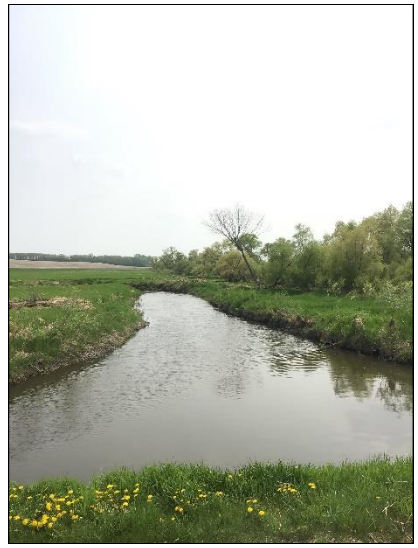
Stressor Identification Update

Sand Hill River Watershed

December 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 Sand Hill River Watershed (SHRW) that were part of Cycle 2 SID. A total of five bioassessment impairments associated with five 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 (NO_3-N). 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 waterbodies 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

- Only one reach with a fish bioassessment impairment appeared to be adversely affected by connectivity-related barriers (Unnamed Creek; AUID 09020301-539); the reach lacked late-maturing fish taxa. Beaver dams (when present), the Bear Park Dam (during high flows), and a private road/field crossing interfere or have the potential to interfere with the longitudinal connectivity of this reach.
- Since the completion of Cycle 1 SID, the Sand Hill River Watershed District (SHRWD) and U.S. Army Corps of Engineers coordinated the replacement of the series of low head dams along the lower end of the Sand Hill River with rock riffles. Fish monitoring conducted by the MPCA has confirmed that the project has successfully restored connectivity to upstream watercourses.

Table 1. Summary of the stressors associated with the bioassessment impairments in the SHRW 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
County Ditch 17 (09020301-515)	Garden Slough to Sand Hill River	M-IBI[E]	NA	+++	++	0	+++	0
County Ditch 6/ SHRWD Project 17 (09020301-518)	Unnamed Creek to Sand Hill River	F-IBI[N]	-	+++	+++	INSUF	INSUF	INSUF
Unnamed Creek (09020301-539)	Unnamed Creek to Sand Hill River	F-IBI[E]	+	+++	++	0	INSUF	0
Sand Hill River (09020301-558)	-95.827, 47.551 to Unnamed Ditch	M-IBI[N]	NA	++	+	0	0	-
Sand Hill River (09020301-559)	Unnamed Ditch to CD 17	M-IBI[N]	NA	++	++	++	+	-

[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.

[E] Existing (Cycle 1 Intensive Watershed Monitoring) bioassessment impairment.

[N] New (Cycle 2 Intensive Watershed Monitoring) bioassessment impairment.

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 mi^2 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 contribute to 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

- According to Table 1, flow regime instability was found to be a stressor for all the impaired reaches. The effects of this stressor were particularly pronounced for County Ditch 17 (AUID 09020301-515), County Ditch 6/SHRWD Project 17 (AUID 09020301-518), and Unnamed Creek (AUID 09020301-539), each of which has an intermittent flow regime (DNR, 2024).
- Reaches affected by flow regime instability often experience insufficient baseflow during the late summer and/or high peak flows following the spring melt and large rain events. Figure 1 provides examples of common low-flow and high-flow conditions along the Sand Hill River (AUID 09020301-559).
- The USGS has monitored flow on the Sand Hill River (AUID 09020301-537) at Climax (Station 05069000; US Hwy 75) since 1947. Over the period of 1993 to 2024, the mean annual flow for the site increased to 134 cfs, which is nearly 40% higher than the mean value for the entire record (96 cfs). Additionally, the five highest mean annual flow values for the site have occurred since 1993. According to the DNR (2023), the SHRW receives 3.4 inches more precipitation per year when compared to the pre-1993 period, which has resulted in an additional 2.0 inches of precipitation per year leaving the watershed as discharge.
- Mean annual precipitation in the SHRW 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).
- All the impaired reaches have an associated subwatershed with a high proportion (>50%) of physically altered watercourses (i.e., channelized, ditched, or impounded).
- 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 flow conditions on the Sand Hill River (AUID 09020301-559) at CR 107, including a mostly dry streambed on August 26, 2021 (left) and spring flooding on April 21, 2022 (right). Such low and high flow conditions are common along the reach due to a combination of natural and anthropogenic factors and tend to limit the diversity of aquatic life and favor taxa that are tolerant of disturbances.

- While flow regime instability is a stressor to the macroinvertebrate community of the Sand Hill River (AUID 09020301-558), the East Polk Soil and Water Conservation District (SWCD) and SHRWD have worked with landowners to install several water and sediment basins in the subwatershed since 2011. The installation of these detention basins has likely helped to reduce peak flows along the upstream portion of the Sand Hill River.
- Drainage water management, flood damage reduction, and water storage are primary focus areas for the SHRWD (2025a), as well as priority issues in the SHRW One Watershed, One Plan (HEI, 2024). Additional projects are being explored within the watershed to further mitigate the impacts of peak flow conditions.

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).

- None of the impaired reaches had a MPCA Stream Habitat Assessment (MSHA) score that was characterized as “good” (≥67/100); all the scores were either rated as “fair” (45-66/100) or “poor” (≤44/100).
- The Sand Hill River (AUID 09020301-558) experienced a substantial improvement in MSHA scores between 2005 (MSHA=34/”poor”) and 2023 (MSHA=57/”fair”). Between 2011 and 2020, the East Polk SWCD and SHRWD worked with landowners to install several sediment-related best management practices (BMPs) in this subwatershed, which likely contributed to improved instream habitat conditions.
- 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.
- While all the biological monitoring stations associated with the impaired reaches were located along a natural segment of their respective reach, all the impaired reaches also have an associated subwatershed with a high proportion (>50%) of physically altered watercourses (i.e., channelized, ditched, or impounded).
- 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 the Sand Hill River (AUID 09020301-559). The reach had high mean TSS tolerance indicator values and a low abundance of high TSS intolerant taxa. This reach was also listed as impaired for aquatic life use due to high turbidity levels on the 2010 Impaired Waters List; TSS and turbidity are often closely correlated. Approximately 22% of the total values exceeded the 30 mg/L TSS standard for the Central TSS Region. The upstream portion of the reach had the highest exceedance rate. Streambank erosion caused by an increase in the frequency and magnitude of high flow events, as well as soil erosion from agricultural fields, are the likely sources of excess sediment to the reach.
- High TSS was not a stressor for the Sand Hill River (AUID 09020301-558), even though the reach has historically been prone to high TSS concentrations. Between 2011 and 2020, the East Polk SWCD and SHRWD worked with landowners to install several sediment-related BMPs in this subwatershed. Since the completion of this work, TSS values have been well below the standard (<20 mg/L).

- County Ditch 6/SHRWD Project 17 (AUID 09020301-518) had a limited amount of discrete TSS data. Furthermore, the SHRWD recently implemented a stabilization project on the portion of the reach upstream of the 350th Ave SW crossing. The project included the installation of rock riffles and a drop structure to control grade. Additional TSS data (post-project) is needed to evaluate whether high TSS is a stressor to the fish community of the reach.

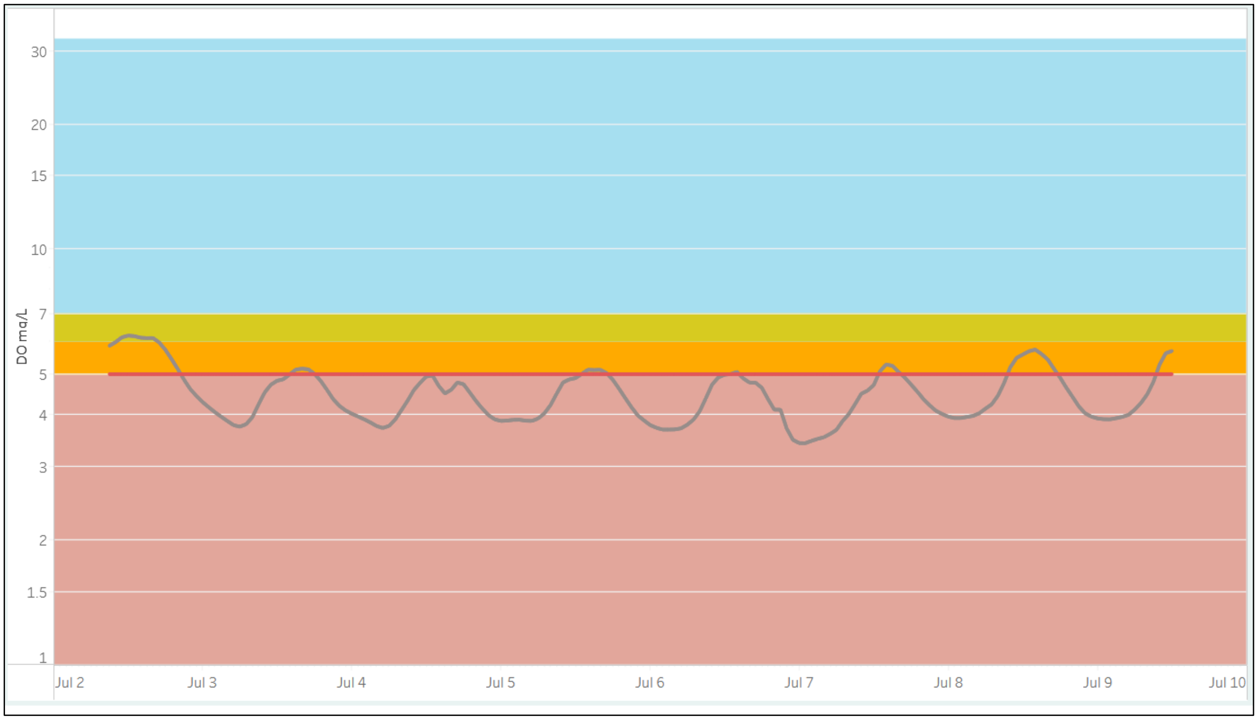
Low Dissolved Oxygen

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 County Ditch 17 (AUID 09020301-515) and the Sand Hill River (AUID 09020301-559).
- County Ditch 17 (AUID 09020301-515) had very limited discrete DO measurements; however, the MPCA conducted continuous DO monitoring at Site W61005001 (450th St SE) along the reach in 2023 and 2024 (Figure 2). During both monitoring periods, the reach had a high proportion of total values (≥60%) and daily minimum values (100%) that failed to meet the 5.0 mg/L standard. Baseflow limitations, as well as wetland conditions (upstream), are likely influencing the DO regime of the reach.
- The Sand Hill River (AUID 09020301-559) was also listed as impaired for aquatic life use due to low DO levels on the 2008 Impaired Waters List. The reach had a high proportion of discrete DO measurements (39%) that were below the 5.0 mg/L standard. Additionally, the MPCA conducted continuous DO monitoring at Site W61011002 (460th St SE) along the reach in 2023. During the continuous monitoring period, 59% of the total values and 100% of the daily minimum values failed to meet the standard. The low gradient of the channel, as well as a pronounced wetland riparian corridor, are likely contributing to low DO concentrations.
- While County Ditch 17 (AUID 09020301-515) and the Sand Hill River (AUID 09020301-559) are both prone to high total phosphorus, eutrophication does not appear to be affecting the DO regime of the reaches.
- County Ditch 6/SHRWD Project 17 (AUID 09020301-518) and Unnamed Creek (AUID 09020301-539) had a limited amount of DO data. Additional monitoring is needed to investigate the effects of low DO on the fish community of these reaches.
- 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 (July 2-9, 2024) for Site W61005001 (450th St SE crossing) along County Ditch 17 (AUID 09020301-515). Baseflow limitations and wetland conditions are likely contributing to the high proportion of values below the 5.0 mg/L DO standard.



High Nitrate-Nitrogen

Nitrate (NO_3) 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, NO_3 transport through leaching can be substantial. Apart from its function as a biological nutrient, some levels of NO_3 can become toxic to organisms. NO_3 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 NO_3-N was not found to be a stressor for any of the bioassessment impaired reaches (Table 1). While high NO_3-N is not a concern for the bioassessment impaired reaches at this time, NO_3 monitoring should be continued.
- Currently, Minnesota has no aquatic life use standards for NO_3, though the MPCA (2022) has developed proposed NO_3 criteria for the protection of aquatic life. The proposed NO_3 chronic criteria value is 8.0 mg/L for Class 2B (cool/warm) waters. Only County Ditch 17 (AUID 09020301-515) had a sample value (11.7 mg/L) exceed the chronic criteria value.
- According to *The Minnesota Nutrient Reduction Strategy* (MPCA, 2025), tile drainage is expected to further expand in the Red River of the North basin. However, permit application data collected by the SHRWD (2025b) suggest that tile drainage may be less prevalent in the SHRW, and especially in the subwatersheds of the bioassessment impaired reaches.

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. While substantial efforts to improve water quality and conditions in the SHRW have been completed, additional projects and practices are needed. The implementation of BMPs should focus on the detention and retention of water on the landscape. Recently completed and future projects 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 SHRW that were evaluated during Cycle 2 SID.

Stressor	Recommended Action
Loss of Longitudinal Connectivity	• When feasible and practicable, remove/modify barriers (e.g., Bear Park Dam) 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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