Long Prairie River Watershed Stressor Identification Report

Minnesota Pollution Control Agency

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Table of Contents

Figures

Tables

Executive summary

This report summarizes the key causes or "stressors," contributing to impairment of fish and aquatic macroinvertebrate communities of the Long Prairie River tributaries in the Long Prairie River (LP) Watershed located in west-central Minnesota. There are four aggregated 12-digit HUCs that will be covered in this report that contain streams that are listed on the 303(d) list of impaired waters for failing to meet established criteria for the index of biological integrity (IBI). Stream biology is scored based on a numeric value given to each of several metrics which comprise the index. Metrics are based on community diversity, and reproductive, feeding, or trophic characteristics that are specific to groups of fish and macroinvertebrates. Low scores indicate a lack of certain groups of fish and invertebrates which mean that the stream is not meeting expectations.

Stressors in the Long Prairie Watershed (8-digit HUC)

The LP Watershed is divided into eight aggregated 12-digit HUCs (see map on page 8). The current condition and biological integrity of streams within each subwatershed is discussed in detail in the LP Assessment Report (MPCA, 2014). This Stressor Identification (SI) Report will present additional data, and discuss the candidate causes for impaired biota in each subwatershed. A comprehensive review of biological, chemical, and physical data was performed to select probable causes for the impairments. Many candidate causes were eliminated after additional data analysis, leaving five for final analysis in this report. Table 1 lists the stream AUID's, along with the biological stressors. The candidate causes for the entire LP Watershed that were evaluated, and have enough data to show that they are a problem, are listed below.

Low dissolved oxygen concentrations

Low dissolved oxygen (DO) has been identified as a stressor in two of the LP Subwatersheds: Harris Creek and Venewitz Creek. DO data indicated daily minimum values below the five mg/L (milligrams per Liter) standard for Class 2B waters. Both sites fish communities were dominated by species that are tolerant to low DO.

Loss of habitat due to excess bedded sediment

Bedded sediment is a stressor in all four of the studied LP subwatersheds. Bedded sediment was measured during pebble counts and a visual observation of fine sediment covering rock and gravel. Bedded sediment covers the available gravel and fills interstitial spaces, which are required for gravel dwelling fish and invertebrate species. The excess amount of fine material being transported downstream is settling out and filling in pools, smothering rock riffles and causing a general degradation of in-stream habitat. The loss of coarse stream substrate directly affects the biological community that depends on this type of stream bottom. A detailed analysis of bank erosion contribution will need to be performed to evaluate this source.

Altered hydrology/channelization

Ditching and urbanization lead to increased rates of runoff into the receiving stream. As areas of the landscape are drained, they lose the ability to store water and slowly release it over time. This leads to flashy streams that have peak discharge immediately following rain events, and have reduced baseflow.

All four subwatersheds that are described in this report are affected by altered hydrology. The abundance of private and public ditches within this watershed is significant to the loss of stream habitat due to channelization.

Loss of connectivity (impoundments/improper placement of culverts)

The network of road crossings scattered throughout the LP Watershed pose a threat to the connectivity of area streams. This network has culverts that are set at an elevation that either make fish passage impossible during high flow events, or are set at such an elevation that, during mid to low flow events there is a drop in elevation on the downstream side creating a physical barrier. There also is a dam located in Spruce Creek. Spruce Creek, tributary to Lake Miltona, and Harris Creek are the most affected by loss of connectivity.

Lack of woody debris

Wood debris located in the stream can have benefits to groups of macroinvertebrates. Wood acts as a feeding place because of the peryphyton and other algal mass that will grow on its structure. Wood can also help narrow channel width and cause scour pools to form, which will increase pool depth and diversity. Spruce Creek and Harris Creek are lacking in woody debris as the riparian corridor are either grazed or wide sedge meadows.

Table 1: Summary of Long Prairie subwatersheds with probable stressors to biotic communities

	Harris Creek	Spruce Creek	Venewitz Creek	Unnamed Creek to Lake Miltona
Daily Dissolved Oxygen Minimum DO readings often below the 5mg/L standard. Wide daily flux also indicates increased nutrient enrichment	X		X	
Increased sediment on stream bed Bedded sediment fills the spaces between gravel and covers the coarse substrate. This leads to loss of gravel-dwelling fish and macroinvertebrate species	X	X	X	X
Altered Hydrology/Channelization Change in hydrology – altered flow rates	X	X	X	X
Lack of woody debris Wood provides cover and stable attachment material for a variety of fish and macroinvertebrates. Lack of wood reduces channel and habitat diversity and abundance of various species.	X	X		
Connectivity Loss of movement by fish species due to physical barriers (impoundments/improper placement of culverts)	X	X	X	X

Introduction

Organization framework of stressor identification

The stressor identification (SI) process is prompted by an assessment of biological monitoring data as not meeting the expected community composition. Through a review of available data, stressor scenarios are developed that may accurately characterize the impairment, the cause, and the sources/pathways of the various stressors. Confidence in the results depends on the quality of data available. In most cases, additional data is then collected from impaired reaches to accurately identify the stressor(s). Figure 1 below shows the process used for stressor identification.

The SI process draws upon a broad variety of disciplines, such as aquatic ecology, hydrology, geology, biology, geomorphology, chemistry, land use analysis, and toxicology. Strength of evidence analysis is used to develop cases in support of, or against, various candidate causes. Typically, much of the information used in the strength of evidence analysis is from the study watershed, but evidence from other case studies and scientific literature is also used in the SI process. The identified stressor(s) is then examined further in the Total Maximum Daily Load (TMDL) study by computer models.

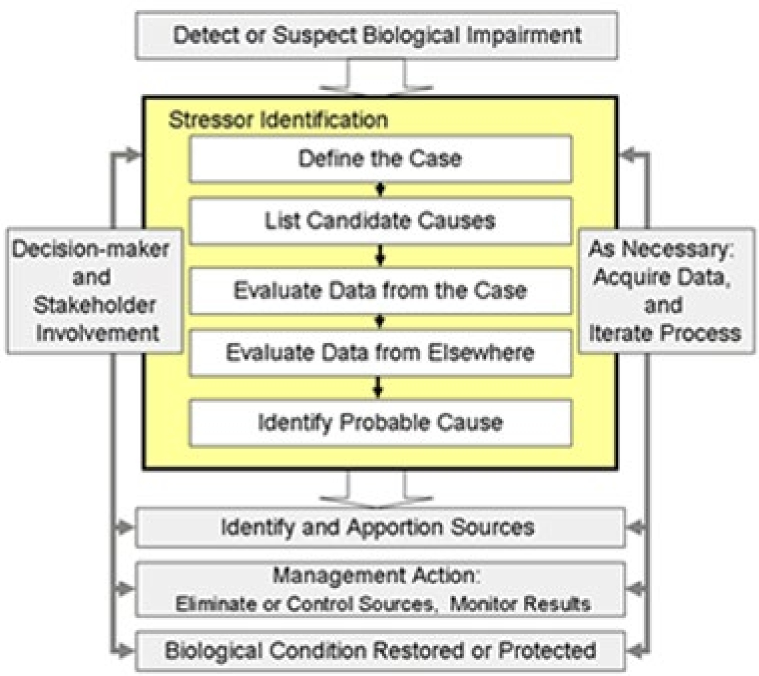

Figure 1: Conceptual model of SI process

Completion of the SI process does not result in a finished TMDL allocation. The product of the SI process is the identification of the stressor(s) for which the TMDL load allocation will be developed.

Overview of watershed impairments

Water quality and biological monitoring in the Long Prairie (LP) watershed has been conducted for several years with the goal of assessing water quality and aquatic life. As part of the MPCA's new Intensive Watershed Monitoring (IWM) approach, which began in 2007, monitoring activities have increased in quantity and rigor. The IWM for the LP Watershed occurred in 2011. Data from the IWM, as well as historic data obtained prior to 2011, was used to identify stream reaches that lacked healthy fish and macroinvertebrate assemblages.

The result of this assessment monitoring effort was the discovery and listing of select LP streams as not supporting their aquatic life use. These reaches are placed on the 303 (d) lists. The biologically-impaired stream reaches in the watershed include the entire Venewitz Creek, the lower portion of Harris Creek, the upper portion of Spruce Creek, and the lower portion of Unnamed Creek to Lake Miltona (Figure 2). Fish and macroinvertebrate data were collected at the biological monitoring stations, and were assessed independently, making it possible for a given stream reach to be impaired for one or both of these biological indicators (Table 2).

LP Watershed streams that are not listed as impaired are either not yet assessed (lacking monitoring data), or are showing good to exceptional biological integrity based on current data. For a complete report on the condition of LP Watershed streams and lakes, see the Long Prairie Watershed Monitoring and Assessment Report (reference).

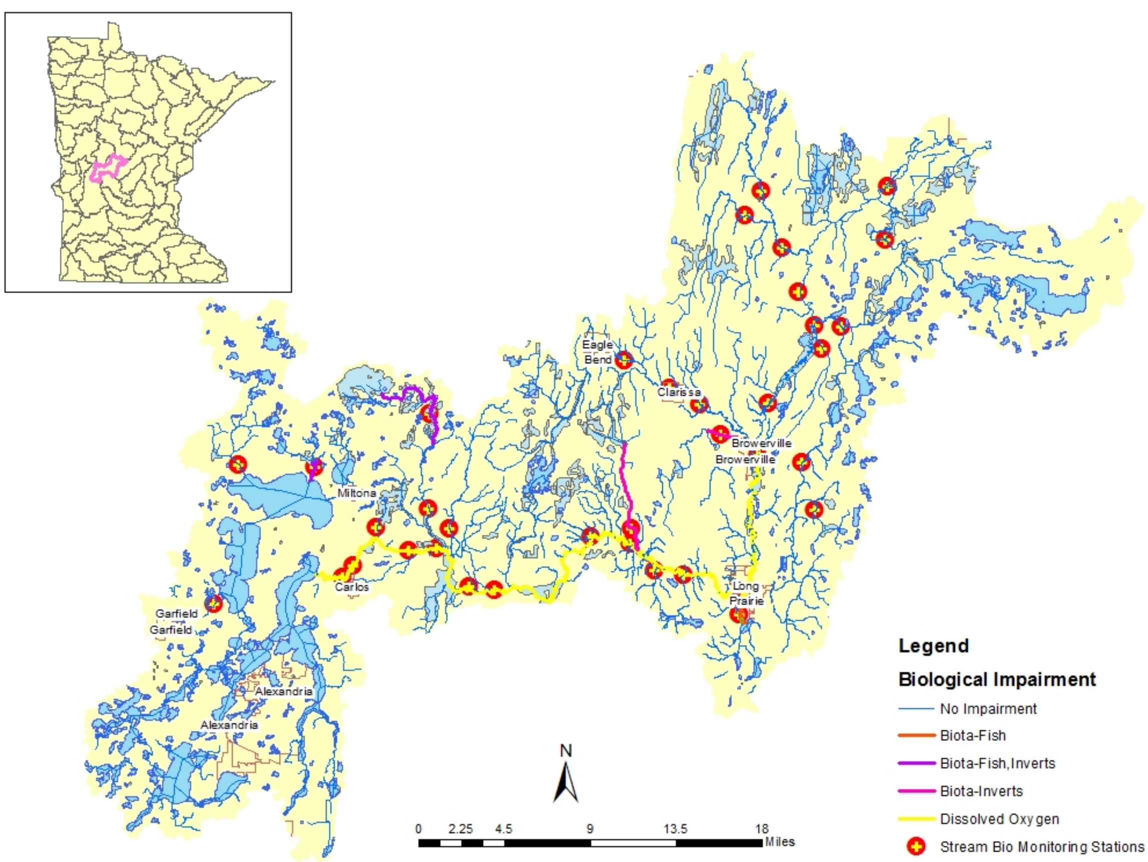

Figure 2: LP Watershed biological monitoring sites for 8-digit HUC (2011 sampling map)

Table 2: Summary of stream reaches with biological impairments in the LP Watershed. Water quality impairments for each stream reach are provided as well.

			Impairments	
AUID #	**Stream Name**	**Reach Description**	**Biological**	**Water Quality**
07010108-595	Unnamed Creek	Headwater to Lake Miltona	Fish and Invertebrate IBI	
07010108-512	Spruce Creek	T131 R36W S31, north line to Unnamed Lake (21-0034-00)	Fish and Invertebrate IBI	
07010108-592	Harris Creek	Unnamed Creek to Eagle Creek	Invertebrate IBI	
07010108-568	Venewitz Creek	Charlotte Lake to Long Prairie R	Fish IBI	
07010108-505	Long Prairie River	Spruce Creek to Eagle Creek	NA-Fish; MTS-Invertebrates	DO
07010108-534	Long Prairie River	Headwaters (Lake Carlos 21-0057-00) to end wetland (CSAH 65)	NA-Fish; MTS-Invertebrates	DO
07010108-535	Long Prairie River	End of Wetland (CSAH 65) to Spruce Creek	NA-Fish; MTS-Invertebrates	DO

MTS=meets standard; NA=not assessable

In addition to the biological impairment listings, there are also a number of water chemistry based impairments in the LP Watershed. As shown in Table 3, several stream reaches listed are impaired for biological and/or chemical parameters. In these cases, it is probable that the water chemistry parameter that resulted in the impairment listing is negatively affecting the aquatic life.

Elements of stream health

The elements of a healthy stream consist of five main components: stream connections, hydrology, stream channel assessment, water chemistry, and stream biology. If one or more of the components are unbalanced, the stream ecosystem fails to function properly and is listed as an impaired water body. The table below shows common stream stressors of fish and invertebrate communities.

Common stream stressors to biology (fish, invertebrates)

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 invertebrates cannot freely move throughout system. Stream temperatures also become elevated due to lack of shade.
Hydrology	**Altered Hydrology** **Loss of habitat due to channelization** **Elevated Levels of TSS** · Channelization · Peak discharge (flashy) · Transport of chemicals	Unstable flow regime within the stream can cause a lack of habitat, unstable stream banks, filling of pools and riffle habitat, and 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 TSS** · 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 invertebrate communities are affected by all of the above listed stressors	If one or more of the above stressors are affecting the fish and invertebrate community, the IBI scores will not meet expectations and the stream will be listed as impaired

Minnesota Department of Natural Resources Watershed Health Assessment Framework

The Minnesota Department of Natural Resources (MDNR) has a web-based tool called the Watershed Health Assessment Framework (WHAF). This framework can be used to evaluate and compare the overall ecological health of a watershed based on the five components of a healthy ecological system: hydrology, geomorphology, biology, connectivity, and water quality. The assessment is based on a multi-metric index for each of these five components. An overall watershed health score is compiled by combining the five component scores. The WHAF can be accessed at http://www.dnr.state.mn.us/whaf/index.html.

The Watershed Health Assessment scores compare conditions found across the state of Minnesota and ranks those results on a scale of 0 to 100. The scores range from the least healthy (0) to most healthy (100) condition. Methodology for scoring each index is different, but the desired healthy condition is a functional and intact natural system. The overall score for the LP Watershed is 59, while the range of overall health scores for the state is 36 to 76. Watersheds around the LP also have scores in the low 50's to low 60's. Much of the score is driven by a land use change from Big Woods-Hardwoods (Oak, Maple, Basswood, Hickory) in the early 1900's to mixed agricultural crop and livestock production of today, along with areas of urbanization. Landscape changes alter the way water moves through the system, along with how nutrients are absorbed and transported.

From the five components evaluated by the WHAF, two of the components score 50 or below. These were the biology and connectivity. The results from this assessment are also validated throughout the SI document. The fish community integrity is limited by the number of crossings (culverts and dams) on the watershed's streams, some of which limit fish movement. There are numerous low head dams which impede upstream movement of most fish species. The high percentage of agricultural land use, both row crop and animal production, has an impact on the water quality within the LP Watershed. The Water Quality Component scored a 64 in the MDNR tool and the field data collected throughout the watershed shows that excessive nutrients are not a watershed-wide problem. The WHAF scores also point out that habitat quality is a limiting factor for biology in this watershed as reflected by the low index score for terrestrial habitat quality.

Long Prairie Watershed

Report overview

The Long Prairie River (LP) watershed consists of eight aggregated 12-digit Hydrologic Unit Code (HUC) subwatersheds (Figure 3). This report describes the step-by-step analytical approach, based on the U.S. Environmental Protection Agency's (EPA) SI process, for identifying probable causes of impairment in a particular system.

This report analyzes the connection between the biological community and the stressor(s) causing the impairments. Stressors are those factors that negatively impact the biological community. Stressors can interact with each other and can be additive to the stress on the biota.

This report includes a discussion of the data collected to support the determination of candidate stressors at the Assessment Unit Identification (AUID) level. A comprehensive review of biological, chemical, and physical data was performed to select probable causes for the impairments. The initial list of candidate causes was narrowed down after additional data analysis leaving five candidate causes for final analysis in this report. The candidate causes that were evaluated and eliminated did not show significant potential for causing biological stress. The candidate causes for the entire LP Watershed were evaluated, and have enough data to show that they are a problem, are listed below:

- Low dissolved oxygen (high nutrient concentrations)
- Increased sediment in stream bed
- Increased total suspended solids
- Altered hydrology/channelization
- Lack of woody habitat
- Connectivity

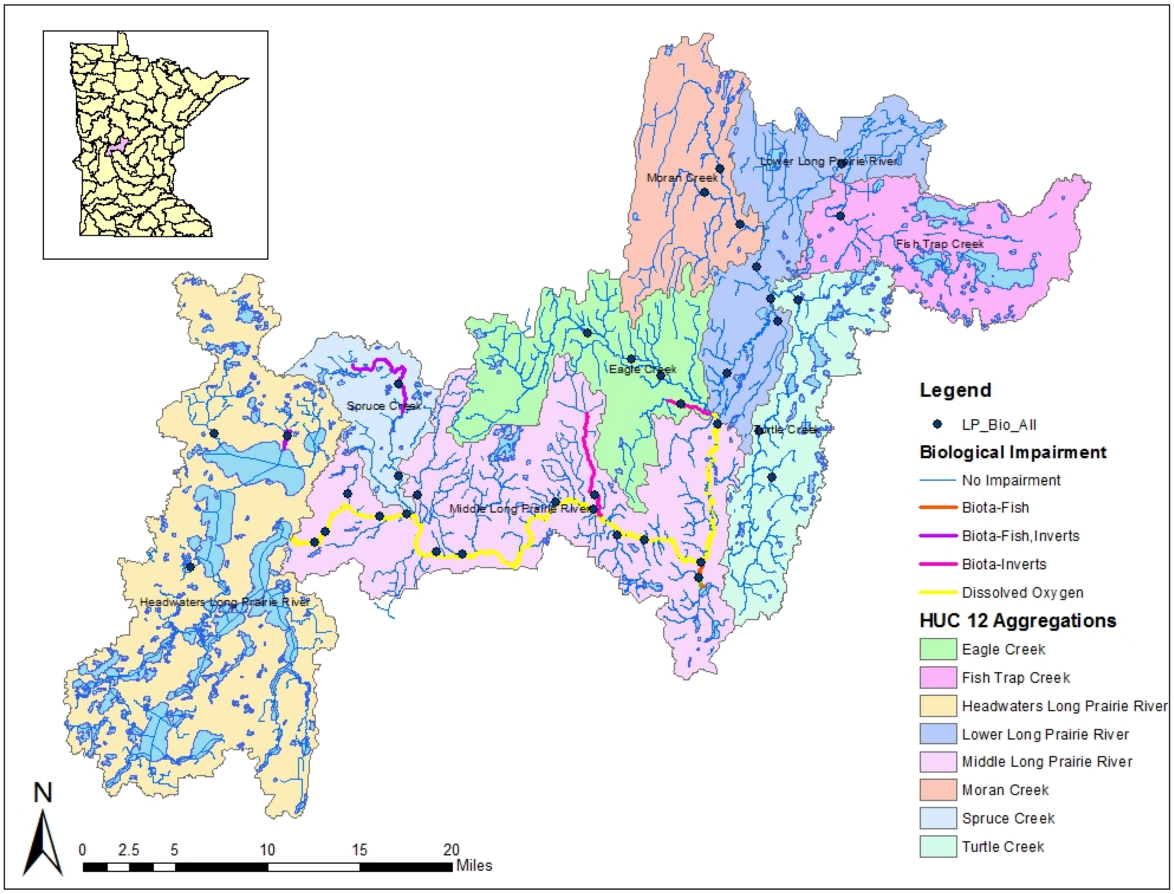

Figure 3: Map showing watershed management units in the LP Watershed. The colored Aggregated 12-digit HUCs are discussed in this report in greater detail (MPCA, 2013).

Watershed background and description

Ecological and administrative regions of the LP Watershed

The LP Watershed resides in the Upper Mississippi River basin, drains approximately 885 square miles and includes portions of five counties. The 8-digit Hydrologic Unit Code number is 07010108. The majority of the watershed is contained within the North Central Hardwood Forest Level III Eco region, with the far eastern end of the watershed in the Northern Lakes and Forests Eco region (Figure 4).

Biological assessment

The LP Watershed was assessed in 2013 for aquatic recreation, aquatic consumption and aquatic life beneficial uses. Based on this assessment process, it was determined that five stream reaches were impaired for biological assemblages, as part of the aquatic life use designation. The biological impairments will be reviewed based on the subwatershed size from the MDNR Minor scale. Each impaired aggregated 12-digit HUC will be presented in the report with smaller subwatersheds analyzed as part of the SI process.

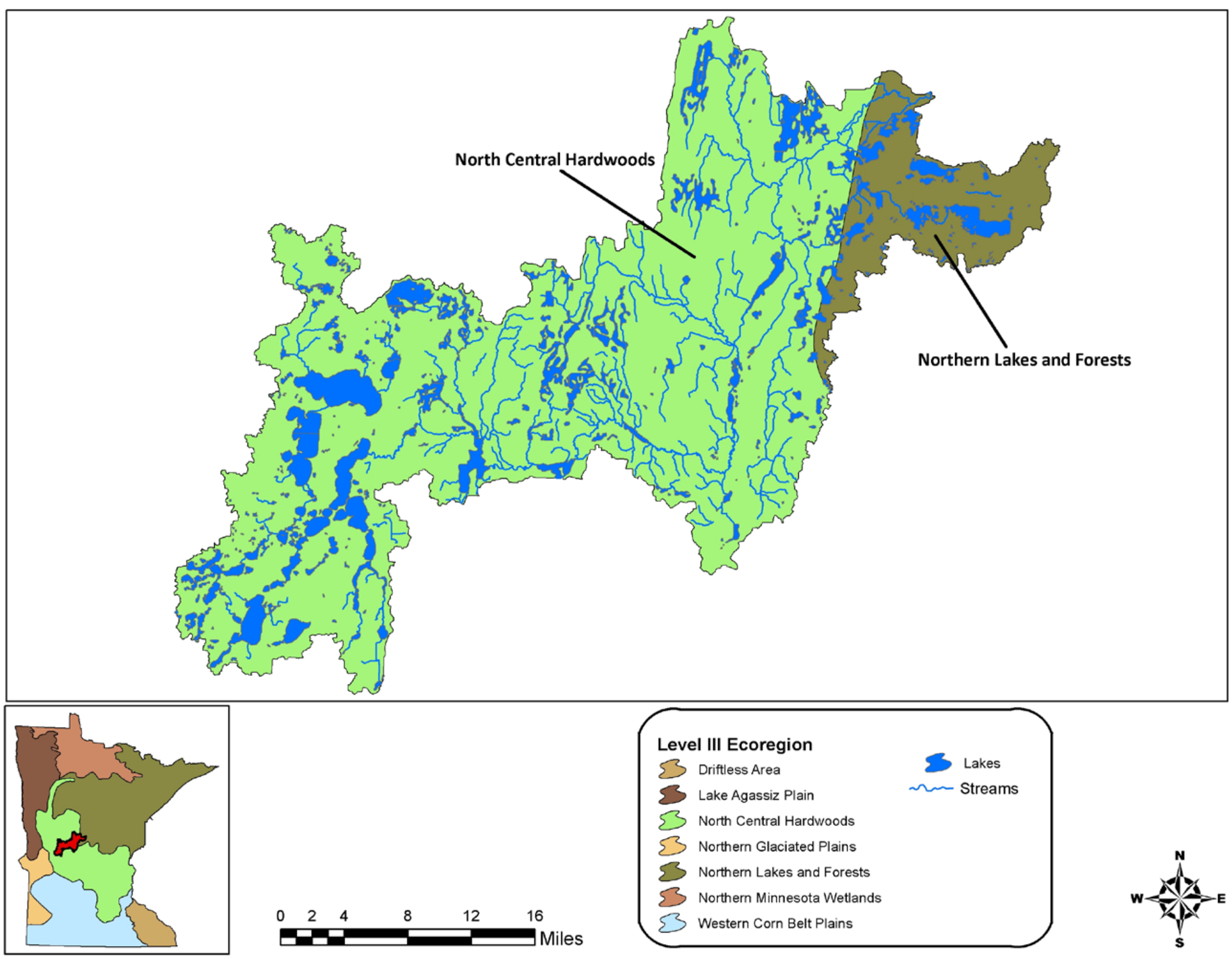

Figure 4: Location of MR-SC Watershed within North Central Hardwood Forest Ecoregion of central Minnesota (MPCA, 2013)

Summary of biological impairments

As part of the aquatic life use portion of the assessment, fish and invertebrates were assessed. The fish and invertebrates within each AUID were compared to a regionally developed threshold and confidence interval and utilized a weight of evidence approach. In the LP Watershed, four AUIDs are currently impaired for a lack of biological assemblage, and two are going to be added in the 2014 assessment cycle (Table 3). The data that was considered during the assessment process was collected from 2002-2011, with data collected in 2013 to be used as supplemental data for the 2014 cycle.

Table 3: List of Long Prairie River impaired biological monitoring sites, biological classifications, and corresponding aggregated 12-digit HUC

AUID ***Reach Name,*** *Reach Description*	Site ID	Stream Name/Biological Impairment	Fish Class	Invert Class	11-Digit HUC
07010108-595 ***Unnamed Creek*** *Headwater to Lake Miltona*	11UM034	Trib. To Lake Miltona/ fish and macroinvertebrate	6	6	07010108010 (Upper Long Prairie River)
07010108-512 ***Spruce Creek*** *T131 R36W S31, north line to Unnamed Lake (21-0034-00)*	09UM089	Spruce Creek/fish and macroinvertebrate	6	9	07010108010 (Upper Long Prairie River)
07010108-592 ***Harris Creek*** *Unnamed Creek to Eagle Creek*	11UM013	Harris Creek/macroinvertebrate only	6	6	07010108-587 (Harris Creek)
07010108-568 ***Venewitz Creek*** *Charlotte Lake to Long Prairie* R	11UM020	Venewitz Creek/ fish only No macroinvertebrate sample collected	7	**NS**	070100108060 (Long Prairie River)
07010108-505 ***Long Prairie River*** *Spruce Cr to Eagle Cr*	11UM025 10EM042 11UM024	Long Prairie River/IF for Fish but resample in 2013 indicates impairment	5	6	07010108010 (Upper Long Prairie River)
07010108-535 ***Long Prairie River*** *End of Wetland (CSAH65) to Long Prairie River*	11UM030	Long Prairie River/ IF for fish but resample in 2013 indicates impairment	5	6	07010108010 (Upper Long Prairie River)

*NS-no sample was collected
*Grey box AUID's have multiple fish samples that have IBI scores at or below the threshold. Both AUID's are currently listed as impaired for dissolved oxygen. It appears that a biological impairment for fish is present.

The fish and invertebrate thresholds and confidence limits are shown by class for sites found in the LP Watershed in Table 4. Table 5 shows the fish and invertebrate Index of Biotic Integrity (IBI) scores for the sites studied further in this report. Fish and invertebrate classes are determined by drainage area and ecological region along with stream gradient for the fish classes. Each class is assigned a threshold value along with upper and lower confidence limits. Sites below the lower confidence limits show severe biological impairment for that class of stream.

Table 4: Fish and Invertebrate IBI thresholds and confidence limits by class for sites located in the Long Prairie River (MPCA, 2012)

Fish Class	Fish Class Name	Fish IBI Thresholds	Upper CL	Lower CL
5	Northern Streams	50	59	41
6	Northern Headwaters	40	56	24
7	Low Gradient	40	50	30

Invertebrate Class	Invertebrate Class Name	Invertebrate IBI Thresholds	Upper CL	Lower CL
6	Southern Forest Streams GP	46.8	60.4	33.2
9	Southern Coldwater	46.1	59.9	32.3

Each IBI is made up of a fish or invertebrate metric that is based on community structure and function and produces a metric score. The number of metrics that make up an IBI will determine the metric score scale. For example, an IBI with 8 metrics would have a scale from 0-12.5 and an IBI with 10 metrics would have a scale from 0-10. The IBI score is then ranked against the IBI thresholds. Below the threshold will place the biological sample on the impaired waters list (303d), which triggers further review of the data and possibly a Total Maximum Daily Load (TMDL) study.

Table 5: Fish and invertebrate IBI scores by biological station for 2013 non-support listing with descriptive color

AUID & Reach	Station	Year	Fish IBI Score	Fish Class	Invertebrate IBI Score	Invertebrate Class
07010108-595 (Unnamed Creek)	11UM034	2011	**0**	6	**37.96**	6
07010108-512 (Spruce Creek)	09UM089	2010	**20**	6	**18.07**	9
07010108-512 (Spruce Creek)	09UM089	2011	**24**	6	**18.07**	9
07010108-592 (Harris Creek)	11UM013	2011	**46**	6	**33.10**	6
07010108-568 (Venewitz Creek)	11UM020	2011	**16**	7	**Not Sampled**	

Table 6: IBI color descriptions

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

Candidate causes for biological impairment

Identifying a set of candidate causes for impairment is an important early step in the SI process. This step provides the framework for assembling key data and for making determinations as to what data are lacking for the causal analysis and strength of evidence process. Candidate causes are defined as the "stressors" or key contributors to the adverse biological effects observed.

Nine candidate causes were selected as potential drivers of biological impairments in the LP Watershed. These nine candidates were chosen after considering a large set of possible candidate causes developed by the EPA. Due to the large size of the study watershed, potential candidate causes were evaluated using a rapid assessment of the biological, water chemistry, land use, and physical habitat data from each of the watershed management zones described in section 2.0.

The nine candidate causes for impairment in the LP Watershed can be broadly grouped into four categories: physical habitat, water quality, flow alteration, and connectivity (Figure 5). These categories will be used as the organizational framework for the strength of evidence analysis that will ultimately define the most probable stressors leading to impaired fish and invertebrate assemblages. In order to keep the causal analysis process more succinct and avoid repetition, all nine candidate causes will be evaluated across the entire watershed, even though several of them are likely to be operative only on a subwatershed scale.

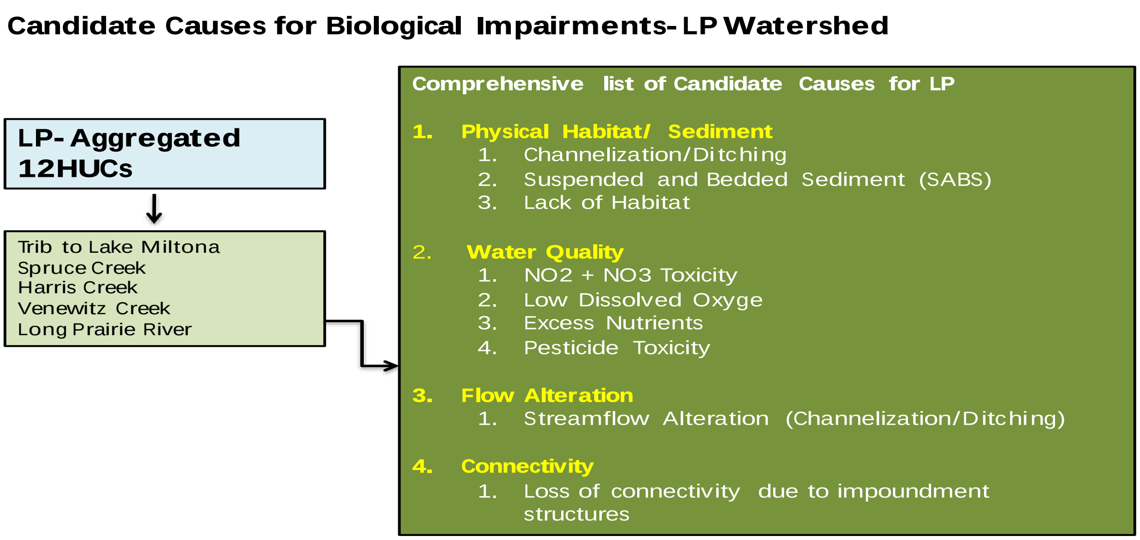

Figure 5: List of candidate causes for biological impairment in the LP Watershed

Candidate Cause: Flow alteration (channelization/ditching)

Background

For the purpose of this report, 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. In the LP Watershed alone, there are numerous county and judicial ditch systems that serve to drain relatively large areas. There are also private ditch networks in the watershed. Due to the existence of agricultural ditching in the LP Watershed, it was identified as a potential cause of fish and invertebrate impairment.

In a study conducted in the east-central Indiana cornbelt region, Lau et al. (2006) found that channelized streams had lower quality fish assemblages when compared to natural streams, based on IBI results. Their results also showed a reduction in riffle and pool habitats associated with channelization, which they considered was the most significant factor affecting the fish assemblage.

Numerous studies have found conventional trapezoidal ditches to be inferior to natural streams in terms of sediment transport capacity and channel stability over time (Urban and Rhoads, 2004; Landwehr and Roads, 2003). Conventional ditches are designed to handle low frequency, high-magnitude flood events. This design may not support adequate water depth and velocities for transporting sediment and maintaining stream features (e.g., glide, riffle, run, pool) during low to moderate flow periods. The common result is excess sedimentation of the stream bed as particles become immobile and aggrade over time. In general, this design does not provide good habitat for aquatic species or provide stability of its streambed and stream banks.

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).

Casual analysis

Many of the LP tributaries are channelized in portions of all subwatersheds (Figure 6). The effects of channelization can impact reaches upstream and downstream that remain in natural channel conditions, so the effects may be more wide-reaching than the map in Figure 7 indicates.

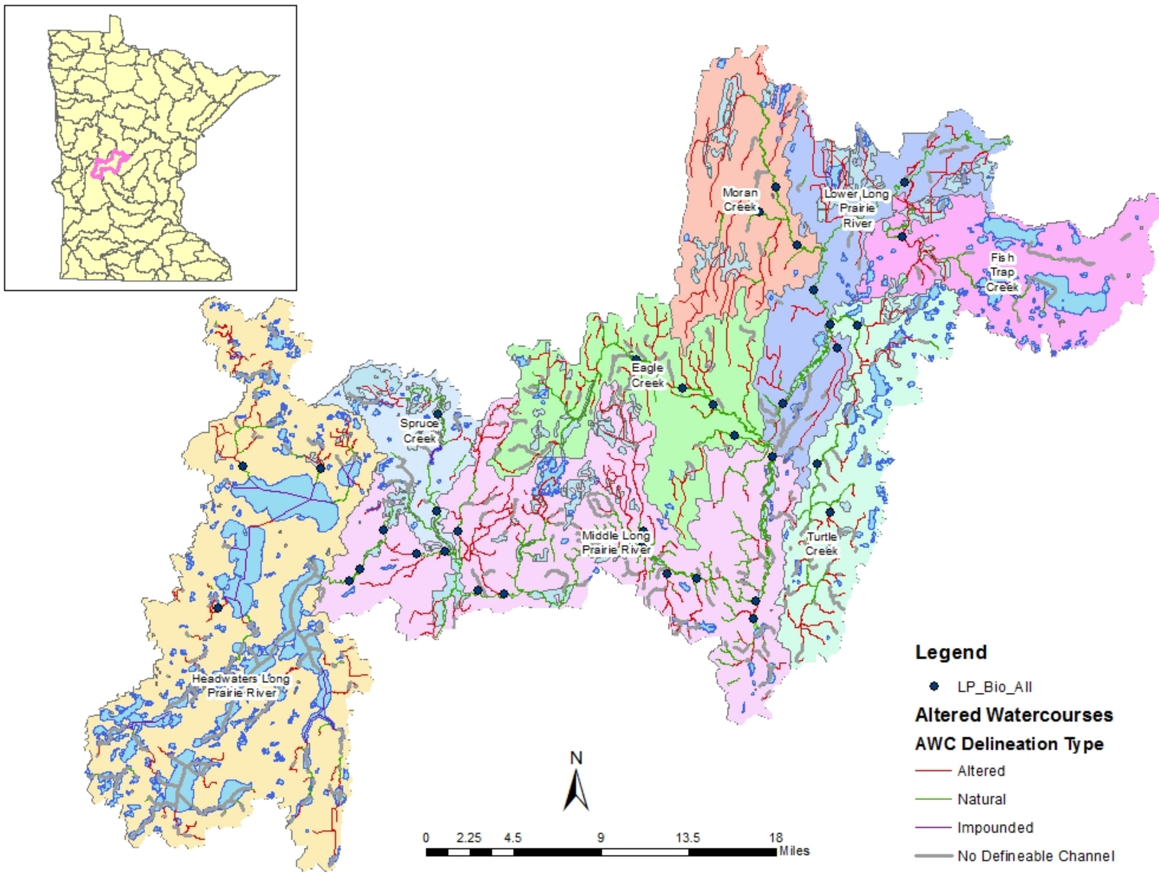

Figure 6: LP Watershed streams that are altered (red) versus natural channel (green) (MPCA, 2013)

Causal pathways model for altered flow

Channelization occurs on ditches serving as first and second order streams to larger streams within this particular watershed. The channelized reaches serve to route water quickly off the landscape, which alters the natural hydrologic regime of the system. The causes and potential sources for altered flow in the LP Watershed are modeled at EPA's CADDIS Flow Alteration webpage. Channelization/ditching is a probable secondary cause of low fish IBI scores in the Unnamed Creek (11UM034) watershed. Nearly 50% of this AUID is channelized. In addition, many of the predicted biological responses routinely associated with channelization in the scientific literature (e.g., loss of riffle habitat, change in trophic structure, and loss of sensitive species) are evident at this sampling location.

Candidate Cause: Suspended sediment (TSS)/bedded sediment

Total suspended solids (TSS) and bedded sediment are related through several common watershed sources and processes, but each can affect aquatic biota in different ways. Due to the inter-related nature of these parameters, they are grouped together in this report for causal analysis purposes, but ultimately each of these candidate causes will be evaluated independently in terms of impact on fish and macroinvertebrate populations.

Whereas suspended solids and turbidity are potential stressors operating in the water column, bedded (= deposited) sediments impact the stream substrate. Excessive deposition of fine sediment can impair macroinvertebrate habitat quality and productivity (Rabeni et al., 2005). To date, bedded sediment has not been extensively studied in the LP Watershed, in part because there is no state or federal water quality standard for this parameter. Quantitative field measurement of bedded sediment is very difficult; however, a significant amount of data on substrate composition and embeddedness (the degree in which fine sediments surround coarse substrates on the surface of a stream bed) was collected. These data will be used to determine whether or not natural coarse substrate (an important habitat type) is being covered up or filled in by excess fine sediment.

Biological effects of TSS and bedded sediment

The presence of excess bedded sediment (embeddedness) in stream habitats has been proven to adversely impact fish and macroinvertebrate species that depend on clean, coarse stream substrates for feeding, refugia, and/or reproduction (Newcombe et al., 1991). Aquatic macroinvertebrates are generally affected in several ways, including: (1) loss of certain taxa due to changes in substrate composition (Erman, 1988); (2) increase in drift (avoidance) due to sediment deposition or substrate instability (Rosenberg, 1978); and (3) changes in the quality and abundance of food sources such as periphyton and other prey items (Peckarsky, 1984). Fish communities are typically influenced via: (1) a reduction in spawning habitat or egg survival (Chapman 1988); and/or (2) a reduction in prey items as a result of decreases in primary production and benthic productivity (Bruton, 1985); (Gray L. a., 1982; Gray & Ward, 1982). The presence of excess bedded sediment (embeddedness) in stream habitats has been proven to adversely impact fish and macroinvertebrate species that depend on clean, coarse stream substrates for feeding, refugia, and/or reproduction (Newcombe et al., 1991). Aquatic macroinvertebrates are generally affected in several ways, including: (1) loss of certain taxa due to changes in substrate composition (Erman, 1988); (2) increase in drift (avoidance) due to sediment deposition or substrate instability (Rosenberg, 1978); and (3) changes in the quality and abundance of food sources such as periphyton and other prey items (Peckarsky, 1984). Fish communities are typically influenced via: (1) a reduction in spawning habitat or egg survival (Chapman 1988); and/or (2) a reduction in prey items as a result of decreases in primary production and benthic productivity (Bruton, 1985); (Gray & Ward, 1982).

Water quality standard

The water quality standard for turbidity is 25 Nephelometric Turbidity Units (NTUs) for Class 2B waters. Total suspended solids and transparency tube/Secchi tube measurements can be used as surrogate standard. A regression of the Total Suspended Solids to turbidity indicates impairment at 30 mg/L for waters within the North Central Hardwoods Ecoregion.

A strong correlation exists between the measurements of TSS concentration and turbidity. In 2010, the MPCA released draft TSS standards for public comment (MPCA, 2009). The new TSS criteria are stratified by geographic region and stream class due to differences in natural background conditions resulting from the varied geology of the state and biological sensitivity. The draft TSS standard for LP Watershed has been set at 30 mg/L. For assessment, this concentration is not to be exceeded in more than 10% of samples within a 10-year data window.

For the purposes of stressor identification, TSS results will be relied upon to evaluate the effects of suspended solids and turbidity on fish and macroinvertebrate populations. TSS results are available for the watershed from state-certified laboratories, and the existing data covers a much larger spatial and temporal scale in the watershed.

Sources and pathways of deposited and bedded sediment: riparian grazing/bank erosion

Rangeland and pasture are common landscape features throughout the LP Watershed. Most of these areas are operated for cattle grazing, but several horse operations were noted during reconnaissance trips throughout the watershed. Cattle pasture within the riparian corridor of rivers and streams has been shown to increase streambank erosion and reduce substrate quality (Kauffman, 1984). In some areas, the riparian corridor along the Long Prairie tributaries has been cleared for pasture and heavily grazed, resulting in a riparian zone that lacks deep-rooted vegetation necessary to protect streambanks and provide shading. Exposures of these areas to weathering, trampling, and shear stress (water friction) from high flow events are increasing the quantity and severity of bank erosion.

Figure 7 shows examples of bank erosion observed in the LP Watershed. Bank erosion occurred within urban/developed areas, along the edges of cultivated cropland, and even heavily-wooded riparian corridors. This suggests that there are multiple land uses and erosional processes contributing to increased sediment inputs and sediment-related stressors to aquatic life. Buffers of inadequate width to protect streambank integrity and aquatic habitat were observed in the LP Watershed. The causes and potential sources for increases in turbidity in the LP Watershed are modeled at EPA's CADDIS Sediments webpage.

Figure 7: Examples of bank erosion from various land cover types in the LP Watershed

Total suspended volatile solids

The presence of algae and other volatile constituents in the water column can contribute to elevated TSS concentrations and high turbidity. Total suspended volatile solids (TSVS) are the particles in a water sample that are lost upon ignition at a temperature around 550˚C. TSVS concentrations can provide a rough approximation of the amount of organic matter present in suspension in the water column. Examples of TSVS constituents in streams include algae and other aquatic microorganisms and detritus. Elevated TSVS concentrations can impact aquatic life in a similar manner as TSS – with the suspended particles reducing water clarity – but unusually high concentrations of TSVS can also be indicative of nutrient imbalance and an unstable dissolved oxygen regime.

Specific effects of TSS on fish and macroinvertebrates

Based on overall IBI scores alone, it is difficult to isolate the potential effects of elevated TSS on biota from other confounding stressors. In-depth analysis of certain species or biological metrics that may be sensitive to elevated TSS concentrations can offer some insight into the role of elevated TSS in biotic impairments in the LP Watershed. Table 7 is a compilation of observed biological responses to elevated TSS and suspended sediment gathered from other research.

Table 7: Impacts of elevated concentrations of suspended sediment on fish and macroinvertebrate assemblages

Biota Impacted	Effect	Source
Invertebrate	↓ filter feeders (esp. Hydropsychidae) (x)	Arruda et al. (1983); Lemley (1982)
Invertebrate	↑collector-gatherer	
Invertebrate	↓ grazer taxa	
Invertebrate	↑ chironomid density	Gray and Ward (1982);
Invertebrate	↓ Ephemeroptera, Trichcoptera	
Fish	↓ abundance / feeding efficiency / growth smallmouth bass	Berry et al. (2003); Paramagian (1991)

Filter feeding groups of macroinvertebrates are reduced in sites that are impacted by TSS and substrate embeddedness. Figure 8 displays the relative abundance of two macroinvertebrate functional feeding groups for streams where the MPCA had collected both macroinvertebrate and stream sediment data. This subset of sites is from impaired streams. There was little substrate data from unimpaired streams to use as a reference. As water quality degrades through the increase in suspended material, or increased fine material in stream bottom, filter- feeding groups are reduced in abundance. The filter-feeding group is composed of species that create nets or have special adaptations for filtering food out of the water column (McCollor, 1993). The collector-filterer group is generally clingers. If stream embeddedness increases and particle size decreases, the clingers have less rock habitat to cling to. The high mineral content of fine sand that deposits may clog nets and impede the filtering process. There is an advantage to gathering your food, and the relative abundance of this feeding group will increase.

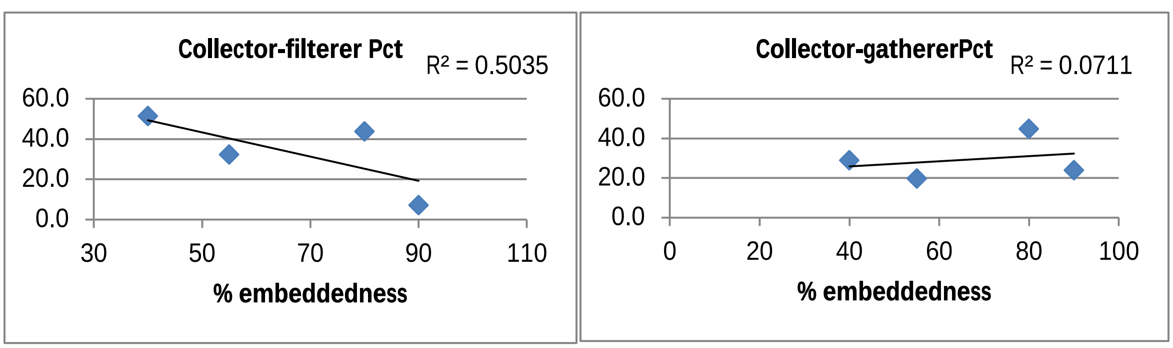

Figure 8: Macroinvertebrate functional feeding groups displaying filtering versus gathering over percent stream embeddedness

Assessment of bedded sediment

Bedded sediment was assessed using a visual observation of the amount of fine sediment surrounding the coarse substrate on the stream bottom. This measurement is part of the qualitative habitat assessment of impaired reaches that was conducted by the MPCA. Assessment of particle size was also conducted at select biological monitoring sites to assess the D^{50} or the mean particle size of the stream bottom. Review of the percent embeddedness and percent fines reveal that the percent embeddedness is highly related to the D^{50} particle size of the stream substrate. Figure 9 shows the relationship between embeddedness and the mean particle size (D^{50}) for each measured reach.

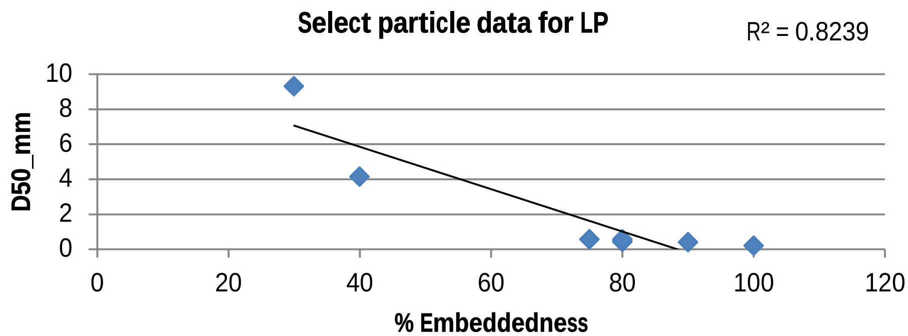

Figure 9: Relationship of particle size (D^{50}) in millimeters to percent embeddedness in select LP Watershed stream locations

Causal analysis-bedded sediment

Review of the biological monitoring stations that have percent embeddedness data shows a negative response by the macroinvertebrate group known as clingers to the amount of stream embeddedness. As coarse substrates become more embedded with fine sediment, the percent of clinger taxa in the macroinvertebrate sample is reduced (Figure 10). This ClingerChTxPct metric is a measure of the relative percentage of taxa adapted to cling to substrate in swift flowing water.

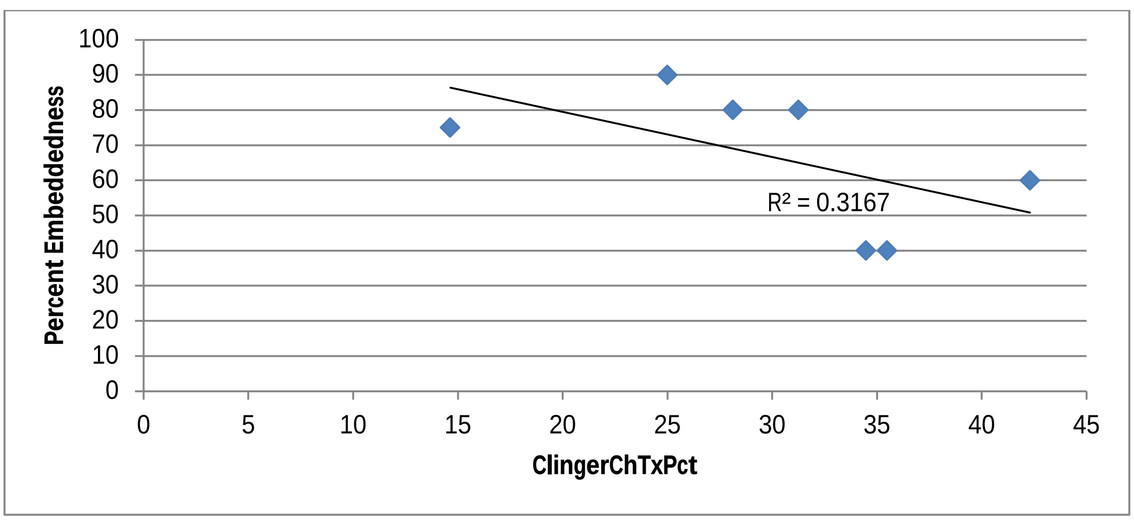

Figure 10: This graph compares the macroinvertebrate group (clinger) compared to stream substrate embeddedness. This graph includes sites that were impaired for both fish and macroinvertebrates.

Strength of evidence summary for bedded sediment

Bedded sediments are likely a stressor to fish and macroinvertebrate assemblages in the LP Watershed. This is especially the case in channelized reaches in the Headwaters Long Prairie River and Spruce Creek Aggregated 12-digit HUC's. Substrate embeddedness levels were high (75-100%) in select areas and the response from biota indicated a cause and effect relationship (low DarterSculpSucTx taxa richness, decrease in clingers). DarterSculpSucTx is the taxa richness of fish that are darters, sculpins, and round bodied suckers.

The presence of excess bedded sediment and negative effects on biota is more difficult to determine in the other Aggregated 12-digit HUC's because we do not have embeddedness data and the associated particle size data from these 12-digit HUC's. There is qualitative data available on substrate composition and embeddedness estimates which are part of the habitat data collected during the fish survey. Looking at all fish sampling sites and comparing to the Minnesota Stream Habitat Assessment (MSHA) embeddedness category shows no correlation between the MSHA embeddedness score and the fish metric DarterSculpSucTxPct.

Candidate Cause: Nitrate-Nitrite

NO_2 – NO_3 water quality standards/ecoregion expectations

Streams classified as Class 1 waters of the state, designated for domestic consumption, in Minnesota have a nitrate-nitrogen water quality standard of 10 mg/L. At this time, none of the AUIDs in the LP Watershed that are impaired for biota are classified as Class 1 streams. Minnesota currently does not have a nitrate standard for other waters of the state besides for Class 1. McCollor and Heiskary (1993) compiled NO_2 – NO_3 data for minimally impacted streams from Minnesota's ecoregions in an effort to provide a basis for establishing water quality goals. Most of the LP Watershed falls within the North Central Hardwood Forest ecoregion, which has an ecoregion norm of 0.04 to 0.26 mg/L for NO_2+NO_3-N. The one sampling location that routinely was above the ecoregion norm was Spruce Creek at S007-439. This site ranged from 0.21 to 2 mg/L.

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 invertebrates. Certain species of caddisflies, amphipods, and salmonid fishes seem to be the most sensitive to nitrate toxicity (Camargo & Alonso, 2006).

Sources and causal pathways of NO_3 - NO_2 toxicity

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 micro-organisms 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).

Given the amount of cultivated cropland in the watershed, it is feasible that fertilizer application is a prominent source of nitrate in surface water (Folmar, Samders, & Julin, 1979). Due to the limited nitrate-nitrite data, this stressor cannot be fully assessed in the LP Watershed. Currently the data set for nitrate-nitrite is not large enough for full understanding of LP stream nitrate-nitrite concentrations. Additional water quality samples should be collected in the impaired AUID's to further understand the seasonal and hydrologic related concentrations. For a complete model of causes and potential causes of nitrates in the LP Watershed, please see the EPA's CADDIS Nitrogen webpage.

Candidate Cause: Pesticide toxicity

Background and Conceptual Model (text courtesy of EPA CADDIS). For a more detailed explanation on herbicides, follow this link: http://www.epa.gov/caddis/ssr_herb_int.html.

Herbicides are chemicals used to manipulate or control undesirable vegetation. The most frequent application of herbicides occurs in row-crop farming, where they are applied before or during planting to maximize crop productivity by minimizing other vegetation. They also may be applied to crops in the fall, to improve harvesting. In suburban and urban areas, herbicides are applied to lawns, parks, golf courses, and other areas. Herbicides are also applied to water bodies to control aquatic weeds that impede irrigation withdrawals or interfere with recreational and industrial uses of water (Folmar, Samders, & Julin, 1979).

Herbicides may cause biological impairments if they occur in water or sediment at sufficient concentrations. Most commonly, they enter surface water in runoff or leachate. Herbicides have relatively low toxicity to fish and invertebrates; therefore, acute toxicity is likely only when they are deliberately or accidentally applied directly to water bodies. Direct applications may result in direct toxicity to non-target plants and animals or indirect effects due to the death and decomposition of plants.

Insecticides are chemicals used to control insects by killing them or preventing them from engaging in behaviors deemed undesirable or destructive. Many insecticides act upon the nervous system of the insect (e.g., Cholinesterase (ChE) inhibition) while others act as growth regulators. Insecticides are commonly used in agricultural, public health, and industrial applications, as well as household and commercial uses (e.g., control of roaches and termites). The U. S. Department of Agriculture (2001) reported that insecticides accounted for 12% of total pesticides applied to the surveyed crops. Corn and cotton account for the largest shares of insecticide use in the United States. To learn about insecticides and their applications, along with associated biological problems, refer to the EPA website on insecticides and causal analysis located at http://www.epa.gov/caddis/ssr_ins_int.html.

Pesticide monitoring in Minnesota and water quality standards

Since 1985, the Minnesota Department of Agriculture (MDA) and Minnesota Department of Health have been monitoring the concentrations of common pesticides in groundwater near areas of intensive agricultural land use. In 1991, these monitoring efforts were expanded to include surface water monitoring sites on select lakes and streams. To learn more about the MDA pesticide monitoring plan and results, go to the following website:
http://www.mda.state.mn.us/protecting/cleanwaterfund/pesticidemonitoring.aspx.

Surface water reference values (text from MDA, 2010)

"The MPCA has developed toxicity-based (for aquatic life) or human health-based enforceable chronic standards for pollutants detected in surface water. The toxicity-based standard is designed to be protective of aquatic life exposure, and is typically based on exposure duration of four days. The human health-based standard (protective for drinking water plus fish consumption) is based on exposure duration of 30 days. For the most current MPCA water quality rules see, Minn. R. ch. 7050: Standards for Protection of Waters of the State (www.revisor.leg.state.mn.us/rules/?id=7050)." A summary of the MPCA's chronic and maximum standard values for common pesticides used in Minnesota are shown in Table 8.

Table 8: Summary of MPCA surface water standards associated with target pesticide anayltes

	Chronic[1] and Maximum[2] Standards (µg/L)		
Pesticide Analyte	**Class 2A[3]**	**Class 2B[4]**	**Maximum Standard[4]**
Acetochlor	3.6	3.6	86
Alachlor	59	59	800
Atrazine	10	10	323
Chlorpyrifos	0.041	0.041	0.083
Metachlor	23	23	271

[1] Chronic standards are defined in Minn. R. ch. 7050 as toxicity-based for aquatic organisms and is protective for an exposure duration of four days.
[2] Maximum standard value for aquatic life & recreation as defined in Minn. R. ch. 7050. Values are the same for all classes of surface waters.
[3] State water classification for coldwater streams and all recreation.
[4] State water classification for cool and warm water streams and all recreation.

Pesticides in the LP Watershed

Sampling on the LP was limited to one sampling event (rain event) in August 2012 at five sites (Table 9). Herbicides are often detected in surface waters with greater regularity and higher concentrations in spring and early summer after significant rain events. Therefore, the sampling results for the LP may not be entirely representative of herbicide and pesticide concentrations in the watershed.

Table 9: Site descriptions and sampling years for pesticide monitoring in the LP Watershed

Site ID	Description	Year Sampled
S000-282	Long Prairie River Bridge on US-10, South of Motley, Minnesota	2012
S002-902	Eagle Creek on Bridge at CSAH 21, 0.5 miles north of Browerville, Minnesota	2012
S002-909	Long Prairie River on Bridge at CR 65, 2.5 miles southeast of Miltona, Minnesota	2012
S002-903	Moran Creek on Bridge at 255th Ave., 8 miles southwest of Staples, MInnesota	2012
S000-283	Long Prairie River, west of Long Prairie	2012

Based on current monitoring data, Atrazine, 2,4-D and Metolachlor were the most commonly detected herbicides in the greater LP Watershed (Table 10). This limited data set does show exceedances of Minnesota state pesticide standards for Acetochlor and Metolachlor. Much more rigorous data collection would be required to conclude that pesticides are not a stressor on the aquatic biota.

Strength of evidence/conclusions

Additional monitoring is recommended to further understand the presence of herbicides/pesticides/ fungicides in the LP Watershed and their potential impact to fish, macroinvertebrates, and other aquatic biota. Monitoring data from various summer rain events would improve confidence in the ability to diagnose or refute pesticide toxicity as a stressor in this watershed. Given these current gaps in the herbicide/pesticide/fungicide data, it is difficult to rule out pesticide toxicity as a possible stressor.

Table 10: Herbicides, insecticides, and fungicides detected in the LP Watershed

Herbicide	S000-282 Long P R. Bridge on US-10	S002-902 Eagle Cr. On BRG at CSAH 21	S000-283 Long P R. west of Long Prairie	S002-909 Long P R. on BRG at CR65	S000-903 Moran Cr on BRG at 255th Ave
Acetochlor	32.8	82.9	ND	ND	ND
Alachlor ESA (ng/L)	113	ND	ND	ND	ND
Atrazine	P	NA	P	P	ND
- Desethylatrazine	P	NA	P	P	ND
Dimethenamid	P	NA	ND	ND	ND
Metolachlor ESA (ng/L)	237	303	66.9	13.9	71.5
Metolachlor OXA (ng/L)	89.1	26.8	11.4	ND	ND
2,4-D (ng/L)	ND	53.5	12.8	50.9	ND
Propazine	ND	NA	ND	ND	ND
Chlorpyrifos	ND	NA	ND	ND	ND
Propiconazole	ND	NA	ND	ND	ND
Tetraconazole	ND	NA	ND	ND	ND

The above stations were only sampled once during low-flow conditions in August 2012
P – Present, but below detection limits
ND – non-detect
NA – parameter not available

Candidate Cause: Chloride toxicity

The negative effects of elevated chloride concentrations on aquatic life have been well documented. 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).

Chloride toxicity was considered a candidate cause for impairment due to the expanding urban, agricultural fertilizer application, commercial, and residential development in the LP Watershed. There is currently chloride data for the LP River in two AUID's (07010108-505 and 535). Data from AUID 505 shows elevated chloride in July and August with samples ranging from 80-100 mg/L. The samples from AUID 535 ranged from 0 -40 mg/L. The remaining LP Watershed does not have chloride data available. Unless some chloride samples are collected, chloride cannot be assessed as a stressor to aquatic life. To better understand if chloride is a stressor to aquatic life, chloride samples should be collected in AUID 07010108-505 during the entire year. There are no winter chloride results to review at this time in the LP Watershed.

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, 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). Many species of fish avoid areas where DO concentrations are below 5 mg/L (Raleigh, 1986).

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 base flow. As temperature increases, the saturation level of DO decreases. Increased water temperature also raises the DO needs for many species of fish (Raleigh, 1986). Low DO can be an issue in streams with slow currents, excessive temperatures, high biological oxygen demand, and/or high groundwater seepage (Hansen, 1975). The Class 2B* water quality standard for DO in Minnesota is 5 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% of the time during both the five-month period of May through September and the seventh-month period of October through April. Accordingly, no more than 10% of DO measurements can violate the standard in either of the two periods.

Further, measurements taken after 9:00 in the morning during the five-month period of May through September are no longer considered to represent daily minimums, and thus measurements of >5 DO later in the day are no longer considered to be indications that a stream is meeting the standard.

A stream is considered impaired if: (1) more than 10% of the "suitable" (taken before 9:00) May through September measurements, or more than 10% of the total May through September measurements, or more than 10% of the October through April measurements violate the standard; and (2) there are at least three total violations.

Types of dissolved oxygen data

1. 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. Because DO concentrations can vary significantly with changes in 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.

2. Longitudinal (Synoptic)

   A series of longitudinal synoptic DO surveys were conducted throughout the LP Watershed in 2013. A synoptic monitoring approach gathers data across a large spatial scale and minimal temporal scale (as close to simultaneously as possible). 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.

3. Diurnal (continuous)

   YSI sondes were deployed for 7-12 day intervals at sites located in the Long Prairie River in late summer to capture the diurnal fluctuations. This data revealed the magnitude and pattern of diurnal DO flux at each site. The diurnal DO sampling results for the Long Prairie River can be found on pages 56-57 of this report.

Potential sources and pathways for low dissolved oxygen

Dissolved oxygen concentrations in streams are driven by a combination of natural and anthropogenic factors. Natural background characteristics of a watershed, such as topography, hydrology, climate, and biological productivity can influence the DO regime of a waterbody. Agricultural and urban land uses, impoundments (dams), and point-source discharges are just some of the anthropogenic factors that can cause unnaturally high, low, or volatile DO concentrations. The conceptual model for low DO as a candidate stressor in the LP Watershed is shown in **EPA CADDIS website by following this link:** **Dissolved oxygen simple conceptual diagram | CADDIS: Sources, Stressors & Responses | US EPA**.

Evidence of causal pathways-nutrients/chlorophyll-a, and oxygen demand

Nutrient enrichment, chlorophyll-a (Chl-a) concentrations, and measures of biological oxygen demand (BOD) are all factors in the dissolved oxygen balance of streams. Currently, the MPCA is developing nutrient criteria for Minnesota Rivers with targets for total phosphorous and several stressor effects that excess nutrients can cause – high diurnal DO flux, high Chl-a concentrations, and elevated BOD levels (Table 11). LP data for these parameters and the river nutrient criteria in development can be used to investigate potential pathways and sources of low dissolved oxygen.

Table 11: Draft river eutrophication criteria ranges by River Nutrient Region for Minnesota

	Nutrient	Stressor		
Region	TP µg/L	Chl-a µg/L	DO flux mg/L	BOD_5 mg/L
Central	100	<20	≤4.5	≤2.0

1. Total phosphorous

   Elevated total phosphorus (TP) levels can cause excessive growth of algae and periphyton in streams, along with excessive submerged aquatic plant growth. Excessive TP concentrations can lead to an increase in turbidity, decrease DO concentrations, and increase fluctuations in diurnal DO levels. Those changes can result in reduction or absence of intolerant species, benthic insectivores, and top carnivores typical of high-quality streams, leading to less desirable assemblages of tolerant species, niche generalists, omnivores, and detritivores typical of degraded streams (Ohio EPA, 1999). Phosphorus is typically the limiting nutrient to primary productivity in streams and rivers under natural conditions.

2. Chlorophyll-a

   Chlorophyll-a concentration is used to measure algal productivity in surface water, and have shown correlations to maximum DO concentrations and DO flux in non-wadable rivers (Heiskary, 2010). There is no chlorophyll-a data collected from the Long Prairie River and its tributaries.

3. Biological oxygen demand

   Biological oxygen demand (BOD) is an important measure of potential stress on a biological community. Heiskary et al. (2010) documented a relationship between BOD and biological condition. Increases in BOD lead to lower DO levels and, thus, may result in a shift in fish and invertebrate trophic structure. Heiskary et al. (2010) observed that many biological metrics indicated a negative shift in biological condition (stress response) at about 2-3 mg/L BOD. There is no BOD data from the LP Watershed.

4. Dissolved oxygen flux

   Hieskary et al. (2010) observed several strong negative relationships between fish and macroinvertebrate metrics and DO flux. Their study found that a diurnal (24-hour) DO flux over 4.5 mg/L reduced macroinvertebrate taxa richness and the relative abundance of sensitive fish species in a population.

Candidate Cause: Loss of connectivity and habitat

Stream impoundments

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

There is one large dam located on Spruce Creek on CR66 in the LP Watershed. This dam is approximately 15.1 feet high and serves as a major fish migration barrier. There is also a water control structure located on Harris Creek (Figure 31), and culverts that are acting as fish barriers on Unnamed Creek (Figure 39).

The impacts of dams on the fish and invertebrate assemblages of the LP rivers and streams are difficult to quantify, but this is probably a medium priority stressor relative to some of the other stressors discussed in this report. There are limited upstream/downstream data sets to show if there are differences in biological integrity in reaches with impoundment structures, although comparisons are difficult when there are other confounding stressors present. The loss or reduction of connectivity between the two Spruce Creek sampling locations is altering fish assemblages locally.

Groundwater or surface water withdrawal

There are very few areas in the LP Watershed that have center pivot irrigation. The corridor along the Long Prairie river has some center pivot irrigation occurring just downstream of the city of Browerville. This area is not likely contributing to altered hydrology in the LP.

Habitat

Habitat is a broad term encompassing all aspects of the physical, chemical, and biological conditions needed to support a biological community. This section will focus on the physical habitat structure including geomorphic characteristics and vegetative features (Griffin, Rashleigh, & Schofield, 2010). Physical habitat is often interrelated to other stressors (e.g., sediment, flow, dissolved oxygen) but will be addressed separately here.

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

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

Habitat characteristics in the LP Watershed

Areas of the upstream portion of Spruce Creek, Harris Creek, and Freemans Creek lack woody riparian and the associated leaf pack. These areas generally lack deep pools and quality riffles as well, because of an increase in fine sediment that is filling the pools. Bank erosion and upland sediment sources are contributing to the increase in fine sediment.

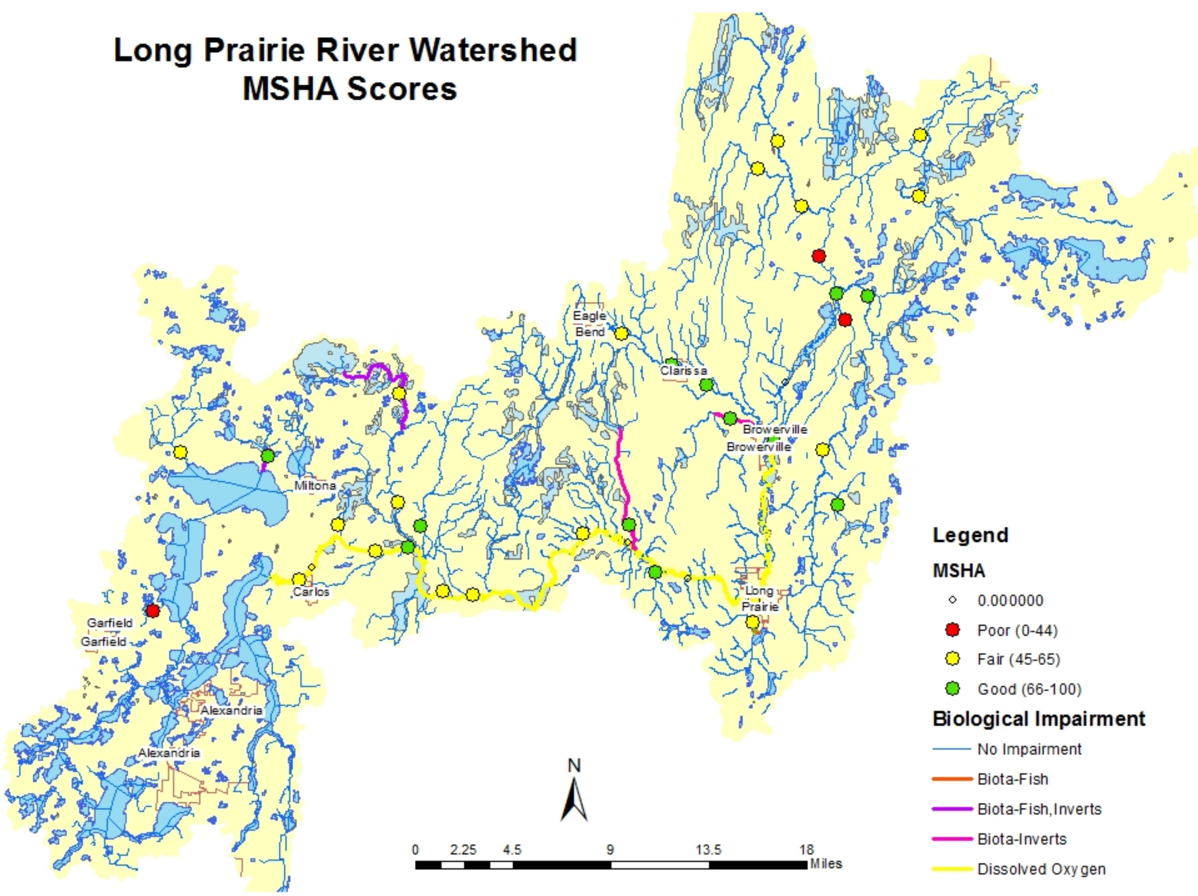

Figure 11: Average MSHA scores at biological sampling stations in the LP Watershed

In the LP Watershed, habitat scores were predominately fair or good (Figure 11). The isolated poor habitat scores occurred in stream AUIDs that had old channelization characteristics. The biological monitoring sites that were studied in 2013 had MSHA scores that were fair or good. More intense channel survey work was conducted at these locations to determine the depth of pools, spacing of pools and riffles and composition of the substrate. Each AUID that was further studied will be discussed later in this report.

Middle Long Prairie River 11-digit HUC

Venewitz Creek AUID (07010108-568) fish impairment only

Venewitz Creek lies in the south side of the LP Watershed. This AUID area starts at Charlotte Lake outlet south of the city of Long Prairie and flows north to the Long Prairie River (Figure 12). The drainage area is 11,620 acres. Historically, this area was dominated by deciduous forest and shrub/scrub, with areas of "emergent herbaceous wetland" along the southern end of the watershed. Current land-use is predominantly agricultural (30% cultivated land, 39% range land) and only 11% of the area remains forest and 5% wetlands (Figure 13).

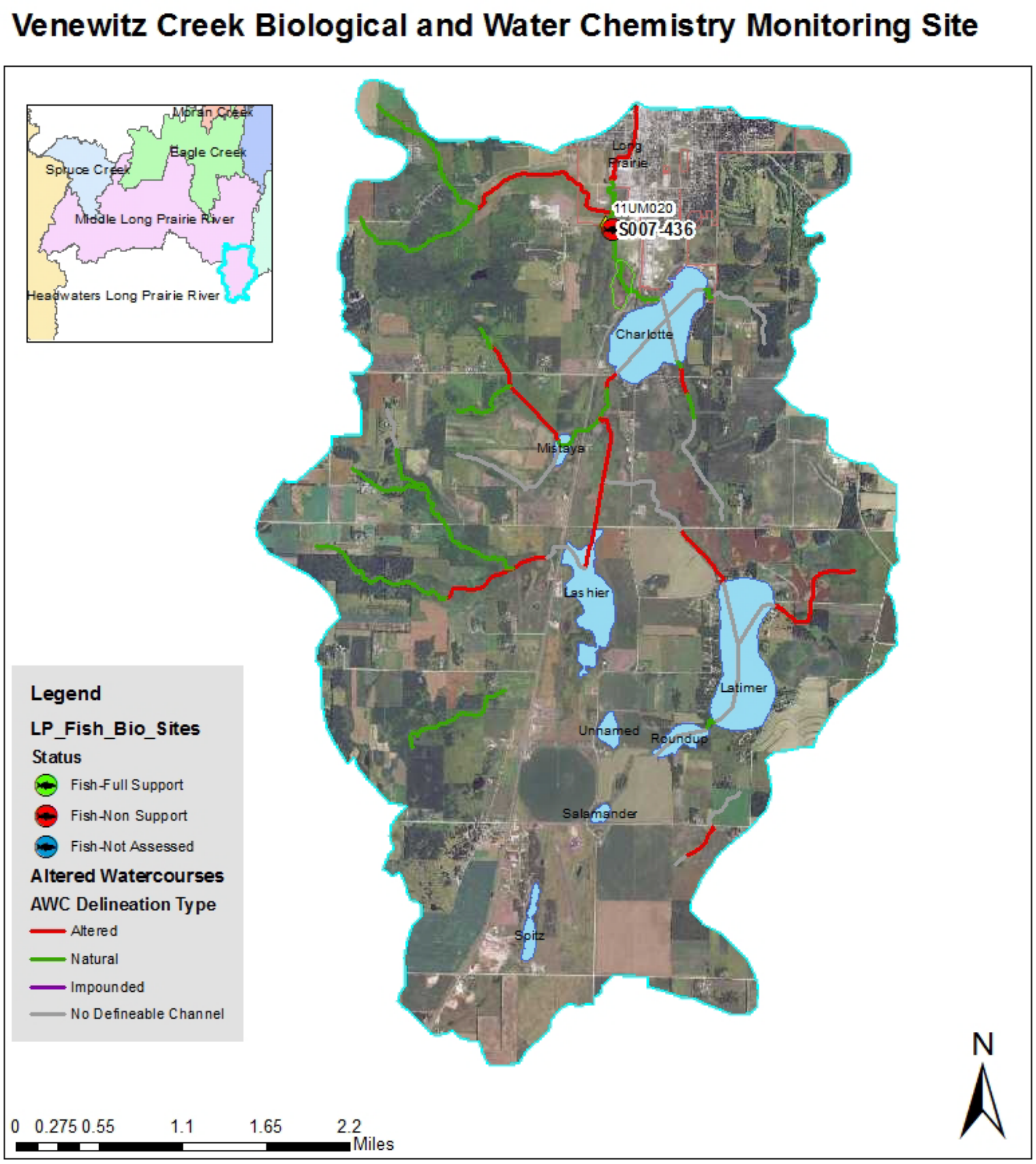

Figure 12: Venewitz Creek minor with impaired biological and investigated water quality sampling locations (MPCA, 2013). Venewitz Creek is a part of the Middle Long Prairie River 11-digit HUC. This subwatershed lies in the far southeastern corner of the Middle Long Prairie River 11-digit HUC. The 8-digit HUC is the entire Long Prairie River and can be seen on page 8.

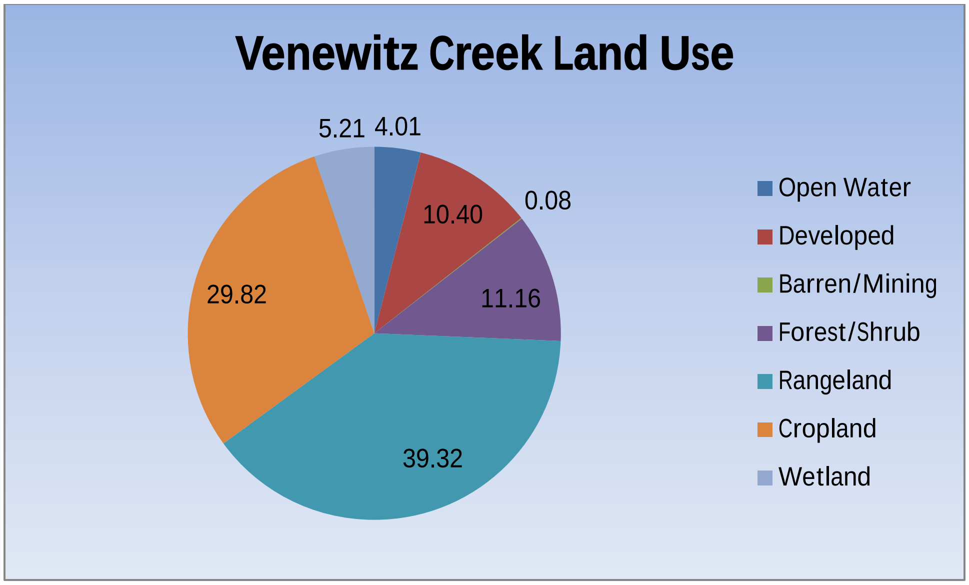

Figure 13: Venewitz Creek MDNR Minor Land use

Another land-use component that may be negatively impacting ecological health is the intensity of developed land in this watershed. Potential stressors related to this land-use are increased nutrient concentrations and increased stream bank instability due to impervious runoff and lack of riparian vegetation in sections of the stream. Once the vegetation along the banks is removed or altered, it leaves the banks of the stream channel susceptible to erosion and mass failure. The increased chance of stormwater runoff causing a peak event in the stream flow can cause stream bank instability. Changes in stream channel alignment are also common practices in developed watersheds. Figure 14 below shows the realignment of a section of channel in Venewitz Creek.

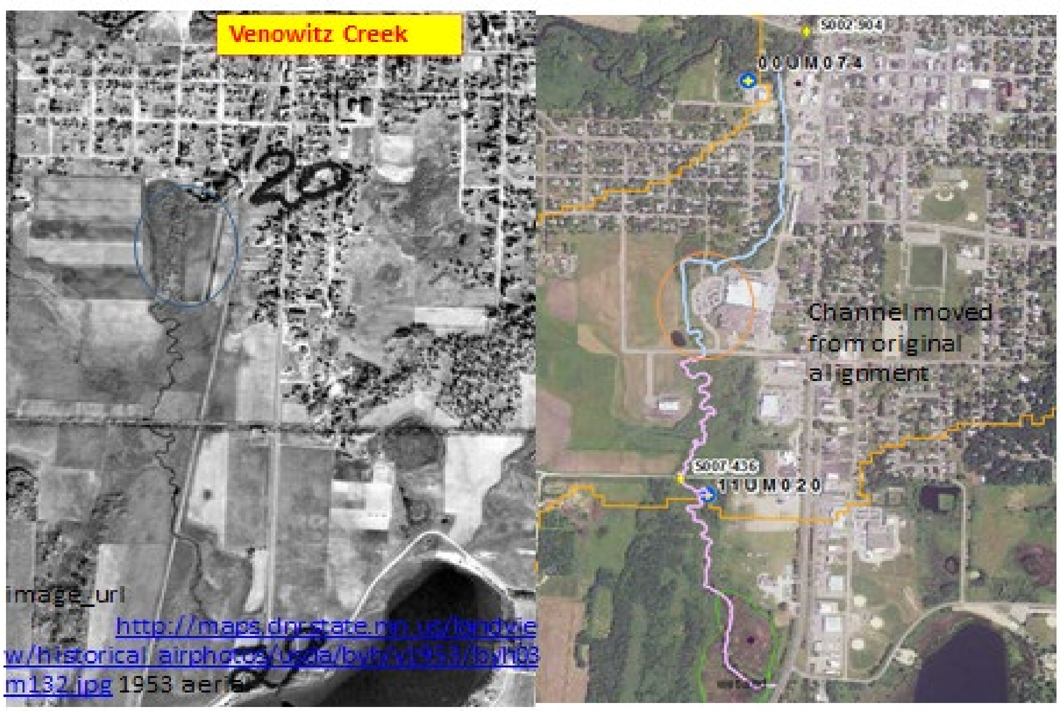

Figure 14: Alignment changes in stream channel in Venowitz Creek from 1953 to present

Permitted facilities such as feedlots and industrial discharge can have an impact on water quality. Currently there are 15 permitted feedlots within the watershed. The majorities of the facilities are upstream of Charlotte Lake and are probably not having a significant impact on the lower reaches of the creek.

Evidence of causal pathways-DO flux, chlorophyll-a, and oxygen demand

Nutrients

Total phosphorus (TP) data was collected in 2013 at EQuIS site S007-436. This site is located on 230th Street on the southwestern edge of the city of Long Prairie just on the downstream end of monitoring site 11UM020 (Figure 14). TP data are well below the proposed River nutrient criteria of 0.1 mg/L for the sampling record in 2013 (Figure 15). Stream flow is directly influenced by the lake level of Lake Charlotte, which empties into Venewitz Creek. Nutrient concentrations are also reflective of Lake Charlotte's water quality because Venewitz Creek outlets from the northwest side of Lake Charlotte. The Creek then flows through a wetland that is impounded by beaver. From there the channel turns north and flows through some scrub/shrub areas before flowing through commercial and residential areas of the city of Long Prairie. TP levels are not considered a stressor at the sampling location.

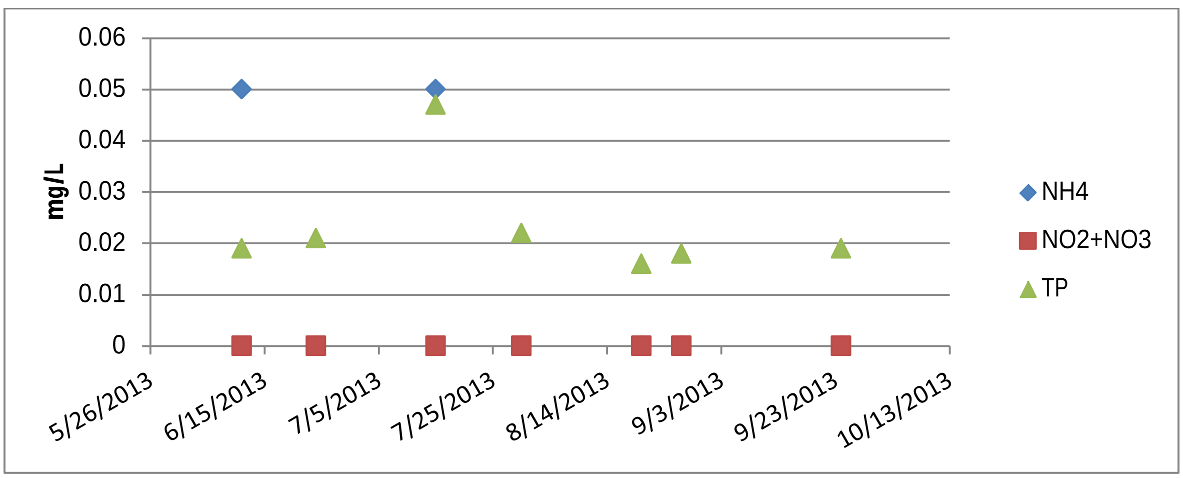

Figure 15: TP values over time collected from Venewitz Creek EQuIS site S007-436

Chlorophyll-a

Chlorophyll-a (Chl-a) concentrations are commonly used to measure algal productivity in surface water, and have been shown to correlate with maximum DO concentrations and DO flux in non-wadable rivers (Heiskary et al., 2010). Field visits at biological monitoring site 11UM020 revealed a lot of submerged plant growth (Figure 16). There were no chlorophyll-a samples collected at this site.

Figure 16: Photo of submerged aquatic plant growth at biological site 11UM020 (August 2013)

Dissolved oxygen flux

No continuous sonde data was collected at 11UM020. Synoptic dissolved oxygen (DO) data was collected throughout the summer of 2013. The majority of the samples were collected before 10 a.m. trying to record the daily minimum DO reading. Most of the readings were below 4 mg/L; however, there was one reading at 7.22 mg/L. Review of the data suggests that the daily flux for DO may be around 3 mg/L.

Low dissolved oxygen

Early morning longitudinal DO readings were collected in the summer of 2013 at one location for Venewitz Creek. Figure 17 indicates that early morning DO concentrations were routinely below the state standard of 5 mg/L, which indicates that low DO is a stressor to aquatic life.

This site is located at 230th Street and is downstream of a beaver impounded wetland. The low-gradient stream section coupled with the upstream impoundment is probably causing the low stream DO readings. This site has an abundance of macrophyte and algae growth, which could be affecting the diurnal DO levels.

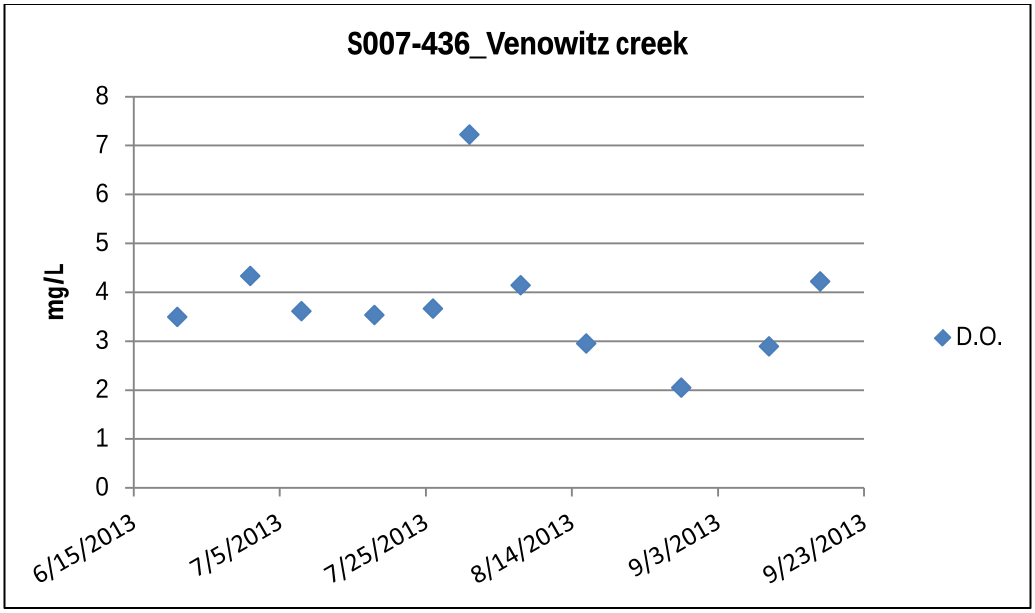

Figure 17: Early morning DO readings

Meador and Carlisle (Meador & Carlisle, 2007) created tolerance metrics for fish based on weighted average Tolerance Values (TIV) for a variety of water chemistry parameters. The MPCA (Sandberg, 2013) also created tolerance metrics for fish based on weighted average TIV for DO. The MPCA DO TIV was based on fish samples from Minnesota that have been collected during previous stream sampling projects. Figure 18 below shows the fish community DO TIV based on the Sandberg scores. Almost the entire fish community is tolerant to low DO concentrations. The sample was dominated by central mudminnow, black bullhead, and northern pike. All three of these species are tolerant to very low DO levels.

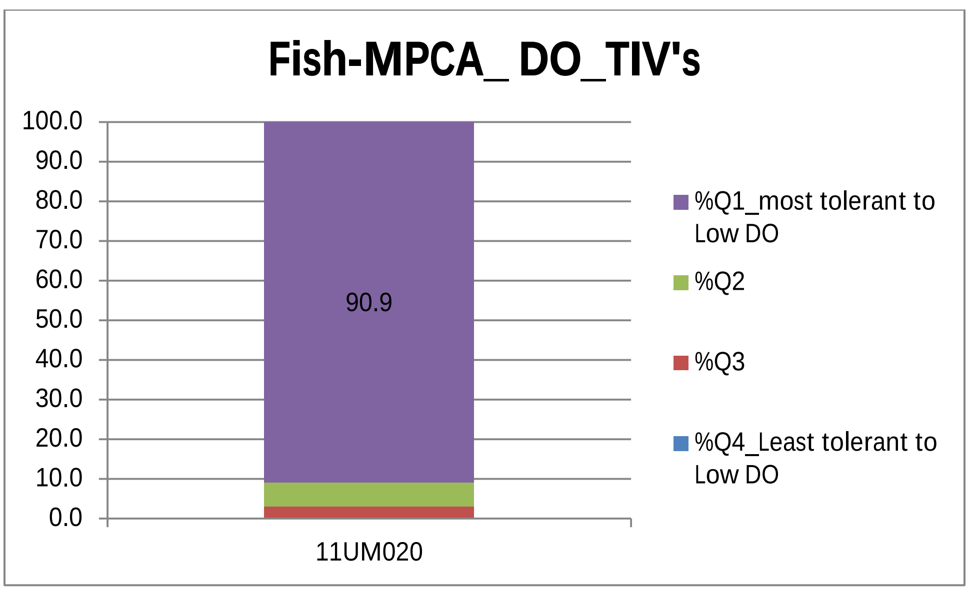

Figure 18: Fish community tolerance to DO concentrations

Sediment: Total suspended solids

Total suspended solids

The draft TSS standard for the Long Prairie River has been set at 30 mg/L. This concentration is not to be exceeded in more than 10% of samples (collected April-September) within a 10-year data window. Figure 19 below displays the TSS concentrations for EQuIS sites S007-436. This limited data set is not enough to evaluate if TSS is a stressor to the aquatic community; however, the TSS concentrations are well below the proposed standard.

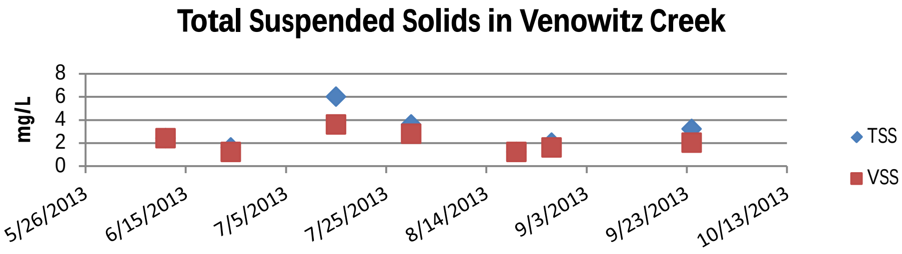

Figure 19: TSS concentrations for EQuIS site S007-436 on Venewitz Creek

Sediment: Bedded sediment

Sources and pathways of bedded sediment

Bank erosion

Areas of bank erosion were observed along the edges of residential and commercial areas downstream from the sampling location. A ditch enters the Creek downstream from the 230th Street sampling point which drains some agricultural areas. This section adds more flow by increasing watershed area and at the confluence of the two systems the channel appears to be over widened. Downstream of 11UM020, a channel elevation survey was conducted on August 9, 2012. During the survey, water surface slope was 0.0005 ft/ft (Figure 20). This is very low gradient and the channel particle size was very small. Channel substrate was made up of 45% gravel less than 22mm, 47% sand and 8% silt. The fine material is coming from landscape and stream bank erosion. Based on the abundance of central mudminnow in the sample, it is believed that the fish community is tolerant to fine bed sediment composition. There are two species present that require gravel for spawning (creek chub and white sucker). Both of these species had one specimen collected during the sampling event. It appears that the small particle size on the channel bottom is a limiting factor for the fish community.

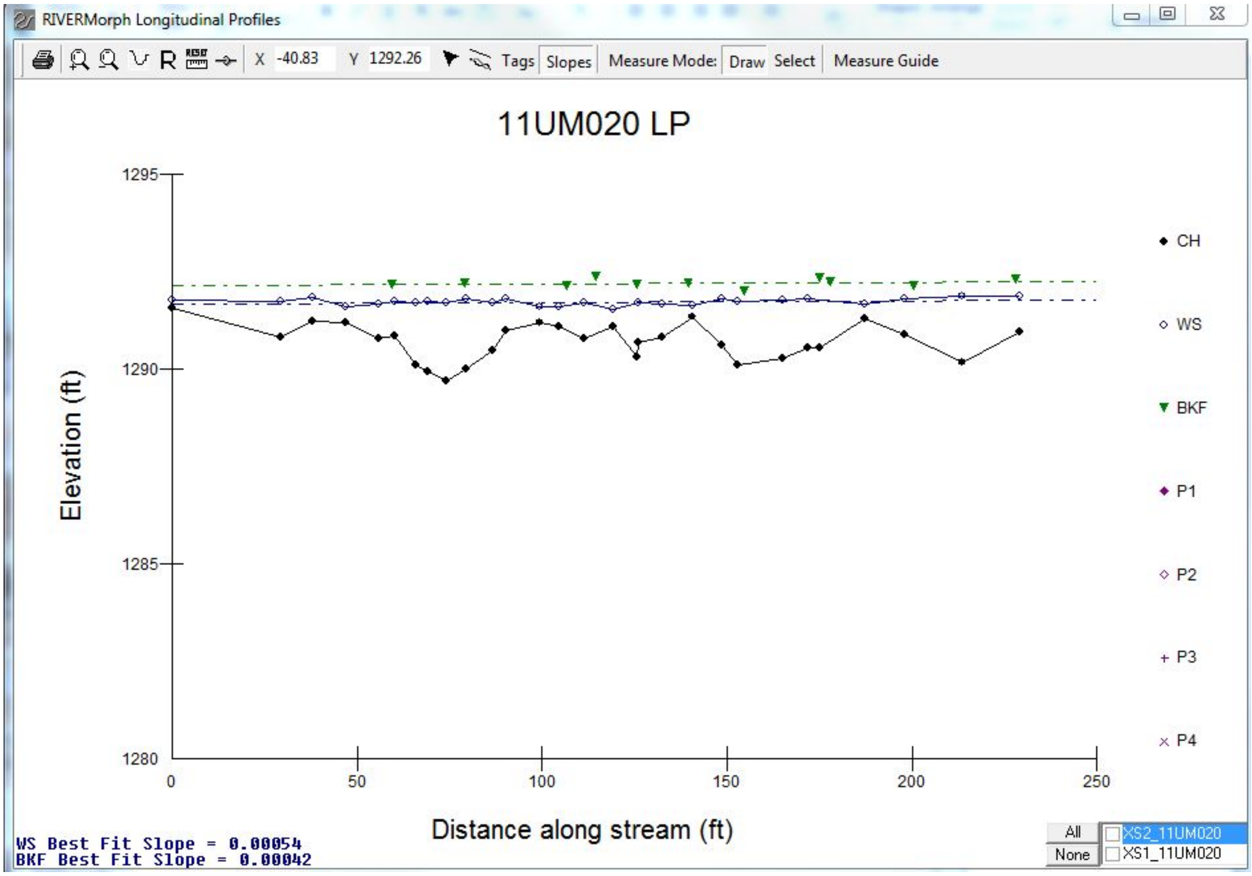

Figure 20: Venewitz Creek Channel profile downstream of monitoring site 11UM020

Nitrate toxicity

Review of the nitrate data that was collected at site S007-436 reveals that nitrate levels during the 2013 sampling period were all below detection levels. There is not enough evidence to determine that nitrate is a stressor to aquatic life.

Connectivity

During the summer of 2013, Todd County conducted a culvert elevation inventory along Venewitz Creek. This survey looked at elevations of both the upstream and downstream culvert inverts to determine the potential for fish passage obstructions. The culverts at 2nd Avenue SW and 3rd Avenue SW are both higher on the downstream side than the upstream side. This will cause a barrier to fish migration and needs to be investigated further to determine if culvert replacement is warranted. Figure 21 below displays the elevations of the culverts along Venewitz Creek collected by Todd County in 2013. Due to the low fish sample size at this site, it is difficult to determine if the culverts are blocking fish passage. The sample had one white sucker which is considered migratory fish. It is not known if the downstream stream reach would have a higher number of migratory fish. Migratory individual fish made up 3% of the fish sample.

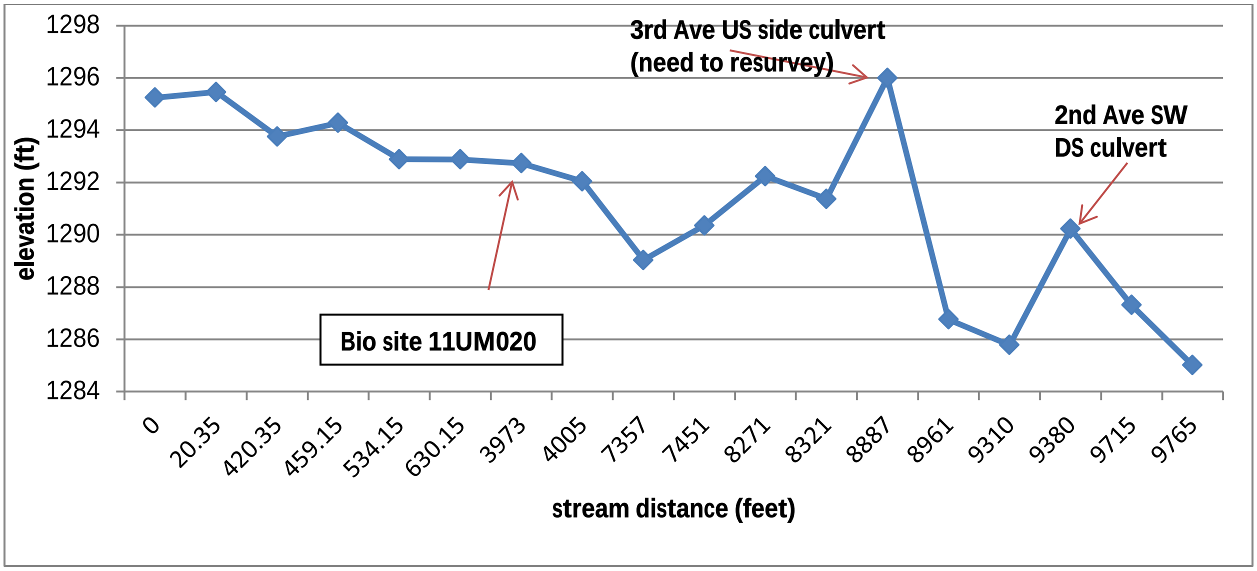

Figure 21: Venewitz Creek culvert elevation survey. 3rd Avenue SW and 2nd Avenue SW culverts are perched.

Additional survey work will need to be completed to verify the culvert elevations. A drop of 10 feet between 3rd Avenue SW and 2nd Avenue SW appears too steep. This brings into question the elevation of the downstream side of the 3rd Avenue culvert. If the elevations are correct, there is a connectivity issue in the lower portion of Venewitz Creek.

Conclusion

The three main stressors to the biotic community in Venewitz Creek are connectivity, low DO concentrations, and bedded sediment. These stressors are all related to the low gradient nature of the channel and the upstream wetland with the beaver impoundment, along with improperly placed culverts. The individual fish samples reveal a high percentage of central mudminnow, along with other species that are tolerant of low DO levels. The fish sample had 33 individual fish collected in 2011. There were 6 fish taxa present during the sampling event. Twenty-five individuals were central mudminnow, which are tolerant to low DO concentrations, survive in wetland riparian stream corridors that have low gradients and have substrates filled with fine sediment. The remaining five fish taxa also generally can survive in low DO conditions and show no preference to tolerance of TSS. No macroinvertebrate sample was collected at this site in 2011.

Eagle Creek 11-Digit HUC (07010108030)

Harris Creek AUID 07010108-592

The Harris Creek AUID (07010108-592) lies in the southeastern side of the Eagle Creek subwatershed. This watershed area lies just west of the city of Browerville (Figure 22). Historically, this area was dominated by deciduous forest, with areas of “emergent herbaceous wetland and woody wetland” along the riparian corridor of the creek. Current land-use is a mixture of agricultural (27% cultivated land, 39% range land) and natural areas (18% of the area remains forest and 9% wetlands).

Harris Creek Biological and Water Chemistry Monitoring Sites

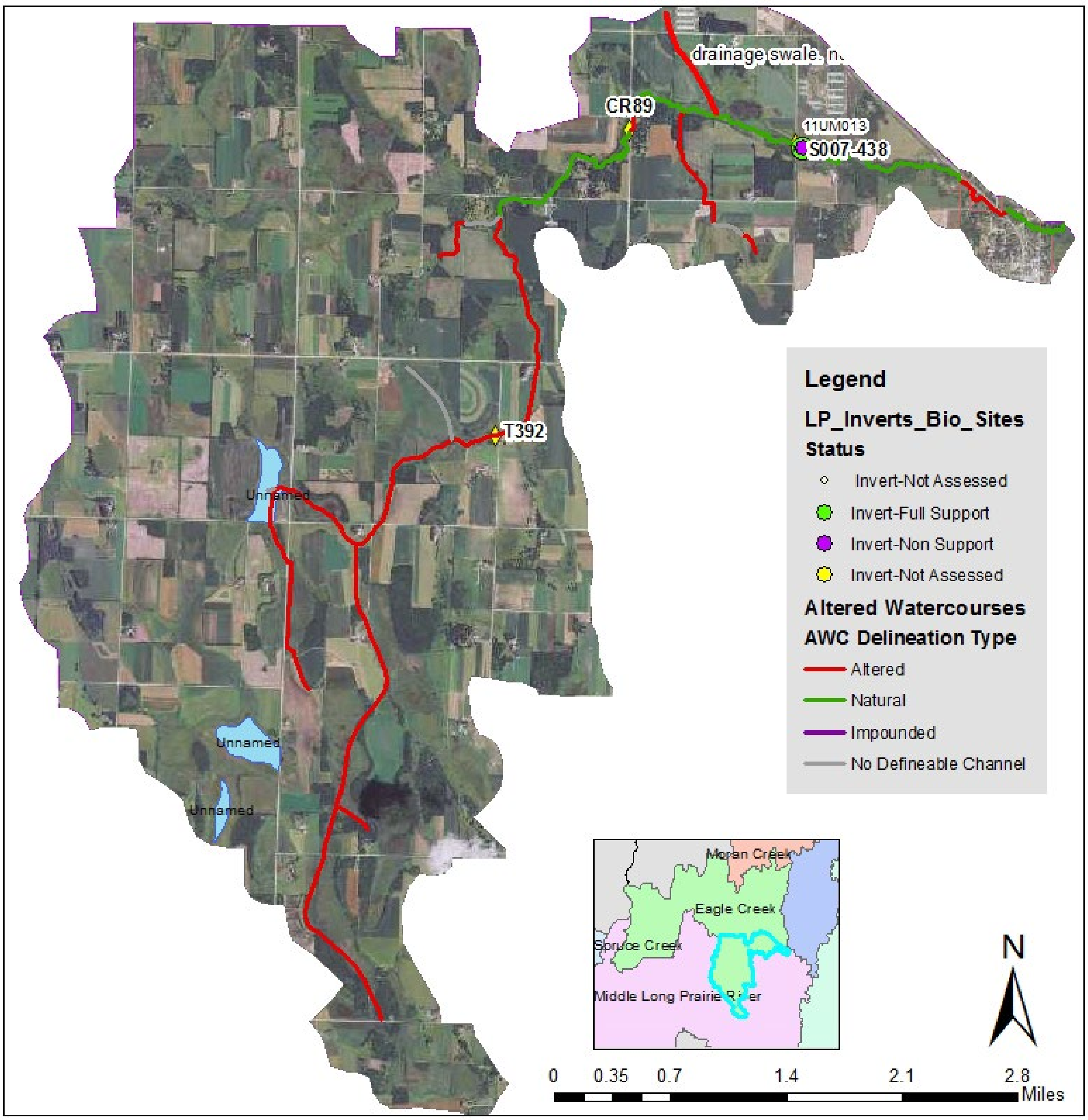

Figure 22: Harris creek AUID (07010108-592) with sampling locations (MPCA, 2013). Harris Creek is located in the Southeastern corner of the Eagle Creek 11-digit HUC.

There are 31 registered feedlots located along the river corridor or its tributaries (Figure 23). There are smaller unregistered pasturing operations that are in this subwatershed that may be contributing to nutrient levels and bank failure due to animal access and trampling. Upstream of sampling location S007-438 to T-382, the stream corridor is actively pastured.

Harris Creek Feedlot and Permitted Facilities

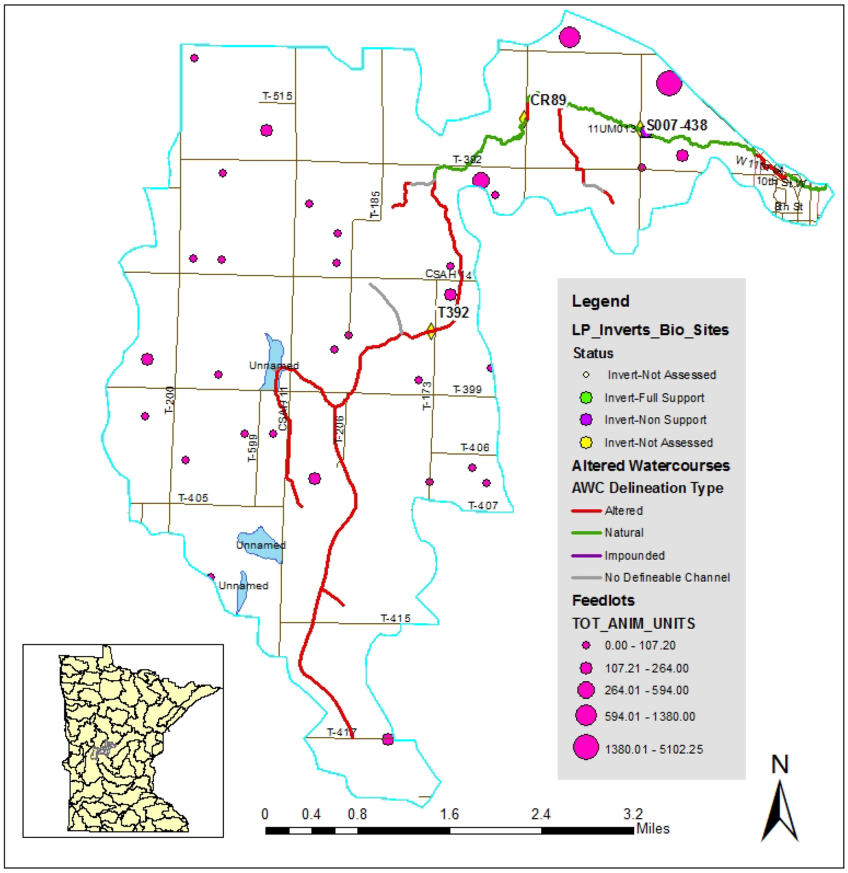

Figure 23: Feedlot density in the Harris Creek AUID (07010108-592) (MPCA, 2013)

Evidence of causal pathways-DO flux, chlorophyll-a, and oxygen demand

Nutrients

Total Phosphorus (TP) data was collected in 2013 at EQuIS site S007-438 (Figure 24). This site is located at the downstream end of the watershed near biological monitoring site 11UM013. TP data are above the proposed river criteria of 0.1 mg/L for the months of July and late August (Figure 25). The August 29 synoptic DO data collection field note indicates that water was very low during this event and cattle were standing in the stream. The spike in TP in the August 27, 2013, sample may be a direct result of the low water conditions. The elevated TP concentrations at this location is probably a result of the animal pasturing areas along with the turkey farm production that is occurring in the northern end of the watershed. High TP values promote excess growth of algae and other aquatic plants, which, in turn, can lead to high dissolved oxygen flux as they decay. Elevated TP concentrations should be considered a stressor within this watershed.

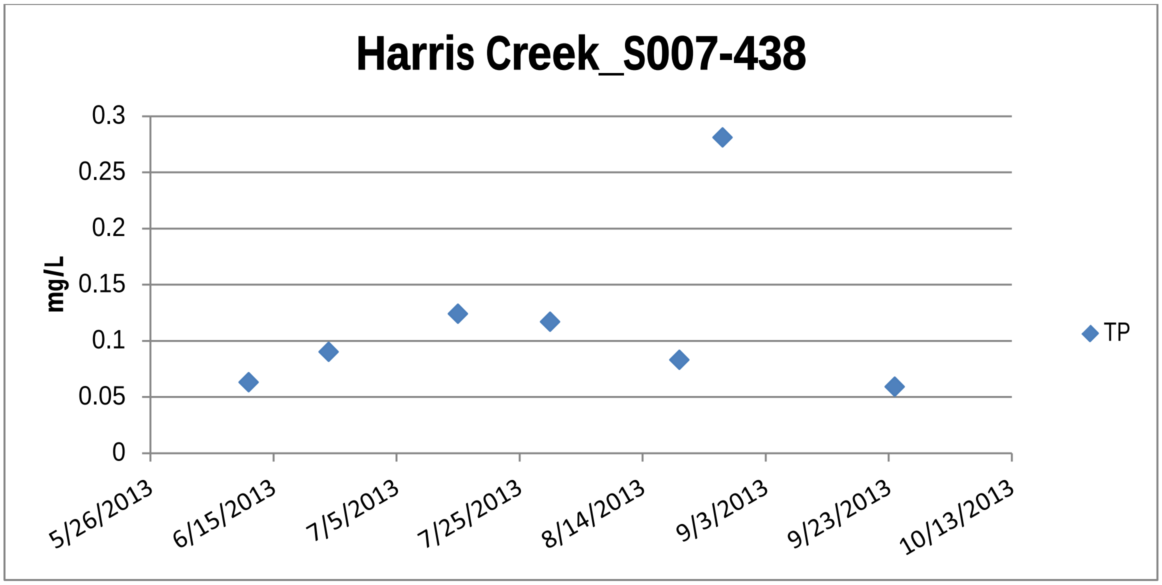

Figure 24: TP values over time collected from Harris Creek EQuIS site

Chlorophyll-a

Chlorophyll-a concentration are commonly used to measure algal productivity in surface water, and have been shown to correlate with maximum DO concentrations and DO flux in non-wadable rivers (Heiskary et al., 2010). Field visits at EQuIS monitoring site S007-438 revealed significant submerged plant and algal growth (Figure 25). There is no chlorophyll-a data for this site. The amount of attached periphyton growth in the channel suggests that elevated nutrients are causing elevated in-stream plant growth.

Figure 25: Algae growth in Harris Creek at sampling site S007-438 (August, 2013)

Sediment: Total suspended solids and bedded sediment

Total suspended solids

Based on suspended-solids related work and several stream reconnaissance trips, there is no evidence showing elevated TSS concentrations as a candidate cause for biological impairments in Harris Creek. The samples collected during the 2013 monitoring season were all below 12 mg/L. This is below the target TSS concentration of 30 mg/L for the LP Watershed.

Bedded sediment

Deposited and bedded sediments are likely a stressor to macroinvertebrate assemblages in Harris Creek. Substrate embeddedness levels were very high (50-75%) at site 11UM013, the riffle D^{50} for particle size was 0.42 mm, which is medium fine sand; however, the response from biota was not clear. The fish community was comprised of 35% simple lithophilic spawners and passed the IBI for fish by 6 points. The macroinvertebrate community was lower scoring than the fish. The very tolerant taxa metric was 23% of the sample and the intolerant taxa metric was 3.2%. The individual macroinvertebrates were analyzed using weighted average Tolerance Values (TIV) developed by (Yuan/EPA, 2006) to determine the percent of the sample that is tolerant to fine sediment. Figure 26 shows that the majority of the samples in AUID 592 fall into Q1 and Q2. Q1 and Q2 are the most tolerant to fine sediment. This suggests that fine sediment is a driving factor in this AUID. Quartiles three and four are less tolerant to fine sediment and the samples have a lower percentage of individuals in this range. The NA quartile is individuals that are not assigned a TIV in the paper. The high percentage of individuals in the macroinvertebrate sample that are tolerant to fine sediment supports the theory that excessive bedded sediments is a stressor to the biological community.

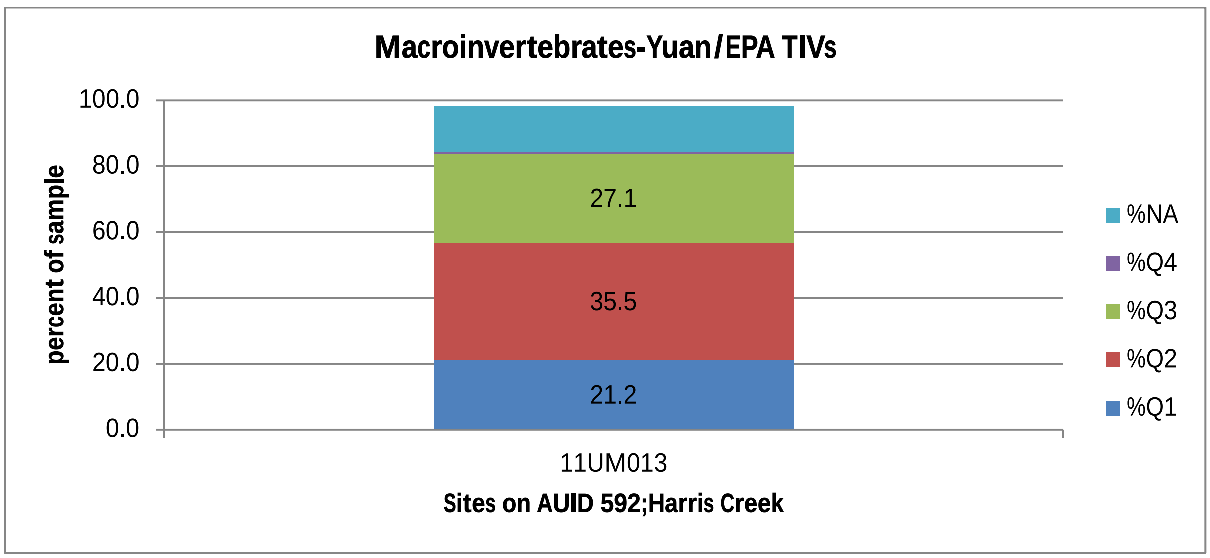

Figure 26: Macroinvertebrate individual percent that are tolerant to fine sediment (Q1-Q2 is tolerant to fine sediment)

The lack of quality gravel substrate in the riffles is reflected by a low Ephemeroptera/Plecoptera/ Trichoptera (EPT) community. The EPT taxa reflect some of the most sensitive taxa and require quality gravel and cobble material in the riffle areas along with high DO concentrations. The EPT taxa made up 15.9% of the macroinvertebrate sample. Class 6 macroinvertebrate sites that have passing MIBI scores have an EPT percent above 20%.

Dissolved oxygen

Early morning (pre-9:00 a.m.) longitudinal DO readings were collected in the summer of 2013 in Harris Creek at two locations. Early morning DO concentrations were routinely below the state standard of 5 mg/L (Figure 27), which indicates that low DO is a stressor to aquatic life. DO at the County Road 89 site was typically well above the 5 mg/L standard. The low DO readings also corresponded with a period of lower stream flow. Land use in this area along the stream corridor is active pasturing and a drainage swale enters Harris Creek from the north in this section of stream (Figure 28).

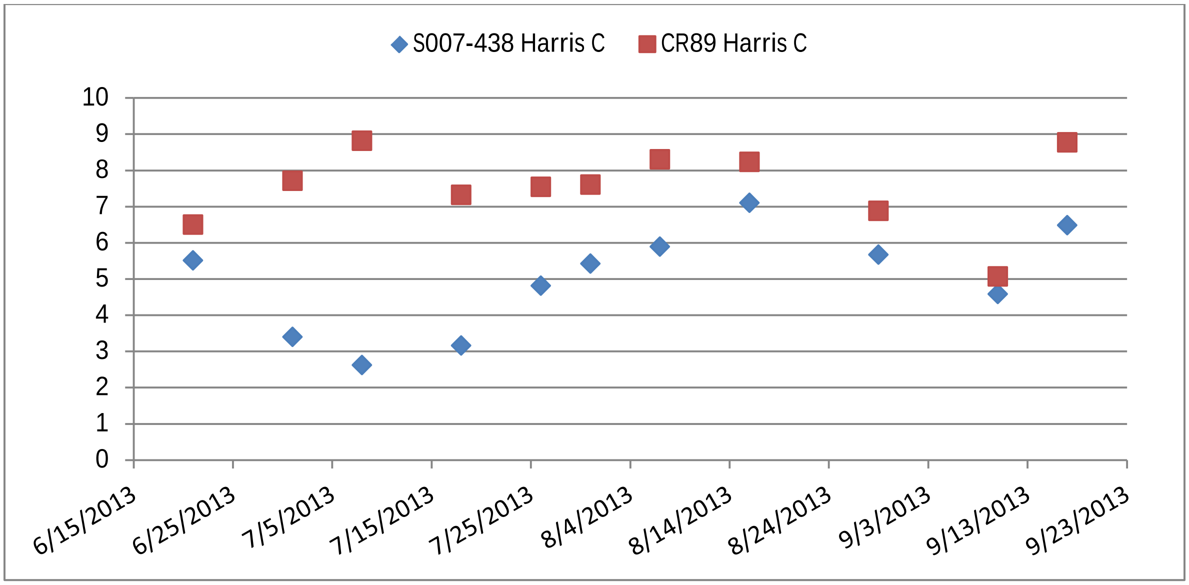

Figure 27: Early morning DO readings Harris Creek at County Road 89 and S007-438

The drop in DO concentrations could be a result of localized animal waste entering the stream through pasturing or some other means. Animal waste can increase BOD, which would result in lower stream DO concentrations. The majority of the macroinvertebrate sample is dominated by tolerant taxa (87.9%). Tolerant taxa can handle periods of low DO while the intolerant taxa (0.3%) cannot. In 2013, the MPCA created a Tolerance Value Index (TVI) for macroinvertebrates using pre 10am DO data. The TVI scores for the upper Mississippi Basin sites were separated into quartiles to determine the TVI score for site 11UM013 in relation to the TVI scores for the rest of the Upper Mississippi Basin. Based on this ranking; site 11UM013 has a DO TVI index score of 7.03, which places it in the 50th percentile range (slightly above Q2) for DO TVI scores. This would suggest that the macroinvertebrate community is not sensitive or tolerant to DO, but falls in the middle of macroinvertebrate communities sampled in the Upper Mississippi Basin. The relative abundance of DO tolerant macroinvertebrates is 19.2% at this site. This value also falls in the middle range (Q2) for relative abundance of DO tolerant macroinvertebrate communities. Based on this information, it is believed that low DO is a secondary stressor in Harris Creek.

Nitrate-nitrite toxicity

Nitrate-nitrite data from site S007-438 reveals that nitrate-nitrite levels are well below ecoregion norms. They do not exceed levels high enough to cause toxicity and are often below 0.25 mg/L. There is not enough evidence to determine if nitrate-nitrite is a stressor to aquatic life. At this time, with the limited dataset for nitrate-nitrite (seven samples), it is recommended that additional water samples be analyzed at site S007-438 for nitrate-nitrite.

Harris Creek Potential Issues

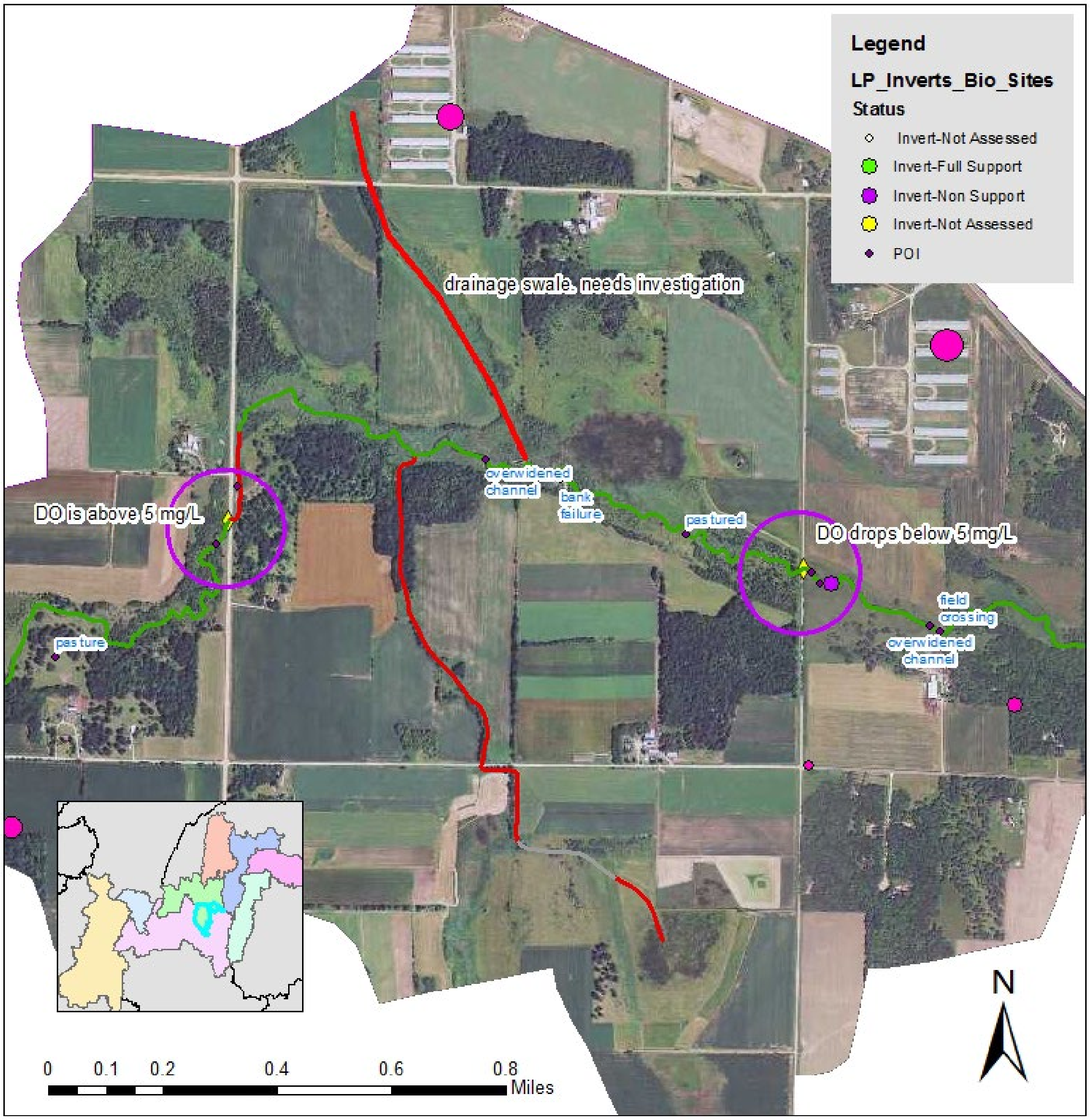

Figure 28: Harris Creek areas potentially contributing to the drop in DO at 11UM013 (MPCA, 2013). Map inset shows position of Harris Creek in relation to 11-digit HUC with the larger 8-digit HUC.

Connectivity/habitat

Connectivity

Harris Creek flows through several active pastures. The pasture ground may have field crossings along with other obstructions that can cause barriers to migration. The fish community passed suggesting that fish passage is good throughout the system. During channel survey work in the fall of 2013; however, it was discovered that a field crossing may be causing other localized problems. This field crossing located on the downstream end of S007-439 is perched by a couple of feet and causing a change in channel slope upstream (Figure 29).

Figure 29: Photo of field crossing located downstream of 11UM013. Crossing is not causing fish passage problem; however, is causing a flattening of the stream channel slope which is causing some pool filling and aggradation.

Channel slope is changed by straightening of the channel, which shortens the stream channel distance. Stream channel slope is also changed by improperly sized and placed culverts. Figure 30 below shows the segment of channel surveyed above the field crossing. There is a slope change in the channel where

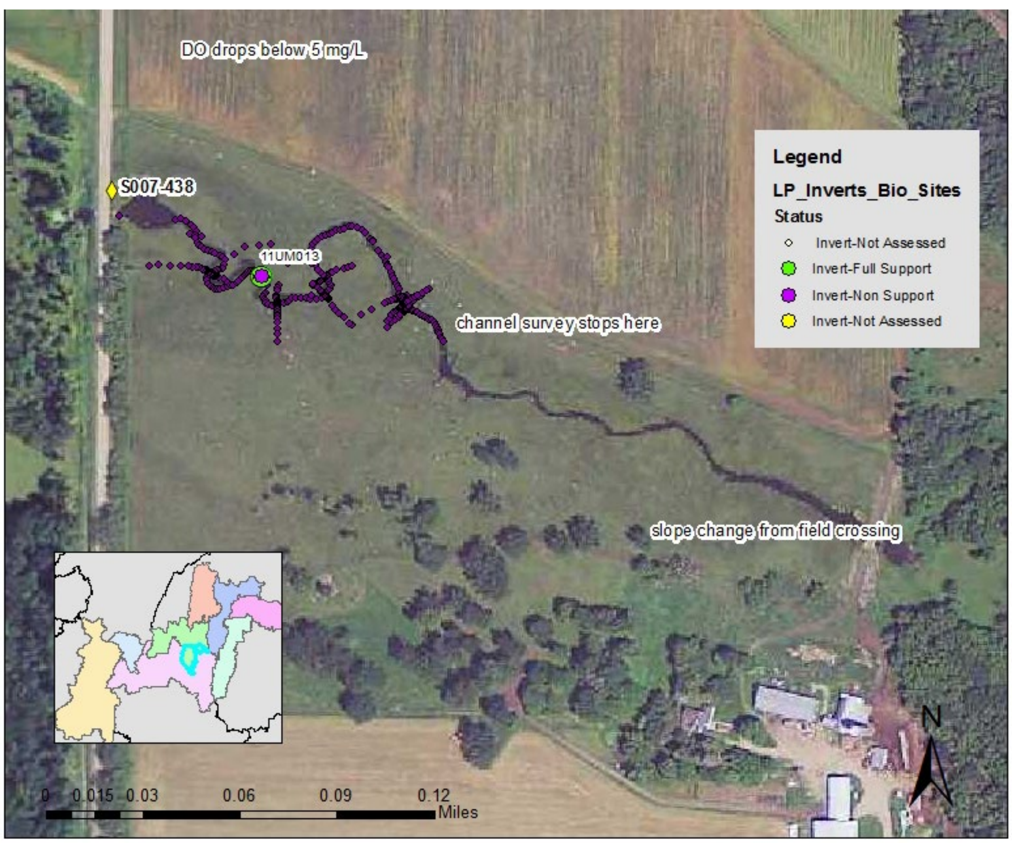

Figure 30: Location of Harris Creek channel profile survey at monitoring site 11UM013. Also shows location of field crossing.

the channel is straightened and the field road is slightly perched. Figure 31 shows the slope of the channel survey along with the facet features of the channel in the surveyed reach. Note that the pool depths are shallow and pool lengths are short. This is also an indication that the channel is filling or aggrading.

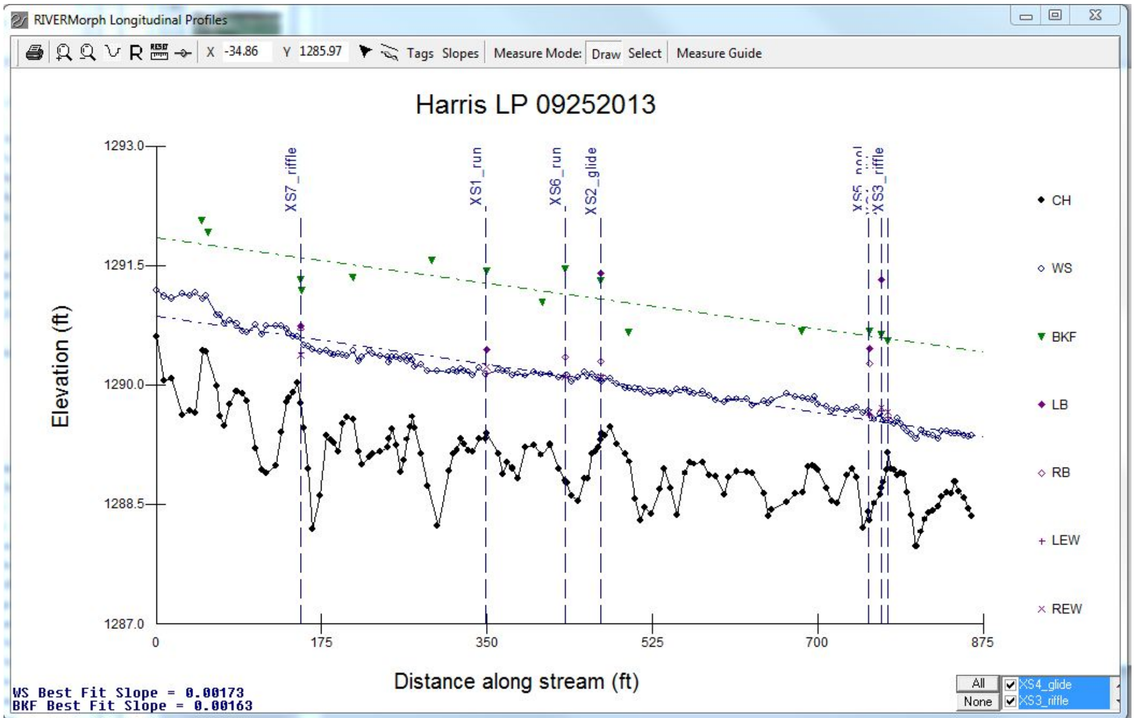

Figure 31: Harris Creek channel slope with facets surveyed at site 11UM013

Habitat

The lack of woody habitat is a stressor to the macro invertebrate community at station 11UM013. The riparian vegetation at this site is dominated by pastured reed canary grass. There is minimal leaf litter from trees and shrubs that can enter the stream and be utilized by macro invertebrates in the shredder feeding group. The percent of shredders in the sample was 13.3%, which verifies that a lack of external leafy material is inhibiting the macro invertebrate community. Biological sites with riparian habitat that consists of trees and shrubs typically have 30% shredders in the sample.

Conclusion

The four main stressors to the biotic community in Harris Creek are bedded sediment, elevated TP, low DO concentrations, and connectivity/habitat. Many of these stressors are related to the agricultural production that is occurring in the Harris Creek 11-digit HUC. Row crop production and animal pasturing in the upper watershed are contributing pollutants to this downstream section, along with the extensive drainage network coming into AUID 592. Pasturing is the single dominant land use within this 11-digit HUC. Thirty-nine percent of the land area is mapped as rangeland and 27% is cropland. This comprises 66% of agricultural land use in the watershed. Channel erosion in the heavily pastured areas is causing an increase in fine sediment deposition in the channel. Reviewing the channel profile summary suggests that the pools are filling and the fine particle size in the riffle also shows filling of interstitial spaces. Stream channel instability from increased bed load appear to be causing a general lack of in-stream habitat along with elevated growth of aquatic plants, which is partially causing abnormal fluctuations in the DO concentrations of the stream.

Headwaters Long Prairie River 11-Digit HUC (07010108010)

Unnamed Creek to Lake Miltona AUID 07010108-595 (fish and invert NS)

Unnamed Creek to Lake Miltona lies in the northeast side of the Headwaters Long Prairie River 11-digit HUC. This watershed area starts in Vermont Lake on the west side and Mud Lake on the east side. Both lakes drain via ditches and join together forming Unnamed Creek just north of CSAH 14. The entire AUID lies just west of MNTH29 and north of Lake Miltona (Figure 32). Historically, this area was dominated by deciduous forest, with areas of "emergent herbaceous wetland" along the riparian corridor of the river. Current land-use is a mixture of agricultural (32% cropland, 24% range land) and natural areas (26% of the area remains forest and 4.5% wetlands) with 4% of the watershed being developed.

Unnamed Creek Biological and Water Chemistry Monitoring Site

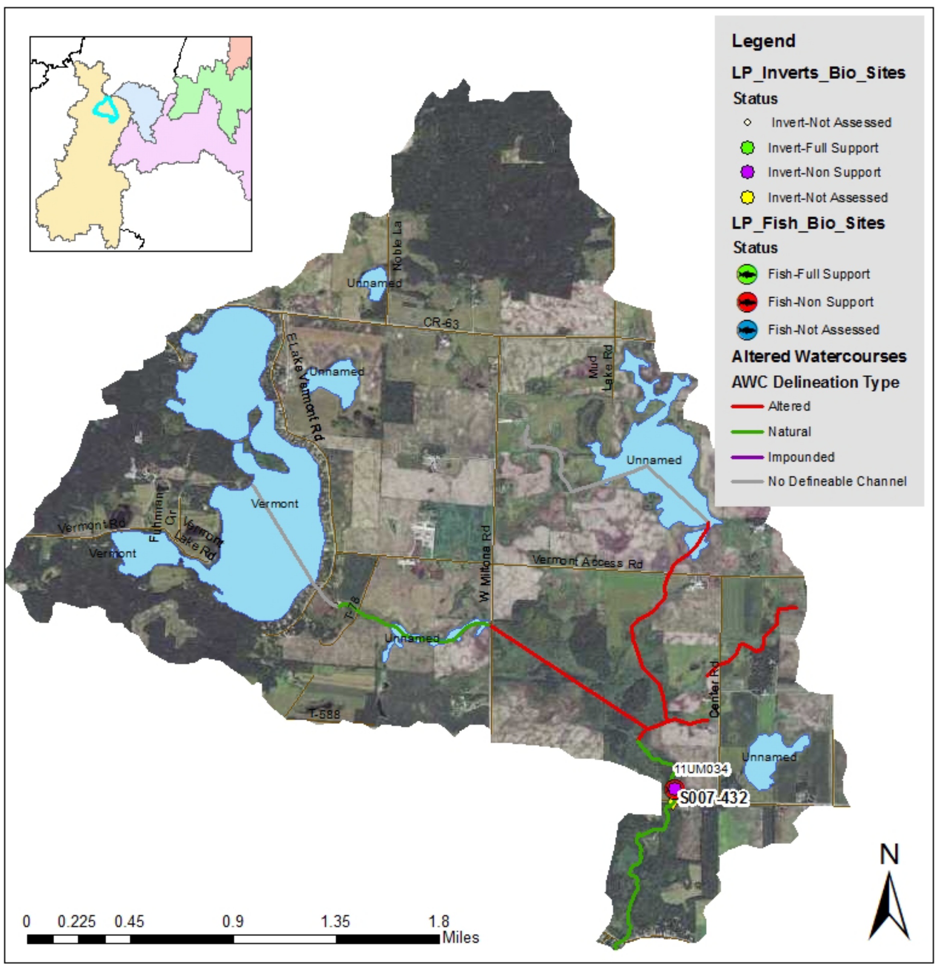

Figure 32: Unnamed Creek to Lake Miltona (07010108-595) with sampling locations (MPCA, 2013). Unnamed Creek lies in the the Northeastern portion of the Headwaters Long Prairie 11-digit HUC. This 11-digit HUC is the furthest upstream in the Long Prairie 8-digit HUC.

There are four registered feedlots located in this subwatershed and likely also some smaller unregistered pasturing operations. These animal production locations are likely not contributing to increased nutrient levels. All registered feedlot locations are located a great distance from the sampling location at S007-432.

Evidence of causal pathways-DO flux, chlorophyll-a, and oxygen demand

Nutrients

Total phosphorus (TP) data was collected during the summer of 2013 at EQuIS site S007-432, near biological monitoring site 11UM034. TP data were above the proposed River criteria of 0.1 mg/L once during the sampling record in 2013 (Figure 33). This value was collected during a period of high flow. In the early summer months, this area experienced above average rainfall and the wetland complexes were full of water and discharged continuously for a longer period than normal. Elevated TP concentrations do not appear to be a stressor within this watershed.

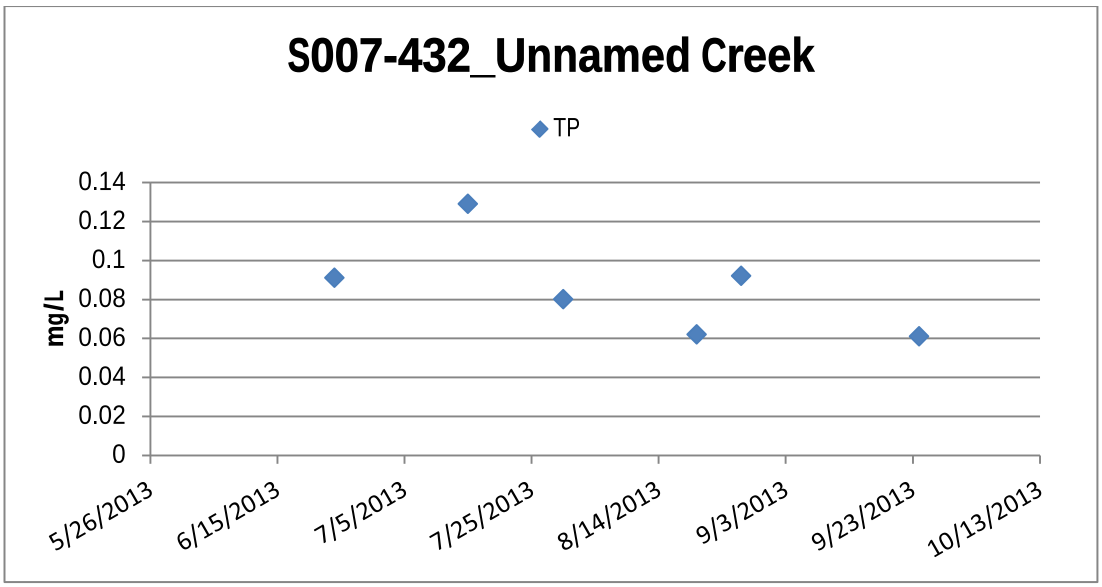

Figure 33: TP values over time collected from Unnamed Trib to Lake Miltona EQuIS site S007-432

Dissolved oxygen flux

There were no water quality sondes deployed in the Unnamed Creek to Lake Miltona watershed; therefore, dissolved oxygen flux cannot be assessed as a stressor to aquatic life.

Dissolved oxygen

Early morning longitudinal DO readings were collected in the summer of 2013 at one location. Early morning DO concentrations were rarely below the state standard of 5 mg/L (Figure 34), which indicates that low DO was not a stressor to aquatic life in 2013. DO concentrations agree with the TP concentrations collected during the same time period. The only DO reading that was below 5 mg/L occurred during a higher flow period that also had an elevated TP level.

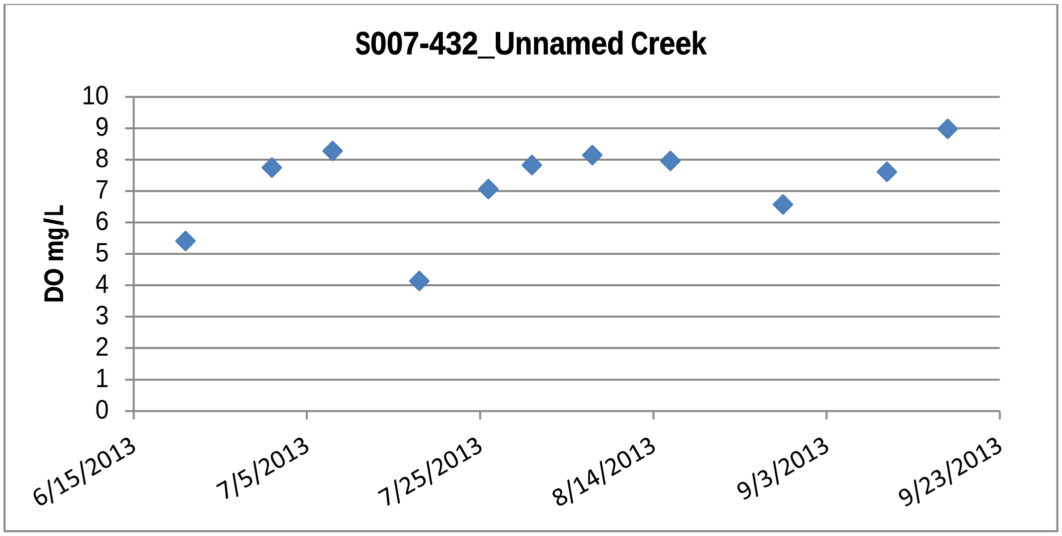

Figure 34: Early morning DO readings pre 9 am for Unnamed Creek (Trib. To Lake Miltona)

Sediment: Total suspended solids and bedded sediment

Total suspended solids

Review of the TSS data, collected in 2013 at site S007-432, suggests that TSS is not an issue in the Unnamed Creek subwatershed (Figure 35) in 2013. The fish community that was sampled supports that TSS is probably not a stressor to the fish community. Eighteen individual fish were sampled in 2011. Of the 18 fish sampled: 16 central mudminnow, 1 northern pike, and 1 white sucker. All three species are not tolerant to high TSS concentrations (they all are in the Q2 range for TSS TIV's). If TSS was a stressor, it is believed that these fish species would not be present.

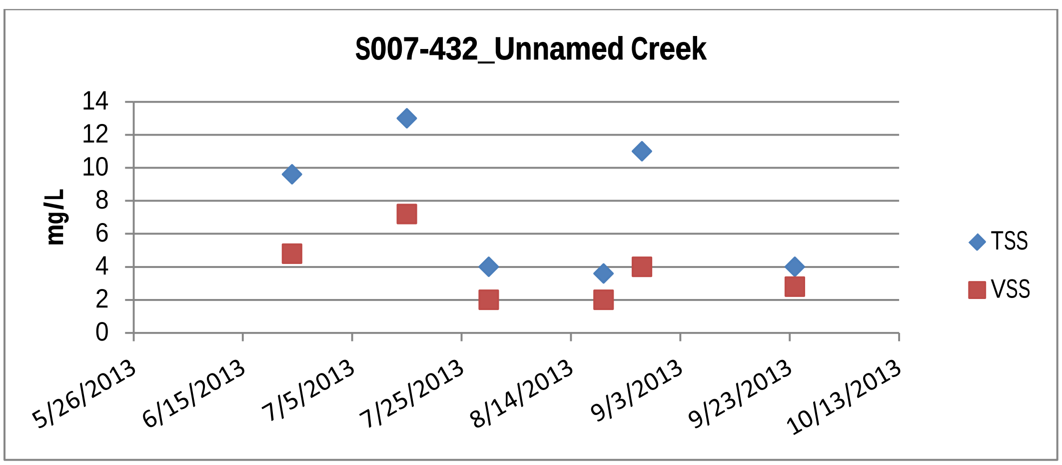

Figure 35: TSS concentrations for Unnamed Creek at EQuIS site S007-432 for 2013 sampling season

Bedded sediment

Bedded sediment is a problem within the sampling location at 11UM034. The substrate at this location is 100% silt and muck. This is due to the very low gradient in this stretch of stream. The culvert located on CSAH 14 is perched and is causing a slope change in the upstream portion of the channel. There was also a long standing beaver dam located in the upstream portion above the CSAH 14 crossing. This beaver dam was removed in 2010 according to the Douglas County Soil and Water Conservation District. The beaver dam also changed the slope of the channel, making it flatter and allowing for the settling of fine sediment particles. Photographs from the biological sampling showed that the channel was filled with a fine, almost clay-like pavement. This pavement material was washed out of the channel by the time the MPCA investigated in 2013. The new pavement was fine sand and some organic silt material. Additionally, the fine material covers hard substrates, which are habitat for macroinvertebrate clingers or scrapers, two important groups contributing to healthy, diverse biological community. Figure 36 shows the individual macroinvertebrate sampled broken into quartiles which represent sensitivity to bedded sediment. Q1 and Q2 are the most tolerant groups to increased fine sediment (Yuan, 2007). The NA group was not assigned a TIV value. Approximately 33% of the macroinvertebrate sample is tolerant of increased sediment load and 28% is intolerant of increased sediment.

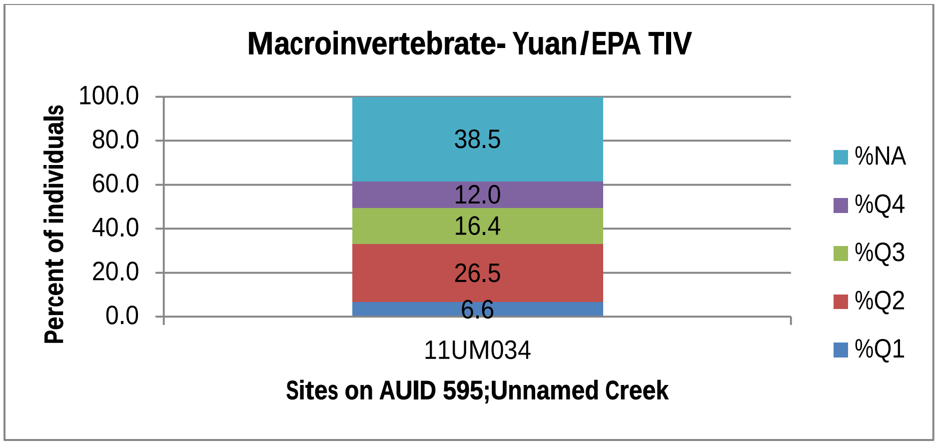

Figure 36: Percent individuals by biological site sampled in Unnamed Creek, for each quartile based on sediment weighted averages (Carlisle, 2007)

The macroinvertebrate sample was dominated by tolerant species (89.3%) and had only 0.3% of intolerant species. Tolerant species are characterized by species that are able to survive in less than ideal conditions. The intolerant macroinvertebrate taxa are characterized by species that require quality habitat and high levels of DO in the water. The only intolerant taxa that were sampled at this site were caddisflies (Trichoptera). Trichoptera made up 0.3% of the sample and are one family in the EPT index. EPT generally require gravel riffles and high levels of DO in the water column. A lack of riffles and the fine sediment are limiting the habitat available for the EPT group. The macroinvertebrate groups that do well in fine sediments are from the order Diptera. These invertebrates are midges and fly larvae that tend to burrow into fine sediment and can tolerate low DO levels. This group is generally associated with poor water quality and made up 69% of the macroinvertebrate sample.

Nitrate toxicity

Nitrate data was collected at site S007-432, which revealed that nitrate levels are very low, often below 0.3 mg/L. There is not enough evidence to determine if nitrate is a stressor to aquatic life.

Connectivity/altered hydrology

Unnamed Creek is believed to have a connectivity problem with the culvert located on County Road 14. During periods of low flow, the culvert apron lies 0.3-0.5 feet above the downstream channel and has, at times less, than 0.1 feet of water in the culvert. At other times during periods of high flow, the culvert has extremely fast velocities, which would prevent fish passage. Figure 37 below shows the two extremes for the culvert.

Figure 37: Unnamed Creek culvert outlet on County Road 14 on July 2, 2013, and July 18, 2013 after heavy rainfall.

A longitudinal survey was conducted at this site to determine the slope of the channel and the position of the CR14 culvert in regards to the stream channel profile. This survey shows that the culvert is placed higher than the natural stream channel and is affecting the upstream slope of the stream channel and acting as a partial fish barrier. Figure 38 shows the stream channel profile with water surface slope and channel bankfull stage. Water surface slope is low upstream of the CR14 culvert and increases downstream of the culvert. The surveyed stream section also had a history of beaver dam activity. Figure 39 shows the remains of a beaver dam that was removed at approximately station 330+00. Father downstream there are two other culverts that need to be investigated. One is just downstream and flows under a private driveway. The second culvert is near Lake Miltona located off of North Lake Miltona Drive. Both culverts could be impeding fish passage and require further review.

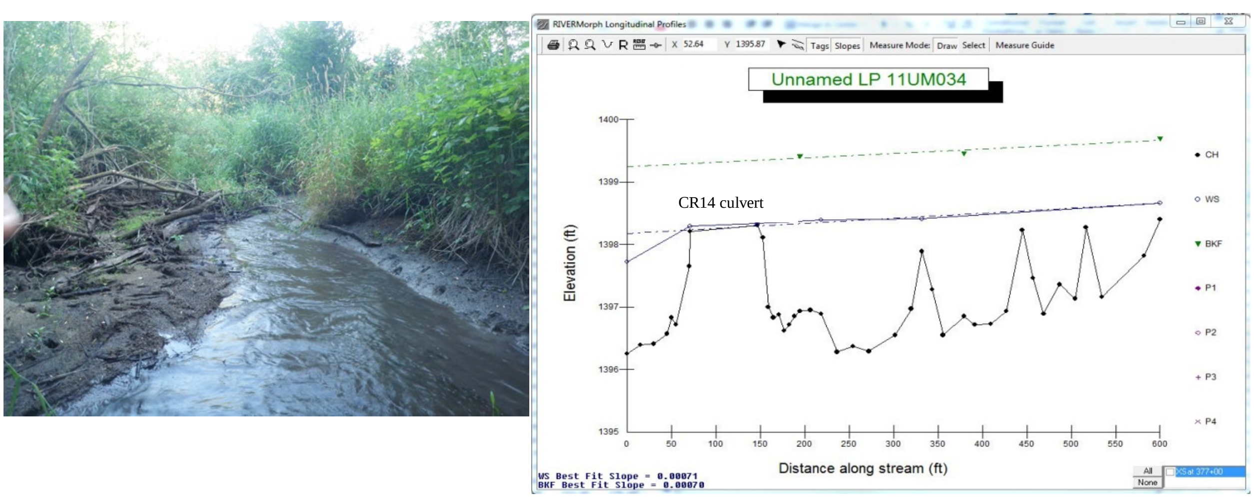

Figure 38: Stream channel profile of Unnamed Creek at CR 14 road crossing. Also picture of old beaver dam located at approximately stream station 330+00.

Altered hydrology is also a concern in this system. The stream is fed by two ditches, one that enters from the west and one from the east. During rain events, both ditches act as a delivery system for increased peak discharges and the associated channel substrate instability associated with increased peak flows. During a field observation on July 18, 2013, the stream velocity in the CR 14 culvert was very fast (estimated at 9+ ft/sec). This was caused by an above-average rainfall; however, it is suspected that even normal rain events can cause a significant increase in stream stage above what would be considered normal for this size drainage area.

Conclusion

The main stressors to the biotic community in the Unnamed Creek Watershed are loss of connectivity/altered hydrology, and excess bedded sediment. The stream channel in the sampled reaches of Unnamed Creek is filled with fine substrates that provide minimal macroinvertebrate habitat. The macroinvertebrate sample was collected from woody debris. There were no macroinvertebrate samples collected from riffle run rocks, leaf packs, or aquatic macrophytes. This suggests that the macroinvertebrate habitat is very limiting at this site. The stream channel particle size in the sampled reach was 0.42 mm, which is fine sand. Below the CR14 culvert, where the stream channel slope increases, the particle size was slightly larger, at 2.02 mm. This particle size is still quite small and the majority of the pebbles counted were coarse sand or smaller. There was an increase in particle size in the downstream reach along with slightly higher frequency of gravel with some cobble. This size and distribution of stream particle size is not suitable habitat for riffle dwelling macroinvertebrates or lithophilic spawning fish. The fish community at 11UM034 is dominated by central mudminnow, which is tolerant to low DO, prefers vegetated areas of small creeks and thrives in less than ideal conditions. The lack of fish competition along with the degraded habitat conditions favors the relative abundance of central mudminnow. The main stressors to the fish and macroinvertebrate community are related to the flat slope caused by the improperly placed culvert on CR 14 and the frequent beaver dams located in this area, along with the large percentage of land (57.5%) that is currently farmed for row crops or utilized as pasture for cattle or horse operations.

Spruce Creek 11-Digit HUC (07010108020)

Spruce Creek lies in the northwest side of the Long Prairie watershed (Figure 39). Historically, this area was dominated by deciduous forest, with areas of "emergent herbaceous wetland" along the riparian corridor of the river. Current land-use is a mixture of agricultural (36.6% cultivated land, 24.8% range land) and natural areas (20.1% of the area remains forest and 13.8% wetlands).

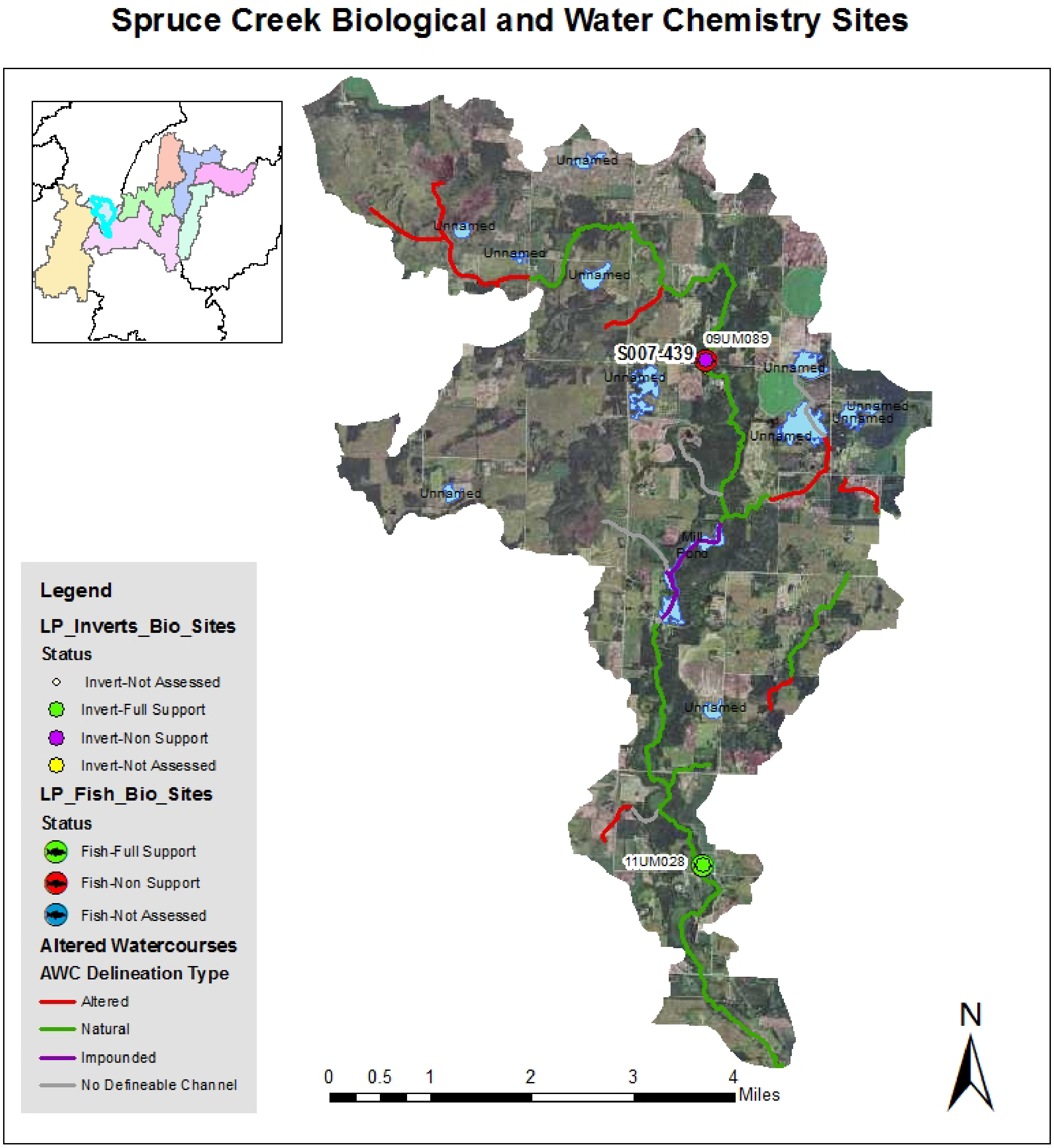

Figure 39: Spruce Creek 11-digit HUC (07010108020) with sampling locations (MPCA, 2013)

There are 0 registered feedlots located along this 11-digit HUC river corridor and its tributaries.

Nutrients

Total Phosphorus data was collected in 2013 at EQuIS site S007-439. This site is located in the lower half of AUID 512 near biological monitoring site 09UM089 on 100th Street. TP data are well below the proposed criteria of 0.1 mg/L during the sampling record. TP values are highest during early July 2013, when stream flow was slightly elevated. TP concentrations ranged from 0.017 to 0.058 mg/L during the 2013 monitoring season. High phosphorus concentrations promote excess growth of algae and other aquatic plants, which, in turn, can lead to high dissolved oxygen flux as these plant material decays. Elevated phosphorus concentrations should not be considered a stressor within this watershed.

Chlorophyll-a

No Chlorophyll-a samples were collected in this region.

Sediment: Total suspended solids and bedded sediment

Total suspended solids

TSS results will be relied upon to evaluate the effects of suspended solids and turbidity on fish and macroinvertebrate populations. The TSS data does not indicate that TSS is a stressor to aquatic biology. TSS concentrations were well below the 30 mg/L proposed standard for the majority of the season. The one TSS sample that was above the TSS proposed standard occurred on June 11, 2013, during a period of very high stream flow. However, because the TSS values are low does not mean that there is not a significant sediment issue within this AUID. Stream channel slope change caused by the dam located on Spruce Centre Drive is causing excess sediment to be deposited to the stream. Some of the influx of sediment is being deposited, filling pools and smothering riffles, thus resulting in the loss of important fish and macroinvertebrate habitat.

In 2013, the MPCA calculated Tolerance Values (TIV's) for individual fish species based on paired water quality parameters associated with a specific fish sample. TIV's were computed for both fish samples from 09Um089 and, based on MPCA data, the fish community does not exhibit a tolerance to high TSS concentrations. All fish species sampled at 09UM089 were below the 50th percentile for exhibiting tolerance to high TSS values. The MPCA also conducted community based TIV's for macroinvertebrates. This dataset suggests that the macroinvertebrate community is tolerant to elevated TSS concentrations. This suggests that either TSS or increased fine sediment substrate has altered the macroinvertebrate community. Both macroinvertebrate sampled at 09UM089 scored in the upper 50th percentile for TSS TIV community score. Both macroinvertebrate samples had a higher number of TSSTolerant taxa than TSSIntolerant taxa.

Bedded sediment

Bedded sediments is likely a stressor to fish and macroinvertebrate assemblages in the upper Spruce Creek AUID. Substrate embeddedness levels were very high (>70%) at site 09UM089, the D^{50} for particle size was 0.39 mm, which is fine sand, and the response from biota indicated a cause and effect relationship (high abundance of pioneering taxa and high abundance of sediment tolerant individuals) (Figures 40 and 41). Individual fish were ranked based on sediment tolerance values (TIV) developed by Meador and Carlisle (2007). Quartiles 1 and 2 are most tolerant to an increase in TSS concentration. The weighted average TSS concentration is placed on the graph, along with the percent of individuals in each quartile. The percent NA are fish that are not assigned a TIV in this paper. The species at site 09UM089 that are not assigned a TIV are central mudminnow and mottled sculpin. Central mudminnow can be found in all types of streams and habitats; however, mottled sculpin are associated with colder streams that have a higher quality.

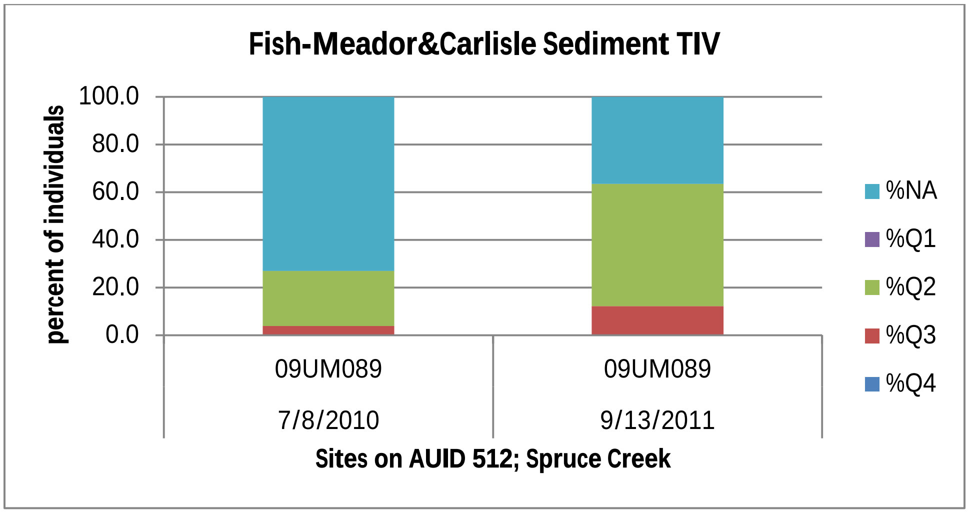

Figure 40: Percentage of fish by biological site sampled in Spruce Creek, for each quartile based on suspended sediment weighted averages (Meador and Carlisle, 2007)

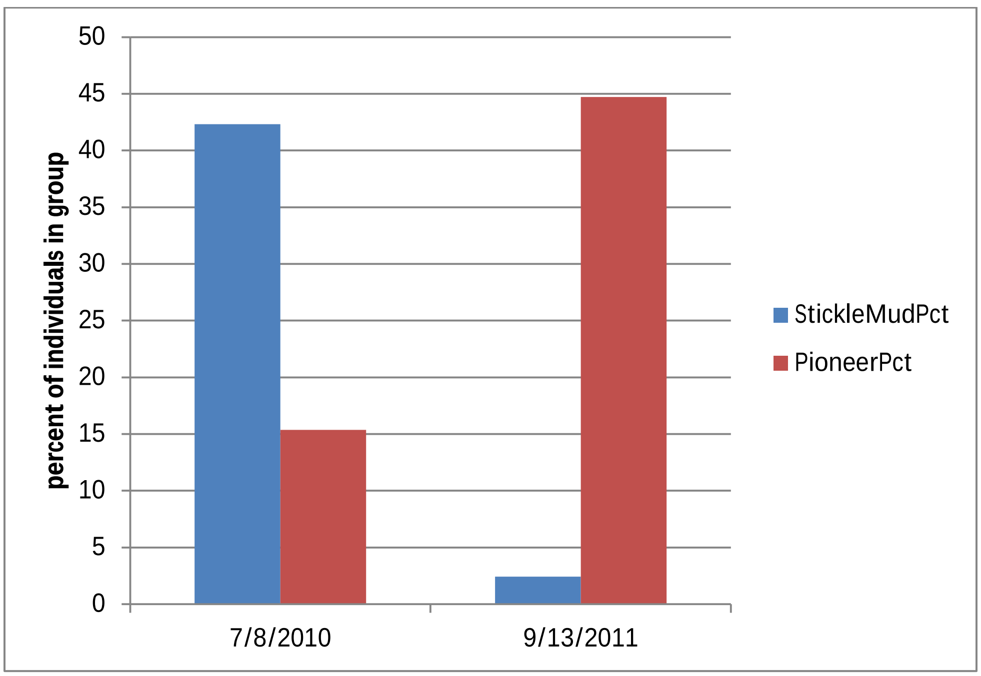

Figure 41: Percentage of fish in the sample that is very tolerant to pollutants or pioneering species

The macroinvertebrate sample (09UM089) was analyzed based on sediment tolerance values (percent sands and fines) calculated by Yuan. The individuals in the macroinvertebrate sample were assigned a Quartile value based on 1-4 to indicate their tolerance to increased fines or bedded sediment. Quartiles 1 and 2 are the most tolerant to increased bedded sediment. Figure 42 shows that during the two sampling periods, the macroinvertebrates that are tolerant to excess bedded sediment decreases. The high percentage of Q1 and Q2 macroinvertebrates at this location indicate that excess fines is a stressor in the farthest upstream reaches of this AUID.

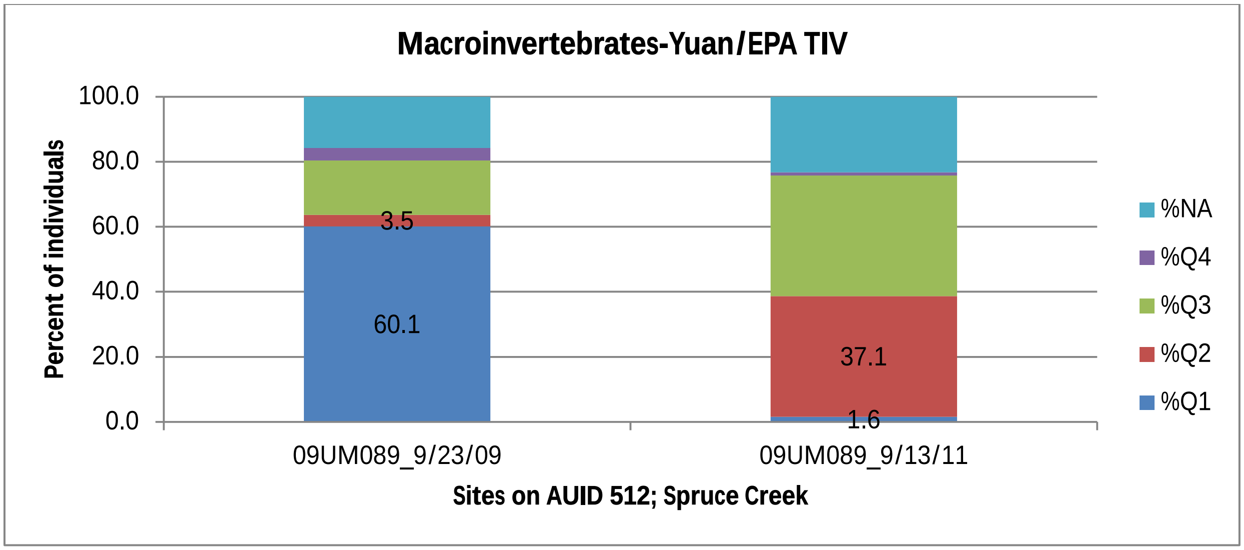

Figure 42: Percent individuals by biological site sampled in Spruce Creek, for each quartile based on sediment weighted averages (Carlisle, 2007)

Dissolved oxygen

Spruce creek is a Class 2A stream (Coldwater). Early morning (pre-9:00 a.m.) DO readings were collected in summer 2013 at two locations. Early morning DO concentrations were always above the Class 2B state standard of 5 mg/L at both sites. The Class 2A state standard is 7 mg/L. The DO measurements show a few coldwater exceedances for DO. Figure 43 below shows the DO data along with stream temperature from the two sampling locations. During the sampling period, stream temperature ranged from 14.3°C at low flow to 22.6°C during periods of increased runoff caused by precipitation.

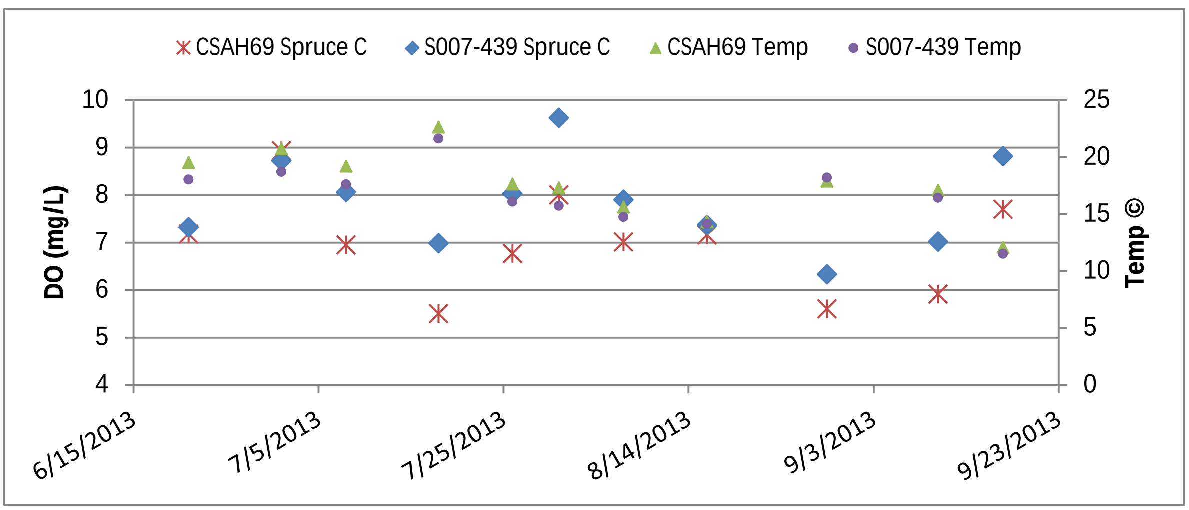

Figure 43: DO and temperature data from two locations on Spruce Creek above the old dam

Connectivity

The dam located on Spruce Centre Drive is acting as a fish barrier. Figure 44 below shows some pictures of the size and grade change caused by this structure. A longitudinal survey (Figure 45) was conducted at site 09UM089 to determine the channel slope and water surface slope for this reach. Pebble counts were conducted to determine channel particle size and estimate the degree of embeddedness within the channel.

Figure 44: Photos of the dam separating the two sampling sites on Spruce Creek. The dam is acting as a fish barrier and changing the slope of the upstream channel (making the slope flatter).

The channel slope was low with a 0.00073 ft/ft slope. The channel in this upstream section is dominated by fine sand and has a D50 of 0.36mm. The surveyed reach had around 12% of the substrate as small gravel (less than 6mm). The stream bottom also was filled with sand dunes that ranged in height from 0.1 to 0.25 feet in height. Figure 46 shows the field survey for this section of Spruce Creek. The two fish samples also confirm that the dam on Spruce Centre Drive is acting as a fish barrier. Table 12 below shows the fish species and numbers from the two locations. Downstream of the dam, the fish community is more diverse and also supports higher numbers of each species.

Conclusion

The two main stressors to the biotic community in Spruce Creek are bedded sediment causing a lack of habitat and loss of connectivity due to the dam located on Spruce Centre Drive. Stream channel instability is causing a general lack of in stream habitat. The riparian corridor immediately adjacent to the stream is dominated by sedges with a few scattered areas of dogwood and willow shrubs. There are few trees located near the channel in the majority of the study reach. This lack of tree canopy limits the amount of woody debris and woody snags available for macroinvertebrate habitat and areas for fish to seek refuge. The macroinvertebrate samples were collected from aquatic vegetation during both sampling events, and from overhanging vegetation on one sampling event and woody debris on one sampling event. There were no riffles, rock, or leafpack available for macroinvertebrate colonization. The stream substrate is dominated by sand. Pools are filling with fine sediment and riffles are lacking coarse substrate in the upper reaches of Spruce Creek. The lack of connectivity to the lower portion of Spruce Creek is causing a lack of fish species and diversity. The sampling location below the dam (11UM028) has 16 species, while the site above the dam (09UM089) has 6 species. The macroinvertebrate community also significantly improves at 11UM028. The EPT taxa increases, the Scraper percentage increases, and the clinger percent increases. This suggests that the gravel and cobble habitat that is not available at 09UM089 is available at 11UM028.

Table 12: Fish species list from Spruce Creek. Site 11UM028 is below the dam on Spruce Centre Drive and 09UM0899 is above the dam.

Fish Species	11UM028	09UM089	Fish Species	11UM028	09UM089	Fish Species	11UM028	09UM089
Northern Pike	8	6	**Fathead Minnow**	5	x	**Mottled Sculpin**	1	42
Central Mudminnow	2	3	**Northern redbelly Dace**	1	x	**Rock Bass**	1	x
Creek Chub	36	1	**Common Shiner**	49	x	**Largemouth Bass**	6	x
Blacknose Dace	95	14	**Greater Redhorse**	2	x	**Johnny Darter**	17	54
Hornyhead Chub	93	x	**Black Bullhead**	1	x	**Logperch**	1	x
White Sucker	15	3						

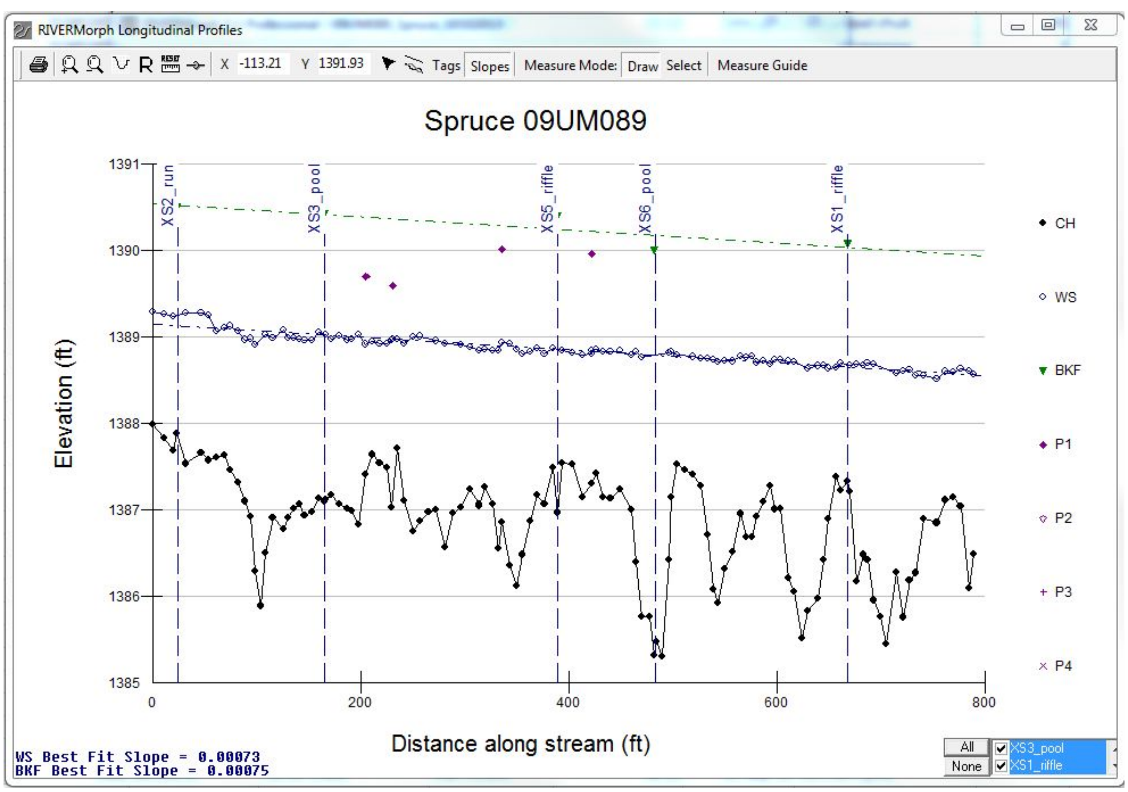

Figure 45: Longitudinal profile of stream channel at sampling site 09UM089. Note the shallow pools and short riffle distances.

Summary of stressors to biology

The four biologically impaired AUID's and the weight of evidence information for each stressor are listed below in Table 13. A + symbol indicates a positive response for that stressor category and is likely causing the lack of biotic integrity at that AUID sampling location.

Table 13: Conclusions and summary of candidate stressor

Summary of Stressors By 11-digit HUC	Harris Creek	Spruce Creek	Venowitz Creek	Unnamed Creek
Loss of Habitat due to Channelization / Ditching	+	+	+	+
Total Suspended Solids	0	0	0	0
Deposited and Bedded Sediments	+	+	+	+
Pesticide Toxicity	NE	NE	NE	NE
Nitrate-Nitrite Toxicity	-	-	-	-
Chloride Toxicity	NE	NE	NE	NE
Dissolved Oxygen	+	0	+	0
Irrigation – Flow Alteration	+	0	0	0
Connectivity – Loss of fish passage	+	+	0	+
Increased Nutrients (Total Phosphorus)	+	-	-	-

Key: + is a positive indicator, - is negative indicator, 0 is neutral, NE is No Evidence

Additional data collected in 2012 and 2013 in LP Watershed

AUID 07010108-505 Long Prairie River

The Long Prairie River has 3 AUIDs that are currently listed as being impaired for dissolved oxygen (DO). In the summer of 2013, DO data was collected from these three AUIDs in an effort to understand the extent and degree of the DO impairment, along with a concern that the fish communities were not potentially meeting standard. As a means of investigating the DO impairments, AUID 070108-505 was sampled at two locations on a weekly basis, along with having sondes deployed at four additional locations for three-week intervals to capture the daily flux of DO along with the daily minimums. Sites S000-282 and S000-283 were sampled weekly before noon and had no DO readings below the 5 mg/L standard. Sites S007-434, S007-435, S002-904, and S002-910 (Figure 46) have continuous data and are listed from upstream to downstream. Figure 48 shows that the DO data at Long Prairie and below (S002-904 and S002-910) do not have any exceedances for the DO standard and on average have a 2 mg/L daily DO flux.

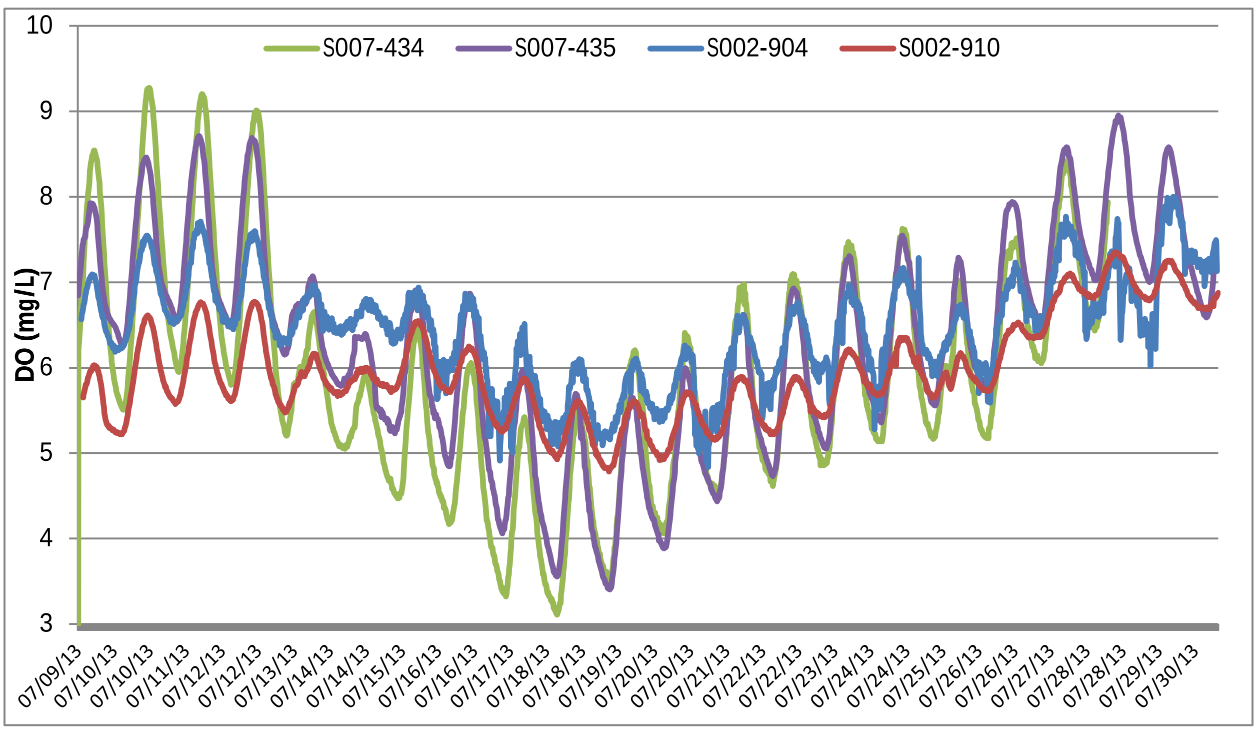

Figure 46: Continuous YSI sonde data from July 9, 2013 through July 30, 2013. Sites are listed from upstream to downstream.

Figure 47: Map of Dissolved Oxygen sampling locations in AUID 07010108-505 (MPCA, 2013)

AUID 07010108-534 Long Prairie River

The upper portion of the Long Prairie River (LP) is AUID 07010108-534. This portion of the LP flows out of Lake Carlos to the east. Figure 48 shows the location of the two sampling locations in this AUID. Sampling site S002-905 is located a couple of river miles downstream of Lake Carlos, while sampling location S002-910 is located at the downstream end of this AUID and at the outlet of a large wetland complex. Dissolved oxygen (DO) at the upstream portion of this AUID is good (Figure 49), there are no DO water quality violations during the 21-day sampling period. At the farther downstream section at S002-910, which is at the downstream discharge point of the large wetland complex, the 7-day DO record shows daily lows of DO in the 2 mg/L range.

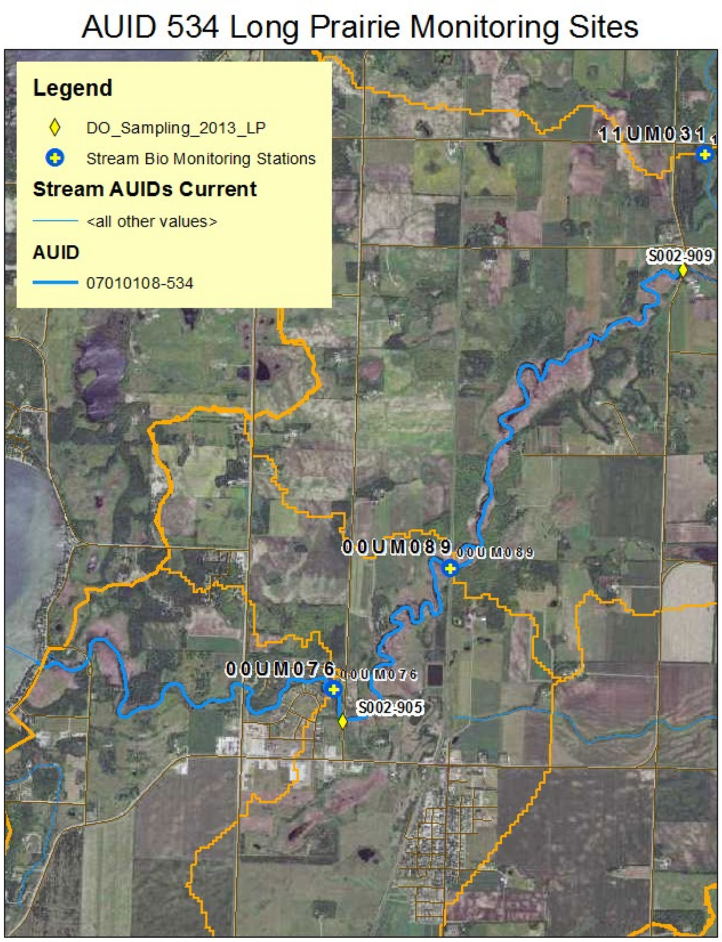

Figure 48: Sampling locations for AUID 07010108-534 in the upper most section of the Long Prairie River (MPCA, 2013)

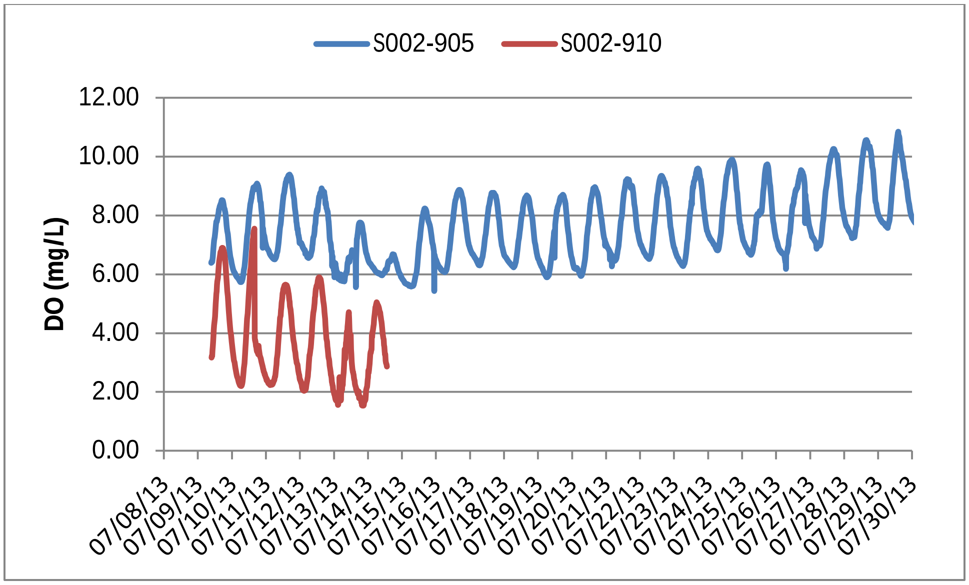

Figure 49: Continuous DO readings at the two sampling locations in the upper most Long Prairie AUID 07010108-534

AUID 07010108-535 Long Prairie River downstream of AUID 534

One sampling location for continuous YSI data was collected in this AUID in 2013. Site S007-432 is located on CSAH 3 downstream of biological site 10EM070. This biological site passed the fish IBI, while the downstream biological station (11UM025) failed the fish IBI. Figure 50 displays the 21-day continuous sonde record for DO and temperature. For the entire record, DO drops below the daily minimum standard of 5 mg/L.

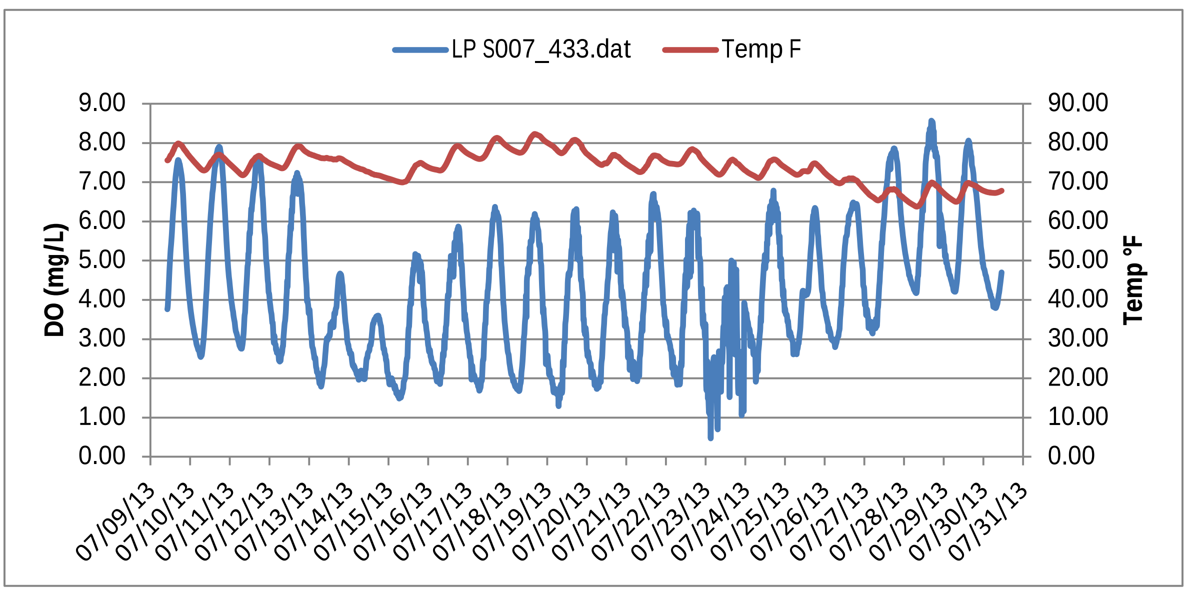

Figure 50: Continuous sonde data at Site S007-433, which is located in the midpoint of AUID 07010108-534 on CSAH 3

AUID 07010108-514 Fish Trap Creek

In the summer of 2012, a continuous sonde was deployed in Fish Trap Creel at biological station 11UM007, just upstream of T-339. This site has an active pasture on the downstream side of the road, along with channelized sections in the upstream portion. The site was not assessed during the 2013 assessment cycle; however, it appeared that DO was a limiting factor to biology, along with high nutrients and poor habitat. Figure 51 below shows the continuous DO and Temperature data that was collected in 2012.

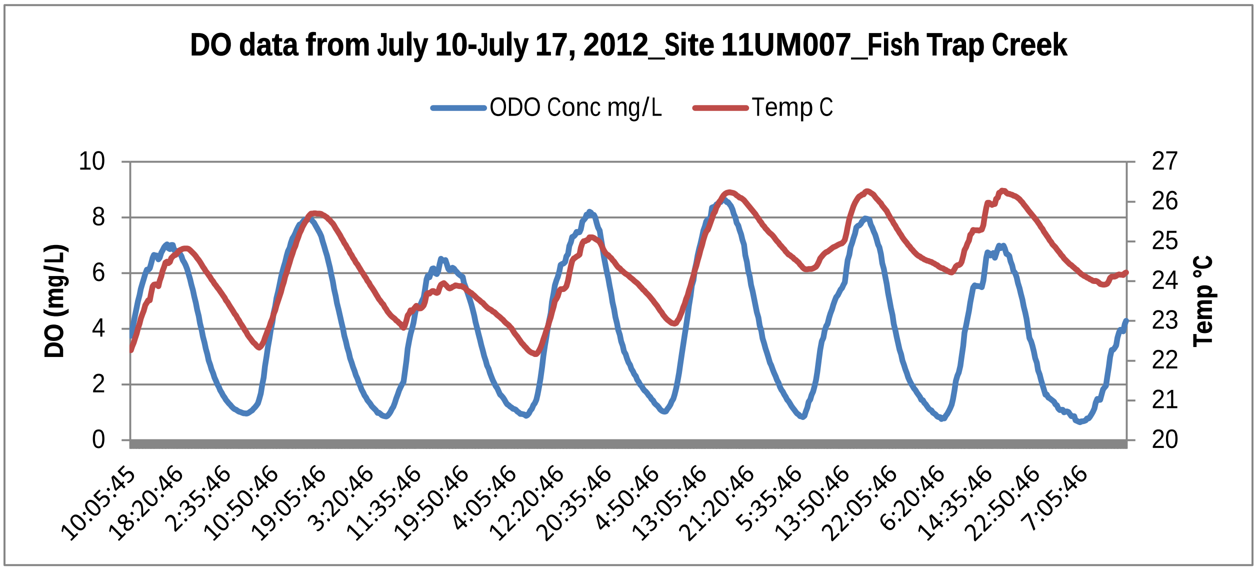

Figure 51: Continuous sonde data collected from Fish trap Creek at bio site 11UM007

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