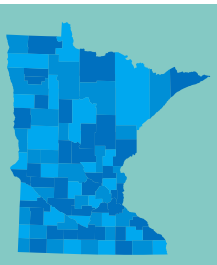
Lac qui Parle River

May 2020

Lac qui Parle River Watershed Stressor ID Report

A study of local stressors limiting the biotic communities in the Lac qui Parle River Watershed.

MINNESOTA POLLUTION CONTROL AGENCY



Authors

Chandra Henrich

Contributors/acknowledgements

Mike Koschak
Jon Lore
Lac qui Parle- Yellow Bank Watershed District

Matt Moon

Brett Nagle

Katherine Pekarek-Scott

Minnesota Pollution Control Agency

520 Lafayette Road North | Saint Paul, MN 55155-4194 |

651-296-6300 | 800-657-3864 | Or use your preferred relay service. | Info.pca@state.mn.us

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Key terms & abbreviations

AUID	Assessment Unit ID
BOD	biological oxygen demand
CADDIS	Causal Analysis/Diagnosis Decision Information System
DO	Dissolved Oxygen
DNR	Minnesota Department of Natural Resources
EPA	United States Environmental Protection Agency of the United States
EPT	Ephemeroptera, Plecoptera, and Trichoptera
FIBI	Fish Index of Biological Integrity
GP	Glide/Pool
HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
IWM	Intensive Watershed Monitoring
MIBI	Macroinvertebrate Index of Biological integrity
mg/L	milligrams per Liter
MPCA	Minnesota Pollution Control Agency
MSHA	MPCA Stream Habitat Assessment
RR	Riffle/Run
SID	Stressor Identification
SOE	Strength of Evidence
TIV	Tolerance Indicator Value
TMDL	Total Maximum Daily Load
WRAPS	Watershed Restoration and Protection Strategy

Executive summary

The Minnesota Pollution Control Agency (MPCA) uses biological monitoring and assessment as a means to determine and report the condition of the state's rivers and streams. This basic approach is to examine fish and aquatic macroinvertebrate communities and related habitat conditions at multiple sites throughout a major watershed. From these data, an Index of Biological Integrity (IBI) score can be developed, which provides a measure of overall community health. Stream and river reaches are assigned an Assessment Unit Identification (AUID) number and will be referred to as the AUID in this report. AUIDs with low IBI scores are determined to have a biological impairment. If biological impairments are found, stressors to the aquatic community must be identified.

Stressor identification is a formal and rigorous process that identifies stressors causing biological impairment of aquatic ecosystems and provides a structure for organizing the scientific evidence supporting the conclusions (Cormier et al. 2000). It looks at causal factors – negative ones harming fish and insects, and positive ones leading to healthy biology. Stressors may be physical, chemical, or biological. In simpler terms, it is the process of identifying the major factors causing harm to aquatic life. Stressor identification is a key component of the major watershed restoration and protection projects being carried out under Minnesota's Clean Water Legacy Act.

This report summarizes stressor identification work in the Lac qui Parle Watershed. There were 29 biological impairments in the Lac qui Parle River Watershed. The impairments in this report are organized by 12-digit Hydrologic Unit Code (HUC). There are eleven HUCs discussed in this report.

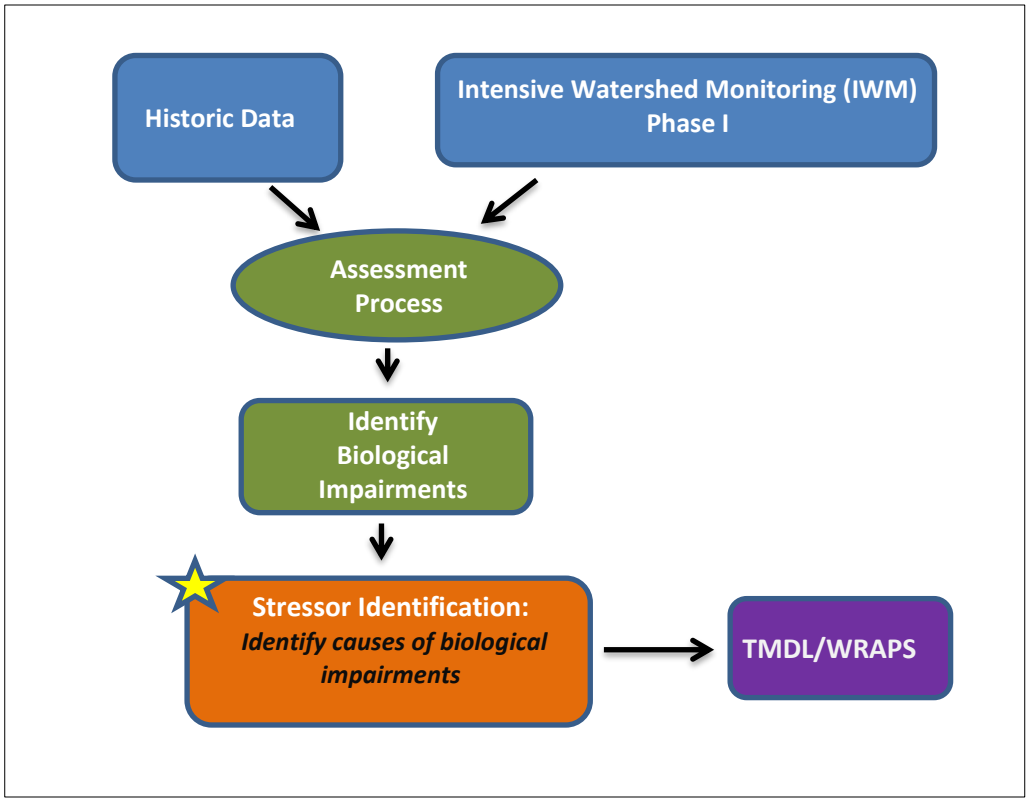
Introduction

Monitoring and assessment

Water quality and biological monitoring in the Lac qui Parle River Watershed have been ongoing for years. As part of the MPCA's Intensive Watershed Monitoring (IWM) approach, monitoring activities increased in rigor and intensity during the years of 2015-2016, and focused on biological monitoring (fish and macroinvertebrates) as a means of assessing stream health. The data collected during this period, as well as historic data obtained prior to 2015, were used to identify stream reaches that were not supporting healthy fish and macroinvertebrate assemblages (Figure 1).

Once a biological impairment is discovered, the next step is to identify the source(s) of stress on the biological community. A Stressor Identification (SID) analysis is a step-by-step approach for identifying probable causes of impairment in a particular system. Completion of the SID process does not result in a finished Total Maximum Daily Load (TMDL) study. The product of the SID process is the identification of the stressor(s) for which the TMDL may be developed. In other words, the SID process may help investigators nail down excess fine sediment as the cause of biological impairment, but a separate effort is then required to determine the TMDL and implementation goals needed to restore the impaired condition.

Figure 1. Process map of Intensive Watershed Monitoring, Assessment, Stressor Identification, and TMDL AND WRAPS processes

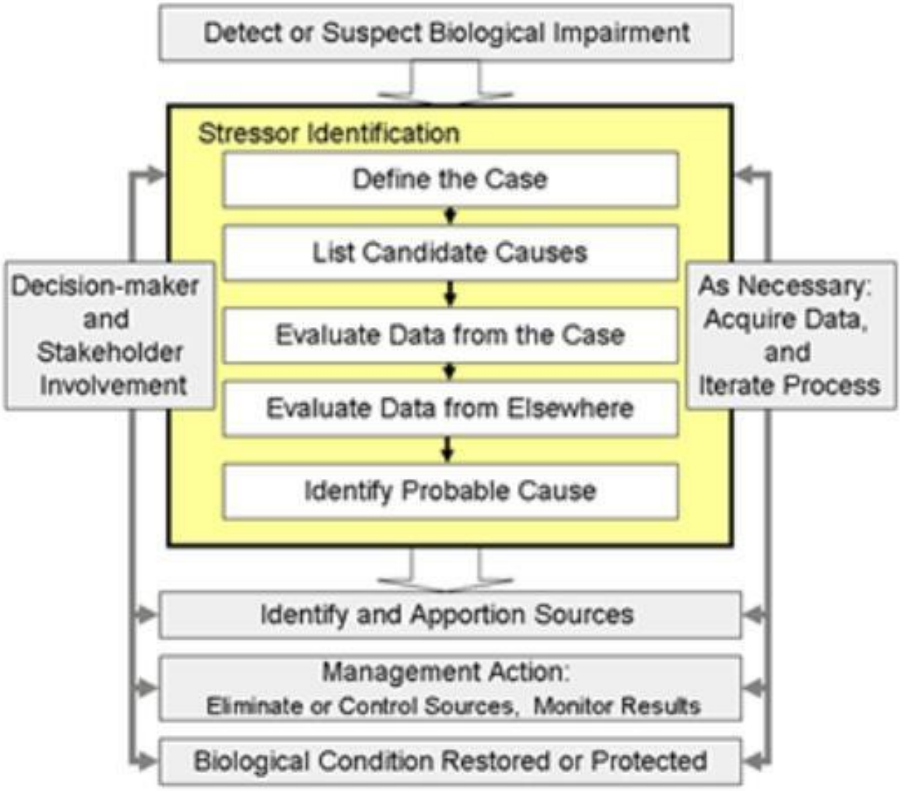


Stressor identification process

The MPCA follows the United States Environmental Protection Agency (EPA)'s process of identifying stressors that cause biological impairment, which has been used to develop the MPCA's guidance to stressor identification (Cormier et al. 2000; MPCA 2008). The EPA has also developed an updated, interactive web-based tool, the Causal Analysis/Diagnosis Decision Information System (CADDIS; EPA 2010). This system provides an enormous amount of information designed to guide and assist investigators through the process of Stressor Identification. Additional information on the Stressor Identification process using CADDIS can be found here: http://www.epa.gov/caddis/.

Stressor Identification is a key component of the major watershed restoration and protection projects being carried out under Minnesota's Clean Water Legacy Act. SID draws upon a broad variety of disciplines and applications, such as aquatic ecology, geology, geomorphology, chemistry, land-use analysis, and toxicology. A conceptual model showing the steps in the SID process is shown in Figure 2. Through a review of available data, stressor scenarios are developed that aim to characterize the biological impairment, the cause, and the sources/pathways of the various stressors.

Figure 2. Conceptual model of Stressor Identification process (Cormier et al. 2000)



Strength of evidence (SOE) analysis is used to evaluate the data for candidate causes of stress to biological communities. The relationship between stressor and biological response are evaluated by considering the degree to which the available evidence supports or weakens the case for a candidate cause. Typically, much of the information used in the SOE analysis is from the study watershed (i.e., data from the case). However, evidence from other case studies and the scientific literature is also used in the SID process (i.e., data from elsewhere).

Developed by the EPA, a standard scoring system is used to tabulate the results of the SOE analysis for the available evidence (Table A1). A narrative description of how the scores were obtained from the evidence should be discussed as well. The SOE table allows for organization of all of the evidence, provides a checklist to ensure each type has been carefully evaluated and offers transparency to the determination process.

The existence of multiple lines of evidence that support or weaken the case for a candidate cause generally increases confidence in the decision for a candidate cause. The scoring scale for evaluating each type of evidence in support of or against a stressor is shown in Table A2. Additionally, confidence in the results depends on the quantity and quality of data available to the SID process. In some cases, additional data collection may be necessary to accurately identify the stressor(s) causing impairment. Additional detail on the various types of evidence and interpretation of findings can be found here: http://www.epa.gov/caddis/si_step_scores.html

Common stream stressors

The five major elements of a healthy stream system are stream connections, hydrology, stream channel assessment, water chemistry and stream biology. If one or more of the components are unbalanced, the stream ecosystem may fail to function properly and is listed as an impaired water body. Table 1 lists the common stream stressors to biology relative to each of the major stream health categories.

Table 1. Common streams stressors to biology (i.e., fish and macroinvertebrates).

Stream Health	Stressor(s)	Link to Biology
Stream Connections	**Loss of Connectivity** • Dams and culverts • Lack of Wooded riparian cover • Lack of naturally connected habitats/ causing fragmented habitats	Fish and macroinvertebrates cannot freely move throughout system. Stream temperatures also become elevated due to lack of shade.
Hydrology	**Altered Hydrology** **Loss of habitat due to channelization** **Elevated Levels of TSS** • Channelization • Peak discharge (flashy) • Transport of chemicals	Unstable flow regime within the stream can cause a lack of habitat, unstable stream banks, filling of pools and riffle habitat, and affect the fate and transport of chemicals.
Stream Channel Assessment	**Loss of Habitat due to excess sediment** **Elevated levels of TSS** • Loss of dimension/pattern/profile • Bank erosion from instability • Loss of riffles due to accumulation of fine sediment • Increased turbidity and or TSS	Habitat is degraded due to excess sediment moving through system. There is a loss of clean rock substrate from embeddedness of fine material and a loss of intolerant species.
Water Chemistry	**Low Dissolved Oxygen Concentrations** **Elevated levels of Nutrients** • Increased nutrients from human influence • Widely variable DO levels during the daily cycle • Increased algal and or periphyton growth in stream • Increased nonpoint pollution from urban and agricultural practices • Increased point source pollution from urban treatment facilities	There is a loss of intolerant species and a loss of diversity of species, which tends to favor species that can breathe air or survive under low DO conditions. Biology tends to be dominated by a few tolerant species.
Stream Biology	Fish and macroinvertebrate communities are affected by all of the above listed stressors	If one or more of the above stressors are affecting the fish and macroinvertebrate community, the IBI scores will not meet expectations and the stream will be listed as impaired.

Overview of Lac qui Parle Watershed

Background

The Lac qui Parle River Watershed drains an area of approximately 1,100 square miles that begins in eastern South Dakota and ends in southwestern Minnesota at the confluence with the Minnesota River in the city of Montevideo (MPCA 2018). Approximately 70% of the watershed lies within Minnesota in

the Lac qui Parle, Yellow Medicine, and Lincoln Counties (MPCA 2018). The cities of Canby, Dawson, and Madison are all located in the watershed.

The watershed is located in the Western Corn Belt Plains and Northern Glaciated Plains ecoregions. Over eighty percent of historic wetlands in the watershed have been removed from the landscape to improve agricultural productivity. The watershed was historically primarily prairie grassland, but is now dominated by cropland for agricultural use. Corn and soybeans are the most prevalent crops.

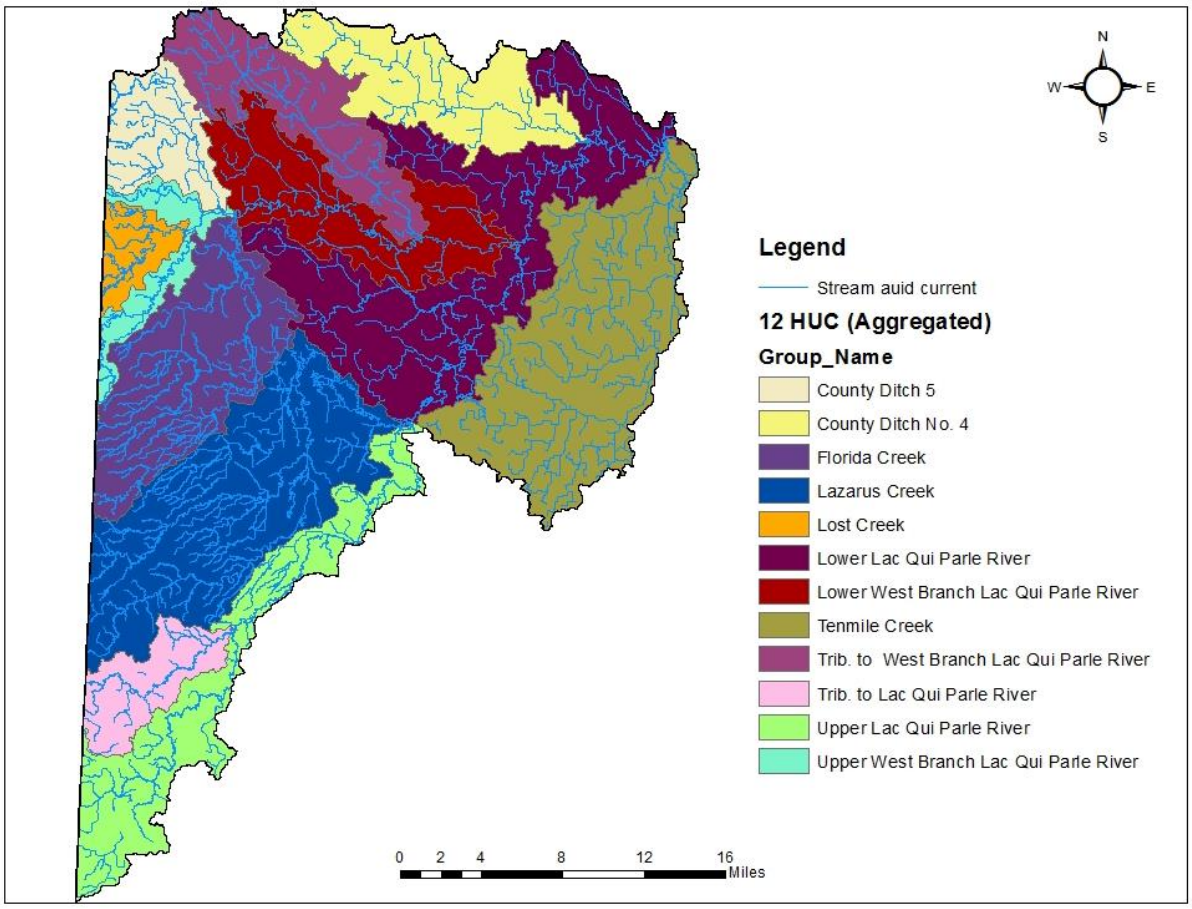
"Overall, scores of biological communities in this watershed were resoundingly poor; not a single general use stream in the Lac qui Parle River Watershed fully supported aquatic life use (MPCA 2018). The most common stressors to the biological communities in the watershed are eutrophication, lack of habitat, and flow alteration. The DNR found that, "Since 1984 all flow analyses have showed an increase, with the fall season showing the biggest changes" (DNR 2019).

Report format

This report is grouped by the eleven 12-digit HUCs in the Lac qui Parle River Watershed that contain biologically impaired streams (Figure 3). The 27 stream and one lake biological impairments are evaluated and discussed in the respective aggregated 12-digit HUC where they are located. The HUCs with impaired reaches are listed below:

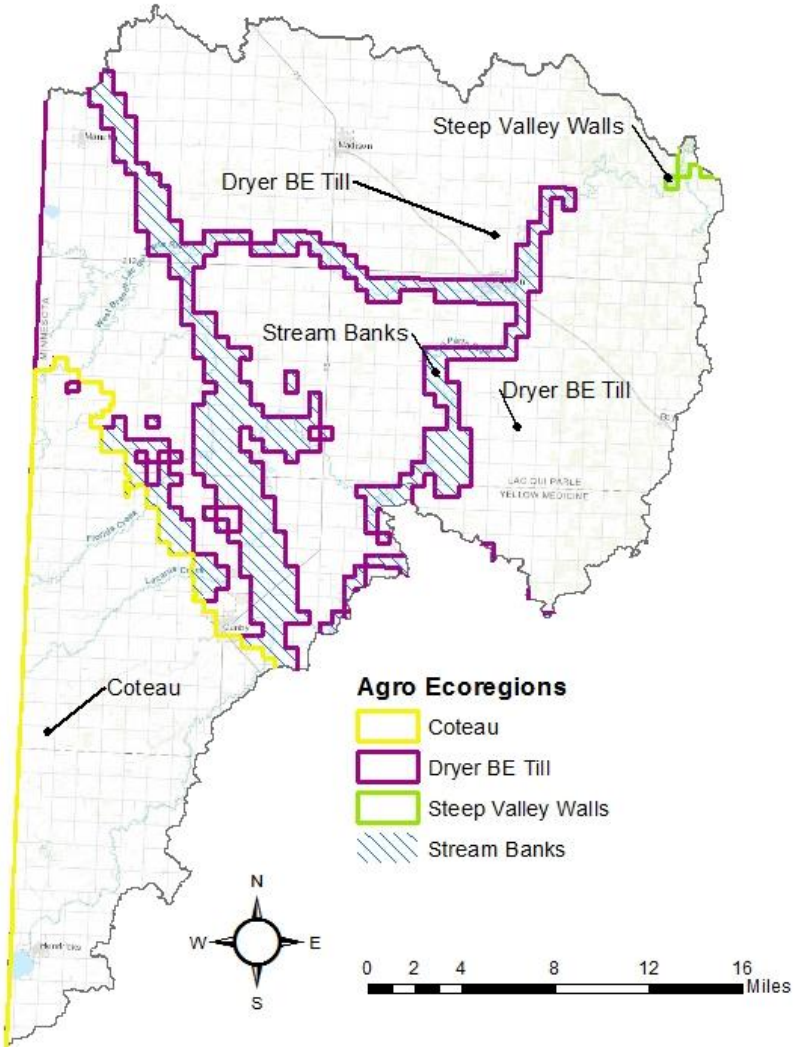
- Lost Creek
- Upper West Branch Lac qui Parle River
- Florida Creek
- Lazarus Creek
- Tributary to Lac qui Parle River
- Upper Lac qui Parle River
- Tenmile Creek
- Lower Lac qui Parle River
- Lower West Branch Lac qui Parle River
- Tributary to West Branch Lac qui Parle River
- County Ditch No 4

Figure 3. Aggregated 12-digit HUCs in the Lac qui Parle River Watershed



The southwestern part of the watershed is part of the Prairie Coteau region, which is the steepest part of the watershed (Figure 4).

Figure 4. UMN Agro Ecoregions in the Lac qui Parle River Watershed



Monitoring overview

In 2015 and 2016, "MPCA biomonitoring staff evaluated fish and macroinvertebrate communities at 52 unique monitoring stations across 35 assessment reaches of stream" (MPCA, 2018). Assessment of the biological information led to 27 stream and one-lake biological impairments; five fish biological stream impairments, eight macroinvertebrate biological impairments, and fourteen streams with both fish and macroinvertebrate impairments (Figure 5). Additional information can be found in subsequent sections of this report, in addition to the comprehensive Lac qui Parle River Watershed Monitoring and Assessment Report.

Chemical impairments of E. coli and Turbidity also exist in the watershed, but this report will focus on streams with biological impairments. On streams with biological impairments, there are also chemical impairments of Turbidity, Total Suspended Sediments (TSS), Dissolved Oxygen (DO), and the pesticide Chloropyrifos (Figure 6).

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Figure 5. Biological sampling stations and biological impairments in the Lac qui Parle River Watershed

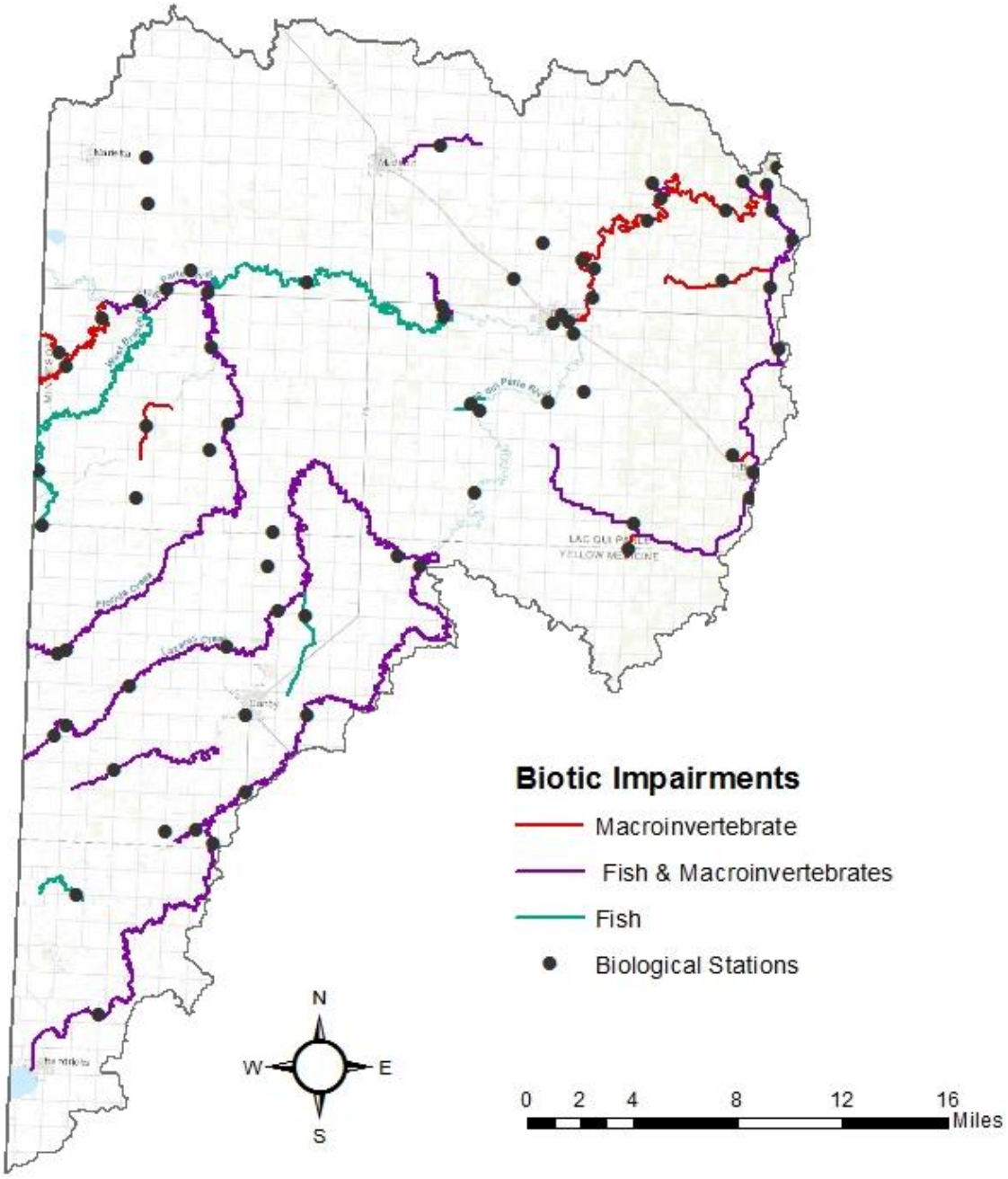
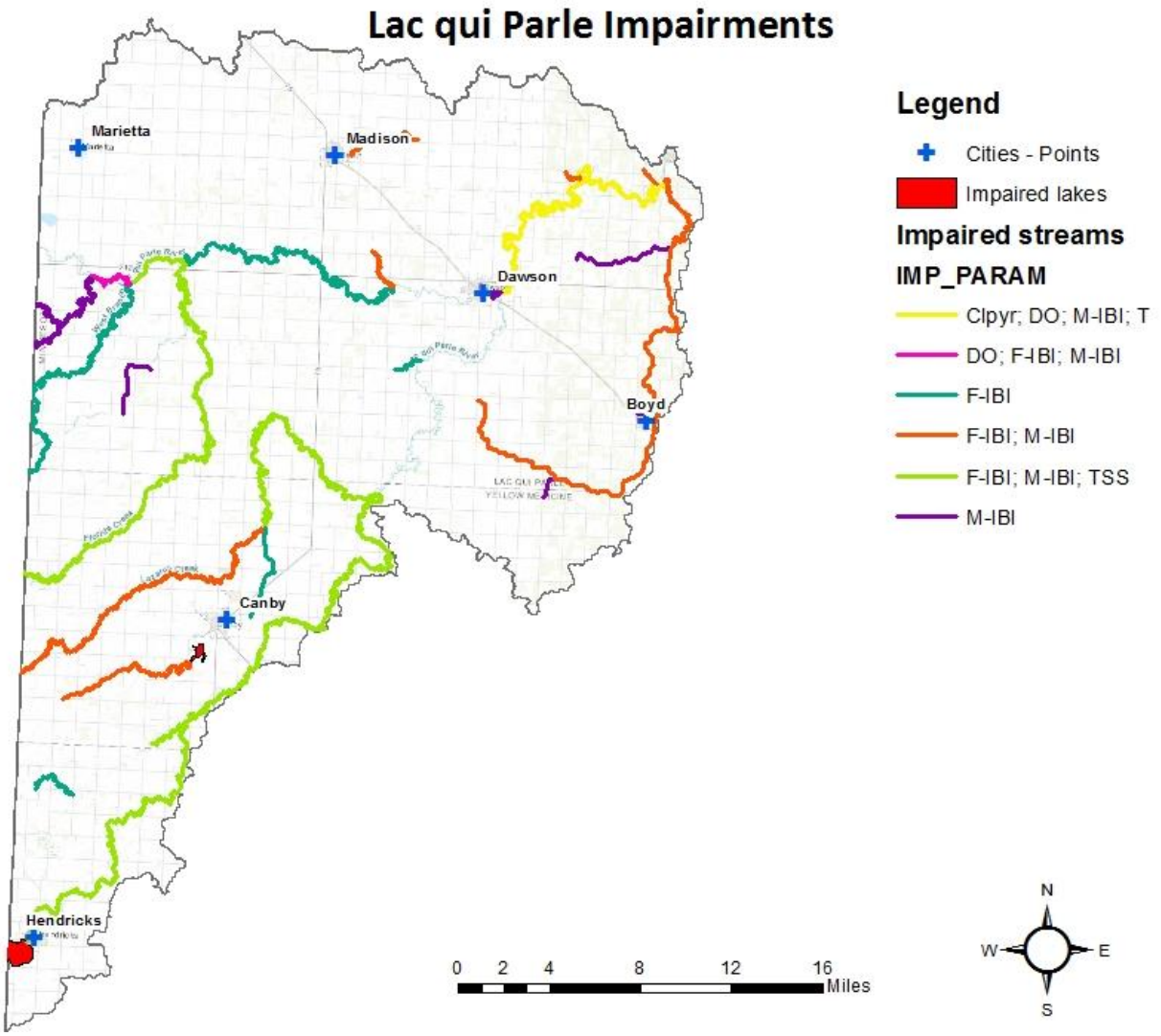


Figure 6. Streams with biological impairments in the Lac qui Parle River Watershed



Summary of biological impairments

The approach used to identify biological impairments includes assessment of fish and aquatic macroinvertebrates communities and related habitat conditions at sites throughout a watershed. The resulting information is used to develop an index of biological integrity (IBI). The IBI scores can then be compared to range of thresholds.

The fish and macroinvertebrates within each Assessment Unit Identification (AUID) were compared to a regionally developed threshold and confidence interval and utilized a weight of evidence approach. The water quality standards call for the maintenance of a healthy community of aquatic life. IBI scores provide a measurement tool to assess the health of the aquatic communities. IBI scores higher than the impairment threshold indicate that the stream reach supports aquatic life. Conversely, scores below the impairment threshold indicate that the stream reach does not support aquatic life. Confidence limits around the impairment threshold help to ascertain where additional information may be considered to help inform the impairment decision. When IBI scores fall within the confidence interval, interpretation and assessment of the waterbody condition involves consideration of potential stressors, and draws upon additional information regarding water chemistry, physical habitat, and land use, etc.

In the Lac qui Parle River Watershed, 27 AUIDs are currently impaired for a lack of biological assemblage (Table 2). The purpose of stressor identification is to interpret the data collected during the biological monitoring and assessment process. Trends in the IBI scores can help to identify causal factors for biological impairments.

Table 2. Biologically impaired AUIDs in the Lac qui Parle River Watershed.

				Impairments	
Stream Name	**AUID #**	**HUC 12**	**Reach Description**	**Biological**	**Water Quality**
Lac qui Parle River	07020003-501	Lower LqP	West Branch LqP River to Tenmile Creek	Invert	DO, Turbidity, Chlorpyrifos
Lac qui Parle River	07020003-505	Upper LqP	Lake Hendricks to Lazarus Cr	Invert, fish	Turbidity
Lazarus Creek	07020003-508	Lazarus Cr	Canby Creek to LqP River	Invert, fish	Turbidity
Lazarus Creek	07020003-509	Lazarus Cr	MN/SD border to Canby Cr	Invert, fish	
West Branch Lac qui Parle River	07020003-513	Lower W Branch LqP	Unnamed ditch to LqP R	Invert	
West Branch Lac qui Parle River	07020003-515	Lower W Branch LqP	Florida Creek to Unnamed Cr	Fish	
West Branch Lac qui Parle River	07020003-516	Upper W Branch LqP	Lost Creek to Florida Creek	Invert, fish	Turbidity
Lost Creek	07020003-517	Lost Cr	Crow Timber Cr to West Branch LqP River	Invert, fish	DO
West Branch Lac qui Parle River	07020003-519	Upper W Branch LqP	MN/SD border to Lost Cr	Fish	
Crow Timber Creek	07020003-520	Lost Cr	MN/SD border to Lost Cr	Invert	

Florida Creek	07020003-521	Florida Cr	MN/SD border to West Branch LqP River	Invert, fish	Turbidity
County Ditch 34	07020003-526	Tenmile Cr	Unnamed ditch to Tenmile Cr	Invert	
Unnamed Creek	07020003-530	Trib. To LqP River	Unnamed creek to LqP R	Invert, fish	TSS
Unnamed Creek	07020003-534	Lower LqP	CD29A to LqP River	Fish	
Canby Creek	07020003-557	Lazarus Cr	180th Ave to Del Clark Lake	Invert, fish	
Unnamed Creek	07020003-567	Lost Cr	Unnamed Cr to Unnamed Cr	Invert	
Unnamed Creek	07020003-569	Trib. To LqP River	Unnamed Cr to Unnamed Cr	Fish	
Unnamed ditch	07020003-570	Tenmile Cr	Unnamed ditch to Tenmile Cr	Invert	
Unnamed ditch	07020003-571	Tenmile Cr	Unnamed ditch to Tenmile Cr	Invert	
Unnamed ditch	07020003-575	County Ditch No. 4	Headwaters to Unnamed ditch	Invert, fish	
Tenmile Creek	07020003-577	Tenmile Cr	Headwaters to CSAH 18	Invert, fish	
Tenmile Creek	07020003-578	Tenmile Cr	CSAH 18 to Lac qui Parle R	Invert, fish	
Unnamed creek	07020003-580	Trib. To W Branch LqP	T-127 to W Br Lac qui Parle R	Invert, fish	
Unnamed ditch (County Ditch 4)	07020003-582	County Ditch No. 4	CSAH 20 to Lac qui Parle R	Invert, fish	
Cobb Creek	07020003-583	Florida Cr	Unnamed Cr to T-149	Invert	
Canby Creek	07020003-586	Lazarus Cr	CSAH 3 to Lazarus Cr	Fish	
Unnamed creek	07020003-588	Lower LqP	CSAH 48 to Lac qui Parle R	Invert, fish	

Hydrological Simulation Program - FORTRAN (HSPF) Model

The Hydrological Simulation Program - FORTRAN (HSPF) is a comprehensive package for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants. HSPF incorporates watershed-scale Agricultural Runoff Model (ARM) and Non-Point Source (NPS) models into a basin-scale analysis framework that includes fate and transport in one dimensional stream channels. It is the only comprehensive model of watershed hydrology and water quality that allows the integrated simulation of land and soil contaminant runoff processes with in-stream hydraulic and sediment-chemical interactions. The result of this simulation is a time history of the runoff flow rate, sediment load, and nutrient and pesticide concentrations, along with a time history of water quantity and quality at the outlet of any subwatershed. HSPF simulates three sediment types (sand, silt, and clay) in addition to a single organic chemical and transformation products of that chemical.

The HSPF watershed model contains components to address runoff and constituent loading from pervious land surfaces, runoff and constituent loading from impervious land surfaces, and flow of water and transport/transformation of chemical constituents in stream reaches. Primary external forcing is provided by the specification of meteorological time series. The model operates on a lumped basis

within subwatersheds. Upland responses within a subwatershed are simulated on a per-acre basis and converted to net loads on linkage to stream reaches within each subwatershed and the upland areas are separated into multiple land use categories.

An HSPF watershed model was run for the Lac qui Parle River Watershed to predict water quality condition throughout the watershed on an hourly basis from 1995-2009. Data from 1995, exclusively may not always be valid however, as the model may take up to one simulated year for parameters to reach calibration targets. Streams with biological impairments used the model output to supplement water quality analyses.

Possible stressors to biological communities

Possible stressors to biological communities

There is a comprehensive list of potential stressors to aquatic biological communities compiled by the EPA (https://www.epa.gov/caddis-vol1/aquatic-stressors-can-potentially-cause-biological-impairment). This comprehensive list serves two purposes. First, it can serve as a checklist for investigators to consider all possible options for impairment in the watershed of interest. Second, it can be used to identify potential stressors that can be eliminated from further evaluation. In some cases, the data may be inconclusive and limit the ability to confidently determine if a stressor is causing impairment to aquatic life. It is imperative to document if a candidate cause was suspected, but there was not enough information to make a scientific determination. In this case, management decisions can include modification of sampling plans and future evaluation of the inconclusive case. Alternatively, there may be enough information to conclude that a candidate cause is not causing biological impairment and therefore can be eliminated. The inconclusive or eliminated causes will be discussed in more detail in the following section.

A candidate cause is defined as a "hypothesized cause of an environmental impairment that is sufficiently credible to be analyzed" (EPA, 2012). Identification of a set of candidate causes is an important early step in the SID process and provides the framework for gathering key data for causal analysis. A more detailed description of possible candidate causes or stressors is provided in the document *Stressors to Biological Communities in Minnesota's Rivers and Streams* (MPCA, 2017). This information provides an overview of the pathway and effects of each candidate stressor considered in the biological stressor identification process with relevant data and water quality standards specific to Minnesota. The EPA has additional information, conceptual diagrams of sources and causal pathways, and publication references for numerous stressors on its CADDIS website. Background information specific to candidate causes/stressors in Minnesota can be found here. This information provides an overview of the pathway and effects of each candidate stressor considered in the biological stressor identification process with relevant data and water quality standards specific to Minnesota.

Inconclusive Causes

- Ammonia
- Toxics
- Predation and interspecies competition
- Physical trampling
- Parasitism

Evaluation of Candidate Causes

The list of candidate causes was narrowed down after initial data evaluation resulting in candidate causes for final analysis in this report. Six candidate causes were selected as possible drivers of biological impairments in the Lac qui Parle River Watershed. The remaining candidate causes are:

- Dissolved oxygen (DO)
- Eutrophication
- Nitrate
- Total suspended solids (TSS)
- Habitat
- Altered hydrology
- Connectivity
- Temperature
- Chloride

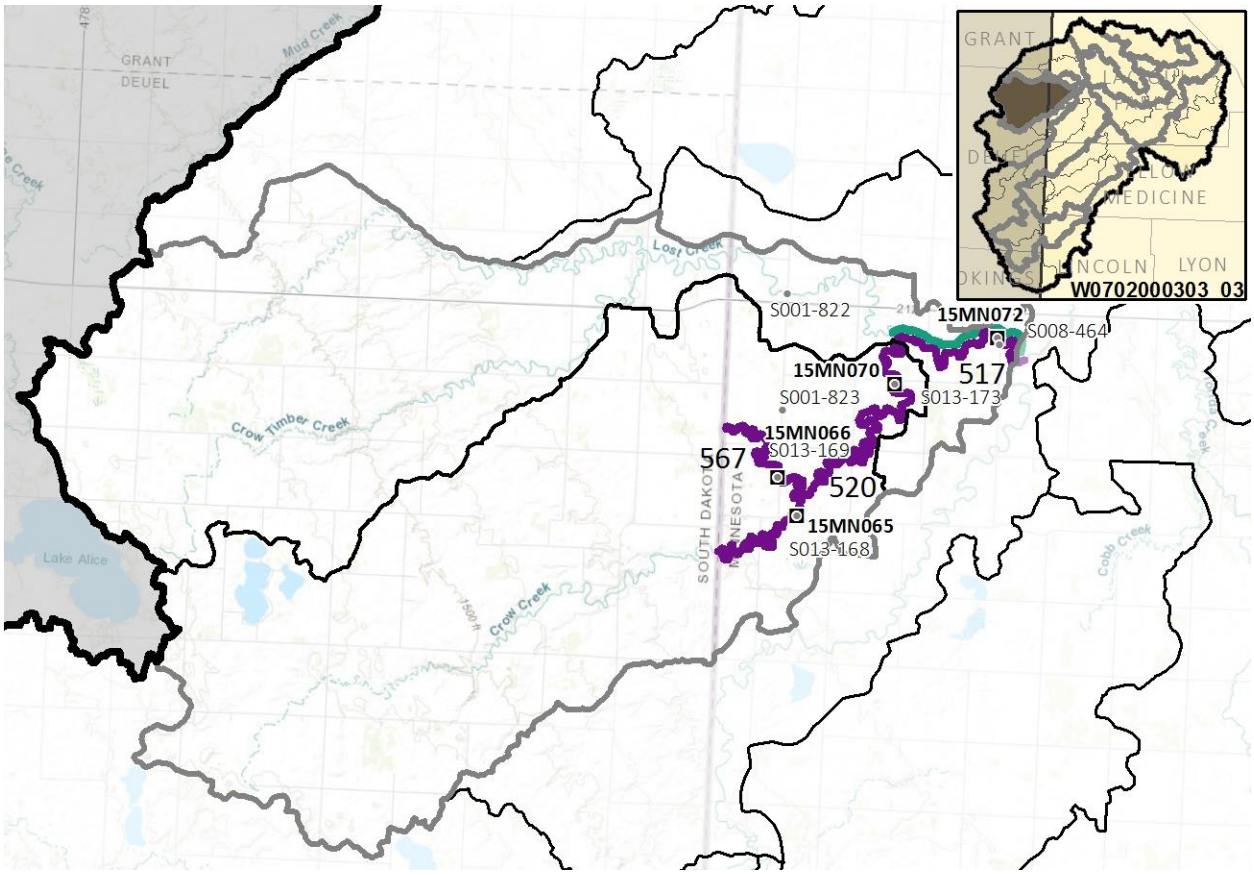
Evaluation of stressors to biological impairments

Lost Creek 12-digit HUC

This aggregated HUC is located along the South Dakota border and contains Crow Timber Creek, which turns into Lost Creek and Unnamed Creek, a tributary to Crow Timber Creek (Figure 7). The streams in this section have the following impairments:

- Unnamed Creek (Tributary to Crow Timber Creek) (-567) impaired for macroinvertebrates (15MN066 & S013-169)
- Crow Timber Creek (-520) impaired for macroinvertebrate (15MN065, 15MN070, S013-168, S013-173, LD00324)
- Lost Creek (-517) impaired for fish and macroinvertebrates (15MN072, S008-464, S013-175)

Figure 7. Impairments in the Lost Creek HUC 12 (turquoise represents a fish impairment and purple represents a macroinvertebrate impairment)



Biological communities

Two of the stations were in fish class 2 and two were in fish class 3. Of the two stations in Class 2, Lost Creek with station 15MN072 was impaired for fish, while station Crow Timber Creek with 15MN070 was not impaired. Station 15MN072 scored zero during both visits for short-lived species (SLvd), while station 15MN070 scored above the score needed to meet the threshold (Figure 8). Station 15MN072 was dominated by common shiners, which are a generalist species meaning that they can survive in a range of environments. Of the fish collected at the 9/10/15 fish visit at station 15MN072, 19% of the fish were covered in black spot (Figure 9).

Figure 8. Fish metric scores at sites in general use fish class 2

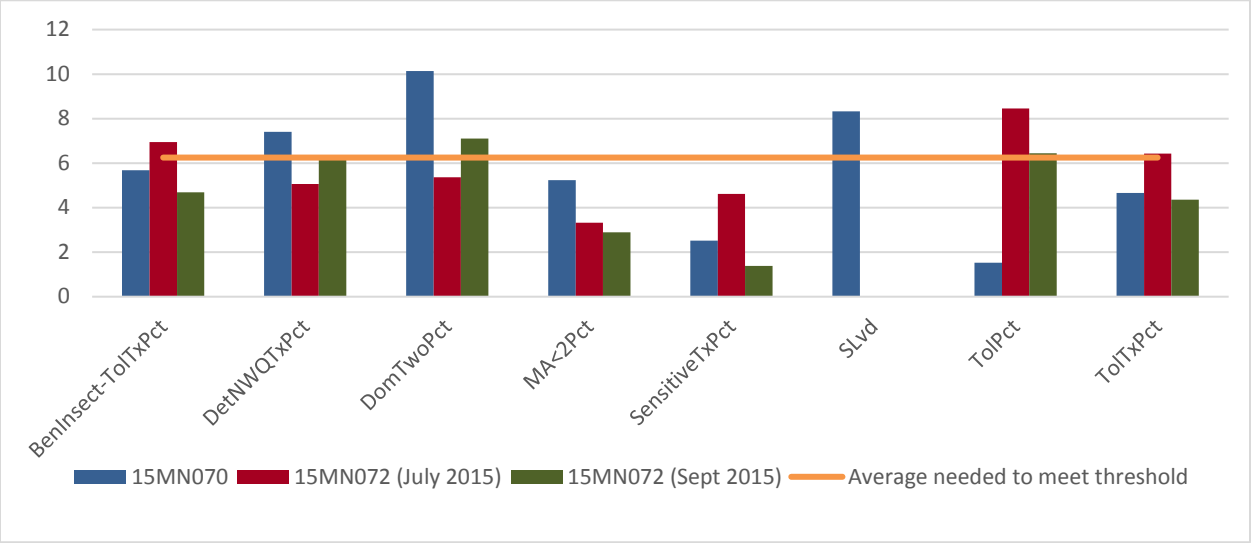
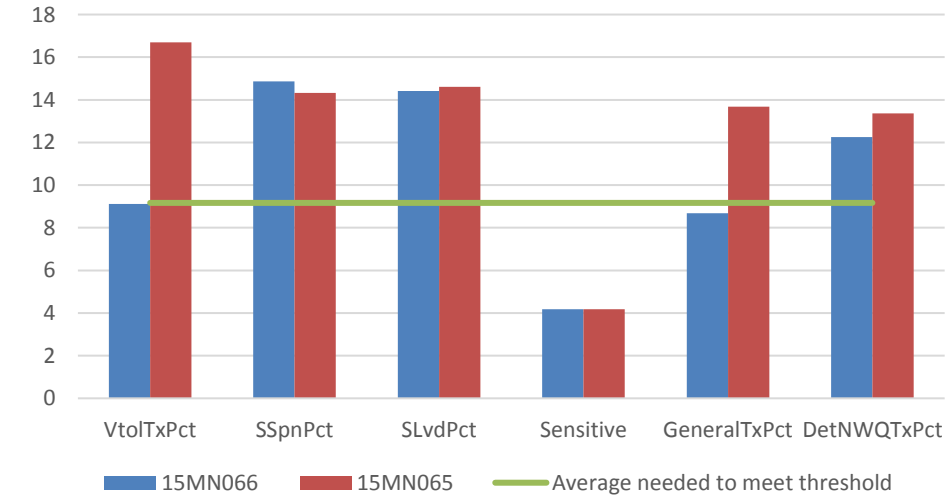


Figure 9. A fish with black spot collected at station 15MN072

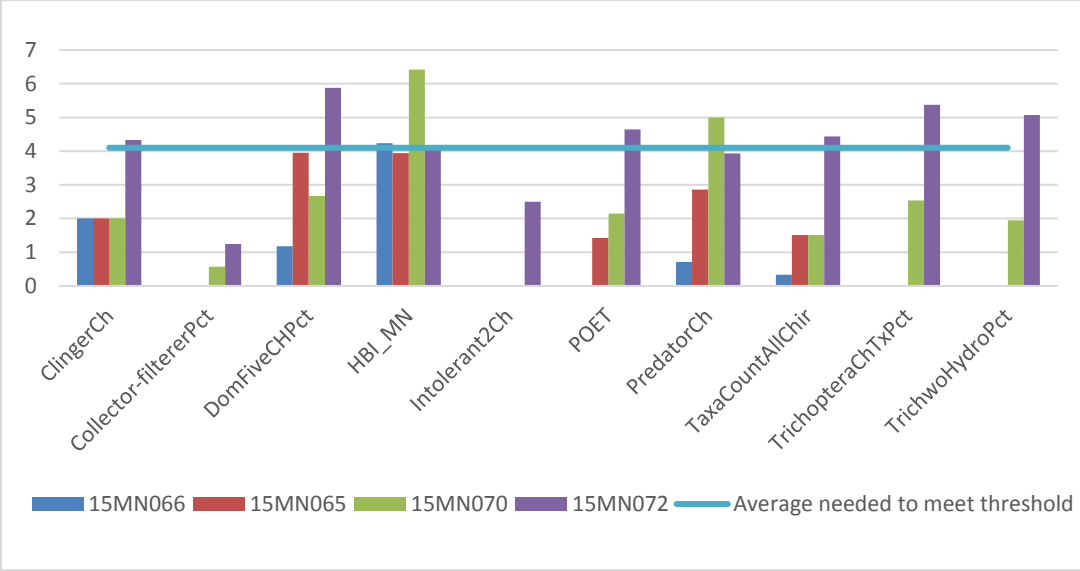
The two stations in fish class 3 (stations 15MN065 and 15MN066) on Crow Timber Creek and Unnamed Creek respectively were not impaired for fish. Station 15MN065 scored better, but all scores for each station were close to or above the average needed to meet the general threshold except for the sensitive species metric score (Figure 10).

Figure 10. Fish metric scores at sites in general use fish class 3



All of the three stream reaches were impaired for macroinvertebrates and each of the four stations were in macroinvertebrate class 7. Station 15MN066 on Unnamed Creek had the lowest metric scores across the board, scoring zero for 5 of the 10 metrics. Both stations on Lost Creek had scores of zero for intolerant taxa richness (Figure 11). Station 15MN072 was comprised of more than 90% tolerant taxa. All four stations had macroinvertebrate communities dominated by snails, which are tolerant to disturbed conditions.

Figure 11. Macroinvertebrate metric scores at sites in general use Class 7



Stations 15MN065, 15MN066, and 15MN070 both had low taxa richness that were dominated by over 90% tolerant taxa. Station 15MN066 is in a pasture with algal growth and poor habitat, had high scraper taxa, an over widened channel, and decreased flow.

Candidate Cause: Dissolved oxygen

Values in this HUC ranged from 1.2 mg/L to 17.78 mg/L in recent years (2015-2017). Both the minimum and maximum values were collected at station 15MN070 (S013-173) on Crow Timber Creek. The wide range of DO values was indicative of possible eutrophication. Eleven values were below 5 mg/L; low values were collected on each of the three AUIDs (Table 3). Lost Creek (-517) is impaired for DO. Limited continuous data was collected at station 15MN072 on Lost Creek, where the recorded minimum was 4.22 mg/L.

Table 3. DO data in the Lost Creek HUC

Stream Reach	# DO values	Range of DO values	# of values below 5 mg/L
Crow Timber Creek (-520)	17	1.20-17.78 mg/L	2
Lost Creek (-517)	32	2.15-12.4 mg/L	8
Unnamed Creek (-567)	4	3.26-7.9 mg/L	1

Additionally, the HSPF model calculated daily minimum DO values from 1996-2012 at Crow Timber Creek and Lost Creek. Over the years, the low, high, and average minimum values were all calculated (Table 4). The minimum values ranged from 0-13.9 mg/L with less than 7% of values below the water quality standard of 5 mg/L at both streams.

Table 4. Modeled DO data in the Lost Creek HUC

Reach Name	WID	Number of Readings	Low daily minimum value (mg/L)	High daily minimum value (mg/L)	Daily minimum average value (mg/L)	Readings below 5 mg/L standard (%)
Unnamed Creek	**-567**	n/a	n/a	n/a	n/a	n/a
Crow Timber Creek	**-520**	6940	0	13.90	9.47	5.78
Lost Creek	**-517**	6940	0	13.89	9.53	6.43

Fish species that are specifically tolerant and intolerant to DO were analyzed at each station. There were no intolerant fish at any station. DO tolerant percentages range from 0% (15MN066 and 15MN072) to 13% (15MN070). The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. All stations had less than 1% of fish that take 3 years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. Serial spawners ranged from 8.9 to 14.9%, all less than statewide averages of stations meeting IBI thresholds (Table 5).

Table 5. DO related fish metrics in the Lost Creek HUC

		DO Related Fish Metrics		
Station	WID	MA>3 years Percentage	Serial Spawning Fish Pct	Fish Taxa Count
15MN065	**-520**	0	10.94	10
15MN066	**-567**	0	8.44	15
Statewide average for Class 3 Southern Headwaters stations meeting the FIBI General Use Threshold (55.0)		**2.06**	**17.09**	**12**
15MN070	**-520**	0	9.89	11
15MN072 (July 2015)	**-517**	0.22	8.93	18
15MN072 (Sept 2015)	**-517**	0.27	14.93	20
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**12.36**	**28.72**	**20**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed (Table 6). Intolerant macroinvertebrate taxa collected ranged from 0 at stations 15MN066 and 15MN070 to 4 at station 15MN072. The percentage of DO tolerant individuals ranged from 10.97% to 27.73%. While there were low DO values collected on each reach, the preponderance of data indicates low DO is inconclusive as a stressor on Crow Timber Creek and the Unnamed Creek. The number of low DO values and the preponderance of evidence indicates low DO is a stressor on Lost Creek.

Table 6. DO related macroinvertebrate metrics in the Lost Creek HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
15MN065	**-520**	24.20	7.67	1	6.66
15MN066	**-567**	10.97	7.58	0	6.59
15MN070	**-520**	20.86	6.91	0	6.62
15MN072	**-517**	27.73	7.63	4	6.48
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**12.98**	**7.55**	**4.46**	**6.91**
Expected response to DO stress		↑	↑	↓	↑

Candidate Cause: Eutrophication

Recent phosphorus data is available on both Lost Creek and Crow Timber Creek, but there was very little data available on the Unnamed Creek (Table 7). The highest values were taken at station S013-173 (0.546 mg/L) on Crow Timber Creek. Station S013-173 is located at the mouth of Crow Timber Creek before it enters Lost Creek.

Table 7. Total Phosphorus data in the Lost Creek HUC

Stream Reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Crow Timber Creek (-520)	21	0.04-0.55 mg/L	4
Lost Creek (-517)	21	0.05-0.27 mg/L	8
Unnamed Creek (-567)	3	0.07-0.11 mg/L	0

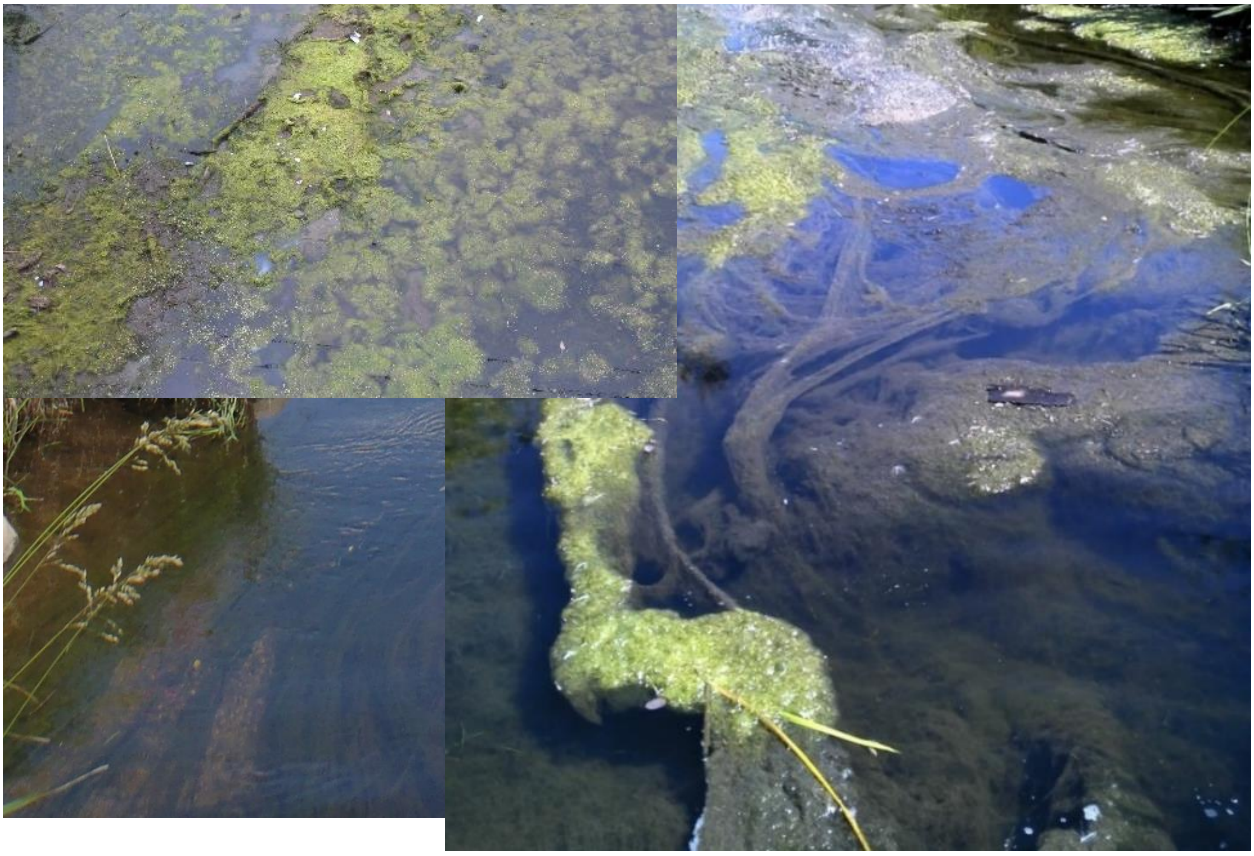
Additionally, the HSPF model calculated daily TP concentrations from 1996-2012. These values ranged from 0.01-33.43 mg/L with a mean of 0.23 mg/L on Crow Timber Creek and 0.26 mg/L on Lost Creek (Table 8).

Table 8. Modeled Phosphorus data in the Lost Creek HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above 0.15 mg/L TP standard (%)
Unnamed Creek	**-567**	n/a	n/a	n/a	n/a	n/a
Crow Timber Creek	**-520**	6931	0.02	9.39	0.23	51.51
Lost Creek	**-517**	6885	0.01	33.43	0.26	39.32

Chlorophyll-a, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus. Chlorophyll-a data of one value from each stream ranged from 1.44 to 2.74 ug/L, with all values far below the southern standard of 40 ug/L. There was no BOD data available. While DO flux is not available, there are a range of DO values ranging from 2.96 mg/L to 17.78 mg/L which is indicative of DO fluctuations. The highest DO values were taken on Crow Timber Creek. Values over 8.5 and large daily pH fluctuations can be tied to nutrient enrichment. pH values ranged from 7.3 to 8.4. Stations 15MN066, 15MN070, and 15MN072 had thick algae growth (Figure 12).

Figure 12. Algal growth on 15MN066 (bottom left 7/21/15), 15MN070 (right 10/27/15), 15MN072 (top left 8/14/17)



Sensitive individual percentages ranged 1.30-12.89% on these reaches, all below the class averages of sites meeting the threshold except at station 15MN065. All sites had less than 8% darter species which is below both class averages (Table 9). The percentage of tolerant fish individuals was at or above class average at each station. Along with tolerant species, a positive relationship exists between eutrophication and omnivorous fish. The omnivorous fish percentage was only above class average at station 15MN066. The biological communities are showing a response to elevated phosphorus, DO, and algal growth. Eutrophication is a stressor to the fish community on each reach.

Table 9. Eutrophication related fish metrics in the Lost Creek HUC

Station	WID	Eutrophication related Fish Metrics: Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
15MN065	**-520**	9.38	2.34	64.84	7.03
15MN066	**-567**	1.30	7.79	77.92	24.68
Statewide average for Class 3 Southern Streams stations that are meeting the FIBI General Use Threshold (55.0)		**8.55**	**12.08**	**70.64**	**14.62**
15MN070	**-520**	2.20	4.40	69.23	16.48
15MN072 (July 2015)	**-517**	9.59	2.18	43.14	7.52
15MN072 (Sept 2015)	**-517**	12.89	2.04	50.75	9.23
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**18.65**	**11.68**	**44.85**	**16.53**
Expected response to increased TP stress		↓	↓	↑	↑

Stations 15MN066 and 15MN070 had macroinvertebrate samples comprised of slightly more than half of the community dominated by two species (Table 10). All stations were dominated by snails, which increase as their food source algae increases. A very small number of EPT species were present at each station, and the number of taxa were all below the class average of sites meeting the threshold. The biological communities are showing the effects of the elevated phosphorus and DO values. Eutrophication is a stressor to the macroinvertebrate communities on a stressor on Lost Creek (-517), Crow Timber Creek (-520), and the Unnamed Creek (-567).

Table 10. Eutrophication related macroinvertebrate metrics in the Lost Creek HUC

Station	WID	Eutrophication Related Macroinvertebrate Metrics: Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
15MN065	**-520**	13	0.96	41.40
15MN066	**-567**	14	0.32	55.48
15MN070	**-520**	17	5.56	58.02
15MN072	**-517**	22	8.27	35.22
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
Expected response to TP stress		↓	↓	↑

Candidate Cause: Nitrates

As with phosphorus, recent nitrate data is available on both Lost Creek and Crow Timber Creek, but there was very little data available on the Unnamed Creek. Sample values ranged from 0.05-6.7 mg/L on the three streams (Table 11). Additionally, site 15MN065 had a drain tile draining directly into the stream. Drain tiles typically contain higher concentrations of nitrates as they drain into the stream from the agricultural fields. The one drain tile sample taken at station 15MN065 was 8.9 mg/L

Table 11. Nitrate data in the Lost Creek HUC

Stream Reach	# nitrate values	Range of values
Crow Timber Creek (-520)	21	0.05-6.7 mg/L
Lost Creek (-517)	21	0.15-6.7 mg/L
Unnamed Creek (-567)	3	0.08-6.5 mg/L

Additionally, the HSPF model calculated daily nitrate concentrations from 1996-2012. These values ranged from 0-43.67 mg/L with a mean of 0.57 mg/L on Crow Timber Creek and 0.66 mg/L on Lost Creek (Table 12).

Table 12. Modeled nitrate data in the Lost Creek HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)
Unnamed Creek	**-567**	n/a	n/a	n/a	n/a
Crow Timber Creek	**-520**	6931	0.01	22.46	0.57
Lost Creek	**-517**	6885	0	43.67	0.66

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration.

Nitrate intolerant macroinvertebrate taxa was one at each site except station 15MN072 where two intolerant taxa were collected. Nitrate tolerant individuals comprised 42% (15MN070) to 70% (15MN065) of the macroinvertebrate communities (Table 13).

Increasing nitrate concentrations also have a negative relationship with non-hydropsychid Trichoptera (caddisfly) individual percentages. Non-hydropsychid Trichoptera are all caddisflies that do not spin nets. Values range from 0 to 2.51%, all below the class average of sites meeting the threshold. Station 15MN065, the upstream site on Crow Timber Creek has some indications of nitrate stress based on the tolerant taxa, lack of Trichoptera taxa, and the nitrate TIV score. Based on the lack of elevated nitrogen values and the inconsistent metric response, nitrate is inconclusive stressor to Lost Creek, Crow Timber Creek, and the Unnamed Creek.

Table 13. Nitrate related macroinvertebrate metrics in the Lost Creek HUC

		Nitrate related Macroinvertebrate Metrics			
Station	WID	TrichwoHydroPct	N % Tolerant Taxa	N % Intolerant Taxa	Nitrogen TIV
15MN065	**-520**	0.00	70.06	19.11	4.60
15MN066	**-567**	0.00	56.77	14.52	5.17
15MN070	**-520**	0.62	42.33	37.73	3.45
15MN072	**-517**	2.51	51.64	16.58	3.87
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate Cause: Sediment

As with other chemical data, recent TSS data is available on both Lost Creek and Crow Timber Creek, but there was very little data available on the Unnamed Creek. Samples ranged in value from 1.6-42 mg/L, with all concentrations below the southern standard of 65 mg/L (Table 14). Additionally, secchi tube measurements ranged from 36-100 cm. Of these measurements, zero were at or below the 10 cm standard for transparency.

Table 14. TSS data in the Lost Creek HUC

Stream Reach	# TSS values	Range of TSS values	# of values above 65 mg/L
Crow Timber Creek (-520)	21	1.6-42 mg/L	0
Lost Creek (-517)	20	2.0-17.0 mg/L	0
Unnamed Creek (-567)	3	1.6-3.6 mg/L	0

Additionally, the HSPF model calculated daily suspended sediment concentrations from 1996-2012. These values ranged from 2.34-1925 mg/L with a mean of 12.57 mg/L on Crow Timber Creek and 16.35 mg/L on Lost Creek (Table 15).

Table 15. Modeled TSS data in the Lost Creek HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above standard (%)
Unnamed Creek	**-567**	n/a	n/a	n/a	n/a	n/a
Crow Timber Creek	**-520**	6931	2.34	1815.6	12.57	0.88
Lost Creek	**-517**	6885	2.65	1925.2	16.35	5.05

There is erosion occurring on Lost Creek, adding sediment to the system. Dredging occurred alongside the river during biological sampling on Crow Timber Creek (Figure 13).

Figure 13. Dredging along station 15MN065 (8/12/15)

A few paired organic solids (TSVS) and inorganic solids (TSS) samples were taken. TSVS values range from 24% on Crow Timber Creek in June, up to 75% of the suspended solid concentrations on the Unnamed Creek in August.

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. There were zero intolerant fish at any station. However, there were also less than 1% of TSS tolerant individuals at each site (Table 16). Herbivore species of fish decrease as TSS values increase. The stations all had herbivore percentages higher than the average of sites meeting the IBI thresholds. Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. Perciform percentages were low at all stations. The other fish metrics were mostly below state average of sites meeting the threshold, but based on the low TSS values, the metrics are likely being affected by other stressors.

Table 16. TSS related fish metrics in the Lost Creek HUC

Station	WID	TSS Related Fish Metrics: BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct	TSS Index Score (RA)
15MN065	**-520**	27.34	0.00	17.19	2.34	0.00	0.00	14.09
15MN066	**-567**	45.45	0.00	17.53	7.79	0.00	0.00	15.14
Statewide average for Class 3 Southern Streams stations meeting the FIBI General Use Threshold (55.0)		**37.83**	**0.89**	**13.33**	**13.93**	**1.95**	**3.56**	
15MN070	**-520**	36.26	0.00	24.18	4.40	0.00	0.00	15.43
15MN072 (July 2015)	**-517**	21.35	0.00	20.04	2.40	0.00	0.22	14.02
15MN072 (Sept 2015)	**-517**	18.72	0.27	10.85	2.58	0.00	0.68	14.69
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**37.38**	**4.89**	**9.61**	**18.66**	**4.97**	**11.68**	
Expected response to TSS stress		↓	↓	↓	↓	↓	↓	↑

Similar to the fish community, the number of TSS intolerant and tolerant macroinvertebrates were both low except at station 15MN066 which had a slightly higher than average TSS tolerant percent (Table 17). The long-lived percentage was also highest at station 15MN066. The metrics were similarly mixed at all sites, while all sites had low collector-filterer and Plecoptera percentages. Based on the low TSS intolerant taxa, lack of elevated TSS tolerant taxa, and TSS values, evidence supports TSS is currently not a stressor on Lost Creek (-517), Crow Timber Creek (-520, and the Unnamed Creek (-567).

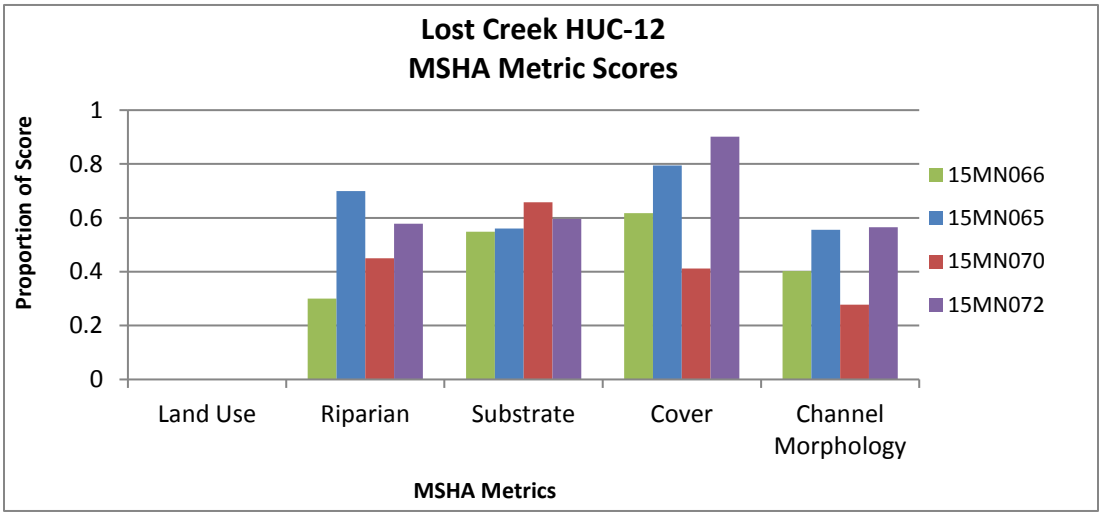
Table 17. TSS related macroinvertebrate metrics in the Lost Creek HUC

Station	WID	TSS related Macroinvertebrate Metrics: TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
15MN065	**-520**	17.15	0	4	38.54	0.32	0.00	4.14
15MN066	**-567**	19.16	0	5	50.32	0.00	0.00	10.97
15MN070	**-520**	15.90	0	6	32.52	2.47	0.00	7.72
15MN072	**-517**	16.83	0.50	9.50	37.96	5.01	0.00	6.1
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**13.2**	**48.28**	**19.13**	**0.22**	**7.99**
Expected response to stress		↑	↓	↑	↑	↓	↓	↓

Candidate Cause: Habitat

Habitat conditions were shown to be poor by MSHA scores at station 15MN066 on Unnamed Creek. Crow Timber Creek had a poor score at station 15MN070 (the downstream site) and a fair score at station 15MN065 (the upstream site). Habitat conditions were also fair on Lost Creek, although heavy erosion was noted at station 15MN072 (Figure 14).

Figure 14. MSHA scores in the Lost Creek HUC



Stations 15MN065 and 15MN072 were both experiencing active erosion (Figure 15) and mid-channel bars indicating a higher sediment load than the streams can carry. Each of the four stations had excess embeddedness of coarse substrates with fine substrates. Station 15MN066 was nearly stagnant in August lacking in fish cover, had no riparian buffer with cows present in the stream. Station 15MN070 was lacking in channel development, depth variability, and was also a pasture.

Figure 15. Erosion at site 15MN072 (8/12/15)

Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were higher than average at each site. Benthic insectivores and darter, sculpin, and sucker individuals however were lowered at each site. Darters are sensitive to siltation. Riffle species also tend to decrease due to lack of habitat. Riffle percentages were slightly lower than the

Class 2 average and slightly higher than the Class 3 average (Table 18). The percentage of tolerant species were close to or above both fish class averages. Based on the poor habitat conditions and preponderance of evidence, lack of habitat is stressor to 15MN066 for fish.

Table 18. Habitat related fish metrics in the Lost Creek HUC

		Habitat Related Fish Metrics							
Station	WID	BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RifflePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
15MN072 (July 2015)	**-517**	2.72	60.68	2.18	27.56	0	90.19	43.14	10.45
15MN072 (Sept 2015)	**-517**	2.44	52.37	2.04	29.99	0.27	92.54	50.75	21.30
15MN070	**-520**	6.59	40.66	4.40	31.87	0	82.42	69.23	29.67
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
15MN066	**-567**	8.44	39.61	7.79	38.96	0	82.47	77.92	32.47
15MN065	**-520**	3.91	41.41	2.34	33.59	0	96.09	64.84	29.69
Statewide average for Class 3 Southern Headwaters stations meeting the FIBI General Use Threshold (55.0)		**14.22**	**33.71**	**12.55**	**28.33**	**1.62**	**69.21**	**70.64**	**37.79**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were below average at all stations (Table 19). Burrowers and legless individuals are a signal of high levels of sedimentation. Even with the prevalence of fine sediments, burrowers were low at all stations, but legless individuals were elevated at each station. Based on the embeddedness of course substrates and excess sedimentation in each of the streams, and the preponderance of evidence of the macroinvertebrate communities, habitat is a stressor.

Table 19. Habitat related macroinvertebrate metrics in the Lost Creek HUC

		Habitat related Macroinvertebrate Metrics				
Station	WID	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
15MN065	**-520**	7.96	62.10	21.66	0.96	89.81
15MN066	**-567**	6.77	77.10	14.84	0.32	81.29
15MN070	**-520**	3.40	71.91	9.26	5.56	71.91
15MN072	**-517**	1.88	59.40	19.38	8.27	65.67
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate Cause: Altered hydrology

Crow Timber Creek and Lost Creek main streams are both natural, with some small-channelized tributaries. The Unnamed Creek section in Minnesota is also natural. Channelization and tile drainage often causes flashy flows; high in the spring and during rain events and low or dry later in the summer. Center-pivot irrigation right up to the banks was noted just upstream of station 15MN072, which could impact groundwater and stream flows and should be monitored.

Candidate Cause: Chloride/Ionic Strength

Chloride values were only available on Lost Creek, with values ranging from 15.3-26.3 mg/L, all well below the standard. Specific conductance is a measure of ions including chloride. Measurements on this stream reach ranged from 864 to 2034 µS/cm. The highest value was taken at station 15MN065. Increased ionic strength can cause an increase in ion tolerant taxa and an increase in ion tolerant life stages, causing fish and invert impairments, but it is difficult to separate this effect from other stressors.

Elevated chloride can lead to increases in sunfish based assemblages. 15MN072 was the only visit to have any Centrarchidae (sunfish) collected, but it was still less than 0.3% (Table 20). Fish species that are tolerant to conditions with high ionic strength comprised a range of 11-26% of the fish community.

A study of Minnesota biological data and stressor linkages found that sites with conductivities higher than 1,000 µS/cm rarely meet the biological thresholds for General Use streams (MBI, 2012). As salinity increases, macroinvertebrate taxa richness and Ephemeroptera richness decrease (Piscart et al., 2005). Ephemeropterea percentages and taxa counts were all at or below class average for sites meeting the threshold. Echols et. al (2009) also found a reduction in EPT abundance as ionic strength values increased. EPT percentage were also all below the class average.

Table 20. Chloride/Ionic strength related metric in the Lost Creek HUC

		Chloride/Ionic strength related metrics				
Station	**WID**	TaxaCountAllChir	EphemeropteraCh	EphemeropteraPct	EPTPct	Cent-TolPct
15MN065	-520	24	1	0.96	0.96	0
15MN066	-567	20	1	0.32	0.32	0
Statewide average for Class 3 Southern Headwaters stations meeting the FIBI General Use Threshold (55.0)						**0.89**
15MN070	-520	24	1	4.94	5.55	0
15MN072 (July 2015)	-517	33	3	5.64	8.15	0
15MN072 (September 2015)	-517					0.27
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)						**4.89**
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**33.59**	**3.45**	**16.52**	**20.58**	
Expected response to Specific Conductance stress		↓	↓	↓	↓	↑

There are instances of elevated specific conductance concentrations that might be influencing the biological community with the low sunfish and mayfly, EPT, and macroinvertebrate richness. While the periodically elevated specific conductance values might be contributing as a stressor, chloride values on other reaches would help confirm chloride and specific conductance as a stressor. It is inconclusive at this time.

Summary and recommendations

The Lost Creek HUC contains three biologically impaired stream reaches. Eutrophication and lack of habitat were the major stressors in this watershed as they were determined to be stressing aquatic life at all three impaired reaches (Table 21). Dissolved Oxygen was are found to be a stressor on one of the three reaches. More chloride data are needed to better determine the impact of this potential stressor in this subwatershed.

The predominant land use in this subwatershed, row crop agriculture, is a contributor to the stressors found in these reaches. Utilizing a variety of nutrient reducing BMPs including: cover crops, nutrient management, saturated buffers, etc., will also help both in phosphorus reduction and sedimentation. Stream improvements and mitigation would be useful both in Minnesota and upstream in South Dakota.

Table 21. Stressors on streams in the Lost Creek HUC

	Stressors:						
Stream Name	**Dissolved Oxygen**	**Eutrophication**	**Nitrate**	**Suspended Sediment**	**Habitat**	**Altered Hydrology**	**Specific Conductance**
Lost Creek (-517)	●	●	o	---	●	---	o
Crow Timber Creek (-520)	o	●	o	---	●	---	o
Unnamed Creek (-567)	o	●	o	---	●	---	o

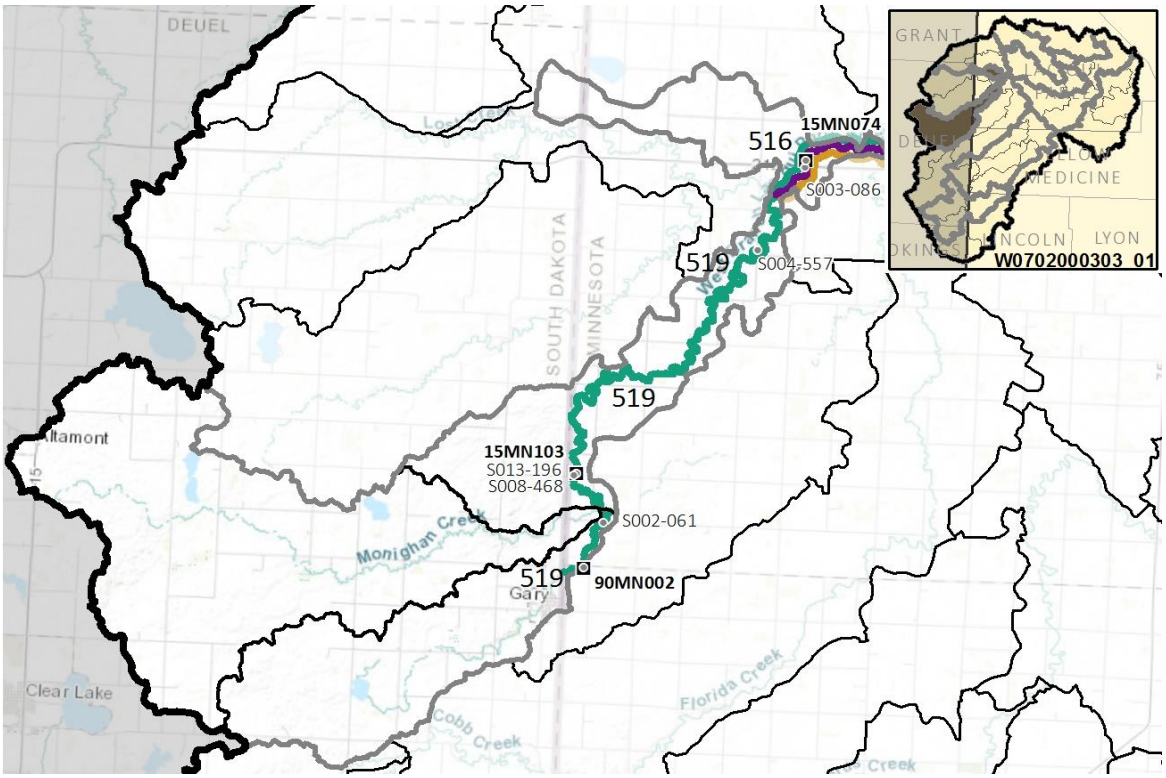
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Upper West Branch Lac qui Parle River HUC

This aggregated HUC is located along the South Dakota border and contains the upper section of the West Branch Lac qui Parle River (Figure 16). LqP is supporting a coldwater marginal fish community in South Dakota (DENR, 2018). The two stream reaches in this section have the following impairments:

- West Branch LqP (-516) is impaired for fish & macroinvertebrates (S003-086, S013-177, 15MN074)
- West Branch LqP (-519) is impaired for fish (15MN103, S013-592, S002-061, S008-468, S013-196, S004-557)

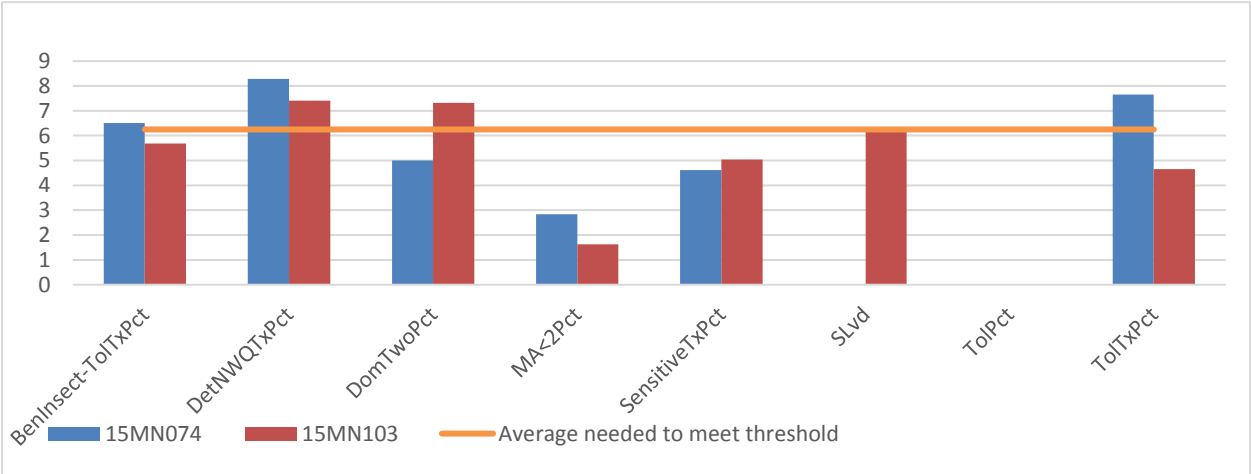
Figure 16 .Impairments in the Upper West Branch Lac qui Parle River HUC (turquoise represents a fish impairment, purple represents a macroinvertebrate impairment, and yellow represents a Turbidity impairment)



Biological communities

Both of the stations on Lac qui Parle River were in fish class 2 and were impaired for fish. Both stations scored zero for tolerant species percentage (TolPct) (Figure 17), based on the fish community being dominated by over 78% tolerant individuals at each station. Station 15MN074 was dominated by brassy minnows, which is a species tolerant to human disturbance.

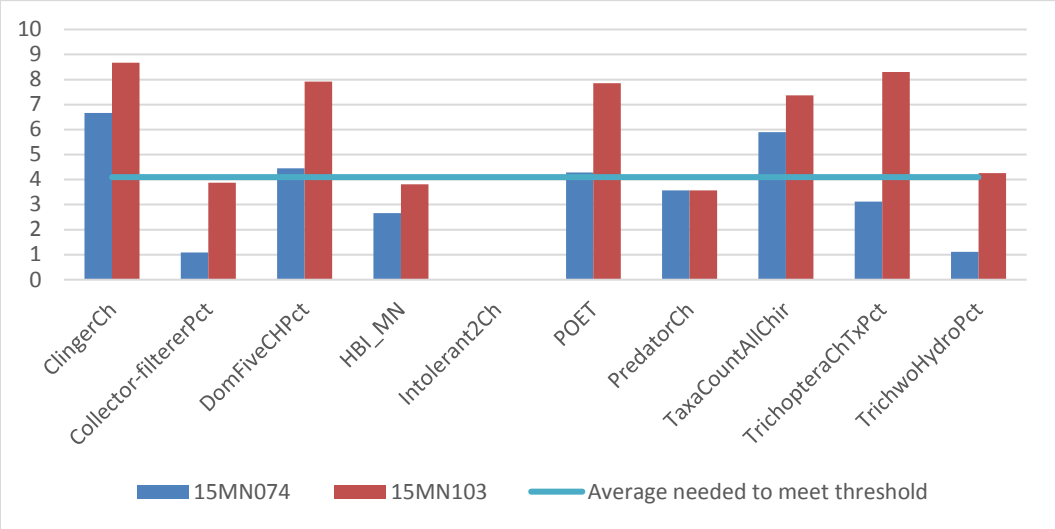
Figure 17. Fish metric scores at sites in general use fish class 2



Both stations on the Upper West Branch Lac qui Parle River were in macroinvertebrate class 7, but only the downstream reach is impaired for macroinvertebrates (station 15MN074). Fifteen EPT taxa were collected at 15MN103, while only six were collected at station 15MN074. Station 15MN074 scored zero for intolerant taxa richness (Figure 18) and was comprised of more than 92% tolerant taxa. Station

15MN074 had a macroinvertebrate community dominated by tolerant snails and midges, while the community at station 15MN103 was dominated by midges and the more sensitive species of mayflies.

Figure 18. Macroinvertebrate metric scores at sites in general use Class 7



Candidate Cause: Dissolved oxygen

Values ranged from 6.30 to 14.81 mg/L on the two reaches of the West Branch Lac qui Parle River (Table 22). There were no recorded values below 5 mg/L. Both the low and high values were collected on the lower reach of the river (-516), below the mouth of Lost Creek. Older DO data from 2002 contained 4 additional values below 5 mg/L, ranging from 4.59-4.95 mg/L on the downstream reach (-516). Continuous data was collected in 2018 at station 15MN103, where all values were above 7.18 mg/L.

Table 22. DO data in the Upper West Branch Lac qui Parle River HUC

Stream Reach	# DO values	Range of DO values	# of values below 5 mg/L
West Branch LqP River (-516)	20	6.30-14.81 mg/L	0
West Branch LqP River (-519)	25	6.70-10.89 mg/L	0

Additionally, the HSPF model calculated daily minimum DO values from 1996-2012 on the West Branch Lac qui Parle River. Over the years, the low, high, and average minimum values were all calculated (Table 23). The minimum values ranged from 6.44-14.02 mg/L with no values below the water quality standard of 5 mg/L on reach -516 and minimum values ranged from 0-13.96 mg/L with less than 3% values below the water quality standard of 5 mg/L on reach -519.

Table 23. Modeled DO data in the Upper West Branch Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low daily minimum value (mg/L)	High daily minimum value (mg/L)	Daily minimum average value (mg/L)	Readings below 5 mg/L standard (%)
West Branch Lac qui Parle R	**-516**	6940	6.44	14.02	10.29	0
West Branch Lac qui Parle R	**-519**	6940	0	13.96	9.95	2.56

Fish species that are specifically tolerant and intolerant to DO were analyzed at each station. There were no intolerant fish at either station. DO tolerant percentages ranged from 10% (15MN103) to 43% (15MN074). The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. All stations had less than 1% of fish that take 3 years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. Serial spawners ranged from 13.65 to 38.24%. Both sites collected in 2015 were below the statewide average of stations meeting IBI thresholds. Based on the lack of low DO data and the conflicting metric response, DO is not a stressor to the fish community.

Table 24. DO related fish metrics in the Upper West Branch Lac qui Parle River HUC

		DO Related Fish Metrics		
Station	**WID**	MA>3 years Percentage	Serial Spawning Fish Pct	Fish Taxa Count
90MN002	**-519**	0.00	38.24	10
Statewide average for Class 3 Southern Streams stations that are meeting the FIBI General Use Threshold (55.0)		**2.06**	**17.09**	**12.16**
15MN074	**-516**	0.27	14.30	24
15MN103	**-519**	0.28	13.65	11
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**12.36**	**28.72**	**20.38**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station. One intolerant macroinvertebrate taxa were collected at station 15MN074 and six were collected at station 15MN103. DO tolerant percentages ranged from 6.65 to 7.10, all below the class average of sites meeting the threshold. Based on the lack of low DO values and lack of a consistent biological response throughout the reach. Low DO is not a stressor to the macroinvertebrate community.

Table 25. DO related macroinvertebrate metrics in the Upper West Branch Lac qui Parle River HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
15MN074	**-516**	6.65	8.06	1	6.92
15MN103	**-519**	7.10	7.71	6	6.81
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**12.98**	**7.55**	**4.46**	**6.91**
Expected response to DO stress		↑	↑	↓	↑

Candidate Cause: Eutrophication

There were about a dozen recent phosphorus data available on both reaches of the West Branch Lac qui Parle River (Table 26). The highest values were taken at station S008-468 (0.905 mg/L) on the upstream reach of the river. Older TP data from 2001-2003 contained 8 additional values over 0.150 mg/L, ranging from 0.152-0.921 mg/L on the downstream reach (-516).

Table 26. Total Phosphorus data in the Upper West Branch Lac qui Parle River HUC

Stream Reach	# TP values	Range of TP values	# of values above 0.150 mg/L
West Branch LqP River (-516)	11	0.05-0.192	1
West Branch LqP River (-519)	12	0.03-0.905	1

Chlorophyll-a, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus. Chlorophyll-a data from station 15MN103 had a value of 1.39 ug/L, far below the southern standard of 40 ug/L. There was no BOD data available. pH values ranged from 7.4 to 8.8. Values over 8.5 and large daily pH fluctuations can be tied to nutrient enrichment. Continuous data collected at station 15MN103 did not have elevated pH fluctuations. Continuous DO data had a range of daily fluctuations ranging from 0.35 to 3.8 mg/L.

Additionally, the HSPF model calculated daily TP concentrations from 1996-2012. These values ranged from 0.01-4.66 mg/L with a mean of 0.145 mg/L on the two reaches of West Branch Lac qui Parle River (Table 27).

Table 27. Modeled Phosphorus data in the Upper West Branch Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above 0.15 mg/L TP standard (%)
West Branch Lac qui Parle R	**-516**	6940	0.02	4.18	0.16	39.38
West Branch Lac qui Parle R	**-519**	6939	0.01	4.66	0.13	22.12

Sensitive individual percentages ranged from 1.77-4.46% on these reaches, below the class average of sites meeting the threshold. All sites had less than 3% darter species, which is also below class average. The percentage of tolerant fish individuals were well above class average at each station. Along with tolerant species, a positive relationship exists between eutrophication and omnivorous fish. The omnivorous fish percentage were not increased. While there were some highly elevated phosphorus, the fish communities are showing a mixed response to eutrophication. Eutrophication is inconclusive as a stressor.

Table 28. Eutrophication related fish metrics in the Upper West Branch Lac qui Parle River HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
15MN074	**-516**	1.77	1.02	80.00	5.86
15MN103	**-519**	4.46	2.51	78.27	10.58
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**18.65**	**11.68**	**44.85**	**16.53**
Expected response to increased TP stress		↓	↓	↑	↑

Stations 15MN074 had a macroinvertebrate community almost 50% dominated by two species; snails and midges (Table 29). Snails increase as their food source algae increases. In comparison, the most dominant species at station 15MN103 were mayflies and midges. While the EPT percentage was high at station 15MN103, the species collected are more tolerant to degraded conditions. The river reaches had some elevated phosphorus values, and the macroinvertebrate community metrics were poor at 15MN074, other stressors could be contributing to the lowered values. Eutrophication is inconclusive stressor to the macroinvertebrate communities.

Table 29. Eutrophication related macroinvertebrate metrics in the Upper West Branch Lac qui Parle River HUC

		Eutrophication Related Macroinvertebrate Metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 InvertACH Pct
15MN074	**-516**	22	4.11	47.47
15MN103	**-519**	26	50.31	31.68
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
Expected response to DO stress		↓	↓	↑

Candidate Cause: Nitrates

Recent nitrate data was available on both reaches of the West Branch Lac qui Parle, with samples values ranging from 0.03-2.35 mg/L (Table 30). Additionally, the HSPF model calculated daily nitrate concentrations from 1996-2012. These values ranged from 0-18.81 mg/L with a mean of 0.40 mg/L on the West Branch Lac qui Parle River (Table 31).

Table 30. Nitrate data in the Upper West Branch Lac qui Parle River HUC

Stream Reach	# nitrate values	Range of values (mg/L)
West Branch LqP River (-516)	11	0.191-1.51
West Branch LqP River (-519)	12	0.03-2.35

Table 31. Modeled nitrate data in the Upper West Branch Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)
West Branch Lac qui Parle River	**-516**	6940	0	18.81	0.47
West Branch Lac qui Parle River	**-519**	6939	0	17.04	0.32

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration.

Nitrate intolerant macroinvertebrate taxa was one at both sites (Table 32). Nitrate tolerant individuals comprised 69% (15MN103) to 77% (15MN074) of the communities. Increasing nitrate concentrations also have a negative relationship with non-hydropsychid Trichoptera (caddisfly) individual percentages. Non-hydropsychid Trichoptera are all caddisflies that do not spin nets. Values were both below 2%, below the class average of sites meeting the threshold. Station 15MN074, the downstream site had some indications of nitrate stress based on the tolerant taxa, lack of Trichoptera taxa, and the nitrate TIV score. However, based on the lack of elevated nitrogen values and the inconsistent metric response, nitrate is inconclusive as a stressor.

Table 32. Nitrate related macroinvertebrate metrics in the Upper West Branch Lac qui Parle River HUC

		Nitrate related Macroinvertebrate Metrics			
Station	WID	TrichwoHydroPct	N % Tolerant Taxa	N % Intolerant Taxa	Nitrogen TIV
15MN074	**-516**	0.32	77.22	0.32	4.96
15MN103	**-519**	1.86	68.52	1.23	3.35
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate Cause: Sediment

As with other chemical data, recent TSS data is available on both reaches of the West Branch Lac qui Parle River. Reach -516 is impaired for Turbidity. Samples ranged in value from 4-604 mg/L, with two concentrations above the southern standard of 65 mg/L (Table 33). The value of 604 mg/L was taken at station S008-468 at the state border after several inches of rain in the area. Additionally, secchi tube measurements ranged from 3-100 cm. Of these measurements, one was below the 10 cm standard for transparency.

Table 33. TSS data in the Upper West Branch Lac qui Parle River HUC

Stream Reach	# TSS values	Range of TSS values	# of values above 65 mg/L
West Branch LqP River (-516)	11	4-83	1
West Branch LqP River (-519)	12	6-604	1

Additionally, the HSPF model calculated daily suspended sediment concentrations from 1996-2012. These values ranged from 2.38-1693 mg/L with a mean of 14.24 mg/L (Table 34).

Table 34. Modeled TSS data in the Upper West Branch Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above standard (%)
West Branch Lac qui Parle R	**-516**	6940	2.81	1693.2	16.30	2.93
West Branch Lac qui Parle R	**-519**	6939	2.38	1149.3	12.18	1.07

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. There were zero intolerant fish at either station (Table 35). However, there were also less than 1% of TSS tolerant individuals at each site. Herbivore species of fish decrease as TSS values increase. The stations both had herbivore percentages higher than the average of sites meeting the IBI thresholds. Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. Perciform percentages were low at both stations. The other fish metrics were mostly below state average of sites meeting the threshold, but based on the low TSS values, the metrics are likely being affected by other stressors.

Table 35. TSS related fish metrics in the Upper West Branch Lac qui Parle River HUC

		TSS Related Fish Metrics						
Station	WID	BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct	TSS Index Score (RA)
15MN074	**-516**	18.23	0.05	53.49	1.08	0.00	0.16	20.46
15MN103	**-519**	13.65	0.00	10.58	2.51	0.00	0.00	14.98
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**37.38**	**4.89**	**9.61**	**18.66**	**4.97**	**11.68**	
Expected response to TSS stress		↓	↓	↓	↓	↓	↓	↑

There were no TSS intolerant taxa at station 15MN074 and tolerant macroinvertebrate individuals comprised 60% of the community, while there was one TSS intolerant taxa collected at station 15MN103 and 49% TSS tolerant individuals (Table 36). While there is some indication of TSS stress, TSS is inconclusive as a stressor on the reaches of the West Branch Lac qui Parle River. More TSS sampling during different flow regimes would be useful.

Table 36. TSS related macroinvertebrate metrics in the Upper West Branch Lac qui Parle River HUC

		TSS related Macroinvertebrate Metrics						
Station	**WID**	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
15MN074	**-516**	19.36	0	16	60.44	4.43	0.00	8.54
15MN103	**-519**	18.48	1	16	48.77	14.91	0.00	4.04
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**13.2**	**48.28**	**19.13**	**0.22**	**7.99**
Expected response to stress		↑	↓	↑	↑	↓	↓	↓

Candidate Cause: Habitat

Habitat conditions were shown to be poor by MSHA scores at station 15MN074, the downstream reach, and fair at station 15MN103 the upstream reach (Figure 19). Station 15MN074 was located in an active cattle pasture resulting in bank trampling, heavy erosion (Figure 20), and a lack of cover for both fish and macroinvertebrates. Station 15MN074 also had a lack of depth variability, channel development, and embeddedness of coarse substrates with fine substrates.

Figure 19. MSHA scores in the Upper West Branch Lac qui Parle River HUC

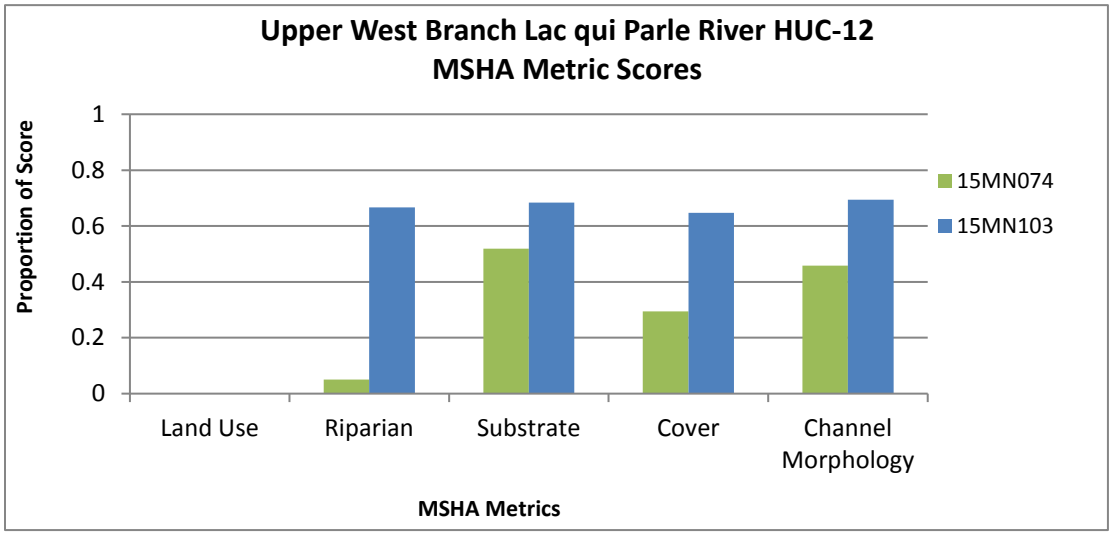


Figure 20. Erosion at site 15MN074 (8/13/15)

While habitat conditions were better at the upstream station 15MN103, there were indications of excess sediment in the stream with mid-channel bars (Figure 21), a lateral riffle, and embeddedness of coarse substrates (Figure 22). A lack of riparian buffer and resulting eroding banks were also noted (Figure 23). This is a nice stream section that would benefit from a sediment load reduction.

Figure 21. Mid-channel bar at station 15MN103

Figure 22. Fine sediments covering coarse substrates at station 15MN103

MDNR did geomorphology survey work at two sites on the West Branch Lac qui Parle River; one downstream of station 15MN103 and one at 15MN074. The upstream West Branch Lac qui Parle River site was found to be deeply incised with little floodplain access and was relatively stable (DNR 2019). The downstream West Branch Lac qui Parle River site was found to be moderately incised and a low sediment contributor compared to other similar sized streams (DNR 2019). Bank erosion along a pool at the downstream survey site was recorded as 0.344 feet over a year period (DNR 2019).

Figure 23. Corn planted next to stream and eroding banks at station 15MN103

Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were lower than average at station 15MN074 and higher than average at station 15MN103. Benthic insectivores, darter, sculpin, and sucker, Piscivore, and riffle individuals however were lowered at both sites (Table 37). Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. The percentage of tolerant species were well above average at both sites. Based on the poor habitat conditions and preponderance of evidence, lack of habitat is stressor to both reaches for fish.

Table 37. Habitat related fish metrics in the Upper West Branch Lac qui Parle River HUC

		Habitat Related Fish Metrics							
Station	**WID**	BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RiffPct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
15MN074	**-516**	1.29	25.43	1.08	18.76	0.22	43.87	80	6.61
15MN103	**-519**	2.79	48.19	2.51	15.32	0	80.78	78.27	30.64
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were below average at both stations (Table 38). Burrowers and legless individuals are a signal of high levels of sedimentation. Burrowers and legless individuals were higher than average at both stations. Based on the embeddedness of course substrates and excess sedimentation, and the preponderance of evidence of the macroinvertebrate communities, habitat is a stressor.

Table 38. Habitat related fish metrics in the Upper West Branch Lac qui Parle River HUC

		Habitat related Macroinvertebrate Metrics				
Station	**WID**	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
15MN074	**-516**	8.54	55.38	18.67	4.11	84.81
15MN103	**-519**	11.49	14.91	31.06	50.31	44.10
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate Cause: Altered hydrology

The mainstem of the West Branch Lac qui Parle River are predominantly natural. Channelization and tile drainage often causes flashy flows; high in the spring and during rain events and low or dry later in the summer.

Summary and recommendations

The Upper West Branch Lac qui Parle River HUC contains two reaches of the biologically impaired West Branch Lac qui Parle River. Lack of habitat was the major stressor in this watershed (Table 39). More phosphorus and TSS data are needed to better determine the impact of these potential stressors in this subwatershed.

The predominant land use in this subwatershed, row crop agriculture, is a contributor to the lack of habitat found in these reaches. This is a nice stream reach that would benefit from sediment load reduction to help improve habitat conditions. Reach -519 where the high TSS value was collected and where a high sediment load was located is located in the Coteau region, with steeper elevation and faster flows. Utilizing a variety of sediment reducing BMPs including: cover crops, erosion control, saturated buffers, etc. will help in reducing stress to the biological communities. Stream improvements and mitigation would be useful both in Minnesota and upstream in South Dakota.

Table 39. Stressors on streams in the Upper West Branch Lac qui Parle HUC

Stream Name	Stressors: Dissolved Oxygen	Eutrophication	Nitrate	Suspended Sediment	Habitat	Altered Hydrology
West Branch Lac qui Parle River (-516)	---	o	---	o	●	---
West Branch Lac qui Parle River (-519)	---	o	---	o	●	---

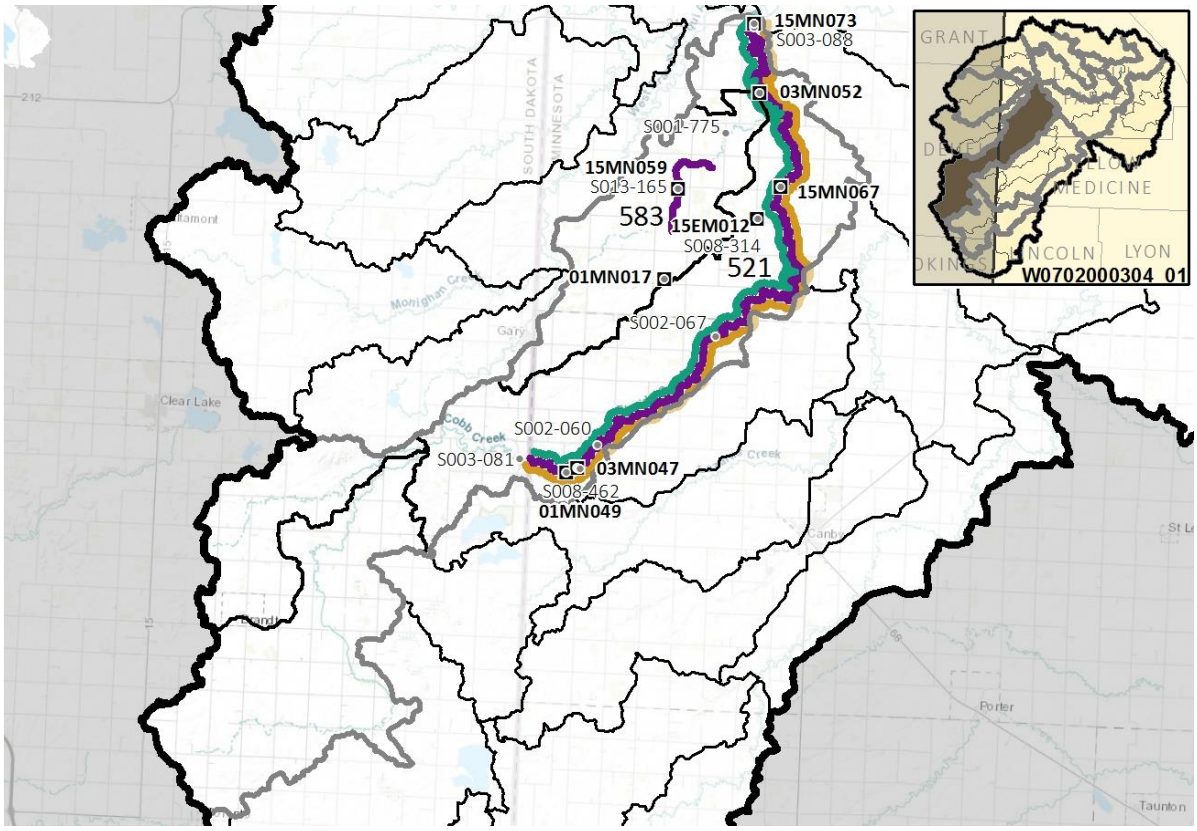
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Florida Creek 12-digit HUC

This aggregated HUC is located along the South Dakota border and contains Cobb Creek and Florida Creek (Figure 24). The two stream reaches in this section have the following impairments:

- Cobb Creek (-583) impaired for inverts (15MN059, S013-165)
- Florida Creek (-521) impaired for fish and inverts (03MN047, 15MN067, 03MN052, 15MN073, S008-462, S002-067, S003-088)

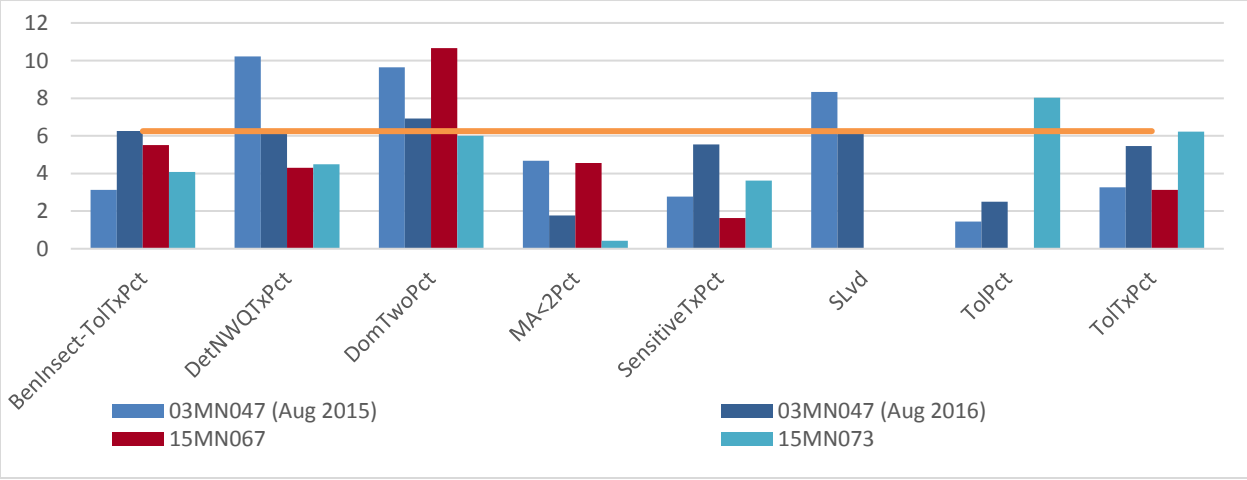
Figure 24. Impairments in the Florida Creek HUC (turquoise represents a fish impairment, purple represents a macroinvertebrate impairment, and yellow represents a Turbidity impairment)



Biological communities

The three stations on Florida Creek were in fish class 2 and were impaired for fish, while station 15MN059 on Cobb Creek was in modified fish class 3 and was not impaired for fish. The IBI scores decreased from upstream to downstream on Florida Creek. Metrics low across the visits were sensitive taxa percent, tolerant taxa percent, and species that have mature reproduction age at less than 2 years of age (Figure 25).

Figure 25. Fish metric scores at sites in general use fish class 2



The upper most station on Florida Creek (03MN047) was in macroinvertebrate class 5 (Figure 26), while the downstream stations were in macroinvertebrate class 7 (Figure 27). Station 15MN059 on Cobb Creek was in modified macroinvertebrate class 7 and was also impaired (Figure 18). Station 03MN047 had low scores for both the taxa count and Trichoptera metrics. The downstream stations (15MN067 and 15MN073) both had metric scores of zero for intolerant taxa. Station 15MN059 on Cobb Creek also had an intolerant metrics score of zero and a low collector-filterer score.

Figure 26. Macroinvertebrate metric scores at sites in general use Class 5

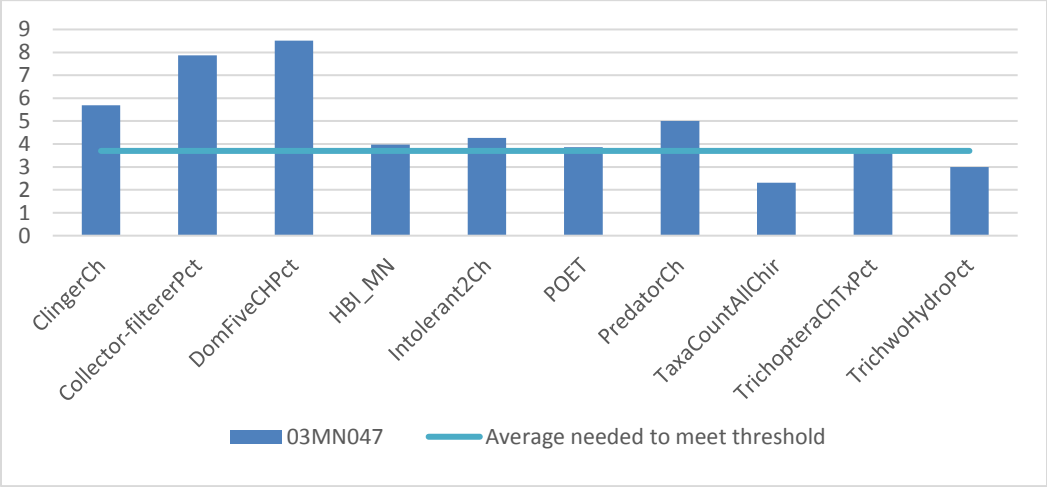


Figure 27. Macroinvertebrate metric scores at sites in general use Class 7

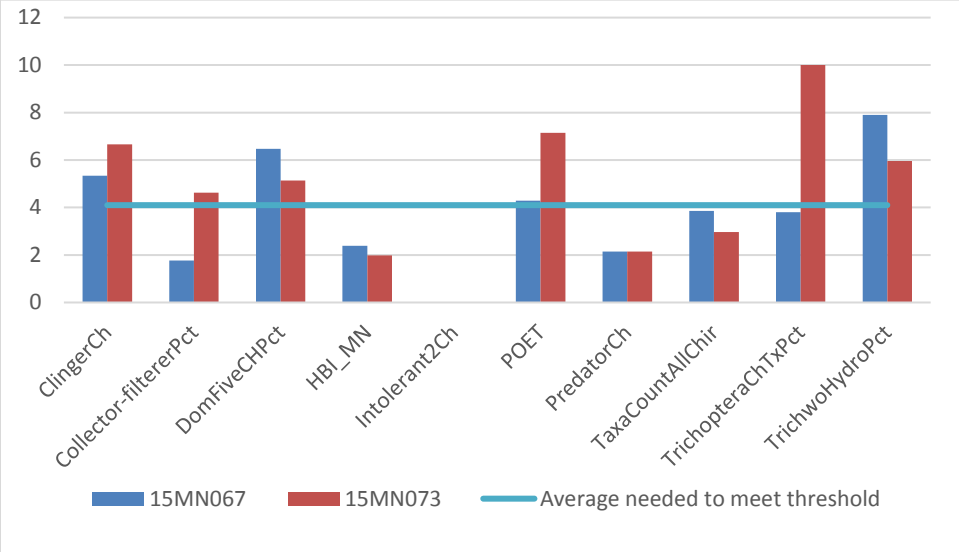
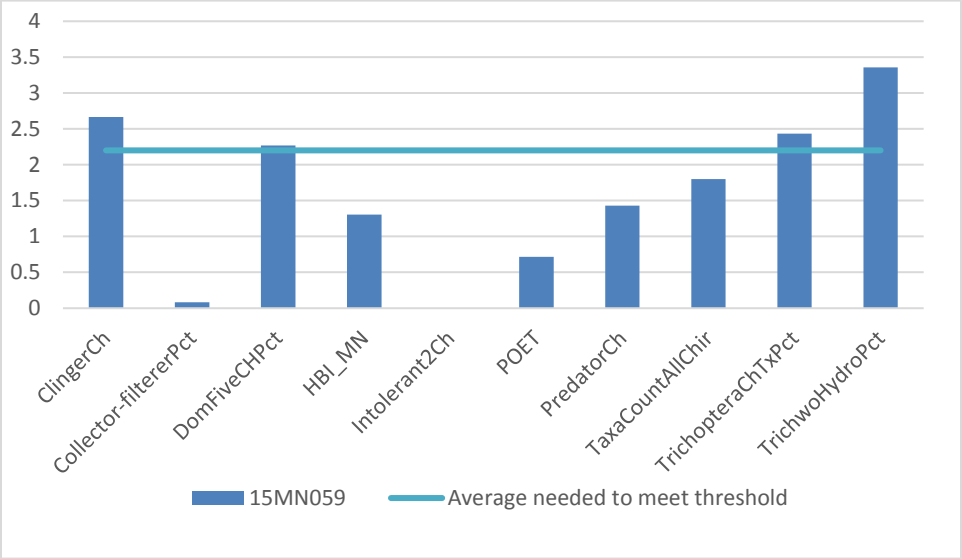


Figure 28. Macroinvertebrate metric scores at sites in modified use Class 7



Candidate Cause: Dissolved oxygen

Values ranged from 2.53 to 12.74 on Cobb Creek and Florida Creek. There was one recorded value below 5 mg/L (Table 40). From the assessment database, "The DO dataset indicates low values are not occurring on a regular basis, one violation is from a low gradient/wetland dominated corridor section of the reach". Continuous data was collected in 2015 on Florida Creek, where all values were above 5.76 mg/L. Continuous data was collected in 2017 at station 15MN059, where all values were above 5.59 mg/L.

Table 40. DO data in the Florida Creek HUC

Stream Reach	# DO values	Range of DO values	# of values below 5 mg/L
Florida Creek (-521)	47	2.53-11.05 mg/L	1
Cobb Creek (-583)	5	7.41-12.74 mg/L	0

Additionally, the HSPF model calculated daily minimum DO values from 1996-2012 on Cobb Creek and Florida Creek. Over the years, the low, high, and average minimum values were all calculated (Table 41). The minimum values ranged from 0.16-13.99 mg/L with less than 1% of values below the water quality standard of 5 mg/L at both streams.

Table 41. Modeled DO data in the Florida Creek HUC

Reach Name	WID	Number of Readings	Low daily minimum value (mg/L)	High daily minimum value (mg/L)	Daily minimum average value (mg/L)	Readings below 5 mg/L standard (%)
Florida Creek	**-521**	6940	0.16	13.99	10.17	0.20
Cobb Creek	**-583**	6940	1.77	13.99	9.68	0.53

Fish species that are specifically tolerant and intolerant to DO were analyzed at each station. There were no intolerant fish at any of the stations. DO tolerant percentages ranged from less than 1% (03MN047) to 44% (15MN059). The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions (Table 42). All stations had less than 1% of fish that take 3 years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. Serial spawners ranged from 7.72 to 18.58%. All sites were below the statewide average of stations meeting IBI thresholds. Based on the lack of low DO data and the conflicting metric response, DO is not a stressor to the fish community.

Table 42. DO related fish metrics in the Florida Creek HUC

		DO Related Fish Metrics		
Station	**WID**	MA>3 years Percentage	Serial Spawning Fish Pct	Fish Taxa Count
15MN059	**-583**	0.00	16.56	13
Statewide average for Class 3 Southern Streams stations meeting the FIBI Modified Use Threshold (55.0)		**1.43**	**10.56**	**10**
03MN047 (Aug 2015)	**-521**	0.00	11.79	10
03MN047 (Aug 2016)	**-521**	0.00	10.09	10
15MN073	**-521**	0.33	18.58	23
15MN067	**-521**	0.00	7.72	17
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**12.36**	**28.72**	**20.38**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station. One intolerant macroinvertebrate taxa were collected at station 15MN059 and six were collected at station 03MN047 (Table 43). DO tolerant percentages ranged from 1.53 to 11.43, all below the class average of sites meeting the threshold. Based on the lack of low DO values and lack of a consistent biological response throughout the reach. Low DO is not a stressor to the macroinvertebrate community.

Table 43. DO related macroinvertebrate metrics in the Florida Creek HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
03MN047	**-521**	1.58	6.99	6	7.38
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**8.62**	**7.04**	**8.97**	**7.09**
15MN059	**-583**	6.77	8.47	1	6.66
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**31.37**	**8.00**	**1.78**	**6.19**
15MN067	**-521**	11.43	8.14	5	7.15
15MN073	**-521**	1.53	8.27	3	7.31
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**12.98**	**7.55**	**4.46**	**6.91**
Expected response to DO stress		↑	↑	↓	↑

Candidate Cause: Eutrophication

There was a phosphorus dataset available on Florida Creek, while only four recent phosphorus values were available on Cobb Creek (Table 44). The highest values were taken at station S008-462 (0.752 mg/L) on the upstream reach of Florida Creek. Chlorophyll-a, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus. Continuous data in 2017 collected on Cobb Creek had a range of DO flux up to 8.59 mg/L, above the southern standard of 5 mg/L. Continuous data in 2015 collected on Florida Creek had a range of DO flux up to 4.32 mg/L. One chlorophyll-a value was available on Cobb Creek with a value of 0.66 ug/L and two values were collected on Florida Creek with a range of 1.9 to 14.8 ug/L. pH values ranged from 6.9 to 9.5. Values over 8.5 and large daily pH fluctuations can be tied to nutrient enrichment. The elevated pH values were all located on Florida Creek with the highest value at station S008-462 in the upstream section of the creek near the state border. Continuous data at site 15MN059 did not have elevated pH values.

Table 44. Total Phosphorus data in the Florida Creek HUC

Stream Reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Florida Creek (-521)	26	0.032-0.752	3
Cobb Creek (-583)	4	0.051-0.088	0

Additionally, the HSPF model calculated daily TP concentrations from 1996-2012. These values ranged from 0.02-6.1 mg/L with a mean of 0.17 mg/L on Florida Creek and 0.24 on Cobb Creek (Table 45).

Table 45. Modeled Phosphorus data in the Florida Creek HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above 0.15 mg/L TP standard (%)
Florida Creek	**-521**	6938	0.015	6.1	0.17	43.32
Cobb Creek	**-583**	6940	0.02	1.20	0.24	68.44

Sensitive individual percentages ranged from 0.08-17.18% on these reaches. All of the sites on Florida Creek had percentages below the class average of sites meeting the threshold, while the sensitive percentage on Cobb Creek was above the class average of sites meeting the modified threshold. Similar to sensitive species, the Florida Creek sites had low darter percentages all below 5%, while a sensitive darter was collected on the Cobb Creek (Table 46). The percentage of tolerant fish individuals were near or above class average at each station. Along with tolerant species, a positive relationship exists between eutrophication and omnivorous fish. The omnivorous fish percentage were not increased. While there were some elevated pH and DO flux on Cobb Creek, the fish communities are showing a mixed response to eutrophication. Eutrophication is inconclusive as a stressor on Cobb Creek. The increased phosphorus and pH values and the preponderance of metric response in Florida Creek indicate eutrophication is a stressor to the fish community.

Table 46. Eutrophication related fish metrics in the Florida Creek HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
03MN047 (Aug 2015)	**-521**	11.03	1.52	69.58	3.80
03MN047 (Aug 2016)	**-521**	10.09	4.59	65.60	3.21
15MN073	**-521**	4.31	4.20	44.80	15.15
15MN067	**-521**	0.08	3.13	81.67	18.72
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**18.65**	**11.68**	**44.85**	**16.53**
15MN059	**-583**	17.18	12.88	79.75	19.63
Statewide average for Class 3 Southern Headwaters stations that are meeting the FIBI Modified Use Threshold (33.0)		**6.02**	**10.56**	**76.69**	**19.80**
Expected response to Eutrophication stress		↓	↓	↑	↑

Stations 15MN067 and 15MN059 had a macroinvertebrate community dominated by two species; snails and beetles at station 15MN059 and snails and midges at station 15MN067 (Table 47). Snails increase as their food source algae increases. The EPT percentage was high at station 03MN047 and 15MN073, however EPT species tolerant to disturbance were the most commonly collected EPT taxa. Based on the elevated DO flux and biological metrics, eutrophication is a stressor to the macroinvertebrate communities on Cobb Creek. Based on the elevated phosphorus values and preponderance of evidence, eutrophication is a stressor to the macroinvertebrate community on Florida Creek.

Table 47. Eutrophication related macroinvertebrate metrics in the Florida Creek HUC

Station	WID	Eutrophication Related Macroinvertebrate Metrics: Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
03MN047	**-521**	34	62.86	20.63
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**42**	**43.90**	
15MN059	**-583**	15	5.81	67.42
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**34**	**20.58**	
15MN067	**-521**	24	30.79	37.46
15MN073	**-521**	23	60.86	46.48
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
Expected response to Eutrophication stress		↓	↓	↑

Candidate Cause: Nitrates

Recent nitrate data was available on both Florida and Cobb Creeks, with samples values ranging from 0.03-5.6 mg/L (Table 48). Additionally, the HSPF model calculated daily nitrate concentrations from 1996-2012. These values ranged from 0-27.64 mg/L with a mean of 0.51 mg/L on Cobb Creek and 0.53 mg/L on Florida Creek (Table 49).

Table 48. Nitrate data in the Florida Creek HUC

Stream Reach	# nitrate values	Range of values (mg/L)
Florida Creek (-521)	24	0.03-1.91
Cobb Creek (-583)	7	2.9-5.6

Table 49. Modeled nitrate data in the Florida Creek HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)
Florida Creek	**-521**	6938	0	27.64	0.53
Cobb Creek	**-583**	6940	0	15.84	0.51

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration.

Nitrate intolerant macroinvertebrate taxa were absent at all sites except 03MN047 where four intolerant taxa were collected. Nitrate tolerant individuals comprised 46% (03MN047) to 93% (15MN059) of the communities (Table 50). Station 03MN047 was the most upstream station on Florida Creek and had a community with the least effect from nitrate. Increasing nitrate concentrations also have a negative relationship with non-hydropsychid Trichoptera (caddisfly) individual percentages. Non-hydropsychid Trichoptera are all caddisflies that do not spin nets. Values were above the class average of sites meeting the threshold at the two upstream sites on Florida Creek; 03MN047 and 15MN067. Based on the lack of elevated nitrate values and the preponderance of metric values, nitrate is not a stressor to Florida Creek. Based on the increased nitrate effect from up to downstream on the reach, nitrate mitigation would be useful. The station on Cobb Creek (15MN059) some indications of nitrate stress based on the tolerant taxa, lack of Trichoptera taxa, and the nitrate TIV score. However, based on the lack of elevated nitrogen values, nitrate is inconclusive as a stressor.

Table 50. Nitrate related macroinvertebrate metrics in the Florida Creek HUC

		Nitrate related Macroinvertebrate Metrics			
Station	**WID**	TrichwoHydroPct	% Tolerant Taxa	% Intolerant Taxa	Nitrogen TIV
03MN047	**-521**	4.13	46.06	7.57	2.74
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (37.0)		**5.94**	**47.60**	**2.92**	**2.95**
15MN059	**-583**	1.29	92.90	0.00	5.99
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI Modified Use Threshold (22.0)		**2.16**	**59.41**	**1.95**	**3.32**
15MN067	**-521**	6.03	82.22	0.00	5.07
15MN073	**-521**	3.36	76.76	0.00	3.92
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
Expected response to Nitrate stress		↓	↑	↓	↑

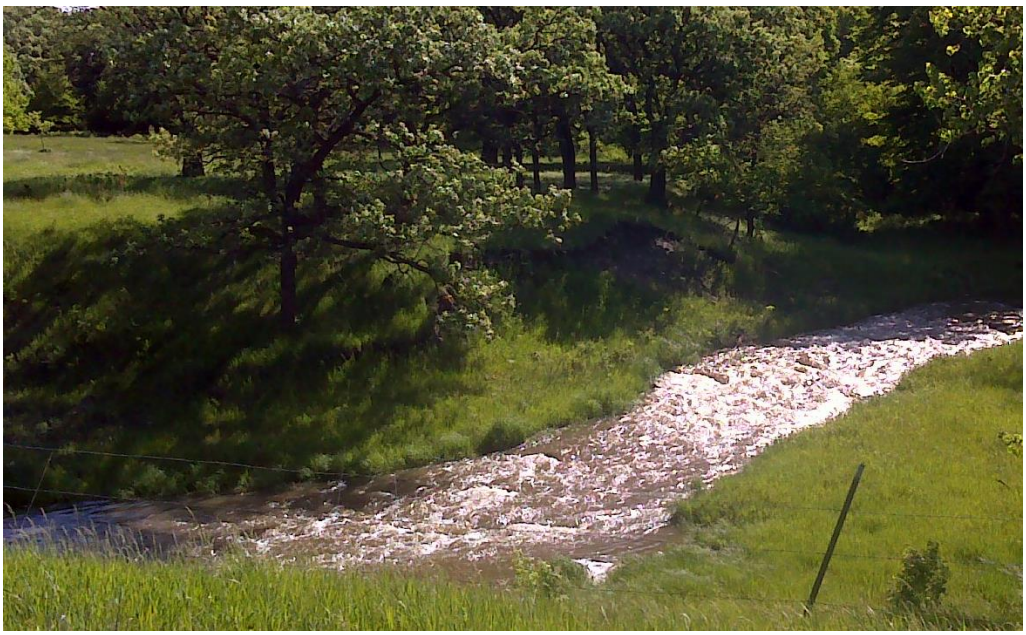
Candidate Cause: Sediment

Florida Creek has a Turbidity impairment. Recent TSS data is available on both streams. Samples ranged in value from 1.2-680 mg/L, with two concentrations above the southern standard of 65 mg/L on Florida Creek (Table 51). The value of 680 mg/L was taken at station S008-462 near the state border after over an inch of rain in the area. The upstream section of Florida Creek is in the higher gradient Coteau region that becomes turbid after rainfall (Figure 29). Additionally, secchi tube measurements ranged from 3-100 cm. Of these measurements, five were below the 10 cm standard for transparency.

Table 51. TSS data in the Florida Creek HUC

Stream Reach	# TSS values	Range of TSS values	# of values above 65 mg/L
Florida Creek (-521)	22	3-680	2
Cobb Creek (-583)	7	1.2-8.8	0

Figure 29. Florida Creek along CR-15 after almost an inch of rain (5/25/17)



Additionally, the HSPF model calculated daily suspended sediment concentrations from 1996-2012. These values ranged from 1.99-1931 mg/L with a mean of 13.51 mg/L on Florida Creek and 10.79 mg/L on Cobb Creek (Table 52).

Table 52. Modeled TSS data in the Florida Creek HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above standard (%)
Florida Creek	**-521**	6938	2.35	1930.5	13.51	1.12
Cobb Creek	**-583**	6940	1.99	1696	10.79	0.84

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. There were zero intolerant fish at either station (Table 53). However, there were also less than 2% of TSS tolerant individuals at each site. Herbivore species of fish decrease as TSS values increase. The stations both had herbivore percentages higher than the average of sites meeting the IBI thresholds. Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. Perciform percentages were above average at all stations except at site 15MN059 on Cobb Creek. Intolerant, Centrarchid, and long-lived species were below average at all sites. Based on the mixed biological response, TSS is inconclusive as a stressor to the fish community.

Table 53. TSS related fish metrics in the Florida Creek HUC

		TSS Related Fish Metrics						
Station	WID	BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct	TSS Index Score (RA)
03MN047 (Aug 2015)	**-521**	29.28	0.00	26.62	1.52	0.00	0.00	14.27
03MN047 (Aug 2016)	**-521**	15.60	0.00	20.18	4.59	0.00	0.00	15.45
15MN073	**-521**	5.75	0.11	11.17	4.42	0.00	1.00	17.30
15MN067	**-521**	29.64	0.00	35.91	3.13	0.00	0.00	18.46
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**37.38**	**4.89**	**9.61**	**18.66**	**4.97**	**11.68**	
15MN059	**-583**	6.75	0.00	6.13	12.88	0.00	0.00	17.31
Statewide average for Class 3 Southern Headwaters stations that are meeting the FIBI Modified Use Threshold (33.0)		**31.38**	**1.00**	**10.83**	**12.43**	**0.52**	**4.91**	
Expected response to TSS stress		↓	↓	↓	↓	↓	↓	↑

There were no TSS intolerant taxa at any of the stations, except at station 03MN037 where three were collected. Tolerant macroinvertebrate individuals comprised a range of 42 to 75% of the community (Table 54). Based on the lack of TSS intolerant taxa, elevated TSS tolerant taxa, and lack of collector-filterer and Plecoptera taxa, evidence supports TSS is a stressor on the downstream reach of Florida Creek and Cobb Creek.

Table 54. TSS related fish metrics in the Florida Creek HUC

		TSS related Macroinvertebrate Metrics						
Station	**WID**	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
03MN047	**-521**	17.05	3	13	42.27	21.27	0.63	16.51
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**15.87**	**3**	**12**	**35.23**	**4.56**	**0.54**	**8.99**
15MN059	**-583**	19.34	0	6	45.81	0.65	0.00	31.29
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**16.25**	**0.6**	**11**	**35.60**	**9.91**	**0.02**	**5.59**
15MN067	**-521**	22.45	0	13	71.11	6.98	0.00	6.67
15MN073	**-521**	23.69	0	12	75.23	17.74	0.00	3.36
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**13.2**	**48.28**	**19.13**	**0.22**	**7.99**
Expected response to TSS stress		↑	↓	↑	↑	↓	↓	↓

Candidate Cause: Habitat

Habitat conditions were shown to be poor according to MSHA scores on Cobb Creek and station 15MN067 on Florida Creek (Figure 30). Stations 03MN047 and 15MN073 both had fair scores. Station 15MN067 was experiencing heavy erosion (Figure 31), and a lack of depth variability and channel development, and embeddedness of fine substrates for both fish and macroinvertebrates. Station 15MN059 also had no riffles, no pools, no coarse substrates, and bank erosion.

Figure 30. MSHA scores in the Florida Creek HUC

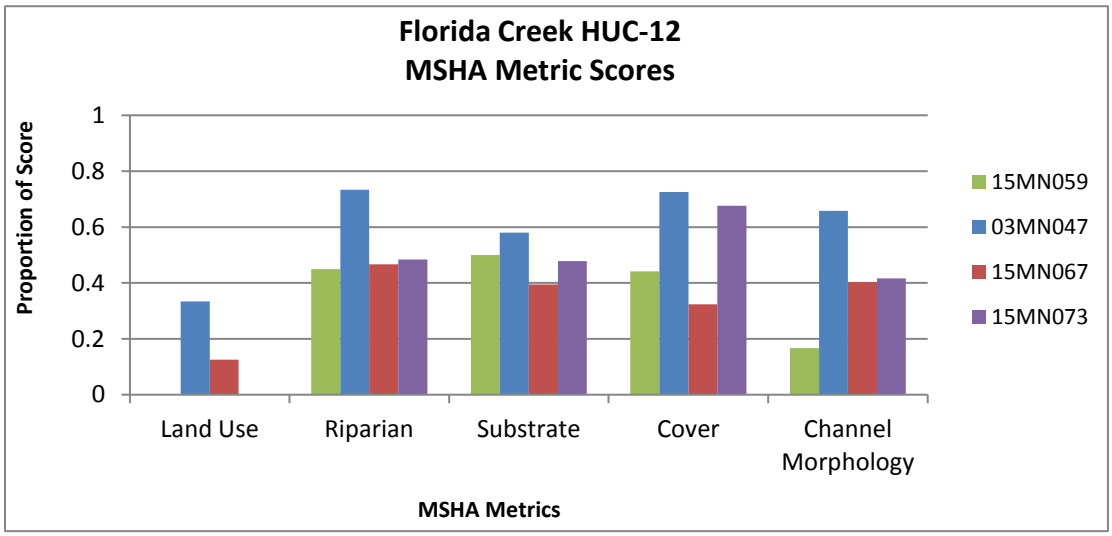


Figure 31. Erosion at station 15MN067 (7/15/15)

MDNR did geomorphology survey work at two sites on Florida Creek and one on Cobb Creek; one near station 03MN047, one at station 15MN067, and one site 4.5 miles downstream of 15MN059. The upstream Florida Creek site was found to have access to its floodplain and have good stability, however more erosion was measured than predicted and there is an undersized culvert at the road which can lead to stream stability issues (DNR 2019). The downstream Florida Creek site was found to be incised

with little floodplain access and to have poor stability (DNR 2019). “Aerial photo investigation of the site shows that Florida Creek had migrated approximately 50’ from 1991-2015, an average of 2.08’ per year prior to the geomorphology survey” (DNR 2019). The Cobb Creek site was found to be have a fair stream channel (DNR 2019).

Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were much lower than average on Cobb Creek, while near or below average at all sites except 15MN073 the downstream site. Benthic insectivores, darter, sculpin, and sucker, and Piscivore individuals were lowered at all sites on Florida Creek (Table 55). Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. Darters were above average at Cobb Creek due to Iowa darters being collected. The percentage of tolerant species were at or above average at all sites. Based on the poor habitat conditions and preponderance of evidence, lack of habitat is stressor to Florida Creek for fish. Habitat as a stressor for fish on Cobb Creek is inconclusive.

Table 55. Habitat related fish metrics in the Florida Creek HUC

		Habitat Related Fish Metrics							
Station	**WID**	BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RifflePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
03MN047 (Aug 2015)	**-521**	1.52	41.06	1.52	38.78	0	94.30	69.58	20.53
03MN047 (Aug 2016)	**-521**	4.59	33.49	4.59	21.10	0	83.94	65.59	36.24
15MN073	**-521**	4.31	51.55	4.31	7.41	0.55	64.82	44.80	28.76
15MN067	**-521**	3.13	33.23	3.13	26.74	0	56.38	81.67	19.40
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
15MN059	**-583**	12.88	4.29	12.88	4.29	0	60.74	79.75	69.33
Statewide average for Class 3 Southern Headwaters stations meeting the FIBI Modified Use Threshold (33.0)		**10.91**	**30.09**	**10.59**	**22.62**	**1.97**	**57.98**	**76.69**	**32.54**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were only below average at site 15MN067. Burrowers and legless individuals are a signal of high levels of sedimentation. Burrowers percentages were lower than average at all stations while legless percentages were only higher than average at sites 15MN059 and 15MN067. EPT percentages were below average at sites 15MN059 and 15MN067. Based on the lack of course substrates and excess sedimentation, and the preponderance of evidence of the macroinvertebrate communities, habitat is a stressor on both reaches.

Table 56. Habitat related macroinvertebrate metrics in the Florida Creek HUC

Station	WID	Habitat related Macroinvertebrate Metrics				
		BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
03MN047	**-521**	4.44	11.11	58.41	62.86	19.37
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**7.54**	**14.71**	**49.54**	**42.46**	**36.03**
15MN059	**-583**	8.06	46.13	32.90	5.81	60.97
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**14.12**	**27.47**	**23.07**	**20.58**	**55.79**
15MN067	**-521**	4.13	49.84	20.00	30.79	55.24
15MN073	**-521**	0.61	29.36	30.58	60.86	33.33
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate Cause: Altered hydrology

Portions of both streams have been channelized; site 15MN059 on Cobb Creek and site 15MN067 on Florida Creek are both channelized. “From the lower Florida Creek geomorphology survey site to a mile upstream of the confluence with the West Branch Lac qui Parle River, channelization has shortened the creek from 11.77 miles to 6.61 miles; a 43% reduction in stream length” (DNR 2019).

Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. Habitat availability can be scarce when flows are interrupted, or low for a prolonged duration. Flows that are reduced beyond normal baseflow decrease living space for aquatic organisms and increase competition for resources.

Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. The site had a population of generalist fish ranging from 50-76%. The numbers of nest guarder species are also positively correlated with increased low flows. The nest guarder species had a population ranging from 2-23%. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The range of long-lived macroinvertebrates ranged from 3-31%. The channelization is likely contributing to the lack of habitat and is a contributing stressor to the biological communities. Restoring the historic channel can help alleviate stress on downstream reaches of Cobb Creek and Florida Creek (DNR 2019).

Summary and recommendations

The Florida Creek HUC contains two biologically impaired reaches. Eutrophication, lack of habitat, suspended sediments, and flow alteration were the major stressors in this watershed as they were determined to be stressing aquatic life at both impaired reaches (Table 57). More nitrate data is needed to better determine the impact of this potential stressor on Cobb Creek.

The predominant land use in this subwatershed, row crop agriculture, is a contributor to the stressors found in these reaches. Reach -521 with the high TSS value and habitat as a stressor, is located in the Coteau region, with steeper elevation and faster flows. Utilizing a variety of nutrient and sediment reducing BMPs including: cover crops, nutrient management, saturated buffers, etc. saturated buffers, etc. will help in reducing stress to the biological communities. Stream improvements and mitigation would be useful both in Minnesota and upstream in South Dakota.

Table 57. Stressors on streams in the Florida Creek HUC

	Stressors:					
Stream Name	**Dissolved Oxygen**	**Eutrophication**	**Nitrate**	**Suspended Sediment**	**Habitat**	**Altered Hydrology**
Florida Creek (-521)	---	●	---	●	●	●
Cobb Creek (-583)	---	●	o	●	●	●

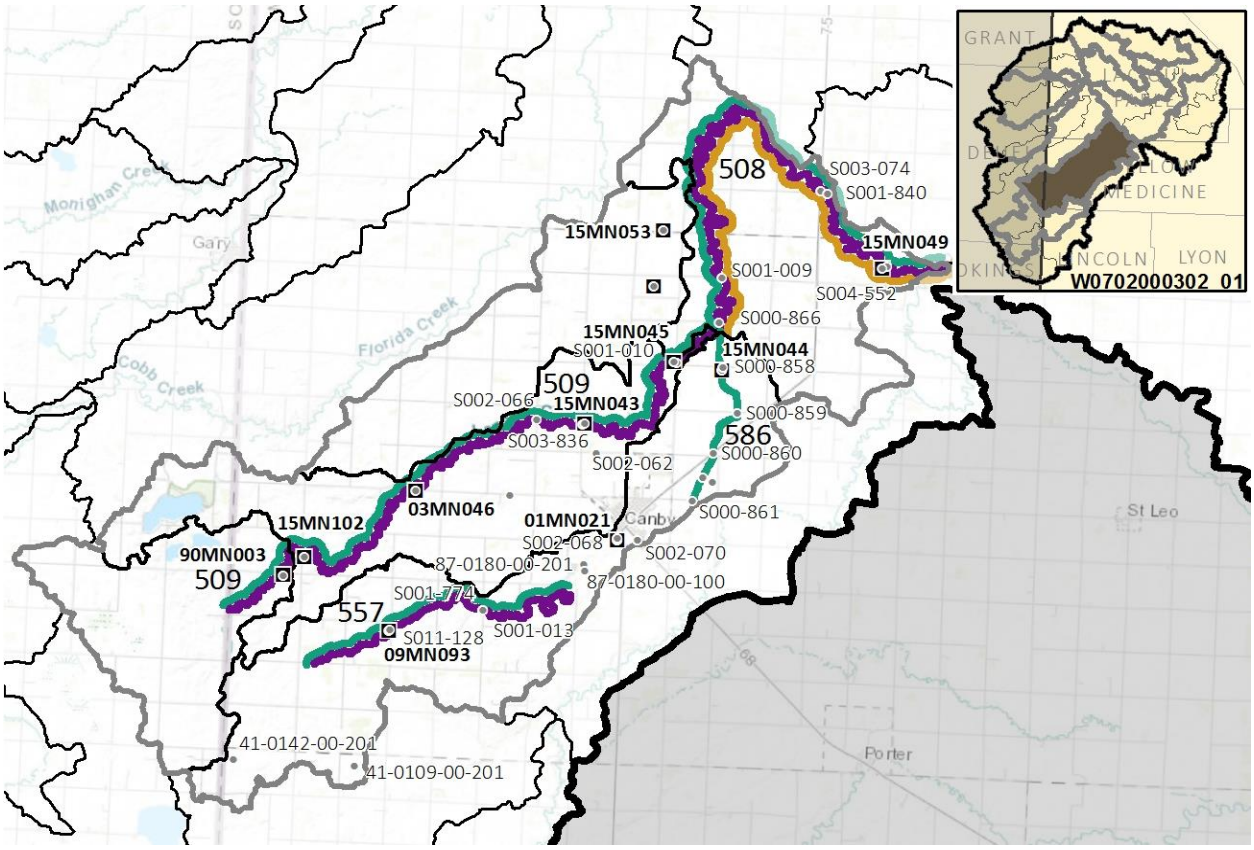
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Lazarus Creek 12-digit HUC

This aggregated HUC is located along the South Dakota border and contains Canby and Lazarus Creek and where they join together (Figure 32). The two stream reaches in this section have the following impairments:

- Canby Creek (-557), impaired for fish and inverts (S011-128, 09MN093)
- Canby Creek (-586), impaired for fish (S000-861, S000-858, 15MN044, LD00322)
- Lazarus Creek (-509), impaired for fish and inverts (15MN045, S001-010, 15MN043, S003-836, S002-066, 15MN102)
- Lazarus Creek (-508), impaired for fish and inverts (S004-552, S003-074, 15MN049)

Figure 32. Impairments in the Lazarus Creek HUC (turquoise represents a fish impairment, purple represents a macroinvertebrate impairment, and yellow represents a Turbidity impairment)



Biological communities

Three stations on Lazarus Creek were in fish class 2 (Figure 33), while station 15MN102 on Lazarus Creek was in general fish class 3 (Figure 34). All sites were impaired for fish. Metrics low across the visits were sensitive species and short-lived species.

Figure 33. Fish metric scores at sites in general use fish class 2

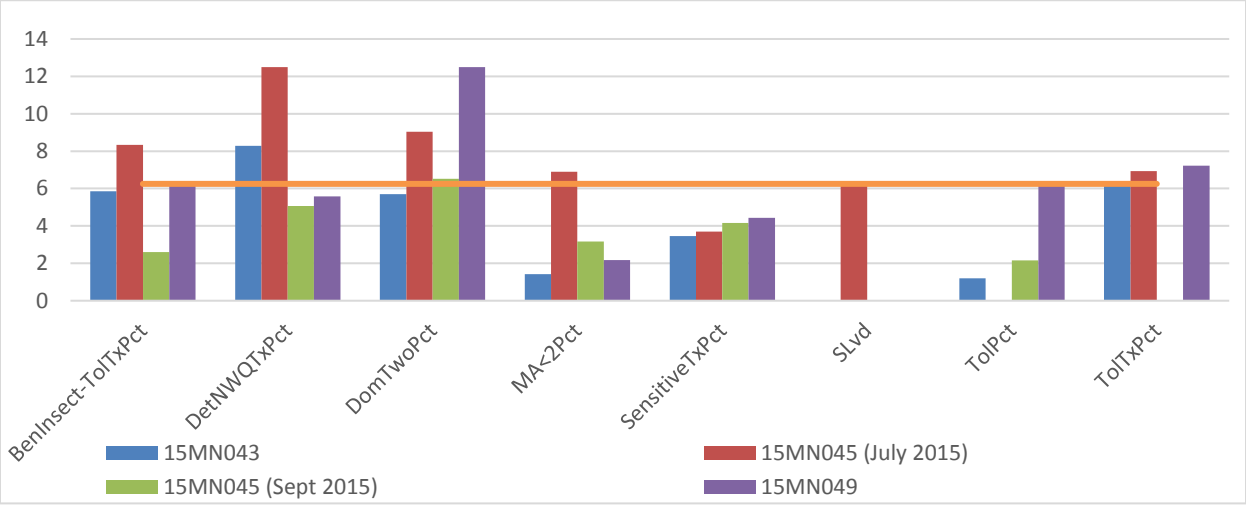
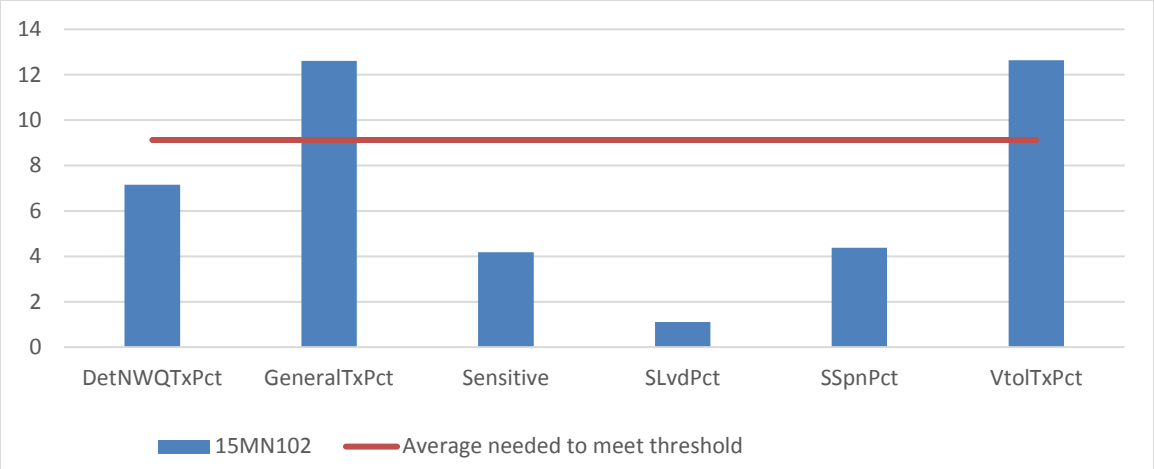
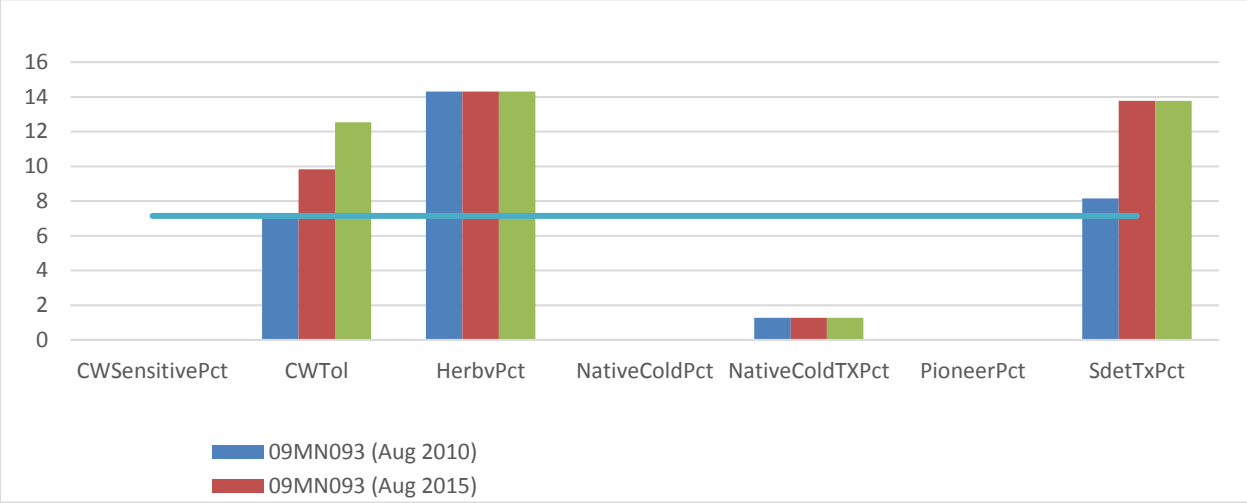


Figure 34. Fish metric scores at sites in general use fish class 3



The sites on Canby Creek were in the coldwater Class 10 fish class and were also impaired for fish. Metrics low across the visits were sensitive species, short-lived species, and coldwater species on Canby Creek (Figure 35). Canby Creek -557 had a -5 DELT subtraction from the FIBI score at site 09MN093. DNR is stocking trout on the stream.

Figure 35. Fish metric scores at sites in general use fish class 10



The upper most station on Lazarus Creek (03MN047) was in macroinvertebrate class 5 (Figure 36), while the downstream stations were in macroinvertebrate class 7 (Figure 37). Station 15MN049 was comprised of over 90% macroinvertebrate tolerant taxa. Lazarus Creek (-509) had a pattern of decreasing biological scores from upstream to downstream (including downstream 508). The three downstream stations on Lazarus Creek all had a metric score of zero and low Trichoptera metric scores.

Station 09MN093 was in coldwater invert Class 9. As remarked in the assessment database (Figure 38), "As a coldwater stream it is likely that thermal impacts and/or diminished groundwater input is impacting the biological community of this stream as no obligate cold water inverts were present in reach, only marginal coldwater taxa such as Tvetenia and Micropsectra".

Figure 36. Macroinvertebrate metric scores at sites in general use macroinvertebrate class 5

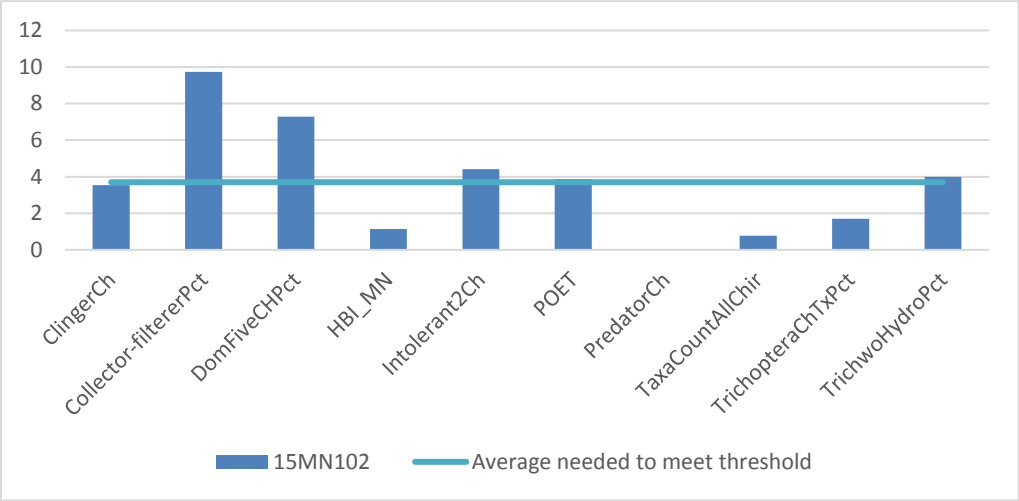


Figure 37. Macroinvertebrate metric scores at sites in general use macroinvertebrate class 7

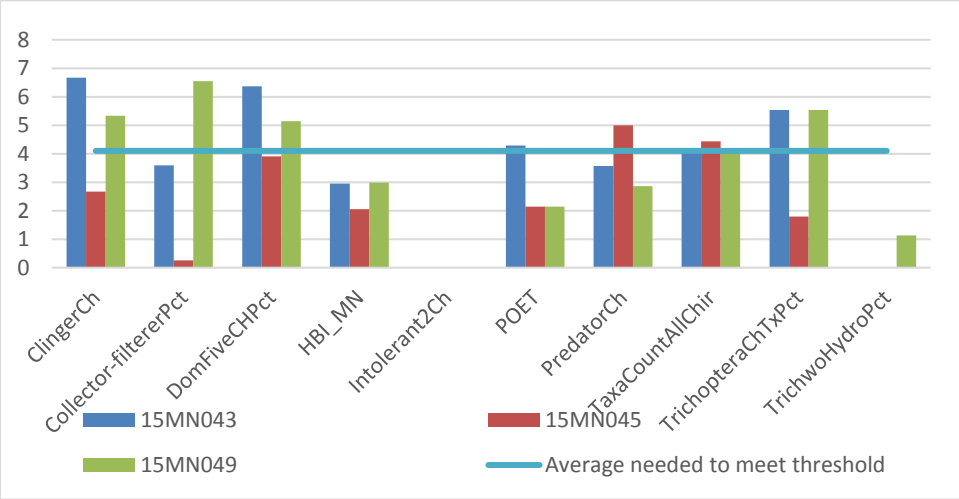
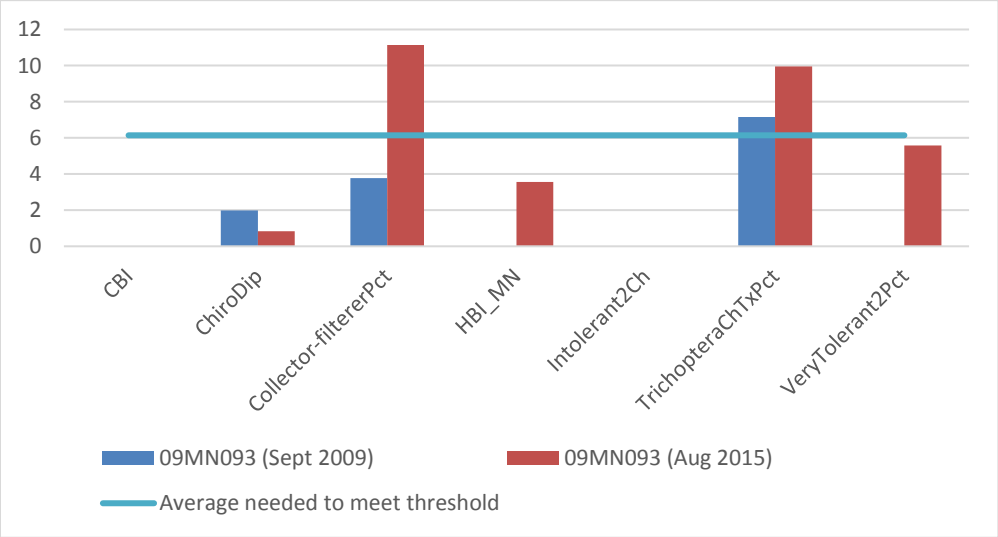


Figure 38. Macroinvertebrate metric scores at sites in general use macroinvertebrate class 9



Candidate Cause: Dissolved oxygen

Values ranged from 4.67 to 13.18 with four values below 5 mg/L (Table 58). All of the values below 5 mg/L were collected on the downstream portion of Lazarus Creek (-508). Continuous data collected in 2015 on Lazarus Creek (-508) and 2017 on Canby Creek (-557) did not have any values below 5 mg/L. The minimum value at 09MN093 in 2017 was 7.54 mg/L and 5.99 mg/L at station 15MN049.

Table 58. DO data in the Lazarus Creek HUC

Stream Reach	# DO values	Range of DO values	# of values below standard
Canby Creek (-557)	14	8.14-10.49 mg/L	0 (values below 7 mg/L)
Canby Creek (-586)	9	7.0-10.66 mg/L	0 (values below 5 mg/L)
Lazarus Creek (-509)	22	6.99-10.24 mg/L	0 (values below 5 mg/L)
Lazarus Creek (-508)	45	4.67-13.18 mg/L	4 (values below 5 mg/L)

Additionally, the HSPF model calculated daily minimum DO values from 1996-2012 on Canby Creek and Lazarus Creek. Over the years, the low, high, and average minimum values were all calculated (Table 59). The minimum values ranged from 0-5.61 mg/L with less than 1% of values below the water quality standard of 5 mg/L at both reaches of Lazarus Creek and the warmwater reach of Canby Creek (-586), while over 22% of modelled values were under the 7 mg/L stand on the coldwater stretch of Canby Creek (-557).

Table 59. Modeled DO data in the Lazarus Creek HUC

Reach Name	WID	Number of Readings	Low daily minimum value (mg/L)	High daily minimum value (mg/L)	Daily minimum average value (mg/L)	Readings below standard (%)
Lazarus Creek	**-508**	6940	5.61	14.04	10.03	0
Lazarus Creek	**-509**	6940	2.55	13.89	9.61	0.71
Canby Creek	**-557**	6938	0	13.80	8.22	22.34
Canby Creek	**-586**	6940	0.08	14.01	9.61	0.52

Fish species that are specifically tolerant and intolerant to DO were analyzed at each station. There were no intolerant fish at any of the stations. DO tolerant percentages ranged from less than 0% (09MN093) to 85% (15MN102). The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions (Table 60). All stations had less than 1.5% of fish that take 3 years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. All sites were above the statewide average of stations meeting IBI thresholds. While there are indications of metric response, based on the lack of low DO data, DO is inconclusive as a stressor to the fish community on -508, -509, and -586. Low DO is not a stressor on -557.

Table 60. DO related fish metrics in the Lazarus Creek HUC

Station	WID	DO Related Fish Metrics		
		MA>3 years Percentage	Serial Spawning Fish Pct	Fish Taxa Count
15MN045 (July 2015)	**-509**	0.00	24.58	15
15MN045 (Sept 2015)	**-509**	0.00	37.68	12
15MN043	**-509**	0.00	44.62	16
15MN049	**-508**	1.30	28.04	25
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**12.36**	**28.72**	**20.38**
15MN044 (July 2015)	**-586**	0.00	23.93	15
15MN044 (Sept 2015)	**-586**	0.00	55.14	11
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI Modified Use Threshold (35.0)		**15.09**	**25.34**	**14.5**
15MN102	**-509**	0.00	56.73	7
Statewide average for Class 3 Southern Streams stations that are meeting the FIBI General Use Threshold (55.0)		**2.06**	**17.09**	**12.16**
09MN093 (Aug 2010)	**-557**	0.00	2.67	6
09MN093 (Aug 2015)	**-557**	0.00	0.00	5
09MN093 (Sept 2015)	**-557**	0.00	0.00	3
Statewide average for Class 10 Southern Coldwater stations that are meeting the FIBI General Use Threshold (50.0)		**60.28**	**1.79**	**5.7**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station (Table 61). DO intolerant macroinvertebrate taxa ranged from zero at station 15MN045 on Lazarus Creek to nine species at 09MN093 on the coldwater reach of Canby Creek. DO tolerant percentages ranged from 3.42 to 32.03. Based on the lack of low DO values and lack of a consistent biological response throughout the reach, low DO is not a stressor to the macroinvertebrate community on Canby Creek (-557 and -586) and is inconclusive on Lazarus Creek (-508 and -509).

Table 61. DO related macroinvertebrate metrics in the Lazarus Creek HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
09MN093 (Sept 2009)	**-557**	18.81	7.59	8	6.94
09MN093 (Aug 2015)	**-557**	3.42	7.11	9	6.06
Statewide average for Class 9 Southern Coldwater stations that are meeting the MIBI General Use Threshold (43.0)		**1.66**	**0**	**10.3**	**7.44**
15MN102	**-509**	10.00	7.96	6	6.88
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**8.62**	**7.04**	**8.97**	**7.09**
15MN044	**-586**	22.81	8.17	2	6.30
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**31.37**	**8.00**	**1.78**	**6.19**
15MN043	**-509**	29.93	7.97	8	6.54
15MN045	**-509**	32.03	8.24	0	6.72
15MN049	**-508**	6.80	7.96	4	6.93
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**12.98**	**7.55**	**4.46**	**6.91**
Expected response to DO stress		↑	↑	↓	↑

Candidate Cause: Eutrophication

Phosphorus data were available on both Canby Creek and Lazarus Creek. The highest value was taken at station S004-552 (0.357 mg/L) on the downstream reach of Lazarus Creek (Table 62). Over 21% of phosphorus values on the downstream reach of Lazarus Creek were over the southern standard of 0.150 mg/L.

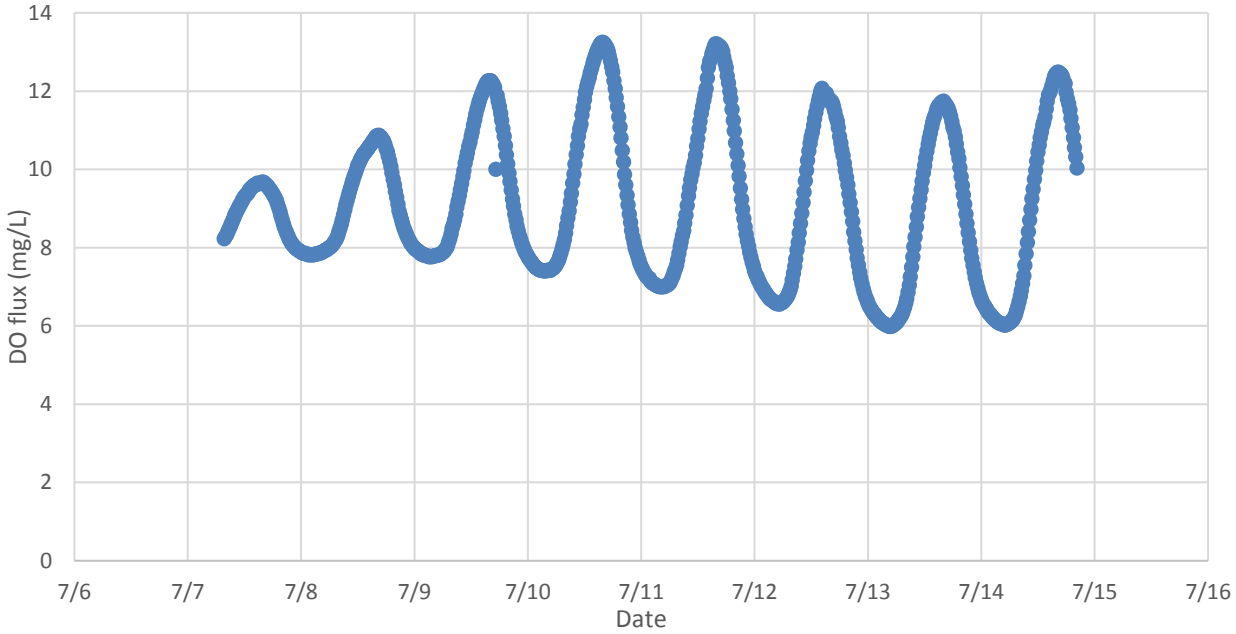
Table 62. Total Phosphorus data in the Lazarus Creek HUC

Stream Reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Canby Creek (-557)	15	0.014-0.206	2
Canby Creek (-586)	9	0.027-0.288	1
Lazarus Creek (-509)	22	0.02-0.178	1
Lazarus Creek (-508)	78	0.043-0.357	17

Chlorophyll-a, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus. Continuous data in 2017 collected on Canby Creek at site 09MN093 had a DO flux range of 0.69-1.81 mg/L. Continuous data in 2015 collected on

Lazarus Creek at site 15MN049 had a DO flux range of 3.05-6.21 mg/L (Figure 39). Of the seven deployment days, four of the daily fluctuations were above 4.5 mg/L, the southern standard. DO values during deployment were elevated to 13.25 mg/L. One chlorophyll-a value was available on Canby Creek with a value of 1.5 ug/L. Values over 8.5 and large daily pH fluctuations can be tied to nutrient enrichment. pH values ranged from 7.85-8.3 at station 09MN093 and 8.12-8.39 at station 15MN049, with a range of pH flux of 0.06-0.25.

Figure 39. Continuous DO data at station 15MN049



Additionally, the HSPF model calculated daily TP concentrations from 1996-2012. These values ranged from 0.01-22.46 mg/L with a mean of 0.395 mg/L on Lazarus Creek and 0.27 on Canby Creek (Table 63).

Table 63. Modeled Phosphorus data in the Lazarus Creek HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above 0.15 mg/L TP standard (%)
Lazarus Creek	**-508**	6940	0.03	3.91	0.29	64.09
Lazarus Creek	**-509**	6940	0.01	9.32	0.50	68.44
Canby Creek	**-557**	6888	0.02	22.46	0.36	58.35
Canby Creek	**-586**	6940	0.03	1.12	0.18	45.55

Sensitive individual percentages ranged from 0-8.47% on these reaches. All sites had percentages below the class average of sites meeting the threshold, except for station 15MN102 which was just above the class average (Table 64). Darter percentages were low on the upper reach of Lazarus Creek (-509) and the lower reach of Canby Creek (-586). The percentage of tolerant fish individuals were above class average at each station. Along with tolerant species, a positive relationship exists between eutrophication and omnivorous fish. The omnivorous fish percentage were elevated on Lazarus Creek. Elevated phosphorus, DO flux data and the preponderance of metric response on the lower reaches of Lazarus Creek (-508) and Canby Creek (-586) and indicate eutrophication is a stressor to the fish

community. Eutrophication is inconclusive as a stressor on the upper reaches of both Lazarus Creek (-509) and Canby Creek (-557).

Table 64. Eutrophication related fish metrics in the Lazarus Creek HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
15MN045 (July 2015)	**-509**	2.54	5.51	81.78	46.19
15MN045 (Sept 2015)	**-509**	0.00	1.45	92.03	49.28
15MN043	**-509**	8.47	8.70	70.48	37.99
15MN049	**-508**	5.22	15.87	51.52	23.91
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**18.65**	**11.68**	**44.85**	**16.53**
15MN044 (July 2015)	**-586**	0.00	0.61	90.18	17.18
15MN044 (Sept 2015)	**-586**	0.00	0.54	94.59	52.43
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI Modified Use Threshold (35.0)		**8.38**	**13.57**	**46.38**	**25.54**
15MN102	**-509**	9.55	9.72	90.28	56.73
Statewide average for Class 3 Southern Streams stations that are meeting the FIBI General Use Threshold (55.0)		**8.55**	**12.08**	**70.64**	**14.62**
09MN093 (Aug 2010)	**-557**	0.00	10.92	89.08	2.67
09MN093 (Aug 2015)	**-557**	0.00	12.54	87.46	0.00
09MN093 (Sept 2015)	**-557**	0.00	21.85	78.15	0.00
Statewide average for Class 10 Southern Coldwater stations that are meeting the FIBI General Use Threshold (50.0)		**72.53**	**3.29**	**23.90**	**15.33**
Expected response to increased TP stress		↓	↓	↑	↑

Each of the stations had less than half their macroinvertebrate community dominated by two species (Table 65). The EPT percentage decreased at station 09MN093 between 2009 and 2015, and were at or lower than the class average at the other sites. Based on the elevated DO flux and biological metrics, eutrophication is a stressor to the macroinvertebrate communities on the upper reach of Lazarus Creek (-509) and the lower reach of Canby Creek (-586). Eutrophication was inconclusive as a stressor to the macroinvertebrate community on the upper reaches of Lazarus Creek (-509) and Canby Creek (-557).

Table 65. Eutrophication related fish metrics in the Lazarus Creek HUC

		Eutrophication Related Macroinvertebrate Metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
09MN093 (Sept 2009)	**-557**	40	55.84	29.34
09MN093 (Aug 2015)	**-557**	38	29.91	29.28
Statewide average for Class 9 Southern Coldwater stations that are meeting the MIBI General Use Threshold (43.0)		**29**	**43.36**	
15MN102	**-509**	42	34.67	29.00
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**42**	**43.90**	
15MN044	**-586**	43	19.81	27.36
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**34**	**20.58**	
15MN043	**-509**	33	39.80	35.86
15MN045	**-509**	34	35.95	48.37
15MN049	**-508**	33	25.89	38.83
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
Expected response to TP stress		↓	↓	↑

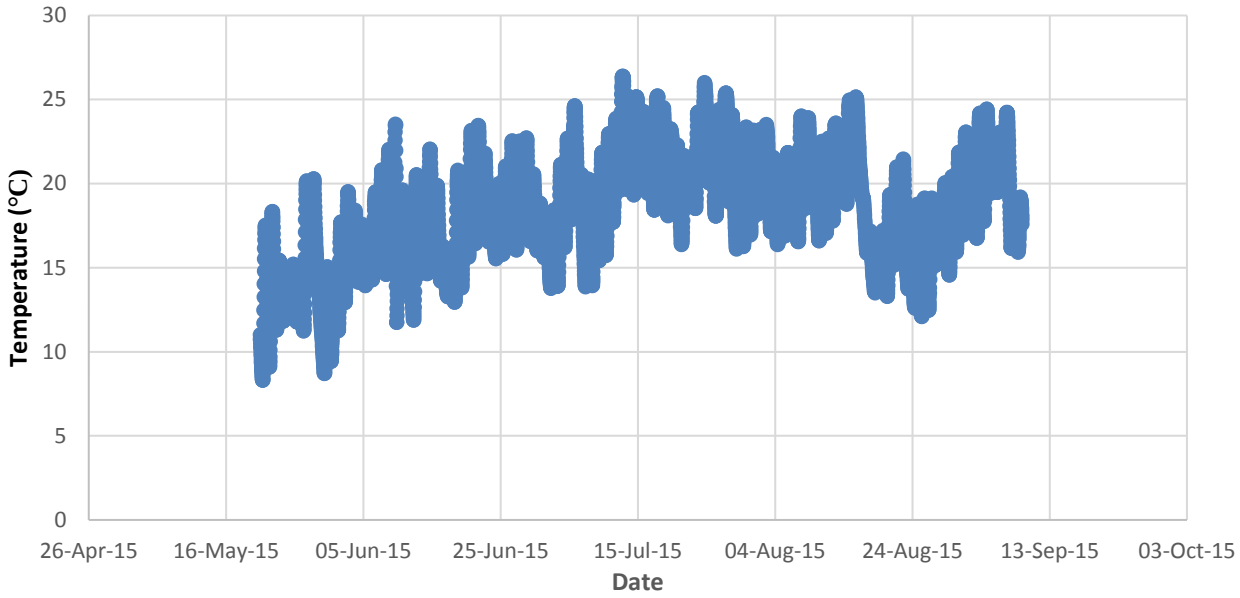
Candidate Cause: Temperature

Temperature data is available on both Lazarus and Canby Creeks (Table 66). The maximum temperature recorded was on the three warmwater reaches was 26.62°C. No temperatures of concern were collected on the warmwater reaches. The high value on the coldwater reach of Canby Creek was 21.7°C. However, continuous temperature data at station 09MN093 in 2015 had a maximum value of 26.4°C (Figure 40). According to Bell (2006), brown trout may be physiologically stressed in the temperature range of 19-22°C. The July and August average temperature for the four stations was 20.3°C and 18.7°C respectively.

Table 66. Temperature data in the Lazarus Creek HUC

Stream Reach	# Temperature values	Range of TP values
Canby Creek (-557)	9	10.8-21.7
Canby Creek (-586)	6	16.9-22.8
Lazarus Creek (-509)	25	10.3-24.8
Lazarus Creek (-508)	74	10.3-26.6

Figure 40. Continuous temperature data at station 09MN093



No coldwater fish communities were collected on the coldwater reach of Canby Creek. The coldwater biotic index (CBI) macroinvertebrate metric score was also zero. Based on the lack of coldwater communities and the number of temperature readings over 25°C , temperature is a stressor to the coldwater reach of Canby Creek (-557). In warmwater reaches, temperatures did not reach unsuitable ranges (>30°C), and temperature stress seemed unlikely.

Candidate Cause: Nitrates

Recent nitrate data was available on both Canby and Lazarus Creeks, with samples values ranging from 0.02-4.8 mg/L (Table 67). A tile drain to station 15MN044 on Canby Creek (-586) had a value of 14 mg/l while the value in Canby Creek was 3.4 mg/L. Additionally, the HSPF model calculated daily nitrate concentrations from 1996-2012. These values ranged from 0-26.41 mg/L with a mean of 0.50 mg/L on Lazarus Creek and 0.63 mg/L on Canby Creek (Table 68).

Table 67. Nitrate data in the Lazarus Creek HUC

Stream Reach	# nitrate values	Range of values (mg/L)
Canby Creek (-557)	11	0.05-9
Canby Creek (-586)	9	0.72-4.7
Lazarus Creek (-509)	18	0.06-3.9
Lazarus Creek (-508)	79	0.02-4.8

Table 68. Modeled nitrate data in the Lazarus Creek HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)
Lazarus Creek	**-508**	6940	0	16.17	0.54
Lazarus Creek	**-509**	6940	0	18.15	0.46
Canby Creek	**-557**	6888	0.01	26.41	0.60
Canby Creek	**-586**	6940	0	9.43	0.65

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration.

Table 69. Nitrate related macroinvertebrate metrics in the Florida Creek HUC

		Nitrate related Macroinvertebrate Metrics			
Station	WID	TrichwoHydroPct	% Tolerant Taxa	Intolerant Taxa	Nitrogen TIV
09MN093 (Sept 2009)	**-557**	5.05	49.53	2	3.08
09MN093 (Aug 2015)	**-557**	4.05	26.71	1	2.39
Statewide average for Class 9 Southern Coldwater stations that are meeting the MIBI General Use Threshold (43.0)		**10.03**	**58.94**	**1.43**	**3.08**
15MN102	**-509**	9	72.00	1	3.77
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**5.94**	**47.60**	**2.92**	**2.95**
15MN044	**-586**	0.63	81.25	1	4.17
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**2.16**	**59.41**	**1.95**	**3.32**
15MN043	**-509**	0	59.87	0.00	3.42
15MN045	**-509**	0	84.97	1	4.84
15MN049	**-508**	0.32	71.20	0.00	4.70
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
Expected response to Nitrate stress		↓	↑	↓	↑

Nitrate intolerant macroinvertebrate taxa ranged from 0 (stations 15MN043 and 15MN049) to 2 (09MN093). Nitrate tolerant individuals comprised 27% (09MN093) to 85% (15MN045) of the communities (Table 69). Increasing nitrate concentrations also have a negative relationship with non-hydropsychid Trichoptera (caddisfly) individual percentages. Non-hydropsychid Trichoptera are all caddisflies that do not spin nets. Values were below the class average at all sites meeting the threshold except at site 15Mn102 on Lazarus Creek. Based on the lack of elevated nitrate values and the mixed biological response of metric values, nitrate is inconclusive as a stressor to Lazarus or Canby Creeks.

Candidate Cause: Sediment

Lazarus Creek has a Turbidity impairment (-508). Recent TSS data is available on both streams (Table 70). Samples ranged in value from 1.6-166 mg/L, with ten concentrations above the southern standard of 65 mg/L on the two reaches of Lazarus Creek (Figure 41). The value of 166 mg/L was taken at station S004-552 near the mouth of Lazarus Creek before it flows into the Lac qui Parle River. Additionally, secchi tube measurements ranged from 3-100 cm. Of these measurements, twenty-two were below the 10 cm standard for transparency.

Table 70. TSS data in the Lazarus Creek HUC

Stream Reach	# TSS values	Range of TSS values	# of values above 65 mg/L
Canby Creek (-557)	11	1.6-62	0
Canby Creek (-586)	9	2.4-13	0
Lazarus Creek (-509)	17	3.2-78	2
Lazarus Creek (-508)	77	6-166	8

Figure 41. Station S003-836 (right) and S001-010 (left) on Lazarus Creek (-509)

Additionally, the HSPF model calculated daily suspended sediment concentrations from 1996-2012. These values ranged from 0.93-1851 mg/L with a mean of 1.19 mg/L on Lazarus Creek and 10.59 mg/L on Canby Creek (Table 71).

Table 71. Modeled TSS data in the Lazarus Creek HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above standard (%)
Lazarus Creek	**-508**	6940	2.33	1671.6	17.31	1.59
Lazarus Creek	**-509**	6940	1.97	1850.6	11.06	0.79
Canby Creek	**-557**	6888	1.60	1602.2	12.81	19.60
Canby Creek	**-586**	6940	0.93	1340.2	15.59	1.57

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. There were zero intolerant fish at either station. However, there were also less than 1% of TSS tolerant individuals at each site except for station 15MN049, where 12% TSS tolerant fish were collected. Herbivore species of fish decrease as TSS values increase (Table 72). Herbivore percentages were lower than average on the lower reach of Lazarus Creek (-508) and the upper reach of Canby Creek (-557). Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. Perciform percentages were below average at all stations except on the coldwater stretch of Canby Creek (-557). Intolerant, Centrarchid, and long-lived species were below average at all sites. Based on the TSS data and the biological response, TSS is a stressor to the two reaches of Lazarus Creek and is inconclusive as a stressor to the fish community on the two reaches of Canby Creek.

Table 72. TSS related fish metrics in the Florida Creek HUC

		TSS Related Fish Metrics						
Station	**WID**	BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct	TSS Index Score (RA)
15MN045 (July 2015)	**-509**	41.53	0.42	15.25	5.93	0.00	0.42	17.32
15MN045 (Sept 2015)	**-509**	20.29	0.72	23.19	2.17	0.00	0.72	20.68
15MN043	**-509**	10.53	0.69	11.67	9.38	0.00	0.69	18.45
15MN049	**-508**	19.78	0.43	3.04	16.74	0.00	1.30	18.96
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**37.38**	**4.89**	**9.61**	**18.66**	**4.97**	**11.68**	
15MN044 (July 2015)	**-586**	33.13	4.91	17.79	5.52	0.00	4.91	16.98
15MN044 (Sept 2015)	**-586**	13.51	0.00	16.22	0.54	0.00	0.54	20.95

Statewide average for Class 2 Southern Streams stations meeting the FIBI Modified Use Threshold (35.0)		**30.08**	**6.17**	**2.88**	**28.69**	**0.86**	**21.25**	
15MN102	**-509**	0.17	0.00	1.91	9.72	0.00	0.00	19.82
Statewide average for Class 3 Southern Streams stations meeting the FIBI General Use Threshold (55.0)		**37.83**	**0.89**	**13.33**	**13.93**	**1.95**	**3.56**	
09MN093 (Aug 2010)	**-557**	13.11	0.00	2.18	10.92	0.00	0.00	13.92
09MN093 (Aug 2015)	**-557**	12.84	0.00	0.30	12.54	0.00	0.00	13.48
09MN093 (Sept 2015)	**-557**	21.85	0.00	0.00	21.85	0.00	0.00	13.31
Statewide average for Class 10 Southern Coldwater stations that are meeting the FIBI General Use Threshold (50.0)		**28.37**	**0.53**	**0.32**	**3.85**	**26**	**53.81**	
Expected response to TSS stress		↓	↓	↓	↓	↓	↓	↓

TSS intolerant taxa at ranged from 0 at all stations except the most upstream station on Lazarus Creek (15MN102) and the coldwater reach of Canby Creek (-557). Tolerant macroinvertebrate individuals comprised a range of 27 to 72% of the community (Table 73). Based on the lack of TSS intolerant taxa, elevated TSS tolerant taxa, and lack of collector-filterer and Plecoptera taxa, evidence supports TSS is a stressor on the reaches of Lazarus Creek and is inconclusive on the reaches of Canby Creek.

Table 73. TSS related macroinvertebrate metrics in the Florida Creek HUC

		TSS related Macroinvertebrate Metrics						
Station	**WID**	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
09MN093 (Sept 2009)	**-557**	16.49	2	11	47.02	19.56	0.32	13.88
09MN093 (Aug 2015)	**-557**	14.12	1	11	41.30	43.30	0.00	12.77
Statewide average for Class 9 Southern Coldwater stations that are meeting the MIBI General Use Threshold (43.0)		**13.56**	**2.3**	**5.5**	**13.36**	**32.86**	**0.26**	**3.11**
15MN102	**-509**	16.47	1	11	37.33	15.67	0.00	8.33
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**15.87**	**3**	**12**	**35.23**	**4.56**	**0.54**	**8.99**
15MN044	**-586**	16.36	0	13	27.50	3.14	0.31	5.97
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**16.25**	**0.6**	**11**	**35.60**	**9.91**	**0.02**	**5.59**
15MN043	**-509**	17.60	0	11	44.08	13.82	0.00	17.76
15MN045	**-509**	19.57	0	10	46.41	1.31	0.00	5.56
15MN049	**-508**	19.78	0	12	72.17	24.92	0.00	12.94
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**13.2**	**48.28**	**19.13**	**0.22**	**7.99**
Expected response to stress		↑	↓	↑	↑	↓	↓	↓

Candidate Cause: Habitat

Habitat conditions were shown to be poor according to MSHA scores on the warmwater reach of Canby Creek and all stations on of Lazarus Creek except for the two upstream stations 15MN102 and 15MN043, which had fair MSHA ratings (Figure 42). The coldwater reach of Canby Creek had a good MSHA score. Station 15MN044 was experiencing a lack of channel development and severe embeddedness of fine substrates. Station 15MN045 had no depth variability and bank erosion (Figure 43). Station 15MN102 is in a pasture and lacked a riparian buffer. Station 15MN044 was comprised entirely of sand substrate (Figure 44).

Figure 42. MSHA scores in the Lazarus Creek HUC

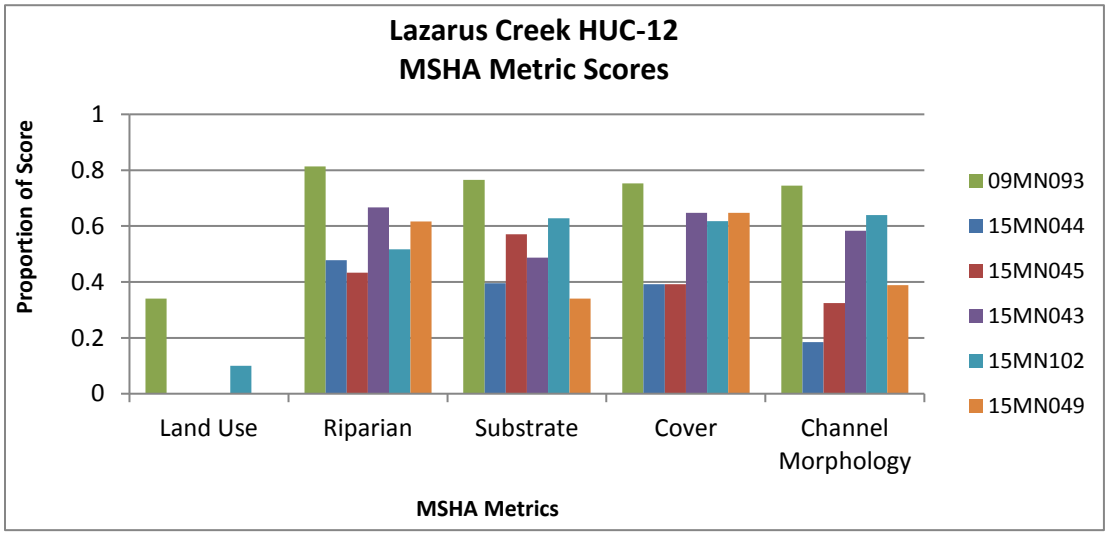


Figure 43. Bank erosion at station 15MN045 (7/8/15)

Figure 44. Sand substrate at station 15MN044 (9/10/15)

Station 15MN049 was found to be severely embedded with moderate to heavy bank erosion (Figure 45). DNR found an unstable system with a high sediment supply, bank slumping, channel widening, mid channel deposition, and riffles choked with sediment at site 15MN049. “Though deep water refuge habitats were existent, the extent of channel instability and shifting stream features likely do not result in much quality fish habitat (DNR, 2019)”.

Figure 45. Bank erosion at station 15MN049 (9/18/14)

Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were lower than average on the upstream reaches of Lazarus Creek (-509) and Canby Creek (-586), and were above average on the downstream reaches. Benthic insectivores, darter, sculpin, sucker, and Piscivore individuals were lowered at all sites on Lazarus Creek and the warmwater reach of Canby Creek (Table 74). Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. Riffles species were below average at the coldwater reach of Canby Creek and the downstream reach of Lazarus Creek (-508). The percentage of tolerant species were above average at all sites. Based on the poor habitat conditions and preponderance of evidence, lack of habitat is stressor to Florida Creek for fish. Habitat as a stressor for fish on both reaches of Lazarus Creek and the warmwater reach of Canby Creek. Habitat is inconclusive as a stressor to the coldwater reach of Canby Creek.

Table 74. Habitat related fish metrics in the Lazarus Creek HUC

		Habitat Related Fish Metrics							
Station	**WID**	BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RiffePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
15MN045 (July 2015)	**-509**	6.36	37.71	5.51	39.41	0	68.22	81.78	41.10
15MN045 (Sept 2015)	**-509**	1.45	23.19	1.45	18.84	0.72	39.85	92.03	49.28
15MN043	**-509**	8.70	25.63	8.70	10.76	0.23	44.85	70.48	47.14
15MN049	**-508**	16.52	44.78	16.30	14.57	0.65	55.87	51.52	35.22
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
15MN044 (July 2015)	**-586**	1.84	21.47	0.61	31.29	0	63.19	90.18	30.67
15MN044 (Sept 2015)	**-586**	0.54	12.43	0.54	12.97	0	35.68	94.59	62.70
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI Modified Use Threshold (35.0)		**3.62**	**26.17**	**16.45**	**19.54**	**8.02**	**35.59**	**46.38**	**23.58**
15MN102	**-509**	9.72	7.48	9.72	0.00	0	15.12	90.28	64.53
Statewide average for Class 3 Southern Streams stations that are meeting the FIBI General Use Threshold (55.0)		**10.91**	**30.09**	**10.59**	**22.62**	**1.97**	**57.98**	**76.69**	**32.54**
09MN093 (Aug 2010)	**-557**	10.92	37.14	10.92	2.18	0	85.68	89.08	59.95
09MN093 (Aug 2015)	**-557**	12.54	40	12.54	0.29	0	86.57	87.46	58.81
09MN093 (Sept 2015)	**-557**	21.85	36.13	21.85	0	0	78.15	78.15	63.87
Statewide average for Class 10 Southern Coldwater stations that are meeting the FIBI General Use Threshold (50.0)		**21.41**	**21.06**	**18.34**	**34.82**	**53.58**	**76.14**	**23.90**	**4.79**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were below average at sites 15MN044 and 15MN045. Burrowers and legless individuals are a signal of high levels of sedimentation (Table 75). Burrowers percentages were higher than average on

Lazarus Creek except at station 15MN045. EPT percentages were only below class average at site 15MN049. EPT and burrowers decreased from 2009 and 2015 while clingers increased over that time. Based on the preponderance of evidence of the macroinvertebrate communities, habitat is a stressor on the warmwater reach of Canby Creek (-586). Habitat is inconclusive as a stressor on the reaches of Lazarus Creek, and is not a stressor on the coldwater reach of Canby Creek (-557).

Table 75. Habitat related macroinvertebrate metrics in the Lazarus Creek HUC

		Habitat related Macroinvertebrate Metrics				
Station	WID	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
09MN093 (Sept 2009)	**-557**	5.36	2.84	44.48	55.84	26.18
09MN093 (Aug 2015)	**-557**	3.43	8.72	71.34	29.91	42.06
Statewide average for Class 9 Southern Coldwater stations meeting the MIBI General Use Threshold (43.0)		**4.84**	**9.0**	**44.78**	**40.36**	**26.93**
15MN102	**-509**	15.67	21.00	46.00	34.67	54.33
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (37.0)		**7.54**	**14.71**	**49.54**	**42.46**	**36.03**
15MN044	**-586**	14.47	22.96	20.75	19.81	72.01
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI Modified Use Threshold (22.0)		**14.12**	**27.47**	**23.07**	**20.58**	**55.79**
15MN043	**-509**	9.21	20.07	31.25	39.80	38.82
15MN045	**-509**	6.21	39.22	8.17	35.95	54.25
15MN049	**-508**	10.03	33.66	40.13	25.89	55.99
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate Cause: Altered hydrology

Portions of Canby Creek on reach -557 and all of reach -586 have been channelized. The majority of Lazarus Creek was natural but has channelized tributaries. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. Habitat availability can be scarce when flows are interrupted, or low for a prolonged duration. Flows that are reduced beyond normal baseflow decrease living space for aquatic organisms and increase competition for resources.

Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. The sites on Canby Creek had a population of generalist fish ranging from 53-86%. The sites on Lazarus Creek had a population of generalist fish ranging from 62-76%. The numbers of nest guarder species are also positively correlated with increased low flows. The nest

guarder species had a population ranging from 13-48% on Canby Creek and 28-73% on Lazarus Creek. Long-lived macroinvertebrates decrease with flow changes, as they are not able to stay in one place as conditions change. The range of long-lived macroinvertebrates ranged from 6-14% on Canby Creek and on Lazarus Creek. The channelization is likely contributing to the lack of habitat and is a contributing stressor to the biological communities on all four-stream reaches.

Candidate Cause: Connectivity

Connectivity is an important aspect of hydrology. Fish migration is dependent on stream connectivity. There are two dams that created reservoirs on Canby Creek including one on Del Clark Lake between stations 09MN093 on -557 and station 01MN021, and another dam in Canby between sites 01MN021 and 15MN044 on -586 (Table 76). There was also a perched culvert at station 09MN093 on Canby Creek and a culvert blocking fish passage upstream at 130th Avenue (DNR 2019) (Figure 46). The dams and culvert are barriers to fish migration from downstream to upstream as less migratory fish were located at the upstream station 09MN093. Connectivity is a stressor to Canby Creek (-557 and -586). There are no known connectivity issue on Lazarus Creek.

Table 76. Migratory fish and fish barriers along Canby Creek

CommonName	09MN093		01MN021		15MN044
blackside darter		Two Dams		Dam	
central stoneroller	X		X		X
golden redhorse					
greater redhorse					
Iowa darter			X		
shorthead redhorse					
silver lamprey					
slenderhead darter					
silver redhorse					
spottail shiner					
quillback					
walleye					
white bass					
white sucker			X		X

Figure 46. Perched culvert at station 09MN093

Summary and recommendations

The Lazarus Creek HUC contains four biologically impaired reaches on two creeks. Eutrophication, suspended sediments, lack of habitat, temperature, altered hydrology and connectivity were all stressors in this watershed (Table 77). More nitrate and DO data are needed to better determine the impact of this potential stressor.

The predominant land use in this subwatershed, row crop agriculture, is a contributor to the stressors found in these reaches. The upper reaches of both Canby and Lazarus Creek are located in the Coteau region, with steeper elevation and faster flows. Utilizing a variety of nutrient and sediment reducing Best Management Practices (BMPs) including: cover crops, nutrient management, saturated buffers, etc. will help in reducing stress to the biological communities. Forested riparian buffers would be particularly helpful with the temperature stress on Canby Creek. While there is a nice forested buffer at Station 09MN093, the upstream is mainly agricultural without a lot of shaded riparian areas. Fixing the perched culvert on Canby Creek would help repair fish migration.

Table 77. Stressors on streams in the Lazarus Creek HUC

Stream Name	Stressors: Dissolved Oxygen	Eutrophication	Nitrate	Suspended Sediment	Habitat	Temperature	Altered Hydrology	Connectivity
Lazarus Creek (-508)	o	●	o	●	●	---	●	---
Lazarus Creek (-509)	o	o	o	●	●	---	●	---
Canby Creek (-557)	---	o	o	o	o	●	●	●
Canby Creek (-586)	o	o	o	o	●	---	●	●

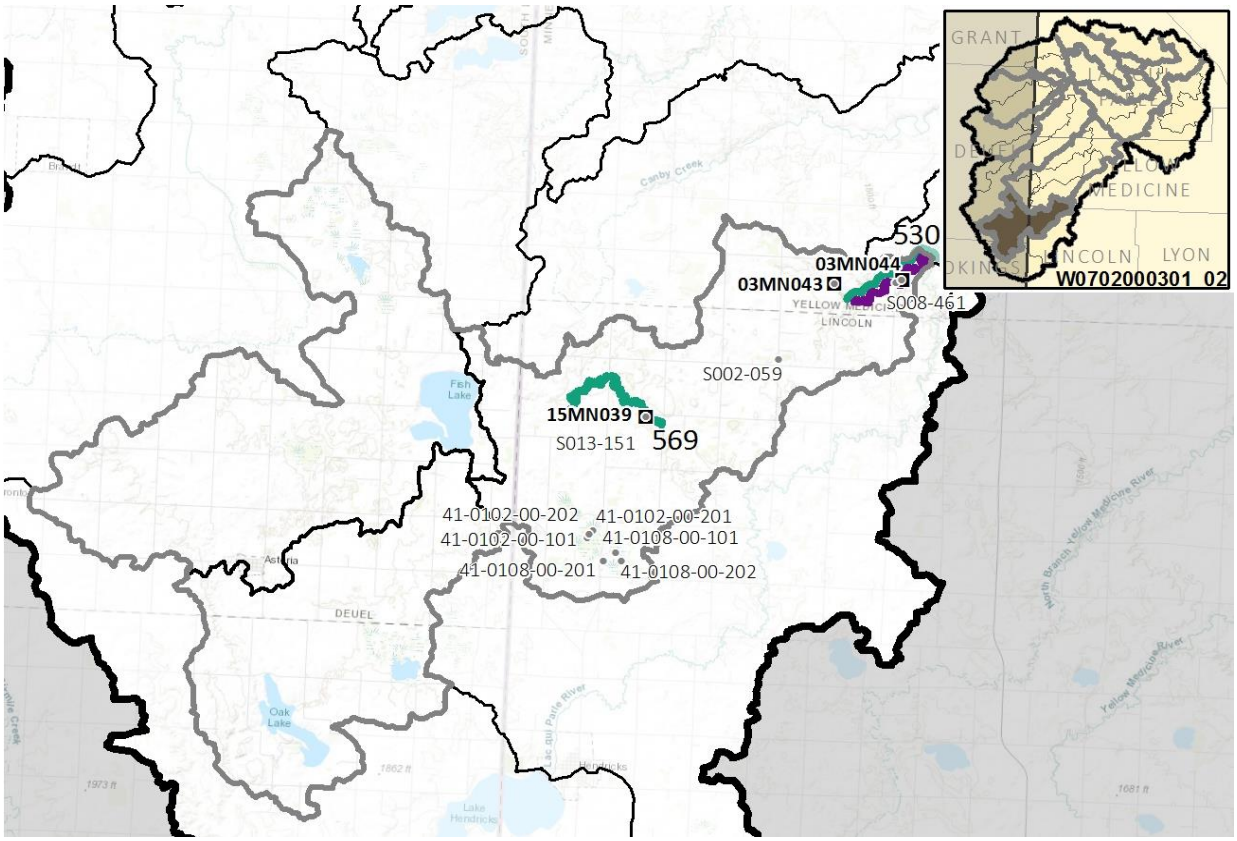
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Tributary to Lac qui Parle River 12-digit HUC

This aggregated HUC is located along the South Dakota border and contains two Unnamed Creeks (Figure 47). Reach -530 is a direct tributary to the Lac qui Parle River. The creeks have the following impairments:

- Unnamed Creek (-569), impaired for fish (15MN039, S013-151)
- Unnamed Creek (-530), impaired for fish and inverts (03MN044, S008-461)

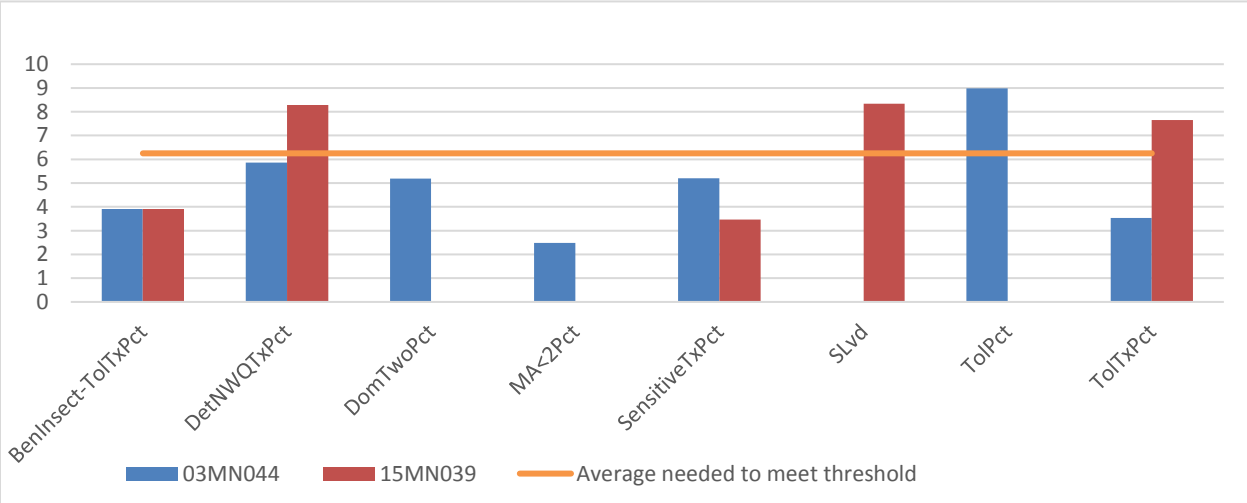
Figure 47.Impairments in the Tributary to Lac qui Parle River HUC (turquoise represents a fish impairment and purple represents a macroinvertebrate impairment)



Biological communities

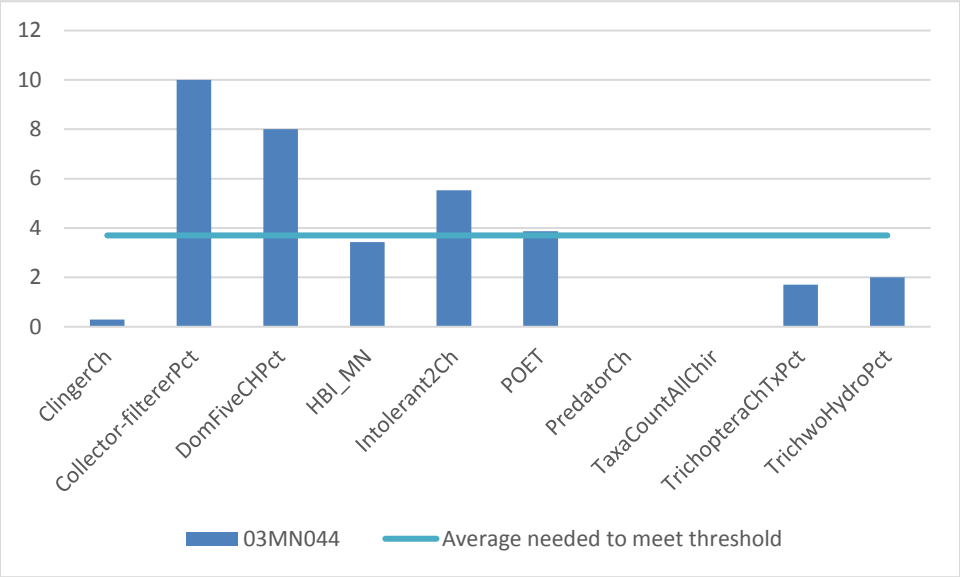
The two stations on two unnamed creeks were in fish class 2 and were impaired for fish. Metrics low across the visits were benthic insectivores, sensitive taxa percent, the percentage of the dominant two species, and species that have mature reproduction age at less than two years of age (Figure 48).

Figure 48. Fish metric scores at sites in general use fish class 2



Station 03MN044 was in macroinvertebrate class 5 (Figure 49). The site had low Trichoptera metric scores, predator taxa, and a low taxa count. Station 15MN039 on stream reach -569 was not assessed for macroinvertebrates.

Figure 49. Macroinvertebrate metric scores at sites in general use class 5



Candidate Cause: Dissolved oxygen

Values on these two reaches ranged from 3.56 to 13.27 with 1 value below 5 mg/L (Table 78). The low value was collected at station 15MN039. Continuous data collected in 2017 at station 03MN044 did not have any values below 5 mg/L, with a low value of 6.85 mg/L.

Table 78. DO data in the Tributary to Lac qui Parle River HUC

Stream Reach	# DO values	Range of DO values	# of values below 5 mg/L
Unnamed Creek (-569)	9	3.56-10.06 mg/L	1
Unnamed Creek (-530)	25	7-13.27 mg/L	0

Additionally, the HSPF model calculated daily minimum DO values from 1996-2012. Reaches fall under the same modeled reach. Over the years, the low, high, and average minimum values were all calculated (Table 79). The minimum values ranged from 0-13.76 mg/L with less than 13.34% of values below the water quality standard of 5 mg/L at both streams.

Table 79. Modeled DO data in the Tributary to Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low daily minimum value (mg/L)	High daily minimum value (mg/L)	Daily minimum average value (mg/L)	Readings below 5 mg/L standard (%)
Unnamed Creek	**-530**	6940	0	13.76	9.05	13.34
Unnamed Creek	**-569**	6940	0	13.76	9.05	13.34

Fish species that are specifically tolerant and intolerant to DO were analyzed at each station. There were no intolerant fish at any of the stations. DO tolerant percentages ranged from 15% (03MN044) to 98% (15MN039). The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions (Table 80). Both stations had less than 1% of fish that take 3 years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. Low DO values also correspond with increased serial spawning fish percentage, as serial spawning occurs with environmental stress. Serial spawners ranged from 46.62 to 94%. Both sites were below the statewide average of stations meeting IBI thresholds. While there is a small DO dataset, the modelled data and metric response indicate DO is a stressor to the fish community on Unnamed Creek (-569). DO as a stressor to Unnamed Creek (-530) is inconclusive.

Table 80. DO related fish metrics in the Tributary to Lac qui Parle River HUC

		DO Related Fish Metrics		
Station	**WID**	MA>3 years Percentage	Serial Spawning Fish Pct	Fish Taxa Count
03MN044	**-530**	0.66	46.62	16
15MN039	**-569**	0.34	93.99	8
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**12.36**	**28.72**	**20.38**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed (Table 81). One intolerant macroinvertebrate taxa was collected at site 15MN039 and seven were collected at site 03MN044. DO tolerant percentages ranged from 0.61 to 2.0, all below the class average of sites meeting the threshold. Based on the lack of low DO values and lack of a consistent biological response, low DO is not a stressor to the macroinvertebrate community on Unnamed Creek (-530). Biological response was mixed on the other Unnamed Creek, making DO as a stressor inconclusive (-569).

Table 81. DO related macroinvertebrate metrics in the Tributary to Lac qui Parle River HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
03MN044	**-530**	0.61	7.18	7	6.96
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**8.62**	**7.04**	**8.97**	**7.09**
15MN039	**-569**	2.00	7.95	1	7.25
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**12.98**	**7.55**	**4.46**	**6.91**
Expected response to DO stress		↑	↑	↓	↑

Candidate Cause: Eutrophication

There were about a dozen recent phosphorus data available on both streams (Table 82). More than half the values at each stream were above the phosphorus standard of 0.150 mg/L.

Table 82. Total Phosphorus data in the Tributary to Lac qui Parle River HUC

Stream Reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Unnamed Creek (-569)	11	0.027-0.278	6
Unnamed Creek (-530)	10	0.041-0.269	7

Chlorophyll-a, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus. Chlorophyll-a data from station 03MN044 had a value of 44 ug/L, above the southern standard of 40 ug/L. There was no BOD data available. pH values ranged from 7.32 to 10.08. Values over 8.5 and large daily pH fluctuations can be tied to nutrient enrichment. Continuous data collected in 2017 reflected a DO flux range of 0.36-2.27 mg/L at station 03MN044. pH flux ranged from 0.08-0.17. Comment during biological sampling was that the "water was exceptionally green with chlorophyll-a", indicative of nutrient issues. Fish Lake in SD is a possible source.

Additionally, the HSPF model calculated daily TP concentrations from 1996-2012, both reaches fall under same modeled reach. The values ranged from 0.02-21.18 mg/L with a mean of 0.24 mg/L (Table 83).

Table 83. Modeled Phosphorus data in the Tributary to Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above 0.15 mg/L TP standard (%)
Unnamed Creek	**-530**	6918	0.02	21.18	0.24	43.90
Unnamed Creek	**-569**	6918	0.02	21.18	0.24	43.90

Sensitive individual percentages ranged from 3.78-31.8% on these reaches. Site 15MN039 had a sensitive percentage well below the class average of sites meeting the threshold. Darter percentages were well below the class average on both streams (Table 84). The percentage of tolerant fish individuals were over 95% at station 15MN039. Along with tolerant species, a positive relationship exists between eutrophication and omnivorous fish. The omnivorous fish percentage were also elevated on reach -569. Elevated phosphorus, chlorophyll-a data and the preponderance of metric response on the unnamed reaches of -530 and -569 indicate eutrophication is a stressor to the fish community.

Table 84. Eutrophication related fish metrics in the Tributary to Lac qui Parle River HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
03MN044	**-530**	31.80	0.16	41.19	15.82
15MN039	**-569**	3.78	3.78	95.53	94.85
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**18.65**	**11.68**	**44.85**	**16.53**
Expected response to increased Eutrophication stress		↓	↓	↑	↑

Station 03MN044 had less than half the macroinvertebrate community dominated by two species (Table 85). The EPT percentage was slightly decreased at station 03MN044 and above average at site 15MN039. Based on the elevated phosphorus values and biological metrics, eutrophication is a stressor to the macroinvertebrate communities on the reach of -530. Eutrophication was inconclusive as a stressor to the macroinvertebrate community on reach -569.

Table 85. Eutrophication related macroinvertebrate metrics in the Tributary to Lac qui Parle River HUC

		Eutrophication Related Macroinvertebrate Metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
03MN044	**-530**	23	39.08	25.54
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**42**	**43.90**	
15MN039	**-569**	13	44.33	66.33
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
Expected response to Eutrophication stress		↓	↓	↑

Candidate Cause: Nitrates

Recent nitrate data was available on both creeks, with samples values ranging from 0.05-8.7 mg/L (Table 86). Additionally, the HSPF model calculated daily nitrate concentrations from 1996-2012, both reaches fall under the same modelled reach. These values ranged from 0.01-14.30 mg/L with a mean of 0.73 mg/L (Table 87).

Table 86. Nitrate data in the Tributary to Lac qui Parle River HUC

Stream Reach	# nitrate values	Range of values (mg/L)
Unnamed Creek (-569)	12	0.072-2.29
Unnamed Creek (-530)	11	0.050-8.7

Table 87. Modeled nitrate data in the Tributary to Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)
Unnamed Creek	**-530**	6918	0.01	14.30	0.73
Unnamed Creek	**-569**	6918	0.01	14.30	0.73

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration.

Nitrate intolerant macroinvertebrate taxa were absent at both sites (Table 88). Nitrate tolerant individuals comprised 42% (03MN044) to 64% (15MN039) of the communities. Increasing nitrate concentrations have a negative relationship with non-hydropsychid Trichoptera (caddisfly) individual percentages. Non-hydropsychid Trichoptera are all caddisflies that do not spin nets. Values were below the class average of sites meeting the threshold at both sites. Based on the lack of elevated nitrate

values and the preponderance of metric values, nitrate is not a stressor to reach -530. The reach of -569 had some indications of nitrate stress based on the tolerant taxa, lack of nitrate intolerant data, and lack of Trichoptera taxa. However, based on the lack of elevated nitrogen values, nitrate is inconclusive as a stressor.

Table 88. Nitrate related macroinvertebrate metrics in the Tributary to Lac qui Parle River HUC

		Nitrate related Macroinvertebrate Metrics			
Station	**WID**	TrichwoHydro Pct	% Tolerant Taxa	% Intolerant Taxa	Nitrogen TIV
03MN044	**-530**	4	42.11	0.00	2.91
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (37.0)		**5.94**	**47.60**	**2.92**	**2.95**
15MN039	**-569**	0.32	64.00	0.00	4.24
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate Cause: Sediment

Unnamed Creek (-530) has a Turbidity impairment. Recent TSS data is available on both streams. Samples ranged in value from 2.6-824 mg/L, with ten concentrations above the southern standard of 65 mg/L (Table 89). The value of 824 mg/L was taken at station S008-461 after a 3-day period of almost 3 inches of rain. Both reaches are located in the higher gradient Coteau region that becomes turbid after rainfall. Additionally, secchi tube measurements ranged from 3-100 cm. Of these measurements, 29% were below the 10 cm standard for transparency.

Table 89. TSS data in the Tributary to Lac qui Parle River HUC

Stream Reach	# TSS values	Range of TSS values	# of values above 65 mg/L
Unnamed Creek (-569)	10	2.6-150	3
Unnamed Creek (-530)	11	4-824	7

Additionally, the HSPF model calculated daily suspended sediment concentrations from 1996-2012, both reaches fall under the same modelled reach. These values ranged from 1.07-1347 mg/L with a mean of 10.13 mg/L (Table 90).

Table 90. Modeled TSS data in the Tributary to Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above standard (%)
Unnamed Creek	**-530**	6918	1.07	1347	10.13	1.24
Unnamed Creek	**-569**	6918	1.07	1347	10.13	1.24

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. There were zero intolerant fish at either station. However, there were also less than 1% of TSS tolerant individuals at both sites. Herbivore species of fish decrease as TSS values increase. No herbivore species were collected at Site 15MN039, but were above average at site 03MN044 (Table 91). Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. Perciform percentages were below average at both. Intolerant, Centrarchid, and long-lived species were below all 1% at both sites. Based on the TSS data and the biological response, TSS is a stressor to the two reaches.

Table 91. TSS related fish metrics in the Tributary to Lac qui Parle River HUC

		TSS Related Fish Metrics						
Station	**WID**	BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct	TSS Index Score (RA)
03MN044	**-530**	15.32	0.00	13.67	0.66	0.00	0.66	15.21
15MN039	**-569**	0.86	0.00	0.00	3.95	0.00	0.34	23.31
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**37.38**	**4.89**	**9.61**	**18.66**	**4.97**	**11.68**	
Expected response to TSS stress		↓	↓	↓	↓	↓	↓	↑

TSS intolerant taxa 0 at both stations. Tolerant macroinvertebrate individuals comprised a range of 31 to 56% of the community (Table 92). Based on the lack of TSS intolerant taxa, elevated TSS tolerant taxa, and lack of Plecoptera taxa, evidence supports TSS is a stressor to macroinvertebrates on the reach of -569 and is inconclusive on the reach of -530.

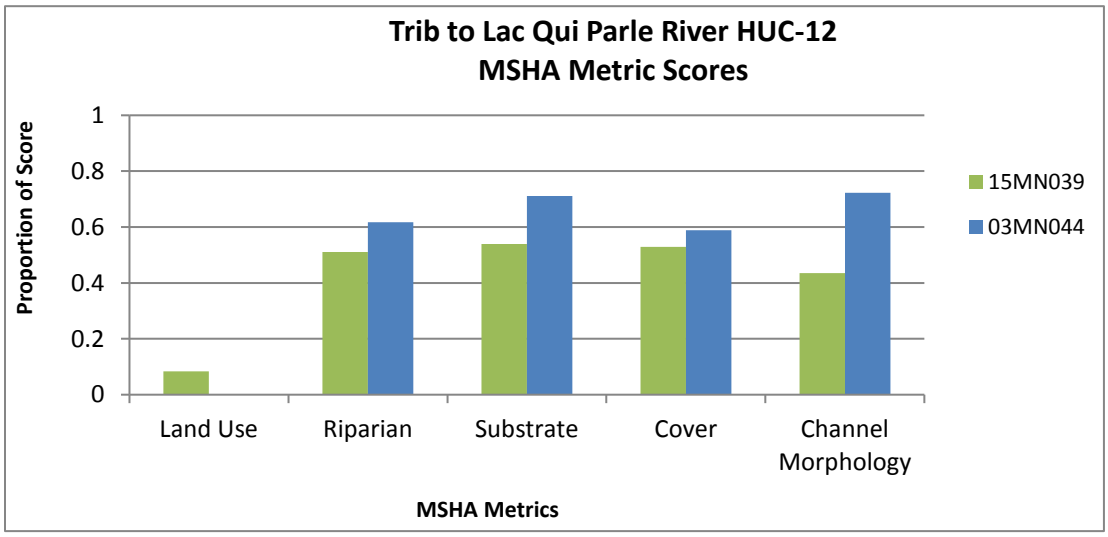
Table 92. TSS related macroinvertebrate metrics in the Tributary to Lac qui Parle River HUC

Station	WID	TSS related Macroinvertebrate Metrics: TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
03MN044	**-530**	15.14	0	12	31.29	31.08	0.00	4.92
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**15.87**	**3**	**12**	**35.23**	**4.56**	**0.54**	**8.99**
15MN039	**-569**	22.72	0	9	55.67	32.67	0.00	1.33
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**13.2**	**48.28**	**19.13**	**0.22**	**7.99**
Expected response to TSS stress		↑	↓	↑	↑	↓	↓	↓

Candidate Cause: Habitat

Habitat conditions were shown to be fair according to MSHA scores on both creeks (Figure 50). Stations 03MN044 and 15MN039 both had a lack of depth variability and channel development, and embeddedness of fine substrates for both fish and macroinvertebrates. The sample in 2003 at station 03MN044 had 6% fine sediments and the coarse substrate were found to be 45% embedded by fine substrates.

Figure 50. MSHA scores in the Tributary to Lac qui Parle River HUC



Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were much lower than average on the reach -569, while just below average on reach -530 (Table 93). Benthic insectivores, darter, sculpin, sucker, and Piscivore individuals were lowered at both sites. Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. Riffle species percentages were below average at reach -569. The percentage of tolerant species were well above average at reach -569. Based on the poor habitat conditions and preponderance of evidence, lack of habitat is stressor on reach -569. Habitat is inconclusive as a stressor to reach -530.

Table 93. Habitat related fish metrics in the Tributary to Lac qui Parle River HUC

Station	WID	Habitat Related Fish Metrics							
		BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RifflePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
03MN044	**-530**	0.33	32.62	0.16	46.79	0.49	82.21	41.19	19.11
15MN039	**-569**	3.78	1.20	3.78	0.86	1.37	1.37	95.53	94.16
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were above average at both sites (Table 94). Burrowers and legless individuals are a signal of high levels of sedimentation. Neither site had an increased percentage of burrowers or legless percentages. EPT percentages were above below class average at both sites. Based on the preponderance of evidence of the macroinvertebrate communities, habitat is not a stressor on either reach.

Table 94. Habitat related macroinvertebrate metrics in the Tributary to Lac qui Parle River HUC

Station	WID	Habitat related Macroinvertebrate Metrics				
		BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
03MN044	**-530**	4.92	18.15	65.54	39.08	43.69
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**7.54**	**14.71**	**49.54**	**42.46**	**36.03**
15MN039	**-569**	3.33	14.00	71.67	44.33	22.00
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate Cause: Altered hydrology

While channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, the majority of both reaches are natural. However during the assessment process, water level manipulation at the upstream Fish Lake on -569 was discussed which could possibly create higher flows. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat.

Candidate Cause: Connectivity

Connectivity is another important aspect of hydrology. Fish migration is dependent on stream connectivity. A former bridge and pool (Figure 51) just upstream of station 15MN039 is a likely migration barrier during low flow conditions (DNR 2019). The DNR also identified two additional migration barriers downstream of station 15MN039 including a perched culvert (DNR 2019). With the upstream and downstream barriers, fish could become isolated during low flow conditions, making connectivity a stressor to -569. There are no known connectivity issues on reach -530.

Figure 51. Fish barrier at station 15MN039 (9/16/14)

Summary and recommendations

The Tributary to Lac qui Parle River HUC contains two biologically impaired reaches on two unnamed creeks. DO, eutrophication, suspended sediments, lack of habitat, and altered hydrology were all stressors in this watershed (Table 95). More nitrate data is needed to better determine the impact of this potential stressor.

Both sites have nice riparian buffers immediately around the site, but the predominant land uses in this subwatershed were row crop agriculture and pasture. The land use is a contributor to the stressors found in these reaches. The entire HUC is located in the Coteau region, with steeper elevation and faster flows. Utilizing a variety of nutrient and sediment reducing BMPs including: cover crops, erosion control, and nutrient management etc. saturated buffers, etc. will help in reducing stress to the biological communities. The water at station 03MN044 was green, and while the site has a nice riparian buffer, upstream nutrient management is important. Removing the fish barrier at station 15MN039 would also be beneficial.

Table 95. Stressors on streams in the Tributary to Lac qui Parle River HUC

Stream Name	Stressors:						
	Dissolved Oxygen	Eutrophication	Nitrate	Suspended Sediment	Habitat	Altered Hydrology	Connectivity
Unnamed Creek (-530)	---	●	---	●	o	---	---
Unnamed Creek (-569)	●	●	o	●	●	o	●

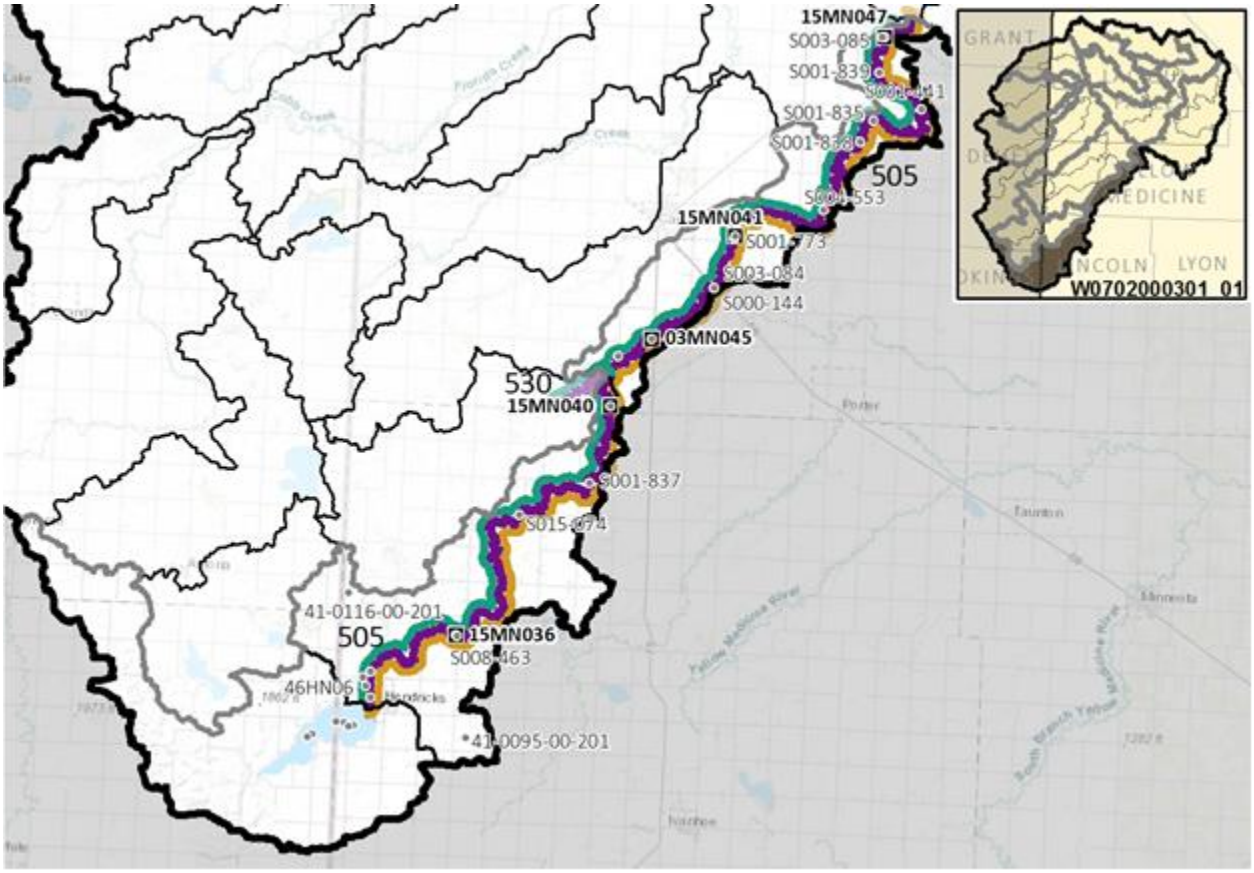
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Upper Lac qui Parle River 12-digit HUC

This aggregated HUC is located along the South Dakota border and contains the headwaters of the Lac qui Parle River (Figure 52). The river in this section has the following impairments:

Lac qui Parle River (-505), impaired for fish and inverts (15MN036, 15MN040, 15MN041, 15MN047)

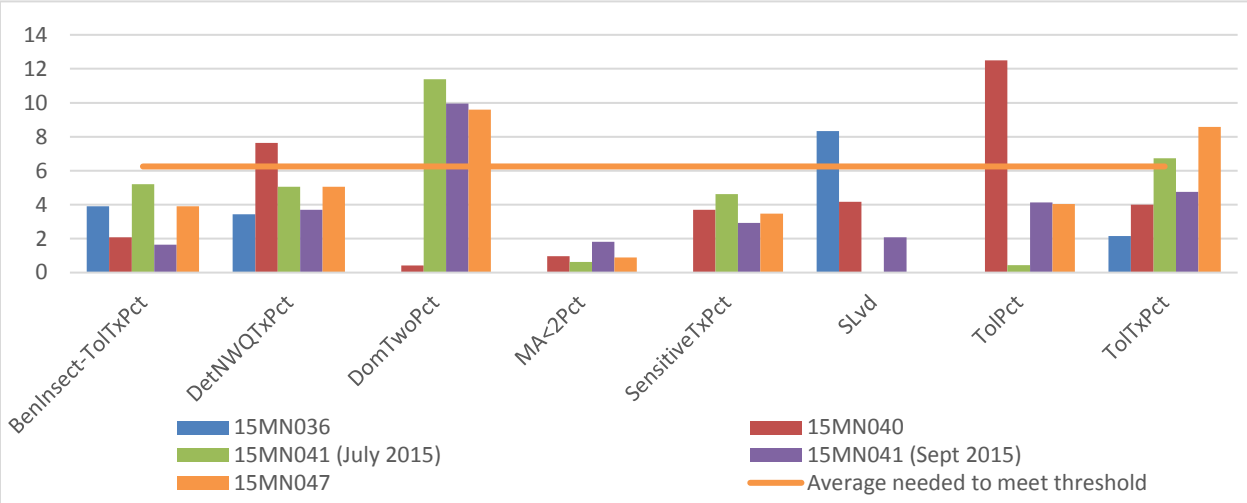
Figure 52. Impairments in the Upper Lac qui Parle River HUC (turquoise represents a fish impairment, purple represents a macroinvertebrate impairment, and yellow represents a Turbidity impairment)



Biological communities

All four stations on the Lac qui Parle River were in fish class 2. All sites were scored below the threshold for fish. Metrics low across the visits were sensitive taxa, benthic insectivores, and species that have mature reproduction age at less than 2 years of age (Figure 53). The lowest score is at the most upstream station.

Figure 53. Fish metric scores at sites in general use fish class 2



The upper section of the stream reach is impaired for macroinvertebrate, while invert scores were highest in the downstream section of the river. Station 15MN040 is in macroinvertebrate Class 5 (Southern Streams), while all other stations on the reach were in macroinvertebrate Class 7 (Prairie Streams). The upper stretch was described in the assessment database to be "largely comprised of tolerant taxa and have fewer EPT taxa than would be expected given habitats present (riffle and woody debris) and normal flows". Stations 15MN036 and 15MN040 also had lowered Predator scores and taxa counts (Figures 54 and 55).

Figure 54. Macroinvertebrate metric scores at sites in general use macroinvertebrate class 5

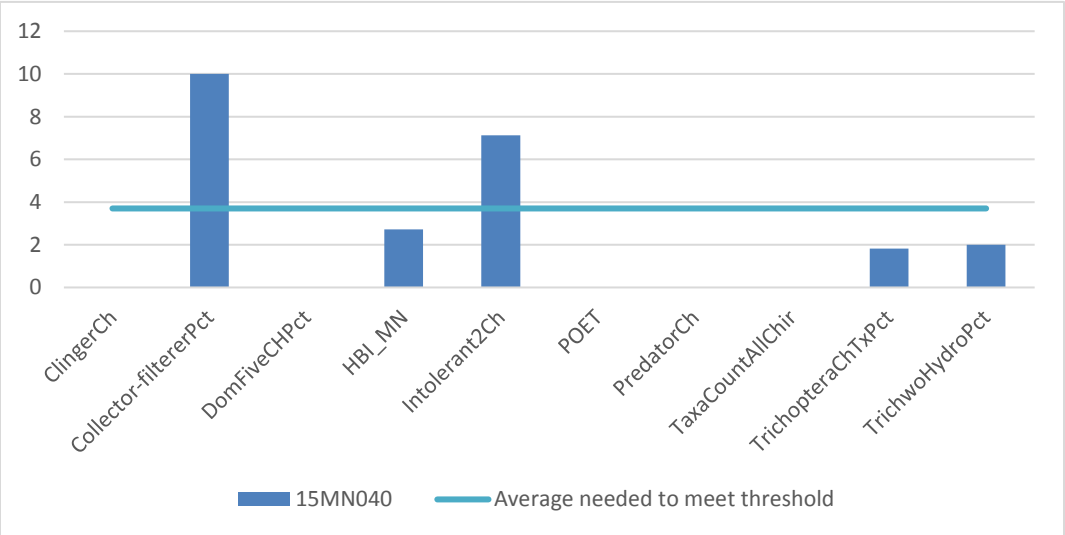
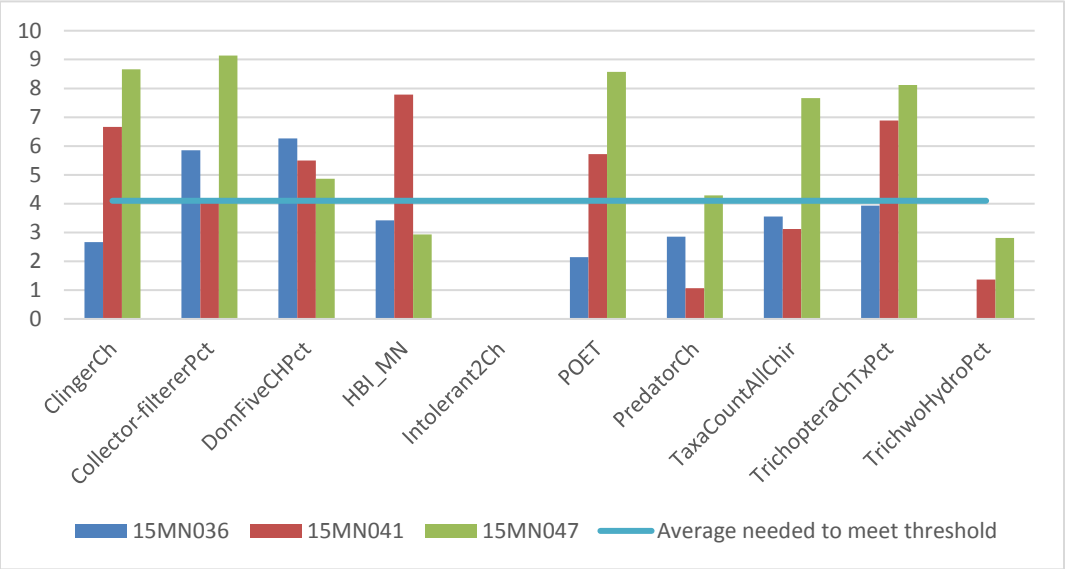


Figure 55. Macroinvertebrate metric scores at sites in general use macroinvertebrate class 7



Candidate Cause: Dissolved oxygen

The large DO dataset on the upper reach of the Lac qui Parle River had values ranging from 5.79 to 13.34 without any values below 5 mg/L (Table 96). The low value was collected at station S008-463. No continuous data was available on this stream. Additionally, the HSPF model calculated daily minimum DO values from 1996-2012. Over the years, the low, high, and average minimum values were all calculated (Table 97). The minimum value was 0 mg/L with less than 2% of values below the water quality standard of 5 mg/L).

Table 96. DO data in the Upper Lac qui Parle River HUC

Stream Reach	# DO values	Range of DO values	# of values below 5 mg/L
Lac qui Parle River (-505)	89	5.79-13.34 mg/L	0

Table 97. Modeled DO data in the Upper Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low daily minimum value (mg/L)	High daily minimum value (mg/L)	Daily minimum average value (mg/L)	Readings below 5 mg/L standard (%)
Lac qui Parle River	**-505**	6940	0	14.00	9.95	1.89

Fish species that are specifically tolerant and intolerant to DO were analyzed at each station. There were no intolerant fish at any of the stations. DO tolerant percentages ranged from 0% (15MN041) to 97% (15MN036). Station 15MN036 is the most upstream site and is closest to the impaired Lake Hendricks. Fish taxa increased from up to downstream (Table 98). The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. All stations had less than 2.5% of fish that take three years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. Serial spawners ranged from 27.8 to 90.21%. All sites were below the statewide average of stations meeting IBI thresholds except for station 15MN040. While the modelled data and metric response indicate DO is a

stressor to the fish community, the large DO dataset did not indicate low DO issues. Low DO is inconclusive as a stressor on this reach of Lac qui Parle River.

Table 98. DO related fish metrics in the Upper Lac qui Parle River HUC

		DO Related Fish Metrics		
Station	**WID**	MA>3 years Percentage	Serial Spawning Fish Pct	Fish Taxa Count
15MN036	**-505**	0.00	90.21	8
15MN040	**-505**	1.40	27.80	15
15MN041 (July 2015)	**-505**	0.68	62.37	24
15MN041 (Sept 2015)	**-505**	0.73	46.36	19
15MN047	**-505**	2.09	54.81	24
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**12.36**	**28.72**	**20.38**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station (Table 99). Intolerant macroinvertebrate taxa ranged from 3 (15MN036) to 8 (15MN040 and 15MN047). DO tolerant percentages ranged from 0 (15MN040) to 16.33 (15MN036). The DO tolerant percentages were all below the class average of sites meeting the threshold except for site 15MN036. There were Indications of stress at site 15MN036 where lowest DO was also collected, but based on the lack of low DO values and lack of a consistent biological response throughout the reach, low DO is inconclusive as a stressor to the macroinvertebrate community on the Lac qui Parle River.

Table 99. DO related macroinvertebrate metrics in the Upper Lac qui Parle River HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
15MN040	**-505**	0.00	7.42	8	7.46
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**8.62**	**7.04**	**8.97**	**7.09**
15MN036	**-505**	16.33	7.83	3	6.27
15MN041	**-505**	1.43	6.50	7	5.47
15MN047	**-505**	4.98	7.98	8	7.06
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**12.98**	**7.55**	**4.46**	**6.91**
Expected response to DO stress		↑	↑	↓	↑

Candidate Cause: Eutrophication

There was a large phosphorus dataset available on this section of the river. More than half the values were above the phosphorus standard of 0.150 mg/L (Table 100).

Table 100. Total Phosphorus data in the Upper Lac qui Parle River HUC

Stream Reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Lac qui Parle River (-505)	158	0.013-1.73	94

Chlorophyll-a, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus. One chlorophyll-a value was collected with a value of 5.4 ug/L, below the southern standard of 40 ug/L. There was no BOD data available. pH values ranged from 7.08 to 8.79. Values over 8.5 and large daily pH fluctuations can be tied to nutrient enrichment.

Additionally, the HSPF model calculated daily TP concentrations from 1996-2012. The values ranged from 0.02-3.44 mg/L with a mean of 0.18 mg/L (Table 101).

Table 101. Modeled Phosphorus data in the Upper Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above 0.15 mg/L TP standard (%)
Lac qui Parle River	**-505**	6938	0.02	3.44	0.18	41.80

Sensitive individual percentages ranged from 0-20.6% (Table 102). All sites had a sensitive percentage below the class average of sites meeting the threshold except for Site 15MN040. Darter percentages were well below the class average at all sites. The percentage of tolerant fish individuals comprised more than 50% of the fish community at all sites except for station 15MN040. Along with tolerant species, a positive relationship exists between eutrophication and omnivorous fish. The omnivorous fish percentage were below average except at one visit of station 15MN041 and 15MN036. Elevated phosphorus and the preponderance of metric response indicate eutrophication is a stressor to the fish community.

Table 102. Eutrophication related fish metrics in the Upper Lac qui Parle River HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
15MN036	**-505**	0.00	0.70	98.60	90.91
15MN040	**-505**	20.60	0.00	24.00	3.00
15MN041 (July 2015)	**-505**	10.62	0.45	73.33	17.06
15MN041 (Sept 2015)	**-505**	14.00	0.36	59.45	5.82
15MN047	**-505**	5.02	2.09	59.83	8.37
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**18.65**	**11.68**	**44.85**	**16.53**
Expected response to increased Eutrophication stress		↓	↓	↑	↑

All stations except 15MN040 had less than half the macroinvertebrate community dominated by two species (Table 103). The EPT percentages were above average at sites 15MN040 and 15MN047, however high numbers of Cheumatopsyche and Hydropsyche, which are indicative of eutrophic conditions, were collected at the stations. Macroinvertebrate taxa were below average at all sites. Based on the elevated phosphorus values and biological metrics, eutrophication is a stressor to the macroinvertebrate communities on the reach of the Lac qui Parle River.

Table 103. Eutrophication related macroinvertebrate metrics in the Upper Lac qui Parle River HUC

Station	WID	Eutrophication Related Macroinvertebrate Metrics: Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
15MN040	**-505**	19	89.06	59.57
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**42**	**43.90**	
15MN036	**-505**	13	5.33	33.67
15MN041	**-505**	21	12.92	40.28
15MN047	**-505**	28	43.33	46.67
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
Expected response to Eutrophication stress		↓	↓	↑

Candidate Cause: Nitrates

A large nitrate dataset was available on this reach of Lac qui Parle River, with samples values ranging from 0.01-5.3 mg/L (Table 104). Additionally, the HSPF model calculated daily nitrate concentrations from 1996-2012. These values ranged from 0-17.19 mg/L with a mean of 0.65 mg/L (Table 105).

Table 104. Nitrate data in the Upper Lac qui Parle River HUC

Stream Reach	# nitrate values	Range of values (mg/L)
Lac qui Parle River (-505)	156	0.01-5.3

Table 105. Modeled nitrate data in the Upper Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)
Lac qui Parle River	**-505**	6938	0	17.19	0.65

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration.

Nitrate intolerant macroinvertebrate taxa were absent at all sites (Table 106). Nitrate tolerant individuals comprised 25% (15MN041) to 80% (15MN047) of the communities. Increasing nitrate concentrations have a negative relationship with non-hydropsychid Trichoptera (caddisfly) individual percentages. Non-hydropsychid Trichoptera are all caddisflies that do not spin nets. Values were below the class average of sites meeting the threshold at all sites. This stream reach had indications of nitrate

stress based on the tolerant taxa, lack of nitrate intolerant data, and lack of Trichoptera taxa. However, based on the lack of elevated nitrogen values, nitrate is inconclusive as a stressor.

Table 106. Nitrate related macroinvertebrate metrics in the Upper Lac qui Parle River HUC

		Nitrate related Macroinvertebrate Metrics			
Station	WID	TrichwoHydroPct	% Tolerant Taxa	# Intolerant Taxa	Nitrogen TIV
15MN040	**-505**	1.82	42.73	0.00	2.67
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (37.0)		**5.94**	**47.60**	**2.92**	**2.95**
15MN036	**-505**	0	56.00	0.00	3.19
15MN041	**-505**	0.48	25.33	0.00	1.95
15MN047	**-505**	1	79.73	0.00	4.02
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate Cause: Sediment

The Lac qui Parle River (-505) has a Turbidity impairment. Recent TSS data is available with samples ranging in value from 4-1540 mg/L, with 43% of concentrations above the southern standard of 65 mg/L (Table 107). The value of 1540 mg/L was taken at station S003-084 after an inch of rain during a 7-day period. The river is located in the higher gradient Coteau region that becomes turbid after rainfall. Additionally, secchi tube measurements ranged from 3-100 cm. Of these measurements, 29% were below the 10 cm standard for transparency.

Table 107. TSS data in the Tributary to Lac qui Parle River HUC

Stream Reach	# TSS values	Range of TSS values	# of values above 65 mg/L
Lac qui Parle River (-505)	157	4-1540	68

Additionally, the HSPF model calculated daily-suspended sediment concentrations from 1996-2012, both reaches fall under the same modelled reach. These values ranged from 1.07-1347 mg/L with a mean of 10.13 mg/L (Table 108).

Table 108. Modeled TSS data in the Tributary to Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above standard (%)
Lac qui Parle River	**-505**	6938	0.43	1547.6	11.27	1.18

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. There were zero intolerant fish at any of the stations. There were also less than 1% of TSS tolerant individuals at sites 15MN036 and 15MN040. Station 15MN041 had a TSS tolerant percentage ranging from 21.8% to 23.8%, while station 15MN047 had a TSS tolerant percentage of 50.4%. Herbivore species of fish decrease as TSS values increase. Herbivore species were below average at all sites except one visit of 15MN041 (Table 109). Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. Perciform percentages were below average at all sites. Intolerant and Centrarchid species were below 1% at all sites. Based on the TSS data and the biological response, TSS is a stressor to the Lac qui Parle River.

Table 109. TSS related fish metrics in the Upper Lac qui Parle River HUC

		TSS Related Fish Metrics						
Station	WID	BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct	TSS Index Score (RA)
15MN036	**-505**	1.40	0.00	0.70	0.70	0.00	0.00	23.06
15MN040	**-505**	6.00	0.00	4.40	0.40	0.00	0.60	14.15
15MN041 (July 2015)	**-505**	5.31	0.11	5.31	1.24	0.00	1.13	20.59
15MN041 (Sept 2015)	**-505**	10.91	0.00	10.55	2.55	0.00	1.27	19.29
15MN047	**-505**	5.86	0.42	3.35	6.28	0.00	3.77	26.42
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**37.38**	**4.89**	**9.61**	**18.66**	**4.97**	**11.68**	
Expected response to TSS stress		↓	↓	↓	↓	↓	↓	↑

TSS intolerant taxa was 0 at all stations. Tolerant macroinvertebrate individuals comprised a range of 19 to 65% of the community (Table 110). Based on the lack of TSS intolerant taxa, elevated TSS tolerant taxa, and lack of Plecoptera taxa, evidence supports TSS is a stressor to macroinvertebrates.

Table 110. TSS related macroinvertebrate metrics in the Upper Lac qui Parle River HUC

Station	WID	TSS related Macroinvertebrate Metrics: TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	LongLivedPct
15MN040	**-505**	17.13	0	11	56.36	56.53	0.00	2.74
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**15.87**	**3**	**12**	**35.23**	**4.56**	**0.54**	**8.99**
15MN036	**-505**	14.46	0	7	18.67	22.33	0.00	0
15MN041	**-505**	12.26	0	3	30.25	15.64	0.16	20.82
15MN047	**-505**	19.34	0	17	65.12	34.67	0.00	1.33
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**13.2**	**48.28**	**19.13**	**0.22**	**7.99**
Expected response to TSS stress		↑	↓	↑	↑	↓	↓	↓

Candidate Cause: Habitat

Habitat conditions were shown to be fair according to MSHA scores at all sites, except for the most downstream site 15MN047 where the habitat score was poor (Figure 56). The sample at station 03MN045 in 2003 had 13% fine sediments and the coarse substrate were found to be 48% embedded by fine substrates. Erosion was noted at 15MN036, 15MN040, and 15MN047 (Figures 57 and 58). Excess sediments were indicated by a lack of depth variability and a lateral riffle at site 15MN040, and over widening and mid-channel bars at 15MN041 (Figure 59.

Figure 56. MSHA scores in the Tributary to Lac qui Parle River HUC

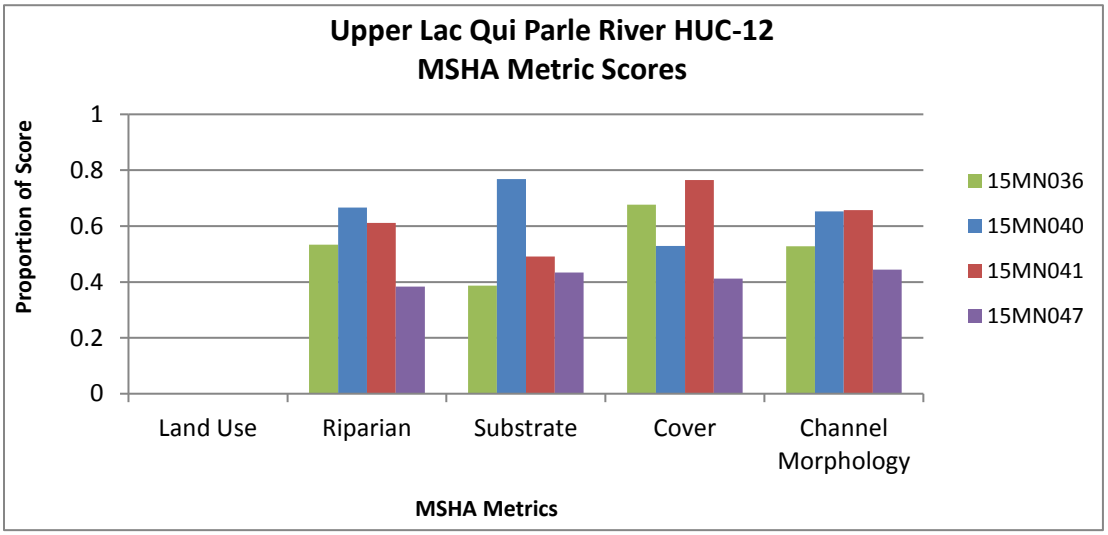
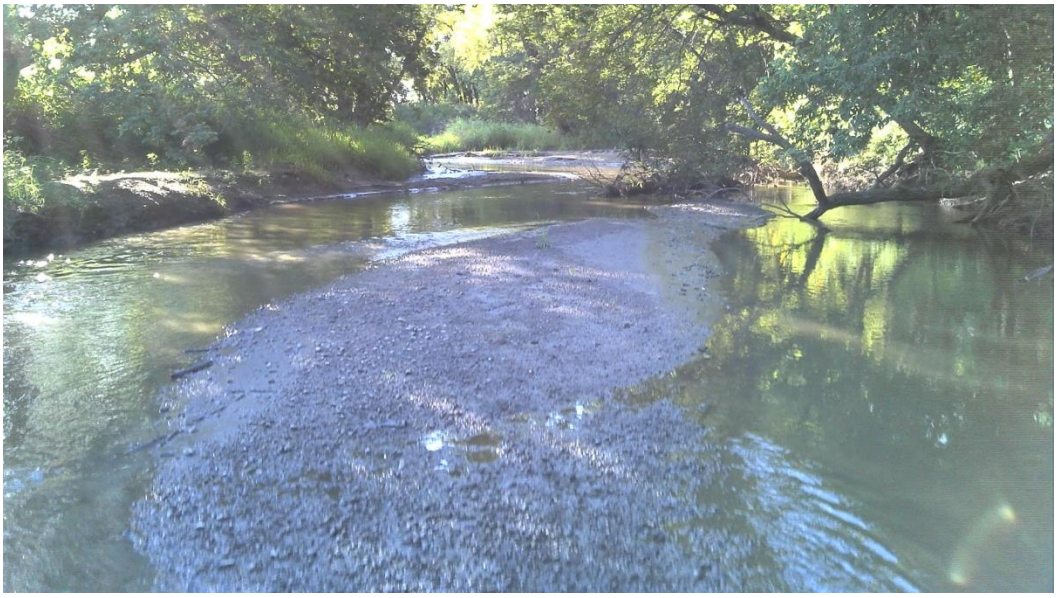


Figure 57. Erosion at station 15MN036 (8/11/15)

Figure 58. Erosion at station 15MN040 (8/11/15)

Figure 59. Mid channel bar at station 15MN041 (8/12/15)



Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were lower than average at all sites except station 15MN040 (Table 111). Benthic insectivores, darter, sculpin, and sucker, riffle, and Piscivore individuals were also below average at all sites. Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. The percentage of tolerant species were above average at all sites except 15MN040. Based on the poor habitat conditions, excess sediment and preponderance of evidence, lack of habitat is stressor on the Lac qui Parle River.

Table 111. Habitat related fish metrics in the Upper Lac qui Parle River HUC

Station	WID	Habitat Related Fish Metrics: BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RifflePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
15MN036	**-505**	0.70	1.40	0.70	0.70	0	2.09	98.60	92.31
15MN040	**-505**	1.00	60.40	0.00	25.60	0.40	89.19	24	7.80
15MN041 (July 2015)	**-505**	0.56	23.28	0.45	15.14	0.56	43.05	73.33	22.60
15MN041 (Sept 2015)	**-505**	0.36	31.82	0.36	23.64	2.18	59.27	59.45	10.36
15MN047	**-505**	2.51	21.34	2.09	5.86	5.02	33.05	59.83	18.83
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were above average at all sites (Table 112). Burrowers and legless individuals are a signal of high levels of sedimentation. Burrowers were increased at sites 15MN036 and 15MN041, while legless percentages were increased at all sites except 15MN040. EPT percentages were below class average at sites 15MN036 and 15MN040. Based on the preponderance of evidence of the macroinvertebrate communities, habitat is a stressor, particularly in the upper reach.

Table 112. Habitat related macroinvertebrate metrics in the Upper Lac qui Parle River HUC

Station	WID	Habitat related Macroinvertebrate Metrics: BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
15MN040	**-505**	1.22	1.22	82.07	89.06	6.69
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**7.54**	**14.71**	**49.54**	**42.46**	**36.03**
15MN036	**-505**	21.67	15.33	36.67	5.33	72.33
15MN041	**-505**	28.52	6.85	39.96	12.92	57.65
15MN047	**-505**	6.00	27.00	40.00	43.33	47.67
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate Cause: Altered hydrology

While channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, the majority of this reach of the Lac qui Parle River is natural. A number of tributaries and the reach that flows out of Lake Hendricks were channelized. Increased flow events can

cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. There are no known barriers on this reach of the Lac qui Parle River.

Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. The sites on the Lac qui Parle River had a population of generalist fish ranging from 36-93%. The numbers of nest guarder species are also positively correlated with increased low flows. The nest guarder species had a population ranging from 2-97%. Long-lived macroinvertebrates decrease with flow changes, as they are not able to stay in one place as conditions change. The range of long-lived macroinvertebrates ranged from 0-21%. The channelization of the upstream section of the river and tributaries to the river are likely contributing to the lack of habitat and is a contributing stressor to the biological communities particularly in the upper reach of the river.

Candidate Cause: Connectivity

Connectivity is another important aspect of hydrology. Fish migration is dependent on stream connectivity. A floodway diversion structure was created in 1976 (DNR, 2019b) on the Lac qui Parle River (-505) downstream of Canby near CR 33 that acts as a fish barrier. Flow was completely diverted to the created channel and sediment accumulated in the natural channel. DNR measured "1.5-2.5 feet of sediment accumulation throughout the entire historic channel" (DNR, 2019b). The floodway is a barrier to fish migration at most flows (DNR, 2019b). There is interest in restoring flow to the historic channel while the floodway would serve as a spillway above the two-year flood stage (DNR, 2019b).

Summary and recommendations

The Upper Lac qui Parle River HUC contains a biologically impaired reach of the Lac qui Parle River. Eutrophication, suspended sediments, lack of habitat, altered hydrology, and connectivity were all stressors in this watershed (Table 113). More DO and nitrate data is needed to better determine the impact of this potential stressor.

The predominant land uses in this subwatershed were row crop agriculture and pasture. The land use is a contributor to the stressors found in these reaches. The upper reach of the Lac qui Parle River is located in the Coteau region, with steeper elevation and faster flows. Utilizing a variety of nutrient and sediment reducing BMPs including: cover crops, erosion control, and nutrient management etc. will help in reducing stress to the biological communities. Erosion control and reducing excess sediment in the river would be beneficial.

Table 113. Stressors on streams in the Upper Lac qui Parle River HUC

	Stressors:						
Stream Name	**Dissolved Oxygen**	**Eutrophication**	**Nitrate**	**Suspended Sediment**	**Habitat**	**Altered Hydrology**	**Connectivity**
Lac qui Parle River (-505)	o	●	o	●	●	●	●

● = stressor; o = inconclusive stressor; --- = not an identified stressor

Tenmile Creek 12-digit HUC

This aggregated HUC is located along the eastern border of the Lac qui Parle Watershed and includes Tenmile Creek (Figure 60). The streams in this section have the following impairments:

County Ditch 34 (-526), is impaired for inverts (15MN077, S001-843)

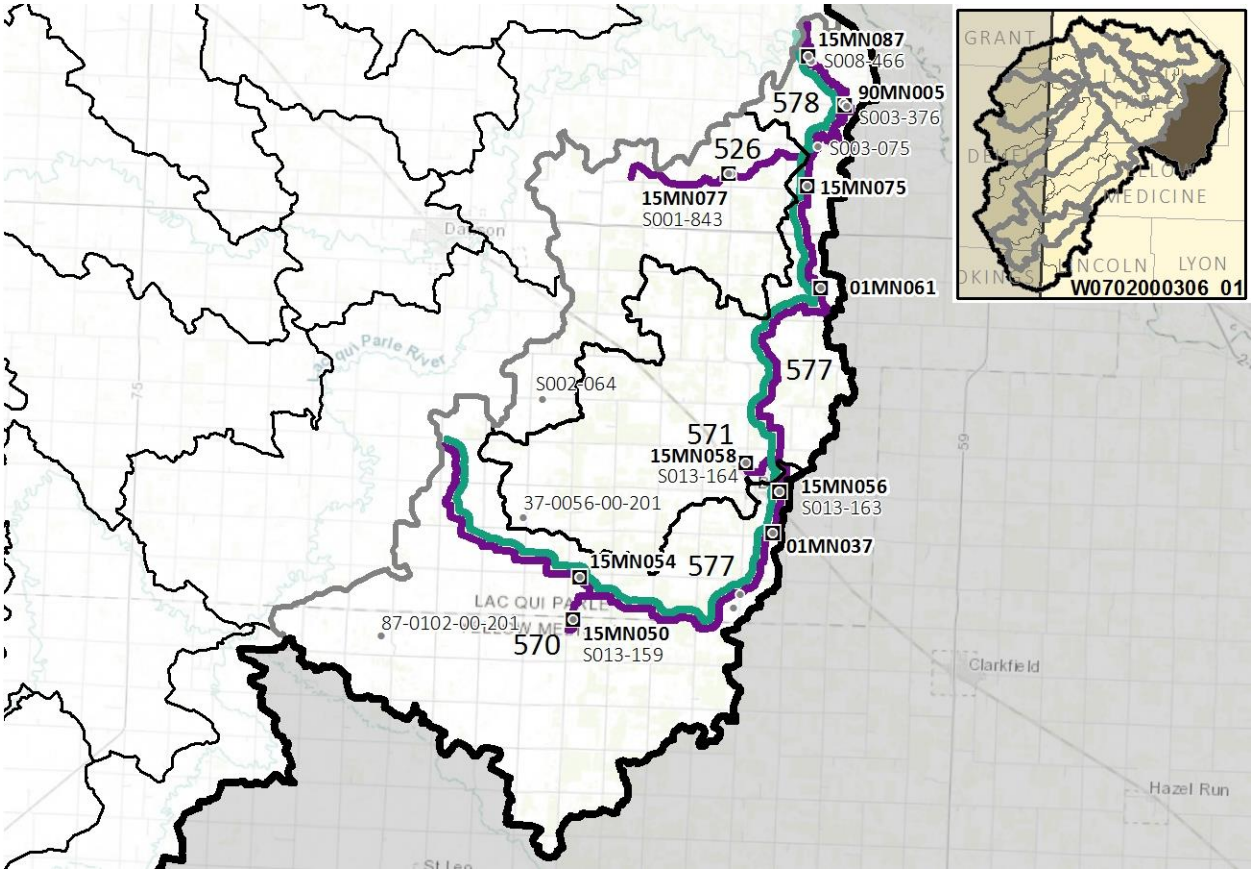
Unnamed ditch (-570), is impaired for inverts (15MN050, S013-159)

Unnamed ditch (-571), is impaired for inverts (15MN058, S013-164)

Tenmile Creek (-577), is impaired for fish and inverts (15MN054, 15MN056, S013-163, 15MN075)

Tenmile Creek (-578), is impaired for fish and inverts (S003-075, S003-376, S008-466, 15MN087)

Figure 60. Impairments in the Tenmile Creek HUC (turquoise represents a fish impairment and purple represents a macroinvertebrate impairment)



Biological communities

Two stations on the upper reach of Tenmile Creek (-577) were in modified fish class 2. This reach was impaired for fish. Metrics low across the visits were sensitive taxa, benthic insectivores, short lived species, and species that have mature reproduction age at less than two years of age (Figure 61). The upstream station (15MN054) on the upper reach of Tenmile Creek was in modified fish class 7. Low metrics were headwater species, minnows, sensitive taxa, and the number of fish collected per meter (Figure 62).

Figure 61. Fish metric scores at sites in modified use fish class 2

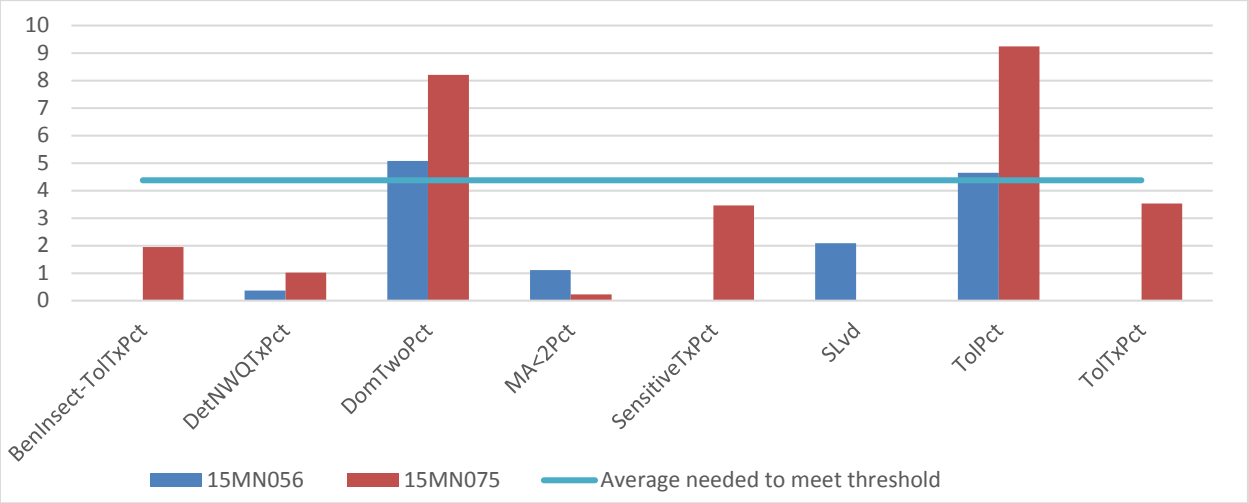
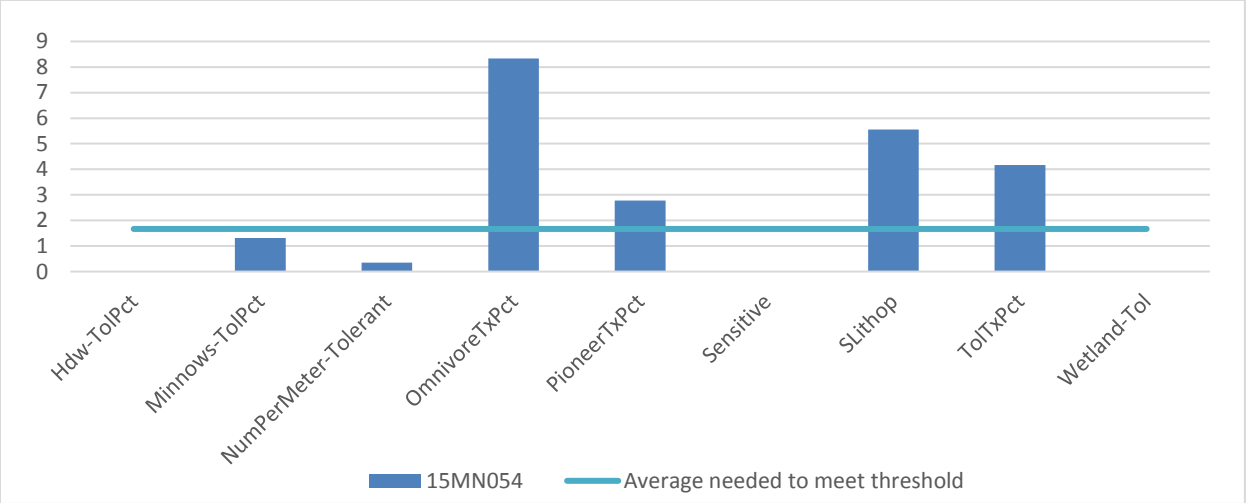
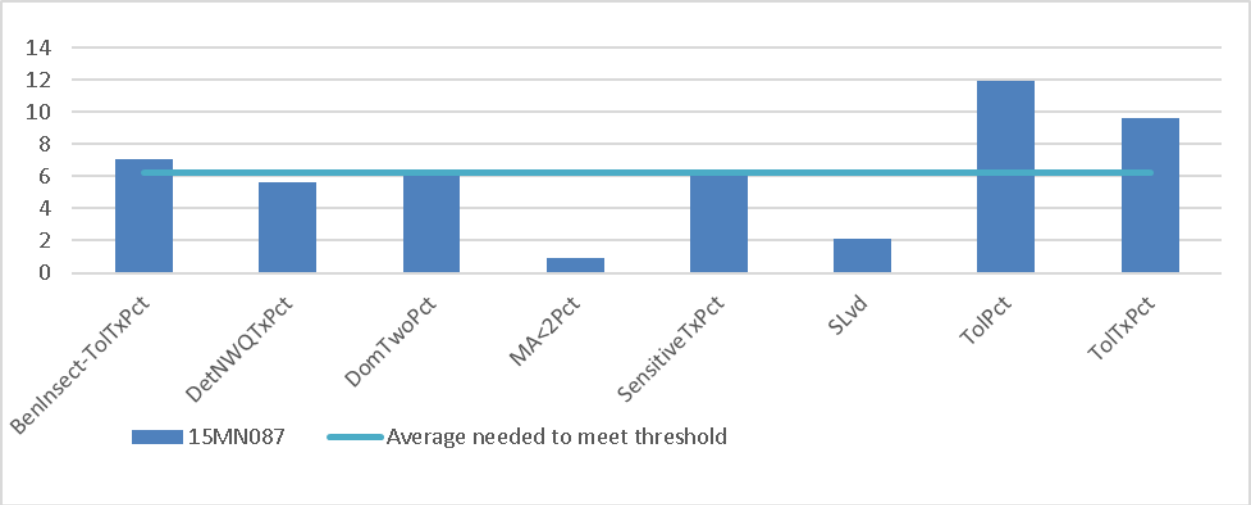


Figure 62. Fish metric scores at sites in general use fish class 2



The station on the lower reach of Tenmile Creek (-578) was in general fish class 2 and was impaired for fish. The lowest metrics scores were short-lived species, and species that have mature reproduction age at less than two years of age (Figure 63).

Figure 63. Fish metric scores at sites in modified use fish class 7



The five stream reaches were all impaired for macroinvertebrates. Station 15MN087 in the lower reach of Tenmile Creek is in macroinvertebrate Class 5 (Southern Streams) (Figure 64), station 15MN075 on the upper reach of Tenmile Creek was in the modified macroinvertebrate Class 5 (Figure 65), while the rest of the sites on Tenmile Creek, the unnamed ditches, and County Ditch 34 were in the modified macroinvertebrate Class 7 (Prairie Streams) (Figure 66). Metric scores low across the sites included clinger taxa, intolerant taxa, POET, and Trichoptera taxa. All sites had low total taxa richness.

Figure 64. Macroinvertebrate metric scores at sites in general use macroinvertebrate class 5

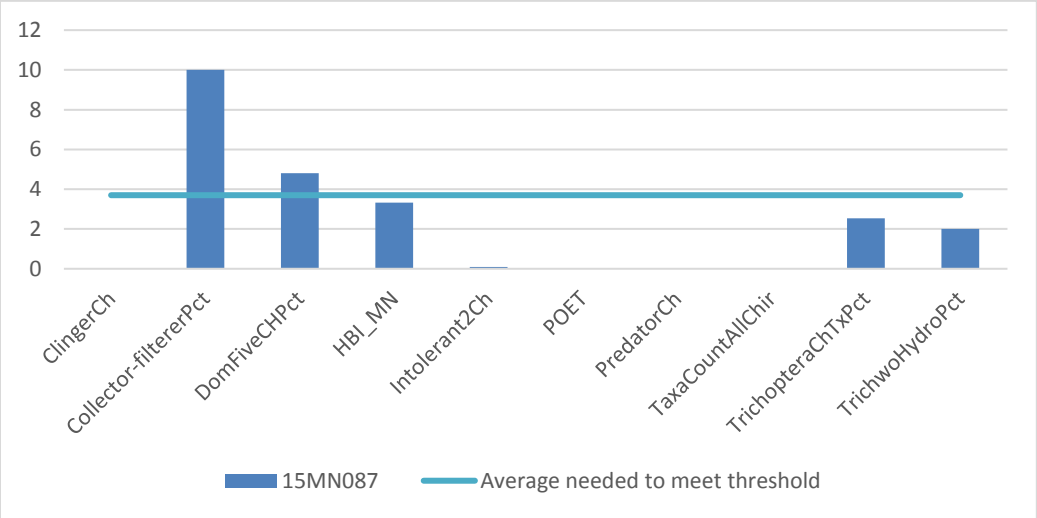


Figure 65. Macroinvertebrate metric scores at sites in modified use macroinvertebrate class 5

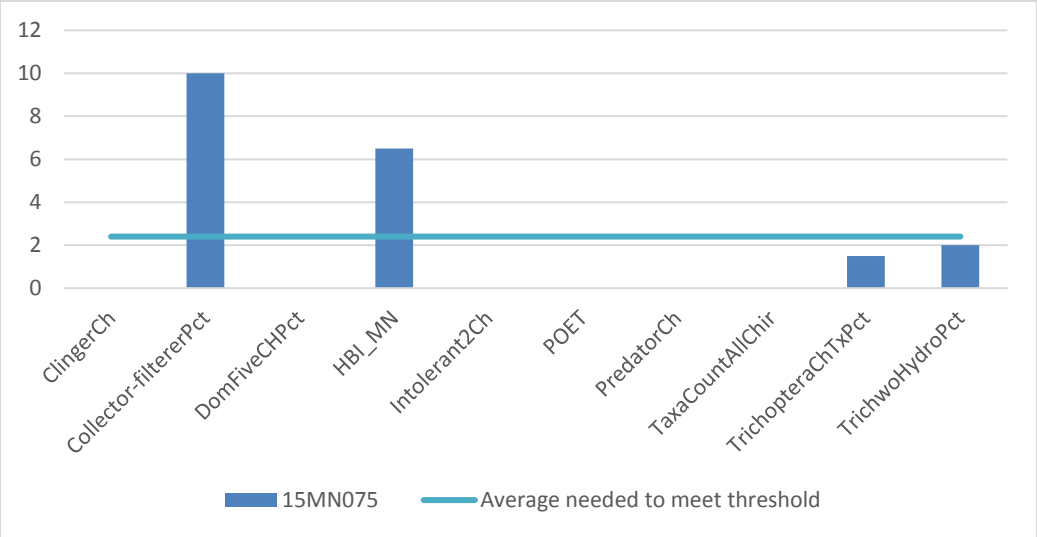
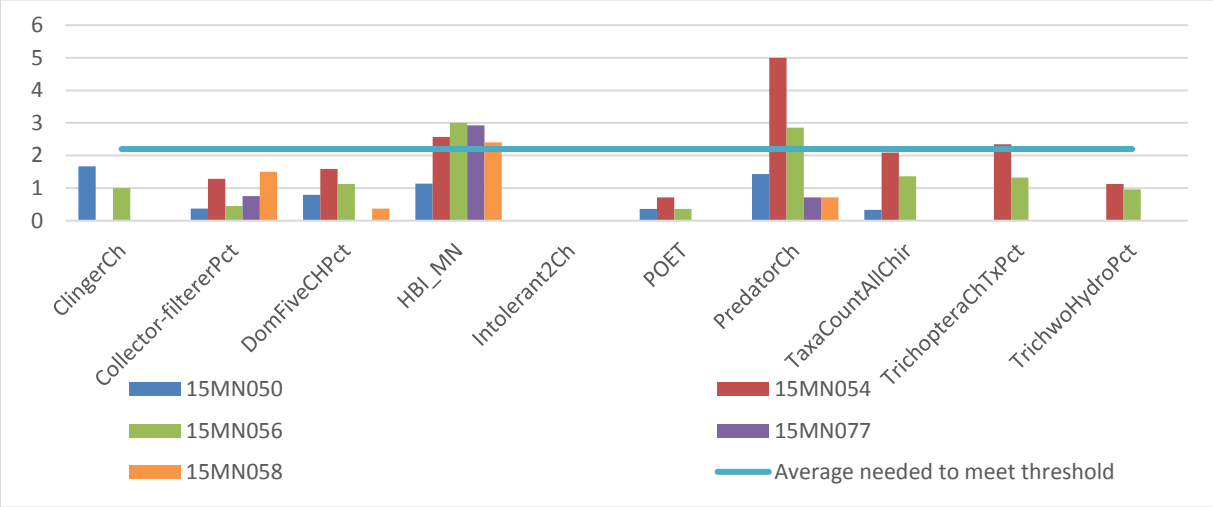


Figure 66. Macroinvertebrate metric scores at sites in modified use macroinvertebrate class 7



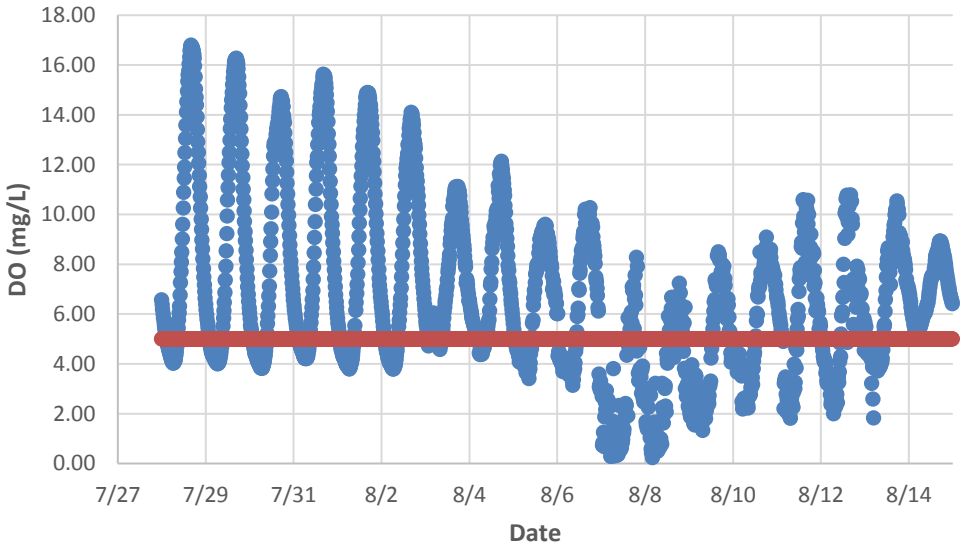
Candidate Cause: Dissolved oxygen

DO values in these four reaches ranged from 3.36 to 19.28 mg/L with three values below 5 mg/L (Table 114). The low values were collected at the upper section of Tenmile Creek and on the Unnamed ditch. Continuous data collected in 2017 at station 03MN044 did not have any values below 5 mg/L, with a low value of 6.85 mg/L. Continuous DO data on Tenmile Creek at station W24035002 had a range of data from 5.87-12.55 mg/L with no values below 5 mg/L. Continuous DO data on Tenmile Creek at station 15MN056 had a range of data from 0.0-16.80 mg/L with daily values below 5 mg/L (Figure 67). Continuous DO data on the unnamed ditch, a tributary to Tenmile Creek, had a DO range of 4.23-18.84 mg/L at station 15MN050. Values were below 5 mg/L on all but 1 day of the 20-day deployment. Continuous DO data on CD 34 had a DO range of 2.71-13.81 mg/L at station 15MN077. Values were below 5 mg/L on 21 days of the 37-day deployment.

Table 114. DO data in the Tenmile Creek HUC

Stream Reach	# DO values	Range of DO values	# of values below 5 mg/L
County Ditch 34 (-526)	8	5.27-19.94	0
Unnamed ditch (-570)	5	3.36-16.20	1
Unnamed ditch (-571)	10	2.72-19.18	3
Tenmile Creek (-577)	12	4.17-19.28	2
Tenmile Creek (-578)	79	6.54-18.40	0

Figure 67. Continuous DO data at station 15MN056



Additionally, the HSPF model calculated daily minimum DO values from 1996-2012. Over the years, the low, high, and average minimum values were all calculated (Table 115). The minimum value was 0 mg/L with a range of 12.15-13.71% of values below the water quality standard of 5 mg/L.

Table 115. Modeled DO data in the Tenmile Creek HUC

Reach Name	WID	Number of Readings	Low daily minimum value (mg/L)	High daily minimum value (mg/L)	Daily minimum average value (mg/L)	Readings below 5 mg/L standard (%)
County Ditch 34	**-526**	6917	0	14.08	8.48	13.71
Unnamed Ditch	**-570**	n/a	n/a	n/a	n/a	n/a
Tenmile Creek	**-577**	6940	0	14.07	8.39	12.5
Tenmile Creek	**-578**	6940	0	15.09	8.49	12.15

Fish species that are specifically tolerant and intolerant to DO were analyzed at each station. There were no intolerant fish at any of the stations. DO tolerant percentages ranged from 0% (15MN087) to 58% (15MN054). Fish taxa were lowest on the upstream section of Tenmile Creek and highest on the downstream section of Tenmile Creek (Table 116). The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. All stations had lower than average percentages of fish that take three years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. Serial spawners ranged from 3.3 to 28.13%. All sites were below the statewide average of stations meeting IBI thresholds except for station 15MN075. Based on low continuous DO values and the preponderance of evidence, DO is a stressor to the fish community on reaches -570 (Unnamed ditch) and -577 (upper reach of Tenmile Creek). DO is also a stressor to the other Unnamed ditch (-571). DO as a stressor to fish is inconclusive on the downstream reach of Tenmile Creek (-578) and CD 34 (-526).

Table 116. DO related fish metrics in the Tenmile Creek HUC

Station	WID	DO Related Fish Metrics		
		MA>3 yrs-Tol Pct	Serial Spawning Fish Pct	Fish Taxa Count
15MN087	**-578**	2.24	24.51	22
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**12.36**	**28.72**	**20.38**
15MN056	**-577**	0.00	3.33	11
15MN075	**-577**	0.00	28.13	16
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI Modified Use Threshold (35.0)		**15.09**	**25.34**	**14.5**
15MN050	**-570**	0.00	5.62	9
15MN077	**-526**	0.00	3.33	10
Statewide average for Class 3 Southern Headwaters stations that are meeting the FIBI Modified Use Threshold (33.0)		**3.16**	**10.56**	**10.03**
15MN054	**-577**	0.00	27.16	8
15MN058	**-571**	0.00	7.35	7
Statewide average for Class 7 Low Gradient stations that are meeting the FIBI Modified Use Threshold (15.0)		**4.38**	**28.58**	**11.74**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station (Table 117). Intolerant macroinvertebrate taxa ranged from 0 to 6.5. DO tolerant percentages ranged from 0.97 (15MN087) to 62.47 (15MN050). The DO tolerant percentages were all below the class average of sites meeting the threshold except for sites 15MN050 and 15MN054. Based on the preponderance of evidence, low DO is not a stressor to the macroinvertebrate community on the lower reach of Tenmile Creek (-578) or on CD 34 (-526), and is inconclusive as a stressor to the upper reach of Tenmile Creek (-577) and the unnamed ditches (-570 and -571).

Table 117. DO related macroinvertebrate metrics in the Tenmile Creek HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
15MN087	**-578**	0.97	7.21	0	6.51
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**8.62**	**7.04**	**8.97**	**7.09**
15MN075	**-577**	4.52	6.14	3	6.88
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI Modified Use Threshold (24.0)		**18.23**	**7.57**	**4.51**	**6.75**
15MN050	**-570**	62.47	8.52	6.5	6.38
15MN054	**-577**	51.94	8.09	0	5.80
15MN056	**-577**	26.56	7.95	2	6.60
15MN058	**-571**	14.57	8.12	0	6.52
15MN077	**-526**	2.52	7.98	6	6.88
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**31.37**	**8.00**	**1.78**	**6.19**
Expected response to DO stress		↑	↑	↓	↑

Candidate Cause: Eutrophication

There was a large phosphorus dataset available on Tenmile Creek, while only a few on the ditches. The highest value was collected at station S003-075, located in the downstream section of reach -577 on Tenmile Creek (Table 118). Algae was noted during sampling at stations 15MN054, 15MN056, 15MN058, 15MN075, and 15MN077 (Figure 68 and 69).

Table 118. Total Phosphorus data in the Tenmile Creek HUC

Stream Reach	# TP values	Range of TP values	# of values above 0.150 mg/L
County Ditch 34 (-526)	3	0.03-0.382	2
Unnamed ditch (-570)	3	0.042-0.063	0
Unnamed ditch (-571)	4	0.036-0.317	2
Tenmile Creek (-577)	64	0.025-1.39	21
Tenmile Creek (-578)	11	0.038-0.401	3

Figure 68. Algae at station 15MN058 (6/10/15)

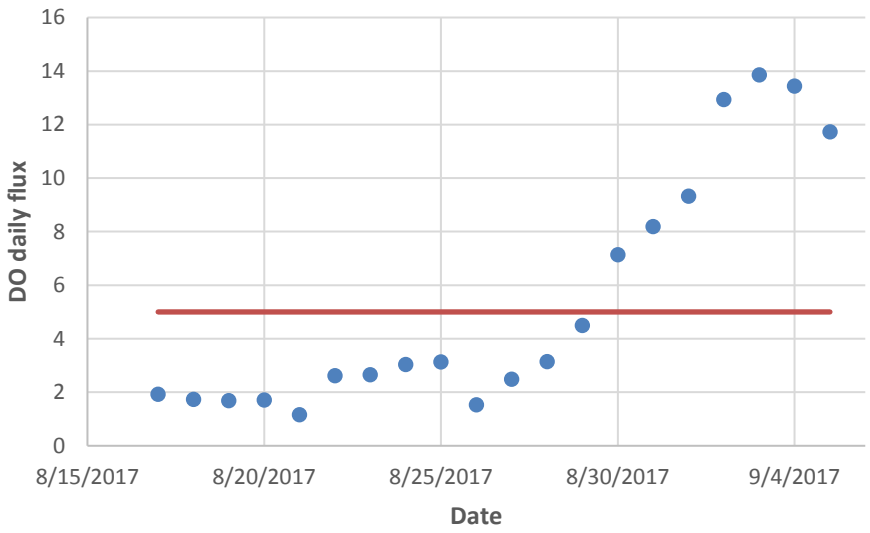
Figure 69. Algae at station 15MN077 (6/10/15)

Chlorophyll-a, BOD, and DO fluctuation values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus. Chlorophyll-a values included 2.45 ug/L at station 15MN056, 3.96 ug/L at station 15MN058, 3.99 ug/L at station 15MN050, and 6.94 ug/L at station 15MN077, all below the southern standard of 40 ug/L. There was no BOD data available. The pH values ranged from 5.77 to 8.66. Values over 8.5 and large daily pH fluctuations can be tied to nutrient enrichment.

Continuous pH data at station 15MN056 had a pH range of 7.78-8.54 with a pH daily range of 0.30-0.74 and station W24035002 had a pH range of 8.15-8.45 with a pH daily range of 0.1-0.27. Station 15MN050 had a pH range of 7.20-8.17 with a daily fluctuation of 0.11-0.67.

Continuous DO data on the downstream reach of Tenmile Creek (-578) in 2015 had a DO flux range of 2.27-6.34 mg/L, with seven of the ten daily fluctuations over the southern standard of 5 mg/L. Continuous DO data on Tenmile Creek (-577) at station 15MN056 had a DO flux range of data from 3.67-14.89 mg/L with 18 of 20 days above the southern standard of 5 mg/L. Continuous DO data on the unnamed ditch, a tributary to Tenmile Creek (-570), had a DO flux range of 1.53-13.44 mg/L with 7 of 20 days above the southern standard of 5 mg/L (Figure 70). Continuous DO data on CD 34 (-526) at station 15MN077 had a DO flux range of 2.11-9.15 mg/L with 24 of 35 days above the southern standard of 5 mg/L.

Figure 70. DO fluctuation at station 15MN050



Additionally, the HSPF model calculated daily TP concentrations from 1996-2012. The values ranged from 0.03-53.87 mg/L with a mean of 0.43 mg/L (Table 119).

Table 119. Modeled Phosphorus data in the Tenmile Creek HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above 0.15 mg/L TP standard (%)
County Ditch 34	**-526**	6812	0.03	26.36	0.40	84.72
Unnamed Ditch	**-570**	n/a	n/a	n/a	n/a	n/a
Tenmile Creek	**-577**	6812	0.03	53.87	0.45	91.05
Tenmile Creek	**-578**	6669	0.05	24.77	0.44	84.57

Sensitive individual percentages ranged from 0-18.7%. All sites had a sensitive percentage below the class average of sites meeting the threshold except for site 15MN075 (Table 120). Darter percentages were well below class average at all sites except for site 15MN077. However, all of the darters collected at station 15MN077 were johnny darters, which are a more tolerant darter. The percentage of tolerant fish individuals comprised more than 40% of the fish community at all sites except for station 15MN087. Along with tolerant species, a positive relationship exists between eutrophication and omnivorous fish. The omnivorous fish percentage were below average at all sites, except at station 15MN058 where it

was elevated. Elevated phosphorus, algal growth, DO fluctuations and the preponderance of metric response indicate eutrophication is a stressor to the fish community.

Table 120. Eutrophication related fish metrics in the Tenmile Creek HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
15MN087	**-578**	16.29	7.47	29.90	4.19
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**18.65**	**11.68**	**44.85**	**16.53**
15MN056	**-577**	0.00	0.00	57.50	7.50
15MN075	**-577**	18.70	10.36	40.19	2.16
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI Modified Use Threshold (35.0)		**8.38**	**13.57**	**46.38**	**25.54**
15MN050	**-570**	0.00	0.00	69.66	8.99
15MN077	**-526**	1.67	25.00	68.33	3.33
Statewide average for Class 3 Southern Headwaters stations that are meeting the FIBI Modified Use Threshold (33.0)		**6.02**	**10.56**	**76.69**	**19.80**
15MN054	**-577**	0.00	4.94	88.89	4.94
15MN058	**-571**	0.00	0.00	83.82	19.12
Statewide average for Class 7 Low Gradient stations that are meeting the FIBI Modified Use Threshold (15.0)		**16.71**	**6.74**	**55.88**	**16.77**
Expected response to increased Eutrophication stress		↓	↓	↑	↑

All stations except 15MN087 had more than half the macroinvertebrate community dominated by two species (Table 121). The EPT percentages were above average at sites 15MN050 and 15MN087, however high numbers of Cheumatopsyche and Hydropsyche, which are indicative of eutrophic conditions, were collected at Station 15MN087. Macroinvertebrate taxa were below average at all sites. Based on the elevated phosphorus values and biological metrics, eutrophication is a stressor to the macroinvertebrate communities to the reaches of the Tenmile Creek HUC.

Table 121. Eutrophication related macroinvertebrate metrics in the Tenmile Creek HUC

		Eutrophication Related Macroinvertebrate Metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
15MN087	-578	19	62.21	29.32
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**42**	**43.90**	
15MN075	-577	13	12.58	78.71
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI Modified Use Threshold (24.0)		**36.82**	**33.60**	
15MN050	-570	11	37.09	58.94
15MN054	-577	18	16.77	54.52
15MN056	-577	12.5	1.24	71.87
15MN058	-571	18	0.00	77.08
15MN077	-526	10	0.00	91.77
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**34**	**20.58**	
Expected response to Eutrophication stress		↓	↓	↑

Candidate Cause: Nitrates

A large nitrate dataset was available on the upper reach of Tenmile Creek, with smaller datasets on the other reaches. Values ranged from 0.04-15.4 mg/L (Table 122). Additionally, the HSPF model calculated daily nitrate concentrations from 1996-2012. These values ranged from 0-57.05 mg/L with a mean of 0.67 mg/L (Table 123). A quantile regression of Invertebrate class 7 streams in Minnesota shows with 90% confidence that if a stream has a nitrate-nitrite reading of 11.5 mg/L or higher, the MIBI score will be below the threshold for that respective class.

Table 122. Nitrate data in the Tenmile Creek HUC

Stream Reach	# nitrate values	Range of values (mg/L)
County Ditch 34 (-526)	4	2.6-14
Unnamed ditch (-570)	3	7.4-11
Unnamed ditch (-571)	4	3-13
Tenmile Creek (-577)	62	0.04-14.3
Tenmile Creek (-578)	11	0.728-15.4

Table 123. Modeled nitrate data in the Tenmile Creek HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)
County Ditch 34	**-526**	6812	0	15.83	0.65
Unnamed Ditch	**-570**	n/a	n/a	n/a	n/a
Tenmile Creek	**-577**	6812	0.01	30.16	0.67
Tenmile Creek	**-578**	6669	0.01	57.05	0.70

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration.

Nitrate intolerant macroinvertebrate taxa were absent at all sites. Nitrate tolerant individuals comprised 39% (15MN075) to 92% (15MN077) of the communities (Table 124). Increasing nitrate concentrations have a negative relationship with non-hydropsychid Trichoptera (caddisfly) individual percentages. Non-hydropsychid Trichoptera are all caddisflies that do not spin nets. Values were below the class average of sites meeting the threshold at all sites except site 15MN087 on Tenmile Creek. Indications of nitrate stress were present on some of these stream reaches based on elevated nitrate values, tolerant taxa, lack of nitrate intolerant data, and lack of Trichoptera taxa. Nitrate is a stressor on CD 34 (-526), the two unnamed ditches (-570 and -571) and the upstream reach of Tenmile Creek (-577). Nitrate is inconclusive as a stressor on the downstream reach of Tenmile Creek (-578).

Table 124. Nitrate related macroinvertebrate metrics in the Tenmile Creek HUC

		Nitrate related Macroinvertebrate Metrics			
Station	**WID**	TrichwoHydroPct	% Tolerant Taxa	% Intolerant Taxa	Nitrogen TIV
15MN087	**-578**	14.98	44.66	3.88	2.69
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**5.94**	**47.60**	**2.92**	**2.95**
15MN075	**-577**	0.32	39.03	52.90	3.51
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI Modified Use Threshold (24.0)		**11.14**	**56.71**	**1.88**	**3.22**
15MN050	**-570**	0.00	76.94	0.00	3.70
15MN054	**-577**	0.32	49.68	0.00	4.15
15MN056	**-577**	0.61	69.49	0.31	6.25

Station	WID	Nitrate related Macroinvertebrate Metrics: TrichwoHydroPct	% Tolerant Taxa	% Intolerant Taxa	Nitrogen TIV
15MN058	**-571**	0	79.14	0	7.62
15MN077	**-526**	0.00	92.11	0.00	8.88
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**2.16**	**59.41**	**1.95**	**3.32**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate Cause: Sediment

Recent TSS data is available with samples ranging in value from 1-320 mg/L, with 6% of concentrations above the southern standard of 65 mg/L (Table 125). The value of 320 mg/L was taken at station S003-075 after over an inch of rain. Additionally, secchi tube measurements ranged from 2-100 cm. Of these measurements, 4% were below the 10 cm standard for transparency.

Table 125. TSS data in the Tenmile Creek HUC

Stream Reach	# TSS values	Range of TSS values	# of values above 65 mg/L
County Ditch 34 (-526)	3	2.4-27	0
Unnamed ditch (-570)	2	5.2-5.2	0
Unnamed ditch (-571)	1	1	0
Tenmile Creek (-577)	62	3-320	3
Tenmile Creek (-578)	11	2-172	2

Additionally, the HSPF model calculated daily suspended sediment concentrations from 1996-2012 on each reach. These values ranged from 1.07-1347 mg/L with a mean of 10.13 mg/L (Table 126).

Table 126. Modeled TSS data in the Tenmile Creek HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above standard (%)
County Ditch 34	**-526**	6812	1.36	1892.1	12.42	0.84
Unnamed Ditch	**-570**	n/a	n/a	n/a	n/a	n/a
Tenmile Creek	**-577**	6812	1.47	1832.2	11.90	0.81
Tenmile Creek	**-578**	6669	0.81	1900.2	15.40	1.36

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. There were zero intolerant fish at any of the stations, however TSS tolerant individuals ranged from 0% to 10%. Herbivore species of fish decrease as TSS values increase. Herbivore species were only below average at sites 15MN087 and 15MN054 (Table 127). Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. Perciform percentages were below average at all sites except station 15MN077. Intolerant and Centrarchid species were below 2% at all sites. Based on the TSS data and the mixed biological response, TSS is inconclusive as a stressor to the fish communities on these reaches.

Table 127. TSS related fish metrics in the Tenmile Creek HUC

		TSS Related Fish Metrics						
Station	**WID**	BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct	TSS Index Score (RA)
15MN087	**-578**	9.72	1.20	4.04	8.82	0.00	1.79	16.23
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**37.38**	**4.89**	**9.61**	**18.66**	**4.97**	**11.68**	
15MN056	**-577**	8.33	0.00	18.33	0.00	0.00	0.83	15.90
15MN075	**-577**	12.67	0.00	17.62	10.36	0.00	1.39	17.11
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI Modified Use Threshold (35.0)		**30.08**	**6.17**	**2.88**	**28.69**	**0.86**	**21.25**	
15MN050	**-570**	7.87	0.00	14.61	0.00	0.00	1.12	15.04
15MN077	**-526**	31.67	0.00	15.00	25.00	0.00	0.00	14.11
Statewide average for Class 3 Southern Headwaters stations that are meeting the FIBI Modified Use Threshold (33.0)		**31.38**	**1.00**	**10.83**	**12.43**	**0.52**	**4.91**	
15MN054	**-577**	4.94	0.00	6.17	4.94	0.00	0.00	16.22
15MN058	**-571**	16.18	0.00	11.76	0.00	0.00	1.47	
Statewide average for Class 7 Low Gradient stations that are meeting the FIBI Modified Use Threshold (15.0)		**12.19**	**4.38**	**8.17**	**13.36**	**2.02**	**7.08**	
Expected response to TSS stress		↓	↓	↓	↓	↓	↓	↑

TSS intolerant taxa was 0 or 1 at all stations. Tolerant macroinvertebrate individuals comprised a range of 12 to 89% of the community (Table 128). While these reaches have a lack of TSS intolerant taxa, other metrics had mixed results, and a lack of elevated TSS value indicates TSS is inconclusive as a stressor to the macroinvertebrate communities.

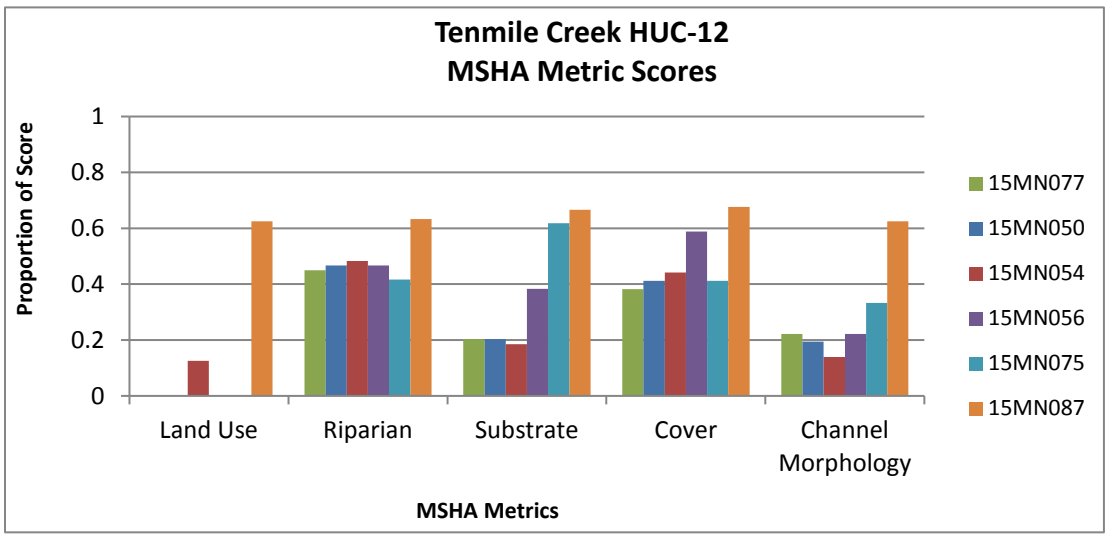
Table 128. TSS related fish metrics in the Upper Lac qui Parle River HUC

		TSS related Macroinvertebrate Metrics						
Station	WID	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	LongllvedPct
15MN087	**-578**	15.04	0	6	42.39	38.44	0.00	12.38
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**15.87**	**3**	**12**	**35.23**	**4.56**	**0.54**	**8.99**
15MN075	**-577**	15.78	1	5	38.71	13.55	0.00	1.29
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI Modified Use Threshold (24.0)		**16.10**	**1.16**	**10.53**	**36.67**	**22.05**	**0.10**	**6.46**
15MN050	**-570**	17.05	0	6	12.24	1.74	0.00	16.93
15MN054	**-577**	16.94	0	6	31.94	5.16	0.00	0.32
15MN056	**-577**	20.76	0	6	63.47	2.03	0.00	1.83
15MN058	**-571**	23.10	0	7	79.14	5.98	0.00	0.00
15MN077	**-526**	23.73	0	3	89.59	3.15	0.00	0.63
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**16.25**	**0.6**	**11**	**35.60**	**9.91**	**0.02**	**5.59**
Expected response to TSS stress		↑	↓	↑	↑	↓	↓	↓

Candidate Cause: Habitat

Habitat conditions were shown to be fair according to MSHA scores at all sites (ranging from 25.38-41.95), except for the most downstream site 15MN087 where the habitat score was fair (64.63) (Figure 71). Erosion was occurring at 15MN087. Moderate to severe embeddedness occurred at all stations. Lack of depth variability and lack of riffles was found at 15MN050, 15MN054, 15MN056, 15MN075, and 15MN077.

Figure 71. MSHA scores in the Tenmile Creek HUC



Upstream of station 15MN056, the DNR surveyed Tenmile Creek where the stream was moderately entrenched, dominated by silt, lacking riffle and pool stream features, no floodplain connectivity, and poor stability. Near site 15MN087 in the downstream reach of Tenmile Creek, the DNR found the site to be deeply incised, without access to its floodplain, but dominated by gravel substrate with riffles and deep pools present (DNR 2019). Along with the stream being incised, the small buffer at station 15MN077 is contributing to erosion into the stream (Figure 72). The gully and the start of a gully on the opposite bank were located at station 15MN050 (Figure 73).

Figure 72. Lack of a buffer at station 15MN077 (5/24/17)

Figure 73. Gullies at station 15MN050 (5/24/17)

Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were only lower than average at station 15MN054 (Table 129). Benthic insectivores and Piscivore individuals were below average at all sites except 15MN075 and 15MN077. Darter, sculpin, and sucker percentages were lower than average at all sites except 15MN077. Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. Riffle dwelling species were lower at all sites except 15MN058. The percentage of tolerant species were above average at sites except 15MN054, 15MN056, and 15MN058.

Table 129. Habitat related fish metrics in the Tenmile Creek HUC

		Habitat Related Fish Metrics							
Station	**WID**	BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RifflePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
15MN087	**-578**	9.27	61.14	7.92	15.84	1.35	76.08	29.83	12.71
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
15MN056	**-577**	0.00	59.17	0.00	8.33	0.00	75.00	57.5	14.17
15MN075	**-577**	10.36	36.32	10.36	19.94	0.00	57.80	40.19	14.68
Statewide average for Class 2 Southern Streams stations meeting the FIBI Modified Use Threshold (35.0)		**3.62**	**26.17**	**16.45**	**19.54**	**8.02**	**35.59**	**46.38**	**23.58**
15MN050	**-570**	0.00	58.43	0.00	7.87	0.00	75.28	69.66	16.85
15MN077	**-526**	25.00	35.00	25.00	8.33	0.00	43.33	68.33	28.33
Statewide average for Class 3 Southern Headwaters stations meeting the FIBI Modified Use Threshold (33.0)		**10.91**	**30.09**	**10.59**	**22.62**	**1.97**	**57.98**	**76.69**	**32.54**
15MN054	**-577**	4.94	7.41	4.94	0.00	0.00	14.81	88.88	17.28
15MN058	**-571**	0.00	30.88	0.00	16.18	0.00	48.53	83.82	19.12

Statewide average for Class 7 Low Gradient stations meeting the FIBI Modified Use Threshold (15.0)		**7.06**	**20.49**	**6.80**	**7.35**	**3.67**	**25.67**	**56.03**	**19.20**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were below average at all sites except sites 15MN087 and 15MN050 (Table 130). Burrowers and legless individuals are a signal of high levels of sedimentation. Burrowers were only increased at site 15MN036 and 15MN087, while legless percentages were increased at sites 15MN075, 15MN056, and 15MN077. EPT percentages were below class average at sites 15MN054, 15MN056, and 15MN077. Based on the preponderance of evidence of the macroinvertebrate communities, habitat is a stressor to the fish and macroinvertebrate communities on reaches -526, -570, and -571, and is inconclusive on the two reaches of Tenmile Creek (-577 and -578).

Table 130. Habitat related macroinvertebrate metrics in the Upper Lac qui Parle River HUC

Station	Habitat related Macroinvertebrate Metrics					
	WID	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
15MN087	**-578**	13.36	4.56	71.99	62.21	21.82
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**7.54**	**14.71**	**49.54**	**42.46**	**36.03**
15MN075	**-577**	1.61	78.71	14.19	12.58	81.61
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI Modified Use Threshold (24.0)		**8.99**	**21.49**	**39.23**	**33.60**	**45.53**
15MN050	**-570**	5.38	10.50	26.16	37.09	21.13
15MN054	**-577**	9.03	31.94	1.61	16.77	48.06
15MN056	**-577**	6.46	62.06	3.89	1.24	73.19
15MN058	**-571**	16.28	76.41	0.66	0.00	97.67
15MN077	**-526**	5.99	91.48	0.95	0.00	99.05
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**14.12**	**27.47**	**23.07**	**20.58**	**55.79**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate Cause: Altered hydrology

While channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency. County Ditch 34, the unnamed ditches, and the upstream reach of Tenmile Creek are completely channelized. The downstream section of Tenmile Creek is a natural channel, but has channelized tributaries. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. There are no known barriers on these reaches.

Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. The sites had a population of generalist fish ranging from 20-76%.

The numbers of nest guarder species are also positively correlated with increased low flows. The nest guarder species had a population ranging from 6-57%. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The range of long-lived macroinvertebrates ranged from 0-28%. The channelization of the upstream section of Tenmile Creek and tributaries to the river are likely contributing to the lack of habitat and is a contributing stressor.

Summary and recommendations

The Tenmile Creek HUC contains five biologically impaired reach on four streams. DO, eutrophication, nitrate, lack of habitat, and altered hydrology were all stressors in this watershed (Table 131). More TSS is needed to better determine the impact of this potential stressor.

The predominant land uses in this subwatershed was row crop agriculture. The land use is a contributor to the stressors found in these reaches. Utilizing a variety of nutrient and sediment reducing Best Management Practices (BMPs) including: cover crops, erosion control, and nutrient management etc. would be helpful to reducing stress to the biological communities. Erosion control and reducing excess sediment in the river would be beneficial. Vegetation management is important in the natural reaches of Tenmile Creek. Undisturbed or lightly grazed buffer strips have shown to provide stability to banks in the lower reaches of the stream (DNR 2019).

Table 131. Stressors on streams in the Tenmile Creek HUC

	Stressors:					
Stream Name	**Dissolved Oxygen**	**Eutrophication**	**Nitrate**	**Suspended Sediment**	**Habitat**	**Altered Hydrology**
Tenmile Creek (-577)	●	●	●	o	o	●
Tenmile Creek (-578)	o	●	o	o	o	●
County Ditch 34 (-526)	o	●	●	o	●	●
Unnamed ditch (-570)	●	●	●	o	●	●
Unnamed ditch (-571)	●	●	●	o	●	●

● = stressor; o = inconclusive stressor; --- = not an identified stressor

Lower Lac qui Parle River 12-digit HUC

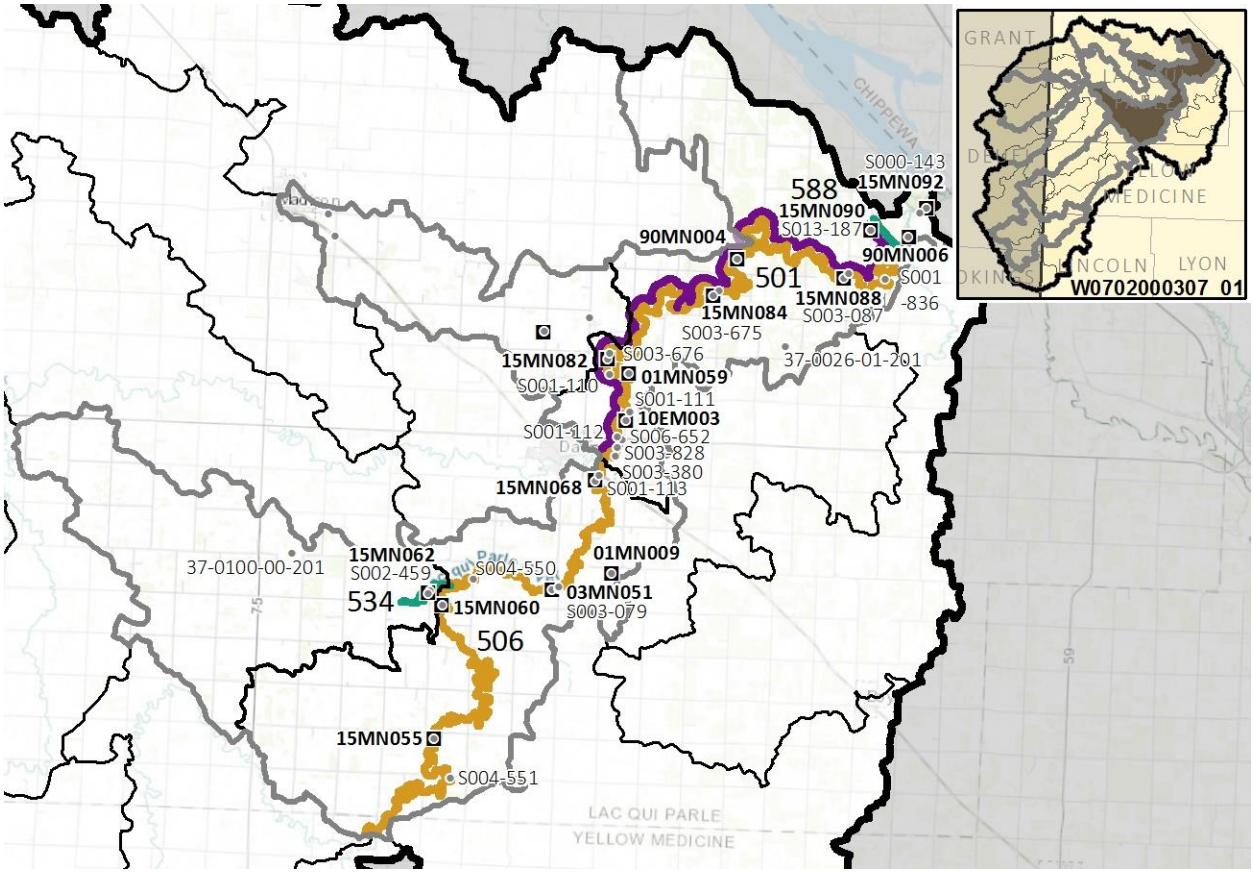
This aggregated HUC contains the lower reach of the Lac qui Parle River, and a few of its tributaries (Figure 74). The city of Dawson is located in this watershed. The streams in this section have the following impairments:

Lac qui Parle (-501), downstream of Dawson is impaired for inverts, Turbidity, DO, and pesticide Chloropyrifos , need more recent data to delist for DO (10EM003, 15MN082, 15MN084, 15MN088, S001-836, S003-675, S003-676, S001-112)

Unnamed Creek (-588), impaired for fish and inverts (15MN090, S013-187)

Unnamed Creek (-534), impaired for fish (15MN062, S002-459, LD000323, S013-167)

Figure 74. Impairments in the Tenmile Creek HUC (turquoise represents a fish impairment, purple represents a macroinvertebrate impairment, and yellow represents a Turbidity impairment)



Biological communities

The four stations on the lower reach of the Lac qui Parle River (-501) were in fish class 1 (Figure 75). This reach was not impaired for fish. IBI scores were highest at the two upstream sites; 10EM003 and 15MN082. The sensitive taxa metric was the only metric that was low across all the sites. The upstream tributary, station 15MN062 on an unnamed creek was in fish class 2 (Figure 76), where all metrics were below the average score needed to meet the threshold. The fish community was dominated by fathead minnows (over 90% of individuals), causing a score of zero in the tolerant, dominant two species, and species that mature at less than two years of age metrics. The downstream tributary, in fish class 3 (15MN090) had an IBI score of zero with all metrics scores being zero.

Figure 75. Fish metric scores at sites in general use fish class 1

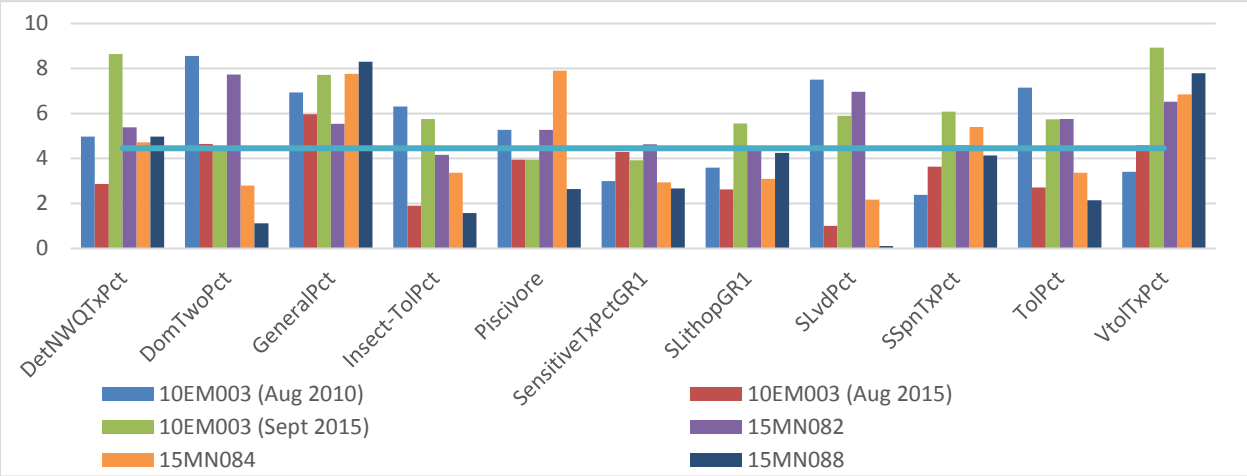
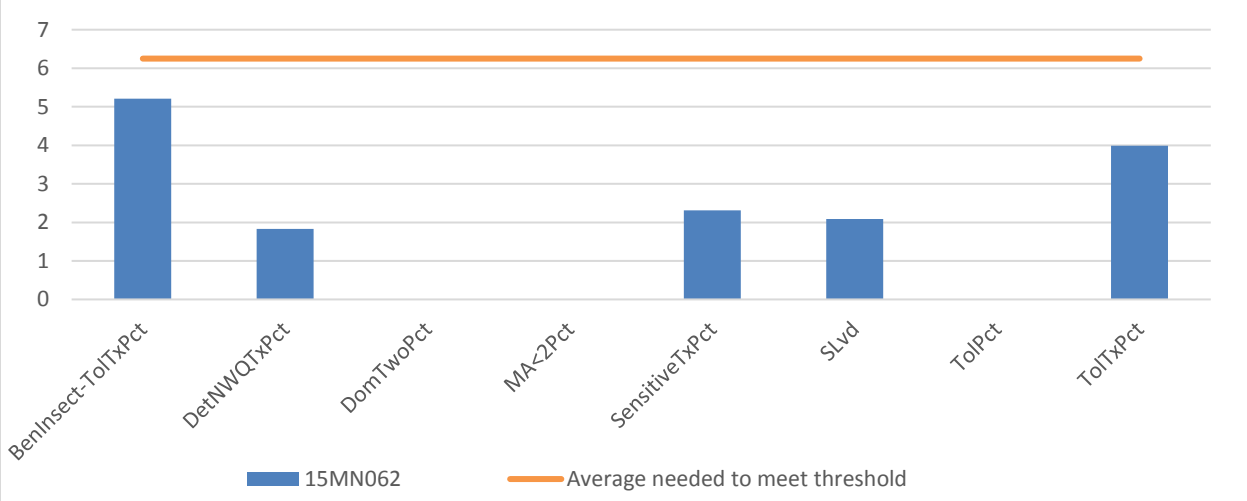


Figure 76. Fish metric scores at sites in general use fish class 2



The stations on the Lac qui Parle River were in macroinvertebrate class 2 while station 15MN090 was in macroinvertebrate class 5. Metric scores on the Lac qui Parle River that were low across the sites included predator taxa and Odonata (dragonflies and damselflies) taxa. Stations 15MN082 and 10EM003 had many EPT taxa, but many were tolerant (Figure 77). The metric scores at station 15MN090 were all below the average score needed to meet the threshold except for the POET metric (Figure 78).

Figure 77. Macroinvertebrate metric scores at sites in general use macroinvertebrate class 2

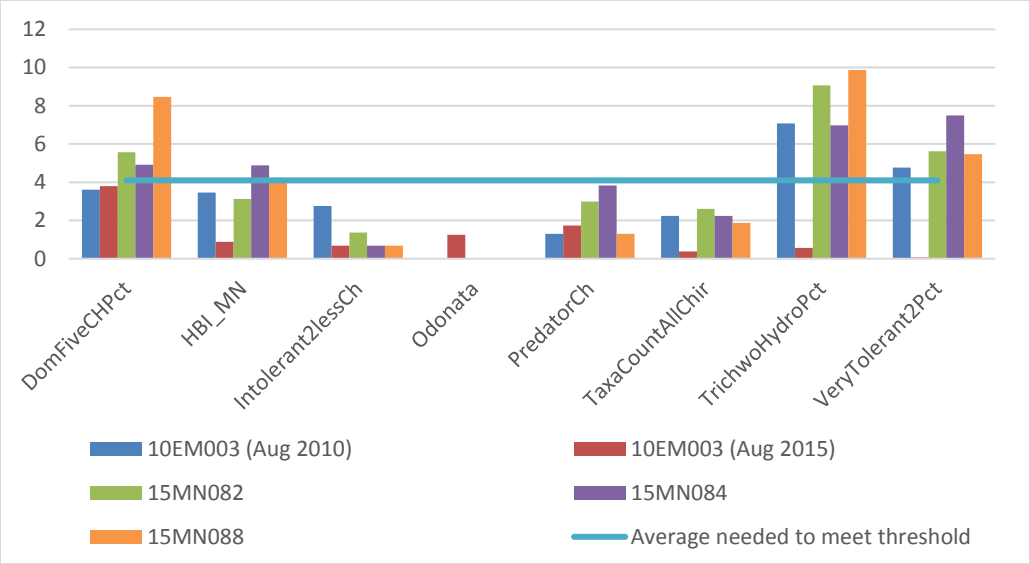
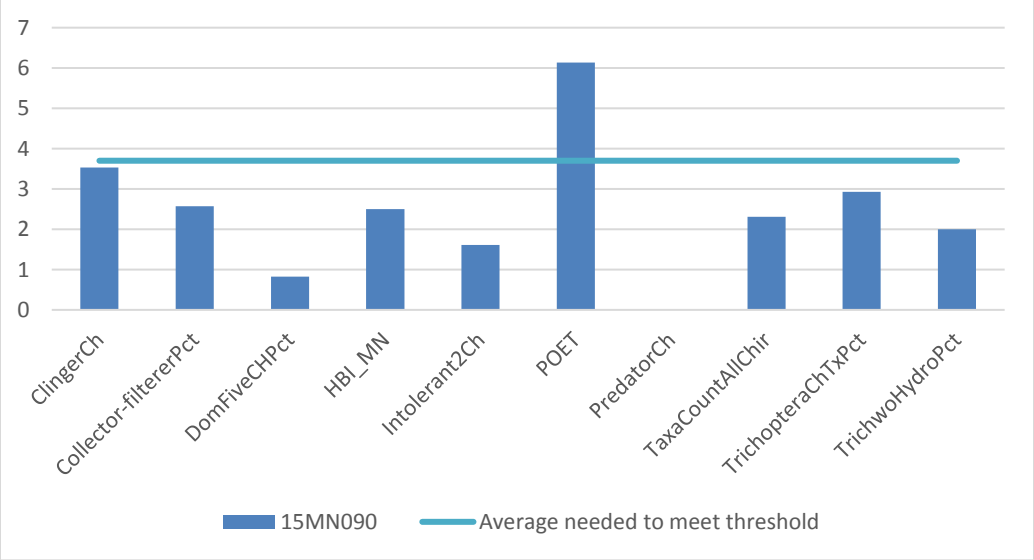


Figure 78. Macroinvertebrate metric scores at sites in general use macroinvertebrate class 5



Candidate Cause: Dissolved oxygen

The large DO dataset on the lower reach of the Lac qui Parle River had values ranging from 4.01 to 16.56 with four value below 5 mg/L (Table 132). The values below 5 mg/L were all collected on one date in 2005 with no recent values below 5 mg/L. Data on -534 had three DO values below 5 mg/L collected in 2017, while the limited data on -588 had no values below 5 mg/L.

Table 132. DO data in the Lower Lac qui Parle River HUC

Stream Reach	# DO values	Range of DO values	# of values below 5 mg/L
Lac qui Parle River (-501)	223	4.01-16.56 mg/L	4
Unnamed Creek (-534)	9	4.19-12.76	3
Unnamed Creek (-588)	4	8.67-13	0

Additionally, the HSPF model calculated daily minimum DO values from 1996-2012. Over the years, the low, high, and average minimum values were all calculated (Table 133). The minimum value was 0 mg/L with a range of 12.15-27.58% of values below the water quality standard of 5 mg/L).

Table 133. Modeled DO data in the Lower Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low daily minimum value (mg/L)	High daily minimum value (mg/L)	Daily minimum average value (mg/L)	Readings below 5 mg/L standard (%)
Lac qui Parle River	**-501**	6940	6.06	14.09	10.41	0
Unnamed Creek	**-534**	6940	0.49	14.06	9.46	1.64
Unnamed Creek	**-588**	6901	0	14.09	7.29	27.58

Fish species that are specifically tolerant and intolerant to DO were analyzed at each station. There were no intolerant fish at any of the stations. DO tolerant percentages ranged from 8% (10EM003) to 93% (15MN062). The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. All stations had lower than average percentages of fish that take 3 years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance (Table 134). Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. Serial spawners ranged from 0 to 93.52%. All sites had values above the statewide average of stations meeting IBI thresholds except for station 15MN090.

Table 134. DO related fish metrics in the Lower Lac qui Parle River HUC

Station	WID	DO Related Fish Metrics		
		MA>3 years Percentage	Serial Spawning Fish Pct	Fish Taxa Count
10EM003 (Aug 2010)	**-501**	22.34	48.40	22
10EM003 (Aug 2015)	**-501**	6.14	67.24	21
10EM003 (Sept 2015)	**-501**	18.59	58.79	18
15MN082	**-501**	17.48	40.56	23
15MN084	**-501**	15.05	64.25	25
15MN088	**-501**	6.98	74.29	22
Statewide average for Class 1 Southern Rivers stations that are meeting the FIBI General Use Threshold (49.0)		**37.47**	**35.61**	**22**
15MN062	**-534**	0.00	91.52	12
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**12.36**	**28.72**	**20.38**
15MN090	**-588**	0.00	0.00	3
Statewide average for Class 3 Southern Headwaters stations that are meeting the FIBI General Use Threshold (55.0)		**2.06**	**17.09**	**12**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station. Intolerant macroinvertebrate taxa ranged from 0 to 2 (Table 135). DO tolerant percentages ranged from 0.32 (15MN082) to 37.50 (15MN090). The DO tolerant percentages were all below the class average of sites meeting the threshold except for sites 15MN090 and 90MN004. Based on the preponderance of evidence, DO is a stressor to the biological communities on Unnamed Creek (-534). DO is inconclusive as a stressor to the biological communities in the lower reach of the Lac qui Parle River (-501) and the Unnamed Creek (-588)).

Table 135. DO related macroinvertebrate metrics in the Lower Lac qui Parle River HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
10EM003 (Aug 2010)	**-501**	1.25	7.55	0	7.51
10EM003 (Aug 2015)	**-501**	5.83	8.13	2	7.13
15MN082	**-501**	0.32	7.63	2	7.43
15MN084	**-501**	5.50	7.22	0	5.49
15MN088	**-501**	3.96	7.41	0	6.53
90MN004	**-501**	12.94	8.17	0	6.56
Statewide average for Class 2 Prairie Forest Rivers stations that are meeting the MIBI General Use Threshold (31.0)		**8.67**	**7.32**	**6.79**	**7.13**
15MN090	**-588**	37.50	7.50	0	6.60
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**8.62**	**7.04**	**8.97**	**7.09**
15MN062	**-534**	12.10	8.19	0	5.88
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**12.98**	**7.55**	**4.46**	**6.91**
Expected response to DO stress		↑	↑	↓	↑

Candidate Cause: Eutrophication

There was a large phosphorus dataset available on the Lac qui Parle River, while only a few on the unnamed creeks (Figure 136). The highest value was collected at station S003-087, located in the downstream section of reach -501 on the Lac qui Parle River. Algae was noted during sampling at stations 15MN084, and 15MN062 (Figure 79). Chlorophyll-a, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus.

Table 136. Total Phosphorus data in the Lower Lac qui Parle River HUC

Stream Reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Lac qui Parle River (-501)	332	0.013-1.31	178
Unnamed Creek (-534)	10	0.044-0.652	5
Unnamed Creek (-588)	4	0.075-0.528	2

One day of continuous data collected in 2007 reflected a DO flux of 5.41 mg/L at station 15MN084, with the one day fluctuation slightly greater than 5 mg/L. pH values ranged from 6.18-9.14. Values over 8.5 and large daily pH fluctuations can be tied to nutrient enrichment. BOD data was only available in 2005,

where data ranged from 1-3.6 mg/L, with one value above the southern standard of 3.5 mg/L. Chlorophyll-a data ranged from 2.46-79.1 ug/L, with five values above the southern standard of 40 ug/L.

Continuous data at station 15MN090 had a range of DO flux values from 1.78-7.44 on reach -588. The daily fluctuations were all below 4 mg/L, except for one day following almost 4 inches of rain. The phosphorus value on the day of increased fluctuation was 0.528 mg/L, indicating that rainfall flushes phosphorus into the stream (which is entirely ditched upstream). The pH and chlorophyll-a value were also increased on the day after the rainfall, with a value of 8.65 and 916 ug/L. Continuous DO, BOD, and Chl-a data was not available on reach -534, but phosphorus was elevated up to 0.652 mg/L.

Figure 79. Algae growth at station 15MN062 (7/12/17)

Additionally, the HSPF model calculated daily TP concentrations from 1996-2012. The values ranged from 0.01-66.18 mg/L with a mean of 0.31 mg/L (Table 137).

Table 137. Modeled Phosphorus data in the Lower Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above 0.15 mg/L TP standard (%)
Lac qui Parle River	**-501**	6940	0.01	1.59	0.11	25.86
Unnamed Creek	**-534**	6940	0.02	2.02	0.27	73.89
Unnamed Creek	**-588**	6692	0.05	66.18	0.55	85.30

Sensitive individual percentages ranged from 0-25.87%. All sites had a sensitive percentage below the class average of sites meeting the threshold except for site 15MN082 and one of three visits at station 10EM003 (Table 138). Darter percentages were well below class average at all sites except for sites 15MN082 and two of three visits at site 10EM003. The percentage of tolerant fish individuals was near or elevated above the average value at all sites. Along with tolerant species, a positive relationship exists between eutrophication and omnivorous fish. The omnivorous fish percentage were below average at

all sites, except at station 15MN062 where it was elevated. Elevated phosphorus, algal growth, DO fluctuations, and the preponderance of metric response indicate eutrophication is a stressor to the fish community on the downstream reach of the Lac qui Parle River and the two unnamed creeks.

Table 138. Eutrophication related fish metrics in the Lower Lac qui Parle River HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
10EM003 (Aug 2010)	**-501**	15.43	10.11	21.81	5.85
10EM003 (Aug 2015)	**-501**	8.19	3.41	59.39	12.29
10EM003 (Sept 2015)	**-501**	9.05	9.05	33.67	5.03
15MN082	**-501**	25.87	11.89	33.57	5.59
15MN084	**-501**	6.72	1.08	53.76	8.33
15MN088	**-501**	6.35	3.81	64.13	1.90
Statewide average for Class 1 Southern Rivers stations that are meeting the FIBI General Use Threshold (49.0)		**13.53**	**4.42**	**22.05**	**15.53**
15MN062	**-534**	0.12	1.25	97.13	91.15
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**18.65**	**11.68**	**44.85**	**16.53**
15MN090	**-588**	0.00	0.00	100.00	0.00
Statewide average for Class 3 Southern Headwaters stations that are meeting the FIBI General Use Threshold (55.0)		**8.55**	**12.08**	**70.64**	**14.62**
Expected response to increased TP stress		↓	↓	↑	↑

The two stations on the unnamed creek (-534 and -588) and one visit on the lower Lac qui Parle River had more than half the macroinvertebrate community dominated by two species (Table 139). The EPT percentages were above average at sites 15MN062, 15MN082, and one visit at site 10EM003, however high numbers of Cheumatopsyche and Hydropsyche, which are indicative of eutrophic conditions were collected. Macroinvertebrate taxa were below average at all sites. Based on the elevated phosphorus values and biological metrics, eutrophication is a stressor to the macroinvertebrate communities to the lower reach of Lac qui Parle River and the two unnamed creeks.

Table 139. Eutrophication related macroinvertebrate metrics in the Lower Lac qui Parle River HUC

		Eutrophication Related Macroinvertebrate Metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
10EM003 (Aug 2010)	-501	24	60.50	41.07
10EM003 (Aug 2015)	-501	16	22.31	51.64
15MN082	-501	25.5	72.38	35.58
15MN084	-501	16	26.54	40.13
15MN088	-501	20	22.44	27.72
90MN004	-501	30	24.84	30.07
Statewide average for Class 2 Prairie Forest Rivers stations that are meeting the MIBI General Use Threshold (31.0)		**35**	**54.79**	
15MN090	-588	20	27.65	54.34
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**42**	**43.90**	
15MN062	-534	11	65.32	64.52
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
Expected response to TP stress		↓	↓	↑

Candidate Cause: Nitrates

A large nitrate dataset was available on the lower upper reach of Lac qui Parle River, with smaller datasets on the other reaches (Table 140). Values ranged from 0.01-11 mg/L. A tile line running into reach -534 next to station 15MN062 had a nitrate value of 10 mg/L. Additionally, the HSPF model calculated daily nitrate concentrations from 1996-2012. These values ranged from 0-35.78 mg/L with a mean of 0.62 mg/L (Table 141).

Table 140. Nitrate data in the Lower Lac qui Parle River HUC

Stream Reach	# nitrate values	Range of values (mg/L)
Lac qui Parle River (-501)	364	0.1-11
Unnamed Creek (-534)	10	0.05-7.3
Unnamed Creek (-588)	5	0.49--11

Table 141. Modeled nitrate data in the Lower Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)
Lac qui Parle River	**-501**	6940	0	15.63	0.56
Unnamed Creek	**-534**	6940	0	10.99	0.55
Unnamed Creek	**-588**	6692	0.01	35.78	0.76

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration.

Nitrate intolerant macroinvertebrate taxa were below 3% at all sites. Nitrate tolerant individuals comprised 37% (15MN084) to 80% (15MN062) of the communities (Table 142). Relationships have shown that Minnesota streams only have a 25% of meeting the IBI threshold with a nitrate tolerant percentage greater than 79.53%. Increasing nitrate concentrations have a negative relationship with non-hydropsychid Trichoptera (caddisfly) individual percentages. Non-hydropsychid Trichoptera are all caddisflies that do not spin nets. Values were below the class average of sites meeting the threshold at sites 90MN004, 15MN084, and one visit of site 10EM003. Indications of nitrate stress was present on some of these stream reaches based on elevated nitrate values, tolerant taxa, lack of nitrate intolerant data, and lack of Trichoptera taxa. However, the metrics were mixed, and nitrate is inconclusive as a stressor on the downstream reach of the Lac qui Parle River and the unnamed creeks.

Table 142. Nitrate related macroinvertebrate metrics in the Lower Lac qui Parle River HUC

		Nitrate related Macroinvertebrate Metrics			
Station	WID	TrichopteraChTxPct	% Tolerant Taxa	% Intolerant Taxa	Nitrogen TIV
10EM003 (Aug 2010)	**-501**	20.00	47.02	0.31	3.10
10EM003 (Aug 2015)	**-501**	7.69	64.89	0.59	4.02
15MN082	**-501**	28.94	65.22	0.62	3.39
15MN084	**-501**	10.00	37.22	2.59	2.54
15MN088	**-501**	20.69	49.83	0.00	3.16
90MN004	**-501**	10.00	64.72	0.97	3.39
Statewide average for Class 2 Prairie Forest Rivers stations that are meeting the MIBI General Use Threshold (31.0)		**13.60**	**47.60**	**2.92**	**2.95**
15MN090	**-588**	13.33	47.44	0.00	2.99

Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**5.94**	**47.60**	**2.92**	**2.95**
15MN062	**-534**	8.33	79.84	0.00	3.66
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate Cause: Sediment

A large dataset of recent TSS data is available on the lower section of the Lac qui Parle River, with smaller datasets on the two unnamed creeks (Table 143). Samples ranged in value from 1.6-990 mg/L, with 40% of concentrations above the southern standard of 65 mg/L (Table X). The value of 990 mg/L was collected at station S003-087 after thawing of several feet of snowfall. Additionally, secchi tube measurements ranged from 2-100 cm. Of these measurements, 14% were below the 10 cm standard for transparency.

Table 143. TSS data in the Lower Lac qui Parle River HUC

Stream Reach	# TSS values	Range of TSS values	# of values above 65 mg/L
Lac qui Parle River (-501)	356	1.6-990	148
Unnamed Creek (-534)	10	3.2-120	1
Unnamed Creek (-588)	4	8.4-70	1

Additionally, the HSPF model calculated daily suspended sediment concentrations from 1996-2012 on each reach. These values ranged from 0.64-1949 mg/L with a mean of 17.88 mg/L (Table 144).

Table 144. Modeled TSS data in the Lower Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above standard (%)
Lac qui Parle River	**-501**	6940	3.14	1417.5	26.93	6.47
Unnamed Creek	**-534**	6940	1.91	1948.9	12.95	1.31
Unnamed Creek	**-588**	6692	0.64	1751.5	13.76	0.94

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. There were zero intolerant fish at any of the stations, while TSS tolerant individuals ranged from 0% to 75%. All sites on the Lac qui Parle River had TSS tolerant percentages over 30% (Table 145). Herbivore species of fish decrease as TSS values increase. Herbivore species were below average at all sites except 15MN088 and one visit at site 10EM003. Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. Perciform percentages were below average at all sites except station 15MN082 and one visit at site 10EM003. Intolerant and Centrarchid species were below 3% at all sites except for one visit at 15MN082.

Table 145. TSS related fish metrics in the Lower Lac qui Parle River HUC

Station	WID	TSS Related Fish Metrics: BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct	TSS Index Score (RA)
10EM003 (Aug 2010)	**-501**	21.28	1.60	0.00	18.62	0.00	17.02	24.33
10EM003 (Aug 2015)	**-501**	6.14	1.37	6.48	8.53	0.00	2.73	27.57
10EM003 (Sept 2015)	**-501**	16.08	2.01	0.00	15.08	0.00	10.55	28.74
15MN082	**-501**	6.99	13.99	0.00	29.37	0.00	6.99	24.44
15MN084	**-501**	18.28	2.96	0.27	7.53	0.00	12.37	29.09
15MN088	**-501**	8.57	0.32	3.49	8.25	0.00	4.76	29.79
Statewide average for Class 1 Southern Rivers stations that are meeting the FIBI General Use Threshold (49.0)		**21.36**	**4.12**	**1.04**	**17.97**	**4.63**	**43.61**	
15MN062	**-534**	2.74	0.00	1.00	1.25	0.00	0.00	23.39
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**37.38**	**4.89**	**9.61**	**18.66**	**4.97**	**11.68**	**37.38**
15MN090	**-588**	0.00	0.00	0.00	0.00	0.00	0.00	14.40
Statewide average for Class 3 Southern Headwaters stations that are meeting the FIBI General Use Threshold (55.0)		**37.83**	**0.89**	**13.33**	**13.93**	**1.95**	**3.56**	**37.83**
Expected response to TSS stress		↓	↓	↓	↓	↓	↓	↑

Invert sampler noted siltation on sediment at station 15MN084. TSS intolerant taxa were 1 or less at all stations. Tolerant macroinvertebrate individuals comprised a range of 32 to 81% of the community (Table 146). The Lac qui Parle River had increased TSS values, increased TSS tolerant fish and macroinvertebrates, and the preponderance of metrics, indicates TSS is a stressor to the biological communities. Based on the TSS data and the mixed biological response, TSS is inconclusive as a stressor to the biological communities on the two unnamed creeks (-534 and -588).

Table 146. TSS related fish metrics in the Lower Lac qui Parle River HUC

Station	WID	TSS related Macroinvertebrate Metrics: TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
10EM003 (Aug 2010)	**-501**	20.11	1	11	68.03	33.86	0.00	27.59
10EM003 (Aug 2015)	**-501**	22.34	0	12	80.64	6.04	0.00	3.45
15MN082	**-501**	19.43	0.5	14	58.91	34.23	0.00	17.18
15MN084	**-501**	13.63	0	8	33.98	12.30	0.00	21.36
15MN088	**-501**	16.35	0	9	43.89	9.57	0.00	22.77
90MN004	**-501**	17.61	1	16	49.84	8.17	0.00	16.01

Statewide average for Class 2 Prairie Forest Rivers stations that are meeting the MIBI General Use Threshold (31.0)		**18.38**	**2.5**	**14.1**	**49.06**	**22.93**	**0.55**	**6.65**
15MN090	**-588**	15.57	0	7	32.37	31.19	0.00	0.96
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**15.87**	**3**	**12**	**35.23**	**4.56**	**0.54**	**8.99**
15MN062	**-534**	16.63	0	3	61.29	54.03	0.00	8.06
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**13.2**	**48.28**	**19.13**	**0.22**	**7.99**
Expected response to stress		↑	↓	↑	↑	↓	↓	↓

Candidate Cause: Habitat

Habitat conditions were shown to be poor according to the MSHA score at site 15MN062 (44), fair at 15MN082 (60), 15MN084 (57), 15MN088 (63), and 10EM003 (54), and good at site 15MN090 (72) (Figure 80). Erosion or excess sedimentation was found at all locations on the Lac qui Parle River (Figure 81). Moderate to severe embeddedness occurred at all stations. Lack of depth variability was found at 15MN082 and 15MN084. Moderate embeddedness was found at 15MN084 and 15MN088. Station 15MN062 had a lack of depth variability, lack of channel development, lack of riffle, and severe embeddedness.

The sample in 2001 at station 90MN004 had 48% fine sediments and the coarse substrate were recorded as 49% embedded by fine substrates. Station 10EM003 in 2001 had a range of 6.82% to 23% fine sediments and 46.43% to 51.88% embeddedness.

Figure 80. MSHA scores in the Lower Lac qui Parle River HUC

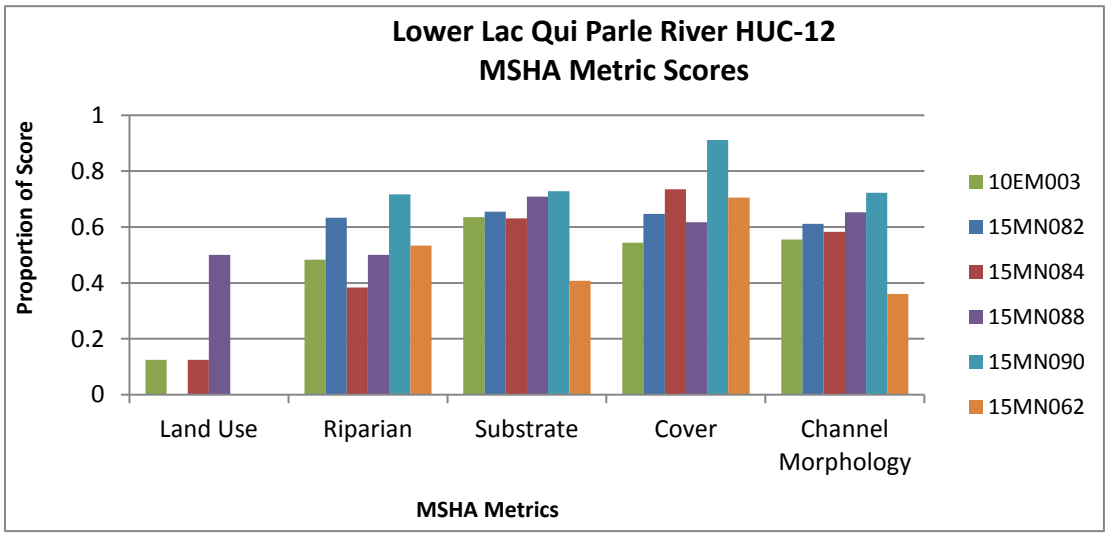


Figure 81. Severe bank erosion at site 10EM003 on 8/4/15 (top) and a sandbar from excess sedimentation at site 15MN082 on 9/15/15 (bottom)

Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were lower than average at all sites except at two visits at stations 10EM003 (Table 147). Benthic insectivores individuals were below average at all sites except one visit at site 10EM003. Darter, sculpin, and sucker percentages were lower than average at all sites except two visits at site 10EM003. Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. Riffle dwelling species were lower at the two unnamed creeks, site 15MN088, and one of the visits at site 10EM003. The percentage of tolerant species was above average at all sites except one visit at site 10EM003. Benthic insectivores, Simple lithophilic spawners, darter, sculpin, and suckers, riffle, and Piscivore percentages all decreased from 2010 to 2015 at site 10EM003.

Table 147. Habitat related fish metrics in the Lower Lac qui Parle River HUC

		Habitat Related Fish Metrics							
Station	WID	BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RiffePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
10EM003 (Aug 2010)	**-501**	27.13	36.17	26.06	25.00	12.23	51.06	21.81	10.64
10EM003 (Aug 2015)	**-501**	6.14	14.33	3.41	7.51	6.48	16.38	59.39	16.72
10EM003 (Sept 2015)	**-501**	20.60	30.15	19.10	16.08	7.54	33.67	33.67	7.54
15MN082	**-501**	14.69	23.78	13.99	16.08	16.78	28.67	33.57	18.18

15MN084	**-501**	12.37	23.92	11.83	13.98	6.18	25.27	53.76	4.84
15MN088	**-501**	7.62	16.19	6.67	11.11	5.08	21.59	64.13	3.17
Statewide average for Class 1 Southern Rivers stations that are meeting the FIBI General Use Threshold (49.0)		**20.61**	**24.97**	**18.51**	**13.92**	**15.18**	**29.21**	**22.05**	**5.21**
15MN062	**-534**	1.25	2.99	1.25	1.62	0.00	3.87	97.13	92.14
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
15MN090	**-588**	0.00	27.27	0.00	0.00	0.00	81.82	100	54.54
Statewide average for Class 3 Southern Headwaters stations that are meeting the FIBI General Use Threshold (55.0)		**10.91**	**30.09**	**10.59**	**22.62**	**1.97**	**57.98**	**76.69**	**32.54**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were above average except at sites 90MN004, 15MN090, and one visit at site 10EM003 (Table 148). Burrowers and legless individuals are a signal of high levels of sedimentation. Burrowers were increased at sites 90MN004, 15MN088, and one visit at site 10EM003. Legless percentages were increased at sites 15MN084, 15MN088, 90MN004, and one visit at site 10EM003. EPT percentages were below class average except at sites 15MN062, 15MN082, and one visit at site 10EM003. Based on the preponderance of evidence of the biological communities, excess sediment, and decreasing scores on the Lac qui Parle over time, habitat is a stressor to the fish and macroinvertebrate communities on reaches -534 and -501, and is inconclusive on the reach -588.

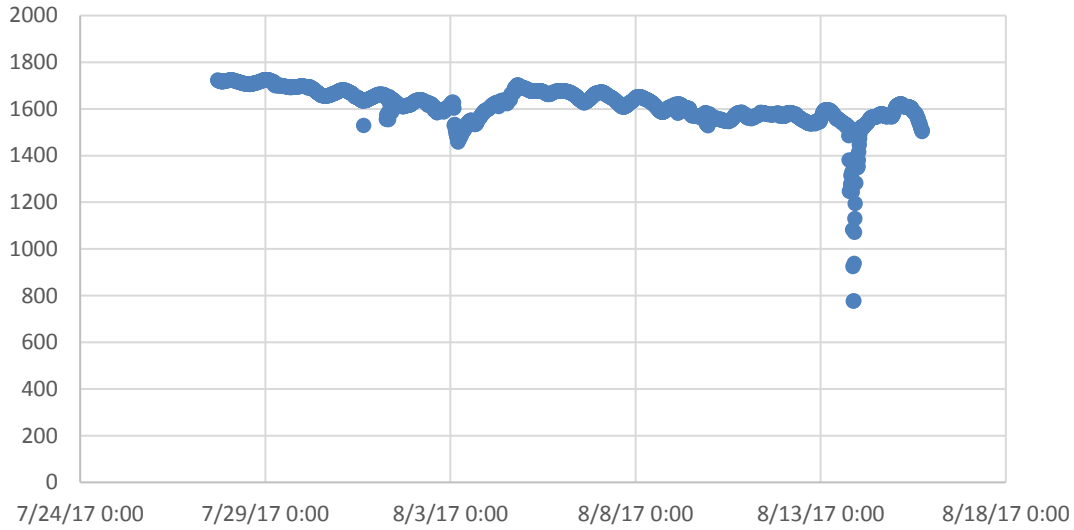
Table 148. Habitat related macroinvertebrate metrics in the Lower Lac qui Parle River HUC

		Habitat related Macroinvertebrate Metrics				
Station	**WID**	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
10EM003 (Aug 2010)	**-501**	4.08	3.13	80.25	60.50	11.29
10EM003 (Aug 2015)	**-501**	4.93	47.88	12.23	22.31	57.85
15MN082	**-501**	3.92	3.59	62.01	72.38	10.81
15MN084	**-501**	26.86	6.80	42.72	26.54	44.98
15MN088	**-501**	23.10	21.78	44.88	22.44	53.47
90MN004	**-501**	11.11	32.35	32.68	24.84	46.41
Statewide average for Class 2 Prairie Forest Rivers stations that are meeting the MIBI General Use Threshold (31.0)		**6.92**	**14.03**	**43.19**	**54.79**	**25.94**
15MN090	**-588**	2.25	14.15	35.69	27.65	23.47
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**7.54**	**14.71**	**49.54**	**42.46**	**36.03**
15MN062	**-534**	9.68	0.81	66.94	65.32	12.90
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate Cause: Chloride/Ionic strength

Chloride values were only available on the Lac qui Parle River, with values ranging from 10-63 mg/L, all well below the standard. Specific conductance is a measure of ions including chloride. Measurements on this stream reach ranged from 196 to 1925 µS/cm. The highest value was taken at station 15MN090. Continuous data collected in 2018 reflected specific conductance values ranging from 777-1724 at station 15MN090 (Figure 82). Increased ionic strength can cause an increase in ion tolerant taxa and an increase in ion tolerant life stages, causing fish and invert impairments, but it is difficult to separate this effect from other stressors.

Figure 82. Continuous specific conductance values at site 15MN090



Elevated chloride can lead to increases in sunfish based assemblages. Site 15MN082 was the only visit to have higher than average Centrarchidae (sunfish) collected. Fish species that are tolerant to conditions with high ionic strength comprised a range of 18-93% of the fish community (Table 149). Station 15MN062 had the elevated percentage.

A study of Minnesota biological data and stressor linkages found that sites with conductivities higher than 1,000 µS/cm rarely meet the biological thresholds for General Use streams (MBI, 2012). As salinity increases, macroinvertebrate taxa richness and Ephemeroptera richness decrease (Piscart et al., 2005). Ephemeropterea percentages and taxa counts were all at or below class average of sites meeting the threshold. Echols et. al (2009) also found a reduction in EPT abundance as ionic strength values increased. EPT percentage were also all below the class average at stations 15MN090, 15MN084, 15MN088, and one visit at station 10EM003.

There are instances of elevated specific conductance concentrations that might be influencing the biological community with the increased sunfish and lowered mayfly, EPT, and macroinvertebrate richness. While the elevated specific conductance values might be contributing as a stressor, chloride values on other reaches would help confirm chloride and specific conductance as a stressor. It is inconclusive at this time.

Table 149. Chloride/Ionic strength related metric in the Lost Creek HUC

		Chloride/Ionic strength related metrics				
Station	**WID**	TaxaCountAllChir	EphemeropteraCh	EphemeropteraPct	EPTPct	Cent-TolPct
10EM003 (Aug 2010)	**-501**	30	8	27.59	60.50	1.59
10EM003 (Aug 2015)	**-501**	20	3	12.93	12.93	1.37
10EM003 (Sept 2015)	**-501**					2.01
15MN082	**-501**	29	8	29.14	70.25	13.98
15MN084	**-501**	30	1	14.24	26.54	2.96
15MN088	**-501**	29	1	2.64	22.44	0.32
Statewide average for Class 1 Southern Rivers stations meeting the FIBI General Use Threshold (49.0)						**4.12**
Statewide average for Class 2 Prairie Forest Rivers stations meeting the MIBI General Use Threshold (31.0)		**35.49**	**7.11**	**33.45**	**54.79**	
15MN062	**-534**	12	1	12.10	65.32	0
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)						**4.89**
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**33.59**	**3.45**	**16.52**	**20.58**	
15MN090	**-588**	30	2	4.82	27.65	0
Statewide average for Class 3 Southern Headwaters stations meeting the FIBI General Use Threshold (55.0)						**0.89**
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (37.0)		**41.92**	**6.04**	**22.91**	**43.90**	
Expected response to Ionic strength stress		↓	↓	↓	↓	↑

Candidate Cause: Altered hydrology

While channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency. Station 15MN090 on one of the unnamed creeks (-588) is natural but the entire upstream is channelized. Station 15MN062 on the other unnamed creek (-534) is partly natural and partly channelized. The Lac qui Parle River is natural but has channelized tributaries. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat.

Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. The sites had a population of generalist fish ranging from 15-94%. Increased generalist species were found at stations 15MN062 and 15MN090, the two unnamed creeks. The numbers of nest guarder species are also positively correlated with increased low flows. The nest guarder species had a population ranging from 4-93%. Increased generalist species were found at station 15MN062. Long-lived macroinvertebrates decrease with flow changes, as they are not able to stay in one place as conditions change. The range of long-lived macroinvertebrates ranged from 2-28%.

The channelization of the upstream section of the two unnamed creeks (-534 and -588) are contributing to the lack of habitat and is a contributing stressor.

Candidate Cause: Connectivity

Connectivity is an important aspect of hydrology. Fish migration is dependent on stream connectivity. There was a perched culvert at station 09MN090 on one of the unnamed creeks (Figure 83). The culvert is a barrier to fish migration from downstream to upstream, as no migratory fish were located at the station 15MN090. Connectivity is a stressor to reach -588.

Figure 83. Perched culvert at site 09MN090

Summary and recommendations

The Lower Lac qui Parle River HUC contains three biologically impaired streams; the Lac qui Parle River and two unnamed creeks. DO, eutrophication, TSS, lack of habitat, connectivity, and altered hydrology were all stressors in this watershed (Table 150). More nitrate is needed to better determine the impact of this potential stressor.

The predominant land uses in this subwatershed was row crop agriculture. The land use is a contributor to the stressors found in these reaches. Utilizing a variety of nutrient and sediment reducing BMPs including: cover crops, erosion control, and nutrient management etc. would be helpful to reducing stress to the biological communities. Nutrient management, sediment reduction, and fixing the perched culvert on reach -588 would be beneficial.

Table 150. Stressors on streams in the Lower Lac qui Parle River HUC

Stream Name	Stressors: Dissolved Oxygen	Eutrophication	Nitrate	Suspended Sediment	Habitat	Chloride	Altered hydrology	Connectivity
Lac qui Parle River (-501)	o	●	o	●	●	o	---	---
Unnamed Creek (-534)	●	●	o	o	●	o	●	---
Unnamed Creek (-588)	o	●	o	o	o	o	●	●

● = stressor; o = inconclusive stressor; --- = not an identified stressor

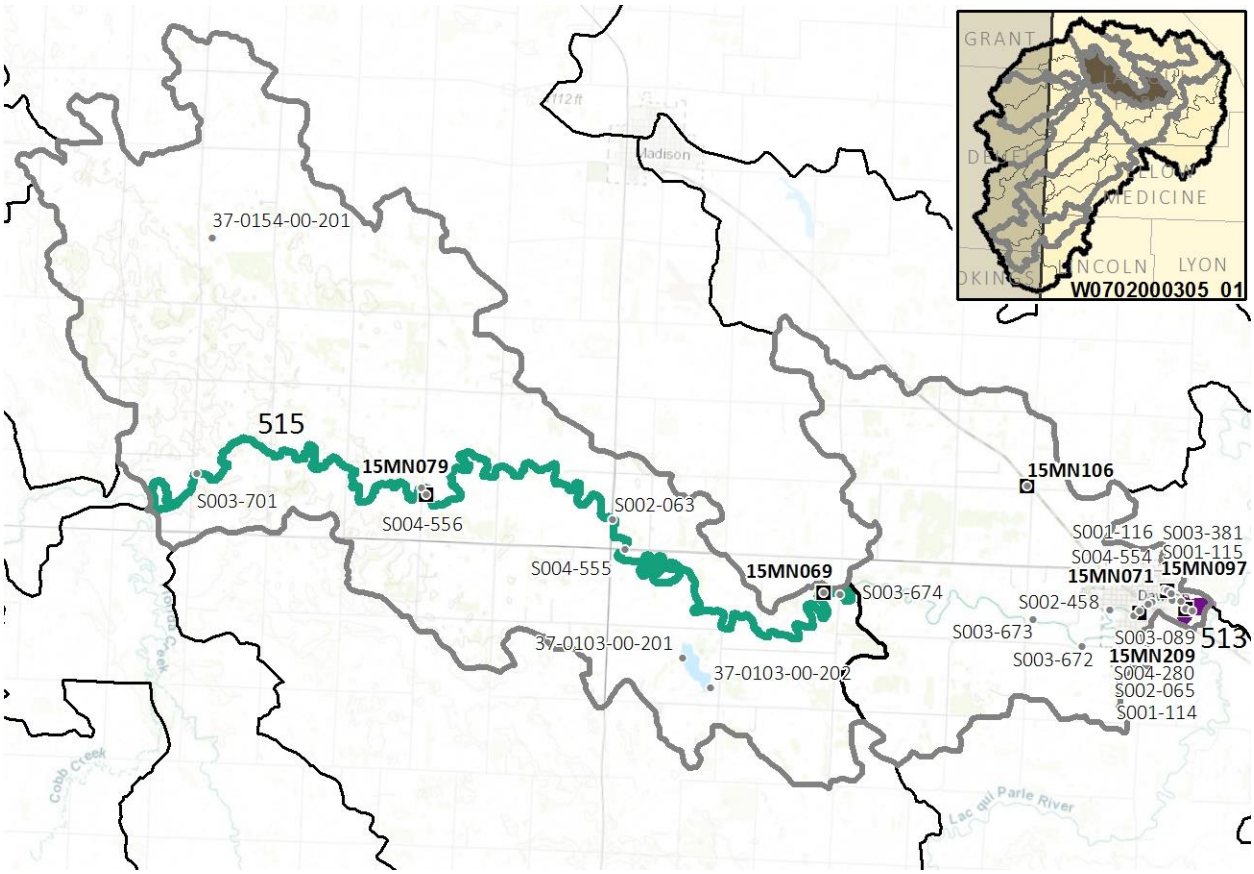
Lower West Branch Lac qui Parle River 12-digit HUC

This aggregated HUC contains the lower reach of the West Branch Lac qui Parle River. The river in this section have the following impairments (Figure 84):

West Branch Lac qui Parle River (-515), impaired for fish (15MN079, 15MN069, S003-701, S004-556, S013-181, S002-063, S004-555, S013-172, and S003-674)

West Branch Lac qui Parle River (-513), impaired for inverts (15MN097, S001-114, S013-193, S004-554, and S001-115)

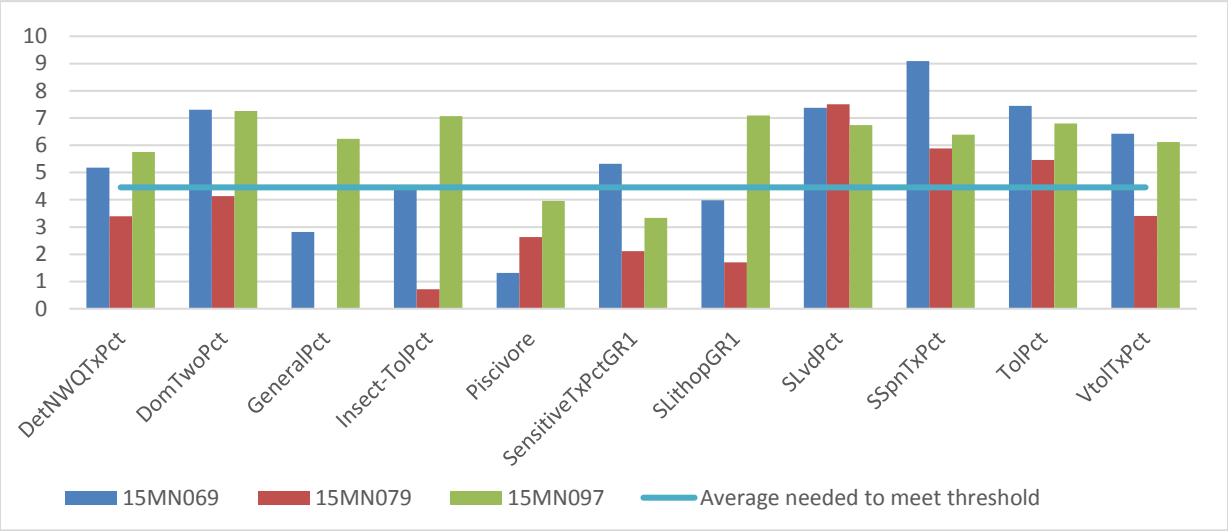
Figure 84. Impairments in the Lower West Branch Lac qui Parle River HUC (turquoise represents a fish impairment and purple represents a macroinvertebrate impairment)



Biological communities

The three stations on the lower reaches of the West Branch Lac qui Parle River were in fish class 1 (Figure 85). IBI scores increased from upstream to downstream along the reaches, where reach (-515) was impaired for fish, but reach (-513) was not. The Piscivore taxa metric was the only metric that was low across all the sites. Station 15MN069 was dominated by generalist taxa like common shiner and green sunfish.

Figure 85. Fish metric scores at sites in general use fish class 1



Station 15MN097 on the West Branch Lac qui Parle River was in macroinvertebrate class 5 (Figure 86) while the two downstream stations were in macroinvertebrate class 7 (Figure 87). Metric scores on were low across the sites for Predator taxa. Station 15MN097 was comprised of over 85% of tolerant taxa with fewer EPT taxa than expected for a stream with riffle/run complexes.

Figure 86. Macroinvertebrate metric scores at sites in general use macroinvertebrate class 5

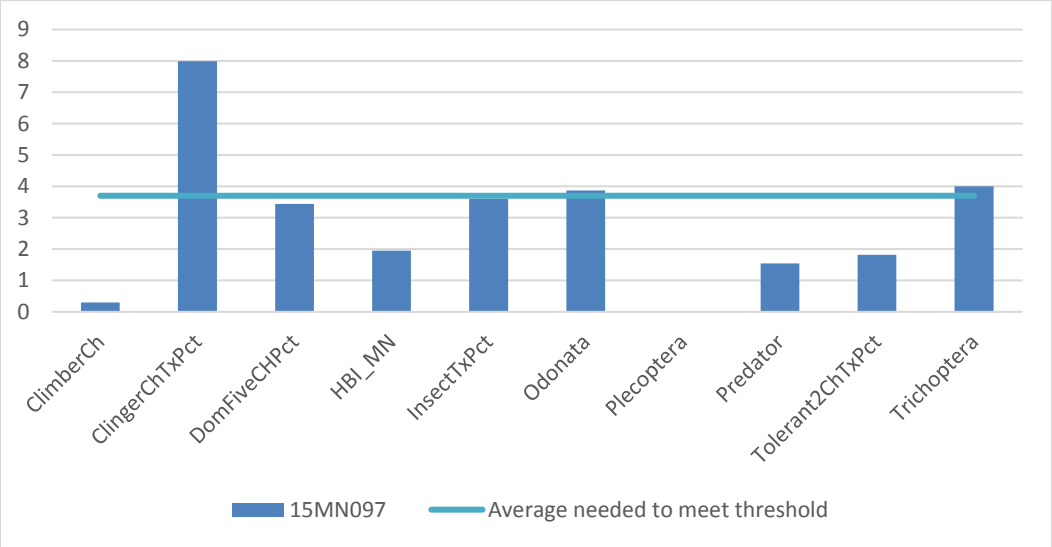
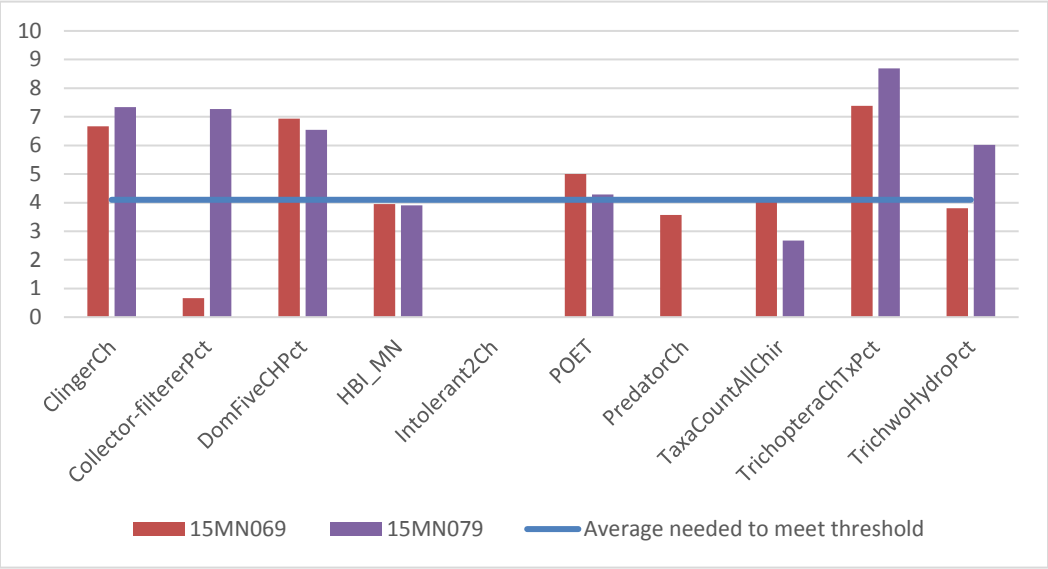


Figure 87. Macroinvertebrate metric scores at sites in general use macroinvertebrate class 7



Candidate Cause: Dissolved oxygen

The DO dataset on the lower reaches of the Lac qui Parle River had values ranging from 3.2 to 11.93 with six values below 5 mg/L (Table 151). The values below 5 mg/L were all collected in 2005 on the upper reach (-515) with no recent values below 5 mg/L. Continuous data collected in 2017 at station 15MN097 had a range of values from 5.23-8.55, with all values above 5 mg/L.

Table 151. DO data in the Lower West Branch Lac qui Parle River HUC

Stream Reach	# DO values	Range of DO values	# of values below 5 mg/L
West Branch Lac qui Parle River (-513)	24	5.19-11.93	0
West Branch Lac qui Parle River (-515)	19	3.2-9.08	6

Additionally, the HSPF model calculated daily minimum DO values from 1996-2012. Over the years, the low, high, and average minimum values were all calculated (Table 152). The minimum value was 5.99 mg/L with zero values below the water quality standard of 5 mg/L).

Table 152. Modeled DO data in the Lower West Branch Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low daily minimum value (mg/L)	High daily minimum value (mg/L)	Daily minimum average value (mg/L)	Readings below 5 mg/L standard (%)
West Branch Lac qui Parle River	**-513**	6940	7.40	14.08	10.57	0
West Branch Lac qui Parle River	**-515**	6940	5.99	14.07	10.35	0

Fish species that are specifically tolerant and intolerant to DO were analyzed at each station. There were no intolerant fish at any of the stations. DO tolerant percentages ranged from 14% (15MN069) to 19% (15MN097). The abundance of fish individuals where females mature at greater than three years in age

decreases with low DO conditions. All stations had lower than average percentages of fish that take 3 years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance (Table 153). Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. Serial spawners ranged from 8.22 to 37.5%. Only station 15MN097 sites had a value above the statewide average of stations meeting the IBI threshold.

Table 153. DO related fish metrics in the Lower West Branch Lac qui Parle River HUC

		DO Related Fish Metrics		
Station	**WID**	MA>3 years Percentage	Serial Spawning Fish Pct	Fish Taxa Count
15MN069	**-515**	10.84	14.46	15
15MN079	**-515**	0.86	8.22	22
15MN097	**-513**	8.70	37.50	28
Statewide average for Class 1 Southern Rivers stations meeting the FIBI General Use Threshold (49.0)		**37.47**	**35.61**	**22**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station (Table 154). Intolerant macroinvertebrate taxa ranged from 2 to 3. DO tolerant percentages ranged from 1.55 (15MN079) to 13.75 (15MN069). The DO tolerant percentages were all below the class average of sites meeting the threshold except for sites 15MN069. Based on the preponderance of evidence, DO is not a stressor to the biological communities on the lower reaches of the West Branch Lac qui Parle River (-513 and -515).

Table 154. DO related macroinvertebrates metrics in the Lower West Branch Lac qui Parle River HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
15MN097	**-513**	4.44	7.68	3	6.45
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (37.0)		**8.62**	**7.04**	**9**	**7.09**
15MN069	**-515**	13.75	7.67	2	7.28
15MN079	**-515**	1.55	7.68	3	6.54
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**12.98**	**7.55**	**4.46**	**6.91**
Expected response to DO stress		↑	↑	↓	↑

Candidate Cause: Eutrophication

There was data available on both reaches of the West Branch Lac qui Parle River (Table 155). The highest value was collected at station S001-114, located just downstream of Dawson. Algae was noted during sampling at station 15MN097.

Table 155. Total Phosphorus data in the Lower West Branch Lac qui Parle River HUC

Stream Reach	# TP values	Range of TP values	# of values above 0.150 mg/L
West Branch Lac qui Parle River (-513)	14	0.103-0.268	9
West Branch Lac qui Parle River (-515)	12	0.081-0.231	6

Chlorophyll-a, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus. There were a small number of BOD measurements taken along the river in 2005, but all values were below the southern standard of 3.5 mg/L. Four chlorophyll-a values were available with a range of values of 5.19-47.3 ug/L; one value was above the southern standard of 40 ug/L. Continuous deployment in 2017 had a range of DO flux values from 0.08-1.32 mg/L, all below the southern standard of 5 mg/L. Values of pH ranged from 7.84-8.19 during continuous deployment, pH daily fluctuations ranged from 0.01-0.12.

Additionally, the HSPF model calculated daily TP concentrations from 1996-2012. The values ranged from 0.01-1.59 mg/L with a mean of 0.125 mg/L (Table 156).

Table 156. Modeled Phosphorus data in the Lower West Branch Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above 0.15 mg/L TP standard (%)
West Branch Lac qui Parle River	**-513**	6940	0.01	1.59	0.12	27.06
West Branch Lac qui Parle River	**-515**	6940	0.02	1.23	0.13	27.44

Sensitive individual fish percentages ranged from 4.29-24.10%. Station 15MN079 was the only station of to have a sensitive percentage below the class average of sites meeting the threshold (Table 157). Darter percentages were above class average at all sites except. The percentage of tolerant fish individuals was below average at station 15MN069, slightly above at station 15MN097, and above at station 15MN079. Along with tolerant species, a positive relationship exists between eutrophication and omnivorous fish. The omnivorous fish percentage were below average at all sites. While there were some elevated phosphorus and chlorophyll-a values, and algal growth, the preponderance of metric response indicate eutrophication is not a stressor to the fish community on the downstream reaches of the West Branch Lac qui Parle River.

Table 157. Eutrophication related fish metrics in the Lower West Branch Lac qui Parle River HUC

		Eutrophication Related Macroinvertebrate Metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
15MN097	-513	19	48.57	44.76
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**42**	**43.90**	
15MN069	-515	22	16.88	30.31
15MN079	-515	15	45.03	34.78
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
Expected response to TP stress		↓	↓	↑

The three stations on the West Branch Lac qui Parle River had less than half the macroinvertebrate community dominated by two species (Table 158). The EPT percentages were above average, except at site 15MN069, however the most common EPT species at site 15MN097 were Cheumatopsyche and Hydropsyche, which can indicate eutrophic conditions. Macroinvertebrate taxa were below average at all sites. Based on the preponderance of evidence, eutrophication is inconclusive as a stressor to the macroinvertebrate community on the West Branch Lac qui Parle River.

Table 158. Eutrophication related macroinvertebrate metrics in the Lower West Branch Lac qui Parle River HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
15MN069	**-515**	24.10	15.06	19.28	8.43
15MN079	**-515**	4.29	9.33	36.07	10.06
15MN097	**-513**	20.52	23.23	24.73	1.90
Statewide average for Class 1 Southern Rivers stations meeting the FIBI General Use Threshold (49.0)		**13.53**	**4.42**	**22.05**	**15.53**
Expected response to increased TP stress		↓	↓	↑	↑

Candidate Cause: Nitrates

A large nitrate dataset was available on the lower upper reach of Lac qui Parle River, with smaller datasets on the other reaches (Table 159). Values ranged from 0.08-6.8 mg/L. Additionally, the HSPF model calculated daily nitrate concentrations from 1996-2012. These values ranged from 0-17.92 mg/L with a mean of 0.52 mg/L (Table 160).

Table 159. Nitrate data in the Lower West Branch Lac qui Parle River HUC

Stream Reach	# nitrate values	Range of values (mg/L)
West Branch Lac qui Parle River (-513)	14	0.037-4.22
West Branch Lac qui Parle River (-515)	14	0.08-6.8

Table 160. Modeled nitrate data in the Lower West Branch Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)
West Branch Lac qui Parle River	**-513**	6940	0	15.92	0.52
West Branch Lac qui Parle River	**-515**	6940	0	17.92	0.52

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration.

Nitrate intolerant macroinvertebrate taxa were below 4% at all sites. Nitrate tolerant individuals comprised 60% (15MN069) to 77% (15MN079) of the communities (Table 161). Increasing nitrate concentrations have a negative relationship with non-hydropsychid Trichoptera (caddisfly) individual percentages. Non-hydropsychid Trichoptera are all caddisflies that do not spin nets. Values were above the class average of sites meeting the threshold. Based on the lack of elevated nitrate values and preponderance of evidence, nitrate is not a stressor on the two reaches of the West Branch Lac qui Parle River.

Table 161. Nitrate related macroinvertebrate metrics in the Lower West Branch Lac qui Parle River HUC

		Nitrate related Macroinvertebrate Metrics			
Station	WID	TrichopteraChTx Pct	% Tolerant Taxa	Intolerant Taxa	Nitrogen TIV
15MN097	**-513**	22.22	65.71	0.00	3.49
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (37.0)		**5.94**	**47.60**	**2.92**	**2.95**
15MN069	**-515**	12.12	60.00	3	4.04
15MN079	**-515**	14.29	76.71	0.00	3.67
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate Cause: Sediment

A dataset of recent TSS data is available on both of the lower sections of the West Branch Lac qui Parle River. Samples ranged in value from 6.4-76 mg/L, with one value above the southern standard of 65 mg/L (Table 162). Additionally, secchi tube measurements ranged from 12-84 cm. Of these measurements, zero were below the 10 cm standard for transparency.

Table 162. TSS data in the Lower West Branch Lac qui Parle River HUC

Stream Reach	# TSS values	Range of TSS values	# of values above 65 mg/L
West Branch Lac qui Parle River (-513)	12	8-36	0
West Branch Lac qui Parle River (-515)	11	6.4-76	1

Additionally, the HSPF model calculated daily suspended sediment concentrations from 1996-2012 on each reach. These values ranged from 2.33-1797 mg/L with a mean of 11.09 mg/L (Table 163).

Table 163. Modeled TSS data in the Lower West Branch Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above standard (%)
West Branch Lac qui Parle River	**-513**	6940	4.67	1539.7	33.63	16.08
West Branch Lac qui Parle River	**-515**	6940	2.33	1797.2	20.23	6.10

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. There were zero intolerant fish at any of the stations, while TSS tolerant individuals ranged from 0% to 29%. Herbivore species of fish decrease as TSS values increase. Herbivore species were below average at two of the three sites (Table 164). Perciform species (smallmouth bass, walleye, etc.) have demonstrated to decrease as TSS increases. Perciform percentages were only below average at sites 15MN079. Intolerant species were below 3% at all sites while Centrarchid were below class average at two of the three sites.

Table 164. TSS related fish metrics in the Lower West Branch Lac qui Parle River HUC

		TSS related Fish Metrics						
Station	WID	BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct	TSS Index Score (RA)
15MN069	**-515**	14.46	6.63	0.00	22.29	0.00	4.22	18.35
15MN079	**-515**	12.88	0.49	6.01	9.94	0.00	1.84	16.91
15MN097	**-513**	12.91	3.40	0.68	27.45	0.14	6.79	23.36
Statewide average for Class 1 Southern Rivers stations meeting the FIBI General Use Threshold (49.0)		**21.36**	**4.12**	**1.04**	**17.97**	**4.63**	**43.61**	
Expected response to TSS stress		↓	↓	↓	↓	↓	↓	↑

TSS intolerant taxa were two or less at all stations. Tolerant macroinvertebrate individuals comprised a range of 49.07 to 64.13% of the community (Table 165). While some metrics indicated TSS stress, based on the low TSS values and the preponderance of metrics, indicates TSS is not a stressor to the biological communities on the two lower reaches of the West Branch Lac qui Parle River creeks (-513 and -515).

Table 165. TSS related macroinvertebrate metrics in the Lower West Branch Lac qui Parle River HUC

		TSS related Macroinvertebrate Metrics						
Station	**WID**	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Longlived Pct
15MN097	**-513**	17.08	0	11	64.13	35.87	0.00	6.03
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (37.0)		**15.87**	**3**	**12**	**35.23**	**4.56**	**0.54**	**8.99**
15MN069	**-515**	19.00	2	13	57.19	2.81	0.00	16.25
15MN079	**-515**	17.35	0	10	49.07	27.64	0.00	5.28
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**13.2**	**48.28**	**19.13**	**0.22**	**7.99**
Expected response to TSS stress		↑	↓	↑	↑	↓	↓	↓

Candidate Cause: Habitat

Habitat conditions were shown to be poor according to the MSHA score at site 15MN079 (44), and fair at sites 15MN069 (50) and 15MN097 (54) (Figure 88). Moderate embeddedness and erosion occurred at all stations (Figure 89). Station 15MN069 had zero riffles. Eroding banks without a buffer occurred at station 15MN069. Station 15MN097, located just downstream of the Dawson WWTP was turbid during biological sampling.

DNR found an unstable system upstream of site 15MN069, however the natural pattern of the channel, low slope, gently sweeping outside bends, and intact riparian corridor make the stream a relatively low sediment contributor for a large stream in southern Minnesota (DNR 2019)".

Figure 88. MSHA scores in the Lower West Branch Lac qui Parle River HUC

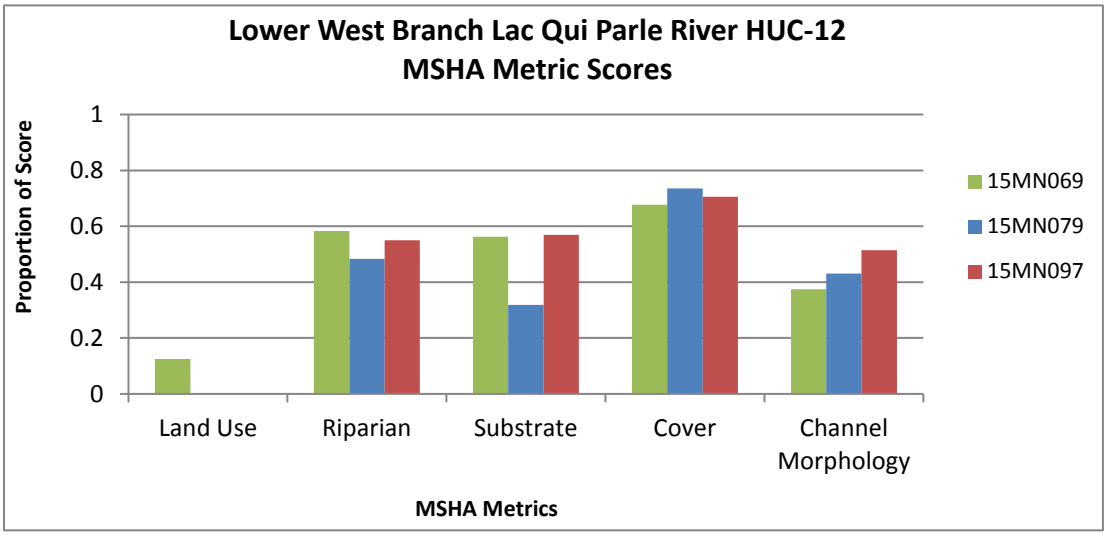


Figure 89. Eroding bank at station 15MN079 (10/30/17)

Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were higher than average at all sites (Table 166). Benthic insectivores individuals were below average at the two upstream sites, but not at 15MN097. Darter, sculpin, and sucker percentages were only lower than average at site 15MN079. Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. Riffle dwelling species were also lower at site 15MN079. The percentage of tolerant species was above average only at site 15MN079, but above average at all three sites. Based on the poor MSHA score and the preponderance of evidence, habitat is a stressor to the upper reach (-515). Habitat is not a stressor on the lower reach (-513).

Table 166. Habitat related fish metrics in the Lower West Branch Lac qui Parle River HUC

Station	WID	Habitat Related Fish Metrics							
		BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RifflePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
15MN069	**-515**	18.67	61.45	18.67	13.86	66.27	19.28	14.46	18.67
15MN079	**-515**	9.33	61.47	9.33	10.67	72.64	36.07	21.10	9.33
15MN097	**-513**	28.67	34.65	28.67	14.27	39.95	24.73	25.54	28.67
Statewide average for Class 1 Southern Rivers stations meeting the FIBI General Use Threshold (49.0)		**20.61**	**24.97**	**18.51**	**13.92**	**15.18**	**29.21**	**22.05**	**5.21**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were only below average at site 15MN069 (Table 167). Burrowers and legless individuals are a signal of high levels of sedimentation. Burrowers were higher than average at sites 15MN069 and 15MN097. Legless percentages were increased at all three sites. EPT percentages were only below class average at site 15MN069. Based on the preponderance of evidence, habitat is a stressor to the macroinvertebrate community on reach -515 (especially at station 15MN079), and is inconclusive on reach -513.

Table 167. Habitat related macroinvertebrate metrics in the Lower West Branch Lac qui Parle River HUC

Station	WID	Habitat related Macroinvertebrate Metrics				
		BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
15MN097	**-513**	11.43	25.40	51.43	48.57	40.63
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (37.0)		**7.54**	**14.71**	**49.54**	**42.46**	**36.03**
15MN069	**-515**	15.31	29.38	30.00	16.88	55.31
15MN079	**-515**	6.83	17.08	57.45	45.03	48.14
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate Cause: Altered hydrology

The two reaches of the West Branch Lac qui Parle River are natural but have channelized tributaries. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat.

Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. The sites had a population of generalist fish ranging from 24-72%. Increased generalist species were found at stations 15MN069 and 15MN079, the two upstream stations on reach -515. The numbers of nest guarder species are also positively correlated with increased low flows. The nest guarder species had a population ranging from 12.5-29%. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The range of long-lived macroinvertebrates ranged from 5-16%. HSPF models show this section of the West Branch Lac qui Parle River is experiencing low flow at less than 5 cfs 16% of the time during the spring-fall months. Variable flows seem to be having some impact on the biological communities, but altered hydrology is inconclusive as a stressor at this time.

Candidate Cause: Connectivity

Connectivity is an important aspect of hydrology. Fish migration is dependent on stream connectivity. On the downstream of this reach (-515) of the West Branch Lac qui Parle River, there is an undersized culvert west of Dawson (Figure 90). The dam in Dawson (downstream of this culvert) was removed in 2010, and replaced with a rock arch rapids (DNR 2019). Removal of the dam restored fish migration potential to 16 MPCA biological monitoring sites on the West Branch Lac qui Parle River (DNR 2019).

Figure 90. Undersized culvert on the West Branch Lac qui Parle River (photo credit DNR)

The upstream fish barrier, the field crossing is a barrier at most flows until it is inundated. The landowner is currently working on a plan to replace the crossing with a structure that does not create a fish barrier" (DNR 2019). With this culvert barrier, the upper reach of the Lac qui Parle River is not connected to fish passage from the Lac qui Parle River or the Minnesota River (Table 168). Connectivity is a stressor to reach (-515), where the culvert is located.

Table 168. Migratory fish and fish barriers along the West Branch Lac qui Parle River

CommonName	15MN069			15MN097
blackside darter	X	Culvert barrier	Dawson rapids (former dam)	X
central stoneroller				X
golden redhorse	X			X
greater redhorse				X
Iowa darter				X
shorthead redhorse	X			X
silver lamprey				
slenderhead darter	X			X
silver redhorse				X
spottail shiner				
quillback				
walleye				X
white bass				
white sucker	X			X

Summary and recommendations

The Lower West Branch Lac qui Parle River HUC contains two biologically impaired reaches of the West Branch Lac qui Parle River. Lack of habitat and connectivity were both stressors to reach -515 (Table 169), while more data is needed to better determine the stressors to reach -513.

The predominant land uses in this subwatershed was row crop agriculture. The land use is a contributor to the lack of habitat found on these reaches. Utilizing a variety of sediment reducing BMPs including: cover crops and erosion control, etc. would be helpful to reducing stress to the biological communities. The plan to fix the undersized culvert would be helpful to migratory fish populations.

Table 169. Stressors on streams in the Lower West Branch Lac qui Parle River HUC

	Stressors:						
Stream Name	**Dissolved Oxygen**	**Eutrophication**	**Nitrate**	**Suspended Sediment**	**Habitat**	**Connectivity**	**Altered hydrology**
West Branch Lac qui Parle River (-513)	---	o	---	---	o	---	o
West Branch Lac qui Parle River (-515)	---	o	---	---	●	●	o

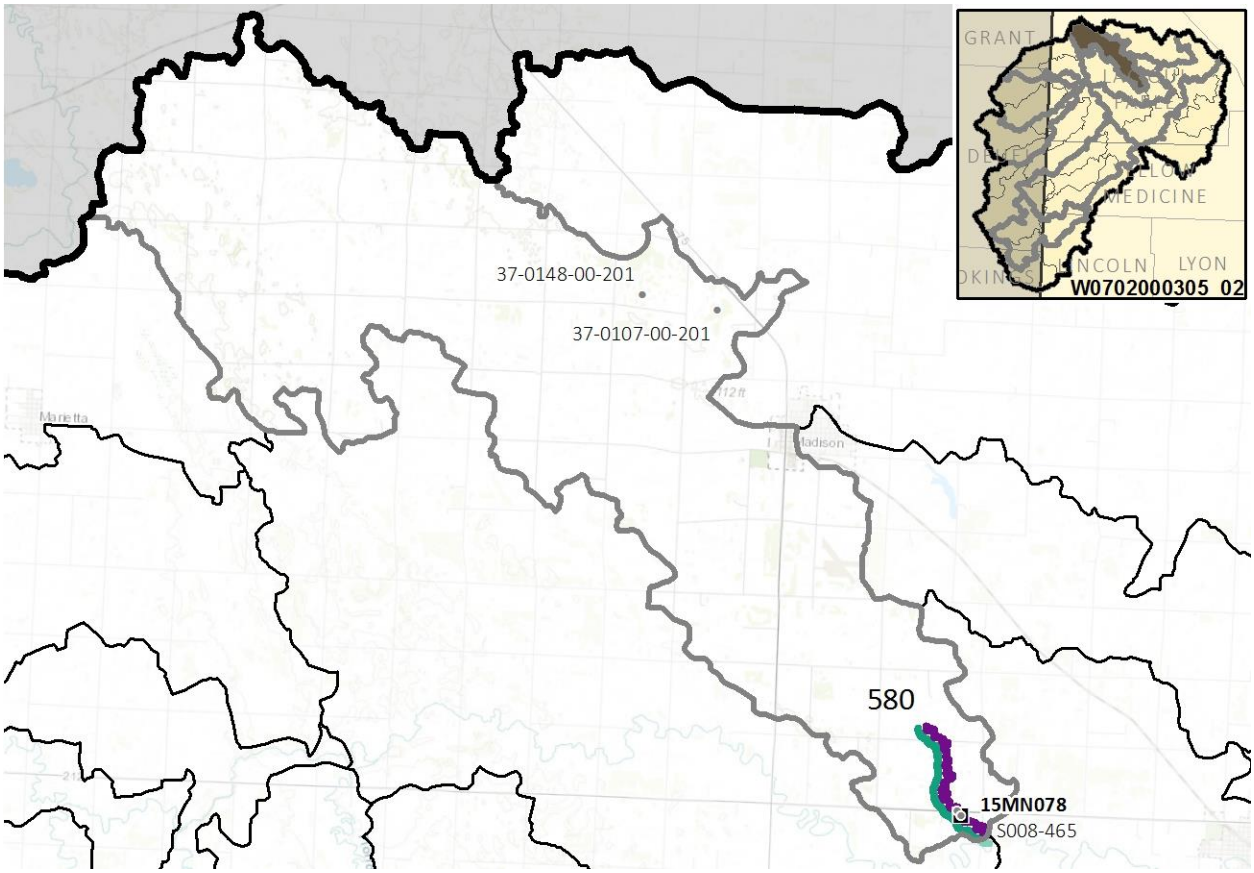
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Tributary to West Branch Lac qui Parle River 12-digit HUC

This aggregated HUC contains a tributary to West Branch Lac qui Parle River. The stream in this section has the following impairments (Figure 91):

Unnamed Creek (-580), impaired for fish and macroinvertebrates (15MN078, S008-465 and S013-180)

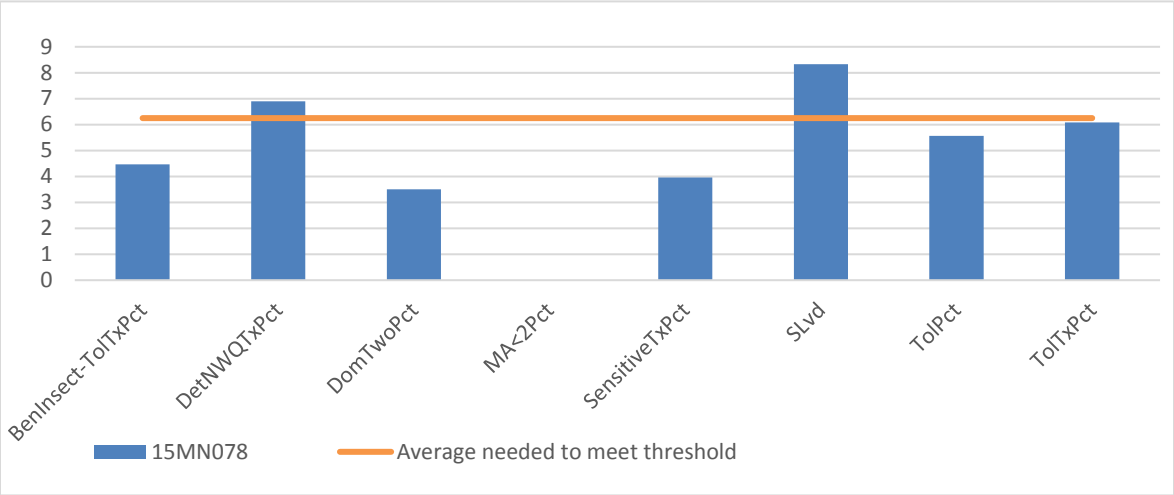
Figure 91. Impairments in the Tributary to West Branch Lac qui Parle River HUC (turquoise represents a fish impairment and purple represents a macroinvertebrate impairment)



Biological communities

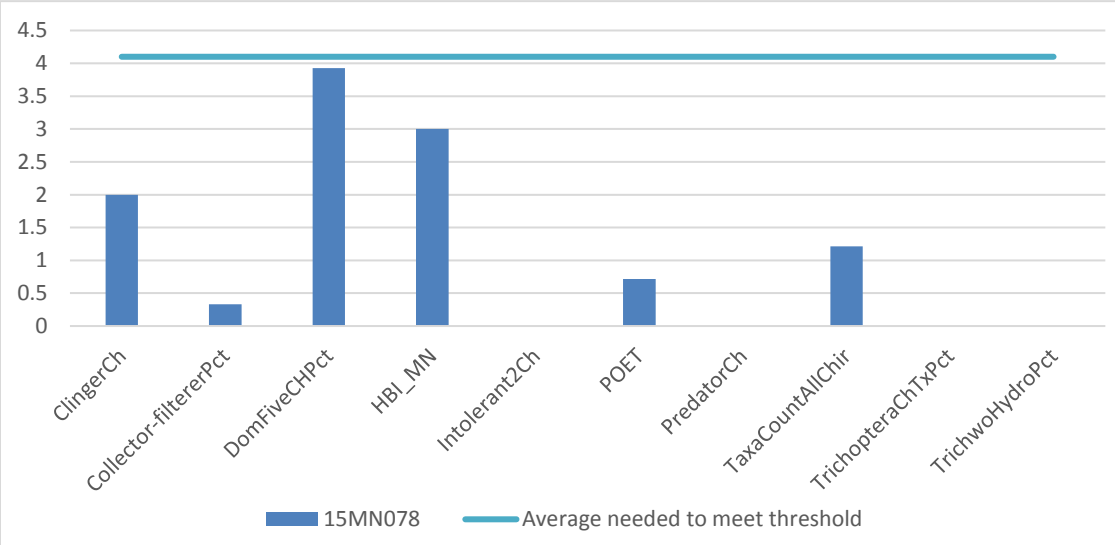
The one station (15MN078) on the unnamed creek was in fish class 2 (Figure 92). The benthic insectivore, dominant two percent, sensitive, tolerant, and species that mature at two years or less were all below the average needed to meet the class threshold. The metric for species that mature at two years or less had a score of zero.

Figure 92. Fish metric scores at sites in general use fish class 2



Station 15MN078 on the unnamed creek was in the general macroinvertebrate class 7. All metric scores were below the average needed to meet the class threshold (Figure 93). Station 15MN078 was comprised of over 87% of tolerant taxa.

Figure 93. Macroinvertebrate metric scores at sites in general use macroinvertebrate class 7



Candidate Cause: Dissolved oxygen

The DO dataset on the Unnamed Creek had values ranging from 0.27 to 7.96 mg/L. Of the 27 recent values collected on this reach, 78% of the values were below 5 mg/L (Table 170). The biological station is downstream of a large wetland complex, and the site itself is a low gradient system (Figure 94).

Table 170. DO data in the Tributary to West Branch Lac qui Parle River HUC

Stream Reach	# DO values	Range of DO values	# of values below 5 mg/L
Unnamed Creek (-580)	27	0.27-7.96	21

Figure 94. Low gradient system at site 15MN078 (8/12/17)

Additionally, the HSPF model calculated daily minimum DO values from 1996-2012. Over the years, the low, high, and average minimum values were all calculated (Table 171). The minimum value was 0.05 mg/L with 1.48% values below the water quality standard of 5 mg/L).

Table 171. Modeled DO data in the Tributary to West Branch Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low daily minimum value (mg/L)	High daily minimum value (mg/L)	Daily minimum average value (mg/L)	Readings below 5 mg/L standard (%)
Unnamed Creek	**-580**	6940	0.05	14.07	9.59	1.48

Zero fish species that are specifically intolerant to DO were located at the station, while 78% of the population was comprised of DO tolerant individuals. The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. Station 15MN078 had zero fish that take 3 years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance (Table 172). Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. The percentage of serial spawners was 5.41%, below the class average of sites that meet the threshold. The fish taxa count was well below the class average. Low DO is a stressor to the fish in the stream. It is unknown to what extent this is natural flushing of the wetlands, and what might be affected by human influence.

Table 172. DO related fish metrics in the Tributary to West Branch Lac qui Parle River HUC

Station	WID	DO Related Fish Metrics: MA>3 years Percentage	DO Related Fish Metrics: Serial Spawning Fish Pct	DO Related Fish Metrics: Fish Taxa Count
15MN078	**-580**	0.00	5.41	7
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**12.36**	**28.72**	**20.38**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed (Table 173). Zero intolerant macroinvertebrate taxa were collected, and the DO tolerant percentages was 47%. The DO tolerant percentage was above the class average of sites meeting the threshold. Based on the preponderance of evidence, DO is also a stressor to the macroinvertebrate community in Unnamed Creek (-580).

Table 173. DO related macroinvertebrates metrics in the Tributary to West Branch Lac qui Parle River HUC

Station	WID	DO Related Macroinvertebrate Metrics: Percentage DO Tolerant Macroinvertebrates	DO Related Macroinvertebrate Metrics: HBI_MN	DO Related Macroinvertebrate Metrics: Intolerant DO Macroinvertebrate Taxa	DO Related Macroinvertebrate Metrics: DO Tolerant Index Score
15MN078	-580	47.02	7.95	0	4.89
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**12.98**	**7.55**	**4.46**	**6.91**
Expected response to DO stress		↑	↑	↓	↑

Candidate Cause: Eutrophication

The phosphorus dataset on the Unnamed Creek had values ranging from 0.054 to 1.12 mg/L (Table 174). Of the 19 recent values collected on this reach, 68% of the values were above 0.150 mg/L, the southern standard. Macrophytes and duckweed were noted during sampling (Figure 95). Chlorophyll-a, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus; however, none of that data was available on this reach. No elevated DO values were collected that were indicative of eutrophication and diurnal fluctuations.

Table 174. Total Phosphorus data in the Tributary to West Branch Lac qui Parle River HUC

Stream Reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Unnamed Creek (-580)	19	0.054-1.12	13

Figure 95. Duckweed and emergent macrophytes at station 15MN078 (8/14/17)

Additionally, the HSPF model calculated daily TP concentrations from 1996-2012. The values ranged from 0.02-2.09 mg/L with a mean of 0.26 mg/L (Table 175).

Table 175. Modeled Phosphorus data in the Tributary to West Branch Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above 0.15 mg/L TP standard (%)
Unnamed Creek	**-580**	6940	0.02	2.09	0.26	73.53

Sensitive individual fish comprised 27% of the fish population, above the class average of sites meeting the threshold. Darter percentages were also above the class average (Table 176). The percentage of tolerant fish individuals was above average however. Along with tolerant species, a positive relationship exists between eutrophication and omnivorous fish. No omnivorous fish were collected. While there were some elevated phosphorus values, the preponderance of metric response indicate eutrophication is inconclusive as a stressor to the fish community.

Table 176. Eutrophication related fish metrics in the Tributary to West Branch Lac qui Parle River HUC

Station	WID	Eutrophication related Fish Metrics			
		Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
15MN078	**-580**	27.03	27.03	54.05	0.00
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**18.65**	**11.68**	**44.85**	**16.53**
Expected response to increased TP stress		↓	↓	↑	↑

Station 15MN078 had just less than half the macroinvertebrate community dominated by two species (Table 177). The EPT percentages were below the class average of sites meeting the class threshold. Macroinvertebrate taxa were also below average. While the macroinvertebrate community is experiencing stress, it is inconclusive if eutrophication is the cause of the lowered taxa and EPT individuals.

Table 177. Eutrophication related macroinvertebrate metrics in the Tributary to West Branch Lac qui Parle River HUC

Station	WID	Eutrophication Related Macroinvertebrate Metrics		
		Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
15MN078	-580	17	25.71	48.28
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
Expected response to TP stress		↓	↓	↑

Candidate Cause: Nitrates

The nitrate dataset on the Unnamed Creek had values ranging from 0.030 to 1.23 mg/L (Table 178). Additionally, the HSPF model calculated daily nitrate concentrations from 1996-2012. These values ranged from 0-7.53 mg/L with a mean of 0.52 mg/L (Table 179).

Table 178. Nitrate data in the Tributary to West Branch Lac qui Parle River HUC

Stream Reach	# nitrate values	Range of values (mg/L)
Unnamed Creek (-580)	19	0.030-1.23

Table 179. Modeled nitrate data in the Tributary to West Branch Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)
Unnamed Creek	**-580**	6940	0	7.53	0.52

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration.

No nitrate intolerant macroinvertebrate taxa were found at site 15MN078. Nitrate tolerant individuals comprised 56% of the community (Table 180). Increasing nitrate concentrations have a negative relationship with non-hydropsychid Trichoptera (caddisfly) individual percentages. Non-hydropsychid Trichoptera are all caddisflies that do not spin nets. While there is some evidence of nitrate stress in the metric values, the lack of elevated nitrate values makes nitrate as a stressor inconclusive as this time. Further nitrate samples would be useful.

Table 180. Nitrate related macroinvertebrate metrics in the Tributary to West Branch Lac qui Parle River HUC

		Nitrate related Macroinvertebrate Metrics			
Station	WID	TrichopteraChTxPct	% Tolerant Taxa	% Intolerant Taxa	Nitrogen TIV
15MN078	**-580**	0.00	56.43	0.00	3.82
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate Cause: Sediment

A dataset of recent TSS data is available on the unnamed creek. Samples ranged in value from 6.4-76 mg/L, with one value above the southern standard of 65 mg/L (Table 181). Additionally, secchi tube measurements ranged from 15-100 cm. Of these measurements, zero were below the 10 cm standard for transparency.

Table 181. TSS data in the Tributary to West Branch Lac qui Parle River HUC

Stream Reach	# TSS values	Range of TSS values	# of values above 65 mg/L
Unnamed Creek (-580)	19	1-29	0

Additionally, the HSPF model calculated daily suspended sediment concentrations from 1996-2012. These values ranged from 1.88-1786 mg/L with a mean of 12.80 mg/L (Table 182).

Table 182. Modeled TSS data in the Tributary to West Branch Lac qui Parle River HUC

Reach Name	WID	Number of Readings	Low Concentration (mg/L)	High Concentration (mg/L)	Average Concentration (mg/L)	Readings above standard (%)
Unnamed Creek	**-580**	6940	1.88	1,786	12.80	1.18

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. There were zero intolerant fish while TSS tolerant individuals comprised less than 1% of the fish community. Herbivore species of fish decrease as TSS values increase. Herbivore species were below average of sites meeting the class threshold (Table 183). Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. Perciform percentages were well above average at site 15MN078. Intolerant and Centrarchid species were both absent. While there is some evidence of suspended sediment stress in the metric values, the lowered metrics could be due to other stressors. Based on the lack of elevated values and the lack of TSS tolerant fish, TSS is not a stressor to the fish community.

Table 183. TSS related fish metrics in the Tributary to West Branch Lac qui Parle River HUC

		TSS related Fish Metrics						
Station	WID	BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct	TSS Index Score (RA)
15MN078	**-580**	0.00	0.00	1.35	27.03	0.00	0.00	14.46
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**37.38**	**4.89**	**9.61**	**18.66**	**4.97**	**11.68**	**37.38**
Expected response to TSS stress		↓	↓	↓	↓	↓	↓	↑

Zero TSS specific intolerant taxa were collected at site 15MN078. Tolerant macroinvertebrate individuals comprised 30.41% of the community (Table 184). While some metrics indicated TSS stress, based on the low TSS values and the preponderance of metrics, indicates TSS is not a stressor to the macroinvertebrate community.

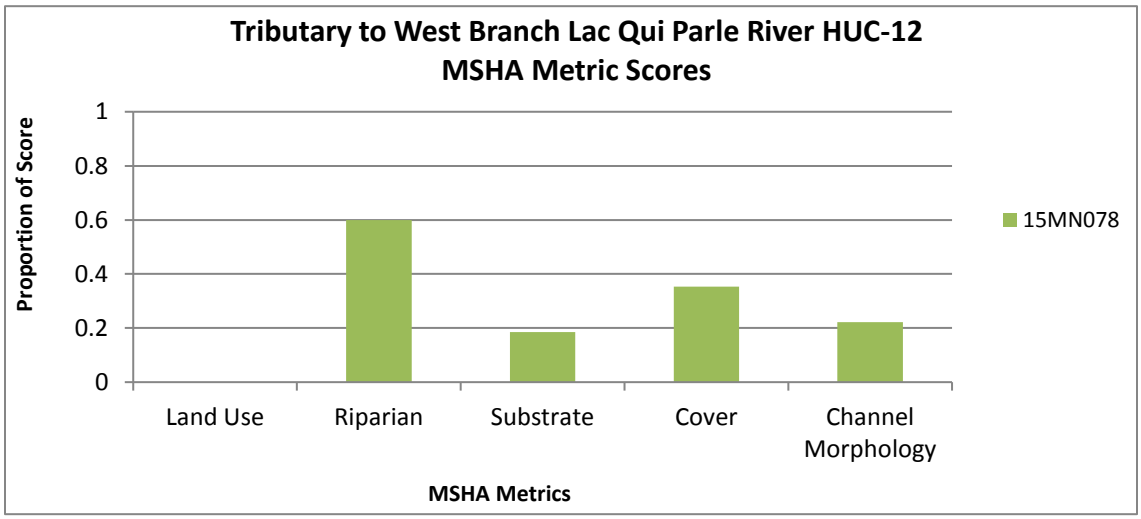
Table 184. TSS related fish metrics in the Tributary to West Branch Lac qui Parle River HUC

Station	WID	TSS related Macroinvertebrate Metrics: TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Longlivd Pct
15MN078	**-580**	14.56	0	6	30.41	1.57	0.00	0.63
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**13.2**	**48.28**	**19.13**	**0.22**	**7.99**
Expected response to stress		↑	↓	↑	↑	↓	↓	↓

Candidate Cause: Habitat

Habitat conditions were shown to be poor according to the MSHA score at site 15MN078 (28) (Figure 96). Station 15MN078 had moderate embeddedness of fine sediment, with silt being the only substrate found. Depth variability and channel development were both lacking and no riffles were present.

Figure 96. MSHA scores in the Tributary to West Branch Lac qui Parle River HUC



Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were lower than average (Table 185). Benthic insectivore and darter, sculpin, and sucker individual percentages were both above average. Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. Riffle dwelling species were absent from the site. The percentage of tolerant species was well below average. Based on the poor MSHA score and the preponderance of evidence, habitat is a stressor to the reach (-580).

Table 185. Habitat related fish metrics in the Tributary to West Branch Lac qui Parle River HUC

Station	WID	Habitat Related Fish Metrics							
		BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RiffflePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
15MN078	**-580**	27.03	13.51	27.03	0.00	16.22	54.05	2.70	27.03
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were below average (Table 186). Burrowers and legless individuals are a signal of high levels of sedimentation. Burrowers were higher than average, and the legless percentage was high above average. EPT percentages were below the class average threshold. Based on the preponderance of evidence, habitat is a stressor to the macroinvertebrate community on reach -580.

Table 186. Habitat related macroinvertebrate metrics in the Tributary to West Branch Lac qui Parle River HUC

Station	WID	Habitat related Macroinvertebrate Metrics					
		BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct	SprawlerPct
15MN078	**-580**	26.65	36.05	6.27	25.71	63.64	29.47
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**	**7.51**
Expected response to Habitat stress		↑	↓	↓	↓	↑	↓

Candidate Cause: Altered hydrology

Site 15MN078 is a natural channel, but the entire upstream watershed has been altered. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat.

Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. The site had a population of generalist fish of 16.22%. The numbers of nest guarder species are also positively correlated with increased low flows. The nest guarder species had a population of 13.51%. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The percentage of long-lived macroinvertebrates was less than 1%. Variable flows seem to be having some impact on the biological communities, and the upstream altered hydrology is a contributing stressor to habitat.

Summary and recommendations

The tributary to West Branch Lac qui Parle River HUC contains one biologically impaired reach. DO, lack of habitat and altered hydrology were stressors in this watershed (Table 187). More data is needed to better determine the impact of nutrients as potential stressors.

The predominant land uses in this subwatershed was row crop agriculture. The land use is a contributor to the stressors on this reach. Utilizing a variety of nutrient reducing BMPs including: cover crops and riparian buffers, etc. would be helpful to reducing stress to the biological communities.

Table 187. Stressors on streams in the Tributary to West Branch Lac qui Parle River HUC

	Stressors:					
Stream Name	**Dissolved Oxygen**	**Eutrophication**	**Nitrate**	**Suspended Sediment**	**Habitat**	**Altered hydrology**
Unnamed Creek (-580)	●	o	o	---	●	●

● = stressor; o = inconclusive stressor; --- = not an identified stressor

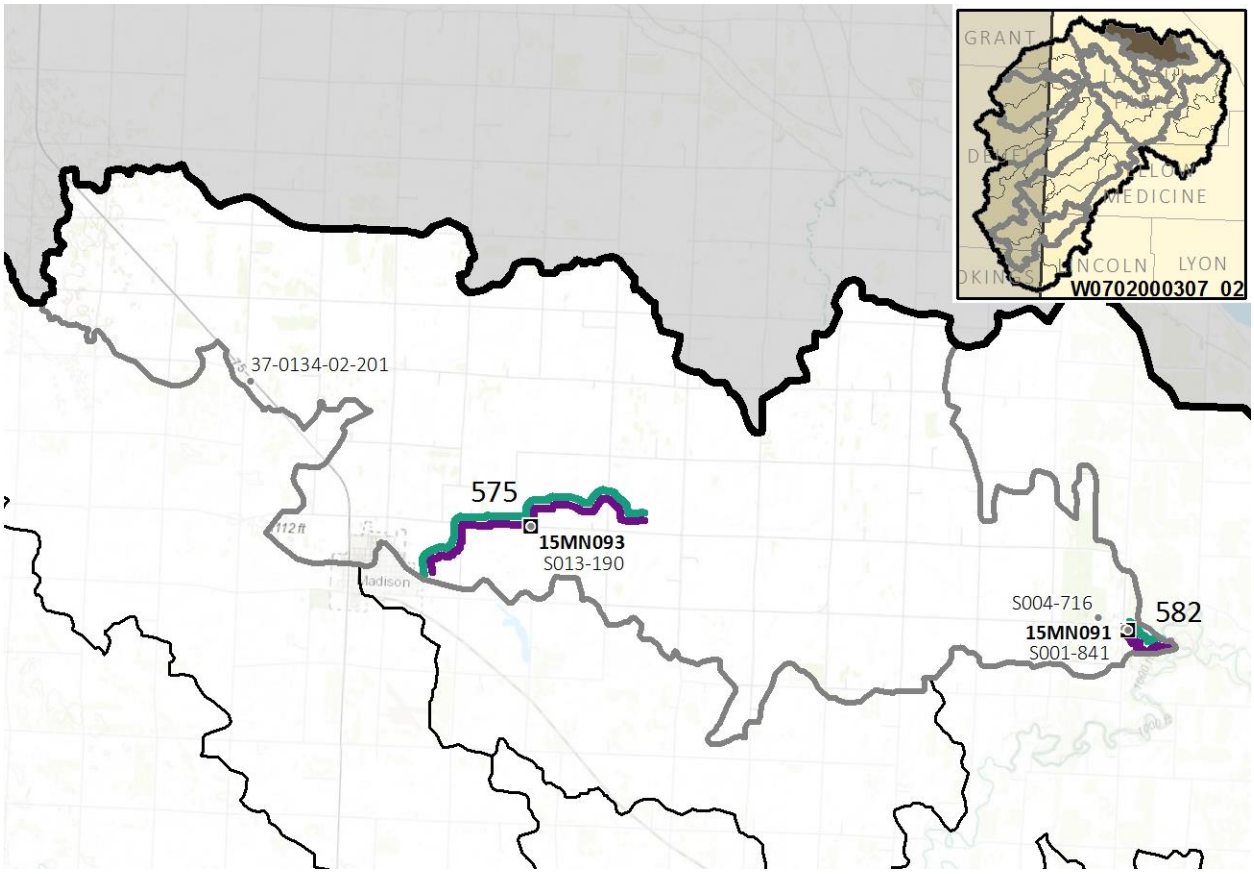
County Ditch No 4 12-digit HUC

This aggregated HUC contains two unnamed ditches. The streams in this section have the following impairments (Figure 97):

Unnamed ditch (-575), is impaired for fish and macroinvertebrates (15MN093, S013-190)

Unnamed ditch (County Ditch 4) (-582), impaired for fish and macroinvertebrates (15MN091, S001-841)

Figure 97. Impairments in the County Ditch No 4 HUC (turquoise represents a fish impairment and purple represents a macroinvertebrate impairment)



Biological communities

Station 15MN093 on the unnamed ditch was in modified fish class 3 (Figure 98). All metrics had a score of zero except for the serial spawning (SSpn) percent. Station 15MN091 on County Ditch 4 was in general fish class 2 (Figure 99). All metrics on County Ditch 4 were below the average needed to meet the threshold except for the tolerant percent metric.

Figure 98. Fish metric scores at sites in modified use fish class 3

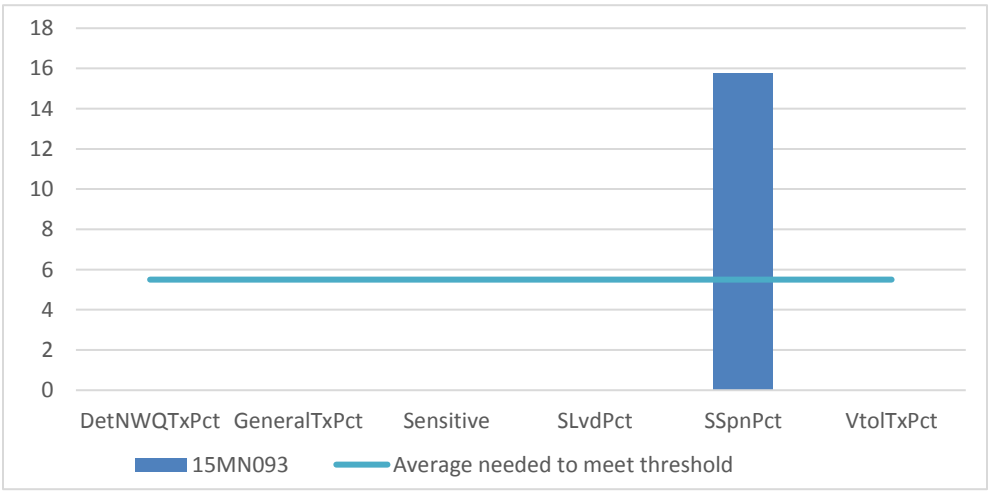
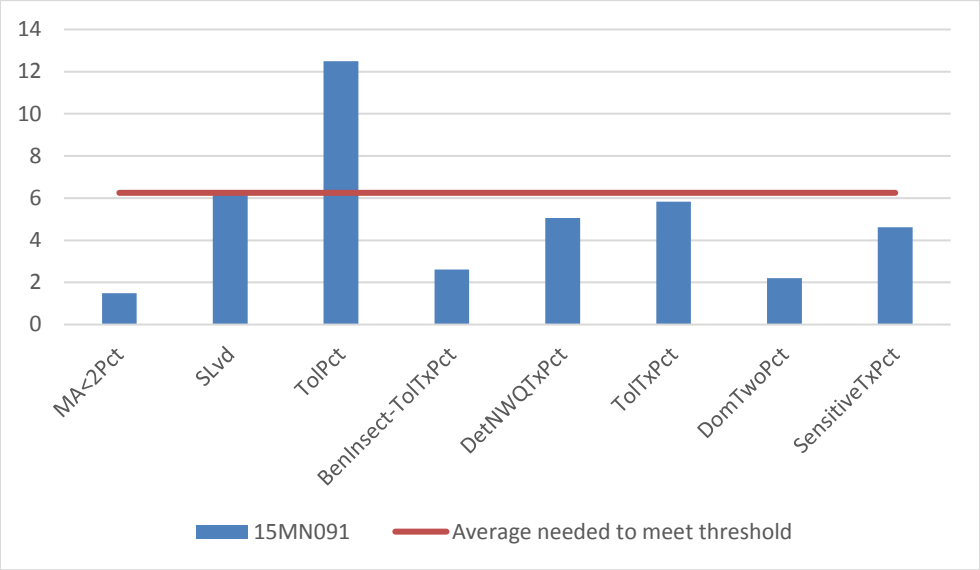
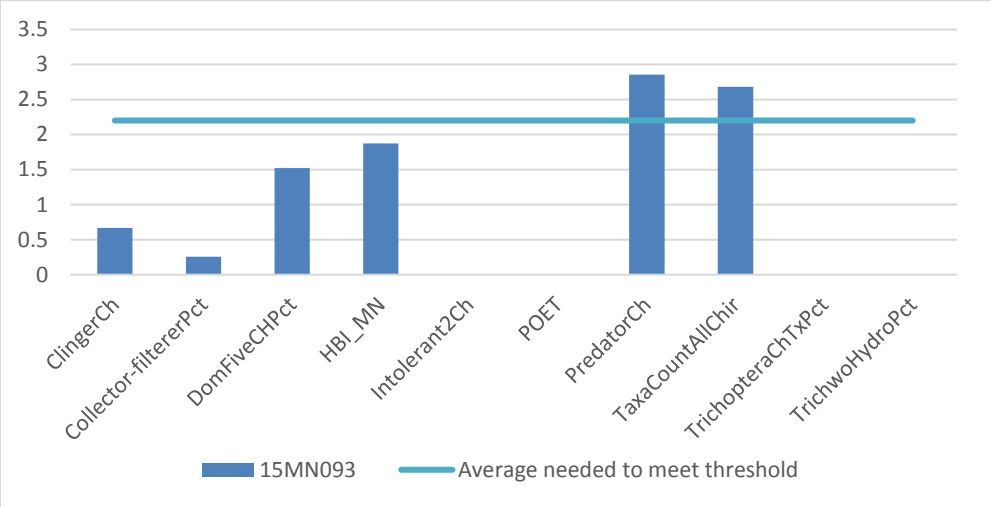


Figure 99. Fish metric scores at sites in general use fish class 2



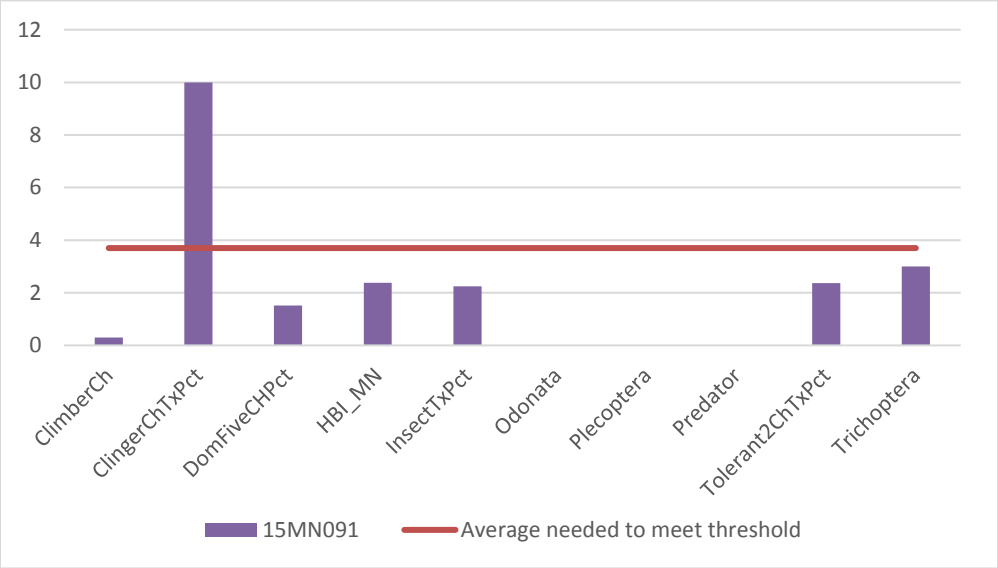
Station 15MN093 on the unnamed ditch was in the modified macroinvertebrate class 7. All metric scores were below the average needed to meet the class threshold except for the predator taxa and the taxa count (Figure 100). Four of the ten metrics had a score of zero.

Figure 100. Macroinvertebrate metric scores at sites in modified use macroinvertebrate class 7



Station 15MN091 on the unnamed ditch was in the general macroinvertebrate class 5. All metric scores were below the average needed to meet the class threshold except for the clinger taxa percent. Three of the 10 metrics had a score of zero.

Figure 101. Macroinvertebrate metric scores at sites in general use macroinvertebrate class 5



Candidate Cause: Dissolved oxygen

There was a small dataset on the two unnamed ditches in this HUC. DO values ranged from 3.88 mg/L to 15.5 mg/L (Table 188). The minimum and maximum values were indications of possible eutrophication on both ditches. Continuous data was collected; the recorded minimum was 2.93 mg/L at station 15MN093 and the recorded minimum was 5.75 mg/L at station 15MN091.

Table 188. DO data in the County Ditch No 4 HUC

Stream Reach	# DO values	Range of DO values	# of values below 5 mg/L
Unnamed ditch (-575)	6	3.88-15.55 mg/L	1
County ditch 4 (-582)	7	4.93-18.49	1

Zero fish species that are specifically intolerant to DO were located at either station. Station 15MN093 was comprised of 100% DO tolerant individuals while station 15MN091 had less than 1% DO tolerant individuals present in the population (Table 189). The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. Both stations had zero fish that take 3 years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. The percentage of serial spawners were not elevated above the class averages of sites that meet the threshold. The fish taxa count were below the class average. Low DO is a stressor to the fish on reach -575, and is inconclusive on reach -582.

Table 189. DO related fish metrics in the County Ditch No 4 HUC

Station	WID	DO Related Fish Metrics: MA>3 years Percentage	DO Related Fish Metrics: Serial Spawning Fish Pct	DO Related Fish Metrics: Fish Taxa Count
15MN093	**-575**	0.00	4.26	3
Statewide average for Class 3 Southern Streams stations meeting the FIBI Modified Use Threshold (33.0)		**1.43**	**10.56**	**10**
15MN091	**-582**	0.00	24.50	12
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**12.36**	**28.72**	**20.38**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed (Table 190). Zero intolerant macroinvertebrate taxa were collected, and the DO tolerant percentages was 66.45% at site 15MN093. Four intolerant macroinvertebrate taxa were collected, and the DO tolerant percentages was 37.5% at site 15MN091. The DO tolerant percentage was above the class average of sites meeting the threshold at both sites. Based on the preponderance of evidence, DO is also a stressor to the macroinvertebrate community on the unnamed ditch on reach (-575), and is inconclusive on County Ditch 4 (-582).

Table 190. DO related macroinvertebrates metrics in the County Ditch No 4 HUC

Station	WID	DO Related Macroinvertebrate Metrics			
		Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
15MN093	**-575**	66.45	8.30	0	5.82
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**31.37**	**8.00**	**1.78**	**6.19**
15MN091	**-582**	37.5	7.54	4	6.52
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**8.62**	**7.04**	**9**	**7.09**
Expected response to DO stress		↑	↑	↓	↑

Candidate Cause: Eutrophication

Limited phosphorus data was available on both ditches. The phosphorus dataset on the unnamed ditch had values ranging from 0.053 to 0.166 mg/L, and the data on County Ditch 4 ranged from 0.039-0.28 mg/L (Table 191). Thick algae was present at station 15MN093 and 15MN091 (Figure 102). Chlorophyll-a, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus. One chlorophyll-a value was collected on reach -575, with a value of 4.87 ug/L, and one chlorophyll-a value on reach -582 with a value of 8.72 ug/L. Both values were below the southern standard. Continuous data at site 15MN091 showed diurnal fluctuations below the southern standard of 5 mg/L. Continuous data at site 15MN093 showed multiple diurnal fluctuations over 14 mg/L, more than two times the southern standard of 5 mg/L.

Table 191. Total Phosphorus data in the Tributary to West Branch Lac qui Parle River HUC

Stream Reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Unnamed ditch (-575)	3	0.053-0.166	1
County Ditch 4 (-582)	3	0.039-0.28	2

Figure 102. Thick algae at stations 15MN093 (left on 7/7/17) and 15MN091 (right on 6/8/15)

Sensitive individual fish were absent from both fish populations. Darter percentages were below the class averages at both sites (Table 192). Tolerant fish individuals comprised 100% of the fish population at site 15MN093, while comprising 24.16% of the population at site 15MN091. Along with tolerant species, a positive relationship exists between eutrophication and omnivorous fish. Omnivorous fish were below the class average at both sites. Based on the some elevated phosphorus values, algae, DO fluctuations, and the preponderance of metric response, eutrophication is a stressor to the fish community on reach -575 and inconclusive on -582.

Table 192. Eutrophication related fish metrics in the County Ditch No 4 HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
15MN093	**-575**	0.00	0.00	100	4.26
Statewide average for Class 3 Southern Streams stations meeting the FIBI Modified Use Threshold (33.0)		**6.02**	**10.56**	**76.69**	**19.80**
15MN091		0.00	4.36	24.16	2.68
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)	**-582**	**18.65**	**11.68**	**44.85**	**16.53**
Expected response to increased TP stress		↓	↓	↑	↑

Both station 15MN091 and 15MN093 had just less than half the macroinvertebrate community dominated by two species (Table 193). The EPT percentages were below the class average of sites meeting the class threshold. Macroinvertebrate taxa were also below average. While the

macroinvertebrate community is experiencing stress, it is inconclusive if eutrophication is the cause of the lowered taxa and EPT individuals.

Table 193. Eutrophication related macroinvertebrate metrics in the County Ditch No 4 HUC

		Eutrophication Related Macroinvertebrate Metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert Taxa Pct
15MN093	-575	17	15.48	49.35
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**34**	**20.58**	
15MN091	-582	23	32.37	47.44
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**42**	**43.90**	
Expected response to TP stress		↑	↑	↓

Candidate Cause: Nitrates

Limited nitrate data was available on both ditches. The nitrate dataset on the unnamed ditch had values ranging from 6.8 to 14 mg/L, and the data on County Ditch 4 ranged from 0.84-12 mg/L (Table 194). Both ditches had elevated values.

Table 194. Nitrate data in the County Ditch No 4 HUC

Stream Reach	# nitrate values	Range of values (mg/L)
Unnamed ditch (-575)	3	6.8-14
County Ditch 4 (-582)	3	0.84-12

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration.

No nitrate intolerant macroinvertebrate taxa were found at site 15MN093, while less than 1% were found at site 15MN091 (Table 195). Nitrate tolerant individuals comprised 56.8% of the community at site 15MN093 and 44.9% at site 15MN091. Increasing nitrate concentrations have a negative relationship with non-hydropsychid Trichoptera (caddisfly) individual percentages. Non-hydropsychid Trichoptera are all caddisflies that do not spin nets. No caddisflies were found at site 15MN093, while the non-hydropsychid Trichoptera percentage was above class average at site 15MN091. While there is some evidence of stress in the nitrate values especially on reach -575, more nitrate data would be helpful to determine the nitrate regime. Nitrate is inconclusive as a stressor.

Table 195. Nitrate related macroinvertebrate metrics in the County Ditch No 4 HUC

		Nitrate related Macroinvertebrate Metrics			
Station	WID	TrichopteraChTxPct	% Tolerant Taxa	% Intolerant Taxa	Nitrogen TIV
15MN093	**-575**	0.00	56.77	0.00	4.28
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**2.16**	**59.41**	**1.95**	**3.32**
15MN091	**-582**	21.74	44.87	0.32	3.15
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**5.94**	**47.60**	**2.92**	**2.95**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate Cause: Sediment

Limited nitrate data was available on both ditches. The suspended sediment dataset on the unnamed ditch had values ranging from 1 to 4.8 mg/L, and the data on County Ditch 4 ranged from 5.6-52 mg/L (Table 196). Additionally, secchi tube measurements ranged from 15-100 cm. Of the small number of measurements, all values were above 60 cm, well above the 10 cm standard for transparency.

Table 196. TSS data in the County Ditch No 4 HUC

Stream Reach	# TSS values	Range of TSS values	# of values above 65 mg/L
Unnamed ditch (-575)	2	1-4.8	0
County Ditch 4 (-582)	3	5.6-52	0

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. There were zero intolerant fish at either station, while TSS tolerant individuals comprised less than 1% of the fish community at both sites. Herbivore species of fish decrease as TSS values increase. Herbivore species were below the average of sites meeting the class threshold at site 15MN091, but well above at site 15MN093 (Table 197). Perciforms species (smallmouth bass, walleye, etc.) have been shown to decrease as TSS increases. Perciform percentages were below class averages at both sites. Intolerant and Centrarchid species were also below class average at both sites. While there is some evidence of suspended sediment stress in the metric values, the lowered metrics could be due to other stressors. Based on the lack of elevated values and the lack of TSS tolerant fish, TSS is inconclusive as a stressor to the fish community on both ditches.

Table 197. TSS related fish metrics in the County Ditch No 4 HUC

Station	WID	TSS related Fish Metrics: BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct	TSS Index Score (RA)
15MN093	**-575**	0.00	0.00	90.43	0.00	0.00	0.00	26.14
Statewide average for Class 3 Southern Streams stations that are meeting the FIBI Modified Use Threshold (33.0)		**31.38**	**1.00**	**10.83**	**12.43**	**0.52**	**4.91**	**31.38**
15MN091	**-582**	13.09	1.68	6.04	6.04	0.00	1.68	
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**37.38**	**4.89**	**9.61**	**18.66**	**4.97**	**11.68**	**37.38**
Expected response to TSS stress		↓	↓	↓	↓	↓	↓	↑

Zero TSS specific intolerant taxa were collected at site 15MN093 and one intolerant taxa was collected at site 15MN091. Tolerant macroinvertebrate individuals comprised 24.84% of the community site 15MN093 and 38.14% at site 15MN091 (Table 198). While some metrics indicated TSS stress, based on the low TSS values and the preponderance of metrics, TSS is not a stressor to the macroinvertebrate community.

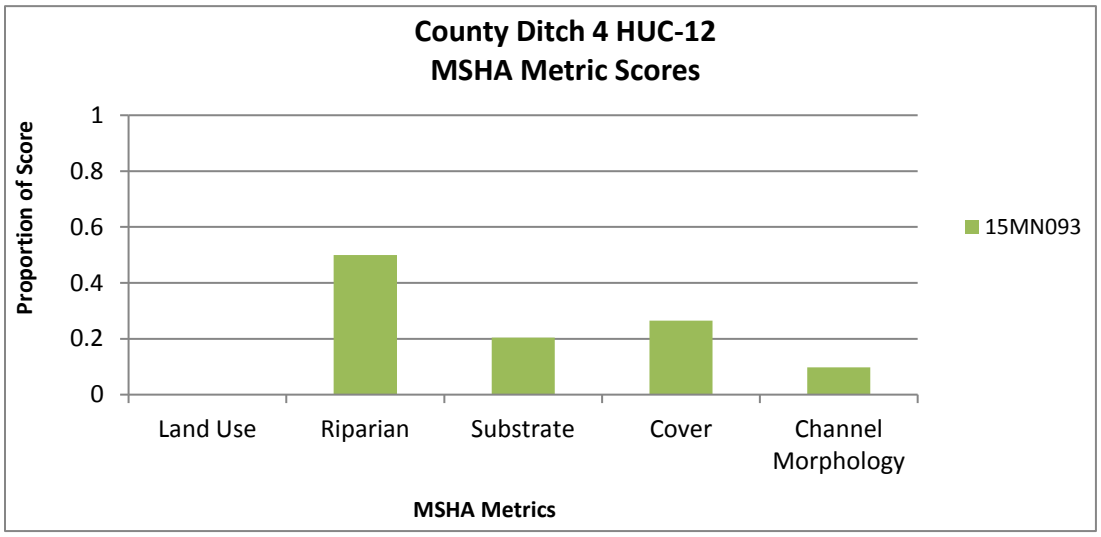
Table 198. TSS related macroinvertebrate metrics in the County Ditch No 4 HUC

Station	WID	TSS related Macroinvertebrate Metrics: TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct
15MN093	**-575**	16.88	0	7	24.84	1.29	0.00
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI Modified Use Threshold (22.0)		**16.25**	**0.6**	**11**	**35.60**	**9.91**	**0.02**
15MN091	**-582**	16.39	1	8	38.14	20.51	0.00
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (37.0)		**15.87**	**3**	**12**	**35.23**	**4.56**	**0.54**
Expected response to TSS stress		↑	↓	↑	↑	↓	↓

Candidate Cause: Habitat

Habitat conditions were shown to be poor according to the MSHA score at site 15MN093 (28), and fair at site 15MN091 (66) (Figure 103). Station 15MN091 had some eroding banks and over widened riffles. Station 15MN093 lacked shade, cover for fish, depth variability and channel development and had moderate embeddedness of coarse substrates with fine sediments.

Figure 103. MSHA scores in the County Ditch No 4 HUC



Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were lower than average at site 15MN093 (Table 199). Benthic insectivore and darter, sculpin, and sucker individual percentages were below average at both sites. Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. Riffle dwelling species were absent from site 15MN091. Tolerant species comprised 100% of the fish community as site 15MN093. Based on the poor MSHA score and the preponderance of evidence, habitat is a stressor to the unnamed ditch (-575) an inconclusive on County Ditch 4 (-582).

Table 199. Habitat related fish metrics in the County Ditch No 4 HUC

		Habitat Related Fish Metrics							
Station	**WID**	BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RiffePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
15MN093	**-575**	0.00	0.00	0.00	0.00	0.00	0.00	100	4.26
Statewide average for Class 3 Southern Streams stations meeting the FIBI Modified Use Threshold (33.0)		**10.91**	**30.09**	**10.59**	**22.62**	**1.97**	**57.98**	**76.69**	**32.54**
15MN091	**-582**	4.36	55.03	4.36	30.20	1.68	90.60	24.16	13.76
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were below average at both sites (Table 200). Burrowers and legless individuals are a signal of high levels of sedimentation. Burrowers and legless percentage were below average at both sites. EPT percentages were below the class average threshold at both sites. Based on the preponderance of evidence, habitat is a stressor to the macroinvertebrate community on reach -575 and -582.

Table 200. Habitat related macroinvertebrate metrics in the County Ditch No 4 HUC

Station	WID	Habitat related Macroinvertebrate Metrics				
		BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
15MN093	**-575**	3.23	37.74	3.23	15.48	45.16
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI Modified Use Threshold (22.0)		**14.12**	**27.47**	**23.07**	**20.58**	**55.79**
15MN091		0.32	16.67	35.26	32.37	26.60
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (37.0)	**-582**	**7.54**	**14.71**	**49.54**	**42.46**	**36.03**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate Cause: Altered hydrology

Site 15MN093 is on a completely channelized reach (-575), and while site 15MN091 is on a natural channel, but the entire upstream watershed has been altered. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat.

Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. Site 15MN091 had a population of generalist fish of 62.42% and site 15MN093 had a population of 4.26%. The numbers of nest guarder species are also positively correlated with increased low flows. The nest guarder species had a population of 7.38% at site 15MN091 and 9.57% at site 15MN093. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The percentage of long-lived macroinvertebrates was less than 1% at both sites. Variable flows seem to be having some impact on the biological communities, and the altered hydrology is a contributing stressor to habitat.

Summary and recommendations

The County Ditch No 4 HUC contains two biologically impaired reach. DO, eutrophication, lack of habitat and altered hydrology were stressors in this watershed (Table 201). More data is needed to better determine the impact of nutrients and suspended sediment as potential stressors.

The predominant land uses in this subwatershed was row crop agriculture. The land use is a contributor to the stressors on this reach. Utilizing a variety of nutrient reducing Best Management Practices (BMPs) including: cover crops, riparian buffers, and nutrient management etc. would be helpful to reducing stress to the biological communities.

Table 201. Stressors on streams in the Tributary to County Ditch No 4 HUC

Stream Name	Stressors: Dissolved Oxygen	Eutrophication	Nitrate	Suspended Sediment	Habitat	Altered hydrology
Unnamed ditch (-575)	●	●	o	o	●	●
Unnamed ditch (County Ditch 4) (-582)	o	o	o	o	●	●

● = stressor; o = inconclusive stressor; --- = not an identified stressor

Conclusions and recommendations

Summary of probable stressors

Table 202. Summary of probable stressors in the Lac qui Parle River Watershed.

Stream Name	AUID	Biological Impairment	Stressors								
			Low DO	Eutrophication	Nitrates	TSS	Lack of Habitat	Altered Hydrology	Connectivity	Temperature	Chloride
Lac qui Parle River	07020003-501	Macroinvertebrates	o	●	o	●	●	---	---	---	o
Lac qui Parle River	07020003-505	Fish, Macroinvertebrates	o	●	o	●	●	●	●	---	---
Lazarus Creek	07020003-508	Fish, Macroinvertebrates	o	●	o	●	●	●	---	---	---
Lazarus Creek	07020003-509	Fish, Macroinvertebrates	o	o	o	●	●	●	---	---	---
West Branch Lac qui Parle River	07020003-513	Macroinvertebrates	---	o	---	---	o	o	---	---	---
West Branch Lac qui Parle River	07020003-515	Fish	---	o	---	---	●	o	●	---	---
West Branch Lac qui Parle River	07020003-516	Fish, Macroinvertebrates	---	o	---	o	●	---	---	---	---
Lost Creek	07020003-517	Fish, Macroinvertebrates	●	●	o	---	●	---	---	---	o
West Branch Lac qui Parle River	07020003-519	Fish	---	o	---	o	●	---	---	---	---
Crow Timber Creek	07020003-520	Macroinvertebrates	o	●	o	---	●	---	---	---	o
Florida Creek	07020003-521	Fish, Macroinvertebrates	---	●	---	●	●	●	---	---	---
County Ditch 34	07020003-526	Macroinvertebrates	o	●	●	o	●	●	---	---	---
Unnamed Creek	07020003-530	Fish, Macroinvertebrates	---	●	---	●	o	---	---	---	---
Unnamed Creek	07020003-534	Fish	●	●	o	o	●	●	---	---	o

Canby Creek	07020003-557	Fish, Macroinvertebrates	---	o	o	o	o	●	●	●	---
Unnamed Creek	07020003-567	Macroinvertebrates	o	●	o	---	●	---	---	---	o
Unnamed Creek	07020003-569	Fish	●	●	o	●	●	o	●	---	---
Unnamed ditch	07020003-570	Macroinvertebrates	●	●	●	o	●	●	---	---	---
Unnamed ditch	07020003-571	Macroinvertebrates	●	●	●	o	●	●	---	---	---
Unnamed ditch	07020003-575	Fish, Macroinvertebrates	●	●	o	o	●	●	---	---	---
Tenmile Creek	07020003-577	Fish, Macroinvertebrates	●	●	●	o	●	●	---	---	---
Tenmile Creek	07020003-578	Fish, Macroinvertebrates	o	●	o	o	o	●	---	---	---
Unnamed Creek	07020003-580	Fish, Macroinvertebrates	●	o	o	---	●	●	---	---	---
Unnamed ditch (CD 4)	07020003-582	Fish, Macroinvertebrates	o	o	o	o	●	●	---	---	---
Cobb Creek	07020003-583	Macroinvertebrates	---	●	o	●	●	●	---	---	---
Canby Creek	07020003-586	Fish	o	o	o	o	●	●	●	---	---
Unnamed Creek	07020003-588	Fish, Macroinvertebrates	o	●	o	o	o	●	●	---	o

● = probable stress0;’or; o = inconclusive stressor; --- = not a stressor

Recommendations

The fish and macroinvertebrate communities are reflective of the effects of multiple stressors. Areas of concern throughout the watershed are streams affected by eutrophication and algae growth (Figure 104) and a lack of habitat conditions. Nutrient values are elevated. Nutrient loading can create an increase in phytoplankton (measured as sestonic chlorophyll); along with the contributing factors of temperature, light, and residence time (Heiskary et al., 2013). Phosphorus, chlorophyll-a, DO flux values are all above the proposed water quality standards in areas.

Field drainage directly into waterbodies should be targeted for riparian buffers (Figure 106). The highest phosphorus values were collected on the mainstem Lac qui Parle River and Tenmile Creek after rain events and snowmelt (six values above 1.15 mg/L). Intercepting and removing nutrient inputs as much as possible should be pursued throughout the entire watershed.

Figure 104. Thick algae growth fueled by excess nutrients (7/7/17)

Areas of severe erosion were present in the watershed and bedded sediment (Figure 105) is affecting the habitat availability in areas. The suspended sediment and bedded sediment are closely tied and need to be addressed together. The aquatic communities would benefit from a decrease in fine sediment; the multiple causes of bank erosion need to be addressed. Increased drainage creates flashy flow events; where high and low flows are amplified. During increased drainage and higher flows, water barrels through channels eroding banks as they flow downstream. Along with altered hydrology, lack of water storage, and no to poor quality vegetative buffers are drivers of bank erosion. These root causes of erosion are causing both suspended and bedded sediment. Current problems observed in the watershed include lack of sufficient buffers (Figure 106), allowing sediments to be carried right into streams along with associated phosphorus on sediments.

Figure 105. Bedded sediment covering coarse substrates (8/30/18)

Figure 106. Lack of riparian areas contributing erosion in the Lac qui Parle River Watershed (5/25/17) and (5/24/17)

Eutrophication, altered hydrology, and a lack of habitat are the main stressors to both communities and should be the primary focus of restoration efforts in the watershed. Fish migration problems arising from lack of connectivity is also an area to focus on. Terracing and grass waterways were observed in the watershed as an example of land use changes that can benefit water quality (Figure 107). The DNR recommends that "Water storage through wetland restorations is a primary goal when addressing hydrologic alterations" (DNR 2019). Important practices to implement include increasing water storage, proper culvert and bridge sizing, riparian buffers with deep roots, stabilizing banks, and restoring connectivity and natural stream channels.

Figure 107. An example of land use that is beneficial to waterways with terracing (5/25/17)

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Appendix

Table A1. Biological metrics included in the SID process

	Metric Description	Explanation	Expected Response to Stress
Fish			
BenInsect-Tol	Relative abundance that are non-tolerant benthic insectivore species (excludes tolerant species)	Benthic insectivores feed from benthic environments and are found with clean gravel substrates	*Decrease*
Darter	Relative abundance of darter species	Darters require riffle habitat and are considered sensitive to water quality degradation	*Decrease*
DarterSculpSuc	Relative abundance that are darter, sculpin & round bodied sucker species	Darter, sculpin, and round bodied suckers require shallow riffle habitats	*Decrease*
DetNWQTX	Relative abundance of taxa that are detritivores	Detritivores are bottom feeders of detritus (dead and decomposing organic matter)	*Decrease*
DomTwo	Combined relative abundance of two most abundant taxa	Taxa richness decreases with water quality degradation and become dominated by a few species	*Increase*
Exotic	Richness of exotic species	Exotic species are often tolerant of water quality degradation	*Increase*
General	Relative abundance that are generalist species	Generalist species are tolerant of water quality degradation	*Increase*
Hdw-Tol	Relative abundance that are headwater species (excludes tolerant species)	Headwater species are sensitive to changes in flow and habitat	*Decrease*
Herbv	Relative abundance that are herbivore species	Herbivorous species eat only plants	*Decrease*
Insect-Tol	Relative abundance that are insectivorous (excludes tolerant species)	Insectivore species are dependent on a stable invertebrate food base	*Decrease*
InsectCyp	Relative abundance that are insectivorous Cyprinids	Insectivore minnows are dependent on a stable invertebrate food base	*Decrease*
MA>3 years-Tol	Relative abundance of females of mature age >=3 excluding tolerant taxa	Species that have late maturity require stable conditions	*Decrease*
Minnows-TolPct	Relative abundance that are Cyprinidae (minnows) (excludes tolerants)	Many minnow species are sensitive to water quality degradation	*Decrease*
NestGuarding	Relative abundance of nest-guarding species	Species that do not require coarse substrate for nests	Increase
NumPerMeter-Tol	Number of individuals per meter of stream sampled (excludes individuals of tolerant species)	A healthy stream system has higher levels of non-tolerant fish present	Decrease

	Metric Description	Explanation	Expected Response to Stress
Omnivorous	Relative abundance that are omnivore species	Omnivorous species eat both plants and animals. They are tolerant of degradation	*Increase*
Perciform	Relative abundance of the order Perciformes	The order Perciformes includes sunfish, perch, and walleye. Sediment effects the growth of smallmouth bass	*Decrease*
Piscivore	Relative abundance that are piscivore species	The presence of piscivores may indicate a stable system that supports lower trophic level organisms such as benthic macroinvertebrates and fish. Proper substrate will also benefit piscivores	*Decrease*
Pioneer	Relative abundance that are pioneer species	Pioneer species are able to thrive in unstable environments and are the first to invade after disturbance	*Increase*
Riffle	Relative abundance that are riffle-dwelling species	Riffle dwelling species are important indicators of available riffle habitat	*Decrease*
Sensitive	Relative abundance that are sensitive species	Species that are sensitive to disturbance. Often the first species to disappear	*Decrease*
SLithop	Relative abundance that are simple lithophilic spawners	Simple lithophilic spawners require clean gravel or cobble substrates for reproductive success	*Decrease*
SSpnTx	Relative abundance that are serial spawning species	Species that attain reproductive maturity at a very young age. The number of fast maturing individuals increases with disturbance	*Increase*
Tol	Relative abundance that are tolerant species	Tolerant fish species are able to survive generally adverse stream conditions	*Increase*
VTolTx	Relative abundance that are very tolerant species	Species that survive the most disturbed conditions	*Increase*
Wetland-Tol	Relative abundance that are wetland species	Wetland species thrive in low gradient systems dominated by a wetland riparian zones	*Decrease*
Macroinvertebrates			
Burrower	Relative abundance of burrowers in subsample	Burrower species “burrow” in fine sediment indicating potential siltation in riffles	*Increase*
Climber	Relative abundance of climbers in subsample	Climber species use habitat such as overhanging vegetation or woody debris	*Decrease*
Clinger	Relative abundance of climbers in subsample	Clinger species attach to rock or woody debris. Clingers may decrease in stream reaches with homogeneous	*Decrease*

	Metric Description	Explanation	Expected Response to Stress
		substrate composition, velocity, and depth.	
Collector-Filterer	Relative abundance of collector-filterers in subsample	Collector-Filterer species filter organic material from the water	*Decrease*
Dominant2InvertTaxa	Relative abundance of dominant two taxa in subsample	Taxa richness decreases with water quality degradation and becomes dominated by a few species	*Increase*
DomFiveCH	Relative abundance of dominant five taxa in subsample (excluding all chironomids)	Taxa richness decreases with water quality degradation	*Increase*
EPT	Relative abundance of Ephemeroptera, Plecoptera & Trichoptera individuals in subsample	EPT are a sensitive group of macroinvertebrates commonly used to measure overall health	*Decrease*
HBI_MN	A measure of pollution based on tolerance values		*Increase*
Legless	Relative abundance of legless individuals in subsample	Legless macroinvertebrates are tolerant species like midges/worms, and snails	*Increase*
Odonata	Relative abundance of Odonata (dragonflies) individuals in subsample	Odonata are a good indicator of water quality	*Decrease*
Plectoptera	Relative abundance of Plecoptera (stoneflies) individuals in subsample	Presence of Plecoptera is a sign of good water quality which require high DO levels	*Decrease*
POET	Taxa richness of Plecoptera, Odonata, Ephemeroptera, & Trichoptera	Stoneflies, Dragonflies, Mayflies, and Caddisflies which are all sensitive to pollution	*Decrease*
Predator	Taxa richness of predators	Predators are an important part of a stream ecosystem that eat other animals	*Decrease*
Sprawler	Relative abundance of sprawler individuals in subsample	Sprawlers live on the surface of floating plants or fine sediments. Many are adapted to keep respiratory surfaces free of silt	*Increase or Decrease*
Swimmer	Relative abundance of swimmer individuals in subsample	Swimmers require low velocity water and their abundance or decline indicate change in water flow or pools	*Decrease*
TaxaCount	Total taxa richness of macroinvertebrates	A healthy stream system has a variety of macroinvertebrates present. The number increases with habitat availability and water quality	*Decrease*
TricopteraChTx	Relative percentage of taxa belonging to Trichoptera (caddisflies)	Presence of Tricoptera is a sign of good water quality	*Decrease*
TricopterawoHydro	Relative abundance of non-hydropsychid Trichoptera individuals in subsample	Tricoptera that do not spin nets and are most sensitive to pollution	*Decrease*