Black Lake Tributary Study:

An assessment of six rivers and streams that supply Black Lake

2018

Prepared for:

Black Lake Preservation Society

By:

Tip of the Mitt Watershed Council

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Abstract

Relatively little is known about the water quality of many tributaries flowing into Black Lake. The general assumption is because Black Lake water quality remains high, so too, is the quality of water flowing into the Lake from the rivers and streams. The Upper Black River Council (UBRC) continues to heavily monitor and manage the high quality Upper Black River, the largest inlet to Black Lake. However, less is known of the other tributaries. The Black Lake Preservation Society partnered with Tip of the Mitt Watershed Council in 2018 to monitor and evaluate the water quality of numerous Black Lake tributaries to identify any problems, document baseline conditions, and facilitate possible corrective actions as necessary. Results indicate that some of the six studied tributaries carry large amounts of phosphorus and nitrogen, two nutrients that can cause excess algae and vegetation growth. Additionally, this was the first monitoring event, providing a snapshot in time for water quality data. Future work should include targeted monitoring of nutrients, education, outreach, and land protection.

Introduction

The most appropriate unit of division when assessing water resources is a watershed. A watershed is defined as the area across the landscape contributing water to a certain point. Precipitation, rain falling and snowmelt flowing over the land's surface either evaporates, soaks in to the ground, or eventually aggregates to form a network of small streams. The small streams eventually flow together to form larger rivers and lakes. Just as small watersheds can be combined when discussing a larger water system, lake-wide watersheds can be broken down into individual tributary watersheds.

Each individual watershed has a distinct drainage area. As water flows over the earth and eventual outlet to a stream or larger water body, water will encounter different materials and processes. While natural land cover like forests and wetlands in a watershed yields high-quality water downstream from natural ecosystem services (e.g. filtering of excess nutrients), an altered landscape generally degrades water quality. Nonpoint sources pollutants including nutrients, and soil particles (sediment) from erosion can result in negative impacts to water quality downstream. Contaminants coming from multiple diffuse sources are called nonpoint source pollution, as opposed to a single source, such as a factory. Contaminants can commonly occur in an urbanized setting, some related to automobiles, others related to cleaning or personal care products. Stormwater, often channeled out of city streets and into water bodies, can contain excess nutrients such as phosphorus and nitrogen. Ions such as chloride from road salt application during the winter is captured during the snowmelt and can be carried into nearby streams. The sum of all interactions in each watershed between land and runoff determines the water quality downstream. Due to this, the waters of any lake are inexorably linked to the watershed by which it is supplied.

Nonpoint source pollution is a continual threat to Michigan's pristine rivers, lakes, and streams. Nitrogen and phosphorus are two nutrients connected to water quality. They are key nutrients that are required for biological growth, but can become ecologically -harmful at excessive levels. Excessive nitrogen and phosphorus can cause shifts in the aquatic food web, encourage colonization by invasive species (e.g. *Phragmites* and narrow-leaved cattail), and cause a river system to become eutrophic. Eutrophic simply means excessive nutrients for biological productivity to the point of nuisance algal and vegetative growth. Too much productivity can lead to reduced dissolved oxygen levels which are harmful to fish and other organisms. This report documents nitrogen, phosphorus, and other physiochemical measurements (temperature, dissolved oxygen, specific conductivity, and pH) in six tributaries of Black Lake, Cheboygan County, Michigan.

To date, little is known about water flowing within all tributaries of Black Lake. The largest tributary, the Upper Black River, is well known to be healthy and continues to be heavily monitored and managed by the Upper Black River Council. There is one site on Stewart Creek downstream of S. Black River Rd. that was monitored in 2005 and 2015. The site (which can be found under the name 21MICH_WQX-160231 in the National Water Quality Monitoring Council's Water Quality Portal) was monitored by the Michigan Department of Environment, Great Lakes, and Energy (EGLE) as part of statewide sampling for trend analysis. The remaining tributaries have not previously been monitored. This project offers the first attempt of documenting baseline conditions in these tributaries. Results of this monitoring effort can be used for future reference and help identify possible water quality issues.

Study Area

As part of the Cheboygan River Watershed, the Black Lake Watershed is 558 square miles. For perspective, Black Lake Watershed comprises 37.7 percent of the 1,493-square-mile Cheboygan River Watershed (Figure 1). This does not mean 37.7% of the water in this large Watershed comes from Black Lake area, but it does show the relative size of area draining into Black Lake.

The surface area of a lake to the size of the watershed can be a bit more specific and help describe susceptibility to water quality issues.

Lakes with a large ratio of watershed area to lake surface area are considered more susceptible to nutrient enrichment and other types of pollution throughout the watershed than lakes with small ratios. As the ratio increases, this means there are additional sources and increased volume flowing into the lake. The potential for landscape changes and watershed development are also increased. This of course does not consider water depth, which could help buffer against potential issues from changes in the watershed. Nonetheless, susceptibility to water quality issues tends to increase as the watershed to lake surface area increases. The ratio of Black Lake's watershed to the lake surface area (watershed-to-surface area ratio) is quite large. Black Lake's Watershed is 35.04 times larger than the surface area of the Lake (Figure 2, a ratio of 35.04:1, or simply 35.04). This is high for large lakes in Northern Michigan. For example, the watershed-to-surface area ratio for Burt Lake is 14.8 and for Mullett Lake, only 9.74, while the ratio for Lake Michigan is 2.

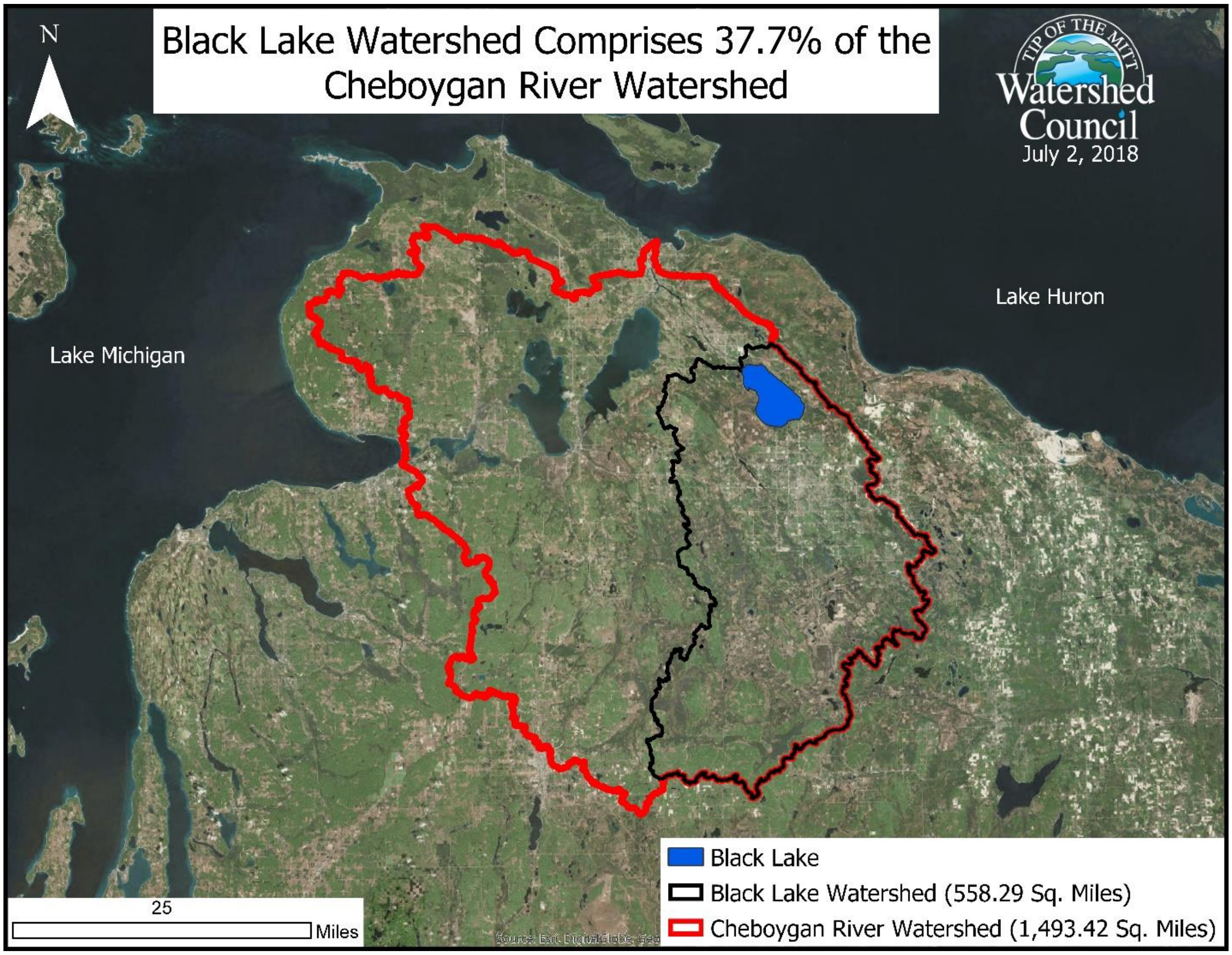

Figure 1. Black Lake Watershed size compared to Cheboygan River Watershed

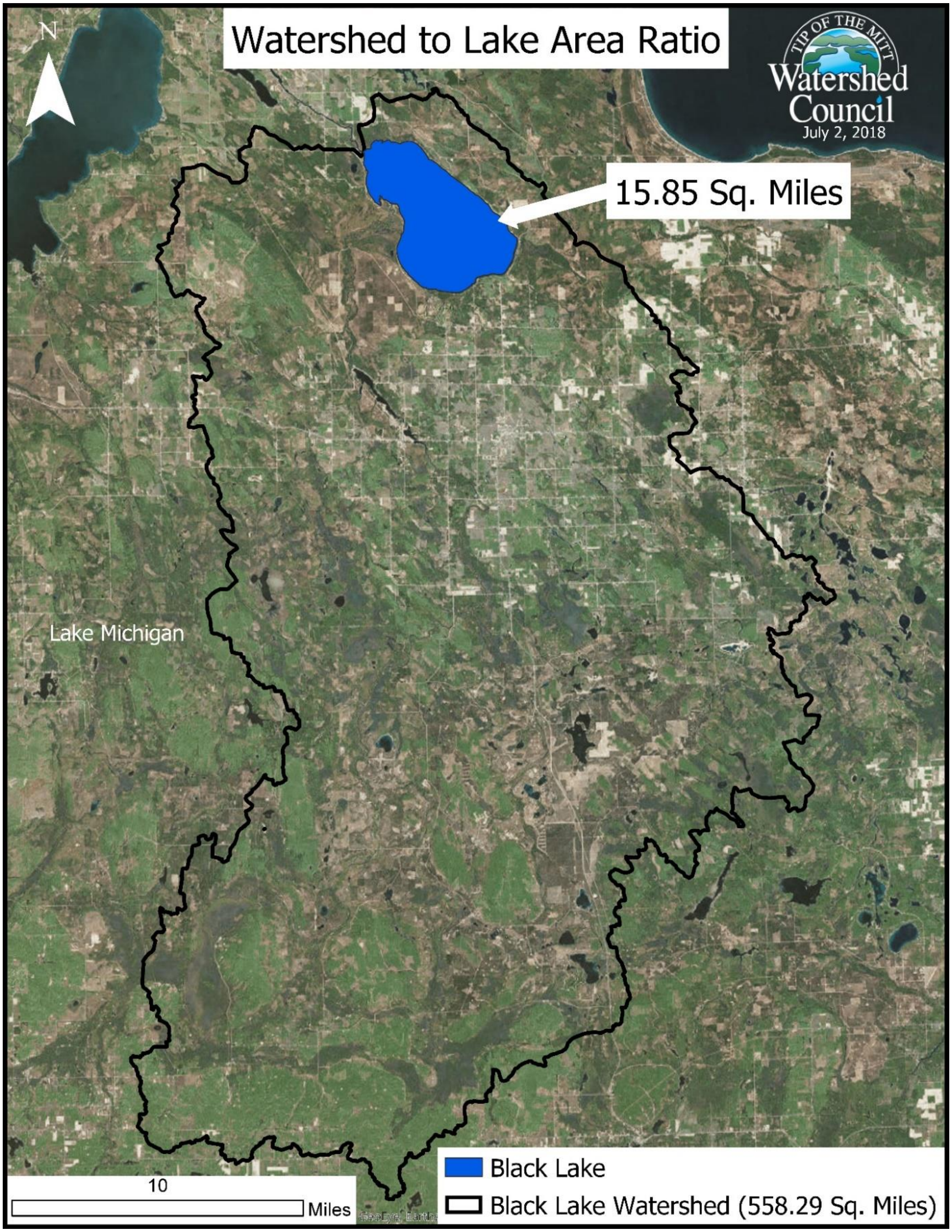

Figure 2. Black Lake Watershed to Surface area ratio

Fortunately, much of Black Lake's Watershed is forested, undeveloped, and has a protected status (Figure 3). The protective status is predominantly through the Pigeon River State Forest. This area is the largest contiguous block of state-owned land in Michigan's Lower Peninsula and is managed separately from other state forest lands in the area. Because of the unique features within the forest (Michigan's only elk herd, numerous high quality rivers and lakes, and the wilderness atmosphere of the area), more protective land and water management policies are in place than on most state forest lands. Undoubtedly the pristine landscape's high percentage of forest (43.74%), wetland (28.13%), and scrub/shrub (9.60%) has helped to maintain high water quality in Black Lake.

According to the Michigan Department of Natural Resources (DNR), many of the tributaries around Black Lake are important for spawning walleye and brook trout. The lower part of the Rainy River is important for closed to fishing in the spring to protect spawning walleye. It also provides spawning habitat for suckers. The upper reaches of the Rainy have cool to warm water, and a few of its tributaries could hold brook trout. Cold Creek is a little warmer than the main stem of the Rainy River. Stoney Creek and Fisher Creek also hold brook trout, although there is no data for Fisher Creek.

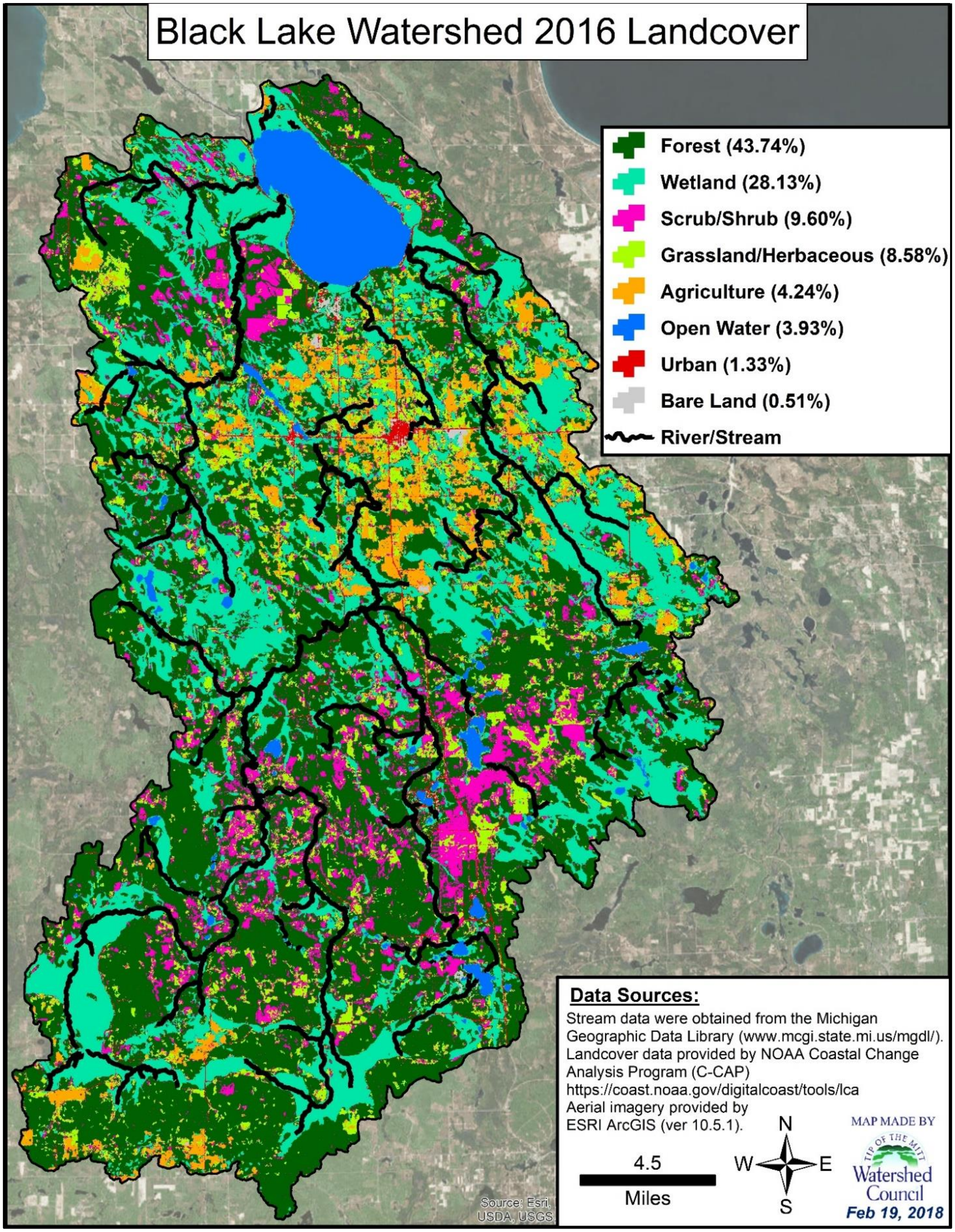

Figure 3. Black Lake Watershed Land Cover, 2016, CCAP

Methods

Detecting potential water quality issues for a lake can be difficult to identify at the lake watershed scale. Dissecting the large Black Lake Watershed down to smaller watersheds for each tributary is a more efficient, and detailed way of monitoring water flowing into Black Lake.

Black Lake has eight major tributaries draining the landscape and bringing water into the lake (Figure 4). The largest of these, the Upper Black River, is managed and maintained regularly by the Upper Black River Council (UBRC) and we would urge readers to seek out UBRC for more information on their work. The Upper Black River is considered incredibly healthy, a high-quality trout stream, surrounded by State forest and public and privately protected land. Due to existing knowledge and status of the Upper Black River, it was not included for this project. Mud Creek is another input that winds through largely wetland area and was also not a focus of this project. The remaining six, smaller tributaries drain a diverse landscape around Black Lake and were the focus for this report.

The six tributaries chosen as a focus were Fisher Creek, Stewart Creek, Stony Creek, Cold Creek, Cain's Creek, and the Rainy River (Figure 4). Each of these tributaries are unique in their position and role in the Watershed. Both Fisher and Stewart Creeks are small streams which flow through Black Lake Golf Course with a majority of their Watersheds residing within the United Auto Workers Conference Center. Both downstream sites on Fisher and Stewart are located just upstream of the Black Lake Golf Course and the upstream sites were on Hutchinson Highway, draining agricultural areas. Stony Creek is the second-longest of the tributaries monitored. The most upstream site (M-68) was chosen to capture water quality near Stoney Links Golf Course. The middle site on N. County Line road matches a Tip of the Mitt Watershed Council Watershed Academy site, which is monitored by local high school students. The N. County Line Rd. site also drains an agricultural area. The most downstream site for Stony Creek is located close to Black Lake at the end of Stewart's Beach Rd. and Waverly Ave. Stony Creek is also the closest tributary to the City of Onaway, and winds through a mixture of wetland, forest, urban, and agricultural areas. Of the tributaries monitored, the Rainy River is the largest and flows through mostly wetland and some agriculture landscape. The Rainy River eventually connects with Cold Creek near the mouth before entering Black Lake. The Rainy's M-68 site is influenced by agriculture. Cold Creek drains a largely wetland area and the site was in the Little Traverse Conservancy (LTC) Cain's Creek Swamp Nature Preserve.

Monitoring was conducted once during the spring and fall, and twice in the summer (Table 1). Water samples were collected at mid-depth in 10% hydrochloric acid-washed Nalgene bottles (250 mL) and transported by cooler to the University of Michigan Biological Station chemistry laboratory. Each sample was processed for a standard suite of nutrient ions. Fluoride, Chloride, Nitrite, Nitrate, Sulfate, Phosphate, Total Nitrogen and Total Phosphorus were measured. An YSI EXO I and Hach Minisonde 4a multiparameter probe were used to collect physiochemical measurements. These measures include temperature, dissolved oxygen, conductivity, and pH. These data, when used in conjunction with chemical analyses, can be used to determine the degree of pollution within each tributary. Dissolved oxygen plays an important role in evaluating the impacts of pollution on life processes in streams, particularly oxygen depletion. Specific conductivity provides a measure of electrical conductance. With more ions (nutrients) in the water, this value typically also increases. Therefore, once a baseline is established, any deviation would help describe an increase or decrease in ions present in the water. Comparing across tributaries also helps describe possible external inputs, such as phosphorus or chloride.

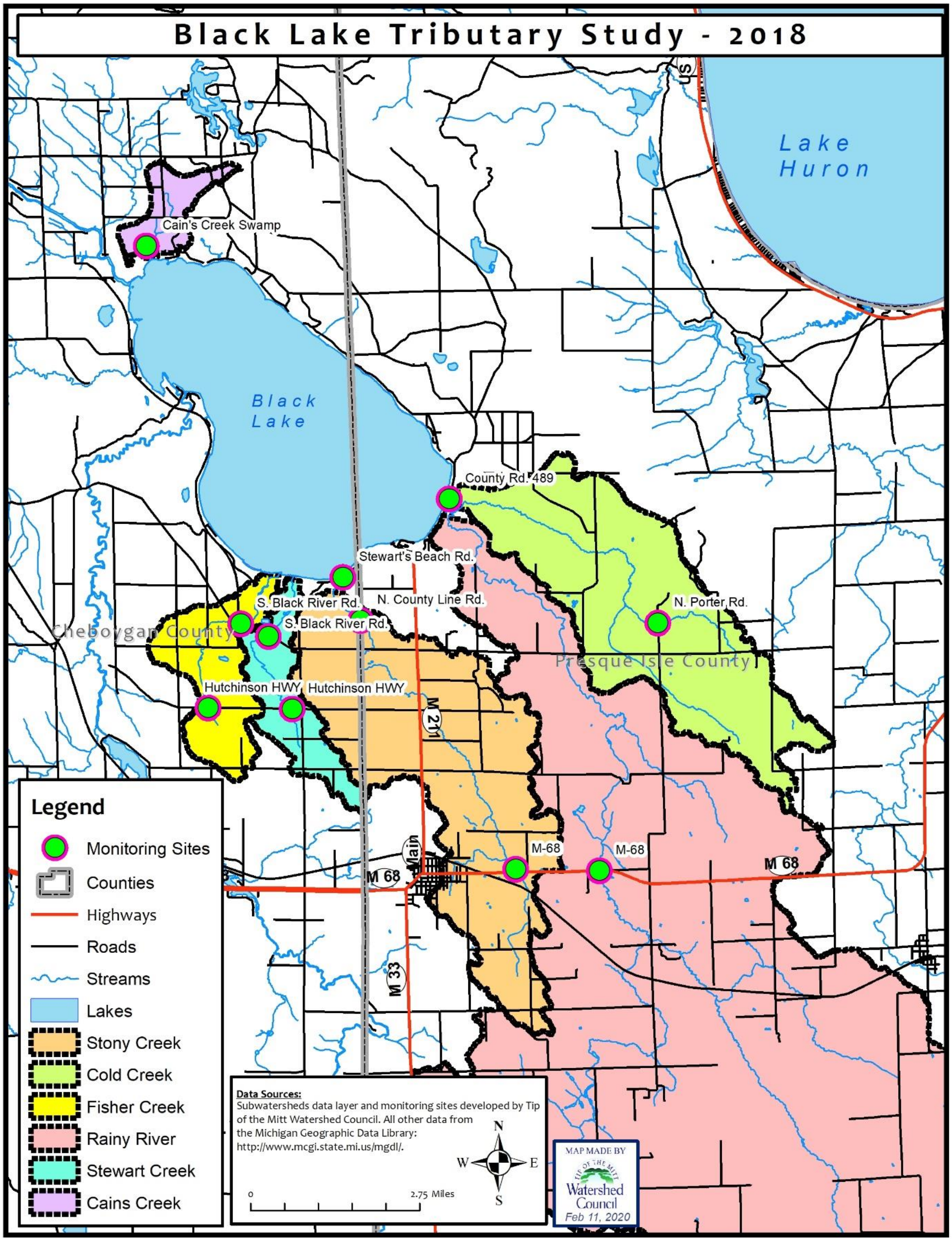

Figure 4. Black Lake Tributary Study 2018 Monitoring Sites and Watersheds

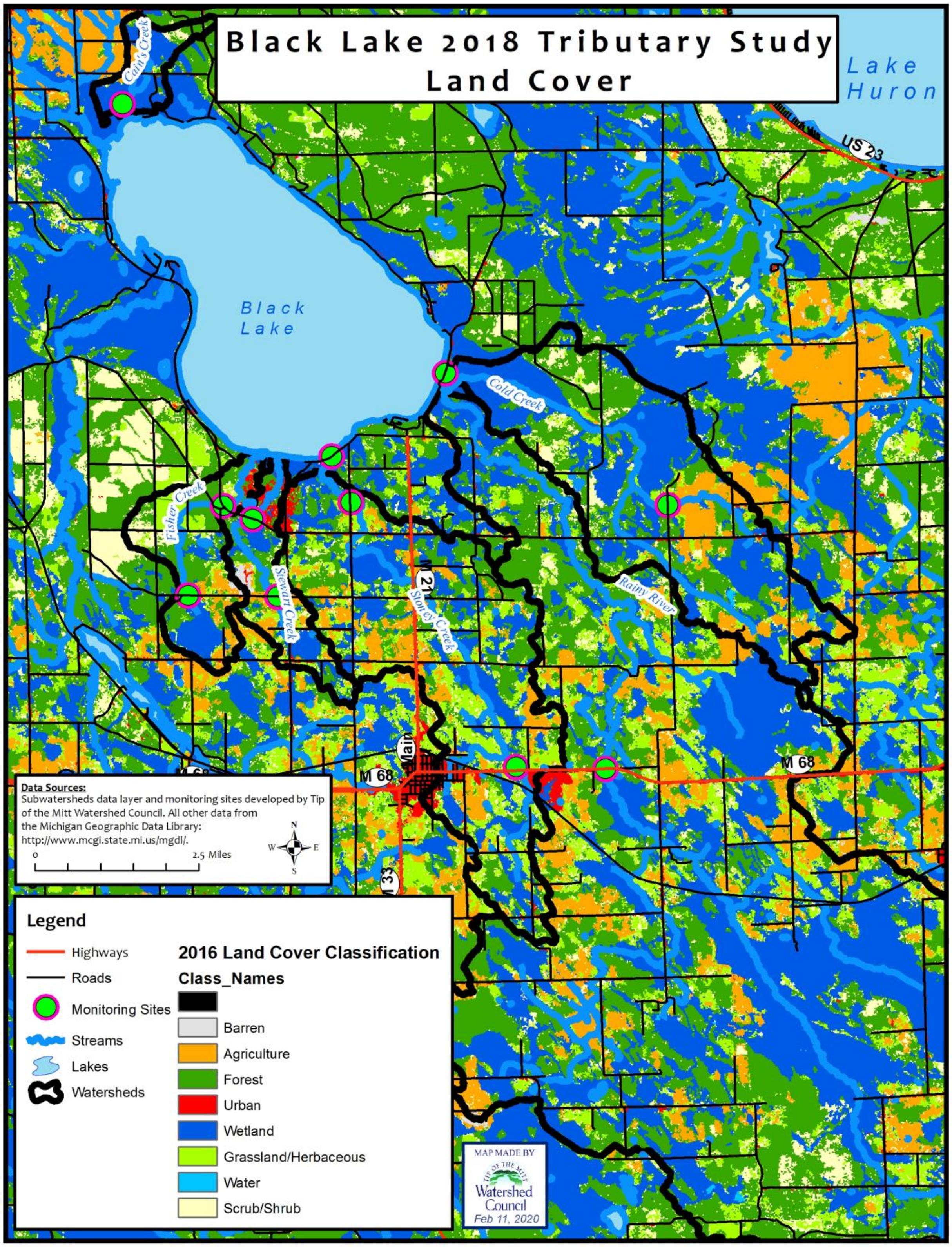

Figure 5. Black Lake Tributary Study 2018 Monitoring Sites and Landcover

Table 1. Black Lake Tributary Study 2018 Monitoring Events

Stream Name	Site Location	Spring	Summer	Summer**	Fall
Cain's Creek	Cain's Creek Swamp	5/10/18	7/21/18	Dried up	10/16/18
Cold Creek	Porter Rd.	5/10/18	7/21/18	Dried up	10/16/18
Fisher Creek	S. Black River Rd.	5/10/18	7/21/18	8/28/18*	10/16/18
	Hutchinson HWY	5/10/18	Dried up	Dried up	10/16/18
Rainy Creek	M-68	5/10/18	7/21/18	8/28/18*	10/16/18
Rainy/Cold Confluence	County Rd. 459	5/10/18	7/21/18	8/28/18*	10/16/18
Stewart Creek	S. Black River Rd.	5/10/18	7/21/18	8/28/18*	10/16/18
	Hutchinson HWY	5/10/18	7/21/18	8/28/18*	10/16/18
Stoney Creek	Stewart's Beach Rd./Waverly Ave.	5/10/18	7/21/18	8/28/18*	10/16/18
	N. County Line Rd.	5/10/18	7/21/18	8/28/18	10/16/18
	M-68	5/10/18*	7/21/18*	8/28/18*	10/16/18

*no temperature, dissolved oxygen, conductivity, or pH

** denotes wet weather event

Results

Physical Measurements

Conductivity is a measure of the ability of water to conduct an electric current resulting from the concentration of charged particles (ions) dissolved in the water. Conductivity is not addressed in EGLE Part 4 Water Quality Standards, though Rule 51 (323.1051) provides a framework for regulating total dissolved solid (TDS) concentrations from point source discharge. TDS in mg/L can be estimated from specific conductivity readings by using the widely applied multiplication factor of 0.67. Estimated TDS concentrations for conductivity measurements from all sites were below the Rule 51 TDS maximum of 750 mg/L. On average, conductivity readings were highest at Stewart Creek at S. Black River Rd. and all sites peaked in July (Figure 6).

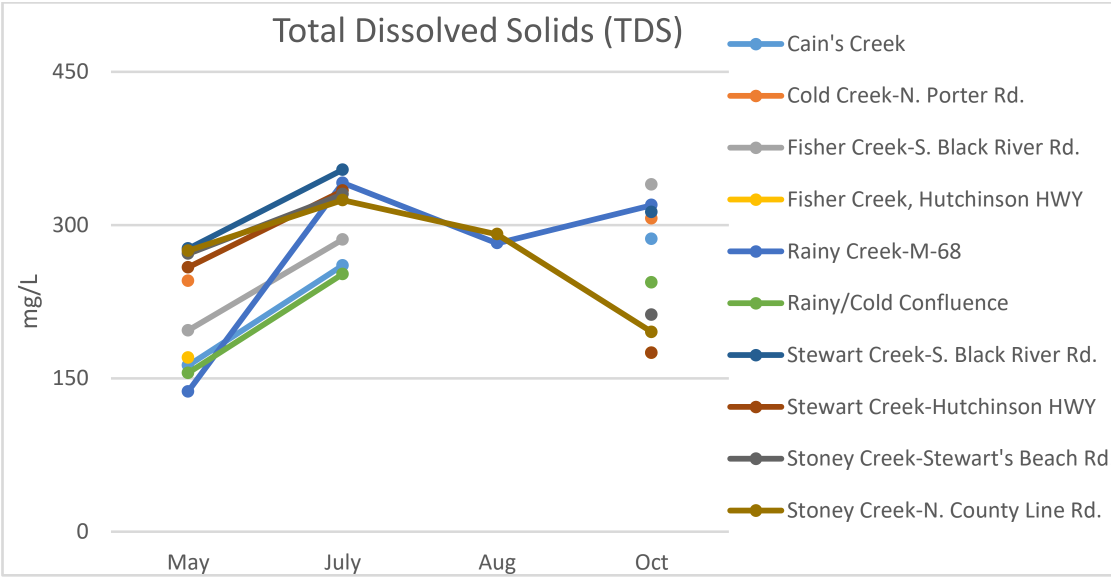

Figure 6. 2018 Black Lake tributaries total dissolved solids.

Hydrogen ions, expressed as pH, ranged from 7.31 to 8.31 throughout all sites and water bodies (Figure 7). All pH readings fell within the range of 6.5 to 9.0 required for all Michigan surface waters according to EGLE Part 4 Water Quality Standards, Rule 53 (323.1053).

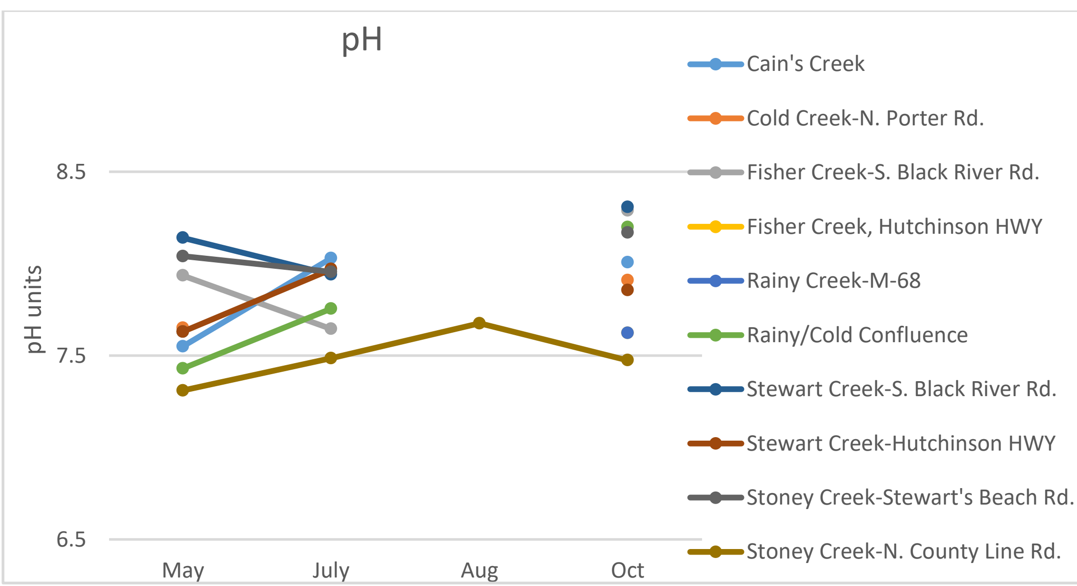

Figure 7. 2018 Black Lake tributaries pH.

Dissolved oxygen concentrations ranged from 4.3 mg/L to 11.01 mg/L (Figure 8). EGLE Part 4 Water Quality Standards minimum dissolved oxygen concentration for sustaining a cold-water fishery is 7 mg/L. Levels were too low to meet the 7 mg/L standard most often at the July monitoring event, likely because there was little flow in each stream channel. Dissolved oxygen was consistently low at Rainy Creek's upstream site at M-68 and Stoney Creek's where it crosses N. County Line Rd. until October.

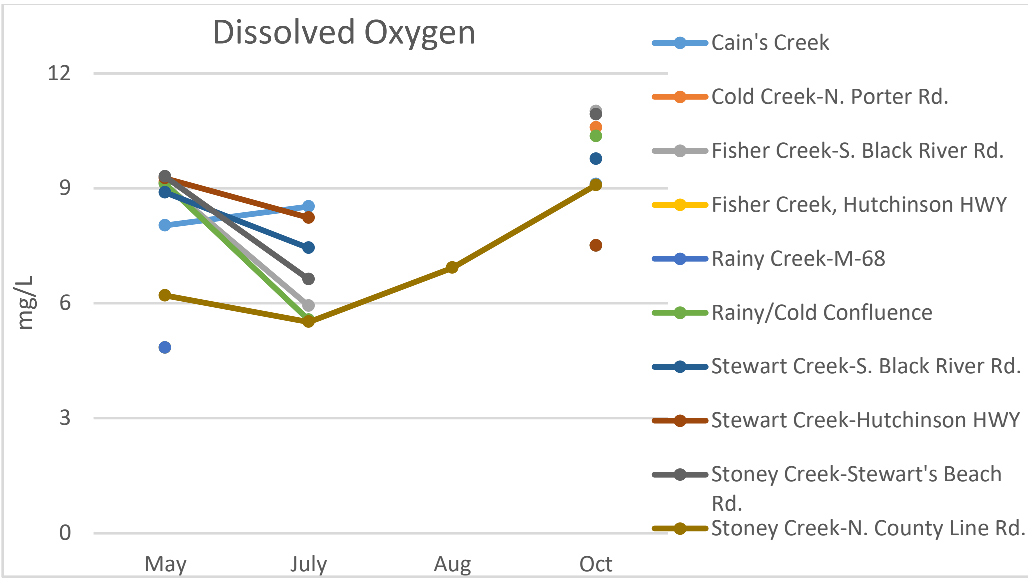

Figure 8. 2018 Black Lake tributaries dissolved oxygen.

The lower Rainy River, Stoney Creek, and Fisher Creek are all cold-water streams that can hold brook trout. According to EGLE Part 4 Water Quality Standards, monthly maximum temperatures for streams supporting cold-water fish are set at 65° Fahrenheit (18.3° Celsius) for May, 68° Fahrenheit (20.0° Celsius) for July and August and 56° Fahrenheit (13.3° Celsius) for October. All sites except for Stewart Creek at M-68, Cain's Creek, and Fisher Creek at S. Black River Rd. exceeded July and August temperature standards for a cold-water fishery (Figure 9).

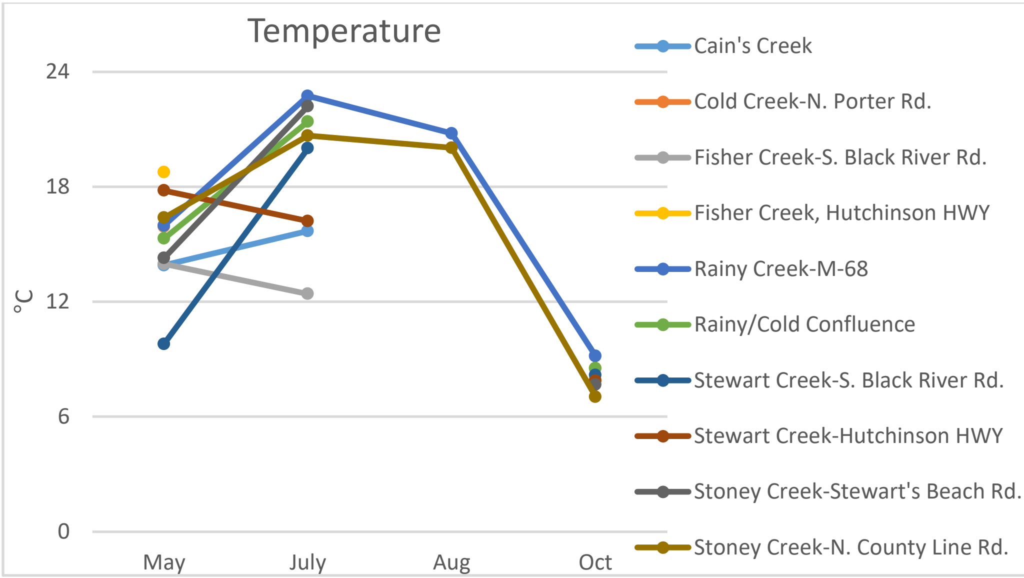

Figure 9. 2018 Black Lake tributaries temperature.

Nutrients

Chloride

Chloride, a component of salt, is naturally present at low levels in Northern Michigan surface waters due to the marine origin of the underlying bedrock (typically < 5 mg/L). Although Michigan has not set limits for chloride in surface waters, the United States Environmental Protection Agency (USEPA) recommends that 230 mg/L be established for chronic toxicity and 860 mg/L for acute toxicity (USEPA, 2012). Although current chloride levels in Northern Michigan are generally far below the USEPA toxicity thresholds, increases are indicative of other pollutants reaching our waterways (e.g., automotive fluids from roads; nutrients/bacteria from septic systems). Chloride concentrations were below USEPA thresholds for all streams, but more than the typical concentration of < 5 mg/L. Notably, Fisher Creek at S. Black River Rd. had the highest concentrations from July to October, while the Creek's upstream site dried up from July to August (Figure 10). The downstream site was likely fed by an impoundment in the golf course, keeping it from drying up, and also loading the stream with more 13x as much chloride in October. Rainy Creek at M-68, had the second highest chloride levels throughout the year, hovering around 25 mg/L. The chloride is likely higher than natural conditions due to agriculture in the Watershed.

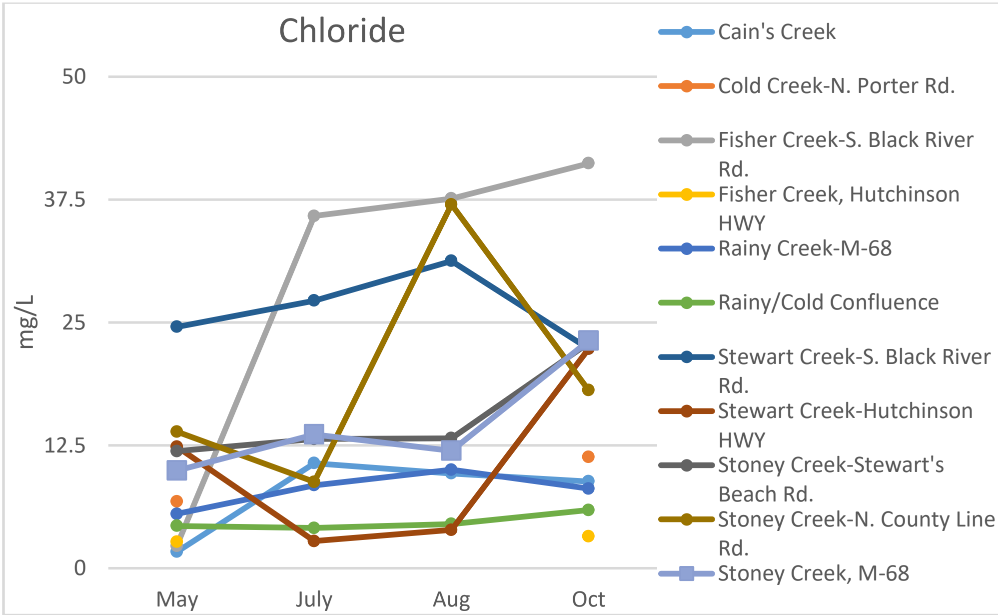

Figure 10. 2018 Black Lake tributaries chloride.

Total Phosphorus and Nitrogen

EGLE Part 4 Water Quality Standards does not include a numerical standard for nutrient concentration limits for surface waters. Regulation for surface waters is limited to the following narrative standard from Rule 60 Plant Nutrients (R 323.1060): “nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the waters of the state.” A TP concentration of 12 µg/L or less for streams in the Northern Michigan ecoregion is considered the reference condition by the United States Environmental Protection Agency (USEPA) “because it is likely associated with minimally impacted conditions, will be protective of designated uses, and provides management flexibility” (USEPA 2001). Total phosphorus (TP), which is a measure of all phosphorus types in the water sample, reached a peak of 237.5 µg/L in August at the first upstream site on Stoney Creek (Figure 11). All streams had concentrations above the EPA’s 12 µg/L standard at least one monitoring event except for Stewart Creek at S. Black River Rd., Fisher Creek at S. Black River Rd., and Stoney Creek at M-68. Rainy Creek at M-68 and Stoney Creek at Stewart’s Beach Rd. followed a similar path through the season with peaks in August (Figure 12). The Stewart Creek at M-68 peaked in October.

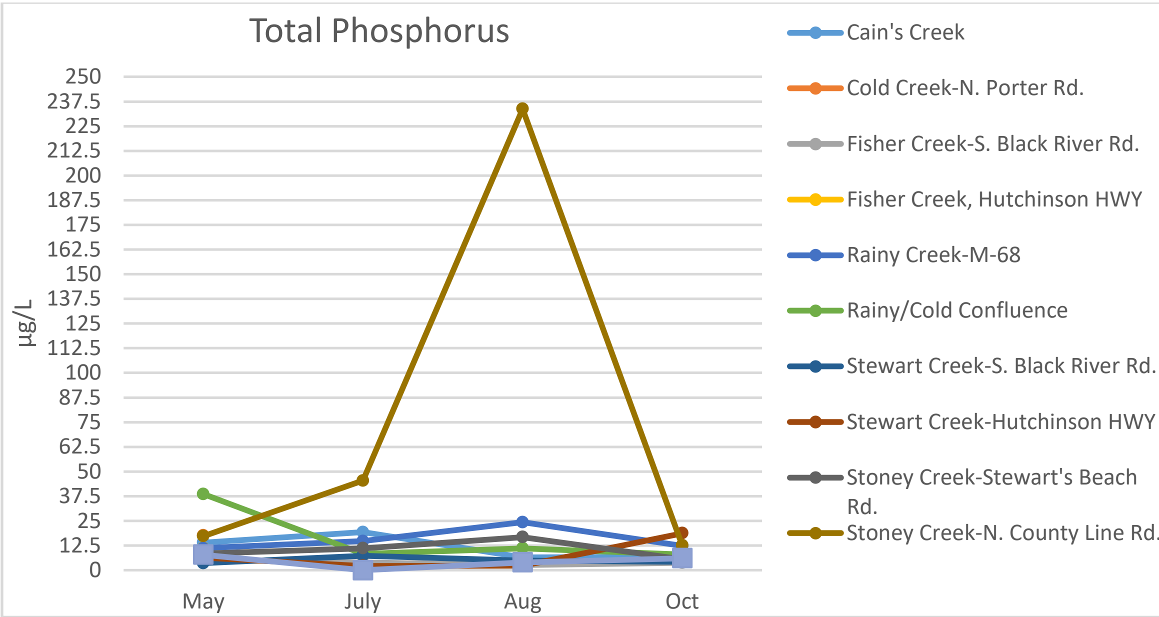

Figure 11. 2018 Black Lake tributaries total phosphorus.

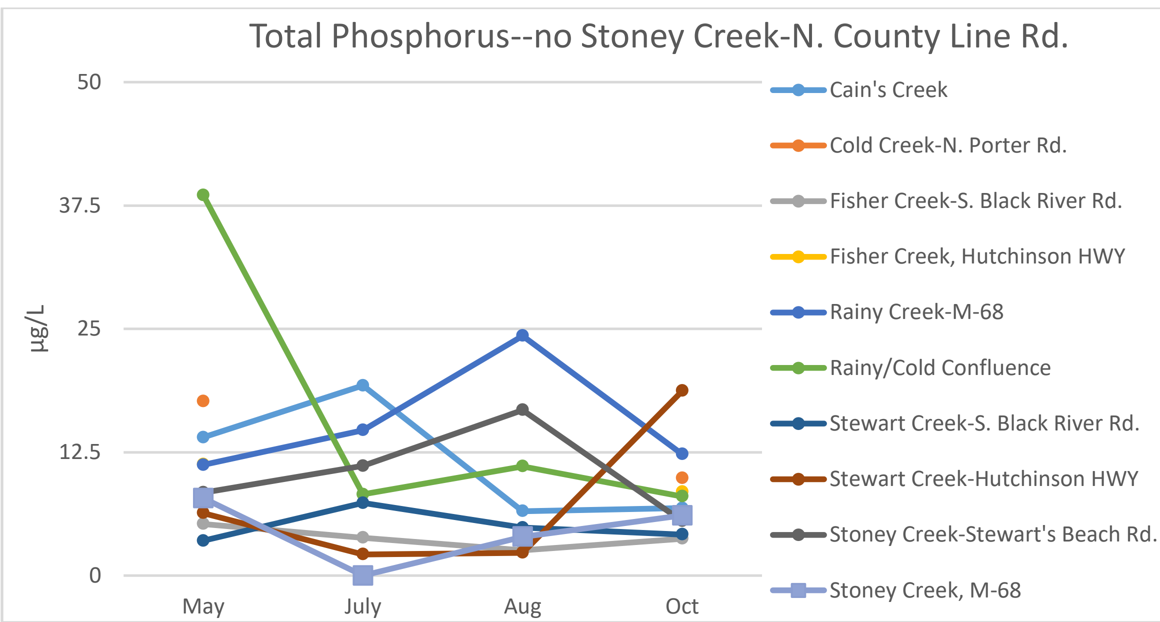

Figure 12. 2018 Black Lake tributaries total phosphorus without Stoney Creek at M-68.

Total nitrogen (TN) is a measure of all nitrogen types in a water sample. The USEPA TN reference condition of 440 µg/L for minimally impacted conditions for Northern Michigan streams was exceeded in May and October at Cain's Creek and the Cold Creek at N. Porter Rd. (Figure 13). Fisher Creek had no exceedances at S. Black River rd., but the upstream site at Hutchinson Highway exceeded standards in both May and October (dried up in July and August). Both Rainy Creek at M-68 and the Rainy/Cold Creeks confluence exceeded standards at every monitoring event except for July and August at the Rainy/Cold Creeks confluence. Stewart at S. Black River Rd. exceeded TN standards in July and October. The Stoney Creek at M-68 site exceed TN standards in May and October. Stewart Creek at Hutchinson Highway's July and August values of 2411.4 µg/L and 3178.4 µg/L, respectively, were the highest recorded during this study. Those values represent concentrations six and seven times greater than minimally impacted conditions for this region.

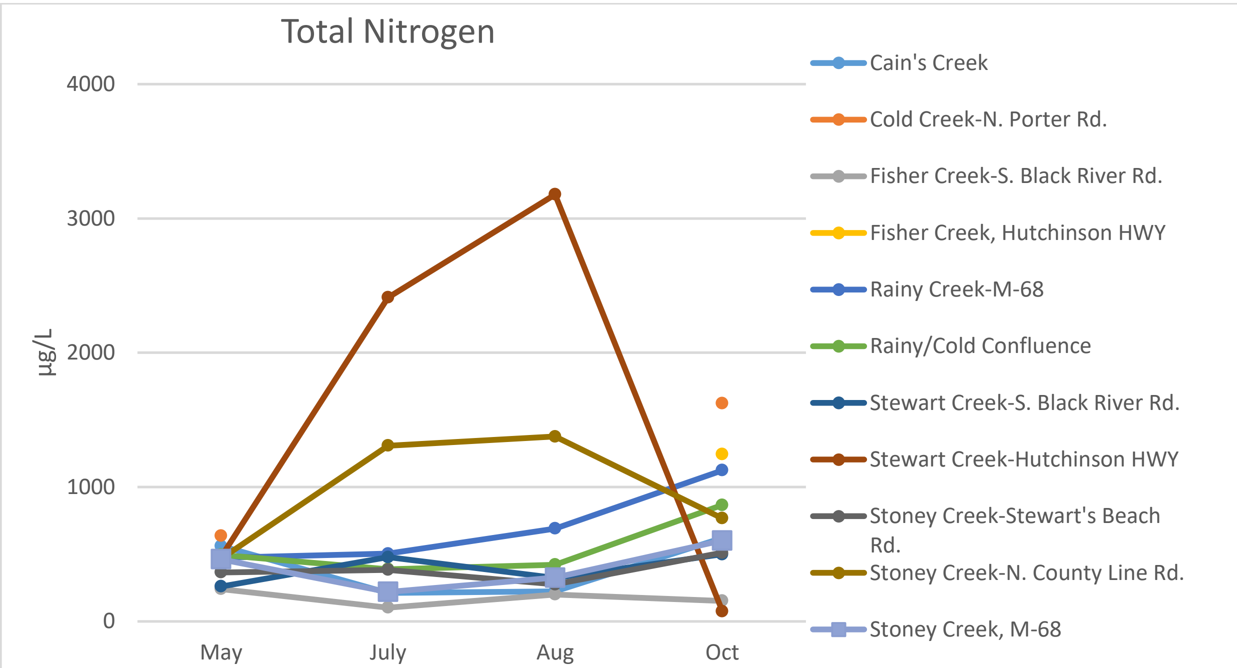

Figure 13. 2018 Black Lake tributaries total nitrogen.

Fluoride

Natural background levels of fluoride in surface waters are expected to be 0.3 mg/L. Only Fisher Creek at S. Black River Rd. showed higher than normal levels. Fisher Creek averaged 2.0 m/L from July to October (Figure 14). The Stoney Creek at Stewart's Beach Rd. measured 0.32 mg/L in July, but all other monitoring events at all streams were < 0.3 mg/L (Figure 15). 4 mg/L is the Maximum Contaminant Level for fluoride in drinking water. By comparison most municipal water supplies are fluoridated on an average of 1.0 mg/L. According to a 1992 report from the Fluoride Action Network Pesticide Project, the UAW Conference Center has a natural level of fluoride of 1.9 mg/L in the water system. Fluoride does not break down in the environment, so it is possible that if the golf course is recycling water from Fisher Creek, fluoride is being increased over time at the downstream site.

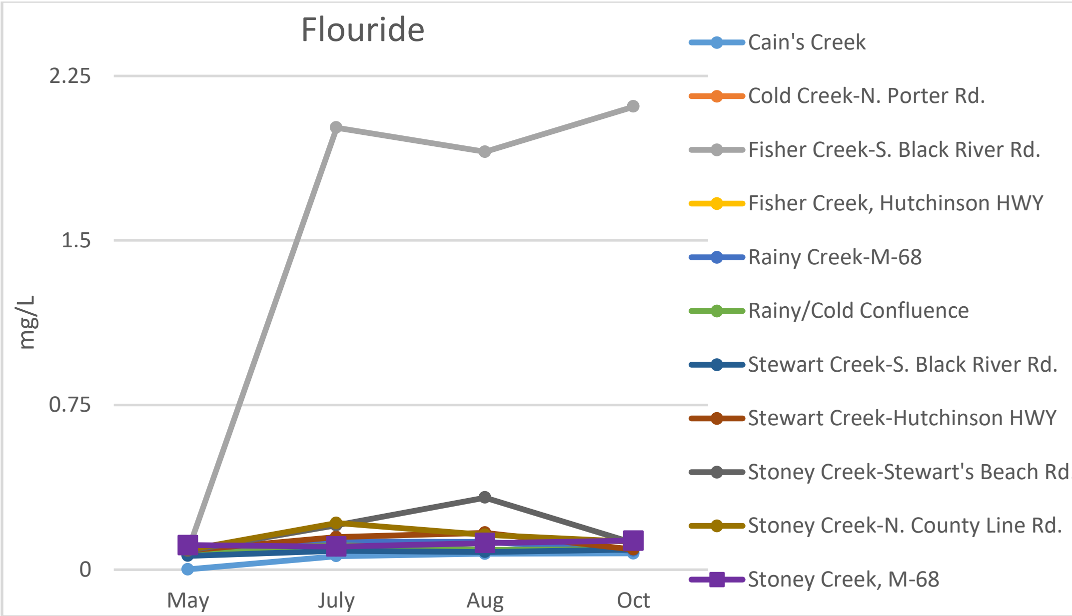

Figure 14. 2018 Black Lake tributaries fluoride.

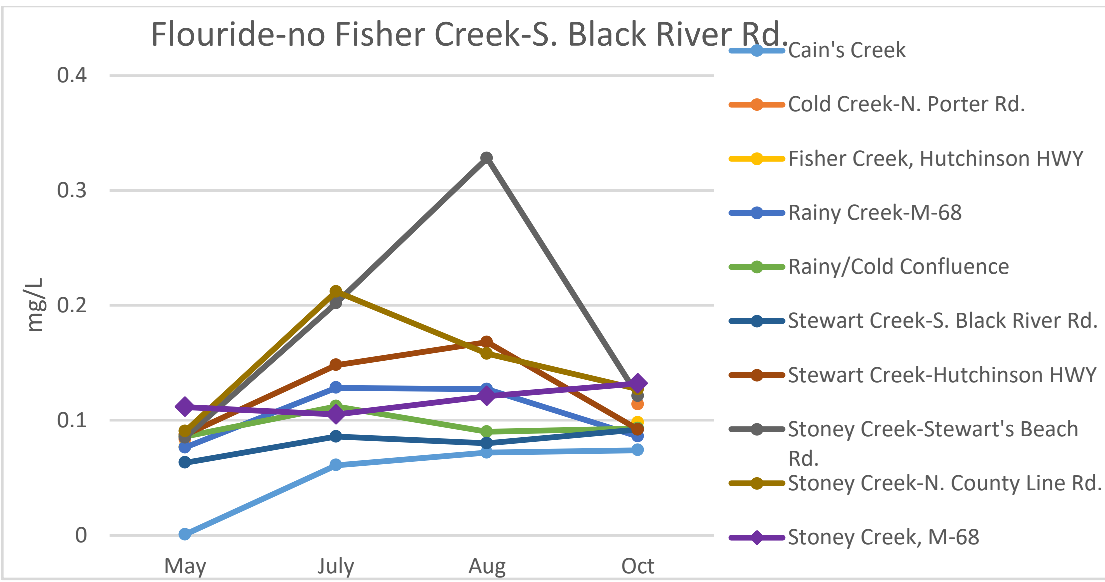

Figure 15. 2018 Black Lake tributaries fluoride without Fisher's Creek at S. Black River Rd.

Sulfate

Sulfate is the reduced form of the element sulfur, known for its rotten egg smell. Sulfate can be naturally occurring and is often the result of the decomposition of organic matter, atmospheric deposition, or they can be picked up by water passing through rock or soil containing gypsum or other minerals. Elemental sulfur is a nutrient for plants and concentrations of more than 0.5 mg/L promote algal growth. Sulfates are not toxic to plants or animals at normal concentrations. Mining activity can produce sulfide (another form of sulfur) runoff, which can then form sulfates by cycling through natural processes in the environment.

High sulfates originating from mining sulfide have been a problem in Minnesota, where groups have worked with the Minnesota Pollution Control Agency (MPCA) to create sulfate water quality standards to protect wild rice. Since 1973 the rule has been 10 mg/L or less. In 2015, an MPCA study found that low sulfide is more important for wild rice production because of the variability of sulfate between individual water bodies, but no amendments to the water quality standards have been approved by the Minnesota legislature. Michigan does not have a water quality standard for sulfate.

Black Lake tributaries also have a variable amount of sulfate, ranging from less than 1 mg/L to nearly 70 mg/L (Figure 16). The middle Stoney Creek site on N. County Line Rd. saw a big spike of sulfate in August and stayed high through October. The upstream Stoney Creek site on M-68 didn't spike until October. The Fisher Creek downstream site on S. Black River Rd. was consistently higher than other sites from July through August. Both sites on Stewart Creek peaked in October. All of these sites have golf courses either upstream or at the site. Fertilizer treatments on golf courses could be contributing sulfur, which may be applied to make the soil more alkaline. The sulfur could be converting to sulfate downstream from the golf courses. Sulfur could naturally be in the system as well and could be identified through drinking water well testing.

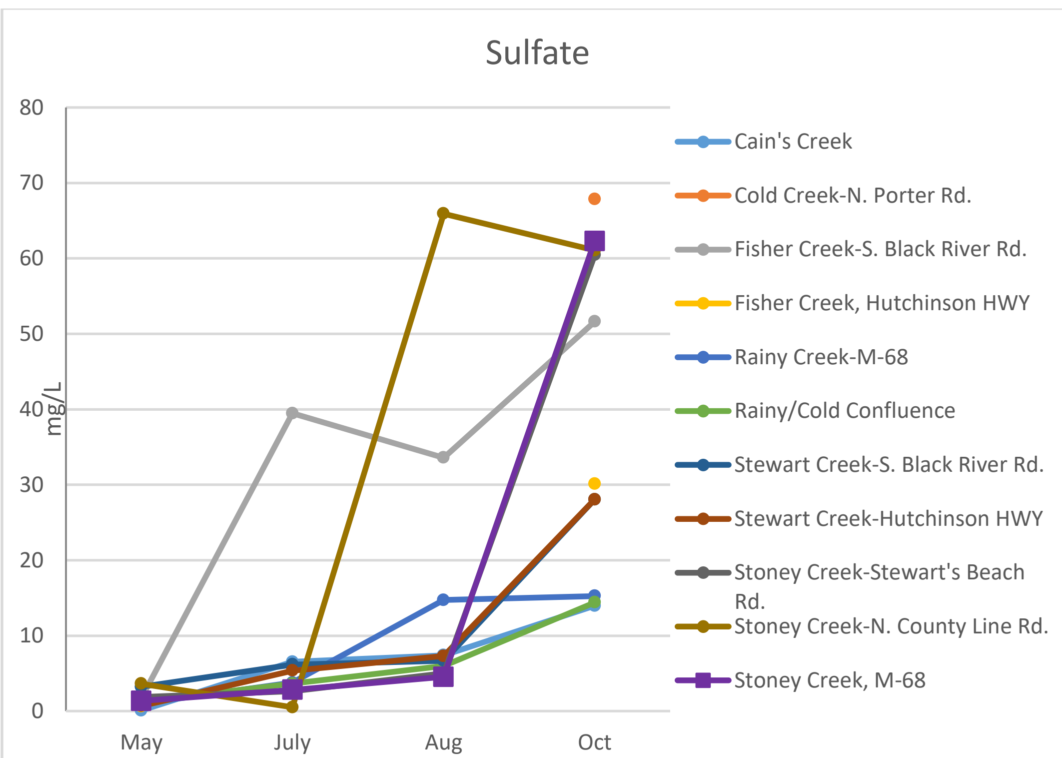

Figure 16. 2018 Black Lake tributaries sulfate.

Stream Biology

In addition to data generated by this tributary study, macroinvertebrates living in Stoney Creek were collected by Watershed Academy students from Onaway High School. Macroinvertebrates are insects and non-insects without a backbone that are big enough to be seen with the naked eye. Common examples would be spiders, "rolli pollis," and worms. The larval form of macroinvertebrates is a beginning life stage that many of the critters spend in streams and lakes before they hatch into adult flying craneflies, black flies, mosquitoes, and mayflies. Macroinvertebrates can be bioindicators of stream health because certain ones (mayflies, stoneflies, and caddisflies) only like to live in very clean water Students have completed monitoring at Stoney Creek at N. County Line Rd. twice per year since 2016. Since 2016, the Stoney Creek site at N. County Line Rd. has always had a sensitive macroinvertebrate population. Using Michigan Clean Water Corps (MiCorps) scoring, it received a "Good" rating (between 34 and 48 points), which is one step below "Excellent" (Table 2). Knowing the stream can support sensitive macroinvertebrates gives more evidence that the stream has good water quality.

Table 2. Macroinvertebrate scores at Stoney Creek at N. County Line rd.

Date	5/12/2016	10/14/2016	5/10/2017	10/13/2017
MICorps Score	35	34.3	38	40
Date	5/14/2018	10/24/2018	5/8/2019	10/4/2019
MICorps Score	42	35.6	34.4	42.1

Discussion

Baseline conditions within six tributaries of Black Lake were monitored in the spring, summer, and fall of 2018. Conductivity (reported as TDS) and pH were not a concern for any stream because they met EGLE water quality standards. Dissolved oxygen was mostly a concern at the Rainy River at M-68, which consistently did not meet EGLE water quality standards.

It is difficult to determine whether temperature fluctuations may be a concern due to the minimal amount of temperature and discharge data. Consistently monitoring temperature (for instance every day or every hour) throughout the spring, summer, and fall seasons, along with measuring the amount of water coming downstream would help describe why temperatures are warmer and if they are affected by large rain events. Since most temperature data was lost for August, the only two comparable sites for August are Cain's Creek and Rainy Creek at M-68. Both sites are minimally shaded and away from developed areas. Both sites saw decreased temperatures in August, which was also the wet monitoring date. This data, although minimal, suggests that surrounding land use is not impacting temperature. Cain's Creek and Fisher Creek were the coldest creeks from May through June, possibly because they are more influenced by groundwater. Assessing fish populations in creeks would help understand if the warmer temperatures can truly support fish and if temperatures are affecting fish populations. Overall, the abundance of natural landcover in the Watersheds of each stream is important in buffering stream temperatures. Natural landcover should be preserved to reduce the possibility of increased water temperatures.

Total nitrogen results were concerning, especially the high values in Stewart and Stoney Creeks. Monitoring conducted by EGLE also found high total nitrogen in Black Lake on July 10, 2019 after monitoring for a blue-green algae bloom. Excess nitrogen from agricultural operations (fertilizers or manures) or lawns (especially large lawns like golf courses) can run off the land during wet events. The abundance of nitrogen found in Stewart and Stoney Creeks at the August monitoring event correlates with a large rain event. The Stewart Creek site was at S. Black River Rd., just at the beginning of the Black Lake Golf Club. Stoney Creek at N. County Line Rd. is a few miles downstream from the Stoney Links Golf Course. While the site nearest the Stoney Links Golf Course did not have a high value, it is unknown if the timing of these monitoring events affected results. Excess nitrogen can cause harmful algal blooms.

Total phosphorus (TP) was most concerning at the middle Stoney Creek site at N. County Line Rd. Rainy Creek at M-68 was also concerning because most results met or exceeded the EPA's 12 µg/L standard. Both of these sites drain agricultural areas, which could contribute to excess TP. Likely, TP is coming from surface water runoff, since the peak for most sites was during the August wet event. Most rivers and streams are phosphorus-limited. Phosphorus drives biological productivity, leading to algae and vegetation growth. When algae and vegetation dies, their decomposition lowers dissolved oxygen in the water. While oxygen was not extremely low during the August phosphorus event at Stoney Creek/N. County Line Rd., excess algae and vegetation dying off afterwards or even farther downstream could lower oxygen later. Phosphorus is also a driver of blue-green algal blooms.

Filamentous algae, which differs from blue-green in that it grows in long hair-like strands, can be a good indicator for excess nutrients. A common kind of filamentous algae is the genus *Cladophora*. In the 2017 Black Lake Shoreline Survey conducted by the Watershed Council, the majority of Black Lake had *Cladophora*. The southern shore was rated very low to medium-high density of *Cladophora* in some areas, especially west and east of Fisher Creek and in other spots near tributary outlets (

Figure 17). The excess nutrients in some of the tributaries may be promoting algal growth along Black Lake's shoreline. The blue-green algae bloom from July 2019 was also located on the southern shore.

While Stoney Creek had some of the highest nutrients, macroinvertebrate scores were good at the N. County Line Rd. site. There is room for improvement at this site, and perhaps reducing nutrients in the stream could improve habitat for macroinvertebrates. Macroinvertebrate surveys in other tributaries would be another tool to help define priorities.

Fluoride levels were elevated slightly above groundwater levels at the Fisher Creek site on S. Black River Rd. The fluoride levels in Fisher Creek may be coming from groundwater and they may also be increased if golf course managers are recycling water in the Black Lake Golf Club reservoir on Fisher Creek. Stewart Creek also runs through the Golf Club and its fluoride levels are less than 0.1 mg/L. Fluoride concentrations on all other streams is at or below expected natural background levels of 0.3 mg/L. Fluoride in increased concentrations can be toxic to fish and invertebrates, but the area's hard water may be buffering the effect. Fisher Creek especially has higher chloride that the other streams in this study, which would make it more likely to buffer toxic effects of fluoride.

Sulfate is not usually a concern for surface water and the same goes for Black Lake tributaries. Sulfates in surface waters usually become a concern when acid mine runoff enters streams. There are no known mining operations in the watersheds of these streams and gypsum deposits are located farther south in Michigan. This baseline monitoring is important for future protection of these waters.

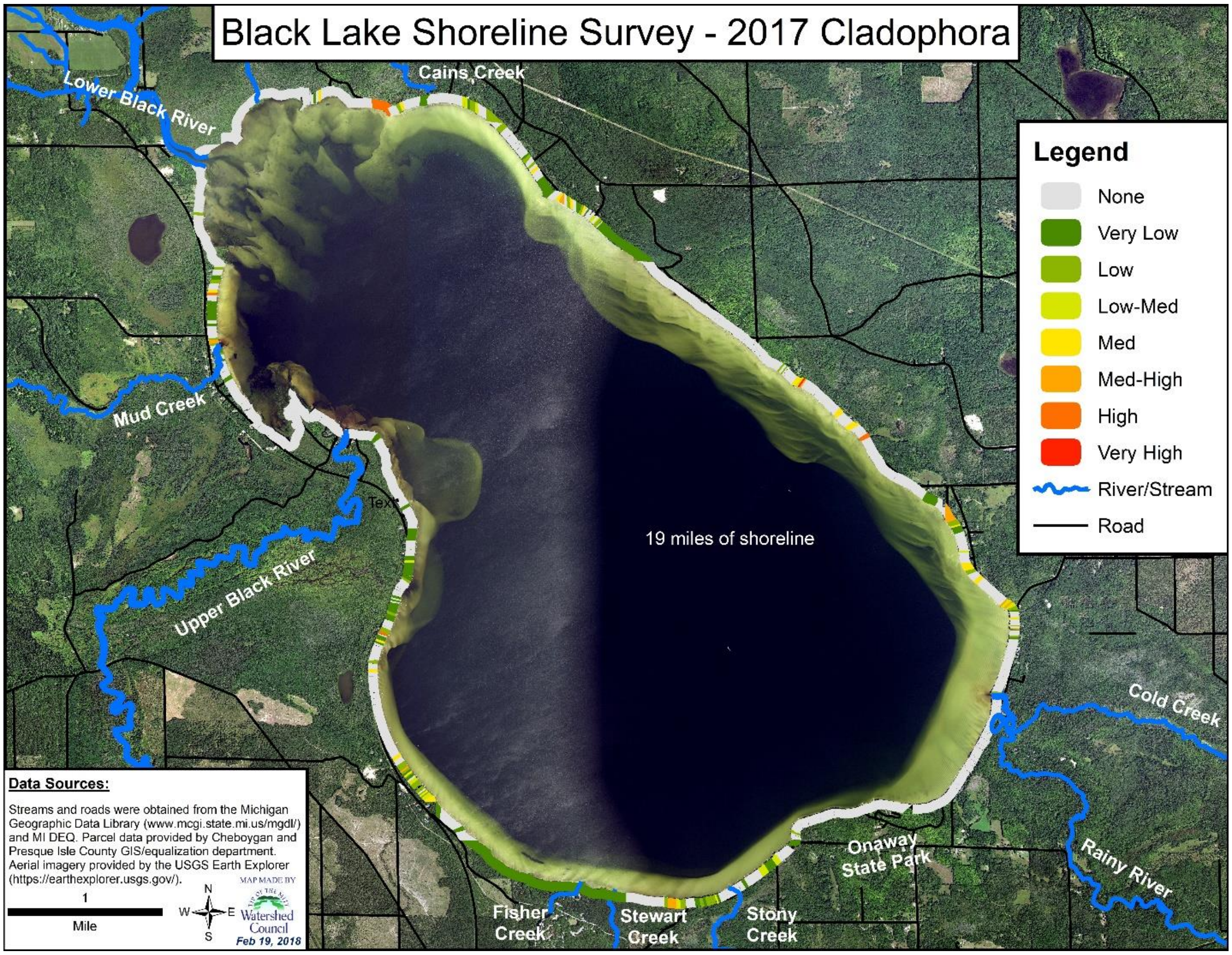

Figure 17. Cladophora findings from the 2017 Black Lake Shoreline Survey.

Recommendations

1. Share the results of this study with Black Lake Preservation Society, Black Lake Association, Huron Pines, Upper Black River Council, Michigan Department of Natural Resources, and Michigan Department of Environment, Great Lakes, and Energy

2. Investigate possible sources of potential groundwater-fed nutrients.

3. Work with golf courses to educate about how nutrients can affect surface water.

4. Work with golf courses to reduce mowing to the water's edge, retaining vegetation to reduce nutrients.

5. Conduct additional targeted monitoring on Fisher, Stewart, and Stoney Creeks to investigate sources of nutrients.

6. Work with Michigan Department of Transportation and county road commissions to minimize nonpoint source pollution (i.e. – chloride) entry at road/stream crossings. Direct

road runoff away from surface waters where feasible. Municipal and private stormwater sources may exist as well.

7. Maintain river protection efforts by commenting on EGLE permit applications and remaining active in local government.

8. Assess algal communities in Black Lake to determine if changes are occurring as a result of excessive inputs from the tributaries.

9. Repeat this monitoring project every five to ten years to evaluate changes in each tributary.

10. Conduct fish population assessment in Fisher Creek.

11. Cooperate with EGLE to report all harmful algal blooms (HABs).

12. Participate in Tip of the Mitt Watershed Council's Volunteer Stream Monitoring programs to continue gathering data.

13. Continue participating in Tip of the Mitt Watershed Council's Volunteer Lake Monitoring program, ensuring nitrogen and phosphorus are measured

14. Work with LTC and Huron Pines to preserve forests and wetlands to keep water quality high.

15. Conduct temperature monitoring from May through October to understand seasonal changes in tributaries.

16. Collect discharge monitoring data to understand how stormwater affects nutrient concentrations in streams.

17. Monitor nitrogen levels on Black Lake during the summer.

18. Participate in Watershed Academy efforts to monitor water quality at Stoney Creek.