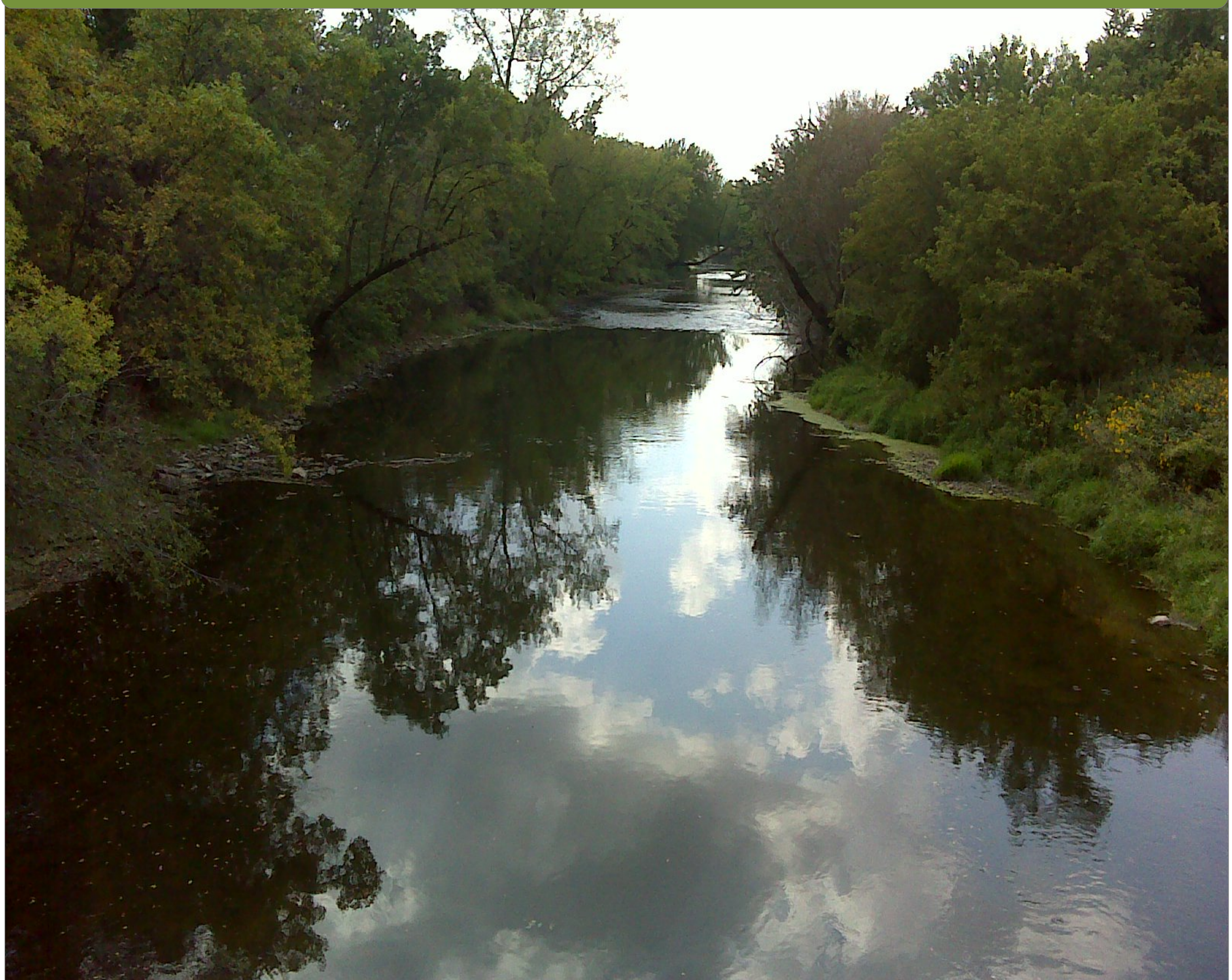
Cedar River Watershed Stressor Identification Report

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



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Acronyms

AUID Assessment Unit ID

BANCS Bank Assessment for Non-point source Consequences of Sediment

BAP Bioavailable Phosphorus

BEHI Bank Erosion Hazard Index

BOD Biological Oxygen Demand

CADDIS Causal Analysis/Diagnosis Decision Information System

Cfs Cubic feet per second

CSAH County State Aid Highway

DELT Deformities, Eroded fins, Lesions, and Tumors

DO Dissolved Oxygen

DOP Dissolved Ortho-phosphorus

EPA U.S. Environmental Protection Agency

EPT Ephemeroptera, Plecoptera, and Trichoptera

F-IBI Fish Index of Biological Integrity

GP Glide Pool

HUC Hydrologic Unit Code

IBI Index of Biotic Integrity

IWM Intensive Watershed Monitoring

M-IBI Macroinvertebrate Index of Biological Integrity

MDNR Minnesota Department of Natural Resources

mg/L milligrams per Liter

MPCA Minnesota Pollution Control Agency

MSHA MPCA Stream Habitat Assessment

Nitrate NO_3

Nitrite NO_2

NTU Nephelometric Turbidity Units

NPS Nonpoint Source

PS Point source

RR Riffle Run

SID Stressor Identification

SOE Strength of Evidence

TALU Tiered Aquatic Life use

TIV Tolerance Indicator Value

TKN total Kjeldahl nitrogen

TMDL Total Maximum Daily Load

TP Total Phosphorus

TSS Total Suspended Solids

TSVS Total Suspended Volatile Solids

USGS United States Geological Survey

VSS Volatile Suspended Solids
WQS Water Quality Standard
WRAPS Watershed Restoration and Protection Strategies
WWTP Wastewater Treatment Plant
YSI Yellow Springs Instruments

Executive summary

Over the past few years, the Minnesota Pollution Control Agency (MPCA) has substantially increased the use of biological monitoring and assessment as a means to determine and report the condition of the state's rivers and streams. This basic approach is to examine fish and aquatic macroinvertebrate communities and related habitat conditions at multiple sites throughout a major watershed. From these data, an Index of Biological Integrity (IBI) scores are calculated, which provides a measure of overall community health. If biological impairments are found, stressors to the aquatic community must be identified.

Stressor identification is a formal and rigorous process that identifies stressors causing biological impairment of aquatic ecosystems and provides a structure for organizing the scientific evidence supporting the conclusions (Cormier et al. 2000). In simpler terms, it is the process of identifying the major factors causing harm to aquatic life. Stressor identification is a key component of the major watershed restoration and protection projects being carried out under Minnesota's Clean Water Legacy Act.

This report summarizes stressor identification work in the Cedar River Watershed. There were 19 reaches identified with biological impairment in the Cedar River Watershed (Table 3). In the Cedar River Watershed, there were 5 streams with fish and macroinvertebrate impairments, while the remaining 14 were impaired for only macroinvertebrates.

After examining many candidate causes for the biological impairments, the following stressors were identified as probable causes of stress to aquatic life in the Cedar River Watershed:

- Habitat/bedded sediment
- Nitrate
- Dissolved oxygen
- Phosphorus
- Total suspended solids
- Flow alteration

The most frequent stressors identified in 17 of the 19 impaired reaches were flow alteration and habitat/bedded sediment. The second most frequent stressor was nitrate-nitrogen. The remaining stressors in the list above were found at fewer sites. It was common to identify multiple stressors that were involved with biotic impairments, as most sites had two or more stressors.

This report builds upon the earlier Watershed Assessment Report for the Cedar River Watershed (MPCA 2012), which is the document that identifies the biotic impairments. The stressor identification report provides some background information on the land and water resources, and assesses all practical aquatic life stressors. Each stream reach with impaired biota is presented individually in the main sections of this report. A determination of probable stressors is made, and a summary of the stressors identified in each stream reach is found in Table 1 on the next page, and at the end of this document, in Table 83.

Table 1: Summary of stressors found in the Cedar River Watershed.

11 Digit HUC	Reach Name	AUID	Biological Impairment	Stressors: Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow Alteration
Middle Fork Cedar River	Cedar River, Middle Fork	549	Macroinvertebrate	•	o	o	o	o	•
	Cedar River, Middle Fork	530	Macroinvertebrate	•	•	•		o	•
Roberts Creek	Unnamed Creek	534	Fish and Macroinvertebrate	•	•	o	o	o	•
	Roberts Creek	506	Fish and Macroinvertebrate	•	•	o		o	•
	Unnamed Creek	593	Macroinvertebrate	•	•	o	o	o	•
	Roberts Creek	504	Macroinvertebrate	•	•	o	•	o	•
Upper Cedar River	Unnamed Creek (Cedar River, West Fork)	591	Macroinvertebrate		o	o	o	o	•
	Unnamed Creek	577	Macroinvertebrate	•	•	o	o	o	•
	Cedar River	503	Macroinvertebrate	•	•	•	•	•	•
	Unnamed Creek	533	Macroinvertebrate	•	•		•	•	•
Turtle Creek	Unnamed Creek	547	Macroinvertebrate		o	o	o	o	•
	Turtle Creek	540	Fish and Macroinvertebrate	•	•	•	•	•	•
Rose Creek	Schwerin Creek	523	Macroinvertebrate	•	•	o	o	o	•
	Unnamed Creek	583	Macroinvertebrate	•	•	o	•	•	•
Lower Cedar River	Unnamed Creek (Woodson Creek)	554	Fish and Macroinvertebrate	•			o	o	•
	Cedar River	515	Macroinvertebrate	•	•	•	•		•
	Cedar River	501	Fish and Macroinvertebrate	•	•		•	•	•
Little Cedar River	Unnamed Creek	520	Macroinvertebrate	•	•	o	o	o	•
	Unnamed Creek	519	Macroinvertebrate	•	•	o	o	o	•

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

1. Introduction

1.1. Monitoring and assessment

Water quality and biological monitoring in the Cedar River Watershed have been ongoing. As part of the MPCA's Intensive Watershed Monitoring (IWM) approach, monitoring activities increased in rigor and intensity during 2009 and focused more on biological monitoring (fish and macroinvertebrates) as a means of assessing stream health. The data collected during this period, as well as historic data obtained prior to 2009, were used to identify stream reaches that were not supporting healthy fish and macroinvertebrate assemblages (Figure 1.

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

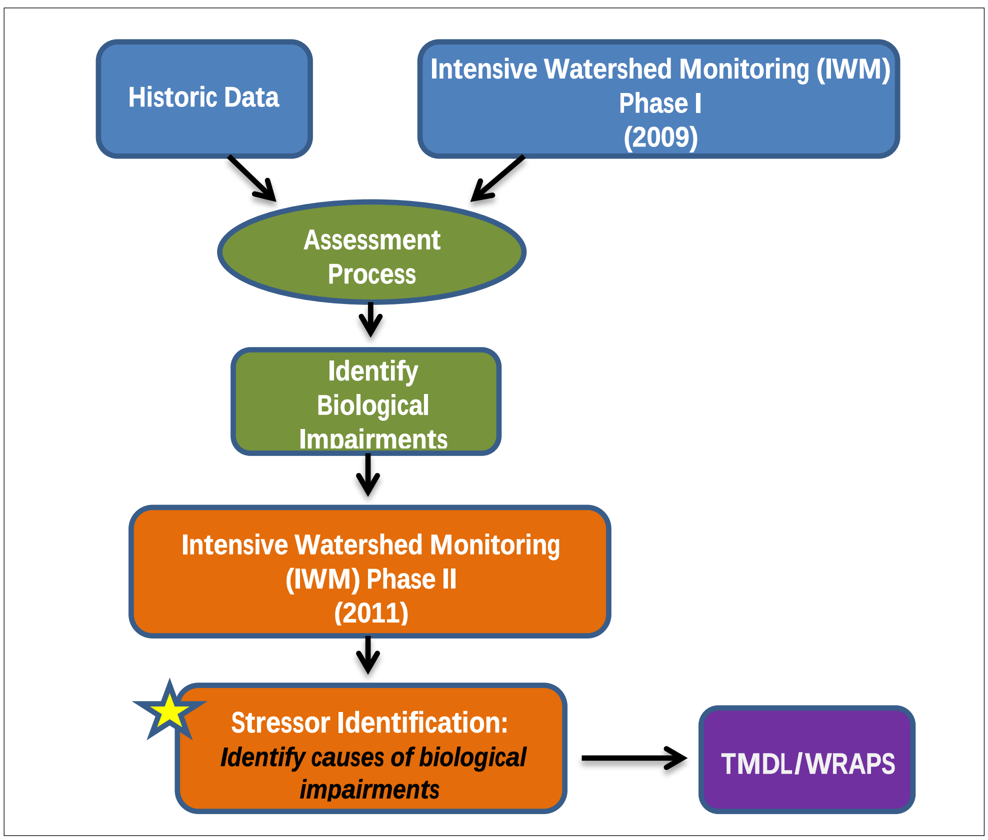


Figure 1: Process map of intensive watershed monitoring, assessment, stressor identification and TMDL processes.

1.2. Stressor identification process

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

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

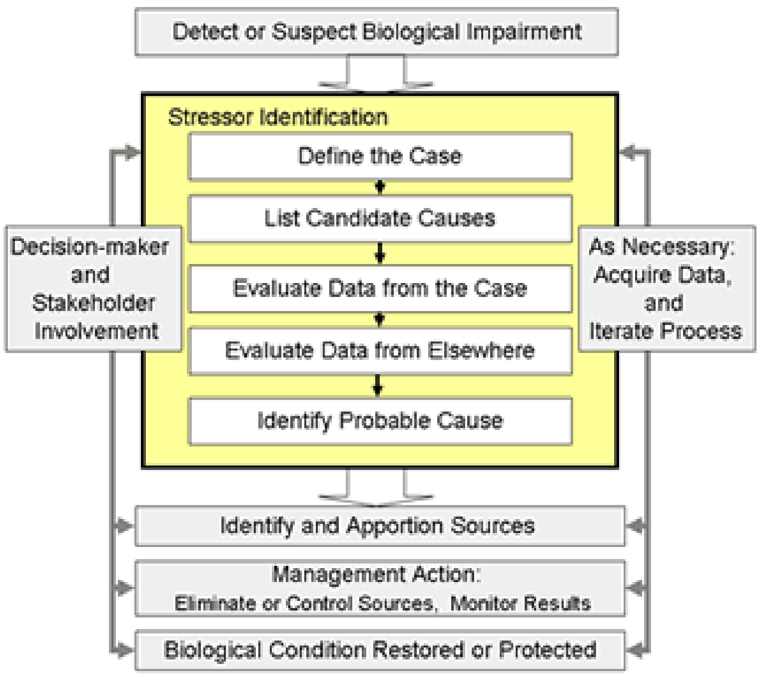


Figure 2: Conceptual model of stressor identification process (Cormier et al. 2000).

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

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

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

1.3. Common stream stressors

The five major elements of a healthy stream system are stream connections, hydrology, stream channel assessment, water chemistry and stream biology. If one or more of the components are unbalanced, the stream ecosystem may fail to function properly and is listed as an impaired water body. Table 2 lists the common stream stressors to biology relative to each of the major stream health categories.

Table 2: Common streams stressors to biology (i.e., fish and macroinvertebrates).

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

2. Cedar River Watershed

Figure 3: Cedar River.

The Upper Cedar River Watershed is located in southeast Minnesota and northeast Iowa. Approximately 42% of the watershed lies in Minnesota. The Cedar River begins in the headwaters of the East Fork Cedar River, Middle Fork Cedar River and West Fork Cedar River in southern Dodge County. The river flows through the city of Austin to the Minnesota/Iowa Border, and into Mitchell County in northeast Iowa. From there, the Cedar River flows southeasterly through the Iowa cities of Charles City, Waverly, and Cedar Rapids. It then enters the Iowa River in Louisa County, Iowa, just before the Iowa River flows into the Mississippi River, below the city of Muscatine, Iowa.

The Cedar River Watershed is in the Western Corn Belt Plains ecoregion of Minnesota. The dominant land use in the Cedar River Watershed is row crop agriculture comprising approximately 88% of the land area with corn and soybeans being predominant crops in the watershed Figure 4:.

The Cedar River and its tributaries have been modified by several dams. They include a dam on the Cedar River that creates the Ramsey Mill Pond reservoir north of Austin, the Austin Mill Pond dam and another dam is located on Dobbins Creek in Austin, which creates the reservoir called East Side Lake.

The Cedar River Watershed was monitored in 2009 and 2010 for aquatic recreation, aquatic consumption and aquatic life beneficial uses by the MPCA and assessed in 2011. Based on this assessment, it was determined that 19 stream reaches were impaired for fish and/or macroinvertebrates, as part of the aquatic life use designation. Aquatic biological impairments occur along the mainstem Cedar River and many tributaries. Twenty-three AUIDS were not assessed for aquatic biology because the stream reach or AUID is greater than 50% channelized. Channelized reaches are currently not being assessed until new biological standards associated with Tiered Aquatic Life Use (TALU) framework are developed. The TALU framework will build upon existing water quality standards with a goal of improving how water resources are monitored and managed. The changes will improve the ability to identify stressors and develop effective tools to improve and maintain the condition of waters in Minnesota.

This report connects the biological community to the stressor(s) causing the impairments. Stressors are those factors that negatively impact the biological community. Biotic stressors can interact with each other and can be additive to the stress on the biota. The Cedar River Watershed Monitoring and Assessment Report are available with background information about the watershed and the results of recent monitoring and assessment (MPCA 2012).

In the Cedar River Watershed, stressors that were examined for possible cause of biotic impairment were:

- Lack of habitat/bedded sediment
- High nitrate-nitrite
- Low dissolved oxygen
- Excess phosphorus
- High suspended solids
- Flow alteration

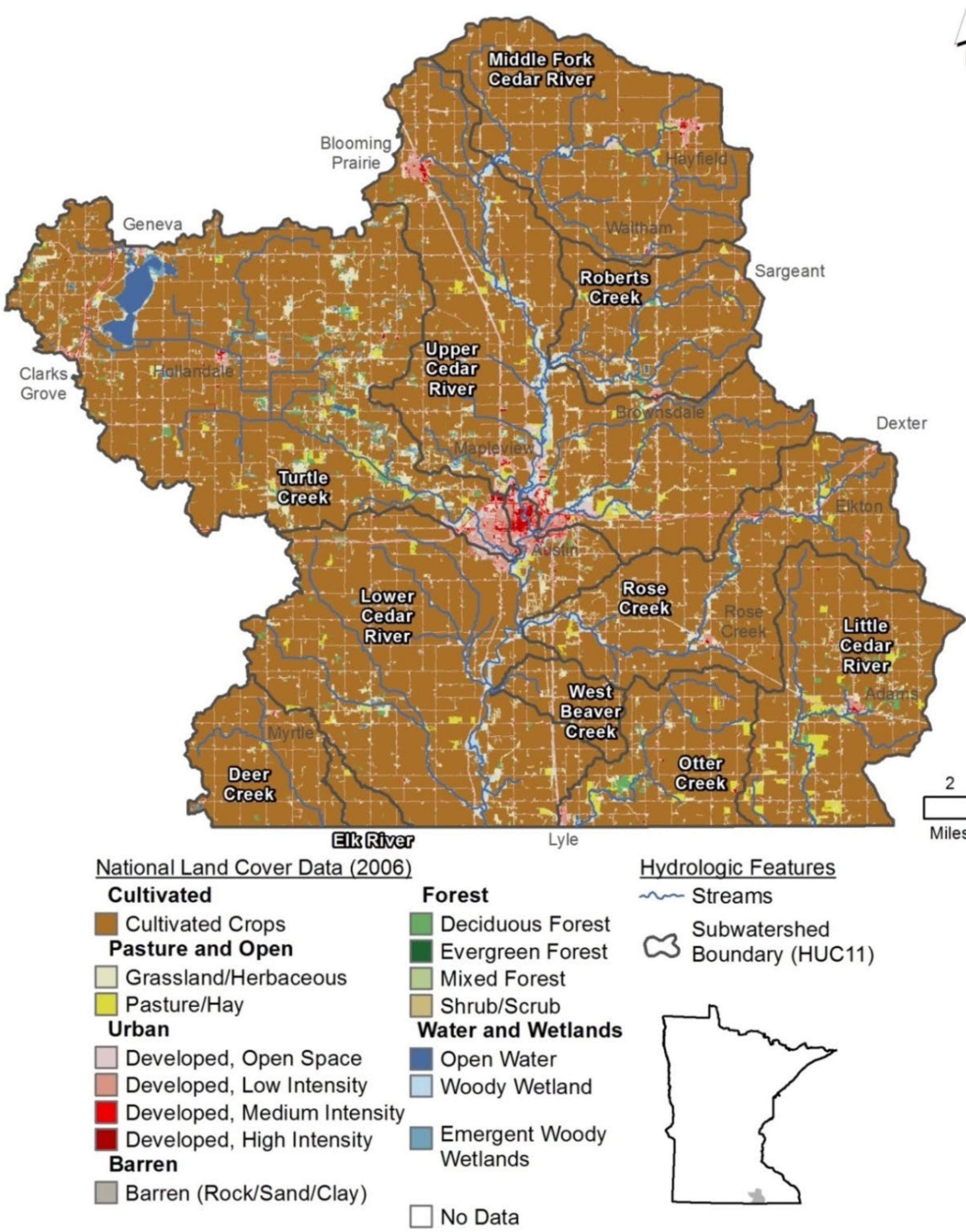


Figure 4: Land use in the Cedar River Watershed.

2.1. Summary of biological impairments

The approach used to identify biological impairments includes monitoring of fish and aquatic macroinvertebrates communities and related habitat conditions at sites throughout a watershed. The resulting information is used to calculate IBI scores for both communities. The IBI scores can then be compared to a range of thresholds to assess whether or not the reach is meeting aquatic life standards.

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

In the Cedar River Watershed, 19 AUIDs are currently impaired for a lack of biological assemblage (Table 3).

Table 3: Summary of stream reaches with biological impairments in the Cedar River Watershed.

11 Digit HUC	Reach Name	Description	AUID	Biological Impairment
Middle Fork Cedar River	Cedar River, Middle Fork	Westfield-Ripley Ditch to Unnamed CR	07080201-549	Macroinvertebrate
	Cedar River, Middle Fork	Unnamed Cr to Cedar R	07080201-530	Macroinvertebrate
Roberts Creek	Unnamed Creek	Unnamed Cr to T103 R17W S10, west line	07080201-534	Fish and Macroinvertebrate
	Roberts Creek	Headwaters to Unnamed Cr	07080201-506	Fish and Macroinvertebrate
	Unnamed Creek	Unnamed Cr to Unnamed Cr	07080201-593	Macroinvertebrate
	Roberts Creek	Unnamed Cr to Cedar R	07080201-504	Macroinvertebrate
Upper Cedar River	Unnamed Creek (Cedar River, West Fork)	Unnamed Cr to Cedar R	07080201-591	Macroinvertebrate
	Unnamed Creek	Unnamed Cr to Cedar R	07080201-577	Macroinvertebrate
	Cedar River	Headwater to Roberts Cr	07080201-503	Macroinvertebrate
	Unnamed Creek	Unnamed Cr to Cedar R	07080201-533	Macroinvertebrate
Turtle Creek	Unnamed Creek	Unnamed Cr to Turtle Cr	07080201-547	Macroinvertebrate
	Turtle Creek	T102 R18 W S4, north line to Cedar R	07080201-540	Fish and Macroinvertebrate
Rose Creek	Schwerin Creek	Headwaters to Rose Cr	07080201-523	Macroinvertebrate
	Unnamed Creek	Unnamed Cr to Rose Cr	07080201-583	Macroinvertebrate

11 Digit HUC	Reach Name	Description	AUID	Biological Impairment
Lower Cedar River	Unnamed Creek (Woodson Creek)	T102 R18W S14, north line to Cedar R	07080201-554	Fish and Macroinvertebrate
	Cedar River	Turtle Cr to Rose Cr	07080201-515	Macroinvertebrate
	Cedar River	Rose Cr to Woodbury Cr	07080201-501	Fish and Macroinvertebrate
Little Cedar River	Unnamed Creek	Unnamed Cr to Unnamed Cr	07080201-520	Macroinvertebrate
	Unnamed Creek	Unnamed Cr to Little Cedar R	07080201-519	Macroinvertebrate

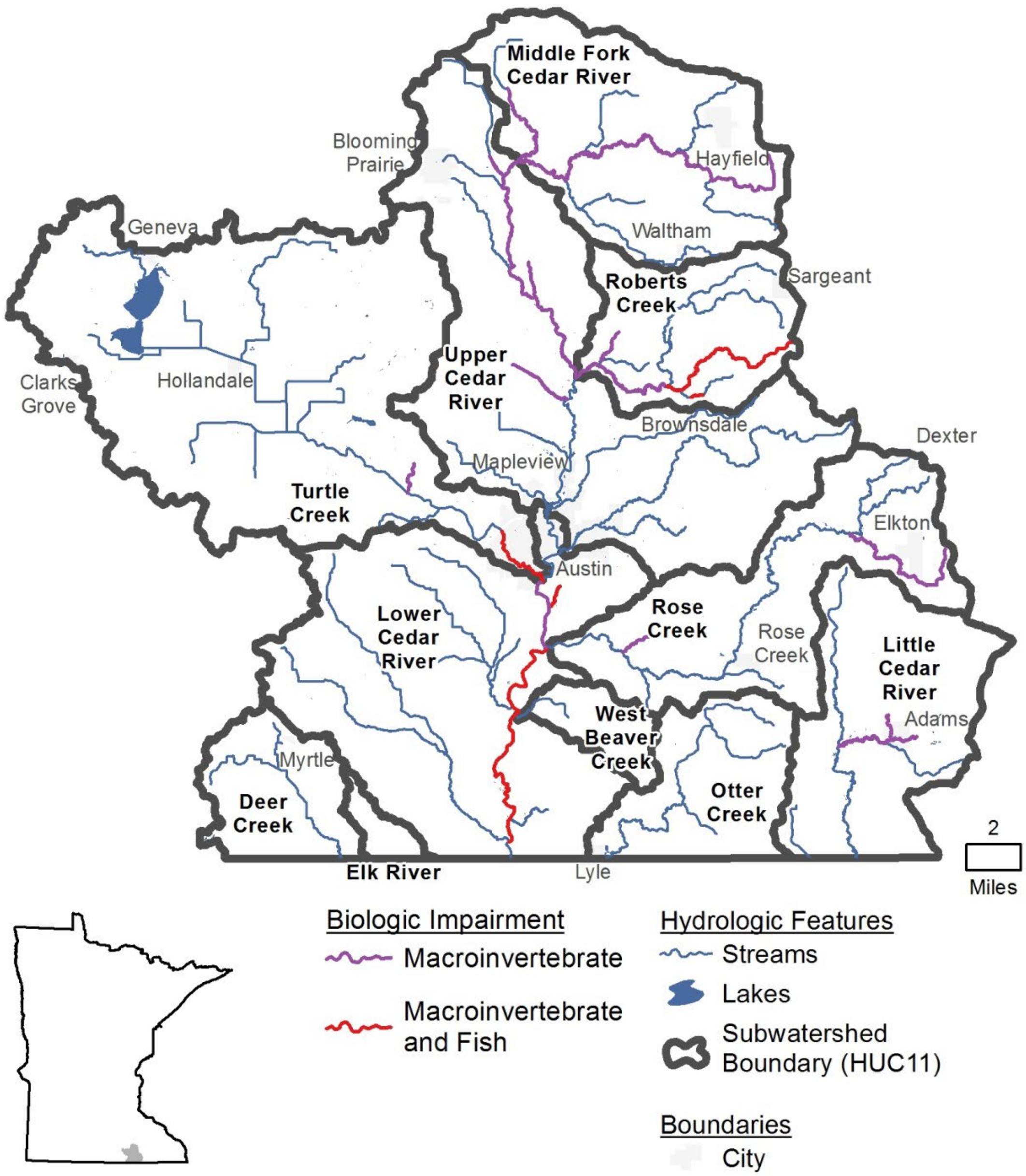


Figure 5: Map of Cedar River Watershed biological impairments.

3. Possible stressors to biological communities

A comprehensive list of potential stressors to aquatic biological communities compiled by the EPA can be found here (http://www.epa.gov/caddis/si_step2_stressorlist_popup.html). This comprehensive list serves two purposes. First, it can serve as a checklist for investigators to consider all possible options for impairment in the watershed of interest. Second, it can be used to identify potential stressors that can be eliminated from further evaluation. In some cases, the data may be inconclusive and limit the ability to confidently determine if a stressor is causing impairment to aquatic life. It is imperative to document if a candidate cause was suspected, but there was not enough information to make a scientific determination of whether or not it is causing harm to aquatic life. In this case, management decisions can include modification of sampling plans and future evaluation of the inconclusive case. Alternatively, there may be enough information to conclude that a candidate cause is not causing biological impairment and therefore can be eliminated. The inconclusive or eliminated causes will be discussed in more detail in the following section.

3.1. Eliminated causes

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

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

Water temperature regime alteration

Coldwater streams

Temperature can be a major factor in determining macroinvertebrate and fish species composition in coldwater streams. Increases in temperature due to altered watersheds can lead directly to loss of coldwater assemblages and introduction of warmwater species. Warmer water impacts organisms indirectly due to the relationship with lower DO and directly through changes in growth and reproduction, egg mortality, disease rates, and direct mortality. Macroinvertebrate species have well-known tolerances to thermal changes, and community composition of macroinvertebrates is useful in tracking the effects of increasing temperature. Fish assemblages, likewise, change with temperature, and coldwater adapted species either leave, are unable to reproduce, or die in warmer regimes.

Fish in coldwater systems can suffer adverse effects due to increases in temperature (Raleigh et al., 1986). When temperatures rise near 21°C, other fish can have a competitive advantage over trout for the food supply (Behnke, 1992). The temperature at which fish continue to feed and gain weight is considered their functional feeding temperatures. The limits for brown trout growth at 4 – 19.5 °C (Elliot and Elliot, 1995); however, for egg development, brown trout need temperatures between 0 and 15 °C (Elliot, 1981). According to Bell 2006, brown trout may be physiologically stressed in the thermal window of 19-22°C. These temperatures are near the upper metabolic limit for trout and may affect the ability to maintain normal physical function and ability to gain weight.

Brook trout functional feeding temperatures are between 12.7°C and 18.3° (Raleigh, 1982). They can briefly tolerate temperatures near 22.2°C, but temperatures of 23.8°C for a few hours are generally lethal (Flick, 1991). Juvenile brook trout density is negatively correlated with July mean water temperatures (Hinz and Wiley, 1997). Growth and distribution of juvenile brook trout is highly dependent on temperature (McCormick et al., 1972).

Warmwater streams

Stream temperature naturally varies due to air temperature, geology, shading, and the inputs from tributaries and springs. Different organisms are adapted to and prefer different temperature regimes. Water temperature regulates the ability of organisms to survive and reproduce (EPA, 1986). Thermal pollution can increase stream temperatures through loss of riparian shading, urban and agricultural runoff, and direct discharges to the stream. Warmer water holds less DO, and higher water temperatures also affects the toxicity of numerous chemicals in the aquatic environment. Algal blooms often occur with temperature increases (EPA, 1986).

Water quality standards

Warmwater: The standard for Class 2B (warmwater) waters of the state is not to exceed five degrees Fahrenheit (°F) above natural (Minn. Stat. 7050.0222 subp. 4), based on monthly average of maximum daily temperature. In no case shall it exceed the daily average temperature of 86 degrees Fahrenheit (30 degrees Celsius).

Coldwater: The state standard for temperature in Class 2A streams is "no material increase" (7050.0222 Specific Water Quality Standards for Class 2 Waters of the State; Aquatic Life and Recreation).

The highest temperature found in the biological impaired reaches was 29.4 degrees Celsius. With the available data, temperature is not a stressor to the biological community at this time.

Physical crushing and trampling

Little of the land use in the Cedar 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 Cedar River Watershed.

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 0(Pringle, 2003). While the tendency is to consider this generally in a longitudinal manner (up-stream to downstream), there are also vertical, horizontal and subsurface connections that are important to the overall ecology of the system.

Impoundment structures (dams) on river systems alter streamflow, water temperature regime, and sediment transport processes-each of which can cause changes in fish and macroinvertebrate assemblages (Cummins, 1979; Waters, 1995). Dams also have a history of blocking fish migrations and can greatly reduce or even extirpate local populations (Brooker, 1981; Tiemann et al., 2004). In Minnesota, there are more than 800 dams on streams and rivers for a variety of purposes, including flood control, wildlife habitat, and hydroelectric power generation. 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.

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 (lake or "still water") condition (Mitchell and Cunjak, 2007).

Water quality standards

There is no applicable water quality standard for connectivity impacts.

Connectivity in the Cedar River Watershed

The Cedar River Watershed has five dams in the watershed (Figure 6), three are in Austin, and two are in the upper Turtle Creek subwatershed. There are also about 640 other flow control structures on the channel and stream network system within the watershed. These structures (culverts, bridges) were located in 2012-2013 and the basic features of each were identified and documented and can be found in Appendix F. 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. While we acknowledge that other forms of connectivity (vertical, horizontal and subsurface) are important in a functioning stream system, the methods employed for this initial SID were not to the level needed to carry forward valid conclusions and decisions. This will be an area where more attention is placed within the second cycle of the watershed approach for the Cedar River Watershed.

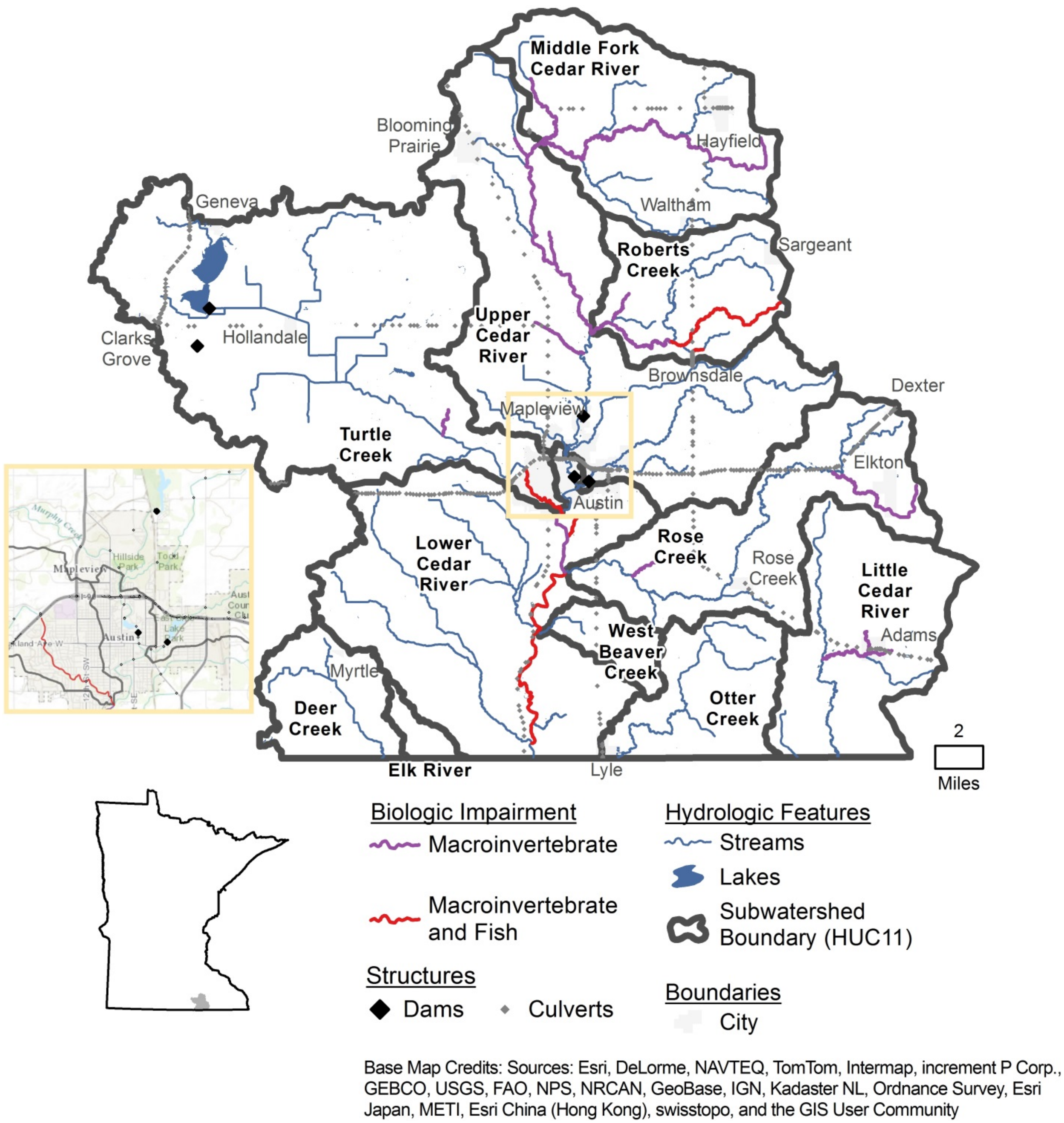


Figure 6: Map of dam locations in the Cedar River Watershed.

Sources and causal pathways model for connectivity

Bridges and culverts can alter the channel creating less sinuosity, while dams create impoundments, all leading to a change in the habitat structure of a stream. This can affect plant, fish, and macroinvertebrate diversity and richness. The conceptual model for physical connectivity as part of flow alteration as a candidate stressor can be found on the EPA CADDIS webpage here.

3.2. Inconclusive causes

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

Specific conductance was measured 353 times with an average of 595 uS/cm in the Cedar River Watershed. On October 13, 1971, specific conductance was 1000 uS/cm and on March 5, 1979, it was 2040 uS/cm on AUID 07080201-501 at EQuIS station S000-136. In the last 10 years, specific conductance on AUID 07080201-501 had a max of 775 uS/cm. In 2012, there was a measurement of elevated specific conductance at station S000-001 in the Cedar River (AUID 07080201-515), with a maximum of 958 uS/cm. With the available data the highest chloride measurement was only 75.4 mg/L, far below the standard. The EPA recommended chronic criterion for aquatic life is a four-day average chloride concentration of 230 mg/L with an occurrence interval of once every three years, and the recommended acute criterion concentration for chloride is 860 mg/L (EPA, 1988). 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 two stations in the Cedar River Watershed had measurements of the metals of cadmium, nickel, copper, lead, and zinc. Station S000-136 and station S000-222 both on the Cedar River AUID 07080201-501. Of the limited data available, none of the metals resulted in any values above their chronic standards.

It is unlikely that the metals are a stressor to the biological community due to the measurements being below 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.

Pesticides

There have been a few pesticide samples taken throughout the Cedar River Watershed. Although 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.

3.3. Summary of candidate causes in the Cedar River Watershed

The candidate causes for final analysis in this report are:

- Habitat/bedded sediment
- Nitrate
- Dissolved oxygen
- Phosphorus
- TSS
- Flow alteration

3.3.1. Candidate cause: Low dissolved oxygen

Dissolved oxygen (DO) 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 macroinvertebrate species (Davis, 1975; Nebeker et al., 1991). DO 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 macroinvertebrates 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 (BOD), 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. In Class 2A streams (coldwater), the standard for DO is 7.0 mg/L as a daily minimum. Additional stipulations have been recently added to this standard. 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 percent 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 percent 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 percent of the "suitable" (taken before 9:00) May through September measurements, or more than 10 percent of the total May through September measurements, or more than 10 percent 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 Cedar River Watershed in 2012. 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. DO 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 Cedar River Watershed

Currently, there are no DO impairments in the Cedar River Watershed. Low DO was determined as a stressor in 4 AUIDs, inconclusive in 12 AUIDs, and was eliminated as a potential stressor in 3 AUIDs. Geneva Lake is a potential source of nutrients that can impact downstream receiving waters by driving many low DO conditions.

Utilizing fish Tolerance Indicator Values (TIVs) for DO (Figure 7) and macroinvertebrate TIV (Figure 8) helps identify areas that have potential DO issues. TIVs were developed from statewide Minnesota data. The common fish species in the Cedar River Watershed were grouped into categories (quartiles) by species present to note their level of relative sensitivity or tolerance to low DO levels (Table 4).

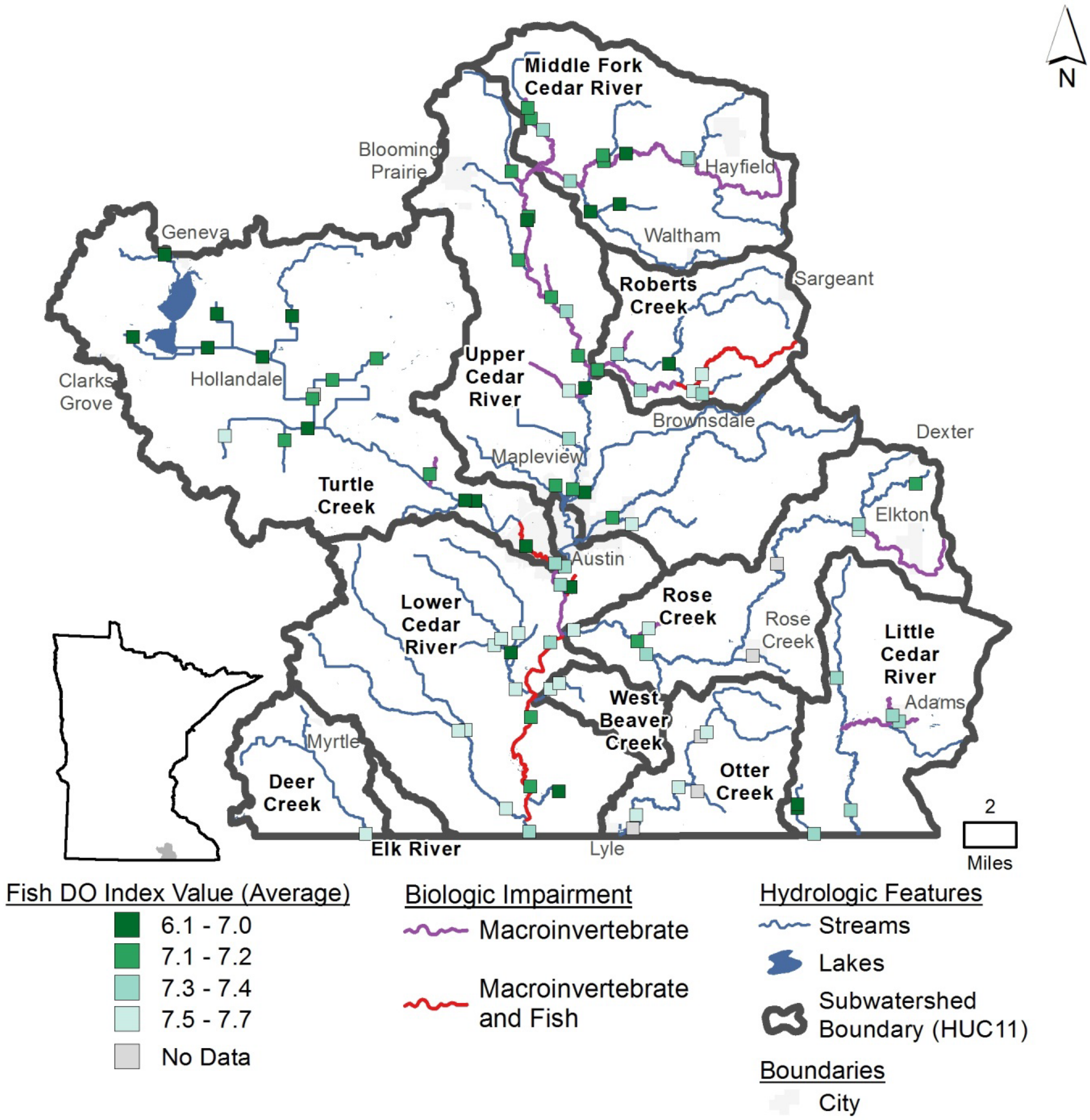


Figure 7: Average fish tolerance indicator value station scores for dissolved oxygen; fish data collected only to genus was not included in station score calculations. Data were ranked for the Cedar River Watershed only, and not on a regional or statewide scale.

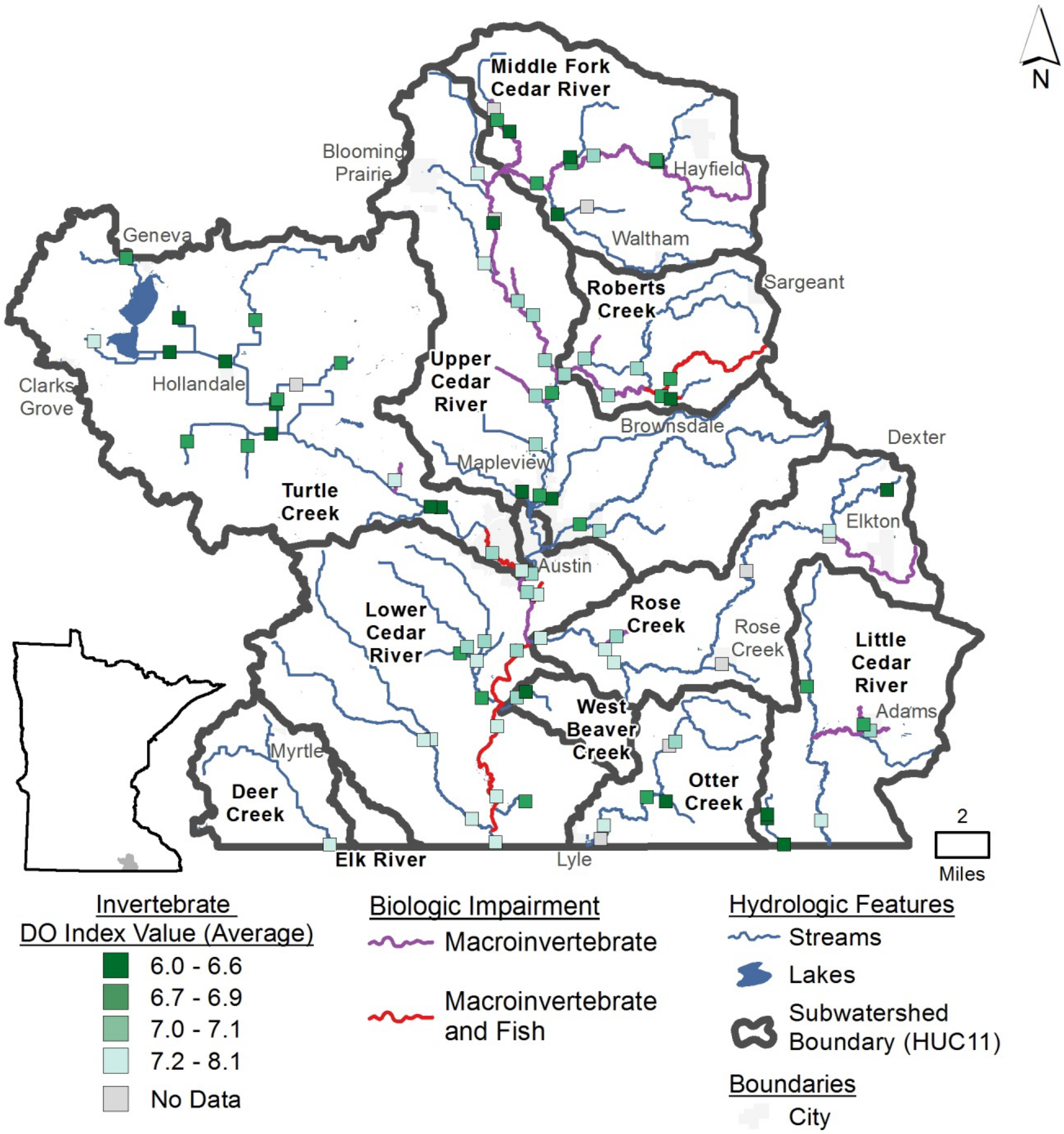


Figure 8: Average macroinvertebrate tolerance indicator values for dissolved oxygen ranked for the Cedar River Watershed only, and not on a regional or statewide scale.

Table 4: Fish species found in the Cedar River Watershed ranked and quartered by dissolved oxygen tolerance indicator values developed for Minnesota.

Common Name	DO TIV	Common Name	DO TIV	Common Name	DO TIV	Common Name	DO TIV
yellow bullhead	4.6	yellow perch	6.3	blackside darter	7.1	sand shiner	7.6
black bullhead	5.0	black crappie	6.3	spotfin shiner	7.1	shorthead redhorse	7.6
central mudminnow	5.0	orangespotted sunfish	6.5	bluntnose minnow	7.1	stonecat	7.6
brook stickleback	5.6	green sunfish	6.5	creek chub	7.2	blacknose dace	7.7
redfin shiner	5.7	bluegill	6.6	hornyhead chub	7.2	banded darter	7.8
tadpole madtom	5.7	brassy minnow	6.7	walleye	7.2	Ozark minnow	7.9
golden shiner	5.8	rock bass	6.8	slenderhead darter	7.3	smallmouth bass	7.9
pearl dace	5.9	least darter	7.0	white sucker	7.3	quillback	8.0
hybrid sunfish	5.9	common shiner	7.0	bigmouth shiner	7.3	southern redbelly dace	8.2
blacknose shiner	6.0	suckermouth minnow	7.0	central stoneroller	7.3	northern hogsucker	8.2
largemouth bass	6.0	johnny darter	7.0	carmine shiner	7.4	fantail darter	8.2
fathead minnow	6.1			golden redhorse	7.5	rainbow darter	8.5
northern pike	6.1					American brook lamprey	9.2
common carp	6.1						
Iowa darter	6.1						

Least Sensitive/Most Tolerant ⟶ Most Sensitive/Least Tolerant

Sources and causal pathways model for 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. A conceptual diagram for low DO as a candidate stressor is displayed at EPA's Caddis Dissolved Oxygen webpage.

3.3.2. Candidate cause: Nutrients (nitrate-nitrite)

Nitrate (NO_3) and nitrite (NO_2) forms of nitrogen are components of the natural nitrogen cycle in aquatic ecosystems. NO_2 anions are naturally present in soil and water, and are routinely converted to NO_3 by microorganisms as part of the nitrification and denitrification processes involved in the nitrogen cycle. Nitrogen cycling in the environment results in nitrogenous compounds such as ammonia denitrifying into the more stable and conservative nitrate ion (NO_3). Nitrate is the dominant form of nitrogen in most streams with elevated total nitrogen, and this pertains to the Cedar River as well (MPCA 2013).

In Minnesota, natural inputs of nitrate to surface waters vary by geographic location. However, when nitrate concentrations in surface water samples from "reference" areas (i.e., areas with relatively little human impact) are compared to samples from areas of greater human impact, the reference areas exhibit much lower nitrate concentrations (Monson and Preimesberger, 2010). Nitrate concentrations under "reference" conditions in Minnesota are typically below 1 mg/L (Heiskary and Wilson, 2005).

Elevated nitrate concentrations in surface water have been linked to a variety of sources and pathways. Anthropogenic alterations of the landscape, namely an increase in agricultural land use, have increased ambient nitrate concentrations in some watersheds to levels that can be toxic to some fish and macroinvertebrates (Lewis and Morris, 1986; Jensen, 2003). In addition to agricultural sources, elevated NO_2 and NO_3 concentrations have also been linked to effluent from facilities producing metals, dyes, and celluloids (Kimlinger, 1975) and sewage (Alleman, 1978).

Effects of nitrate-N toxicity on aquatic organisms

The intake of nitrite and nitrate by aquatic organisms has been shown to convert oxygen-carrying pigments into forms that are unable to carry oxygen, thus inducing a toxic effect on fish and macroinvertebrates (Grabda et al, 1974; Kropouva et al, 2005). Certain species of caddisflies, amphipods, and salmonid fishes seem to be the most sensitive to nitrate toxicity (Camargo and Alonso, 2006).

Nitrate toxicity to freshwater aquatic life is dependent on concentration and exposure time, as well as the overall sensitivity of the organism(s) in question. Comargo et al (2005) cited a maximum level of 2 mg/L nitrate-N as appropriate for protecting the most sensitive freshwater species, although in the same review paper, the authors also offered a recommendation of NO_3 concentrations under 10 mg/L as protective of several sensitive fish and aquatic macroinvertebrate taxa.

Water quality standards

Streams classified as Class 1 waters of the state, designated for domestic consumption (drinking water), in Minnesota have a nitrate water quality standard of 10 mg/L. Minnesota currently does not have a nitrate standard for other waters of the state except for class 1. Currently, the state has a draft standard for nitrate, but it is subject to change as research continues.

Sources and causal pathways model for nitrate and nitrite

A conceptual diagram of causes and potential sources for nitrate toxicity are shown at EPA's Caddis Nitrogen webpage. Given the abundance of cultivated cropland in the watershed, it is feasible that fertilizer application is a prominent source of nitrate in surface water. Lefebvre et al. (2007) determined that fertilizer application and land-cover were the two major determinants of nitrate signatures observed in surface water, and that nitrate signatures in surface waters increased with fertilization intensity. Nitrogen pathways can be different depending on geology and hydrology of the watershed.

Nitrogen is commonly applied as a crop fertilizer. Eighty-eight percent of the Cedar River Watershed mainly consists of cultivated cropland, and is likely that various forms of nitrogen including nitrate and anhydrous ammonia are being applied 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. When water moves quickly through the soil profile (as in the case of heavily tiled watersheds) nitrate transport can become large.

A statewide nitrogen study found that cropland commercial fertilizers make up 47% of nitrogen added to the landscape, 21% occurs through cropland legume fixation, 16% from manure application, and 15% from atmospheric deposition (MPCA, 2013). Nitrogen can reach waterways through surface runoff, tile drainage, and leaching to groundwater, with tile drainage being the largest pathway (MPCA, 2013).

Calculated information from this statewide study that pertains directly to the Cedar River Watershed includes the following statistics (2007-2009) for the watershed above the USGS gauge (which is directly downstream of Austin):

- NO3 + NO2 –N Yield (lbs/acre) > 9.6
- Total Nitrogen Yield (lbs/acre) >11.6
- NO3 + NO2 –N flow weighted mean concentration (mg/L) 8.0
- Total Kjeldahl –N flow-weighted mean concentration (mg/L) 1.0 – 1.2
- Total Kjeldahl Yield (lbs/acre) 2.1-2.6

Table 5. Nitrate monitoring site locations/numbers and associated number of observations and U.S. Geological Survey streamflow gauging station number.

Station Number	Name/Location	No. of Observations	USGS Gauging Station No.
S000-137	Cedar River, Lansing	206	05457000
S000-136	Cedar River, Austin	300	05457000

From 1976 – 2010, both sites in the above table have shown an increasing trend in nitrate concentrations. This equates to an average annual percentage change of about +2%, for both Cedar River sites.

When these same sites are analyzed using a slightly different timeframe for flow adjusted nitrate concentrations in the Cedar River, the concentrations have been steadily increasing since 1967 (Table 6; MPCA 2013).

Table 6.Trends in flow-adjusted nitrate concentrations at two sites along the Cedar River.

Site Location	Timeframe	% Change in Nitrate	Ending Concentration (mg/L
Cedar River, Lansing	1980-2010	+53%	7.1
Cedar River, Austin	1967-2009	+113	6.4

The Austin Wastewater Treatment Plant (WWTP) is a point source (PS) of nitrogen to the Lower Cedar River. For example, NO3-N concentrations of the plant's effluent water that is discharged to the river, ranged from 43 to 83 mg/L, between 2010 and 2013. This nitrate load is most significant during periods of lower stream flows. The Austin WWTP is one of 16 facilities in the Cedar River Watershed in Minnesota (12 are domestic wastewater, and 4 are industrial wastewater facilities).

When we aggregate data from all of these facilities in the watershed, the estimated annual average point source pollutant loads (and wastewater flow) and yields, from 2005-2009 for the Cedar River Watershed, are as follows (MPCA 2013):

Parameter	Pollutant Load (and Flow)	Pollutant Yield^ (pounds/acre/year)
Flow	2,838 million gallons/year*	
NHx	63,720 pounds/year	0.14
TKN	92,124 pounds/year	0.20
Nitrate-N	299,303 pounds/year	0.66
Total N	391,530 pounds/year	0.86

^ A drainage area of 454,000 acres is used in the yield calculation.

*This is approximately 8,700 acre-feet of wastewater per year (an acre-foot being the area of one acre that is 1 foot deep). For comparison, the city of Austin's land area is about 7,000 acres. The Cedar River flow below Austin averages about 223,000 acre-feet, for the 5-year timeframe of 2008-2012. Using these data, this wastewater volume is about 4% of the average stream flow, but it varies from around 2% to 14%, depending primarily upon the stream runoff conditions for a given year.

Another source of complimentary nitrogen data is the MPCA's watershed pollutant load monitoring network, which calculates flow-weighted mean concentrations (FWMC) and pollutant loads at specific river monitoring sites. For the main Cedar River below Austin site (Hydstra E48020001), where the watershed drainage area is 255,360 acres, the following FWMCs were calculated for both nitrite-nitrate ($N0_2$ + $N0_3$) nitrogen and total Kjeldahl nitrogen (TKN) for 2008-2012 (n=21-50 samples /year):

Year	N02+NO3-FWMC (mg/L)	TKN-FWMC (mg/L)
2008	8.9	1.52
2009	9.2	1.11
2010	8.9	1.35
2011	10.0	1.35
2012	8.9	0.94

3.3.3. Candidate cause: Lack of habitat/bedded sediment

Throughout the Cedar River Watershed, qualitative habitat was measured with the Minnesota Stream Habitat Assessment (MSHA). 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.

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 diversity enables fish and macroinvertebrate 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 resource extraction, agriculture, forestry, silviculture, urbanization, and industrial activities. 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).

Excess fine sediment deposition on benthic habitat has been proven to adversely impact fish and macroinvertebrate species that depend on clean, coarse stream substrates for feeding, refugia, and/or reproduction (Newcombe & MacDonald, 1991). Aquatic macroinvertebrates are generally affected in several ways: (1) loss of certain taxa due to changes in substrate composition (Erman & Ligon, 1988); (2) increase in drift (avoidance by movement with current) due to sediment deposition or substrate instability (Rosenberg & Wiens, 1978); and (3) changes in the quality and abundance of food sources such as periphyton and other prey items (Pekarsky, 1984). Fish communities are typically influenced through: (1) a reduction in spawning habitat or egg survival (Chapman, 1988) and (2) a reduction in prey items as a result of decreases in primary production and benthic productivity (Bruton, 1985); (Gray & Ward, 1982). Fish species that are simple lithophilic spawners require clean, coarse substrate for reproduction. These fish do not construct nests for depositing eggs, but rather broadcast them over the substrate. Eggs often find their way into interstitial spaces among gravel and other coarse particles in the stream bed. Increased sedimentation can reduce reproductive success for simple lithophilic spawning fish, as eggs become smothered by sediment and become oxygen deprived. The sediments primarily responsible for causing an embedded condition in southern Minnesota streams are sand and silt particles, which can be transported in the water column under higher flows, or as a bedload component. When stream velocities decrease, these sediments can “settle out” into a coarser bottom substrate area, thus causing an embedded condition.

According to the EPA CADDIS website, there are six attributes of physical habitat structure provided by a stream: *stream size and channel dimensions, channel gradient, channel substrate size and type, habitat complexity and cover, vegetation cover and structure in the riparian zone, and channel-riparian interactions.* To learn more about physical habitat go to the EPA CADDIS webpage here.

Water quality standards

There currently is no applicable standard for lack of habitat due to deposited and bedded sediment for biotic communities.

Habitat characteristics in the Cedar River

Habitat is variable throughout the Cedar River Watershed and is vital in understanding the biological communities. Throughout the Cedar River Watershed, qualitative habitat was measured with the MSHA along with the fish surveys (Figure 9). 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.

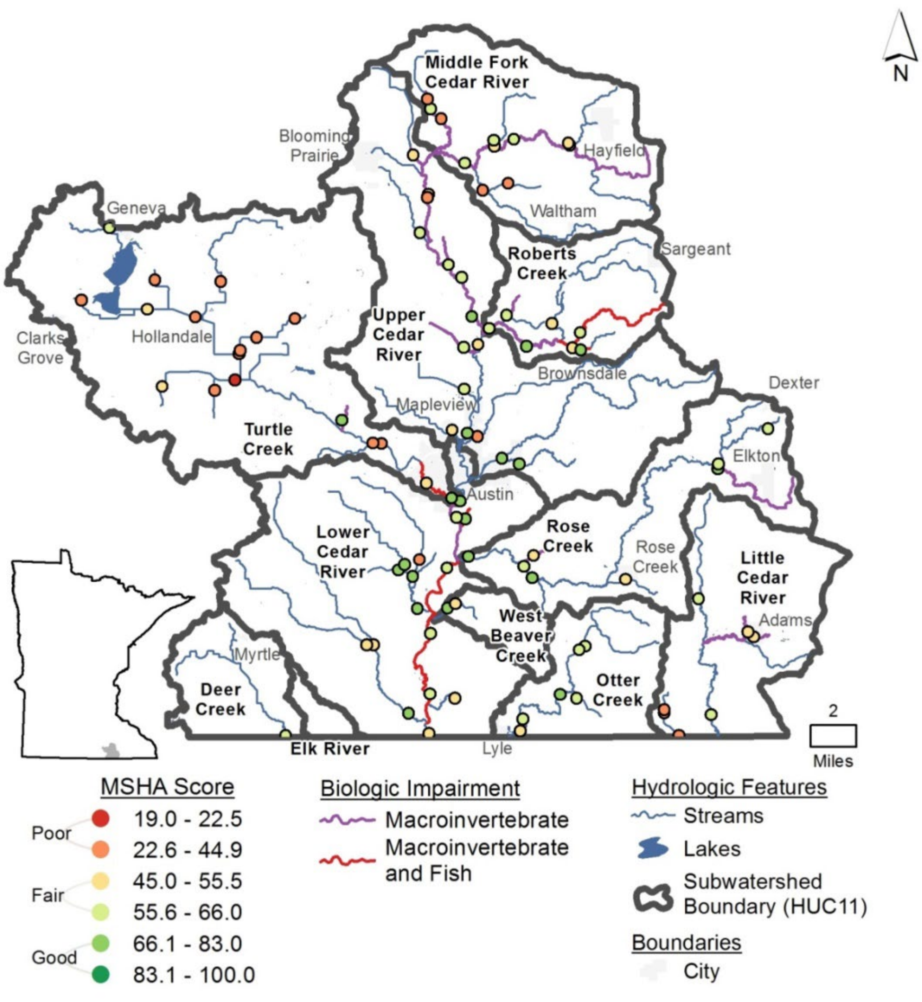


Figure 9: Map of MSHA total scores for all biological sites in the Cedar River Watershed.

Fish and macroinvertebrate communities can both respond to varying types of habitat stress. Biological metrics are used to help understand the biological response associated with habitat-related stress. The metrics examined in the Cedar River can be found in Appendix A. Many of these metrics can respond similarly to other stressors as well, so understanding all potential stressors is important. Habitat stress was found in all but two of the reaches analyzed in the SID process. Many of the habitat stressors in these reaches demonstrate excessive sediment deposition and substrate embeddedness. Erosion, lack of riparian corridor and land use (including historical land use in this watershed) has contributed to the habitat stress observed.

Sources and causal pathways model for habitat

Alterations of physical habitat, defined here as changes in the structural geomorphic or vegetative features of stream channels, can adversely affect aquatic organisms. Many human activities and land uses can lead to myriad changes in in-stream physical habitat. Mining, agriculture, forestry and silviculture, urbanization, and industry can contribute to increased sedimentation (e.g., via increased erosion) and changes in discharge patterns (e.g., via increased stormwater runoff and point effluent discharges), as well as lead to decreases in streambank habitat and instream cover, including large woody debris (see the Sediment and Flow modules for more information on sediment and flow related stressors).

Direct alteration of streams channels also can influence physical habitat, by changing discharge patterns, changing hydraulic conditions (water velocities and depths), creating barriers to movement, and decreasing riparian habitat. These changes can alter the structure of stream geomorphological units (e.g., by increasing the prevalence of run habitats, decreasing riffle habitats, and increasing or decreasing pool habitats).

Typically, physical habitat degradation results from reduced habitat availability (e.g., decreased snag habitat, decreased riffle habitat) or reduced habitat quality (e.g., increased fine sediment cover). Decreases in habitat availability or habitat quality may contribute to decreased condition, altered behavior, increased mortality, or decreased reproductive success of aquatic organisms; ultimately, these effects may result in changes in population and community structure and ecosystem function. Narrative and conceptual model can be found on the EPA CADDIS webpage here.

3.3.4. Candidate cause: Elevated 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 macroinvertebrates. 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

The newly adopted river eutrophication standard for the South River Nutrient Region is a maximum total phosphorus (TP) concentration of 150 µg/L. Total phosphorus is the causative variable involved with this standard. Also at least one response-variable must be above a threshold value, or out of a desired range. The appropriate response variables for the South River Nutrient Region are listed below:

Chlorophyll a	35 µg/L
Dissolved oxygen flux	≤4.5 mg/L
Biochemical oxygen demand	≤3.0 mg/L
Periphyton density	150 mg chlorophyll a / sq. meter

Ecoregion data are available to show if specific data from the Cedar River Watershed are within the expected norms (http://www.pca.state.mn.us/index.php/view-document.html?gid=14947). The Cedar River system is within the Western Cornbelt Plains aquatic ecoregion, where the following TP values have been found from minimally-impacted streams from 1970-1992:

Total Phosphorus µg/L

25%	50%	75%
210	270	350

Phosphorus in the Cedar River Watershed

As shown the Cedar River Watershed Monitoring and Assessment Report (MPCA 2012), concentrations for the three year period from 2008 through 2010 show that 94%, 100%, and 93% of the individual TP samples exceeded the 150 µg/L standard, respectively. Figure 25 from the report shows that all of the FWMC for those same years are 0.311, 0.390, and 0.355 mg/L, respectively, more than twice the water quality standard.

The Cedar River was also included in a broader assessment of phosphorus in 2004, which resulted in the Detailed Assessment of Phosphorus Sources to Minnesota Watersheds (MPCA 2004). Sources (point and nonpoint) of both TP and bioavailable phosphorus (BAP) were estimated for dry conditions (low flow), average conditions, and wet conditions (high flow). It is useful to note that while the water quality standard is set for TP, the forms of phosphorus that are readily available to the plant and microbial communities is a part of the TP. In general, the association of phosphorus with particulate or organic matter reduces bioavailability. Bioavailable phosphorus is normally dominated by the dissolved inorganic phosphate, also called orthophosphate.

Specific and relevant information contained in the Detailed Assessment of Phosphorus Sources document (MPCA 2004) regarding the Cedar River are outlined below.

Total Cedar River Watershed in Minnesota drainage area	1,028 sq. miles
Total point source phosphorus load	62.8 tons/year
Average soil phosphorus content in the Cedar River Basin	
· Area-weighted Bray-P	32.21
· Area-weighted average soil TP content	529.84 mg/kg

Estimated annual basin load by phosphorus, by form, and flow condition (tons/year)

Stream flow	TP	TotalDP	TotalPP	Total BAP
Low flow	15	2	13	4
Average flow	119	19	99	37
High flow	257	49	207	86

TP = Total phosphorus
Total DP = Total dissolved phosphorus
Total PP = Total particulate phosphorus
Total BAP = Total bioavailable phosphorus

During the development of the river nutrient standards for Minnesota, MPCA staff developed some phosphorus statistics for Minnesota streams. The following Cedar River Watershed streams were displayed in a map format (MPCA 2013b, Figure 56), with data from January 1995 to March 2009:

Stream / River Name	Mean TP (ug/L)	Stream AUID# (description)
Cedar River, Headwaters	243	07080201-503 (Headwaters to Roberts Cr.)
Cedar River, Middle	368	07080201-515 (Turtle Creek to Rose Creek)
Cedar River, Lower	336	07080201-501 (Rose Creek to Woodbury Cr.)
Turtle Creek, Upper	207	07080201-538 (Turtle Creek)
Turtle Creek, Lower	117	07080201-540 (lowest 3 miles)
Deer Creek	172	07080201-546 (tributary to Turtle Cr.)
Rose Creek	124	07080201-522 (overall creek length)
Un-named tributary	75	07080201-504 (in Roberts Creek subshed)
Little Cedar River	89	07080201-518 (overall river length)

With this longer data set for some of these sites, all but three of the stream sites are less than the TP water quality standard of 150 µg/L.

Another source of complimentary phosphorus data is the MPCA's watershed pollutant load monitoring network, which calculates FWMC and pollutant loads at specific river monitoring sites. For the main Cedar River below Austin site (Hydstra E48020001), where the watershed drainage area is 255,360 acres, the following FWMCs were calculated for both TP and dissolved ortho-phosphorus (DOP) for 2008-2012 (n=21-50 samples /year).

Year	TP-FWMC (µg/L)	DOP-FWMC (µg/L)
2008	311	234
2009	390	314
2010	331	258
2011	320	227
2012	No data	542

All of the TP concentrations are well above the water quality standard of 150 µg/L. Dissolved ortho-phoshorous accounts for 70-80 % of the TP, for this time sequence.

One caution regarding TP concentrations is that 2012 samples may be biased low due to lab methodologies.

Sources and causal pathways model for excess phosphorus

This detailed assessment of phosphorus report confirms the importance of both PS and nonpoint source (NPS) phosphorus loading in the Cedar, with point sources most significant at low flows (66% PS: 34% NPS), with those percentages switched for high flow conditions (32% PS: 68% NPS), and at average flow conditions, the ratio is more even (47% PS: 53% NPS). The importance of streambank erosion under high flow conditions should be noted, as these sediments are a source of phosphorus, and also physically affect channel conditions and aquatic habitats. Other nonpoint sources of phosphorus are croplands and pastures, urban runoff, subsurface sewage treatment systems (SSTS), and atmospheric deposition. Point sources of P are dominated by two categories - human wastewater products and commercial and industrial process waters (MPCA 2004).

A conceptual diagram of causes and potential sources for excess phosphorus are modeled at [EPA's CADDIS Nutrients webpage].

3.3.5. Candidate cause: Total suspended solids

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 (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). Sediment can also cause increases in water temperature through particles trapping heat.

The presence of algae and other volatile solids, such as detritus in the water column can contribute to elevated TSS concentrations and high turbidity. Total suspended volatile solids (TSVS) can provide a rough estimation of the amount of organic matter present in suspension in the water column. Elevated TSVS concentrations can impact aquatic life in a similar manner as suspended sediment-with the suspended particles reducing water clarity. Unusually high concentrations of TSVS can also be indicative of nutrient imbalance and an unstable DO regime.

Water quality standards

The water quality standard (WQS) for aquatic life support has changed during the development of this effort for the Cedar River Watershed. The old WQS was based on the optical measurement of turbidity, with 25 Nephelometric Turbidity Units (NTU) being the standard for Class 2B waters, such as those in the Cedar River Watershed. The MPCA developed a new regionally-based WQS for TSS that took effect in August 2014. This new and current TSS standard for the region that includes the Cedar River is 65 mg/L (a concentration-based standard). The organic portion of suspended sediment is estimated with a test for volatile suspended solids (VSS). The remainder of TSS (i.e. the non-organic component) is composed of mineral material, often dominated by silts, clays, and fine sand particles. For assessment purposes going forward, this concentration is not to be exceeded in more than 10% of samples, within a 10-year data window.

For the purposes of SID, transparency tube measurements, secchi tube measurements, TSS and VSS have been used to estimate and/or quantify the suspended material present, from which conclusions can be made regarding the effects of suspended solids on fish and macroinvertebrate populations.

For those seeking more information on the change from turbidity to TSS, and other background information on suspended sediment, the reader is referred to MPCA's Aquatic Life Water Quality Standards Draft Technical Support Document for Total Suspended Solids (Turbidity), at MPCA (2011).

Turbidity, TSS, and VSS are specific water testing methods utilized for obtaining representative data for a stream or river. It should be understood that these methods are for water column estimates, and do not include bedload. Bedload materials are heavier particles which "bounce" along the stream bottom or bed. And under periods of higher flows and velocities, the heavier particles such as sands can be entrained and brought up in the water column. Field observations in many streams in the Cedar River Watershed have shown that sands are the most active bedload component. Because these sands can rapidly "drop out" into coarser substrates in riffles, they have a negative effect on benthic macroinvertebrate community overall. Ongoing applied research work in Minnesota will help with future assessments for an overall and comprehensive evaluation of stream sediment.

Turbidity in the Cedar River Watershed

Currently, there are eight AUIDs in the Cedar River Watershed that are impaired for turbidity (Table 7). Of those, three 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 Cedar River Watershed 42 smallmouth bass were surveyed. Twenty-four smallmouth bass were surveyed in the Cedar River, 6 in Dobbins Creek, 5 in Turtle Creek, 4 in Rose Creek and 3 in the Little Cedar River.

Table 7: Cedar River Watershed reaches impaired for turbidity.

Assessment Unit	ID	Added to Inventory
Cedar River: Woodbury Cr to MN/IA border	07080201-516	2012
Dobbins Creek: T103 R18W S36, east line to East Side Lk	07080201-535	2012
Cedar River: Roberts C to Upper Austin Dam	07080201-502	2002
Cedar River: Turtle Cr to Rose Cr*	07080201-515	2012
Rose Creek: Headwaters to Cedar R	07080201-522	2012
Dobbins Creek: East Side Lk to Cedar R	07080201-537	2006
Turtle Creek: T102 R18W S4, north line to Cedar R*	07080201-540	2006
Cedar River: Rose Cr to Woodbury Cr*	07080201-501	2002

Another source of complimentary TSS data is the MPCA's watershed pollutant load monitoring network, which calculates FWMC and pollutant loads at specific river monitoring sites. For the main Cedar River below Austin site (Hydstra E48020001 and AUID 07080201-515), where the watershed drainage area is 255,360 acres, the following FWMC and mass was calculated for TSS, for 2008-2012 (n=21-50 samples /year).

Year	TSS-FWMC (mg/L)	TSS Mass (Tons)
2008	148	49,036
2009	34	7,120
2010	30	13,411
2011	33	14,420
2012	17	1,477

The highly variable mass is related to both the concentration variability from year to year, noted in the FWMC column, as well as the stream flow, which varied for these five years from about 64,000 to 326,000 acre-feet of total water flow/ year.

Additional information regarding suspended sediment, turbidity, and TSS is briefly summarized below by the data collection source/agency. The reader wishing to obtain more sediment information should check with those referenced agencies.

Mower County

Mower County staff led an effort to sample area streams for water quality parameters in 2000 and 2001. A total of 15 sites were sampled in Mower County, and based on the short-term duration of the study, staff reported that suspended solids were consistently lower north of Austin, and increased in the Cedar River south of Austin. Of all sites, Turtle Creek showed the highest average TSS for both years (Mostrom, 2001).

Cedar River Watershed District

Cedar River Watershed District personnel have conducted a yearly water monitoring program since 2008. About 10 samples are collected from spring to fall, with graphs and statistics based upon concentrations. For example, in 2013 the stream sites with the highest TSS concentrations were both on Rose Creek (200-300 mg/L TSS), while most of the other sites were below 65 mg/L TSS (CRWD 2015).

U.S. Geological Survey

The U.S. Geological Survey (USGS) has maintained a river gauging station on the Cedar River south of Austin since 1909. The site identification number is 05457000, and the drainage area is 399 square miles. Suspended sediment concentration was collected at this site by USGS personnel from March 1971 to September 1981. There are 355 suspended sediment concentration values collected for that 10-year timeframe, which provides some helpful comparison data to our current watershed conditions of land use/land management, as well as rainfall-runoff and stream suspended sediment conditions 30-40 years ago. The MPCA utilized these USGS data to develop some stream flow and suspended sediment relationships, which for the Cedar River, the following were reported (MPCA 2004):

- Estimated bankfull discharge rates from flow frequency analysis:
  - Entire period of flow record: 3068 cubic feet per second (cfs)
  - Suspended sediment record: 3,279 cfs

Note: there are a few other relevant items that can be used from the 2004 MPCA Lower Mississippi River Basin Regional Sediment Report that are applicable to this SID.

The bankfull stream discharge, which occurs on a frequency of every 1.5-2.0 years, is an important factor in stream channel morphology, and consequently for stream habitat conditions.

Sources and causal pathways model for turbidity

A conceptual diagram of causes and potential sources for increases in turbidity are displayed 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 and stream channels. A variable mix of perturbations in the landscape are involved, such as channelization of waterways, agricultural drainage, riparian land cover alteration, loss of water storage, and increases in impervious surfaces. The current estimate is that about 40% of the stream sediment in the mainstem Cedar River is derived from in-channel sources; predominantly the stream banks (MPCA 2012).

In the Cedar River Watershed, June is often the month in which the highest levels of TSS concentrations are recorded. However, this is a function of the current land use and crop covers in the watershed, and the type and timing of a given storm event. Higher inorganic suspended sediment concentrations are often seasonal, with peaks occurring in the spring, before a crop canopy is established. But, heavier rainfalls onto soils that are wet, can result in erosion and suspended sediment transport, when the crops are actively growing (June – August).

3.3.6. Flow alteration

Increasing surface water runoff and seasonal variability in stream flow have the potential for both indirect and direct effects on fish populations (Schlosser, 1990). Indirect effects include alteration in habitat suitability, nutrient cycling, production processes, and food availability. Direct effects include decreased survival of early life stages and potentially lethal temperature and oxygen stress on adult fish (Bell, 2006). Increased channel shear stress, associated with increased flows, results in increased scouring and bank destabilization. The fish and macroinvertebrate communities may be influenced by the negative changes via loss of habitat and increased sediment.

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 macroinvertebrate community may be negatively impacted by these changes to habitat and sediment. High flows can also cause the displacement of fish and macroinvertebrates 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 macroinvertebrates, 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 populations. Macroinvertebrates 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. (2010) found that there is a strong correlation between diminished streamflow and impaired biological communities. 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 outcompete more sensitive taxa, and this can result in an increase in tolerant populations. Low flows of prolonged duration tend to lead to macroinvertebrate and fish communities that have preference for standing water or are comprised of generalist species (CADDIS 2011; Olden and Kennard 2009).

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). Twelve nest guarding species (excluding lithophilic spawners) are found in the Cedar River Watershed (most common in the Cedar River Watershed are bluntnose minnows, johnny darters, fathead minnows and brook stickleback).

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 macroinvertebrate 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).

Tile drainage

Agricultural drainage systems are used to intentionally reduce soil moisture by moving precipitation or irrigation waters from subsurface soils, through pipe, and eventually into ditches or streams and thereby altering flow. Figure 10 shows an example of a drain tile outlet draining to a nearby stream in the Cedar River Watershed.

For a current and straightforward review of agricultural tile drainage as well as surface drainage features such as drainage ditches, please see Chapters 8 and 9 in Part 1 of the University of Minnesota (2015) report titled *Field to Streams*. As a general conclusion, this report acknowledges that while there is wide variation, tiles tend to increase the amount of water leaving a field (i.e. increase water yield from 5-10%). And on a larger watershed scale, subsurface drainage systems generally do not increase the height of peak flows, but do increase the duration of elevated flows. The overall impact of agricultural drainage systems depends on the interplay of six important factors:

- Type of drainage
- Scale of impacts
- Precipitation patterns
- Field conditions
- Conditions in the rest of the watershed
- System design and landscape details

Eighty-eight percent of the Cedar River Watershed consists of cultivated cropland. Of that, based on Geographic Information System (GIS) analysis, 38% of the entire watershed area is drained by field tile. This is likely an underestimate due to GIS data limitations, and general lack of specific data. Tile drainage areas were predicted using land cover, soil hydrologic group and surface slope (MPCA, 2014 N Study).

Figure 10: Example of a drain tile outlet to a stream in the Cedar River Watershed.

Channelization/ditching

Ditching is defined as the digging of a trench to divert water where no channel previously existed. Channelization is the process of straightening a preexisting natural channel. Drainage ditches are a common feature in Minnesota watersheds dominated by agricultural land uses. There is an estimated 27,000 miles of drainage ditches in the state, many of which have been in place since the turn of the 20th century. Figure 11 shows an example of a channelized stream located in the Cedar River Watershed.

Channelization and or ditching will also change the flow regime for a waterway. The result is increased peak discharges and often reduced baseflow. As water is diverted from the landscape and routed through manmade or altered channels, there are losses of habitat features. The habitat features that are commonly affected include loss of pool depth, increased embeddedness of gravel and cobble in riffles, loss of floodplain connectivity, and often loss of woody material in the channel. The flow regime is increasingly viewed as the key driver of the ecology of wetlands, streams, and associated floodplains. The alteration of flow regimes affects ecosystem structure and function, which may shift the dominance in native community assemblages and facilitate the invasion and success of exotic and introduced species (Bunn, 2002).

Figure 11: Example of a channelized stream in the Cedar River Watershed.

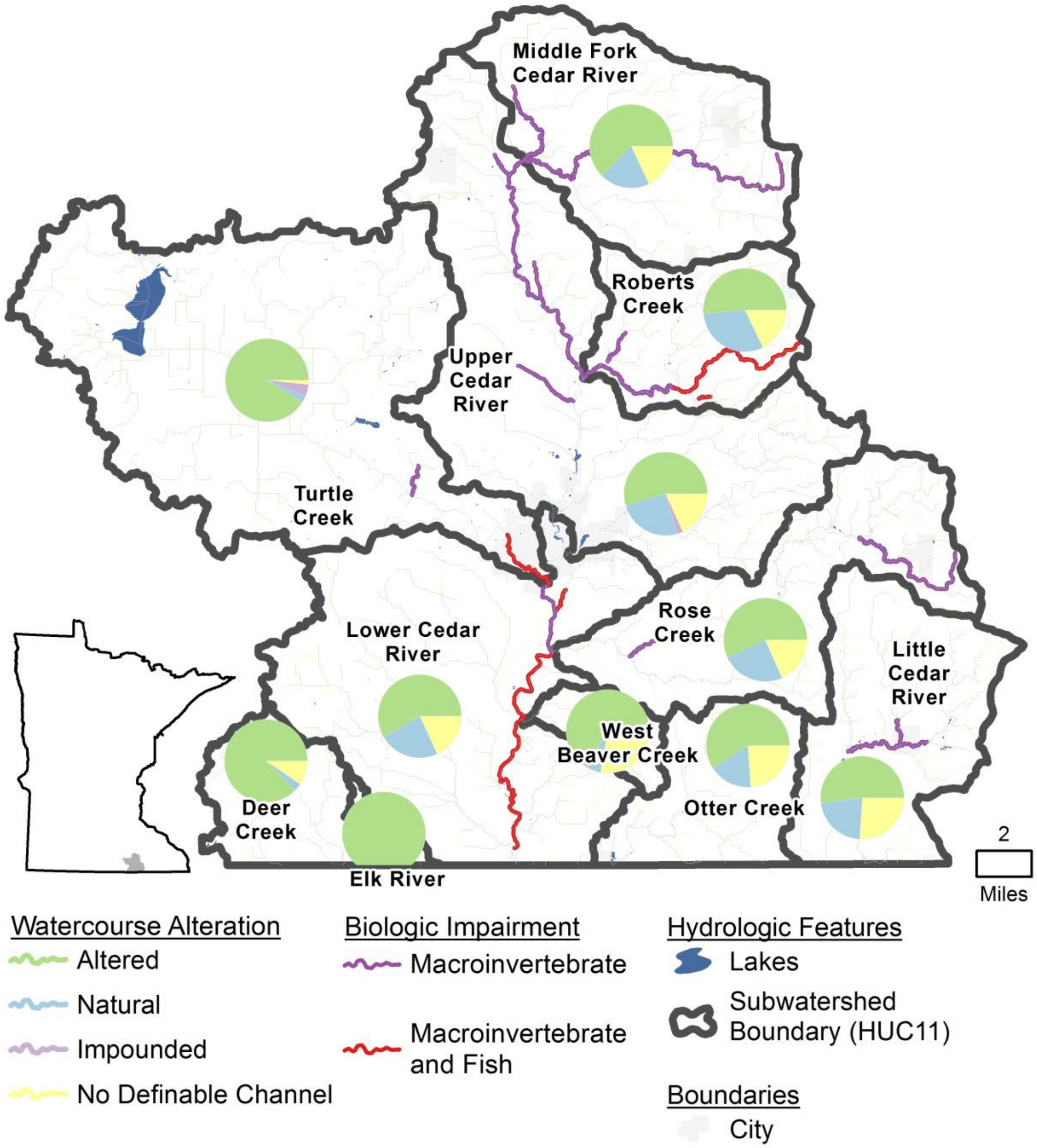


Figure 12: Watercourse type category for HUC 11 subwatersheds in the Greater Cedar River Basin in Minnesota.

On a hydrologic unit code scale as shown in Figure 12, the alteration of watercourses average is about 60%, with a range from 50-85%.

Water quality standards

There is not a specific standard regarding the alteration of maximum peak flows. The standard for minimum streamflow, according to Minn. Stat. 7050.0210, subp. 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 Cedar River Watershed

Stream flows in the Cedar River Watershed system result from an interaction of complex factors, including land use, land management, soils, topography, and an array of climatic factors. Peak flows are one important aspect of stream hydrology, which affect both water quality and stream channel conditions.

The peak flows in a river are a response of overland and shallow subsurface pathways. In urban areas (about 7% of the land), runoff can occur rapidly due to impervious surfaces, and peak flows can occur quickly. In rural areas (about 83% of the land), peak flows can occur fairly rapidly, or over a more prolonged period of time, depending upon the drainage area, soil moisture conditions, crop status, and type of storm event. Some stream reaches in the Cedar River system have flows derived from both urban and rural areas, while many smaller streams and the mainstem Cedar above Austin exhibit runoff from mainly rural areas.

Baseflow, which sustains river flow between runoff events, is supplied by aquifers (derived from various subsurface paths). An increase in surface runoff and/or subsurface runoff can result in more flow volume in the river channels. This in turn can increase channel scour and more water diverted into surface channels could equate to a long-term reduction in infiltration, which lowers the water table and reduces the seasonal baseflow component (Poff et al., 1997).

A long term (since about 1910) stream flow record is available for the Cedar River below Austin, at the stream monitoring site maintained by the USGS (Gage # 0457000). Some recent statistical analysis of these data shows that stream flows have increased during the timeframe of 1981-2010, when compared with the entire period of record (Minnesota Department of Natural Resources). Since 1979 on the Cedar River, the deviation is showing an increasing amount of runoff per value of precipitation (Figure 14). The change in slope relationship indicates runoff from the watershed is increasing relative to the amount of rain. Within the entire data set, both low and high annual precipitation volumes were recorded suggesting that a period of wet or dry conditions does not affect this relationship. Looking at overall trends for the Cedar River

Figure 15), the discharge and precipitations values show the precipitation trend is fairly flat, while the discharge trend is increasing, thus supporting an alteration of stream flows.

The Cedar River Watershed has experienced decades of activities that have cumulatively led to flow alterations- these actions include land use conversions, ditch construction, channelization, draining of wetlands, installation of dams, tile drainage and stormwater systems, and increasing impervious surfaces (Figure 13). For example, in the Turtle Creek Watershed a large wetland complex was drained and ditched in the late 1800s and early 1900s and planted to vegetable crops (Albert Lea Farms Company and Payne Investment Company). Rivers that have been straightened, deepened, and widened will, in general, decrease their stability and natural function and will create maintenance problems (Rosgen, 2006). To sum up, the interplay of these factors and conditions, across this complex watershed, can cause an increase in the surface or subsurface drainage runoff, for a given runoff event.

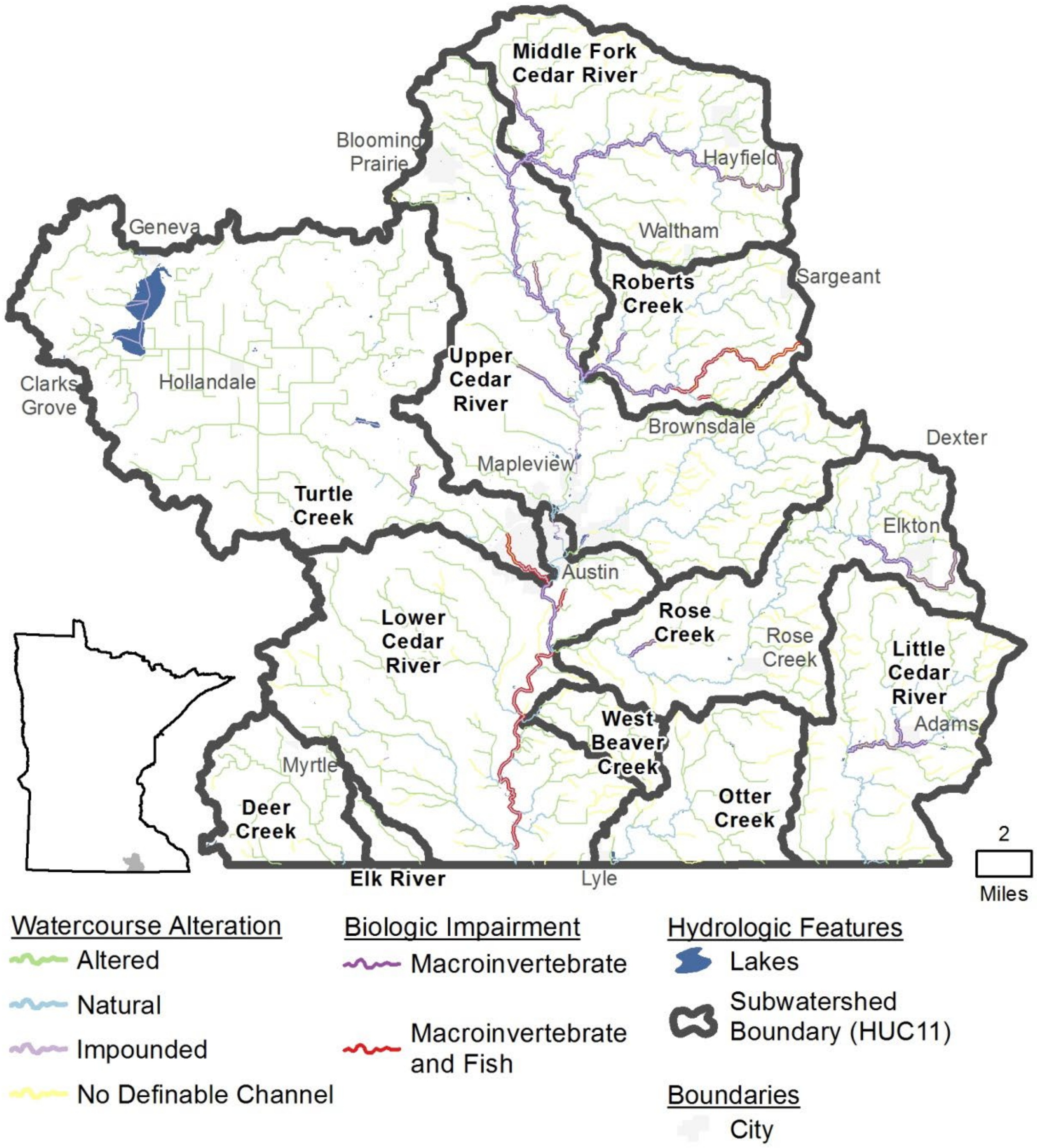


Figure 13: Watercourse alteration categories and impaired biota reaches in the Cedar River Watershed.

Erosion within the stream channel is an important source of sediment for streams in Southern Minnesota. The flow conditions in a stream are an important factor in stream bank erosion, which is a natural process, but has been accelerated due to changes in land use and climate. When streambank erosion occurs at an excessive rate, it can lead to a disproportionate sediment supply, stream channel instability, land loss, aquatic habitat loss and other adverse effects (Rosgen, 2006). Stream systems are adjusting to manage new discharge and sediment loads.

In the nearby watershed of the Minnesota River Basin, 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, intensifying 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 basic premise of our water quality work in the Cedar River Watershed comes from an awareness of cumulative effects of many activities over the decades. The transformation in land use has affected hydrology, which has created multiple stressors to the aquatic environment. The Cedar River's increased delivery of water, sediment, and nutrients now represents an important water quality problem that requires action.

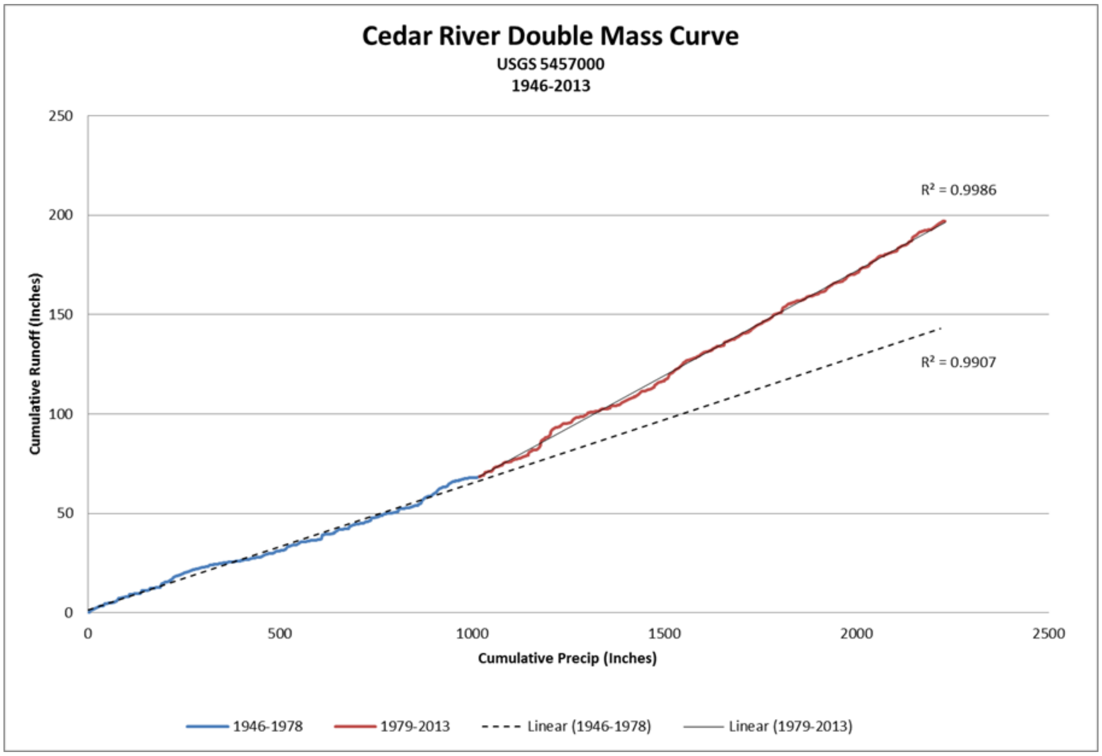


Figure 14: Runoff versus precipitation on the Cedar River in Austin (MDNR).

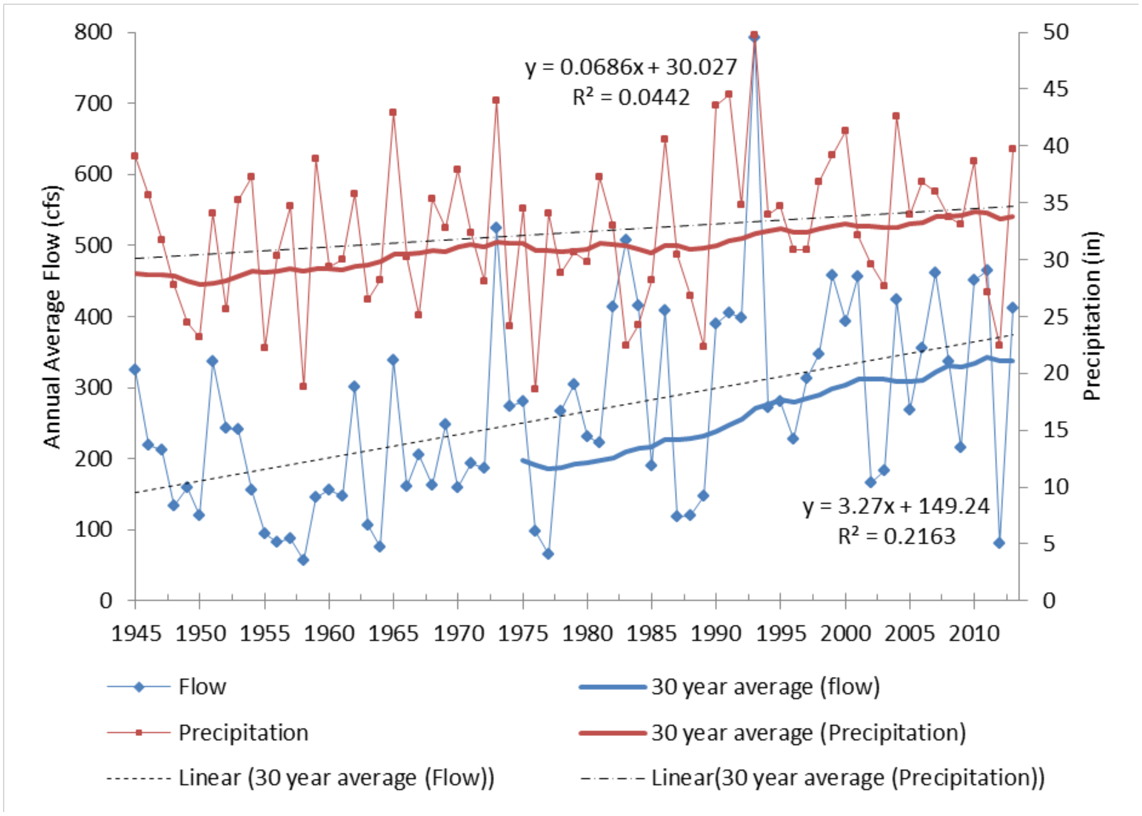


Figure 15: Cedar River average annual flow and total annual precipitation near Austin, MN, 1945 – 2013.

"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 biological community in the Cedar River is impacted directly by flow conditions. 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. Variability in the biological response is expected across the watershed, as flows scour in some areas and deposit in others.

The biological community is also impacted by response stressors that result from an altered hydrologic regime. The two main stressors that come into play here are lack of habitat and sediment issues. Tolerant organisms are able to take over when there is change in stream function. The percent of tolerant macroinvertebrate individuals ranges in the Cedar River Watershed from 64 to 100% (Figure 16). In many of the head water reaches, the number of tolerant species was particularly high. Additionally, the range of tolerant fish individuals in the Cedar River Watershed was from 0 to 100%, with the highest percentages of tolerant fish present in the subwatersheds of Turtle Creek and Rose Creek (Figure 19).

Another indication of hydrologic alteration is the reduction of long lived species (Olden and Kennard 2009). Long lived fish were also reduced in some areas of the Cedar River Watershed, with a high percentage of short lived fish (Figure 20 and Figure 21). Long lived macroinvertebrates also have a tendency to decrease with changes in hydrologic regime. The percentage of long lived macroinvertebrates was fairly low, ranging from 0 to 22% (Figure 18).

Flow changes can increase the percentage of macroinvertebrates that are swimmers. Throughout the watershed there were varying percentages of swimmers, likely due in part to the varying habitat present (Figure 17). The average percentage of swimmers in natural channels of the Cedar River Watershed was 7%, and ranges from 0 to 59%.

The biological communities will vary in their response to hydrologic alteration. As the watershed has been changed, and the rainfall/runoff has changed, the aquatic environment has been affected and the biota has in turn changed.

Figures 16-21 that follow have various categories and scales, which vary depending upon the data being displayed. This is necessary in order to highlight the metrics being used in this discussion. The reader is cautioned to follow the scales carefully.

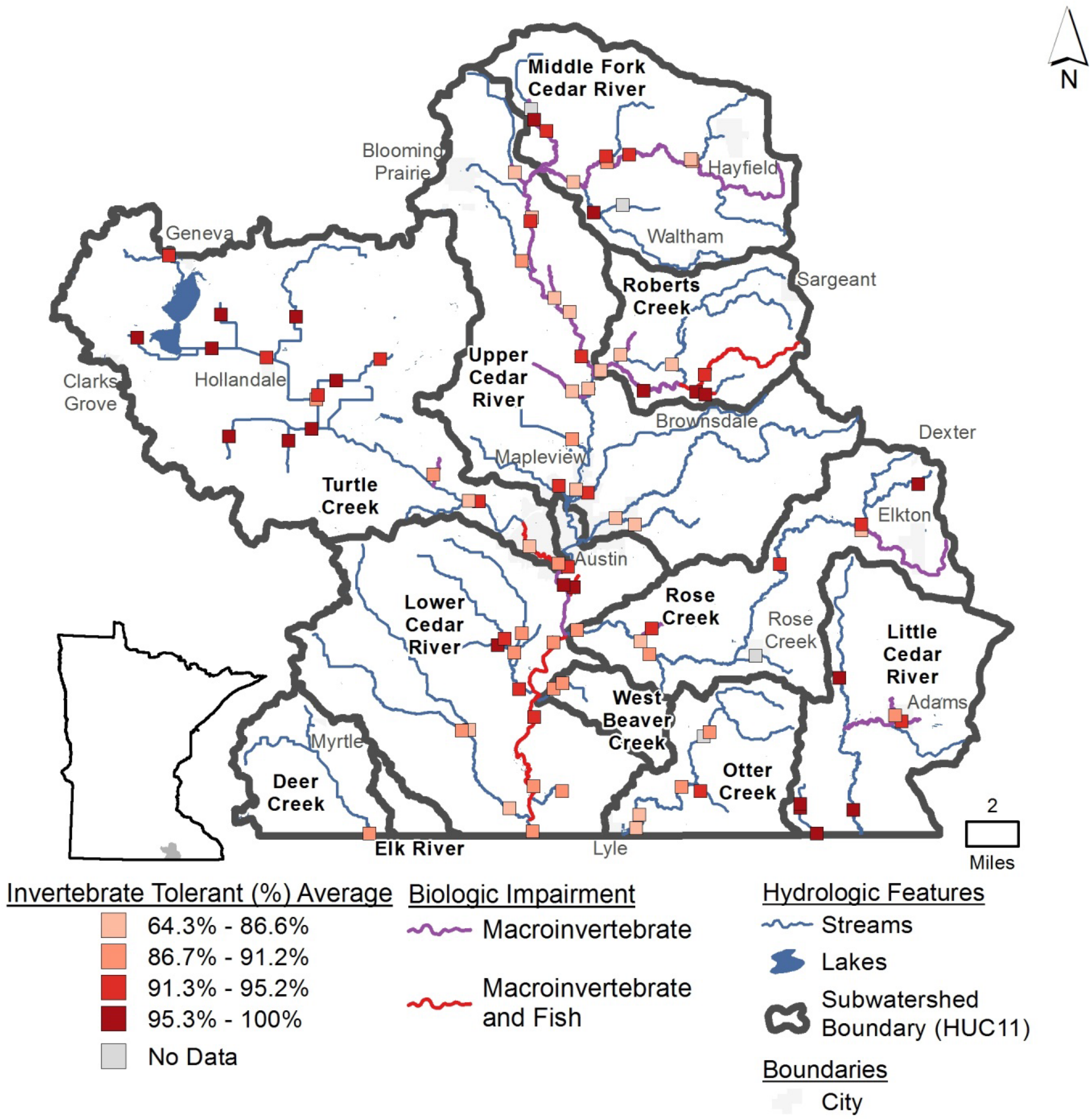


Figure 16: Percent tolerant macroinvertebrate individuals of the Cedar River Watershed.

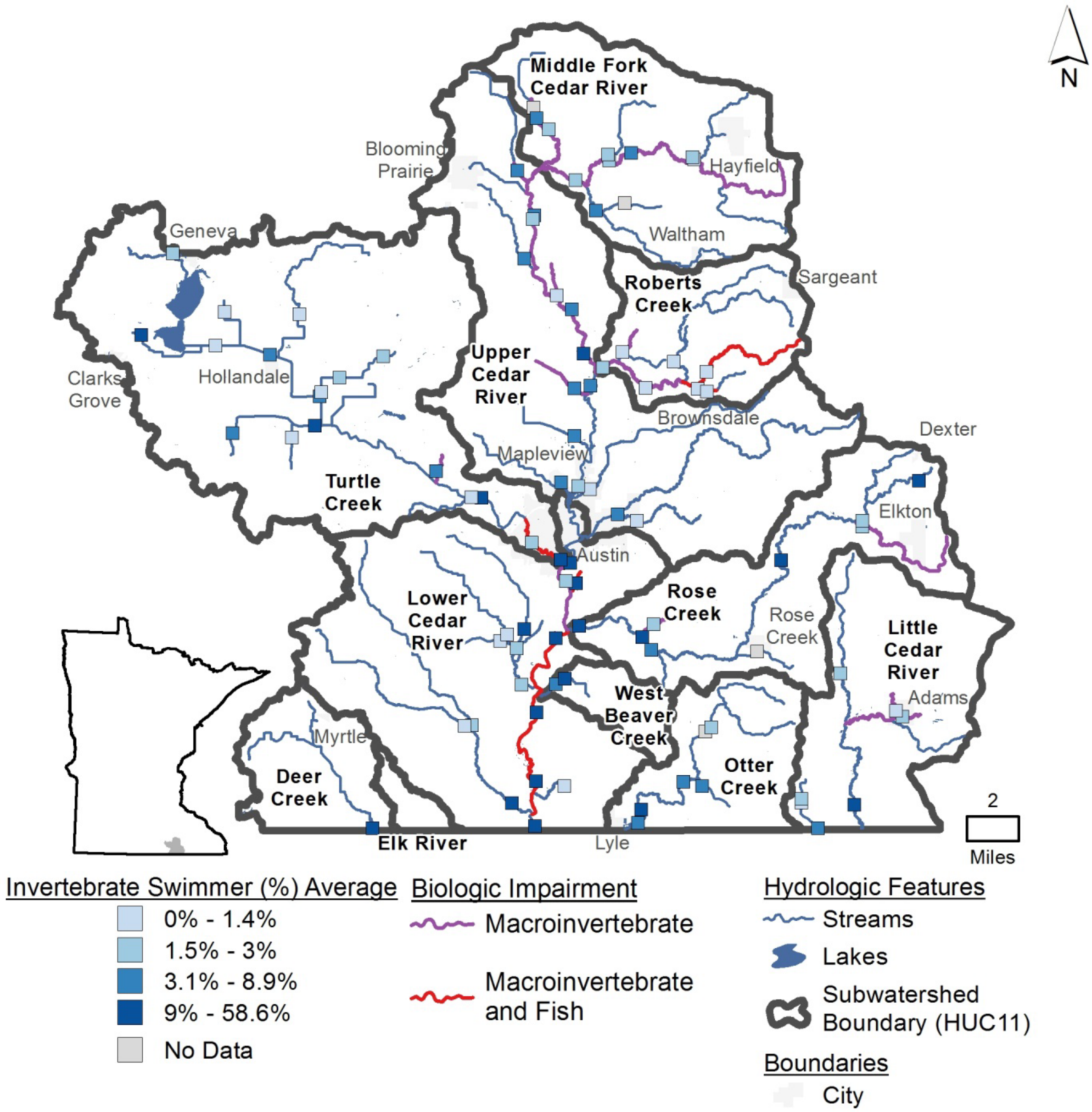


Figure 17: Percentage of macroinvertebrate swimmer individuals in the Cedar River Watershed.

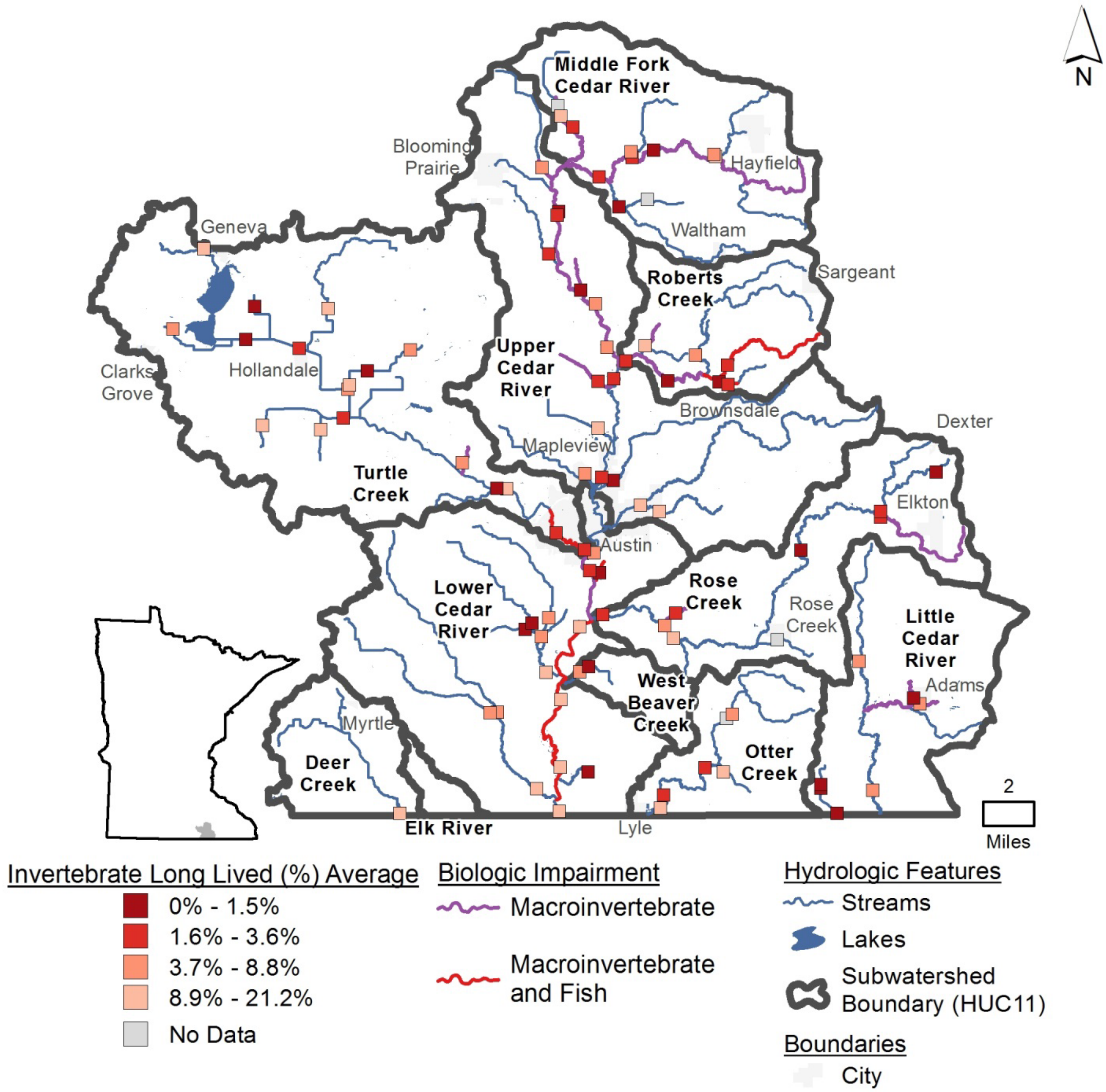


Figure 18: Percentage of long lived macroinvertebrates in the Cedar River Watershed.

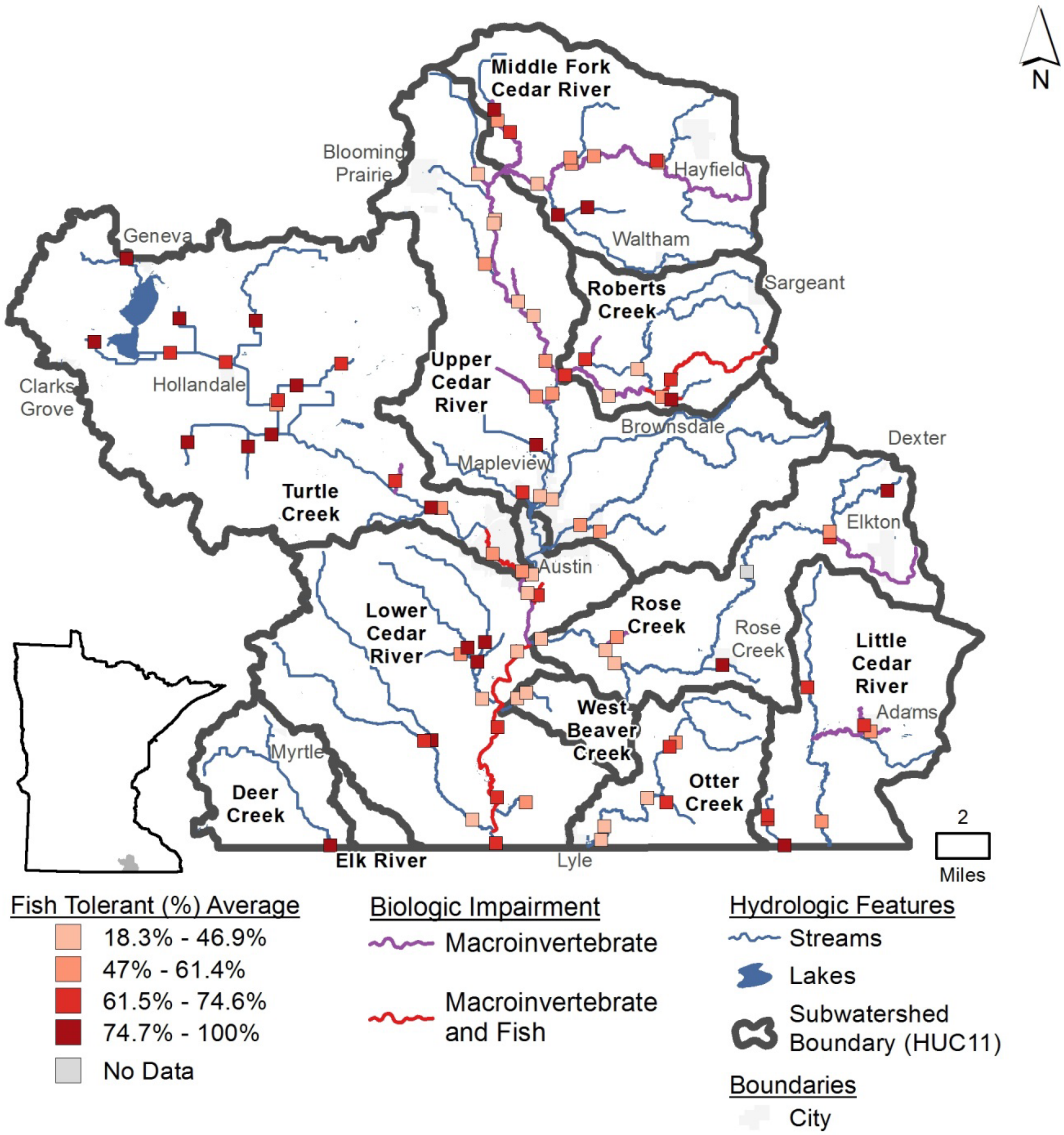


Figure 19: Percent tolerant fish individuals in the Cedar River Watershed.

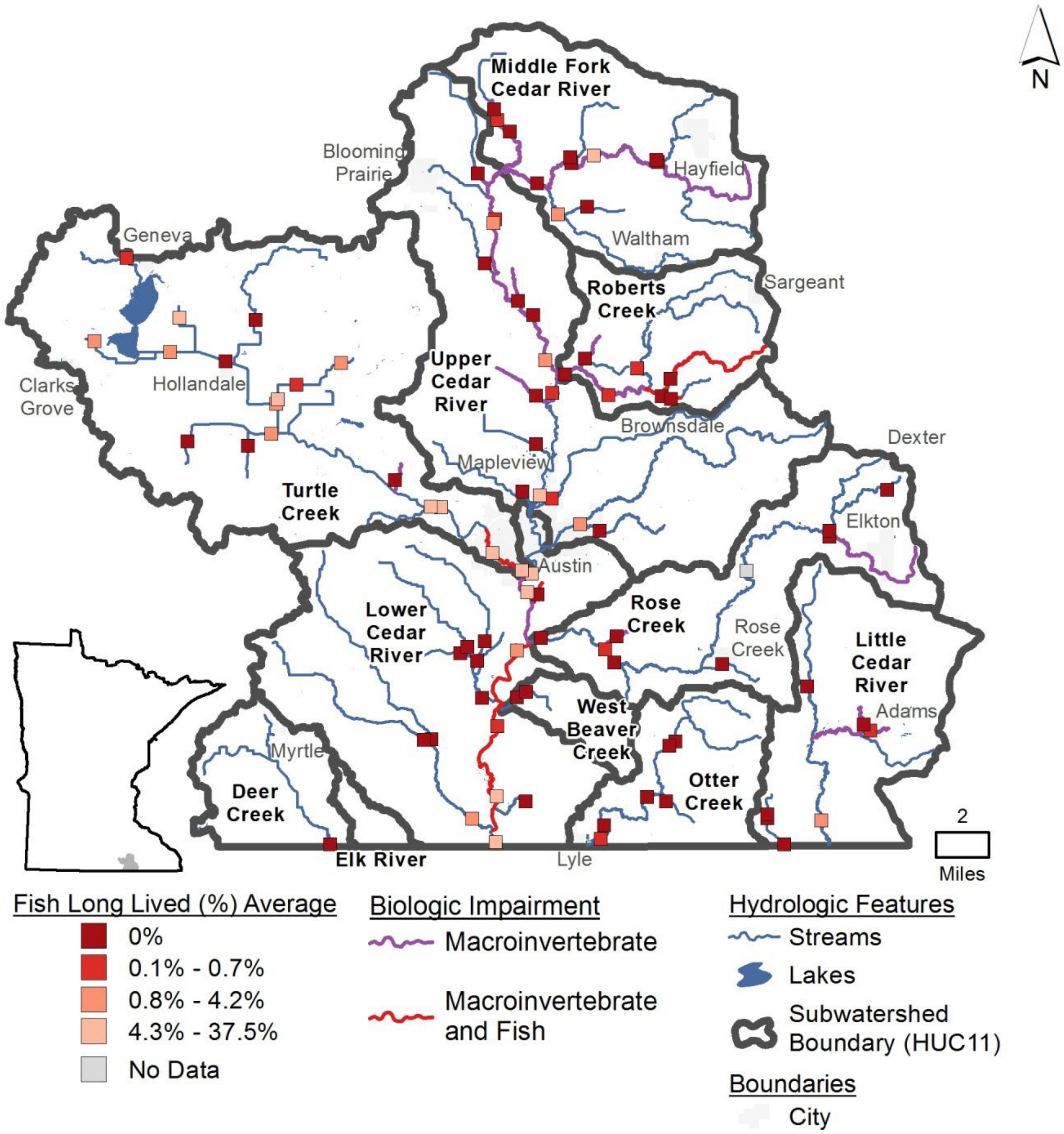


Figure 20: Percent of long lived fish in the Cedar River Watershed.

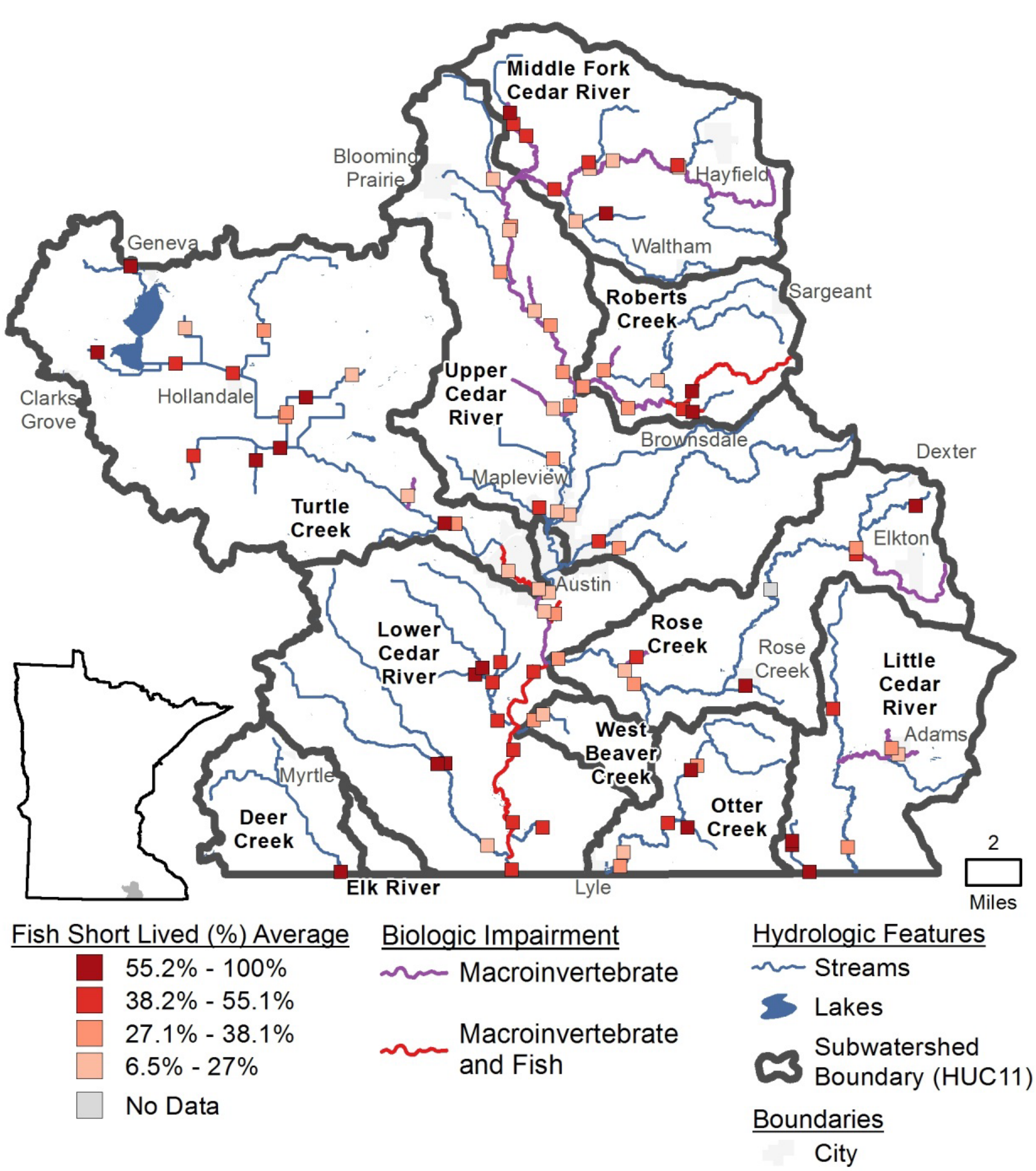


Figure 21: Percentage of short lived fish in the Cedar River Watershed.

Sources and causal pathways model for altered flow

The Cedar River Watershed has transitioned from tall grasslands, wetlands, oak savanna and maple basswood woodlands to agricultural land cover, with loss of wetlands and 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. The presence of drain tile was predicted in the watershed by utilizing a derived 100 meter resolution raster using the following criteria: 2009 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 to 3%; and Soil Survey Geographic Database (SSURGO) soil drainage classes of very poorly drained or poorly drained. The watersheds range from 29% to 57% predicted to have drain tile, and is a wide spread problem in the watershed (Figure 22). The Cedar River Watershed is in the top 10% of watersheds in Minnesota for the extent of estimated tile drainage (MPCA 2013).

Additional stream miles have been added to the Cedar River Watershed since the late 1800s and early 1900s, particularly in the headwater regions that cumulatively affect downstream streams and rivers. Additional stream miles change numerous facets of the hydrologic regime including timing and magnitude of both high and low flows.

A conceptual diagram of causes and potential sources for altered flow are modeled at EPA's CADDIS Flow Alteration webpage.

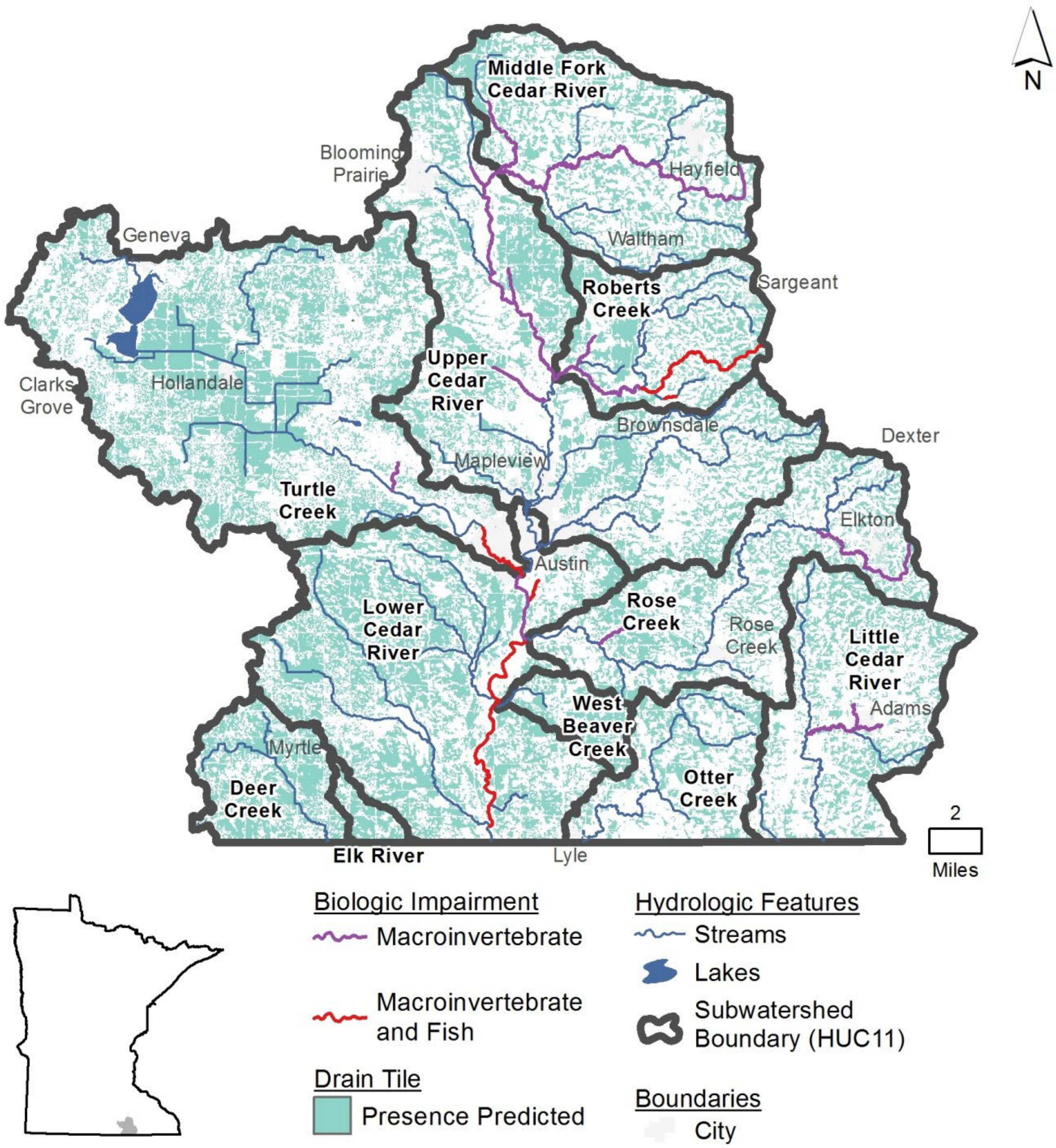


Figure 22: Predicted tile drainage presence, as a percent of the HUC11 watershed area. Tile drained is predicted to be present if three conditions are met: presence of row crops, slopes equal to or less than 3% and poorly drained and very poorly drained soils.

4. Middle Fork Cedar River Watershed Unit

The Middle Fork Cedar River Watershed Unit begins as a series of channelized streams that flow together to become three tributaries to the Cedar River. The west fork of the Cedar River begins north of Blooming Prairie and connects with the Cedar River just north of CSAH 2 near the Dodge/Mower County border. The east fork of the Cedar River begins near Hayfield and travels west until it connects with the Middle Fork of the Cedar River east of Blooming Prairie. The Middle Fork Cedar River Watershed Unit drains 72 square miles. Based on the NLCD 2011 Data, over 90% is used for agricultural production, of which, 88% is used for row-crop cultivation and 3.4% is in pasture. Of the remaining acreage, 7% is developed land.

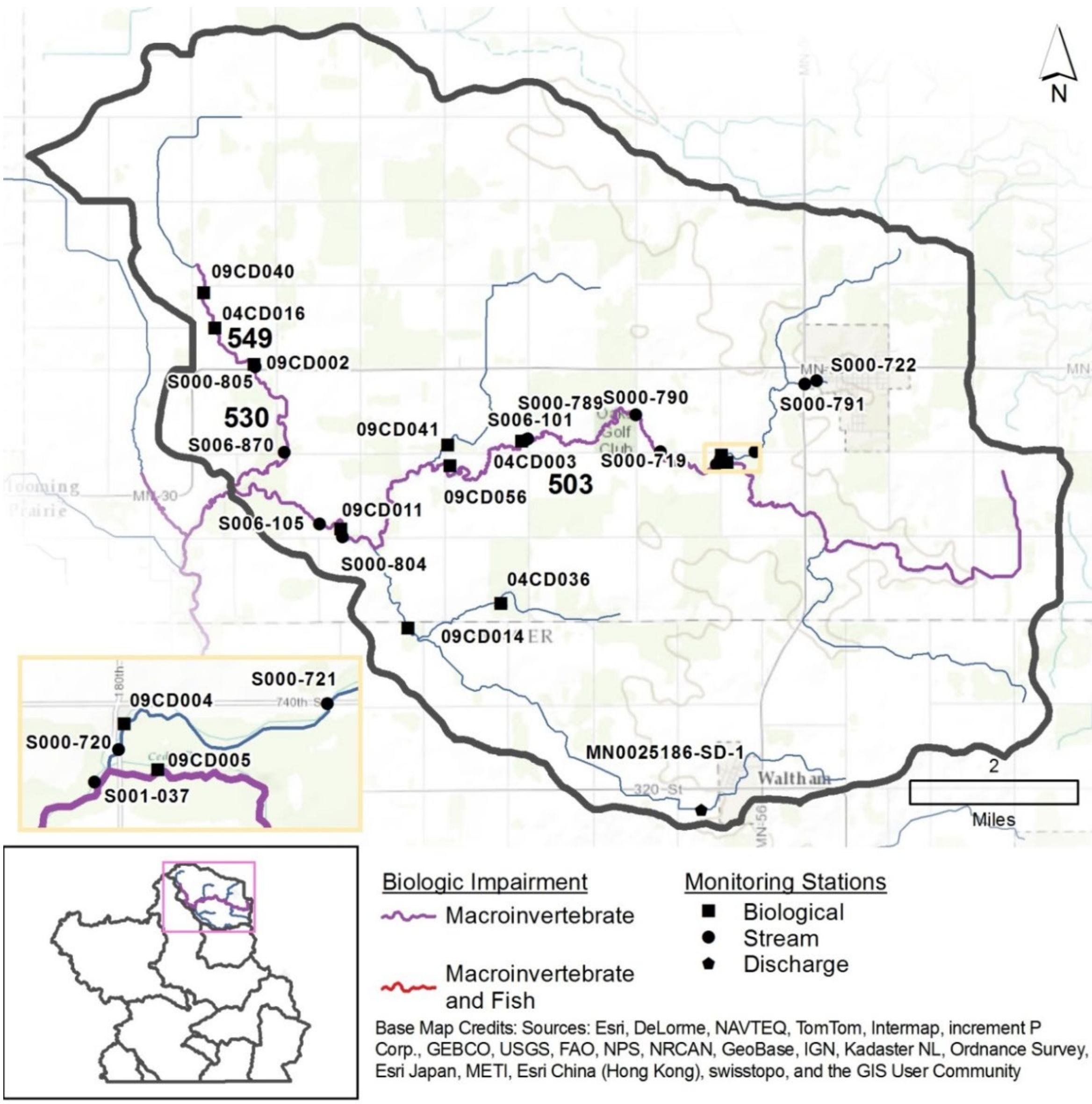


Figure 23: Map of biological impairments in the Middle Fork Cedar River Watershed.

4.1. Middle Fork Little Cedar River: Westfield-Ripley Ditch to unnamed creek (AUID: 07080201-549)

The impaired reach is located in Dodge County (Figure 23). The Middle Fork Little Cedar River (-549) is listed as non-supporting of aquatic life for aquatic macroinvertebrate communities. The stream reach is 1.35 miles in length.

Biological station 04CD016 was sampled in 2004 and an additional biological station (09CD040) was sampled in 2009 on the upper reach of the AUID, but was not assessable due to channelization.

There was not a water quality station on AUID 549. The only data available was the data collected at the time of fish sampling. It would be beneficial to collect samples in the future on AUID 549.

4.1.1. Biology in Middle Fork Cedar River

The Macroinvertebrate Index of Biological Integrity (M-IBI) was 36.71 for biological station 04CD016 (Table 8). The score was below the threshold of 46.8 for macroinvertebrate metrics of the Southern Forest Streams. It was noted that the station sampled in 2004 was sampled the day after the fish sampling occurred and the anthropogenic disturbance was apparent. The macroinvertebrate community is not meeting standards for biological station 04CD016. The Fish Index of Biological Integrity (F-IBI) score for station 04CD016 was 66, which is above the threshold and confidence interval for the Southern Headwaters class and are meeting standards.

Table 8: Summary of biological impairments in the Cedar River, Middle Fork.

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-549, Westfield-Ripley Ditch to unnamed creek	04CD016	Cedar River, Middle Fork	12.95	Southern Forest Streams	46.8	36.71	Southern Headwaters	51	66

Macroinvertebrates in the class Southern Forest Streams glide pool (GP) scored poorly in the metrics of intolerant taxa richness of (Intolerant2Ch), collector-filterers (Collector-filtererPct) and HBI_MN at biological station 04CD016 (Figure 24). The biological station also had a low percentage of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) and percentage of taxa that are clingers (ClingerChTxPct). The biological station scored above the average needed to be above the threshold in the metrics of Plecoptera, Odonata, Ephemeroptera and Trichoptera taxa (POET). The taxa richness of predators (PredatorCh) scored low at station 04CD016. Five species dominated the sample (DomFiveCHPct; 54.2%) and the percent tolerant taxa was really high (Tolerant2ChTxPct; 91.7%).

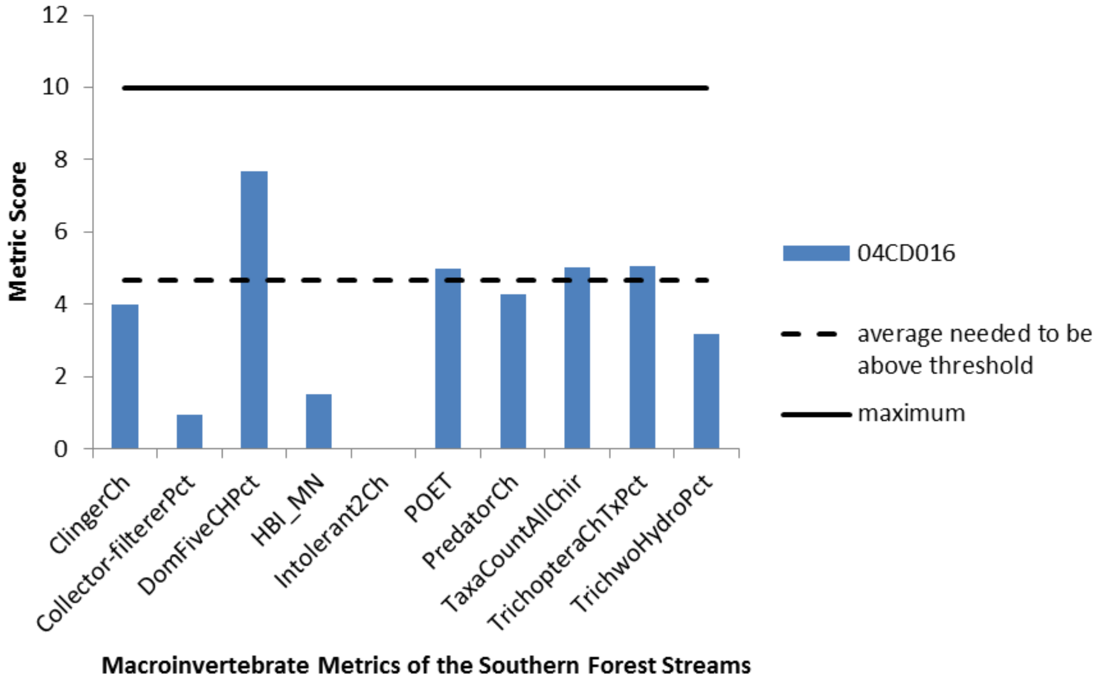


Figure 24: Macroinvertebrate metrics of the southern forest streams GP in biological station 04CD016.

This fish community was not listed as impaired. There was a lack of sensitive species at biological station 04CD016. The biological station had high metric scores for general taxa (GeneralTxPct), detritivore taxa (DetNWQTxPct), serial spawners (SSpnPct) and relative abundance of very tolerant taxa (VtolTxPct; (Figure 25). There were no fish deformities, eroded fins, lesions, and tumors (DELTs). If DELTs were present they would have contributed negatively to the IBI. The upper most station on stream reach (-549), 09CD040, is channelized and was not compared against the threshold (Table 9). This station did not have any sensitive taxa, had fish that are quick to mature, and are shortlived compared to the two downstream natural channels.

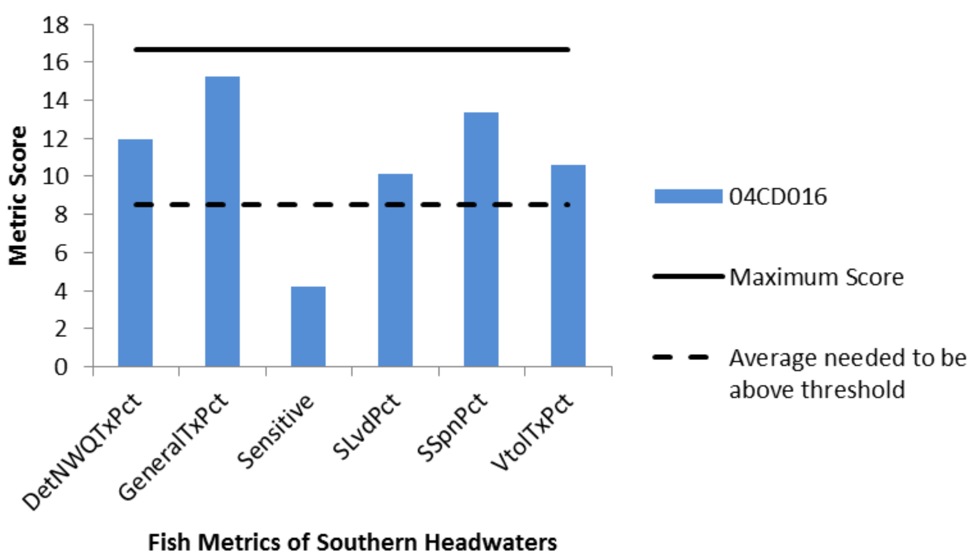


Figure 25: Fish metrics of the southern headwaters in biological station 04CD016.

Table 9: Fish metrics of the southern headwaters IBI for site 09CD040.

Site	DetNWQTxPct	GeneralTxPct	Sensitive	SLvdPct	SSpnPct	VtolTxPct
09CD040	9.54	7.25	0.00	6.16	4.36	4.51

4.1.2. Candidate cause: Lack of habitat/bedded sediment

Biological station 04CD016 scored 65.3 on the MSHA (fair; Table 10). It scored low due to low subcategory scores of substrate and channel morphology. The substrate MSHA score was 16.75. This indicates fine sediments and a lack of coarse substrate at the sampling location. There was little riffle present in the biological reach (5%). The channel stability was moderate and channel development poor.

The surrounding land use was noted as row crop with a wide (150 to 300 ft.) riparian buffer. There was little bank erosion on the left and right banks. Moderate cover was noted, with multiple cover types including undercut banks, overhanging vegetation, deep pools, logs or woody debris and macrophytes (Figure 26). The habitat that was sampled for macroinvertebrates was woody debris/snags/rootwads, undercut banks and overhanging vegetation. This site is lacking good quality riffles.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. The Middle Fork Cedar River Watershed is approximately 63% channelized. The watershed begins with a series of channelized streams. Current estimations are that this AUID is 40% channelized. Thirty-four percent of this watershed is tile drained to help move water off farm fields and to the streams rather quickly. This causes the flows of this stream system to become very inconsistent. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

Burrowers (12.3%) were found in abundance and found above the average for Southern Forest Streams GP macroinvertebrate class (8.66%; Figure 27). Burrowers may suggest potential fine sedimentation issues in the riffles. The percentage of ephemeroptera, plecoptera, and trichoptera (EPT) individuals (11.9%) was lower than the average for Southern Forest Streams GP macroinvertebrate class (30.9%). The percentage of generally tolerant legless macroinvertebrate individuals was high (78.7%). The macroinvertebrates that are known to cling to large substrate and woody debris (42.8%) were just above the mean for Southern Forest Streams GP.

The high percentage of tolerant legless insects and burrowers indicate a lack of quality, diverse habitat at station 04CD016. The upper portions of this AUID and above are channelized. The biological station was made up of 86.5% fine sediments, and when coarse substrates were present, they were 89.3% embedded with fine sediments. This evidence points to sedimentation and overall degradation limiting the macroinvertebrate community. Lack of habitat is a stressor in Cedar River, Middle Fork (-549), but not likely the primary stressor.

A geomorphology survey was conducted on the Cedar River, Middle Fork upstream of Highway 30 Bridge 2.5 miles northeast of Blooming Prairie in 2010. This study reach is classified as a C5c- stream type, with a sand dominated substrate and very low gradient. This stream reach is strongly influenced by the grass and emergent wetlands bordering the stream. The stream channel has very good floodplain connectivity and shows little channel incision or down cutting of the stream bed. The riparian corridor immediately above and below this reach is well intact and wide enough to preserve good floodplain function and channel maintenances.

Figure 26: Biological station 09CD040 on April 18, 2012 (Left) and biological station 04CD016 on September 1, 2004 (right).

Table 10: MSHA results for Cedar River, Middle Fork.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	04CD016	Cedar River, Middle Fork (-549)	0	11.5	16.8	13	24	65.3	Fair

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA>66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

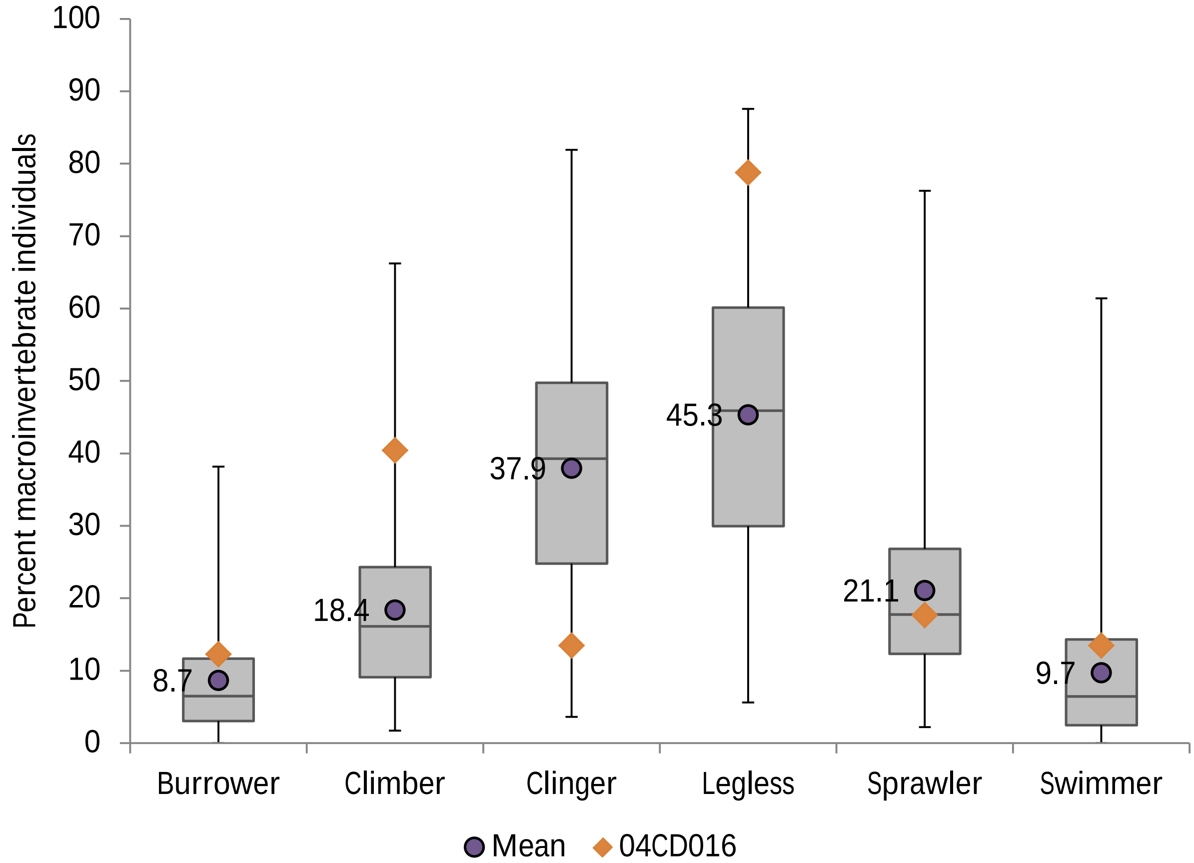


Figure 27: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Forest Streams GP stations with M-IBI greater than 46.8 (threshold), mean of those stations, and metric values from station 04CD016.

4.1.3. Candidate cause: High nitrate-nitrite

The only nitrate sample was 21 mg/L during fish sampling September 1, 2004 at biological station 04CD016. Unionized ammonia was 0.002 mg/L. The nitrate sample at the time of fish sampling is not representative of all conditions. The non-hydropsychid caddisflies were low (1.2%). These caddisflies can respond to increased nitrate levels. At station 04CD041, there were 91.7% nitrate tolerant macroinvertebrates, with 22 nitrate tolerant taxa and no nitrate intolerant taxa. The information available in this reach is inconclusive if elevated nitrate is a stressor to the biological community. Additional nitrate data should be collected throughout the reach to further understand the duration and magnitude of nitrate as well as the spatial extent within the watershed.

4.1.4. Candidate cause: Low dissolved oxygen

At times, DO was below the standard, likely limiting the biological community. A YSI sonde was deployed at biological station 09CD040 from August 1, 2012, through August 15, 2012, taking measurements every 15 minutes, which had DO measurements below the DO standard of 5 mg/L (Figure 28). At this station, the DO flux was approaching concern with a flux of over 6 mg/L. This very upstream biological station appears to have DO concerns, but was not assessed due to channelization. The DO measurements that were made within this watershed at time of fish sampling were above the standard, but collected after 9 am (Table 11). The DO tolerance indicator value (TIV) for macroinvertebrates at biological station 04CD016 was 6.8, at the average for the Cedar River basin. The numbers of macroinvertebrate taxa collected that are intolerant to low DO were 3, and the percentage of DO tolerant species collected were 10.2. The average number of intolerant taxa collected in the Cedar River basin was 4.6 and the average percentage of DO tolerant taxa was 20.

The macroinvertebrate community comprised of a low percentage of EPT taxa (5.1%) compared to the average for Southern Forest Streams GP (25.2%). The tolerance metric HBI_MN resulted in low metric score at biological station 04CD016, which often indicates organic enrichment sufficient to decrease oxygen levels. The tolerant taxa was elevated in 2004 (55.6%) and the taxa count was low at biological station 04CD016 (36). It would be beneficial to have additional data collected. Longitudinal DO surveys along with diurnal DO measurements within this stream reach to help understand the DO regime. Low DO is likely stressing the macroinvertebrate community in stream reach (-549), yet findings are inconclusive due to lack of data.

Table 11: Dissolved oxygen measurements in the Middle Fork Little Cedar (-549).

Station	AUID	Date and Time	DO (mg/L)
09CD040	549	7/6/09 2:05 PM	14.93
04CD016	549	7/13/04 2:00 PM	11.00

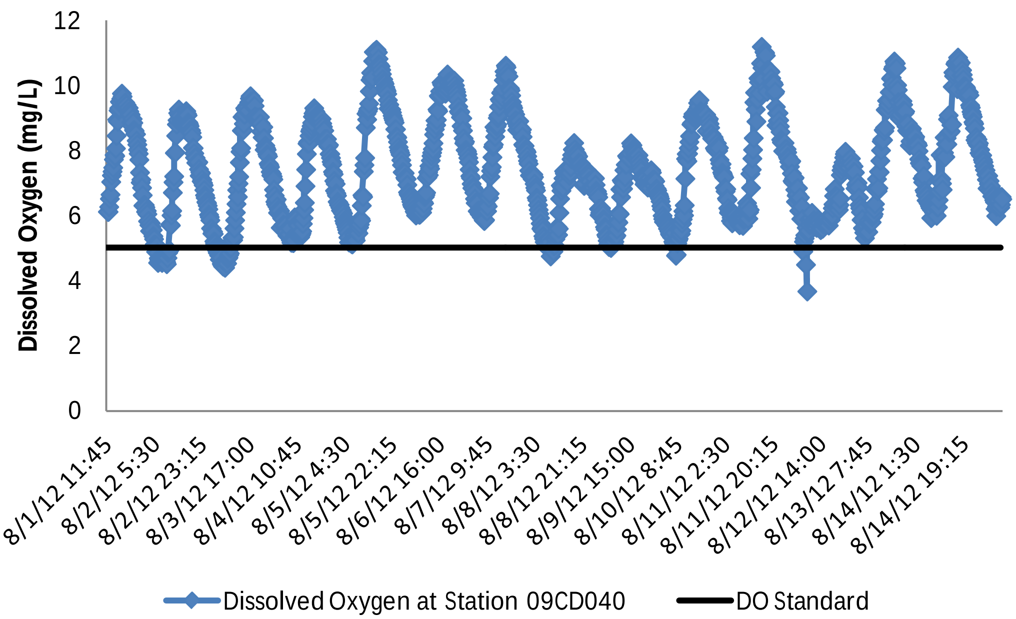


Figure 28: Dissolved oxygen measured in 15 minute intervals at Station 09CD040 from August 1 to August 15, 2012.

4.1.5. Candidate cause: High phosphorus

At the time of fish sampling, total phosphorus was 0.032 mg/L at biological station 04CD016, and is the only sample collected on this stream reach. Phosphorus often has a profound effect through other response variables 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. The response variable to DO flux has not been measured in the natural stream.

Stream reach (-549) has a low taxa count (TaxaCountAllChir; 36) compared to the average for Southern Forest Streams GP macroinvertebrate class (41). Biological station 04CD016 lacked intolerant taxa and the percent tolerant taxa was really high (Tolerant2ChTxPct; 91.7%). The percentage of intolerant taxa will decrease and the percentage of tolerant taxa will increase with increases in phosphorus. The percentage of scrapers was 21.9%, which was above the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. The number of collector-gather taxa (12) and collector-filterer taxa (5) were both low as well. There were 5 EPT taxa in this stream reach. The range of EPT taxa within the Cedar River Watershed was 0 to 20. The metric, EPT, provides a relative measure of the presence and diversity of pollution-sensitive macroinvertebrate groups.

Additional sampling should occur to gain a better understanding of the impact phosphorus may be having on the biological community. The information available in this stream reach (-549) is inconclusive if elevated phosphorus is a stressor to the biological community.

4.1.6. Candidate cause: High suspended sediment

Biological station 04CD016 had low TSS at the time of fish sampling on September 1, 2004, (2.4 mg/L), along with an excellent transparency tube reading (60 cm), the maximum length using transparency tube 60 cm. There is a lack of sediment data on this stream reach (-549).

This biological station had a low percentage of macroinvertebrates that are collector-filterers and had above average for the watershed of scrapers. Collector-filterers are reduced when TSS is elevated. Collector-filterer species collect their food by filtering it from the water column. The percentage of long lived macroinvertebrates was low (4.2%) and there were no intolerant species (Table 12). Long lived macroinvertebrates are often reduced with increases in TSS. Generally intolerant and long lived macroinvertebrates can also decrease with increased TSS stress.

The biological station had a macroinvertebrate TSS station index score (16.5) that was just above the average compared to the average warmwater stations in the Cedar River Watershed (16.3). The station also had a high percentage of TSS tolerant individuals (32.6%) and TSS tolerant taxa (10.0) compared to the averages for warmwater stations in the Cedar River Watershed for percent of TSS tolerant individuals (25.9%) and TSS tolerant taxa (9.0).

There are biological indications that TSS or turbidity may be a concern, but 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 on this stream reach to discern the impacts to the biota. Findings are inconclusive due to limited data

Table 12: Macroinvertebrate metrics relevant to TSS for stations in Middle Fork Little Cedar River compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
04CD016	**16.5**	**0**	**10**	**32.6**	**0**	**2**
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

4.1.7. Conclusions

The stressors to Cedar River, Middle Fork are summarized in Table 13. Habitat is a stressor to the macroinvertebrate community found at 04CD016, but not the primary stressor. Flow alteration is also a stressor. Changes in the surrounding land use, especially in the channelized headwaters of this watershed, would help with high intensity flows that occur during hydrologic events. These high flows can lead to easy transport of nutrients, eroding stream banks, destruction of habitat, and sedimentation of the stream channel. The high percentage of burrowers and legless macroinvertebrates indicate habitat stress. Site evidence and local land use support the notion that fine sedimentation is a major driver to substrate embeddedness and subsequent habitat loss found in this reach.

Data is limited to a few samples and additional data to further characterize the water chemistry of this stream would be helpful. Additional monitoring is needed to confirm or rule out these potential stressors.

Table 13: Summary of stressors found in Cedar River, Middle Fork (-549).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors					
			Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-549 Cedar River, Middle Fork Westfield-Ripley Ditch to unnamed creek	04CD016	M-IBI	•	o	o	o	o	•

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

4.2 Middle Fork Little Cedar River: unnamed creek to Cedar River (AUID: 07080201-530)

The impaired reach is located in Dodge County (Figure 23). The Middle Fork Little Cedar River (-530) is listed as non-supporting of aquatic life for aquatic macroinvertebrate communities. The stream reach is 3.1 miles in length.

Biological station 09CD002 was sampled for fish and macroinvertebrates in 2009 on stream reach (-530). The biological station is located upstream of highway 30, 3.5 miles northeast of Blooming Prairie.

Water quality samples were taken at EQuIS station S000-805 on MN-30 northeast of Blooming Prairie on AUID 530. Water quality data from 2008 to 2012 were used to determine stressors.

4.2.1. Biology in Middle Fork Cedar River

The macroinvertebrate IBI (M-IBI) was 45.53 for biological station 09CD002 which was below the threshold of 46.8 for the Southern Forest Streams class (Table 14). The macroinvertebrate community is not meeting standards at biological station 09CD002. The F-IBI score for station 09CD002 was 65. The F-BI score was above the threshold (51) and confidence interval for biological station 09CD002 for the Southern Headwaters class and is meeting standards.

Table 14: Summary of biological impairments in the Cedar River, Middle Fork (-530).

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-530, unnamed creek to Cedar River	09CD002	Cedar River, Middle Fork	18.9	Southern Forest Streams	46.8	43.53	Southern Headwaters	51	65

Macroinvertebrates in the Southern Forest Streams GP class scored poorly in the metrics of intolerant taxa richness (Intolerant2Ch), collector-filterers (Collector-filtererPct) and HBI_MN at both biological stations (Figure 29). Biological station 09CD002 also had a low percentage of non-hydropsychid Trichoptera individuals (TrichwoHydroPct), percentage of taxa that are clingers (ClingerChTxPct) and Plecoptera, Odonata, Ephemeroptera and Trichoptera taxa (POET). Relative abundance percent of taxa that are very tolerant (VtolTXPct) was 55%. The percent tolerant taxa was really high (Tolerant2ChTxPct; 91.5%).

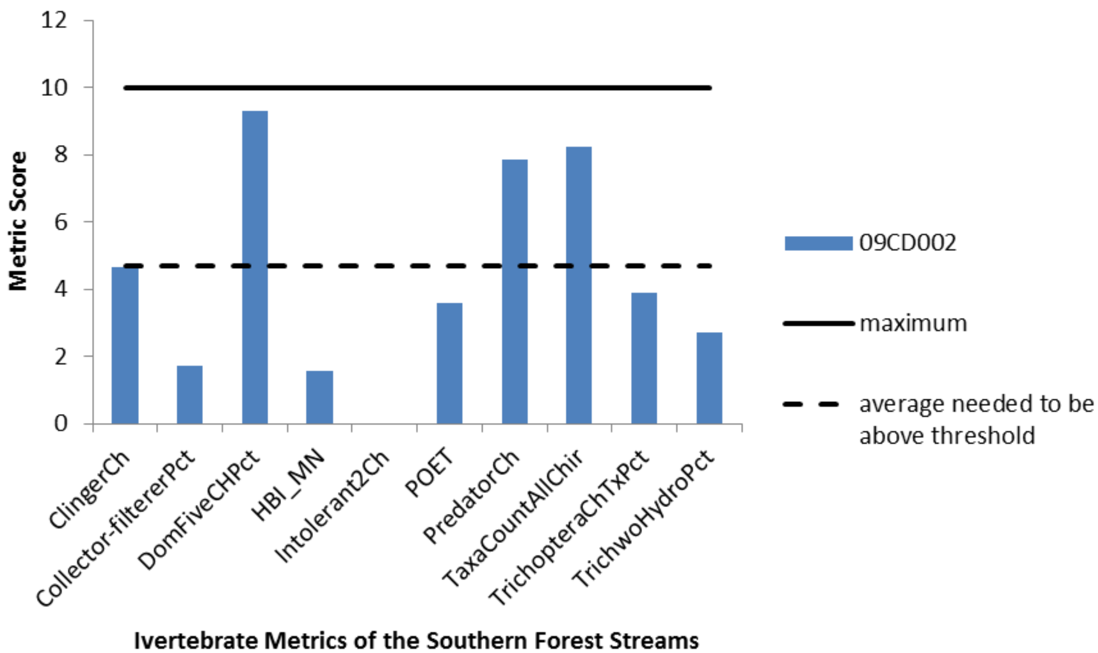


Figure 29: Macroinvertebrate metrics of the Southern Forest Streams GP at biological station 09CD002.

This fish community was not listed as impaired. Biological station 09CD002 had a low metric score for the relative abundance of short lived individuals (SLvdPct). There were high metric scores for general taxa (GeneralTxPct), detritivore taxa (DetNWQTxPct), serial spawners (SSpnPct) and relative abundance of very tolerant taxa (VtolTxPct; Figure 30). Biological station 09CD002 did not have fish deformities, eroded fins, lesions, and tumors (DELTs). If DELTs were present they would have contributed negatively to the IBI.

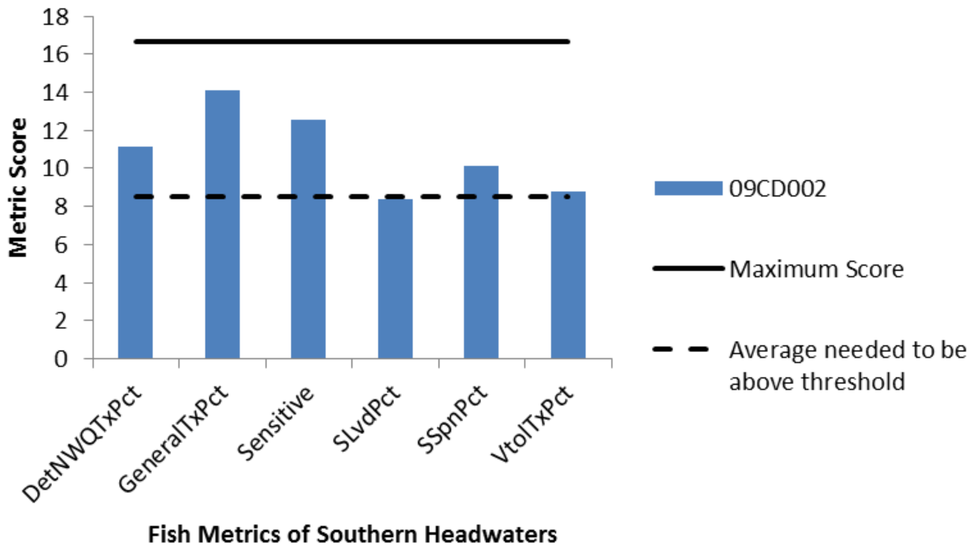


Figure 30: Fish metrics of the Southern Headwaters in biological station 09CD002.

4.2.2. Candidate cause: Lack of habitat/bedded sediment

Biological station 09CD002 scored 42 on the MSHA (poor; Table 15). It scored low due to low subcategory scores for land use, riparian, substrate, fish cover and channel morphology. The substrate MSHA score was 9.5. This indicates fine sediments and a lack of coarse substrate at the sampling location. The Channel morphology score was also low at 15 due to moderately unstable channel stability and poor channel development. There was 10% riffle present in the biological reach.

The surrounding land use was noted as row crop with a narrow (15 to 30 ft.) riparian buffer. There was little to moderate bank erosion (Figure 31). Sparse cover was noted, with multiple cover types including overhanging vegetation, deep pools, logs or woody debris and macrophytes. The habitat that was sampled for macroinvertebrates was woody debris/snags/rootwads over hanging vegetation. This site was lacking good quality riffles, and no coarse substrate was found.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. The Middle Fork Cedar River Watershed is approximately 63% channelized. The watershed begins with a series of channelized streams. Thirty percent of this watershed is tile drained to help move water off farm fields and to the streams rather quickly. This causes the flows of this stream system to become very inconsistent. Frequent high flows can lead to large amounts of erosion. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

Macroinvertebrate burrowers were found in abundance (23.1%) and found above the average for Southern Forest Streams GP class (8.66%; Figure 32). An abundance of burrowers, may suggest potential fine sedimentation issues in the riffles. The percentage of EPT individuals (11.9%) was less than the average for Southern Forest Streams GP class (30.9%). Additionally, there was a high percentage of macroinvertebrates that climb (32.1%) at station 09CD002, coupled with a high percentage of legless macroinvertebrates (81.4%). The macroinvertebrates that are known to cling to large substrate and woody debris were below average for this stream class (only 20.2% compared to statewide average of 37.9%). This is also demonstrated where the clinger metric scored below the average needed to be above the IBI threshold. Clingers can decrease in stream reaches with homogenous substrate composition, velocity, and depth (CADDIS).

Lack of habitat is a stressor in Middle Fork Little Cedar River (-530) due to a poor MSHA score, bedded sediment, altered hydrology and a moderately unstable channel. The higher percentage of legless macroinvertebrates and a shift to less clingers helps support the habitat stressor.

Table 15: MSHA results for Cedar River, Middle Fork.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	09CD002	Cedar River, Middle Fork (-530)	0	9.5	9.5	8	15	42	Poor

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA>66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

Figure 31: Habitat conditions at biological station 09CD002 on July 08, 2009.

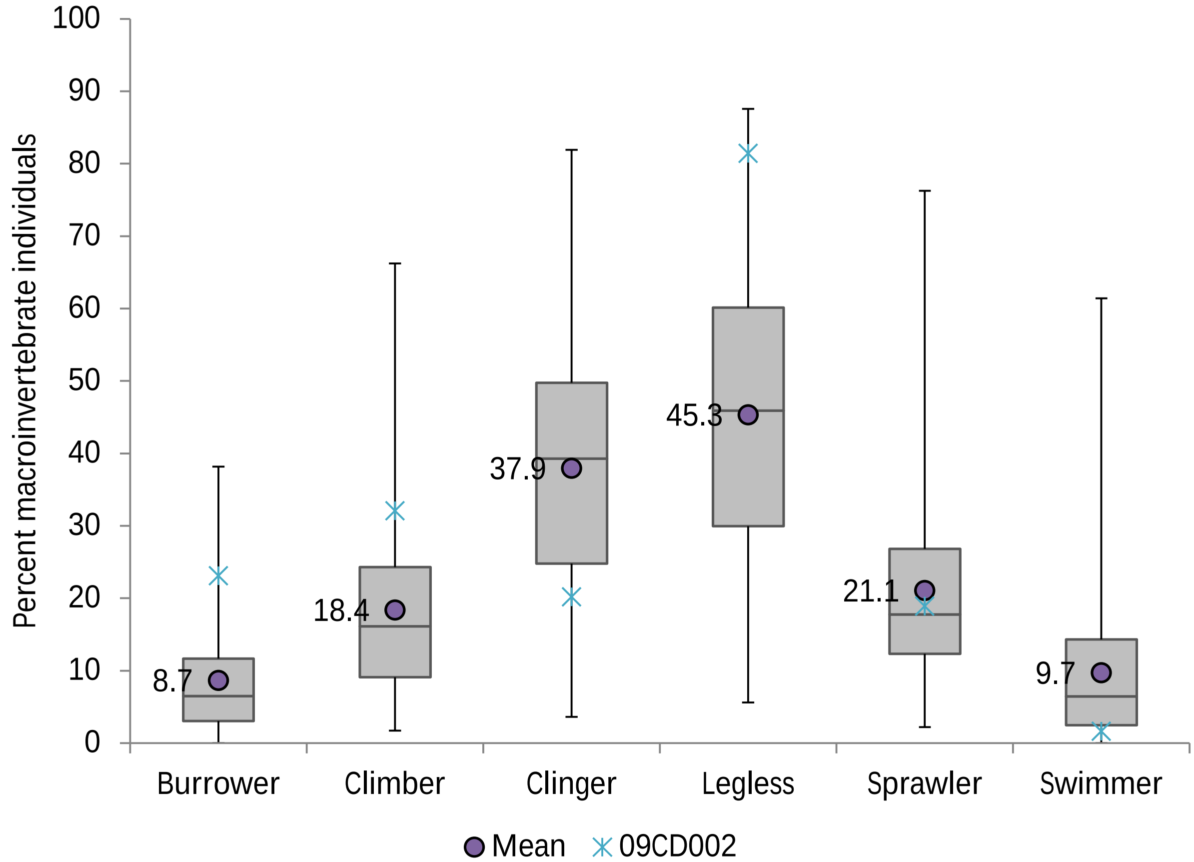


Figure 32: Macroinvertebrate habitat metrics with box plots showing range of values from natural channel Southern Forest Streams GP stations with M-IBI greater than 46.8 (threshold), mean of those stations, and metric values from station 09CD002.

4.2.3. Candidate cause: High nitrate-nitrite

At biological station 09CD002, the nitrate value during fish sampling was 11 mg/L on July 8, 2009. On this stream reach (-530), nitrate has been sampled for a total of 36 times from 2008 through 2012. The highest sample was 34 mg/L on June 22, 2012 while the lowest nitrate sample was 0.21 mg/L on August 12, 2009 (Figure 33). The highest observed nitrate levels are in May and June and drop through the summer and increase again in October and November. The mean nitrate was 9.32 mg/L. Unionized ammonia is not a concern based on the limited data available.

This reach of the Little Cedar River, Middle Fork, less than 1% of the macroinvertebrate population was non-hydropsychid caddisflies. These caddisflies can respond to increased nitrate levels. The macroinvertebrates in this reach had a very high percent of tolerant taxa and lacked intolerant taxa. At station 09CD002, there were 55.3% nitrate tolerant macroinvertebrates, with 26 nitrate tolerant taxa and no nitrate intolerant taxa. Nitrate is a primary stressor to the macroinvertebrate community in Middle Fork Cedar River.

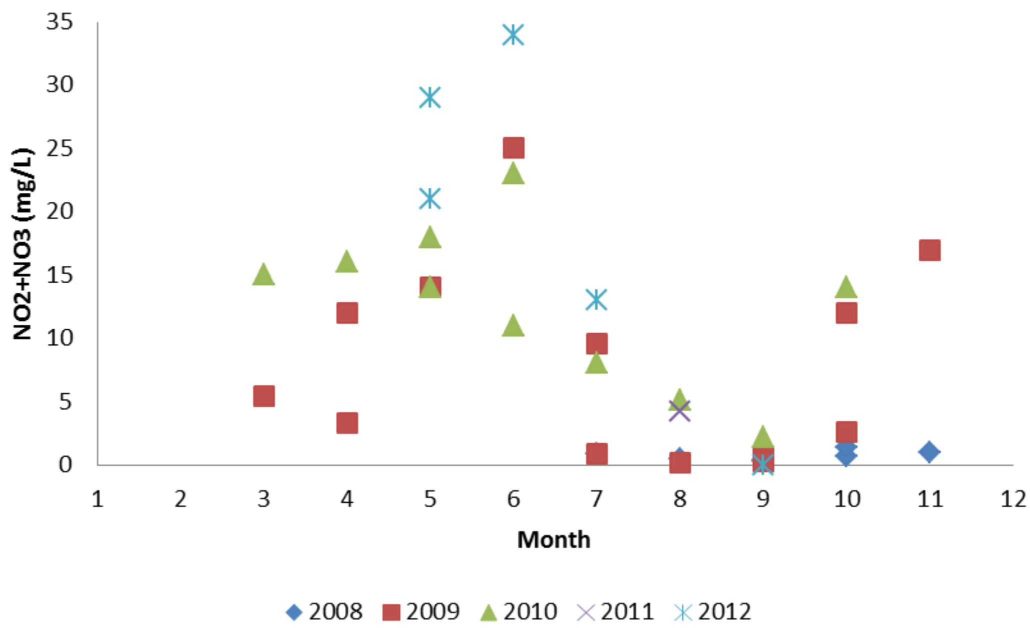


Figure 33: Nitrate-nitrite in the Middle Fork Cedar River (-530) by month and by year.

4.2.4. Candidate cause: Low dissolved oxygen

At times, DO was below the standard (5 mg/L), likely limiting the biological community. The DO measurements at time of fish sampling were above the standard (Table 16). DO went below the standard once at chemistry station S000-805 on September 25, 2008 at 10:11 am with a DO of 3.38 mg/L. Chemistry station S006-870 had a one-time DO sample of 6.78 mg/L collected after 9 am. The DO TIV for macroinvertebrates at biological station 09CD002 had a macroinvertebrate DO TIV of 6.5, below the average for the Cedar River Watershed (6.8). There were one DO intolerant taxa, which is below the average for the Cedar River basin (4.6), and 30% tolerant DO macroinvertebrates, which is above the average for the Cedar River basin (20%).

The macroinvertebrate community comprised of a very low percentage of EPT taxa (5.1%) compared to the average for the Southern Forest Streams GP class (25.2%). The tolerance metric HBI_MN resulted in a low metric score, which often indicates organic enrichment sufficient to decrease oxygen levels. The tolerant taxa were elevated in 2009 (91.5%) and was above average for the Southern Forest Streams GP (74.9%) class. It would be beneficial to have diurnal DO measurements within these reaches to help understand the DO regime. Low DO is a stressor to the macroinvertebrate community in stream reach (-530).

Table 16: Dissolved oxygen measurements in the Middle Fork Little Cedar (-530).

Station	AUID	Date & Time	DO (mg/L)
09CD002	530	7/08/09 5:20 PM	8.2
S000-805	530	7/31/08 - 9/4/12	3.38 - 16.30
S006-870	530	8/18/11 11:20 AM	6.78

4.2.5. Candidate cause: High phosphorus

Phosphorus in this stream reach (-530) was elevated as high as 0.577 mg/L (Figure 34). At the time of fish sampling, total phosphorus was 0.073 mg/L at station 09CD002 below the standard (0.15 mg/L). Chemistry station S000-805 was sampled from July 2008 through September 2012. Total phosphorus ranged from 0.012 to 0.577 mg/L. Of the thirty-six samples taken at this station, seven were greater than the standard. Phosphorus often has a profound effect through other response variables such as chlorophyll-a, pH, BOD, and DO flux. There is no available BOD or chlorophyll-a data on these AUIDs at this time to assess the potential influences. The response variable to DO flux has not been measured in the natural streams. At station S000-805, pH data was measured 65 times between 2008 and 2012 and ranged from 7.2 to 8.88.

The macroinvertebrate community on stream reach (-530) has a high taxa count (TaxaCountAllChir; 47) which is above the average for the Southern Forest Streams GP class (41.2). Biological station 09CD002 lacked intolerant taxa and the percent tolerant taxa was high (Tolerant2ChTxPct; 91.5%). The percentage of intolerant taxa will decrease and the percentage of tolerant taxa will increase with increases in phosphorus. The percentage of scrapers was 19.2%, which was above the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. The number of collector-gather taxa (19), which is high and collector-filterer taxa (4) was low. There were five EPT taxa in this stream reach which is below the average for this class.

The high phosphorus values on AUID (-530), low percentages of intolerant individuals and higher DO values make it possible that phosphorus is a stressor. The lack of chlorophyll-a, BOD and DO flux data on AUID (-530) makes it difficult to assess the potential influences. Additional sampling should occur to gain a better understanding of the impact phosphorus may be having on the biological community.

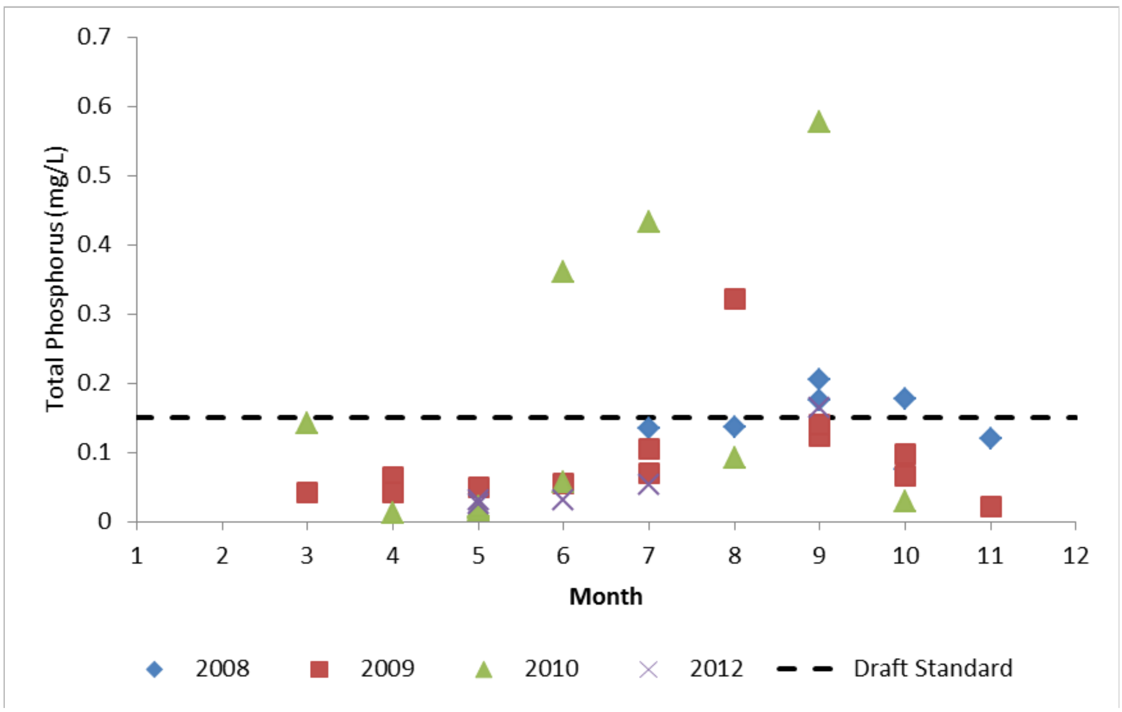


Figure 34: Total phosphorus by month for Middle Fork Cedar River at Station S000-805 on AUID (-530).

4.2.6. Candidate cause: High suspended sediment

Biological station 09CD002 had low TSS at the time of fish sampling on July 8, 2009 (16 mg/L), along with a fair transparency tube reading (37). Flow conditions were noted as normal for the fish sampling visit. In 2008 through 2010 there were 29 TSS measurements; three measurements were above 65 mg/L. There were 35 transparency tube readings from 2008 through 2010 and 2012 ranging from 4 cm to 80 cm. Of those 35 readings, 4 of them were under 20 cm (the surrogate water quality standard).

On stream reach (-530) at biological station 09CD002 there were a high percentage of herbivorous fish. Herbivorous fish decrease with increases in TSS. There were a low percentage of macroinvertebrates that are collector-filterers (6.7%) and a high percentage of scrapers (19.2%). Collector-filterers are reduced when TSS is elevated. Collector-filterer species collect their food by filtering it from the water column. The percentage of long lived macroinvertebrates was very low (2.2%). Long lived macroinvertebrates are often reduced with increases in TSS. The TSS station index score at the biological station had a score of 16.5 (Table 17) above the average for warmwater stations in the Cedar River Watershed (16.3). There were 21.52% TSS tolerant macroinvertebrates, with 15 TSS tolerant taxa and one intolerant taxon. 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 Cedar River, Middle Fork to discern the impacts to the biota.

Table 17: Macroinvertebrate metrics relevant to TSS for stations in Middle Fork Little Cedar River compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
09CD002	**16.5**	1	**15**	**21.5**	**0**	**4**
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

4.2.7. Conclusions

The stressors to Cedar River, Middle Fork are summarized in Table 18. Habitat, nitrate, low DO and flow alteration are stressors to the macroinvertebrate community found at 09CD002. Nitrate and habitat have the most consistent biological response and may be driving the issues of biological impairment in the Cedar River, Middle Fork. Nitrate concentrations are elevated having some of the highest concentrations found in the Cedar River Watershed. DO is likely a secondary stressor. TSS cannot be concluded as a stressor to Cedar River, Middle Fork at this time, but lacks sufficient chemical data to understand sediment concentrations. Additional TSS information should be collected. Cedar River, Middle Fork would likely benefit from habitat improvement and alter the surrounding landscape to control sedimentation and improve refuge for the macroinvertebrates.

Table 18: Summary of stressors found in Cedar River, Middle Fork (-530).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors: Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-530 Cedar River, Middle Fork unnamed creek to Cedar River	09CD002	Macroinvertebrate IBI	•	•	•		o	•

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

5. Roberts Creek Watershed Unit

The Roberts Creek Watershed Unit is located in north central Mower County and drains 39 square miles (Figure 35). The headwaters of Roberts Creek begin just south of Sargeant and north of Brownsdale. Over 90% is used for agricultural production, of which, 81.1% is used for row-crop cultivation and 7% is in pasture. Of the remaining acreage, 6.7% is developed land.

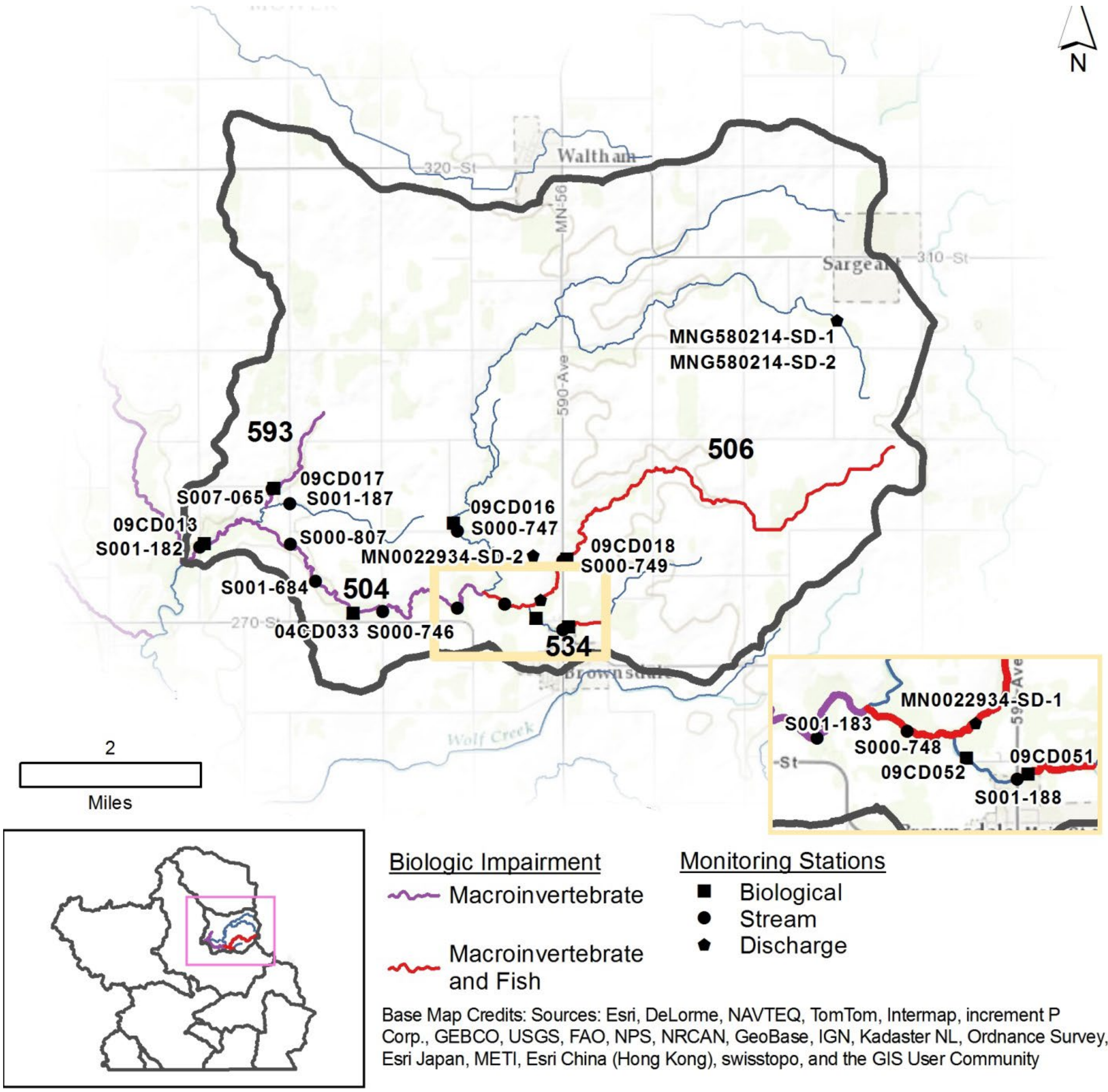


Figure 35: Map of biological impairments of Roberts Creek Watershed.

5.1. Unnamed creek: unnamed creek to T103 R17W S10, West Line (AUID: 07080201-534)

One biological station 09CD051 was sampled for fish and macroinvertebrates in 2009 on stream reach (-534). Biological station 09CD029 is located upstream of Highway 56, 0.5 mi. north of Brownsdale.

Water quality sampling was done at EQuIS station S001-188 at MN-56 in Brownsdale. Water quality data from 2012 were used to determine stressors.

5.1.1. Biology in unnamed creek (A headwaters tributary to the South Branch Roberts Creek)

The MPCA surveyed one biological station 09CD051 on June 30, 2009, on AUID 07080201-534 for fish and sampled the macroinvertebrates on August 5, 2009. The macroinvertebrate and fish communities are not meeting standards for unnamed creek (-534). The M-IBI was 16.96 which are below the threshold of 46.8 and confidence interval for a Southern Forest Streams GP (Table 19). The F-IBI score for this station was 46 and is also below the threshold but within the confidence interval for a Southern Headwaters Stream.

Table 19: Summary of biological impairments in unnamed creek (-534).

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-534, unnamed creek to T103 R17W S10, West Line	09CD051	unnamed creek	2.75	Southern Forest Streams GP	46.8	16.96	Southern Headwaters	51	46

Macroinvertebrates in the class Southern Forest Streams GP for biological station 09CD051 scored poorly in the metrics of clinger taxa, collector-filterers (Collector-filtererPct), Plecoptera, Odonata, Ephemeroptera and Trichoptera taxa (POET) and taxa richness of predators (Predator), total taxa richness of macroinvertebrates (TaxaCountAllChir; Figure 36). Biological station 09CD051 lacked a measure of pollution based on tolerance values assigned to each individual taxon (HBI_MN), non-hydropsychid caddisflies (TrichwoHydroPct) and Trichoptera (TrichopteraChTxPct). Unnamed Creek also lacked intolerant taxa (intolerant2Ch). Five species dominated the sample (DomFiveCHPct; 77.22%) and the percent tolerant taxa was extremely high (Tolerant2ChTxPct; 91.18%).

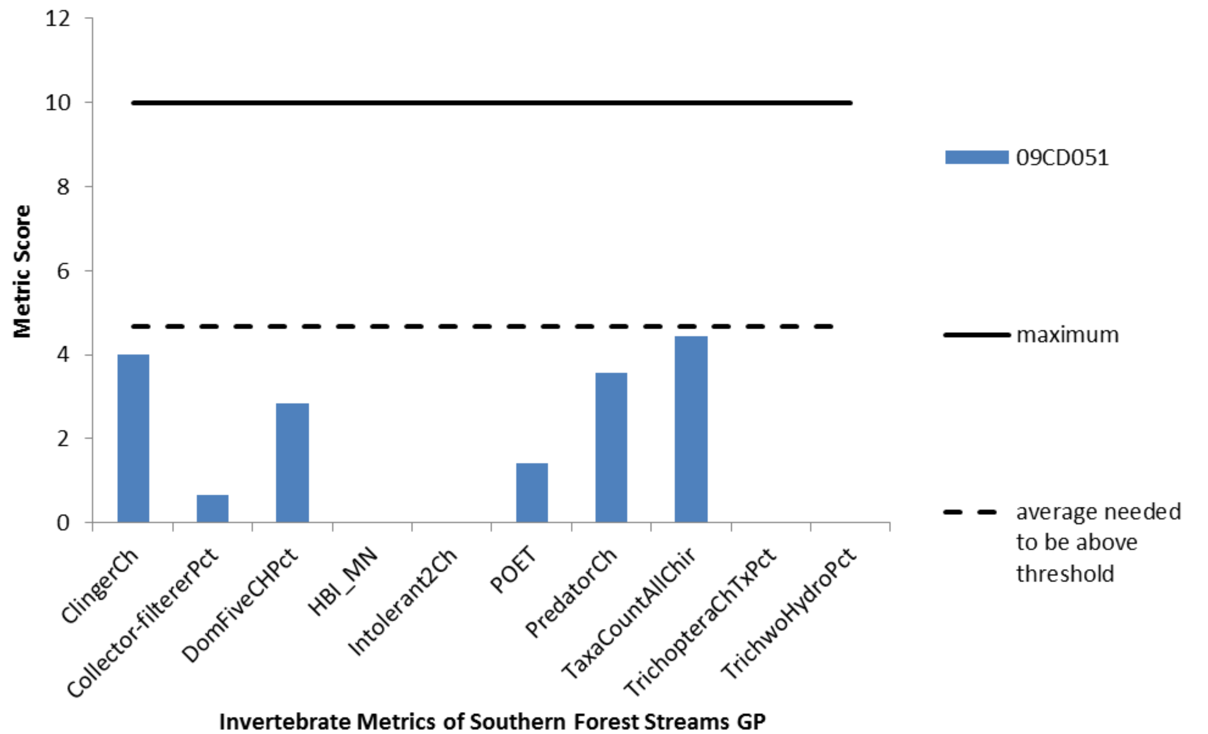


Figure 36: Macroinvertebrate metrics of the Southern Forest Streams GP in stations 09CD051in unnamed creek.

Biological station 09CD051 had high fish metric scores for: generalist taxa (General Txpct) and relative abundance of serial spawners (SSpnPct; Figure 37). Fish in the class Southern Headwaters for biological station 09CD051 scored poorly in the metrics of detritivore taxa (DETNWQTxPct), the relative abundance of short-lived individuals (SLvdPct) and very tolerant taxa (VtolTxPct). Biological station 09CD051 lacked taxa richness of sensitive species. Unnamed creek did not have fish DELTs, that if present, would have contributed negatively to the IBI.

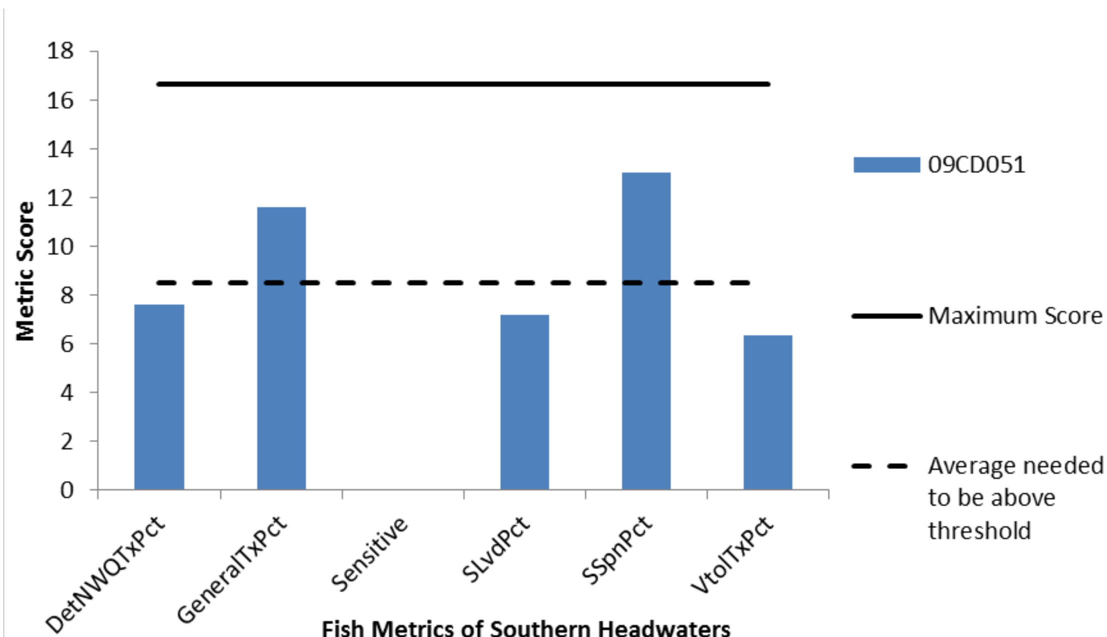


Figure 37: Fish metrics of the Southern Headwaters in stations 09CD051in unnamed creek.

5.1.2. Candidate cause: Lack of habitat/bedded sediment

The unnamed creek station 09CD051 scored 68.2 (good) on the MSHA ( ). Of the five subcategories in the MSHA, land use and substrate scored poorly. The field crew noted unnamed creek had moderate channel stability. The water was clear, on the June 2009 sampling date. This reach contained 25% riffle and was dominated by sand and gravel, with light embeddedness.

The surrounding land use was noted as row crop with a wide (150 to 300 ft.) riparian buffer on the left side and narrow (15-30 ft.) on the right side of the stream. There is little bank erosion on the left banks and moderate bank erosion on the right banks (Figure 38). Moderate cover was noted, with multiple cover types including undercut banks, deep pools, logs or woody debris, boulders and rootwads. The habitat that was sampled for macroinvertebrates was woody debris/snags/rootwads, overhanging vegetation and undercut banks.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Roberts Creek watershed is approximately 51% channelized. Sampling in late summer and early fall of 2012 was not able to occur due to dry conditions (Figure 38). This site has frequent intermittent flows due to small drainage area and impacts available habitat for biota. Tile drainage used in this watershed (37%) helps move water off the farm fields and to the streams rather quickly. This causes the flows of this stream system to become very inconsistent. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

Burrowers were found below the statewide average for Southern Forest Streams GP macroinvertebrate class (5.38%; Figure 39). The percentage of EPT individuals (2.22%) was much less than the statewide average for Southern Forest Streams GP macroinvertebrate class (30.9%). The percentage of legless macroinvertebrate individuals was dramatically high (90.5%), which shows a shift in generally tolerant species present. The macroinvertebrates that are known to cling to large substrate and woody debris were low (below statewide averages for this class). This is also found in the M-IBI metrics, the number of clinger taxa (ClingerCh) was below the average metric score needed for the M-IBI to be at the threshold. The high percentage of legless macroinvertebrates and lack of clingers is indicative of lack of habitat.

Biological station 09CD051 had a fish community lacking in riffle dwelling fish (8.46%), non-tolerant benthic insectivores (1.54%), simple lithophilic spawners (8.46%), and darter, sculpin and round bodied suckers (1.54%). Biological station 09CD051 also lacked piscivores (0%). These habitat related fish metrics were all well below averages for stations in the Cedar River Watershed. The most abundant fish species found at biological station 09CD051 were blacknose dace and creek chub. In addition, the percentage of pioneer species was higher than average for the Cedar River Watershed, which are species that can thrive in unstable environments. This is further reinforced by a high percentage of tolerant fish species in unnamed creek (91.54%).

Overall, site conditions/photos, macroinvertebrate and fish response strongly support habitat as a stressor in this reach particularly in terms of channel erosion, bedded sediment, lack of stability and intermittent flows.

Table 20: MSHA scores for Roberts Creek Watershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	09CD051	unnamed creek	0	11.5	15.7	12	29	68.2	Good

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA > 66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA < 45)


Figure 38: Biological station 09CD051 on July 13, 2009 showing low channel stability (left) and dry conditions on July 19, 2012 at station S001-188 (right).

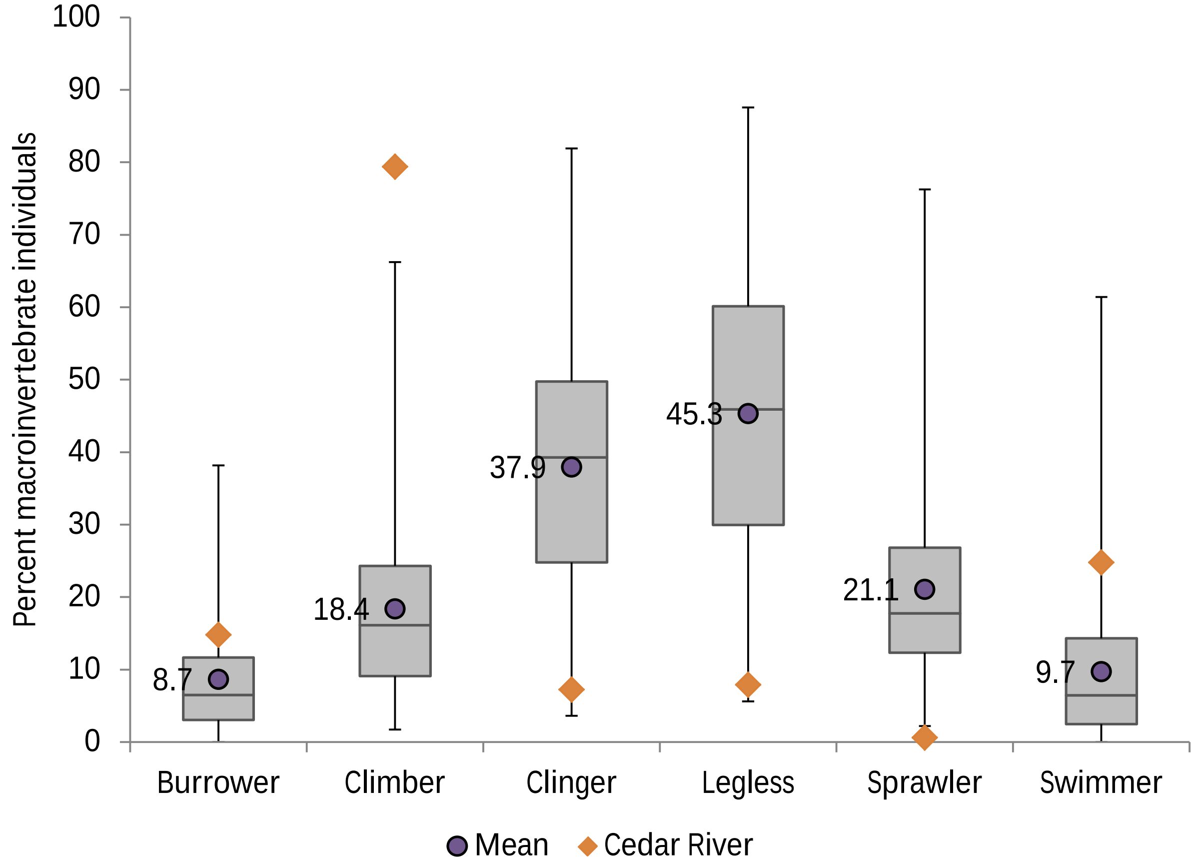


Figure 39: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Forest Streams GP stations with M-IBI greater than 46.8 (threshold), mean of those stations, and metric values from station 09CD051.

5.1.3. Candidate cause: High nitrate-nitrite

Nitrate was 3.2 mg/L during fish sampling on July 13, 2009, at biological station 09CD051. Nitrate was sampled four times in 2012 at station S001-188. The highest sample was 22 mg/L on June 22, 2012 while the lowest nitrate sample was 17 mg/L on May 15, 2012. One sample (4 mg/L) was also taken on September 27, 1989.

The macroinvertebrates in this reach were made up of 91.2% tolerant taxa and lacked intolerant taxa as defined by MPCA. Biological station 09CD051 was lacking non-hydropsychid Trichoptera. Trichoptera are often considered sensitive to nitrate and respond with decreases in taxa. At station 09CD051, there were 90.8% nitrate tolerant macroinvertebrates, with 21 nitrate tolerant taxa and only 1 nitrate intolerant taxon.

In terms of the fish community, stations in this reach lacked 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. With the limited nitrate data available, nitrate is a stressor to the impaired biota. More nitrate data should be collected to help characterize the nitrate in this unnamed creek.

5.1.4. Candidate cause: Low dissolved oxygen

There was a lack of DO data within this reach. There were only six measurements of DO collected. All of them were collected after 9 am. None of the measurements were below the standard (5 mg/L). One of the measurements was taken at the time of fish sampling (9.1 mg/L). The DO measurements in 2012 were taken late morning and ranged from 9.52 mg/L to 10.25 mg/L. There were two DO measurements taken in 1989 (6.8 mg/L and 7.5 mg/L). There is no indication in this small dataset for excessive DO flux.

The macroinvertebrate community comprised of a low percentage of EPT taxa (8.8%). The tolerant taxa was elevated in 2009 (91.2%) and the taxa count was abundant (34). The macroinvertebrates in this AUID had a low metric HBI_MN, a measure of pollution based on tolerance values assigned to each individual taxon. Station 09CD051 received a high metric score (9.2) higher than the average score needed to be above the threshold. The macroinvertebrate DO TIV station score (6.6) was below the average for the Cedar River (6.8). At station 09CD051, the numbers of macroinvertebrate taxa collected that are intolerant to low DO were 2, and the percentage of DO tolerant species collected were 11.6. The average number of intolerant taxa collected in the Cedar River basin was 4.6 and the average percentage of DO tolerant taxa was 20.

The fish community was in the upper half of DO aggregate fish scores (7.3), indicating that when compared to other stations in the Cedar River, there is some sensitivity to DO. The most DO sensitive fish found at this station were southern redbelly dace and there was a presence of DO tolerant fish such as central mudminnows and fathead minnows. With the lack of DO data it is currently inconclusive if DO is contributing to the biological impairment. It would be beneficial 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.

5.1.5. Candidate cause: High phosphorus

Total phosphorus (0.158 mg/L) was just above the standard (0.150 mg/L at the time of fish sampling in unnamed creek on July 15, 2009. Four samples were taken during the sampling season of 2012 that ranged from 0.013 mg/L to 0.056 mg/L. All four samples were below the standard. There were two phosphorus samples in 1989 (0.52 mg/L and 0.62 mg/L) were also below the standard. As interacting variables to eutrophication, phosphorus, pH and chlorophyll-a were compared to normal ranges and standards. The response variable, DO flux was not measured. There were no measurements of BOD. Chlorophyll-a had two samples in 1989 and were below 35 µg/L, below the standard. There were three pH samples from 2012 and ranged from 7.94 to 8.06.

This stream reach has a low taxa count (TaxaCountAllChir; 34). Biological station 09CD051 lacked intolerant taxa (0) and the percent tolerant taxa was extremely high (Tolerant2ChTxPct; 91.2%). The percentage of intolerant taxa will decrease and the percentage of tolerant taxa will increase with increases in phosphorus. The percentage of scrapers was 68.7%, which was well above the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. The number of collector-gather taxa (14) and collector-filterer taxa (3) were both low as well. There were 3 EPT taxa in this stream reach. The range of EPT taxa within the Cedar River Watershed was 0 to 20. The metric, EPT, provides a relative measure of the presence and diversity of pollution-sensitive macroinvertebrate groups.

This reach had a moderate percentage of carnivorous fish (30.8%). Carnivorous fish often decrease with increases in phosphorus (MPCA 2013). As previously mentioned, this reach lacks sensitive fish taxa relative to the total taxa present. The tolerant individuals comprise of 91.5% of the total fish individuals surveyed, resulting in a low metric score. Non-tolerant benthic insectivores taxa were below average (1.5%). Generalists comprise of over half of the community (76.2%).

Due to the low values, lack of data (phosphorus, chlorophyll-a, or BOD) or response such as DO flux, and mixed biological response, phosphorus is inconclusive as a stressor to the fish and macroinvertebrate community. It would be recommended to collect additional data to assist with further understanding.

5.1.6. Candidate cause: High suspended sediment

Biological station 09CD051 had low TSS at the time of fish sampling on June 30, 2009 (<1.0 mg/L), along with an excellent transparency tube reading (>100 cm). In 2012, there were three transparency tube readings, all of the readings were 100 cm and above. There were no measurements of TSS collected. There were two measurements of turbidity collected in 1989 and both were very low. TSS data for a range of flows should be collected in unnamed creek to determine the impacts to the biota.

In 2009, biological station 09CD051 had a high percentage of herbivorous fish and a high percentage of macroinvertebrates that are scrapers and a low percentage of collector-filters. Collector-filterers and herbivorous fish are reduced when TSS is elevated. Collector-filterer species collect their food by filtering it from the water column. The percentage of long- lived macroinvertebrates was very low (1.90%). Long lived macroinvertebrates are often reduced with increases in TSS. Biological station 09CD054 had a low TSS station index score (14.4; Table 21) below the average for warmwater station in the Cedar River Watershed. The biological station had a low percentage of TSS tolerant individuals (7.8%) and below average TSS tolerant taxa (5) compared to the averages for warmwater stations in the Cedar River Watershed for percent of TSS tolerant individuals (25.9%) and TSS tolerant taxa (9). There are biological indications that TSS or turbidity may be a concern, yet findings are inconclusive due to limited data.

Table 21: Macroinvertebrate metrics relevant to TSS for stations in unnamed creek compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
09CD054	14.4	**0**	5	7.8	1	**1**
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

5.1.7. Conclusions

The stressors to unnamed creek are summarized in Table 22. Habitat, flow alteration and nitrate are stressors to the macroinvertebrate and fish communities found at 09CD051. Nitrate concentrations are elevated and having an impact on the biota. The primary reason for flow alteration is the lack of consistent base flow. When a stream frequently dries up or becomes intermittent it makes it extremely difficult for many species, especially sensitive species, of biota to re-establish themselves and complete their respective life cycles. With the lack of DO and phosphorus data it is currently inconclusive if DO and phosphorus are contributing to the biological impairment. TSS cannot be concluded as a stressor to unnamed creek at this time, lacking sufficient chemical data to understand sediment concentrations. Having a consistent base flow of water will allow this stream to be monitored more frequently for these stressors. Additional TSS information should be collected.

Unnamed creek would likely benefit from habitat improvement that would control sedimentation and improve refuge for the macroinvertebrates and fish communities. Nitrate levels are elevated (22 mg/L), and should be monitored over time. Better management of nutrients would benefit the biological communities of unnamed creek. Overall, there is little chemical information on this reach, and additional information should be collected to confirm or rule out these potential stressors.

Table 22: Summary of stressors found in unnamed creek (-534).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors					
			Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-534 unnamed creek unnamed creek to T103 R17W S10, west line	09CD051	Macroinvertebrate IBI F-IBI	•	•	o	o	o	•

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

5.2. Roberts Creek: Headwaters to unnamed creek (AUID: 07080201-506)

One biological station 09CD018 was sampled for fish and macroinvertebrates in 2009 on stream reach (-506). Biological station 09CD018 is located upstream of Highway 56, 1.5 miles north of Brownsdale.

Water quality sampling was done at EQuIS station S000-749 at MN-56 one mile north of Brownsdale and EQuIS station S000-748 between tributaries one mile northwest of Brownsdale. Water quality data from 1980, 1989 and 2012 were used to determine stressors.

The city of Brownsdale WWTP discharges to this stream reach. It is a controlled discharge pond facility that is not authorized to discharge from June 15th to September 15th.

5.2.1. Biology in Roberts Creek

The MPCA surveyed one biological station 09CD018 on July 1, 2009 on AUID 07080201-506 for fish and sampled the macroinvertebrates on August 5, 2009. The macroinvertebrate and fish communities are not meeting aquatic life standards on Roberts Creek (-506). The macroinvertebrate IBI was 29.32 which are below the threshold of 46.8 and confidence interval for a Southern Forest Streams GP (Table 23). The F-IBI score for this station was 39 also below the threshold (51) and within confidence interval for a Southern Headwaters Stream.

Table 23: Summary of biological impairments in Roberts Creek.

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-506, Headwaters to unnamed creek	09CD018	Roberts Creek	5.53	Southern Forest Streams GP	46.8	29.32	Southern Headwaters	51	39

Macroinvertebrates in the class Southern Forest Streams GP for biological station 09CD018 scored poorly in the metrics of clinger taxa (ClingerCh), collector-filterers (Collector-filtererPct), Plecoptera, Odonata, Ephemeroptera and Trichoptera taxa (POET), total taxa richness of macroinvertebrates (TaxaCountAllChir), a measure of pollution based on tolerance values assigned to each individual taxon (HBI_MN), non-hydropsychid caddisflies (TrichwoHydroPct) and Trichoptera (TrichopteraChTxPct; Figure 40). Roberts Creek lacked intolerant taxa (intolerant2Ch). Taxa richness of predators (Predator) was above the average needed to be above the threshold. Five species dominated the sample (DomFiveCHPct; 65.59%) and the percent tolerant taxa was high (Tolerant2ChTxPct; 85.29%).

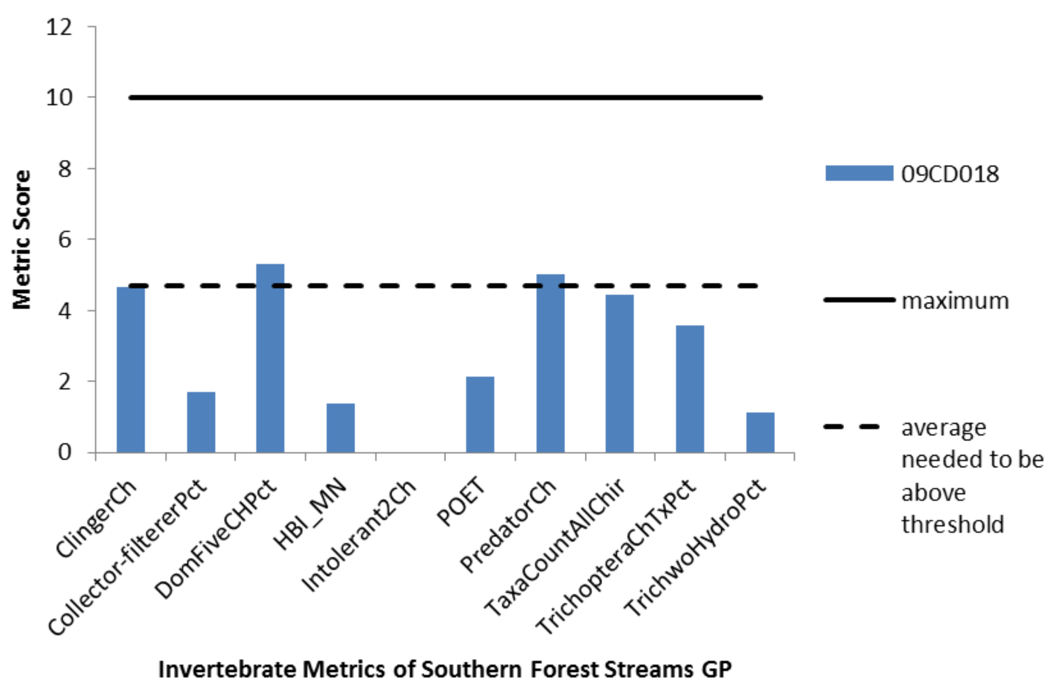


Figure 40: Macroinvertebrate metrics of the Southern Forest Streams GP in biological stations 09CD018.

Biological station 09CD018 had moderate F-IBI metric scores for: generalist taxa (General Txpct) and detritivore taxa (DETNWQTxPct; Figure 41). Fish in the class Southern Headwaters for biological station 09CD018 scored poorly in the metrics of the relative abundance of short-lived individuals (SLvdPct), relative abundance of serial spawners (SSpnPct) and very tolerant taxa (VtolTxPct). Biological station

09CD018 lacked taxa richness of sensitive species. Roberts Creek did not have fish DELTs, that if present, would have contributed negatively to the IBI.

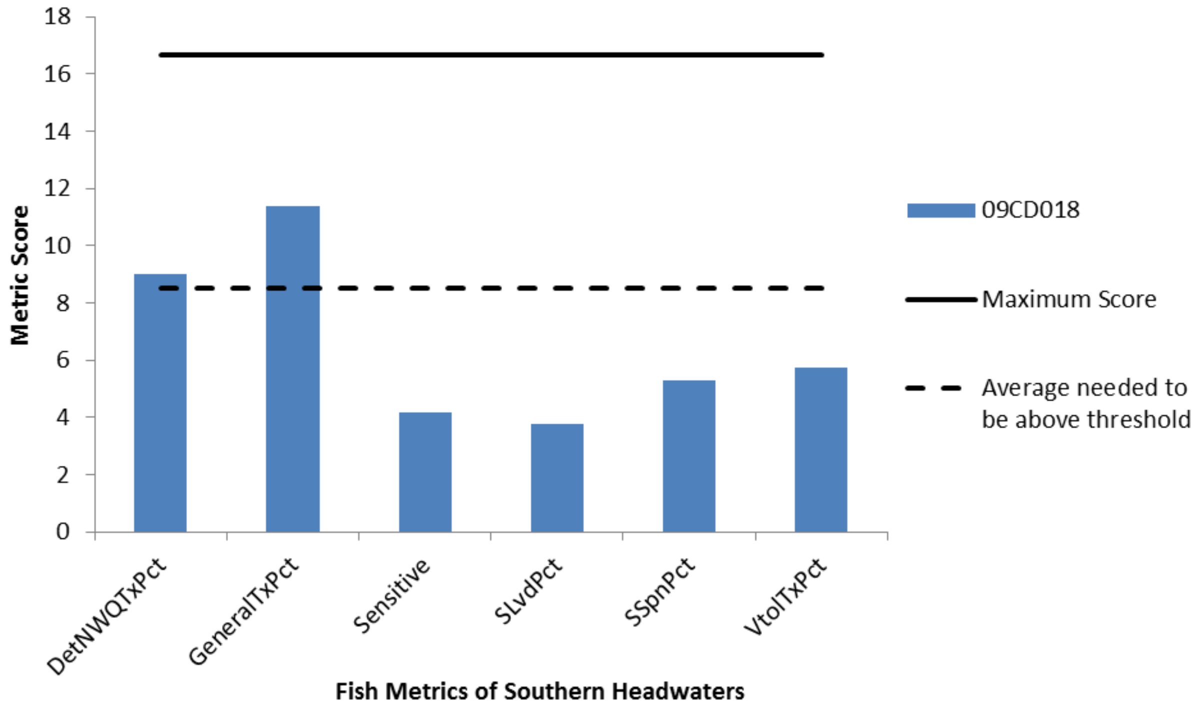


Figure 41: Fish metrics of the Southern Headwaters in stations 09CD018 in Roberts Creek.

5.2.2. Candidate cause: Lack of habitat/bedded sediment

Biological station 09CD018 scored 63.2 (fair) on the MSHA (Table 24). Of the five subcategories in the MSHA, land use, substrate, cover type and channel morphology scored poorly. The field crew noted Roberts Creek had moderate channel stability. The water was clear. This reach only contained 5% riffle and had cobble and gravel substrate, with moderate embeddedness. Sand substrate was dominant in the pools.

The surrounding land use was noted as row crop and residential with moderate (30 to 150 ft.) riparian buffer on the left side and extensive (>300 ft.) on the right side of the stream. There is little bank erosion on the left and right banks (Figure 42). Moderate cover was noted, with multiple cover types including deep pools, logs or woody debris, rootwads and macrophytes. The habitat that was sampled for macroinvertebrates was woody debris/snags/rootwads.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Roberts Creek has been observed dry during the summer and fall of 2012. This site has frequent intermittent flows due to small drainage area which reduces the connectivity and impacts available habitat for biota. Current estimations are that this AUID is 40% channelized. Thirty-seven percent of this watershed is tile drained to help move water off farm fields and to the streams rather quickly. This causes the flows of this stream system to become very inconsistent. Frequent high flows can lead to large amounts of erosion. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

The percentage of macroinvertebrates that are burrowers were not elevated at biological station 09CD018 since riffle habitat was not sampled (Figure 43). Burrowers can be found in other habitats as well, like overhanging vegetation or undercut banks. The biological station had less than average percentages of clingers and EPT individuals. Clinger species attach to rocks or woody debris. Clingers can decrease in stream reaches with homogenous substrate composition, velocity, and depth (CADDIS). EPT taxa are commonly used to measure overall health of ecosystems, due to their sensitivity to many stressors including habitat. In addition, the percentage of tolerant "legless" individuals was dramatically high during the visit at the biological station (94.5%). Snails were the dominant species collected, which are both legless and climbers, increasing both those numbers. There were a good percentage of climber individuals found at all visits, which is expected (dominant habitat type).

Biological station 09CD018 had a fish community with a low percentage of riffle dwelling fish (2.0%), non-tolerant benthic insectivores (15.4%), and darter, sculpin and round bodied suckers (2.5%). Biological station 09CD018 also lacked piscivores (0%).These habitat related fish metrics were all well below averages for stations in the Cedar River Watershed. The most abundant fish species found at biological station 09CD018 were southern redbelly dace, bigmouth shiner, blacknose dace and creek chub. In addition, the percentage of pioneer species was below the average for the Cedar River Watershed, which is species that can thrive in instable environments. This is further reinforced by a high percentage of tolerant fish species in Roberts Creek (69%).

Due to the reduced percentages of macroinvertebrate clingers, EPT individuals and tolerant "legless" taxa and low percentage of riffle dwelling and benthic insectivore fish show that a lack of suitable habitat and substrate embeddedness is limiting the macroinvertebrate and fish communities in this reach. Lack of habitat is considered a stressor to the macroinvertebrate and fish communities in Roberts Creek (-506).

Table 24: MSHA scores for Roberts Creek Watershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	09CD018	Roberts Creek	1	12	15.2	11	24	63.2	Fair

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA > 66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA < 45)

Figure 42: Photograph of habitat conditions at biological station 09CD018 on July 1, 2009 (left) and dry conditions on July 19, 2012 at station S000-749 (right).

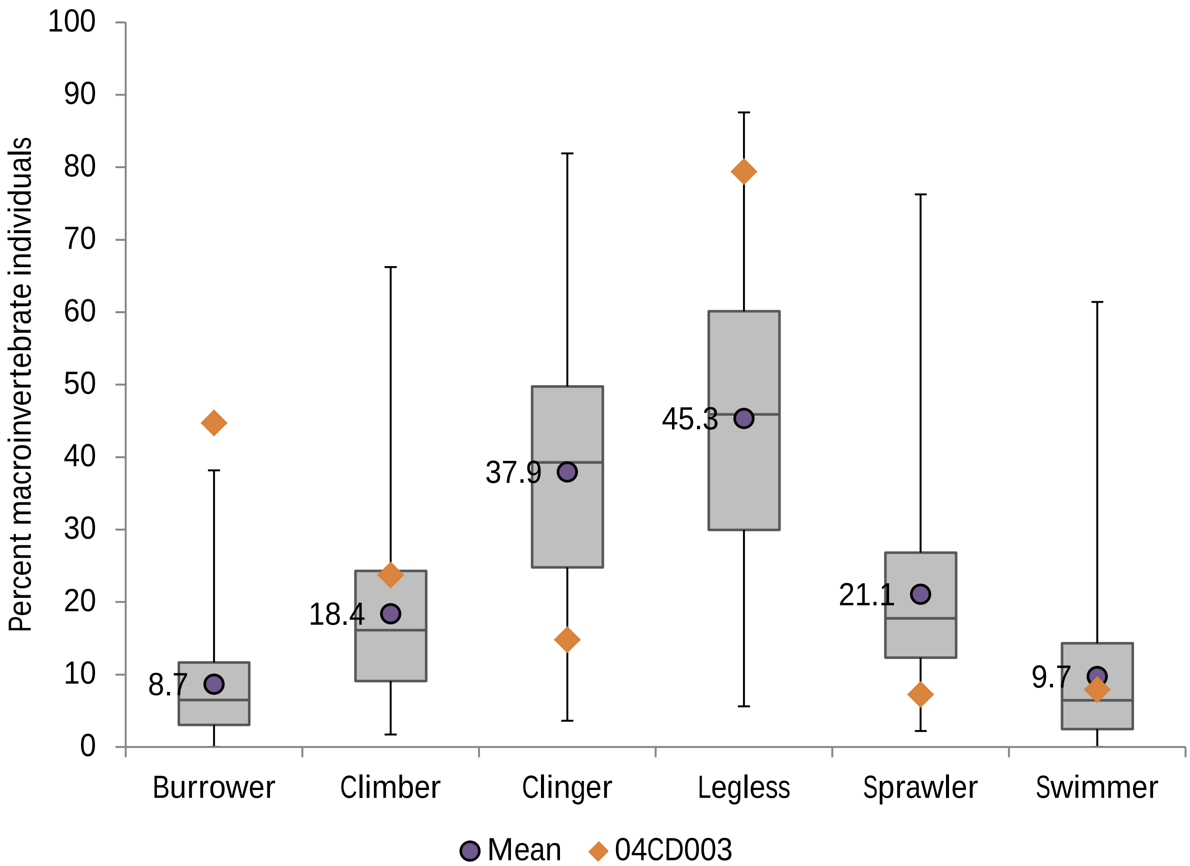


Figure 43: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Forest Streams GP stations with M-IBI greater than 46.8 (threshold), mean of those stations, and metric values from station 09CD018.

5.2.3. Candidate cause: High nitrate-nitrite

Nitrate was 17 mg/L during fish sampling on July 1, 2009 at biological station 09CD018. Nitrate was sampled four times in 2012 at station S000-749. The highest sample was 26 mg/L on June 22, 2012 while the lowest nitrate sample was less than 0.05 mg/L on July 19, 2012. The two other samples were both 19 mg/L in the month of May 2012. Three samples were taken in 1989, and were 6.1 mg/L and below. There were two nitrate measurements taken in 1980 and were 1.6 mg/L and 1.8 mg/L. The only available data from the city of Brownsdale WWTP was low at 0.2 mg/L in June 2012.

The macroinvertebrates in this reach were made up of 85.3% tolerant taxa and lacked intolerant taxa as defined by MPCA. Biological station 09CD018 was lacking non-hydropsychid Trichoptera. Trichoptera are often considered sensitive to nitrate and respond with decreases in taxa. At station 09CD018, there were 85.3% nitrate tolerant macroinvertebrates, with 17 nitrate tolerant taxa and no nitrate intolerant taxa.

In terms of the fish community, stations in this reach lacked sensitive taxa which may be indicative of the high nitrate levels. The biological station also has fish that are quick to mature and are short-lived. With the limited nitrate data available, nitrate is a stressor to the impaired biota. More nitrate data should be collected to help characterize the nitrate in Roberts Creek (-506).

5.2.4. Candidate cause: Low dissolved oxygen

There were four measurements of DO collected in 2012 that ranged from 2.85 mg/L to 9.85 mg/L. One measurement of 2.85 mg/L was below the standard (5 mg/L). This low DO measurement was taken July 19, 2012, at 11:55 am during very low flow conditions. There were seven DO measurements from 1980 and 1989. A measurement on July 23, 1980, and August 23, 1989, were below the standard. On July 1, 2009, the DO measurement taken at the time of fish sampling at biological station 09CD018 was 8.92 mg/L. A longitudinal study of DO took place in 2012, and the stream was sampled in the morning (prior to 9 am) and again in the afternoon to see if DO flux took place. The early morning DO measured from that day at station S000-749 was 3.56 mg/L, which is below the water quality standard. The afternoon measurement was 7.9 mg/L showing the flux to be less than the proposed standard. The proposed standard for DO flux in the south region of the state is 4.5 mg/L. Due to low flow conditions a YSI sonde was not deployable in order to collect diurnal flux.

The macroinvertebrate community comprised of a low percentage of EPT taxa (5.9%). The tolerant taxa was elevated in 2009 (85.3%) and the taxa count was low (TaxaCountAllChir; 34). The macroinvertebrates in this AUID had a low metric HBI_MN, a measure of pollution based on tolerance values assigned to each individual taxon. Station 09CD018 received a low metric score (1.4) lower than the average score needed to be above the threshold. The macroinvertebrate DO TIV station score (6.7) was below the average for the Cedar River (6.8). The DO intolerant macroinvertebrate taxa (2) and the percent DO tolerant taxa (12.4%) were both below the average for the Cedar River basin.

The fish community was in the upper half of DO aggregate fish scores (7.45), indicating that comparatively to other stations in the Cedar River, there is some sensitivity to DO. The most DO sensitive fish found at this station were southern redbelly dace and there was a presence of DO tolerant fish such as central mudminnows, brook stickleback and fathead minnows.

This stream should continue to be monitored under differing weather conditions to deepen the DO data set and better understand the DO dynamics. Until the DO dynamics are better understood, DO is considered to be inconclusive as a stressor.

5.2.6. Candidate cause: High phosphorus

Total phosphorus (0.025 mg/L) was below the standard at the time of fish sampling in Roberts Creek on July 1, 2009. Four samples were taken during the sampling season of 2012 and all but one was below the standard. There were two phosphorus measurements in 1980 and both were more than double the standard. In 1989, there were three measurements and one was more than double the standard. As interacting variables to eutrophication, phosphorus, pH, chlorophyll-a and BOD were compared to normal ranges and standards. One of the response variables, DO flux was measured. There were two measurements of BOD and were high at 8.3 mg/L and 5.5 mg/L. Chlorophyll-a had five samples in 1980 and 1989, one measurement was above 35 µg/L.

This stream reach has a low taxa count (TaxaCountAllChir; 34). Biological station 09CD018 lacked intolerant taxa (0) and the percent tolerant taxa was high (Tolerant2ChTxPct; 85.3%). The percentage of intolerant taxa will decrease and the percentage of tolerant taxa will increase with increases in phosphorus. The percentage of scrapers was 53.1%, which was well above the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. The number of collector-gather taxa (11) was low and collector-filterer taxa (6) were above the average for the Cedar River Watershed. There were 2 EPT taxa in this stream reach. The range of EPT taxa within the Cedar River Watershed was 0 to 20. The metric, EPT, provides a relative measure of the presence and diversity of pollution-sensitive macroinvertebrate groups.

This reach had a moderate percentage of carnivorous fish (19%). Carnivorous fish often decrease with increases in phosphorus (MPCA 2013). As previously mentioned, this reach lacks sensitive fish taxa relative to the total taxa present. The tolerant individuals comprise of 69% of the total fish individuals surveyed, resulting in a low metric score. Non-tolerant benthic insectivores taxa were below average (15.4%). Generalists comprise of 39% of the community. Elevated phosphorus is not a stressor to the biological community in Roberts Creek (-506).

5.2.7. Candidate cause: High suspended sediment

Biological station 09CD018 had low TSS at the time of fish sampling on July 1, 2009, (1.0 mg/L), along with an excellent transparency tube reading (100 cm). In 2012, there were four transparency tube readings. Two of the measurements were greater than 100 cm (excellent), one was 86 cm (good) and the fourth measurement was 34 cm (fair). There were two measurements of TSS collected in 1980. TSS was not elevated above the draft standard of 65 mg/L. There were two measurements of turbidity collected in 1980 and three measurements collected in 1989 and were low. TSS data for a range of flows should be collected in Roberts Creek to determine the impacts to the biota.

In 2009, biological station 09CD018 had a high percentage of herbivorous fish and a high percentage of macroinvertebrates that are scrapers and a low percentage of macroinvertebrates that are collector-filters. Herbivorous fish also decrease with increases in TSS. Collector-filterers are reduced when TSS is elevated (Markus, 2011). Collector-filterer species collect their food by filtering it from the water column. The percentage of long lived macroinvertebrates was very low (1.9%). Long-lived macroinvertebrates are often reduced with increases in TSS. The biological station had a macroinvertebrate TSS station index score (15.7; Table 25) that was below the average compared to the average warmwater stations in the Cedar River Watershed (16.3). The station had a very low percentage of TSS tolerant individuals (5%) and TSS tolerant taxa (5) compared to the averages for warmwater stations in the Cedar River Watershed for percent of TSS tolerant individuals (25.9%) and TSS tolerant taxa (9). There are biological indications that TSS or turbidity may be a concern, yet findings are inconclusive due to limited data.

Table 25: Macroinvertebrate metrics relevant to TSS for stations in Roberts Creek compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
09CD018	15.7	2	5	5.13	**0**	5
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

5.2.8. Conclusions

The stressors to Roberts Creek (-506) are summarized in Table 26. Habitat, flow alteration nitrate are stressors to the macroinvertebrate and fish communities found at 09CD018. Nitrate concentrations are elevated and having an impact on the biota. The primary reason for flow alteration is the lack of consistent base flow. When a stream frequently dries up or becomes intermittent it makes it extremely difficult for many species, especially sensitive species, of biota to re-establish themselves and complete their respective life cycles. With the lack of DO and phosphorus data it is currently inconclusive if DO and phosphorus are contributing to the biological impairment. TSS cannot be concluded as a stressor to Roberts Creek at this time, lacking sufficient chemical data to understand sediment concentrations. Having a consistent base flow of water will allow this stream to be monitored more frequently for these stressors. Additional TSS information should be collected.

Roberts Creek would likely benefit from habitat improvement for the macroinvertebrates and fish communities and altering the surrounding landscape to help return the flow regime back to a more consistent and less flashy system. Nitrate levels are elevated (26 mg/L), and should be monitored over time. Better management of nutrients would benefit Roberts Creek. Overall, there is little chemical information on this reach, and additional information should be collected to confirm or rule out these potential stressors.

Table 26: Summary of stressors found in Roberts Creek (-506).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors					
			Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-506 Roberts Creek Headwaters to unnamed creek	09CD018	Macroinvertebrate IBI F-IBI	•	•	o		o	•

• = stressor; o = inconclusive stressor; 'blank'-not an identified stressor

5.3. Unnamed Creek: unnamed creek to unnamed creek (AUID: 07080201-593)

One biological station 09CD017 was sampled for fish and macroinvertebrates in 2009 on stream reach (-593). Biological station 09CD017 is located upstream of 285th Street, 3 miles northwest of Brownsdale.

Water quality sampling was done at EQuIS station S007-065 just upstream of 285th Street, 3.5 miles northwest of Brownsdale. Water quality data from 2012 were used to determine stressors.

5.3.1. Biology in unnamed creek

The MPCA surveyed one biological station 09CD017 on July 9, 2009, on AUID 07080201-593 for fish and sampled the macroinvertebrates on August 5, 2009. The M-IBI was 45.91 which are below the threshold of 46.8 and within the confidence interval for a Southern Forest Streams GP (Table 27). The F-IBI score for this station was 62 which are above the threshold (51) and within confidence interval for a Southern Headwaters Stream. The macroinvertebrate community is not meeting standards for unnamed creek (-593).

Table 27: Summary of biological impairments in unnamed creek (-593).

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-593, unnamed creek to unnamed creek	09CD017	unnamed creek	5.53	Southern Forest Streams	46.8	45.91	Southern Headwaters	51	62

Macroinvertebrates in the class Southern Forest Streams GP for biological station 09CD017 scored poorly in the metrics of collector-filterers (Collector-filtererPct), Plecoptera, Odonata, Ephemeroptera and Trichoptera taxa (POET), a measure of pollution based on tolerance values assigned to each individual taxon (HBI_MN), non-hydropsychid caddisflies (TrichwoHydroPct) and Trichoptera (TrichopteraChTxPct; Figure 44). Biological station 09CD017 scored above the average needed to be above the threshold in the metrics of clinger taxa, taxa richness of predators (Predator), and total taxa richness of macroinvertebrates (TaxaCountAllChir). Unnamed creek also lacked intolerant taxa (intolerant2Ch). Five species dominated the sample (DomFiveCHPct; 47.13%) and the percent tolerant taxa was high (Tolerant2ChTxPct; 77.55%).

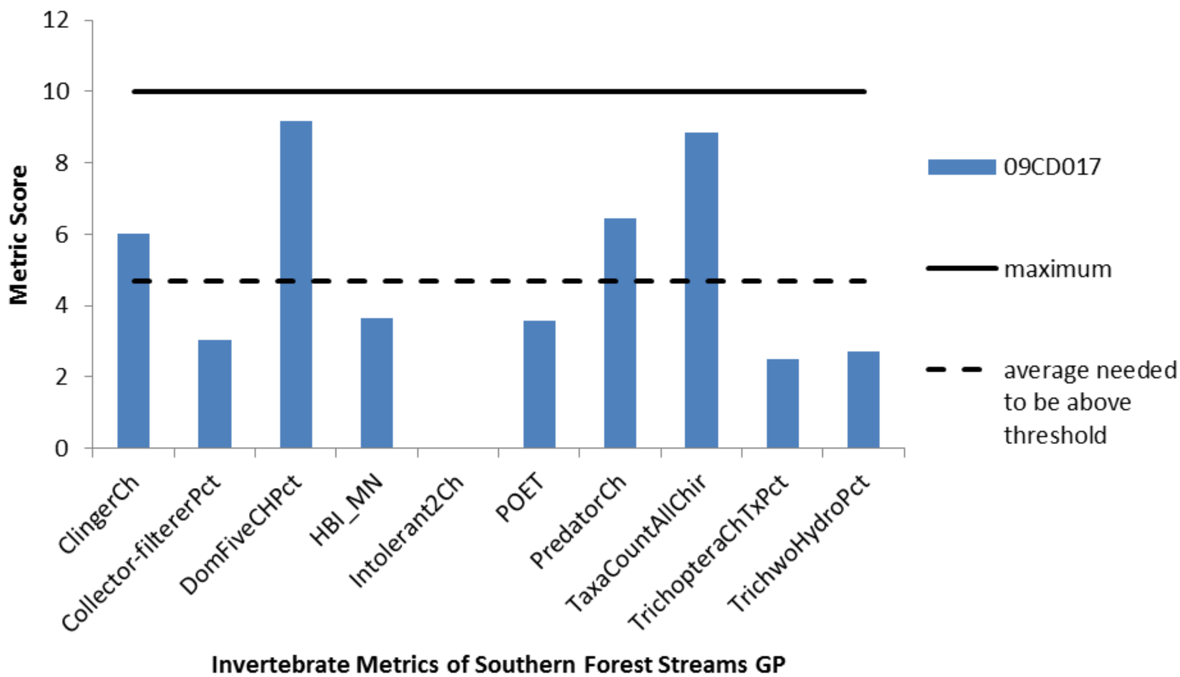


Figure 44: Macroinvertebrate metrics of the Southern Forest Streams GP in biological station 09CD017 in unnamed creek.

Biological station 09CD017 had high F-IBI metric scores for: detritivore taxa (DETNWQTxPct), generalist taxa (General Txpct), the relative abundance of short lived individuals (SLvdPct) and relative abundance of serial spawners (SSpnPct; Figure 45). Fish in the class Southern Headwaters for biological station 09CD051 scored poorly in the metrics of taxa richness of sensitive species and very tolerant taxa (VtolTxPct). Unnamed creek did not have fish DELTs, that if present, would have contributed negatively to the IBI.

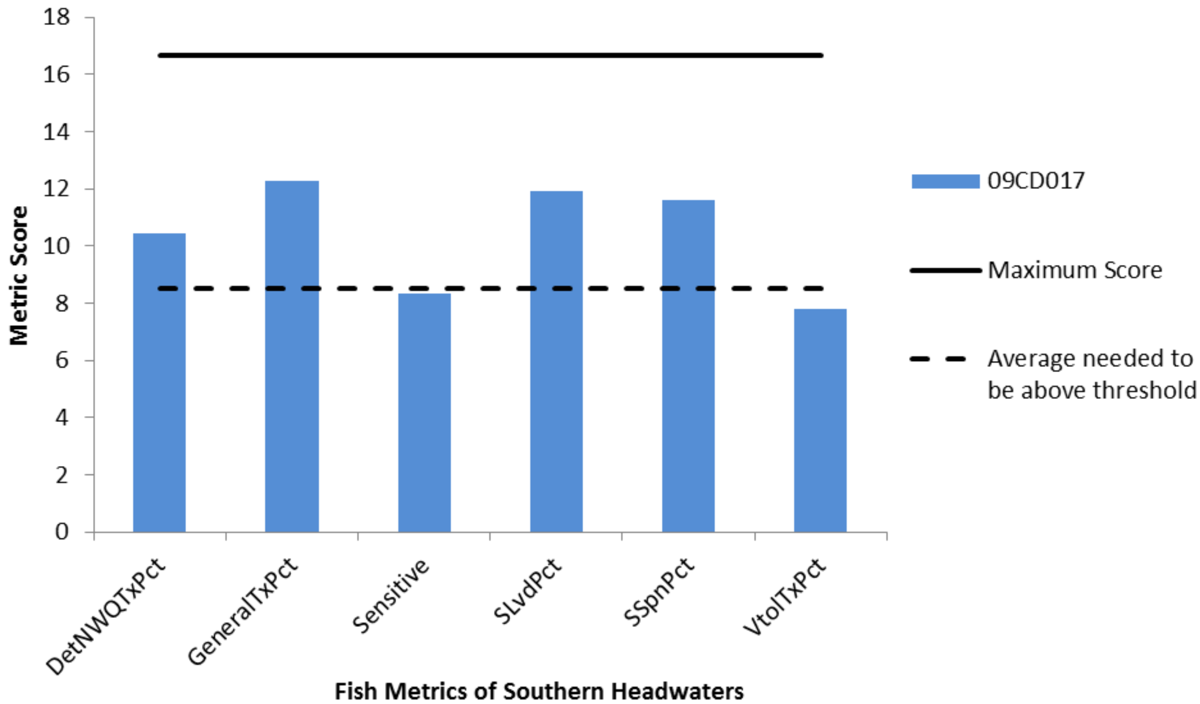


Figure 45: Fish metrics of the Southern Headwaters in biological station 09CD017 in unnamed creek.

5.3.2. Candidate cause: Lack of habitat/bedded sediment

The unnamed creek station 09CD017 scored 61.2 (fair) on the MSHA (Table 28). Of the five subcategories in the MSHA, land use and substrate scored poorly. The field crew noted unnamed creek had moderate channel stability. The water was clear. This reach contained 20% riffle and was dominated by sand and silt, with light embeddedness.

The surrounding land use was noted as row crop with a wide (150 to 300 ft.) riparian buffer on the right side and moderate (30-150 ft.) on the right side of the stream. There is little bank erosion on the left banks and moderate bank erosion on the right banks (Figure 46). Moderate cover was noted, with multiple cover types including overhanging vegetation, deep pools, logs or woody debris, rootwads and macrophytes. The habitat that was sampled for macroinvertebrates was woody debris/snags/rootwads, overhanging vegetation and undercut banks.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Roberts Creek Watershed is approximately 51% channelized. Thirty-seven percent of Roberts Creek Watershed is tiled, which helps move water off the farm fields and to the streams rather quickly. This causes the flows of this stream system to become very inconsistent. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

Macroinvertebrates that are burrowers were found above the statewide average for Southern Forest Streams GP class (17.5%; Figure 47). The percentage of EPT individuals was below the statewide average for Southern Forest Streams GP class (8.3%). The percentage of generally tolerant legless macroinvertebrate individuals was quite high (81.2%), which shows a shift in generally tolerant species present. The higher percentage of more legless macroinvertebrates, with a shift to more climbers is a result of habitat stress in this reach. The macroinvertebrates that are known to cling to large substrate and woody debris were above statewide averages for this class. This is also found in the M-IBI metrics, the number of clinger taxa (ClingerCh) was below the average metric score needed for the M-IBI to be at the threshold.

Site conditions/photos and macroinvertebrate response strongly supports habitat as a stressor in unnamed creek particularly in terms of erosion, bedded sediment and lack of stability.

Figure 46: Biological station 09CD017 on July 09, 2009 showing cut banks (left) and low flow conditions on July 26, 2012 at station S007-065 (right).

Table 28: MSHA scores for Roberts Creek Watershed

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	09CD017	unnamed creek	0	12	15.2	12	22	61.2	Fair

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA > 66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA < 45)

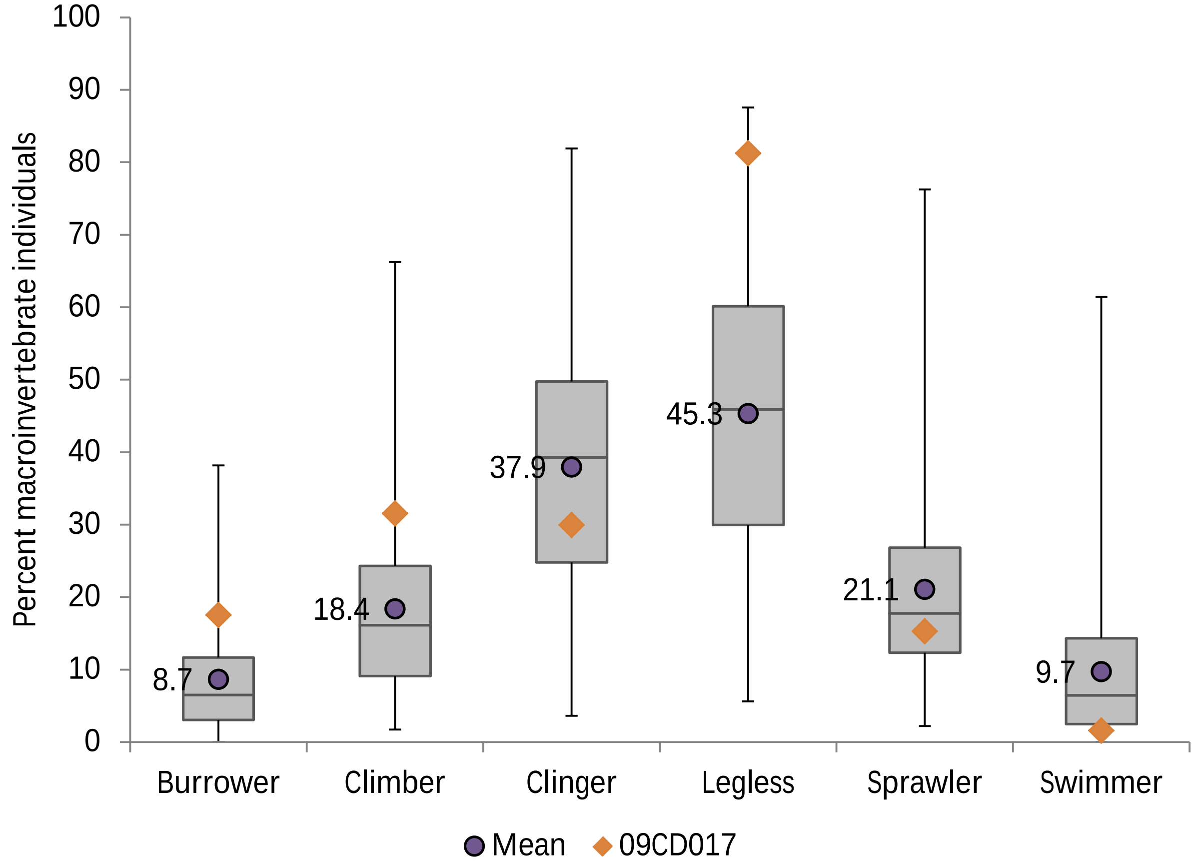


Figure 47: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Forest Streams GP stations with M-IBI greater than 46.8 (threshold), mean of those stations, and metric values from station 09CD017.

5.3.3. Candidate cause: High nitrate-nitrite

Nitrate was 10 mg/L during fish sampling on July 9, 2009, at biological station 09CD017. Nitrate was sampled five times in 2012 at station S007-065. The highest sample was 23 mg/L on June 22, 2012 while the lowest nitrate sample was 3.4 mg/L on July 19, 2012.

The macroinvertebrates in this reach were made up of 63.27% tolerant taxa and lacked intolerant taxa (4.08%) as defined by MPCA. Biological station 09CD017 was lacking non-hydropsychid Trichoptera (0.96%). Trichoptera are often considered sensitive to nitrate and respond with decreases in taxa. At station 09CD017, there were 89.86% nitrate tolerant macroinvertebrates, with 32 nitrate tolerant taxa and only one nitrate intolerant taxon. With the limited nitrate data available, nitrate is a stressor to the impaired biota. More nitrate data should be collected to help characterize the nitrate in this unnamed creek.

5.3.4. Candidate cause: Low dissolved oxygen

There was a lack of DO data within this reach. There were only six measurements of DO collected. Do measurements ranged from 6.77 mg/L to 9.16 mg/L. One of the measurements was taken at the time of fish sampling (8.12 mg/L). The DO measurements in 2012 were taken late morning (after 9 am) and were over 1.5 mg/L above the standard. There is no indication in this small dataset for excessive DO flux.

The macroinvertebrate community comprised of a low percentage of EPT taxa (8.28%). The tolerant taxa was elevated in 2009 (77.55%) and the taxa count was abundant (TaxaCountAllChir; 49). The macroinvertebrates in this AUID had a low metric HBI_MN, a measure of pollution based on tolerance values assigned to each individual taxon. Station 09CD017 received a low metric score (3.66) lower than the average score needed to be above the threshold. The macroinvertebrate DO TIV station score (6.9) was above the average for the Cedar River basin (6.8). At station 09CD017, the numbers of macroinvertebrate taxa collected that are intolerant to low DO were 5, and the percentage of DO tolerant species collected were 9.6. The average number of intolerant taxa collected in the Cedar River basin was 4.6 and the average percentage of DO tolerant taxa was 20.

With the lack of DO data it is currently inconclusive if DO is contributing to the biological impairment. It would be beneficial to collect more diurnal DO information to understand the reoccurrence of low DO.

5.3.5. Candidate cause: High phosphorus

Total phosphorus (0.08 mg/L) was below the standard at the time of fish sampling in unnamed creek on July 9, 2009. Five samples were taken during the sampling season of 2012 ranging from 0.044 mg/L to 0.143 mg/L. As interacting variables to eutrophication, phosphorus, pH, BOD and chlorophyll-a were compared to normal ranges and standards. The response variable, DO flux was not measured. There were no measurements of BOD and chlorophyll-a.

This stream reach has a high macroinvertebrate taxa count (TaxaCountAllChir; 49). Biological station 09CD017 lacked intolerant taxa (2) and the percent tolerant taxa was high (Tolerant2ChTxPct; 77.55%). The percentage of intolerant taxa will decrease and the percentage of tolerant taxa will increase with increases in phosphorus. The percentage of scrapers was 5.4%, which was below the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. The number of collector-gather taxa (23) and collector-filterer taxa (5) were both high as well. There were five EPT taxa in this stream reach. The range of EPT taxa within the Cedar River Watershed was 0 to 20. The metric, EPT, provides a relative measure of the presence and diversity of pollution-sensitive macroinvertebrate groups.

Due to the low values, lack of data (phosphorus, chlorophyll-a, or BOD) or low DO, and mixed biological response, phosphorus is inconclusive as a stressor to the macroinvertebrate community. It would be recommended to collect additional data to assist with further understanding.

5.3.6. Candidate cause: High suspended sediment

Biological station 09CD017 had low TSS at the time of fish sampling on June 30, 2009, (9 mg/L), along with an excellent transparency tube reading (67.5 cm). In 2012, there were five transparency tube readings, all of the readings were 34 cm (fair) and above. There were no additional measurements of TSS and turbidity collected. TSS data for a range of flows should be collected in unnamed creek.

In 2009, biological station 09CD017 had a low percentage of herbivorous fish and a low percentage of macroinvertebrates that are scrapers and collector-filters. Collector-filterers are reduced when TSS is elevated. Collector-filterer species collect their food by filtering it from the water column. Herbivorous fish also decrease with increases in TSS. The percentage of long lived macroinvertebrates was above average for the Cedar River Watershed (7.32%). The station had a high percentage of TSS tolerant individuals (26.5%; Table 29) and average TSS tolerant taxa (9) compared to the averages for warmwater stations in the Cedar River Watershed for percent of TSS tolerant individuals (25.9%) and TSS tolerant taxa (9). There are biological indications that TSS or turbidity may be a concern, yet findings are inconclusive due to limited data.

Table 29: Macroinvertebrate metrics relevant to TSS for stations in unnamed creek compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
09CD017	15.68	2	9	26.5	**0**	7
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

5.3.7. Conclusions

The stressors to unnamed creek (-593) are summarized in Table 30. Habitat, flow alteration and nitrate are stressors to the macroinvertebrate found at 09CD017. Nitrate concentrations are elevated and having an impact on the biota. Roberts Creek watershed is more than 50% channelized. With a drainage area of 5.53 square miles, the flashy tendencies of the stream caused by widespread channelization have negative impact on the biological communities. With the lack of DO and phosphorus data it is currently inconclusive if DO and phosphorus are contributing to the biological impairment. There is little chemical information on this reach for TSS, but the biological community overall is showing sensitivity to TSS. Findings are inconclusive due to limited data. TSS data for a range of flows should be collected in unnamed creek to determine the impacts to the biota.

Unnamed creek would likely benefit from habitat improvement for the macroinvertebrates. Nitrate levels are elevated (23 mg/L), and should be monitored over time. Better management of nutrients would benefit unnamed creek. Overall, there is little chemical information on this reach, and additional information should be collected to confirm or rule out these potential stressors.

Table 30: Summary of stressors found in unnamed creek (-593).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors					
			Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-593 unnamed creek unnamed creek to unnamed creek	09CD017	Macroinvertebrate IBI	•	•	o	o	o	•

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

5.4. Roberts Creek: unnamed creek to Cedar River (AUID: 07080201-504)

The impaired reach is located in Mower County and is 5.8 miles long (Figure 35). Roberts Creek (AUID 07080201-504) was listed in 2006 as impaired for aquatic recreation due to high bacteria counts, and is listed as non-supporting of aquatic life for aquatic macroinvertebrate community.

There are two biological stations on Roberts Creek (-504). Biological station 04CD033 located downstream of 570th Avenue, two miles east of Lansing and 09CD013 is located upstream of 550th Avenue, three miles northeast of Brownsdale, and were sampled for fish and macroinvertebrates in 2004 and 2009.

Water quality sampling was done at multiple EQuIS stations throughout the stream reach. The outlet of Roberts Creek was sampled for water chemistry at 550th Avenue, four miles west of Brownsdale. This location is also represented by Cedar River Watershed District station #8 and MPCA's EQuIS station S001-182. Water quality data was also collected in 2012 at EQuIS station S000-746, which was located at CSAH-16, two miles west of Brownsdale. Water quality data from 1989 to 2012 were used to determine stressors.

The Brownsdale and Sargeant WWTPs are located upstream of this stream reach. Both facilities have controlled discharge stabilization ponds and do not authorize discharges from June 15th to September 15th.

5.4.1. Biology in Roberts Creek

The MPCA surveyed one biological station 04CD033 on August 25, 2004, and biological station 09CD013 on July 22, 2009, on AUID 07080201-504 for fish. Biological station 04CD033 was surveyed on September 1, 2004, for macroinvertebrates and August 5, 2009, at biological station 09CD013. The macroinvertebrate IBI was 10.70 which were below the threshold of 35.9 and confidence interval for Southern Streams Riffle Run (RR). The M-IBI was 65.15 at biological station 09CD013, which was above the threshold of 46.8 and confidence interval for Southern Forest Streams GP (Table 31). The F-IBI score for biological station 04CD033 was 74 which were above the threshold of 51 and confidence interval for Southern Headwaters. The F-IBI score for biological station 09CD013 was 49 which were above the threshold of 45 and below the confidence interval for Southern Streams. The macroinvertebrate community does not meet standards for Roberts Creek (-504).

Table 31: Summary of biological impairments in Roberts Creek (-504).

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-504, unnamed creek to Cedar River	09CD013	Roberts Creek	39.07	Southern Forest Streams GP	46.8	65.15	Southern Streams	45	49
	04CD033	Roberts Creek	26.01	Southern Streams RR	35.9	10.70	Southern Headwaters	51	74

Biological station 04CD033 had 9 out of the 10 M-IBI metrics below the average metric score needed for an IBI score greater than the threshold (Figure 48). Macroinvertebrates in the class Southern Streams RR scored poorly in the metrics of taxa richness of climbers (ClimberCh, percentage of taxa that are clingers (ClingerChTxPct), and taxa richness of Odonata, predators (PredatorCh) and taxa richness of Trichoptera (Trichoptera). The biological station also lacked stoneflies (Plecoptera). Five species dominated the sample (DomFiveCHPct; 79.71%) and was overly abundant with tolerant taxa as well (Toleranct2ChTxPct; 91.30). Macroinvertebrates scored just above the average needed to be above the threshold in the metrics of a measure of pollution based on tolerance values assigned to each individual taxon (HBI_MN).

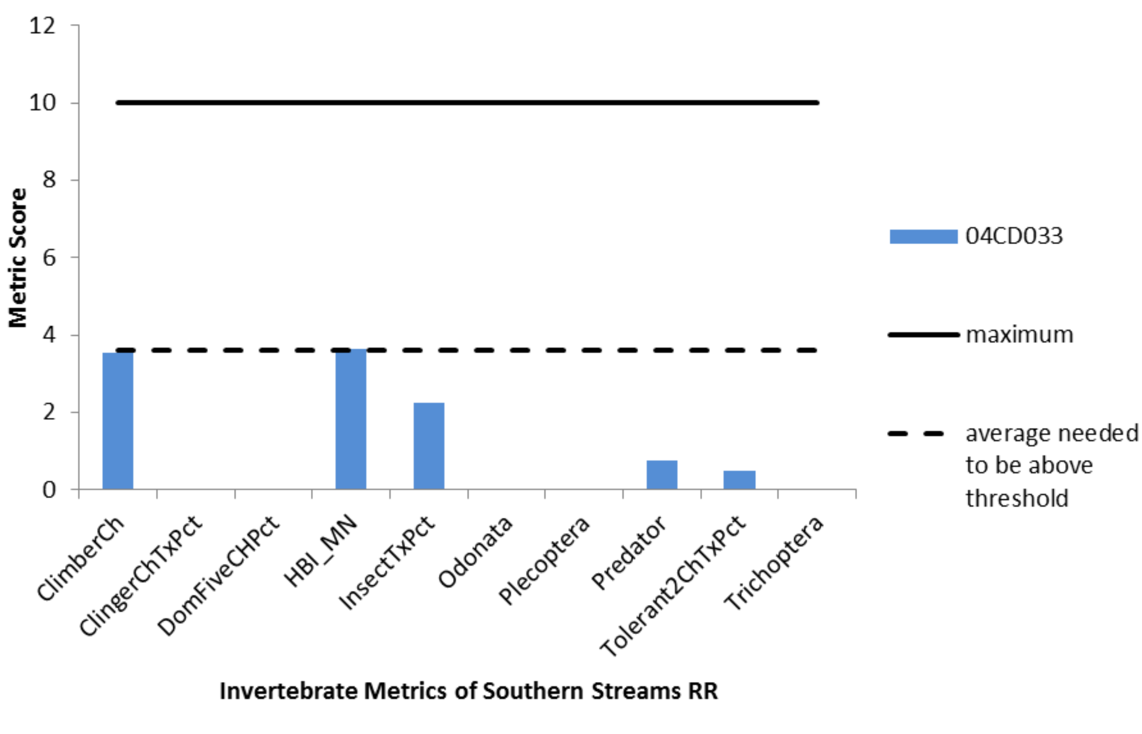


Figure 48: Macroinvertebrate metrics of the Southern Streams RR in biological station 04CD033 in Roberts Creek.

Macroinvertebrates in the class Southern Forest Streams GP had nine metrics score above the average needed to be above the threshold (Figure 49). Biological station 09CD013 lacked intolerant taxa (intolerant2Ch) and was abundant with tolerant taxa (Tolerant2ChTxPct; 80.39%).

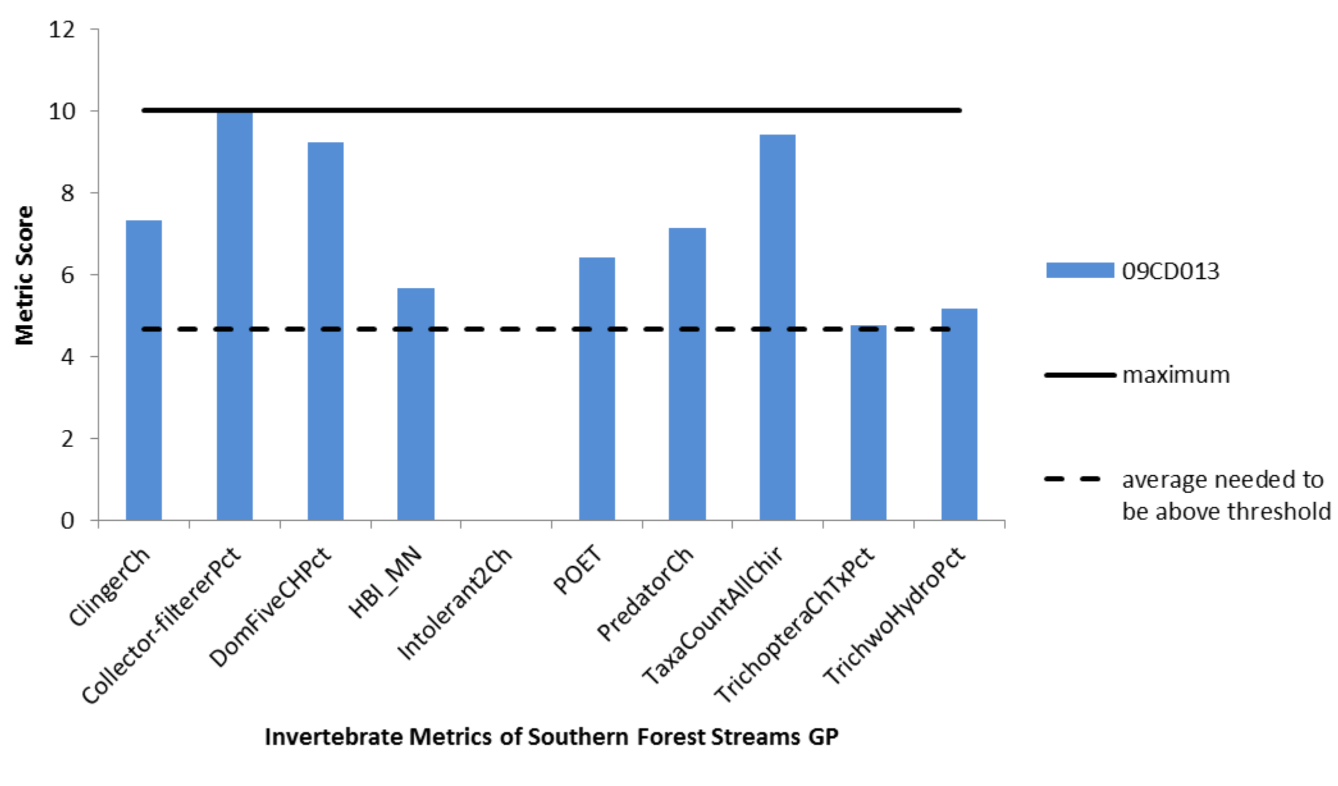


Figure 49: Macroinvertebrate metrics of the Southern Forest Streams GP in biological station 09CD013 in Roberts Creek.

The fish community was not listed as impaired. Fish in the class Southern Headwaters had five of the six metrics score above the average needed to be above the threshold: detritivore taxa (DETNWQTxPct), generalist taxa (General Txpct), Sensitive taxa (Sensitive TxPct) relative abundance of individuals that are short-lived (SLvdPct), and relative abundance of taxa that are very tolerant (VtolTxPct; Figure 50). There is an abundance of of individuals that are serial spawners (SSpnPct). This reach did not have fish DELTs, that if present, would have contributed negatively to the IBI.

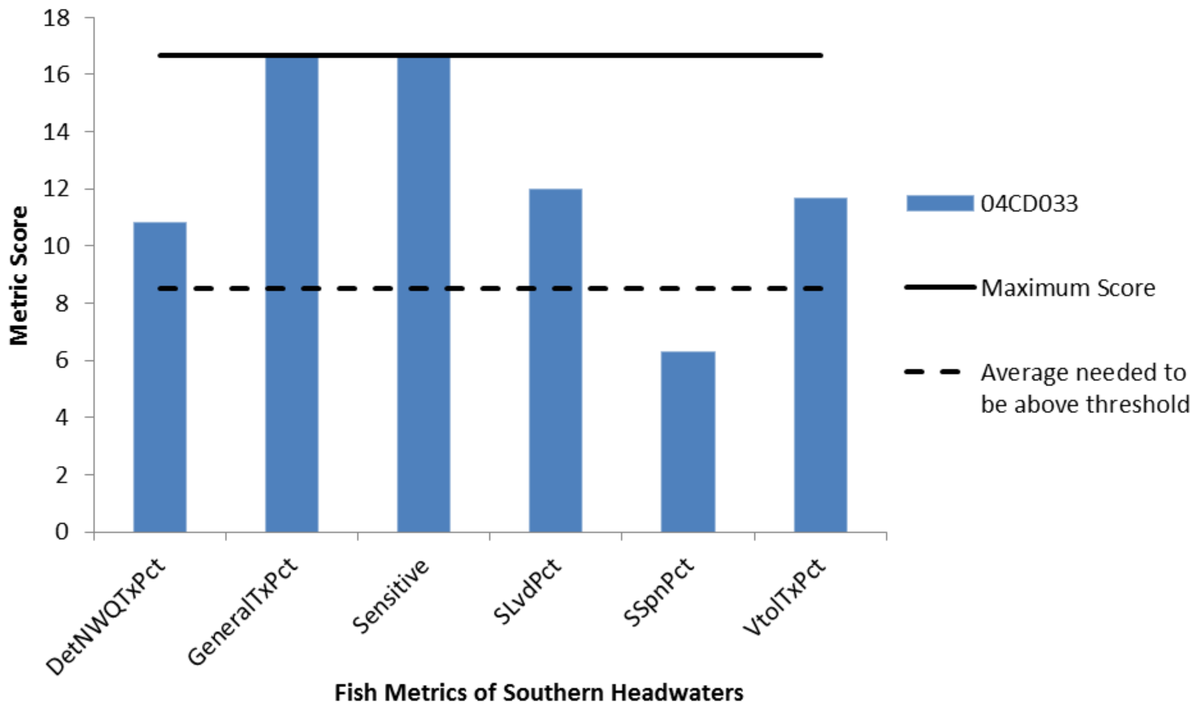


Figure 50: Fish metrics of the Southern Headwaters in biological station 04CD033 in Roberts Creek.

Biological station 09CD013 had an abundance of fish that reach maturity before the age of two (MA<2Pct), relative abundance of individuals that are tolerant species (TolPct) and have short lived species (SLvd; Figure 51). The metrics that were above the average needed to be above the threshold were abundant with taxa that are benthic insectivores (excludes tolerant species (BenInsect-TolTxPct), taxa that are detritivorous (DetNWQTXPct) and combined relative abundance of two most abundant taxa (DomTwoPct). There were a low number of taxa that are sensitive (SensitiveTxPct), and an abundance of taxa that are tolerant (TolTxPct). Biological station 09CD013 had no DELT deductions for the IBI.

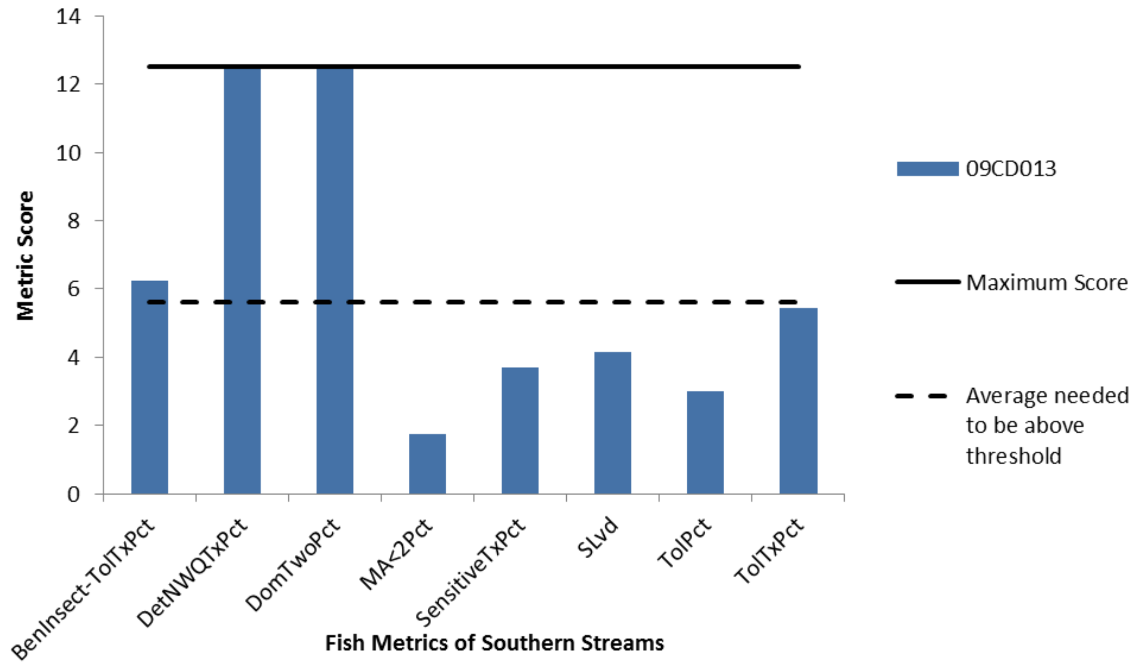


Figure 51: Fish metrics of the Southern Streams in biological station 09CD013 in Roberts Creek.

5.4.2. Candidate cause: Lack of habitat/bedded sediment

Biological station 04CD033 is further upstream and scored 66.5 (good) and biological station 09CD013 scored 64.8 (fair; Table 32). The water was clear with normal water level during the time of fish sampling at biological station 04CD033, and at biological station 09CD013 the water level was low and brown in color. This stream reached lacked riffle habitat having only 5% at biological station 04CD033 with cobble and gravel substrate with moderate (50–75%) embeddedness. The lower biological station 09CD013 lacked riffle habitat (10%) with sand and gravel substrate and light embeddedness (25-50%).

At biological station 04CD033 the surrounding land uses was noted as row crop with wide (150 to 300 ft) riparian buffer on the left bank and extensive riparian buffer (>300ft) on the right bank. There is little bank erosion on the left side and heavy erosion on the right bank (Figure 52). Sparse cover was noted, with multiple cover types including undercut banks, overhanging vegetation, deep pools, logs or woody debris, boulders and rootwads. The habitat that was sampled for macroinvertebrates was woody debris/snags/rootwads, under cut banks and overhanging vegetation and riffle/run/rock. Biological station 04CD033 has high channel stability with good channel development.

At biological station 09CD013 the surrounding land uses was noted as row crop and hay field with extensive (>300 ft.) riparian buffer. There is moderate erosion on both stream banks (Figure 52). Moderate cover was noted, with multiple cover types including overhanging vegetation, deep pools, logs or woody debris and rootwads. The habitat that was sampled for macroinvertebrates was woody debris/snags/rootwads. Biological station 09CD013 has low channel stability with good channel development.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. Roberts Creek has been observed dry during the summer and fall of 2012, which reduces the connectivity and the ability for this stream to support healthy fish and macroinvertebrate populations. Tile drainage used in this watershed helps move water off the farm fields and to the streams rather quickly. This causes the flows of this stream system to become very inconsistent. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

The Minnesota Department of Natural Resources (MDNR) conducted a geomorphology survey on Roberts Creek Watershed (Figure 53 and Figure 54). This reach is located 1.25 miles northwest of Brownsdale and in the upper reach of stream reach (-504). Roberts Creek is classified as a C5 stream type with sand substrate. The survey site has a moderate stream gradient and partially wooded riparian corridor. The channel in this reach is slightly incised with moderate stream bank erosion. The sinuosity and stream slope, entrenchment ratio, width/depth ratio and D50 particle size are all within the range for a C5 stream type. The riffles in this reach were poorly defined as well as the pools, which may suggest excess bedload is covering these features. The impact of more frequent higher flow events is forcing some larger scale channel changes in this reach. The channel is undergoing early channel evolution driven by excess hydrology, ditching, draining and stripping the riparian corridor causing channel incision and eventually total entrenchment. The more frequent higher flows this stream reach is experiencing reflect upon the land use practices upstream of this site. The study reach is located in valley type VIII, which is a wide, gentle valley slope with well-developed flood plain adjacent to river and/or glacial terraces.

There was an abundance of macroinvertebrates that are burrowers found at biological station 04CD033, which demonstrates sedimentation issues (65.43%; Figure 55). The percentage of EPT individuals was much less than the statewide average for Southern Forest Streams GP macroinvertebrate class (0.57% and 10.03%). Reduced EPT individuals are likely due to sediment covering and limiting available riffle habitat. The percentage of generally tolerant legless macroinvertebrate individuals was extremely high at both biological stations (99.14% and 88.88%; Figure 55 and Figure 56). The macroinvertebrates that are known to cling to large substrate and woody debris were low at biological station 04CD033 (below statewide average for Southern Streams RR), likely due to lack of woody material that is available to support these individuals. The macroinvertebrates that are clingers were above the statewide average for Southern Forest Streams GP at biological station 09CD013. This is also found in the M-BI metrics, the number of clinger taxa (ClingerCh) were below the average metric score needed for the M-IBI to be at the threshold at biological station 04CD033 and the number of clinger taxa (ClingerCh) were above the average metric score needed for the M-IBI to be at the threshold at biological station 09CD013.

Lack of sufficient habitat and substrate embeddedness is a stressor for the macroinvertebrate community at biological station 04CD033 on Roberts Creek. Habitat improvements would likely improve the macroinvertebrate community.

Table 32: MSHA scores for Roberts Creek Watershed.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	09CD013	Roberts Creek	0.8	12	18	11	23	64.8	Fair
1	04CD033	Roberts Creek	0	11.5	16	9	30	66.5	Good
Average Habitat Results			0.4	11.75	17	10	26.5	65.65	Fair

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA > 66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA < 45)

Figure 52: Roberts Creek at Biological Station 04CD033 (left) and Roberts Creek at Biological Station 09CD013 (right).

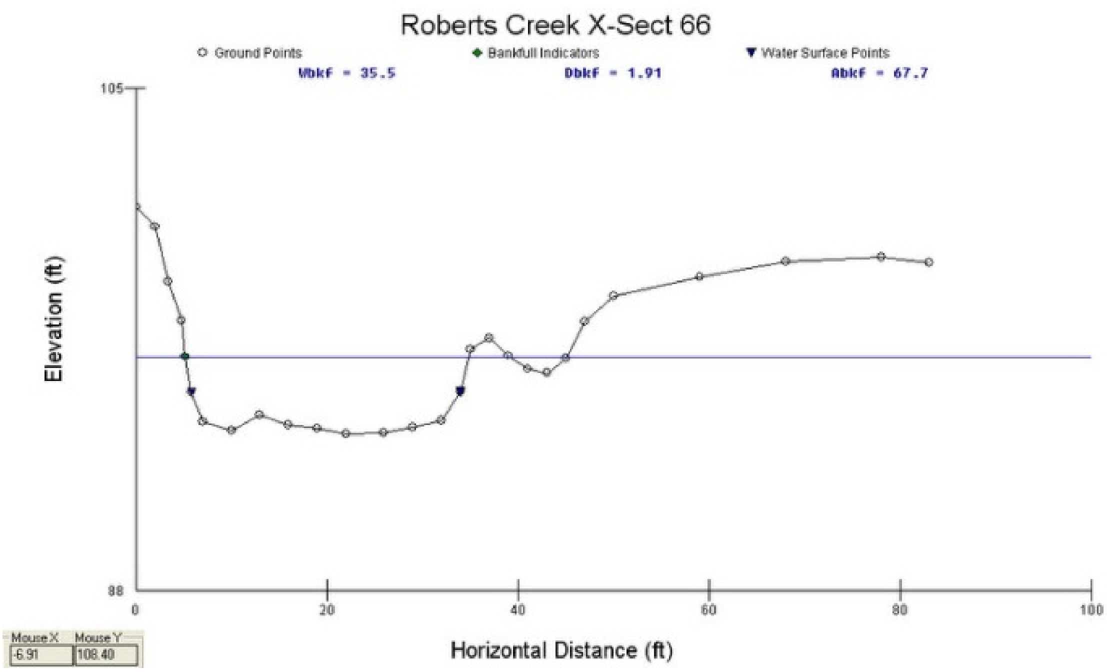


Figure 53: Riffle cross section with bankfull width of 35 feet for Roberts Creek.

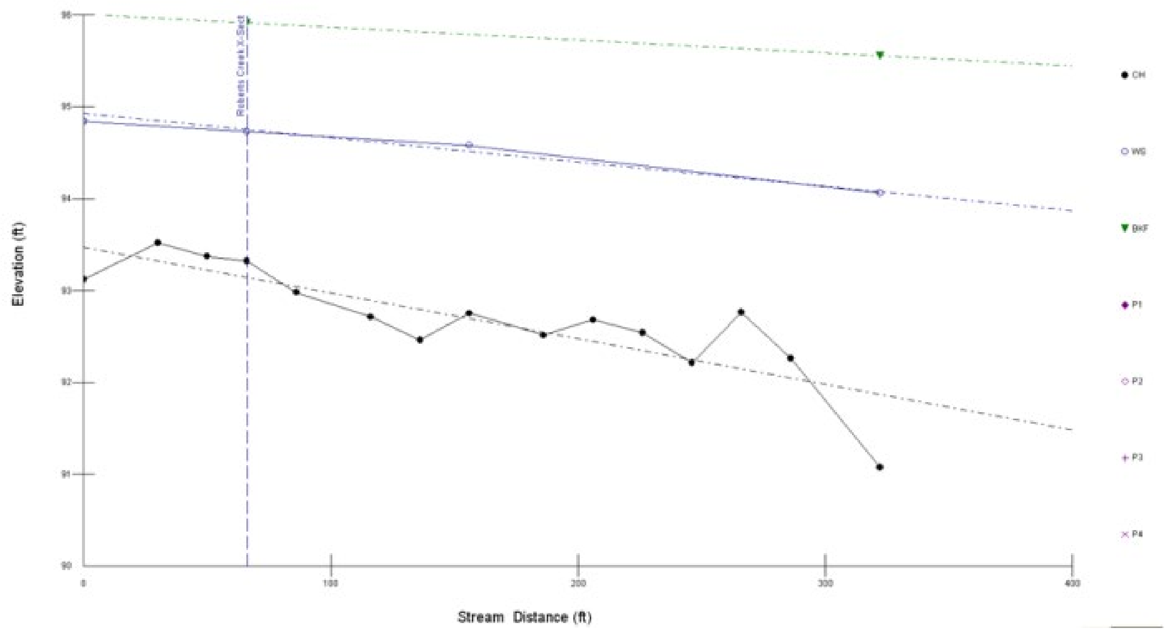


Figure 54: Longitudinal profile for Roberts Creek.

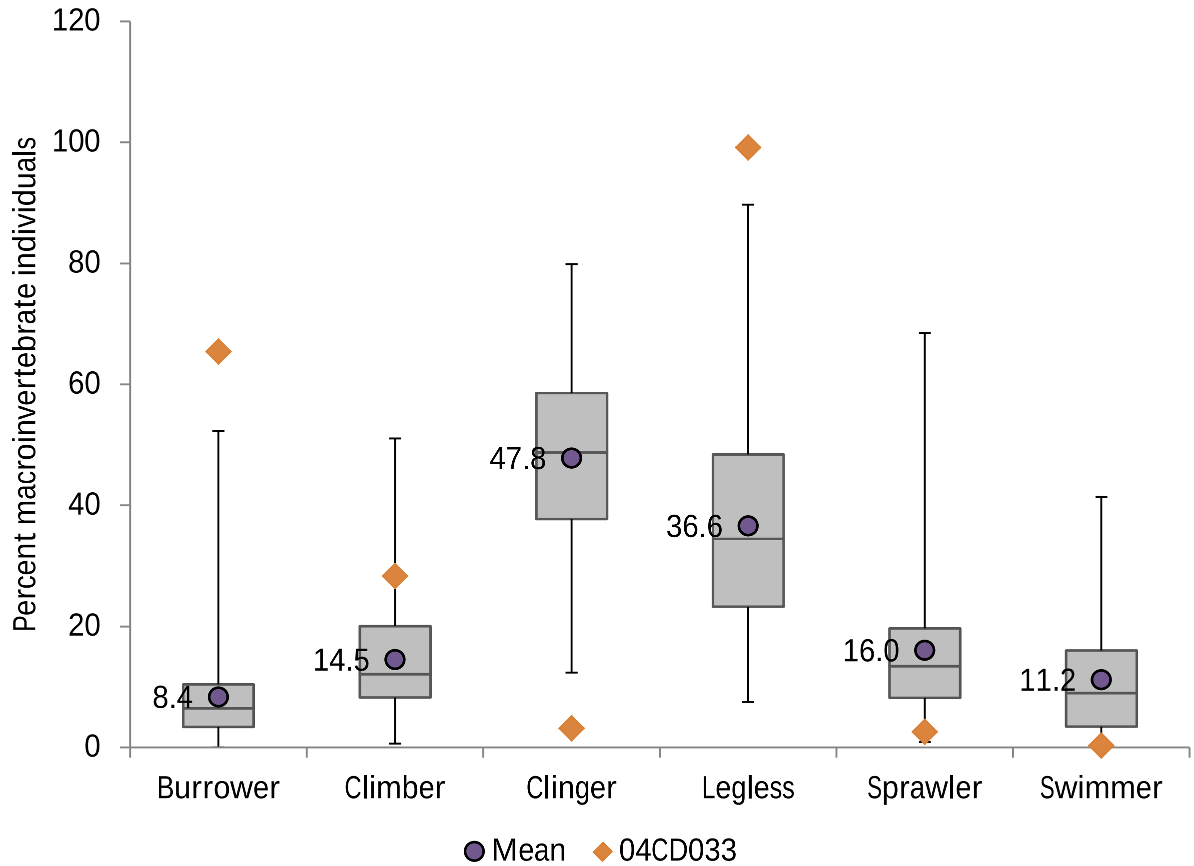


Figure 55: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Streams RR stations with M-IBI greater than 35.9 (threshold), mean of those stations, and metric values from station 04CD033.

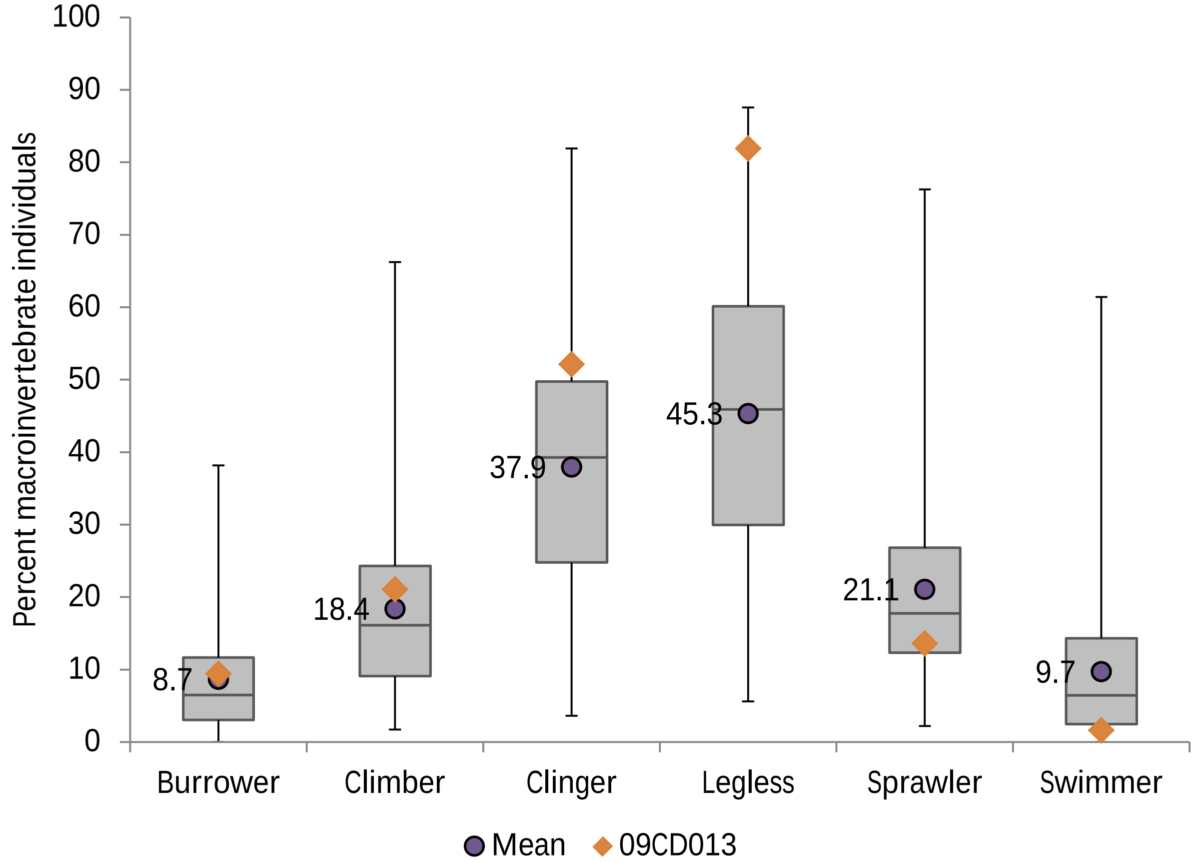


Figure 56: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Forest Streams GP stations with M-IBI greater than 46.8 (threshold), mean of those stations, and metric values from station 09CD013.

5.4.3. Candidate cause: High nitrate-nitrite

On this stream reach (-504), nitrate has been sampled for a total of 56 times in 1980, 1989, 2008 through 2010, and 2012. The highest sample was 27 mg/L on June 22, 2012 while the lowest nitrate sample was 0.11 mg/L on July 19, 2012, (Figure 57). The highest observed nitrate levels are in May and June and drop through the summer. The mean nitrate concentration was 5.56 mg/L. Unionized ammonia is not a concern based on the data available. Brownsdale WWTP had a single nitrate sample of 0.2 mg/L and there was no data available for Sargeant WWTP.

At both biological stations on this stream reach, less than 3% of the macroinvertebrate population was non-hydropsychid caddisflies at the two stations sampled. These caddisflies are sensitive to increased nitrate levels. The macroinvertebrates in this reach had a very high percent of tolerant taxa and lacked intolerant taxa as defined by the MPCA. At station 04CD033, there were 93.48% nitrate tolerant macroinvertebrates, with 14 nitrate tolerant taxa and no nitrate intolerant taxa. At station 09CD013, there were 57.48% nitrate tolerant macroinvertebrates, with 34 nitrate tolerant taxa and one nitrate intolerant taxon. The upstream biological station is showing the most potential stress. Nitrate is a primary stressor to the macroinvertebrate community in Roberts Creek (-504).

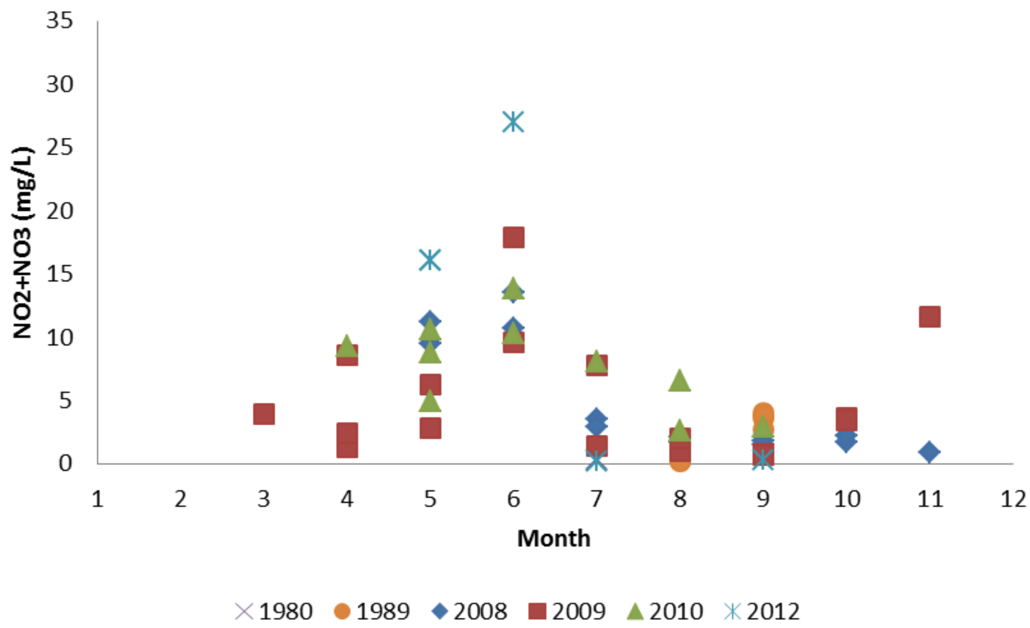


Figure 57: Nitrate-nitrite in Roberts Creek (-504) by month and by year.

5.4.4. Candidate cause: Low dissolved oxygen

There were 15 measurements of DO collected in 2010 and 2012. One measurement of 2.29 mg/L was below the standard (5 mg/L). This low DO measurement was taken September 4, 2012, at 10:15 a.m. during very low flow conditions. There were 10 DO measurements from 1980 and 1989. A measurement on August 23, 1989, was also below the standard. On August 25, 2004, the DO measurement taken at the time of fish sampling at biological station 04CD033 was 11.65 mg/L. The DO measurement at biological station 09CD013 at the time of fish sampling was 8.18 mg/L. There were no measurements made prior to 9 a.m., making it difficult to rule out low DO as a potential stressor. There is indication in this small dataset for excessive DO flux.

The macroinvertebrate community comprised of a low percentage of EPT taxa (8.69%) at biological station 04CD033 and a high percentage of EPT taxa (17.65%) at biological station 09CD013. The tolerant taxa was elevated in 2004 and 2009 (97.30% and 80.39%) and the taxa count was abundant at the lower biological station (51) compared to the upper biological station score (23). The macroinvertebrates in this AUID had a high metric HBI_MN, a measure of pollution based on tolerance values assigned to each individual taxon. Station 04CD033 received a high metric score (3.64), where station 09CD013 had a score even higher (5.67) than the average score needed to be above the threshold. The macroinvertebrate DO TIV station scores (6.9 and 7.0) were both above the average for the Cedar River basin (6.8). At station 04CD033, the numbers of macroinvertebrate taxa collected that are intolerant to low DO were 3, and the percentage of DO tolerant species collected were 8.2. At station 09CD013, the numbers of macroinvertebrate taxa collected that are intolerant to low DO were 11, and the percentage of DO tolerant species collected were 13. The average number of intolerant taxa collected in the Cedar River basin was 4.6 and the average percentage of DO tolerant taxa was 20. With no early morning DO measurements and the DO TIV station scores above average for the Cedar River Watershed it is currently inconclusive if DO is contributing to the biological impairment. It would be beneficial to collect more diurnal DO information to understand the reoccurrence of low DO.

5.4.5. Candidate cause: High phosphorus

Total phosphorus (0.053 mg/L) was low at the time of fish sampling at biological station 04CD033 on August 25, 2004. Total phosphorus (0.143 mg/L) was just below the standard (0.150 mg/L) on July 22, 2009, at biological station 09CD013. There were a total of 47 phosphorus samples from 2008 through 2012. Phosphorus was elevated in this reach numerous times from March to October (Figure 58). Five out of the six years of data has samples above the standard for phosphorus. As interacting variables to eutrophication, phosphorus, pH, BOD, and chlorophyll-a were compared to normal ranges and standards. The response variable, DO flux was not measured. There was one measurement of BOD in 1980 (7.2 µg/L). Chlorophyll-a had 10 samples and 8 of them were below the standard (35 µg/L). The Brownsdale WWTP has an average TP of 1.4 mg/L and Sargeant WWTP has an average TP of 2.98 mg/L.

Biological station 04CD033 had a low macroinvertebrate taxa count at the upper biological station compared to the lower biological station 09CD013 (TaxaCountAllChir; 23 and 51). Biological station 04CD033 and 09CD013 lacked intolerant taxa and the percent tolerant taxa was very high (Tolerant2ChTxPct; 97.30% and 80.39%). The percentage of intolerant taxa will decrease and the percentage of tolerant taxa will increase with increases in phosphorus. The percentage of scrapers was 7.7% and 7.1%, which was below the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. The number of collector-gather taxa (8 and 22) and collector-filterer taxa (3 and 7) were low at biological station 04CD033 and above the average in the Cedar River Watershed at biological station 09CD013. There were 2 EPT taxa in biological station 04CD033 and 9 EPT taxa in biological station 09CD013. The range of EPT taxa within the Cedar River Watershed was 0 to 20. The metric, EPT, provides a relative measure of the presence and diversity of pollution-sensitive macroinvertebrate groups. Elevated levels of phosphorus are likely contributing to the impaired macroinvertebrate community.

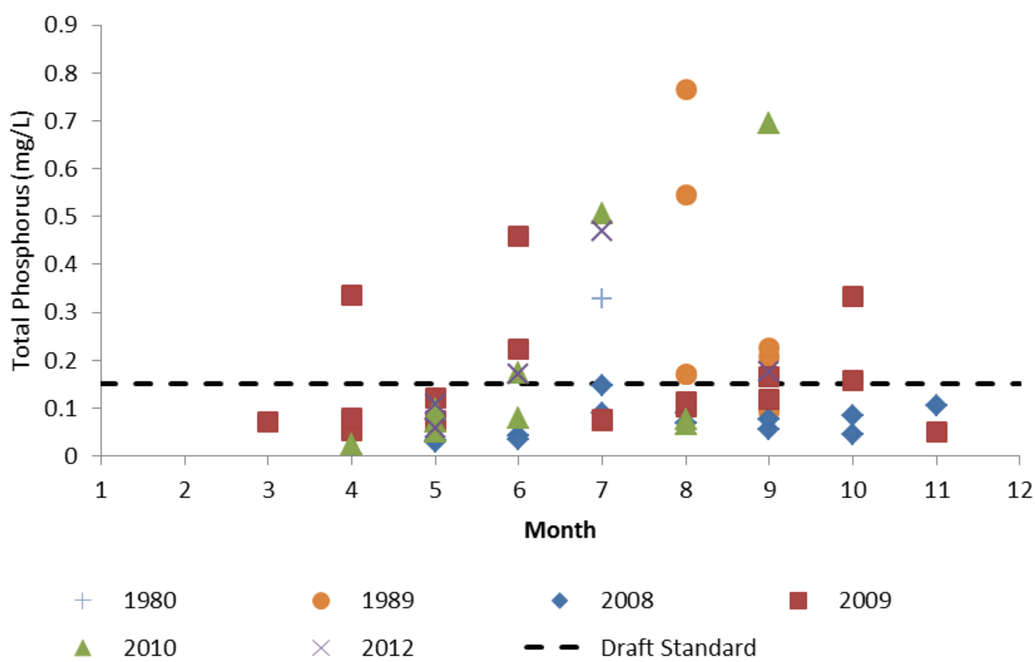


Figure 58: Total phosphorus by month for Roberts Creek on AUID (-504).

5.4.6. Candidate cause: High suspended sediment

Biological station 04CD033 had low TSS at the time of fish sampling on August 25, 2004, (3.2 mg/L), along with an excellent transparency tube reading (>60 cm). TSS at the time of fish sampling on biological station 09CD013 on July 22, 2009, was below the draft standard (65 mg/L) and had a poor transparency tube reading (14). Transparency tube data was collected at three sampling locations (S000-746, S001-182 and S000-807; Figure 60). Transparency was measured 225 times between 2000 and 2012. The transparency values ranged from 0 cm to >100 cm. The average value was 47 cm. TSS was measured 66 times between 2000 and 2010 (Figure 59). The TSS values range from 2 mg/L to 244 mg/L. The average TSS was 19.4 mg/L, and the maximum value was 244 mg/L.

In 2004, biological station 04CD033 had a high percentage of herbivorous fish and biological station 09CD013 had a low percentage of herbivorous fish. Herbivorous fish decrease with increases in TSS. Both biological stations had a low percentage of macroinvertebrates that are scrapers. Biological station 04CD033 had low percentage of collector-filters and biological station 09CD013 had a high percentage of collector-filters. Collector-filterers are reduced when TSS is elevated. Collector-filterer species collect their food by filtering it from the water column. The percentage of long lived macroinvertebrates was very low (0 and 2.27%). Biological station 04CD033 had a high percentage of TSS tolerant individuals (44.6%; Table 33) and below average TSS tolerant taxa (5) and biological station 09CD013 had a low percentage of TSS tolerant individuals (11.6%) and above average TSS tolerant taxa (9) compared to the averages for warmwater stations in the Cedar River Watershed for percent of TSS tolerant individuals (25.9%) and TSS tolerant taxa (9). The information available in this reach is inconclusive if elevated turbidity or TSS is a stressor to the biological community.

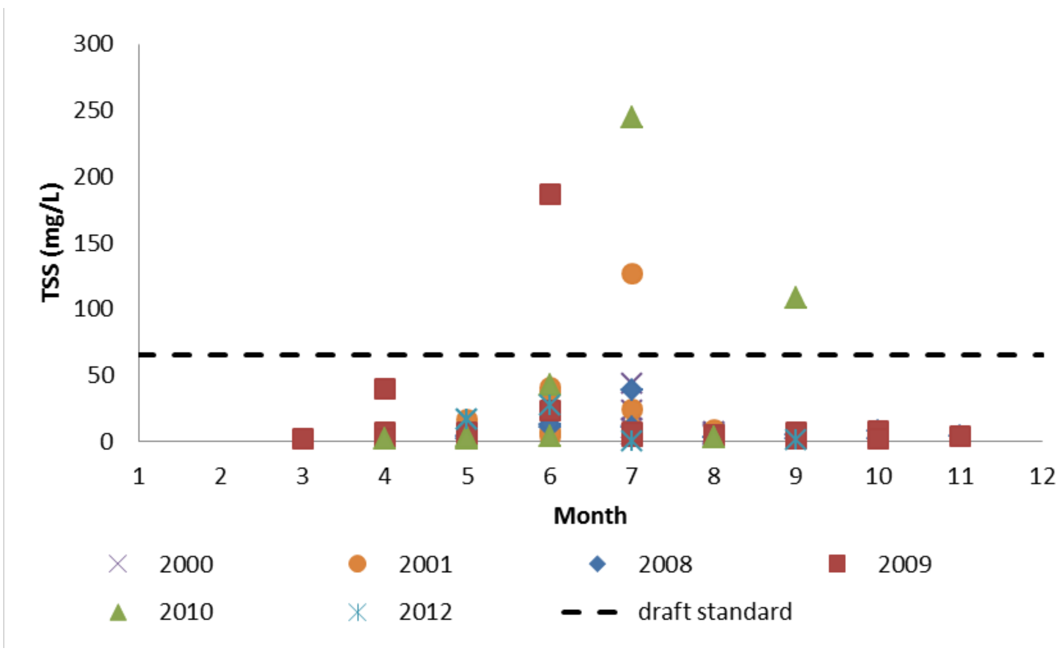


Figure 59: Total suspended solids for Roberts Creek by month and by year.

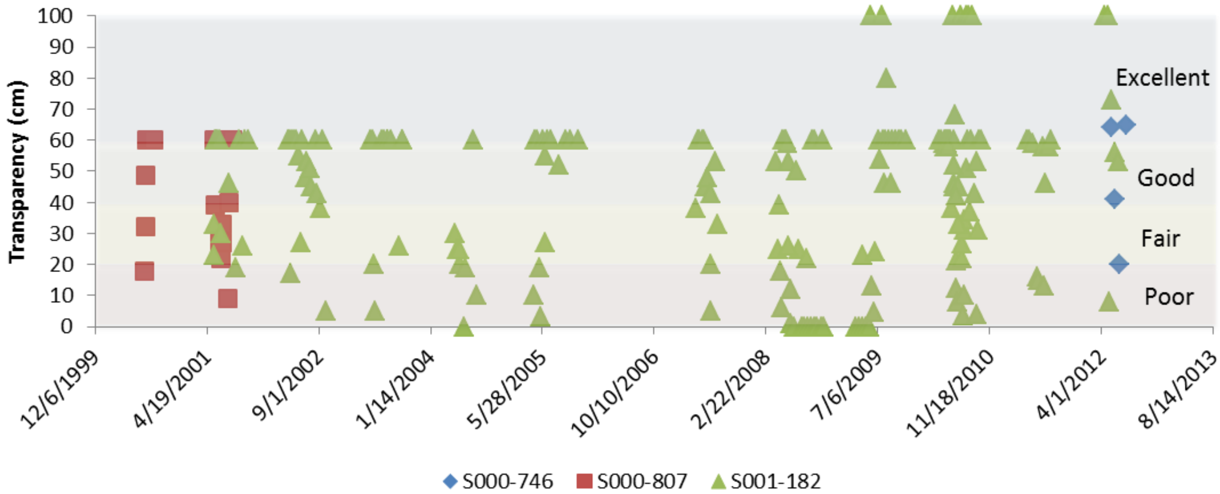


Figure 60: Graph of transparency tube data collected at three stations on Roberts Creek.

Table 33: Macroinvertebrate metrics relevant to TSS for stations in Roberts Creek compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
09CD013	14.2	1	9	11.6	**0**	**0**
04CD033	**18.1**	**0**	5	**44.6**	**0**	6
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

5.4.7. Conclusions

The stressors to Roberts Creek (-504) are summarized in Table 34. Habitat, nitrate, phosphorus and flow alteration are stressors to the macroinvertebrate community. Habitat is being impacted by more frequent higher flow events forcing some larger scale channel changes in this reach, which reflects upon the land use practices upstream. Nitrate and phosphorus concentrations are elevated and having an impact on the biota. With the lack of DO it is currently inconclusive if DO was contributing to the biological impairment. Findings are inconclusive whether TSS is a stressor due to limited data. TSS data for a range of flows should be collected in Roberts Creek to determine the impacts to the biota.

Roberts Creek would likely benefit from habitat improvement for the macroinvertebrates, and most importantly to alter the surrounding landscape to help return the flow regime back to a more consistent and less flashy system. Nitrate levels are elevated (27 mg/L), and should be monitored over time. Better management of nutrients would benefit Roberts Creek. Additional chemical information should be collected to confirm or rule out these potential stressors.

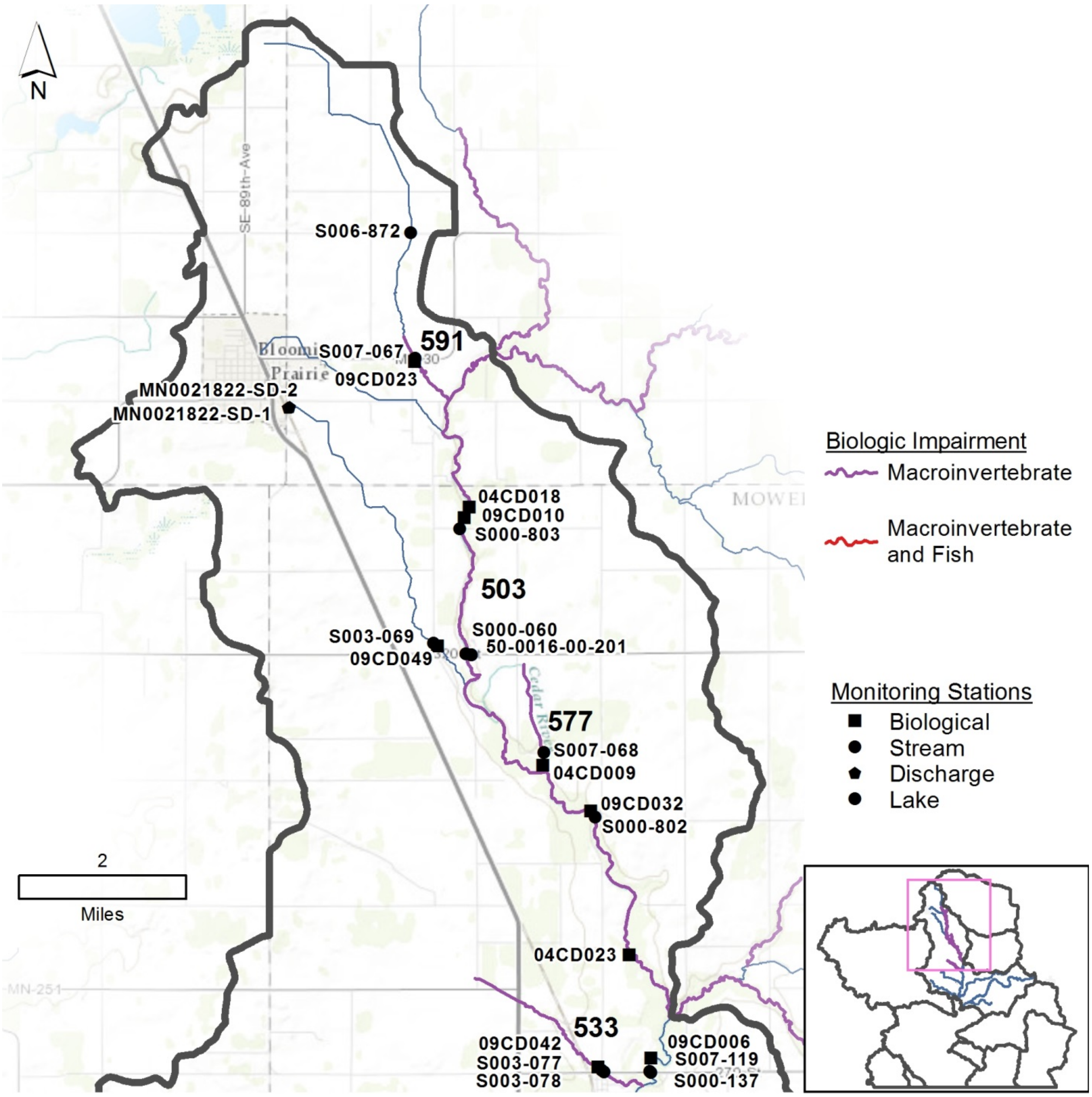
Table 34: Summary of stressors found in Roberts Creek (-504).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors					
			Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-504 Roberts Creek unnamed creek to Cedar River	04CD033 09CD013	Macroinvertebrate IBI Bacteria	•	•	o	•	o	•

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

6. Upper Cedar River Watershed Unit

The Upper Cedar River Watershed is the second largest subwatershed and drains 131 square miles of Dodge, Freeborn, Mower, and Steele counties (Figure 61). Cultivated row crop comprises 79.3% of the watershed. There are four impairments due to low macroinvertebrate IBI scores: unnamed creek (West Fork of the Cedar River, AUID 07080201-591), unnamed creeks to Cedar River (AUIDs 07080201-577, 07080201-503 and 07080201-533). There are no fish impairments in this unit.



Base Map Credits: Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

Figure 61: Map of Upper Cedar River Watershed biological impairments.

6.1. Unnamed Creek (Cedar River, West Fork): unnamed creek to Cedar River (AUID: 07080201-591)

The MPCA surveyed one biological station 09CD023 that was sampled in 2009 on AUID 07080201-591. Biological station 09CD023 and EQuIS station S007-067 are located downstream of Highway 30, 1.5 miles E of Blooming Prairie. Water quality data from 2012 were used to determine stressors.

6.1.1. Biology in unnamed creek (Cedar River, West Fork)

The macroinvertebrate IBI was 44.02 which are below the threshold of 46.8 and within the confidence interval for Southern Forest Streams GP (Table 35). The F-IBI score for this station was 68 above the threshold of 51 and the confidence interval for a Southern Headwaters stream. The macroinvertebrate community is not meeting standards for unnamed creek (Cedar River, West Fork).

Table 35: Summary of biological impairments in unnamed creek (-591).

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-591, unnamed creek to Cedar River	09CD023	unnamed creek (Cedar River, West Fork)	9.27	Southern Forest Streams	46.8	44.02	Southern Headwaters	51	68

Macroinvertebrates in the class Southern Forest Streams GP scored poorly in the metrics of collector-filterers (Collector-filtererPct), a measure of pollution based on tolerance values assigned to each individual taxon (HBI_MN), Plecoptera, Odonata, Ephemeroptera and Trichoptera taxa (POET) and Trichoptera (TrichopteraChTxPct) at biological station 09CD023 (Figure 62). Biological station 09CD023 was also lacking non-hydropsychid caddisflies (TrichwoHydroPct). Five species dominated the sample (DomFiveCHPct; 47.84%) and the percent tolerant taxa was relatively high (Tolerant2ChTxPct; 67.92%). Station 09CD023 had a very high taxa count (TaxaCountAllChir; 53).

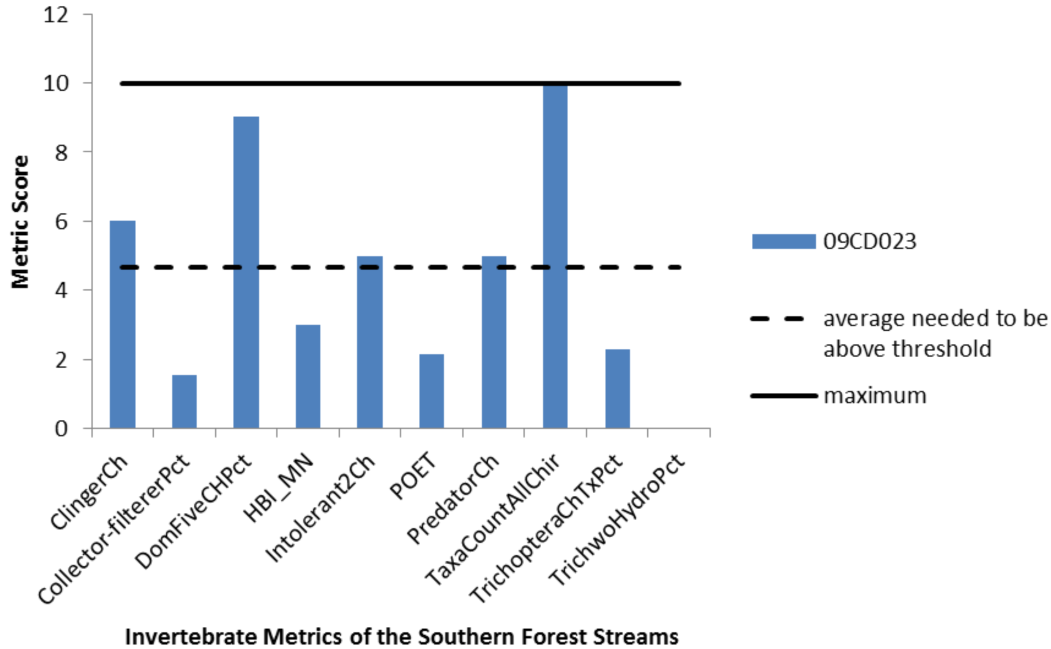


Figure 62: Macroinvertebrate metrics of the Southern Forest Streams IBI in station 09CD023 in unnamed creek (Cedar River, West Fork).

The fish community was not listed as impaired. At this station there was an abundance of: detritivore taxa (DETNWQTxPct), generalist taxa (General Txpct), SLvdPct, SSpnPct and VtolTxPct. Sensitive taxa (Sensitive TxPct) were just below the threshold. This reach did not have fish DELTs, that if present, would have contributed negatively to the IBI.

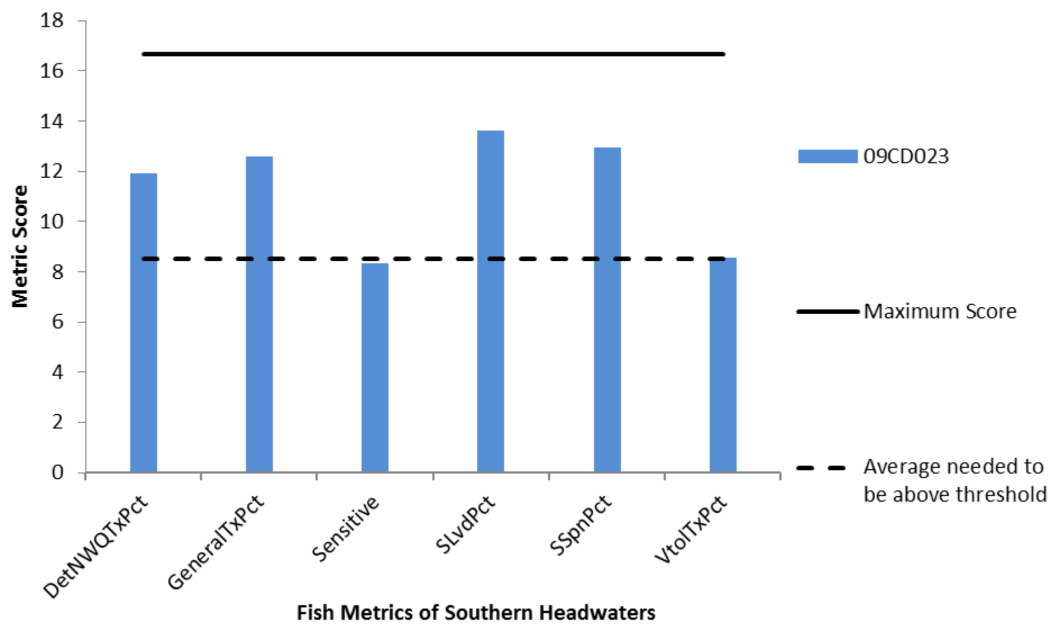


Figure 63: Fish metrics of the Southern Headwaters IBI in station 09CD023 in unnamed creek (Cedar River, West Fork).

6.1.2. Candidate cause: Lack of habitat/bedded sediment

The unnamed creek (Cedar River, West Fork) biological station 09CD023 scored 51.5 (fair) on the MSHA (Table 36). The surrounding land use was noted as row crop, thus receiving no points for land use. Of the five subcategories in the MSHA, land use, substrate, and channel morphology scored poorly. There is a moderate (30 to 150 ft) riparian buffer. There is moderate shade with moderate (25%-50%) bank erosion on the left bank and light (5%-25%) on the right banks. This stream reach contains 5% riffle and consists of sand and gravel with a lack of diverse substrate types and has moderate embeddedness. There is moderate cover present in the reach; 25 to 50% present.

The community is sampled based on dominant habitat types found at each station. The habitat that was sampled for macroinvertebrates was undercut banks and overhanging vegetation (Figure 64). If riffles were available, they would have been sampled for macroinvertebrates. Burrowers were found above the mean of natural channel stations meeting the M-IBI (Figure 65). The percentage of EPT individuals (7.1%) was less than the statewide average. At station 09CD023, there was a high percentage of legless macroinvertebrates (83.3%). The percentage of climbers was above the mean of natural channel station meeting M-IBI (29 %), but likely due to overhanging vegetation being sampled and their preference for that habitat. Taxa that are known to cling (ClingerCh) were below the statewide average, as shown in Figure 65. Clinger species attach to rocks or woody debris. Clingers can decrease in stream reaches with homogenous substrate composition, velocity, and depth (CADDIS).

There are aspects of habitat that could be improved in this reach. Erosion within this reach should be stabilized to prevent the risk of further degradation to the habitat. Moderate embeddedness of coarse substrates is present.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. The Upper Cedar River Watershed is approximately 54% channelized. Thirty-five percent of the Upper Cedar River Watershed is tile drained to help move water off the farm fields and to the streams rather quickly. This causes the flows of this stream system to become very inconsistent.

Habitat issues do not appear to be limiting the macroinvertebrate community throughout this reach and is not a stressor at this time.

Figure 64: unnamed creek at EQuIS Station S007-067.

Table 36: MSHA results for unnamed creek (-591).

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	09CD023	unnamed creek (-591)	0	8.5	15.95	12	15	51.5	Fair

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA>66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

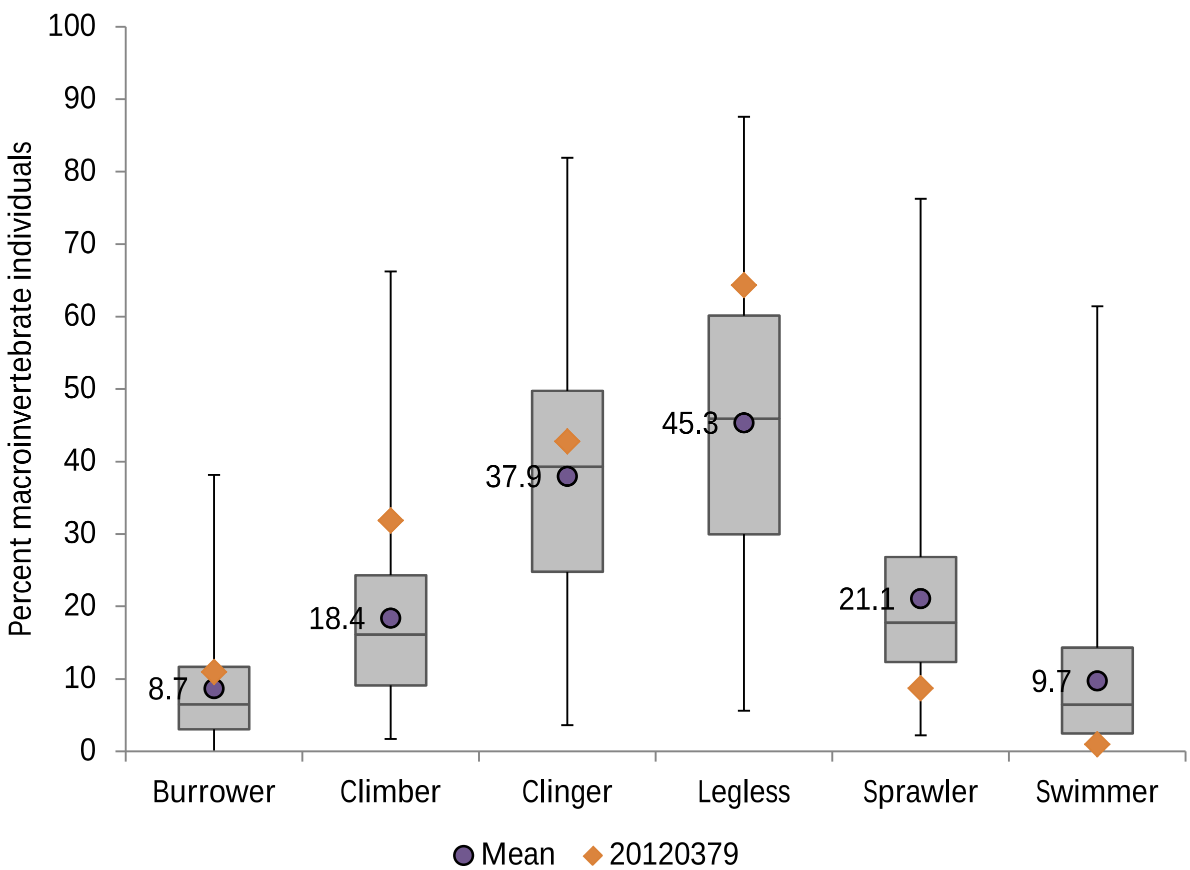


Figure 65: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Forest Streams GP stations with M-IBI greater than 46.8 (threshold), mean of those stations, and metric values from station 09CD023.

6.1.3. Candidate cause: High nitrate-nitrite

Nitrate sample was taken at the time of fish sampling on July 13, 2009, and measured 6.5 mg/L. Nitrate was sampled five times in 2012. The highest sample was 17 mg/L on June 22, 2012, while the lowest nitrate sample was 3.8 mg/L on July 19, 2012.

The macroinvertebrates in this reach were made up of 68% tolerant taxa and very low intolerant taxa. Biological station 09CD023 was lacking non-hydropsychid Trichoptera. Trichoptera are often considered sensitive to nitrate and respond with decreases in taxa. At station 09CD023, there were 87.62% nitrate tolerant macroinvertebrates, with 32 nitrate tolerant taxa and three nitrate intolerant taxa. Nitrate is inconclusive with the limited nitrate data available. More nitrate data should be collected to help characterize the nitrate in unnamed creek (Cedar River, West Fork, -591).

6.1.4. Candidate cause: Low dissolved oxygen

There was a lack of DO data to review within this reach. There were only six measurements, which were all above the standard. One of the measurements was taken at the time of fish sampling; four of them were taken prior to 10AM and were over 2 mg/L above the standard.

The macroinvertebrate community comprised of a very low percentage of EPT taxa (5.25%). The tolerant taxa was elevated in 2009 (73%) and the taxa count was high (53). The macroinvertebrates in this AUID had a low metric HBI_MN, a measure of pollution based on tolerance values assigned to each individual taxon. Station 09CD023 received a low metric score (3.00) below the average score needed to be above the threshold. The macroinvertebrate DO TIV station score (7.1) was above the average for the Cedar River (6.8). The numbers of macroinvertebrate taxa collected that are intolerant to low DO were 11, and the percentage of DO tolerant species collected were 8.3. The average number of intolerant taxa collected in the Cedar River basin was 4.6 and the average percentage of DO tolerant taxa was 20.

The fish community at this station indicated the species that were present were more sensitive to low DO with a station TIV of 7.15 (in the upper half of station scores in the Cedar River Watershed; Table 4). The most DO sensitive fish found at this station were fantail darter, southern redbelly dace and blacknose dace; and there was a presence of DO tolerant fish such as central mudminnows. Blacknose dace were the third most common species collected and in the least sensitive to DO group. The common shiner and white sucker were the most common species and they are in the middle scores of sensitivity to DO.

There is limited data available, and there is no DO information indicating it is a stressor at this time. Further DO monitoring including diurnal monitoring should take place to better understand the DO regime.

6.1.5. Candidate cause: High phosphorus

Total phosphorus was low at the time of fish sampling in unnamed creek (Cedar River, West Fork) (0.067 mg/L). Samples were taken a total of five times during the sampling season of 2012. The highest phosphorus sample was 0.112 mg/L taken on July 19, 2012. The lowest grab sample was 0.031 mg/L on May 15, 2012. There is no available BOD or chlorophyll-a data on this AUID at this time to assess the potential influences.

The percentage of intolerant macroinvertebrates was reduced in the stream (1%). The information available in this reach is inconclusive if elevated phosphorus is a stressor to the biological community.

This stream reach has a high taxa count (TaxaCountAllChir; 53). Biological station 09CD023 lacked intolerant taxa (1) and the percent tolerant taxa was high (Tolerant2ChTxPct; 67.92%). The percentage of intolerant taxa will decrease and the percentage of tolerant taxa will increase with increases in phosphorus. The percentage of scrapers was 6.2%, which was below the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. The number of collector-gather taxa (25) and collector-filterer taxa (5) were both high. There were 3 EPT taxa in this stream reach. The range of EPT taxa within the Cedar River Watershed was 0 to 20. The metric, EPT, provides a relative measure of the presence and diversity of pollution-sensitive macroinvertebrate groups. The data does not connect elevated phosphorus and the impaired biota, but there is limited data at this time. Phosphorus is not a stressor, but should be continued to be collected to understand the nutrient dynamics in this system.

6.1.6. Candidate cause: High suspended sediment

Biological station 09CD023 had very low TSS at the time of fish sampling on July 13, 2009 (1.2 mg/L), along with an excellent transparency tube reading (> 100 cm). Transparency tube readings in 2012 were all excellent. No other chemical data was available for analysis on this stream reach. In 2012, there was very little rain and low flow conditions. TSS data for a range of flows should be collected in unnamed creek (Cedar River, West Fork).

In 2009, biological station 09CD023 had a very low percentage of herbivores fish and a low percentage of macroinvertebrates that are scrapers collector-filters. Collector-filterers are reduced when TSS is elevated. Collector-filterer species collect their food by filtering it from the water column. The percentage of long lived macroinvertebrates was low (6.48%). Biological station 09CD023 had a low percentage of TSS tolerant individuals (23.2%; Table 37) and below average TSS tolerant taxa (5) compared to the averages for warmwater stations in the Cedar River Watershed for percent of TSS tolerant individuals (25.9%) and TSS tolerant taxa (9). There are biological indications that TSS or turbidity may be a concern, yet findings are inconclusive due to limited data.

Table 37: Macroinvertebrate metrics relevant to TSS for stations in unnamed creek (Cedar River, West Fork) compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
09CD023	15.9	2	5	23.2	1	**4**
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

6.1.7. Conclusions

The stressors to unnamed creek (Cedar River, West Fork, -591) are summarized in Table 38. Flow alteration is the only identified stressors to the macroinvertebrate community at this time. The abundant channelization within the watershed can lead to flashy flows in the stream by quickly moving water following rain events into the stream system. This water moves through the system very fast disrupting normal flows that the stream may have while also contributing to increased amounts of erosion.

Additional chemical information should be collected to have a better understanding of the potential stressors. Habitat is being impacted by more frequent higher flow events forcing some larger scale channel changes in this reach, which reflects upon the land use practices upstream. However, habitat issues do not appear to be limiting the macroinvertebrate community throughout this reach and is not a stressor at this time. With the lack of DO, phosphorus, nitrate and TSS data, they are currently inconclusive if these potential stressors are contributing to the biological impairment. Overall, there is limited chemical information and additional chemical information should be collected to confirm or rule out these potential stressors.

Table 38: Summary of stressors found in unnamed creek (Cedar River, West Fork) (-591).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors: Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-591 unnamed creek (Cedar River, West Fork) unnamed creek to Cedar River	09CD023	Macroinvertebrate IBI		o	o	o	o	•

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

6.2. Unnamed Creek: unnamed creek to Cedar River (AUID: 07080201-577)

The MPCA surveyed one biological station 04CD009 that was sampled in 2004 on AUID 07080201-577. The station is located at the southeast end of 530th Avenue, 6 miles SE of Blooming Prairie.

Water quality samples were taken at EQuIS station S007-068 at the southeast end of 530th Avenue, 6 miles SE of Blooming Prairie. Water quality data from 2012 were used to determine stressors.

6.2.1. Biology in unnamed creek

The macroinvertebrate IBI was 33.10 which are below the threshold of 46.8 for a Southern Forest Streams GP (Table 39). The F-IBI score for this station was 65 above the threshold of 51 for a southern headwaters stream. The macroinvertebrate community is not meeting standards for unnamed creek.

Table 39: Summary of biological impairments in unnamed creek (-577).

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-577, Unnamed creek to Cedar River	04CD009	unnamed creek	1.0	Southern Forest Streams	46.8	33.10	Southern Headwaters	51	65

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA>66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

Station 04CD009 had seven metrics below the average metric score needed for an IBI score greater than the threshold (Figure 66). Macroinvertebrates in the class Southern Forest Streams scored poorly in the metrics of clinger taxa, predators (PredatorCh), a low taxa count (TaxaCountAllChir), and Trichoptera (TrichopteraChTxPct). This stream reach was also lacking Plecoptera, Odonata, Ephemeroptera and Trichoptera taxa (POET), intolerant taxa (intolerant2Ch) and non-hydropsychid caddisflies (TrichwoHydroPct). The HBI_MN metric was above the average metric score needed to be above the threshold. The percentage of collector-filterers was decent (38%). Five species dominated the sample (DomFiveCHPct; 64%) and the percent tolerant taxa was relatively high (Tolerant2ChTxPct; 84%).

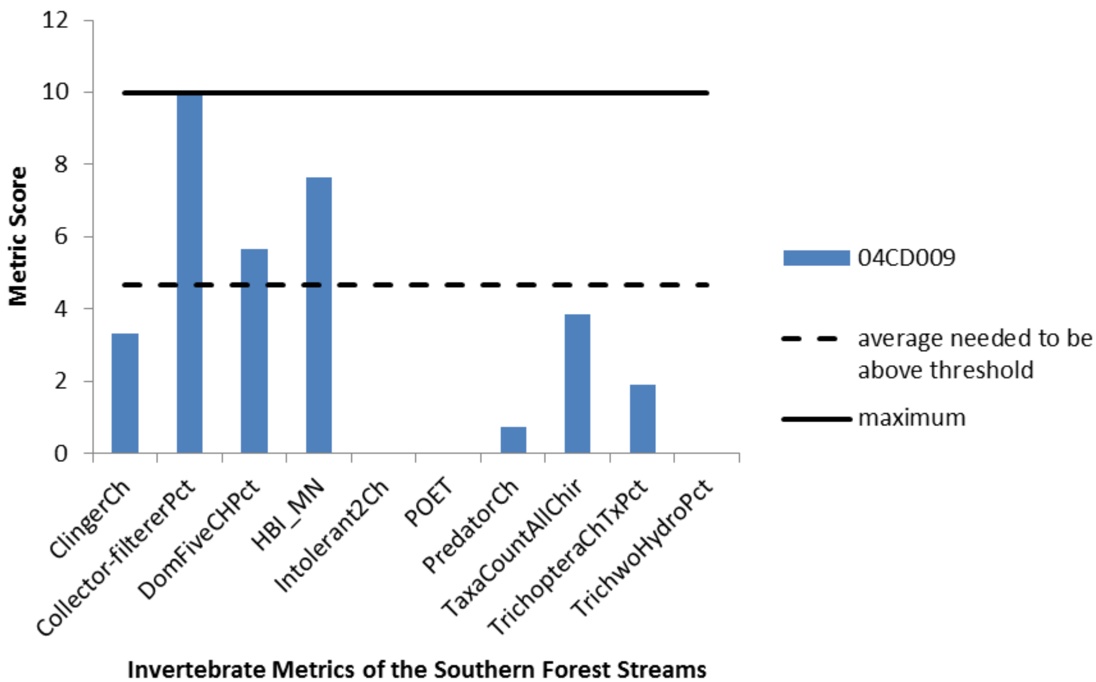


Figure 66: Macroinvertebrate metrics of the Southern Forest GP class in station 04CD009 in unnamed creek.

The fish community was not listed as impaired. Biological station 09CD029 had high metric scores for: detritivore taxa (DETNWQTxPct), generalist taxa (General Txpct), and the relative abundance of short lived individuals (SLvdPct), serial spawners (SSpnPct) and relative abundance of very tolerant taxa

(VtolTxPct; Figure 67). Sensitive taxa (Sensitive TxPct) were just below the average metric score needed to be above the threshold. This reach did not have fish DELTs, that if present, would have contributed negatively to the IBI.

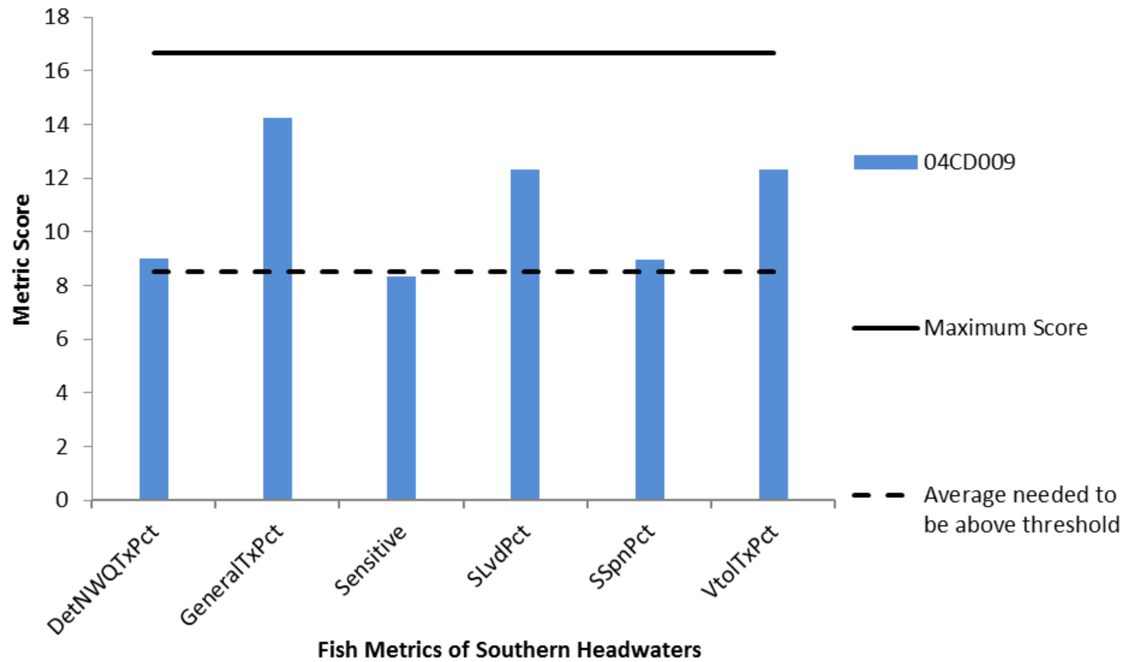


Figure 67: Fish metrics of the Southern Headwaters IBI in station 04CD009 in unnamed creek.

6.2.2. Candidate cause: Lack of habitat/bedded sediment

The unnamed creek station 04CD009 scored 60.1(fair) on the MSHA (Table 40). Of the five subcategories in the MSHA, land use and substrate scored poorly. The substrate MSHA score was 6.1. This indicates fine sediments and a lack of coarse substrate at the sampling location. The field crew noted that the site had clear water with higher water levels at the time of sampling. The field crew also noted unnamed creek had moderate channel stability. This reach only contained 10% riffle and was dominated by sand, with severe embeddedness where coarse substrates were present. Silt and detritus were dominant in the pools.

The surrounding land use was noted as row crop with extensive (> 300 ft) riparian buffer. There was no erosion reported in 2004, but recent photos taken in 2012 show bank erosion (Figure 68). Extensive cover was noted, with multiple cover types including overhanging vegetation, deep pools, logs or woody debris, rootwads, and macrophytes. The habitat that was sampled for macroinvertebrates was woody debris/snags/rootwads. There is heavy cover present in the reach; greater than 75% present. This site is lacking good quality riffles.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. The Upper Cedar River Watershed is approximately 54% channelized. Unnamed Creek has been observed dry during the summer and fall of 2012. Thirty-five percent of the Upper Cedar River Watershed is tile drained to help move water off the farm fields and to the streams rather quickly. This causes the flows of this stream system to become very inconsistent. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

There was an abundance of burrowers found in biological station 04CD009, which demonstrates sedimentation issues (48.84%; Figure 69). The percentage of EPT individuals (1.16%) was much less than the statewide average for Southern Forest Streams GP macroinvertebrate class (8.87%). The percentage of generally tolerant legless macroinvertebrate individuals was high (95.38%). The macroinvertebrates that are known to cling to large substrate and woody debris were less abundant (below statewide averages for this class). This is also found in the M-IBI metrics, the number of clinger taxa (ClingerCh) was just below the average metric score needed for the M-IBI to be at the threshold. Clingers can decrease in stream reaches with homogenous substrate composition, velocity, and depth (CADDIS). There were a low percentage of climbers (2.31%) due to lack of grass habitat. The biological station was made up of 98.1% fine sediments. This evidence points to sedimentation and overall degradation limiting the macroinvertebrate community.

Overall, MSHA information, site conditions/photos, and macroinvertebrate response strongly support habitat as a stressor in this reach. Habitat is a stressor in this reach due to lack of lack of quality riffle habitat and substrate embeddedness.

Figure 68: Biological station 04CD009 showing bank erosion in 2012 (left) and low flow conditions in 2012 (right).

Table 40: MSHA results for unnamed creek (-577).

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	04CD009	unnamed creek (-577)	0	14	6.1	15	25	60.1	Fair

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA>66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

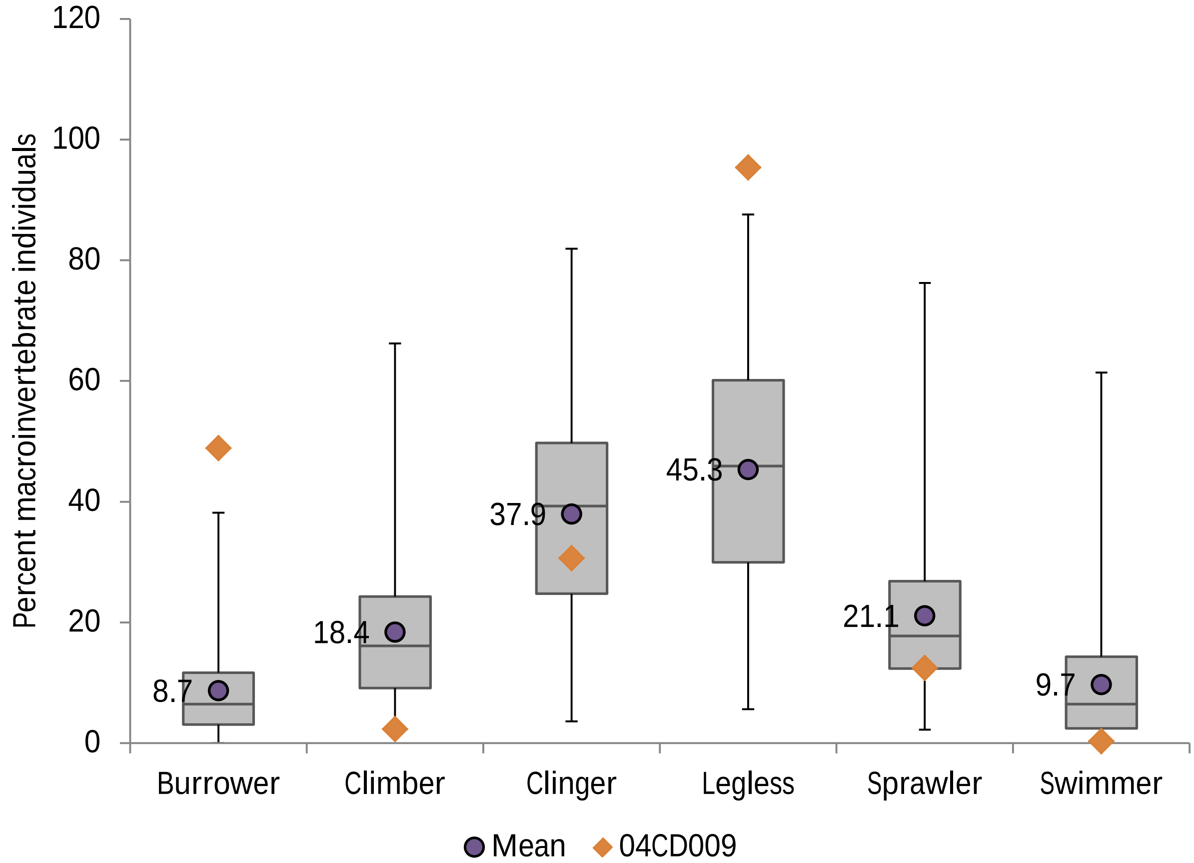


Figure 69: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Forest Streams GP stations with M-IBI greater than 46.8 (threshold), mean of those stations, and metric values from station 09CD009.

6.2.3. Candidate cause: High nitrate-nitrite

Nitrate sample was taken at the time of fish sampling on July 13, 2004, and measured 25 mg/L. Nitrate was sampled five times in 2012. The highest sample was 22 mg/L on June 22, 2012 while the lowest nitrate sample was 0.06 mg/L on September 4, 2012.

The macroinvertebrates in this reach were made up of 78% tolerant taxa and lacked intolerant taxa. Biological station 04CD009 was lacking non-hydropsychid Trichoptera. Trichoptera are often considered sensitive to nitrate and respond with decreases in taxa. With the limited nitrate data available, nitrate is a stressor to the impaired biota. At station 04CD009, there were 94.97% nitrate tolerant macroinvertebrates, with 18 nitrate tolerant taxa and no nitrate intolerant taxa. With the limited nitrate data available, nitrate is a stressor to the impaired biota. More nitrate data should be collected to help characterize the nitrate in this unnamed creek.

6.2.4. Candidate cause: Low dissolved oxygen

There was a lack of DO data within this reach. There were only six measurements of DO collected. DO measurements ranged from 1.82 mg/L to 10.26 mg/L. One measurement (1.82 mg/L) was below the standard (5 mg/L). This measurement was taken on September 4, 2012, during very low flow conditions. Another measurement was taken at the time of fish sampling on July 13, 2004, measuring at 6.85 mg/L.

The macroinvertebrate community comprised of a very low percentage of EPT taxa (1.15%). The tolerant taxa was elevated in 2004 (79.5%) and the taxa count was low (32). The macroinvertebrates in this AUID had a high metric HBI_MN, a measure of pollution based on tolerance values assigned to each individual taxon. The macroinvertebrate DO TIV station score (6.96) was above the average for the Cedar River basin (6.8). The numbers of macroinvertebrate taxa collected that are intolerant to low DO were 4, and the percentage of DO tolerant species collected were 11.6. The average number of intolerant taxa collected in the Cedar River basin was 4.6 and the average percentage of DO tolerant taxa was 20. Based on the HBI and TIV score, DO does not seem to be a stressor to the macroinvertebrates. While the EPT taxa are low and tolerant taxa are elevated, they are also affected by other stressor.

The fish community at this station indicated the species that were present were neither highly sensitive to DO nor very tolerant to DO with a station TIV of 7.09 (in the upper half of station scores in the Cedar River Watershed; Table 4). The most DO sensitive fish found at this station were blacknose dace; and there was a presence of DO tolerant fish such as brook stickleback. There are slight biological indications that DO may be a concern, yet findings are inconclusive due to limited data. It would be beneficial to collect more diurnal DO information.

6.2.5. Candidate cause: High phosphorus

At the time of fish sampling, total phosphorus was above the standard (0.15 mg/L) at 0.163 mg/L. One other measurement of 2.49 mg/L was taken on September 4, 2012 during low flow conditions. There is no available BOD or chlorophyll-a data on these AUIDs at this time to assess the potential influences. It would be recommended to collect additional data to assist with further understanding.

This stream reach has a high macroinvertebrate taxa count (TaxaCountAllChir; 32). Biological station 04CD009 lacked intolerant taxa and the percent tolerant taxa was high (Tolerant2ChTxPct; 84.38%). The percentage of intolerant taxa will decrease and the percentage of tolerant taxa will increase with increases in phosphorus. The percentage of scrapers was 2.6%, which was below the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. The number of collector-gather taxa (18) was above the average for the Cedar River Watershed. The collector-filterer taxa (3) were below the average for the Cedar River Watershed. There were one EPT taxa in this stream reach. The range of EPT taxa within the Cedar River Watershed was 0 to 20. The metric, EPT, provides a relative measure of the presence and diversity of pollution-sensitive macroinvertebrate groups. The data connects elevated phosphorus and the impaired biota, but is inconclusive due to limited data at this time. Phosphorus should be continued to be collected to understand the nutrient dynamics in this system.

6.2.6. Candidate cause: High suspended sediment

Biological station 04CD009 had low TSS at the time of fish sampling on July 13, 2004, (4.4 mg/L), along with an excellent transparency tube reading (> 60 cm). Turbidity was low as well during fish sampling (1.95 NTU). Transparency tube readings in 2012 were all excellent. In 2012, there was very little rain and low flow conditions. Photographs taken at the biological station show eroded banks. TSS data for a range of flows should be collected in unnamed creek (-577) to determine the impacts to the biota.

In 2004, biological station 04CD009 had a very low percentage of herbivores (1.45%), and a low percentage of scrapers (2.6%). The collector-filters were relatively high, 5th highest of the stations in the Cedar (40%). Collector-filterers are reduced when TSS is elevated. Collector-filterer species collect their food by filtering it from the water column. Long lived macroinvertebrates were lacking in this stream reach. Biological station 04CD009 had a low percentage of TSS tolerant individuals (3.1%; Table 41) and below average TSS tolerant taxa (6) compared to the averages for warmwater stations in the Cedar River

Watershed for percent of TSS tolerant individuals (25.9%) and TSS tolerant taxa (9). There are biological indications that TSS or turbidity may be a concern, yet findings are inconclusive due to limited data.

Table 41: Macroinvertebrate metrics relevant to TSS for stations in unnamed creek compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
04CD009	13.4	**0**	6	3.1	**0**	**1**
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

6.2.7. Conclusions

The stressors to unnamed creek (-577) are summarized in Table 42. Habitat, flow alteration and nitrate are stressors to the macroinvertebrate community. The reach was dominated by sand and silt substrate with little riffle habitat. Habitat is being impacted by lack of stability in flow with more frequent higher flow events and low flow conditions forcing channel changes in this reach, which reflects upon the land use practices. Nitrate concentrations are elevated and having an impact on the biota. With the lack of DO and phosphorus data it is currently inconclusive if DO and phosphorus were contributing to the biological impairment. Findings are inconclusive whether TSS is a stressor due to limited data. TSS data for a range of flows should be collected in unnamed creek to determine the impacts to the biota.

Unnamed creek (-577) would likely benefit from habitat improvement for the macroinvertebrates. Nitrate levels are elevated (25 mg/L), and should be monitored over time. Better management of nutrients would benefit unnamed creek. Additional chemical information should be collected to confirm or rule out these potential stressors.

Table 42: Summary of stressors found in unnamed creek (-577).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors					
			Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-577 unnamed creek unnamed creek to Cedar River	04CD009	Macroinvertebrate IBI	•	•	o	o	o	•

• = stressor; o = inconclusive stressor; 'blank'-not an identified stressor

6.3. Cedar River: Headwaters to Roberts Creek (AUID: 07080201-503)

The Cedar River (-503) was listed as impaired for aquatic recreation due to high bacteria counts in 2006. This same AUID was also listed for aquatic consumption for mercury in fish tissue in 1998 and for PCBs in 2002. The Cedar River (-503) is a 29 mile stretch that begins in the Middle Fork Cedar River Watershed unit and continues into the Upper Cedar River Watershed unit (Figure 61). This listed reach is non-supporting of aquatic life for aquatic macroinvertebrate communities.

Eight biological stations (09CD005, 04CD003, 09CD056, 09CD011, 04CD018, 04CD023, 09CD010 and 09CD032) were sampled for fish and macroinvertebrates in 2004 and 2009 on this stream reach. The biological stations are throughout the stream reach from the headwaters to Roberts Creek.

There are nine Water quality sampling EQuIS stations throughout this stream reach of the Cedar River. Water quality data from 2000 to present were used to determine stressors.

The Waltham WWTP, Blooming Prairie WWTP, and Viking Chemical Company all discharge upstream of this stream reach.

6.3.1. Biology in the Cedar River (Headwaters to Roberts Creek)

Along the Cedar River, four of the eight biological stations scored below the threshold (46.8) for Southern Forest Stream class and (35.9) for Southern Stream class. Biological stations 09CD005 and 04CD003 scored the worst with an IBI score below the threshold and the confidence interval. The F-IBI at biological station 09CD010 was 41 which were just below the threshold of 45 for the fish class Southern Streams. Three of the biological stations were compared against the average metric score needed to be at or above the threshold for Southern Headwaters, and the remaining five biological stations were compared against the average metric score needed to be at or above the threshold for Southern Streams. All eight stations were compared against the average metric score needed to be at or above the threshold for the macroinvertebrate Southern Forest Streams GP (Table 43).

Table 43: Summary of biological impairments in the Cedar River: Headwaters to Roberts Creek.

AUID (Assessment Unit ID)	Station ID	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-503, Cedar River, Headwaters to Roberts Creek	09CD005	12.25	Southern Forest Streams	46.8	30.9	**Southern Headwaters**	**51**	**62**
	04CD003	24.78	Southern Streams	35.9	25.7	**Southern Headwaters**	**51**	**67**
	09CD056	27.20	Southern Forest Streams	46.8	39.2	Southern Headwaters	51	60
	09CD011	48.68	Southern Forest Streams	46.8	59.7	Southern Streams	45	46
	04CD018	88.95	Southern Forest Streams	46.8	53.3	Southern Streams	45	47
	04CD023	118.28	Southern Forest Streams	46.8	52.1	Southern Streams	45	58
	09CD010	89.01	Southern Forest Streams	46.8	38.8	Southern Streams	45	41
	09CD032	113.52	Southern Forest Streams	46.8	74.3	Southern Streams	45	54

The biological stations had six macroinvertebrate metrics below the average metric score needed for an IBI score greater than the threshold (Figure 70). Macroinvertebrates in the class Southern Forest Streams GP scored poorly in the metrics of collector-filterers (Collector-filtererPct), a measure of pollution based on tolerance values assigned to each individual taxon (HBI_MN), Plecoptera, Odonata, Ephemeroptera and Trichoptera taxa (POET) and Trichoptera (TrichopteraChTxPct), Trichoptera (TrichopteraChTxPct) and non-hydropsychid caddisflies (TrichwoHydroPct). This stream reach was also lacking intolerant taxon (intolerant2Ch). The metrics of taxa richness of predators (Predator) scored greater than the threshold. Five species dominated the sample (DomFiveCHPct; 43 to 61%) and the percent tolerant taxon was relatively high (Tolerant2ChTxPct; 71 to 93%).

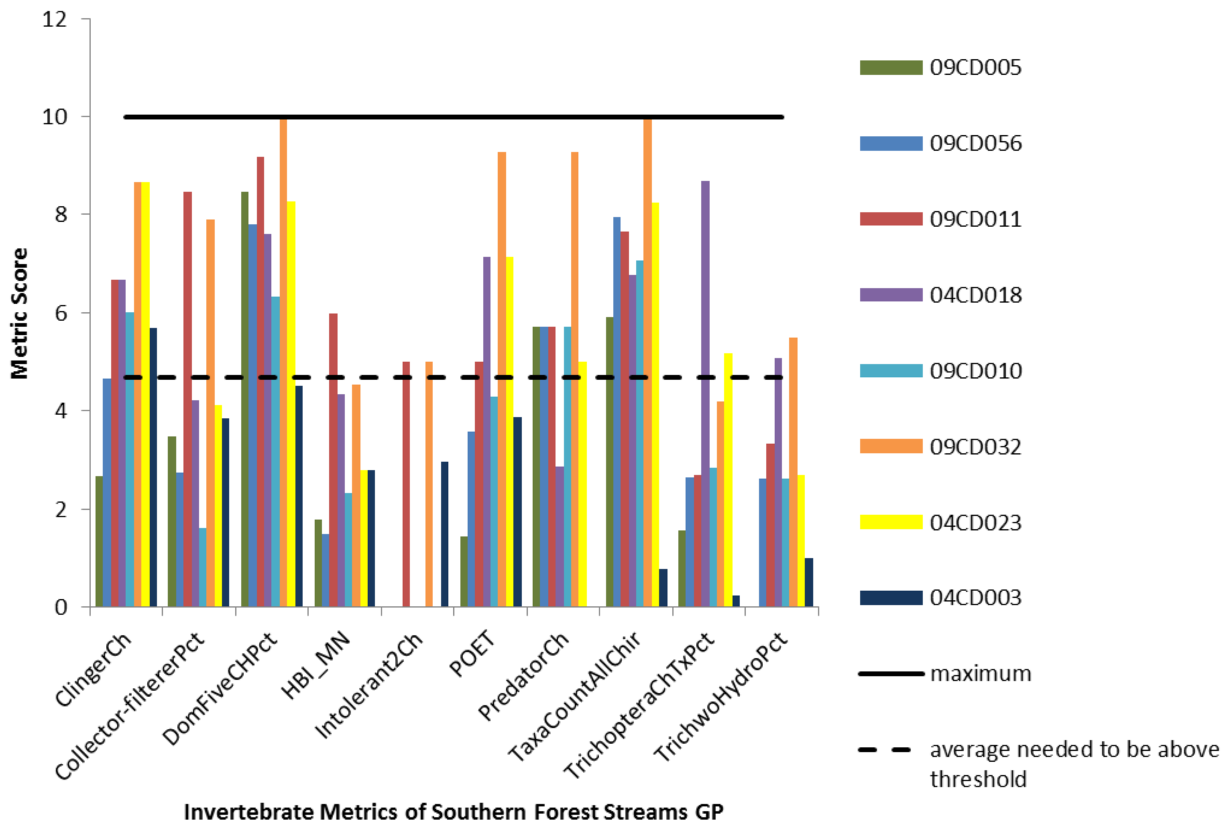


Figure 70: Macroinvertebrate metrics of the Southern Forest GP class in the Cedar River.

The fish community was not listed as impaired. The three biological stations in the Southern Headwaters class had high metric score for: taxa that are detritivorous (DETNWQTxPct), relative abundance (%) of taxa that are generalist feeders (General Txpct), abundance of short lived species (SLvdPct) and relative abundance of individuals that are serial spawners (SSpnPct; Figure 71). The percentage of sensitive individuals (Sensitive) and relative abundance of taxa that are very tolerant (VtolTxPct) were lower than the average metric score needed to be at or above the threshold for two of the three biological stations. In 2004 and 2009, this stream reach did not have fish DELTs, that if present, would have contributed negatively to the IBI.

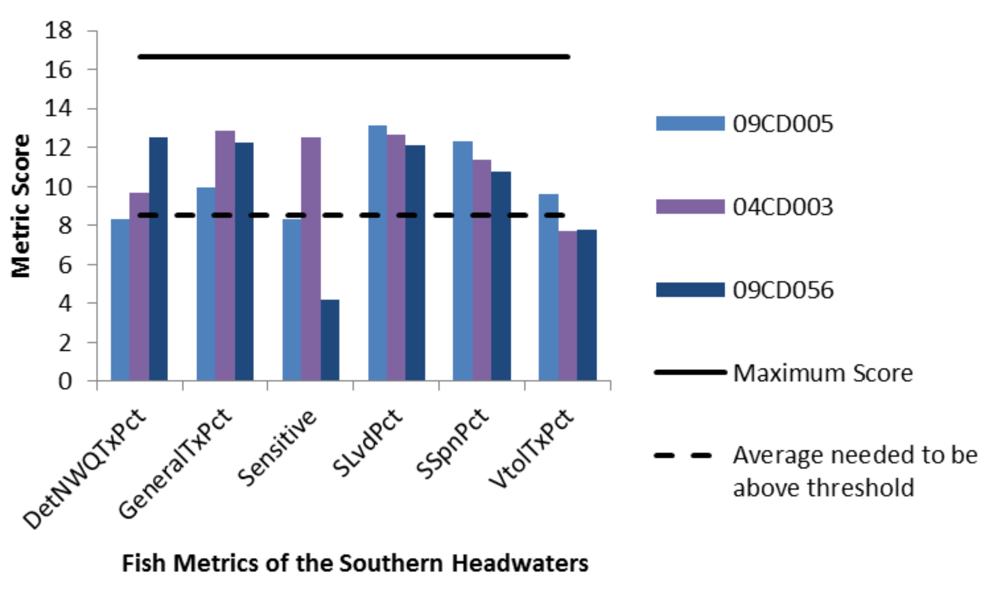


Figure 71: Fish metrics of the Southern Headwaters IBI at biological stations in the Cedar River.

All biological stations had an abundance of fish that reach maturity before the age of 2 (MA<2Pct), relative abundance of individuals that are tolerant species (TolPct) and have short lived species (SLvd; Figure 72.)

The biological stations were above the average needed to be above the threshold were abundant with taxa that are benthic insectivores (excludes tolerant species (BenInsect-TolTxPct), taxa that are detritivorous (DetNWQTXPct) and combined relative abundance of two most abundant taxa (DomTwoPct). There were a low number of taxa that are sensitive (SensitiveTxPct), and an abundance of taxa that are tolerant (TolTxPct). All biological stations had no DELT deductions for the IBI.

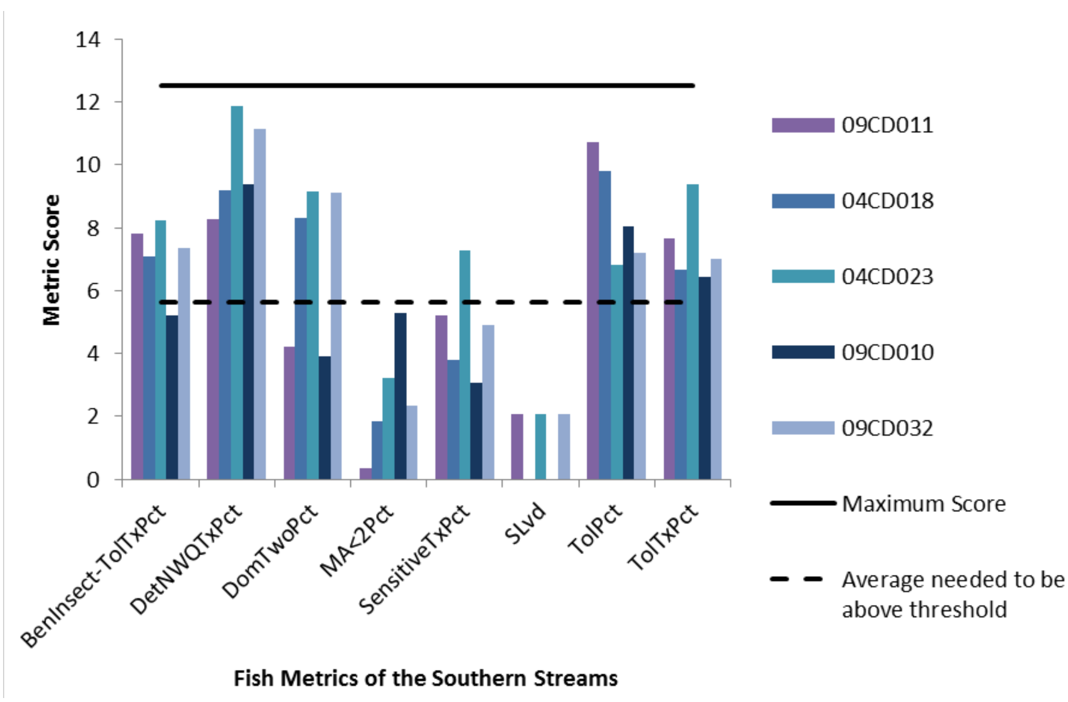


Figure 72: Fish metrics of the Southern Streams IBI at biological stations in the Cedar River.

6.3.2. Candidate cause: Lack of habitat/bedded sediment

This 29 mile reach originates in the Middle Fork Cedar River Watershed unit and begins as a series of channelized streams that flow together to become three tributaries to the Cedar River and continues into the Upper Cedar River Watershed unit. MPCA Stream Habitat Assessment scores from the natural channel biological stations had five biological stations that scored fair while biological station 09CD010 scored poor and biological station 04CD023 had a MSHA rating of good. Stations vary on which subcategories scored the poorest; however all stations scored poorly on land use except for biological station 04CD023 which had a good MSHA score. Biological station 09CD010 scored the lowest on all five subcategories (Table 44). Only two of the biological stations (04CD003 and 09CD0560) that scored below the threshold had 5% riffle with sand and gravel substrate within the station at the time of fish sampling.

The MDNR conducted several geomorphology surveys on the mainstem Cedar River upstream of Austin, Minnesota (Figure 73). This stream reach is classified as a C5c- stream type with a low gradient sand bed channel. The study reach is located in valley type VIII, which is a wide, gentle valley slope with well-developed flood plain adjacent to river and/or glacial terraces.

The upper reach of the Cedar River has very flat water slope providing less stream power and bankfull discharge at the surveyed riffle cross section (Figure 74). The pool and riffle quality in this stream reach is fair. There appears to be excess bedload occurring in this stream reach. Stream bank erosion is prominent with numerous erosion sites on the outside banks (Figure 80). Stream channel dynamics and connectivity with the floodplain appear relatively good but connections are not consistent along this entire reach. Bank erosion estimates done by the MDNR suggest that 36,735 tons of total sediment load is entering the Cedar River from stream banks in this watershed area.

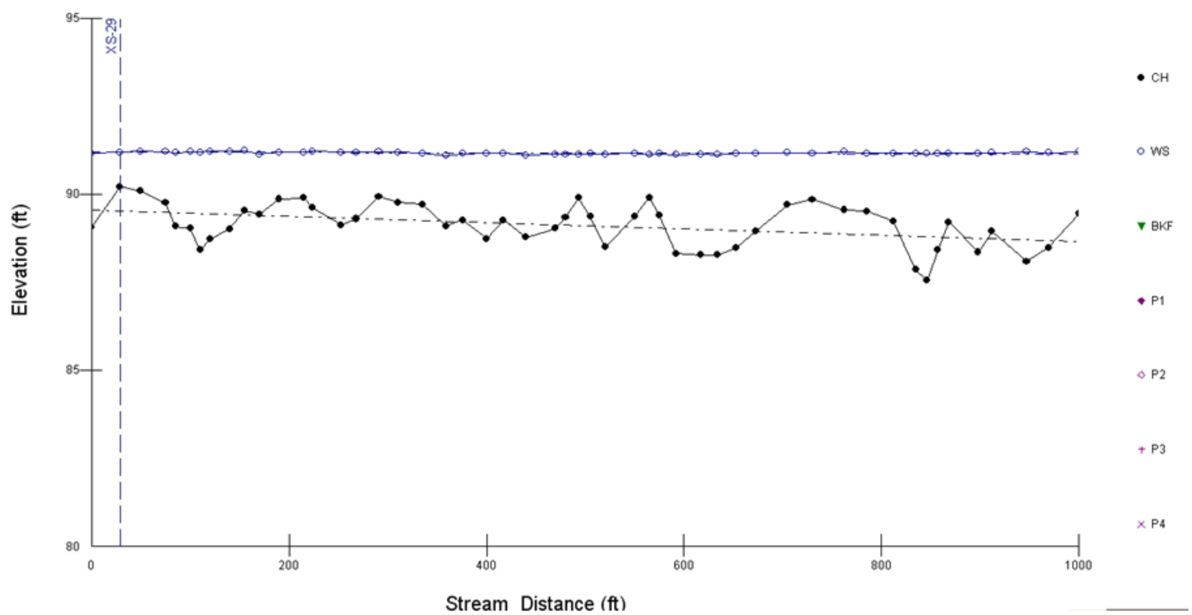


Figure 73: Longitudinal profile on the Cedar River upstream of 740th Street crossing.

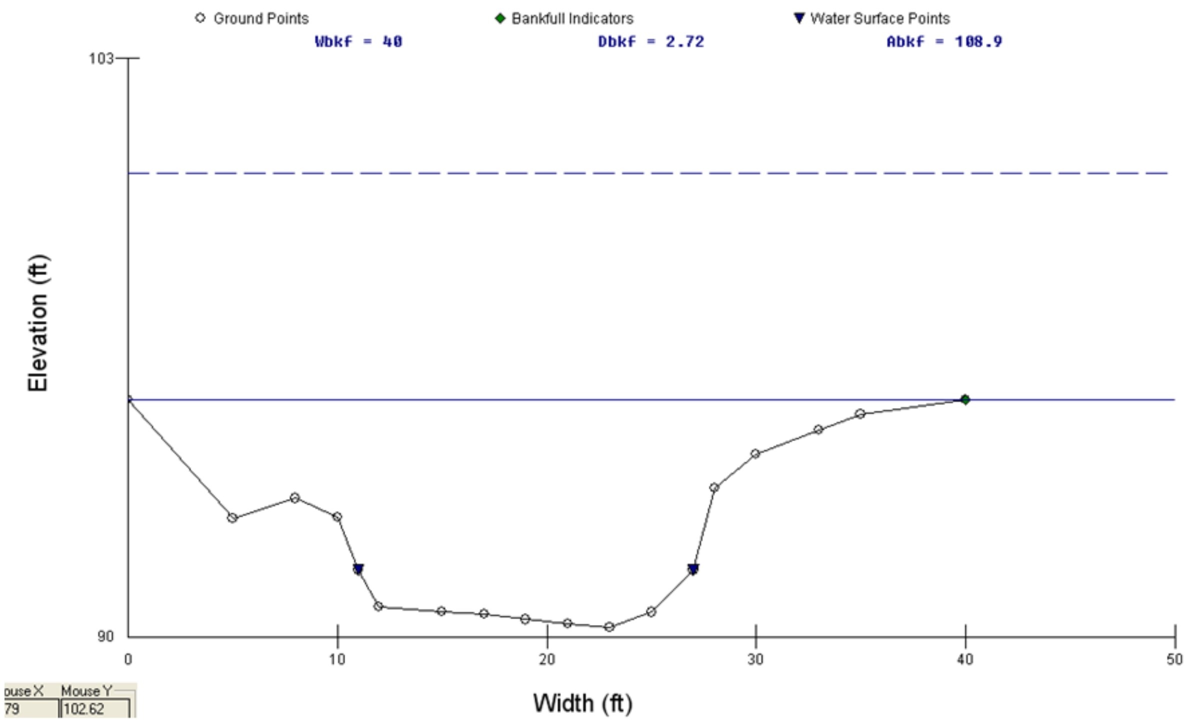


Figure 74: Riffle cross section on the Cedar River upstream of 740th Street crossing.

A second stream reach studied by the MDNR is upstream of County Road 1 crossing on the Cedar River (Figure 75). This stream reach also classified as a C5c- with a low gradient sand bed channel. Sinuosity, like all of the previous reaches is below the normal range for this stream class which may imply the straighter channel is an indication of the stream channel evolution that is occurring in this watershed. The pool and riffle quality in this stream reach is average to fair (Figure 76). There appears to be little excess bedload occurring in this stream reach. Stream bank erosion is notable as there are numerous meander scrolls and oxbow cutoffs that exist in floodplain. The floodplain also contains large deposits of alluvium and unconsolidated coarse outwash materials that provide instability for maintaining good stream dimension, pattern and profile. The narrowly vegetated floodplain in this reach provides some channel stability.

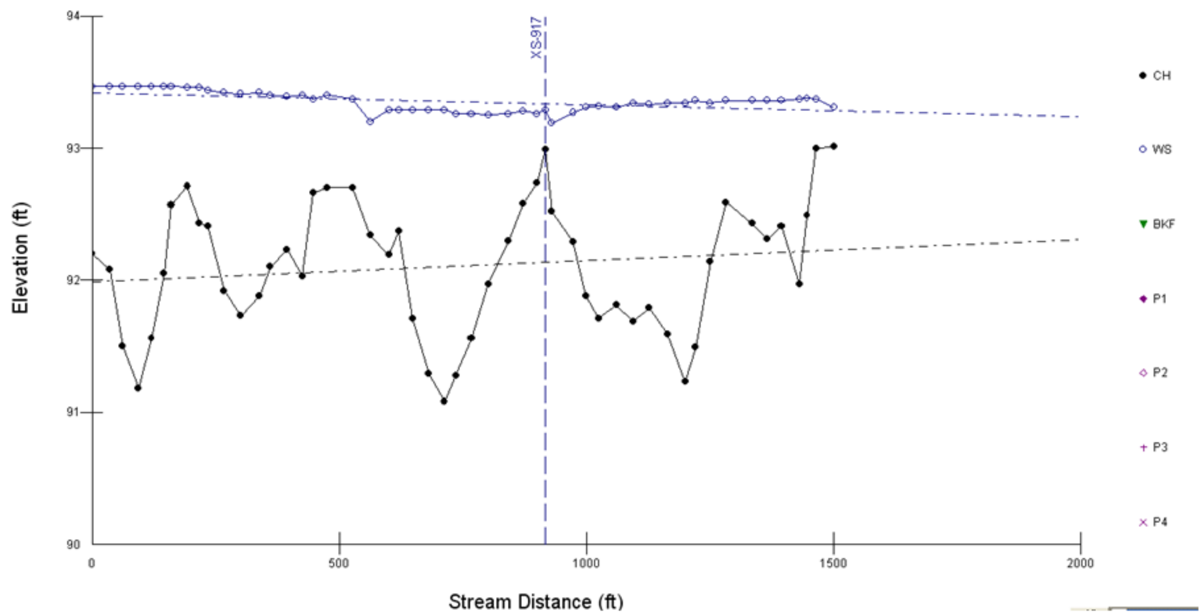


Figure 75: Longitudinal profile on the Cedar River upstream of County Road 1.

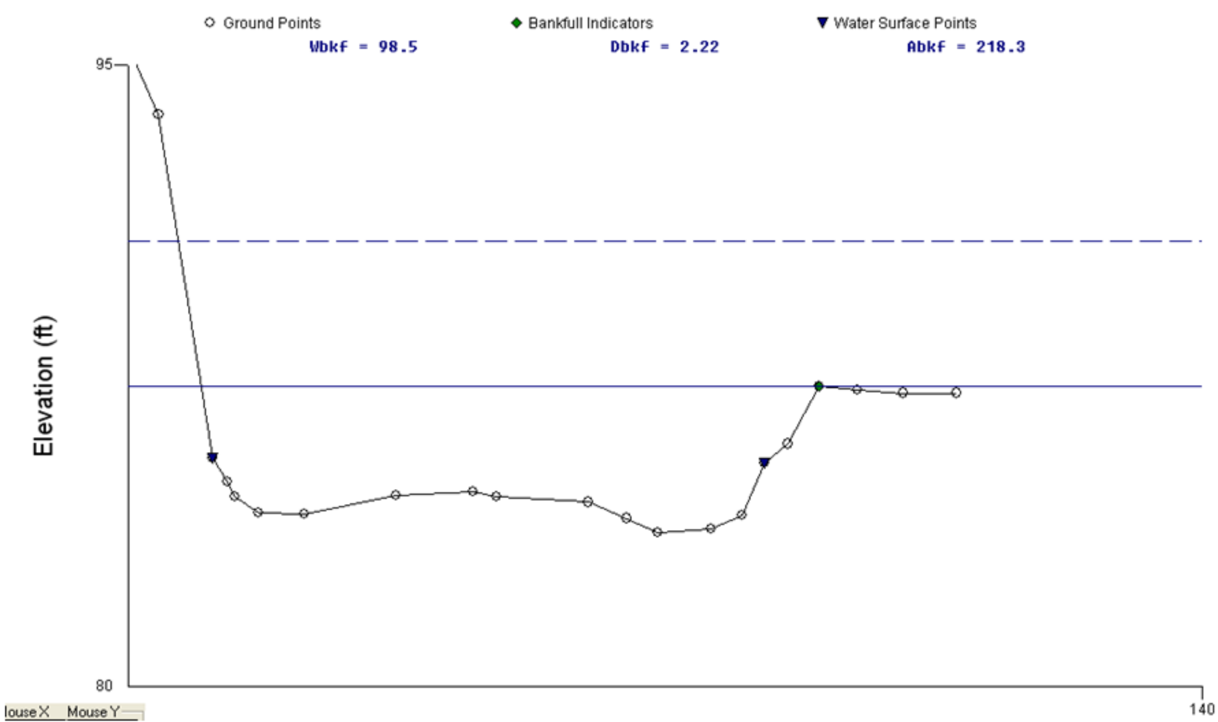


Figure 76: Riffle cross section on the Cedar River upstream of County Road 1.

A third stream reach studied by the MDNR is between County Road 25 and Ramsey Mill Dam on the Cedar River (Figure 77). This stream reach also classified as a C5c- with a low-gradient sand bed channel. The MDNR states there are four to five miles of good riparian area upstream of this reach that is well forested and represents a wider than typical corridor. Sinuosity, like all of the previous reaches, is below the normal range for this stream class which may imply the straighter channel is an indication of the stream channel evolution that is occurring in this watershed. The pool and riffle quality in this stream reach is fair to good (Figure 78 and Figure 79). There appears to be no excess bedload occurring in this stream reach. The channel is effectively routing the sediment load from the watershed by good channel dynamics and connectivity with the floodplain. Stream bank erosion is prominent as there are numerous meander scrolls and oxbow cutoffs that exist in and above this reach's floodplain. Bank erosion estimates suggest as much as 29,905 tons of total sediment load (suspended, wash and bedload) is entering the Cedar River from stream banks in this watershed area. The floodplain also contains large deposits of alluvium and unconsolidated coarse outwash materials that provide instability for maintaining good stream dimension, pattern and profile. The well vegetated floodplain in this reach provides channel stability. Frequent old cutoff channels appear active during flooding and provide near channel detention basins. The reach erosion rate is 0.152 tons/year/ foot.

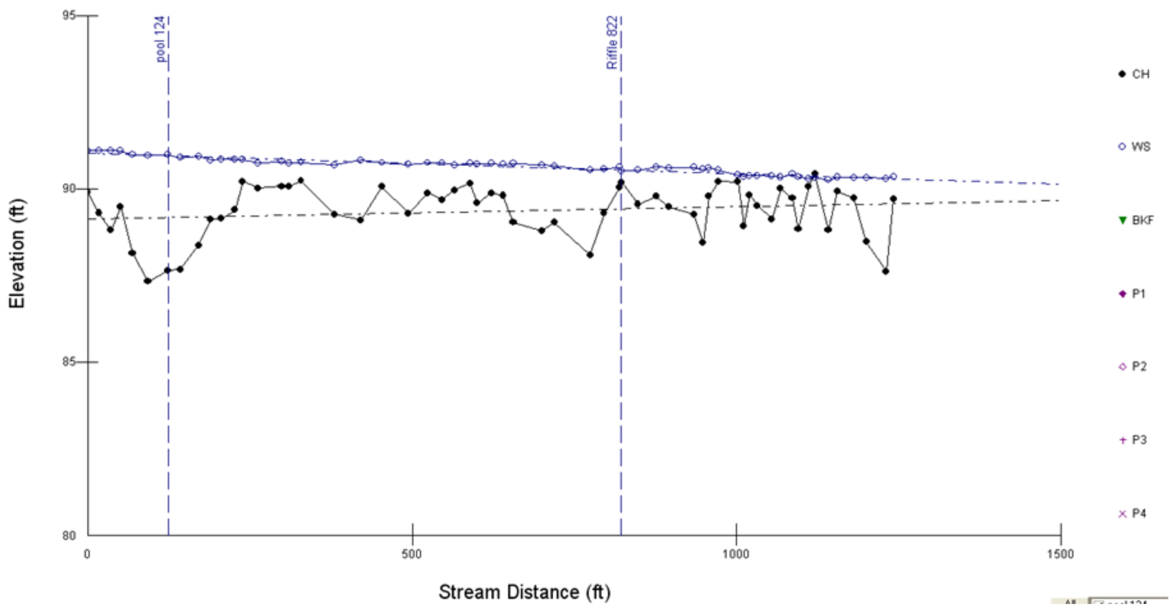


Figure 77: Longitudinal profile on the Cedar River between County Road 25 and Ramsey Mill Dam.

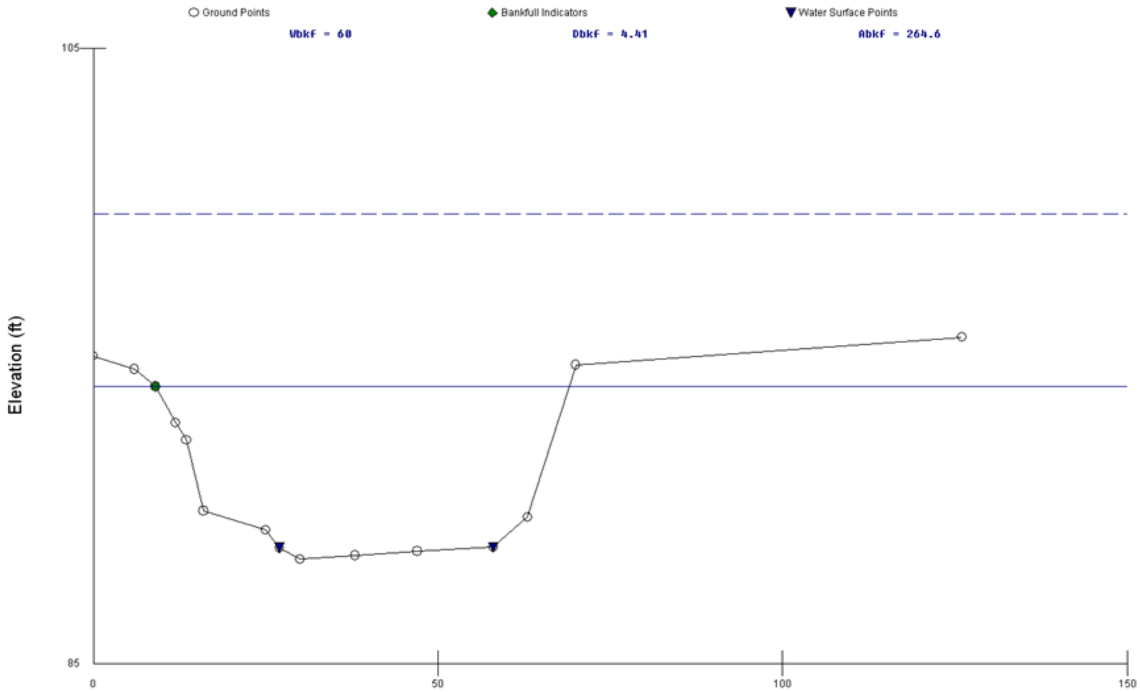


Figure 78: Riffle cross section on the Cedar River between County Road 25 and Ramsey Mill Dam.

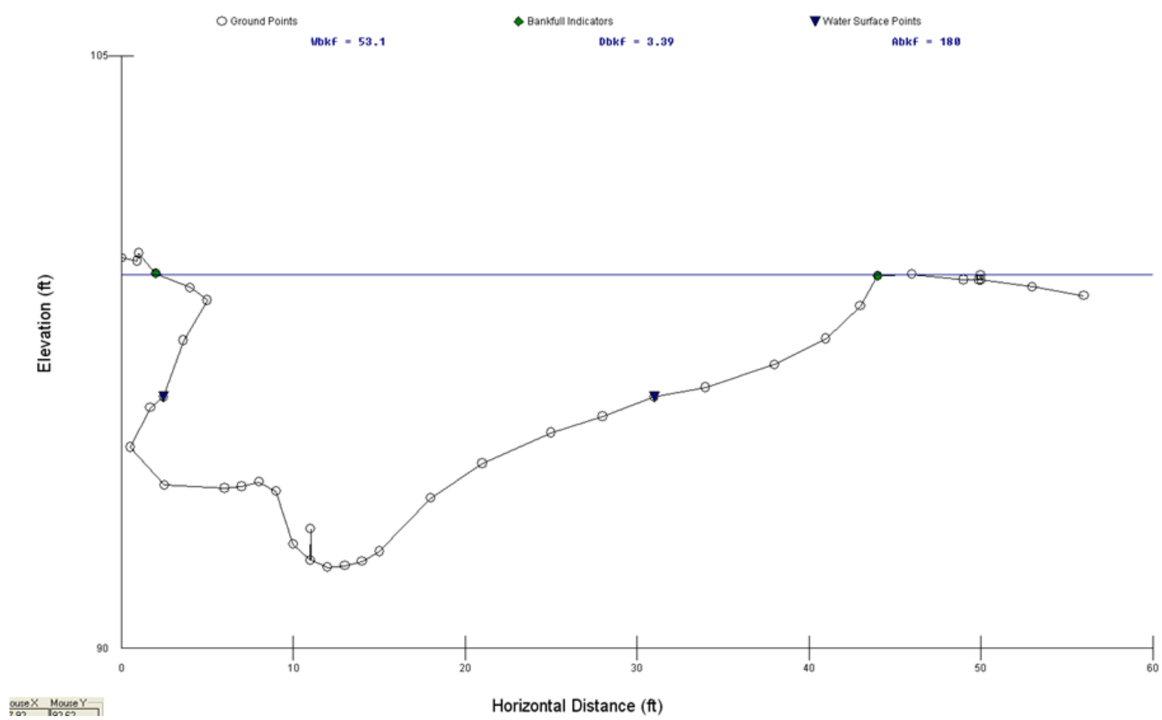


Figure 79: Bank pool cross section on the Cedar River between County Road 25 and Ramsey Mill Dam.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. Over 54% of the waterways in the Upper Cedar River Watershed are channelized. Current estimations are that this AUID is 26% channelized. Thirty-five percent of this watershed is tile drained to help move water off farm fields and to the streams rather quickly. This causes the flows of this stream system to become very inconsistent. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

Burrowers and the percentage of generally tolerant legless macroinvertebrate individuals were above the average of Southern Forest Streams GP (Figure 81). The percentage of EPT individuals were below the average to be above the threshold for Southern Forest Streams GP. The macroinvertebrates that are known to cling to large substrate and woody debris were lacking (below statewide averages for this class), likely due to the lack of woody material that is not available to support these individuals. The percentage of sprawlers was also low compared to statewide averages except for biological stations 09CD056 and 09CD032 (4.73 to 35.67%). Sprawlers can be found in areas with excess sediment, and generally do not prefer rocky substrate, but are more common with smaller fine substrates and slow moving water.

Habitat is a primary stressor in the Cedar River. Site sampling information indicates that there are some aspects of habitat that could be improved in this reach (i.e. lack of riffle, and adjacent land use, bank erosion and excess bedload). Habitat improvements would likely improve the macroinvertebrate community.

Figure 80: Biological station 04CD003 on May 26, 2004 (upper left), biological station 09CD005 on June 30, 2009 (upper right), biological station 09CD010 on July 14, 2009 (lower left) and biological station 09CD56 on July 13, 2009 (lower right).

Table 44: MSHA results for Cedar River (-503).

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	09CD005	Cedar River	0	11.5	12.5	13	15	52	Fair
1	04CD003	Cedar River	0	8.5	17.6	8	29	63.1	Fair
1	09CD056	Cedar River	1.3	9	13.1	12	16	51.3	Fair
1	09CD011	Cedar River	0	11.5	17.2	10	27	65.7	Fair
1	04CD018	Cedar River	0	7.5	17.1	9	18	51.6	Fair
1	04CD023	Cedar River	5	14	20	13	23	75	Good
1	09CD010	Cedar River	1.3	10	8.6	13	7	39.9	Poor
2	09CD032	Cedar River	1.9	10	19.8	9.5	22	63.2	Fair
Average Habitat Results			1.2	10.25	15.7	10.9	19.6	57.7	Fair

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA>66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

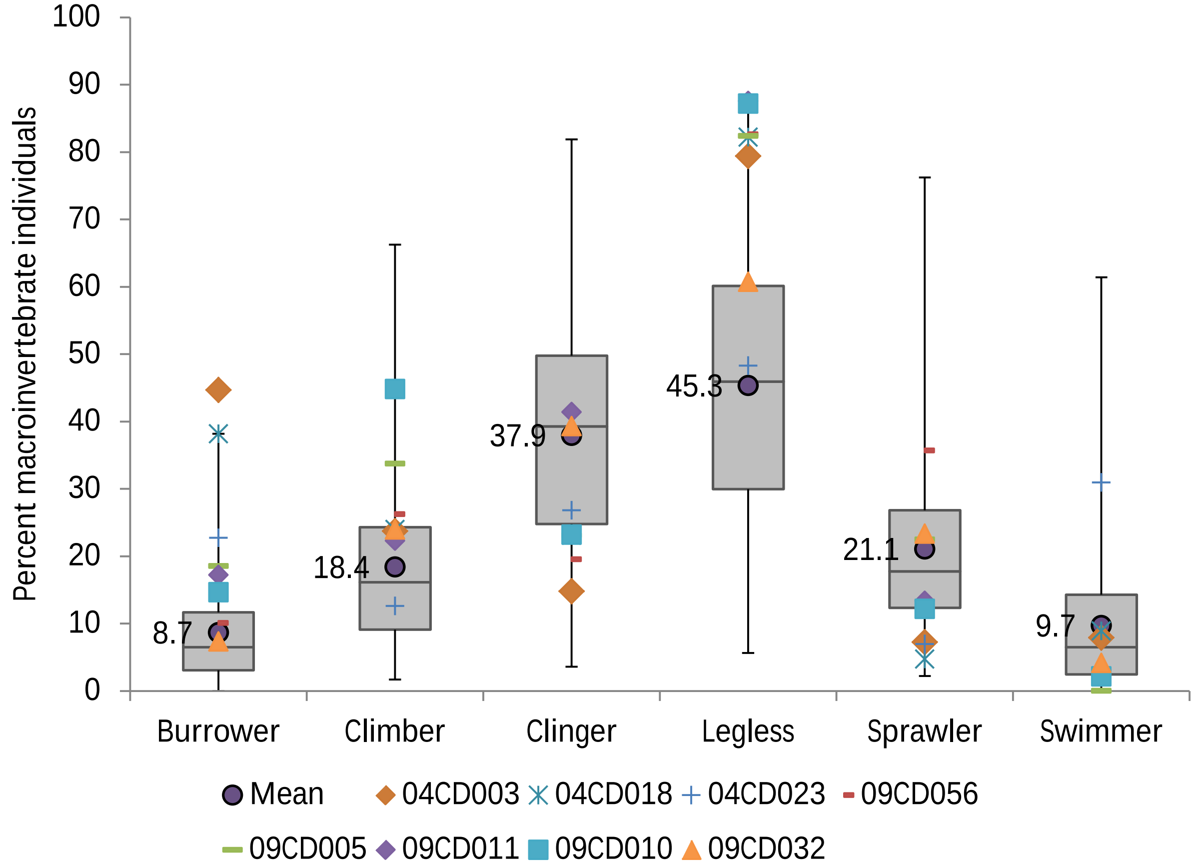


Figure 81: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Forest Streams GP stations with M-IBI greater than 46.8 (threshold), mean of those stations, and metric values from station 04CD003, 04CD018, 04CD023, 09CD056, 09CD005, 09CD011, 09CD010 and 09CD032.

6.3.3. Candidate cause: High nitrate-nitrite

In this AUID of the Cedar River, nitrate levels have been measured as high as 24 mg/L on June 22, 2012, (Figure 82). Nitrate was sampled 120 times from 1980 through 2012 at multiple EQuIS stations. The mean nitrate was 7.58 mg/L. Observed nitrate was highest in April through July and then decreases. Nitrate ranged from 3.2 to 21mg/L during fish sampling at all biological stations on this stream reach. Unionized ammonia was observed to be below the standard in this reach.

The macroinvertebrate community shows an indication of stress from nitrate. The macroinvertebrates in this reach were made up of 57 to 78% tolerant taxa and lacked intolerant taxa. This stream reach was lacking non-hydropsychid Trichoptera in 2004 and 2009. Trichoptera are often considered sensitive to nitrate and respond with decreases in taxa. In this reach there were 57.73 to 94.25% nitrate tolerant macroinvertebrates, with 23 to 33 nitrate tolerant taxa and 1 to 5 nitrate intolerant taxa.

The biological response data does not show evidence to support nitrate as a stressor throughout this reach, even though concentrations are consistently elevated. Elevated nitrate can impact macroinvertebrate communities more at stations with multiple stressors acting on the community. In particular, elevated nitrate concentrations have more of an impact on macroinvertebrate communities in conjunction with poor habitat conditions. Therefore, elevated nitrate is acting as a localized stressor at biological stations 04CD003 and 09CD010 due to decreased non-hydropsychid trichoptera, increased nitrate tolerant percentage, and increased nitrate tolerant taxa.

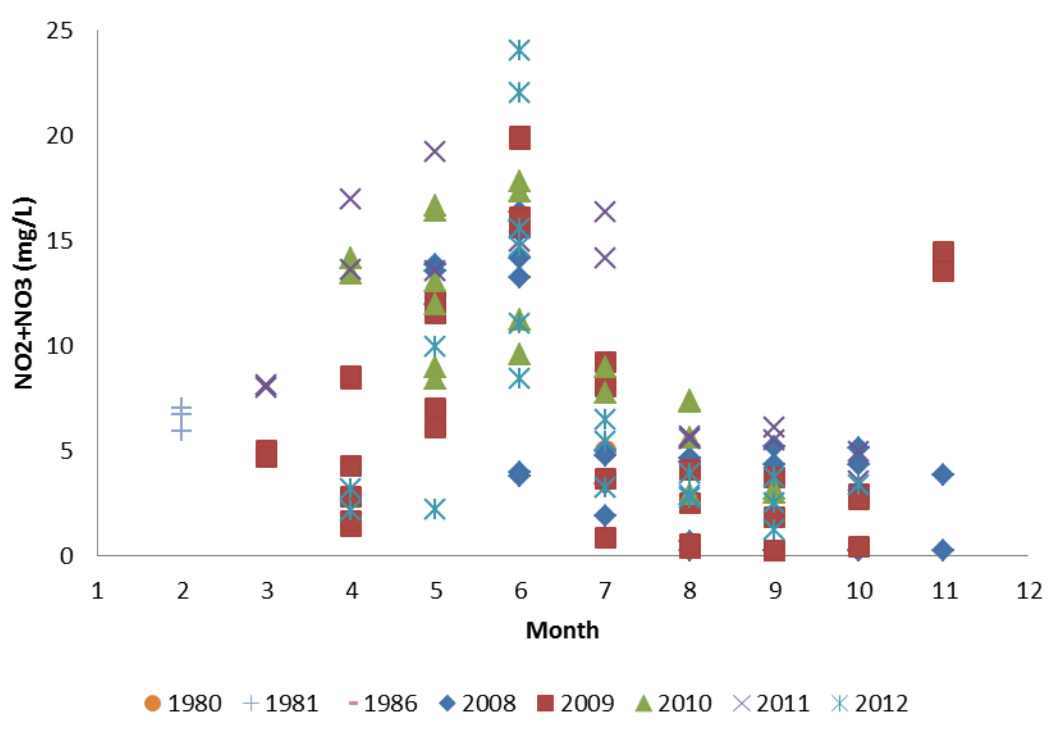


Figure 82: Nitrate-nitrite in the Cedar River (-503) by month and by year.

6.3.4. Candidate cause: Low dissolved oxygen

Dissolved oxygen (DO) concentrations during biological sampling ranged from 6.35 mg/L to 9.57 mg/L in 2004 and 2009. Field measurements were taken as early as 1958, but for this purpose, only measurements taken between 2008 and 2012 were analyzed. During this time frame, DO measurements show a range from 3.44 mg/L to 13.92 mg/L. There were four measurements before 9 a.m. and all were above the standard (5mg/L). Three continuous multi-parameter sondes were deployed in August through early September 2012 throughout this stream reach of the Cedar. DO measurements taken in 15 minute increments shows measurements below the standard. Diurnal DO ranged from 1.31 to 8.95 mg/L and a daily flux as high as 4.45 mg/L at CSAH 2 east of Blooming Prairie (Figure 83), below the daily flux standard of 4.5 mg/L. The Cedar River at 335th Street, SE of Blooming Prairie had a diurnal DO range from 2.46 to 12.68 mg/L with a daily flux as high as 5.25 mg/L (Figure 84). Diurnal DO ranged from 5.47 to 10.45 mg/L and a daily flux as high as 3.76 mg/L at the Cedar River at CSAH 2, east of Lansing (Figure 85). During this time, the flow was low and air temperatures were warm. These are prime conditions for low DO.

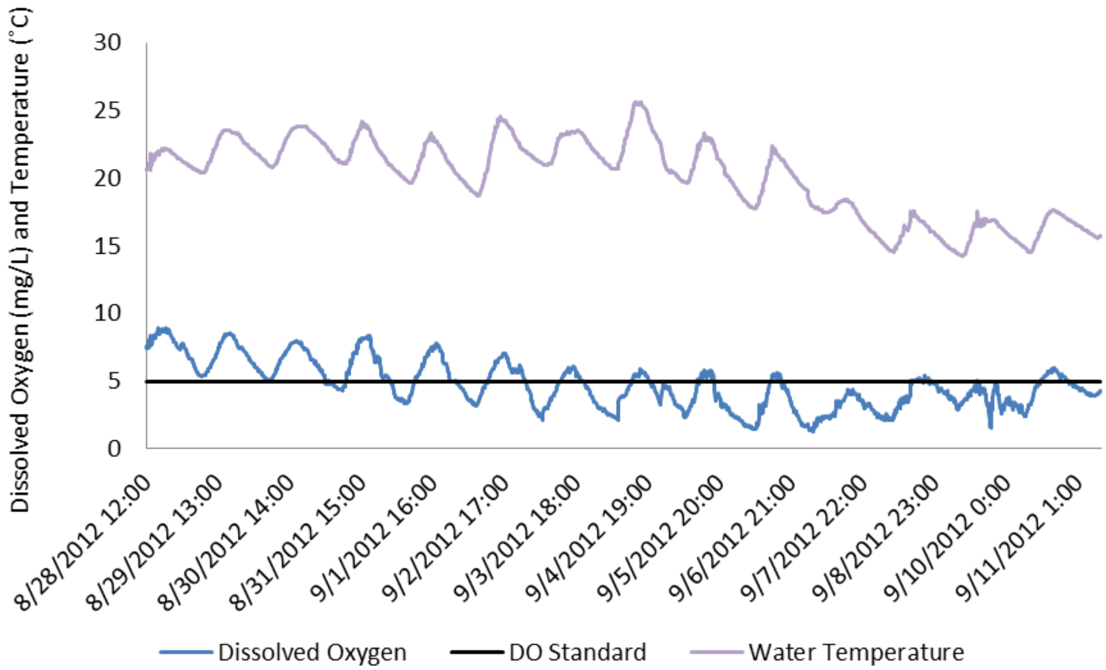


Figure 83: Dissolved oxygen and temperature measured in 15 minute intervals at Cedar River at CSAH 2 east of Blooming Prairie, from August 28 to September 11, 2012.

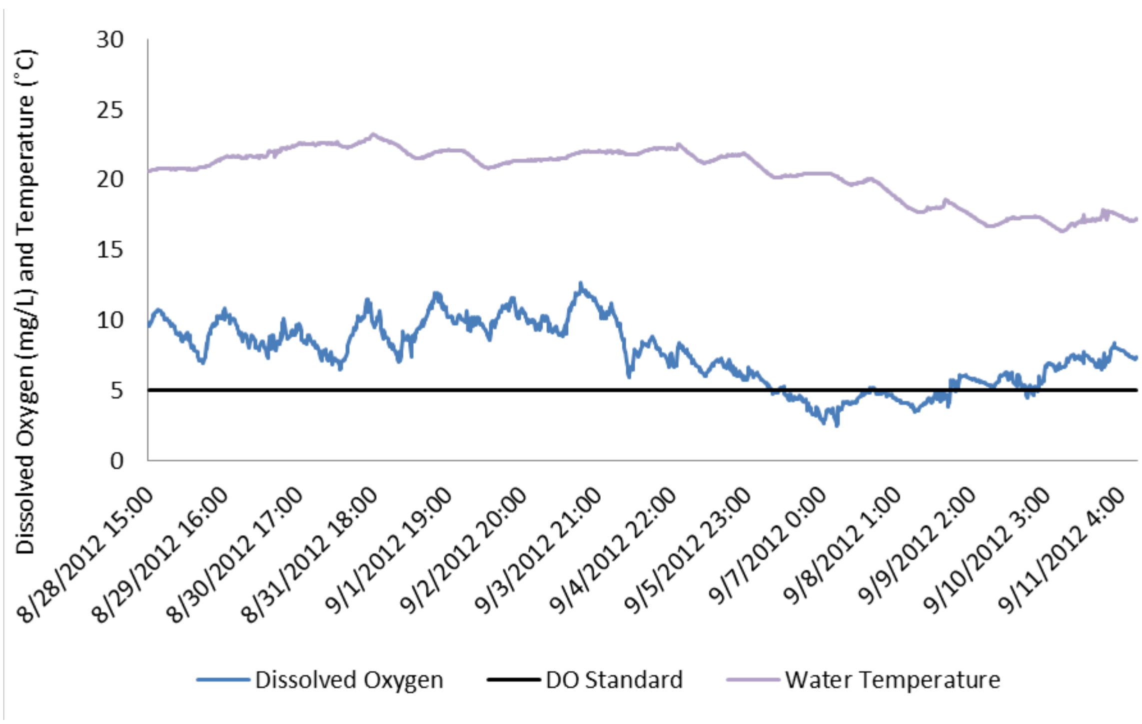


Figure 84: Dissolved oxygen and temperature measured in 15 minute intervals at Cedar River at 335th Street, southeast of Blooming Prairie from August 28 to September 11, 2012.

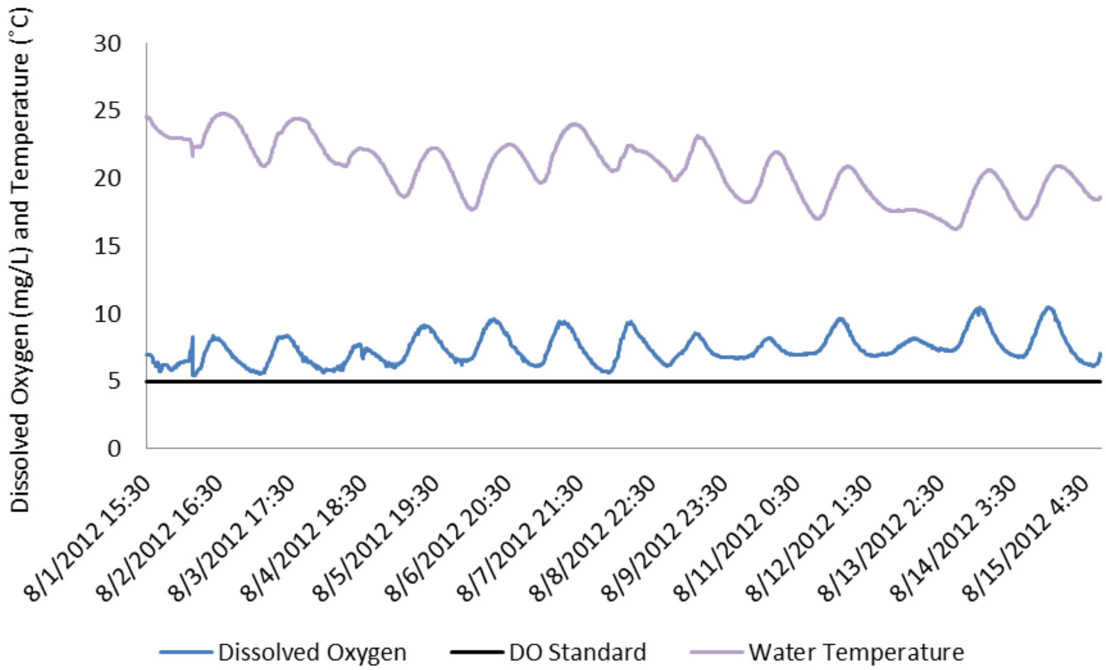


Figure 85: Dissolved oxygen and temperature measured in 15 minute intervals at Cedar River at CSAH 2, east of Lansing from August 1 to August 15, 2012.

The macroinvertebrate community DO TIV index scores for all biological stations in this reach ranged from 6.58 to 7.05, with four out of the seven sites greater than the average for Cedar River basin. The number of DO intolerant species ranged from one to nine (average Cedar River stations is 4.6). There were 4.5% to 24.7% tolerant to low DO species. Biological station 09CD010 was the only station above average for the Cedar River basin (20%) at 24.7%. EPT taxa are generally sensitive to low DO and large DO fluxes, which can be reflected in the metrics percentage of EPT individuals and number of EPT taxa. In 2004 and 2009, the percentage of EPT individuals at the three stations in the Cedar River ranged from 0.61 to 42.90%. There were a low percentage of EPT taxa at three of the eight biological sites (Table 45). The range of EPT taxa within the Cedar River Watershed was 0 to 20 and the average number of EPT taxa at natural channel reaches was 6.3. There was a moderate amount of tolerant taxa (57% to 78%). The macroinvertebrate taxon (TaxaCountAllChir; 39-58) increases downstream. Taxa richness can be decreased with increases in DO flux. Dissolved oxygen is likely contributing to the biological impairment.

Table 45: Ephemeroptera, Plecoptera and Trichoptera taxa longitudinally by station in the Cedar River.

Stations	09CD005	04CD003	09CD056	09CD011	04CD018	09CD010	09CD032	04CD023
Visit Year	2009	2004	2009	2009	2004	2009	2009	2004
EPT Taxa	2	11	6	7	13	6	11	10

6.3.5. Candidate cause: High phosphorus

Phosphorus in this reach was elevated above the standard (0.15 mg/L) in the Cedar River (Figure 86). The TP ranged from 0.017 mg/L to 1.19 mg/L since 2008. The mean concentration in this entire reach was 0.163 mg/L. There were limited chlorophyll-a data, one measurement was above the standard (35 µg/L) and there were 10 measurements of BOD data for this AUID. BOD and chlorophyll-a measurements were from 1981 and earlier, and will not be considered for analysis given the lapse in time since sampling. The DO was discussed in the previous section, and showed there was low DO, along with high flux (5.25 mg/L). Phosphorus is likely contributing to increased plant and algal growth which contributes to DO flux and low DO conditions.

In this reach of the Cedar River, intolerant macroinvertebrates were lacking along with the low metric scores for the modified Hilsenhoff Index for Minnesota. There were a low percentage of EPT taxa at seven of the eight biological sites and a moderate amount of tolerant taxa (57% to 78%). The percentage of scrapers ranged from 9.2% to 34.4%. The first biological station and the last biological station were above the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. It is likely that high phosphorus is altering the macroinvertebrate community.

The high phosphorus values and the absence of intolerant individuals, along with the high DO flux make it likely that phosphorus is impacting the biological community in the Cedar River.

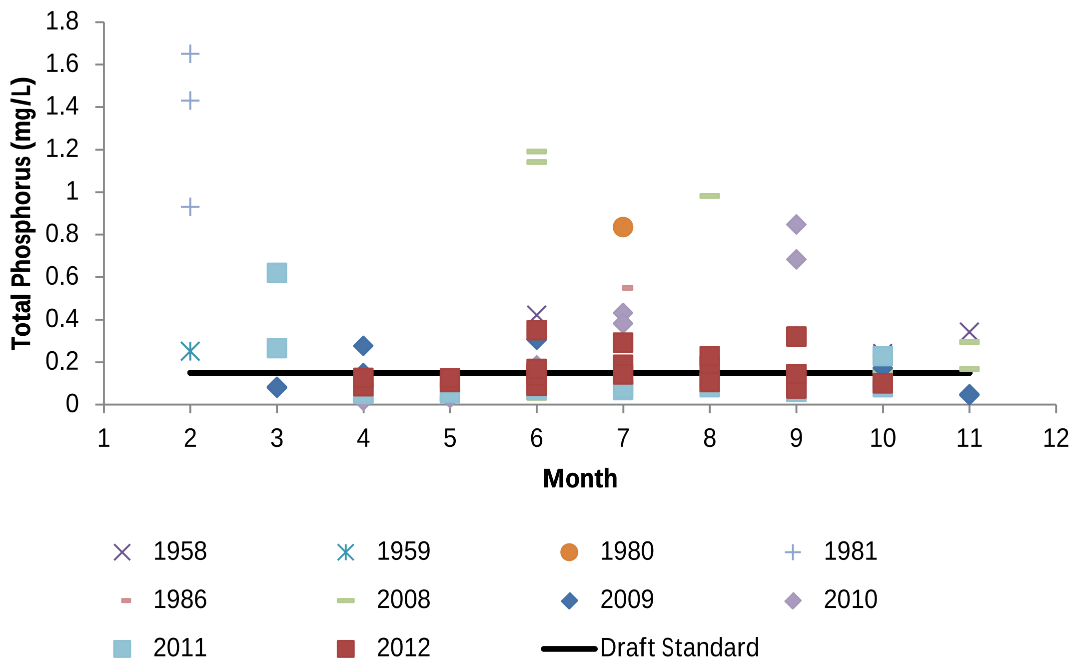


Figure 86: Total phosphorus by month for the Cedar River on AUID (-503).

6.3.6. Candidate cause: High suspended sediment

TSS during the fish visits ranged from 1 to 10mg/L, along with excellent transparency tube readings (65-96 cm). Transparency tube data was collected at six sampling locations. The collection of the transparency data resulted in most observations in the good category during the summer months. There are 150 TSS samples in this reach of the Cedar River, with eight higher than the proposed standard (65 mg/L). TSS has been recorded as high as 760 mg/L and averaged 24.91 mg/L.

TSS station index scores for macroinvertebrates there were one to three TSS intolerant taxa present, TSS tolerant taxa ranged from 7 to 14 and the percentage of TSS tolerant macroinvertebrates ranged from 11.15 to 55% (Table 46). The percentage of intolerant macroinvertebrates was low and six out of the eight biological stations had a low percentage of long-lived macroinvertebrates for the Cedar River Watershed. Collector-filterers were above average at six out of the eight biological stations for Southern Forest Streams GP in this stretch of the Cedar River. Collector-filterers are reduced when TSS is elevated.

Collector-filterer species collect their food by filtering it from the water column. Therefore, elevated TSS is acting as a localized stressor at biological stations 04CD018 and 04CD023 due to these stations having fewer than average intolerant taxa. Additionally, biological station 04CD018 also had fewer than average long-lived macroinvertebrate taxa, both which often decrease with increases in TSS stress.

Table 46: Macroinvertebrate metrics relevant to TSS for stations in the Cedar River from the headwaters to Roberts Creek compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
09CD005	16.06	2	7	11.1	**0**	**4**
04CD003	**16.6**	1	**12**	**31.7**	2	5
09CD056	16.2	2	9	17.1	**0**	**2**
09CD011	14.0	3	**11**	14.0	1	**3**
04CD018	**17.25**	**0**	**14**	**36.3**	**0**	**3**
04CD023	**18.3**	**0**	**13**	**55**	**0**	7
09CD010	14.8	2	**10**	12.3	**0**	**4**
09CD032	15.8	3	**13**	**28.1**	1	7
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

6.3.7. Conclusions

Monitoring stations along this Cedar River AUID suggest that while fish performed well, there appears to be an upstream to downstream gradient in aquatic macroinvertebrate community condition where the headwater reaches rated poor while the downstream reaches rated fair to good.

The stressors found in this reach are summarized in Table 47. Multiple stressors are acting on the biological community in this reach. The most consistent biological response is seen with the habitat limitations and substrate embeddedness. Additionally, elevated TSS, low DO, elevated nitrate, elevated phosphorus and flow alteration are all also impacting the macroinvertebrate community.

This stream reach is classified as a C5c- stream type, with a sand dominated substrate and very low gradient. Stream bank erosion is prominent with numerous erosion sites on the outside banks. There appears to be excess bedload occurring in the upper stream reach while the lower part of this stream reach appears to have no excess bedload occurring. The channel is effectively routing the sediment load from the watershed by good channel dynamics and connectivity with the floodplain. Site sampling information indicates that there are some aspects of habitat that could be improved in this reach (i.e. lack of riffle, and adjacent land use and bank erosion). Habitat improvements would likely improve the macroinvertebrate community. Nutrient management of both nitrogen and phosphorus is needed throughout the watershed.

Table 47: Summary of stressors found in the Cedar River (-503).

AUID Reach Name, Reach Description	**Biological Station ID**	**Impairment(s)**	**Stressors**					
			Habitat/Bedload Sediment	**Nitrate**	**Dissolved Oxygen**	**Phosphorus**	**Suspended Sediment**	**Flow alteration**
07080201-503 Cedar River Headwaters to Roberts Creek	09CD005 04CD003 09CD056 09CD011 04CD018 04CD023 09CD010 09CD032	Macroinvertebrate IBI Bacteria	•	•	•	•	•	•

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

6.4. Unnamed creek: unnamed creek to Cedar River (AUID: 07080201-533)

The MPCA surveyed one biological station 09CD042 that was sampled in 2009 on AUID 07080201-533. Biological station is located upstream of 540th Avenue, in Lansing.

Water quality samples were taken at EQuIS station S003-078 at County Road 2 in Lansing, 3.75 miles north of Austin. A second EQuIS station S003-077 at Highway 25 in Lansing also had available data from 2001. Water quality data from 2001, 2008 to 2012 were used to determine stressors.

6.4.1. Biology in the Cedar River

The M-IBI was 37.45 which are below the threshold of 46.8 for a Southern Forest Streams (Table 48). The F-IBI score for this station was 66, above the threshold of 51 for a Southern Headwaters Streams. The macroinvertebrate community is not meeting aquatic life standards on unnamed creek (-533).

Table 48: Summary of biological impairments in unnamed creek (-533).

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-533, unnamed creek to Cedar River	09CD042	unnamed creek	5.04	Southern Forest Streams	46.8	37.45	Southern Headwaters	51	66

Macroinvertebrates in the class Southern Forest Streams GP scored poorly in the metrics of collector-filterers (Collector-filtererPct), a measure of pollution based on tolerance values assigned to each individual taxon (HBI_MN), Plecoptera, Odonata, Ephemeroptera and Trichoptera taxa (POET) and Trichoptera (TrichopteraChTxPct), taxa richness of predators (Predator)at biological station 09CD042 (Figure 87). This stream reach was also lacking intolerant taxa (intolerant2Ch) and non-hydropsychid caddisflies (TrichwoHydroPct). It was abundant with tolerant taxa (Tolerant2ChTxPct; 67%), as well as also receiving a low metric score for HBI_MN. Five species dominated the sample (DomFiveCHPct; 47.98%).

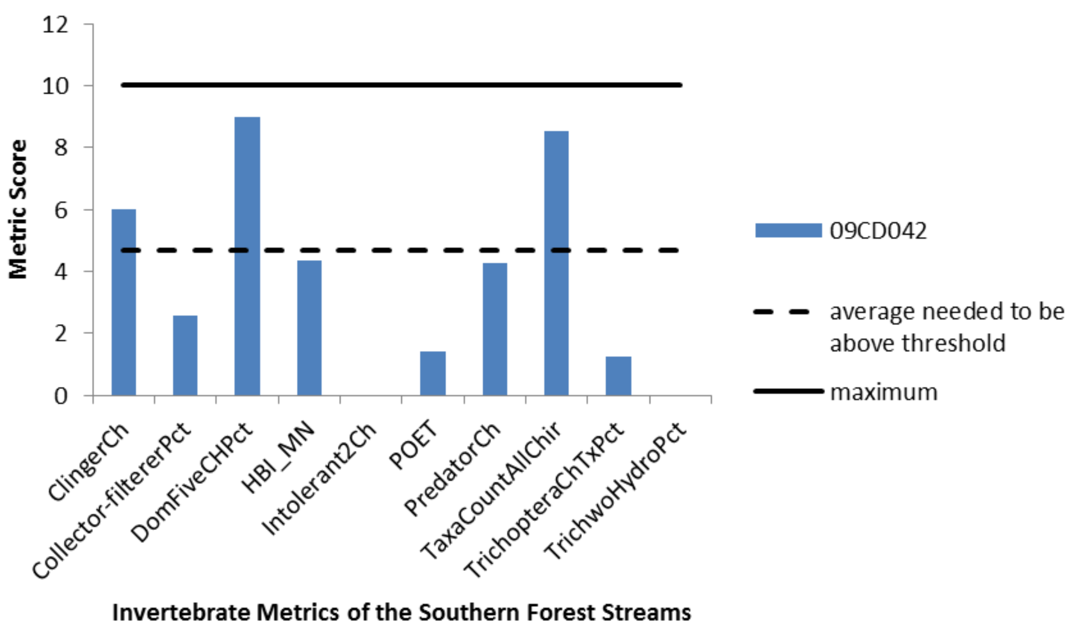


Figure 87: Macroinvertebrate metrics of the Southern Forest Streams GP IBI in station 09CD042 in unnamed creek.

The fish community was not listed as impaired. At this station there was an abundance of: taxa that are detritivorous (DETNWQTxPct), relative abundance (%) of taxa that are generalist feeders (General Txpct), abundance of short lived species (SLvdPct) and relative abundance of individuals that are serial spawners (SSpnPct; Figure 88). The percentage of sensitive individuals (Sensitive) were lower than the average metric score needed to be at or above the threshold. This stream reach were lacking relative abundance of taxa that are very tolerant (VtolTxPct). The reach did not have fish DELTs, that if present, would have contributed negatively to the IBI.

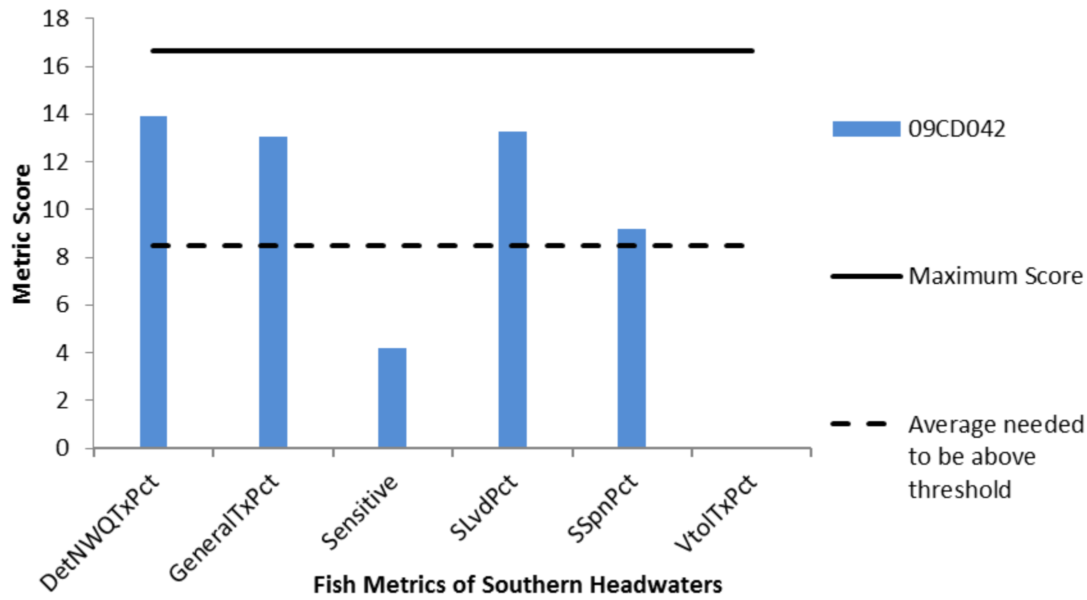


Figure 88: Fish metrics of the Southern Headwaters IBI in station 09CD042 in unnamed creek.

6.4.2. Candidate cause: Lack of habitat

The unnamed creek station 09CD042 scored 61.7 (fair) on the MSHA (Table 49). Of the five subcategories in the MSHA, land use and substrate scored poorly. Unnamed creek had good channel morphology, with moderate to high channel stability. The water was clear and at a normal water level at the time of fish sampling. This reach contained 20% riffle and was dominated by sand and gravel, with light embeddedness of coarse substrate. Sand and gravel substrate was also dominant in the pools.

The surrounding land use was noted as row crop with a moderate (15 to 30 ft) riparian buffer on the right bank and wide (150 to 300 ft) riparian buffer on the left bank. There is little bank erosion (Figure 89). Moderate cover was noted, with multiple cover types including undercut banks, overhanging vegetation and logs or woody debris. The habitat that was sampled for macroinvertebrates was undercut banks and over hanging vegetation (Figure 89). This site is lacking good quality riffles.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. The Upper Cedar River Watershed is approximately 54% channelized. This AUID is estimated to be 27% channelized. The Upper Cedar River is estimated to have 35% tile drainage, which is used to help move water off the farm fields and to the streams rather quickly. This causes the flows of this stream system to become very inconsistent. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

Burrowers were high at biological station 09CD042 (14.09%; Figure 90). The percentage of EPT individuals was much less than the statewide average for Southern Forest Streams GP macroinvertebrate class (4.36%). The percentage of generally tolerant legless macroinvertebrate individuals was high (89.10%). The macroinvertebrates that are known to cling to large substrate and woody debris were low (below statewide averages for this class), likely due to the lack of woody material to support these individuals. This is also found in the M-IBI metrics, the number of clinger taxa (ClingerCh) was just below the average metric score needed for the M-IBI to be at the threshold.

Clingers can decrease in stream reaches with homogenous substrate composition, velocity, and depth (CADDIS).

The site is lacking good quality riffles and woody debris, as the only habitat available to sample macroinvertebrates was undercut banks and overhanging vegetation. Habitat is limiting the macroinvertebrate community found at this station.

Figure 89: Biological station 09CD042 overhanging vegetation (left) and on July 13, 2009 (right).

Table 49: MSHA results for unnamed creek (-533).

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	09CD042	unnamed creek (533)	0	10.5	17.2	10	24	61.7	Fair

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA>66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

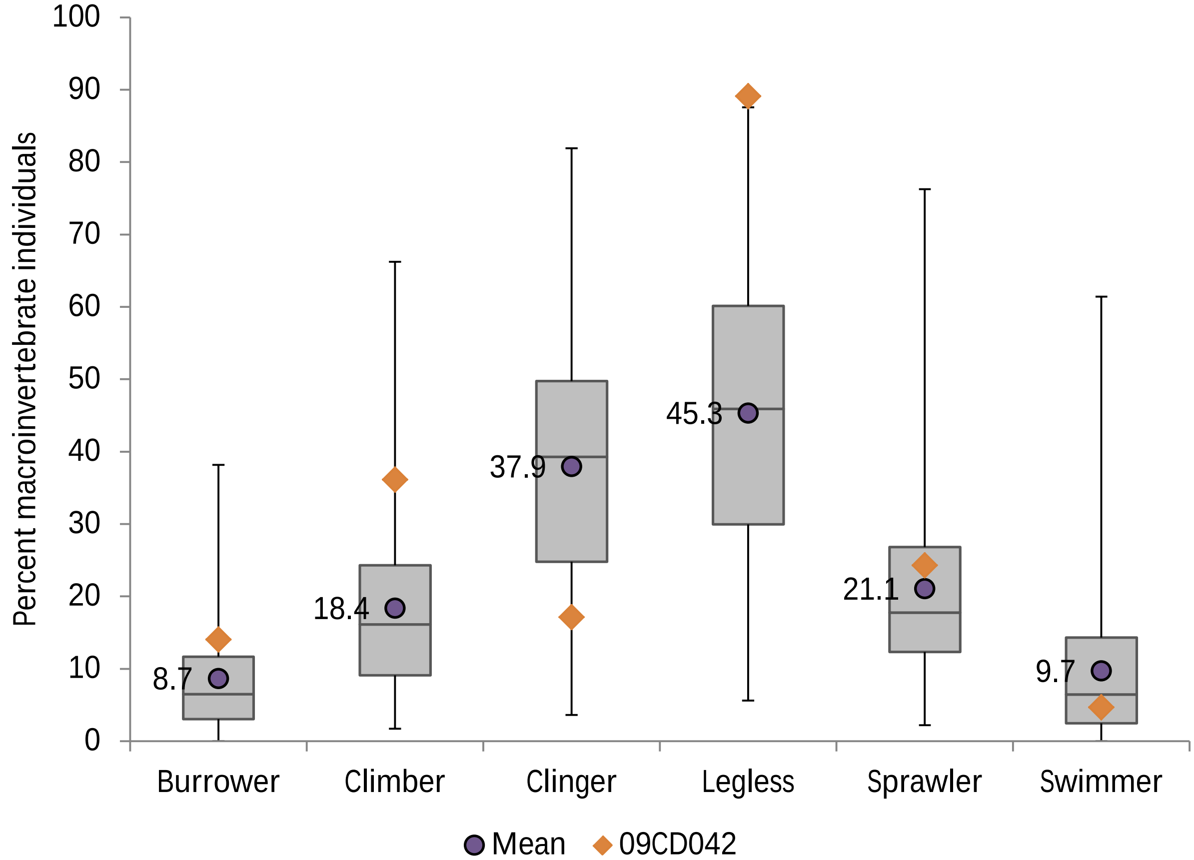


Figure 90: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Forest Streams GP stations with M-IBI greater than 46.8 (threshold), mean of those stations, and metric values from station 09CD042.

6.4.3. Candidate cause: High nitrate-nitrite

Nitrate sample of 9.9 mg/L was taken at the time of fish sampling on July 13, 2009. Nitrate has been sampled a total of 72 times from 2008 through 2012. The highest sample was 15.9 mg/L on June 9, 2009, while the lowest sample was 3.64 mg/L on September 23, 2010, (Figure 91). The highest observed nitrate levels persist in June and drop through the summer with August having the lowest levels. The mean nitrate was 8.44 mg/L. Unionized ammonia is not a concern based on the data available.

The macroinvertebrates in this reach were made up of 77% tolerant taxa and 4% intolerant taxa. This AUID was lacking non-hydropsychid caddisflies. Trichoptera are considered sensitive to nitrate and respond with decreases in taxa. At biological station 09CD042, there were 84.26% nitrate tolerant macroinvertebrates, with 31 nitrate tolerant taxa and no nitrate intolerant taxa. Nitrate is a stressor to the impaired biota.

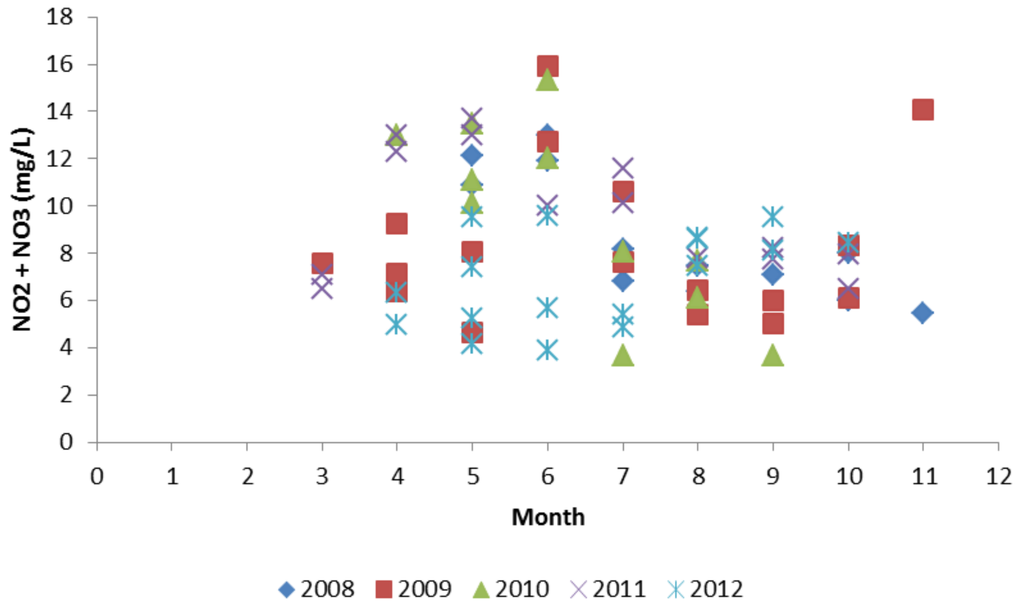


Figure 91: Nitrate-nitrite in unnamed creek (-533) by month and by year

6.4.4. Candidate cause: Low dissolved oxygen

The DO measurement was 7.71 mg/L on the day of fish sampling, July 13, 2009. The 76 measurements of DO from 2008 to 2012 do not fall below the standard (5 mg/L). Six measurements were made prior to 9 a.m. ranging from 6.79 mg/L to 9.07 mg/L. DO flux was not observed.

The macroinvertebrate survey in 2009 had 48 taxa (total taxa richness of macroinvertebrates), above the average taxa count for the Southern Forest Streams GP macroinvertebrate class for the Cedar River Watershed of 39.56. Taxa richness can be decreased with increases in DO flux. Tolerant taxa were elevated at 77%. Also a low percentage of EPT taxa (4%) are present at this site. EPT taxa are typically intolerant of low DO levels. The macroinvertebrate community DO TIV index score for 09CD042 is 7.05, which is better than the average of 6.8 for Cedar River basin. The numbers of macroinvertebrate taxa collected that are intolerant to low DO were 7, and the percentage of DO tolerant species collected were 8.3. The average number of intolerant taxa collected in the Cedar River basin was 5.6 and the average percentage of DO tolerant taxa was 20. Dissolved oxygen is not a stressor to the macroinvertebrate community at this time.

The fish community at this station indicated the species that were present were less tolerant of low DO (in upper quartile of sensitivity for DO based on data from Cedar River Watershed with a station TIV of 7.49; Table 4). The most DO sensitive fish found at this station were fantail darters; and there was a presence of DO tolerant fish such as brook stickleback. Therefore, It is unlikely that DO is a stressor at this time.

6.4.5. Candidate cause: High phosphorus

The unnamed creek at biological station 09CD042 had a TP level of 0.381 mg/L at the time of fish sampling, which is above the standard of 0.15 mg/L (Figure 92). TP ranged from 0.018 mg/L to 0.57 mg/L. DO flux was not measured as previously discussed. There is currently no BOD and chlorophyll-a data available for this AUID.

This stream reach has a high macroinvertebrate taxa count (TaxaCountAllChir; 48) compared to the average for the Cedar River Watershed (40.5). Biological station 09CD029 lacked intolerant tax and the percent tolerant taxa was high (Tolerant2ChTxPct; 66.7%). The percentage of intolerant taxa will decrease and the percentage of tolerant taxa will increase with increases in phosphorus. The percentage of scrapers was 22.9%, which was above the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. The number of collector-gather taxa (22) and collector-filterer taxa (6) were both high. There were 2 EPT taxa in this stream reach. The range of EPT taxa within the Cedar River Watershed was 0 to 20. The metric, EPT, provides a relative measure of the presence and diversity of pollution-sensitive macroinvertebrate groups. The data connects elevated phosphorus and the impaired biota. Phosphorus should be continued to be collected to understand the nutrient dynamics in this system.

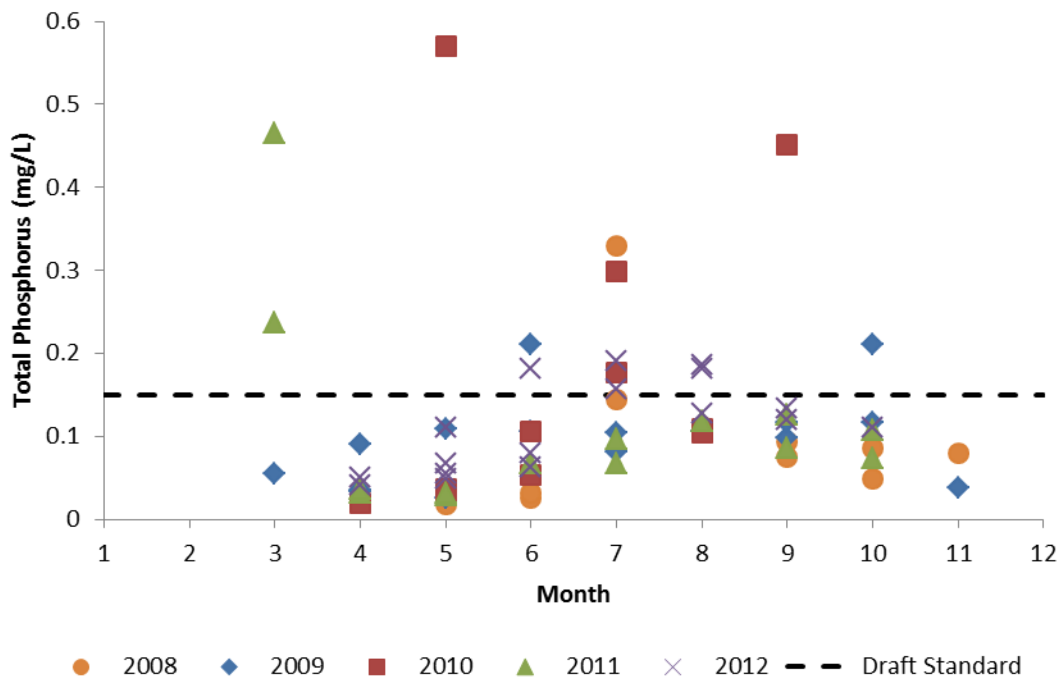


Figure 92: Total phosphorus by month for unnamed creek (-533) in 2008 through 2012.

6.4.6. Candidate cause: High suspended sediment

Biological station 09CD042 had low TSS at the time of fish sampling on July 13, 2009, (12 mg/L), along with a good transparency tube reading (55 cm). The collection of transparency data resulted in 6 out of the 102 observations in the poor category. Turbidity was elevated 6 out of 64 samples. The mean turbidity was well below the 25 NTU standard. There were 85 TSS samples collected from 2001, 2008 through 2010, and 2012, ranging from 1 mg/L to 68 mg/L with only one higher than the proposed standard (65 mg/L).

In 2009, biological station 09CD042 had a low percentage of fish that are herbivores (3.42%) and scrapers (6.5%). The macroinvertebrate collector-filters were very low (10%). Collector-filterers are reduced when TSS is elevated. Collector-filterer species collect their food by filtering it from the water column. Long-lived macroinvertebrates were low (1.9%) in this stream reach (Table 50). Long-lived macroinvertebrates can decrease with increased TSS stress. Biological station 09CD042 had a low percentage of TSS tolerant individuals (22.9%) and below average TSS tolerant taxa (6) compared to the averages for warmwater stations in the Cedar River Watershed for percent of TSS tolerant individuals

(25.9%) and TSS tolerant taxa (9). 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. Elevated TSS is a stressor to the biological community.

Table 50: Macroinvertebrate metrics relevant to TSS for stations in unnamed creek compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
09CD042	14.5	1	6	22.9	**0**	**4**
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

6.4.7. Conclusions

The stressors to unnamed creek (-533) are summarized in Table 51. Habitat, nitrate, phosphorus, TSS, and flow alteration are stressors to the macroinvertebrate community. The site is lacking good quality riffles and woody debris, as the only habitat available to sample macroinvertebrates was undercut banks and overhanging vegetation. Habitat is being impacted by lack of stability in flow with more frequent higher flow events and low flow conditions forcing channel changes in this reach, which reflects upon the land use practices. Nitrate concentrations are elevated and having an impact on the biota. While a DO stressor does not seem likely, additional information on the DO regime in this stream would be useful in completely ruling out that stressor. Phosphorus is contributing to the biological impairment. Hydrology is the driver for the elevated TSS. There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

Unnamed creek (-533) would likely benefit from habitat improvement for the macroinvertebrates. Nitrate levels are elevated (15.9 mg/L), and should be monitored over time. Better management of nutrients would benefit unnamed creek.

Table 51: Summary of stressors found in unnamed creek (-533).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors: Habitat	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-533 unnamed creek unnamed creek to Cedar River	09CD042	M-IBI Bacteria	•	•		•	•	•

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

7. Turtle Creek Watershed Unit

The Turtle Creek Watershed is located in Freeborn, Mower, and Steele counties (Figure 93). It is the largest subwatershed draining 154 square miles. Currently, the watershed is largely utilized for row-crop agriculture (76.8%) and pasture (7.4%) and 9.3% is developed land. The impaired reach (-547) is 1.35 miles in length and located in Freeborn County.

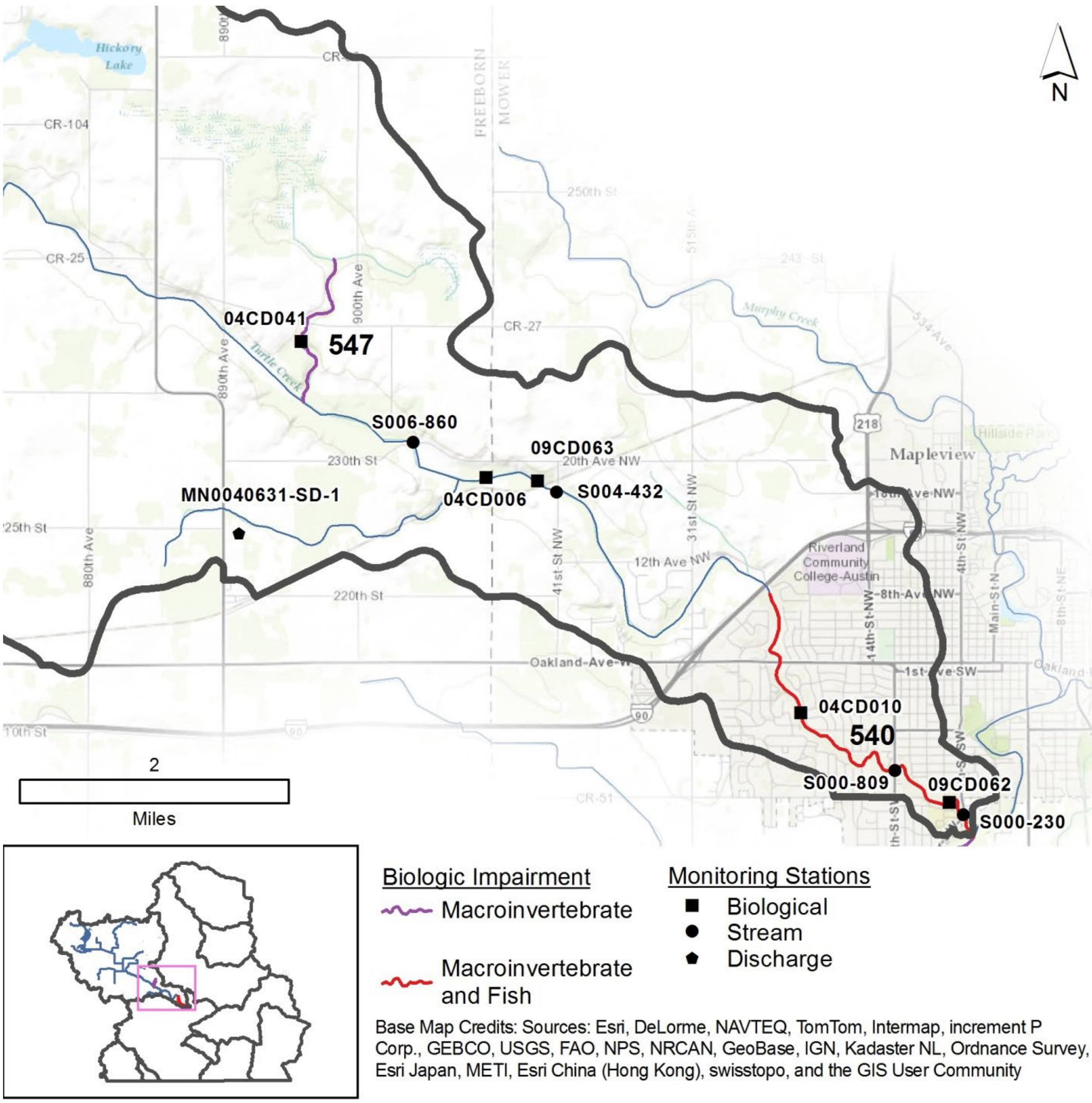


Figure 93: Map of Turtle Creek biological impairments.

7.1. Unnamed creek: unnamed creek to Turtle Creek (AUID: 07080201-547)

The MPCA surveyed one biological station 04CD041 that was sampled in 2004 on AUID 07080201-547. Biological station 04CD041 is located downstream of CSAH 25, 4.5 miles NW of Austin.

There is limited data on this AUID. No additional water quality samples have been taken.

7.1.1. Biology in unnamed creek

The M-IBI was 35.16 which is below the threshold of 35.9 and scored within the confidence interval for macroinvertebrate metrics of the Southern Streams (Table 52). The F-IBI at 04CD041 station was 64 which were above the threshold of 51 for Southern Headwaters class. The macroinvertebrate community is not meeting standards for unnamed creek (-547).

Table 52: Summary of biological impairments in unnamed creek (-547).

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-547, unnamed creek to Turtle Creek	04CD041	unnamed creek	4.42	Southern Streams	35.9	35.16	Southern Headwaters	51	64

Macroinvertebrates in the Southern Streams RR class scored poorly in the metrics of predators (PredatorCh), percentage of tolerant taxa (Tolerant2ChTxPct) and taxa richness of Trichoptera (Trichoptera; Figure 94). The biological station also lacked stoneflies (Plecoptera). Five species dominated the sample (DomFiveCHPct; 60%) and was overly abundant with tolerant taxa as well. Macroinvertebrates scored above the average needed to be above the threshold 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 Odonata.

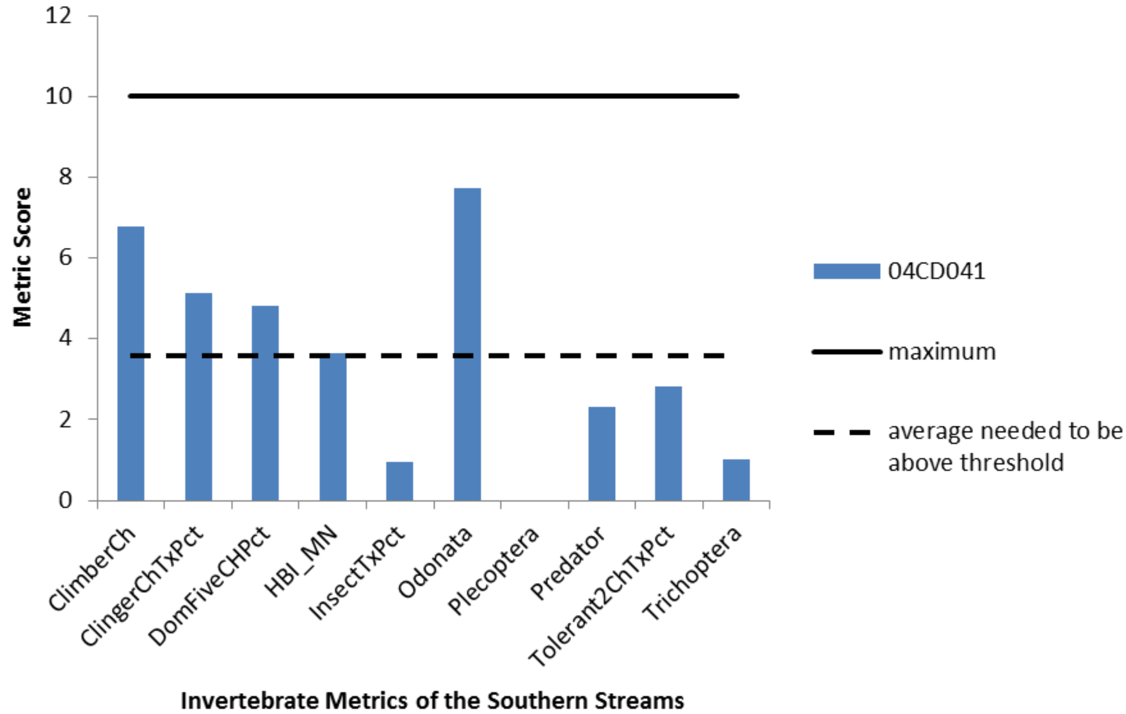


Figure 94: Macroinvertebrate metrics of the Southern Streams RR in station 04CD041 in unnamed creek.

The fish community was not listed as impaired. Biological stations 04CD041 had high metric scores for: generalist taxa (GeneralTxPct), detritivore taxa (DetNWQTxPct), individuals that are short-lived (SLvdPct), serial spawners (SSpnPct) and very tolerant taxa (VtolTxPct). At this station there was a lack of sensitive taxa (Figure 95).

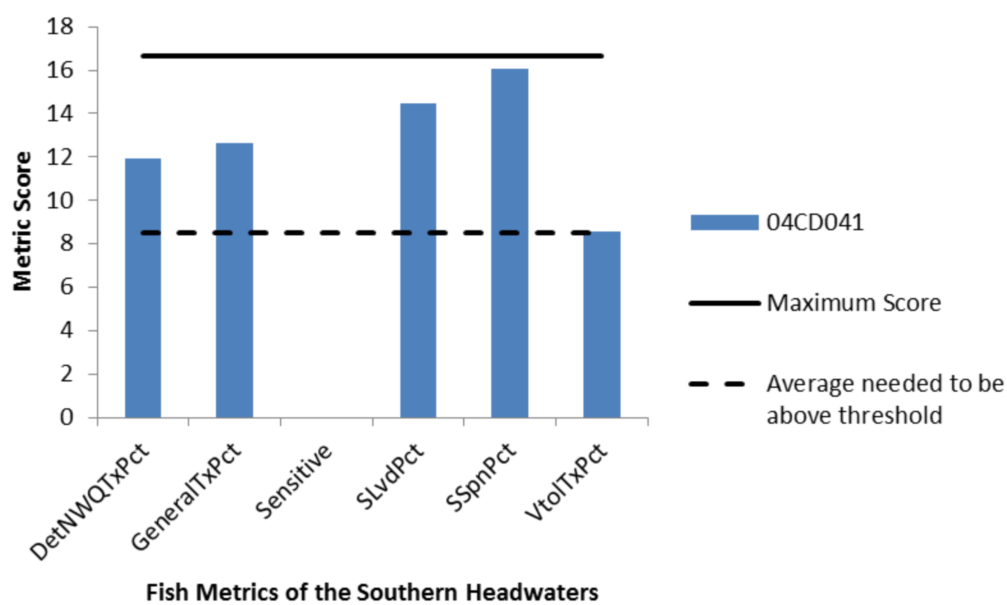


Figure 95: Fish metrics of the Southern Headwaters in station 04CD041 in unnamed creek.

7.1.2. Candidate cause: Lack of habitat/bedded sediment

The unnamed creek station 04CD041 scored 75.9 (good) on the MSHA (Table 53). Of the five subcategories in the MSHA, land use scored poorly. The field crew noted unnamed creek had moderate channel stability with excellent sinuosity. Unnamed creek is a high gradient stream. The water was brown in color and stained. This reach contained 30% riffle and was dominated by cobble, with light embeddedness. Sand and gravel substrate was found in the pools. Diverse substrate types were present.

The surrounding land use was noted as row crop with no riparian buffer. There is little bank erosion (Figure 96). Extensive cover was noted, with multiple cover types including undercut banks, overhanging vegetation, deep pools, logs or woody debris, boulders, rootwads, and macrophytes. The habitat that was sampled for macroinvertebrates was woody debris/snags/rootwads, undercut banks, and overhanging vegetation along with riffle/run rock. This site has good quality riffles. Altered hydrology (including climate change and tile drainage) is one potential area of concern. Upstream reaches of this watershed are channelized. However an altered landscape should also be considered as an impact.

Macroinvertebrate burrowers at biological station 04CD041 were just above the average for Southern Forest Streams GP class, which validates there are not sedimentation issues (9.12%; Figure 97). The percentage of EPT individuals was much higher than the statewide average (57.19%). The percentage of generally tolerant legless macroinvertebrate individuals was very low (28.42%). The macroinvertebrates that are known to cling to large substrate and woody debris were abundant (above statewide averages for this class), likely due to the woody material that is available to support these individuals. This is also found in the M-IBI metrics, the number of clinger taxa (ClingerCh) was above the average metric score needed for the M-IBI to be at the threshold.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. The Turtle Creek Watershed is approximately 91% channelized. This AUID is estimated to be 48.4% channelized. The Turtle Creek watershed is estimated to have 42% tile drainage, which is used to help move water off the farm fields and to the streams rather quickly. This causes the flows of this stream system to become very inconsistent. These are system-wide changes, which become cumulative in nature, and do affect the stream biota. Maintaining the appropriate agricultural setbacks and better riparian corridor management recommended, both on this scale, and watershed-wide. Although there may be some aspects of habitat that could be improved, with some diverse habitat present, it is not likely that habitat is currently a driving force of macroinvertebrate impairment in the majority of this reach. Habitat is not limiting at station 09CD041 and not a stressor to the macroinvertebrate community at this time.

Figure 96: Photograph of Station 04CD041 on July 14, 2004.

Table 53: MSHA results for unnamed creek (-547)

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	04CD041	unnamed creek	0	9	20.9	17	29	76	Good

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA>66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)

Figure 97: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Streams RR stations with M-IBI greater than 35.9 (threshold), mean of those stations, and metric values from station 04CD041.

7.1.3. Candidate cause: High nitrate-nitrite

The only nitrate sample was taken on July 14, 2004, at the time of fish sampling at station 04CD041. The nitrate level was low, 2.2 mg/L. Unionized ammonia is not a concern based on the data available. The nitrate sample at the time of fish sampling is not representative of all conditions. The non-hydropsychid caddisflies were not present. These caddisflies can respond to increased nitrate levels. At station 04CD041, there were 36.7% nitrate tolerant macroinvertebrates, with 19 nitrate tolerant taxa and no nitrate intolerant taxa. The information available in this reach is inconclusive if elevated nitrate is a stressor to the biological community. More nitrate data should be collected to help characterize the nitrate in unnamed creek (-547).

7.1.4. Candidate cause: Low dissolved oxygen

One DO sample was taken at the time of fish sampling. The DO measurement was 5.4 mg/L, just above the standard (5.0 mg/L).

The macroinvertebrate community comprised of a low percentage of EPT taxa (16.66%) just below the average (17.04%) for the Cedar River Watershed. The macroinvertebrate HBI_MN metric, a measure of pollution based on tolerance values assigned to each individual taxon had a score just above the average score needed to be above the threshold. The tolerant taxa was elevated in 2009 (80.55%) and the taxa count was low (36). The macroinvertebrate DO TIV station score (7.35) was above the average for the Cedar River basin (6.8). The numbers of macroinvertebrate taxa collected that are intolerant to low DO were 9, and the percentage of DO tolerant species collected were 6.3. The average number of intolerant taxa collected in the Cedar River basin was 4.6 and the average percentage of DO tolerant taxa was 20.

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 tolerance indicator value of 7.11 (in the middle of station scores in the Cedar River Watershed; Table 4). The most DO sensitive fish found at this station was blacknose dace; and DO tolerant fish such as creek chubs and brook stickleback were present. Creek chubs dominated the fish community. The three most common species were in the two most sensitive quartiles to low DO. Low DO may be playing a role in shaping these communities, but more data is needed. It is recommended that DO be monitored in this reach to determine if DO levels remain at a sufficient level for the biota.

There is no DO information indicating it is a stressor at this time, yet findings are inconclusive due to limited data.

7.1.5. Candidate cause: High phosphorus

Only one TP sample was taken at the time of fish sampling on July 14, 2014. The phosphorus level was 0.152 mg/L just above the standard (0.15 mg/L). There is no available BOD or chlorophyll-a data on this AUID at this time to assess the potential influences.

This stream reach has a low macroinvertebrate taxa count (TaxaCountAllChir; 36). Biological station 04CD041 lacked intolerant taxa and the percent tolerant taxa was relatively high (Tolerant2ChTxPct; 80.6%). The percentage of intolerant taxa will decrease and the percentage of tolerant taxa will increase with increases in phosphorus. The percentage of scrapers was 9.4%, which was below the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. The number of collector-gather taxa (13) was low and collector-filterer taxa (7) were high. There were 6 EPT taxa in this stream reach. The range of EPT taxa within the Cedar River Watershed was 0 to 20. The metric, EPT, provides a relative measure of the presence and diversity of pollution-sensitive macroinvertebrate groups. The limited data in this reach is inconclusive if elevated phosphorus is a stressor to the biological community. It is recommended to collect additional data to help determine if phosphorus is playing a role in the degraded biological community.

7.1.6. Candidate cause: High suspended sediment

At the time of biological sampling, TSS was not elevated (7.2 mg/L). Field turbidity was 2.7 NTU. Transparency tube reading at time of fish sampling was greater than 60 cm. Flow conditions were noted above normal, which is when TSS is likely to be an issue.

The fish community sampled at 04CD041 had a low percentage of herbivores (<1%) and a low percentage of scrapers (9%). Herbivorous fish are often reduced with increased TSS levels. The macroinvertebrate community at this station had 46% collector-filterers and a moderate percentage of long-lived macroinvertebrates (22%). Collector-filterers are reduced when TSS is elevated. Collector-filterer species collect their food by filtering it from the water column. Long-lived macroinvertebrates can decrease with increased TSS stress. Biological station 04CD041 had a high percentage of TSS tolerant individuals (26.7% and 58%; Table 54) and average TSS tolerant taxa (9) compared to the averages for warmwater stations in the Cedar River Watershed for percent of TSS tolerant individuals (25.9%) and TSS tolerant taxa (9). There are biological indications that TSS or turbidity may be a concern, yet findings are inconclusive due to limited data. Additional TSS data for a range of flows should be collected.

Table 54: Macroinvertebrate metrics relevant to TSS for stations in unnamed creek compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
04CD041 (2004)	**16.4**	**0**	9	**26.7**	**0**	8
04CD041 (2012)	**18.2**	1	9	**58**	1	7
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

7.1.7. Conclusions

The biological stressors in unnamed creek (-547) are summarized in Table 55. Habitat was good (MSHA 75.9) with good riffles with cobble substrate. The habitat that was sampled for macroinvertebrates was woody debris/snags/rootwads, undercut banks, and overhanging vegetation along with riffle/run rock. There was also extensive cover amount with a wide variety of cover types. Riparian habitat and land use were not optimal with in this reach. Flow alteration (including climate change, channelization and tile drainage) is one potential area of concern. Upstream reaches of this stream are channelized. However an altered landscape should also be considered as an impact. It is inconclusive if elevated nitrate is a stressor to the biological community due to lack of data. The biology indicates that nitrate may be an issue. There is also limited TSS/turbidity data at this time. Additional TSS data for a range of flows should be collected to better understand the impact to the biota. DO and total phosphorus are inconclusive due to limited data.

Overall, there is little chemical information on this reach, and additional information should be collected to confirm or rule out these potential stressors.

Table 55: Summary of stressors found in unnamed creek (-547).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors					
			Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-547 unnamed creek unnamed creek to Turtle Creek	04CD041	Macroinvertebrate IBI		o	o	o	o	•

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

7.2. Turtle Creek: T102 R18W S4, north line to Cedar River (AUID: 07080201-540)

This listed reach, which is three miles long, is non-supporting of aquatic life for fish and aquatic macroinvertebrate communities. This stretch goes through the developed area of the city of Austin (Figure 93). Upstream of the listed reach is a channelized agricultural drainage ditch. Biological criteria have not been developed yet for channelized streams and ditches so the assessment of fish and macroinvertebrates for aquatic life use support was not possible. One tributary stream (unnamed creek 07080201-547) is also non-supporting of aquatic life for aquatic macroinvertebrates.

Two biological stations were sampled in 2004 and 2009 on this stream reach. The 2009 (09CD062) station is at the bottom of the AUID near the confluence with the Cedar River and the 2004 (04CD010) station is 1.5 miles upstream of the 2009 station.

Sampling was done at the outlet of Turtle Creek at CSAH 23 (4th Drive SW) represented by EQuIS station S000-230 and biological station 09CD062. Construction on the bridge at CSAH-23 occurred during the summer of 2012 so sampling was relocated upstream to MN-105 in Austin and represented by EQuIS station S000-809.

The Hollandale and Oakland Sanitary District WWTPs discharge upstream of this stream reach.

7.2.1. Biology in Turtle Creek

The macroinvertebrate community is not meeting standards for 09CD062 and 04CD010 stations. The M-IBI at station 09CD062 was 34.71 below the threshold of 35.9 and scored within the confidence interval for macroinvertebrate class Southern Streams RR, and the IBI at station 04CD010 was particularly low with a score of 31.39, below the threshold of 46.8 and below the confidence interval for the macroinvertebrate class Southern Forest Streams; Table 56).

The F-IBI at 04CD010 station was 45 which is the threshold for Southern Streams. Station 09CD062 has an IBI of 67 and is above the threshold of 45. The biological stations sampled on Turtle Creek differed in some metric scores, leading to differences in the IBI score. The figure below shows the metric scores for each of the stations, with the maximum score possible and the average metric score needed to have an

IBI score above the threshold. The upper station sampled in 2004 is dominated by green sunfish with very few sensitive taxa and individuals, and the lower station sampled in 2009 has good diversity and high numbers of sensitive taxa and individuals.

Table 56: Summary of biological impairments in Turtle Creek (-540).

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-540, Turtle Creek, T102 R18W S4, north line to Cedar River	04CD010	Turtle Creek	151.81	Southern Forest Streams	46.8	31.39	Southern Streams	45	45
	09CD062	Turtle Creek	152.94	Southern Streams	35.9	34.71	Southern Streams	45	67

Macroinvertebrates in the class Southern Forest Streams GP scored poorly in the metrics of collector-filterers (Collector-filtererPct) and non-hydropsychid caddisflies (TrichwoHydroPct;Figure 98). Clingers (ClingerCh), Plecoptera, Odonata, Ephemeroptera and Trichoptera taxa (POET) and taxa richness of predators (Predator) scored just below the average metric score needed for an IBI score greater than the threshold at biological station 04CD010. This stream reach was lacking intolerant taxa (intolerant2Ch). It also received a low metric score for HBI_MN. Five species dominated the sample (DomFiveCHPct; 73%) and was abundant with tolerant taxa as well.

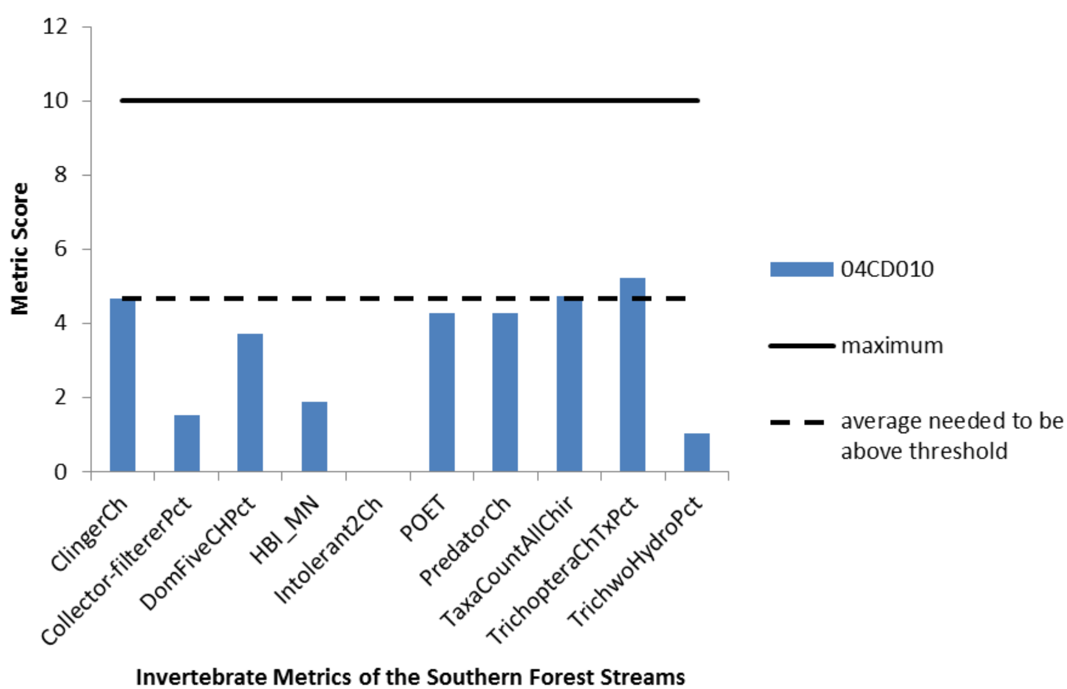


Figure 98: Macroinvertebrate metrics of the Southern Forest Streams GP in station 04CD010 in Turtle Creek.

Macroinvertebrates in the Southern Streams RR class scored poorly in the metrics of macroinvertebrates that climb (ClimberCh), taxa richness of Odonata, predators (PredatorCh) and taxa richness of Trichoptera (Trichoptera; Figure 99). The biological station also lacked stoneflies (Plecoptera). There is a high percentage of taxa that are clingers (ClingerChTxPct). Five species dominated the sample (DomFiveCHPct; 56.25%) and was overly abundant with tolerant taxa (Tolerant2ChTxPct), as well as also receiving a low metric score for HBI_MN.

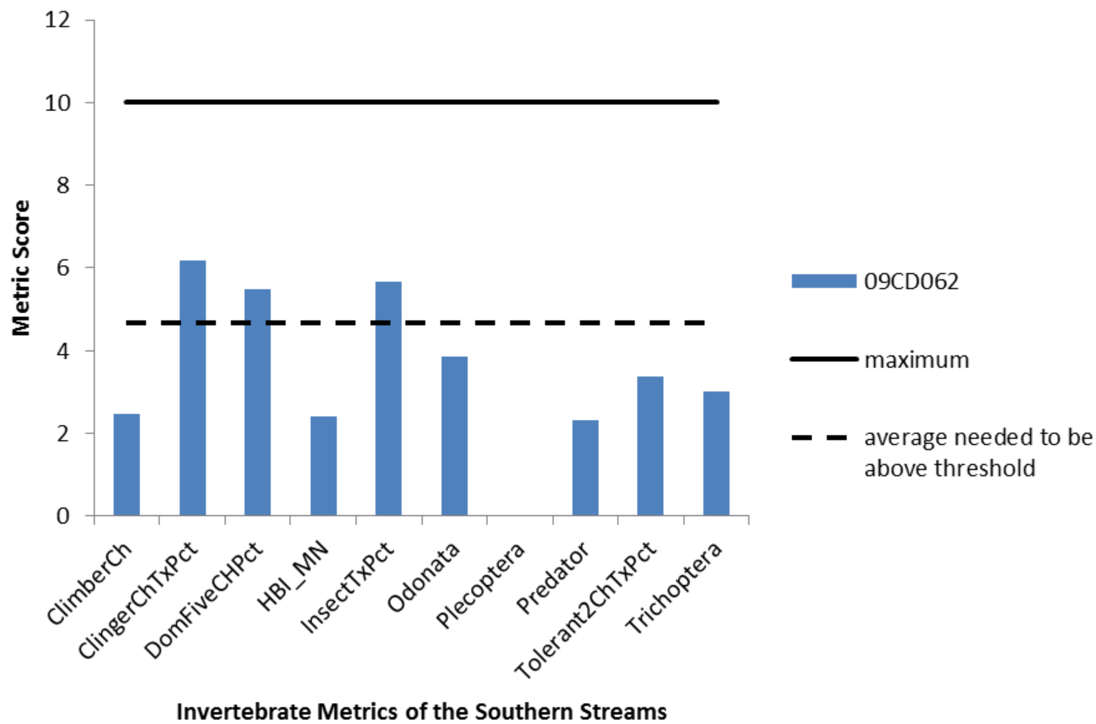


Figure 99: Macroinvertebrate metrics of the Southern Streams RR in station 09CD062 in Turtle Creek.

Biological station 04CD010 had an abundance of fish that reach maturity before the age of two years (MA<2Pct), relative abundance of individuals that are tolerant species (TolPct) and short-lived species (SLvd; Figure 100). The biological sample was abundant with taxa that are benthic insectivores (excludes tolerant species (BenInsect-TolTxPct), taxa that are detritivorous (DetNWQTXPct), combined relative abundance of two most abundant taxa (DomTwoPct), taxa that are sensitive to pollution (SensitiveTxPct), and taxa that are tolerant of pollution (TolTxPct). Biological station 04CD010 had no DELT deductions for the IBI.

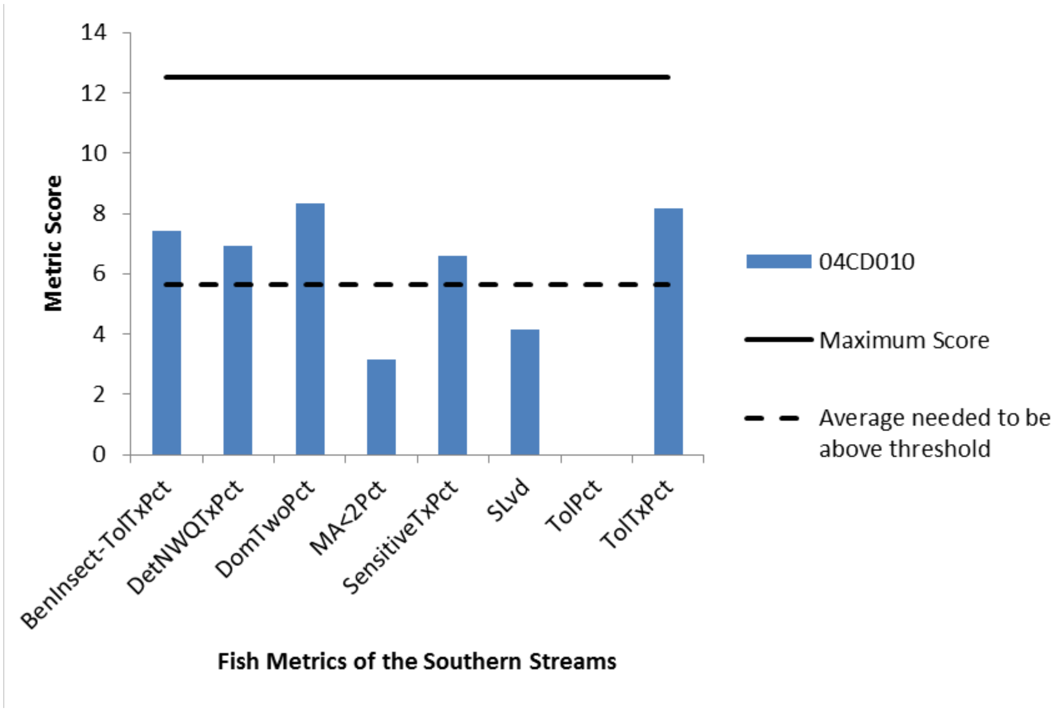


Figure 100: Fish metrics of the Southern Streams class in station 04CD010 in Turtle Creek.

At biological station 09CD062 short-lived species (SLvd) were in abundance. The fish scored higher at this station than further upstream on this AUID. Biological station 09CD062 had no DELT deductions for the IBI.

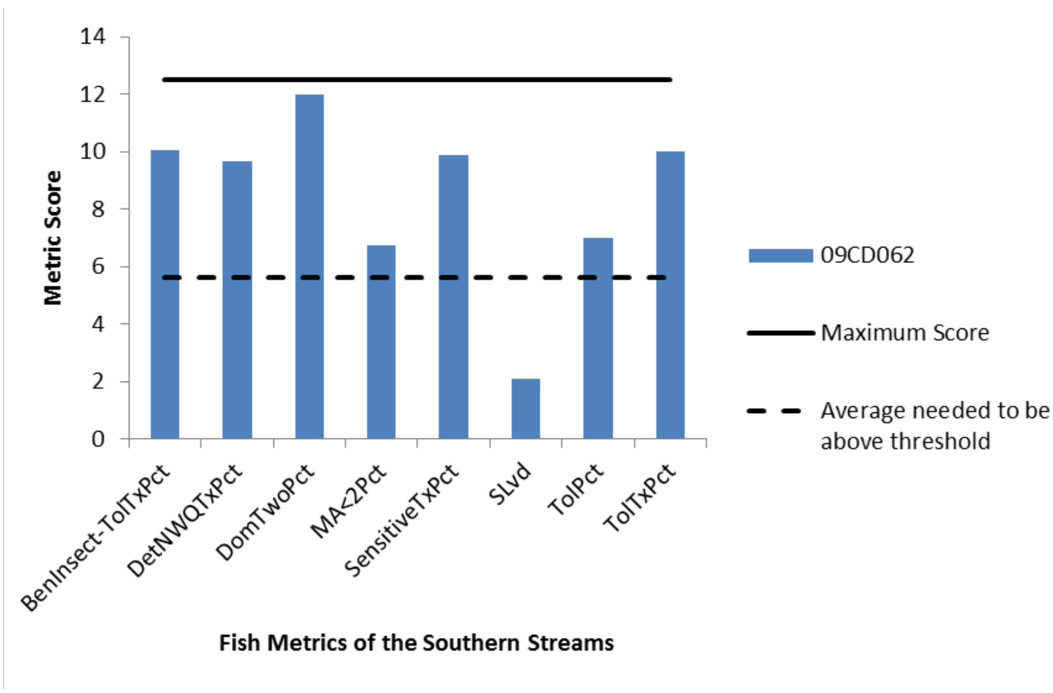


Figure 101: Fish metrics of the Southern Streams at station 09CD062 on Turtle Creek.

7.2.2. Candidate cause: Lack of habitat/bedded sediment

The two biological stations were considerably different in terms of habitat. Station 04CD010 is further upstream with a lower gradient than station 09CD062. Both stations scored relatively high on the MSHA (Table 57). Station 04CD010 scored 53.5 (fair) and station 09CD062 scored 77.1 (good).

Biological station 04CD010 has a fair habitat score (53.5) and is lacking quality habitat (no depth variability) and appears to be over widened for the size of the drainage area. The water was turbid with normal water level during the time of fish sampling. This reach did not contain any riffles. The entire reach was a run with gravel and sand substrate and light (25-50%) embeddedness.

The surrounding land uses was noted as residential with moderate (15 to 30 ft) riparian buffer on the right bank and very narrow (3 to 15 ft) on the left bank. There is no erosion on the left and little erosion on the right bank of the sampling reach (Figure 102). Sparse cover was noted, with multiple cover types including undercut banks, overhanging vegetation, deep pools, logs or woody debris, boulders, and rootwads. The habitat that was sampled for macroinvertebrates was woody debris/snags/rootwads, under cut banks, and overhanging vegetation. Biological station 04CD041 has moderate channel stability with poor channel development. There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

The lower station 09CD062 is in good condition with good depth variability. The water was clear with normal water level during the time of fish sampling. This reach contained 30% riffle with cobble and gravel substrate and moderate embeddedness.

The surrounding land uses was noted as residential with moderate (30 to 150 ft) riparian buffer on the left bank and very narrow (3 to 15 ft) on the right bank. There is no erosion on both stream banks (Figure 102). Moderate cover was noted, with multiple cover types including overhanging vegetation, deep pools, logs or woody debris, boulders and macrophytes. The habitat that was sampled for macroinvertebrates was woody debris/snags/rootwads, under cut banks, overhanging vegetation, and riffle/run rock. Biological station 09CD062 has moderate/high channel stability with excellent channel development.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

The MDNR conducted a geomorphology survey on the Lower Turtle Creek Watershed. The Lower Turtle Creek is classified as a B4/1c stream type. B channels are moderately entrenched, relatively narrow channels, with low sinuosity, relatively stable, and not a high source of sediment (Figure 103). Many B channels are structurally controlled with materials derived from rock or from colluvial and/or alluvial deposition. A B4/1c 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. The study reach is located in valley type VIII (a), alluvial gulch fill. Utilizing the Bank Erosion Hazard Index (BEHI) and National Institute of Standards and Technology methods, stream bank had an estimated erosion rate of 0.0038 tons/year/foot for Turtle Creek between County Road 23 and 140th Street covering 9.3 river miles.

There was an abundance of macroinvertebrate burrowers found in biological station 04CD010, which indicates sedimentation issues (15.5%; Figure 105). The percentage of EPT individuals was much less than the statewide average for Southern Forest Streams GP class (7.89%) at the upper biological station, while there was an abundance of EPT individuals (38.75%) in the lower biological station. The percentage of generally tolerant legless macroinvertebrate individuals was high at both biological stations (84.5% and 55.31%). The macroinvertebrates that are known to cling to large substrate and woody debris were low at both stations (below statewide averages for each class), likely due to lack of woody material that is available to support these individuals (Figure 106). Clingers can decrease in stream reaches with homogenous substrate composition, velocity, and depth (CADDIS). This is also found in the M-IBI metrics, the number of clinger taxa (ClingerCh) were below the average metric score needed for the M-IBI to be at the threshold.

The fish community at biological station 04CD010 had low percentage of individuals that are lithophilic spawners in 2004 (41%) and was higher than the average for the Cedar River Watershed in 2012 (77%). Generalist feeders make up 85% of the fish individuals surveyed at biological station 04CD010 and 52.2% at biological station 09CD062.

Habitat is a stressor for the macroinvertebrate and fish communities in this reach of Turtle Creek. Habitat improvements would likely improve the fish and macroinvertebrate communities.


Figure 102: Turtle Creek at Biological Station 04CD010 (left) and Turtle Creek at Biological Station 09CD062 (right).

Table 57: MSHA results for Turtle Creek.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	04CD010	Turtle Creek	2	9.5	18	9	15	53.5	Fair
1	09CD062	Turtle Creek	2	11.5	18.6	12	33	77.1	Good
Average Habitat Results			2	10.5	18.3	10.5	24	65.3	Fair

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA>66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

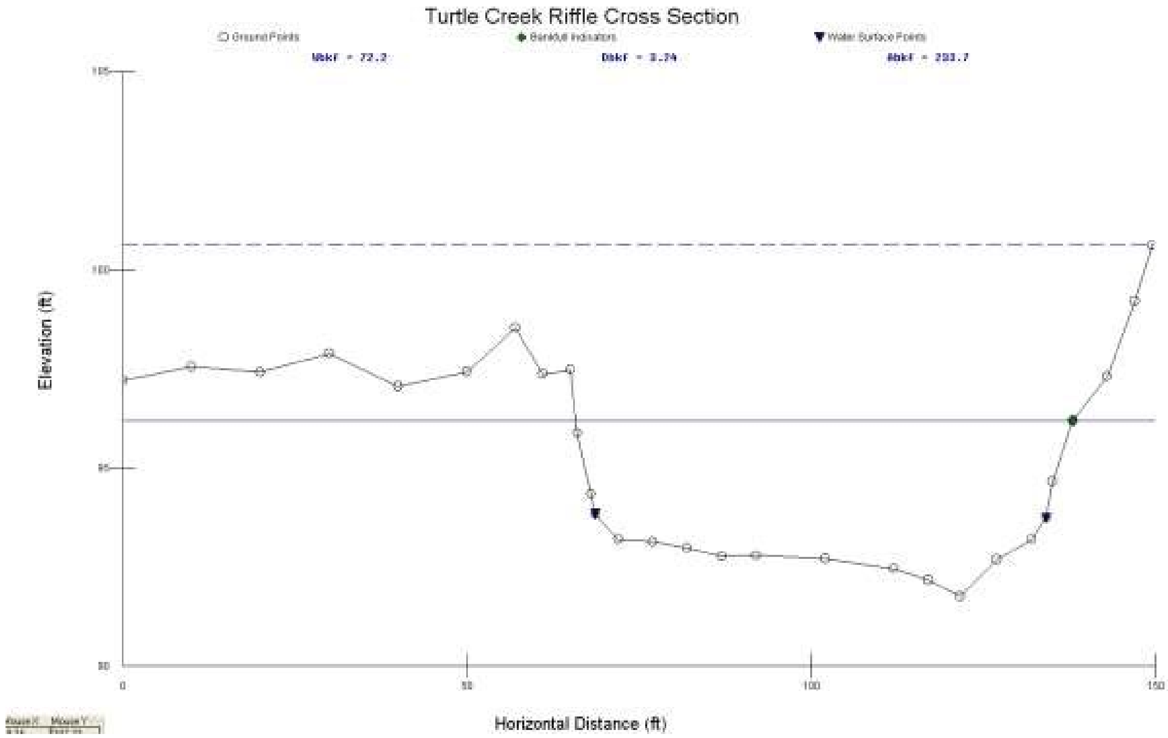


Figure 103: Riffle cross section with bankfull and flood prone area.

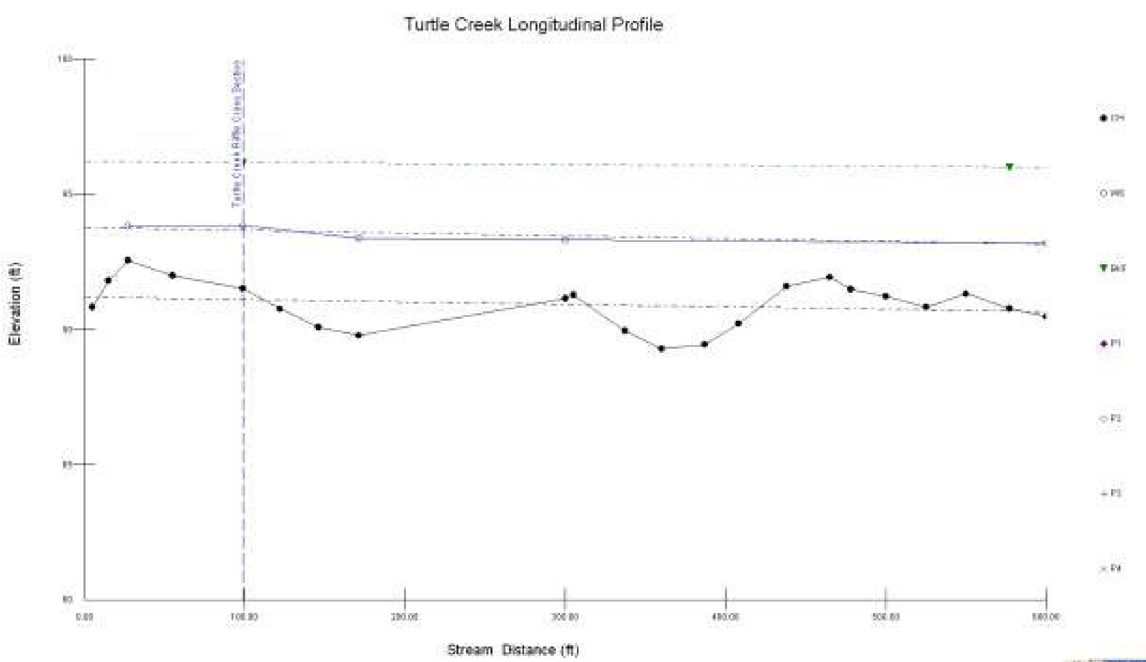


Figure 104: Longitudinal profile for Turtle Creek.

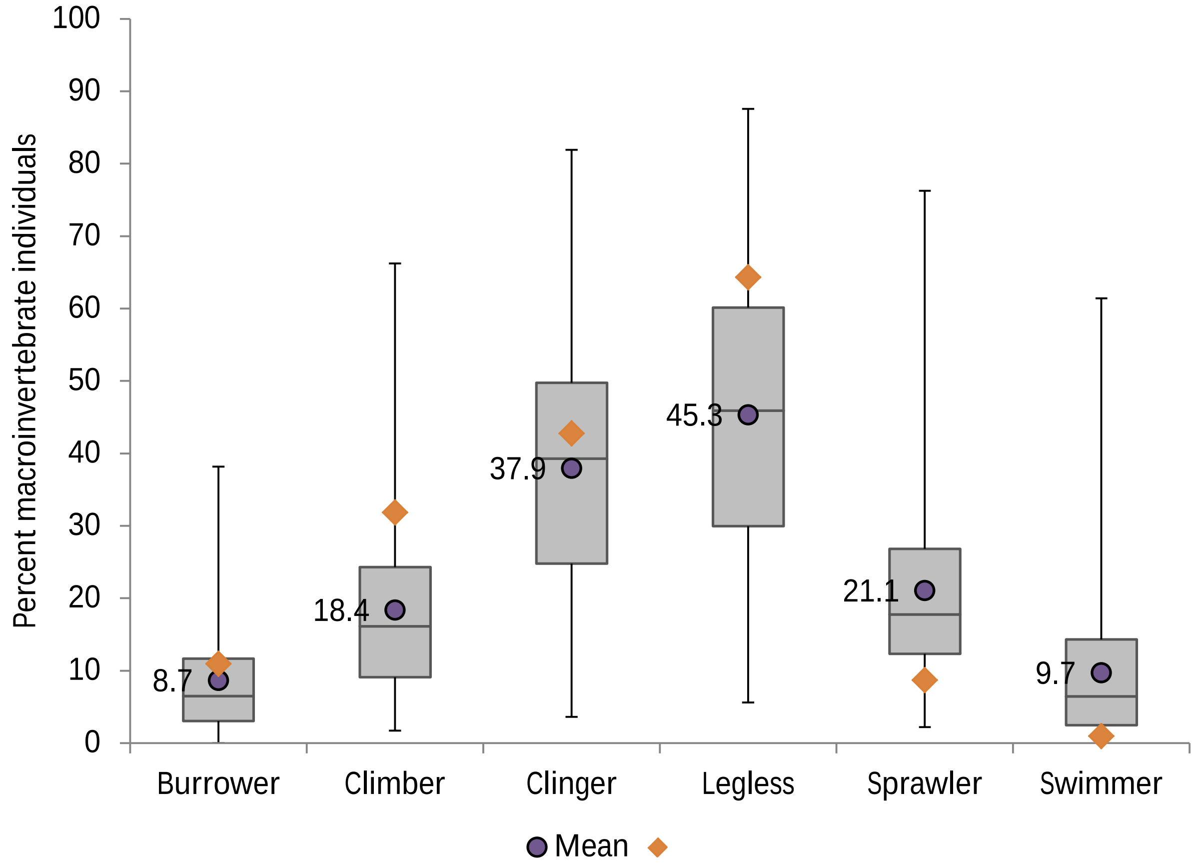


Figure 105: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Forest Streams GP stations with M-IBI greater than 46.8 (threshold), mean of those stations, and metric values from station 04CD010.

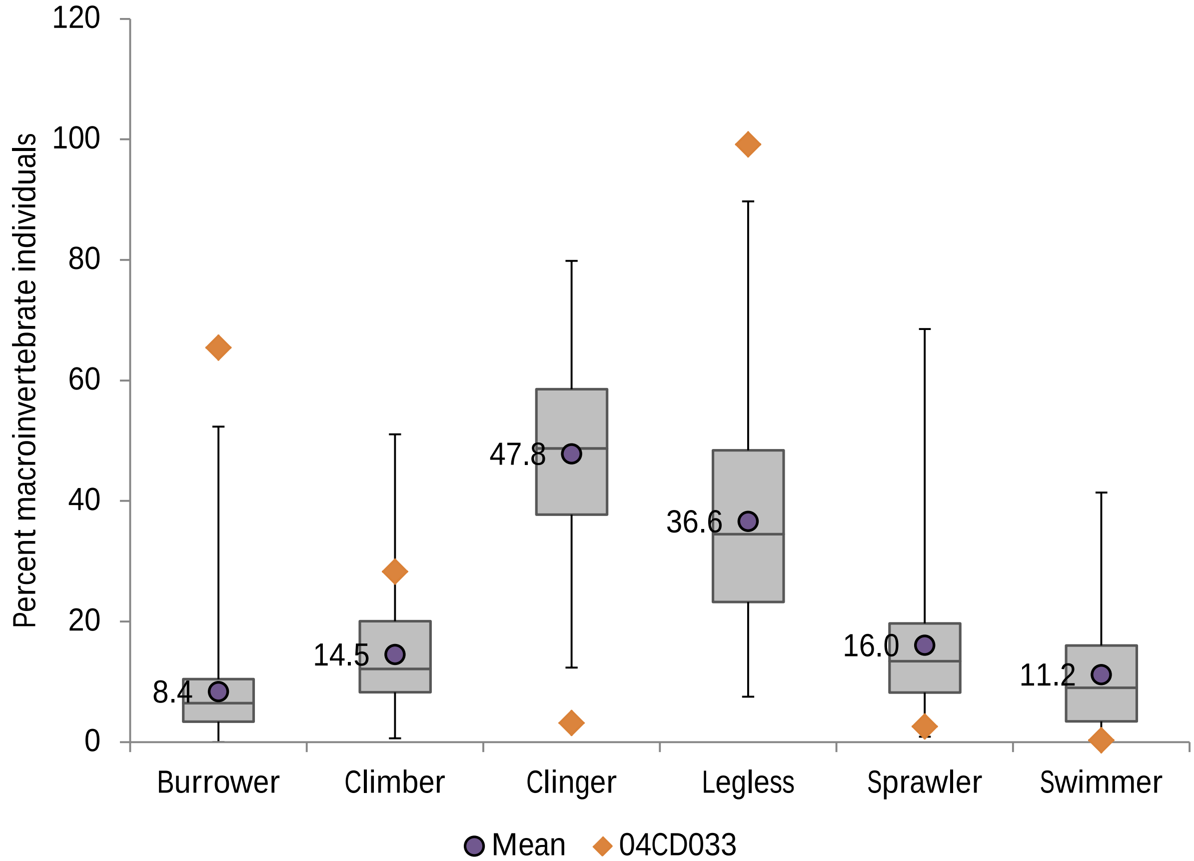


Figure 106: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Streams RR stations with M-IBI greater than 35.9 (threshold), mean of those stations, and metric values from station 09CD062.

7.2.3. Candidate cause: High nitrate-nitrite

Nitrate was 8 mg/L during fish sampling July 28, 2004, at biological station 04CD010. At biological station 09CD062, the nitrate value during fish sampling was 0.89 mg/L on July 20, 2009. On this stream reach (-540), nitrate has been sampled for a total of 14 times between 2009 and 2012. The highest sample was 12 mg/L on June 22, 2009 while the lowest nitrate sample was <0.05 mg/L on September 4, 2012, (Figure 107). The highest observed nitrate levels are in May and June and drop through the summer. The mean nitrate was 2.07 mg/L. Unionized ammonia is not a concern based on the data available.

In this reach of the Turtle Creek River, less than 1% of the macroinvertebrate population was non-hydropsychid caddisflies at the two stations sampled. These caddisflies can respond to increased nitrate levels. The macroinvertebrates in this reach has a high prevalence of tolerance taxa, ranging from 78 to 89%, and a complete absence of intolerant taxa. The number of Trichoptera taxa ranged from 3 to 5 at the biological stations (8 was the maximum taxa richness of Trichoptera found in the Cedar River Watershed). At biological station 04CD010, there were 87% nitrate tolerant macroinvertebrates, with 24 nitrate tolerant taxa and no nitrate intolerant taxa. Biological station 09CD062, there were 72.4% nitrate tolerant macroinvertebrates, with 28 nitrate tolerant taxa and two nitrate intolerant taxa.

Fish lack a strong biological response in relation to elevated nitrate. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration. In terms of the fish community, stations in these reaches were lacking in sensitive taxa which may be indicative of the high nitrate levels. The stations also have fish that are quick to mature. The sensitive fish individuals make up 4.3 and 28.6% of the surveyed communities at the two biological stations sampled; whereas the tolerant fish individuals make up 77% and 49% of the surveyed fish communities. There were seven fantail darters between the two biological stations and three rainbow darters at the lower biological station. Fantail darters and rainbow darters are pollution sensitive fish.

The nitrate concentrations are elevated based on grab sample results. The lack of macroinvertebrate trichoptera taxa, and non-hydrophsychid trichoptera, nitrate intolerant taxa, and abundance of nitrate tolerant taxa show biological response consistent with elevated nitrate. Elevated nitrate can impact macroinvertebrate communities more at stations with multiple stressors acting on the community. In particular, elevated nitrate concentrations have more of an impact on macroinvertebrate communities in conjunction with poor habitat conditions. Therefore, elevated nitrate is acting as a localized stressor at station 04CD010 due to decreased non-hydropsychid trichoptera, increased nitrate tolerant percentage, and increased nitrate tolerant taxa. Nitrate is a stressor in this reach, but is considered secondary to a more prominent stressor.

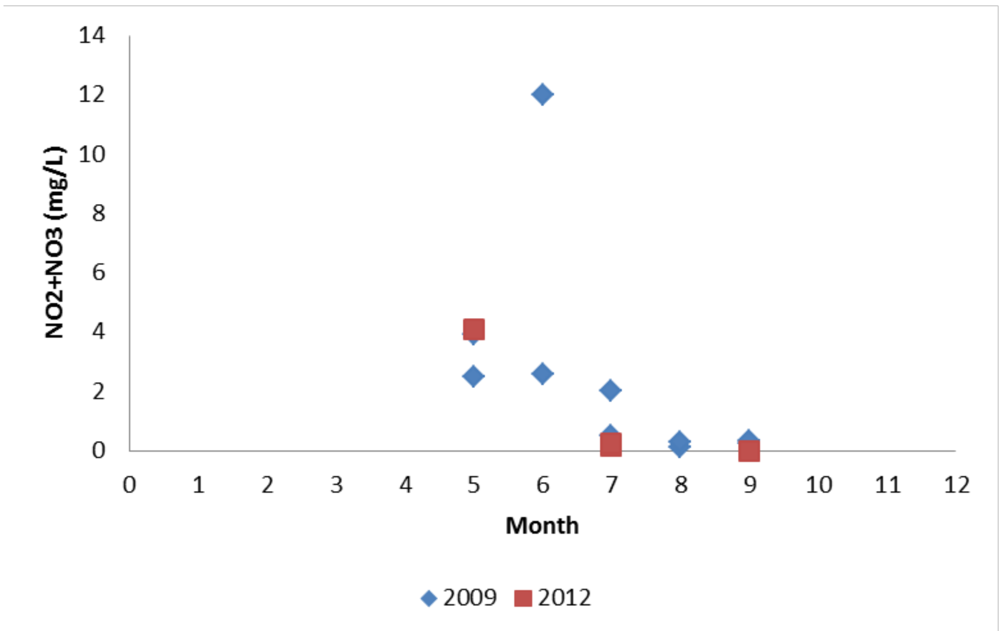


Figure 107: Nitrate-nitrite in the Turtle Creek (-540) by month and by year.

7.2.4. Candidate cause: Low dissolved oxygen

At times, DO was below the standard (5.0 mg/L), likely limiting the biological community. At the time of fish sampling, DO was 7.15 mg/L at biological station 04CD010 and 13.76 mg/L at biological station 09CD062.

In 2012, a longitudinal synoptic DO survey was conducted on the morning and afternoon of July 13th. At 6:50 a.m. on July 13, 2012 DO was measured at station S000-809 on Turtle Creek was 4.84 mg/L. The DO was 8.43 mg/L at 4:15 p.m. that afternoon. These two sampling time frames typically represent the maximum and minimum diurnal patterns, with a DO flux of 3.59 mg/L, which is below the draft standard of 4.5 mg/L.

A multiparameter sonde was deployed on July 17, 2012 through July 31, 2012 at station S000-809 (Figure 108). A second multiparameter sonde was deployed upstream of both biological stations on Oakland Avenue in Austin (Figure 109). The sonde was deployed from August 15, 2012, through August 28, 2012. Water level was low and the water was green in color. DO flux was observed at both locations. Station

S000-809 had a DO flux greater than 7 mg/L with DO measurements dipping below the standard. At the location on Oakland Avenue the DO flux was greater than 8 mg/L and DO measurements did not go below the standard but came close at 5.45 mg/L. The proposed standard for DO flux in the southern region is 4.5 mg/L. Increasing algae and macrophyte production, which in turn increases photosynthesis, respiration, and decomposition. This cycle creates large fluctuations in DO levels. High daily fluctuations of DO are connected to increased nutrient concentrations and a greater risk for low DO.

Data collected from a multiparameter sonde at sampling station S000-809 showed pH levels from 7.57 to 8.23. Data collected at Oakland Avenue showed pH levels ranging from 7.57 to 8.15. At both sites the ranges were within the pH standard values of 6.5-9.0. Measurements taken from 2009, 2010 and 2012, also showed an acceptable pH range of 7.60-8.50. There was no available chlorophyll-a data for this reach and BOD was last sampled twice in 1973, resulting in 2.7mg/L and 3.8 mg/L. Water level was low and the water was green in color.

Low DO can be an issue in streams with slow currents, excessive temperatures, high biological oxygen demand, and/or high groundwater seepage (Hansen, 1975). Heiskary et al. (2013) observed several strong negative relationships between fish and macroinvertebrate metrics and DO flux.

The tolerance metric HBI_MN resulted in a low metric score at both biological stations, which often indicates organic enrichment sufficient to decrease oxygen levels. There were no stoneflies in this reach of Turtle 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 6 to 9, at the two stations in Turtle Creek. The range of EPT taxa within the Cedar River Watershed was 0 to 20 and the average number of EPT taxa was 5.37. The decrease in EPT at stations 04CD010 and 09CD062 may be in part to low DO levels. Biological station 04CD010 has a low taxa count and the biological station 09CD062 had a high taxa count (TaxaCountAllChir; 35 and 50).

Often low DO results in a decrease in sensitive taxa and an increase in tolerant taxa. Throughout this reach, tolerant individuals were high (48.69 to 77.26% of the total population and a total of 21 and 28 species) which resulted in a low metric score for the IBI score at biological station 04CD010. Sensitive individuals were abundant (23.81 and 35.71% of the total population; resulting in a metric score above the threshold for the IBI score. The fish community in Turtle Creek was not comprised of many sensitive individuals at the upper biological station. The surveys revealed only 12 sensitive individuals at biological station 04CD010 (14.13% of sensitive individuals) and 197 sensitive individuals at biological station 09CD062 (28.63% of sensitive individuals).

Utilizing Minnesota derived tolerance indicator values for DO, the fish communities in this reach of Turtle Creek vary longitudinally. Biological station 04CD010 had a TIV score of 7.04 which is below the average for the Cedar River Watershed. At biological station 09CD062 had a TIV score of 7.21 which was above the average for the Cedar River Watershed. The fish community was comprised of fish that are relatively more sensitive to low DO (Figure 110). DO is contributing to the biological impairment.

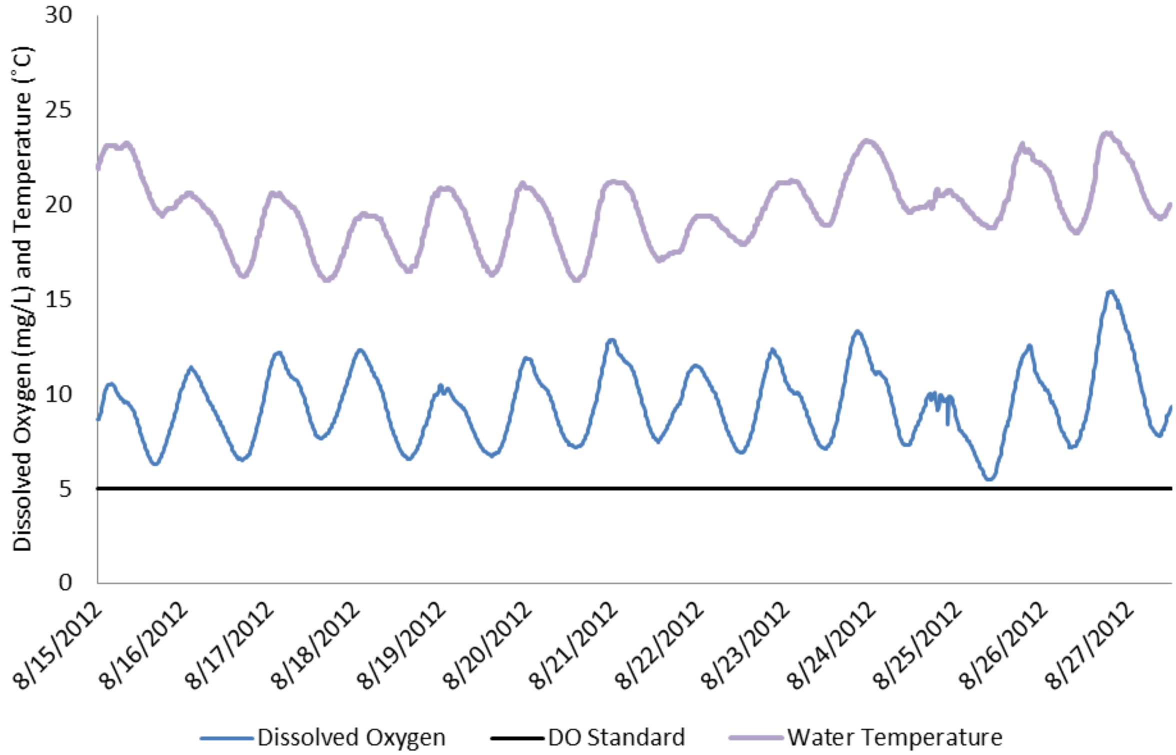


Figure 108: Dissolved oxygen and temperature measured in 15 minute intervals at Oakland Ave West from August 15 to August 28, 2012.

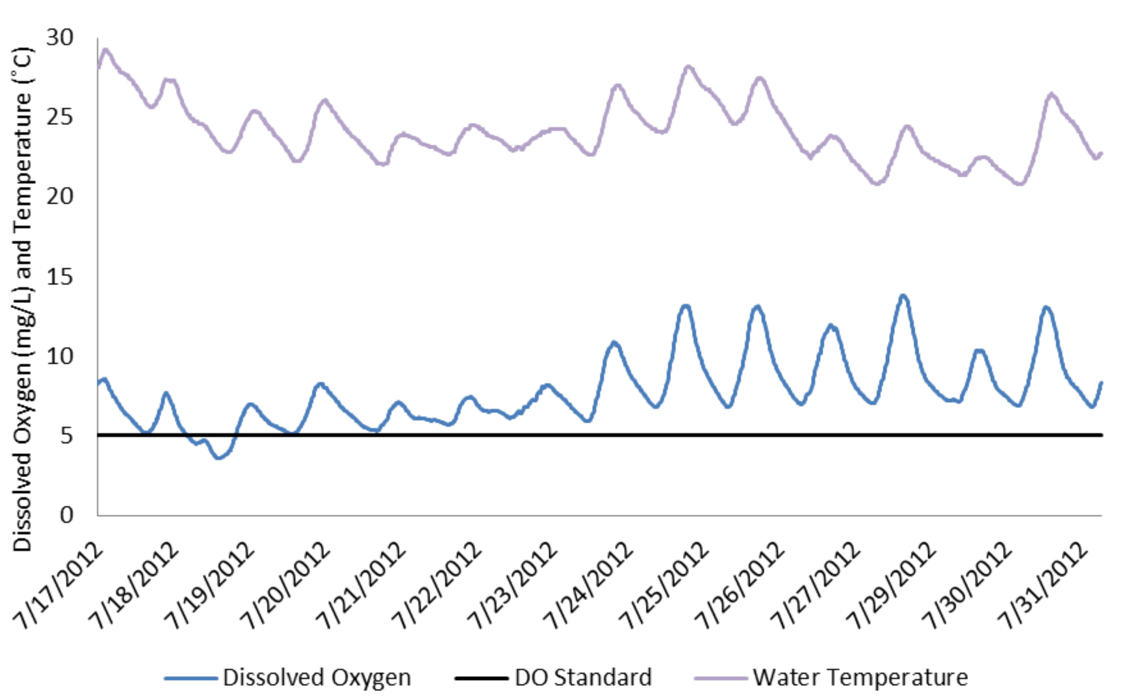


Figure 109: Dissolved oxygen and temperature measured in 15 minute intervals at Station S000-809 from July 17 to July 31, 2012.

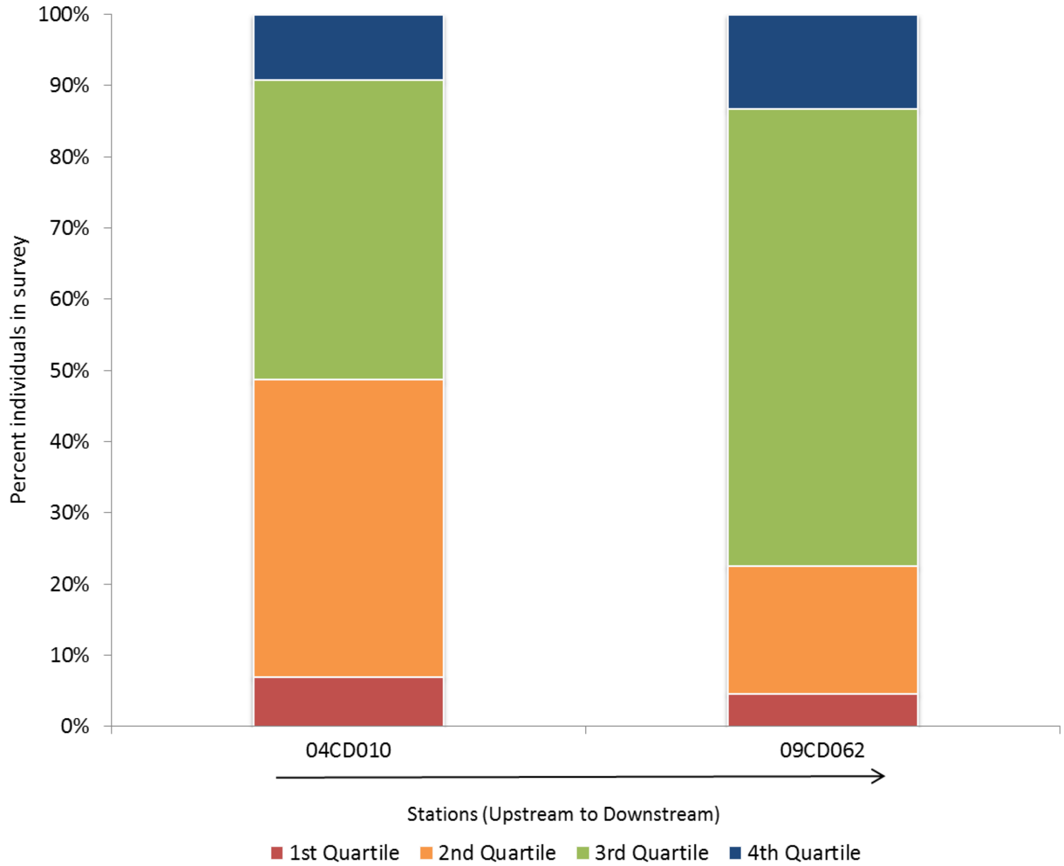


Figure 110: Percent of fish individuals by dissolved oxygen tolerance indicator quartiles for Turtle Creek.

7.2.5. Candidate cause: High phosphorus

Total phosphorous (TP) was elevated above the standard (0.15 mg/L) 5 out of the 16 grab samples on AUID 540 in Turtle Creek (Figure 111). The DO was discussed in the previous section, and showed at times there was low DO, along with high flux, making it likely that the high phosphorus is a contributor to the low DO conditions. There was no available chlorophyll-a data for this reach. BOD was last sampled twice in 1973, resulting in 2.7mg/L and 3.8 mg/L.

Biological station 04CD010 has a low taxa count and the biological station 09CD062 had a high taxa count (TaxaCountAllChir; 35 and 50). Both biological stations lacked intolerant taxa (2 and 4) and the percent tolerant taxa was relatively high (Tolerant2ChTxPct; 88.57% and 78%). The percentage of intolerant taxa will decrease and the percentage of tolerant taxa will increase with increases in phosphorus. The percentage of scrapers was 8.1%, which was below the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. The number of collector-gather taxa (13 and 22) and collector-filterer taxa (4 and 9) were both low as well. There were 6 and 12 EPT taxa in this stream reach. The range of EPT taxa within the Cedar River Watershed was 0 to 20. The metric, EPT, provides a relative measure of the presence and diversity of pollution-sensitive macroinvertebrate groups.

Carnivorous fish comprised 10.47 to 49.82% of the fish community throughout the Turtle Creek biological stations on AUID 540. Carnivorous fish often decrease with increases in phosphorus (MPCA River Nutrient Criteria Development, 2013). The non-tolerant benthic insectivores taxa were also present ranging from 5.71 to 8% of the number of represented taxa, but lacked the percent individuals of non-tolerant insectivores. There was a lack of sensitive taxa compared to the total number of taxa, with sensitive individuals ranging from 14 to 28% of the surveyed population, but the tolerant taxa do not overwhelm the population. Generalists comprise of 52 to 59% of the community depending on the station and year visited. The high phosphorus values, low numbers of collector-filterers taxa, collector gather taxa and a lack of intolerant individuals, along with the high DO flux make it likely that phosphorus is impacting the biological community in this reach within Turtle Creek.

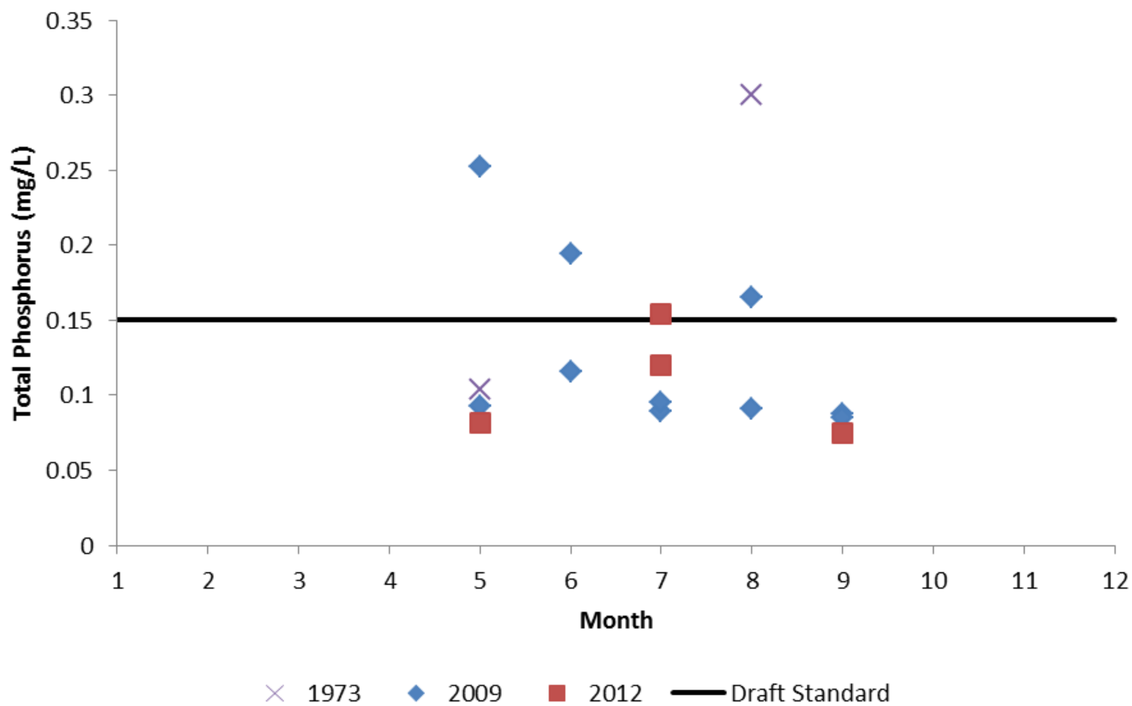


Figure 111: Total phosphorus by month for Turtle Creek in 1973, 2009 and 2012 and compared with draft standard.

7.2.6. Candidate cause: High suspended sediment

Turtle Creek was listed for turbidity in 2006. Biological station 04CD10 was elevated above the draft standard of 65 mg/L at the time of fish sampling on July 28, 2004, (110 mg/L), along with a poor transparency tube reading. Biological station 09CD062 had low TSS at the time of fish sampling on July 20, 2009, (6.8 mg/L), along with a good transparency tube reading (64 cm). TSS was elevated above the draft standard of 65 mg/L in Turtle Creek. The 39 TSS samples taken in 2000, 2001, 2009, and 2012 had an average of 59.77 mg/L. June had the highest average TSS over this time period, 79.13 mg/L (nine samples). There were 533 transparency tube readings mostly collected by Citizen Stream Monitoring Program. The transparency tube readings were taken from 2000 through 2012 with an average of 24.5 cm. Of those 533 transparency readings, 50% of them were below 20 cm, which is considered poor. There were 13 TSVS samples and ranged from 2 mg/L to 17 mg/L with an average of 7.3 mg/L. There were three samples in 2012 and ranged from 9 to 12 mg/L. The chemical data presented does show the potential for high TSS concentrations. This is consistent with the existing turbidity listing. The TSS equivalent to the 25 NTU water quality standard has been calculated to be 78 mg/L, and this was based on continuous turbidity data as well as lab samples. This was used in the load duration curve analysis for the TMDL.

Common carp were present throughout the biological stations. Common carp are likely suspending fine materials between events. Herbivorous fish are reduced in Turtle Creek. Herbivores (fish) are often reduced when turbidity or TSS levels are high.

There is a low percentage of macroinvertebrates that are scrapers in this reach of Turtle Creek. The percentage of long lived macroinvertebrates was very low as well and there was an abundance of tolerant macroinvertebrates. The percentages of collector-filterers were high, above the average for the Cedar River. Biological station 04CD010 had a high percentage of TSS tolerant individuals (21.1% and 18.7%; Table 58) and average TSS tolerant taxa (10 and 12). Biological station 09CD062 had a high percentage of TSS tolerant individuals (18.4%) and average TSS tolerant taxa (14) compared to the averages for warmwater stations in the Cedar River Watershed for percent of TSS tolerant individuals (25.9%) and TSS tolerant taxa (9). The degraded conditions of the fish and macroinvertebrate community are due to elevated turbidity.

Table 58: Macroinvertebrate metrics relevant to TSS for stations in Turtle Creek compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
04CD010 (2004)	**21.1**	**0**	**10**	**71.9**	**0**	6
04CD010 (2012)	**18.7**	**0**	**12**	**56.1**	**0**	**3**
09CD062	**18.4**	1	**14**	**50.3**	**0**	**4**
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

7.2.7. Candidate cause: Flow alteration

Turtle Creek is a major tributary that feeds into the Cedar River with a drainage area of 146 square miles. Historically, much of the Turtle Creek Watershed was a large wetland complex, covering over 15,000 acres near the city of Hollandale. In the 1920s the area was ditched and the wetlands were drained for vegetable production (Albert Lea Farms Company and Payne Investment Company, undated). Additionally, some shallow lakes have also been drained. Approximately 91% of the waterways in Turtle Creek Watershed are channelized (Figure 12). The Turtle Creek Watershed is dominated by row-crop agriculture (76.8%), with about 42% of the land being tiled; this widespread practice has negative effects on the biological communities.

The city of Austin's land area is about 12.06 square miles, and approximately 28% of this land drains to Turtle Creek. Increased stormwater runoff from the city of Austin in turn causes an increase in the frequency and severity of flooding, accelerated channel erosion and alteration of the stream bead composition.

Stream modifications such as straightening have caused channel instability and downstream habitat degradation. The land use and channel conditions cause the flows of this stream system to become very inconsistent and flashy. Significant channelization and tile drainage used in the headwaters of this watershed helps move water off the farm fields and to the streams rather quickly. Frequent high flows can lead to an increase in soil erosion, while numerous periods of intermittent or no flow reduces the connectivity, and ultimately the ability for this stream to support healthy fish and macroinvertebrate populations.

Figure 112 displays a four-year discharge record for Turtle Creek just NW of Austin on 43rd Street (Site # 48027001). The flashy nature of this 146 square mile watershed is noted in three of the four years displayed. Depressed low flows are present in both 2012 and 2013, with some extended periods with flows less than 10-15 cfs.

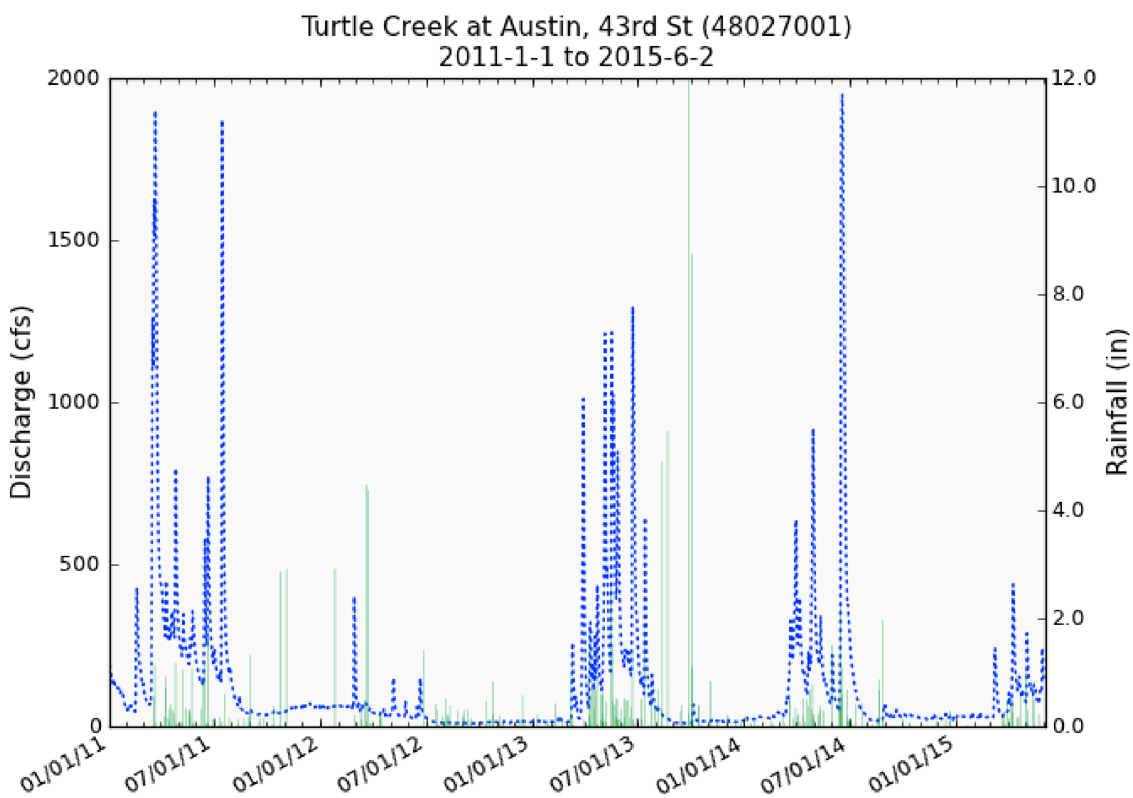


Figure 112: Comparison of daily discharge and precipitation for Turtle Creek Watershed MDNR/MPCA stream gaging at Austin, Minnesota (2011 - 2015).

Biologically, the fish populations in Turtle Creek consisted of 77% tolerant species at biological station 04CD010 and 49% at biological station 09CD062 compared to the Cedar River average of 60%. At biological station 04CD010 the macroinvertebrate population lacked swimmer taxa (3%), which are also indicative of a stream stressed by frequent periods of low to zero flow.

Channelization of waterways is a common practice throughout this watershed. This leads to inconsistent flows of water hindering colonization of many types of biota and can result in erosion during high flows following precipitation events. Altered waterways can also provide an easier access point for other nutrients to enter the water system. The overall lack of consistent flow makes it difficult for biological communities to survive and reproduce and therefore, flow alteration is a stressor to the biological community in Turtle Creek.

7.2.8. Conclusions

The stressors found in this reach are summarized in Table 59. Multiple stressors are acting on the biological community in this reach. Flow alteration and habitat are the driving force for macroinvertebrate and fish impairment at biological station 04CD010. Additionally, elevated TSS, low DO, elevated nitrate and elevated phosphorus are all also impacting the macroinvertebrate and fish communities.

The Lower Turtle Creek is classified as a B4/1c stream type. Habitat stress appears to be largest in the upstream location, 04CD010. There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. These are system-wide changes, which become cumulative in nature, and do affect the stream biota. Hydrology is the driver for the elevated TSS, and lack of stream stability causing the lack of habitat. Nitrate and phosphorus concentrations are elevated and having an impact on the biota as well. High daily fluctuations of DO are connected to increased nutrient concentrations and greater risk for low DO.

Table 59: Summary of stressors found in the Turtle Creek (-540).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors: Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow Alteration
07080201-540 Turtle Creek T102 R18W S4, north line to Cedar R	04CD010 09CD062	Macroinvertebrate IBI F-IBI Turbidity Bacteria	•	•	•	•	•	•

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

8. Rose Creek Watershed Unit

Rose Creek Watershed (43,436 acres) is located in Mower County. Cultivated row crop comprises 83.4% of the watershed. Schwerin Creek and unnamed creek (-583) were assessed as non-supporting of aquatic life for lack of macroinvertebrate assemblages. Rose Creek itself is 27 miles in length, but was not listed as impaired for either fish or macroinvertebrates. However, Rose Creek does have an existing turbidity listing.

8.1. Schwerin Creek: Headwaters to Rose Creek (AUID: 07080201-523) and unnamed creek: unnamed creek to Rose Creek (AUID: 07080201-583)

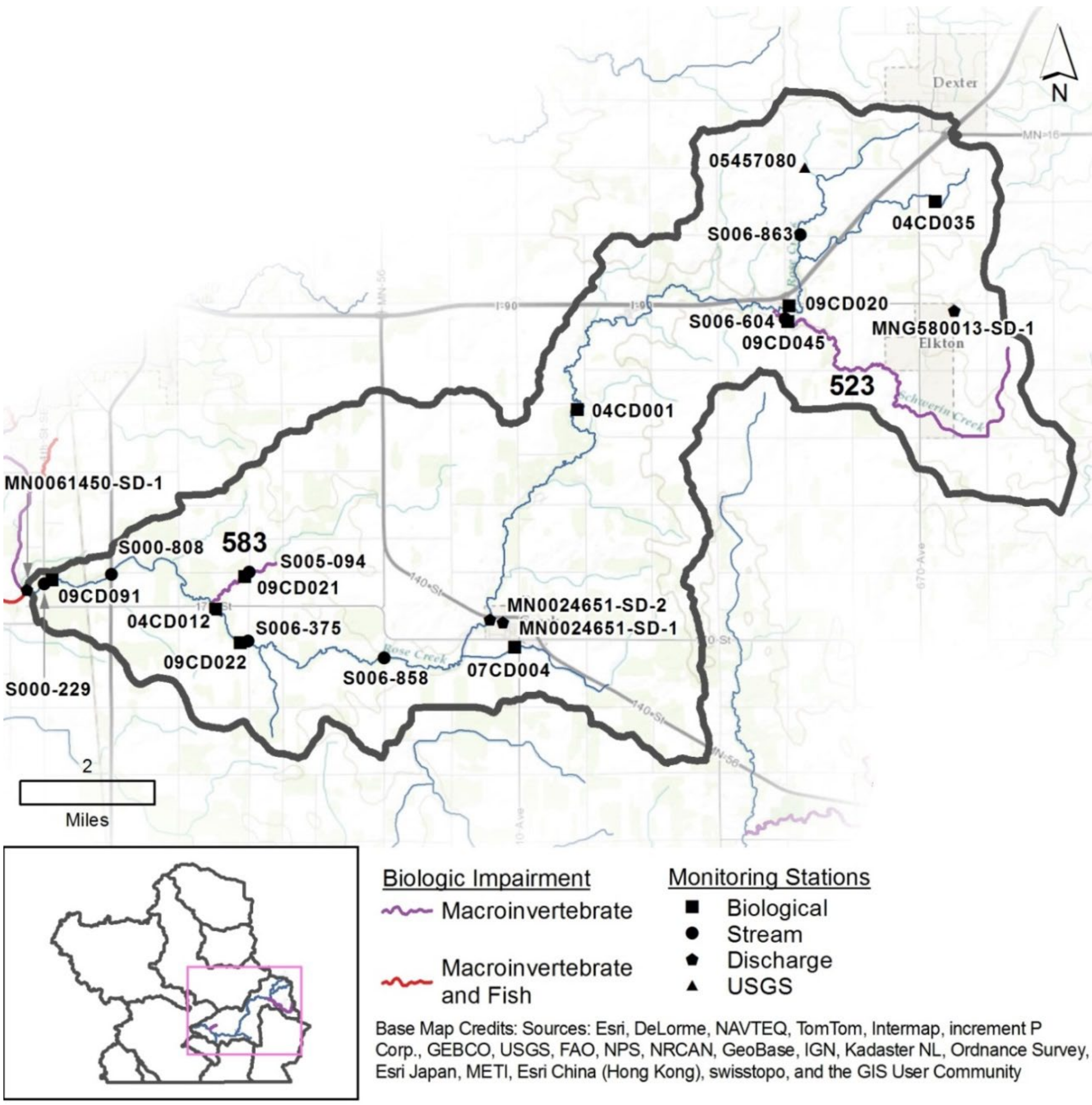


Figure 113: Map of Rose Creek Watershed biological impairments.

The MPCA surveyed one biological station (09CD045) in 2009 on Schwerin Creek (AUID -523) located Upstream of 650th Ave, 5 mi. NE of Rose Creek. Biological station 09CD021 was sampled on July 15, 2009, on unnamed creek (AUID -583) located downstream of 575th Avenue, 4 miles SE of Austin.

On Schwerin Creek, water quality samples were taken at EQuIS station S006-604 at 650th Avenue, a half mile northeast of Rose Creek. Water quality data from 2012 were used to determine stressors on Schwerin Creek. Water quality samples were taken at EQuIS station S005-094 at 570th Avenue, 4.5 miles southeast of Austin on unnamed creek (-583). Water quality data from 2008 to 2012 were used to determine stressors.

The Elkton WWTP discharges upstream of this stream reach.

8.1.1. Biology in Schwerin Creek and unnamed creek

The macroinvertebrate community is not meeting aquatic life standards for both stream reaches. The M-IBI at station 09CD045 on Schwerin Creek was 38.35 and 32.20 at 09CD021 on unnamed creek (-583), both of which are below the threshold of 46.8 for the Southern Forest Streams GP class (Table 60). The F-IBI score was above the threshold at both biological stations. The fish community is balanced and sensitive species are present in unnamed creek (-583).

Table 60: Summary of biological impairments in Schwerin Creek (-523) and unnamed creek (-583).

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-523, Headwaters to Rose Creek	09CD045	Schwerin Creek	9.28	Southern Forest Streams	46.8	38.35	Southern Headwaters	51	57
07080201-583, unnamed creek to Rose Creek	09CD021	unnamed creek	9.04	Southern Forest Streams	46.8	32.20	Southern Headwaters	51	53

Macroinvertebrates in the class Southern Forest Streams GP at both biological stations scored poorly in the metrics of intolerant taxa richness of (Intolerant2Ch), Plecoptera, Odonata, Ephemeroptera and Trichoptera taxa (POET), Trichoptera (TrichopteraChTxPct), and non-hydropsychid Trichoptera individuals (TrichwoHydroPct; Figure 114). The taxa richness of predators (PredatorCh) scored low at biological station 09CD045. Biological station 09CD021 scored poorly in the metrics of collector-filterers (Collector-filtererPct), and percentage of taxa that are clingers (ClingerChTxPct) and a measure of pollution based on tolerance values assigned to each individual taxon (HBI_MN). Five species dominated the sample (DomFiveCHPct; 49.04% and 55.34%) and the percent tolerant taxa was really high (Tolerant2ChTxPct; 82.22% and 85%).

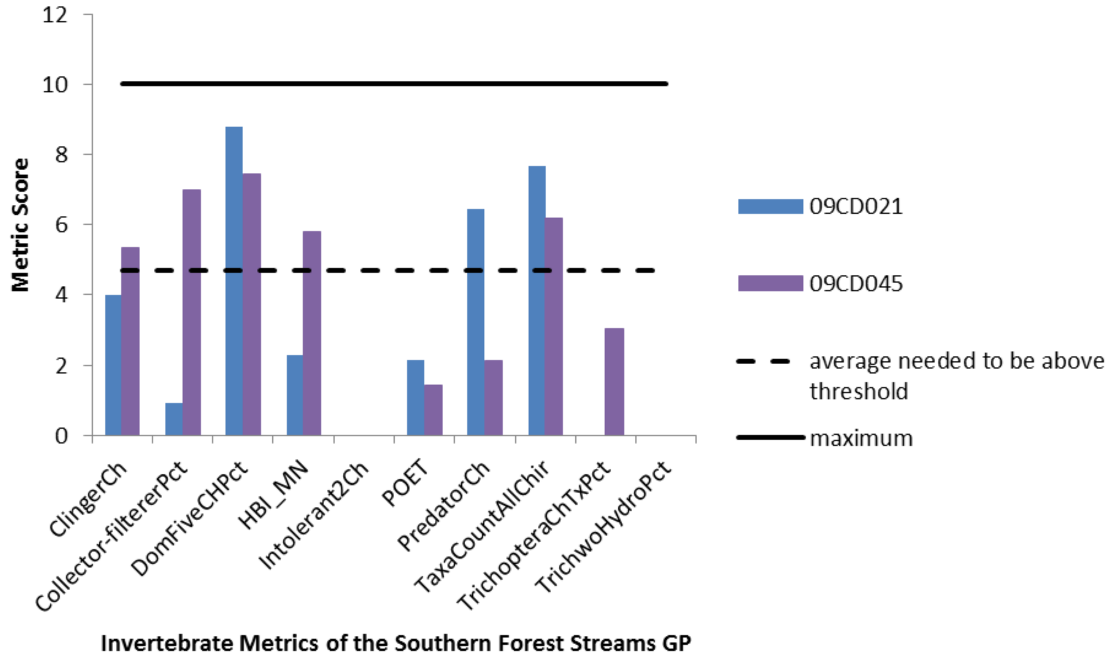


Figure 114: Macroinvertebrate metrics of the Southern Forest Streams GP in biological stations 09CD021 and 09CD045.

The fish community was not listed as impaired. Biological station 09CD045 had high metric scores for: detritivore taxa (DETNWQTxPct), generalist taxa (General Txpct), serial spawners (SSpnPct) and VtolTxPct (Figure 115). Station 09CD021 had an abundance of detritivore taxa (DETNWQTxPct) and generalist taxa (General Txpct). Both stations were just below the threshold in sensitive TxPct and the relative abundance of short lived individuals (SLvdPct). Station 09CD021 also scored just below the threshold in serial spawners (SSpnPct) and relative abundance of very tolerant taxa (VtolTxPct). These two reaches did not have fish DELTs, that if present, would have contributed negatively to the IBI.

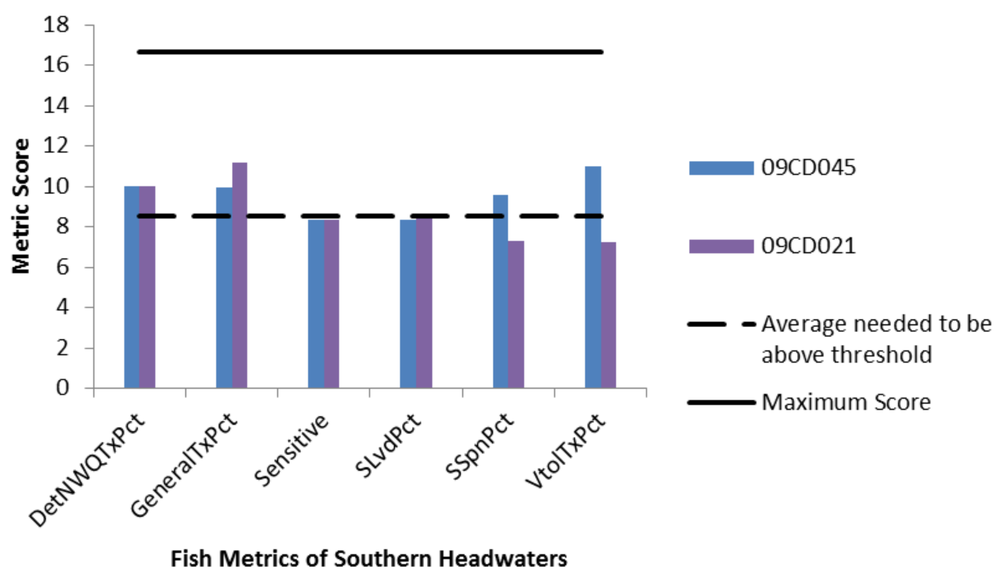


Figure 115: Fish metrics of the Southern Headwaters in biological stations 09CD045 and 09CD021.

The analysis of candidate causes for the two reaches in Rose Creek Watershed are lumped together below.

8.1.2. Candidate cause: Lack of habitat/bedded sediment

Unnamed creek (07080201-583):

The unnamed creek biological station 09CD021 scored 54.3(fair) on the MSHA (Table 61). Of the five subcategories in the MSHA, land use, substrate, and channel morphology scored poorly. The channel stability assessment suggests that this stream is unstable with excess cutting, bank erosion and unstable substrates. The field crew also noted unnamed creek had a moderately unstable channel. The water was clear and normal water level. This reach only contained 20% riffle and was dominated by sand and gravel, with moderate embeddedness. Sand and clay substrate was dominant in the pools. The watershed of this AUID is dominated by agriculture and has several large feed lots.

The surrounding land use was noted as row crop and forest with a moderate (30 to 150 ft) riparian buffer. There is moderate bank erosion on the left and right banks (Figure 116). Sparse cover was noted, with multiple cover types including undercut banks, overhanging vegetation, deep pools, logs or woody debris and macrophytes. The habitat that was sampled for macroinvertebrates was undercut banks and overhanging vegetation. This site is lacking good quality riffles. It was also noted that unnamed creek is a flashy system.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. Over 57% of the waterways in Rose Creek watershed are channelized. Current estimations are that this AUID is 32% channelized. With a drainage area of only 9.04 square miles, the flashy tendencies of the stream caused by widespread channelization have a negative impact on the biological communities. This water moves through the system very fast disrupting normal flows that the stream may have while also contributing to increased amounts of erosion. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

The percentage of burrowers (10.83%) found in biological station 09CD021 were above the statewide average for Southern Forest Streams GP macroinvertebrate class, which demonstrates sedimentation issues (Figure 118). The percentage of EPT individuals was much less than the statewide average for Southern Forest Streams GP macroinvertebrate class (3.5%). The percentage of generally tolerant legless macroinvertebrate individuals was high (90.45%). The macroinvertebrates that are known to cling to large substrate and woody debris were low (below statewide averages for this class), likely due to the lack of woody material available to support these individuals. Clingers can decrease in stream reaches with homogenous substrate composition, velocity, and depth (CADDIS). This is also found in the M-IBI metrics, the number of clinger taxa (ClingerCh) was below the average metric score needed for the M-IBI to be at the threshold.

Overall, MSHA information, site conditions/photos, and macroinvertebrate response strongly support habitat as a stressor in this reach particularly bedded sediment. Habitat is a stressor in this reach.

Figure 116: Habitat conditions at unnamed creek at biological station 09CD021.

Schwerin Creek (07080201-523):

Biological station 09CD045 scored 75.8 on the MSHA (good; Table 61). The lowest scoring part of the MSHA is land use. In this area, the land use is 80-90% agriculture. The reach was found to have 20% riffle, 60% run, and 20% pool with adequate diverse substrate types. Field staff noted there were habitat issues evident (channel instability and excess sedimentation).

The surrounding land use was noted as row crop and pasture with a moderate (30 to 150 ft.) riparian buffer on the left bank and a very narrow (3-15 ft.) riparian buffer on the right bank. There was little bank erosion at this site. Moderate cover was noted, with multiple cover types including overhanging vegetation, deep pools, logs or woody debris, boulders and macrophytes (Figure 117).

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. Over 57% of the waterways in Rose Creek watershed are channelized. Current estimations are that this AUID is 46.5% channelized. With a drainage area of only 9.28 square miles, the flashy tendencies of the stream caused by widespread channelization have a negative impact on the biological communities. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

There was an abundance of burrowers found in biological station 09CD045, which suggests potential fine bedded sedimentation issues (13.59%; Figure 118). The percentage of EPT individuals was less than the statewide average for Southern Forest Streams GP macroinvertebrate class (8.74%). The percentage of generally tolerant legless macroinvertebrate individuals was very high (88.03%). The macroinvertebrates that are known to cling to large substrate and woody debris were low (below statewide averages for this class). This is also found in the M-IBI metrics, the number of clinger taxa (ClingerCh) was just below the average metric score needed for the M-IBI to be at the threshold. Clingers can decrease in stream reaches with homogenous substrate composition, velocity, and depth (CADDIS).

An abundance of burrowers reveal potential sedimentation issues, in addition to lower percentage of EPT individuals and clingers. The biological metrics related to habitat for macroinvertebrates reveal issues with available and quality habitat in Schwerin Creek.

Figure 117: Schwerin Creek at biological station 09CD045 showing bedded sediment and erosion of the stream banks.

Table 61: MSHA results for Schwerin Creek and unnamed creek.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	09CD045	Schwerin Creek	1	11	19.8	12	32	75.8	Good
1	09CD021	unnamed creek	1.3	10	16	8	19	54.3	Fair
Average Habitat Results			1.15	10.5	17.9	10	25.5	65.05	Fair

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA>66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

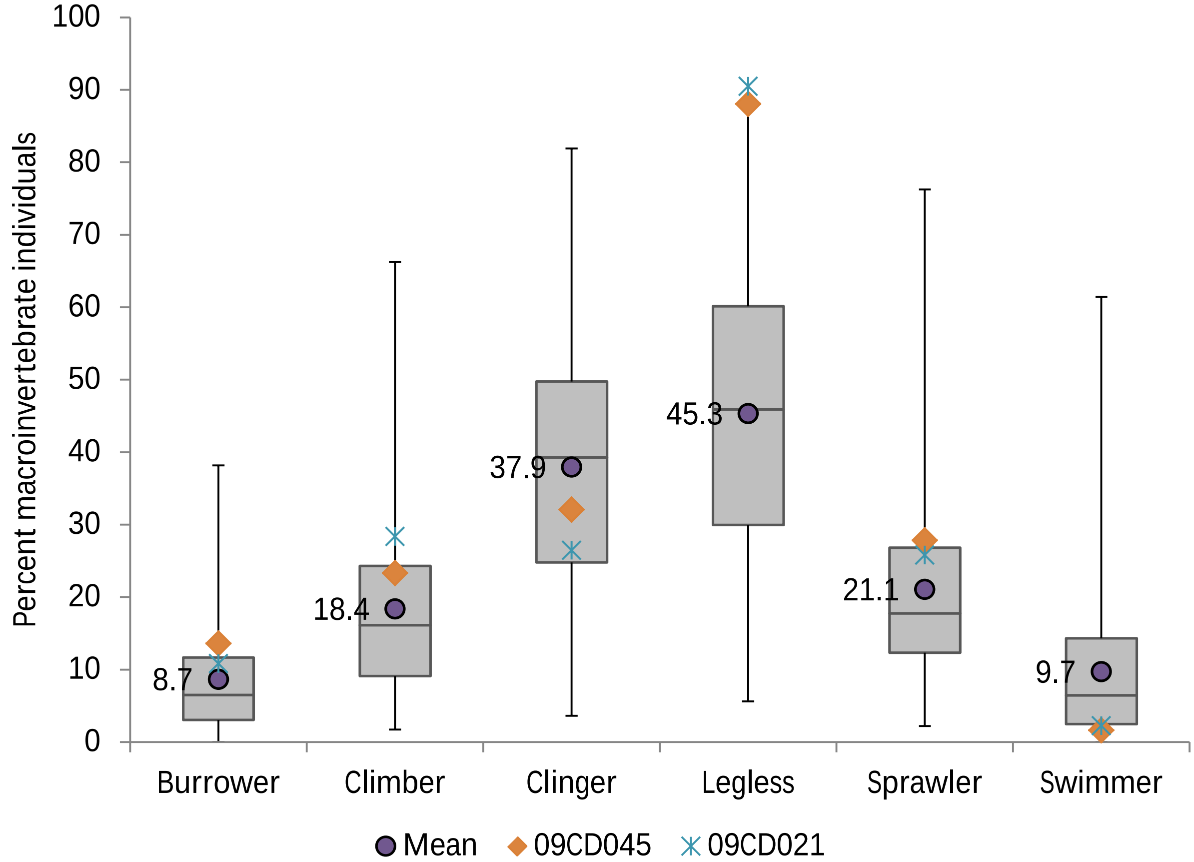


Figure 118: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Forest Streams GP stations with M-IBI greater than 46.8 (threshold), mean of those stations, and metric values from station 09CD045 and 09CD021.

8.1.3. Candidate cause: High nitrate-nitrite

Unnamed creek (07080201-583):

Nitrate was 12.0 mg/L during fish sampling on July 15, 2009 at biological station 09CD021. Nitrate levels have been measured as high as 18 mg/L (Figure 119). Observed nitrate was highest in March through June and then decreases. The mean nitrate level for all data collected in this reach was 5.7 mg/L. There were no unionized ammonia data available.

The macroinvertebrates in this reach were made up of 79.3% tolerant taxa and lacked intolerant taxa as defined by MPCA. Biological station 09CD021 was lacking non-hydropsychid Trichoptera. Trichoptera are often considered sensitive to nitrate and respond with decreases in taxa. At station 09CD021, there were 85.16% nitrate tolerant macroinvertebrates, with 33 nitrate tolerant taxa and no nitrate intolerant taxa. Nitrate is a stressor to the impaired biota.

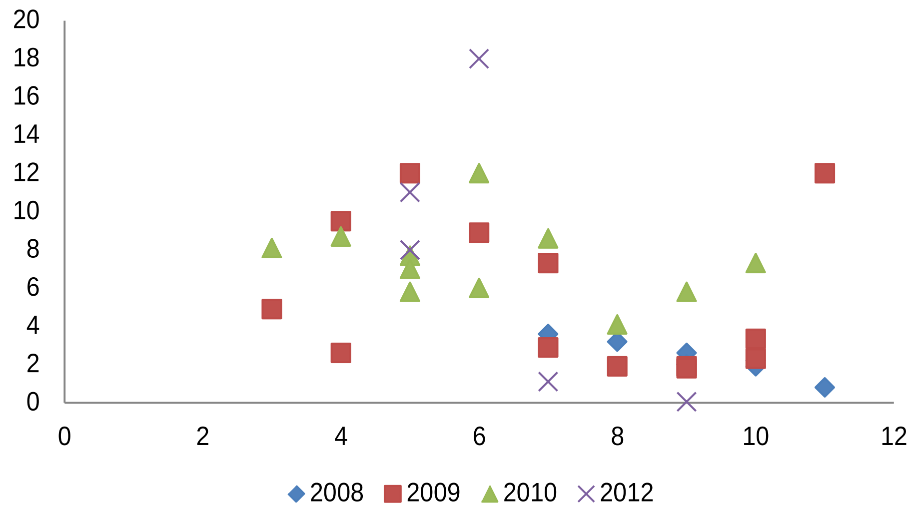


Figure 119: Nitrate-nitrite measurements for unnamed creek (-583) by month.

Schwerin Creek (07080201-523):

Nitrate was 15 mg/L during fish sampling on July 1, 2009 at biological station 09CD045. Nitrate was sampled five times in 2012 at station S006-604. The highest sample was 21 mg/L on June 22, 2012 while the lowest nitrate sample was 0.55 mg/L on September 4, 2012.

The macroinvertebrates in this reach were made up of 66.34% tolerant taxa and lacked intolerant taxa as defined by MPCA. Biological station 09CD045 was lacking non-hydropsychid Trichoptera. Trichoptera are often considered sensitive to nitrate and respond with decreases in taxa. At station 09CD045, there were 76.1% nitrate tolerant macroinvertebrates, with 27 nitrate tolerant taxa and only one nitrate intolerant taxa. With the limited nitrate data available, nitrate is a stressor to the impaired biota. More nitrate data should be collected to help characterize the nitrate in Schwerin Creek.

8.1.4. Candidate cause: Low dissolved oxygen

Unnamed creek (07080201-583):

There was a lack of DO data available prior to 9 a.m. All measurements occurred between 10 a.m. and 2:30 p.m.; and ranged from 6.17 to 12.22 mg/L with a potential for DO flux. DO at the time of fish sampling was 7.14 mg/L.

The macroinvertebrate community comprised of a low percentage of EPT taxa (8.89%). The tolerant taxa was elevated in 2009 (66.67%) and the taxa count was abundant (TaxaCountAllChir; 45). HBI_MN metric at station 09CD021 received a metric score (2.27) lower than the average score needed to be above the threshold. The macroinvertebrate DO TIV station score (6.96) was just above the average for the Cedar River (6.8). The numbers of macroinvertebrate taxa collected that are intolerant to low DO were 6, and the percentage of DO tolerant species collected were 13.5. The average number of intolerant taxa collected in the Cedar River basin was 4.6 and the average percentage of DO tolerant taxa was 20. 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.

Schwerin Creek (07080201-523):

There was a lack of DO data within this reach. There were six measurements of DO collected. There were no measurements below the standard (5 mg/L). All five DO measurements were taken in 2012 during very low flow conditions. One of the measurements was taken at the time of fish sampling (9.01

mg/L). Five of the six measurements in 2012 were taken in the early afternoon and were over 1 mg/L above the standard. There were no early DO readings observed.

The macroinvertebrate community comprised of a high percentage of EPT taxa (12.5%). The tolerant taxa was elevated in 2009 (66.3%) and the taxa count was abundant (TaxaCountAllChir; 40). The macroinvertebrates in this AUID had a high metric HBI_MN, a measure of pollution based on tolerance values assigned to each individual taxon. Station 09CD045 received a metric score (5.78) higher than the average score needed to be above the threshold. 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.

8.1.5. Candidate cause: High phosphorus

Unnamed creek (07080201-583):

Total phosphorus (0.075 mg/L) was low at the time of fish sampling in unnamed creek. Samples were taken a total of 36 times from 2008 through 2010 and in 2012 (Figure 121). Phosphorus was elevated above the standard in unnamed creek. The highest phosphorus sample was 0.807 mg/L taken on September 23, 2010. The lowest grab sample was 0.029 mg/L on April 7, 2010.

This stream reach has a high taxa count (TaxaCountAllChir; 45). Biological station 09CD021 lacked intolerant taxa (0) and the percent tolerant taxa was high (Tolerant2ChTxPct; 82.22%). The percentage of intolerant taxa will decrease and the percentage of tolerant taxa will increase with increases in phosphorus. The percentage of scrapers was 12.1%, which was below the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. The number of collector-gather taxa (21) was above the average for the Cedar River Watershed. Collector-filterer taxa (2) were below the average for the Cedar River Watershed, which may be a response to increases in suspended sediment, but would likely increase with increases in algae. There were 4 EPT taxa in this stream reach. The range of EPT taxa within the Cedar River Watershed was 0 to 20. The metric, EPT, provides a relative measure of the presence and diversity of pollution-sensitive macroinvertebrate groups. The data connects elevated phosphorus and the impaired biota. Phosphorus along with response variables should continue to be collected to understand the nutrient dynamics in this system.

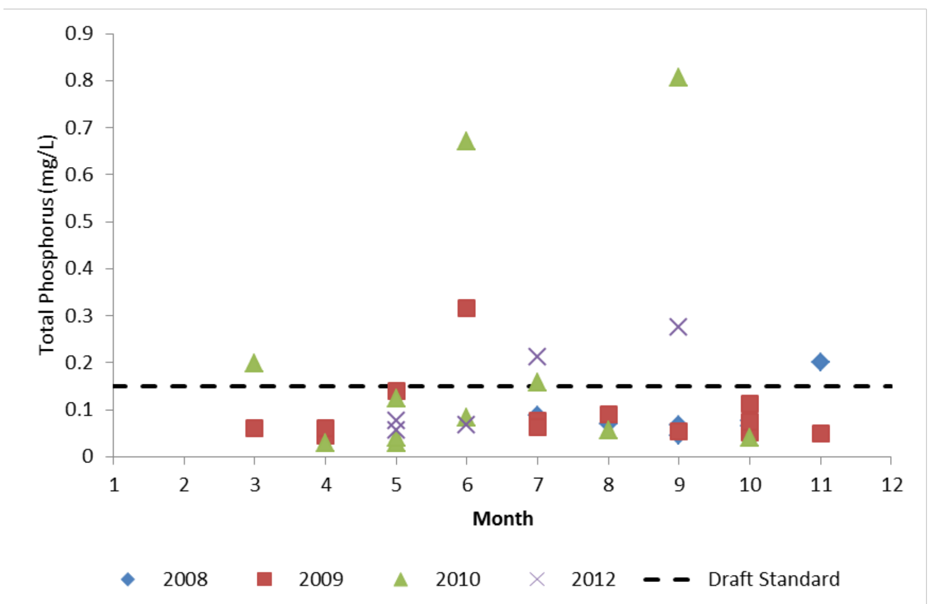


Figure 120: Total phosphorus by month for unnamed creek at Station S005-094 on AUID (-583).

Schwerin Creek (07080201-523):

Total phosphorus (0.035 mg/L) was low at the time of fish sampling in Schwerin Creek. Samples were taken a total of four times during the sampling season of 2012. The highest phosphorus sample was 0.204 mg/L taken on June 22, 2012. The lowest grab sample was 0.07 mg/L on May 30, 2012.

This stream reach has a high taxa count (TaxaCountAllChir; 40). Biological station 09CD045 lacked intolerant taxa (0) and the percent tolerant taxa was high (Tolerant2ChTxPct; 85%). The number of collector-gather taxa (22) and collector-filterer taxa (6) were both above the average for the Cedar River Watershed. There were 4 EPT taxa in this stream reach. The range of EPT taxa within the Cedar River Watershed was 0 to 20. The metric, EPT, provides a relative measure of the presence and diversity of pollution-sensitive macroinvertebrate groups. With the lack of elevated phosphorus, it is currently inconclusive if elevated phosphorus is a stressor to the biological community. Phosphorus should be continued to be collected to understand the nutrient dynamics in this system.

8.1.6. Candidate cause: High suspended sediment

Unnamed creek (07080201-583):

Biological station 09CD021 had low TSS at the time of fish sampling on July 15, 2009 (5.2 mg/L), along with a good transparency tube reading (47 cm). In 2008 through 2010, there were 47 transparency tube readings, four of the readings were below 20 cm. Thirty-five measurements of TSS were collected in 2008 through 2010 and 2012. Four TSS measurements were elevated above the draft standard of 65 mg/L. TSS data for a range of flows should be collected in unnamed creek to determine the impacts to the biota.

In 2009, there were a low percentage of macroinvertebrates that are scrapers (12.10%) along with a low percentage of collector-filters (3.82%). Collector-filterers are reduced when TSS is elevated. Collector-filterer species collect their food by filtering it from the water column. The percentage of long lived macroinvertebrates was very low (2.55%). At station 09CD021, there were 21.61% TSS tolerant macroinvertebrates, with 7 TSS tolerant taxa and only one TSS intolerant taxa (Table 62). There are biological indications that TSS or turbidity is a stressor to the biota, but not the primary stressor.

Table 62: Macroinvertebrate metrics relevant to TSS for stations in unnamed creek compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
09CD021	16.1	1	7	21.6	**0**	**3**
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

Schwerin Creek (07080201-523):

Biological station 09CD045 had low TSS at the time of fish sampling on July 1, 2009 (4 mg/L), along with an excellent transparency tube reading (80 cm). In 2012, there were five transparency tube readings, four out of the five readings were 20 cm and above. One transparency reading was 9 cm on June 22, 2012, during a rain event. Five measurements of TSS were collected in 2012. One TSS measurement on June 22, 2012, was elevated above the draft standard of 65 mg/L. TSS data for a range of flows should be collected in Schwerin Creek.

In 2009, biological station 09CD045 had a low percentage of herbivorous fish and a low percentage of macroinvertebrates that are scrapers along with a high percentage of collector-filters. The percentage of long lived macroinvertebrates was very low (1.61%). At station 09CD045, there were 28.1% TSS tolerant macroinvertebrates, with six TSS tolerant taxa and only one TSS intolerant taxa (Table 63). There are biological indications that TSS or turbidity may be a concern, yet findings are inconclusive due to limited data.

Table 63: Macroinvertebrate metrics relevant to TSS for stations in Schwerin Creek compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
09CD045	15.2	1	6	**28.1**	**0**	**3**
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

8.1.7. Conclusions

Unnamed creek (07080201-583):

The stressors found in this reach are summarized in Table 64. Habitat, nitrate, phosphorus, TSS and flow alteration are causing stress to the macroinvertebrate community. Habitat, flow alteration and nitrate appear to be driving biological stress in this reach. This stream reach is unstable with excess cutting, bank erosion and unstable substrates. There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation and driving the sedimentation issues. Nitrate was measured as high as 18 mg/L, and phosphorus was measured as high as 0.807 mg/L. Nutrient management of both nitrogen and phosphorus is needed throughout the watershed. DO was considered inconclusive due to lack of information. Further DO monitoring including diurnal monitoring should take place to better understand the DO regime.

Table 64: Summary of stressors found in unnamed creek (-583).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors					
			Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-583 unnamed creek unnamed creek to Rose Creek	09CD021	M-IBI	•	•	o	•	•	•

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

Schwerin Creek (07080201-523):

The stressors found in this reach are summarized in Table 65. Habitat, flow alteration and nitrate are causing stress to the macroinvertebrate community. This stream reach is unstable with excess sedimentation that is affecting the habitat quality. The riparian corridor of Schwerin Creek could be improved (more forested riparian area), which would also improve in stream habitat as well. Schwerin Creek has a good amount of row crop agriculture, and increasing the number of filter strips and grassed waterways could help with sediment reduction and habitat loss seen in Schwerin Creek. There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation and driving the sedimentation issues. Upstream reaches of this watershed are channelized. Nitrate was measured as high as 21 mg/L. There are biological indications that TSS may be a concern, yet findings are inconclusive due to limited data. TSS data for a range of flows should be collected in Schwerin Creek. With the lack of elevated phosphorus, it is currently inconclusive if elevated phosphorus is a stressor to the biological community. Phosphorus should be continued to be collected to understand the nutrient dynamics in this system. DO was considered inconclusive due to lack of information. Additional information should be collected on DO to help rule out this potential stressor.

Table 65: Summary of stressors found in the Schwerin Creek (-523).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors					
			Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-523 Schwerin Creek Headwaters to Rose Creek	09CD045	M-IBI	•	•	o	o	o	•

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

9. Lower Cedar River Watershed Unit

The Lower Cedar River Watershed is the third largest subwatershed within the Cedar River Watershed (Figure 121). It lies within Freeborn and Mower counties. This watershed is dominated by cultivated crop (83%), and includes a portion of the city of Austin. The Ramsey Mill Pond is the only lake in this watershed, and it exists due to a dam.

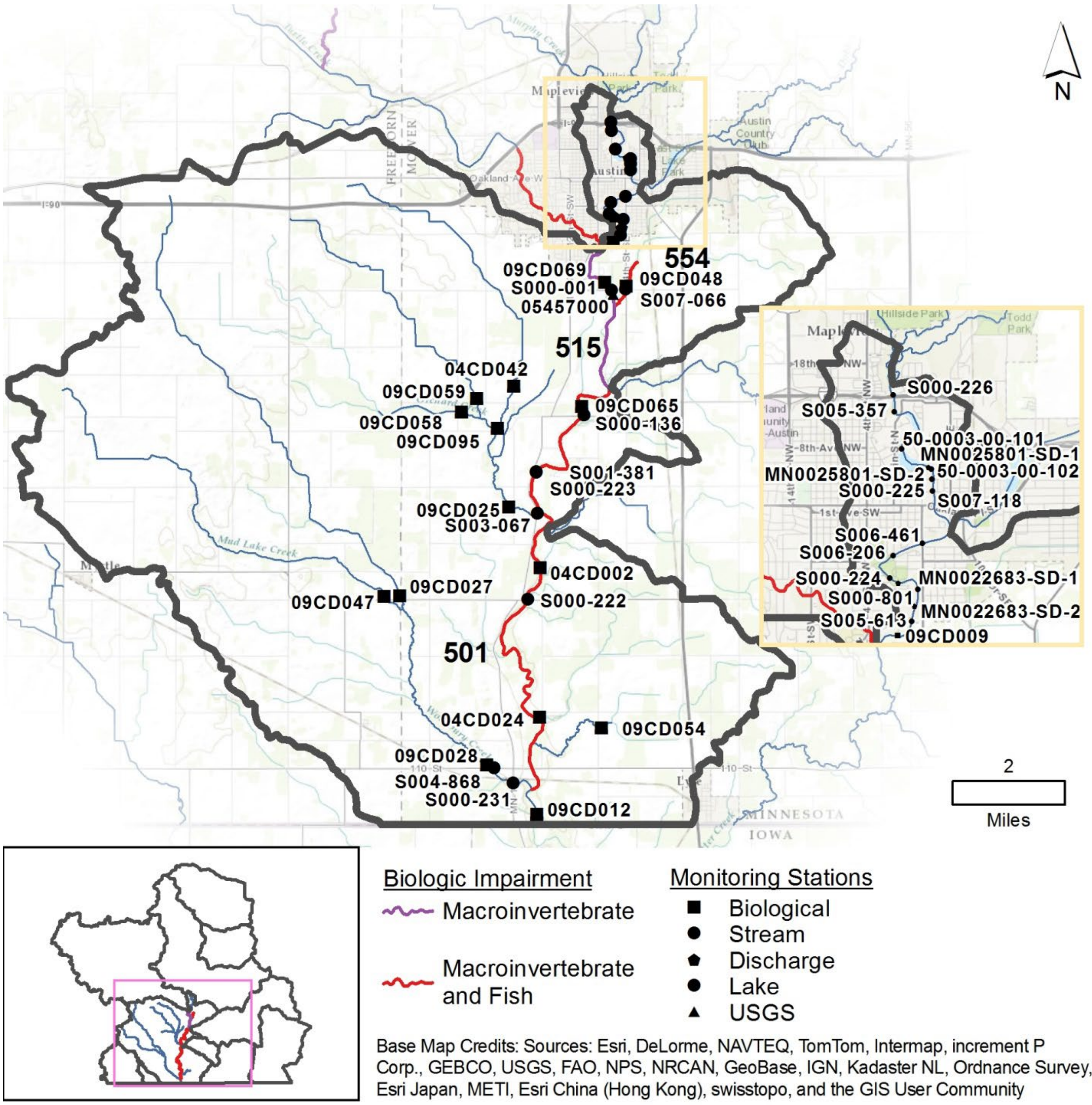


Figure 121: Map of Lower Cedar River Watershed biological impairments.

9.1. Unnamed creek (Woodson Creek), T102 R18Q S14, north line to Cedar River (AUID: 07080201-554)

This listed reach is non-supporting of aquatic life for coldwater fish and aquatic macroinvertebrate communities. Woodson Creek is the only MDNR designated coldwater stream in the Cedar River Watershed (Figure 121).

The MPCA surveyed one biological station 09CD048 that was sampled in 2009 on AUID 07080201-554. The biological station is located upstream of CSAH 28 (29th St), east of 4th Street SE, 1 mile south of Austin

Water quality sampling was done at EQuIS station S007-066 on County Road 29 one mile south of Austin. Sampling occurred just downstream of the biological station. Water quality data from 2012 were used to determine stressors.

9.1.1. Biology in unnamed creek (Woodson Creek)

The macroinvertebrate IBI was 34.52 which were below the threshold of 46.1 for a southern coldwater stream (Table 66). The F-IBI score for this station was 19 which are also below the threshold of 45 for a southern coldwater stream. The macroinvertebrate and fish communities are not meeting standards for Woodson Creek.

Table 66: Summary of biological impairments in Woodson Creek.

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201 -554, T102 R18W S14, north line to Cedar River	09CD048	unnamed creek (Woodson Creek)	6.52	Southern Coldwater	46.1	34.52	Southern Coldwater	45	19

The macroinvertebrate community had an IBI score of 34.52 in 2009. The macroinvertebrate metrics in the Southern Coldwater macroinvertebrate IBI that scored low were the ratio of chironomid abundance to total dipteran abundance (ChiroDip), relative abundance of collector-filterer individuals (Collector-filtererPct),the metric that is a measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN; Figure 122). The metric of taxa richness of macroinvertebrates with tolerance values less than or equal to two, using MN TVs (Intolerant2Ch) were lacking along with the relative percentage of taxa belonging to Trichoptera (TrichopteraChTxPct). The Coldwater Biotic Index score based on coldwater tolerance values derived from Minnesota taxa and temperature data (CBI) and the relative abundance percentage of macroinvertebrate individuals with tolerance values equal to or greater than eight, using MN TVs (VeryToleranct2Pct) scored above the average needed to be above the threshold.

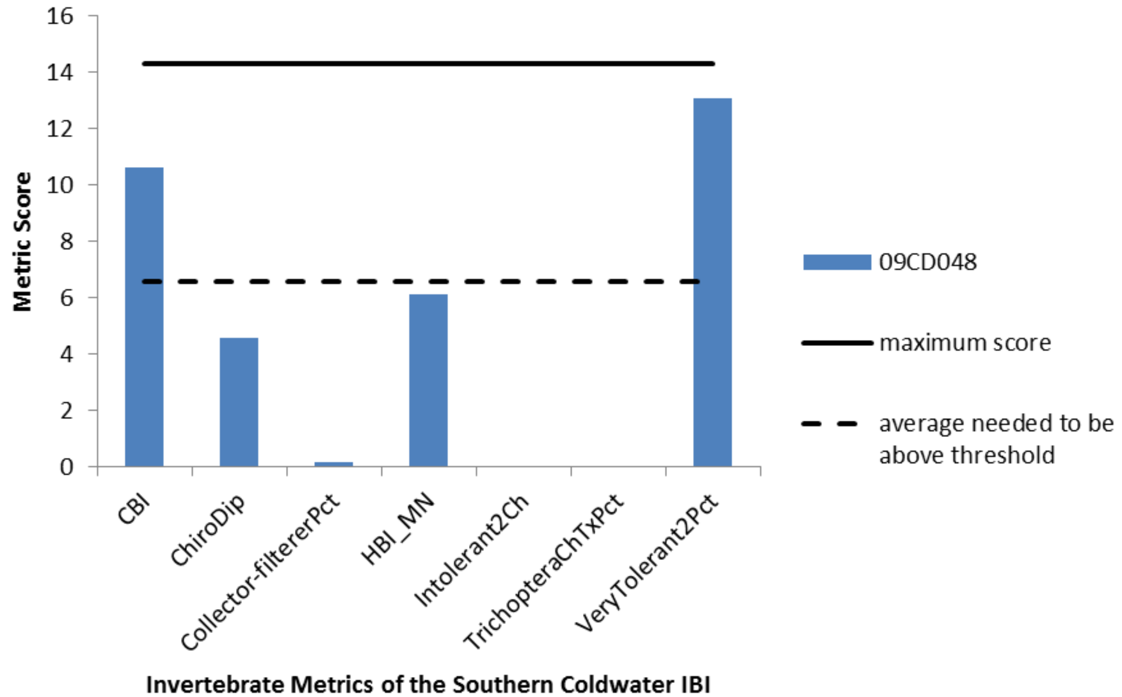


Figure 122: Macroinvertebrate metrics of the Southern Coldwater IBI in stations 09CD048 in Woodson Creek.

There were five metrics that fall below the average metric score needed to have the F-IBI score greater than the threshold for impairment (Figure 123). CWSensitivePct_10DrgArea and CWTol_10DrgArea were both very low. NativeColdPct, NativeColdTXpct_10DrgArea and SdetTXPct_10DrgArea were all zeros. The metric NativeColdPct is the percent of individuals that are native coldwater species, the metric NativeColdTXPct_10DrgArea is the percent of taxa that are native coldwater species (adjusted for drainage area) and SdetTXPct_10DrgArea is the percent of taxa that are detritivorous.

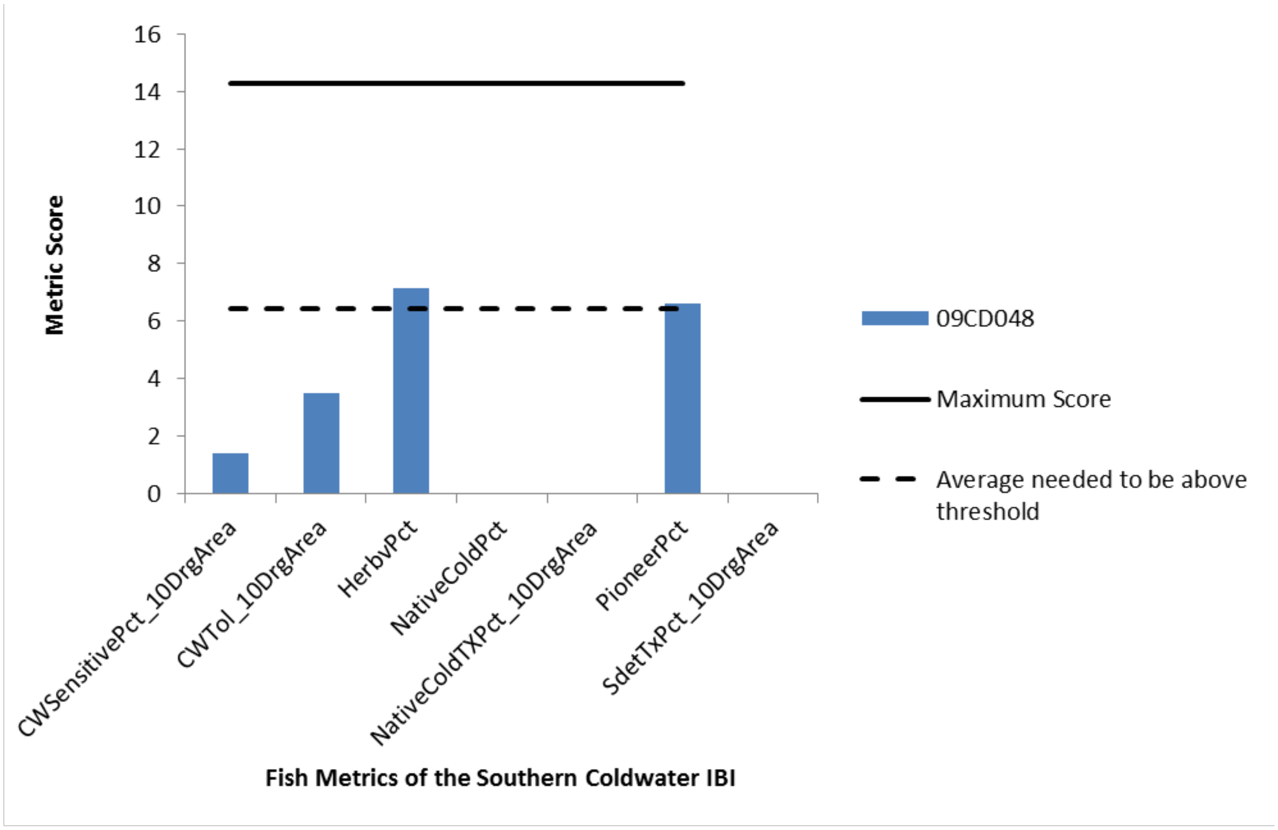


Figure 123: Fish metrics of the Southern Coldwater IBI in stations 09CD048 in Woodson Creek.

9.1.2. Candidate cause: Lack of habitat

Biological station 09CD048 received a fair MSHA score in 2009 (64.8; Table 67). The station was characterized as having a very narrow riparian width (3-15 ft.), with natural, row crop and residential adjacent to the site. There was no bank erosion noted with moderate cover (50-75%) and heavy shade.

There was moderate/high channel stability and good channel development also noted. The reach was found to have 30% riffle, 35% run, and 35% pool. The riffle contained cobble and gravel substrate while the pools and runs contained gravel and sand substrate. Moderate cover was noted, with multiple cover types including undercut banks, overhanging vegetation, deep pools, logs or woody debris and macrophytes (Figure 124). The habitat that was sampled for macroinvertebrates was undercut banks, overhanging vegetation and aquatic macrophytes. It was noted by the field crew that very few taxa were collected from the stream bank and aquatic plant habitats.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications have caused habitat degradation. These are system-wide changes, which become cumulative in nature, and do affect the stream biota. A report done by the MDNR in 1980 mentioned that private landowners built a rock dam that may have interrupted the natural flow and migration of brook trout. Landowners also dug wide ponds that filled in with silt and created a habitat for undesirable species which competed with trout. The downstream reach was pasture with bank erosion, over widened and lacks shade and cover (Figure 124).

The percentage of EPT was very high at 58.6%; well above average for coldwater stations statewide (39.2%). EPT macroinvertebrates are sensitive to habitat disturbances among other stressors. The macroinvertebrates that are known to cling to large substrate and woody debris were not found in abundance in 2009 (8.9%) and were below statewide averages (40.6%) for southern coldwater metrics

(Figure 125). The macroinvertebrate community at station 09CD048 was below average for the percentage of climbers (2.5%), and a low percentage of macroinvertebrate individuals that are legless (14.7%). There were a higher percentage of macroinvertebrates that are sprawlers (28.8%) than the average for coldwater stations statewide. The biological sampling noted slow water, and a high number of swimmer taxa (58.6%) were sampled compared to other Southern Coldwater macroinvertebrate sites. Biological station 09CD048 lacks long lived individuals indicating very unstable habitat conditions where tolerant individuals are able to thrive.

Surveys done by the MDNR in previous years (1980s) indicate brook trout were once present; however, it is not clear if they were native or introduced. A survey done in 2003 did not observe brook trout, and the survey done by the MPCA in 2009 did not observe any trout. Pearl dace remain as coldwater indicators. The percent benthic feeders at this site are also low (7.4%) which indicate a community lacking individuals who rely on benthic habitats to feed. The percent riffle dwelling fish (7.41%), non-tolerant benthic insectivores (7.41%), and darter, sculpin, and round-bodied suckers (0%) are all below the statewide average for Southern Coldwater streams. Simple lithophilic spawners were below average and general lithophilic spawners were above average due to presence of blacknose dace which are also tolerant and short-lived. All of the fish captured were five inches or less; demonstrating the potential lack of habitat for larger fishes. There was a lack of piscivore species and the fish sample had 9% creek chub. Creek chub are considered pioneers and are the first to invade a site after disturbance. In addition to this, 64.8% of the fish community is classified as tolerant.

Lack of habitat due to habitat degradation, lack of stable substrate and lack of riparian cover is a driving stressor for both the fish and macroinvertebrate communities found at this station in Woodson Creek.

Table 67: MSHA results for unnamed creek (-554).

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	09CD048	unnamed creek (Woodson Creek)	2.3	9	16.5	12	23	64.8	Fair

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA>66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

Figure 124: Photograph of biological station 09CD048 on June 29, 2009 (left) and pasture downstream of biological station on May 15, 2012 (right).

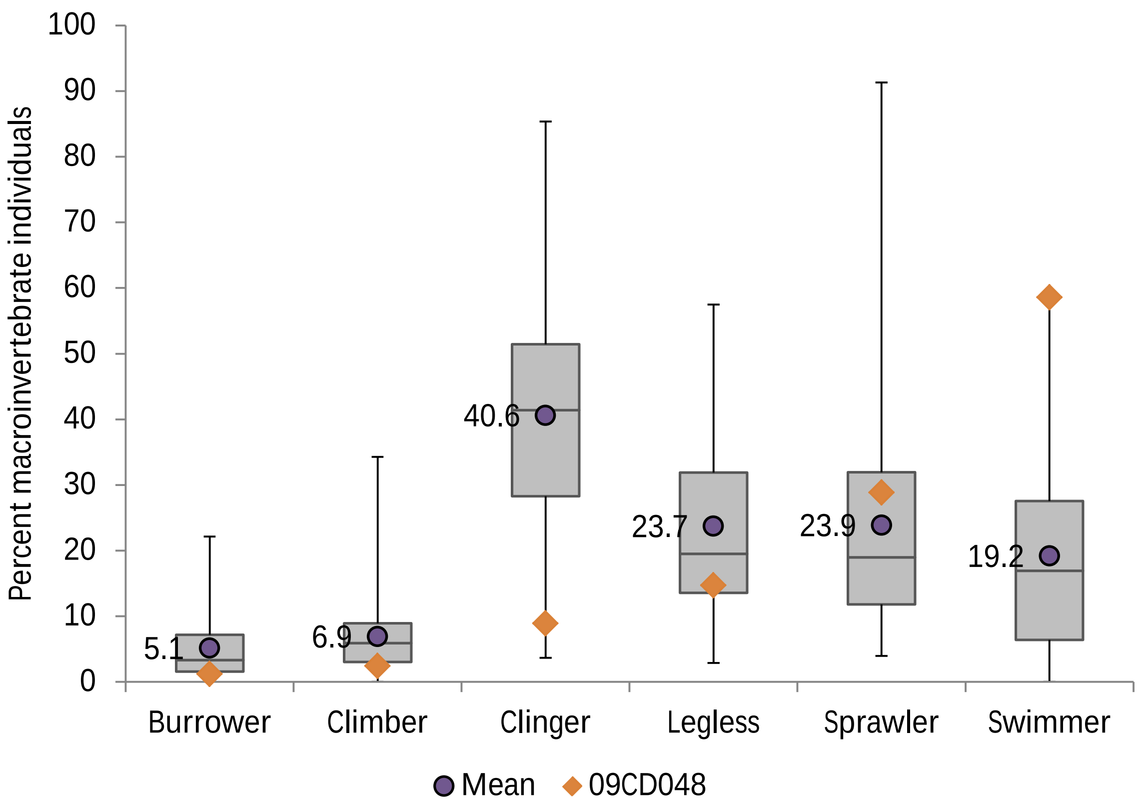


Figure 125: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel southern coldwater streams stations with M-IBI greater than 46.1 (threshold), mean of those stations, and metric values from station 09CD048.

9.1.3. Candidate cause: High nitrate-nitrite

The grab sample taken at the time of fish sampling had a nitrate level of 3.4 mg/L. There were five grab samples taken during the sampling season of 2012. Those values ranged from 2.0 to 2.3 mg/L.

The macroinvertebrates in this reach have an overabundance of very tolerant taxa and a complete absence of intolerant taxa as defined by MPCA. Trichoptera are often considered sensitive to nitrate and respond with decreases in taxa. There were no Trichoptera taxa found at the biological station 09CD048.

The macroinvertebrate metric HBI_MN is a measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart. The HBI_MN value and consequent metric score have a significant relationship with nitrate at the time of fish sampling. The HBI_MN metric score decreases with increased in nitrate. In Woodson Creek, the metric score was 5.15 at station 09CD048 (out of 14.3) below the average metric score needed to be at the Southern Coldwater M-IBI threshold (6.6). At station 09CD048, there were 88.61% nitrate tolerant macroinvertebrates, with 10 nitrate tolerant taxa and no nitrate intolerant taxa.

Fish lack a strong biological response in relation to elevated nitrate. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration. The fish community at 09CD048 lacked sensitive taxa and had a large number of tolerant taxa. This station also has fish that are quick to mature and are short-lived. Sensitive taxa found at this site were pearl dace.

Although the macroinvertebrate and fish communities is degraded in a manner comparable with a potential nitrate issue, the low nitrate values make it difficult to conclude that nitrate is a stressor. The biological response may be due to other stressors present. There is not adequate information to conclude nitrate as a stressor in Woodson Creek. Additional monitoring of nitrate levels during spring runoff and other seasons would be recommended.

9.1.4. Candidate cause: Low dissolved oxygen

There was a lack of DO data within this reach. There were only five measurements, which were all above the minimum standard of 7 mg/L for coldwater streams. During biological sampling, the DO concentration was 7.35 mg/L at 3pm, which is close to the 7 mg/L standard set for coldwater streams. Grab samples taken in 2012, during the summer months, showed a DO range from 8.73 mg/L to 10.43 mg/L.

The fish community at 09CD048 was lacking sensitive taxa and has a larger proportion of taxa that are detritivores. Detritivores are fish that feed on decaying organic material. Fathead minnows make up 13% of the fish community. Fathead minnows are known for their ability to survive in low DO conditions. The fish community suggests there may be DO issues, but the TIV aggregate scores indicate adequate DO levels for both fish and macroinvertebrates.

The macroinvertebrate TIV score was 8.1 which is above the average of 6.8 for the Cedar River basin. The numbers of macroinvertebrate taxa collected that are intolerant to low DO were five, and the percentage of DO tolerant species collected were less than one. The average number of intolerant taxa collected in the Cedar River basin was 4.6 and the average percentage of DO tolerant taxa was 20.The index score for the fish was 6.2 which are below the average for the Cedar River Watershed (7.2). Low DO is not likely the cause of the overall stress to the biological community in Woodson Creek at this time, but it cannot be completely ruled out.

9.1.5. Candidate cause: High phosphorus

There was only one sample of phosphorus (0.062 mg/L) that was taken at time of fish sampling on June 29, 2009. This sample was below the standard of 0.15 mg/L. There was no BOD or chlorophyll-a data available on this reach.

There was also an absence of collector-filterers which would likely increase with increases in algae. The intolerant macroinvertebrates were completely absent. The percentage of scrapers was 1.2%, which was below the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus.

The carnivorous fish in this reach make up 33% of the fish community. Carnivorous fish often decrease with increases in phosphorus. The sensitive fish taxa lacks relative to the total taxa present. The tolerant individuals comprise of 64.8% of the total fish individuals surveyed, resulting in a low metric score. There was a lack of sensitive individuals, predators and decreased taxa richness.

With the lack of elevated phosphorus, it is currently inconclusive if elevated phosphorus is a stressor to the biological community. Phosphorus should be continued to be collected to understand the nutrient dynamics in this system.

9.1.6. Candidate cause: High suspended sediment

During fish sampling the TSS concentration was very low, at 2 mg/L. There was no turbidity or TSVS data available for this reach. There are five transparency tube readings in the year 2012. Of those five samples, one reading was below 20 cm (poor). This sample was during low flow conditions and cows were observed in the stream just upstream of the sample.

Biological station 09CD048 had a low percentage of scrapers (1.22 %). Additionally, biological station 09CD048 had a low percentage of collector-filters (8 %) in 2009. Collector-filterers are reduced when TSS is elevated. Collector-filterer species collect their food by filtering it from the water column. TSS may have been low with the normal and below normal flow conditions, 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.

In 2009, the fish community at biological station 09CD048 had a low percentage of herbivores (6.48 %) and the percent carnivore metric (33.33%) was below average for coldwater sites statewide (47%). The percent carnivore metric is expected to decrease with increases in TSS. Biological station 09CD048 was just over the average TSS station index score for fish for coldwater stations in Minnesota.

The biological communities indicate that TSS may be a concern; however it is difficult to conclude due to the lack of chemistry data. Additional TSS data should be collected at this location.

9.1.7. Candidate cause: Temperature

A continuous temperature logger was deployed at biological station 09CD048 from May 19, 2009 through September 1, 2009 (Figure 126). The July monthly average was 12.07 degrees Celsius, with a maximum of 16.70 degrees C. In August the average temperature was 11.89 degrees C with a maximum of 16.65 degrees C. A second continuous temperature logger was deployed in Woodson Creek west of 4th St SE, 1 mile south of Austin from April, 18, 2012 through September 1, 2012 (Figure 127). The late summer time period is most important to consider when determining if the stream is responding to the warm summer air temperatures. The July monthly average was 15.24 degrees C, with a maximum of 21.94 degrees C. In August the average was 13.6 degrees C, with a maximum of 20.08 degrees C. The year 2012 was a very dry year with low flows. The July maximum temperature is above optimum for coldwater systems.

The macroinvertebrate CBI (coldwater biotic index) metric scored above the average needed to be above the IBI threshold (Figure 122). This indicates adequate coldwater macroinvertebrate taxa are present in adequate numbers in Woodson Creek. The MPCA did not collect any coldwater fish species, but collected 27 pearl dace during biological sampling which are cool water species, along with a dozen brook sticklebacks. The fish community present shows a lack of coldwater fish species, which can indicate thermal degradation, but can also respond to other stressors. The continuous 2012 data does suggest the water was slightly warmer than optimal for coldwater species due to the low flow conditions that year. Temperature was not identified as a stressor to aquatic life in Woodson Creek at this time, but should continue to be evaluated to ensure adequate temperatures remain within this reach as well as downstream of the biological station.

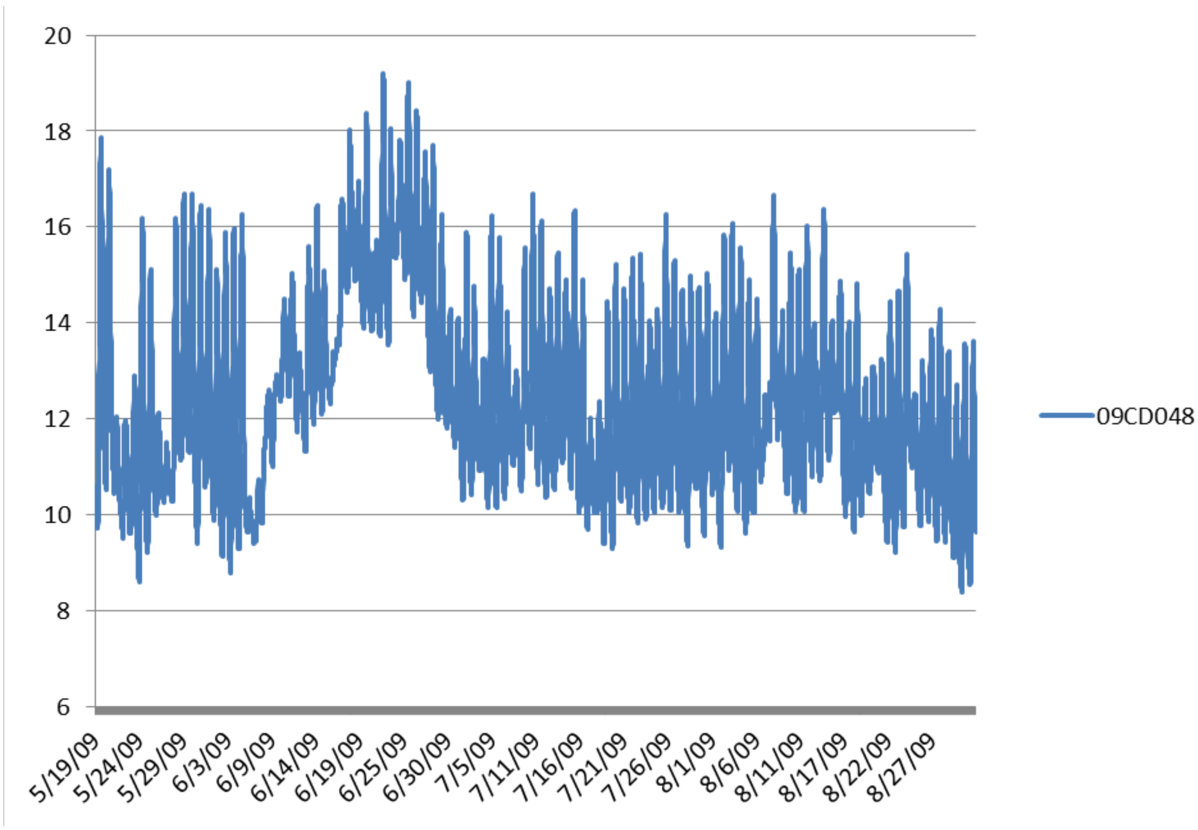


Figure 126: Water temperature measured in 15 minute intervals collected in Woodson Creek (-554) from May 19 through September 1, 2009.

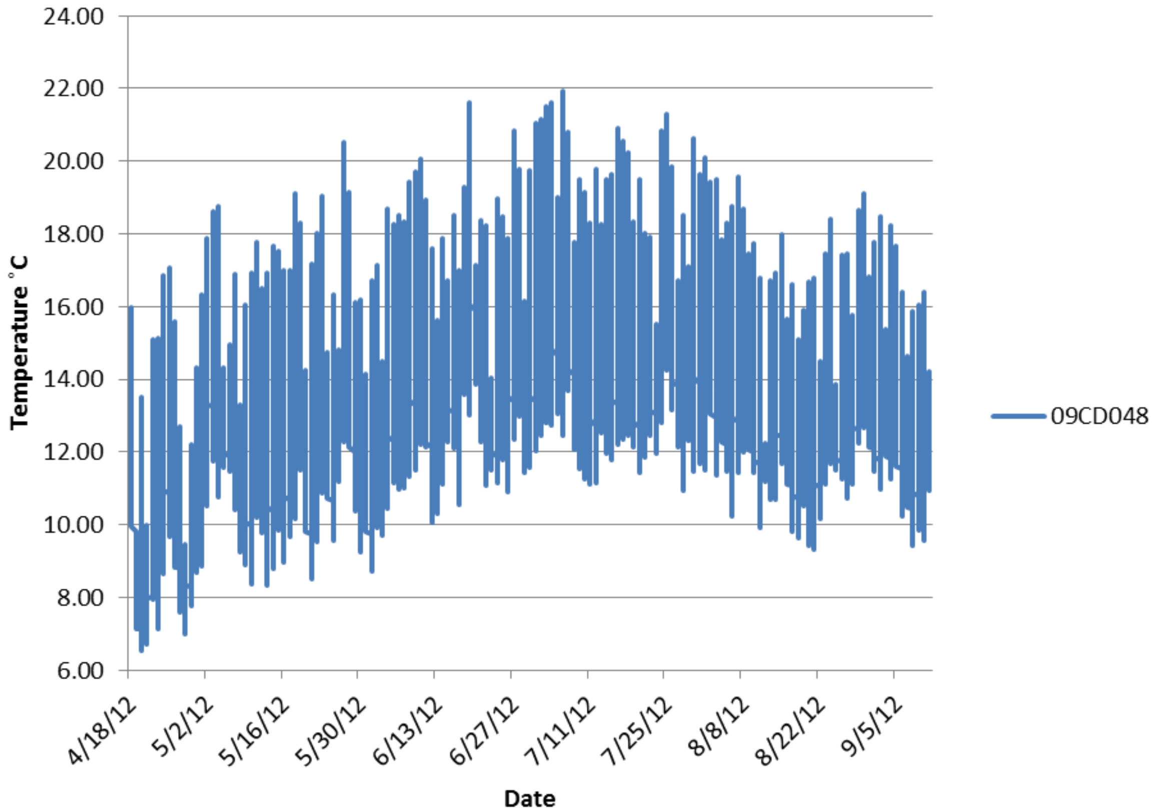


Figure 127: Water temperature measured in 15 minute intervals collected in Woodson Creek (-554) from April 18 through September 11, 2012.

9.1.8. Conclusions

Woodson Creek is the only MDNR designated coldwater stream in the Cedar River Watershed. The fish and macroinvertebrate communities are impaired for aquatic life. Surveys done by the MDNR reported that brook trout were once present in Woodson Creek but a survey done by the MPCA in 2009 did not report brook trout.

The stressors found in this reach are summarized in Table 68. Habitat is causing stress to the macroinvertebrate and fish communities. Lack of suitable and diverse habitat is a stressor to both the fish and macroinvertebrate communities in this reach. There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Flow alteration is a stressor to the biological community. A report done by the MDNR in 1980 mentioned that private landowners built a rock dam that may have interrupted the natural flow and migration of brook trout. Landowners also dug wide ponds that filled in with silt and created a habitat for undesirable species which competed with trout. There are biological indications that TSS may be a concern, yet findings are inconclusive due to limited data. TSS data for a range of flows should be collected in Woodson Creek. With the lack of elevated phosphorus, it is currently inconclusive if elevated phosphorus is a stressor to the biological community. Phosphorus should be continued to be collected to understand the nutrient dynamics in this system. Dissolved oxygen, nitrate and temperature we not considered a stressor to the aquatic life in Woodson Creek at this time.

Table 68: Summary of stressors found in the unnamed creek (-554).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors						
			Habitat	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Temperature	Flow alteration
07080201-554 unnamed creek (Woodson Creek) T102 R18W S14, north line to Cedar River	09CD048	Macroinvertebrate IBI F-IBI	•			o	o		•

• = stressor; o = inconclusive stressor; 'blank'-not an identified stressor

9.2. Cedar River: Turtle Creek to Rose Creek (AUID: 07080201-515)

This listed reach is non-supporting of aquatic life for aquatic macroinvertebrate communities and turbidity. This stretch of the Cedar River is 2.99 miles long. It runs from the confluence with Turtle Creek and ends at the confluence of Rose Creek (Figure 121).

A load monitoring station is located on the Cedar River on CSAH 28 south of Austin represented by MPCA EQuIS station S000-001 and this is also a longer-term USGS flow monitoring station. Intensive water quality sampling is collected annually at this site. Roughly 35 grab samples are collected with sampling frequency greatest during periods of high flow. Low flow periods are sampled less frequently as concentrations are generally more stable when compared to periods of elevated flow. Annual pollutant loads and flow weighted means are calculated for total suspended solids (TSS), dissolved orthophosphate (DOP), total phosphorus (TP), nitrate-nitrite nitrogen (NO3 + NO2-N) and total Kjeldahl nitrogen (TKN). Data from this station was used to determine stressors.

One biological station (09CD069) was sampled twice for fish and once for macroinvertebrates in 2009 on this stream reach. The biological station is near the end of the AUID just above CSAH 28 and a mile south of Austin.

Water quality sampling was done at EQuIS station S000-001 on CSAH 28, just downstream of the biological station. Water quality data from 2007 to present were used to determine stressors.

The Austin WWTP, Austin Utilities Plants and Hormel Foods Company (cooling water) discharge upstream of this stream reach.

9.2.1. Biology in the Cedar River

The macroinvertebrate community is not meeting standards for station 09CD069. The macroinvertebrate IBI was 22.22 which were below the threshold of 46.8 and below the lower confidence interval for the Southern Forest Streams GP class (Table 69). The F-IBI was 45 which were just below the threshold of 46 and the second visit was 68 in August, which was above the threshold of 46 for the Southern Rivers class. The Minnesota Department of Natural Resources also had a station in 2008 in this reach that scored above the threshold.

Table 69: Summary of biological impairments in Cedar River.

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-515, Turtle Creek to Rose Creek	09CD069	Cedar River	397.83	Southern Forest Streams	46.8	22.22	Southern Rivers	46	45 & 68

Biological station 09CD069 had nine metrics below the average metric score needed for an IBI score greater than the threshold (Figure 128). Macroinvertebrates in the class Southern Forest Streams GP scored poorly in the metrics of collector-filterers (Collector-filtererPct), a measure of pollution based on tolerance values assigned to each individual taxon (HBI_MN), Plecoptera, Odonata, Ephemeroptera and Trichoptera taxa (POET) and Trichoptera (TrichopteraChTxPct), taxa richness of predators (Predator) and non-hydropsychid caddisflies (TrichwoHydroPct)at biological station 09CD069. This stream reach was also lacking intolerant taxon (intolerant2Ch). Five species dominated the sample (DomFiveCHPct; 89%) and the percent tolerant taxon was relatively high (Tolerant2ChTxPct; 85%).

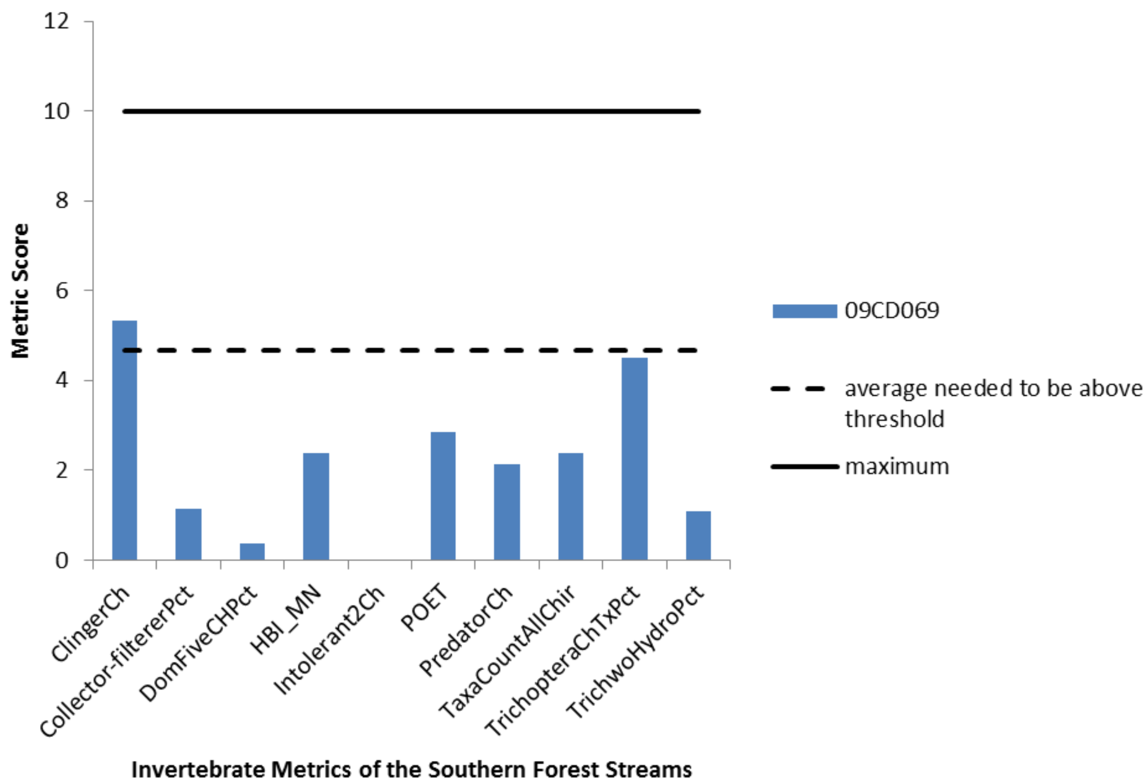


Figure 128: Macroinvertebrate metrics of the southern forest streams in station 09CD069 in the Cedar River.

Station 09CD069 was sampled twice, once in July 2009 and a follow up visit in August 2009. The July visit resulted in an IBI score below the threshold, although the sample in August 2009 was better than in July (Figure 129). Both times the station lacked piscivores (Piscivore). Serial spawner taxa (SSpnTxPct) decreased in the August sample. In 2009, this stream reach did not have fish DELTs, that if present, would have contributed negatively to the IBI.

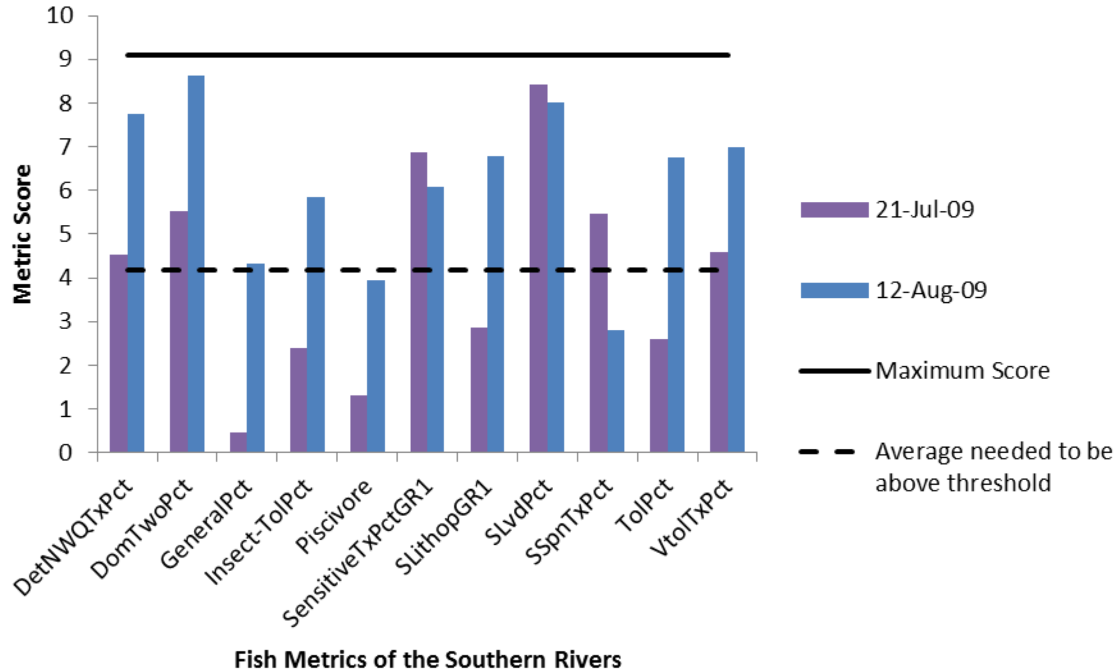


Figure 129: Fish metrics of the southern rivers in station 09CD069 in the Cedar River.

9.2.2. Candidate cause: Lack of habitat/bedded sediment

The Cedar River at biological station 09CD069 scored 59.7(fair) on the MSHA (Table 70). Of the five subcategories in the MSHA, land use, substrate, cover and channel morphology scored poorly. The field crew noted that the site had normal flow and the water was brown in appearance. The field crew also noted the Cedar River had moderate/high channel stability. This reach only contained 5% riffle and was dominated by sand and cobble, with moderate embeddedness. Sand substrate is dominant in the pools. This stream reach lacks riffle habitat.

The surrounding land use was noted as row crop and residential with a wide (150 to 300 ft) riparian buffer. There is little bank erosion on the left and right banks (Figure 130). Sparse cover was noted, with multiple cover types including undercut banks, overhanging vegetation, deep pools, logs or woody debris, boulders, rootwads and macrophytes. The only habitat available to sample for macroinvertebrates was rootwads.

The MDNR conducted a geomorphology survey on the mainstem Cedar River 2,500 feet upstream of the Country Road 5 crossing. This stream reach is classified as a C4/1 stream type with gravel bed having bedrock grade control. The bedrock grade control occurs at 93 feet elevation on the longitudinal profile (Figure 132). The bedrock is providing both horizontal and vertical confinement of the channel. The site supports a steeper slope which has more stream power reflecting in larger bed materials and more effective sediment routing. The pool and riffle quality in this stream reach is fair to good and not overwhelm with excess bedload (Figure 131). Stream bank erosion is less notable in this reach and is likely due to the bedrock features limiting the erosion of the stream banks and the stream bed. Using the Bank Assessment for Non-point source Consequences of Sediment (BANCS) assessment method, an estimated erosion rate of 0.101 tons/year/foot from the mouth of the Turtle Creek downstream to the Iowa boarder was used to develop a total sediment load estimate for this reach of the Cedar River. The study reach is located in valley type VIII, which is a wide, gentle valley slope with well-developed flood plain adjacent to river and/or glacial terraces.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

Burrowers, percentage of EPT individuals, percentage of generally tolerant legless macroinvertebrate individuals were below the average of the Southern Forest Streams GP class (Figure 133). The macroinvertebrates that are known to cling to large substrate and woody debris were lacking (below statewide averages for this class), likely due to the lack of woody material that is not available to support these individuals. Clingers can decrease in stream reaches with homogenous substrate composition, velocity, and depth (CADDIS). The percentage of sprawlers was abnormally high compared to statewide averages (84.66%). Sprawlers can be found in areas with excess sediment, and generally do not prefer rocky substrate, but are more common with smaller fine substrates.

Given the lack of quality diverse habitat types (only rootwads was sampled), homogenous sand substrate, substrate embeddedness, reduced percentages of particular macroinvertebrate groups and an increase in sprawlers, habitat is considered a stressor to this reach.

Table 70: MSHA results for Cedar River.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
2	09CD069	Cedar River	0.8	11.3	18.15	9.5	20	59.7	Fair

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA>66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

Figure 130: Biological station 09CD069 (left) and EQuIS station S000-001 (right).

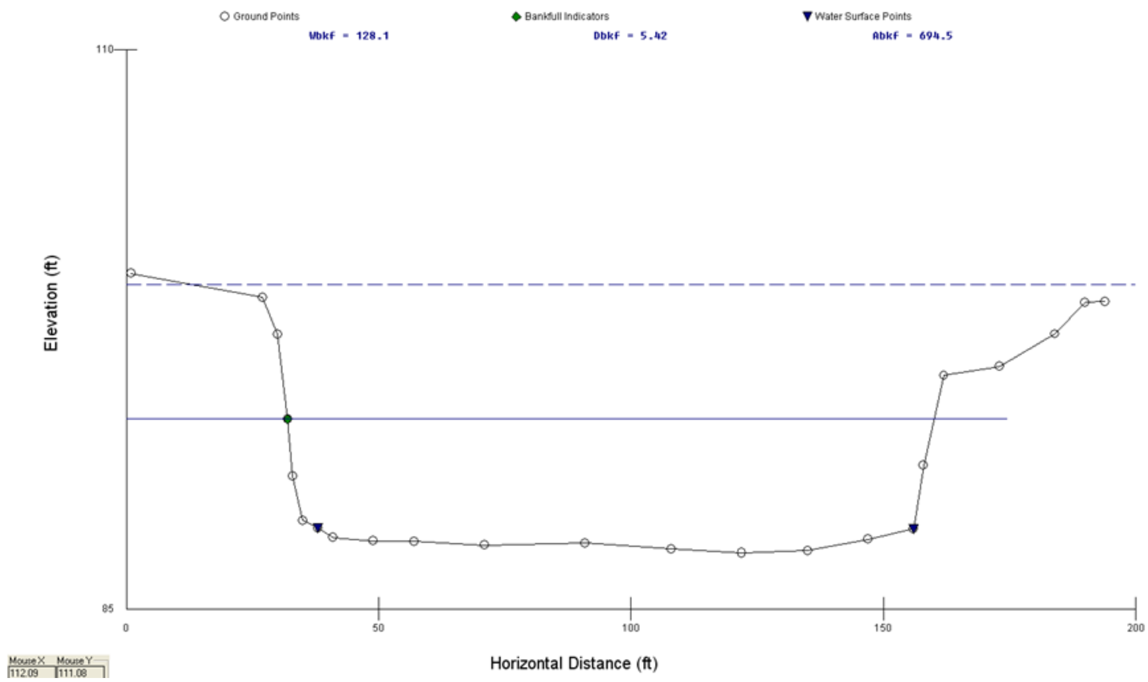


Figure 131: Riffle cross section on the Cedar River below Austin, MN.

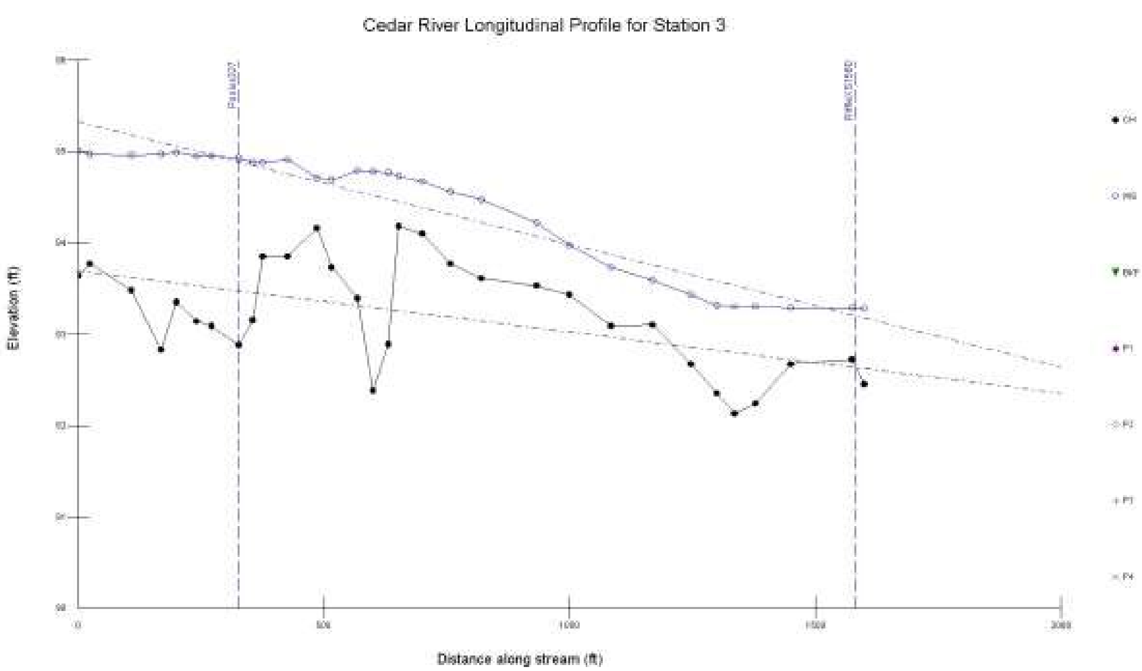


Figure 132: Stream channel longitudinal profile for Reach 2 on the Cedar River.

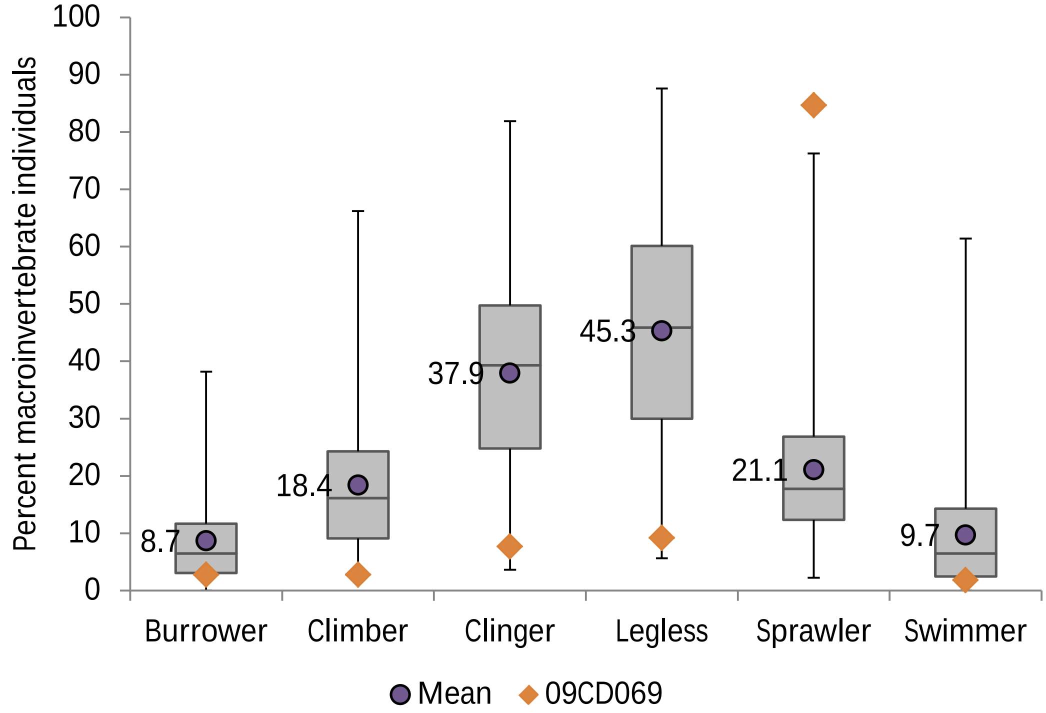


Figure 133: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Forest Streams GP stations with M-IBI greater than 46.8 (threshold), mean of those stations, and metric values from station 09CD069.

9.2.3. Candidate cause: High nitrate-nitrite

Nitrate in this AUID has been elevated as high as 19 mg/L on June 25, 2012 and the lowest nitrate sample was 2.2 mg/L on February 11, 2009 (Figure 134). Nitrate was sampled 235 times from 2007 through 2012 at station S000-001. Observed nitrate is high throughout the entire year. Nitrate was 7.5 mg/L during fish sampling on July 21, 2009 at biological station 09CD069. Unionized ammonia was observed to be below the standard in this reach. Austin WWTP has reported seven effluent nitrate values between September 2012 and September 2013 ranging from 42.7 mg/L to 82.9 mg/L with an average of 69.9 mg/L.

The macroinvertebrate community shows an indication of stress from nitrate. The macroinvertebrates in this reach were made up of 85.2% tolerant taxa and lacked intolerant taxa. Biological station 09CD069 was lacking non-hydropsychid Trichoptera in 2009. Trichoptera are often considered sensitive to nitrate and respond with decreases in taxa. At station 09CD069, there were 12.8% nitrate tolerant macroinvertebrates, with 16 nitrate tolerant taxa and no nitrate intolerant taxa. Nitrate is a stressor to the biological community within this reach.

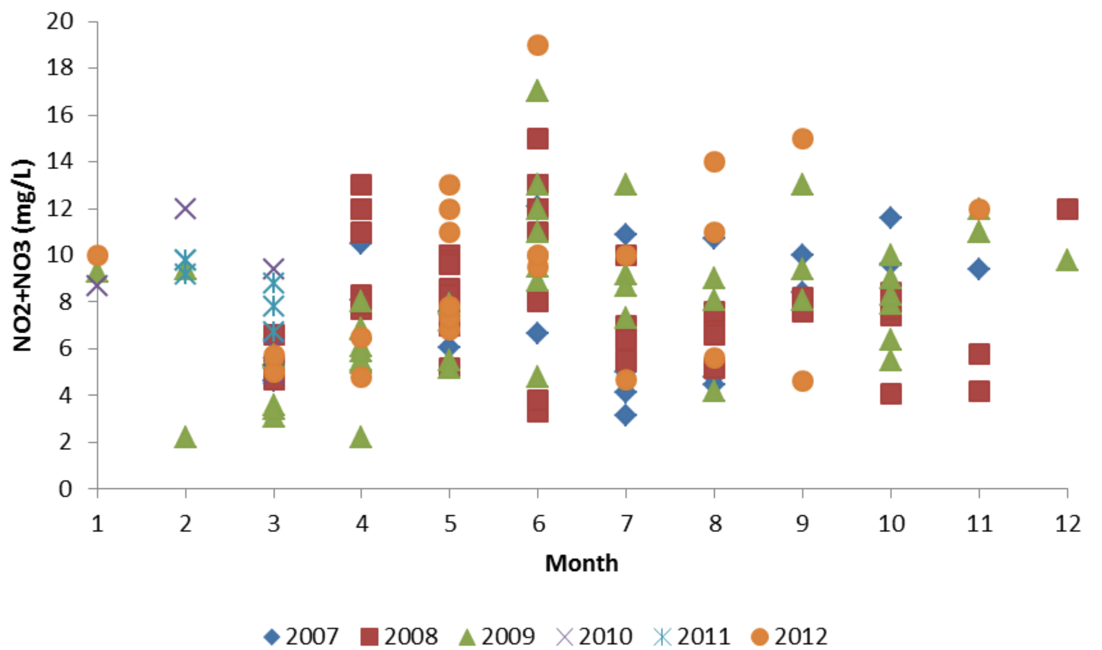


Figure 134: Nitrate-nitrite levels for the Cedar River (-515) by month and by year.

9.2.4. Candidate cause: Low dissolved oxygen

DO concentrations during biological sampling were 12.75 mg/L on July 21, 2009 and 5.4 mg/L on August 12, 2009. Field measurements taken with DO probe were taken during the summer months from 2007 through 2012, and show a range from 4.64 to 14.06 mg/L. A continuous multi-parameter sonde was deployed from July 17, 2012 through July 30, 2012 at the load monitoring station located on the Cedar River on CSAH 28. DO measurements taken in 15 minute increments shows measurements below 5 mg/L. The daily DO flux was well above the daily flux standard of 4.5 mg/L each day recorded except for one with a DO flux of 4.05 mg/L (Figure 135). Daily flux was recorded as high as 10.79 mg/L. Diurnal DO ranged from 2.92 to 15.01 mg/L and an average concentration of 5.91 mg/L. During this time, the flow was very low and air temperatures were warm. These are critical conditions for low DO.

The macroinvertebrate community DO TIV index score for 09CD069 is 6.9, which is slightly better than average for the Cedar River basin (6.8). The number of DO intolerant species is less than average at 3 (average Cedar River basin is 4.6). There are only 3.4% tolerant to low DO species, which is less than the average of 20%. The macroinvertebrate survey in station 09CD069 had 18 taxa (with chironomid and baetid taxa each treated as one taxon), below the average taxa count for the Southern Forest Streams macroinvertebrate class for the Cedar River Watershed of 20.27. Taxa richness can be decreased with increases in DO flux. Also a low percentage of EPT taxa are present at this site. EPT taxa are typically intolerant of low DO levels. The macroinvertebrate community is signaling DO stress.

In terms of the macroinvertebrate community, in this reach tolerant individuals were high (60.23% of the total population and a total of 8 species). Sensitive individuals were also low (15.85% of the total population). Station 09CD069 had a low presence of sensitive species (38.10% of the total population). Often low DO results in a decrease in sensitive taxa and an increase in tolerant taxa.

The ranges in DO (flux) observed are a cause of concern. The average daily flux was 6 mg/L (draft standard is 4.5 mg/L) indicating a potential stressor related to nutrients. Based on low EPT percentages, the lower than average number of intolerant DO species, DO is a stressor to the macroinvertebrate community in the Cedar River from Turtle Creek to Rose Creek.

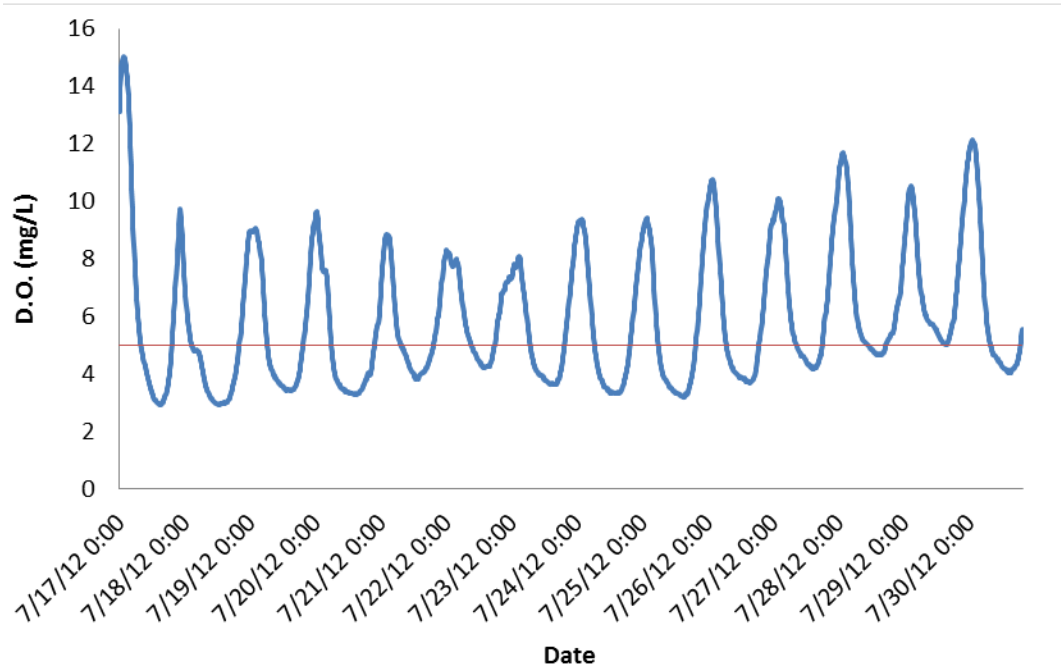


Figure 135: Dissolved oxygen measured in 15 minute intervals at sampling location S000-001 from July 17 to July 30, 2012.

9.2.5. Candidate cause: High phosphorus

Phosphorus in this reach was elevated above the standard in the Cedar River (Figure 136). Total phosphorus was measured 237 times between 2007 and 2012 with a range of 0.115 mg/L and 1.87 mg/L. The average total phosphorus concentration was 0.384 mg/L. There were 14 pH readings over 8.5 (8.51-9.08) at station S000-001. The limited chlorophyll-a data was below 35 µg/L and there was no BOD data for this AUID. The Austin WWTP has reported effluent phosphorus concentrations in the 5 mg/L to 9 mg/L range. There are weekly phosphorus samples that go back to 2002. During the last two weeks of July 2012 when the DO sonde was deployed, Austin reported effluent concentrations of 7.34 mg/L and loads in the 140 kg/day range. The DO was discussed in the previous section, and showed there was low DO, along with high flux making it possible that the high phosphorus is a contributor to the low DO conditions.

In this reach of the Cedar River, intolerant macroinvertebrates were lacking. Along with the low metric scores for the modified Hilsenhoff Index for Minnesota, a high percentage of EPT taxa (18.5%) above the average for the Cedar River Watershed (17%), and a moderate amount of tolerant taxa (85.2%). It is likely that high phosphorus is altering the macroinvertebrate community.

In 2009, this reach had a low percentage of carnivorous fish (13%) in July and above average (14.7%) in August compared to the average of 14% for the Cedar River Watershed. Carnivorous fish often decrease with increases in phosphorus (MPCA River Nutrient Criteria Development, 2013). This reach has a moderate percentage of sensitive fish taxa relative to the total taxa present, and the non-tolerant insectivores were also present in acceptable percentages. It does, however, have a range of generalists ranging from 36.6 to 61.7% of the total fish population which translates to a metric score of 4.8 and 0.5. The tolerant individuals comprised 60.2 and 25.2% of the total fish individuals surveyed. Although high phosphorus is a likely stressor, it is not the only stressor contributing to the degraded condition of the biological communities.

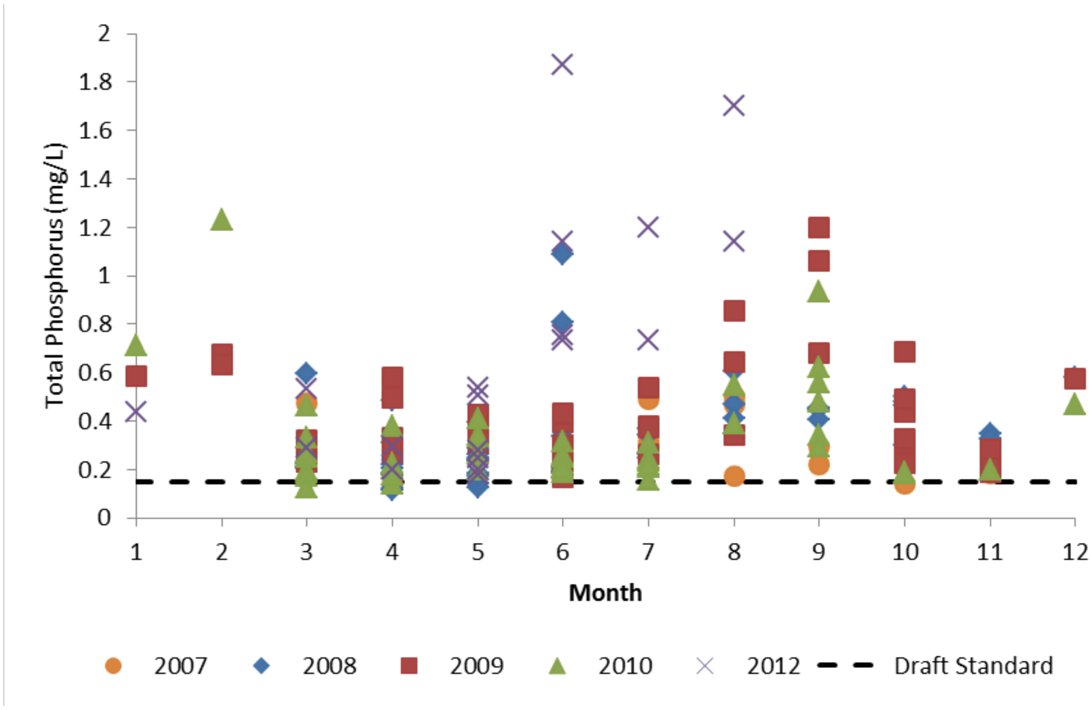


Figure 136: Total phosphorus by month for the Cedar River (-515) in 2007 through 2012.

9.2.6. Candidate cause: High suspended sediment

This reach is impaired for turbidity. TSS during the fish visit on August 12, 2009 was low (1.2 mg/L), along with an excellent transparency tube reading (80 cm). This reach has elevated suspended sediment and turbidity readings, corresponding with the turbidity listing (Figure 137). The transparency values ranged from 2 cm to >100 cm. The average value was 46 cm, and the maximum value was >100 cm. Finally, the turbidity was measured 18 times in 2007. The turbidity values range from 4 NTU to 93 NTU. The average turbidity value was 18.3 NTU, and the maximum was 93 NTU. The higher TSS values are during higher flow conditions.

The biological station visit had macroinvertebrate TSS station index score was better than average compared to the average stations in the Cedar River Watershed (Table 71). Additionally, the percentage of TSS tolerant individuals was low, and the stations were not dominated by TSS tolerant taxa. The generally intolerant macroinvertebrate taxa and long-lived often decrease with increases in TSS. A slight response to this is shown in 2009, but it is not overwhelming. The invertebrates are likely responding to another stressor present, not TSS. TSS is not considered a stressor to the Cedar River at this time.

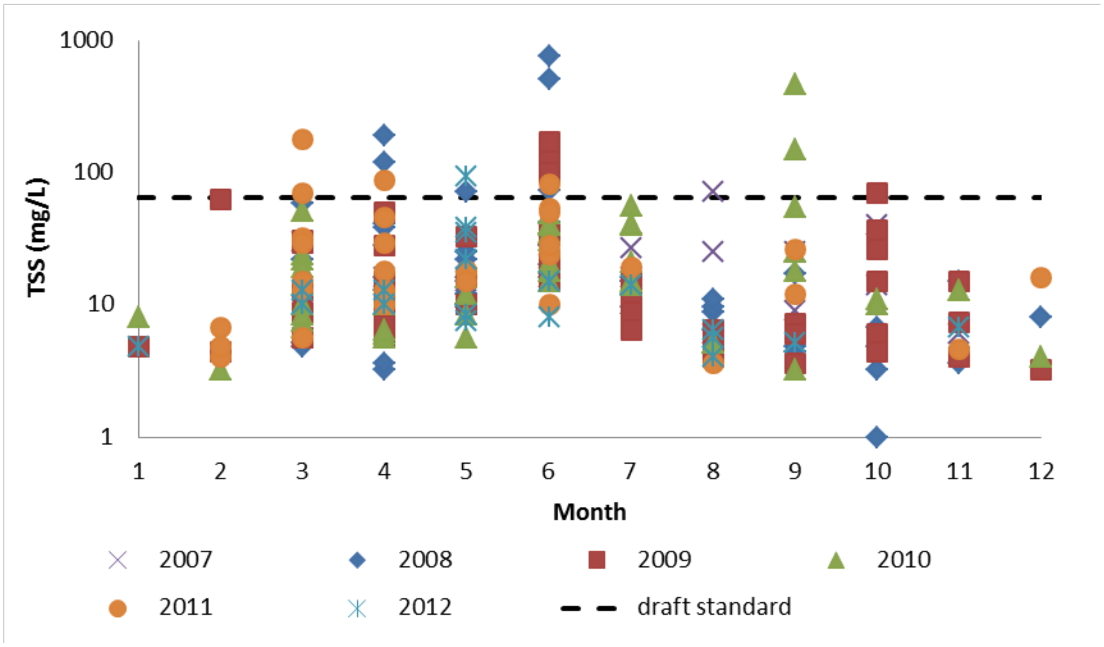


Figure 137: Total suspended solids by month for the Cedar River (-515) in 2007 through 2012.

Table 71: Macroinvertebrate metrics relevant to TSS for stations in the Cedar River compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
09CD069	10.8	**0**	8	6.9	**0**	**4**
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

9.2.7. Conclusions

The stressors found in this reach are summarized in Table 72. The stressors to the macroinvertebrate community in this reach of the mainstem Cedar River is habitat, nitrate, phosphorus, and low DO. The biological and chemical data all provide good evidence that these stressors are playing a role in shaping the macroinvertebrate community present here. Elevated nitrate and total phosphorus levels and DO fluctuations are the primary stressors to the macroinvertebrate community. The impact of the Austin WWTP is known to contribute to excess phosphorus concentrations and that preliminary data suggest that it is a significant source of nitrate. Nutrient management of both nitrogen and phosphorus is needed throughout the watershed.

The lack of quality diverse habitat types (only rootwads was sampled), homogenous sand substrate, and reduced percentages of particular macroinvertebrate groups, habitat is considered a stressor to this reach. Currently, it appears there are multiple drivers that could be responsible for the changes in suspended sediment and habitat dynamics seen in the main stem Cedar River. There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. These are system-wide changes, which become cumulative in nature, and do affect the stream biota. It is not fully understood the relative contribution each of these variables has on the entire Cedar River system, therefore the link to stressors is unknown. Flow alteration is a driver for sediment and habitat issues in the mainstem.

Regardless, the majority of the changes which will improve the macroinvertebrate community in the mainstem Cedar River are needed on an entire watershed-wide scale, and will take many years to implement. Most changes that are localized may not have success, or be sustainable if the larger river system contributions are not addressed.

Table 72: Summary of stressors found in the Cedar River (-515).

AUIDReach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors					
			Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-515 Cedar River Turtle Creek to Rose Creek	09CD069	Macroinvertebrate IBI	•	•	•	•		•

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

9.3. Cedar River: Rose Creek to Woodbury Creek (AUID: 07080201-501)

This 10.3 mile long stream segment, Rose Creek to Woodbury Creek is part of the Cedar River Watershed in Mower County (Figure 121). This listed reach is non-supporting of aquatic life for fish and macroinvertebrate communities and also for turbidity.

Three biological stations (09CD069, 04CD002 and 04CD024) were sampled for fish and macroinvertebrates in 2004 and in 2009 on this stream reach. The biological stations are spread out along this stretch of the Cedar River. Biological station 04CD002 is located east of Highway 105, six miles south of Austin. One mile upstream of CSAH 6, three miles northwest of Lyle is biological station 04CD024 and biological station 09CD065 is upstream of 170th Street, four and a half miles south of Austin.

Water quality sampling was done at EQuIS stations S000-222, S000-136 and S001-381. The water quality stations were spread out along this stretch of the Cedar River. Water quality data from 2003 to present were used to determine stressors.

9.3.1. Biology in the Cedar River

The macroinvertebrate community is not meeting standards for all three stations. The macroinvertebrates are doing better at the top of the AUID and decrease towards the bottom of the river reach. The macroinvertebrate IBIs were 30.53 at biological station 04CD002 and 28.87 at biological station 04CD024 which both were below the threshold of 30.7 and above the lower confidence interval for Prairie Forest Rivers (Table 73). The macroinvertebrate IBI at biological station 09CD065 was 35.54 which were below the threshold of 35.9 and above the lower confidence interval for the Southern Forest Streams RR class. The F-IBI was 35 at both biological stations 04CD002 and 04CD024 which were below the threshold of 46 and at the lower confidence interval for the Southern Rivers class. At biological station 09CD065 the F-IBI was 54 which were above the threshold of 46 and above the lower confidence interval for Southern Rivers. Additionally, there is an MDNR station from 2002 that falls between the two stations sampled in 2004 and the IBI score was below the threshold and at the lower confidence interval.

Table 73: Summary of biological impairments in the Cedar River.

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-501, Rose Creek to Woodbury Creek	04CD002	Cedar River	521.7	Prairie Forest Rivers	30.7	30.53	Southern Rivers	46	35
	04CD024	Cedar River	530.8	Prairie Forest Rivers	30.7	28.87	Southern Rivers	46	35
	09CD065	Cedar River	475.0	Southern Streams RR	35.9	35.54	Southern Rivers	46	54

Station 09CD065 had five macroinvertebrate metrics below the average needed for an IBI score greater than the threshold (Figure 138). Macroinvertebrates in the class Southern Streams RR scored poorly in the macroinvertebrates that climb (ClimberCh), metrics of a measure of pollution based on tolerance values assigned to each individual taxon (HBI_MN), predators (PredatorCh), relative percentage of taxa with tolerance values equal to or greater than six, using MN Tolerance Values (Tolerant2ChTxPct),and taxa richness of Trichoptera. The biological station also lacked stoneflies (Plecoptera). It was overly abundant with tolerant taxa (82%) as well.

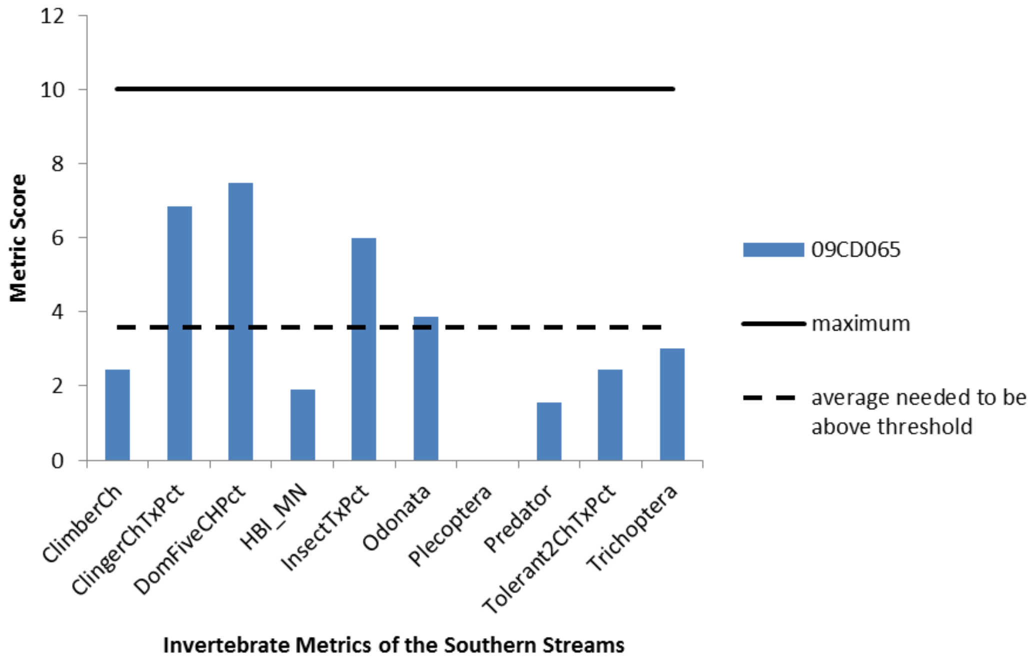


Figure 138: Macroinvertebrate metrics of the Southern Streams RR in station 09CD065 in the Cedar River.

Biological stations 04CD002 and 04CD024 were sampled for macroinvertebrates in AUID 501 (Figure 139). The low M-IBI scores are a result of degradation among multiple metrics. There are low metric scores for a measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN) and taxa richness of macroinvertebrates with tolerance values less than or equal to four, using MN TVs (Intolerant2lessCh) and relative abundance of non-hydropsychid Trichoptera individuals in subsample (TrichwoHydroPct). The lower biological station04CD024 had a low metric score of Odonata (dragonflies and damselflies) and predators were less abundant, and there were a higher percentage of very tolerant species (VeryTolerant2Pct).

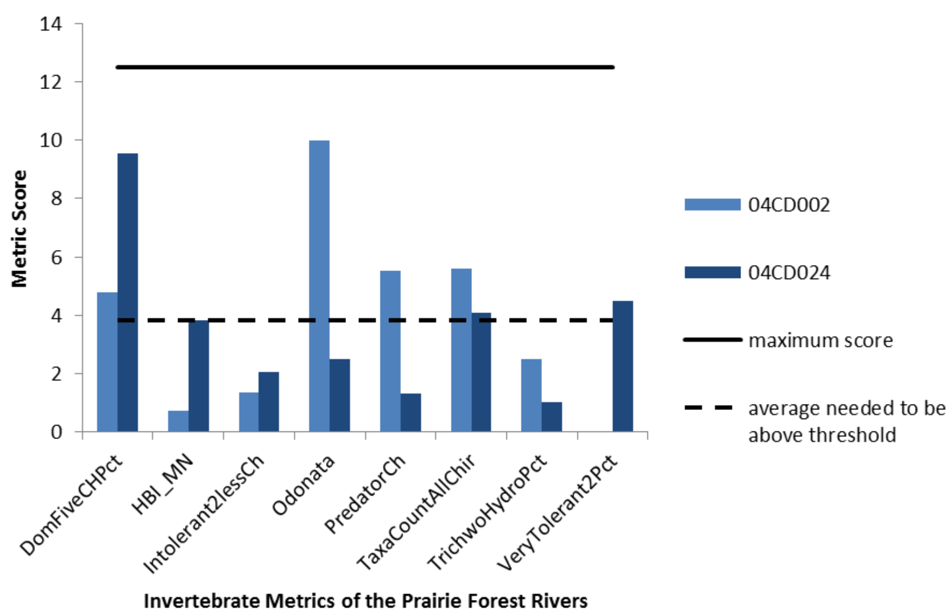


Figure 139: Macroinvertebrate metrics of the Prairie Forest Rivers in stations 04CD002 and 04CD024 in the Cedar River.

An analysis of F-IBI metrics of the Southern Rivers IBI show only two metrics were greater than the average metric score needed for the IBI to be above the threshold. The metrics that scored the poorest were: relative abundance (%) of individuals that are short-lived (SLvdPct), relative abundance of individuals that are tolerant species (TolPct), relative abundance of individuals that are insectivore species excluding tolerant species (Insect-TolPct) and relative abundance of taxa that are serial spawners (SSpnTxPct). This reach did not have fish DELTs, that if present, would have contributed negatively to the IBI.

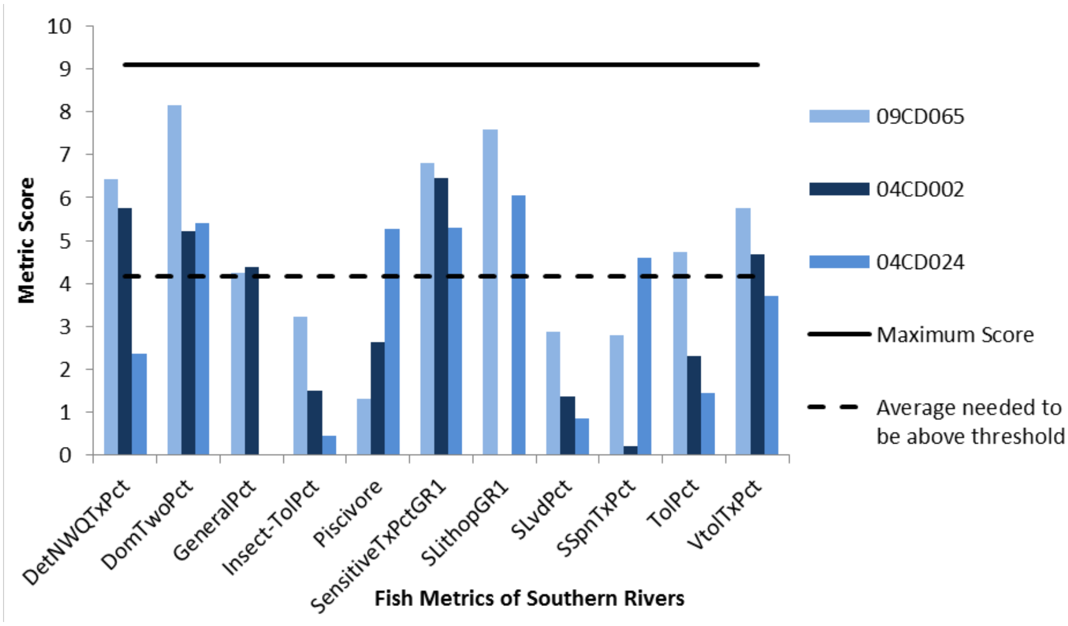


Figure 140: Fish metrics of the Southern Rivers in biological stations 09CD065, 04CD002 and 04CD024 in the Cedar River.

9.3.2. Candidate cause: Lack of habitat

Biological station 09CD065 is farthest upstream and scored 56.7 (fair), biological station 04CD002 scored 55.7 (fair) and biological station 04CD024 scored 61.5 (fair; Table 74). The water was stained and turbid with normal water level during the time of fish sampling at all three biological stations. This stream reach had 0-20% riffle habitat throughout the stream reach with cobble and gravel substrate with moderate (50–75%) embeddedness. This stream reach of the Cedar River lacked pools and 80-100% of the reach was a run.

The surrounding land uses was noted as row crop with moderate to wide (30 to 300 ft) riparian buffer on the left bank and narrow to wide riparian buffer (15 to 300 ft) on the right bank. Land use along the AUID is dominated by agriculture. There is little to moderate bank erosion on the left side and none to moderate erosion on the right bank (Figure 141). The middle biological station had light shade while the other biological stations had heavy shade. Sparse to moderate cover was noted, with multiple cover types including undercut banks, overhanging vegetation, logs or woody debris, boulders, rootwads and macrophytes. The habitat that was sampled for macroinvertebrates was woody debris/snags/rootwads and RR rock at all three biological stations. At biological station 04CD002 under cut banks and overhanging vegetation were also sampled. This stream reach of the Cedar River has moderate to high channel stability with fair channel development.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

The MDNR conducted a geomorphology survey on the mainstem Cedar River upstream of the Country Road 5 crossing (Figure 142). This stream reach is classified as a C4/1c- stream type with gravel bed containing considerable sand substrate. This reach is characterized as having a deeply incised channel where flood flows nearly not getting onto the floodplain (Figure 143). This stream segment also continues to incise and widen. As these changes occur, there will be increases in bank erosion, channel widening, sediment loading, deposition and average stream temperature. The study reach is located in valley type VIII, which is a wide, gentle valley slope with well-developed flood plain adjacent to river and/or glacial terraces.

There was an abundance of burrowers found at all three biological stations, which demonstrates sedimentation issues (18.4%, 14.7% and 11.4%; Figure 144 and Figure 145). The percentage of EPT individuals was above the statewide average for both stream classes (44.8%, 58.3 and 19.9%). The percentage of generally tolerant legless macroinvertebrate individuals was high at two of the biological stations (41.5%, 26.7% and 57.7%). The macroinvertebrates that are known to cling to large substrate and woody debris were high at the upper most biological station 09CD065 (above statewide average for Southern Streams RR), and the lower two biological stations were below the statewide average for Prairie Forest Rivers likely due to lack of woody material and coarse substrate that is available to support these individuals. The macroinvertebrates that are climbers were above the statewide average for Prairie Forest Rivers at biological station 04CD002. The percentages of macroinvertebrates that are considered sprawlers were below average, but swimmers were above the average for their stream classes except for biological station 04CD002.

All three biological stations 04CD002, 04CD024 and 09CD065 had a fish community fairly rich in riffle dwelling fish (21.1%, 33.3% and 23%). All three stations were below the average for stations in the Cedar River Watershed for non-tolerant benthic insectivores (4.3%, 12.1% and 1.7%) and darter, sculpin and round bodied suckers (4.3%, 11.2% and 1.2%). Two of the biological stations had low percentage of simple lithophilic spawners and the lower biological station 04CD024 was above the average for the Cedar River Watershed for relative abundance of individuals that are lithophilic spawners.

The high percentage of burrowers and legless macroinvertebrates, coupled with lower percentages of clingers indicate that habitat stress, especially at 04CD002. Site evidence and local land use support the notion that fine sedimentation is a major driver to substrate embeddedness and subsequent habitat loss found in this reach. Habitat is considered a stressor to the macroinvertebrate and fish communities in Cedar River (-501).

Table 74: MSHA results for the Cedar River.

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	04CD002	Cedar River	0	7.5	13.2	9	26	55.7	Fair
1	04CD024	Cedar River	0	10.5	19	12	20	61.5	Fair
1	09CD065	Cedar River	0	12.5	18.2	7	19	56.7	Fair
Average Habitat Results			0	10.2	25.2	9.3	21.7	57.97	Fair

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA>66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

Figure 141: Biological station 04CD002 on September 2, 2004 (top left), Biological station 04CD024 on September 9, 2004 (top right), biological station 09CD065 on July 22, 2009 (bottom left) and EQuIS station S000-222 on July 26, 2012 during low flow conditions.

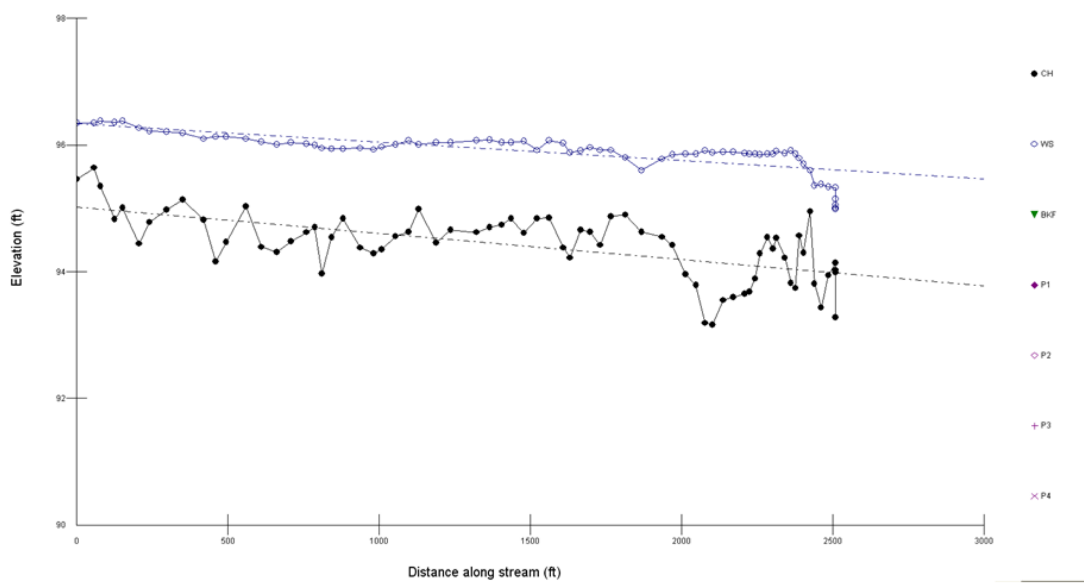


Figure 142: Stream channel longitudinal profile on the Cedar River below Austin, MN.

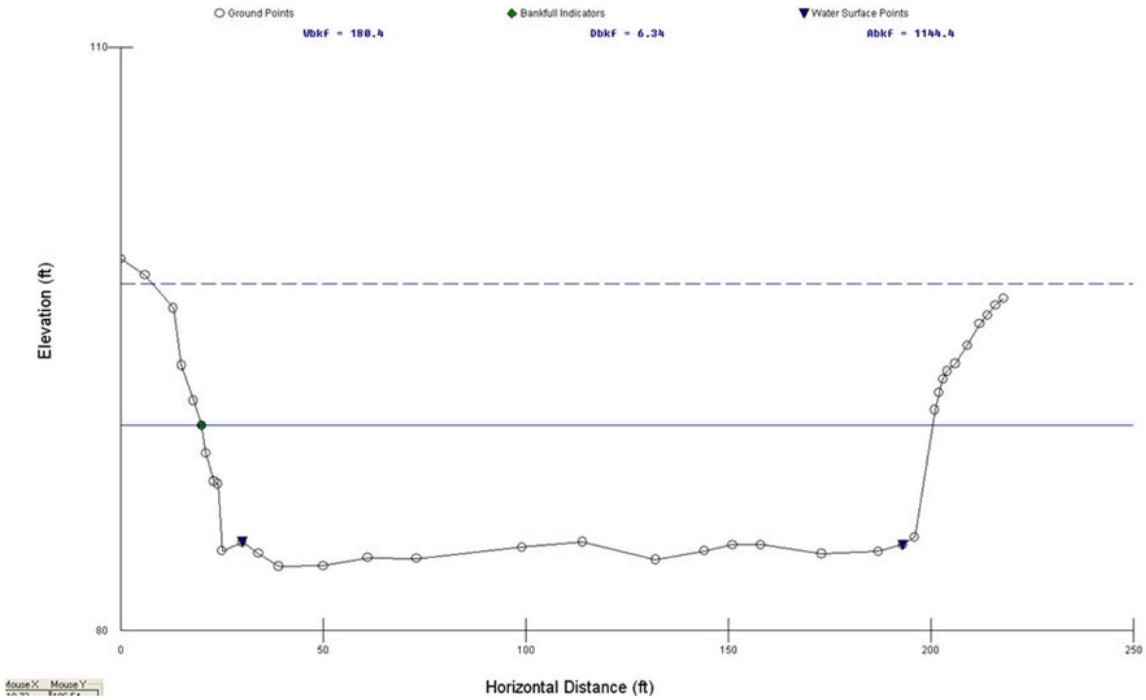


Figure 143: Riffle cross section on the Cedar River.

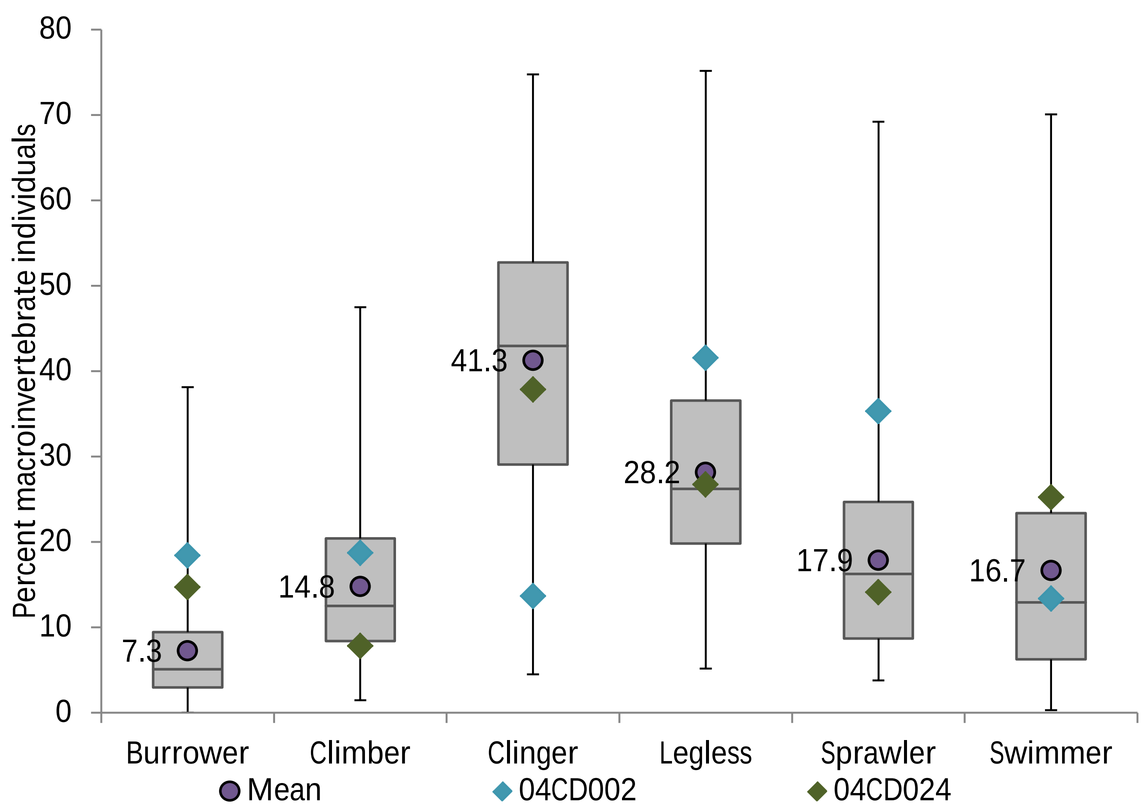


Figure 144: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Prairie Forest River stations with M-IBI greater than 30.7 (threshold), mean of those stations, and metric values from station 04CD002 and 04CD024.

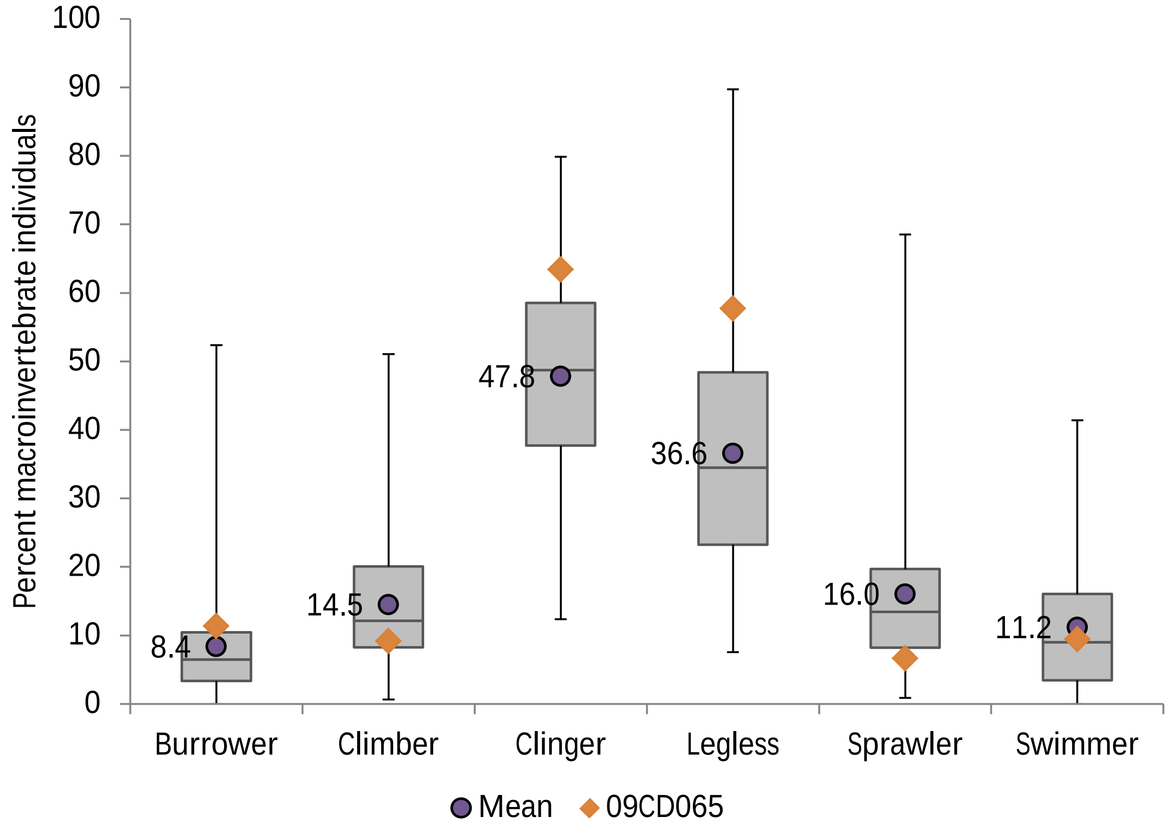


Figure 145: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel southern streams RR stations with M-IBI greater than 35.9 (threshold), mean of those stations, and metric values from station 09CD065.

9.3.3. Candidate cause: High nitrate-nitrite

Nitrate was 8.3 mg/L during fish sampling September 2, 2004, at biological station 04CD002. At biological station 04CD024, the nitrate value during fish sampling was 5.7 mg/L on September 9, 2004, and nitrate was 4.8 mg/L during fish sampling July 22, 2009, at biological station 09CD065. On this stream reach (-501), nitrate has been sampled for a total of 51 times in 1999 through 2001, 2003 through 2004, 2006, 2008 through 2009, and 2011 through 2012. The highest sample was 19 mg/L on June 24, 2004, while the lowest nitrate sample was 2 mg/L on February 11, 2009 (Figure 146). The highest observed nitrate levels are in May and June and drop through the summer. For the years noted above, the mean nitrate was 7.37 mg/L. Unionized ammonia is not a concern based on the data available.

At all three biological stations on this stream reach, less than 3% of the macroinvertebrate population was non-hydropsychid caddisflies. These caddisflies can respond to increased nitrate levels. The macroinvertebrates in this reach had a very high percent of tolerant taxa and lacked intolerant taxa. Nitrate tolerant macroinvertebrates ranged from 68% to 89% with 16-22 nitrogen tolerant taxa and 1-2 nitrate intolerant taxa on this stream reach.

Fish lack strong biological response evidence in relation to elevated nitrate. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration. In terms of the fish community, stations in this reach the total number of fish taxa at the stations within this reach range from 5 to 10 with sensitive taxa decreasing longitudinally from the confluence with Turtle Creek to the confluence of Rose Creek. The sensitive taxa make up 26 to 38% of each of the surveyed fish populations, which are all above the average for the Cedar River Watershed (14.8%). Sensitive taxa may be indicative of high nitrate levels. The tolerant fish individuals make up 42 to 70% of the surveyed fish communities. The stations also have fish that mature in less than two years (80%-94%). Nitrate is a primary stressor to the biological community in the Cedar River (-501).

Figure 146: Nitrate measurements collected within the Cedar River (-501).

9.3.4. Candidate cause: Low dissolved oxygen

Dissolved oxygen concentrations during biological sampling were 11.0 mg/L on September 2, 2004, at biological station 04CD002, 11.75 mg/L on September 4, 2004, at biological station 04CD024 and 6.96 mg/L on July 22, 2009, at biological station 09CD065. Field measurements have been taken since 1967, but only those from the most recent 10 years (2003 through 2012) were analyzed, and show a range from 6.15 to 18.25 mg/L. There were no measurements before 9 a.m. A continuous multi-parameter sonde was deployed from July 31, 2012, through August 15, 2012 (Figure 147). DO measurements taken in 15 minute increments shows measurements below 5 mg/L during the first couple days and stays just above 5 mg/L during the remainder of the time. During this time, the flow was low and air temperatures were warm. These are prime conditions for low DO. Diurnal DO ranged from 4.34 to 16.53 mg/L and an average concentration of 9.04 mg/L. The average daily flux was 8.09 mg/L. The proposed water quality standard for DO flux in the south region of the state is 4.5 mg/L; a flux above this indicates a potential stressor related to nutrients. Elevated daily DO fluctuations can be stressful on aquatic communities. Plant and algal respiration and photosynthesis are considered the primary drivers of daily flux in DO. Interacting variables include increased temperature, lack of habitat, and lack of shading, all of which are present in the Cedar River. Phosphorus concentrations are high, algal growth is present in the stream.

The macroinvertebrate community DO TIV index score for biological station 04CD002 is 7.3, biological station 04CD024 is 7.5 and biological station 09CD065 is 6.9, which were greater than average for the Cedar River basin (6.8). The number of DO intolerant species is greater than average at six and seven (average for the Cedar River basin is 4.6). There were 4.06% to 23.49% tolerant to low DO species. Biological station 09CD065 was the only station above average of 20%. EPT taxa are generally sensitive to low DO and large DO fluxes, which can be reflected in the metrics percentage of EPT individuals and number of EPT taxa. In 2004 and 2009, the percentage of EPT individuals at the three stations in the Cedar River ranged from 19.87 to 58.26%. All three of the stations were well above the average percentage of EPT for all macroinvertebrate classes in the Cedar River Watershed. All stations had above average number of EPT taxa. The macroinvertebrate taxa (TaxaCountAllChir) are 45 at biological station 09CD065 and decreases downstream. Taxa richness can be decreased with increases in DO flux.

Often low DO results in a decrease in sensitive fish taxa and an increase in tolerant fish taxa. Throughout this reach, tolerant individuals were high (42.19 to 70% of the total population). Sensitive individuals were also low (15.68% to 39.61% of the total population). Utilizing Minnesota derived tolerance indicator values for DO; biological station 04CD002 had a TIV score of 7.19, biological station 04CD024 had a TIV score of 7.17 and biological station 09CD065 had a TIV score of 7.38 which were all above the average for the Cedar River Watershed. The fish community was comprised of fish that are relatively more sensitive to low DO. Given the current information, DO is not considered a stressor to the macroinvertebrate and fish communities at this time.

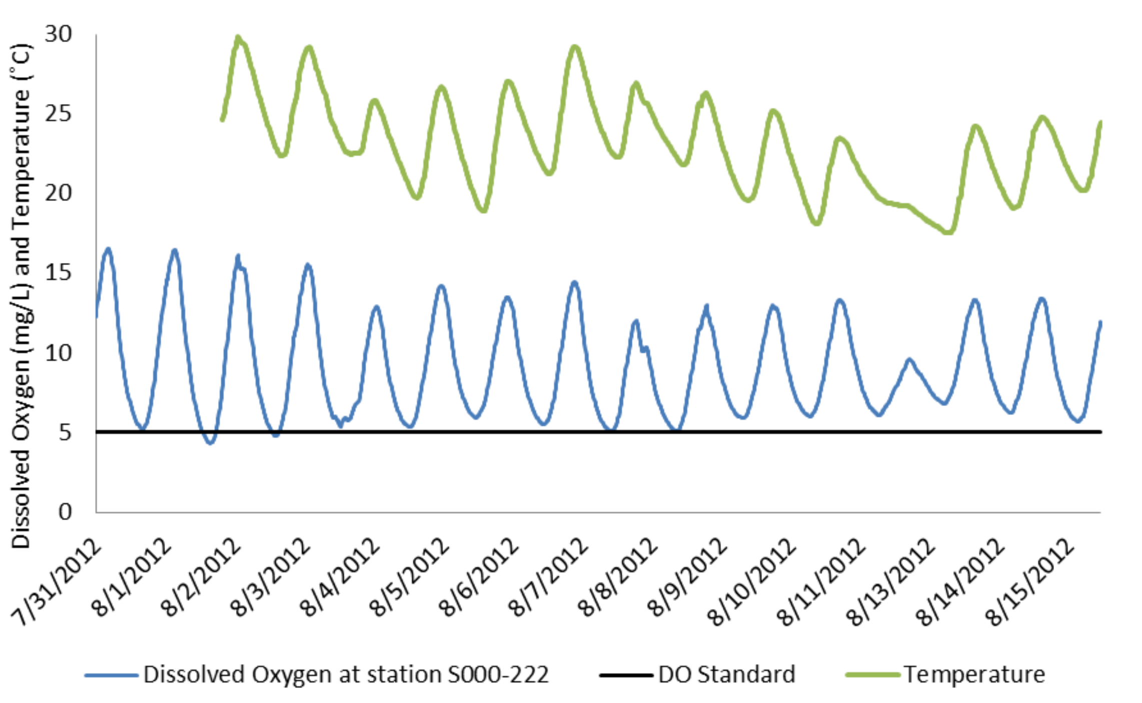


Figure 147: Dissolved oxygen measured in 15 minute intervals at sampling location S000-222 from July 31 to August 15, 2012.

9.3.5. Candidate cause: High phosphorus

Phosphorus in this reach was elevated greater than the nutrient standard (0.15 mg/L; Figure 148). There were 315 TPs values ranging from 0.02-2.70 mg/L, the average was 0.647 mg/L. The DO was discussed in the previous section, and showed there was low DO at times, along with high flux, making it likely that the high phosphorus is a contributor to the low DO that was measured. From late 1967 through 2009, BOD was measured 275 times with a range of 0.6 mg/L to 32 mg/L and an average of 4.98 mg/L. Chlorophyll-a has been sampled 15 times and was below 35 µg/L, below the level known to be a stressor to biology in Minnesota.

The macroinvertebrate community at all three biological stations has a very low percentage of intolerant individuals. The percentage of scrapers ranged from 7.1% to 15.5%. Biological station 09CD065 was above the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. Along with the low metric scores for the modified Hilsenhoff Index for Minnesota, it is likely that high phosphorus is altering the macroinvertebrate community.

Carnivorous fish comprised of 7.3 to 16.7% of the individuals surveyed compared to the average of 14% for the Cedar River Watershed, and the non-tolerant insectivores was relatively low representing only 1.7 to 12.1% of the community in this reach compared to 18.8% for the Cedar River Watershed. Carnivorous fish often decrease with increases in phosphorus (MPCA River Nutrient Criteria Development, 2013). Sensitive fish taxa compared to the total taxa found at the station; 15.7 to 39.6% of the individuals were considered sensitive, which were all above the average for the Cedar River Watershed (14.8%). The tolerant individuals comprised 42.2 to 70% of the total fish individuals surveyed. It does, however, have a range of generalists ranging from 36.2 to 65.5% of the total fish population which translates to a metric score of 0 to 4.4.

The high phosphorus values, low percentages of intolerant individuals, low metric scores for the modified Hilsenhoff index for Minnesota and the fish responses, along with the high DO flux are all indicative of changes to the nutrient regime. Phosphorus is impacting the biological community within the Cedar River.

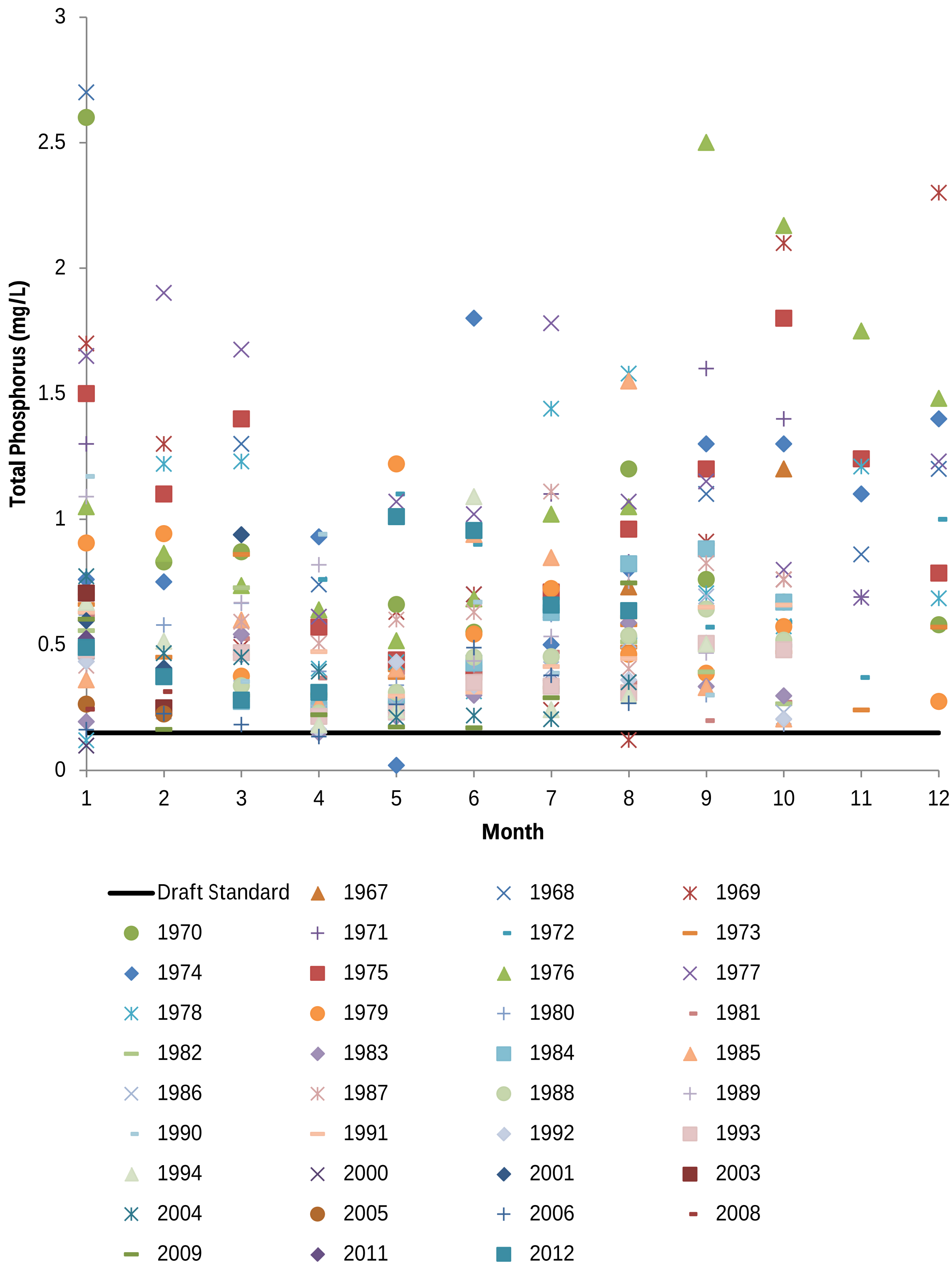


Figure 148: Total phosphorus samples for the Cedar River (-501) shown by month and year compared with the standard.

9.3.6. Candidate cause: High suspended sediment

When this reach of the Cedar River was listed for turbidity in 2002, there were 19 exceedances of turbidity and transparency tube data, out of 49 sampling points over eight years of collection. TSS during the fish visits ranged from 12 to 28mg/L, along with fair transparency tube readings (29-35 cm). Transparency tube data was collected at four sampling locations (S000-136, S000-222, S000-223 and S001-381). The transparency values ranged from 1 cm to >100 cm. The average value was 40 cm, and the maximum value was >100 cm. The collection of the transparency data resulted in most observations in the poor category during the summer months. There are 337 TSS samples in this reach of the Cedar River, with 33 higher than the proposed standard. TSS has been recorded as high as 1400 mg/L and averaged 43.25 mg/L. The TSS equivalent to the 25 NTU turbidity standard was calculated to be 57 mg/L, based upon lab samples. This was used in the load duration curve analysis for the TMDL.

TSS station index scores for macroinvertebrates there were one to two TSS intolerant taxa present, TSS tolerant taxa ranged from 12 to 14 and the percentage of TSS tolerant macroinvertebrates was ranged from 42.1 to 77.3% compared to the averages for warmwater stations in the Cedar River Watershed for percent of TSS tolerant individuals (25.9%) and TSS tolerant taxa (9). The percentage of intolerant macroinvertebrates was low and long-lived macroinvertebrates were high for the Cedar River Watershed. Collector-filterers were reduced at the top two biological stations for the Prairie Forest Rivers and Southern Streams RR. Collector-filterers are reduced when TSS is elevated. Collector-filterer species collect their food by filtering it from the water column. At the lowest Prairie Forest Rivers biological station, the collector-filterers were above average for this class. TSS is affecting the macroinvertebrate community.

There were 20 common carp in this stream reach, which may play a role in disturbing the embedded sediments in this stream reach to increase TSS levels. The most dominant fish species in this reach was the sand shiner. Sand shiners, a species fairly tolerant to suspended sediment (Meador and Carlisle, 2007), were the most abundant taxa found at two of the three surveys. Suspended sediment and the resulting turbidity are affecting the fish community in this reach. Bluntnose minnow, sand shiner, common shiner, carmine shiner and hornyhead chub were common in this reach.

Herbivores (fish) are often reduced when turbidity or TSS levels are high. The percent herbivores ranged from 0% to 2.46%. The average percent of herbivore fish in natural channels of the Cedar River Watershed was 7.13%, with a range of 0% to 38.72%. The Cedar River Watershed has several 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. TSS is a stressor to the macroinvertebrate and fish communities within this reach.

Table 75: Macroinvertebrate metrics relevant to TSS for stations in the Cedar River (-501) compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
04CD002	**24.2**	1	**14**	**77.3**	1	8
04CD024	**20.4**	1	**12**	**68.9**	**0**	6
09CD065	**18.0**	2	**13**	**42.1**	**0**	**4**
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

9.3.7. Conclusions

The stressors found in this reach are summarized in Table 76. The stressors to the macroinvertebrate and fish communities in this reach of the mainstem Cedar River is elevated suspended sediment concentrations, habitat, nitrate, flow alteration, and TP. The biological and chemical data all provide good evidence that these stressors are playing a role in shaping the macroinvertebrate and fish communities present here. Elevated nitrate and TP levels are also stressors to the macroinvertebrate community. Nutrient management of both nitrogen and phosphorus is needed throughout the watershed.

Currently, it appears there are multiple drivers that could be responsible for the changes in suspended sediment and habitat dynamics seen in the main stem Cedar River. There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. These are system-wide changes, which become cumulative in nature, and do affect the stream biota. Flow alteration is a stressor and a driver for sediment and habitat issues in the mainstem.

Regardless, the majority of the changes which will improve the macroinvertebrate and fish communities in the mainstem Cedar River are needed on an entire watershed-wide scale, and will take many years to implement. Most changes that are localized may not have success, or be sustainable if the larger river system contributions are not addressed.

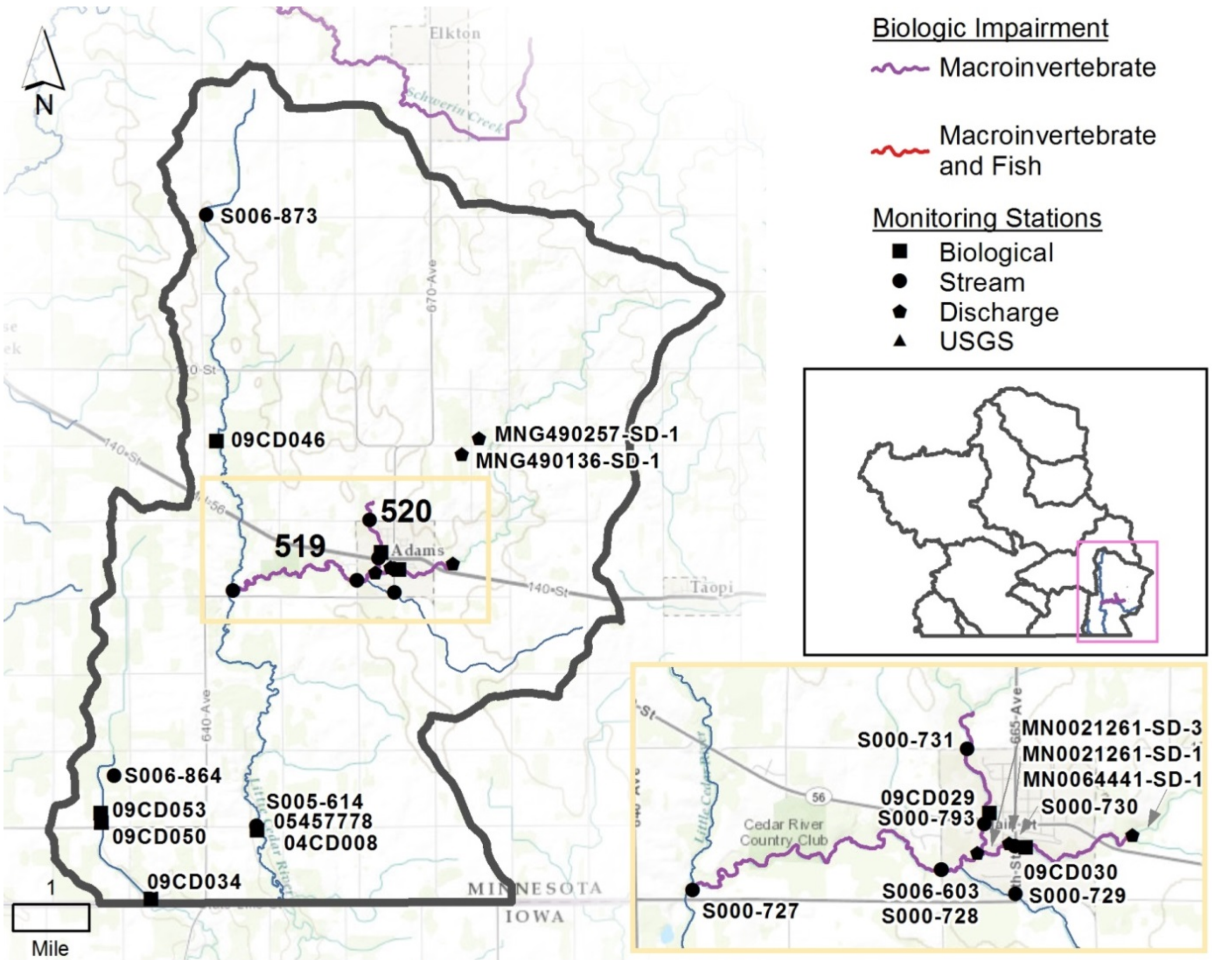
Table 76: Summary of stressors found in the Cedar River (-501).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors: Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-501 Cedar River Rose Creek to Woodbury Creek	09CD065 04CD002 04CD024	Macroinvertebrate IBI F-IBI Bacteria Turbidity	●	●		●	●	●

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

10. Little Cedar River Watershed Unit

The Little Cedar River Watershed is located in Mower County and drains 58.7 square miles. This river flows directly south into Iowa, and joins the main Cedar River near the town of Nashau (Figure 149). Cultivated row crop comprises 82% of the watershed. Two unnamed creeks near Adams were assessed as non-supporting of aquatic life for lack of macroinvertebrate assemblages.



Base Map Credits: Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

Figure 149: Map of Little Cedar River Watershed biological impairments.

10.1. Unnamed creek: unnamed creek to unnamed creek (AUID: 07080201-520) and unnamed creek: unnamed creek to Little Cedar River (AUID: 07080201-519)

One biological station 09CD029 was sampled for fish and macroinvertebrates in 2009 on stream reach (520), and another biological station 09CD030 was sampled on stream reach (519). Biological station 09CD029 is located upstream of West Main Street, in Adams, and the biological station 09CD030 is upstream of 4th Street SW, in Adams.

Water quality sampling was done at EQuIS station S000-730 on 4th Street SW, in Adams on AUID 519. Water quality sampling was also done at EQuIS station S000-793 on W Main Street, in Adams on AUID 520. Water quality data from 2012 were used to determine stressors.

The Adams WWTP discharges into unnamed creek (-519).

10.1.1. Biology in the Little Cedar River

The macroinvertebrate community is not meeting standards for stations 09CD029 and 09CD030. The M-IBI was 29.58 for biological station 09CD029 and 39.78 for station 09CD030, which were below the threshold of 46.8 for the Southern Forest Streams GP M-IBIs (Table 77). The F-IBI was 56 for station 09CD029 and 70 for station 09CD030. Both of the F-IBI were above the threshold for the Southern Headwaters.

Table 77: Summary of biological impairments in unnamed creek (-520) and unnamed creek (-519).

AUID	Station ID	Name	Sq. Mi	Invert Class	Threshold	Invert IBI	Fish Class	Threshold	F-IBI
07080201-520, unnamed creek to unnamed creek	09CD029	unnamed creek	10.63	Southern Forest Streams	46.8	29.58	Southern Headwaters	51	56
07080201-519, unnamed creek to Little Cedar River	09CD030	unnamed creek	13.04	Southern Forest Streams	46.8	39.78	Southern Headwaters	51	70

Biological stations 09CD029 and 09CD030 had eight metrics below the average metric score needed for an M-IBI score greater than the threshold (Figure 150). Macroinvertebrates in the class Southern Forest Streams GP for both biological stations 09CD029 and 09CD030 scored poorly in the metrics of collector-filterers (Collector-filtererPct), a measure of pollution based on tolerance values assigned to each individual taxon (HBI_MN), Plecoptera, Odonata, Ephemeroptera and Trichoptera taxa (POET) and taxa richness of predators (Predator). At station 09CD030 also scored poorly in non-hydropsychid caddisflies (TrichwoHydroPct) and Trichoptera (TrichopteraChTxPct). Station 09CD029 lacked in non-hydropsychid caddisflies (TrichwoHydroPct) and Trichoptera (TrichopteraChTxPct). Both stream reaches were also lacking intolerant taxa (intolerant2Ch). Five species dominated the sample (DomFiveCHPct; 62.23% and 63%) and the percent tolerant taxa was relatively high (Tolerant2ChTxPct; 81.81% and 73.81%).

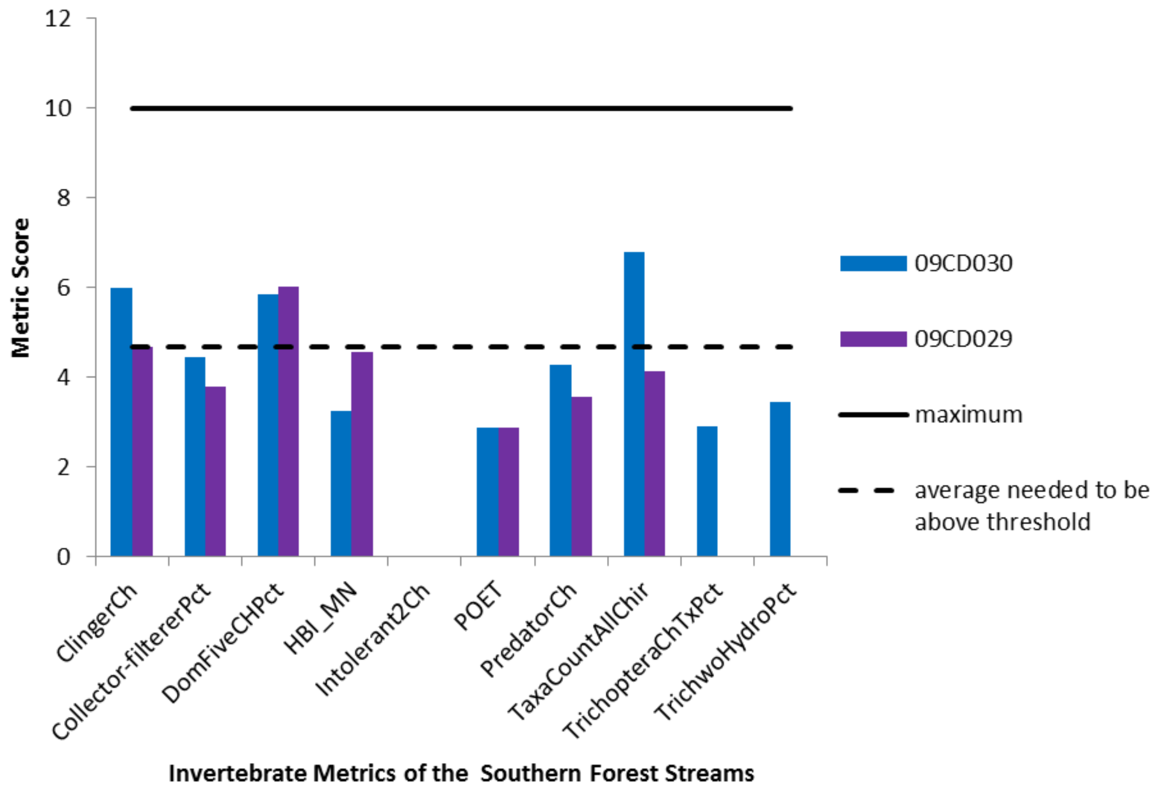


Figure 150: Macroinvertebrate metrics of the Southern Forest Stream GP in stations 09CD029 and 09CD030 in the Little Cedar River.

The fish community was not listed as impaired. Biological station 09CD029 had high IBI metric scores for: generalist taxa (General Txpct) and the relative abundance of short lived individuals (SLvdPct; Figure 151). The metrics of detritivore taxa (DETNWQTxPct), sensitive taxa, serial spawners (SSpnPct) and relative abundance of very tolerant taxa (VtolTxPct) were just below the average metric score needed to be above the threshold. At station 09CD030 all metrics were above the average metrics score needed to be above the threshold, except for the relative abundance of serial spawners (SSpnPct). These two reaches did not have fish DELTs, that if present, would have contributed negatively to the IBI.

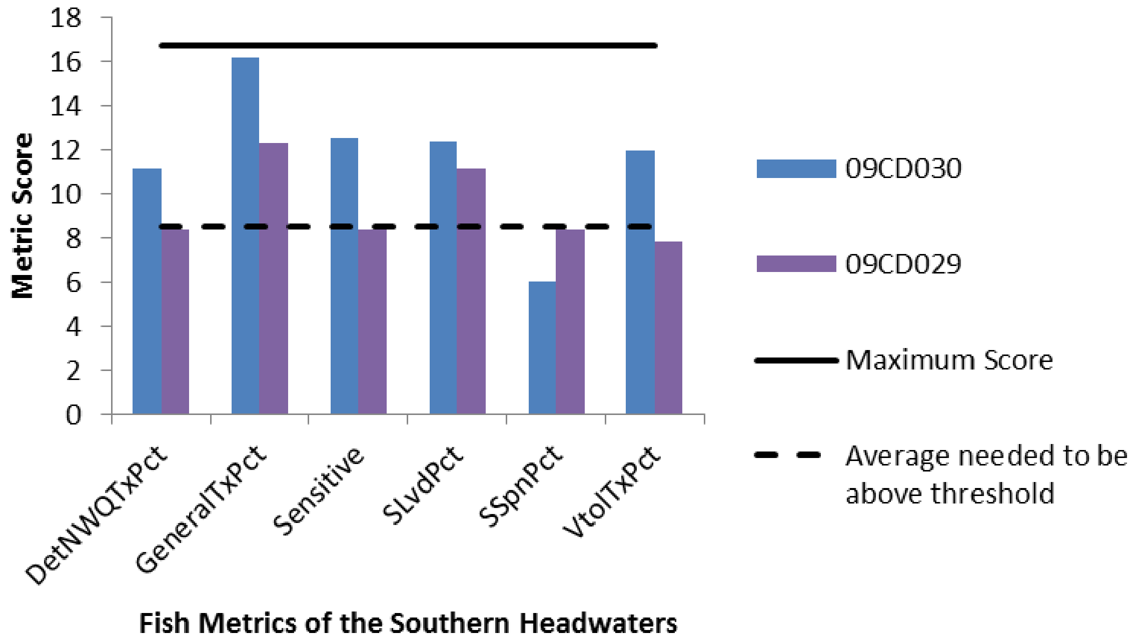


Figure 151: Fish metrics of the Southern Headwaters in stations 09CD029 and 09CD030 in the Little Cedar River.

10.1.2. Candidate cause: Lack of habitat/bedded sediment

Unnamed creek (07080201-520)

The unnamed creek station 09CD029 scored 46.1(fair) on the MSHA (Table 78). Of the five subcategories in the MSHA, land use, substrate, and channel morphology scored poorly. The field crew noted that the site had limited macroinvertebrate habitat and low flow. The field crew also noted unnamed creek had an unstable channel. The water was green in color and turbid. This reach contained 10% riffle and was dominated by sand and gravel, with severe embeddedness. Sand substrate was also dominant in the pools.

The surrounding land use was noted as row crop and residential with a moderate (30 to 150 ft) riparian buffer. There is heavy bank erosion on the left and right banks (Figure 152). Extensive cover was noted, with multiple cover types including undercut banks, overhanging vegetation, deep pools, logs or woody debris and macrophytes. The habitat that was sampled for macroinvertebrates was woody debris/snags/rootwads. There is moderate cover present in the reach; 50 to 75% present. It was also noted that there was problematic mid channel bars indicating excess sedimentation along with an over widened stream channel. This site is lacking good quality riffles.

There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. Over 52% of the waterways in the Little Cedar River Watershed are channelized. Current estimations are that this AUID is 31% channelized. Thirty percent of this watershed is tile drained to help move water off farm fields and to the streams rather quickly. This causes the flows of this stream system to become very inconsistent. Frequent high flows can lead to large amounts of erosion. These are system-wide changes, which become cumulative in nature, and do affect the stream biota.

There was an abundance of burrowers found in biological station 09CD029, which demonstrates sedimentation issues (18.26%; Figure 155). The percentage of EPT individuals was much less than the statewide average for Southern Forest Streams GP macroinvertebrate class (1.86%). The percentage of generally tolerant legless macroinvertebrate individuals was high (95%). The macroinvertebrates that are known to cling to large substrate and woody debris were just above statewide averages for this class, likely due to the woody material that is available to support these individuals. This is also found in the M-IBI metrics, the number of clinger taxa (ClingerCh) was just below the average metric score needed for the M-IBI to be at the threshold. Overall, MSHA information, site conditions/photos, and macroinvertebrate response strongly support habitat as a stressor in this reach particularly bedded sediment. Habitat is a stressor in this reach.

Figure 152: Cut banks and excess sedimentation at biological station 09CD029 looking upstream.

Unnamed creek (07080201-519)

The unnamed creek biological station 09CD030 scored 46.4(fair) on the MSHA (Table 78). Of the five subcategories in the MSHA, land use, substrate, and channel morphology scored poorly. The surrounding land use was noted as row crop and residential with a moderate (30 to 150 ft) riparian buffer. There is heavy shade with heavy bank erosion on the left and right banks (Figure 153 and Figure 154). This reach contains 40% riffle and consists of sand and gravel, with moderate embeddedness. The habitat that was sampled for macroinvertebrates was snags/woody debris/rootwads, undercut banks and overhanging vegetation. There is little cover present in the reach; 5 to 25% present.

Burrowers, which may suggest potential fine sedimentation issues in the riffles, were not found in high abundance (Figure 155). The percentage of EPT individuals (5%) was less than the statewide averages at all locations. At station 09CD030, there was a high percentage of legless macroinvertebrates (78%). The percentage of climbers was high (45%), but likely due to overhanging vegetation was sampled and their preference for that habitat. Taxa that are known to cling (ClingerCh) were below the statewide average, as shown in Figure 155. Clinger species attach to rocks or woody debris. Clingers can decrease in stream reaches with homogenous substrate composition, velocity, and depth (CADDIS).

There are aspects of habitat that could be improved in this reach. Erosion within this reach should be monitored to evaluate the risk of further degradation to the habitat. There are significant indicators that stream hydrology has changed, due to both changes in land use and precipitation. Stream modifications such as straightening have caused channel instability and downstream habitat degradation. These are system-wide changes, which become cumulative in nature, and do affect the stream biota. The local land use, photos, MSHA, and some macroinvertebrate metrics reveal habitat conditions which are less than ideal. Biological station 09CD030 lacks the diversity of habitat types to support a diverse macroinvertebrate community, substrate embeddedness are considered a stressor to the macroinvertebrate community in this reach, but not likely the primary stressor.

Figure 153: Biological station 09CD030 on July 14, 2009.

Figure 154: Biological station 09CD030 on July 14, 2009.

Table 78: MSHA results for unnamed creek (-520) and unnamed creek (-519).

# Visits	Biological Station ID	Reach Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Fish Cover (0-17)	Channel Morph. (0-36)	MSHA Score (0-100)	MSHA Rating
1	09CD029	unnamed creek (520)	1	7	13.1	12	13	46.1	Fair
1	09CD030	unnamed creek (519)	1	8	15.4	6	16	46.4	Fair
Average Habitat Results			1	7.5	14.25	9	14.5	46.25	Fair

Qualitative habitat ratings
Good: MSHA score above the median of the least-disturbed sites (MSHA>66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

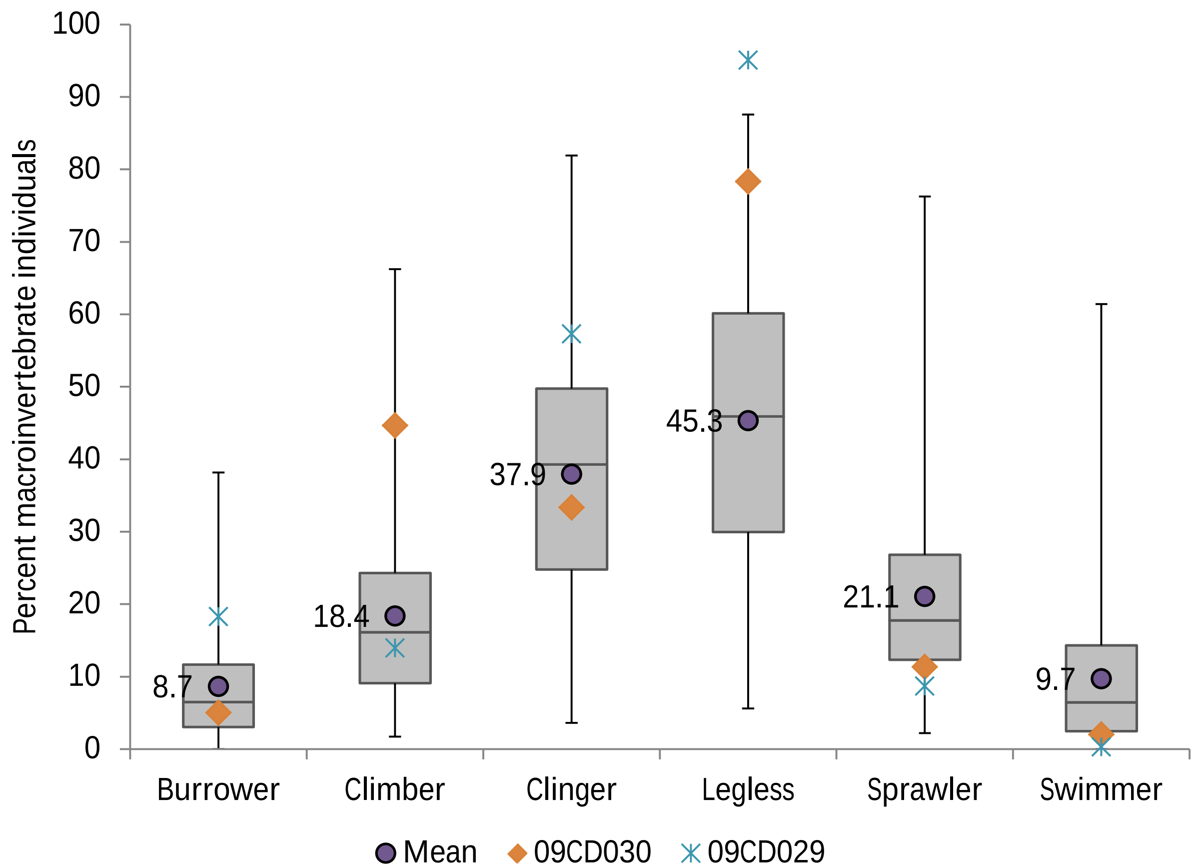


Figure 155: Macroinvertebrate habitat metrics with box plot showing range of values from natural channel Southern Forest Streams GP stations with M-IBI greater than 46.8 (threshold), mean of those stations, and metric values from station 09CD029 and 09CD030.

10.1.3. Candidate cause: High nitrate-nitrite

Unnamed creek (07080201-520):

Nitrate was 6.7 mg/L during fish sampling on July 14, 2009, at biological station 09CD029. Nitrate was sampled five times in 2012 at station S000-793. The highest sample was 24 mg/L on June 22, 2012, while the lowest nitrate sample was <0.25mg/L on September 4, 2012.

The macroinvertebrates in this reach were made up of 81.81% tolerant taxa and lacked intolerant taxa as defined by MPCA. Biological station 09CD029 was lacking non-hydropsychid Trichoptera. Trichoptera are considered sensitive to nitrate and respond with decreases in taxa. At station 09CD029, there were 78.2% nitrate tolerant macroinvertebrates, with 19 nitrate tolerant taxa and only one nitrate intolerant taxon. With the limited nitrate data available, nitrate is a stressor to the impaired biota. More nitrate data should be collected to help characterize the nitrate in this unnamed creek.

Unnamed creek (07080201-519):

Nitrate was 6.1 mg/L during fish sampling July 14, 2009, at biological station 09CD030. Nitrate was sampled five times in 2012 at station S000-730. The highest sample was 24 mg/L on June 22, 2012, while the lowest nitrate sample was 3.2 mg/L on July 19, 2012.

The macroinvertebrates in this reach were made up of 73.8% tolerant taxa and lacked intolerant taxa as defined by MPCA. At biological station 09CD030 the non-hydropsychid Trichoptera comprise less than 2% of the community. Trichoptera are considered sensitive to nitrate and respond with decreases in taxa. At station 09CD030, there were 78.9% nitrate tolerant macroinvertebrates, with 29 nitrate tolerant taxa and no nitrate intolerant taxa. With the limited nitrate data available, nitrate is a stressor to the impaired biota.

10.1.4. Candidate cause: Low dissolved oxygen

Unnamed creek (07080201-520):

There were six measurements of DO collected. One measurement of 0.68 mg/L, was well below the standard (5 mg/L). This low DO measurement was taken September 4, 2012, during very low flow conditions. One of the measurements was taken at the time of fish sampling (6.26 mg/L). Three of the six measurements in 2012 were taken in the early afternoon and were 2 mg/L or more above the standard. One measurement was one mg/L above the standard at 2:30 p.m. There were early DO readings observed in early 1981 that were below and just above the standard.

The macroinvertebrate community comprised of a very low percentage of EPT taxa (1.86%). The tolerant taxa was elevated in 2009 (81.81%) and the taxa count was abundant (33). The macroinvertebrates in this AUID had a low metric HBI_MN, a measure of pollution based on tolerance values assigned to each individual taxon. Station 09CD029 received a low metric score (4.55), where station 09CD030 had a score even lower (3.25) than the average score needed to be above the threshold. The macroinvertebrate DO TIV station score (6.7) was slightly below the average for the Cedar River basin (6.8). The numbers of macroinvertebrate taxa collected that are intolerant to low DO were 2, and the percentage of DO tolerant species collected were 26.5. The average number of intolerant taxa collected in the Cedar River basin was 4.6 and the average percentage of DO tolerant taxa was 20.

The fish community was in the upper half of DO aggregate fish scores, indicating that comparatively to other stations in the Cedar River, there is some sensitivity to low DO. The most DO sensitive fish found at this station were fantail darter and there was a presence of DO tolerant fish such as brook stickleback. There are biological indications that DO may be a concern, yet findings are inconclusive due to limited data. It would be beneficial to collect diurnal DO information.

Unnamed creek (07080201-519):

There was a small data set of DO data within this reach. There were only six measurements, which were all above the standard. One of the measurements was taken at the time of fish sampling (8.19 mg/L); four of them were taken in the early afternoon and ranged from 7.16 mg/L to 11.44 mg/L. No early DO measurement was made prior to 9 a.m., making it difficult to rule out low DO as a potential stressor.

The macroinvertebrate community comprised of a very low percentage of EPT taxa (4.66%). The macroinvertebrates in this AUID had a low metric HBI_MN, a measure of pollution based on tolerance values assigned to each individual taxon. The tolerant taxa was elevated in 2009 (73.8%) and the taxa count was high (42). The macroinvertebrate DO TIV station score (7.1) was above the average for the Cedar River basin (6.8). The numbers of macroinvertebrate taxa collected that are intolerant to low DO were 8, and the percentage of DO tolerant species collected were 11. The average number of intolerant taxa collected in the Cedar River basin was 4.6 and the average percentage of DO tolerant taxa was 20. The fish community at this station indicated the species that were present were more sensitive to low DO with a station tolerance indicator value (TIV) of 7.37 (in the upper half of station scores in the Cedar River Watershed; Table 4).

The most DO sensitive fish found at this station were fantail darter (61) and there was a presence of DO tolerant fish such as brook stickleback (3). There are biological indications that DO may be a concern, yet findings are inconclusive due to limited data.

10.1.5. Candidate cause: High phosphorus

Unnamed creek (07080201-520):

Total phosphorus (0.09 mg/L) was low at the time of fish sampling in unnamed creek on July 14, 2009. One sample was taken during the sampling season of 2012. The phosphorus sample was 0.339 mg/L taken on September 4, 2012. Total Phosphorus was more than double the standard for the south region. As interacting variables to eutrophication, phosphorus, pH, BOD and chlorophyll-a were compared to normal ranges and standards. The response variable, DO flux was not measured. There was one measurement of BOD in 1980 (1.3 µg/L) and one measurement in 1981 at 0.8 µg/L. Chlorophyll-a had one sample and was below 35 µg/L, below the level known to be a stressor to biology in Minnesota (Heiskary et al., 2013).

This stream reach has a low taxa count (TaxaCountAllChir; 33). Biological station 09CD029 lacked intolerant taxa (3) and the percent tolerant taxa was relatively high (Tolerant2ChTxPct; 81.81%). The percentage of intolerant taxa will decrease and the percentage of tolerant taxa will increase with increases in phosphorus. The percentage of scrapers was 22.9%, which was above the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. The number of collector-gather taxa (16) and collector-filterer taxa (3) were both low as well. There were 3 EPT taxa in this stream reach. The range of EPT taxa within the Cedar River Watershed was 0 to 20. The metric, EPT, provides a relative measure of the presence and diversity of pollution-sensitive macroinvertebrate groups. With the lack of elevated phosphorus, it is currently inconclusive if elevated phosphorus is a stressor to the biological community. Phosphorus should be continued to be collected to understand the nutrient dynamics in this system.

Unnamed creek (07080201-519):

Total phosphorus (0.066 mg/L) was low at the time of fish sampling in unnamed creek. Samples were taken a total of five times during the sampling season of 2012. The highest phosphorus sample was 0.068 mg/L taken on July 19, 2012. The lowest grab sample was 0.031 mg/L on May 15, 2012. As interacting variables to DO, phosphorus, pH, BOD and chlorophyll-a were compared to normal ranges and standards. There were three measurements of BOD in 1980 and three measurements in 1981 at 2.9

µg/L and below. Chlorophyll-a had three samples in 1980 and one sample in 1981. All four samples were below 35 µg/L.

This stream reach has a high taxa count (TaxaCountAllChir; 42). Biological station 09CD030 lacked intolerant taxa (4) and the percent tolerant taxa was moderate (Tolerant2ChTxPct; 54.76%). The percentage of intolerant taxa will decrease and the percentage of tolerant taxa will increase with increases in phosphorus. The percentage of scrapers was 11.3%, which was below the Cedar River average (15.7%). The percentage of scrapers increases with the increase of phosphorus. The number of collector-gather taxa (20) and collector-filterer taxa (6) were both above the average for the Cedar River Watershed. There were 4 EPT taxa in this stream reach. The range of EPT taxa within the Cedar River Watershed was 0 to 20. The metric, EPT, provides a relative measure of the presence and diversity of pollution-sensitive macroinvertebrate groups. With the lack of elevated phosphorus, it is currently inconclusive if elevated phosphorus is a stressor to the biological community. Phosphorus should be continued to be collected to understand the nutrient dynamics in this system.

10.1.6. Candidate cause: High suspended sediment

Unnamed creek (07080201-520):

Biological station 09CD029 had low TSS at the time of fish sampling on July 14, 2009 (1.2 mg/L), along with a good transparency tube reading (44.1 cm). In 2012, there were five transparency tube readings, all of the readings were 20 cm and above. One measurement of TSS and turbidity were collected in 1980 and 1981. TSS was not elevated above the draft standard of 65 mg/L. TSS data for a range of flows should be collected in unnamed creek to determine the impacts to the biota.

In 2009, biological station 09CD029 had a low percentage of herbivorous fish. Macroinvertebrates that are scrapers were above average (22.9%). collector-filters were above the average for the Cedar River Watershed (14.1%). Collector-filterers and herbivorous fish are reduced when TSS is elevated. Collector-filterer species collect their food by filtering it from the water column. The percentage of long lived macroinvertebrates was very low (1.5%) compared to the average for the Cedar River Watershed (6%). Biological station 09CD029 had a low percentage of TSS tolerant individuals (10.5%) and below average TSS tolerant taxa (5) compared to the averages for warmwater stations in the Cedar River Watershed for percent of TSS tolerant individuals (25.9%) and TSS tolerant taxa (9;). There are biological indications that TSS or turbidity may be a concern, yet findings are inconclusive due to limited data.

Table 79: Macroinvertebrate metrics relevant to TSS for stations in unnamed creek (-520) compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
09CD029	14.1	**0**	5	10.5	**0**	5
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

Unnamed creek (07080201-519):

Biological station 09CD030 had low TSS at the time of fish sampling on July 14, 2009 (2.8 mg/L), along with an excellent transparency tube reading (> 100 cm). Transparency tube readings in 2012 were all excellent. In 2012, there was very little rain and low flow conditions. TSS data was last collected in 1981 on this stream reach. Photographs taken at the biological station, show incised channels, severely eroded banks and mid channel bars. TSS data for a range of flows should be collected in unnamed creek to determine the impacts to the biota.

In 2009, biological station 09CD030 had a very low percentage of herbivorous fish and a low percentage of macroinvertebrates that are scrapers (11.3%). Collector-filters (17%) were above average for the Cedar River Watershed (14.1%). Collector-filterers and herbivorous fish are reduced when TSS is elevated. Collector-filterer species collect their food by filtering it from the water column. The percentage of long lived macroinvertebrates was low (4%). Biological station 09CD030 had a high percentage of TSS tolerant individuals (36.9%) and below average TSS tolerant taxa (8) compared to the averages for warmwater stations in the Cedar River Watershed for percent of TSS tolerant individuals (25.9%) and TSS tolerant taxa (9; Table 80). There are biological indications that TSS or turbidity may be a concern, yet findings are inconclusive due to limited data.

Table 80: Macroinvertebrate metrics relevant to TSS for stations in unnamed creek (-519) compared to averages for warmwater stations in the Cedar River Watershed. Bold and highlighted equals the metric score is higher or lower than average, depending on expected response with increased stress.

TSS Relevant Metrics	TSS Station Index Score	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Intolerant Macroinvertebrate Taxa	Long-lived Macroinvertebrate Taxa
09CD030	**16.7**	1	8	**36.9**	**0**	6
Expected response with increased TSS stress	increase	decrease	increase	increase	decrease	decrease
Averages for warmwater stations in the Cedar River Watershed	16.3	0.8	9.0	25.9	0.09	4.2

10.1.7. Conclusions

Unnamed creek (07080201-520):

The stressors to unnamed creek (-520) are summarized in. Limited information on unnamed creek suggests that habitat, flow alteration and nitrate are impacting the biological community present. Flow alteration is a source of the habitat alteration and a stressor to the biology. During macroinvertebrate sampling it was noted by biologist that macroinvertebrate habitat was limited, and that the reach was dominated by sand substrate with little riffle habitat. The biological metrics related to habitat demonstrate this, with a reduced percentage of EPT taxa and a shift to a higher percentage of tolerant legless macroinvertebrates. There is little chemical information on this reach for TSS, but the macroinvertebrate community overall is showing some sensitivity to TSS. Total suspended solids should have further attention and monitoring to ensure adequate levels. There are some indications that DO and total phosphorus could be potential stressors, but with a lack of connecting chemical information, those stressors cannot be confirmed at this time. Overall, there is little chemical information on this reach, and additional information should be collected to confirm or rule out these potential stressors.

Unnamed creek would likely benefit from habitat improvement for the macroinvertebrates. Nitrate levels are elevated (24 mg/L), and should be monitored over time. Better management of nutrients would benefit unnamed creek. Additional chemical information should be collected to confirm or rule out these potential stressors.

Table 81: Summary of stressors found in unnamed creek (-520).

AUID Reach Name, Reach Description	Biological Station ID	Impairment(s)	Stressors					
			Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-520 unnamed creek unnamed creek to unnamed creek	09CD029	Macroinvertebrate IBI	•	•	o	o	o	•

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

Unnamed creek (07080201-519):

The stressors to unnamed creek (-520) are summarized in Table 82. Nitrate, flow alteration and a lack of habitat, in particular poor substrate and lack of features, is a stressor to the macroinvertebrate community in unnamed creek. Dissolved oxygen, phosphorus, and TSS are inconclusive as a stressor due to limited data available. It is recommended that additional data be collected.

Unnamed creek would likely benefit from habitat improvement for the macroinvertebrates. Nitrate levels are elevated (24 mg/L), and should be monitored over time. Better management of nutrients would benefit unnamed creek. Additional chemical information should be collected to confirm or rule out these potential stressors.

Table 82: Summary of stressors found in unnamed creek (-519).

AUID Reach Name Reach Description	Biological Station ID	Impairment(s)	Stressors					
			Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow alteration
07080201-519 unnamed creek unnamed creek to Little Cedar River	09CD030	Macroinvertebrate IBI	•	•	o	o	o	•

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

11. Conclusions

A summary of the stressors to aquatic life in the Cedar River Watershed are found in Table 83 below, which are the same stressors as in Table 1 (Executive summary).

Table 83: Summary of stressors found in the Cedar River Watershed.

11 Digit HUC	Reach Name	AUID	Biological Impairment	Stressors: Habitat/Bedded Sediment	Nitrate	Dissolved Oxygen	Phosphorus	Suspended Sediment	Flow Alteration
Middle Fork Cedar River	Cedar River, Middle Fork	549	Macroinvertebrate	•	o	o	o	o	•
	Cedar River, Middle Fork	530	Macroinvertebrate	•	•	•		o	•
Roberts Creek	Unnamed Creek	534	Fish and Macroinvertebrate	•	•	o	o	o	•
	Roberts Creek	506	Fish and Macroinvertebrate	•	•	o		o	•
	Unnamed Creek	593	Macroinvertebrate	•	•	o	o	o	•
	Roberts Creek	504	Macroinvertebrate	•	•	o	•	o	•
Upper Cedar River	Unnamed Creek (Cedar River, West Fork)	591	Macroinvertebrate		o	o	o	o	•
	Unnamed Creek	577	Macroinvertebrate	•	•	o	o	o	•
	Cedar River	503	Macroinvertebrate	•	•	•	•	•	•
	Unnamed Creek	533	Macroinvertebrate	•	•		•	•	•
Turtle Creek	Unnamed Creek	547	Macroinvertebrate		o	o	o	o	•
	Turtle Creek	540	Fish and Macroinvertebrate	•	•	•	•	•	•
Rose Creek	Schwerin Creek	523	Macroinvertebrate	•	•	o	o	o	•
	Unnamed Creek	583	Macroinvertebrate	•	•	o	•	•	•
Lower Cedar River	Unnamed Creek (Woodson Creek)	554	Fish and Macroinvertebrate	•			o	o	•
	Cedar River	515	Macroinvertebrate	•	•	•	•		•
	Cedar River	501	Fish and Macroinvertebrate	•	•		•	•	•
Little Cedar River	Unnamed Creek	520	Macroinvertebrate	•	•	o	o	o	•
	Unnamed Creek	519	Macroinvertebrate	•	•	o	o	o	•

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

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Effects of Agricultural Drainage on Aquatic Ecosystems: A Review
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Appendix A. 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 B. Weight 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, -

Weight of evidence

Weight of evidence tables for the biologically impaired AUIDs in the Cedar River Watershed is available upon request.

Appendix C. Selected fish and macroinvertebrate metrics for analysis of habitat stress in the Cedar River Watershed

	Metric Description	Explanation	Expected Response to Habitat Stress
Fish			
BenInsect-TolPct	Relative abundance (%) of individuals that are non-tolerant benthic insectivore species	Benthic insectivores are found in riffle habitats, with clean gravel substrates	*Decrease*
SLithopPct	Relative abundance (%) of individuals that are simple lithophilic spawners	Simple lithophilic spawners require clean gravel or cobble substrates for reproductive success	*Decrease*
DarterSculpSucPct	Relative abundance (%) of individuals that are darter, sculpin, and round bodied sucker species	Darter, sculpin, and round bodied suckers require shallow riffle habitats	*Decrease*
RifflePct	Relative abundance (%) of individuals that are riffle-dwelling species	Riffle dwelling species are important indicators of available riffle habitat	*Decrease*
PiscivorePct	Relative abundance (%) of individuals that are piscivore species	Piscivores require pool habitats for predator-prey relationship. Proper substrate will also benefit piscivores	*Decrease*
LithFrimPct	Relative abundance (%) of individuals that are lithophilic spawners	Require interstitial spaces within stable, coarse gravel, cobble, or boulder substrate unembedded by fines	*Decrease*
TolPct	Relative abundance (%) of individuals that are tolerant species	Tolerant fish species are able to survive generally adverse stream conditions	*Increase*
PioneerPct	Relative abundance (%) of individuals that are pioneer species	Pioneer species are able to thrive in unstable environments and are the first to invade after disturbance	*Increase*
Macroinvertebrates			
BurrowerPct	Relative abundance (%) of burrowers in subsample	Burrower species “burrow” in fine sediment indicating potential siltation in riffles	*Increase*
ClimberPct	Relative abundance (%) of climbers in subsample	Climber species use habitat such as overhanging vegetation or woody debris	*Decrease*
ClingerPct	Relative abundance (%) of climbers in subsample	Clinger species attach to rock or woody debris. Clingers may decrease in stream reaches with homogeneous substrate composition, velocity, and depth.	*Decrease*
EPTPct	Relative abundance (%) of Ephemeroptera, Plecoptera & Trichoptera individuals in subsample	EPT are a sensitive group of macroinvertebrates commonly used to measure overall health of ecosystems	*Decrease*
LeglessPct	Relative abundance (%) of legless individuals in subsample	Legless macroinvertebrates are tolerant species like midges/worms, and snails	*Increase*
SprawlerPct	Relative abundance (%) of sprawler individuals in subsample	Sprawlers live on the surface of floating plants or fine sediments. Many are adapted to keep respiratory surfaces free of silt	*Increase or Decrease*
SwimmerPct	Relative abundance (%) of swimmer individuals in subsample	Swimmers require low velocity water and their abundance or decline may indicate changes in water flow or pool abundance	*Increase or Decrease*

Appendix D. M-IBI and metric fact sheets applicable to the Cedar River Watershed

Macroinvertebrate 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

Macroinvertebrate 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 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

Macroinvertebrate 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

Macroinvertebrate Class 9 – Southern Coldwater Streams

Classification criteria:

This classification is in general representative for those streams that occur in the southern portions of Minnesota, which are often characterized by the Eastern Broadleaf Forest, Prairie Parklands, and Tall Aspen Parklands ecological provinces. However, sites located on the boundaries of these divisions may be more or less representative of a given classification, and therefore decisions regarding an individual site classification may be predicated on other factors.

Examples:

Beaver Creek, Browns Creek, Hay Creek, Little Rock Creek, Pine Creek, Riceford Creek, South Branch and Fork of Root River, Trout Brook, Trout Creek, Vermillion River, Wells Creek, Whitewater River, and Willow Creek

Biocriteria:

Upper C.L. 59.9
Threshold 46.1
Lower C.L. 32.3

Metric Name	Category	Response	Metric Description
Coldwater Biotic Index	Habitat	Increase	Coldwater Biotic Index score based on coldwater tolerance values derived from Minnesota taxa/temperature data.
ChiroDip	Composition	Increase	Ratio of Chironomidae abundance to total Dipteran abundance.
Percent (%) Collector – Filterers	Trophic	Decrease	Relative abundance (%) of collector-filterer individuals in a subsample
Hilsenhoff Biotic Index, MN TVs	Tolerance	Increase	A measure of pollution based on tolerance values assigned to each individual taxon, developed by Chirhart
Intolerant Taxa Richness, 2 ch	Tolerance	Decrease	Taxa richness of macroinvertebrates with tolerance values less than or equal to 2, using MN TVs
Percent (%) Trichoptera Taxa	Composition	Decrease	Relative percentage of taxa belonging to Trichoptera
Percent (%) Very Tolerant, 2	Tolerance	Increase	Relative abundance (%) of macroinvertebrate individuals in subsample with tolerance values equal to or greater than 8, using MN TVs.

Appendix E. F-IBI and metric fact sheets applicable to the Cedar River Watershed

Southern rivers

Classification criteria:

Large warm/coolwater rivers in southern Minnesota 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:

Upper CL: 57
Impairment threshold: 46
Lower CL: 35

Low-end scoring:

<25 individuals (IndPct metrics = 0)
<6 taxa (TX and TXPct metrics = 0)

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

Southern streams

Classification criteria:

Large warm/coolwater streams and small rivers in southern Minnesota 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:

Upper CL: 54
Impairment threshold: 45
Lower CL: 36

Low-end scoring:

<25 individuals (IndPct metrics = 0)
<6 taxa (TX and TXPct metrics = 0)

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

Southern headwaters

Classification criteria:

Small, moderate to high-gradient warm/coolwater streams in southern Minnesota 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:

Upper CL: 58
Impairment threshold: 51
Lower CL: 44

Low-end scoring:

<25 individuals (IndPct metrics = 0)
<4 taxa (TX and TXPct metrics = 0)

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	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

Southern coldwater

Classification criteria:

Coldwater streams in southern Minnesota and the far-western portion of the Red River Basin

Examples:

South Fork of Root River, Trout Run, Vermillion River, Valley Creek, Hemingway Creek

Biocriteria:

Upper CL: 58
Impairment threshold: 45
Lower CL: 32

Low-end scoring:

Not applicable

MetricName	Category	Response	Metric_Desc_tech
CWSensitivePct_10DrgArea	tolerance	positive	Relative abundance (%) of individuals that are sensitive in coldwater streams (scoring adjusted for drainage area)
CWTol_10DrgArea	tolerance	negative	Taxa richness of tolerant species in coldwater streams (scoring adjusted for drainage area)
NativeColdTXPct_10DrgArea	habitat	positive	Relative abundance (%) of taxa that are native coldwater species (scoring adjusted for drainage area)
NativeColdPct	habitat	positive	Relative abundance (%) of individuals that are native coldwater species
HerbvPct	trophic	negative	Relative abundance (%) of individuals that are herbivorous
SdetTXPct_10DrgArea	trophic	negative	Relative abundance (%) of taxa that are detritivorous (scoring adjusted for drainage area)
PioneerPct	life history	negative	Relative abundance (%) of individuals that are pioneer species
FishDELTPct	tolerance	negative	Relative abundance (%) of individuals with Deformities, Eroded fins, Lesions, or Tumors

Appendix F. Flow control structure locations

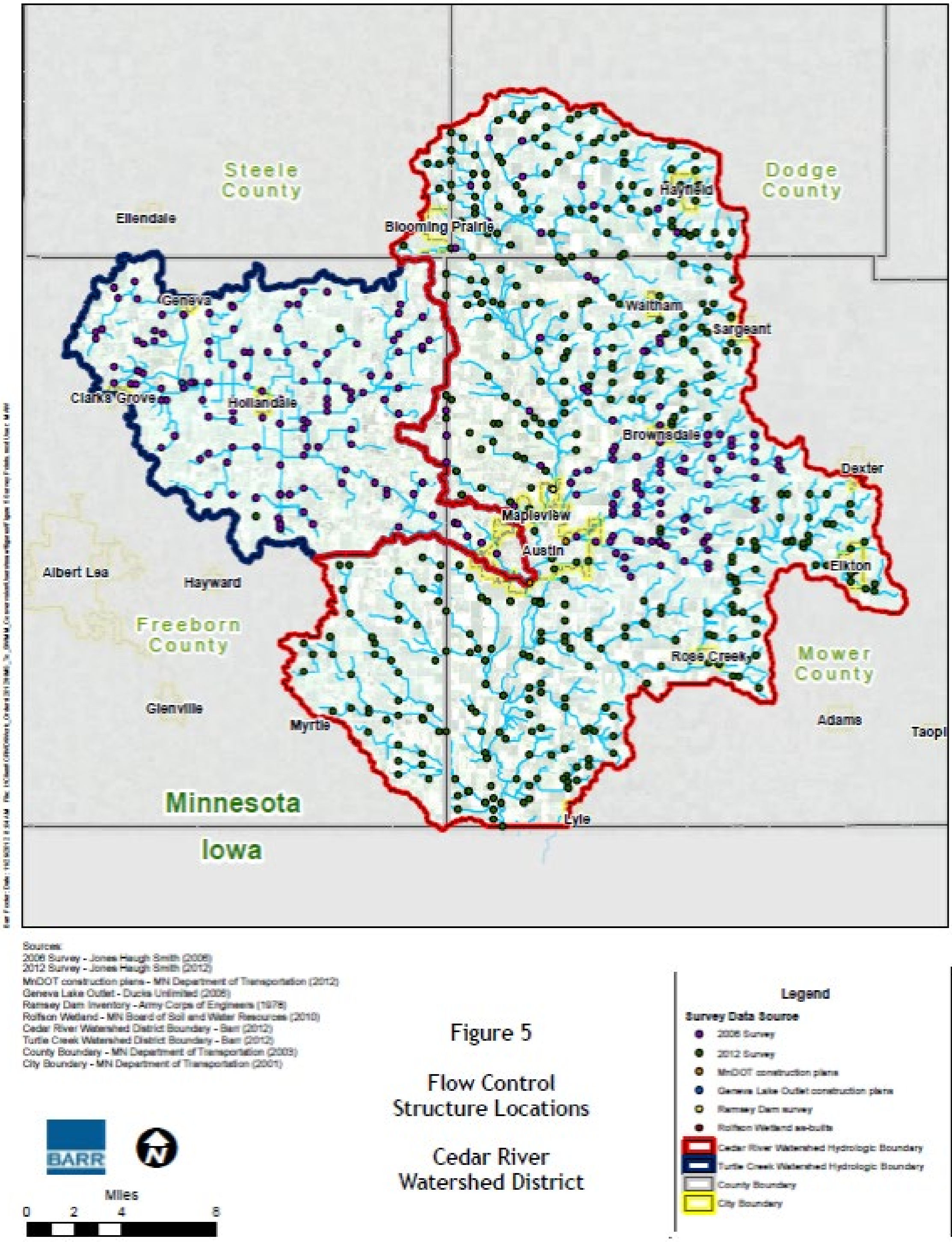

Figure 5

Flow Control Structure Locations

Cedar River Watershed District