Le Sueur River Watershed
Biotic Stressor Identification

A study of local stressors limiting the biotic communities in the Le Sueur River Watershed.

Minnesota Pollution Control Agency

May 2014

Legislative charge

Minn. Statutes § 116.011 Annual Pollution Report

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HIST: 1995 c 247 art 1 s 36; 2001 c 187 s 3

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Acronyms, abbreviations and commonly used terms in this report

ARM – Agricultural Runoff Model
AUID – Assessment Unit Identification
BANCS – Bank Assessment for Non-point source Consequences of Sediment
BEHI – Bank Erosion Hazard Index
BOD – Biological Oxygen Demand
CADDIS – Causal Analysis/Diagnosis Decision Information System
Caddisfly – Trichoptera
CD – County Ditch
Cfs – Cubic feet per second
CR – County Road
CSAH – County State Aid Highway
CSMP – Citizen Stream Monitoring Program
DELTs – deformities, eroded fins, lesions, and tumors
DNR – Department of Natural Resources
DO – dissolved oxygen
EPA – U. S. Environmental Protection Agency
EPT – Ephemeroptera, Plecoptera and Trichoptera
GP – Glide Pool
HSPF – Hydrological Simulation Program-FORTRAN
HUC – Hydrologic Unit Code
IBI – Index of Biological Integrity
IMPLNDS – Impervious Land Surface
JD – Judicial Ditch
MDNR – Minnesota Department of Natural Resources
MNSU – Minnesota State University – Mankato
MPCA – Minnesota Pollution Control Agency
MSHA – MPCA Stream Habitat Assessment
NAWQA – National Water Quality Assessment (USGS)
NCHF – North Central Hardwood Forest
NBS – Near Bank Stress
NPS – Non-Point Source
NTU – Nephelometric Turbidity Units
PERLNDS – Pervious Land Surface
POET – Plecoptera, Odonata, Ephemeroptera and Trichoptera taxa
RR – Riffle Run
SID – Stressor Identification
SOE – Strength of Evidence
TIV – Tolerance Indicator Value
TMDL – Total Maximum Daily Load
TP – Total Phosphorus
TSS – Total Suspended Solids
TSVS – Total Suspended Volatile Solids

USDA – United States Department of Agriculture
USGS – United States Geological Survey
VSS – Volatile Suspended Solids
WCBP – Western Corn Belt Plains
YSI – Yellow Springs Instruments

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Executive Summary

A Stressor Identification analysis is a step-by-step approach for identifying probable causes of impairment in a particular system. There are sixteen Assessment Unit Identification (AUID)s within the Le Sueur River Watershed that were identified as impaired for aquatic life based on a lack of biological assemblage, fish or invertebrates. Further evaluation was completed to connect the biological community to the stressor(s) causing the impairment. The objectives of this report are to provide an evaluation of the environmental data and to diagnose of the probable causes of the biological impairments. Numerous candidate causes for impairment were evaluated using U.S. Environmental Protection Agency's (EPA's) Causal Analysis/Diagnosis Decision Information System (CADDIS), Minnesota Pollution Control Agency's (MPCA's) biological Total Maximum Daily Load (TMDL) protocols, and a weight of evidence analysis.

The results of the Stressor Identification analysis pointed to probable stressors in each of the impaired reaches which include (asterisk indicates limited data available):

Little Le Sueur River (07020011-573)

- Lack of Habitat
- Altered Hydrology

County Ditch 15-2 (07020011-609)

- Elevated Nitrate*
- Lack of Habitat
- Altered Hydrology

County Ditch 12 (07020011-558)

- Lack of Habitat
- Elevated Nitrate*
- Altered Hydrology

County Ditch 19 (07020011-608)

- Lack of Habitat
- Altered Hydrology

Iosco Creek (07020011-576)

- Lack of Habitat
- Lack of Physical Connectivity
- Elevated Nitrate*
- Altered Hydrology

County Ditch 6 (07020011-522)

- Lack of Habitat
- Elevated Nitrate*
- Elevated Phosphorus*
- Altered Hydrology

Unnamed Creek (07020011-510)

- Lack of Habitat
- Elevated Phosphorus*
- Altered Hydrology

Le Sueur River (07020011-619)

- Elevated Nitrate*
- Elevated Turbidity/TSS
- Altered Hydrology

Le Sueur River (07020011-507)

- Elevated Phosphorus
- Elevated Nitrate
- Elevated Turbidity/TSS
- Lack of Habitat
- Altered Hydrology

Le Sueur River (07020011-501)

- Elevated Phosphorus
- Elevated Nitrate
- Elevated Turbidity/TSS
- Lack of Habitat
- Altered Hydrology

Little Cobb River (07020011-504)

- Low Dissolved Oxygen (DO)
- Elevated Phosphorus
- Elevated Nitrate
- Elevated Turbidity/TSS
- Lack of Habitat
- Altered Hydrology

Cobb River (07020011-568)

- Elevated Turbidity/TSS
- Lack of Habitat
- Elevated Nitrate*
- Altered Hydrology

Cobb River (07020011-556)

- Elevated Phosphorus
- Elevated Nitrate
- Elevated Turbidity/TSS
- Lack of Habitat
- Altered Hydrology

Rice Creek (07020011-531)

- Low DO
- Elevated Phosphorus
- Elevated Nitrate
- Elevated Turbidity/TSS
- Lack of Habitat
- Altered Hydrology

Maple River (07020011-535)

- Elevated Turbidity/TSS (fish only)
- Lack of Habitat
- Altered Hydrology

Maple River (07020011-534)

- Elevated Phosphorus
- Elevated Nitrate
- Elevated Turbidity/TSS
- Lack of Habitat
- Altered Hydrology

This process identifies areas needing further research to better understand the impacts to the biological community. Recommendations are also developed to help direct restoration or protection efforts in this watershed.

Introduction

The Le Sueur River Watershed was assessed in 2010 for aquatic recreation, aquatic consumption and aquatic life beneficial uses. Based on this investigation, it was determined that sixteen AUIDs were impaired for fish and/or invertebrates, as part of the aquatic life use designation. This report describes the connection between the biological community and the stressor(s) causing the impairments. Stressors are those factors that negatively impact the biological community. Stressors can interact with each other and can be an additive to the stress on the biota. The Le Sueur River Monitoring and Assessment Report is available and provides background information about the watershed and the results of recent monitoring and assessment.

This report describes the step-by-step analytical approach, based on the EPA's Stressor Identification process (SID), for identifying probable causes of impairment in a particular system (Figure 1). In the Le Sueur River Watershed, stressors examined for possible cause of biotic impairment were: low DO, high nitrate-nitrite, excess phosphorus, high turbidity, lack of habitat, lack of connectivity, and altered flow regime. Other stressors were considered but did not have sufficient evidence for further analysis.

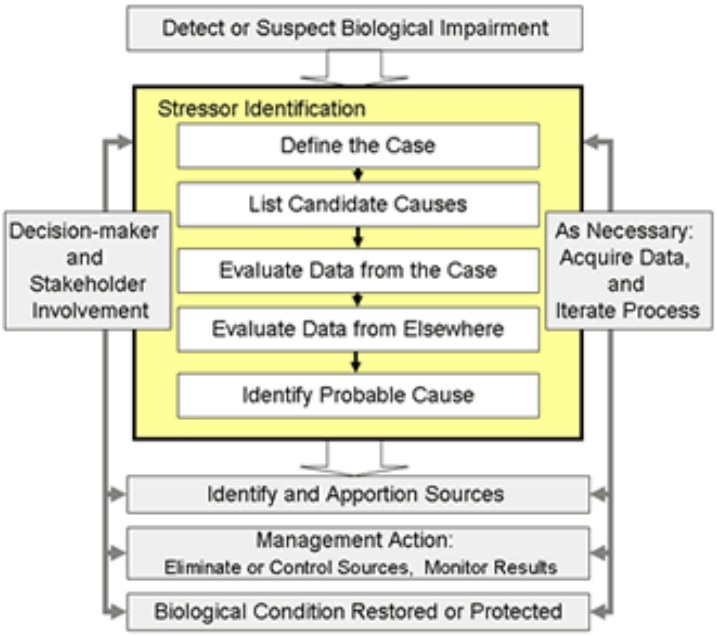

Figure 1. Conceptual model of stressor identification (SID) process (CADDIS, 2012)

Organization framework of stressor identification

The SID is prompted by biological assessment data indicating that a biological impairment has occurred, by an impairment of the fish or invertebrate communities. Through a review of available data, stressor scenarios are developed that may accurately characterize the impairment, the cause, and the sources/pathways of the various stressors. Confidence in the results often depends on the quality of data available to the SID process. In some cases, additional data collection may be necessary to accurately identify the stressor(s).

SID draws upon a broad variety of disciplines including; aquatic ecology, geology, geomorphology, chemistry, land-use analysis, and toxicology. Strength of evidence (SOE) analysis is used to develop cases in support of, or against various candidate causes. Typically, the majority of the information used in the SOE analysis is from the study watershed, although evidence from other case studies or scientific literature can also be drawn upon in the SID process.

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 load allocation will be developed. For example, the SID process may help investigators determine that excess fine sediment as the cause of biological impairment, but a separate effort is then required to determine the TMDL and identify implementation actions needed to restore the impaired condition.

Report format

The SID report follows a format that first summarizes candidate stressors. Within this summary, there is information about how the stressor broadly relates to the Le Sueur River Watershed, standards and ecoregion norms, effects on biology, and sources and causal pathways.

The second section is organized by watershed unit and impaired AUID reach. This includes biological information regarding that AUID, impairment status and detailed information regarding potential stressors in that AUID. The section then is summarized by a weight of evidence table, followed by the conclusions including any recommendations regarding additional monitoring, potential restoration, and potential protection.

Stations

Stations identified in Figure 2 were primarily for water chemistry collection. Figure 3 shows the biological stations and associated field codes. These locations may be co-located with the chemistry station near a road crossing and the biological station. Please see Appendix A. Water monitoring stations in the Le Sueur River Watershed with nearby biological stations, for exact location of water chemistry sites and Appendix 2 in the Le Sueur River Watershed Monitoring and Assessment Report for biological monitoring station locations.

Figure 2. Map of water chemistry stations

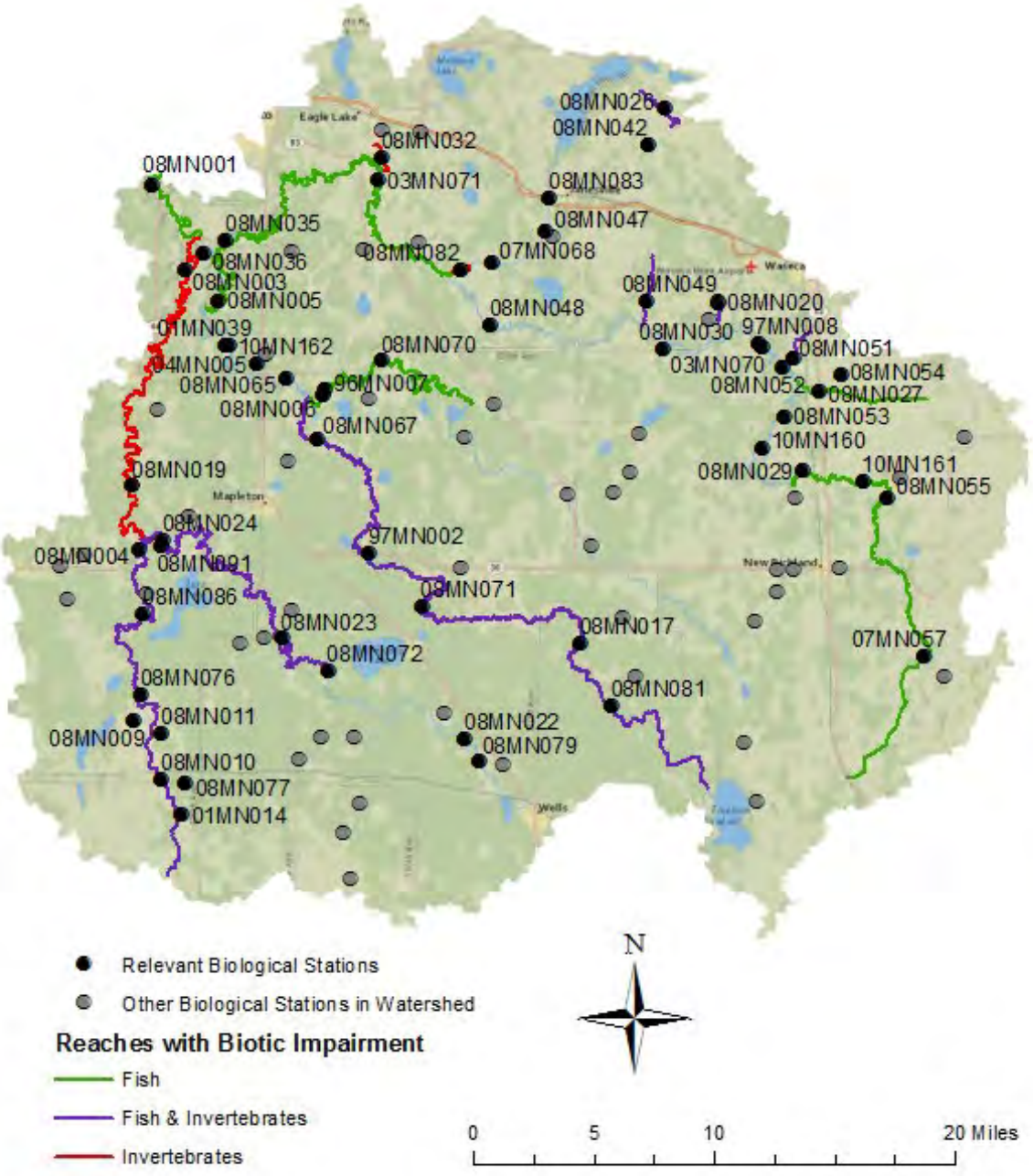

Figure 3. Map showing relevant biological stations in the Le Sueur River Watershed

Summary of Biological Impairments

As part of the aquatic life use portion of the assessment, fish and invertebrate were assessed for biological assemblage using an Index of Biological Integrity (IBI) score. The fish and invertebrates IBI scores within each AUID were compared to a regionally developed threshold and confidence interval and utilized a weight of evidence approach. Sixteen AUIDs are currently impaired for a lack of biological assemblage (Figure 4). The data considered during the assessment process were collected from 2001 to 2010. Of the sixteen listed AUIDs, seven are impaired for both fish and invertebrates, six are impaired for only fish, and three are impaired for only invertebrates.

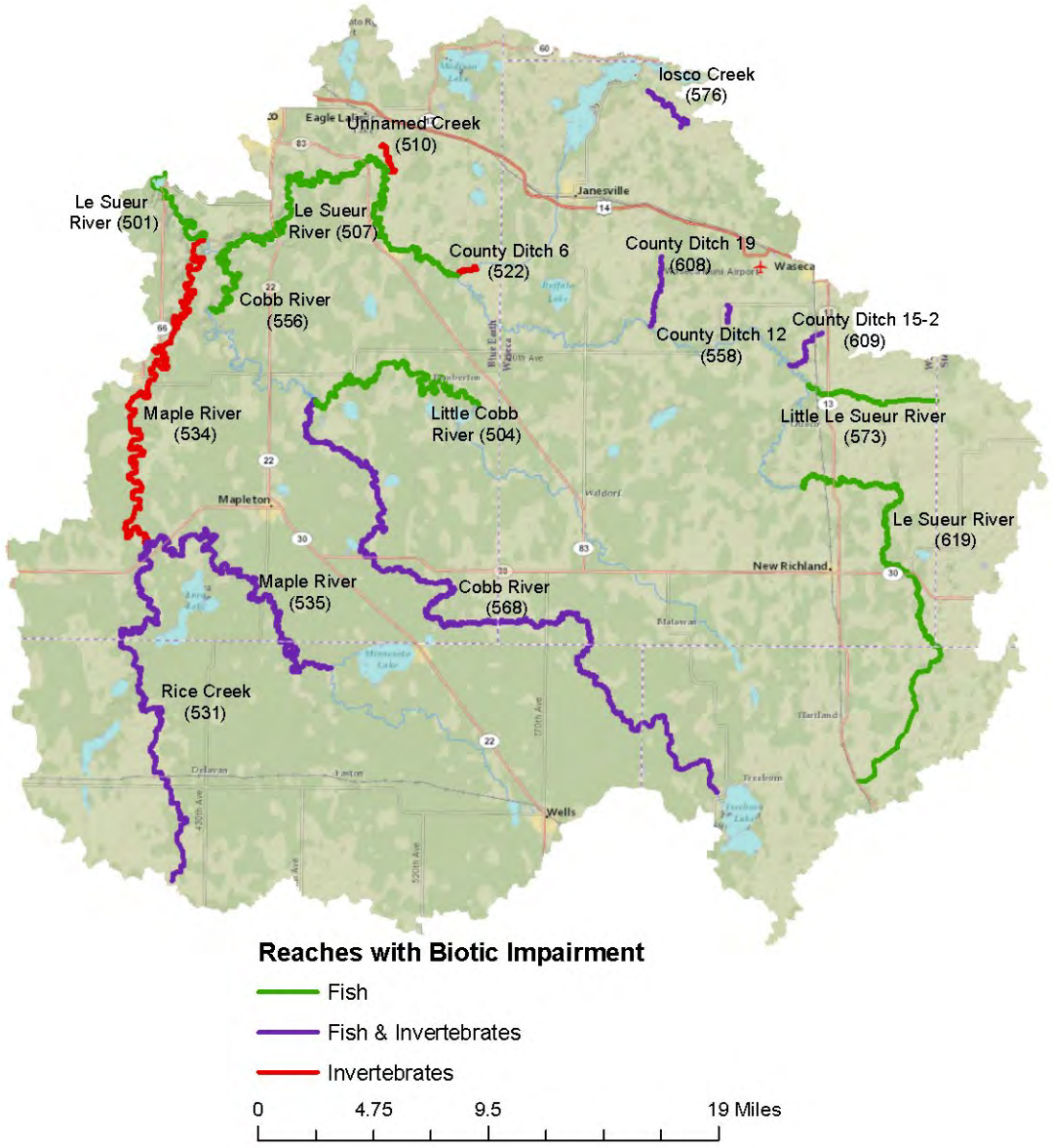

Figure 4. Map of the Le Sueur River watershed showing AUIDs with biological impairments; AUID is 07020011-XXX, with AUID last three digits are shown on map.

The fish and invertebrate IBI score thresholds and confidence limits that are applicable to the Le Sueur River Watershed are shown by class in Table 1. More information on classes (based on geographical area, drainage area and gradient) for fish and invertebrates can be found in the Appendix C and D. Table 3 shows the fish and invertebrate IBIs by station for the AUIDs that are impaired. The IBI scores are color coded by relationship to threshold and confidence interval which is available in Table 2.

Each IBI is comprised of fish or invertebrate metrics. Those metrics are based on community structure and function and produces a metric score. The number of metrics that make up an IBI will determine the metric score scale. For example, an IBI with 8 metrics would have a scale from 0 – 12.5 and an IBI with 10 metrics would have a scale from 0 – 10.

Table 1. Fish and invertebrate IBI thresholds and confidence limits

Class	Class Name	Fish IBI Thresholds	Upper CL	Lower CL
1	Southern Rivers	46	57	35
2	Southern Streams	45	54	36
3	Southern Headwaters	51	58	44

Class	Class Name	Invertebrate IBI Thresholds	Upper CL	Lower CL
2	Prairie Forest Rivers	30.7	41.5	19.9
5	Southern Streams Riffle Run (RR)	35.9	48.5	23.3
6	Southern Forest Streams Glide Pool (GP)	46.8	66	38.8
7	Prairie Streams GP	38.3	51.9	24.7

Table 2. IBI descriptors by color for Table 3

At or Below Lower Confidence Limit	At or Below Threshold, Above Lower Confidence Limit	At or Below Upper Confidence Limit, Above Threshold	Above Upper Confidence Limit

Table 3. Fish and invertebrate IBI scores by biological station (natural channels only) within AUID with descriptive color

7020011-573 Little Le Sueur River

Station	Year	Fish IBI	Fish class	Invertebrate IBI	Invertebrate class
08MN027	2008	46	3	50.42	6

7020011-609 County Ditch 15-2

Station	Year	Fish IBI	Fish class	Invertebrate IBI	Invertebrate class
08MN051	2008	33	3	25.73	5
	2010	47	3	22.35	5

7020011-558 County Ditch 12

Station	Year	Fish IBI	Fish class	Invertebrate IBI	Invertebrate class
08MN020	2008	38	3	13.70	5

7020011-608 County Ditch 19

Station	Year	Fish IBI	Fish class	Invertebrate IBI	Invertebrate class
08MN049	2008	42	3	29.76	5

7020011-576 Iosco Creek

Station	Year	Fish IBI	Fish class	Invertebrate IBI	Invertebrate class
08MN026	2008	12	3	25.38	5

7020011-522 County Ditch 6

Station	Year	Fish IBI	Fish class	Invertebrate IBI	Invertebrate class
08MN082	2008	46	2	33.36	5

7020011-510 Unnamed Creek

Station	Year	Fish IBI	Fish class	Invertebrate IBI	Invertebrate class
08MN032	2008	49	2	34.26	5

7020011-619 Le Sueur River

Station	Year	Fish IBI	Fish class	Invertebrate IBI	Invertebrate class
08MN055	2008	41	2	39.05	5
	2010	52	2	21.49	5
10MN161	2010	38	2	42.73	7
08MN029	2008	39	2	51.30	6

7020011-507 Le Sueur River

Station	Year	Fish IBI	Fish class	Invertebrate IBI	Invertebrate class
03MN071	2003	39	1	42.18	5
	2008	32	1	47.23	5
08MN035	2008	43	1	44.07	5

7020011-501 Le Sueur River

Station	Year	Fish IBI	Fish class	Invertebrate IBI	Invertebrate class
08MN001	2008	37	1	43.18	2

7020011-504 Little Cobb River

Station	Year	Fish IBI	Fish class	Invertebrate IBI	Invertebrate class
96MN007	1996	32	2	Not Sampled	
	1997	37	2		
	1998	34	2		
	2002	41	2		
	2003	41	2		
	2004	32	2		
	2005	25	2		

7020011-568 Cobb River

Station	Year	Fish IBI	Fish class	Invertebrate IBI	Invertebrate class
08MN081	2008	27 32	3	22.1	7
08MN017	2008	33	2	24.98	5
08MN071	2008	39	2	Not Sampled	
97MN002	1997	19	2	Not Sampled	

7020011-556 Cobb River

Station	Year	Fish IBI	Fish class	Invertebrate IBI	Invertebrate class
08MN005	2008	25	1	41.07	5
	2010	38	1	37.64	5

7020011-531 Rice Creek

Station	Year	Fish IBI	Fish class	Invertebrate IBI	Invertebrate class
08MN010	2008	52	3	22.61	5
08MN076	2008	30	2	38.26	7
08MN086	2008	47	2	30.91	7
03MN067	2003	48	2	35.94	5
08MN004	2008	45	2	46.17	7

7020011-535 Maple River

Station	Year	Fish IBI	Fish class	Invertebrate IBI	Invertebrate class
08MN023	2008	42	2	20.65	7
08MN091	2008	Not Sampled		61.87	7
08MN024	2008	53	2	Not Sampled	

7020011-534 Maple River

Station	Year	Fish IBI		Fish class	Invertebrate IBI	Invertebrate class
08MN019	2008	49	45	1	47.79	7
08MN003	2008	56		1	31.83	5

Hydrological Simulation Program – FORTRAN (HSPF) Model

The Hydrological Simulation Program – FORTRAN (HSPF) is a comprehensive modeling 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 can represent up to nine sediment particle size classes. In this application, three particle size classes (sand, silt, and clay) were used.

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, the upland areas are separated into multiple land use categories.

Within the Le Sueur River watershed modeled output was used for analysis. The subwatersheds are numbered and shown in Figure 5 along with the biological impairments.

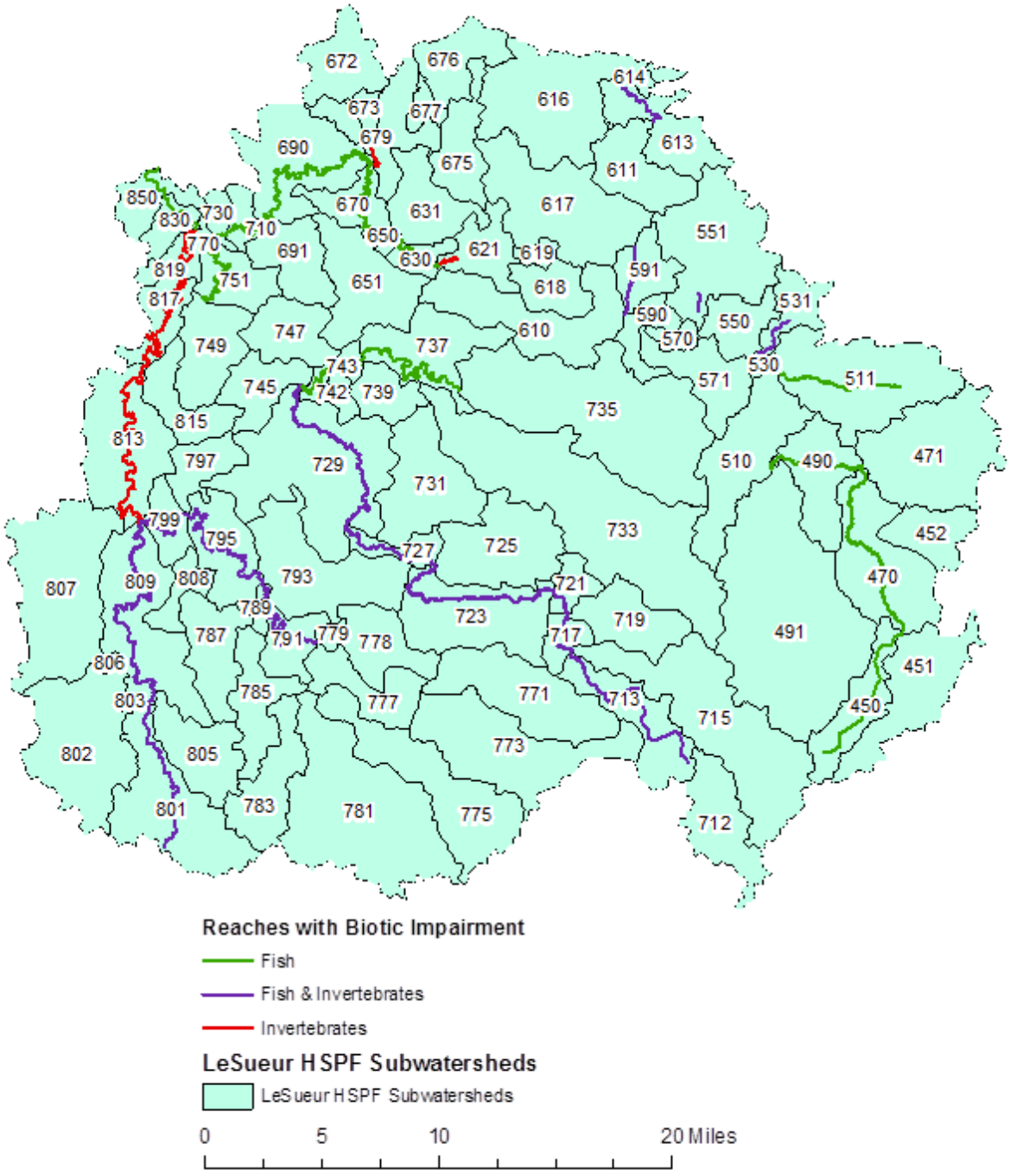

Figure 5. HSPF subwatersheds with reaches that have biological impairment

Geomorphic Study of Select Locations

Geomorphic studies were completed on the Le Sueur River during the 2008, 2010 and 2011 summer field seasons by MPCA and MDNR. Other entities have collected information about geomorphology in the Le Sueur River watershed as well. The purpose of these studies was to collect baseline data on the dimension, pattern, and profile of the river and its tributaries, to assess river stability and sediment supply, to relate the findings to water quality and biological impairments, and to suggest potential restoration activities in the locations where they would be most effective. The data collection included information on stream condition, stream classification, bank erosion potential, stream habitat condition, riparian condition, indices of stream stability, identification of representative areas for collection of additional data, and identification of potential problem and restoration areas.

The procedure for estimating bank erosion rates and total erosion during the reconnaissance portion of the investigation was a modified version of the "Bank Assessment for Non-point source Consequences of Sediment" (BANCS) model (Rosgen, 1996, 2001, 2006). This empirical model uses the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) erosion estimation tools. Visual estimates of the BEHI were made for stream banks where erosional processes were observed. Waypoints and photographs were collected along with bank height and length measurements using laser range finders and waypoint information. Near Bank Stress was estimated through analysis of aerial photos using method 2, found in the River Stability Field Guide. This method uses the ratio of the radius of curvature of the meanders to the bankfull width of the channel, and is a measure of the tightness of the bends in the river and the degree of boundary shear stress acting on those banks. The annual streambank erosion rate can then be estimated using the BEHI and NBS ratings, and measured erosion rates using those relationships. Erosion rates from Colorado data were used to estimate a range of possible erosion rates for the study. As more bank studies in Minnesota are conducted, we will more accurately constrain our local erosion rate relationships with BEHI and NBS, but at this time the Colorado curve fits fairly well.

Other tasks included: 1) determining bankfull indicators and relative bankfull elevation, 2) estimating the degree of channel incision by comparing bankfull elevation with low bank elevation, 3) determining stream classification to describe the reach, 4) identifying potential fluvial geomorphology assessment stations and 5) identifying possible problem areas.

Several stream reaches were subjected to more intensive geomorphic assessments at locations in the Le Sueur River watershed. These assessments followed the procedures outlined in the "River Stability Field Guide" (Rosgen 2008) levels I-IV. Level I assessment procedures were completed during field reconnaissance including broad level stream classification and valley classification. Level II tasks included cross sections, longitudinal profiles, pebble counts, hydraulic relations, level II stream classification, and morphological descriptions. Level III procedures included the prediction of annual streambank erosion rates using the BANCS empirical model (uses the Bank Erosion Hazard Index and Near Bank Stress). Level IV procedures included the validation of streambank erosion rates by setting up study banks with bank and bed pins and measuring actual annual erosion rates to start to develop local bank erosion relationships.

Overview of Candidate Causes

A list of candidate causes was formed at the start of the stressor identification process. The original list included:

- Dissolved oxygen regime alteration
- Hydrologic regime alteration (includes flow or depth conditions; timing, duration, frequency, etc.)
- Nutrient regime alteration
- pH regime alteration
- Suspended solids and/or turbidity alteration
- Water temperature regime alteration
- Habitat destruction
  - Bed sediment load changes, including siltation
- Habitat fragmentation (e.g., barriers to movement, exclusion from habitat)
- Physical crushing and trampling
- Toxic substances
  - Herbicides and fungicides
  - Chloride
  - Insecticides
  - Metals

Candidate causes ruled out

Some candidate causes were ruled out as unlikely candidates. The potential causes ruled out included:

- Water temperature regime alteration
- pH regime alteration
- Physical crushing and trampling

Water temperature regime alteration

The highest temperature found in the biological impaired reaches was 30.8 degrees Celsius. With the available data, temperature is an unlikely stressor to the biological community.

PH regime alteration

Of the AUIDs impaired for biology, there were five measurements of pH that were recorded above the 9.0 pH standard for 2B streams, between 2006 and 2009. Stations that had elevated pH are listed in Table 4. During 2007 through 2009, 34 measurements of pH were taken in the Le Sueur River, AUID 07020011-501, of those only one was greater than 9.0. Similarly, Rice Creek, AUID 07020011-531, had 20 measurements of pH from 2008 and 2009, which only one greater than the standard. The Cobb River at station S003-446 had 3 elevated measurements of pH out of 35, 2008 – 2009. With the given information it is unlikely that pH is a concern; however these stations should be monitored further. All other AUIDs that are impaired for biology did not have pH ranges outside of the standard (6.5 –9).

Table 4. Elevated pH measurements in biological impaired reaches

AUID	Station	Location	Date	Time	pH
07020011-501	S000-340	LESUEUR R MN-66 1.5 MI NE OF RAPIDAN	7/14/2009	14:30	9.24
07020011-531	S002-431	RICE CK AT CR-151 0.9 MI SE OF STERLING CENTER, MN	6/30/2009	13:30	9.12
07020011-556	S003-446	COBB R AT CSAH-16, 4.4 MI NE OF GOOD THUNDER, MN	4/14/2009	13:45	9.02
			7/14/2009	15:15	9.05
			7/21/2009	14:00	9.17

Physical crushing and trampling

Little of the land use in the Le Sueur River watershed is pasture. Pastured animals in the stream or river would be the most likely process in which crushing or trampling may take place. Due to the lack of evidence of this occurring, it is not currently a stressor to the biologically impaired reaches in the Le Sueur River watershed.

Candidate causes without enough information (inconclusive)

Some candidate causes were unable to be considered further due to the lack of connecting data between the potential stressor and the biological community; and/or there was not enough data available. The potential causes that were inconclusive included:

- Toxic substances
  - Ionic Strength/Chloride
  - Metals
  - Pesticides (herbicides, insecticides, and fungicides)

Ionic strength/chloride

In 2003, there were a few measurements of elevated specific conductance at station S002-427 in the Maple River (AUID 07020011-534), with a maximum of 1125 uS/cm. With the available data the highest chloride measurement was only 54 mg/L, far below the standard. Ionic strength and chloride should continue to be monitored within the watershed, but there is no evidence to suggest they are stressors at this time.

Metals

Only eight stations in the Le Sueur River watershed had measurements of the metals of cadmium, nickel, copper, lead, and zinc. The standards could not be calculated for all samples of metals due to the lack of hardness data. Of the limited data available, total cadmium and total nickel did not result in any values above the chronic standard. Of the samples that were able to have the standard calculated, copper, lead and zinc resulted in a couple measurements greater than the standard (Table 5). These samples that resulted in elevated concentrations were collected without ultra clean methodologies.

Total copper resulted in nine measurements in the Le Sueur River watershed above the standard. Copper was elevated two days in a row at station S003-860 (August 19 and 20, 2007), in the Le Sueur River. On August 22, 2007, copper was measured below the standard. Total lead resulted in seven measurements in the Le Sueur River watershed above the standard. Total zinc resulted in two measurements in the Le Sueur River watershed above the standard.

It is unlikely that the metals are a stressor to the biological community due to the low number of measurements above the chronic standard; however it is recommended to continue monitoring of these metals to ensure that they are below the standard and to increase metals monitoring to locations that do not have any data at this time.

Table 5. Elevated measurements of copper, lead and zinc in the Le Sueur River watershed

AUID	Station	Location	Date	Time	Metal	Value (ug/L)
07020011-501	S000-340	LESUEUR R MN-66	8/19/2007	13:09	Copper	20.3
					Lead	12.7
07020011-556	S003-446	COBB R AT CSAH-16	8/19/2007	13:45	Copper	13.6
					Lead	8.4
			3/23/2009	16:00	Copper	15.8
					Lead	9
			6/23/2009	12:40	Zinc	498
07020011-504	S003-574	LITTLE COBB NEAR CSAH-16	7/18/2008	12:35	Copper	24.2
07020011-507	S003-860	LE SUEUR R AT CSAH-8	7/27/2007	16:00	Copper	22
			8/19/2007	15:45	Copper	20.4
					Lead	14.7
			8/20/2007	10:10	Copper	17
					Lead	11
			4/11/2008	12:00	Copper	18.1
					Lead	13.5
			3/23/2009	13:45	Copper	33.1
					Lead	25.2
			7/14/2009	15:35	Zinc	401

Pesticides

There have been numerous pesticide samples taken throughout the Le Sueur River watershed. There are currently impaired waters listings for Acetochlor in the most downstream reach of the Le Sueur River and in Little Beauford Ditch.

In many of the samples, although numerous pesticides were present, none were above the state or federal standards. With the limited data available, the effects of pesticides on the biological community within this reach are inconclusive. Currently, the additive effect of pesticides on aquatic organisms at

levels below state or federal standards is unknown. More research needs to be developed to characterize this potential effect.

Additional monitoring is recommended to further understand the presence of pesticides and their potential impacts to the biological community. Given the current gaps in understanding of the additive effects, it is difficult to rule out pesticide toxicity as a possible stressor or conclude that it may be a stressor.

Candidate causes considered further

The potential stressors that went through further consideration were DO, nitrate-nitrite, phosphorus, turbidity/TSS, lack of habitat, lack of connectivity, and flow alteration.

Dissolved oxygen

Dissolved oxygen refers to the concentration of oxygen gas within the water column. Low or highly fluctuating concentrations of DO can have detrimental effects on many fish and invertebrate species (Davis, 1975; Nebeker et al., 1991). Dissolved oxygen concentrations change seasonally and daily in response to shifts in ambient air and water temperature, along with various chemical, physical, and biological processes within the water column. If DO concentrations become limited or fluctuate dramatically, aerobic aquatic life can experience reduced growth or fatality (Allan, 1995). Some invertebrates that are intolerant to low levels of DO include mayflies, stoneflies and caddisflies (Marcy, 2007). Many species of fish avoid areas where DO concentrations are below 5 mg/L (Raleigh et al., 1986). Additionally, fish growth rates can be significantly affected by low DO levels (Doudoroff and Warren, 1965).

In most streams and rivers, the critical conditions for stream DO usually occur during the late summer season when water temperatures are high and stream flows are reduced to baseflow. As temperatures increase, the saturation levels of DO decrease. Increased water temperature also raises the DO needs for many species of fish (Raleigh et al., 1986). Low DO can be an issue in streams with slow currents, excessive temperatures, high biological oxygen demand, and/or high groundwater seepage (Hansen, 1975).

Water Quality Standards

In Class 2B streams, the Minnesota standard for DO is 5.0 mg/L as a daily minimum. Additional stipulations have been recently added to the guidance for assessment of DO. The following is from the Guidance Manual for Assessing the Quality of Minnesota Surface Waters (MPCA, 2009):

> *Under revised assessment criteria beginning with the 2010 assessment cycle, the DO standard must be met at least 90% of the time during both the 5-month period of May through September and the 7-month period of October through April. Accordingly, no more than 10% of DO measurements can violate the standard in either of the two periods.*
>
> *Further, measurements taken after 9:00 in the morning during the 5-month period of May through September are no longer considered to represent daily minimums, and thus measurements of > 5 DO later in the day are no longer considered to be indications that a stream is meeting the standard.*
>
> *A stream is considered impaired if 1) more than 10% of the "suitable" (taken before 9:00) May through September measurements, or more than 10% of the total May*

through September measurements, or more than 10% of the October through April measurements violate the standard, and 2) there are at least three total violations.

Types of dissolved oxygen data

Point measurements

Instantaneous DO data is available throughout the watershed and can be used as an initial screening for low DO. These measurements represent discrete point samples, usually conducted in conjunction with surface water sample collection utilizing a sonde. Because DO concentrations can vary significantly as a result of changing flow conditions and time of sampling, instantaneous measurements need to be used with caution and are not completely representative of the DO regime at a given site.

Longitudinal (synoptic)

A series of longitudinal synoptic DO surveys were conducted throughout the Le Sueur River Watershed in 2011. A synoptic monitoring approach aims to gather data across a large spatial scale and minimal temporal scale. In terms of DO, the objective was to sample a large number of sites from upstream to downstream under comparable ambient conditions. For the most part, the surveys took place in mid to late summer when low DO is most commonly observed. Dissolved oxygen readings were taken at pre-determined sites in the early morning in an attempt to capture the daily minimum DO reading.

Diurnal (continuous)

Where warranted, Yellow Springs Instruments (YSI) sondes were deployed for numerous days throughout the watershed in late summer to capture diurnal fluctuations over the course of a number of diurnal patterns and measure the amount of diurnal flux.

Overview of dissolved oxygen in the Le Sueur River Watershed

Currently, there is only one AUID that is listed as impaired for low DO. The Little Cobb River, from Bull Run Creek to Cobb River, was added to the impaired waters list in 2010. Utilizing fish Tolerance Indicator Values (TIVs) for DO helps identify areas that have potential DO issues (Figure 6). TIVs were developed from statewide Minnesota data. The data were quartered by species present in the Le Sueur River Watershed to note their level of relative sensitivity or tolerance (Table 6). Other TIVs are in development for other potential stressors as well.

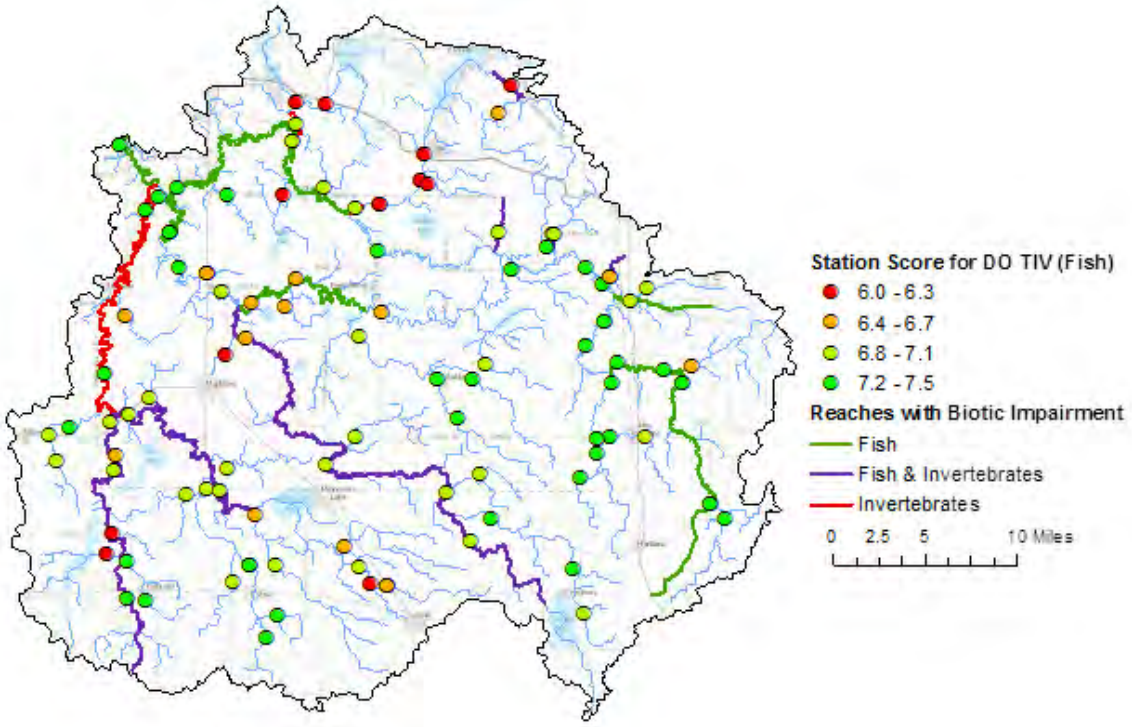

Figure 6. Average fish tolerance indicator value station scores for DO; fish data collected only at genus was not included in station score calculations. Data were ranked for the Le Sueur River watershed only, and not on a regional or statewide scale.

Table 6. Fish species found in the Le Sueur River watershed ranked and quartered by dissolved oxygen tolerance indicator values developed for Minnesota

1		2		3		4	
Common Name	DO TIV	Common Name	DO TIV	Common Name	DO TIV	Common Name	DO TIV
bowfin	2.82	orangespotted sunfish	6.48	walleye	7.24	smallmouth bass	7.86
yellow bullhead	4.60	green sunfish	6.48	slenderhead darter	7.28	smallmouth buffalo	7.95
black bullhead	5.00	bluegill	6.61	white sucker	7.29	quillback	7.97
central mudminnow	5.05	brassy minnow	6.68	bigmouth shiner	7.30	longnose gar	8.14
brook stickleback	5.57	bigmouth buffalo	6.80	central stoneroller	7.31	northern hogsucker	8.20
tadpole madtom	5.75	common shiner	6.96	carmine shiner	7.36	shovelnose sturgeon	8.32
golden shiner	5.82	johnny darter	7.01	golden redhorse	7.48	sauger	8.68
largemouth bass	6.04	blackside darter	7.06	silver redhorse	7.49	gizzard shad	8.70
fathead minnow	6.05	spotfin shiner	7.07	sand shiner	7.57	flathead catfish	8.83
northern pike	6.09	bluntnose minnow	7.10	shorthead redhorse	7.59	shortnose gar	8.90
common carp	6.09	freshwater drum	7.10	stonecat	7.60	river carpsucker	9.02
Iowa darter	6.10	creek chub	7.16	emerald shiner	7.61	silver chub	9.06
yellow perch	6.25	channel catfish	7.17	blacknose dace	7.70	highfin carpsucker	9.10
black crappie	6.26	hornyhead chub	7.23	banded darter	7.81		

Least Sensitive/Most Tolerant → Most Sensitive/Least Tolerant

Sources and causal pathways model for low dissolved oxygen

Dissolved oxygen concentrations in lotic environments are often driven by a combination of natural and anthropogenic factors. Natural background characteristics of a watershed, such as topography, hydrology, climate, and biological productivity can influence the DO regime of a waterbody. Agricultural and urban land-uses, impoundments (dams), and point-source discharges are just some of the anthropogenic factors that can cause unnaturally high, low, or volatile DO concentrations. The conceptual model for low DO as a candidate stressor in the Le Sueur River watershed is modeled at EPA's CADDIS Dissolved Oxygen webpage.

Nitrate - Nitrite

Nitrate is both a naturally occurring nutrient and important in the life-cycle of plants. Nitrate can influence biological communities in streams when present at concentrations exceeding those of reference areas where there is little human impact to the landscape (Monson, 2010). Exposure to elevated nitrite or nitrate concentrations can lead to the development of methemoglobinemia. The iron site of the hemoglobin molecule in red blood cells preferentially bonds with nitrite molecules over oxygen molecules. Methemoglobinemia ultimately limits the amount of oxygen which can be absorbed by fish and invertebrates (Grabda et al., 1974). Certain species of caddisflies, amphipods, and salmonid fishes seem to be the most sensitive to nitrate toxicity according to Camargo and Alonso (2006).

Water quality standards

Streams classified as Class 1 waters of the state, designated for domestic consumption, in Minnesota have a nitrate water quality standard of 10 mg/L. At this time, none of the AUIDs in the Le Sueur River watershed that are impaired for biota are classified as Class 1 streams. Minnesota currently does not have a nitrate standard for other waters of the state besides for class 1; however an aquatic life nitrate standard is being drafted.

Ecoregion data

McCollor & Heiskary (1993) developed a guidance of stream parameters by ecoregion for Minnesota streams. The majority of the Le Sueur River Watershed is within the Western Corn Belt Plains (WCBP) ecoregion with a small portion residing in the North Central Hardwoods Forest ecoregion (Figure 7). The annual 75th percentile nitrate values where used for comparison (Table **7**).

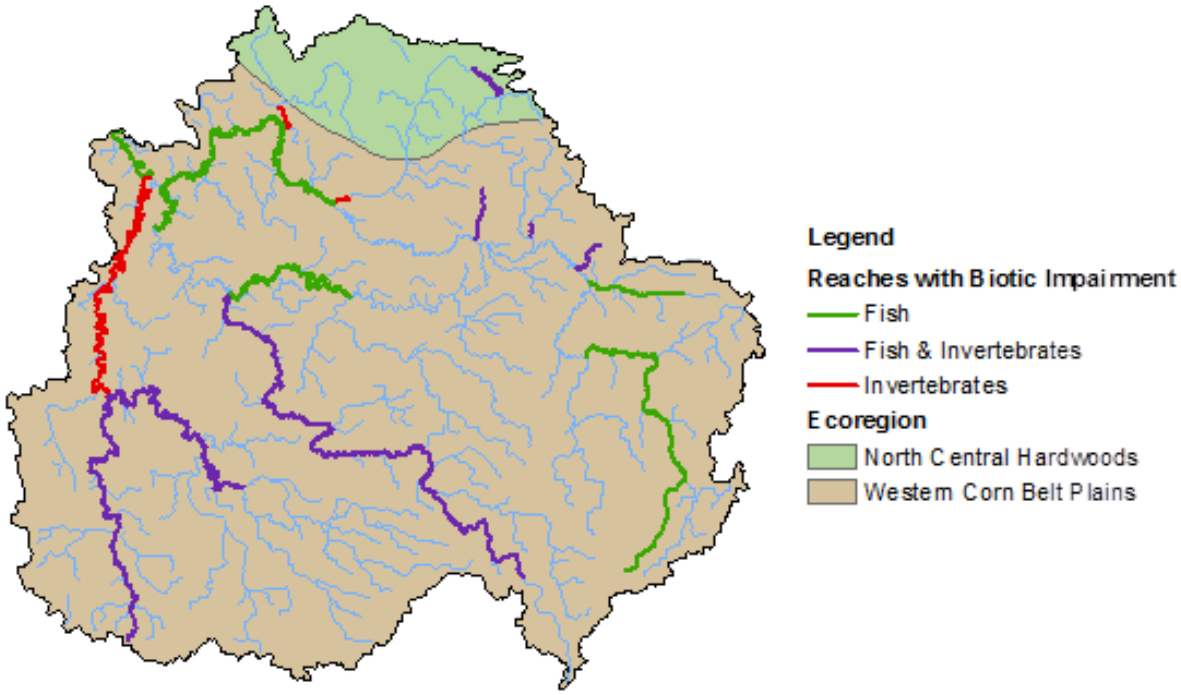

Figure 7. Map of ecoregions of the Le Sueur River Watershed and biological impairments

Table 7. Ecoregions in the Le Sueur River watershed with the associated annual 75th percentile nitrate-nitrite level

Ecoregion	75 Percentile value (mg/L)
North Central Hardwood Forest (NCHF)	0.28
Western Corn Belt Plains (WCBP)	6.9

Collection methods for nitrate and nitrite

Water samples analyzed for nitrate-nitrite were collected throughout the watershed for purposes of assessment and stressor identification. Typically water samples contain a small proportion of nitrite relative to nitrate due to the instability of nitrite, which quickly oxidizes to nitrate. The water samples collected were analyzed for nitrate-N at a Minnesota Department of Health certified lab.

Inorganic nitrogen (nitrate and nitrite) in the Le Sueur River Watershed

From 2003 to 2012, there were 1980 inorganic nitrogen (nitrate and nitrite) samples collected throughout the Le Sueur River watershed. Values ranged from 0.04 to 40.4 mg/L. May and June generally had higher inorganic nitrogen values indicating much of the watershed experiences seasonal fluctuations of nitrate. Nitrate values were elevated throughout the watershed.

Sources and causal pathways model for nitrate and nitrite

The causes and potential sources for nitrate-nitrite in the Le Sueur River watershed are modeled in Figure 8. Helsel (1995) reported nitrate concentrations were the highest below agricultural or urban areas.

Nitrogen is commonly applied as a crop fertilizer. Over 75% of the Le Sueur River watershed is comprised of cropland (Appendix B. Summarized landcover data from 2009 NASS Landcover Profile for select watersheds encompassing biotic impairments); it is likely that various forms of nitrogen including nitrate and ammonia are being applied to the cropland throughout the watershed. The specific timing and rate of nitrogen fertilizer application is unknown, but nitrogen isotopes could assist in the source identification of excess nitrate in future monitoring.

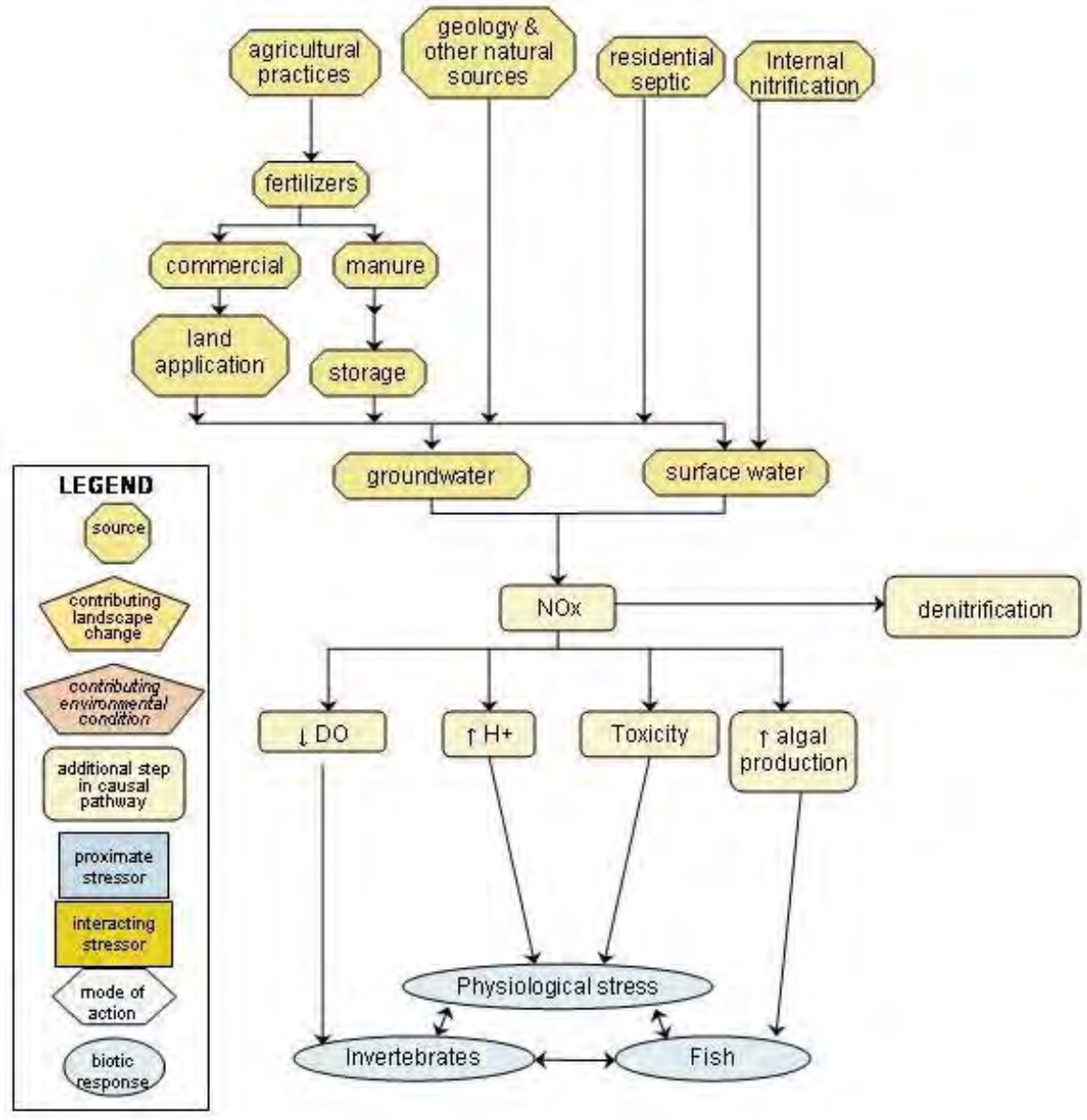

Figure 8. Conceptual model for nitrate stressor on the biotic community (adapted from Schofield, 2010)

Phosphorus

Phosphorus is an essential nutrient for all aquatic life, but elevated phosphorus concentrations can result in an imbalance which can impact stream organisms. Excess phosphorus does not result in direct harm to fish and invertebrates. Rather, its detrimental effect occurs as it alters other factors in the water environment. Altered DO, pH, water clarity, and changes in food resources and habitat are all stressors that can result when there is excess phosphorus.

Water quality standards and ecoregion norms

There is no current water quality standard for total phosphorus (TP); however, there is a draft nutrient standard for rivers of Minnesota as well as ecoregion data to show if the data is within the expected norms. The current draft standard is a maximum concentration of 0.15 mg/L with at least one response variable out of desired range (pH, biological oxygen demand (BOD), DO flux, chlorophyll-a) for the Le Sueur River watershed.

Phosphorus in the Le Sueur River Watershed

As shown the Le Sueur River Watershed Monitoring and Assessment Report, concentrations from 2007 through 2009 show that 65, 51, and 36% of the individual TP samples exceeded the 0.15 mg/L draft standard, respectively. Figure 13 from the report shows that all of the flow weighted mean concentrations from 2007 to 2009 were considerably higher than the draft standard at 0.38, 0.22, and 0.30 mg/L, respectively. Researches at Minnesota State University – Mankato (MNSU) and MPCA looked at TP concentration data from 2000 to 2008 and found with one statistical test there was no trend and the other found a significant declining trend (Sanjel, 2009). The report can be found at Minnesota River Basin Statistical Trend Analysis on MNSU's webpage.

Sources and causal pathways for excess phosphorus

Phosphorus is delivered to streams by wastewater treatment facilities, urban stormwater, agriculture, and direct discharges of sewage. The causes and potential sources for excess phosphorus in the Le Sueur River watershed are modeled at EPA's CADDIS Nutrients webpage.

Turbidity/TSS

Reduced transparency can increase due to suspended particles such as sediment, algae and organic matter. Increases in suspended sediment and turbidity within aquatic systems are now considered one of the greatest causes of water quality and biological impairment in the United States (U.S. EPA, 2003). Although sediment delivery and transport are important natural processes for all stream systems, sediment imbalance (either excess sediment or lack of sediment) can result in the loss of habitat in addition to the direct harm to aquatic organisms. As described in a review by Waters (1995), excess suspended sediments cause harm to aquatic life through two major pathways: (1) direct, physical effects on biota (i.e. abrasion of gills, suppression of photosynthesis, avoidance behaviors); and (2) indirect effects (i.e. loss of visibility, increase in sediment oxygen demand). Elevated turbidity levels and total suspended solids (TSS) concentrations can reduce the penetration of sunlight and thus impede photosynthetic activity and limit primary production (Munawar et al., 1991; Murphy et al., 1981).

Elevated volatile suspended sediments (VSS) concentrations can impact aquatic life in a similar manner as TSS – with the suspended particles reducing water clarity – but unusually high concentrations of VSS can also be indicative of nutrient imbalance and an unstable DO regime.

Water quality standards

The water quality standard for turbidity is 25 Nephelometric Turbidity Units (NTUs) for Class 2B waters for protection of aquatic life. Total suspended solids and transparency tube measurements can be used as surrogate standard. A strong correlation exists between the measurements of TSS concentration and turbidity. In 2010, MPCA released draft TSS standards for public comment (Markus). The new TSS criteria are stratified by geographic region and stream class due to differences in natural background conditions resulting from the varied geology of the state and biological sensitivity. The draft TSS standard for the Le Sueur River has been set at 65 mg/L. For assessment, this concentration is not to be exceeded in more than 10% of samples within a 10-year data window.

For the purposes of stressor identification, transparency tube measurements, TSS, VSS, and HSPF modeling results will be relied upon to quantify the suspended material present, from which conclusions can be made regarding the effects of suspended solids on fish and invertebrate populations.

Turbidity/TSS in the Le Sueur River Watershed

Currently, there are thirteen AUIDs in the Le Sueur River watershed that are impaired for turbidity (Table 8). Of those, nine have listings for biological impairments (denoted with an asterisk after Assessment Unit description). One biological effect of increased suspended sediment is a decrease in smallmouth bass. In the Le Sueur River watershed only two smallmouth bass were surveyed, both in the Le Sueur River.

Table 8. Le Sueur River Watershed reaches impaired for turbidity

Assessment Unit	ID	Added to Inventory
Cobb River: T104 R23W S34, south line to Little Cobb R*	07020011-568	2010
Cobb River: T107 R26W S30, west line to Le Sueur R*	07020011-556	2008
County Ditch 3 (Judicial Ditch 9): JD 9 to Maple R	07020011-552	2010
Le Sueur River: Headwaters to Boot Cr*	07020011-619	2010
Le Sueur River: Boot Cr to CD 6	07020011-620	2010
Le Sueur River: CD 6 to Cobb R*	07020011-507	2008
Le Sueur River: Cobb R to Maple R	07020011-506	2010
Le Sueur River: Maple R to Blue Earth R*	07020011-501	2002
Little Cobb River: Bull Run Cr to Cobb R*	07020011-504	2002
Maple River: Minnesota Lk outlet to Rice Cr*	07020011-535	2010
Maple River: Rice Cr to Le Sueur R*	07020011-534	2008
Rice Creek: Headwaters to Maple R*	07020011-531	2010
Unnamed creek (Little Beauford Ditch): Headwaters to Cobb R	07020011-503	2002

Sources and causal pathways for turbidity/TSS

The causes and potential sources for increases in turbidity/TSS in the Le Sueur River watershed are modeled at EPA's CADDIS Sediments webpage. High turbidity can occur when heavy rains fall on unprotected soils, dislodging the soil particles which are transported by surface runoff into the rivers and streams (MPCA and MSUM, 2009). The soil may be unprotected for a variety of reasons, such as construction, mining, agriculture, or insufficiently vegetated pastures. Decreases in bank stability and altered hydrology can also lead to sediment loss from the stream banks, often caused by perturbations in the landscape such as channelization of waterways, tile drainage, riparian land cover alteration, and increases in impervious surfaces. The Le Sueur River watershed also has knickpoints that are migrating upstream that contribute to the increases in turbidity and TSS downstream of these knickpoints. Additionally, a large number of bottom feeders (such as carp), which stir up bottom sediments can be a source of turbidity. Common carp are found in the Le Sueur River watershed with stations ranging in their abundance from 0 to 1025 fish (Figure 9). Utilizing HSPF output, most subwatersheds of the Le Sueur River the in stream scour is occurring at a greater proportion than deposition (Figure 10). In the Le Sueur River watershed, June is often the month in which the highest levels of TSS concentrations are recorded.

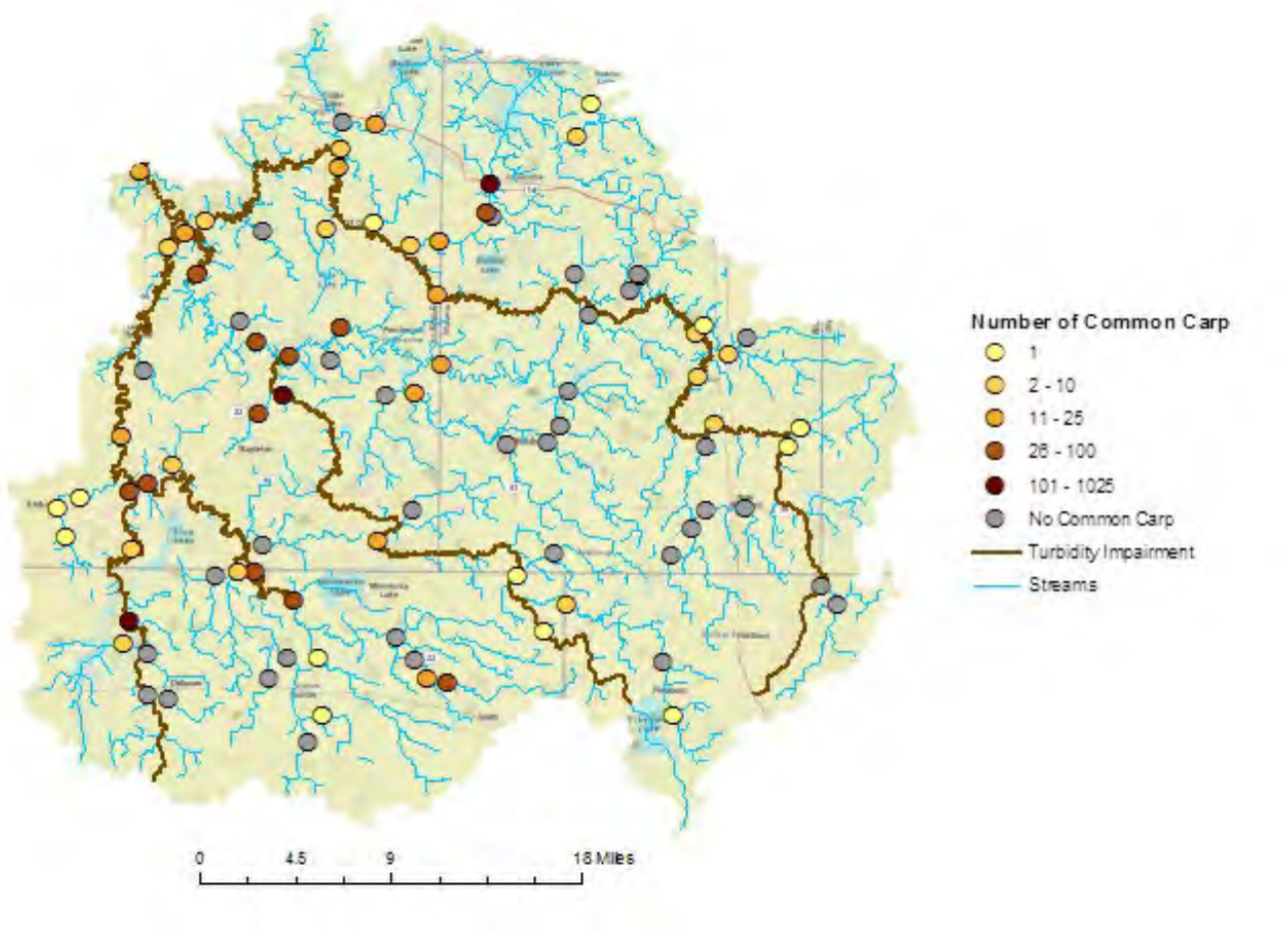

Figure 9. Average number of common carp at biological stations in the Le Sueur River Watershed

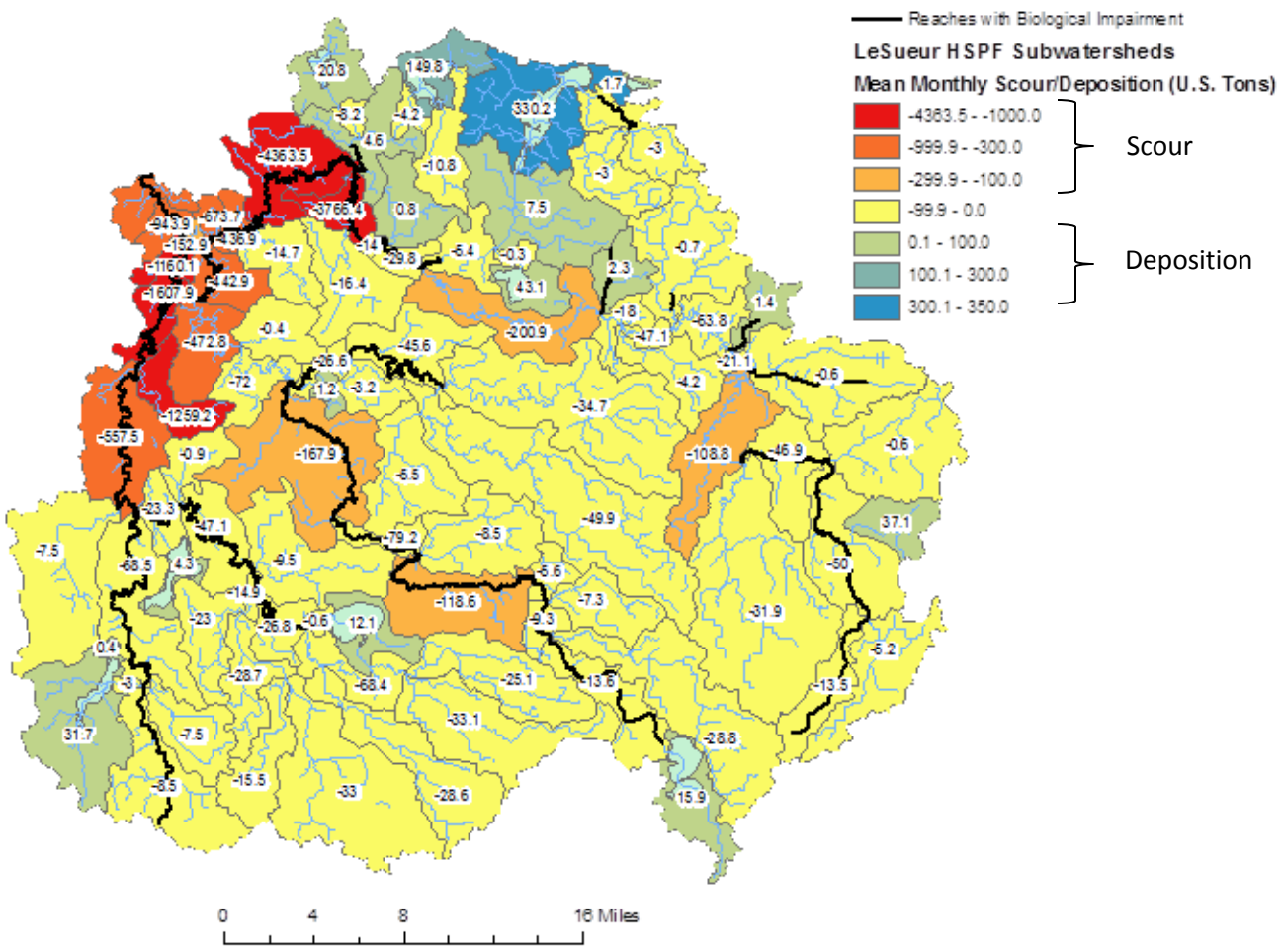

Figure 10. Mean monthly scour and deposition for the Le Sueur River Watershed by subwatersheds

Lack of habitat

Habitat is a broad term encompassing all aspects of the physical, chemical and biological conditions needed to support a biological community. This section will focus on the physical habitat structure including geomorphic characteristics and vegetative features (Griffith et al., 2010). Physical habitat is often interrelated to other stressors (e.g., sediment, flow, DO) and will be addressed separately. Fish passage will also be addressed in a separate section.

Physical habitat diversity enables fish and invertebrate habitat specialists to prosper, allowing them to complete their life cycles. Some examples of the requirements needed by habitat specialists are: sufficient pool depth, cover or refuge from predators, and riffles that have clean gravel or cobble which are unimpeded by fine sediment (Griffith et al., 2010).

Specific habitats that are required by a healthy biotic community can be minimized or altered by practices on our landscape by way of resource extraction, agriculture, forestry, silviculture, urbanization, and industry. These landscape alterations can lead to reduced habitat availability, such as decreased riffle habitat; or reduced habitat quality, such as embedded gravel substrates. Biotic population changes can result from decreases in availability or quality of habitat by way of altered behavior, increased mortality, or decreased reproductive success (Griffith et al. 2010).

Water quality standards

There currently is no applicable standard for lack of habitat for biotic communities.

Habitat characteristics in the Le Sueur River

Habitat is variable throughout the Le Sueur River watershed and is vital in understanding the biological communities. Throughout the Le Sueur River watershed, qualitative habitat was measured with the MPCA Stream Habitat Assessment (MSHA) along with the fish surveys (Figure 11). The MSHA is useful in describing the aspects of habitat needed to obtain an optimal biological community. It includes five subcategories: land use, riparian zone, substrate, cover, and channel morphology. The total score can be broken up into poor (<45), fair (45-66) and good (>66) categories.

Figure 12 and Figure 13 show the relationship between the IBI thresholds and the MSHA score. While the relationship is weak (as indicated by the R^2 values), there is a correlation between poor habitat and the IBI score falling below the threshold.

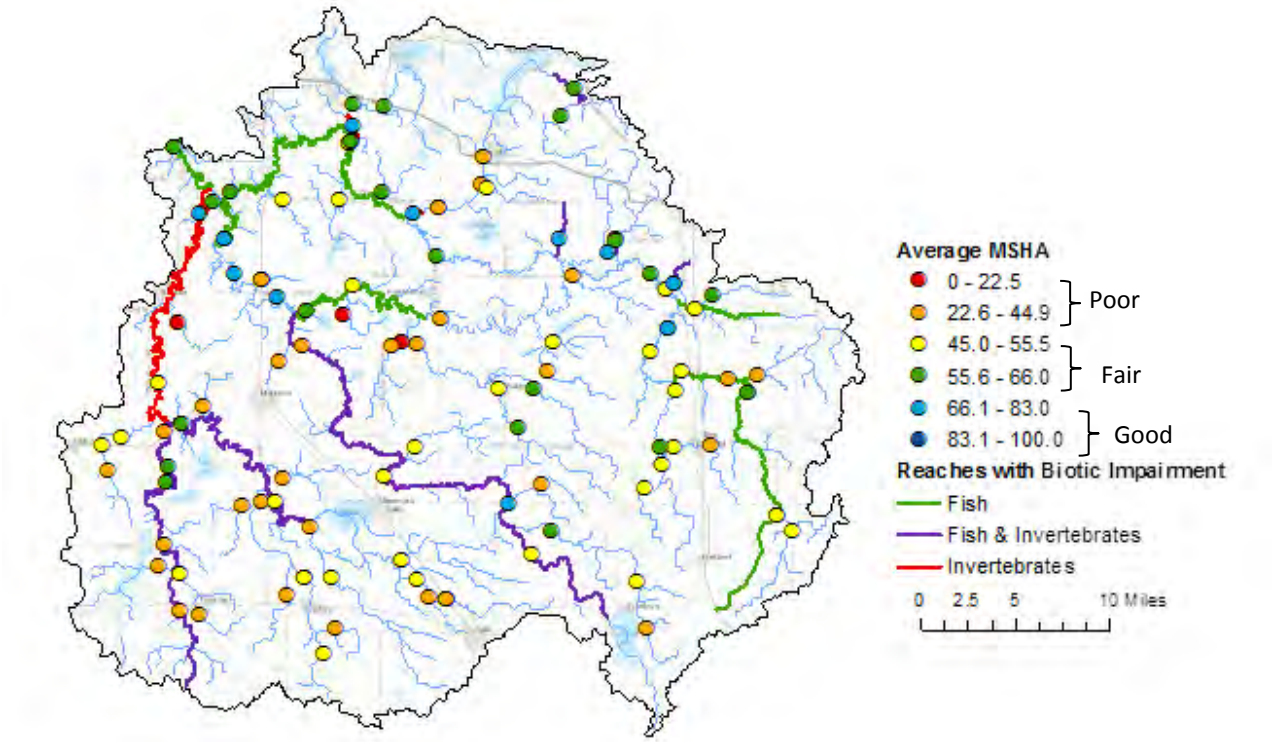

Figure 11. Map of average MSHA total scores for all biological sites in the Le Sueur River Watershed

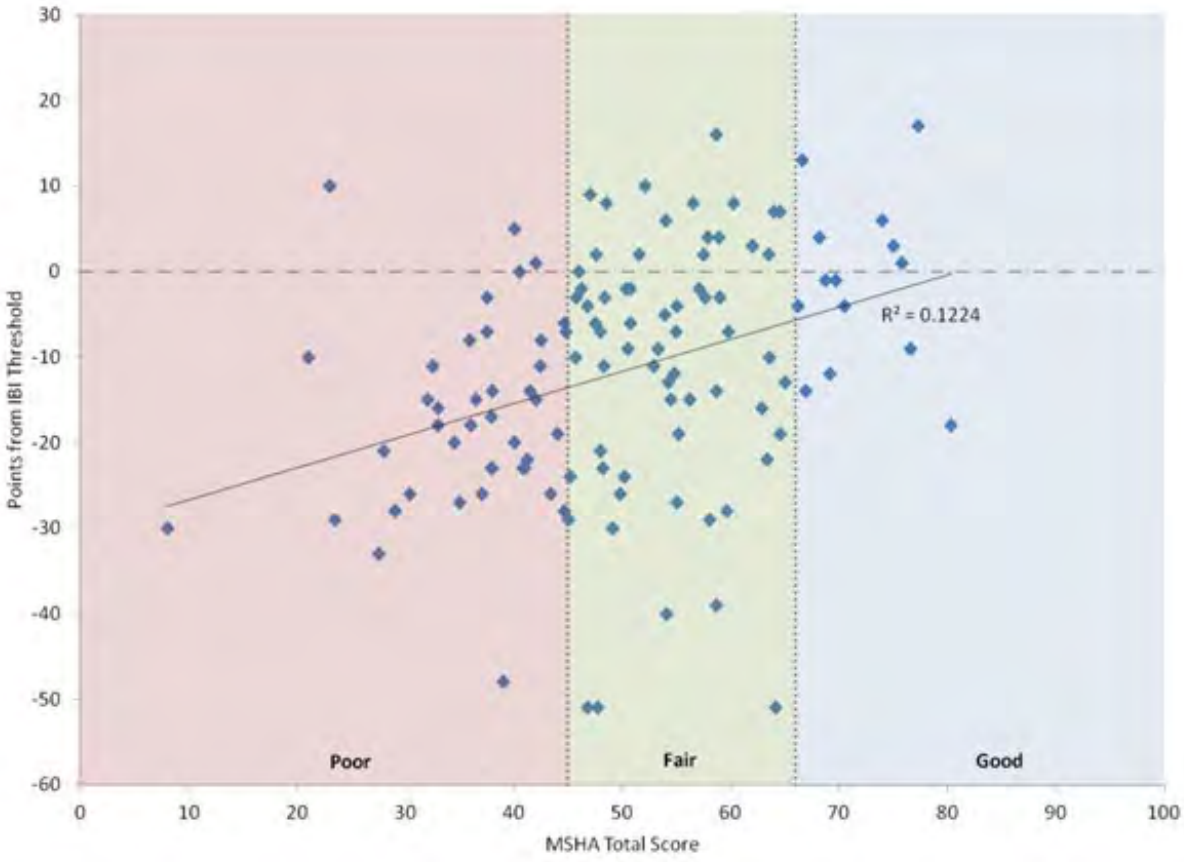

Figure 12. MPCA Stream Habitat Assessment scores and points above or below fish IBI threshold for biological sites in the Le Sueur River Watershed

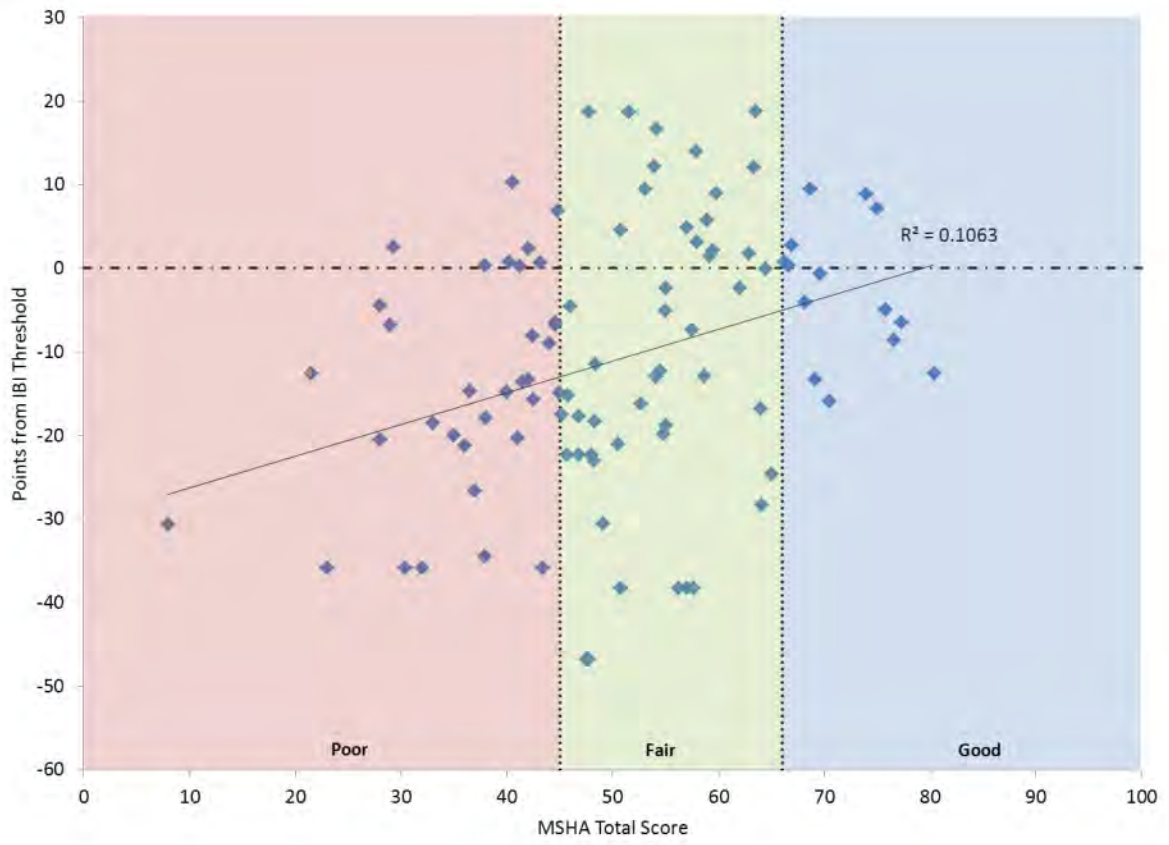

Figure 13. Average MSHA scores (by year) and points above or below invertebrate IBI threshold for biological sites in the Le Sueur River Watershed

Sources and causal pathways model for habitat

The causes and potential sources for lack of habitat in the Le Sueur River watershed are modeled at EPA's CADDIS Physical Habitat webpage. Many riparian areas along the Le Sueur River and tributaries are influenced by row crop agriculture, this in turn decreases riparian and bank vegetation. Along with altered hydrology, the alteration of habitat caused by channelization and impoundments has numerous pathways of influence affecting the biological community such as decreases in woody debris and course substrate.

Connectivity

Connectivity in river ecosystems refers to how waterbodies and waterways are linked to each other on the landscape and how matter, energy, and organisms move throughout the system (Pringle, 2003). There are many components of connectivity, but this section will only address the physical barriers of dams.

Dams, both human-made and natural, can cause changes in flow, sediment, habitat and chemical characteristics of a waterbody. They can alter the hydrologic connectivity, which may obstruct the movement of migratory fish causing a change in the population and community structure. The stream environment is also altered upstream of a dam to a predominately lentic surrounding (Mitchell and Cunjak, 2007).

Humans have placed dams on the landscape for many reasons including flood control, livestock watering, and irrigation. Beavers build dams to create impoundments with adequate water depth for a winter food cache (Collen and Gibson, 2001). Beaver dams, even though natural, can also be barriers to fish migration.

Water Quality Standards

There is no applicable water quality standard for connectivity impacts.

Connectivity in the Le Sueur River Watershed

The Le Sueur River watershed has numerous dams throughout the watershed (Figure 14). Dams are known to alter connectivity for biological communities; however, there are no known dams on biologically impaired reaches in the watershed. Channelized stations may yet have barriers impacting the reach, but they have not been assessed at this time. Dams also can alter the hydrologic regime of a stream system, which is covered under the flow alteration section following this section.

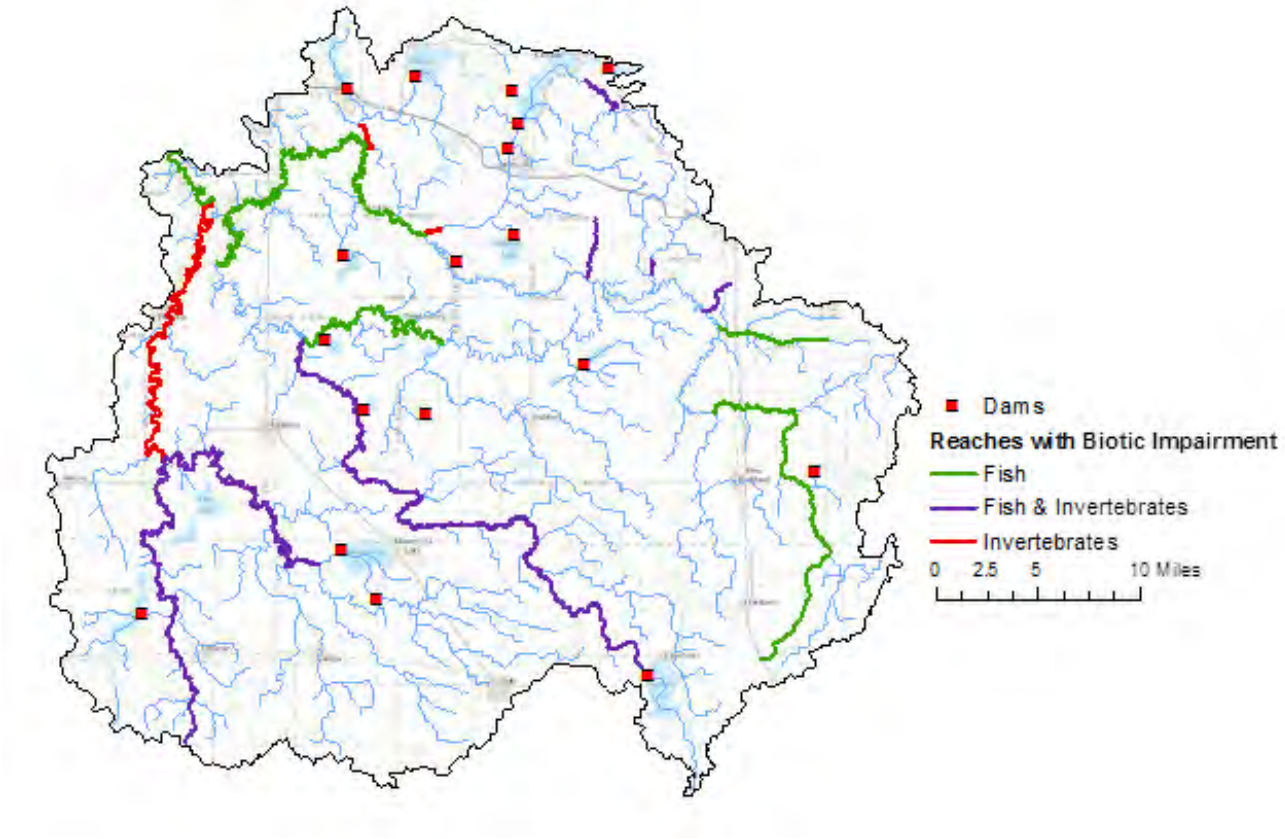

Figure 14. Map of dam locations from the National Inventory of Dams (MDNR)

Sources and causal pathways model for connectivity

The causes and potential sources for connectivity in the Le Sueur River watershed are modeled in Figure 15. Impoundments placed on rivers and streams can create barriers to fish passage and can alter the aquatic community.

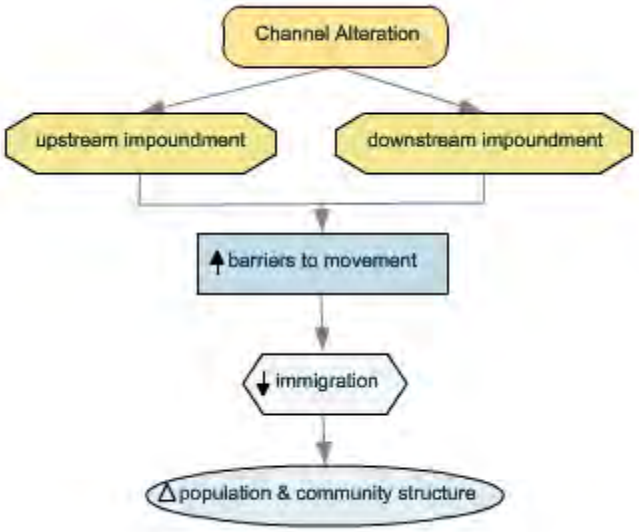

Figure 15. Conceptual model for connectivity (adapted from CADDIS)

Flow alteration

Flow alteration results in increased flows, change in duration of flows, flashiness, decreased baseflow, loss of groundwater recharge, changes in floodplain connection, changes to habitat, and changes in timing of flows. Flow alteration can be devastating to a biological community.

High flows

Increased flows may directly impair the biological community and/or contribute to additional stressors. Elevated channel shear stresses, associated with increased flows, often causes added scouring and bank destabilization. The fish and invertebrate community may be negatively impacted by these changes to habitat and sediment. High flows can also cause the displacement of fish and invertebrates downstream if they cannot move into tributaries or refuges along the margins of the river or if refuges are not available. Such aspects as high velocities, the mobilization of sediment, woody debris and plant material can also be detrimental, especially to the fish and invertebrates, all of which can cause significant dislodgement of the biota. When high flows become more frequent, species that do not manage well under those conditions will be reduced, leading to altered population. Invertebrates may shift from those of long life cycles to short life cycles needing to complete their life history within the bounds of the recurrence interval of flow conditions (CADDIS, 2011).

Low flows

Across the conterminous U.S., Carlisle et al. found that there is a strong correlation between diminished streamflow and impaired biological communities (2010). Habitat availability can be scarce when flows are interrupted, low for a prolonged duration, or extremely low, leading to a decreased wetted width, cross sectional area, and water volume. Aquatic organisms require adequate living space and when flows are reduced beyond normal baseflow, competition for resources increases. Pollutant concentrations often increase when flows are lower than normal, making it more difficult for populations to maintain a healthy diversity. Often tolerant individuals that can outcompete in limiting situations will thrive. Low flows of prolonged duration tend to lead to invertebrate and fish communities that have preference for standing water or are comprised of generalist species (CADDIS 2011).

When baseflows are reduced, fish communities respond with an increase in nest guarding species (Carlisle et al., 2010). This adaptation increases the reproductive ability for nest guarders by protecting from predators and providing "continuous movement of water over the eggs, and to keep the nest free from sediment" (Becker, 1983). Fifteen nest guarding species (excluding lithophilic spawners) are found in the Le Sueur River watershed (most common in the Le Sueur River watershed are fathead minnows, bluntnose minnows, johnny darters, and green sunfish).

Flow conditions can have an effect on the type of fish species that are present. Active swimmers, such as the green sunfish, contend better under low velocity conditions (Carlisle et al., 2010). Streamlined species have bodies that allow fish to reduce drag under high velocities (Blake, 1983). Similarly, the invertebrate communities exhibit changes with increasing swimming species and decreasing taxa with slow crawling rates. EPA's CADDIS lists the response of low flow alteration with reduced total stream productivity, elimination of large fish, changes in taxonomic composition of fish communities, fewer species of migratory fish, fewer fish per unit area, and a greater concentration of some aquatic organisms (potentially benefiting predators).

Water quality standards

There is not a specific standard regarding the alteration of maximum peak flows. The standard for minimum streamflow, according to Minnesota State Statute 7050.0210 Subpart 7 is:

> *Point and nonpoint sources of water pollution shall be controlled so that the water quality standards will be maintained at all stream flows that are equal to or greater than the $7Q_{10}$ [the lowest streamflow for 7 consecutive days that occurs on average once every 10 years] for the critical month or months, unless another flow condition is specifically stated as applicable in this chapter.*

Flows in the Le Sueur River Watershed

The peak flows in a river are a response of overland and shallow subsurface pathways. Baseflow, which sustains river flow between runoff events, is supplied by aquifers (derived from various subsurface paths). Impermeable surfaces, lack of vegetative cover, and extensive drainage systems occur in both urban (developed) and agricultural (cropland) land areas in the Le Sueur River watershed, 8.3% and 75.4% respectively (Appendix B. Summarized landcover data from 2009 NASS Landcover Profile for select watersheds encompassing biotic impairments). All of these conditions can cause an increase in the surface or subsurface drainage runoff flow component produced by a given runoff event. The increased surface runoff and subsurface runoff components can result in channel scour and a long-term reduction in infiltration, which lowers the water table and reduces the seasonal baseflow component (Poff et al., 1997). The Le Sueur River watershed has characteristics that have led to flow alterations, such as dams, field tile, channelization, extension/expansion of the surface drainage network, and impervious surfaces.

Significant changes to land use and subsequently, hydrology, have impacted the Le Sueur River Watershed; the loss of wetlands and wetland functions: water storage, evapotranspiration, and soil infiltration, coupled with an increase in drainage and natural precipitation events, has compounded the watershed's stressors. The conversion of the prairie ecosystem to agricultural production and the drainage of wetland basins have drastically altered the drainage pattern and drainage area within the watershed (Figure 16). In its natural state, the Le Sueur Watershed was a series of prairie, wet prairie, and open water wetland complexes with hardwood forests at the lower reaches of each river system discharging to the Le Sueur River. Major changes to the watershed include the drainage of wetlands through ditching in the late 1800's and 1900's to today's increase in pattern tiling to improve drainage at the individual field scale. Compared to uncleared land under natural conditions, improved drainage

usually increases peak runoff rates, sediment losses, and pollutant loads on surface-water resources (Zucker, L.A. and L.C. Brown (Eds.). 1998).

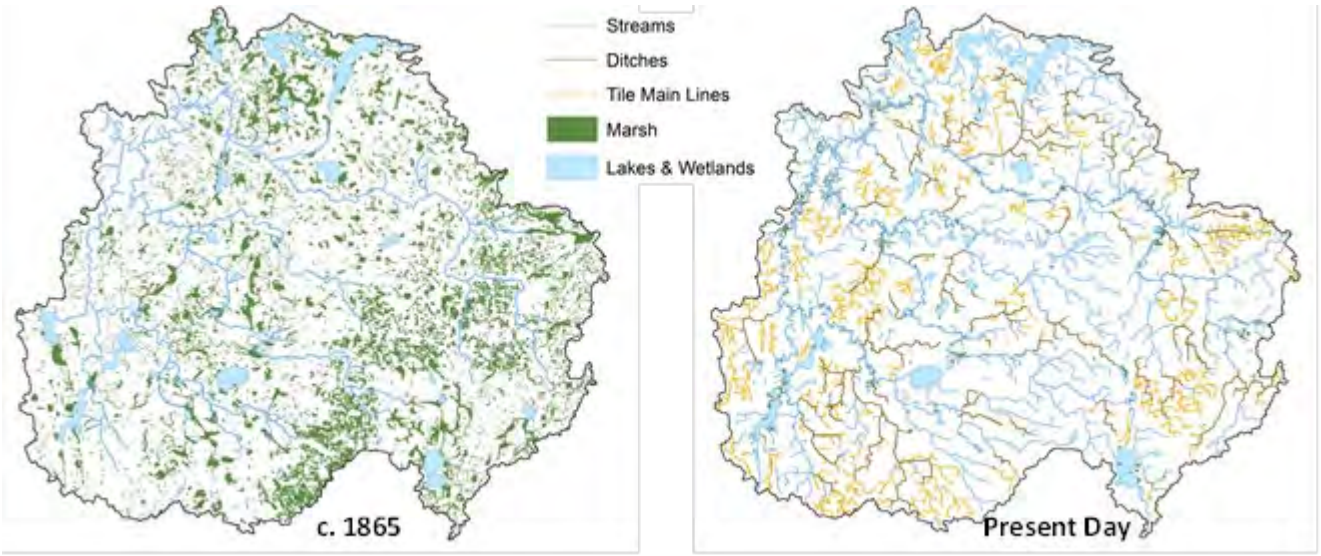

Figure 16. Between 1855 and 2006, significant changes in land use and drainage drastically reduced the wetland (marshland) acres while increasing the total amount of channeled flow (stream length)

Seemingly minor and disconnected land use improvements have created pronounced cumulative effects in the watershed. The transformation of the prairie-wetland system to agricultural production has influenced the transport of water and sediment, effectively altering the delivery of water and contributing to higher flows and reduced evapotranspiration and storage throughout the basin. Water storage and buffering of storm events have been substantially decreased through the drainage of wetland basins. Alternately, the significant decrease in wetland acreage has, in part, contributed to the increase in channel length, which promotes instability of the river and an increase in its erosive potential.

While stream bank erosion is a natural process, acceleration of this natural process due to changes in land use and hydrology lead to a disproportionate sediment supply, stream channel instability, land loss, aquatic habitat loss, and other adverse effects (Rosgen, 2006). Major transformations in drainage pattern, natural land cover, and variable precipitation have created instability within the watershed, causing streams to manage new discharge and sediment loads. Multiple factors have acted to increase river discharge and erosion of near-channel sediment sources. The extensive tile and ditch network has increased connectivity between uplands and the channel network, effectively increasing both the drainage area and efficiency. In addition, mean precipitation and extreme event magnitude and frequency have increased, exacerbating land use-driven hydrologic alterations. Increases in sediment due to sources including bank erosion and surface runoff have increased the already large natural sediment loading in the river by a factor of four to five (Gran et al., 2011).

The nearly complete transformation of the land surface and consequently, hydrology, over the past two centuries has created multiple stressors in the Le Sueur River Watershed. Changes in hydrology have created unnatural and typically higher flow regimes, increased sediment and nutrient loadings, and cascading effects to the ecology of the area. With pressures increasing from downstream stakeholders including communities of the Minnesota and Mississippi Rivers, the Le Sueur River's increased delivery of water, sediment, and nutrients now represents an important water quality problem that necessitates action.

The hydrology in the Le Sueur River has been altered thus creating an increase in annual average flow that can only be partly due to increases in precipitation over the same time period (Figure 17). Flows are increasing in the Le Sueur River (and likely upstream reaches) which can lead to degradation of vital requirements of the biological community.

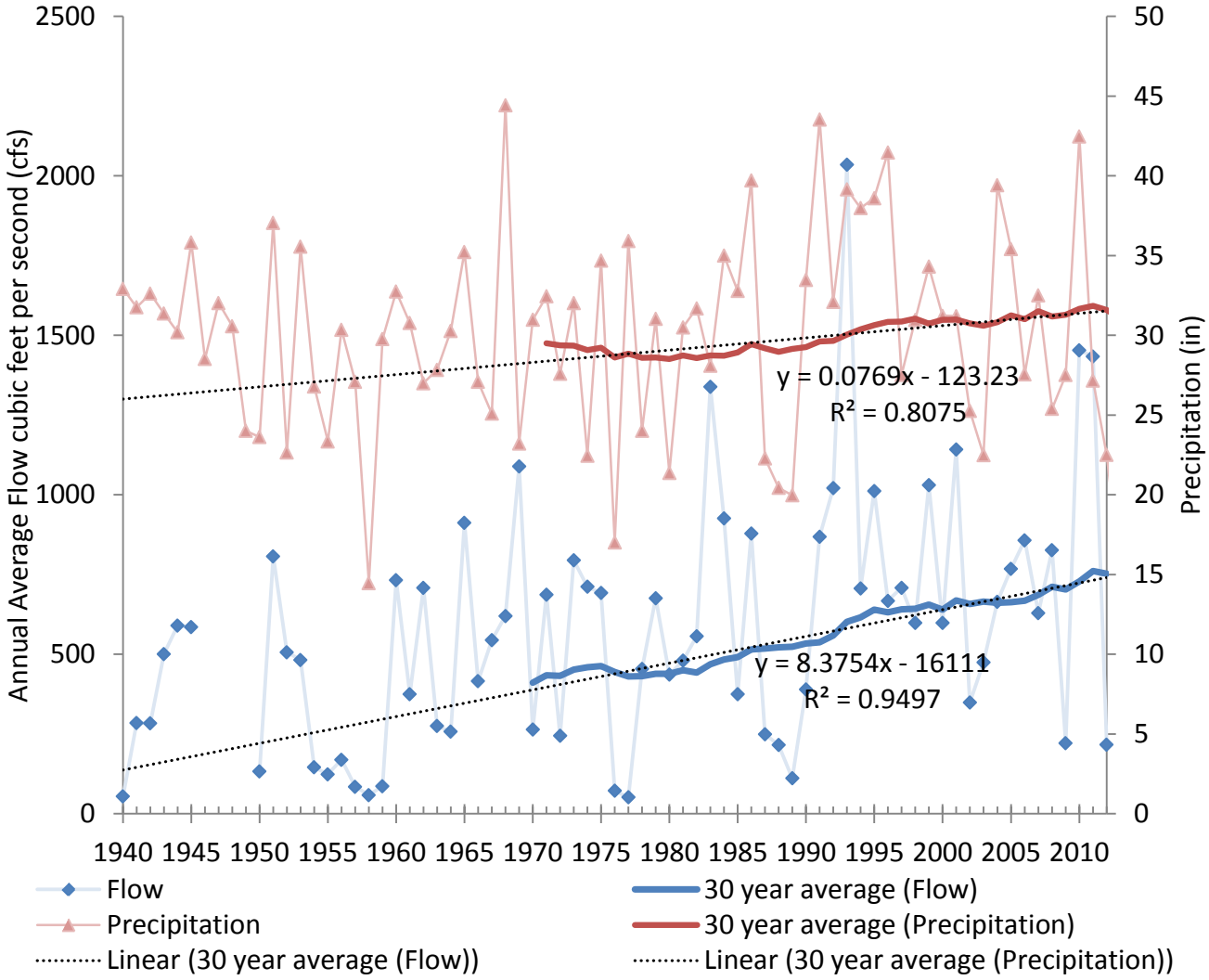

Figure 17. Annual average flow from United States Geological Survey (USGS) Gage Station on the Le Sueur River near Rapidan with annual precipitation

The long term geomorphic effect of increased runoff in the Le Sueur watershed has been, and will continue to be, larger stream channels and more rapid stream channel migration (Gran et al. MPCA Report, June 2011; An Integrated Sediment Budget for the Le Sueur River Basin). "Natural rivers, which are self-constructed and self-maintained, constantly seek their own stability" (Leopold et al. 1964). Rivers that have been straightened, deepened, and widened will, in general, decrease their stability and natural function and will create maintenance problems and high failure of the banks within the systems added to costs and loss of land and decrease in biological functions (Rosgen, 2006). The habitat availability during low flow and the refuge during high flow have a large influence on how well the biological community responds to these events. The variability in the biological response is expected across the watershed as flows scour in some areas and deposit in others, as stability is altered by anthropogenic and natural changes.

The biological community in the Le Sueur River is impacted either directly or via response stressors from altered hydrology, such as lack of habitat and sediment issues. Tolerant organisms are able to take over when there is change in stream function. The percent of tolerant invertebrate individuals ranges in the Le Sueur River Watershed from 73% to 99% (Figure 18). In many of the head water reaches, the number of tolerant species was particularly high. Additionally, the range of tolerant fish individuals in the Le Sueur River watershed was from 26% to 100%, with the highest percentages of tolerant fish present in the subwatersheds of the Le Sueur and Cobb Rivers (Figure 21).

Another indication of hydrologic alteration is the reduction of long lived species. Long lived fish were also reduced in some areas of the Le Sueur River watershed, with a high percentage of short lived fish (Figure 22 and Figure 23). Long lived invertebrates also have a tendency to decrease with changes in hydrologic regime. The percentage of long lived invertebrates ranged from 0% to 41.95% (Figure 22).

Flow changes can increase the percentage of invertebrates that are swimmers. Throughout the watershed there were varying percentages of swimmers, likely due in part to the varying habitat present (Figure 19). The average percentage of swimmers in natural channels of the Minnesota River basin was 7.8%, and ranges from 0% to 41.72% in natural channels of the Le Sueur River watershed.

The biological communities vary in their response to hydrologic alteration, but it is certain that much of this watershed area has been changed and that has direct impacts to the communities within the stream network. It is difficult to compare changes within the Le Sueur to surrounding the Minnesota River Basin when much of the basin has also undergone hydrologic alteration.

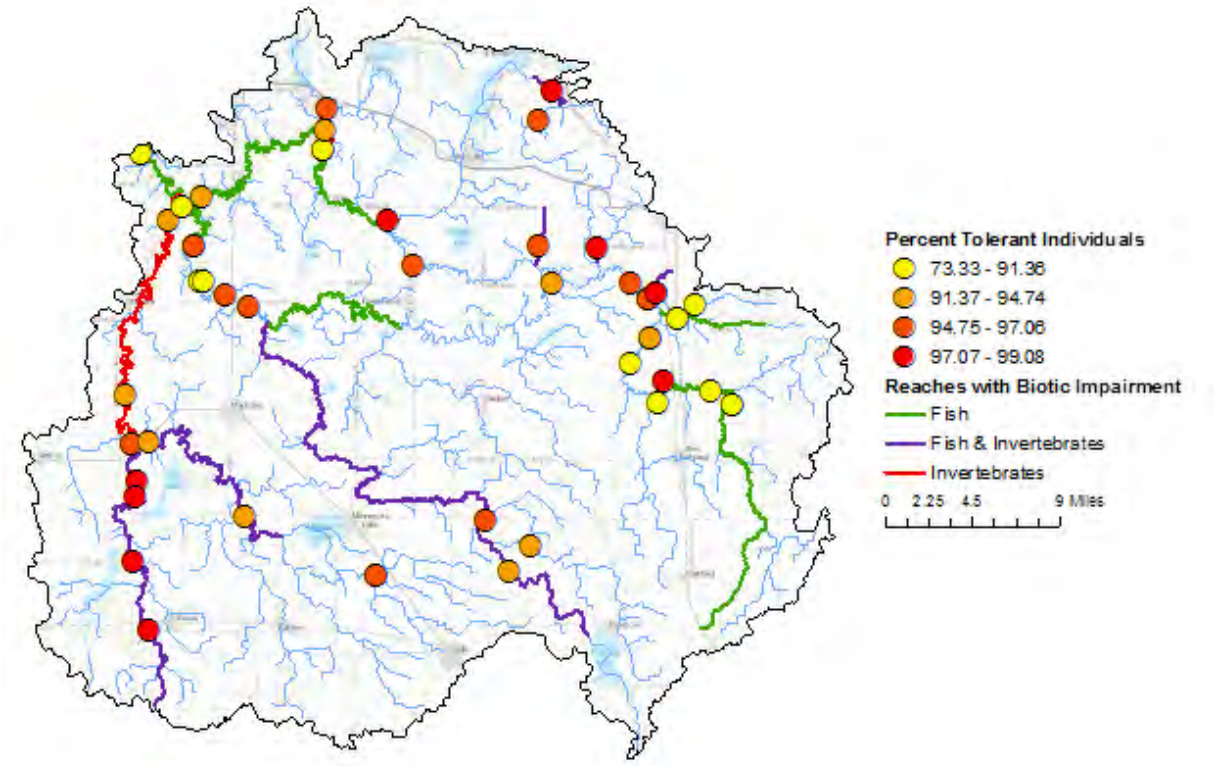

Figure 18. Percent tolerant invertebrate individuals in the natural channels of the Le Sueur River Watershed

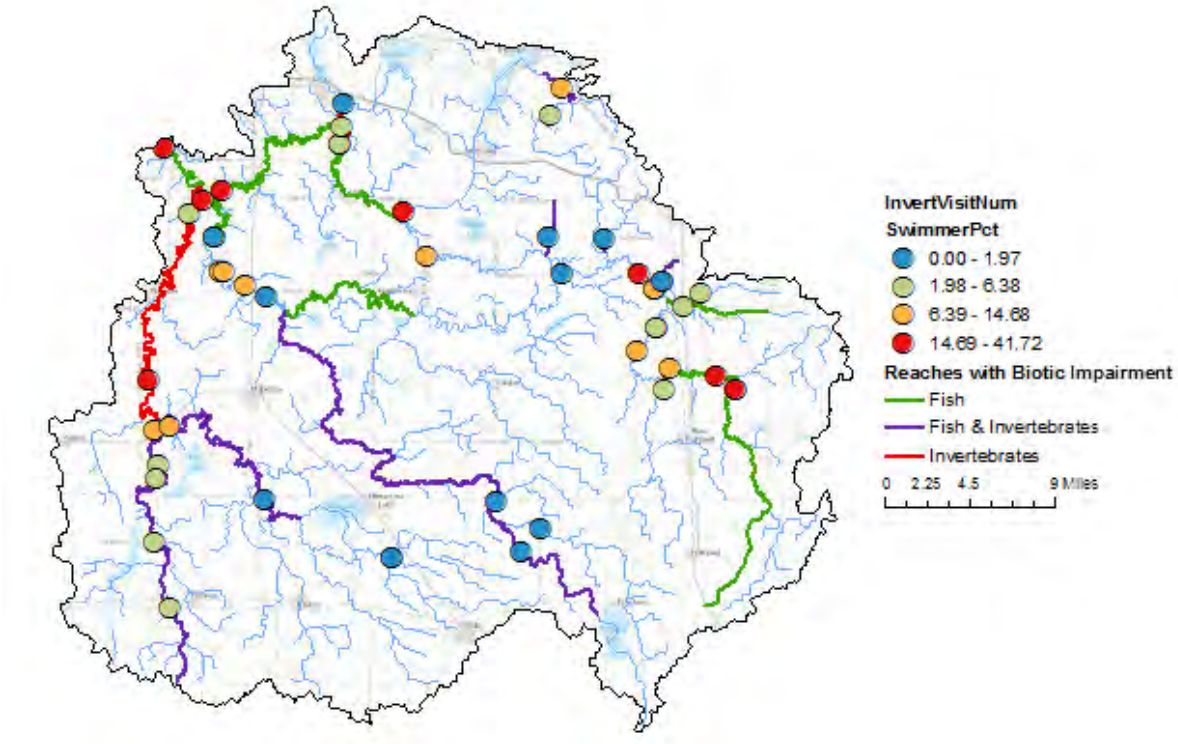

Figure 19. Percentage of invertebrate swimmer individuals in the natural channels of the Le Sueur River Watershed

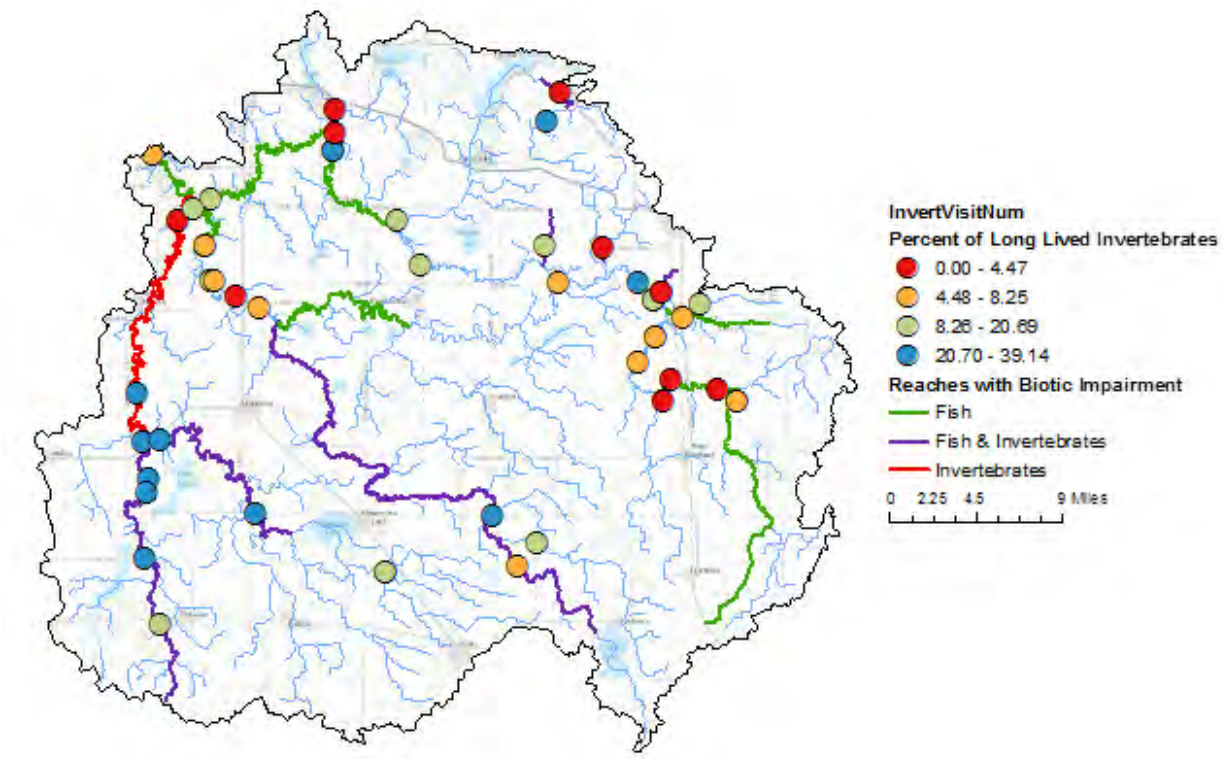

Figure 20. Percentage of long lived invertebrates in the natural channels of the Le Sueur River Watershed

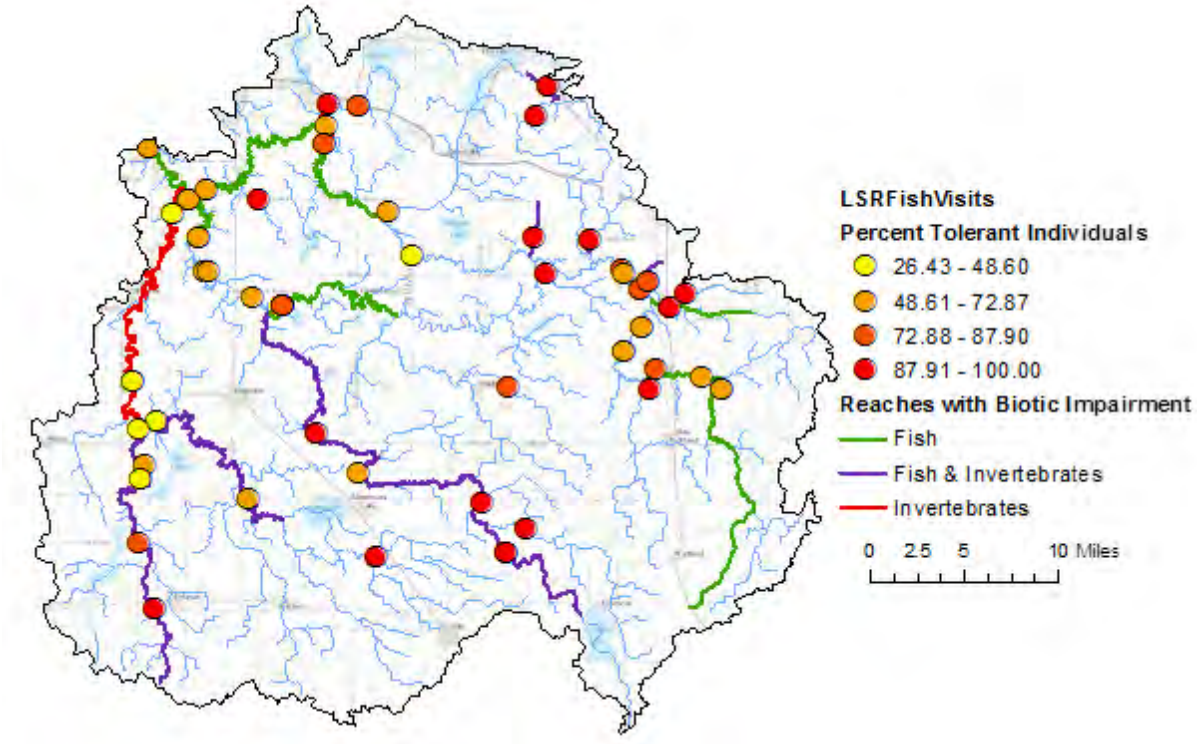

Figure 21. Percent tolerant fish individuals in the natural channels of the Le Sueur River Watershed

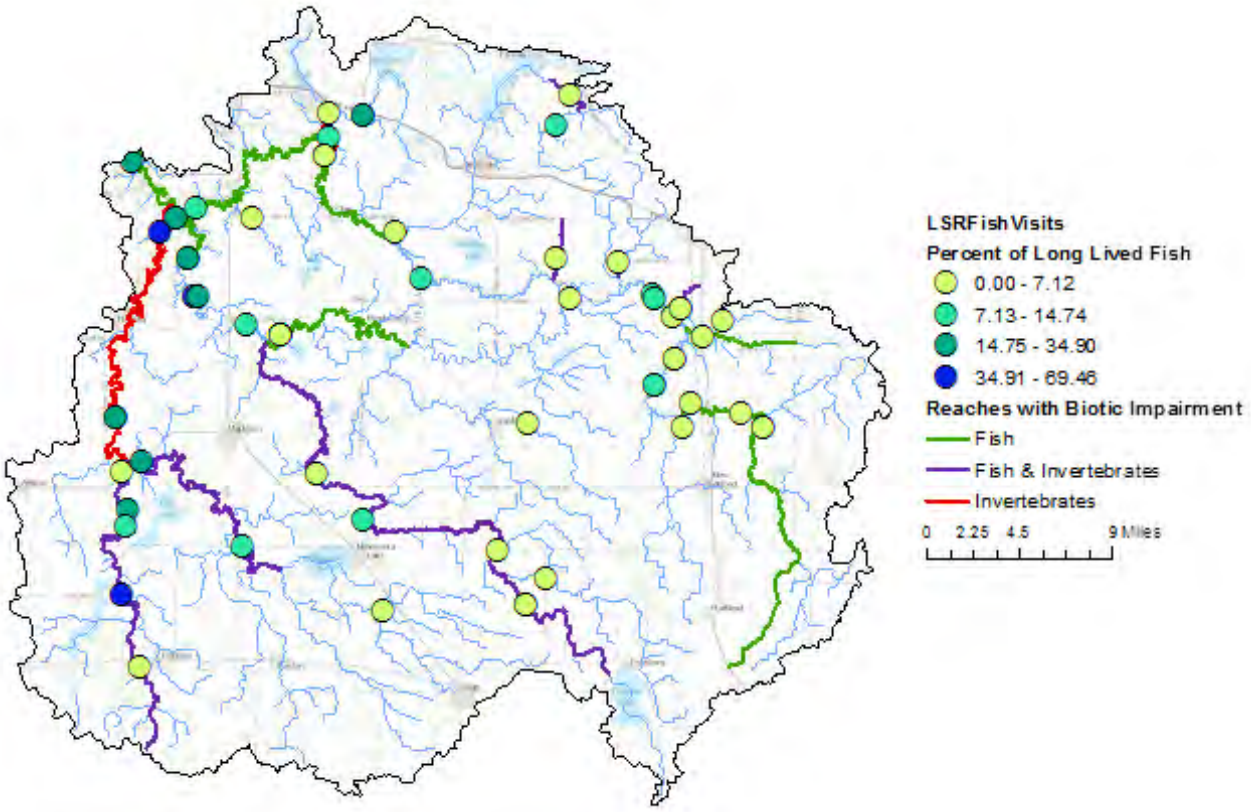

Figure 22. Percent of long lived fish in the natural channels of the Le Sueur River Watershed

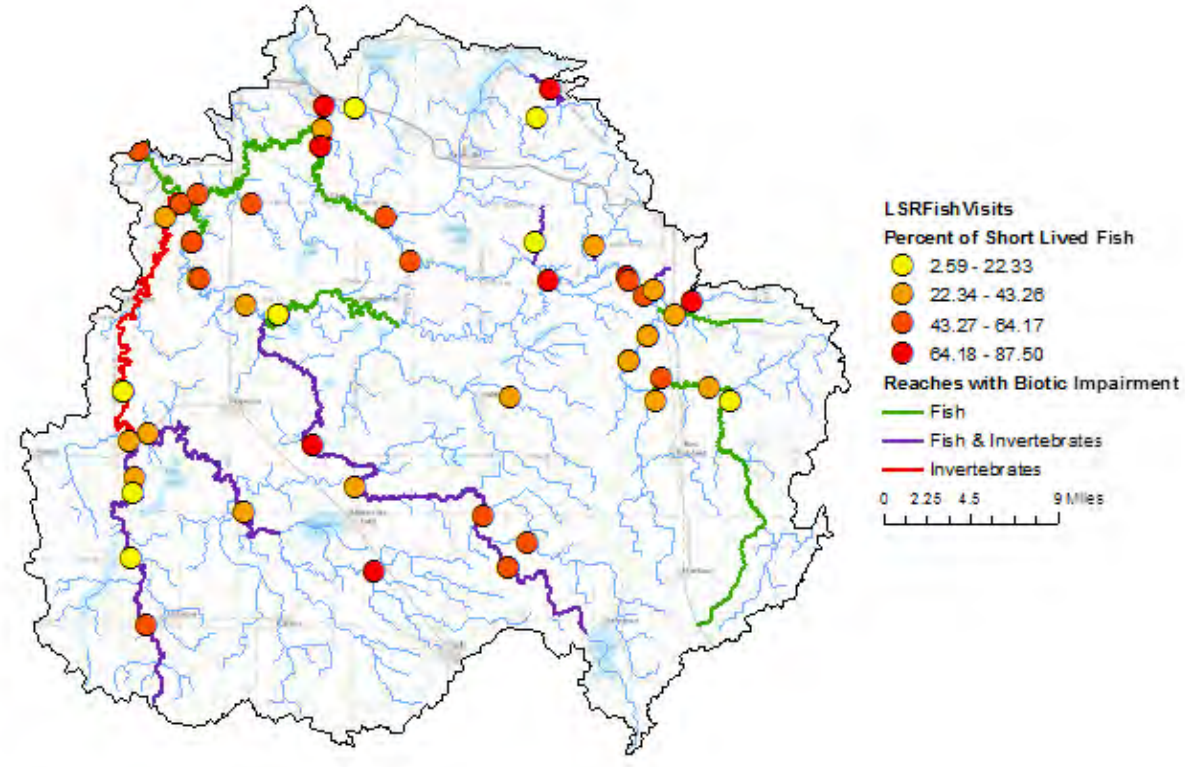

Figure 23. Percentage of short lived fish in the natural channels of the Le Sueur River Watershed

Sources and causal pathways model for altered flow

The Le Sueur River watershed has transitioned from perennial grasses to agricultural landcover, with loss of wetlands and increased channelization of waterways with surface and subsurface drainage. The combination of these landscape altering modifications has led to alteration of the river's hydrologic regime.

Channelization occurred on ditches serving as first and second order streams to larger streams and rivers. The channelized reaches and subsurface tiling serve to route water quickly off the landscape which alters the natural hydrologic regime of the system. Potential for subsurface tiling in the watershed was estimated utilizing a derived 100 meter resolution raster using the following criteria: 2009 United States Department of Agriculuture (USDA) Crop Data for row crops (corn, sweet corn, soybeans, dry beans, peas, potatoes, sunflowers, sugar beets); USGS National Elevation Dataset, with a 30-meter Digital Elevation Model, and a slope ranging from 0%-3%; and SSURGO soil drainage classes of very poorly drained or poorly drained. The highest estimated tiling occurs in the upper Maple River and Cobb River portions of the watershed (Figure 24).

Additional stream miles have been added to the Le Sueur River watershed since 1855, particularly in the headwater regions that cumulatively affect downstream streams and rivers (Figure 25 and Figure 26). Additional stream miles change numerous facets of the hydrologic regime including timing and magnitude of both high and low flows.

The causes and potential sources for altered flow in the Le Sueur River watershed are modeled at EPA's CADDIS Flow Alteration webpage.

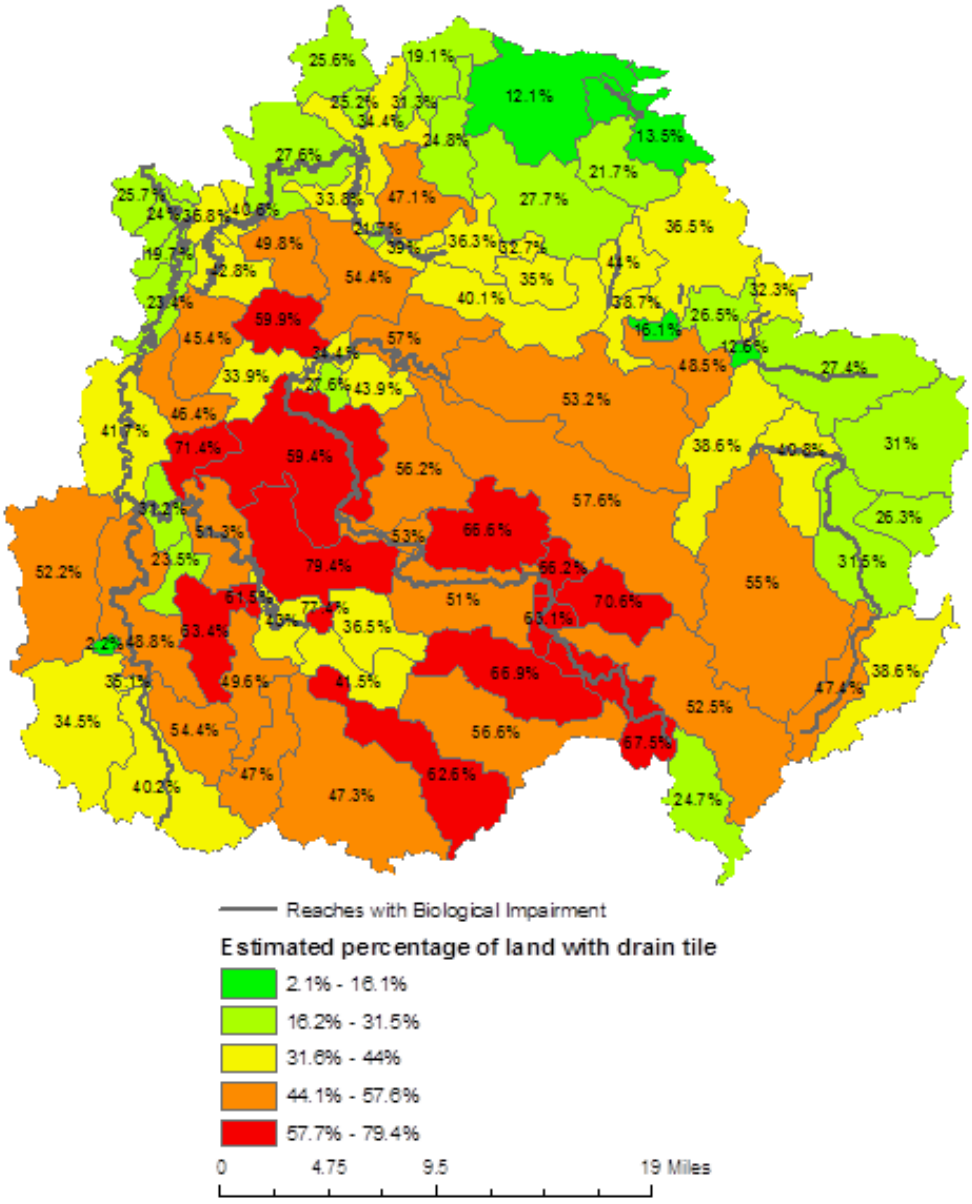

Figure 24. Estimates for potential tile drainage in the Le Sueur River Watershed, by HSPF subwatershed

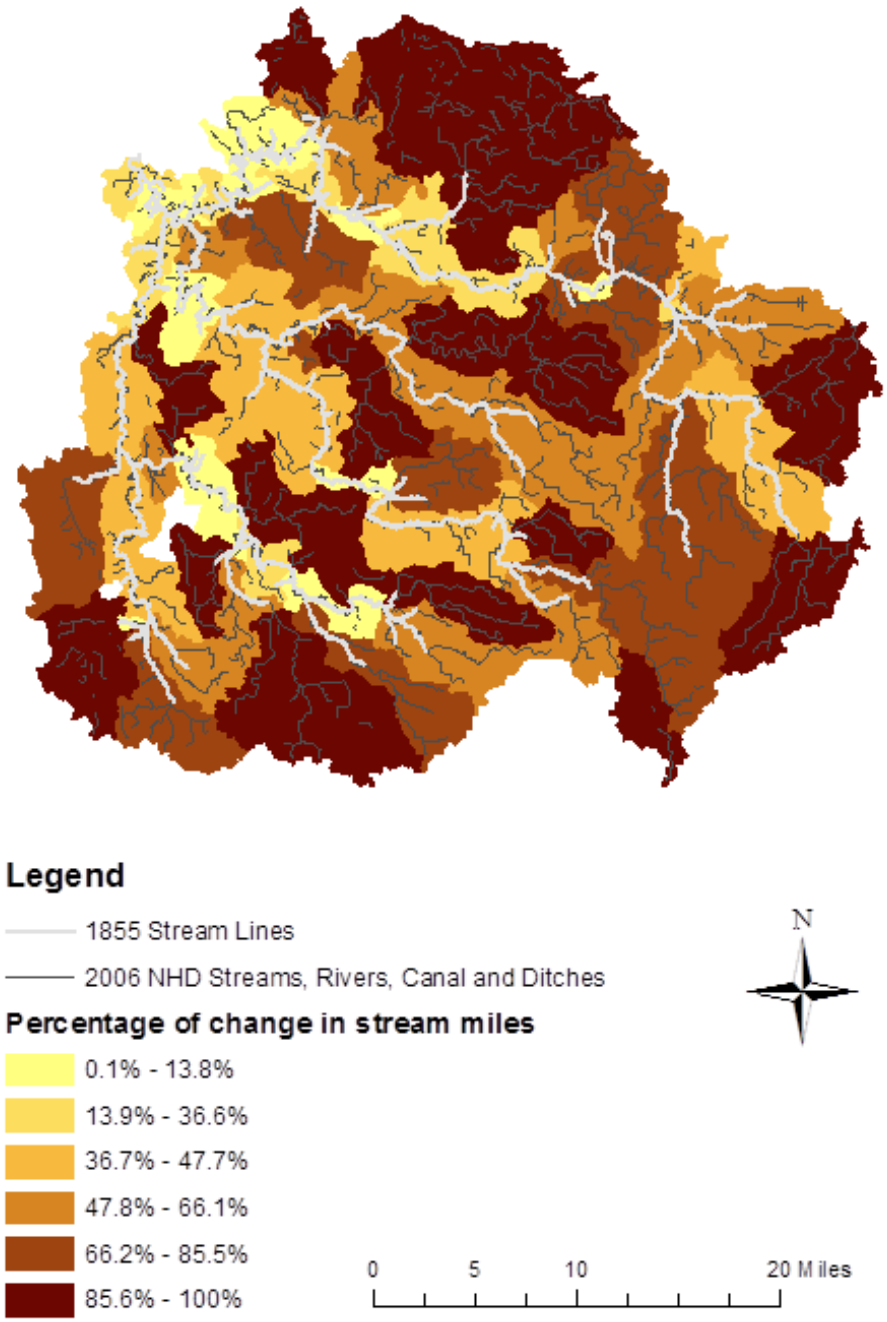

Figure 25. Percentage of change in stream miles by subwatershed (not including upstream changes); comparison of 1855 stream miles to 2006 stream miles (public land survey and National Hydrography Database)

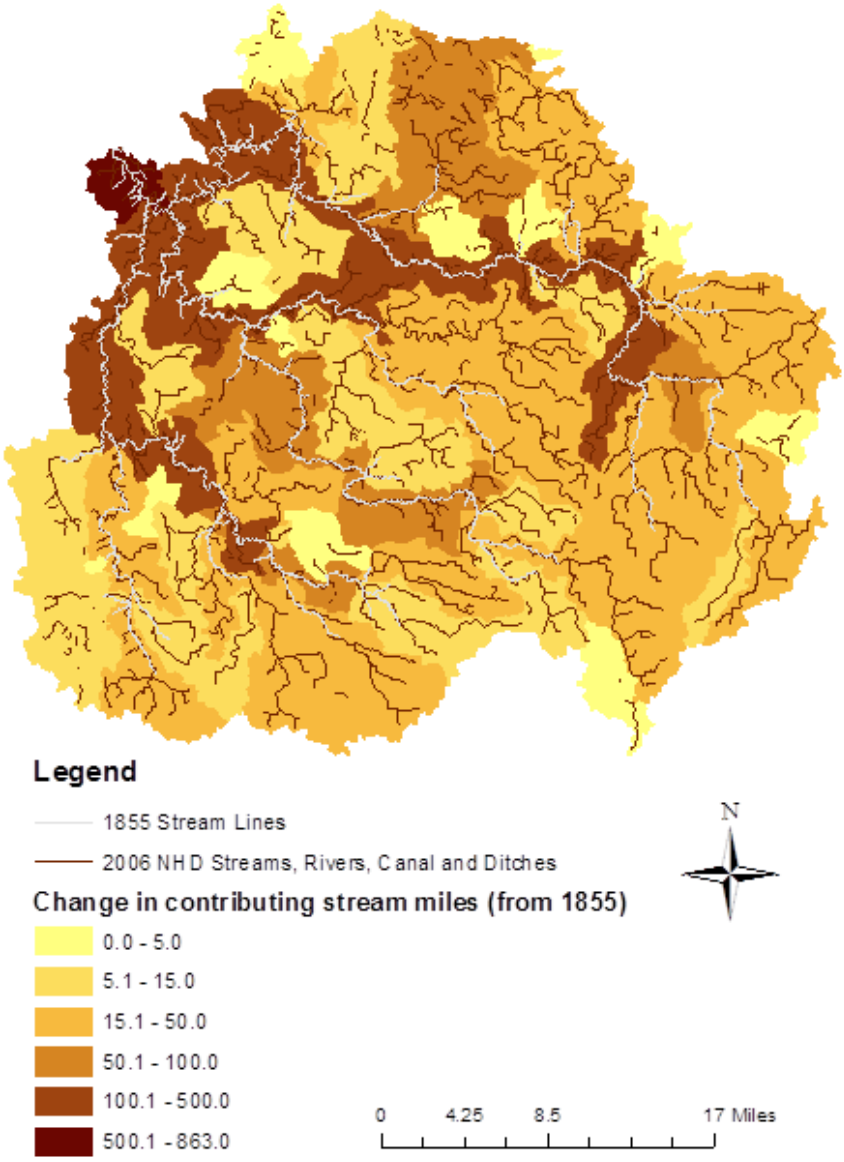

Figure 26. Changes in contributing stream miles by subwatershed in the Le Sueur River Watershed (from 1855 to 2006)

Candidate Causes by Stream Reach

Small tributaries to the Le Sueur River

The tributaries covered in this section are:

07020011-573 Little Le Sueur River
07020011-609 County Ditch 15-2
07020011-558 County Ditch 12
07020011-608 County Ditch 19
07020011-576 Iosco Creek
07020011-522 County Ditch 6
07020011-510 Unnamed Creek

The most of the tributaries directly enter into the Le Sueur River. Iosco Creek is the only small stream that is not a direct tributary, but takes a pathway from Iosco Creek to Lake Elysian to County Ditch 6 to the Le Sueur River. These reaches had not been assessed prior to the 2010 assessment cycle, and there are no additional impairments at this time.

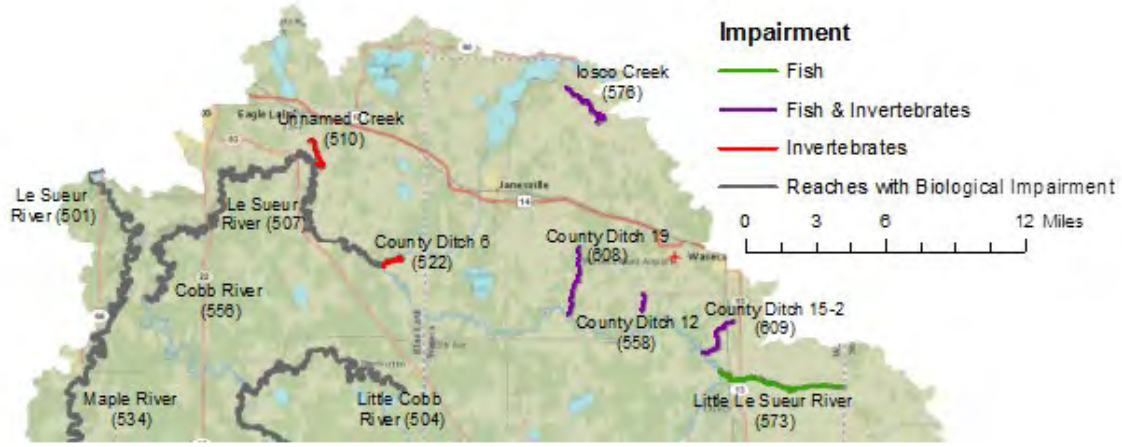

Figure 27. Map of Impaired Tributaries to the Le Sueur River

Biology in the tributaries to the Le Sueur River

The fish communities are impaired in five of the AUIDs: Little Le Sueur River, County Ditch 15-2, County Ditch 12, County Ditch 19, and Iosco Creek. The Southern Headwater fish IBI scores for these impaired reaches ranged from 12 at Iosco Creek to 47 at County Ditch 15-2. Two AUIDs were not impaired for fish: County Ditch 6 and Unnamed Creek. These stations had fish communities that scored above the threshold but within the confidence interval for the Southern Rivers fish IBI, with IBIs of 46 and 49, respectively.

There are similarities in the fish communities (Figure 28). Metrics that scored below the average metric threshold to meet the threshold are: relative abundance (%) of taxa that are detritivorous (DetNWQTxPct), relative abundance (%) of taxa that are generalist feeders (GeneralTxPct), taxa richness of sensitive species and relative abundance (%) of taxa that are very tolerant (VtolTxPct). See Appendix C and D for more information about the IBI metrics. In general, tolerance is an issue for these reaches, as the species present are lacking in sensitive individuals and belong to very tolerant species. There was a high presence of detritivore and generalist species. Generalists refers to fish that are highly adaptable

rather than specializing in one feeding preference. This is advantageous to these fish during extremes in conditions or when resources may be limiting. Detritivores are fish that feed on decaying organic material. An increase in these species may be indicative of an imbalance in nutrients.

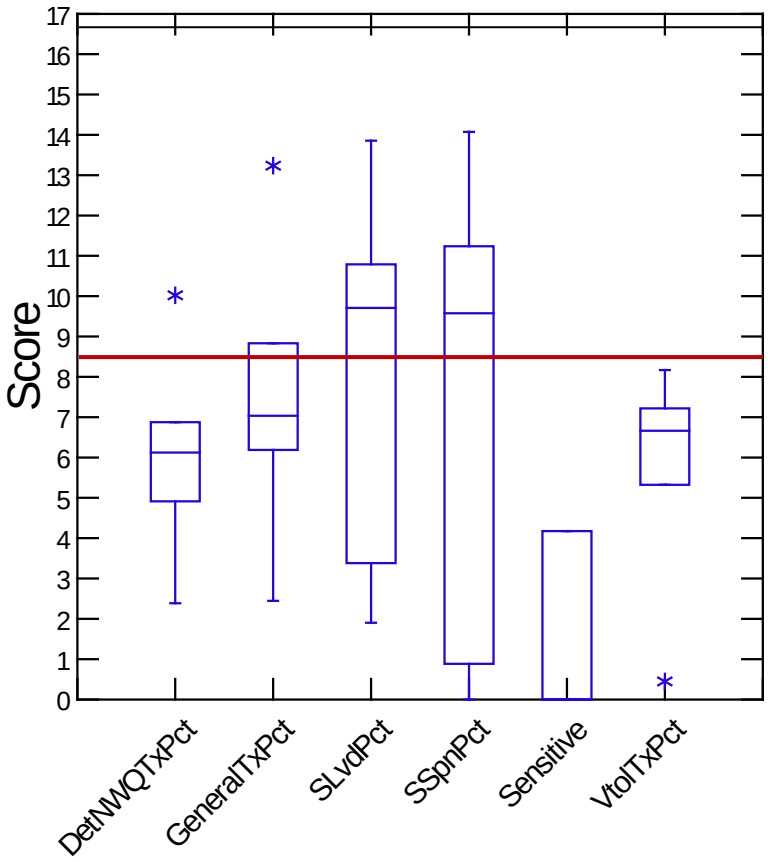

Figure 28. Fish metrics of the Southern Headwater IBI for impaired tributaries to the Le Sueur River; red line indicates the average metric score (8.5) needed for the IBI score to be at the threshold (Stations 08MN027, 08MN051, 08MN020, 08MN049, and 08MN026)

The invertebrate community in the Little Le Sueur River scored above the threshold for the Southern Forest Streams Glide Pool invertebrate IBI and is not impaired for invertebrates. The communities that were impaired for invertebrates were County Ditch 15-2, County Ditch 12, County Ditch 19, Iosco Creek, County Ditch 6, and Unnamed Creek. The Southern Streams Riffle Run IBI scores ranged from 13.7 in County Ditch 12 to 34.26 in Unnamed Creek.

The invertebrates in the impaired reaches of the tributaries to the Le Sueur River also show similarities (Figure 29). There were seven metrics that fall below the average metric score needed to have the IBI score greater than the threshold for impairment. Four metrics were particularly low; taxa richness of Plecoptera (Plecoptera), taxa richness of Trichoptera (Trichoptera), relative percentage of taxa with tolerance values equal to or greater than 6, using MN Tolerance Values (Tolerant2ChTxPct), and taxa richness of predators (Predator). At each of the stations in the tributaries to the Le Sueur River there was a complete lack of stoneflies (Plecoptera). Similarly there was a lower than expected number of caddisfly (Trichoptera) taxa. Station 08MN082, in County Ditch 6, was the only station to have a desirable number of caddisfly taxa (7). The other stations ranged from 1 to 4 caddisfly taxa, all resulting in a metric score less than desirable. The tolerant taxa in these stations ranged from 79.4% to 92.1% of the total taxa. The range of taxa considered predators was only 3 to 7, all below a healthy community balance of predators. This is indicative of a trophic shift in the invertebrate composition.

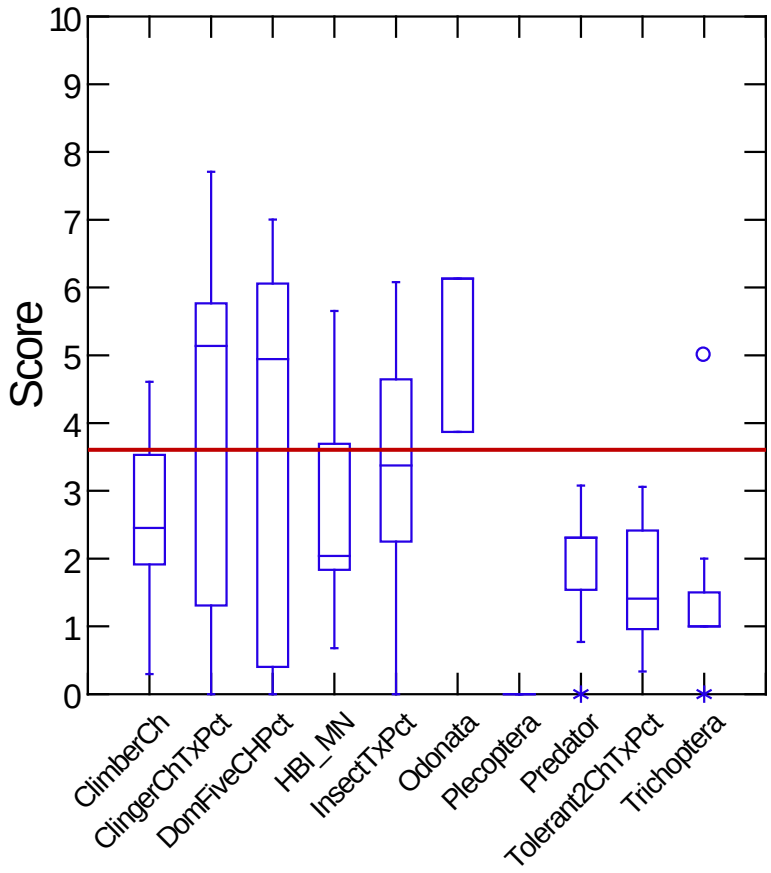

Figure 29. Invertebrate metrics of the Southern Streams RR IBI for impaired tributaries to the Le Sueur River; red line indicates the average metric score (3.6) needed for IBI score to be at the threshold (Stations 08MN051, 08MN020, 08MN049, 08MN026, 08MN082 and 08MN032)

Candidate cause: Low dissolved oxygen

There is limited DO data available for the impaired tributaries to the Le Sueur River to date. The lack of field data limits the ability to consider further or eliminate low DO as a stressor.

The modified Hilsenhoff Index for Minnesota for invertebrates resulted in low metric scores at many of the biological stations. Additionally, fish communities were lacking sensitive taxa and have a larger proportion of taxa that are detritivores. Fathead minnows and creek chub dominate the communities in these tributaries. Fathead minnows are known for their ability to survive in low DO conditions. Low DO may be playing a role in shaping these communities, but more data is needed.

At this time, it is recommended that DO be monitored in these reaches to determine if DO remains at a level sufficient for the biota.

Little Le Sueur River (07020011-573): Diurnal DO measurements taken in 15 minute increments from September 19 to October 4 did not indicate measurements below 5 mg/L in the Little Le Sueur River at County Road 5 and monitoring station 08MN027. The tributary to the Little Le Sueur River, Judicial Ditch (JD) 10, had one measurement of low DO of 4.77 mg/L on August 30, 2010 at 17:58; however, this monitoring station is approximately one mile upstream from the confluence with the Little Le Sueur River and may have rebounded, or it may have been a time of low or discontinued flow for the tributary. The fish community was in the upper quartile of DO aggregate fish scores, indicating that comparatively

to other stations in the Le Sueur River, there is some sensitivity to DO. There is limited data available, but there is no DO information indicating it is a stressor at this time.

County Ditch 15-2 (07020011-609): There were only 4 measurements of DO in CD 15-2. Two samples were taken in both 2008 and 2010 during fish sampling. The additional two samples were taken in the early morning and late afternoon in 2010 to investigate DO flux in the reach. DO was measured at station S006-583 in CD 15-2 at 7.18 mg/L on July 22, 2010 at 4:47pm, and on the following day at 8:05am at 7.75 mg/L. This indicated little flux in DO levels and that DO is likely not an issue. However, the fish community at this station indicated the species that were present are fairly DO tolerant with a station TIV of 6.7 (in the lower half found in the Le Sueur River watershed; Figure 6). In 2008 and 2010, the invertebrate populations in County Ditch 15-2 had a decent taxa count (34 and 27), low percentage of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa (11.8% and 14.8%) and a moderate amount of tolerant taxa (81.5% and 79.4%). The biology suggests that DO could be a potential problem, but there is a lack of measured DO data that does not allow for further analysis of DO in this reach.

County Ditch 12 (07020011-558): The only DO measurement in this reach was taken at station 08MN020 at 1:15 pm on the day of fish sampling, June 26, 2008. The DO measurement was 10.06 mg/L, well above the standard. The fish community at this station indicated the species that were present were neither highly sensitive to DO nor highly tolerant to DO with a station TIV of 7.0 (in the upper half of station scores in the Le Sueur River watershed; Figure 6). The most DO sensitive fish found at this station was blacknose dace; and there was a presence of DO tolerant fish such as brook stickleback and fathead minnows. The invertebrate community comprised of a very low percentage of EPT taxa (6.5%). The tolerant taxa was elevated in 2008 (87%) and the taxa count was very low (17). There are slight biological indications that DO may be a concern, yet findings are inconclusive due to limited data.

County Ditch 19 (07020011-608): Continuous DO measurements taken at station 08MN049 from August 12 to 19, 2011, had no low DO measurements. The daily minimum for DO had a decreasing trend through the period of measurement. The fish community present were neither highly sensitive to DO nor highly tolerant to DO with a station TIV of 6.98 (in the upper half found in the Le Sueur River watershed; Figure 6). The invertebrate community was comprised of 24 taxa; at the statewide average for the same invertebrate class (Southern Streams RR).The invertebrate community at station 08MN049 was dominated by tolerant taxa (88.4%) and had very few relative EPT taxa (9.3%). It is unlikely that DO is a stressor, but the limited data cannot eliminate DO as a potential stressor.

Iosco Creek (07020011-576): Continuous DO measurements taken at station 08MN026, from August 12 to 19, 2011, had no DO measurements below 5 mg/L. The daily minimum for DO had a decreasing trend through the period of measurement. At this station the DO flux was approaching concern with a flux of 4 mg/L. The DO flux was not sustained during the period of measurements, but may still be having an effect. The DO measurements that were made within this watershed at time of fish sampling were above the standard. The average DO TIV for fish at station 08MN026 was 6.1, near the minimum for the watershed (Figure 6). Station 08MN042, upstream on Silver Creek, had a DO TIV of 6.6. There were no low DO measurements in the stream, but the connection to Lake Elysian and the history of winterkills in the lake may also play a role on the response of the fish community in Iosco Creek. The invertebrate community had a slightly lower than state average of EPT taxa (26.7%), and it was comprised of 90% tolerant taxa. Station 08MN026 had a lower taxa count (22) than the average taxa count in stations of the same invertebrate IBI class (Southern Streams RR). Silver Creek, station 08MN042, had a higher taxa count (31). The potential effect of low DO cannot be determined due to insufficient data.

County Ditch 6 (07020011-522): In the AUID upstream DO was found to be below the standard for Class 2 streams at station S000-654 on two occasions; however, that upstream reach is a Class 7 stream (Figure 30). Additionally in the upstream reach, high DO (up to 15.5 mg/L) was also observed.

In a visit in 2011, it was evident that beavers were active within the reach. Beaver activity can alter re-aeration by either increasing or decreasing re-aeration pooling water limits re-aeration but a dam can allow aeration at times. There is also a manmade structure between the upstream station S000-654 and the downstream biological station that may also cause re-aeration.

The fish TIV's for DO support the theory of potential re-aeration (Figure 6). Station 08MN082 has a TIV greater than those stations further upstream (6.98). The invertebrate community at station 08MN082 had a decent number of taxa (25), an elevated percentage of tolerant taxa (92.1%), and high percentage of EPT taxa (36.8%). The biology indicates that there is likely not an issue with DO at the lowest station. Without additional DO measurements, it is difficult to completely rule out.

Figure 30. Locations of downstream stations on County Ditch 6

Unnamed Creek (07020011-510): Station 08MN032 was sampled for fish on July 24, 2008. Prior to sampling that day, at 10:17am, DO was measured at 8.99 mg/L. At this time, it is the only DO measurement. It is unlikely that DO is an issue in this reach based on the diversity of fish species present that would likely be diminished if DO was problematic. The fish community present were neither highly sensitive to DO nor highly tolerant to DO with a station TIV of 6.9 (in the upper half found in the Le Sueur River watershed; Figure 6). The invertebrate community at station 08MN032 had a slightly lower than average percentage of EPT taxa (21.4%). The total invertebrate taxa were decent (25), yet the tolerant taxa were elevated compared to the statewide average (83.3%). The biological community does not rule out DO as a stressor, nor does it strongly support it. Due to the lack of data DO cannot be ruled out as a stressor to the biological community in the Unnamed Creek.

Candidate cause: High phosphorus

Total phosphorus ranged from 0.053 to 0.28 mg/L at time of fish sampling in the tributaries. Only three stream reaches had phosphorus greater than the draft standard of 0.15 mg/L.

Phosphorus often has a profound effect through other response stressors such as chlorophyll-a, BOD, and DO flux. There is no available BOD or chlorophyll-a data on these AUIDs at this time to assess the potential influences. There is limited DO data, as discussed in the previous section.

In all of the reaches, there were fewer intolerant invertebrates observed than expected (Figure 31). Along with the low metric scores for the modified Hilsenhoff Index for Minnesota, it is likely that high phosphorus is altering the invertebrate community, yet there is a lack of connecting data to confirm that this is a stressor.

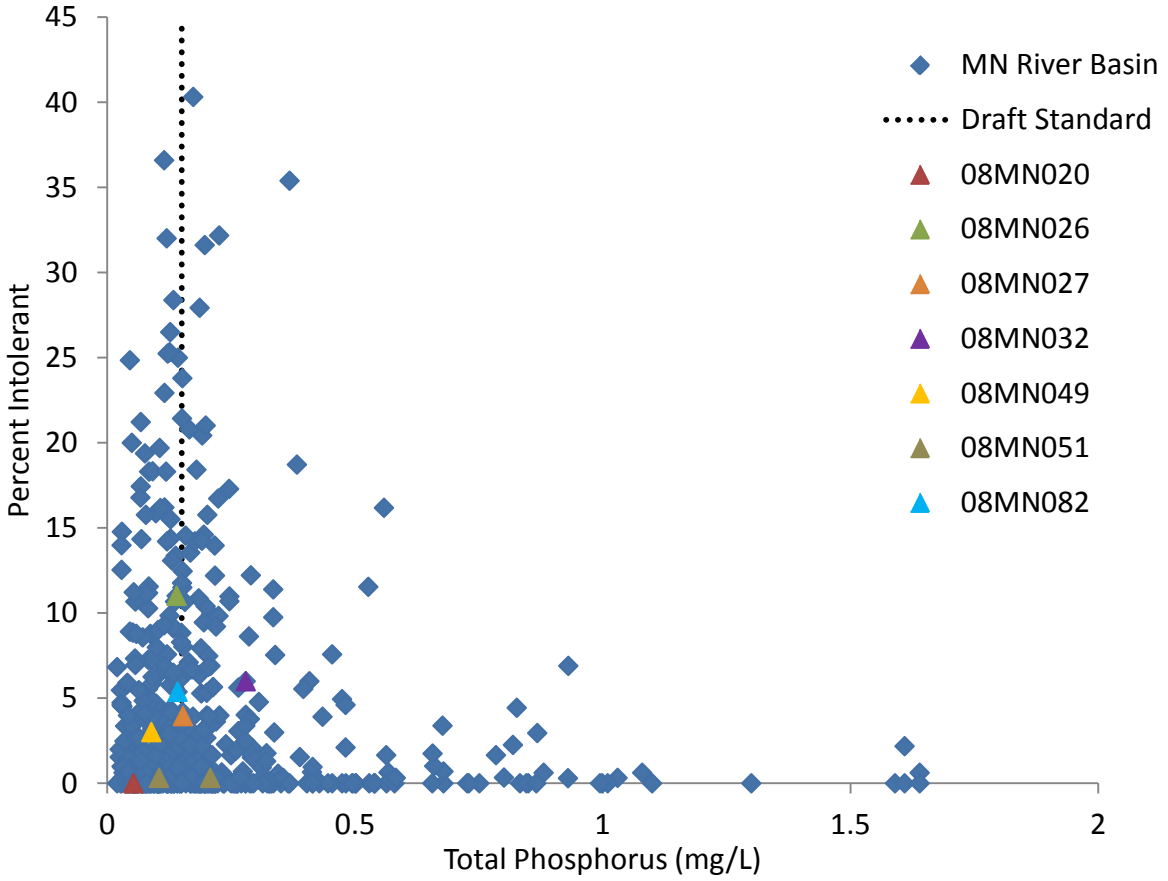

Figure 31. Total phosphorus and percent intolerant invertebrates for the MN River Basin and impaired tributaries of the Le Sueur River.

Little Le Sueur River (07020011-573): The Little Le Sueur at station 08MN027 had a phosphorus level of 0.153 mg/L at the time of fish sampling. HSPF model output (reach 511) shows that 50.7% of the TP daily averages are greater than 0.150 mg/L, from 1996 to 2009.The invertebrate visit resulted in a percent intolerant of only 3.9%. The information available in this reach is inconclusive if elevated phosphorus is a stressor to the biological community.

County Ditch 15-2 (07020011-609): County Ditch 15-2 at station 08MN051 was not found to have elevated phosphorus in 2008, but in 2010, phosphorus was 0.208 mg/L. HSPF model output (reach 531) shows that 57.5% of the TP daily averages are greater than 0.150 mg/L, from 1996 to 2009.The percentage of intolerant invertebrates was less than 1% in both 2008 and 2010. The HBI_MN metric for each invertebrate sampling visit resulted in a moderate metric score, higher than others of the small tributaries to the Le Sueur River. The information available in this reach is inconclusive if elevated phosphorus is a stressor to the biological community.

County Ditch 12 (07020011-558): Station 08MN020 had a low TP level at time of fish sampling (0.053 mg/L). HSPF model output (reach 551) shows that 100% of the TP daily averages are greater than 0.150 mg/L, from 1996 to 2009.The intolerant invertebrates were completely absent. The information available in this reach is inconclusive if elevated phosphorus is a stressor to the biological community.

County Ditch 19 (07020011-608): Total phosphorus was low at the time of fish sampling in County Ditch 19 (0.089 mg/L). HSPF model output (reach 591) shows that 43.8% of the TP daily averages are greater than 0.150 mg/L, from 1996 to 2009.The percentage of intolerant invertebrates was reduced in the stream (3%). The information available in this reach is inconclusive if elevated phosphorus is a stressor to the biological community.

Iosco Creek (07020011-576): At the time of fish sampling, TP was slightly below the draft standard at 0.14 mg/L. HSPF model output (reach 613) shows that 39.7% of the TP daily averages are greater than 0.150 mg/L, from 1996 to 2009. The percentage of intolerant was the highest of the small tributaries to the Le Sueur River (11%). The information available in this reach is inconclusive if elevated phosphorus is a stressor to the biological community.

County Ditch 6 (07020011-522): On County Ditch 6, a chemistry station (S000-654) upstream of the impaired AUID was sampled numerous times in 2008. Total Phosphorus ranged from 0.086 to 0.226 mg/L. Station 08MN082 had a TP level close to the draft standard (0.142 mg/L). HSPF model output (reach 621) shows that 26.8% of the TP daily averages are greater than 0.150 mg/L, from 1996 to 2009. The percentage of intolerant invertebrates was low at the station on this downstream AUID on CD 6 (5.36%). The data connects elevated phosphorus and the impaired biota, but there is limited data at this time.

Unnamed Creek (07020011-510): The highest phosphorus level amongst the small tributaries to the Le Sueur River at time of fish sampling was at the unnamed creek, station 08MN032, with phosphorus near double the draft standard (0.28 mg/L). HSPF model output (reach 679) shows that 21.3% of the TP daily averages are greater than 0.150 mg/L, from 1996 to 2009. Intolerant invertebrates comprised of little of the community in the Unnamed Creek (6%). The data connects elevated phosphorus and the impaired biota, but there is limited data at this time.

Candidate cause: High nitrate

The grab samples taken at the time of fish sampling had nitrate levels from 0.91 to 15 mg/L. The two lowest nitrate samples were taken in locations with greater drainage areas than those with higher nitrate levels and also were taken at dates later in the summer. The seasonality of measured nitrate suggests that these stations may experience higher nitrate at other times in the summer; however it is unknown (Figure 32).

The fish communities in the tributaries to the Le Sueur River lack in sensitive species as well as have an overabundance of very tolerant taxa. Fathead minnows (very tolerant) and creek chub (tolerant) were the most abundant species in the impaired tributaries to the Le Sueur River.

The invertebrates in these reaches have a high prevalence of tolerant taxa, ranging from 79% to 92%, and a complete absence of intolerant taxa as defined by MPCA. Total invertebrate taxa range from 16 to 25, with a Minnesota River Basin average of 21.4. Only two stations were below the basin average for taxa count: station 08MN051 and station 08MN020.

Trichoptera are often considered sensitive to nitrate and respond with decreases in taxa. The number of Trichoptera taxa ranged from one to four at the majority of the biological stations within these tributaries, with seven Trichoptera taxa found at 08MN082 (eight Trichoptera in one station was the highest prevalence found in the Le Sueur River watershed). In the Minnesota River basin, non-hydropsychid Trichoptera generally decrease as nitrate increases for both invertebrate stream classes as shown in Figure 33.

Within the tributaries to the Le Sueur River, less than 6% of the invertebrate population was non-hydropsychid Trichoptera. The two locations with lower nitrate values still had lower percentages of

non-hydropsychid Trichoptera, which may be due to the seasonality of the sample collected, as previously discussed.

The percentage of nitrate tolerant invertebrate individuals ranged from 63.7-96.8%. Only one station in the tributaries to the Le Sueur River had presence of a nitrate intolerant taxon, station 08MN032, in Unnamed Creek. This station also had the lowest percentage of nitrate tolerant invertebrates. All stations had 12 or more taxa considered very tolerant to nitrate. Overall, evidence points to elevated nitrate as a likely stressor for the biological communities in the tributaries to the Le Sueur River.

Little Le Sueur River (07020011-573): On July 21, 2008, nitrate was measured at station 08MN027 with a value of 5.8 mg/L. At station 08MN054 on JD 10, nitrate was found to higher than at the downstream station on the Little Le Sueur River, on July 2, 2008 (11 mg/L). HSPF model output (reach 511) shows that 12.9% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009. At station 08MN027, the tolerant central stonerollers were the second most abundant species. Station 08MN027 had one sensitive species present at the time of sampling in 2008, northern hogsucker. Only two of the sensitive individuals present. Meador and Carlisle do not rank northern hogsuckers as particularly sensitive to nitrate (2007). They had ordinal ranks of eight, with 10 being most tolerant and one most sensitive. Although the invertebrate community is not impaired, there were 74.3% nitrate tolerant invertebrates present at station 08MN027. The information available in this reach is inconclusive if elevated nitrate is a stressor to the biological community.

County Ditch 15-2 (07020011-609): Nitrate was elevated on June 30, 2008 (13 mg/L). In 2010, nitrate was lower, but also sampled later in the season (7.4 mg/L). HSPF model output (reach 531) shows that 14.7% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009. Station 08MN051 had one sensitive species present at the time of sampling in 2008, Iowa darter (and only two individuals). Iowa darters were not on Meador and Carlisle's species list for tolerance values; however Iowa darters are not particularly sensitive to nitrate in Minnesota. For example, they have been found in waters with nitrate greater than 19.0 mg/L (95th percentile). The station was dominated by tolerant fathead minnows (72%). The percentage of nitrate tolerant invertebrates was high with 87.2% in 2008 and 96.8% in 2010. The data connects elevated nitrate as a potential stressor to the impaired biota, but there is limited data at this time.

County Ditch 12 (07020011-558): At station 08MN020, nitrate was elevated on June 26, 2008 (15 mg/L). HSPF model output (reach 551) shows that 44.3% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009. The dominant fish species was tolerant creek chub (33.7%). Creek chub and the other tolerant species comprised of a high percentage of the community (96.3%). Nitrate tolerant invertebrates comprised 93.1% of the invertebrate community at station 08MN020. The data connects elevated nitrate as a potential stressor to the impaired biota, but there is limited data at this time.

*County Ditch 19 (*07020011-608): Nitrate sample was taken at the time of fish sampling on July 3, 2008, and measured 7.7 mg/L. HSPF model output (reach 591) shows that 15.4% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009. The fish in CD 19 were dominated by creek chub and secondarily by fathead minnows. The invertebrate community comprised of 84.9% nitrate tolerant individuals. The information available in this reach is inconclusive if elevated nitrate is a stressor to the biological community.

Iosco Creek (07020011-576): Nitrate was measured at 12 mg/L on July 2, 2008, at station 08MN026. Silver Creek, tributary to Iosco at station 08MN042 had nitrate at 13 mg/L on the same date. HSPF model output (reach 613) shows that 14.8% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009. Station 08MN026 had fathead minnows dominating the community and the second most abundant fish species was the tolerant white suckers; however, there were only five individuals, comprising of about 5% of the community present at the time of sampling. The invertebrate

community was comprised of 64.7% nitrate tolerant individuals. The data connects elevated nitrate as a potential stressor to the impaired biota, but there is limited data at this time.

County Ditch 6 (07020011-522): On County Ditch 6, at the time of fish sampling, August 19, 2008, nitrate levels were low (0.91 mg/L). HSPF model output (reach 621) shows that 5.0% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009. The upstream AUID had nitrate levels as high as 7.4 mg/L on May 5, 2008, indicating that seasonality may be a component in understanding the nitrate within this system. The nitrate sample at the time of fish sampling is not representative of all conditions. The invertebrate community had 77.6% nitrate tolerant individuals at station 08MN082. The data available does not connect elevated nitrate as a stressor to the impaired biota, but there is limited data at this time.

Unnamed Creek (07020011-510): The only nitrate sample was taken on July 24, 2008 at the time of fish sampling at station 08MN032. The nitrate level was low, 1.8 mg/L. HSPF model output (reach 679) shows that 5.4% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009. Station 08MN032 had 63.7% nitrate tolerant invertebrate individuals in 2008. The information available in this reach is inconclusive if elevated nitrate is a stressor to the biological community.

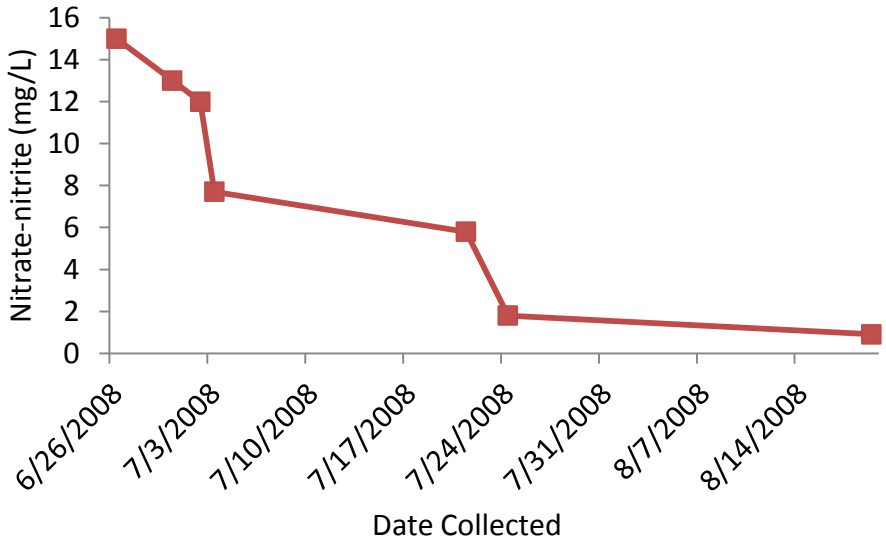

Figure 32. Nitrate results at time of fish sample for biological stations in tributaries to the Le Sueur River in 2008

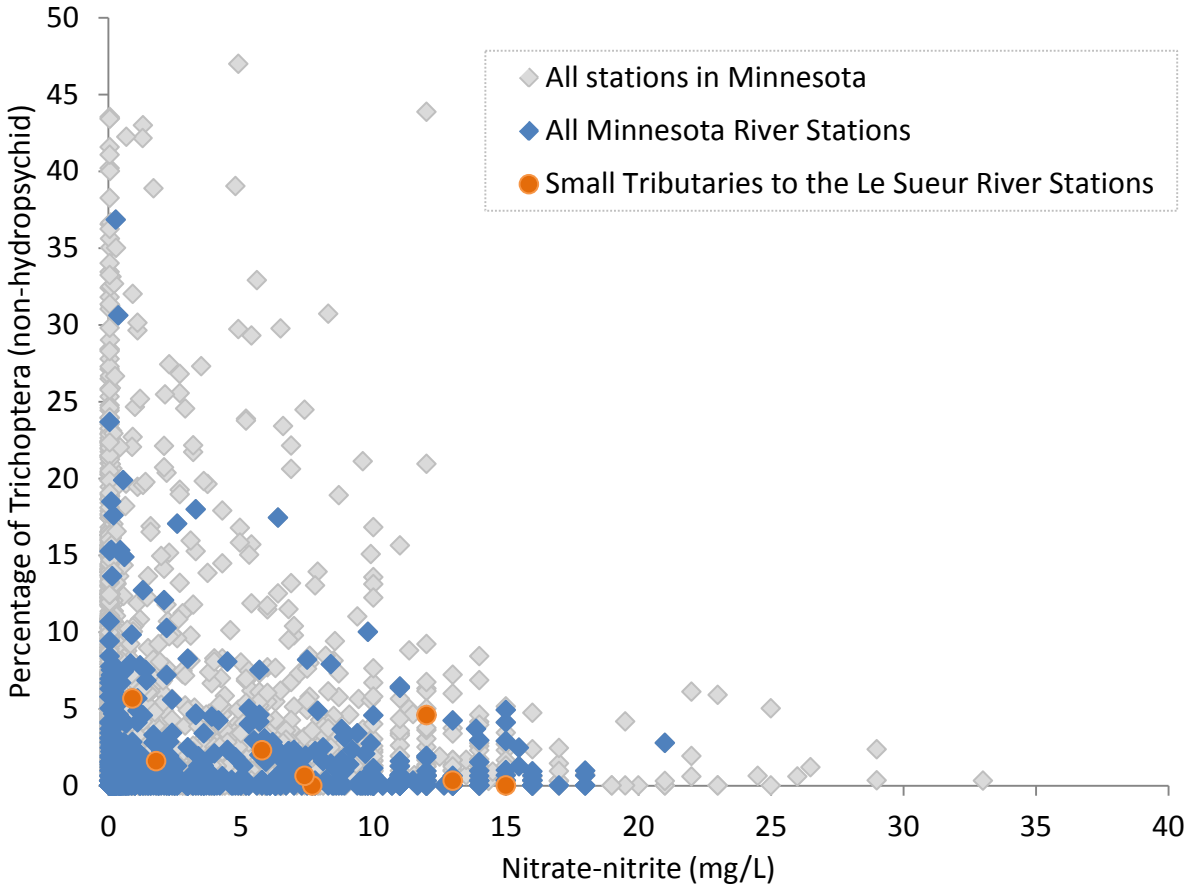

Figure 33. Nitrate with percent Trichoptera (non-hydropsychid) in the Minnesota River Basin and small tributaries to the Le Sueur River

Candidate cause: High suspended sediment

At the time of biological sampling, TSS was not elevated at any of the stations. However, flow conditions were noted as normal or below normal, which is when TSS is not likely to be an issue.

Four station fish visits in the tributaries to the Le Sueur River fell below the average percentage of herbivores for the Le Sueur River Watershed and all but two were below the statewide average (Table 9). As shown in the Aquatic Life Water Quality Standards Draft Technical Support Document for Total Suspended Solids (Turbidity), the percent herbivores have a negative relationship with TSS in the South Region. Benthic feeders also have a sharp decrease in percentile as TSS increases (Markus et al., 2011). All benthic feeders in the stations in the small tributaries of the Le Sueur River were less than 34%, which is lower than the changepoint analysis in the Aquatic Life Water Quality Standards Draft Technical Support Document for Total Suspended Solids (Turbidity) (Markus et al., 2011).

The invertebrates that are adapted to feed by scraping at all stations of the small tributaries to the Le Sueur River were below the Le Sueur River watershed average for those stations that scored above the threshold for Class 5 (Table 10). These invertebrates are often reduced with elevated TSS levels. Additionally, collector-filterers are reduced when TSS is elevated (Markus, 2011). Invertebrates that are collector-filterers collect their food by filtering it out of the water column. The percentage of collector-filterers in the small tributaries to the Le Sueur River ranged from 3.1% to 36%. Long lived invertebrates are often reduced with increases in TSS. For the stations discussed below the percentage of long lived invertebrates ranged in percentages from 1.0% to 12.3%.

With a lack of sediment data it is difficult to rule out suspended sediment or consider it further as a potential stressor. TSS data for a range of flows should be collected in these tributaries to discern the impacts to the biota.

Little Le Sueur River (07020011-573): Total Suspended Solids at the time of fish sampling, July 21, 2008, was low (18 mg/L). The transparency tube at the same time read 44 cm (good). HSPF model output (reach 511) shows that 9% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009. The Little Le Sueur River is currently only impaired for fish, and due to the high number of herbivores it is difficult to connect to a potentially elevated TSS to the fish impairment. However, the invertebrate community was comprised of a low percentage of scrapers (6.25%) and a low percentage of collector-filters (10.2%). In 2008, there were a moderate percentage of long lived invertebrates (8.2%). The data available does not connect elevated turbidity or TSS as a stressor to the impaired biota, but there is limited data at this time.

County Ditch 15-2 (07020011-609): Total Suspended Solids was low on June 30, 2008 and August 19, 2010 (5.6 and 8.4 mg/L). Both transparency readings on these dates were excellent (78 and 66 cm). HSPF model output (reach 531) shows that 8.6% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009. In 2008, station 08MN051 had the lowest percentage of herbivores and the lowest percentage of scrapers for the small tributaries to the Le Sueur River (Table 9 and Table 10). Additionally, station 08MN051 had the lowest percentage of collector-filters of the small tributaries to the Le Sueur River (3.1%) in 2010. In 2008, collector-filterers were also low at 12.2%. CD 15-2 had a very low percentage of long lived invertebrates (1.3%). TSS may have been low with the normal and below normal flow conditions during which the TSS samples were taken, but the biology signals an issue with TSS. The information available in this reach is inconclusive if elevated turbidity or TSS is a stressor to the biological community.

County Ditch 12 (07020011-558): Station 08MN020 had low TSS at the time of fish sampling on June 26, 2008 (11 mg/L), along with an excellent transparency tube reading (>100 cm). HSPF model output (reach 551) shows that 8.6% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009. CD 12 had both a high percentage of herbivores and a relatively higher percentage of scrapers and of collector-filters. The percentage of long lived invertebrates was the lowest of the stations in the small tributaries to the Le Sueur River (1.0%). The data available does not connect elevated turbidity or TSS as a stressor to the impaired biota, but there is limited data at this time.

County Ditch 19 (07020011-608): Station 08MN049 had low TSS at the time of fish sampling on July 3, 2008 (8.8 mg/L). Additionally, the transparency tube was excellent at that time (72 cm). HSPF model output (reach 591) shows that 6.3% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009. The percentage of herbivores in CD 19 was near the average for the watershed in the same stream classes as the small tributaries to the Le Sueur River (9.68%; Table 9). CD 19 had a low percentage of scrapers present in 2008 (3%; Table 10). The percentage of collector-filterers was decent (30%), as well as a moderate percentage of long lived invertebrates (9.3%). The data available does not connect elevated turbidity or TSS as a stressor to the impaired biota, but there is limited data at this time.

Iosco Creek (07020011-576): TSS was low and transparency was good on July 2, 2008, at the time of fish sampling (12 mg/L and 50 cm). HSPF model output (reach 613) shows that 9.2% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009. Iosco Creek had a low percentage of herbivores and moderate percentage of scrapers (5.21% and 16.51%). Station 08MN026 also had a moderate percentage of collector-filterers (26.9%) and a low percentage of long lived invertebrates (3.1%). The data available does not connect elevated turbidity or TSS as a stressor to the impaired biota, but there is limited data at this time.

County Ditch 6 (07020011-522): Station S000-654 on CD 6, upstream of the impaired AUID, was sampled 10 times in 2008. TSS ranged from 6.2 to 22 mg/L. Stream transparency ranged from 20 to 72 cm, with a median of 24 cm. The median stream transparency fell in lower portion the fair range (20 – 40 cm) and was close to the poor range (<20 cm). Under lower flow conditions in small streams and rivers, transparencies in the fair range may indicate water quality problems (MPCA, 2006). At station 08MN082 transparency was good at the time of fish sampling on August 19, 2008 (42 cm). TSS was also low on that date at station 08MN082 (11 mg/L). HSPF model output (reach 621) shows that 10.5% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009. Station 08MN082 had a low percentage of herbivores as well as a low percentage of scrapers in 2008. The collector-filters at the downstream station of CD 6 were moderately low (20.2%). The information available in this reach is inconclusive if elevated turbidity or TSS is a stressor to the biological community.

Unnamed Creek (07020011-510): Station 08MN032 had moderate TSS on July 24, 2008 (28 mg/L). Transparency tube was only 22 cm on the same date, approaching the poor category. Total Suspended Volatile Solids (TSVS) was the highest at this station of the stations on the small tributaries to the Le Sueur River. The transparency may not be sediment driven but rather algal drive, as the phosphorus was also very high at the time of fish sampling (flow was noted as normal). HSPF model output (reach 679) shows that 8.7% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009. The percentage of scrapers at station 08MN032 was low, but the percentage of collector-filterers was relatively high – highest of the stations on the small tributaries to the Le Sueur River (36%). The information available in this reach is inconclusive if elevated turbidity or TSS is a stressor to the biological community.

Table 9. The percentage of herbivores in the tributaries to the Le Sueur River

Station	Visit	Stream Name	Percent of Herbivores
08MN051	6/30/08	County Ditch 15-2	2.87
08MN026	7/2/08	Iosco Creek	5.21
08MN032	7/24/08	Unnamed Creek	6.05
08MN082	8/19/08	County Ditch 6	7.29
Le Sueur River Watershed Average for Classes 2 and 3			*9.67*
08MN049	7/3/08	County Ditch 19	9.68
MN River Basin Wide Average for Classes 2 and 3			*12.60*
08MN051	8/19/10	County Ditch 15-2	14.97
Statewide Average for Classes 2 and 3			*16.80*
08MN020	6/26/08	County Ditch 12	18.41
08MN027	7/21/08	Little Le Sueur River	31.03

Table 10. Percentage of scrapers in tributaries to the Le Sueur River compared to averages

Station	Visit	Stream Name	Percentage of Scrapers
08MN051	8/13/08	County Ditch 15-2	2.88
08MN049	8/14/08	County Ditch 19	3.00
08MN027	8/13/08	Little Le Sueur River	6.25

Station	Visit	Stream Name	Percentage of Scrapers
08MN032	8/27/08	Unnamed Creek	6.94
08MN082	8/21/08	County Ditch 6	8.20
08MN051	8/25/10	County Ditch 15-2	8.75
Le Sueur River Watershed Average for Class 5 (below IBI threshold)			*11.87*
MN River Basin Wide Average for Class 5			*15.04*
Le Sueur River Watershed Wide Average for Class 5			*15.67*
08MN026	8/21/08	Iosco Creek	16.51
08MN020	8/14/08	County Ditch 12	18.18
Le Sueur River Watershed Average for Class 5 (above IBI threshold)			*20.15*

Candidate cause: Lack of habitat

Strong variations in habitat quality exist in the small tributaries of the Le Sueur River.

Little Le Sueur River (07020011-573): Geomorphology surveys were conducted on the Little Le Sueur River at CR 5 and Highway 13. The Little Le Sueur at CR5 is the most upstream geomorphology station on the Little Le Sueur River. This station is classified as an E5 stream type, meaning it has a low width to depth ratio and high sinuosity, with a sand dominated substrate. Upstream, the channel has been channelized. Throughout the longitudinal profile there is evidence of undercut banks and a stream in transition. The riparian area consists primarily of dense reed canary grass. An E5 stream has very high sensitivity to disturbance with good recovery potential. The sediment supply is moderate with high stream bank erosion potential. One bank assessed utilizing the BEHI and NBS methods had an estimated 0.0029 tons/year/foot of eroding stream bank. Figure 34 shows more information about this site.

The Little Le Sueur at State Highway 13 geomorphology station is two miles downstream of CR 5 and is co-located with biological station 08MN027. This station is classified as a G5c stream type, an entrenched gully. Bed features in G streams are often unstable with degrading step/pool morphology. Lower in-stream and overhead cover, pool quality, habitat and diversity are found in G channels versus a C or E channel. The sensitivity to disturbance is extreme and recovery potential is very poor. Both sediment supply and stream bank erosion potential are high. Utilizing the BEHI and NBS methods, estimated bank erosion was 0.002 tons/year/foot within this reach. Vegetation plays a significant role in influencing the width/depth ratio for channel stability. Figure 35 shows more information about this site.

The Little Le Sueur River at biological station 08MN027 scored 53.9 on the MSHA (fair). It scored low due to lacking subcategory scores of substrate and channel morphology. There was little riffle present in the biological reach (5%) with lack of diverse substrate types. Under the bridge there is a riffle that appears to have been created by the bridge construction (Figure 36). The channel stability was low and channel development poor. Erosion is severe on outside bends, even though riparian vegetation appears healthy in some areas (Figure 37).

The fish community was reflective of the habitat condition present. Simple lithophilic spawners have a tendency to decrease with a decrease in substrate score of the MSHA. The wedge shape of data in Figure 38 shows the decrease in these simple lithophilic spawners as the substrate score decreases. Those locations that have low simple lithophilic spawners, yet better substrate scores, may be lacking due to other reasons other than poor substrate. At station 08MN027 it is clear that the lack of adequate

substrate has influenced the fish community present. Along with the lack of bed variability which allows for less specialists, accordingly the percent generalists in this reach was 66%. There was sufficient overhanging vegetation and woody debris for the invertebrate community; but in particular, the substrate and lack of features is a stressor to the fish community.

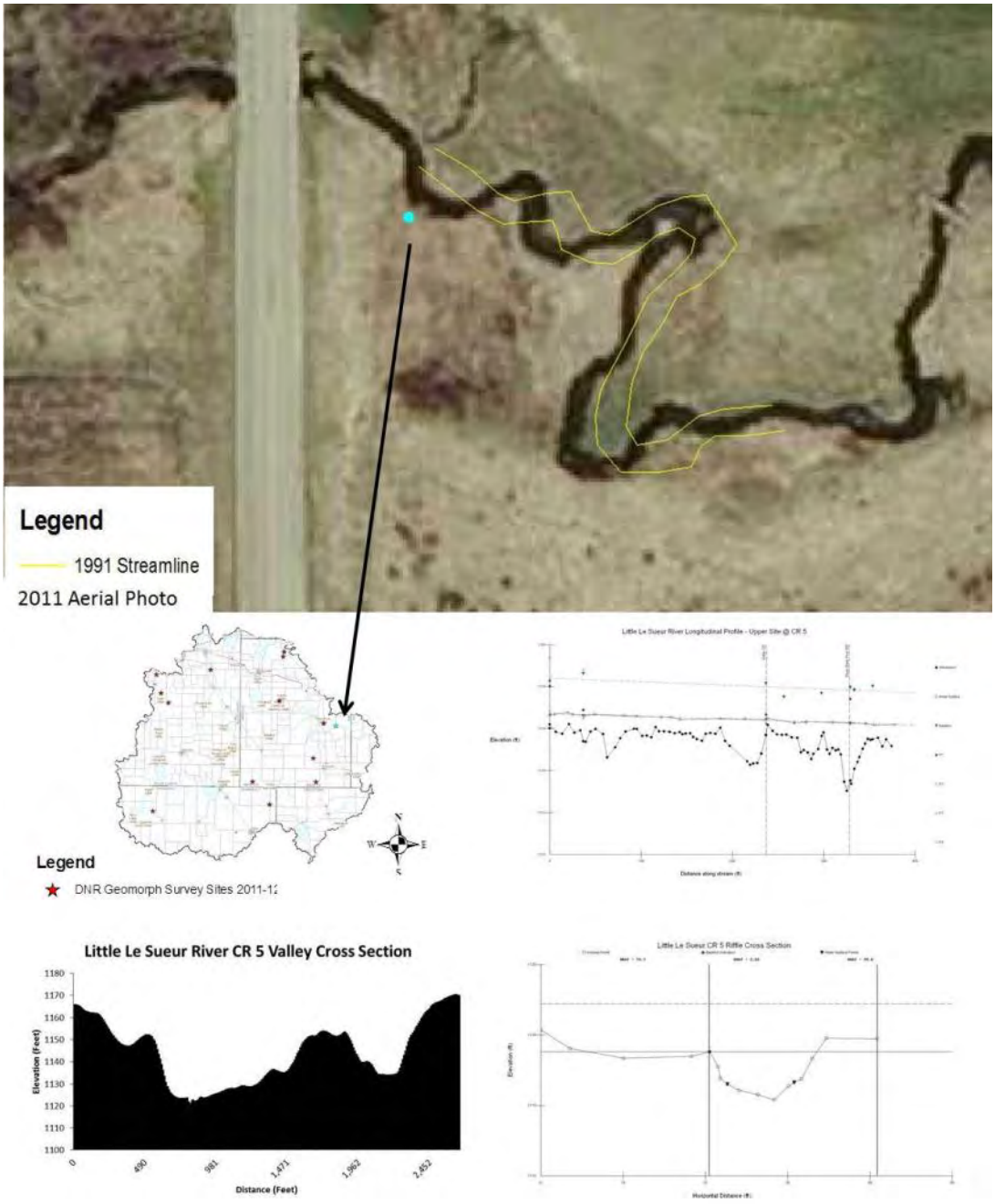

Figure 34. Location of the Little Le Sueur River site with aerial photo, LiDAR derived valley cross section, actual surveyed longitudinal profile and cross section. The yellow line on the aerial photo is the 1991 stream line to show how the reach has changed from 1991-2011

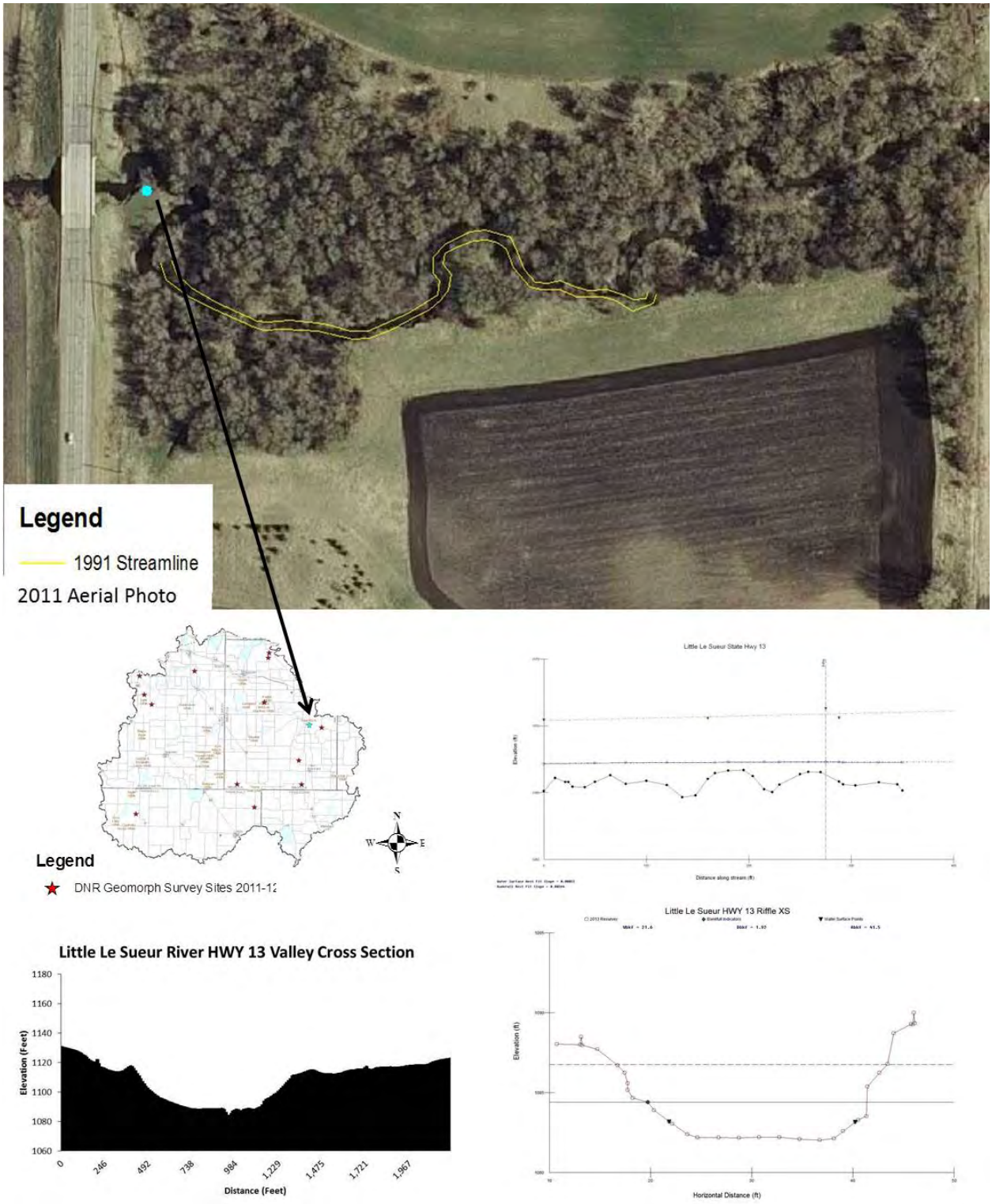

Figure 35. Location of the Little Le Sueur HWY 13 site with aerial photo, LiDAR derived valley cross section, actual surveyed longitudinal profile and cross section. The yellow line on the aerial photo is the 1991 stream line to show how the reach has changed from 1991-2011

Figure 36. Riffle under bridge near biological station 08MN027

Figure 37. Erosion on stream bank near biological station 08MN027

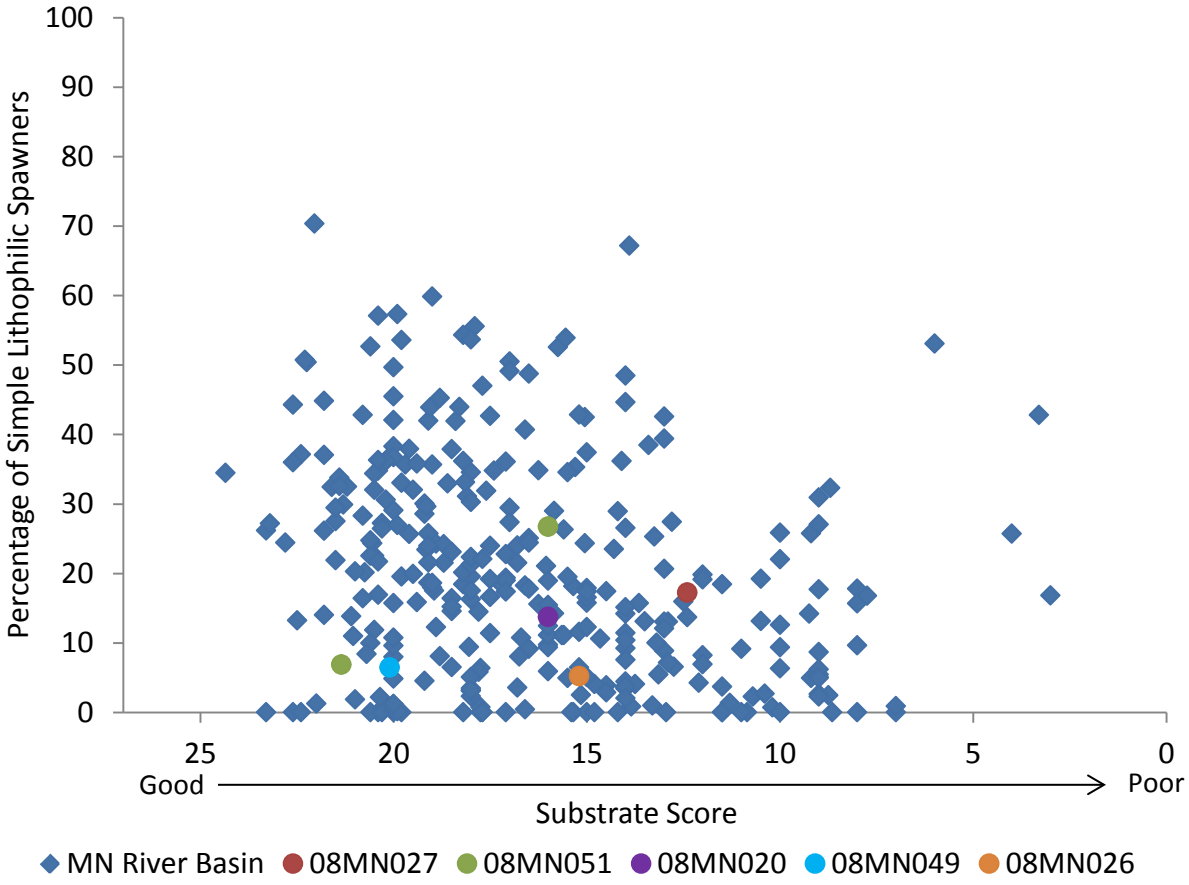

Figure 38. MPCA Stream Habitat Assessment substrate score with percentage of simple lithophilic spawners for the natural channels of the MN River basin and impaired tributaries to the Le Sueur River

County Ditch 15-2 (07020011-609): Station 08MN051 scored quite high on the MSHA relative to other stations in the Le Sueur River watershed, with a score of 80.35 (good) in 2008 and 70.5 (good) in 2010. Many habitat characteristics scored well both years at station 08MN051.

Although the MSHA scores were good, there were a few factors that could improve. The substrate was noted in 2008 as having light embeddedness and in 2010 as having moderate embeddedness; this may be in part due to the low flow conditions in 2010. In 2010, a temperature probe was buried by 6 inches of fine sediment and sand. Changes in bedded sediment may be contributing to the impaired condition. The lack of riffle habitat did not allow for the sampling invertebrates to include rock from riffles or runs. The invertebrate community was lacking climbers but did have sufficient clingers in the reach during 2010 and was reverse in 2008. Both of these metrics respond to changes in habitat.

The fish community had only two taxa representing riffle-dwelling fish (central stoneroller and white sucker); both species are also tolerant. Simple lithophilic spawners comprised of 6.9% of the community in 2008 and 26.8% in 2010. In part the changes in habitat are currently a limiting factor at this station, due to changes in sediment deposition.

County Ditch 12 (07020011-558): In 2008, biological station 08MN020 scored a 65 (fair) on the MSHA. This reach appears to be readjusting in stability. It has eroding banks with mass wasting (Figure 39 and Figure 40). The stream has evidence that it is widening; however the vegetation is allowing for some protection from widening. Many trees appear to have been undercut and fallen into the stream within this reach. The substrate is a mixture of clay and gravel that is likely shifting as the stream tries to regain stability.

This reach lacks simple lithophilic spawners and generalists make up 72% of the fish individuals surveyed in 2008. The invertebrate community was dominated by four generalist taxa: Cheumatopsyche, Physa, Polypedilum, and Oligochaeta (net-spinning caddisflies, snails, midges and worms). All the tolerant individuals comprise of 98% of the sample. Habitat improvements would likely improve the fish and invertebrate communities in this reach.

Figure 39. Photograph of station 08MN020 showing eroding banks.

Figure 40. Photograph of station 08MN020 showing mass wasting of stream bank including tree

County Ditch 19 (07020011-608): Station 08MN049 received a MSHA score of 64.6 (fair). At the road crossing there is a wooden box culvert that may be holding back water and may be a fish barrier under low flow conditions. The channel was found to be in a state of flux when surveyed for invertebrates in 2008, including most banks showing signs of continuing erosion.

Figure 41. Photograph of Station 08MN049 showing erosion, widening and aggradation

The station was part of a geomorphic survey which resulted in the stream classification as a B5c, moderately entrenched with a low width to depth ratio and sand substrate. Intermittent flows likely limit the habitat and diversity in the stream. A B5c stream type has a moderate sensitivity to disturbance with excellent recovery potential. The sediment supply, stream bank erosion potential, and vegetation controlling influence were all moderate compared to other stream types. Utilizing the BEHI and NBS methods, one stream bank had an estimated erosion rate of 0.0252 tons/year/foot. Figure 42 shows more information about this site.

The fish community was dominated by creek chubs and has an abundance of generalists (70%). There was also great number of detritivorous fish present indicating a high level of decaying organic materials. Additionally, there was a low proportion of clinger taxa, resulting in a low metric score for the invertebrate IBI. This is likely due to a lack of habitat and high input of organic materials into the stream, in part due to the erosion/widening and in-channel deposition that was observed in 2008. Another invertebrate metric that often responds to habitat is EPT, as reduced EPT numbers are often correlated with an increase in stress. At station 08MN049, there were only two taxa present, both mayflies, in 2008. There was a complete lack of stoneflies and caddisflies present, resulting in low metric scores for the IBI. The poor habitat is causing stress to the biological community in this reach.

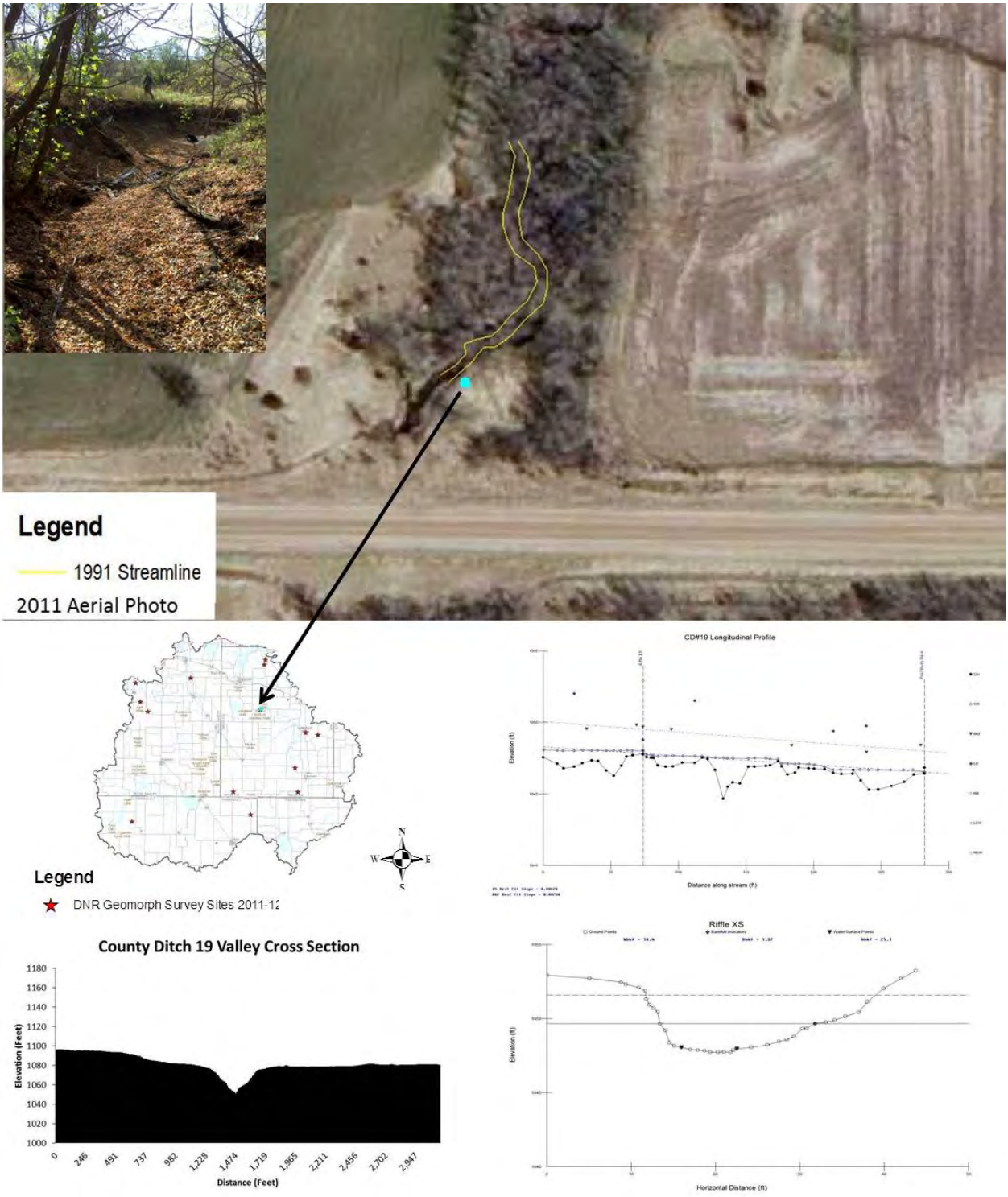

Figure 42. Location of station 08MN049 with aerial photo, LiDAR derived valley cross section, actual surveyed longitudinal profile and cross section. The yellow line on the aerial photo is the 1991 stream line to show how the reach has changed from 1991-2011. Due to tree cover, it was difficult to get representative streamlines for 1991

Iosco Creek (07020011-576): At station 08MN026, a geomorphic survey was completed. The survey reach on Iosco Creek is classified as an E4. The stream flows toward Lake Elysian and is in contact with its floodplain above channel forming, bankfull flows. Stable E streams are a result of extensive riparian

or wetland vegetation along the stream banks. Typically, they are narrow and deep channels. Iosco creek has been channelized in certain areas, as indicated in the air photo below (Figure 43). The E4 stream type has gravel substrate with a very high sensitivity to disturbance, good recovery potential, moderate sediment supply, and high stream bank erosion potential. One stream bank within this reach was assessed for erosion potential using the BEHI and NBS methods at 0.0007 tons/year/foot. Figure 44 shows more information about this site.

The MSHA score for station 08MN026 was 58.7 (fair). It was lacking particularly in the cover and substrate subcategories. The fish community was comprised of slightly more than 5% simple lithophilic spawners (five white sucker individuals). This may be due to the lack of adequate substrate (Figure 38). The community was dominated by tolerant fathead minnows. Iosco Creek biological station and the biological station on the tributary to Iosco Creek, Silver Creek, both scored poorly for the very tolerant metric, meaning a high percentage of very tolerant taxa were present in these stations.

Of the invertebrate taxa at station 08MN026, 27 of 30 were tolerant. Twenty percent of the taxa were non-insects, which is high for this stream type. However, there was also a high percentage of clinger taxa (12 of 30), which are often reduced in numbers when habitat is poor. There was a lack of caddisflies as compared to similar stations of the Southern Streams RR, with only four taxa present which were all clingers and considered tolerant (MN tolerance values greater than 6). There were no stoneflies present at the time of sampling. The degraded biological communities are in part due to a lack of habitat available, but it is not the only stressor present.

Figure 43. Aerial photos in 1951 and 2011 of station 08MN026 in Iosco Creek, note the new ditch through the wetland complex circled in red

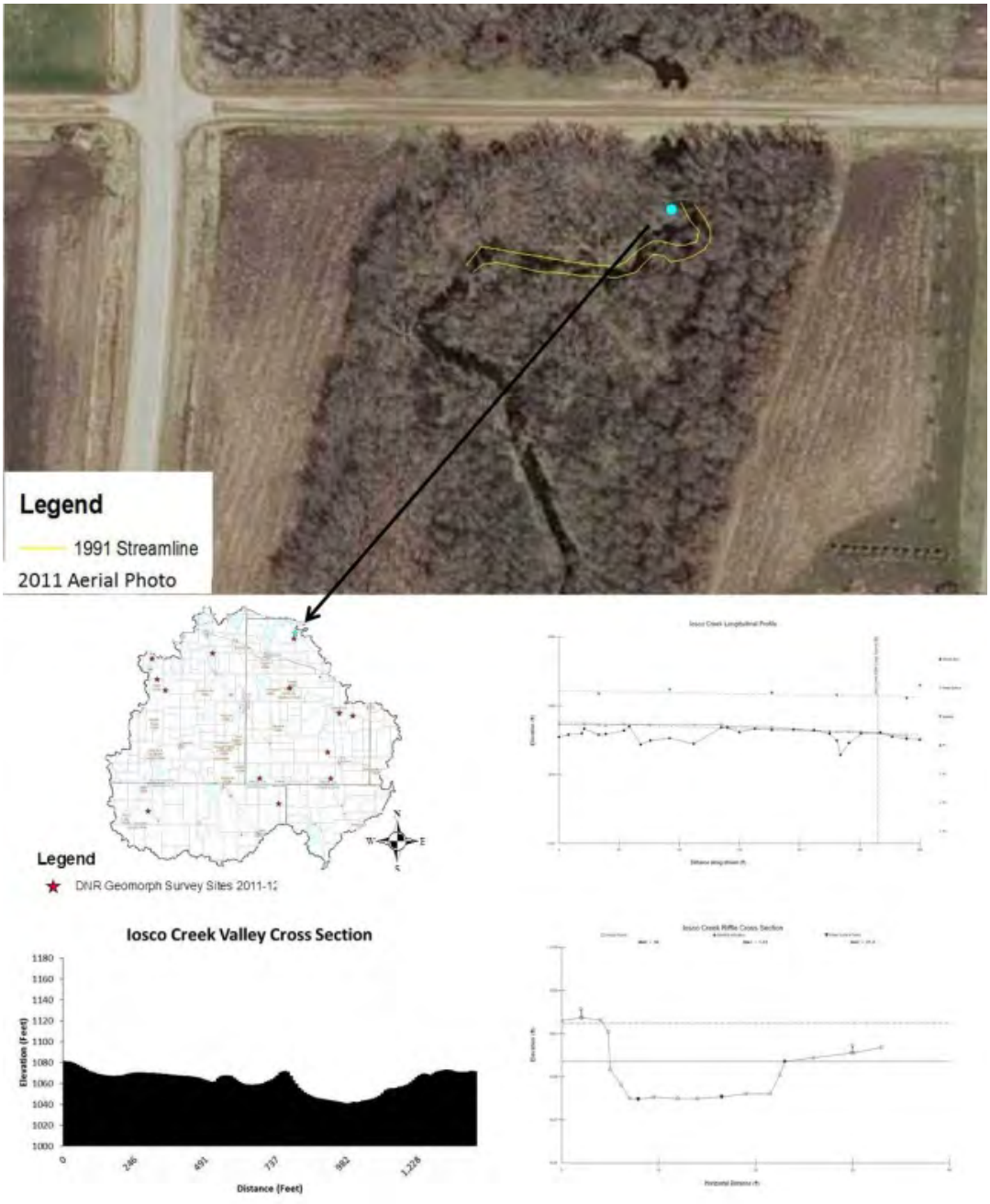

Figure 44. Location of the Iosco Creek site with aerial photo, LiDAR derived valley cross section, actual surveyed longitudinal profile and cross section. The yellow line on the aerial photo is the 1991 stream line to show how the reach has changed from 1991-2011

County Ditch 6 (07020011-522): Station 08MN082, located on CD 6, and received a MSHA score of 75.8 (good). Yet there were some indicators of degraded habitat (Figure 45). At the time of sampling in 2008, a landowner commented that he had observed changes to the stream including a lot of fine cement-like sediment crusted on rocks, and he used to see mussel beds but now does not. Extensive bank erosion is present; some appears 'healed' with vegetative protection and other areas were still exposed. There was also a lateral riffle, an indicator of instability, at the downstream end of the station. The Southern Streams RR invertebrate IBI has two metrics related to habitat, the taxa richness of climbers and the percentage of taxa adapted to cling in swift flowing water. The invertebrate community at station 08MN082 exhibits less climbers (score of 2.5 out 10) than would be expected in this stream class, but

those that cling in swift flowing water were fair (5.5 out of 10 score). Although the MSHA score was relatively good, habitat could be improved in this reach and changes in stream stability should be monitored further. It is unclear if habitat is a stressor in this reach. If it is a stressor, it is likely not the only stressor affecting the invertebrate community.

Figure 45. Photographs from within station 08MN082 healed slump (upper left), (upper right), and middle of reach looking downstream (bottom)

Unnamed Creek (07020011-510): The unnamed creek station 08MN032 scored 68.2 (good) on the MSHA. The surrounding land use was noted as row crop, thus receiving no points for land use, yet scored moderately well on the other four subcategories. Heavy bank erosion was noted on the left bank (Figure 46) and little on the right bank. The habitat that was sampled for invertebrates was snags/woody debris/rootwads and riffle/run/rock. The Southern Streams RR invertebrate IBI has two metrics related to habitat, the taxa richness of climbers and the percentage of taxa adapted to cling in swift flowing water. The invertebrate community in the unnamed creek exhibits slightly less climbers than would be expected (3.5 out 10 score), but those that cling in swift flowing water scored fair for the stream class (6 out 10 score). It seems despite the presence of habitat, the invertebrate community is not thriving. Erosion within this reach should be monitored to evaluate the risk of further degradation to the habitat.

Figure 46. Photographs of station 08MN032 left bank showing heavy erosion (right) and view of reach from downstream end looking upstream (left)

Candidate cause: Lack of connectivity

The only impaired biological reach to have a potential for reduced fish migration and re-colonization is Iosco Creek. Iosco Creek is a tributary to Lake Elysian. The lake has poor water quality and a history of winterkills. The only migratory fish species found in Iosco Creek was white sucker.

County Ditch 6 is the outlet of Lake Elysian, and there were seven migratory fish species at station 08MN082. Upstream of station 08MN082 there is an impoundment (Figure 47). In the stations found upstream of the impoundment one migratory species, white suckers, were surveyed. The impoundment is limiting migratory fish from moving further upstream in CD 6 and to Iosco Creek. Additionally the poor water quality found in Lake Elysian further reduced the re-colonization of diverse fish species into Iosco Creek. The lack of connectivity is one reason that the fish community is degraded.

Figure 47. View of structure on County Ditch 6 from Twp Hwy 111 looking upstream

Weight of evidence

The evidence for each potential stressor, the quantity and quality of each type of evidence, was evaluated. The consistency and credibility of the evidence was also evaluated. Each step for the small tributaries to the Le Sueur River was scored and summarized in Tables 11 through 17. For more information on scoring please see EPA's CADDIS Summary Table of Scores.

Table 11. Weight of evidence table for potential stressors in Little Le Sueur River (-573)

Evidence using data from Little Le Sueur River (-573)						
Types of Evidence	**Scores**					
	Dissolved Oxygen	**Phosphorus**	**Nitrate-Nitrite**	**Suspended Sediment**	**Physical Habitat**	**Altered Hydrology**
Spatial/temporal co-occurrence	0	+	0	---	+	+
Temporal sequence	NE	+	NE	NE	+	++
Field evidence of stressor-response	NE	NE	NE	NE	NE	0
Causal pathway	+	+	+	+	++	++
Evidence of exposure, biological mechanism	0	+	+	0	+	+
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE	NE
Verified or tested predictions	NE	NE	NE	NE	NE	NE
Symptoms	0	+	+	0	+	+
Evidence using data from other systems						
Mechanistically plausible cause	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE
Multiple lines of evidence						
Consistency of evidence	0	0	0	-	+	+
Explanatory power of evidence	0	0	0	0	++	++

Table 12. Weight of evidence table for potential stressors in CD 15-2 (-609)

Evidence using data from County Ditch 15-2 (-609)						
Types of Evidence	**Scores**					
	Dissolved Oxygen	**Phosphorus**	**Nitrate-Nitrite**	**Suspended Sediment**	**Physical Habitat**	**Altered Hydrology**
Spatial/temporal co-occurrence	0	+	+	0	+	+
Temporal sequence	NE	0	+	NE	+	++
Field evidence of stressor-response	NE	NE	NE	NE	NE	0
Causal pathway	0	+	+	+	+	++
Evidence of exposure, biological mechanism	0	+	+	++	+	+
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE	NE
Verified or tested predictions	NE	NE	NE	NE	NE	NE
Symptoms	+	0	+	+	+	+
Evidence using data from other systems						
Mechanistically plausible cause	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE
Multiple lines of evidence						
Consistency of evidence	0	0	+	0	+	+
Explanatory power of evidence	0	0	0	0	0	++

Table 13. Weight of evidence table for potential stressors in CD 12 (-558)

Evidence using data from County Ditch 12 (-558)						
Types of Evidence	**Scores**					
	Dissolved Oxygen	**Phosphorus**	**Nitrate-Nitrite**	**Suspended Sediment**	**Physical Habitat**	**Altered Hydrology**
Spatial/temporal co-occurrence	0	0	+	---	+	+
Temporal sequence	NE	0	+	NE	+	++
Field evidence of stressor-response	NE	NE	NE	NE	NE	0
Causal pathway	0	+	+	+	+	++
Evidence of exposure, biological mechanism	0	+	+	--	++	+
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE	NE
Verified or tested predictions	NE	NE	NE	NE	NE	NE
Symptoms	0	+	+	---	+	+
Evidence using data from other systems						
Mechanistically plausible cause	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE
Multiple lines of evidence						
Consistency of evidence	0	0	+	-	+++	+
Explanatory power of evidence	0	0	0	0	++	++

Table 14. Weight of evidence table for potential stressors in CD 19 (-608)

Evidence using data from County Ditch 19 (-608)						
Types of Evidence	**Scores**					
	Dissolved Oxygen	**Phosphorus**	**Nitrate-Nitrite**	**Suspended Sediment**	**Physical Habitat**	**Altered Hydrology**
Spatial/temporal co-occurrence	0	0	+	---	+	+
Temporal sequence	NE	0	+	NE	+	+
Field evidence of stressor-response	NE	NE	NE	NE	NE	0
Causal pathway	0	+	+	+	+	+
Evidence of exposure, biological mechanism	0	+	+	--	++	+
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE	NE
Verified or tested predictions	NE	NE	NE	NE	NE	NE
Symptoms	0	+	+	---	+	+
Evidence using data from other systems						
Mechanistically plausible cause	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE
Multiple lines of evidence						
Consistency of evidence	0	0	0	-	+++	+
Explanatory power of evidence	0	0	0	0	++	++

Table 15. Weight of evidence table for potential stressors in Iosco Creek (-576)

Evidence using data from Iosco Creek (-576)							
Types of Evidence	**Scores**						
	Dissolved Oxygen	**Phosphorus**	**Nitrate-Nitrite**	**Suspended Sediment**	**Physical Habitat**	**Altered Hydrology**	**Physical Connectivity**
Spatial/temporal co-occurrence	0	0	+	---	+	+	+
Temporal sequence	NE	NE	+	NE	+	++	+
Field evidence of stressor-response	NE	NE	NE	NE	NE	0	NE
Causal pathway	0	NE	+	+	+	++	+
Evidence of exposure, biological mechanism	0	0	+	0	+	+	+
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE	NE	NE
Verified or tested predictions	NE	NE	NE	NE	NE	NE	NE
Symptoms	+	0	+	0	+	+	+
Evidence using data from other systems							
Mechanistically plausible cause	+	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+	++
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE	NE
Multiple lines of evidence							
Consistency of evidence	0	0	+	-	+	+	+
Explanatory power of evidence	0	0	0	0	++	++	++

Table 16. Weight of evidence table for potential stressors in CD 6 (-522)

Evidence using data from County Ditch 6 (-522)						
Types of Evidence	**Scores**					
	Dissolved Oxygen	**Phosphorus**	**Nitrate-Nitrite**	**Suspended Sediment**	**Physical Habitat**	**Altered Hydrology**
Spatial/temporal co-occurrence	0	+	---	0	0	+
Temporal sequence	NE	+	NE	0	0	+
Field evidence of stressor-response	--	NE	NE	NE	NE	0
Causal pathway	+	++	+	+	+	+
Evidence of exposure, biological mechanism	--	+	0	+	+	+
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE	NE
Verified or tested predictions	NE	NE	NE	NE	NE	NE
Symptoms	---	+	0	+	+	+
Evidence using data from other systems						
Mechanistically plausible cause	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE
Multiple lines of evidence						
Consistency of evidence	-	+	-	0	+	+
Explanatory power of evidence	-	0	0	0	0	++

Table 17. Weight of evidence table for potential stressors in Unnamed Creek (-510)

Evidence using data from Unnamed Creek (-510)						
Types of Evidence	**Scores**					
	Dissolved Oxygen	**Phosphorus**	**Nitrate-Nitrite**	**Suspended Sediment**	**Physical Habitat**	**Altered Hydrology**
Spatial/temporal co-occurrence	0	+	0	0	0	+
Temporal sequence	NE	+	NE	0	0	++
Field evidence of stressor-response	NE	NE	NE	NE	NE	0
Causal pathway	0	+	+	+	+	++
Evidence of exposure, biological mechanism	0	+	0	0	+	+
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE	NE
Verified or tested predictions	NE	NE	NE	NE	NE	NE
Symptoms	0	+	0	0	+	+
Evidence using data from other systems						
Mechanistically plausible cause	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE
Multiple lines of evidence						
Consistency of evidence	0	+	0	0	+	+
Explanatory power of evidence	0	+	0	0	0	++

Conclusions

The small tributaries to the Le Sueur River biologically had a lack of sensitive species and an abundance of tolerant taxa for both fish and invertebrates. In general, there is a lack of water chemistry data in the small tributaries to the Le Sueur River. To refine the understanding about the inconclusive stressors, additional data should be collected. Further data about DO, phosphorus, nitrate, and turbidity/TSS information would provide further discernment of these potential stressors. Altered hydrology is a stressor in each of the small tributaries, and lack of habitat is stressor in nearly all of the reaches.

Little Le Sueur River (07020011-573): There is limited data for DO, phosphorus, nitrate and turbidity/TSS. Turbidity/TSS is not a stressor given the limited data available. Dissolved oxygen, phosphorus, and nitrate are inconclusive as potential stressors. It is recommended that additional data be collected. Lack of habitat, in particular poor substrate and lack of features, is a stressor to the fish community in the Little Le Sueur River. Additionally, altered hydrology is source of the habitat alteration and a stressor to the biology.

County Ditch 15-2 (07020011-609): There is limited data for DO, phosphorus, nitrate and turbidity/TSS. Dissolved oxygen, phosphorus, and turbidity/TSS are inconclusive within this reach. Given the little data, nitrate is a stressor to the impaired fish and invertebrate communities. Lack of habitat is a stressor in this reach despite the high MSHA scores. Bedded sediment and deposition are having a role in shaping the invertebrate and fish communities. Altered hydrology is altering the biological community in County Ditch 15-2.

County Ditch 12 (07020011-558): There is limited data for DO, phosphorus, nitrate and turbidity/TSS. Dissolved oxygen and phosphorus are inconclusive within this reach. Given the little data, nitrate is a stressor to the impaired fish and invertebrate communities. Turbidity/TSS is not a stressor given the limited data available. Lack of habitat, due to stream instability, is a stressor to the biological community. Additionally, altered hydrology is source of the habitat alteration and a stressor to the biology.

County Ditch 19 (07020011-608): There is limited data for DO, phosphorus, nitrate and turbidity/TSS. Dissolved oxygen, phosphorus, and nitrate are inconclusive within this reach. Turbidity/TSS is not a stressor given the limited data available. Lack of habitat, due to stream instability, is a stressor to the fish and invertebrate community in County Ditch 19. Additionally, altered hydrology is source of the habitat alteration and a stressor to the biology.

Iosco Creek (07020011-576): There is limited data for DO, phosphorus, nitrate and turbidity/TSS. Dissolved oxygen and phosphorus are inconclusive within this reach. Turbidity/TSS is not a stressor given the limited data available. Given the little data, nitrate is a stressor to the impaired fish and invertebrate communities. Lack of habitat, in particular, poor substrate and lack of in-stream cover, is a stressor to the biological community. Altered hydrology is source of the habitat alteration and a stressor to the biology. This AUID has biological communities that are stressed due to physical barriers or lack of connectivity. The barriers are on downstream connections on County Ditch 6.

County Ditch 6 (07020011-522): There is limited data for DO, phosphorus, nitrate and turbidity/TSS. Turbidity/TSS is inconclusive as a stressor within this reach. Dissolved oxygen and nitrate are not likely issues within this reach, but there is limited DO data. With the limited data, elevated phosphorus is a stressor to the invertebrate community in CD 6. Habitat, in particular stream stability, and altered hydrology are also stressors in CD 6.

Unnamed Creek (07020011-510): There is limited data for DO, phosphorus, nitrate and turbidity/TSS. Dissolved oxygen, nitrate, and turbidity/TSS are inconclusive as stressors within the Unnamed Creek. Although limited data, phosphorus was elevated at the time of fish sampling in 2008, at near double the draft standard (0.28 mg/L). Habitat is moderate, and should be monitored for further erosion. Altered hydrology is an issue with in the Unnamed Creek including the upstream dams.

Le Sueur River (07020011-619)

In 2010, this headwaters reach of the Le Sueur River was listed for aquatic life due to elevated turbidity. In 2012, an impairment of aquatic life was added to the reach due to lack of fish assemblage.

Biology in the Le Sueur River

The Le Sueur River AUID 07020011-619 has four biological stations, three are located on natural reaches (stations 08MN055, 10MN161, and 08MN029) and one is located on a channelized reach (station 07MN057). The AUID is impaired for fish IBI. All visits on natural channel stations, in 2008, scored below the fish IBI threshold for Southern Streams IBI. In 2010, station 08MN055, scored above the threshold but within the confidence interval. This reach did not have fish deformities, eroded fins, lesions, and tumors (DELTs). If DELTs were present they would have contributed negatively to the IBI.

The natural channel stations on this reach have a high percentage of tolerant fish as well as fish that mature in less than two years (MA<2Pct; Figure 48). They were also lacking in taxa that are sensitive (SensitiveTxPct). A high number of taxa found in this reach were short lived (SLvd). Similar to the natural reaches, station 07MN057 was lacking sensitive fish and has a high percentage of very tolerant taxa (Sensitive and VtolTxPct; Table 18). Longitudinally, stations of fish class Southern Streams on the Le Sueur River had metric scores show that the upstream (impaired AUID -619) scores were just slightly lower than downstream scores (unimpaired AUID -620; Figure 49). Throughout these biological stations they show similar responses, this may indicate that although the fish community may not be listed as impaired in the downstream AUID, it may be experiencing some stressors similar to the upstream AUID.

The invertebrate community was not listed as impaired based on 2008 data. In 2010, station 08MN055 scored below the threshold and below the confidence interval while other data in the AUID was above the threshold and within the confidence interval. The habitats sampled were different between the two visits and may explain some the differences observed in the IBI; however, it is difficult to be certain.

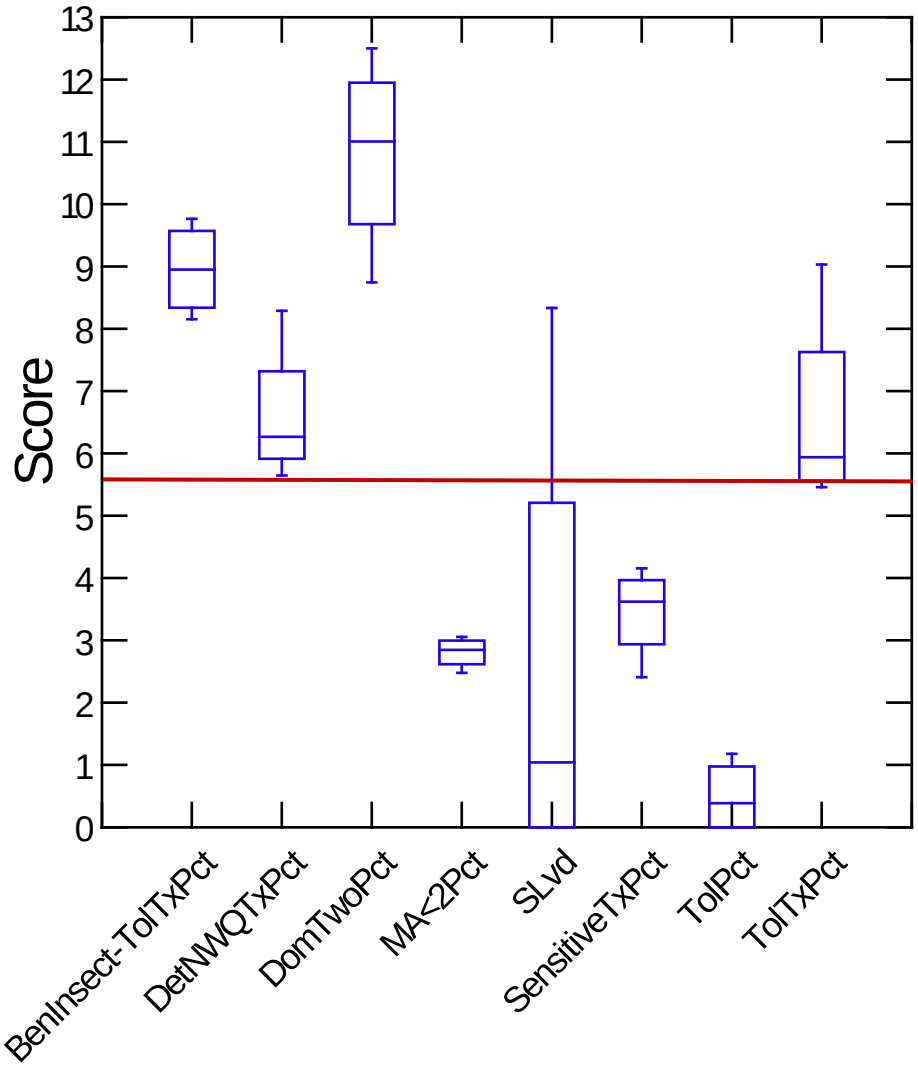

Figure 48. Fish metrics of the Southern Streams IBI for impaired reaches of the Le Sueur River; red line indicates the average metric score (5.6) needed for IBI score to be at the threshold (Stations 08MN055, 10MN161, and 08MN029)

Table 18. 07MN057, channelized reach, fish metrics of the Southern Headwaters IBI

Site	DetNWQTxPct	GeneralTxPct	Sensitive	SLvdPct	SSpnPct	VtolTxPct
07MN057 (avg. of 2 visits; 2007 and 2008)	7.8	9.7	2.1	9.8	15	6.7

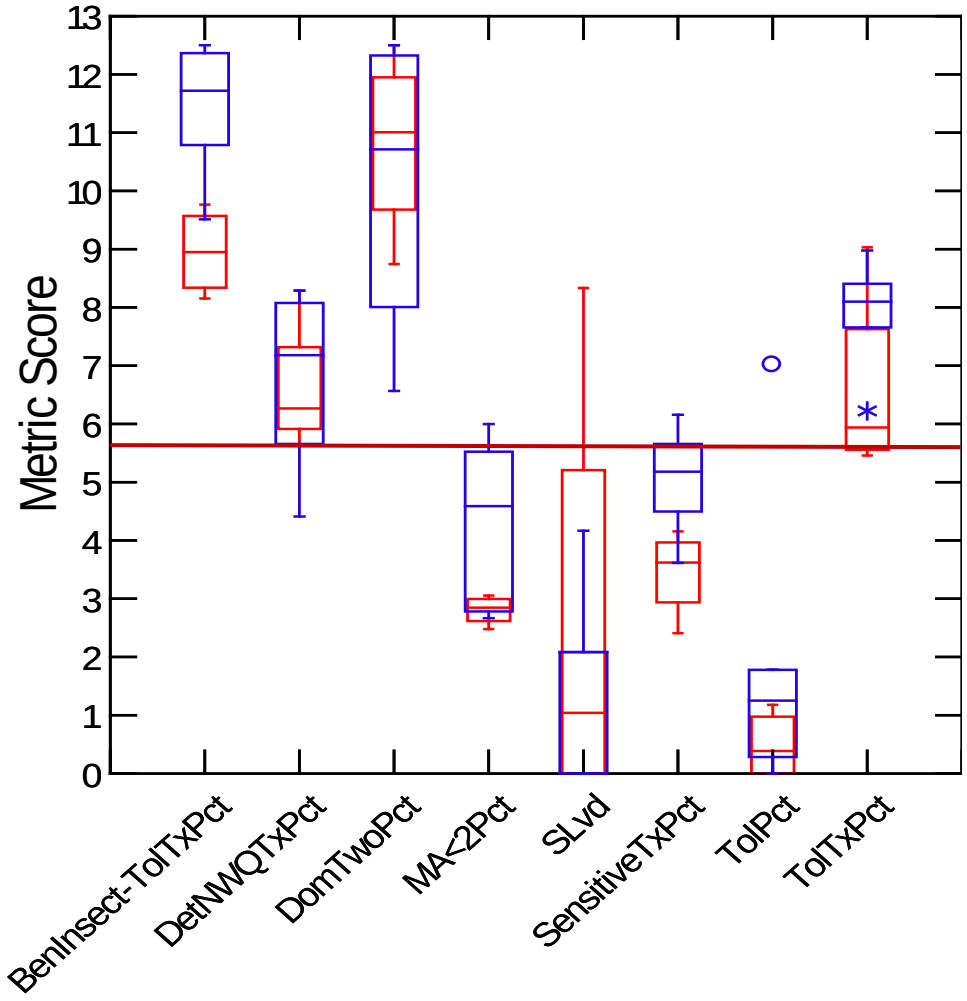

Figure 49. Fish metrics of the Southern Streams IBI for impaired reaches (red boxes; stations 08MN055, 10MN161, and 08MN029) and unimpaired reaches (blue boxes; stations 10MN160, 08MN053, 08MN052, 03MN070, 97MN008, 08MN030, and 08MN048) of the Le Sueur River

Candidate cause: Low dissolved oxygen

Between 3:00 and 4:00 PM on July 22, 2010 DO was measured at five locations on the Le Sueur River, ranging from 7.33 to 7.88 mg/L. The following day, July 23, 2010, between 6:00 and 7:00 AM DO was measured from 7.30 to 7.99 mg/L. These two sampling time frames typically represent the maximum and minimum diurnal patterns. Two additional data points resulted in DO well above the standard in 2010. At the time of fish sampling, DO ranged from 6.72 to 10.8 mg/L during visits in 2007, 2008, and 2010. There is no evidence of low DO or elevated DO flux with the limited data available.

The fish community was comprised of fish that are relatively more sensitive to low DO. The stations in this reach had TIV aggregate scores that were in the upper quartile indicating the relative sensitivity to low DO of the fish community (Figure 6). Due to the intolerance to low DO in the fish community and the lack of low DO and high DO flux, DO is not a stressor to the fish community at this time.

Candidate cause: High phosphorus

Of the seven phosphorus samples taken in this reach (2007 – 2010), only one was greater than the draft standard (Figure 50). HSPF model output at the outlet of the reach (reach 490) shows that 42.2% of the

TP daily averages are greater than 0.150 mg/L, from 1996 to 2009. This reach had a moderate percentage of carnivorous fish (21.5% – 35.6%; Figure 66). As previously mentioned, this reach lacks sensitive fish taxa relative to the total taxa present. The tolerant individuals comprise of 70.6% to 92% of the total fish individuals surveyed, resulting in a low metric score. At the natural channel stations, the non-tolerant benthic insectivores taxa were also present in acceptable percentages (ranging from 26.1% – 31.3% of the number of represented taxa). There was a lack of sensitive taxa compared to the total number of taxa, with sensitive individuals ranging from 1.3% – 5.5% of the surveyed population, but the tolerant taxa do not overwhelm the population. Generalists comprise of over half of the community (51.2% – 60.2%) in the natural channel stations. Station 07MN057 had a higher percentage of generalists in 2007 and 2008 (68.5% and 74.5%).

Due to the low values, lack of data (phosphorus, chlorophyll-a, or BOD) or response such as low DO, and mixed biological response, phosphorus is not currently a stressor to the fish community. It would be recommended to collect additional data to assist with further understanding.

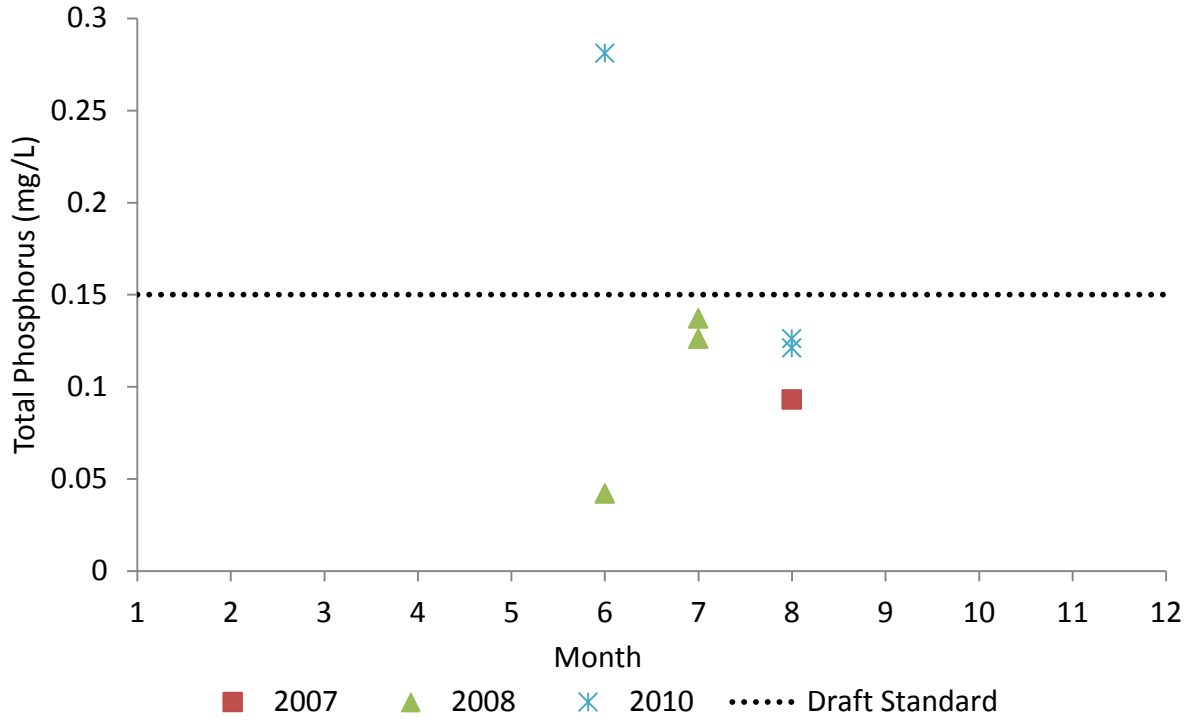

Figure 50. Total phosphorus by month for the Le Sueur River (-619) in 2007, 2008 and 2010

Candidate cause: High nitrate

Nitrate has been sampled for a total of seven times in June, July, and August of 2007, 2008 and 2010. The highest sample was 14 mg/L on June 25, 2008 while the lowest nitrate sample was 0.41 mg/L on August 30, 2010 (Figure 51). The highest observed nitrate levels persist in June and drop through the summer with August having the lowest levels. The mean nitrate was 6.33 mg/L. HSPF model output (reach 490) shows that 15.7% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009. Unionized ammonia is not a concern based on the data available.

In terms of the fish community, stations in this reach were lacking in sensitive taxa which may be indicative of the high nitrate levels. The stations also have fish that are quick to mature and are short-lived. The predominant fish species at all stations was creek chub. Sensitive species taxa found in this

reach were banded darter, northern hogsucker, slenderhead darter, and one stonecat was found at station 08MN055 in 2008. Although these are sensitive species, they are not particularly sensitive to nitrate, as their weighted mean values for nitrate sensitivity are in the upper portion of Minnesota's taxa, with a 5% chance of finding them above 13.4 mg/L nitrate (or higher depending on the species).

Although the invertebrate community is not considered impaired currently, the non-hydropsychid caddisflies comprise less than 2% of the community. These caddisflies can respond to increased nitrate levels. Invertebrate taxa count ranged from 15 to 25 with three of the four samples having taxa counts lower than the Minnesota River Basin average. The number of caddisfly taxa was above the MN River Basin average for three of the four samples. Station 08MN055 had only two caddisfly taxa in 2010. The nitrate tolerance invertebrates comprised of 72.9-80.4% of the communities in this reach, except at station 08MN055 had 43.7% in 2008. Similarly to the nitrate tolerant percentages, the very tolerant invertebrate individuals comprised of greater than 50% of the communities at all stations, except 08MN055 in 2008, which was 25.5%.

With the limited nitrate data available, nitrate is affecting the biological community in this reach. Although only fish are impaired, both fish and invertebrates exhibit responses to the elevated nitrate. However, high nitrate may not be the primary stressor to the fish community.

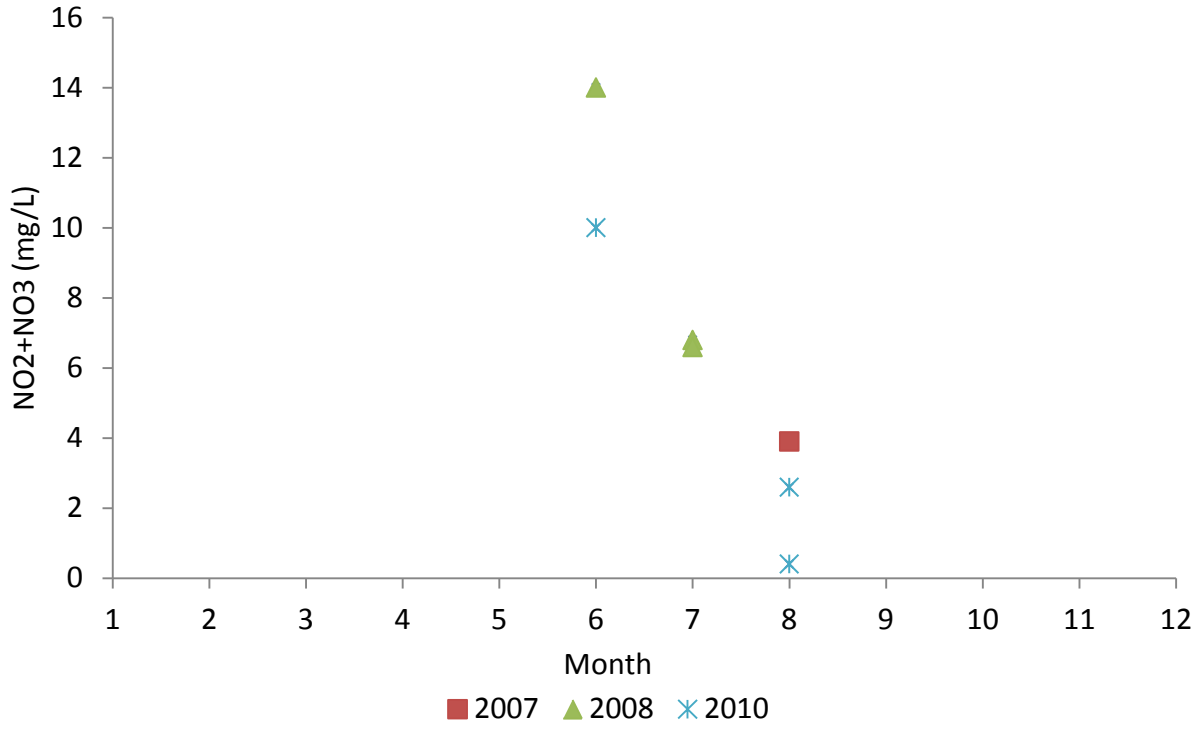

Figure 51. Nitrate measurements collected within the Le Sueur River (-619)

Candidate cause: High Suspended sediment

Total Suspended Solids during the fish visits ranged from 4.4 to 25 mg/L (6 samples from 2007, 2008 and 2010). There was no turbidity or TSVS data for this reach. Transparency data, on July 22 and 23, 2010, reveals that longitudinally through this reach, transparency began in the fair category (above 20 cm) and reduced to the poor category (below 20 cm) after the first two upstream stations (Figure 52). In 2005, transparency at station S003-900 by the citizen stream monitoring program showed that on the dates sampled, many were in the poor category (less than 20 cm; Figure 53). Hydrological Simulation

Program - FORTRAN predicts many months with mean TSS values greater than the draft standard of 65 mg/L (Figure 54). HSPF model output (reach 490) shows that 15.6% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009.

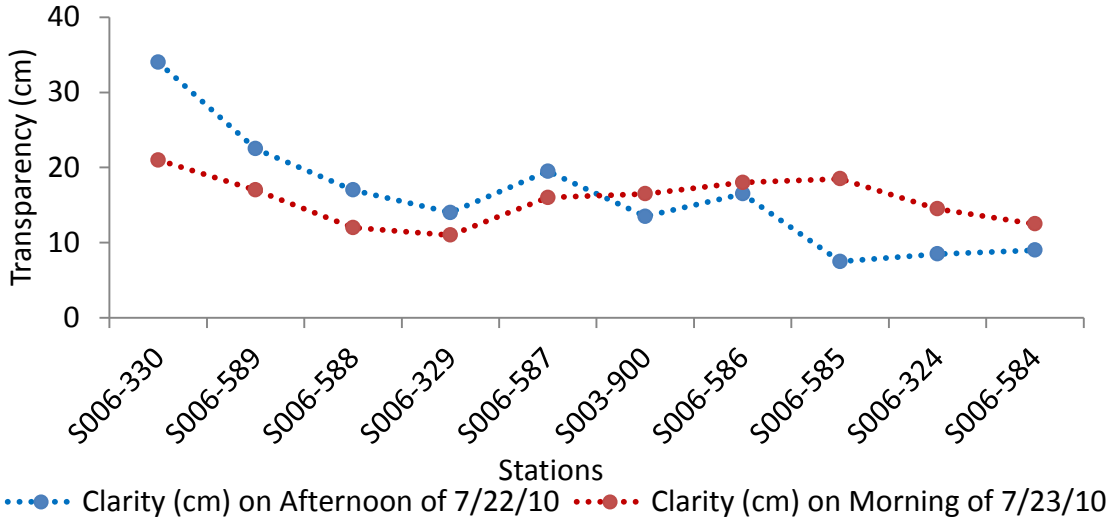

Figure 52. Transparency longitudinally in the Le Sueur River (-619) on July 22 and 23, 2010

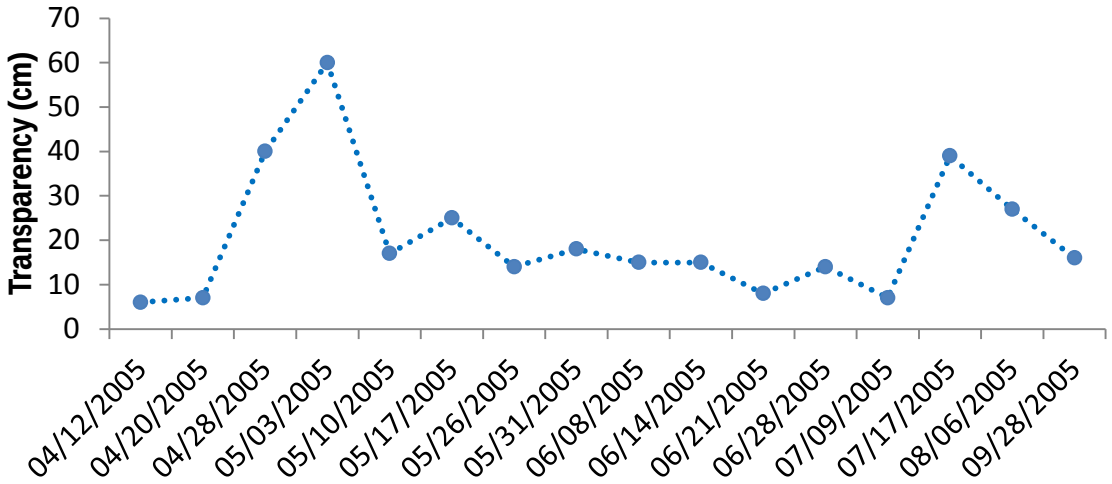

Figure 53. Transparency at station S003-900 by the citizen stream monitoring program in 2005

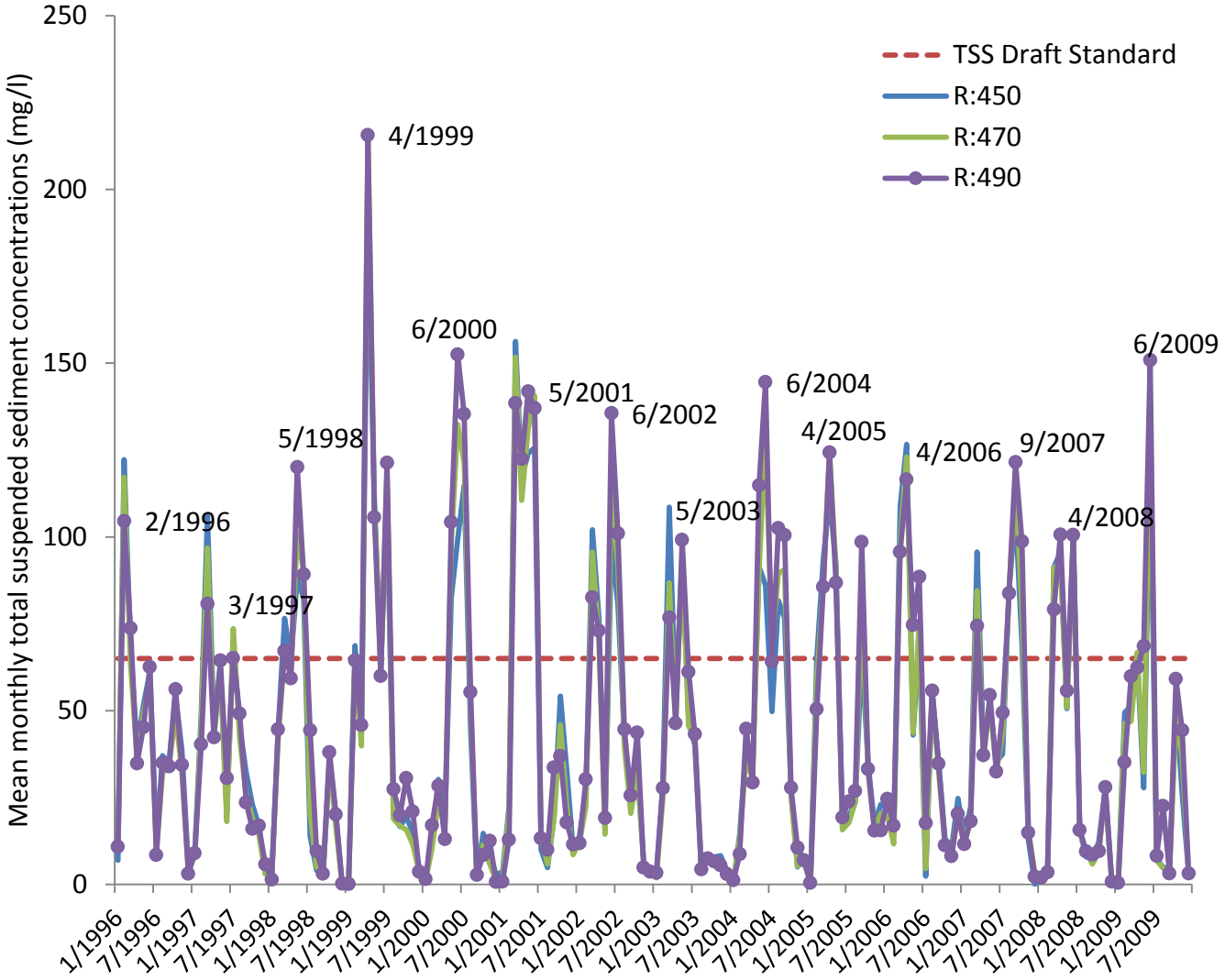

Figure 54. Mean monthly TSS concentrations as predicted by the HSPF model for Reaches 450, 470, and 490; collocated with the Le Sueur River (619)

As mentioned previously, sensitive taxa were reduced and tolerant individuals comprised more of the community than desired. Sensitive taxa found in this reach were banded darter, northern hogsucker, slenderhead darter, and one stonecat was found at station 08MN055 in 2008. Herbivores (fish) are often reduced when turbidity or TSS levels are high. The percent herbivores, as defined by the National Water Quality Assessment – USGS (NAWQA) database, ranged from 12% to 17% (Figure 55). The average percent of herbivore fish in natural channels of the Le Sueur River watershed was 9.9%, with a range of 0% to 58%. The Le Sueur River watershed has many reaches currently listed for turbidity. Herbivorous fish populations throughout the watershed are influenced by the high turbidity that is prevalent throughout the watershed.

Herbivores in the Minnesota River Basin appear to decrease with increased drainage area (Figure 55). However, when looking beyond the Minnesota River Basin to the entire fish class 1 and 4 (Southern Rivers and Northern Rivers); the percentage of herbivores does not decrease with drainage area (Figure 56). The increase may be due to the widespread turbidity issues that are present in the Minnesota River Basin. Within the Minnesota River Basin, herbivores range from 0% to 20.51% at stations with drainage areas ranging from 600 to 1500 sq. miles. The highly tolerant fish individuals present in this reach are likely due to increases in turbidity within this reach. Turbidity is a stressor to the fish community within this reach.

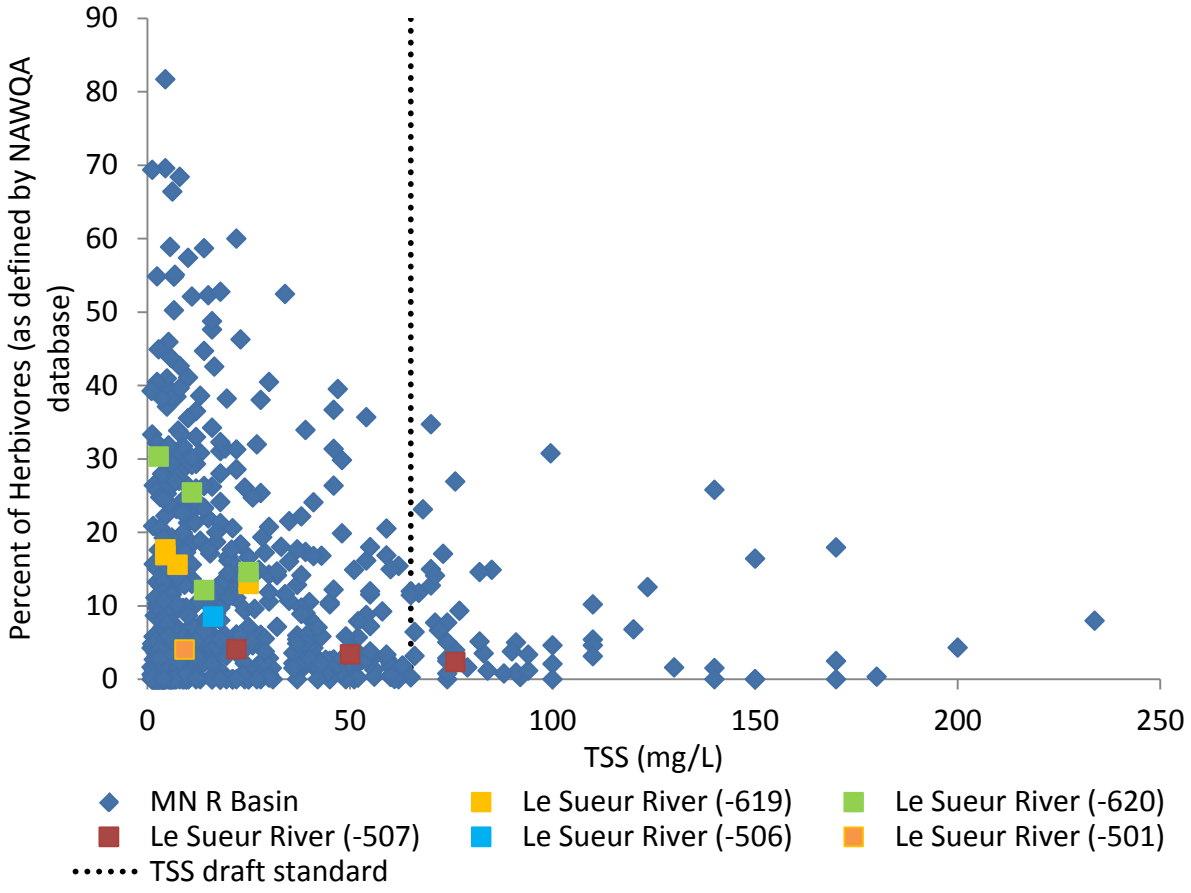

Figure 55. Percent herbivores and TSS for the Minnesota River Basin stations and stations in reaches of the Le Sueur River

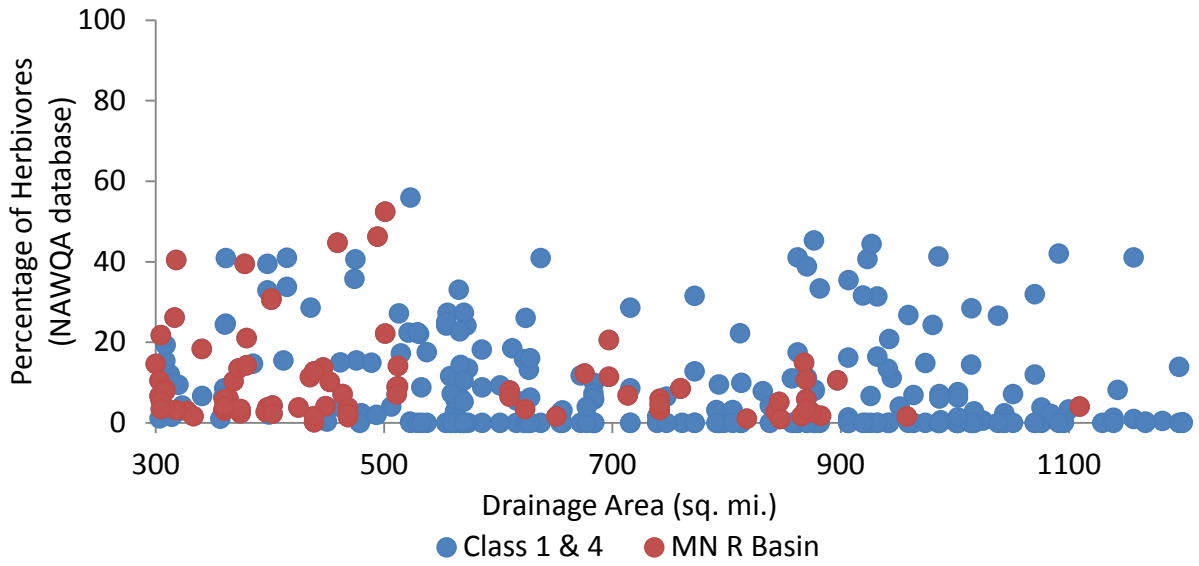

Figure 56. Percentage of herbivores (as defined by the NAWQA database) for all fish class 1 and 4 stations in Minnesota and for those stations within the Minnesota River Basin

Candidate cause: Lack of habitat

The MSHA in this reach of the Le Sueur River ranged from 44.8 to 66.2. In general, downstream stations 10MN161 and 08MN029 scored poorer than station 08MN055. Stations in this AUID were found to have moderate to moderate-high channel stability and moderate to good depth variability.

Station 08MN055 was sampled twice, once in 2008 and once in 2010. There is little difference in the subcategory scores between the two years (Figure 57). The percent riffle ranged from 30% in 2008 to 25% in 2010. Both years surveyors noted presence of cobble and gravel with sand and silt creating more diverse substrates than the other stations downstream. It was also noted that there was moderate to high channel stability in the station (Figure 58).

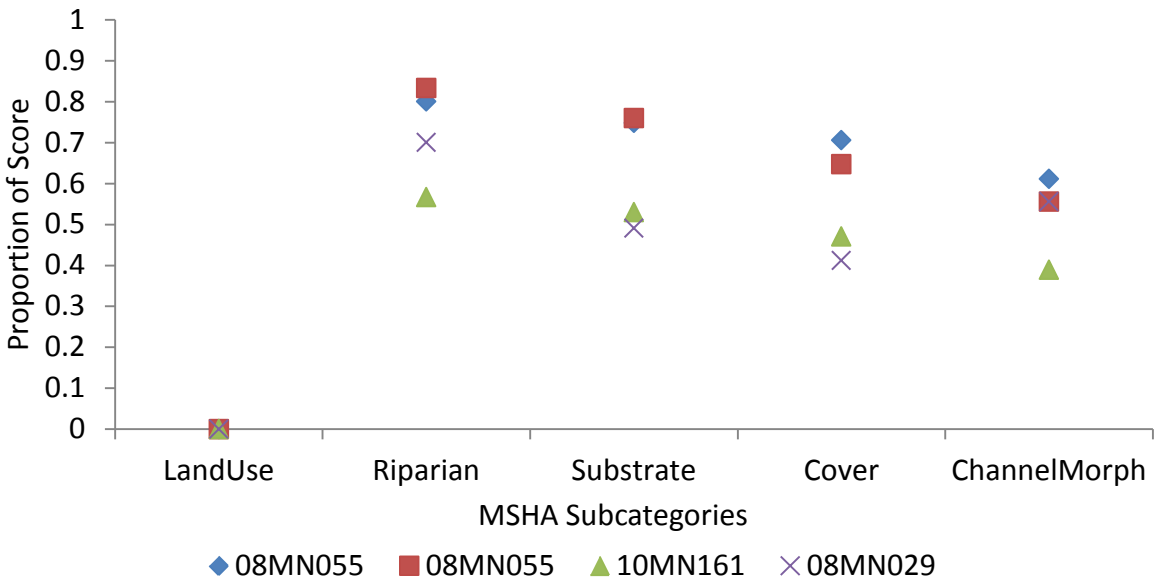

Figure 57. MPCA Stream Habitat Assessment subcategory proportion of scores for the Le Sueur River (-619)

Figure 58. Station 08MN055 on August 19, 2010

Station 10MN161 was characterized with a moderate to narrow riparian buffer with 5% to 25% bank erosion (Figure 59). Only 5% of the 446 meter reach was riffle. The reach was dominated by sand and silt with a lack of diverse substrates. It was also noted that there was problematic mid channel bars indicating excess sedimentation. There was sparse cover with moderate depth variability.

Figure 59. Station 10MN161 on August 23, 2010

Station 08MN029 was characterized as having a wide riparian buffer, but moderate to heavy bank erosion (Figure 60). The station had no riffle present and no course substrate present, thus lacking a diversity of substrates for a diversity of fish species. Additionally, there was a lack of cover present at this station, although good depth variability.

Figure 60. Station 08MN029 on July 22, 2008

Riffle dwelling fish in this AUID ranged from 15.5% at station 08MN029 to 18.6% at station 08MN055 (Figure 61). The range in the Le Sueur River watershed for the percentage of riffle dwelling fish was 0 to 57, with a mean in natural channels of 13%. However, for stream reaches at or above the IBI threshold in the entire Minnesota River basin, the mean percentage of riffle dwelling fish was 20.2. Furthermore,

for the subset within the Southern Streams class, the mean percentage of riffle dwelling fish was 26.5%. In other words, riffle dwelling fish were comparatively less present in this AUID than in similar AUIDs.

There were five to six riffle dwelling taxa at each of the stations despite the lack of riffle habitat and diverse substrates at stations 10MN161 and 08MN029. Seven riffle dwelling taxa were the most that have been surveyed at one station within the Le Sueur River watershed and within the Minnesota River Basin. Simple lithophilic spawner taxa ranged from seven to eight within this AUID, at stations downstream in the Le Sueur River, simple lithophils ranged from 8 to 11 taxa.

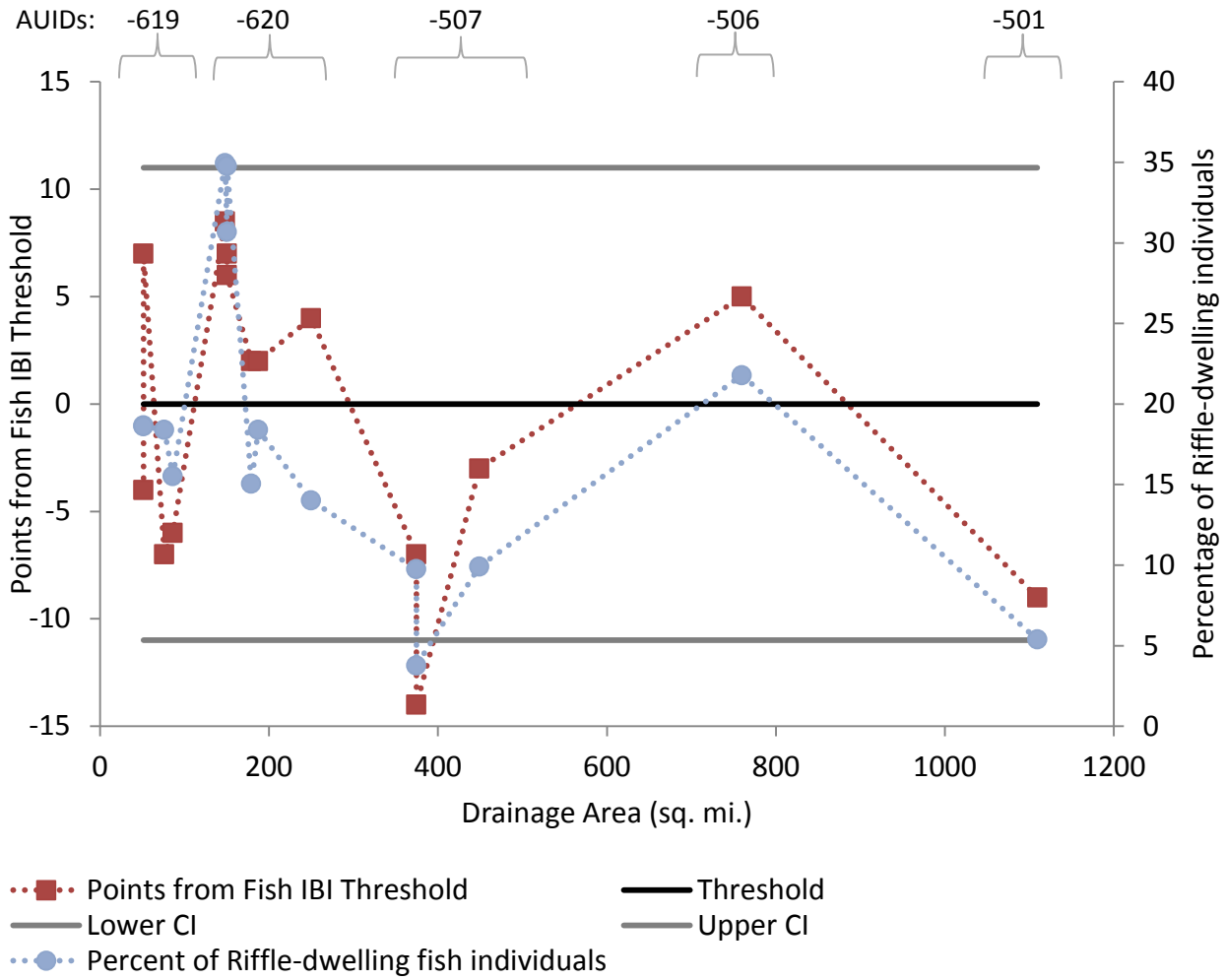

Figure 61. Points from Fish IBI threshold and percentage of riffle-dwelling individuals longitudinally in the Le Sueur River by drainage area

Generally, degraded habitat can lead to increases in tolerant fish. Within this reach, there were not a high number of tolerant taxa, but a high percentage of individuals belonging to those tolerant taxa. Tolerant taxa were dominating the community, but other taxa were present. Benthic insectivores that are not tolerant do not seem to be lower than other similar reaches in the Minnesota River Basin (Figure 62). Sometimes when degraded habitat is present two species will dominate over others that may be present, but in this reach of the Le Sueur River, that does not appear to be an issue (Figure 48).

Although the habitat in this reach is not optimal, there is a lack of connecting data besides the prevalence of low IBI scores and general degraded habitat. Habitat within this AUID has potential to be improved, which may improve the fish community but may not be the main stressor to the biological community.

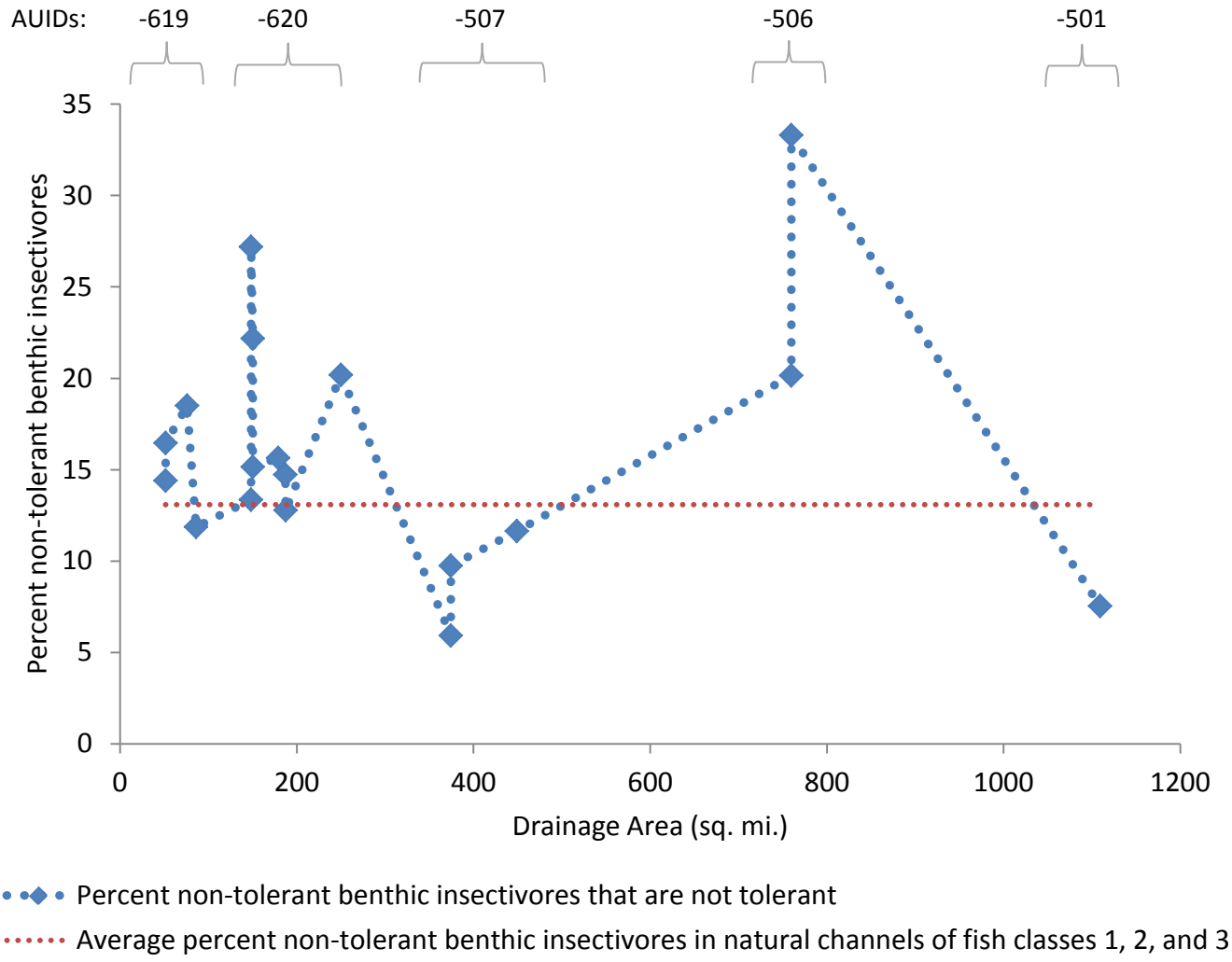

Figure 62. Percentage of non-tolerant benthic insectivores longitudinally in the Le Sueur River and the average percent of non-tolerant benthic insectivores in natural channels of fish classes 1, 2, and 3 in the Minnesota River Basin

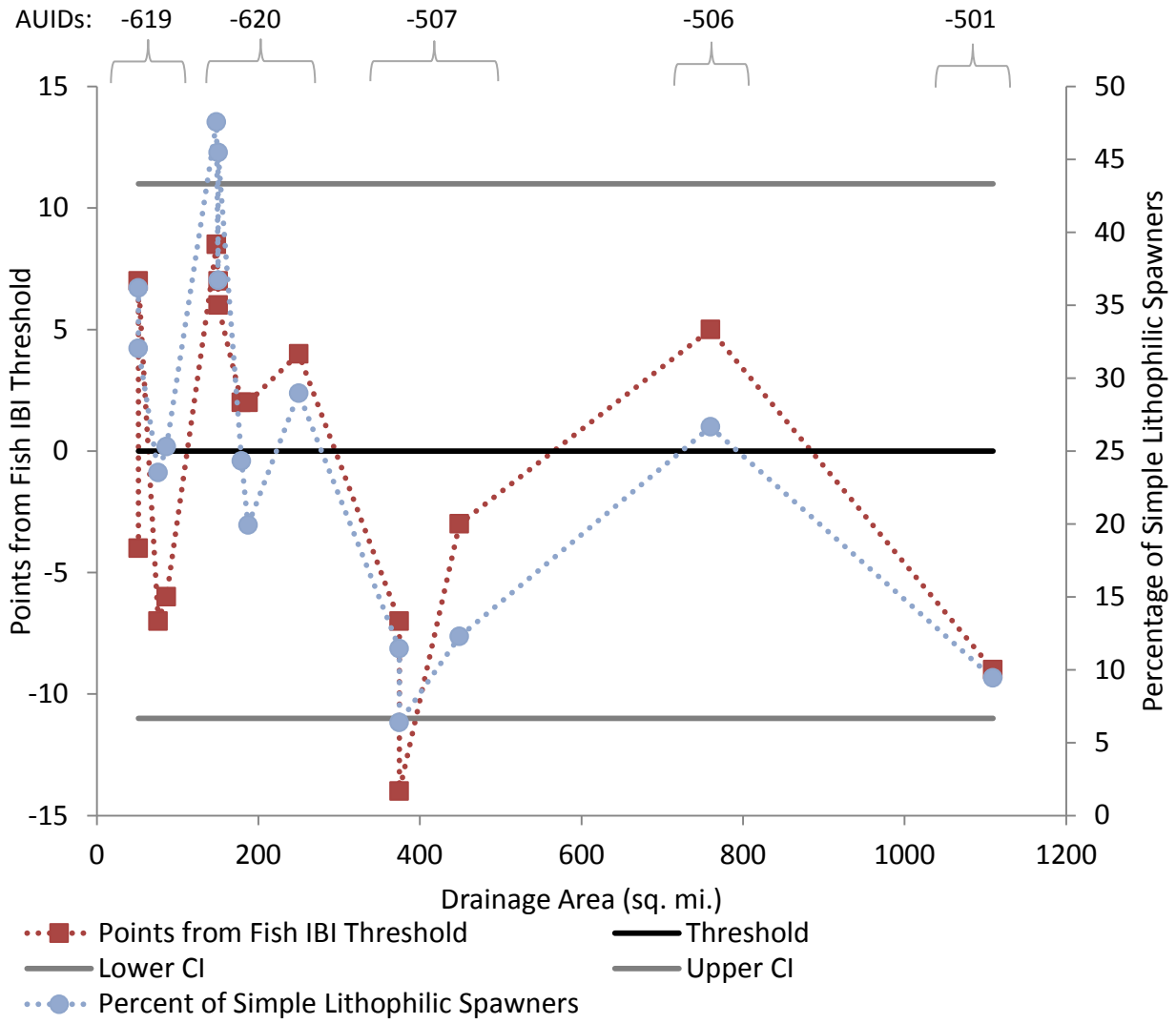

Figure 63. Points from the fish IBI threshold and the percentage of simple lithophilic spawners on the Le Sueur River longitudinally by drainage area

Weight of evidence

The evidence for each potential stressor, the quantity and quality of each type of evidence was evaluated. The consistency and credibility of the evidence was evaluated. Each step for the Le Sueur River (-619) was scored and summarized in Table 19. For more information on scoring please see EPA's CADDIS Summary Table of Scores.

Table 19. Weight of evidence table for potential stressors in the Le Sueur River (-619)

Evidence using data from Le Sueur River (-619)						
Types of Evidence	Scores					
	Dissolved Oxygen	Phosphorus	Nitrate-Nitrite	Suspended Sediment	Physical Habitat	Altered Hydrology
Spatial/temporal co-occurrence	R	0	+	+	0	+
Temporal sequence		0	+	+	0	++
Field evidence of stressor-response		NE	NE	NE	NE	0
Causal pathway		+	+	+	+	++
Evidence of exposure, biological mechanism		0	+	+	--	+
Field experiments /manipulation of exposure		NE	NE	NE	NE	NE
Laboratory analysis of site media		NE	NE	NE	NE	NE
Verified or tested predictions		NE	NE	NE	NE	NE
Symptoms		---	+	+	0	+
Evidence using data from other systems						
Mechanistically plausible cause	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE
Multiple lines of evidence						
Consistency of evidence		0	+	+	-	+
Explanatory power of evidence		0	++	++	0	++

Conclusions

In the headwaters reach of the Le Sueur River (-619), the fish community was comprised of a high abundance of tolerant fish, quick to mature, and short lived. Synoptic samples in 2007, 2008, and 2010 revealed no issues related to DO. Targeted DO measurements within the reach in late July 2010 did not indicated much flux in the dissolved oxygen or low DO conditions. Low DO is not a stressor at this time.

There was limited phosphorus data, seven measurements, with only one greater than the proposed standard. The biological response was mixed when looking at metrics that respond to increases in phosphorus. Due to the limited data and the mixed biotic response, phosphorus was inconclusive as a stressor. It is recommended that further monitoring be conducted regarding the phosphorus in this reach of the Le Sueur River.

Both fish and invertebrates exhibited negative responses to elevated nitrate. There is limited nitrate data. Of the seven samples, the maximum sample was taken June 25, 2008 at 14 mg/L. Nitrate is a stressor given the limited available data. To further the understanding of the nitrate dynamics additional monitoring should be conducted.

This reach of the Le Sueur River is impaired for turbidity in addition to the lack of fish assemblage. Turbidity/TSS is a stressor to the fish community in this reach. Transparency has been measured in the poor category (<20cm). Additionally HSPF predicts mean monthly TSS concentrations well above the proposed standard of 65 mg/L. The fish in this reach are highly tolerant and are impacted by the elevated turbidity/TSS levels.

Habitat within this reach was not optimal, with some biological stations lacking in riparian buffers and lack of depth. Other stations exhibited moderate to heavy bank erosion and lack of course substrate. Despite the lacking habitat in some areas, riffle dwelling taxa were present and moderate percentage of non-tolerant benthic insectivores. The habitat within the headwaters of the Le Sueur River could be improved upon, yet there are not strong connections with the degraded fish community.

Significant changes to land use, additions of stream miles, and loss of water storage are some of the reasons the hydrologic regime is altered in the Le Sueur River watershed. Greater than 50 stream miles have been added to the pour point of this headwaters of the Le Sueur River reach since 1855, not including subsurface drainage. There are few long lived fish or invertebrates within this reach, indicating that they need to complete their life cycle quickly in order to persist. Altered hydrology is a stressor to the fish community within this reach of the Le Sueur River. The hydrologic component is linked to the turbidity/TSS issues as well.

Le Sueur River (07020011-507)

In 2008, this reach of the Le Sueur River, from CD 6 to Cobb River, was listed for turbidity. In 2012, lack of fish assemblage was added to the list of impairments for this AUID.

Biology in the Le Sueur River

The Le Sueur River, AUID 07020011-507, has three biological stations on it. Two of the stations had reportable visits (03MN071 and 08MN035). One station visit, 90MN105, was not reportable due to inconsistent sampling methodology.

The fish IBI scores for stations 03MN071 and 08MN035 ranged from 32 to 43 (Table 3). Station 03MN071 scored the poorest, with both sampling resulting in IBIs less than the threshold. This reach did not have fish DELTs, that if present, would have contributed negatively to the IBI.

An analysis of metrics of the Southern Rivers IBI show only three metrics were greater than the average metric score needed for the IBI to be above the threshold (Figure 64). The metrics that scored the poorest were: relative abundance (%) of individuals that are short-lived (SLvdPct), relative abundance of taxa that are sensitive taxa adjusted for Log10 gradient using the residuals calculated for Class 1 (SensitiveTxPctGR1), relative abundance of individuals that are tolerant species (TolPct), relative abundance of individuals that are insectivore species excluding tolerant species (Insect-TolPct), relative abundance of taxa that are serial spawners (SSpnTxPct) and relative abundance of individuals of the dominant two species (DomTwoPct).

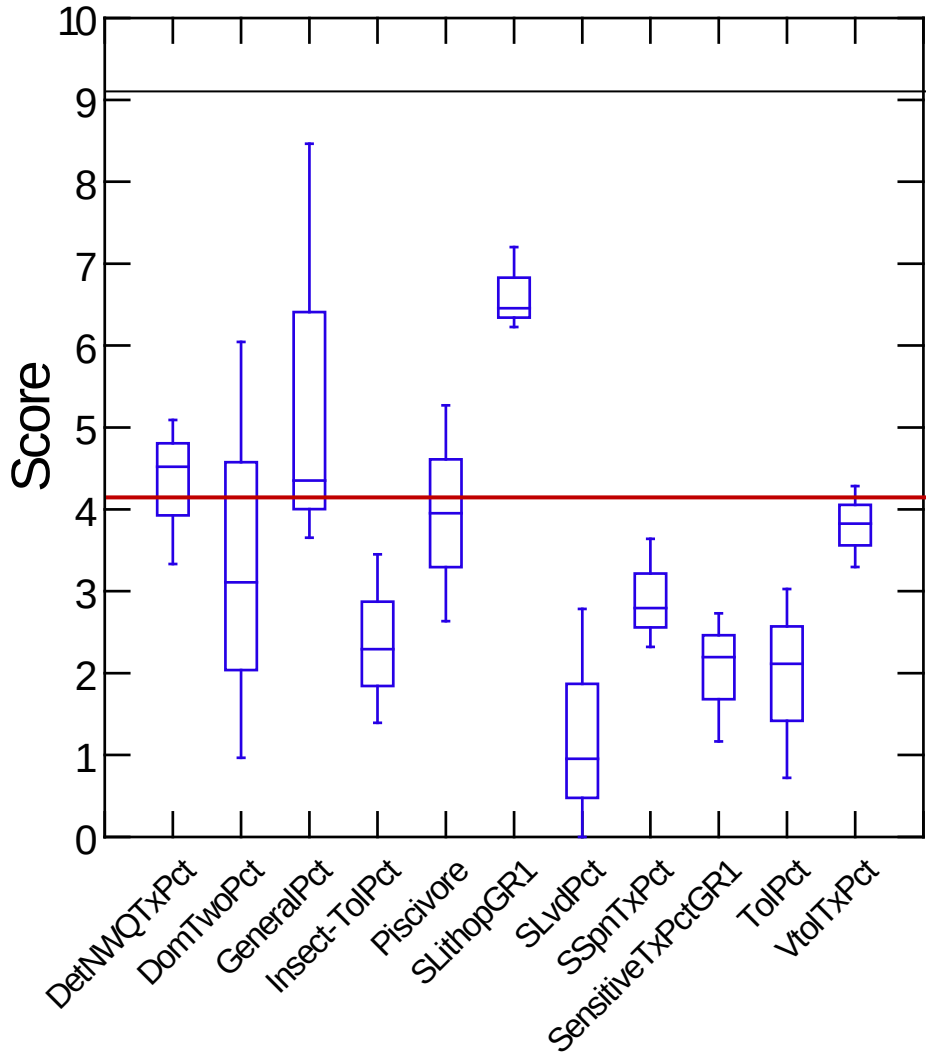

Figure 64. Fish metrics of the Southern Rivers IBI for the Le Sueur River; red line indicates the average metric score (4.18) needed for IBI score to be at the threshold and black line indicates maximum possible score (Stations 03MN071 and 08MN035)

Candidate cause: Low dissolved oxygen

There were no low DO measurements below the standard. There were a handful of very high DO measurements in March of 2011, but those measurements corresponded with low temperatures and were taken in the morning, unlikely indicating DO problems. Additionally, the TIV scores for DO were in the upper half of all scores for the Le Sueur River watershed (Figure 6). At this time it is not believed that DO is a stressor to the biological community.

Candidate cause: High phosphorus

Phosphorus in this reach was elevated (Figure 65). HSPF model output at the outlet of the reach (reach 730) shows that 33.3% of the TP daily averages are greater than 0.150 mg/L, from 1996 to 2009.The response variable to DO flux has not been measured, but as stated in the previous section, low DO is not a stressor at this time. There was only one measurement of BOD in 1980 at 1.1 mg/L. Chlorophyll-a has

been sampled over 300 times and was elevated above 35 µg/L, above the level known to be a stressor to biology in Minnesota (Heiskary et al., 2013; Table 20).

In 2008, this reach had particularly low percentage of carnivorous fish (Figure 66). As previously mentioned, this reach lacks sensitive fish taxa relative to the total taxa present, and the non-tolerant insectivore percentage was low for this stream class. It does, however, have a range of generalists ranging from 9.7% to 40.9% of the total fish population which translates to a metric score of 3.65 to 8.46. The tolerant individuals comprised 56.7% to 76.2% of the total fish individuals surveyed.

The invertebrate community has a relatively high percentage of intolerant individuals at station 03MN071 in 2008 (16.7%), but the downstream station, 08MN035, had half as many at 8.8%. It is likely that high phosphorus, with the resulting stressor variable chlorophyll-a, is altering the nutrient dynamics and contributing to the degraded fish community. Although high phosphorus is a likely stressor, it is not the only stressor contributing to the degraded condition of the biological communities.

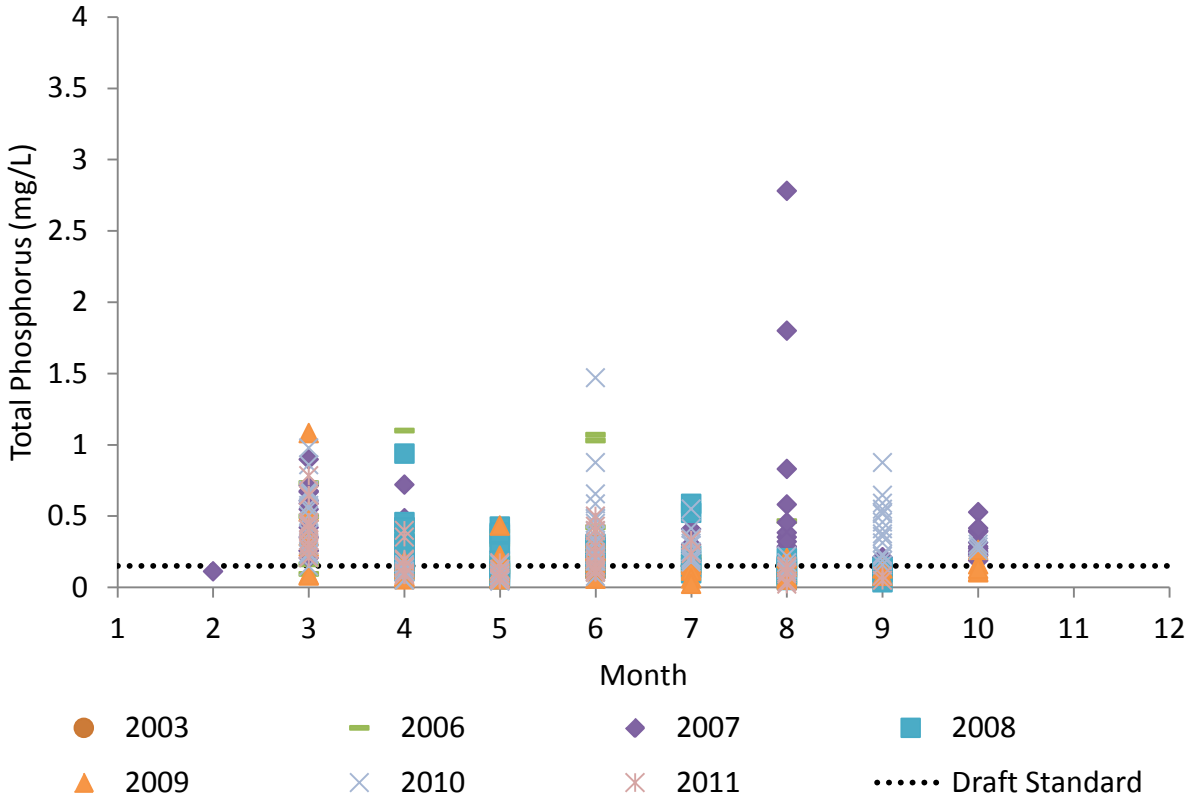

Figure 65. Total phosphorus samples for the Le Sueur River (-507) shown by month and year

Table 20. Summary of chlorophyll-a data for the Le Sueur River (-507)

Chlorophyll-a (µg/L)	2006	2007	2008	2009	2010	2011	All Years
Mean	27.62	32.51	25.36	36.06	22.62	17.51	26.59
Median	25	18.5	19	28.5	18	16	19.5
25th Percentile	18	13.25	17	17	11	9.35	13
75th Percentile	33	41.75	26.5	49	30	21	30
Maximum	83	160	100	150	68	53	160

Minimum	8.3	3.6	5.6	4.8	3.7	<1	<1
Number of Samples	37	62	55	40	66	50	310

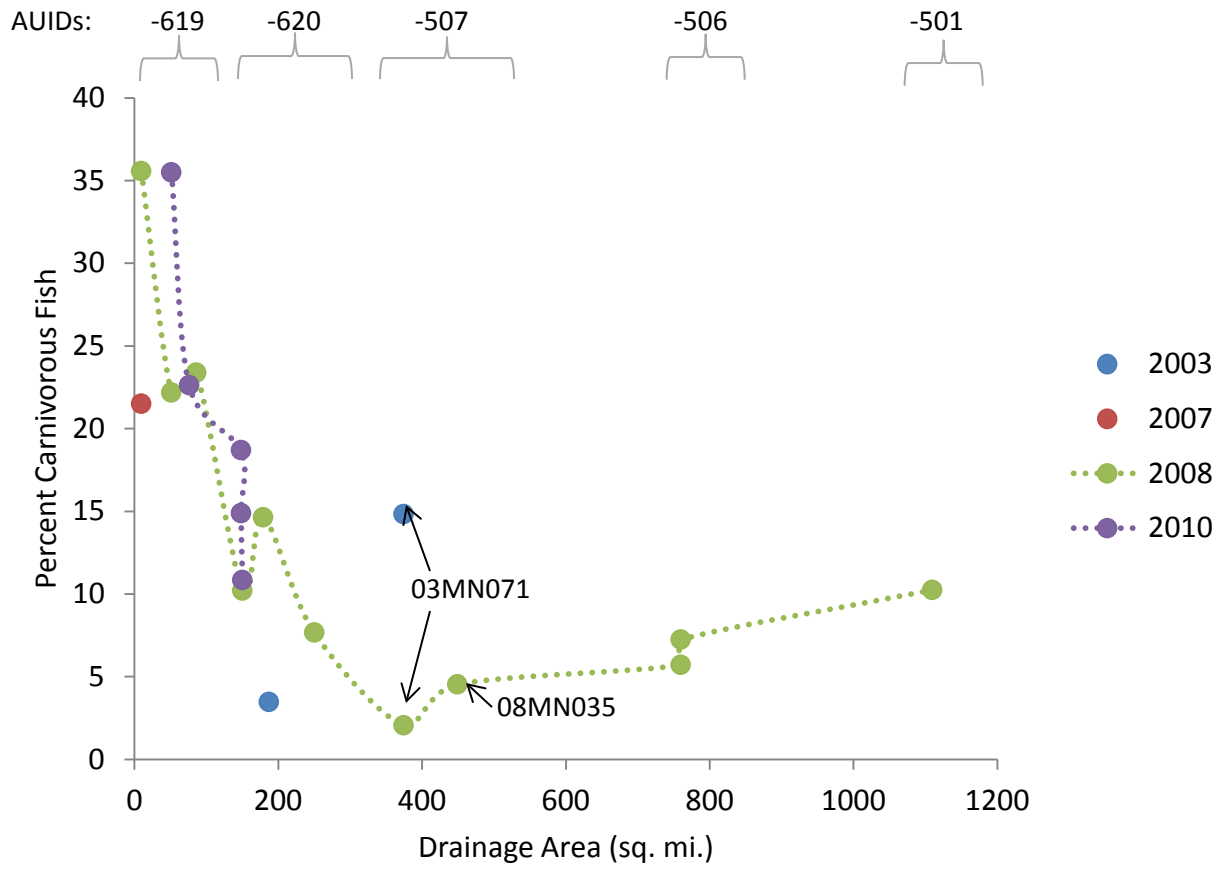

Figure 66. Percent carnivorous fish longitudinally in the Le Sueur River by drainage area

Candidate cause: High nitrate

In this AUID of the Le Sueur River, nitrate levels have been measured as high as 19 mg/L (Figure 67). Observed nitrate was highest in March through June and then decreases. HSPF model output (reach 730) shows that 14.4% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009. Observed unionized ammonia was below the standard in this reach. Within the reach, there was a lack of sensitive fish taxa and an abundance of tolerant individuals. The stations had between 25 and 28 taxa; 34 taxa was the most found at one monitoring station within the Le Sueur River watershed in the Southern Streams fish class and 37 taxa was the most found at one monitoring station in all stations within the Southern Streams fish class. The invertebrate community is not impaired but shows a possible indication of stress from nitrate: the non-hydropsychid caddisflies comprised of 3.7% and 7.9% at station 03MN071 in 2003 and 2008, respectively (Figure 68). The nitrate at the time of fish sampling was over 8 mg/L each of those years. At station 08MN035, the non-hydropsychid caddisflies comprised of a greater percentage of the sample, 17.9%, and at fish sampling had nitrate measured at 3.3 mg/L. The invertebrate taxa count at station 03MN071 is higher than station 08MN035 and the Minnesota River basin average. The caddisfly taxa was also higher than the Minnesota River Basin average. Yet, the percentage of nitrate tolerant invertebrate individuals ranged from 64.1-73.8% of the communities

surveyed. It is likely that the degraded biological condition within this AUID is in part due to the elevated nitrate levels.

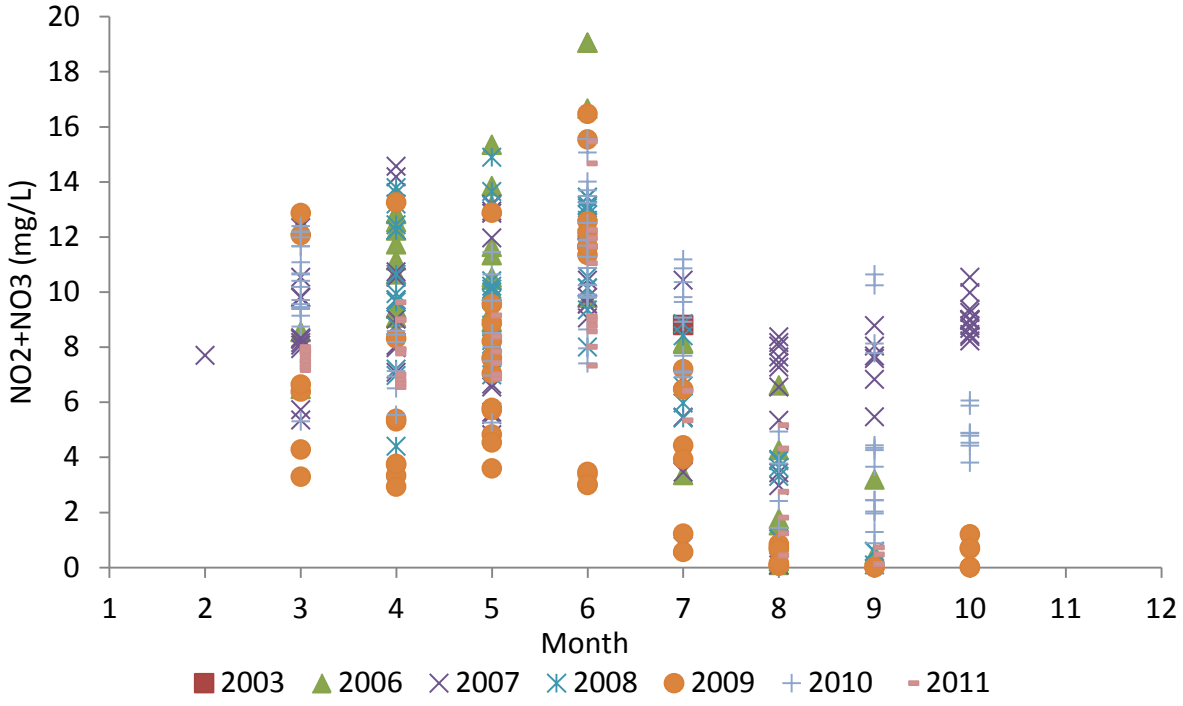

Figure 67. Nitrate-nitrite levels for the Le Sueur River (-507) by month and by year

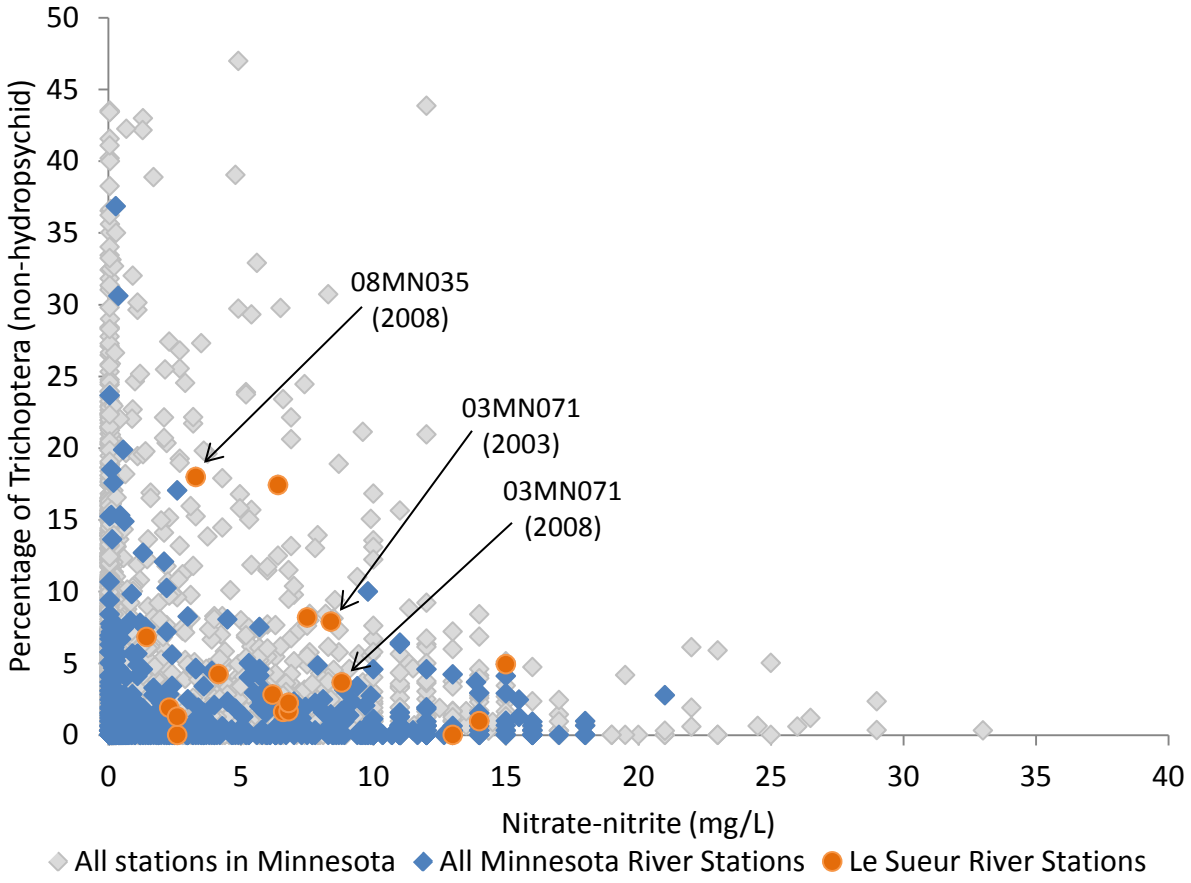

Figure 68. Percentage of non-hydropsychid caddisflies for all stations in Minnesota, all stations in the Minnesota River, and stations on the Le Sueur River

Candidate cause: High suspended sediment

This reach has very high suspended sediment, corresponding with the turbidity listing (Figure 69). HSPF model output (reach 730) shows that 28.6% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009. In the spring of 2012, MDNR staff navigated the Le Sueur River from St. Clair to Red Jacket Trail with kayaks assessing stream bank erosion sites at flows that ranged from normal (600-2000 cubic feet per second (cfs)) to nearly bankfull stages of 3100 cfs. Figure 70 shows the Le Sueur River watershed with each assessed reach labeled. Most banks assessed in these reaches were on outside bends where it was apparent that stream bank erosion was occurring in excess of the deposition rate on the inside point on that meander bend. Considerable amounts of sediment are coming from the banks within these reaches (Figure 71).

One aspect of the biological response to TSS is shown in Figure 55, with herbivorous fish decreasing with increases in TSS. Herbivorous fish at these two stations comprise 2.3% to 4.1% of the surveyed fish population. The average percent of herbivore fish in natural channels of the Le Sueur River watershed was 9.9%, with a range of 0% to 58%. The Le Sueur River watershed has many reaches currently listed for turbidity. Herbivorous fish populations throughout the watershed are influenced by the high turbidity that is prevalent throughout the watershed. Additionally, there was an abundance of tolerant fish individuals and a lack of sensitive fish taxa, which is partially attributed to the high suspended sediment in this reach. Sand shiners, a species fairly tolerant to suspended sediment (Meador and Carlisle, 2007), were the most abundant taxa found at each of the three surveys. Suspended sediment and the resulting turbidity are affecting the fish community in this reach.

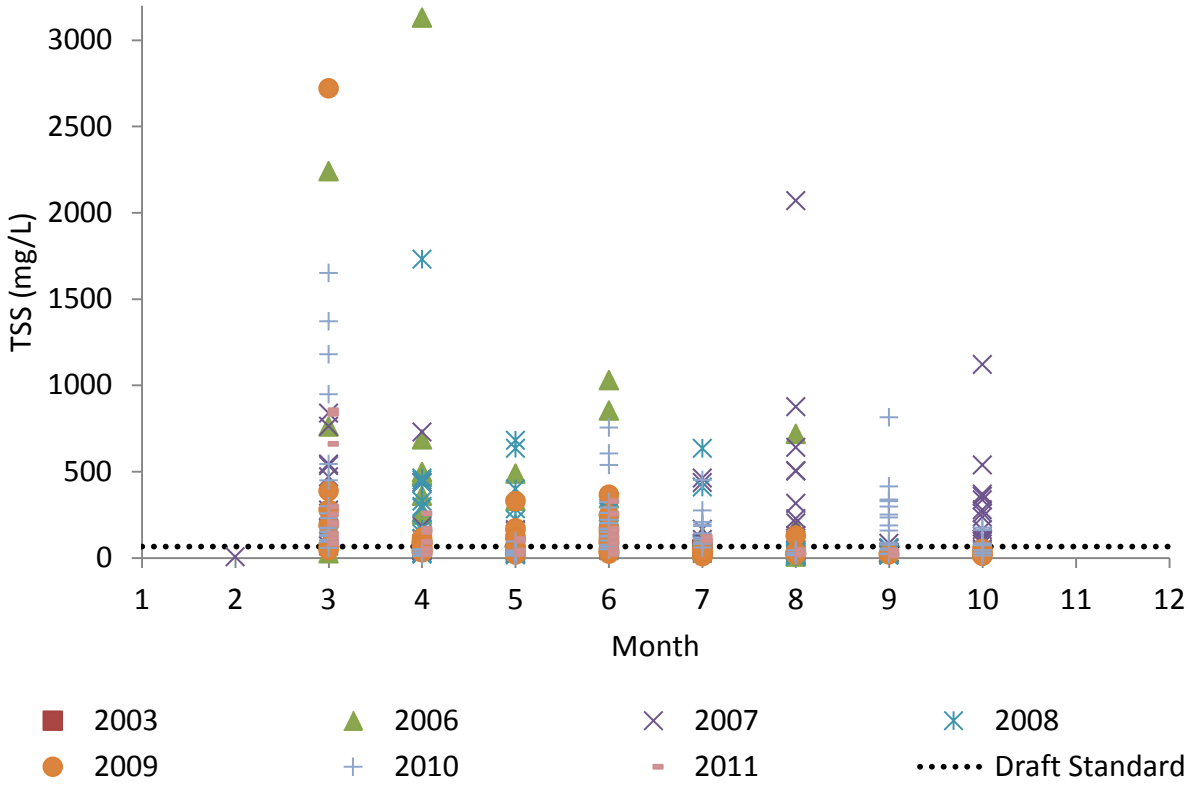

Figure 69. Total Suspended Solids samples for the Le Sueur River (-507) by month and by year

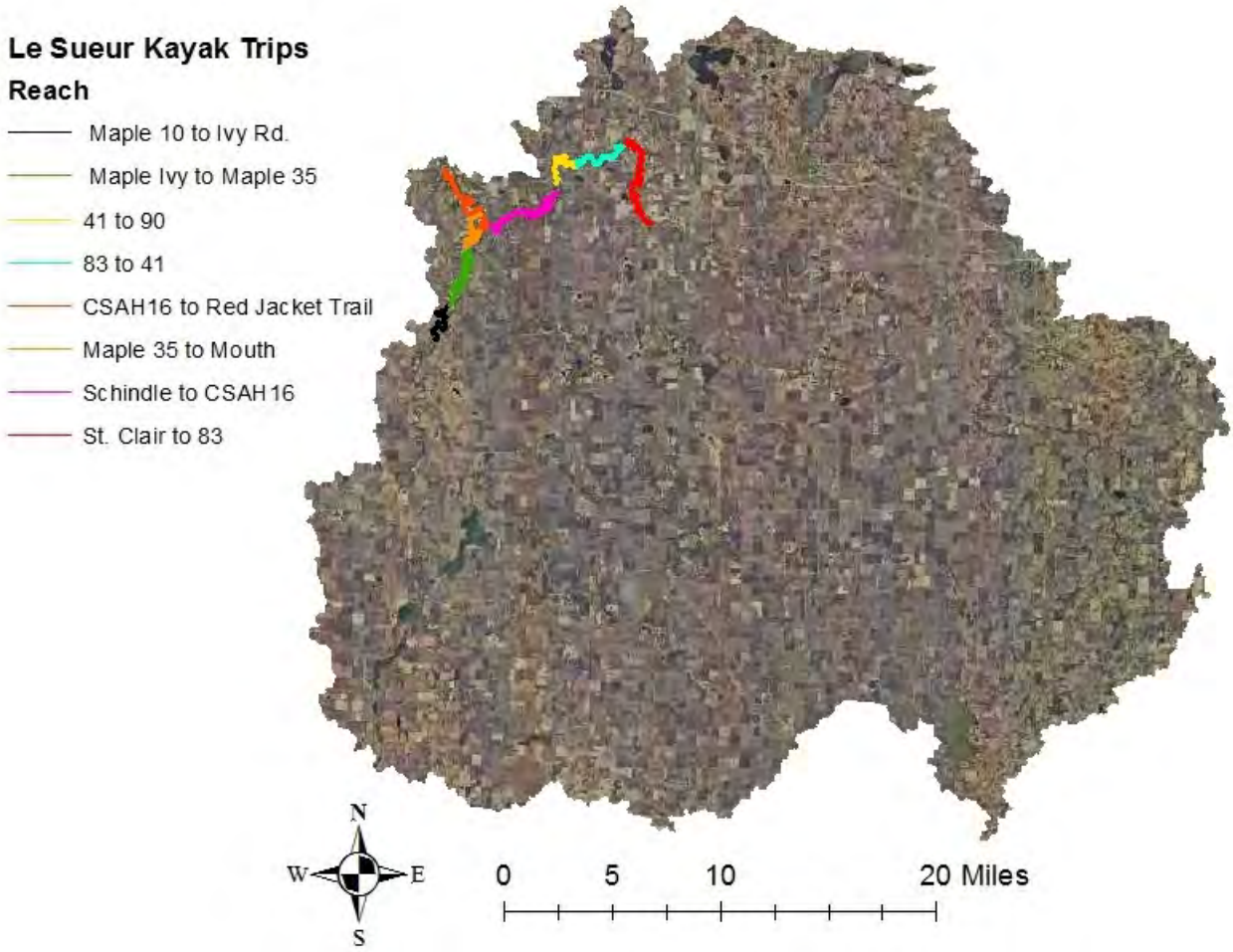

Figure 70. Map of the Le Sueur River Watershed with BANCS assessment sites highlighted

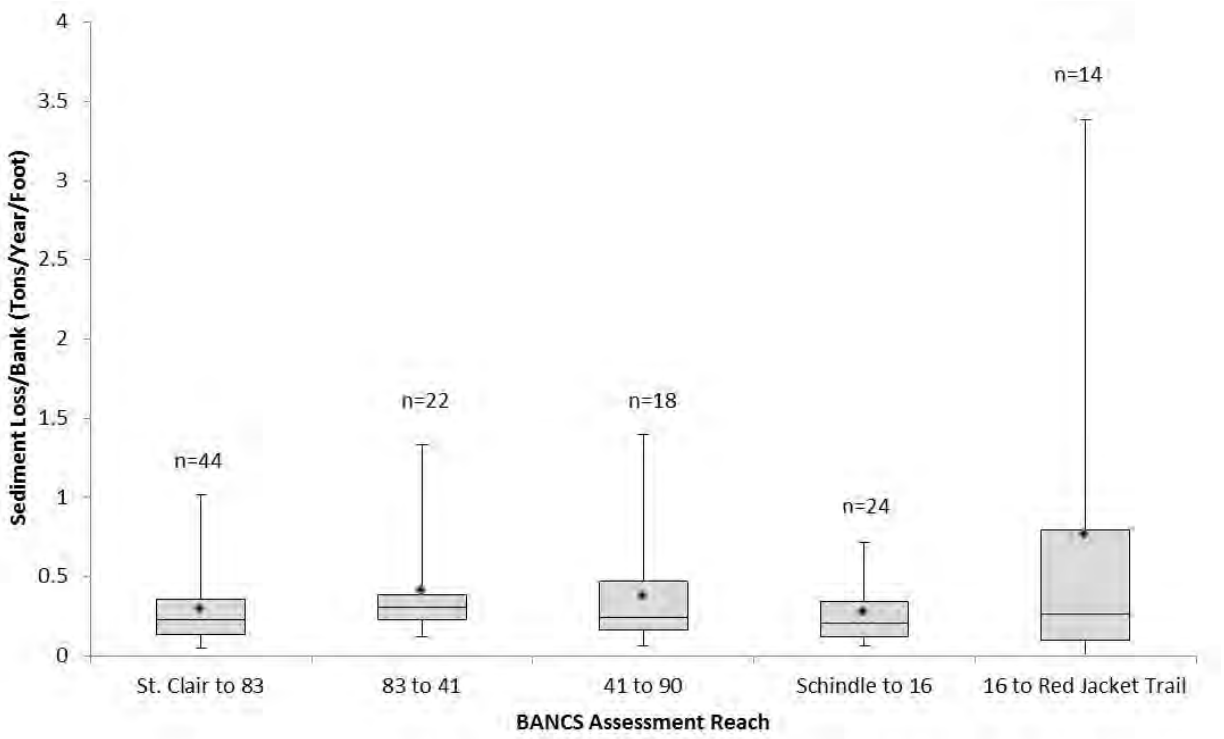

Figure 71. Boxplot showing the sediment loading of each bank per foot of bank in reaches of the Le Sueur River assessed using the BANCS Model and Colorado estimate for bank erosion rates. Error bars show the minimum to maximum loading banks within the reach. The line in the middle of each box is the median value, while the black diamond signifies the average for each reach.

Candidate cause: Lack of habitat

MPCA Stream Habitat Assessment scores in this reach ranged from 46 to 59.75 (fair). The proportion of the score varies by station (Figure 72). In general, land use scored very poorly, with riparian and cover subcategories also not optimal at some times. Station 03MN071 is characterized as having moderate riparian buffers, moderate to substantial shade, a lack of diverse substrate that is dominated by sand and gravel, sparse cover, and moderate to low channel stability (Figure 74). Severe embeddedness and light embeddedness was noted in 2008. The variation in embeddedness is likely due to the scouring and deposition that occurs within this reach (Figure 10).

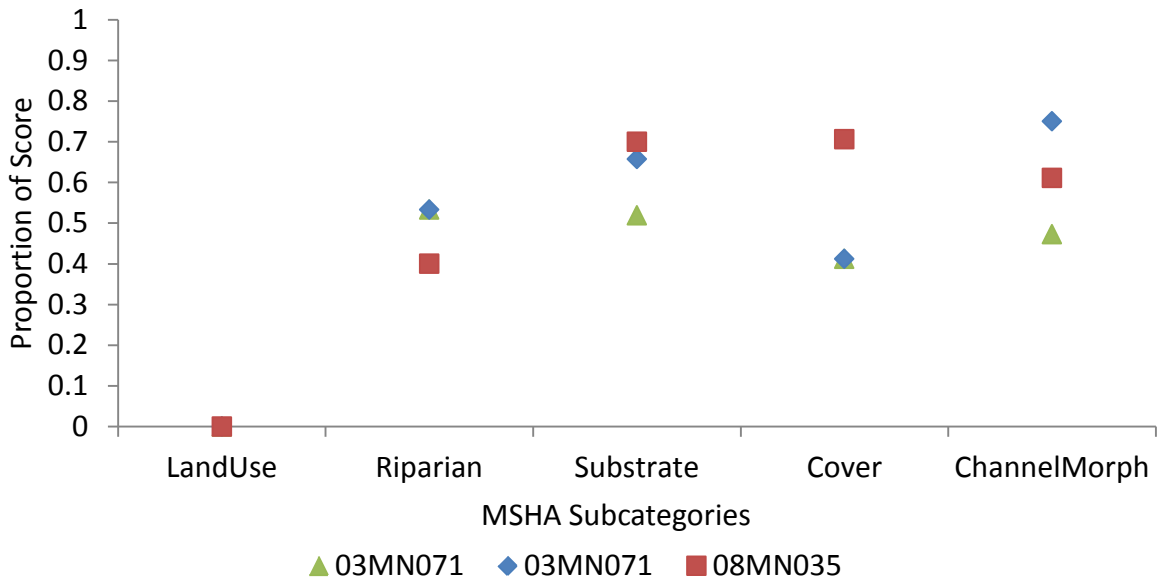

Figure 72. MPCA Stream Habitat Assessment subcategory scores for the Le Sueur River (-507)

The MDNR conducted a geomorphic survey of the reach through Wildwood Park (Figure 73), just downstream of biological station 03MN071. At this location, the Le Sueur River is classified as a sand dominated F5 stream, unable to access the floodplain during flood flows. The influence of middle channel bars throughout the reach results in higher near bank stress and higher BEHIs. This site shows evidence of channel widening while outside banks were poorly vegetated and showing signs of recent streambank erosion (Figure 74). Mid-channel bars indicate an overwide channel that is not able to transport bedload in an effective manner. Three banks within this reach were assessed using the BEHI and NBS methods and estimated to have 0.4262 tons/year/foot of stream bank erosion. The study reach is located in valley type VIII(b), alluvial fill. The Pfankuch rating for stream stability at this site was 132, a poor rating for a F5 stream with high sediment supply and degrading streambed stability.

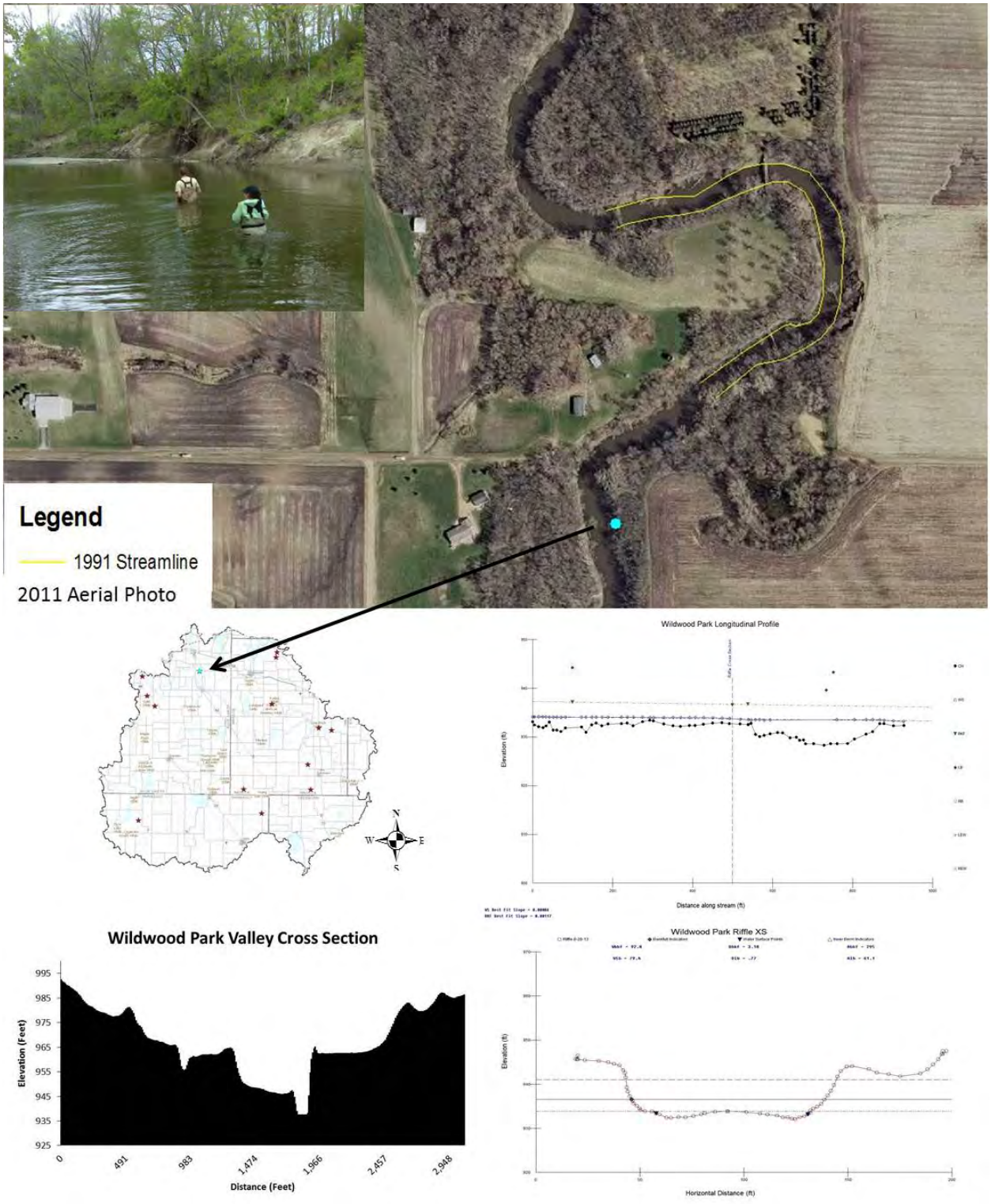

Figure 73. Location of the Wildwood Park site (near station 03MN071) with aerial photo, LiDAR derived valley cross section, actual surveyed longitudinal profile and cross section. The yellow line on the aerial photo is the 1991 stream line to show how the reach has changed from 1991-2011

Figure 74. Station 03MN071 in 2003 view from middle of reach looking upstream

The downstream station 08MN035 is characterized as having a moderate riparian buffer, moderate to heavy erosion, and light shade with moderate cover (Figure 75). The reach has a diversity of substrates with gravel and cobble present and was noted in 2008, as was the upstream station, as having light embeddedness. Mid-channel bars were present which indicate low channel stability at this station.

Figure 75. Station 08MN035 in 2008 at upstream location of station looking downstream

The fish community was comprised of a low percentage of benthic insectivores, which is likely related to the low channel stability within these stations (Figure 62). The presence of simple lithophilic spawners in this reach was within the expected range; this taxa comprised approximately 40% of the surveys in this AUID (Figure 64). The fish community was dominated by individuals from two species, which is likely due in part to a lack of diverse habitat. As previously mentioned, sand shiners were the dominant fish taxa and either spotfin shiners or bluntnose minnows were the second most abundant in the surveys. Riffle dwelling individuals were reduced compared to both upstream and downstream reaches (Figure 61), representing only 3.7% to 9.9% of the fish community in this reach.

Habitat, in terms of the lack of stability and diversity of habitat types, is a stressor to the fish community. Particularly, the erosion and scour/deposition cycle is causing stress.

Weight of evidence

The evidence for each potential stressor, the quantity and quality of each type of evidence was evaluated. The consistency and credibility of the evidence was evaluated. Each step for the Le Sueur River (-507) was scored and summarized in Table 21. For more information on scoring please see EPA's CADDIS Summary Table of Scores.

Table 21. Weight of evidence table for potential stressors in the Le Sueur River (-507)

Evidence using data from Le Sueur River (-507)						
Types of Evidence	**Scores**					
	Dissolved Oxygen	**Phosphorus**	**Nitrate-Nitrite**	**Suspended Sediment**	**Physical Habitat**	**Altered Hydrology**
Spatial/temporal co-occurrence	R	+	+	+	+	+
Temporal sequence		+	+	+	+	++
Field evidence of stressor-response		NE	NE	NE	NE	0
Causal pathway		++	++	++	+	++
Evidence of exposure, biological mechanism		+	+	+	+	+
Field experiments /manipulation of exposure		NE	NE	NE	NE	NE
Laboratory analysis of site media		NE	NE	NE	NE	NE
Verified or tested predictions		NE	NE	NE	NE	NE
Symptoms		+	+	+	+	+
Evidence using data from other systems						
Mechanistically plausible cause	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE
Multiple lines of evidence						
Consistency of evidence		+	+	+++	+	+
Explanatory power of evidence		++	++	++	++	++

Conclusions

In this middle reach of the Le Sueur River, the fish community was comprised of an abundance of short lived, serial spawners, and tolerant fish. It lacked non-tolerant insectivore fish and sensitive taxa. There were no low DO measurements and the elevated DO was explainable due to low water temperatures. DO is not an issue at this time to the fish community.

Phosphorus was elevated in this reach, well above the proposed standard. Additionally, chlorophyll-a was elevated above 35 µg/L. In 2008, this reach had particularly low percentage of carnivorous fish. Phosphorus is a stressor to the fish community.

Nitrate was also elevated in this reach of the Le Sueur River, with a maximum sample of 19 mg/L. The fish community had lack of sensitive taxa and an abundance of tolerant individuals. It is likely the degraded fish community is stressed due to elevated nitrate levels. Additionally, the invertebrate community, although not impaired, shows some results of being impacted by the elevated nitrate levels.

Total Suspended Solids in this reach of the Le Sueur River is quite high at times. Herbivorous fish are decreased in comparison to other reaches in the Le Sueur. Sand shiners were the most abundant fish species and are also fairly tolerant to suspended sediment. TSS is a primary stressor to the fish community in the Le Sueur River (-507).

Riparian habitat and cover habitat were not optimal with in this reach. Severe embeddedness is problematic, with mid-channel bars present indicating an overwide channel unable to transport the bedload. There were a low percentage of benthic insectivores likely related to the low channel stability at the two biological stations in this reach.

The low channel stability and elevated TSS are related to the hydrologic regime. Similarly the elevated Total Suspended Solids is related to the hydrology too. An estimated 318 upstream miles have been added to this reach since 1855. In 2008, the biological stations had over 50% short lived fish, showing the hydrologic regime influence the fish community. Alterations to the continuum of habitat shaping and sediment transport balancing have negative impacts on the biological communities. Hydrologic alteration is a stressor to the fish community within this reach of the Le Sueur River.

The stressors present in the Le Sueur River (-507) are elevated phosphorus, elevated nitrate, elevated TSS/turbidity, lack of habitat, and altered hydrology.

In 2002, this furthest downstream reach of the Le Sueur River was listed for turbidity. Acetochlor was added to the impaired waters list for this AUID in 2008 and lack of fish assemblage was listed in 2012.

Biology in the Le Sueur River

This downstream AUID of the Le Sueur River only had one biological station, 08MN001. The station scored below the fish IBI threshold and scored above the invertebrate IBI threshold (Table 3). The fish community in this reach of the Le Sueur River is characterized as having two dominate taxa (DomTwoPct): sand shiner and spotfin shiner. It has few non-tolerant insectivores (Insect-TolPct) and was lacking in sensitive taxa (SensitiveTxPctGR1) compared to the other taxa found at station 08MN001 (Table 22). The fish species present were generally short-lived (SLvdPct) and serial spawners (SSpnTxPct). There were a large percentage of individuals that are tolerant (TolPct; 61%).

Table 22. Fish metrics of the Southern Rivers IBI for the Le Sueur River (-501); bold indicates metric score is below the average metric score (4.18) needed for the IBI score to be at the threshold

Site	DetNWQTxPct	DomTwoPct	GeneralPct	Insect-TolPct	Piscivore	SensitiveTxPctGR1	SLithopGR1	SLvdPct	SSpnTxPct	TolPct	VtolTxPct
08MN001	5.8	**2.5**	7.1	**1.9**	**4**	**1.1**	5.5	**0.7**	**2.3**	**2.4**	**3.8**

Candidate cause: Low dissolved oxygen

The 58 measurements of DO from 2007 to 2011 do not indicate low DO or elevated DO flux. Only one measurement was made prior to 9:00 AM, making it difficult to rule out low DO as a potential stressor. However, the fish present were less tolerant of low DO (in the upper quartile of sensitivity for DO based on data from Le Sueur River watershed; Figure 6). Therefore, It is unlikely that DO is a stressor at this time.

Candidate cause: High phosphorus

Total phosphorus was elevated in this reach (Figure 76). HSPF model output at the outlet of the reach (reach 850) shows that 35.8% of the TP daily averages are greater than 0.150 mg/L, from 1996 to 2009. The response variable, DO flux was not observed and is unlikely a biological stressor, as previously discussed. From late 1989 through 1992, BOD was measured 37 times with an average of 4.07 mg/L and a maximum of 14.5 mg/L, both above the 3.5 mg/L BOD response variable criteria for river nutrients. Due to the time that has passed since these measurements, it is uncertain if BOD remains at those levels today or during the 2008 biological sampling. The other response/stressor variable, chlorophyll-a, was elevated throughout the time period of 2001 to 2011 (Figure 77), and may be acting on the biological community in a negative manner. At station 08MN001, carnivorous fish comprised only 10.2% of the individuals surveyed and non-tolerant insectivores represent only 27% of the community in this reach. There was also a lack of sensitive fish taxa compared to the total taxa found at the station; only 5.4% of the individuals were considered sensitive. With these negative impacts to the biological community, phosphorus, chlorophyll-a are confirmed stressors; and BOD should be monitored further.

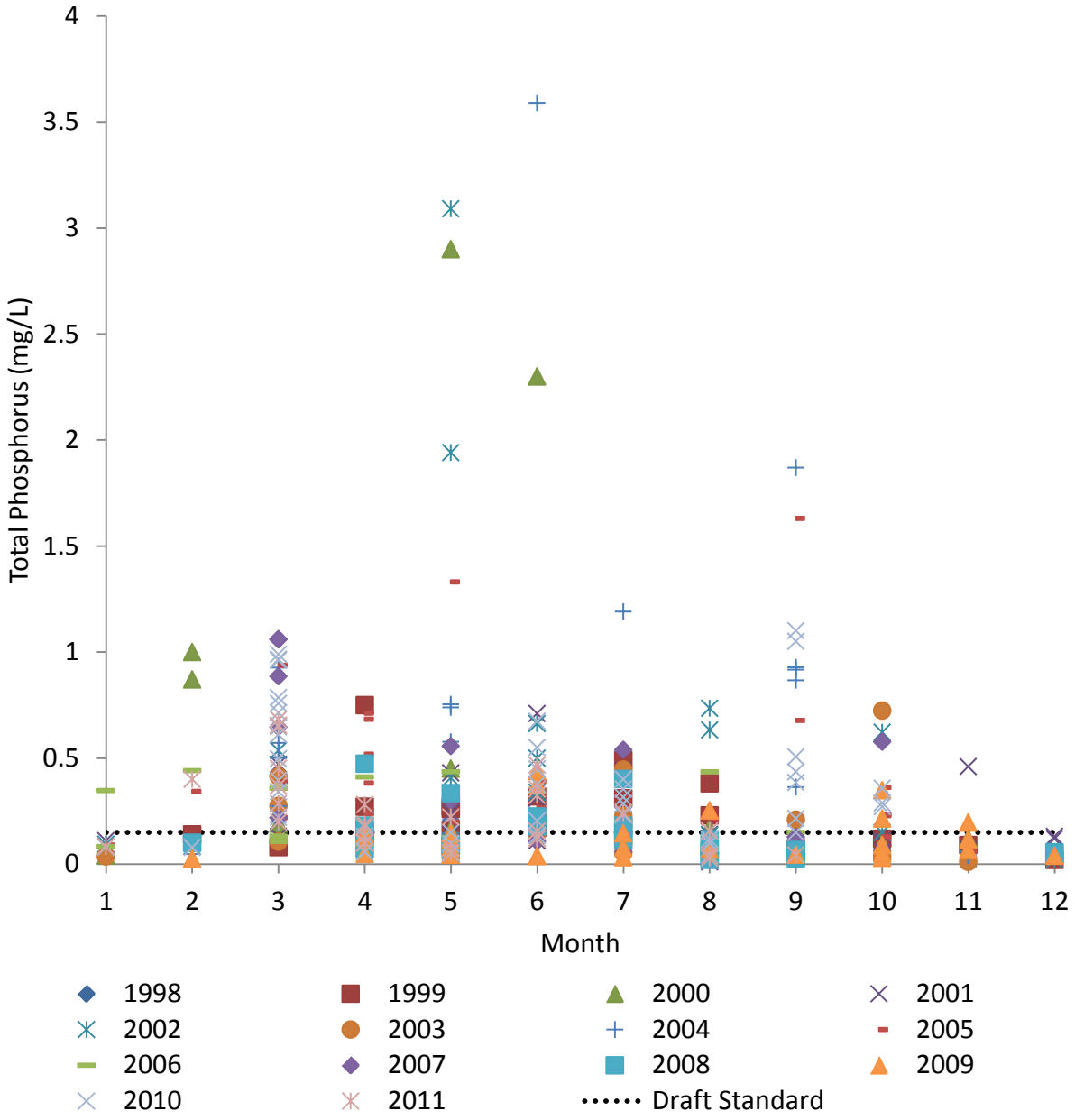

Figure 76. Total phosphorus for the Le Sueur River (-501) by month and year

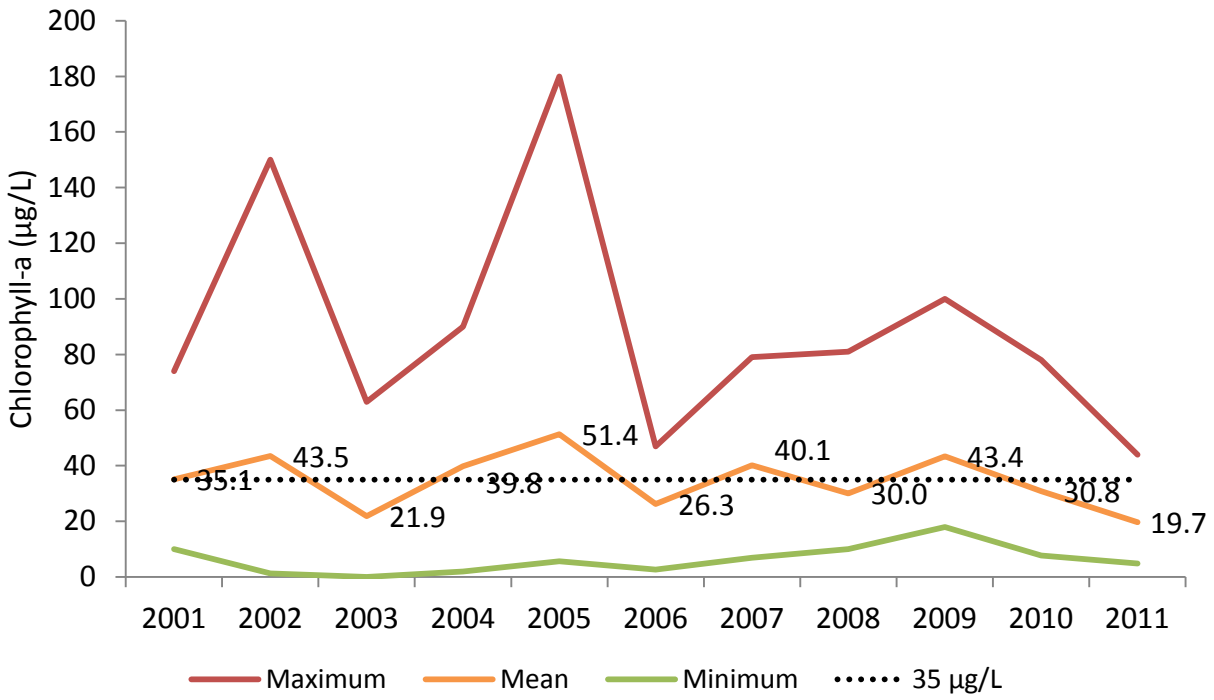

Figure 77. Summary statistics of chlorophyll-a for the Le Sueur River (-501) by year

Candidate cause: High nitrate

Nitrate in this AUID has been as elevated as high as 21 mg/L in May, 2004 (Figure 78). The months in which nitrate was the highest were April through August. HSPF model output (reach 850) shows that 14.7% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009. Unionized ammonia was observed to be below the standard in this reach. The fish community at this station was dominated by two fish species: sand shiner and spotfin shiner. The four sensitive taxa found at station 08MN001 were banded darter, highfin carpsucker, northern hogsucker and stonecat. Together these sensitive species comprised 5.4% while the tolerant species comprised 61.7% of the surveyed species. In addition to the fish community, the invertebrate community had few non-hydropsychid caddisflies (1.9% of sample, Figure 68). The invertebrates did have 25 taxa in the sample with 5 taxa as caddisflies, both of these are above the Minnesota River Basin averages. Nitrate tolerant invertebrate individuals comprised of 71.4% of the survey at station 08MN001, with less than 2% nitrate intolerant (5 individuals). Nitrate is in part a stressor to the biological community within this reach.

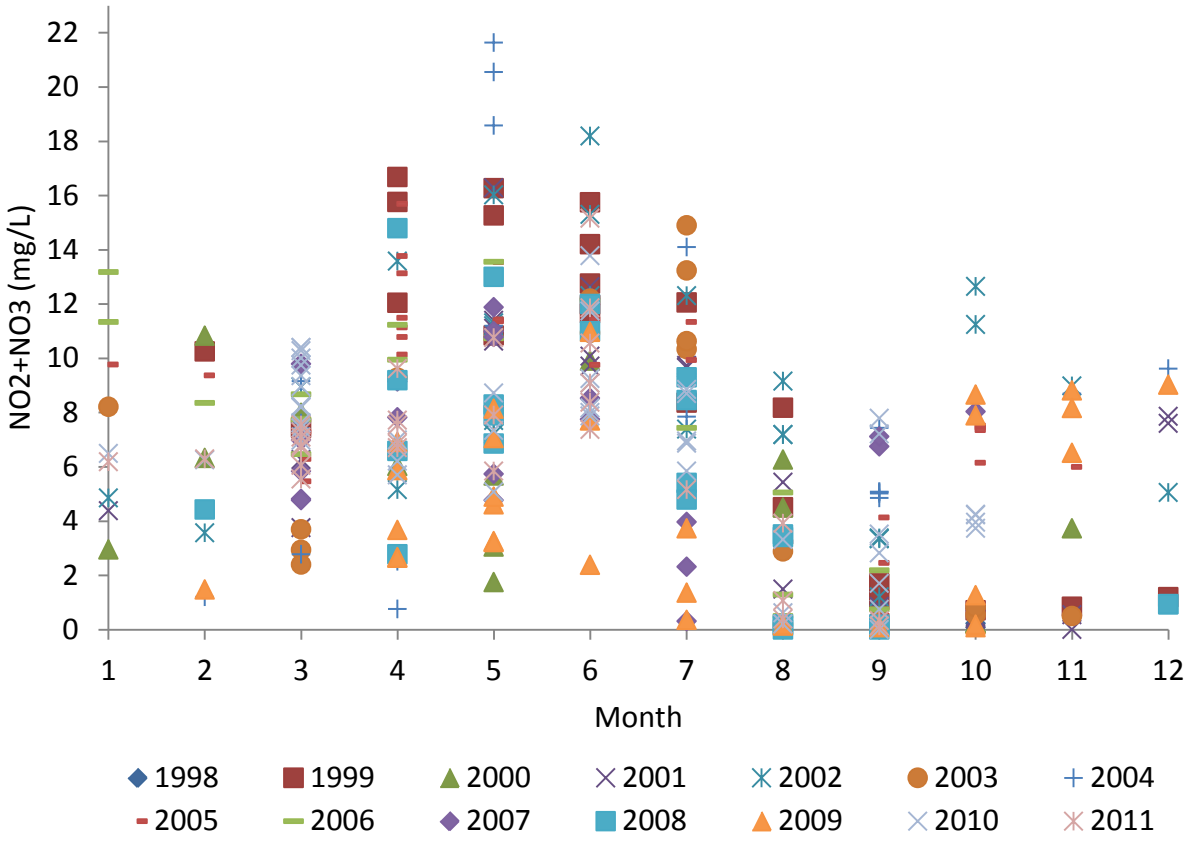

Figure 78. Nitrate-nitrite in the Le Sueur River (-501) by month and by year

Candidate cause: High suspended sediment

Total suspended sediment was elevated at this reach (Figure 79). HSPF model output (reach 850) shows that 28.4% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009. Like the upstream impaired AUID (-507), this station was dominated by sand shiners, which are tolerant to suspended sediment (41% of individuals surveyed). Herbivorous fish comprised only 4% of the surveyed population at station 08MN001. The average percent of herbivore fish in natural channels of the Le Sueur River watershed was 9.9%, with a range of 0% to 58%. The Le Sueur River watershed has many reaches currently listed for turbidity. Herbivorous fish populations throughout the watershed are influenced by the high turbidity that is prevalent throughout the watershed. Additionally, there was an abundance of tolerant fish individuals and a lack of sensitive fish taxa, which can be partially attributed to the increased suspended sediment in this reach. High suspended sediment and turbidity are stressing the fish community in this reach.

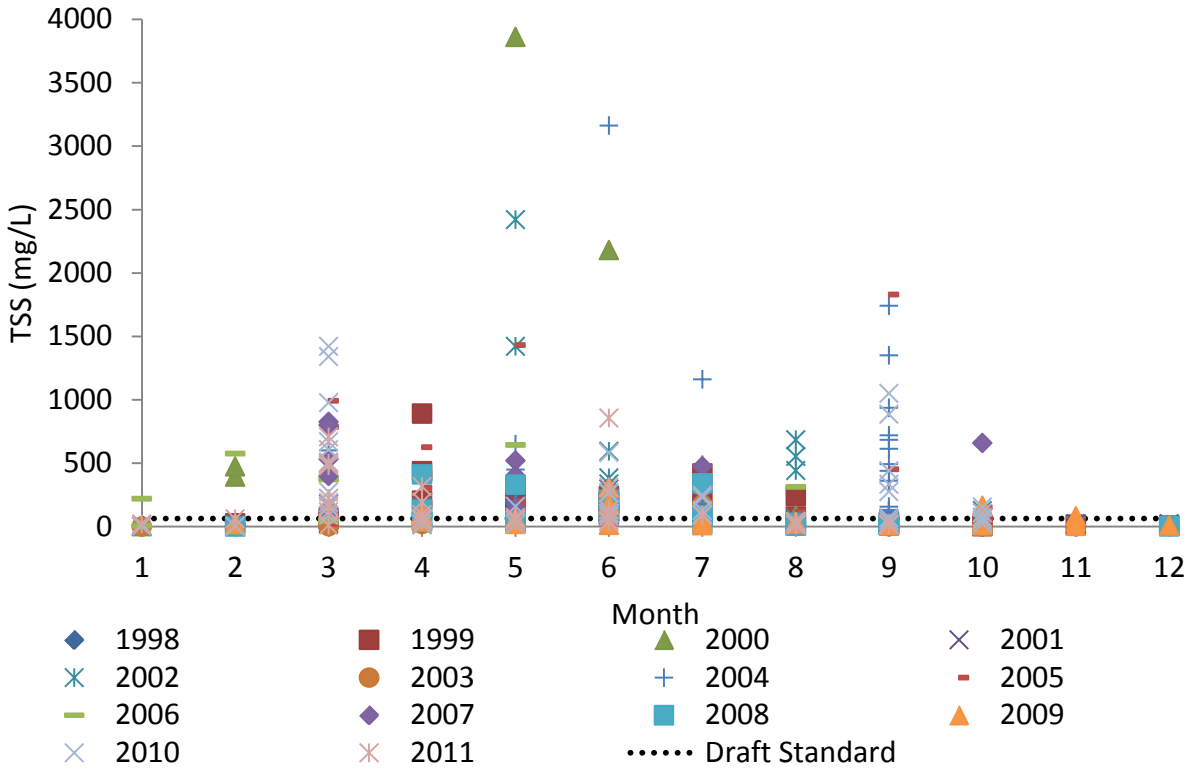

Figure 79. Total Suspended Solids for the Le Sueur River (-501) by month and by year

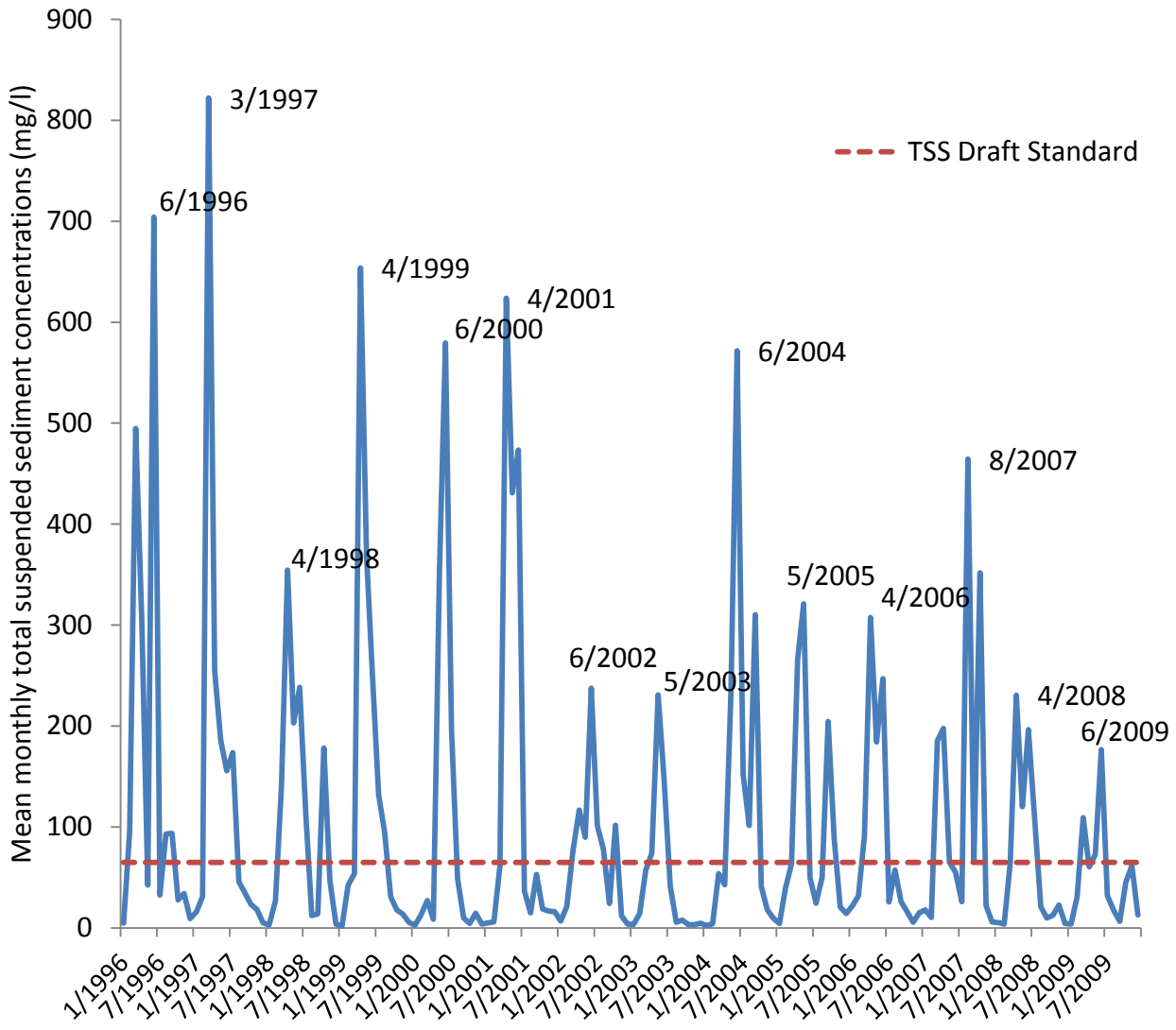

Figure 80. Monthly total suspended sediment concentrations for the outlet of the Le Sueur River as simulated by HSPF from 1996 to 2009

Candidate cause: Lack of habitat

The MSHA total score was 57.05 at station 08MN001 in 2008. The subcategories that scored particularly low were land use and cover (Table 23). The station is situated between row crop and urban/industrial land uses. It has heavy erosion present on the left bank. It has sparse cover available with some deep pools, woody debris and boulders available. There is a lack of diverse substrates and at the time of fish surveying, light embeddedness was observed.

Table 23. Proportion of MSHA subcategory scores for station 08MN001 in the Le Sueur River, bold represents subcategory received less than half of the maximum possible score

	LandUse	Riparian	Substrate	Cover	ChannelMorph
08MN001	**0.00**	0.60	0.67	**0.35**	0.67

The channel in this study reach is classified as F4 since flows (i.e., two times bankfull flow) are not accessing the floodplain. This inability to access the floodplain results in channel incision and floodplain deposition. The immediate floodplain appears to have aggraded by nearly two feet while the stream

channel has likely incised by four to five feet since the gage station was established in the late 1930s. The F classification at this site also relates to the channel width/depth ratio of 119. F channels are wide and shallow in nature, therefore providing less in-stream cover, poor fish habitat, low pool quality, and low diversity. These features typically result in higher water temperatures, mid-channel bars, and increased shear stress on both banks resulting in increased sediment loading. The Bank Erosion Hazard Index and the Near Bank Shear-Stress methods were used to estimate bank erosion rates within the reach following the Colorado estimates developed by Dave Rosgen. Four banks in this reach were assessed and the estimated bank erosion is 0.2447 tons/year/foot. This reach is controlled by a valley type VIII(c), alluvial terraced valley. F channels in alluvial terraced valleys continue to widen until they can create a C channel with a new floodplain inside the old channel. The Pfankuch rating for stream stability at this site was 127, which means the channel has poor stability for an F4 channel.

The fish community was comprised of a low percentage of benthic insectivores, which is likely related to the poor stability of the stream (Figure 62). The population of simple lithophilic spawners were sufficient (35.7% of the surveyed population at station 08MN001) (Figure 64). The fish community was dominated by individuals from two species, which is likely due in part to a lack of diverse habitat. As previously mentioned, sand shiners were the dominant fish taxa with spotfin shiners as the second most abundant fish taxa in the survey. Riffle dwelling individuals represented only 5.4% of the fish community (Figure 61).

Habitat, in terms of the lack of stability and diversity of habitat types, is a stressor to the fish community. Particularly, the erosion and scour/deposition cycle is likely also causing stress.

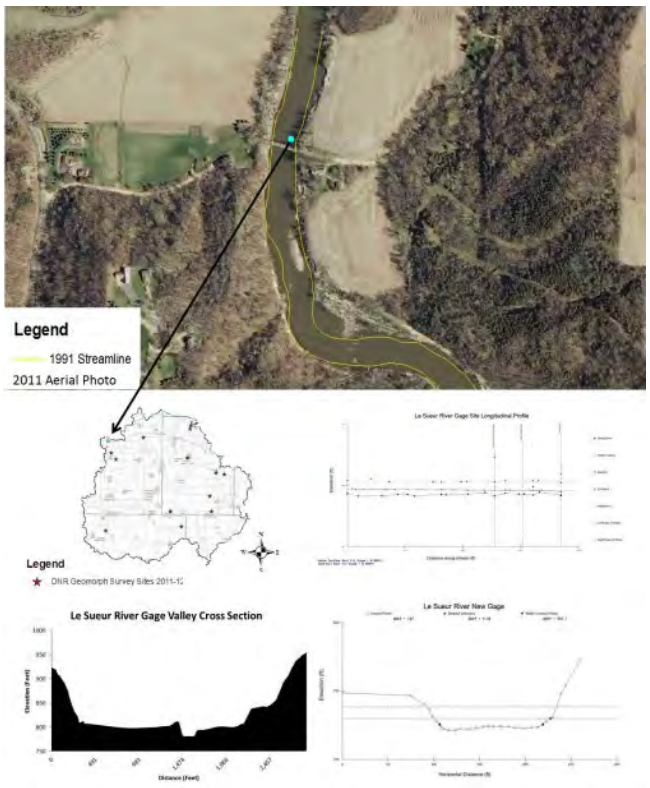

Figure 81. Location of Le Sueur Gage site with aerial photo, LiDAR derived valley cross section, actual surveyed longitudinal profile and cross section. The yellow line on the aerial photo is the 1991 stream line to show how the reach has changed from 1991-2011

Weight of evidence

The Le Sueur River (-501) was scored and summarized in Table 24. The evidence for each potential stressor, the quantity and quality of each type of evidence was evaluated. The consistency and credibility of the evidence is evaluated. For more information on scoring please see EPA's CADDIS Summary Table of Scores.

Table 24. Weight of evidence table for potential stressors in the Le Sueur River (-501)

Evidence using data from Le Sueur River (-501)						
Types of Evidence	**Scores**					
	Dissolved Oxygen	**Phosphorus**	**Nitrate-Nitrite**	**Suspended Sediment**	**Physical Habitat**	**Altered Hydrology**
Spatial/temporal co-occurrence	---	+	+	+	+	+
Temporal sequence	0	+	+	+	+	++
Field evidence of stressor-response	NE	NE	NE	NE	NE	0
Causal pathway	+	+	+	+	+	++
Evidence of exposure, biological mechanism	--	++	+	+	+	+
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE	NE
Verified or tested predictions	NE	NE	NE	NE	NE	NE
Symptoms	---	+	+	+	+	+
Evidence using data from other systems						
Mechanistically plausible cause	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE
Multiple lines of evidence						
Consistency of evidence	-	+	+	+	+	+
Explanatory power of evidence	-	++	++	++	++	++

Conclusions

In this furthest downstream reach of the Le Sueur River, the fish community was dominated by two species: sand shiner and spotfin shiner. It was lacking sensitive taxa and the fish were short-lived and serial spawners. With the limited available early morning DO data and the fish characterized as less tolerant to low DO, DO is not an issue at this time to the fish community.

A lack of carnivorous fish and non-tolerant insectivores are symptomatic of the elevated phosphorus and chlorophyll-a. Phosphorus is a stressor to the fish community in this downstream reach of the Le Sueur River.

Nitrate has been measured as high as 21 mg/L in this reach. With a dominance of tolerant fish and few sensitive taxa, nitrate is a stressor to the biological community. It is also influencing the invertebrate community is evident in the lack of non-hydropsychid caddisflies.

Total Suspended Solids is elevated within this reach of the Le Sueur River. Sand shiners comprised of 41% of the fish surveyed and are tolerant to suspended sediment. There was a lack of herbivorous fish related to the elevated TSS. High suspended sediment and turbidity are stressing the fish community.

At the biological station 08MN001, the classification of an F4 indicates an extremely wide and shallow river that is unable to access it's floodplain due to incision. There is also a lack of cover within this reach. In relationship to the poor stability, there was a low percentage of benthic insectivores. The dominance of two species is due, in part, to the lack of diverse habitat. Habitat is a driving stressor within this reach.

Hydrology is the driver for the elevated TSS, and lack of stream stability causing the lack of habitat. An estimated 862 stream miles have been added upstream of the pour point of the Le Sueur River since 1855. The magnitude of that change is reflected in the hydrologic issues that remain. The stream is wide and unable to access its floodplain at station 08MN001. These factors lead to less refuge for the fish community. Altered hydrology is a stressor to the fish community within this reach of the Le Sueur River.

The stressors present in this reach of the Le Sueur River (-501) are elevated phosphorus, elevated nitrate, elevated TSS/turbidity, lack of habitat, and altered hydrology.

Little Cobb River (07020011-504)

During the 2002 assessment cycle, the Little Cobb River was listed as impaired for fish and turbidity. In 2010 it was listed for low DO.

Biology in the Little Cobb River

In the Little Cobb River, biological station 96MN007 was sampled by USGS from 1996-1998 and 2002-2005. All of the fish surveys at station 96MN007 resulted in IBI scores less than threshold, ranging from 25 to 41. The other stations are located on channelized sections of the reach, but are important to consider since fish are likely to move through these other stations at times, too. In 2008, MPCA sampled two stations on the lowest AUID (504) of the Little Cobb River (stations 08MN070 and 08MN006). The upstream AUID of the Little Cobb River (524) had three stations sampled, two in 2008 and one in 2007.

At station 96MN007, the metrics that scored the lowest were: relative abundance (%) of individuals with a female mature age less than or equal to two (MA<2Pct), taxa richness of short-lived species (SLvd), relative abundance of taxa that are sensitive (SensitiveTxPct), relative abundance of individuals that are tolerant species (TolPct), and relative abundance of taxa that are tolerant species (TolTxPct; Figure 82). Relative abundance of taxa that are detritivorous (DetNWQTxPct) was also below the average metric needed for the IBI score to be at the threshold, but not quite as low as the others mentioned. There was a range of scores for the dominant two percent (DomTwoPct), and the highest percent occurred in 1998 and 2005. There appears to be no trend over the period of record indicating the health of the fish community is changing.

The fish community in the channelized stations (08MN070, 08MN039, and 08MN006) had similar response in metric scores for relative abundance (%) of individuals with a female mature age less than or equal to two (MA<2Pct), relative abundance of taxa that are sensitive (SensitiveTxPct), and relative abundance of individuals that are tolerant species (TolPct; Figure 83).

Invertebrates were not collected at 96MN007. In 2008, stations 08MN070, 08MN039 and 08MN006 were not sampled for invertebrates due to insufficient or no flow at time of attempted sample between August 21 and 26.

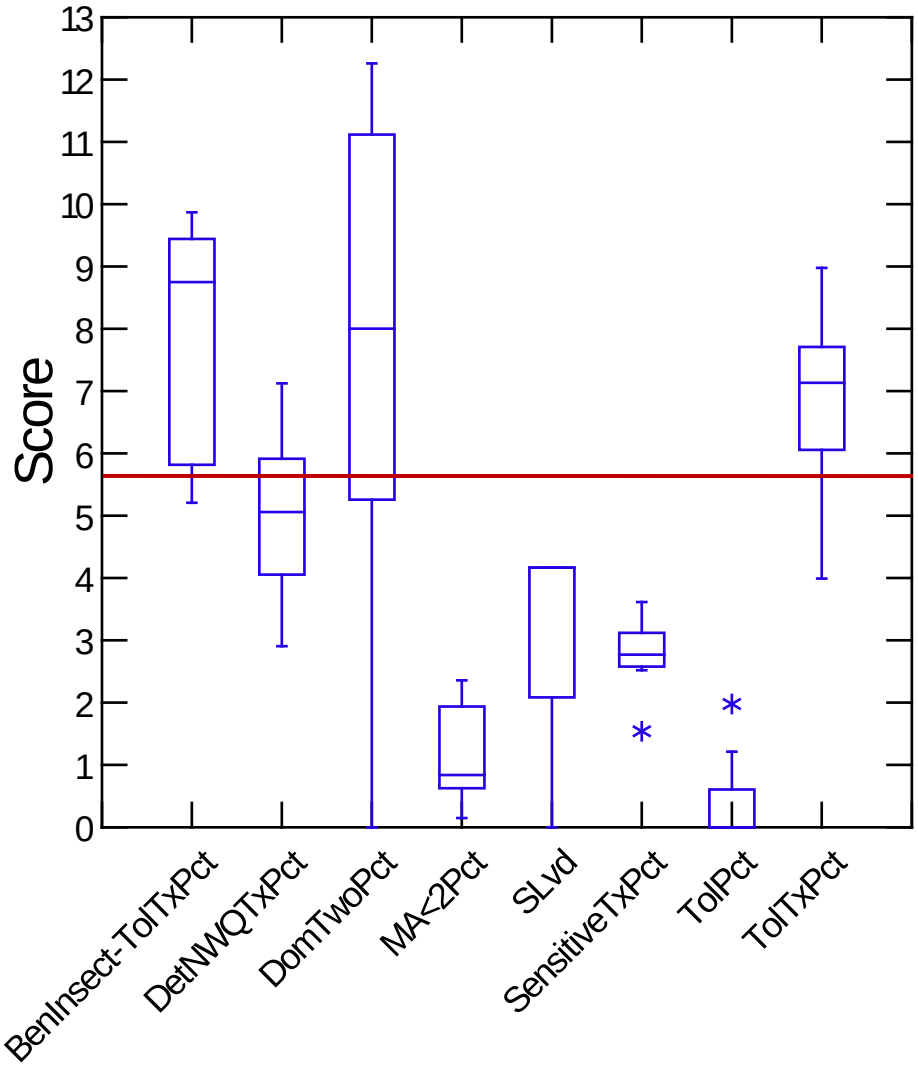

Figure 82. Fish metrics of the Southern Streams IBI for station 96MN007 from 1996-1998 and 2002-2005; red line indicates the average metric score (5.6) needed for the IBI score to be at the threshold

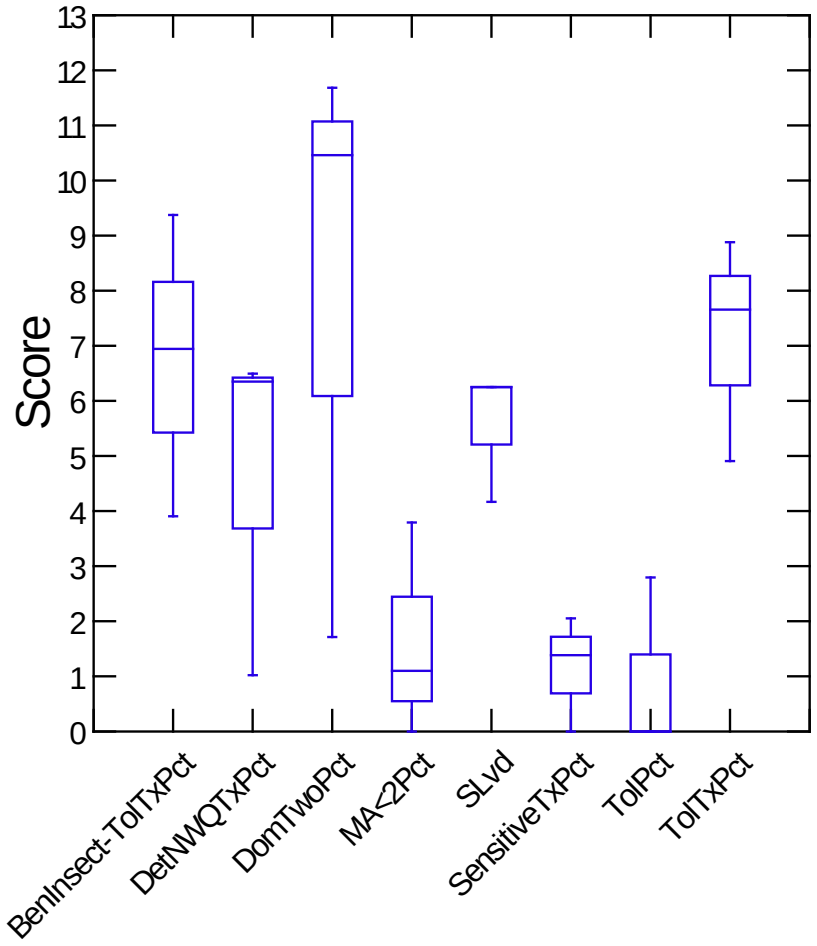

Figure 83. Fish metrics of the Southern Streams IBI in the Little Cobb River; on channelized stations 08MN070, 08MN039, and 08MN006 (Max 12.5)

Candidate cause: Low dissolved oxygen

In general, low DO corresponds to lower flows in the Little Cobb River (Figure 84). Of the nineteen measurements of low DO by USGS in 2005 and 2006, eighteen of them were at or below 10 cfs. Higher flux also generally occurs at lower flows; however the majority of the flux measurements were less than 4.5 mg/L (above which would indicate a potential stressor related to high nutrients). As part of follow-up monitoring, a longitudinal view of the DO was measured in late July 2010 (Figure 85). Flows were high during this time with 101 and 94 cfs on each of the sampling dates (7/20/10 and 7/21/10). The only low measurement was a contributor to the Little Cobb River, Perch Lake (07-0058-00). At this location, DO was low in the morning (which is expected) and again in the afternoon (when it is expected to rebound). It is unknown why this location had sustained low DO. Further monitoring of the DO is recommended.

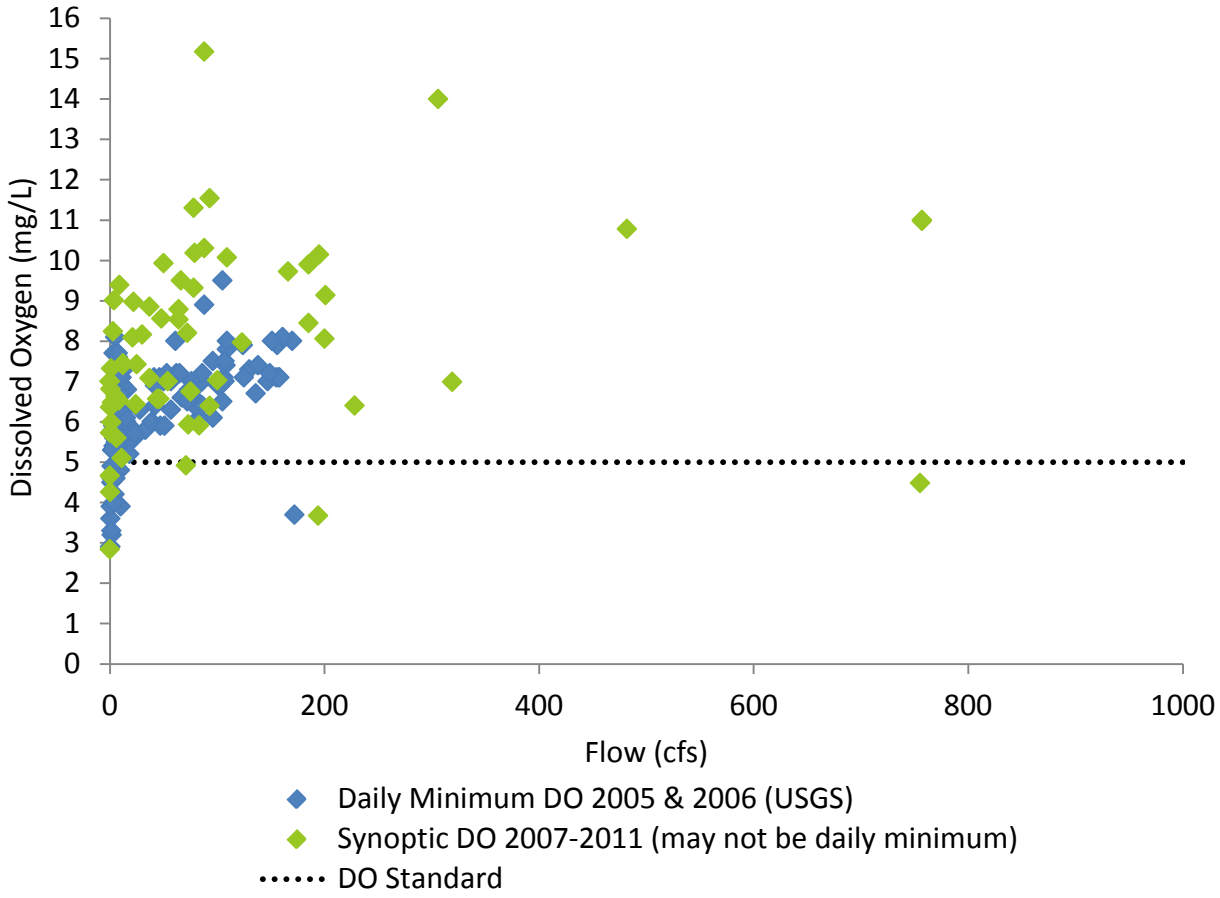

Figure 84. Dissolved oxygen measurements relative to flow at station S003-574

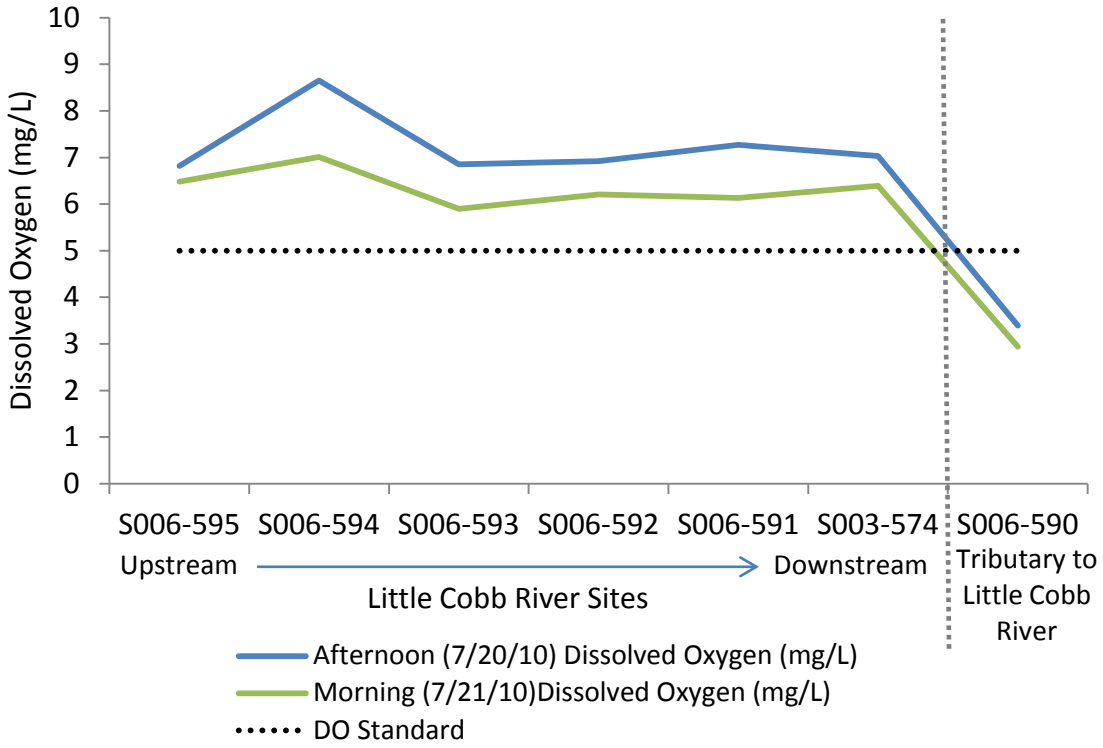

Figure 85. Longitudinal DO survey results on the Little Cobb River and tributary on July 20 and 21, 2010

Often low DO results in a decrease in sensitive taxa and an increase in tolerant taxa. Throughout this reach, tolerant individuals were high (64% to 97% of the total population and a total of 14 species) which resulted in a low metric score for the IBI score. Sensitive individuals were also low (less than 2.18% of the total population; Table 25), resulting in a low metric score for the IBI score. All stations sampled in 2008 had a near absence of sensitive species (less than 0.77% of the total population). The three sensitive species found in the Little Cobb River were: northern hogsucker, slenderhead darter, and stonecat. Slenderhead darters, a migratory species, have been found at the two most downstream stations, which may indicate that they migrate upstream from the Cobb River when conditions are right. Even if migration has been occurring, they were present in limited numbers in this reach (10 or less per survey).

According to Wisconsin's Guidelines for Designating Fish and Aquatic Life Uses (2004), there are nine fish species that may tolerate low DO. Of those nine, six were found within the Little Cobb River: black bullhead, brook stickleback, common carp, fathead minnow, green sunfish, and yellow bullhead. Low DO contributes to some of the degraded biological condition within the Little Cobb River.

Table 25. Percent abundance of sensitive fish individuals and individuals tolerant to low DO

	Upstream → Downstream									
	08MN038		08MN039		08MN070		96MN007		08MN006	
	Sensitive	Tol to Low DO	Sensitive	Tol to Low DO	Sensitive	Tol to Low DO	Sensitive	Tol to Low DO	Sensitive	Tol to Low DO
1996							0.8%	25.7%		
1997							2.2%	45.2%		
1998							1.2%	27.4%		
2002							1.8%	46.9%		
2003							1.1%	59.4%		
2004							2.2%	33.8%		
2005							0.8%	67.5%		
2008	0.0%	2.5%	0.0%	30.9%	0.8%	38.6%			0.1%	72.6%

Candidate cause: High phosphorus

Total phosphorous was elevated in the Little Cobb River (Figure 86). HSPF model output at the outlet of the reach (reach 743) shows that 50.5% of the TP daily averages are greater than 0.150 mg/L, from 1996 to 2009. As previously described, DO flux does not appear to be problematic at this time, even though DO at low flows is a stressor. There was no available BOD data for this reach. Chlorophyll-a has been sampled 191 times from 2001 to 2002 and 2008 to 2011. The mean chlorophyll-a was above the proposed criteria of 35 µg/L in 2008 and 2009 and just below 2010 and 2011 (Figure 87).

Carnivorous fish comprised 7.0% to 65.7% of the fish community throughout all of the Little Cobb biological stations. The non-tolerant benthic insectivores taxa were also present in acceptable percentages (ranging from 12.5% to 35% of the number of represented taxa), but the percent individuals of non-tolerant insectivores was relatively low (ranging from 2.5% to 15%). There was a lack of sensitive taxa compared to the total number of taxa, with sensitive individuals ranging from 0% to 2.5% of the surveyed population, but the tolerant taxa do not overwhelm the population. Generalists comprised 34.4% to 87.6% of the community depending on the station and year visited. There appears to be some yearly variability in the response of the fish community, but it does appear the phosphorus and the associated variable of chlorophyll-a are impacting the fish community in this reach of the Little Cobb River.

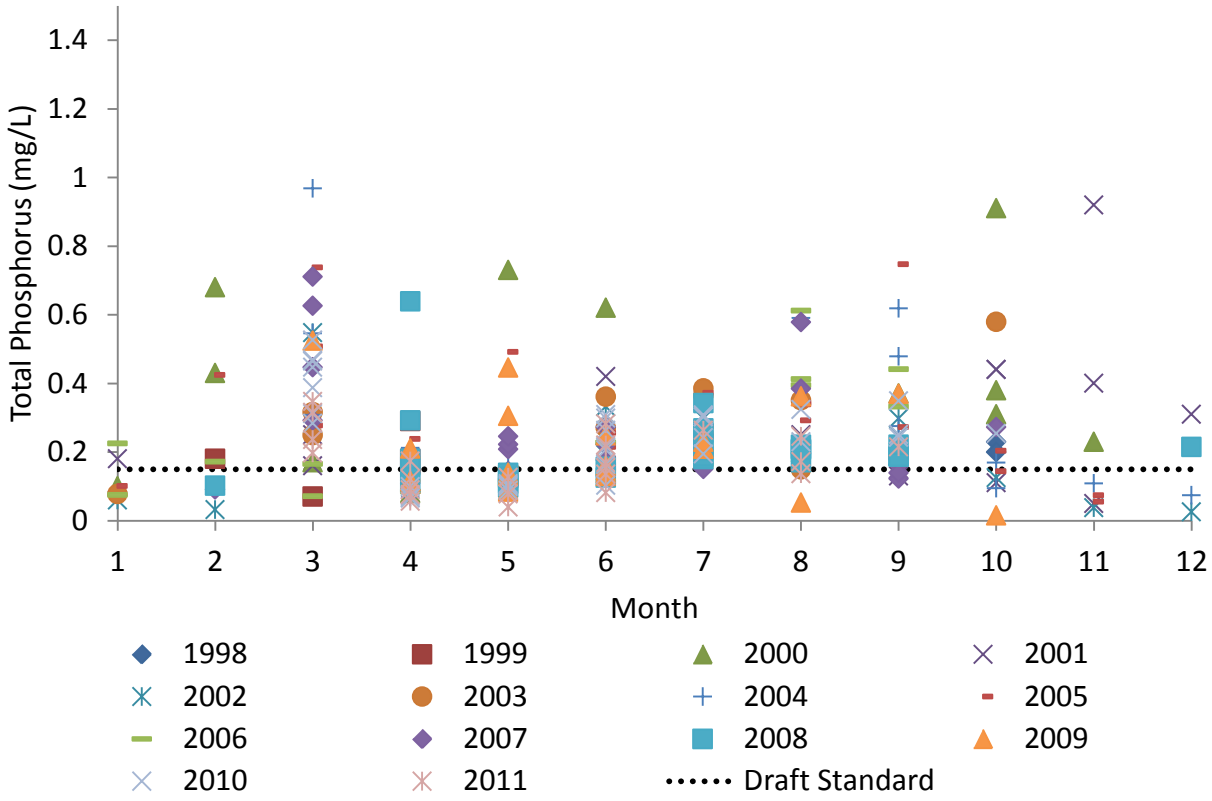

Figure 86. Total phosphorous for the Little Cobb River by month and year

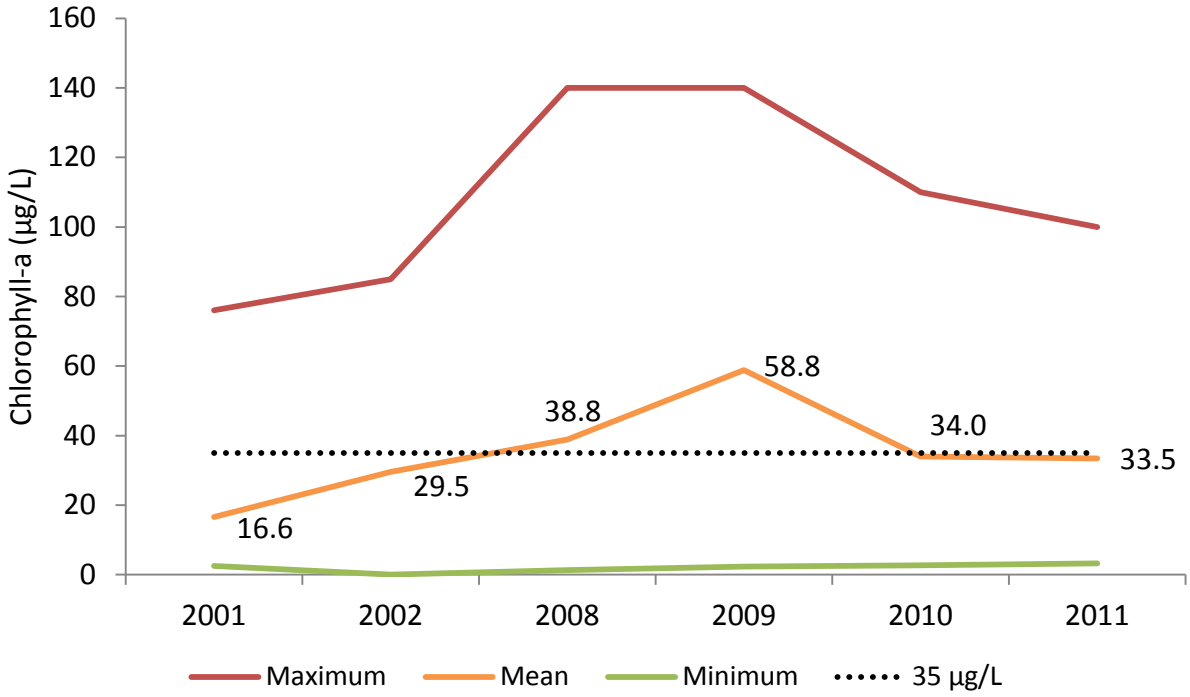

Figure 87. Chlorophyll-a summary statistics for the Little Cobb River

Candidate cause: High nitrate

Nitrate in the Little Cobb River has been measured as high as 18.5 mg/L (Figure 88). The highest measurements generally were during April through June. HSPF model output (reach 743) shows that 17.2% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009. The fish taxa count ranges from 13 taxa in the channelized headwater station 08MN038, to the channelized downstream station with 27 taxa. Fish populations in the natural channel station 96MN007 ranged from 18 to 25 taxa during the seven visits. At all stations there was less than 2% sensitive fish individuals. Only one station on the Little Cobb River was sampled for invertebrates in 2008, station 08MN038. Less than 1% of the sample comprised of caddisflies; however the station is channelized and likely experiencing additional stressors. It is likely that nitrate is playing a role in shaping the biological community in the Little Cobb River, but other stressors are likely playing a larger role.

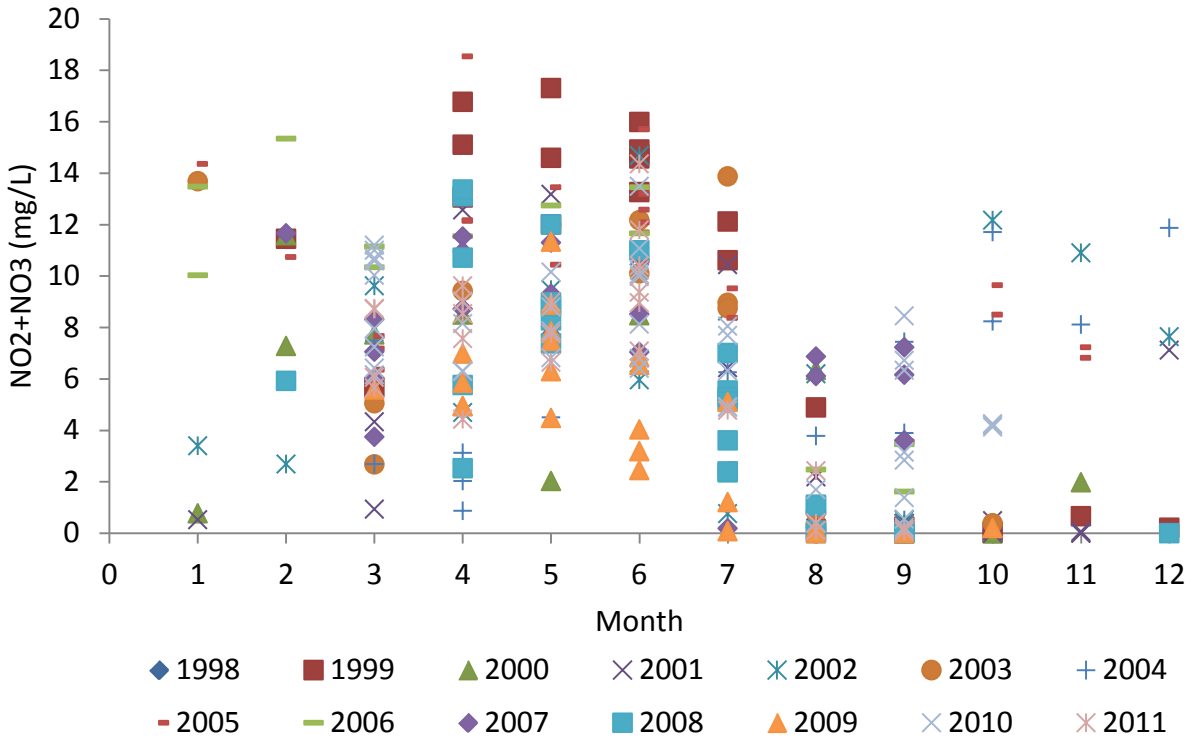

Figure 88. Nitrate-nitrite in the Little Cobb River by month and by year

Candidate cause: High suspended sediment

Total Suspended Solids in the Little Cobb River was elevated (Figure 89). The 311 TSS samples taken from 1998 to 2011 had an average of 63.6 mg/L. June had the highest average TSS over this time period, 107.5 mg/L (49 samples). Nearly all of the data collected in this AUID was at station S003-574. Additional data longitudinally through the AUID would be beneficial to understand the elevated TSS dynamics throughout the reach. Longitudinal transparency measurements on July 20 and 21, 2010, showed little variation between stations. The transparency ranged from 10.5 to 14 cm (poor). HSPF model output (reach 743) shows that 14.3% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009.

There was a generous abundance of common carp throughout the reach that likely stir up bottom materials adding to the turbid conditions. The three sensitive fish species found in the Little Cobb River were slenderhead darters, stonecat and northern hogsucker. According to Becker (1983), slenderhead

darters have often been located in turbid waters. Northern hogsuckers appear to be a bit more sensitive to turbid waters, but their numbers have been relatively low and have only been found at stations 96MN007 and 08MN006. At the two upstream stations, herbivorous fish appear to be doing relatively well (22% and 31% of the total population), but downstream, the percentage of herbivorous fish dramatically drops (0.3% to 8.5.% of the population). The average percent of herbivore fish in natural channels of the Le Sueur River watershed was 9.9%, with a range of 0 to 58%. The Le Sueur River watershed has many reaches currently listed for turbidity. Herbivorous fish populations throughout the watershed are influenced by the high turbidity that is prevalent throughout the watershed. Additionally, there was an abundance of tolerant fish individuals and a lack of sensitive fish taxa, which can be partially attributed to the increased suspended sediment in this reach. Turbidity and total suspended sediment are affecting the fish community in this reach.

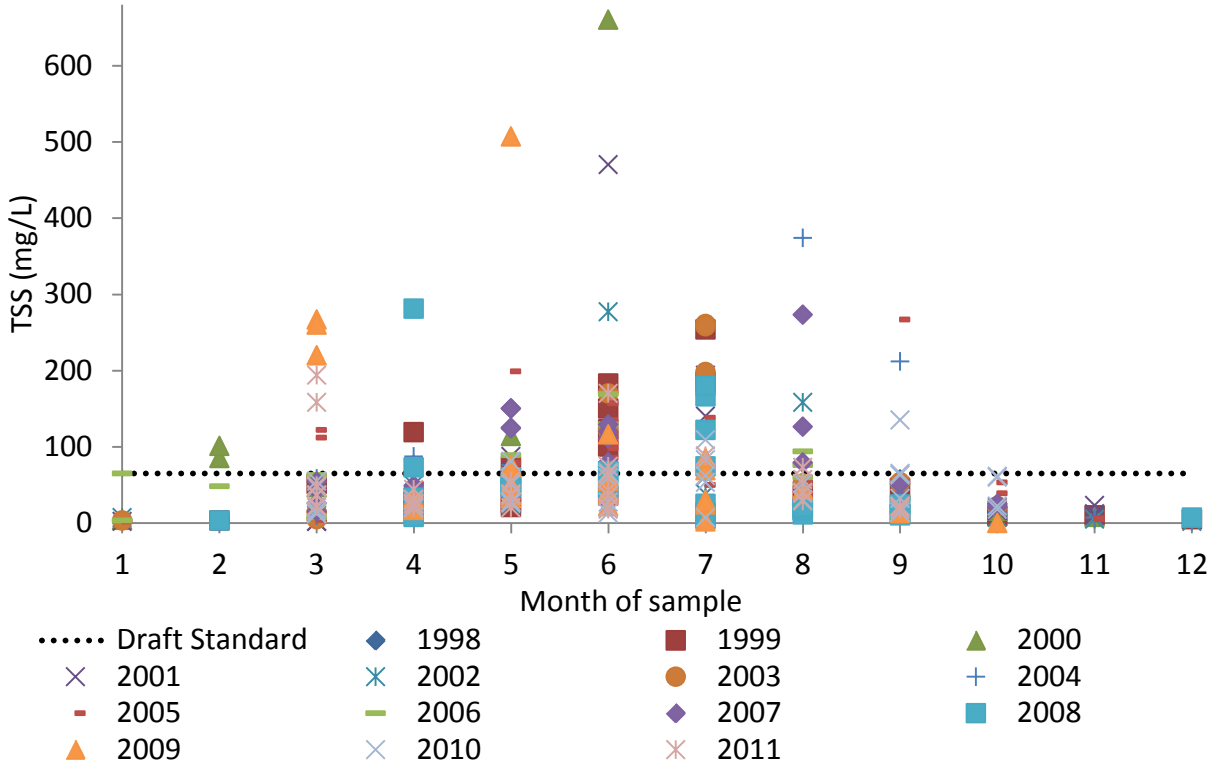

Figure 89. Total suspended solids samples for the Little Cobb River by month and by year

Candidate cause: Lack of habitat

Biological station 96MN007 was sampled by USGS and did not have the MSHA completed on the station. The other stations are located on channelized sections of the reach, but are important to consider since fish are likely to move through these other stations at times, too. The MSHA ranged from 55 (fair) at station 08MN038, 32 (poor) at station 08MN039, 47.6 (fair) at station 08MN070, and up to 56.2 (fair) at the downstream station of 08MN006. The subcategory scores also vary by station (Figure 90). The channelization and loss of sinuosity throughout this AUID contribute negatively to the habitat. There is a loss of habitat types available for species when there is channelization. The three upstream stations had no riffle present in the station, and the downstream station only had 10% riffle, indicating the loss of habitat.

Riffle-dwelling fish at station 96MN007 ranged from 1.2% to 9.3% of the total population during the 7 surveys. Although there is no riffle present in either of the stations 08MN038 or 08MN039, those

locations had the greatest percentage of riffle-dwelling fish, with 21.5% and 31%, respectively. The range of riffle dwelling fish in the Le Sueur River Watershed was 0 to 57%, with a mean in natural channels of 13%. However if you broaden that perspective to the Minnesota River basin, and only include those at or above the IBI threshold, the mean of riffle dwelling fish was 20.2%. In the lower stations of the Little Cobb River, the percentage of riffle dwelling fish is less than desired.

The benthic insectivores in the Little Cobb were only present in the range of 2.5% to 15.1% and at 96MN007, the range was only 3.8% to 5.6%. Similarly, simple lithophilic spawners only were present from 2.9% to 11.8%. Along with the added evidence for the strong presence of tolerant individuals in this AUID, it is highly likely that the lack of diverse habitat is a stressor to the biological community.

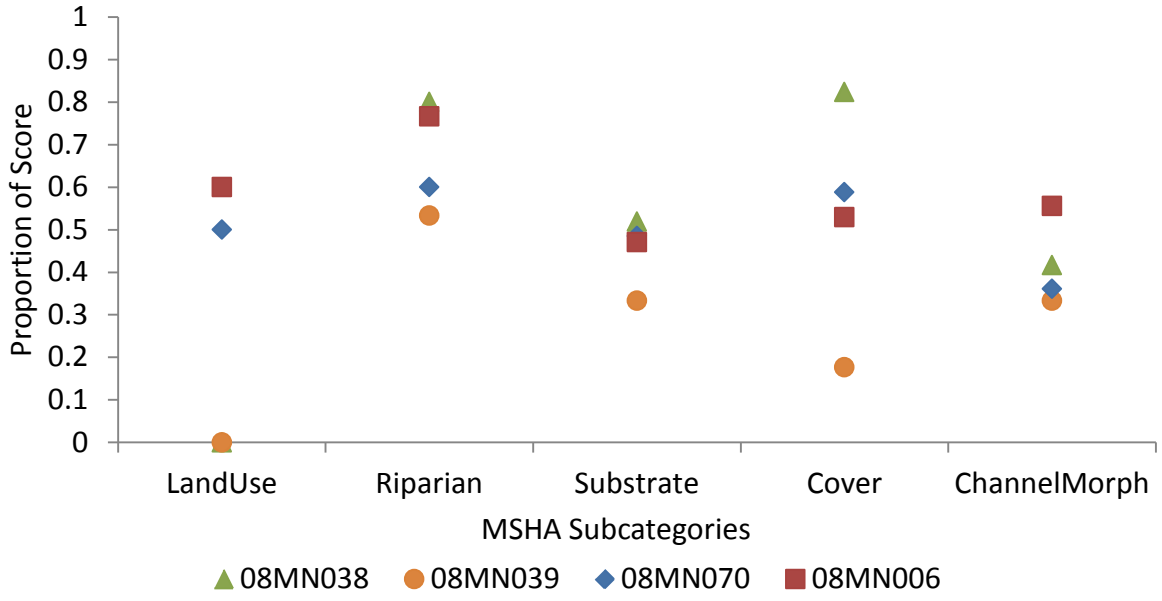

Figure 90. MPCA Stream Habitat Assessment subcategory proportion of score for the Little Cobb River

Weight of evidence

The Little Cobb River was scored and summarized in Table 26. The evidence for each potential stressor, the quantity and quality of each type of evidence was evaluated. The consistency and credibility of the evidence was evaluated. For more information on scoring please see EPA's CADDIS Summary Table of Scores.

Table 26. Weight of evidence table for potential stressors in the Little Cobb River (-504)

Evidence using data from Little Cobb River (-504)						
Types of Evidence	**Scores**					
	Dissolved Oxygen	**Phosphorus**	**Nitrate-Nitrite**	**Suspended Sediment**	**Physical Habitat**	**Altered Hydrology**
Spatial/temporal co-occurrence	+	+	+	+	+	+
Temporal sequence	+	+	+	+	+	++
Field evidence of stressor-response	NE	NE	NE	NE	NE	0
Causal pathway	++	+	+	++	+	++
Evidence of exposure, biological mechanism	+	+	+	+	+	+
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE	NE
Verified or tested predictions	NE	NE	NE	NE		NE
Symptoms	+	+	+	+	+	+
Evidence using data from other systems						
Mechanistically plausible cause	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE
Multiple lines of evidence						
Consistency of evidence	+	+	+	+	+	+
Explanatory power of evidence	++	++	++	++	++	++

Conclusions

The fish community is impaired in the Little Cobb River. The fish were made up of species that mature quickly, are short-lived and tolerant. Low flows on the Little Cobb River correspond to episodes of low DO. In 2008, the stations sampled had a near absence of sensitive species. Additionally, of nine species known to tolerate low DO, six were present in the Little Cobb River (Wisconsin DNR, 2004). Low DO contributes to some of the degraded biological condition.

Both phosphorus and chlorophyll-a were elevated within this reach of the Little Cobb River. There was a lack of sensitive taxa and generalists varied by year and station. There was a mixed response in the carnivorous fish with a wide range present (7% to 65.7%). There is some variability in the fish response to the elevated phosphorus, but it is impacting the fish community within this reach.

Nitrate has been measured as high as 18.5 mg/L and is generally highest from April through June. The fish community varies in the number of taxa present, again depending on location. There were less than 2% sensitive fish individuals present and less than 1 percent caddisflies. Nitrate is contributing to the degraded fish community.

The average TSS (63.6 mg/L) of 311 samples from 1998 to 2011 was just under the draft TSS standard (65 mg/L). Longitudinal transparency data in 2010 showed that there is little variation in the poor conditions up to downstream throughout this reach. There was a generous abundance of common carp within this reach that likely add to the turbid conditions. Herbivorous fish vary in abundance with upstream stations having greater proportions than downstream. There was a lack of sensitive fish taxa, with only three found in the Little Cobb River. The ability for tolerant fish to thrive is due to the turbidity and TSS within this reach.

The downstream biological stations lacked riffle-dwelling fish. Stations 08MN038 and 08MN039, despite having no riffle present within the reach had the greatest amount of riffle-dwelling fish. Benthic insectivores and simple lithophilic spawners were present in low proportions. The upstream channelization and loss of sinuosity contribute to the lack of habitat diversity. In particular, riffle habitat, substrate diversity and channel stability are key habitat features missing within this reach.

At station 96MN007, long lived fish were generally low in abundance, with a high proportion of tolerant fish. In 2008, stations 08MN070, 08MN039 and 08MN006 were not sampled for invertebrates due to insufficient or no flow between the dates of August 21 and 26. Low DO was concurrent with low flow. The lack of stream stability is also related to the flow conditions. Upstream of the confluence with the Cobb River, the Little Cobb River has gained approximately 116 stream miles since 1855. Changes to how water is routed on the landscape have effects on duration and sustained baseflows. Flow alteration is a stressor to the biological community in the Little Cobb River. Low DO, elevated phosphorus, elevated nitrate, elevated TSS/turbidity, lack of habitat, and altered hydrology are all stressors to the biological community in the Little Cobb River.

Cobb River (07020011-568)

This upper reach of the Cobb River was impaired for fish in 2004, turbidity in 2010 and invertebrates in 2012.

Biology in the Cobb River

The fish IBI scores in this reach of the Cobb River ranged from 19 to 39, with all stations scoring below the threshold for their fish class. At the headwaters of the AUID, fish were sampled twice at station 08MN081. At this station there was a lack of sensitive taxa, an abundance of: generalist taxa (GeneralTxPct), detritivore taxa (DetNWQTxPct), and very tolerant taxa (VtolTxPct; Table 27). There was also an abundance of serial spawners (SSpnPct) at this station. The next three stations downstream of 08MN081 had a lack of sensitive taxa (SensitiveTxPct) and an abundance of tolerant individuals (TolPct; Figure 91). There was a range in the metric score for the dominant two percent (DomTwoPct) and also in those that mature within two years (MA<2Pct). The furthest downstream station on this AUID, 08MN067, is channelized and was not compared against the threshold (Table 28). There was a similar population in this downstream reach compared to the three assessable stations upstream.

Table 27. Fish metrics of the Southern Headwaters IBI for site 08MN081; bold indicates metric score below average score (8.5) needed to be above threshold

Site	DetNWQTxPct	GeneralTxPct	Sensitive	SLvdPct	SSpnPct	VtolTxPct
08MN081 (avg. of 2 visits in 2008)	**4.06**	**6.72**	**0.00**	9.12	**6.96**	**2.48**

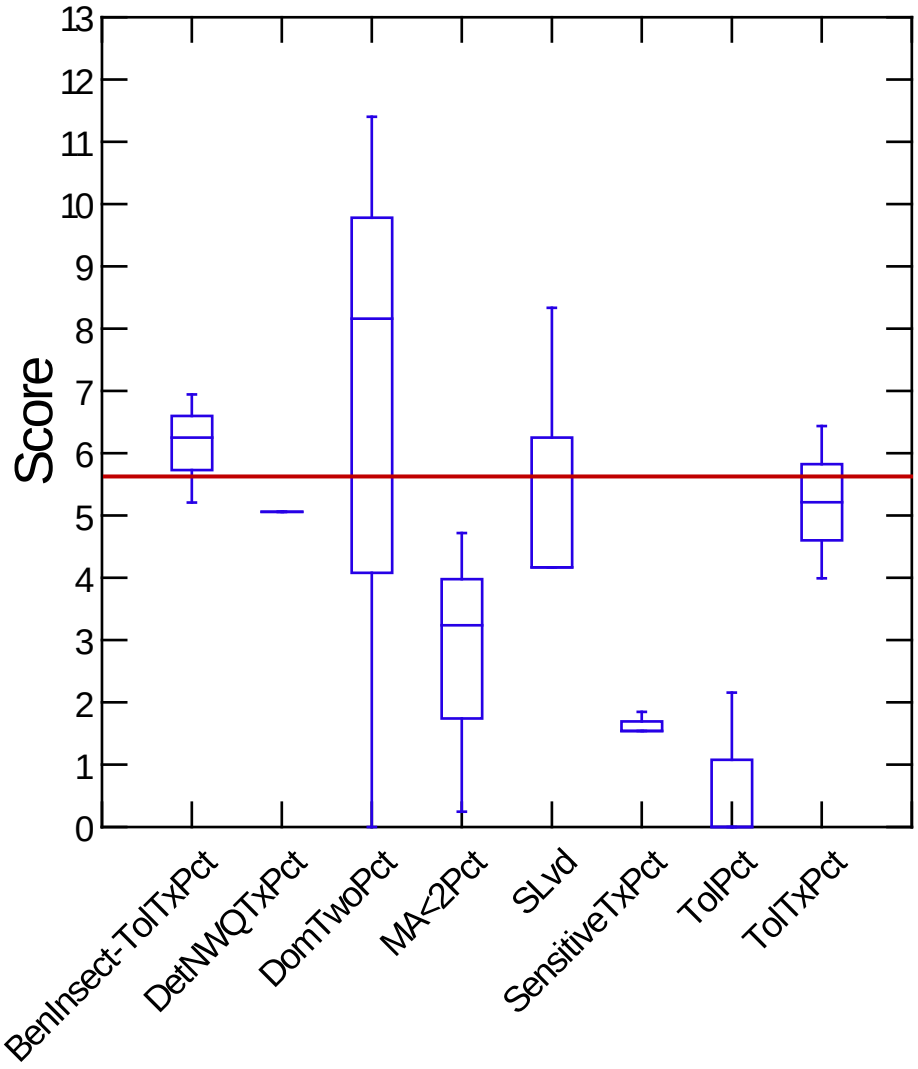

Figure 91. Fish metrics of the Southern Streams IBI for the Cobb River (upper); red line indicates the average metric score (5.6) needed for IBI score to be at the threshold (Stations 08MN017, 08MN071, and 97MN002)

Table 28. Fish metrics of the Southern Streams IBI for site 08MN067; channelized reach

Site	BenInsect-TolTxPct	DetNWQTxPct	DomTwoPct	MA<2Pct	SensitiveTxPct	SLvd	TolPct	TolTxPct
08MN067	7.81	6.67	8.82	0.56	2.31	4.17	0.00	8.57

Three stations were sampled for invertebrates in this AUID. The natural channel stations sampled resulted in two scores below threshold and below the lower confidence interval. Station 08MN081 was lacking invertebrate taxa that cling (ClingerCh), collector-filterers (Collector-filtererPct), intolerant taxa

(Intolerant2Ch), predators (PredatorCh), non–hydropsychid caddisflies (TrichwoHydroPct), and Plecoptera, Odonata, Ephemeroptera and Trichoptera taxa (POET). Additionally, it had a low metric score for HBI_MN, a measure of pollution based on tolerance values assigned to each individual taxon. Station 08MN017 lacked invertebrates that climb (ClimberCh), stoneflies (Plecoptera), predators (Predator), and caddisflies (Trichoptera). It was overly abundant with tolerant taxa, as well as also receiving a low metric score for HBI_MN.

Table 29. Invertebrate metrics of the Prairie Streams GP IBI for site 08MN081; bold indicates metric score below average score needed to be above threshold; *station 08MN067 is channelized and not currently comparable with a threshold.

Site	ClingerCh	Collector-filtererPct	DomFiveCHPct	HBI_MN	Intolerant2Ch	POET	PredatorCh	TaxaCountAllChir	TrichopteraChTxPct	TrichwoHydroPct
08MN081	**2.7**	**0.8**	4.2	**1.7**	**0**	**3.6**	**2.1**	**2.7**	4.3	**0**
08MN067*	3.3	0	4.5	3.2	0	6.4	4.3	3.3	2.0	2.1

Table 30. Invertebrate metrics of the Southern Streams RR IBI for site 08MN017; bold indicates metric score below average score needed to be above threshold

Site	ClimberCh	ClingerChTxPct	DomFiveCHPct	HBI_MN	InsectTxPct	Odonata	Plecoptera	Predator	Tolerant2ChTxPct	Trichoptera
08MN017	**2.5**	5.1	3.8	**0**	5.1	6.1	**0**	**0.8**	**0.6**	**1**

Candidate cause: Low dissolved oxygen

There was a lack of DO data within this reach. There were only six measurements, which were all above the standard. Five of the measurements were taken at the time of fish sampling; three of them were taken prior to 10:00 AM and were over 2 mg/L above the standard. Likewise, there is no indication in this small dataset for excessive DO flux. The biological data also indicates that for much of the reach, there was some sensitivity to low DO, except for the fish community at the channelized station 08MN067 which had slightly more individuals that are tolerant to low DO (Figure 6). Low DO is not a likely cause of the overall stress to the biological community within this reach, but it cannot be completely ruled out.

Candidate cause: High phosphorus

Of the six samples for phosphorus, five were above the draft standard (0.15 mg/L). The highest was 0.2 mg/L on July 10, 2008 at the time of biological sampling at 08MN067. HSPF model output at the outlet of the reach (reach 729) shows that 32.5% of the TP daily averages are greater than 0.150 mg/L, from

1996 to 2009.There was no BOD or chlorophyll-a data available on this reach and a lack of information about the DO flux. With the lack of connecting data it is difficult to determine if phosphorus is a stressor to the biological community. There is some biological data that suggests it is not a stressor, including the carnivorous fish in this reach which make up a greater percentage of the surveyed population than downstream, where phosphorus is a stressor (Figure 92). Benthic insectivore taxa were satisfactory within this reach, except there were many tolerant insectivores present, which may be indicative of a shift in community dynamics (Figure 93). However, in terms of the invertebrate community, the response was mixed with a lack of: sensitive individuals, predators, and decreased taxa richness. There was a lack of collector-filterers, which may be a response to increases in suspended sediment, but would likely increase with increases in algae. The mixed biological signals along with the lack of data make it difficult to either rule out or conclude that phosphorus is a stressor. It is recommended that further monitoring of phosphorus with response variables be conducted to help determine the role phosphorus is playing in the degraded biological community.

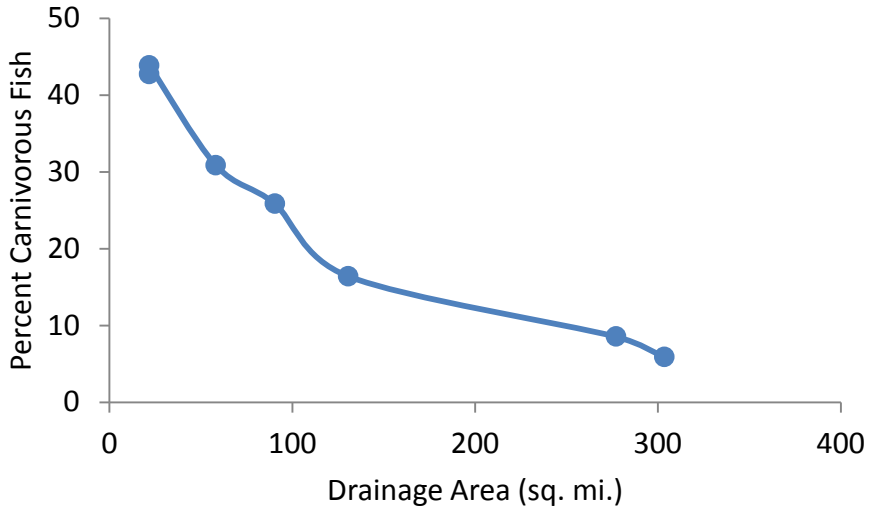

Figure 92. Percent carnivorous fish in 2008 longitudinally in the Cobb River

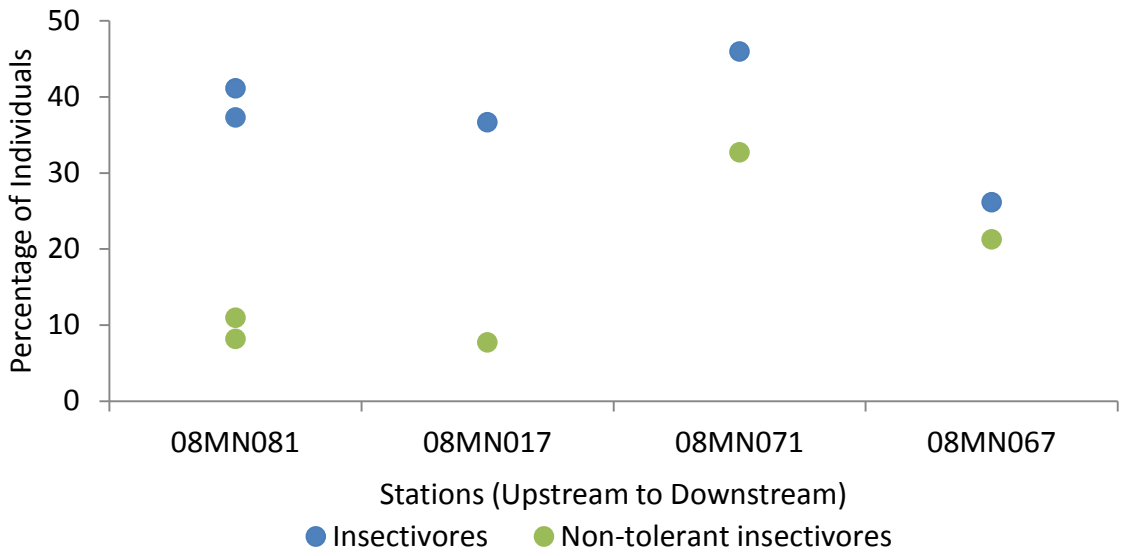

Figure 93. Percentage of insectivores and percentage of non-tolerant insectivores in the Cobb River (-568)

Candidate cause: High nitrate

Only six samples of nitrate have been collected on this AUID (in 2008 at the time of fish sampling and in 2010); the values range from 0.68 to 12 mg/L. Two of the nitrate samples were greater than 10 mg/L and only one sample was less than 6 mg/L. HSPF model output (reach 729) shows that 13.8% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009.

The invertebrate taxa counts were below the average for the Minnesota River basin. Station 08MN081 also had fewer caddisfly taxa than the Minnesota River basin average. The percentage of non-hydropsychid caddisflies with nitrate make a biological response wedge shaped plot. Those stations with high nitrate and low percentage of non-hydropsychid caddisflies are likely impacted by the elevated nitrate. The stations found near the low values of nitrate and higher percentages of non-hydropsychid caddisflies are likely not impacted by nitrate. Those stations found near the lower values for both nitrate and non-hydropsychid caddisflies may be impacted by nitrate or other factors. In this reach of the Cobb River, less than 1% of the invertebrate population was non-hydropsychid caddisflies at three stations sampled (Figure 94). Nitrate tolerant invertebrate individuals comprised of 82.1-84.9% in the natural channel stations, but only 42.3% at station 08MN067. Stations 08MN081 and 08MN067 had presence of one and two nitrate intolerant taxa, but the individuals comprised of less than 2%.

The total number of fish taxa at the stations within this reach range from 10 to 24 with sensitive taxa increasing longitudinally from the headwaters to the downstream end of this reach, where two sensitive taxa were observed at station 08MN067. The sensitive taxa make up less than 1% of each of the surveyed fish populations. The tolerant fish individuals make up 66% to 92% of the surveyed fish communities. There was a lack of nitrate data, making it difficult to conclude that nitrate is a definite stressor; however there was preponderance of degraded biological conditions that is likely in part associated with the nitrate conditions in the Cobb River.

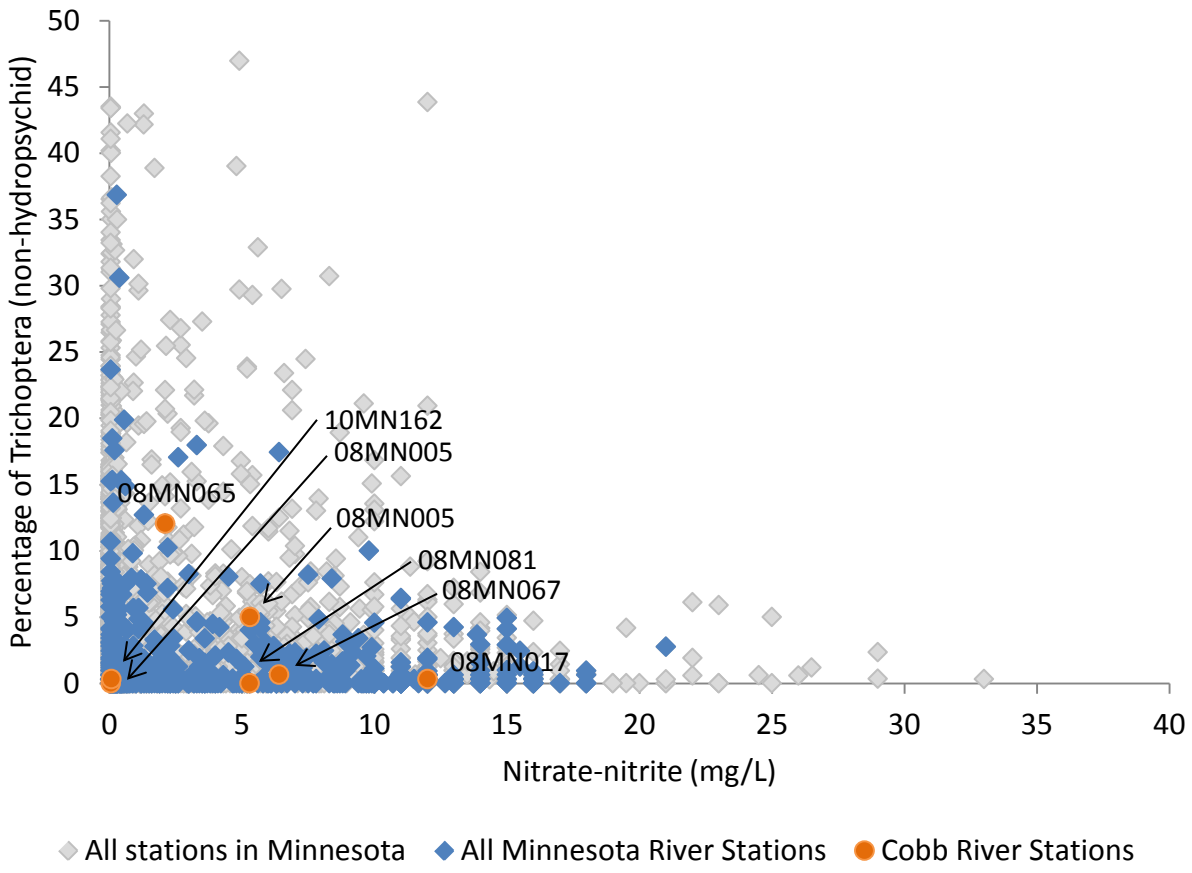

Figure 94. Percentage of non-hydropsychid Trichoptera with Nitrate-nitrite at the time of fish sampling for all stations in Minnesota, all Minnesota River Basin Stations, and the Cobb River Stations

Candidate cause: High suspended sediment

Within this reach, the only five TSS samples were collected on the dates fish surveys were conducted (during 2008). The only elevated TSS sample was at the channelized station 08MN067 (84 mg/L on July, 10, 2008). The transparency at the time of fish sampling was poor at all locations sampled in 2008. Citizen Stream Monitoring Program (CSMP) data set in 2003 and 2006 was sampled at regular intervals and shows 24 of 33 samples exceeded the standard. While this data set is not large, there were a high magnitude of exceedances and there was a lack of recovery from seasonal events that elevated transparency. HSPF model output (reach 729) shows that 24.2% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009.

There were a number of common carp throughout this reach, with 107 common carp at the downstream most station 08MN067. Carp may be playing a role in suspending fine materials during times between high flow events. In the Cobb River, herbivorous fish vary by location, ranging from 1.2% to 19.9% (Table 31). Herbivorous fish are often reduced with increased in TSS levels. The lower amount of herbivorous fish in the Cobb River likely reflects changes in the fish community due to suspended sediment. In this AUID of the Cobb River, it appears that the furthest upstream station (08MN081) and the two downstream stations (97MN002 and 08MN067) have the lowest percentages of herbivores. The average percent of herbivore fish in natural channels of the Le Sueur River watershed was 9.9%, with a range of 0% to 58%. The Le Sueur River watershed has many reaches currently listed for turbidity.

Herbivorous fish populations throughout the watershed are influenced by the high turbidity that is prevalent throughout the watershed.

The fish community was also lacking in sensitive taxa and has many tolerant individuals. The invertebrate community shows a similar response, with a lack of collector-filterers as shown in the metric score. There was also an abundance of tolerant invertebrates that made up much of the sample (92% to 98%). The degraded biological condition in both the fish and the invertebrate community is due to the turbidity within this reach.

Table 31. Percentage of herbivores as defined by NAWQA database longitudinally in the Cobb River by visit year

	Biological Stations								
	Upstream →								→ Downstream
Visit Year	08MN081	08MN017	08MN071	97MN002	08MN067	08MN065	10MN162	01MN039	08MN005
1997				2.7					
2001								2.9	
2008	1.8 2.1	14.1	19.9		1.2	3.9			6.7
2010							4.9		10.4

Candidate cause: Lack of habitat

The stations in this AUID of the Cobb River range in MSHA total scores from 44.6 to 69.1 (fair to good). There is a broad range of habitats within these stations, with the greatest variability in the cover subcategory of the MSHA (Figure 95).

Throughout the middle study reach (east of Waseca County State Aid Highway(CSAH 3)), between stations 08MN017 and 08MN071, the Big Cobb River is classified as a C5c- stream, with a sand dominated substrate and very low gradient. The river is in contact with its floodplain during channel forming, bankfull flows. The influence of middle channel bars throughout the reach results in higher near bank stress and higher BEHIs. There is evidence of channel widening as mature trees are losing support and falling into the channel. Throughout the reach, estimates of streambank erosion were evident with high to extreme using the BEHI ratings. Five banks in this reach were assessed using the BEHI and NBS methods and estimated stream bank erosion was 0.0701 tons of sediment/year/foot. The C5 stream type has a very high sensitivity to disturbance and fair recovery potential. With very high sediment supply and possibility for streambank erosion, the influence of riparian vegetation plays a critical role in maintaining the dimensions, pattern, and profile for a stabile C5 stream. The study reach is located in valley type 8c (terraced alluvial). The Pfankuch rating for stream stability at this site was 148, a poor rating for a C5 stream with very high sediment supply and degrading streambed stability.

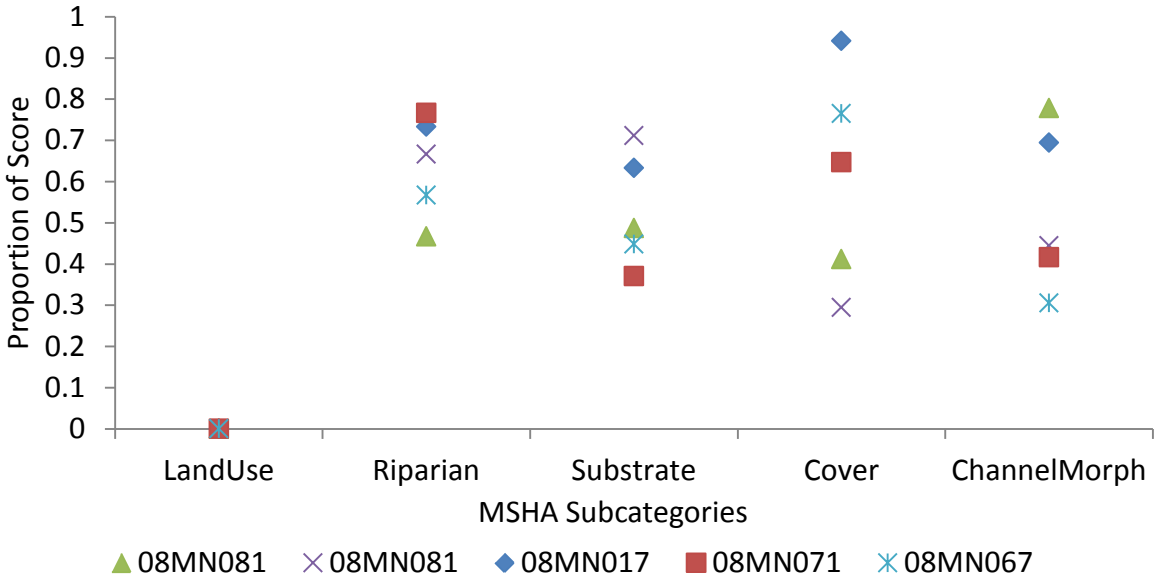

Figure 95. MPCA Stream Habitat Assessment subcategory proportion of scores for the Cobb River

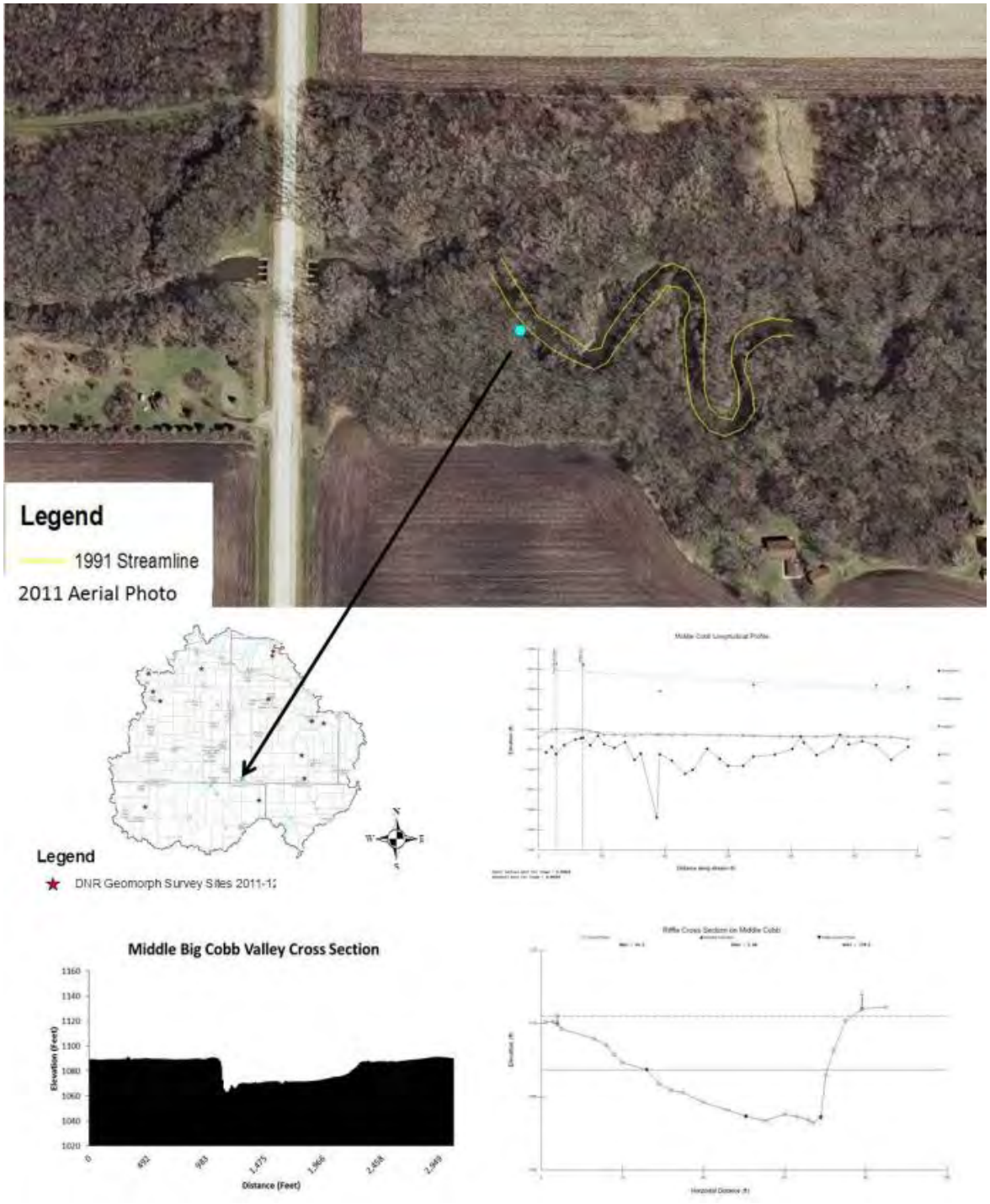

Figure 96. Location of the Middle Big Cobb site with aerial photo, LiDAR derived valley cross section, actual surveyed longitudinal profile and cross section. The yellow line on the aerial photo is the 1991 stream line to show how the reach has changed from 1991-2011

The Upper Cobb at Waseca CSAH 35 (on the downstream side of station 08MN081) is classified as a G5c stream type. This system is an entrenched gully and is not accessing its floodplain during channel forming flows. Bed features in G streams are often unstable with degrading step/pool morphology. Lower instream and overhead cover, pool quality, habitat and diversity are found in G channels versus a C channel. The sensitivity to disturbance is extreme and recovery potential is very poor. Both sediment supply and stream bank erosion potential are high. Vegetation plays a significant role in influencing the

width/depth ratio for channel stability. Four banks were assessed with the BEHI and NBS method in this reach with a total estimate of 0.0515 tons of sediment/year/foot of stream reach. The study reach is located in valley type X (lacustrine) with very broad to gentle valley slopes associated with lacustrine deposits. The Pfankuch rating for stream stability at this site was a 119, a fair rating with moderate sediment supply and degrading stream bed stability.

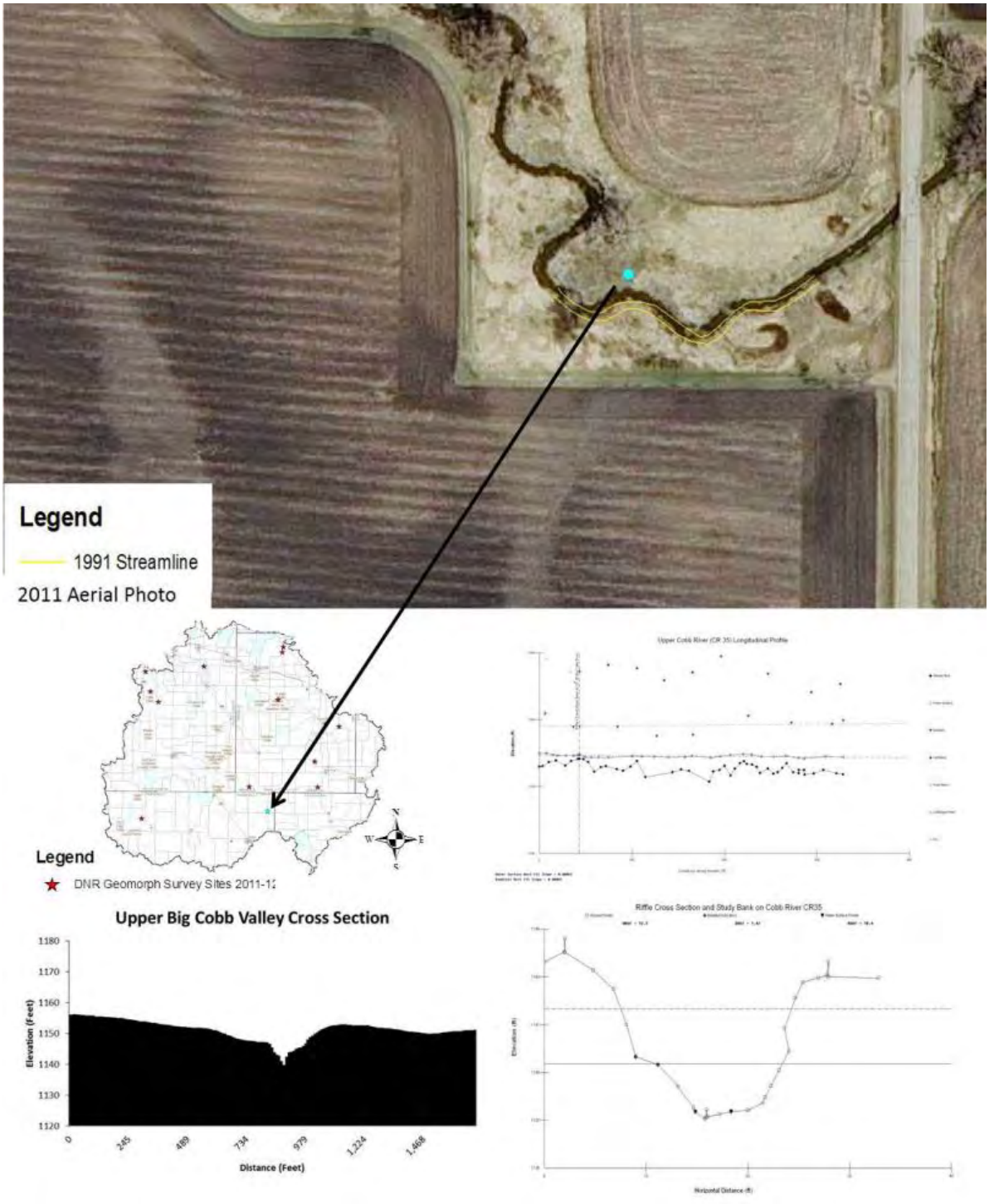

Figure 97. Location of the Upper Big Cobb site with aerial photo, LiDAR derived valley cross section, actual surveyed longitudinal profile and cross section. The yellow line on the aerial photo is the 1991 stream line to show how the reach has changed from 1991-2011

Although there was presence of benthic insectivore taxa resulting in a moderate metric score for the IBI, the individuals only comprised 0.95% to 10.3% of the surveyed fish communities. The average percent of non-tolerant benthic insectivores in natural channels of fish classes 1, 2, and 3 was 13.09%. The range in the Le Sueur River watershed for the percentage of riffle dwelling fish is 0 to 57, with a mean in natural channels of 13%. However if you broaden that perspective to the Minnesota River basin, and only

include those at or above the IBI threshold, the mean percentage of riffle dwelling fish was 20.2. The percent of riffle dwelling individuals is highly variable throughout the Cobb River; however, these individuals were generally found nearby riffle habitat. Simple lithophilic spawners also follow a similar pattern in the Cobb River.

The invertebrates that were sampled show a low number of taxa that use the adaptation of climbing. This may be in part due to the poor quality riparian area adjacent to the river, as it was noted that the stations surveyed had narrow to moderate riparian widths with moderate to heavy erosion, and severe on the right bank of station 08MN067. The percentage of taxa that cling was sufficient; but as previously mentioned, there was an abundance of tolerant taxa.

Lack of sufficient habitat is a stressor to both fish and invertebrate biological communities. There is a stronger link between the fish community and the habitat than the link between the invertebrate community and habitat. Improving the stability of this AUID would greatly benefit both biological assemblages.

Weight of evidence

The evidence for each potential stressor, the quantity and quality of each type of evidence was evaluated. The consistency and credibility of the evidence was evaluated. Each step for the Cobb River (-568) was scored and summarized in Table 32. For more information on scoring please see EPA's CADDIS Summary Table of Scores.

Table 32. Weight of evidence table for potential stressors in the Cobb River (-568)

Evidence using data from Cobb River (-568)						
Types of Evidence	**Scores**					
	Dissolved Oxygen	**Phosphorus**	**Nitrate-Nitrite**	**Suspended Sediment**	**Physical Habitat**	**Altered Hydrology**
Spatial/temporal co-occurrence	0	0	+	+	+	+
Temporal sequence	0	0	0	+	+	++
Field evidence of stressor-response	NE	NE	0	NE	NE	0
Causal pathway	0	+	+	+	+	++
Evidence of exposure, biological mechanism	--	0	+	+	+	+
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE	NE
Verified or tested predictions	NE	NE	NE	NE	NE	NE
Symptoms	---	0	+	+	+	+
Evidence using data from other systems						
Mechanistically plausible cause	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE
Multiple lines of evidence						
Consistency of evidence	-	0	+	+	+	+
Explanatory power of evidence	-	0	0	++	++	++

Conclusions

In the upper AUID of the Cobb River, there was limited DO, phosphorus and nitrate data. With the available data DO was an unlikely stressor, elevated phosphorus was inconclusive, and elevated nitrate is a stressor given the limited data. Elevated TSS/turbidity, lack of habitat, and altered hydrology were all found to be stressors to the biotic community.

The fish community in this section of the Cobb River lacked sensitive fish at all biological stations. Generally, it had a high percentage of tolerant fish. The invertebrate community was lacking in numerous metrics in the IBIs. Dissolved oxygen should be monitored further, given the small dataset available at this time. Dissolved oxygen is unlikely as a stressor and the biological data did not strongly support it as a stressor either.

Phosphorus analysis was also limited by the dataset. Of the six samples in the reach, five were above the draft standard. There is no BOD and chlorophyll-a data, and limited DO data making it difficult to analyze. The fish data suggests that it may not be a stressor with the high proportion of carnivorous fish and benthic insectivores, but high percentage of tolerant fish. The invertebrate community response is mixed with lack of sensitive individuals, predators, and decreased taxa richness. The lack of collector-filterers complicates the findings; however they may be lacking due to elevated TSS. It is recommended that future monitoring of phosphorus be conducted for further analysis of this as a potential stressor. At this time phosphorus is inconclusive as a stressor, but limited dataset suggests efforts to reduce phosphorus should be employed.

Similar to DO and phosphorus, only six samples of nitrate have been collected; two above 10 mg/L. Less than one percent of the invertebrates were non-hydropsychid caddisflies. The fish comprised of less than 1% sensitive taxa. It is likely that elevated nitrate is negatively impacting the biological communities, but this is with limited data. It would be advantageous to collect more nitrate data under a range of conditions and seasons to understand the nitrate dynamics as well as refine the understanding of the response of the biological community.

Total Suspended Solids has only been collected five times within this reach of the Cobb River, with only one elevated measurement. Transparency was poor at all biological stations when sampled for fish. Transparency was poor throughout much of the 2003 and 2006 data collected by CSMP. Common carp were abundant throughout the biological stations. Common carp are likely suspending fine materials between events. Herbivores are also reduced in the Cobb River. As previously mentioned there is a lack of collector-filterers and an abundance of tolerant invertebrates. The degraded conditions of the fish and invertebrate community are due to elevated turbidity.

The MSHA revealed the habitat to be fair to good in this reach of the Cobb River. Between stations 08MN017 and 08MN071 the Cobb River is classified as a C5c- with a sand dominated substrate. The stream stability at this location is poor with vegetation playing a large role in maintaining any sort of stability. On the Cobb River immediately downstream of 08MN081, the river is an entrenched gully with a classification of G5c-. The proportion of benthic insectivores was low despite having sufficient taxa presence. There was also a low proportion of climbing invertebrate taxa, potentially due to the lack of quality riparian vegetation. Lack of sufficient habitat, is contributing to the degraded biological communities.

This reach of the Cobb River had a high percentage of tolerant invertebrates, and a variable percentage of long lived invertebrates. The fish were comprised of a fairly high percentage of short lived fish at three of the four stations and few long lived fish. The surrounding land use in this watershed is comprised heavily of cropland and has an estimated large percentage of land with drain tile. Since 1855, 95 stream miles have been added upstream of the pour point of this reach. The lack of connection with

the floodplain, lack of stream stability, and lack of adequate transparency are all connected to the flow conditions within this reach.

In this reach of the Cobb River, elevated nitrate is a stressor given the limited data. Elevated TSS/turbidity, lack of habitat, and altered hydrology were all found to be stressors to the biotic community.

Cobb River (07020011-556)

In 2008, this reach of the Cobb River was listed for turbidity. An impairment for fish was listed in 2012.

Biology in the Cobb River

Station 08MN005 was sampled twice, once in 2008 and a follow up visit in 2010. Each visit resulted in an IBI score below the threshold, although the sample in 2010 was better than 2008. Both times the station lacked non-tolerant insectivores (Insect-TolPct), piscivores (Piscivore), and sensitive taxa (SensitiveTxPctGR1). It had an abundance of shortlived fish individuals (SLvdPct), serial spawner taxa (SSpnTxPct), tolerant individuals (TolPct), and very tolerant taxa (VtolTxPct). In 2008, a DELT deduction was applied to the IBI of -5.

Table 33. Fish metrics of the Southern Rivers IBI for the Cobb River (-556); bold indicates metric score is below the average metric score (4.18) needed for the IBI score to be at the threshold

Site	DetNWQTxPct	DomTwoPct	GeneralPct	Insect-TolPct	Piscivore	SensitiveTxPctGR1	SLithopGR1	SLvdPct	SSpnTxPct	TolPct	VtolTxPct
08MN005 (2008)	**2.9**	6.7	**4.0**	**2.4**	**1.3**	**0.7**	**3.5**	**3.1**	**1.8**	**2.0**	**1.3**
08MN005 (2010)	4.9	4.4	7.7	**3.2**	**4.0**	**0.0**	5.4	**0.6**	**1.4**	**2.5**	**4.1**

Candidate cause: Low dissolved oxygen

There were 67 synoptic DO measurements from 2008 through early 2011. There was one measurement below the standard; on July 15, 2010 at 15:50 DO was 4.87 mg/L. There were also two elevated DO measurements in the middle of the summer, July 21, 2009 and August 24, 2010, that appear to have been driven by rain events. It would be beneficial to have diurnal DO measurements within this reach to help understand the DO regime. The fish community does not appear to be tolerant of low DO (Figure 6). The DO concentration is not a stressor at this time to the biotic community.

Candidate cause: High phosphorus

This reach of the Cobb River has elevated TP (Figure 98). HSPF model output at the outlet of the reach (reach 751) shows that 36.7% of the TP daily averages are greater than 0.150 mg/L, from 1996 to 2009.There is currently no BOD data available, nor is there information regarding the DO flux within the reach. There were 163 chlorophyll-a measurements, from 2006 to 2011, indicating elevated levels (Figure 99). There was a lack of non-tolerant insectivorous individuals, piscivorous taxa and sensitive taxa; as well as an increase in both the percentage of individuals that are tolerant and very tolerant taxa. Additionally, during these two fish surveys, generalists made up 65% to 68% of the surveyed population. Carnivorous fish often decrease with increases in phosphorus (MPCA River Nutrient Criteria Development, 2013). The carnivorous fish only comprised 3.6% to 5.9% of the individuals surveyed at this station. A little further upstream, at station 10MN162, 9.8% of the surveyed fish were carnivorous and even further upstream 43% of the surveyed fish were carnivorous (Figure 92). The fish responses

are all indicative of changes to the nutrient regime. It is likely that the phosphorus contributing to changes in chlorophyll-a and are altering the food web for the fish community.

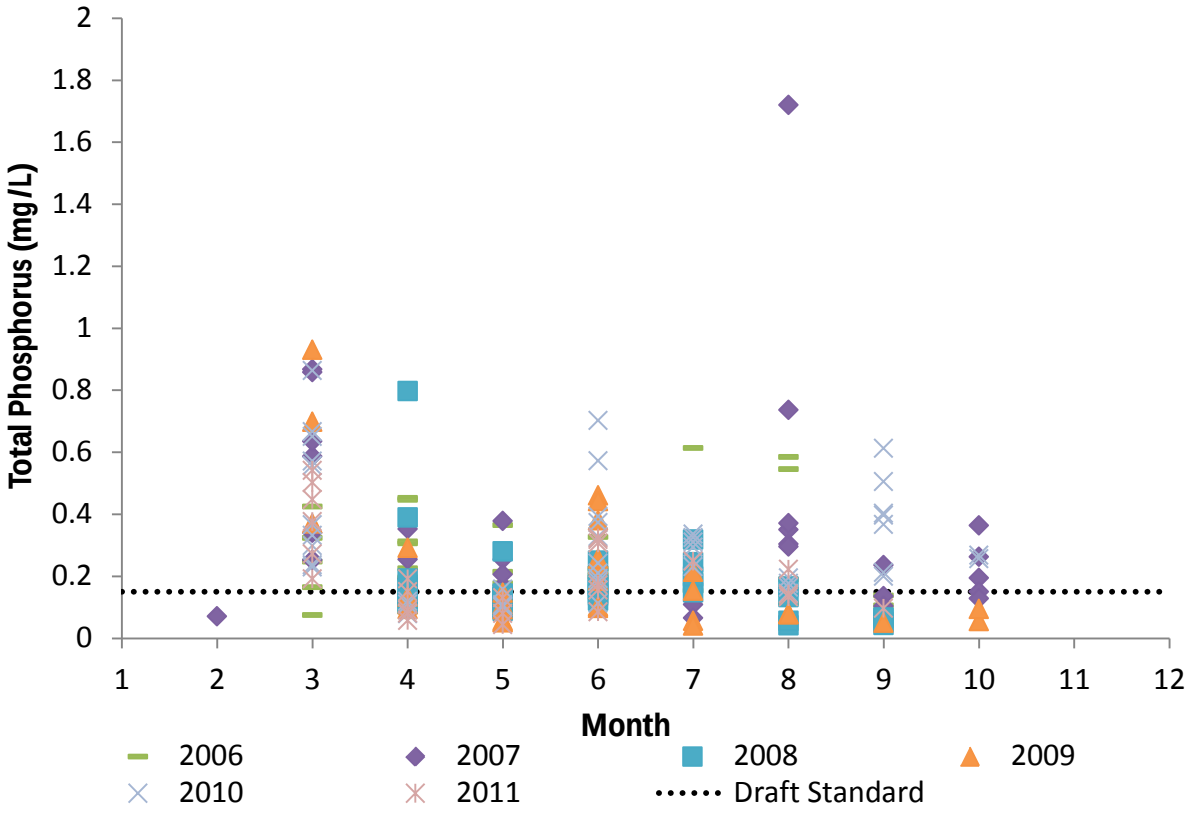

Figure 98. Total phosphorus in the Cobb River (556) by month and year

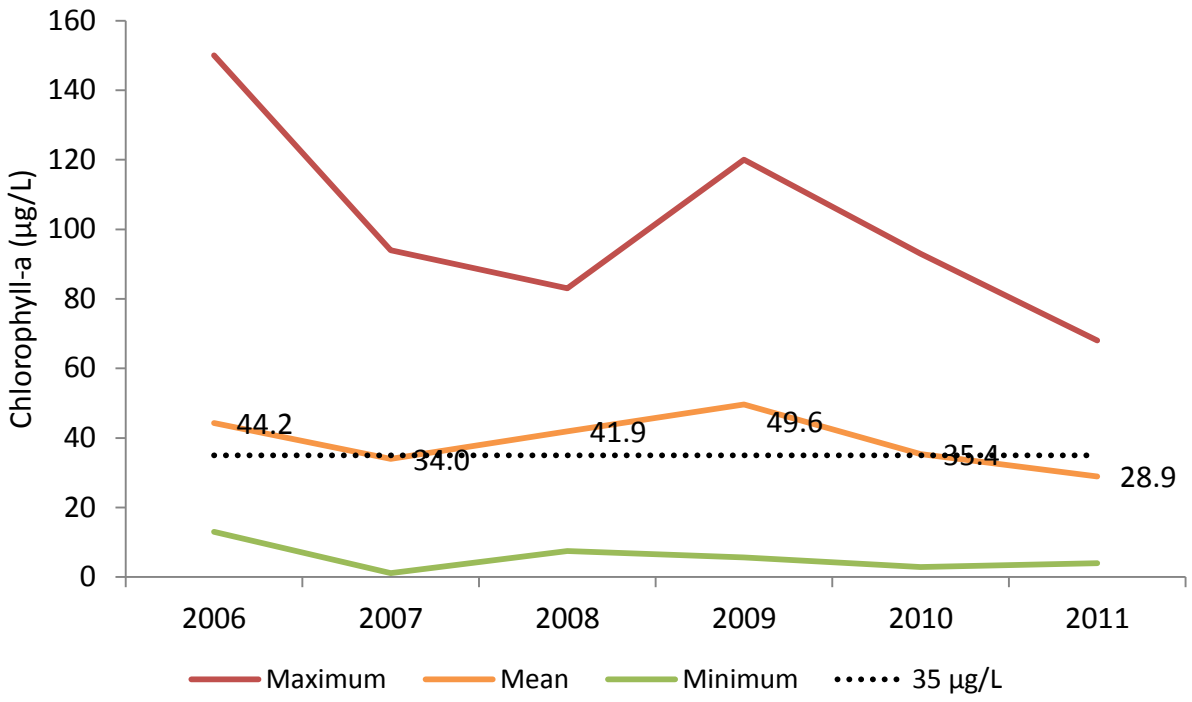

Figure 99. Chlorophyll-a summary statistics in the Cobb River (-556)

Candidate cause: High nitrate

Nitrate in this reach of the Cobb was generally elevated in April through June, with the highest measured concentration of 15.96 mg/L occurring in June 2011 (Figure 100). HSPF model output (reach 751) shows that 15.3% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009. This reach of the Cobb River has a lack of sensitive fish taxa: only four sensitive taxa in each sample (out of 24 and 29 total taxa). The sensitive fish individuals make up 6.5 and 11% of the surveyed communities in the two years sampled; whereas the tolerant individuals comprised 61.3% and 65.7% of the surveyed community. Similar to the impaired upstream AUID, this AUID has a low percentage of non-hydropsychid caddisflies, 5% in 2008 and 0% in 2010. The station also had a low taxa count both years it was sampled and in 2010 had a low number caddisfly taxa compared to Minnesota River Basin averages. Nitrate tolerant invertebrate individuals made up 75.7% of the community in 2008 and 51.1% in 2010. Both years there was presence of nitrate intolerant taxa, but they comprised of less than 2% of the individuals. It is likely that in combination with other stressors, nitrate is influencing the fish community within this reach.

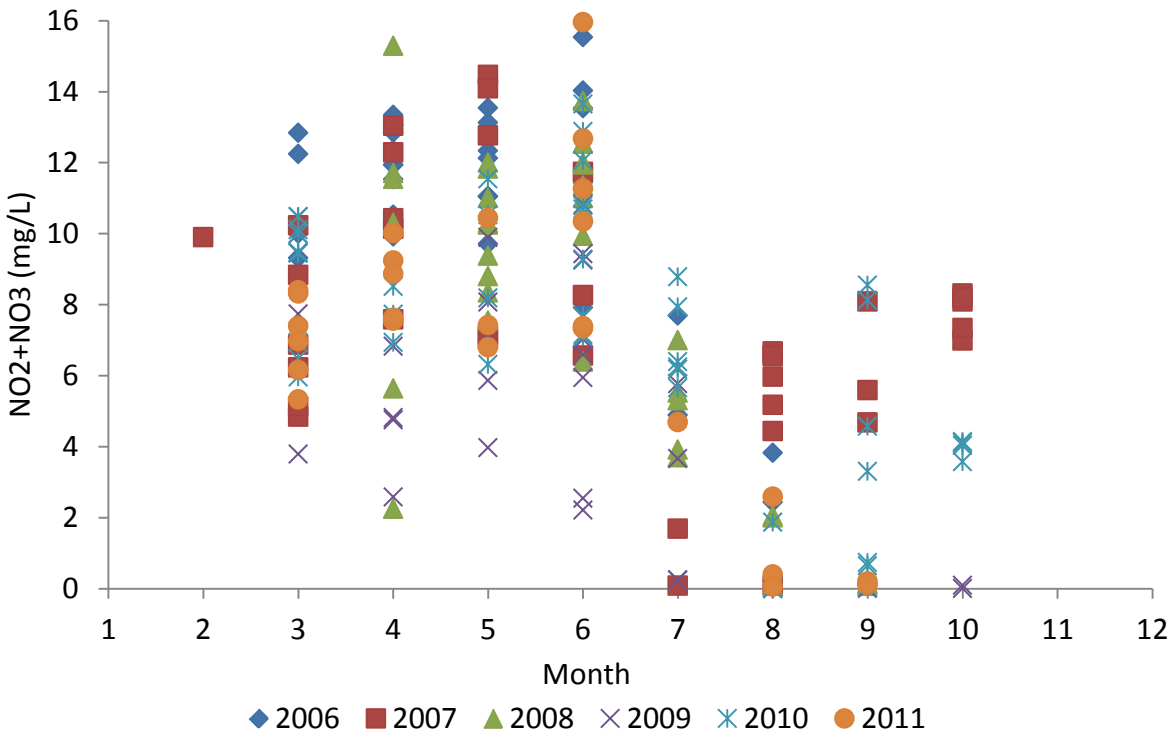

Figure 100. Nitrate-nitrite for the Cobb River by month and by year

Candidate cause: High suspended sediment

Suspended sediment concentrations were elevated within this reach (Figure 101). HSPF model output (reach 751) shows that 23.6% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009. During both visits of station 08MN005, sand shiners dominated the survey. Sand shiners are fairly tolerant to suspended sediment conditions (Meador and Carlisle, 2007). The percentage of herbivores found at station 08MN005 was 6.7% in 2008 and 10.4% in 2010 (Table 31). The average percent of herbivore fish in natural channels of the Le Sueur River watershed was 9.9%, with a range of 0% to 58%. The Le Sueur River watershed has many reaches currently listed for turbidity. Herbivorous fish populations within the watershed are influenced by the high turbidity that is prevalent throughout the watershed. This station has a lack of sensitive taxa, and an abundance of tolerant individuals and tolerant taxa. Turbidity and total suspended sediment are affecting the fish community in this reach.

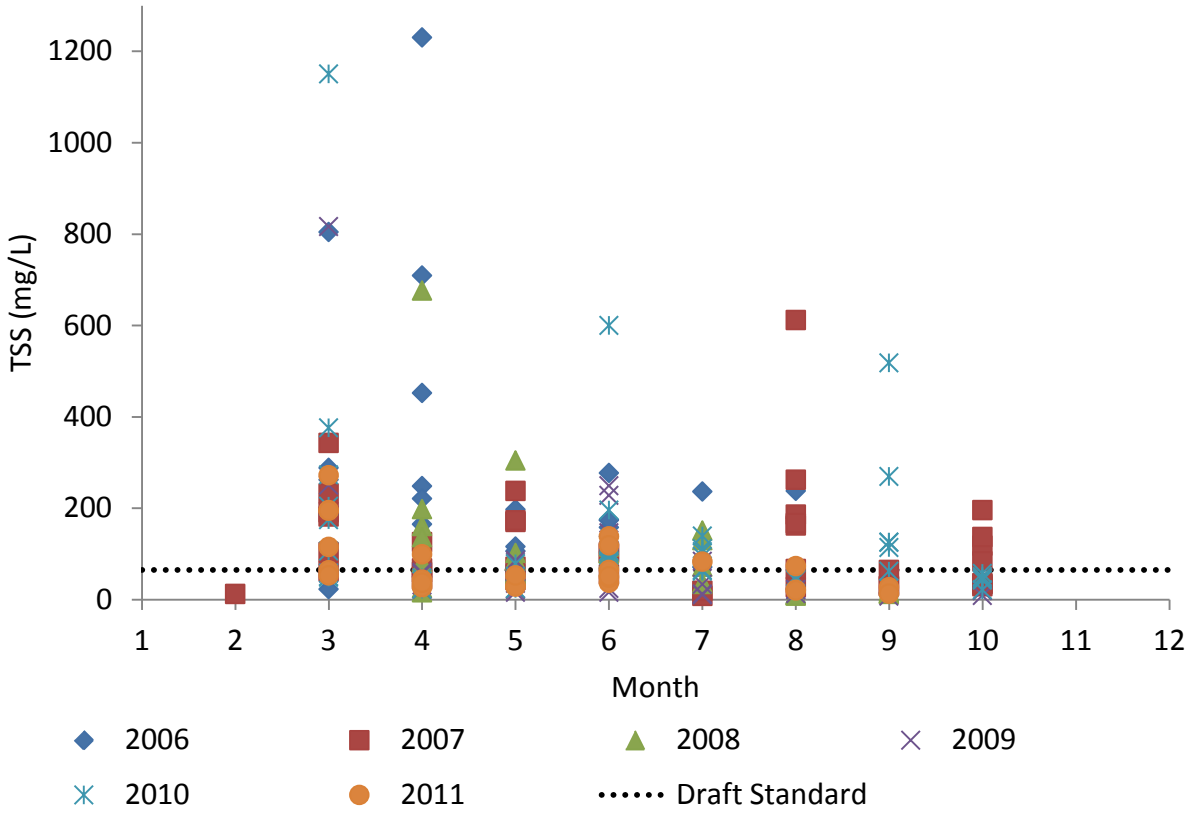

Figure 101. Total suspended solids for the Cobb River by month and by year

Candidate cause: Lack of habitat

South of Mankato at CSAH 16, just upstream from station 08MN005, the Big Cobb River is classified as a C4 channel, a couple of miles upstream of where it pours into the Le Sueur River. With an entrenchment ratio of 2.51, the river still has good floodplain connectivity at two times bankfull flows, yet is still moderately incised. This site has a high width/depth ratio of 30.77, which shows that the site has likely widened over time, but still has some good riffle and pool quality. Water slope at this site is 0.00249 ft/ft, making it steeper than many of our sites in the watershed. This site has shown a lot of lateral erosion since 1991 (Figure 102) and routes its bedload through the study reach with no signs of mid-channel bars or pool filling. MDNR assessed 5 banks in this reach using the BEHI and NBS methods and estimated 0.0186 tons of sediment/year/foot of stream bank in the reach. The C4 stream type has a very high sensitivity to disturbance and good recovery potential. With high sediment supply and possibility for streambank erosion, the influence of riparian vegetation plays a critical role in maintaining the dimensions, pattern, and profile for a stable C4 stream. The study reach is located in valley type VIIIc (terraced alluvial; see figure for Valley cross-section). The Pfankuch rating for stream stability at this site was 94, a fair rating for a C4 stream, with little signs of aggradation or degradation.

The MSHA scores for the two visits to biological station 08MN005 were 66.9 and 69.65 (good). The presence of riffle-dwelling fish were below the Minnesota River Basin mean for reaches at or above the IBI threshold (20.2%). The range in the Le Sueur River watershed for the percentage of riffle dwelling fish was 0 to 57, with a mean in natural channels of 13%. Station 08MN005 had 11% and 16.4% riffle dwelling fish during the two surveys. Additionally, simple lithophilic spawner taxa were below expectations in 2008. Although the MSHA score was good, indications of moderate stream stability along with lateral riffles and mid channel bars indicate that along with the fish response, habitat may be

a contributing factor, but likely not the primary stressor to the fish community at the biological station in this reach.

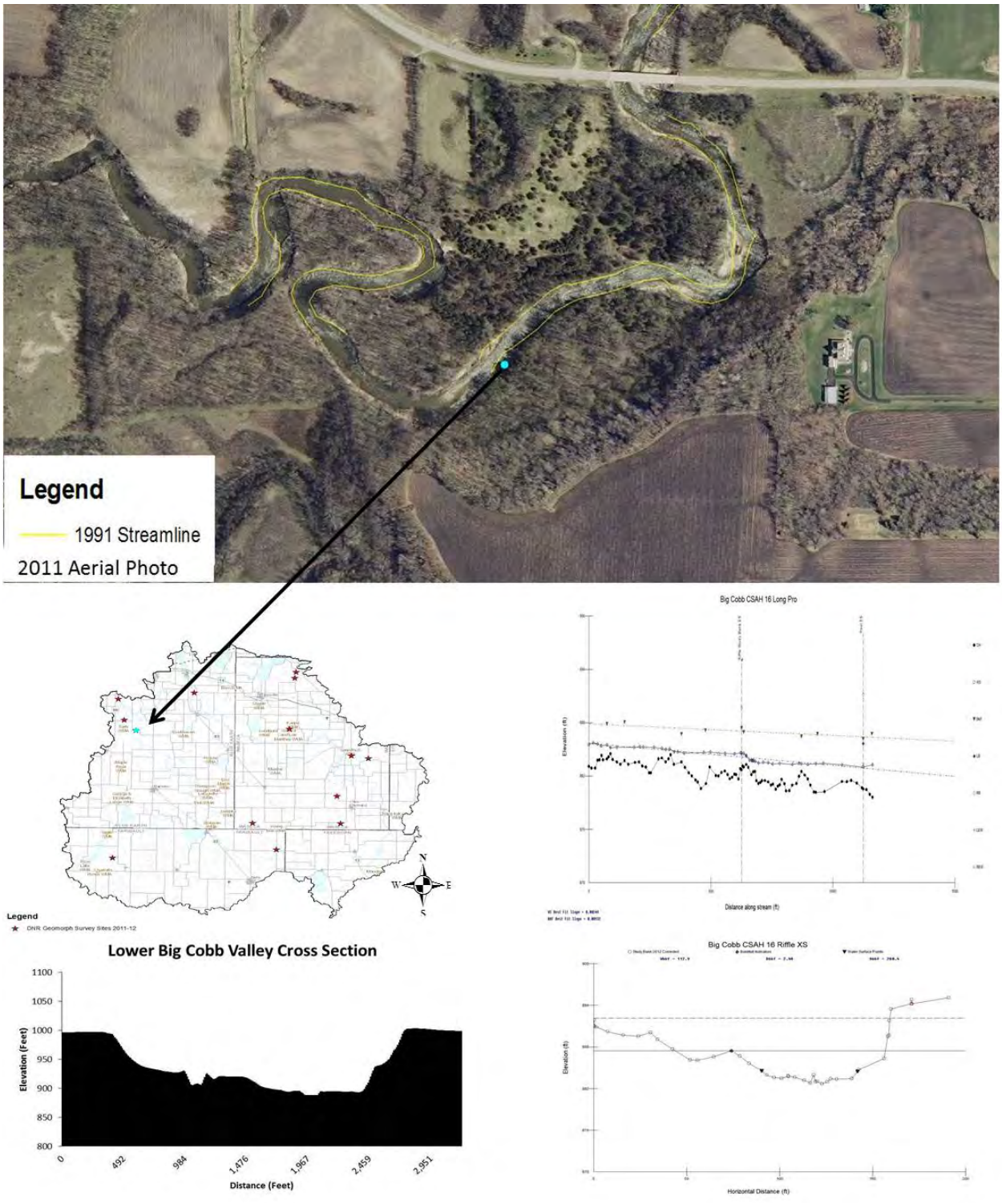

Figure 102. Location of the Big Cobb geomorphology site (upstream of station 08MN005) with aerial photo, LiDAR derived valley cross section, actual surveyed longitudinal profile and cross section. The yellow line on the aerial photo is the 1991 stream line to show how the reach has changed from 1991-2011

Weight of evidence

The evidence for each potential stressor, the quantity and quality of each type of evidence was evaluated. The consistency and credibility of the evidence was evaluated. Each step for the Cobb River was scored and summarized in Table 34. For more information on scoring please see EPA's CADDIS Summary Table of Scores.

Table 34. Weight of evidence table for potential stressors in the Cobb River (-556)

Evidence using data from Cobb River (-556)						
Types of Evidence	**Scores**					
	Dissolved Oxygen	**Phosphorus**	**Nitrate-Nitrite**	**Suspended Sediment**	**Physical Habitat**	**Altered Hydrology**
Spatial/temporal co-occurrence	---	+	+	+	0	+
Temporal sequence	0	+	+	+	+	++
Field evidence of stressor-response	NE	NE	NE	NE	NE	0
Causal pathway	+	+	+	+	+	++
Evidence of exposure, biological mechanism	--	+	+	+	0	+
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE	NE
Verified or tested predictions	NE	NE	NE	NE	NE	NE
Symptoms	---	+	+	+	0	+
Evidence using data from other systems						
Mechanistically plausible cause	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE
Multiple lines of evidence						
Consistency of evidence	-	+	+	+	+	+
Explanatory power of evidence	-	++	++	++	0	++

Conclusions

In this furthest downstream reach of the Cobb River, the fish community lacks non-tolerant insectivores, piscivores, and sensitive taxa. The community was comprised of fish that were shortlived, serial spawners, and tolerant.

Although there was one DO measurement below the standard, and some elevated DO measurements that appear to have been driven by rain events, DO is not an issue at this time to the fish community, due to the relative sensitivity of the fish community to low DO. However, it would be greatly beneficial to monitor this reach further with diurnal DO monitoring to understand both the minimum DO along with the DO flux.

Phosphorus was elevated in this reach of the Cobb River, as well as elevated chlorophyll-a levels. Fish generalists comprised the majority of the fish surveyed in 2008 and 2010 at station 08MN005. Carnivorous fish were reduced at this station. Phosphorus is contributing to the degraded fish community.

Nitrate within this reach of the Cobb River was highest April through June. The sensitive fish comprised few of total surveyed fish during both years. The non-hydropsychid caddisflies were also reduced. It is likely in combination with other stressors that nitrate is influencing the fish community.

Total Suspended Solids concentrations were elevated within this reach. Sand shiners dominated both fish surveys and are fairly tolerant to high suspended sediment. Additionally, the percentage of herbivores was low. The fish in this reach of the Cobb River are influenced by the high concentrations of TSS.

Station 08MN005 had low percentage of riffle-dwelling fish and in 2008, simple lithophilic spawner taxa were reduced below expectations. Habitat could be improved in this reach as there is a presence of lateral riffles that have undergone a large amount of lateral erosion since 1991. Although habitat may be contributing to the degraded biological condition, it is not the primary stressor.

Hydrology influences the habitat availability and sediment balance; which are both degraded for the fish community. The fish community had greater than 60% tolerant during each sample in 2008 and 2010, and a high proportion of short lived fish. Since 1855, the outlet of this reach has gained 228 contributing stream miles in the upstream portion of the watershed. It is estimated that the land within this watershed, upstream of this reach, has a high proportion of land with drain tile. Hydrology shapes the fish community within this reach.

The stressors to the fish community present in this reach of the Cobb River are elevated phosphorus, elevated nitrate, elevated TSS/turbidity, lack of habitat, and altered hydrology.

Rice Creek (07020011-531)

Rice Creek is a small tributary to the Maple River. In 2006, Rice Creek was listed for fish. In 2010, turbidity was added to the impairment list and in 2012, invertebrates were listed for Rice Creek.

Biology in Rice Creek

In Rice Creek two of the five stations scored below the threshold. Station 08LM076 scored the poorest with an IBI score below the threshold and the confidence interval. Four of the stations in Rice Creek were compared against the average metric score needed to be at or above the threshold for the Southern Streams IBI (Figure 103). The metrics that scored particularly poorly were fish that reach the mature age in less than two years (MA<2Pct) and the percentage of sensitive taxa (SensitiveTxPct). The mean score for the percentage of dominant two species (DomTwoPct) was low, but the range was variable through the stations. Two upstream stations that are within the fish class Southern Headwaters, and the metrics within the IBI were compared in a similar manner (Table 35). Two metrics that were lower than the average metric score needed to be at or above the threshold were the percentage of sensitive individuals and the abundance of short lived species (SLvd). There were no DELT deductions in this AUID.

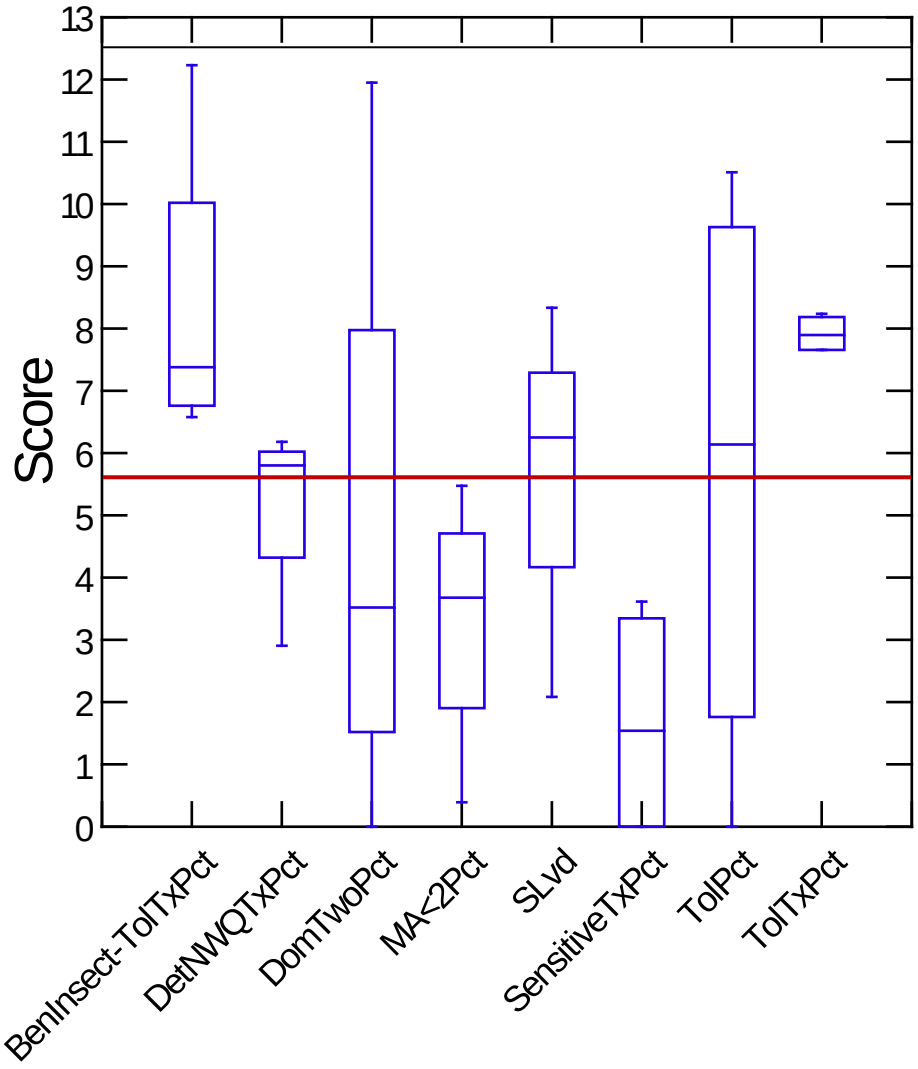

Figure 103. Fish metrics of the Southern Streams IBI for Rice Creek; red line indicates the average metric score (5.6) needed for IBI score to be at the threshold (Stations 08MN076, 08MN086, 03MN067 and 08MN004)

Table 35. Fish metrics of the Southern Headwaters IBI for Rice Creek; bold indicates value is below the average metric score (8.5) needed for the IBI score to be at the threshold (Station 01MN014 is channelized and therefore not compared to the threshold)

Site	DetNWQTxPct	GeneralTxPct	Sensitive	SLvdPct	SSpnPct	VtolTxPct
01MN014	0	2.4	0	1.3	12	2.5
08MN010	12	13	**0**	**6.1**	13	8.6

Generally, invertebrates of Rice Creek are in worse conditions in the upstream and improve downstream (Table 3). The three upstream stations scored below the threshold and station 08MN010, the furthest upstream, scored below the confidence interval too. Invertebrates in the class Southern Streams RR scored poorly in the metrics of taxa richness of climbers (ClimberCh), percentage of taxa that are

clingers (ClingerChTxPct), a measure of pollution based on tolerance values assigned to each individual taxon (HBI_MN), and taxa richness of Trichoptera (Trichoptera; Table 36). Station 08MN010 also scored poorly on taxa richness of Odonata and Plecoptera, and the percentage of tolerant taxa (Tolerant2ChTxPct). Stations in the Prairie Streams GP class, all scored zero on the metric for intolerant taxa (Intolerant2Ch; Table 37). Additionally, the percentage of individuals that are collector-filterers (Collector-filtererPct) were low and translated to a low metric score. The tolerance metric HBI_MN was poor also in this class. Station 08MN086 had a low number of predators (PredatorCh) and generally a low taxa count (TaxaCountAllChir). Stations 08MN086 and 08MN076 had low percentage of non-hydropsychid Trichoptera individuals (TrichwoHydroPct).

Table 36. Invertebrate metrics of the Southern Streams RR IBI for Rice Creek; bold indicates the metric value is below the average metric score (3.6) needed for the IBI to be at the threshold

Site	ClimberCh	ClingerChTxPct	DomFiveCHPct	HBI_MN	InsectTxPct	Odonata	Plecoptera	Predator	Tolerant2ChTxPct	Trichoptera
08MN010	**3.5**	**2.4**	6.6	**0.5**	3.6	**0.0**	**0.0**	3.8	**0.0**	**2.0**
03MN067	**2.5**	**3.2**	0.0	**1.7**	5.0	6.1	5.0	6.9	3.6	**2.0**

Table 37. Invertebrate metrics of the Prairie Streams GP IBI for Rice Creek; bold indicates the metric value is below the average metric score (3.8) needed for the IBI to be at the threshold (Station 01MN014 is channelized and therefore not compared to the threshold)

Site	ClingerCh	Collector-filtererPct	DomFiveCHPct	HBI_MN	Intolerant2Ch	POET	PredatorCh	TaxaCountAllChir	TrichopteraChTxPct	TrichwoHydroPct
01MN014	0.7	0.9	2.5	1.8	0.0	4.3	3.6	3.0	0.0	0.0
08MN076	4.0	**0.0**	5.2	**2.4**	**0.0**	5.7	7.9	5.3	4.9	**2.8**
08MN086	5.3	**1.2**	4.9	**2.9**	**0.0**	7.1	**2.1**	**3.3**	4.1	**0.0**
08MN004	8.0	**0.2**	5.1	**3.4**	**0.0**	7.1	5.7	6.5	4.5	5.7

Candidate cause: Low dissolved oxygen

At times, DO was below the standard, likely limiting the biological community. In 2010, a longitudinal synoptic DO survey was conducted on the afternoon of July 14 and the morning of the 15 (Figure 104). Dissolved oxygen was below the standard at chemistry station S006-175 and S006-598, and recovered with a decrease in the flux further downstream. The flux was elevated upstream (greater than 7 mg/L) at chemistry station S006-365 but did not go below the standard during these measurements. At stations 08MN076 and 08MN086, YSI sondes were deployed on August 29, 2011 through September 6 (Figure 105 and Figure 106). Station 08MN076 had little flow when the sonde was deployed. The DO shows temperature dependence, with limited precipitation that allowed for the resuming of flowing water and increased DO. With the data available, it appears as though the DO at station 08MN076 was at a further degraded condition than downstream station 08MN086, which has shorter excursions below the standard of 5 mg/L.

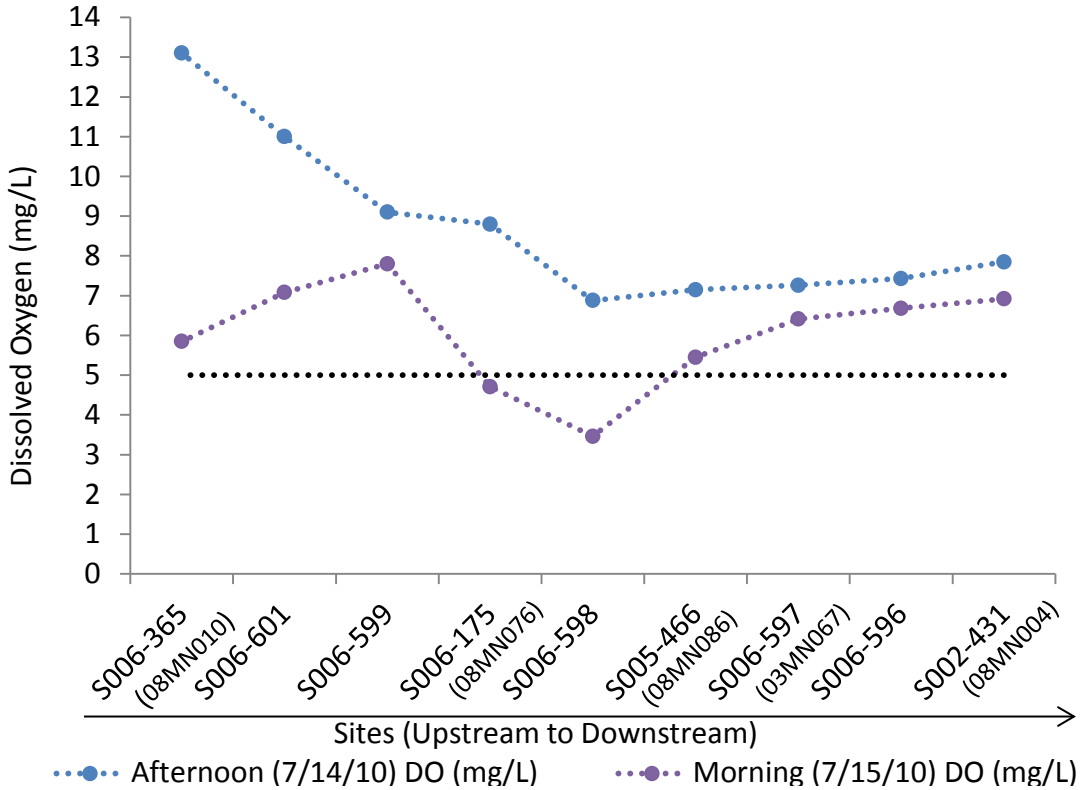

Figure 104. Longitudinal DO measurements from the afternoon of July 14 and early morning July 15, 2010 in Rice Creek

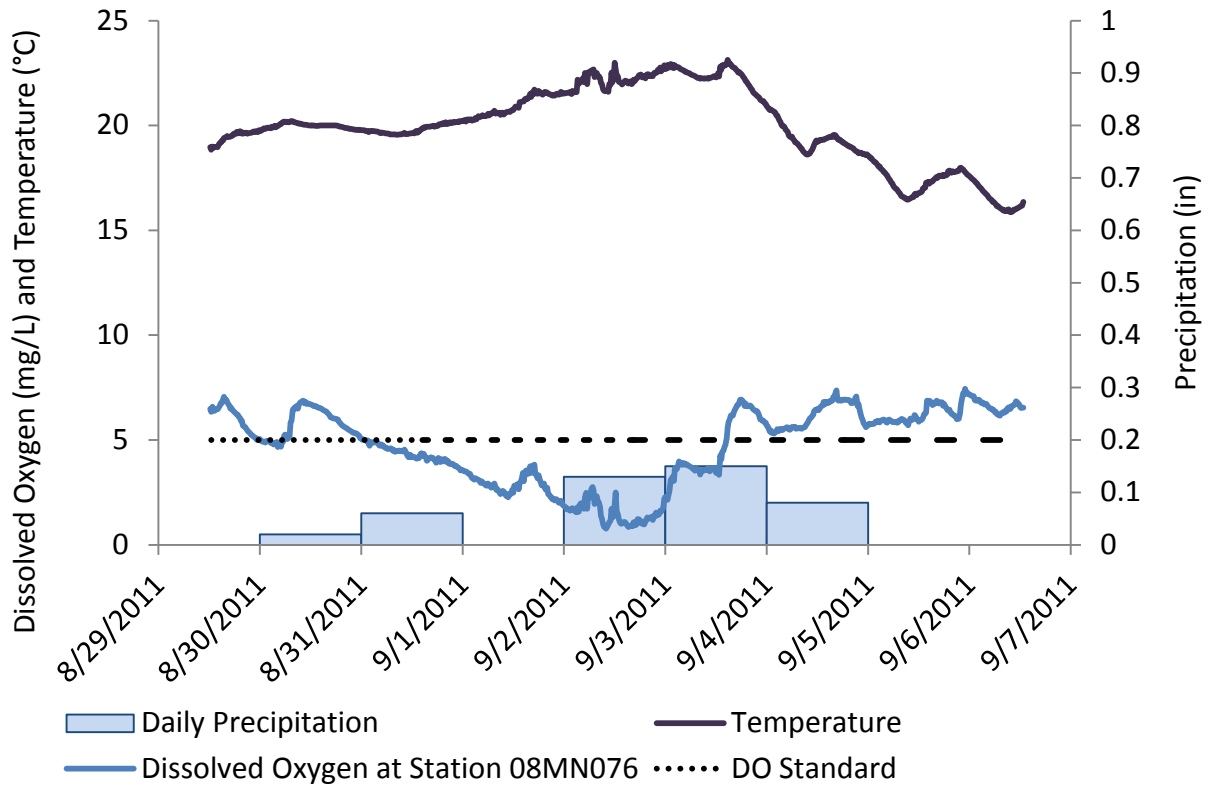

Figure 105. Dissolved oxygen and temperature measured in 15 minute intervals at Station 08MN076 from August 29 to September 6, 2011, with daily precipitation measured at Winnebago (Station 219046; MN State Climatology Office)

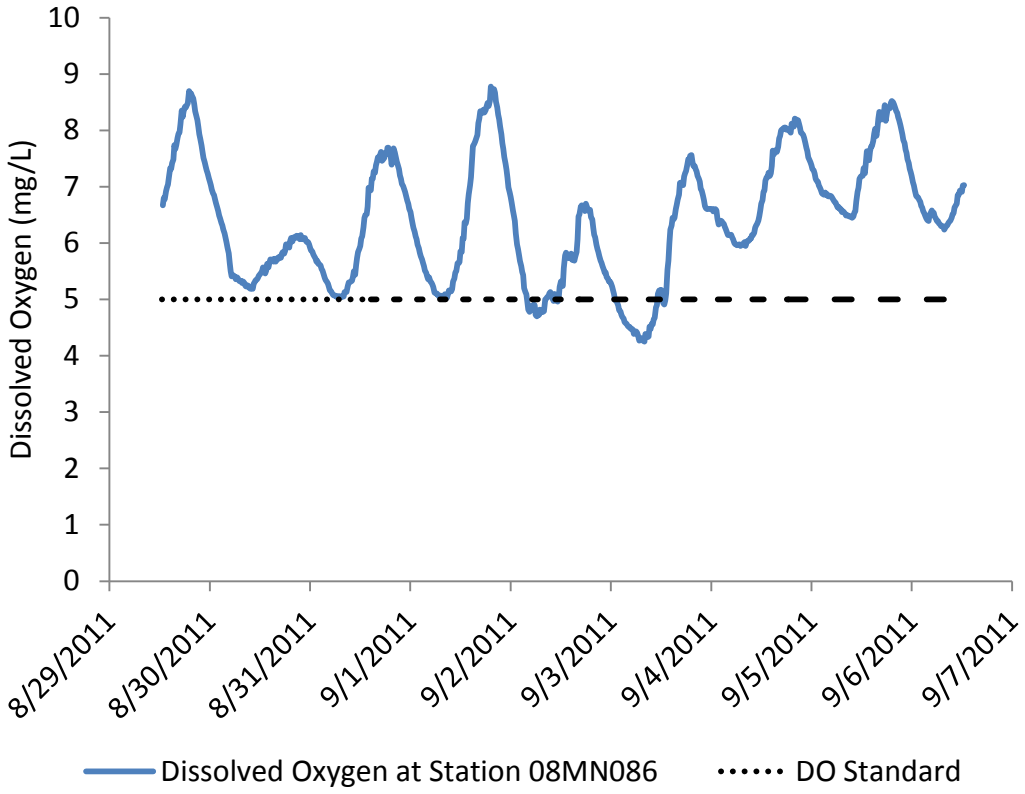

Figure 106. Dissolved oxygen measured in 15 minute intervals at Station 08MN086 from August 29 to September 6, 2011

The tolerance metric HBI_MN resulted in low metric score at all biological stations, which often occurs with increases in nutrients and low DO levels. There were few stoneflies in Rice Creek, which may be due to a lack of DO, but also may be due to a potential lack of habitat. The range of EPT taxa was 5 to 15, at the stations within Rice Creek (Table 38). The range of EPT taxa within the Le Sueur River watershed was 0 to 23 and the average number of EPT taxa at natural channel reaches was 10.85. The decrease in EPT at stations 08MN076 and 08MN086 may be in part to low DO levels.

Table 38. Ephemeroptera, Plecoptera and Trichoptera taxa longitudinally by station in Rice Creek (* station is channelized)

Stations	01MN014*	08MN010	08MN076	08MN086	03MN067	08MN004
Visit Year	2001	2008	2008	2008	2003	2008
EPT Taxa	5	10	7	9	15	11

The fish community in Rice Creek was not comprised of very many sensitive individuals. The surveys revealed only a total of four sensitive individuals at 03MN067 in 2003 and three sensitive individuals in 2008 at station 08MN004. Of the most abundant species per biological station, three are very tolerant, three are tolerant, and one taxa, spotfin shiners, is neither sensitive nor tolerant.

Utilizing Minnesota derived tolerance indicator values for DO; the fish communities in reaches of Rice Creek vary longitudinally (Figure 107). Common carp, an invasive species, dominated the community, and comprised 66% of the individuals surveyed at station 08MN076 in 2008. The most tolerant quartile of fish would still comprise 53% of the individuals without the common carp present.

Dissolved oxygen is likely contributing to the biological impairment. It would be advantageous to collect more diurnal DO information with biological data to understand the reoccurrence of low DO as well as the influence on the biological community.

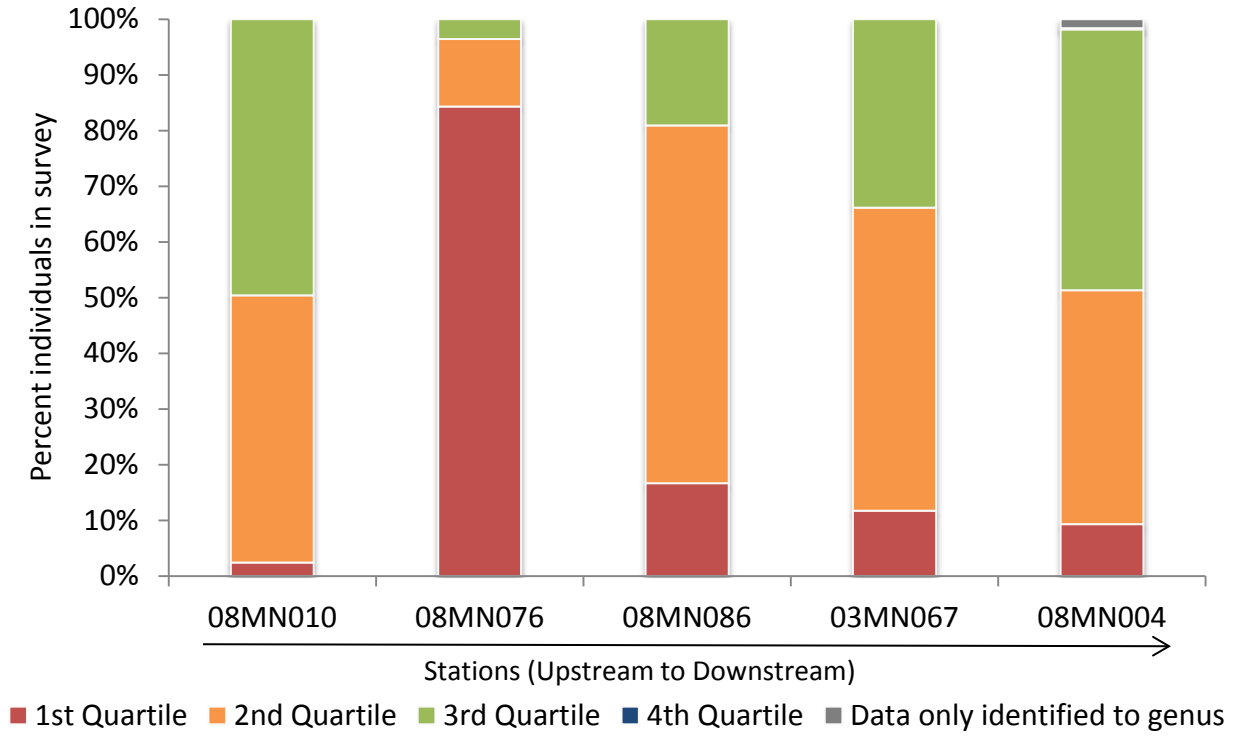

Figure 107. Percent individuals by DO tolerance indicator quartiles for reaches in Rice Creek

Candidate cause: High phosphorus

Phosphorus was elevated above the draft standard in Rice Creek. HSPF model output at the outlet of the reach (reach 809) shows that 37.9% of the TP daily averages are greater than 0.150 mg/L, from 1996 to 2009.The limited chlorophyll-a data was below 35 µg/L and there was no BOD data for this AUID. The DO was discussed in the previous section, and showed at times there was low DO, along with high flux in the upper reaches, making it likely that the high phosphorus is a contributor to the low DO conditions.

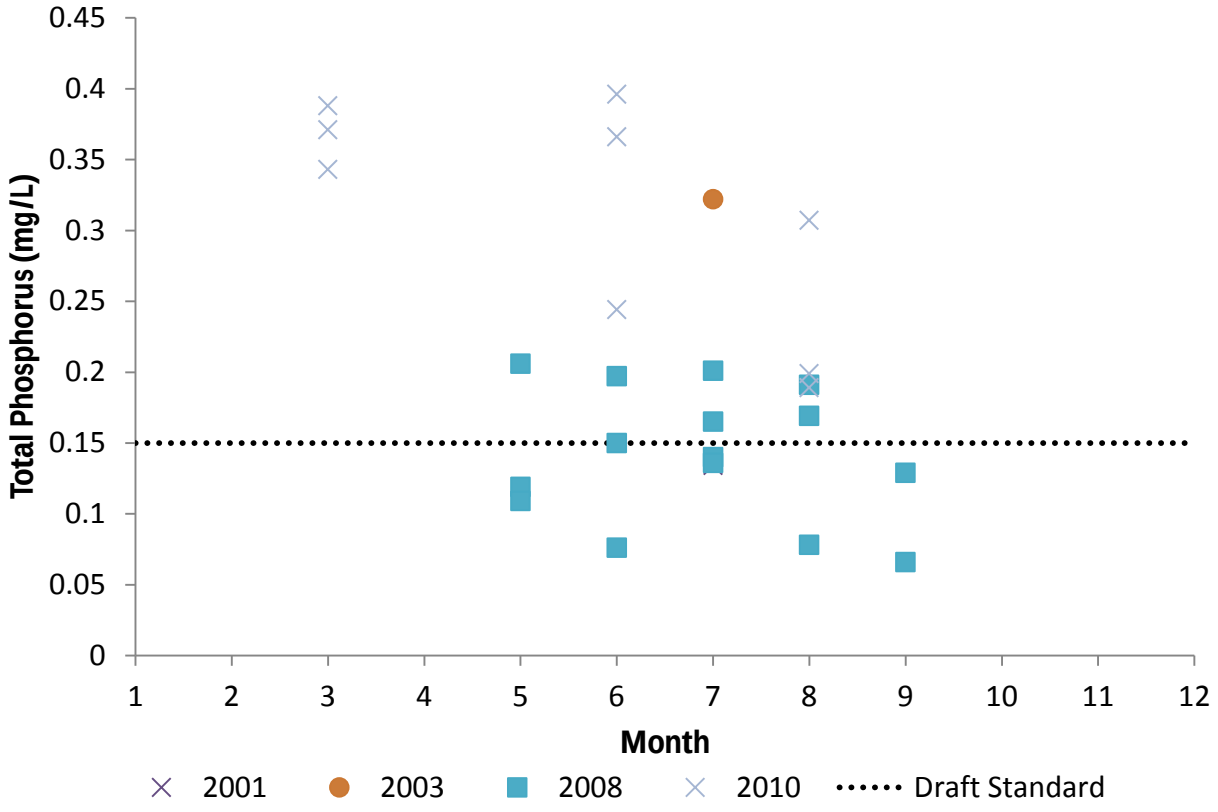

Figure 108. Total Phosphorus by month for Rice Creek in 2001, 2003, 2008 and 2010 and compared with draft standard

Carnivorous fish comprised 4% to 33% of the fish community throughout all of the natural channel Rice Creek biological stations. The non-tolerant benthic insectivores taxa were also present in acceptable percentages (ranging from 10% to 43% of the number of represented taxa), but the percent individuals of non-tolerant insectivores was relatively low (ranging from 2% to 12%). There was a lack of sensitive taxa compared to the total number of taxa, with sensitive individuals ranging from 0% to 5% of the surveyed population, but the tolerant taxa do not overwhelm the population. Generalists comprise of 21 to 88% of the community in natural channel stations of Rice Creek.

The highest percentages of intolerant invertebrate individuals in Rice Creek was at station 08MN010 and then 01MN014 (Figure 109). These stations also had the lowest TP in 2008 at the time of fish sampling. Upstream of station 08MN076, there were only three data points, with only one in each year (2001, 2008 and 2010). Only the 2010 sample was greater than the proposed standard. The sample was also taken with the note of 'very low flow', which may contribute to the high concentration of phosphorus.

Two tributaries that enter Rice Creek in this area, JD 1 and Unnamed Creek, have had TP measurements under the proposed standard. However, Rice Lake does have a couple elevated phosphorus measurements from its limited dataset. There was only one measurement of TP below the discharges in Delavan in JD 1. The one measurement was below the draft standard. It is unclear as to where the phosphorus is entering the stream. Other potential sources include row crop within the 50 ft. buffer and feedlots. Additionally, greater drainage area may allow for increased contributions of phosphorus into the system.

The high phosphorus values and low percentages of intolerant individuals, along with the high DO flux make it likely that phosphorus is impacting the biological community in some reaches within Rice Creek. Further information should be collected to clarify the sources.

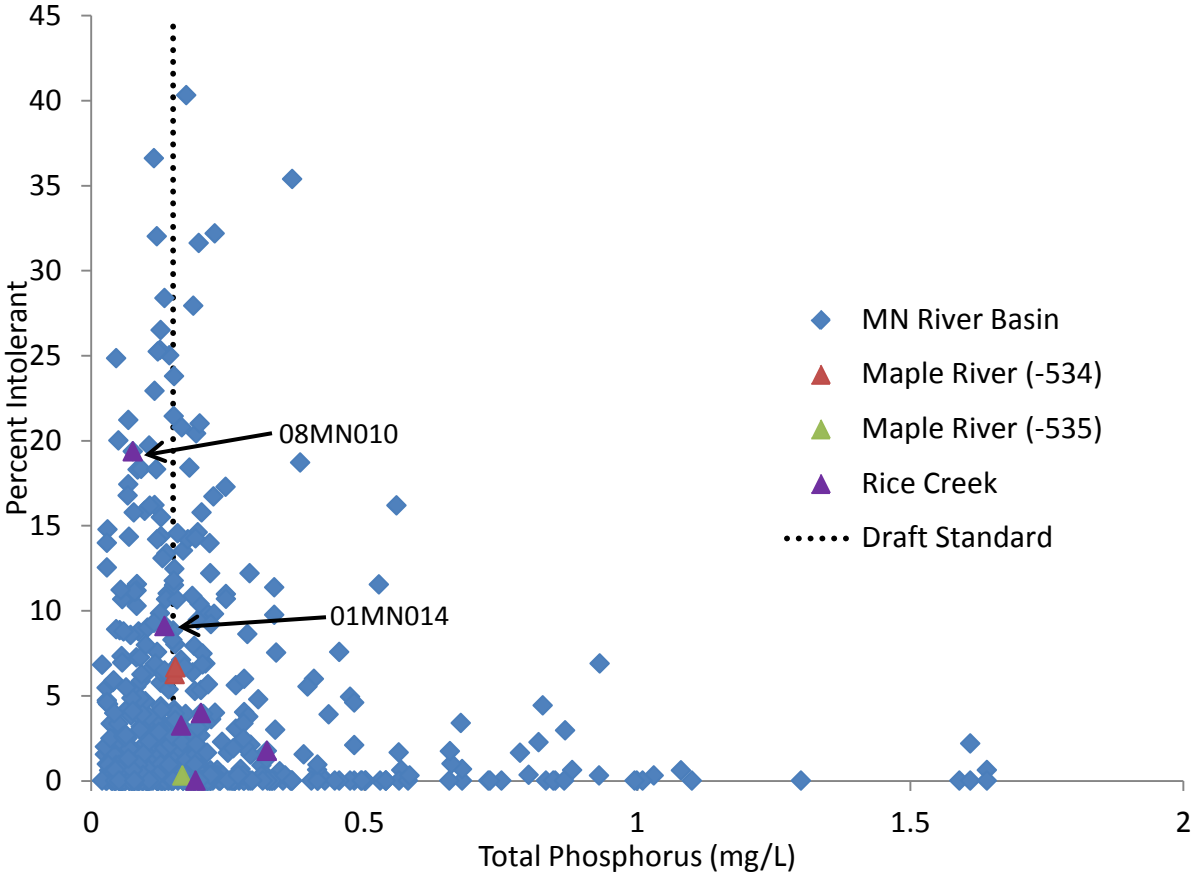

Figure 109. Total phosphorus and percent intolerant invertebrates for the MN River Basin, Maple River, and Rice Creek

Candidate cause: High nitrate

Nitrate levels in this reach of Rice Creek were elevated during the first half of the summer months (Figure 110 and Figure 112). The mean nitrate level for all data collected in this reach was 4.8 mg/L. Generally, nitrate within Rice Creek was elevated higher in the headwaters reaches than the downstream reaches (Table 39). At the pour point of Rice Creek, HSPF model output (reach 809) shows that 10% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009, with a maximum value of 30.1 mg/L. In the upstream reach of Rice Creek the HSPF model output (reach 801) shows that 11.5% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009.

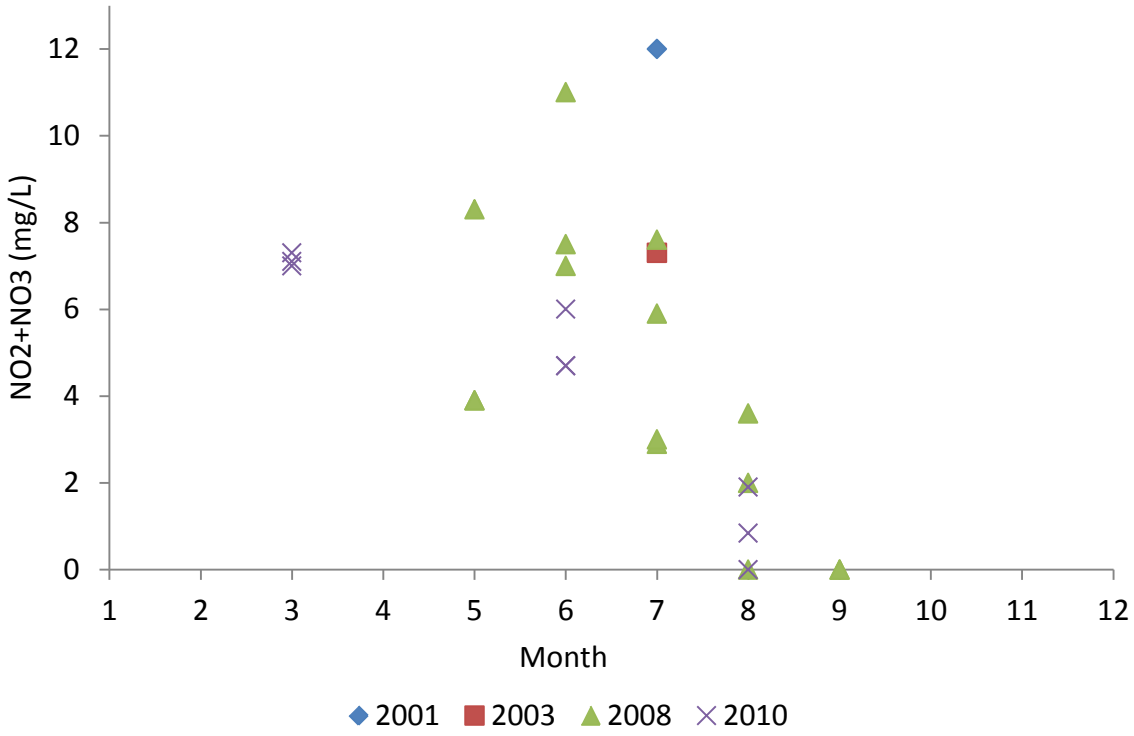

Figure 110. Nitrate-nitrite measurements for Rice Creek (-531) by month

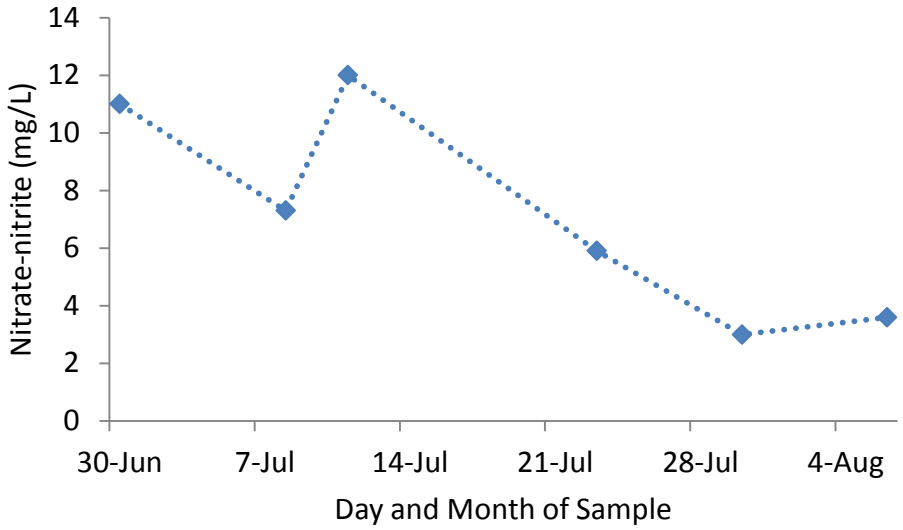

Figure 111. Nitrate-nitrate at time of fish sampling with corresponding day and month of sample (multiple years)

Table 39. Maximum nitrate-nitrite levels sampled at each biological station longitudinally in Rice Creek

	Station	Maximum Nitrate-nitrite (mg/L)	Number of Samples
Upstream	01MN014	12	1
	08MN010	11	2
	08MN076	7.1	4
	08MN086	7.3	3
	03MN067	7.3	1
Downstream	08MN004	8.3	15

The fish community in Rice Creek was lacking in sensitive species, scoring poorly on metrics that gage sensitivity. Of the most abundant species per biological station, three are very tolerant, three are tolerant, and one taxa, spotfin shiners, is neither sensitive nor tolerant. Only three species that are considered sensitive have been surveyed in Rice Creek; slenderhead darter (3), stonecat (3), and northern hogsucker (1). Meador and Carlisle do not rank northern hogsuckers or stonecats as particularly sensitive to nitrate (2007). They both had ordinal ranks of eight; with 10 being most tolerant and one most sensitive. Slenderhead darters were not included in their study; however they are not particularly discerning when it comes to nitrate in Minnesota, at times they are found in waters with nitrate greater than 13.4 mg/L (95th percentile).

The invertebrate communities were lacking intolerant species that may be sensitive to higher nitrate levels. The percentage of tolerant individuals ranged from 90% to 98%. Trichoptera are often considered sensitive to nitrate and respond with decreases in taxa. The number of Trichoptera taxa ranged from 0 to 4 at the biological stations within Rice Creek (8 was the maximum taxa richness of Trichoptera found in the Le Sueur River watershed). The non-hydropsychid Trichoptera in Rice Creek appear to follow the wedge shaped relationship between nitrate and these select Trichoptera (Figure 112). The percentage of nitrate tolerant invertebrate individuals ranged from 51.6-73%. There were few individuals of nitrate

intolerant invertebrates. At station 01MN014, there was the greatest percentage of nitrate intolerant invertebrates with 8.4%.It is likely that in part, nitrate is playing a role in shaping the biological communities in these reaches; however due the complexity of the stressors it is unclear how much of a role it is playing compared to other stressors present.

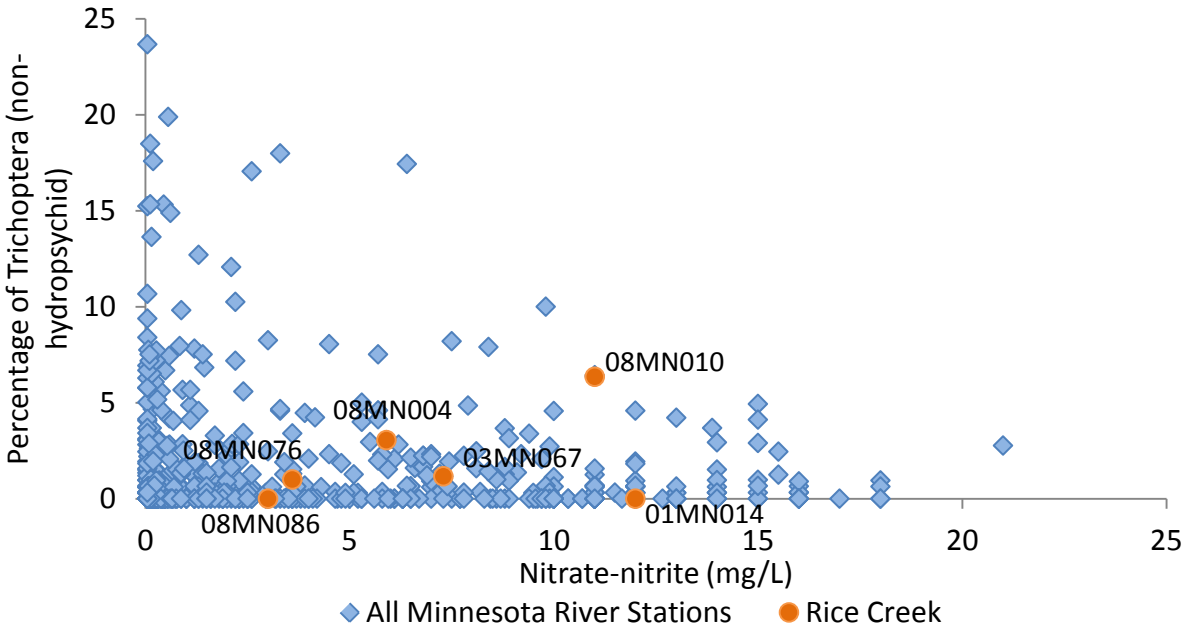

Figure 112. Percentage of non-hydropsychid Trichoptera versus nitrate-nitrite sample taken at time of fish sampling in the Minnesota River Basin and Rice Creek

Candidate cause: High suspended sediment

When Rice Creek was listed for turbidity in 2010, there were 95 exceedances of turbidity and transparency tube data, out of 135 sampling points over five years of collection. In 2008, the same year that much of the biological data was collected, transparency tube data was collected at two sampling locations (S002-431 and S005-466). The collection of the transparency data resulted in most observations in the poor category during the summer months (Figure 113). Fifteen of the seventeen TSS samples in Rice Creek were collected in 2008, with two higher than the proposed standard (Figure 114). HSPF model output (reach 809) shows that 4.3% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009.

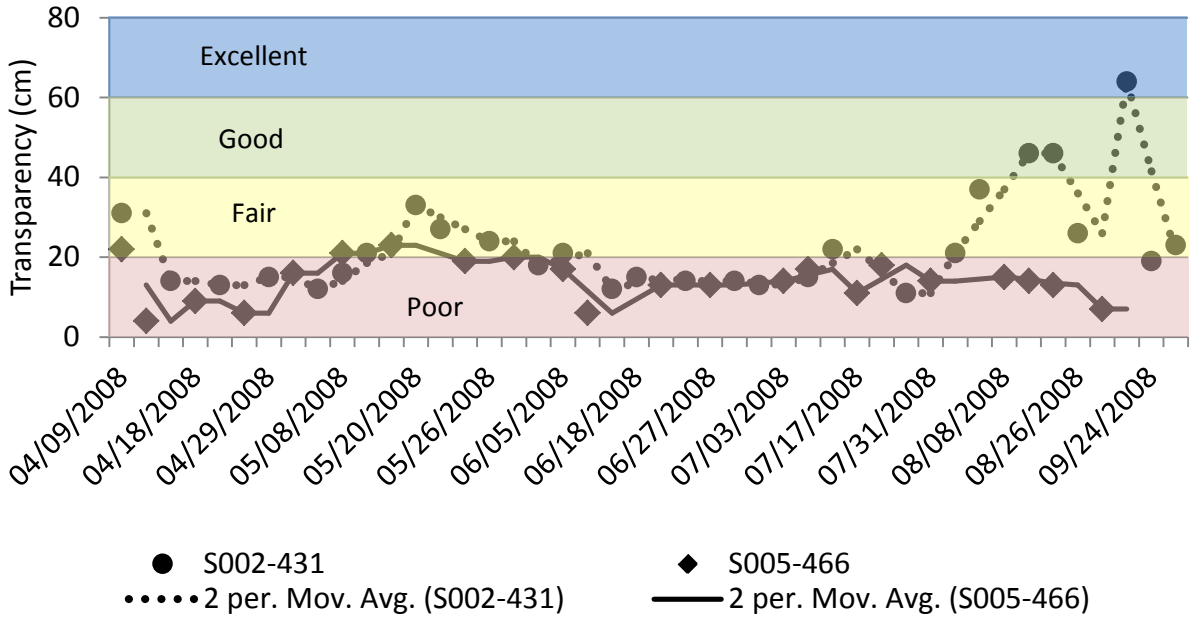

Figure 113. Graph of transparency tube data collected at two stations on Rice Creek in 2008

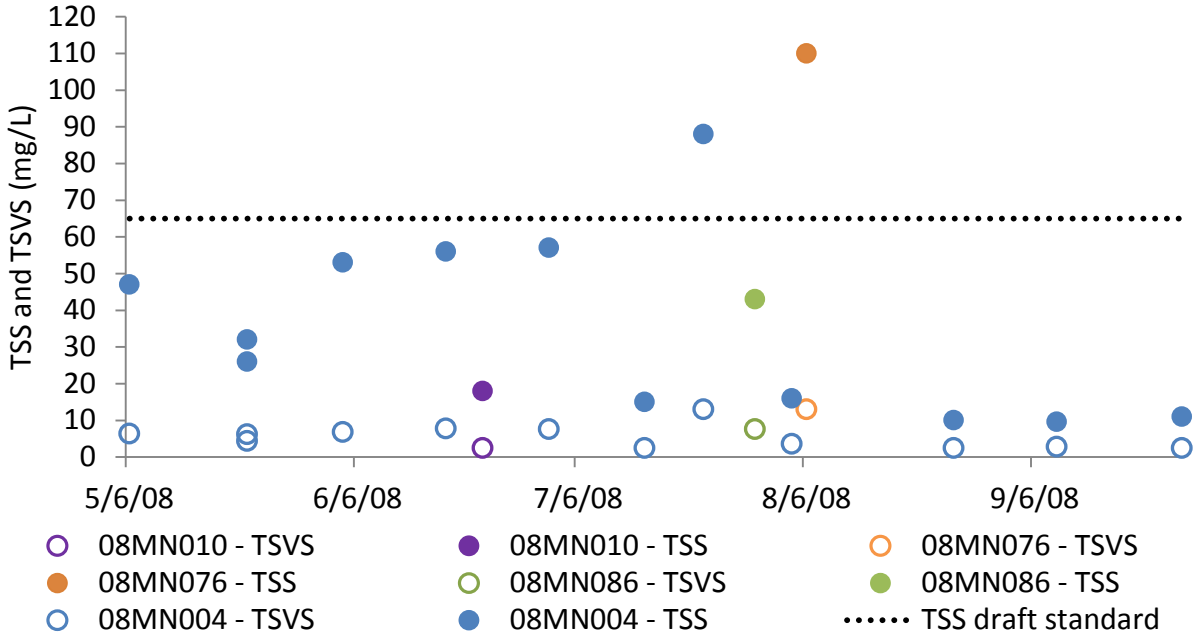

Figure 114. Total Suspended Solids and TSVS at biological reaches in Rice Creek during 2008

There was an abundance of common carp at biological station 08MN076 (740 fish) which may play a role in disturbing the severe embedded sediments at this station to increase TSS levels (Figure 9). The second most dominate fish species in this reach was the spotfin shiner. The spotfin shiner is 'tolerant of a wide variety of habitats and usually the most numerous shiner where waters are turbid' (Becker, 1983). Common carp, spotfin shiner, black bullhead, bluntnose minnow, sand shiner and blacknose dace were common in this reach. Yellow perch were also present and less tolerant of increases in suspended sediment; however they were only present at biological station 08MN076.

Herbivores (fish) are often reduced when turbidity or TSS levels are high. The percent herbivores, as defined by the NAWQA database, ranged from 0% to 5.8%. The average percent of herbivore fish in natural channels of the Le Sueur River watershed was 9.9%, with a range of 0% to 58%. The Le Sueur River watershed has many reaches currently listed for turbidity. Herbivorous fish populations throughout the watershed are influenced by the high turbidity that is prevalent throughout the watershed. Turbidity is affecting the fish community in this reach and the fish community (common carp) is likely impacting suspended sediment levels during times between events.

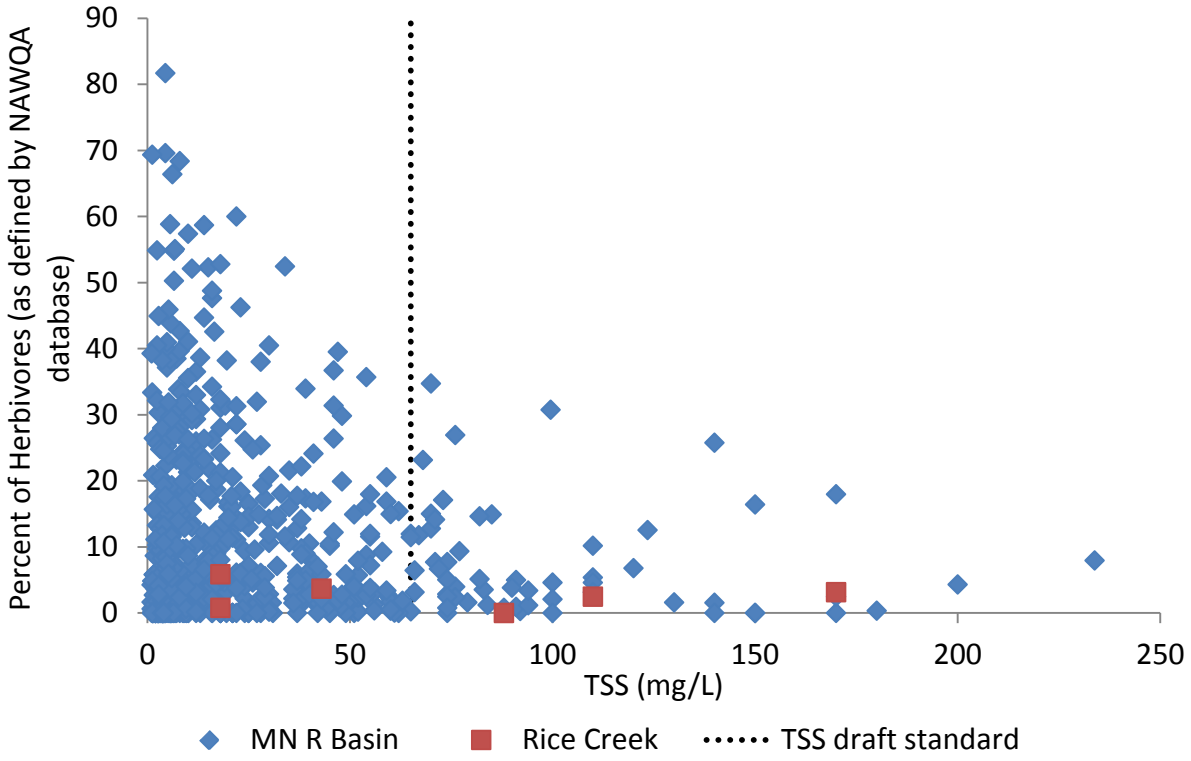

Figure 115. Percentage of herbivores (fish) in the Minnesota River Basin and Rice Creek in comparison to TSS at the time of fish sampling and the TSS draft standard

The invertebrate diversity in this reach ranges from 0.073 to 0.181 (Simpson's Index of Diversity) with no gradient associated longitudinally through the reach. All but the lowest biological station lacked Trichoptera which often decreases with increased turbidity (Table 36 and Table 37), yet may also be connected to other stressors (see nitrate). There was a lack of intolerant invertebrate species at all biological stations; and collector-filterers were reduced at the Prairie Streams GP stations in Rice Creek. The complete absence of intolerant individuals, makes it likely that turbidity is in part causing the degraded invertebrate condition.

Candidate cause: Lack of habitat

This 28 mile reach begins with a channelized portion, and is channelized in some reaches throughout. MPCA Stream Habitat Assessment scores from the natural channel biological stations are grouped into two ranges. Three stations ranged from 40.5 to 42; and two stations ranged from 57.5 to 62. Photos at all sites show some bank sliding, down-cutting, or large deposits of sediment from overland flows. As shown in Figure 12, MSHA scores less than 45 (poor category) often result in fish IBI scores below the threshold. Stations vary on which subcategories scored the poorest; however all stations scored 0 out

of 5 points on the land use. Station 08MN010 scored the lowest on three other subcategories: riparian, cover and channel morphology (Figure 116).

Only two of the biological stations, 08MN010 and 03MN067, had a riffle within the station at the time of fish sampling. The two lowest substrate scores in Rice Creek, also correspond to the two lowest percentages of lithophilic spawners, and were both below the IBI threshold (Figure 117). Figure 118 shows how the IBI varies in a similar pattern as the substrate subcategory score.

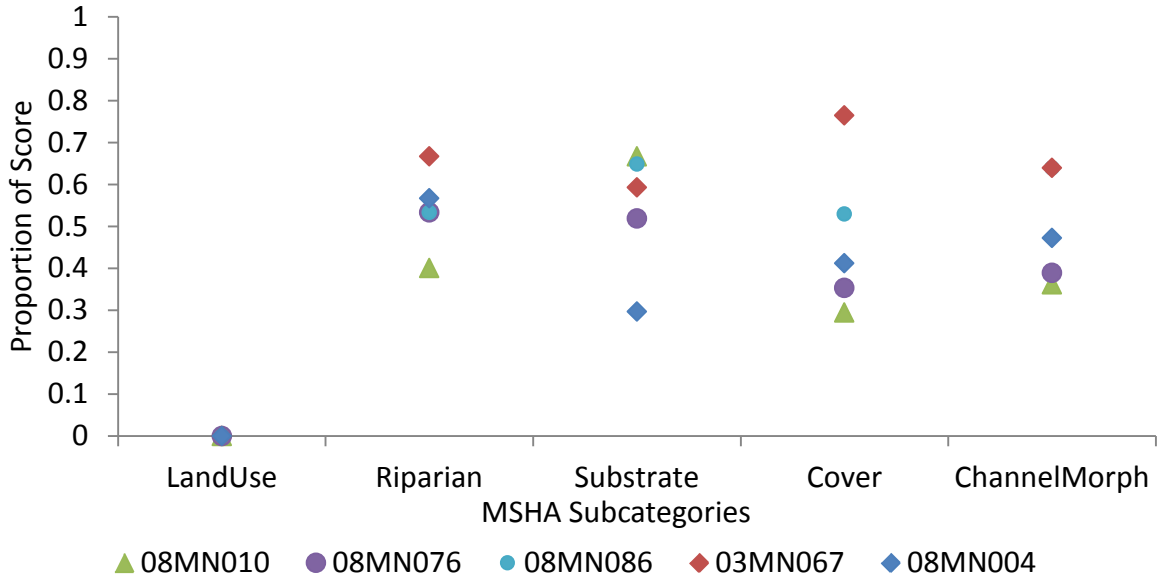

Figure 116. MPCA Stream Habitat Assessment subcategory proportion of score by biological station in Rice Creek

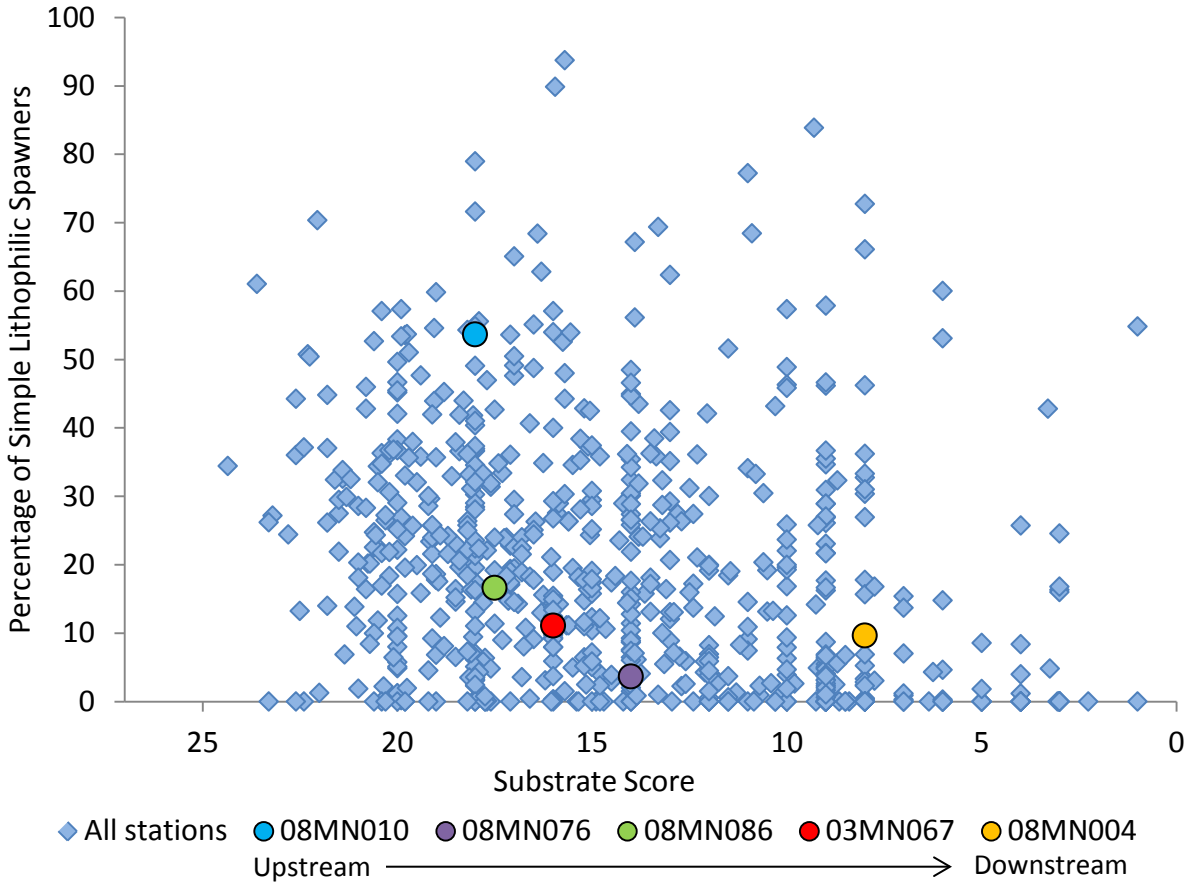

Figure 117. Percentage of Lithophilic Spawners in the Minnesota River Basin and Stations in Rice Creek

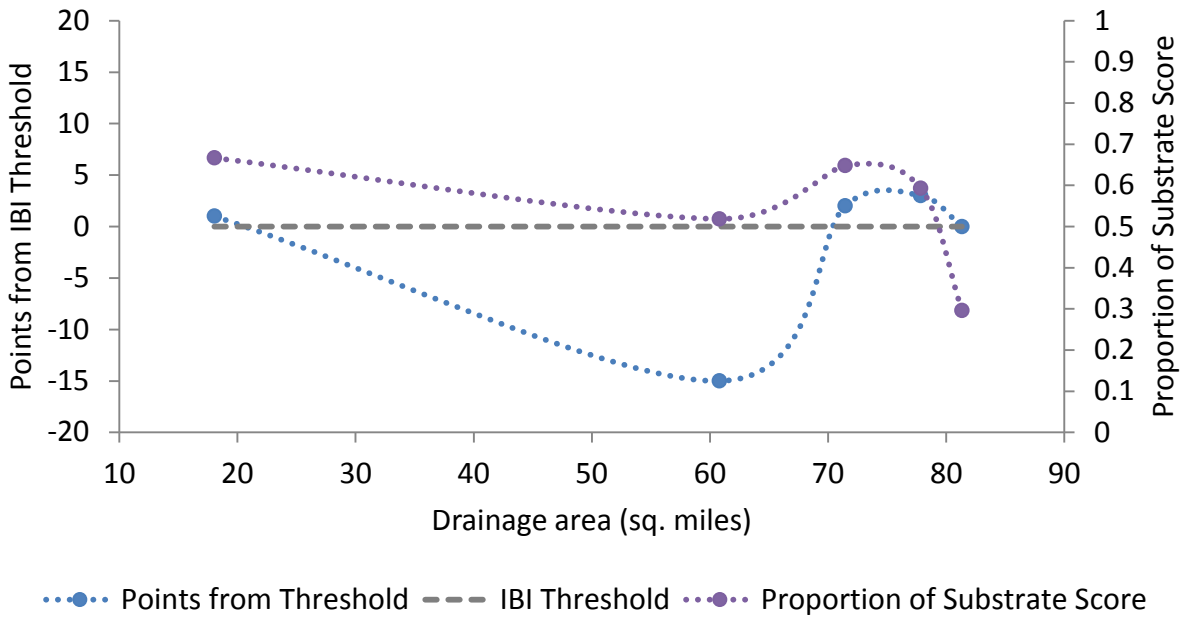

Figure 118. Points from the fish IBI threshold and the proportion of the MSHA substrate score longitudinally in Rice Creek

Habitat is a distinguishing characteristic between these biological stations, although all stations were within the confidence interval or lower for fish IBI, there are some relationships that single out habitat as a driver of the fish community. And although visually similar in pattern (Figure 118), there is not a statistically correlated relationship between the proportion of the substrate score and the points from the threshold within Rice Creek, although this may be due to multiple interacting factors including a small sample size by only looking at Rice Creek stations.

The invertebrates have metrics built into the IBI that directly address habitat, although they are not the only metrics to consider when examining habitat, they are a good place to start. Station 08MN010 and 03MN067 were the only two stations to exhibit riffle habitat (20% and 10% respectively). They were also expected to have a greater percentage of taxa that cling than other stations that do not have that type of habitat; however they do not differ greatly from the other stations in Rice Creek (Figure 120). The stations that represent glide pool morphology had sufficient taxa richness of clingers resulting in metric scores above the average metric score needed to be above the IBI for that type of habitat (Table 37). It is expected that those habitats with riffle morphology and faster flowing water would have higher proportions of taxa that cling. Both of these stations also had low channel stability where as other reaches in Rice Creek had moderate to moderate/high stability (Figure 119).

Britta Suppes analyzed stations 08MN010 and 08MN004 within Rice Creek for her master's project were analyzed in "Comparing channel stability assessment tools for low-gradient streams in agricultural watersheds of the Minnesota River Basin" (Suppes, 2009). The analysis found that station 08MN010 was a Rosgen channel type G6c that was deeply incised with a width depth ratio of 7.4. Station 08MN004 was a C5c- channel type; slightly incised with a width depth ratio of 14.8. Suppes found both of the stations to be degrading and widening.

The instability in the Rice Creek system is affecting the habitat availability for fish and invertebrate communities in these reaches.

Figure 119. Photographs showing low channel stability at station 03MN067 downstream looking upstream (left) and station 08MN010 middle of reach looking downstream (right)

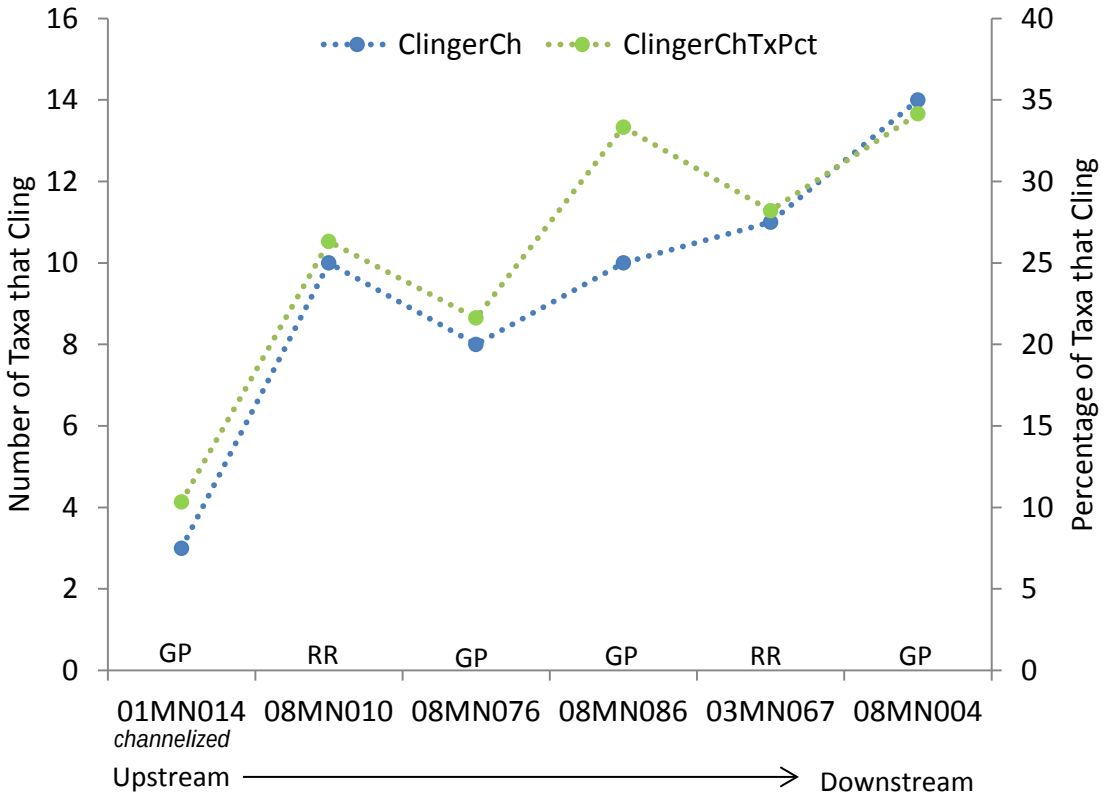

Figure 120. Taxa richness and percentage of taxa that cling longitudinally in Rice Creek

Weight of evidence

The evidence for each potential stressor, the quantity and quality of each type of evidence was evaluated. The consistency and credibility of the evidence was evaluated. Each step for Rice Creek was scored and summarized in Table 40. For more information on scoring please see EPA's CADDIS Summary Table of Scores.

Table 40. Weight of evidence table for potential stressors in Rice Creek (-531)

Evidence using data from Rice Creek (-531)						
Types of Evidence	**Scores**					
	Dissolved Oxygen	**Phosphorus**	**Nitrate-Nitrite**	**Suspended Sediment**	**Physical Habitat**	**Altered Hydrology**
Spatial/temporal co-occurrence	+	+	+	+	+	+
Temporal sequence	+	+	+	+	+	++
Field evidence of stressor-response	++	+	0	0	0	0
Causal pathway	++	+	+	+	+	++
Evidence of exposure, biological mechanism	+	+	+	+	+	+
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE	NE
Verified or tested predictions	NE	NE	NE	NE	NE	NE
Symptoms	+	+	+	+	+	+
Evidence using data from other systems						
Mechanistically plausible cause	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE
Multiple lines of evidence						
Consistency of evidence	+++	+	+	+	+	+
Explanatory power of evidence	++	++	++	++	++	++

Conclusions

In Rice Creek, the fish and invertebrates are impaired. The fish were comprised of individuals that were quick to mature, tolerant, and in some cases, dominated by two species. There was a lack of sensitive fish taxa too. The invertebrate communities were worse upstream and generally improve downstream in Rice Creek. Both the metrics of climbers and clingers were reduced, as well as Trichoptera, in the Southern Streams RR class. In the Prairie Streams GP class, collector-filterers were reduced and intolerant scored zero for the metric score at all four stations in the class. The tolerance based metric HBI_MN resulted in a low metric score at all station in Rice Creek.

Dissolved oxygen has been measured below 5 mg/L at times. Additionally, at the upstream station S006-365, DO flux has been greater than 7 mg/L at times. The DO is dependent on flow conditions and likely driven in part by low flow. Indicators of this affecting the invertebrate community include low metric score of the HBI_MN metric, few stoneflies, and decreased EPT taxa. The fish community lacked sensitive individuals. The fish community was comprised of very tolerant and tolerant fish. All stations had a large percentage of tolerant fish to low DO and only the furthest downstream station 08MN004 had one fish sensitive to low DO. Low DO is definitely stressing the biological communities. Additional data on the reoccurrence of the low DO would be advantageous to gather for further understanding of this stressor in Rice Creek.

Phosphorus was elevated above the draft standard at times. The limited chlorophyll-a data resulted in values less than 35 µg/L. As mentioned previously, the DO was low at times and had a high flux in the upper reaches, likely due to the elevated phosphorus. There was a low percentage of intolerant invertebrates and a lack of sensitive fish. The negative attributes to the biological community can be attributed to the elevated phosphorus. Additional data should be collected to understand the sources of phosphorus in Rice Creek.

Nitrate is generally higher in the headwater reaches than downstream and is highest in June and July, according to samples of nitrate in Rice Creek. The fish community is lacking sensitive species. The invertebrate community was comprised of 90% to 98% tolerant individuals and had a reduced number of Trichoptera taxa. Nitrate is a stressor to the biological community, but may not be a primary stressor.

In 2008, the year that much of the biological data was collected, transparency tube data resulted in the poor category during the summer months. Of 15 TSS samples in 2008, only 2 were greater than the proposed standard. The large presence of common carp is likely influencing the transparency by disturbing the embedded sediments in this reach. Herbivores were reduced symptomatic of elevated turbidity or TSS issues. Invertebrate collector-filterers were reduced in the Prairie Streams GP class and there was a complete lack of intolerant individuals. Turbidity is a stressor to both fish and invertebrates in Rice Creek.

Rice Creek is channelized in the headwater reaches and in some reaches throughout. The MSHA resulted in poor to fair habitat at the biological stations. The lowest substrate subcategory scores also resulted in the lowest percentage of lithophilic spawners, and appears to be a major driver of the fish community IBI scores. The stations with riffle morphology would be expected to have a higher percentage of invertebrate species that cling, but they do not differ from other glide/pool morphology stations in Rice Creek. Stations 08MN010 and 08MN004 were both found to be degrading and widening (Suppes, 2009). Lack of adequate habitat is a stressor to the fish and invertebrate communities in Rice Creek.

Flows in Rice Creek, initially come from channelized headwater reaches. Some of the headwater subwatersheds have gained 50% to 100% of their stream miles since 1855. Low flow appears to drive the low DO, and the flows are related to turbidity and habitat. Throughout Rice Creek, tolerant invertebrates dominate; however there is also some high percentages of long lived invertebrates. The fish community has some stations with a high proportion of long lived fish, but other stations have few.

Rice Creek may not be the worst watershed in terms of hydrologic alteration, but the biology is responding to the effects of the altered hydrology.

In Rice Creek, low DO, elevated phosphorus, elevated nitrate, elevated TSS/turbidity, lack of habitat, and altered hydrology are all stressors to the biological community.

Maple River (07020011-535)

This reach of the Maple River was assessed in 2010 as impaired for turbidity. In 2012, fish and invertebrates were added to the impairment list.

Biology in the Maple River

The fish and invertebrate communities are impaired in this reach of the Maple River. For the fish community, both stations scored within the confidence interval of the IBI threshold, one station scored below and the other scored above the threshold. Both stations have an abundance of fish that reach maturity before the age of 2 (MA<2Pct) and have short lived species (SLvd; Table 41). They were lacking in fish species that are sensitive (SensitiveTxPct). This AUID had no DELT deductions for the IBI.

The two biological stations that were sampled for invertebrates in 2008 were 08MN023 and 08MN091. The scores differed greatly between the two stations. Station 08MN023 scored below the threshold and below the confidence interval with an IBI score of 20.65. Station 08MN091 scored above the threshold and above the confidence interval with an IBI score of 61.87. Although there was a difference in IBI scores, one particular similarity was the taxa richness of invertebrates with tolerance values less than or equal to 2 (Intolerant2Ch; using MN TVs, Table 42). Station 08MN023, had nine of the ten metrics in the Prairie Streams GP IBI below the average metric score needed for the IBI to be at the threshold.

Table 41. Fish metrics of the Southern Streams IBI for the Maple River (-535); bold indicates the metric value is below the average metric score (5.6) needed for the IBI score to be at the threshold

Site	BenInsect-TolTxPct	DetNWQTxPct	DomTwoPct	MA<2Pct	SensitiveTxPct	SLvd	TolPct	TolTxPct
08MN023	7.8	6.7	8.3	**1.2**	**2.3**	**4.2**	**3.6**	7.7
08MN024	10	8.7	9.2	**3**	**3.3**	**2.1**	7.2	9.9

Table 42. Invertebrate metrics of the Prairie Streams GP IBI for Maple River (-535); bold indicates the metric value is below the average metric score (3.8) needed for the IBI score to be at the threshold

Site	ClingerCh	Collector-filtererPct	DomFiveCHPct	HBI_MN	Intolerant2Ch	POET	PredatorCh	TaxaCountAllChir	TrichopteraChTxPct	TrichwoHydroPct
08MN023	**0.7**	**0.0**	4.6	**2.6**	**0.0**	**3.6**	**2.9**	**0.9**	**2.8**	**2.7**
08MN091	10.0	6.3	6.5	4.4	**0.0**	10.0	4.3	5.3	10.0	5.1

Candidate cause: Low dissolved oxygen

Only three measurements of DO have been collected on this reach of the Maple River, only one prior to 9:00 AM. All of the measurements were above the standard of 5 mg/L.

Table 43. Dissolved oxygen measurements in the Maple River (-535)

Station	Date and Time	DO (mg/L)
08MN024	8/6/08 9:52 AM	7.56
08MN023	7/24/08 8:40 AM	7.07
S005-312	3/22/10 11:50 AM	10.86

Upstream, Minnesota Lake has had seven measurements of DO on five dates in the summer months of 2008 and 2009. The lowest measurement of DO in the lake was on September 22, 2009 at 9:15 PM with 5.76 mg/L. The next reach of the Maple River upstream (-580), there has only been one measurement. On August 18, 2008 at 6:40 PM, the DO was 7.97.

The invertebrates in this AUID of the Maple River had a mixed response of the metric HBI_MN, a measure of pollution based on tolerance values assigned to each individual taxon. Station 08MN023 received a low metric score, where station 08MN091 had a score just above the average score needed to be above the threshold. Similarly, the EPT taxa were less upstream than downstream. It is uncertain if this relationship would be similar as the DO levels in the reach due to the lack of DO data.

The fish community was not particularly tolerant to low DO (Figure 6). There was a lack of sensitive taxa in the reach. The data available suggests that DO is not a stressor in this reach of the Maple River; however data is not available to confirm that assumption. It would be advantageous to collect additional DO data particularly in the upstream sections of the reach.

Candidate cause: High phosphorus

Three samples of TP collected within the reach, were all higher than the draft standard (Table 44). There is not enough data available at this time to look at trends longitudinally through this reach. HSPF model output at the outlet of the reach (reach 799) shows that 51.4% of the TP daily averages are greater than 0.150 mg/L, from 1996 to 2009.

Invertebrate taxa, clinger taxa and EPT taxa were considerably less in stations 08MN072 and 08MN023 than the downstream station 08MN091 (Table 45). This may be due to higher phosphorus levels upstream than downstream, even with the limited data, phosphorus levels were high throughout the reach. Within the South Region, the taxa richness seen in 08MN019 was less than would be expected in streams with lower phosphorus (see Minnesota River Nutrient Criteria Development, November 2010, pg. 151). This may indicate that phosphorus is a causal agent for response stressor; however, this is not apparent in the dataset either due to a lack of data or there are no response stressors present. It is inconclusive on the biological impacts of phosphorus.

Table 44. Phosphorus samples in the Maple river (-535)

Station	Date	Total Phosphorus (mg/L)
08MN024	8/6/2008	0.206
08MN023	7/24/2008	0.167
S005-312	3/22/2010	0.261

Table 45 Invertebrate metrics that are expected to decrease with increased TP for stations 08MN072, 08MN023, and 08MN019 on the Maple River

Metric	08MN072	08MN023	08MN091
Taxa	18	17	26
Clinger Taxa	4	3	16
EPT Taxa	6	7	17

Candidate cause: High nitrate

Only three measurements of nitrate have been collected on this reach of the Maple River (Table 46). All three measurements were elevated. There is not enough data available at this time to look at trends longitudinally through this reach. HSPF model output (reach 799) shows that 16.9% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009.

Trichoptera are often considered sensitive to nitrate and respond with decreases in taxa, which was observed in station 08MN023, but not in station 08MN091. The only species of Trichoptera at 08MN023 was *Pycnopsyche*. Station 08MN091 had seven species of Trichoptera present at time of sample in 2008. Station 08MN023 had 60.5% nitrate tolerant individuals, with no nitrate intolerant individuals. Station 08MN091 had 55.4% nitrate tolerant individuals, with less than 2% nitrate intolerant individuals. Due to the lack of longitudinal data it is difficult to distinguish if nitrate reaches higher levels at stations 08MN023 and S005-312, which are co-located, or if it is a function of the sampling times. However, a channelized station, 08MN072, which had similar invertebrate response as 08MN023, had 0.78 mg/L nitrate at the time of fish sampling. It is a potential that these stations upstream in the river experience higher nitrate levels than those in downstream portions.

In terms of the fish community, both stations were lacking in sensitive taxa which may be indicative of the high nitrate levels. The stations also had fish that are quick to mature and are shortlived. In particular, the fish community was dominated by bluntnose minnows and spotfin shiners, having presence in nitrate rich waters above 15.5 and 13.2 mg/L respectively (95th percentile presence in MN streams). Additionally, Meador and Carlisle (2007) also consider these two fish species tolerant of nitrate.

The lack of sensitive fish taxa and the lack of intolerant invertebrate taxa are potentially a response in part due to high nitrate levels. However with the lack of nitrate data available, and the presence of some species, it may be a lesser stressor to another predominate stressor to the biological communities.

Table 46. Nitrate samples in the Maple River (-535)

Station	Date	Nitrate (mg/L)
08MN024	8/6/2008	4.8
08MN023	7/24/2008	8.9
S005-312	3/22/2010	8.9

Candidate cause: High suspended sediment

This reach is impaired for turbidity. The turbidity was over the standard in both years data were collected. Total suspended solids have been measured six times in this reach. Two of the samples were taken at the time of fish sampling in 2008, these both resulted in TSS less than the draft standard of 65 mg/L. In 2009, three locations were sampled on the same date with a range of 82.58 to 94.76 mg/L TSS.

HSPF model output (reach 799) shows that 10% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009.

The dominate fish species in this reach was the spotfin shiner. The spotfin shiner is 'tolerant of a wide variety of habitats and usually the most numerous shiner where waters are turbid' (Becker, 1983). Bluntnose minnows, sand shiners, fathead minnows, orangespotted and green sunfish, and common carp were common in this reach. Yellow perch were also present and less tolerant of increases in suspended sediment; however they were present in low numbers.

Herbivorous fish are often reduced when turbidity or TSS levels are high. The hervivorous fish in this AUID of the Maple River are low (2.3% – 6%). The average percent of herbivore fish in natural channels of the Le Sueur River watershed was 9.9%, with a range of 0% to 58%. The Le Sueur River watershed has many reaches currently listed for turbidity. Herbivorous fish populations throughout the watershed are influenced by the high turbidity that is prevalent throughout the watershed. Turbidity and total suspended sediment are affecting the fish community in this reach.

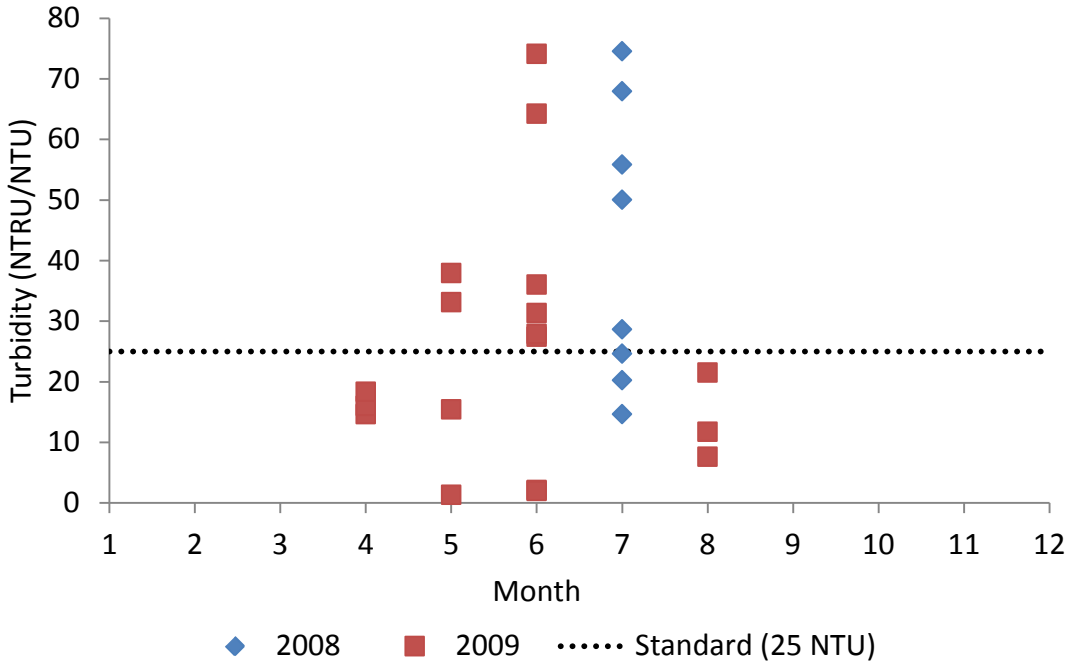

Figure 121. Turbidity measurements for the Maple River (-535) by month from 2008 to 2009

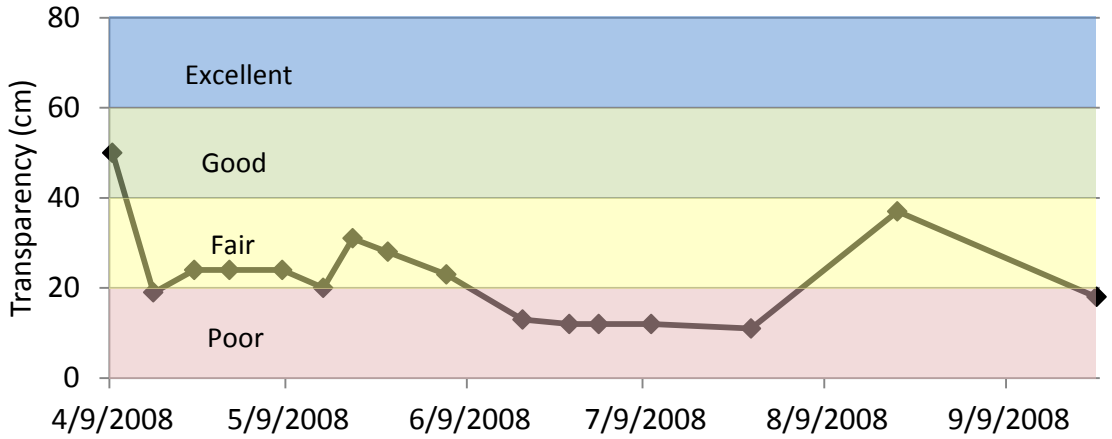

Figure 122. Transparency (cm) for station S005-305 in 2008

Invertebrates that feed by filtering and scraping often decrease with increased turbidity. Station 08MN023, scored poorly in the collector-filterer percent metric; however station 08MN091 did not score poorly, rather in the middle of the range of scores possible. This is contradictory to expectations of increased TSS.

Table 47. Invertebrate feeding method metrics for stations 08MN023 and 08MN091 by taxa and percent individuals

Station 08MN023			Station 08MN091		
Feeding Method	**Taxa**	**Percent**	**Feeding Method**	**Taxa**	**Percent**
Filterer	0	0	Filterer	6	23.9
Gatherer	10	53.9	Gatherer	10	25.8
Predator	8	23.1	Predator	10	5.7
Scraper	2	19.6	Scraper	5	40.4
Shredder	2	2	Shredder	5	5

Similarly, there were differences in the invertebrate metrics (diversity, taxa richness, tolerant taxa and percent individuals, Ephemeroptera & Trichoptera taxa and percent individuals) between these two stations. It would be expected that the stations would have similar invertebrate responses to a stressor that is found at both locations. This suggests that turbidity may not be a distinguishing stressor for the invertebrates at these stations, yet still a present stressor acting negatively in combination with other stressors. It could definitely be improved upon. Other stressors are likely acting on station 08MN023 contributing to the differences observed in the biological communities.

Candidate cause: Lack of habitat

Both natural channel stations' MSHA total scores were in the fair range for this AUID of the Maple River (45.75 and 56.5). The subcategory scores reveal differences in habitat between the two stations (Figure 123). Station 08MN023 is characterized as having a narrow riparian buffer, little erosion and moderate shade. There was no riffle or course substrate in the station, along with a lack of diverse substrates. Cover was noted as sparse and it was noted as having moderate channel stability. Station 08MN024 had a wide riparian buffer, little erosion and moderate shade. There was a riffle present consisting of 10% of the reach, along with the presence of gravel and cobble. Similar to upstream there was a lack of cover noted along with moderate channel stability.

The biological community shows some differences between upstream and downstream that may correlate with differences seen in the habitat parameters. The upstream station was lacking invertebrate taxa that cling, but the downstream station was not. Although non-tolerant benthic insectivores were lacking at both locations, they were higher downstream than upstream with 16% downstream and 5% at station 08MN023. Riffle-dwelling fish individuals were also markedly lower upstream than downstream.

The differences in IBI scores and the differences metrics are related in part to the differences in habitat available to the biological communities.

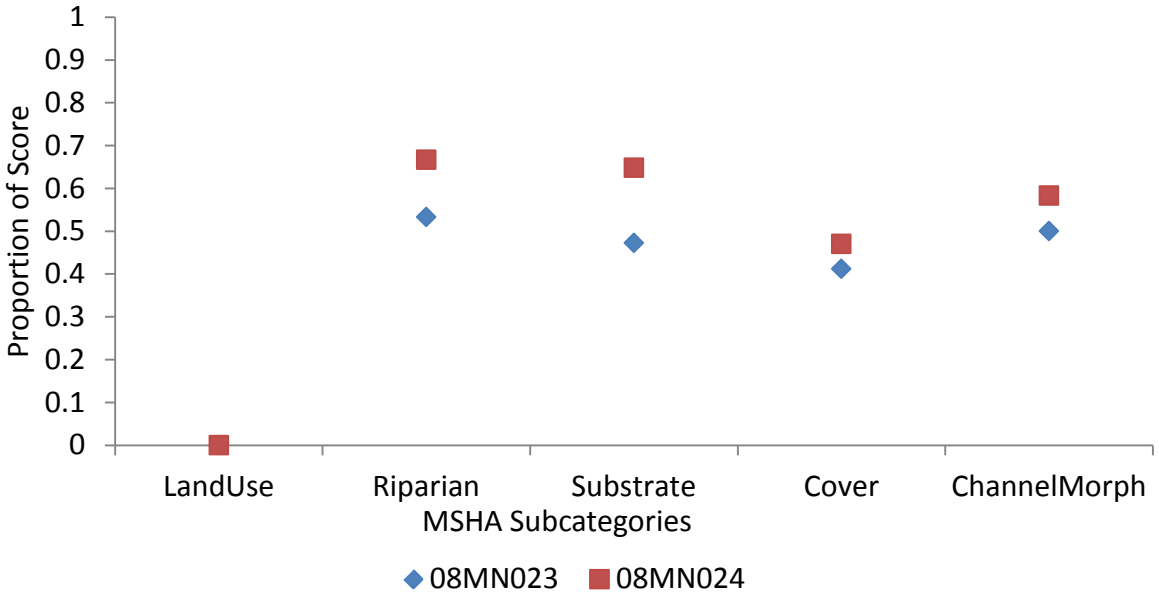

Figure 123. MPCA Stream Habitat Assessment subcategory proportion of score for the stations in the Maple River

Weight of evidence

The evidence for each potential stressor, the quantity and quality of each type of evidence was evaluated. The consistency and credibility of the evidence was evaluated. Each step for the Maple River (-535) was scored and summarized in Table 48. For more information on scoring please see EPA's CADDIS Summary Table of Scores.

Table 48. Weight of evidence table for potential stressors in Maple River (-535)

Evidence using data from Maple River (-535)						
Types of Evidence	**Scores**					
	Dissolved Oxygen	**Phosphorus**	**Nitrate-Nitrite**	**Suspended Sediment**	**Physical Habitat**	**Altered Hydrology**
Spatial/temporal co-occurrence	0	0	0	+	+	+
Temporal sequence	NE	0	0	+	+	++
Field evidence of stressor-response	NE	0	0	0	+	0
Causal pathway	+	+	+	+	+	++
Evidence of exposure, biological mechanism	--	0	0	+	+	+
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE	NE
Verified or tested predictions	NE	NE	NE	NE	NE	NE
Symptoms	---	0	0	+	+	+
Evidence using data from other systems						
Mechanistically plausible cause	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE
Multiple lines of evidence						
Consistency of evidence	-	0	0	+	+	+
Explanatory power of evidence	0	0	0	++	++	++

Conclusions

In the Maple River (-535), the fish and invertebrate community are impaired. Stations 08MN023 and 08MN024 did not differ much in fish community and both had an abundance of fish that mature quickly and are short-lived. The fish in this reach of the Maple River were lacking in sensitive taxa. The invertebrate community was further degraded at station 08MN023 than the downstream 08MN091 station. Station 08MN023 scored poorly on nine of ten metrics in the Prairie Streams GP IBI class. Station 08MN091 only scored poorly due to a lack of intolerant invertebrate species.

In the upstream AUID of the Maple River, there was limited data for DO, phosphorus and nitrate. It is unlikely that DO is an issue for the biological community in this reach, but it is difficult to completely rule out due to the limited data. Phosphorus and nitrate were inconclusive as potential stressors, without enough data to discern. It is recommended that more data is collected regarding the nutrient dynamics within this reach of the Maple River.

This reach of the Maple River is impaired for turbidity. Total Suspended Solids has only been measured six times. Spotfin shiners dominated this reach, which are tolerant of turbid waters. The herbivores were reduced. Elevated TSS/turbidity is a stressor to the fish community, but was not connected to the invertebrate community. Station 08MN023 scored poorly on the collector-filterer metric, but station 08MN091 did not score poorly. Similarly there were differences in the invertebrate response that are not expected with elevated TSS.

The MSHA score was fair at the two stations, however differences were noted between them. Upstream station 08MN023 had no riffle, a lack of diverse substrates, little cover, and a narrow riparian buffer. Downstream had a small amount of riffle habitat, along with presence of gravel and cobble, but also lacked cover despite a wide riparian buffer. Similar to the habitat variability, the invertebrates that cling were okay downstream, but not at the upstream station, and riffle-dwelling fish followed the same pattern. Lack of habitat is a stressor to the invertebrate and fish communities.

Turbidity and habitat are strongly influenced by hydrology and are both stressors to the biological community. Altered hydrology is also a stressor to both the fish and the invertebrate communities. This reach of the Maple River does have a relatively high percentage of long lived invertebrates and long lived fish. At the upstream station, the Maple River has a low percentage of invertebrate swimmers but downstream there is a greater than average of invertebrates that are swimmers. As similarly seen throughout the Le Sueur River watershed, the Maple River (-535) has a greater than 90% tolerant invertebrate individuals. The fish community is not dominated by as many tolerant fish in this reach of the Maple River. The alteration of the landscape, along with the changes in hydrology, has impacted the biological community. Over 140 stream miles have been added upstream of the pour point of this reach of the Maple River since 1855. Along with other changes in the landscape that control when water is delivered to the stream, these increases in drainage have altered the hydrologic regime and influenced habitat and sediment dynamics too.

Maple River (07020011-534)

This reach of the Maple River was assessed in 2008 as impaired for turbidity. In 2012, invertebrates were added to the impairment list for this reach. Although standards currently could not be applied, nitrate-nitrite, TP and suspended solids were above ecoregion expectations.

Biology in the Maple River

In this reach of the Maple River, invertebrate populations are impaired. The IBI score was low for station 08MN003 (below the threshold but within the confidence interval). Station 08MN019 scored above the threshold, but within the confidence interval. Due to the nature of these two stations being of different classes, there are not immediately comparable.

Station 08MN019 had three metrics that are encompassed in the IBI that scored below the average metric score needed for an IBI score greater than the threshold (Table 49). There was a lack of percent collector-filters (Collector-filtererPct), a lack of intolerant species (Intolerant2Ch), and a lack of predators (PredatorCh).

Table 49. Invertebrate metrics of the Prairie Streams GP IBI for station 08MN019; bold indicates the metric value is below the average metric score (3.8) needed for the IBI score to be at the threshold

Site	ClingerCh	Collector-filtererPct	DomFiveCHPct	HBI_MN	Intolerant2Ch	POET	PredatorCh	TaxaCountAllChir	TrichopteraChTxPct	TrichwoHydroPct
08MN019	8.7	**2.9**	5.9	4.0	**0.0**	7.9	**2.9**	5.3	4.9	5.5

Station 08MN003 had six metrics below the average metric score needed for an IBI score greater than the threshold (Table 51). In 2008, this station lacked climbers (ClimberCh), odonates (Odonata), caddisflies (Trichoptera), and predators (Predator). Five species dominated the sample (DomFiveCHPct; 76%) and the percent tolerant taxa was relatively high (Tolerant2ChTxPct; 76%).

Table 50. Invertebrate metrics of the Southern Streams RR IBI for station 08MN003; bold indicates the metric value is below the average metric score (3.6) needed for the IBI score to be at the threshold

Site	ClimberCh	ClingerChTxPct	DomFiveCHPct	HBI_MN	InsectTxPct	Odonata	Plecoptera	Predator	Tolerant2ChTxPct	Trichoptera
08MN003	**0.0**	7.1	**0.4**	4.6	9.1	**0.0**	5.0	**0.0**	**3.6**	**2.0**

Candidate cause: Low dissolved oxygen

There was limited data available for DO prior to 9 am. Only one measurement occurred prior to 900 AM on May 22, 2008, with a value of 10.5 mg/L. The other 24 measurements occurred between 10:00 AM and 4:00 PM; and ranged from 6.54 to 12.63 mg/L.

The HBI_MN metric was above the average metric score needed to be above the threshold. The fish communities within this reach were comprised of fish that had greater sensitivity than other stations, falling in the upper quartile in the Le Sueur River (Figure 6). It is difficult to rule out low DO as a potential stressor due to the lack of early morning DO data; more information is needed.

Candidate cause: High phosphorus

Phosphorus was elevated in this reach numerous times from March to October (Figure 124). The nine years of data all have samples above the draft standard for phosphorus; the annual mean phosphorus was also greater than the draft standard. HSPF model output at the outlet of the reach (reach 819) shows that 45.9% of the TP daily averages are greater than 0.150 mg/L, from 1996 to 2009. There was no available BOD or chlorophyll-a data for this AUID, in addition to the limited DO data previously discussed.

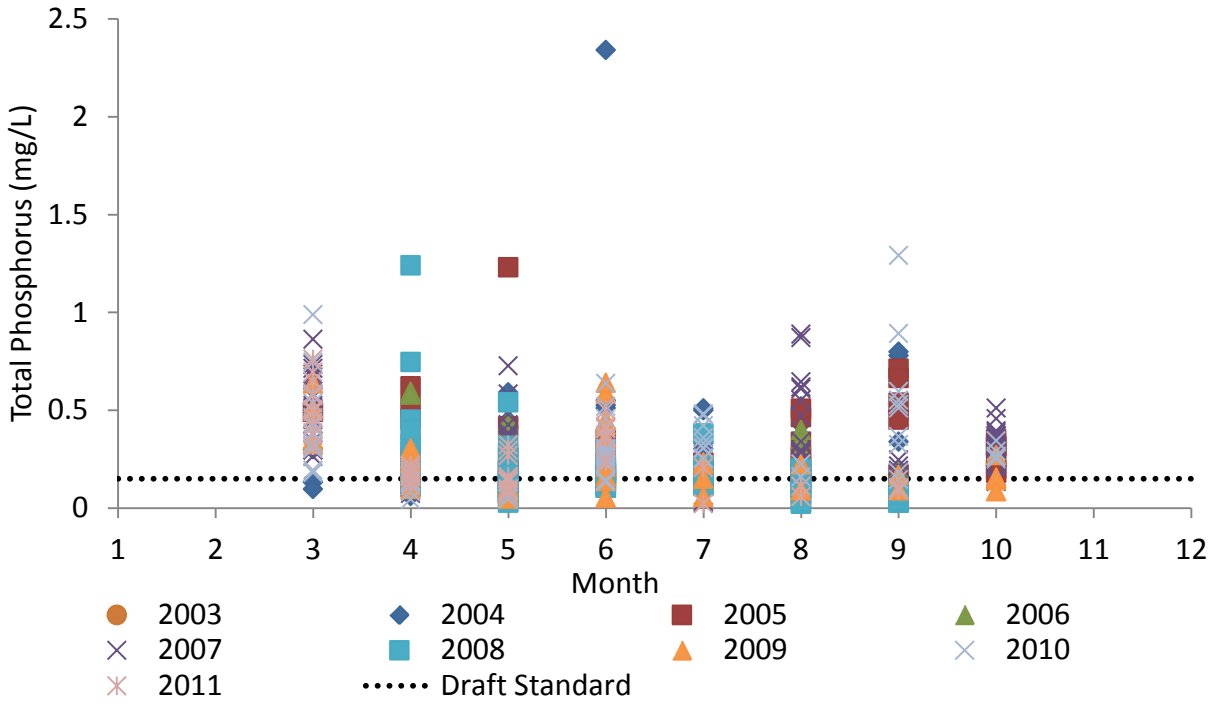

Figure 124. Total phosphorus measurements for the Maple River (-534) by month from 2003 to 2011.

In Minnesota, the number of invertebrate taxa are known to decrease with increased TP (see Minnesota River Nutrient Criteria Development for more information). The number of invertebrate taxa, clinger taxa, and EPT taxa were lower at station 08MN003 than at 08MN019 (Table 51). However, Figure 125 shows the TP levels at each of these locations was similar. Station S002-427 had the higher concentrations, but not considerably. Station 08MN019 had the higher richness of taxa. It would be expected that due to the phosphorus levels at both locations, similar responses may be seen. Elevated levels of phosphorus likely contributing to the impaired invertebrate community but are not the distinguishing variable between the two stations with differing IBI scores.

Table 51. Invertebrate metrics that are expected to decrease with increased total phosphorus for stations 08MN003 and 08MN019 on the Maple River

Metric	08MN003	08MN019
Taxa	26	37
Clinger Taxa	8	12
EPT Taxa	10	12

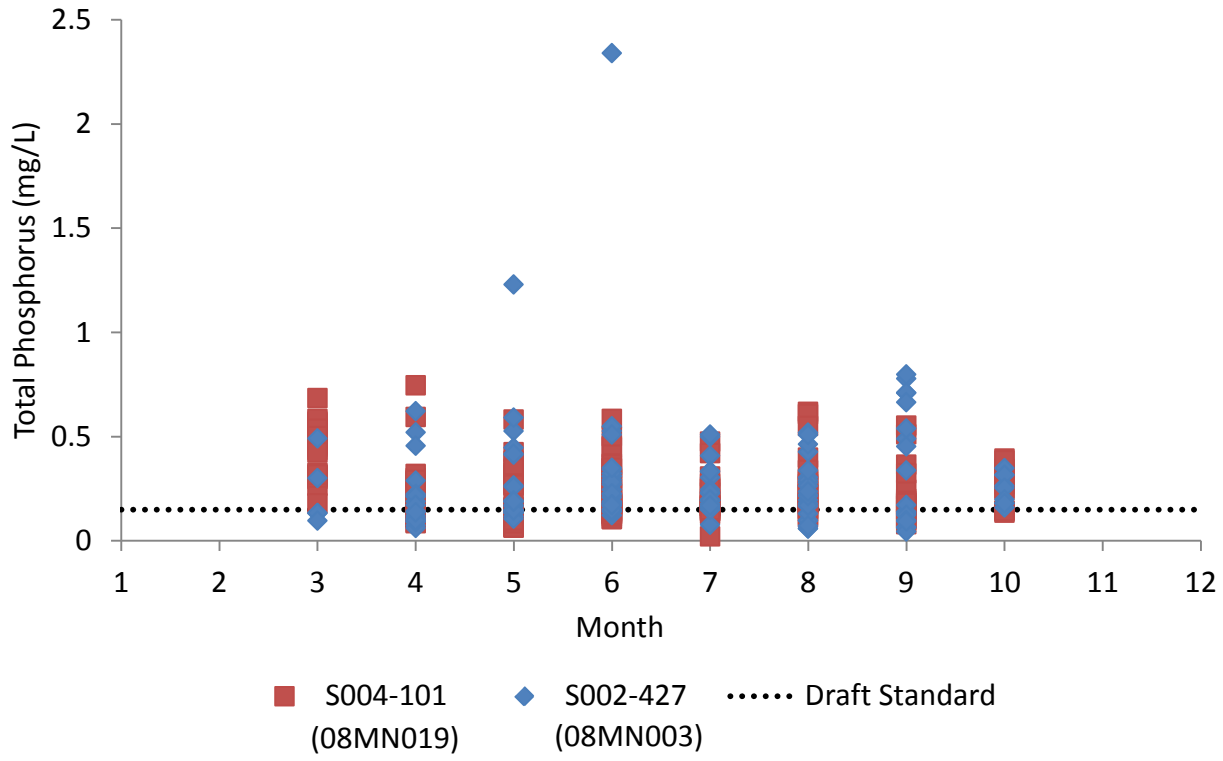

Figure 125. Total phosphorus measurements by month for stations S004-101 and S002-427

Candidate cause: High nitrate

Nitrate-nitrite was elevated through many of the months sampled (Figure 126). From 2003 to 2011, the maximum annual nitrate-nitrite level was at or exceeded 13 mg/L, with the highest measured nitrate-nitrite of 27.3 mg/L, in 2004. The annual mean of the samples ranged from 5.9 to 10.7 mg/L. Nitrate levels were not different between the two major sampling locations in the reach (Figure 127). HSPF model output (reach 819) shows that 15% of the nitrate-nitrite daily averages are greater than 10 mg/L, from 1996 to 2009. Unionized ammonia is not elevated in the reach, and therefore is not a current concern.

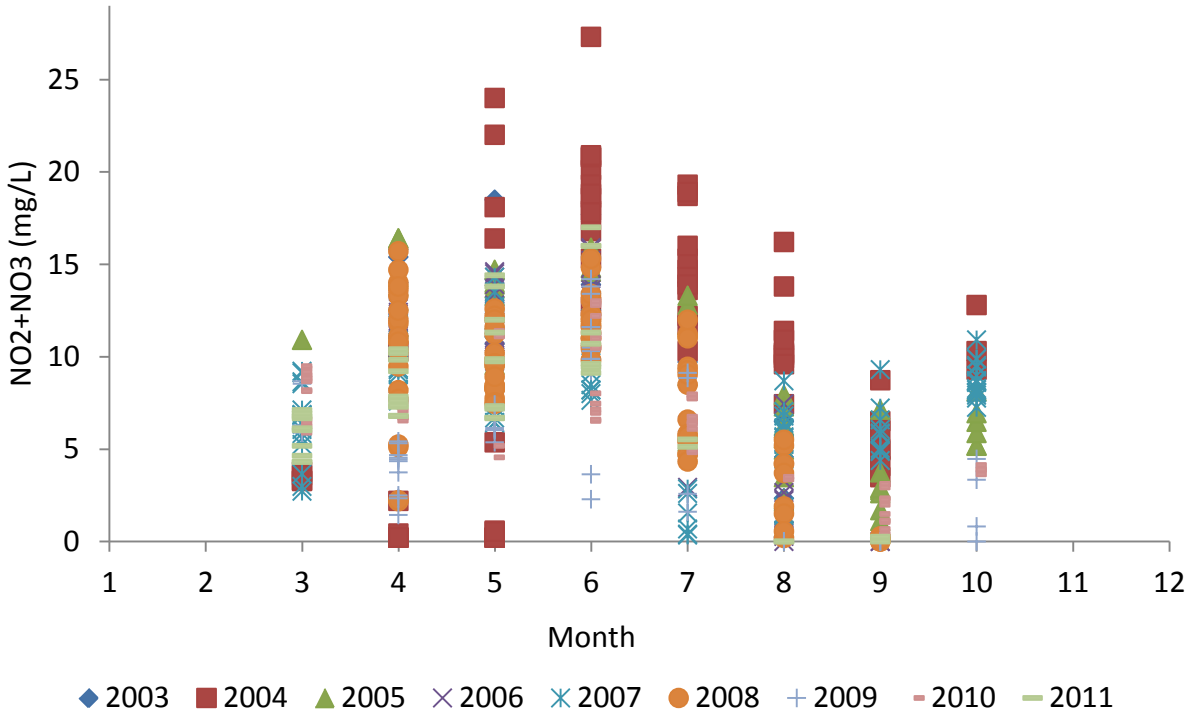

Figure 126. Nitrate-nitrite measurements for the Maple River (-534) by month

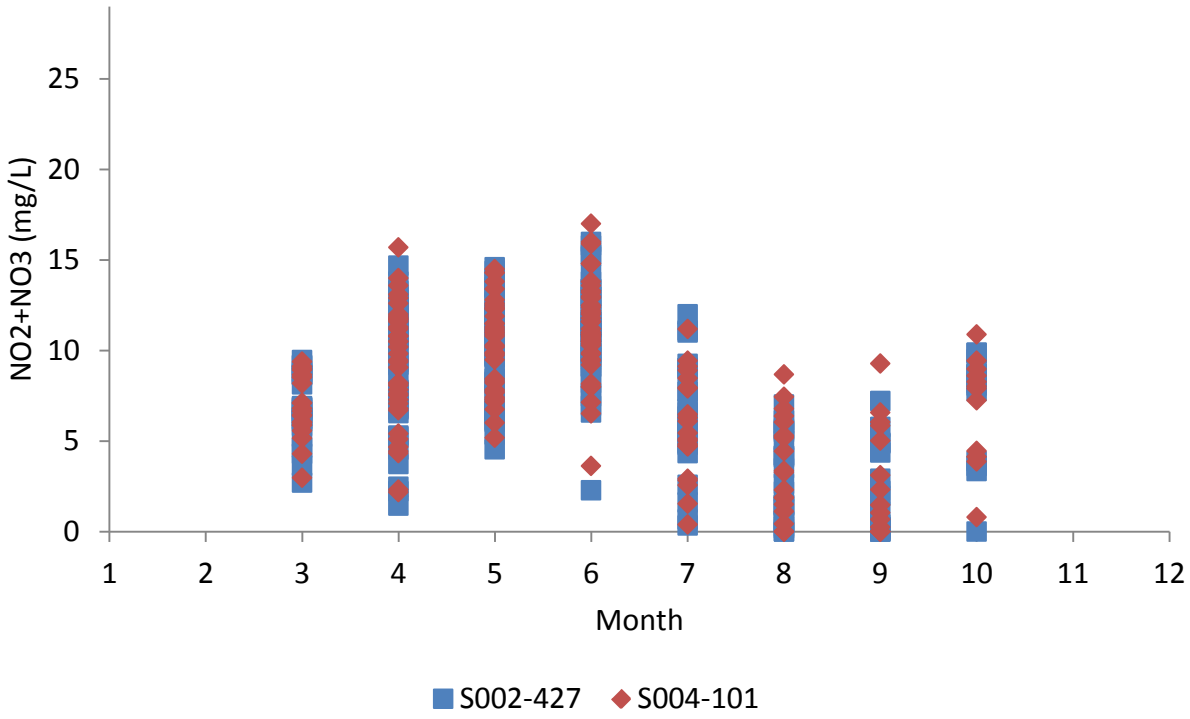

Figure 127. Nitrate-nitrite measurements for stations S002-427 and S004-101, from 2006 to 2011.

Station 08MN003 was dominated by Oligochaeta (49%) which are aquatic and terrestrial. At the time of fish surveying on July 30, 2008, nitrate was 5.7 mg/L. Invertebrates were sampled on August 20, 2008.

From seasonal trends, it is likely at the time of invertebrate sampling nitrate was lower than when sampled for fish. Since invertebrates synthesize environmental conditions throughout their life span, not only was the nitrate level important at the time of sampling but also prior to sampling. Utilizing data from Minnesota, Oligochaeta indicates they are fairly tolerant of high nitrate levels. Both station 08MN003 and station 08MN019 were comprised of tolerant individuals (greater than 93% at both stations). At station 08MN003 there was a low taxa count compared to the average for stations in the Minnesota River basin. There were above average caddisfly taxa counts compared to the Minnesota River basin, but expectations are greater for the higher gradient station 08MN003 which received a low metric score for the lack of caddisfly taxa (Trichoptera). The percentage of non-hydropsychid caddisflies decreases with increased nitrate values. The Maple River had 2.9% non-hydropsychid caddisflies at station 08MN019 and 7.5% at station 08MN003. There was a complete lack of intolerant taxa at both stations. The invertebrates considered nitrate tolerant comprised of 75.2% and 79.2% at stations 08MN003 and 08MN019, respectively. Station 08MN019 had one nitrate tolerant taxon present in 2008, with 3 individuals, comprising of less than 1% of the community. Due to the relationships between stressors, the some of the differences in the two stations may be explainable by other stressors.

The high level of nitrate coupled with the abundance of tolerant species makes it likely that nitrate is contributing in part to the degraded biological condition throughout the reach.

Candidate cause: High suspended sediment

This reach of the Maple River is listed as impaired for turbidity. Turbidity is elevated throughout many of the measurements from 2003 to 2011; with the mean turbidity for each of the years above the 25 NTU standard (Figure 128). Similarly, TSS is also elevated above the draft standard of 65 mg/L. HSPF model output (reach 819) shows that 26.3% of the total suspended sediment daily averages are greater than 65 mg/L, from 1996 to 2009.

By the samples collected at stations corresponding to biological stations 08MN019 and 08MN003, TSS was higher at the downstream station, 08MN003. The different TSS levels between the stations are, in part, reflected in the difference observed in the response of the invertebrate community. There was a particular difference in diversity, with 08MN003 having a lower diversity than 08MN019; 0.2654 and 0.1064 respectively (Simpson's Diversity Index). Station 08MN003 lacked Trichoptera which often decreases with increased turbidity (Table 50). The prevalence of tolerant invertebrates at both biological stations also relates to the high levels of suspended sediment throughout this reach.

The suspended sediment is a stressor to the invertebrate community in this reach. It corresponds to the differences observed in the biological response, with both the higher levels of sediment and lower invertebrate condition occurring at the downstream station.

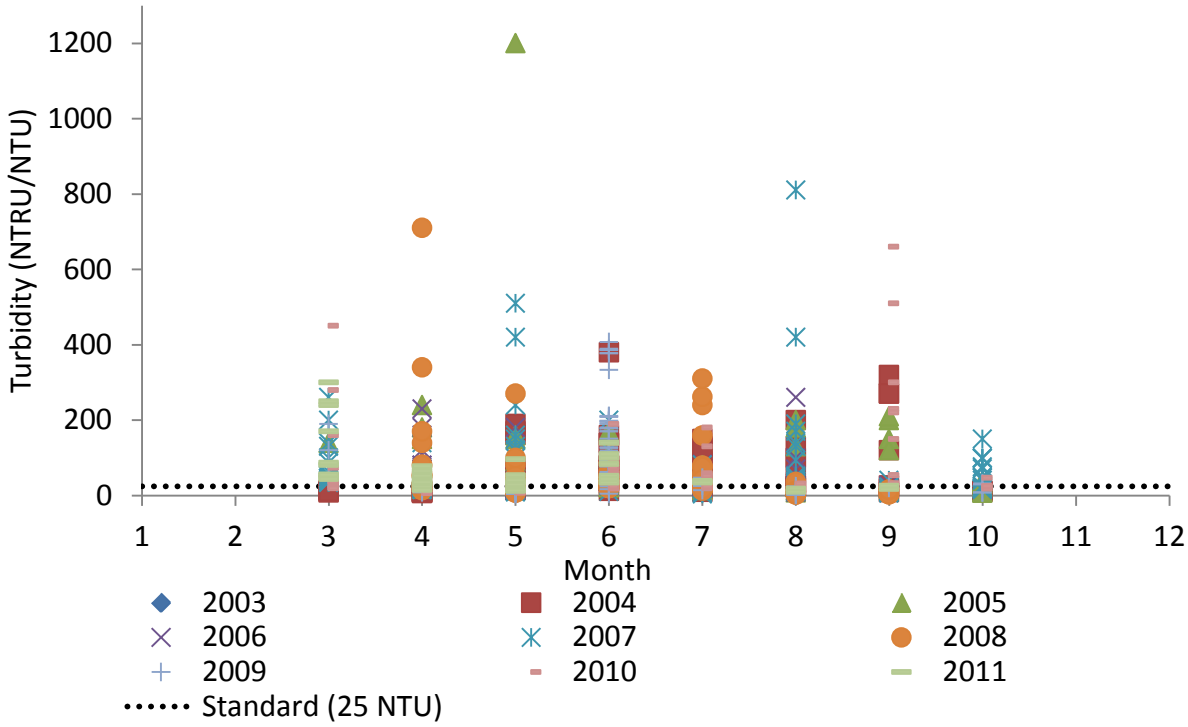

Figure 128. Turbidity measurements for the Maple River (-534) by month from 2003 to 2011

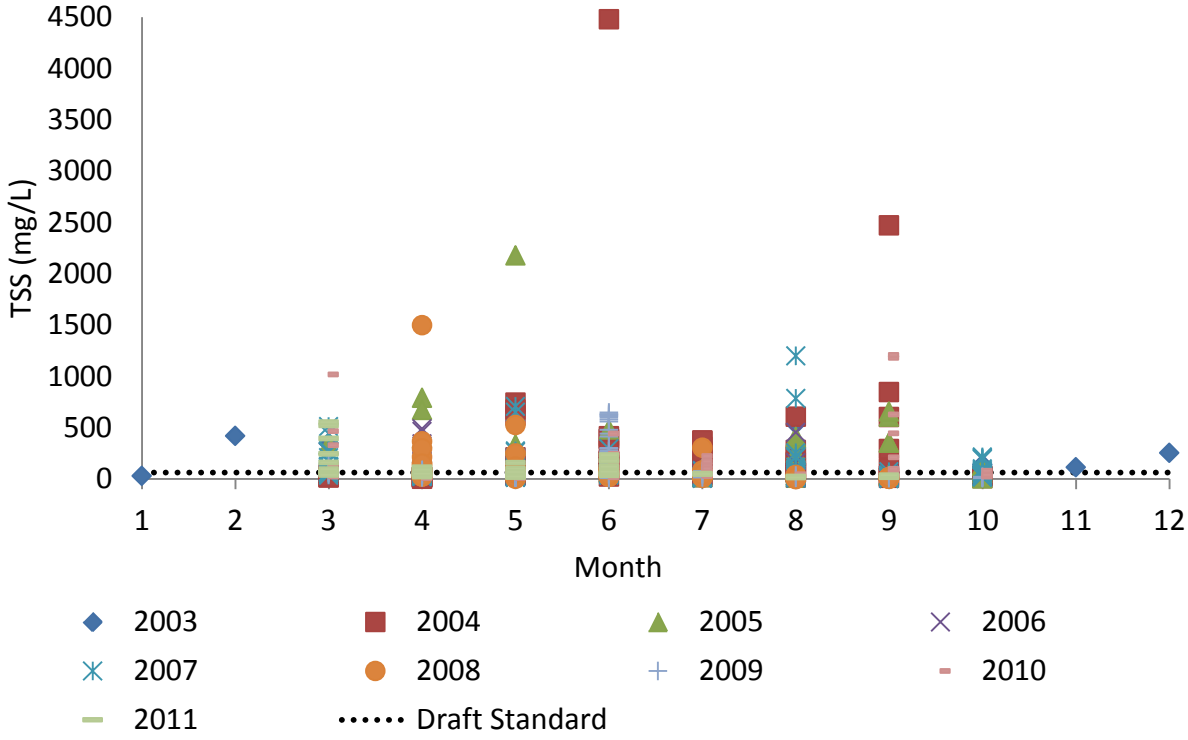

Figure 129. Total suspended solids measurements for the Maple River (-534) by month from 2003 to 2011

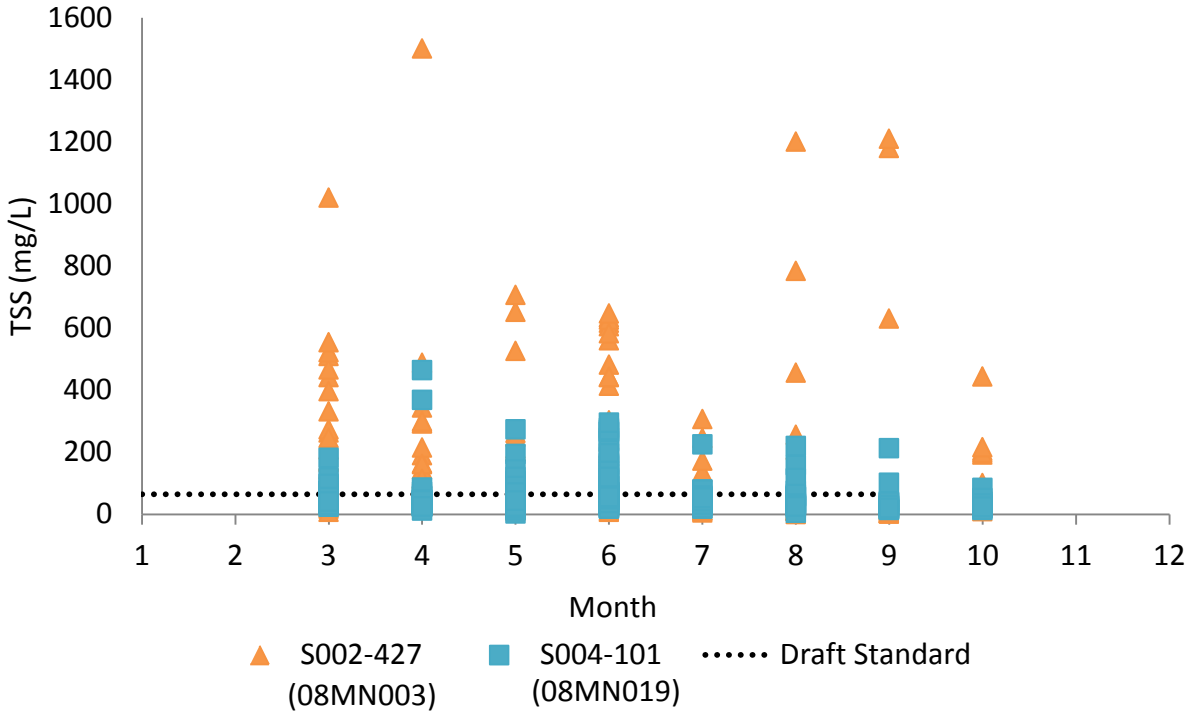

Figure 130. Total suspended solids measurements by month for stations S004-101 and S002-427, from 2006 to 2011

On May 21, 2012, MDNR staff assessed eroding banks from the CSAH 10 canoe landing to Ivy Road on the Maple River. Like much of the lower Maple River, this reach was still showing the effects of the 2010 flood event. This reach has shortened nearly 0.5 miles from what it was when LiDAR data were taken in 2005. These abandoned channels can be easily seen as active oxbows in the aerial photo in Figure 131. This reach consisted mostly of abandoned terraces with some bluff influence containing the lateral movements of the stream channel.

The crew assessed 20 banks in this 4.5 mile reach of stream. Together, these 20 banks contribute an estimated 3,293 tons of sediment and bedload annually, ranging from 31 to 791 tons per bank (Figure 132). On average, banks in this reach contribute 0.1485 tons of sediment per foot of stream.

Figure 133 shows LiDAR derived valley cross section, actual surveyed longitudinal profile and cross section. The yellow line on the aerial photo is the 1991 stream line to show how the reach has changed from 1991-2011.

Figure 131. Location of the BANCS assessment reaches with bank examples

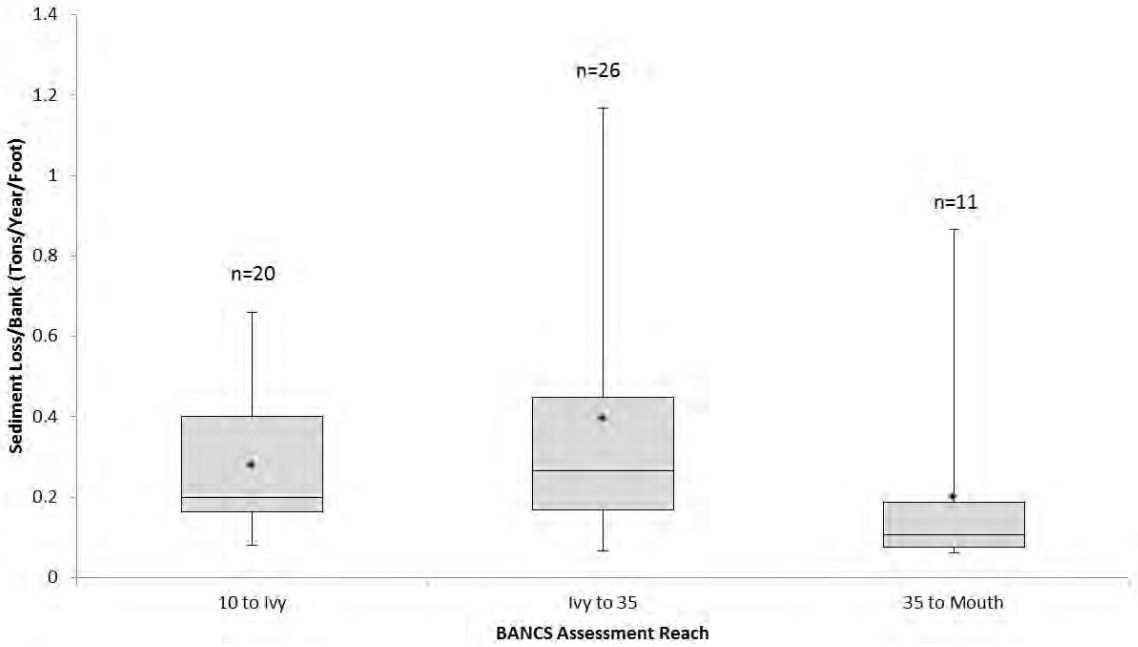

Figure 132. Boxplot showing the sediment loading of each bank per foot of bank in reaches of the Maple River assessed using the BANCS Model and Colorado estimate for bank erosion rates. Error bars show the minimum to maximum loading banks within the reach. The line in the middle of each box is the median value, while the black diamond signifies the average for each reach.

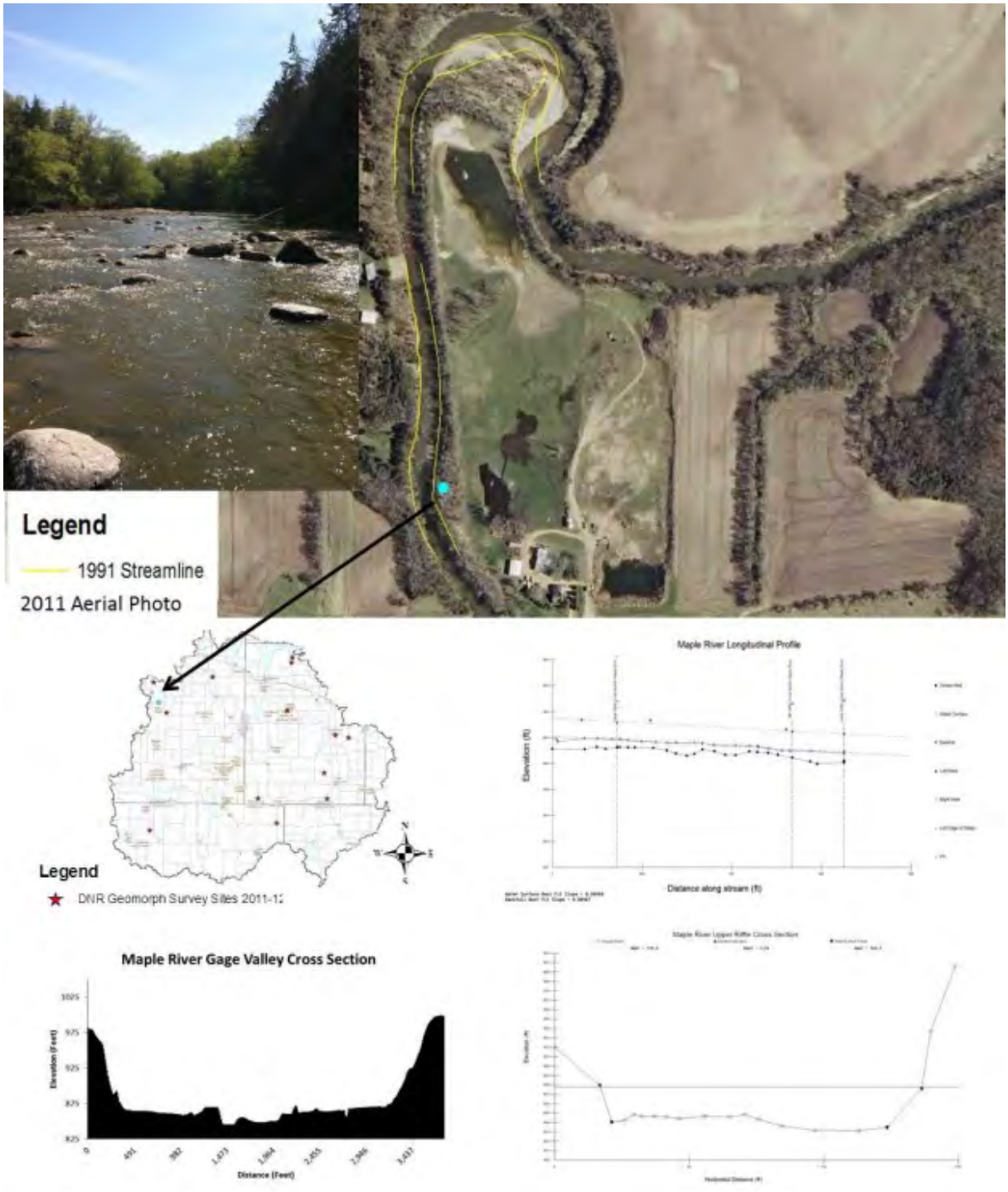

Figure 133. Location of Maple River Gage site with aerial photo, LiDAR derived valley cross section, actual surveyed longitudinal profile and cross section. The yellow line on the aerial photo is the 1991 stream line to show how the reach has changed from 1991-2011.

Candidate cause: Lack of habitat

The two biological stations were considerably different in terms of habitat. Station 08MN019 is further upstream with a lower gradient than station 08MN003, which is in a high gradient zone of the Maple River. Both stations scored relatively high on the MSHA. Station 08MN003 scored 77.3 and station

08MN019 scored 52.1 and 54 (visited twice in 2008). However, the invertebrate community was lacking in metrics that respond to habitat. There was only one taxa that climbs at station 08MN003, producing a metric score of 0 out of 10 for the IBI. There were sufficient taxa that cling at 08MN019. Both stations had an abundance of individuals that are tolerant, each approximately 93% of the sample.

The MDNR conducted a survey of this reach at the Maple River gage station, near station 08MN003. Bedrock outcrops were observed along the banks in this reach and the channel is somewhat entrenched and incised. Three riffle cross sections were taken, as indicated in the longitudinal profile. Two riffle cross sections classify the channel as F4/1 and one as a B4/1c. The channel in this study reach is classified as an F4/1 since flood prone elevations (i.e., 2X bankfull) are not getting out on the floodplain and there is a high width-depth ratio. The water surface slope is 0.001 between riffles, indicating the gradient is slightly steeper here than at other study sites in the watershed. We assessed 3 banks within this reach using the BEHI and NBS methods and estimated 0.0711 tons/year/foot of stream bank is eroding.

F channels are wide and shallow in nature, therefore providing less in-stream cover, poor fish habitat, low pool quality, and low diversity. These features typically result in higher water temperatures, mid-channel bars, and increased shear stress on both banks resulting in increased sediment loading. B channels are moderately entrenched and many are structurally controlled with materials derived from rock or from colluvial and/or alluvial deposition. B4 streams are typically stabile and not a high source of sediment. The width to depth ratio is lower in a B channel compared to an F. The study reach is located in valley type VIII (a), alluvial gulch fill. The Pfankuch rating for stream stability at this site was 81, which classifies as good for an F4 stream and moderate for a B4 stream.

Habitat is not likely the primary stressor for the invertebrate community in this reach of the Maple River, but it likely contributing to the degraded condition.

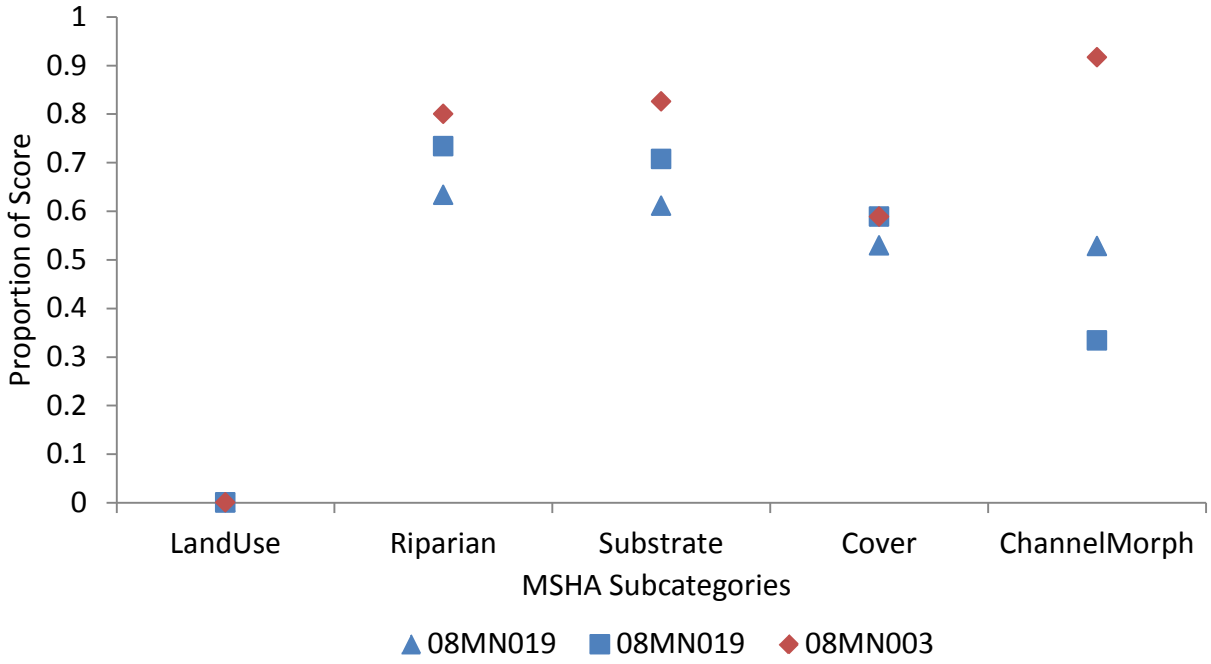

Figure 134. MPCA Stream Habitat Assessment subcategory proportion of scores for stations in the Maple River

Weight of evidence

The evidence for each potential stressor, the quantity and quality of each type of evidence was evaluated. The consistency and credibility of the evidence was evaluated. Each step for the Maple River (-534) was scored and summarized in Table 52. For more information on scoring please see EPA's CADDIS Summary Table of Scores.

Table 52. Weight of evidence table for potential stressors in the Maple River (-534)

Evidence using data from Maple River (-534)						
Types of Evidence	**Scores**					
	Dissolved Oxygen	**Phosphorus**	**Nitrate-Nitrite**	**Suspended Sediment**	**Physical Habitat**	**Altered Hydrology**
Spatial/temporal co-occurrence	0	0	+	+	+	+
Temporal sequence	0	+	+	+	+	++
Field evidence of stressor-response	-	0	+	++	0	0
Causal pathway	+	+	+	++	+	++
Evidence of exposure, biological mechanism	--	+	+	++	+	+
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE	NE
Verified or tested predictions	NE	NE	NE	NE	NE	NE
Symptoms	---	+	+	+	+	+
Evidence using data from other systems						
Mechanistically plausible cause	+	+	+	+	+	+
Stressor-response in other lab studies	++	NE	NE	NE	NE	NE
Stressor-response in other field studies	++	++	+	++	++	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NE
Multiple lines of evidence						
Consistency of evidence	-	+	+	+++	+	+
Explanatory power of evidence	-	0	++	++	++	++

Conclusions

The prominent stressor in this downstream reach of the Maple River is TSS/turbidity. Total Suspended Solids is different between the two stations where chemical and biological data was collected, and similarly the biological data shows correlation with observed TSS values. Both stations are impacted by elevated concentrations of TSS, but the downstream station 08MN003, is more impacted than the upstream station.

Lack of habitat is also an evident stressor. There were an abundance of tolerant invertebrates and a lack of climbers at station 08MN003. Near station 08MN003 the stream was classified as an F stream type with a lack of access to the floodplain under two times bankfull flows. In the Maple that relates to a lack of in-stream cover and refuge, along with a disconnected floodplain. Altered hydrology is a driver for both the elevated TSS and lack of habitat. The increase in annual average flows throughout this watershed, have led to tolerant invertebrates at both stations, but a decrease in long lived invertebrates at the downstream station 08MN003. The changes in the flow regime have led to less habitat availability due to the stream instability.

Nitrate-nitrite has been measured as high as 27.3 mg/L. There is an abundance of tolerance invertebrates including Oligochaeta. They comprised 49% of the sample at station 08MN003. Nitrate is a stressor to the biological communities within this reach of the Maple River. The phosphorus with a maximum of 2.34 mg/L in the reach is a stressor to the biological community in this reach of the Maple River. Phosphorus is not a clear as a stressor as other stressors, lacking in the explanatory power of the evidence. There is a lack of DO data but the biological communities do not lead to believe that low DO is a stressor at this time. Phosphorus, nitrate, TSS/turbidity, lack of habitat, and altered hydrology are all stressors to the biological community.

Conclusions and General Recommendations

In the Le Sueur River watershed, lack of habitat and altered hydrology are stressors throughout many of the stream and river reaches that are impaired for biology. Elevated turbidity and TSS are common as well. Elevated levels of phosphorus and nitrate are stressors in many of the larger rivers, but additional data needs to be collected in some of the smaller systems. Low DO is problematic in the Little Cobb River and in Rice Creek. Both of these systems appear to be experiencing low DO under low flow conditions. Physical barriers exist on CD 6 that does not allow for the migration of fish species through Lake Elysian to Iosco Creek. Table 53 shows the stressors to the biology by AUID.

Additional data collection efforts should be focused on upstream reaches where there is not a wealth of data and many indicators of issues exist. In addition, monitoring at the lake outlets would also provide needed information to assist source information of elevated nutrient concentrations and loads. Additional diurnal DO data would refine the relationships where there are low DO issues, and early morning DO should be collected in many of the small tributaries to the Le Sueur River under a variety of flow conditions.

Reductions of sensitive species and abundance of tolerant species are one of the attributes of too much nutrients. Nitrate, much from drain tile, should be reduced along with reductions in phosphorus. They are vital to have but are way too abundant in many locations in the watershed.

Much of this watershed would benefit from extending water holding time to maintain a biologically adequate baseflow and reduce the export of water from the watershed. Additionally, connections to floodplains should be maintained in areas that it is present, but those areas where there is not a connection to a flood plain, measures should be taken to move closer to stream stability where there is balance in flows and balance in sediment transport.

Lack of habitat should be dealt with on a station to station basis as it is variable throughout the watershed. In general, much of the lack of habitat is due to lack of stream stability, lack of riparian vegetation/buffers, and excess embeddedness.

Table 53. Primary stressors to the biological community by impaired reach; Yes = stressor present; No = stressor is not present; 0 = unable to conclude regarding stressor; * = limited data available; if limited data available but yes or no is present means limited evidence suggests yes or no

Reach	Reach Name	Biotic Impairments	Stressors to the biological community						
			Dissolved Oxygen	Phosphorus	Nitrate	Turbidity/ TSS	Habitat	Altered Hydrology	Connectivity
07020011-573	Little Le Sueur River	Fish	0*	0*	0*	No*	Yes	Yes	NA
07020011-609	County Ditch 15-2	Fish & Invertebrates	0*	0*	Yes*	0*	Yes	Yes	NA
07020011-558	County Ditch 12	Fish & Invertebrates	0*	0*	Yes*	No*	Yes	Yes	NA
07020011-608	County Ditch 19	Fish & Invertebrates	0*	0*	0*	No*	Yes	Yes	NA
07020011-576	Iosco Creek	Fish & Invertebrates	0*	0*	Yes*	No*	Yes	Yes	NA
07020011-522	County Ditch 6	Invertebrates	No*	Yes*	No*	0*	Yes	Yes	Yes
07020011-510	Unnamed Creek	Invertebrates	0*	Yes*	0*	0*	Yes	Yes	NA
07020011-619	Le Sueur River	Fish	No	0*	Yes*	Yes	No	Yes	NA
07020011-507	Le Sueur River	Fish	No	Yes	Yes	Yes	Yes	Yes	NA
07020011-501	Le Sueur River	Fish	No	Yes	Yes	Yes	Yes	Yes	NA
07020011-504	Little Cobb River	Fish	Yes	Yes	Yes	Yes	Yes	Yes	NA
07020011-568	Cobb River	Fish & Invertebrates	No*	0*	Yes*	Yes	Yes	Yes	NA
07020011-556	Cobb River	Fish & Invertebrates	No	Yes	Yes	Yes	Yes	Yes	NA
07020011-531	Rice Creek	Fish & Invertebrates	Yes	Yes	Yes	Yes	Yes	Yes	NA
07020011-535	Maple River	Fish & Invertebrates	No*	0*	0*	Yes – fish No – invert.	Yes	Yes	NA
07020011-534	Maple River	Invertebrates	No*	Yes	Yes	Yes	Yes	Yes	NA

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Appendix A. Water monitoring stations in the Le Sueur River Watershed with nearby biological stations

Station ID	Station Name	Latitude	Longitude	Nearby Biological FieldNum
S000-340	LESUEUR R MN-66 1.5 MI NE OF RAPIDAN	44.117306	-94.049667	08MN001
S003-574	LITTLE COBB NEAR CSAH-16, 6.3 MI W OF PEMBERTON, MN	43.996667	-93.908333	96MN007
S006-591	LITTLE COBB RIVER AT 559TH AVE., 5.3 MI W OF PEMBERTON, MN	44.003116	-93.888376	
S006-592	LITTLE COBB RIVER AT CR-169, 3.8 MI W OF PEMBERTON, MN	44.014982	-93.858661	08MN070
S006-593	LITTLE COBB RIVER AT CSAH-14, 2.3 MI W OF PEMBERTON, MN	43.999803	-93.828594	
S006-594	LITTLE COBB RIVER AT CR-168, 1.4 MI SW OF PEMBERTON, MN	43.994974	-93.803481	
S007-299	COBB RIVER 1.5 MI W OF BEAUFORD, MN	44.007025	-93.967201	04MN005
S001-282	COBB R AT CONFL WITH LESUEUR R	44.0775	-94.000806	
S003-859	LE SUEUR R AT CSAH-16, 5 MI S OF MANKATO, MN	44.080583	-94.008593	08MN036
S003-860	LE SUEUR R AT CSAH-8, 5.1 MI SSE OF MANKATO, MN	44.084737	-93.988737	08MN035
S005-317	LESUEUR R AT CSAH-22, 5.5 MI SE OF MANKATO, MN	44.090987	-93.954335	
S003-810	LE SUEUR R W OF TWP HWY 169, 4 MI SE OF MANKATO, MN	44.097706	-93.948621	
S003-447	LE SUEUR R AT CSAH-90, 3 MI SE OF MANKATO, MN	44.109528	-93.944687	
S005-318	LESUEUR R AT CSAH-41, 4.5 MI SE OF MANKATO, MN	44.120491	-93.927365	
S005-310	LESUEUR R AT MN-83, 2.1 MI S OF EAGLE LAKE, MN	44.134379	-93.882196	
S001-409	LESUEUR R AT HANGING BRG IN WILDWOOD PK 2.75MI N OF ST.CLAIR	44.1235	-93.865694	03MN071
S003-448	LE SUEUR R AT CSAH 28 IN SAINT CLAIR, MN	44.083	-93.854978	
S003-449	LE SUEUR R AT SCHALOW ST CULVERT IN SAINT CLAIR, MN	44.082422	-93.852894	
S000-653	LESUEUR R AT CSAH-15 0.5 MI E OF ST CLAIR	44.08	-93.838611	
S000-654	CD#6 AT CSAH-14 BTN S13/18 4 MI SW OF JANESVILLE	44.07425	-93.768333	07MN068

Station ID	Station Name	Latitude	Longitude	Nearby Biological FieldNum
S002-431	RICE CK AT CR-151 0.9 MI SE OF STERLING CENTER, MN	43.898794	-94.062158	08MN004
S006-596	RICE CREEK AT 113TH ST., 1.6 MI SE OF STERLING CENTER, MN	43.884327	-94.067174	
S006-597	RICE CREEK AT 555TH AVE., 2.5 MI SE OF STERLING CENTER, MN	43.872875	-94.058089	03MN067
S005-466	RICE CK AT CSAH-1 (555TH AVE), 7 MI SW OF MAPLETON	43.860675	-94.058305	08MN086
Station ID	Station Name	Latitude	Longitude	Nearby Biological FieldNum
S006-598	RICE CREEK AT CSAH-15, 4 MI S OF STERLING CENTER, MN	43.848012	-94.078868	
S006-175	RICE CK AT CSAH-18, 6 MI NE OF WINNEBAGO	43.81123	-94.06046	08MN076
S006-599	RICE CREEK AT 210TH ST., 2.1 MI NW OF DELAVAN, MN	43.789372	-94.048761	
S006-601	RICE CREEK AT 200TH ST., 1.6 MI W OF DELAVAN, MN	43.774885	-94.049372	
S006-365	RICE CREEK AT MINNESOTA STATE HIGHWAY 109/190TH STREET (BETWEEN COUNTY STATE AID HIGHWAY 11 AND 420TH AVENUE), 1.2 MILES SOUTHWEST OF DELVAN, MINNESOTA.	43.760518	-94.040003	08MN010
S004-343	MAPLE R AT CONF. WITH LE SUEUR R, 5.5 MI S OF MANKATO, MN	44.087148	-94.015191	
S002-434	MAPLE R OFF OF TOWNSHIP RD-146 5 MI S OF MANKATO, MN	44.082964	-94.023241	
S002-427	MAPLE R AT CSAH 35 5.2 MI S OF MANKATO, MN	44.065221	-94.02602	08MN003
S002-435	MAPLE R AT TOWNSHIP RD-96, 2 MI NE OF GOOD THUNDER, MN	44.0261	-94.041249	
S002-547	MAPLE R OFF TOWNSHIP RD 365, 1.25 MI NE OF GOOD THUNDER, MN	44.015272	-94.043842	
S002-436	MAPLE R 0.2 MI N OF CSAH-10, 0.5 MI E OF GOOD THUNDER, MN	44.006855	-94.056444	
S004-304	MAPLE R AT CSAH-10 BRG, 0.5 MI E OF GOOD THUNDER	44.0032	-94.0566	
S002-430	MAPLE R .2 MI SW OF TOWNSHIP RD 531 .9 MI SE OF GOOD THUNDER	43.992906	-94.062312	
S004-101	MAPLE R AT CSAH-18, 2 MILES NORTH OF STERLING CENTER	43.935091	-94.070865	08MN019
S002-433	MAPLE R AT TOWNSHIP RD-367 1 MI E OF STERLING CENTER MN	43.906699	-94.053545	
S005-305	MAPLE R AT MN-30, 7 MI S OF GOOD THUNDER, MN	43.907438	-94.041094	08MN024

Station ID	Station Name	Latitude	Longitude	Nearby Biological FieldNum
S005-311	MAPLE R AT CSAH-7, 3.5 MI S OF MAPLETON, MN	43.876276	-93.960471	
S005-312	MAPLE R AT CSAH-46, 5.5 MI SSE OF MAPLETON, MN	43.848211	-93.938873	08MN023
S003-446	COBB R AT CSAH-16, 4.4 MI NE OF GOOD THUNDER, MN	44.047138	-94.000504	08MN005
S000-660	CD#12 AT CSAH-9 BTN S22/27 3.5 MI SW OF WASECA	44.05125	-93.5805	08MN020
S005-313	UNN STR 0.1 MI N OF CR-164, 4 MI NE OF MAPLETON, MN	43.958535	-93.886669	
S006-183	COBB R (BIG) AT 108TH ST, 1 3/4 MI N OF MINNESOTA LAKE	43.86975	-93.82552	08MN071
S004-300	COBB R (AKA BIG COBB R) AT CSAH-3 BRG 5 MI NE MINNESOTA LAKE	43.8615	-93.7276	
S002-472	COBB R AT 250TH STREET, 6.8 MI E OF MN LK, MN	43.847849	-93.693456	08MN017
S006-326	LITTLE LE SUEUR RIVER AT COUNTY STATE AID HIGHWAY 4 / 180TH STREET, 2 MILES NORTHWEST OF LEMOND, MINNESOTA.	43.99493	-93.40656	
Station ID	Station Name	Latitude	Longitude	Nearby Biological FieldNum
S006-583	COUNTY DITCH 15-2 AT CSAH-4, 0.9 MI E OF WILTON, MN	44.018101	-93.516769	08MN051
S003-900	LE SUEUR R AT 128TH ST 3.6 MI N OF NEW RICHLAND, MN	43.949494	-93.511669	08MN029
S006-587	LE SUEUR RIVER AT CR-56, 1.0 MI SE OF VISTA, MN	43.945297	-93.456506	10MN161
S006-329	LE SUEUR RIVER ON 260TH AVENUE, .5 MILE WEST OF 170TH STREET, 2 MILES SOUTHEAST OF VISTA, MINNESOTA.	43.93523	-93.43713	08MN055
S006-588	LE SUEUR RIVER AT CSAH-8, 2.3 MI ENE OF NEW RICHLAND, MN	43.906121	-93.450553	
S006-589	LE SUEUR RIVER AT MN-30, 3.2 MI E OF NEW RICHLAND, MN	43.891556	-93.429859	
S006-330	LE SUEUR RIVER AT 220TH AVENUE, BETWEEN MINNESOTA STATE HIGHWAY 30 AND 170TH STREET, 4 MILES SOUTHEAST OF NEW RICHLAND, MINNESOTA.	43.87709	-93.420124	
S005-319	LESUEUR R AT CR-172, 3.7 MI NNW OF PEMBERTON, MN	44.06168	-93.798383	
S005-306	LESUEUR R AT CSAH-14, 2 MI NE OF PEMBERTON, MN	44.037222	-93.768296	08MN048
S000-655	LESUEUR R AT CR-54 5.5 MI S OF JANESVILLE	44.035278	-93.731667	
S000-656	LESUEUR R AT CSAH-3 6 MI S OF JANESVILLE	44.027333	-93.697472	

Station ID	Station Name	Latitude	Longitude	Nearby Biological FieldNum
S000-657	LESUEUR R AT CSAH-33 6 MI S OF JANESVILLE	44.033417	-93.667278	
S000-658	LESUEUR R AT ROAD BTN S31/32 6 MI SW OF WASECA	44.031667	-93.627194	
S000-295	LE SUEUR RIVER CSAH-9 BY WASECA	44.02225	-93.604417	
S000-659	LESUEUR R AT CSAH-29 BTN S4/33 5 MI SW OF WASECA	44.022083	-93.596889	
S000-662	LESUEUR R AT ROAD BTN S34/35 4 MI SW OF WASECA	44.035417	-93.567111	
S006-584	LE SUEUR R AT CSAH-4, 0.4 MI E OF WILTON, MN	44.014178	-93.525617	08MN052
S006-324	LE SUEUR RIVER AT 120TH STREET, 1 MILE WEST OF OTISCO, MINNESOTA.	43.982358	-93.526627	08MN053
S006-585	LE SUEUR RIVER AT CSAH-20, 2.2 MI WSW OF OTISCO, MN	43.964197	-93.541055	10MN160
S006-586	LE SUEUR RIVER AT 120TH AVE., 2.8 MI SW OF OTISCO, MN	43.942468	-93.526516	

Appendix B. Summarized landcover data from 2009 NASS Landcover Profile for select watersheds encompassing biotic impairments

	573 - Little Le Sueur River		609 - County Ditch 15-2		558 - County Ditch 12		608 - County Ditch 19	
Land Cover	**Acres**	**Percent (%)**	**Acres**	**Percent (%)**	**Acres**	**Percent (%)**	**Acres**	**Percent (%)**
Cropland	10185	65.8	2313	64.5	10585	75.2	3334	82.5
Water	21	0.1	12	0.3	26	0.2	2	0.0
Grassland	3215	20.8	466	13.0	1355	9.6	213	5.3
Forestland	551	3.6	57	1.6	180	1.3	77	1.9
Developed	1151	7.4	625	17.4	1631	11.6	275	6.8
Wetland	361	2.3	113	3.2	289	2.1	138	3.4
NoData/Barren	7	0.0	0	0.0	1	0.0	0	0.0
Total	15491	100.0	3587	100.0	14068	100.0	4040	100.0

	576 - Iosco Creek		522 - County Ditch 6		510 - Unnamed Creek	
Land Cover	**Acres**	**Percent (%)**	**Acres**	**Percent (%)**	**Acres**	**Percent (%)**
Cropland	9563	70.2	34536	63.4	14598	54.4
Water	33	0.2	3300	6.1	2794	10.4
Grassland	1761	12.9	7153	13.1	3258	12.1
Forestland	640	4.7	2110	3.9	1086	4.0
Developed	1128	8.3	4801	8.8	3036	11.3
Wetland	487	3.6	2583	4.7	2043	7.6
NoData/Barren	4	0.0	22	0.0	3	0.0
Total	13615	100.0	54505	100.0	26819	100.0
	619 - Le Sueur River		**507 - Le Sueur River**		**501 - Le Sueur River**	

Land Cover	Acres	Percent (%)	Acres	Percent (%)	Acres	Percent (%)
Cropland	43101	78.1	202338	70.8	535910	75.4
Water	238	0.4	6746	2.4	14808	2.1
Grassland	5451	9.9	30575	10.7	57190	8.0
Forestland	1364	2.5	9629	3.4	19175	2.7
Developed	4377	7.9	25942	9.1	59022	8.3
Wetland	641	1.2	10517	3.7	24847	3.5
NoData/Barren	2	0.0	44	0.0	112	0.0
Total	55173	100.0	285792	100.0	711063	100.0

	504 - Little Cobb River		568 - Upper Cobb River		556 - Lower Cobb River	
Land Cover	Acres	Percent (%)	Acres	Percent (%)	Acres	Percent (%)
Cropland	66483	79.6	72655	78.3	154781	78.1
Water	1019	1.2	2518	2.7	3560	1.8
Grassland	5978	7.2	5589	6.0	13614	6.9
Forestland	1103	1.3	1495	1.6	3954	2.0
Developed	6187	7.4	7640	8.2	15265	7.7
Wetland	2789	3.3	2831	3.1	7059	3.6
NoData/Barren	3	0.0	9	0.0	13	0.0
Total	83563	100.0	92737	100.0	198246	100.0

	531 - Rice Creek		531 - Rice Creek		531 - Rice Creek	
Land Cover	Acres	Percent (%)	Acres	Percent (%)	Acres	Percent (%)
Cropland	40685	77.8	103941	82.8	174893	79.9
Water	2239	4.3	1978	1.6	4336	2.0

	531 - Rice Creek		531 - Rice Creek		531 - Rice Creek	
Land Cover	**Acres**	**Percent (%)**	**Acres**	**Percent (%)**	**Acres**	**Percent (%)**
Grassland	2763	5.3	5474	4.4	11681	5.3
Forestland	964	1.8	1375	1.1	4343	2.0
Developed	3441	6.6	10410	8.3	16945	7.7
Wetland	2167	4.1	2412	1.9	6617	3.0
NoData/Barren	4	0.0	3	0.0	29	0.0
Total	52262	100.0	125593	100.0	218845	100.0

Appendix C. Invertebrate IBI and metric fact sheets applicable to the Le Sueur River watershed

Invertebrate Class 2 - Prairie Forest Rivers

Classification Criteria:

Sites in Minnesota that are representative of the Eastern Broadleaf forest, Prairie Parklands, and Tall Aspen Parklands ecological provinces. Sites included in this class have watershed areas that exceed 500 square miles.

Examples:

Blue Earth River, Bois de Sioux River, Buffalo River, Cannon River, Cedar River, Chippewa River, Crow River, Des Moines River, Minnesota River, Mississippi River, Ottertail River, Pomme de Terre River, Red Lake River, Red River, Redwood River, Root River, Roseau River, Sauk River, St. Croix River, Two Rivers, Wild Rice River, and Zumbro River.

Biocriteria:

Upper C.L. 41.5
Threshold 30.7
Lower C.L. 19.9

Metric Name	Category	Response	Metric Description
DomFiveCHPct	Composition	Increase	Relative abundance (%) of dominant five taxa in subsample (Chironomid genera treated individually)
HBI_MN	Tolerance	Increase	A measure of pollution based on tolerance values assigned to each individual taxon, developed by Chirhart
Intolerant2lessCh	Tolerance	Decrease	Taxa richness of macroinvertebrates with tolerance values less than or equal to 4, using MN TVs
Odonata	Richness	Decrease	Taxa richness of Odonata
PredatorCh	Trophic	Decrease	Taxa richness of predators
TaxaCountAllChir	Richness	Decrease	Total taxa richness of macroinvertebrates
TrichwoHydroPct	Composition	Decrease	Relative abundance (%) of non-hydropsychid Trichoptera individuals in subsample
VeryTolerant2Pct	Tolerance	Increase	Relative abundance (%) of macroinvertebrate individuals in subsample with tolerance values equal to or greater than 8; metric uses tolerance values developed for the HBI_MN metric

Invertebrate Class 5 – Southern Streams (Riffle/Run Habitats)

Classification Criteria:

Sites within this class are representative of the Eastern Broadleaf forest, Prairie Parklands, and Tall Aspen Parklands ecological provinces, as well as streams in Hydrological Simulation Program – FORTAN (HUC) 07030005. Sites included in this class have watershed areas less than 500 square miles.

Examples:

Ashley Creek, Beaver Creek, Cedar River, Chippewa River, Clearwater River, Cobb River, Deer Creek, Elk River, , Le Sueur River, Okabena Creek, Otter Creek, Pomme de Terre River, Redwood River, Rice Creek, Rock River, Root River, Wells Creek, Yellow Medicine River, and Zumbro River.

Biocriteria:

Upper C.L.	48.5
Threshold	**35.9**
Lower C.L.	23.3

Metric Name	Category	Response	Metric Description
ClimberCh	Habitat	Decrease	Taxa richness of climbers
ClingerChTxPct	Habitat	Decrease	Relative percentage of taxa adapted to cling to substrate in swift flowing water
DomFiveChPct	Composition	Increase	Relative abundance (%) of dominant five taxa in subsample (chironomid genera treated individually)
HBI_MN	Tolerance	Increase	A measure of pollution based on tolerance values assigned to each individual taxon, developed by Chirhart
InsectTxPct	Composition	Decrease	Relative percentage of insect taxa
Odonata	Richness	Decrease	Taxa richness of Odonata
Plecopotera	Richness	Decrease	Taxa richness of plecoptera
PredatorCh	Trophic	Decrease	Taxa richness of predators
Tolerant2ChTxPct	Tolerance	Increase	Relative percentage of taxa with tolerance values equal to or greater than 6, using MN TVs
Trichoptera	Richness	Decrease	Taxa richness of Trichoptera

Invertebrate Class 6 – Southern Forest Streams (Glide/Pool Habitats)

Classification Criteria:

Sites within this class have watershed characteristics representative of Eastern broadleaf forest ecological province, as well as streams in HUC 07030005. Sites included in this class have watershed areas less than 500 square miles.

Examples:

Battle Creek, Cedar River, Deer Creek, Elk River, Goose Creek, Le Sueur River, Little Cedar River (Middle Fork), Long Prairie River, Mill Creek, Money Creek, Otter Creek, Pine Creek, Rice Creek, Riceford Creek, Root River, Rush Creek, Shell Rock River, Sucker Creek, Sunrise River, and Wells Creek.

Biocriteria:

Upper C.L.	60.4
Threshold	**46.8**
Lower C.L.	33.2

Metric Name	Category	Response	Metric Description
ClingerCh	Habitat	Decrease	Taxa richness of clinger taxa
Collector-filtererPct	Trophic	Decrease	Relative abundance (%) of collector-filterer individuals in a subsample
DomFiveChPct	Composition	Increase	Relative abundance (%) of dominant five taxa in subsample (chironomid genera treated individually)
HBI_MN	Tolerance	Increase	A measure of pollution based on tolerance values assigned to each individual taxon, developed by Chirhart
Intolerant2Ch	Tolerance	Decrease	Taxa richness of macroinvertebrates with tolerance values less than or equal to 2, using MN TVs
POET	Richness	Decrease	Taxa richness of Plecoptera, Odonata, Ephemeroptera, & Trichoptera (baetid taxa treated as one taxon)
PredatorCh	Trophic	Decrease	Taxa richness of predators
TaxaCountAllChir	Richness	Decrease	Total taxa richness of macroinvertebrates
TrichopteraChTxPct	Composition	Decrease	Relative percentage of taxa belonging to Trichoptera
TrichwoHydroPct	Composition	Decrease	Relative abundance (%) of non-hydropsychid Trichoptera individuals in subsample

Invertebrate Class 7 – Prairie Streams (Glide/Pool Habitats)

Classification Criteria:

Sites in Minnesota that are representative of the Prairie Parklands and Tall Aspen Parklands ecological provinces. Sites included in this class have watershed areas less than 500 square miles.

Examples:

Ashley Creek, Beaver Creek, Buffalo River, Crow River, Maple River, Marsh Creek, Middle River, Mud Creek, Pomme de Terre River, Rice Creek, Shakopee Creek, Snake River, Tamarac River, Two Rivers, Whiskey Creek, Wild Rice River (South Branch), and Yellow Medicine River.

Biocriteria:

Upper C.L. 51.9
Threshold 38.3
Lower C.L. 24.7

Metric Name	Category	Response	Metric Description
ClingerCh	Habitat	Decrease	Taxa richness of clinger taxa
Collector-filtererPct	Trophic	Decrease	Relative abundance (%) of collector-filterer individuals in a subsample
DomFiveChPct	Composition	Increase	Relative abundance (%) of dominant five taxa in subsample (chironomid genera treated individually)
HBI_MN	Tolerance	Increase	A measure of pollution based on tolerance values assigned to each individual taxon, developed by Chirhart
Intolerant2Ch	Tolerance	Decrease	Taxa richness of macroinvertebrates with tolerance values less than or equal to 2, using MN TVs
POET	Richness	Decrease	Taxa richness of Plecoptera, Odonata, Ephemeroptera, & Trichoptera (baetid taxa treated as one taxon)
PredatorCh	Trophic	Decrease	Taxa richness of predators
TaxaCountAllChir	Richness	Decrease	Total taxa richness of macroinvertebrates
TrichopteraChTxPct	Composition	Decrease	Relative percentage of taxa belonging to Trichoptera
TrichwoHydroPct	Composition	Decrease	Relative abundance (%) of non-hydropsychid Trichoptera individuals in subsample

Appendix D. Fish IBI and metric fact sheets applicable to the Le Sueur River watershed

Fish Class 1 – Southern Rivers

Classification Criteria:

Large warm/coolwater rivers in southern MN and the western portion of the Red River Basin

Sites in southern Minnesota and the Glacial Lake Agassiz Basin (GLAB) ecoregion, where watershed area exceeds 300 square miles.

Examples:
Red River of the North, Minnesota River, St. Croix River (below Taylors Falls), Red Lake River (within GLAB), Blue Earth River, Chippewa River, Otter Tail River (within GLAB), Zumbro River

Exclusions:
Mississippi River (below St. Anthony Falls), Minnesota River (above Laq qui Parle confluence)

Biocriteria:		**Low-End Scoring**
Upper CL:	57	<25 individuals (IndPct metrics = 0)
Impairment threshold:	**46**	<6 taxa (TX and TXPct metrics = 0)
Lower CL:	35	

MetricName	Category	Response	Metric_Desc_tech
DetNWQTXPct	trophic	negative	Relative abundance (%) of taxa that are detritivorous
GeneralPct	trophic	negative	Relative abundance (%) of individuals that are generalist feeders
Insect-TolPct	trophic	positive	Relative abundance (%) of individuals that are insectivore species (excludes tolerant species)
Piscivore	trophic	positive	Taxa richness of piscivorous species
SLvdPct	life history	negative	Relative abundance (%) of individuals that are short-lived
SSpnTXPct	reproductive	negative	Relative abundance (%) of taxa that are serial spawners (multiple times per year)
TolPct	tolerance	negative	Relative abundance (%) of individuals that are tolerant
VtolTXPct	tolerance	negative	Relative abundance (%) of taxa that are very tolerant
SensitiveTXPct	tolerance	positive	Relative abundance (%) of taxa that are sensitive (scoring adjusted for gradient)
SLithop	reproductive	positive	Taxa richness of simple lithophilic spawning species (scoring adjusted for gradient)
DomTwoPct	dominance	negative	Combined relative abundance of two most abundant taxa
FishDELTPct	tolerance	negative	Relative abundance (%) of individuals with Deformities, Eroded fins, Lesions, or Tumors

Fish Class 2 – Southern Streams

Classification Criteria:

Large warm/coolwater streams and small rivers in southern MN and the far-western portion of the Red River Basin

Sites in southern Minnesota and the Glacial Lake Agassiz Basin (GLAB) ecoregion, where watershed area exceeds 30 square miles but is less than 300 square miles.

Examples:
Cobb River, Tamarac River, Sleepy Eye Creek, Middle River, Rock River, Hawk Creek, Minnehaha Creek, Shell Rock River

Biocriteria:

		Low-End Scoring
Upper CL:	54	<25 individuals (IndPct metrics = 0)
Impairment threshold:	45	<6 taxa (TX and TXPct metrics = 0)
Lower CL:	36	

MetricName	Category	Response	Metric_Desc_tech
BenInsect-TolTXPct	trophic	positive	Relative abundance (%) of taxa that are benthic insectivores (excludes tolerant species)
DetNWQTXPct	trophic	negative	Relative abundance (%) of taxa that are detritivorous
MA<2Pct	reproductive	negative	Relative abundance (%) of early-maturing individuals (female mature age <=2 years)
SensitiveTXPct	tolerance	positive	Relative abundance (%) of taxa that are sensitive
SLvd	life history	negative	Taxa richness of short-lived species
TolTXPct	tolerance	negative	Relative abundance (%) of taxa that are tolerant
TolPct	tolerance	negative	Relative abundance (%) of individuals that are tolerant
DomTwoPct	dominance	negative	Combined relative abundance of two most abundant taxa
FishDELTPct	tolerance	negative	Relative abundance (%) of individuals with Deformities, Eroded fins, Lesions, or Tumors

Fish Class 3 – Southern Headwaters

Classification Criteria:

Small, moderate to high-gradient warm/coolwater streams in southern MN and the far-western portion of the Red River Basin

Sites in southern Minnesota and the Glacial Lake Agassiz Basin (GLAB) ecoregion, where watershed area is less than 30 square miles and gradient is greater than 0.5 m/km.

Examples:
Cobb Creek, Otter Creek, Pine Island Creek, Milliken Creek, Little Cottonwood River, Okabena Creek, Chaska Creek

Biocriteria:		**Low-End Scoring**
Upper CL:	58	<25 individuals (IndPct metrics = 0)
Impairment threshold:	**51**	<4 taxa (TX and TXPct metrics = 0)
Lower CL:	44	

MetricName	Category	Response	Metric_Desc_tech
DetNWQTXPct	trophic	negative	Relative abundance (%) of taxa that are detritivorous
GeneralTXPct	trophic	negative	Relative abundance (%) of taxa that are generalist feeders
Sensitive Species	tolerance	positive	Taxa richness of sensitive species
SLvdPct	life history	negative	Relative abundance (%) of individuals that are short-lived
SSpnPct	reproductive	negative	Relative abundance (%) of individuals that are serial spawners (multiple times per year)
VtolTXPct	tolerance	negative	Relative abundance (%) of taxa that are very tolerant
FishDELTPct	tolerance	negative	Relative abundance (%) of individuals with Deformities, Eroded fins, Lesions, or Tumors

Appendix E. Values used to score evidence in the stressor identification process developed by EPA

Rank	Meaning	Caveat
+++	*Convincingly supports*	*but other possible factors*
++	*Strongly supports*	*but potential confounding factors*
+	*Some support*	*but association is not necessarily causal*
0	*Neither supports nor weakens*	*(ambiguous evidence)*
-	*Somewhat weakens support*	*but association does not necessarily reject as a cause*
--	*Strongly weakens*	*but exposure or mechanism possible missed*
---	*Convincingly weakens*	*but other possible factors*
R	*Refutes*	*findings refute the case unequivocally*
NE	*No evidence available*	
NA	*Evidence not applicable*	
D	*Evidence is diagnostic of cause*	

Appendix F. Strength of evidence scores for various types of evidence used in stressor ID analysis

Types of Evidence	Possible values, high to low
Evidence using data from case	
Spatial / temporal co-occurrence	+, 0, ---, R
Evidence of exposure, biological mechanism	++, +, 0, --, R
Causal pathway	++, +, 0, -, ---
Field evidence of stressor-response	++, +, 0, -, --
Field experiments / manipulation of exposure	+++, 0, ---, R
Laboratory analysis of site media	++, +, 0, -
Temporal sequence	+, 0, ---, R
Verified or tested predictions	+++, +, 0, -, ---, R
Symptoms	D, +, 0, ---, R
Evidence using data from other systems	
Mechanistically plausible cause	+, 0, --
Stressor-response relationships in other field studies	++, +, 0, -, --
Stressor-response relationships in other lab studies	++, +, 0, -, --
Stressor-response relationships in ecological models	+, 0, -
Manipulation of exposure experiments at other sites	+++, +, 0, --
Analogous stressors	++, +, -, --
Multiple lines of evidence	
Consistency of evidence	+++, +, 0, -, --
Explanatory power of evidence	++, 0, -