

Stressor Identification Update

Lake of the Woods Watershed

March 2026



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 watercourses that have been assessed as impaired due to a substandard fish and/or macroinvertebrate community 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.

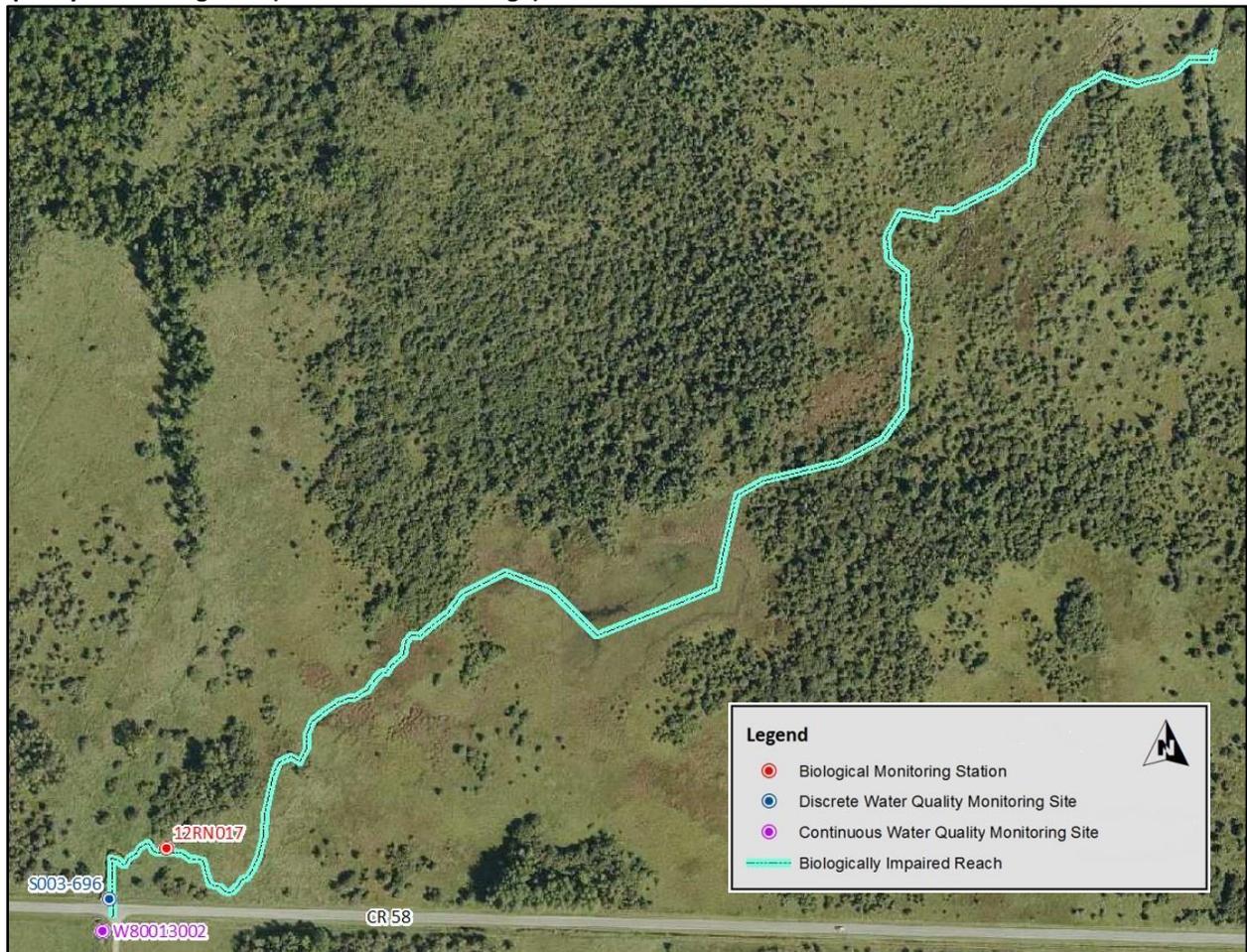
The findings provided in this SID update are from the evaluation of the lone bioassessment-related impairment that resulted from the assessment of Cycle 2 Intensive Watershed Monitoring (IWM) data for the Lake of the Woods Watershed (LOWW). A segment of Tomato Creek (AUID 09030009-518) was assessed as being impaired for aquatic life due to low macroinvertebrate Index of Biological Integrity (M-IBI) scores. Information on prior SID efforts in the watershed can be found in the *Lake of the Woods Watershed Stressor Identification Report* (MPCA, 2016). Four candidate causes were investigated as potential stressors to the macroinvertebrate community of the impaired reach of Tomato Creek, including insufficient baseflow, inadequate physical habitat, high total suspended solids (TSS), and low dissolved oxygen (DO). An overview of each of these candidate causes is provided in *Stressors Candidate Causes* (MPCA, 2022). The following subparts summarize the SID findings for the impaired segment of Tomato Creek.

Tomato Creek (AUID 09030009-518)

Physical setting

This reach represents the segment of Tomato Creek from the County Road (CR) 58 crossing to its confluence with an unnamed creek located approximately one mile downstream of the CR 58 crossing (Figure 1). The reach has a subwatershed area of 9.7 square miles (6,215 acres). According to the Minnesota Department of Natural Resources (DNR, 2026b), there are 3.6 miles of watercourses within the subwatershed (namely Tomato Creek). Based on the 2021 National Land Cover Database (USGS, 2021), wetland (96%) was the predominant land cover in the subwatershed. Other notable land cover groups in the subwatershed included developed (2%), forest (1%), and hay/pasture (1%).

Figure 1. Map of Tomato Creek (AUID 09030009-518) and associated biological monitoring station and water quality monitoring sites (2023 NAIP aerial image). The flow direction is from the southwest to northeast.



Biological impairment

Macroinvertebrate

The macroinvertebrate community of this segment of Tomato Creek was monitored at Station 12RN017 (0.1 miles downstream of the CR 58 crossing) on July 31, 2012 (Cycle 1 IWM), August 26, 2014 (Cycle 1 IWM), and August 20, 2024 (Cycle 2 IWM). The location of the station is shown in Figure 1. The station was designated as General Use within the Northern Forest Streams Glide/Pool (warmwater) M-IBI Class (Class 4). Accordingly, the impairment threshold for the station is an M-IBI score of 51. Monitoring of the station during Cycle 1 IWM yielded M-IBI scores of 24 (2012) and 49 (2014), which were below the impairment threshold. The Cycle 2 IWM score (29) was also substantially below the threshold. According to the MPCA biological monitoring staff: “The 2024 macroinvertebrate sample was dominated by midges, and low DO tolerant/wetland-adapted beetles (*Peltodytes*, *Dubiraphia*, *Haliplidae*, *Hydrochus*) and showed very little diversity within pollution sensitive POET (Plecoptera, Odonata, Ephemeroptera, and Trichoptera) taxa groups apart from *Leptophlebiidae* (60 individuals) and the generally pollution intolerant mayfly taxa *Eurylophella*”.

Candidate causes

Insufficient Baseflow

Available data

There are no flow monitoring data for Tomato Creek. According to M. Hirst, Lake of the Woods Soil and Water Conservation District (personal communication, 2026), the reach is prone to going stagnant or dry, particularly during the late summer, even though it likely receives some groundwater contributions. StreamStats (USGS, 2025) estimated that the normal range of flow values at the downstream end of the reach to be less than 0.1 cfs (Q75; value exceeded 75% of the time) to 0.7 cfs (Q25; value exceeded 25% of the time). Also, the estimated 1.5-year peak flood flow was 84.9 cfs, while the 7 day, 10-year low flow value for the reach was less than 0.01 cfs. The MPCA biological monitoring staff observed “slow flow” during the August 20, 2024, macroinvertebrate monitoring visit to Station 12RN017. A drone flight at the time of monitoring revealed that beaver dams (Figure 2) were impounding water immediately upstream. The DNR (2009) documented that beaver dams are common along Tomato Creek. Additionally, the MPCA SID staff conducted seven separate field visits to the reach between April and November of 2025 and flow was estimated during each visit. Flow estimations ranged from 2 cfs flow (August 26, 2025; Figure 2), to 15 cfs (April 25, 2025). Overall, the available data suggest the reach is prone to periods of minimal to no flow.

Figure 2. Flow-related images for Tomato Creek (AUID 09030009-518), including beaver dams (adjacent to 82nd Ave NW) impounding water immediately upstream of the CR 58 crossing on August 20, 2024 (left), and low-flow (\approx 2 cfs) conditions at Site S003-696 (CR 58 crossing) on August 26, 2025 (right).



Biological response

Frequent and/or prolonged periods of minimal to no flow tends to limit the diversity and taxa richness of macroinvertebrates and favor tolerant taxa that can adapt to disturbances (Klemm et al., 2002; Poff and Zimmerman, 2010; EPA, 2012). The biological response data suggest that the macroinvertebrate community of the reach is adversely affected by insufficient baseflow. According to Table 1, nearly all the metric scores for Station 12RN017 failed to meet their respective statewide mean. In addition, many of the scores were outside one standard deviation from the mean. The multiple lines of evidence **strongly support** the case for insufficient baseflow as a stressor to the macroinvertebrate community of this reach of Tomato Creek.

Table 1. Summary of insufficient baseflow-related biological metric data for Station 12RN017 along Tomato Creek (AUID 09030009-518), 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 (↓)	31 ± 17	12RN017 ¹² (0)
			12RN017 ¹⁴ (12)
			12RN017 ²⁴ (20)
LongLivedPct	Relative abundance (%) of long-lived individuals (↓)	6 ± 6	12RN017 ¹² (19)
			12RN017 ¹⁴ (16)
			12RN017 ²⁴ (3)
TaxaCountAllChir	Total taxa richness of macroinvertebrates (↓)	45 ± 8	12RN017 ¹² (35)
			12RN017 ¹⁴ (40)
			12RN017 ²⁴ (27)
Tolerant2ChTxPct	Relative abundance (%) of taxa with tolerance values equal to or greater than six (↑)	64 ± 7	12RN017 ¹² (77)
			12RN017 ¹⁴ (70)
			12RN017 ²⁴ (74)
TrichwoHydroPct	Relative abundance (%) of non-hydrospsychid Trichoptera individuals (↓)	7 ± 7	12RN017 ¹² (0)
			12RN017 ¹⁴ (3)
			12RN017 ²⁴ (0)

¹ Statewide score included stations that provided General Use habitat within the Northern Forest Streams Glide/Pool M-IBI Class (Class 4) and met or exceeded the IBI threshold (51).

¹² Sampled on July 31, 2012; ¹⁴ sampled on August 26, 2014; ²⁴ sampled on August 20, 2024.

■ 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 one standard deviation of the mean.

■ Poor: Score for the biologically impaired reach did not meet the statewide mean and was outside of one standard deviation of the mean.

Inadequate physical habitat

Available data

According to A. Pirkl, Lake of the Woods County Public Works (personal communication, 2026), there is no record of channel alteration along this segment of Tomato Creek. However, the channel of Tomato Creek has been slightly altered immediately upstream of the reach, as well as completely channelized downstream of the reach. The physical habitat of the reach was evaluated during four biological monitoring visits to Station 12RN017 using the MPCA Stream Habitat Assessment (MSHA). The station yielded “fair” MSHA results, with scores ranging from 48 (August 26, 2014) to 56 (July 10, 2012, and September 9, 2024). The presence of pasture within the immediate vicinity of the station somewhat limited its land use subcategory scores. The riparian subcategory scores were positively influenced by a mostly “extensive” riparian zone width; however, “moderate” bank erosion was also noted during the

August 26, 2014, and August 20, 2024, monitoring visits. While the station offered limited riffle habitat, some coarse substrate (i.e., cobble and gravel) was noted during three of the visits. However, this substrate had had a “light” to “severe” amount of embeddedness. The cover subcategory scores for the station were positively affected by a “moderate” to “extensive” amount of cover. Identified cover types included deep pools, macrophytes (emergent, submergent, and floating leaf), overhanging vegetation, rootwads, undercut banks, and woody debris. Lastly, the station scored relatively low in the morphology subcategory due in part to “fair” channel development and “fair” sinuosity.

On November 4, 2025, the DNR (2026a) completed a fluvial geomorphic assessment at Station 12RN017 along this reach of Tomato Creek. The stream type at this location was determined to be an E6 (very low width-to-depth ratio, slightly entrenched, silt bed stream). The site yielded a Pfankuch stability rating of 65 (moderately unstable). Below is an excerpt from the assessment summary for the site:

“This reach of Tomato Creek was classified as an E6 stream type with a low width-to-depth ratio (5.4) and a silt bed. The Pfankuch rating for this reach was fair (moderately unstable). Through the survey reach, the upper and lower banks scored very well, and the channel was not incised. The low banks were at the bankfull elevation, and the river had access to a wide floodplain at both bankfull and the floodprone elevation. The deposition of fine particles on the channel bottom pushed the Pfankuch rating just into the fair category. Although the pools had sufficient depth and holding cover, the fine nature of the substrate does not provide for optimal habitat for aquatic organisms. Additionally, ditching upstream and downstream, as well as beaver activity, are likely impacting the stability of the survey reach as it relates to the Pfankuch channel bottom metrics.”

Overall, the available data suggest the reach has habitat-related deficiencies, including the predominance of fine substrate (i.e., silt) and presence of some bank erosion and embeddedness, that limit its ability to support a healthy macroinvertebrate community.

Biological response

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). The biological response data suggest that the macroinvertebrate community of the reach may be adversely affected by inadequate physical habitat. According to Table 2, Station 12RN017 had multiple monitoring visits with a high abundance of burrower and legless individuals. Additionally, the 2014 monitoring visit to the station yielded a low abundance of clinger individuals and a high abundance of sprawler individuals. The multiple lines of evidence **somewhat support** the case for inadequate physical habitat as a stressor to the macroinvertebrate community of this reach of Tomato Creek.

Table 2. Summary of inadequate physical habitat-related biological metric data for Station 12RN017 along Tomato Creek (AUID 09030009-518), as well as statewide stations that support a healthy macroinvertebrate community.

Metric	Description (expected response to stressor)	Statewide score ¹ (mean ± SD)	Station (score)
BurrowerPct	Relative abundance (%) of burrower individuals (↑)	9 ± 10	12RN017 ¹² (40)
			12RN017 ¹⁴ (9)
			12RN017 ²⁴ (35)
ClingerPct	Relative abundance (%) of clinger individuals (↓)	38 ± 18	12RN017 ¹² (38)
			12RN017 ¹⁴ (28)
			12RN017 ²⁴ (50)
LeglessPct	Relative abundance (%) of legless individuals (↑)	44 ± 19	12RN017 ¹² (76)
			12RN017 ¹⁴ (39)
			12RN017 ²⁴ (72)
SprawlerPct	Relative abundance (%) of sprawler individuals (↑)	23 ± 13	12RN017 ¹² (13)
			12RN017 ¹⁴ (35)
			12RN017 ²⁴ (5)

¹ Statewide score included stations that provided General Use habitat within the Northern Forest Streams Glide/Pool M-IBI Class (Class 4) and met or exceeded the IBI threshold (51).

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High suspended sediment

Available data

A total of seven discrete TSS samples were collected at Site S003-696 (CR 58 crossing) along this reach of Tomato Creek. The TSS concentrations for this site ranged from 0 mg/L (May 28, 2025) to 57 mg/L (September 9, 2024), with a mean of 12 mg/L. Two of the values exceeded the 15 mg/L TSS standard for the Northern TSS Region. The sample with highest TSS concentration was collected shortly after the August 20, 2024, macroinvertebrate monitoring visit to Station 12RN017, in which MPCA staff documented substantial iron precipitate in the water column (Figure 3); iron precipitate can cause high TSS. Iron precipitation in groundwater-fed streams during low-flow conditions is a natural process resulting from the mixing of anoxic, iron-rich groundwater with oxygenated surface water. During higher flow conditions, the proportion of groundwater in the streamflow is lower, which limits the formation of iron precipitate; Figure 3 provides an example of this from Site S003-696 on July 2, 2024. Additionally, the MPCA biological monitoring staff encountered a “moderate” amount of bank erosion during the August 26, 2014, and August 20, 2024, monitoring visits. Given the limited amount of discrete TSS

samples for the reach, additional monitoring data are needed to further evaluate whether the reach experiences periods of high TSS, as well as the impact of iron precipitate events on TSS concentrations.

Figure 3. Images of Tomato Creek (AUID 09030009-518) at Site S003-696 (CR 58 crossing) during low-flow conditions with high iron precipitate in the water column on August 20, 2024 (left) and during normal-flow conditions with minimal to no iron precipitate in the water column on July 2, 2024 (right).



Biological response

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, 2012; Jones et al., 2012). Sediment suspended in the water column can limit collector species and species that filter using a net-spinning casing. Table 3 shows the high TSS-related metric scores for the macroinvertebrate community of this reach of Tomato Creek. Station 12RN017 met the statewide mean for the TSS indicator value and the abundance of TSS tolerant taxa metrics. However, the station scored below the mean for the abundance of TSS intolerant taxa; the scores were within one standard deviation of the mean. Due to the limited amount of discrete TSS data, there is ***insufficient information*** available to evaluate whether high TSS is a stressor to the macroinvertebrate community of this reach of Tomato Creek.

Table 3. Summary of high TSS-related biological metric data for Station 12RN017 along Tomato Creek (AUID 09030009-518), 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 (↑)	14 ± 2	12RN017 ¹² (14)
			12RN017 ¹⁴ (14)
			12RN017 ²⁴ (12)
ToITSS	Relative abundance (%) of high TSS tolerant taxa (↑)	20 ± 12	12RN017 ¹² (8)
			12RN017 ¹⁴ (14)
			12RN017 ²⁴ (1)
InToITSS	Relative abundance (%) of high TSS intolerant taxa (↓)	8 ± 8	12RN017 ¹² (0)
			12RN017 ¹⁴ (0)
			12RN017 ²⁴ (0)

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Low dissolved oxygen

Available data

A total of five discrete DO measurements were collected at Site S003-696 (CR 58 crossing) along this reach of Tomato Creek. The DO concentrations for this site ranged from 2.2 mg/L (August 20, 2024) to 7.9 mg/L (September 9, 2024), with a mean of 5.6 mg/L. Only one value failed to meet the 5.0 mg/L DO 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 W80013002 (CR 58 crossing) from July 24, 2025, to July 31, 2025. During the continuous monitoring period, flow was estimated to be 3 to 5 cfs. The monitoring results are provided in Table 4, as well as displayed in Figure 4. Collectively, 66% of the total values and 100% of the daily minimum values failed to meet the standard. Extensive wetland conditions along and upstream of the reach (Figure 5), as well as substantial groundwater inputs (Figure 5), are likely naturally limiting DO concentrations. Overall, the available data suggest the reach experiences frequent periods of low DO.

Table 4. Continuous DO data (July 24-31, 2025) for Site W80013002 (CR 58 crossing) along Tomato Creek (AUID 09030009-518).

Site	Start date - End date	<i>n</i>	Min. (mg/L)	Max. (mg/L)	% Total values below standard	% Daily min. values below standard	Mean daily flux (mg/L)
W80013002	7/24/2025 - 7/31/2025	671	3.4	6.9	66	100	2.6

Figure 4. Continuous DO data (July 24-31, 2025) for Site W80013002 (CR 58 crossing) along Tomato Creek (AUID 09030009-518).

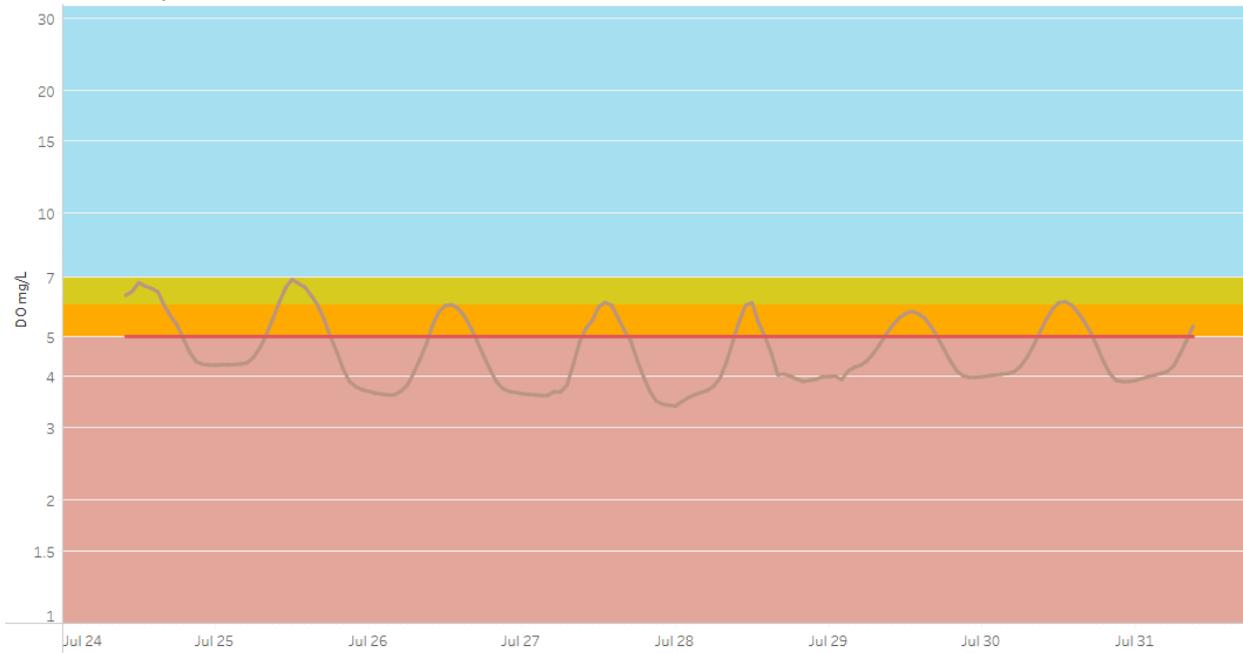
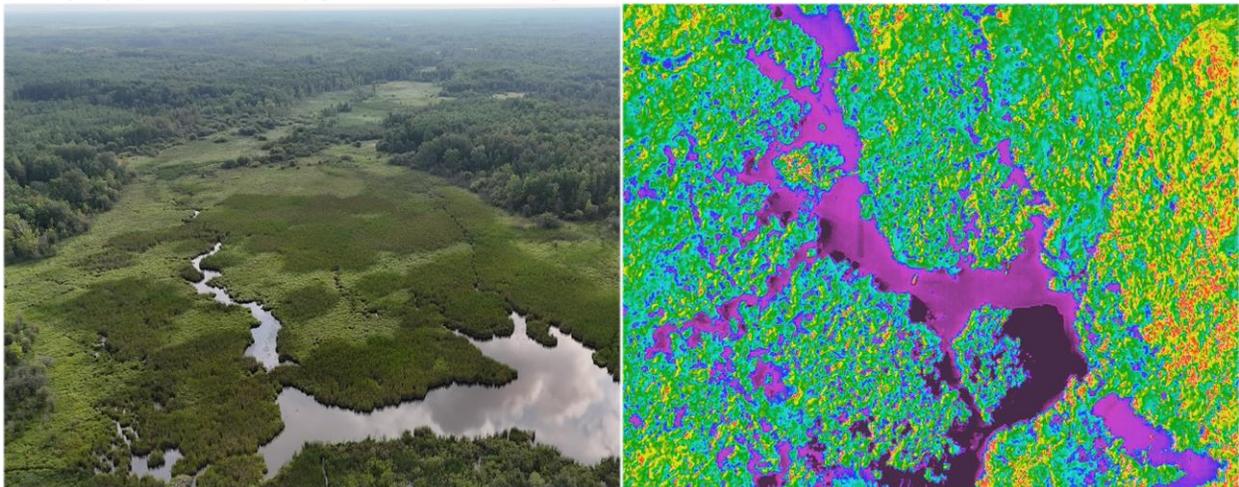


Figure 5. Images captured with a drone immediately upstream of Tomato Creek (AUID 09030009-518), including an extensive area of wetlands on August 20, 2024 (left), and thermal imagery showing a plume of cold water (dark purple), which is likely groundwater discharge, on November 5, 2025 (right).



Eutrophication-related data for the reach includes the following parameters: total phosphorus (TP), chlorophyll-*a* (chl-*a*), and DO flux. A total of eight discrete TP samples were collected at Site S003-696. Four (50%) of the values exceeded the 50 µg/L Northern River Nutrient Region TP standard, with a maximum concentration of 194 µg/L. A total of six discrete chl-*a* samples were collected at Site S003-696. One value (15 µg/L) exceeded the 7 µg/L Northern River Nutrient Region chl-*a* standard. Lastly, the mean daily DO flux documented during continuous DO monitoring at Site W80013002 was 2.6 mg/L for the 2025 monitoring period, which met the 3.0 mg/L Northern River Nutrient Region DO flux standard. In addition, the MPCA SID staff documented only a minimal amount of rooted macrophytes and filamentous algae during seven separate field visits to the reach between April and November of 2025. While the reach appears to be prone to high TP concentrations, the available response variable data suggest that eutrophication is likely not adversely affecting the DO regime of the reach.

Biological response

Frequent or extended periods of low DO can alter a macroinvertebrate community by limiting the abundance of taxa that are intolerant of such conditions (Davis, 1975, EPA, 2012). Table 5 provides the low DO-related metric scores for the macroinvertebrate community of this reach of Tomato Creek. None of the metrics scores for Station 12RN017 met their respective statewide mean. Additionally, the station had multiple monitoring visits with a high abundance of low DO tolerant taxa. The multiple lines of evidence **strongly support** the case for low DO as a stressor to the macroinvertebrate community of this reach of Tomato Creek.

Table 5. Summary of low DO-related biological metric data for Station 12RN017 along Tomato Creek (AUID 09030009-518), 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	12RN017 ¹² (6)
			12RN017 ¹⁴ (6)
			12RN017 ²⁴ (6)
ToIDO	Relative abundance (%) of low DO tolerant taxa (↑)	21 ± 17	12RN017 ¹² (47)
			12RN017 ¹⁴ (32)
			12RN017 ²⁴ (47)
InToIDO	Relative abundance (%) of low DO intolerant taxa (↓)	7 ± 9	12RN017 ¹² (0)
			12RN017 ¹⁴ (1)
			12RN017 ²⁴ (0)

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Conclusions and Recommendations

Insufficient baseflow and low DO are the primary stressors limiting the macroinvertebrate community of this reach of Tomato Creek. The reach commonly has minimal to no flow during the late summer months likely due to its relatively small drainage area (<10 mi²), as well as an abundance of beaver dams impounding flow within the subwatershed. Low DO concentrations regularly occur along the reach due to natural factors, including the impact of vast wetlands along and upstream of the reach, as well as groundwater inputs. Inadequate physical habitat was identified as a secondary stressor for the reach. Habitat conditions were limited by factors including the predominance of fine substrate (i.e., silt) and presence of some bank erosion and embeddedness. The latter issues are likely a result of the channelization that has occurred upstream and downstream of the reach. Lastly, while the reach has experienced some high TSS concentrations, additional monitoring is needed to evaluate TSS as a stressor and the likely linkage between TSS and iron precipitate.

The stressors affecting this reach of Tomato Creek are largely driven by natural factors and given the mainly natural state of its subwatershed, there are limited opportunities to implement actions to address the stressors affecting the macroinvertebrate community. Restoration of the channelized portions of Tomato Creek upstream and downstream of the impaired reach is a potential action that would likely help to reduce bank erosion and improve habitat conditions. However, it is unlikely that this action would result in a meaningful improvement to the macroinvertebrate community given the predominance of other stressors. Due to the natural factors causing low DO concentrations along the reach, the development of a TMDL to address low DO as a stressor is not recommended.

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