SOUTHERN CREEKS IN MANITOWOC COUNTY WATER QUALITY COMPARISON, 2010 – 2015

INTRODUCTION
The purpose of this report is to summarize the water quality data collected from five creeks in southern Manitowoc County. The creeks were sampled during the summers of 2010-2015. In general, there were differences between baseflow and rain events with higher turbidity, nutrient, and bacteria following rain events. For all water quality parameters, significant differences were seen between the creeks at baseflow levels, however only for *E. coli* did the creeks separate into distinct groups. For stormflow events, the creeks were not significantly different for any water quality parameters, although the values were higher than baseflow conditions. This suggests that runoff from the watershed during rain events is impacting the water quality of the creeks in southern Manitowoc County.

STUDY AREA
The study area covers five watersheds in southeastern Manitowoc County. The watersheds are Calvin, Pine, Point, Fischer, and Centerville (Figure 1). The Calvin Creek and Centerville watersheds are the smallest in area at less than 20 square kilometers. The Point Creek watershed is the largest, covering 56.4 square kilometers (Table 1). In all five creeks the majority of the land is covered in cultivated crops or pasture/hay, with Calvin the lowest at 67% and Fischer the highest at 82% (Tables 2 and 3, Figures 2 and 3).

Table 1. Area and length of the five Southern Manitowoc County creeks sampled in this study.

Site	Area (mile^2)	Length (miles)	Area (km^2)	Length (km)
Calvin	7.2	7.1	18.7	11.5
Centerville	7.4	9.8	19.1	15.7
Fischer	11.5	18.8	29.8	30.3
Pine	10.9	15.1	28.2	24.3
Point	21.8	28.6	56.4	46.0

Table 2. Percentage of type of land use for each creek in the study, 2011.

Code	Class	Calvin	Centerville	Fischer	Pine	Point
11	Open Water	1.30	0.40	0.16	0.33	0.12
21	Developed, Open Space	3.77	6.12	3.26	3.32	3.60
22	Developed, Low Intensity	4.43	7.44	1.96	4.29	2.46
23	Developed, Medium Intensity	0.57	2.15	0.21	0.69	0.27
24	Developed High Intensity	0.11	0.31	0.01	0.17	0.06
31	Barren Land (Rock/Sand/Clay)	0.10	0.16	0.28	0.18	0.16
41	Deciduous Forest	3.25	5.91	5.56	3.34	4.08
42	Evergreen Forest	0.00	0.21	0.09	0.03	0.01
43	Mixed Forest	0.27	0.19	0.44	0.20	0.43
52	Shrub/Scrub	1.74	0.20	0.39	0.69	0.37
71	Grassland/Herbaceous	1.54	0.64	0.39	0.59	0.42
81	Pasture/Hay	**42.08**	**30.62**	**34.08**	**36.57**	**32.47**
82	Cultivated Crops	**26.86**	**40.57**	**48.21**	**42.92**	**47.69**
90	Woody Wetlands	**13.53**	**4.99**	**4.46**	**6.22**	**6.76**
95	Emergent Herbaceous Wetlands	0.46	0.08	0.50	0.45	1.09

Table 3. Percentage of type of land use, broken into larger categories, for each creek in the study, 2011.

Class	Calvin	Centerville	Fischer	Pine	Point
Open water (11)	1.30	0.40	0.16	0.33	0.12
Developed (21,22,23,24)	8.88	16.02	5.44	8.47	6.40
Natural (31,41,42,43,52,71)	6.89	7.31	7.14	5.03	5.46
Wetland (90,95)	13.99	5.08	4.96	6.67	7.85
Agriculture (81,82)	68.93	71.19	82.29	79.49	80.16

Source: National Land Cover Database. http://www.mrlc.gov/nlcd11_data.php

METHODS

Student interns working with faculty at UW Manitowoc collected water samples during the summers of 2010, 2011, 2012, 2013, 2014, and 2015. Samples were taken weekly from late May through the end of August (Baseflow). Samples were also taken following rain events greater than a half inch at both 24 and 48 hours (Table 4). Rain event sample dates are "stormflow" while non-rain event sample dates are "baseflow" in this report.

Water quality samples were collected at 11 sites across the 5 creeks. There were two sites on Calvin, Fischer, Point, and Pine Creeks. Centerville Creek had ten total sampling sites, three on the Main Branch, four on the North Branch, and three on the South Branch of the creek. All sampling was done in the area between I-43 and Lake Michigan. Weekly averages were calculated for each stream and each branch of Centerville creek for baseflow and stormflow. These averages were used to test for differences between the streams in the water quality variables.

Physical indicators were measured by field probes

- Dissolved Oxygen (YSI 550A DO Probe)
- Temperature/pH
- Turbidity (LaMotte 2020 we)
- Stream Velocity (Global Water Instrumentation, Inc)
- Conductivity

Nutrient indicators

- Ammonia (NH_3/NH_4) measured with Hach field kit for Ammonia Nitrogen
- Total Orthophosphate (TP) and Total Dissolved Phosphate (TDP)
- Acid hydrolysis with H_2SO_4
- Colorimetric analysis via ammonium molybdate-stannous chloride method

Biological Indicators

- E. coli fecal coliform analysis (Colilert-24)

Statistical Analysis

Statistical analyses were completed on data collected from 2012 to 2015. Analyses were not included for 2010 and 2011 because the only data available was from Centerville Creek. These data have been analyzed in a previous report.

Differences between the creeks, including the three separate branches of Centerville Creek, were tested for differences in baseflow and stormflow data separately. Mean weekly values for each creek were tested using a blocked Analysis of Variance (ANOVA). The block design allowed for testing over all four years at once, with difference in each weekly block used for the ANOVA. When significant differences were indicated by the ANOVA, a Tukey-Kramer post-hoc test was used to determine the differences between streams. All statistical analyses were done in JMP Pro Version 11 (SAS Institute Inc., Cary, NC). Mapping and watershed analysis completed using ArcMap Version 10.1 (ESRI, Redlands, CA).

Table 4. Number of weeks sampled each summer in the creeks of Southern Manitowoc County. Storm events are rainfalls greater than a half inch, sampled at both 24 and 48 hours.

Creek	Year	# Baseflow Sample Weeks	# Stormflow Sample Weeks	Total # Sample Weeks	# Baseflow Sample Days	# Stormflow Sample Days	Total # Sample Days
Calvin	2012	14	3	17	27	6	33
	2013	12	0	12	26	0	26
	2014	13	6	19	26	10	36
	2015	10	9	19	22	18	40
Centerville	2010	9	3	12	45	14	59
	2011	6	7	13	42	49	91
	2012	14	6	20	127	52	179
	2013	12	0	12	134	0	134
	2014	13	6	19	148	52	200
	2015	10	9	19	110	90	200
Fischer	2012	14	3	17	28	6	34
	2013	12	0	12	26	0	26
	2014	13	6	19	26	11	37
	2015	10	9	19	22	18	40
Pine	2012	14	3	17	28	6	34
	2013	12	0	12	26	0	26
	2014	13	6	19	26	11	37
	2015	10	9	19	22	18	40
Point	2012	14	3	17	28	6	34
	2013	12	0	12	26	0	26
	2014	13	6	19	26	11	37
	2015	10	9	19	22	18	40

RESULTS

Temperature

- Water temperature influences both biological activity and growth, including fish, insects, zooplankton, and phytoplankton have a preferred temperature range in which they thrive (USGS 2015).
- Water temperature also influences water chemistry, especially dissolved oxygen, which have a lower capacity to hold oxygen at higher temperatures (USGS 2015).
- Baseflow temperatures were significantly different by branch and river ($p<0.0001$). Temperatures in Pine Creek and Fischer Creek were significantly different from each

other and the other creeks. The branches of Centerville, Calvin, and Point Creek had similar temperatures (Table 5 and Figure 5).

- Baseflow temperatures were significantly different by week ($p<0.0001$). Variation of temperature between the weeks, seasons, and years is playing a large role in creek temperature.
- Stormflow temperatures were significantly different by branch and river ($p<0.0001$). While the stormflow temperatures were significantly different between Calvin and Pine Creek, none of the other creeks were different from one another (Table 6 and Figure 6).

Table 5. Average baseflow temperature (^{o}C) for 2012 – 2015 at the southern Manitowoc County Creeks. The letters in Column 2 are the results of the ANOVA analysis, where sites connected by the same letter are not significantly different.

Level					Mean ^{o}C
CE Main	A				18.673611
Calvin	A	B			18.418750
Point	A	B			18.406250
CE South		B			17.935417
CE North		B			17.895313
Pine			C		16.963542
Fischer				D	16.215625

Table 6. Average stormflow temperature (^{o}C) for 2012 – 2015 at the southern Manitowoc County Creeks. The letters in Column 2 are the results of the ANOVA analysis, where sites connected by the same letter are not significantly different.

Level				Mean ^{o}C
Calvin	A			18.509259
Point	A	B		18.058519
Pine	A	B		17.847778
CE South	A	B		17.803086
CE North		B	C	17.697222
CE Main		B	C	17.469136
Fischer			C	16.951296

Turbidity

- Turbidity is defined as the presence of suspended solids in water (Lind 19) and is reported in NTU. Lower turbidity levels mean that the water is clearer, which generally means there is better water quality.
- In general, average baseflow turbidity levels were lower than average stormflow turbidity levels in all creeks over all sample years (Figures 7 and 8).
- In 2015, both average baseflow and average stormflow turbidity levels in all creeks were lower than levels in 2013 and 2014.

- Point Creek 02 (PO02), further downstream than Point Creek 03 (PO03), was an outlier and had extremely high turbidity levels at a rain event in June 2014 and baseflow levels in July 2014.
- Baseflow turbidity levels were significantly different by creek (and branch of Centerville) ($p<0.0001$). Centerville North branch was significantly different from Fischer creek, there was a gradient along the other creeks that were not significant from one another (Table 7).
- Baseflow turbidity levels were significantly different by week ($p<0.0001$), as turbidity levels were variable over seasons and years (Figure 9).
- Stormflow turbidity levels were similar between all creeks ($p=0.3168$) and were significant by week ($p=0.0002$), showing variance over time (Figure 10).

Table 7. Average turbidity levels (NTU) for baseflow, separated by creek or branch. The letters in Column 2 are the results of the ANOVA analysis, where sites connected by the same letter are not significantly different.

Level				**Mean**
CE North	A			12.035260
Calvin	A	B		11.309167
CE Main	A	B		9.720069
Pine	A	B	C	7.153125
CE South		B	C	6.965625
Point		B	C	6.305521
Fischer			C	3.597500

Total Phosphorus

- Phosphorus is an essential nutrient for both aquatic plants and animals. In most fresh water systems, phosphorus is often the nutrient in lowest concentrations. Therefore, even a small increase in phosphorus can cause “accelerated plant growth, algae blooms, low dissolved oxygen levels, and the death of certain fish, invertebrates, and other aquatic animals” in streams, rivers, and lakes (EPA 2015).
- There are natural (soil and rocks) and human sources of phosphorus, including, wastewater treatment plants, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas, disturbed land areas, drained wetlands, and water treatment (EPA 2015).
- Total phosphorus concentrations measure all forms of phosphorus in the water and is the sum of the soluble phosphorus (PO_4; dissolved phosphorus) and particulate phosphorus (Horne & Goldman 155). Soluble phosphorus is the amount of phosphorus available for plants and algae to take up.
- For this report, total phosphorus levels were analyzed and are reported in mg/L.

- In Wisconsin, small streams and rivers are considered impaired if total phosphorus levels exceeds 0.075 mg/L. Large rivers, such as the Fox River, are considered impaired at 0.1 mg/L (NR 102.06 (3) WDNR).
- Overall, all years and all creeks have baseflow total phosphorus concentrations greater than 0.075 mg/L.
- For all creeks, baseflow total phosphorus concentrations in 2012 and 2013 were less variable than total phosphorus concentrations in 2014 and 2015 (Figure 11).
- In general, baseflow total phosphorus levels for all three branches of Centerville Creek and Calvin Creek had higher total phosphorus levels than the other creeks.
- In general, stormflow total phosphorus levels in 2010, 2011, and 2012 were less than those levels in 2014 and 2015 (Figure 12).
- Baseflow total phosphorus levels were significantly different by branch and creek ($p<0.0001$). The three Centerville branches were significantly different from Fischer Creek, there was a gradient along the other creeks that were not significant from one another (Table 8).
- Baseflow total phosphorus levels were significantly different by week ($p<0.0001$), as total phosphorus levels were variable over seasons and years (Figure 13).
- Stormflow total phosphorus levels were similar between all creeks ($p=0.1836$) and were significant by week ($p<0.0001$), showing variance over time (Figure 14).

Table 8. Average total phosphorus levels (mg/L) for baseflow, separated by creek or branch. The letters in Column 2 are the results of the ANOVA analysis, where sites connected by the same letter are not significantly different.

Level					Mean
CE North	A				0.65546569
CE Main	A	B			0.49521742
CE South	A	B	C		0.48489291
Calvin	A	B	C		0.47134825
Point		B	C	D	0.34903796
Pine			C	D	0.26862944
Fischer				D	0.24028305

Nitrogen (NH4)

- Ammonia (NH_4) is the preferred form of nitrogen for plant growth in aquatic systems (Horne & Goldberg 133).
- NH_4 is reported in mg/L and is commonly present in concentrations less than 1 mg/L (Lind, 84).
- For all creeks and branches, in general, baseflow and stormflow NH_4 levels were less than 1 mg/L and stormflow levels were only slightly higher than baseflow NH_4 levels (Figures 15 & 16).

- Calvin Creek 03 (CA03) had higher peaks of NH_4 in June 2012, August 2014, and July and August 2015. These peaks are higher than are seen at the other sample locations at all the creeks.
- Baseflow NH_4 levels were significantly different by branch and creek ($p<0.0001$). Calvin Creek was significantly different from Point Creek, Fischer Creek, and the Main Branch of Centerville Creek, there was a gradient along the other creeks that were not significant from one another (Table 9).
- Baseflow NH_4 levels were significantly different by week ($p=0.0084$), as NH_4 levels were variable over seasons and years (Figure 17).
- Stormflow NH_4 levels were similar between all creeks ($p=0.3573$) and were significant by week ($p<0.0001$), showing variance over time (Figure 18).

Table 9. Average NH_4 levels (mg/L) for baseflow, separated by creek or branch. The letters in Column 2 are the results of the ANOVA, where sites connected by the same letter are not significantly different.

Level				Mean
Calvin	A			0.33405478
CE North	A	B		0.29574727
CE South		B	C	0.24298789
Pine		B	C	0.20966331
Point			C	0.19581407
CE Main			C	0.18567859
Fischer			C	0.18514002

E. Coli

- Escherichia coli (*E. coli*) are bacteria that, when found in water in high concentrations, can be an indicator that pathogenic bacteria may be present. Pathogenic bacteria can cause serious illness in humans. *E. coli* is reported as CFU/ml or MPN/ml (used interchangeably).
- The EPA recommends that advisories at beaches be issued when *E. coli* levels in the water reach 235 CFU/100ml (WDNR).
- In general, baseflow *E. coli* levels (Figure 19) were lower than stormflow *E. coli* levels (Figure 20).
- In general, both sites in Calvin Creek appear to have higher *E. coli* levels than the other creeks.
- Baseflow *E. coli* levels at all creeks are highly variable.
- When analyzing *E. coli*, the detection limit for the method used is 2419.6 CFU/100ml. When samples reach the limit, they are recorded as 2419.6 CFU/100ml and it is not known how much larger the count for the sample could actually be. The statistical analyses used the detection limit, which adds bias to the testing but does not affect the

numbers that exceed health standards. The number of samples exceeding the detection limit can be seen in Table 10.

- More stormflow samples exceed the detection limit than baseflow samples.
- More stormflow samples exceed the advisory beach warning level than baseflow samples. Approximately 75% of baseflow samples and 90% of stormflow levels exceeded the safe beach *E. coli* level (Table 10).
- Baseflow *E. coli* levels were significantly different by branch and creek ($p<0.0001$). The creeks grouped into three significantly different groups. Calvin and Centerville North Branch, Centerville Main and South Branches, and Fischer, Point, and Pine Creek (Table 11).
- Baseflow *E. coli* levels were significantly different by week ($p<0.0001$), as *E. coli* levels were variable over seasons and years (Figure 21).
- Stormflow *E. coli* levels were significant by branch and between all creeks ($p=0.0152$) although no sites were significant from one another (Table 12).
- Stormflow *E. coli* levels were significant by week ($p<0.0001$), showing variance over time (Figure 22).

Table 10. Mean *E. coli* values by site and year. Advisory level (235 CFU/100 ml) based on standards for Wisconsin beaches. Maximum detection level was 2419.6 CFU/100 ml.

		BASE FLOW				STORM FLOW			
Site	Year	# Samples	Mean Baseflow	% Exceed Advisory Level	% Exceed Detection Limit	# Samples	Mean Stormflow	% Exceed Advisory Level	% Exceed Detection Limit
Calvin Creek	2012	27	1262.48	81.5	0.0	6	2419.6	100	0.0
	2013	26	1318.38	76.9	0.0	0	-	-	-
	2014	26	1431.23	80.8	0.0	10	1966.26	90.0	0.0
	2015	22	1050.91	68.2	9.1	18	1579.08	100	33.3
Centerville Creek Main Branch	2010	27	945.29	100	0.0	8	1292.94	62.5	0.0
	2011	18	437.22	66.7	0.0	21	1140.65	81.0	28.6
	2012	29	1122.86	96.6	3.4	10	2419.6	100	100
	2013	43	639.40	65.1	7.0	0	-	-	-
	2014	48	1004.73	64.6	12.5	17	2419.6	100	88.2
	2015	33	973.79	63.6	12.1	27	1585.02	100	33.3
Centerville Creek North Branch	2010	9	1399.51	100	0.0	4	1511.9	75.4	0.0
	2011	18	785.65	72.2	5.6	21	1053.63	71.4	19.0
	2012	56	1230.25	92.9	25.0	24	2335.44	100	91.7
	2013	52	1203.47	86.5	28.8	0	-	-	-
	2014	56	1053.58	75.0	17.9	20	2419.6	100	95.0
	2015	44	1195.00	81.8	20.5	36	2054.82	100	63.9
Centerville Creek South Branch	2010	9	562.44	100	0.0	2	686.7	50	0.0
	2011	6	534.42	83.3	0.0	7	743.51	71.4	14.3
	2012	42	966.39	85.7	9.5	18	2323.32	100	88.9
	2013	39	808.45	71.8	10.3	0	-	-	-
	2014	44	842.28	70.5	11.4	15	2226.07	100	80.0
	2015	33	790.77	81.8	9.1	27	1331.59	92.6	33.3
Fischer Creek	2012	28	623.38	75.0	10.7	6	2419.6	100	100
	2013	26	577.97	69.2	7.7	0	-	-	-
	2014	22	552.16	73.1	7.7	11	2054.46	100	72.7
	2015	22	446.05	77.3	0.0	18	1353.79	94.4	33.3
Pine Creek	2012	28	496.89	57.1	0.0	6	1958.68	100	0.0
	2013	26	580.75	53.8	0.0	0	-	-	-
	2014	26	451.87	65.4	0.0	11	1924.84	100	0.0
	2015	22	444.11	50.0	0.0	18	1214.6	100	27.8
Point Creek	2012	28	503.54	64.3	7.1	6	2419.6	100	100
	2013	26	578.86	38.5	7.7	0	-	-	-
	2014	26	559.52	57.7	3.8	11	2184.17	100	81.8
	2015	22	365.05	50.0	0.0	18	1217.55	83.3	27.8

Table 11. Average *E. coli* levels for baseflow, separated by creek or branch. The letters in Column 2 are the results of the ANOVA analysis, where sites connected by the same letter are not significantly different.

Level				**Mean**
Calvin	A			1307.0644
CE North	A			1175.8737
CE Main		B		906.6863
CE South		B		857.5363
Fischer			C	575.8622
Point			C	527.9356
Pine			C	503.2178

Table 12. Average *E. coli* levels for stormflow, separated by creek or branch. The letters in Column 2 are the results of the ANOVA analysis, where sites connected by the same letter are not significantly different.

Level			**Mean**
CE North	A		2211.9491
Calvin	A	B	1965.8315
CE Main	A	B	1916.2599
CE South	A	B	1746.4389
Fischer	A	B	1634.9135
Point	A	B	1579.6020
Pine		B	1445.0624

CONCLUSION

In general, the impacts of storm events can be seen on the water quality of the southern creeks in Manitowoc County. For all of the creeks, total phosphorus and *E. coli* levels consistently exceeded levels at which the water is considered unimpaired. Land use is likely having a large impact on the water quality of each of these creeks, with high percentages of agricultural land use in each watershed.

References

EPA (Environmental Protection Agency) 2015. “Volunteer Monitoring”. http://water.epa.gov/type/rsl/monitoring/vms56.cfm. Modified 11-March-2015.

Horne, Alexander J. and Goldman, Charles R. 1994. Limnology. 2nd edition. McGraw-Hill, Inc. New York.

Lind, Owen T. 1985. Limnology: Handbook of Common Methods. 2nd edition. Kendall/Hunt Publishing Company. Dubuque, IA.

McKay, L., Bondelid, T., Dewald, T., Johnston, J., Moore, R., and Rea, A., “NHDPlus Version 2: User Guide”, 2012

NR 102.06 (3). WDNR. http://dnr.wi.gov/topic/surfacewater/phosphorus.html

USGS (United States Geological Survey) 2015. “Temperature – Water Properties”. http://water.usgs.gov/edu/temperature.html. Modified 27-Jul-2015 14:42:36 EDT.

WDNR (Wisconsin Department of Natural Resources) “Beach Monitoring Program Requirements”. http://dnr.wi.gov/topic/Beaches/documents/BeachMonitoringRequirements.pdf

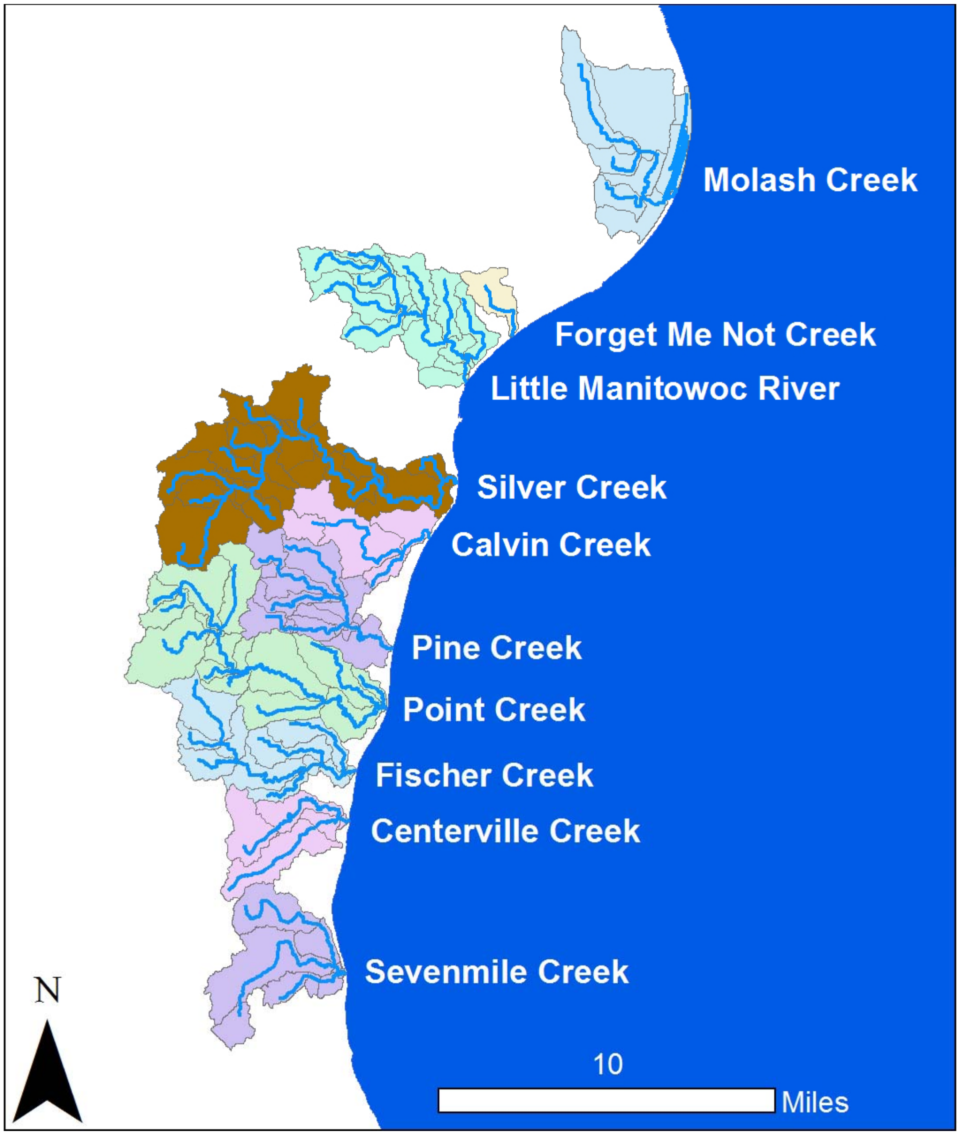


FIGURE 1. Watersheds of Southern Manitowoc County, WI.

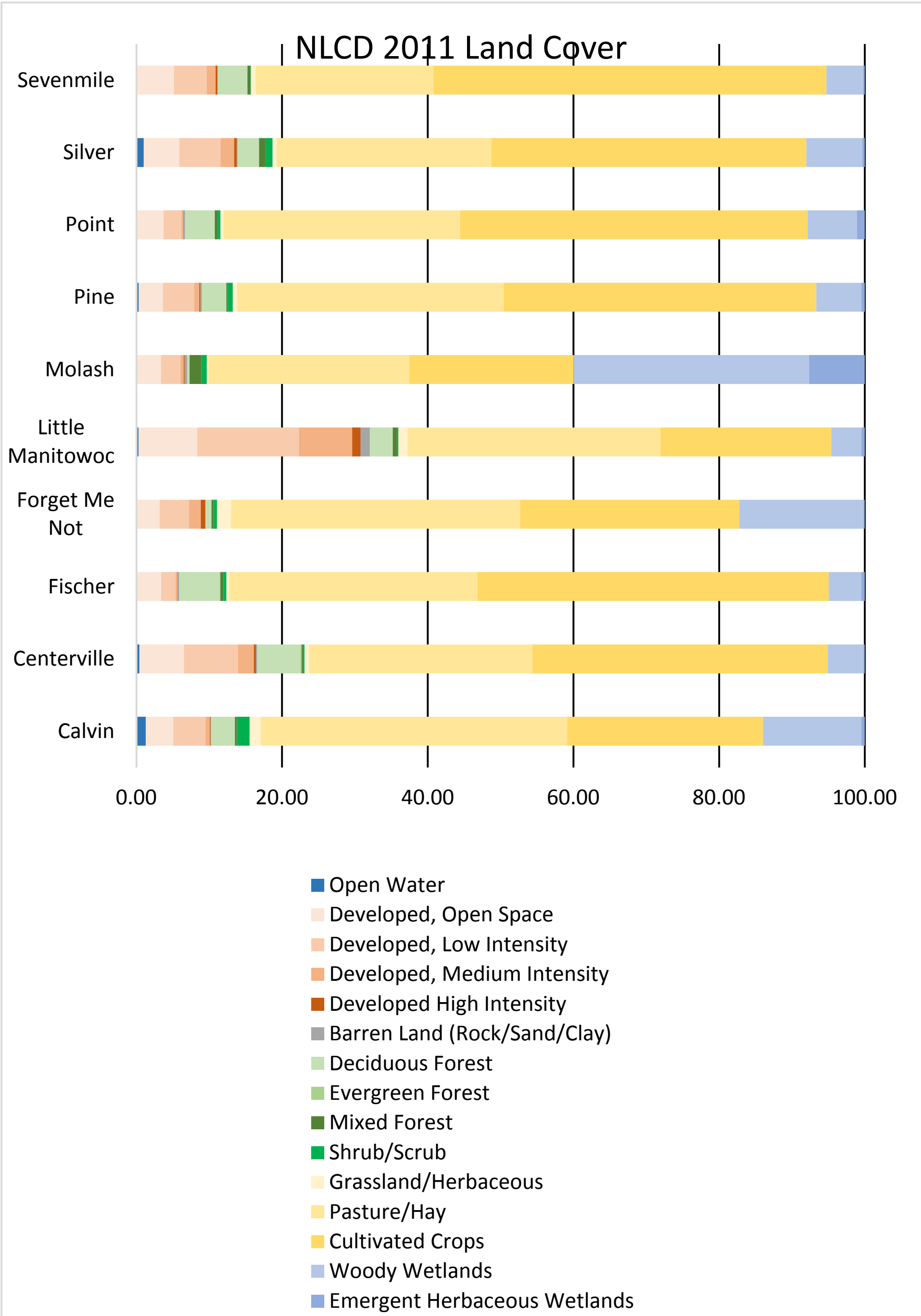


Figure 2. Percentage of land cover and land use of 10 southern Manitowoc creek watersheds.

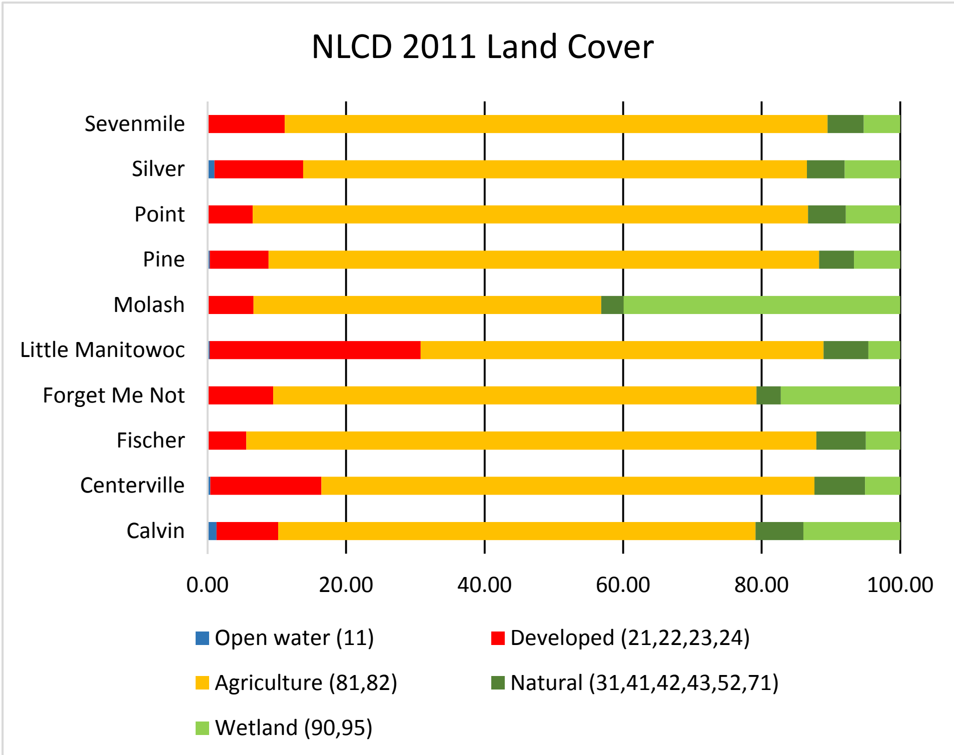


FIGURE 3. Percentage of land cover and land use of 10 southern Manitowoc creek watersheds, broken into more general categories.

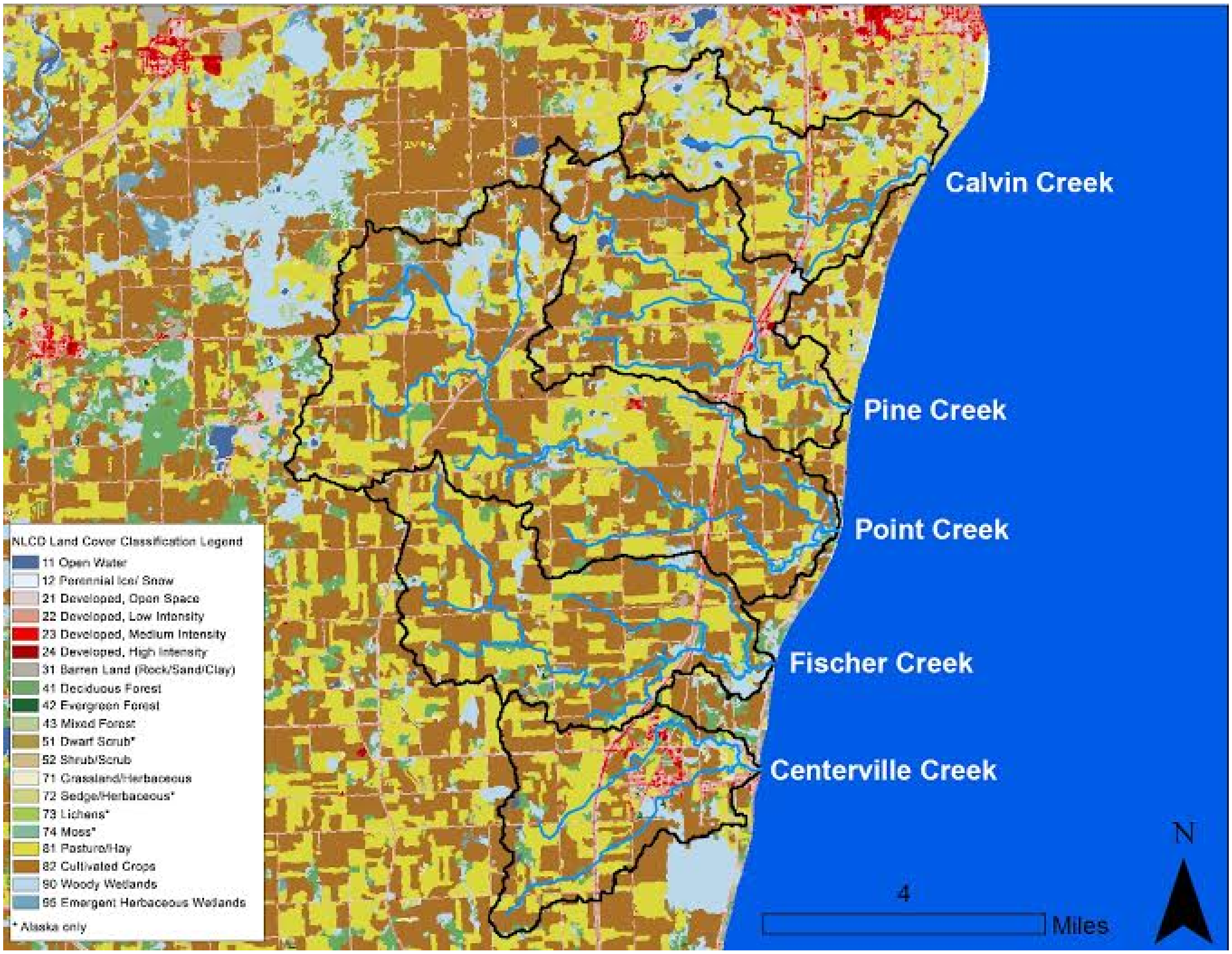


FIGURE 4. Southern Manitowoc creeks, watersheds, and landuse.

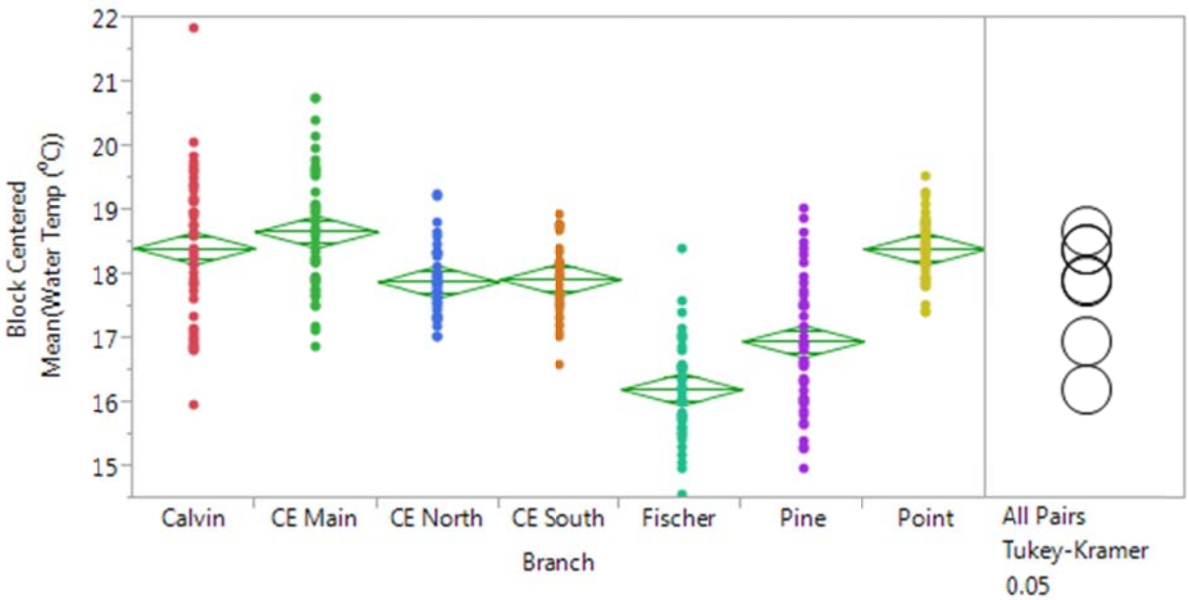


FIGURE 5. Block Centered Mean Water Temperature for baseflow in the southern Manitowoc creeks.

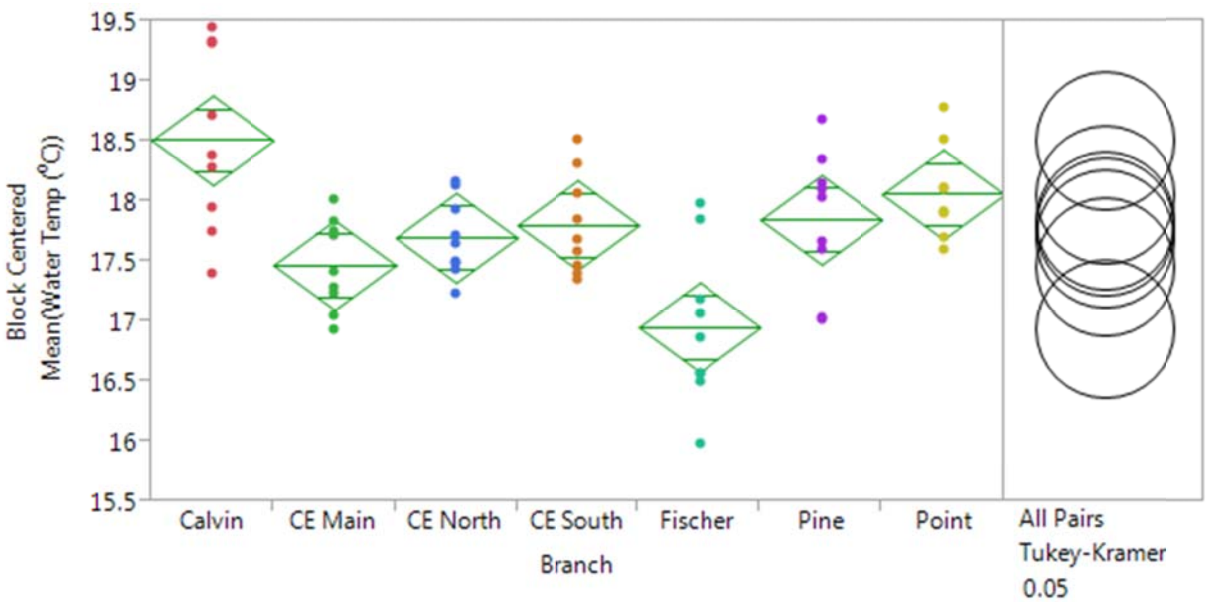


FIGURE 6. Block Centered Mean Water Temperature for stormflow in the southern Manitowoc creeks.

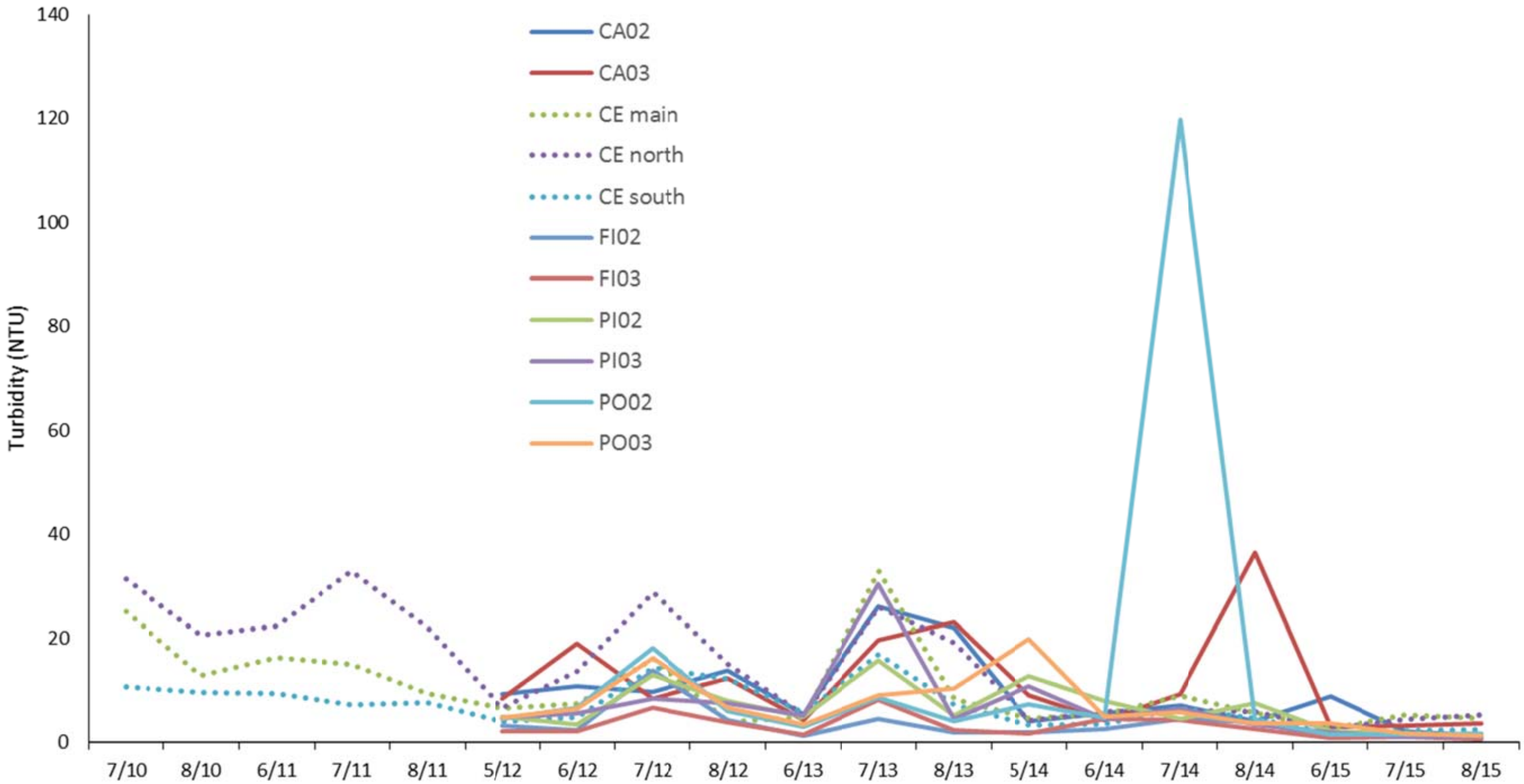


FIGURE 7. Average baseflow turbidity (NTU) for the southern creeks of Manitowoc County, Summer 2010-2015.

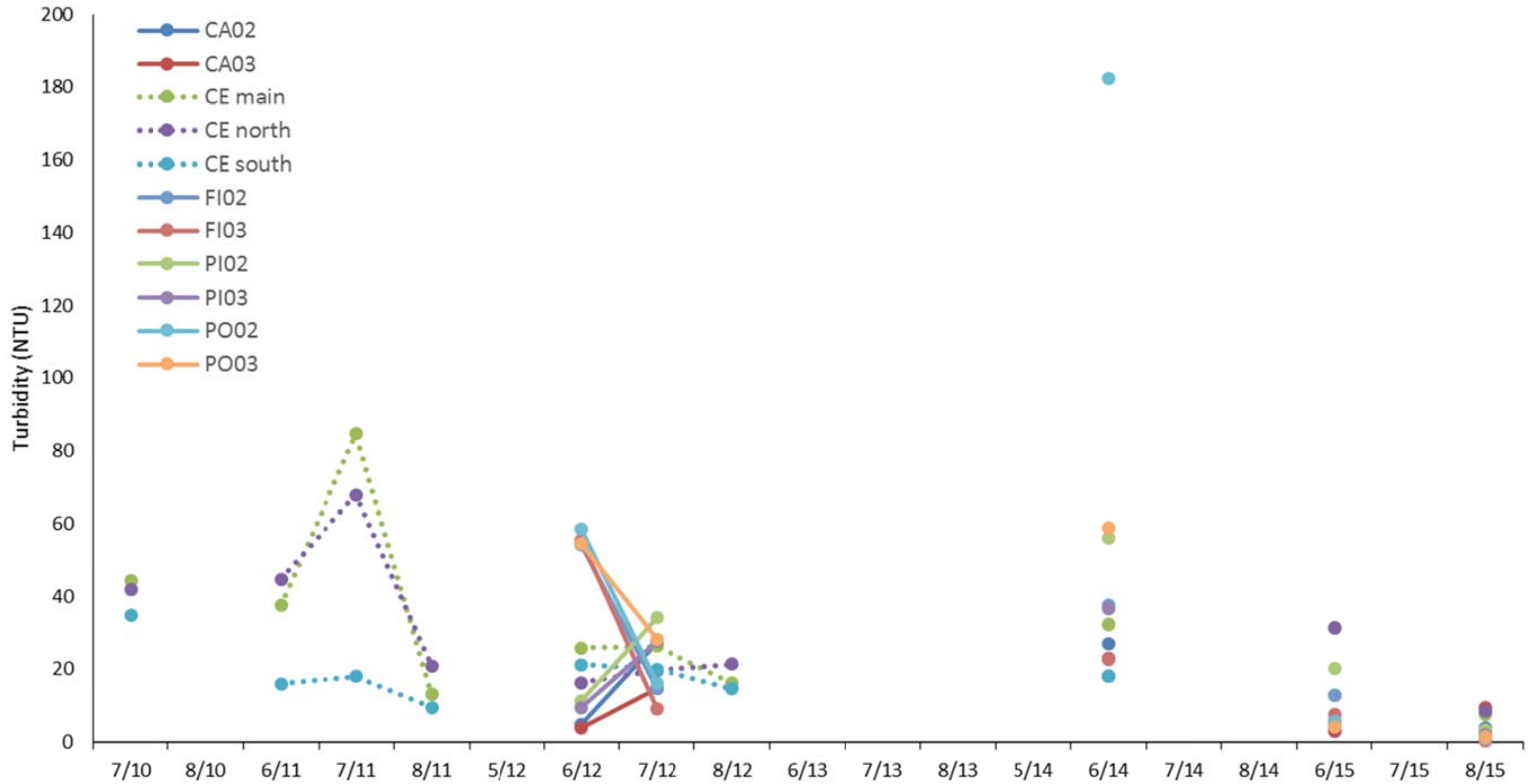


FIGURE 8. Average stormflow turbidity (NTU) for the southern creeks of Manitowoc County, Summer 2010-2015.

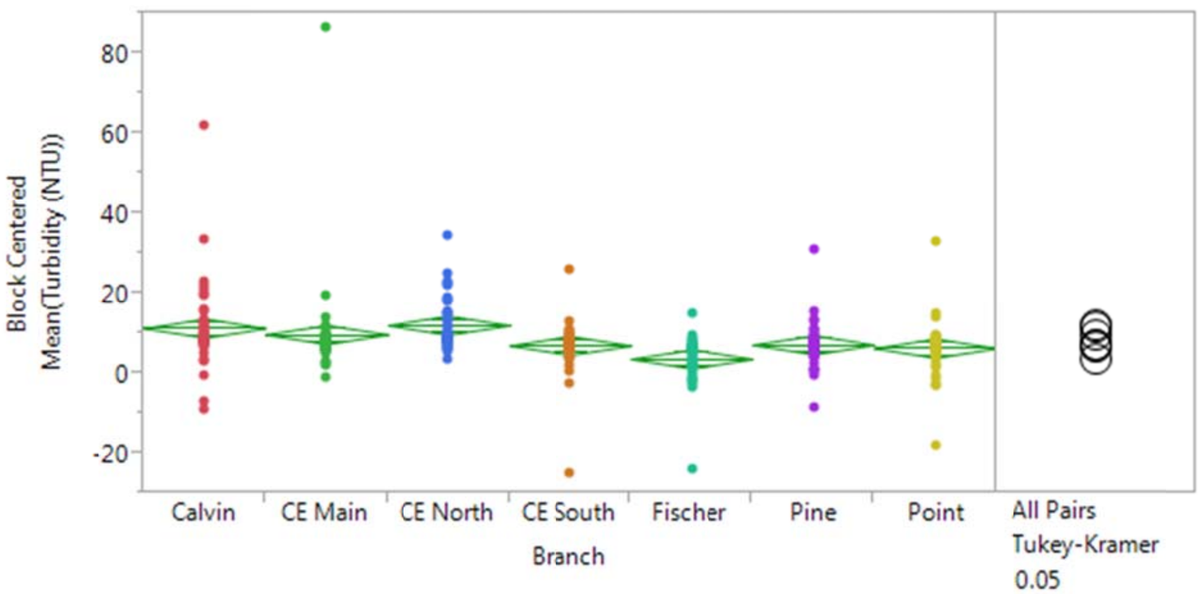


FIGURE 9. Block Centered Mean Turbidity for baseflow in the southern Manitowoc creeks.

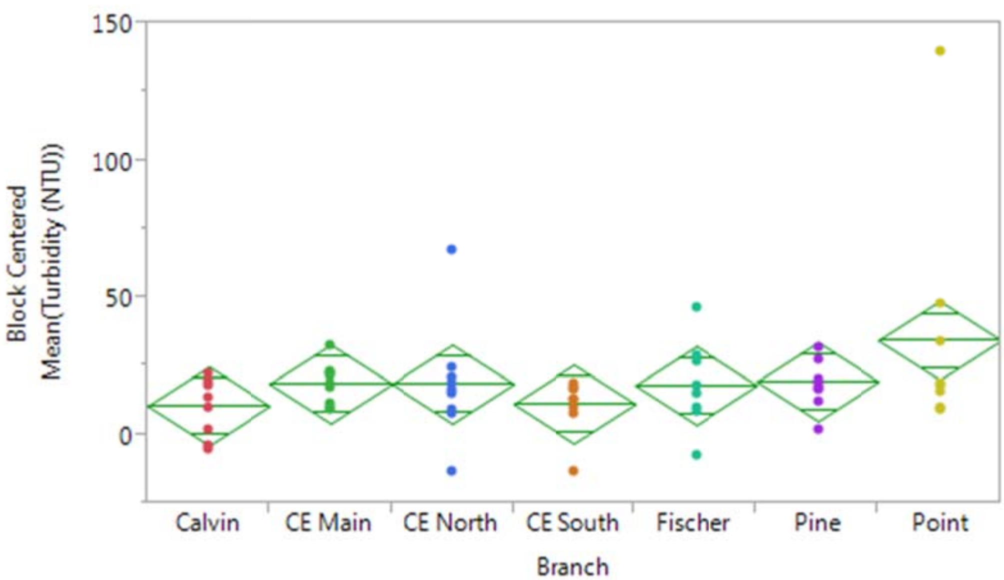


FIGURE 10. Block Centered Mean Turbidity for stormflow in the southern Manitowoc creeks.

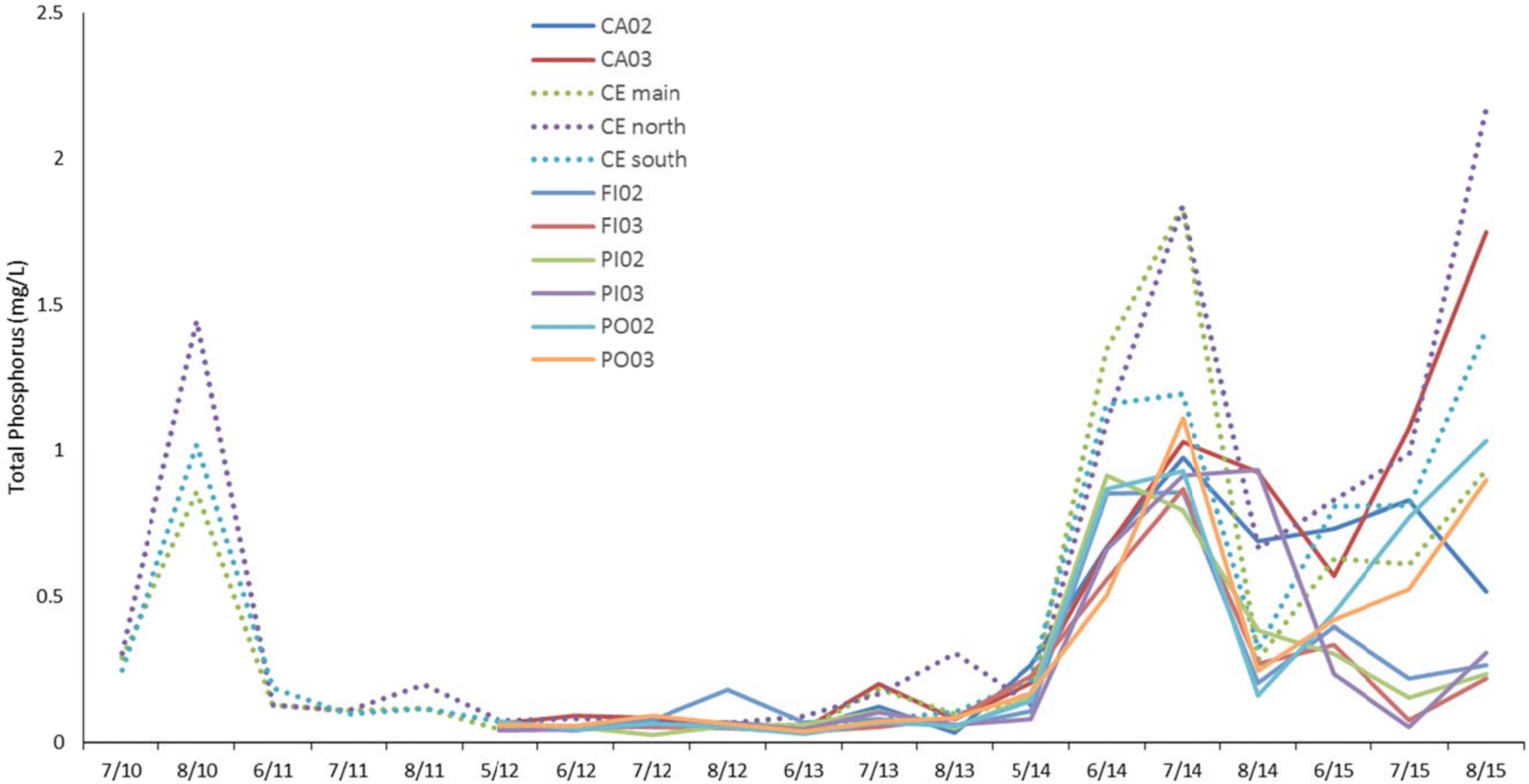


FIGURE 11. Average baseflow total phosphorus levels (mg/L) for the southern creeks of Manitowoc County, Summer 2010-2015.

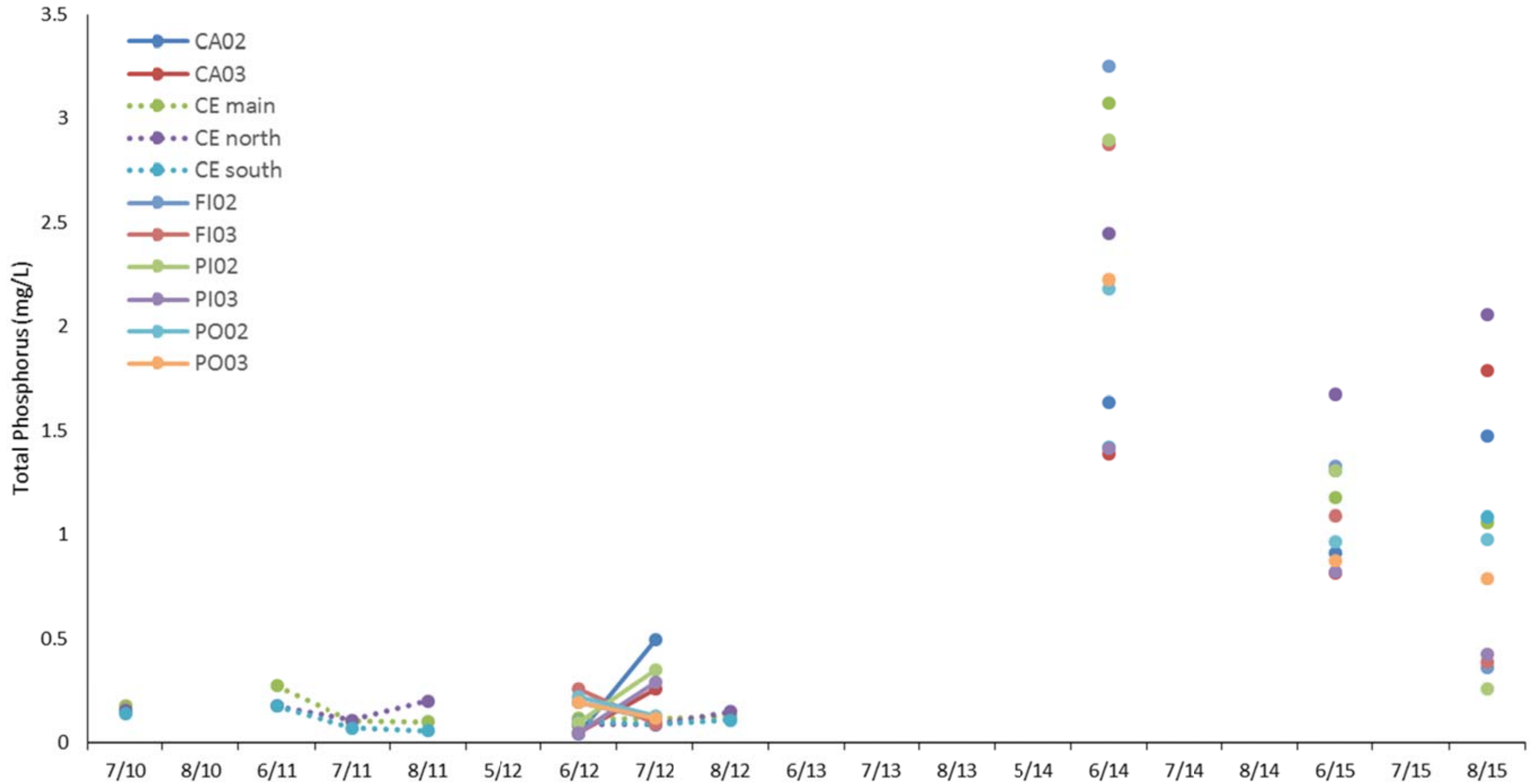


FIGURE 12. Average stormflow total phosphorus levels (mg/L) for the southern creeks of Manitowoc County, Summer 2010-2015.

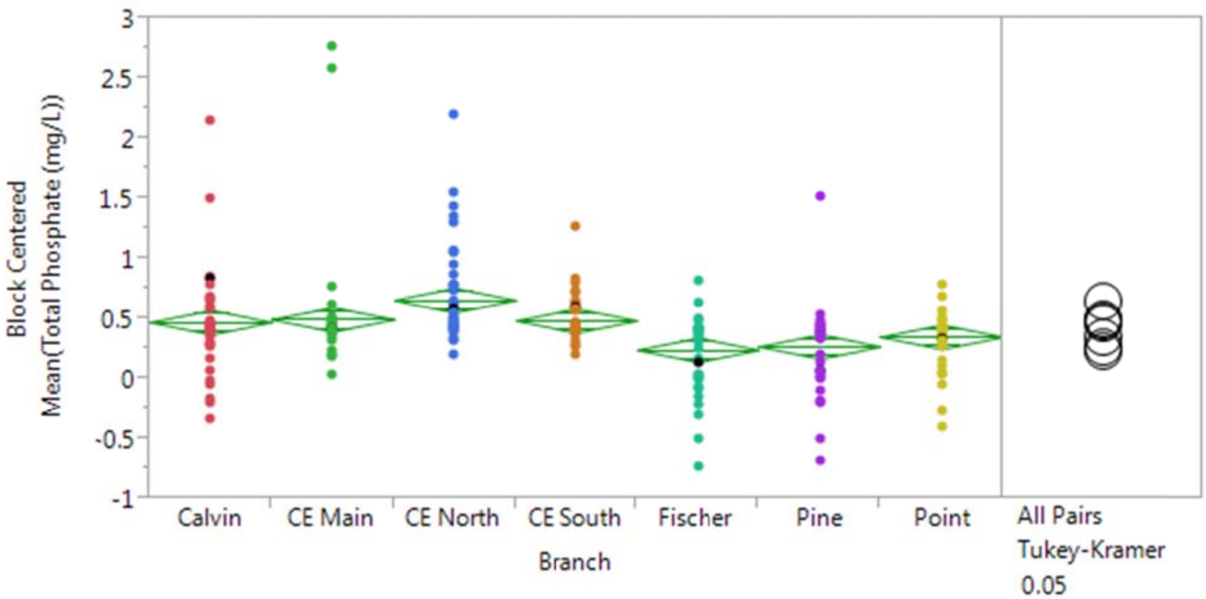


FIGURE 13. Block Centered Mean Total Phosphorus for baseflow in the southern Manitowoc creeks.

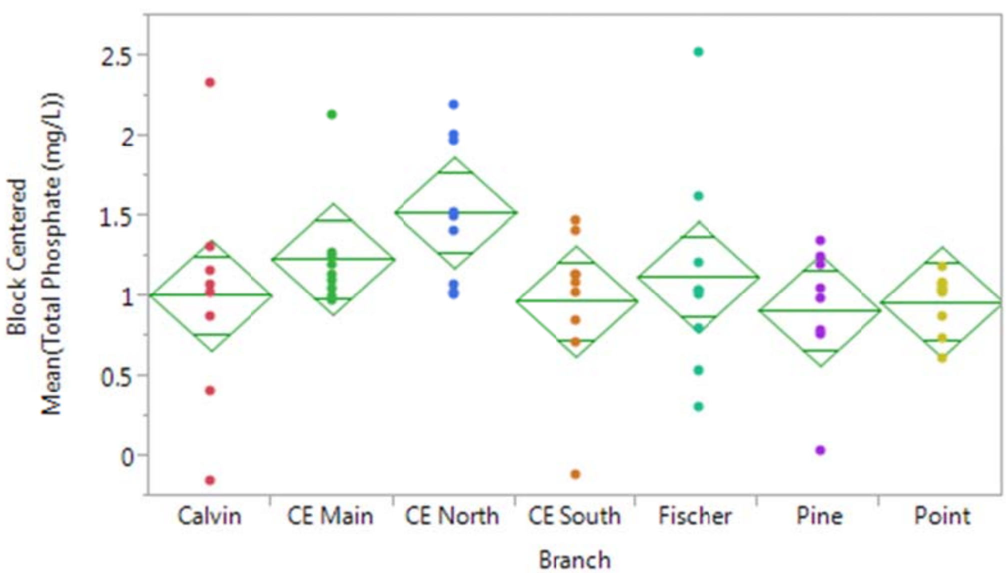


FIGURE 14. Block Centered Mean total phosphorus for stormflow in the southern Manitowoc creeks.

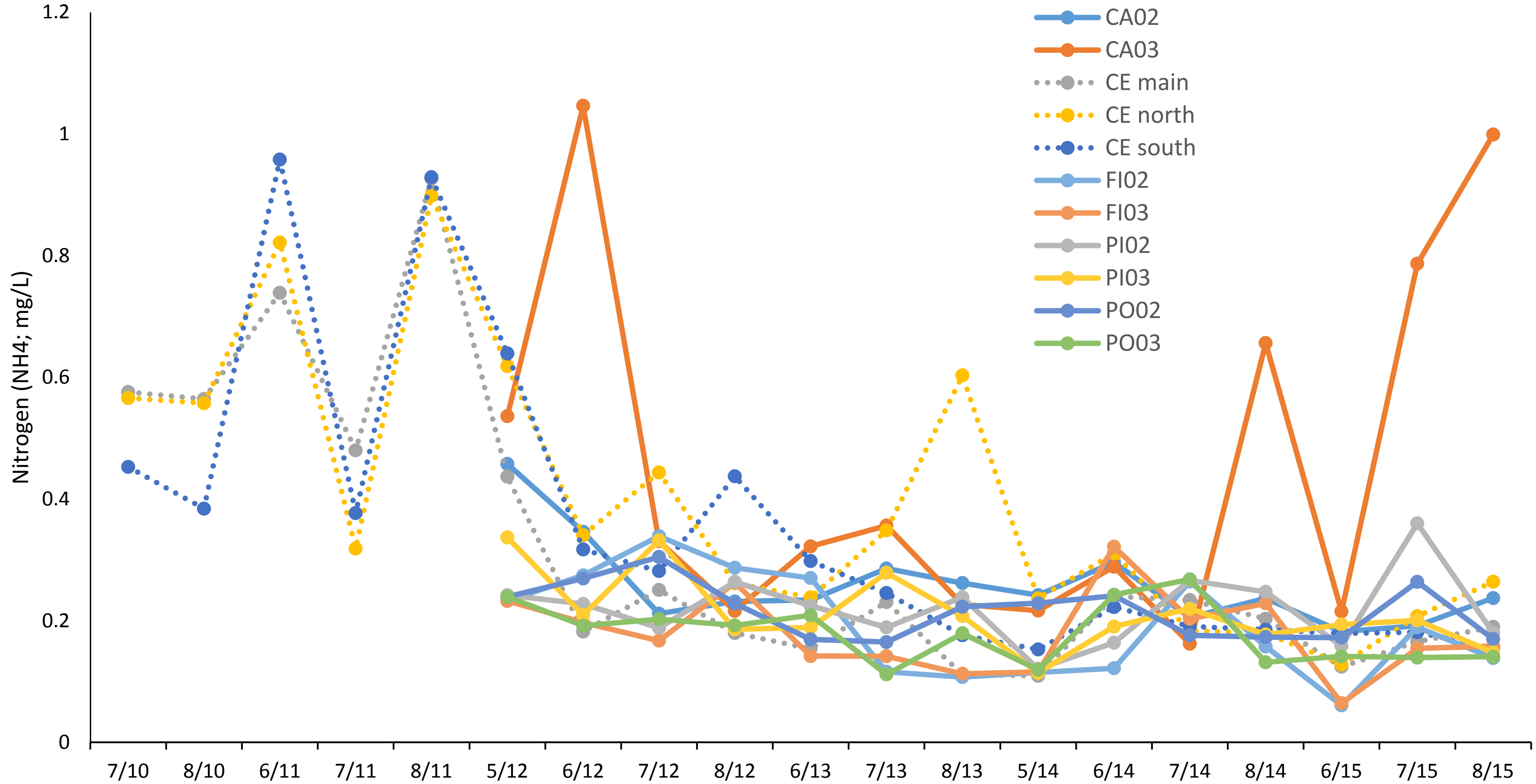


FIGURE 15. Average baseflow NH_4 levels (mg/L) for the southern creeks of Manitowoc County, Summer 2010-2015.

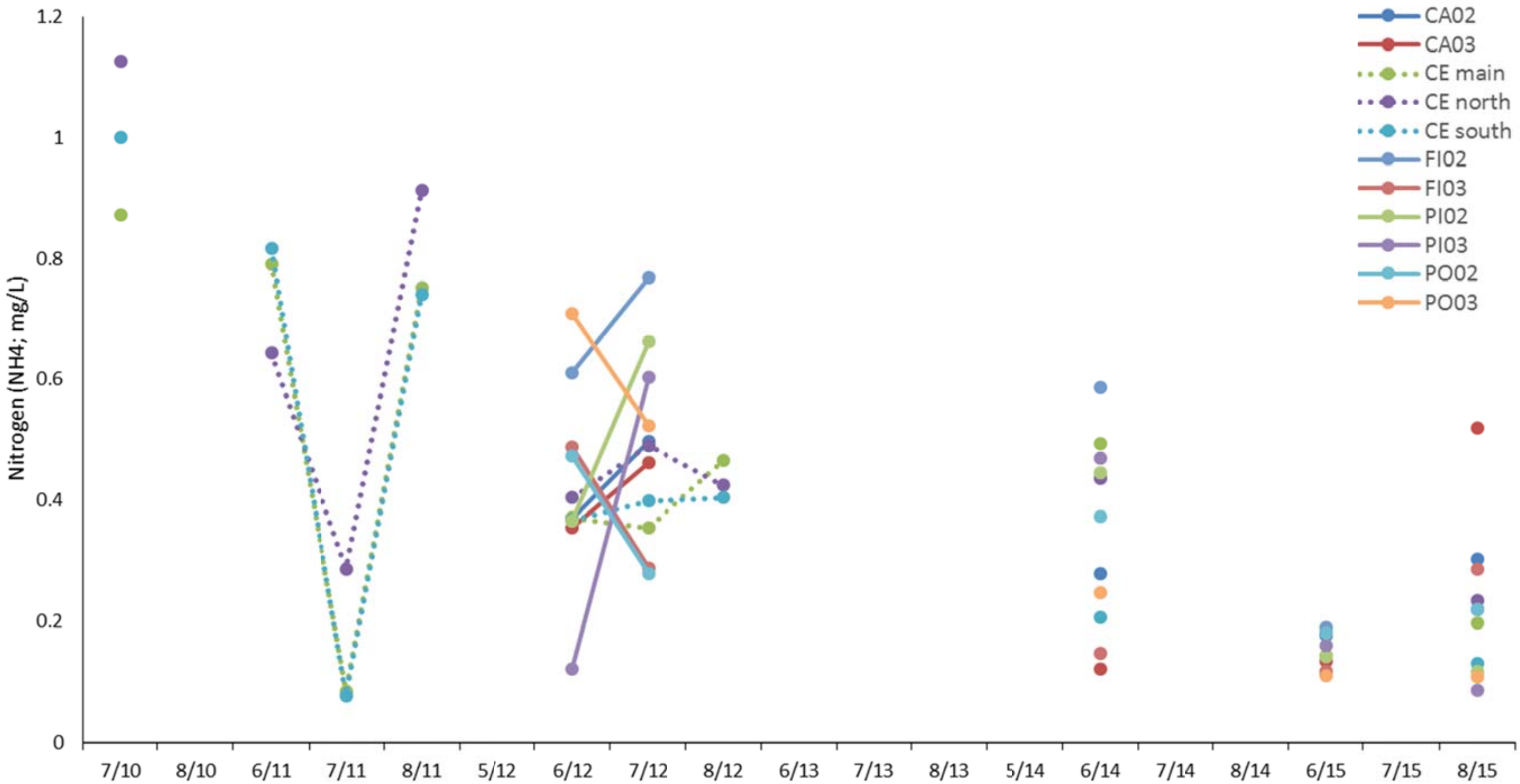


FIGURE 16. Average stormflow NH_4 levels (mg/L) for the southern creeks of Manitowoc County, Summer 2010-2015.

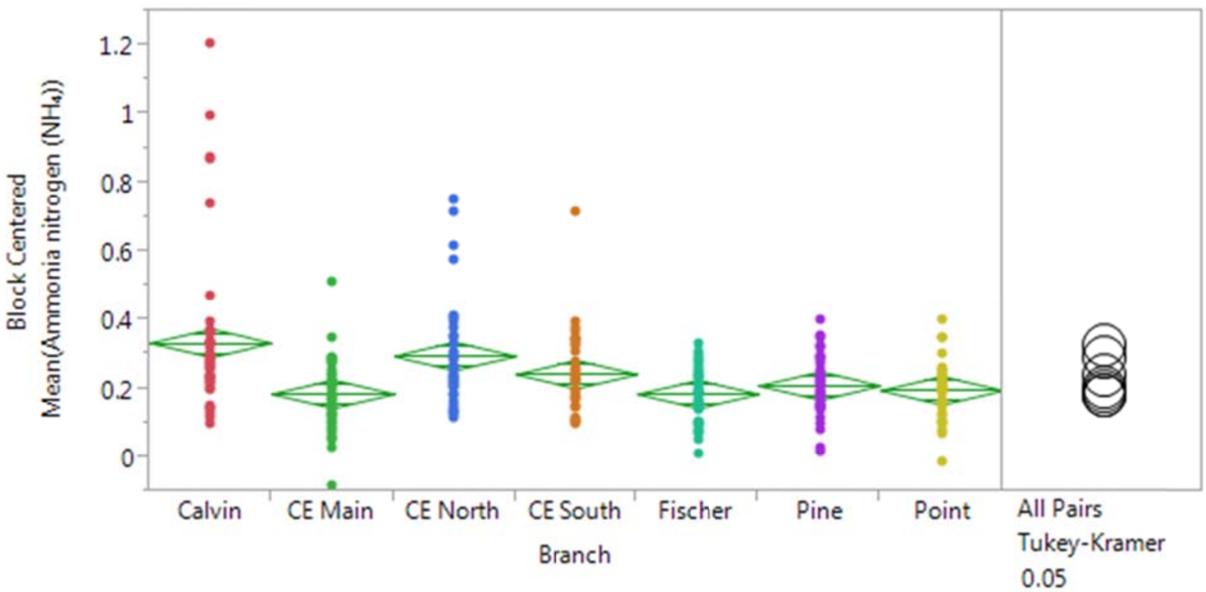


FIGURE 17. Block Centered Mean NH_4 levels for baseflow in the southern Manitowoc creeks.

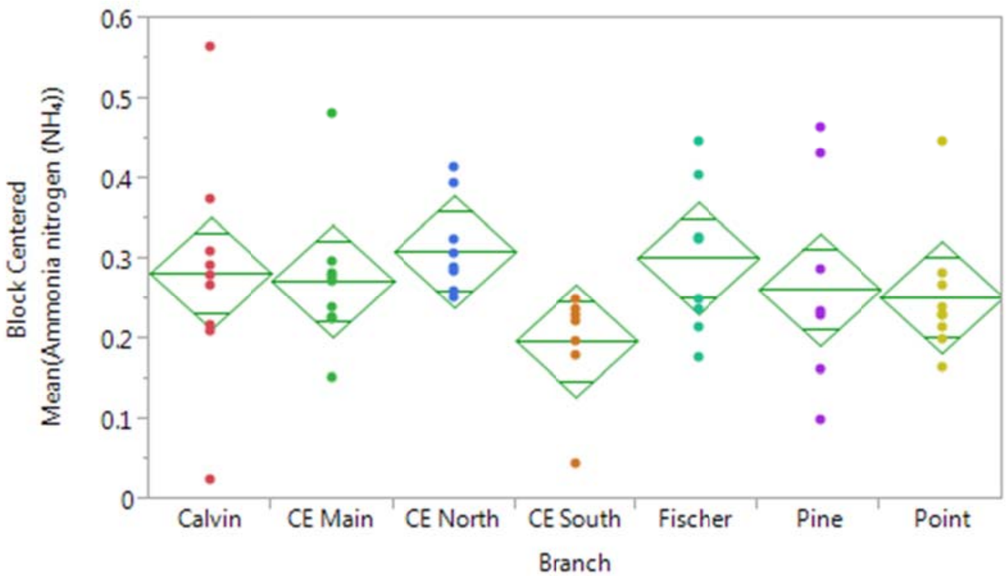


FIGURE 18. Block Centered Mean NH_4 levels for stormflow in the southern Manitowoc creeks.

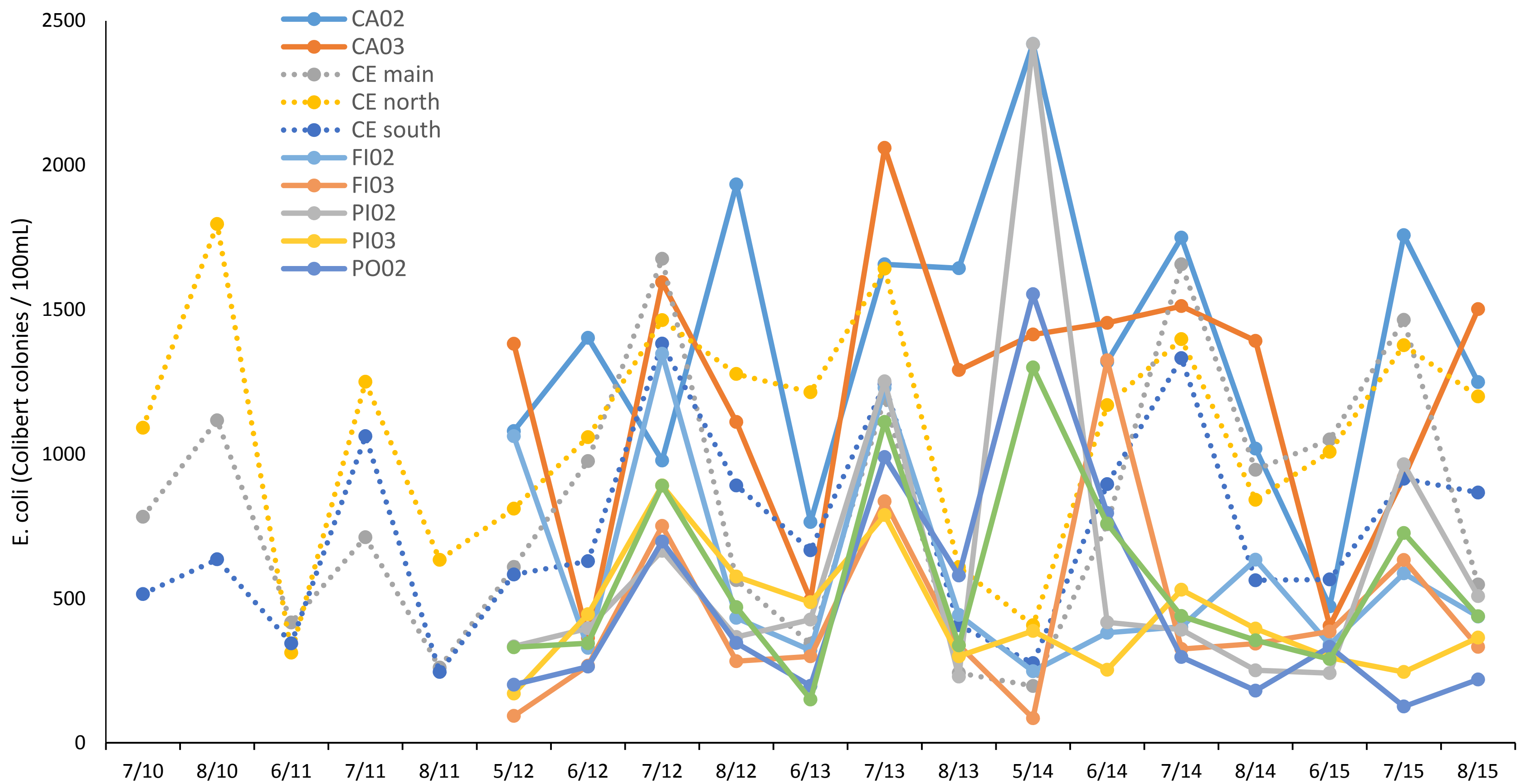


FIGURE 19. Average baseflow E. coli levels for the southern creeks of Manitowoc County, Summer 2010-2015.

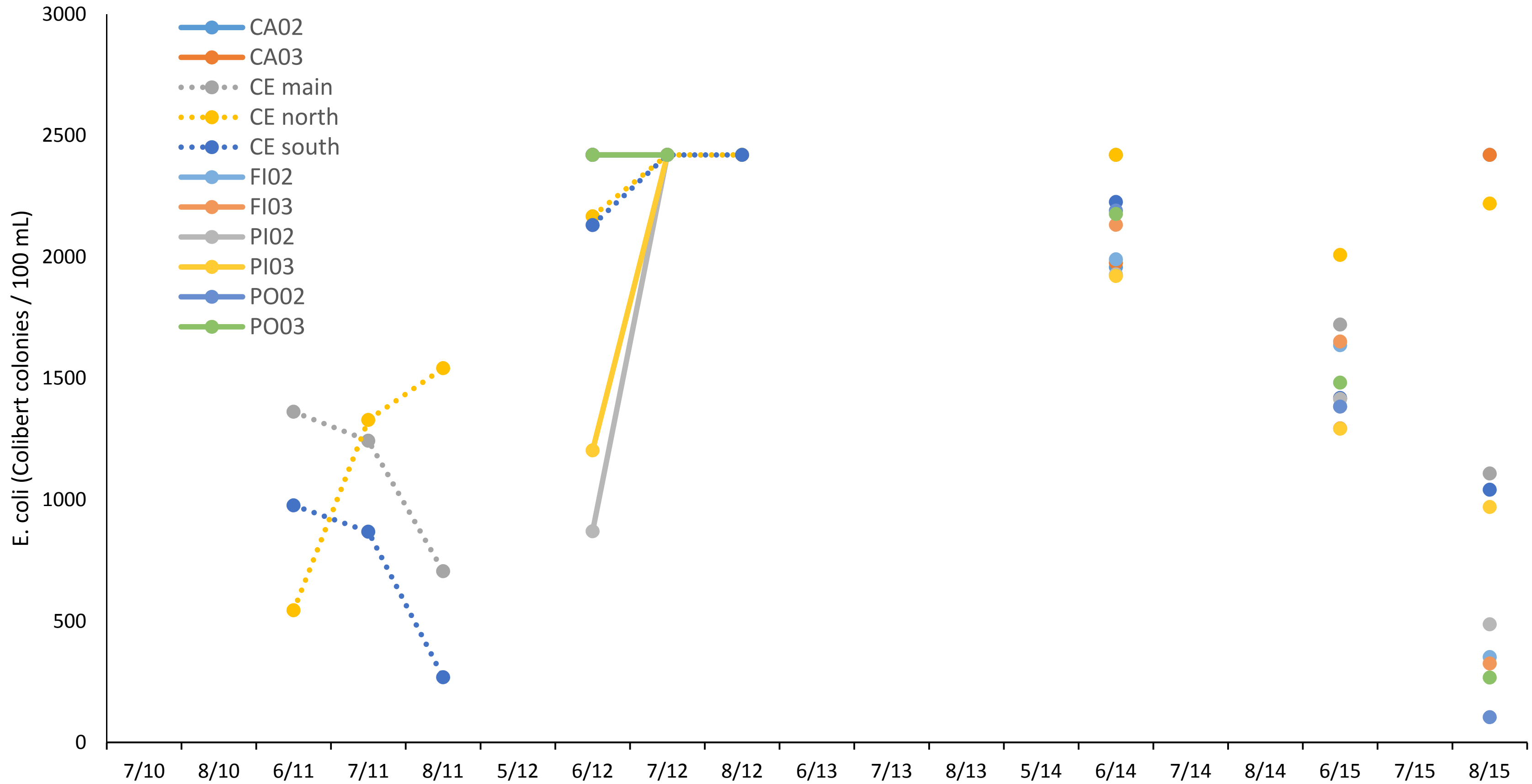


FIGURE 20. Average stormflow E. coli levels for the southern creeks of Manitowoc County, Summer 2010-2015.

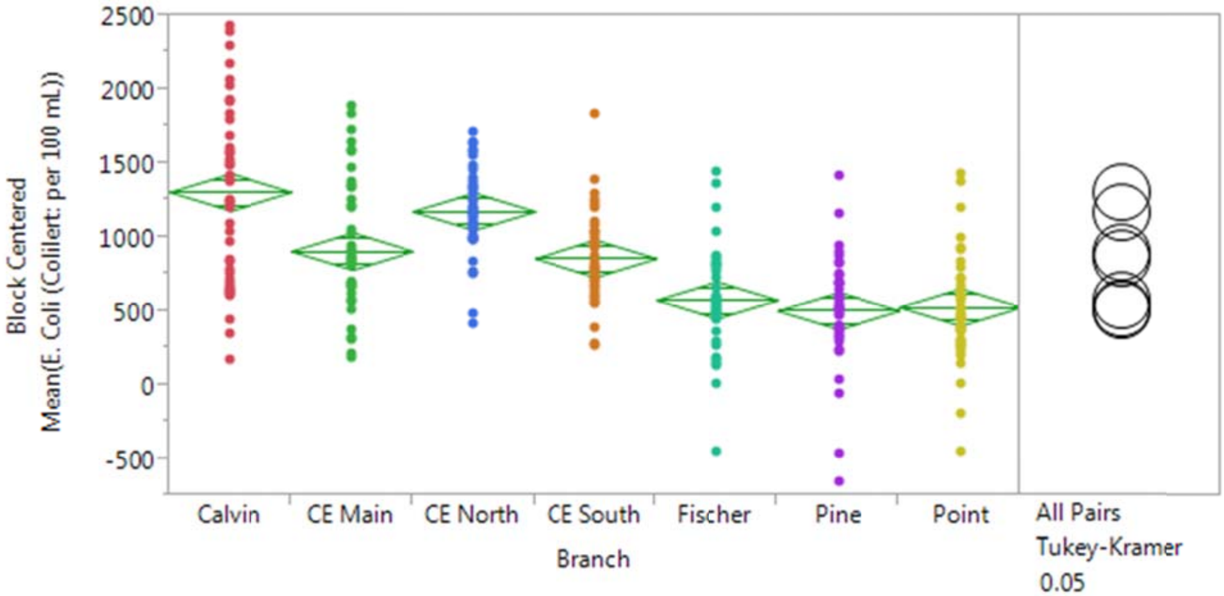


FIGURE 21. Block Centered Mean *E. coli* levels for stormflow in the southern Manitowoc creeks.

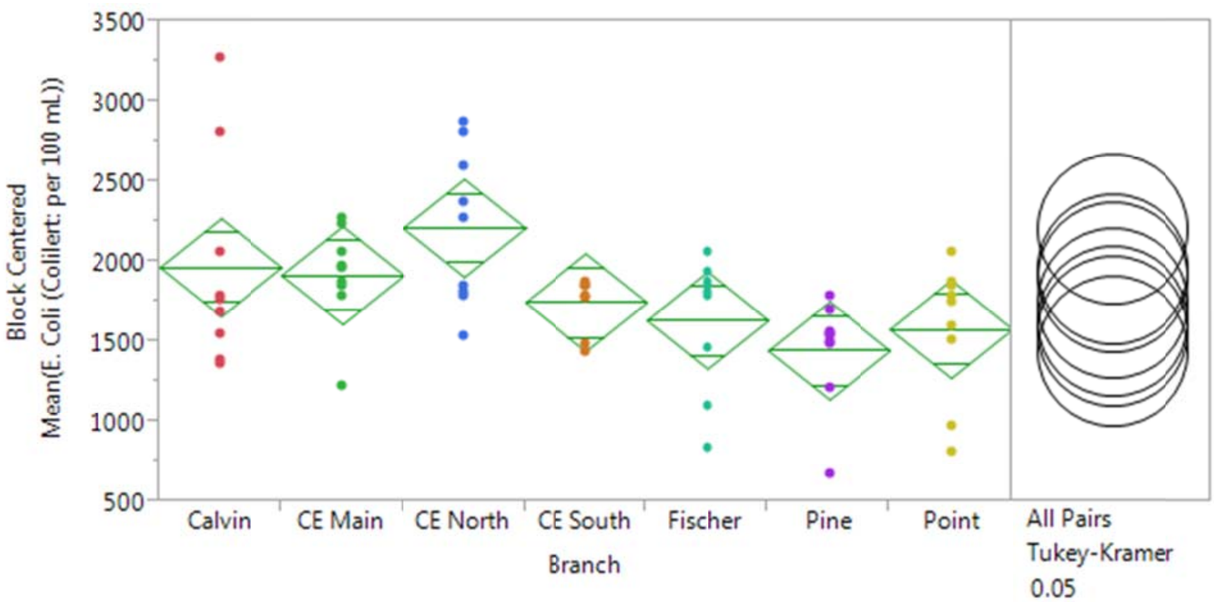


FIGURE 22. Block Centered Mean *E. coli* levels for stormflow in the southern Manitowoc creeks.

CENTERVILLE CREEK WATER QUALITY REPORT, 2010 – 2015
Lakeshore Natural Resource Partnership

SUMMARY

The purpose of this report is to summarize the water quality data collected at Centerville Creek during the summers of 2010-2015. Overall, it was difficult to discern patterns between the branches of Centerville Creek. Generally the North Branch had higher nutrient concentrations at times than the South Branch. Patterns may not be obvious because of the small size of watershed, close proximity of the sampling locations, and the large proportion of agricultural land use in the watershed. Variation appears to be larger between the years when comparing sites than between the sites themselves.

For total phosphorus and *E. coli*, the measured values exceed recommended levels for an unimpaired creek. This is especially true after rain events, when water quality parameters tend to be higher than baseflow conditions. Significant differences between baseflow and stormflow levels for all parameters were seen in 2014 and in all years for *E. coli*. Although the small number of stormflow samples (including zero samples in 2013) may account for some of the nonsignificant results in stormflow and baseflow in some years.

STUDY AREA

Centerville Creek is a small watershed (7.2 mi^2, 18.7 km^2) located southern Manitowoc County and containing the village of Cleveland, WI (Table 1, Figure 1). The watershed is heavily influenced by agricultural land use (71.4%), with less developed land (15.6%), forest (6.6%), and wetland (5.2%). There was slightly more agricultural land use in the north branch (75.1%) than south branch (68.7%), while the south branch had more developed land (Village of Cleveland; 17.4%) than the north branch (12.7%) (Table 2; Figure 2, 3, & 4). Ten sites were sampled along Centerville Creek during the study (Table 3). Centerville Creek consists of a main branch downstream and a north and south branch (Figure 5).

Table 1. Area and length of the study stream and four Southern Manitowoc County creeks sampled.

Site	Area ($mile^2$)	Length (miles)	Area (km^2)	Length (km)
Calvin	7.2	7.1	18.7	11.5
Centerville	7.4	9.8	19.1	15.7
Fischer	11.5	18.8	29.8	30.3
Pine	10.9	15.1	28.2	24.3
Point	21.8	28.6	56.4	46.0

Table 2: Centerville Creek land use (NLCD 2006).

Class	Main	North	South
Water	0.0	0.6	0.2
Developed, open space	19.4	5.0	5.1
Developed, low	43.3	6.1	11.0
Developed, medium	2.0	1.6	1.2
Developed, high	0.4	0.1	0.1
Forest	3.2	6.8	5.7
Pasture/Hay	20.6	36.0	25.7
Cultivated crops	4.0	39.1	43.0
Wetland	7.1	3.5	6.9
Other	0.0	0.9	0.9

Table 3. List of the 10 sites sampled in Centerville Creek and years that data were collected.

SITE CODE	DESCRIPTION	2010	2011	2012	2013	2014
CE01	Centerville Flowage Dam	X	X	X	X	X
CE02	Centerville Flowage Midpoint	X	X	X	X	X
CE03	Centerville Flowage Confluence	X	X	X	X	X
CE04	Centerville South Branch Birch St.	X	X	X	X	X
CE05	Centerville South Branch Center Rd.			X	X	X
CE06	Centerville South Branch South Cleveland Rd.			X	X	X
CE07	Centerville North Branch Franklin Dr.	X	X	X	X	X
CE08	Centerville North Branch Dairyland Dr.		X	X	X	X
CE09	Centerville North Branch LTC		X	X	X	X
CE10	Centerville North Branch Washington Rd.			X	X	X

METHODS

Student interns working for faculty at UW-Manitowoc collected water samples during the summers of 2012, 2013, 2014, and 2015. Samples were taken weekly from late May through the end of August (baseflow). Samples were also taken following rain events greater than a half inch at both 24 and 48 hours (Table 4). Rain event sample dates are “stormflow” while non-rain event sample dates are “baseflow” in this report (Table 5).

Table 4. Number of weeks sampled each summer in Centerville Creek. Storm events are rainfalls greater than a half inch, sampled at both 24 and 48 hours.

Creek	Year	# Baseflow Sample Weeks	# Stormflow Sample Weeks	Total # Sample Weeks	# Baseflow Sample Days	# Stormflow Sample Days	Total # Sample Days
Centerville	2010	9	3	12	45	14	59
	2011	6	7	13	42	49	91
	2012	14	6	20	127	52	179
	2013	12	0	12	134	0	134
	2014	13	6	19	148	52	200
	2015	10	9	19	110	90	200

Table 5. Sample dates for Centerville Creek, Summer 2010 – 2015. Storm events are rainfalls greater than a half inch, sampled at both 24 and 48 hours.

Date	Storm Event	Date	Storm Event	Date	Storm Event	Date	Storm Event	Date	Storm Event	Date	Storm Event
6/17/2010	Yes	6/13/2011	Yes	5/22/2012	No	6/3/2013	No	5/27/2014	No	6/1/2015	No
6/18/2010	Yes	6/20/2011	Yes	5/29/2012	No	6/10/2013	No	6/2/2014	Yes	6/8/2015	No
6/22/2010	No	6/23/2011	Yes	6/5/2012	No	6/17/2013	No	6/3/2014	Yes	6/12/2015	Yes
7/1/2010	No	6/27/2011	No	6/12/2012	No	6/24/2013	No	6/4/2014	Yes	6/13/2015	Yes
7/6/2010	No	7/5/2011	No	6/19/2012	Yes	7/1/2013	No	6/9/2014	No	6/15/2015	Yes
7/14/2010	No	7/11/2011	Yes	6/20/2012	Yes	7/8/2013	No	6/10/2014	No	6/16/2015	Yes
7/21/2010	Yes	7/19/2011	Yes	6/26/2012	No	7/15/2013	No	6/16/2014	No	6/17/2015	Yes
7/29/2010	No	7/25/2011	No	7/2/2012	No	7/22/2013	No	6/17/2014	Yes	6/23/2015	Yes
8/3/2010	No	8/2/2011	Yes	7/10/2012	No	7/29/2013	No	6/18/2014	Yes	6/24/2015	Yes
8/10/2010	No	8/8/2011	No	7/17/2012	No	8/5/2013	No	6/19/2014	Yes	6/29/2015	No
8/17/2010	No	8/15/2011	Yes	7/24/2012	No	8/12/2013	No	6/23/2014	No	7/6/2015	No
8/25/2010	No	8/22/2011	No	7/26/2012	Yes	8/19/2013	No	6/30/2014	No	7/13/2015	No
		8/29/2011	No	7/27/2012	Yes	8/27/2013	No	7/2/2014	No	7/20/2015	No
				7/31/2012	No			7/7/2014	No	7/27/2015	No
				8/7/2012	No			7/8/2014	No	8/3/2015	No
				8/10/2012	Yes			7/14/2014	No	8/8/2015	Yes
				8/11/2012	Yes			7/15/2014	No	8/9/2015	Yes
				8/14/2012	No			7/21/2014	No	8/10/2015	No
				8/22/2012	No			7/28/2014	No	8/17/2015	No
				8/29/2012	No			8/4/2014	No	8/24/2015	No
								8/5/2014	No		
								8/11/2014	No		
								8/18/2014	No		
								8/25/2014	No		

All sampling sites were located in the area between I-43 and Lake Michigan. Weekly averages were calculated for each stream for baseflow and stormflow. For each branch of Centerville Creek, data was combined for all sites in each branch to do the analyses. These averages were used to test for differences between the streams in the water quality variables.

Physical indicators were measured by field probes

- Dissolved Oxygen (YSI 550A DO Probe)
- Temperature/pH
- Turbidity (LaMotte 2020 we)
- Stream Velocity (Global Water Instrumentation, Inc)
- Conductivity

Nutrient indicators

- Ammonia (NH_3/NH_4) measured with Hach field kit for Ammonia Nitrogen
- Total Orthophosphate (TP) and Total Dissolved Phosphate (TDP)
- Acid hydrolysis with H_2SO_4
- Colorimetric analysis via ammonium molybdate-stannous chloride method

Biological Indicators

- E. coli fecal coliform analysis (Colilert-24)

Statistical Analysis

Differences between the two creeks, between the sites, and between the years were tested for differences in baseflow and stormflow data separately. Mean weekly values for each creek were tested using a blocked Analysis of Variance (ANOVA). The block design allowed for testing over all four years at once, with difference in each weekly block used for the ANOVA. When significant differences were indicated by the ANOVA, a Tukey-Kramer post-hoc test was used to determine the differences between streams. All statistical analyses were done in JMP Pro Version 11 (SAS Institute Inc., Cary, NC). Mapping and watershed analysis completed using ArcMap Version 10.1 (ESRI, Redlands, CA).

Comparisons between baseflow and stormflow were done using only weeks for which there were both baseflow and stormflow data available. A blocked ANOVA was used to make the comparisons, but only 7 pairs of data were available. This method of data section was used in order to minimize the influence of a more numerous baseflow data set, and to focus on the differences between baseflow and stormflow at similar times.

RESULTS

Temperature

- Water temperature influences both biological activity and growth, including fish, insects, zooplankton, and phytoplankton have a preferred temperature range in which they thrive (USGS 2015).
- Water temperature also influences water chemistry, especially dissolved oxygen, which have a lower capacity to hold oxygen at higher temperatures (USGS 2015).

- In general, the temperatures are lower in late spring/early summer and warm up over summer (Figure 6). This is expected because of the seasonal changes in temperature in this region.
- Temperatures for all branches of the river are similar (Figure 6).
- Comparing differences between branch, baseflow and stormflow temperatures were not significantly different (Tables 7 and 8).
- Comparing differences between years, baseflow and stormflow temperatures were significantly different at all branches (Table 9).
- In the south branch, baseflow temperatures in 2010 were significantly different from 2013, while 2011, 2012, 2014, and 2015 were similar to all years. In the main branch, 2010 was significantly different from all the other years, while the other years were similar to one another. In the north branch, baseflow temperatures in 2010 were significantly different from 2012, 2013, 2014, and 2015 while 2011 was similar to both (Table 9).
- Comparing differences between years, stormflow temperatures in the main branch were significantly different, except 2014 which was similar to 2011 and 2015 (Table 10).
- Baseflow and stormflow temperatures were significantly different at all branches in 2015 (Table 11).

Turbidity

- Turbidity is defined as the presence of suspended solids in water (Lind 19) and is reported in NTU. Lower turbidity levels mean that the water is clearer, which generally means there is better water quality.
- Turbidity levels were more variable, and higher, in 2010 through 2013 than in 2014 and 2015 (Figure 7).
- Stormflow turbidity levels were higher than baseflow levels (Figure 8).
- In general, lower average turbidity levels were detected in the south branch and highest levels in the north branch (Figure 7).
- Average turbidity levels were lower in 2014 and 2015 than the previous years (Figure 8).
- Comparing differences between branches, baseflow turbidity levels were significantly different between branches in 2010, 2011, 2012, and 2015. The significant difference in 2015 was noted by the p-value but the tukey analysis was not able to detect actual differences in the branches. The north branch was significantly different from the other branches in those years turbidity levels were significantly different. The main branch and south branch were similar to one another (Table 7).
- When comparing branches, stormflow turbidity levels were not significantly different by branch (Table 2). This indicates that the differences observed during baseflow are not occurring during stormflow because of increased erosion by storms throughout the watershed.
- When comparing years, baseflow turbidity levels were significantly different at all branches by year. Baseflow turbidity levels in 2010 were significantly different from 2015 (Table 9).
- Comparing years, stormflow turbidity levels were not different in the main and north branches. In the south branch, 2015 was significantly different from 2014 and 2012, which were similar (Table 10).
- During all years, baseflow turbidity levels in the main branch were significantly different from stormflow levels in the main branch. Stormflow turbidity levels in 2014 were significantly

different from baseflow levels at all branches and in only the south branch in 2010 and 2012 (Table 11).

Total Phosphorus

- Phosphorus is an essential nutrient for both aquatic plants and animals. In most fresh water systems, phosphorus is often the nutrient in lowest concentrations. Therefore, even a small increase in phosphorus can cause "accelerated plant growth, algae blooms, low dissolved oxygen levels, and the death of certain fish, invertebrates, and other aquatic animals" in streams, rivers, and lakes (EPA 2015).
- There are natural (soil and rocks) and human sources of phosphorus, including, wastewater treatment plants, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas, disturbed land areas, drained wetlands, and water treatment (EPA 2015). The majority of the Centerville Creek watershed is agricultural land use.
- Total phosphorus concentrations measure all forms of phosphorus in the water and is the sum of the soluble phosphorus (PO_4; dissolved phosphorus) and particulate phosphorus (Horne & Goldman 155). Soluble phosphorus is the amount of phosphorus available for plants and algae to take up.
- For this report, total phosphorus levels were analyzed and are reported in mg/L.
- In Wisconsin, small streams and rivers are considered impaired if total phosphorus levels exceeds 0.075 mg/L. Large rivers, such as the Fox River, are considered impaired at 0.1 mg/L (NR 102.06 (3) WDNR).
- All three years have baseflow total phosphorus concentrations greater than 0.075 mg/L. Phosphorus levels in all branches of Centerville Creek rarely fell below this level between 2010 and 2015.
- Total phosphorus levels have move more variation between years than between the sites themselves (Figure 9).
- In general, baseflow and stormflow phosphorus levels are lower for the south branch than the north and main branches (Figure 10).
- North branch in 2015 has higher total phosphorus levels than the other branches (Figure 11).
- Comparing differences between branches, total baseflow phosphorus levels had significant differences in 2012 and 2015. The main branch was significantly different from the north branch in both years. While the south branch was similar to the main branch in 2012 and to both of the other branches in 2015 (Table 7).
- When comparing branches, stormflow total phosphorus levels were only significantly different by branch in 2015. Main and south branches were significantly different from the north branch (Table 8).
- Comparing years, baseflow total phosphorus was significantly different in the main branch, with 2014 different from 2011, 2012, and 2013, while 2010 and 2015 were similar to both. North and south branches have similar results, with 2014 and 2015 significantly different from 2012 (Table 9).
- Comparing differences between years, stormflow total phosphorus in the main branch in 2014 was significantly different from all others years, with all other years being similar (Table 10).

- Comparing baseflow to stormflow, baseflow total phosphorus levels were significantly different from stormflow levels at all three branches in 2012 and 2014 and in the main branch in 2015 (Table 11).

Nitrogen (NH4)

- Ammonia (NH_4) is the preferred form of nitrogen for plant growth in aquatic systems (Horne & Goldberg 133).
- NH_4 is reported in mg/L and is commonly present in concentrations less than 1 mg/L (Lind, 84).
- More variation was seen 2010 to 2013 than in 2014 and 2015 (Figures 11 and 12).
- Both baseflow and stormflow NH_4 were generally lower in 2015 than in the earlier years (Figure 11 and 12).
- Baseflow NH_4 was significantly different between branch in 2010 and 2013. In 2010, the main and north branches were significantly different from the south branch. In 2013, the main and south branch were significantly different from the north branch (Table 7).
- Stormflow total NH_4 levels were significantly different by branch in 2015, with the north branch significantly different from the south and the main branch similar to both (Table 8).
- Comparing differences in year, total NH_4 was significantly different at all branches. The main branch has the least variation, with 2012-2015 being similar and significantly different from the previous years. With baseflow NH_4 levels 2014 was similar to 2015 at all branches (Table 9).
- When comparing years, stormflow total NH_4 was significantly different in all years, with 2015 significantly different from all previous years, except at the south branch when 2015 was similar to 2014 (Table 10)
- Baseflow and stormflow NH_4 were significantly different for the main and north branches in 2014 and the south branch in 2010 and 2015 (Table 11).

E. Coli

- Escherichia coli (*E. coli*) are bacteria that, when found in water in high concentrations, can be an indicator that pathogenic bacteria may be present. Pathogenic bacteria can cause serious illness in humans. *E. coli* is reported as CFU/ml or MPN/ml (used interchangeably).
- The EPA recommends that advisories at beaches be issued when *E. coli* levels in the water reach 235 CFU/100ml (WDNR)
- In general, baseflow *E. coli* levels seem to peak in mid-summer in all branches (Figure 13).
- E. coli levels following rain events are generally higher than the baseflow levels (Figure 14).
- Due to the number of sites that reached the detection limit of *E. coli* (2419.6 #/100mL), the mean should not be used for absolute values, however it is useful for comparing trends between sites and streams. Values easily exceed the recommended safe levels.
- A higher percentage of samples exceeded the detection limit for *E. coli* following rain events. (Table 6).
- Comparing branches, baseflow *E. coli* levels were significant in only 2010 and 2013 when the north branch was significantly different from the other branches (Table 7).
- Comparing branches, *E. coli* stormflow levels were significantly different in 2014 and 2015. The significance difference in 2014 was notable by the p-value but post-hoc test was not able to

detect actual differences in the branches. In 2015, the main and south branches were significantly different from the north branch (Table 8).

- Year was not significantly different for baseflow *E. coli* levels for the north or south branches. For the main branch, all sites were similar except 2012 was significantly different from 2011 (Table 9).
- When comparing differences between years, stormflow *E. coli* was significant at each branch. 2013 and 2014 were similar at each branch while and at the north branch in 2015. While the main branch and south branch in 2015 were significantly different from those years (Table 10).
- Baseflow and stormflow E. coli levels were significantly different for all branches in 2012, 2014, and 2015 (Table 11).

Table 6. Mean *E. coli* values by site and year. Advisory level (235 CFU/100 ml) based on standards for Wisconsin beaches. Maximum detection level was 2419.6 CFU/100 ml.

		BASE FLOW				STORM FLOW			
Site	Year	# Samples	Mean Baseflow	% Exceed Advisory Level	% Exceed Detection Limit	# Samples	Mean Stormflow	% Exceed Advisory Level	% Exceed Detection Limit
Centerville Creek Main Branch	2010	27	945.29	100	0.0	8	1292.94	62.5	0.0
	2011	18	437.22	66.7	0.0	21	1140.65	81.0	28.6
	2012	29	1122.86	96.6	3.4	10	2419.6	100	100
	2013	43	639.40	65.1	7.0	0	-	-	-
	2014	48	1004.73	64.6	12.5	17	2419.6	100	88.2
	2015	33	973.79	63.6	12.1	27	1585.02	100	33.3
Centerville Creek North Branch	2010	9	1399.51	100	0.0	4	1511.9	75.4	0.0
	2011	18	785.65	72.2	5.6	21	1053.63	71.4	19.0
	2012	56	1230.25	92.9	25.0	24	2335.44	100	91.7
	2013	52	1203.47	86.5	28.8	0	-	-	-
	2014	56	1053.58	75.0	17.9	20	2419.6	100	95.0
	2015	44	1195.00	81.8	20.5	36	2054.82	100	63.9
Centerville Creek South Branch	2010	9	562.44	100	0.0	2	686.7	50	0.0
	2011	6	534.42	83.3	0.0	7	743.51	71.4	14.3
	2012	42	966.39	85.7	9.5	18	2323.32	100	88.9
	2013	39	808.45	71.8	10.3	0	-	-	-
	2014	44	842.28	70.5	11.4	15	2226.07	100	80.0

Formatted Table

2015	33	790.77	81.8	9.1	27	1331.59	92.6	33.3

Statistical Tables

Table 7. Comparison of differences **between branches** of Centerville Creek, **baseflow** levels for all variables. Anova with tukey test was run on all baseflow data. Sites connected by the same letter, within each variable, were not significantly different.

		Branch			
Variable	**Year**	**Main**	**North**	**South**	**P-value**
Total Phosphorus	2010				0.6328
	2011				0.0818
	2012	B	A	B	<0.0001
	2013				0.1022
	2014				0.5249
	2015	B	A	AB	0.0058
Turbidity	2010	AB	A	B	0.0189
	2011	B	A	B	0.0002
	2012	B	A	B	0.0005
	2013				0.2611
	2014				0.2863
	2015	A	A	A	0.0414
Ammonia NH_4	2010	A	A	B	0.022
	2011				0.8969
	2012				0.1168
	2013	B	A	B	0.0011
	2014				0.5242
	2015				0.3689
Temperature	2010				0.3931
	2011				0.9386
	2012				0.7915
	2013				0.148
	2014				0.0858
	2015				0.4783
E. coli	2010	B	A	C	0.0002
	2011				0.2896
	2012				0.2677
	2013	B	A	B	0.0023
	2014				0.4669
	2015				0.1074

Table 8. Comparison of differences **between branches** of Centerville Creek, **stormflow** levels for all variables. Anova with tukey test was run on all baseflow data. Sites connected by the same letter, within each variable, were not significantly different.

		Branch			
Variable	**Year**	**Main**	**North**	**South**	**P-value**
Total Phosphorus	2010				0.1481
	2011				0.5703
	2012				0.5805
	2014				0.1661
	2015	B	A	B	0.0008
Turbidity	2010				0.3047
	2011				0.4056
	2012				0.1844
	2014				0.3189
	2015				0.4983
Ammonium NH4	2010				0.8179
	2011				0.9364
	2012				0.5658
	2014				0.0862
	2015	AB	A	B	0.0463
Temperature	2010				0.3901
	2011				0.9109
	2012				0.9687
	2014				0.262
	2015				0.7564
E. coli	2010				0.6412
	2011				0.6329
	2012				0.7361
	2014	A	A	A	0.0443
	2015	B	A	B	0.0012

Table 9. Comparison of differences **between years** by branch of Centerville Creek, **baseflow** levels for all variables. Anova with tukey test was run on all baseflow data. Sites connected by the same letter, within each variable, were not significantly different.

		Year						
Variable	**Branch**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**P values**
Total Phosphorus	Main	AB	B	B	B	A	AB	**<0.0001**
	North	AB	BC	C	BC	A	A	**<0.0001**
	South	AB	BC	C	C	A	A	**<0.0001**
Turbidity	Main	A	ABC	ABC	AB	BC	C	**0.0027**
	North	A	A	A	A	B	B	**<0.0001**
	South	AB	AB	A	A	B	B	**<0.0001**
Ammonium NH_4	Main	B	A	C	C	C	C	**<0.0001**
	North	AB	A	B	B	C	C	**<0.0001**
	South	BC	A	B	CD	D	D	**<0.0001**
Temperature	Main	A	B	B	B	B	B	**<0.0001**
	North	A	AB	B	B	B	B	**0.0006**
	South	A	AB	AB	B	AB	AB	**0.0161**
E. coli	Main	AB	B	A	AB	AB	AB	**0.0045**
	North							0.3392
	South							0.5386

Table 10. Comparison of differences **between years** by branch of Centerville Creek, **stormflow** levels for all variables. Anova with tukey test was run on all baseflow data. Sites connected by the same letter, within each variable, were not significantly different.

Variable	Year	Year					
		2010	2011	2012	2014	2015	P values
Total Phosphorus	Main	B	B	B	A	B	<0.0001
	North	AB	B	B	A	A	<0.0001
	South	AB	B	B	A	A	<0.0001
Turbidity	Main						0.0725
	North						0.7463
	South	AB	AB	A	A	B	0.0069
Ammonium NH4	Main	A	A	AB	A	B	0.0003
	North	A	A	A	A	B	<0.0001
	South	A	A	A	B	B	<0.0001
Temperature	Main	A	C	B	CD	D	<0.0001
	North	A	B	A	BC	C	<0.0001
	South	AB	BC	A	BC	C	<0.0001
E. coli	Main	B	B	A	A	B	<0.0001
	North	AB	B	A	A	A	<0.0001
	South	AB	B	A	A	B	<0.0001

Table 10. Comparison of differences **between storm flow and baseflow** by branch of Centerville Creek, for all variables. Anova with tukey test was run on all baseflow data. Sites connected by the same letter, within each variable, were not significantly different.

Formatted: Not Highlight

Variable	Branch	2010	2011	2012	2014	2015
Total Phosphorus	Main	0.3558	0.2143	**<0.0001**	**0.016**	**0.0003**
	North	0.4658	0.7584	**0.0001**	**0.0006**	0.089
	South	0.5631	0.7303	**<0.0001**	**0.0223**	0.1021
Turbidity	Main	**0.0001**	**0.0424**	**<0.0001**	**0.0009**	**0.0254**
	North	0.147	0.1306	0.8123	**<0.0001**	0.2208
	South	**0.0042**	0.0691	**0.0045**	**0.0002**	0.1569
Ammonium NH_4	Main	0.6547	0.1621	0.1085	**0.0093**	0.8045
	North	0.4338	0.5564	0.492	**<0.0001**	0.7499
	South	**0.0408**	0.4573	0.9443	0.7127	**0.0482**
Temperature	Main	0.5351	**0.04**	0.2145	**0.0052**	**0.0002**
	North	0.751	0.0528	**0.039**	0.4169	**0.0021**
	South	0.9081	0.1117	**0.0195**	0.5977	**0.0015**
E. coli	Main	0.0901	**0.0075**	**<0.0001**	**<0.0001**	**0.0058**
	North	0.797	0.3699	**<0.0001**	**<0.0001**	**<0.0001**
	South	0.6461	0.5869	**<0.0001**	**<0.0001**	**0.0138**

CONCLUSION

Patterns between years appear to have a greater influence on water quality than differences between the branches in Centerville Creek. The watershed has been converted to agricultural land, which is a major contributor of nutrients and sediments. Although urban land use is generally low intensity, it still has a major footprint in portions of the watershed, especially the south branch. Nutrient concentrations are high and vary depending on precipitation events. Nutrient and sediment retention in the watershed would be a potential pathway to improving water quality in Centerville Creek.

Differences in stormflow and baseflow nutrient levels were significant in 2014 for all variables except temperature. Rain events also had an impact on water quality in total phosphorus levels in 2012 and most *E. coli* levels.

For Centerville Creek, whole watershed patterns appear more important than single branch patterns. Total phosphorus and *E. coli* levels consistently exceeded levels at which the water is considered unimpaired. Lower turbidity and NH_4 levels were measured in 2014 and 2015 while total phosphorus was higher in those years compared to the previous years studied in Centerville Creek.

References

EPA (Environmental Protection Agency) 2015. "Volunteer Monitoring". http://water.epa.gov/type/rsl/monitoring/vms56.cfm. Modified 11-March-2015.

Horne, Alexander J. and Goldman, Charles R. 1994. Limnology. 2nd edition. McGraw-Hill, Inc. New York.

Lind, Owen T. 1985. Limnology: Handbook of Common Methods. 2nd edition. Kendall/Hunt Publishing Company. Dubuque, IA.

McKay, L., Bondelid, T., Dewald, T., Johnston, J., Moore, R., and Rea, A., "NHDPlus Version 2: User Guide", 2012

NR 102.06 (3). WDNR. http://dnr.wi.gov/topic/surfacewater/phosphorus.html

USGS (United States Geological Survey) 2015. "Temperature – Water Properties". http://water.usgs.gov/edu/temperature.html. Modified 27-Jul-2015 14:42:36 EDT.

WDNR (Wisconsin Department of Natural Resources) "Beach Monitoring Program Requirements". http://dnr.wi.gov/topic/Beaches/documents/BeachMonitoringRequirements.pdf

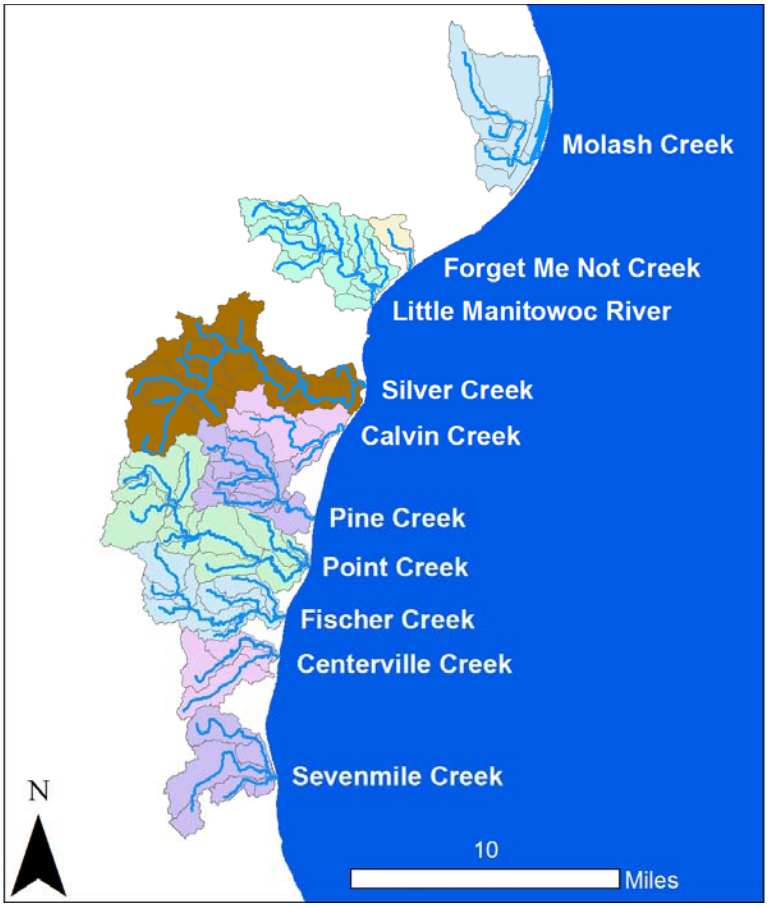


FIGURE 1. Watersheds of Southern Manitowoc County, WI.

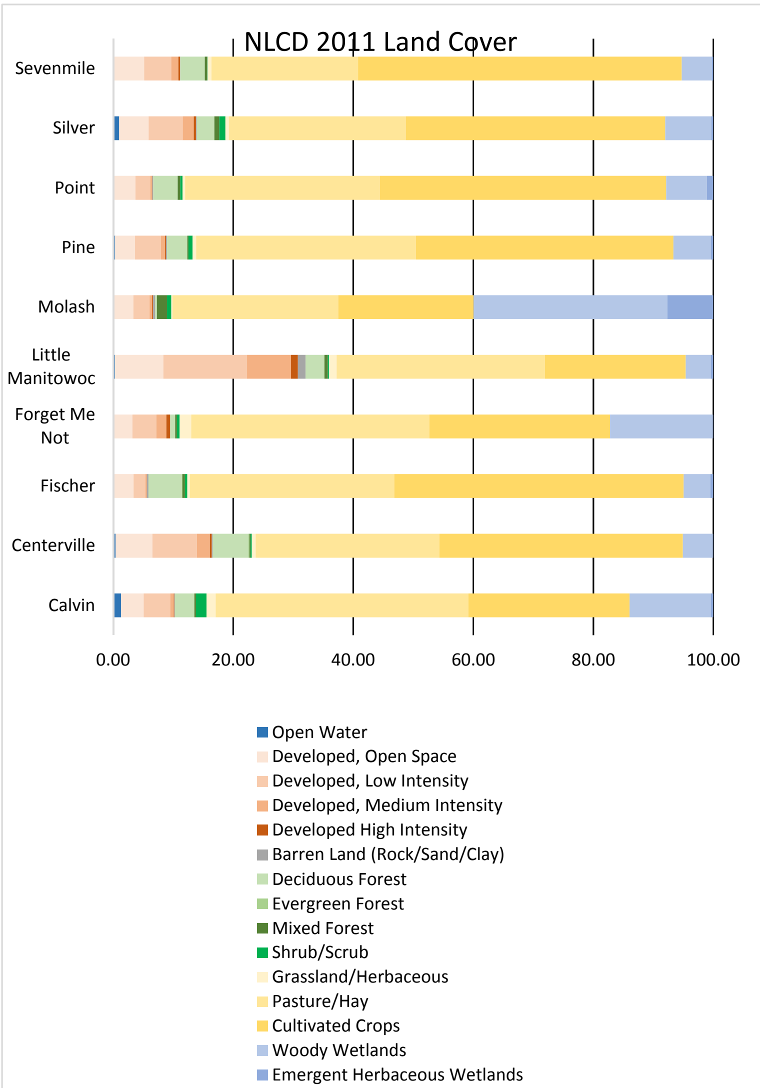


Figure 2. Percentage of land cover and land use of 10 southern Manitowoc creek watersheds.

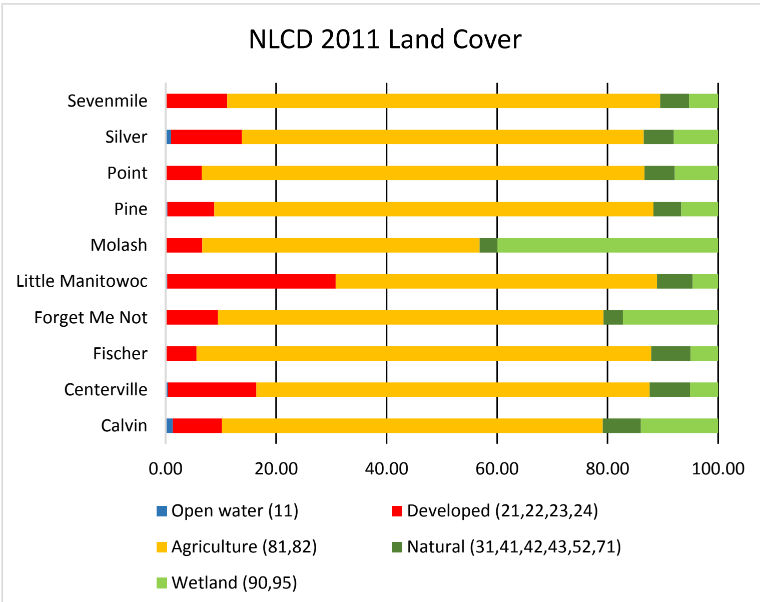


FIGURE 3. Percentage of land cover and land use of 10 southern Manitowoc creek watersheds, broken into more general categories.

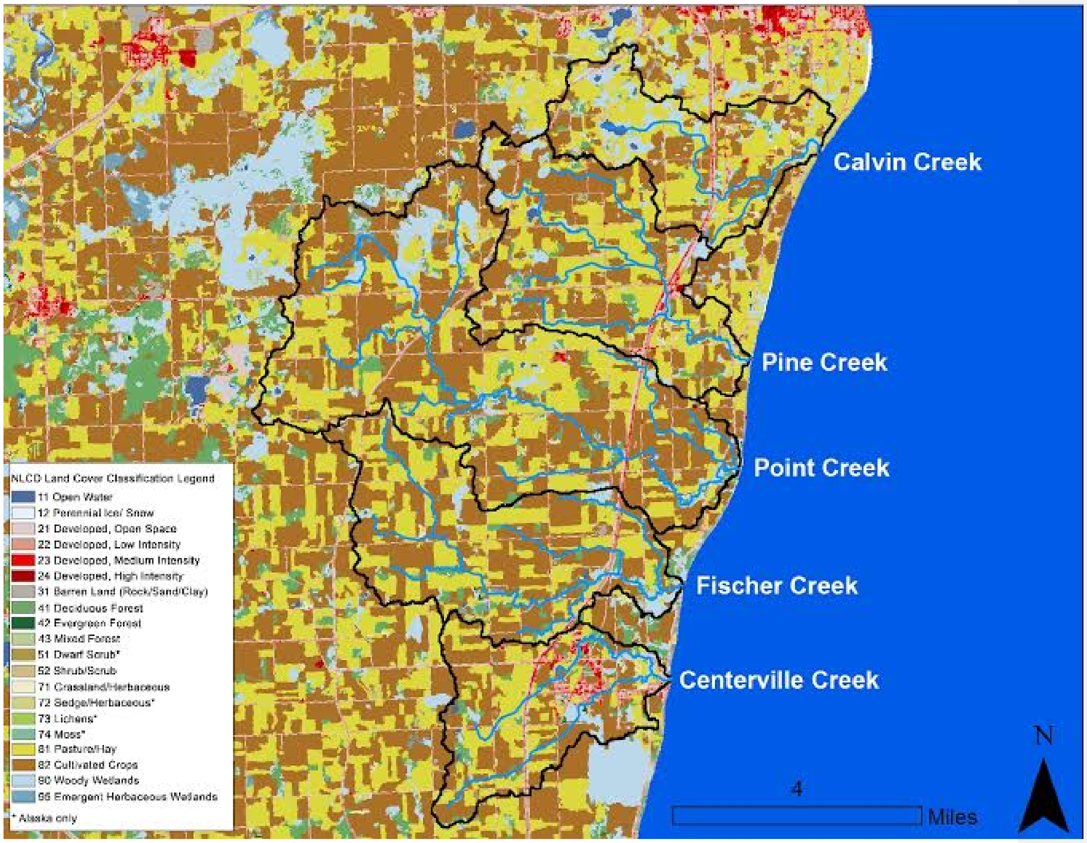


FIGURE 4. Southern Manitowoc creeks, watersheds, and landuse.

FIGURE 5. Sample site locations on Centerville Creek. Red sites are the main branch, purple sites are the north branch and black sites are the south branch.

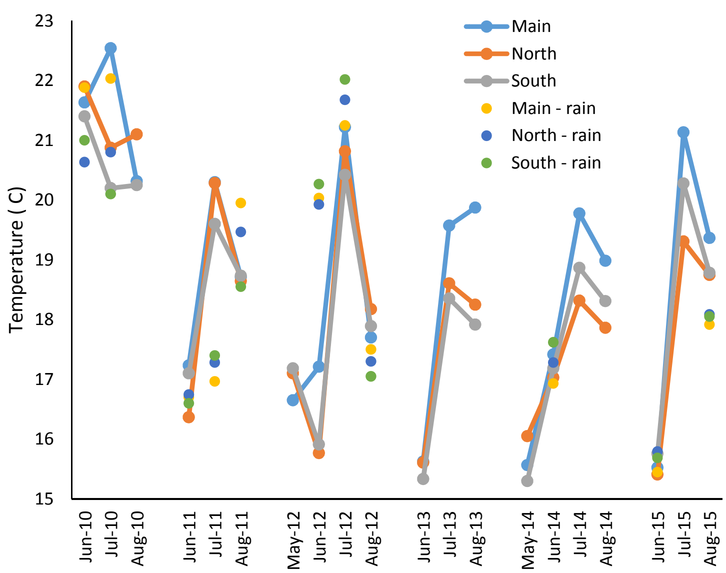


FIGURE 6. Monthly mean temperature (^{o}C), baseflow and stormflow (dots), at each site in Centerville Creek, 2010 – 2015.

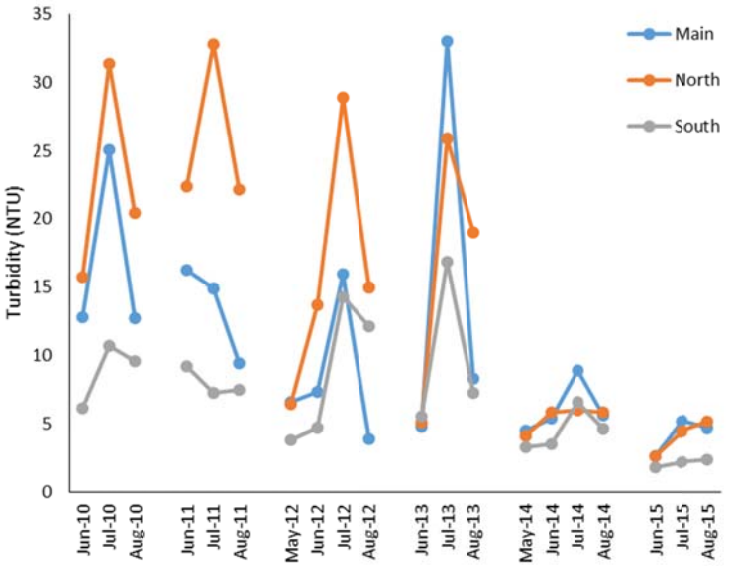


Figure 7. Average baseflow turbidity levels by month and year for Centerville Creek, 2010 – 2015.

Comment [ST1]: Is this needed? Fig 8 has same data.

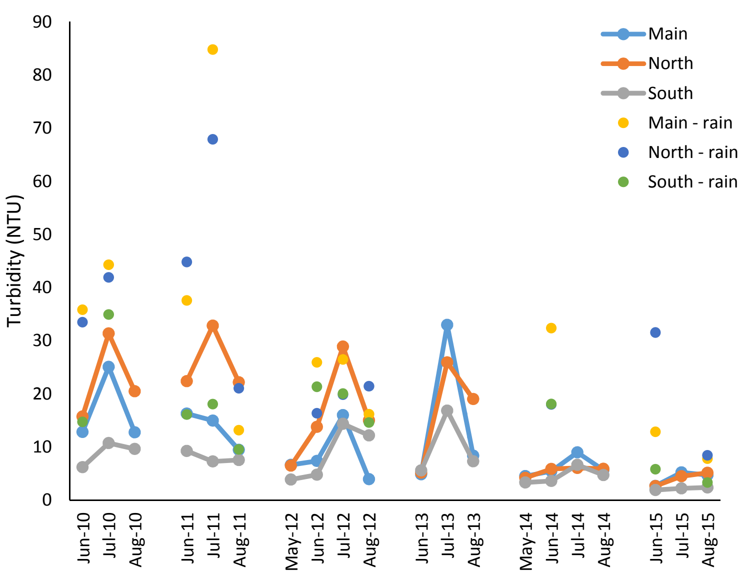


FIGURE 8. Monthly mean turbidity levels (NTU), baseflow and stormflow (dots), at each site in Centerville Creek, 2010 – 2015.

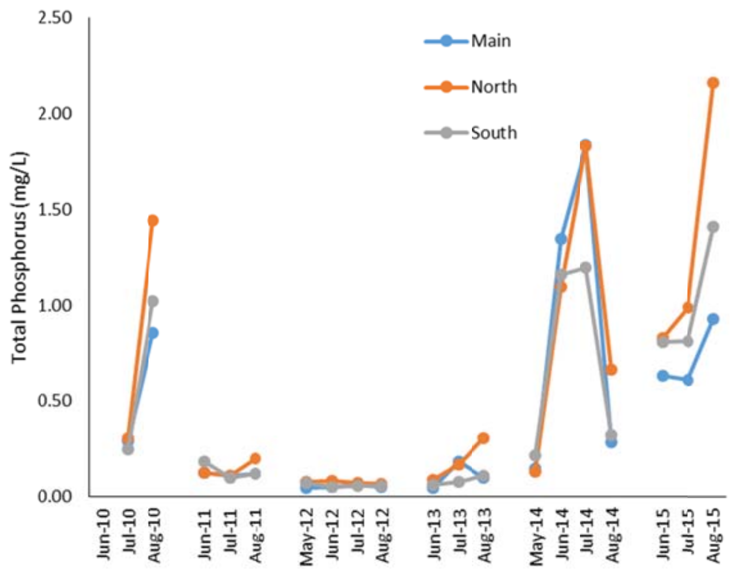


FIGURE 9. Average baseflow total phosphorus levels by month and year for Centerville Creek, 2010 – 2015. Rain events are not included in the average.

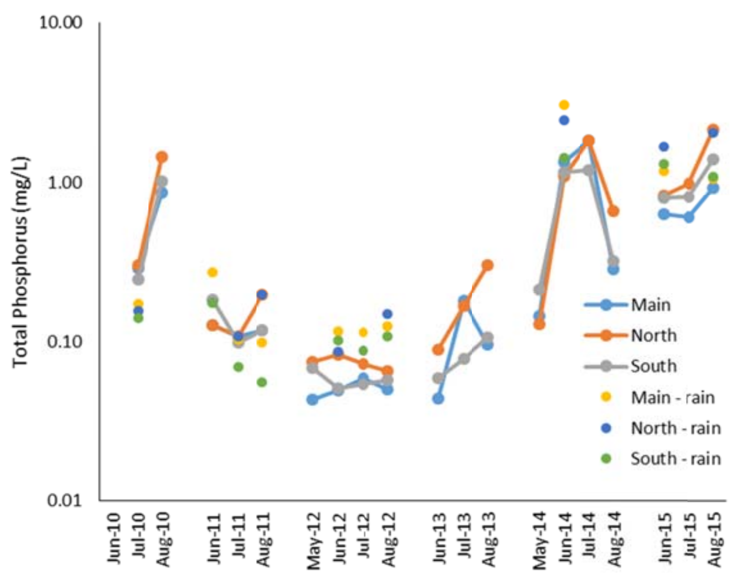


FIGURE 10. Average total phosphorus (log scale) for rain events per month and average baseflow total phosphorus levels by month and year for Centerville Creek, 2010 – 2014.

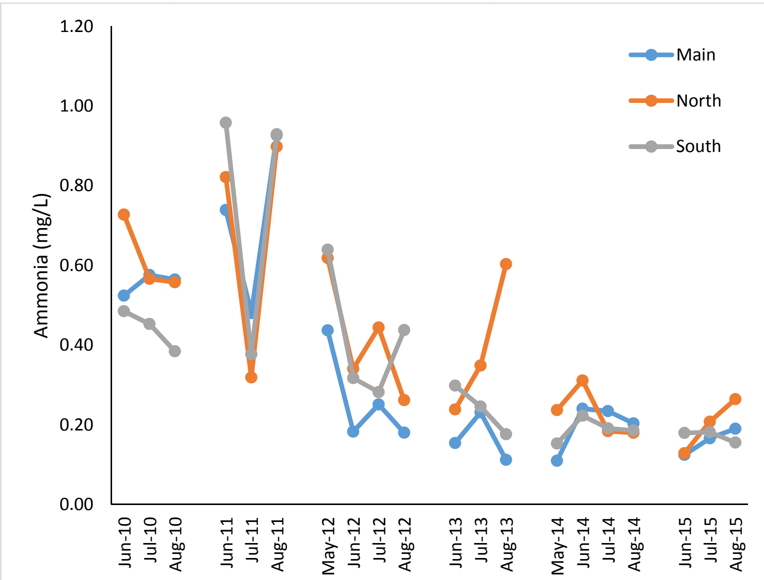


Figure 11. Average baseflow NH_4 levels by month and year for Centerville Creek, 2010 – 2015.

Comment [ST2]: Is this needed?

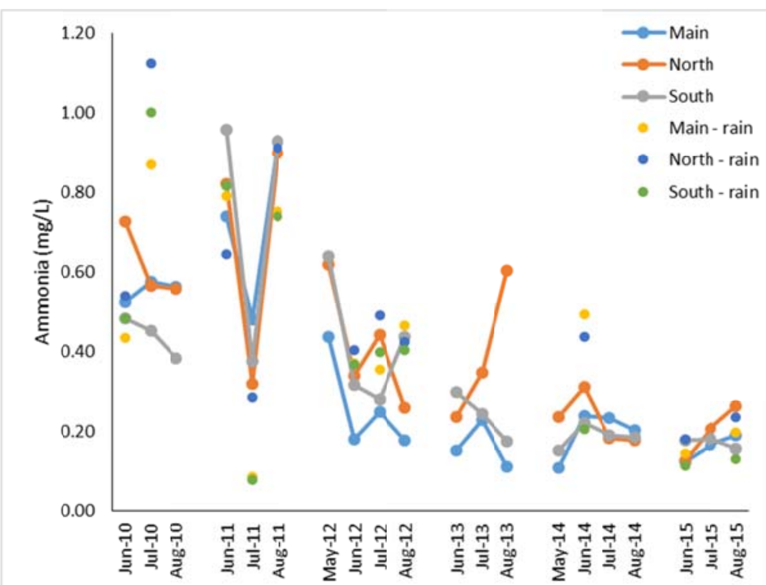


Figure 12. Average NH_4 for rain events per month and average baseflow NH_4 levels by month and year for Centerville Creek, 2010 – 2015.

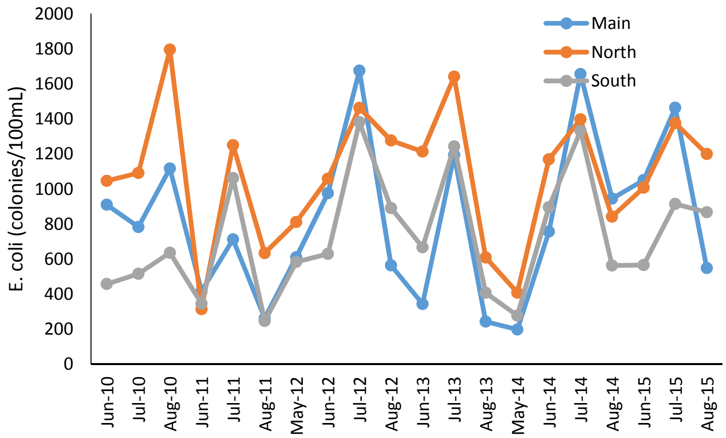


Figure 13. Average *E. coli* for rain events per month and average baseflow *E. coli* levels by month and year for Centerville Creek, 2010 – 2015.

Comment [ST3]: Needed?

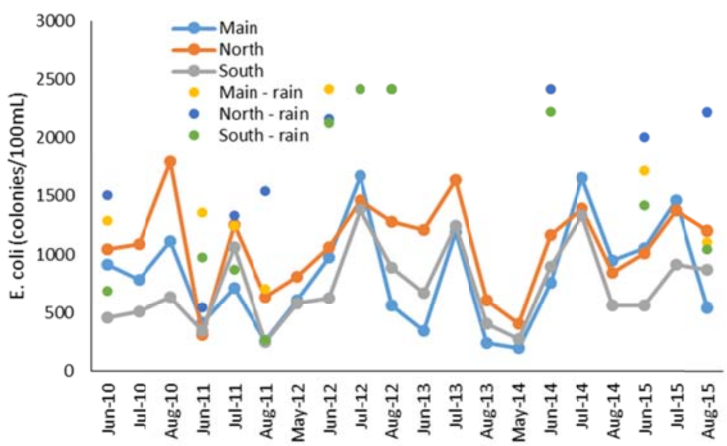


Figure 14. Average *E. coli* for rain events per month and average baseflow *E. coli* -levels by month and year for Centerville Creek, 2010 – 2015.

FISCHER CREEK AND POINT CREEK WATER QUALITY REPORT, 2012– 2015
Lakeshore Natural Resource Partnership

INTRODUCTION

The purpose of this report is to summarize the water quality data collected at sites in Fischer Creek and Point Creek during the summers of 2012-2015. In general, there were differences between baseflow and rain events with higher turbidity, nutrients, and bacteria following rain events. Differences between sites within each creek were small with differences between years having a larger impact on the variations seen in the water quality values.

STUDY AREA

Fischer and Point Creeks are small watersheds located in southern Manitowoc County (Table 1, Figure 1). Both watersheds are heavily influenced by agricultural land use (approximately 80%), with less developed land (6%), forest, and wetland (Tables 2 & 3; Figures 2, 3, & 4). Two sites were sampled in Fischer Creek and two sites were also sampled in Point Creek (Figure 5).

Table 1. Area and length of the study stream and four Southern Manitowoc County creeks sampled.

Site	Area (mile^2)	Length (miles)	Area (km^2)	Length (km)
Calvin	7.2	7.1	18.7	11.5
Centerville	7.4	9.8	19.1	15.7
Fischer	11.5	18.8	29.8	30.3
Pine	10.9	15.1	28.2	24.3
Point	21.8	28.6	56.4	46.0

Table 2. Percentage of type of land use for Fischer Creek and Point Creek in the study, 2011.

Code	Class	Fischer	Point
11	Open Water	0.16	0.12
21	Developed, Open Space	3.26	3.60
22	Developed, Low Intensity	1.96	2.46
23	Developed, Medium Intensity	0.21	0.27
24	Developed High Intensity	0.01	0.06
31	Barren Land (Rock/Sand/Clay)	0.28	0.16
41	Deciduous Forest	5.56	4.08
42	Evergreen Forest	0.09	0.01
43	Mixed Forest	0.44	0.43
52	Shrub/Scrub	0.39	0.37
71	Grassland/Herbaceous	0.39	0.42
81	Pasture/Hay	**34.08**	**32.47**
82	Cultivated Crops	**48.21**	**47.69**
90	Woody Wetlands	**4.46**	**6.76**
95	Emergent Herbaceous Wetlands	0.50	1.09

Table 3. Percentage of type of land use, broken into larger categories, for Fischer and Point Creeks in the study, 2011.

Class	Fischer	Point
Open water (11)	0.16	0.12
Developed (21,22,23,24)	5.44	6.40
Natural (31,41,42,43,52,71)	7.14	5.46
Wetland (90,95)	4.96	7.85
Agriculture (81,82)	82.29	80.16

Source: National Land Cover Database. http://www.mrlc.gov/nlcd11_data.php

METHODS

Student interns working for faculty at UW-Manitowoc collected water samples during the summers of 2012, 2013, 2014, and 2015. Samples were taken weekly from late May through the end of August (baseflow). Samples were also taken following rain events greater than a half inch at both 24 and 48 hours (Table 4). Rain event sample dates are “stormflow” while non-rain event sample dates are “baseflow” in this report (Table 5).

All sampling sites were located in the area between I-43 and Lake Michigan. Weekly averages were calculated for each stream for baseflow and stormflow. These averages were used to test for differences between the streams in the water quality variables.

<u>Physical indicators were measured by field probes</u>

- •Dissolved Oxygen (YSI 550A DO Probe)
- •Temperature/pH
- •Turbidity (LaMotte 2020 we)
- •Stream Velocity (Global Water Instrumentation, Inc)
- •Conductivity

<u>Nutrient indicators</u>

- •Ammonia (NH_3/NH_4) measured with Hach field kit for Ammonia Nitrogen
- •Total Orthophosphate (TP) and Total Dissolved Phosphate (TDP)
- •Acid hydrolysis with H_2SO_4
- •Colorimetric analysis via ammonium molybdate-stannous chloride method

<u>Biological Indicators</u>

- •E. coli fecal coliform analysis (Colilert-24)

Statistical Analysis

Differences between the two creeks, between the sites, and between the years were tested for differences in baseflow and stormflow data separately. Mean weekly values for each creek were tested using a blocked Analysis of Variance (ANOVA). The block design allowed for testing over all four years at once, with difference in each weekly block used for the ANOVA. When significant differences were indicated by the ANOVA, a Tukey-Kramer post-hoc test was used to determine the differences between streams. All statistical analyses were done in JMP Pro Version 11 (SAS Institute Inc., Cary, NC). Mapping and watershed analysis completed using ArcMap Version 10.1 (ESRI, Redlands, CA).

Comparisons between baseflow and stormflow were done using only weeks for which there were both baseflow and stormflow data available. A blocked ANOVA was used to make the comparisons, but only 7 pairs of data were available. This method of data section was used in order to minimize the influence of a more numerous baseflow data set, and to focus on the differences between baseflow and stormflow at similar times.

Table 4. Number of weeks sampled each summer in Fischer and Point Creeks. Storm events are rainfalls greater than a half inch, sampled at both 24 and 48 hours.

Creek	Year	# Baseflow Sample Weeks	# Stormflow Sample Weeks	Total # Sample Weeks	# Baseflow Sample Days	# Stormflow Sample Days	Total # Sample Days
Fischer	2012	14	3	17	28	6	34
	2013	12	0	12	26	0	26
	2014	13	6	19	26	11	37
	2015	10	9	19	22	18	40
Point	2012	14	3	17	28	6	34
	2013	12	0	12	26	0	26
	2014	13	6	19	26	11	37
	2015	10	9	19	22	18	40

Table 5. Sample dates for Fischer and Point Creeks, summers 2012 – 2015. Storm events are rainfalls greater than a half inch, sampled at both 24 and 48 hours.

Date	Storm Event	Date	Storm Event	Date	Storm Event	Date	Storm Event
5/22/2012	No	6/3/2013	No	5/27/2014	No	6/1/2015	No
5/29/2012	No	6/10/2013	No	6/2/2014	Yes	6/8/2015	No
6/5/2012	No	6/17/2013	No	6/3/2014	Yes	6/12/2015	Yes
6/12/2012	No	6/24/2013	No	6/4/2014	Yes	6/13/2015	Yes
6/19/2012	Yes	7/1/2013	No	6/9/2014	No	6/15/2015	Yes
6/20/2012	Yes	7/8/2013	No	6/10/2014	No	6/16/2015	Yes
6/26/2012	No	7/15/2013	No	6/16/2014	No	6/17/2015	Yes
7/2/2012	No	7/22/2013	No	6/17/2014	Yes	6/23/2015	Yes
7/10/2012	No	7/29/2013	No	6/18/2014	Yes	6/24/2015	Yes
7/17/2012	No	8/5/2013	No	6/19/2014	Yes	6/29/2015	No
7/24/2012	No	8/12/2013	No	6/23/2014	No	7/13/2015	No
7/26/2012	Yes	8/19/2013	No	6/30/2014	No	7/20/2015	No
7/27/2012	Yes	8/27/2013	No	7/7/2014	No	7/27/2015	No
7/31/2012	No			7/14/2014	No	8/3/2015	No
8/7/2012	No			7/21/2014	No	8/8/2015	Yes
8/14/2012	Yes			7/28/2014	No	8/9/2015	Yes
8/22/2012	Yes			8/4/2014	No	8/10/2015	No
8/14/2012	No			8/11/2014	No	8/17/2015	No
8/22/2012	No			8/18/2014	No	8/24/2015	No
8/29/2012	No			8/25/2014	No		

RESULTS

Temperature

- Water temperature influences both biological activity and growth, including fish, insects, zooplankton, and phytoplankton have a preferred temperature range in which they thrive (USGS 2015).
- Water temperature also influences water chemistry, especially dissolved oxygen, which have a lower capacity to hold oxygen at higher temperatures (USGS 2015).
- Temperatures were similar during all sampling seasons (Figure 6).
- Point Creek sites were slightly warmer than Fischer Creek at all sampling periods, except FI02 which was higher than the other sampling sites in May 2014.
- Stormflow and baseflow temperatures were similar (Figure 7).

Turbidity

- Turbidity is defined as the presence of suspended solids in water (Lind 19) and is reported in NTU. Lower turbidity levels mean that the water is clearer, which generally means there is better water quality.
- Baseflow turbidity levels were greatest in 2012 and were lowest and with the least variation in the summer of 2015 (Figure 8).
- Turbidity levels at all sites follow similar trends, with turbidity levels in Point Creek generally greater than Fischer Creek levels.
- Stormflow turbidity levels were generally higher than baseflow turbidity levels (Figure 9).
- Stormflow turbidity values were smallest in 2015 and the peak value was at the Point 02 site in June 2014 measuring 180 NTU, whereas all other turbidity levels were less than 100 NTU.
- Baseflow turbidity levels between years were not significantly different, except at FI03, where 2012 and 2013 were similar and significantly different from 2015 (Table 6).
- Stormflow turbidity levels between years were not significantly different, except at PO03, where 2015 was different from 2012 and 2014 (Table 7).

Table 6. Comparison of differences in baseflow turbidity levels between years at each site. Anova with tukey test was run on baseflow data. Sites connected by the same letter, within each variable, were not significantly different.

	FI02	**FI03**	**PO02**	**PO03**
2012		A		
2013		A		
2014		AB		
2015		B		
P value	0.1871	0.0119	0.0538	0.0655

Table 7. Comparison of differences in stormflow turbidity levels between years at each site. Anova with tukey test was run on baseflow data. Sites connected by the same letter, within each variable, were not significantly different.

	FI02	**FI03**	**PO02**	**PO03**
2012				AB
2014				AB
2015				B
P value	0.1784	0.0923	0.2211	0.0107

Total Phosphorus

- Phosphorus is an essential nutrient for both aquatic plants and animals. In most fresh water systems, phosphorus is often the nutrient in lowest concentrations. Therefore, even a small increase in phosphorus can cause “accelerated plant growth, algae blooms, low dissolved oxygen levels, and the death of certain fish, invertebrates, and other aquatic animals” in streams, rivers, and lakes (EPA 2015).
- There are natural (soil and rocks) and human sources of phosphorus, including, wastewater treatment plants, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas, disturbed land areas, drained wetlands, and water treatment (EPA 2015).
- Total phosphorus concentrations measure all forms of phosphorus in the water and is the sum of the soluble phosphorus (PO_4; dissolved phosphorus) and particulate phosphorus (Horne & Goldman 155). Soluble phosphorus is the amount of phosphorus available for plants and algae to take up.
- For this report, total phosphorus levels were analyzed and are reported in mg/L.
- In Wisconsin, small streams and rivers are considered impaired if total phosphorus levels exceeds 0.075 mg/L. Large rivers, such as the Fox River, are considered impaired at 0.1 mg/L (NR 102.06 (3) WDNR).
- All three years have baseflow total phosphorus concentrations consistently greater than 0.075 mg/L.
- Baseflow total phosphorus levels in 2014 and 2015 were largest and had the most variation (Figure 10).
- Both creeks had higher baseflow total phosphorus levels in 2014. In 2015, Point Creek had higher baseflow levels (greater than 0.6 mg/L) while Fischer Creek had baseflow levels below 0.4 mg/L.
- Stormflow total phosphorus levels in 2014 and 2015 were higher than levels in 2012 at all sites (Figure 11).
- Significant differences for baseflow total phosphorus were found between years at all of the sites (Table 8). 2012 and 2013 were significantly different from 2014 and 2015, except in 2015, when both Fischer Creek sites in 2015 were similar to 2012 and 2013.

- Stormflow total phosphorus levels were only significantly different between years at sites FI03 and PO02 (Table 9).

Table 8. Comparison of differences of baseflow total phosphorus levels between years at each site. Anova with tukey test was run on baseflow data. Sites connected by the same letter, within each variable, were not significantly different.

	FI02	**FI03**	**PO02**	**PO03**
2012	B	B	B	B
2013	B	B	B	B
2014	A	A	A	A
2015	AB	B	A	A
P value	<0.0001	<0.0001	<0.0001	<0.0001

Table 9. Comparison of differences of stormflow total phosphorus levels between year at each site. Anova with tukey test was run on baseflow data. Sites connected by the same letter, within each variable, were not significantly different.

	FI02	**FI03**	**PO02**	**PO03**
2012		B	B	
2014		A	B	
2015		AB	AB	
P value	0.0726	0.0326	0.0329	0.0662

Nitrogen (NH4)

- Ammonia (NH_4) is the preferred form of nitrogen for plant growth in aquatic systems (Horne & Goldberg 133).
- NH_4 is reported in mg/L and is commonly present in concentrations less than 1 mg/L (Lind, 84).
- Stormflow NH_4 levels were only slightly higher than baseflow NH_4 levels (Figures 12 & 13).
- Stormflow NH_4 was more variable in 2012 and 2014 than the stormflow values in 2015.
- NH_4 levels for baseflow were significantly different by year at both Fischer Creek sites, though not at the Point Creek sites (Table 10). The significant difference in FI03 was noted by the p-value but the tukey analysis was not able to detect actual differences in the years.
- Stormflow NH_4 levels were significantly different by year for FI03 and PO03 (Table 10).

Table 10. Comparison of differences in baseflow NH_4 levels between years at each site. Anova with tukey test was run on baseflow data. Sites connected by the same letter, within each variable, were not significantly different.

	FI02	FI03	PO02	PO03
2012	A	A		
2013	B	A		
2014	B	A		
2015	B	A		
P value	0.0002	0.0192	0.287	0.3515

Table 11. Comparison of differences in stormflow NH_4 levels between years at each site. Anova with tukey test was run on stormflow data. Sites connected by the same letter, within each variable, were not significantly different.

	FI02	FI03	PO02	PO03
2012		A		A
2014		AB		B
2015		B		B
P value	0.082	0.0382	0.3837	0.0003

E. Coli

- Escherichia coli (*E. coli*) are bacteria that, when found in water in high concentrations, can be an indicator that pathogenic bacteria may be present. Pathogenic bacteria can cause serious illness in humans. *E. coli* is reported as CFU/ml or MPN/ml (used interchangeably).
- The EPA recommends that advisories at beaches be issued when *E. coli* levels in the water reach 235 CFU/100ml (WDNR)
- Baseflow *E. Coli* levels were highly variable (Figure 13).
- Stormflow *E. Coli* levels were high at all sampling times at all sites, except in August 2015, when lower levels were detected at all sites (Figure 14).
- Baseflow *E. Coli* levels were not significantly different between years at any of the sites (Table 12).
- Stormflow *E. Coli* levels were significantly different by year for both Point Creek sites and not for the Fischer Creek sites (Table 13). For PO02, 2014 stormflow *E. Coli* levels were significantly different from 2015. At PO03, the significance was noted by the p-value but the tukey analysis was not able to detect actual differences in the years.

- When analyzing *E. coli*, the detection limit for the method used is 2419.6 CFU/100ml. When samples reach the limit, they are recorded as 2419.6 CFU/100ml and it is not known how much larger the count for the sample could actually be. The statistical analyses used the detection limit, which adds bias to the testing but does not affect the numbers that exceed health standards. The number of samples exceeding the detection limit can be seen in Table 14.
- More stormflow samples exceed the detection limit than baseflow samples.
- Nearly all stormflow samples exceeded the advisory beach warning level. Or baseflow, approximately 70% of the samples at all sites and years in Fischer Creek exceeded the beach warning level and approximately 50% of all baseflow samples at both sites and years at Point Creek exceeded the beach warning levels (Table 14).

Table 12. Comparison of differences in baseflow *E. coli* levels between years at each site. Anova with tukey test was run on baseflow data. Sites connected by the same letter, within each variable, were not significantly different.

	FI02	**FI03**	**PO02**	**PO03**
2012				
2013				
2014				
2015				
P value	0.3031	0.8102	0.5889	0.9775

Table 13. Comparison of differences in stormflow *E. Coli* levels between years at each site. Anova with tukey test was run on baseflow data. Sites connected by the same letter, within each variable, were not significantly different.

	FI02	**FI03**	**PO02**	**PO03**
2012			AB	A
2014			A	A
2015			B	A
P value	0.1553	0.125	0.0216	0.0416

Table 14. Mean *E. coli* values by site and year for the Little Manitowoc River. Advisory level (235 CFU/100 ml) based on standards for Wisconsin beaches. Maximum detection level was 2419.6 CFU/100 ml.

		BASE FLOW				STORM FLOW			
Site	Year	# Samples	Mean Baseflow	% Exceed Advisory Level	% Exceed Detection Limit	# Samples	Mean Stormflow	% Exceed Advisory Level	% Exceed Detection Limit
Fischer Creek	2012	28	623.38	75.0	10.7	6	2419.6	100	100
	2013	26	577.97	69.2	7.7	0	-	-	-
	2014	22	552.16	73.1	7.7	11	2054.46	100	72.7
	2015	22	446.05	77.3	0.0	18	1353.79	94.4	33.3
Point Creek	2012	28	503.54	64.3	7.1	6	2419.6	100	100
	2013	26	578.86	38.5	7.7	0	-	-	-
	2014	26	559.52	57.7	3.8	11	2184.17	100	81.8
	2015	22	365.05	50.0	0.0	18	1217.55	83.3	27.8

CONCLUSION

No significant differences were seen in water quality parameters between Fischer and Point Creeks or between sites. Differences in the values are mostly driven by differences between the years. Differences can also be seen between the baseflow and stormflow nutrient levels, indicating that water running off the land in the watershed is contributing to higher levels during those periods.

References

EPA (Environmental Protection Agency) 2015. "Volunteer Monitoring". http://water.epa.gov/type/rsl/monitoring/vms56.cfm. Modified 11-March-2015.

Horne, Alexander J. and Goldman, Charles R. 1994. Limnology. 2nd edition. McGraw-Hill, Inc. New York.

Lind, Owen T. 1985. Limnology: Handbook of Common Methods. 2nd edition. Kendall/Hunt Publishing Company. Dubuque, IA.

McKay, L., Bondelid, T., Dewald, T., Johnston, J., Moore, R., and Rea, A., "NHDPlus Version 2: User Guide", 2012

NR 102.06 (3). WDNR. http://dnr.wi.gov/topic/surfacewater/phosphorus.html

USGS (United States Geological Survey) 2015. "Temperature – Water Properties". http://water.usgs.gov/edu/temperature.html. Modified 27-Jul-2015 14:42:36 EDT.

WDNR (Wisconsin Department of Natural Resources) "Beach Monitoring Program Requirements". http://dnr.wi.gov/topic/Beaches/documents/BeachMonitoringRequirements.pdf

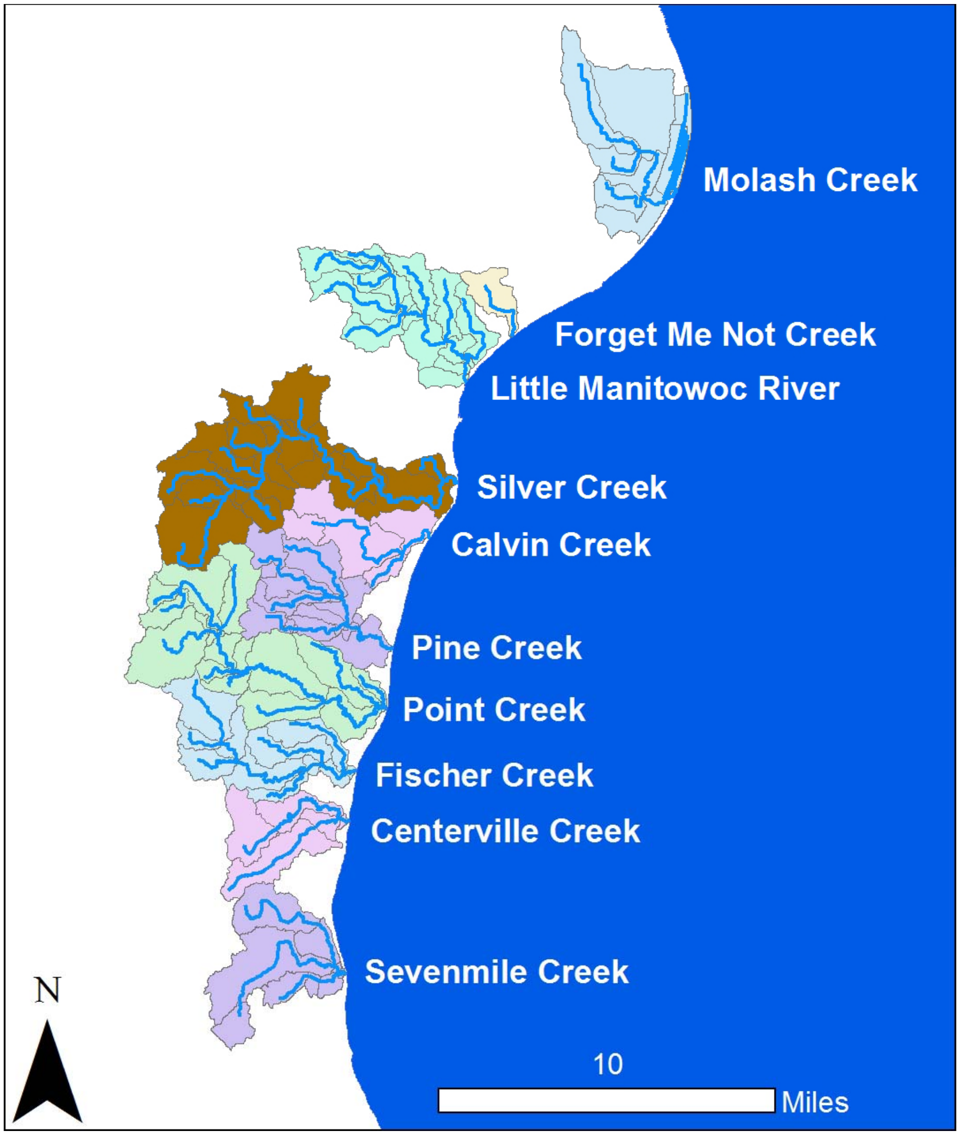


FIGURE 1. Watersheds of Southern Manitowoc County, WI.

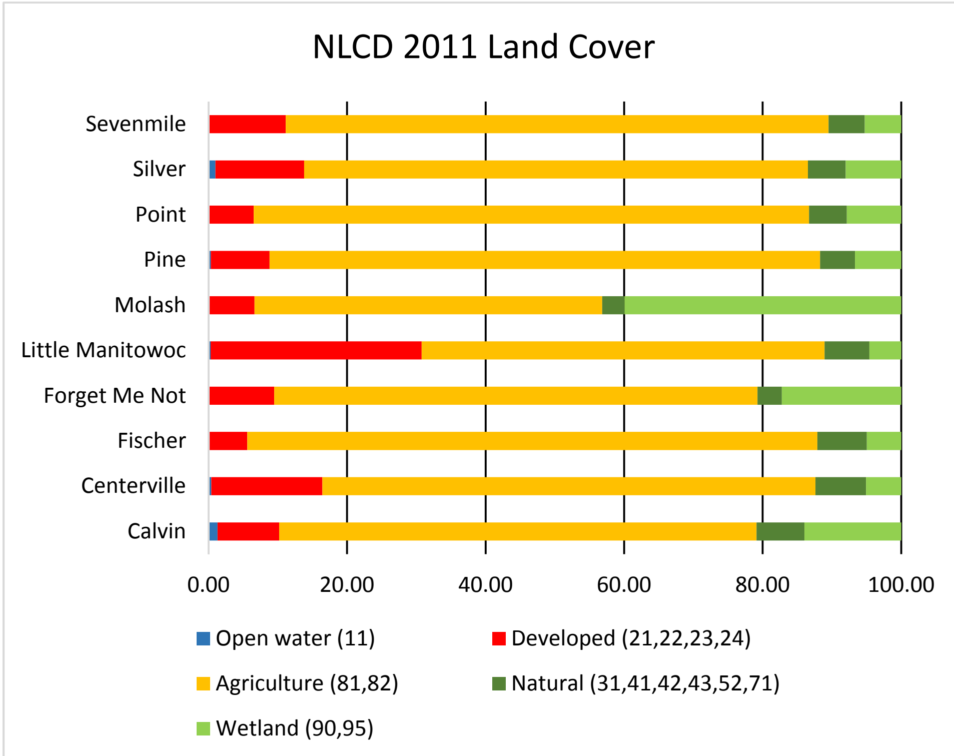


FIGURE 2. Percentage of land cover and land use of 10 southern Manitowoc creek watersheds.

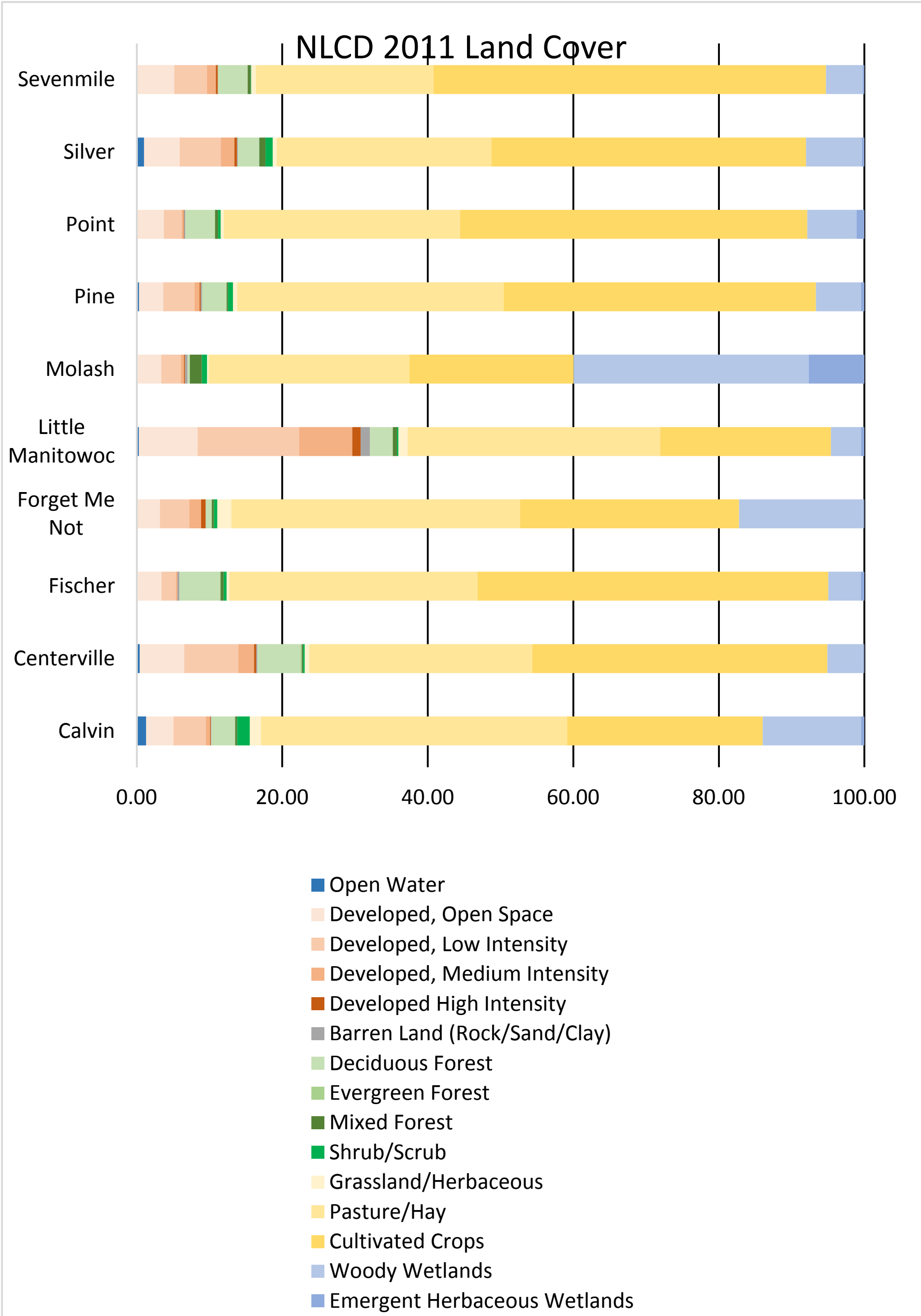


FIGURE 3. Percentage of land cover and land use of 10 southern Manitowoc creek watersheds, broken into more general categories.

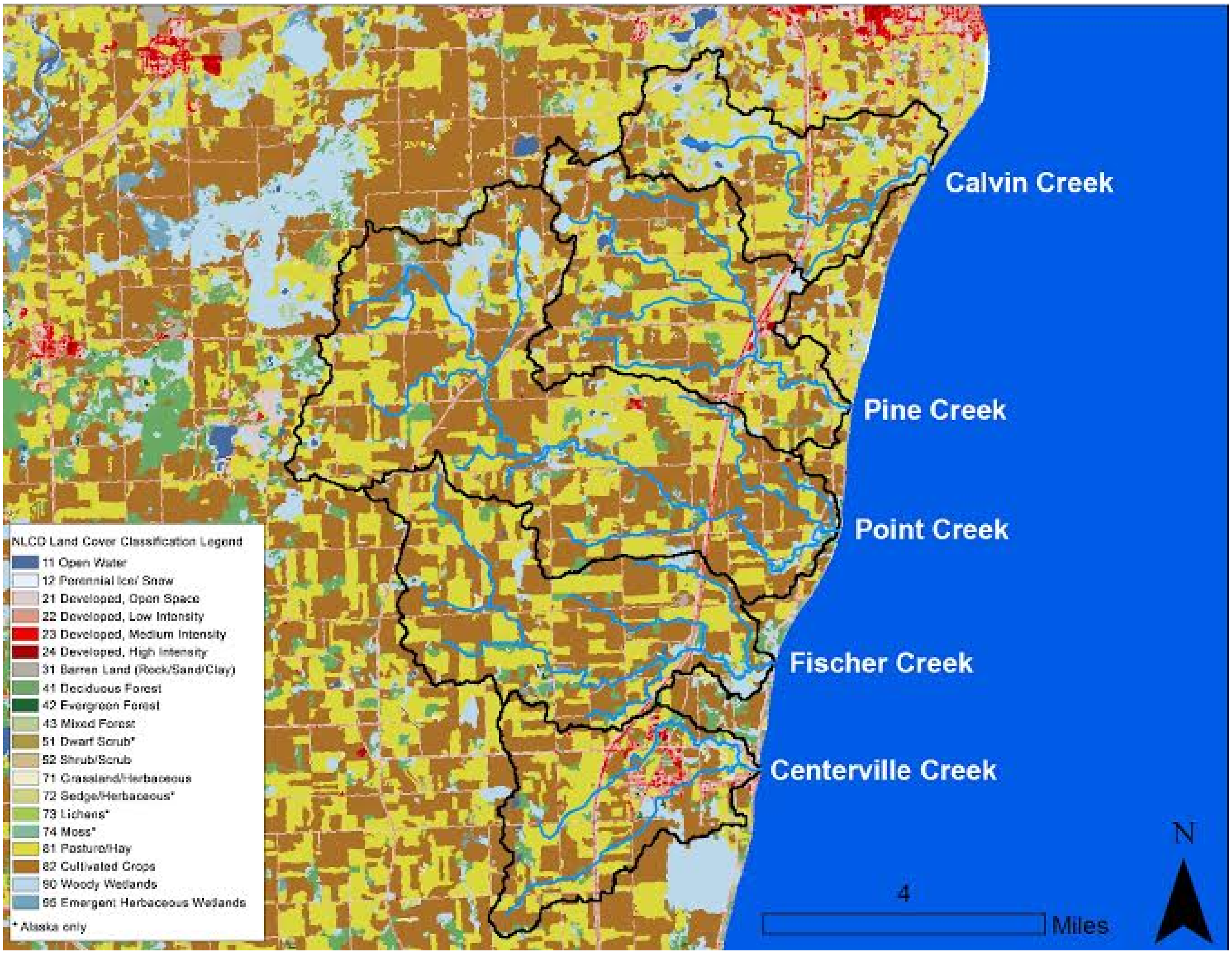


FIGURE 4. Southern Manitowoc creeks, watersheds, and landuse.

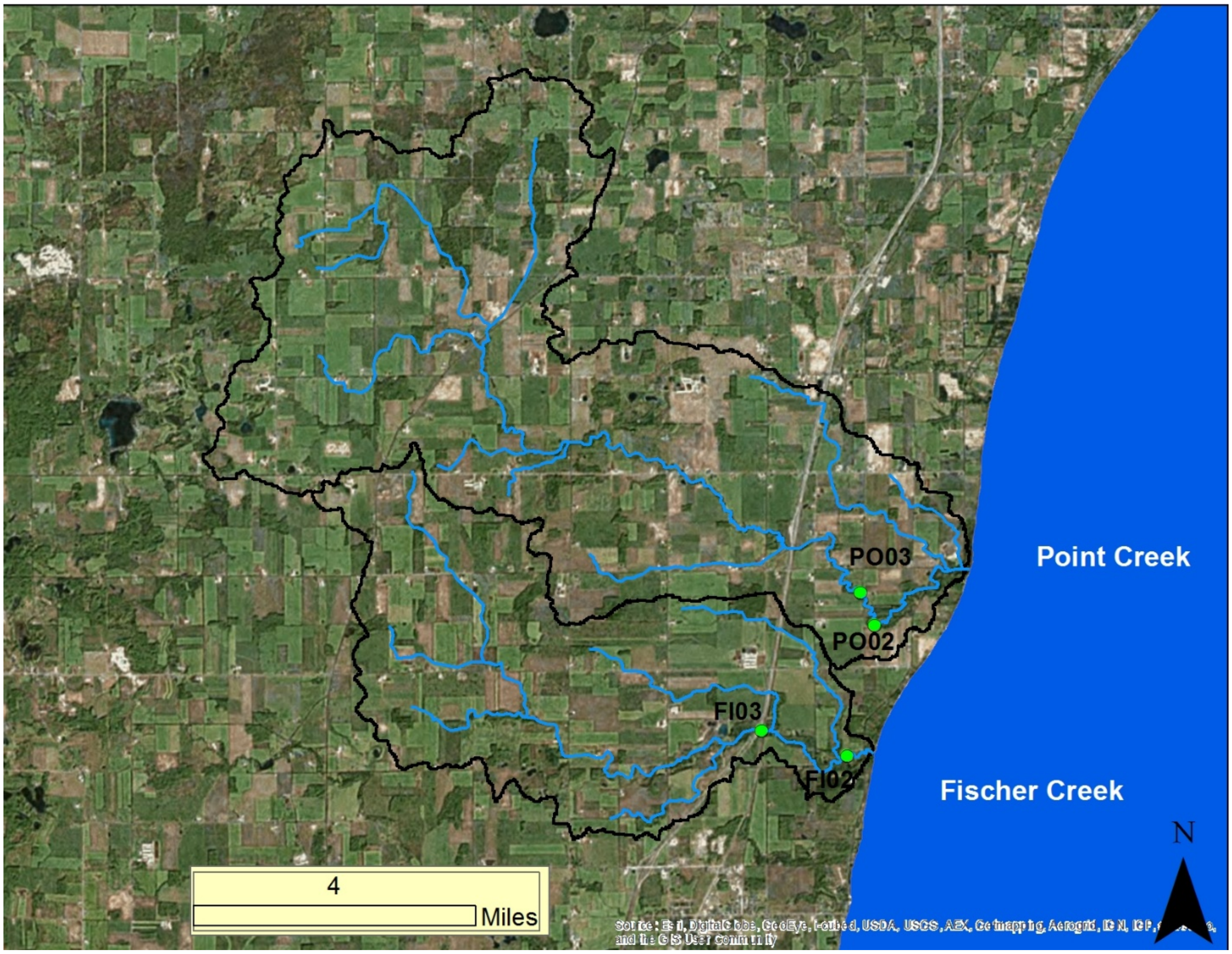


FIGURE 5. Sampling locations for Fischer Creek and Point Creek.

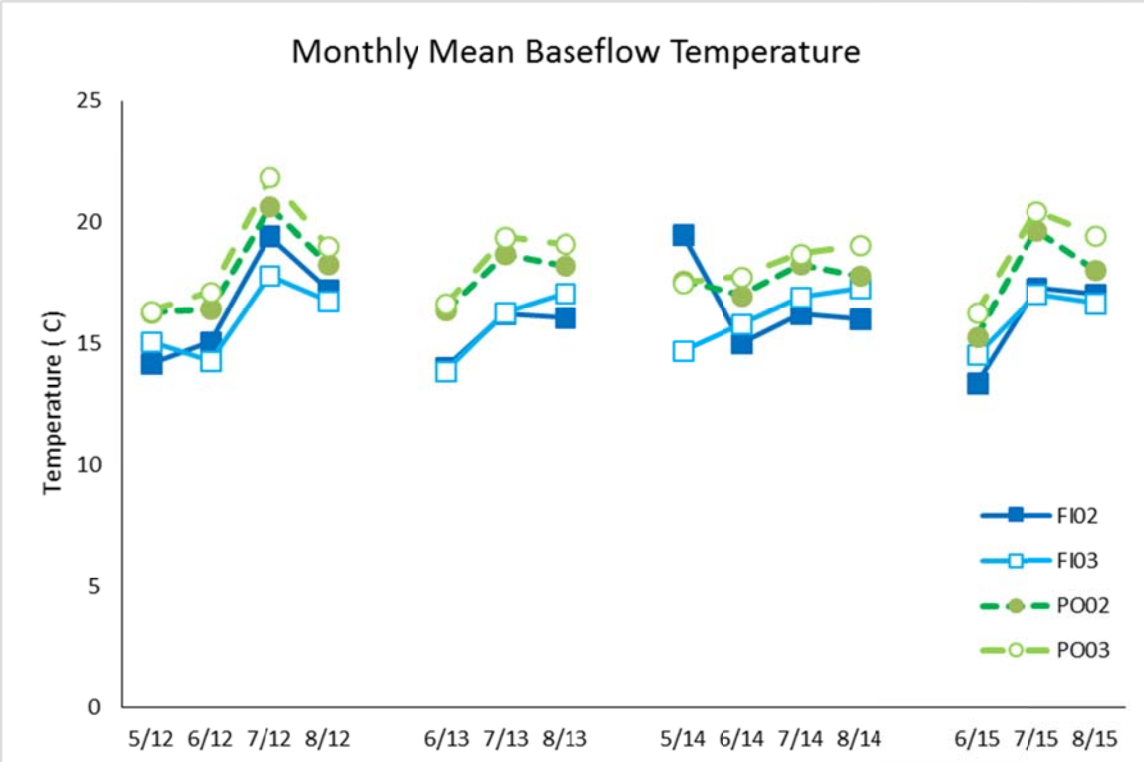


FIGURE 6. Monthly mean baseflow temperature (^{o}C) for Fischer Creek and Point Creek, summer 2012 – summer 2015.

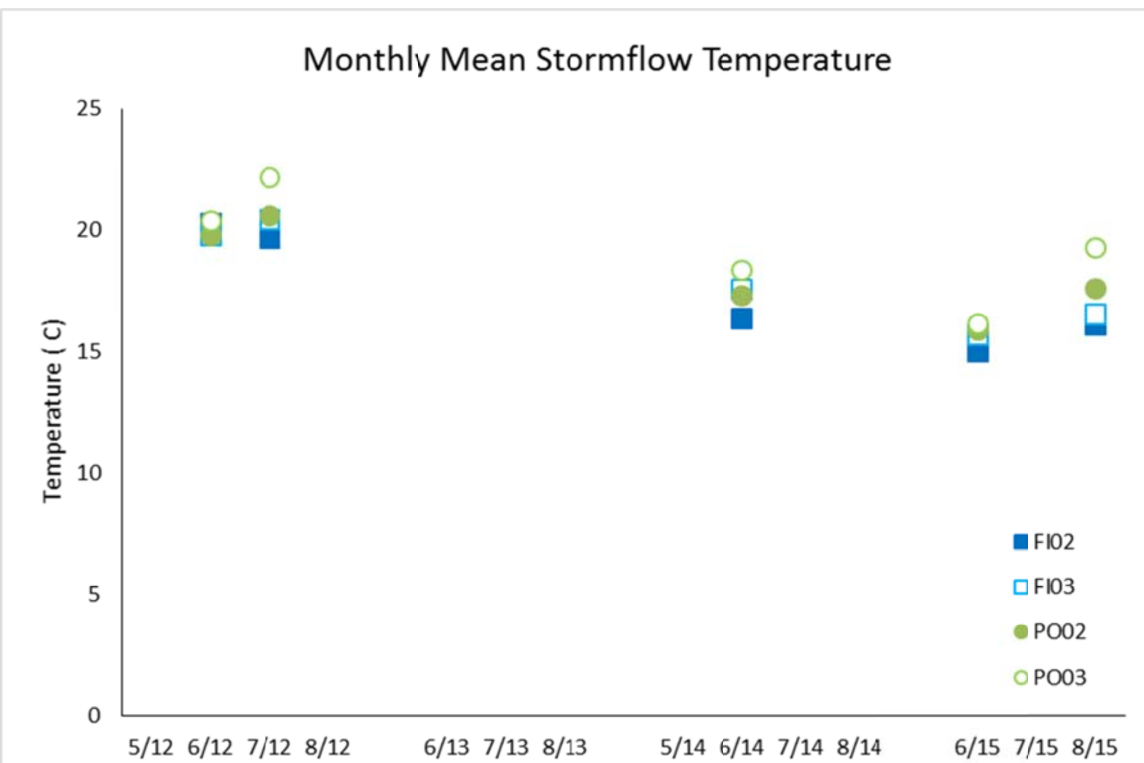


FIGURE 7. Monthly mean stormflow temperature (^{o}C) for Fischer and Point Creeks, summer 2012 – summer 2015.

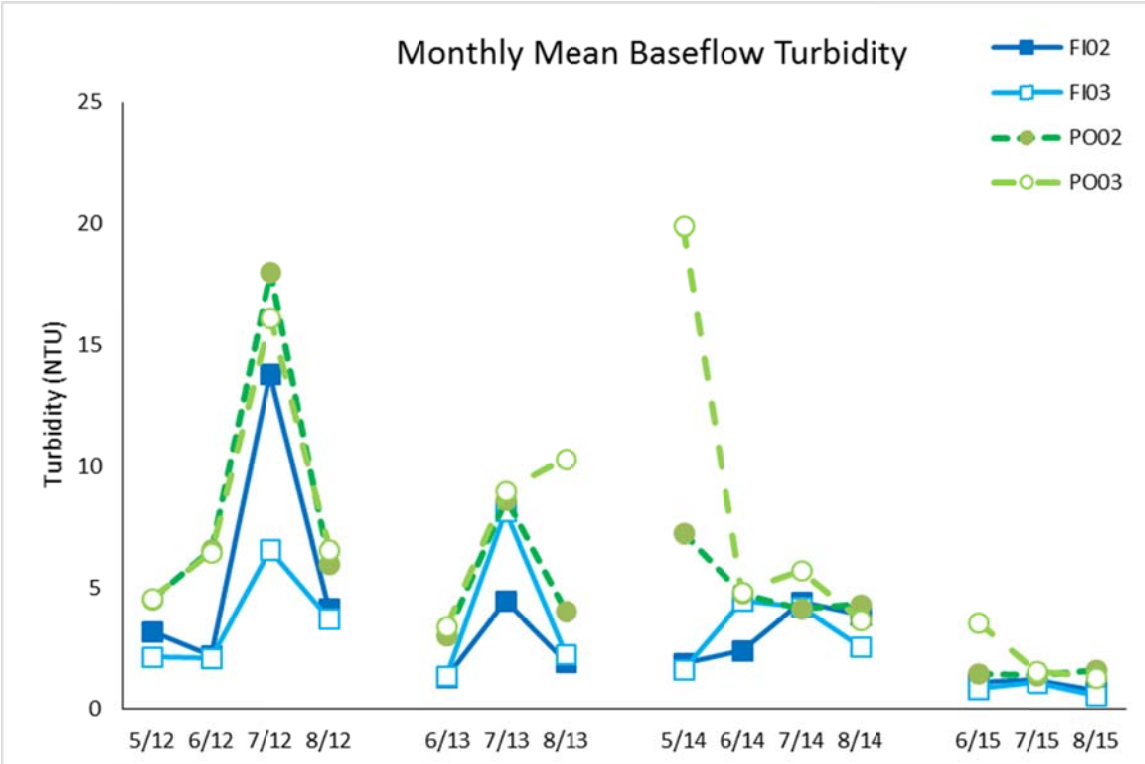


FIGURE 8. Monthly mean baseflow turbidity (NTU) for Fischer Creek and Point Creek, summer 2012 – summer 2015. (Turbidity graphs do NOT have equal X-scale).

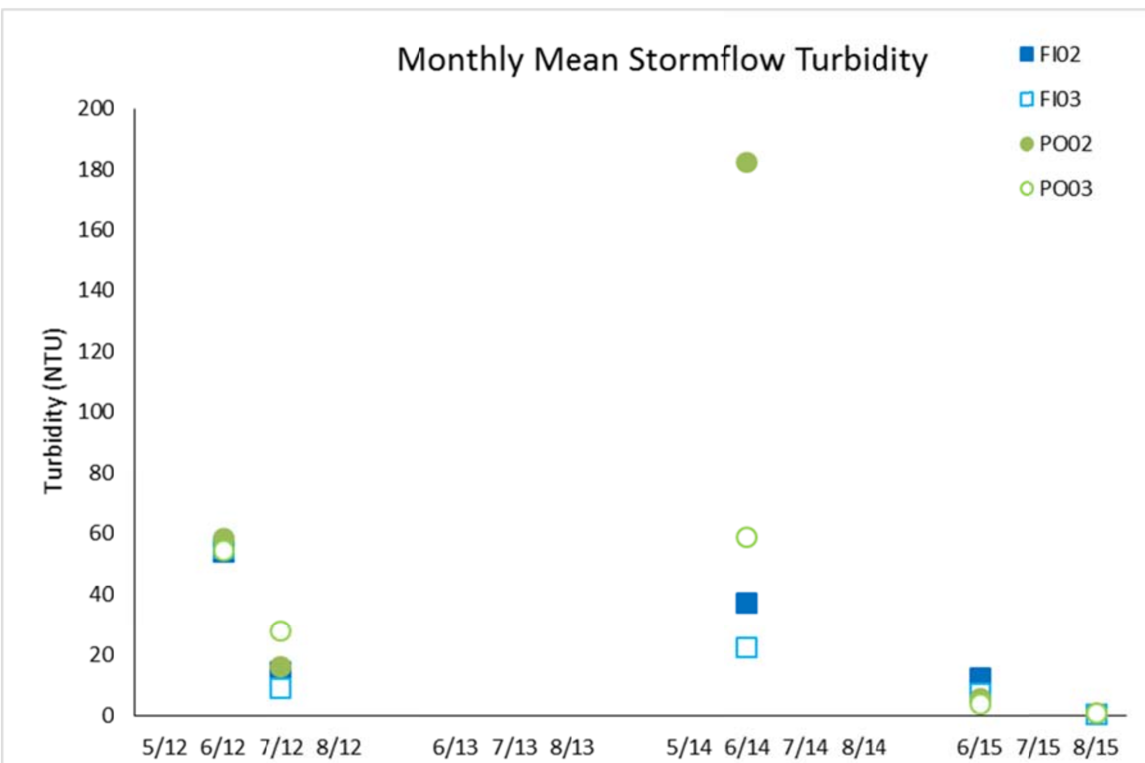


FIGURE 9. Monthly mean stormflow turbidity (NTU) for Fischer Creek and Point Creek, summer 2012 – summer 2015. (Turbidity graphs do NOT have equal X-scale).

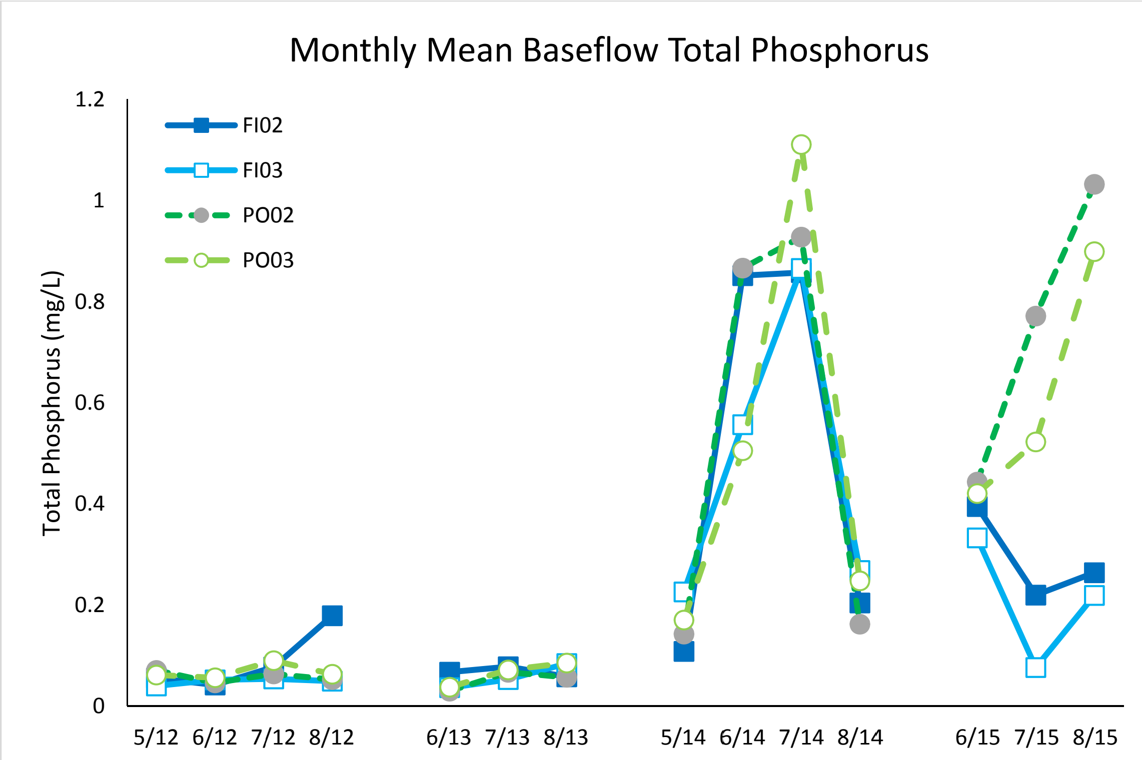


FIGURE 10. Monthly mean baseflow total phosphorus (mg/L) for Fischer Creek and Point Creek, summer 2012 – summer 2015. (Total phosphorus graphs do NOT have equal X-scale).

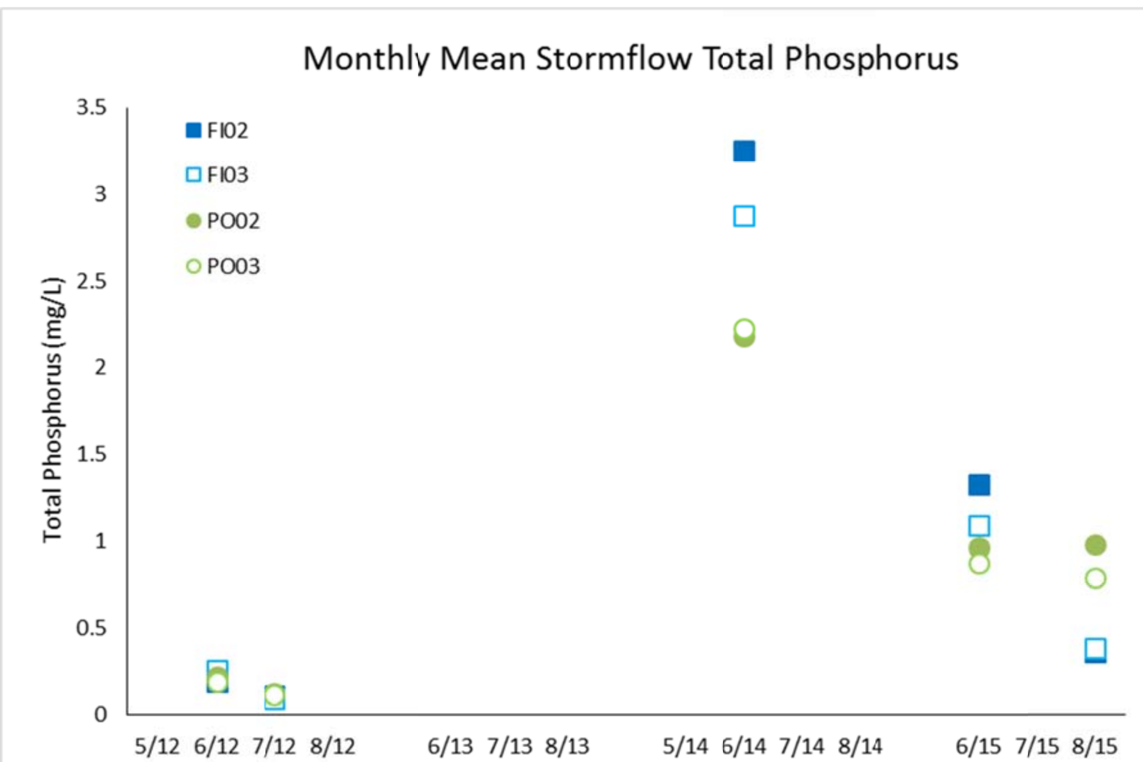


FIGURE 11. Monthly mean stormflow total phosphorus (mg/L) for Fischer Creek and Point Creek, summer 2012 – summer 2015. (Total phosphorus graphs do NOT have equal X-scale).

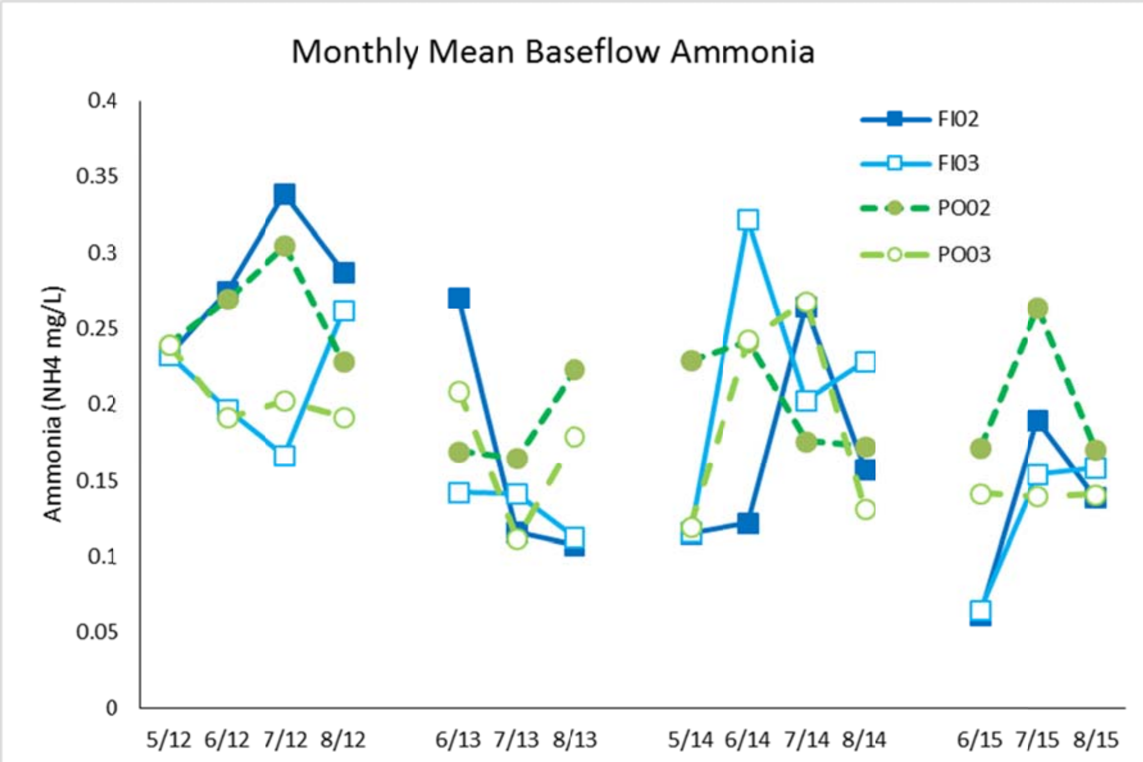


FIGURE 12. Monthly mean baseflow NH_4 levels (mg/L) for Fischer Creek and Point Creek, summer 2012 – summer 2015. (NH_4 graphs do NOT have equal X-scale).

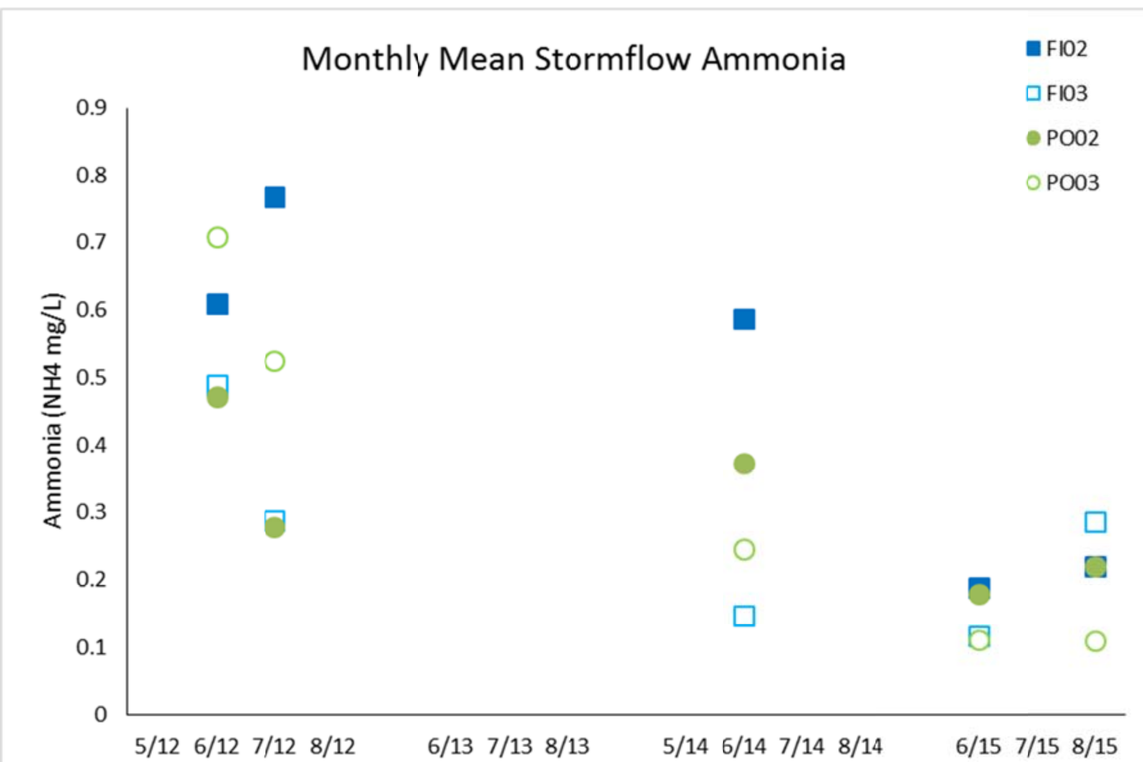


FIGURE 13. Monthly mean stormflow NH_4 levels (mg/L) for Fischer Creek and Point Creek, summer 2012 – summer 2015. (NH_4 graphs do NOT have equal X-scale).

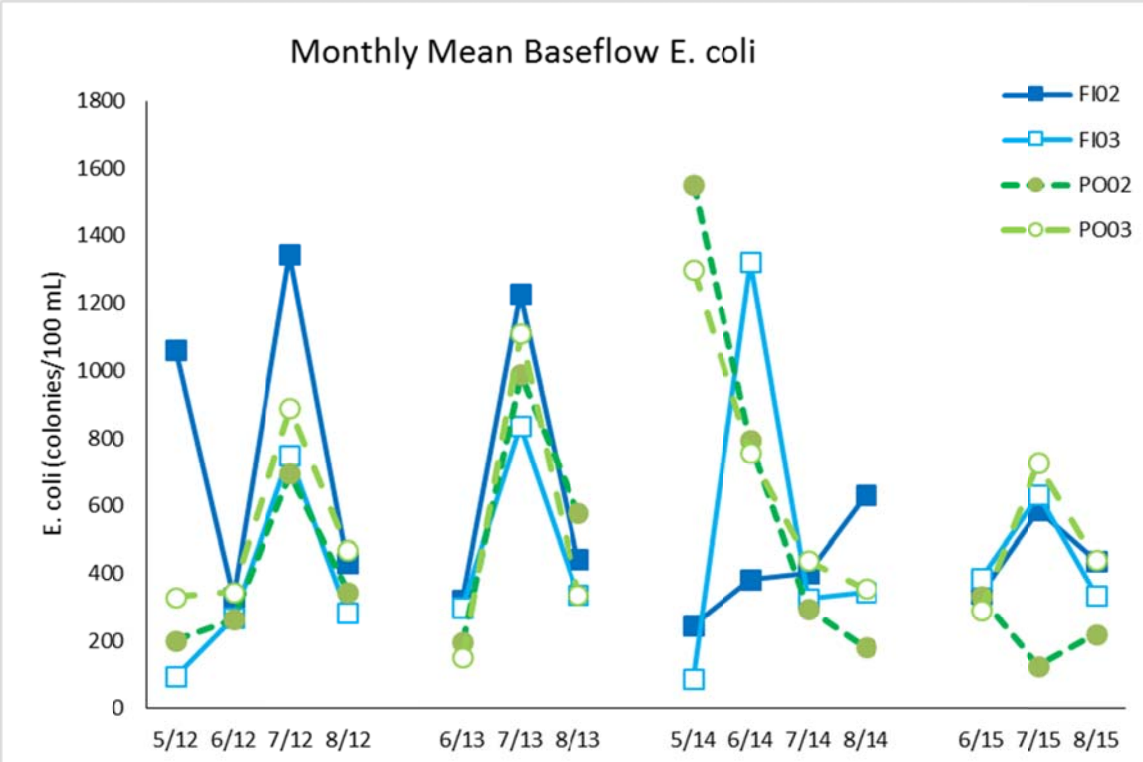


FIGURE 14. Monthly mean baseflow *E. coli l*evels for Fischer Creek and Point Creek, summer 2012 – summer 2015.

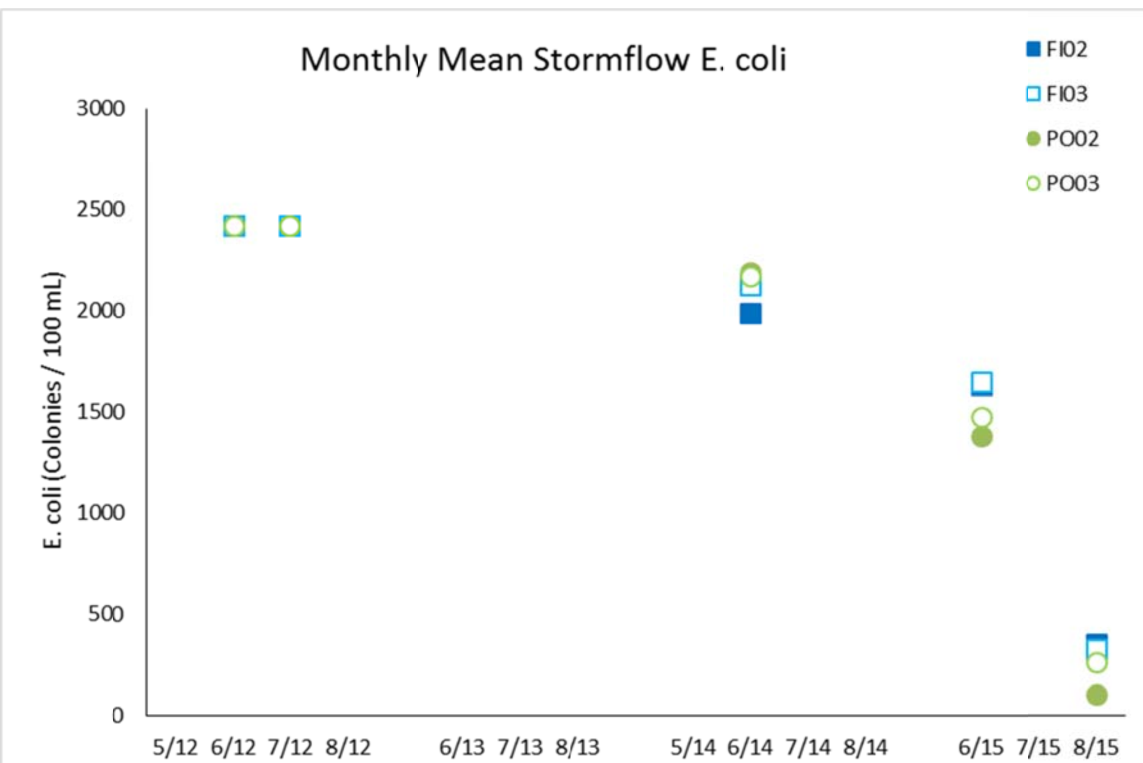


FIGURE 15. Monthly mean stormflow *E. coli l*evels for Fischer Creek and Point Creek, summer 2012 – summer 2015.

CALVIN CREEK / PINE CREEK WATER QUALITY REPORT, 2012-2015
Lakeshore Natural Resource Partnership

INTRODUCTION

The purpose of this report is to summarize the water quality data collected at four sites in Calvin Creek and Pine Creek in southern Manitowoc County during the summers of 2012-2015. In all water quality parameters, the measured values exceed recommended levels for an unimpaired creek. This is especially true after rain events, when water quality parameters tend to be higher than baseflow conditions. Although, in this report, the differences between the stormflow and baseflow levels were not significantly different (except in *E. coli*), which may be due to the small number of stormflow samples collected.

Calvin Site 03 had baseflow spikes of turbidity and ammonia in 2012, 2014, and 2015 that were not seen at the other sites. Also, the Calvin Creek *E. coli* levels were higher than the levels at Pine Creek, although both sites were consistently above the nonimpaired levels.

STUDY AREA

The study area covers two watersheds in southeastern Manitowoc County, Calvin Creek and Pine Creek (Figure 1). Both watersheds are small, with the Calvin Creek watershed at only 7.2 square miles and the Pine Creek watershed is 10.9 square miles (Table 1). The majority of the land is covered in cultivated crops or pasture/hay in both watersheds, with Calvin lower at 67% and Pine at 80% (Tables 2 and 3, Figures 2 and 3).

Table 1. Area and length of the Pine and Calvin Creek.

Site	Area ($mile^2$)	Length (miles)	Area (km^2)	Length (km)
Calvin	7.2	7.1	18.7	11.5
Pine	10.9	15.1	28.2	24.3

Table 2. Percentage of type of land use for each creek in the study, 2011.

Class	Calvin	Pine
Open water (11)	1.30	0.33
Developed (21,22,23,24)	8.88	8.47
Natural (31,41,42,43,52,71)	6.89	5.03
Wetland (90,95)	13.99	6.67
Agriculture (81,82)	68.93	79.49

Table 3. Percentage of type of land use, broken into smaller categories, for Calvin and Pine Creeks, 2011.

Code	Class	Calvin	Centerville	Fischer	Pine	Point
11	Open Water	1.30	0.40	0.16	0.33	0.12
21	Developed, Open Space	3.77	6.12	3.26	3.32	3.60
22	Developed, Low Intensity	4.43	7.44	1.96	4.29	2.46
23	Developed, Medium Intensity	0.57	2.15	0.21	0.69	0.27
24	Developed High Intensity	0.11	0.31	0.01	0.17	0.06
31	Barren Land (Rock/Sand/Clay)	0.10	0.16	0.28	0.18	0.16
41	Deciduous Forest	3.25	5.91	5.56	3.34	4.08
42	Evergreen Forest	0.00	0.21	0.09	0.03	0.01
43	Mixed Forest	0.27	0.19	0.44	0.20	0.43
52	Shrub/Scrub	1.74	0.20	0.39	0.69	0.37
71	Grassland/Herbaceous	1.54	0.64	0.39	0.59	0.42
81	Pasture/Hay	**42.08**	**30.62**	**34.08**	**36.57**	**32.47**
82	Cultivated Crops	**26.86**	**40.57**	**48.21**	**42.92**	**47.69**
90	Woody Wetlands	**13.53**	**4.99**	**4.46**	**6.22**	**6.76**
95	Emergent Herbaceous Wetlands	0.46	0.08	0.50	0.45	1.09

Source: National Land Cover Database. http://www.mrlc.gov/nlcd11_data.php

METHODS

Student interns working for faculty at UW-Manitowoc collected water samples during the summers of 2012, 2013, 2014, and 2015. Samples were taken weekly from late May through the end of August (baseflow). Samples were also taken following rain events greater than a half inch at both 24 and 48 hours (Table 4). Rain event sample dates are “stormflow” while non-rain event sample dates are “baseflow” in this report (Table 5).

Table 4. Number of weeks sampled each summer Calvin and Pine Creeks. Storm events are rainfalls greater than a half inch, sampled at both 24 and 48 hours.

Creek	Year	# Baseflow Sample Weeks	# Stormflow Sample Weeks	Total # Sample Weeks	# Baseflow Sample Days	# Stormflow Sample Days	Total # Sample Days
Calvin	2012	14	3	17	27	6	33
	2013	12	0	12	26	0	26
	2014	13	6	19	26	10	36
	2015	10	9	19	22	18	40
Pine	2012	14	3	17	28	6	34
	2013	12	0	12	26	0	26
	2014	13	6	19	26	11	37
	2015	10	9	19	22	18	40

Table 5. Sample dates for Pine and Calvin Creeks, summers 2012 – 2015. Storm events are rainfalls greater than a half inch, sampled at both 24 and 48 hours.

Date	Storm Event	Date	Storm Event	Date	Storm Event	Date	Storm Event
5/22/2012	N	6/3/2013	N	5/27/2014	N	6/1/2015	N
5/29/2012	N	6/10/2013	N	6/3/2014	Y	6/8/2015	N
6/6/2012	N	6/17/2013	N	6/4/2014	Y	6/12/2015	Y
6/13/2012	N	6/24/2013	N	6/9/2014	N	6/13/2015	Y
6/20/2012	Y	7/1/2013	N	6/16/2014	N	6/15/2015	Y
6/27/2012	N	7/8/2013	N	6/17/2014	Y	6/16/2015	Y
7/3/2012	N	7/15/2013	N	6/18/2014	Y	6/17/2015	Y
7/11/2012	N	7/22/2013	N	6/19/2014	Y	6/23/2015	Y
7/18/2012	N	7/29/2013	N	6/23/2014	N	6/24/2015	Y
7/25/2012	N	8/5/2013	N	6/30/2014	N	6/29/2015	N
7/26/2012	Y	8/12/2013	N	7/7/2014	N	7/6/2015	N
7/27/2012	Y	8/19/2013	N	7/14/2014	N	7/13/2015	N
8/1/2012	N	8/27/2013	N	7/21/2014	N	7/20/2015	N
8/8/2012	N			7/28/2014	N	7/27/2015	N
8/15/2012	N			8/4/2014	N	8/3/2015	N
8/21/2012	N			8/11/2014	N	8/8/2015	Y
8/28/2012	N			8/18/2014	N	8/9/2015	Y
				8/25/2014	N	8/10/2015	N
						8/17/2015	N
						8/24/2015	N

For this analysis, comparisons were made at two different sampling locations on each creek. These sites were sampled in three consecutive years (2012-2015) between the months of May and August. In Calvin Creek, CA02 (Hwy U) is the downstream site and CA03 (S. Gass Lake Rd.) the upstream site. PI02 (S. 26th St.) is the downstream site for Pine Creek and PI03 (Northeim Rd.) is the upstream site (Figure 5). All sampling was done in the area between I-43 and Lake Michigan. Weekly averages were calculated for each stream for baseflow and stormflow. These averages were used to test for differences between the streams in the water quality variables.

Physical indicators were measured by field probes

- Dissolved Oxygen (YSI 550A DO Probe)
- Temperature/pH
- Turbidity (LaMotte 2020 we)
- Stream Velocity (Global Water Instrumentation, Inc)
- Conductivity

Nutrient indicators

- Ammonia (NH_3/NH_4) measured with Hach field kit for Ammonia Nitrogen
- Total Orthophosphate (TP) and Total Dissolved Phosphate (TDP)
- Acid hydrolysis with H_2SO_4
- Colorimetric analysis via ammonium molybdate-stannous chloride method

Biological Indicators

- E. coli fecal coliform analysis (Colilert-24)

Statistical Analysis

Differences between the two creeks, between the sites, and between the years were tested for differences in baseflow and stormflow data separately. Mean weekly values for each creek were tested using a blocked Analysis of Variance (ANOVA). The block design allowed for testing over all four years at once, with difference in each weekly block used for the ANOVA. When significant differences were indicated by the ANOVA, a Tukey-Kramer post-hoc test was used to determine the differences between streams. All statistical analyses were done in JMP Pro Version 11 (SAS Institute Inc., Cary, NC). Mapping and watershed analysis completed using ArcMap Version 10.1 (ESRI, Redlands, CA).

Comparisons between baseflow and stormflow were done using only weeks for which there were both baseflow and stormflow data available. A blocked ANOVA was used to make the comparisons, but only 7 pairs of data were available.

RESULTS

Temperature

- Water temperature influences both biological activity and growth, including fish, insects, zooplankton, and phytoplankton, which have a preferred temperature range in which they thrive (USGS 2015). High temperatures can result in the local extirpation of species, like Brook Trout, which are considered a coldwater species.
- Water temperature also influences water chemistry, especially dissolved oxygen, which have a lower capacity to hold oxygen at higher temperatures (USGS 2015).
- The PI02 had consistently lower temperature over all years, baseflow and stormflow, compared to the other three sites (Figures 6 and 7).
- For both Calvin and Pine Creeks, the site furthest upstream (CA03 and PI03) had warmer temperatures than the downstream sites (CA02 and PI02).
- Temperature was not significantly different at any site when comparing baseflow and stormflow temperatures.

Table 6. Average monthly temperature (^oC) for each site separated by baseflow and stormflow. Temperature was not significantly different at any site when comparing baseflow and stormflow temperatures.

	CA02	CA03	PI02	PI03
Baseflow				
Stormflow				
P value	0.2815	0.3223	0.15	0.1381

Turbidity

- Turbidity is defined as the presence of suspended solids in water (Lind 19) and is reported in NTU. Lower turbidity levels mean that the water is clearer, which generally means there is better water quality.
- In general, there was less variation in the baseflow turbidity levels at all four sites as well as lower levels in 2015. The exception in 2015 was CA02, which was higher than the other 2015 baseflow turbidity levels (Figure 8).
- Baseflow turbidity levels was highest at all sites in July 2013.
- CA03 baseflow turbidity levels spiked in June 2012 and August 2014.
- Stormflow turbidity levels were highest in 2014 at all sites (Figure 9).
- All baseflow and stormflow turbidity levels were below 40 NTU except at PI02 in June 2014 stormflow levels.

Comment [ST1]: This is interesting because we don't have any stormflow data points from 2013, but the NTU was the highest that year. We should probably take a look at this.

- Baseflow turbidity levels between years were not significantly different at CA03 or PI02 (Table 7).
- At CA02, baseflow turbidity levels in 2013 were significantly different from 2014 and 2015. While 2012 was similar to all years and 2014 and 2015 were only similar to one another (Table 7).
- Stormflow turbidity levels between years were significantly different in both Calvin Creek sites and in PI03, not at PI02 (Table 8).
- 2014 stormflow turbidity levels was significantly different from 2015 at those three sites, while 2012 stormflow turbidity levels were similar to both years.
- Stormflow and baseflow turbidity levels were not significantly different from one another at any site (Table 9).

Table 7. Average turbidity levels (NTU) for baseflow separated by year. The letters are the results of the Standard Least Squares analysis, where sites connected by the same letter are not significantly different.

Year	CA02	CA03	PI02	PI03
2012	AB			AB
2013	A			A
2014	B			AB
2015	B			B
P Value	0.0031	0.4639	0.2178	0.0475

Table 8. Average turbidity levels (NTU) for stormflow separated by year, for the Little Manitowoc River. The letters are the results of the Standard Least Squares analysis, where sites connected by the same letter are not significantly different.

Year	CA02	CA03	PI02	PI03
2012	AB	AB		AB
2014	A	A		A
2015	B	B		B
P Value	0.043	0.0093	0.1305	0.018

Table 9. Average turbidity levels (NTU) for each site separated by baseflow and stormflow. Stormflow and baseflow turbidity levels were not significantly different at any site.

	CA02	CA03	PI02	PI03
Baseflow				
Stormflow				
P value	0.3973	0.7317	0.0593	0.0648

Total Phosphorus

- Phosphorus is an essential nutrient for both aquatic plants and animals. In most fresh water systems, phosphorus is often the nutrient in lowest concentrations. Therefore, even a small increase in phosphorus can cause "accelerated plant growth, algae blooms, low dissolved oxygen levels, and the death of certain fish, invertebrates, and other aquatic animals" in streams, rivers, and lakes (EPA 2015).
- There are natural (soil and rocks) and human sources of phosphorus, including, wastewater treatment plants, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas, disturbed land areas, drained wetlands, and water treatment (EPA 2015).
- Total phosphorus concentrations measure all forms of phosphorus in the water and is the sum of the soluble phosphorus (PO_4; dissolved phosphorus) and particulate phosphorus (Horne & Goldman 155). Soluble phosphorus is the amount of phosphorus available for plants and algae to take up.
- For this report, total phosphorus levels were analyzed and are reported in mg/L.
- In Wisconsin, small streams and rivers are considered impaired if total phosphorus levels exceeds 0.075 mg/L. Large rivers, such as the Fox River, are considered impaired at 0.1 mg/L (NR 102.06 (3) WDNR).
- All years have baseflow total phosphorus concentrations greater than 0.075 mg/L.
- In general, baseflow phosphorus concentrations (Figure 10) were lower than stormflow concentrations (Figure 11).
- In general, baseflow and stormflow total phosphorus levels in 2012 and 2013 were less than total phosphorus levels in 2014 and 2015 (Figure 10).
- Total phosphorus baseflow levels followed similar patterns at all four sites except in 2015 when baseflow total phosphorus was higher at the Pine Creek sites than the Calvin sites (Figure 10).

Comment [ST2]: This is an interesting pattern. Maybe we should add a graph of the 2015 TP data only (not monthly means).

- In August 2015, baseflow total phosphorus levels were higher at CA03 than other sites (Figure 10).
- Stormflow total phosphorus levels were highest in June 2014, with PI02 being the highest (Figure 11).

- Baseflow total phosphorus levels were significantly different by year at all sites (Table 10).
- Baseflow total phosphorus levels for 2012 and 2013 were significantly different from 2014 levels at all sites. In 2015, the Calvin sites were similar to 2014 levels and significantly higher from 2012 and 2013. While the Pine sites in 2015 were significantly different from 2014 and similar to the 2012 and 2013 levels (Table 10). Pine Creek concentrations in 2014 were higher than the other years.
- Stormflow total phosphorus levels were significantly different by year only at PI02. At all other sites the years were similar. At PI02, 2014 was significantly different from 2012 while 2015 was similar to both years (Table 11). The general trend was higher total phosphorus concentrations during storm events. This is an important observation because most of the total annual flow in the river in terms of volume takes place during stormflow events.
- Only CA02 was significantly different when comparing baseflow to stormflow (Table 12).

Table 10. Average baseflow total phosphorus levels (mg/L), separated by year. The letters are the results of the block design ANOVA, where sites connected by the same letter are not significantly different.

Year	CA02	CA03	PI02	PI03
2012	B	B	B	B
2013	B	B	B	B
2014	A	A	A	A
2015	A	A	B	B
P Value	<0.0001	<0.0001	<0.0001	0.0005

Table 11. Average stormflow total phosphorus levels (mg/L), separated by year. The letters are the results of the block design ANOVA, where sites connected by the same letter are not significantly different.

Year	CA02	CA03	PI02	PI03
2012			B	
2014			A	
2015			AB	
P Value	0.1291	0.0735	0.0327	0.0778

Table 12. Average total phosphorus levels (mg/L) for each site separated by baseflow and stormflow.

	CA02 (Avg. T.P.)	CA03	PI02	PI03
Baseflow	0.36264			
Stormflow	1.04861			
P value	0.022	0.1049	0.1027	0.3315

Nitrogen (NH4)

- Ammonia (NH_4) is the preferred form of nitrogen for plant growth in aquatic systems (Horne & Goldberg 133).
- NH_4 is reported in mg/L and is commonly present in concentrations less than 1 mg/L (Lind, 84).
- In general, stormflow NH_4 levels were larger than baseflow NH_4 levels (Figures 12 and 13).
- Calvin Creek site CA03 had high baseflow concentrations of NH_4 in June 2012, August 2014, July 2015, and August 2015. These higher baseflow measurements were larger than all stormflow NH_4 levels at all sites.

- Baseflow NH_4 levels were not significantly different between years (Table 13).
- Stormflow levels of NH_4 were significantly different between years for Calvin Creek while Pine Creek levels were not significantly different the years (Table 14).
- Stormflow and baseflow NH_4 levels were not significantly different from one another at any site (Table 15).

Table 13. Average baseflow NH_4 levels (mg/L), separated by year. The letters are the results of the block design ANOVA, where sites connected by the same letter are not significantly different.

Year	CA02	CA03	PI02	PI03
2012				
2013				
2014				
2015				
P Value	0.6598	0.375	0.9716	0.6326

Table 14. Average stormflow NH_4 levels (mg/L), separated by year. The letters are the results of the block design ANOVA, where sites connected by the same letter are not significantly different.

Year	CA02	CA03	PI02	PI03
2012	A	A		
2014	AB	B		
2015	B	AB		
P Value	0.0426	0.049	0.1392	0.0773

Table 15. Average turbidity levels (NTU) for each site separated by baseflow and stormflow. Stormflow and baseflow turbidity levels were not significantly different at any site.

	CA02	CA03	PI02	PI03
Baseflow				
Stormflow				
P Value	0.487	0.6632	0.4253	0.351

E. Coli

- Escherichia coli (*E. coli*) are bacteria that, when found in water in high concentrations, can be an indicator that pathogenic bacteria may be present. Pathogenic bacteria can cause serious illness in humans. *E. coli* is reported as CFU/ml or MPN/ml (used interchangeably).
- The EPA recommends that advisories at beaches be issued when *E. coli* levels in the water reach 235 CFU/100ml (WDNR).
- At both sites, baseflow and stormflow *E. coli* levels were highly variable (Figures 14 and 15).
- In general, baseflow and stormflow *E. coli* levels for both sites at Calvin Creek were greater than the *E. coli* levels for both sites at Pine Creek.
- When analyzing *E. coli*, the detection limit for the method used is 2419.6 CFU/100ml. When samples reach the limit, they are recorded as 2419.6 CFU/100ml and it is not known how much larger the count for the sample could actually be. The statistical analyses used the detection limit, which adds bias to the testing but does not affect the numbers that exceed health standards. The number of samples exceeding the detection limit can be seen in Table 16.
- More baseflow and stormflow samples at Calvin Creek exceeded the detection limit than Pine Creek (Table 16).
- Calvin Creek (81.5% - 68.2%) had a higher percentage of baseflow samples exceeding the advisory level than Pine Creek (65.4% - 50.0%) (Table 16).

- *E. coli* levels for both baseflow and stormflow were not significantly different between the years (Tables 17 and 18).
- *E. coli* levels between baseflow and stormflow was significantly different at both Pine Creek sites and CA03. Stormflow and baseflow *E. coli* levels were not significantly different (Table 19).

Table 16. Mean *E. coli* values by creek and year. Advisory level (235 CFU/100 ml) based on standards for Wisconsin beaches. Maximum detection level was 2419.6 CFU/100 ml.

		BASE FLOW				STORM FLOW			
Site	Year	# Samples	Mean Baseflow	% Exceed Advisory Level	% Exceed Detection Limit	# Samples	Mean Stormflow	% Exceed Advisory Level	% Exceed Detection Limit
Calvin Creek	2012	27	1262.48	81.5	32.0	6	2419.6	100	100
	2013	26	1318.38	76.9	33.3	0	-	-	-
	2014	26	1431.23	80.8	29.2	10	1966.26	90.0	70.0
	2015	22	1050.91	68.2	11.1	18	1579.08	100	44.4
Pine Creek	2012	28	496.89	57.1	3.8	6	1958.68	100	66.7
	2013	26	580.75	53.8	8.3	0	-	-	-
	2014	26	451.87	65.4	8.3	11	1924.84	100	63.6
	2015	22	444.11	50.0	4.2	18	1214.6	100	27.8

Comment [ST3]: This is the best piece of data in the whole thing. There are actually things we can say.

Table 17. Average baseflow *E. coli* (mg/L), separated by year. The letters are the results of the block design ANOVA, where sites connected by the same letter are not significantly different.

Year	CA02	CA03	PI02	PI03
2012				
2013				
2014				
2015				
P Value	0.8852	0.554	0.8311	0.6222

Table 18. Average stormflow *E. coli* (mg/L), separated by year. The letters are the results of the block design ANOVA, where sites connected by the same letter are not significantly different.

Year	CA02	CA03	PI02	PI03
2012				
2014				
2015				
P Value	0.3639	0.1809	0.2598	0.2086

Table 19. Average *E. coli* (mg/L), for each site separated by baseflow and stormflow.

	CA02	CA03 (Avg. level)	PI02 (Avg. level)	PI03 (Avg. level)
Baseflow		1107.45	453.34	371.64
Stormflow		2028.47	1464.07	1507.6
P value	0.0658	0.0146	0.0249	0.0053

CONCLUSION

In general, water quality of both Calvin and Pine Creeks is poor, with high level of nutrients and *E. coli* commonly being detected. This is especially true after rain events, when, water quality parameters tend to increase. Although, in this report, the differences between the stormflow and baseflow levels were not significantly different (except in *E. coli*), and be due to the small number of stormflow samples.

Of note, Calvin Site 03 had baseflow spikes of turbidity and ammonia in 2012, 2014, and 2015 that were not seen at the other sites. Also, the Calvin Creek *E. coli* levels were larger than the levels at Pine Creek, although both sites were consistently above the nonimpaired levels.

References

EPA (Environmental Protection Agency) 2015. “Volunteer Monitoring”. http://water.epa.gov/type/rsl/monitoring/vms56.cfm. Modified 11-March-2015.

Horne, Alexander J. and Goldman, Charles R. 1994. Limnology. 2nd edition. McGraw-Hill, Inc. New York.

Lind, Owen T. 1985. Limnology: Handbook of Common Methods. 2nd edition. Kendall/Hunt Publishing Company. Dubuque, IA.

McKay, L., Bondelid, T., Dewald, T., Johnston, J., Moore, R., and Rea, A., “NHDPlus Version 2: User Guide”, 2012

NR 102.06 (3). WDNR. http://dnr.wi.gov/topic/surfacewater/phosphorus.html

USGS (United States Geological Survey) 2015. “Temperature – Water Properties”. http://water.usgs.gov/edu/temperature.html. Modified 27-Jul-2015 14:42:36 EDT.

WDNR (Wisconsin Department of Natural Resources) “Beach Monitoring Program Requirements”. http://dnr.wi.gov/topic/Beaches/documents/BeachMonitoringRequirements.pdf

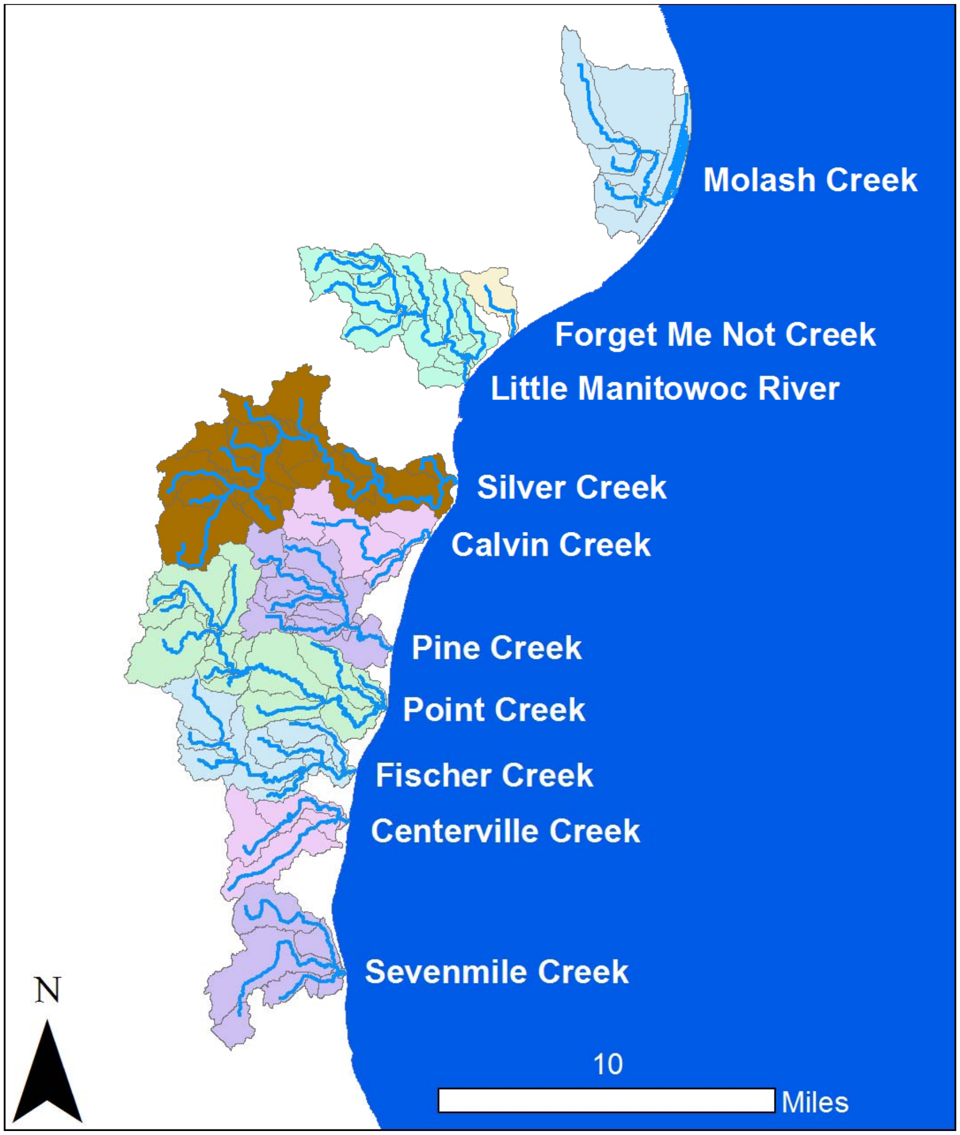


FIGURE 1. Watersheds of Southern Manitowoc County, WI.

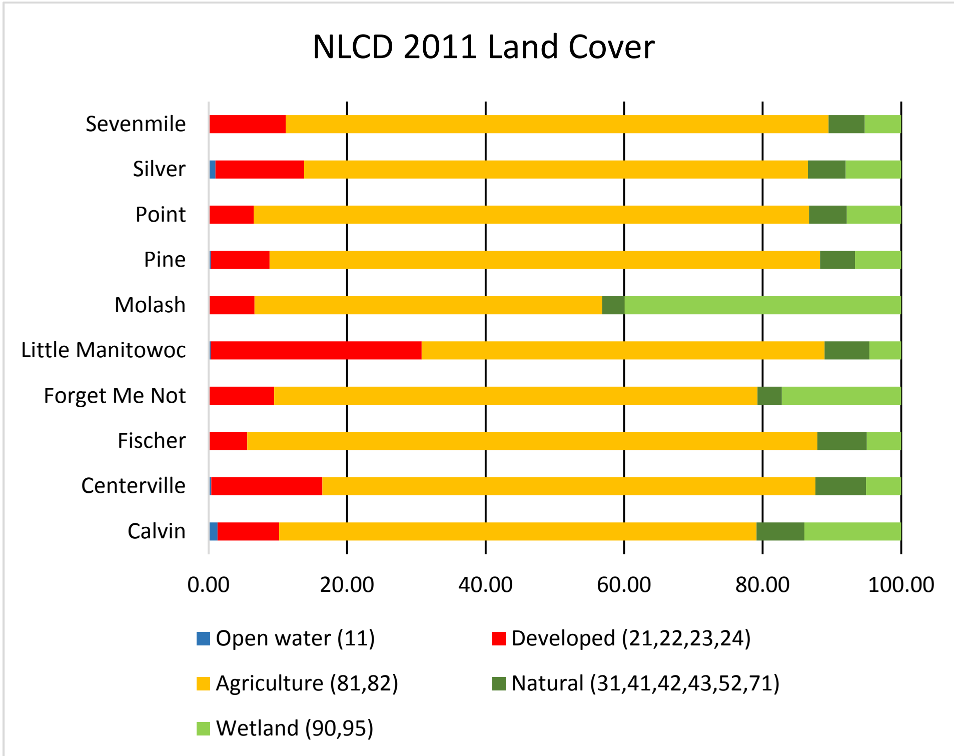


FIGURE 2. Percentage of land cover and land use of 10 southern Manitowoc creek watersheds.

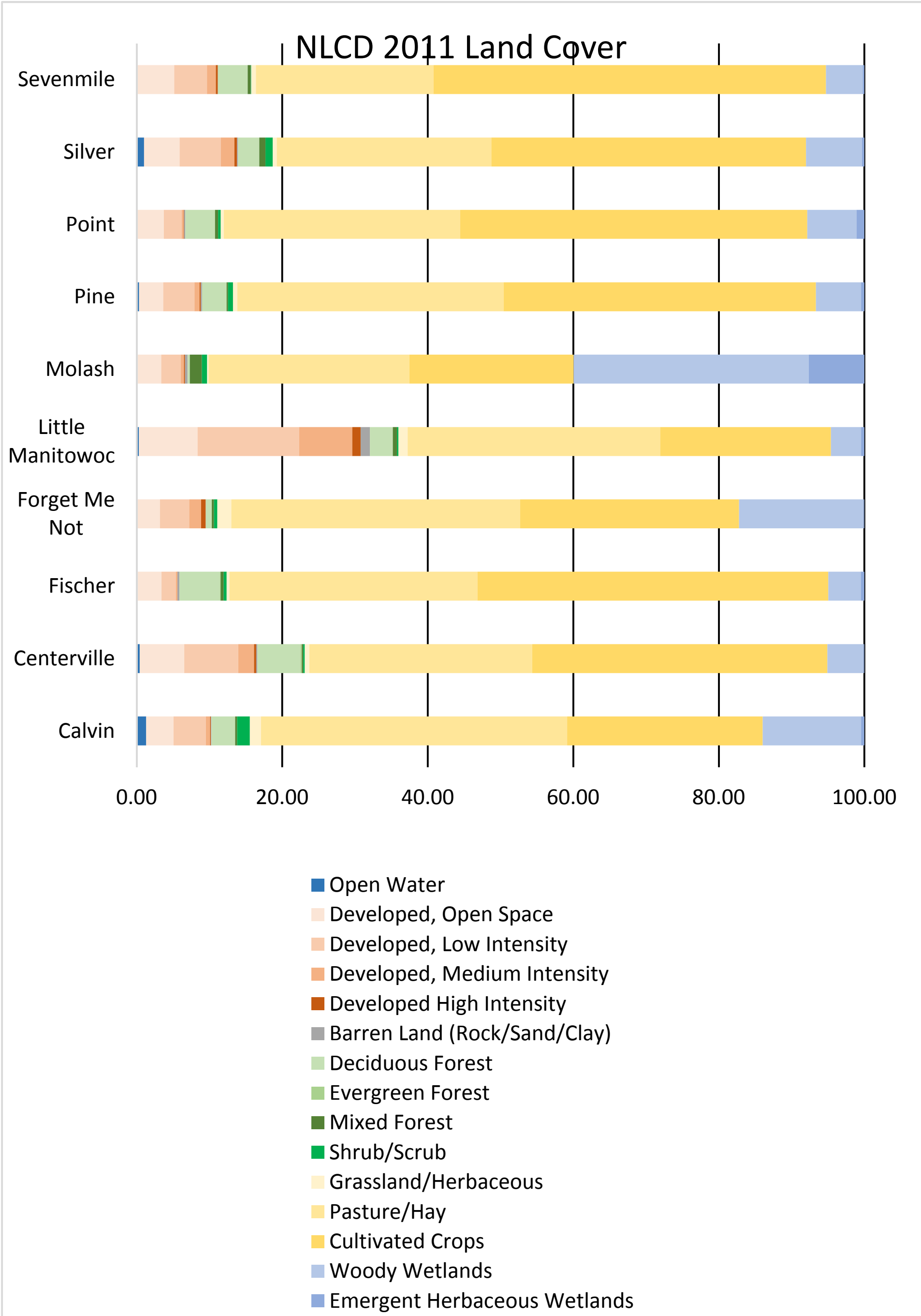


FIGURE 3. Percentage of land cover and land use of 10 southern Manitowoc creek watersheds, broken into more general categories.

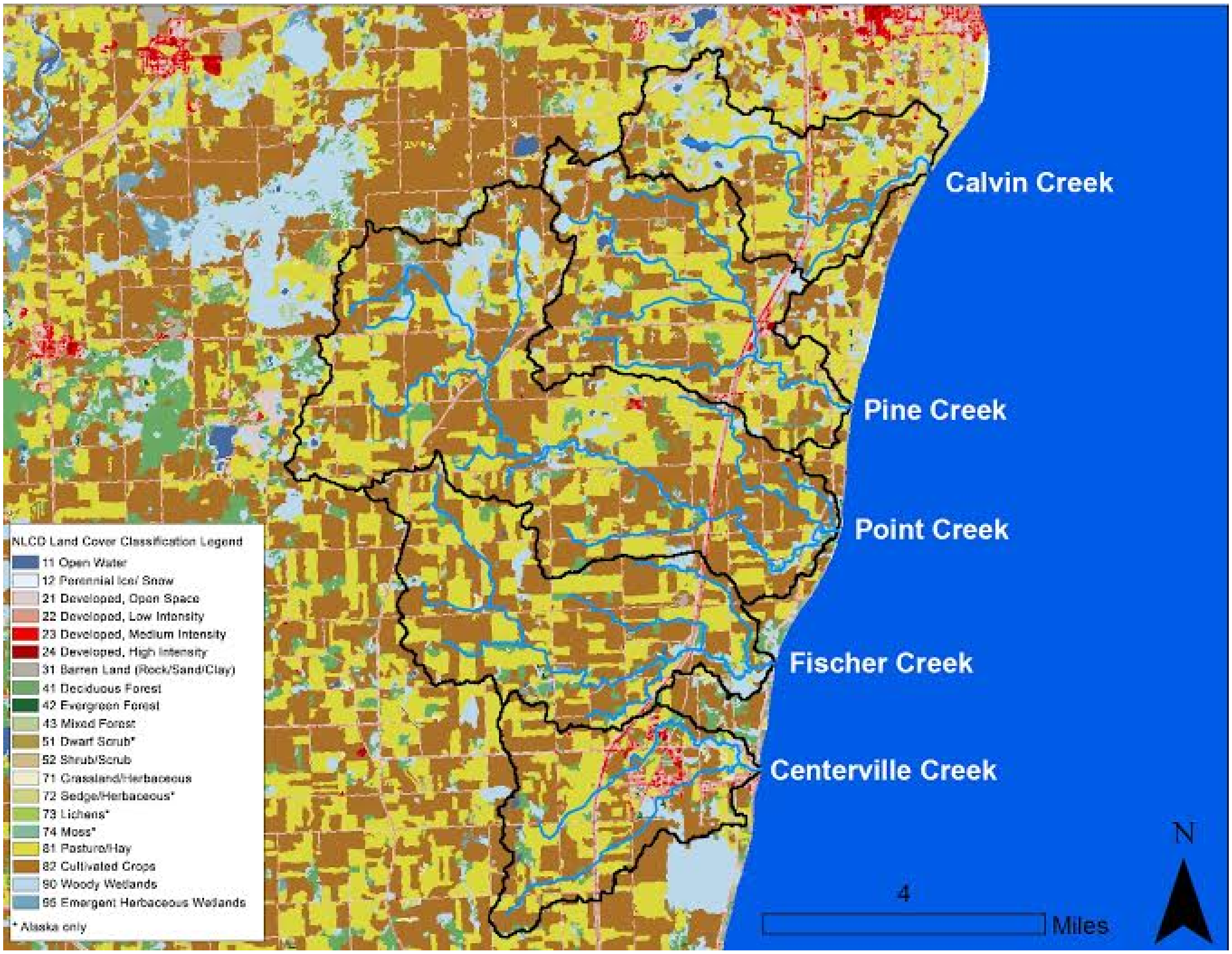


FIGURE 4. Southern Manitowoc creeks, watersheds, and landuse.

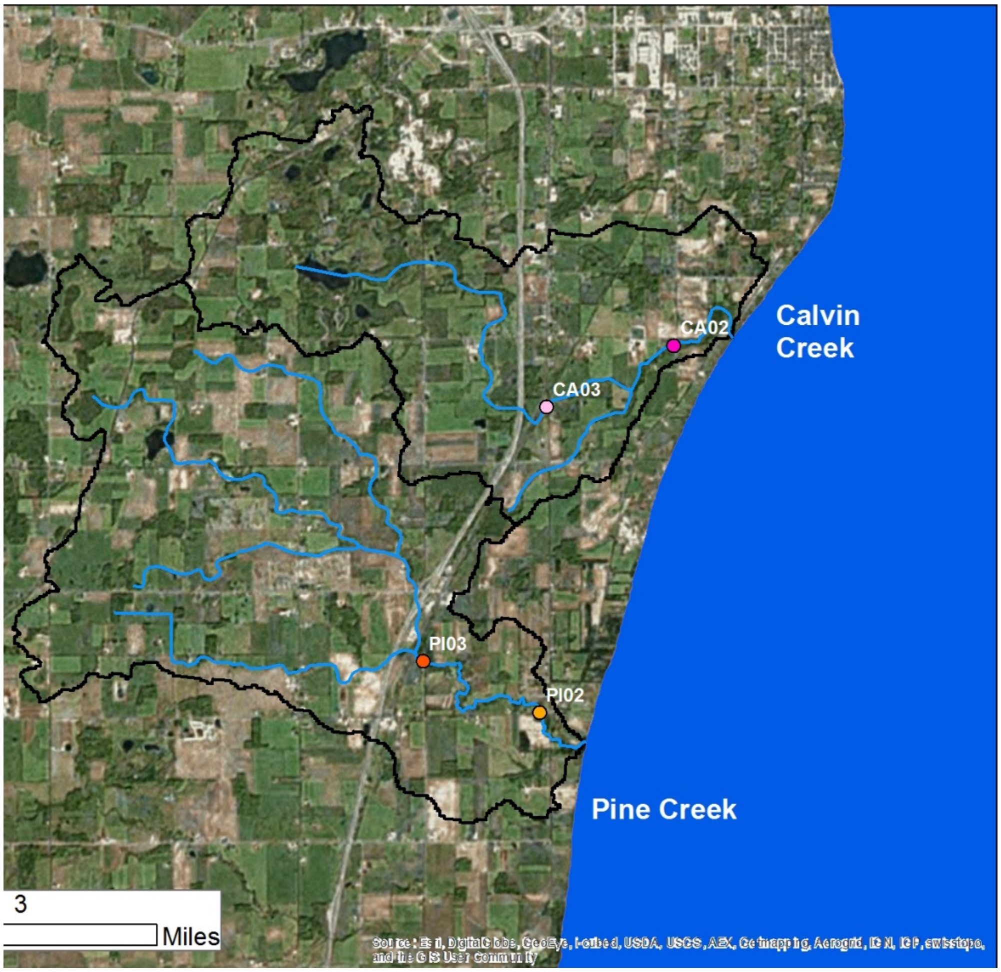


FIGURE 5. Sampling locations for Calvin Creek and Pine Creek.

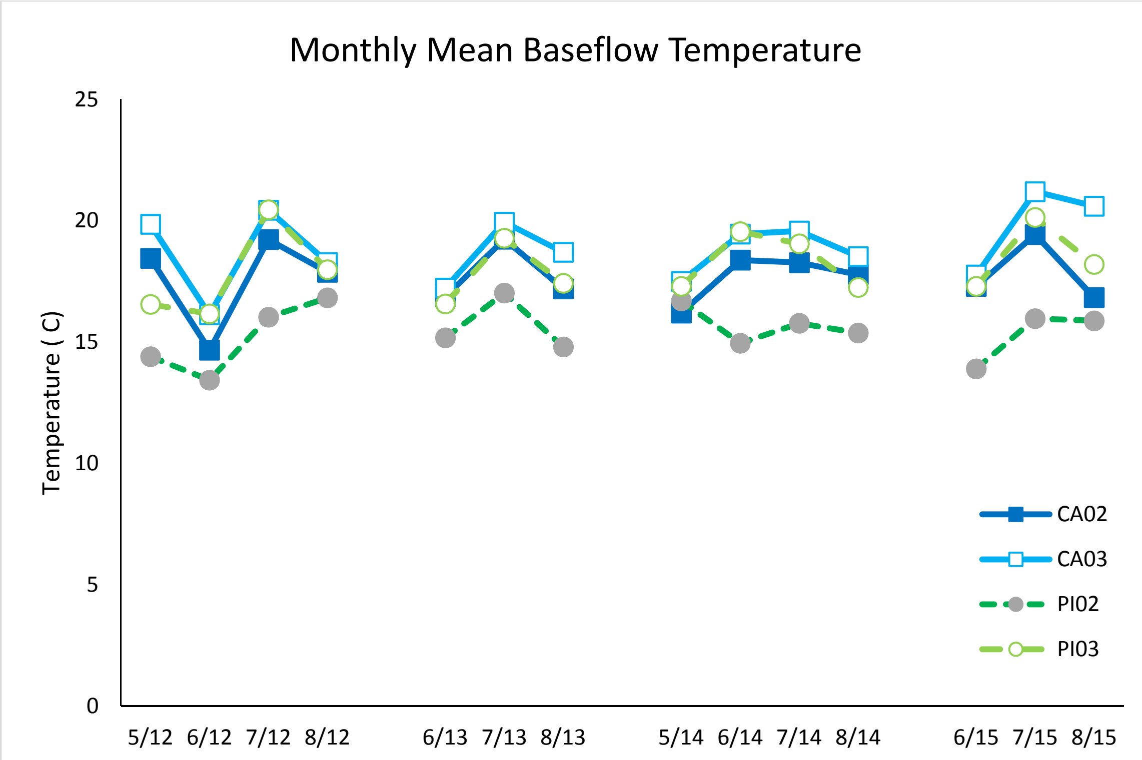


FIGURE 6. Monthly mean baseflow temperature (°C) for Calvin Creek and Pine Creek, summer 2012 – summer 2015.

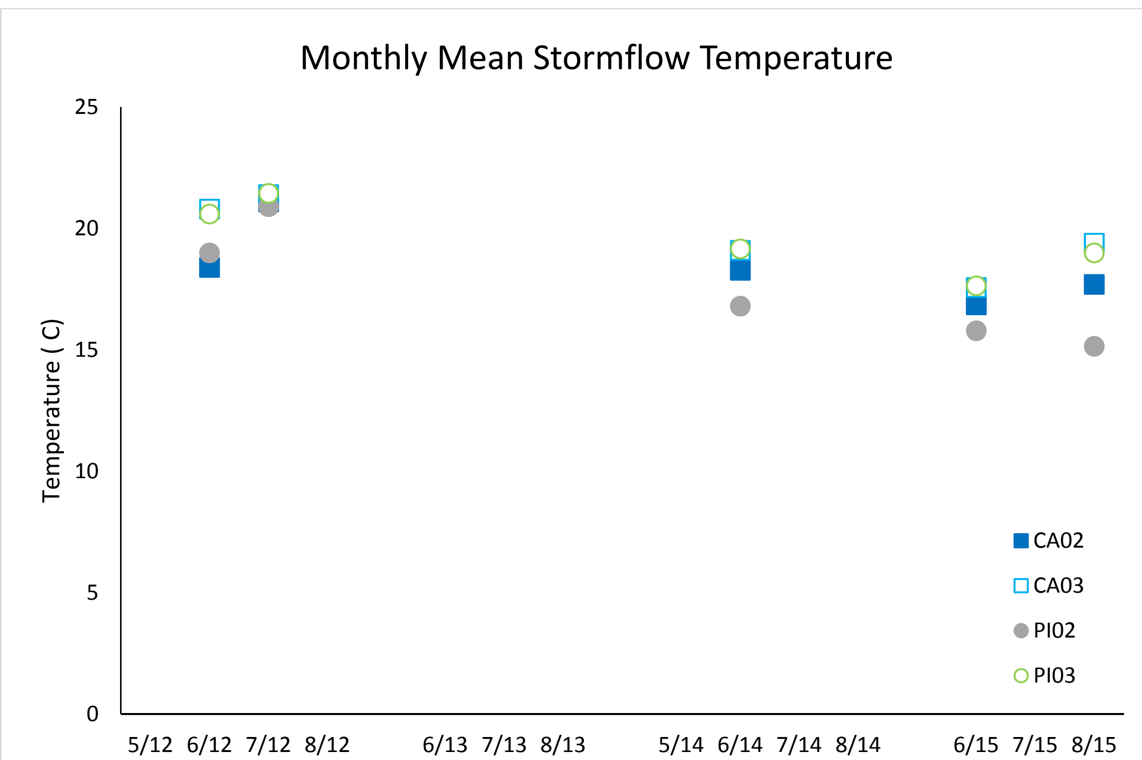


FIGURE 7. Monthly mean stormflow temperature (°C) for Calvin Creek and Pine Creek, summer 2012 – summer 2015.

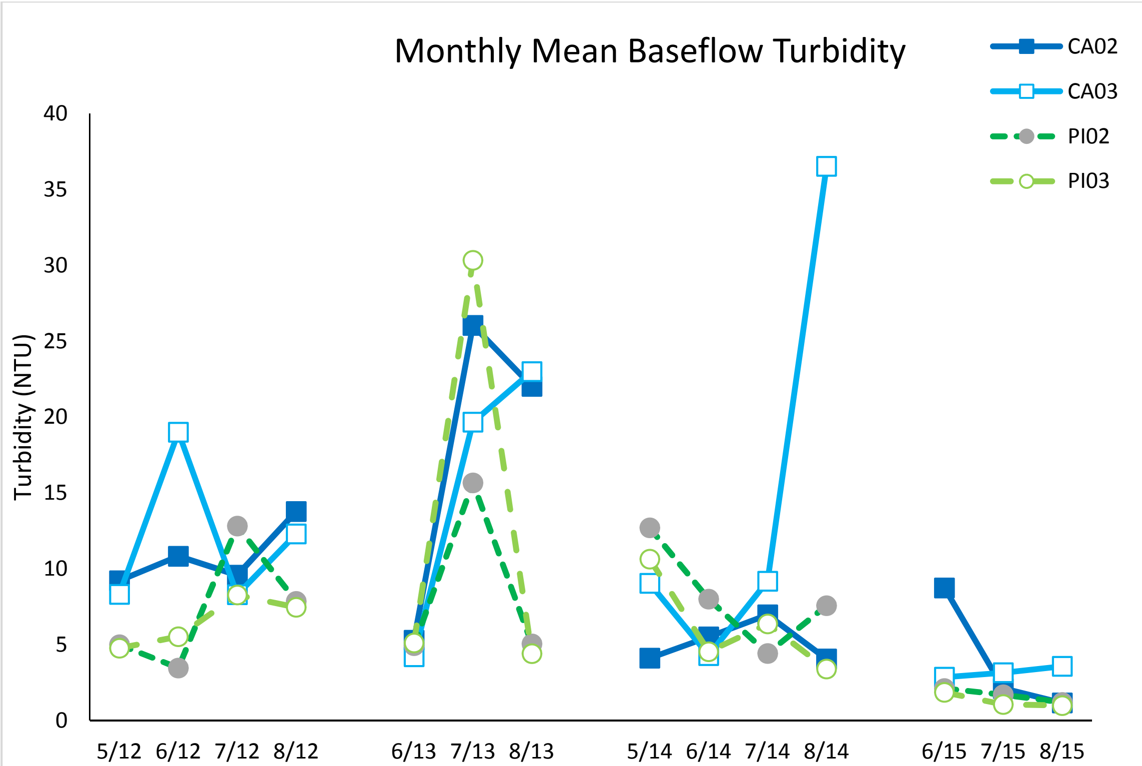


FIGURE 8. Monthly mean baseflow turbidity (NTU) for Calvin Creek and Pine Creek, summer 2012 – summer 2015. (Turbidity graphs do NOT have equal X-scale).

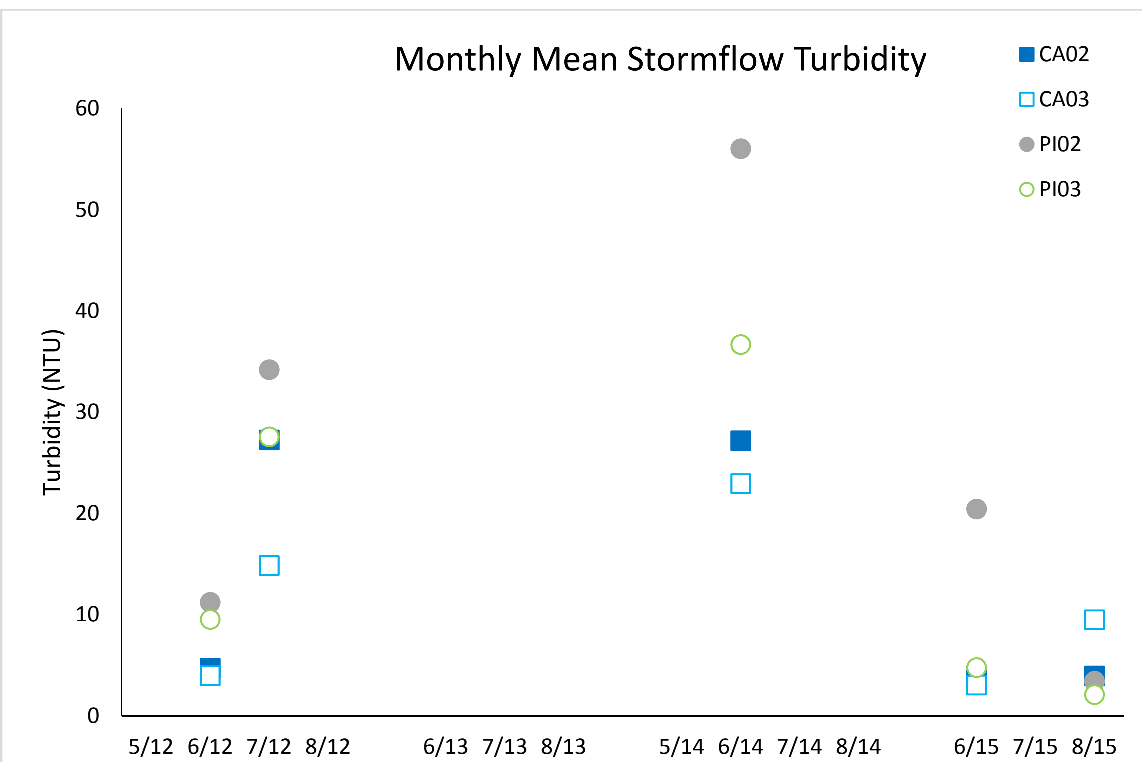


FIGURE 9. Monthly mean stormflow turbidity (NTU) for Calvin Creek and Pine Creek, summer 2012 – summer 2015. (Turbidity graphs do NOT have equal X-scale).

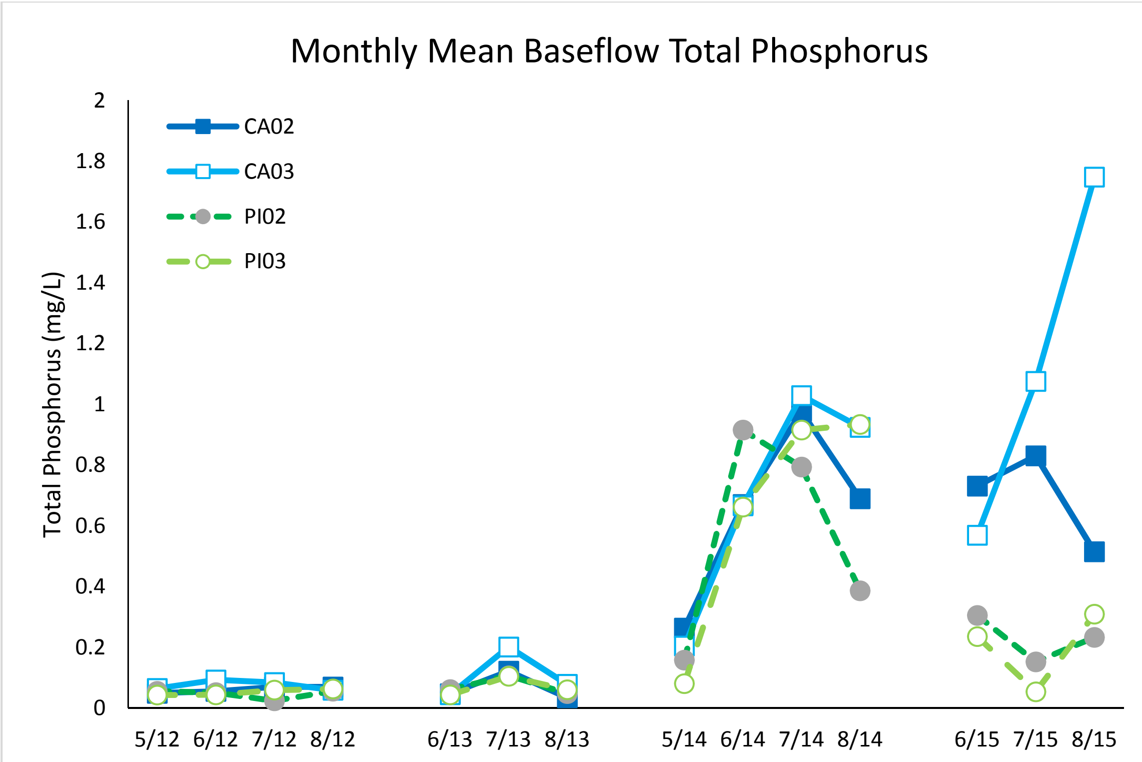


FIGURE 10. Monthly mean baseflow total phosphorus (mg/L) for Calvin Creek and Pine Creek, summer 2012 – summer 2015. (Total phosphorus graphs do NOT have equal X-scale).

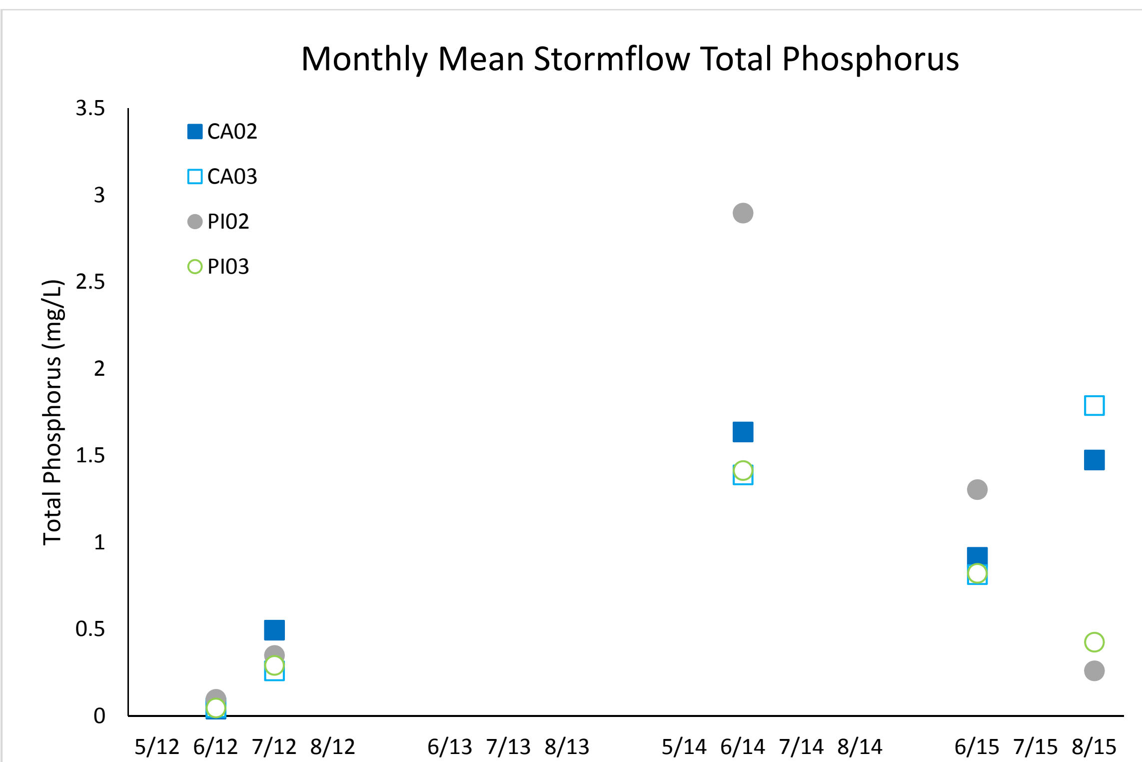


FIGURE 11. Monthly mean stormflow total phosphorus (mg/L) for Calvin Creek and Pine Creek, summer 2012 – summer 2015. (Total phosphorus graphs do NOT have equal X-scale).

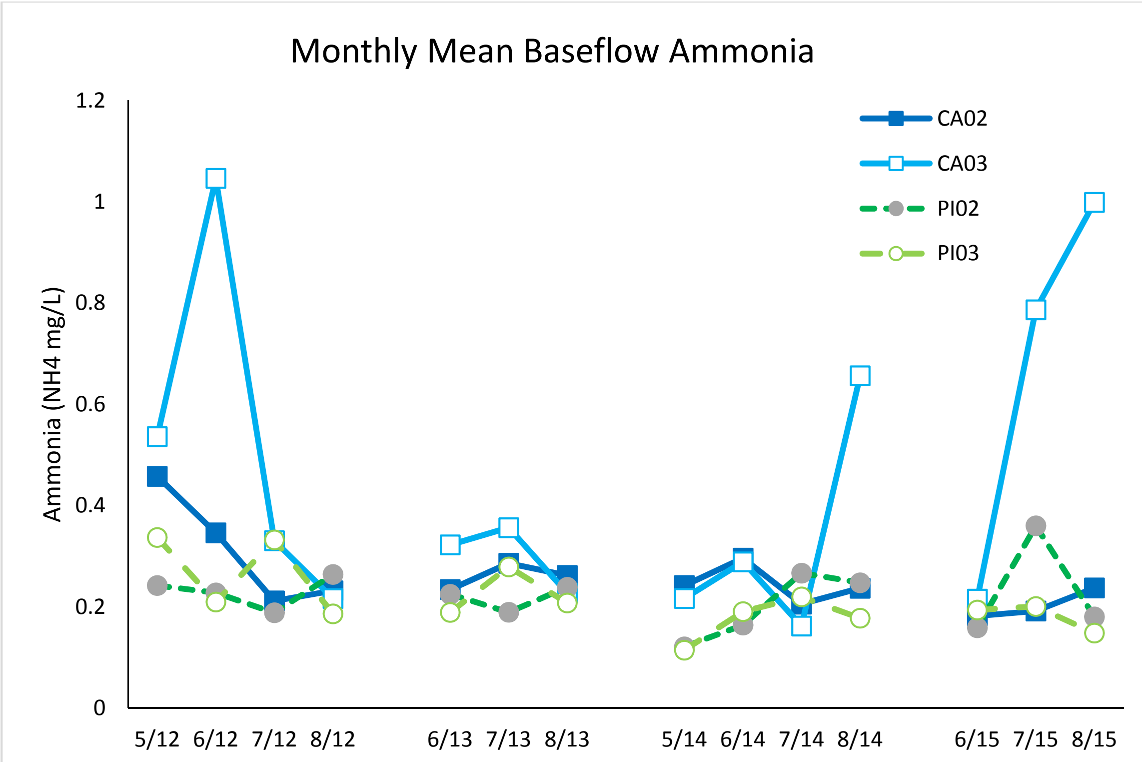


FIGURE 12. Monthly mean baseflow NH_4 levels (mg/L) for Calvin Creek and Pine Creek, summer 2012 – summer 2015. (NH_4 graphs do NOT have equal X-scale).

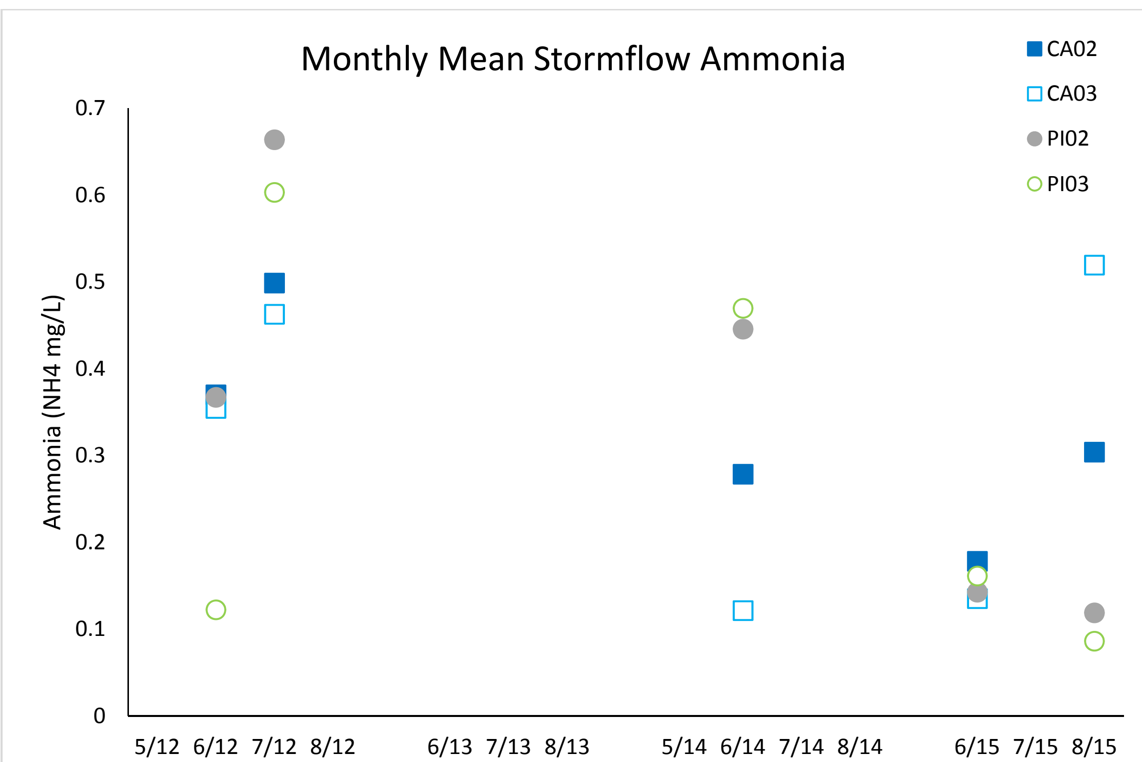


FIGURE 13. Monthly mean stormflow NH_4 levels (mg/L) for Calvin Creek and Pine Creek, summer 2012 – summer 2015. (NH_4 graphs do NOT have equal X-scale).

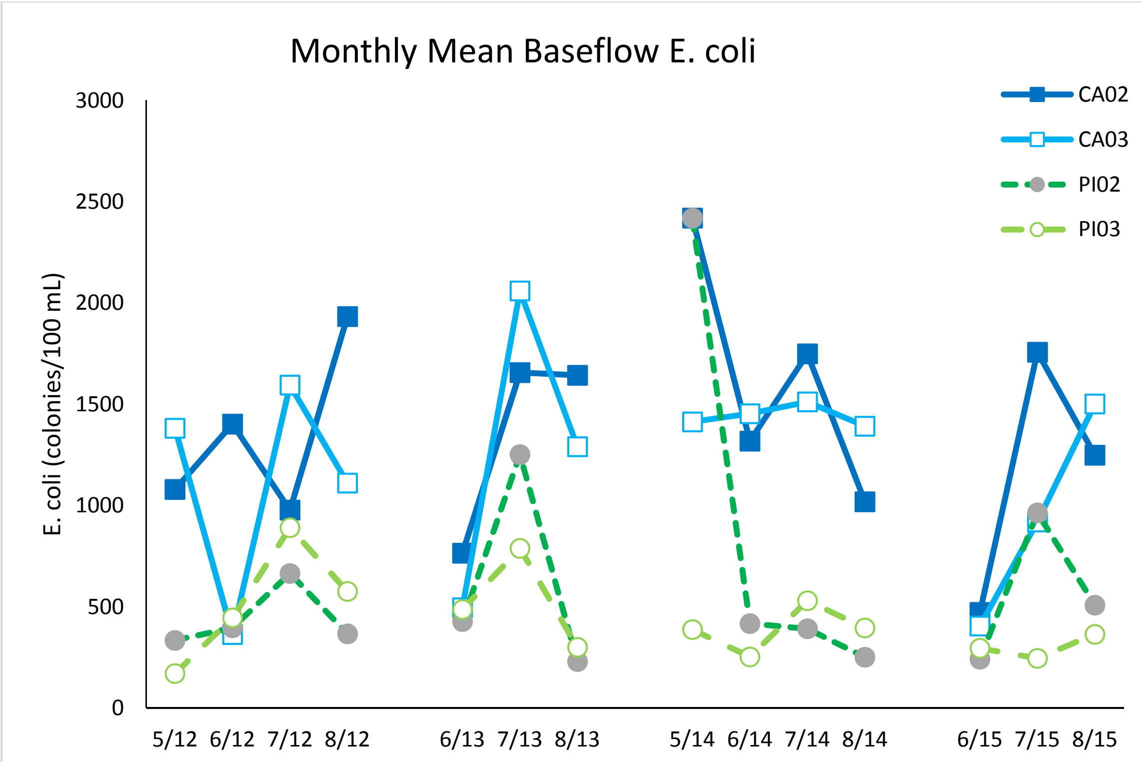


FIGURE 14. Monthly mean baseflow *E. coli l*evels for Calvin Creek and Pine Creek, summer 2012 – summer 2015.

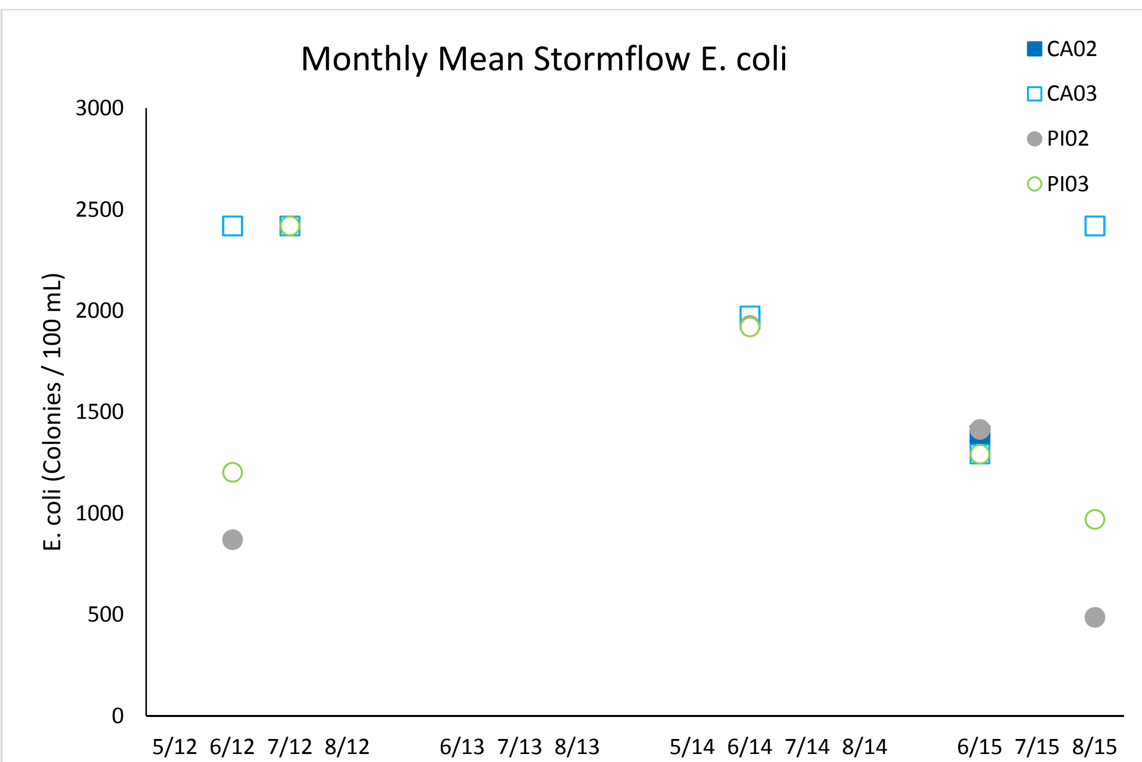


FIGURE 15. Monthly mean stormflow *E. coli l*evels for Calvin Creek and Pine Creek, summer 2012 – summer 2015.

2015 Lakeshore Water Summit

Wednesday, October 21, 2015
5:30-8:00 p.m.
Hosted by the Lakeshore Water Institute at UW-Manitowoc (H102 Lecture Hall)

Lakeshore Water Institute
LWI
Cultivating a water ethic through education and community engagement.

Agenda:

5:30–6:00 pm: Networking Social & Light Refreshments, followed by introductions by Jim Kettler, Lakeshore Natural Resource Partnership

6:00-6:30 pm: – Emerging Trends in Stream Quality, UW-Manitowoc Faculty

6:30-7:30: Data Stories, UW-Manitowoc Interns

7:30-8:00 pm: Q & A

UNIVERSITY OF WISCONSIN
Manitowoc

LAKESHORE NATURAL RESOURCE PARTNERSHIP INC.
LNRP

IMPACT OF RAINFALL ON THE WATER QUALITY OF THE TRIBUTARY CREEKS OF LAKE MICHIGAN IN MANITOWOC, WISCONSIN

STUDENT INTERNS: PAIGE ARNESON, CHELSY COUTERMARSH, AUBRI URBANEK, CATHERINE HINKLE, AND GEORGIA PLOEDERL
STUDENT MENTOR: MALLARY SCHENIAN FACULTY ADVISORS: REBECCA ABLER AND RICK HEIN

Introduction: In the summer of 2015, UW-Manitowoc conducted water quality research on tributaries in Southern Manitowoc County . Like previous years, Pine, Calvin, Point, Fischer, and Centerville Creeks had their nutrient, biological, and physical parameters tested to achieve a better understanding of the effect that rainfall has on the tributaries and thus Lake Michigan. Samples of water were taken 24 and 48 hours after rainfall and analyzed for dissolved and total phosphate, E. coli, and other important parameters. Weekly sampling was conducted to note the differences of water quality with and without rainfall. A rain event was considered when 0.5 inches of rain or more fell; a change from previous years' testing. Ten individual sites were tested for Centerville Creek because of the water management and reconstruction efforts conducted on it. All other creeks were designated two sites to determine the impact of the flow of water. Research was also collected in the spring of 2016 to analyze the impact of snowmelt on the same tributaries. The sites were reduced to five for Centerville Creek and one for each of the other creeks to collect samples for an overall idea of total and dissolved phosphate, E. coli, temperature, and stream velocities during the initial snowmelt. Similar trends in data have been indicated in both instances of water quality research in each creek. Initial snowmelt and rainfall data heavily suggest a relationship between themselves and higher bacterial and nutrient levels.

Discussion:

Summer rainfall observations:

Most of rainfall events occurred during seven day period where the 24 hr and 48 hr sampling overlapped multiple times. The parameters, off the charts for *E. coli* and unusually high compared to previous rainfall data at the beginning, decreased steadily over the week's time. While still high from non-rainfall sampling, the amount of runoff and bacteria/nutrients deplete from the soil and the rainfall doesn't disturb more than average parameter levels into the creek. Only one other separate event happened more than a month later and the overall parameters were closer to acceptable levels than the large rain event period, but stayed in higher levels compared to non-rainfall sampling. Rainfall increases *E. coli* levels often to levels our equipment can't detect and is realistically higher than what our averages project.

Snow melt observations:

While collecting for initial snow melt the weather was fairly warm, little to no visible snow left. Waters were high, but moving slow on first testing date. On second sampling date, creeks were much lower and temperature dipped back under 32 °C consistently. While parameters did lower in previous years from the initial snowmelt to later test dates, the large decrease in phosphates can be mostly attributed to most of runoff and build-up materials being deposited into the creeks after the first data point. Lower *E. coli* levels can be explained by the temperature prohibiting proper bacterial growth.

Materials and Methods:

Water Quality Parameter	Method	Units
Water Temperature	Thermometer	°C
pH	Meter	1-12 scale
Stream Velocity	Flow meter	Feet per second
Turbidity	Meter	NTU (**Nephelometric Turbidity Units**)
Ammonia nitrogen	Hach test kit	mg/L
Phosphate	Colorimetric method using a Spectrophotometer	mg/L
Conductivity	Meter	µS (microsiemen)
Dissolved oxygen	Dissolved oxygen meter	mg/L
E. coli	Colilert method	MPN/100 ml (Most Probable Number)

- Rainfall data was taken 24 and 48 hours after any accumulation of 0.5 inches or more of rain
- Snowmelt samples were taken twice for Centerville Creek and once for Pine, Calvin, Point, and Fischer Creeks

Results and Analysis:

Pine Creek

•Summer: Overall decreasing trend in nearly all parameters with the most drastic change in total and dissolved phosphate; cut in half when comparing data from 2014.

•Snowmelt: Decrease in total and dissolved phosphates as well as *E. Coli* levels between the two snowmelt event data points.

Calvin Creek

•Summer: Parameters did not change in any drastic measure from previous data years.. *E.coli* levels had the greatest decrease from 2014, but were still well above the closed limit.

•Snowmelt:

Point Creek

•Summer: Overall decreasing trend in nearly all parameters with the most drastic change in total and dissolved phosphate from previous data. Levels decreased, but remained above the acceptable range.

•Snowmelt: Overall decrease in total and dissolved phosphates, although not a drastic decrease.

Fischer Creek

•Summer: Phosphate and *E. coli* levels decreased, but stayed in unacceptable levels.

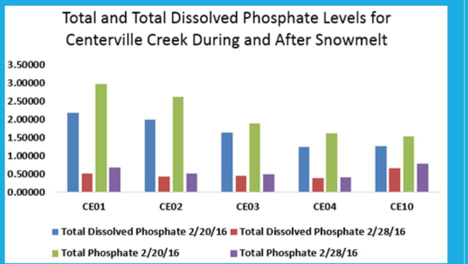
•Snowmelt: Dissolved and total phosphates decreased from 2014 data and *E. coli* decreased into open levels.

Centerville Creek

•Summer: Well above average levels for dissolved and total phosphates compared to other sites. *E. coli* was also high compared to other sites and many readings were off the charts.

•Snowmelt: Decreases in total and dissolved phosphates with the most drastic decrease compared to other sites.

Average for All Creek Rainfall Sample Points	Pine Creek (PI02,PI03)	Point Creek (PO02,PO03)	Centerville Creek (CE01-CE10)	Calvin Creek (CA02,CA03)	Fischer Creek (F102,F103)
Water Temperature (°C)	16.8	16.5	16.2	17.5	15.6
pH	8.85	8.82	8.72	8.57	8.82
Turbidity (NTU)	10.40	4.41	18.37	4.06	8.06
Stream flow (m/sec)	0.3	0.4	0.5	0.6	0.3
Conductivity (µS)	716.4	848.4	876.0	703.2	878.1
Dissolved Oxygen (mg/L)	7.69	7.67	7.15	6.20	7.75
Total Dissolved Phosphate (mg/L)	0.752912	0.749455	1.131553	0.782230	0.779796
Total Phosphate (mg/L)	0.902668	0.908329	1.426686	1.034565	1.022145
Ammonia Nitrogen (NH_3) (mg/L)	0.043288	0.034891	0.027374	0.057549	0.029155
Ammonia Nitrogen (NH_4) (mg/L)	0.140882	0.145731	0.159567	0.213335	0.174886
E. coli (MPN/100 mL)	1214.6	1217.6	1701.0	1579.1	1353.8



Southern Manitowoc County Creeks Water Quality Summary

Calvin, Pine, Point, Fischer, and Centerville Creeks

SUMMARY

Land use practices are one of the most important factors influencing water quality in most water systems. All types of land use can have a positive or negative effect on water quality. Impaired water quality affects the habitat and biota in the streams. This report describes five streams in southern Manitowoc County with degraded water quality. Turbidity, total phosphorus, and bacteria (*E. coli*) levels are commonly above targeted levels for an unimpaired river system. Water quality following rain events is consistently worse than before the storm, suggesting that runoff from the watershed during rain events is severely impacting the water quality of the creeks.

Centerville Creek at Center Road

WHY

- Freshwater is an essential resource to human existence, recreation, and biodiversity, as well as for agriculture and industry.
- Water quality monitoring is a valuable tool to raise awareness of the consequences of present and future contamination. Monitoring also provides a basis for planning and actions.
- While water testing can be both expensive and time consuming, it is necessary to collect benchmark data to develop and assess effective management plans.

WHO

- The Lakeshore Natural Resource Partnership, UW Manitowoc and Friends of Hika Bay, working through the Lakeshore Water Research Institute, have developed a cooperative water quality monitoring program in southern Manitowoc County.
- UW Manitowoc Foundation provided funding to support two student interns each summer.

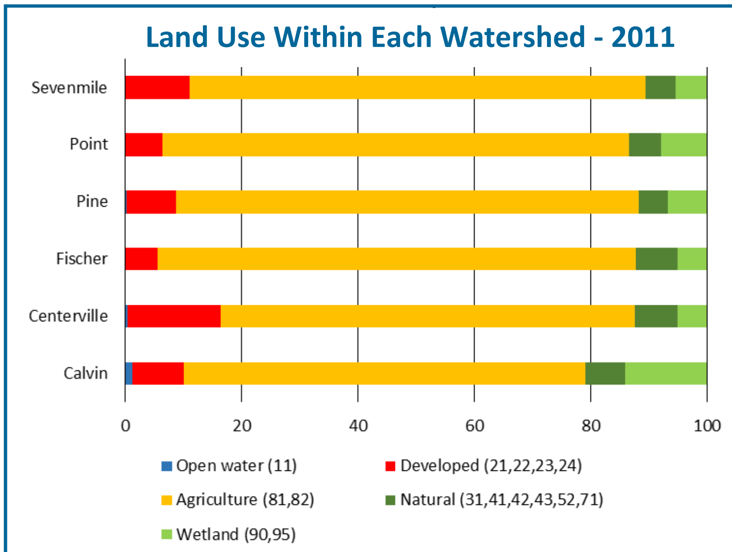
Confluence of the north and south branches of Centerville Creek

Lakeshore Water Institute LWI — Cultivating a water ethic through education and community engagement.

Friends of Hika Bay
Calvin, Pine, Point, Fischer & Centerville Watersheds

WATERSHED APPROACH

- A watershed is the area of land where all the water drains to a common outlet (such as Lake Michigan).
- Land practices can cause direct and indirect pollution. Common pollutants impacting water quality include nutrients, pesticides, metals, oil and petroleum products, and road salt.
- Properly managed land-based activities will protect and improve water resources in the watershed.
- The watershed approach brings together people within the watershed to educate on and address the activities that may impact water quality.
- For the southern Manitowoc County creeks, the majority of the land is covered in cultivated crops or pasture/hay, with Fischer the highest at 82% and Centerville the lowest at 67%.
- Urban land use is low in all watersheds, as is wetland and natural areas.

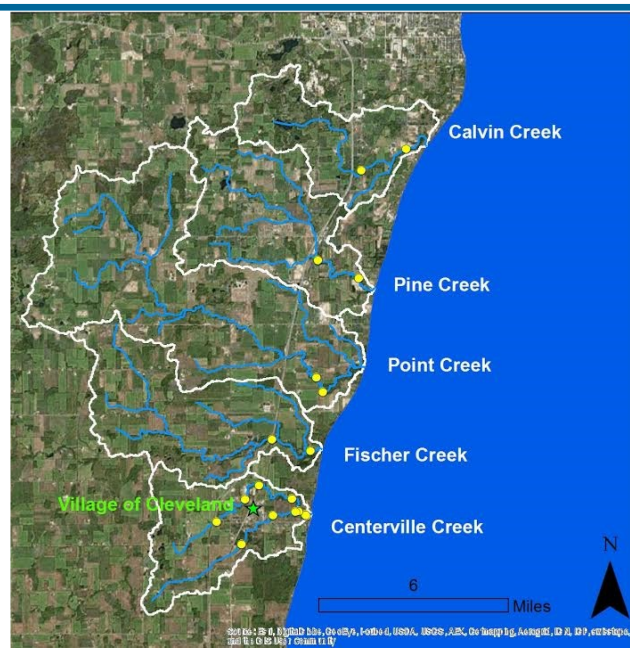


Source: National Land Cover database. http://www.mrlc.gov/nlcd11_data.php

METHODS

- Water samples were collected at 11 sites across the 5 creeks during the summers of 2010—2015.
- Samples were taken weekly from late May through the end of August (baseflow).
- Samples were also taken following rain events greater than a half inch at 24 and 48 hour intervals (stormflow).
- There were no storm events in 2013.
- Samples were analyzed for turbidity, total phosphorus, and bacteria (E. coli).

Interns gather water samples in Centerville Creek.



Southern Manitowoc County watersheds with sampling locations (yellow dots). All sampling was east of I-43.

Centerville Creek near Franklin Drive. The exposed creek bank is one source of turbidity after rain events.

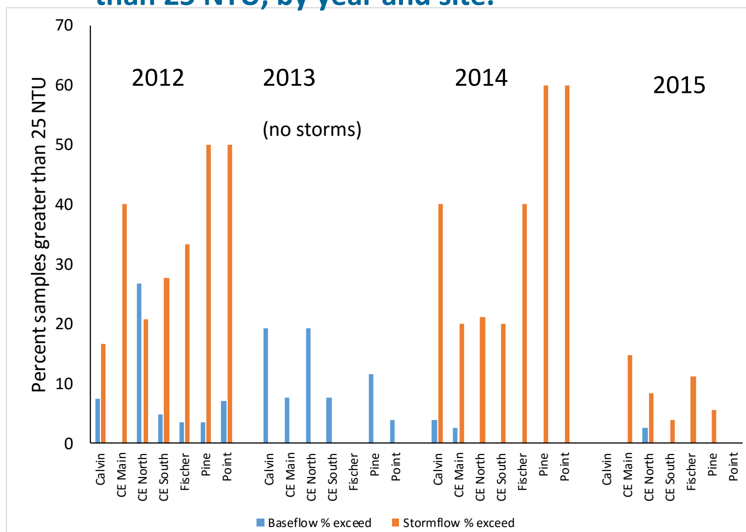
Turbidity

- Turbidity is defined as particles suspended in water and is reported as Nephelometric Turbidity Units (NTU).
- Lower NTU levels are associated with clearer water and higher NTU levels with cloudier water. Sediment is often the main cause of turbidity in streams.
- Baseflow turbidity levels were lower than stormflow turbidity levels in all creeks for all sample years.
- In 2015, both average baseflow and average stormflow turbidity levels in all creeks were lower than levels in 2013 and 2014.
- Minnesota developed a turbidity water quality standard of 25 NTU as the upper limit for turbidity in 2008 (Wisconsin does not have a NTU standard).

High turbidity levels are apparent in this photo taken during a rain event in Pine Creek at Highway U.

- Stormflow samples exceed the advisory level more than baseflow samples.
- The percentage of samples exceeding 25 NTU was lower in 2015 than in the previous years.

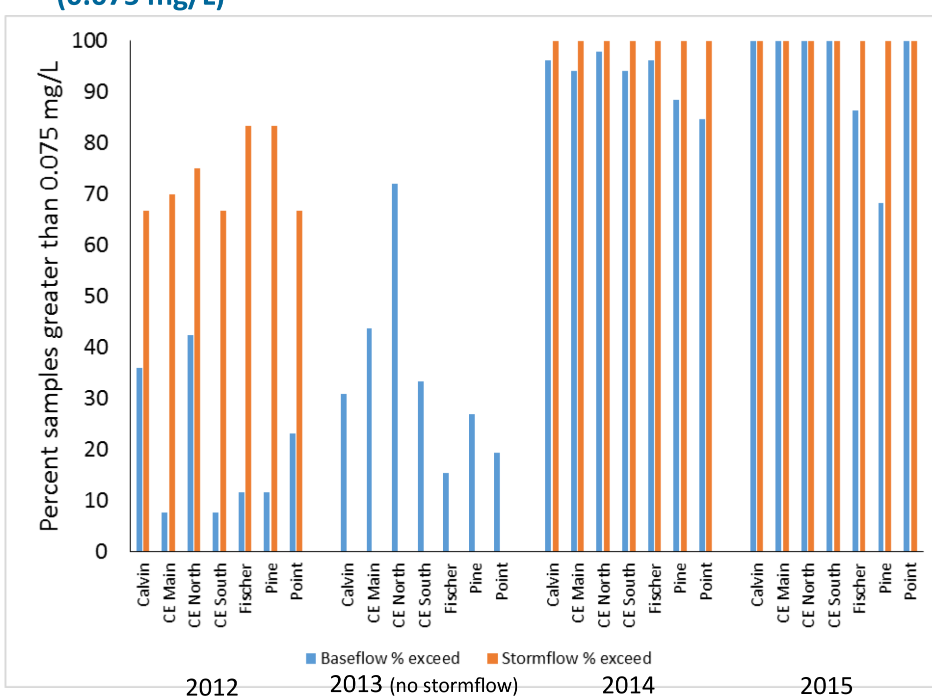
Percent of samples with turbidity levels greater than 25 NTU, by year and site.



Total Phosphorus

- Phosphorus is an essential nutrient for both aquatic plants and animals.
- Increases in phosphorus can cause "accelerated plant growth, algae blooms, low dissolved oxygen levels, and the death of certain fish, invertebrates, and other aquatic animals" in streams, rivers, and lakes (EPA 2015).
- Natural phosphorus sources (soil and rocks) are generally low, while human sources of phosphorus, including wastewater treatment plants, runoff from cropland, failing septic systems, and runoff from animal manure storage areas, (EPA 2015), can be higher.
- Baseflow total phosphorus levels in Centerville Creek and Calvin Creek were higher than total phosphorus levels in the other creeks.
- Stormflow total phosphorus was higher than baseflow levels.
- In Wisconsin, streams are impaired if total phosphorus levels exceed 0.075 mg/L.
- Baseflow samples exceeded this level 10% (2012) to over 90% (2014 & 2015).
- Stormflow samples exceeded this level 65% to 100%.

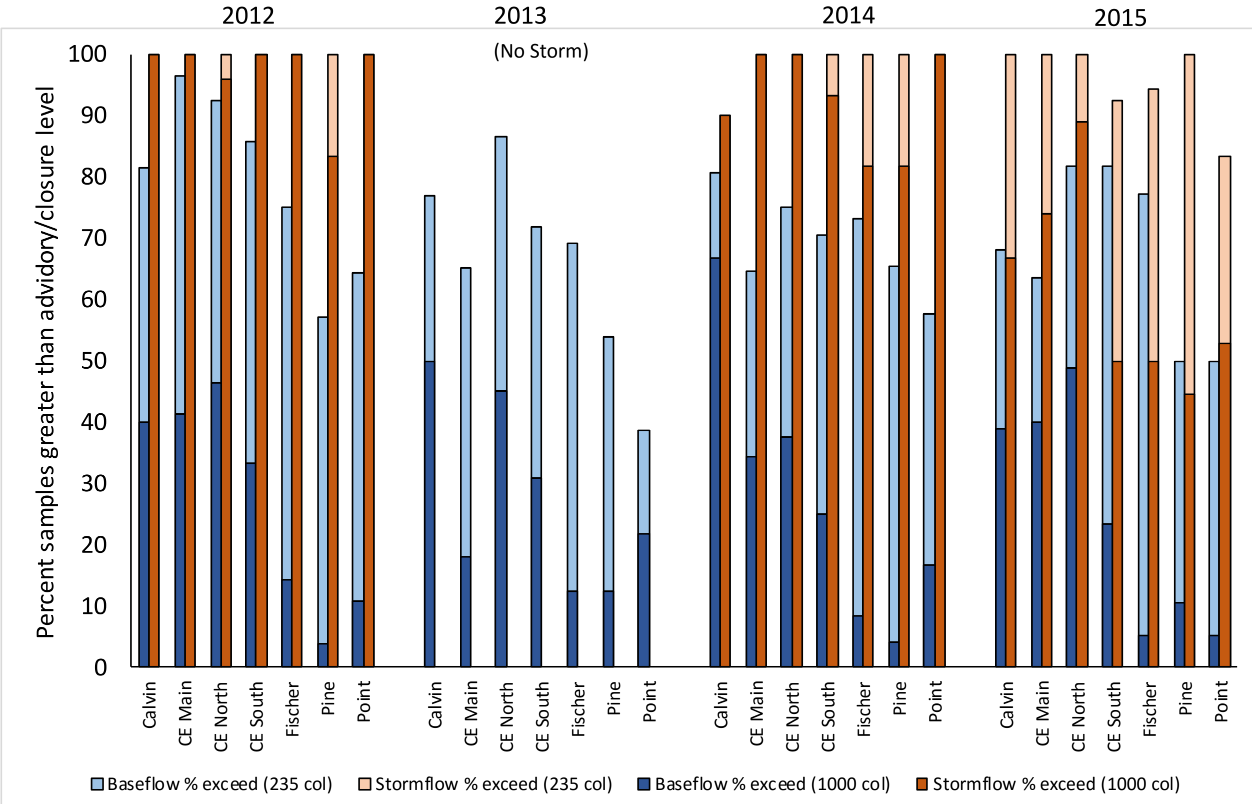
Percent of Total Phosphorus Samples Exceeding Unimpaired Levels (0.075 mg/L)



Bacteria (*E. Coli*)

- Escherichia coli (*E. coli*) are bacteria that, when found in water in high concentrations, can be an indicator that pathogenic bacteria may be present, which can cause serious illness in humans. *E. coli* is reported as CFU/ml or MPN/ml (used interchangeably).
- The EPA recommends that advisories at beaches be issued when *E. coli* levels in the water reach 235 CFU/100ml and be closed when levels reach 1000 CFU/100mL. There are no standards for creeks, so these are used as a comparison of harmful levels.
- More stormflow samples exceed the advisory beach warning level than baseflow samples. Approximately 75% of baseflow samples and 90% of stormflow levels exceeded the advisory beach *E. coli* level.
- Nearly 100% of all of the stormflow samples at all of the sites exceeded the closure level for *E. coli*.

Percentage of Samples Exceeding Advisory (235 colonies/) and Closure (1000 colonies/) Levels for *E. coli*.



Conclusions

- **The five streams in this study have impaired water quality from sediment, nutrient, and bacteria run-off.**
- **These impacts are likely affecting the organisms living in the streams.**
- **This monitoring can inform management plans to improve the water quality and overall biotic integrity of these streams and watersheds.**

Works cited: EPA (Environmental Protection Agengy http://water.epa.gov/type/rsl/monitoring/vms56.cfm. Modified 11-March-2015.

Calvin Creek at Northeim Road.

Bio 191—Environmental Science
Fall Semester

Instructor: Dr. Rebecca Abler
Office: F165
Phone: 683-4730 (Cell: 629-0314)
Email: rebecca.abler@uwc.edu

Lecture: MWF 11:00-11:50 (F170)
Lab: M 2:25-5:15 p.m. (F166)

Office Hours: Wednesday, 2:00-3:30; Thursday, 11:00-12:00, or by appointment*

**Note on Office Hours and Drop-Ins:* I realize that the office hours listed may not work for your schedule. Making time for students is my number one priority, and I encourage you to stop by any time you need to chat. I am often in my office or in the lab when not in classes or meetings. If I can't meet with you right away, we will work together to find a time that is appropriate. If you have a specific time in mind, please feel free to contact me either in class or by email to make an appointment.

Texts: Enger and Smith, *Environmental Science*: *A Study of Interrelationships*; 12th Ed.

Course Description: A contemporary study of the natural world through the human perspective. Emphasis on humans as a modifying force in the biophysical environment, including selected topics in ecological principles, pollution, population biology, and environmental management. This course is approved as meeting the statutory requirement for Conservation of Natural Resources as required for state certification of teachers of science and social sciences. Lecture, lab, and may also include demonstrations, discussions, and field trips (Fee required).

Course Policies and Grading

Attendance: Attendance is required in this course. Good attendance results in success, both in lecture and in the hands-on laboratory portion of the course. If you miss any graded activity due to an unexcused absence, you will receive a zero for the assignment. Excessive absences will negatively affect your participation grade, and will likely affect your performance in the course. In the event of an excused absence, arrangements will be made with the instructor. It is your responsibility to contact the instructor **before** the date and time of the absence, or within a reasonable period (24 hrs) after an unexpected absence, so that arrangements can be made. Documentation of an excused absence *may* be required at the discretion of the instructor.

Academic Integrity and Misconduct: Chapter 14 of the University of Wisconsin Administrative Code (UWS 14) defines academic misconduct. Please refer to the brochure entitled, "Academic Misconduct: Guidelines for Students: Cheating: Rules and Disciplinary Actions." UWS 14 is available to all students in the Office of Student Services as well as online (http://www.uwc.edu/students/uwc-student-rights-regulations-booklet.pdf.). Academic misconduct is taken VERY seriously, and will be pursued in all cases.

Special Note on Plagiarism: Plagiarism is the use of someone else's *words and ideas* without giving proper credit. This can occur either intentionally or unintentionally, but is considered a serious offense. Plagiarism tends to occur for several reasons: some students intentionally try to cheat the system, but many simply make a mistake or error in judgment. Do not do this! Plagiarism is a dishonest practice and is considered a punishable offense in this class and other classes. The best thing to do if you are uncertain as to whether what you are doing constitutes plagiarism, or if you are stressed or concerned about an assignment, is to see your instructor and talk about whatever issue may be occurring. There are solutions out there that, unlike cheating, will not risk your grade and academic career. I will help you find those solutions!

Technology Policies and Resources:

1. Campus Email/D2L: You are expected to check your campus email on a regular basis Failure to change your password and/or access your email will NOT be an acceptable excuse for late assignments.

I will use Desire to Learn (D2L) as an instructional tool. Your email login and password will allow you access to the BIO 108 D2L site. I will use this site, as well as campus email, to communicate important information outside of class. You are responsible for any messages, instructions, and assignments announced on D2L, so make it a habit to check the site often. In addition, I will post lecture outlines, handouts, useful links, and midterm/final grades on D2L. I will also use D2L to hold online study sessions. Finally, all lecture prep quizzes will be posted on D2L (see online quiz section, below). If you have any problems accessing D2L, please let me know as soon as possible.

2. Coursecasting: As an additional resource, I will be recording the lectures in this course (audio only). These lectures will be posted on the web at http://coursecast.uwc.edu. *The lecture coursecasts are in no way a substitute for coming to lecture*. You are expected to attend and participate in lecture.

3. Use of Technology in the Classroom: In the past, students have asked about using laptops, PDAs, etc, in the classroom. While this can be a valuable resource, past experience has indicated that the use of these devices is distracting to others in the room and…well, let's just say it's not smart to friend your professor on Facebook and then post updates during class (yep, it's happened)! Therefore, *unless specifically indicated by the instructor*, use of laptops, cell phones, Blackberries, etc., is not allowed in class. On exam days, you will be asked to turn off any such device and put it in a designated area. Laptops *may* be used in lab once you begin working on your activity for the day.

4. Electronic Submission of Assignments: I encourage the use of Dropbox D2L to turn in written assignments electronically, when possible. The advantage is that you will save on paper printing costs. However, technology is not perfect and files can be lost, email can get lost in the ether, and so forth. Technological glitches like these will not be accepted excuses for late assignments. Always back up your work! If you wish to turn in your work electronically, you may use the Dropbox feature on D2L. Please do not email assignments to me.

Disabilities/Accomodation Plans: If you have a disability with accommodation plan, please come speak with me during the first week of class so we can talk about how to make the class work best for you. If you have a disability, but do not have an accommodation plan, I encourage you to make an appointment in Student Services as soon as possible so that they may assist you in determining whether a plan may be appropriate for you.

Grading Scale and Criteria: There are a total of 950 possible points. Other assignments may be given during the semester for regular or extra credit.

Lecture Exams:	400 points (4 @ 100 points each)
Reading Quizzes:	70 points (5 pts; lowest score dropped)
Current Events Response Blog:	80 points (8 @ 10 points each)
Superfund Discussion	20 points
Stream Assessment	
• **Group Presentation:**	100 points
• **Weekly Data/Summaries:**	60 points
• **Letter to Stakeholders:**	50 points
• **Data Analysis Check-In**	10 pts
Lab Reports (exc. Stream Assessment):	80 points
Lecture Participation/Work:	50 points
Lab Participation:	30 points

Grading Scale:	92-100 % -- A	80-81+% --B-	68-69+% --D+
	90-91+ % -- A-	78-79+% --C+	62-67+ -- D
	88-89+ % -- B+	72-77+% --C	60-61+ -- D-
	82-87+ % -- B	70-71+% --C-	<60 -- F

Graded Course Components:

1. Lecture Exams: There will be four 1 hour exams, as indicated on the lecture schedule. These will be **non-comprehensive** in nature, including the final exam. Exams will be reviewed but will not be returned permanently. Each exam is worth 100 points, for a total of 400 points. Make-up exams will not be allowed.

2. Reading assignments and reading quizzes: You should read each assignment before the material is discussed in class. Assignments will consist of readings from your text, with occasional short supplemental readings. You will have one short, online quiz that **must be completed by the beginning of class on Monday of each week*.**

*****=*Quiz 1 will be due on Friday, September 9. All other quizzes, beginning with Quiz 2, are due on Monday.*

How to Access the Online Reading Quizzes:

- Log in to D2L (http://d2l.uwc.edu/)
- Go to the course website for BIO 108
- Click on "Quizzes" on the blue taskbar at the top of the page (just under the course title)
- Click on the quiz for that week

Each quiz will be worth 5 points. You may use your reading materials to take the quiz, and you may retake the quiz once. You will have a 2 hour window to complete both attempts. Please contact me IMMEDIATELY if you have any problems with the quiz. Your lowest quiz score will be dropped.

3. Lab: Attendance and participation are required for all lab sessions. There is no lab manual for this class. You should have a **folder or binder (3 ring is best)** for BIO 108 lab. You will also need to purchase a **bound** (not spiral) **lab notebook.** Lab notes, handouts, and assignments (lab reports) will be put in order in your 3 ring binder. Lab assignment due dates will be announced in lab each week.

Labs, continued: Lab activities will take several forms:

- Short-term lab experiments: These are stand-alone activities that will be completed in one or two lab sessions. Lab reports will usually consist of group or class data and a conclusion consisting of a concise paragraph and/or answers to questions on the lab handout. These will be worth 5-10 points.

- Field trips: We will be taking several field trips relevant to the topics we are studying in class. We will be taking a bus to all field trip sites as required under state regulations. Field trips will be completed during your 3 hour class period. Some hints for field trip preparation follow:
    - SHOULD BRING: water, hat/sunscreen, shoes for hiking, lunch/snacks, rain gear, appropriate pants, field notebook, etc.
    - MAY BRING: camera, binoculars, cell phone (for emergencies ONLY.)
    - PLEASE LEAVE BEHIND: iPod, CD player, laptop, etc.

  With the exception of the creek trips, field reports will consist of summary and analysis paragraphs and/or open-notes quizzes following the trip. These will be worth 10 points.

- <u>Southern Manitowoc County Watershed Research Project</u>: This is an *exciting* new project that ties in directly to ongoing biological research conducted by scientists at UW-Manitowoc. We will be working with community partners to conduct important monitoring and assessment of the health of four creeks in Manitowoc County. You will be responsible for collecting and analyzing data, sharing data with your classmates, writing a weekly summary assessment of your work, and sharing your final results and analysis with stakeholders in Manitowoc County. Detailed information will be provided to you in your lab packet. This project will be worth 200 points.

4. Current Events Response Blog Throughout the session you will be expected to write a short summary of a relevant current event related to scientific aspects of environmental biology. These summaries will be posted to the class blog at http://bio103fall11.blogspot.com. You will be expected to comment on other posts as well. The summary should be of an article or report in a <u>reputable</u> print-media periodical (New York Times, Newsweek, Wisconsin State Journal, etc). Online versions of periodicals are preferred, as you can link to the article from your blog.. You will turn in both the article and your summary. By the end of the semester, you will have covered at least 2 articles from each of the three categories:

1. Local (Manitowoc County/Wisconsin)
2. National/North America (Canada, Mexico, or the United States)
3. International (not Canada, Mexico, or the United States)

You may choose any of the three categories for the other two blogs. You do not have to go in any particular order. Include your name, the date, the article category, a paragraph summarizing the article, and a paragraph explaining the significance and relevance of the article to our class (this paragraph may include your opinions on the article). Please see your "Current Events Response Blog" handout for more details. The first entry will be due **Friday, September 16.**

5. In-class assignments: Throughout the semester you will be given various assignments in lecture and discussion. These will generally be team-based assignments, and may include worksheets, case studies, and informal inquiry writings. These assignments will be graded using the check mark system:

- A √+ indicates superior work, equivalent to 100% (A)
- A √ indicates satisfactory work, equivalent to 80% (B-)
- A √- indicates that some improvement is needed, equivalent to 65% (D)
- Absent or non participating individuals will receive a zero for that assignment

At the end of the semester, we will calculate an average "score" for your checkmarks, and scale that to 25 points.

6. Participation: BIO 108 is a *participatory* course, meaning that each student will be expected to participate fully in class discussions and laboratory exercises. The instructor's participation evaluation will be based upon <u>attendance</u>, preparedness, neatness, respect for other students and the professor, development of laboratory technique, participation in class discussions, and cooperation. The participation grade in this course is worth 25 points in lecture and 30 points in laboratory. Your laboratory participation grade will consist of an instructor's evaluation as well as a peer evaluation completed by your lab group.

Hints and Tips for Success in this Class:

1. Take advantage of where you are: UW-Manitowoc *not* "Year 13", "5th Year High School", or anything similar that you may have heard this place called (I did it too, when I was in high school…*back in the day…*). <u>This course has the same level of content, and same demands, as you will find at any other school in the UW-System</u>. The difference is, here you will be taught by Ph.D faculty who have dedicated their careers to teaching. Take advantage of this by taking this course seriously.

- Come to class prepared, *with enthusiasm*, and ready to learn
- Read the text BEFORE class. Answer the review questions at the end of each chapter. Take charge of your education.
- Actively participate in team learning
- Use the web links I provide in D2L
- Review, review, review—alone, with your classmates, and with me if needed
- ASK QUESTIONS!! This is the *most important thing* you can do to succeed in a college-level course.
- Get help when you need it.

2. Take charge of your education--what the heck does that mean? Sometimes, you hear students say that a professor "gave" them a grade on an assignment or in a class. This is not how it works—you earn the grade. You work for that grade, take pride in that! Think about joining a gym…you're paying for the membership, you might even pay for a trainer…but you still have to do the heavy lifting yourself. You need to do the reading, take good notes, and study on your own. And just like a trainer would, I am going to push you to your limits at times, and at times you will not like me one bit for that. But remember—*I am doing this to help you become your best*. Many times, I will not give you the answers. This is *not* to make you feel stupid; in fact, it is because I know you are NOT stupid. Do not let this turn you off. Although I this may seem like a pain, I am also your biggest cheerleader in this class. So please, do the heavy lifting on your own, but also feel free to come in and talk to me whenever you need help.

3 Words of wisdom from other professors: (as compiled by the UW-Colleges staff)

- Attend classes. Turn in the assignment. Come in to take the test. This may sound simple, but most students who get a failing grade simply did not do this.
- Do not procrastinate with papers, and assignments.
- Don't try to copy every word, or PowerPoint slide. You will not be listening to information given. By having this outline, you will have a study guide for exams.
- If you signed up for a lab, make sure that you are willing to spend the required time doing work. Do not ask if we are done yet. If you have extra time, use it to write your lab reports
- At various times, talk to the instructor in order to find out where you may need to improve.

Assessment Statement (required on all syllabi):

A UW Colleges-wide assessment program has been put into place to enhance the quality and effectiveness of the curriculum, programs and services of the institution. The following areas of proficiency will be assessed because they are of primary importance in the education of our students: Analytical Skills, Quantitative Skills, Communication Skills, and Aesthetic Skills. The Biology Department has also determined a number of core proficiencies for students enrolled in biology classes. For more information, go to www.uwc.edu/resources/assess/.

This course will *not* be assessed this semester.

Final note: I hope you enjoy this class, and that you take something meaningful with you when you leave it. If there is ever any way that I can help you be successful, please do not hesitate to come talk to me. I am ALWAYS willing to work with you to make this the experience you want it to be!!

"We abuse land because we see it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect."

–Aldo Leopold, American scientist, author, and educator

BIO 191 - Environmental Science
Stream Assessment Project

Introduction: Manitowoc County is home to several creeks which feed into Lake Michigan. These creeks have been compromised by several factors, including dams, runoff of manure, fertilizer, and pesticides, erosion, and overuse. There has been great interest in protecting and restoring these creeks, but restoration must be done in a method based on scientific data and monitoring, or it won't be successful. In order to accomplish this, two of the main stakeholders in Manitowoc County creek restoration—Centerville CARES and Lakeshore Natural Resources Partnership— are working with UW-Manitowoc faculty and students to gather real baseline data on creek health. Your job will be to collect this baseline data for four of the six creeks of interest in Manitowoc county.

What you will need: You will need the following materials for this lab:

- A *folder* or *binder* for lab handouts, data sheets, etc.
- A bound (not spiral) *field notebook*
- Your lab packet on data gathering and analysis
- Tennis or hiking shoes for hiking in the field
- Long pants (recommended)
- Bug spray (optional)
- Camera (optional)

What you will do: For four weeks, you will go out into the field and sample one of the four streams listed on the syllabus (Centerville, Point, Fischer, and Pine). You will work with your lab group to take physical, chemical, and biological data on the stream. You will also make qualitative observations of what you see ("sunny day, stream is flowing rapidly, no observable algae..." etc) and write it down in your lab notebook. Although we are doing the same samples each week, each stream has unique and interesting characteristics to it, so your observations are very important! We will analyze some data in the field and some in the lab. You will share your data with the class each week. After all the data is gathered, we will finish our analysis of the compiled data.

Each student will be responsible for several *deliverables* to the public: the first is a letter to stakeholders, which will tell them what you learned. The second is a short group presentation on one aspect of the research you did. We will talk details after the data has been collected.

What you will turn in/how you will be graded: This project is worth 220 points, which is about 23% of your total grade in this course. The grade breakdown is as follows:

- Weekly Data/Summaries: 60 pts
- Data Analysis Check-in: 10 pts
- Letter to Stakeholders: 50 pts
- Group Presentation: 100 pts

In addition, you will do a *Soils Analysis Lab* that will use soil collected from your research sites, worth 10 points, and you will turn in your field notebook at the end of the semester, which will be part of your lab participation grade (30 pts total).

The next page will describe each part of the grade in some detail.

1. Field Notebook: You will use your bound notebook to take notes in the field whenever we go outside of the lab. This will include your field trips to the creek, in addition to Vanderbloemen Bog and the Wastewater Treatment Plant. The field notebook should be well organized, with a table of contents at the beginning. For each week's lab, you will clearly title and date the notebook entry, and then will have three parts:

   Journal: The "journal" part will consist of observations made on the site. For example, if we are at Centerville Creek, you will want to describe the general terrain, vegetation, and the state of the creek. You should also describe important abiotic and biotic factors—e.g., "Sunny and warm, 24 hours after rainfall. Creek is running quickly, slightly cloudy, no algae present. Several crawfish observed." This information will be used to send me your weekly summaries.

   Data: You should record what you are responsible for collecting (e.g., Phosphate, Biotic Index, and E. coil), make any notes on the collection if needed (e.g., "E. coli sample spilled, so we took a second sample), and record your results in the notebook

   Questions or Other thoughts: Here you would record any questions you had for the next time, or thoughts about how to do future sampling (e.g., "Curious as to whether amount of debris in stream affects biotic index. Next time we will...(etc)"

   The field notebook is very important! Good notes will allow you to write good summaries, which are part of your grade, and will help you when it is time to do the presentation

2. Weekly Data Updates: Each group will collect a portion of the data needed for the week. It is *crucial* that we share data with our classmates in a timely manner. To make this easier, I have set up a spreadsheet on Google Docs for you to use. Each week, you will input the data collected for your group. This must be done before the next class! Each week is worth 5 points for getting your data on the spreadsheet on time. Failure to share the data on the spreadsheet is worth 0 points. Failure to *collect* the data will be a deduction on the total grade to no higher than a C for the project.

   You will receive an invitation to the Google Doc, and a link will be provided on D2L.

3. Weekly Summaries: Each *individual* will write a weekly summary of their experience. The summary should include both the data you collected, and your own individual experiences as recorded in your notebook. Your summary should end with a good question about the research project that you'd like answered. This can be a question about the actual biology/ecology of the project, or a logistical procedure question. This will be turned in to me using the Dropbox feature on D2L. You may keep one running document with all your summaries if you wish—just add a new summary into the document each week. If you do that, make sure the date is provided for each summary so that I grade the correct one. Each summary is worth 10 points.

4. Data analysis check-in: We will analyze weekly data for our individual groups, but at the end we will need to do an in-depth analysis of what all the data mean. We will hold an in-class workshop on data analysis on Monday, October 31, and you will turn in your analyses to-date on November 7. It is worth it to spend a good amount of time with the analysis at this point, as it will make your group presentation much easier. This check-in will be worth 10 points.

5. Letter to Stakeholders: As part of your analysis/communication portion of the lab, you will write a letter to interested stakeholders describing what you learned during this semester. "Stakeholders" are any interested parties—for the most part, we will focus on landowners and municipal governments in the area of your creeks. Each group will write a letter, and turn it in via Dropbox. Each group will be responsible for one creek (there will be two creeks that have two groups writing a letter about it). These letters will be compiled and made available to the homeowners and officials at the end of the semester. You will be given guidelines for writing the letter when all the data is collected. This letter is worth 50 points.

6. Group Presentation: Each group will present one aspect of the research project to their classmates, to Biology Department Faculty, and to Russ Tooley and Jim Kettler on Monday, December 5, at our "Classroom Research Presentation/Celebration Day." Your presentations will focus on a portion of the project, but will compare results from all four creeks. Presentations should be about 10 minutes in length—there will be six presentations that day, so you should *not* go over 12-13 minutes. You will receive a rubric and guidelines for the presentation when all the data is collected. This is worth 100 points.

Note: All handouts, links, etc., will be made available to you on D2L in either the "Links" or "Content" section. You should not have to print anything out, however, unless you lose a copy of your handout. If you have ANY questions, just ask!

BIO 294-Internship in Biological Sciences
Centerville Creek Restoration Project
Summer/Fall, 2011

Instructors:

Dr. Rebecca Abler
Office: F165
Phone: 683-4730
Email: rebecca.abler@uwc.edu

Dr. Rick Hein
Office: F167
Phone: 683-4730
Email: richard.hein@uwc.edu

Course Description (catalog):

An individually arranged internship in an area field site, public agency, community organization or industry to gain practical experience in a biological science discipline. The internship is intended for advanced science students with previous college level biology coursework. Students will work under the supervision of a faculty member, and will receive credit based on hours employed and completion of a final report summarizing their experiences and how they build upon previous classroom experiences. Presentation of any research performed would be arranged through the supervising faculty member. Repeatable for a maximum of 6 credits.

Internship overview: This internship is part of a partnership between the University of Wisconsin-Manitowoc, local community members, and the non-profit groups Lakeshore Natural Resource Partnership (LNRP) and Centerville CARES. LNRP, in conjunction with the Village of Cleveland, is developing a program for rehabilitation of the abandoned millpond within the Centerville Creek watershed and for enhancement of Hika Park. In the late 1800s, a dam was erected in Centerville Creek, creating a mill pond impoundment area. Years of sediment buildup in the millpond have remained since removal of the dam, which has the potential to impede stream flow, create nutrient pollution through runoff, and destroy valuable ecological habitat. In addition, Centerville Creek flows into Lake Michigan at Hika Bay. The beach along Hika Bay is a US EPA BEACH Act monitoring station, and years of monitoring have revealed that Hika suffers from *Cladophora* algae growth and from frequent spikes in *E. coli* bacterial levels. Therefore, restoration of the creek is desirable in order to improve the ecological, aesthetic, and recreational value of the watershed.

In order to develop and assess a restoration and management plan, benchmark data must be collected. These data include biological, physical, and chemical assessments of stream quality. Student interns will be responsible for data collection and analysis on a weekly basis throughout the summer. Data will be recorded manually, uploaded to a public website, and shared with advisors and stakeholders periodically during the sampling period. Following completion of the sampling period, student interns will each be responsible for a public presentation of the project results and a written report that will be submitted to the faculty advisors and representatives of partner groups.

Prerequisites/Assessment: Students participating in the internship must have completed at least 5 credit hours of introductory biology (ZOO 101, BIO 109, or BOT 130) prior to Summer 2011. Student performance will be assessed based on internship participation (communication/time commitment), development of lab and field skills, and completion of specified deliverables at the end of the internship period. Each of these assessment areas will be described on the following pages.

Schedule of Important Dates:

- June 3, 2011: Initial meeting with faculty and community/non-profit representatives (Abler, Hein, Jim Kettler, Russ Tooley)
- June 8, 2011: Training session on laboratory techniques/analysis (Abler, Hein)
- June 13, 2011: Training session on field sampling; *start of field sampling season* (Kettler, Tooley)
- June 13-August 29, 2011: Weekly sampling/analysis; Centerville Creek
- July 5, 2011: Monthly sampling, Fischer and Point Creeks
- August 2, 2011: Monthly sampling, Fischer and Point Creeks
- September/October, 2011: Final report due (written)—*official deadline TBA in consultation with student and advisors*
- November, 2011: Presentation to LNRP/public meeting—*date TBA*

Expectations:

1. Data collection and analysis

Field Work: student will complete the following activities in the field:

- Sampling 7 points along Centerville Creek: Dam Barrier, Midpoint, Confluence, South Branch, North Branch-Franklin Rd., North Branch-Dairyland Dr., North Branch-North Ave/LTC on a weekly basis (Mondays)
- Measurements taken in field: pH, temperature, current speed, nitrogen
- Samples collected for lab analysis: Phosphate, D.O., *E. coli*, Turbidity/Conductivity
- Observational data recorded in field book

Lab Analysis: student will complete the following activities in the lab on a weekly basis

- Measurement of turbidity, dissolved oxygen, phosphate, conductivity (same day as sampling)
- Analysis of *E. coli* levels
- Filing of lab data sheets in research binder
- Updating data spreadsheet
- Sending data/observations to Russ Tooley via email for uploading on Hika Bay website

2. Communication

- Research binder will be up-to-date with all data sheets from each week's collection. All data sheets are to be filled out completely and should be readable by any of the advisors. Any notes should be included on the back of the data sheet
- Field notebook should be kept for each sampling period. Notebook should include all qualitative observations made by the student during sampling, and should be readable by any of the advisors. Notebook guidelines will be provided to the student.
- A spreadsheet for all the data collected will be created and updated weekly by the student.

- The student will send all sampling data (spreadsheet) and a short narrative paragraph summarizing the observations recorded in the field notebook via email to the advisors each week. Russ Tooley will upload the data/observations to the Hika Bay website. These will be sent by the Friday of each sampling week.
- The student will be proactive in seeking any help or assistance needed from any of the advisors/community partners, and will communicate any issues promptly.
- The student will participate in an informal meeting of the Centerville and Beach Research Groups in mid-summer.

3. Time/Travel

- The student will work on a weekly schedule at Centerville Creek: sampling and laboratory work on Mondays, and finishing analysis of *E. coli* levels and updating the paperwork/spreadsheet on Tuesday (with the exception of the week of July 4, when sampling may be done later in the week)
- The student will work with Russ Tooley and community volunteers to take samples from Fischer and Point Creeks on the first Tuesday of each month.
- The student will keep a log of his/her time and mileage each week.

4. Deliverables:

- A formal written report will be produced following the end of sampling, due in September or October, 2011 (date TBA).
- The student will present their results/analysis at a meeting of the public, tentatively scheduled for November, 2011.
- The student will have the opportunity to create a poster for presentation at a state or regional meeting, such as Posters on the Rotunda in spring 2012 (optional, recommended).

Assessment of Performance: Student interns will be assessed on the expectations outlined above. Credits and grades will be assigned by faculty advisors Abler and Hein *in consultation with community partners Kettler and Tooley*.

- Data collection and analysis: 50%, includes the following checkpoints:
  - Data sheets in binder
  - Spreadsheet up to date
  - Field notebook updated weekly
  - Weekly updates to website completed
  - Lab work done neatly and efficiently
  - Student is available and responds to inquiries/requests from advisors and partners in a timely manner
  - Participation in lab meetings, including mid-summer meeting

- Written Report: 25%

- Presentation: 25%

Signature: I have read and commit to the expectations outlined in this syllabus:

____