 2000

Average Concentrations

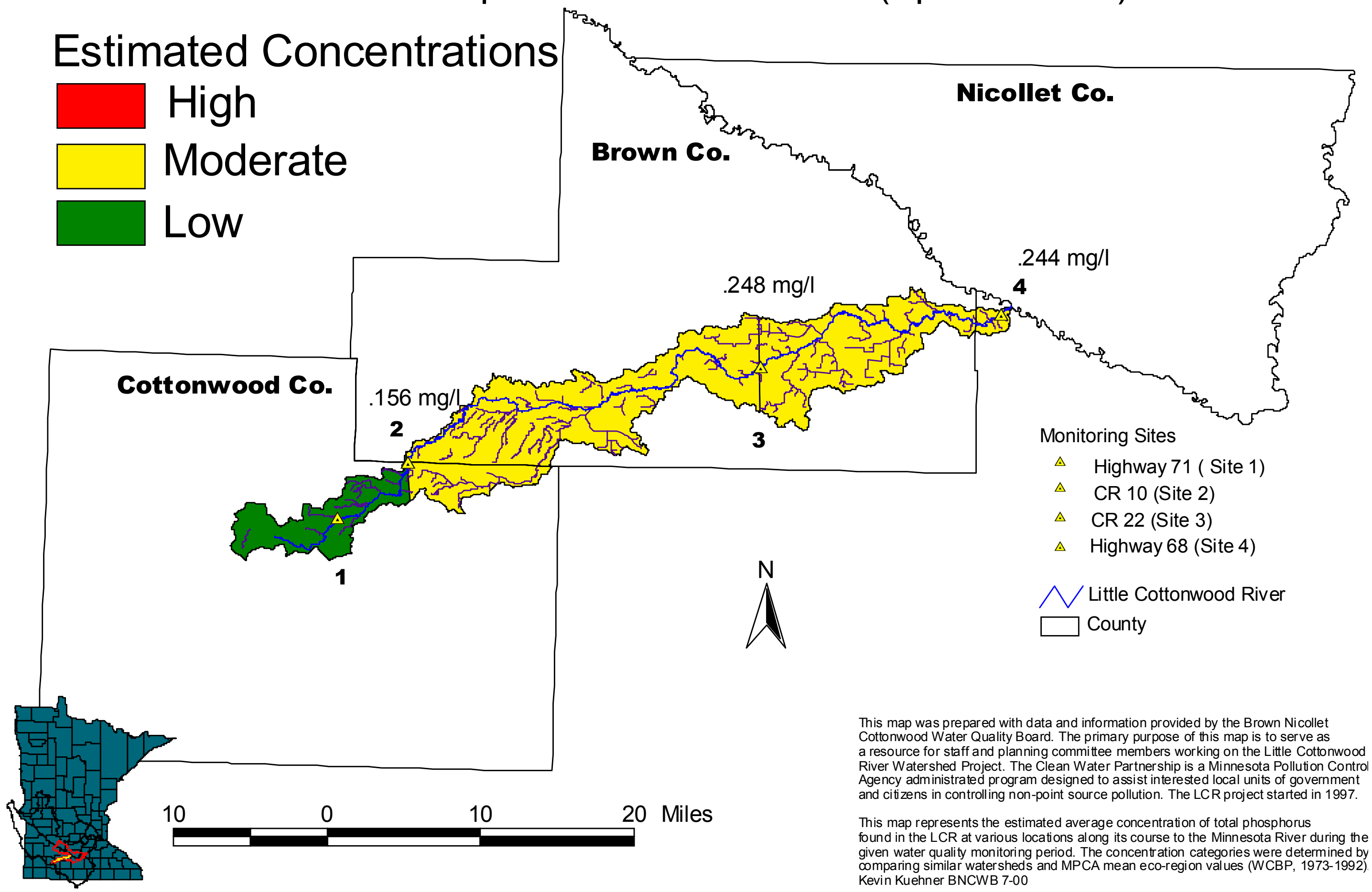
Map 18



Map 19

Little Cottonwood River Watershed

1999 Flux Flow Weighted Mean Concentrations
Total Phosphorus Concentrations (April-October)



This map was prepared with data and information provided by the Brown Nicollet Cottonwood Water Quality Board. The primary purpose of this map is to serve as a resource for staff and planning committee members working on the Little Cottonwood River Watershed Project. The Clean Water Partnership is a Minnesota Pollution Control Agency administrated program designed to assist interested local units of government and citizens in controlling non-point source pollution. The LCR project started in 1997.

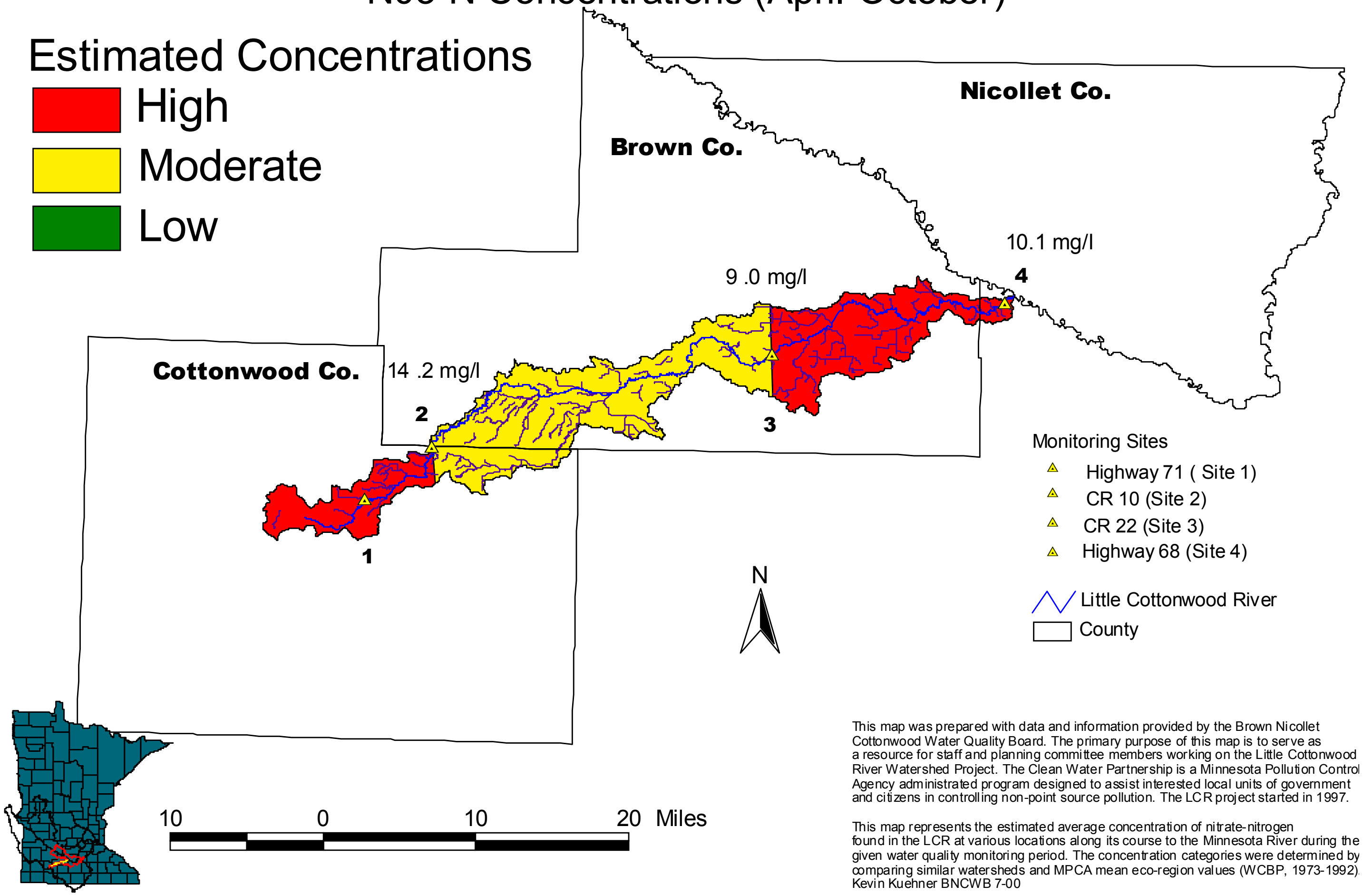
This map represents the estimated average concentration of total phosphorus found in the LCR at various locations along its course to the Minnesota River during the given water quality monitoring period. The concentration categories were determined by comparing similar watersheds and MPCA mean eco-region values (WCBP, 1973-1992).
Kevin Kuehner BNCWB 7-00

Map 20

Little Cottonwood River Watershed

1999 Flux Flow Weighted Mean Concentrations

N03-N Concentrations (April-October)

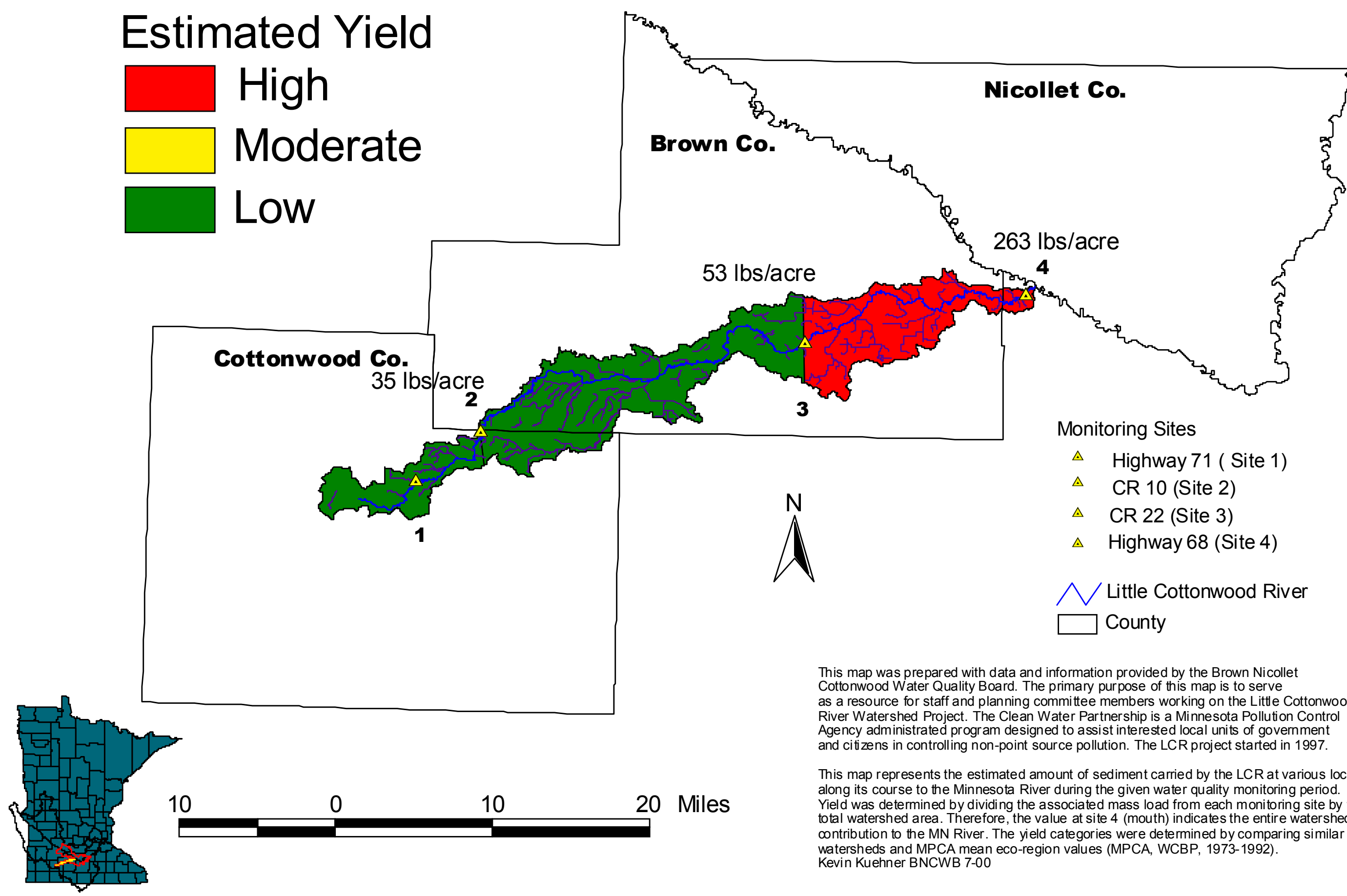


Map 21

Little Cottonwood River Watershed

1999 Flux Yield

Total Suspended Sediment Yield (April-October)



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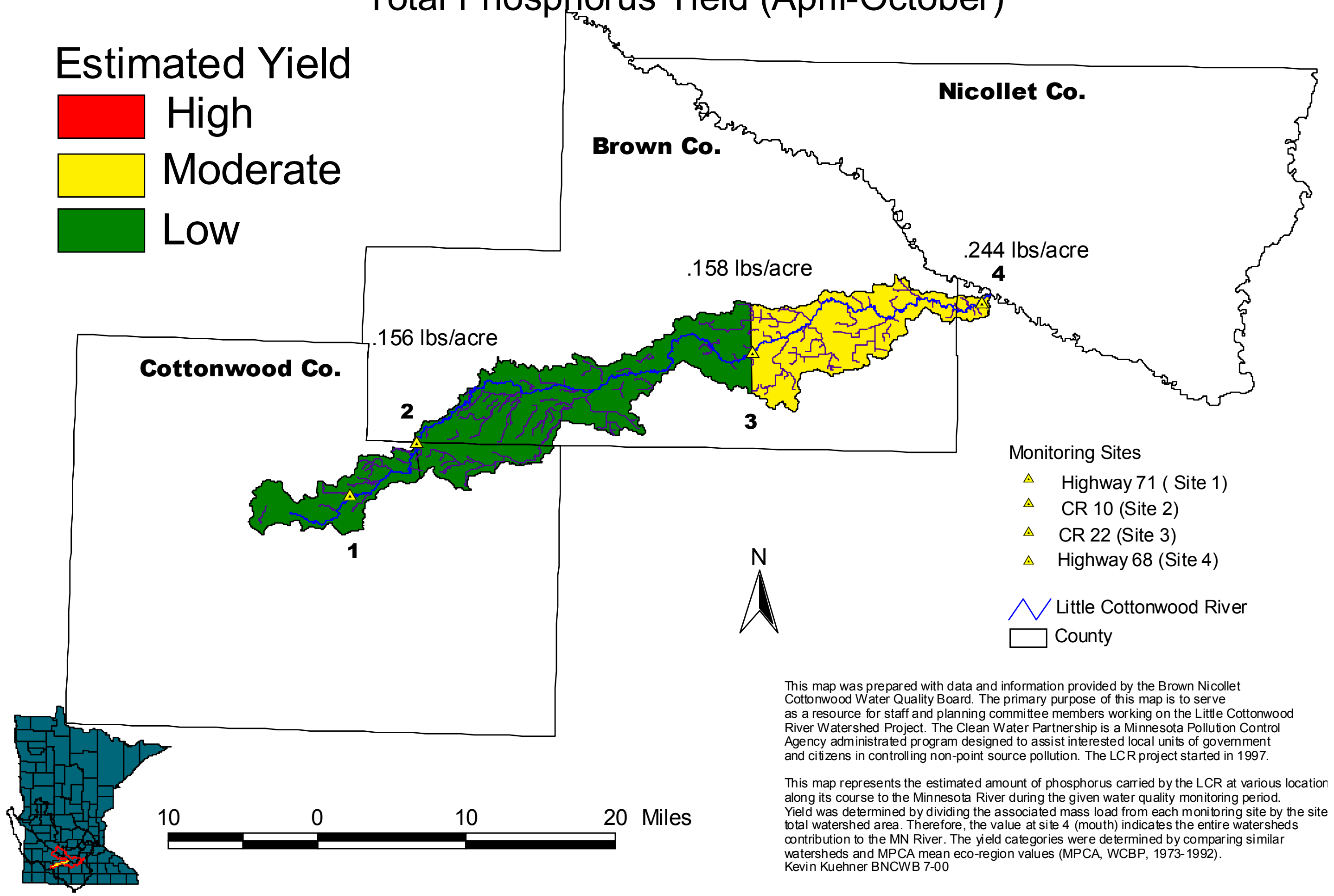
This map represents the estimated amount of sediment carried by the LCR at various locations along its course to the Minnesota River during the given water quality monitoring period. Yield was determined by dividing the associated mass load from each monitoring site by the sites total watershed area. Therefore, the value at site 4 (mouth) indicates the entire watersheds contribution to the MN River. The yield categories were determined by comparing similar watersheds and MPCA mean eco-region values (MPCA, WCBP, 1973-1992).
Kevin Kuehner BNCWB 7-00

Map 22

Little Cottonwood River Watershed

1999 Flux Yield
Total Phosphorus Yield (April-October)



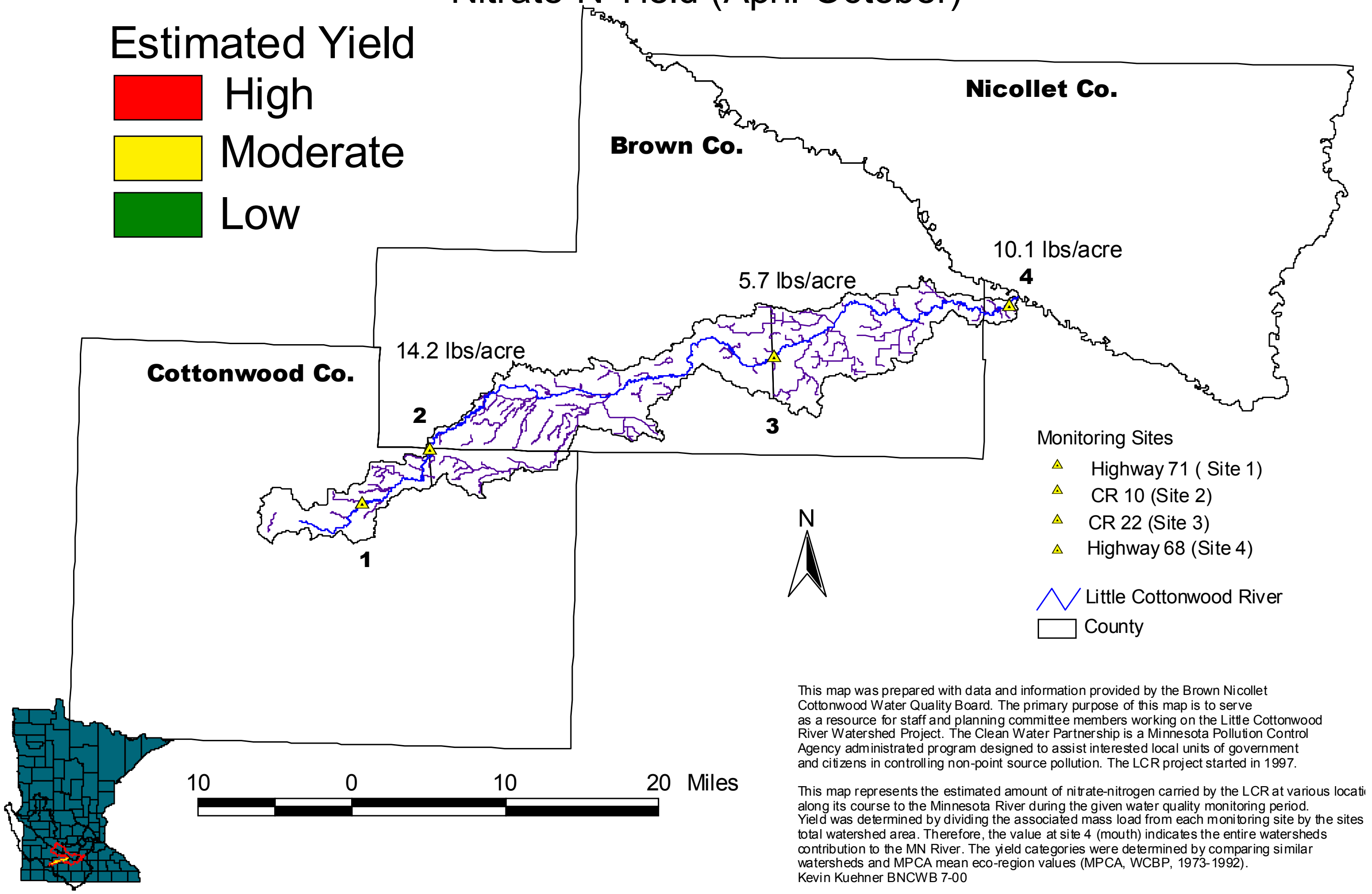
This map was prepared with data and information provided by the Brown Nicollet Cottonwood Water Quality Board. The primary purpose of this map is to serve as a resource for staff and planning committee members working on the Little Cottonwood River Watershed Project. The Clean Water Partnership is a Minnesota Pollution Control Agency administrated program designed to assist interested local units of government and citizens in controlling non-point source pollution. The LCR project started in 1997.

This map represents the estimated amount of phosphorus carried by the LCR at various location along its course to the Minnesota River during the given water quality monitoring period. Yield was determined by dividing the associated mass load from each monitoring site by the site total watershed area. Therefore, the value at site 4 (mouth) indicates the entire watersheds contribution to the MN River. The yield categories were determined by comparing similar watersheds and MPCA mean eco-region values (MPCA, WCBP, 1973-1992).
Kevin Kuehner BNCWB 7-00

Map 23

Little Cottonwood River Watershed

1999 Flux Yield
Nitrate-N Yield (April-October)



This map was prepared with data and information provided by the Brown Nicollet Cottonwood Water Quality Board. The primary purpose of this map is to serve as a resource for staff and planning committee members working on the Little Cottonwood River Watershed Project. The Clean Water Partnership is a Minnesota Pollution Control Agency administrated program designed to assist interested local units of government and citizens in controlling non-point source pollution. The LCR project started in 1997.

This map represents the estimated amount of nitrate-nitrogen carried by the LCR at various locati along its course to the Minnesota River during the given water quality monitoring period. Yield was determined by dividing the associated mass load from each monitoring site by the sites total watershed area. Therefore, the value at site 4 (mouth) indicates the entire watersheds contribution to the MN River. The yield categories were determined by comparing similar watersheds and MPCA mean eco-region values (MPCA, WCBP, 1973-1992).
Kevin Kuehner BNCWB 7-00

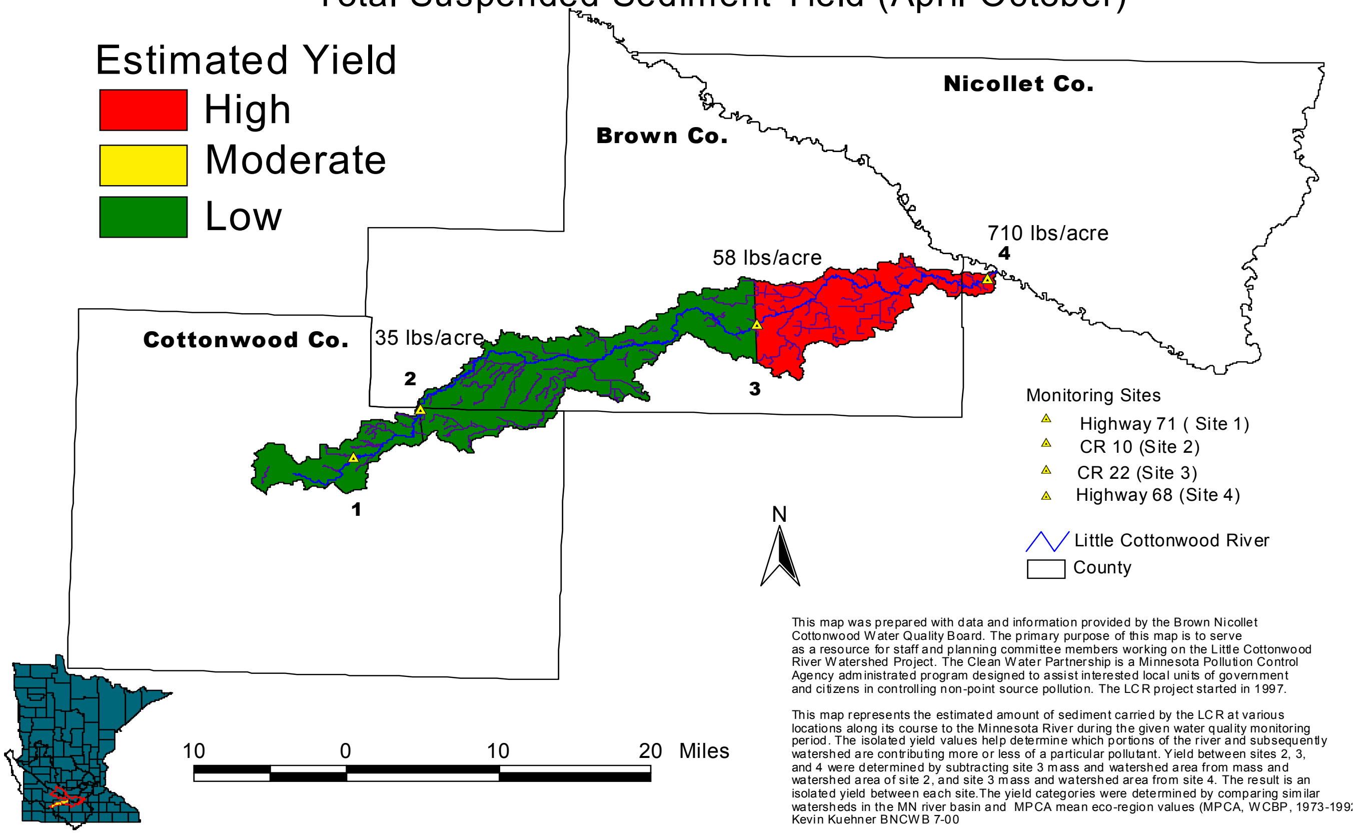
Isolated Yield

Map 24

Little Cottonwood River Watershed

1999 Flux Isolated Yield

Total Suspended Sediment Yield (April-October)

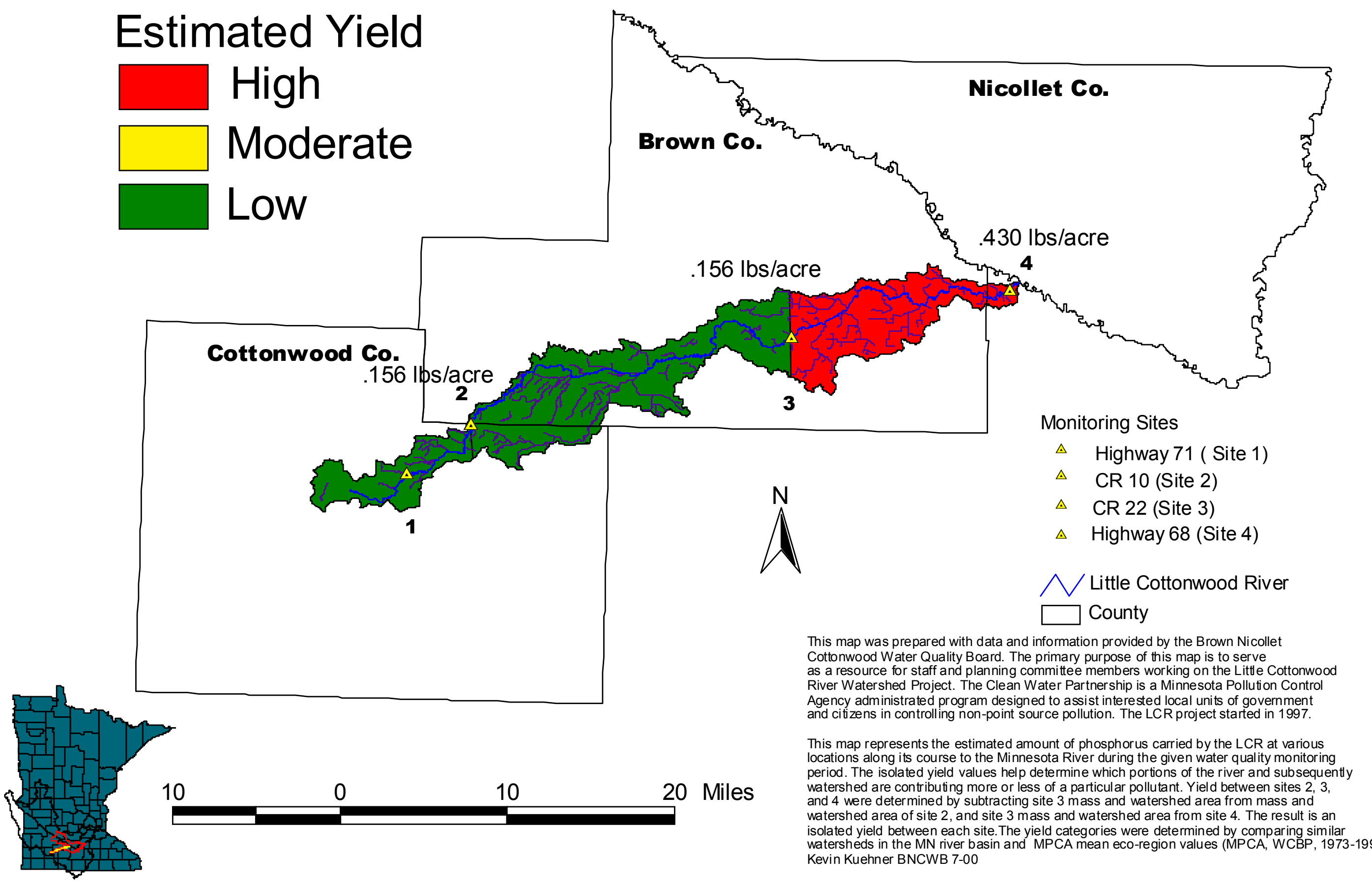


Map 25

Little Cottonwood River Watershed

1999 Flux Isolated Yield

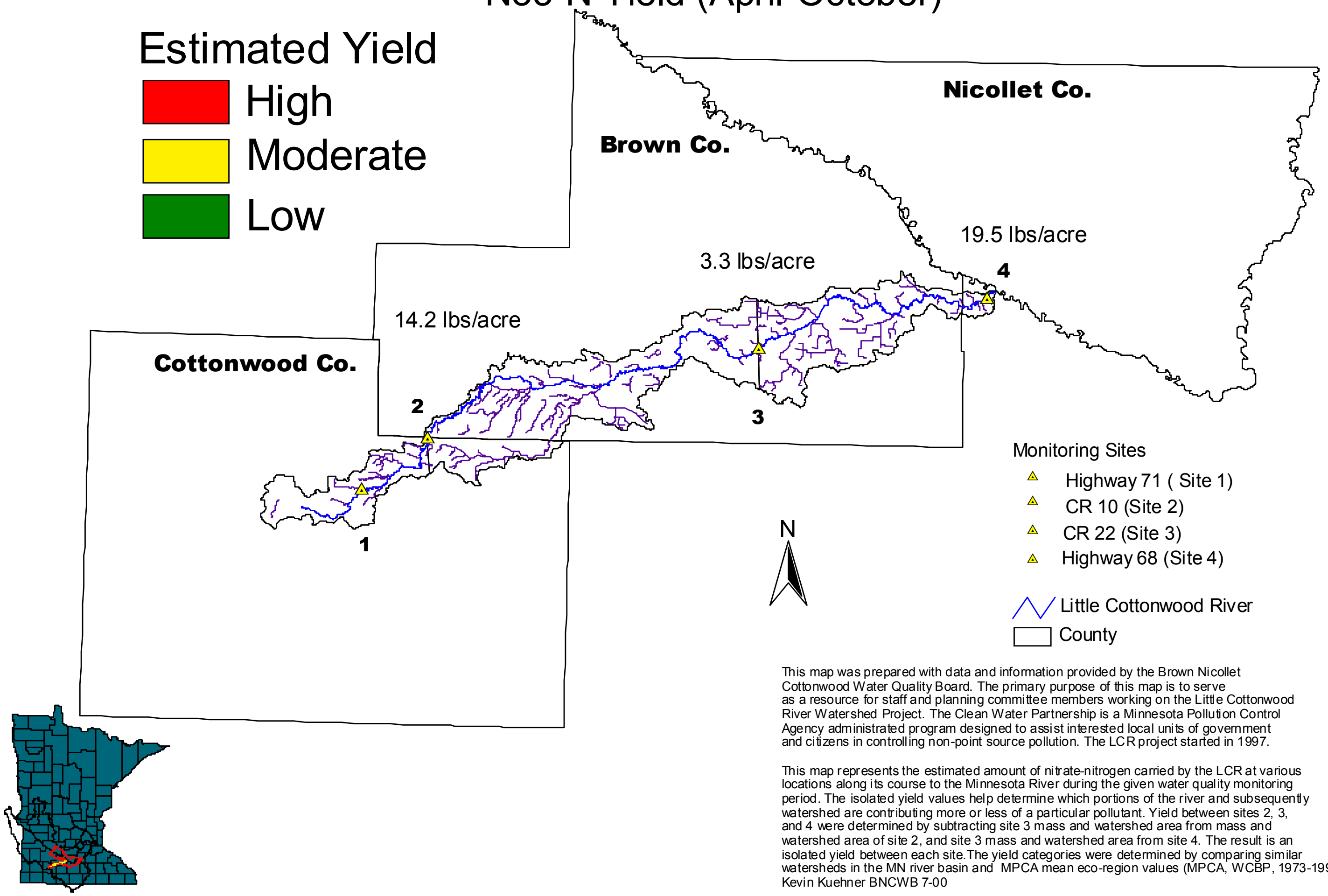
Total Phosphorus Yield (April-October)



Map 26

Little Cottonwood River Watershed

1999 Flux Isolated Yield
No3-N Yield (April-October)



Summary of pollutant loads

A primary goal of this study was to examine specific pollutants, the processes affecting their transport, and appropriate measures to reduce their delivery to the water resource. Examination of the relative amount of pollutant load assists in accomplishing this goal. Below is a brief summary of the loading rates for the LCR. The summary below uses the 1999 monitoring since the loading rates, monitoring techniques, and climate most closely represents the water quality of the Little Cottonwood River during the three years of study.

Considering the drainage area, the upper portion of the watershed contributed high to very high levels of nitrate loading. In contrast, within the middle portion of the watershed (between monitoring stations 2 and 3), nitrate loads (lbs/acre) decreased by 77% in 1999. Sediments increased 66% while phosphorus showed little change. A high number of wetland/floodplain acres and their associated assimilation/transformation processes are suspected to be the main reasons for the appreciable decreases within the middle portion. In general, the lower portion of the watershed contributed the most pollution overall. Between monitoring stations three and four, sediment levels increased 1124%, Nitrates 491% and Total Phosphorus 170%. An increase in the amount of growing season rainfall (leading to more runoff), increase in flows, watershed slope and general decrease in the amount of agricultural conservation practices help to explain some of the large increases in pollutants within this area of the watershed. Bacteria levels increased during runoff events. Fecal coliform levels were highest in the middle portion of the watershed mainly due to higher feedlot concentrations and animal access locations to river.

- Total Suspended Sediment loads for the entire watershed were high. Loads incrementally increased downstream. The entire watershed fit into the high TSS concentration and yield categories. The largest contribution of loads comes after site 3 in the watershed. Yields jump from 58 lbs./acre to 710 lbs/acre an increase of 652 lbs/acre or 1124% increase.
    - On average every 20 minutes 1 ton of soil (soil in suspension) was dumped into the MN River from the Little Cottonwood from April through October in 1999. Or another way of looking at it, every 3 hours a 10-ton dump truck load.
- Nitrates are moderate to high for parts of the watershed. The highest concentrations and yields seen are in the upper portions of the watershed near site 2 and upstream. Nitrate yields between sites 2 and 3 actually dropped substantially from 14.2 to 3.3 lbs./acre resulting in a 77% decrease. Possible reasons include denitrification and plant assimilation processes attributed from the high number of wetland habitat systems in the middle portion of watershed.
    - On average 201 lbs. of Nitrogen entered the MN River per hour from the Little Cottonwood during the April through October 1999 season.
- Total Phosphorus concentrations and yields are in the low to moderate categories for portions of the watershed. The entire watershed fits in the moderate category for both concentration and yield. The largest load again shows up after site 3. An additional .274 lbs./acre is picked up from this section resulting in a 170% increase.
    - On average 4.8 lbs. of phosphorus entered the MN River per hour from the Little Cottonwood from April through October in 1999.

The flow weighted mean concentrations and yields for 1999 reveal substantial differences between monitoring sites. For example in 1999 the TSS levels between site 3 and 4 show an increase of 1124%, increase of 491% for nitrate and 170% increase for TP. There are several possible reasons for the increase. First, this area of the watershed receives six more inches of rainfall fall during the growing season compared to the western reaches. This would suggest that additional sediment and nutrient load between sites 3 and 4 is related to the additional runoff. Second, this area of the watershed has the highest amount of potential erodibility according to the RUSLE model (Table 10). Steep ravines and general increase in river gradient can increase the transport of runoff into surface water. As a result of TISWA and tillage transect surveys, conservation tillage on row cropped acres is generally the lowest in this portion of the watershed. Furthermore, upland pollution stored in riverbanks and channel bed can be re-transported through the system during high river flows. Other possible reasons for the very large increase in loads is in general it is easier to capture higher flows near the mouth than near the upper portion of the watershed. Since the upper portion of the watershed is much more flashier (fast peak and recession on the hydrograph), most of the load has the potential to pass through the system before a grab sample can be taken. This inadvertent overestimating due to timing of grab sampling in relation to flow was addressed. As can be seen from the hydrographs (figures 16-18) a major portion of the grab samples were taken near the same peaks as site 4.On occasion the hydrograph at site 2 was receding, while at the mouth, flows were still increasing. However, despite these occasional differences the impact of this concern was thought to be negligible and the general increase in the amount of precipitation and therefore runoff was considered to more of a factor for the increase in load within this section of the watershed.

Conversely in 1999, sediment and nutrient loads seem to decrease significantly after site 2 in the watershed. Processes related to wetlands may pose an explanation of the general decline in this area. Between sites 2 and 3 the river gradient deceases substantially and land cover comprising of wetlands increases (table 14). General wetland processes such as assimilation of nitrogen and phosphorus by wetland plants help to explain the decrease. Biogeochemical processes found in wetlands, may help to remove some phosphorus and nitrate loads. Nitrogen yields drop 11 lbs./acre and concentrations drop from 14 mg/l to 9 mg/l. Phosphorus yields remain about the same. From a water quality standpoint the deceasing trend in nutrient loads and concentrations within this area of the watershed further emphasizes the important role of wetlands.

Loading Rates vs. Monitoring Year

Appreciable differences in yield exist between monitoring years. Figures 19-21 show the differences in loading rates between various parameters in 1998, 1999 and 2000. These figures further demonstrate the need for many years worth of monitoring over various climatic conditions to get a true representation of the water quality at a watershed scale.

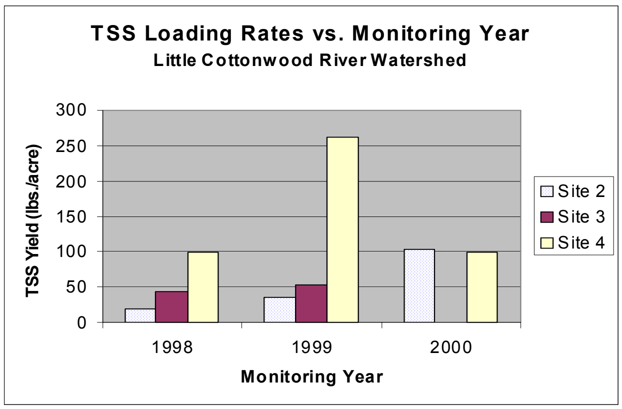


Figure 19: TSS vs. Monitoring Year

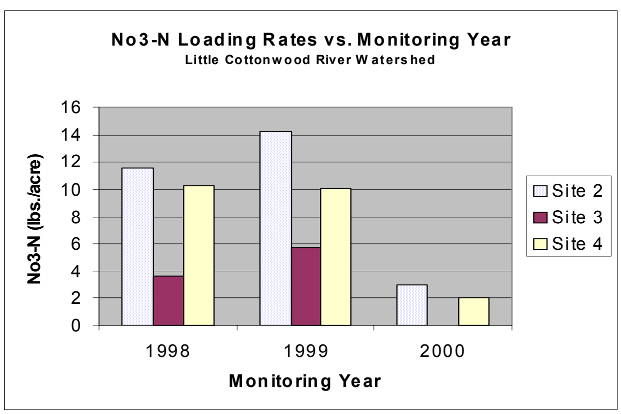


Figure 20: Nitrate vs. Monitoring Year

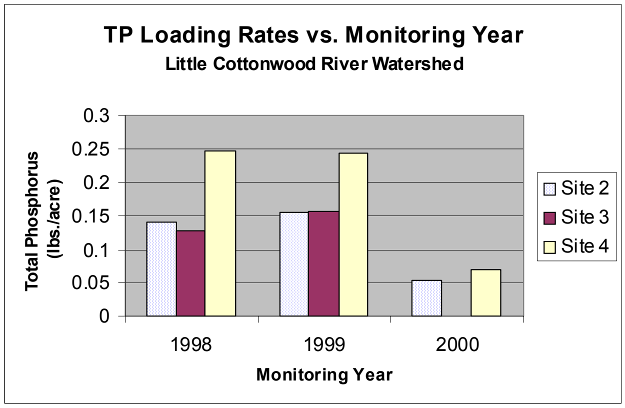


Figure 21: TP vs. Monitoring Year

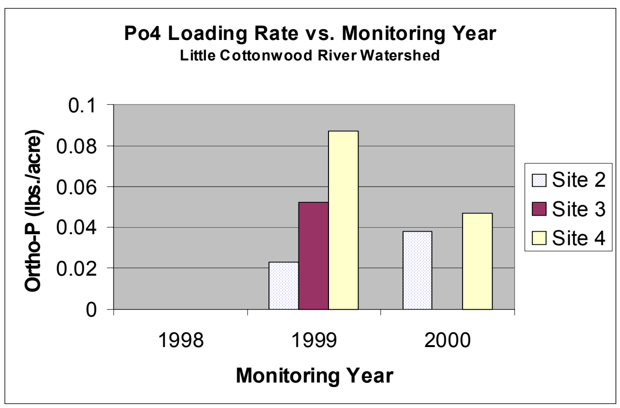


Figure 22: Po4 vs. Monitoring Year

Comparison of Little Cottonwood River Watershed Yields vs. Other Similar Watersheds

Like the Little Cottonwood, several other watersheds have performed water quality studies either through Clean Water Partnerships or other similar programs. To understand how the Little Cottonwood ranks with other watersheds, data from those projects were included in this report for comparative purposes. Watershed technicians, engineers and CWP staff affiliated with the projects, submitted the yield data in 2000. 1999 was chosen since it most closely represents the water quality of the LCR. Methods and approaches for calculating yields are assumed to be similar and/or identical to the LCR. Values shown (figures 23-25) below represent the yield at the mouth of the watershed for 1999 during April- October, unless otherwise noted.

*Redwood River represents average yields combined from 1990-1999

*Cottonwood River values for the mouth were not available for 1999. Values upstream near Leavenworth were used instead. Includes 1997-1999.

Out of the six watersheds chosen for comparison, the Little Cottonwood Ranks third in contribution of total suspended sediment and total phosphorus yield. The Redwood River ranks the highest in this category. As for nitrate yield however, the Little Cottonwood ranks number one followed by the Cottonwood and Redwood River.

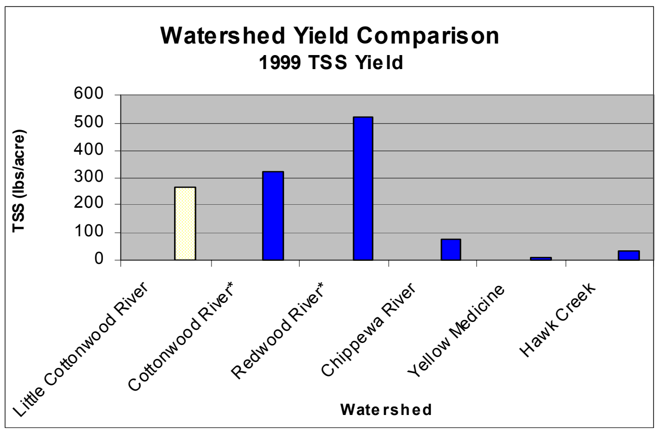


Figure 23: TSS yield comparison.

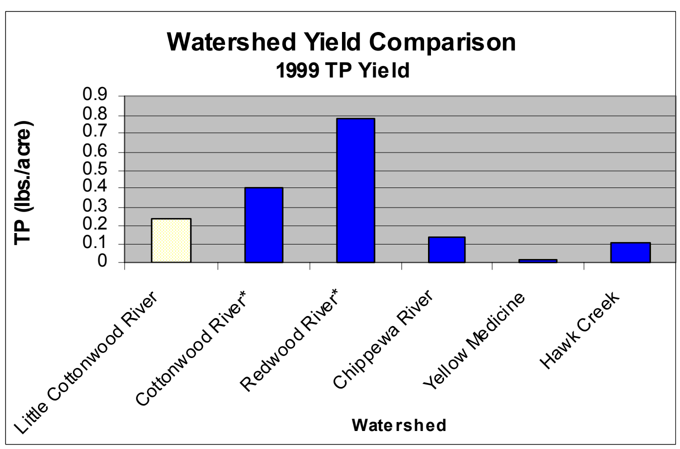


Figure 24: TP Yield Comparison

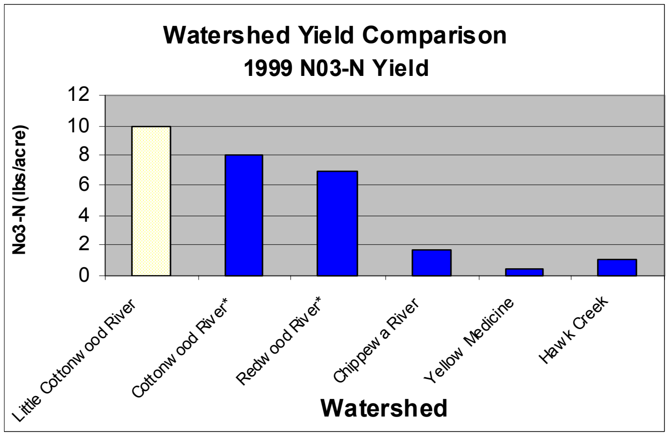


Figure 25: No3-N comparison

TSS vs. Transparency Tube Readings

Information adopted from MPCA 1998 report on water quality of MN streams[5]

The transparency tube was developed in Australia as a tool for measuring stream water clarity, which serves as a basic indicator of water quality. The tube is 2 feet long X 1.5 inch diameter, made of clear plastic, and has a release valve at the bottom. A stopper inserted at one end of the tube is painted black and white so that when you look down into the tube a distinct symbol is visible at the bottom. To measure water clarity, the tube is filled with water collected from a stream or river. Looking down into the tube, water is released through the valve until the black and white symbol is visible. The depth of the water when the symbol becomes visible is recorded in centimeters, which are marked on the side of the tube. If the symbol is visible when the tube is full, the transparency is "> than 60" cm. A greater transparency reading in centimeters reflects higher water quality.

In various studies conducted by the MPCA on Minnesota streams it was found that transparency and total suspended solids were interrelated. Based on preliminary work conducted during 1997, MPCA staff identified significant relationships between transparency tube measurements, TSS, and turbidity. These relationships are reflected by the high correlation coefficients (R^2) between transparency tube readings and TSS (r^2=.75) and turbidity (r^2=.86). Correlation coefficients provide a numerical measure of the strength of relationship between two factors. The significant relationships described above suggest the potential to predict stream TSS or turbidity based on transparency tube measurements. Understanding the interaction among transparency, TSS, and turbidity could provide a basis for characterizing the health of a stream relative to existing water quality standards, such as the 25 NTU turbidity standard; or by comparisons to eco-region "yardsticks" as compiled from reference streams (table). For example, TSS in the 10-60 mg/l is typical for streams in the WCBP eco-region. In terms of transparency, this corresponds to measures in the 45 to 15 cm range for the WCBP.

TSS vs. Transparency Specific to the LCR

Similar to MCPA methods of correlating TSS with T-tube readings, a correlation was conducted using data specific to the LCR. The T-tube readings were correlated with TSS lab results. Figure 26

5 1998 Report on the Water Quality of Minnesota Streams, MPCA, Environmental Outcomes Division December 1999.

represents the results of the correlation. Over 40 T-tube readings were utilized in the correlation. The r^2 value or tightness of fit, of .88 shows a very good correlation between TSS lab readings and in field transparency readings. The average t-tube reading (1999 and 2000) for the LCR was 29 cm. A river specific relationship between TSS and transparency is of great value to the project since the simple and quick t-tube test can be substituted for more expensive TSS laboratory procedures. It also increases the value of watershed volunteers using T-tubes, water quality awareness, and refinements to BMP implementation.

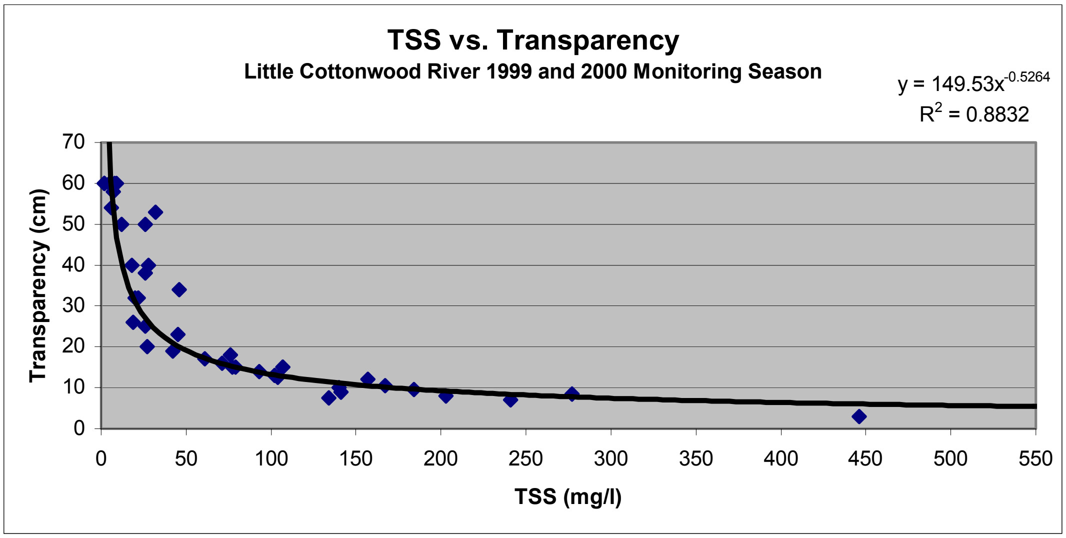


Figure 26: TSS and Transparency Relationship for LCR

1999 TISWA Survey Results

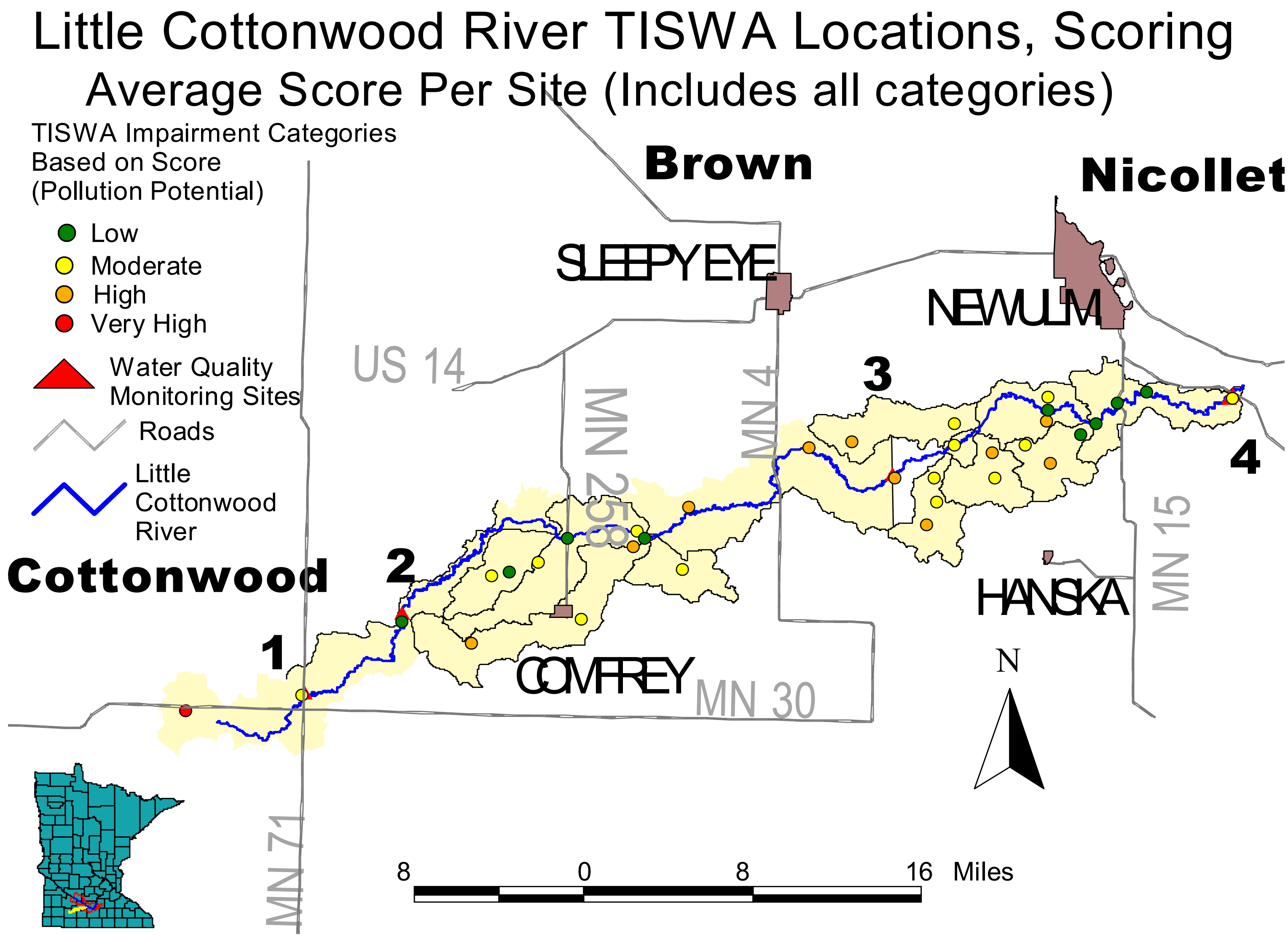
Map 27 shows the results of the 1999-fall TISWA survey. A transition from green to red indicates increasing pollution potential.

Based on the road survey, the area where sub-watersheds 2805, 28086, 28087, 28088 converge indicates moderate to high pollution potential. The majority of high pollution potential ranking within this watershed is the result of little or no riparian zone, stream bank erosion resulting from cattle trampling, tillage practices, natural erosion, and little or no conservation tillage-especially on soybeans.

The single area indicating the highest impairment (unstable banks and little or no riparian zone) was near the headwaters at the newly constructed ditch site. Lowest areas of impairment were near the near 28057 sub-watershed. Here, other than the possibility of failing septics and natural slope erosion, pollution potential is low due to well-established buffering of riparian zones.

Notes from survey

In many areas conservation practices were adequate or more than adequate. However, those notes were not included in this report in attempt to focus on sub-watersheds that need special attention. Sub-watersheds 28091 and 28089 were not listed with individual notes because either none were taken or did not warrant any. TISWA sites are located in parentheses. Sub-watersheds in bold indicate areas with more impairments compared to others.


Little Cottonwood River TISWA Locations, Scoring
Average Score Per Site (Includes all categories)
TISWA Impairment Categories
Based on Score
(Pollution Potential)
Low
Moderate
High
Very High
Water Quality
Monitoring Sites
Roads
Little
Cottonwood
River
Brown
Nicollet
Cottonwood
SLEEPY EYE
NEW ULM
HANSKA
COMFREY
US 14
MN 4
MN 258
MN 15
MN 30
MN 71
1
2
3
4
N
8
0
8
16
Miles

Sub-watershed

28057

- Need for buffers (1-3)
- Need for cattle fencing on East side (1-3)

28087

- Conservation tillage needed for bean ground. Moldbord plowed. (3-3)
- Excellent opportunity of upland ditch buffers (3-3)

28088

- Wetland Restoration Possibility near tributary (4-1)
- Good block CRP and filter strip potential due to large number of slopes planted into corn along stream. (4-1)
- Need for wider buffer along ditch to buffer effects of dairy cows in nearby pasture (4-1)

28086

- Conservation tillage needed. < 30 residue. (5-1)
- Buffers needed. Good potential due to slopes (5-1)
- Sediment in channel, turbid even during low or no flow. (5-2)
- Extensive tillage with little or no residue (5-2)
- Buffers needed, ditch slope away from stream, but vegetation would buffer intakes.(5-2)

28084

- Accumulated sediments in ditch (6-1)
- Need for buffers (6-1)
- Possible wetland restoration and/or augmentation to existing wetland (6-2)
- Need for more Conservation Tillage(CT) (6-2)
- Good potential for more buffers, CREP due to frequent or recent flooding.(6-3)

28085

- Cows have free access to river (7-1)
- Areas with stream bank erosion (7-1)
- Cattle have free access to stream (7-2)
- Banks unstable (7-2)
- Need for CT-especially beans (7-2)
- Excellent location for CREP, frequent flooding (7-3)
- Need for more buffers, cropped to edge of LCR (7-3)
- CT needed, <10% bean residue (7-3)

28090

- Stream banks unstable due to natural properties of soil. Course sandy soil with little structure. (9-1)
- Very good baseflow (9-1)
- Need more buffers to keep equipment near edge (9-2)
- Need buffers (9-3)
- Beans disked in fall-More CT (9-3)

28097

- Need for buffering, fair number of slopes (10-2)
- Cattle have free access to stream (10-2)
- CT needed on bean ground (10-2)

28081

- Some bank erosion (11-1)
- Cattle have free access to stream on North side, however good pasture management (11-1)

28080

- Very poor ditch stabilization (12-2)
- High algae content (12-2)
- Channel filling in with yellow sub-soil clay (12-2)

2000 Fishery Survey Results

In the summer of 2000, a biological assessment was conducted to compliment the 1986 survey. Fish species present within the water habitats of the LCR were surveyed using electro-fishing techniques. As part of the biological survey macro-invertebrates were also sampled. The results of the survey are listed below. Figure 27 lists the species found in the LCR during the 2000 DNR fish survey. A discussion of the 2000 results and comparison of the 1886 survey with 2000 is included below. The discussion is by Fisheries Specialist, Craig Berberich, of the Minnesota Department of Natural Resources.

The population structure of the Little Cottonwood River continues to dominated by non-game and minnow species, which is typical of warm-water river in southern Minnesota. Game fish were not abundant except for channel catfish sampled at stations 1 and 4 (mi. 0-27.6). The 1986 survey samples three walleye, fourteen northern pike, two smallmouth bass, and two channel catfish, compared to five channel catfish captured in the 2000 survey.

Fish populations in the River are probably influenced by the Minnesota River and the channel catfish sampled at the lower station (mi. 1.7) were probably migrants. The lack of habitat (deep pools) and low water periods are probably the primary limiting factors to gamefish. The species list for the Little Cottonwood River has expanded from 32 species in 1986 to 36 species in 2000. New species found in 2000 include brassy minnow, emerald shiner, fantail darter, and Johnny darter. Species absent in the 2000 survey compared to the 1986 survey include northern pike, black bullhead, yellow bullhead, small mouth bass, rock bass, slender darter, walleye and spotfin shiner.

Little Cottonwood River Species List

common carp	*Cyprinus carpio*
creek chub	*Semotilus atromaculatus*
hornyhead chub	*Nocomis bigattutas*
central stoneroller	*Campostoma anomalum*
blacknose dace	*Rhinichthys atratulus*
bluntnose minnow	*Pimephales notatus*
fathead minnow	*Pimephales promelas*
brassy minnow	*Hybognathus hankinsoni*
common shiner	*Luxilus cornutus*
emerald shiner	*Notropis atherinoides*
bigmouth shiner	*Notropis dorsalis*
sand shiner	*Notropis stamineus*
spotfin shiner	*Cyprinella spiloptera*
northern hog sucker	*Hypentelium nigricans*
white sucker	*Catostomus commersoni*
shorthead redhorse	*Moxostoma macrolepidotum*
golden redhorse	*Moxostoma erythurum*
bigmouth buffalo	*Ictiobus cyprinellus*
quillback	*Carpiodes cyprinus*
channel catfish	*Ictalurus punctatus*
tadpole madtom	*Noturus gyrinus*
stonecat	*Noturus flavus*
green sunfish	*Lepomis cyanellus*
orangespotted sunfish	*Lepomis humilis*
fantail darter	*Etheostoma flabellare*
johnny darter	*Etheostoma nigrum*
blackside darter	*Percina maculata*
logperch	*Percina caprodes*

Figure 27: Fish species sampled in 2000

Species not sampled in 2000

northern Pike
Black Bullhead
yellowbullhead
smallmouth bass
rock bass
slender darter
walleye
spotfin Shiner

Species not sampled in 1986

brassy minnow
emerald shiner
fantail darter
johnny darter

Table 43

MNDNR 2000

Invertebrates Present*	Site 1	Site 2[1]	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
Mayflies (Ephemeroptera)	X	X	X	X			X	X	X
Stoneflies (Plecoptera	X	X						X	
Caddisflys (Trichoptera)	X	X					X	X	X
True bugs (Hemitera)				X	X	X	X		
Crayfishes (Decapoda)	X							X	X
Flies and midges (Diptera)	X	X	X	X	X	X	X	X	X
Clams (Pelecypoda)									X
Snails (Gastropoda)	X		X	X				X	X
Worms (Annelida)				X			X		X
(Odonata)							X		
Beetles (Colepotera)	X	X				X	X	X	X
(Mollusca)							X	X	
(Hirudinea)									X
Scuds (Amphipoda)									X

***Macro invertebrates which were present or absent during survey**

[1]Note: sample does not contain as many individuals

Fish Survey 2000 MNDNR- Waterville Region

Fish Survey taken place at 9 sites along the LCR in early August. Backpack electro-fishing device set at 400 volts used to temporarily stun and capture fish. Larger species of fish identified, pectoral scale taken from game fish for aging, and weight information taken from field. Smaller fish species were preserved and taken back to office for further identification and reporting.

Table 44

MNDNR 2000 Fish Survey

Date(s): July - September 2000

Stream: Little Cottonwood River

(34) Fishery Characteristics

a) Station No.	1	2	3	4
b) Date	08/17/00	08/17/00	08/17/00	08/18/00
c) Loc. (miles from mouth)	1.7	8.8	18.0	27.6
d) Length of Station	1000 ft	1000 ft.	1000 ft.	1000 ft.
e) Gear	Smith-Root Model 12 back pack shocker: J-4, setting 400 v.	Smith-Root Model 12 back pack shocker: J-4, setting 400 - 500v.	Smith-Root Model 12 back pack shocker: J-4, setting 400 v.	Smith-Root Model 12 back pack shocker: J-4, setting 400 v.
f) Amt. of sampling effort	30 min	30 min	30 min	30 min

g) Species present	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
carp	18	10900	2	2700	6	7300	2	1050
creek chub	2		5		14		1	
hornyhead chub	2		18		1			
central stoneroller	14		17					
blacknose dace	3		7					
bluntnose minnow	4		3		2		21	
fathead minnow	2				17		2	
brassy minnow					18		19	
common shiner	18		92	1500	39		5	
emerald shiner	2							
bigmouth shiner	4				5		2	
sand shiner	16		33		15		40	
spotfin shiner	12		7		18		17	
unkown minnow yoy			1				26	
northern hogsucker	3	600	23	3200				
white sucker			1		3			
shorthead redhorse	2	150	10	1800	9	1900		
golden redhorse							4	1500
bigmouth buffalo					5			
quillback							1	170
channel catfish	4	4650					1	1100
tadpole madtom	1	35	1	42				
stonecat	1		5				1	
green sunfish					1		3	
orangespotted sunfish					1		1	
fantail darter	2		5					
	2				3			
	3				2			
logperch	1		1					
h) Gamefish young-of-year SPECIES:								

Table 44

Date(s): July - September 2000 Stream: Little Cottonwood River

(34) Fishery Characteristics

a) Station No.	5	6	7	8
b) Date	08/18/00	08/18/00	08/28/00	08/18/00
c) Loc. (miles from mouth)	36.6	45.2	59.1	67.9
d) Length of Station	1000 ft	1000 ft.	600 ft.	1000 ft.
e) Gear	Smith-Root Model 12 back pack shocker: J-4, setting 400 v.	Smith-Root Model 12 back pack shocker: J-4, setting 400 - 500v.	Smith-Root Model 12 back pack shocker: J-4, setting 400 v.	Smith-Root Model 12 back pack shocker: J-4, setting 400 v.