Stressor Identification Update

Bois de Sioux River Watershed

March 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 Bois de Sioux River Watershed (BdSRW) that were part of Cycle 2 SID. A total of 13 bioassessment impairments associated with nine 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 impairments in the watershed. Data and information specific to each bioassessment impairment, including stressor analysis, can be provided by contacting the SID staff listed at the end of the update. 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 watercourses 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

- According to Table 1, five of the reaches with a fish bioassessment impairment appeared to be adversely affected by one or more connectivity-related barriers, including culverts, beaver dams, and the White Rock Dam.
- Perched culverts impact fish passage on Unnamed Creek (AUID 09020101-535), Unnamed Creek (AUID 09020101-539), Unnamed Ditch/Grant County Ditch #5 (AUID 09020101-557), and Unnamed Creek (AUID 09020101-566). Three of these reaches are tributaries to Lake Traverse that have experienced erosion around culverts caused by the combination of high flows and steep gradient.

Additionally, undersized culverts can act as a velocity barrier, which is a potential concern for many of the impaired reaches.

- Beaver dams were noted along five reaches with a fish bioassessment impairment. Several of these beaver dams were a partial or complete barrier to fish passage.
- Reaches affected by a loss of longitudinal connectivity generally scored below the statewide average in the abundance of migratory and late-maturing fish taxa.

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

Reach Name (AUID)	**Reach Extent**	**Bioassessments 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**
Bois de Sioux River (09020101-501)	Rabbit River to Otter Tail River	M-IBI[N]	NA	+++	+++	+++	+++	-
Bois de Sioux River (09020101-503)	Mud Lake to Rabbit River	F-IBI[N]	+	++	++	++	+++	-
		M-IBI[N]	NA	+++	++	0	+++	-
Rabbit River, South Fork (09020101-512)	Wilkin County line to Rabbit River	M-IBI[N]	NA	+++	++	+	+++	-
Unnamed Creek (09020101-535)	Unnamed Creek to Lake Traverse	M-IBI[N]	NA	+	+	INSUF	0	INSUF
Unnamed Creek (09020101-539)	Unnamed Creek to County Ditch 52	F-IBI[D]	++	++	++	0	0	-
County Ditch 53 (09020101-545)	Judicial Ditch 3 to County Ditch 43	F-IBI[N]	+	+++	+++	INSUF	INSUF	-
		M-IBI[N]	NA	+++	+	INSUF	INSUF	-
Unnamed Ditch/Grant County Ditch #5 (09020101-557)	Unnamed Ditch to Judicial Ditch 2	F-IBI[D]	0	++	++	++	+++	-
Judicial Ditch 2 (09020101-559)	Unnamed Ditch to Unnamed Ditch	F-IBI[D]	+	++	+++	++	++	-
		M-IBI[D]	NA	++	+	++	++	-
Unnamed Creek (09020101-566)	Unnamed Creek to Lake Traverse	F-IBI[N]	+	++	++	INSUF	-	-
		M-IBI[N]	NA	+	+	INSUF	-	-

[1] Aquatic life impairment for fish bioassessment (F-IBI) 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.

[D] Deferred (Cycle 1 Intensive Watershed Monitoring) bioassessment impairment added to the 2020 Impaired Waters List.

[N] New (Cycle 2 Intensive Watershed Monitoring) bioassessment impairment added to the 2024 Impaired Waters List.

Flow Regime Instability

Flow is considered a “master variable” that affects many fundamental characteristics of stream ecosystems, including biodiversity (Bunn and Arthington, 2002; Hart and Finelli, 1999; Poff et al., 1997; Power et al., 1995). According to Poff and Zimmerman (2010), the flow regime of a stream is largely a function of climate and runoff-related controls. A characteristic trend of streams in the Red River of the North basin is the high frequency of intermittent flow due to natural (i.e., evapotranspiration exceeding precipitation) and anthropogenic (i.e., changes in land cover and drainage) factors (EOR, 2009). Headwater streams (<200 sq mi drainage area) in the basin commonly have an intermittent flow regime (EOR, 2009). The natural flow regime of most watercourses in the basin has been anthropogenically altered by changes in land cover and drainage for agricultural purposes. Drainage practices, including ditching, channelization of natural streams, modification/cultivation of headwater streams, subsurface tiling, and wetland drainage, can cause increased and quicker peak discharges following rain events and reduced base flows during dry periods (EOR, 2009; Miller, 1999; Mitsch and Gosselink, 2007; Moore and Larson, 1979; Verry, 1988). These effects are further exacerbated by climate-related challenges, including an increase in the frequency and magnitude of large rain events and droughts. Collectively, the “flashiness” or instability in stream flow 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

- As identified in Table 1, flow regime instability was found to be a stressor for all the bioassessment impaired reaches.
- Reaches affected by flow regime instability often experience high and rapid peak flows following the spring snow melt and large rain events, as well as extended periods of minimal to no baseflow during the late summer when precipitation and runoff are generally low. Figure 1 provides examples of extremes in flow conditions that are common among the impaired reaches.
- Except for Unnamed Creek (AUID 09020101-566), all the bioassessment impaired reaches have an associated subwatershed with a high proportion (>50%) of physically altered watercourses (i.e., channelized, ditched, or impounded).
- Mean annual precipitation in the BdSRW increased at a rate of 0.14 inches/decade between 1895 and 2025 (DNR, 2025). Additionally, the frequency of “mega-rain” events (six inches of rain covering more than 1,000 square miles in 24 hours or less, with at least eight inches falling somewhere in that area) has increased statewide since 2000 (DNR, 2024).
- The USGS has monitored flow on the Bois de Sioux River (AUID 09020101-503) at the outlet of White Rock Dam since 1942; the discharge from the dam is controlled by the U.S. Army Corps of Engineers. Over the period of 1993 to 2022, the mean annual flow for the site has increased to 283 cfs, which is nearly double that of the mean annual flow value (154 cfs) for the entire period of record. Additionally, the 12 highest mean annual flow values for the site have occurred since 1993.

- Flow regime instability was found to limit biotic diversity and favor fish and macroinvertebrate taxa that are generalist, early maturing, pioneering, short-lived, and tolerant to disturbances.

Figure 1. Images of extremes in flow conditions in the BdSRW, including high flow conditions on the Bois de Sioux River (AUID 09020101-503) downstream of White Rock Dam on April 25, 2023, and low flow conditions on Judicial Ditch 2 (AUID 09020101-559) near State Hwy 55 on July 21, 2021.

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).
- Seven of the reaches had at least one MPCA Stream Habitat Assessment (MSHA) score that was characterized as “poor” (≤44/100). None of the MSHA scores for the impaired reaches was characterized as “good” (≥67/100).
- Common habitat deficiencies noted for the bioassessment impaired reaches included: bank erosion, minimal shading, 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, poor channel stability, and poor channel development. These deficiencies can be

attributed to a combination of natural (e.g., surficial geology) and anthropogenic (e.g., channel alteration) factors.

- Five of the bioassessment impaired reaches had a channel that was mostly (>50%) altered, along with a subwatershed with mostly (>50%) 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. Instream and soil erosion are commonly the largest sources of sediment to streams in the Red River of the North basin (EOR, 2009; 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 five of the bioassessment impaired reaches. This stressor was most pronounced for the downstream segment of the Bois de Sioux River (AUID 09020101-501), which had a TSS standard (65 mg/L) exceedance rate of 41% at Site S000-553 (CSAH 6 crossing).
- The Bois de Sioux River (AUID 09020101-503) and Judicial Ditch 2 (AUID 09020101-559) each have an existing TSS impairment on the Impaired Waters List. Additionally, the Bois de Sioux River (AUID 09020101-501) and Rabbit River, South Fork (AUID 09020101-512) have an existing impairment for turbidity, which is often strongly correlated to TSS. A TMDL for the turbidity impairment associated with the Bois de Sioux River reach was completed in 2020. The MPCA will further evaluate the need for a TMDL to address the remaining TSS and turbidity impairments in the future.
- The amount of discrete TSS data was limited for Unnamed Creek (AUID 09020101-535), County Ditch 53 (AUID 09020101-545), and Unnamed Creek (AUID 09020101-566). Six or less discrete TSS samples were available for these reaches. Additional TSS data is needed to evaluate whether high TSS is a stressor to the fish and/or macroinvertebrate communities of these reaches.
- Generally, there is a direct relationship between TSS concentrations and flow in the watershed. High TSS is common during the spring snowmelt, when agricultural fields are particularly vulnerable to erosion, as well as following larger rain events during other seasons.

- Reaches affected by high TSS generally had a high mean TSS tolerance indicator value and a low abundance of high TSS intolerant taxa.

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

- Low DO was a stressor for five of the bioassessment impaired reaches (Table 1). This stressor was very pronounced for the Bois de Sioux River (AUID 09020101-501), Bois de Sioux River (AUID 09020101-503), Rabbit River, South Fork (AUID 09020101-512), and Unnamed Ditch/Grant County Ditch #5 (AUID 09020101-557).
- Three of the bioassessment impaired reaches also have an existing DO impairment on the Impaired Waters List, including the Bois de Sioux River (AUID 09020101-501), Unnamed Ditch/Grant County Ditch #5 (AUID 09020101-557), and the Rabbit River, South Fork (AUID 09020101-512). A TMDL for the downstream segment of the Bois de Sioux River was completed in 2020. The MPCA will further evaluate the need for a TMDL to address the remaining DO impairments in the future.
- The amount of discrete DO data was limited for County Ditch 53 (AUID 09020101-545), which only had two DO measurements. Additional monitoring is needed to investigate the effects of low DO on the biology of this reach.
- Continuous DO monitoring was performed on seven of the bioassessment impaired reaches between 2020 and 2023. Monitoring was conducted 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 reach was monitored at least once for a minimum period of seven consecutive days. Of the monitored reaches, five had at least one monitoring period in which at least 10% of the recorded values were below the 5.0 mg/L DO standard.
- Eutrophication appeared to adversely impact the DO regime of six of the low DO stressed reaches. The effects of eutrophication, such as high DO flux (Figure 2), were often exacerbated by low flow conditions. Figure 3 displays images of eutrophication documented in the watershed.

- Total phosphorus (TP) is a causative variable for eutrophication. All the low DO affected reaches had at least one monitoring site with a TP standard (150 µg/L) exceedance rate of greater than 50% (minimum of 14 TP values).
- Response indicators of eutrophication include chlorophyll-*a* (chl-*a*) and DO flux. Four of the low DO stressed reaches had at least one monitoring site with a chl-*a* standard (40 µg/L) exceedance rate of greater than 40% (minimum of five samples). The DO flux data for the reaches were derived from the continuous DO monitoring. Three of the reaches had least one monitoring period in which the mean daily DO flux exceeded the 5.0 mg/L DO flux standard.
- Reaches prone to low DO generally 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 2. Continuous DO data (August 5-12, 2020) for Site W54007001 (State Hwy 55 crossing) along Judicial Ditch 2 (AUID 09020101-559). Excessive primary production caused DO supersaturation during the day (maximum concentration of 16.4 mg/L), low DO concentrations at night (minimum concentration of 0.2 mg/L), and high daily DO flux (mean of 13.7 mg/L).

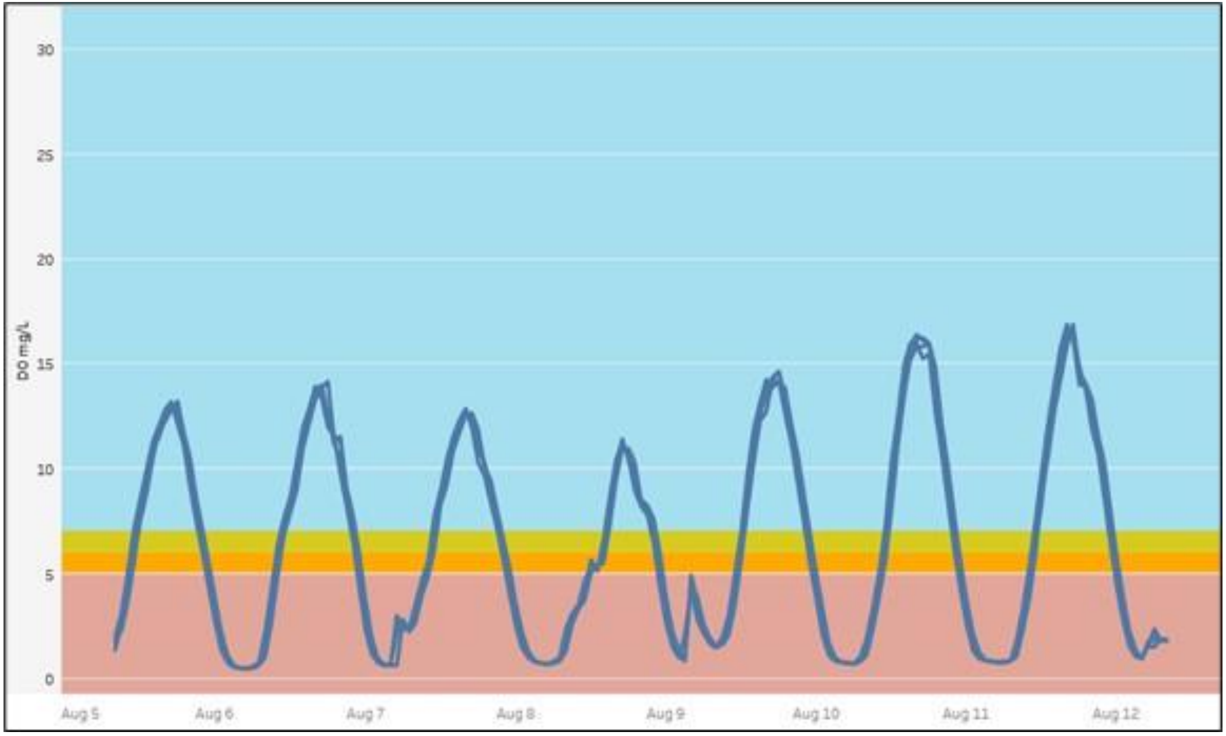

Figure 3. Images of eutrophication-related conditions, including excessive filamentous algae and duckweed at Site S003-274 (State Hwy 55 crossing) along Judicial Ditch 2 (AUID 09020101-559) on September 20, 2023 (left) and sestonic algae in the Van Dorn water sampler at Site S004-176 (490th St crossing) along the Rabbit River, South Fork (AUID 09020101-512) on June 10, 2021.

High Nitrate-Nitrogen

Nitrate (NO3) is the most abundant form of nitrogen in aquatic ecosystems and is a common biotic stressor. 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. Three reaches had at least one sample value that exceeded the chronic criteria value.
- Among the impaired reaches, Judicial Ditch 2 (AUID 09020102-559) had the highest maximum nitrate concentration (14.3 mg/L).
- 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.

- While high nitrate-nitrogen is not a concern for the bioassessment impaired reaches at this time, nitrate monitoring should be continued.

Recommendations

Table 2 provides recommended actions to address the stressors that are limiting the aquatic life of the bioassessment impaired reaches. Among the most common stressors identified for these reaches 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 BMPs should focus on the detention and retention of water on the landscape. Recently completed and future projects in the watershed that address water storage and sediment reduction will be critical in addressing the bioassessment impairments.

Table 2. Recommended actions to address the stressors associated with the bioassessment impairments in the BdSRW that were evaluated during Cycle 2 SID.

Stressor	Recommended Action
Loss of Longitudinal Connectivity	• When feasible and practicable, remove/modify barriers (e.g., dams and culverts) 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 hydrology.
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.
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.

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CLEAN WATER LAND & LEGACY AMENDMENT

MINNESOTA POLLUTION CONTROL AGENCY

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