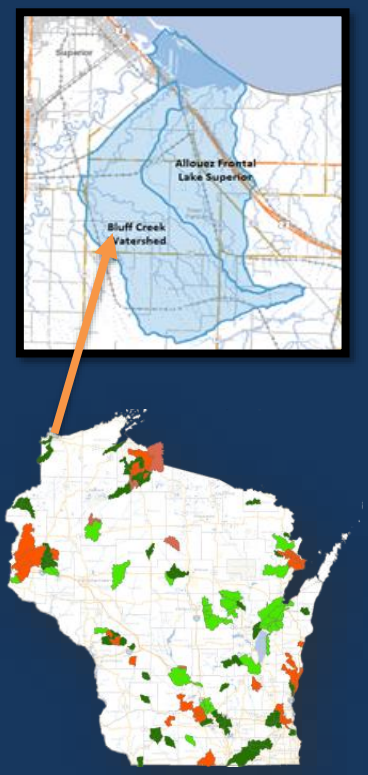
Bear and Bluff Creeks Watershed Assessment: A Water Quality Plan to Restore Wisconsin Watersheds, 2020

A Water Quality Monitoring Report created by the Bureau of Water Quality in support of the Clean Water Act.

St. Louis and Lower Nemadji River Watershed (LS01)
HUC 12 - 040103010504
HUC 12 - 040103010502

Bear Creek near Highway 2/53
Photo by Craig Roesler, North District Water Quality Biologist
Department of Natural Resources



*To learn more about this area, see this **Wisconsin TWA Project Online**!*

***Find** more about these waters, watersheds and projects on Explore Wisconsin's Waters Online !*

EGAD # 3200-2019-11
Water Quality Bureau
Wisconsin DNR

Contents

Figures

Tables

Targeted Watershed Assessment Study Summary

The Bear (Allouez Bay-Frontal Lake Superior) and Bluff Creek watersheds are located in northern Douglas County, Wisconsin (Figure 1). A Targeted Watershed Assessment monitoring project was conducted there to analyze current conditions and to make recommendations for future management actions. The most recent monitoring was conducted during 2018. Previous monitoring data collected from several sites between 2006 and 2013 was also compiled and reviewed. Monitoring included fish surveys, fish habitat evaluations, macroinvertebrate sampling, water quality monitoring, and diatom monitoring. The extent of monitoring varied between sites.

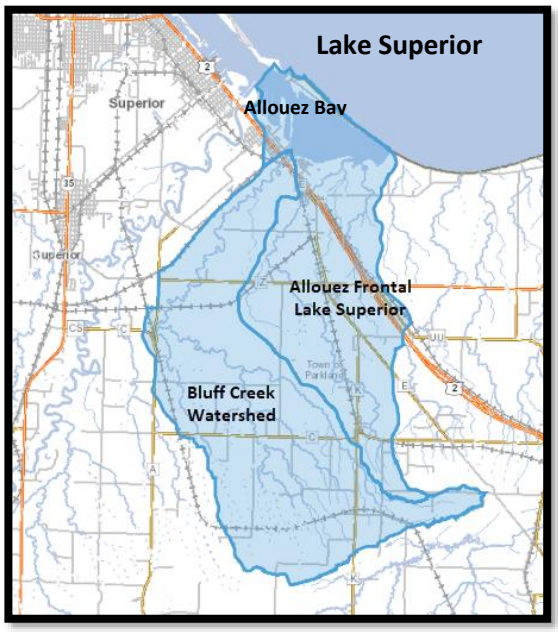


Figure 1. Bear (Allouez Bay-Frontal Lake Superior) and Bluff Creek Watersheds Location

About the Watershed

In the Bluff Creek Watershed forest (48%) is the largest single land use followed by wetlands (35%). In the Bear Creek Watershed, wetlands (53%) is the largest land use percent, followed by forest (15%), open water (12%) and urban (12%). Undeveloped land uses (forest, wetlands, and open water) comprise the majority of both watersheds (78% for Bear Creek and 83% for Bluff Creek). Grassland (pasture and hayfield) is the most widespread agricultural land use (9% for Bear Creek and 14% for Bluff Creek).

Both watersheds are located in the Lake Superior Clay Plain ecoregion. Clay rich soils in the Clay Plain have very low infiltration rates and high runoff rates. This enhances export of nutrients and bacteria from land surfaces. Streambank erosion is a major source of suspended sediment and turbidity to streams in this area. Streams tend to be "flashy" with very low base flows due to little groundwater input, and very high flows during runoff events.

Bear and Bluff Creek drain into Allouez Bay, which is a large shallow, turbid bay in the Saint Louis River Estuary (SLRE). The SLRE is part of a Great Lakes Area of Concern (AOC). The AOC has nine beneficial use impairments (BUI's) listed in the Remedial Action Plan. One of the BUI's is "Excessive Loading of Sediments and Nutrients." Any potential reductions in sediment and nutrient sources in the Bear and Bluff Creek watersheds can contribute to the goals of the AOC.

Biological Communities and Water Quality

Fish communities showed all stream segments had warm transition (cool-water) thermal conditions. Fifteen sites were warm transition headwaters and the two sites closest to the stream mouths were warm transition mainstems. Some gamefish and panfish were present at the mainstem sites but were absent at all headwater sites. The majority of fish at headwater sites were pioneer species which are adept at re-colonizing stream segments with fluctuating habitat availability. Fish index of biotic integrity ratings ranged from poor to excellent, with 16 of 21 surveys rating fair or good.

Qualitative fish habitat ratings from 17 sites all had ratings of fair or good. Ratings were lowered mostly due to bank erosion and an abundance of sand or silt substrate. Macroinvertebrate communities generally indicate good water quality and habitat conditions for macroinvertebrates. Nineteen of 21 samples had macroinvertebrate index of biotic integrity ratings of excellent (n=12) or good (n=7).

Bear and Bluff Creeks are on Wisconsin's impaired waters list due to high total phosphorus concentrations (TP's). The tributaries in these watersheds, including those with minimal subwatershed development, were also found to have high TP's. This suggests that the state stream TP standard of 75 ug/l may not be achievable or appropriate for Clay Plain streams. Total suspended solids concentrations and turbidities are also high in these streams. Sites with larger subwatershed areas have greater total stream channel length, higher flows,more potential for streambank erosion, and higher total suspended solids concentrations and turbidities. Two monitoring sites downstream of areas with concentrations of livestock had relatively high nutrient concentrations. E. coli concentrations were highly variable and couldn't be correlated with land uses. One undeveloped subwatershed with no human or livestock influence had relatively high stream E. coli concentrations, indicating wildlife sources of E. coli can be significant.

Recommendations

- The DNR should work with the Douglas County Land and Water Conservation Department to identify options for reducing phosphorus input to watershed streams. Any barnyards or locations with concentrated livestock in the watershed should be identified and assessed for potential application of runoff controls.
- The DNR should work with the Douglas County Land and Water Conservation Department to identify options for reducing peak flows in the watershed ("Slow the Flow" efforts).
- Douglas County will be taking actions required by July 2000 revisions to the Wisconsin Plumbing Code. Actions required include: an inventory of all private onsite wastewater systems, inspections of systems installed before July 2000, implementation of a maintenance tracking program.
- Actions will be taken over a 3-year period, starting in the southern third of the County and working northward. Systems in the Bear and Bluff Creek watersheds will be addressed in 2021.

Wisconsin Water Quality Monitoring and Planning

This Water Quality Management Plan was created under the state's Water Resources Planning and Monitoring Programs. The plan reflects water quality program priorities and Water Resources Monitoring Strategy 2015-2020 and fulfills Wisconsin's Areawide Water Quality Management Plan requirements under Section 208 of the Clean Water Act. Condition information and resource management recommendations support and guide program priorities for the planning area.

This WQM Plan is approved by the Wisconsin DNR and is a formal update to Lake Superior Basin Areawide Water Quality Management Plan and Wisconsin's statewide Areawide Water Quality Management Plan (AWQM Plan). This plan will be forwarded to USEPA for certification as a formal update to Wisconsin's AWQM Plan.

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Basin/Watershed Partners

Douglas County Land and Water Conservation Department

Report Acknowledgements

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- Lisa Helmuth, Program Coordinator, Water Quality Bureau, Wisconsin DNR

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Abbreviations

AEL: Aquatic Entomology Laboratory at UW – Stevens Point: the primary laboratory for analysis of macroinvertebrate taxonomy in the State of Wisconsin.

BMP: Best Management Practice. A land management practice used to prevent or reduce nonpoint source pollution such as runoff, total suspended solids, or excess nutrients.

DATCP: Wisconsin Department of Agriculture, Trade and Consumer Protection – the state agency in partnership with DNR responsible for a variety of land and water related programs.

DNR: Department of Natural Resources. Wisconsin Department of Natural Resources is an agency of the State of Wisconsin created to preserve, protect, manage, and support natural resources.

END: Endangered Species - Wisconsin species designated as rare or unique due to proximity to the farthest extent of their natural range or due to anthropogenic deleterious impacts on the landscape or both.

ERW: Exceptional Resource Water- Wisconsin's designation under state water quality standards to waters with exceptional quality and which may be provided a higher level of protection through various programs and processes.

FHMD: Fisheries and Habitat Management Database – or Fish Database – the state's repository for fish taxonomy and auto-calculated metrics involving fish assemblage condition and related.

FIBI: Fish Index of biological integrity (Fish IBI). An Index of Biological Integrity (IBI) is a scientific tool used to gauge water condition based on biological data. Results indicate condition and provide insight into potential degradation sources. In Wisconsin, specific fish IBI tools are developed for specific natural communities. Biologists review and confirm the natural community to use the correct fish IBI tool.

HUC: Hydrologic Unit Code. A HUC is a code that represents nested hydrologic watersheds delineated by multiple agencies at the federal and state level including USGS, USFS, and Wisconsin DNR.

MIBI: Macroinvertebrate Index of biological integrity. In Wisconsin, the MIBI, or macroinvertebrate Index of biological integrity, was developed to assess macroinvertebrate community condition.

Monitoring Seq. No.: Monitoring Sequence Number refers to a unique identification code generated by the Surface Water Integrated Monitoring System (SWIMS), which holds much of the state's water quality monitoring data.

MDM: Maximum Daily Averages – maximum daily average is a calculated metric that may be used for temperature, dissolved oxygen and related chemistry parameters to characterize water condition.

NC: Natural Community. A system of categorizing water based on inherent physical, hydrologic, and biological components. Streams and Lakes have uniquely derived systems that result in specific natural community designations for each lake and river segment in the state. These designations dictate the appropriate assessment tools which improves the condition result, reflecting detailed nuances reflecting the modeling and analysis work foundational to the assessment systems.

mg/L: milligrams per liter - a volumetric measure typically used in chemistry analysis characterizations.

NOAA: National Oceanic and Atmospheric Administration – a federal agency responsible for water / aquatic related activities involve the open waters, seas and Great Lakes.

ND: No detection – a term used typically in analytical settings to identify when a parameter or chemical constituent was not present at levels higher than the limit of detection.

NRCS: USDA Natural Resources Conservation Service - the federal agency providing local support and land management outreach work with landowners and partners such as state agencies.

ORW: Outstanding Resource Water- Wisconsin's designation under state water quality standards to waters with outstanding quality and which may be provided a higher level of protection through various programs and processes.

SC: Species of Special Concern- species designated as special concern due to proximity to the farthest extent of their natural range or due to anthropogenic deleterious impacts on the landscape, or both.

SWIMS ID.: Surface Water Integrated Monitoring System (SWIMS) identification number is the unique monitoring station identification number for the location of monitoring data.

TDP: Total Dissolved Phosphorus – an analyzed chemistry parameter collected in aquatic systems positively correlated with excess productivity and eutrophication in Wisconsin waters.

TMDL: Total Maximum Daily Load – a technical report required for impaired waters Clean Water Act. TMDLs identify sources, sinks and impairments associated with the pollutant causing documented impairments.

TP: Total Phosphorus - an analyzed chemical parameter collected in aquatic systems frequently positively correlated with excess productivity and eutrophication in many of Wisconsin's waters.

TWA: Targeted Watershed Assessment. A monitoring study design centered on catchments or watersheds that uses a blend of geometric study design and targeted site selection to gather baseline data and additional collection work for unique and site-specific concerns for complex environmental questions including effectiveness monitoring of management actions, evaluation surveys for site specific criteria or permits, protection projects, and generalized watershed planning studies.

TSS: Total suspended solids – an analyzed physical parameter collected in aquatic systems that is frequently positively correlated with excess productivity, reduced water clarity, reduced dissolved oxygen and degraded biological communities.

WATERS ID.: The Waterbody Assessment, Tracking, and Electronic Reporting System Identification Code. The WATERS ID is a unique numerical sequence number assigned by the WATERS system, also known as "Assessment Unit ID code." This code is used to identify unique stream segments or lakes assessed and stored in the WATERS system.

WBIC: Water Body Identification Code. WDNR's uniqe identification codes assigned to water features in the state. The lines and information allow the user to execute spatial and tabular queries about the data, make maps, and perform flow analysis and network traces.

WSLH: Wisconsin State Laboratory of Hygiene– the state's certified laboratory that provides a wide range of analytical services including toxicology, chemistry, and data sharing.

WQC: Water quality criteria – a component of Wisconsin's water quality standards that provide numerical endpoints for specific chemical, physical, and biological constituents.

Bear Creek at Highway 2/53, moderately low flow with exposed perched culvert. Photo by Craig Roesler, October 2018.

Bluff Creek Bank Erosion Near City Limits Road. Photo by Craig Roesler, October 2018

WQM Plan Goals

The overall goal of this plan is to identify water quality conditions and work to improve and protect water quality in the Bear and Bluff Creek Watersheds of the Lake Superior Basin. This Targeted Watershed Assessment project funded the collection of data to monitor chemistry, biological and habitat data for analyzing current conditions. This plan presents results, identifies concerns in the area found during the project, and presents recommendations to improve or protect water quality consistent with Clean Water Act guidelines and state water quality standards.

Resources Overview

Location and Size

The Bluff Creek Watershed (HUC12 040103010502) has an area of 50.6 km^2 or 19.5 mi^2 and drains to Allouez Bay (Figure 2). The Bear Creek Watershed (Allouez Bay-Frontal Lake Superior) (HUC12 040103010504) is 39.1 km^2 or 15.1 mi^2 and includes Allouez Bay. Both HUC12s are located with the St. Louis and Lower Nemadji River Watershed (Figure 2), all of which are are located in northern Douglas County.

Land Use, Population

Land use percentages from WiscLand2 (2016) for the Bluff Creek and the Bear Creek (Allouez Bay-Frontal Lake Superior) Watersheds are shown in Figures 3 and 4. Distribution of land uses is shown in Figure 5. In the Bluff Creek Watershed forest (48%) is the largest single land use followed by wetlands (35%); in the Bear Creek Watershed, wetlands (53%) is the largest land use percent, followed by forest (15%), open water (12%) and urban (12%). Undeveloped land uses (forest, wetlands, and open water) comprise the majority of both watersheds (78% for Bear Creek and 83% for Bluff Creek). Grassland (pasture and hayfield) is the most widespread agricultural land use (9% for Bear Creek and 14% for Bluff Creek).

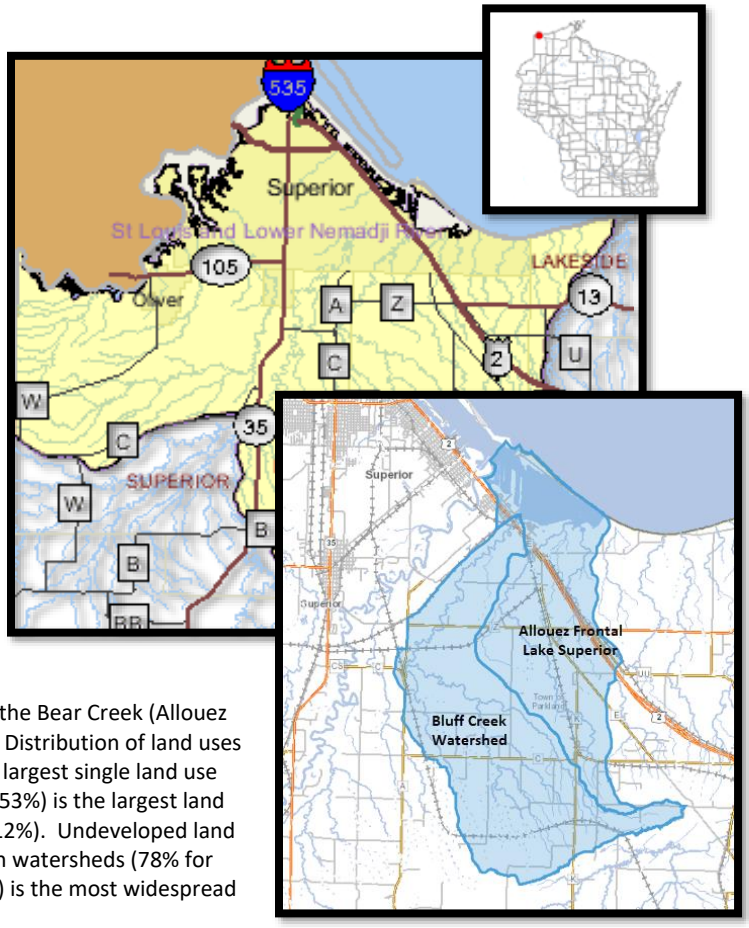


Figure 2. Bluff Creek Watershed and Allouez Bay- Frontal Lake Superior (Bear Creek) Watersheds and the larger St. Louis and Lower Nemadji River Watershed (LS01)

Figure 3. Bluff Creek Watershed Land Use Percentages

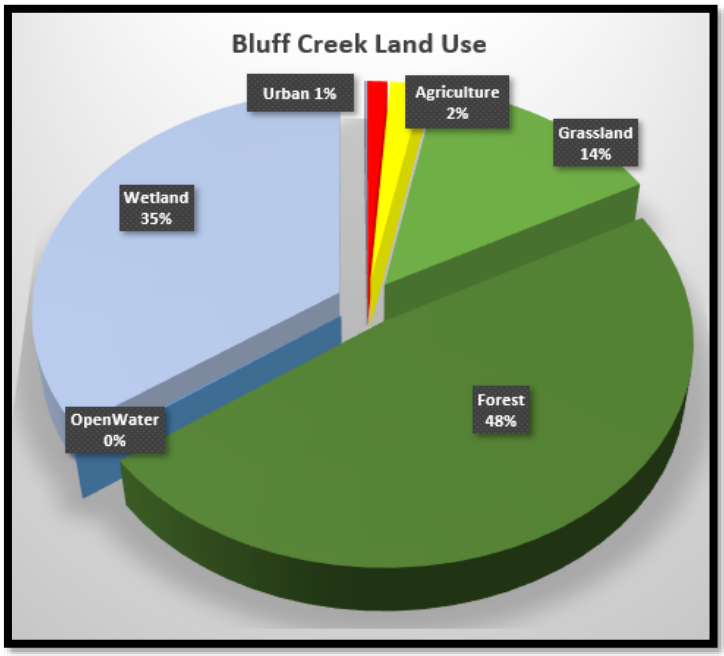


Figure 4. Bear Creek (Allouez Bay-Frontal Lake Superior) Watershed Land Use Percentages

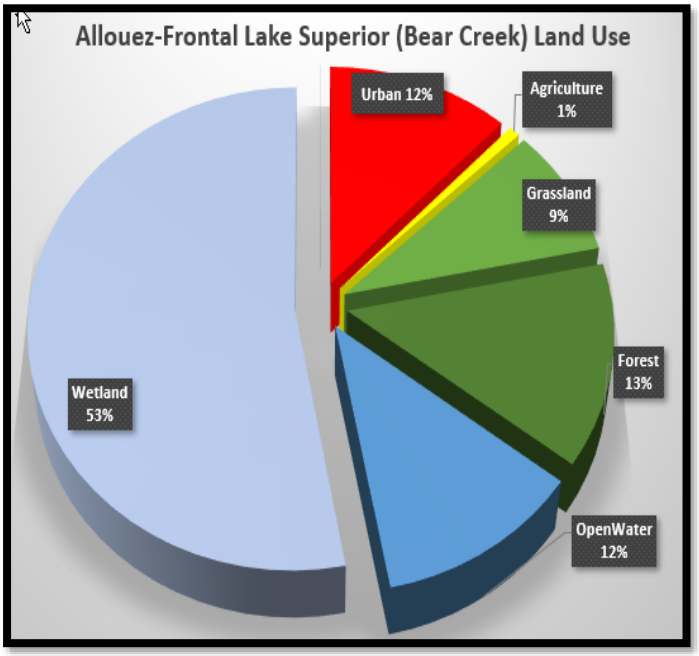
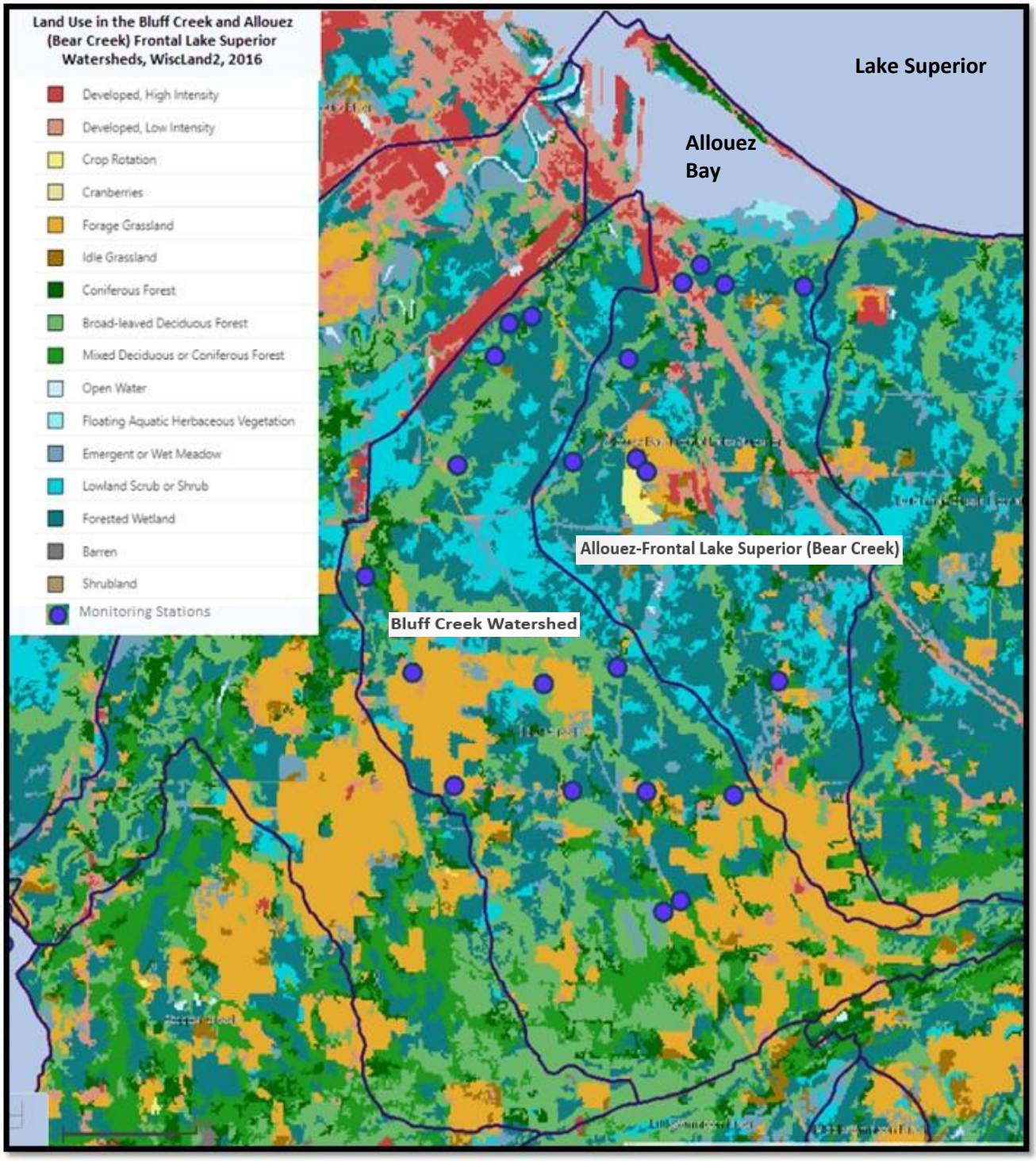


Figure 5. Bear Creek (Allouez Bay-Frontal Lake Superior) and Bluff Creek Watersheds Land Use (WisLand2, 2016)



The population of the Bluff Creek watershed is estimated at 681 people, based on the population density in the Town of Parkland. The population of the monitored portion of the Bear Creek watershed is estimated at 464 people. There is an additional unestimated population in the Bear Creek watershed in the City of Superior on the southwest side of Allouez Bay. However, none of the monitoring sites were influenced by this area. The remainder of the City of Superior, with a total population of 27,244 (2010), is located immediately to the northwest of the two watersheds.

Ecological Landscapes

Both watersheds are located in the Lake Superior Clay Plain ecoregion (Figure 6). Clay rich soils in the Clay Plain have very low infiltration rates and high runoff potential. This enhances export of nutrients and bacteria from land surfaces.

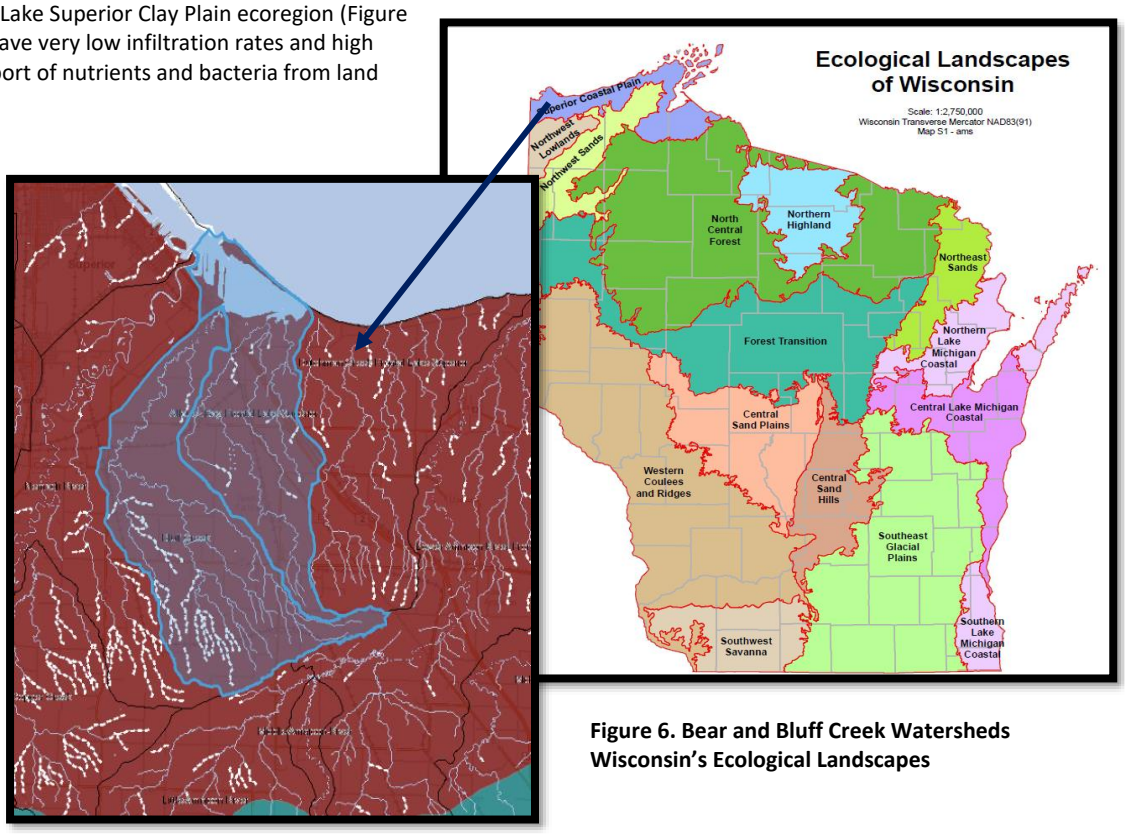


Figure 6. Bear and Bluff Creek Watersheds Wisconsin's Ecological Landscapes

Hydrology

Bear and Bluff Creeks flow into Allouez Bay, which is a large, shallow, turbid bay in the Saint Louis River Estuary (SLRE). Allouez Bay flows into Lake Superior. The SLRE is a Great Lakes Area of Concern (AOC). The AOC has nine beneficial use impairments (BUI's) listed in the Remedial Action Plan. One of the BUI's is "Excessive Loading of Sediments and Nutrients". Any potential reductions in sediment and nutrient sources in the Bear and Bluff Creek watersheds can contribute to the goals of the AOC. The clay-rich soils result in "flashy" stream flows with very high flows during runoff events and very low baseflows.

Soils

Soils in the watershed contain high amounts of clay and scattered subsurface bands of sand. There is little infiltration of precipitation or snowmelt which results in little groundwater input to streams and high runoff rates. Land development that reduces vegetative cover further increases runoff rates. Stream flows rise rapidly during runoff events. The soils also have poor stability as stream banks. Even fully vegetated stream banks are subject to slumping and severe erosion (see Bluff Creek photo, p. 7).

Streambank erosion is a major source of suspended sediment and turbidity to streams in this area.

Bear Creek at Highway 2/53 during high flow, October 2017

Trout Waters

DNR classifies trout streams throughout the state. Class I are naturally reproducing populations; class II are supplemented by stocking, and class III are exclusively supported by stocking. There are no trout waters in the Bear and Bluff Creek watersheds. Appendix D lists trout waters in the larger St. Louis and Lower Nemadji River watershed.

Outstanding and Exceptional Resource Waters

Wisconsin designates the highest quality waters as Outstanding Resource Waters (ORWs) or Exceptional Resource Waters (ERWs), these are surface waters that provide outstanding recreational opportunities, support valuable fisheries and wildlife habitat, have good water quality, and are not significantly impacted by human activities. There are no ORW or ERW waters in the Bear and Bluff Creek watersheds. There are two ERW waters in the larger St. Louis and Lower Nemadji River watershed – Red River (WBIC 2845800), and an unnamed tributary to Copper Creek (WBIC 2836700). These streams are identified as class I trout waters.

Impaired Waters

Section 303(d) of the Clean Water Act requires states to publish a list of waters that do not meet water quality standards. Bear Creek and Bluff Creek are on the Impaired Waters List for high total phosphorus concentrations (> the 75 ug/l Wisconsin stream standard). Monthly samples from May-October 2015 documented these high concentrations. Birch Creek, a tributary of Bluff Creek is on the Impaired Waters List due to a degraded biological community (fish index of biotic integrity ratings of poor). Impaired waters in the larger St. Louis and Lower Nemadji River watershed are listed in Appendix D (see footnotes).

Monitoring Project Discussion

Purpose of TWA Project

The Bear and Bluff Creek Targeted Watershed Assessment was designed to assess the overall chemical, physical and biological condition of the waters in the Bear and Bluff Creek watersheds (Figure 7).

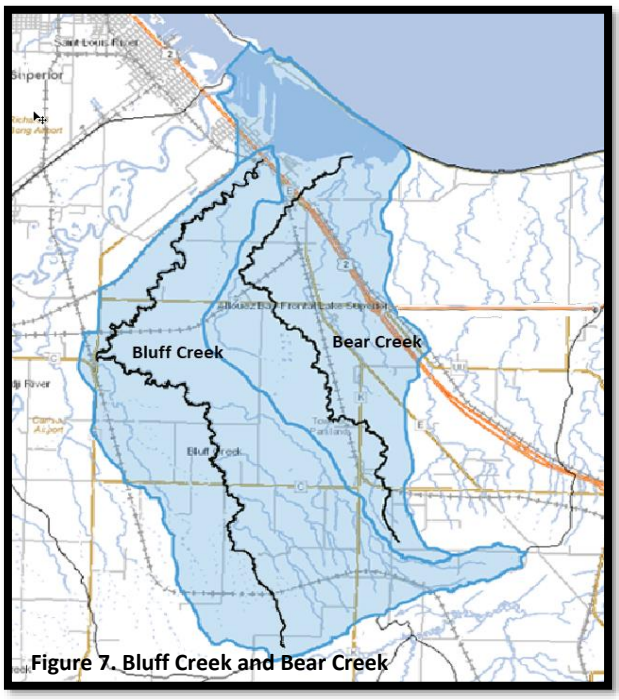


Figure 7. Bluff Creek and Bear Creek

Site Selection and Study Design

This study collected fish community, macroinvertebrate, diatom, water chemistry, and qualitative habitat data at multiple sites in the Bear and Bluff Creek watersheds (Monitoring data for the Allouez Bay portion of the Bear Creek watershed is available in Roesler et al. 2018). During 2018, five sites were monitored for fish communities and qualitative habitat and two sites were monitored for diatoms. Also, during 2018, seven sites in the Bluff Creek watershed and five sites in the Bear Creek watershed (Table 1) were monitored on six dates for water quality parameters (temperature, dissolved oxygen, pH, conductivity, turbidity, transparency, total phosphorus, total nitrogen, total suspended solids, and E. coli). Monitoring dates were selected to provide three dates with low flow rates, and three dates with higher flow rates. Sites were selected to represent a range of developed land uses in the subwatershed.

In addition to monitoring during 2018, monitoring data from recent previous years was compiled and reviewed. During 2006-2012 thirteen sites were monitored for various monitoring components (fish communities, 12 sites; macroinvertebrates, 11 sites; qualitative habitat, 6 sites; multi-date water quality, 4 sites) (Table 1). Monitoring site locations are shown in Figure 8.

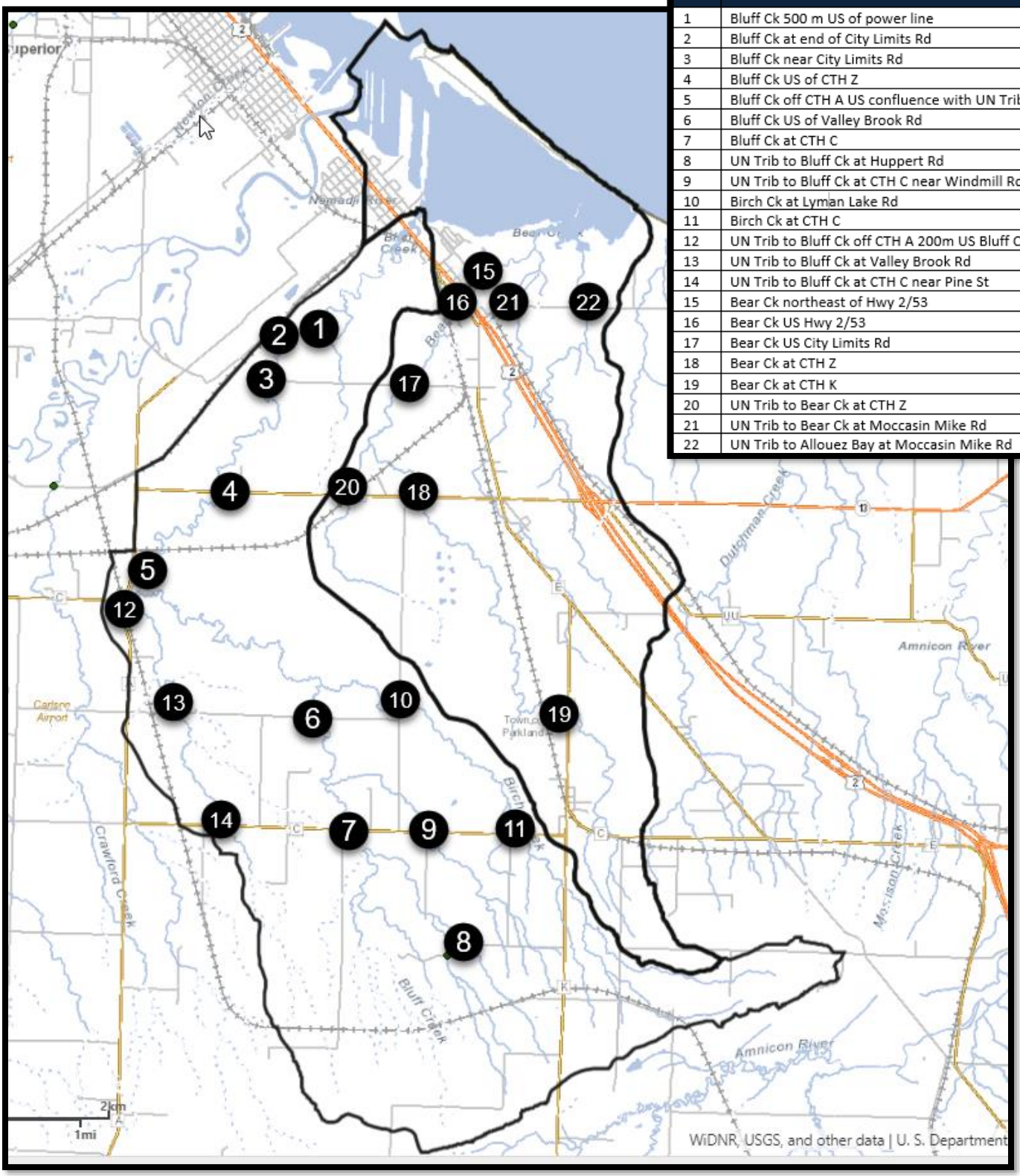
2006-2018 monitoring data assessed included:

- Fish community surveys at 17 sites. Water chemistry, habitat, and flow data were collected at the time of most fish surveys. Water chemistry parameters measured were total phosphorus, total Kjeldahl nitrogen, ammonia nitrogen, nitrate plus nitrite nitrogen, total suspended solids, dissolved oxygen, pH, temperature, conductivity, turbidity, and transparency.
- Qualitative habitat assessments at 11 sites.
- Macroinvertebrate samples at 11 sites.
- Diatoms samples from 2 sites.
- Multi-date water chemistry samples at 5 sites during 2006-2012. Parameters included temperature, dissolved oxygen, pH, conductivity, turbidity, transparency, total phosphorus, dissolved phosphorus, total Kjeldahl nitrogen, ammonia-nitrogen, nitrate plus nitrite-nitrogen, and total suspended solids.
- Water chemistry sampling at 12 sites on six dates during 2018. Parameters tested are listed above.

Table 1. Bear and Bluff Creek Watersheds Monitoring Stations and Data Collection

						Monitoring Component / Year				
Map Site No.	Site Description	WBIC	SWIMS station	Latitude	Longitude	Fish	Macro-invertebrates	Quali-tative Habitat	Water Quality	Diatoms
1	Bluff Ck 500 m US of power line	2833200	10030045	46.6678	-92.0348	2009	2009, 2010	2009		
2	Bluff Ck at end of City Limits Rd	2833200	10031958	46.6668	-92.0392	2010		2010		
3	Bluff Ck near City Limits Rd	2833200	10040432	46.6623	-92.04192	2018		2018	2018	2018
4	Bluff Ck US of CTH Z	2833200	10015462	46.6475	-92.0488	2006, 2009	2009 (2), 2010		2009,2010, 2012	
5	Bluff Ck off CTH A US confluence with UN Trib	2833200	10030049	46.6345	-92.0657	2010	2009,2010			
6	Bluff Ck US of Valley Brook Rd	2833200	10015463	46.6184	-92.0306	2006, 2009	2009,2010(2)		2009,2010	
7	Bluff Ck at CTH C	2833200	163231	46.604	-92.02436				2018	
8	UN Trib to Bluff Ck at Huppert Rd	2834200	10051098	46.5898	-92.00227				2018	
9	UN Trib to Bluff Ck at CTH C near Windmill Rd	2833900	10050950	46.6043	-92.00959				2018	
10	Birch Ck at Lyman Lake Rd	2833500	10032011	46.6209	-92.016		2010			
11	Birch Ck at CTH C	2833500	10017177	46.6041	-91.99218				2018	
12	UN Trib to Bluff Ck off CTH A 200m US Bluff Ck	2833400	10030050	46.6322	-92.0666	2009				
13	UN Trib to Bluff Ck at Valley Brook Rd	2833400	10040736	46.619	-92.05661				2018	
14	UN Trib to Bluff Ck at CTH C near Pine St	2833400	10050949	46.6044	-92.04785				2018	
15	Bear Ck northeast of Hwy 2/53	2834600	10029779	46.6753	-92.00140	2018		2018	2010,2012	
16	Bear Ck US Hwy 2/53	2834600	10048234	46.673	-92.00492				2018	2018
17	Bear Ck US City Limits Rd	2834600	10015470	46.662	-92.0155	2006, 2009	2009(2),2010	2009	2009,2010	
18	Bear Ck at CTH Z	2834600	10038884,10030049	46.6476,	-92.01120	2009	2009, 2010		2009,2010, 2018	
19	Bear Ck at CTH K	2834600	10050952	46.6196	-91.98386				2018	
20	UN Trib to Bear Ck at CTH Z	2834800	10030043	46.6477	-92.02550	2018		2018	2018	
21	UN Trib to Bear Ck at Moccasin Mike Rd	2834700	10050953	46.6726	-91.99655	2018		2018	2018	
22	UN Trib to Allouez Bay at Moccasin Mike Rd	2835100	10048235	46.6728	-91.98075	2018		2018		

Figure 8. Bear and Bluff Creek Watersheds Monitoring Sites



Map Site No.	Site Description
1	Bluff Ck 500 m US of power line
2	Bluff Ck at end of City Limits Rd
3	Bluff Ck near City Limits Rd
4	Bluff Ck US of CTH Z
5	Bluff Ck off CTH A US confluence with UN Trib
6	Bluff Ck US of Valley Brook Rd
7	Bluff Ck at CTH C
8	UN Trib to Bluff Ck at Huppert Rd
9	UN Trib to Bluff Ck at CTH C near Windmill Rd
10	Birch Ck at Lyman Lake Rd
11	Birch Ck at CTH C
12	UN Trib to Bluff Ck off CTH A 200m US Bluff Ck
13	UN Trib to Bluff Ck at Valley Brook Rd
14	UN Trib to Bluff Ck at CTH C near Pine St
15	Bear Ck northeast of Hwy 2/53
16	Bear Ck US Hwy 2/53
17	Bear Ck US City Limits Rd
18	Bear Ck at CTH Z
19	Bear Ck at CTH K
20	UN Trib to Bear Ck at CTH Z
21	UN Trib to Bear Ck at Moccasin Mike Rd
22	UN Trib to Allouez Bay at Moccasin Mike Rd

Methods, Equipment, and Quality Assurance

Fish Assemblage and Natural Community

Fish surveys were conducted by electroshocking a section of stream with a station length of 35 times the mean stream width (100 m minimum and 400 m maximum station length) (Lyons, 1992). One or two backpack shockers were used, depending on mean stream width. One shocker was used where mean stream width was < 3 m, and two shockers were used where mean stream width was > 3 m. All fish were collected, identified, and counted. Surveys were conducted using the following methods:

- Wadeable Stream Fish Community Evaluation Form 3600-230 (R 7/00)
- Guidelines for Assessing Fish Communities of Wadeable Streams in Wisconsin

Fish Habitat Evaluation

Qualitative fish habitat ratings were determined at the time of most fish surveys. Ratings are based on estimates of stream characteristics including riparian buffer width, bank erosion, pool area, width to depth ratio, riffle:riffle or bend:bend ratio, fine sediment substrate, and fish cover.Methods used were:

- Guidelines for Qualitative Physical Habitat Evaluation of Wadeable Streams
- Wadeable Stream Qualitative Fish Habitat Rating for Streams Less than 10m Wide Form (3600-532A) (R 6/07)

Macroinvertebrate Evaluation

Macroinvertebrate samples were obtained by kick sampling using a D-frame net in gravelly or cobbly riffles. Samples were preserved and sent to the University of Wisconsin-Stevens Point for analyses. Standard metrics were calculated for the macroinvertebrate communities found. Field methods used were:

- Guidelines for Collecting Macroinvertebrate Samples in Wadeable Streams
- Wadeable Macroinvertebrate Field Data Report Form 3200-081 (R 08/14)

Water Quality Monitoring

During 2018, stream grab samples were collected directly in sample bottles for analyses of lab parameters. Samples were acidified, as needed, and kept on ice in the field. Water samples were shipped on ice to the State Laboratory of Hygiene where they were analyzed for total phosphorus, total nitrogen, and total suspended solids. Additional samples were kept on ice and hand delivered to the Lake Superior Research Institute at UW-Superior where they were analyzed for E. coli.

A YSI ProDSS multiparameter meter was used to measure dissolved oxygen, pH, temperature, conductivity, and turbidity. The meter was calibrated daily for dissolved oxygen and pH, and monthly for conductivity and turbidity. Transparency was measured with a 120 cm transparency tube.

Water chemistry samples were also collected and a flow measurement was made at the time of each 2018 fish survey. Parameters measured were total phosphorus, total Kjeldahl nitrogen, ammonia nitrogen, nitrate plus nitrite nitrogen, total suspended solids, dissolved oxygen, pH, temperature, conductivity, turbidity, and transparency. Methods used were the same as above.

Multi-date water samples were collected at five sites prior to 2018 (Table 2). The frequency of sampling was variable. Parameters measured are listed above. Additional methods documentation can be found at:

- Guidelines and Procedures for Surface Water Grab Sampling (Dec. 2005 Version 3)
- Guidance for Flow Monitoring Wadeable Streams (v1.0) 2016
- Guidance for Dissolved Oxygen Meter Sampling

Diatom Sampling

Diatom samples were collected at two sites during 2018. However, diatom results are not yet available to present in this report. Diatom sampling protocols are described in the document below.

- *Diatom Collections for Calculation of the Diatom Nutrient Index (DNI) WQ Monitoring 2016 SOP v2.3*

Project Results and Discussion

Fish Assemblage

Fish survey data is summarized in Tables 2, 3 and 4. Fish species identified at each site are enumerated. The expected modeled Natural Community and the verified Natural Community based on the existing fish populations are also listed.

Pioneer fish species (creek chub, central mudminnow, fathead minnow, johnny darter, and brook stickleback) comprise the majority (54 – 100%) of the fish populations at 17 of the 18 headwater sites and comprise 48% of the population at one of the headwater sites. Pioneer fish are adept at re-colonizing stream segments with fluctuating habitat availability. Habitat availability fluctuations in headwater stream segments probably result from summer base flows periodically becoming zero and stream water freezing to the bottom at some sites during winter base flow. Flash flooding during runoff events also contributes to habitat instability.

Creek chubs were the most abundant fish species in 12 of the 18 headwater surveys. Brook stickleback and central mudminnow each were the most abundant fish species in 3 headwater surveys.

Sport fish (gamefish and panfish) were absent at all headwater survey sites. Several species of sport fish (walleye, northern pike, yellow perch, black crappie, bluegill, rock bass) were present at the two mainstem sites. Since fish surveys are done in mid-summer, fish species that make spring spawning runs are generally not well represented.

Bluff Ck Tributary at Valley Rd 10-31-18, Photo by Craig Roesler, WDNR.

Fish Communities

The verified Natural Communities (Lyons 2013) for most sites are warm transition headwaters. The two sites closest to the stream mouths (Bear Creek northeast of Hwy 2/53, and Bluff Creek 500 m upstream of powerline) are warm transition mainstems. The modeled Natural Communities (Lyons 2008) for all sites were colder than what was verified. The model is probably over-estimating groundwater discharge to streams in this area.

Fish Condition

Fish Index of Biotic Integrity (IBI) ratings, based on the verified natural community and the species present, (Lyons 2006, 2012) ranged from poor to excellent, with 16 of the 21 surveys rating fair or good (Tables 2, 3, 4, and Figure 9). Four surveys produced poor ratings. The three headwater sites with a poor survey rating all had second surveys that produced fair or good ratings. The poor survey rating produced at a mainstem site (Bluff Creek 500 m upstream of powerline) requires some additional consideration. Base flows at this site are much lower than a typical mainstem. The site is also close to the stream mouth at Allouez Bay, so bay fish populations can have influence. The cool-warm transition IBI scoring system may not be fully applicable to these circumstances.

Bluff Creek During High Flow Near City Limits Road 10-3-17. Photo by Craig Roesler, WDNR.

Table 2. Bear and Bluff Creek 2018 Fish Survey Data Summary

Fish Species	Unnamed trib to Bear Creek at CTH Z 10030043 6/27/2018	Bluff Creek Near City Limits rd 10031958 7/9/2018	Bear Creek northeast of Hwy 2/53 10029779 7/6/2018	Unnamed trib to Bear Creek at Moccasin Mike Rd 10050953 6/27/2018	Unnamed trib to Allouez Bay at Moccasin Mike Rd 10048235 6/27/2018	Fish Tolerance Rating
brassy minnow	42		2			intermediate
brook stickleback	3		1	3	19	tolerant
central mudminnow	17	9	2	12	48	tolerant
common shiner	15	47	54	8		intermediate
creek chub	62	151	42	27	58	tolerant
fat head minnow	41		2	4	5	tolerant
fantail darter			1			intermediate
johnny darter		4	3			intermediate
lake chub			1			intermediate
log perch		4	7			intermediate
northern pike			2			intermediate
pearl dace		2		2		intermediate
rockbass			6			intolerant
trout perch		13	23	3		intermediate
white sucker	4	36	37	16	14	tolerant
yellow perch			2			intermediate
Verified Natural Community	Warm Transition Headwater	Warm Transition Headwater	Warm Transition Mainstem	Warm Transition Headwater	Warm Transition Headwater	
Modeled Natural Community	Cold Transition Headwater	Cold Transition Headwater	Cold Transition Headwater	Cold Transition Headwater	Cold Transition Headwater	
Small Stream IBI score	80	70		70	40	
Cool-Warm Transition IBI Score			80			
IBI Rating	good	good	excellent	good	fair	
%Tolerant Individuals	67	74	45	83	100	
Qualifier						
Total Species	7	8	15	8	5	
Total Fish	184	266	185	75	144	

Condition (Rating) Categories for Small Stream Fish Index of Biotic Integrity (fIBI)	
fIBI	Condition
91-100	excellent
61-90	good
31-60	fair
0-30	poor

Condition (Rating) Categories for Cool-Warm Mainstem Fish Index of Biotic Integrity (fIBI)	
fIBI	Condition
61-100	excellent
41-60	good
21-40	fair
0-20	poor

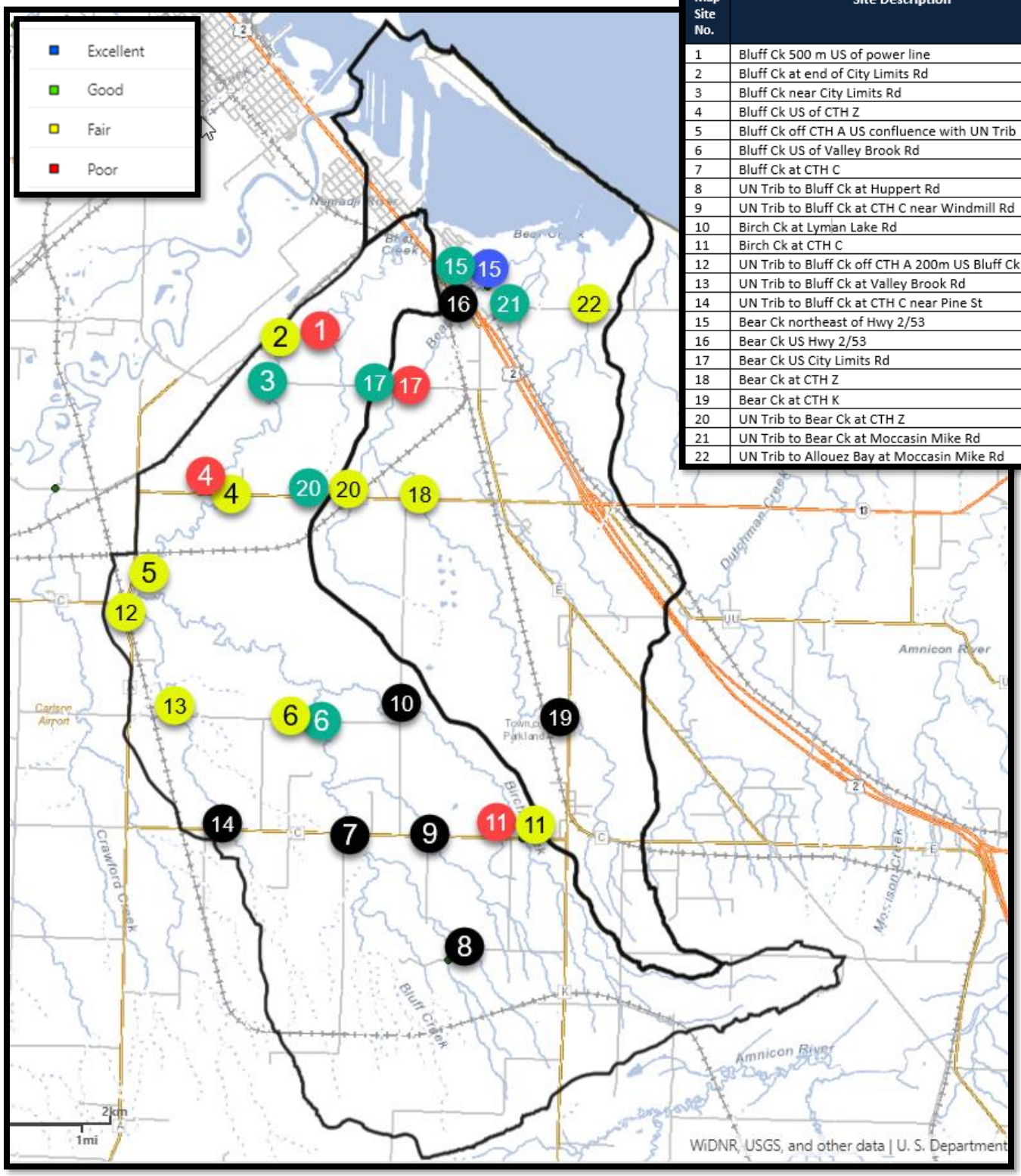
Table 3. Summary of Pre-2018 Fish Surveys for the Bluff Creek Watershed

	Bluff Ck 500 m above Powerline	Bluff Ck at end of City Limits Rd	Bluff Ck upstream of CTH Z		Unnamed trib to Bluff Ck 200 m above confluence, off CTH A	Bluff Ck off CTH A, upstream of confluence with unnamed trib	Birch Ck Trib at CTH C		Bluff Ck upstream of Valley Brook Rd		Unnamed trib to Bluff Ck at Valley Broook Rd	Fish Tolerance Rating
	10030045	10031958	10015462		10030050	10030049	10017177		10015463		10040736	
Fish Species	6/24/2009	9/28/2010	7/17/2006	6/17/2009	7/31/2009	9/23/2010	6/28/2006	6/17/2009	6/27/2006	6/17/2009	6/27/2013	
black bullhead						28						tolerant
brassy minnow		3										intermediate
brook stickleback	1	1	3	2	26	13	23	6		15	1	tolerant
central mudminnow	5	5	7	7	28	44	8	6	18	29	78	tolerant
common shiner	17	24		48		30				19	1	intermediate
creek chub	22	121	94	157	16	61	6	2	24	66	1	tolerant
fat head minnow	6	5		9	45	10	2		1	25	12	tolerant
johnny darter			1	5		1						intermediate
lake chub	6			1								intermediate
northern pike	2											intermediate
pearl dace									3			intermediate
pumpkinseed	1											intermediate
walleye	1											intermediate
white sucker	63	39	34	87	25	21			10	125	1	tolerant
Verified Natural Community	Warm Transition Mainstem	Warm Transition Headwater	Warm Transition Headwater		Warm Transition Headwater	Warm Transition Headwater	Warm Transition Headwater		Warm Transition Headwater		Warm Transition Headwater	
Modeled Natural Community	Cold Transition Headwater	Cold Transition Headwater	Cold Transition Headwater		Cold Transition Headwater	Cold Transition Headwater	Coldwater		Coldwater		Coldwater	
Small Stream IBI score		60	20	60	40	60	40	20	40	70	50	
Cool-Warm Transition IBI score	20											
IBI Rating	poor	fair	poor	fair	fair	fair	fair	poor	fair	good	fair	
%Tolerant Individuals	78.2	86.4	99.3	82.4	100	85	100	100	95	93	99	
Qualifier								<25 fish				
Total Species	10	7	5	8	5	8	4	3	5	6	6	
Total Fish	124	198	139	316	140	208	39	20	56	279	94	

Table 4. Summary of Pre-2018 Fish Surveys for the Bear Creek Watershed

	Bear Ck northeast of Hwy 2/53	Bear Ck upstream of City Limits Rd		Bear Ck at CTH Z	Unnamed Trib to Bear Ck downstream of CTH Z	Fish Tolerance Rating
	10029779	10015470		10029778	10030043	
Fish Species	9/10/2010	7/17/2006	6/17/2009	6/16/2009	6/16/2009	
black bullhead	2					tolerant
black crappie	7					intermediate
bluegill	35					intermediate
brassy minnow	5		24	3	3	intermediate
brook stickleback			6	39	50	tolerant
central mudminnow	45	11	7	64	11	tolerant
common shiner	42		19			intermediate
creek chub	85	5	124	20	30	tolerant
fat head minnow	1	3	25	13	7	tolerant
golden shiner	2					tolerant
horny head chub	1					intermediate
johnny darter	8					intermediate
log perch	10					intermediate
white sucker		16	89			tolerant
yellow perch	1					intermediate
Verified Natural Community	Warm Transition Mainstem	Warm Transition Headwater		Warm Transition Headwater	Warm Transition Headwater	
Modeled Natural Community	Cold Transition Headwater	Cold Transition Headwater	Cold Transition Headwater	Cold Transition Headwater	Cold Transition Headwater	
Small Stream IBI score		20	70	60	60	
Cool-Warm Transition IBI score	60					
IBI Rating	good	poor	good	fair	fair	
%Tolerant Individuals	65	100	91.8	97.8	97.0	
Qualifier						
Total Species	13	4		5	5	
Total Fish	312	35	294	139	101	

Figure 9. Bear and Bluff Creek Watersheds, Fish Index of Biotic Integrity (fIBI) Conditions



Map Site No.	Site Description
1	Bluff Ck 500 m US of power line
2	Bluff Ck at end of City Limits Rd
3	Bluff Ck near City Limits Rd
4	Bluff Ck US of CTH Z
5	Bluff Ck off CTH A US confluence with UN Trib
6	Bluff Ck US of Valley Brook Rd
7	Bluff Ck at CTH C
8	UN Trib to Bluff Ck at Huppert Rd
9	UN Trib to Bluff Ck at CTH C near Windmill Rd
10	Birch Ck at Lyman Lake Rd
11	Birch Ck at CTH C
12	UN Trib to Bluff Ck off CTH A 200m US Bluff Ck
13	UN Trib to Bluff Ck at Valley Brook Rd
14	UN Trib to Bluff Ck at CTH C near Pine St
15	Bear Ck northeast of Hwy 2/53
16	Bear Ck US Hwy 2/53
17	Bear Ck US City Limits Rd
18	Bear Ck at CTH Z
19	Bear Ck at CTH K
20	UN Trib to Bear Ck at CTH Z
21	UN Trib to Bear Ck at Moccasin Mike Rd
22	UN Trib to Allouez Bay at Moccasin Mike Rd

Qualitative Fish Habitat Ratings

Qualitative fish habitat ratings for seven Bear Creek watershed sites and nine Bluff Creek watershed sites are shown in tables 5 and 6. All sites have fair or good ratings. Ratings were lowered mostly by bank erosion which was moderate to extensive at most sites, and the abundance of fine sediment, with most sites having >60% of the stream bed covered with sand or silt.

Table 5. Qualitative Fish Habitat Ratings for Bear Creek Watershed Streams (< 10 m Wide)

	Stream Site							
Rating Item (maximum potential score)	Bear Creek northeast of Hwy 2/53 (2018)	Bear Creek northeast of Hwy 2/53 (2010)	Bear Ck at CTH Z	Bear Ck upstream of City Limits Rd	Unnamed trib to Bear Ck downstream of CTH Z	Unnamed trib to Bear Ck downstream of CTH Z	Bear Creek northeast of Hwy 2/53	Unnamed trib to Allouez Bay at Moccasin Mike Rd
Station ID	10029779	10029779	10029778	10015470	10030043	10030043	10050953	10048235
riparian buffer width (15)	15	15	5	15	15	15	15	15
Bank Erosion (15)	5	5	10	0	5	10	5	5
Pool Area (10)	7	0	3	3	3	7	7	10
Width/ Depth Ratio (15)	10	10	15	10	10	10	10	10
Riffle:Riffle or Bend:Bend Ratio (15)	10	10	5	10	10	10	10	15
Fine Sediments (15)	10	0	0	0	0	0	0	0
Cover for Fish (15)	10	5	10	5	5	5	15	15
Total Score	67	45	48	43	48	57	62	70
Rating	good	fair	fair	fair	fair	good	good	good

Table 6. Qualitative Fish Habitat Ratings for Bluff Creek Watershed Streams (< 10 m Wide)

	Stream Site										
Rating Item (maximum potential score)	Bluff Ck 500 m above powerline	Bluff Ck at end of City Limits Rd	Bluff Creek near City Limits Rd	Bluff Ck upstream of Valley Brook Rd (2008)	Bluff Ck upstream of Valley Brook Rd (2010)	Bluff Ck upstream of CTH Z	Bluff Ck off CTH A, upstream of confluence with unnamed trib (2009)	Bluff Ck off CTH A, upstream of confluence with unnamed trib (2010)	Unnamed trib to Bluff Ck 200 m above confluence, off CTH A	Unnamed Trib to Bluff Ck at Valley Brook Rd	Birch Creek at CTH C
Station ID #	10030045	10031958	10040432	10015463	10015463	10015462	10030049	10030049	10030050	10040736	10017177
riparian buffer width (15)	15	15	15	10	10	15	15	15	10	15	15
Bank Erosion (15)	0	0	5	15	5	0	0	5	5	5	0
Pool Area (10)	7	0	7	3	0	3	3	0	0	3	3
Width/ Depth Ratio (15)	10	10	5	5	15	10	10	15	5	10	10
Riffle:Riffle or Bend:Bend Ratio (15)	10	0	5	5	0	5	5	5	10	5	5
Fine Sediments (15)	0	0	0	0	0	0	0	0	0	0	5
Cover for Fish (15)	10	5	10	5	10	10	5	5	0	5	10
Total Score	52	30	47	43	40	43	38	45	30	43	48
Rating	good	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair

Condition (Rating) Categories for Qualitative Habitat (Stream Width < 10 m)	
Score	Condition
>75	excellent
50-75	good
25-49	fair
< 25	poor

Macroinvertebrate Data

Macroinvertebrate sampling results are summarized in Table 7 and Figure 10. Results generally indicate good water quality and habitat conditions for macroinvertebrates. Nineteen of the twenty-one macroinvertebrate samples had mIBI ratings (Weigel 2003) of excellent or good. Two macroinvertebrate samples had mIBI ratings of fair. Hilsenhoff biotic index (HBI) (Hilsenhoff 1987) ratings range from fairly poor to good. Eighteen of the 21 samples had HBI ratings of fair or good. Three samples had HBI ratings of fairly poor. Two of these three sites with HBI ratings of fairly poor had good or fair ratings for other samples collected at the same site. HBI's are primarily influenced by dissolved oxygen (D.O.) availability. These ratings indicate D.O. availability is not a problem at most sites but may be a concern at some sites Species richness values are moderate to high and range from 15 to 43 species per site.

Table 7. Summary of Macroinvertebrate Sample Results

Site Description	Map Site No.	SWIMS No.	Date	MIBI*	MIBI Rating	HBI*	HBI Rating	Species Richness (No. of Species)	%EPT* (genera/indivduals)
Bluff Ck 500 m US of powerline	1	10030045	5/12/2009	9.05	excellent	5.14	good	20	26/9
			4/28/2010	6.88	good	6.33	fair	43	21/15
Bluff Ck US CTH Z	4	10015462	5/12/2009	9.22	excellent	5.92	fair	23	20/3
			10/28/2009	7.22	good	5.6	fair	29	21/63
			10/19/2010	8.71	excellent	6.72	fairly poor	17	24/56
Bluff Ck off CTH A US confluence with UN Trib	5	10030049	5/14/2009	9.17	excellent	5.18	good	15	25/1
			10/19/2010	8.79	excellent	5.92	fair	23	26/77
Bluff Ck at Valley Brook Rd	6	10015463	5/14/2009	8	excellent	5.13	good	26	13/2
			4/28/2010	8.82	excellent	5.59	fair	26	25/17
			10/19/2010	10.29	excellent	6.07	fair	28	23/29
UN Trib to Bluff Ck at Valley Brook Rd	13	10040736	10/17/2013	2.75	fair	7.26	fairly poor	34	6/28
Birch Ck at Lyman Lake Rd	10	10032011	11/4/2010	3.71	fair	5.11	good	18	72/6
Birch Ck at CTH C	11	10017177	5/14/2009	8.02	excellent	5.66	fair	26	10/1
Bear Ck northeast of Hwy 2/53	15	10029779	4/28/2010	6.44	good	5.89	fair	28	23/6
			10/19/2010	6.05	good	5.38	good	33	23/33
Bear Ck US City Limits Rd	17	10015470	10/28/2009	5.25	good	5.33	good	18	28/70
			5/12/2009	9.71	excellent	6.66	fairly poor	26	27/2
			10/19/2010	5.22	good	5.06	good	16	31/51
Bear Ck at CTH Z	18	10029778	5/11/2009	7.88	excellent	5.34	good	27	10/1
			4/28/2010	8.46	excellent	5.45	good	25	19/2
UN Trib to Bear Ck at CTH Z	20	10030043	5/12/2009	5.8	good	5.74	fair	20	12/4

*MIBI = macroinvertebrate index of biotic integrity
HBI = Hilsenhoff biotic index
%EPT = percent Ephemeroptera, Plecoptera, and Trichoptera

Condition (Rating) Categories for Macroinvertebrate Index of Biotic Integrity (MIBI)	
Score	Condition
>75	excellent
50-75	good
25-49	fair
< 25	poor

Condition (Rating) Categories for HBI's	
HBI	Condition
0.00-3.50	excellent
3.51-4.50	very good
4.51-5.50	good
5.51-6.50	fair
6.51-7.50	fairly poor
7.51-8.50	poor
8.51-10.00	very poor

Diatoms

Diatom samples were collected from one site in Bear Creek and one site in Bluff Creek during 2018 (Table 1). Samples were not analyzed in time to include in this report.

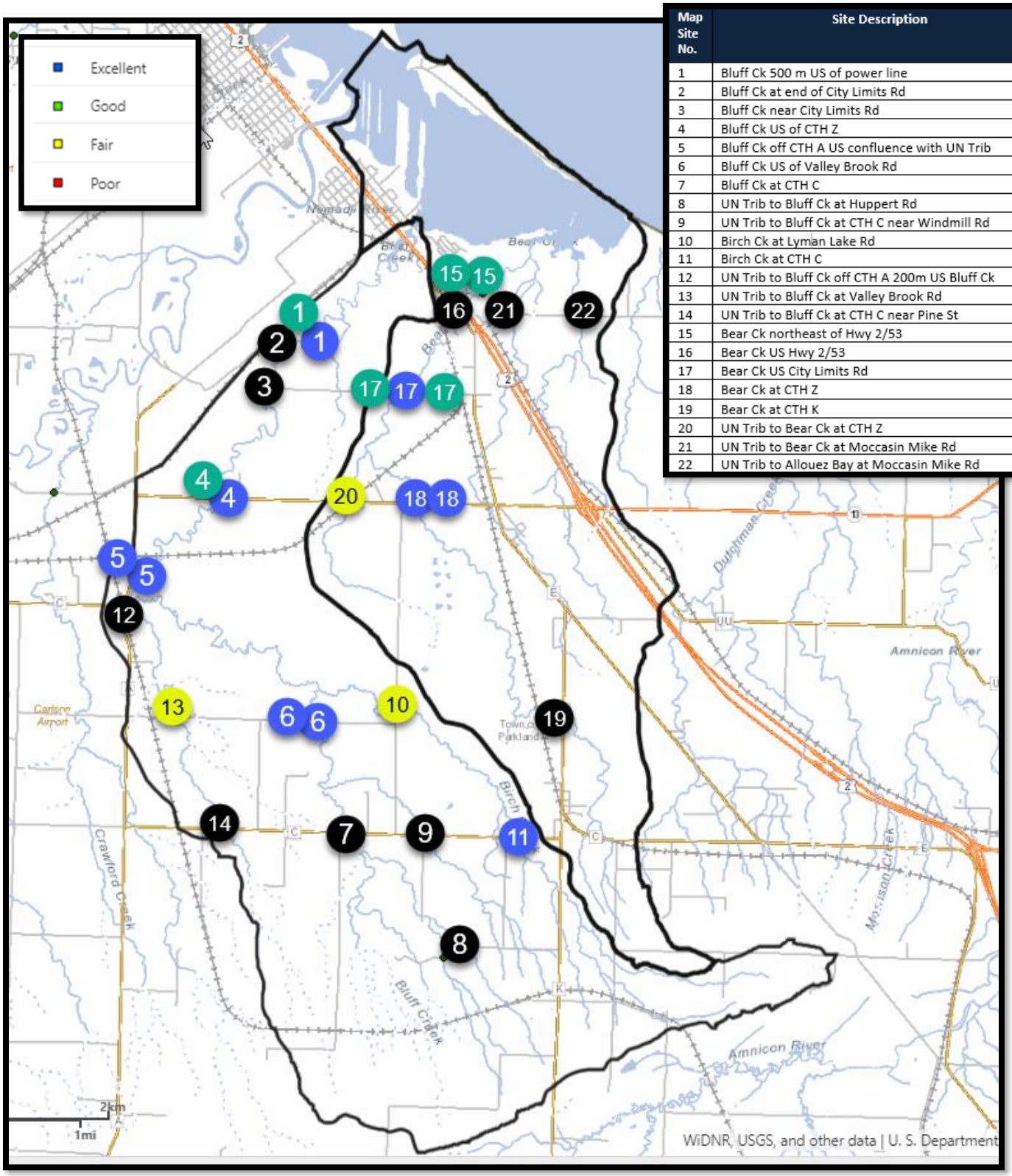
Water Quality

Twelve sites were monitored for water quality in the Bear and Bluff Creek watersheds (Table 1) on six dates during 2018. The first three dates monitored had low flow conditions and the last three dates monitored had high flow conditions with runoff occurring. Appendix A contains details of water quality monitoring results, including:

- A table with complete 2018 water quality results.
- Bar graphs showing 2018 lab results by sampling date for total phosphorus, total nitrogen, total suspended solids, and E. coli.
- Bar graphs showing 2018 lab result statistics (low flow medians, high flow medians, all flow medians, and all flow means (with 90% confidence intervals)).
- A table with 2009-2012 water quality data

Subwatershed areas, land uses, and notable features for the twelve water quality monitoring sites are shown in Table 8 below.

Figure 10. Bear and Bluff Creek Watersheds, Macroinvertebrate Index of Biotic Integrity (mIBI) Condition.



Map Site No.	Site Description
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16	Bear Ck US Hwy 2/53
17	Bear Ck US City Limits Rd
18	Bear Ck at CTH Z
19	Bear Ck at CTH K
20	UN Trib to Bear Ck at CTH Z
21	UN Trib to Bear Ck at Moccasin Mike Rd
22	UN Trib to Allouez Bay at Moccasin Mike Rd

Table 8. Land use percentages by subwatersheds

MAP SITE NO.	SUBWATERSHED AREA (KM^2)	% AGRICULTURE (ROW CROPS)	% GRASSLAND (PASTURE AND HAYFIELD)	% FOREST	% WETLAND	% DEVELOPED	% UNDEVELOPED (FOREST PLUS WETLAND)	NOTABLE FEATURES
3	45.8	0.0	22.5	39.0	37.6	0.0	76.6	Bluff Ck near mouth
13	6.4	0.0	30.0	35.0	34.2	0.0	69.2	downstream of beef cattle
14	3.24	0.0	12.7	58.5	28.3	0.6	86.8	upstream of beef cattle
7	10.5	0.0	15.7	68.0	15.5	0.8	83.5	
9	2.73	0.0	50.8	23.9	22.1	4.1	46.0	downstream of barnyard
11	5.4	0.0	48.5	36.7	12.2	2.4	49.0	
8	1	0.0	50.7	43.8	5.2	1.3	49.0	
19	3.9	0.0	40.6	21.5	32.4	6.4	53.9	
18	9.45	3.0	23.4	16.1	52.4	5.7	68.5	
20	3.82	0.0	3.0	3.1	93.6	1.3	96.6	wetlands with beaver ponds
21	4.49	0.0	4.0	15.0	66.6	14.4	81.6	
16	17.45	1.6	16.3	15.5	60.8	6.0	76.3	Bear Ck near mouth

Subwatershed Characteristics / Water Quality Correlations

Water quality monitoring results from the 12 sites in the Bear and Bluff Creek watersheds were plotted against subwatershed characteristics (Subwatershed Area, % Wetland, % Grassland, % Undeveloped Land (wetland plus woodland)). Some significant correlations ($R^2 > 0.30$) between subwatershed characteristics and water quality were found.

Subwatershed area was correlated ($R^2 = 0.50$) with the mean total suspended solids concentrations (TSS's) for all flows (all sampling dates) (Figure 11). Subwatershed area was also correlated ($R^2 = 0.45$) with the mean turbidity for all flows/dates (Figure 12). Streambank erosion has been shown to be the source of the great majority of total suspended solids in Lake Superior Clay Plain streams (Butcher 2016, Carlton County 2002, NRCS 1998). Sites with larger subwatershed areas have greater total stream channel length, higher flows, more potential for streambank erosion, and higher TSS's. Turbidity is generally controlled by TSS, and so mean turbidity for all flows/dates shows a similar correlation with subwatershed area.

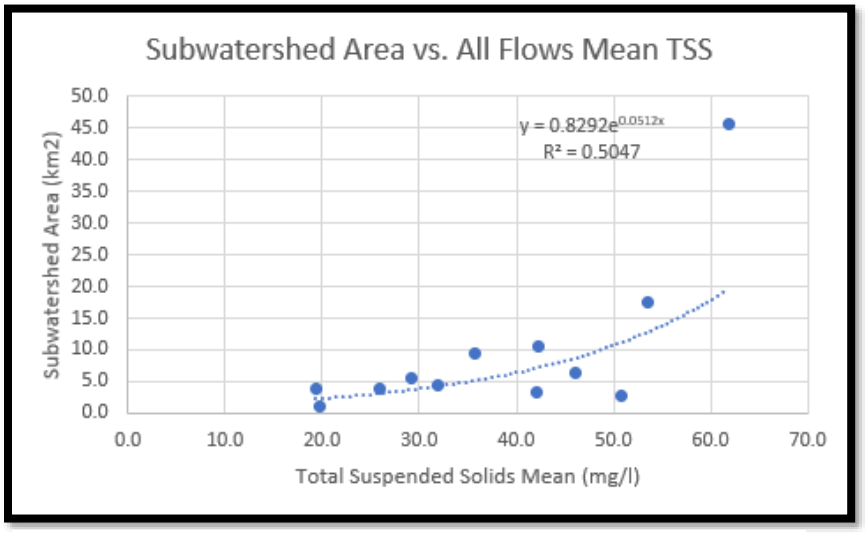


Figure 11. Subwatershed Area versus All Flows Mean TSS.

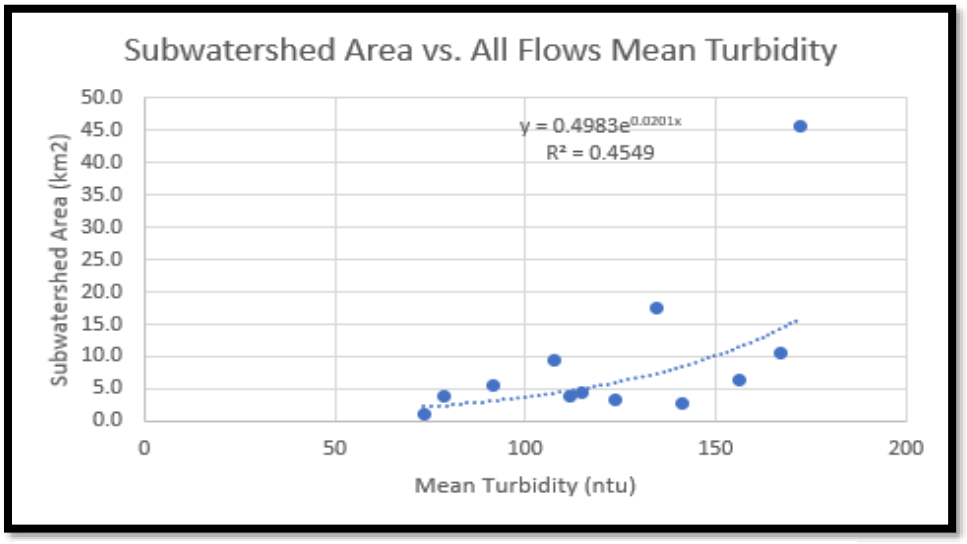


Figure 12. Subwatershed Area versus All Flows Mean Turbidity.

Median turbidity during high flows is inversely correlated with the percent of wetland area in the subwatershed (R^2 = 0.30) (Figure 13). Subwatersheds with less wetland area have higher turbidities during high flows. Soils in wetlands are protected from erosion by vegetation and so this source of turbidity is reduced. Turbid runoff flowing through wetlands can be partially clarified as suspended silt and clay particles settle or are attached to biofilms on surfaces of living or dead vegetation.

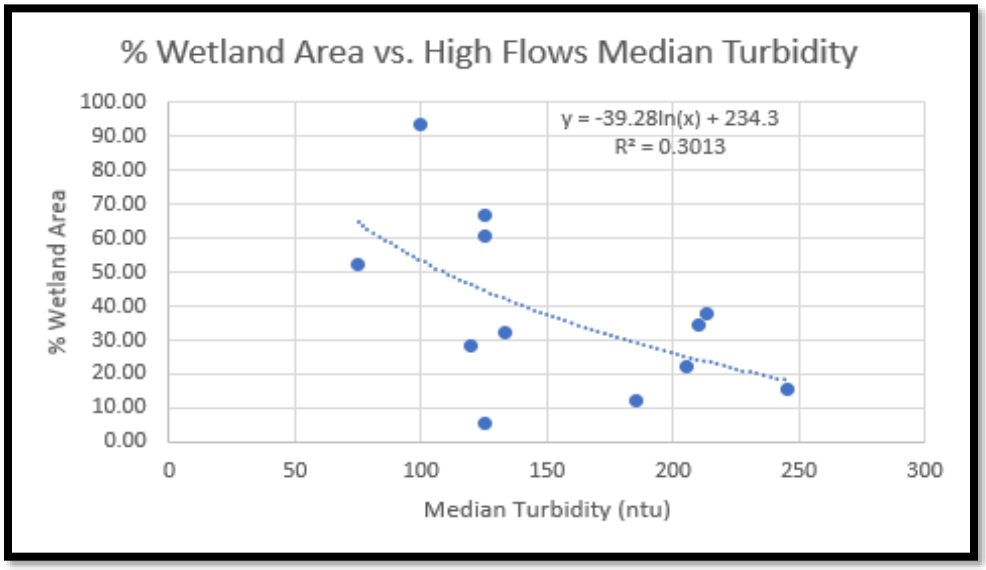


Figure 13. Percent Wetland Area versus High Flows Median Turbidity.

Median total nitrogen concentrations (TN's) during low flows are positively correlated with the percent of wetland area in the subwatershed (R^2 = 0.67) (Figure 14). Median total nitrogen concentrations (TN's) during low flows are also positively correlated with the percent of undeveloped land (R^2 = 0.34). The wetland fraction of undeveloped land is the more significant driver of that correlation. Wetland drainage is probably a substantial source of stream flow during periods of low flow. There is little inflow of groundwater to most Clay Plain streams.

Median conductivities during low flows are negatively correlated with % wetland area (Figure 15). Wetland drainage has low conductivity, while groundwater discharge has high conductivity. This probably explains the low flow TN/wetland relationship observed. Flows at sites with a higher percentage of wetlands in their subwatersheds are more heavily supported by wetland drainage, which has higher TN's than groundwater discharge. Flows at sites with a lower percentage of wetlands in their subwatersheds are more heavily supported by groundwater discharge, which has lower TN's.

TN results from only two low flow sampling dates were available. A lab mix-up resulted in the third low flow sample being tested for nitrate plus nitrite nitrogen, rather than TN. Nitrate plus nitrite nitrogen concentrations were very low (< 0.036 mg/l at 11 sites, and 0.100 mg/l at one site (3)), and so are only making a minor contribution to TN's. Past monitoring of Bear and Bluff Creek (Roesler et al. 2018, and appendix A, Tables 13,14) showed the great majority of TN is present as organic nitrogen.

Median turbidity during low flows was positively correlated with the percent of wetland area in the subwatershed ($R^2 = 0.42$) (Figure 16). The reason for the low flow turbidity/wetland relationship observed is uncertain. Higher stream flows at sites with a high percentage of wetlands in their subwatersheds was noticed on low flow sampling dates. Relatively higher flows on low flow dates may contribute to higher turbidity due to channel erosion.

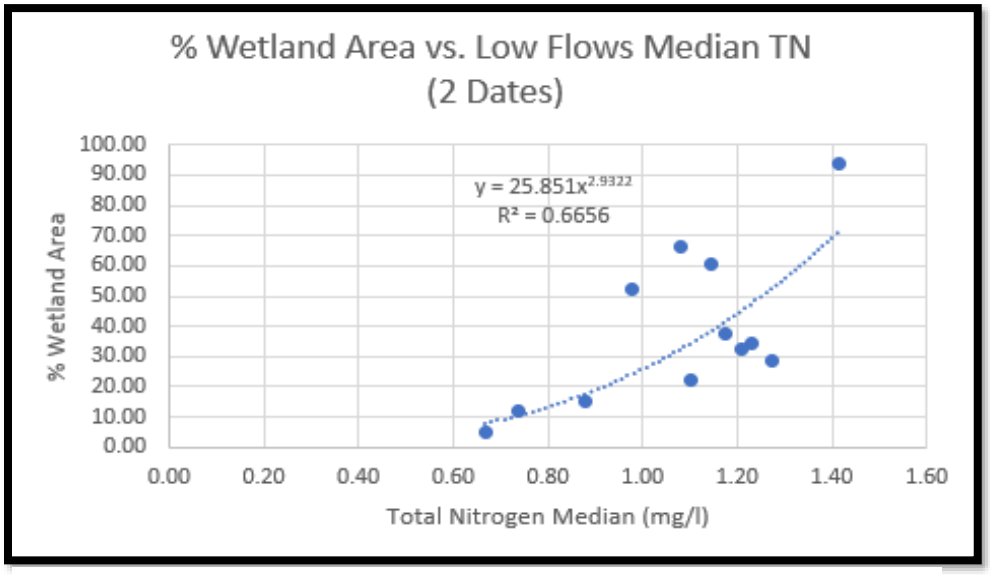


Figure 14. Percent Wetland Area versus Low Flows Median TN

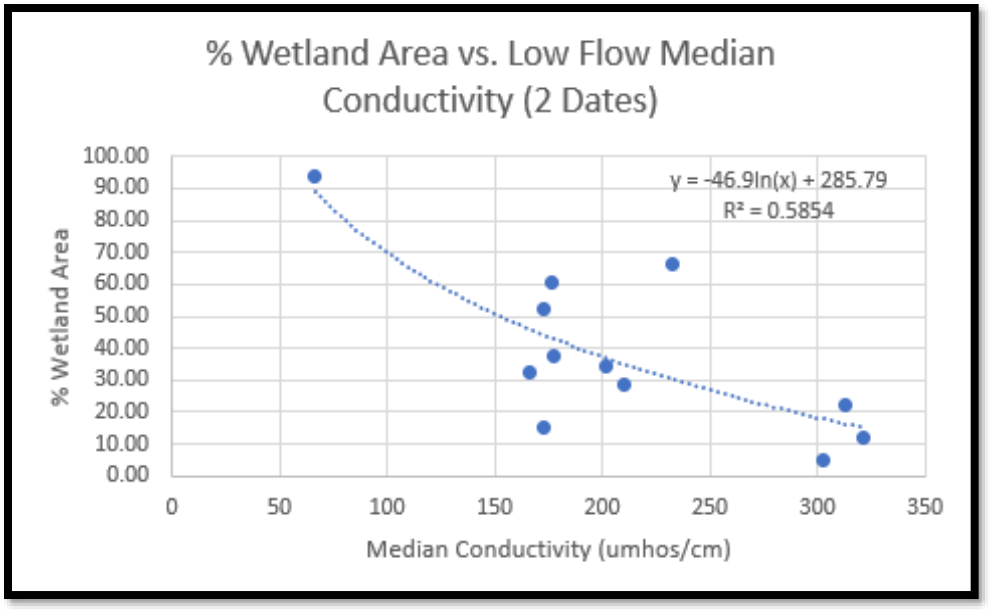


Figure 15. Percent Wetland Area versus Low Flows Median Conductivity

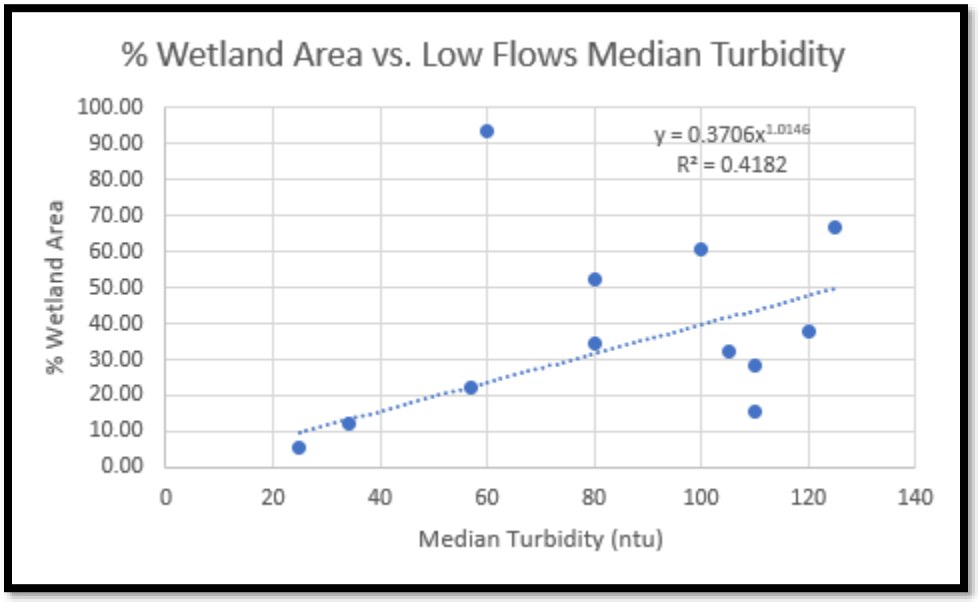


Figure 16. Percent Wetland Area versus Low Flows Median Turbidity

Site-Specific Water Quality Monitoring Results

Mean total phosphorus concentrations for all dates ranged from 92 ug/l (site 20) to 241 ug/l (site 13). Wisconsin's stream total phosphorus concentration (TP) standard is 75 ug/l. High phosphorus concentrations promote excess algae growth in streams and downstream waters. Sixty-four of the 72 samples collected had TP's greater than 75 ug/l. All calculated median and mean TP's were > 75 ug/l, except for the low flow median TP for site 8 (73 ug/l) (Appendix A, Figure 18). Median and mean TP's were > 75 ug/l for the four subwatersheds with the highest percentages of undeveloped land use (14: 87%, 7: 84%, 20: 97%, 21: 82%). This suggests it will be difficult to achieve the 75 ug/l standard and the standard may not be appropriate for Clay Plain streams. Low infiltration rates and high runoff rates probably minimize retention of phosphorus by soils and maximize phosphorus export.

Mean total nitrogen concentrations for all dates ranged from 0.98 mg/l (site 7) to 2.44 mg/l (site 11). Wisconsin does not have a stream standard for total nitrogen. High nitrogen concentrations can also promote excess growth of algae and aquatic plants in streams and downstream waters.

Two monitoring sites are downstream of areas with concentrations of livestock (sites 13, 11). Stream nutrient concentrations were relatively high at those sites.

Site 13 had:

- The highest mean total phosphorus concentration (241 ug/l) for all flows.
- The highest high flow median total nitrogen concentration (2.32 mg/l).
- The second highest mean total nitrogen concentration (1.83 mg/l) for all flows.

Site 11 had:

- The highest mean total nitrogen concentration (2.44 mg/l) for all flows.
- The highest single date total nitrogen concentration (8.13 mg/l; 8/28/18).
- The highest single date total phosphorus concentration (458 ug/l; 8/28/18).

A 2009 fish survey at site 11 (Birch Ck at CTH C; table 3) found a fish community with an index of biotic integrity rating of poor. Birch Creek is currently on Wisconsin's impaired waters list due to poor fish community index of biotic integrity ratings.

Mean total suspended solids concentrations for all dates ranged from 13.6 mg/l (site 8) to 61.9 mg/l (site 3). As mentioned above, streambank erosion tends to be the largest source of total suspended solids concentrations in Lake Superior Clay Plain streams. Site 3 near the mouth of Bluff Creek had:

- The highest mean total suspended solids concentration (61.9 mg/l) for all flows.
- The highest single date total suspended solids concentration (301 mg/l; 10/10/18).

Site 3 has the largest subwatershed size and thus greater total stream channel length and higher flows, providing more potential for streambank erosion.

Mean E. coli concentrations could not be calculated for many sites since several analyses were reported as "greater than" some value. Wisconsin does not currently have an E. coli standard for streams, but it does apply EPA E. coli standards to swimming beaches. An "advisory" standard of 235 mpn/100 ml results in a caution sign being placed at a beach to warn of an increased risk of exposure to fecal bacteria and viruses. A "closure" standard of 1,000 mpn/100 ml results in beach closure.

For the three low flow sampling dates, 10 of 36 samples exceeded 235 mpn/100 ml. For the three high flow sampling dates, 31 of 36 samples exceeded 235 mpn/100 ml. Twenty-seven of 72 samples had E. coli concentrations greater than 1,000 mpn/100 ml, with the highest concentration at 24,196 mpn/100 ml.

Common strains of E. coli do not cause disease. E. coli serves as a tracer of fecal wastes from warm-blooded animals including humans. When E. coli concentrations are high, the presence of disease- causing bacteria and viruses is likely. Common E. coli sources include failing residential wastewater systems, livestock manure, and wildlife wastes. The low infiltration rates and high runoff rates of Clay Plain soils probably maximize E. coli export.

E. coli concentrations were highly variable with no obvious differences between sites. All sites had multiple samples with E. coli concentrations > 235 mpn/100ml. Site 20 has a subwatershed that is 97% undeveloped and has no human or livestock presence. All three high flow samples from this site had E. coli concentrations > 235 mpn/100 ml, with one sample having a concentration >2,420 mpn/100 ml. It appears wildlife sources alone can produce high E. coli concentrations in streams at times. Air photos show beaver ponds are present in this subwatershed, but the ponds are not visible from access points. It was not determined if the ponds were in active use by beavers or if there was a substantial waterfowl presence during 2018.

Management Options

Management Recommendations for DNR and Partners

- The DNR and the Douglas County Soil and Water Conservation Dept. should evaluate the potential for "Slow the Flow" projects, which could potentially reduce peak flows and streambank erosion in the Bear and Bluff Creek watersheds.

- The DNR and the Douglas County Soil and Water Conservation Dept. should review the operations of the two areas of concentrated livestock in the Bluff Creek watershed (upstream of site 13 and 11), and work with landowners to implement any practical measures to reduce nutrient runoff.

Management Recommendations for Partners

- Douglas County will be taking actions required by July 2000 revisions to the Wisconsin Plumbing Code. Actions required include:

    - an inventory of all private onsite wastewater systems
    - inspections of systems installed before July 2000
    - implementation of a maintenance tracking program

- Actions will be taken over a 3-year period, starting in the southern third of the County and working northward. Systems in the Bear and Bluff Creek watersheds will be addressed in 2021.

Appendix A. Bear and Bluff Creek Watershed Water Quality Data

Table 9. Bear and Bluff Creek Watersheds May & June 2018 Monitoring Results (May and June dates had "low flow" conditions)

DATE	5/22/2018												
Map No.	Site Description	WBIC	SWIMS no.	Field Measurements						Lab Measurements			
				Temp °C	Dissolved oxygen (mg/l)/(% sat.)	pH (s.u.)	Conductivity (umhos/cm)	Turbidity (ntu)	Transparency (cm)	Total phosphorus (ug/l)	Total nitrogen (mg/l)	Total suspended solids (mg/l)	E.coli (mpn)
3	Bluff Ck near City Limits Rd	2833200	10040432	12.6	9.5/89%	7.6	171	120	12	111	1.09	8.4	39.9
13	Un. Trib. To Bluff Ck at Valley Brook Rd	2833400	10040736	16.8	7.8/83%	7.4	227	80	15	95	1.04	15.6	435.2
14	Un. Trib. To Bluff Ck at CTH C near Pine St	2833400	10050949	12.2	5.5/52%	6.9	293	51	28	81	0.993	9.8	307.6
7	Bluff Ck at CTH C	2833200	163231	13.7	9.0/89%	7.7	186	95	19	78	0.751	9.7	204.6
9	Un. Trib. To Bluff Ck at CTH C near Windmill Rd	2833900	10050950	11.5	8.8/83%	7.5	347	57	62	75	1.02	ND	1
11	Birch Ck at CTH C	2833500	10017177	13.1	8.2/80%	7.7	334	34	57	52	0.649	5.0	5.2
8	Un. Trib. To Bluff Ck at Huppert Rd	2834200	10051098	12.7	7.2/70%	7.5	341	11	>121	24	0.498	ND	235.9
19	Bear Ck at CTH K	2834600	10050952	11.6	9.4/88%	7.5	159	83	25	92	1.12	8.8	>2419.6
18	Bear Ck at CTH Z	2834600	10038884	12.2	8.2/78%	7.5	170	80	24	78	0.982	7.7	24.3
20	Un. Trib. To Bear Ck at CTH Z	2834800	10030043	15.1	8.9/91%	7.1	63	60	26	60	1.33	10.3	34.5
21	Un. Trib. To Bear Ck at Mocassin Mike Rd	2834700	10050953	11	10.3/95%	7.7	198	125	12	85	1.06	9.0	172.2
16	Bear Ck upstream Hwy 2/53	2834600	10048234	12.4	9.9/94%	7.7	165	100	15	79	1.12	11.8	38.9
DATE	6/12/2018												
Map No.	Site Description	WBIC	SWIMS no.	Field Measurements						Lab Measurements			
				Temp °C	Dissolved oxygen (mg/l)/(% sat.)	pH (s.u.)	Conductivity (umhos/cm)	Turbidity (ntu)	Transparency (cm)	Total phosphorus (ug/l)	Total nitrogen (mg/l)	Total suspended solids (mg/l)	E.coli (mpn)
3	Bluff Ck near City Limits Rd	2833200	10040432	12.9	8.8/86%	7.6	184	140		122	1.26	14.0	65.7
13	Un. Trib. To Bluff Ck at Valley Brook Rd	2833400	10040736	15.8	7.5/77%	7.6	176	144		193	1.42	10.0	218.7
14	Un. Trib. To Bluff Ck at CTH C near Pine St	2833400	10050949	17.4	8.3/89%	7.6	127	178		187	1.55	14.5	325.5
7	Bluff Ck at CTH C	2833200	163231	13.4	9.2/91%	7.7	160	133		101	1.01	8.0	88.6
9	Un. Trib. To Bluff Ck at CTH C near Windmill Rd	2833900	10050950	11.7	6.7/64%	7.4	279	77		129	1.18	4.7	53.7
11	Birch Ck at CTH C	2833500	10017177	12.8	8.8/65%	7.8	309	55		87	0.826	3.7	107.1
8	Un. Trib. To Bluff Ck at Huppert Rd	2834200	10051098	12.2	7.9/76%	7.6	264	64		73	0.838	ND	920.8
19	Bear Ck at CTH K	2834600	10050952	11.8	8.4/80%	7.6	173	136		156	1.3	11.5	20.3
18	Bear Ck at CTH Z	2834600	10038884	13.1	7.4/71%	7.5	175	105		98	0.97	12.5	56.5
20	Un. Trib. To Bear Ck at CTH Z	2834800	10030043	15.7	7.6/78	7.2	70	76		79	1.5	17.5	31.3
21	Un. Trib. To Bear Ck at Mocassin Mike Rd	2834700	10050953	11.5	9.8/93%	7.8	268	145		104	1.1	12.0	52.1
16	Bear Ck upstream Hwy 2/53	2834600	10048234	12.9	9.9/96%	7.8	188	130		95	1.17	15.0	34.1

Table 10. Bear and Bluff Creek Watersheds July & August 2018 Monitoring Results (July date had "low flow" conditions; August date had "high flow" conditions)

DATE	7/26/2018												
Map No.	Site Description	WBIC	SWIMS no.	Field Measurements						Lab Measurements			
				Temp °C	Dissolved oxygen (mg/l)/(% sat.)	pH (s.u.)	Conductivity (umhos/cm)	Turbidity (ntu)	Transparency (cm)	Total phosphorus (ug/l)	NO3 + NO2-N (mg/l)	Total suspended solids (mg/l)	E.coli (mpn)
3	Bluff Ck near City Limits Rd	2833200	10040432	17.4	6.7/72%	7.7	316	60	28	70	0.0999	9.5	107.5
13	Un. Trib. To Bluff Ck at Valley Brook Rd	2833400	10040736	18	7.9/86%	7.9	291	74	17	248	ND(<0.0360)	39.0	248.9
14	Un. Trib. To Bluff Ck at CTH C near Pine St	2833400	10050949	17.3	3.4/36%	7.4	266	110	15	5	ND(<0.0360)	90.3	>2419.6
7	Bluff Ck at CTH C	2833200	163231	17.6	5.4/58%	7.4	297	110	13	131	ND(<0.0360)	51.0	76.7
9	Un. Trib. To Bluff Ck at CTH C near Windmill Rd	2833900	10050950	16.4	5.8/61%	7.5	343	57	30	177	ND(<0.0360)	23.8	6.3
11	Birch Ck at CTH C	2833500	10017177	16.4	2.5/26%	7.1	614	29	44	139	ND(<0.0360)	9.8	69.7
8	Un. Trib. To Bluff Ck at Huppert Rd	2834200	10051098	15.7	1.4/14%	7.1	327	25	85	128	ND(<0.0360)	4.0	2
19	Bear Ck at CTH K	2834600	10050952	16	.04/4%	7.2	338	105	22	236	ND(<0.0360)	49.7	106.9
18	Bear Ck at CTH Z	2834600	10038884	17.4	3.9/42%	7.5	282	54	27	74	ND(<0.0360)	15.8	23.8
20	Un. Trib. To Bear Ck at CTH Z	2834800	10030043	18.8	5.3/58%	7.2	145	49	45	83	ND(<0.0360)	10.8	32.7
21	Un. Trib. To Bear Ck at Mocassin Mike Rd	2834700	10050953	15.9	4.3/46%	7.5	497	44	59	64	ND(<0.0360)	3.0	770.1
16	Bear Ck upstream Hwy 2/53	2834600	10048234	18.1	7.4/80%	7.8	370	73	25	86	ND(<0.0360)	15.5	517.2
DATE	8/28/2018												
Map No.	Site Description	WBIC	SWIMS no.	Field Measurements						Lab Measurements			
				Temp °C	Dissolved oxygen (mg/l)/(% sat.)	pH (s.u.)	Conductivity (umhos/cm)	Turbidity (ntu)	Transparency (cm)	Total phosphorus (ug/l)	Total nitrogen (mg/l)	Total suspended solids (mg/l)	E.coli (mpn)
3	Bluff Ck near City Limits Rd	2833200	10040432	16.7	6.8/72%	7.8	334	213	9	90	1.06	28.4	980.4
13	Un. Trib. To Bluff Ck at Valley Brook Rd	2833400	10040736	17.6	4.6/49%	7	333	235	9	344	2.68	64.0	>2419.6
14	Un. Trib. To Bluff Ck at CTH C near Pine St	2833400	10050949	17.2	6.3/67%	7.5	265	102	8	217	2.52	57.5	>2419.6
7	Bluff Ck at CTH C	2833200	163231	17.2	5.8/62%	7.5	135	315		147	0.894	73.5	>2419.6
9	Un. Trib. To Bluff Ck at CTH C near Windmill Rd	2833900	10050950	16.4	7.3/77%	7.5	169	350		329	2.27	127.0	>2419.6
11	Birch Ck at CTH C	2833500	10017177	17.2	7.1/76%	7.7	493	185	7	458	8.13	79.2	>2419.6
8	Un. Trib. To Bluff Ck at Huppert Rd	2834200	10051098	16.9	7.3/77%	7.2	229	150	10	129	1.3	33.6	>2419.6
19	Bear Ck at CTH K	2834600	10050952	16.9	2.7/29%	7.5	426	63	26	162	1.99	18.0	1119.9
18	Bear Ck at CTH Z	2834600	10038884	17.6	4.2/45%	7.5	631	57	28	89	0.84	14.0	648.8
20	Un. Trib. To Bear Ck at CTH Z	2834800	10030043	17.5	5.1/55%	7.5	222	100	15	142	1.45	36.0	>2419.6
21	Un. Trib. To Bear Ck at Mocassin Mike Rd	2834700	10050953	16.3	4.5/47%	7.5	744	125	12	105	0.89	32.8	1553.1
16	Bear Ck upstream Hwy 2/53	2834600	10048234	17.1	6.9/74%	7.7	626	80	16	121	1.55	28.4	1732.9

Table 11. Bear and Bluff Creek Watersheds October 2018 Monitoring Results (both October dates had "high flow" conditions)

DATE	10/5/2018												
Map No.	Site Description	WBIC	SWIMS no.	Field Measurements						Lab Measurements			
				Temp °C	Dissolved oxygen (mg/l)/(% sat.)	pH (s.u.)	Conductivity (umhos/cm)	Turbidity (ntu)	Transparency (cm)	Total phosphorus (ug/l)	Total nitrogen (mg/l)	Total suspended solids (mg/l)	E.coli (mpn)
3	Bluff Ck near City Limits Rd	2833200	10040432	8.5	7.8/90%	8	228.9	110	14	116	1.14	9.8	110
13	Un. Trib. To Bluff Ck at Valley Brook Rd	2833400	10040736	7.8	10.1/87%	7.7	194	195	10	320	2.32	73.3	14136
14	Un. Trib. To Bluff Ck at CTH C near Pine St	2833400	10050949	7.8	10.6/91%	7.8	117	120	13	142	1.47	21.6	6181
7	Bluff Ck at CTH C	2833200	163231	7.5	9.3/80%	7.7	210	105	24	93	0.828	5.6	171
9	Un. Trib. To Bluff Ck at CTH C near Windmill Rd	2833900	10050950	7.6	9.3/76%	7.8	252	100	19	146	1.3	6.5	529
11	Birch Ck at CTH C	2833500	10017177	7.5	8.6/73%	7.5	345	60	35	103	0.939	7.2	120
8	Un. Trib. To Bluff Ck at Huppert Rd	2834200	10051098	7.4	10.6/90%	7.8	190	65	27	66	1.08	12.8	1046
19	Bear Ck at CTH K	2834600	10050952	7.1	8.3/70%	7.5	260	133	13	111	1.02	14.0	96
18	Bear Ck at CTH Z	2834600	10038884	8.1	9.2/79%	7.7	242	75	28	82	0.883	6.0	181
20	Un. Trib. To Bear Ck at CTH Z	2834800	10030043	8.8	8.9/78%	7.5	118	86	18	85	1.44	23.6	249
21	Un. Trib. To Bear Ck at Mocassin Mike Rd	2834700	10050953	9	9.9/87%	8.1	501	125	12	95	1	12.8	226
16	Bear Ck upstream Hwy 2/53	2834600	10048234	8.2	10.8/93%	7.9	296	125	12	113	1.06	19.4	865
DATE	10/10/2018												
Map No.	Site Description	WBIC	SWIMS no.	Field Measurements						Lab Measurements			
				Temp °C	Dissolved oxygen (mg/l)/(% sat.)	pH (s.u.)	Conductivity (umhos/cm)	Turbidity (ntu)	Transparency (cm)	Total phosphorus (ug/l)	Total nitrogen (mg/l)	Total suspended solids (mg/l)	E.coli (mpn)
3	Bluff Ck near City Limits Rd	2833200	10040432	7.4	10.4/89%	7.6	95	390	3	408	1.97	301.00	15531
13	Un. Trib. To Bluff Ck at Valley Brook Rd	2833400	10040736	7.3	10.9/93%	7.2	58	210	5	243	1.7	74.40	6867
14	Un. Trib. To Bluff Ck at CTH C near Pine St	2833400	10050949	7.5	10.9/94%	7.2	47	180	8	192	1.57	59.00	5794
7	Bluff Ck at CTH C	2833200	163231	7.5	11.0/95%	7.4	72	245	7	223	1.44	106.00	2282
9	Un. Trib. To Bluff Ck at CTH C near Windmill Rd	2833900	10050950	7.1	10.7/92%	7.3	117	205	7	245	1.74	92.00	19166
11	Birch Ck at CTH C	2833500	10017177	6.9	11.4/98	7.4	101	185	9	207	1.67	70.00	6867
8	Un. Trib. To Bluff Ck at Huppert Rd	2834200	10051098	7.2	11.3/97	7.5	72	125	12	134	1.24	28.50	1860
19	Bear Ck at CTH K	2834600	10050952	7.1	10.6/91%	7.2	84	150	9	162	1.27	54.00	1872
18	Bear Ck at CTH Z	2834600	10038884	7.5	10.2/102%	7.4	101	275	7	265	1.64	158.00	2909
20	Un. Trib. To Bear Ck at CTH Z	2834800	10030043	7.4	9.7/83%	7	50	100	13	102	1.86	18.00	1376
21	Un. Trib. To Bear Ck at Mocassin Mike Rd	2834700	10050953	7.5	10.4/89%	7.6	114	124	5	211	1.49	122.00	2909
16	Bear Ck upstream Hwy 2/53	2834600	10048234	7.6	10.6/91%	7.5	101	300	4	281	1.69	231.00	2481

Figure 17. 2018 Bear and Bluff Creek Watersheds Total Phosphorus Concentrations by Site and Date

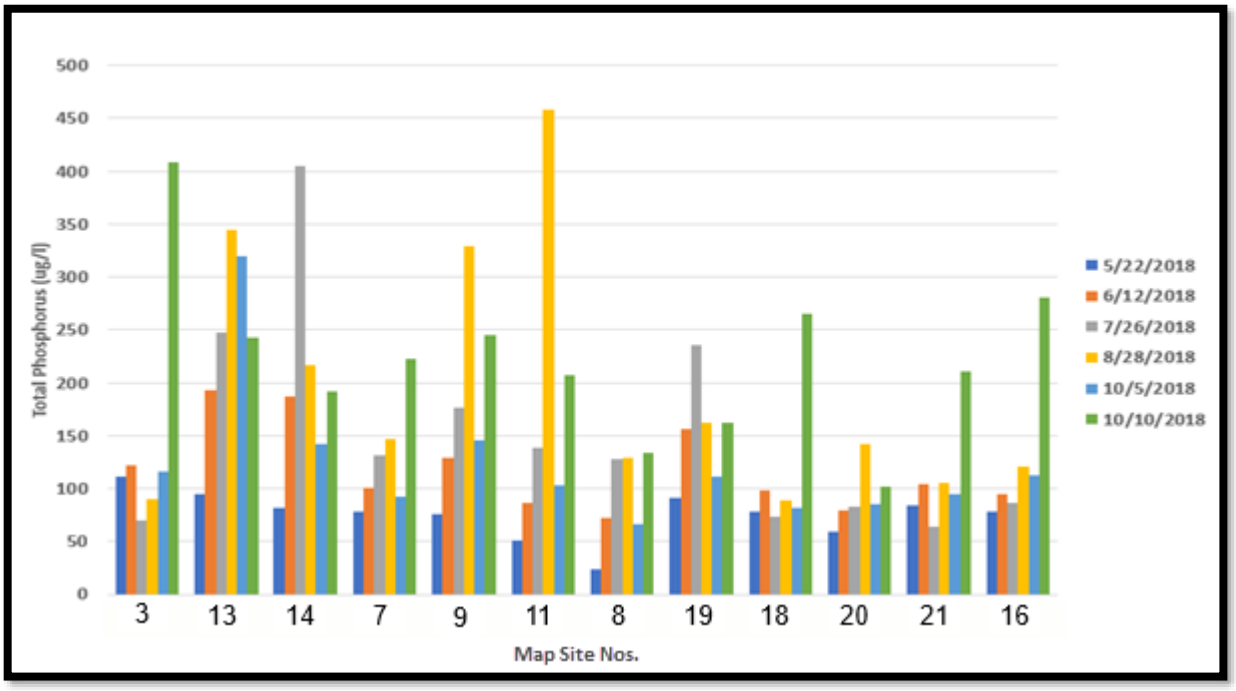
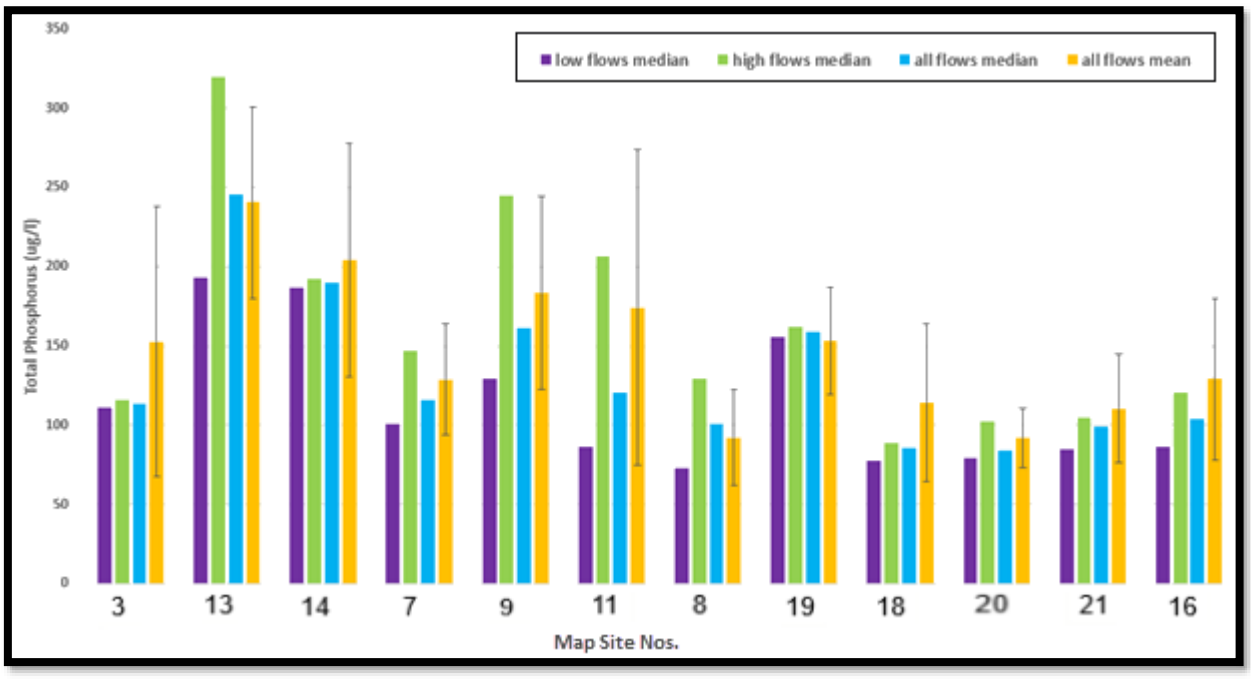


Figure 18. 2018 Bear and Bluff Creek Watersheds Total Phosphorus Concentration Statistics



***Error bars are 90% confidence intervals*

Figure 19. 2018 Bear and Bluff Creek Watersheds Total Nitrogen Concentrations by Site and Date

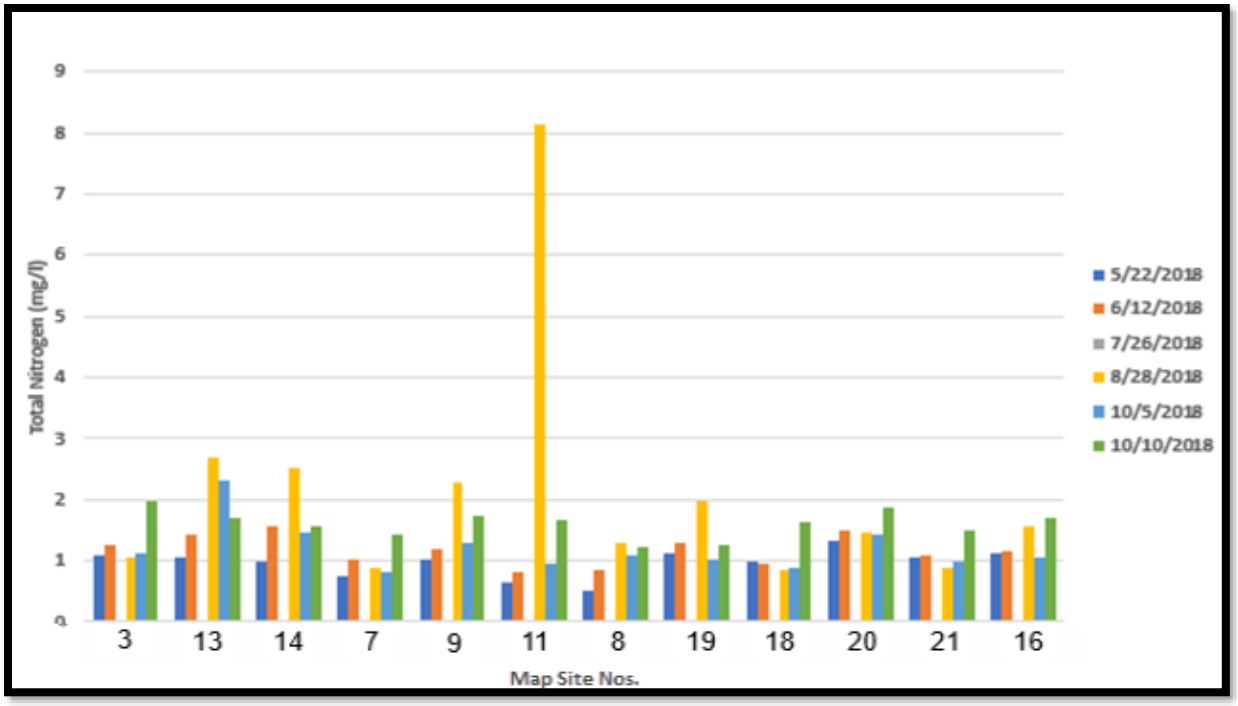
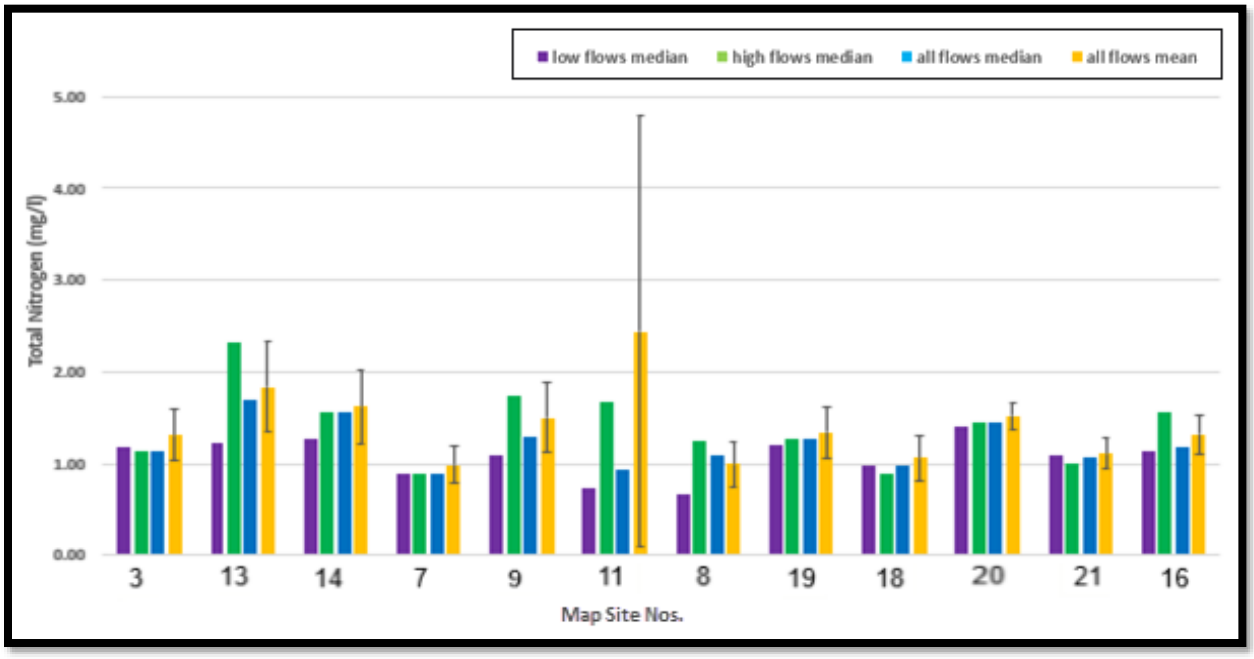


Figure 20. 2018 Bear and Bluff Creek Watersheds Total Nitrogen Concentration Statistics



***Error bars are 90% confidence intervals*

Figure 21. 2018 Bear and Bluff Creek Watersheds Total Suspended Solids Concentrations by Site and Date

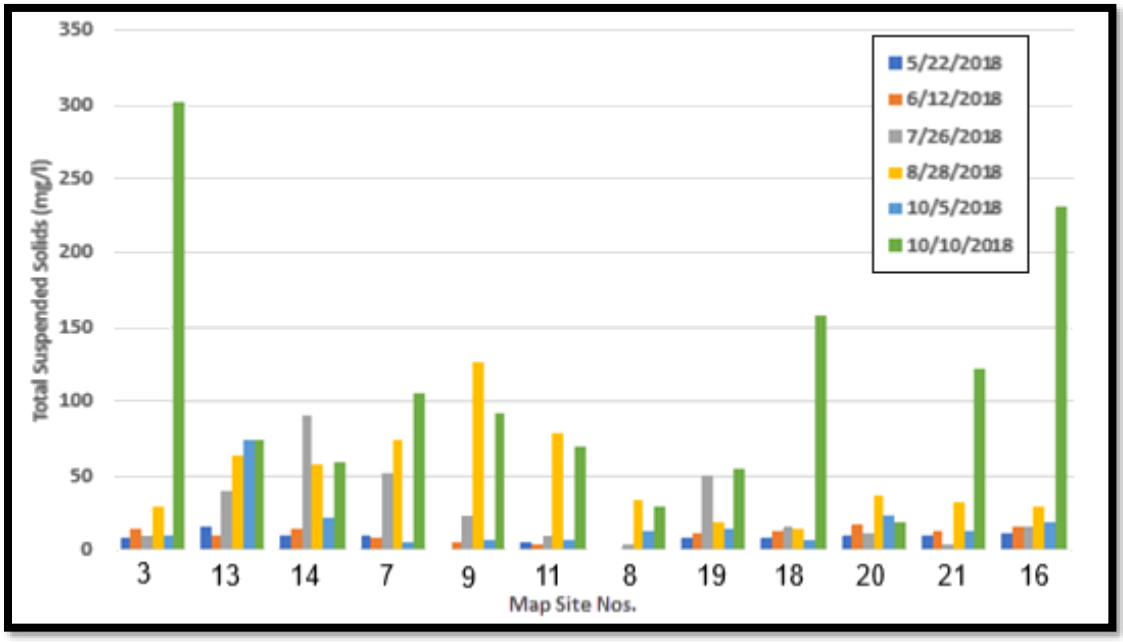
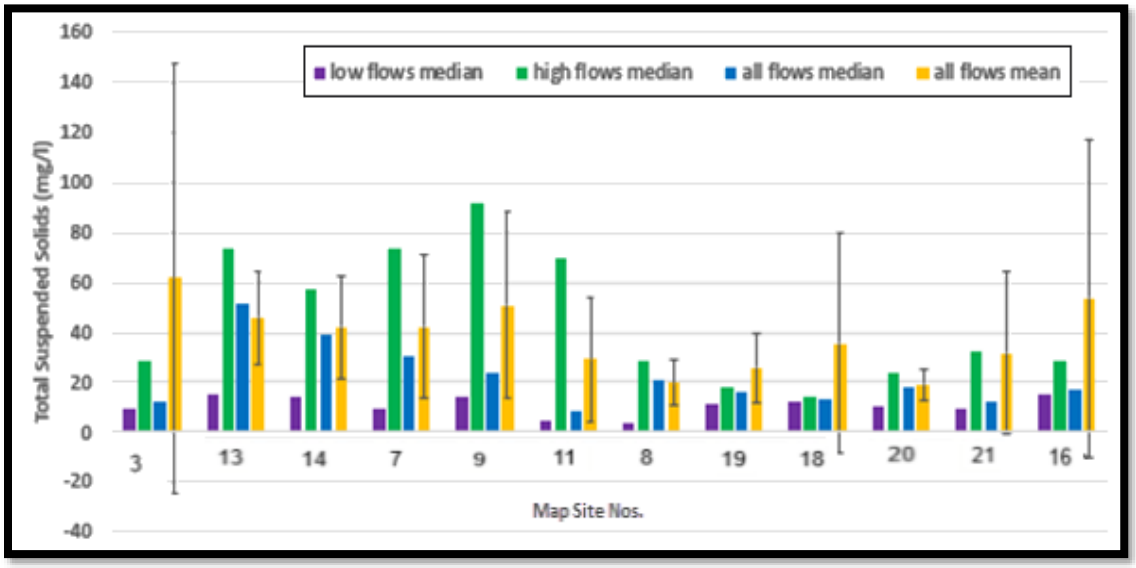
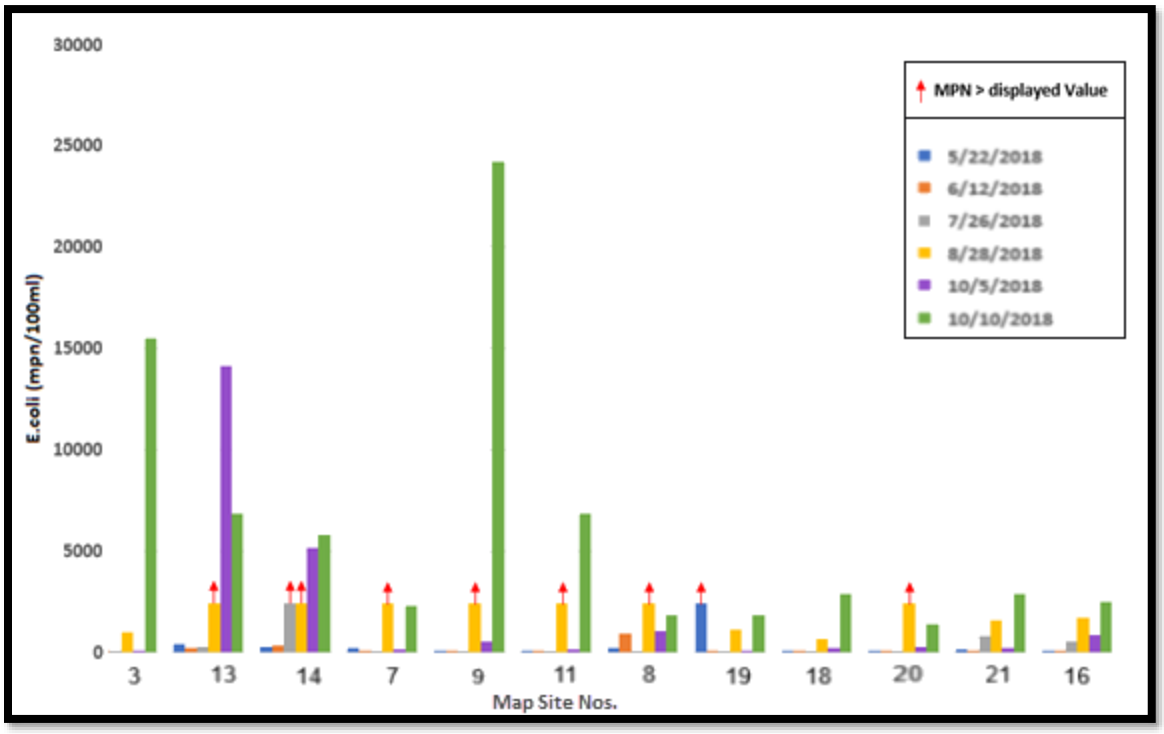


Figure 22. 2018 Bear and Bluff Creek Watersheds Total Suspended Solids Concentration Statistics



***Error bars are 90% confidence intervals*

Figure 23. 2018 Bear and Bluff Creek Watersheds E. coli Concentrations by Site and Date



***E. coli concentration statistics couldn't be generated because some concentrations were reported as "greater than" some value.*

Table 12. Bluff Creek Watershed Water Quality Data 2009-2012

Bluff Ck. upstream of Powerline					Station 10030046								
	Lab parameters						Field parameters						
	NH3	NO3+2	TKN	TP	TSS	Turbidity	Temp	D.O.	D.O.sat.	pH	Cond.	Transp.	
Date	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(NTU)	(C)	(mg/l)	(%)	(SU)	(umhos/cm)	(cm)	
06/10/2009	0.02	0.07	1.4	138	22	153	10.5	10.2	91.3	7.3	197	9	
Bluff Ck. @ CTH Z	Station 10015462												
	Lab parameters								Field parameters					
	NH3	NO3+2	TKN	TP	TSS	Turbidity	Chl. A	DP	Temp	D.O.	D.O.sat.	pH	Cond.	Transp.
Date	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(NTU)	(ug/l)	(ug/l)	(C)	(mg/l)	(%)	(SU)	umhos/cm	(cm)
06/10/2009	0.028	ND	1.36	160	30	117			13.4	9.9	94.9	7.7	208	5
08/20/2009					46	97.3			15.4	8.2	81.7	7.4	220	9
09/29/2009				94	16	27.5			10.7	5.4	48.1		801	36
10/30/2009				198	83	182			6.6	11.1	90.2	7.2	162	8
08/05/2010		0.077	1.83	151	30	99.4			22.6	6	70.1	7.1		11.5
08/18/2010	0.046	0.072	1.95	42	192	275			17.1	8.2	84.7	7	100	5
08/09/2010		0.055	1.66	167	47	135			20.9	7.1	86.5	7.1		9.5
08/16/2010	0.056	0.062	1.93	152	29	120			18.6	6.3	81.8	7.7	145	12
09/14/2010	0.024	ND	1.46	140	32	123			13.1	4.2	39.8		207	14
10/06/2010				131	26	68			10	3.7	31.8	7		20
10/26/2010				183	45	135			9.4	9.9	86.5	7.8	130	8
11/16/2010				168	27	132			1.6	13.9	98.6	6.8		11
06/13/2012	0.015	ND	0.67	88	13	71	9.3	28	19.5	5.1		7.4	225	18
09/20/2012	ND	ND	0.94	108	16	18	1.6	62	14	4.2		7.4	429	48
Range =	ND-.056	ND-.077	.67-1.95	42-198	13-192	18-275				3.7-13.9		6.8-7.8	100-801	5-48
Median =	0.026	0.03	1.56	151	30	118.5				6.7		7.3	207.5	11.25

Bluff Ck. near CTH A						Station 10030053						
	Lab parameters						Field parameters					
	NH3	NO3+2	TKN	TP	TSS	Turbidity	Temp	D.O.	D.O.sat.	pH	Cond.	Transp.
Date	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(NTU)	(C)	(mg/l)	(%)	(SU)	(umhos/cm)	(cm)
06/10/2009	0.02	ND	2.86	121	22	94.3	13.9	9.1	88.3	7.4	210	15.5
Bluff Ck. at Valley Brook Rd			Station 10015463									
	Lab parameters						Field parameters					
	NH3	NO3+2	TKN	TP	TSS	Turbidity	Temp	D.O.	D.O.sat.	pH	Cond.	Transp.
Date	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(NTU)	(C)	(mg/l)	(%)	(SU)	(umhos/cm)	(cm)
06/10/2009	0.022	ND	1.01	99	22	87.6	16.3	9.3	95.5	7.7	210	14
08/16/2010	0.058	0.041	1.71	159	37	138	20.1	6.3	69.4	7.1	136	11
08/18/2010	0.077	0.042	2.35	47	506	459	17.3	7.6	79.1	6.9	83	9
Range =	.022-.077	ND-.042	1.01-2.35	47-159	22-506	87.6-459		6.3-9.3		6.9-7.7	83-210	9-14
Median =	0.058	0.041	1.71	99	37	138		7.6		7.1	136	11
Unnamed tributary to Bluff Ck @ CTH C					Station 10017178							
	Lab parameters						Field parameters					
	NH3	NO3+2	TKN	TP	TSS	Turbidity	Temp	D.O.	D.O.sat.	pH	Cond.	Transp.
Date	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(NTU)	(C)	(mg/l)	(%)	(SU)	(umhos/cm)	(cm)
06/10/2009	0.021	ND	0.92	73	4	11.7	13.9	9.7	93.7	7.7	422	95

Table 13. Bear Creek Watershed Water Quality Data 2009-2012

Bear Ck. downstream Hwy 2/53 Station 10029781

	Lab parameters								Field parameters					
Date	NH3 (mg/l)	NO3+2 (mg/l)	TKN (mg/l)	TP (ug/l)	TSS (mg/l)	Turbidity (NTU)	Chl. A (ug/l)	DP (ug/l)	Temp (C)	D.O. (mg/l)	D.O.sat. (%)	pH (SU)	Cond. (umhos/cr	Transp. (cm)
08/16/2010	0.056	0.069	2.26	125	18	66.2			19.3	8.2	87.7	7.5	178	15
08/18/2010	0.049	0.08	2.06	230	329	335			17.1	8.5	88.5	7	111	7
09/10/2010	0.035	0.069	1.42	104	24	76.9			12.4	8.1	76.3	7.5		12.5
10/06/2010				109	21	79.3			8.9	6.6	57.6	7.5		12
11/16/2010				164	24	119			1.1	12.9	91.6	7		13
06/13/2012	0.017	0.068	1.21	102	71	65.4	17.4	22	18.7	7.1	92.5	7.7	450	13
09/20/2012	ND	ND	0.95	112	9	14.9	1.61	62	13.2	7.4	70	7.6	939	50.5
Range =	ND-.056	ND-.080	.95-2.26	102-230	9-329	14.9-335				6.6-12.9		7-7.7	111-939	7-50.5
Median =	0.035	0.069	1.42	112	24	76.9				8.1		7.5	314	13

Bear Ck. near City Limits Rd Station 10015470

	Lab parameters						Field parameters					
Date	NH3 (mg/l)	NO3+2 (mg/l)	TKN (mg/l)	TP (ug/l)	TSS (mg/l)	Turbidity (NTU)	Temp (C)	D.O. (mg/l)	D.O.sat. (%)	pH (SU)	Cond. (umhos/cm)	Transp. (cm)
06/10/2009			1.42	125	29	128	12.6	9.4	88.6	7.5	295	6
09/29/2009				154	18	16.5	9.8	6.8	60.2	7.7	494	46
10/30/2009				143	30	124	6.7	11.2	91.2	7.2	272	10
08/05/2010		0.025	1.74	128	25	74	23.1	6.2	72.5	7.2		13
08/09/2010		0.027	1.79	178	30	86.9	21.6	7.9	89.9	6.8		13
08/16/2010	0.061	0.041	1.45	128	24	68.9	19.3	7.8	84.9	7.2	142	23
08/18/2010		0.071	1.82	179	118	164	17	8	83	6.9		11
09/14/2010	0.038	0.039	1.61	98	13	37.5	13	5.5	86		177	57
Range =	.038-.061	0.25-.071	1.42-1.82	98-179	13-118	16.5-164		5.5-11.2		6.8-7.7	142-494	6.0-46
Median =	0.05	0.039	1.68	135.5	27	80.5		7.9		7.2	272	13

Bear Ck. @ CTH Z Station 10029778

	Lab parameters						Field parameters					
Date	NH3 (mg/l)	NO3+2 (mg/l)	TKN (mg/l)	TP (ug/l)	TSS (mg/l)	Turbidity (NTU)	Temp (C)	D.O. (mg/l)	D.O.sat. (%)	pH (SU)	Cond. (umhos/cm)	Transp. (cm)
06/10/2009	0.027	ND	1.3	136	17	113	13.3	8.4	80.3	7.4	178	10
08/20/2009					45	117	15	7.1	70	7.4		11
09/14/2010	0.022	ND	1.21	86	9	52.1	12.8	3.7	34.3	7.4	212	35
Range =	.022-.027	ND-ND	1.21-1.3	86-136	9.0-45	52.1-117		3.7-8.4		7.4-7.4	178-212	Oct-35
Median =	0.024	ND	1.26	111	17	113		7.1		7.4	195	11

Unnamed Tributary to Bear Ck. @ CTH Z Station 10015462

	Lab parameters						Field parameters					
Date	NH3 (mg/l)	NO3+2 (mg/l)	TKN (mg/l)	TP (ug/l)	TSS (mg/l)	Turbidity (NTU)	Temp (C)	D.O. (mg/l)	D.O.sat. (%)	pH (SU)	Cond. (umhos/cm)	Transp. (cm)
06/10/2009	0.051	0.066	1.93	162	24	107	15.1	9.4	93.5	7.3	88	9

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Appendix C: Stream Narratives

Waters in the St. Louis and Lower Nemadji River Watershed

Bear Creek (2834600)

This stream is a small and at least partly intermittent drainage feeder to Allouez Bay of the St. Louis River and has variable and seasonal flows. The mouth of Bear Creek is an important spawning area for northern pike and many other warm water species (Pratt 1996).

Bluff Creek (2833200)

Bluff Creek is an approximately 18.2 mile red-clay tributary of Lake Superior, which flows into Allouez Bay on the southeast side of the City of Superior. It is flashy in nature during high-water storm events or runoff periods, with seasonal low flow conditions.

Pratt (1996) noted that the mouth of Bluff Creek is an important spawning area for northern pike and other warm-water species. Epstein (1997) documented significant sources of pollutants include barnyards, livestock, cropland, and erodible stream banks, with septic system contributions present. Impacts to Bluff Creek noted from surveys conducted in 1997 and also 303d assessment in 2009 include significant turbidity, silt or sedimentation, and low flow conditions. It has also been previously noted that runoff from Burlington Northern rail-yards and engine house reaches the stream (Lake Superior Basin Water Quality Management Plan, WDNR, 1999).
Epstein (1997) found moderate richness of macroinvertebrate taxa and one rare macroinvertebrate at his study site.

Copper Creek (2836100)

Copper Creek flows 11.2-miles north of the Superior escarpment into the Nemadji River. Most of the stream is assumed to support a balanced fishery. The reach beginning from the town road crossing in section 25-26, T47N R14W and extending downstream about two miles to a warm water tributary is considered Class II trout waters reported to support brook trout. The unnamed tributary flowing north to Copper Creek in section 22, T27N, R14W is classified as supporting a Class I reproducing brook trout population and is listed as an exceptional resource water. The tributary has an extremely high gradient of 145 feet per mile but has a relatively small base flow. The bottom is mostly unstable sand with small amounts of gravel. Precipitated iron deposits cover most of the stream substrate at the headwaters. About an eighth of a mile of the stream flows within Pattison State Park. Both creeks are considered flashy based on in-stream debris and eroded banks.

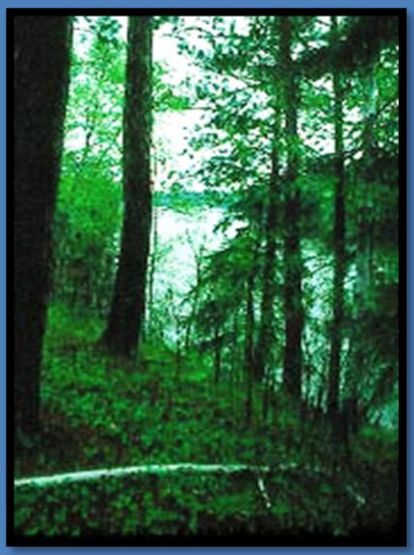
Crawford Creek (2835500)

Crawford Creek is a warmwater tributary to the Nemadji River, located just south of Superior, Wisconsin. It is primarily a runoff stream, with a turbid water supply due to mucky clay substrates and highly eroded clay banks. It is flashy in nature, characterized with low flows (it can be intermittent or dry in its upper portions) and having very high flows during storm or runoff events. Evidence of high flow or flooding events is common throughout, with banks five to six feet high and eroding into the creek, and log or brush jams common.

Faxon (Central Park) Creek (2843700)

Faxon Creek, which is also known locally as Central Park Creek, is 'officially' an unnamed tributary to Superior Bay (Lake Superior). The entire stream is within the City of Superior, Douglas County. From its mouth at Superior Bay and heading upstream, it flows for about its last 0.4 miles underground, passing under approximately six roads, highways, or RR crossings. Another 0.1 – 0.2 miles is channelized in this section leading upstream into Central Park.

Dwight's Point and Pokegama Wetlands is a state natural area (No. 300). Located at the confluence of the Pokegama and St. Louis Rivers near Lake Superior, Dwight's Point and Pokegama Wetlands features boreal forest, emergent marsh, and wet clay flats supporting shrub swamp and wet meadow. The SNA borders the St. Louis River estuary. Extensive deep and shallow marshes border the Pokegama River.



DNR SNA, photo by Thomas A. Meyer

Learn more about this SNA

City of Superior Dept. of Parks & Rec

Erosion on Bluff Creek – unstable side slopes can not withstand erosive flashy runoff events

Dutchman Creek (2847100)

Dutchman Creek is a nine-mile-long tributary to Lake Superior located on the eastern border of the City of Superior. On its way to Lake Superior, the creek flows near the city's municipal landfill and can be affected by trash. The creek is very turbid and although its riparian area is relatively undeveloped, it does receive some stormwater input from private landowner residences. Its principle water source is spring runoff and rain events. During seasonal low flow events, the river mouth can disconnect from Lake Superior and it cuts through sand beaches before reaching the lake. This is an important coastal wetland area for.

Nemadji River (2835300)

The Nemadji River drains approximately 433 square miles of land in Minnesota and Wisconsin before entering the Duluth-Superior Harbor in Superior Bay near the Burlington Northern Ore Docks in the City of Superior. High turbidity in the water column, mainly from high sediment loads, impair in-stream physical habitat in the river and its tributaries.

Rocky Run (2836300)

Rocky Run is a small, intermittent drainage feeder to Copper Creek, with unpredictable seasonal flows. A baseline survey conducted upstream of East Twin Creek Road in 2006 lends support to a current use designation of WWFF, with six fish species found during sampling at that site. However, Epstein (1997) noted significant problems (streambank erosion, barnyards, livestock, croplands, impoundment and tile, and minor contributions from septic systems, leading to significant turbidity and to a lesser extent, silt) which were identified during survey work conducted as part of the coastal wetlands evaluation. During this evaluation, only moderate invertebrate taxa richness was found, and no rare species.

Stony Brook (2836400)

Stony Brook is a four-mile long intermittent, drainage stream that originates just outside of Pattison State Park and is a tributary to Copper Creek. Although it was sampled as part of the coastal wetland evaluation (Epstein, 1997), it's existing and potential biological uses are listed as "unknown". Agricultural runoff from barnyards, livestock and cropland, streambank erosion, and to a lesser degree septic systems, all potentially contribute to significant turbidity and flashy or low flows.

Bluff Ck Trib At CTH C Near Pine St 10-31-18, Photo by Craig Roesler, Wisconsin DNR.

Appendix D: St. Louis and Lower Nemadji River Watershed Fish and Aquatic Life Use Attainment

Table 14. Use Attainment Watershed Table

Stream Name	WBIC	Local Waterbody Name	Start Mile	End Mile	Current Use	Attainable Use	Supporting Attainable Use	Designated Use	Source of Designated Use	Assessment	Data Quality	Cate-gory	MAP
Bear Creek	2834600	Bear Creek	0	11	WWFF	WWFF	Not Supporting - Impaired	Default FAL	NR102 Classification	Monitored	B1, B4, P3	5P	Map
Birch Creek	2833500	Birch Creek	0	6.87	FAL	FAL	Supporting	Default FAL	NR102 Classification	Monitored	B4	2	Map
Bluff Creek	2833200	Bluff Creek	0	18.2	WWSF	WWSF	Not Supporting - Impaired	Default FAL	NR102 Classification	Monitored	B4, B1, P3	5P	Map
Copper Creek	2836100	Copper Creek	0	7.18	Cold (Class II Trout)	Cold (Class II Trout)	Not Assessed	Cold	1980 Trout Book Classification	Evaluated	B1	3	Map
Copper Creek	2836100	Copper Creek	7.18	9.58	Cold (Class II Trout)	Cold (Class II Trout)	Not Assessed	Cold	1980 Trout Book Classification	Evaluated	B1	3	Map
Copper Creek	2836100	Copper Creek	9.6	11.2	Cold (Class II Trout)	Cold (Class II Trout)	Not Assessed	Cold	1980 Trout Book Classification	Evaluated	B1	3	Map
Crawford Creek	2835500	Crawford Creek	0	9.12	WWFF	FAL	Not Supporting - Impaired	Default FAL	NR102 Classification	Evaluated: Older Data	B1, B2	5A	Map
Dutchman Creek	2847100	Dutchman Creek	0	9.68	WWFF	WWFF	Supporting	Default FAL	NR102 Classification	Monitored	B1, B2	2	Map
L. Superior Beach	2751220	Wisconsin Point Beach 5	0	0.22	FAL	FAL	Not Assessed	Default FAL	NR102 Classification	Monitored	NA	2	Map
L. Superior Beach	2751220	Wisconsin Point Beach 3	0	0.11	FAL	FAL	Not Supporting - Impaired	Default FAL	NR102 Classification	Monitored	NA	5A	Map
L. Superior Beach	2751220	Wisconsin Point Lot 12 Beach	0	9.83	FAL	FAL	Not Assessed	Default FAL	NR102 Classification	Monitored	NA	2	Map
L. Superior Beach	2751220	Wisconsin Point Beach #2	0	0.48	FAL	FAL	Not Supporting - Impaired	Default FAL	NR102 Classification	Monitored	NA	5A	Map
L. Superior Beach	2751220	Allouez Bay Beach 3	0	0.04	FAL	FAL	Not Assessed	Default FAL	NR102 Classification	Monitored	NA	2	Map
L. Superior Beach	2751220	Wisconsin Point Beach 4	0	0.13	FAL	FAL	Not Assessed	Default FAL	NR102 Classification	Monitored	NA	2	Map
L. Superior /Amnicon River	2751220	Lake Superior, Mouth of Amnicon	0	59.1	FAL	FAL	Not Assessed	Default FAL	NR102 Classification	Not Assessed	NA	3	Map
L. Superior Beach	2751220	Barker Island Inner Beach	0	0.4	FAL	FAL	Recreational Use Impaired	Default FAL	NR102 Classification	Monitored	NA	5A	Map

Stream Name	WBIC	Local Waterbody Name	Start Mile	End Mile	Current Use	Attainable Use	Supporting Attainable Use	Designated Use	Source of Designated Use	Assessment	Data Quality	Cate-gory	MAP
Lake Superior	2751220	Lake Superior	0	186 acres in WI	Cold	Cold	Recreation/Fish Consumption (Hg, PCBs)	Default FAL	NR102 Classification	Monitored	B1	5A	Map
Little Pokegama R.	2845200	Little Pokegama R.	0	8.55	FAL	FAL	Fully Supporting	Default FAL	NR102 Classification	Monitored	B1, P3	2	Map
Morrison Creek	2847900	Morrison Creek	0	8.6	WWFF	WWFF	Not Assessed	Default FAL	NR102 Classification	Evaluated	B1	3	Map
Mud Lake	3000116	Mud Lake	0	135	FAL	FAL	Not Assessed	Default FAL	NR102 Classification	Evaluated	NA	3	Map
Nemadji River	2835300	Lower Nemadji River	0	38.2	WWSF	WWSF	Not Supporting - Impaired	FAL Warmwater	NR102 Classification	Monitored	B1, B4	5A	Map
Newton Creek	2843650	Newton Creek	0	1.76	LAL	WWFF	Not Supporting - Impaired	LFF	Classification Survey Pending	Monitored	B1, B4, P3	5A	Map
Pokegama River	2844000	Pokegema River	0	25.7	FAL	FAL	Not Supporting - Impaired	LFF	NR104 Classification Survey	Monitored	B1, B4, T2, P3	5P	Map
Red River	2845800	Red River	0	6.3	Class III Trout	Cold (Class I Trout)	Supporting	Default FAL	NR102 Classification	Monitored	B1, B2	2	Map
Red River	2845800	Red River	6.3	7.35	FAL	FAL	Not Assessed	Default FAL	NR102 Classification	Not Assessed	NA	3	Map
Rocky Run	2836300	Rocky Run Creek	1.8	3.62	WWFF	WWFF	Supporting	Default FAL	NR102 Classification	Evaluated	B1, B2	3	Map
Unnamed	2836700	Trib. to Copper Creek	0		class I trout water	class I trout water	ERW and class I trout water	Class I Trout	NR102 Classification	Monitored	B1	2	

This table reflects the condition of waters in the study area and is stored in the Water Assessment Tracking and Electronic Reporting System (WATERS) and is continuously updated.

Current Use – current condition of water based on monitoring data.
Attainable Use – "ecological potential" of water based on water type, natural community, lack of human-induced disturbances.
Supporting Attainable Use – decision on whether the water's current condition is supporting its designated use under "water quality standards".
Designated Use – the water's classified use under NR102, Wisconsin Water Quality Standards, for Fish and Aquatic Life.
Source of Designated Use – Source of designation listed in designated use.
Assessment – field indicates what type of data or information supports the decisions in the table (current, attainable, and supporting attainable).
Data Quality – Specific data areas used for the decision
P –Physical, B – Biological, C – Chemistry, PA – Pathogens, H – Habitat

Data Quality Range 1-4 (1 – lowest level, 4 most sophisticated data collection)

Category indicates whether the water is meeting or not meeting standards

Category 2: Water meets at least 1 WQ standard

Category 3: Insufficient data

Category 4A: Water is impaired, TMDL in progress

Category 5A: Water is impaired, TMDL required.

Category 5P are waters that have total phosphorus levels that exceed the state water qulaity standard but which currently do not exhibit biological impairmnents.