Grand Marais Creek Watershed Total Maximum Daily Load Study

This is a report on restoring waters throughout the Grand Marais Creek Watershed that are impaired due to *E. coli* bacteria, low dissolved oxygen, or low index of biological integrity scores.

MINNESOTA POLLUTION CONTROL AGENCY

April 2019

wq-iw5-13e

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Acronyms

ALU	Aquatic Life Use
ARU	Aquatic Recreation Use
AU	Animal Units
AUID	Assessment Unit ID
BMP	Best Management Practice
BOD	biochemical oxygen demand
BWSR	Board of Water and Soil Resources
CAFO	Concentrated Animal Feeding Operation
CFS	cubic feet per second
CRP	Conservation Reserve Program
DNR	Minnesota Department of Natural Resources
DO	Dissolved Oxygen
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
EQuIS	Environmental Quality Information System
F-IBI	Fish Index of Biological Integrity
HSPF	Hydrologic Simulation Program-Fortran
HUC	Hydrologic Unit Code
IBI	Index of Biological Integrity
ISTS	Individual Sewage Treatment System
ITPHS	Imminent Threat to Public Health and Safety
LA	Load Allocation
Lb	pound
lb/day	pounds per day
lb/yr	pounds per year
LDC	Load Duration Curve
LC	Loading Capacity
LGU	Local Government Unit
m	meter
M-IBI	Macroinvertebrate Index of Biological Integrity
MDA	Minnesota Department of Agriculture
mg/L	milligrams per liter
mL	milliliter
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
MPN	Most Probable Number
MS4	Municipal Separate Storm Sewer Systems
MSTRWD	Middle Snake Tamarac Rivers Watershed District
MU	Modified Use (Tiered Aquatic Life Use subclass)
NAIP	National Agriculture Imagery Program

NASS	National Agricultural Statistics Service
ND	North Dakota
NLCD	National Land Cover Dataset
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
P	Phosphorus
PCB	Polychlorinated Biphenol
PS	Prairie Stream-Glide/Pool Habitats
RC	Reserve Capacity
RLWD	Red Lake Watershed District
SDS	State Disposal System
SID	Stressor Identification
SS	Southern Stream
SSTS	Subsurface Sewage Treatment Systems
SWCD	Soil and Water Conservation District
T	Temperature
TAC	Technical Advisory Committee
TALU	Tiered Aquatic Life Use
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TP	Total phosphorus
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UV	Ultraviolet
WLA	Wasteload Allocation
WPLMN	Watershed Pollutant Load Monitoring Network
WRAPS	Watershed Restoration and Protection Strategies
WWTP	Wastewater Treatment Plant

Executive Summary

The Federal Clean Water Act (1972) requires that each state develop a report to identify and restore any waterbody that is found to be impaired, as defined by state regulations. A Total Maximum Daily Load (TMDL) Study is required by the United States Environmental Protection Agency (EPA) as a provision of the federal Clean Water Act. A TMDL identifies the pollutant that is causing the impairment and how much of that pollutant can enter the waterbody and still meet water quality standards.

The waterways of the Grand Marais Creek Watershed, Hydrologic Unit Code (HUC) 09020306, flow to the Red River of the North, in northwestern Minnesota. This TMDL study addresses bacteria in the form of *Escherichia coli* (*E. coli*) impairments in three watercourses located in the Grand Marais Creek Watershed that are on Minnesota's Draft 2016 303(d) list of impaired waters. This report also describes the non-pollutant causes of two dissolved oxygen (DO) impairments, three fish index of biological integrity (F-IBI) impairments, and two macroinvertebrate index of biological integrity (M-IBI) impairments. The DO, F-IBI, and M-IBI impairments were not addressed with calculated TMDLs because they were not caused by quantifiable pollutants.

Information from multiple sources was used to evaluate the ecological health of each waterbody:

- All available water quality data from 2005 through 2014 (10-year assessment period)
- Grand Marais Creek Watershed Hydrologic Simulation Program – FORTRAN (HSPF) model
- Stream geomorphic and field surveys
- Stressor identification (SID) investigations
- Stakeholder input

TMDLs were calculated for reaches that were impaired by a quantifiable pollutant (*E. coli*). Loading capacities and allocations were calculated for *E. coli* using the load duration curve (LDC) method. Sources of *E. coli* pollution have been identified and described in this report along with strategies for addressing those sources. Recommendations are also given for impairments that are not caused by pollutants, to improve DO levels and the quality of aquatic life.

A Watershed Restoration and Protection Strategy (WRAPS) report was developed concurrently with tis TMDL report. The purpose of the WRAPS process is to support local working groups in developing ecologically sound restoration and protection strategies for subsequent implementation planning. The process provided opportunities to inform and involve the public. The findings of the TMDL study aided in the selection of implementation strategies and actions during the Grand Marais Creek WRAPS process and the development of the Red Lake River One Watershed One Plan (1W1P). There has been great cooperation among agencies for project implementation and monitoring in this watershed. The Grand Marais Creek WRAPS Report is publicly available on the Minnesota Pollution Control Agency (MPCA) Grand Marais Creek Watershed website: https://www.pca.state.mn.us/water/watersheds/red-river-north-grand-marais-creek

1 Project Overview

1.1 Purpose

The state of Minnesota has determined that streams in the Grand Marais Creek Watershed are impaired because they exceed established state water quality standards and, in accordance with the Clean Water Act, TMDL studies must be completed on impaired waters. The goals of this TMDL are to provide load allocations (LA) and wasteload allocations (WLA) for pollutant sources for impaired waters within Minnesota, and to quantify the pollutant reductions that are needed to meet Minnesota water quality standards. This TMDL study addresses the following impairments within the Grand Marais Creek Watershed (HUC 09020306) (Figure 1-1) that are included in Minnesota's Draft 2016 303(d) list:

- Aquatic recreation use impairments due to excess *E. coli* in three stream reaches (TMDLs calculated)
- Aquatic life use impairments due to fish/macroinvertebrate bioassessments, and/or DO in five stream reaches (No TMDL calculations due to non-pollutant causes, discussion only)

Other Grand Marais Creek Watershed studies referenced in the development of this TMDL include:

- Grand Marais Creek Watershed SID Study (MPCA 2015)
- Grand Marais Creek Watershed Monitoring and Assessment Report (MPCA 2016)

The TMDL study's results aided in the selection of implementation activities during the Grand Marais Creek WRAPS process. The purpose of the WRAPS process is to support local working groups in developing scientifically-supported restoration and protection strategies for subsequent implementation planning. On April 26, 2017, the Red Lake River 1W1P was approved by the Minnesota Board of Water and Soil Resources (BWSR). The Red Lake River 1W1P includes the Red Lake River Major Watershed and most of the Grand Marais Creek Major Watershed (the area that flows into Grand Marais Creek). Due to the concurrence of the 1W1P and WRAPS processes, findings of the TMDL and WRAPS process informed the 1W1P process while implementation recommendations in the TMDL and WRAPS documents were influenced by the prioritization of actions for the 1W1P. The 1W1P document will be updated, if necessary, when the TMDL and WRAPS documents are completed.

The Grand Marais Creek WRAPS Report is publicly available on the MPCA Grand Marais Creek Watershed website:

https://www.pca.state.mn.us/water/watersheds/red-river-north-grand-marais-creek

Additional information about the Grand Marais Creek Watershed (studies, reports, and links to online resources) can be found on a website that was created to be a watershed-based clearinghouse of information: http://www.rlwdwatersheds.org/.

Figure 1-1. Impaired streams in the Grand Marais Creek Watershed addressed by this TMDL

1.2 Identification of Waterbodies

This TMDL study addresses existing and proposed impairment listings for several streams in the Grand Marais Creek Watershed (HUC 09020306) as shown in Figure 1-1. The Grand Marais Creek Watershed does not include any tribal lands or waters. TMDLs were developed for impairments with pollutant-based stressors. These include impairments for aquatic recreation due to *E. coli* in three streams. Three existing impairments are proposed for delisting in the draft 2016 impaired waters list, awaiting EPA approval, due to changes in state water quality rules, evaluation of additional water quality data, or changes in hydrologic function. Aquatic life use impairments due to non-pollutant stressors, such as habitat or flow, will be addressed by strategies outlined in the WRAPS report (see Section 4.2).

The aquatic life use impairment due to the insecticide Chlorpyrifos (trade-name Lorsban) in the Grand Marais Creek Cutoff Channel (09020306-522) will be addressed by the Minnesota Department of Agriculture (MDA) and MPCA. The MDA will work with farmers throughout the watershed and conduct additional sampling, overseen by the MPCA staff.

The 303d list of impaired waters also includes several reaches of the Red River impaired for aquatic consumption, which are not addressed in this TMDL (Table 1-2). These impairments include impairments for aquatic consumption due to mercury in fish tissue or mercury in the water column, some of which were addressed in the Minnesota State-Wide Mercury TMDL (2007); and impairments for aquatic consumption due to arsenic in the water column, or Polychlorinated Biphenyls (PCB) in fish tissue.

1.3 Priority Ranking

The MPCA's schedule for TMDL completions, as indicated on the 303(d) impaired waters list, reflects Minnesota's priority ranking of this TMDL. The MPCA has aligned its TMDL priorities with the watershed approach and the WRAPS cycle. The schedule for TMDL completion corresponds to the WRAPS report completion on the 10-year cycle. The MPCA developed a state plan Minnesota's TMDL Priority Framework Report to meet the needs of EPA's national measure (WQ-27) under EPA's Long-Term Vision for Assessment, Restoration and Protection under the Clean Water Act Section 303(d) Program. As part of these efforts, the MPCA identified water quality impaired segments that will be addressed by TMDLs by 2022. The Grand Marais Creek Watershed waters addressed by this TMDL are part of that MPCA prioritization plan to meet the EPA's national measure.

Table 1-1. Aquatic Life and Aquatic Recreation Use impairments in the Grand Marais Creek Watershed

Aquatic Life and Aquatic Recreation Use impairments in the Grand Marais Creek Watershed							
AUID	**Reach Name**	**Reach Description**	**Designated Use Class**	**Listing Year**	**Target Start/ Completion**	**Pollutant/Stressor (Affected Use)**	**Impairment Addressed by:**
09020306-507	Grand Marais Creek	Headwaters to CD2	2B, 3C	2006	2013/ 2018	DO (ALU)	*Non-pollutant stressors**
				~~2006~~		~~Turbidity (ALU)~~	*Proposed delisting***
09020306-509	RLWD Ditch 15	Headwaters to CD66	2B, 3C	2016	2012/ 2018	DO (ALU)	*Non-pollutant stressors**
09020306-515	County Ditch 2	CD66 to Grand Marais Creek	2B, 3C	2016	2012/ 2018	*E. coli* (ARU)	***E. coli* TMDL in this report**
						F-IBI (ALU)	*Non-pollutant stressors**
						M-IBI (ALU)	
09020306-517	County Ditch 43 (Judicial Ditch 25)	Unnamed ditch to CD7	2B, 3C	2016	2012/ 2018	F-IBI (ALU)	*Non-pollutant stressors**
						M-IBI (ALU)	
09020306-519	Judicial Ditch 1	CD7 to Red River	2B, 3C	2016	2012/ 2018	*E. coli* (ARU)	***E. coli* TMDL in this report**
09020306-520	Judicial Ditch 75	CD7 to Red River	2B, 3C	2016	2012/ 2018	*E. coli* (ARU)	***E. coli* TMDL in this report**
						F-IBI (ALU)	*Non-pollutant stressors**
09020306-522	Grand Marais Cutoff Channel	Grand Marais Creek to Red River		2016	2012/ 2018	Chlorpyrifos (ALU)	*To be addressed by Minnesota Department of Agriculture*

*Stressor ID report indicates that the primary stressor is not pollutant-based (lack of base flow, loss of habitat, or loss of connectivity). A TMDL has not been calculated for these impairments and will remain on the 303(d) list of impaired waters as a category 5 unless there is evidence to recategorize to 4C. See Section 4.2.

**Delisted on the Draft 2018 List of Impaired Waters

Key: ALU = aquatic life use; ARU = aquatic recreation use; F-IBI = fish index of biotic integrity; M-IBI = macroinvertebrate index of biotic integrity; *E. coli* = *Escherichia coli* (bacteria)

Table 1-2. Aquatic Consumption Use impairments in the Grand Marais Creek Watershed

Aquatic Consumption Use impairments in the Grand Marais Creek Watershed							
AUID	**Name**	**Location/Reach Description**	**Designated Use Class**	**Listing Year**	**Target Completion Year**	**Affected Use**	**Pollutant/ Stressor**
09020306-523	Red River	English Coulee (ND) to Turtle R (ND)	1C, 2Bdg, 3C	1998	2031	Aquatic Consumption	Mercury in fish tissue*
				2008	2031	Aquatic Consumption	Mercury in water column*
09020306-524	Red River	Turtle R (ND) to Park R (ND)	1C, 2Bdg, 3C	1998	2031	Aquatic Consumption	Mercury in fish tissue*
				2008	2031	Aquatic Consumption	Mercury in water column*

* Mercury impairments have been addressed by a state-wide Mercury TMDL that was approved by the EPA in 2007. Links to the most recent revisions of the TMDL and its appendices can be found on the MPCA website: https://www.pca.state.mn.us/water/statewide-mercury-reduction-plan

2 Applicable Water Quality Standards and Numeric Water Quality Targets

All waterbodies have a Designated Use Classification, defined by the MPCA, which defines the optimal purpose for that waterbody (see Section 2). The streams addressed by this TMDL study fall into one of the following two designated use classifications:

2B, 3C – a healthy warm water aquatic community; industrial cooling and materials transport without a high level of treatment

2C – a healthy indigenous fish community

Class 2 waters are protected for aquatic life and aquatic recreation, and Class 3 waters are protected for industrial consumption as defined by Minn. R. ch. 7050.0140. The most protective of these classes is 2B, for which water quality standards are provided below.

The Minnesota narrative water quality standard for all Class 2 waters (Minn. R. 7050.0150, subp. 3) states, "For all Class 2 waters, the aquatic habitat, which includes the waters of the state and stream bed, shall not be degraded in any material manner, there shall be no material increase in undesirable slime growths or aquatic plants, including algae, nor shall there be any significant increase in harmful pesticide or other residues in the waters, sediments, and aquatic flora and fauna; the normal fishery and lower aquatic biota upon which it is dependent and the use thereof shall not be seriously impaired or endangered, the species composition shall not be altered materially, and the propagation or migration of the fish and other biota normally present shall not be prevented or hindered by the discharge of any sewage, industrial waste, or other wastes to the waters".

2.1 Streams

2.1.1 *E. coli* Bacteria

The numeric standards in Minn. R. ch. 7050 (Waters of the State) that directly protect for primary (swimming and other recreation where immersion and inadvertently ingesting water is likely) and secondary (boating and wading where the likelihood of ingesting water is much smaller) body contact are the *E. coli* standards shown in Table 2-1. *E. coli* standards are applicable only during the warm months, since there is very little swimming in Minnesota in the non-summer months. Exceedances of the *E. coli* standard mean that the recreational use is not being met.

The MPCA uses an *E. coli* standard based on a geometric mean EPA criterion of 126 *E. coli* colony forming units (CFU) per 100 ml. *E. coli* has been determined by EPA to be the preferred indicator of the potential presence of waterborne pathogens.

There is a considerable amount of *E. coli* data available in Minnesota, and older fecal coliform data. For assessment purposes, only *E. coli* measurements will be used. Grand Marais Creek bacteria impairments and TMDLs only used *E. coli* data.

Data over the full 10-year period are aggregated by individual month (e.g. all April values for all 10 years, all May values, etc.). At least five values for each month is ideal, while a minimum of five values per month for at least three months, preferably between June and September, is necessary to make a determination. Assessment with less than these minimums may be made on a case-by-case basis.

Where multiple bacteria/pathogen samples have been taken on the same day on an assessment unit, then the geometric mean of all the measurements will be used for the assessment analysis.

If the geometric mean of the aggregated monthly values for one or more months exceeds 126 organisms per 100 ml, that reach is considered impaired. In addition, a water body is considered impaired if more than 10% of individual values over the 10-year period (independent of month) exceed 1,260 organisms per 100 ml. This assessment methodology more closely approximates the five-samples-per-month requirement of the standard while recognizing typical sampling frequencies, which rarely provide five samples in a single month and usually only one.

Expert review of the data provides a further evaluation. When fewer than five values are available for most or all months, the individual data are reviewed. In some circumstances where four values are available for some or all months, a mathematical analysis is done to determine the potential for a monthly geometric mean to exceed the 126 organisms/100ml standard. All assessments are reviewed by the Watershed Assessment Team (WAT) for each watershed.

Considerations in making the impairment determination include the following:

- Dates of sample collection (years and months)
- Variability of data within a month
- Magnitude of exceedances
- “Remark” codes associated with individual values
- Previous assessments and 303(d) listings

The *E. coli*-impaired reaches in the Grand Marais Creek Watershed flow into the Red River of the North, which is a boundary water between North Dakota and Minnesota. North Dakota uses the same 126 org/100ml geomean standard that is used by Minnesota. Also, the portion of the Red River that receives drainage from the Grand Marais Creek watershed was not listed as impaired for *E. coli* in Minnesota or ND as of 2018. The *E. coli* TMDLs in this document will be equally protective of the identical Minnesota and North Dakota chronic *E. coli* standards that apply to the Red River of the North.

Table 2-1. Numeric water quality standards of bacteria (*E. coli*) for the beneficial use of aquatic recreation (primary and secondary body contact)

Past and Current Numeric Water Quality Standards of Bacteria				
Parameter	**Use Classes**	**Standard**	**Criteria**	**Months of the Year to Which the Standard Applies**
E. coli	2A, 2B, 2Bd, 2C, 2D	126 MPN per 100 ml	Maximum geometric mean	April - October
E. coli	2A, 2B, 2Bd, 2C, 2D	1,260 MPN per 100 ml	Maximum = 10% of Samples	April - October

2.1.2 Dissolved Oxygen

DO is required for essentially all aquatic organisms to live. When DO drops below acceptable levels, desirable aquatic organisms, such as fish, can be killed or harmed. DO standards differ depending on the use class of the water.

Class 2Bd, 2B, 2C. Not less than 5 mg/L as a daily minimum

The standard for DO is expressed in terms of daily minimums and concentrations generally follow a diurnal cycle. Consequently, measurements in open-water months (April through November) should be made before 9:00 a.m.

A stream is considered impaired if:

1. More than 10% of the “suitable” (taken before 9:00 a.m.) May through September measurements, or more than 10% of the October through April measurements violate the standard, and
2. There are at least three violations.

Because the underlying criterion is that water quality standards can be exceeded no more than 10% of the relevant time, it is usually essential that measurements are a representative sample of overall water quality and are not biased towards certain types of conditions, such as storm events or certain times of the year. The relevant time generally refers not to the entire year, but rather to the usual water quality monitoring portion of the year. The requirement of at least three exceedances helps ensure that the measured data set is sufficiently large to provide an adequate picture of overall conditions.

A designation of “full support” for DO generally requires at least 20 suitable measurements from a set of monitoring data that give a representative, unbiased picture of DO levels over at least two different years. However, if it is determined that the data set adequately targets periods and conditions when DO exceedances are most likely to occur, a smaller number of measurements may suffice for a determination of “full support.”

Table 2-2. Stream dissolved oxygen standards (Minn. R. 7050.0220)

Stream Dissolved Oxygen Standards	
Stream Class	Daily Minimum Dissolved Oxygen (mg/L)
2A – Cold water	7
2B – Cool water or Warm water	5

2.1.3 Fish Index of Biotic Integrity (F-IBI)

The presence of a healthy, diverse, and reproducing aquatic community is a good indication that the aquatic life beneficial use is being supported by a lake, stream, or wetland. The aquatic community integrates the cumulative impacts of pollutants, habitat alteration, and hydrologic modification on a water body over time. Monitoring the aquatic community, or biological monitoring, is therefore a relatively direct way to assess aquatic life use support. Interpreting aquatic community data is accomplished using an index of biological integrity or IBI. The IBI incorporates multiple attributes of the aquatic community, called “metrics,” to evaluate a complex biological system. The MPCA has developed fish and invertebrate IBIs to assess the aquatic life use of rivers and streams statewide in Minnesota.

The state officially adopted the Tiered Aquatic Life Use (TALU) framework for assessing aquatic life in 2015. This framework refines Minnesota's single goal for aquatic life into three tiers that are based on the aquatic life potential for a water body. These tiered uses are Exceptional, General (GU), and Modified (MU). The process for determining the appropriate tier is called a Use Attainability Analysis and it is carried out before the assessment process. The actual mechanisms for performing an assessment of TALUs are similar to the current process with the only major difference being the biocriteria threshold.

Further interpretation of aquatic community data is provided by an assessment threshold of biocriteria against which an IBI score can be compared. In general, an IBI score above this threshold is indicative of aquatic life use support, while a score below the threshold is indicative of non-support. Bracketing each IBI assessment threshold is a 90% confidence interval that is based on the variability of IBI scores obtained at sites sampled multiple times in the same year (i.e., replicates). Confidence intervals account for variability due to natural temporal changes in the community as well as method error. For assessment purposes, sites with IBI scores within the 90% confidence interval are considered "potentially impaired." Upon further review of available supporting information, an IBI parameter review may change to "indicating support" or "indicating severe impairment" depending on the extent and nature of this additional information.

The aquatic life impairments in CD2 (Assessment Unit ID (AUID) 09020306-515), CD 43 (AUID 09020306-517); and JD 75 (AUID 09020306-520) were each characterized by low F-IBI scores. Degradation of surface waters can lead to changes in biological communities as pollutant intolerant species are replaced by pollutant tolerant species. The F-IBI and other indices of biological integrity are biological monitoring frameworks used to quantify changes in the composition of biological communities. The development of an F-IBI framework for Minnesota is described in the MPCA document wq-bsm2-03, published in 2014. The F-IBI threshold for impaired streams in the Grand Marais Creek Watershed are listed Table 2-3.

Table 2-3. State of Minnesota F-IBI score impairment thresholds for streams in the Grand Marais Creek Watershed.

State of Minnesota F-IBI Score Impairment Thresholds		
Impaired Reach Name (AUID)	**F-IBI Class§ /(Use†)**	**F-IBI Score Threshold**
CD2 (09020306-515)	SS (MU)	35
CD43 (09020306-517)		
JD75 (09020306-520)		
CD43(09020306-517)	NH (MU)	23

§F-IBI Classes: Southern Stream (SS) and Northern Headwaters (NH)
†Tiered Aquatic Life Use (TALU) Framework Designation: Modified Use (MU)

2.1.4 Macroinvertebrate Index of Biotic Integrity (M-IBI)

The aquatic life impairments in CD2 (AUID 09020306-515) and CD 43 (AUID 09020306-517) were each characterized by low M-IBI scores. Degradation of surface waters can lead to changes in biological communities as pollutant intolerant species are replaced by pollutant tolerant species. The M-IBI and other indices of biological integrity are biological monitoring frameworks used to quantify changes in the composition of biological communities. The development of an M-IBI framework for Minnesota is described in MPCA document wq-bsm4-01, published in 2014.

Narrative language within Minnesota Administrative Rule identifies an IBI calculation as the primary determinant for evaluating impairment of aquatic biota (Minn. R. 7050.0150, subp. 6, Impairment of biological community and aquatic habitat). The M-IBI threshold for impaired streams in the Grand Marais Creek Watershed are listed Table 2-4.

Table 2-4. Minnesota M-IBI score impairment thresholds for streams in the Grand Marais Creek Watershed

State of Minnesota M-IBI Score Impairment Thresholds		
Impaired Reach Name (AUID)	M-IBI Class[§] /(Use[†])	M-IBI Score Threshold
CD2 (09020306-515)	PS (MU)	22
CD43 (09020306-517)		

[§]M-IBI Classes: Prairie Stream-Glide/Pool Habitats (PS)

[†]Tiered Aquatic Life Use (TALU) Framework Designation: Modified Use (MU)

3 Watershed and Water body Characterization

The impaired streams included in this study are located within the Grand Marais Creek Watershed (HUC 09020306), a tributary to the Red River of the North in Minnesota's portion of the Red River of the North Basin (Figure 1-1). The Grand Marais Creek Watershed drains approximately 592 square miles (378,880 acres) in Polk, Marshall, and Pennington Counties with a majority of the watershed located in Polk County. Grand Marais Creek begins in agricultural land near Fisher, Minnesota and flows North and West to the Red River. The predominant land use in the watershed is cropland (91.6%) and drainage ditch networks are a prominent feature of the landscape.

In the early 1900s, a State/County project to increase drainage diverted the lower six miles of Grand Marais Creek into a ditch (cut-off channel) that emptied into the Red River a short distance upstream of its original confluence. A recently completed restoration project (Project 60) has restored the flow back into the original natural, meandering channel. The old cut-off channel has been buffered and stabilized but will only receive flow during greater than 1.25-year recurrence interval high flow events along with local runoff. This completed restoration should greatly enhance the water quality at the outlet. (MPCA 2016)

3.1 Streams

Direct and total drainage area for the impaired stream reaches are listed in Table 3-1. Direct drainage areas were delineated from the Grand Marais Creek HSPF model. The direct drainage areas include only the area downstream of any monitored upstream lake or stream.

Table 3-1. Direct drainage and total watershed areas of impaired waters

Impaired Stream Reach Direct Drainage and Total Watershed Areas				
AUID 09020306-	Name/Description	Direct Drainage Area (ac)	Upstream AUID	Total Drainage Area (ac)
507	Grand Marais Creek, Headwaters to CD2	120,212	n/a	120,212
509	RLWD Ditch 15, Headwaters to CD66	26,568	n/a	26,568
515	County Ditch 2, CD66 to Grand Marais Creek	39,447	509	66,015
519	Judicial Ditch 1, CD7 to Red River	42,935	n/a	42,935
520	Judicial Ditch 75, CD7 to Red River	33,560	517	71,244

3.2 Subwatersheds

The subwatersheds of impaired streams and monitoring stations that are referenced in this TMDL are illustrated in Figure 3-1 below.

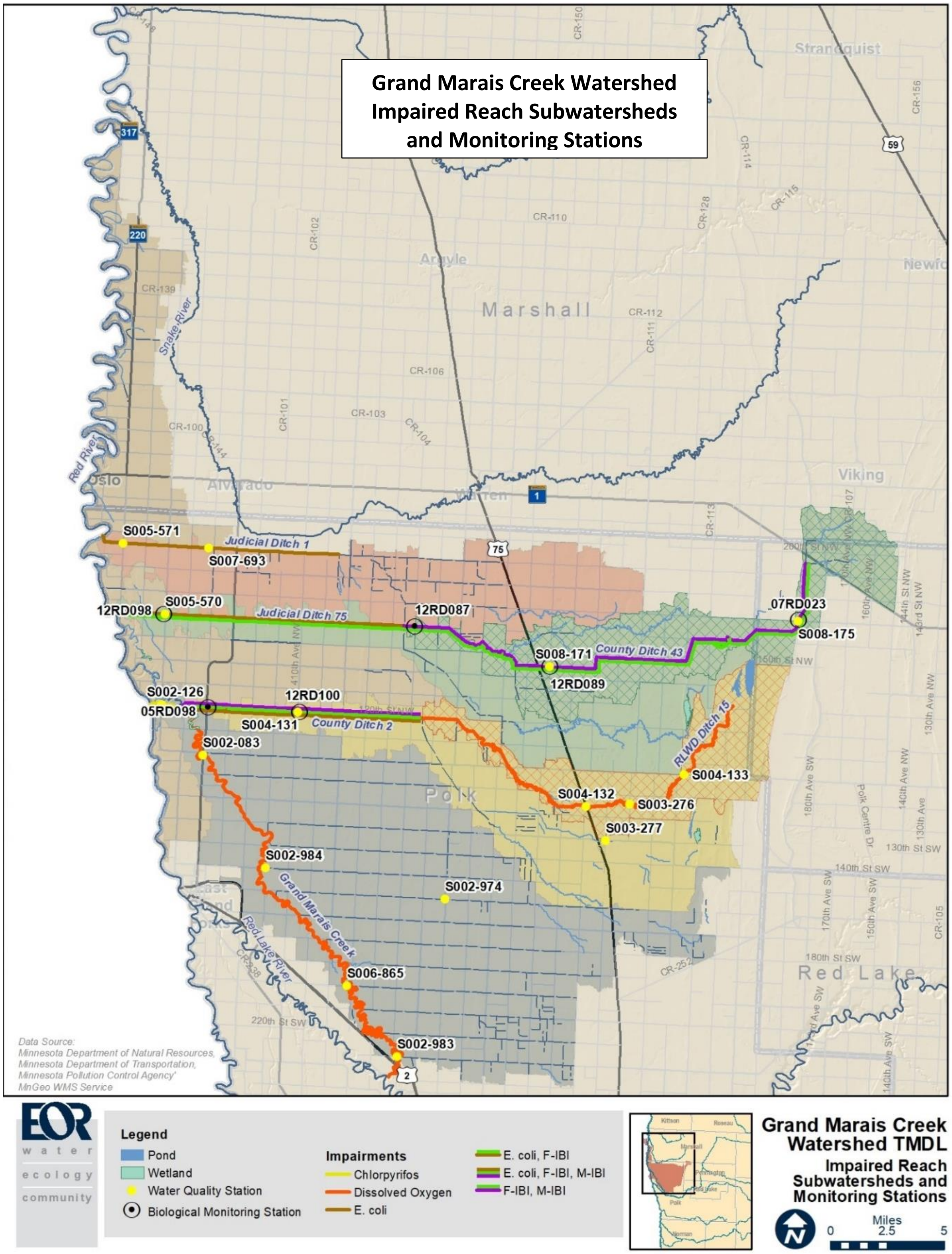

Figure 3-1. Impaired stream drainage areas and monitoring stations referenced in this TMDL

3.3 Land Use

Land cover in the Grand Marais Creek watershed was assessed using the Multi-Resolution Land Characteristics Consortium 2011 National Land Cover Dataset (https://www.mrlc.gov/data), and the crop cover distribution using the U.S. Department of Agriculture (USDA) 2012 National Agriculture Statistics Service (https://www.nass.usda.gov/). This information is necessary to draw conclusions about pollutant sources and best management practices (BMP) that may be applicable within each subwatershed.

The land cover distribution within impaired stream watersheds is summarized in Table 3-2 and Figure 3-2. This data was simplified to reduce the overall number of categories.

- **Developed:** developed open space, and low, medium and high density developed areas.
- **Undeveloped**: evergreen forests, deciduous forests, mixed forests, and shrub/scrub
- **Cropland**: all annually planted row crops (corn, soybeans, wheat, oats, barley, etc.) and fallow crop fields
- **Grassland:** native grass stands, alfalfa, clover, long term hay, government funded set-aside i.e. CRP,RIM, and pasture
- **Open Water/Wetland:** wetlands, marshes, lakes, and rivers.

The primary land cover within the Grand Marais Creek Watershed is cropland (91.6%). The drainage areas of impaired watercourses have land cover distributions very similar to the Grand Marais Creek Watershed as a whole. The dominant crop types are spring wheat and soybeans, which make up 28% and 21% respectively of the total land cover in the Grand Marais Creek Watershed (Table 3-3 and Figure 3-3).

Table 3-2. Grand Marais Creek Watershed and impaired streams subwatershed land cover (NLCD 2011)

Grand Marais Creek Watershed Land Cover Summary					
Waterbody Name	Developed	Undeveloped	Cropland	Grassland/ Pasture	Open Water/ Wetlands
Grand Marais Creek, Headwaters to CD2 (09020306-507)	4.8%	0.4%	93.2%	0.0%	1.6%
RLWD Ditch 15 (09020306-509)	4.6%	1.4%	89.7%	1.0%	3.3%
County Ditch 2, CD66 to Grand Marais Creek (09020306-515)	4.6%	0.9%	92.0%	0.5%	2.0%
Judicial Ditch 1 (09020306-519)	4.9%	0.7%	93.7%	0.7%	<0.1%
Judicial Ditch 75 (09020306-520)	4.5%	2.1%	91.6%	0.7%	1.1%
Grand Marais Creek Watershed	**4.8%**	**1.0%**	**91.6%**	**0.3%**	**2.3%**

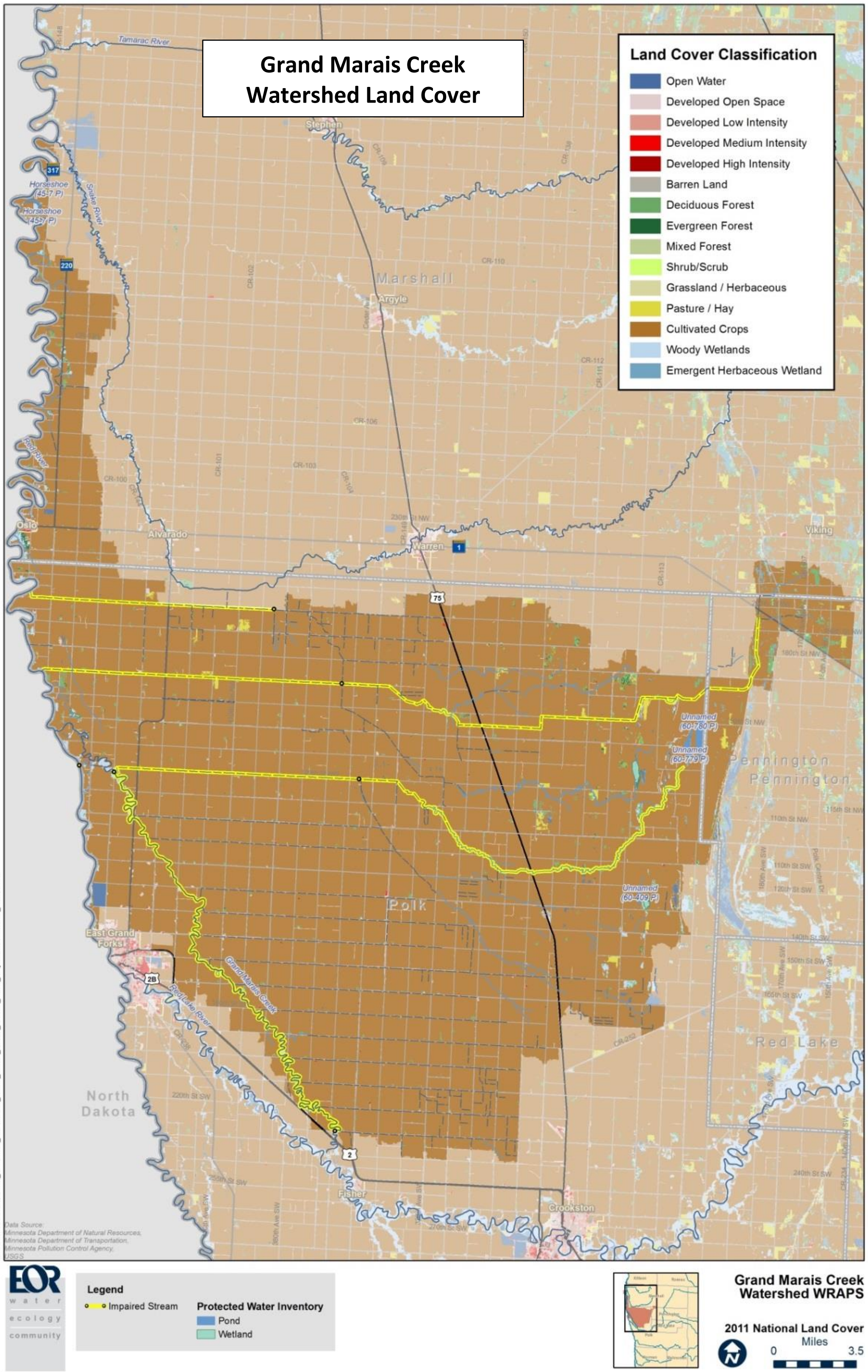

Figure 3-2. Land cover in the Grand Marais Creek Watershed (NLCD 2011)

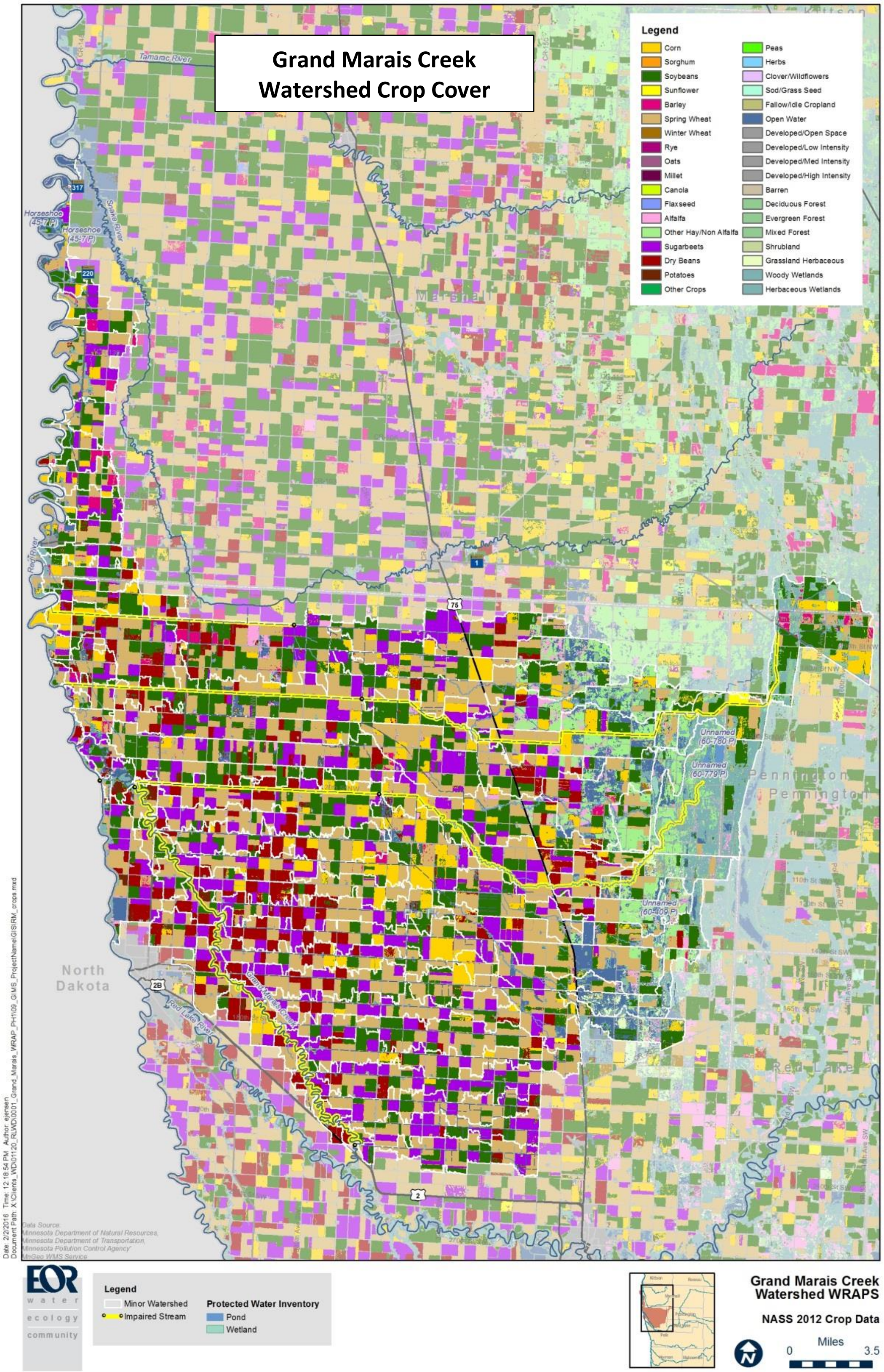

Figure 3-3. Crop cover in the Grand Marais Creek Watershed (NASS 2012)

Table 3-3. Breakdown of annual crop cover in the Grand Marais Creek Watershed type by crop type (NASS 2012)

Crop Distribution	
Crop	**% Land Cover**
Spring Wheat	28.0%
Soybeans	21.0%
Sugar Beets	13.0%
Dry Beans	7.4%
Corn	6.2%
Fallow/Other	16.0%
Total Cropland	**91.6%**

3.4 Current/Historical Water Quality

The existing in-stream water quality conditions were quantified using data downloaded from the MPCA Environmental Quality Information System (EQuIS) database and available for the most recent 10-year assessment period (2005 through 2014), overlapping with the MPCA's most recent intensive monitoring conducted in the watershed from 2012 and 2013.

3.4.1 Dissolved Oxygen

3.4.1.1 Grand Marais Creek, Headwaters to CD2 (AUID 09030206-507)

Based on May through September monitoring records for the period 2005 through 2014, observed DO conditions meet the criteria for impairment (Section 2.1.2) at two water quality monitoring sites in Grand Marais Creek for samples collected at any flow condition (Table 3-4). DO data are also summarized for samples not collected during low flow conditions, but the percent of samples below 5 mg/L are similar to samples collected at any flow condition.

The number of samples with DO concentrations less than 5mg/L is plotted by month and station in Figure 3-5. DO levels below 5 mg/L are most common in July and August. DO values generally decreased following spring, reached annual lows and sometimes dropped below the water quality standard during the summer months, and then increased again into the fall.

DO levels are lower in areas that are more ponded. There is relatively little drainage area upstream of monitoring site S002-983, which is essentially an oxbow wetland, resulting in naturally low DO levels.

Table 3-4. May-September DO (mg/L) sampling in Grand Marais Creek, Headwaters to CD2, 2005-2014

Dissolved Oxygen Data Summary for Grand Marais Creek, Headwaters to CD2 (2005-2014)					
Waterbody	Monitoring Station (in order from upstream to downstream)	Total May-Sept Samples	DO < 5 mg/L		Impairment Status
			# Samples	%	
Grand Marais Creek, headwaters to CD2 (AUID 09020306-507)	**All Flow Conditions:**				
	S002-983 (at 230th Ave SW)	3	2	67%	Insufficient data
	S002-984 (at CSAH 19)	32	12	38%	Impaired
	S002-083 (at CSAH 220)	20	8	40%	Impaired
	Excluding Low Flow Conditions:				
	S002-983 (at 230th Ave SW)	3	2	67%	Insufficient data
	S002-984 (at CSAH 19)	29	11	38%	Impaired
	S002-083 (at CSAH 220)	17	6	35%	Impaired

Impaired = Exceeds the threshold (10%) for DO impairment based on all samples taken from May through September (see Section 2.1.2). **Insufficient data** = Insufficient number of observations at this location to determine impairment status (≥ 20 independent observations needed).

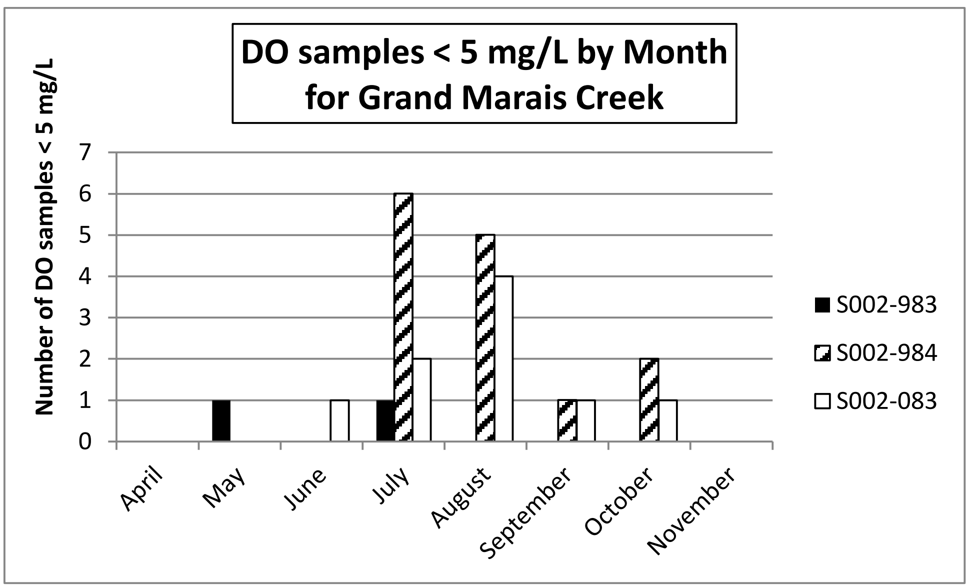

Figure 3-4. Number of samples with DO < 5 mg/L by month and station for Grand Marais Creek, 2005-2014

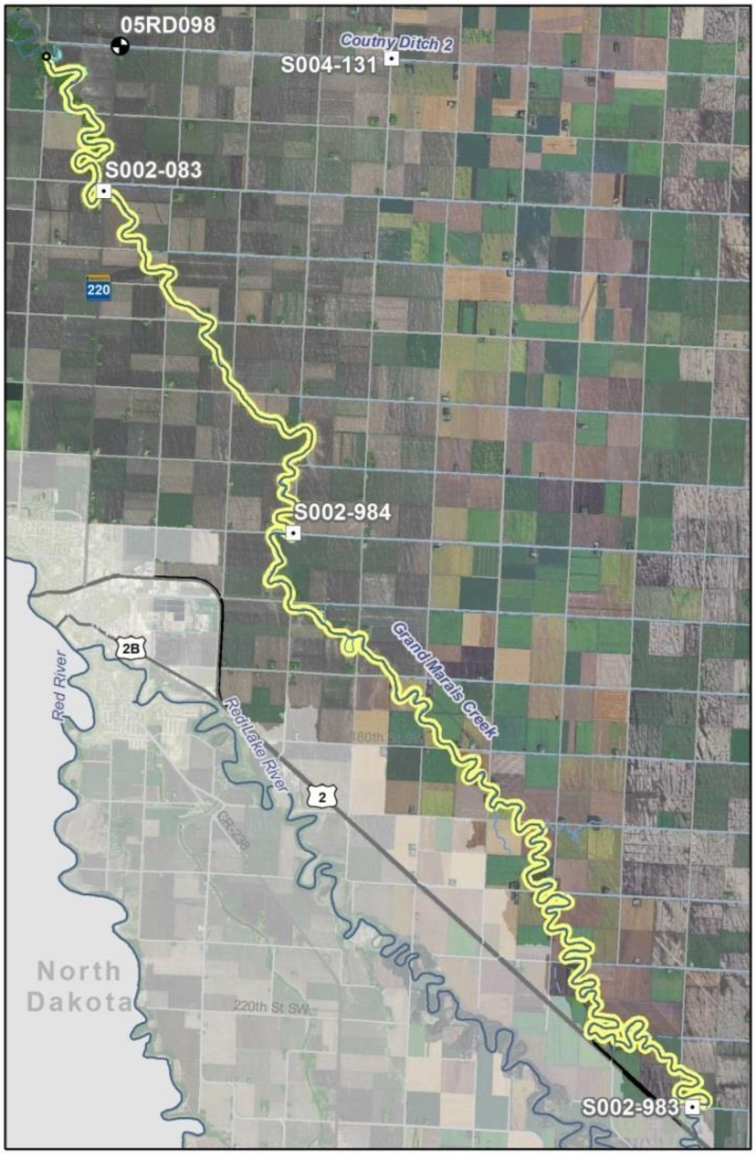

Figure 3-5. DO monitoring stations along Grand Marais Creek

3.4.1.2 RLWD Ditch 15, Headwaters to CD66 (AUID 09030206-509)

Based on May through September monitoring records for the period 2005 through 2014, observed DO conditions meet the criteria for impairment (Section 2.1.2) at two water quality monitoring sites in RLWD 15 collected at any flow condition (Table 3-5). DO data are also summarized for samples not collected during low flow conditions, but the percent of samples below 5 mg/L are similar to samples collected at any flow condition for monitoring station S004-132 and slightly greater at S003-276. No flow data were available at monitoring station S004-133. Note that monitoring station S003-276 is located at the Brandt Impoundment outlet.

The number of samples with DO concentrations less than 5 mg/L is plotted by month and station in Figure 3-7. DO levels below 5 mg/L are most common in June, July and August. DO values generally decreased following spring, reached annual lows and sometimes dropped below the water quality standard during the summer months, and then increased again into the fall.

Table 3-5. May – September DO (mg/L) RLWD Ditch 15, 2005-2014

Dissolved Oxygen Data Summary for RLWD Ditch 15 (2005-2014)					
Waterbody	Monitoring Station (in order from upstream to downstream)	Total May-Sept Samples	DO < 5 mg/L		Impairment Status
			# Samples	%	
RLWD Ditch 15, headwaters to CD66 (AUID 09020306-509)	**All Flow Conditions:**				
	S004-133 (at CSAH 21)	23	6	26%	Impaired
	S003-276 (at 260th Ave NW)	22	2	9%	Not impaired
	S004-132 (at Hwy 75)	52	15	29%	Impaired
	Excluding Low Flow Conditions:				
	S004-133 (at CSAH 21)	n/a (no flow data available for this station)			
	S003-276 (at 260th Ave NW)	13	2	15%	Insufficient data
	S004-132 (at Hwy 75)	43	13	30%	Impaired

Impaired = Exceeds the threshold (10%) for DO impairment based on all samples taken from May through September (see Section 2.1.2). **Insufficient data** = Insufficient number of observations at this location to determine impairment status (≥ 20 independent observations needed).

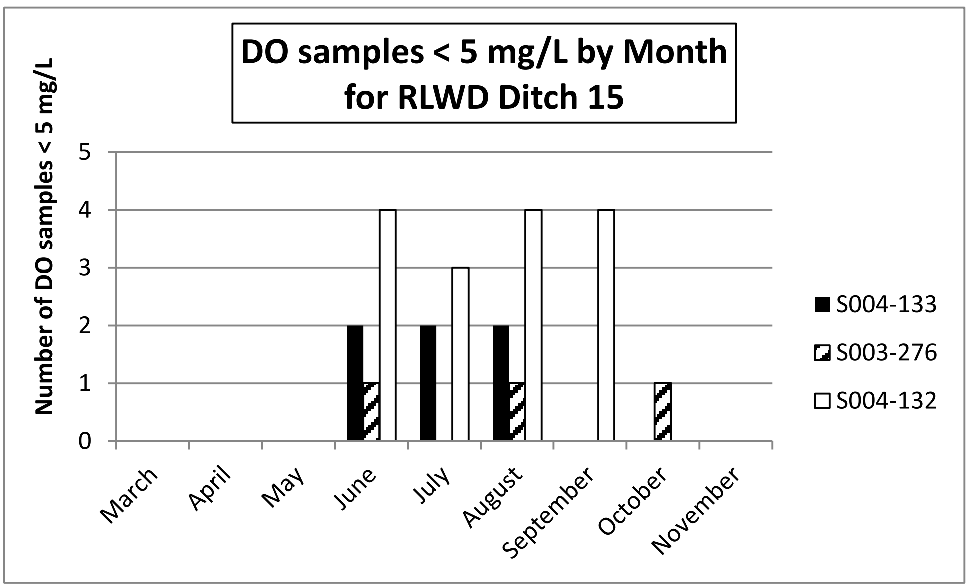

Figure 3-6. Number of samples with DO < 5 mg/L by month and station for RLWD Ditch 15, 2005-2014

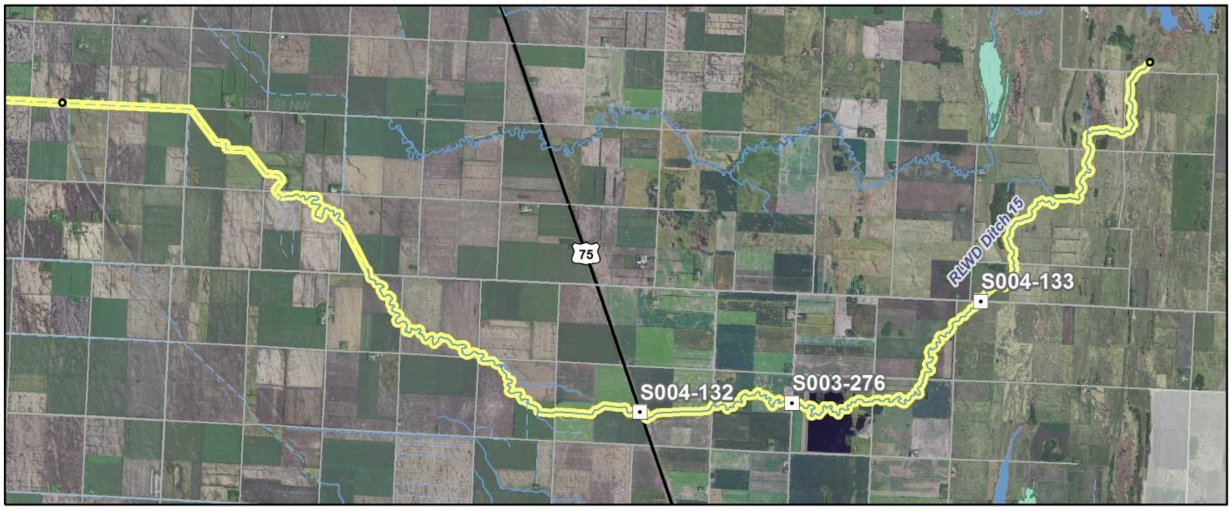

Figure 3-7. DO monitoring stations along RLWD Ditch 15

3.4.2 *Escherichia coli*

Three streams in the Grand Marais Creek Watershed are impaired for aquatic recreation due to high *E. coli* concentrations. Using data from the most recent 10-year period (2005 through 2014), geometric mean *E. coli* concentrations were calculated by month for each impaired stream (Table 3-6). Few *E. coli* monitoring data were available for the assessment, therefore additional monitoring is recommended to verify the impairments.

3.4.2.1 County Ditch 2, CD66 to Grand Marais Creek

Geometric mean *E. coli* concentrations exceeded the chronic water quality standard (126 org/100 mL monthly geometric mean or 1,260 org/100ml in individual samples) during the months of July and August. There was only one sample collected during the month of September (the ditch often stops flowing by that time of the year), but the concentration of that one sample was much higher than the 126 org/100ml standard. Two samples exceeded the individual sample standard (1,260 org/100 mL) at monitoring station S004-131 (5.9% of samples were >1,260 org/100ml).

3.4.2.2 Judicial Ditch 1, CD7 to Red River

E. coli concentrations exceeding the water quality standard (126 org/100 mL geometric mean or 1,260 org/100 mL individual sample) were observed during July and August. Geometric mean *E. coli* concentrations exceeded the water quality standard during the month of July (triggering the impairment), and two samples exceeded the individual sample standard (1,260 org/100 mL) at monitoring station S005-571.

3.4.2.3 Judicial Ditch 75, CD7 to Red River

E. coli concentrations exceeding the water quality standard (126 org/100 mL geometric mean or 1260 org/mL individual sample) were observed during June and July. Geometric mean *E. coli* concentrations exceeded the water quality standard during the months of June and July; one sample exceeded the individual sample standard (1,260 org/100 mL) at monitoring station S005-570.

Table 3-6. 10-year geometric mean *E. coli* (org/100mL) concentrations by month, 2005-2014
Bold font indicates an exceedance of an *E. coli* water quality standard (geometric or individual).

E.coli Data Summary (2005-2014)					
Waterbody	Monitoring Station	Month	Number of Samples	Geometric Mean (org/100mL)	Min – Max (org/100mL)
County Ditch 2, CD66 to Grand Marais Creek (AUID 09020306-515)	S004-131 (CR-62)	May	1	96.0	96.0
		June	13	61.9	10.0 – 410.6
		July	11	**184.2**	**55.1 – 1732.9**
		August	8	**273.7**	**45.0 – 2419.6**
		September	1	721.5	721.5
		October	1	60.2	60.2
		Total	34		
		Total Samples > 1,260 org/100 mL			**2**
Judicial Ditch 1, CD7 to Red River (AUID 09020306-519)	S005-571 (JD1@ CSAH-22)	June	11	78.8	29.8 – 410.0
		July	11	**161.5**	**9.7 – 1553.1**
		August	10	108.5	**5.2 – 2419.6**
		Total	32		
		Total Samples > 1,260 org/100 mL			**3**
Judicial Ditch 75, CD7 to Red River (AUID 09020306-520)	S005-570 (JD 75@ CSAH-22)	**June**	11	**132.2**	**11.0 – 730.0**
		July	12	**167.1**	**29.2 – 1732.9**
		August	10	92.9	29.5 – 365.4
		Total	33		
		Total Samples > 1,260 org/100 mL			**1**

3.4.3 Fish and Macroinvertebrate Index of Biotic Integrity

The presence of a healthy, diverse, and reproducing aquatic community is a good indication that the aquatic life beneficial use is being supported by a lake, stream, or wetland. Characterization of an aquatic community is accomplished using IBI, which incorporates multiple attributes of the aquatic community, called "metrics", to evaluate complex biological systems. The aquatic community integrates the cumulative impacts of pollutants, habitat alteration, and hydrologic modification on a waterbody over time. For further information regarding the development of stream IBIs, refer to the MPCA *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment: 305(b) Report and 303(d) List*.

In 2012, the MPCA conducted biological monitoring at several stations throughout the Grand Marais Creek Watershed. These data were combined with biological monitoring conducted in 2005 and 2007. Table 3-7 provides the F-IBI and M-IBI scores for each of the six biological monitoring stations that were sampled for fish and/or macroinvertebrates along three separate reaches in the watershed. All of the stations scored below their respective F-IBI impairment threshold, while five of the stations scored below their respective M-IBI impairment threshold; these scores are highlighted in bold. Overall, the fish and/or macroinvertebrate bioassessment impairments in the watershed were characterized by low IBI scores for fish and/or macroinvertebrates. However, 2012 was a very dry year, which typically have lower IBI scores compared to average water years.

Table 3-7. Summary of F-IBI and M-IBI scores for biological monitoring stations in the GMCW

F-IBI and M-IBI Score Summary for the Grand Marais Creek Watershed								
AUID Suffix	Reach Name	Station (upstream to downstream)	Fish-IBI			Macroinvertebrate-IBI		
			Class[1] (Use[3])	Impairment Threshold	Score (Mean)	Class[2] (Use[3])	Impairment Threshold	Score (Mean)
-515	County Ditch 2	12RD100	SS (MU)	35	**19**	PS (MU)	22	**11**
		05RD098	SS (MU)	35	**29**	PS (MU)	22	**15**
-517	County Ditch 43	07RD023	NH (MU)	23	**0**	PS (MU)	22	**14**
		12RD089	SS (MU)	35	**13**	PS (MU)	22	**13**
		12RD087	SS (MU)	35	**13**	PS (MU)	22	**5**
-520	JD 75	12RD098	SS (MU)	35	**0**	PS (MU)	22	32

[1] F-IBI Classes: Northern Headwaters (NH) and Southern Streams (SS)
[2] M-IBI Class: Prairie Streams-Glide/Pool Habitats (PS)
[3] Tiered Aquatic Life Use (TALU) Framework Designation: Modified Use (MU)

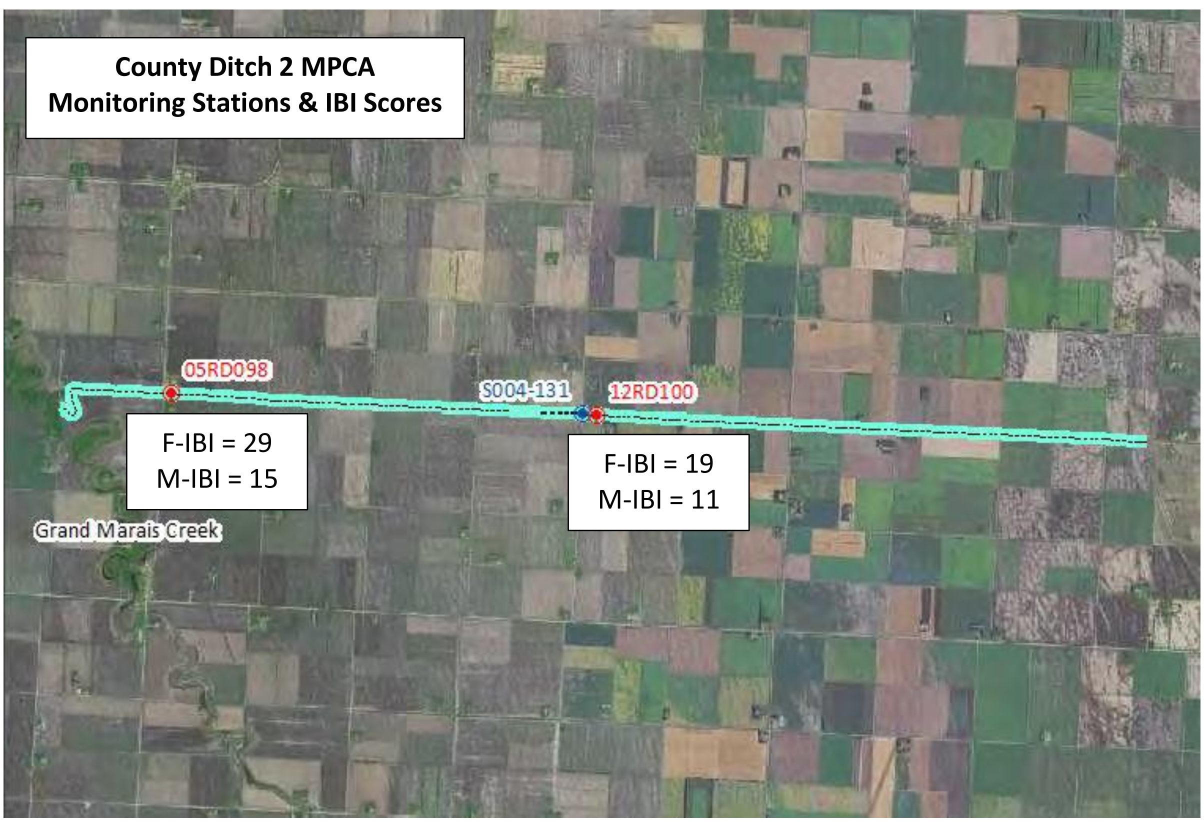

Figure 3-8. Map of AUID 515 and associated biological monitoring stations and water quality monitoring site (2010 National Agriculture Imagery Program (NAIP) aerial image)

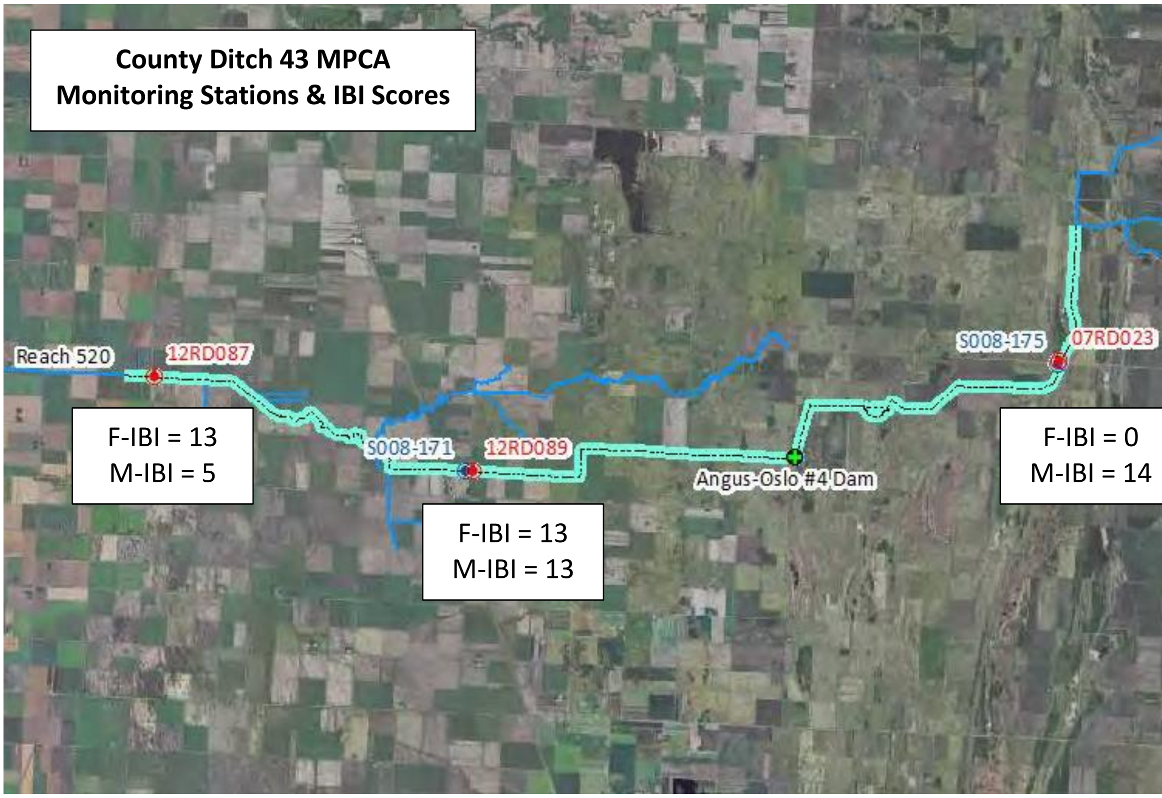

Figure 3-9. Map of AUID 517 and associated biological monitoring stations and water quality monitoring sites (2010 NAIP aerial image)

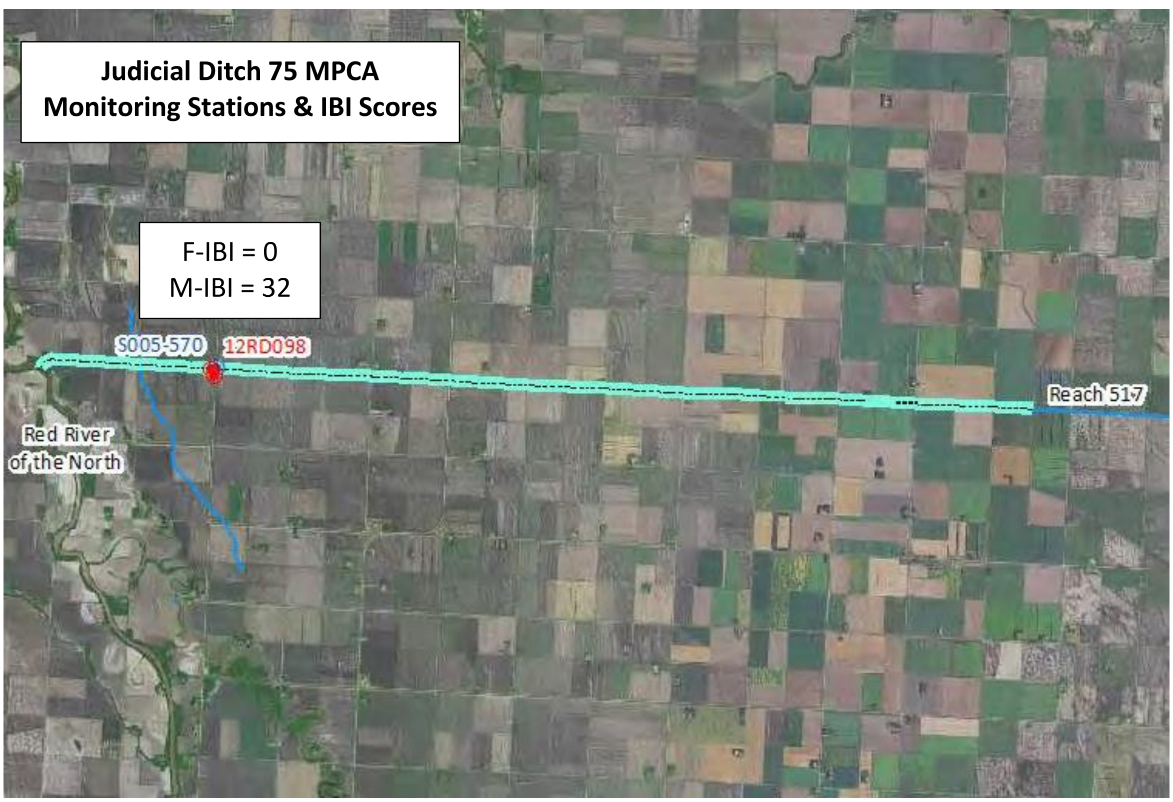

Figure 3-10. Map of AUID 520 and associated biological monitoring station and water quality monitoring site (2010 NAIP aerial image)

3.5 Pollutant Sources and Stressors Summary

3.5.1 Stream *E. coli*

Humans, pets, livestock, and wildlife all contribute bacteria to the environment. These bacteria, after appearing in animal waste, are dispersed throughout the environment by an array of natural and human-made mechanisms. Bacteria fate and transport is affected by disposal and treatment mechanisms, methods of manure reuse, permeability of land surfaces, and natural decay and die-off due to environmental factors such as ultraviolet (UV) exposure and detention time in the landscape. The following discussion highlights sources of bacteria in the environment and mechanisms that drive the delivery of bacteria to surface waters.

3.5.1.1 Permitted

There are no permitted (e.g., concentrated animal feeding operation (CAFOs), wastewater treatment plant (WWTPs), and MS4s) sources of bacteria in the Grand Marais Creek Watershed.

3.5.1.2 Non-permitted

Individual Sewage Treatment Systems

"Failing" subsurface sewage treatment systems (SSTS) are specifically defined as systems that are failing to protect groundwater from contamination. Failing SSTS were not considered a source of fecal pollution to surface water. However, systems that discharge partially treated sewage to the ground surface, road ditches, tile lines, and directly into streams, rivers and lakes are considered an imminent threat to public health and safety (ITPHS). ITPHS systems also include illicit discharges from unsewered communities (sometimes called "straight-pipes"). Straight pipes are illegal and pose an imminent threat to public health as they convey raw sewage from homes and businesses directly to surface water. Community straight pipes are more likely to be found in small rural communities.

ITPHS data are derived from surveys of County staff and County level SSTS status inventories. The MPCA's 2012 SSTS Annual Report provides the percentage of systems in unsewered communities that are ITPHS for each county in Minnesota (Table 3-8). The number of ITPHS within each impaired reach subwatershed was estimated based on the county ITPHS percentages and the county population estimates from 2011 U.S. Census data (Table 3-9). Most of the population within the impaired stream drainage areas resides within Polk County, which has no known ITPHS, and therefore ITPHS systems are not expected to be a significant source of *E. coli* within the drainage areas of the impaired streams.

However, one of the closest sites at which microbial DNA samples were collected by RLWD was S002-132 on the Black River in the Red Lake River Watershed. The only positive test result on that reach was for Human Bacteroidetes. Additional microbial DNA sampling should be conducted along the impaired reaches in this watershed to confirm the presence of human sources of bacteria.

Table 3-8. Estimate of % Imminent Threat to Public Health & Safety Systems (ITPHSS) as reported by each county

County Imminent Threat to Public Health & Safety Systems (ITPHSS) Estimates:	
County	ITPHSS (as % of all septics)
Pennington	2%
Polk	0%

Table 3-9. Estimated ITPHSS within each impaired stream drainage area

Estimated ITPHSS within each impaired stream drainage area:			
Impaired Reach (09020306-XXX)	2011 US Census Counts		Estimated number of ITPHSS
	Population	Households	
-515	300	137	0
-519	139	63	0
-520	244	114	0 or 1

Livestock

Livestock have the potential to contribute bacteria to surface water through grazing activities or if their manure is not properly managed or stored. Solid manure is typically surface spread on cropland. Liquid livestock manure is typically collected and applied to nearby fields through injection, which significantly reduces the transport of bacteria contained in manure to surface waters. The population estimates provided in this study are meant to identify areas where livestock are located. These areas should be monitored closely by each County to ensure proper management and storage of manure. The number of feedlot animals registered with the MPCA located in the Grand Marais Creek Watershed was confirmed by each county in the spring of 2015 (Table 3-10).

Table 3-10. MPCA registered feedlot animals by impaired stream subwatershed

MPCA registered feedlot animals by impaired stream subwatershed:							
Stream Reach	Feedlot Name	MPCA ID	CAFO?	Active?	Animal Units	Animal Type	Location in Drainage Area
-515	Weiland Hay Feedlot	119-103533	No	Yes	175	Cattle	Headwaters
-519	Mathsen Dairy	119-103526	No	No	131.5	Dairy	Near S005-571
-520	Dale R. Olson Farm	113-63637	No	Yes	24	Cattle	Headwaters
-520	Raymond S. Olson Farm	113-64175	No	Yes	40.8	Cattle	Headwaters

Beaver

Beaver activities in streams can act as sources of fecal contamination. Beaver dams have been observed at least once at monitoring station S005-570 (JD 75, -520) and on numerous occasions at monitoring stations S004-131, S004-132, & S004-133 (CD 2, -515) during recent years of monitoring (2010 through 2015, EQuIS database) (Table 3-11). The locations of recently observed beaver dams/beaver activity by the MPCA staff in the Grand Marais Creek Watershed are shown in Figure 3-11.

Table 3-11. Monitoring stations with observed beaver activity by impaired stream subwatershed

Observed Beaver Activity by Impaired Stream Subwatershed:	
Stream Reach	Beavers Observed at Monitoring Station:
-515	S004-131, S004-132, & S004-133
-519	None
-520	S005-570

Birds

The presence of large numbers of birds on or near surface waters can act as sources of fecal contamination. In two neighboring watersheds, water samples were tested for gene biomarkers for fecal coliform bacteria. Birds were found to be a major contributor to fecal pollution in the Thief River (Thief River Watershed) and a potential contributor to fecal pollution the Kripple Creek (Red Lake River Watershed). Although similar testing has not been completed for water samples collected in the Grand Marais Creek Watershed, the presence of birds in the water or under bridges has been noted, including in field monitoring notes on numerous occasions at monitoring stations located within the impaired stream reaches (S005-570, S005-571, and S004-131) during a recent year of monitoring (EQuIS database, 2010 through 2014). Direct inputs from nesting and migratory birds likely contribute to fecal pollution in the impaired streams.

Table 3-12. Monitoring stations with observed presence of birds by impaired stream subwatershed

Observed Presence of Birds by Impaired Stream Subwatershed:	
Stream Reach	Birds Observed at Monitoring Station:
-515	S004-131
-519	S005-571
-520	S005-570

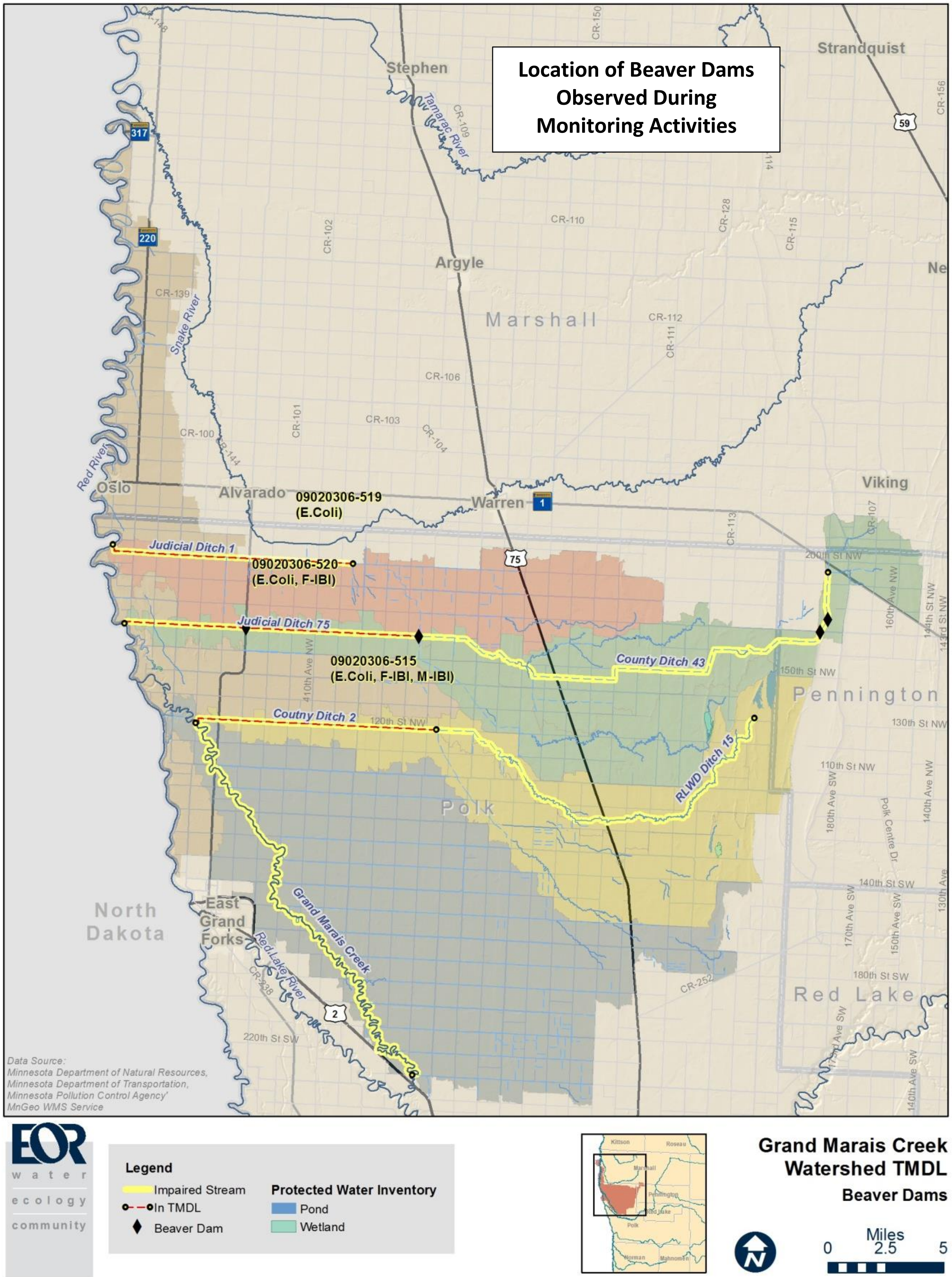

Figure 3-11. Location of beaver dams observed during monitoring activities within the Grand Marais Creek Watershed, 2014-2015

3.5.1.3 Relationships with Flow

E. coli concentrations and stream flow were compared in all three impaired stream reaches to determine whether *E. coli* sources were driven by watershed runoff sources during rain events (high flows) or near stream sources that contribute during all flow conditions, including baseflow (low flow) conditions. High *E. coli* levels under low flow conditions could also be regrowth of naturalized *E. coli* strains in the stream bottom sediment. High flow, watershed runoff sources include livestock that do not have direct access to the stream. Low flow, near stream sources include nesting birds, livestock grazing in the stream, straight pipe septic systems, and naturalized *E. coli* strains.

In CD2, high *E. coli* concentrations occurred over a wide-range of flow conditions, suggesting a mix of watershed and near stream bacteria sources (Figure 3-12). In JD1, all but one *E. coli* sample > 126 org/100 mL occurred at no flow, suggesting predominantly near stream bacteria sources (Figure 3-13). In JD75, all but three *E. coli* samples > 126 org/ 100mL occurred at no flow, also suggesting predominantly near stream bacteria sources (Figure 3-14).

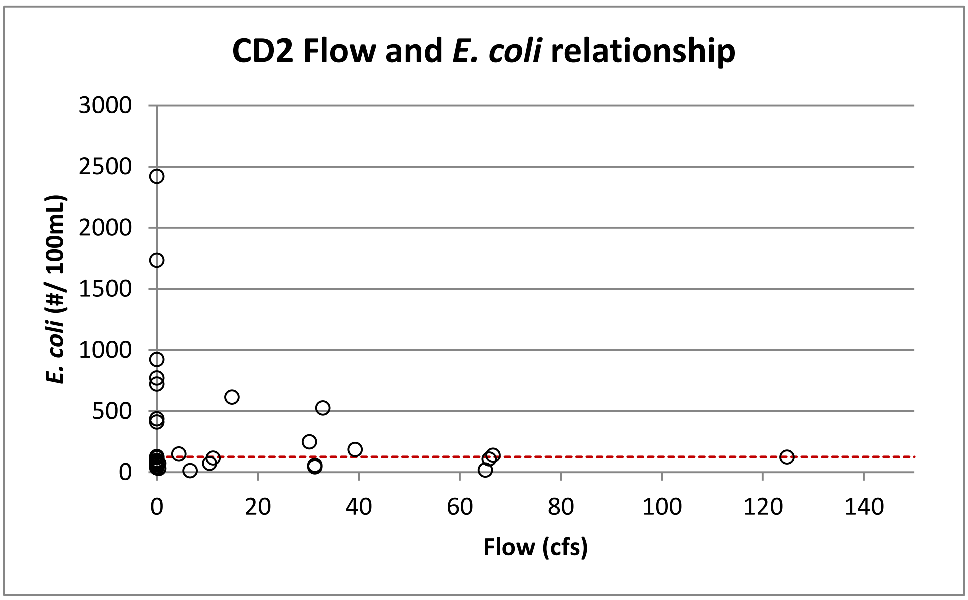

Figure 3-12. Flow and *E. coli* relationships in CD2

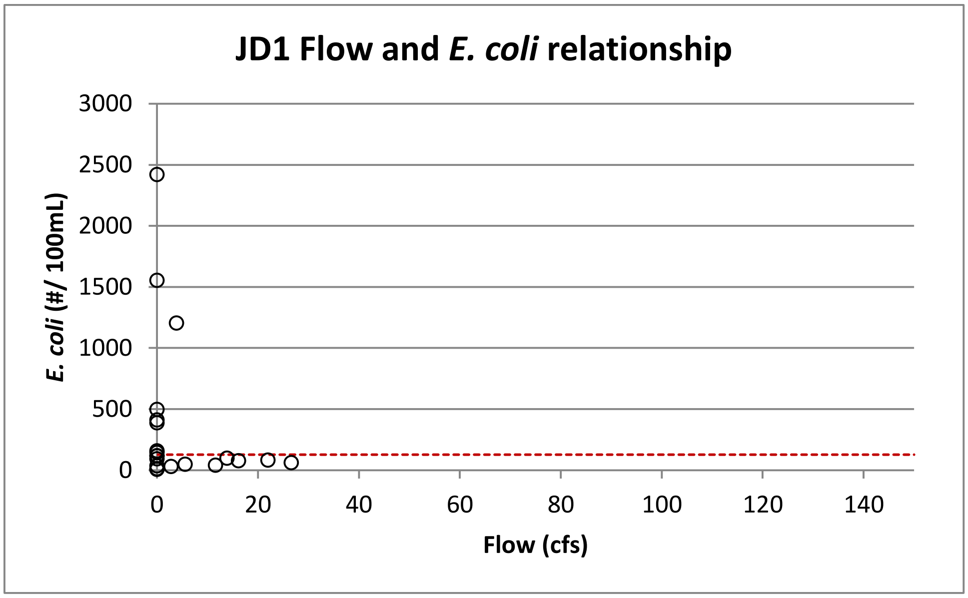

Figure 3-13. Flow and *E. coli* relationships in JD1

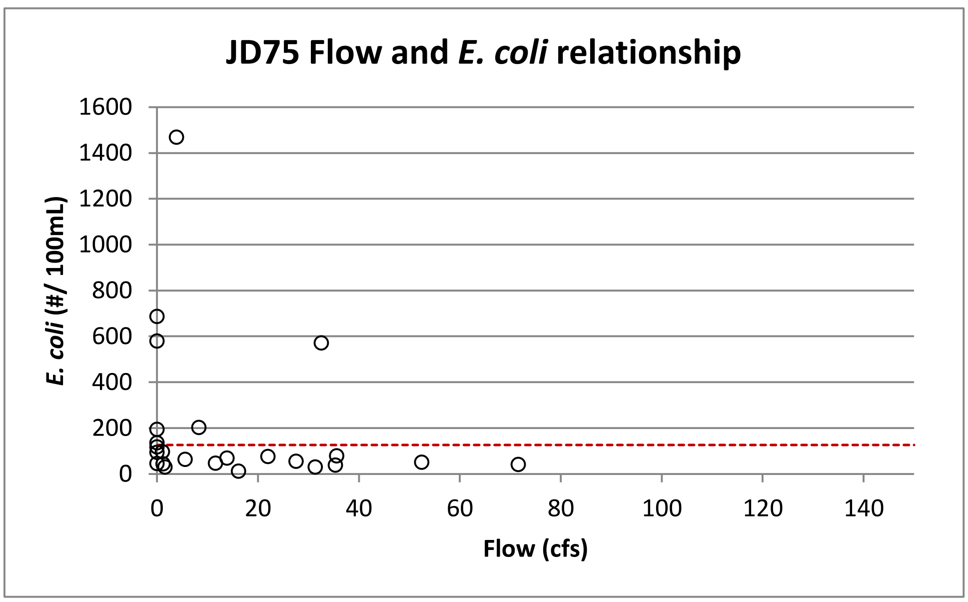

Figure 3-14. Flow and *E. coli* relationships in JD75

3.5.1.4 Summary

There is a notable lack of point sources, ITPHS septic systems, and active feedlots in the impaired stream subwatersheds, despite high observed *E. coli* concentrations in the streams. The most likely cause of bacteria impairments in the Grand Marais Creek Watershed is beaver activity along CD 2 (-515) and JD 75 (-520), and nesting swallows under road bridges near the water quality monitoring stations on CD 2 (-515), JD 1 (-519), and JD 75 (-520). Mathsen Dairy feedlot may have contributed fecal contamination to JD 1 (-519) in the past, but this feedlot is no longer active. Relationships between *E. coli* concentrations and flow in each impaired stream suggest a mix of watershed and near-stream sources of bacteria in CD2, and predominantly near-stream sources of bacteria in JD1 and JD75. Human and bird microbial

DNA has been found in impaired streams in the neighboring watershed, and therefore may also be a source in the Grand Marais Creek Watershed.

There is evidence to support multiple potential sources of bacteria in each impaired stream (Table 3-13). Additional bacteria and microbial DNA sampling is recommended to identify the specific source of bacteria in each impaired stream. These samples could be collected at multiple sites along each reach to spatially target these sources of bacteria.

Table 3-13. Bacteria source summary by impaired stream subwatershed

Bacteria Source Summary by Impaired Stream Subwatershed					
	Humans	Livestock	Wildlife	Wildlife	Watershed v. near-stream source
Impaired Stream Reach	Estimated Number of ITPHSS	Active Feedlot Animals	Observed Beaver Activity	Observed Presence of Birds	Based on *E. coli and* flow relationship
CD2 (-515)	0	175 cattle located in the headwater drainage area	Yes	Yes	Watershed & near-stream
JD1 (-519)	0	Inactive dairy farm (131.5 animals)	No	Yes	Near-stream
JD75 (-520)	0 or 1	65 cattle located in the headwater drainage area	Yes	Yes	Near-stream

3.5.2 Dissolved Oxygen

Aquatic life impairments in Grand Marais Creek, AUID 09020306-507, and RLWD Ditch 15, AUID 09020305-509 were triggered by low DO levels. A SID study was conducted as part of this TMDL study to determine the cause of low DO levels in each impaired reach.

3.5.2.1 Grand Marais Creek (AUID 09020306-507)

Current Conditions

Water quality was monitored at three stations (S002-083, S002-983, and S002-984) on Grand Marais Creek (AUID 09020306-508). Data available from the most recent 10 years (2005 through 2014) for these locations were used to assess DO levels and potential relationships with other stream characteristics, such as nutrients, flow, and water temperature.

Observed DO levels in Grand Marais Creek are summarized by monitoring station in Section 3.4.1. DO levels below the water quality standard (5 mg/L) were observed most frequently in July and August, but were also observed during June, September and October at one or more monitoring stations.

Candidate Causes

Stream Flow

DO levels can be greatly affected by stream flow. Several major factors affecting stream flow were analyzed for Grand Marais Creek: water agitation, flashiness, ponding, and historic alteration of the Grand Marais Creek system.

Decreased stream flow and lack of water agitation, particularly over rock riffles, may result in lower levels of DO due to lower rates of oxygen mixing from the air. There is a distinct lack of rock riffles along the Grand Marais Creek. Observed mean stream flows at the CSAH 65 gauge site on the Grand Marias Creek decreased from June to August (Figure 3-15), as did DO levels at water quality stations upstream and downstream of the gauge (Figure 3-16), indicating that low flow conditions may contribute to poor DO conditions during the summer months.

The Red Lake River used to flow through the Grand Marais Creek to the Red River. However, the Red Lake River path was modified to bypass Grand Marais Creek and flow directly to the Red River west of Fisher, Minnesota. Grand Marais Creek today is essentially a beheaded river that is now too small to fill its channel due to the alteration of the path of the Red Lake River. The headwaters of the Grand Marais Creek is now a series of oxbow wetlands (Figure 3-18 and Figure 3-19), with flows insufficient to move sediment like a typical river system until further downstream where a narrower, more discernible channel has formed. These low flows and standing water in the oxbow wetlands results in naturally low levels of oxygen. This ponding of water in the headwater oxbows is further exacerbated by several road crossings (Figure 3-18) and agricultural impoundments, which pre-date the watershed district (personal communication, RLWD March 3, 2016). These road crossing and impoundments cause the Grand Marais Creek to pool with standing water at dispersed locations along the main channel when water levels recede after runoff events. Without flow from the Red Lake River, modifications to Grand Marais Creek to restore the historic stream channel and increase flow may be problematic and ultimately unsuccessful.

The natural drainage system of Grand Marais Creek has been further altered by the growth of agriculture in the watershed over the last century. Concentrated flow is delivered to the stream at various locations along the reach via ditch systems. Ditched systems are designed to be flashy, which means they carry a lot of water very quickly during rain events, but leave little to no base flow between rain events. Constant baseflow is needed to support fish and macroinvertebrate populations.

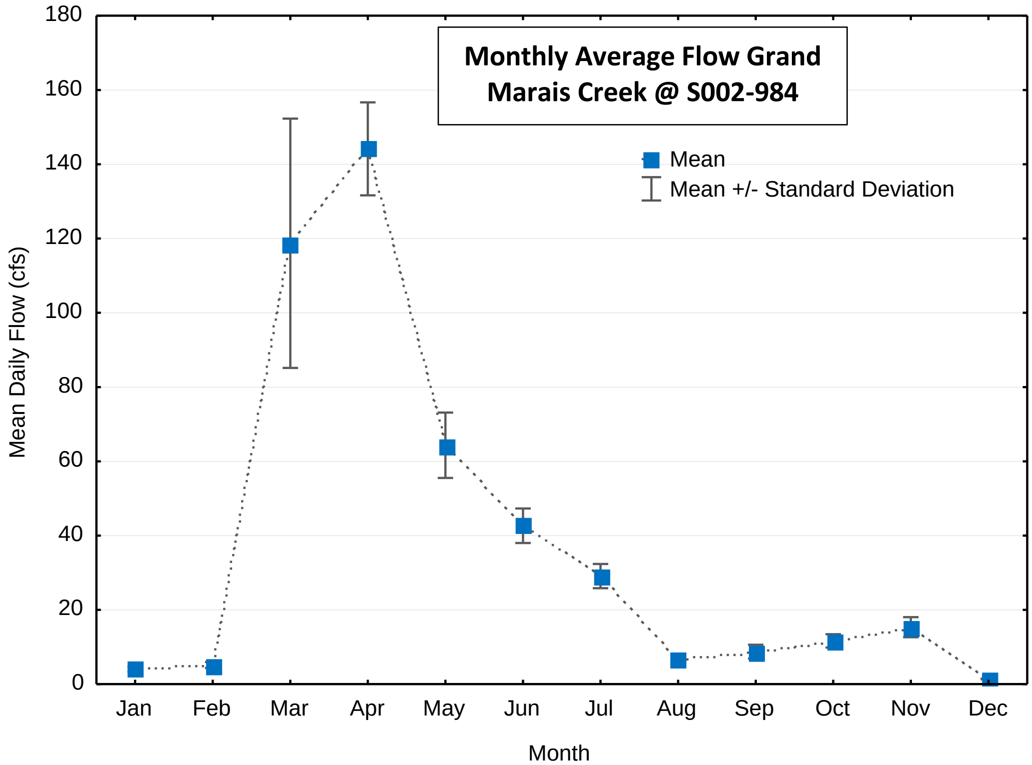

Figure 3-15. Monthly average flow in Grand Marais Creek at WQ station S002-984, 2013-2015

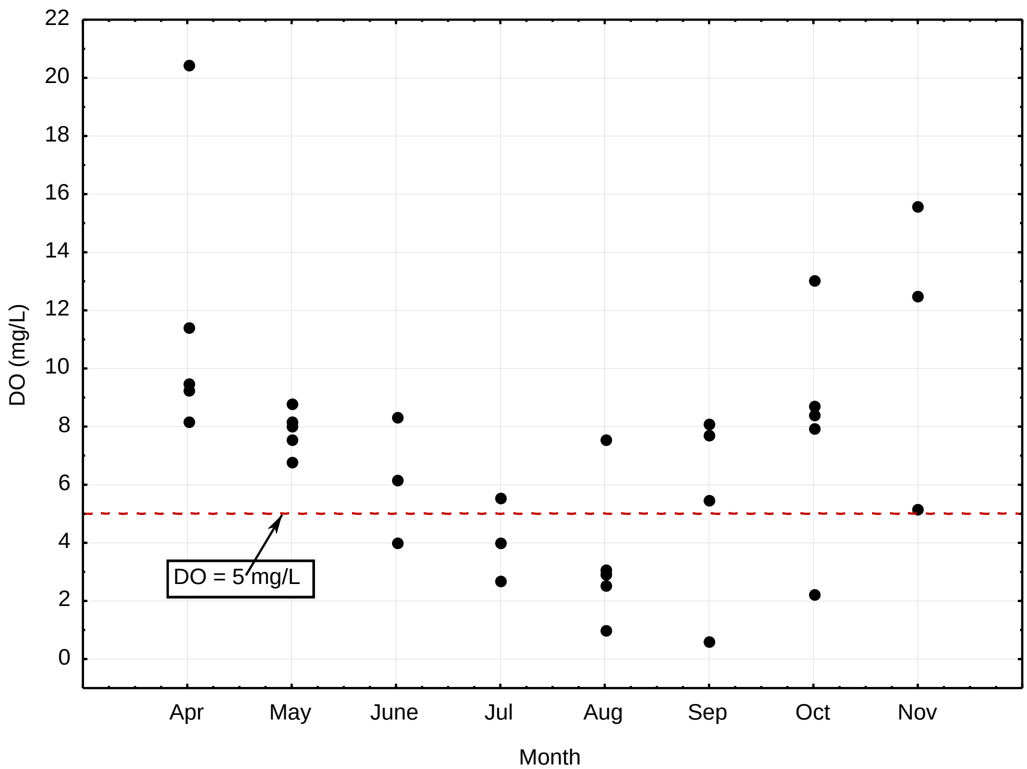

Figure 3-16. Dissolved oxygen vs. month in Grand Marais Creek at WQ station S000-083, 2005-2015

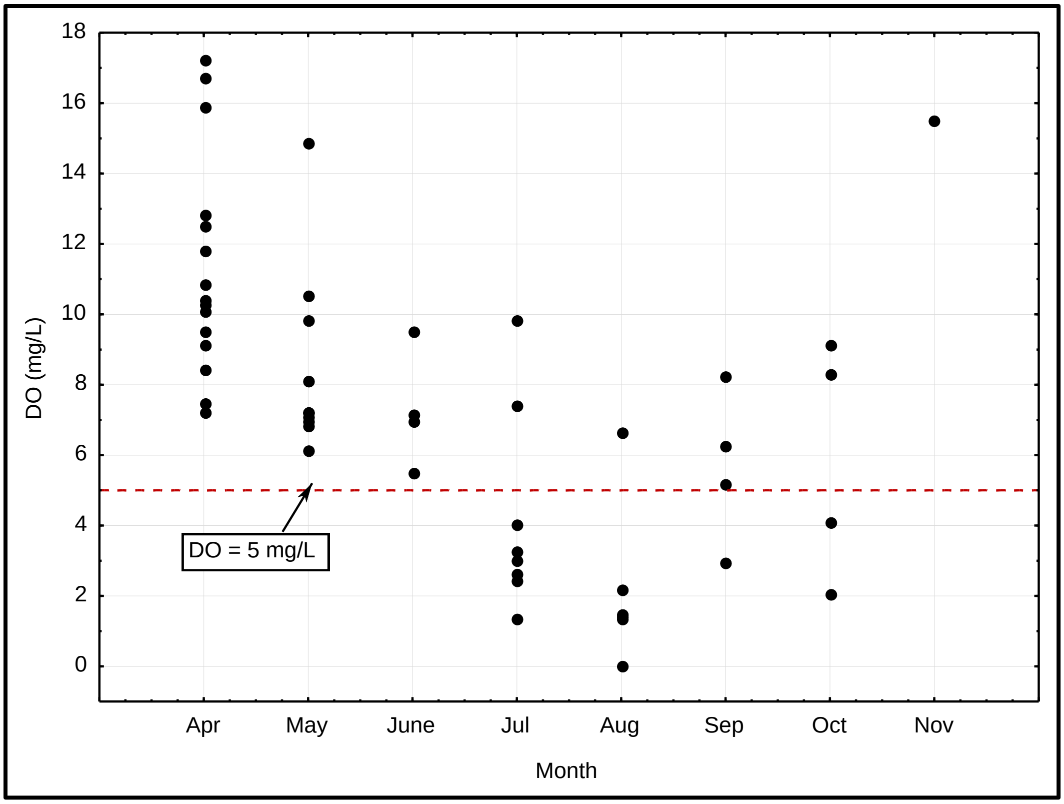

Figure 3-17. Dissolved oxygen vs. month in Grand Marais Creek at WQ station S000-984, 2005-2015

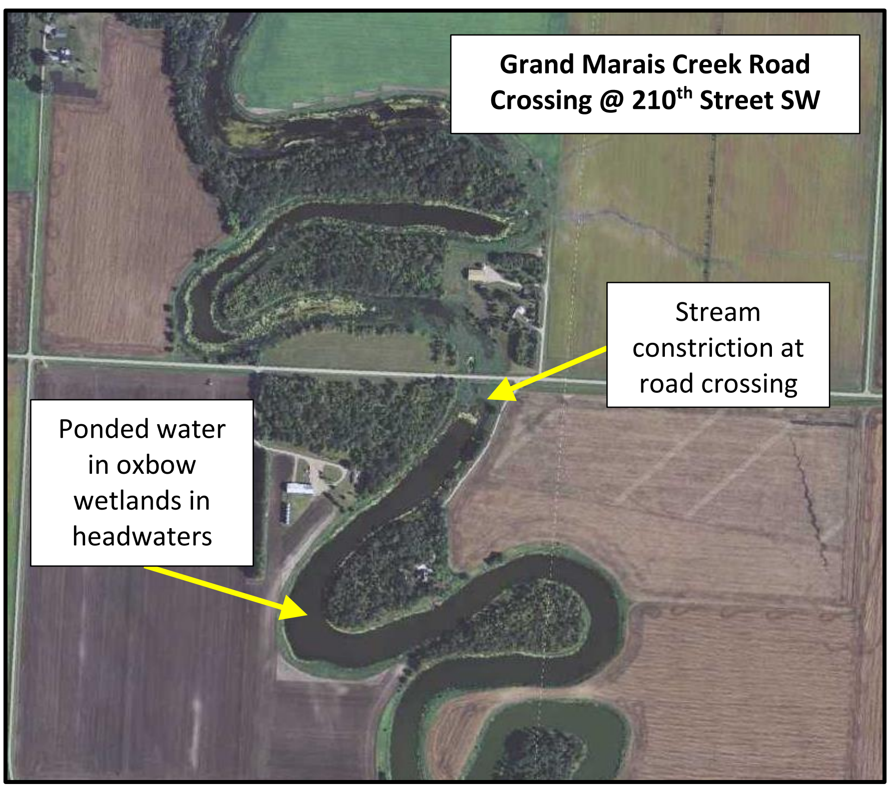

Figure 3-18. Road crossing at 210th Street SW, Grand Marais Creek (AUID 09020306-507)

Figure 3-19. Lentic, marsh-like characteristics of the water within the Grand Marais Creek channel upstream of 210th Street SW (AUID 09020306-507)

Stream Temperature

Warmer waters hold less oxygen than cooler waters. In addition, warmer waters have increased rates of organic matter decomposition, which consumes oxygen. During the summer months, runoff and stream temperatures tend to increase in response to warming air and soil temperatures. Increased stream temperatures are likely a contributing stressor for low DO levels during the summer months. DO concentrations below the standard were observed most frequently in July and August when stream temperatures were warmest (Figure 3-20); however, many of the observed violations cannot be accounted for by variations in stream temperature only (those that lie outside of 99% confidence intervals; Figure 3-21, Figure 3-22). Therefore, other factors likely contribute to low DO in Grand Marais Creek.

Low flow conditions in Grand Marais Creek (Figure 3-15) coincide with warmer air temperatures in July and August. Since low flow conditions can decrease the dissipation of thermal energy in streams, it is likely that warmer air temperatures exacerbate already poor conditions for DO that occur during periods of low/stagnant flow during the late summer.

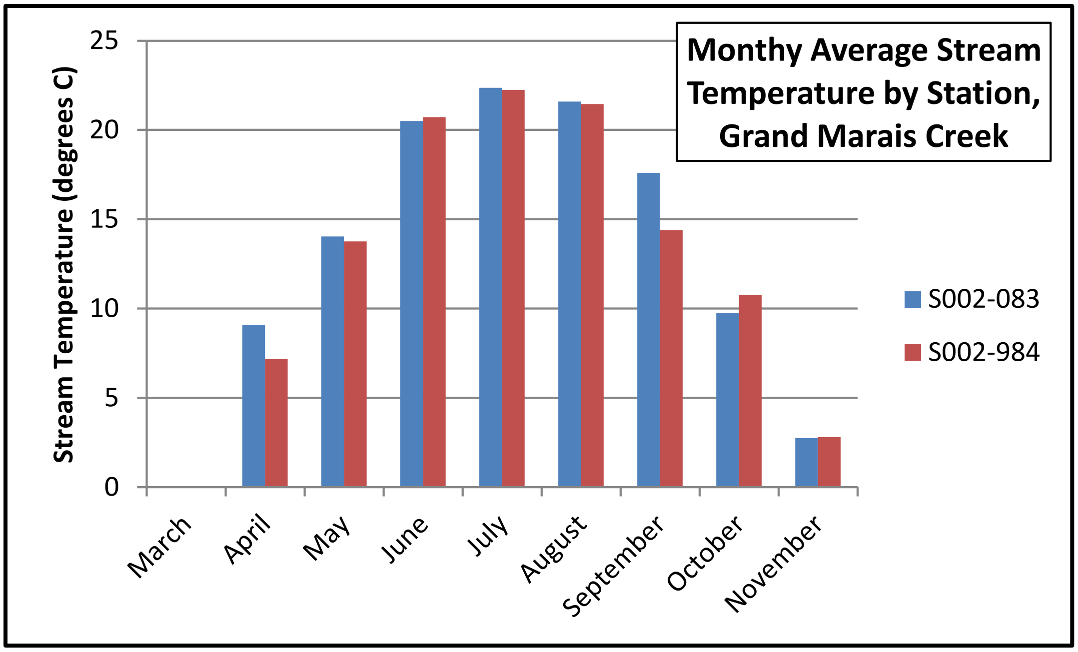

Figure 3-20. Monthly average stream temperature by station in Grand Marais Creek, 2005-2014

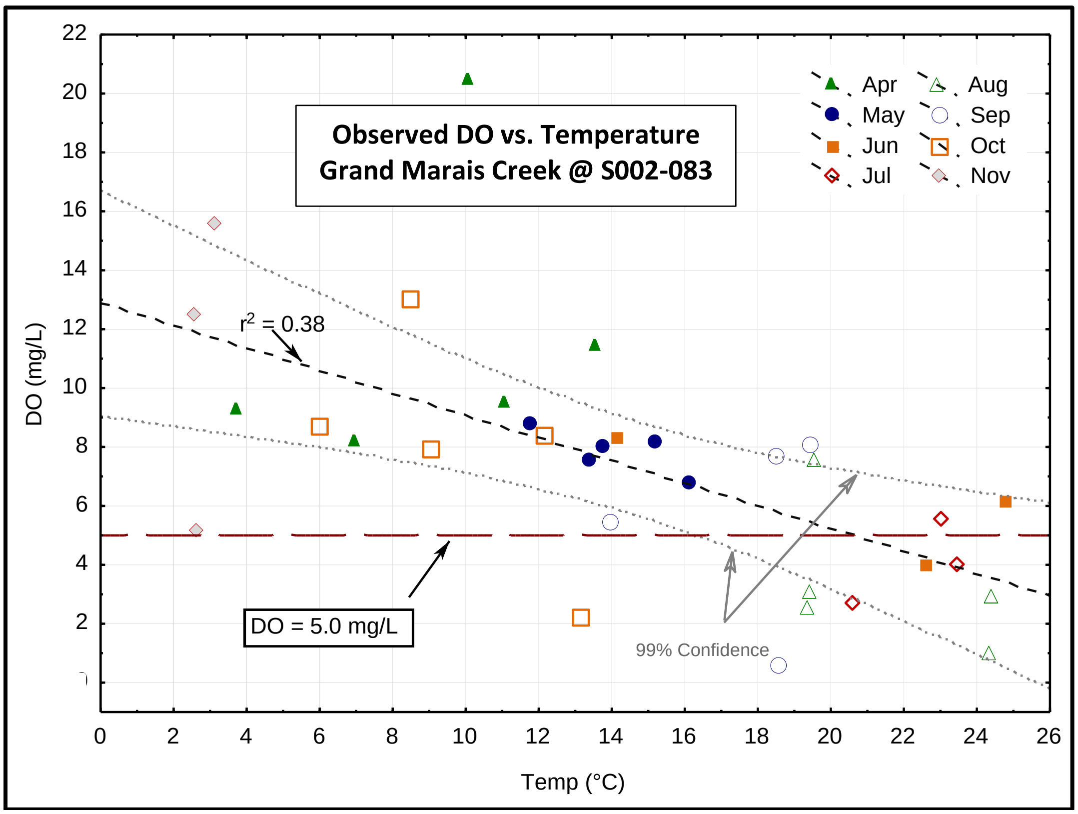

Figure 3-21. Observed DO vs. temperature at monitoring station S002-083 in Grand Marais Creek, 2005-2014

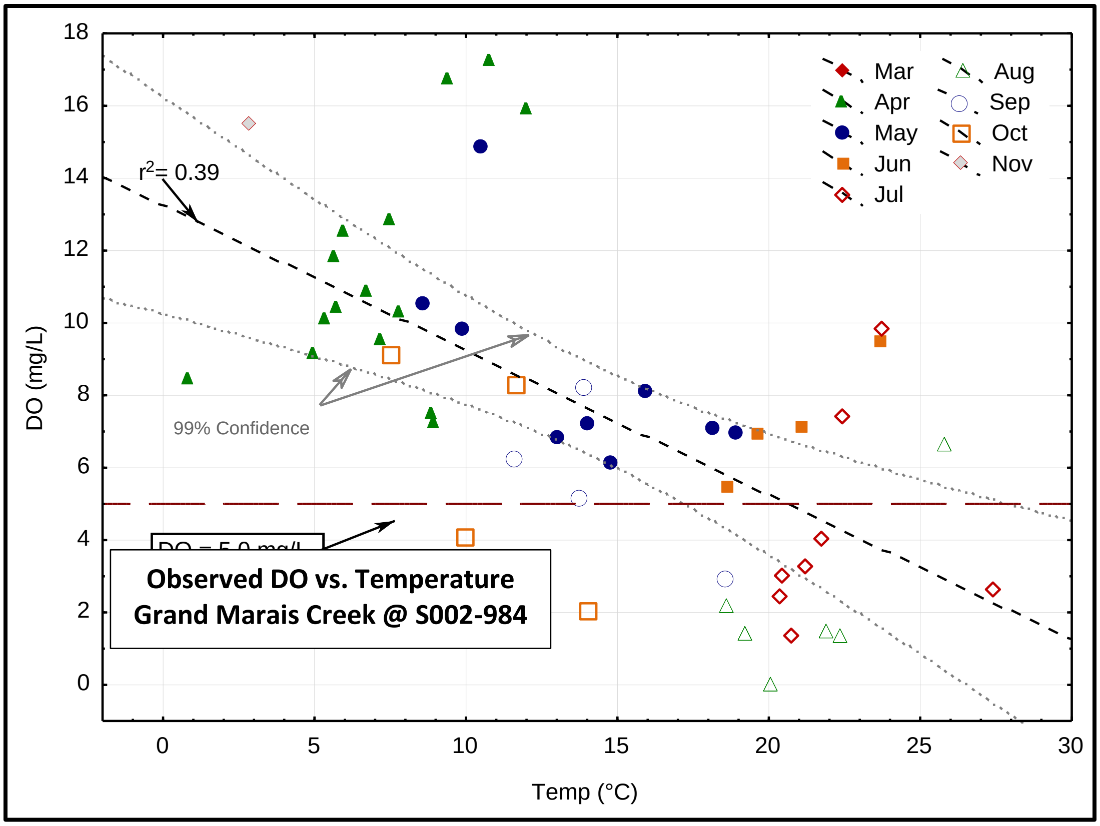

Figure 3-22. Observed DO vs. temperature at monitoring station S002-984 in Grand Marais Creek, 2005-2014

Nutrients (Eutrophication)

Excess phosphorus (P) in streams can increase algae and other plant growth. When algae and plant growth reach very high levels, the decomposition of and respiration from algae and aquatic plants can consume large amounts of DO, resulting in stream DO levels that are too low to support fish.

Mean P concentrations in Grand Marais Creek were highest during the months of July and August (Figure 3-23) when mean DO concentrations were lowest (Figure 3-16, Figure 3-17) and temperatures were highest (Figure 3-21 and Figure 3-22). There are few overlapping DO and total phosphorus (TP) data at monitoring stations along Grand Marais for the period of assessment (2005 through 2014). In general, DO concentrations decreased as P concentrations increased, but analysis does not indicate a strong relationship between these factors (low r^2 values) (Figure 3-24, Figure 3-25). High TP in the late summer is likely a contributing factor, but not the primary cause of low DO. Even if P levels were greatly reduced in the stream, low DO conditions would continue due to stagnant flow conditions.

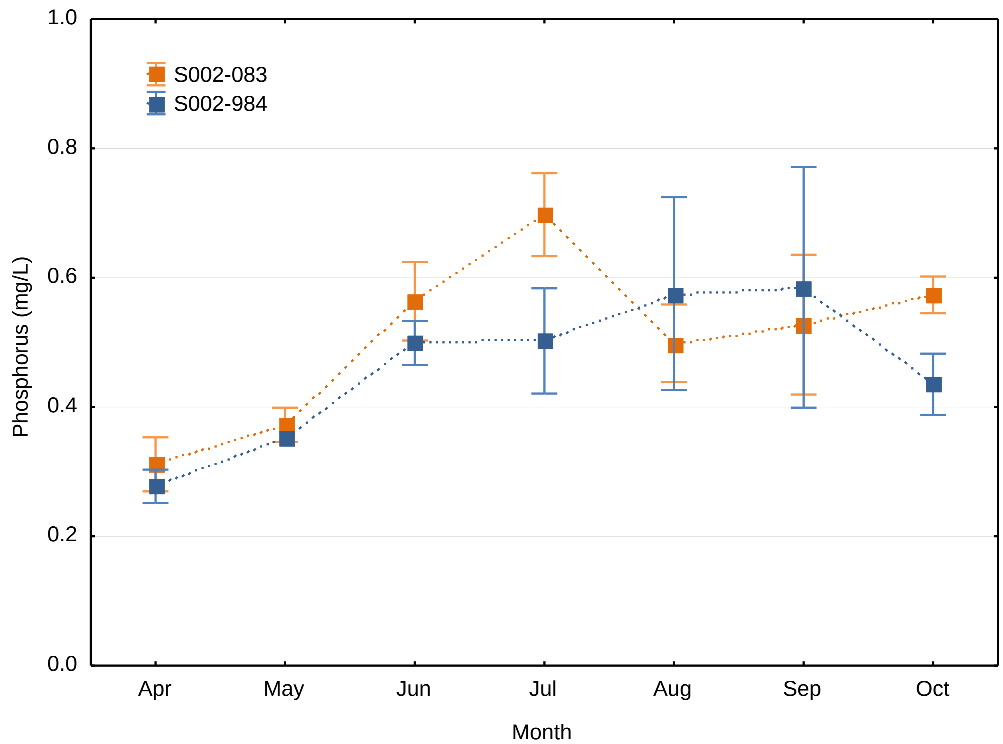

Figure 3-23. Mean ±Standard Deviation TP by Month in Grand Marais Creek (2005-2014)

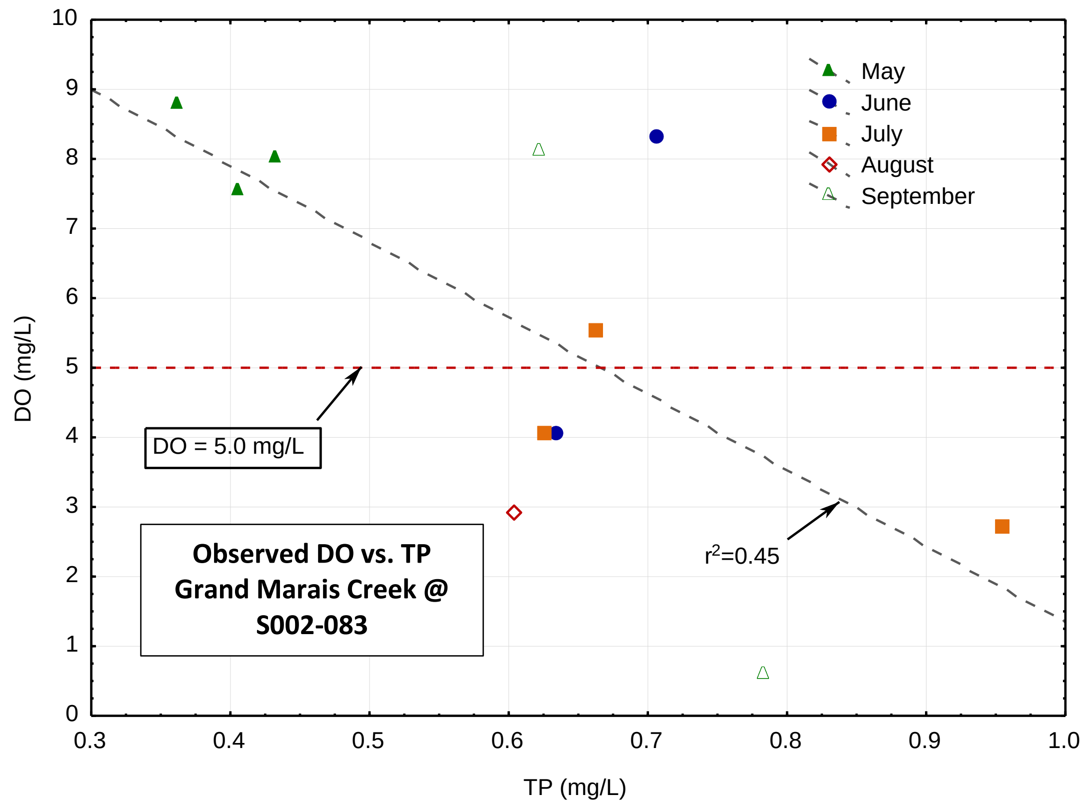

Figure 3-24. Observed DO vs. TP at water quality station S002-083, 2005-2014

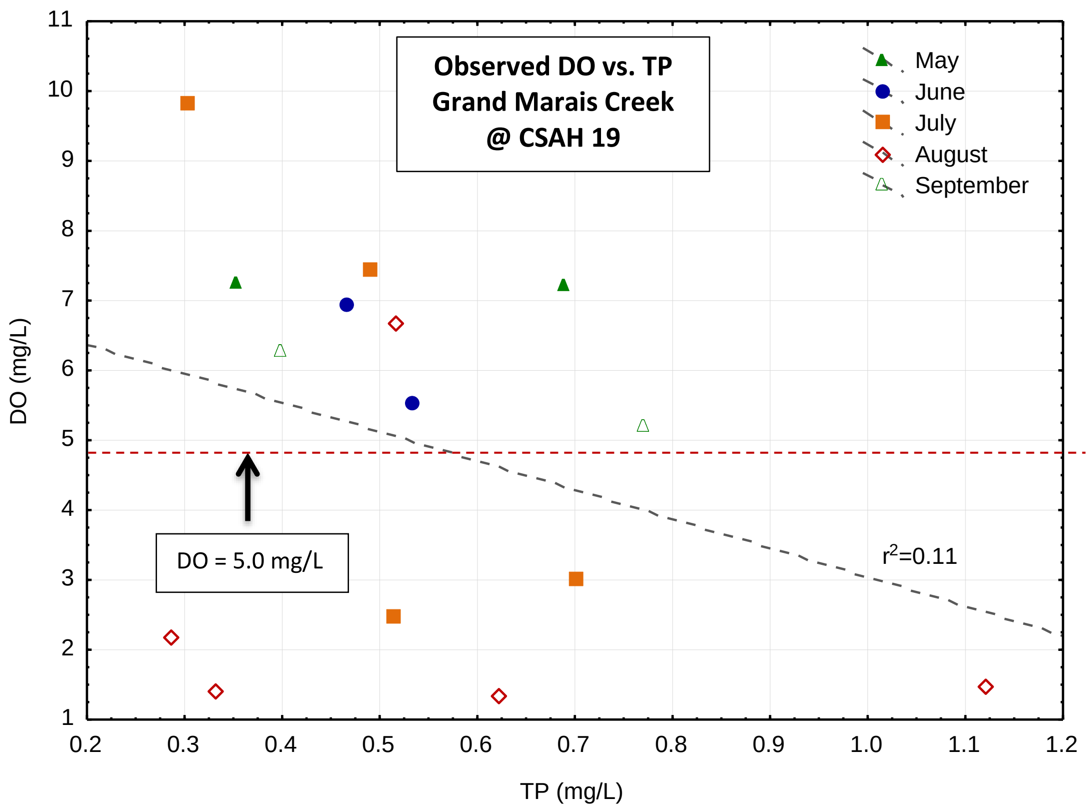

Figure 3-25. Observed DO vs. TP in Grand Marais Creek at CSAH 19, monitoring station S004-984, 2005-2014

<u>**Conclusion/Summary**</u>

The primary stressor to low DO in Grand Marais Creek in this study is altered hydrology, which results in low flow and stagnant conditions in late summer months. Low and stagnant flows are a result of the formation of headwater oxbow wetlands from the historic alteration of flow from Red Lake River away from the Grand Marais Creek channel, in addition to flashy ditch systems in the watershed and ponding upstream of road crossings. The headwaters portion of Grand Marais Creek channel is essentially a chain of wetlands with little contributing flow. Low DO conditions are also likely exacerbated by warm temperatures in the mid to late summer. High TP in the late summer is also likely a minor contributing factor, but even if P levels were greatly reduced in the stream, low DO conditions would continue due to stagnant flow conditions. Therefore, a TP TMDL was not completed to address this impairment.

3.5.2.2 Red Lake Watershed District (RLWD) Ditch 15 (09020306-509)

<u>**Current Conditions**</u>

Water quality was monitored at three stations (S002-376, S004-132, and S004-133) on RLWD Ditch 15 (AUID 09020306-509). Data available from the most recent 10 years (2005 through 2014) for these locations were used to assess DO levels and potential relationships with other stream characteristics, such as nutrients, flow, and water temperature.

Observed DO levels in RLWD Ditch 15 are summarized by monitoring station in Section 3.4.1. DO levels below the water quality standard (5 mg/L) were observed with similar frequency in June, July, August, and September at each monitoring station.

Candidate Causes

Stream Flow

DO levels can be greatly affected by water agitation. Decreased stream flow and water movement may result in lower levels of DO due to lower rates of diffusion from the air. Observed mean stream flows were highest in RLWD Ditch 15 during the month of June, decreased over the summer months, and were lowest in September (Figure 3-26). DO levels in RLWD also decreased from June to August (Figure 3-27 through Figure 3-29), but did increase somewhat as temperatures decreased in September (Figure 3-32).

Flow in RLWD Ditch 15 is controlled at the Brandt Impoundment, a major floodwater impoundment located on RLWD Ditch 15 in Section 7, Belgium Township. The impoundment can retain up to 3,912 acre-feet of floodwater. Impoundment release records for the period 2007 through 2014 were examined to see whether DO levels in RLWD Ditch 15 were influenced by flow augmentation from the impoundment. DO observations at Hwy 75 (S004-132) and 260th Avenue Northwest (S003-276) for which there are corresponding flow estimates at the Brandt impoundment are limited (30 or fewer observations). Among this limited set of observations, DO concentrations below the water quality standard occurred across a range of flows. Although the impoundment may dampen flashiness in the RLWD Ditch 15 system, periods of extended drawdown over the summer may add only minimal flow to the system downstream of the impoundment.

Paired DO and flow data for the stream gauge site (Hwy 75) are limited to several observations during 2006 and 2007 at water quality monitoring station S004-132 (Figure 3-30), which were taken before and during the construction of the Brandt Impoundment. It is unknown how construction conditions might have impacted DO levels in RLWD Ditch 15 during that time.

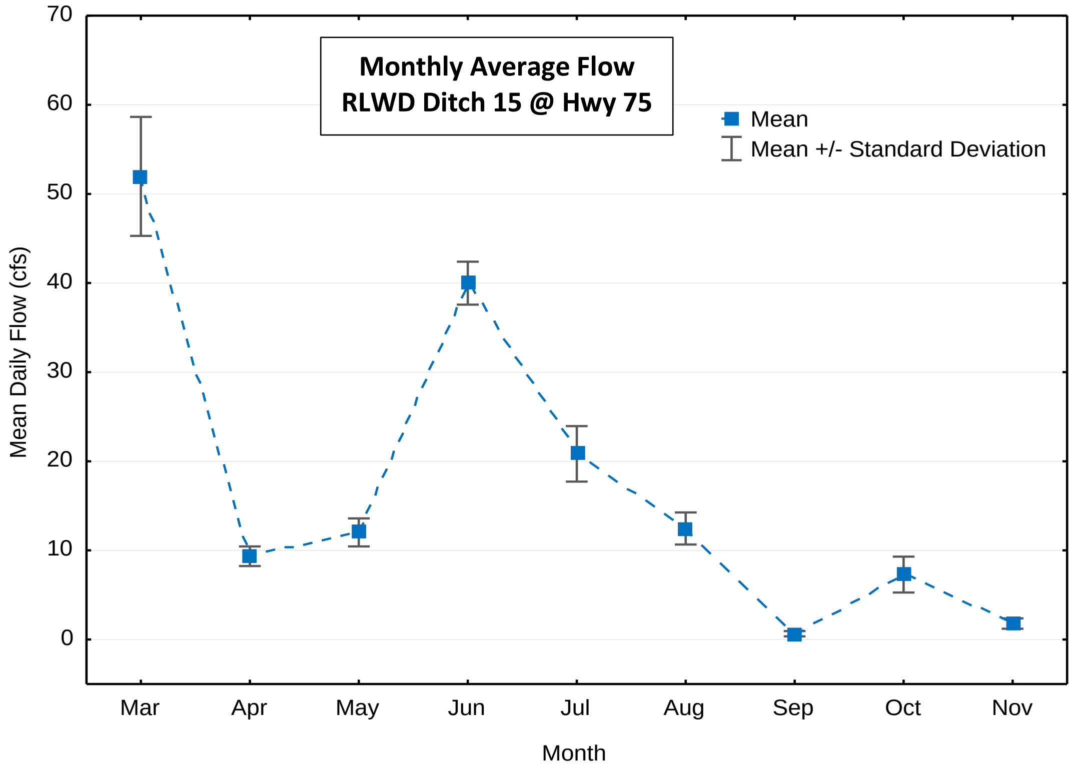

Figure 3-26. Observed mean flow by month, RLWD Ditch 15 at Hwy 75, 2006-2015

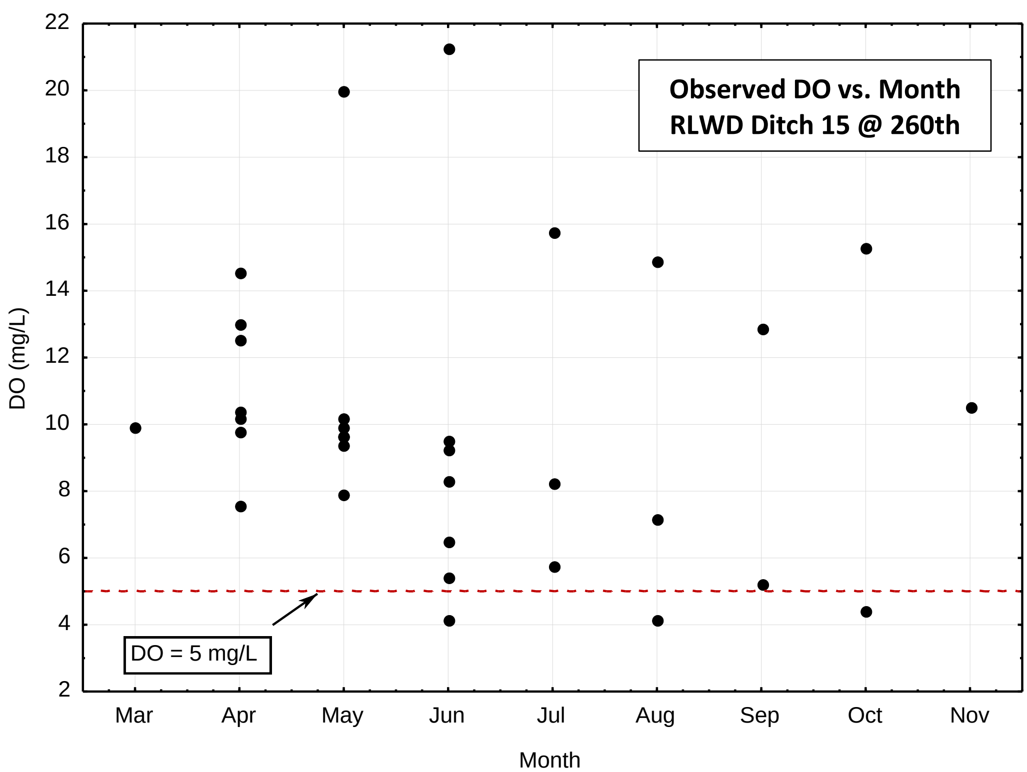

Figure 3-27. Observed DO vs month in RLWD Ditch 15 at 260th Street (S003-276), 2006-2015

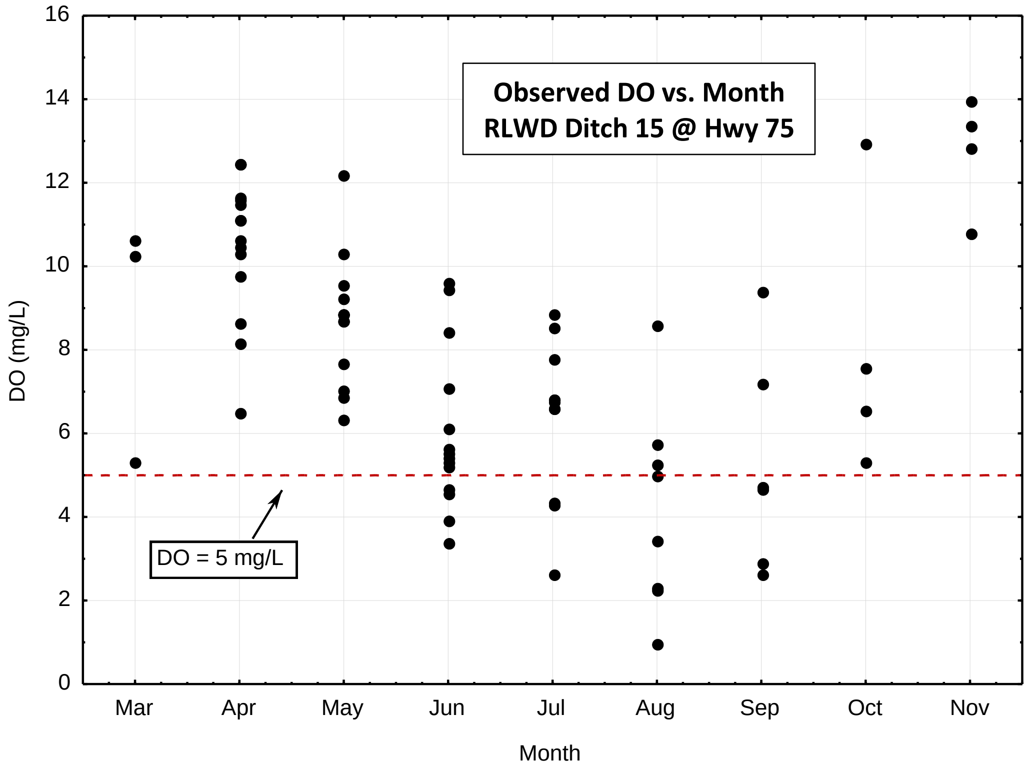

Figure 3-28. Observed DO vs month in RLWD Ditch 15 at Hwy 75 (S004-132), 2006-2015

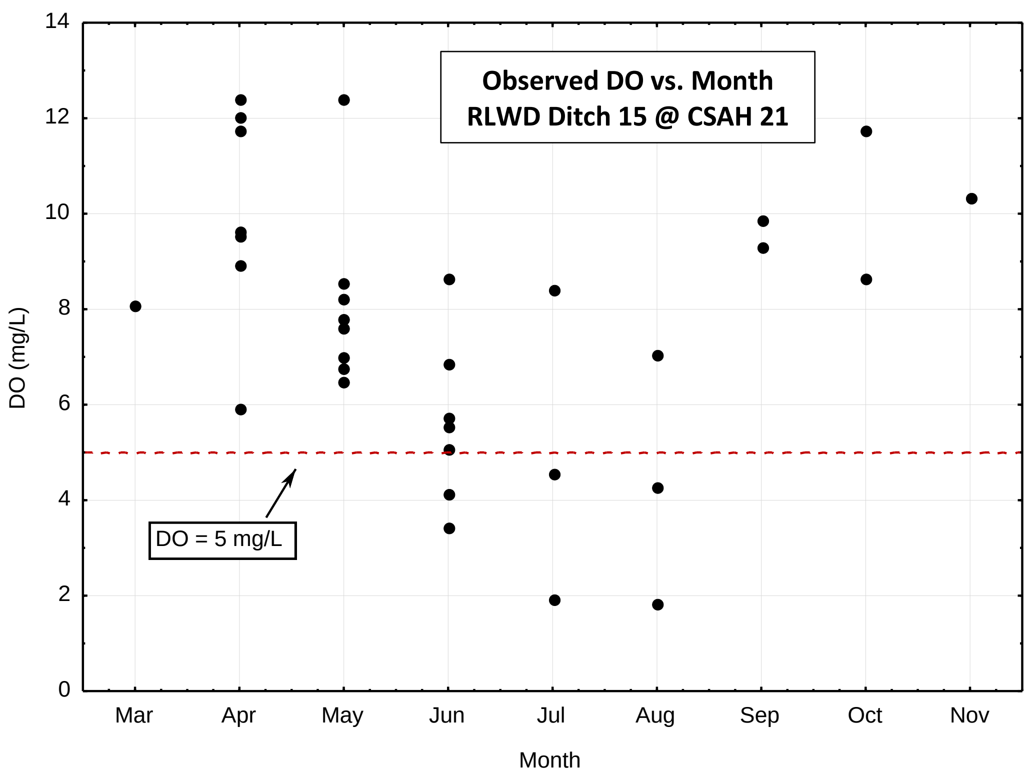

Figure 3-29. Observed DO vs month in RLWD Ditch 15 at CSAH 21 (S004-133), 2006-2015

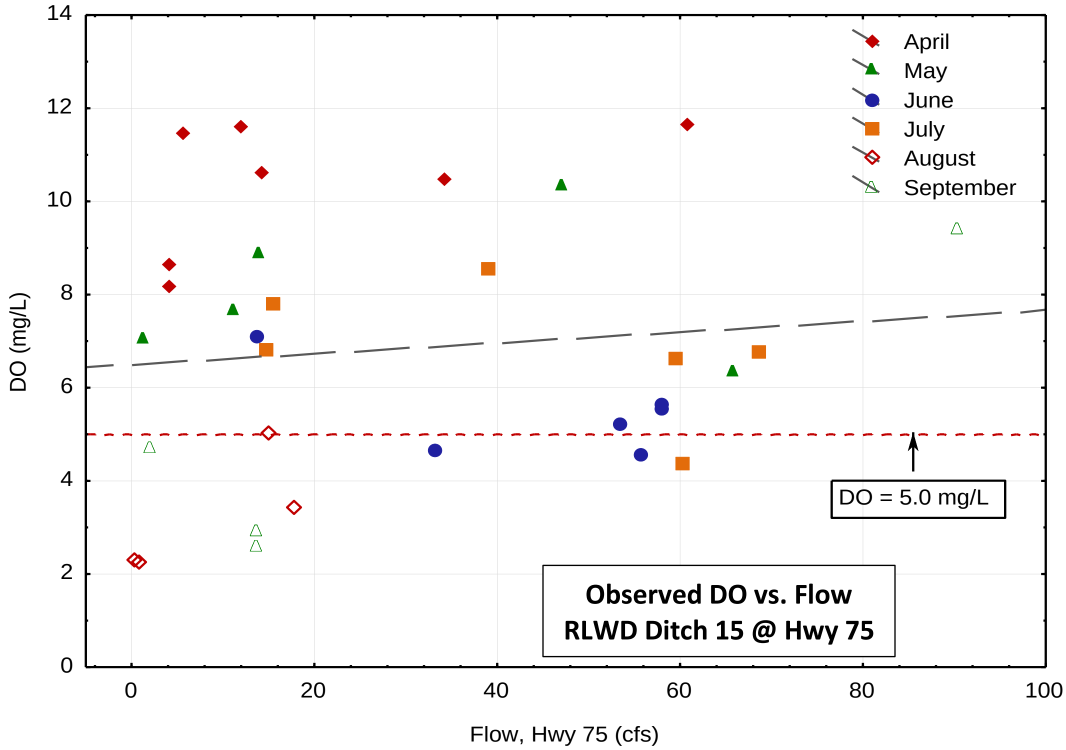

Figure 3-30. Observed lack of correlation between DO and Flow in RLWD Ditch 15 at Hwy 75 (S004-132), 2006-2007

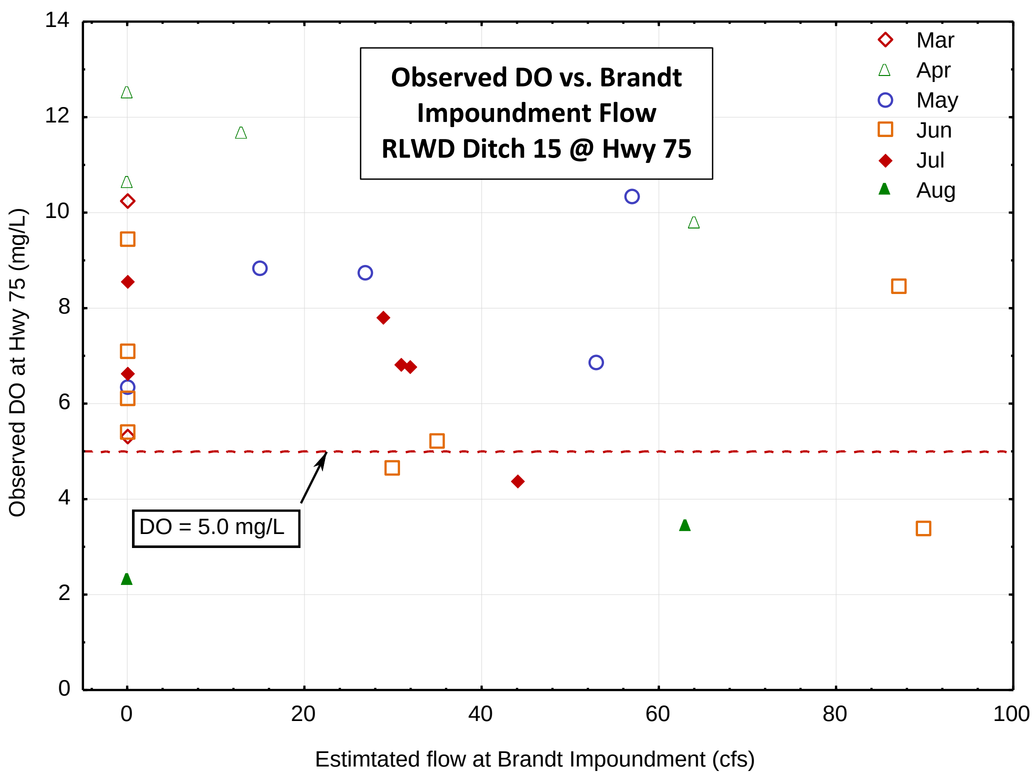

Figure 3-31. Observed DO at Hwy 75 (S004-132) vs. Estimated Flow at the Brandt Impoundment

Stream Temperature

Warmer waters hold less oxygen than cooler waters. In addition, warmer waters have increased rates of organic matter decomposition, which consumes oxygen. During the summer months, runoff and stream temperatures tend to increase in response to warming air and soil temperatures. Increased stream temperatures are likely a contributing stressor for low DO levels during the summer months. DO concentrations below the standard were observed most frequently in June, July, and August when stream temperatures were warmest (Figure 3-32); however, many of the observed violations cannot be accounted for by variations in stream temperature only (low r^2, 99% confidence intervals; Figure 3-33 through Figure 3-35). Therefore, other factors likely contribute to low DO in Grand Marais Creek.

Flows decrease from June to September in RLWD Ditch 15 (Figure 3-26), while average air temperatures increase from June to August and decrease again slightly in September. Since low flow conditions can decrease the dissipation of thermal energy in streams, it is likely that warmer air temperatures exacerbate already poor conditions for DO that occur during periods of low/stagnant flow during the late summer.

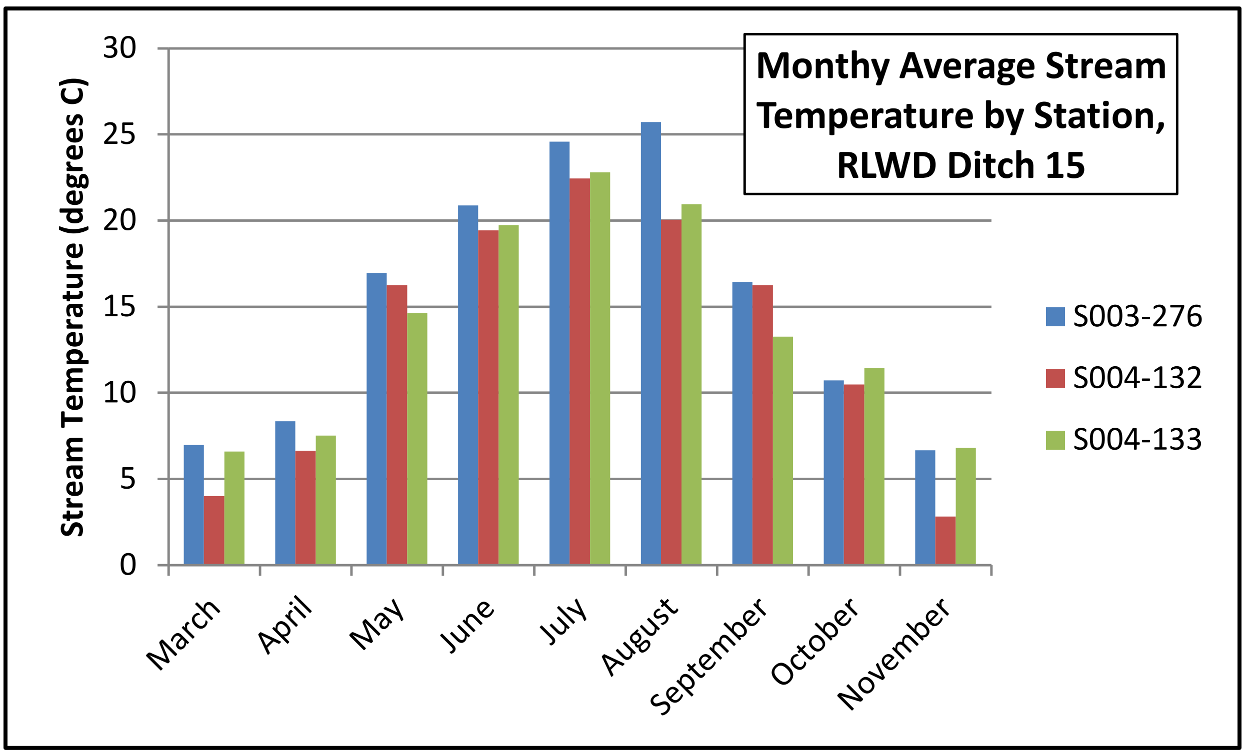

Figure 3-32. Stream temperature by station in RLWD Ditch 15, 2005-2014

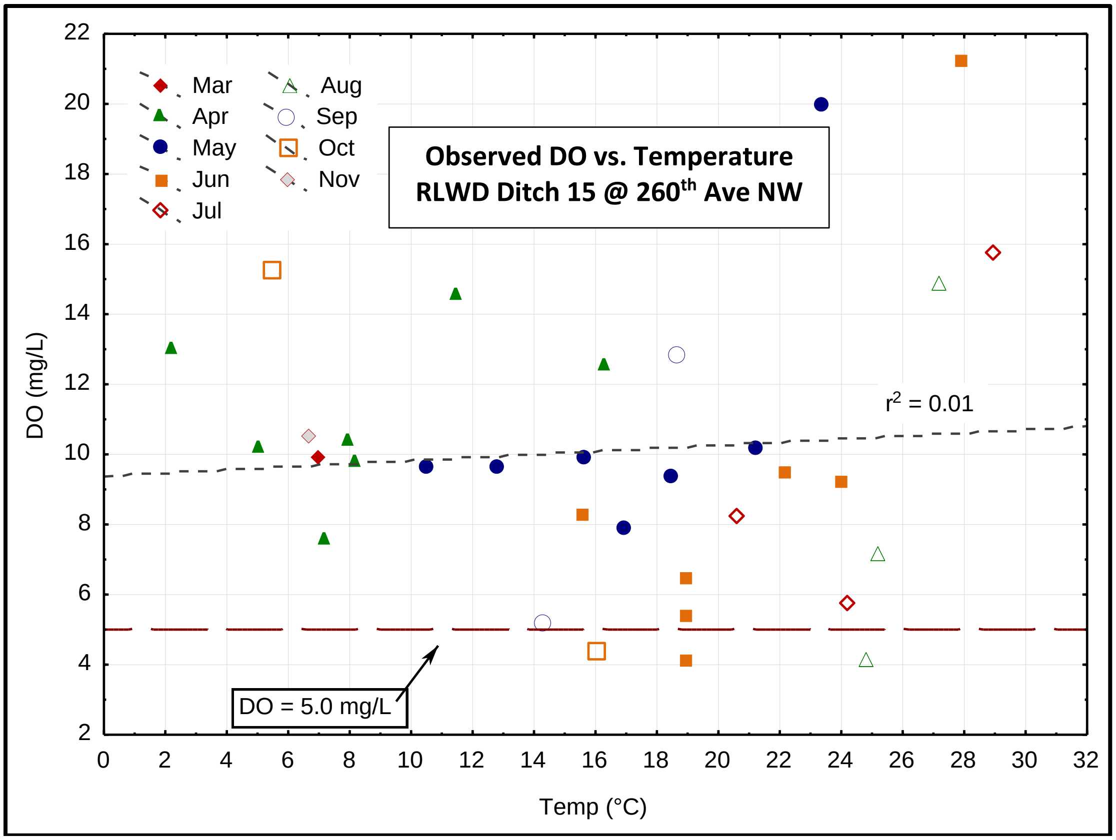

Figure 3-33. Observed DO and temperature, RLWD Ditch 15 @ 260th Ave NW (S003-276), 2005-2014

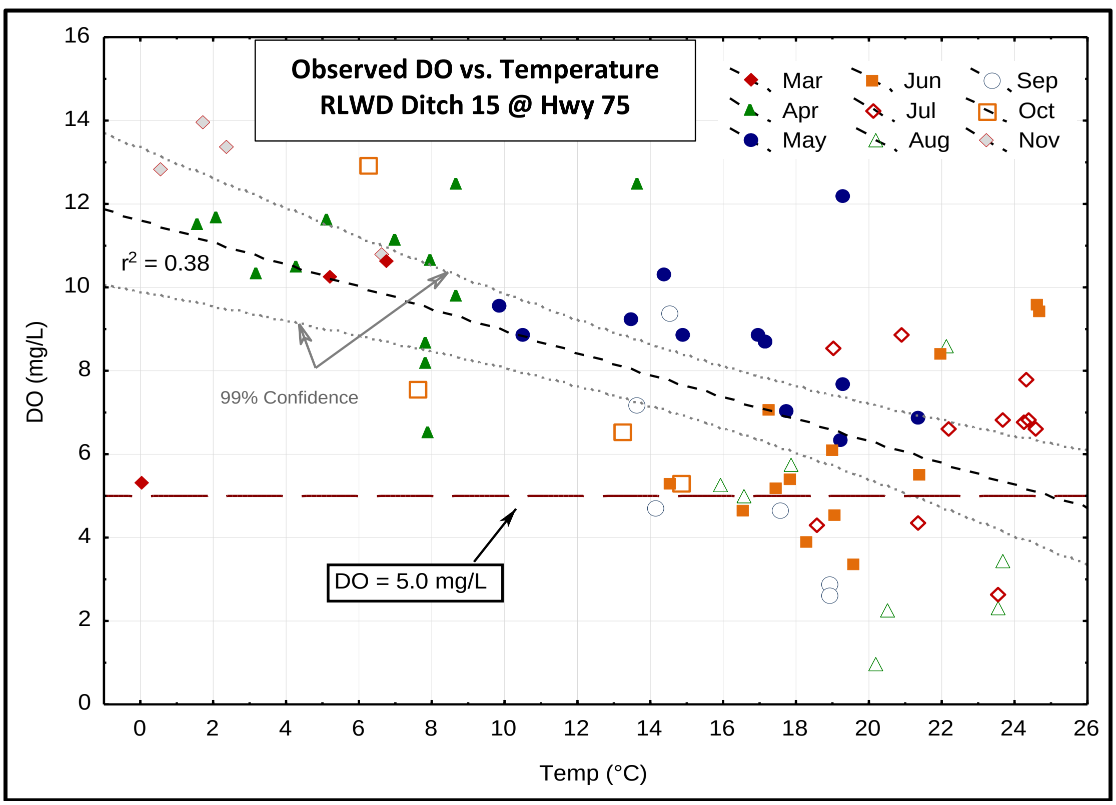

Figure 3-34. Observed DO and temperature, RLWD Ditch 15 @ Hwy 75 (S004-132), 2005-2014

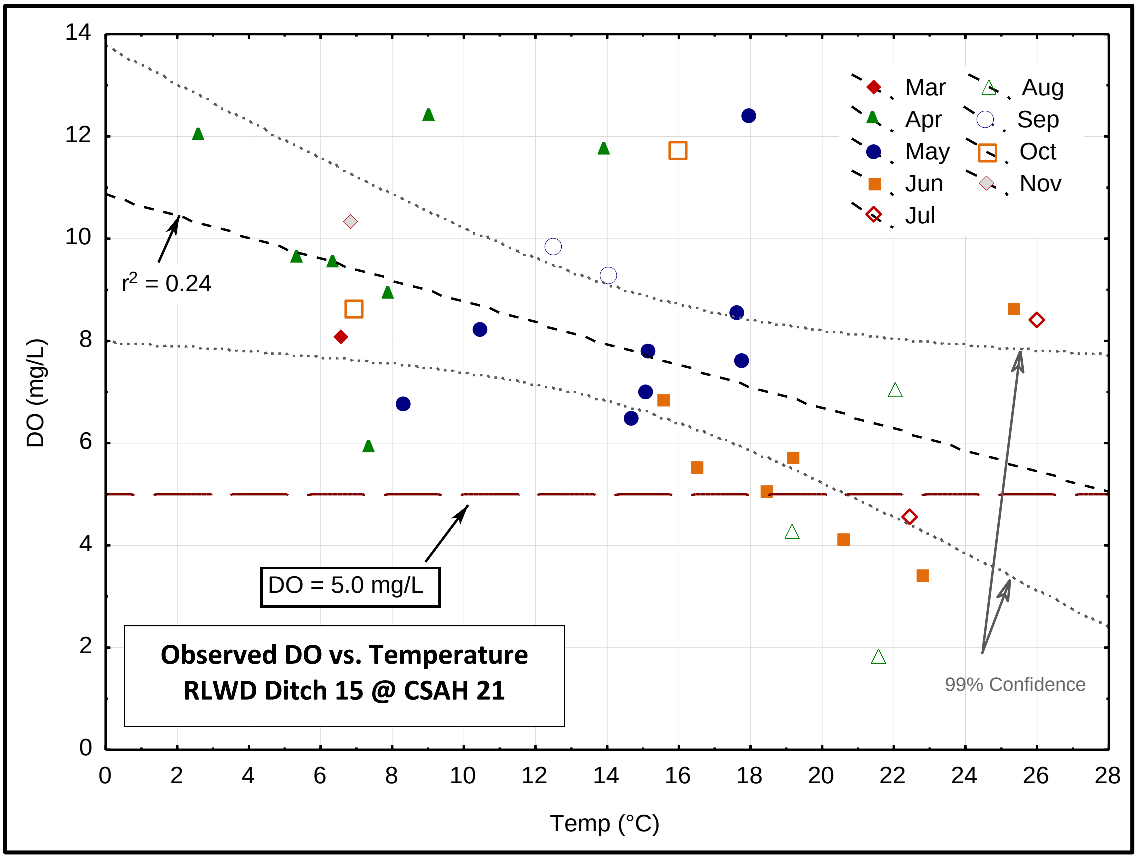

Figure 3-35. Observed DO and temperature, RLWD Ditch 15 @ CSAH 21 (S004-133), 2005-2014

Nutrients (Eutrophication)

Excess P in the stream increases algae and other plant growth. When algae and plant growth reach very high levels, the decomposition of and respiration from algae and aquatic plants can consume large amounts of DO resulting in stream DO levels that are too low to support fish.

Mean P concentrations in RLWD Ditch 15 were highest during the months of July and August (Figure 3-36) when mean DO concentrations were lowest (Figure 3-27 through Figure 3-29). In general, DO concentrations decreased as P concentrations increased in RLWD Ditch 15, but analysis does not indicate a strong relationship between these factors (low r^2 values) (Figure 3-37 - Figure 3-39). High TP in the late summer is likely a contributing factor, but not the primary cause of low DO. That is to say, even if P levels were greatly reduced in the stream, low DO conditions would continue due to stagnant flow conditions.

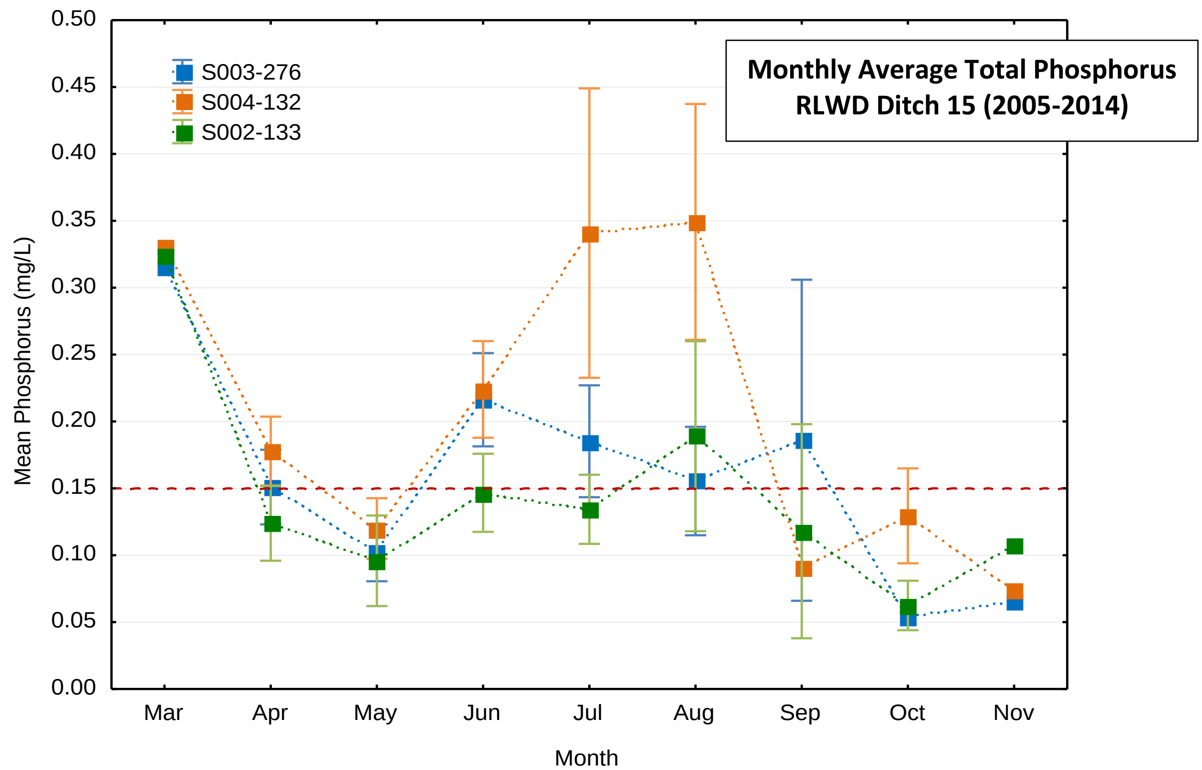

Figure 3-36. Mean ±Standard Deviation TP by Month in RLWD Ditch 15 (2005-2014)

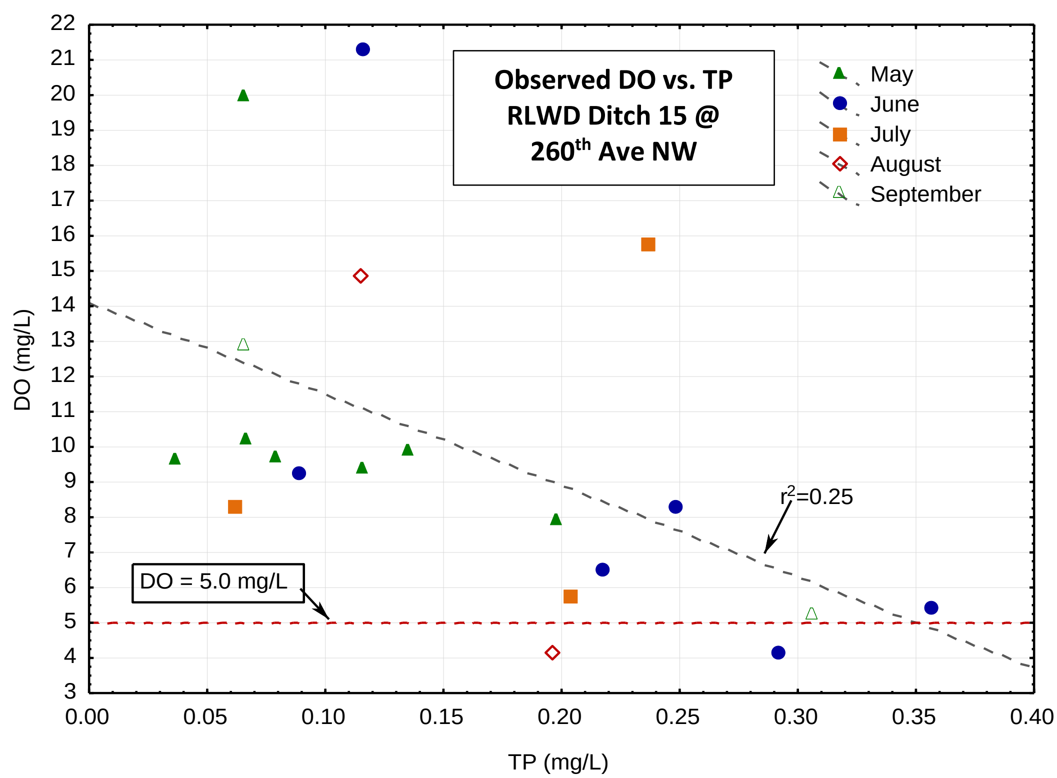

Figure 3-37. Observed DO vs. TP, RLWD 15 @ 260th Ave NW, monitoring station S003-276, 2005-2014

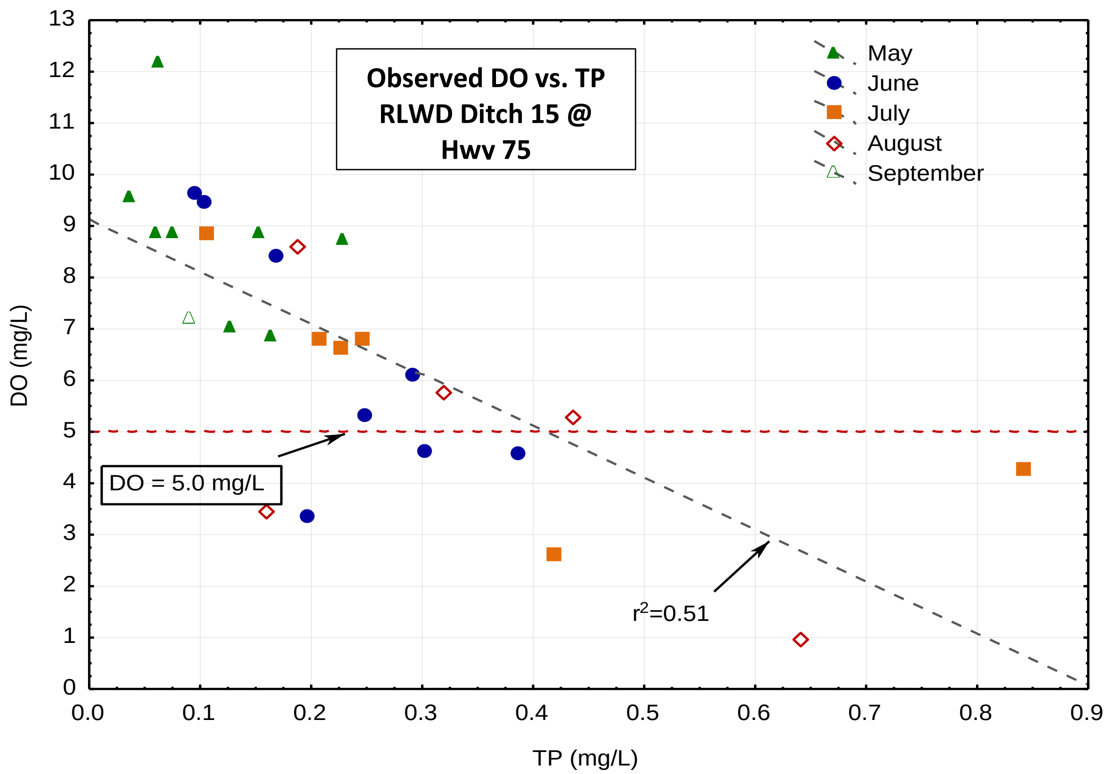

Figure 3-38. Observed DO vs. TP, RLWD 15 @ Hwy 75, monitoring station S004-132, 2005-2014

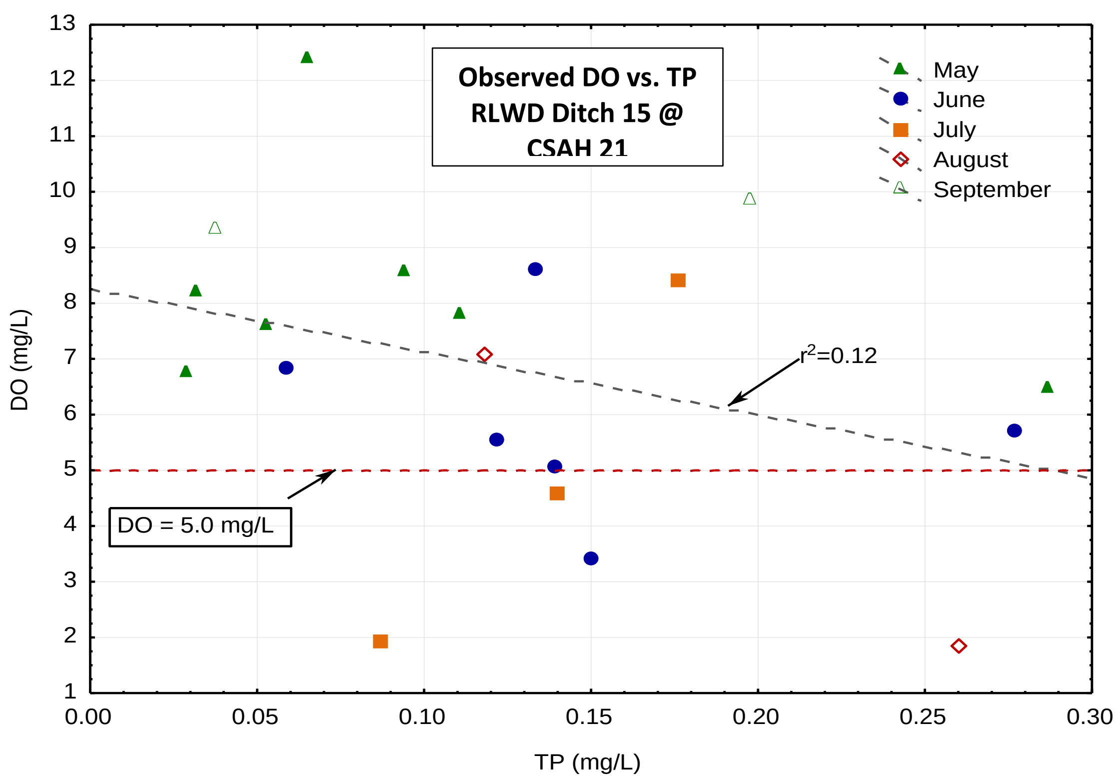

Figure 3-39. Observed DO vs. TP, RLWD 15 @ CSAH 21, monitoring station S004-133, 2005-2014

Conclusions/Summary

The primary stressor to low dissolved in RLWD Ditch 15 in this study is altered hydrology, which results in low flow and stagnant conditions in late summer months. Low and stagnant flows are a result of the flashy, flat ditch systems in the watershed with low baseflow and ponded water. Low DO conditions are also likely exacerbated by warm temperatures in the mid to late summer.

Lack of shading due to poor quality buffers is another factor to consider. The buffer width is lacking in many areas and that should be improved under the Buffer Law (http://www.bwsr.state.mn.us/buffers/). The buffer quality, however, is limited in many areas by regular mowing and spraying that limits the opportunity for growth of deep-rooted woody and broadleaf vegetation, which can provide shading. High TP in the late summer is also likely a minor contributing factor, but even if P levels were greatly reduced in the stream, low DO conditions would continue due to stagnant flow conditions. Therefore, a TP TMDL was not completed to address this impairment.

3.5.3 Stream Fish and Macroinvertebrate Bioassessments

A SID study was completed to determine the cause of low fish and macroinvertebrate IBI scores in the Grand Marais Creek Watershed (MPCA 2015). A lack of base flow, lack of instream habitat, and low DO were identified as stressors for all of the biological impairments (Table 3-14). All of the reaches are ditch systems and are subject to frequent periods of minimal to no flow. Moreover, one year of monitoring, 2012, was a notable dry year, potentially biasing IBI scores. The lack of instream habitat associated with reaches is attributed their construction (i.e., traditional, trapezoidal design) and physiographic setting (i.e., lake plain). All of the reaches are prone to periods of low DO, which appear to coincide with low flow conditions. High suspended sediment is contributing to the M-IBI impairments in the watershed. However, a total suspended solids (TSS) TMDL is not warranted at this time because the streams currently meet the TSS standard. Lastly, a loss of physical connectivity is a stressor for the F-IBI impairments in the watershed.

In the case of many stressors, a mass reduction is not the appropriate means of addressing these issues, thus no TMDL is computed (i.e., habitat stressors). None of the primary stressors required pollutant mass reductions; non-pollutant stressors will be addressed through the WRAPS process. See Section 4.2 for more information.

Table 3-14. Summary of the stressors associated with the biologically impaired reaches in the GMCW

Summary of Stressors to the Biological Community in the Grand Marais Creek Watershed							
AUID Suffix	Reach Name	Biological Impairment(s)	Candidate Cause[1]				
			Loss of Physical Connectivity	Lack of Base Flow	Lack of Instream Habitat	High Suspended Sediment	Low Dissolved Oxygen
515	County Ditch 2	F-IBI	++	+++	++		+
		M-IBI		+++	++	+	+
517		F-IBI	++	+++	++	+	+

Summary of Stressors to the Biological Community in the Grand Marais Creek Watershed							
AUID Suffix	Reach Name	Biological Impairment(s)	Candidate Cause[1]				
			Loss of Physical Connectivity	Lack of Base Flow	Lack of Instream Habitat	High Suspended Sediment	Low Dissolved Oxygen
	County Ditch 43	M-IBI		+++	++	+	+
520	Judicial Ditch 75	F-IBI	++	+++	++		+

[1] **Key:** +++ the available evidence *convincingly supports* the case for the candidate cause as a stressor, ++ the available evidence *strongly supports* the case for the candidate cause as a stressor, and + the available evidence *somewhat supports* the case for the candidate cause as a stressor. A blank space indicates that the available evidence *does not* support the case for the candidate cause as a stressor.

4 TMDL Development

This section presents the overall approach to estimating the components of the TMDL. The pollutant sources were first identified and estimated in the pollutant source assessment. The loading capacity (LC); TMDL) of each lake or stream was then estimated using an in-lake water quality response model or stream LDC and was divided among WLAs and LAs. A TMDL for a waterbody that is impaired, as the result of excessive loading of a particular pollutant, can be described by the following equation:

$$\textbf{TMDL = LC} = \sum \textbf{WLA} + \sum \textbf{LA} + \textbf{MOS} + \textbf{RC}$$

Where:

Loading capacity (LC): the greatest pollutant load a waterbody can receive without violating water quality standards;

Wasteload allocation (WLA): the pollutant load that is allocated to point sources, including wastewater treatment facilities, regulated construction stormwater, and regulated industrial stormwater, all covered under National Pollution Discharge Elimination System (NPDES) permits for a current or future permitted pollutant source;

Load allocation (LA): the pollutant load that is allocated to sources not requiring NPDES permit coverage, including non-regulated stormwater runoff, atmospheric deposition, and internal loading;

Margin of Safety (MOS): an accounting of uncertainty about the relationship between pollutant loads and receiving water quality;

Reserve Capacity (RC): the portion of the LC attributed to the growth of existing and future load sources.

4.1 Bacteria (*E. coli*)

4.1.1 Loading Capacity Methodology

The loading capacities for impaired stream reaches receiving a TMDL, as a part of this study, were determined using LDCs. Duration curves are used to determine the flow conditions (flow regimes) under which water quality standards exceedances occur. Flow duration curves provide a visual display of the variation in flow rate for the stream. The x-axis of the plot indicates the percentage of time that a flow exceeds the corresponding flow rate as expressed by the y-axis. LDCs take the flow distribution information constructed for the stream and factor in pollutant loading to the analysis. A standard curve is developed by applying a particular pollutant standard or criteria to the stream flow duration curve, and is expressed as a load of pollutant per day. The standard curve represents the upper limit of the allowable in-stream pollutant load (LC) at a particular flow. Monitored loads of a pollutant are plotted against this curve to display how they compare to the standard. Monitored values that fall above the curve represent an exceedance of the standard.

For the stream TMDL derivation, HSPF model's simulated daily flow data from the years 2006 through 2009 and monitored flow from the years 2013 through 2015 were used to develop flow duration curves. The loading capacities were determined by applying the *E. coli* water quality standard (126 org/ 100 mL) to the flow duration curve to produce a bacteria standard curve. Loading capacities presented in the allocation tables represent the median *E. coli* load (in billion org/day) along the bacteria standard curve within each flow regime. A bacteria LDC and a TMDL allocation table are provided for each stream in Section 4.1.6. Limited observations and estimates of existing bacteria loads are plotted along with the bacteria standard curve for each impaired stream. Existing loads were estimated by pairing observed *E. coli* concentrations with flow records for each impaired reach.

The following process is used to convert the desired concentration (org/100ml) and a rate of flow (ft^3/sec) in to a daily load (billions of organisms/day).

1. Multiply the concentration by the rate of flow.
2. Multiply by 28,316.8 (milliliters in one cubic foot) to get the number of *organisms per second.*
3. Multiply by 86,400 (seconds in one day) to get the number of *organisms per day.*
4. Divide that number by one billion to calculate *billions of organisms per day*.

The LDC method is based on an analysis that encompasses the cumulative frequency of historical flow data over a specified period. Because this method uses a long-term record of daily flow volumes, virtually the full spectrum of allowable loading capacities is represented by the resulting curve. In the TMDL tables of this report, only five points on the entire LC curve are depicted (the midpoints of the designated flow zones). However, it should be understood that the entire curve represents the TMDL and is what is ultimately approved by EPA.

4.1.2 Load Allocation Methodology

LAs represent the portion of the LC that is designated for non-regulated sources of *E. coli*, as described in Section 3.5.1.2, that are located downstream of any other impaired waters with TMDLs located in the Grand Marais Creek Watershed. Because there are no regulated sources, and thus no WLAs, in the watershed, the LA is the total LC minus the MOS.

4.1.3 Wasteload Allocation Evaluation

4.1.3.1 MS4 Regulated Stormwater

There is no Municipal Separate Storm Sewer Systems (MS4) regulated stormwater in the Grand Marais Creek Watershed.

4.1.3.2 Regulated Construction Stormwater

E. coli WLAs for regulated construction stormwater (Permit #MNR100001) were not developed since *E. coli* is not a typical pollutant from construction sites.

4.1.3.3 Regulated Industrial Stormwater

There are no *E. coli* benchmarks associated with the industrial stormwater permit because no industrial sectors regulated under the permit are known to be *E. coli* sources. Therefore, *E. coli* TMDLs will not include an industrial stormwater WLA.

4.1.3.4 Feedlots Requiring NPDES/SDS Permit Coverage

There are no active NPDES permitted feedlot operations (CAFO) within an *E. coli* impaired stream reach drainage area in the Grand Marais Creek Watershed. See Section 3.5.1.2 and 4.1.2 for registered feedlots.

4.1.3.5 Municipal and Industrial Waste Water Treatment Systems

There are no permitted municipal or industrial wastewater facilities located within the watersheds of the impaired streams addressed in this TMDL.

4.1.4 Margin of Safety

An explicit MOS equal to 10% of the LC was used for the stream TMDLs based on the following considerations:

- Most of the uncertainty in flow is the result of extrapolating flows in upstream areas of the watershed, based on HSPF model calibration at stream gauges near the outlet of the Grand Marais Creek Watershed. The explicit MOS, in part, accounts for this.
- Allocations are a function of flow, which varies from high to low flows. This variability is accounted for through the development of a TMDL for each of five flow regimes.

- The load duration analysis does not address bacteria re-growth in sediments, die-off, and natural background levels. The MOS helps to account for the variability associated with these conditions.

4.1.5 Seasonal Variation

Use of these water bodies for aquatic recreation occurs from April through October, which includes all or portions of the spring, summer, and fall seasons. *E. coli* loading varies with the flow regime and season. Spring is associated with large flows from snowmelt, the summer is associated with the growing season as well as periodic storm events and receding streamflows, and the fall brings increasing precipitation and rapidly changing agricultural landscapes.

Critical conditions and seasonal variation are addressed in this TMDL through several mechanisms. The *E. coli* standard applies during the recreational period, and data was collected throughout this period. The water quality analysis conducted on these data evaluated variability in flow through the use of five flow regimes: from high flows, such as flood events, to low flows, such as baseflow. Through the use of LDCs and monthly summary figures, *E. coli* loading was evaluated at actual flow conditions at the time of sampling (and by month), and monthly *E. coli* concentrations were evaluated against precipitation and streamflow.

4.1.6 TMDL Summary

4.1.6.1 County Ditch 2, CD66 to Grand Marais Creek, *E. coli* TMDL

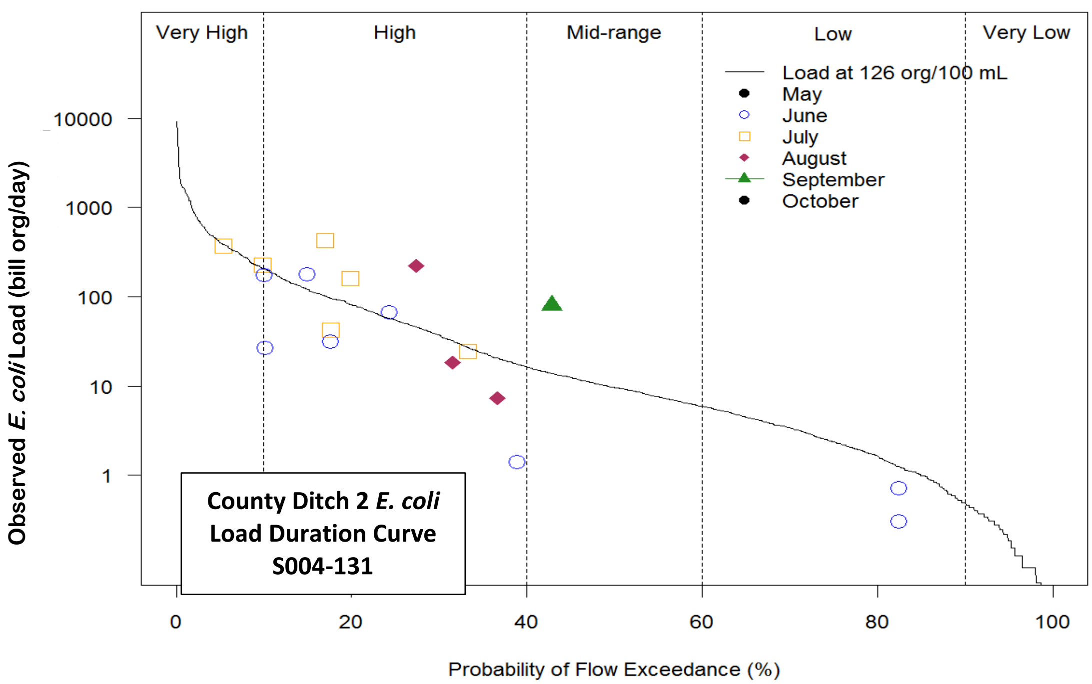

Figure 4-1. County Ditch 2 (AUID 09020306-515) *E. coli* Load Duration Curve, S002-131

Note: Exceedances of the E. coli water quality standard occurred on numerous dates when stagnant flow conditions were observed (see Section 11.2.1). Pollutant loads under stagnant conditions cannot be represented using the flow duration methodology; nevertheless, exceedances of the water quality standard present a threat to recreational use (see Section 4.1.7).

Table 4-1. County Ditch 2 (AUID 09020306-515) *E. coli* TMDL and Allocations

County Ditch 2 (AUID 09020306-515) *E. coli* TMDL and Allocations						
County Ditch 2 09020306-515 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		E. coli (billion organisms per day)				
Total Loading Capacity		**397.95**	**53.75**	**9.53**	**2.34**	**0.22**
10% MOS		**39.79**	**5.47**	**0.95**	**0.23**	**0.02**
Wasteload Allocations	*NPDES Permitted Feedlots*	*NA*	*NA*	*NA*	*NA*	*NA*
	Total WLA	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Load Allocations	*Watershed Runoff*	*358.16*	*48.28*	*8.58*	*2.11*	*0.20*
	Total LA	**358.16**	**49.28**	**8.58**	**2.11**	**0.20**

§*Estimated reductions are also discussed in Section 4.1.7*

NA= No load allocations were necessary for this category.

4.1.6.2 Judicial Ditch 1, CD 7 to Red River, *E. coli* TMDL

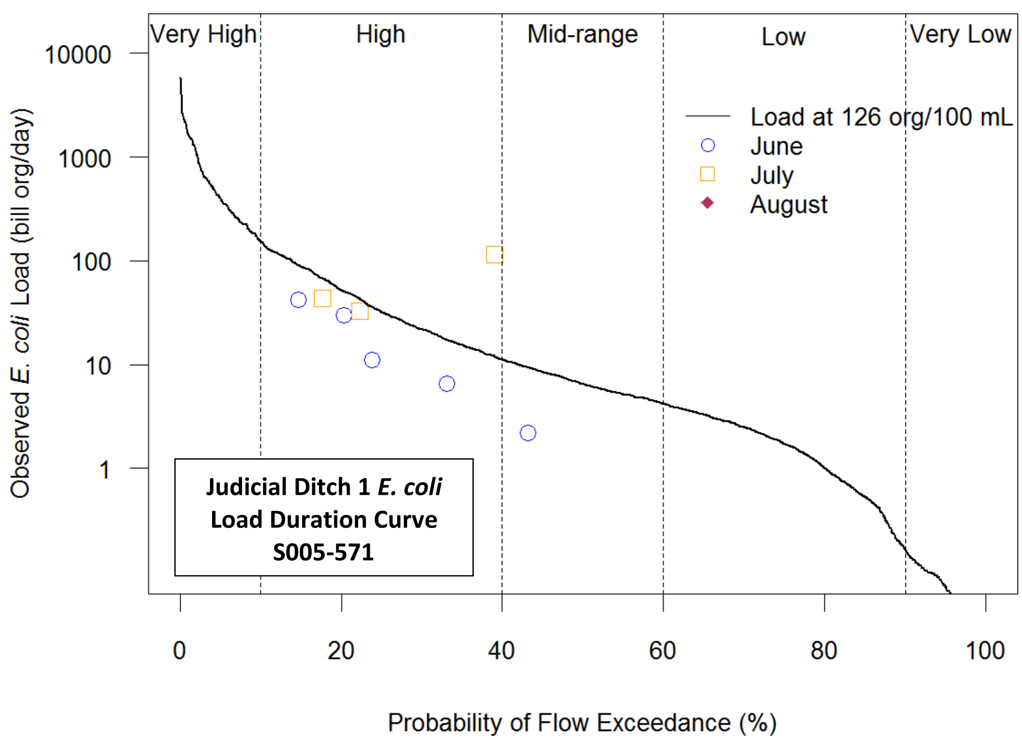

Figure 4-2. Judicial Ditch 1 (AUID 09020306-519) *E. coli* Load Duration Curve, S005-571

Note: Exceedances of the E. coli water quality standard occurred on numerous dates when stagnant flow conditions were observed (see Section 11.2.2). Pollutant loads under stagnant conditions cannot be represented using the flow duration methodology; nevertheless, exceedances of the water quality standard present a threat to recreational use (see Section 4.1.7).

Table 4-2. Judicial Ditch 1 (AUID 09020306-519) *E. coli* TMDL and Allocations

Judicial Ditch 1 (AUID 09020306-519) TMDL and Allocations						
Judicial Ditch 1 09020306-519 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		E. coli (billion organisms per day)				
Total Loading Capacity		**404.41**	**32.13**	**6.46**	**1.70**	**0.08**
10% MOS		**40.44**	**3.21**	**0.65**	**0.17**	**0.01**
Wasteload Allocations	*NPDES Permitted Feedlots*	*NA*	*NA*	*NA*	*NA*	*NA*
	Total WLA	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Load Allocations	*Watershed Runoff*	*363.97*	*28.92*	*5.81*	*1.53*	*0.07*
	Total LA	**363.97**	**28.92**	**5.81**	**1.53**	**0.07**

Estimated reductions are discussed in Section 4.1.7

NA=No load allocations were necessary for this category.

4.1.6.3 Judicial Ditch 75, CD7 to Red River, *E. coli* TMDL

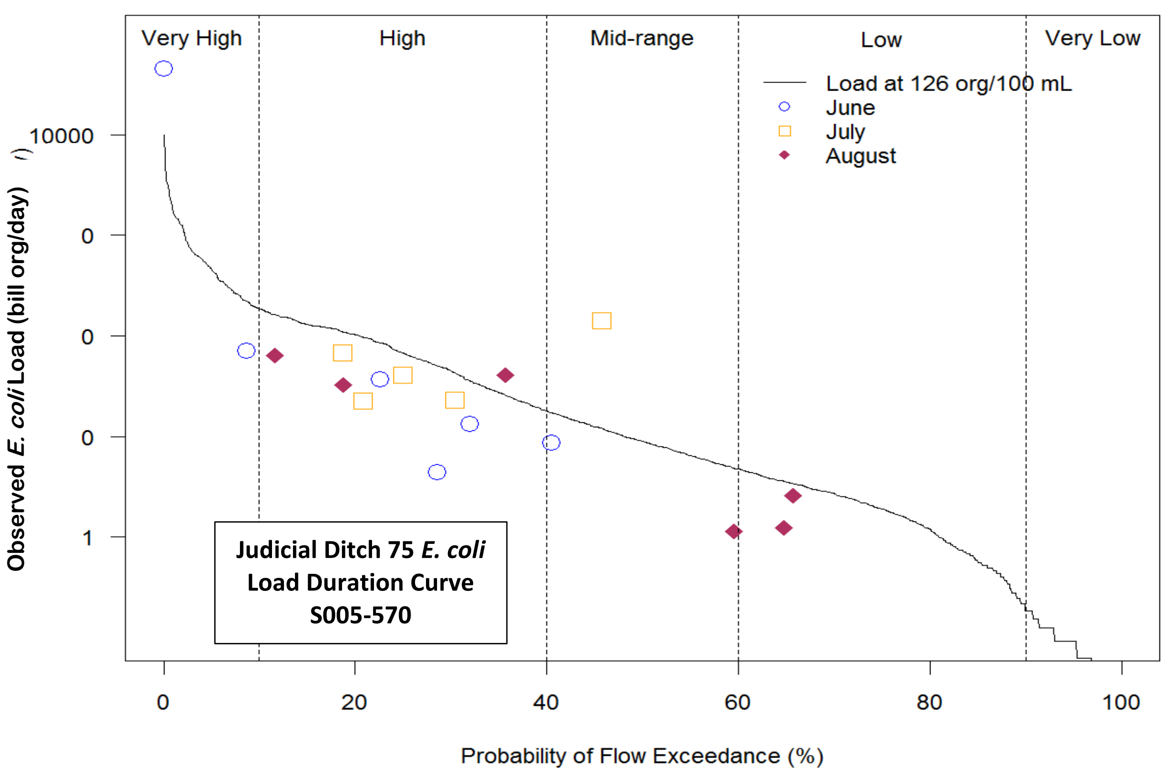

Figure 4-3. Judicial Ditch 75 (AUID 09020306-520) *E. coli* Load Duration Curve, S005-570

Note: Exceedances of the E. coli water quality standard occurred on numerous dates when stagnant flow conditions were observed (see Section 11.2.2). Pollutant loads under stagnant conditions cannot be represented using the flow duration methodology; nevertheless exceedances of the water quality standard present a threat to recreational use.

Table 4-3. Judicial Ditch 75 (AUID 09020306-520) *E. coli* TMDL and Allocations

Judicial Ditch 75 (AUID 09020306-520) *E. coli* TMDL and Allocations						
Judicial Ditch 75 09020306.520 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		E. coli (billion organisms per day)				
Total Loading Capacity		**457.88**	**67.23**	**8.88**	**1.88**	**0.09**
10% MOS		**45.79**	**6.72**	**0.89**	**0.19**	**0.01**
Wasteload Allocations	*NPDES Permitted Feedlots*	*NA*	*NA*	*NA*	*NA*	*NA*
	Total WLA	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Load Allocations	*Watershed Runoff*	*412.09*	*60.51*	*7.99*	*1.69*	*0.08*
	Total LA	**412.09**	**60.51**	**7.99**	**1.69**	**0.08**

Estimated reductions are discussed in Section 4.1.7

NA=No load allocations were necessary for this category.

4.1.7 Reductions

Although individual observed *E. coli* loads are plotted with *E. coli* standard curves in Section 4.1.6, these limited observations are not representative of the total range of *E. coli* loads in the impaired streams based on the complete water quality data record. Paired flow data (observed or modeled) were not available for all water quality samples, and pollutant loads cannot be calculated for water quality samples taken during stagnant flow conditions (no stream flow). In all cases, half or more of observed exceedances occurred on dates on which stagnant flow conditions were observed, or for which there was no corresponding flow data (See Section 11.2). Based on observed geometric mean *E. coli* concentrations for each impaired reach (Section 3.4.2), required reductions of approximately 5% to 54% of *E. coli* loads are needed during months for which geometric mean *E. coli* concentration exceeded the water quality standard (126 org/100 mL).

Table 4-4. Estimated *E. coli* reductions, by month for each impaired reached, Grand Marais Creek Watershed TMDL.

Grand Marais Creek Watershed Estimated *E. coli* Reductions to Meet the TMDL Goal							
Impaired Reach (AUID)	Month	Median Monthly Flow* (cfs)	Observed Geometric Mean *E. coli*§ (org/100 mL)	Estimated Median Daily Load (billion org/day)	Estimated Reduction Needed to Achieve 126 org/100 mL		
					Concentration (org/100 mL)	Load	
						(bill org/ day)	%
CD 2 (09020306-515)	July	4.3	184.2	19.4	58.2	6.1	**32%**
	August	2.8	273.7	18.8	147.7	10.1	**54%**
JD 1 (09020306-519)	July	2.7	161.5	10.7	35.5	2.4	**22%**
JD 75 (09020306-520)	June	19.6	132.2	63.4	6.2	3.0	**5%**
	July	7.9	167.1	32.3	41.1	7.9	**25%**

*See Table 11-1.

§Only months with five or more observations (see Table 3-6).

4.1.8 TMDL Baseline

The stream *E. coli* TMDLs are based on flow and water quality records results for the period 2006 through 2015. Any activities implemented after the mid-point of the TMDL time period (2010) that lead to a reduction in loads or an improvement in an impaired stream water quality may be considered as progress towards meeting a LA.

4.2 Impairments not addressed by TMDLs

DO, turbidity and macroinvertebrate/fish bioassessment impairments can sometimes be linked back to a mass pollutant, but those links were not able to be made for six impaired reaches in the Grand Marais Creek Watershed. A list of the aquatic life use impairments not addressed by TMDL calculations in this report are provided in Table 4-5, with explanations of causes of the impairments. These impairments will be addressed through restoration strategies identified in the WRAPS report. The Grand Marais Creek WRAPS Report will be publicly available on the MPCA Grand Marais Creek Watershed website: https://www.pca.state.mn.us/water/watersheds/red-river-north-grand-marais-creek.

Table 4-5. Grand Marais Creek Watershed aquatic life use impairments not addressed by TMDLs

<table>
<tr><th colspan="2">Rationale for Aquatic Life Use Impairments Not Addressed by TMDLs</th></tr>
<tr><th>AUID
Waterbody Name
Listed Pollutant or Stressor</th><th>Reason</th></tr>
<tr><td>09020306-507
Grand Marais Creek, Headwaters to CD2
Dissolved Oxygen</td><td>DO: The primary stressor to low DO in Grand Marais Creek in this study is altered hydrology, which results in low flow and stagnant conditions in late summer months. Low and stagnant flows are a result of the formation of headwater oxbow wetlands from the historic alteration of flow from Red Lake River away from the Grand Marais Creek channel, in addition to flashy ditch systems in the watershed and ponding upstream of road crossings. The headwaters portion of Grand Marais Creek channel is essentially a chain of wetlands with little contributing flow. Low DO conditions are also likely exacerbated by warm temperatures in the mid to late summer.</td></tr>
<tr><td>09020306-507
Grand Marais Creek, Headwaters to CD2
Turbidity</td><td>Turbidity: The impairment for aquatic life due to excess turbidity in Grand Marais Creek, headwaters to CD2 was first listed in 2006. Water quality data for this reach do not support an impairment listing for TSS under the new water quality standards. The turbidity impairment will be removed from the 303(d) list during the next assessment cycle.</td></tr>
<tr><td>09020306-509
RLWD Ditch 15, Headwaters to CD66
Dissolved Oxygen</td><td>The primary stressor to low DO in RLWD Ditch 15 in this study is altered hydrology, which results in low flow and stagnant conditions in late summer months. Low and stagnant flows are a result of the flashy, flat ditch systems in the watershed with low baseflow and ponded water. Low DO conditions are also likely exacerbated by warm temperatures in the mid to late summer.</td></tr>
<tr><td>09020306-515
County Ditch 2, CD66 to Grand Marais Creek
Fish & Macroinvertebrate Bioassessments</td><td rowspan="2">Available evidence convincingly supports lack of base flow as a stressor, and strongly supports loss of physical connectivity (for fish) and lack of instream habitat as stressors. TSS and sediment affect aquatic life to some extent, but the streams meet the State's TSS standard. And since flow has no mass-based pollutant load surrogate that can be regulated by a TMDL, it is recommended that this stressor be addressed in the following ways:
• Prevent or mitigate activities that will further alter the hydrology of the watershed.
• Consider opportunities and options to reduce peak flows and increase base flows throughout the watershed.
• Incorporate the principles of natural channel design into stream restoration and ditch maintenance activities.
• Increase the quantity and quality of instream habitat throughout the watershed.</td></tr>
<tr><td>09020306-517
Judicial Ditch 25, Unnamed ditch to CD7
Fish & Macroinvertebrate Bioassessments</td></tr>
</table>

Rationale for Aquatic Life Use Impairments Not Addressed by TMDLs	
AUID **Waterbody Name** **Listed Pollutant or Stressor**	**Reason**
09020306-520 **Judicial Ditch 75, CD7 to Red River** **Fish Bioassessments**	• Establish and/or protect riparian corridors along all waterways, including ditches, using native vegetation whenever possible. • Remove or retrofit physical connectivity barriers to enable fish passage at a greater range of flow conditions. • Conduct an inventory of culverts in the watershed that are limiting fish passage.

5 Future Growth/Reserve Capacity

The top economic activity in the Grand Marais Creek Watershed is agriculture, with 92% of the land in cultivated cropland and no sewered communities. Land use is not expected to change much in the future, as it has not changed much in the recent past.

How changing sources of pollutants may or may not impact TMDL allocations are discussed below, in the event that population and land use in the Grand Marais Creek Watershed do change over time.

5.1 New or Expanding Permitted MS4 WLA Transfer Process

Note that there are currently no MS4s located in the Grand Marais Creek Watershed. Future transfer of watershed runoff loads in this TMDL may be necessary if any of the following scenarios occur within the project watershed boundaries:

1. New development occurs within a regulated MS4. Newly developed areas that are not already included in the WLA must be transferred from the LA to the WLA to account for the growth.
2. One regulated MS4 acquires land from another regulated MS4. Examples include annexation or highway expansions. In these cases, the transfer is WLA to WLA.
3. One or more non-regulated MS4s become regulated. If this has not been accounted for in the WLA, then a transfer must occur from the LA.
4. Expansion of a U.S. Census Bureau Urban Area encompasses new regulated areas for existing permittees. An example is existing state highways that were outside an Urban Area at the time the TMDL was completed but are now inside a newly expanded Urban Area. This will require either a WLA to WLA transfer or a LA to WLA transfer.
5. A new MS4 or other stormwater-related point source is identified and is covered under a NPDES Permit. In this situation, a transfer must occur from the LA.

Load transfers will be based on methods consistent with those used in setting the allocations in this TMDL (see Section 4.1.3). One transfer rate was defined for each impaired stream as the total WLA (in billion org/day) divided by the watershed area downstream of any upstream impaired waterbody (acres). In the case of a load transfer, the amount transferred from LA to WLA will be based on the area (acres) of land coming under permit coverage multiplied by the transfer rate (in billion org/ac-day). The MPCA will make these allocation shifts. In cases where WLA is transferred from or to a regulated MS4, the permittees will be notified of the transfer and have an opportunity to comment.

5.2 New or Expanding Wastewater

Note that there are currently no permitted wastewater treatment facilities that discharge in the Grand Marais Creek Watershed. The MPCA, in coordination with the EPA Region 5, has developed a streamlined process for setting or revising WLAs for new or expanding wastewater discharges to waterbodies with an EPA approved TMDL (MPCA 2012). This procedure will be used to update WLAs in approved TMDLs for new or expanding wastewater dischargers whose permitted effluent limits are at or below the in-stream target and will ensure that the effluent concentrations will not exceed applicable water quality standards or surrogate measures. The process for modifying any and all WLAs will be handled by the MPCA, with input and involvement by the EPA, once a permit request or reissuance is submitted. The overall process will use the permitting public notice process to allow for the public and EPA to comment on the permit changes based on the proposed WLA modification(s). Once any comments or concerns are addressed, and the MPCA determines that the new or expanded wastewater discharge is consistent with the applicable water quality standards, the permit will be issued and any updates to the TMDL WLA(s) will be made.

For more information on the overall process, visit the MPCA's TMDL Policy and Guidance webpage.

6 Reasonable Assurance

6.1 Non-regulatory

Moderate watershed nonpoint source bacteria load reductions were identified for several impaired streams addressed in this TMDL. In addition, several non-pollutant stressors were identified to be addressed, including: mitigating altered hydrology, reduce peak flows, increase base flows, incorporate natural channel designs into ditch maintenance, increase instream habitat, protect riparian corridors, and remove stream connectivity barriers.

The implementation plan from the Grand Marais Creek Watershed TMDL and the restoration and protection strategies from the Grand Marais Creek WRAPS will be incorporated into local water management plans. The listing of implementation activities within a local water management plan such as a 1W1P will improve the chance of those projects being funded by state grant funds. The cooperation among local agencies is excellent within the Grand Marais Creek Watershed. Recently, LGUs cooperated for a 1W1P process for the Red Lake River planning area, which includes the drainage are of Grand Marais Creek. The processes of writing the Red Lake River 1W1P and the TMDL/WRAPS documents were concurrent and shared similar details and goals. Local staff that managed the WRAPS project also participated in the 1W1P process. Members of the 1W1P planning group were also members of the WRAPS Technical Advisory Committee (TAC)/Core Team.

At the local level, the West Polk SWCD, Red Lake Watershed District (RLWD), National Resources Conservation Service (NRCS), Middle Snake Tamarac Rivers Watershed District (MSTRWD), and Pennington SWCD currently implement programs that target improving water quality and have been actively involved in projects to improve water quality in the past. The RLWD provides cost-share funding to SWCDs for erosion projects ($15,000/year/SWCD). Leftover funding from the Pennington County SWCD's ditch inventory was shared with the West Polk SWCD so that ditches throughout the entirety of the Red Lake River Watershed 1W1P Planning Area will be inventoried for erosion problems and buffer compliance. Local, State, Tribal, and Federal agencies that have cooperated on projects in the past and plan to work together in the future to improve water quality and habitat in this watershed include:

- RLWD
- West Polk SWCD
- MSTRWD
- NRCS
- United States Fish and Wildlife Service (USFWS)
- Minnesota Department of Natural Resources (DNR)
- MPCA
- BWSR

Willing landowners, within this watershed, have implemented many practices in the past including: cover crops, no till/strip till, seasonal residue use, filter strips/buffers/field borders, field and farmstead windbreaks, structures for water control, grade stabilization structures, ring dikes, nutrient and pest management, pasture management systems, CRP grass seeding, and wetland restorations. Currently, the most common practices are cover crops, seasonal residue use, and structures for grade and water control. It is assumed that these activities will continue. Information about grants received and projects completed or in progress can be found on the RLWD website: http://www.redlakewatershed.org and the MSTRWD website: http://www.mstrwd.com.

Ditch management (herbicide applications, mowing), traditional approaches to ditch construction, traditional approaches to culvert sizing, added costs of two-stage ditch design, and added costs of larger culverts (for fish passage) are some of the known barriers to the establishment of quality aquatic life communities. However, there are solutions that can help overcome these obstacles.

Clean Water Fund grants are a significant source of state funding for implementation projects. At the federal level, funding can be provided through Section 319 grants that provide cost-share dollars to implement activities in the watershed. State Clean Water Partnership 0% interest loans are available through the MPCA. Various other funding and cost-share sources exist, which will be listed in the Grand Marais Creek WRAPS Report.

Restoration projects such as the Brandt Channel Outlet Restoration and Grand Marais Creek Outlet Restoration projects have been completed and the success of those projects could aid the planning and funding of future projects. Monitoring will continue, and adaptive management will be in place to evaluate the progress made towards achieving water quality goals. Extensive lists of projects and goals for the watershed can be found in Grand Marais Creek WRAPS (https://www.pca.state.mn.us/water/watersheds/red-river-north-grand-marais-creek) and Red Lake River Watershed 1W1P (http://westpolkswcd.com/1w1p.html) documents.

6.2 Regulatory

While there are no regulated sources of water pollution in the watershed at this time, the following are the approaches for addressing any possible future regulated sources. The state's buffer law is also described at the end of this section.

6.2.1 Regulated Construction Stormwater

State implementation of the TMDL will be through action on NPDES permits for regulated construction stormwater. To meet the WLA for construction stormwater, construction stormwater activities are required to meet the conditions of the Construction General Permit under the NPDES program and properly select, install, and maintain all BMPs required under the permit, including any applicable additional BMPs required in Appendix A of the Construction General Permit for discharges to impaired waters, or meet local construction stormwater requirements if they are more restrictive than requirements of the State General Permit.

6.2.2 Regulated Industrial Stormwater

To meet the WLA for industrial stormwater, industrial stormwater activities are required to meet the conditions of the industrial stormwater general permit or Nonmetallic Mining & Associated Activities general permit (MNG49) under the NPDES program and properly select, install and maintain all BMPs required under the permit.

6.2.3 Wastewater National Pollutant Discharge Elimination System and State Disposal System Permits

The MPCA issues permits for wastewater treatment facilities that discharge into waters of the state. The permits have site-specific limits on bacteria that are based on water quality standards. Permits regulate discharges with the goals of: (1) protecting public health and aquatic life, and (2) assuring that every facility treats wastewater. In addition, State Disposal System (SDS) Permits set limits and establish controls for land application of sewage.

6.2.4 Subsurface Sewage Treatment Systems Program

SSTS, commonly known as septic systems, are regulated by Minn. Stat. 115.55 and 115.56.

These regulations detail:

- Minimum technical standards for individual and mid-size SSTS;

- A framework for local administration of SSTS programs and;
- Statewide licensing and certification of SSTS professionals, SSTS product review and registration, and establishment of the SSTS Advisory Committee.

6.2.5 Feedlot Rules

The MPCA regulates the collection, transportation, storage, processing and disposal of animal manure and other livestock operation wastes. The MPCA Feedlot Program implements rules governing these activities and provides assistance to counties and the livestock industry. The feedlot rules apply to most aspects of livestock waste management including the location, design, construction, operation and management of feedlots and manure handling facilities.

There are two primary concerns about feedlots in protecting water:

- Ensuring that manure on a feedlot or manure storage area does not run into water;
- Ensuring that manure is applied to cropland at a rate, time and method that prevents bacteria and other possible contaminants from entering streams and ground water.

6.2.6 Minnesota Buffer Law

Minnesota's Buffer Law (http://www.bwsr.state.mn.us/buffers/) was originally signed into law by Governor Dayton in June 2015 and was more recently amended by the Legislature and signed into law by Governor Dayton on April 25, 2016. Minnesota's buffer law establishes new perennial vegetation buffers of 50 feet along public waters and 16.5 feet along ditches. The law provides flexibility and financial support for landowners to install and maintain buffers. Many segments of streams and ditches have been poorly buffered due to landowner choice, "grandfathering" status of old ditches that are not subject to current rules, and incomplete enforcement. This law will provide the means and support needed to fix those problems and significantly improve and protect water quality. Funding may also be available to LGUs for implementation and enforcement the law.

7 Monitoring Plan

7.1 Stream Monitoring

As part of the MPCA Intensive Watershed Monitoring strategy, four stream sites were monitored for biology (fish and macroinvertebrates) and water chemistry: Judicial Ditch 75 at CR 22, County Ditch 2 at CR 62, Grand Marais Creek at CR 64, and Judicial Ditch 1 at CR 22. Additional sites will be sampled in the next 10-year cycle. Fewer sites were sampled as part of the assessment for this TMDL study due to no water in many streams during 2012, which was a dry year. Details about the MPCA IWM strategy can be found in the Grand Marais Creek Watershed Monitoring and Assessment Report: https://www.pca.state.mn.us/sites/default/files/wq-ws3-09020306b.pdf

The RLWD has been collecting water quality samples in the Grand Marais Creek Watershed for its long-term monitoring program since 1980. Field measurements of DO, temperature, turbidity, specific conductivity, pH, and stage are collected during each site visit (if there is water). Four rounds of samples are also collected and analyzed for TP, OP, TSS, total dissolved solids, TKN, ammonia nitrogen, nitrates + nitrites, and *E. coli* at most of the sites. For the past few years, biochemical oxygen demand (BOD) analysis has been added for the sites that are located on reaches that have had low DO levels. BOD was replaced with chemical oxygen demand analysis in 2014 because too many BOD levels were too low to be measured. Sampling months are alternated each year with the goal of collecting at least five samples per calendar month within a 10-year period. Within the Grand Marais Creek Watershed, the RLWD monitors:

1. Grand Marais Creek at Polk County Road 35 (130th Street Northwest, S008-903)
2. Grand Marais Creek at 110th Street Northwest (S008-902)
3. Polk County Ditch 2 at Polk County Road 62 (S004-131)
4. RLWD Ditch 15 at CSAH 20 (S008-897)

River Watch is a volunteer monitoring program that gives high school students the opportunity to collect water quality data. These data are collected using the same methods that are used by professionals, and is stored in the EQuIS database along with all other data that is collected within the watershed. Students from East Grand Forks (Sacred Heart High School) and Fisher High School have participated in the program and collected data within the Grand Marais Creek Watershed. RLWD and International Water Institute staff should continue to work with those schools and encourage the inclusion of Grand Marais Creek Watershed sites in their monitoring repertoire.

The Red Lake River Monitoring sites that are co-located with United States Geological Survey (USGS) gauging stations have been intensively monitored for other projects, including the Major Watershed Pollutant Load Monitoring Network (WPLMN). Frequent sampling may continue for the MPCA's WPLMN. The International Water Institute has worked with the MPCA to conduct that sampling.

Overall, less data has been collected in the Grand Marais Creek Watershed compared to other watersheds. Additional data needs to include long-term flow monitoring on Grand Marais Creek upstream of CD2, continuous DO data collection on streams with biological impairments, and regular water quality monitoring on all assessed AUIDs.

The collection of continuous DO data is essential, at most sites, for the collection of DO measurements prior to 9:00 am. The MPCA requires a record of pre-9am DO readings in order to declare that the waterway contains enough DO to fully support aquatic life. DO logging equipment can collect regular DO measurements (e.g. every 30 minutes) while deployed in a waterway. Equipment is deployed for a maximum of two weeks at a time before it is retrieved for data download, cleaning, and re-calibration. Prior to the next State water quality assessment of the Grand Marais Creek Watershed, continuous DO monitoring should be conducted to fully assess the capacity of key reaches in the watershed to support aquatic life. Priority should be given to reaches and sites that are too remotely located from LGU offices for pre-9am measurements.

It is recommended, contingent on funding availability and priorities, that continuous, long-term flow monitoring stations be established on Grand Marais Creek at S008-897, on County Ditch 2 at S004-131, on County Ditch 2 at S008-897, on Judicial Ditch 1 at S005-571, and on Judicial Ditch 75 at S005-570) to improve future load calculations and assess how altered hydrology impacts impairments in this watershed.

Bolstered data collection efforts, contingent on funding availability and priorities, at key sites would aid with pre/post project and BMP evaluation:

1. RLWD Ditch 15 (Brandt Channel) at Highway 75 (S004-132) for evaluation of the effects of the Brandt Impoundment and outlet restoration project.
2. RLWD Ditch 15 at CSAH 20 (S008-897) as a pour-point monitoring site for AUID 09020306-509.
3. Polk County Ditch 2 at Polk County Road 62 (S004-131) to evaluate the effects of the Brandt Impoundment, Euclid Impoundment, Brandt Outlet Channel Restoration Project, and the Ditch 15 project.
4. Grand Marais Creek at Polk County Road 35 (130th Street Northwest, S008-903) to evaluate the effects of the Grand Marais Creek Outlet Restoration Project.
5. Grand Marais at 110th Street Northwest (S008-902) as a pour-point monitoring site for the Headwaters to CD 2 reach (09020306-507) of Grand Marais Creek.

7.2 BMP Monitoring

On-site monitoring of implementation practices, contingent on funding availability and priorities, should also take place in order to better assess BMP effectiveness. A variety of criteria such as land use, soil type, and other watershed characteristics, as well as monitoring feasibility, will be used to determine which BMPs to monitor. Under these criteria, monitoring of a specific type of implementation practice can be accomplished at one site and the results applied to similar practices under similar criteria and scenarios. Effectiveness of other BMPs can be extrapolated based on monitoring results.

8 Implementation Strategy Summary

The TMDL study's results aided in the selection of implementation activities during the Grand Marais Creek WRAPS process. The purpose of the WRAPS process is to support local working groups in developing scientifically-supported restoration and protection strategies for subsequent implementation planning. The Grand Marais Creek WRAPS Report is publicly available on the MPCA Grand Marais Creek Watershed website: https://www.pca.state.mn.us/water/watersheds/red-river-north-grand-marais-creek.

8.1 Permitted Sources

No permitted sources were identified as part of this TMDL.

8.2 Non-Permitted Sources

8.2.1 Bacteria Impairments

The following implementation activities were identified to address and further understand high *E. coli* levels in the impaired streams:

- Molecular source tracking sample analysis to identify specific sources of *E. coli* such as birds, beaver, humans, ruminants (cattle), geese, etc.
- Road overpass bird nesting deterrence practices
- Beaver dam removal and deterrence
- Signage near road crossings over impaired streams alerting residents of the high *E. coli* levels
- Continued monitoring.

8.2.2 Non-pollutant Stressors

The following implementation activities were identified during the SID study to address non-pollutant stressors that are impairing aquatic life:

- Prevent or mitigate activities that will further alter the hydrology of the watershed.
- Consider opportunities and options to reduce peak flows and increase base flows throughout the watershed.
- Incorporate the principles of natural channel design into stream restoration and ditch maintenance activities.
- Increase the quantity and quality of instream habitat throughout the watershed.
- At a minimum, enforce the requirements of the Minnesota Buffer Law. Seek opportunities and funding to improve and/or protect the quality of riparian corridor vegetation along all waterways, including ditches, using native vegetation whenever possible.
- Remove or retrofit physical connectivity barriers to enable fish passage at a greater range of flow conditions.
- Conduct an inventory of culverts in the watershed that are limiting fish passage.

In addition, the WRAPS TAC group identified the following strategies and projects to address non-pollutant stressors that are impairing aquatic life:

- Manage impoundments to allow discharge for base flow augmentation
- Improve fish passage and increase base flow in CD 43 and JD75 by retrofitting drop structures
- Install windrows to reduce field sediment erosion
- Retrofit JD1, JD75 and state ditch 3 with two-stage ditch to prevent bank slumping sources of sediment

- Large stream restoration along Grand Marais Creek with riparian buffer and field crossing modifications to increase connectivity and flow. Alternatively, a stream restoration project may be possible over a wider spatial scale on a smaller financial scale than the Outlet Restoration Project. The amount of channel excavation should be limited. Focus on the points in which there are clear barriers to flow/fish and address those in a scientifically sound manner.
- Implement perennial vegetation buffers of up to 16.5 feet or 50 feet (as indicated by the DNR Buffer Map: http://arcgis.dnr.state.mn.us/gis/buffersviewer/) along rivers, streams and ditches to filter nutrients and sediment, stabilize stream banks, and provide habitat for aquatic life in accordance with Minnesota's new Buffer Law. Provide incentives for the establishment of high-quality riparian buffers with deep-rooted native and woody vegetation.
- Sample tributary ditches at their pour-points during runoff events to prioritize ditches for stabilization and other BMPs to reduce sedimentation within Grand Marais Creek.

Implementation practices to restore the impaired streams within the Grand Marais Creek Watershed are discussed in more detail and prioritized in the WRAPS report and 1W1P.

8.3 Education and Outreach

Crucial to the success of the WRAPS and 1W1P implementation efforts to clean up impaired streams and protect non-impaired water bodies will be participation from local citizens. In order to gain support from these citizens, education and civic engagement opportunities will be necessary. A variety of educational avenues can and will be used throughout the Grand Marais Creek Watershed. These include (but are not limited to):

- Events, meetings, workshops, focus groups, trainings
  - Northwest Minnesota Water Festivals (Warren, Minnesota; Fertile, Minnesota)
  - Monthly watershed district meetings
  - Public meetings for TMDL, WRAPS, and 1W1P Reports
- Publications
  - Monthly water quality reports
  - Annual reports
  - County newsletter
- Websites
  - RLWD Facebook page: https://www.facebook.com/Red-Lake-Watershed-District-266521753412008/
  - www.redlakewatershed.org
  - www.rlwdwatersheds.org
  - http://westpolkswcd.com/1w1p.html

Local staff (conservation district, watershed, county, etc.) and board members work to educate the residents of the watersheds about ways to clean up their streams on a regular basis. Education will continue throughout the Grand Marais Creek Watershed.

8.4 Technical Assistance

The SWCDs, watershed districts, NRCS, and county staff within the watershed provide assistance to landowners for a variety of projects that benefit water quality. Assistance provided to landowners includes agricultural and rural BMPs. This technical assistance includes education and one-on-one training. Many opportunities for technical assistance are as a result of educational workshops of trainings. It is important that these outreach opportunities for watershed residents continue. Marketing is necessary to motivate landowners to participate in voluntary cost-share assistance programs.

Programs such as state cost share, Clean Water Legacy funding, Clean Water Partnership 0% interest loans, AG BMP loans, Environmental Quality Incentives Program (EQIP), and Conservation Reserve Program (CRP) are available to help implement the best conservation practices that each parcel of land is eligible for to target the best conservation practices per site. Conservation practices may include, but are not limited to: stormwater bioretention, septic system upgrades, feedlot improvements, invasive species control, wastewater treatment practices, and agricultural and rural BMPs. More information about types of practices and implementation of BMPs are discussed in the Grand Marais Creek WRAPS Report and 1W1P.

8.5 Partnerships

Partnerships with counties, cities, townships, citizens, businesses, watersheds, are one mechanism through which the RLWD, MSTRWD, and the Polk and Pennington County SWCDs will protect and improve water quality. Strong partnerships with state and local government to protect and improve water resources and to bring waters within the Grand Marais Creek Watershed into compliance with State standards will continue. A partnership with local government units (LGUs) and regulatory agencies such as cities, townships and counties may be formed to develop and update ordinances to protect the areas water resources.

8.6 Cost

The Clean Water Legacy Act requires that a TMDL include an overall approximation of the cost to implement a TMDL [Minn. Stat. 2007, § 114D.25]. The cost estimate for bacteria load reduction is based on unit costs for the two major sources of bacteria: livestock and imminent threat to public health septic systems (ITPHSS). The unit cost for bringing animal units (AU) under manure management plans and feedlot lot runoff controls is $350/AU. This value is based on USDA EQIP payment history and includes buffers, livestock access control, manure management plans, waste storage structures, and clean water diversions. Repair or replacement of ITPHSS was estimated at $7,500/system (EPA 2011). Multiplying those unit costs by an estimated 1 ITPHSS and 240 AU in the impaired reach subwatersheds provides a total cost of approximately $91,500.

8.7 Adaptive Management

This list of implementation elements and the more detailed WRAPS report that will be prepared following this TMDL assessment focuses on adaptive management Figure 8-1. Continued monitoring and "course corrections" responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in this TMDL. Management activities will be changed or refined to efficiently meet the TMDL and lay the groundwork for de-listing the impaired water bodies.

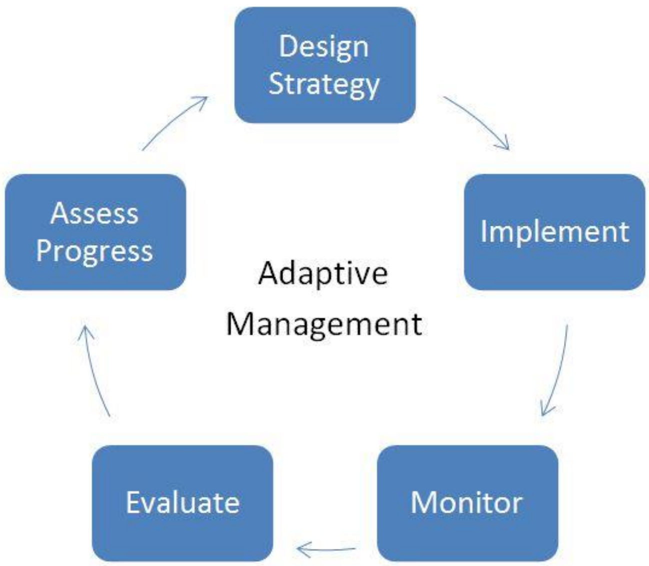

Figure 8-1. Adaptive Management

9 Public Participation

9.1 Technical Committee Meetings

The Grand Marais Creek Watershed TAC is made up of numerous local partners who have been involved at various levels throughout the project. The TAC is made up of members representing the RLWD, Middle-Snake-Tamarac Rivers Watershed District, MPCA, DNR, BWSR, Counties, NRCS, and SWCDs within the watershed. Table 9-1 outlines the meetings that occurred regarding the Grand Marais Creek Watershed monitoring, TMDL development, and WRAPS report planning. Additional information about technical committee members and meeting agendas can be found on the Grand Marais Creek Watershed TMDL and WRAPS website. The 1W1P process overlapped with this project and many of the same organizations and individuals were included in both processes.

Table 9-1. Grand Marais Creek Watershed TMDL Technical Advisory Committee Meetings

Grand Marais Creek Watershed TMDL Technical Advisory Committee Meetings		
Date	**Location**	**Meeting Focus**
April 18, 2013	Cabela's, East Grand Forks, MN	Impairment and Data Summary Existing Watershed Model Review Communications Plan
March 9, 2015	Public Library, East Grand Forks, MN	Stressor ID, TMDL and WRAPS Update Stream Geomorphic Survey Results Coordination with 1W1P Process
April 13, 2016	RLWD Office, Thief River Falls, MN	TMDL Results WRAPS Kick-off

9.2 Civic Engagement

The MPCA along with the local partners and agencies in the Grand Marais Creek Watershed recognize the importance of public involvement in the watershed process. Table 9-2 outlines the opportunities used to engage the public and targeted stakeholders in the watershed.

Table 9-2. Grand Marais Creek Watershed TMDL Civic Engagement Meetings

Grand Marais Creek Watershed TMDL Civic Engagement Meetings		
Date	**Location**	**Focus**
April 18, 2013	Cabela's, East Grand Forks, MN	Overview of WRAPS process State of Grand Marais Watershed Water Quality and Science of TMDLs Social Aspects of TMDLs
March 9, 2015	Public Library, East Grand Forks, MN	Bacteria Impairments Turbidity Impairments Biological Impairments 1W1P Status RLWD Information

Public Notice

An opportunity for public comment on the draft TMDL report was provided via a public notice in the State Register from January 7, 2019 through February 6, 2019. Only one comment letter was received during the public notice period that resulted in minor changes to this document.

10 Literature Cited

East Polk County Soil and Water Conservation District (SWCD); West Polk County SWCD. 2012. Polk County Local Water Plan. http://westpolkswcd.com/local-water-management.html

Minnesota Pollution Control Agency (MPCA). 2012. Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List. *Wq-iw1-04,* 52 pp.

Minnesota Pollution Control Agency (MPCA). October 2015. Grand Marais Creek Watershed Restoration and Protection Project: Stressor Identification Report. https://www.pca.state.mn.us/sites/default/files/wq-ws5-09020306a.pdf

Minnesota Pollution Control Agency (MPCA). June 2016. Grand Marais Creek Watershed Monitoring and Assessment Report. https://www.pca.state.mn.us/sites/default/files/wq-ws3-09020306b.pdf.

Red Lake River Watershed District (RLWD). 2006. Red Lake Watershed District 10-Year Comprehensive Plan. http://www.redlakewatershed.org/planupdate/Final%20Draft/RLWD%2010-yr%20Plan-Atts_5.19.06_mk.pdf

US Census Bureau. 2011. Census 2010 Data Minnesota. Prepared by the US Census Bureau, 2011.

Red Lake River One Watershed One Plan. August 16, 2016 Draft report. http://westpolkswcd.com/uploads/3/4/8/5/34855804/red_lake_river_1w1p_draft_aug_2016.pdf

Emmons & Olivier Resources, Inc. and Chris Lenhart. May 30, 2014. Geomorphic and Hydrologic Influences on TMDL Impairments in the Grand Marais Creek Watershed (AUID 09020306). http://www.eorinc.com/documents/GM%20Geomorph.pdf.

11 Load Duration Curve Supporting Information

11.1 Flow and Water Quality Data Sources

Table 11-1. *E. coli* load duration curve flow and water quality data sources

***E. coli* load duration curve flow and water quality data sources:**					
Impaired Reach AUID	**Flow Record**		**Water Quality**		**Comments**
	Data Source	**Date Range***	**Data Source**	**Date Range**	
09020306-515	RLWD gauge at S004-131	2006-2007, 2013-2015	S004-131	2008-2010, 2012-2014	The location of WQ station S004-131 coincides with the RLWD gauge and the outlet of HSPF 357.
	HSPF basin 357	2006-2009			
09020306-519	RLWD gauge at S007-693**	2013-2015	S005-571	2009-2013	Gaged flow area-weighted to water quality monitoring station S005-571.
	HSPF basin 521	2006-2009			

E. coli load duration curve flow and water quality data sources:					
Impaired Reach AUID	Flow Record		Water Quality		Comments
	Data Source	Date Range*	Data Source	Date Range	
09020306-520	RLWD gauge at S005-570	2013-2015	S005-570	2009-2013	The location of WQ station S005-570 coincides with the RLWD gauge and outlet of HSPF basin 475.
	HSPF basin 475	2006-2009			

*Stage data converted to flow on additional dates for which stage data available in EQuIS.

Table 11-2. Flow and water quality data used in Dissolved Oxygen Stressor ID (see Section 3.5.2).

E. coli load duration curve flow and water quality data sources:						
Impaired Reach AUID	Flow Record		Water Quality			
			Monitoring Station	Data Range		
	Data Source	Date Range*		DO	TP	Temperature
09020306-507	RLWD gauge at CSAH 65	2014-2015	S002-083	2004-2014	2004-2009, 2011-2012, 2014	2004-2010, 2013
			S002-984	2005-2007, 2010-2014	2010-2014	2005, 2007, 2010-2014
09020306-509	RLWD gauge at S007-693	2006-2007, 2010	S003-276	2006-2013	2006-2013	2006-2013
			S004-132	2006-2014	2006-2014	2006-2014
			S004-133	2006-2013	2006-2013	2006-2013

*Stage data converted to flow on additional dates for which stage data available in EQuIS.

11.2 Paired *E. coli* water quality and flow records

Figures 3-12 through 3-14 show that some high *E. coli* concentrations have occurred while flow was zero. Data was examined to see if excluding days with no flow (and no load) would change the outcome of the assessment calculations.

11.2.1 CD 2 (AUID 09020306-515) at S004-131

The July geometric mean for only the samples collected during measurable flow (6 of the 11 July samples) would still exceed the water quality standard at a concentration of 154.85 org/100ml. There are insufficient August samples with measurable flow (2 of the 8 August samples) to meet minimum data requirements for an assessment. Because the July geometric mean still exceeds the standard with sufficient data, the reach remains impaired and a TMDL is still necessary. Additional monitoring is recommended.

Table 11-3. Paired *E. coli* and flow records for CD2. Observed exceedances of the *E. coli* water quality standard for which there is no paired flow are in bold.

Paired *E. coli* water quality and flow records for CD 2 (AUID 09020306-515) at S004-131		
Date	Observed *E. coli* (MPN/100mL)	Flow (cfs)
8/14/2008	45	0
9/22/2008	721.5	0
6/9/2009	148.3	4.42
6/17/2009	71.2	.41
6/23/2009	410.6	0
7/9/2009	137.6	66.63
7/16/2009	248.1	30.22
7/22/2009	114.5	11.17
8/4/2009	70.6	10.48
8/12/2009	127.4	0
8/18/2009	613.1	14.92
6/9/2010	**186**	**39.28**
6/14/2010	108	65.86
7/6/2010	55.1	31.29
7/21/2010	**524.7**	**32.93**
6/5/2012	34.5	0
6/12/2012	29.9	.41
6/18/2012	62.3	0
7/9/2012	**1,732.9**	**0**
7/24/2012	90.9	**0**
7/31/2012	**435.2**	**0**
8/7/2012	**770.1**	**0**
8/15/2012	**920.8**	**0**
8/28/2012	**2,419.6**	**0**
5/20/2013	96	0
6/12/2013	41	31.29
6/20/2013	10	6.64
6/25/2013	86	0
7/11/2013	75	0

Paired *E. coli* water quality and flow records for CD 2 (AUID 09020306-515) at S004-131		
Date	Observed *E. coli* (MPN/100mL)	Flow (cfs)
7/18/2013	116.9	0
8/5/2013	74	0
6/18/2014	16.6	65.1
7/24/2014	122	124.8
10/2/2014	60.2	0

11.2.2 JD 1 (AUID 09020306-519) at S005-571

There are few samples collected at JD1 during July days with measurable or unknown (shown as N/A, or "not available") levels of flow (five), but they still exceed the monthly geomean standard for July (132 org/100ml geomean for days with measurable or unknown flow).

Table 11-4. Paired *E. coli* and flow records for JD1.

Paired *E. coli* water quality and flow records for JD 1 (AUID 09020306-519) at S005-571		
Date	Observed *E. coli* (MPN/100mL)	Flow (cfs)
6/2/2009	75.5*	16.2
6/9/2009	38.4	11.6
6/17/2009	47.1	5.6
7/9/2009	80.1	22.0
7/16/2009	96	13.9
7/22/2009	1203.3	0
6/14/2010	61.3	Normal
6/23/2010	35	Normal
7/6/2010	41.9	Normal
7/21/2010	105.4	Low
8/4/2010	73.3	Normal
8/12/2010	38.4	Low
8/19/2010	**1046.2**	**Low**
6/5/2012	410	Low
6/12/2012	117.8	Low
6/18/2012	**387.3**	**Low**
7/9/2012	**157.6**	**Low**

Paired *E. coli* water quality and flow records for JD 1 (AUID 09020306-519) at S005-571		
Date	Observed *E. coli* (MPN/100mL)	Flow (cfs)
7/24/2012	90.4	Low
7/31/2012	9.7	0
8/7/2012	115.3	0
8/15/2012	35	0
8/28/2012	5.8*	0
6/12/2013	59.1	26.6
6/25/2013	29.8	2.8
7/11/2013	**143**	**0**
7/18/2013	**1553.1**	**0**
8/8/2013	**2419.6**	**0**
8/21/2013	**495.4**	**0**

* Average of replicates
Stream condition notes were used for dates on which neither modeled nor measured flow data were available.
Observed exceedances of the *E. coli* water quality standard for which there is no paired flow are in bold.

11.2.3 JD 75 (AUID 09020306-520) at S005-570

When JD1 June and July *E. coli* data from days with known, measurable flow are assessed, the geometric means for those months meet the 126 org/100ml standard. However, the July geometric mean still exceeds the standard (161.5 org/100ml) when days with unknown (N/A in Table 11-5) are included in the analysis. Therefore, there is insufficient data to recommend a delisting. Additional monitoring is recommended for *E. coli* and flow. Discrete state measurements from sampling events and a flow rating curve for S005-570 were used to calculate the values in Table 11-5.

Table 11-5 Paired *E. coli* and flow records for JD75.

Paired *E. coli* water quality and flow records for JD 75 (AUID 09020306-520) at S005-570		
Date	Observed *E. coli* (MPN/100mL)	Flow (cfs)
6/2/2009	11	43.76
6/9/2009	46.4	6.53
6/17/2009	62	1.22
7/9/2009	74.9	6.33
7/16/2009	67.7	3.10
7/22/2009	1468.1*	26.43
8/4/2009	43.1	0

Paired *E. coli* water quality and flow records for JD 75 (AUID 09020306-520) at S005-570		
Date	Observed *E. coli* (MPN/100mL)	Flow (cfs)
8/12/2009	96	0
8/18/2009	201.4	16.74
6/14/2010	**291**	**15.97**
6/23/2010	90.9	6.72
7/6/2010	**172.3**	**Normal**
7/21/2010	**980.4**	**31.58**
8/4/2010	**228.2**	**Normal**
8/12/2010	**365.4**	**0**
6/5/2012	**570.0**	**32.59**
6/12/2012	**579.4**	**0**
6/18/2012	**686.7**	**0**
7/9/2012	**193.5**	**0**
7/24/2012	44.1	0
7/31/2012	117.1	0
8/7/2012	**135.4**	**0**
8/15/2012	**93.4**	**0**
6/12/2013	40.4	71.6
6/25/2013	53.7	27.6
7/11/2013	29.2	31.4
7/18/2013	78	35.6
8/1/2013	49.5	52.5
8/8/2013	37.3	35.4
8/21/2013	29.5	1.6

* Average of replicates
Stream condition notes were used for dates on which neither modeled nor measured flow data were available.
Observed exceedances of the *E. coli* water quality standard for which there is no paired flow are in bold.