Chetek Lakes Watershed 2012 Synoptic Sample Survey Results

Submitted to the Chetek Lakes Protection Association
and the
Barron County Soil & Water Conservation Department

Prepared by:

Dave Blumer: Project Manager/Lake Scientist
Jacob A. Macholl: Lake Scientist
Short Elliott Hendrickson Inc
1701 W. Knapp Street, Suite B
Rice Lake, WI 54868-1350

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1.0 Introduction

The Chetek Lakes are a chain of lakes (Chetek, Ojaski, Prairie, Pokegama, and Tenmile Lakes) in southeast Barron County, Wisconsin created by the impoundment of Pokegama Creek, Moose Ear Creek, and Tenmile Creek. The Chetek Lakes are on the 303(d) list of impaired waters due to eutrophication caused by excessive phosphorus. A synoptic water quality survey was completed for analysis of nutrients and other substances to characterize background nutrient, sediment, and pollutant loading in the Chetek Lakes Watershed. The objective of the synoptic sampling was to determine the total amount or load of various nutrients, sediment and pollutants that move past a monitoring station during a particular period of time. To approximate growing season baseflow loads of these constituents, water quality samples were collected during in the early and late part of the growing season and averaged.

The data collected will aid with targeting areas where pollution and erosion are disproportionately severe and the potential for improving water quality and preventing soil loss is disproportionately great. The information collected also provides a snapshot of the watershed to evaluate the effectiveness of management activities over time. Funding for the sample collection was provided by a WDNR lake grant and in-kind volunteer match provided by the Chetek Lakes Protection Association and Barron County provided the funding for data analyses.

2.0 Methods

A total of 29 sites were selected to be sampled in June and September throughout the Chetek Lakes watershed. Sites were selected based on changes in land use/cover in the stream's watershed, accessibility, and distribution about the Chetek Lakes watershed. Sampling was undertaken at least 4 days after rainfall events totaling more than 0.25 inches to ensure baseflow conditions. Mr. Mike Steiner and students from the Chetek Environmental Charter School collected water quality samples and streamflow was measured by SEH using either a SonTek FlowTracker or Marsh-McBirney Flo-Mate velocimeter following the U.S. Geological Survey 6/10 depth method.

Grab samples were collected at the upstream end of a bridge or culvert crossing to avoid the possible effects of roads, bridges, or scour pools on water quality, unless it was safer to sample at the downstream end. The location of sampling with respect to the crossing was documented at each site. The samples were collected just below the water surface at mid-stream. Samples were stored on ice and shipped to the Wisconsin State Lab of Hygiene for analysis of chloride, nitrate+nitrite, ammonia, total Kjeldahl nitrogen, total phosphorus (TP), dissolved reactive phosphorus, and total suspended solids (TSS). The total nitrogen (TN) was calculated as the sum of the total Kjeldahl nitrogen, ammonia, and nitrate+nitrite. Results reported as below detection limits were substituted with one-half the detection limit for analysis. Stream flow measurements were taken at the time of sample collection using the float method and using a flow meter following the 0.6-depth method.

Reference concentrations, also referred to as background (natural) or potential (obtainable) water quality concentrations, for TP and TN in Wisconsin have been developed by Robertson and others (2006). Values for environmental phosphorus zone (EPZ) 1, in which the Chetek Lakes Watershed is located, were compared to the concentrations measured during the synoptic survey. The median reference concentration was used as the reference (background) concentration, and 75th and 90th percentiles for EPZ 1 were used to categorize concentrations from moderate to excessive.

Calculating the loads requires streamflow data, pollutant concentration data, and a timeframe. For this investigation, data from each sampling event were converted to loads of pounds per day and averaged. The load in pounds per day was computed by multiplying product of the concentration in mg/L and the flow in cubic feet per second by a conversion factor of 5.3938.

The unit area load, or yield, is used to compare the pollutant runoff from different watersheds and is used to identify critical areas for pollutant load reduction consideration. The yield is calculated by dividing the load by the watershed area. For example, the growing season TSS load from site CW-28 (Tenmile Creek at Co. Rd. D) is 11,977 pounds and the load from CW-17 (Moose Ear Creek at Co. Rd. D) is larger at 17,581 pounds; however, the yield from CW-28 is 0.99 pounds per acre, higher than that of CW-17 which has a yield of 0.73 pounds per acre. This indicates that a larger mass of TSS is passing the CW-17 site, but the mass of TSS entering the stream per acre of land is greater in the CW-28 watershed. In this example, CW-28 would take priority for TSS reduction activities.

Yields for prioritizing individual segments of drainage areas (the area between two monitoring sites) were calculated by subtracting the influent (upstream) station load to obtain a net load. The net load was then divided by the drainage area between the sites. The yields mapped for prioritizing catchments therefore do not show cumulative impact from upstream activities. It is possible to have negative net loads for a subwatershed segment using this approach when downstream loads are less than upstream loads. Negative load values can represent measurement errors, residual effects of data censoring, or an actual net loss of constituents within the subwatershed.

3.0 Results and Discussion

Synoptic sample surveys were conducted in June and September of 2012 in the Chetek Lakes Watershed. The location of the sample sites and a description of the site location are shown in Figure 1 and Table 1, respectively. Of the 29 sample sites selected, two sites (CW-16 and CW-27) during the June sample round and 3 sites (CW-16, CW-19, and CW-27) during the September sample round had no flow and therefore were not sampled. Summary statistics of the June and September synoptic sample events are shown in Table 2 and Table 3, respectively. The water quality data from the June and September synoptic surveys, data analyses, and GIS data developed for this report can be found in Attachment 1-Digital Data.

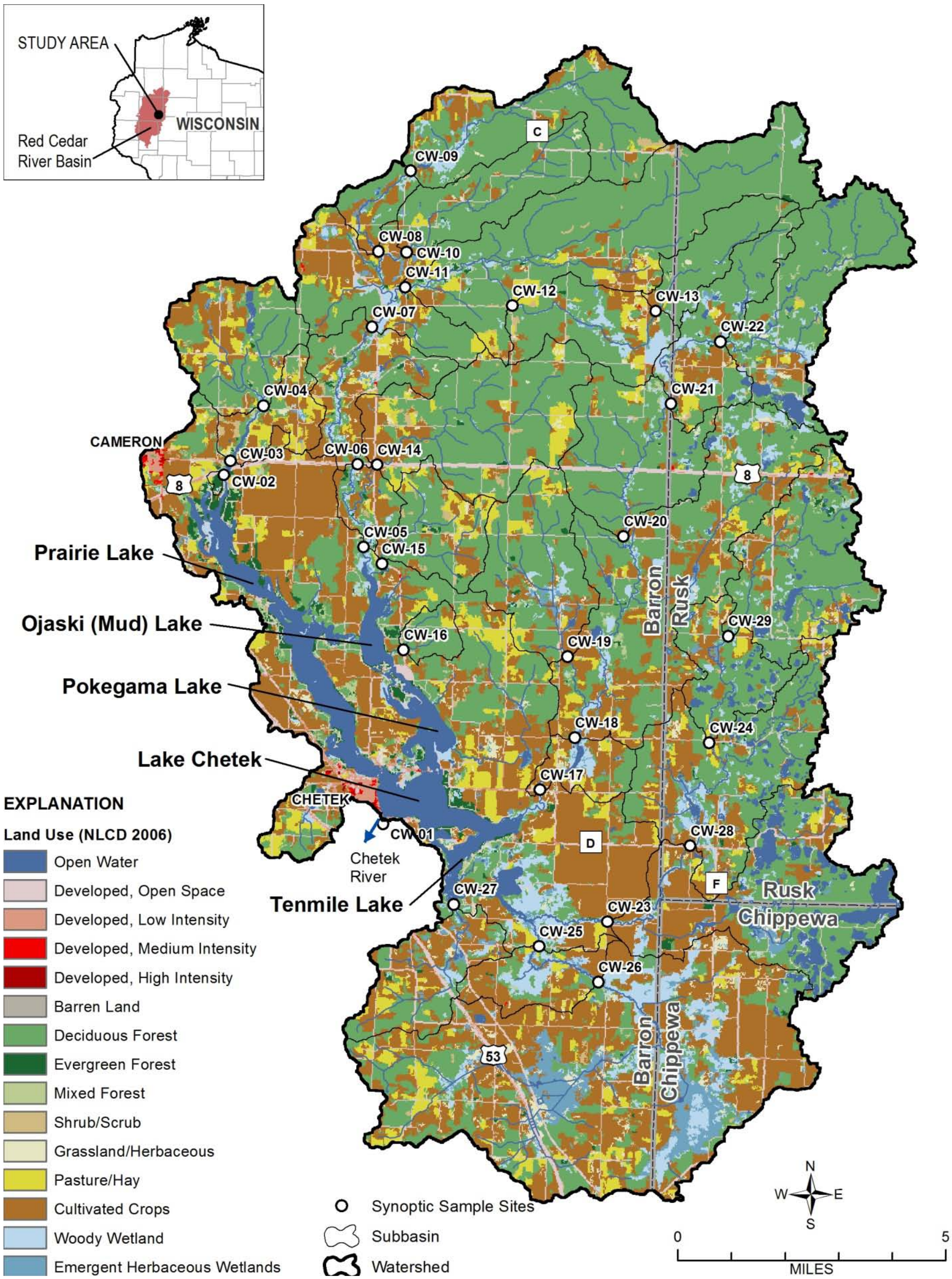

Figure 1. Summer 2012 synoptic sample site locations in the Chetek Lakes Watershed.

Table 1. Summer 2012 synoptic sample site locations.

Station ID	Station Name	Latitude	Longitude	County
CW-01	Chetek Rv below Chetek Dam (upstream of WWTP)	45.311133	-91.647946	Barron
CW-02	Unnamed Spring at 21-1/2 Street	45.404509	-91.711769	Barron
CW-03	Rice Ck at Hwy 8	45.408332	-91.709501	Barron
CW-04	Rice Ck upstream of 15th Avenue	45.42346	-91.69715	Barron
CW-05	Pokegama Ck at 12-3/4 Avenue	45.385783	-91.657612	Barron
CW-06	Pokegama Ck at Hwy 8	45.408158	-91.660498	Barron
CW-07	Pokegama Ck at Co Rd M	45.445319	-91.656052	Barron
CW-08	Pokegama Ck at 18th Avenue	45.465814	-91.654261	Barron
CW-09	Pokegama Ck downstream of 25th Street	45.487804	-91.64249	Barron
CW-10	Silver Ck at 18th Avenue	45.465719	-91.643466	Barron
CW-11	Rock Ck downstream of 25th Street	45.456245	-91.643684	Barron
CW-12	UT to Rock Ck at 27th Street	45.451834	-91.602472	Barron
CW-13	UT to Rock Ck at 17th Avenue	45.451102	-91.54738	Barron
CW-14	German Ck at Hwy 8	45.4081	-91.65298	Barron
CW-15	UT to Ojaski Lk (N) at Co Rd M	45.381397	-91.650553	Barron
CW-16	UT to Ojaski Lk (S) at Co Rd M	45.35818	-91.641508	Barron
CW-17	Moose Ear Ck at Co Rd D	45.321062	-91.588163	Barron
CW-18	Moose Ear Ck at 9th Ave	45.335411	-91.575223	Barron
CW-19	UT to Moose Ear Ck at 10-1/2 Ave	45.357231	-91.578578	Barron
CW-20	Moose Ear Ck at 12-3/4 Avenue	45.390064	-91.558051	Barron
CW-21	Moose Ear Ck at County Line Rd (30th St)	45.426149	-91.54081	Rusk
CW-22	Moose Ear Ck downstream of Log Cabin Road	45.443233	-91.52225	Rusk
CW-23	Tenmile Ck at 29th Street	45.28577	-91.56132	Barron
CW-24	Tenmile Creek at Hogsback Rd	45.334732	-91.5236	Rusk
CW-25	Beaver Ck at 5th Avenue	45.278712	-91.587338	Barron
CW-26	Beaver Ck at 29th Street	45.269397	-91.564405	Barron
CW-27	Short Ck at 6th Avenue	45.28971	-91.62035	Barron

UT = Unnamed tributary

Table 2. Summary statistics for water samples from the Chetek Lakes Watershed, June 2012.

Constituent	Units	Limit of Detection	Samples censored	Minimum	Mean	Median	Maximum
Chloride	mg/L	1.0	0	1.3	3.7	3.6	6.9
Ammonia	mg/L	0.015	0	0.017	0.045	0.034	0.177
Nitrate + nitrite	mg/L	0.019	5	0.01	0.717	0.154	3.330
Total Kjeldahl nitrogen	mg/L	0.14	0	0.16	0.63	0.51	1.73
Total nitrogen	mg/L	n.a.	5	0.30	1.39	1.13	3.93
Total phosphorus	µg/L	5	0	47	140	128	446
Dissolved orthophosphate	µg/L	2	1	1	75	62	347
Total suspended solids	mg/L	2	3	1	5	3	39

Table 3. Summary statistics for water samples from the Chetek Lakes Watershed, September 2012.

Constituent	Units	Limit of Detection	Samples censored	Minimum	Mean	Median	Maximum
Chloride	mg/L	1.0	0	1.8	4.6	4.3	8.2
Ammonia	mg/L	0.015	10	0.008	0.059	0.019	0.775
Nitrate + nitrite	mg/L	0.019	6	0.01	0.975	0.284	4.530
Total Kjeldahl nitrogen	mg/L	0.14	5	0.07	0.43	0.25	2.69
Total nitrogen	mg/L	n.a.	10	0.12	1.46	0.72	5.22
Total phosphorus	µg/L	5	0	27	123	88	442
Dissolved orthophosphate	µg/L	2	0	9	64	31	342
Total suspended solids	mg/L	2	16	1	3.6	1	18

3.1 Chloride

Chloride is an indicator of human activities due to its low natural concentrations. A combination of road salt, fertilizer use, and septic system effluent are likely sources of elevated chloride concentrations. Because chloride is relatively un-reactive in the environment, is used throughout the watershed, and development increases in a downstream direction, it is expected that the chloride load will also increase in a downstream direction. This was the case in the Chetek Lakes Watershed and therefore net load decreases in other constituents (which coincide with chloride load increases) are assumed to represent an actual net loss, for example via biological activity or sedimentation, rather than a measurement error. A negative total suspended solids net load value for a subwatershed segment suggests sedimentation (deposition) is occurring. The negative nutrient net load from the Chetek Lakes suggests nutrients are being utilized in the lake trophic system. The chloride concentrations found during this study are not problematic to aquatic organisms. Figure 2 shows the average chloride concentration of the synoptic samples for each site.

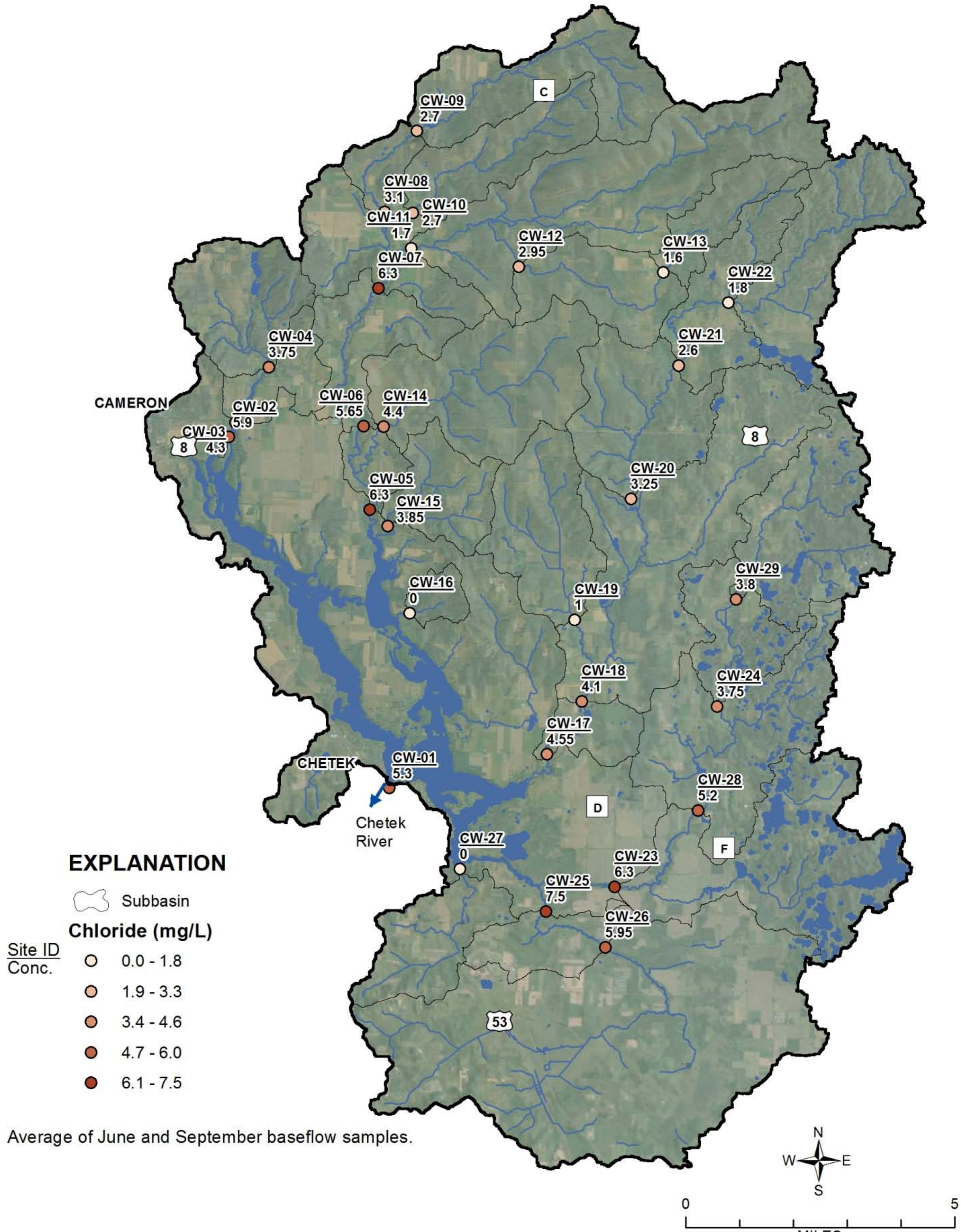

Figure 2. Average chloride concentration at synoptic sites during summer 2012 sampling.

3.2 Total Phosphorus

Total phosphorus concentrations ranged from 47 to 446 µg/L with a median of 128 µg/L for the June sample period and in September ranged from 27 to 442 µg/L with a median of 88 µg/L. Except for CW-07 in September, all of the sample sites had TP above the EPZ 1 median reference concentration of 32 µg/L and the majority had TP above the Wisconsin phosphorus criteria of 75 µg/L for streams. Figure 3 shows the average total phosphorus concentration of the synoptic samples for each site.

3.1 Total Nitrogen

The median TN concentration for the June samples was 1.13 mg/L and ranged from 0.30 to 3.93 mg/L. In September, TN was in general lower throughout the watershed with a median concentration of 0.72 mg/L and a range of 0.12 to 5.22 mg/L. It is common for TN to decrease as the growing season progresses due to plant uptake of nitrogen for growth. TN is elevated in the Chetek Lakes Watershed as the majority of sites in both June and September had TN well above the reference concentration of 0.557 mg/ L for EPZ 1. Three sites had values below 0.557 mg/L in June and 9 sites in September, all of which were fed by forested or headwater watersheds. Figure 4 shows the average total nitrogen concentration of the synoptic samples for each site.

3.2 Total Suspended Solids

Total suspended solids, which includes organic and inorganic materials suspended in the water, ranged from below detection limits (1 mg/L) to 39 mg/L in June and from below detection limits to 18 mg/L in September. The majority of streams during both sample rounds had TSS concentrations below 5 mg/L. Most people consider water with a TSS concentration less than about 20 mg/L to be clear, levels between 40 and 80 mg/L appears cloudy, and concentrations over 150 mg/L appears to be dirty; however, the nature of the particles may cause these numbers to vary. The only numerical limits for TSS are U.S. Environmental Protection Agency rules for municipal sewerage treatments plants, which must meet TSS limits of 30 mg/L as a monthly average and 45 mg/L as a 7-day average. Figure 5 shows the average total suspended solids concentration of the synoptic samples for each site.

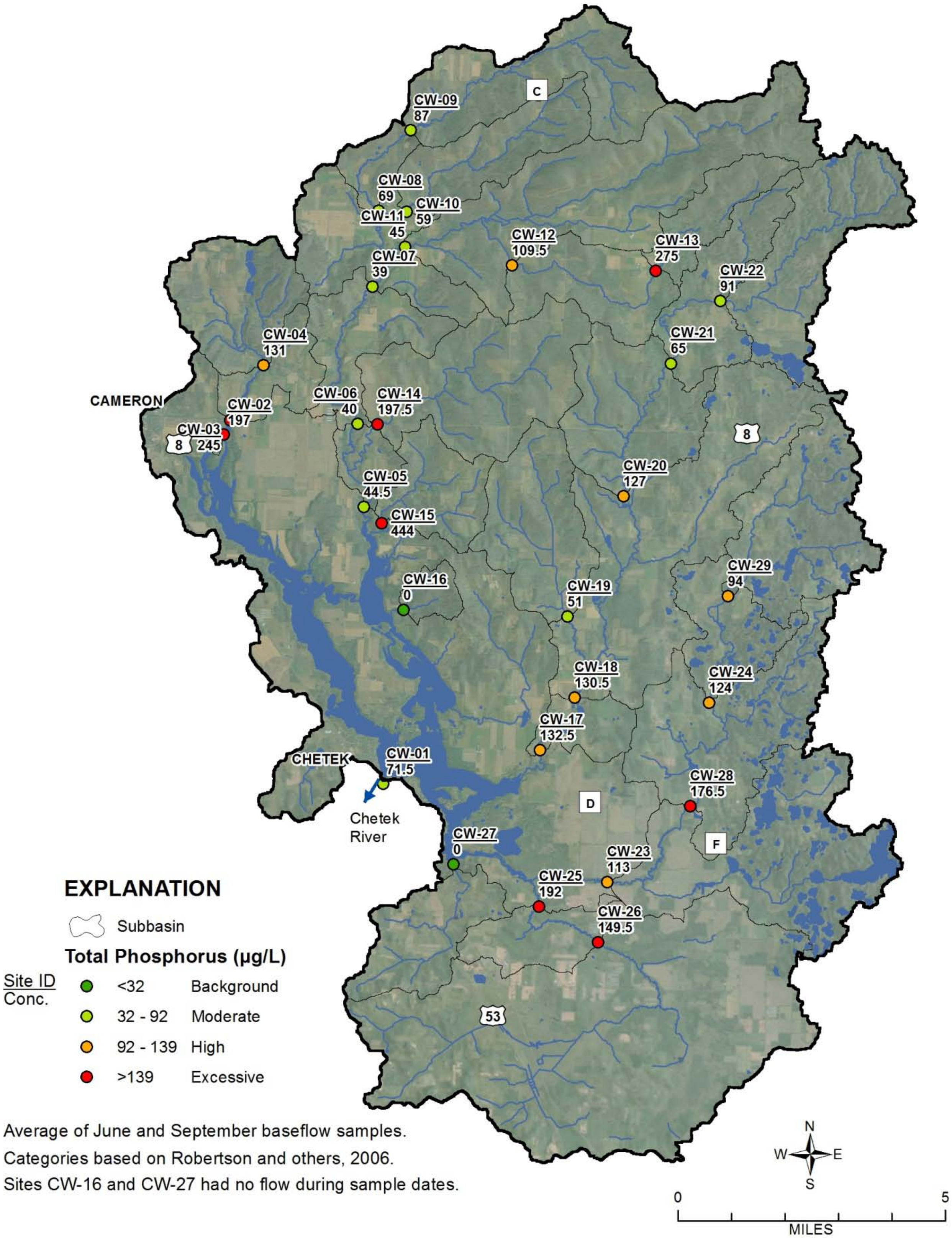

Figure 3. Average total phosphorus concentration at synoptic sites during summer 2012 sampling.

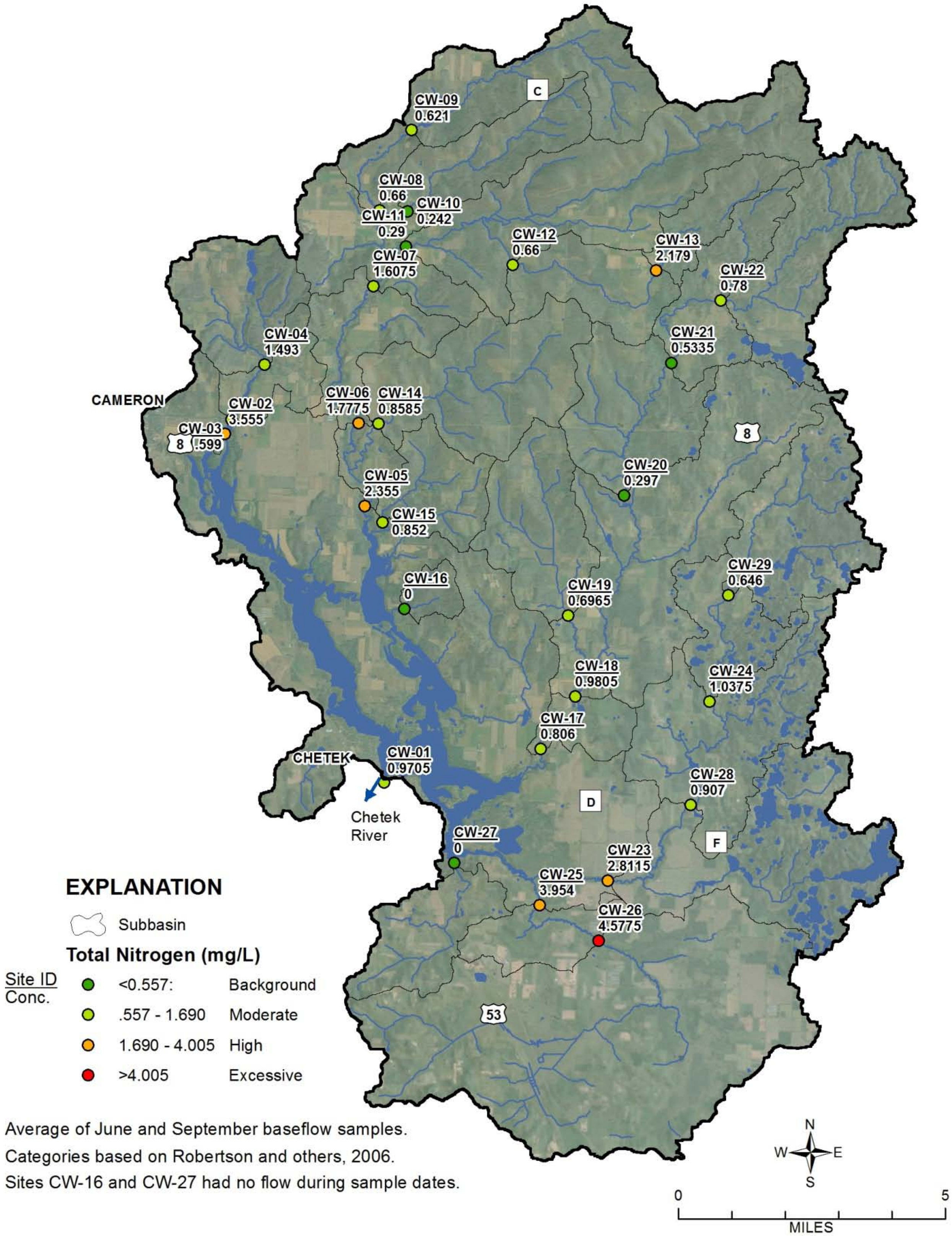

Figure 4. Average total nitrogen concentration at synoptic sites during summer 2012 sampling.

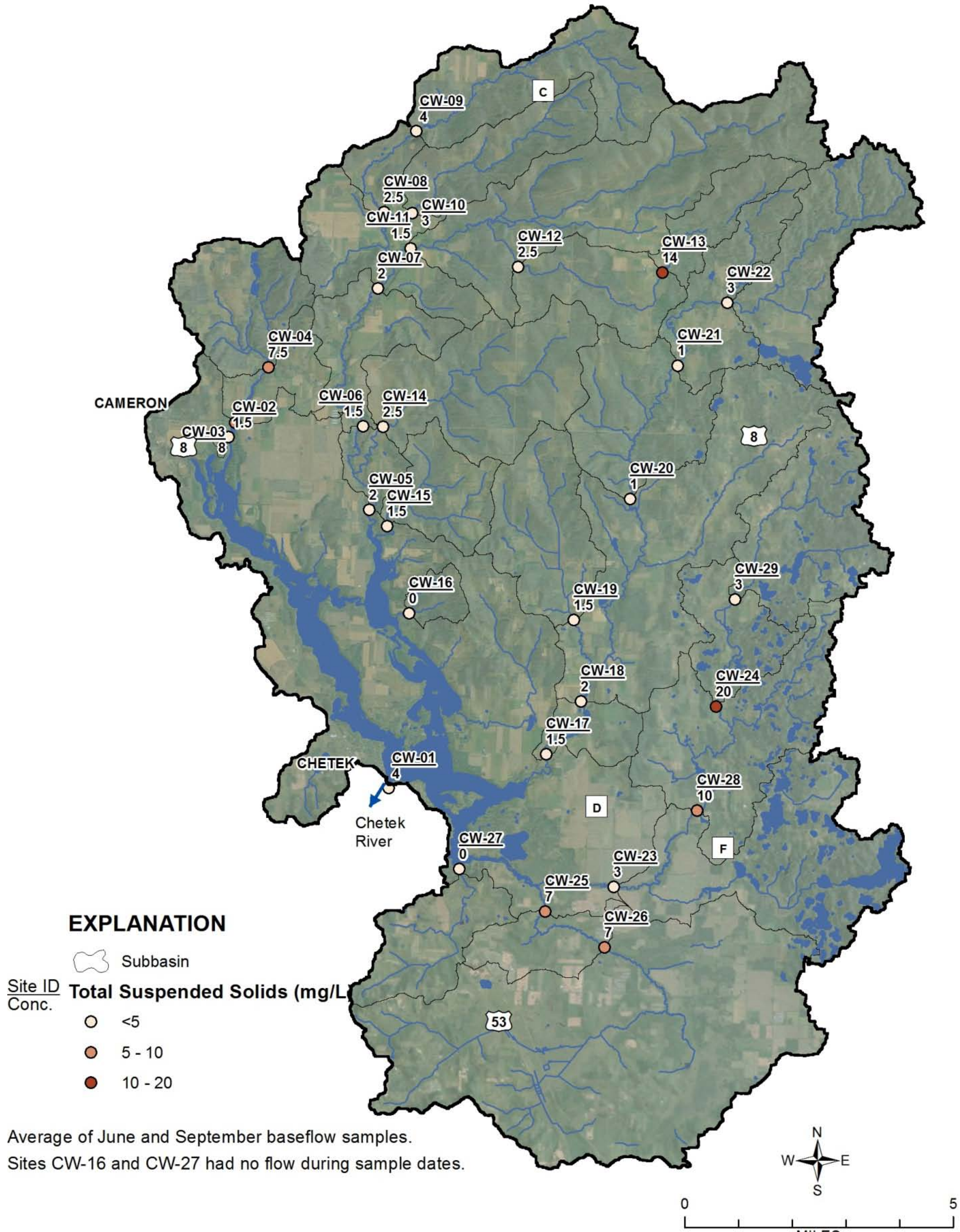

Figure 5. Average total suspended solids concentration at synoptic sites during summer 2012 sampling.

3.3 Flow Conditions

The 2012 growing season had below normal precipitation and baseflow conditions dominated. To estimate hydrologic conditions for the Chetek River, a flow duration curve was created for the Hay River in Wheeler, Wis., a U.S. Geological Service streamflow monitoring station (station number 058368000). The close proximity and similar land use in the Hay River watershed make the monitoring station a good candidate for estimating hydrologic statistics for the Chetek River. A flow duration curve for the Hay River site was created using the mean daily flows and a recurrence interval using the annual peak discharges for the period of record of 1950 – 2011 (Figure 6).

Streamflows corresponding with the synoptic sample dates and streamflow at CW-01 (Chetek River below the Chetek Dam) are highlighted on the flow duration curve in Figure 6. Based on the Hay River at Wheeler flow duration curve, samples in June were collected during mid-range flow conditions and samples in September were collected during dry conditions to low flows. On average, streamflows in September were 49.7 percent lower than streamflows in June.

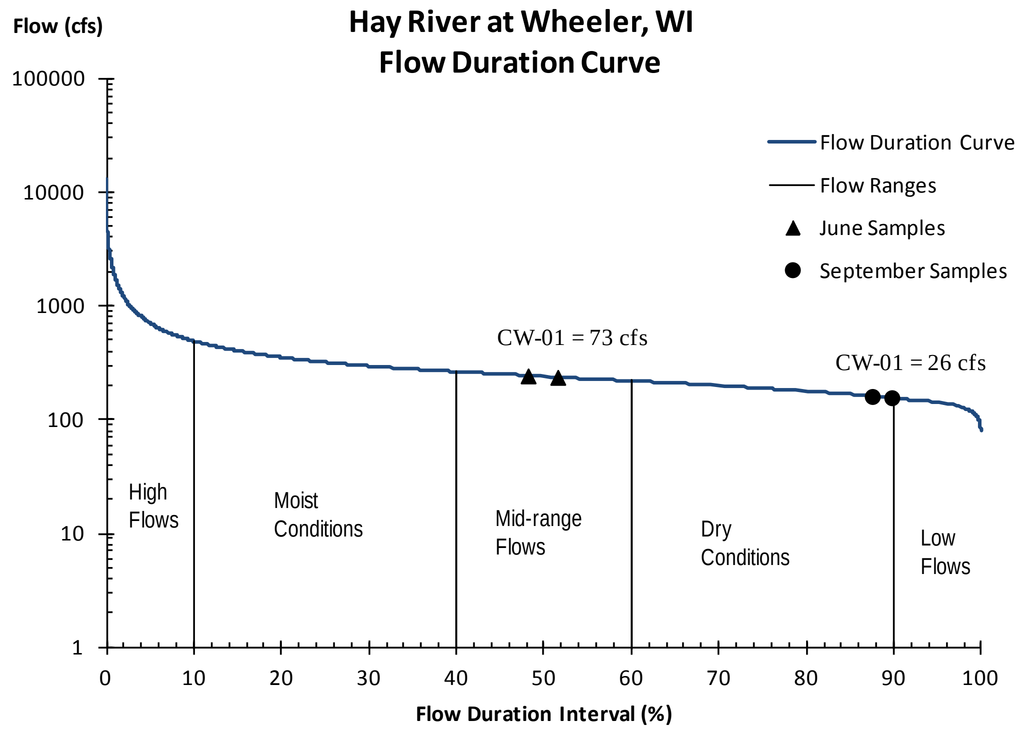

Figure 6. Flow duration curve for Hay River at Wheeler and corresponding synoptic sample dates. The flow at the Chetek Dam (CW-01) is shown.

3.4 Field Observations of Note

CW-01: Pokegama Creek at CTH M. Curly-leaf pondweed (*Potamogeton crispus*), an exotic aquatic plant, was noted in the stream channel during both the June and September sample rounds. A curly-leaf bed is located about 100 yards upstream from the road crossing. Also noted at the site in September was an adult American brook lamprey (*Lampetra appendix*), a non-parasitic lamprey native to Wisconsin.

CW-11: Rock Creek downstream of 25th Street. Cattle were noted in the stream during both sample rounds and the stream banks were trampled (Figure 7). It is evident that the road bridge is used as an underpass for cattle crossing.

CW-13: Unnamed Tributary to Rock Creek at 17th Avenue. Although not present at the time of sampling, it was evident that cattle had access to a large portion of the stream. The stream was widened due to shoreline trampling and trash was noted along the shore.

CW-24: Tenmile Creek at Hogsback Road. Cattle were noted in the stream during the September sample round. Steep banks had trampled and eroding areas. It is evident that the road bridge is used as an underpass for cattle crossing.

Figure 7. Cattle in stream and trampled banks at Rock Creek and 25th Street (CW-11), June 2012.

3.5 Nutrient and Sediment Yields

Prioritization of subwatersheds based on nutrient and sediment concentrations are shown Table 4 and in Figures 8 though 10. Headwater subwatersheds generally had lower total phosphorus yields and the higher yields were primarily in the Rice Creek watershed and the predominantly agricultural Moose Ear Creek and Tenmile Creek watersheds (Figure 8). Total nitrogen yields followed a similar pattern as total phosphorus, but were in general elevated in subwatersheds with larger proportions of row cropping regardless of landscape position (Figure 9).

The negative nutrient yields of the Chetek Lakes direct drainage area (CW-01) is attributed to the lakes acting as nutrient sinks. The daily phosphorus load into the lake was 43.9 pounds in June and 23.6 pounds in September, whereas the load out of the lakes was much lower: 27.8 pounds in June and 10.2 pounds in September. The nitrate load also decreased dramatically from inflow to outflow. In June, the daily load to the lake was 523.4 pounds and 18.4 pounds were exported. The total Kjeldahl nitrogen (organic nitrogen) export was much higher at 517.0 pounds than the load in of 151.2 pounds indicating uptake into the trophic system. The relatively high total suspended solids yield from the Chetek Lakes is attributed to the conversion of the nutrients into algae, which was noted in the samples collected at the Chetek Dam.

Table 4. Prioritization of subwatersheds for BMP evaluation and implementation based on nutrient and sediment yields. Monitoring sites are sorted by total phosphorus priority.

	Total Phosphorus		Total Nitrogen		Total Suspened Solids	
Site	Yield (lb/ac/day)	Priority	Yield (lb/ac/day)	Priority	Yield (lb/ac/day)	Priority
CW-02	0.00847	1	0.15285	1	0.0654	4
CW-03	0.00414	2	0.02145	5	0.1083	2
CW-17	0.00194	3	0.00011	26	-0.0068	28
CW-25	0.00184	4	0.02759	3	0.0467	5
CW-05	0.00177	5	0.12303	2	0.1243	1
CW-23	0.00099	6	0.02628	4	-0.0022	25
CW-28	0.00085	7	0.00173	12	-0.0121	29
CW-04	0.00053	8	0.00603	8	0.0300	6
CW-20	0.00048	9	0.00020	21	0.0028	15
CW-24	0.00038	10	0.00370	10	0.0929	3
CW-18	0.00038	11	0.00426	9	0.0089	9
CW-15	0.00030	12	0.00067	17	0.0012	19
CW-06	0.00026	13	0.01640	6	-0.0001	24
CW-07	0.00016	14	0.01397	7	0.0131	8
CW-22	0.00015	15	0.00138	13	0.0044	13
CW-26	0.00013	16	0.00337	11	0.0058	11
CW-08	0.00013	17	0.00116	14	0.0052	12
CW-13	0.00012	18	0.00081	15	0.0084	10
CW-29	0.00011	19	0.00072	16	0.0043	14
CW-09	0.00005	20	0.00048	18	0.0025	16
CW-14	0.00005	21	0.00022	20	0.0007	20
CW-12	0.00004	22	0.00016	24	-0.0024	26
CW-11	0.00004	23	0.00035	19	0.0019	17
CW-10	0.00003	24	0.00013	25	0.0018	18
CW-21	0.00003	25	0.00017	23	-0.0035	27
CW-19	0.00001	26	0.00017	22	0.0004	21
CW-27	0	27	0	27	0	22
CW-16	0	28	0	28	0	23
CW-01	-0.00058	29	-0.01072	29	0.0205	7

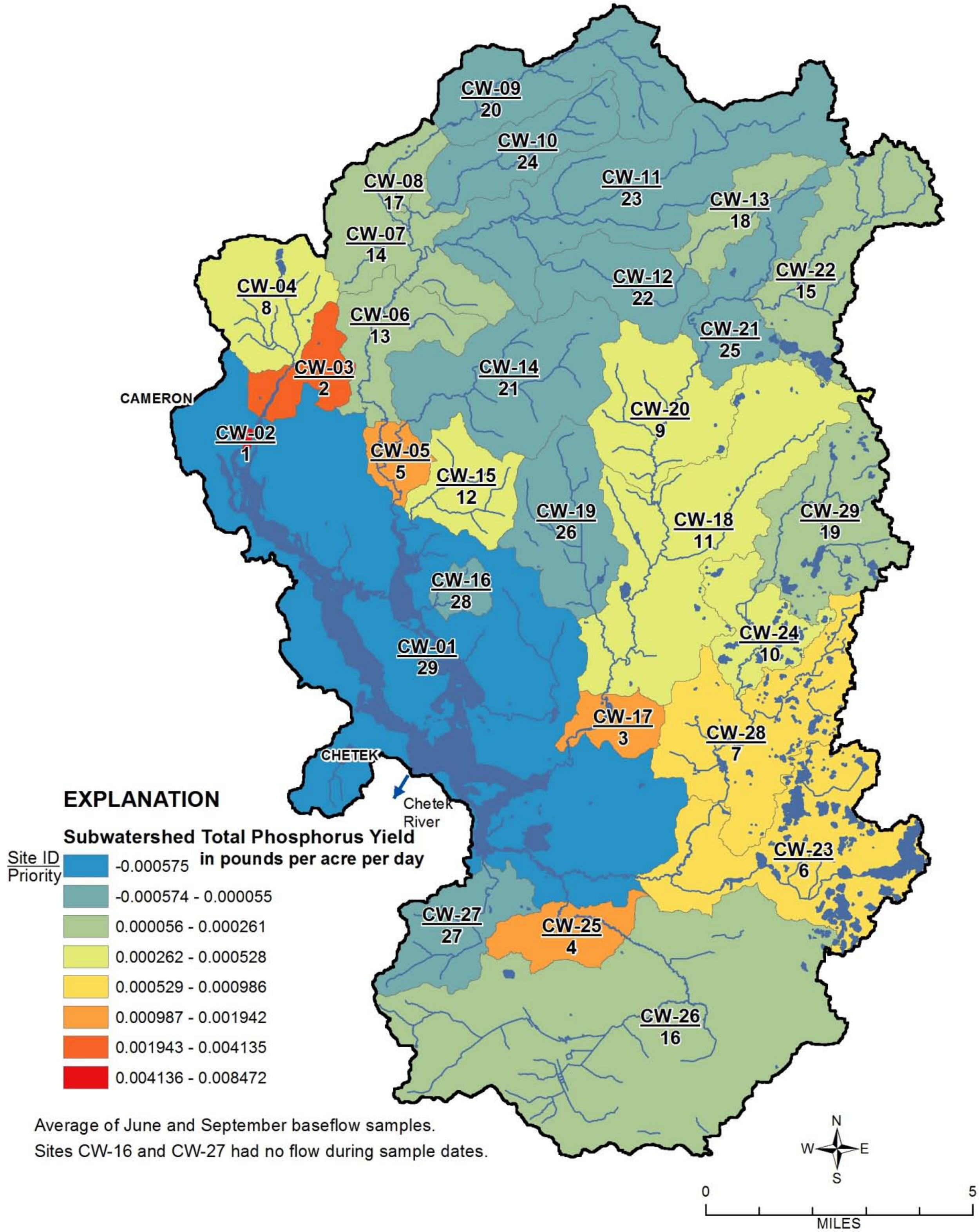

Figure 8. Daily total phosphorus yields in subwatersheds of the Chetek Lakes watershed.

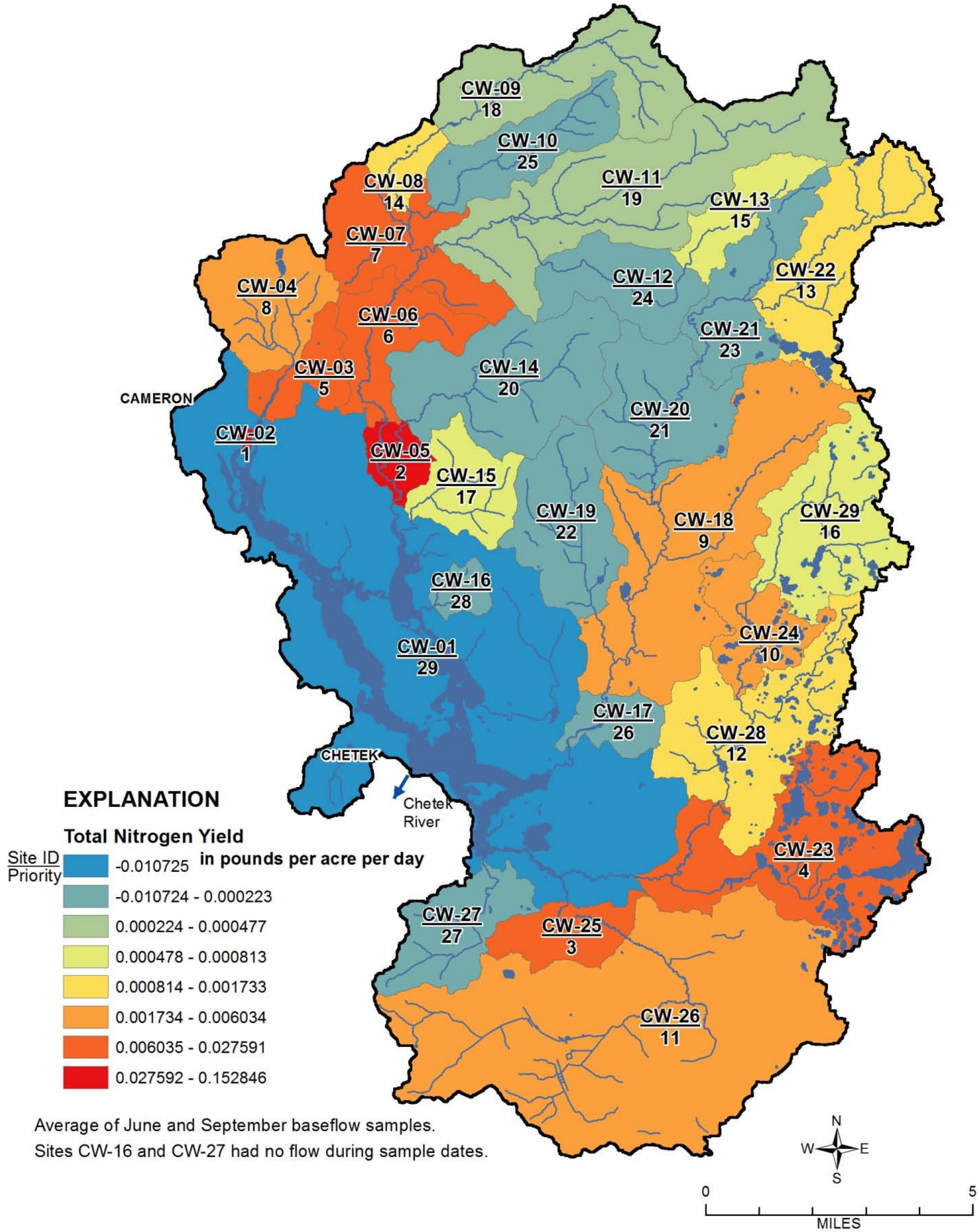

Figure 9. Daily total nitrogen yields in subwatersheds of the Chetek Lakes watershed.

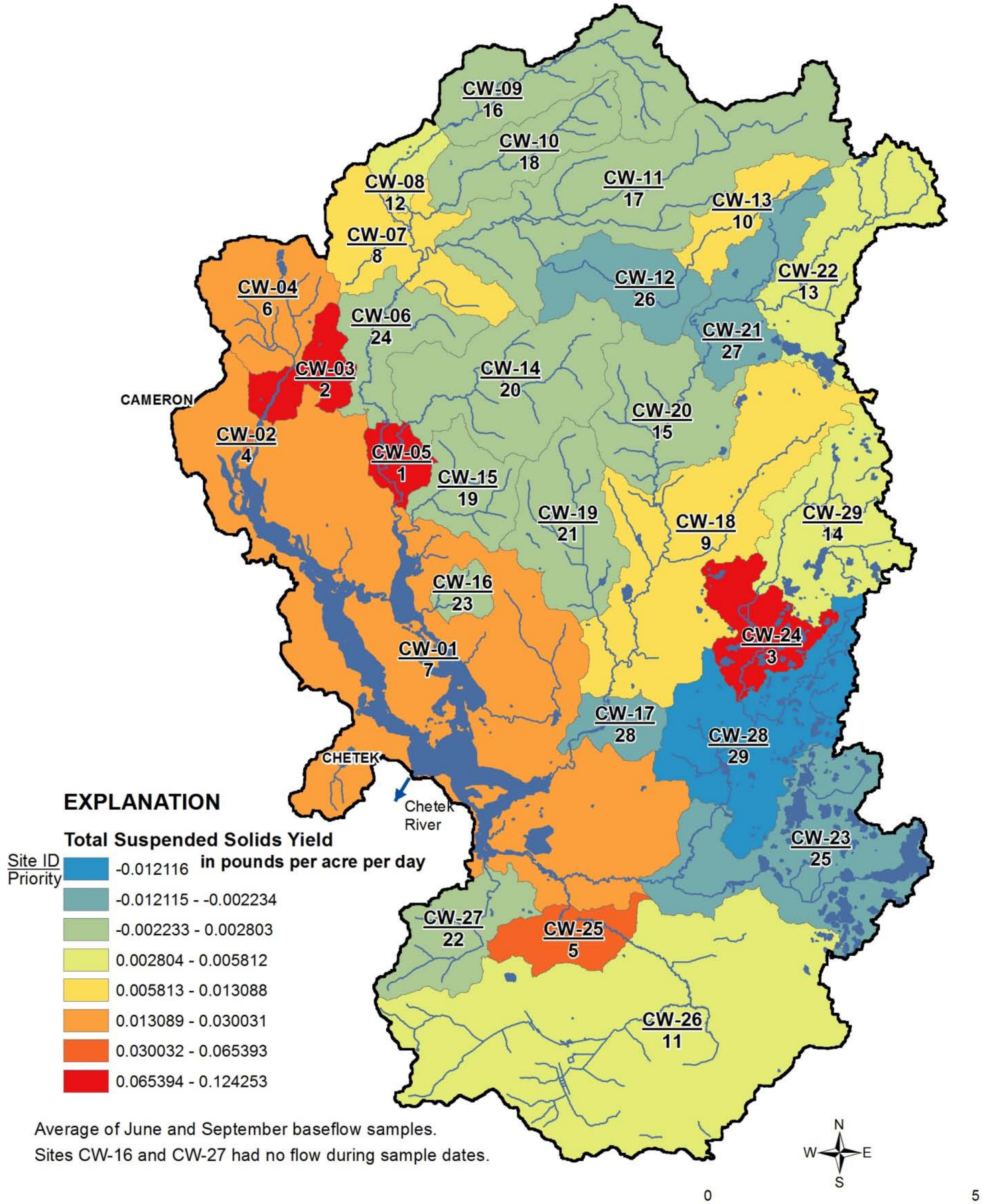

Figure 10. Daily total suspended solids yields in subwatersheds of the Chetek Lakes watershed.

4.0 Recommendations

The information collected during the synoptic surveys can be used to examine sources of nutrients to the lakes and explore management options. Because phosphorus limits production in the Chetek Chain of Lake during most of the growing season, implementation of BMPs should follow subwatershed ranking based on primarily on total phosphorus yields, that is, areas providing the most phosphorus should be evaluated first. Practices that should be evaluated for implementation that would benefit the Chetek Chain of Lakes and their watershed include grassed waterways, fencing livestock out of streams, nutrient management planning, manure management, and cover cropping.

The utilization of nutrients in the lakes is likely shadowing the loading from the primarily developed landscape in the direct drainage area. Because of its close proximity and direct impact to the lakes, the direct drainage area is also high priority for residential and agricultural non-point source BMPs. Monitoring site CW-13 had elevated nutrient and sediment concentrations (likely due to the cattle access to the stream) and should be a high priority for BMP implementation.

Site CW-02 a groundwater spring with a forested surface watershed, was found to have very high nutrient yields. This, coupled with the high nutrient concentrations measured throughout the watershed during this baseflow study, indicates that the landscape is well saturated with nutrients to the level where groundwater quality is affected. It is therefore important for BMP selection to be undertaken that also considers groundwater quality.

Other desktop analyses can further refine prioritization. For example, a GIS can be used to rank the subwatersheds based on soil loss characteristic (e.g., RUSLE K-factor) and runoff generating characteristics (e.g. RUSLE LS-factor). This additional information can be combined with yield and load data to develop an existing conditions model and further prioritize subwatersheds.

Field reconnaissance of the target subwatersheds should be completed to verify boundary delineations and existing BMPs, to identify optimal sites for specific BMPs and identify previously undetected treatment options, and to take site-specific notes for each potential BMP. The field recon data should be entered into a GIS for data management and tracking.

A treatment and costs analysis should be performed following the field recon. This entails quantifying pollutant removal for potential BMPs (using spreadsheets, RUSLE c-factor modification, or other methods) and estimating project costs for construction, planning and design, maintenance, and outreach. Once a cost analysis has been completed, grant funding should be sought for implementation using the catchment and cost analysis reports as primary references.

References

U.S. Environmental Protection Agency, 2000. Ambient water quality criteria recommendations—Information supporting the development of state and tribal nutrient criteria: rivers and streams in nutrient ecoregion VII. U.S. Environmental Protection Agency Office of Water Report EPA 822-B-00-018, 28 p. and 3 appendices.