Stressor Identification Update

Thief River Watershed

November 2025

Introduction

Stressor identification (SID) is a formal and rigorous process for identifying the pollutant and nonpollutant causes, or “stressors”, that are likely contributing to the impairment of aquatic ecosystems. The Minnesota Pollution Control Agency (MPCA) conducts SID on fish and macroinvertebrate bioassessment impairments as a key component of the major watershed restoration and protection projects being carried out under Minnesota’s Clean Water Legacy Act. Once completed, the findings from SID are used to support the development of Watershed Restoration and Protection Strategy (WRAPS) and Total Maximum Daily Load (TMDL) reports, which help inform local water planning efforts to address impaired conditions.

The findings provided in this update are from the evaluation of bioassessment impairments associated with watercourses in the Thief River Watershed (TRW) that were part of Cycle 2 SID. A total of 12 bioassessment impairments associated with 9 watercourse reaches in the watershed were evaluated during Cycle 2 SID. Candidate causes investigated as stressors included: a loss of longitudinal connectivity, flow regime instability, insufficient physical habitat, high total suspended solids (TSS), low dissolved oxygen (DO), and high nitrate-nitrogen. Table 1 provides a summary of the stressors associated with each of the bioassessment impaired reaches; the location of these reaches is shown in Figure 1. Data and information specific to each of the bioassessment impairments, including stressor analysis, are provided on the MPCA’s TRW webpage. The following subparts summarize the Cycle 2 SID findings for the watershed.

Loss of Longitudinal Connectivity

Connectivity in aquatic ecosystems refers to how water bodies and waterways are linked to each other on the landscape and how matter, energy, and organisms move throughout the system (Pringle, 2003). Dams and other water control structures on river systems alter hydrologic (longitudinal) connectivity, often obstructing the movement of migratory fish and causing a change in the population and community structure (Brooker, 1981; Tiemann et al., 2004).

Findings

- Loss of longitudinal connectivity was found to be a stressor to all the reaches with a fish bioassessment impairment (Table 1). These reaches had a low abundance of late-maturing, nontolerant taxa.
- Dams limit fish passage throughout the watershed. The Thief River Falls Dam, located just downstream of the Thief River outlet, completely obstructs connectivity with the downstream segment of the Red Lake River, as well as the Red River of the North. Additionally, there are

several dams within the watershed that contribute to the fish bioassessment impairments. These dams are associated with impoundments that are managed for flood damage reduction and/or waterfowl and other wildlife. The highest concentration of these dams is found within the Agassiz National Wildlife Refuge.

Table 1. Summary of the stressors associated with the bioassessment impairments in the TRW that were evaluated during Cycle 2 SID.

Reach Name (AUID)	Reach Extent	Bioassessment Impairment[1]	Candidate Cause[2]					
			Loss of Longitudinal Connectivity	Flow Regime Instability	Insufficient Physical Habitat	High Total Suspended Solids	Low Dissolved Oxygen	High Nitrate-Nitrogen
Thief River (09020304-501)	Agassiz Pool to Red Lake River	F-IBI[N]	+	+++	++	+++	0	-
		M-IBI[N]	NA	+++	+	+	0	-
Thief River (09020304-504)	Thief Lake to Agassiz Pool	F-IBI[E]	++	+++	++	+++	++	-
Unnamed Ditch (09020304-511)	Unnamed Ditch to Unnamed Ditch	F-IBI[E]	+	++	++	-	++	-
		M-IBI[E]	NA	++	+	-	++	-
County Ditch 20 (09020304-519)	County Ditch 30 (Br A) to County Ditch 20 (Br D)	F-IBI[N]	+	++	++	-	0	-
Judicial Ditch 11, Branch 200 (09020304-534)	Unnamed Ditch to Coordinates -95.84, 48.27	M-IBI[N]	NA	++	++	-	++	INSUF
County Ditch 20 (09020304-548)	Unnamed Ditch to Unnamed Ditch	F-IBI[E]	+	++	+	0	0	-
Moose River (09020304-565)	Headwaters to T157N, R38W, S1, West Line	F-IBI[E]	++	+++	++	-	++	-
Mud River (09020304-568)	Coordinates -95.69, 48.32 to Judicial Ditch 11	F-IBI[E]	++	++	++	++	++	-

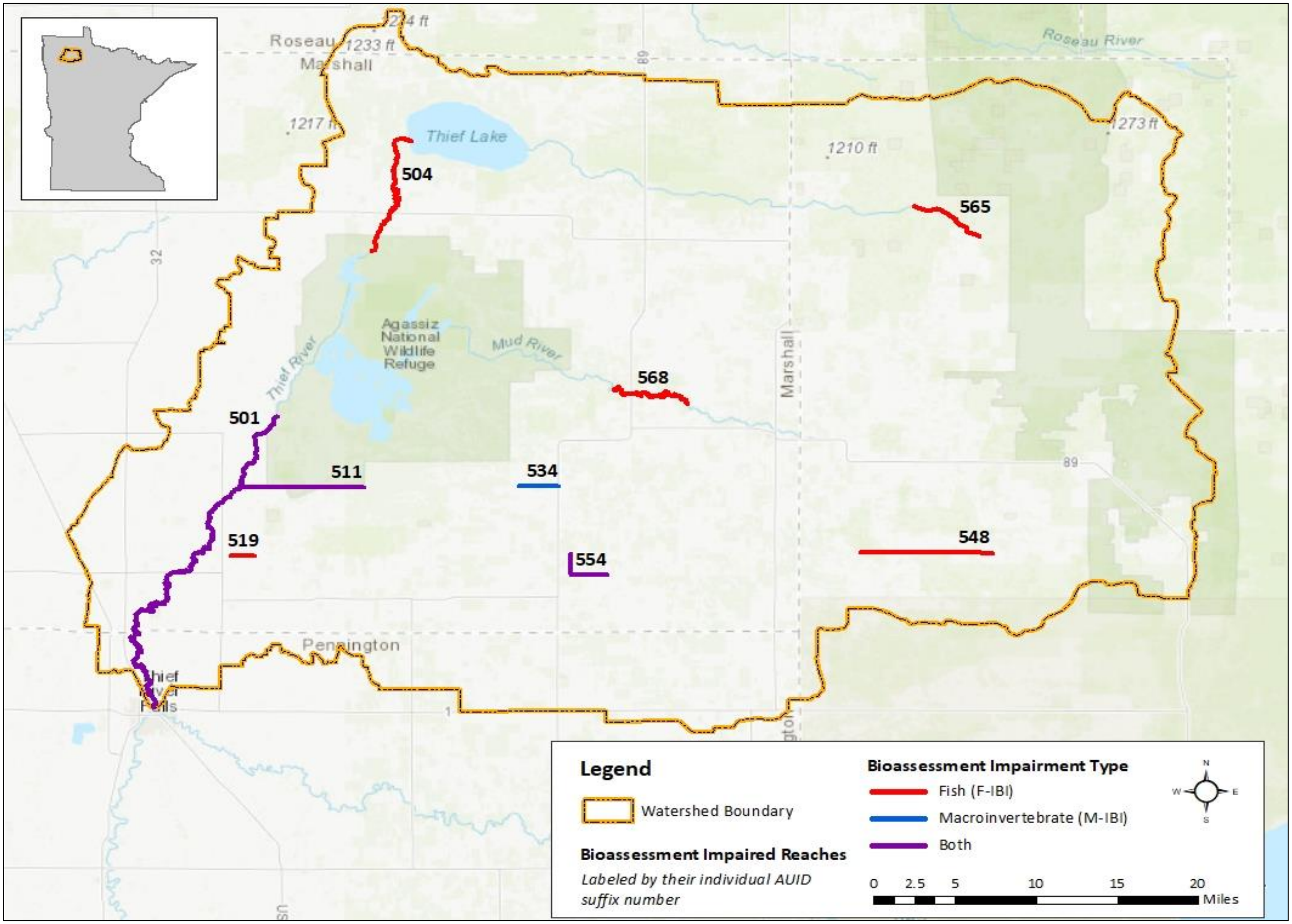
[1] Aquatic life impairment for fish bioassessment (F-IBI) and/or benthic macroinvertebrate bioassessment (M-IBI).

[2] **Weight of Evidence:** +++ 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; **0** the multiple lines of evidence ***neither support nor refute*** the case for the candidate cause as a stressor; **–** the multiple lines of evidence ***refute*** the case for the candidate cause as a stressor; **INSUF** there is ***insufficient information*** to evaluate the candidate cause as a stressor; and **NA** the candidate cause is ***not applicable*** as a stressor due to type of bioassessment impairment or the use classification of the reach.

[E] Existing (Cycle 1 Intensive Watershed Monitoring) bioassessment impairment included on the 2020 Impaired Waters List.

[N] New (Cycle 2 Intensive Watershed Monitoring) bioassessment impairment to be included on the 2026 Impaired Waters List.

Figure 1. Map of the TRW and associated bioassessment impairments.



Flow Regime Instability

Flow is considered a “master variable” that affects many fundamental characteristics of stream ecosystems, including biodiversity (Power et al., 1995; Poff et al., 1997). Drainage-related practices (e.g., ditching, channelization, and subsurface tiling) are known to cause increased and quicker peak discharges following rain events and reduced base flows during dry periods (Franke and McClymonds, 1972; Mitsch and Gosselink, 2007). These effects are further exacerbated by changes in precipitation. This “flashiness” or instability in the flow regime tends to limit species diversity and favor taxa that are tolerant to disturbances (Bunn and Arthington, 2002; Bragg et al., 2005; Poff and Zimmerman, 2010).

Findings

- According to Table 1, flow regime instability was found to be a stressor for all the impaired reaches, limiting biotic diversity and favoring fish and macroinvertebrate taxa that are generalist, early maturing, pioneering, short-lived, and tolerant to disturbances.
- Reaches affected by flow regime instability often experience high peak flows following the spring melt and large rain events and/or insufficient baseflow during the late summer and fall.
- Figure 2 provides examples of extremes in flow conditions that are common in the watershed. The flow regime of the Thief River (AUIDs 09020304-501 and 09020304-504), Unnamed Ditch (AUID 09020304-511), Moose River (AUID 09020304-565), and Mud River (AUID 09020304-568) are directly influenced by the operation of one or more impoundments upstream.
- All the impaired reaches have an associated subwatershed with a high proportion (>70%) of physically altered (i.e., channelized, ditched, or impounded) watercourses.
- Mean annual precipitation in the TRW increased at a rate of 0.06 inches/decade between 1895 and 2025 (DNR, 2025). Additionally, the frequency of “mega-rain” events (6 inches of rain covering more than 1,000 square miles in 24 hours or less, with at least 8 inches falling somewhere in that area) has increased statewide since 2000 (DNR, 2024).

Figure 2. Images of extremes in flow conditions on County Ditch 32 (AUID 09020304-554) at 230th St NE, including high flow conditions on July 9, 2024 (left), and no flow/stagnant conditions on October 18, 2024 (right).

- The USGS has monitored flow on the Thief River (AUID 09020304-501) near Thief River Falls (Station 05076000; near 140th Ave NE) since 1909. The highest flow logged at the site was 5580 cfs. Over the period of 1993 to 2024, the mean annual flow for the site increased to 334 cfs, which is nearly 58% higher than the mean value for the entire period of record (212 cfs). The four highest mean annual flow values for the site have occurred since 1993. Additionally, the frequency of bankfull flows has increased substantially since 1993, with 11% of mean daily flows exceeding the bankfull discharge value of 1006 cfs, as estimated by the DNR (2015). Low flows have also been common at the site, with 20% of values being less than or equal to 0.2 cfs over the record. However, the occurrence of such low flow values has decreased substantially in recent decades, corresponding to the increase in mean annual flow values.

Insufficient Physical Habitat

Physical habitat is primarily a function of channel geomorphology (Rosgen, 1996) and flow (Bovee, 1986). Geomorphology is determined naturally by geology and climate (Leopold et al., 1994) but may be altered directly by channelization and indirectly by land use changes affecting runoff and the removal of riparian vegetation (Aadland et al., 2005). A high frequency of bank-full flows often results in a subsequent increase in channel cross-sectional area (Verry, 2000) and a decrease in sinuosity (Verry and Dolloff, 2000). These geomorphic changes can result in reduced habitat quality and diversity, loss of interstitial space due to embeddedness, loss of pool depth due to sedimentation, and loss of cover (Aadland et al., 2005). Biotic population changes can result from decreases in availability or quality of habitat by way of altered behavior, increased mortality, or decreased reproductive success (EPA, 2012).

Findings

- All the bioassessment impaired reaches are affected by insufficient physical habitat as a stressor (Table 1).
- Nearly all the MPCA Stream Habitat Assessment (MSHA) scores for the impaired reaches were rated as “poor” or “fair”. Only Station 11RD031, which is located along a natural segment of the Thief River (AUID 09020304-501), had a MSHA score that was that was characterized as “good”.
- Common habitat deficiencies noted in the watershed included: bank erosion, minimal shading, narrow riparian zone width, absence of riffle habitat, limited coarse substrate, embeddedness of coarse substrate, limited cover types (e.g., boulders, deep pools, and undercut banks), limited velocity types, and poor channel development.
- All the bioassessment impaired reaches had a channel that was either highly (>50%) or entirely altered (i.e., channelized, ditched, or impounded), as well as a subwatershed with a high proportion (>70%) of altered watercourses.
- Reaches with insufficient physical habitat generally had a low abundance of riffle dwelling, simple lithophilic spawning, and benthic insectivorous fish taxa, while the macroinvertebrate communities commonly had a low abundance of clinger taxa and contained a high percentage of

burrower, legless, and sprawler taxa. These community compositions often indicate that critical habitat facets (e.g., coarse substrate and riffles) have been degraded or are naturally lacking.

High Total Suspended Solids

TSS is a measurement of the weight of suspended mineral (e.g., soil particles) or organic (e.g., algae) sediment per volume of water. Soil erosion from agricultural fields is commonly the largest source of sediment to streams in the Red River Basin (Lauer et al., 2006). According to Waters (1995), high TSS can cause harm to fish and macroinvertebrates through two major pathways: 1) direct, physical effects (e.g., abrasion of gills) and 2) indirect effects (e.g., increase in sediment oxygen demand). High TSS can also reduce the penetration of sunlight and thus impede photosynthetic activity and limit primary production (Munavar et al., 1991; Murphy et al., 1981).

Findings

- As identified in Table 1, high TSS was found to be a stressor for the Thief River (AUIDs 09020304-501 and 09020304-504), as well as the Mud River (AUID 09020304-568).
- Each of the reaches affected by high TSS had at least one monitoring site with a TSS standard (30 mg/L) exceedance rate of 7% or greater (minimum of 20 samples), along with a maximum TSS concentration greater than 200 mg/L.
- The Thief River (AUID 09020304-501) was listed as impaired for aquatic life use due to high turbidity levels on the 2006 Impaired Waters List. In 2019, the EPA approved a TSS TMDL to address this impairment. According to the *Thief River Watershed Total Maximum Daily Load Report* (MPCA, 2019), stream bank erosion, overland erosion from agricultural fields, and the flushing of sediment from Agassiz Pool within the Agassiz National Wildlife Refuge are substantial sources of sediment to this reach of the Thief River.
- The Thief River (AUID 09020304-504) will be listed as impaired for aquatic life use due to TSS levels on the 2026 Impaired Waters List.
- According to the biological indices, the reaches affected by high TSS had high mean TSS tolerance indicator values and low conditional probabilities of meeting the TSS standard.

Low Dissolved Oxygen

DO refers to the concentration of oxygen gas within the water column. Oxygen diffuses into water from the atmosphere (turbulent flow enhances this diffusion) and from aquatic plants during photosynthesis. The concentration of DO changes seasonally and daily in response to shifts in ambient air and water temperature, along with various chemical, physical, and biological processes within the water column. Low or highly fluctuating DO concentrations can cause adverse effects (e.g., avoidance behavior, reduced growth rate, and fatality) for many fish and macroinvertebrate species (Allan, 1995; Davis, 1975; Marcy, 2007; Nebeker et al., 1992; EPA, 2012). The critical conditions for DO usually occur during the late summer, when the water temperature is high and stream flow is low. Additionally, eutrophication (i.e., increased phosphorus) can cause excessive aquatic plant and algal growth, which can ultimately result in a decline in daily minimum DO concentrations and an increase in the magnitude of daily DO concentration fluctuations.

Findings

- According to Table 1, low DO was noted to be a stressor for the Thief River (AUID 09020304-504), Unnamed Ditch (AUID 09020304-511), Judicial Ditch 11, Branch 200 (AUID 09020304-534), Moose River (AUID 09020304-565), and Mud River (AUID 09020304-568).
- Continuous DO monitoring was performed on each of the low DO affected reaches by the MPCA and/or Red Lake Watershed District (RLWD) between 2019 and 2023. Monitoring was conducted for a period of at least seven consecutive days, generally during the months of July and August, when the water temperature is often the highest; there is an inverse relationship between temperature and DO. Each of the reaches had at least one monitoring period in which 10% or more of the recorded values were below the 5.0 mg/L DO standard.
- The following bioassessment impaired reaches have an existing or new DO impairment on the Impaired Waters List without an EPA-approved TMDL study: Thief River (AUID 09020304-504), Unnamed Ditch (AUID 09020304-511), and Judicial Ditch 11, Branch 200 (AUID 09020304-534), and Mud River (AUID 09020304-568). Additionally, the Thief River (AUID 09020304-501) had a DO impairment on the 2006 Impaired Waters List; however, this impairment was delisted in 2018 due to improved DO conditions.
- County Ditch 32 (AUID 09020304-554) had a limited amount of DO data. Additional DO monitoring is needed to investigate the effects of low DO on the fish and macroinvertebrate communities of this reach.
- Impoundments can be a source of low DO water (EPA, 2012). In August 2024, the RLWD staff documented low DO concentrations along Unnamed Ditch (AUID 09020304-511) caused by a drawdown of the Farmes Pool Impoundment within the Agassiz National Wildlife Refuge. Other bioassessment impaired reaches are located downstream of an impoundment include the Thief River (AUIDs 09020304-501 and 09020304-504), Moose River (AUID 09020304-565), and Mud River (AUID 09020304-568).
- Eutrophication appeared to adversely impact the DO regime of the Thief River (AUID 09020304-504), Unnamed Ditch (AUID 09020304-511), Judicial Ditch 11, Branch 200 (AUID 09020304-534), and Mud River AUID 09020304-568). Figure 3 provides examples of eutrophication documented in the watershed. Eutrophication commonly causes wide fluctuations between daily minimum and maximum DO concentrations (Figure 4). The effects of eutrophication are often exacerbated by low flow conditions.
- Total phosphorus (TP) is a causative variable for eutrophication. The following bioassessment impaired reaches had at least one monitoring site with a TP standard exceedance rate of greater than 10% (minimum of 12 samples): Thief River (AUIDs 09020304-501 and 09020304-504), Unnamed Ditch (AUID 09020304-511), County Ditch 20 (AUID 09020304-519), Moose River (AUID 09020304-565), and Mud River (AUID 09020304-568). The Thief River (AUID 09020304-

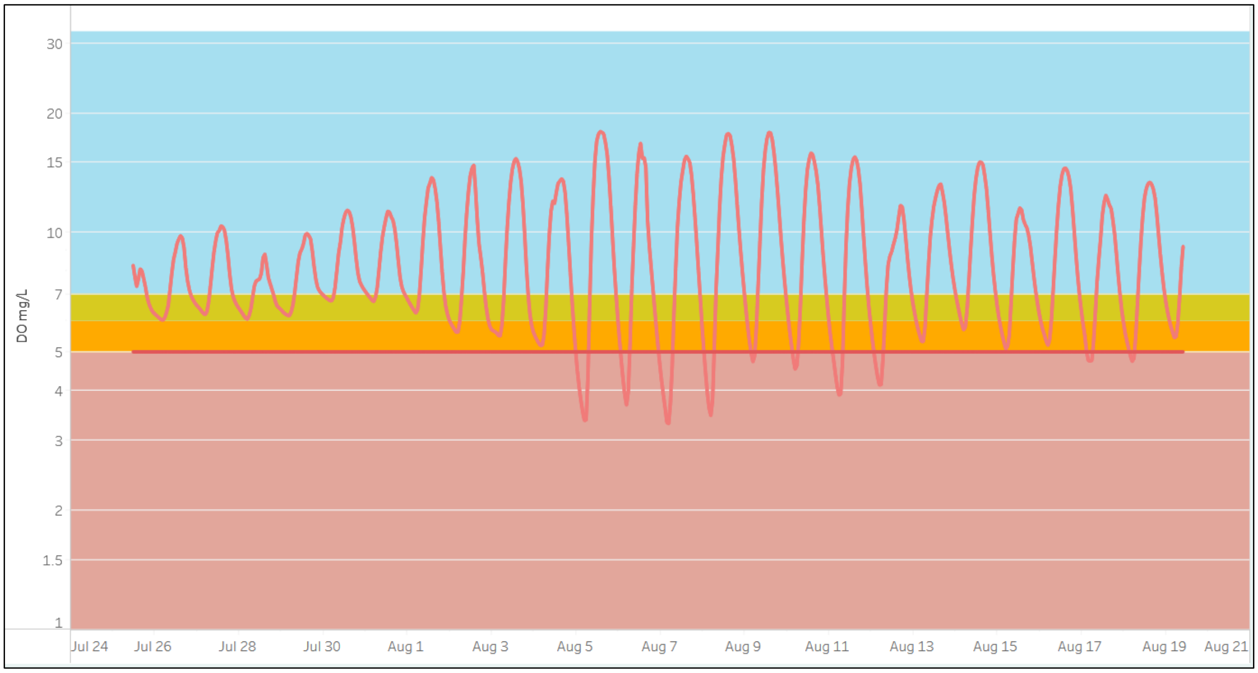
501) had the highest maximum TP concentration (8390 µg/L). High TP concentrations are not only a concern for the bioassessment impaired reaches in the watershed, but also Lake Winnipeg, which is located downstream and is adversely affected by algae blooms (MPCA, 2025).

- Response indicators of eutrophication include chlorophyll-*a* (chl-*a*) and DO flux. Only the Moose River (AUID 09020304-565) and Mud River (AUID 09020304-568) had at least one monitoring site with a chl-*a* standard exceedance rate of greater than 10% (minimum of 12 samples). The DO flux data for the reaches were derived from the continuous DO monitoring. The following bioassessment impaired reaches had least one monitoring period in which the mean daily DO flux exceeded the DO flux standard: Thief River (AUID 09020304-504), Unnamed Ditch (AUID 09020304-511), Judicial Ditch 11, Branch 200 (AUID 09020304-534), County Ditch 20 (AUID 09020304-548), Moose River (AUID 09020304-565), and Mud River (AUID 09020304-568).

- Reaches prone to low DO generally had a low conditional probability of meeting the DO standard and/or scored above the statewide average in the abundance of low DO tolerant taxa, as well as below the statewide average in the abundance low DO sensitive taxa.

Figure 3. Images of excessive primary production (i.e., filamentous algae) at Station 22RD005 along Judicial Ditch 11, Branch 200 (AUID 09020304-534) on August 24, 2022 (left) and Station 20EM088 along the Mud River (AUID 09020304-568) on June 14, 2021 (right).

Figure 4. Continuous DO data (July 25-August 8, 2019) for Site W65041002 (State Hwy 89 crossing) along the Mud River (AUID 09020304-568). Excessive primary production caused DO supersaturation during the day (maximum concentration of 18.2 mg/L), low DO concentrations at night (minimum concentration of 3.1 mg/L), and high daily DO flux (mean of 8.8 mg/L).



High Nitrate-Nitrogen

Nitrate (NO3) is the most abundant form of nitrogen in aquatic ecosystems. The transport pathways of nitrogen in the environment vary depending on geology and hydrology. When water moves quickly through the soil profile, as in the case of areas that are heavily tiled or dominated by outwash, nitrate transport through leaching can be substantial. Apart from its function as a biological nutrient, some levels of nitrate can become toxic to organisms. Nitrate toxicity can affect fish and macroinvertebrates depending on the concentration, length of exposure, and sensitivity of the individual organism (Grabda et al., 1974; Camargo and Alonso, 2006).

Findings

- High nitrate-nitrogen was not found to be a stressor for any of the bioassessment impaired reaches (Table 1).
- Currently, Minnesota has no aquatic life use standards for nitrate, though the MPCA (2022) has developed proposed nitrate criteria for the protection of aquatic life. The proposed nitrate chronic criteria value is 8.0 mg/L for Class 2B (cool/warm) waters. The Thief River (AUID 09020304-504) and Mud River (AUID 09020304-568) each had one sample value that slightly exceeded the chronic criteria value; the exceedances were 9.1 mg/L and 8.9 mg/L, respectively.
- According to *The Minnesota Nutrient Reduction Strategy* (MPCA, 2025), tile drainage is expected to further expand in the Red River of the North Basin, which could result in higher nitrate

loading to surface waters. In the future, high nitrate-nitrogen may emerge as a stressor in the watershed.

Recommendations

Table 2 provides recommended actions to eliminate or reduce the influence of stressors that are currently limiting or have the potential to limit the fish and macroinvertebrate communities of the watershed. Among the most common stressors identified in the watershed were flow regime instability, insufficient physical habitat, high TSS, and low DO. These stressors are directly influenced by land use activities and changes in hydrology. Additionally, climate-related challenges (e.g., an increase in the frequency and magnitude of large rain events) are expected to continue to exacerbate these stressors. The implementation of best management practices (BMPs) should focus on the detention and retention of water on the landscape, as well as augmenting baseflows. Recently completed and future projects in the watersheds that address water storage and sediment reduction will be critical in addressing the bioassessment impairments.

Table 2. Recommended actions to address stressors in the TRW.

Stressor	Recommended Action
Loss of Longitudinal Connectivity	• When feasible and practicable, remove/modify barriers that are impeding 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 **and** **High Total Suspended Solids**	• Increase runoff detention/retention efforts to attenuate peak flows and augment baseflows. • Establish and/or protect riparian corridors using native vegetation whenever possible. • Reduce soil erosion through the implementation of BMPs, such as side inlet structures and conservation tillage. • Incorporate the principles of natural channel design into stream restoration and ditch maintenance activities. • Integrate the DNR’s Toe Wood-Sod Mat design into streambank restoration and stabilization projects whenever possible.
Low Dissolved Oxygen	• Increase runoff detention/retention efforts to attenuate peak flows and augment baseflows. • Reduce soil erosion through the implementation of BMPs, such as side inlet structures and conservation tillage. • Improve agricultural nutrient management.
High Nitrate-Nitrogen	• Improve agricultural nutrient management. • Manage and treat tile drainage water.

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