Stressor Identification

July 2019

Otter Tail River Watershed Stressor Identification Report

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Acronyms

AUID – Assessment Unit Identification

BMP – Best Management Practice

BRRWD – Buffalo-Red River Watershed District

Chl-a – Chlorophyll-a

CR – County Road

CSAH – County State Aid Highway

cfs – cubic feet per second

DNR – Minnesota Department of Natural Resources

DO – Dissolved Oxygen

EPA – United States Environmental Protection Agency

EPT – Ephemeroptera, Plecoptera, and Trichoptera

F-IBI – Fish Index of Biological Integrity

HSPF – Hydrological Simulation Program - FORTRAN

IBI – Index of Biological Integrity

IWM – Intensive Watershed Monitoring

M-IBI – Macroinvertebrate Index of Biological Integrity

MPCA – Minnesota Pollution Control Agency

MSHA – MPCA's Stream Habitat Assessment

NAIP – National Agriculture Imagery Program

NLCD – National Land Cover Database

OTRW – Otter Tail River Watershed

PRWD – Pelican River Watershed District

SD – Standard Deviation

SID – Stressor Identification

TIV – Tolerance Indicator Value

TP – Total Phosphorus

TSS – Total Suspended Solids

USACE – United States Army Corps of Engineers

USGS – United States Geological Survey

WHAF – Watershed Health Assessment Framework

Executive summary

The Minnesota Pollution Control Agency (MPCA) follows a watershed approach to systematically monitor and assess surface water quality in each of the state's 80 major watersheds. A key component of this approach is Intensive Watershed Monitoring (IWM), which includes biological (i.e., fish and macroinvertebrate) monitoring to evaluate overall stream health. In 2016 and 2017, the MPCA conducted biological monitoring at several stations throughout the Otter Tail River Watershed (OTRW). An Index of Biological Integrity (IBI) score was calculated for each fish (F-IBI) and macroinvertebrate (M-IBI) monitoring visit. The biological monitoring results for the OTRW were then assessed to identify individual stream reaches that were not supporting a healthy fish and/or macroinvertebrate assemblage. A reach with a low IBI score(s) (i.e., below an established threshold) is considered "impaired" (i.e., unable to support its designated beneficial use) for aquatic life. A total of six reaches were determined to have a F-IBI and/or M-IBI impairment in the OTRW, including segments of the Otter Tail River, Pelican River, Toad River, and Judicial Ditch 2.

This report identifies the probable causes, or "stressors", that are likely contributing to the biological impairments in the OTRW. Five candidate causes were examined as potential stressors for the biologically impaired reaches: loss of longitudinal connectivity, flow regime instability, insufficient physical habitat, high suspended sediment, and low dissolved oxygen (DO). Causal analysis was then performed to determine and evaluate connections between each candidate cause and the biological impairments.

Table 1 lists the stressors identified for each of the biologically impaired reaches. Connectivity barriers (e.g., dams, perched culverts, and beaver dams) appear to be adversely affecting fish passage along the Toad River (526), Pelican River (767), and Judicial Ditch 2 (764). Flow regime instability (i.e., high and quick peak flows and/or prolonged periods of low or no discharge) is a substantial stressor for Judicial Ditch 2 (764), and to a lesser extent, the Pelican River (772). Nearly all of the reaches have instream habitat that is either naturally limited (e.g., lack of coarse substrate) or has been degraded (e.g., embeddedness) due to alterations to the stream channel and/or the natural hydrology of the landscape. Similarly, almost all of the reaches experience periods of high suspended sediment as a result of bank instability and/or soil erosion. Lastly, low DO is a stressor to the Pelican River (772 and 767) and Judicial Ditch 2 (764), particularly in the summer months.

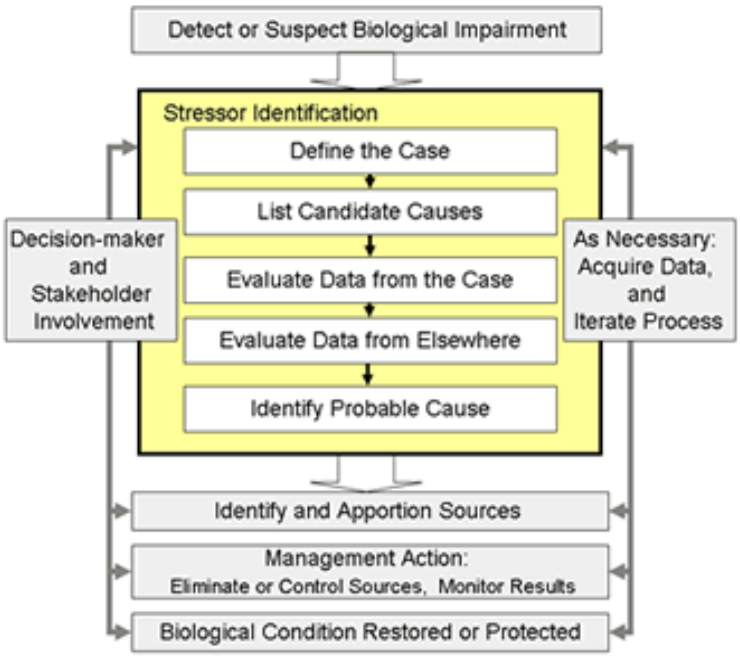
Table 1. Summary of the stressors associated with the biologically impaired reaches in the OTRW.

Reach name (AUID suffix)	Biological impairment(s)	Stressors				
		Loss of longitudinal connectivity	Flow regime instability	Insufficient physical habitat	High suspended sediment	Low dissolved oxygen
Toad River (526)	F-IBI	●		●	●	
Pelican River (772)	F-IBI/M-IBI		●	●	●	●
Pelican River (767)	F-IBI	●		●		●
Judicial Ditch 2 (764)	F-IBI	●	●	●	●	●
Otter Tail River (504)	M-IBI				●	
Otter Tail River (502)	F-IBI			●	●	

Introduction

Stressor identification (SID) is a formal and rigorous methodology for determining the causes, or "stressors", that are likely contributing to the biological impairment of aquatic ecosystems (United States Environmental Protection Agency (EPA), 2000). The initial step in the SID process (Figure 1) is to define the subject of the analysis (i.e., the case) by determining the geographic scope of the investigation and the effects that will be analyzed. Thereafter, a list of candidate causes (i.e., potential stressors) that may be responsible for the observed biological effects is developed. The candidate causes then undergo causal analysis, which involves the evaluation of available data. Typically, the majority of the data used in the analysis is from the study watershed, although evidence from other case studies or scientific literature can also be drawn upon. Analyses conducted during this step combine measures of the biological response, with direct measures of proximate stressors. Upon completion of causal analysis, strength-of-evidence analysis is used to determine the probable stressors for the biological impairment. Confidence in the final SID results often depends on the quality of data available to the process. In some cases, additional data collection may be necessary to accurately identify the stressors.

Figure 1. Conceptual model of the SID process (EPA, 2012a).



Section 1: Watershed overview

1.1 Physical setting

The Otter Tail River Watershed (OTRW), United States Geological Survey (USGS) Hydrologic Unit Code 09020103, is situated in northwestern Minnesota and is part of the larger Red River of the North Basin. The OTRW has a drainage area of 1,909 square miles and encompasses portions of the following counties, listed in order of the percentage of watershed area: Otter Tail (65%), Becker (28%), Wilkin (5%), Clearwater (1%), Clay (<1%), and Mahnomen (<1%). Cities within the watershed include Battle Lake, Breckenridge, Detroit Lakes, Fergus Falls, Frazee, New York Mills, Pelican Rapids, and Perham.

1.2 Surface water resources

The Otter Tail River and Pelican River are the prominent rivers in the OTRW. The Otter Tail River extends from its origin at the outlet of Elbow Lake, situated approximately 22 miles northeast of Detroit Lakes, to its confluence with the Bois de Sioux River, located in Breckenridge; the confluence of these rivers forms the Red River of the North. The Pelican River stretches from its headwaters, located approximately five miles north of Detroit Lakes, to its confluence with the Otter Tail River, located at the western edge of Fergus Falls. The OTRW contains 387 miles of perennial stream and river, 316 miles of intermittent stream, 154 miles of intermittent drainage ditch, and 69 miles of perennial drainage ditch (DNR, 2014b). There are also 605 named lakes in the watershed (DNR, 2014b), the largest of which are Big Pine, Dead, North Lida, Otter Tail, Pelican, Rush, Star, and West Battle.

According to the MPCA (2013), at least 41% of the watercourses in the OTRW have been physically altered (i.e., channelized, ditched, or impounded). These alterations, coupled with historical changes in land cover (i.e., native vegetation to cropland), have altered the natural flow regime of many watercourses (EOR, 2009).

1.3 Geology and soils

The OTRW is divided into three physiographic regions. The Itasca Moraine region encompasses the upstream portion of the watershed. Soils in this region are derived from outwash and glacial till material, with textures ranging from sand to sandy loam. The middle segment of the watershed is characterized by the Alexandria Moraine Complex and an outwash plain. The soils of this region formed from glacial till and outwash and have textures ranging from sand to clay loam. Lastly, the Fergus Falls Till Plain and the Glacial Lake Agassiz Lake Plain are located in the downstream portion of the watershed. Soils in this region formed from glacial till and lacustrine sediments, with textures ranging from loam to clay.

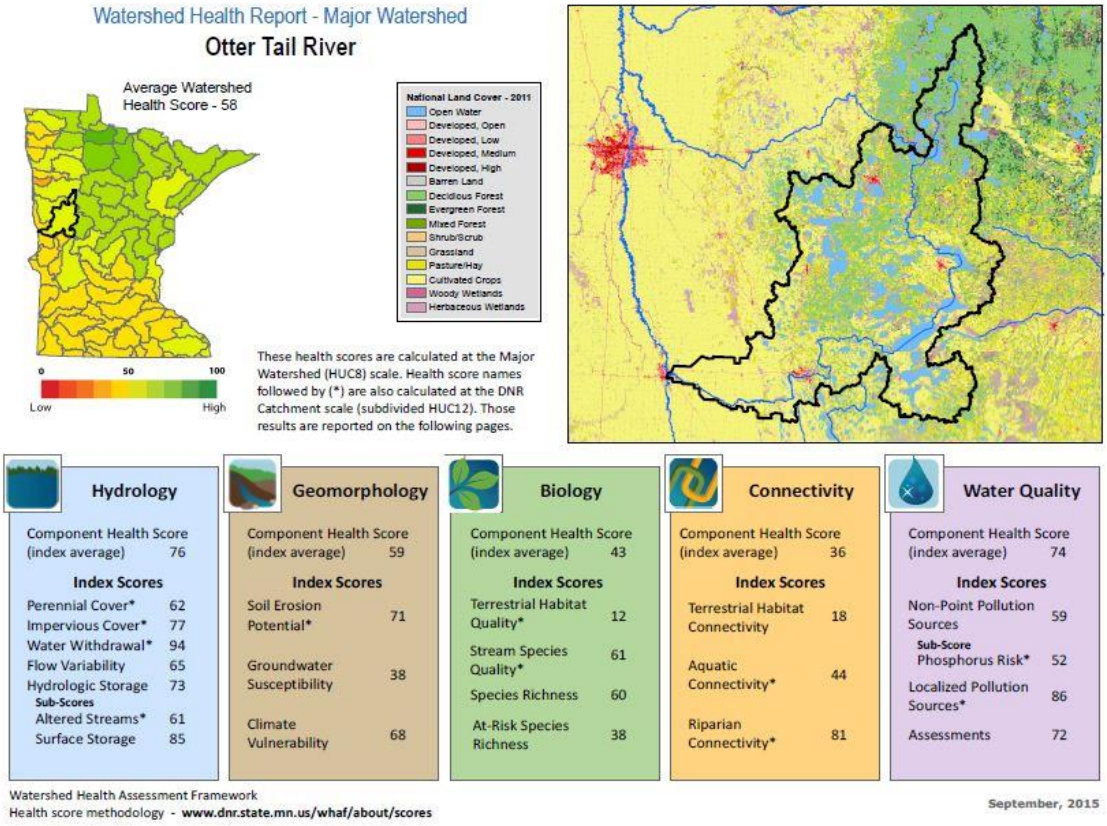
1.4 Land use and ecoregions

According to the National Land Cover Database (NLCD) 2011 (USGS, 2011), cultivated crops (27%) and deciduous forest (27%) are the prominent land uses in the OTRW. Other notable land cover groups in the OTRW included open water (15%), hay/pasture (14%), wetlands (7%), developed (6%), herbaceous (4%), and shrub/scrub (1%). The OTRW intersects three distinct ecoregions (EPA, 2012b). The North Central Hardwood Forests ecoregion (74%) covers the largest portion of the OTRW, while the Northern Lakes and Forests ecoregion (16%) is located in the upstream extent of the watershed and the Red River Valley ecoregion (10%) is found in the downstream extent of the watershed.

1.5 Ecological health

The Minnesota Department of Natural Resources (DNR) developed the Watershed Health Assessment Framework (WHAF) to assess the overall ecological health of a watershed. The WHAF evaluates and provides a score to each of the five core components of watershed health: hydrology, geomorphology, biology, connectivity, and water quality. Scores are ranked on a scale from 0 ("low") to 100 ("high"). Figure 2 presents the watershed health scorecard for the OTRW. The mean health score for the OTRW was 58.

Figure 2. Watershed health assessment scores for the OTRW.



1.6 Hydrological Simulation Program – FORTRAN Model

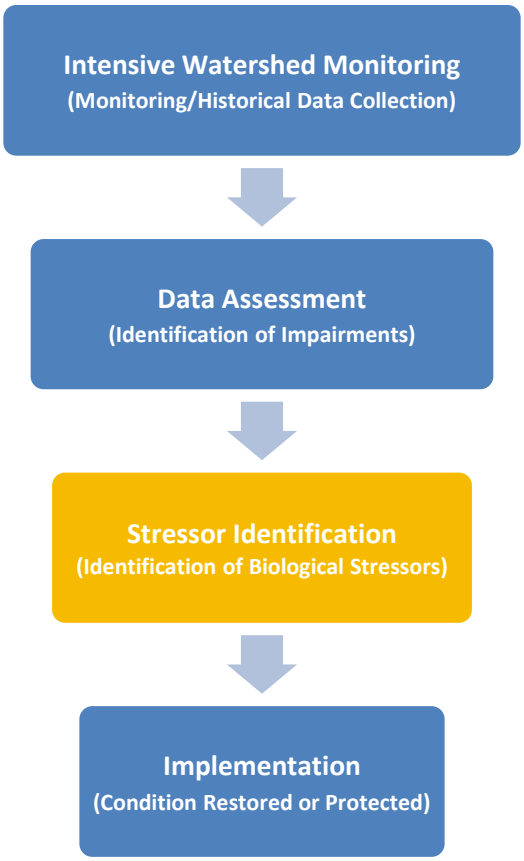
A Hydrological Simulation Program – FORTRAN (HSPF) model was developed for the OTRW to simulate the hydrology and water quality conditions throughout the watershed on an hourly basis from 1995 to 2014. The HSPF model incorporates watershed-scale Agricultural Runoff Model and Non-Point Source models into a basin-scale analysis framework that includes fate and transport in one dimensional stream channels. The model enables the integrated simulation of land and soil contaminant runoff processes with in-stream hydraulic and sediment-chemical interactions. The result of this simulation is a time history of the water quality and quantity at the outlet of each subwatershed. The HSPF model outputs were used in the evaluation of several of the candidate causes outlined in this SID report.

Section 2: Biological monitoring and impairments

2.1 Watershed approach

The MPCA utilizes a watershed approach (Figure 3) to systematically monitor and assess surface water quality in each of the state's 80 major watersheds. A key component of this approach is Intensive Watershed Monitoring (IWM), which includes biological (i.e., fish and macroinvertebrate) monitoring to evaluate overall stream health. In 2016 and 2017, the MPCA conducted biological monitoring at several stations throughout the OTRW. An Index of Biological Integrity (IBI) score was calculated for each fish (F-IBI) and macroinvertebrate (M-IBI) monitoring visit. The biological monitoring results for the OTRW were then assessed to identify individual stream reaches that were not supporting a healthy fish and/or macroinvertebrate assemblage. A reach with a low IBI score(s) (i.e., below an established threshold) is considered "impaired" (i.e., unable to support its designated beneficial use) for aquatic life. The biological impairments of the OTRW are the focus of this SID report. The results of the SID process will guide the development of implementation strategies to correct the impaired conditions, which may include the preparation of a Total Maximum Daily Load study.

Figure 3. Conceptual model of the watershed approach processes.



2.2 Monitoring stations

Table 2 lists the 28 biological monitoring stations that were sampled for fish and/or macroinvertebrates in the OTRW. The stations are situated along 21 separate reaches; individual reaches will be referred to by their respective three-digit Assessment Unit Identification (AUID) number suffix.

Table 2. List of biological monitoring stations in the OTRW.

AUID suffix	AUID	Name	Length (mi)	Monitoring station(s)
502	09020103-502	Otter Tail River	8	10EM060, 16RD001
504	09020103-504	Otter Tail River	19	16RD008
506	09020103-506	Otter Tail River	8	91RD001
521	09020103-521	Otter Tail River	12	05RD091, 16RD020
526	09020103-526	Toad River	11	16RD025, 16RD026
529	09020103-529	Otter Tail River	21	10EM178, 16RD030
532	09020103-532	Otter Tail River	11	16RD028
561	09020103-561	Brandborg Creek	3	05RD089
563	09020103-563	Dead Horse Creek	6	10RD079, 10RD082
565	09020103-565	Solid Bottom	2	09RD066
574	09020103-574	Otter Tail River	3	16RD034
611	09020103-611	Otter Tail River	5	05RD074
622	09020103-622	Unnamed Creek	5	05RD092
653	09020103-653	Reed Creek	1	16RD047
764	09020103-764	Judicial Ditch 2	2	16RD009
767	09020103-767	Pelican River	24	16RD016, 16RD019
768	09020103-768	Pelican River	23	16RD013
770	09020103-770	Toad River	4	16RD022
772	09020103-772	Pelican River	1	16RD032
773	09020103-773	Otter Tail River	16	91RD009
774	09020103-774	Otter Tail River	14	15EM084, 16RD012

2.3 Monitoring results

Table 3 provides the F-IBI and M-IBI scores for each of the biological monitoring stations in the OTRW. A total of six stations (22%) scored below their F-IBI impairment threshold, while three stations (11%) scored below their M-IBI impairment threshold; these stations are highlighted red.

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

Fish					Macroinvertebrate				
AUID suffix	Station	F-IBI class[1] (Use[3])	F-IBI impairment threshold	F-IBI score (mean)	AUID suffix	Station	M-IBI class[2] (Use[3])	M-IBI impairment threshold	M-IBI score (mean)
502	10EM060	SR(G)	49	63	**502**	**10EM060**	**PF(G)**	**31**	**21**
502	**16RD001**	**SR(G)**	**49**	**33**	502	16RD001	Not sampled		
504	16RD008	SR(G)	49	71	**504**	**16RD008**	**PF(G)**	**31**	**26**
506	91RD001	SR(G)	49	82	506	91RD001	PF(G)	31	43
521	05RD091	NR(G)	38	38	521	05RD091	PF(G)	31	57
521	16RD020	NR(G)	38	42	521	16RD020	PF(G)	31	53
526	**16RD025**	**NS(G)**	**47**	**37**	526	16RD025	NG(G)	51	54
526	16RD026	NH(G)	42	56	526	16RD026	NR(G)	53	64
529	10EM178	NS(G)	47	51	529	10EM178	SG(G)	43	69
529	16RD030	NS(G)	47	53	529	16RD030	SR(G)	37	53
532	16RD028	NR(G)	38	50	532	16RD028	SG(G)	43	67
561	05RD089	NC(G)	35	40	561	05RD089	SC(G)	43	51
563	**10RD079**	**NC(G)**	**35**	**31**	563	10RD079	NC(G)	32	34
563	10RD082	NC(G)	35	41	563	10RD082	NC(G)	32	35
565	09RD066	NC(G)	35	48	565	09RD066	NC(G)	32	32
574	16RD034	NR(G)	38	52	574	16RD034	PF(G)	31	47
611	05RD074	NS(G)	47	48	611	05RD074	NR(G)	53	59
622	05RD092	NH(G)	42	54	622	05RD092	NR(G)	53	55
653	16RD047	LG(G)	42	68	653	16RD047	SG(G)	43	72
764	16RD009	SS(M)	35	35	764	16RD009	PG(M)	22	28
767	**16RD016**	**NS(G)**	**47**	**36**	767	16RD016	SG(G)	43	67
767	**16RD019**	**NS(G)**	**47**	**34**	767	16RD019	SG(G)	43	65
768	16RD013	SR(G)	49	74	768	16RD013	SR(G)	37	55
770	16RD022	NS(G)	47	60	770	16RD022	SR(G)	37	45
772	**16RD032**	**NH(G)**	**42**	**27**	**772**	**16RD032**	**SR(G)**	**37**	**36**
773	91RD009	NR(G)	38	50	773	91RD009	PF(G)	31	54
774	15EM084	Not assessed			774	15EM084	PF(G)	31	33
774	16RD012	NS(G)	47	65	774	16RD012	PF(G)	31	70

[1] F-IBI Classes: Low Gradient (LG), Northern Coldwater (NC), Northern Headwaters (NH), Northern Rivers (NR), Northern Streams (NS), Southern Rivers (SR), Southern Steams (SS)
[2] M-IBI Class: Northern Coldwater (NC), Northern Forest Streams-Glide/Pool Habitats (NG), Northern Forest Streams-Riffle/Run Habitats (NR), Prairie Forest Rivers (PF), Prairie Streams-Glide/Pool Habitats (PG), Southern Coldwater (SC), Southern Forest Streams-Glide/Pool Habitats (SG), Southern Streams-Riffle/Run Habitats (SR),
[3] Tiered Aquatic Life Use Framework Designation: General Use (G), Modified Use (M)

2.4 Assessments and impairments

The biological monitoring results for the OTRW were formally assessed as part of the development of the *Otter Tail River Watershed Monitoring and Assessment Report* (MPCA, 2019) to determine if individual stream reaches met applicable aquatic life standards. As shown in Table 4, six reaches were determined to be biologically impaired; these reaches are highlighted red. The relative location of these reaches is displayed in Figure 4.

Table 4. Assessment results for reaches with biological monitoring data in the OTRW.

AUID suffix	Name	Description	Biological impairment(s)
502	**Otter Tail River**	**Breckenridge Lake to Bois de Sioux River**	**F-IBI**
504	**Otter Tail River**	**Judicial Ditch 2 to Breckenridge Lake**	**M-IBI**
506	Otter Tail River	Orwell Dam to Judicial Ditch 2	None
521	Otter Tail River	Big Pine Lake to Rush Lake	None
526	**Toad River**	**Little Toad Lake to T138, R38W, S30, SW Corner**	**F-IBI**
529	Otter Tail River	Height of Land Lake to Albertson Lake	None
532	Otter Tail River	Rice Lake to Mud Lake	None
561	Brandborg Creek	T133, R38W, S28, East Line to East Battle Lake	None
563	Dead Horse Creek	T138, R38W, S4, North Line to Toad River	None
565	Solid Bottom	T143, R38W, S32, North Line to Elbow Lake	None
574	Otter Tail River	Unnamed Lake (56-0821-00) to Pelican River	None
611	Otter Tail River	Ice Cracking Lake Outlet to Egg River	None
622	Unnamed Creek	Unnamed Creek to Big Pine Lake	None
653	Reed Creek	Reed Lake to Pelican River	None
764	**Judicial Ditch 2**	**Unnamed Ditch to Otter Tail River**	**F-IBI**
767	**Pelican River**	**Lake Lizzie to Reed Creek**	**F-IBI**
768	Pelican River	Reed Creek to Otter Tail River	None
770	Toad River	Unnamed Creek to Big Pine Lake	None
772	**Pelican River**	**Highway 10 to Detroit Lake**	**F-IBI, M-IBI**
773	Otter Tail River	West Long Lake to River Diversion	None
774	Otter Tail River	River Diversion to Unnamed Lake (56-1203-00)	None

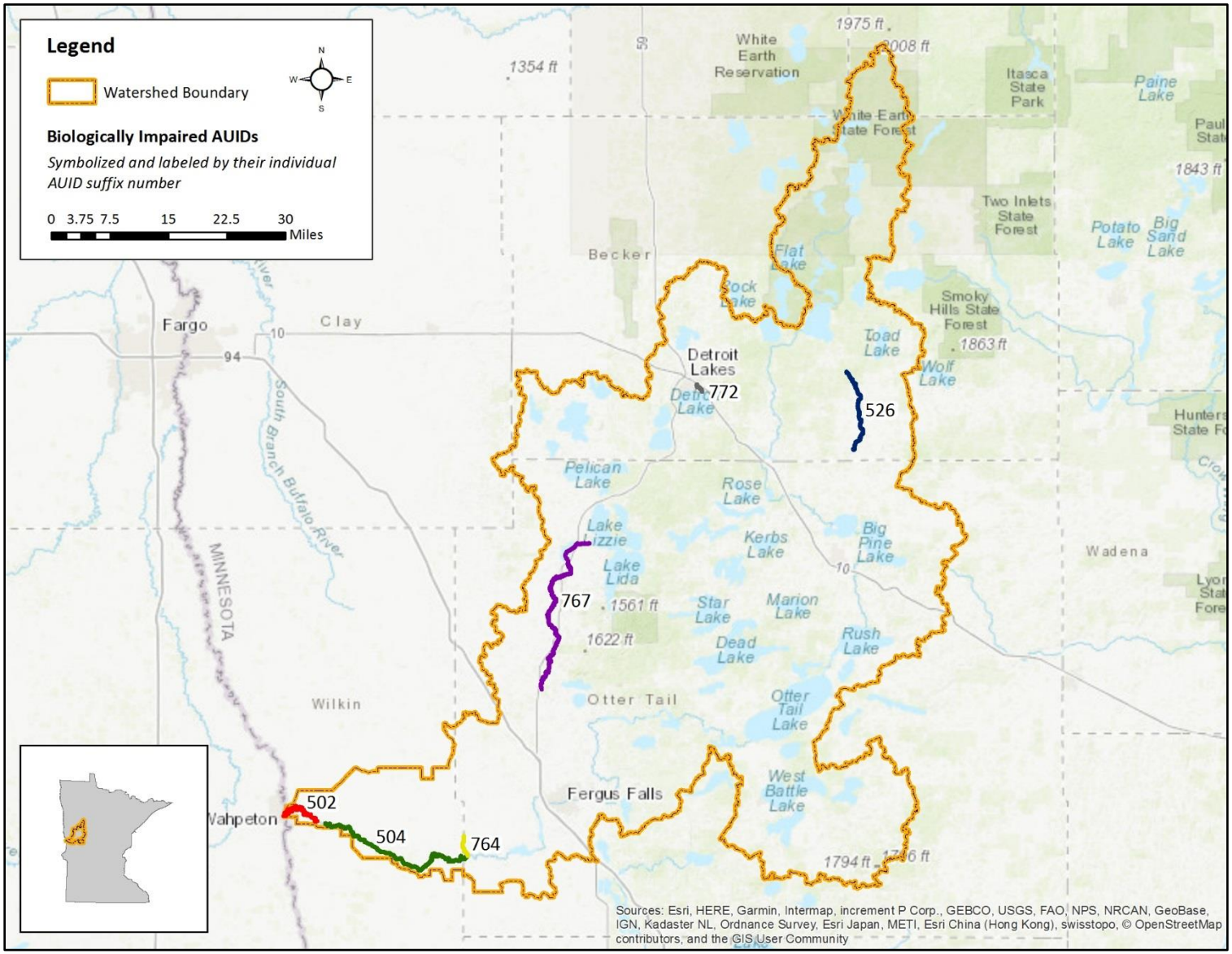
In addition to the aforementioned biological impairments, seven reaches in the OTRW have an existing or proposed water quality impairment that affects aquatic life (Table 5). Five of these reaches are also biologically impaired.

Table 5. Conventional water quality impairments affecting aquatic life associated with reaches in the OTRW.

AUID suffix	Name	Description	Water quality impairment(s)
502	Otter Tail River	Breckenridge Lake to Bois de Sioux River	Turbidity[2,3]
504	Otter Tail River	Judicial Ditch 2 to Breckenridge Lake	Turbidity[2,3]
532	Otter Tail River	Rice Lake to Mud Lake	Dissolved Oxygen[2]
543	Campbell Creek	Campbell Lake to Floyd Lake	Total Suspended Solids[1]
764	Judicial Ditch 2	Unnamed Ditch to Otter Tail River	Dissolved Oxygen[1]
767	Pelican River	Lake Lizzie to Reed Creek	Dissolved Oxygen[1]
772	Pelican River	Highway 10 to Detroit Lake	Dissolved Oxygen[1]

[1] New impairment to be included on the proposed 2020 Impaired Waters List.
[2] Existing impairment included on the 2018 Impaired Waters List.
[3] Turbidity standard has since been replaced with a total suspended solids standard.

Figure 4. Map of the OTRW and associated biologically impaired AUIDs.



Section 3: Possible stressors to biological communities

3.1 Identification of candidate causes

A candidate cause is defined as a "hypothesized cause of an environmental impairment that is sufficiently credible to be analyzed" (EPA, 2012a). Identification of a set of candidate causes is an important early step in the SID process and provides the framework for gathering key data for causal analysis. Table 6 lists the seven common biotic stressors that were considered as potential candidate causes in the OTRW; an overview of these stressors is provided in *Stressors to Biological Communities in Minnesota's Rivers and Streams* (MPCA, 2017). The list was developed based upon the results of the *Red River Valley Biotic Impairment Assessment* (EOR, 2009) and other completed SID reports in the state. The credibility of each candidate cause as a possible stressor to the fish and/or macroinvertebrate community of the biologically impaired reaches in the OTRW was then evaluated through a comprehensive review of available information, including water quality and quantity data, as well as existing plans and reports, including the *Otter Tail River Watershed Monitoring and Assessment Report* (MPCA, 2019), the *Becker County Local Water Management Plan* (Becker County, 2017), and the *Otter Tail County Local Water Management Plan* (Otter Tail County, 2014). Based upon the results of this evaluation, five candidate causes were identified to undergo causal analysis (Section 3.2).

Table 6. Summary of common biotic stressors evaluated as potential candidate causes for the biologically impaired reaches of the OTRW.

Stressor	Candidate cause identification	
	Summary of available information	Candidate cause (Yes/No)
Loss of longitudinal connectivity	Several of the biologically impaired reaches have connectivity barriers (e.g., dams) that are potential obstructions to fish passage.	**Yes**
Flow regime instability	The flow regime of each of the biologically impaired reaches has been altered, to a varying extent, by drainage and historical changes in land cover, which can affect peak and baseflow conditions.	**Yes**
Insufficient physical habitat	Several of the biologically impaired reaches have insufficient instream habitat to support a diverse and healthy biotic community.	**Yes**
High suspended sediment	Several of the biologically impaired reaches have discrete total suspended solids (TSS) values that exceed the applicable state standard.	**Yes**
Low dissolved oxygen	Several of the biologically impaired reaches have discrete and/or continuous dissolved oxygen (DO) values that are below the applicable state standard. Eutrophication may be a contributing factor to these low DO values.	**Yes**
High nitrate-nitrogen	Nitrate-nitrogen concentrations associated with the biologically impaired reaches were generally well below the level expected to cause stress to aquatic biota (<10 mg/L).	No
pH	Nearly all of the pH values associated with the biologically impaired reaches were within the state standard range (6.5-9.0).	No

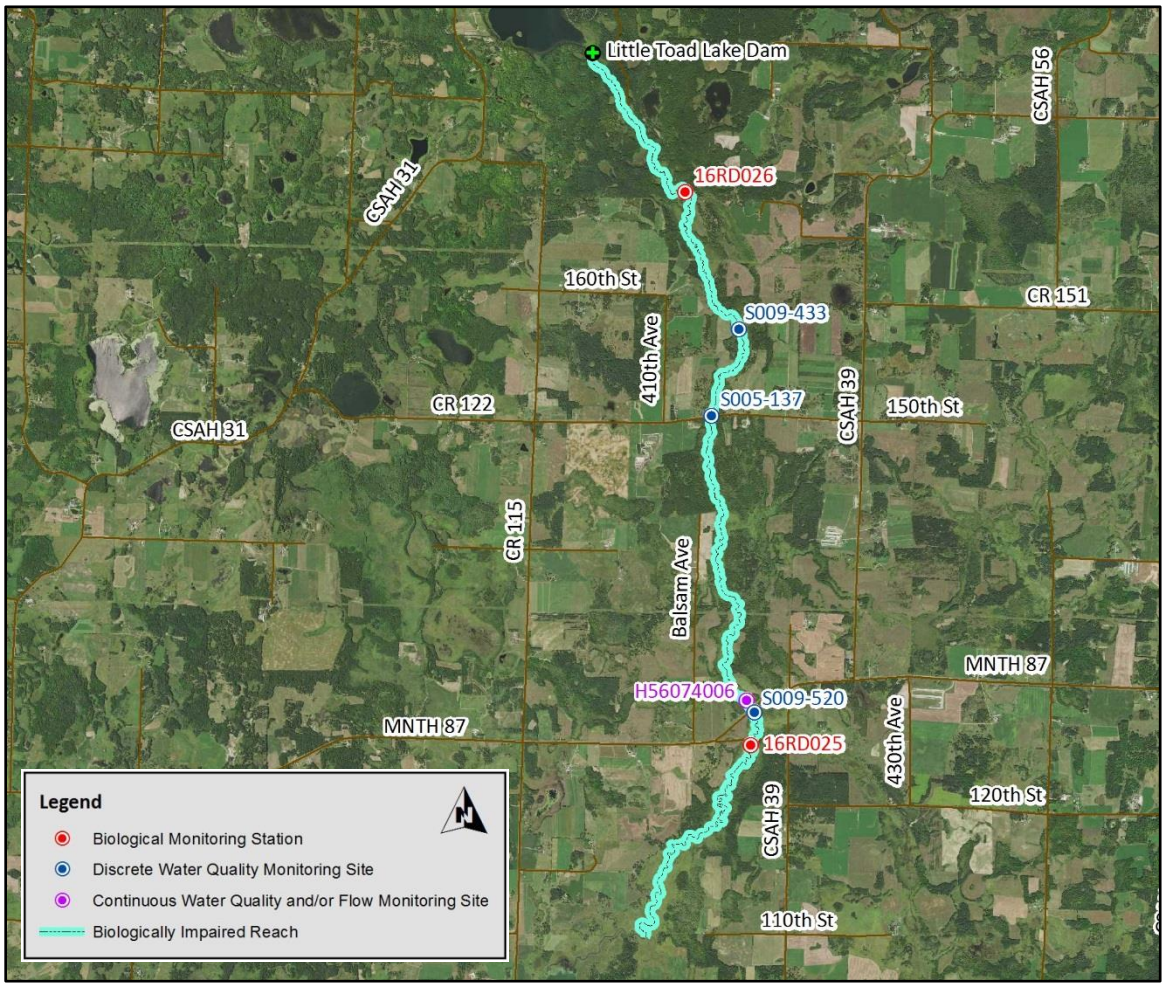
3.2 Causal analysis – Profile of individual biologically impaired reaches

3.2.1 Toad River (526)

Physical setting

This reach represents the segment of the Toad River from its headwaters, situated at the outlet of Little Toad Lake, to its confluence with an unnamed creek, located approximately one mile upstream of Dead Lake (Figure 5); a total length of 11 miles. The reach has a subwatershed area of 83 square miles (52,929 acres). The subwatershed contains 37 miles of intermittent stream, 28 miles of perennial stream and river (e.g., Toad River), and 3 miles of intermittent drainage ditch (DNR, 2014b). According to the MPCA (2013), 23% of the watercourses in the subwatershed have been physically altered (i.e., channelized, ditched, or impounded); the entire length of the Toad River (526) is classified as natural stream channel. The NLCD 2011 (USGS, 2011) lists forest (45%) and hay/pasture (24%) as the predominant land covers in the subwatershed. Other notable land cover groups in the subwatershed included wetlands (9%), cultivated crops (8%), open water (6%), developed (4%), and herbaceous (4%).

Figure 5. Map of the Toad River (526) and associated biological monitoring stations and water quality monitoring sites (2017 National Agriculture Imagery Program (NAIP) aerial image). Flow direction is north to south.



Biological impairments

Fish (F-IBI)

The fish community of the Toad River (526) was monitored at Stations 16RD025 (0.4 miles downstream of the State Highway 87 crossing) and 16RD026 (2.2 miles upstream of the County Road (CR) 122 crossing) on June 20, 2016. The location of these stations is shown in Figure 5. Station 16RD025 was designated as General Use within the Northern Streams F-IBI Class (Class 5); the associated impairment threshold is an F-IBI score of 47. Station 16RD026 was designated as General Use within the Northern Headwaters F-IBI Class (Class 6); the impairment threshold is an F-IBI score of 42. Station 16RD025 (F-IBI=37) scored below its impairment threshold, while Station 16RD026 (F-IBI=56) scored well above its impairment threshold. A total of 23 species were sampled between the stations (Table 7). The fish assemblage of Station 16RD025 had higher numbers of detritivores (e.g., white sucker) and serial spawners (e.g., bigmouth shiner), while Station 16RD026 higher numbers of insectivores (e.g., johnny darter) and simple lithophilic spawners (e.g., blacknose dace).

Table 7. Summary of fish taxa sampled at Stations 16RD025 and 16RD026 along the Toad River (526).

Common name	# sampled	
	16RD025	16RD026
bigmouth shiner	4	
black bullhead	1	2
black crappie	1	9
blacknose dace		25
blackside darter	8	1
bluegill	2	2
bluntnose minnow	11	
brassy minnow	3	1
brook stickleback	15	
centeral mudminnow	4	3
common shiner	4	7
creek chub	1	49
golden shiner		1
johnny darter	33	59
logperch		1
mimic shiner		1
northern pike		4
northern redbelly dace	2	
pearl dace	28	
pumpkinseed		6
white sucker	30	6
yellow bullhead		1
yellow perch	2	

Candidate causes

Loss of longitudinal connectivity

Available data

According to R. Hemphill, DNR Area Hydrologist (personal communication, 2019), beaver dams are prevalent along the Toad River (526), particularly upstream of the CR 122 crossing. The MPCA biological monitoring staff did not observe any connectivity-related issues during their visits to Stations 16RD025 and 16RD026. According to the DNR (2014a), the Little Toad Lake Dam is located at the outlet of Little Toad Lake, which represents the upstream end of the biologically impaired reach. The dam, which is owned by the DNR, was constructed in 1937 and is six feet high; it is a near-complete barrier to connectivity. On June 6, 2018, MPCA SID staff completed a longitudinal assessment of the reach. Approximately twelve beaver dams were noted, many of which were located upstream of the CR 122 crossing. Staff also noted that the metal culvert at the CR 122 crossing (Figure 6) is severely undersized and has partially collapsed under the road bed, thereby further restricting flow. During moderate and high stage conditions, the flow velocity through the culvert is likely high enough to impede connectivity for many fish species. In addition to the assessment, MPCA SID staff documented a beaver dam at the State Highway 87 crossing on August 23, 2018. Lastly, MPCA SID staff performed a detailed review of a May 18, 2015, aerial photo (courtesy of Google Earth) of the reach. A large beaver dam and associated impoundment was noted upstream of the CR 122 crossing (Figure 6). In summary, the Little Toad Lake Dam, CR 122 culvert, and beaver dams interfere with connectivity along the Toad River (526).

Figure 6. Images of connectivity-related issues associated with Toad River (526), including an undersized and damaged culvert at the CR 122 crossing (left) and a large beaver dam located upstream of the CR 122 crossing on May 18, 2015 (right), courtesy of Google Earth.

Biological response: Fish

Migratory and late maturing fish species require well-connected environments in order to access the habitats and resources necessary to complete their life history (Saunders, 2007). Barriers to connectivity (e.g., dams) can limit the availability of critical habitats and resources, thereby reducing the abundance of these species, along with overall species diversity (Poole, 2002; Cross et al., 2013; Gardner, et al. 2013; Aadland, 2015). Table 8 shows the loss of longitudinal connectivity-related metric scores for the fish community of the Toad River (526). Both monitoring stations scored below the statewide mean in migratory and late maturing taxa. The multiple lines of evidence ***strongly support*** the case for loss of longitudinal connectivity as a stressor to the fish community of the Toad River (526).

Table 8. Summary of loss of longitudinal connectivity-related biological metric data for Stations 16RD025 and 16RD026 along the Toad River (526), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Fish class	Statewide score[1] (mean ± SD)	Station (score)
MgrTxPct	Relative abundance (%) of taxa that are migratory (↓)	5	18 ± 7	16RD025 (13)
		6	13 ± 7	16RD026 (12)
MA>3-TolTxPct	Relative abundance (%) of taxa with a female mature age of ≥ 3 years, excluding tolerant taxa (↓)	5	24 ± 11	16RD025 (6)
		6	8 ± 10	16RD026 (0)

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Flow regime instability

Available data

The MPCA biological monitoring staff did not encounter any flow-related issues (e.g., intermittency) at Stations 16RD025 and 16RD026. According to the MPCA (2013), 23% of the watercourses in the subwatershed have been physically altered (i.e., channelized, ditched, or impounded); the entire length of the Toad River (526) is classified as natural stream channel. There are no flow monitoring data for the reach. The USGS (2018) estimated that the median flow (Q50) for the reach at its outlet was 34.1 cubic feet per second (cfs), while the normal range of flow values was 66.2 (Q25) to 21.8 (Q75) cfs. The ratio of Q25 to Q75 flow values was approximately 3:1, which is indicative of a hydrologically stable system. By comparison, several of the more hydrologically stable rivers in the Red River Basin (e.g., Buffalo River, Clearwater River, and Otter Tail River) had a Q25 to Q75 ratio of 7:1 or less. Additionally, the 7 day, 10 year low flow value for the reach was 8.0 cfs, which suggests that the reach has sustained baseflow and does not regularly experience periods of intermittency. The MPCA SID staff conducted reconnaissance along the reach on seven separate dates between the spring and fall of 2018 and documented flow conditions. Staff noted that a beaver dam at the State Highway 87 crossing had impounded the water level by an estimated two feet on August 23, 2018 and September 26, 2018. Overall, the available data suggest the Toad River (526) has a stable flow regime but is prone to impounding caused by beaver dams.

Biological response: Fish

Flow regime instability has been shown to limit species diversity and favor taxa that are generalists, early maturing, pioneering, short-lived, and tolerant to disturbances (Aadland et al., 2005; Poff and Zimmerman, 2010). Table 9 shows the flow regime instability-related metric scores for the fish community of the Toad River (526). A total of five metric scores met the statewide mean; these scores were largely associated with Station 16RD026. Four metrics scores did not meet the statewide mean but were within the confidence interval. Lastly, three metric scores fell below the statewide mean and were outside of the confidence interval. Given the ambiguity of the metric scores, the multiple lines of evidence are ***inconclusive*** as to whether flow regime instability is a stressor to the fish community of the Toad River (526).

Table 9. Summary of flow regime instability-related biological metric data for Stations 16RD025 and 16RD026 along the Toad River (526), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Fish class	Statewide score[1] (mean ± SD)	Station (score)
DomTwo Pct	Relative abundance (%) of the two most abundant taxa (↑)	5	51 ± 13	16RD025 (42)
		6	58 ± 14	16RD026 (61)
GeneralTx Pct	Relative abundance (%) of individual that are generalists (↑)	5	24 ± 8	16RD025 (31)
		6	35 ± 10	16RD026 (41)
MA<2Tx Pct	Relative abundance (%) of taxa with a female mature age ≤ 2 years (↑)	5	58 ± 12	16RD025 (75)
		6	78 ± 15	16RD026 (71)
NumPer Meter-Tol	Number of individuals per meter of stream sampled, excluding tolerant species (↓)	5	1 ± 1	16RD025 (0)
		6	1 ± 1	16RD026 (1)
PioneerTx Pct	Relative abundance (%) of taxa that are pioneers (↑)	5	12 ± 5	16RD025 (19)
		6	19 ± 7	16RD026 (12)
SLvdPct	Relative abundance (%) of individuals that are short-lived (↑)	5	9 ± 13	16RD025 (23)
		6	25 ± 20	16RD026 (15)

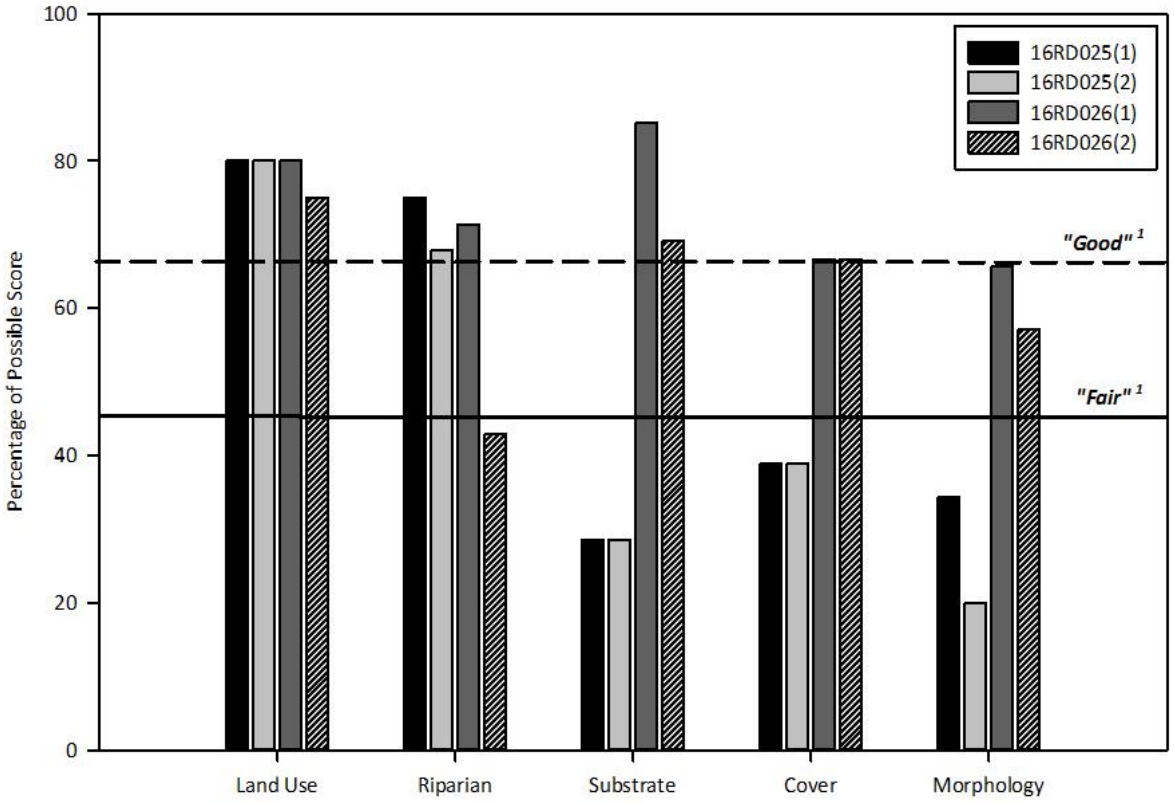
[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
- Good: Score for the biologically impaired reach met or was equal to the statewide mean.
- Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
- Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Insufficient physical habitat

Available data

The physical habitat of the Toad River (526) was evaluated at Stations 16RD025 and 16RD026 using the MPCA's Stream Habitat Assessment (MSHA). The entire reach is classified as natural stream channel (MPCA, 2013). Station 16RD026 (MSHA=61/"fair" and 73/"good"), which is located along the upstream extent of the reach, had substantially higher MSHA scores than 16RD025 (MSHA=35/"poor" and 41/"poor"), which is situated further downstream. Figure 7 displays the MSHA subcategory results for each of the stations. The stations scored well in the land use subcategory due to the surrounding natural conditions. The riparian subcategory scores were positively influenced by a "moderate" to "extensive" riparian zone width, although some bank erosion was noted at Station 16RD026. Station 16RD025 scored substantially lower than Station 16RD026 in the substrate subcategory due to the absence of riffles and coarse substrate; the substrate was dominated by sand and silt. The coarse substrate (i.e., cobble and gravel) at Station 16RD026 was slightly degraded by a "light" amount of embeddedness. The cover subcategory scores varied greatly between the stations, with Station 16RD025 offering a "sparse" amount of cover, while Station 16RD026 offered a "moderate" amount of cover. Noted cover types along the reach included deep pools, macrophytes (emergent and submergent), overhanging vegetation, oxbows, rootwads, shallows, undercut banks, and woody debris. Lastly, Station 16RD025 scored markedly lower in the morphology subcategory than Station 16RD026 due to "low" to "moderate" channel stability and "poor" to "fair" channel development.

Figure 7. MSHA subcategory results for Stations 16RD025 and 16RD026 along the Toad River (526).

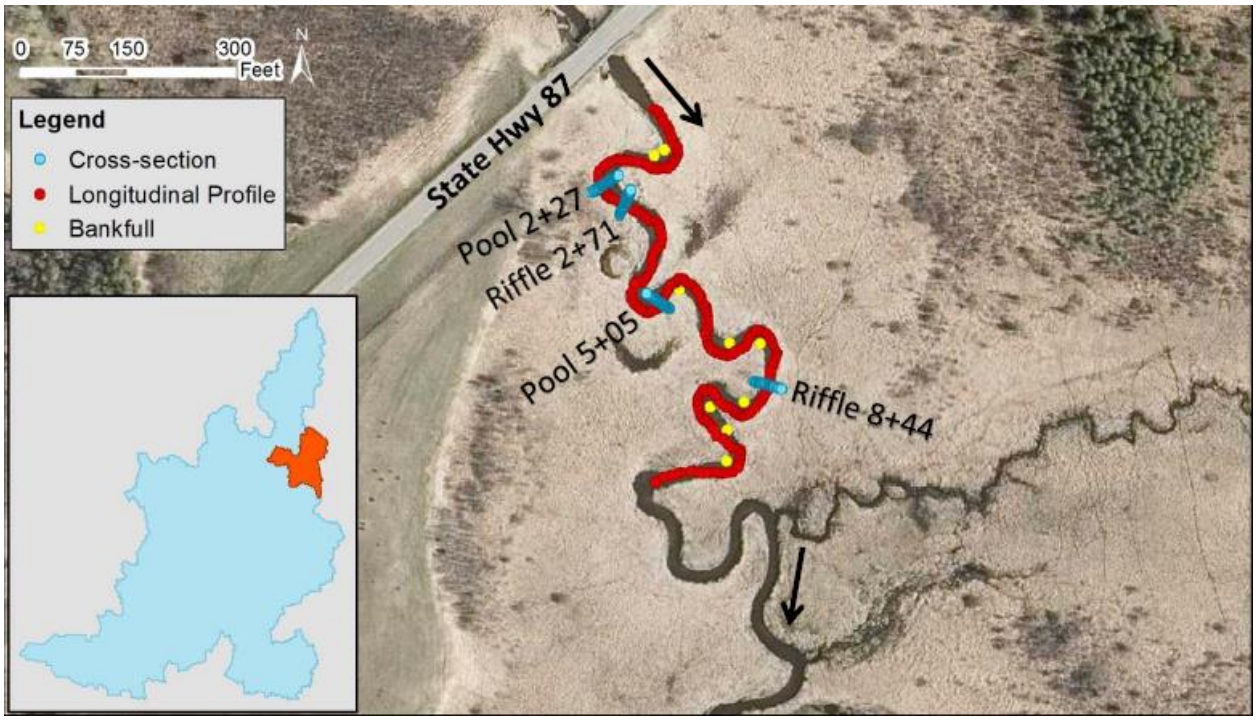


[1] The minimum percentage of each subcategory score needed for the station to achieve a "fair" and "good" MSHA rating.

On September 14, 2018, Clark and Vinje (2018) completed a fluvial geomorphic assessment downstream of the State Highway 87 crossing (Figure 8) along the Toad River (526). The stream type at this location was determined to be an E5 (very low width-to-depth ratio, slightly entrenched, sand bed stream). The site yielded a Pfankuch stability rating of 103 (unstable). Below are excerpts from the assessment summary for the site:

> *"The Toad River at this location was highly sinuous and had a wide floodplain. The pools were wider and a larger cross-sectional area than the riffles, but they were only slightly deeper than the riffles. A full reach particle count was not completed as the substrate was predominantly sand-sized. The channel did appear to have down-cut, creating an incised system. In this condition the channel will likely widen, attempting to recreate floodplain capacity that was lost. It would be beneficial to assess whether hydrology, sediment supply, crossings, and/or land use has induced this instability."*

Figure 8. Fluvial geomorphic assessment site downstream of the State Highway 87 crossing along the Toad River (526).



In summary, the MSHA data suggest the upstream portion of the reach (i.e., Station 16RD026) offers substantially better physical habitat than the downstream portion of the reach (i.e., Station 16RD025). The MSHA scores for Station 16RD025 were limited by a number of factors including a lack of riffles and coarse substrate, a minimal amount of available cover, and inadequate channel morphology characteristics. Many of these deficiencies can be attributed to the surficial geology of the area (i.e., undifferentiated outwash). Clark and Vinje (2018) also noted channel incision along the lower end of the Toad River (526). Further investigation is needed to determine the cause of this instability.

Biological response: Fish

Insectivores (e.g., darters and sculpins) and simple lithophilic spawners require quality benthic habitat (e.g., clean, coarse substrate and riffles) for feeding and/or reproduction purposes, while detritivores utilize decomposing organic matter (i.e., detritus) as a food resource and, therefore, are less dependent upon the quality of instream habitat (Aadland and Kuitunen, 2006). Table 10 shows the insufficient physical habitat-related metric scores for the fish community of the Toad River (526). More than half (58%) of the metrics scores for the biological monitoring stations did not meet the statewide mean. The largest deviation from the mean occurred in riffle dwelling, simple lithophilic spawning, benthic insectivores, and detritivorous taxa, which can indicate that critical habitat facets (e.g., coarse substrate and riffles) have been degraded or are naturally lacking. The multiple lines of evidence ***convincingly support*** the case for insufficient physical habitat as a stressor to the fish community of the Toad River (526).

Table 10. Summary of insufficient physical habitat-related biological metric data for Stations 16RD025 and 16RD026 along the Toad River (526), as well as statewide stations that support a healthy fish community

Metric	Description (expected response to stressor)	Fish class	Statewide score[1] (mean ± SD)	Station (score)
RiffleTxPct	Relative abundance (%) of taxa that predominately utilize riffle habitats (↓)	5	20 ± 8	16RD025 (6)
		6	17 ± 10	16RD026 (6)
SLithopTx Pct	Relative abundance (%) of taxa that are simple lithophilic spawning species (↓)	5	35 ± 10	16RD025 (19)
		6	29 ± 12	16RD026 (29)
Insect-TolPct	Relative abundance (%) of individuals that are insectivorous excluding tolerant species (↓)	5	45 ± 19	16RD025 (49)
		6	28 ± 20	16RD026 (39)
BenInsect-TolTxPct	Relative abundance (%) of taxa that are benthic insectivores, excluding tolerant species (↓)	5	27 ± 10	16RD025 (13)
		6	19 ± 11	16RD026 (18)
DetNWQ TxPct	Relative abundance (%) of taxa that are detritivorous (↑)	5	10 ± 5	16RD025 (19)
		6	14 ± 7	16RD026 (12)
DarterSculpTxPct	Relative abundance (%) of taxa that are darters and sculpins (↓)	5	14 ± 6	16RD025 (13)
		6	14 ± 7	16RD026 (18)

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

High suspended sediment

Available data

The MPCA biological monitoring staff collected a discrete water quality sample at Stations 16RD025 and 16RD026 along the Toad River (526) at the time of fish monitoring. The samples were analyzed for several parameters, including TSS. The biological monitoring stations had TSS concentrations of 13 and 5 mg/L, respectively; which are well below the 30 mg/L TSS standard for the Central TSS Region. Figure 9 displays all available discrete TSS data for Sites S005-137 (CR 122 crossing; 2008-2010; *n*=26) and S009-520 (State Highway 87 crossing; 2018; *n*=6); the location of the sites is shown in Figure 5. Collectively, the mean TSS concentration for the sites was 8 mg/L, while the highest concentration was 59 mg/L and the lowest concentration was 1 mg/L. Only one value exceeded the TSS standard. The OTRW HSPF model estimates that the reach had a TSS concentration in excess of the standard 1% of the time during the period of 1995 to 2014. On June 6, 2018, MPCA SID staff completed a longitudinal assessment of the reach. Staff documented a few areas of bank instability (Figure 10) along the reach. Overall, the available data suggest the Toad River (526) experiences infrequent periods of high suspended sediment.

Figure 9. Discrete TSS data for Sites S005-137 and S009-520 along the Toad River (526).

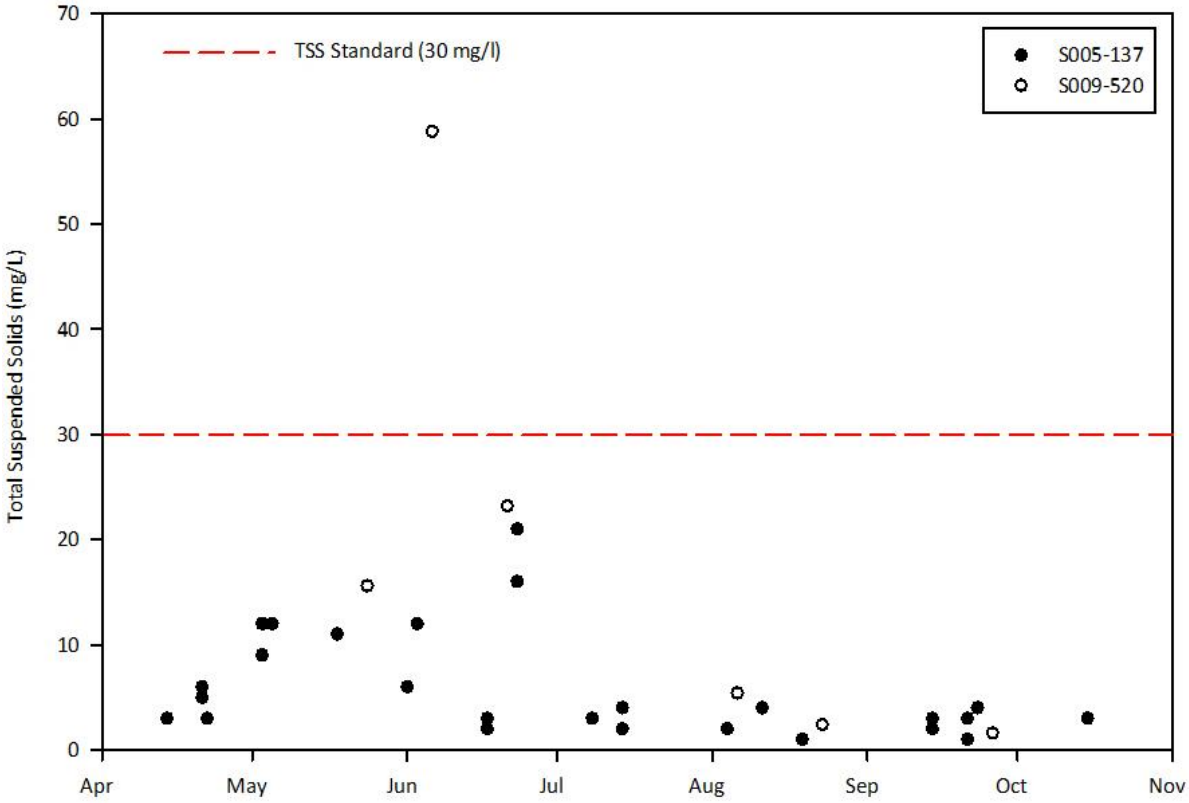


Figure 10. Images of bank erosion along the Toad River (526) on June 6, 2018, including upstream of the CR 122 crossing (left) and downstream of the State Highway 87 crossing (right).

Biological response: Fish

Excessive suspended sediment can affect a fish community in various ways depending on the concentration and duration of exposure. The deposition of sediment can fill interstitial spaces in riffles and coarse substrate that are important for lithophilic and insectivorous taxa (Bilotta and Brazier, 2008). Sediment deposition can also block pores in the streambed, thereby preventing exchange within the hyporheic zone (Greig et al., 2005). Table 11 shows the high TSS-related metric scores for the fish community of the Toad River (526). A majority of the metrics scores for the monitoring stations did not meet the statewide mean, which suggests that sedimentation may be adversely affecting the fish community. The probability of meeting the TSS standard displayed the largest deviation from the mean.

The multiple lines of evidence ***somewhat support*** the case for high suspended sediment as a stressor to the fish community of the Toad River (526).

Table 11. Summary of high total suspended solids-related biological metric data for Stations 16RD025 and 16RD026 along the Toad River (526), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Fish class	Statewide score[1] (mean ± SD)	Station (score)
TSS TIV	Mean TSS (mg/L) tolerance indicator value (TIV) (↑)	5	12 ± 2	16RD025 (14)
		6	13 ± 2	16RD026 (13)
CondProb	Probability of meeting the TSS standard (↓)	5	86 ± 10	16RD025 (73)
		6	86 ± 7	16RD026 (76)

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Low dissolved oxygen

Available data

The MPCA biological monitoring staff collected a combined four discrete DO measurements at Stations 16RD025 and 16RD026 along the Toad River (526) at the time of fish and macroinvertebrate monitoring. All of the measurements were well above the 5.0 mg/L DO standard; values ranged from 7.6 to 9.8 mg/L. Figure 11 displays all available discrete DO data for Sites S005-137 (2008-2010; *n*=32) and S009-433 (0.7 miles upstream of the CR 122 crossing; 2007-2017; *n*=8). Collectively, none of the values were below the standard; however, none of the measurements were collected prior to 9:00 a.m., when values are typically lowest. The MPCA conducted continuous DO monitoring at Site H56074006 (State Highway 87 crossing) from August 13, 2018, to August 15, 2018; the location of the site is shown in Figure 5. The monitoring results are provided in Table 12, as well as displayed in Figure 12. None of the values for the site fell below the standard. Additionally, the OTRW HSPF model estimates that the reach had a DO concentration below the standard less than 1% of the time during the period of 1995 to 2014. Overall, the available data suggest the Toad River (526) experiences infrequent periods of low DO.

Figure 11. Discrete DO data for Sites S005-137 and S009-520 along the Toad River (526).

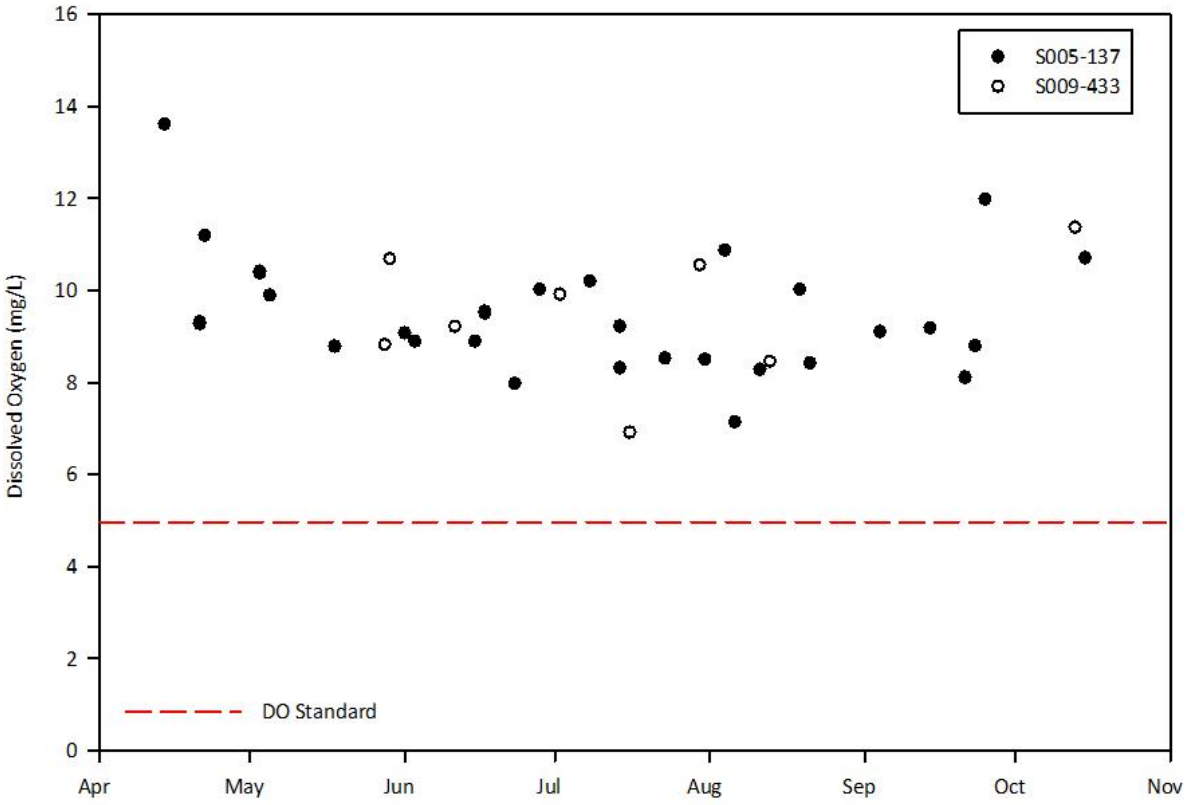
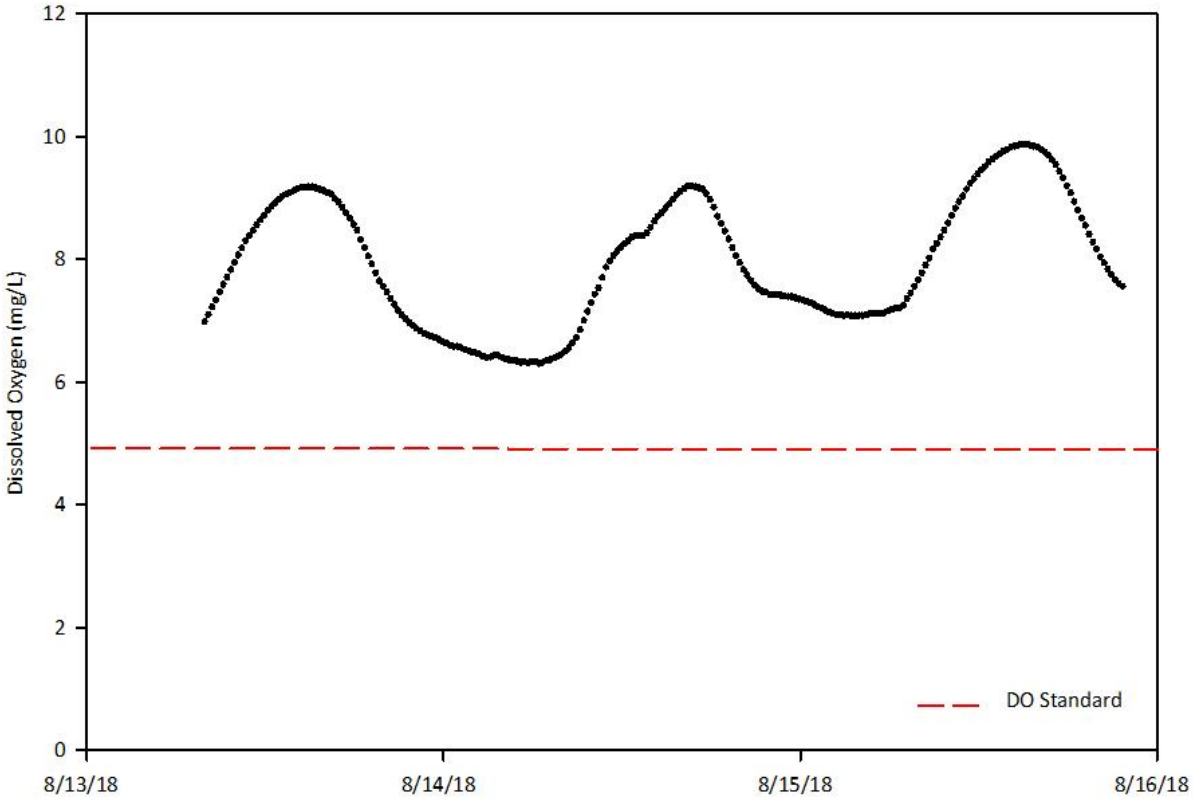


Table 12. Continuous DO data for Site H56074006 along the Toad River (526).

Site	Start date - End date	*n*	Max. (mg/L)	Min. (mg/L)	% Total values below standard	% Daily min. values below standard	Mean daily flux (mg/L)
H56074006	8/13/2018 - 8/15/2018	248	9.9	6.3	0	0	NA

Figure 12. Continuous DO data (August 13-15, 2018) for Site H56074006 along the Toad River (526).



Eutrophication-related data for the Toad River (526) includes the following parameters: total phosphorus (TP) and chlorophyll-a (Chl-a). The MPCA biological monitoring staff collected a discrete water quality sample at Stations 16RD025 and 16RD026 along the reach at the time of each fish monitoring visit. The samples were analyzed for several parameters, including TP. The stations had TP concentrations of 138 and 47 µg/L, respectively. The TP standard for the North River Nutrient Region is 50 µg/L. Discrete TP data are also available for Sites S005-137 (2008-2009; *n*=17) and S009-520 (2018; *n*=6). Collectively, the mean TP concentration for the sites was 68 µg/L, while the highest concentration was 273 µg/L and the lowest concentration was 29 µg/L. Approximately 43% of the values exceeded the TP standard. Discrete Chl-a data are also available for Site S009-520 (2018; *n*=5). The mean Chl-a concentration for the site was 2 µg/L, while the highest concentration was 4 µg/L and the lowest concentration was 1 µg/L. There were no exceedances of the 7 µg/L North River Nutrient Region Chl-a standard. In addition, the MPCA SID staff did not observe any signs of eutrophication (e.g., excessive algal growth) during their reconnaissance visits along the reach. While the Toad River (526) is prone to high TP concentrations, there is insufficient response variable data to determine if eutrophication if adversely affecting the DO regime.

Biological response: Fish

Frequent or extended periods of low dissolved oxygen can alter a fish community by limiting the abundance of species that are intolerant of such conditions (Davis, 1975, EPA, 2012a). Table 13 shows the low DO-related metric scores for the fish community of the Toad River (526). Most of the metric scores for the biological monitoring stations met the statewide mean. Only one score (probability of meeting the DO standard) was below the statewide mean; however, the score was within the confidence interval. The multiple lines of evidence **refute** the case for low dissolved oxygen as a stressor to the fish community of the Toad River (526).

Table 13. Summary of low dissolved oxygen-related biological metric data for Stations 16RD025 and 16RD026 along the Toad River (526), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Fish class	Statewide score[1] (mean ± SD)	Station (score)
DO TIV	Mean DO (mg/L) tolerance indicator value (↑)	5	7 ± 0	16RD025 (7)
		6	7 ± 1	16RD026 (7)
CondProb	Probability of meeting the dissolved oxygen standard (↓)	5	73 ± 20	16RD025 (54)
		6	61 ± 26	16RD026 (76)

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Summary of stressors

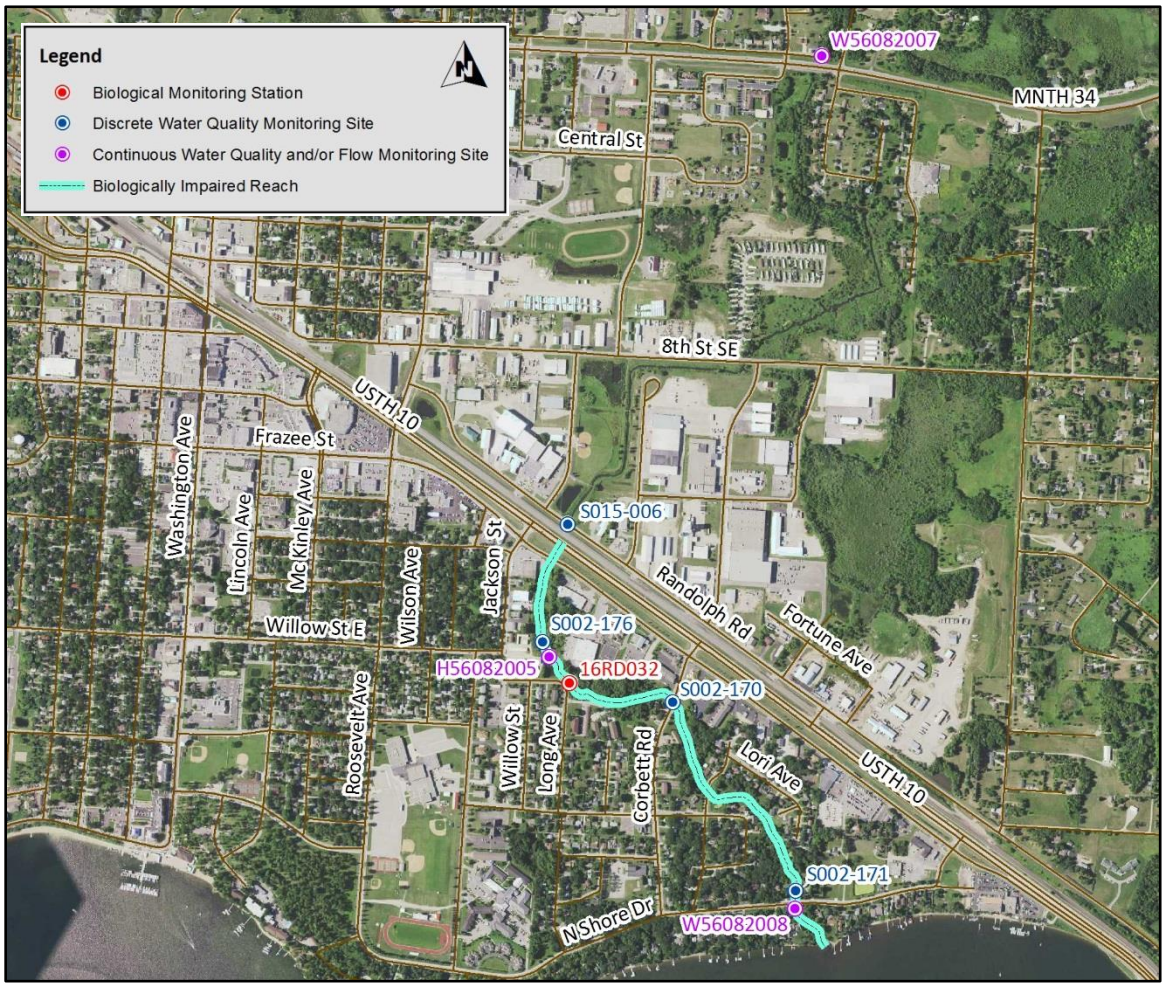
The evidence suggests that the F-IBI impairment associated with the Toad River (526) is attributed to a loss of longitudinal connectivity, insufficient physical habitat, and to a lesser extent, high suspended sediment. Several beaver dams were noted to be interfering with fish passage during reconnaissance. The impoundment of water caused by these dams can also alter sediment transport processes, thereby degrading physical habitat. Removal of beaver dams should be considered to restore connectivity along the reach. Additionally, the culvert at the CR 122 crossing is severely undersized and has partially collapsed. During moderate and high stage conditions, the flow velocity through the culvert is likely high enough to impede connectivity for many fish species. The installation of a properly sized culvert at this intersection is highly recommended. The physical habitat of the downstream portion of the reach is naturally limited by its surficial geology (undifferentiated outwash). As a result, the substrate in this segment is dominated by sand, with minimal cover present. Channel incision was also noted in a geomorphology assessment completed along the lower extent of the Toad River (526). Further investigation is needed to determine the cause(s) of this instability.

3.2.2 Pelican River (772)

Physical setting

This reach represents the segment of the Pelican River from its US Highway 10 crossing, to its outlet to Detroit Lake (Figure 13); a total length of one mile. The reach has a subwatershed area of 57 square miles (36,345 acres). The subwatershed contains 17 miles of perennial stream and river (e.g., Pelican River), 16 miles of perennial drainage ditch, and one mile of intermittent stream (DNR, 2014b). According to the MPCA (2013), 49% of the watercourses in the subwatershed have been physically altered (i.e., channelized, ditched, or impounded), including 21% of the Pelican River (772). The NLCD 2011 (USGS, 2011) lists forest (37%) as the predominant land cover in the subwatershed. Other notable land cover groups in the subwatershed included hay/pasture (21%), cultivated crops (13%), wetlands (9%), open water (8%), developed (8%), and herbaceous (3%).

Figure 13. Map of the Pelican River (772) and associated biological monitoring station and water quality monitoring sites (2017 NAIP aerial image). Flow direction is north to south.



Biological impairments

Fish (F-IBI)

The fish community of the Pelican River (772) was monitored at Station 16RD032 (0.2 miles upstream of the Corbett Road crossing) on June 22, 2016. The location of the station is shown in Figure 13. The station was designated as General Use within the Northern Headwaters F-IBI Class (Class 6); the associated impairment threshold is an F-IBI score of 42. Monitoring of the station yielded an F-IBI score (27) well below the impairment threshold. While the fish assemblage included 17 species (Table 14), it was largely dominated by tolerant taxa (e.g., blacknose dace and hybrid sunfish).

Table 14. Summary of fish taxa sampled at Station 16RD032 along the Pelican River (772).

Common name	# sampled
black bullhead	15
black crappie	1
blacknose dace	79
brown bullhead	3
central mudminnow	17
common shiner	2
fathead minnow	1
green sunfish	1
hornyhead chub	3
hybrid sunfish	90
Iowa darter	44
northern pike	3
northern redbelly dace	1
spottail shiner	4
tadpole madtom	1
white sucker	3
yellow bullhead	7

Macroinvertebrate (M-IBI)

The macroinvertebrate community of the Pelican River (772) was monitored at Station 16RD032 on August 8, 2017. The station was designated as General Use within the Southern Streams-Run/Riffle Habitats M-IBI Class (Class 5). Accordingly, the impairment threshold for the station is an M-IBI score of 37. Monitoring of the station yielded an M-IBI score (36) slightly below the impairment threshold. Table 15 provides a summary of macroinvertebrate taxa sampled at the station. The assemblage had a high abundance of tolerant taxa, including *Polypedilum* (midges) and *Simulium* (black flies).

Table 15. Summary of macroinvertebrate taxa sampled at Station 16RD032 along the Pelican River (772).

	Species (order)	# individuals sampled
Insects	Beetles	4
	Caddisflies	112
	Dragonfly/Damselflies	10
	Flies (midges)	108
	Mayflies	50
Non-insects	Clams	3
	Mites	6
	Scuds	3
	Snails	20
	Worms	1

Candidate causes

Loss of longitudinal connectivity

Available data

The MPCA biological monitoring staff did not observe any connectivity-related issues during their visits to Station 16RD032. According to the DNR (2014a), there are no man-made dams along the Pelican River (772). On October 18, 2018, MPCA SID staff completed a longitudinal assessment of the reach. A breached beaver dam (Figure 14) was documented at the downstream end of a trail crossing located between the U.S. Highway 10 and Corbett Road crossings. Staff also noted a beaver dam (Figure 14) at the upstream side of this trail crossing on September 6, 2017. In addition to the longitudinal assessment, MPCA SID staff performed a detailed review of a May 18, 2015, aerial photo (courtesy of Google Earth) of the reach. No connectivity-related issues were identified in the photo. Overall, there are no permanent barriers to connectivity along the Pelican River (772). However, beaver dams have the potential to limit connectivity when present.

Figure 14. Images of beaver dams located near a trail crossing between the U.S. Highway 10 and Corbett Road crossings along the Pelican River (772) on October 18, 2018 (left) and September 6, 2017 (right).

Biological response: Fish

Migratory and late maturing fish species require well-connected environments in order to access the habitats and resources necessary to complete their life history (Saunders, 2007). Barriers to connectivity (e.g., dams) can limit the availability of critical habitats and resources, thereby reducing the abundance of these species, along with overall species diversity (Poole, 2002; Cross et al., 2013; Gardner, et al. 2013; Aadland, 2015). Table 16 shows the loss of longitudinal connectivity-related metric scores for the fish community of the Pelican River (772). Station 16RD032 scored above the statewide mean for migratory taxa but fell below the mean for late maturing taxa. Given the fact that fish passage is largely unimpeded along the reach, it is possible that the "poor" score for late maturing taxa could be attributed to other stressors. The multiple lines of evidence are ***inconclusive*** as to whether loss of longitudinal connectivity is a stressor to the fish community of the Pelican River (772).

Table 16. Summary of loss of longitudinal connectivity-related biological metric data for Station 16RD032 along the Pelican River (772), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
MgrTxPct	Relative abundance (%) of taxa that are migratory (↓)	18 ± 7	16RD032 (18)
MA>3-TolTxPct	Relative abundance (%) of taxa with a female mature age of ≥ 3 years, excluding tolerant taxa (↓)	24 ± 11	16RD032 (0)

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
- Good: Score for the biologically impaired reach met or was equal to the statewide mean.
- Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
- Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Biological response: Macroinvertebrate

Macroinvertebrates are not readily affected by longitudinal connectivity barriers. Populations can re-establish in a segmented stream channel to reflect stable community composition upstream and downstream of a connectivity barrier. Consequently, there is ***no biological response data*** for analysis of loss of longitudinal connectivity as a stressor to the macroinvertebrate community of the Pelican River (772).

Flow regime instability

Available data

The MPCA biological monitoring staff did not encounter any flow-related issues (e.g., intermittency) at Station 16RD032. According to the MPCA (2013), 49% of the watercourses in the subwatershed have been physically altered (i.e., channelized, ditched, or impounded), including 21% of the Pelican River (772). Additionally, the reach is located within the City of Detroit Lakes and there are multiple stormwater drains to the river. There are no flow monitoring data for the reach. The USGS (2018) estimated that the median flow (Q50) for the reach at its outlet was 23.1 cfs, while the normal range of flow values was 46.6 (Q25) to 14.5 (Q75) cfs. The ratio of Q25 to Q75 flow values was approximately 3:1, which is indicative of a hydrologically stable system. By comparison, several of the more hydrologically stable rivers in the Red River Basin (e.g., Buffalo River, Clearwater River, and Otter Tail River) had a Q25 to Q75 ratio of 7:1 or less. Additionally, the 7 day, 10 year low flow value for the reach was 4.8 cfs, which suggests that the reach has sustained baseflow and does not regularly experience periods of intermittency. The MPCA SID staff conducted reconnaissance along the reach on seven separate dates

between the spring and fall of 2018 and documented flow conditions. No flow-related issues were noted. While the available model data and observations suggest the Pelican River (772) has a stable flow regime, stormwater drainage from the city undoubtedly intensifies peak flow conditions.

Biological response: Fish

Flow regime instability has been shown to limit species diversity and favor taxa that are generalists, early maturing, pioneering, short-lived, and tolerant to disturbances (Aadland et al., 2005; Poff and Zimmerman, 2010). Table 17 shows the flow regime instability-related metric scores for the fish community of the Pelican River (772). Five of the six metric scores for Station 16RD032 fell below the statewide mean. Two of these scores were below the statewide mean and outside of the confidence interval (generalist and short-lived taxa). An increase in generalist and short-lived taxa can indicate a fish community that is stressed by periods of low to no flow and/or high peak flows. The multiple lines of evidence ***somewhat support*** the case for flow regime instability as a stressor to the fish community of the Pelican River (772).

Table 17. Summary of flow regime instability-related biological metric data for Station 16RD032 along the Pelican River (772), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
DomTwo Pct	Relative abundance (%) of the two most abundant taxa (↑)	51 ± 13	16RD032 (61)
GeneralTx Pct	Relative abundance (%) of individual that are generalists (↑)	24 ± 8	16RD032 (47)
MA<2Tx Pct	Relative abundance (%) of taxa with a female mature age ≤ 2 years (↑)	58 ± 12	16RD032 (65)
NumPer Meter-Tol	Number of individuals per meter of stream sampled, excluding tolerant species (↓)	1 ± 1	16RD032 (0.4)
PioneerTx Pct	Relative abundance (%) of taxa that are pioneers (↑)	12 ± 5	16RD032 (12)
SLvdPct	Relative abundance (%) of individuals that are short-lived (↑)	9 ± 13	16RD032 (45)

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
- Good: Score for the biologically impaired reach met or was equal to the statewide mean.
- Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
- Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Biological response: Macroinvertebrate

Flow regime instability tends to limit the diversity and taxa richness of macroinvertebrates and favor tolerant individuals that can adapt to disturbances. Several authors have documented an inverse relationship between flow regime instability and benthic aquatic insects, particularly taxa belonging to the orders of Ephemeroptera, Plecoptera, and Trichoptera (Bunn and Arthington, 2002; Bragg et al., 2005; Dewson et al., 2007). Table 18 shows the flow regime instability-related metric scores for the macroinvertebrate community of the Pelican River (772). Station 16RD032 scored below the statewide mean in three out of five metrics. The total taxa richness of the macroinvertebrates was below the statewide mean and outside of the confidence interval. The station yielded a robust community of macroinvertebrates from the orders of Ephemeroptera, Plecoptera, and Trichoptera. However, many of

these individuals were highly tolerant. The multiple lines of evidence ***somewhat support*** the case for flow regime instability as a stressor to the macroinvertebrate community of the Pelican River (772).

Table 18. Summary of flow regime instability-related biological metric data for Station 16RD032 along the Pelican River (772), as well as statewide stations that support a healthy macroinvertebrate community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
EPTPct	Relative abundance (%) of Ephemeroptera, Plecoptera, and Trichoptera (↓)	44 ± 18	16RD032 (51)
LongLived Pct	Relative abundance (%) of long-lived individuals (↓)	9 ± 7	16RD032 (3)
TaxaCount AllChir	Total taxa richness of macroinvertebrates (↓)	42 ± 8	16RD032 (32)
Tolerant2 ChTxPct	Relative abundance (%) of taxa with tolerance values equal to or greater than six (↑)	72 ± 9	16RD032 (75)
Trichwo HydroPct	Relative abundance (%) of non-hydrospsychid Trichoptera individuals (↓)	6 ± 7	16RD032 (7)

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
- Good: Score for the biologically impaired reach met or was equal to the statewide mean.
- Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
- Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Insufficient physical habitat

Available data

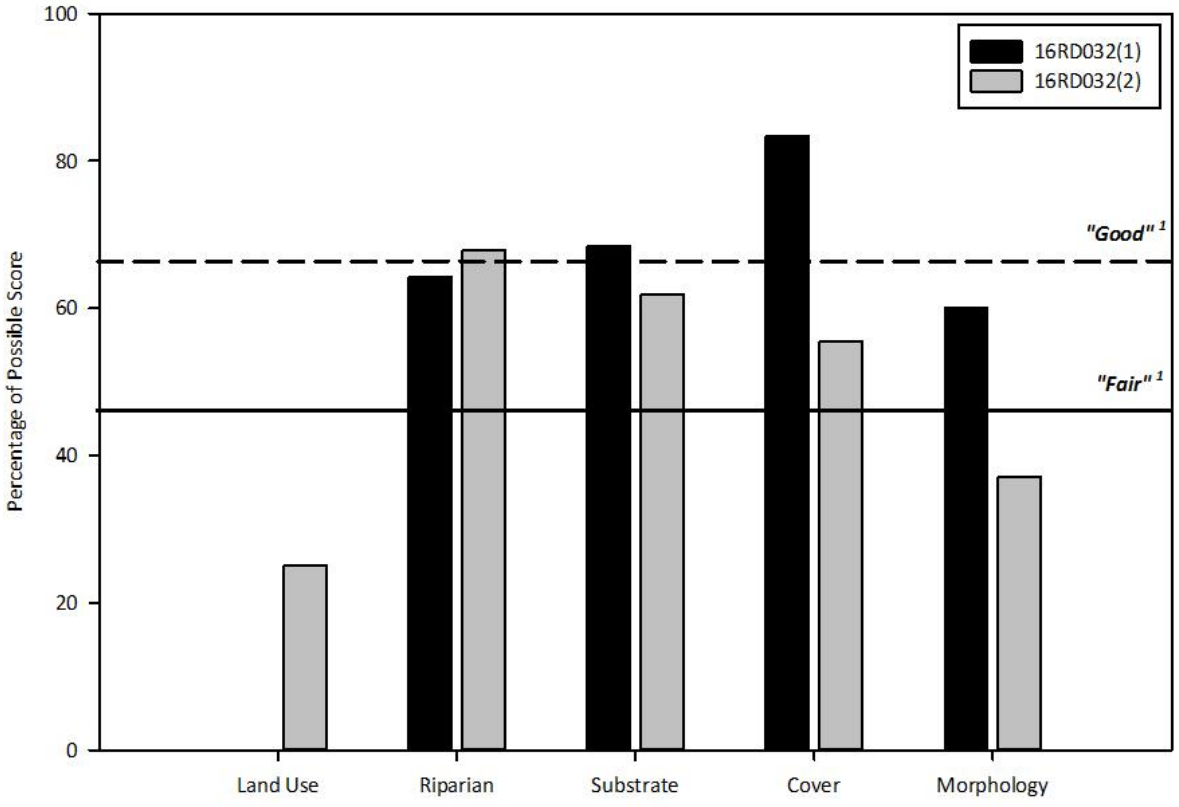
The physical habitat of the Pelican River (772) was evaluated at Station 16RD032 using the MSHA. The station is located along a natural segment of the reach (MPCA, 2013). The station yielded "fair" MSHA scores (MSHA=51 and 64). Figure 15 displays the MSHA subcategory results for the station. The predominance of urban/industrial land uses in the immediate vicinity of the station limited its land use subcategory score. The riparian subcategory score was positively influenced by "little" bank erosion and "substantial" shading. The station scored well in the substrate subcategory offering both riffle habitat and coarse substrate (i.e., boulders and gravel). However, the substrate of the station was slightly degraded by a "little" amount of embeddedness. The station also scored well in the cover subcategory due to the diversity and "moderate" amount of cover present; however, dense mats of decaying algae appeared to be limiting cover availability at the time of the August 8, 2017, macroinvertibrate monitoring visit. Noted cover types included deep pools, macrophytes (emergent, submergent, and floating leaf), overhanging vegetation, oxbows, rootwads, shallows, undercut banks, and woody debris. Lastly, the morphology subcategory score was limited by "poor" to "good" sinuosity and "fair" channel development.

On October 18, 2018, the MPCA SID staff completed a longitudinal assessment of the Pelican River (772). Staff noted a substantial amount of sediment deposition between the US Highway 10 crossing and Site S002-176. From Station 16RD032 to Detroit Lake, staff observed several areas of quality riffle habitat and other areas of coarse substrate. Staff also identified multiple areas where landowners were maintaining their lawns to the edge of the river channel (Figure 16), thereby causing bank instability in

some instances. Lastly, staff observed a homeowner actively blowing all of the fallen leaves from their yard into the river.

In summary, the MSHA and longitudinal assessment data suggest the Pelican River (772) has many areas with sufficient instream habitat to support a heathy biological community. However, the effects of an urban setting and past channel alteration are substantial threats to the quality of habitat found along the reach.

Figure 15. MSHA subcategory results for Station 16RD032 along the Pelican River (772).



[1] The minimum percentage of each subcategory score needed for the station to achieve a "fair" and "good" MSHA rating.

Figure 16. Figure 16. Images of lawns being maintained to the edge of the river channel downstream of Corbett Avenue (left) and downstream of Lori Avenue (right) along the Pelican River (772) on October 18, 2018.

Biological response: Fish

Insectivores (e.g., darters and sculpins) and simple lithophilic spawners require quality benthic habitat (e.g., clean, coarse substrate and riffles) for feeding and/or reproduction purposes, while detritivores utilize decomposing organic matter (i.e., detritus) as a food resource and, therefore, are less dependent upon the quality of instream habitat (Aadland and Kuitunen, 2006). Table 19 shows the insufficient physical habitat-related metric scores for the fish community of the Pelican River (772). Station 16RD032 scored below the statewide mean for all of the metrics. The scores for the abundance of simple lithophilic spawning, insectivorous, and darter and sculpin taxa did not meet the statewide mean and were below the lower confidence interval. Two other metric scores did not meet the statewide mean but were within the confidence interval (riffle dwelling and detritivorous taxa). The multiple lines of evidence ***somewhat support*** the case for insufficient physical habitat as a stressor to the fish community of the Pelican River (772).

Table 19. Summary of insufficient physical habitat-related biological metric data for Station 16RD032 along the Pelican River (772), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
RiffleTxPct	Relative abundance (%) of taxa that predominately utilize riffle habitats (↓)	20 ± 8	16RD032 (12)
SLithopTx Pct	Relative abundance (%) of taxa that are simple lithophilic spawning species (↓)	35 ± 10	16RD032 (18)
Insect-TolPct	Relative abundance (%) of individuals that are insectivorous excluding tolerant species (↓)	45 ± 19	16RD032 (19)
BenInsect-TolTxPct	Relative abundance (%) of taxa that are benthic insectivores, excluding tolerant species (↓)	27 ± 10	16RD032 (12)
DetNWQ TxPct	Relative abundance (%) of taxa that are detritivorous (↑)	10 ± 5	16RD032 (12)
DarterScul pTxPct	Relative abundance (%) of taxa that are darters and sculpins (↓)	14 ± 6	16RD032 (6)

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
- Good: Score for the biologically impaired reach met or was equal to the statewide mean.
- Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
- Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Biological response: Macroinvertebrate

Clinger taxa require clean, coarse substrate or other objects to attach themselves to or feed from, while burrower, legless, and sprawler macroinvertebrates are generally tolerant of degraded benthic habitat (Gore et al., 2001). Table 20 shows the insufficient physical habitat-related metric scores for the macroinvertebrate community of the Pelican River (772). Station 16RD032 met the statewide mean for all of the metrics. Over half (62%) of the sample was made up of clinger individuals, indicating the presence of coarse substrate and suitable cover habitats. Additionally, there was a relatively low abundance of burrower, legless, and sprawler individuals, which often dominate systems with degraded habitat. The multiple lines of evidence are ***inconclusive*** as to whether insufficient physical habitat is a stressor to the macroinvertebrate community of the Pelican River (772).

Table 20. Summary of insufficient physical habitat-related biological metric data for Station 16RD032 along the Pelican River (772), as well as statewide stations that support a healthy macroinvertebrate community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
Burrower Pct	Relative abundance (%) of burrower individuals (↑)	8 ± 8	16RD032 (1)
ClingerPct	Relative abundance (%) of clinger individuals (↓)	50 ± 15	16RD032 (62)
LeglessPct	Relative abundance (%) of legless individuals (↑)	36 ± 17	16RD032 (26)
Sprawler Pct	Relative abundance (%) of sprawler individuals (↑)	17 ± 11	16RD032 (6)

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

High suspended sediment

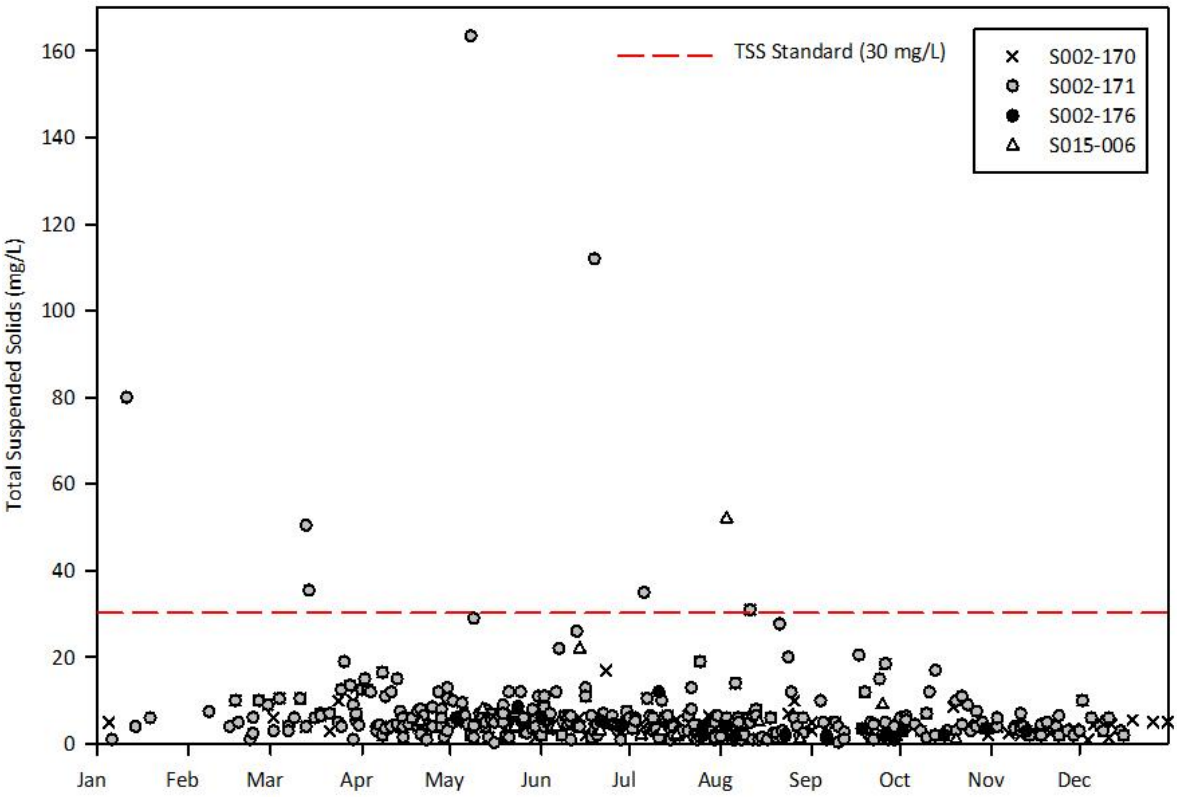
Available data

According to T. Guetter, Pelican River Watershed District (PRWD) Administrator (personal communication, 2019), there are multiple stormwater-related issues within the City of Detroit Lakes that are likely contributing excessive sediment to the Pelican River (772). Of particular concern is the lack of stormwater control within certain areas of the industrial park, which is located directly upstream of the reach. Additionally, there is a catch basin near Site S002-176 that has structurally failed and is discharging stormwater from several blocks directly to the river, instead of a nearby stormwater pond.

The MPCA biological monitoring staff collected a discrete water quality sample at Station 16RD032 along the Pelican River (772) at the time of fish monitoring. The sample was analyzed for several parameters, including TSS. The station had a TSS concentration of 5 mg/L, which is well below the 30 mg/L TSS standard for the Central TSS Region. Figure 17 displays available discrete TSS data for Sites S002-170 (Long Avenue crossing; 1998-2004; *n*=154); S002-171 (North Shore Drive crossing; 1988-2017; *n*=323), S002-176 (Corbett Road crossing; 1999-2018; *n*=21), and S015-006 (Randolph Road crossing located less than 0.1 miles upstream of the reach; 2017; *n*=14); the location of these sites is shown in Figure 13. For the purposes of displaying the most values, the TSS axis of the graph was only extended to 160 mg/L; therefore, two high values for Site S002-171 (366 and 2054 mg/L) were excluded. Collectively, the mean TSS concentration for the sites was 11 mg/L, while the highest concentration was 2054 mg/L and the lowest concentration was 1 mg/L. Approximately 2% of the values exceeded the TSS standard. The OTRW HSPF model estimates that Pelican River (772) had a TSS concentration in excess of the standard 1% of the time during the period of 1995 to 2014.

Overall, the available data suggest the Pelican River (772) experiences infrequent periods of high suspended sediment; however, during these periods, TSS concentration values can be extremely high.

Figure 17. Discrete TSS data for Sites S002-170, S002-171, S002-176, and S015-006 along Pelican River (772).



Biological response: Fish

Excessive suspended sediment can affect a fish community in various ways depending on the concentration and duration of exposure. The deposition of sediment can fill interstitial spaces in riffles and coarse substrate that are important for lithophilic and insectivorous taxa (Bilotta and Brazier, 2008). Sediment deposition can also block pores in the streambed, thereby preventing exchange within the hyporheic zone (Greig et al., 2005). Table 21 shows the high TSS-related metric scores for the fish community of the Pelican River (772). Station 16RD032 did not meet the statewide mean for either metric. The score for the TSS conditional probability metric was below the mean and outside of the confidence interval. The multiple lines of evidence ***somewhat support*** the case for high suspended sediment as a stressor to the fish community of the Pelican River (772).

Table 21. Summary of high total suspended solids-related biological metric data for Station 16RD032 along the Pelican River (772), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
TSS TIV	Mean TSS (mg/L) tolerance indicator value (↑)	12 ± 2	16RD032 (14)
CondProb	Probability of meeting the TSS standard (↓)	86 ± 10	16RD032 (74)

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Biological response: Macroinvertebrate

Similarly, high suspended sediment can adversely affect macroinvertebrates in various ways depending on the concentration and duration of exposure. Excessive suspended sediment often results in a limited macroinvertebrate community that is dominated by tolerant taxa (Henley et al., 2000; EPA, 2012a; Jones et al., 2012). Sediment suspended in the water column can limit collector species and species that filter using a net-spinning casing. Table 22 shows the high TSS-related metric scores for the macroinvertebrate community of the Pelican River (772). Station 16RD032 met the statewide mean for the TSS TIV metric but failed to meet the mean in the percentage of high TSS tolerant and intolerant taxa. However, the latter metric scores within the confidence interval of meeting the statewide mean. The multiple lines of evidence ***somewhat support*** the case for high suspended sediment as a stressor to the macroinvertebrate community of the Pelican River (772).

Table 22. Summary of high total suspended solids-related biological metric data for Station 16RD032 along the Pelican River (772), as well as statewide stations that support a healthy macroinvertebrate community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
TSS TIV	Mean TSS (mg/L) tolerance indicator value (↑)	16 ± 2	16RD032 (15)
TolTSS	Relative abundance (%) of high TSS tolerant taxa (↑)	35 ± 14	16RD032 (40)
InTolTSS	Relative abundance (%) of high TSS intolerant taxa (↓)	5 ± 8	16RD032 (3)

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.

- Good: Score for the biologically impaired reach met or was equal to the statewide mean.
- Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
- Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Low dissolved oxygen

Available data

The proposed 2020 Impaired Waters List includes a new DO impairment for the Pelican River (772). The MPCA biological monitoring staff collected a discrete DO measurement at Station 16RD032 along the reach at the time of fish (6.5 mg/L) and macroinvertebrate (9.7 mg/L) monitoring. Both measurements were well above the 5.0 mg/L DO standard. Figure 18 displays all available discrete DO data for Site S002-176 (2016-2018; *n*=25). Approximately 40% of the values were below the standard; however, only 3 of the measurements were collected prior to 9:00 a.m., when values are typically lowest. The MPCA conducted continuous DO monitoring at Site H56082005 (near Corbett Road crossing) from September 6, 2017, to September 13, 2017 and from August 27, 2018, to September 5, 2018; the location of the site is shown in Figure 13. The monitoring results are provided in Table 23, as well as displayed in Figures 19 and 20. During the September 2017 monitoring period, 20% of the total values and 33% of the daily minimum values fell below the standard. These percentages were substantially higher during the 2018 monitoring period, as 35% of the total values and 87% of the daily minimum values were below the standard. Additionally, the MPCA SID staff conducted continuous DO monitoring at Sites W56082007 (State Highway 34 crossing; located 1.3 miles upstream of AUID 772) and W56082008 (North Shore Drive crossing) from June 15, 2018, to June 18, 2018 to capture the influence of a storm event on the DO regime of the reach; the location of these sites is shown in Figure 13. The area received approximately three inches of rainfall during the monitoring period. As shown in Figure 21, the DO concentrations for both sites dropped dramatically throughout the monitoring period. Site W56082007 had the lowest DO

concentrations, with 65% of values below the standard, while Site W56082008 had 47% of values below the standard. Lastly, the OTRW HSPF model estimates that the reach had a DO concentration below the standard less than 1% of the time during the period of 1995 to 2014. Overall, the available data suggest the Pelican River (772) experiences frequent periods of low DO.

Figure 18. Discrete DO data for Site S002-176 along the Pelican River (772).

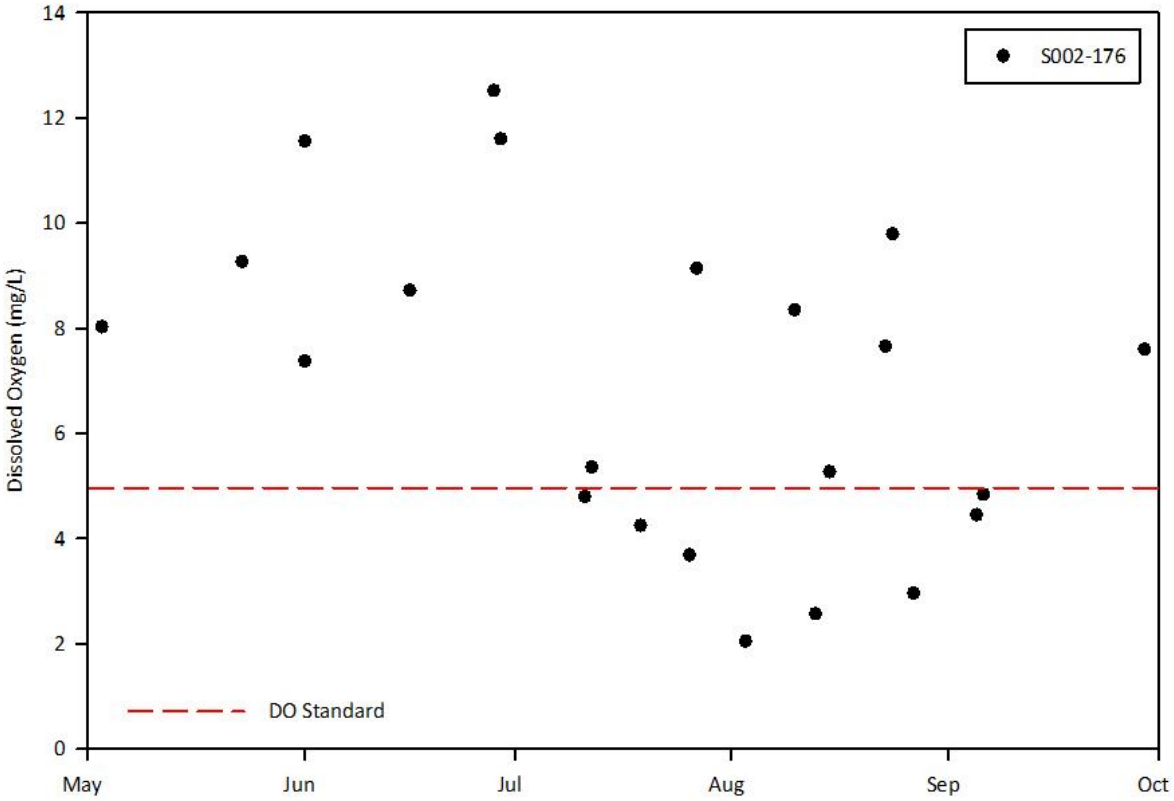


Table 23. Continuous DO data for Site H56082005 along the Pelican River (772).

Site	Start date - End date	*n*	Max. (mg/L)	Min. (mg/L)	% Total values below standard	% Daily min. values below standard	Mean daily flux (mg/L)
H56082005	9/6/2017 - 9/13/2017	671	9.7	3.8	20	33	4.1
H56082005	8/27/2018 - 9/5/2018	863	9.2	3.0	35	87	3.7

Figure 19. Continuous DO data (September 6-13, 2017) for Site H56082005 along the Pelican River (772).

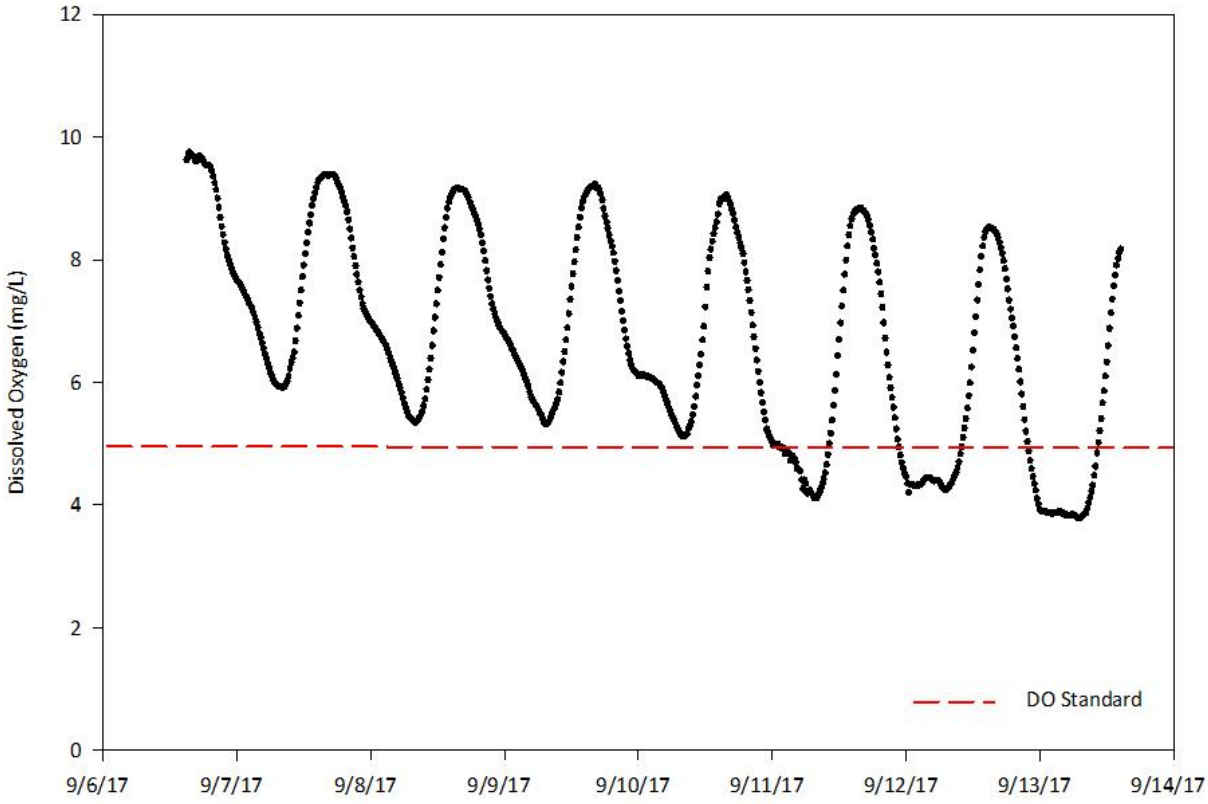


Figure 20. Continuous DO data (August 27-September 5, 2018) for Site H56082005 along the Pelican River (772).

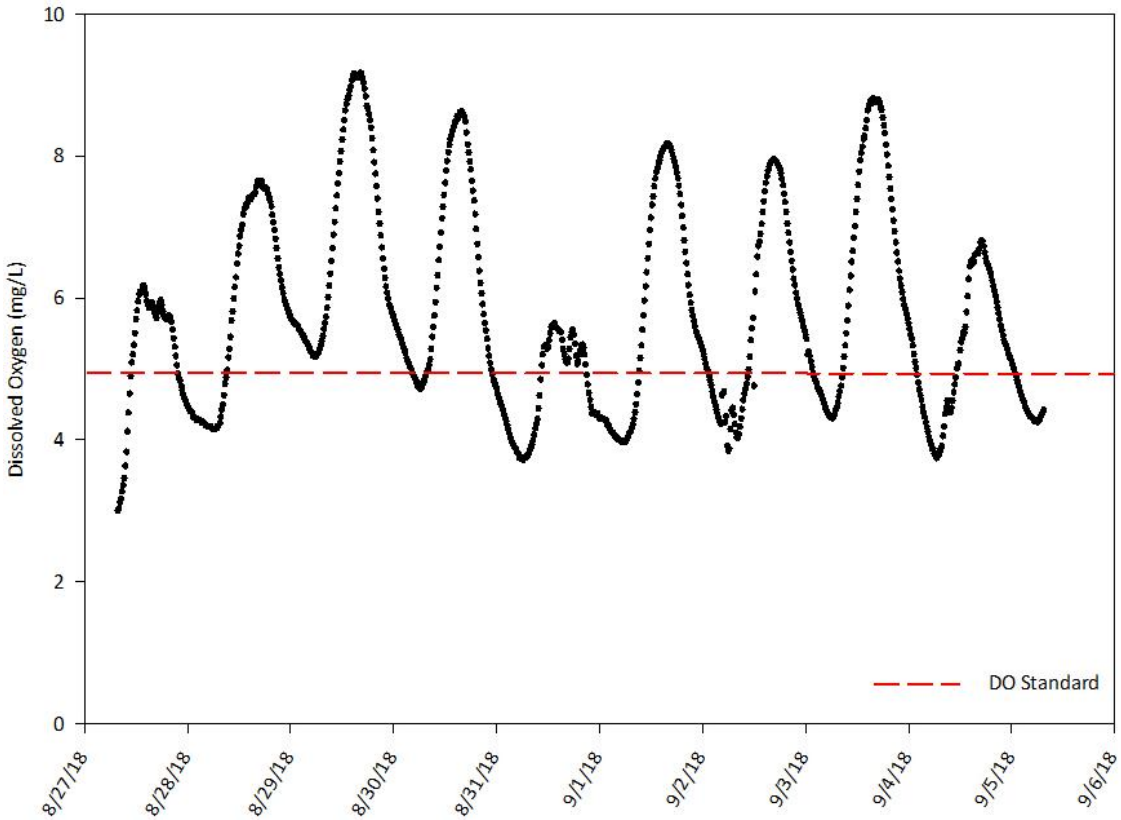
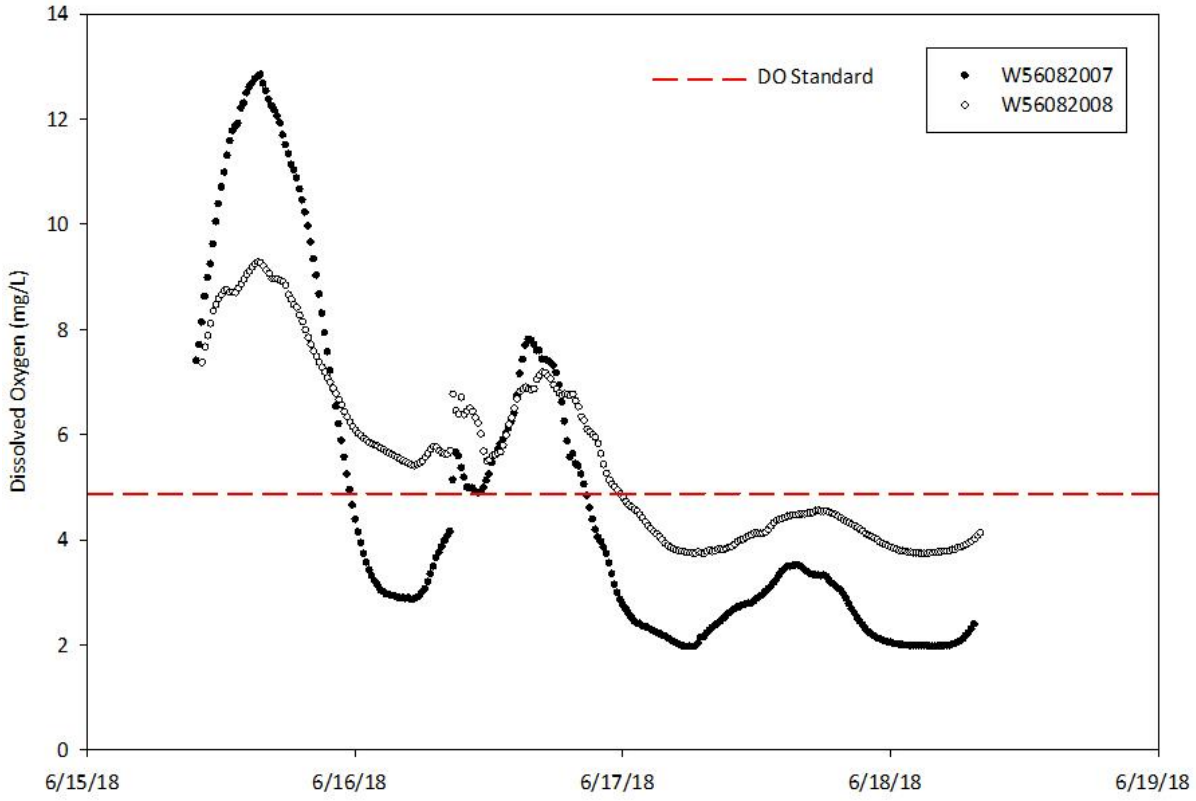


Figure 21. Continuous DO data (June 15-18, 2018) for Sites W56082007 (State Highway 34) and W56082008 (North Shore Drive) along the Pelican River (772).



Eutrophication-related data for the Pelican River (772) includes the following parameters: TP, Chl-a, and DO flux. The MPCA biological monitoring staff collected a discrete water quality sample at Station 16RD032 along the reach at the time of the fish monitoring visit. The sample was analyzed for several parameters, including TP. The station had a TP concentration of 73 µg/L, which is below the 100 µg/L Central River Nutrient Region TP standard. Discrete TP data are also available for Sites S002-170 (1995-2010; *n*=196), S002-171 (1988-2017; *n*=445), and S002-176 (1999-2018; *n*=23). Collectively, the mean TP concentration for the sites was 78 µg/L, while the highest concentration was 6,113 µg/L and the lowest concentration was 6 µg/L. Approximately 15% of the values exceeded the TP standard. Discrete Chl-a data are also available for Site S002-176 (2018; *n*=5). The mean Chl-a concentration for the site was 6 µg/L, while the highest concentration was 18 µg/L and the lowest concentration was 2 µg/L. There were no exceedances of the 18 µg/L Central River Nutrient Region Chl-a standard. The mean daily DO flux documented during continuous DO monitoring at Site H56082005 was 4.1 and 3.7 mg/L, which is slightly above the 3.5 mg/L Central River Nutrient Region standard. In addition, the MPCA biological monitoring staff noted an excessive amount of filamentous algae at Station 16RD032 during the August 8, 2017, macroinvertebrate monitoring visit. The MPCA SID staff documented excessive sestonic and filamentous algae and duck weed during September 6, 2017 site reconnaissance. In 2018, staff documented clear water with a moderate amount of primary production including submergent macrophytes and periphytic algae.

According to PRWD (2017), studies and monitoring data have identified Rice Lake, a 280 acre ditched wetland located approximately two miles upstream of the Pelican River (772), as a primary source of phosphorus loading to the Pelican River; annual TP loads range from 3,000 to 4,000 pounds per year. To reduce the release of phosphorus from the wetland, the PRWD and several partnering agencies have devised a plan and acquired funding for the Rice Lake Nutrient Reduction Project. The project will

involve the installation of two dams that will be used to increase and stabilize the water level of the wetland, thereby increasing water residence time and preventing phosphorus from leaching out of the peat soils. According to T. Guetter, PRWD Administrator (personal communication, 2019), implementation of the project may begin in 2019.

Overall, the available data indicate that the Pelican River (772) is prone to high TP concentrations, much of which can be attributed to the influence of the Rice Lake wetland complex. Additional eutrophication-related monitoring should be conducted after the completion of the Rice Lake Nutrient Reduction Project.

Biological response: Fish

Frequent or extended periods of low dissolved oxygen can alter a fish community by limiting the abundance of species that are intolerant of such conditions (Davis, 1975, EPA, 2012a). Table 24 shows the low DO-related metric scores for the fish community of the Pelican River (772). Station 16RD032 met the statewide mean for the DO TIV metric but scored below the mean for the DO conditional probability metric. The latter score was well below the lower confidence interval. The very low probability of meeting the standard is an indication that the fish community is adversely affected by low DO. Additionally, this reach has a newly listed DO impairment and MPCA SID staff documented low DO conditions along the reach. The multiple lines of evidence ***strongly support*** the case for low dissolved oxygen as a stressor to the fish community of the Pelican River (772).

Table 24. Summary of low dissolved oxygen-related biological metric data for Station 16RD032 along the Pelican River (772), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
DO TIV	Mean DO (mg/L) tolerance indicator value (↑)	7 ± 0	16RD032 (7)
CondProb	Probability of meeting the dissolved oxygen standard (↓)	73 ± 20	16RD032 (42)

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
- Good: Score for the biologically impaired reach met or was equal to the statewide mean.
- Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
- Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Biological response: Macroinvertebrate

Frequent or extended periods of low dissolved oxygen can alter a macroinvertebrate community by limiting the abundance of taxa that are intolerant of such conditions (Davis, 1975, EPA, 2012a). Table 25 shows the low DO-related metric scores for the macroinvertebrate community of the Pelican River (772). Station 16RD032 met the statewide mean for the DO TIV and abundance of low DO tolerant taxa metrics. However, the abundance of low DO intolerant taxa was below the statewide mean but within the confidence interval. The multiple lines of evidence **somewhat support** the case for low dissolved oxygen as a stressor to the macroinvertebrate community of the Pelican River (772).

Table 25. Summary of low dissolved oxygen-related biological metric data for Station 16RD032 along the Pelican River (772), as well as statewide stations that support a healthy macroinvertebrate community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
DO TIV	Mean DO (mg/L) tolerance indicator value (↑)	7 ± 1	16RD032 (7)
TolDO	Relative abundance (%) of low DO tolerant taxa (↑)	9 ± 11	16RD032 (4)
InTolDO	Relative abundance (%) of low DO intolerant taxa (↓)	25 ± 16	16RD032 (16)

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
- Good: Score for the biologically impaired reach met or was equal to the statewide mean.
- Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
- Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Summary of stressors

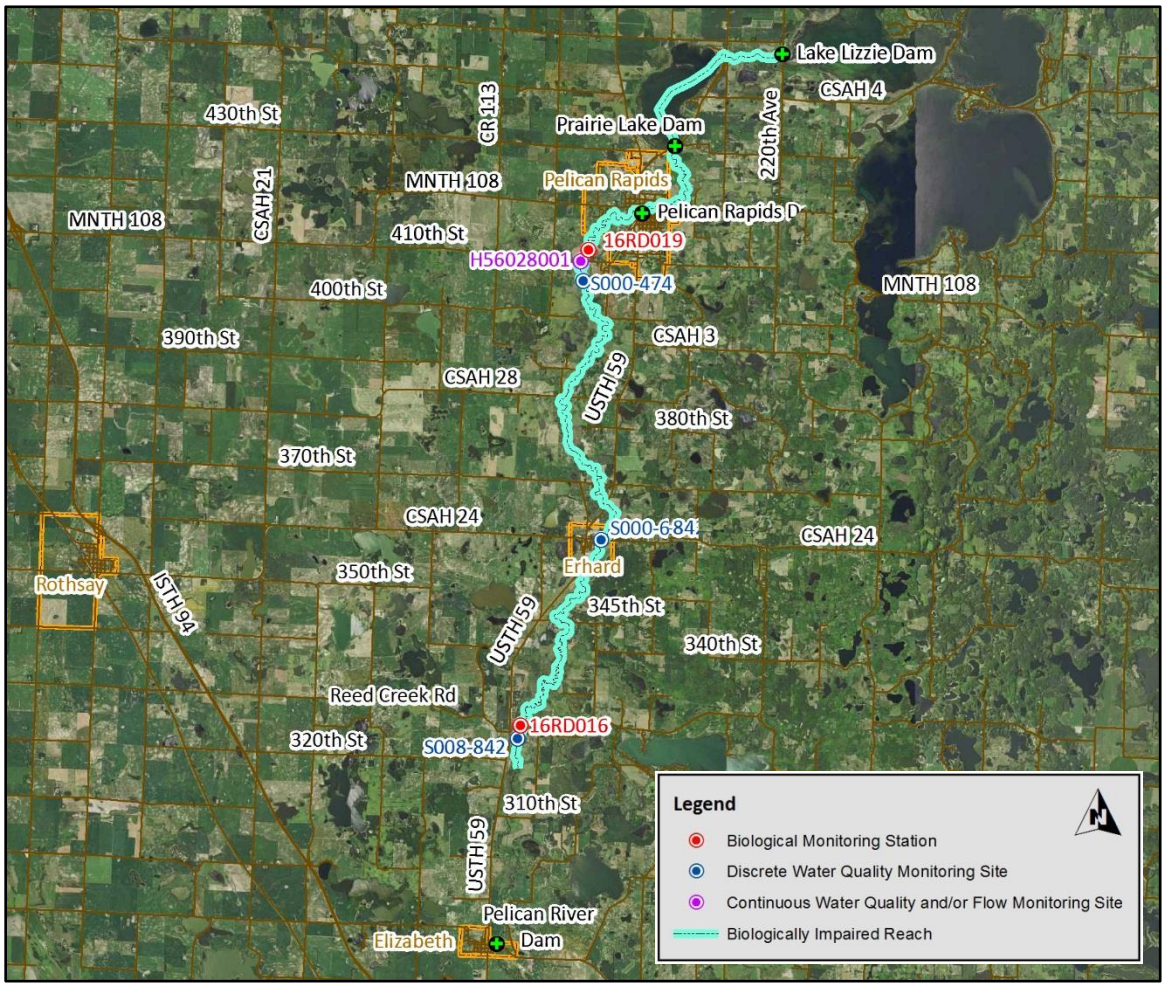
The evidence suggests that the biological community is limited by flow regime instability, insufficient physical habitat, high suspended sediment, and low dissolved oxygen. The reach is prone to frequent periods of low dissolved oxygen. Discharge from the Rice Lake wetland complex is a contributing factor to these conditions. The implementation of the Rice Lake Nutrient Reduction Project is intended to increase water residence time and decrease phosphorus loading to the Pelican River. Additional DO and eutrophication-related monitoring should be performed after the completion of the project to evaluate its effectiveness. During high precipitation events, the reach can be prone to extreme TSS concentrations. Identified deficiencies or failures in existing stormwater system infrastructure need to be corrected. Additionally, areas that lack sufficient stormwater controls (e.g., areas of the industrial park) should be targeted for the implementation of best management practices (BMPs). Lastly, areas along the lower extent of the Pelican River (772) would benefit from the installation of natural riparian buffers to mitigate runoff and prevent streambank instability.

3.2.3 Pelican River (767)

Physical setting

This reach represents the segment of the Pelican River from the outlet of Lake Lizzie, to its confluence with Reed Creek (Figure 22); a total length of 24 miles. The reach has a subwatershed area of 419 square miles (268,180 acres). The subwatershed contains 65 miles of perennial stream and river (e.g., Pelican River), 23 miles of intermittent stream, 21 miles of perennial drainage ditch, and seven miles of intermittent drainage ditch (DNR, 2014b). According to the MPCA (2013), 32% of the watercourses in the subwatershed have been physically altered (i.e., channelized, ditched, or impounded), including 4% of the Pelican River (767). The NLCD 2011 (USGS, 2011) lists forest (27%) as the predominant land cover in the subwatershed. Other notable land cover groups in the subwatershed included cultivated crops (20%), open water (18%), hay/pasture (17%), developed (7%), wetlands (7%), and herbaceous (4%).

Figure 22. Map of the Pelican River (767) and associated biological monitoring stations and water quality/flow monitoring sites (2017 NAIP aerial image). Flow direction is north to south.



Biological impairments

Fish (F-IBI)

The fish community of the Pelican River (767) was monitored at Station 16RD016 (0.2 miles upstream of the Reed Creek crossing) on August 29, 2017, as well as at Station 16RD019 (0.3 miles upstream of the 410th Street crossing) on June 21, 2016 and August 28, 2017. The location of these stations is shown in Figure 22. Both stations were designated as General Use within the Northern Streams F-IBI Class (Class 5); the associated impairment threshold is an F-IBI score of 47. The F-IBI scores for the stations ranged from 32 to 36, which are well below the impairment threshold. A total of 31 species were sampled between the stations (Table 26). The assemblage contained a high abundance of generalist and tolerant taxa (e.g., blacknose dace, common shiner, fathead minnow, and white sucker).

Table 26. Summary of fish taxa sampled at Stations 16RD016 and 16RD019 along the Pelican River (767).

Common name	# sampled		
	16RD016	16RD019[16]	16RD019[17]
black bullhead	2	5	43
black crappie			3
blackchin shiner		2	
blacknose dace	16	90	192
blacknose shiner	1	90	30
blackside darter	2	10	1
bluegill	9	1	16
bluntnose minnow			5
brook stickleback		17	
brown bullhead		2	11
central mudminnow	1	15	2
common carp	3	24	
common shiner	89	141	1788
creek chub	33	9	131
fathead minnow		300	227
golden shiner		12	5
green sunfish	12	7	82
hornyhead chub	25	19	165
hybrid sunfish			1
Iowa darter		7	17
johnny darter	19	15	129
largemouth bass	16		43
longnose dace		19	
northern pike	1		
northern redbelly dace		191	27
pugnose shiner		1	
pumpkinseed	3		9
rockbass		1	1
tadpole madtom	6	2	27
white sucker	66	174	48
yellow bullhead	1		33

[16] Sampled on June 21, 2016; [17] sampled on August 28, 2017.

Candidate causes

Loss of longitudinal connectivity

Available data

The MPCA biological monitoring staff did not observe any connectivity-related issues during their visits to Stations 16RD016 and 16RD019. According to the DNR (2014a), there are four dams (Figure 23) along the Pelican River (767). The Lake Lizzie Dam, which is located at the outlet of Lake Lizzie, is owned by the DNR and was constructed in 1938. The dam is approximately one foot high and is a partial barrier to fish passage. The Prairie Lake Dam is situated at the outlet of Prairie Lake and is also owned by the DNR. The dam was built in 1936 and is approximately one foot high, representing a partial barrier to fish passage. The Pelican Rapids Dam, which is located within the City of Pelican Rapids, is owned by the city and was constructed in 1870. The dam is 14 feet high and is a complete barrier to fish passage at all flow conditions. Lastly, the Pelican River Dam is located approximately five miles downstream of the reach in the City of Elizabeth. The dam is privately owned and was constructed in 1922. The dam is 14 feet high and is a complete barrier to fish passage at all flow conditions. On July 18, 2018 and August 22, 2018, MPCA SID staff completed a longitudinal assessment of the reach. No additional obstructions to connectivity (e.g., perched culverts and beaver dams) were identified. In addition to the assessment, MPCA SID staff performed a detailed review of May 18, 2015 and August 21, 2016, aerial photos (courtesy of Google Earth) of the reach. No other connectivity-related issues were identified in the photos. In summary, the aforementioned dams, particularly the Pelican Rapids and Pelican River dams, impede connectivity along the Pelican River (767).

Biological response: Fish

Migratory and late maturing fish species require well-connected environments in order to access the habitats and resources necessary to complete their life history (Saunders, 2007). Barriers to connectivity (e.g., dams) can limit the availability of critical habitats and resources, thereby reducing the abundance of these species, along with overall species diversity (Poole, 2002; Cross et al., 2013; Gardner, et al. 2013; Aadland, 2015). Table 27 shows the loss of longitudinal connectivity-related metric scores for the fish community of the Pelican River (767). Stations 16RD016 and 16RD019 scored below the statewide mean for both metrics. Three of the four scores were below the mean and outside of the confidence interval, while one score was within the confidence interval. Additionally, there were obvious barriers to fish passage documented along the reach. Table 28 contrasts the collective fish assemblage that was sampled immediately upstream (AUID 767) and downstream (AUID 768) of the Pelican River Dam. While several species were found both above and below the dam, a total of 11 species, including two that are considered “vulnerable” to extirpation by connectivity barriers (i.e., channel catfish and silver redhorse), were only noted downstream of the dam. The presence of these species contributed to the biological monitoring stations along AUID 768 scoring near or above the Exceptional Use threshold within the Southern Rivers F-IBI Class (Class 1). The multiple lines of evidence ***convincingly support*** the case for loss of longitudinal connectivity as a stressor to the fish community of the Pelican River (767).

Figure 23. Images of dams affecting the Pelican River (767), including the Lake Lizzie Dam on November 28, 2018 (upper left); Prairie Lake Dam on November 1, 2018 (upper right); Pelican Rapids Dam on May 7, 2018 (lower left); and Pelican River Dam on May 7, 2018 (lower right).

Table 27. Summary of loss of longitudinal connectivity-related biological metric data for Stations 16RD016 and 16RD019 along the Pelican River (767), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Fish class	Statewide score[1] (mean ± SD)	Station (score)	Station score (mean ± SD)
MgrTxPct	Relative abundance (%) of taxa that are migratory (↓)	4	25 ± 9	16RD016 (11)	NA
		5	18 ± 7	16RD019[16] (13) 16RD019[17] (12)	12 ± 0
MA>3-TolTxPct	Relative abundance (%) of taxa with a female mature age of ≥ 3 years, excluding tolerant taxa (↓)	4	36 ± 11	16RD016 (0)	NA
		5	24 ± 11	16RD019[16] (8) 16RD019[17] (4)	6 ± 3

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.

[16] Sampled on June 21, 2016; [17] sampled on August 28, 2017.

Good: Score for the biologically impaired reach met or was equal to the statewide mean.

Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.

Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Table 28. Summary of fish taxa sampled upstream and downstream of the Pelican River Dam along the Pelican River (767).

Common name[1]	Present upstream of the Pelican River Dam[2]	Present downstream of the Pelican River Dam[3]
bigmouth shiner		X
black bullhead	X	
black crappie	X	
blackchin shiner	X	X
blacknose dace	X	X
blacknose shiner	X	
blackside darter	X	X
bluegill	X	X
bluntnose minnow	X	X
bowfin		X
brook stickleback	X	X
brown bullhead	X	
central mudminnow	X	
central stoneroller		X
channel catfish		**X**
common carp	X	X
common shiner	X	X
creek chub	X	X
fathead minnow	X	X
golden redhorse		X
golden shiner	X	
green sunfish	X	X
hornyhead chub	X	X
hybrid sunfish	X	
Iowa darter	X	
johnny darter	X	X
largemouth bass	X	X
logperch		X
longnose dace	X	X
northern hogsucker		X
northern pike	X	X
northern redbelly dace	X	
pugnose shiner	X	
pumpkinseed	X	

[1] Species highlighted red are those designated by Aadland (2015) as "vulnerable" to extirpation by barrier dams.
[2] Stations 16RD016 and 16RD019 along Pelican River (767).
[3] Stations 05RD111 and 16RD013 along Pelican River (768).

Table 28. Summary of fish taxa sampled upstream and downstream of the Pelican River Dam along the Pelican River (767). (Continued)

Common name[1]	Present upstream of the Pelican River Dam[2]	Present downstream of the Pelican River Dam[3]
rock bass	X	X
shorthead redhorse		X
silver redhorse		**X**
smallmouth bass		X
spotfin shiner		X
tadpole madtom	X	X
white sucker	X	X
yellow bullhead	X	X

[1] Species highlighted red are those designated by Aadland (2015) as "vulnerable" to extirpation by barrier dams.
[2] Stations 16RD016 and 16RD019 along Pelican River (767).
[3] Stations 05RD111 and 16RD013 along Pelican River (768).

Flow regime instability

Available data

The MPCA biological monitoring staff did not encounter any flow-related issues (e.g., intermittency) at Stations 16RD016 and 16RD019. According to the MPCA (2013), 32% of the watercourses in the subwatershed have been physically altered (i.e., channelized, ditched, or impounded), including 4% of Pelican River (767). There are no flow monitoring data for the reach. The USGS (2018) estimated that the median flow (Q50) for the reach at its outlet was 151.0 cfs, while the normal range of flow values was 300.0 (Q25) to 91.4 (Q75) cfs. The ratio of Q25 to Q75 flow values was approximately 3:1, which is indicative of a hydrologically stable system. By comparison, several of the more hydrologically stable rivers in the Red River Basin (e.g., Buffalo River, Clearwater River, and Otter Tail River) had a Q25 to Q75 ratio of 7:1 or less. Additionally, the 7 day, 10 year low flow value for the reach was 33.4 cfs, which suggests that the reach has sustained baseflow and does not regularly experience periods of intermittency. The MPCA SID staff conducted reconnaissance along the reach on seven separate dates between the spring and fall of 2018 and documented flow conditions. No flow-related issues were noted. Overall, the available data suggest the Pelican River (767) has a stable flow regime.

Biological response: Fish

Flow regime instability has been shown to limit species diversity and favor taxa that are generalists, early maturing, pioneering, short-lived, and tolerant to disturbances (Aadland et al., 2005; Poff and Zimmerman, 2010). Table 29 shows the flow regime instability-related metric scores for the fish community of the Pelican River (767). While several of the metric scores for Station 16RD016 and 16RD019 did not meet the statewide mean, the available data suggest that the reach has a stable flow regime. Therefore, it is possible that the "fair" and "poor" metric scores are correlated to the loss of connectivity stressor. The multiple lines of evidence are ***inconclusive*** as to whether flow regime instability is a stressor to the fish community of the Pelican River (767).

Table 29. Summary of flow regime instability-related biological metric data for Stations 16RD016 and 16RD019 along the Pelican River (767), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Fish class	Statewide score[1] (mean ± SD)	Station (score)	Station score (mean ± SD)
DomTwo Pct	Relative abundance (%) of the two most abundant taxa (↑)	4	51 ± 14	16RD016 (51)	NA
		5	51 ± 13	16RD019[16] (43) 16RD019[17] (66)	54 ± 17
GeneralTx Pct	Relative abundance (%) of individual that are generalists (↑)	4	18 ± 7	16RD016 (44)	NA
		5	24 ± 8	16RD019[16] (42) 16RD019[17] (44)	43 ± 2
MA<2Tx Pct	Relative abundance (%) of taxa with a female mature age ≤ 2 years (↑)	4	47 ± 11	16RD016 (78)	NA
		5	58 ± 12	16RD019[16] (75) 16RD019[17] (68)	72 ± 5
NumPer Meter-Tol	Number of individuals per meter of stream sampled, excluding tolerant species (↓)	4	1 ± 1	16RD016 (0.4)	NA
		5	1 ± 1	16RD019[16] (1) 16RD019[17] (5)	3 ± 3
PioneerTx Pct	Relative abundance (%) of taxa that are pioneers (↑)	4	8 ± 5	16RD016 (17)	NA
		5	12 ± 5	16RD019[16] (17) 16RD019[17] (20)	18 ± 2
SLvdPct	Relative abundance (%) of individuals that are short-lived (↑)	4	10 ± 13	16RD016 (6)	NA
		5	9 ± 13	16RD019[16] (60) 16RD019[17] (16)	38 ± 31

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
[16] Sampled on June 21, 2016; [17] sampled on August 28, 2017.
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

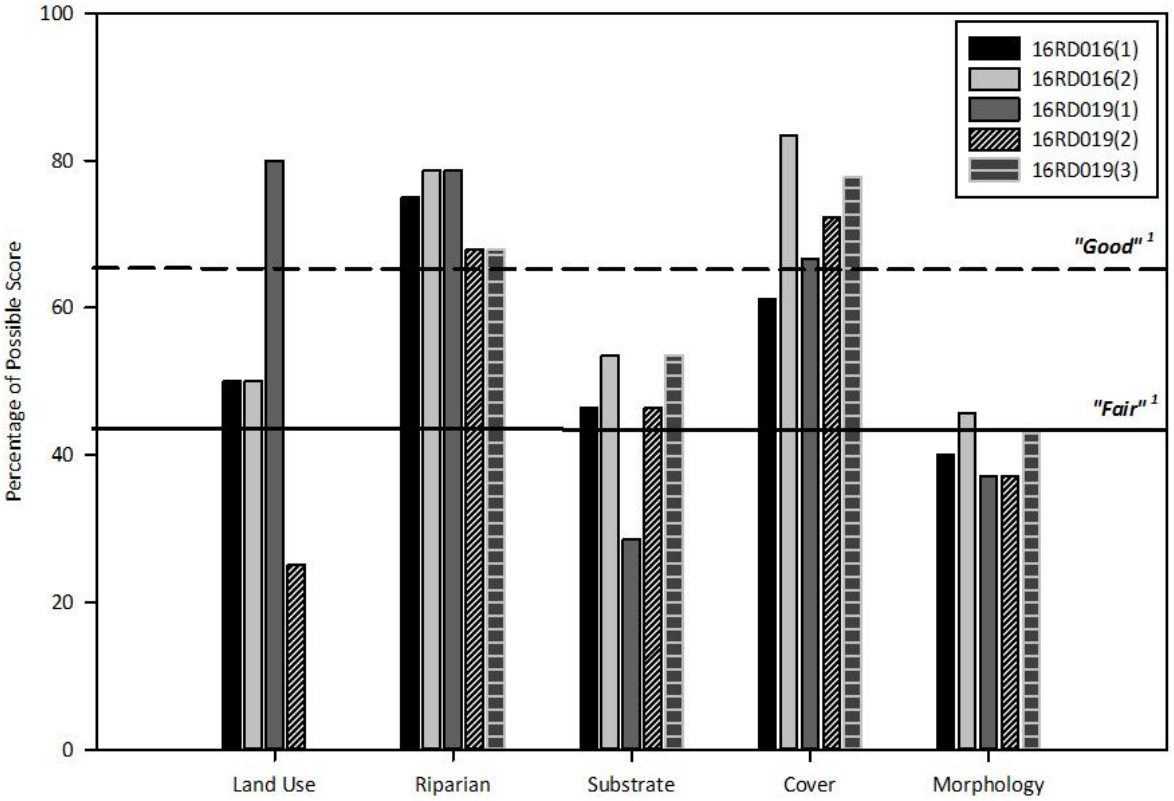
Insufficient physical habitat

Available data

The physical habitat of the Pelican River (767) was evaluated at Stations 16RD016 and 16RD019 using the MSHA. Both stations are found along natural segments of the reach (MPCA, 2013). Station 16RD016 (MSHA=51/"fair" and 59/"fair"), which is located along the downstream extent of the reach, had a slightly higher average MSHA score than 16RD019 (MSHA=48/"fair", 50/"fair", and 53/"fair"), which is situated further upstream. Figure 24 displays the MSHA subcategory results for each of the stations. The predominance of agricultural row crops in the immediate vicinity of Stations 16RD016 and 16RD019 limited their land use subcategory scores. The stations scored above the "good" rating threshold in the riparian subcategory due to a "moderate" to "extensive" riparian zone width and "little" to no bank erosion. While both stations offered riffle habitat and coarse substrate (e.g., boulders, cobble, and gravel), the dominant substrate types were sand and silt, which negatively affected scores in the substrate subcategory. The scores for the cover subcategory were positively influenced by a "moderate" to "extensive" amount of cover. Noted cover types along the reach included deep pools, macrophytes (emergent, floating leaf, and submergent), overhanging vegetation, oxbows, shallows, undercut banks,

and wood debris. Lastly, both stations scored poorly in the morphology subcategory due in part to "poor" to "fair" channel development and a lack of velocity types.

Figure 24. MSHA subcategory results for Stations 16RD016 and 16RD019 along the Pelican River (767).

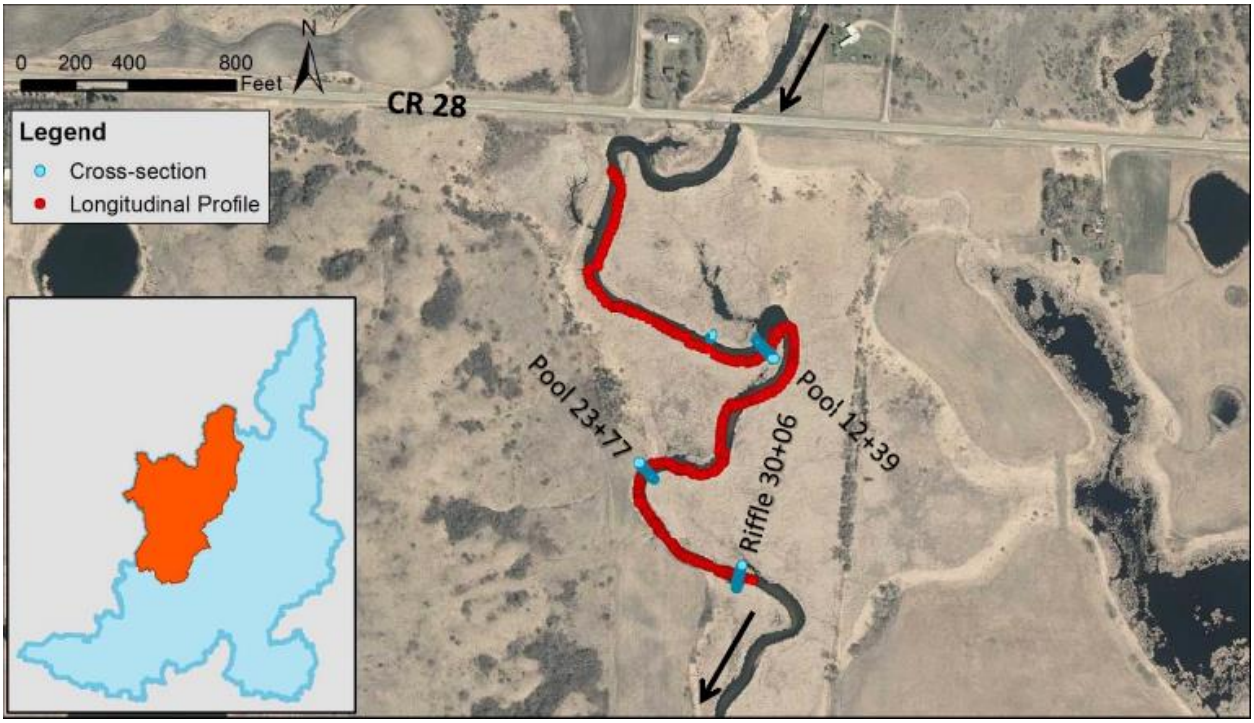


[1] The minimum percentage of each subcategory score needed for the station to achieve a "fair" and "good" MSHA rating.

On September 10, 2018, Clark and Vinje (2018) completed a fluvial geomorphic assessment downstream of the County State Aid Highway (CSAH) 28 crossing (Figure 25) along the Pelican River (767). The stream type at this location was determined to be a C5 (moderate to high width-to-depth ratio, slightly entrenched, sand bed stream). The site yielded a Pfankuch stability rating of 66 (stable). Below are excerpts from the assessment summary for the site:

> *"The Pelican River was in a stable condition at this site. The pools and riffles were similar in width and cross-sectional area, but the pools were slightly deeper than the riffles. The substrate was predominantly moderately packed sand. There was one tall bank between pool 23+77 and Riffle 30+06. The exposed soils on this bank consisted of loose sand and likely is a source of sediment to the channel; however, it likely is not eroding at an excessive rate. The channel bumps against the valley wall on this bend, but it also has a wide floodplain on the opposite bank. In addition, the thalweg is not near the outside bend; rather, it runs approximately down the center of the channel."*

Figure 25. Fluvial geomorphic assessment site downstream of the CSAH 28 crossing along the Pelican River (767).



In summary, the MSHA data suggest the physical habitat of the Pelican River (767) is primarily limited by substrate and channel morphology factors, including the predominance of sand and silt substrate types, inadequate channel development, and a lack of velocity types. Clark and Vinje (2018) completed a geomorphic assessment of a segment of the reach located between the biological monitoring stations and determined that it was in stable condition, despite the presence of an exposed bank.

Biological response: Fish

Insectivores (e.g., darters and sculpins) and simple lithophilic spawners require quality benthic habitat (e.g., clean, coarse substrate and riffles) for feeding and/or reproduction purposes, while detritivores utilize decomposing organic matter (i.e., detritus) as a food resource and, therefore, are less dependent upon the quality of instream habitat (Aadland and Kuitunen, 2006). Table 30 shows the insufficient physical habitat-related metric scores for the fish community of the Pelican River (767). Only two metric scores met the statewide mean (detritivorous and darter/sculpin taxa); both of these scores were attributed to Station 16RD016. Both monitoring stations scored below the statewide mean and confidence interval for the abundance of lithophilic spawning and insectivorous taxa metrics. Six other metric scores did not meet the statewide mean; however, the scores were close to meeting the mean. While the biological scores indicate that physical habitat may be limited, these metrics can also be affected by a loss of connectivity. The multiple lines of evidence ***somewhat support*** the case for insufficient physical habitat as a stressor to the fish community of the Pelican River (767).

Table 30. Summary of insufficient physical habitat-related biological metric data for Stations 16RD016 and 16RD019 along the Pelican River (767), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Fish class	Statewide score[1] (mean ± SD)	Station (score)	Station score (mean ± SD)
RiffleTxPct	Relative abundance (%) of taxa that predominately utilize riffle habitats (↓)	4	17 ± 8	16RD016 (11)	NA
		5	20 ± 8	16RD019[16] (13) 16RD019[17] (8)	10 ± 3
SLithopTx Pct	Relative abundance (%) of taxa that are simple lithophilic spawning species (↓)	4	37 ± 11	16RD016 (22)	NA
		5	35 ± 10	16RD019[16] (21) 16RD019[17] (16)	18 ± 3
Insect-TolPct	Relative abundance (%) of individuals that are insectivorous excluding tolerant species (↓)	4	55 ± 18	16RD016 (21)	NA
		5	45 ± 19	16RD019[16] (14) 16RD019[17] (13)	14 ± 1
BenInsect-TolTxPct	Relative abundance (%) of taxa that are benthic insectivores, excluding tolerant species (↓)	4	28 ± 11	16RD016 (17)	NA
		5	27 ± 10	16RD019[16] (21) 16RD019[17] (16)	18 ± 3
DetNWQ TxPct	Relative abundance (%) of taxa that are detritivorous (↑)	4	13 ± 7	16RD016 (11)	NA
		5	10 ± 5	16RD019[16] (17) 16RD019[17] (12)	14 ± 3
DarterSculpTxPct	Relative abundance (%) of taxa that are darters and sculpins (↓)	4	11 ± 6	16RD016 (11)	NA
		5	14 ± 6	16RD019[16] (13) 16RD019[17] (12)	12 ± 0

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
[16] Sampled on June 21, 2016; [17] sampled on August 28, 2017.
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

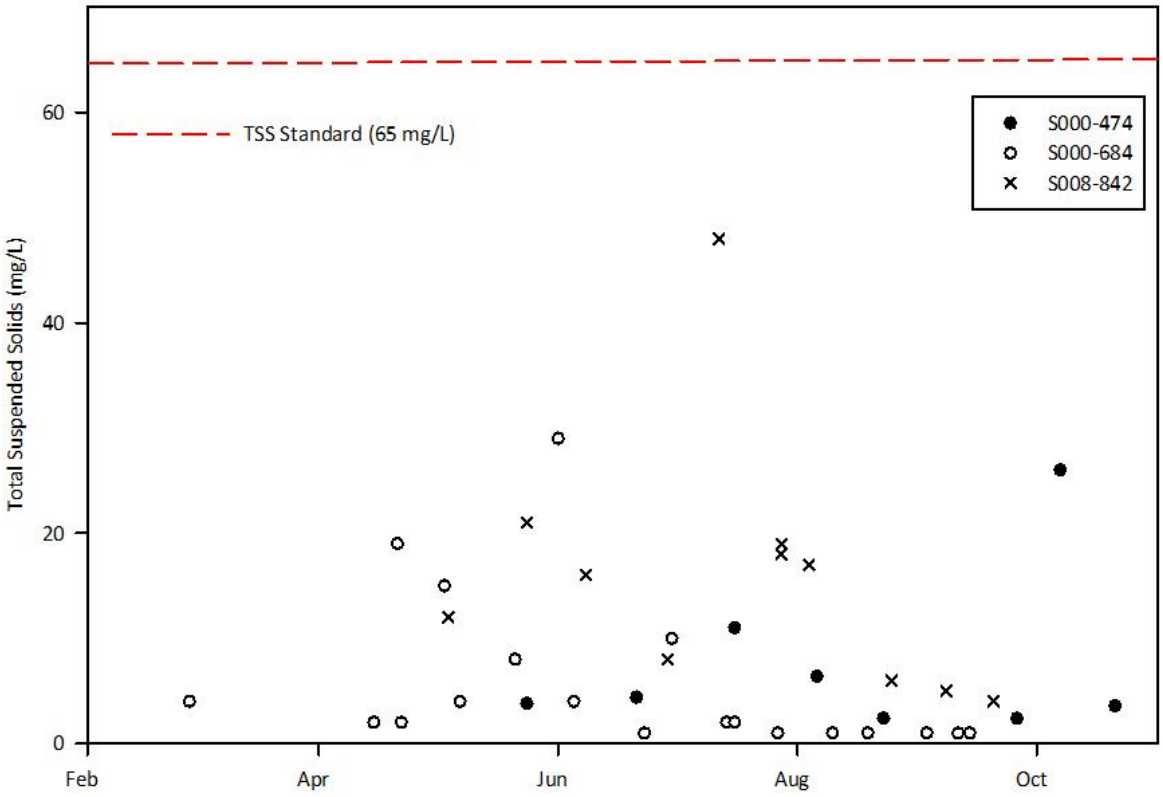
High suspended sediment

Available data

The MPCA biological monitoring staff collected a combined three discrete water quality samples at Stations 16RD016 and 16RD019 along the Pelican River (767) at the time of fish and macroinvertebrate monitoring. The samples were analyzed for several parameters, including TSS. The stations had TSS concentrations ranging from 3 to 11 mg/L; the values were well below the 65 mg/L TSS standard for the Southern TSS Region. Figure 26 displays all available discrete TSS data for Sites S000-474 (410th Street crossing; 1977-2018; *n*=9), S000-684 (CSAH 24; 1980-2010; *n*=21), and S008-842 (Reed Creek Road crossing; 2016; *n*=11); the location of the sites is shown in Figure 22. Collectively, the mean TSS concentration for the sites was 9 mg/L, while the highest concentration was 48 mg/L and the lowest concentration was 1 mg/L. None of the TSS values for these sites exceeded the standard. The OTRW HSPF model estimates that the reach had a TSS concentration in excess of the standard 1% of the time during the period of 1995 to 2014. On July 18, 2018 and August 22, 2018, MPCA SID staff completed a longitudinal assessment of the reach. Staff documented a few areas of bank instability (Figure 27) along

the reach. Overall, the available data suggest the Pelican River (767) experiences infrequent periods of high suspended sediment.

Figure 26. Discrete TSS data for Sites S000-474, S000-684, and S008-842 along the Pelican River (767).



Biological response: Fish

Excessive suspended sediment can affect a fish community in various ways depending on the concentration and duration of exposure. The deposition of sediment can fill interstitial spaces in riffles and coarse substrate that are important for lithophilic and insectivorous taxa (Bilotta and Brazier, 2008). Sediment deposition can also block pores in the streambed, thereby preventing exchange within the hyporheic zone (Greig et al., 2005). Table 31 shows the high TSS-related metric scores for the fish community of the Pelican River (767). Three out of the four metrics scores for the stations did not meet the statewide mean. Station 16RD016 had the only score that met the mean (TSS TIV). While the metric data suggests that TSS may be a stressor to the fish community, there were no exceedance of the TSS standard. Additionally, the reach supported excellent M-IBI scores, with a high level of species diversity. The level of diversity in the macroinvertebrate community suggest that high suspended sediment is not limiting the biological community. The multiple lines of evidence are ***inconclusive*** as to whether high suspended sediment is a stressor to the fish community of the Pelican River (767).

Figure 27. Images of potential sediment sources along the Pelican River (767) on July 18, 2018, including an eroded bank upstream of the 410th Street crossing (upper left); a denuded bank caused by cattle access upstream of the CSAH 28 crossing (upper right); an eroded bank upstream of the CSAH 28 crossing (lower left); and an eroded bank downstream of the CSAH 28 crossing (lower right).

Table 31. Summary of high total suspended solids-related biological metric data for Stations 16RD016 and 16RD019 along the Pelican River (767), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Fish class	Statewide score[1] (mean ± SD)	Station (score)	Station score (mean ± SD)
TSS TIV	Mean TSS (mg/L) tolerance indicator value (↑)	4	15 ± 4	16RD016 (14)	NA
		5	12 ± 2	16RD019[16] (16) 16RD019[17] (14)	15 ± 1
CondProb	Probability of meeting the TSS standard (↓)	4	74 ± 21	16RD016 (55)	NA
		5	86 ± 10	16RD019[16] (48) 16RD019[17] (56)	52 ± 6

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
[16] Sampled on June 21, 2016; [17] sampled on August 28, 2017.
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Low dissolved oxygen

Available data

The proposed 2020 Impaired Waters List includes a new DO impairment for the Pelican River (767). The MPCA biological monitoring staff collected a combined five discrete DO measurements at Stations 16RD016 and 16RD019 along the reach at the time of fish and macroinvertebrate monitoring. All of the measurements were well above the 5.0 mg/L DO standard; values ranged from 8.6 to 10.9 mg/L. Figure 28 displays all available discrete DO data for Sites S000-474 (1977-2018; *n*=9), S000-684 (1980-2010; *n*=29), and S008-842 (2016-2017; *n*=21). Collectively, 27% of the values were below the standard; however, only 9 of the measurements were collected prior to 9:00 a.m., when values are typically lowest. Generally, the lowest DO levels were in the months of July, August, and September. The MPCA conducted continuous DO monitoring at Site W56046001 (410th Street crossing) from September 6, 2017, to September 13, 2017 and from August 14, 2018, to August 23, 2018; the location of the site is shown in Figure 22. The monitoring results are provided in Table 32, as well as displayed in Figures 29 and 30. While none of the measurements for the September 2017 monitoring period were below the standard, 33% of the total values and all of the daily minimum values for the August 2018 monitoring period were below the standard. Additionally, the OTRW HSPF model estimates that the reach had a DO concentration below the standard less than 1% of the time during the period of 1995 to 2014. Overall, the available data suggest the Pelican River (767) experiences frequent periods of low DO.

Figure 28. Discrete DO data for Sites S000-474, S000-684, and S008-842 along the Pelican River (767).

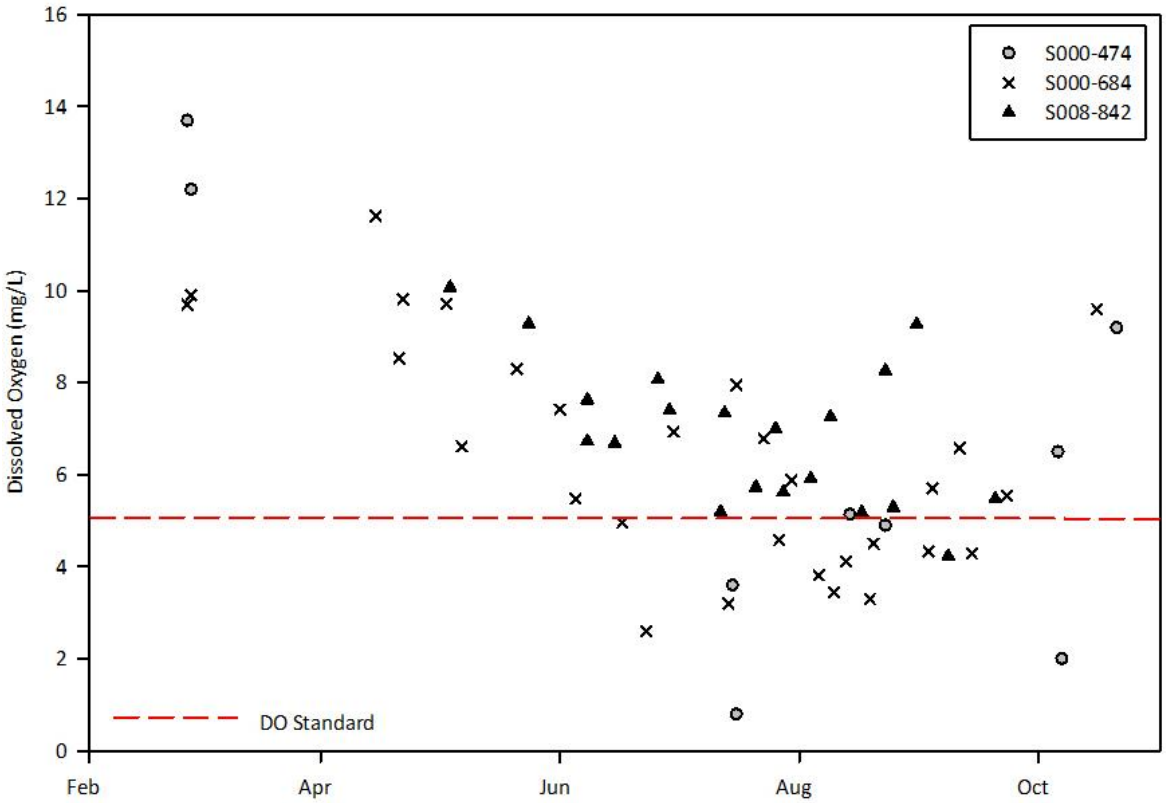


Table 32. Continuous DO data for Site W56046001 along the Pelican River (767).

Site	Start date - End date	*n*	Max. (mg/L)	Min. (mg/L)	% Total values below standard	% Daily min. values below standard	Mean daily flux (mg/L)
W56046001	9/6/2017 - 9/13/2017	672	11.7	5.8	0	0	4.4
W56046001	8/14/2018 - 8/23/2018	855	11.7	3.2	33	100	7.1

Figure 29. Continuous DO data (September 6-13, 2017) for Site W56046001 along the Pelican River (767).

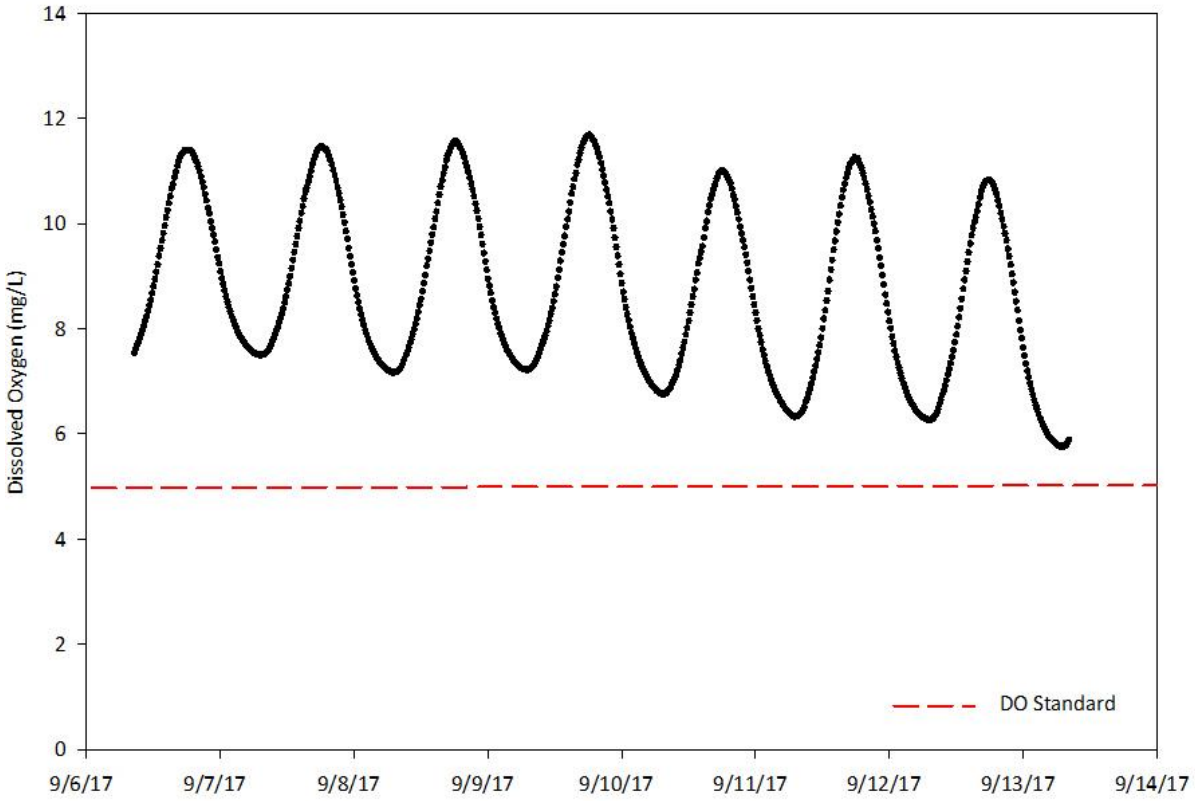
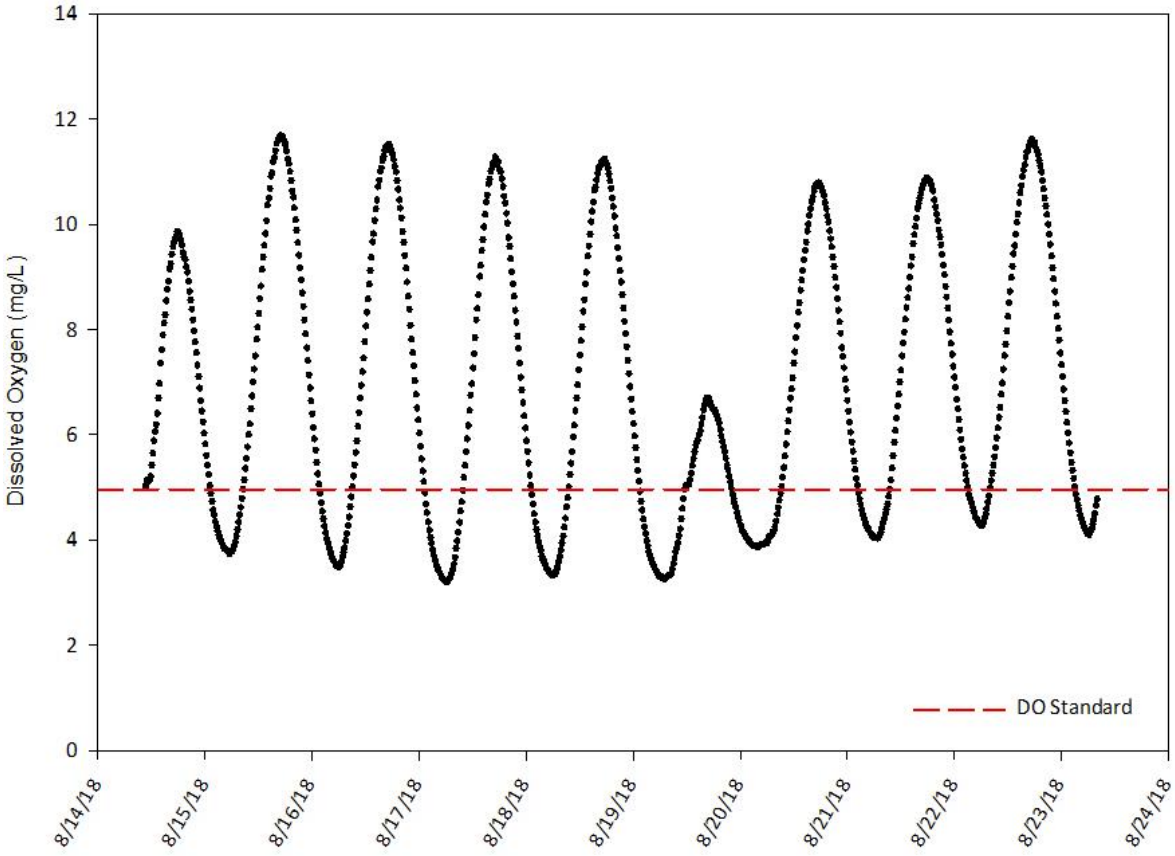


Figure 30. Continuous DO data (August 14-23, 2018) for Site W56046001 along the Pelican River (767).

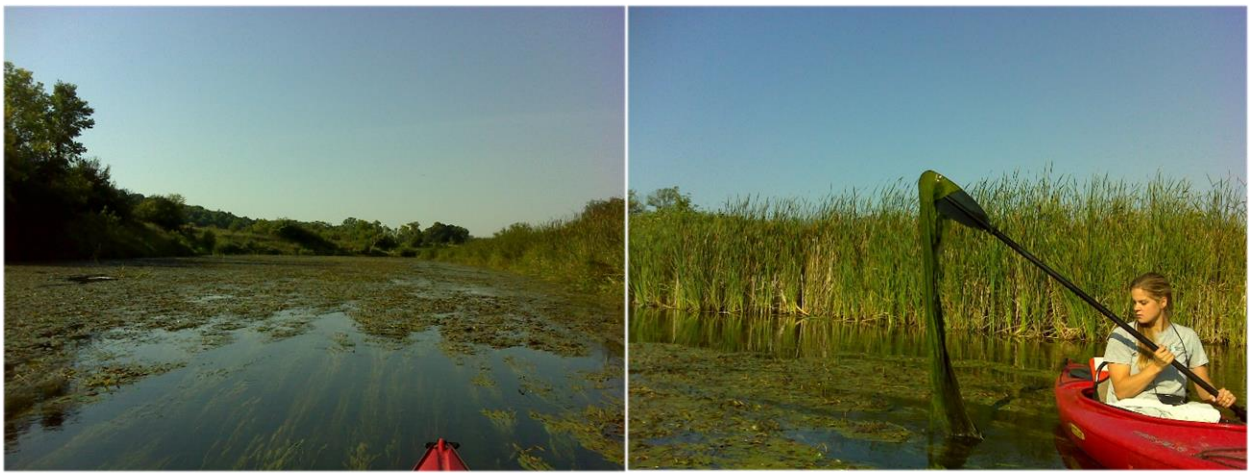


Eutrophication-related data for the Pelican River (767) includes the following parameters: TP, Chl-a, and DO flux. The MPCA biological monitoring staff collected a combined three discrete water quality samples at Stations 16RD016 and 16RD019 along the reach at the time of fish and macroinvertebrate monitoring. The samples were analyzed for several parameters, including TP. The stations had TP concentrations ranging from 22 to 39 µg/L; all of the values were below the 100 µg/L Central River Nutrient Region TP standard. Discrete TP data are also available for Sites S000-474 (1977-2018; *n*=9), S000-684 (1980-2009; *n*=11), and S008-842 (2016; *n*=11). Collectively, the mean TP concentration for the sites was 96 µg/L, while the highest concentration was 645 µg/L and the lowest concentration was 19 µg/L. Approximately 19% of the values exceeded the TP standard. Discrete Chl-a data are also available for Site S000-474 (2018; *n*=5). The mean Chl-a concentration for the site was 5 µg/L, while the highest concentration was 10 µg/L and the lowest concentration was 1 µg/L. There were no exceedances of the 18 µg/L Central River Nutrient Region Chl-a standard. The mean daily DO flux documented during continuous DO monitoring at Site W56046001 was 4.4 and 7.1 mg/L, which is well above the 3.5 mg/L Central River Nutrient Region standard. In addition, the MPCA SID staff noted several areas of excessive filamentous algae and macrophyte growth (Figure 31) along the reach during the August 22, 2018 longitudinal assessment. The MPCA SID staff also documented supersaturated DO levels during continuous DO monitoring at Site W56046001 in September 2017 and August 2018.

The Pelican Rapids wastewater treatment facility discharges to the Pelican River (767). The MPCA SID staff reviewed the discharge records for the facility between 2014 and 2018 for compliance with the applicable 1 mg/L TP limit. In 2015, the facility had multiple exceedances of the standard, with the highest concentration being 3.6 mg/L. However, in 2016 the city completed a substantial upgrade to the facility and there have been no exceedances of the TP limit since.

In summary, the available data suggest that eutrophication may be affecting the DO regime of the Pelican River (767). Further investigation of potential sources of TP is needed. Specifically, the extensive wetland riparian area bordering the river should be further studied as a source of TP.

Figure 31. Images of excessive filamentous algae and macrophytes along the Pelican River (767) on August 22, 2018.



Biological response: Fish

Frequent or extended periods of low dissolved oxygen can alter a fish community by limiting the abundance of species that are intolerant of such conditions (Davis, 1975, EPA, 2012a). Table 33 shows the low DO-related metric scores for the fish community of the Pelican River (767). Stations 16RD016 and 16RD019 met the statewide mean for the DO TIV metric but scored below the mean for the DO conditional probability metric. However, the scores for the latter metric were generally close to meeting the mean. Additionally, the reach supported excellent M-IBI scores, with a high level of species diversity. The level of diversity in the macroinvertebrate community suggest that low DO is not limiting the biological community. The multiple lines of evidence ***somewhat support*** the case for low dissolved oxygen as a stressor to the fish community of the Pelican River (767).

Table 33. Summary of low dissolved oxygen-related biological metric data for Stations 16RD016 and 16RD019 along the Pelican River (767), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Fish class	Statewide score[1] (mean ± SD)	Station (score)	Station score (mean ± SD)
DO TIV	Mean DO (mg/L) tolerance indicator value (↑)	4	7 ± 0	16RD016 (7)	NA
		5	7 ± 0	16RD019[16] (7) 16RD019[17] (7)	7 ± 0
CondProb	Probability of meeting the dissolved oxygen standard (↓)	4	77 ± 17	16RD016 (74)	NA
		5	73 ± 20	16RD019[16] (40) 16RD019[17] (70)	55 ± 21

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.

[16] Sampled on June 21, 2016; [17] sampled on August 28, 2017.

Good: Score for the biologically impaired reach met or was equal to the statewide mean.

Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.

Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Summary of stressors

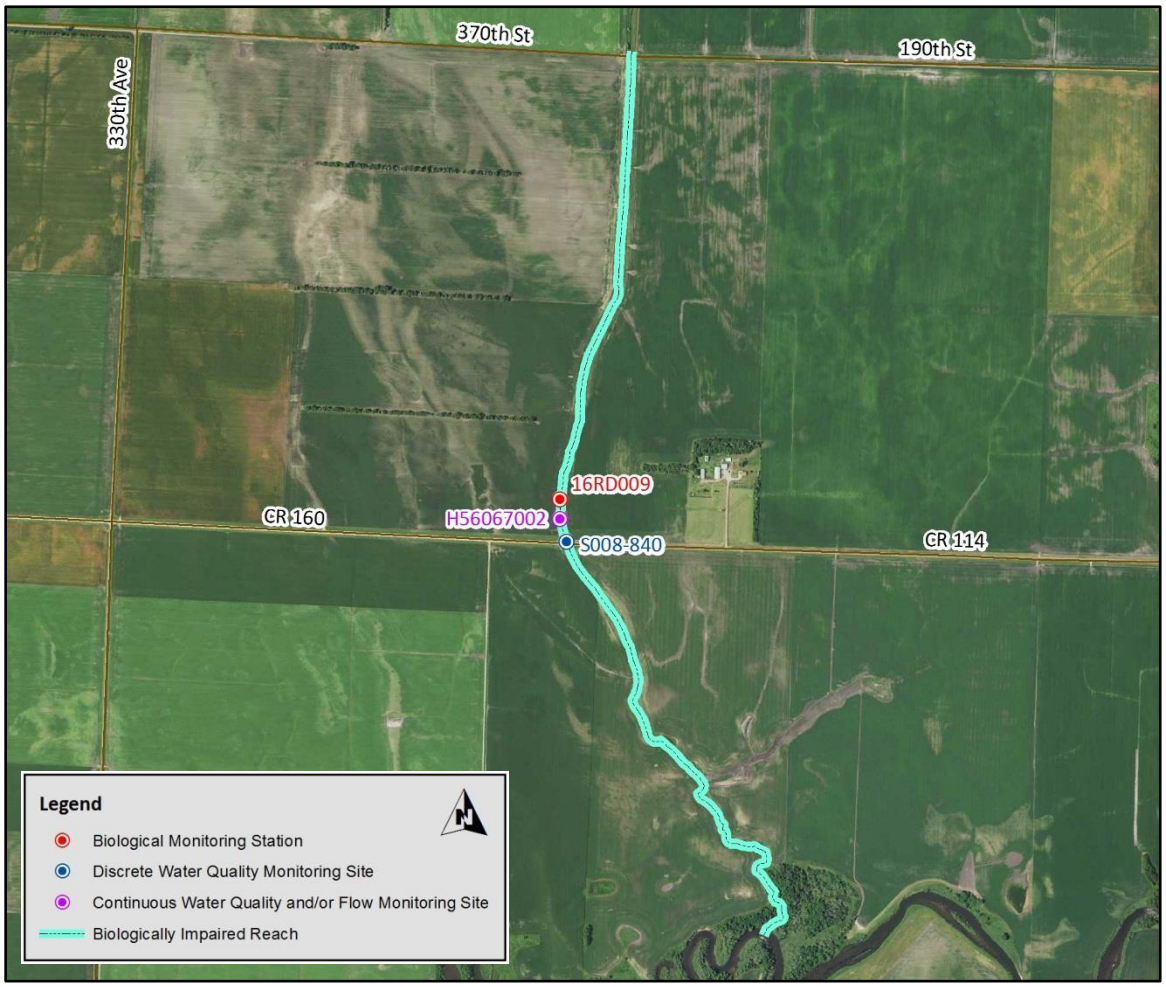
The evidence suggests that the F-IBI impairment associated with the Pelican River (767) is attributed to a loss of longitudinal connectivity, and to a far lesser extent, insufficient physical habitat and low dissolved oxygen. The Pelican River Dam, which is located downstream of the reach, is a complete barrier to fish passage. Several late maturing and migratory fish species (e.g., channel catfish and silver redhorse) were sampled below the dam along the Pelican River (768) but were absent from the fish community of the Pelican River (767). The lack of these species severely limits the F-IBI scores of the reach. The modification or removal of the Pelican River Dam is likely the only means of addressing the F-IBI impairment. The fish community does indicate slight stress to low dissolved oxygen and lack of habitat; however, these stressors could be confounding with the connectivity stressor. The low levels of dissolved oxygen are likely attributed to the adjacent wetland riparian zone that is present along a majority of the stream reach.

3.2.4 Judicial Ditch 2 (764)

Physical setting

This reach represents the segment of Judicial Ditch (JD) 2 from its confluence with an unnamed ditch, located approximately one mile upstream of the CR 160 crossing, to its confluence with the Otter Tail River (Figure 32); a total length of two miles. The reach has a subwatershed area of 68 square miles (43,733 acres). The subwatershed contains 60 miles of intermittent stream and 21 miles of intermittent drainage ditch (DNR, 2014b). According to the MPCA (2013), 59% of the watercourses in the subwatershed have been physically altered (i.e., channelized, ditched, or impounded), including 88% of JD 2 (764). The NLCD 2011 (USGS, 2011) lists cultivated crops (76%) as the predominant land cover in the subwatershed. Other notable land cover groups in the subwatershed included open water (6%), developed (5%), hay/pasture (4%), wetlands (4%), forest (3%), and herbaceous (1%).

Figure 32. Map of JD 2 (764) and associated biological monitoring station and water quality monitoring sites (2017 NAIP aerial image). Flow direction is north to south.



Biological impairments

Fish (F-IBI)

The fish community of JD 2 (764) was monitored at Station 16RD009 (0.1 miles upstream of the CR 160 crossing) on June 22, 2016. The location of the station is shown in Figure 32. The station was designated as Modified Use within the Southern Streams F-IBI Class (Class 2); the associated impairment threshold is an F-IBI score of 35. Monitoring of the station yielded an F-IBI score (35) at the impairment threshold. However, JD 2 (764) was determined to be impaired due to a limited fish assemblage (Table 34) that was dominated by tolerant species (e.g., creek chub and fathead minnow).

Table 34. Summary of fish taxa sampled at Station 16RD009 along JD 2 (764).

Common name	# sampled
bigmouth shiner	6
black bullhead	3
common shiner	16
creek chub	58
fathead minnow	69
Iowa darter	2
orangespotted sunfish	12
white sucker	50

Candidate causes

Loss of longitudinal connectivity

Available data

The MPCA biological monitoring staff observed and documented that the downstream end of the culverts beneath CR 160 are perched approximately four feet (Figure 33). Rocks have been installed to stabilize the grade. The perched culverts likely obstruct connectivity at most flow conditions; fish passage may be possible at high stage levels. According to the DNR (2014a), there are no man-made dams along JD 2 (764). On August 29, 2018, MPCA SID staff completed a longitudinal assessment of the reach. No additional obstructions to connectivity (e.g., beaver dams) were identified. In addition to the assessment, MPCA SID staff performed a detailed review of an August 21, 2016, aerial photo (courtesy of Google Earth) of the reach. No other connectivity-related issues were identified in the photo. In summary, the perched culverts beneath CR 160 severely limit connectivity along JD 2 (764).

Figure 33. Images of perched culverts located at the downstream end of the CR 160 crossing on May 7, 2018 (left) and August 23, 2018 (right).

Biological response: Fish

Migratory and late maturing fish species require well-connected environments in order to access the habitats and resources necessary to complete their life history (Saunders, 2007). Barriers to connectivity (e.g., dams) can limit the availability of critical habitats and resources, thereby reducing the abundance

of these species, along with overall species diversity (Poole, 2002; Cross et al., 2013; Gardner, et al. 2013; Aadland, 2015). Table 35 shows the loss of longitudinal connectivity-related metric scores for the fish community of JD 2 (764). Station 16RD009 scored above the statewide mean for the migratory taxa metric but scored well below the mean in late maturing taxa. Additionally, there is a perched culvert that is limiting fish passage along the reach. The multiple lines of evidence ***strongly support*** the case for loss of longitudinal connectivity as a stressor to the fish community of JD 2 (764).

Table 35. Summary of loss of longitudinal connectivity-related biological metric data for Stations 16RD009 along JD 2 (764), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
MgrTxPct	Relative abundance (%) of taxa that are migratory (↓)	21 ± 8	16RD009 (25)
MA>3-TolTxPct	Relative abundance (%) of taxa with a female mature age of ≥ 3 years, excluding tolerant taxa (↓)	17 ± 10	16RD009 (0)

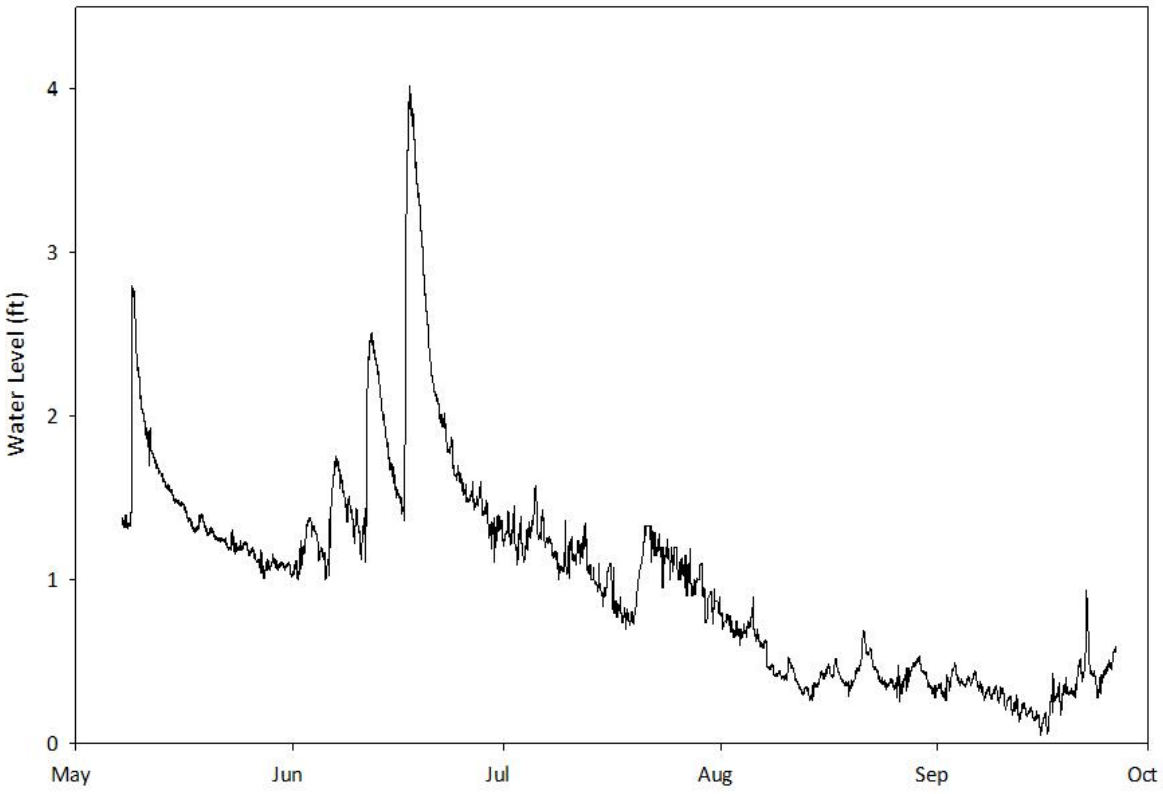
[1] Statewide score included stations that provided Modified Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Flow regime instability

Available data

The MPCA biological monitoring staff encountered "very little flow" at the time of the August 30, 2016, macroinvertebrate monitoring visit. According to the MPCA (2013), 59% of the watercourses in the subwatershed have been physically altered (i.e., channelized, ditched, or impounded), including 88% of JD 2 (764). There are no flow monitoring data for the reach. The MPCA conducted continuous water level monitoring at Site S008-840 (CR 160 crossing) from May 7, 2018, to September 26, 2018; the location of the site is shown in Figure 32. The monitoring results are displayed in Figure 34. The highest water depths were observed early in the season, corresponding with spring precipitation events. In the months of August and September, the water level dropped substantially, to a depth of less than six inches. The USGS (2018) estimated that the median flow (Q50) for the reach at its outlet was 13.8 cfs, while the normal range of flow values was 25.5 (Q25) to 9.11 (Q75) cfs. The ratio of Q25 to Q75 flow values was approximately 3:1, which is indicative of a hydrologically stable system. By comparison, several of the more hydrologically stable rivers in the Red River Basin (e.g., Buffalo River, Clearwater River, and Otter Tail River) had a Q25 to Q75 ratio of 7:1 or less. Additionally, the 7 day, 10 year low flow value for the reach was 3.1 cfs, which suggests that the reach has sustained baseflow and does not regularly experience periods of intermittency. The MPCA SID staff conducted reconnaissance along the reach on seven separate dates between the spring and fall of 2018 and documented flow conditions. Minimal flow (≈0.1 cfs) was noted at Station 16RD009 on August 23, 2018, August 29, 2018 and September 26, 2018. Overall, the recorded water level and field observations suggest JD 2 (764) is prone to flow regime instability.

Figure 34. Continuous water level data (May 7, 2018, to September 26, 2018) for Site S008-840 along JD 2 (764).



Biological response: Fish

Flow regime instability has been shown to limit species diversity and favor taxa that are generalists, early maturing, pioneering, short-lived, and tolerant to disturbances (Aadland et al., 2005; Poff and Zimmerman, 2010). Table 36 shows the flow regime instability-related metric scores for the fish community of JD 2 (764). None of the scores for Station 16RD009 met the statewide mean. Additionally, three of the scores were outside of the confidence interval. The multiple lines of evidence ***strongly support*** the case for flow regime instability as a stressor to the fish community of JD 2 (764).

Table 36. Summary of flow regime instability-related biological metric data for Stations 16RD009 along JD 2 (764), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
DomTwo Pct	Relative abundance (%) of the two most abundant taxa (↑)	53 ± 15	16RD009 (59)
GeneralTx Pct	Relative abundance (%) of individual that are generalists (↑)	35 ± 10	16RD009 (63)
MA<2Tx Pct	Relative abundance (%) of taxa with a female mature age ≤ 2 years (↑)	62 ± 11	16RD009 (75)
NumPer Meter-Tol	Number of individuals per meter of stream sampled, excluding tolerant species (↓)	0.5 ± 0.4	16RD009 (0.1)
PioneerTx Pct	Relative abundance (%) of taxa that are pioneers (↑)	20 ± 9	16RD009 (25)
SLvdPct	Relative abundance (%) of individuals that are short-lived (↑)	14 ± 14	16RD009 (36)

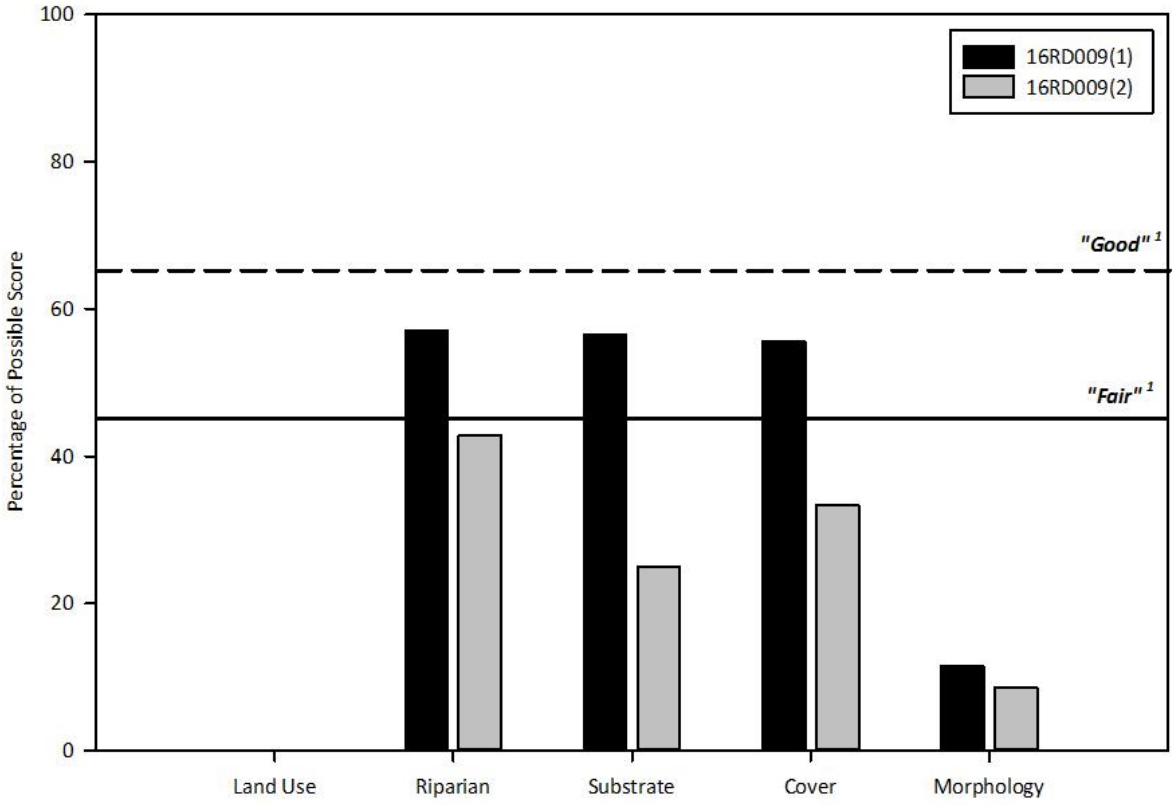
[1] Statewide score included stations that provided Modified Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Insufficient physical habitat

Available data

The physical habitat of JD 2 (764) was evaluated at Station 16RD009 using the MSHA. The station is located along a channelized segment of the reach (MPCA, 2013). The station yielded "poor" MSHA scores (MSHA=22 and 38). Figure 35 displays the MSHA subcategory results for the station. The predominance of agricultural row crops in the immediate vicinity of the station limited its land use subcategory scores. The riparian subcategory scores were limited by a "narrow" to "moderate" riparian zone width and "little" to "moderate" banks erosion. While the station did not offer any riffle habitat, it did offer some coarse substrate (i.e., cobble and gravel). However, this substrate was degraded by a "moderate" to "severe" amount of embeddedness. The cover subcategory scores for the station were negatively affected by the amount ("moderate" to "sparse") and limited types of cover present. The only cover types noted were macrophytes (emergent, submergent, and floating leaf), overhanging vegetation, and undercut banks. Lastly, the station scored poorly in the morphology subcategory due "poor" channel development, "poor" sinuosity, and limited depth variability and velocity types.

Figure 35. MSHA subcategory results for Station 16RD009 along JD 2 (764).



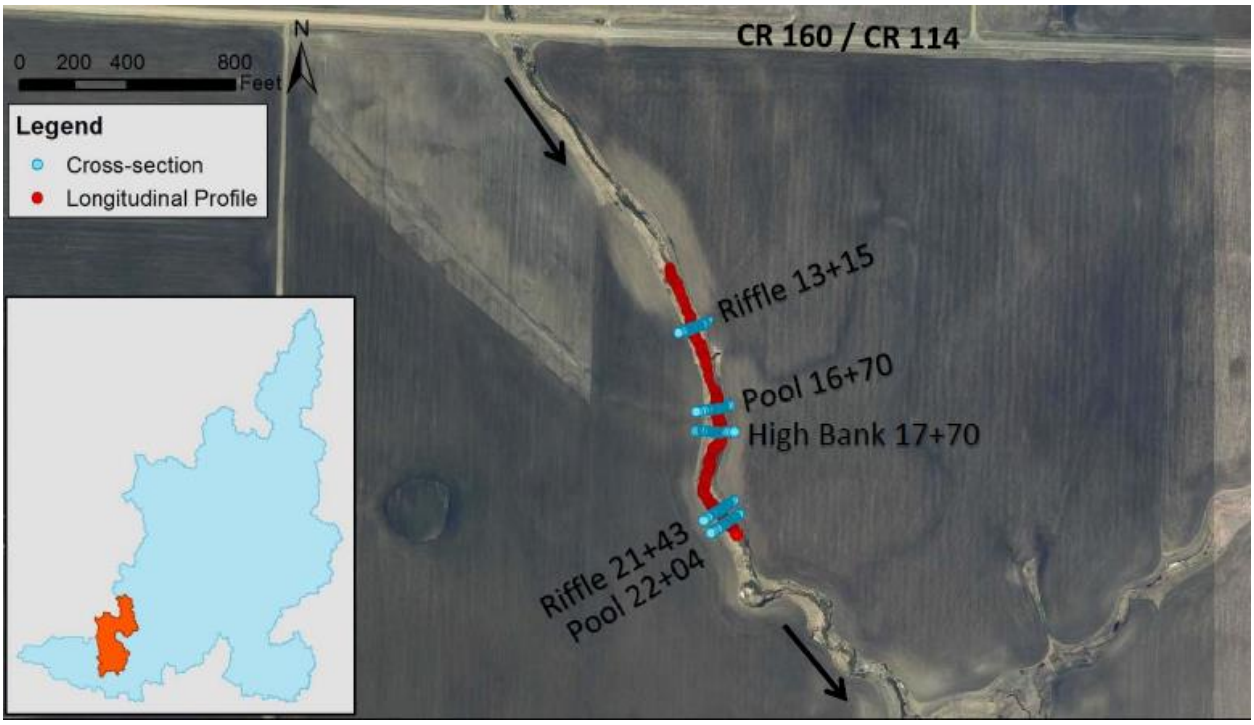
[1] The minimum percentage of each subcategory score needed for the station to achieve a "fair" and "good" MSHA rating.

On September 18, 2018, Clark and Vinje (2018) completed a fluvial geomorphic assessment downstream of the CR 160 crossing (Figure 36) along JD 2 (764). The stream type at this location was determined to be a G5/B5 (low to moderate width-to-depth ratio, entrenched, sand bed stream). Based upon field observations, the potential stream type is likely an E5 (very low width-to-depth ratio, slightly entrenched, sand bed stream). The site yielded a Pfankuch stability rating of 108 (unstable). Below are excerpts from the assessment summary for the site:

> *"At this location JD 2 exhibited signs of instability. The channel appeared to have down-cut in the past, only holding its elevation near grade-control structures. This led to cutting on the lower banks and possibly widening of the channel as it attempts to recreate floodplain capacity that was lost. The channel bed was inconsistent in its particle sizes, with an unsorted mixture of clay-sized to boulder-sized particles tallied. Aquatic vegetation was spotty and the particles were predominantly bright, indicating an actively moving bed. A rehabilitation of the channel and floodplain at this location would be beneficial for channel stability, sediment transport, and aquatic habitat."*

According to E. Jones, Buffalo-Red River Watershed District (BRRWD) Engineer (personal communication, 2019), the district is in the process of developing a repair plan to address the instability issues along the downstream portion of JD 2 (764). The plan will involve the installation of several grade stabilization structures and the reshaping of channel sidewalls slopes to a more stable condition. Additionally, easements may be acquired along this segment of the reach to provide a continuous buffer along the channel. In locations where concentrated flow is directly entering the ditch, a side inlet culvert will be installed to control discharge and prevent erosion. Once approved, the repair plan will be implemented, which may begin as early as the summer of 2019.

Figure 36. Fluvial geomorphic assessment site downstream of the CR 160 crossing along JD 2 (764).



In summary, the MSHA scores for the reach were limited by a number of factors including the presence of bank erosion, absence of riffle habitat, embeddedness of coarse substrate, a minimal amount of available cover, and inadequate channel morphology characteristics. Many of these deficiencies can be attributed to the fact that this segment of the reach has been ditched. Clark and Vinje (2018) also noted substantial instability and down-cutting downstream of Station 16RD009. The implementation of the proposed repair plan by the BRRWD should address many of the channel stability concerns along this portion of the reach.

Biological response: Fish

Insectivores (e.g., darters and sculpins) and simple lithophilic spawners require quality benthic habitat (e.g., clean, coarse substrate and riffles) for feeding and/or reproduction purposes, while detritivores utilize decomposing organic matter (i.e., detritus) as a food resource and, therefore, are less dependent upon the quality of instream habitat (Aadland and Kuitunen, 2006). Table 37 shows the insufficient physical habitat-related metric scores for the fish community of JD 2 (764). Five out of the six scores for Station 16RD009 did not meet the statewide mean. Additionally, the station scored well below the lower confidence interval for the abundance of insectivorous individuals. A fish community lacking insectivores can signify a loss of habitat, especially foraging habitat (e.g., stream bed and cover structures). The multiple lines of evidence ***strongly support*** the case for insufficient physical habitat as a stressor to the fish community of JD 2 (764).

Table 37. Summary of insufficient physical habitat-related biological metric data for Stations 16RD009 along JD 2 (764), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
RiffleTxPct	Relative abundance (%) of taxa that predominately utilize riffle habitats (↓)	18 ± 10	16RD009 (13)
SLithopTx Pct	Relative abundance (%) of taxa that are simple lithophilic spawning species (↓)	27 ± 14	16RD009 (25)
Insect-TolPct	Relative abundance (%) of individuals that are insectivorous excluding tolerant species (↓)	37 ± 20	16RD009 (1)
BenInsect-TolTxPct	Relative abundance (%) of taxa that are benthic insectivores, excluding tolerant species (↓)	23 ± 10	16RD009 (13)
DetNWQ TxPct	Relative abundance (%) of taxa that are detritivorous (↑)	21 ± 6	16RD009 (25)
DarterSculpTxPct	Relative abundance (%) of taxa that are darters and sculpins (↓)	13 ± 6	16RD009 (13)

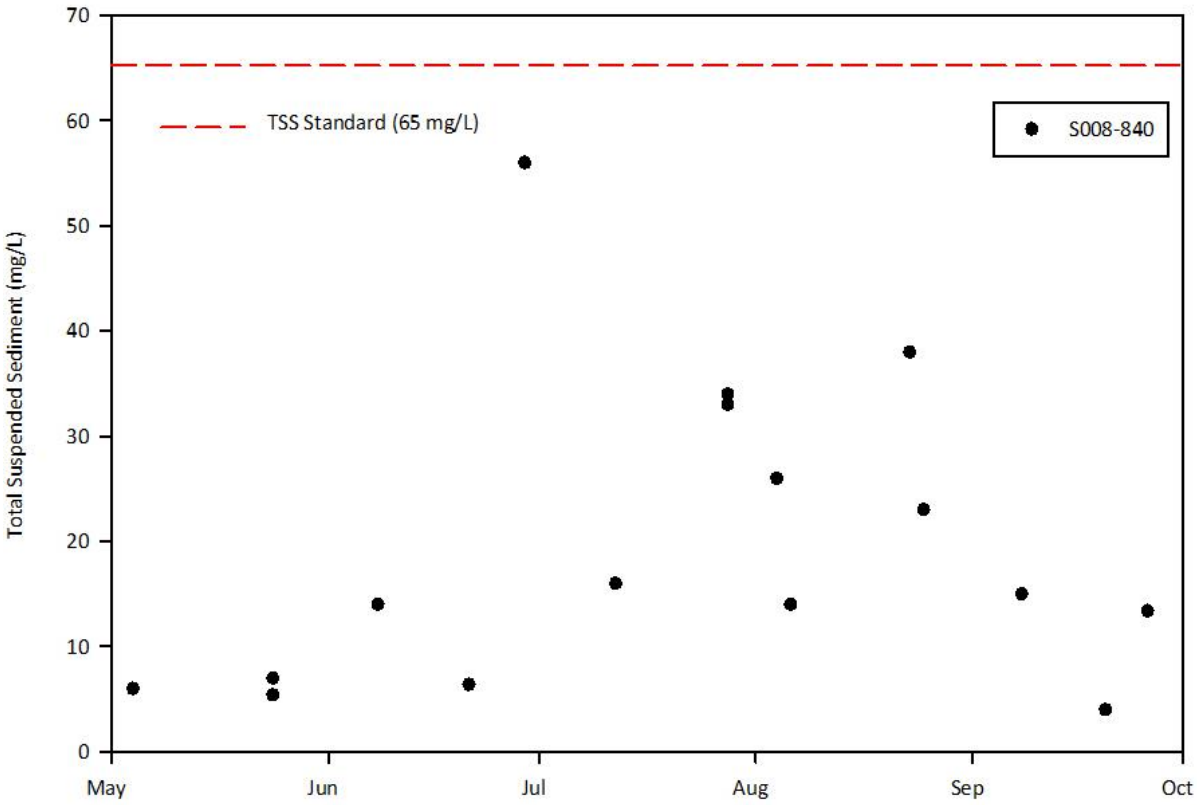
[1] Statewide score included stations that provided Modified Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
- Good: Score for the biologically impaired reach met or was equal to the statewide mean.
- Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
- Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

High suspended sediment

Available data

The MPCA biological monitoring staff collected a discrete water quality sample at Station 16RD009 along JD 2 (764) at the time of fish monitoring. The sample was analyzed for several parameters, including TSS. The station had a TSS concentration of 13 mg/L, which is well below the 65 mg/L TSS standard for the Southern TSS Region. Figure 37 displays all available discrete TSS data for Site S008-840 (2016-2018; *n*=16). Overall, the mean TSS concentration for the site was 19 mg/L, while the highest concentration was 56 mg/L and the lowest concentration was 4 mg/L. None of the values exceeded the standard. The OTRW HSPF model estimates that the reach had a TSS concentration in excess of the standard 2% of the time during the period of 1995 to 2014. On May 24, 2018, MPCA SID staff noted that several road ditch tributaries to JD 2 located upstream of State Highway 210 had minimal to no buffer. Additionally, on August 29, 2018, MPCA SID staff completed a longitudinal assessment of the reach. Staff documented a substantial amount of bank instability (Figure 38) downstream of the CR 160 crossing. Additionally, the aforementioned MSHA results indicate that the deposition of excess fine sediment caused the "moderate" to "severe" level of embeddedness of coarse substrate documented at Station 16RD009. Overall, the available data suggest that JD 2 (764) experiences at least occasional periods of high suspended sediment.

Figure 37. Discrete TSS data for Site S008-840 along JD 2 (764).



Biological response: Fish

Excessive suspended sediment can affect a fish community in various ways depending on the concentration and duration of exposure. The deposition of sediment can fill interstitial spaces in riffles and coarse substrate that are important for lithophilic and insectivorous taxa (Bilotta and Brazier, 2008). Sediment deposition can also block pores in the streambed, thereby preventing exchange within the hyporheic zone (Greig et al., 2005). Table 38 shows the high TSS-related metric scores for the fish community of JD 2 (764). While Station 16RD009 did not meet the statewide mean for either of the metrics, both scores were well within their respective confidence interval. The multiple lines of evidence ***somewhat support*** the case for high suspended sediment as a stressor to the fish community of JD 2 (764).

Figure 38. Images of potential sediment sources to Judicial Ditch 2, including a tributary road ditch with no buffer located along 320th Street on May 24, 2018 (upper left) and eroded banks downstream of the CR 160 crossing on August 29, 2018 (upper right, lower left, and lower right).

Table 38. Summary of high total suspended solids-related biological metric data for Stations 16RD009 along JD 2 (764), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
TSS TIV	Mean TSS (mg/L) tolerance indicator value (↑)	19 ± 5	16RD009 (20)
CondProb	Probability of meeting the TSS standard (↓)	37 ± 17	16RD009 (30)

[1] Statewide score included stations that provided Modified Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.

Good: Score for the biologically impaired reach met or was equal to the statewide mean.

Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.

Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Low dissolved oxygen

Available data

The proposed 2020 Impaired Waters List includes a new DO impairment for JD 2 (764). The MPCA biological monitoring staff collected a discrete DO measurement at Station 16RD009 along the reach at the time of fish (16.0 mg/L) and macroinvertebrate (10.7 mg/L) monitoring. While both values were well above the 5.0 mg/L DO standard, the measurements had a very high saturation percentage (125 and 192%, respectively). Such supersaturation is commonly caused by excessive aquatic plant (i.e., algae and submergent macrophyte) growth. Figure 39 displays all available discrete DO data for Site S008-840 (2016-2018; *n*=22). Approximately 36% of the values were below the standard; however, none of the measurements were collected prior to 9:00 a.m., when values are typically lowest. The MPCA conducted continuous DO monitoring at Site W56067001 (CR 160 crossing) from August 18, 2017, to August 31, 2017 and from August 13, 2018, to August 23, 2018; the location of the site is shown in Figure 32. The monitoring results are provided in Table 39, as well as displayed in Figures 40 and 41. While only 3% of the total values and 17% of daily minimum values for the August 2017 monitoring period were below the standard, 69% of the total values and all of the daily minimum values for the August 2018 monitoring period were below the standard. Additionally, the OTRW HSPF model estimates that the reach had a DO concentration below the standard less than 1% of the time during the period of 1995 to 2014. Overall, the available data suggest that JD 2 (764) experiences frequent periods of low DO.

Figure 39. Discrete DO data for Site S008-840 along JD 2 (764).

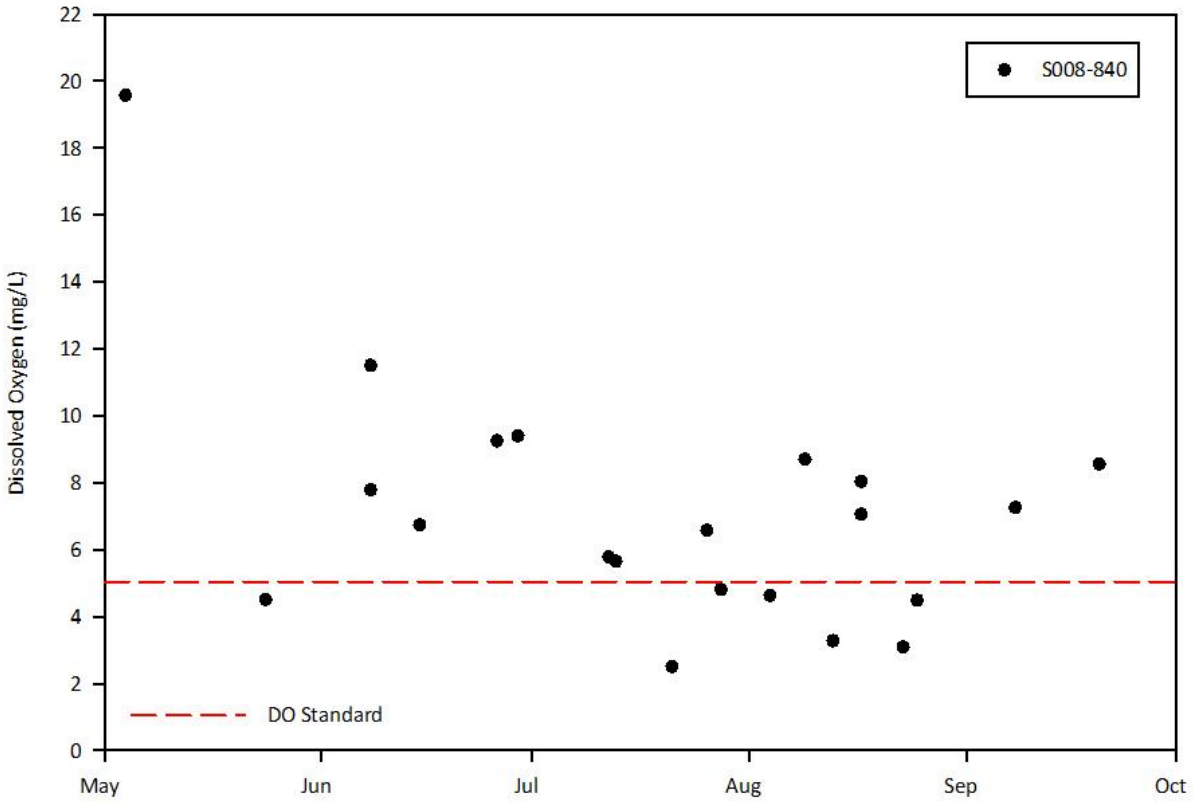


Table 39. Continuous DO data for Site W56067001 along JD 2 (764).

Site	Start date - End date	*n*	Max. (mg/L)	Min. (mg/L)	% Total values below standard	% Daily min. values below standard	Mean daily flux (mg/L)
W56067001	8/18/2017 - 8/31/2017	1242	13.8	4.5	3	17	5.7
W56067001	8/13/2018 - 8/23/2018	949	9.3	1.8	69	100	4.6

Figure 40. Continuous DO data (August 18-31, 2017) for Site W56067001 along JD 2 (764).

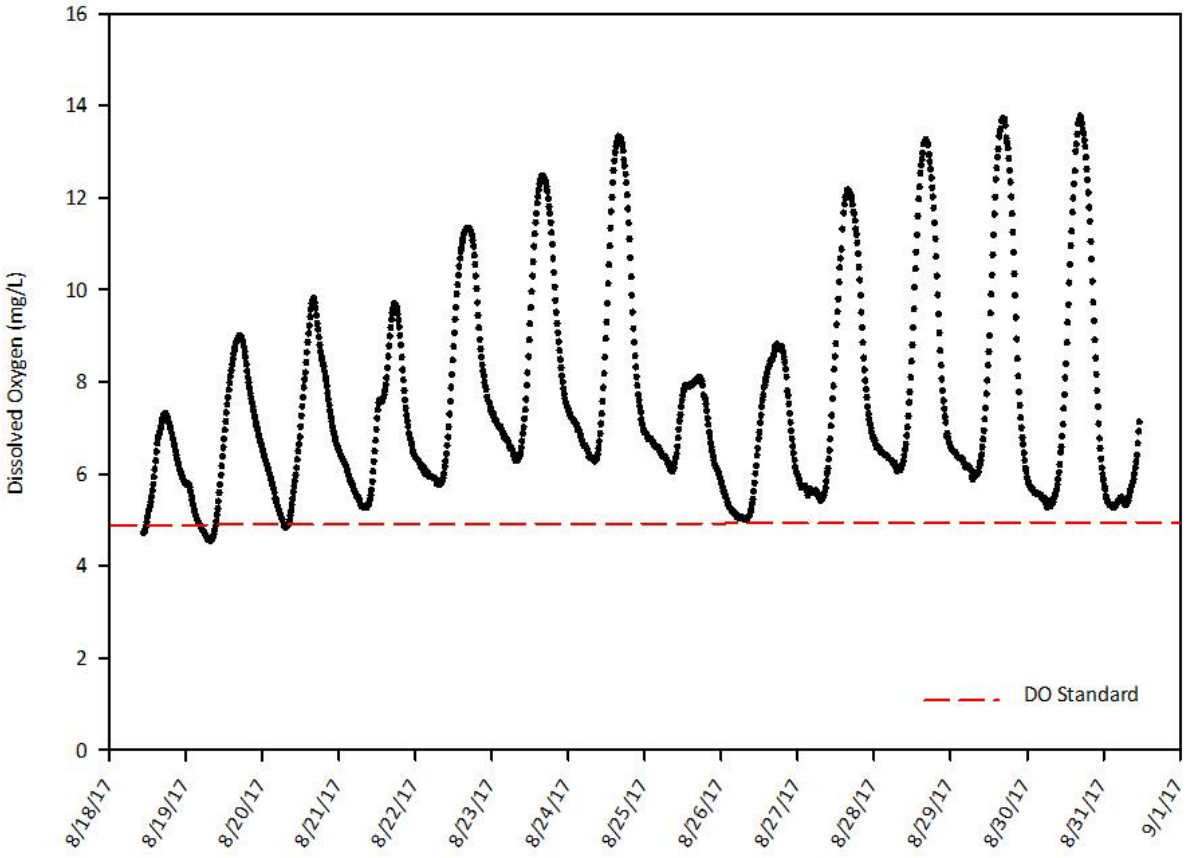
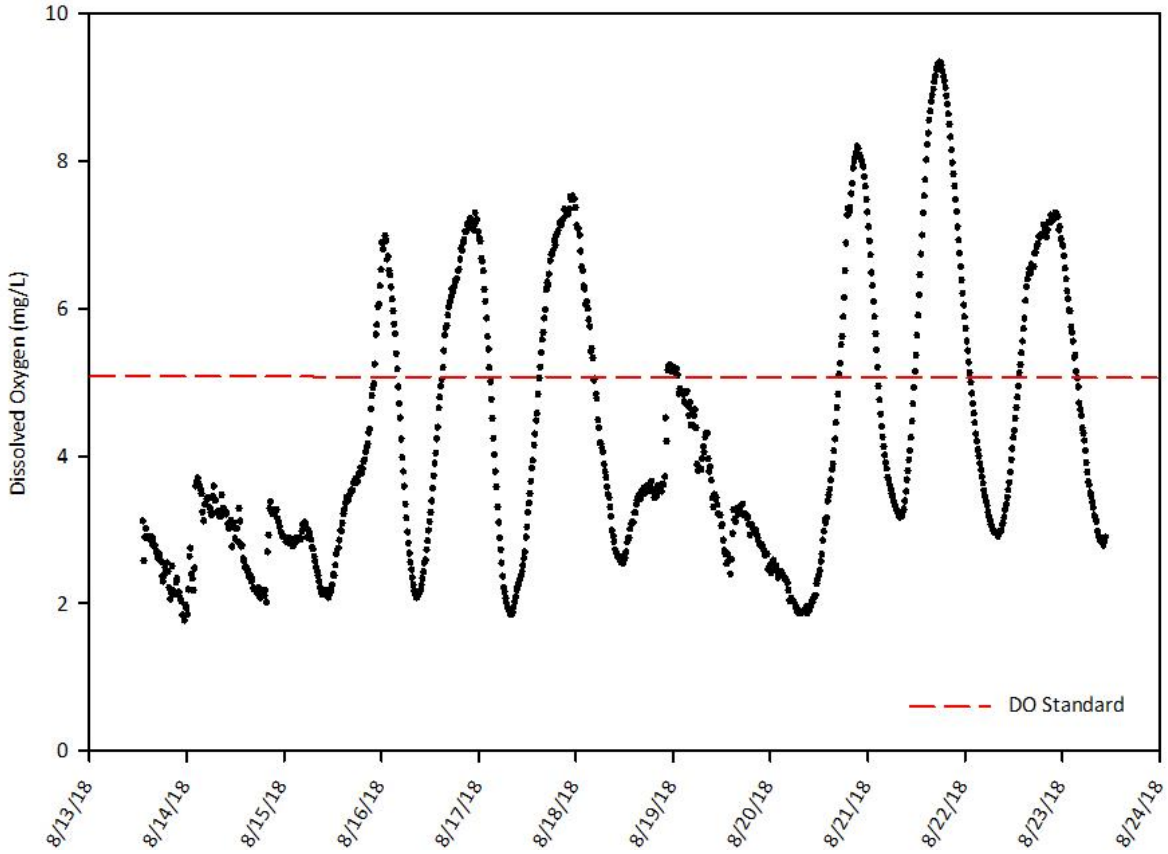


Figure 41. Continuous DO data (August 13-23, 2018) for Site W56067001 along JD 2 (764).



Eutrophication-related data for JD 2 (764) includes the following parameters: TP, Chl-a, and DO flux. The MPCA biological monitoring staff collected a discrete water quality sample at Station 16RD009 along the reach at the time of the fish monitoring visit. The sample was analyzed for several parameters, including TP. The station had a TP concentration of 66 µg/L, which is below the 150 µg/L South River Nutrient Region TP standard. Discrete TP data are also available for Site S008-840 (2016-2018; *n*=16). The mean TP concentration for the site was 199 µg/L, while the highest concentration was 339 µg/L and the lowest concentration was 57 µg/L. Approximately 62% of the values exceeded the TP standard. Discrete Chl-a data are also available for Site S008-840 (2018; *n*=5). The mean Chl-a concentration for the site was 7 µg/L, while the highest concentration was 13 µg/L and the lowest concentration was 1 µg/L. There were no exceedances of the 40 µg/L South River Nutrient Region Chl-a standard. The mean daily DO flux documented during continuous DO monitoring at Site W56067001 was 5.7 and 4.6 mg/L; the South River Nutrient Region standard is 5.0 mg/L. The MPCA SID staff also documented severely supersaturated DO levels during continuous DO monitoring at Site W56067001 in August 2017, as well as a moderate to excessive amount of algae and aquatic macrophyte growth along the reach during multiple reconnaissance visits. While JD 2 (764) is prone to high TP concentrations, additional response variable data are needed to determine if eutrophication is adversely affecting the DO regime.

Low dissolved oxygen

Biological response: Fish

Frequent or extended periods of low dissolved oxygen can alter a fish community by limiting the abundance of species that are intolerant of such conditions (Davis, 1975, EPA, 2012a). Table 40 shows the low DO-related metric scores for the fish community of JD 2 (764). Station 16RD009 met the statewide mean for the DO TIV metric but failed to meet the mean for the DO conditional probability

metric. However, the score for the latter metrics was just below the mean. The multiple lines of evidence ***somewhat support*** the case for low dissolved oxygen as a stressor to the fish community of JD 2 (764).

Table 40. Summary of low dissolved oxygen-related biological metric data for Stations 16RD009 along JD 2 (764), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
DO TIV	Mean DO (mg/L) tolerance indicator value (↑)	7 ± 0	16RD009 (7)
CondProb	Probability of meeting the dissolved oxygen standard (↓)	64 ± 23	16RD009 (59)

[1] Statewide score included stations that provided Modified Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Summary of stressors

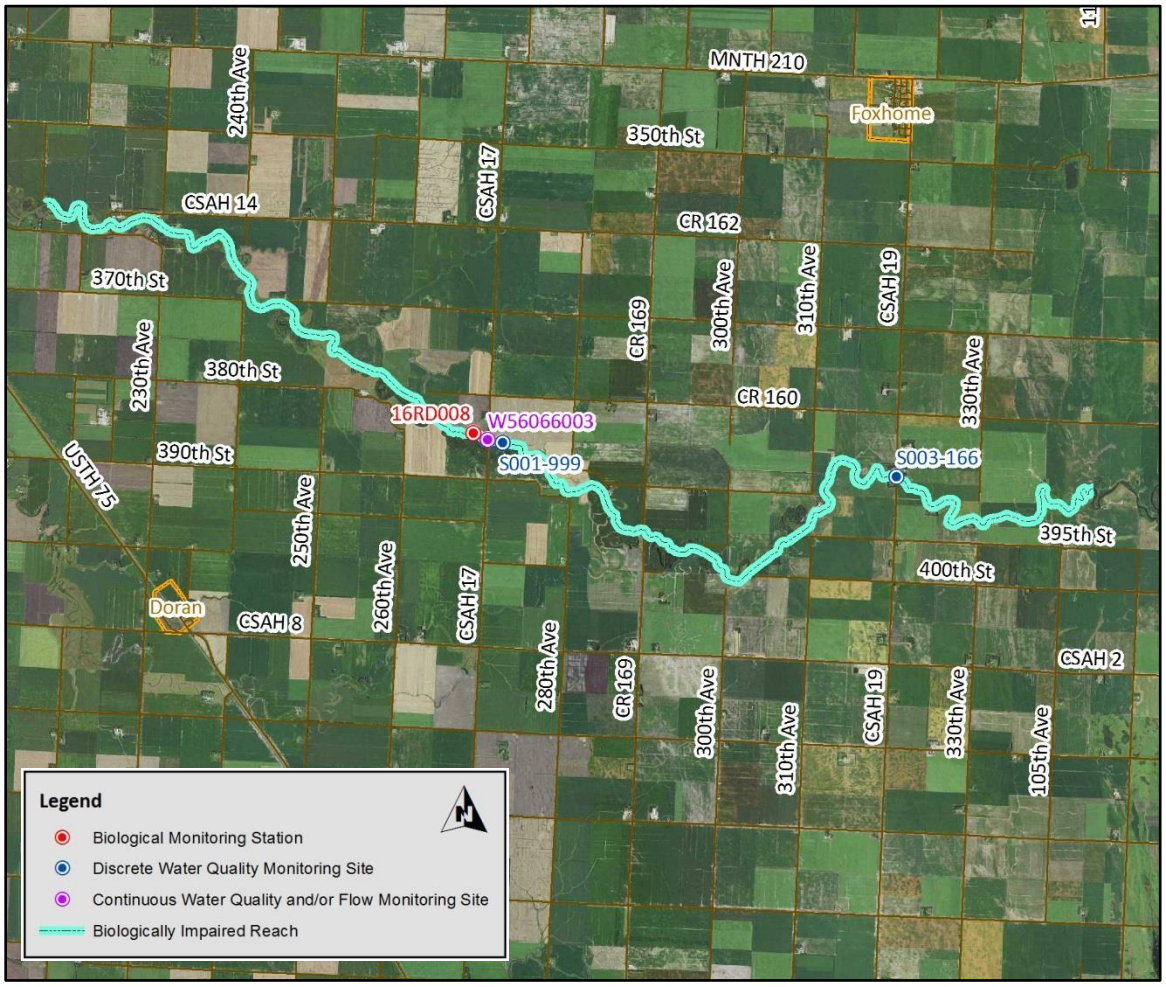
The evidence suggests that the F-IBI impairment associated with JD 2 (764) is attributed to a loss of longitudinal connectivity, flow regime instability, insufficient physical habitat, and to a lesser extent, high suspended sediment and low dissolved oxygen. The perched culvert at CR 160 is nearly a complete barrier to fish passage. The installation of several grade stabilization structures as part of the proposed repair plan for JD 2 may help to alleviate this stressor. Flow regime instability, specifically high peak flows and extended periods of minimal to no flow, is adversely affecting the fish community. High flow conditions have resulted in channel stability issues, thereby degrading available physical habitat and increasing sediment loading. The lack of baseflow, particularly in the later summer months, creates low dissolved oxygen conditions. Additional runoff detention/retention options should be considered in the subwatershed to attenuate peak flows and augment baseflows. The implementation of the aforementioned repair plan should address many of the existing channel stability concerns along the lower segment of the reach. Lastly, additional agricultural BMPs should be implemented throughout the subwatershed to reduce sediment and nutrient loading to JD 2 (764).

3.2.5 Otter Tail River (504)

Physical setting

This reach represents the segment of the Otter Tail River from its confluence with Judicial Ditch 2, to the inlet of Breckenridge Lake (Figure 42); a total length of 19 miles. The reach has a subwatershed area of 1,865 square miles (1,193,820 acres). The subwatershed contains 377 miles of perennial stream and river (e.g., Otter Tail River), 294 miles of intermittent stream, 99 miles of intermittent drainage ditch, and 69 miles of perennial drainage ditch (DNR, 2014b). According to the MPCA (2013), 40% of the watercourses in the subwatershed have been physically altered (i.e., channelized, ditched, or impounded), including 56% of the Otter Tail River (504). The NLCD 2011 (USGS, 2011) lists forest (28%) and cultivated crops (26%) as the predominant land covers in the subwatershed. Other notable land cover groups in the subwatershed included open water (15%), hay/pasture (14%), wetlands (7%), developed (6%), and herbaceous (4%).

Figure 42. Map of the Otter Tail River (504) and associated biological monitoring station and water quality monitoring sites (2017 NAIP aerial image). Flow direction is east to west.



Biological impairments

Macroinvertebrate (M-IBI)

The macroinvertebrate community of the Otter Tail River (504) was monitored at Station 16RD008 (0.2 miles downstream of the CSAH 17 crossing) on August 29, 2017. The location of the station is shown in

Figure 42. The station was designated as General Use within the Prairie Forest River M-IBI Class (Class 2). Accordingly, the impairment threshold for the station is an M-IBI score of 31. Monitoring of the station yielded an M-IBI score (26) below the impairment threshold. Table 41 provides a summary of the macroinvertebrate taxa sampled at the station. The assemblage was dominated by tolerant taxa, specifically *Simulium* (black flies).

Table 41. Summary of macroinvertebrate taxa sampled at Station 16RD008 along the Otter Tail River (504).

	Species (order)	# individuals sampled
Insects	Beetles	27
	Caddisflies	27
	Dragonflies/Damselflies	3
	Flies (midges)	219
	Mayflies	33
Non-insects	Limpets	4
	Mussels	1

Candidate causes

Loss of longitudinal connectivity

Available data

The MPCA biological monitoring staff did not observe any connectivity-related issues during their visits to Station 16RD008. According to the DNR (2014a), there are no man-made dams along the Otter Tail River (504). On August 29, 2018, MPCA SID staff completed a longitudinal assessment of the reach. No obstructions to connectivity were identified. In addition to the assessments, MPCA SID staff performed a detailed review of August 2, 2015 and August 21, 2016, aerial photos (courtesy of Google Earth) of the reach. No connectivity-related issues were identified in the photos. In summary, there are no barriers to connectivity along the Otter Tail River (504).

Biological response: Macroinvertebrate

Macroinvertebrates are not readily affected by longitudinal connectivity barriers. Populations can re-establish in a segmented stream channel to reflect stable community composition upstream and downstream of a connectivity barrier. Consequently, there is ***no biological response data*** for analysis of loss of longitudinal connectivity as a stressor to the macroinvertebrate community of the Otter Tail River (504).

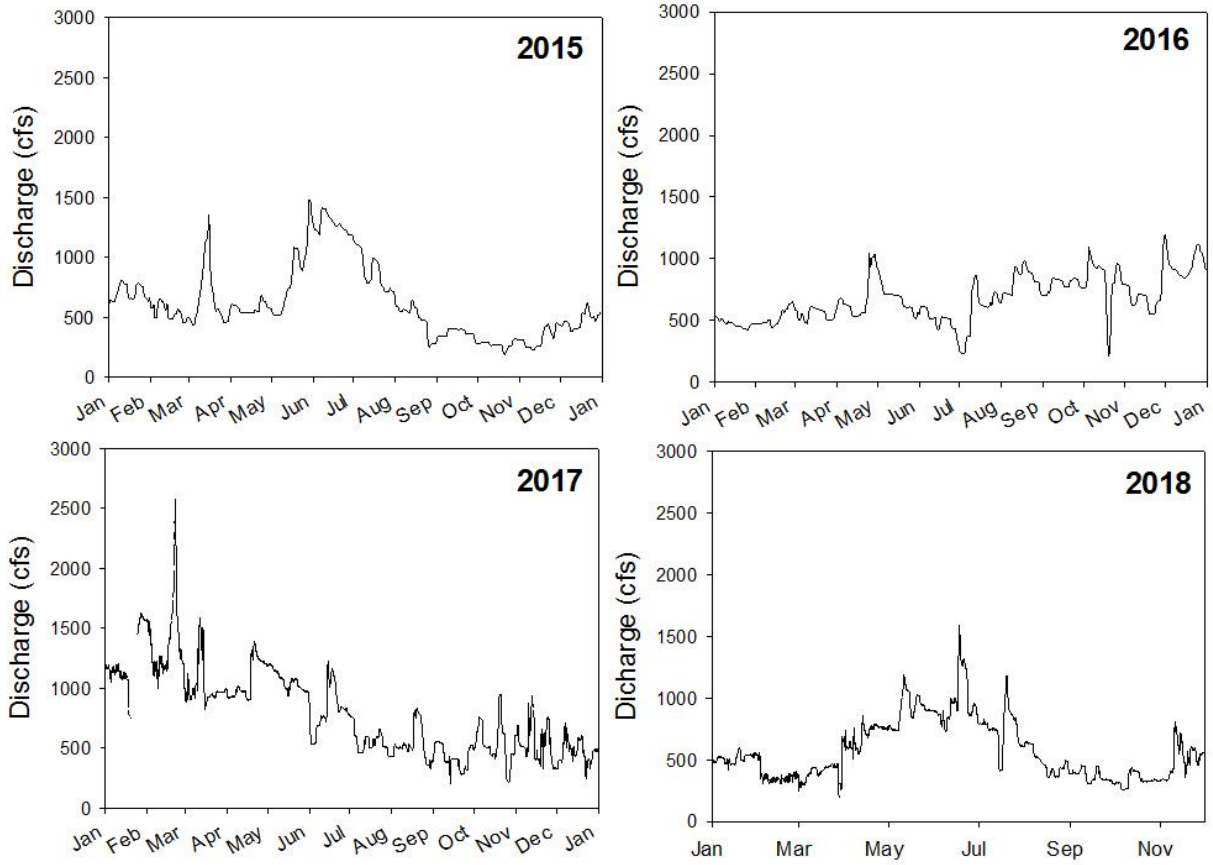
Flow regime instability

Available data

The MPCA biological monitoring staff did not encounter any flow-related issues (e.g., intermittency) at Station 16RD008. According to the MPCA (2013), 40% of the watercourses in the subwatershed have been physically altered (i.e., channelized, ditched, or impounded), including 56% of the Otter Tail River (504). While there are no dams along the reach, there are 59 dams within its subwatershed (DNR, 2014a). Of these dams, the Orwell Dam, which is located eight miles upstream of the reach, has the most direct influence on its flow regime. The Orwell Dam is owned and operated by the United States Army Corps of Engineers (USACE) and was completed in 1953 for the purposes of flood control and water supply. The dam has a maximum height of 47 feet and has an approximately 1.5 square miles

reservoir. There are no flow monitoring data for the reach. However, the USACE has operated a continuous flow monitoring site (05046000) on the Otter Tail River (506), just downstream of the Orwell Dam, since 1930. Figure 43 provides the annual hydrographs for the site for 2015 through 2018. During this time period, the highest mean daily flow was 1410 cfs, while the lowest mean daily flow was 143 cfs. While the hydrographs exhibit some irregularity due to the management of the reservoir upstream, the river maintained excellent year-round baseflow. The USGS (2018) estimated that the median flow (Q50) for the reach at its outlet was 675.0 cfs, while the normal range of flow values was 1220.0 (Q25) to 425.0 (Q75) cfs. The ratio of Q25 to Q75 flow values was approximately 3:1, which is indicative of a hydrologically stable system. By comparison, several of the other hydrologically stable rivers in the Red River Basin (e.g., Buffalo River and Clearwater River) had a Q25 to Q75 ratio of 7:1 or less. Additionally, the 7 day, 10 year low flow value for the reach was 193.0 cfs, which suggests that the reach has sustained baseflow and does not regularly experience periods of intermittency. The MPCA SID staff conducted reconnaissance along the reach on seven separate dates between the spring and fall of 2018 and documented flow conditions. No flow-related issues were noted. Overall, the available data suggest the Otter Tail River (504) has a stable flow regime.

Figure 43. Annual hydrographs (2015-2018) for Site 05046000 along the Otter Tail River (506).



Biological response: Macroinvertebrate

Flow regime instability tends to limit the diversity and taxa richness of macroinvertebrates and favor tolerant individuals that can adapt to disturbances. Several authors have documented an inverse relationship between flow regime instability and benthic aquatic insects, particularly taxa belonging to the orders of Ephemeroptera, Plecoptera, and Trichoptera (Bunn and Arthington, 2002; Bragg et al., 2005; Dewson et al., 2007). Table 42 shows the flow regime instability-related metric scores for the macroinvertebrate community of the Otter Tail River (504). Four out of the five scores for Station

16RD008 did not meet the statewide mean. However, given the fact that the available flow-related data suggest that the reach has a stable flow regime and the biological metric data was derived from one sample, there is uncertainty as to whether flow regime instability is a stressor. The multiple lines of evidence are ***inconclusive*** as to whether flow regime instability is a stressor to the macroinvertebrate community of the Otter Tail River (504).

Table 42. Summary of flow regime instability-related biological metric data for Station 16RD008 along the Otter Tail River (504), as well as statewide stations that support a healthy macroinvertebrate community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
EPTPct	Relative abundance (%) of Ephemeroptera, Plecoptera, and Trichoptera (↓)	55 ± 20	16RD008 (19)
LongLived Pct	Relative abundance (%) of long-lived individuals (↓)	7 ± 6	16RD008 (9)
TaxaCount AllChir	Total taxa richness of macroinvertebrates (↓)	35 ± 11	16RD008 (23)
Tolerant2 ChTxPct	Relative abundance (%) of taxa with tolerance values equal to or greater than six (↑)	74 ± 10	16RD008 (87)
Trichwo HydroPct	Relative abundance (%) of non-hydrospsychid Trichoptera individuals (↓)	8 ± 10	16RD008 (4)

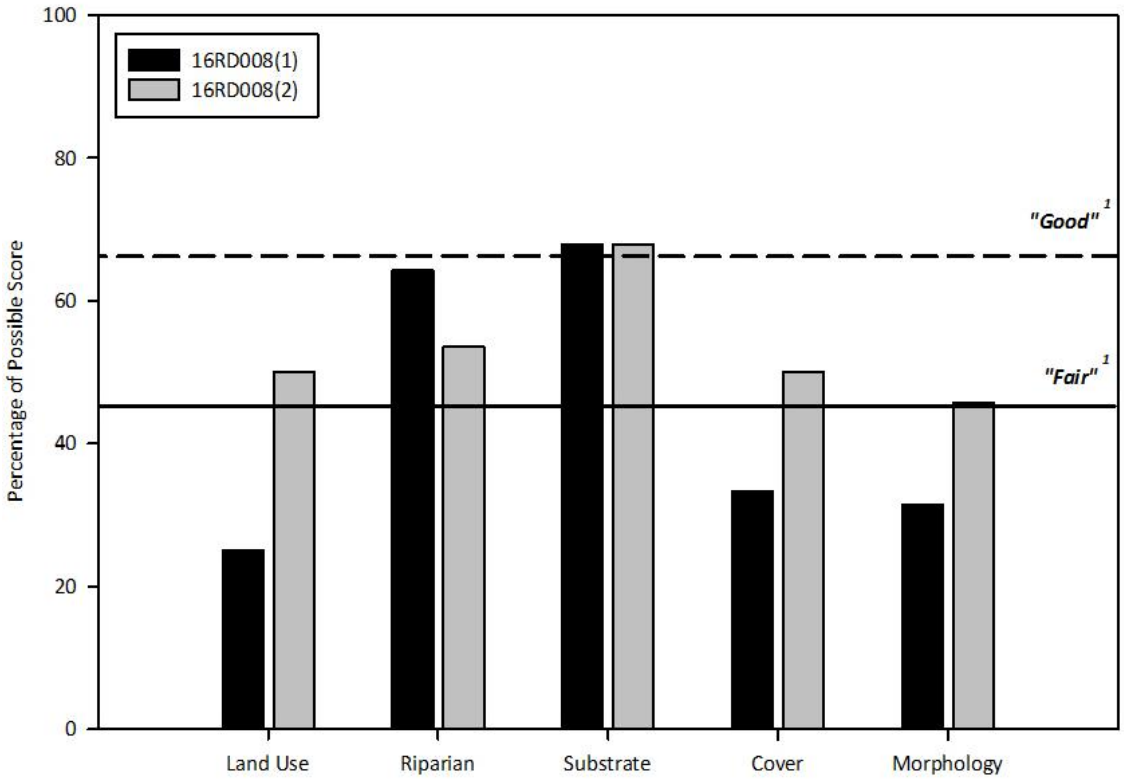
[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
- Good: Score for the biologically impaired reach met or was equal to the statewide mean.
- Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
- Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Insufficient physical habitat

Available data

The physical habitat of the Otter Tail River (504) was evaluated at Station 16RD008 using the MSHA. The station is located along a channelized segment of the reach (MPCA, 2013). The station yielded "fair" MSHA scores (MSHA=46 and 54). Figure 44 displays the MSHA subcategory results for the station. The predominance of agricultural row crops in the immediate vicinity of the station limited its land use subcategory scores. The riparian subcategory scores were positively influenced by a "moderate" to "extensive" riparian zone width; however, "moderate" to "heavy" bank erosion was also noted. While the station did not offer any riffle habitat, it did offer coarse substrate (i.e., cobble and gravel) with only a "light" amount of embeddedness. The cover subcategory scores for the station were negatively affected by a "sparse" amount of cover. Identified cover types included deep pools, macrophytes (emergent, submergent, and floating leaf), overhanging vegetation, rootwads, shallows, and woody debris. Lastly, the station scored low in the morphology subcategory due in part to "fair" to "poor" channel development and "fair" sinuosity.

Figure 44. MSHA subcategory results for Station 16RD008 along the Otter Tail River (504).



[1] The minimum percentage of each subcategory score needed for the station to achieve a "fair" and "good" MSHA rating.

In 2016, the BRRWD and Wilkin County SWCD received Federal EPA Section 319 and Clean Water Fund grants to evaluate options to restore the altered portions of the Otter Tail River (504). According to the *Engineer's Design Report* (Jones, 2019) that was prepared as part of the grants, the river was channelized and enlarged by the USACE in the early 1950s to protect adjacent farmland from flooding. Up to 27 oxbows were disconnected from the river as part of the project, thereby reducing the length of the channel from 18 miles to 11 miles. The resulting increase in slope has degraded the channel by several feet in many locations, causing substantial streambank erosion. The proposed restoration plan would involve reconnection of the 27 oxbows and stabilization of a headcut along the reach. Expected benefits of the plan would include improved bank stability, decreased sediment loading, and enhanced instream habitat diversity and quality.

In summary, the MSHA data suggest the physical habitat of the Otter Tail River (504) is primarily limited by cover and channel morphology factors, including a limited amount of cover, inadequate channel development, and minimal sinuosity. These deficiencies can be attributed to the channelization of the reach decades ago. The implementation of the proposed restoration plan would address these issues and improve the overall physical habitat of the reach.

Biological response: Macroinvertebrate

Clinger taxa require clean, coarse substrate or other objects to attach themselves to or feed from, while burrower, legless, and sprawler macroinvertebrates are generally tolerant of degraded benthic habitat (Gore et al., 2001). Table 43 shows the insufficient physical habitat-related metric scores for the macroinvertebrate community of the Otter Tail River (504). All of the scores for Station 16RD008 met the statewide mean. The majority of the sample was made up of clinger individuals (86%), indicating the presence of coarse substrate and sufficient cover habitats. Also, there were very few burrower, legless,

and sprawler individuals, which often dominate systems with degraded habitat. While the biological metric data does not suggest limitations in physical habitat, the reach has several documented habitat-related deficiencies due to the effects of past channelization. The multiple lines of evidence are ***inconclusive*** as to whether insufficient physical habitat is a stressor to the macroinvertebrate community of the Otter Tail River (504).

Table 43. Summary of insufficient physical habitat-related biological metric data for Station 16RD008 along the Otter Tail River (504), as well as statewide stations that support a healthy macroinvertebrate community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
Burrower Pct	Relative abundance (%) of burrower individuals (↑)	7 ± 8	16RD008 (1)
ClingerPct	Relative abundance (%) of clinger individuals (↓)	43 ± 18	16RD008 (86)
LeglessPct	Relative abundance (%) of legless individuals (↑)	26 ± 15	16RD008 (11)
Sprawler Pct	Relative abundance (%) of sprawler individuals (↑)	18 ± 12	16RD008 (4)

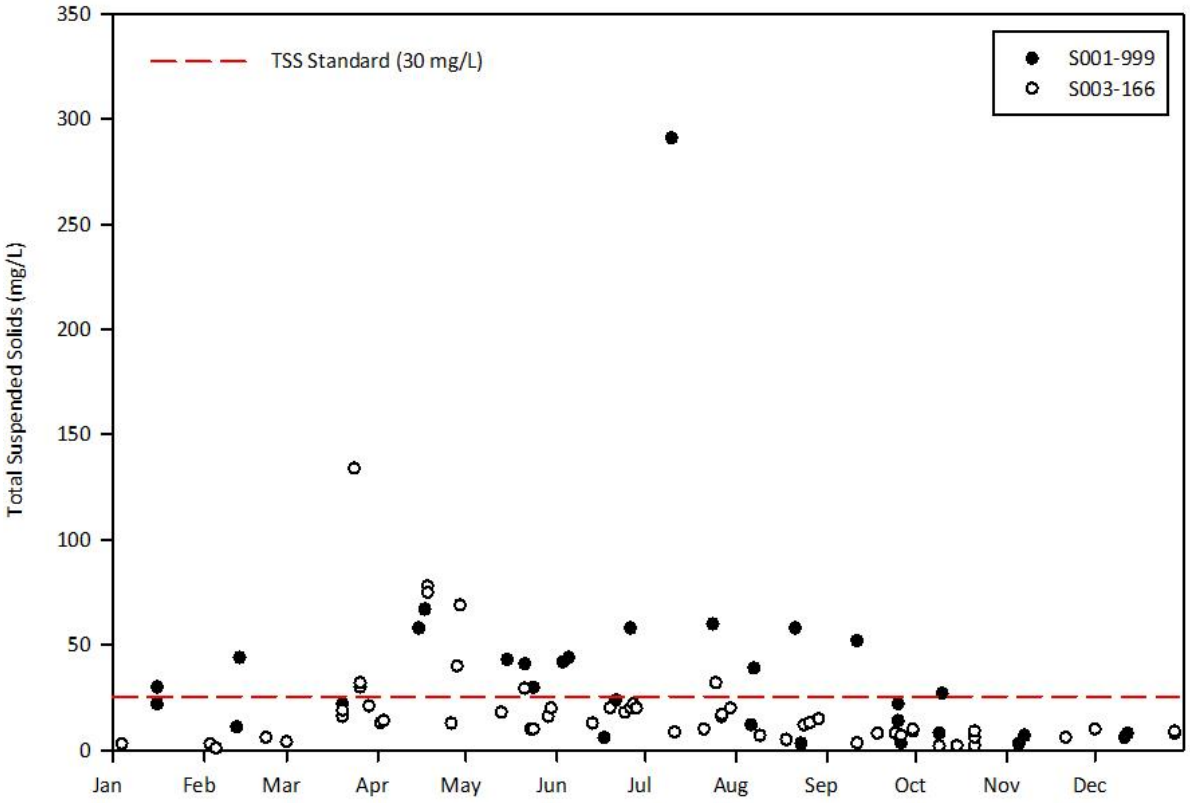
[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

High suspended sediment

Available data

The reach has an existing turbidity impairment that was included on the 2018 Impaired Waters List. The MPCA biological monitoring staff collected a discrete water quality sample at Station 16RD008 along the Otter Tail River (504) at the time of fish monitoring. The sample was analyzed for several parameters, including TSS. The station had a TSS concentration of 3 mg/L, which is well below the 30 mg/L TSS standard for the Central TSS Region. Figure 45 displays all available discrete TSS data for Sites S001-999 (CSAH 17 crossing; 2001-2018; *n*=31) and S003-166 (CSAH 19 crossing; 2002-2018; *n*=58); the location of the sites is shown in Figure 42. Collectively, the mean TSS concentration for the sites was 25 mg/L, while the highest concentration was 291 mg/L and the lowest concentration was 1 mg/L. Approximately 22% of the values exceeded the TSS standard. The OTRW HSPF model estimates that the reach had a TSS concentration in excess of the standard 63% of the time during the period of 1995 to 2014. On August 29, 2018, MPCA SID staff completed a longitudinal assessment of the reach. Staff documented a substantial amount of bank erosion (Figure 46) along the reach, particularly upstream of CSAH 17, as well as several areas that had minimal to no riparian buffer. According to Jones (2019), bank erosion along the altered segments of the reach contributes more than 27,000 tons of sediment to the river per year on average. Overall, the available data suggest the Otter Tail River (504) experiences frequent periods of high suspended sediment.

Figure 45. Discrete TSS data for Sites S001-999 and S003-166 along the Otter Tail River (504).



Biological response: Macroinvertebrate

Similarly, high suspended sediment can adversely affect macroinvertebrates in various ways depending on the concentration and duration of exposure. Excessive suspended sediment often results in a limited macroinvertebrate community that is dominated by tolerant taxa (Henley et al., 2000; EPA, 2012a; Jones et al., 2012). Sediment suspended in the water column can limit collector species and species that filter using a net-spinning casing. Table 44 shows the high TSS-related metric scores for the macroinvertebrate community of the Otter Tail River (504). Station 16RD008 met the statewide mean for the TSS indicator value and the abundance of TSS tolerant taxa metrics. The station scored below the mean for the abundance of TSS intolerant taxa; however, the score was within the confidence interval. The multiple lines of evidence ***somewhat support*** the case for high suspended sediment as a stressor to the macroinvertebrate community of the Otter Tail River (504).

Figure 46. Images of eroded banks in the vicinity of the CSAH 19 crossing along the Otter Tail River (504) on August 29, 2018.

Table 44. Summary of high total suspended solids-related biological metric data for Station 16RD008 along the Otter Tail River (504), as well as statewide stations that support a healthy macroinvertebrate community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
TSS TIV	Mean TSS (mg/L) tolerance indicator value (↑)	18 ± 3	16RD008 (16)
TolTSS	Relative abundance (%) of high TSS tolerant taxa (↑)	49 ± 18	16RD008 (21)
InTolTSS	Relative abundance (%) of high TSS intolerant taxa (↓)	4 ± 7	16RD008 (1)

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.

- Good: Score for the biologically impaired reach met or was equal to the statewide mean.
- Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
- Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Low dissolved oxygen

Available data

The MPCA biological monitoring staff collected a discrete DO measurement at Station 16RD008 along the Otter Tail River (504) at the time of fish (12.0 mg/L) and macroinvertebrate (7.7 mg/L) monitoring. While both values were well above the 5.0 mg/L DO standard, the fish monitoring measurement had a very high saturation percentage (141%). Such supersaturation is commonly caused by excessive aquatic plant (i.e., algae and submergent macrophyte) growth. Figure 47 displays all available discrete DO data for Sites S001-999 (2001-2018; *n*=32) and S003-166 (2002-2018; *n*=62). None of the values for the sites were below the standard; however, only 6 of the measurements were collected prior to 9:00 a.m., when values are typically lowest. Generally, the lowest DO levels were in the months of June, July, August, and September. The MPCA conducted continuous DO monitoring at Site W56066002 (CSAH 17 crossing) from September 6, 2017, to September 13, 2017 and from August 13, 2018, to August 23, 2018; the location of the site is shown in Figure 42. The monitoring results are provided in Table 45, as well as displayed in Figures 48 and 49. Collectively, none of the values for the monitoring periods were below the standard. Additionally, the OTRW HSPF model estimates that the reach did not have a DO concentration below the standard during the period of 1995 to 2014. Overall, the available data suggest the Otter Tail River (504) experiences infrequent periods of low DO.

Figure 47. Discrete DO data for Sites S001-999 and S003-166 along the Otter Tail River (504).

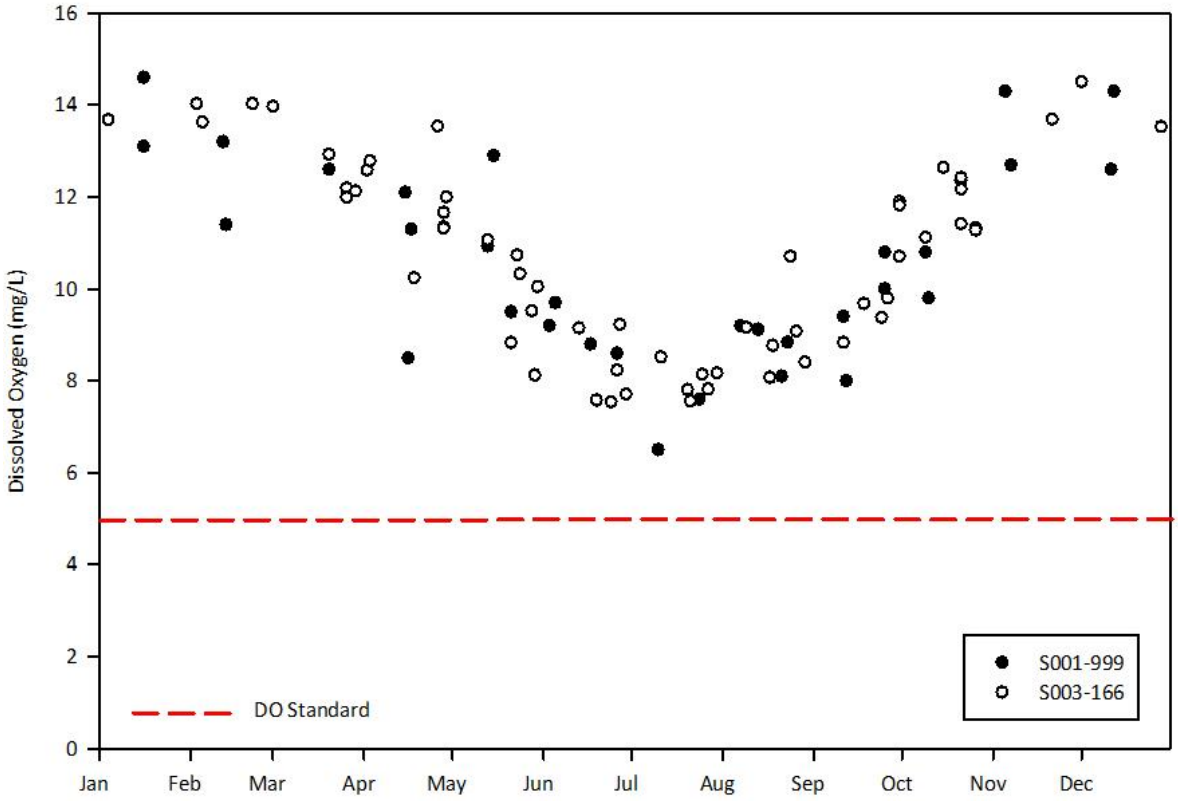


Table 45. Continuous DO data for Site W56066002 along the Otter Tail River (504).

Site	Start date - End date	*n*	Max. (mg/L)	Min. (mg/L)	% Total values below standard	% Daily min. values below standard	Mean daily flux (mg/L)
W56066002	9/6/2017 - 9/13/2017	672	10.9	6.9	0	0	2.9
W56066002	8/13/2018 - 8/23/2018	951	11.8	6.1	0	0	3.7

Figure 48. Continuous DO data (September 6-13, 2017) for Site W56066002 along the Otter Tail River (504).

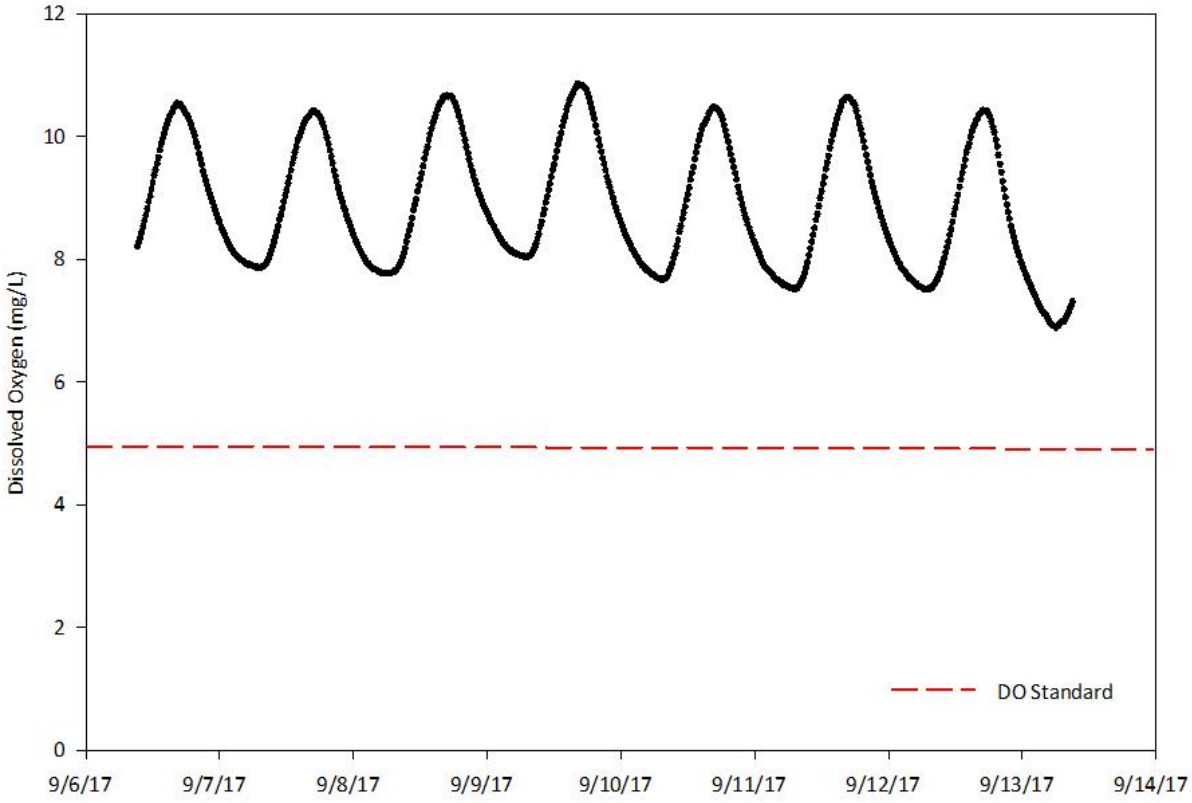
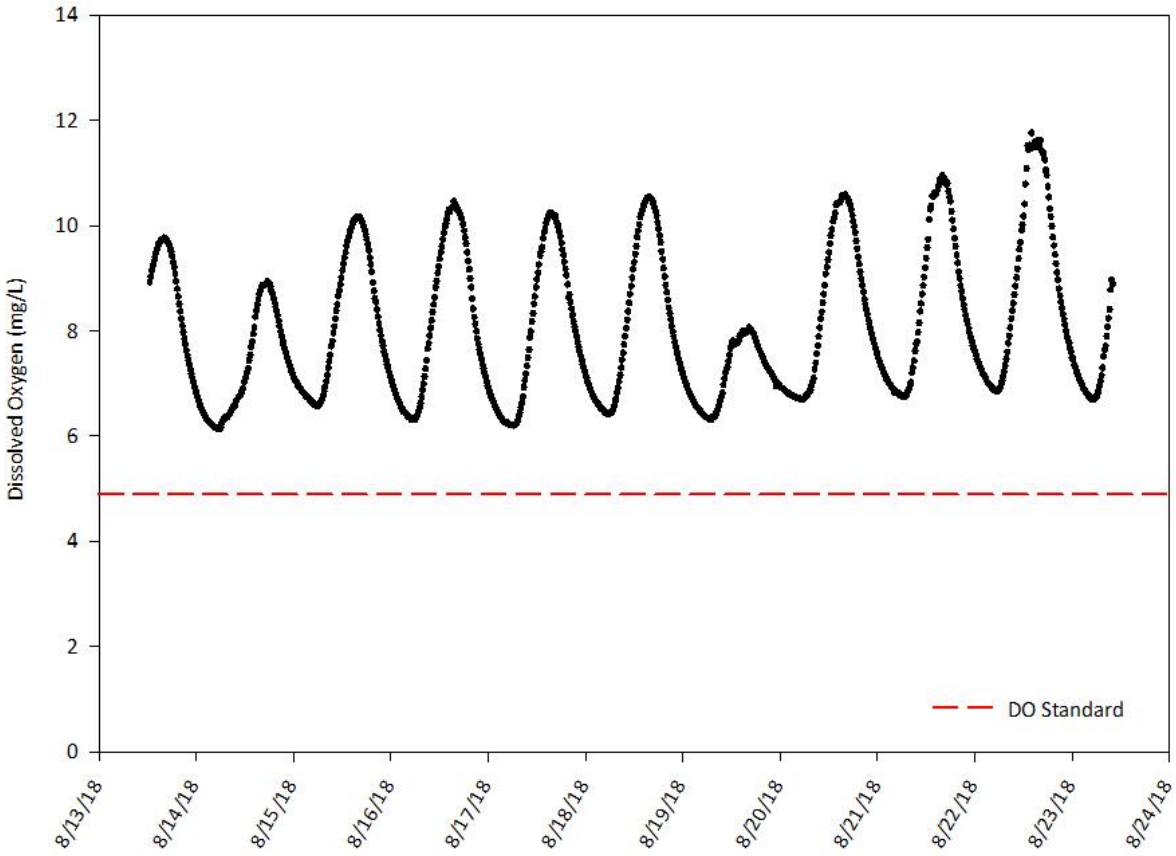


Figure 49. Continuous DO data (August 13-23, 2018) for Site W56066002 along the Otter Tail River (504).



Eutrophication-related data for the Otter Tail River (504) includes the following parameters: TP, Chl-a, and DO flux. The MPCA biological monitoring staff collected a discrete water quality sample at Station 16RD008 along the reach at the time of the macroinvertebrate monitoring visit. The sample was analyzed for several parameters, including TP. The station had a TP concentration of 25 µg/L, which is below the 100 µg/L Central River Nutrient Region TP standard. Discrete TP data are also available for Sites S001-999 (2001-2018; *n*=33) and S003-166 (2002-2018; *n*=58). Collectively, the mean TP concentration for the sites was 66 µg/L, while the highest concentration was 402 µg/L and the lowest concentration was 13 µg/L. Approximately 15% of the values exceeded the TP standard. Discrete Chl-a data are also available for Site S001-999 (2018; *n*=32). The mean Chl-a concentration for the site was 10 µg/L, while the highest concentration was 26 µg/L and the lowest concentration was 1 µg/L. There was one exceedance of the 18 µg/L Central River Nutrient Region Chl-a standard. The mean daily DO flux documented during continuous DO monitoring at Site W56066002 was 2.9 and 3.7 mg/L; the Central River Nutrient Region standard is 3.5 mg/L. In addition, the MPCA biological monitoring staff noted blue-green algae at Station 16RD008 during the August 29, 2017, fish monitoring visit. The MPCA SID staff also documented mild supersaturated DO levels during continuous DO monitoring at Site W56066002 in September 2017 and August 2018. While the Otter Tail River (504) is prone to high TP concentrations, additional response variable data are needed to determine if eutrophication is adversely affecting the DO regime.

Biological response: Macroinvertebrate

Frequent or extended periods of low dissolved oxygen can alter a macroinvertebrate community by limiting the abundance of taxa that are intolerant of such conditions (Davis, 1975, EPA, 2012a). Table 46 shows the low DO-related metric scores for the macroinvertebrate community of the Otter Tail River

(504). Station 16RD008 met the statewide mean for the DO indicator value and the abundance of low DO tolerant taxa metrics. The station scored below the mean for the abundance of low DO intolerant taxa metric, but the score was within the confidence interval. Given the available biological metric and water quality data, it is unlikely that the macroinvertebrate community is being adversely affected by low DO. The multiple lines of evidence **refute** the case for low dissolved oxygen as a stressor to the macroinvertebrate community of the Otter Tail River (504).

Table 46. Summary of low dissolved oxygen-related biological metric data for Station 16RD008 along the Otter Tail River (504), as well as statewide stations that support a healthy macroinvertebrate community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)
DO TIV	Mean DO (mg/L) tolerance indicator value (↑)	7 ± 1	16RD008 (8)
TolDO	Relative abundance (%) of low DO tolerant taxa (↑)	9 ± 12	16RD008 (1)
InTolDO	Relative abundance (%) of low DO intolerant taxa (↓)	20 ± 15	16RD008 (6)

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Summary of stressors

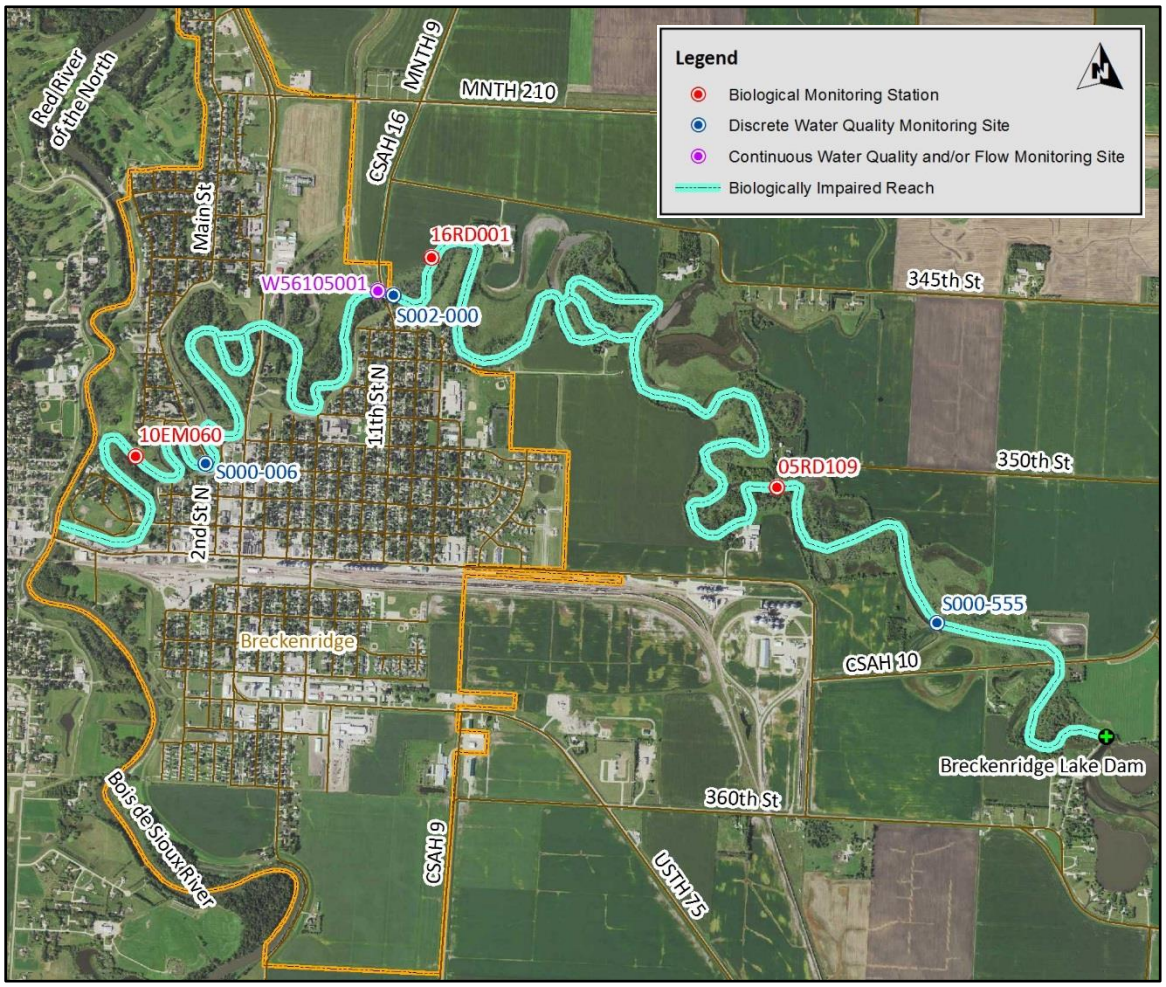
The evidence suggests that the M-IBI impairment associated with the Otter Tail River (504) is attributed to high suspended sediment. A large portion of the reach was straightened and enlarged by the USACE in the 1950s with the goal of improving drainage efficiency. However, the alteration of the river channel has resulted in substantial channel instability, which has increased sediment loading. A proposed restoration plan has been developed to restore the natural channel of the river. If implemented, the plan would improve bank stability, decrease sediment loading, and enhance instream habitat.

3.2.6 Otter Tail River (502)

Physical setting

This reach represents the most downstream segment of the Otter Tail River from the outlet of Breckenridge Lake, to its confluence with the Bois de Sioux River (Figure 50); a total length of 8 miles. The OTRW has an area of 1,909 square miles (1,222,030 acres). The watershed contains 387 miles of perennial stream and river (e.g., Otter Tail River), 316 miles of intermittent stream, 154 miles of intermittent drainage ditch, and 69 miles of perennial drainage ditch (DNR, 2014b). According to the MPCA (2013), 41% of the watercourses in the watershed have been physically altered (i.e., channelized, ditched, or impounded); the entire length of the Otter Tail River (502) is classified as natural channel. According to the NLCD 2011 (USGS, 2011), cultivated crops (27%) and deciduous forest (27%) are the prominent land uses in the OTRW. Other notable land cover groups in the OTRW included open water (15%), hay/pasture (14%), wetlands (7%), developed (6%), herbaceous (4%), and shrub/scrub (1%).

Figure 50. Map of the Otter Tail River (502) and associated biological monitoring stations and water quality/flow monitoring sites (2017 NAIP aerial image). Flow direction is east to west.



Biological impairments

Fish (F-IBI)

The fish community of the Otter Tail River (502) was monitored at Station 10EM060 (0.4 miles downstream of the Main Street crossing) on September 22, 2011 and August 12, 2015, as well as Station 16RD001 (0.2 miles upstream of the 11th Street crossing) on August 29, 2017. The location of these stations is shown in Figure 50. Both stations were designated as General Use within the Southern Rivers F-IBI Class (Class 1); the associated impairment threshold is an F-IBI score of 49. Station 10EM060 scored slightly below the impairment threshold in 2011 (F-IBI=48) but had a substantially higher score in 2015 (F-IBI=77). Station 16RD001 scored well below the impairment threshold in 2017 (F-IBI=33). Table 47 provides a summary of the results for the aforementioned monitoring visits, as well as two additional monitoring visits that were not able to be included in the assessment process. Collectively, 39 species were sampled between the stations. Notably, the two substandard scores had a high abundance of tolerant taxa (e.g., black bullhead and bluntnose minnow).

Table 47. Summary of fish monitoring data for Stations 05RD109, 10EM060, and 16RD001 along the Otter Tail River (502).

Common name	# sampled				
	05RD109[06]	16RD001[10]	10EM060[11]	10EM060[15]	16RD001[17]
bigmouth shiner			1		7
black bullhead			734		
black crappie			16		
blackside darter					6
bluegill			29		15
bluntnose minnow					111
channel catfish	12	21	7	43	4
common carp	15	13	8	44	10
creek chub			9		
emerald shiner	14		38	46	
fathead minnow			1		2
freshwater drum	2	3	4	3	
golden redhorse	45	7	6	27	1
goldeye	5	17	2	30	
greater redhorse	1		2	2	1
green sunfish	1		9	1	32
johnny darter			4		20
logperch		1			
mooneye					1
northern pike	4		16	6	
orangespotted sunfish	1	1	19		73
quillback	1		2	1	7
river redhorse		1			
rock bass		2	1	4	

[06] Sampled on August 22, 2006; [10] sampled on August 18, 2010; [11] sampled on September 22, 2011; [15] sampled on August 12, 2015; [17] sampled on August 29, 2017

Table 47. Summary of fish monitoring data for Stations 05RD109, 10EM060, and 16RD001 along the Otter Tail River (502). (Continued)

Common name	# sampled				
	05RD109[06]	16RD001[10]	10EM060[11]	10EM060[15]	16RD001[17]
sand shiner		4		1	6
sauger			1		
shorthead redhorse	10	5	8	72	
silver redhorse	8	1	2	10	1
smallmouth bass	4	2	42	30	1
smallmouth buffalo			1	2	
southern brook lamprey					1
spotfin shiner	125	18	66	33	48
stonecat			3		
walleye	2	1	1	4	1
white bass	4	1	2	2	
white crappie		1	1		
white sucker				3	
yellow bullhead			1		
yellow perch			6		

[06] Sampled on August 22, 2006; [10] sampled on August 18, 2010; [11] sampled on September 22, 2011; [15] sampled on August 12, 2015; [17] sampled on August 29, 2017

Candidate causes

Loss of longitudinal connectivity

Available data

The MPCA biological monitoring staff did not observe any connectivity-related issues during their visits to Stations 10EM060 and 16RD001. According to the DNR (2014a), the Breckenridge Lake Dam is located at the outlet of Breckenridge Lake, which represents the upstream end of the Otter Tail River (502). The dam, which is owned by Wilkin County, was constructed in 1935 for the purpose of water supply. In 2007, the dam was modified to restore connectivity through the installation of a series of arch rapids (Figure 51). On September 12, 2018, MPCA SID staff completed a longitudinal assessment of the reach. No obstructions to connectivity were identified. In addition to the assessment, MPCA SID staff performed a detailed review of an August 2, 2015, aerial photo (courtesy of Google Earth) of the reach. No connectivity-related issues were identified in the photo. In summary, there are no existing barriers to connectivity along the Otter Tail River (502).

Figure 51. Images of arch rapids at the Breckenridge Lake Dam along the Otter Tail River (502) on October 24, 2018.

Biological response: Fish

Migratory and late maturing fish species require well-connected environments in order to access the habitats and resources necessary to complete their life history (Saunders, 2007). Barriers to connectivity (e.g., dams) can limit the availability of critical habitats and resources, thereby reducing the abundance of these species, along with overall species diversity (Poole, 2002; Cross et al., 2013; Gardner, et al. 2013; Aadland, 2015). Table 48 shows the loss of longitudinal connectivity-related metric scores for the fish community of the Otter Tail River (502). Collectively, the stations scored above the statewide mean for both of the metrics. Additionally, based upon reconnaissance, there are no obvious barriers to fish passage. The multiple lines of evidence ***refute*** the case for loss of longitudinal connectivity as a stressor to the fish community of the Otter Tail River (502).

Table 48. Summary of loss of longitudinal connectivity-related biological metric data for Stations 05RD109, 10EM060, and 16RD001 along the Otter Tail River (502), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)	Station score (mean ± SD)	*Station (2005 score[2])*
MgrTxPct	Relative abundance (%) of taxa that are migratory (↓)	31 ± 8	10EM060[11] (26) 10EM060[15] (40) 16RD001[10] (29) 16RD001[17] (30)	31 ± 6	*05RD109 (41)*
MA>3-TolTxPct	Relative abundance (%) of taxa with a female mature age of ≥ 3 years, excluding tolerant taxa (↓)	41 ± 11	10EM060[11] (45) 10EM060[15] (55) 16RD001[10] (59) 16RD001[17] (40)	50 ± 9	*05RD109 (59)*

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.

[2] 2005 data were not used for the purposes of assessment; data were outside of 10-year assessment window.

[11] Sampled on September 22, 2011; [15] sampled on August 12, 2015; [10] sampled on August 18, 2010; [17] sampled on August 29, 2017.

Good: Score for the biologically impaired reach met or was equal to the statewide mean.

Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.

Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Flow regime instability

Available data

The MPCA biological monitoring staff did not encounter any flow-related issues (e.g., intermittency) at Stations 10EM060 and 16RD001. According to the MPCA (2013), 41% of the watercourses in the watershed have been physically altered (i.e., channelized, ditched, or impounded); the entire length of the Otter Tail River (502) is classified as natural stream channel. There are no flow monitoring data for the reach. The USGS (2018) estimated that the median flow (Q50) for the reach at its outlet was 678.0 cfs, while the normal range of flow values was 1240.0 (Q25) to 424.0 (Q75) cfs. The ratio of Q25 to Q75 flow values was approximately 3:1, which is indicative of a hydrologically stable system. By comparison, several of the other hydrologically stable rivers in the Red River Basin (e.g., Buffalo River and Clearwater River) had a Q25 to Q75 ratio of 7:1 or less. Additionally, the 7 day, 10 year low flow value for the reach was 190.0 cfs, which suggests that the reach has sustained baseflow and does not regularly experience periods of intermittency. The MPCA SID staff conducted reconnaissance along the reach on seven separate dates between the spring and fall of 2018 and documented flow conditions. No flow-related issues were noted. Overall, the available data suggest the Otter Tail River (502) has a stable flow regime.

Biological response: Fish

Flow regime instability has been shown to limit species diversity and favor taxa that are generalists, early maturing, pioneering, short-lived, and tolerant to disturbances (Aadland et al., 2005; Poff and Zimmerman, 2010). Table 49 shows the flow regime instability-related metric scores for the fish community of the Otter Tail River (502). The stations did not meet the statewide mean for three of the metrics (DomTwoPct, NumPerMeter-Tol, and PioneerTxPct); however, the scores within their respective confidence interval. The multiple lines of evidence are ***inconclusive*** as to whether flow regime instability is a stressor to the fish community of the Otter Tail River (502).

Table 49. Summary of flow regime instability-related biological metric data for Stations 05RD109, 10EM060, and 16RD001 along the Otter Tail River (502), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)	Station score (mean ± SD)	*Station (2005 score[2])*
DomTwo Pct	Relative abundance (%) of the two most abundant taxa (↑)	49 ± 13	10EM060[11] (80) 10EM060[15] (36) 16RD001[10] (39) 16RD001[17] (53)	52 ± 20	*05RD109 (71)*
GeneralTx Pct	Relative abundance (%) of individual that are generalists (↑)	25 ± 8	10EM060[11] (26) 10EM060[15] (25) 16RD001[10] (6) 16RD001[17] (25)	20 ± 10	*05RD109 (18)*
MA<2Tx Pct	Relative abundance (%) of taxa with a female mature age ≤ 2 years (↑)	48 ± 10	10EM060[11] (45) 10EM060[15] (40) 16RD001[10] (41) 16RD001[17] (55)	45 ± 7	*05RD109 (41)*
NumPer Meter-Tol	Number of individuals per meter of stream sampled, excluding tolerant species (↓)	0.8 ± 0.9	10EM060[11] (0.5) 10EM060[15] (0.6) 16RD001[10] (0.2) 16RD001[17] (0.2)	0.4 ± 0.2	*05RD109 (0.5)*
PioneerTx Pct	Relative abundance (%) of taxa that are pioneers (↑)	8 ± 5	10EM060[11] (13) 10EM060[15] (5) 16RD001[10] (0) 16RD001[17] (20)	9 ± 9	*05RD109 (6)*
SLvdPct	Relative abundance (%) of individuals that are short-lived (↑)	14 ± 15	10EM060[11] (0) 10EM060[15] (0) 16RD001[10] (4) 16RD001[17] (36)	10 ± 17	*05RD109 (0)*

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
[2] 2005 data were not used for the purposes of assessment; data were outside of 10-year assessment window.
[11] Sampled on September 22, 2011; [15] sampled on August 12, 2015; [10] sampled on August 18, 2010; [17] sampled on August 29, 2017
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

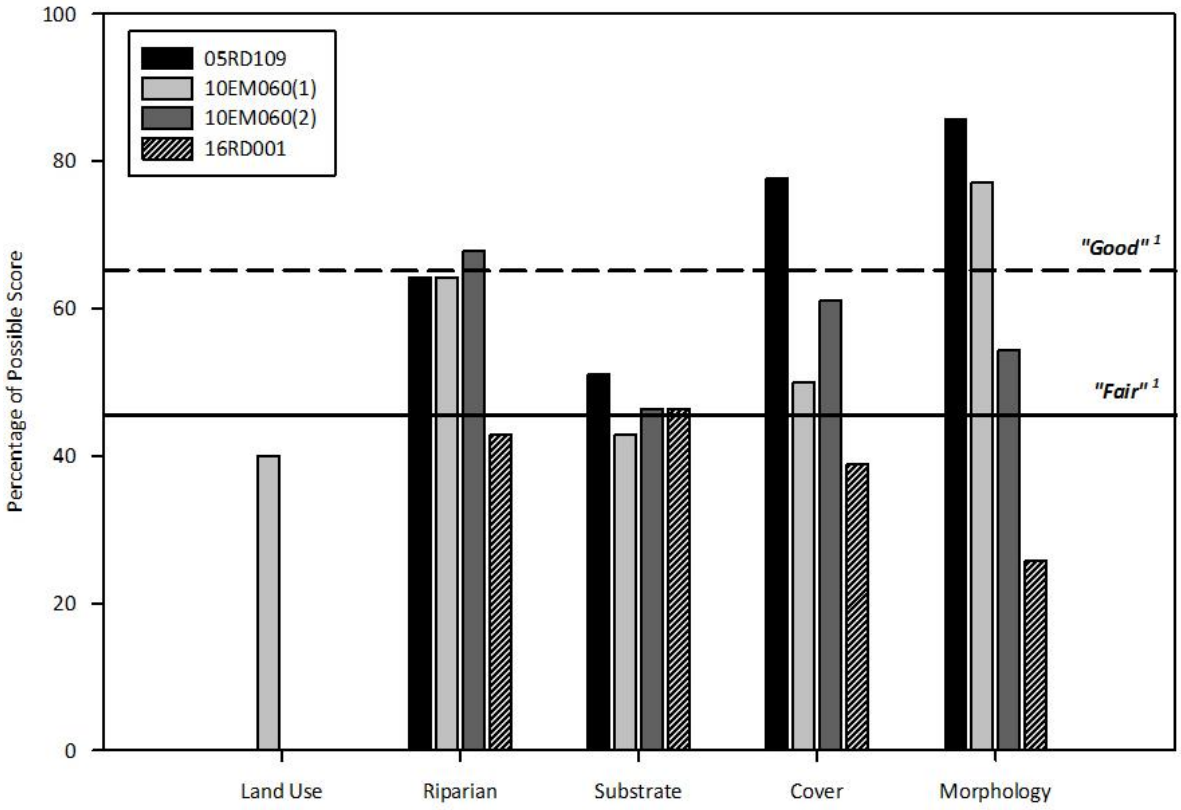
Insufficient physical habitat

Available data

The physical habitat of the Otter Tail River (502) was evaluated at Stations 05RD109, 10EM060, and 16RD001 using the MSHA. The entire reach is classified as natural stream channel (MPCA, 2013). Station 05RD109 (MSHA=67/"good"), which is situated along the upstream extent of the reach, had a higher MSHA score than Stations 10EM060 (MSHA=52/"fair" and 59/"fair") and 16RD001 (MSHA=35/"poor"), which are located further downstream. Figure 52 displays the MSHA subcategory results for each of the stations. The predominance of agricultural row crops in the immediate vicinity of the stations severely limited their land use subcategory scores. The stations generally scored well in the riparian subcategory due to a broad riparian zone width and minimal to no bank erosion. However, "severe" bank erosion was noted at Station 16RD001. The stations scored near the "fair" rating threshold in the substrate subcategory. While each of the stations offered some coarse substrate (e.g., cobble and gravel) with only "light" embeddedness, only Station 05RD109 provided riffle habitat. Station 16RD001 scored poorly

in the cover subcategory due to a "sparse" amount of cover. Noted cover types at the stations included boulders, deep pools, overhanging vegetation, oxbows, rootwads, shallows, submergent macrophytes, undercut banks, and woody debris. Lastly, Station 16RD001 scored substantially lower in the morphology subcategory than the other stations due in part to "poor" channel development. Additionally, the biological monitoring staff could not obtain a macroinvertebrate sample because there was no available habitat to sample. Overall, the physical habitat of the downstream portion of the Otter Tail River (502) is limited due to a number of factors including bank erosion, a lack of riffle habitat, a limited amount of cover, and inadequate channel development.

Figure 52. MSHA subcategory results for Stations 05RD109, 10EM060, and 16RD001 along the Otter Tail River (502).



[1] The minimum percentage of each subcategory score needed for the station to achieve a "fair" and "good" MSHA rating.

Biological response: Fish

Insectivores (e.g., darters and sculpins) and simple lithophilic spawners require quality benthic habitat (e.g., clean, coarse substrate and riffles) for feeding and/or reproduction purposes, while detritivores utilize decomposing organic matter (i.e., detritus) as a food resource and, therefore, are less dependent upon the quality of instream habitat (Aadland and Kuitunen, 2006). Table 50 shows the insufficient physical habitat-related metric scores for the fish community of the Otter Tail River (502). The stations scored below the statewide mean, but within the lower confidence interval, for five of the six metrics. A decline in riffle dwelling, simple lithophilic spawning, insectivorous, and darter and sculpin taxa can suggest a degradation of physical habitat. The multiple lines of evidence ***somewhat support*** the case for insufficient physical habitat as a stressor to the fish community of the Otter Tail River (502).

Table 50. Summary of insufficient physical habitat-related biological metric data for Stations 05RD109, 10EM060, and 16RD001 along the Otter Tail River (502), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)	Station score (mean ± SD)	*Station (2005 score[2])*
RiffleTxPct	Relative abundance (%) of taxa that predominately utilize riffle habitats (↓)	14 ± 9	10EM060[11] (6) 10EM060[15] (10) 16RD001[10] (6) 16RD001[17] (0)	6 ± 4	*05RD109 (6)*
SLithopTx Pct	Relative abundance (%) of taxa that are simple lithophilic spawning species (↓)	34 ± 9	10EM060[11] (23) 10EM060[15] (35) 16RD001[10] (35) 16RD001[17] (25)	29 ± 7	*05RD109 (35)*
Insect-TolPct	Relative abundance (%) of individuals that are insectivorous excluding tolerant species (↓)	57 ± 16	10EM060[11] (13) 10EM060[15] (56) 16RD001[10] (54) 16RD001[17] (27)	37 ± 21	*05RD109 (82)*
BenInsect-TolTxPct	Relative abundance (%) of taxa that are benthic insectivores, excluding tolerant species (↓)	25 ± 10	10EM060[11] (19) 10EM060[15] (20) 16RD001[10] (29) 16RD001[17] (25)	23 ± 5	*05RD109 (24)*
DetNWQ TxPct	Relative abundance (%) of taxa that are detritivorous (↑)	24 ± 6	10EM060[11] (13) 10EM060[15] (25) 16RD001[10] (18) 16RD001[17] (30)	21 ± 8	*05RD109 (18)*
DarterSculpTxPct	Relative abundance (%) of taxa that are darters and sculpins (↓)	8 ± 7	10EM060[11] (3) 10EM060[15] (0) 16RD001[10] (6) 16RD001[17] (10)	5 ± 4	*05RD109 (0)*

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.
[2] 2005 data were not used for the purposes of assessment; data were outside of 10-year assessment window.
[11] Sampled on September 22, 2011; [15] sampled on August 12, 2015; [10] sampled on August 18, 2010; [17] sampled on August 29, 2017.
Good: Score for the biologically impaired reach met or was equal to the statewide mean.
Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.
Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

High suspended sediment

Available data

The Otter Tail River (502) has an existing turbidity impairment that was included on the 2018 Impaired Waters List. According to the *Lower Otter Tail River TMDL Implementation Plan* (Wilkin County SWCD and MPCA, 2007), the USGS estimated that the annual sediment load of the river in Breckenridge was 40,400 tons. Jones (2019) estimated that bank erosion along the altered portion of the Otter Tail River (504) is responsible for a substantial portion (68%) of this sediment load. The MPCA biological monitoring staff collected a combined five discrete water quality samples at Stations 05RD109 and 10EM060 along the reach at the time of fish and macroinvertebrate monitoring. The samples were analyzed for several parameters, including TSS. The biological monitoring stations had TSS concentrations ranging from 36 to 74 mg/L; all of the values exceeded the 30 mg/L TSS standard for the Central TSS Region. Figure 53 displays all available discrete TSS data for Sites S000-006 (4th Street

crossing; 1953-2010; *n*=491), S000-555 (CR 164 crossing; 1978-2003; *n*=28), and S002-000 (11th Street crossing; 2001-2018; *n*=480); the location of the sites is shown in Figure 50. Collectively, the mean TSS concentration for the sites was 84 mg/L, while the highest concentration was 830 mg/L and the lowest concentration was 2 mg/L. Approximately 66% of the values exceeded the TSS standard. The OTRW HSPF model estimates that the reach had a TSS concentration in excess of the standard between 62% and 89% of the time during the period of 1995 to 2014. On September 12, 2018, MPCA SID staff completed a longitudinal assessment of the reach. Staff documented several areas of bank erosion (Figure 54) along the reach, particularly between the Breckenridge Lake Dam and the City of Breckenridge. A substantial amount of bank armoring has been done within the City of Breckenridge in an attempt to prevent future erosion. Overall, the available data suggest the Otter Tail River (502) experiences frequent periods of high suspended sediment.

Figure 53. Discrete TSS data for Sites S000-006, S000-555, and S002-000 along the Otter Tail River (502).

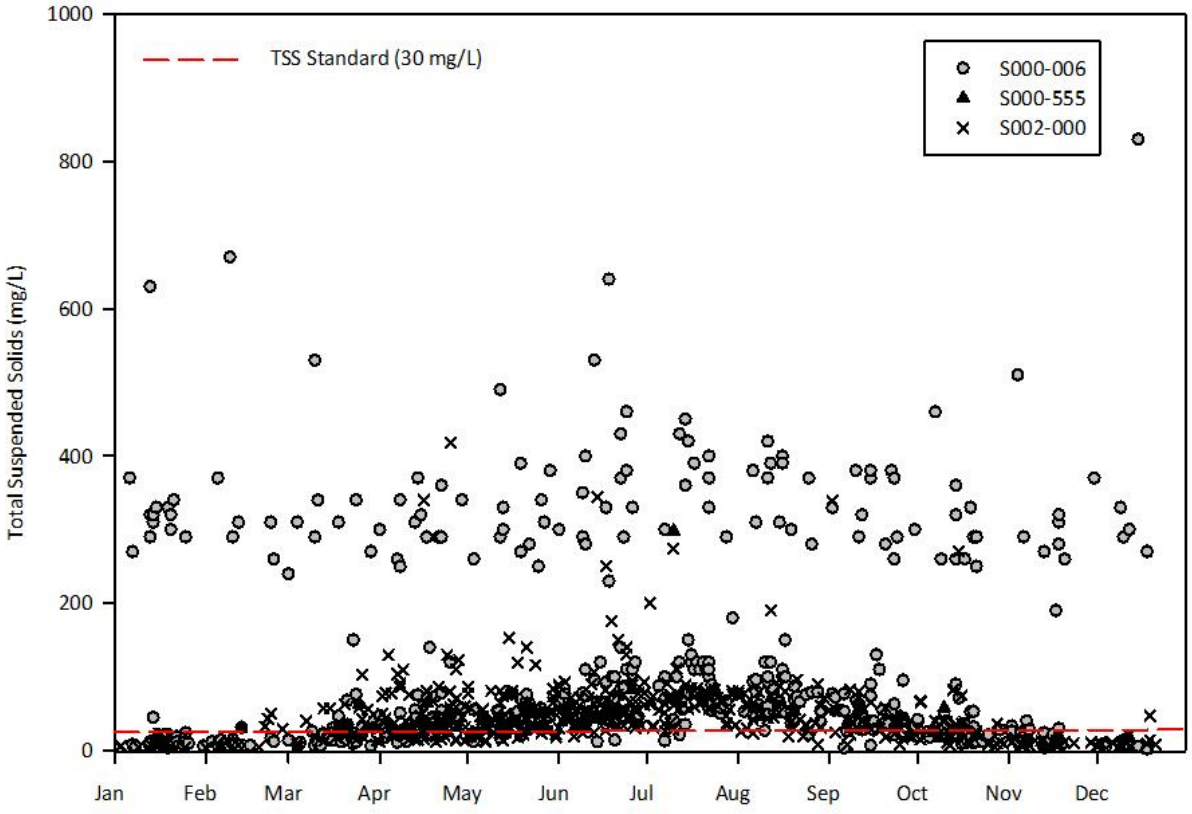


Figure 54. Images of eroded banks in the vicinity of the CSAH 10 crossing along the Otter Tail River (502) on September 12, 2018.

Biological response: Fish

Excessive suspended sediment can affect a fish community in various ways depending on the concentration and duration of exposure. The deposition of sediment can fill interstitial spaces in riffles and coarse substrate that are important for lithophilic and insectivorous taxa (Bilotta and Brazier, 2008). Sediment deposition can also block pores in the streambed, thereby preventing exchange within the hyporheic zone (Greig et al., 2005). Table 51 shows the high TSS-related metric scores for the fish community of the Otter Tail River (502). The stations met the statewide mean for the TSS TIV metric but scored below the mean for the probability of meeting the TSS standard metric. The conditional probability metric score suggests that suspended sediment may be adversely affecting the fish community. The multiple lines of evidence ***somewhat support*** the case for high suspended sediment as a stressor to the fish community of the Otter Tail River (502).

Table 51. Summary of high total suspended solids-related biological metric data for Stations 05RD109, 10EM060, and 16RD001 along the Otter Tail River (502), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)	Station score (mean ± SD)	*Station (2005 score[2])*
TSS TIV	Mean TSS (mg/L) tolerance indicator value (↑)	34 ± 9	10EM060[11] (26) 10EM060[15] (32) 16RD001[10] (40) 16RD001[17] (29)	32 ± 6	*05RD109 (32)*
CondProb	Probability of meeting the TSS standard (↓)	11 ± 16	10EM060[11] (6) 10EM060[15] (1) 16RD001[10] (0) 16RD001[17] (2)	2 ± 3	*05RD109 (1)*

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.

[2] 2005 data were not used for the purposes of assessment; data were outside of 10-year assessment window.

[11] Sampled on September 22, 2011; [15] sampled on August 12, 2015; [10] sampled on August 18, 2010; [17] sampled on August 29, 2017

Good: Score for the biologically impaired reach met or was equal to the statewide mean.

Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.

Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Low dissolved oxygen

Available data

The MPCA biological monitoring staff collected a combined eight discrete DO measurements at Stations 05RD109, 10EM060, and 16RD001 along the Otter Tail River (502) at the time of fish and macroinvertebrate monitoring. All of the measurements were well above the 5.0 mg/L DO standard; values ranged from 6.0 to 10.1 mg/L. Figure 55 displays all available discrete DO data for Sites S000-006 (1953-2010; *n*=415), S000-555 (2001-2003; *n*=33), and S002-000 (2001-2018; *n*=460). Collectively, less than 1% of the values were below the standard; however, only 34 of the measurements were collected prior to 9:00 a.m., when values are typically lowest. Generally, the lowest DO levels were in the months of June, July, and August. The MPCA conducted continuous DO monitoring at Site W56105001 (11th Street crossing) from July 17, 2017, to July 31, 2017 and from August 13, 2018, to August 23, 2018; the location of the site is shown in Figure 50. The monitoring results are provided in Table 52, as well as displayed in Figures 56 and 57. Collectively, none of the values for the monitoring periods were below the standard. Additionally, the OTRW HSPF model estimates that the reach had a DO concentration below the standard less than 1% of the time during the period of 1995 to 2014. Overall, the available data suggest the Otter Tail River (502) experiences infrequent periods of low DO.

Figure 55. Discrete DO data for Sites S000-006, S000-555, and S002-000 along the Otter Tail River (502).

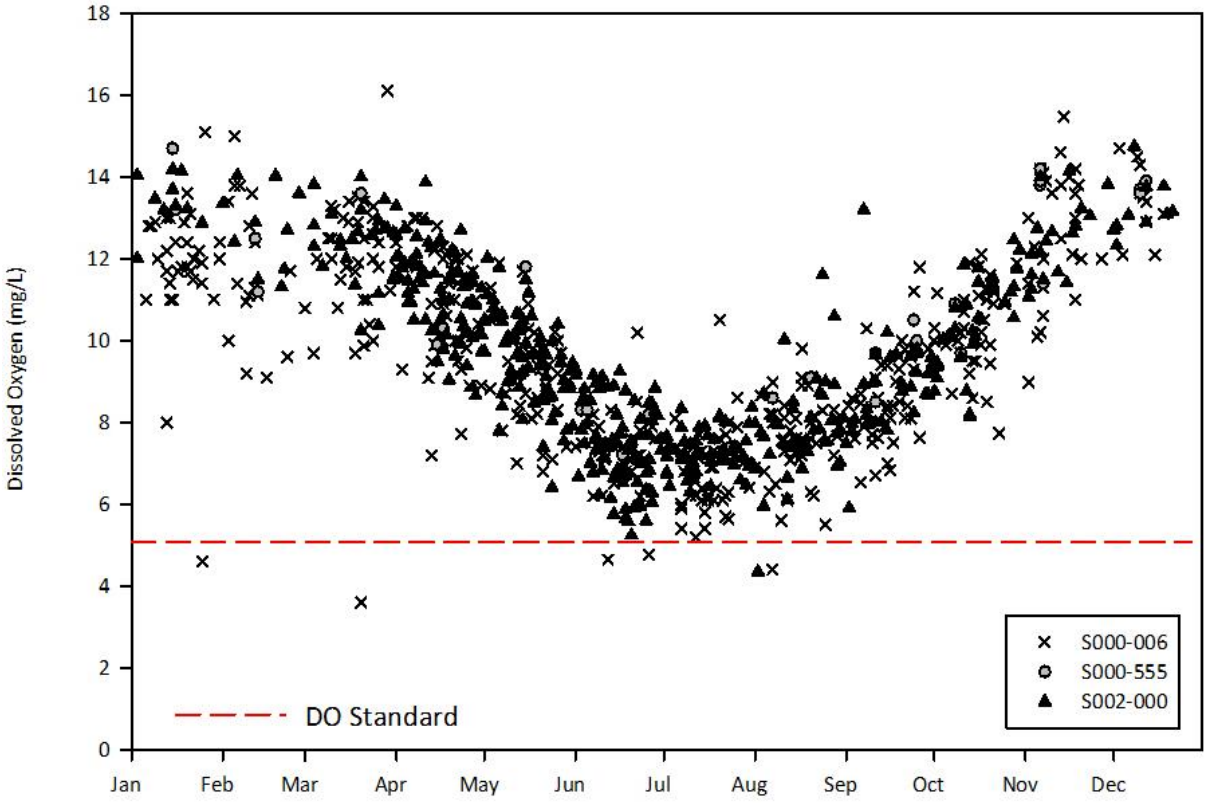


Table 52. Continuous DO data for Site W56105001 along the Otter Tail River (502).

Site	Start date - End date	*n*	Max. (mg/L)	Min. (mg/L)	% Total values below standard	% Daily min. values below standard	Mean daily flux (mg/L)
W56105001	7/17/2017 - 7/31/2017	1345	7.9	6.4	0	0	0.9
W56105001	8/13/2018 - 8/23/2018	792	8.7	6.9	0	0	1.0

Figure 56. Continuous DO data (July 17-31, 2017) for Site W56105001 along the Otter Tail River (502).

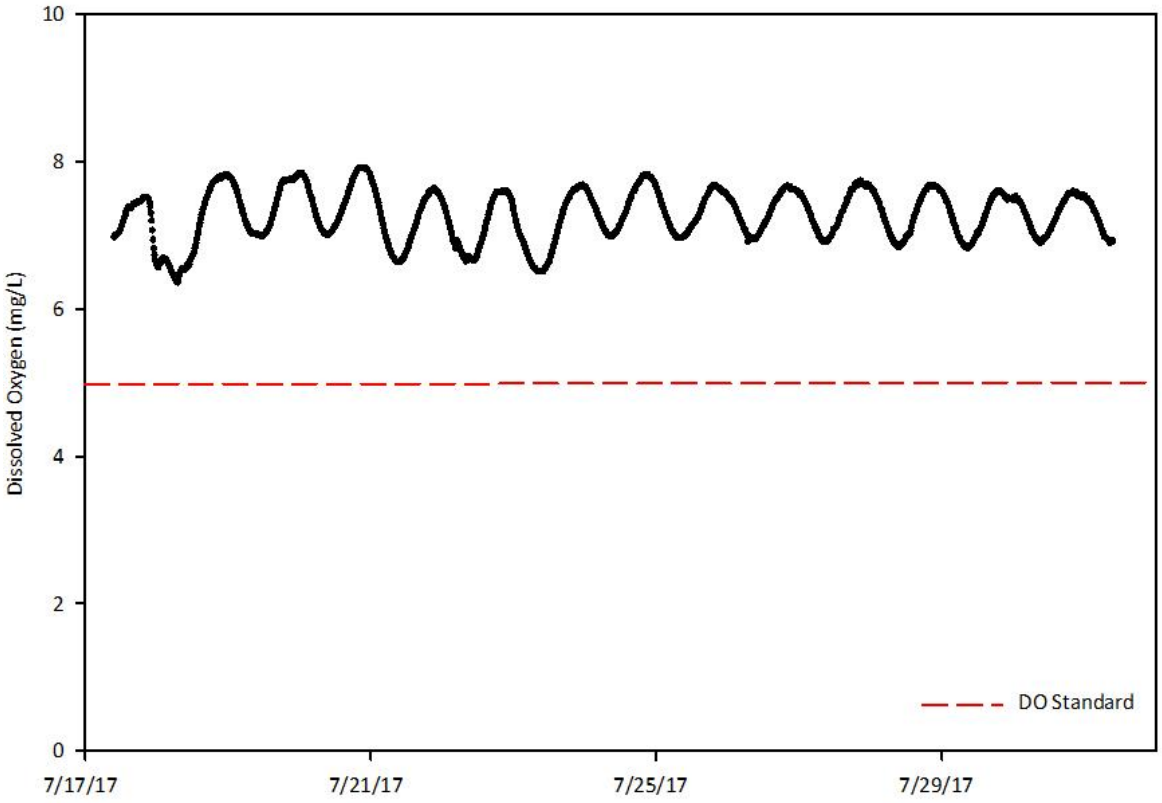
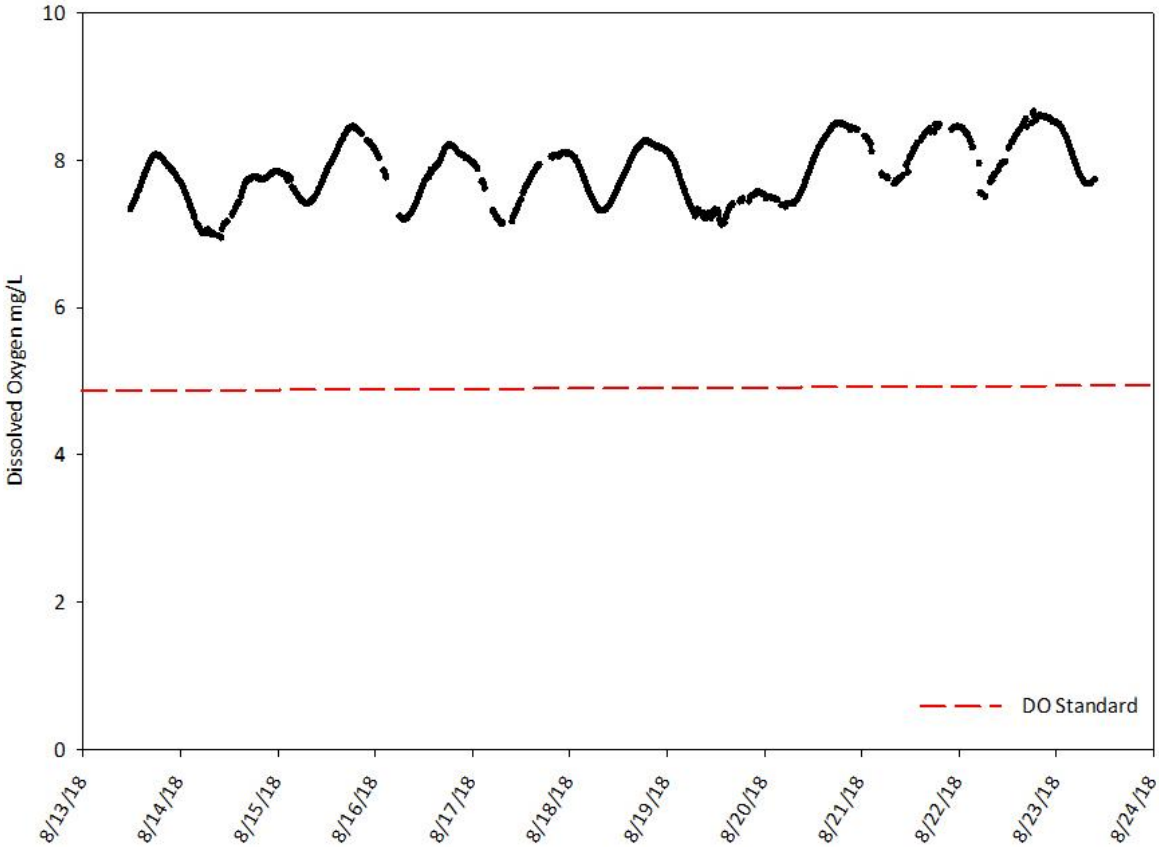


Figure 57. Continuous DO data (August 13-23, 2018) for Site W56105001 along the Otter Tail River (502).



Eutrophication-related data for the Otter Tail River (502) includes the following parameters: TP, Chl-a, and DO flux. The MPCA biological monitoring staff collected a combined five discrete water quality samples at Stations 05RD109 and 10EM060 along the reach at the time of fish and macroinvertebrate monitoring. The samples were analyzed for several parameters, including TP. The stations had TP concentrations ranging from 34 to 110 µg/L; one value exceeded the 100 µg/L Central River Nutrient Region TP standard. Discrete TP data are also available for Sites S000-006 (1958-2010; *n*=358), S000-555 (2001-2003; *n*=26), and S002-000 (2001-2018; *n*=417). Collectively, the mean TP concentration for the sites was 121 µg/L, while the highest concentration was 570 µg/L and the lowest concentration was 16 µg/L. Approximately 49% of the values exceeded the TP standard. Discrete Chl-a data are also available for Sites S000-006 (2000-2010; *n*=25), S000-555 (2001-2003; *n*=29), and S002-000 (2001-2018; *n*=63). The mean Chl-a concentration for the site was 11 µg/L, while the highest concentration was 46 µg/L and the lowest concentration was 1 µg/L. Approximately 12% of the values exceeded the 18 µg/L Central River Nutrient Region Chl-a standard. The mean daily DO flux documented during continuous DO monitoring at Site W56105001 was 0.9 and 1.0 mg/L, respectively; the values were well below the 3.5 mg/L Central River Nutrient Region standard. While the Otter Tail River (502) is prone to high TP and Chl-a concentrations, additional response variable data are needed to determine if eutrophication is adversely affecting the DO regime.

Biological response: Fish

Frequent or extended periods of low dissolved oxygen can alter a fish community by limiting the abundance of species that are intolerant of such conditions (Davis, 1975, EPA, 2012a). Table 53 shows the low DO-related metric scores for the fish community of the Otter Tail River (502). The stations did not meet the statewide mean for either metric; however, the scores were within the confidence interval. Additionally, the available discrete and continuous data suggest that the reach has a stable DO regime. The multiple lines of evidence are ***inconclusive*** as to whether low dissolved oxygen is a stressor to the fish community of the Otter Tail River (502).

Table 53. Summary of low dissolved oxygen-related biological metric data for Stations 05RD109, 10EM060, and 16RD001 along the Otter Tail River (502), as well as statewide stations that support a healthy fish community.

Metric	Description (expected response to stressor)	Statewide score[1] (mean ± SD)	Station (score)	Station Score (mean ± SD)	*Station (2005 score[2])*
DO TIV	Mean DO (mg/L) tolerance indicator value (↑)	8 ± 0	10EM060[11] (6) 10EM060[15] (8) 16RD001[10] (8) 16RD001[17] (7)	7 ± 1	*05RD109 (7)*
CondProb	Probability of meeting the dissolved oxygen standard (↓)	90 ± 7	10EM060[11] (8) 10EM060[15] (92) 16RD001[10] (74) 16RD001[17] (69)	61 ± 37	*05RD109 (87)*

[1] Statewide score included stations that provided General Use habitat within the same IBI class and met or exceeded the applicable IBI threshold.

[2] 2005 data were not used for the purposes of assessment; data were outside of 10-year assessment window.

[11] Sampled on September 22, 2011; [15] sampled on August 12, 2015; [10] sampled on August 18, 2010; [17] sampled on August 29, 2017.

Good: Score for the biologically impaired reach met or was equal to the statewide mean.

Fair: Score for the biologically impaired reach did not meet the statewide mean but was within the confidence interval.

Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside the confidence interval.

Summary of stressors

The evidence suggests that the F-IBI impairment associated with the Otter Tail River (502) is attributed to insufficient physical habitat and high suspended sediment. The reach is located at the bottom of the Glacial Lake Agassiz Lake Plain, which often naturally limits the amount of coarse substrate and cover present. Watercourses in the lake plain region also tend to have higher concentrations of TSS due to the prevalence of fine lacustrine sediment. The Breckenridge Lake Dam and upstream channelization have altered the sediment regime of the reach and contributed to channel instability. The implementation of the aforementioned restoration plan for the Otter Tail River (504) would decrease sediment loading to the reach.

Section 4: Conclusions and recommendations

4.1 Conclusions

Table 1 presents a summary of the stressors associated with the biologically impaired reaches in the OTRW. Connectivity barriers are adversely affecting fish passage along the Toad River (526), Pelican River (767), and Judicial Ditch 2 (764). The Pelican River Dam, which is a complete barrier to fish passage, is severely limiting the fish community of the Pelican River (767). Restoration of a healthy fish community along this reach will be difficult, if not impossible, without the removal or modification of this dam. Most of the reaches have a relatively stable flow regime. The exception is Judicial Ditch 2, which is prone to high and quick peak flows, as well as prolonged periods of low or no discharge. Many of the reaches have instream habitat that is either naturally limited (e.g., lack of coarse substrate) or has been degraded (e.g., loss of facets) due to alterations of the natural hydrology of the landscape. High suspended sediment is a stressor for nearly all of the reaches. Bank instability and soil erosion are the primary sources of this sediment. Lastly, low DO is a stressor for the Pelican River (772 and 767) and Judicial Ditch 2, particularly in the summer months, when flow is low and the water temperature is high.

Table 54. Summary of the stressors associated with the biologically impaired reaches in the OTRW.

Reach name (AUID suffix)	Biological impairment(s)	Candidate causes[1]				
		Loss of longitudinal connectivity	Flow regime instability	Insufficient physical habitat	High suspended sediment	Low dissolved oxygen
Toad River (526)	F-IBI	++	0	+++	+	-
Pelican River (772)	F-IBI	0	+	+	+	++
	M-IBI	ND	+	0	+	+
Pelican River (767)	F-IBI	+++	0	+	0	+
Judicial Ditch 2 (764)	F-IBI	++	++	++	+	+
Otter Tail River (504)	M-IBI	ND	0	0	+	-
Otter Tail River (502)	F-IBI	-	0	+	+	0

[1] **Key: +++** the multiple lines of evidence ***convincingly support*** the case for the candidate cause as a stressor, **++** the multiple lines of evidence ***strongly support*** the case for the candidate cause as a stressor, **+** the multiple lines of evidence ***somewhat support*** the case for the candidate cause as a stressor, **–** the multiple lines of evidence ***refute*** the case for the candidate cause as a stressor, **0** the multiple lines of evidence are **inconclusive** as to whether the candidate cause is a stressor, and **ND *no biological response data*** is available for analysis of the candidate cause as a stressor.

4.2 Recommendations

The recommended actions listed below, as well as included in *The Aquatic Biota Stressor and Best Management Practice Selection Guide* (MPCA, 2016), will help to reduce the influence of or better understand the stressors that are limiting the fish and macroinvertebrate communities of the OTRW.

Loss of longitudinal connectivity

- Remove/modify barriers (e.g., dams and culverts) that are impeding fish passage.
- Evaluate the potential impact of culverts as velocity barriers to fish passage.

Flow regime instability

- Increase runoff detention/retention efforts to attenuate peak flows and augment baseflows.
- Mitigate activities that will further alter the hydrology of the watershed.

Insufficient physical habitat

- Increase runoff detention/retention efforts to attenuate peak flows and augment baseflows.
- Establish and/or protect riparian corridors along all waterways, including ditches, using native vegetation whenever possible.
- Reduce soil erosion through the strategic implementation of BMPs.
- Incorporate the principles of natural channel design into stream restoration and ditch maintenance activities.

High suspended sediment

- Increase runoff detention/retention efforts to attenuate peak flows and augment baseflows.
- Establish and/or protect riparian corridors along all waterways, including ditches, using native vegetation whenever possible.
- Reduce soil erosion through the strategic implementation of BMPs.
- Incorporate the principles of natural channel design into stream restoration and ditch maintenance activities.

Low dissolved oxygen

- Increase runoff detention/retention efforts to attenuate peak flows and augment baseflows.
- Reduce soil erosion through the strategic implementation of BMPs.
- Improve agricultural nutrient management.
- Collect additional eutrophication-related data (i.e., TP, Chl-a, and DO flux) for each of the reaches to better understand the relationship, if any, to low DO.

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