Stressor Identification

September 2022

Mississippi River-St. Cloud Watershed Stressor Identification Update, 2022

A study of local stressors limiting the biotic communities in the Mississippi River-St. Cloud Watershed.

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Key terms and abbreviations

AOP	Aquatic Organism Passage Program
AUID	Assessment Unit Identification
DNR	Minnesota Department of Natural Resources
DO	Dissolved Oxygen
EPA	U.S. Environmental Protection Agency
HUC	Hydrologic Unit Code
IBI	Index of Biological Integrity
MPCA	Minnesota Pollution Control Agency
MSHA	Minnesota Stream Habitat Assessment
SID	Stressor Identification
TALU	Tiered Aquatic Life Use
TIV	Tolerance Index Value
TP	Total Phosphorus
TSS	Total Suspended Solids
TMDL	Total Maximum Daily Load
UAA	Use Attainability Analysis

Introduction

Since 2008, the Minnesota Pollution Control Agency (MPCA) has substantially increased the use of biological monitoring and assessment as a means to determine and report the condition of the state's rivers and streams. This basic approach is to examine fish and aquatic macroinvertebrate communities and related habitat conditions at multiple sites throughout a major watershed. From these data, an Index of Biological Integrity (IBI) score can be developed, which provides a measure of overall community health. These scores are then compared to the appropriate IBI thresholds (stream class), which are determined by the type and location of the stream or river that was sampled. If the fish or macroinvertebrate IBI score fails to meet the standards set by the stream class, it is termed a "biological impairment" and is placed on the United States Environmental Protection Agency's (EPA) impaired wasters list. If biological impairments are found, stressors to the aquatic community must be identified.

Stressor identification (SID) is a formal and rigorous process that identifies stressors causing biological impairment of aquatic ecosystems and provides a structure for organizing the scientific evidence supporting the conclusions (Cormier et al. 2000). In simpler terms, it is the process of identifying the probable factors causing harm to aquatic life. SID is a key component of the major watershed restoration and protection projects being carried out under Minnesota's Clean Water Legacy Act. Information on the SID process can be found on the EPA website http://www.epa.gov/caddis/. Specific information on Minnesota's processes for SID in streams can be found on MPCA's webpage "Is Your Water Stressed" at https://www.pca.state.mn.us/business-with-us/stressor-identification". The Minnesota Department of Natural Resources (DNR) has a similar webpage for lakes - "Stressors to Biological Communities in Minnesota's Lakes" https://www.dnr.state.mn.us/waters/surfacewater_section/lake_ibi/index.html.

This report details the SID process for the Mississippi River-St. Cloud Watershed, following the second cycle of biological monitoring. This report also contains SID work that was completed after the first cycle of watershed monitoring, on stations that were channelized. Until the Tiered Aquatic Life Use (TALU) assessment process was written into rule in 2014, the MPCA did not have the tools to assess channelized streams. Stations that were sampled in 2009 on channelized streams, were not assessed until TALU criteria were finalized; as a result, these Assessment Unit Identification (AUIDs) were not included in the cycle I SID report (MPCA 2013).

Overview of the Mississippi River-St. Cloud Watershed

The Mississippi River-St. Cloud Hydrologic Unit Code (HUC)-8 watershed (07010203) is divided into 30 HUC-12 subwatersheds (Figure 1).

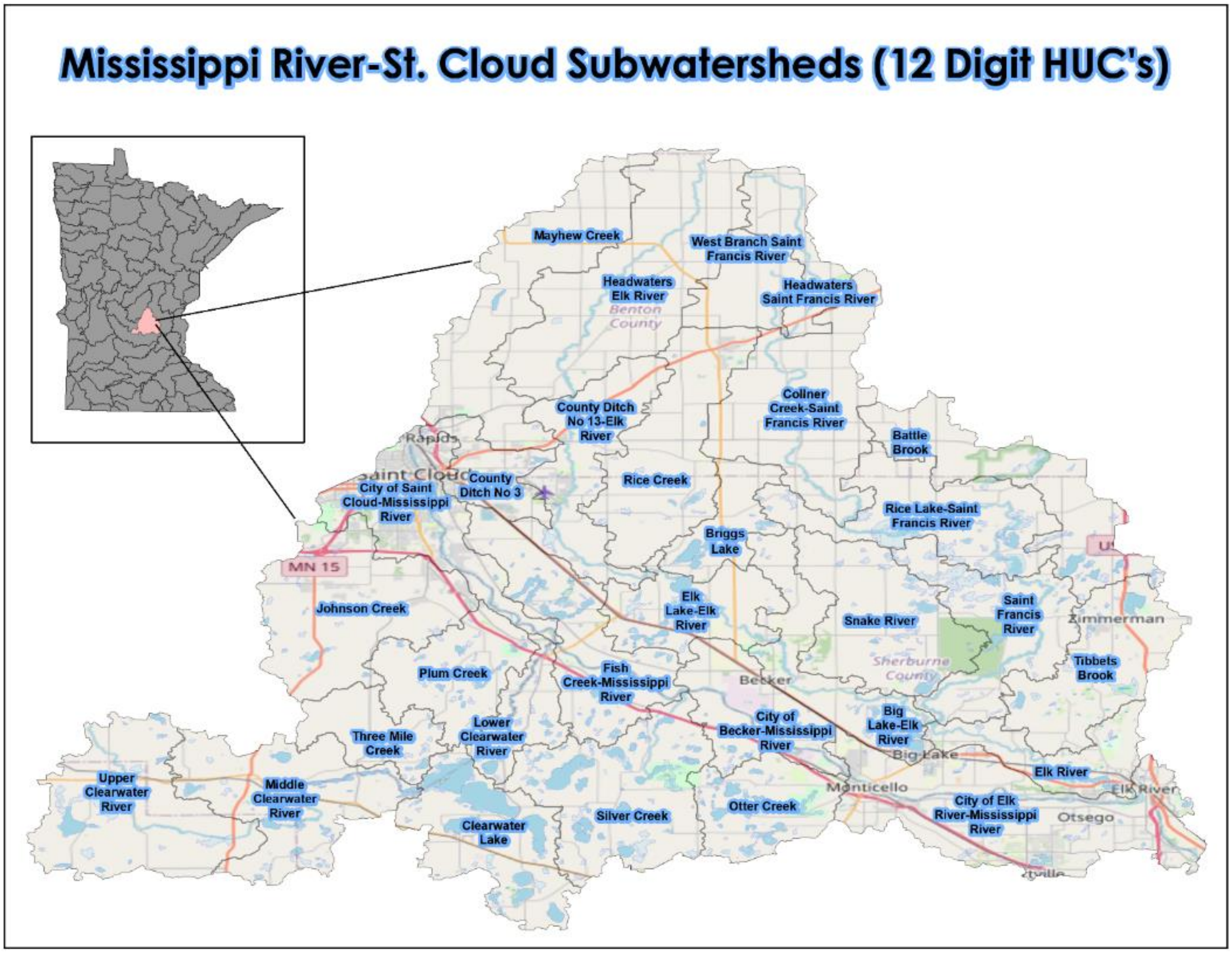
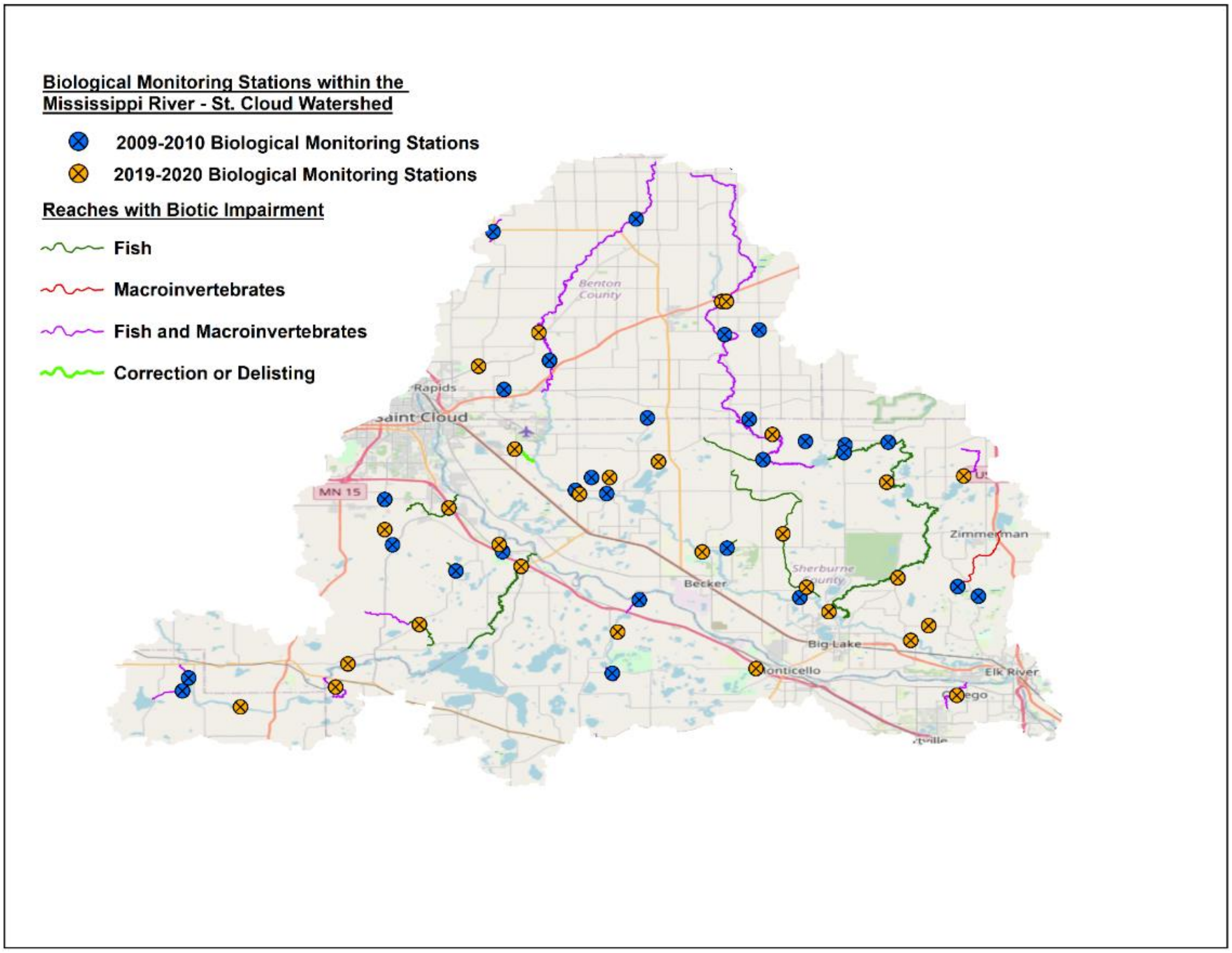


Figure 1. HUC-12 Subwatersheds within the Mississippi River - St. Cloud HUC-8 Watershed.

Within the first cycle of watershed monitoring, a biological station was placed at the outlet of the HUC 14, 12, 10, and 8 levels in an attempt to monitor each HUC-8 watershed in an unbiased manner. As the MPCA moved into the second cycle of monitoring, efforts were scaled back in an attempt to provide the ability to sample stations that were local priorities, while still monitoring at a sufficient level to detect change. Biological monitoring stations are placed at the outlet of each of the HUC-12 subwatersheds, with a preference for stations that have existing data from the cycle I monitoring efforts (Figure 2).

Figure 2. Biological Monitoring Stations and Biological Impairments within the Mississippi River - St. Cloud Watershed.



Biologically-impaired streams

Biological sampling from the cycle II monitoring effort resulted in four stream reaches being assessed as having impaired fish and/or macroinvertebrate communities. One reach was also identified as vulnerable to future impairment, and another reach was able to be delisted due to restoration action. In addition to the four new impairments from the cycle II monitoring, eight stream reaches that were sampled in the first cycle, but were deferred due to being channelized, were also assessed as impaired. These reaches, along with two additional reaches that were not investigated from cycle I were brought into the SID update process. These reaches are listed below (Table 1).

Table 1. Summary of aquatic life impairments and stressors in the Mississippi River - St. Cloud Watershed.

• = direct stressor (stressor directly contributing to the biological impairment), X = secondary stressor (stressor that is not the direct stressor, but is still contributing to the biological impairment), ◊ = Possible contributing root cause (stressor that is not a direct or secondary stressor, but may be contributing to other stressors, causing stress to the biological communities, ? = Inconclusive

Stream	AUID	Aquatic Life Impairment	Monitoring Data Source Year	Dissolved Oxygen	Phosphorus	TSS	Connectivity	Hydrology / Geomorphology	Habitat	Flow
Luxemburg Creek (Trib. to Johnson Creek)	-561	Vulnerable	Vulnerable in 2019						•	
Johnson Creek	-639	Fish	Additional Reach not Investigated in 2011					•	•	
Plum Creek*	-740	Fish	Channelized Stream From 2009 Sampling	?	?	?		•	•	•
County Ditch 44*	-550	Fish, Macroinvertebrates	Channelized Stream From 2009 Sampling	•	•	•		•	•	•
County Ditch 20*	-738	Fish, Macroinvertebrates	Channelized Stream From 2009 Sampling	•	•	◊	?	•	•	•
Threemile Creek	-545	Fish	New Impairment from 2019 Sampling			?		•		
Threemile Creek	-564	Fish, Macroinvertebrates	New Impairment from 2019 Sampling			?		•		
Unnamed Creek	-684	Fish, Macroinvertebrates	Delisted due to restoration, 2021							
St. Francis River, West Branch*	-693	Fish, Macroinvertebrates	Channelized Stream From 2009 Sampling		X		•	•		•
County Ditch 22*	-695	Fish	Channelized Stream From 2009 Sampling				•	•	•	•
Unnamed Creek*	-743	Fish	Channelized Stream From 2009 Sampling				•	•	•	
Snake River*	-558	Fish	New Impairment from 2019 Sampling				•	•	•	
Snake River*	-529	Fish	New Impairment from 2019 Sampling				•	•	•	
Unnamed Creek*	-745	Fish	Channelized Stream From 2009 Sampling		?			•	•	
Unnamed Ditch*	-523	Macroinvertebrates	Channelized Stream From 2009 Sampling					•	•	

Stream	AUID	Aquatic Life Impairment	Monitoring Data Source Year	Dissolved Oxygen	Phosphorus	TSS	Connectivity	Hydrology / Geomorphology	Habitat	Flow
Silver Creek*	-662	Fish, Macroinvertebrates	Additional Reach not Investigated in 2011	?	•	?	•	•	•	•

Denotes Stearns County
Denotes Sherburne County
Denotes Meeker County
Denotes Wright County
Denotes Benton County

* Please note that some of the stream reaches are channelized within the Mississippi River – St. Cloud Watershed and those discussed within this report may also serve as public drainage ditches.

The SID data collection, analysis, and recommendations for each of these impaired AUIDS will be discussed and sorted into HUC-12 subwatersheds for the duration of this report.

Johnson Creek Subwatershed

The Johnson Creek Subwatershed covers 34,685 acres, located just south of Waite Park (Figure 3). Half of the streams within the subwatershed have been straightened.

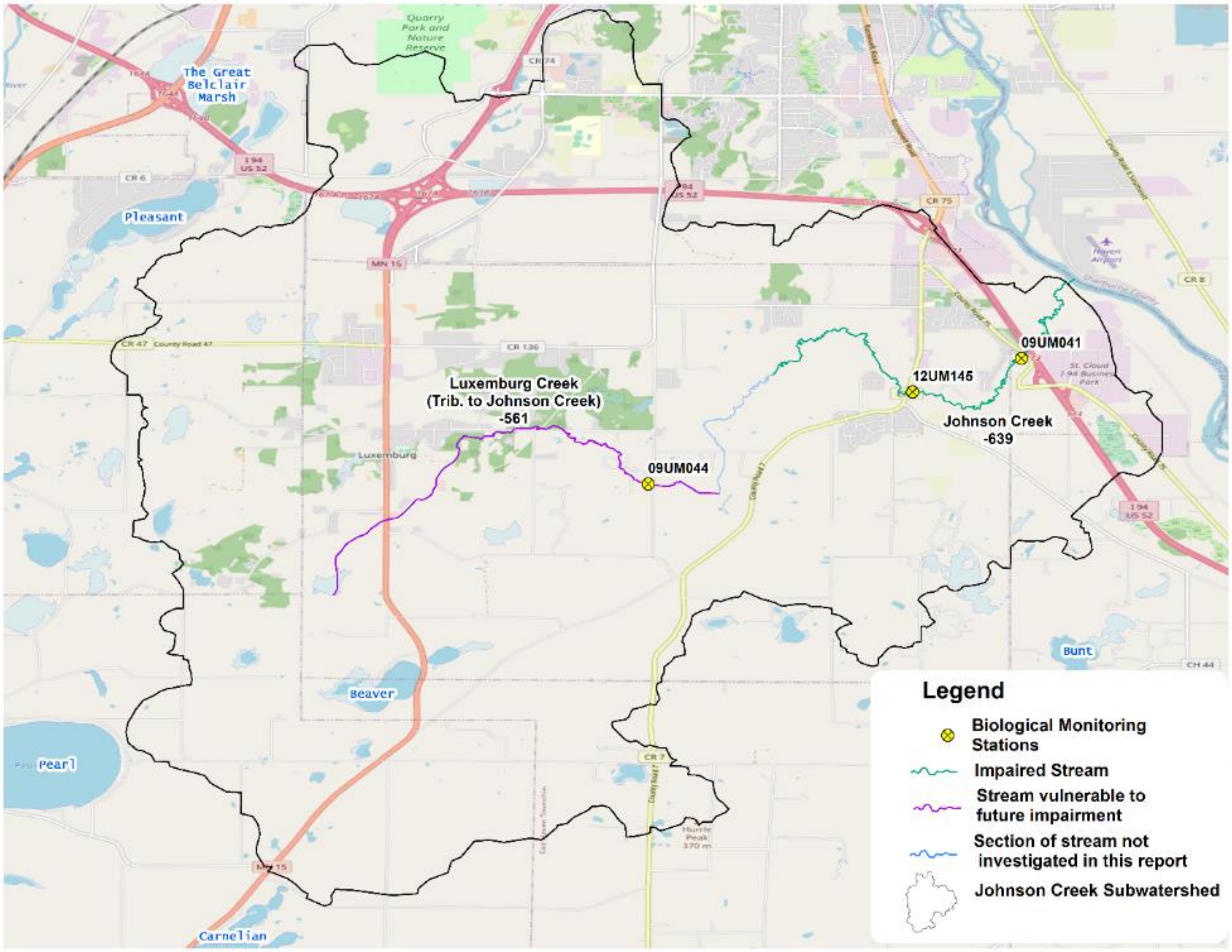


Figure 3. Biological monitoring stations in the Johnson Creek Subwatershed.

The land use within the Johnson Creek Subwatershed is dominated by cropland (46.5%), followed by rangeland (16.6%), and wetlands (13.9%) (Figure 4).

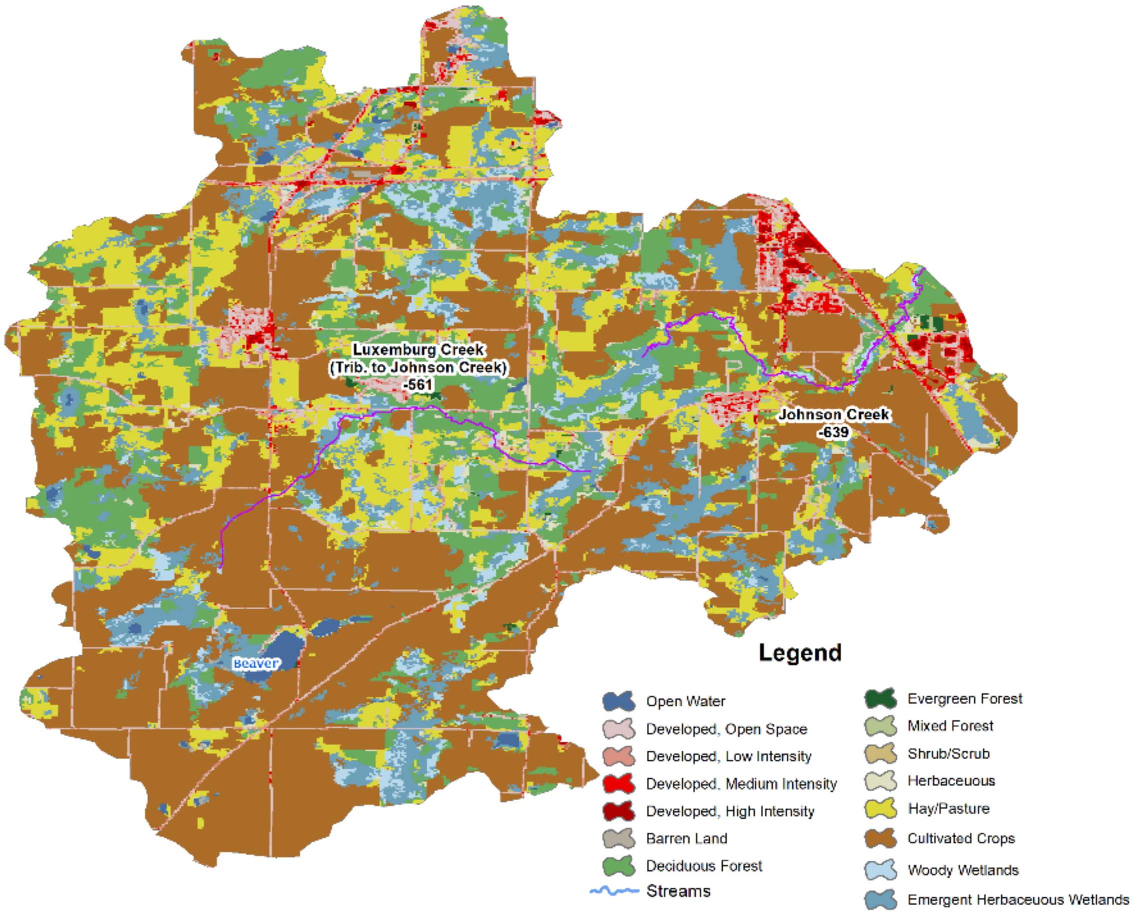


Figure 4. Land use in the Johnson Creek Subwatershed. Credit: NLCD 2016.

Luxemburg Creek (Trib. to Johnson Creek) (07010203-561)

In decline: Luxemburg Creek (AUID -561) flows for 5.5 miles before reaching its confluence with Johnson Creek, 7 miles east of Rockville, and is classified as a coldwater trout stream. The headwaters portion of the channel has been channelized, but most of the reach that was sampled for fish and macroinvertebrates remains natural. There is 1 biological monitoring station (09UM044) (Figure 3) on AUID -561 that was sampled in 2009 as part of the cycle I monitoring effort, and repeated in 2019 as part of the cycle II monitoring effort. The fish and macroinvertebrate samples were assessed in 2021, which indicated that while these communities were still meeting standards, the IBI scores fell significantly between 2009 and 2019. Due to this decline, Luxemburg Creek was identified as vulnerable to future impairment, and was included in the SID process.

The MSHA habitat scores for Luxemburg Creek were rated as good following the 2009 fish sample, but dropped slightly after the 2019 samples (Figure 5).

Figure 5. MSHA habitat scores for Luxemburg Creek.

Due to this slight drop within the habitat scores, the MPCA SID staff requested that DNR hydrologists conduct a geomorphology study on Luxemburg Creek to help identify what was leading to the reduction in habitat scores. The results from this study, are described below.

The DNR conducted a geomorphic survey near the biological monitoring station (09UM044) in July 2021, just west of 43rd avenue in Stearns County (Figure 6). The site has a drainage area of 15 mi^2 (9,773 acres) and is part of a watershed with land use consisting of mostly cultivated land (54%) with portions of pasture and hay (14%), forest (12%) and wetlands (12%) (MN WHAF 2022). The channel is classified as an F4 stream type with a median pebble size of 4.0 mm in the riffle (small gravel) (Table 2). Water surface slope is 0.0019 and the channel has a sinuosity of 1.2. The stream is incised and does not have access to the floodplain. Dominate channel characteristics include deposits of fine material, and loose highly mobile particles, resulting in poor a Pfankuch rating (a habitat assessment tool for stream channel stability).

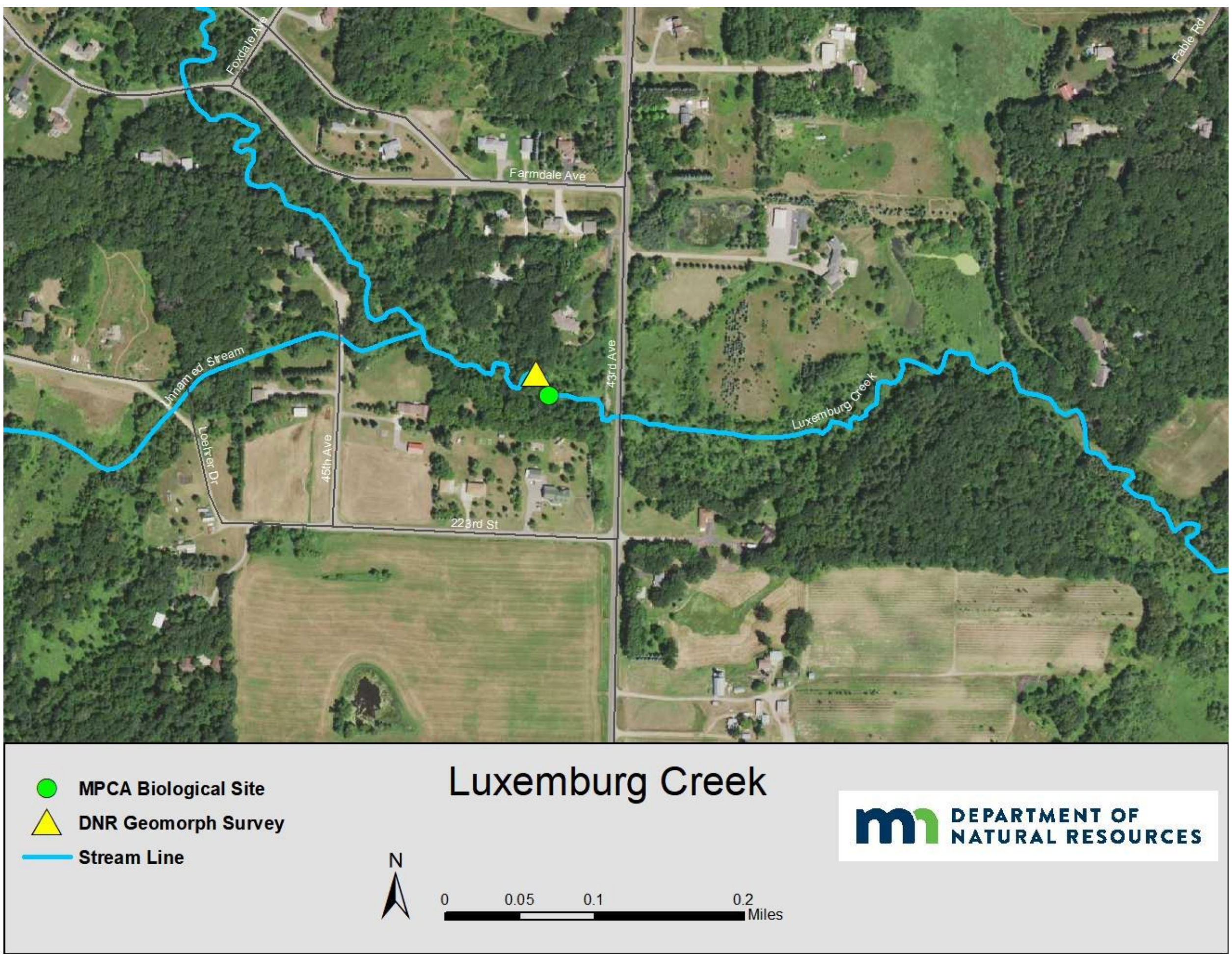


Figure 6. Location of DNR geomorphic survey and MPCA biological monitoring station on Luxemburg Creek.

Table 2. Geomorphic data summary for survey on Luxemburg Creek.

Survey Results			
Stream Type	F4	**Velocity (fps)**	2.9
Valley Type	U-GL-GO	**Discharge (cfs)**	45.83
Sinuosity	1.24	**Riffle D50 (mm)**	4
Water Slope	0.0019	**Mean Riffle Depth (ft)**	1.01
Bankfull Width	15.4	**Max Pool Depth (ft)**	2.3
Entrenchment Ratio	1.19	**Bank Erosion Estimates (tons/yr/ft)**	0.01
Width/Depth Ratio	15.24	**Pfankuch Stability Rating**	Poor
Bankfull Area (ft^2)	15.6	**Competence Condition**	NA

Figure 7 shows the flood prone elevation (2x bankfull depth) contained within the channel banks. A measured entrenchment ratio of 1.19 at the riffle classifies the channel as entrenched, no longer connected to the flood plain. As well as being entrenched, the reach is also considered deeply incised. Incision is measured by dividing the lowest bank height by the maximum bankfull depth (bank-height ratio). Streams with high bank height ratio values generally contribute disproportionate amounts of sediment from streambanks and channel beds due to high shear stress (Rosgen 2009).

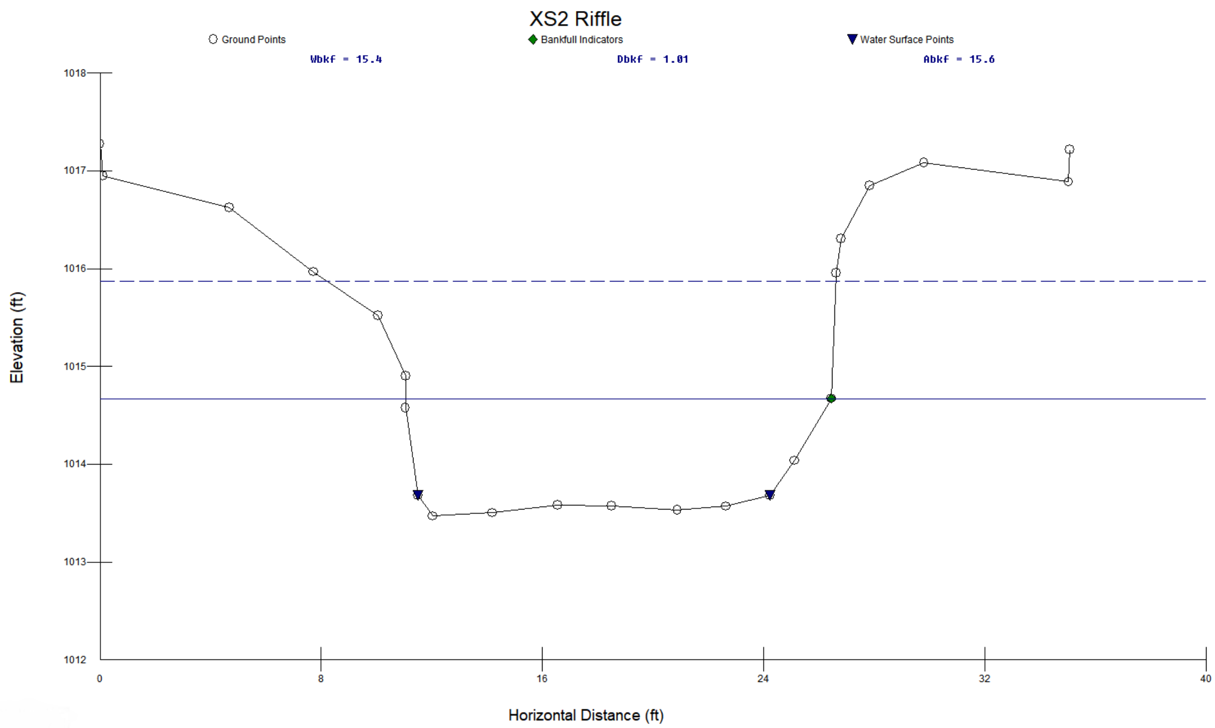


Figure 7. Cross section of riffle showing bankfull elevation (solid line) and flood prone elevation (dashed line).

The longitudinal profile is 230 feet long, containing 4 riffles and 5 pools (Figure 8). The dimensionless ratio of max pool depth to riffle mean depth is a good measure for comparing pool depths. The ratio along the longitudinal profile is 2.0. Reference max pool to riffle mean depth ratios are usually 2.0 to 4.0, suggesting the pools are relatively shallow.

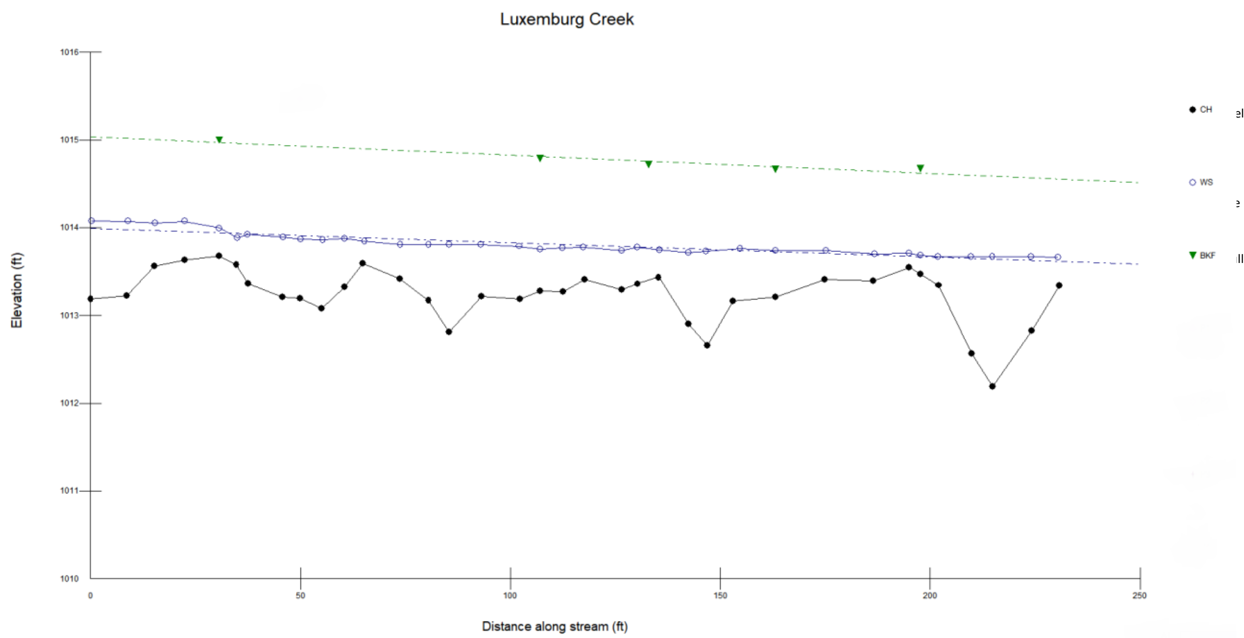


Figure 8. Longitudinal profile of survey, including bankfull.

A total of six banks were observed to be contributing sediment in this reach. The reach classified as moderately unstable with an estimated total erosion rate of 0.01 tons/yr/ft (Table 3). The reach is aided by dense herbaceous and woody vegetation along the banks helping to stabilize banks. Aerial photo comparison and stream digitization from 1991 to 2011 show little movement over that timespan (Figure 9).

Table 3. Streambank erosion stability categories, adapted from Rosgen 2014.

	Stable	Moderately Unstable	Unstable	Highly Unstable
Streambank Erosion Rate (tons/yr/ft)	<0.006	0.006 - 0.04	0.041 - 0.07	> 0.07

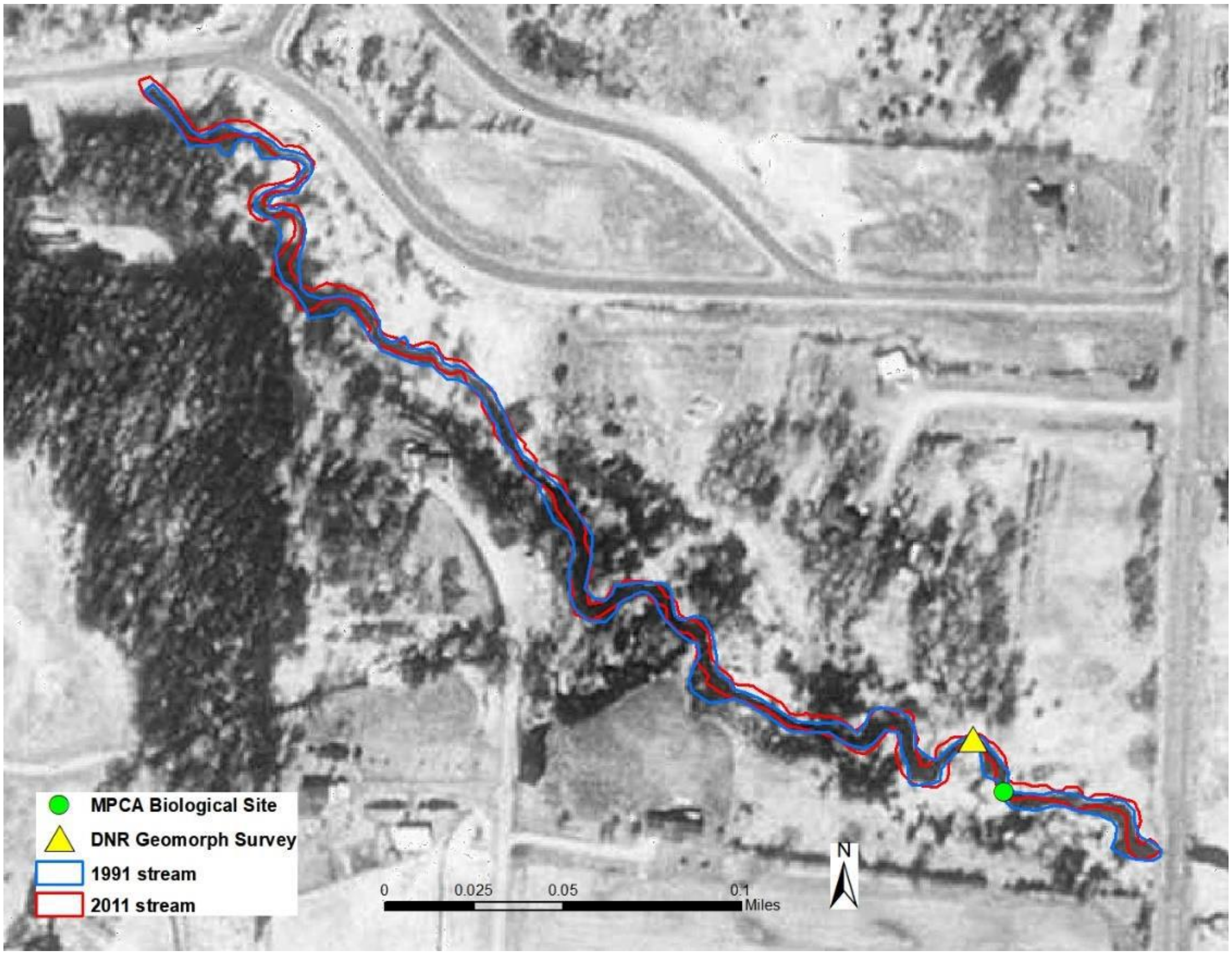


Figure 9. Outlines of Luxemburg Creek in 1991, comparing to 2011, showing little movement.

SID Implications

F stream types within the existing valley type (Unconfined Glacial Outwash) are most often unstable, and entrenched with high width/depth ratios. The high width/depth ratios mean the stream is wide, shallow, and unable to transport sediment properly. The inability to transport sediment is documented by the max pool depth/mean riffle depth ratio being low, compared to a reference C stream type. The filling of pools is likely negatively impacting fish habitat. F stream types are associated with accelerated streambank due to higher flows being contained within the channel.

The stable stream type within this valley is a C stream type. A C stream type is a riffle-pool system with floodplain connectivity. Deep water refugia within long, deep pools are typical features in this stream type. Stream succession scenarios of F stream types evolving into C stream types illustrate the adjustments needed for the stream to reach its stable form (Figure 10). The stream would need to create a floodplain at its current elevation, and develop a deeper narrower channel seen in Figure 11. Stream evolution may take years to decades and include continued stream bank erosion.

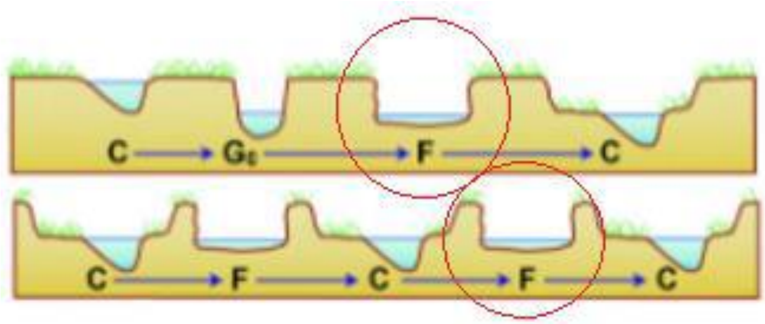


Figure 10. Likely stream succession scenarios for the discussed reach and the current condition circled in red.

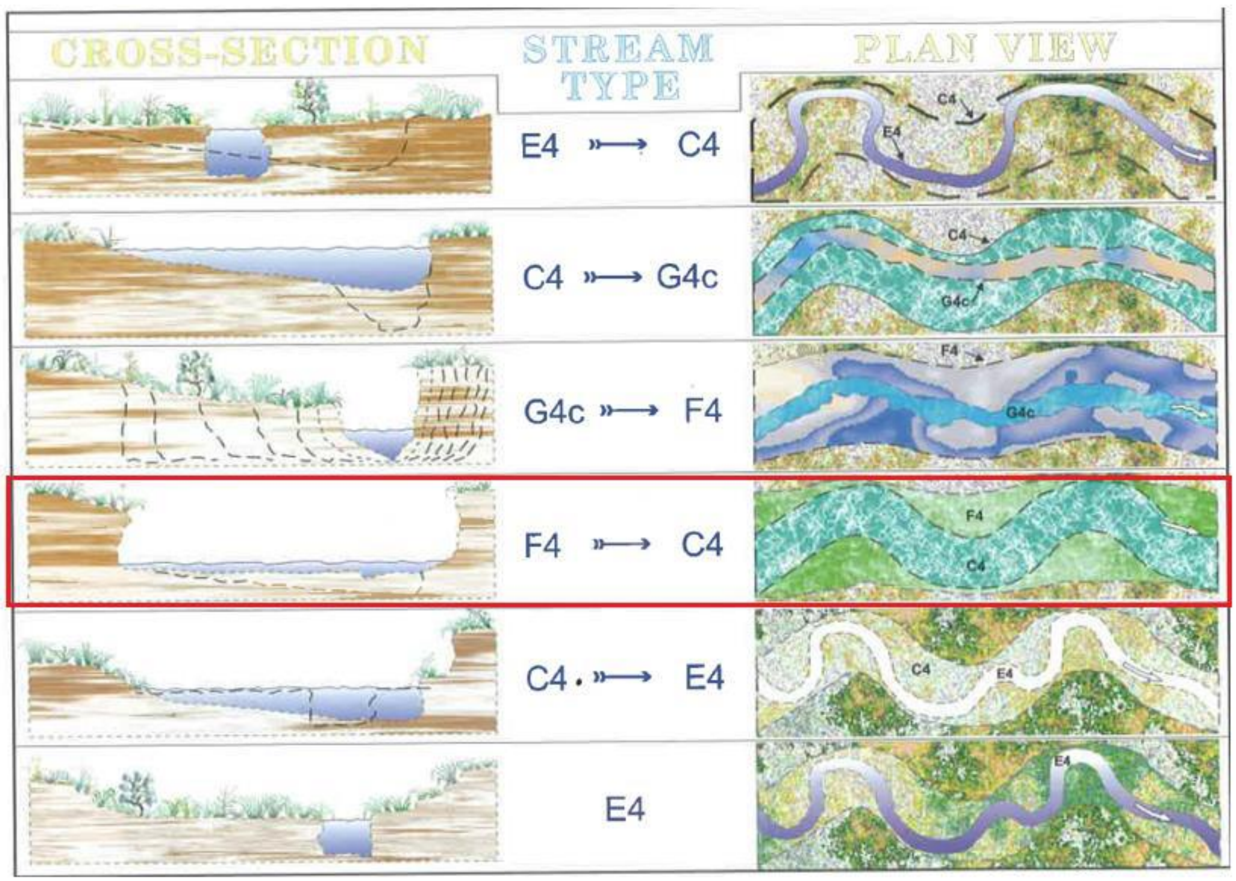


Figure 11. Dimension and pattern adjustments through successional stages, highlighting the adjustment from an F stream type to a C. From Rosgen 2009.

It is also possible that the excess sediment within the channel may have come from a failed sediment barrier during the construction of the Cherrywood Estates development in 2001 and 2002 (DNR 2003). During the excavation of the Cherrywood Estates properties, the contractors failed to implement appropriate erosion control measures on the bare soil, and this combined with higher-than-average rainfall events, lead to large amounts of bare soil to be washed into the creek (DNR 2003). Although the geomorph survey was not able to confirm if the source of the sediment originated from this event, it is possible that the historic sediments from this event have been moving downstream throughout time, and have recently reached the MPCA biological sampling reach on Luxemburg Creek, causing the reduction in IBI scores between the cycle I and cycle II monitoring efforts.

In addition to the geomorphology study, SID staff installed a level logger (a small optical logger that measures the water level above the logger) at 09UM044 in the summer of 2020 to investigate flow levels within the creek (Figure 12). These data indicated that there is positive flow throughout the summer, and therefore lack of flow is not a stressor to the aquatic life within Luxemburg Creek.

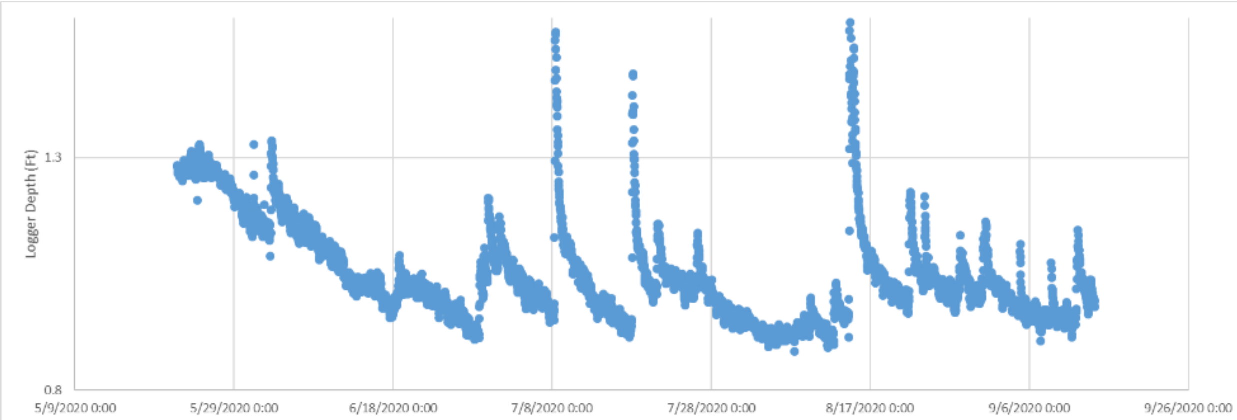


Figure 12. Level logger data for Luxemburg Creek.

Recommendations

In order for Luxemburg Creek to stabilize from the transition of the F stream type into a C stream type, the stream would need to create a floodplain at its current elevation, and develop a deeper narrower channel. This stream evolution may take years to decades and include continued stream bank erosion, before the transition into a C stream type is complete. There may be some projects that could speed up this transition such as rebuilding the channel offline, or constructing grade control riffles to increase the water depth, but these would most likely be cost prohibitive. Therefore, it may be difficult, but waiting for the creek to naturally stabilize into a C stream type may be the best course of action.

Johnson Creek (07010203-639)

Impairment: Johnson Creek (AUID -639) flows for 6.6 miles before reaching its confluence with the Mississippi River, 6.5 miles south of St. Cloud. Most of the stream reach has remained natural, with the exception of one short section in the headwaters, which has been channelized. There are two biological monitoring stations (12UM145, 09UM041) that were sampled on Johnson Creek (Figure 3). Fish were sampled at 09UM041 in 2009, 2012, 2013, 2014, and 2019 and macroinvertebrates were sampled in 2009, 2014, and 2019. Similarly, fish were sampled at 12UM145 in 2012, 2013, 2014, and 2015 and macroinvertebrates were sampled in 2014 and 2015. These data indicated that the fish within Johnson Creek were not meeting standards and resulted in a new fish impairment. The fish class at 09UM041 is fish class 5 (Northern Streams) and the fish class at 12UM145 is class 6 (Northern Headwaters). The macroinvertebrate class at 09UM041 is class 6 (Southern Streams Glide/Pool) and the macroinvertebrate class at 12UM145 is class 5 (Southern Steams Riffle/Run).

Data and Analyses

Chemistry

Extensive water chemistry data has been collected on Johnson Creek from 2004-2020 at several monitoring locations (S003-370, S003-765, S003-766, S006-854, S006-855, and S012-270) (Table 4).

Table 4. Water chemistry data collected on Johnson Creek from 2004-2020. Data available at https://webapp.pca.state.mn.us/surface-water/search.

Parameter	Sample Count	Applicable Standard	Avg. Result	Min. Result	Max. Result
Chlorophyll a, corrected for pheophytin	14	18.0 mg/L	3.07	1	6
Dissolved oxygen (DO)	278	5.0 mg/L	9.12	2.16	18.97
Inorganic nitrogen (nitrate and nitrite)	47	N/A	1.54	0.07	2.7
pH	292	N/A	7.9	5.03	8.99
Phosphorus	57	0.100 mg/L	0.05	0.02	0.132
Specific conductance	292	N/A	531.47	0.51	661
Temperature, water	368	N/A	15.35	1.22	25.56
Total suspended solids	59	30.0 mg/L	9.79	2	43
Transparency, tube with disk	419	N/A	73.25	19	120
Volatile suspended solids	28	N/A	3.14	1.2	7.6

Nutrients – Phosphorus

Phosphorus values from the extensive dataset on Johnson Creek (Table 4), shows that the average total phosphorus (TP) is well below the Central Region River Nutrient standard (0.100 mg/L) with an average value of 0.05 mg/L. However, although the average phosphorus value is low, there is evidence that TP can become elevated during the summer months, as 5% of the samples were above the standard. Overall, due to 95% of the phosphorus values meeting the standard, phosphorus is not considered to be a stressor in Johnson Creek.

Dissolved Oxygen

Extensive dissolved oxygen (DO) data has been collected on Johnson Creek (Table 4), which indicated that the DO levels are good within the creek with 99% of the values occurring above the standard. DO is not considered to be a stressor within Johnson Creek.

Total Suspended Solids

The total suspended solids (TSS) dataset for Johnson Creek indicates that TSS values are low within the creek, with 95% of the values occurring below the standard of 30 mg/L (Table 4). TSS is not considered to be a stressor to the aquatic life in Johnson Creek.

Conductivity

Specific conductivity values were within range on Johnson Creek (Table 4), and is not considered to be a stressor within Johnson Creek.

Temperature

Temperature values were within range on Johnson Creek (Table 4), and is not considered to be a stressor within Johnson Creek.

Habitat

Habitat was classified as fair/good on Johnson Creek, through the Minnesota Stream Habitat Assessment (MSHA) evaluations during the fish and macroinvertebrate samples (Figure 13).

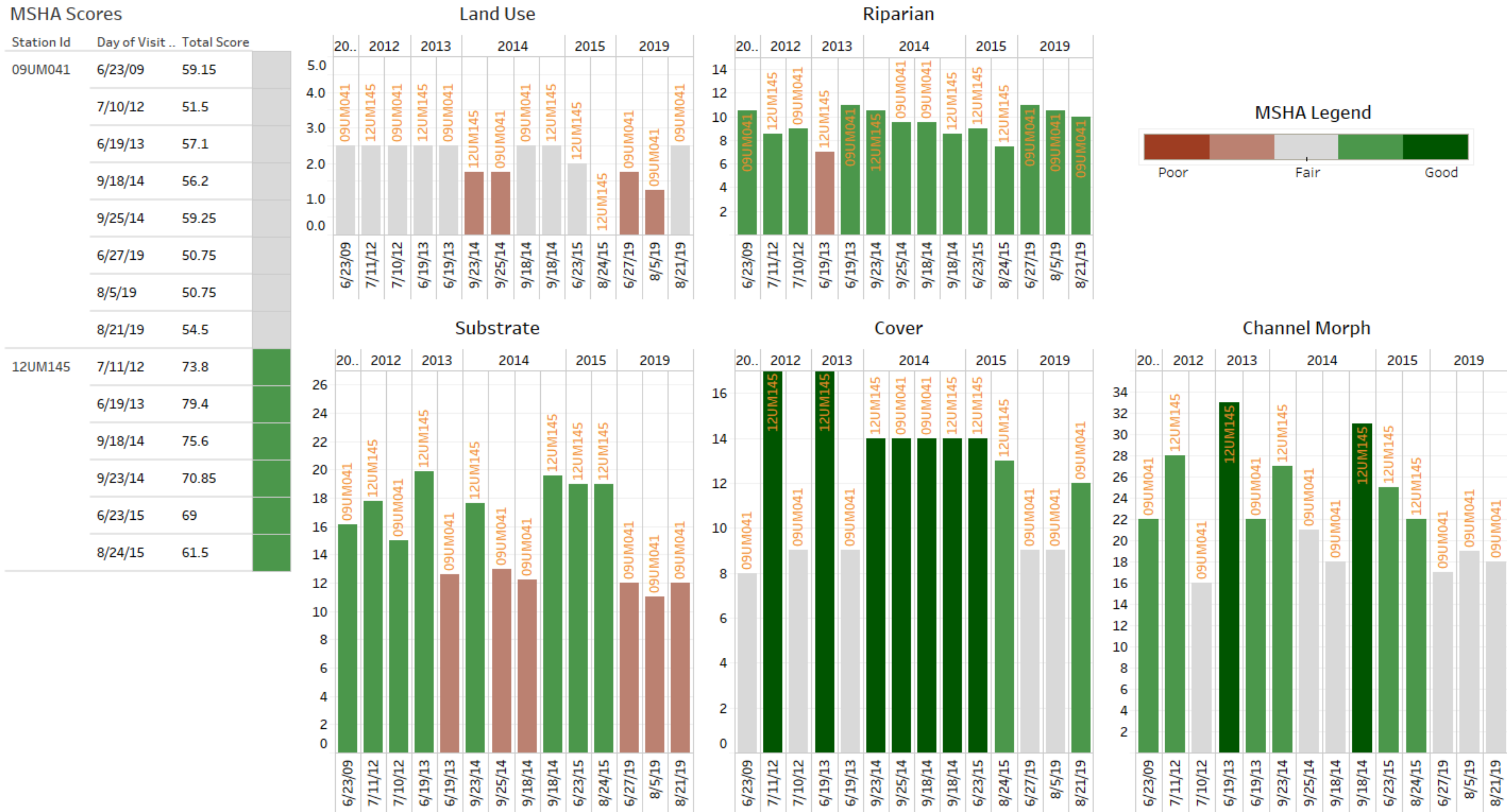


Figure 13. MSHA habitat scores for Johnson Creek.

In general, the MSHA evaluations score well on Johnson Creek, however, there is a stark difference in the habitat availability between the upstream biological monitoring station (12UM145) and the downstream station (09UM041; Figure 13). The most significant differences between the two stations can be seen in the substrate and channel morphology categories. The substrate at 12UM145 was dominated by gravel and sand, with the presence of cobble and boulders also noted. The substrate at 09UM041 was dominated by sand, with the presence of silt noted. Healthy fish communities need coarse substrate in order to build nests and spawn. Excessive fine sediment also affects juvenile fishes, as the sediment is stirred into the water column creating TSS. This can easily tear sensitive juvenile fish gills. Similarly, many sensitive macroinvertebrates also have specialized gills that are used to breathe DO. Excessive fine sediments can damage these gills, similar to juvenile fishes, making the creek uninhabitable for sensitive species.

In addition to the differences in substrate between the two biological monitoring stations, channel morphology also changed between the two stations. The channel morphology score at 12UM145 indicated that the channel development was excellent (well defined pools, runs, and riffles). In contrast, the channel morphology score at 09UM041 was fair, as no riffles were present within the reach, and the pools were small (10% of the reach). Sensitive fish and macroinvertebrates require well defined pools, riffles, and runs to feed, spawn, and to use as refuge during high precipitation events.

Lack of habitat is a direct stressor to the aquatic life within 09UM041 due to poor channel morphology and substrate.

Hydrology and geomorphology

Due to the limited habitat in the downstream portion of Johnson Creek, cross section and longitudinal profile data were collected by the MPCA SID staff in 2014. The purpose of the survey was to determine the current available habitat in terms of channel gradient, pool depths and frequency of riffles in the two study areas. The two areas that were surveyed were located at the city park off CR 7 (12UM145) and the second location was located downstream by CR75 near the Highway 94 crossing (09UM041) (Figure 14, Figure 15). The following data was collected with a Trimble R8 survey grade GPS.

Figure 14. Geomorphic survey areas for Johnson Creek circled in red. Credit Google Earth.

Figure 15. The farthest upstream site was located by Kiffmeyer Park. Credit Google Earth.

The longitudinal profile survey in the downstream reach by CR75 crossing revealed a very flat slope. The water surface slope is 0.0003 ft and the channel slope is 0.00005. This section is very flat and does not appear to have enough energy to keep the pools scoured, and therefore, there is very little habitat variability. The substrate in this downstream reach was dominated by sand and had very little to no gravel. In addition, a large cattle pasture is located upstream of 09UM041 and it appears that the historical bank erosion caused by the cattle in the stream has transported a large volume of sand downstream. This lower section has also lost a fair amount of stream length because of suspected sedimentation and channel abandonment over time. Google Earth aerial photos from 1991 to 2003, show several streams abandoned channels (Figure 16, Figure 17).

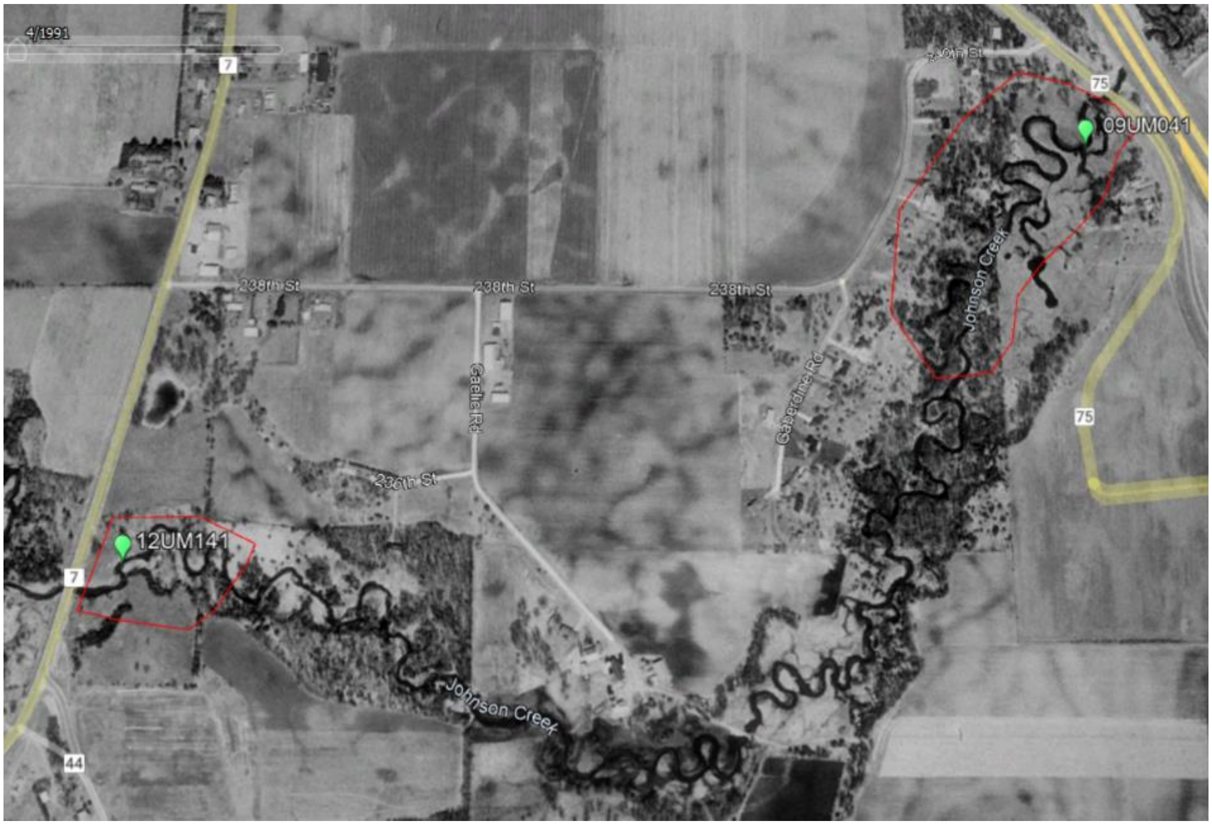


Figure 16. 1991 Aerial image of Johnson Creek, showing several abandoned channels. Credit Google Earth.

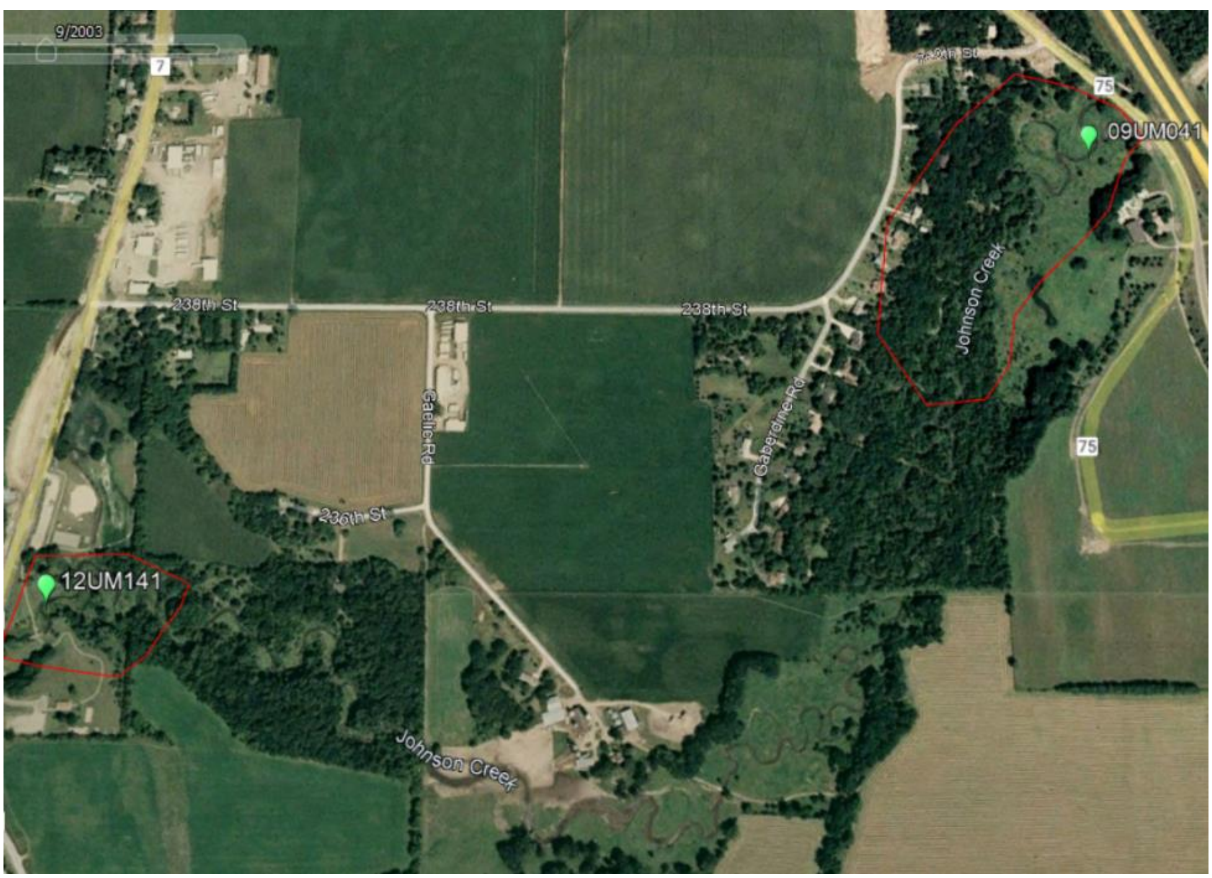


Figure 17. 2003 Aerial image of Johnson Creek, showing several abandoned channels. Credit Google Earth.

As for the cross sections, the two steam sections that were surveyed were very similar in cross sectional area, with both cross sections being classified as C channels that are slightly entrenched. The main difference between the two stream reaches was in channel slope and available pool quality for fish habitat. The upstream section near Kiffmeyer Park has a slope of 0.00192, a distance of 736 ft and a height change of -1.41 ft. This section Johnson Creek had sand, gravel and cobble substrate, and the bankfull pool depths were greater than two times the bankfull riffle depths. Habitat in the upstream reach is of better quality than the habitat downstream by CR75 and the I94 culverts. The downstream cross-sectional area in the pasture and downstream to 09UM041 is dominated by sandy substrates, and the confluence of Johnson Creek and the Mississippi River shows a large sand delta in a 7/4/2021 photo (Figure 18). With the sand substrate and the flattened slope, the available biological habitat is very limited in the lower section of the creek, and therefore, the hydrology and geomorphology within the lower portion of Johnson Creek is considered to be a direct stressor.

Figure 18. Large sand delta located at the confluence of Johnson Creek and the Mississippi River on 7/24/2021. Credit Google Earth.

Connectivity

The bridge crossings by 12UM145 and 09UM41 are not fish barriers. It is possible that the long box culvert under I94 could be a velocity barrier under certain flow conditions, but that was not investigated for this report.

Stressor signals from biology

Fish

Fish were sampled at 09UM041 in 2009, 2012, 2013, 2014, and at 12UM145 in 2012, 2013, 2014, and 2015 as part of the cycle I monitoring effort. Fish were resampled at 09UM041 in 2019 as part of the cycle II monitoring effort. An average of 17 fish species were collected from both 09UM041 and 12UM145. These communities were comprised of fish species that are considered to be tolerant species (Central Mudminnow, White Sucker) and intolerant species (Burbot, Mottled Sculpin, Longnose Dace). The fish IBI scores from the fish samples collected at 09UM041 were all below the impairment threshold except for the 2019 sample, which was one point above the threshold. As for 12UM145, the fish IBI scores from all four samples were all well above the threshold.

Macroinvertebrates

Macroinvertebrates were sampled at 09UM041 in 2009 and 2014, and at 12UM145 in 2014 and 2015 as part of the cycle I monitoring effort. 09UM041 was also resampled once in 2019 as part of the cycle II monitoring effort. All of these samples produced macroinvertebrate IBI scores that were above the threshold, and therefore, macroinvertebrates are meeting standards in Johnson Creek at this time.

Conclusions about stressors

Geomorphology and habitat quality declines from the upstream portion to the downstream portion of Johnson Creek. Due to the lower channel slope and additional sediment input from historic cattle management practices, the lower portion of Johnson Creek has poor habitat quality, as the pools and riffles have filled in with sand. This may explain the reduction of fish IBI scores between the upstream biological monitoring station (12UM145) and the downstream biological monitoring station (09UM041). Therefore, loss of habitat and poor geomorphology is the direct stressor within Johnson Creek.

In addition to the habitat and geomorphological stressors, the discrepancy in IBI scores between the upstream and downstream stations may be explained by the proximity to Luxemburg Creek. Luxemburg Creek (as mentioned above) is a coldwater stream that is located upstream of the Kiffmeyer park area and biological monitoring station 12UM145. It is possible that sensitive coldwater fish species from Luxemburg Creek migrate downstream to the upper portions of Johnson Creek where the water temperatures are still cool. This could explain the presence of Mottled Sculpin and Burbot in all of the fish samples at 12UM145, yet limited to a few of the samples at 09UM041, which would help to increase the IBI score.

Due to the extensive chemistry dataset collected on Johnson Creek, the conventional chemistry stressors such as DO, TSS, and TP were able to be ruled out as stressors to the aquatic life within the creek, as these parameters are meeting their respective standards.

Recommendations

The work that has been completed on Johnson Creek as part of the *E. coli* Total Maximum Daily Load (TMDL) (LeFevre et. al 2014) has significantly improved the sediment transport coming downstream from the large cattle operation between the upstream and downstream monitoring locations. Maintaining the work that was completed at part of the *E. coli* TMDL (fencing the cattle out of the creek upstream of 09UM041) will make the biggest impact to the creek, by reducing the amount of sediment that is filling in key habitat features in the downstream portion of Johnson Creek.

Plum Creek Subwatershed

The Plum Creek Subwatershed covers just under 19,000 acres, located just east of Clearwater (Figure 19). Half of the streams within the subwatershed have been straightened.

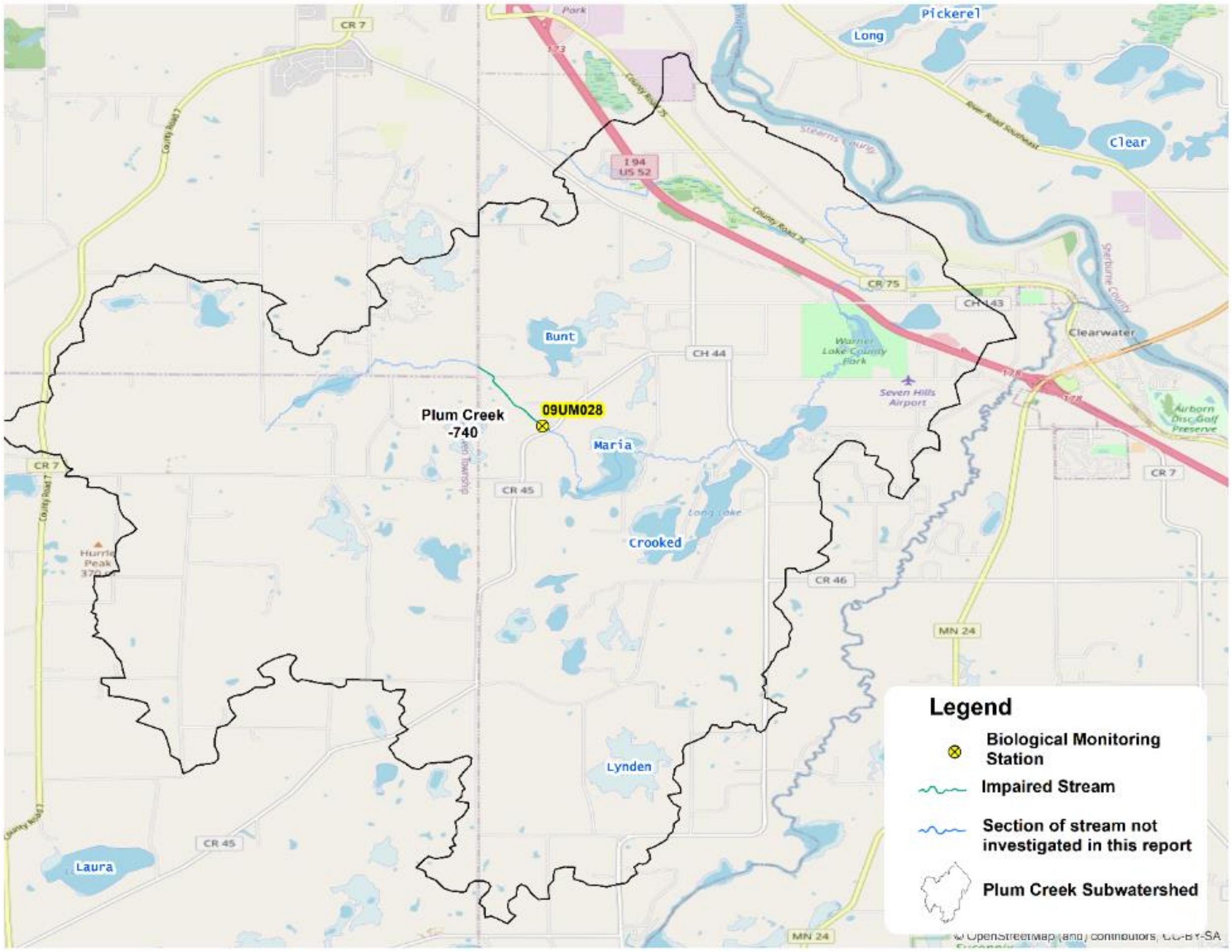


Figure 19. Biological monitoring station in the Plum Creek Subwatershed.

The land use within the Plum Creek Subwatershed is dominated by cropland (42.5%), followed by forestland (20.3%), and rangeland (13.3%) (Figure 20).

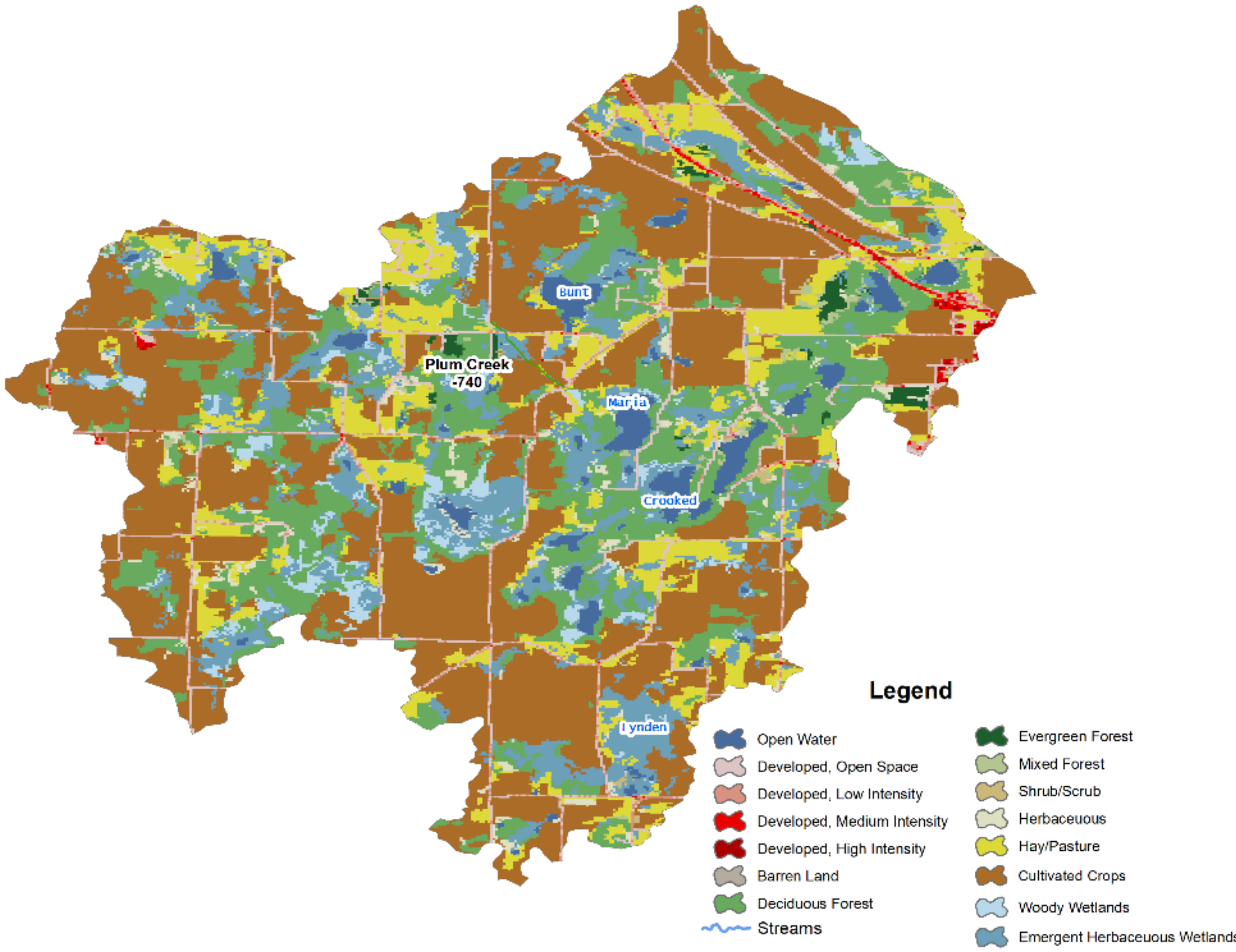


Figure 20. Land use in the Plum Creek Subwatershed. Credit: NLCD 2016.

Plum Creek (07010203-740)

Impairment: Plum Creek (AUID -740) flows for just under a mile from 13th Ave to CSAH 45, before eventually flowing into Lake Maria, four miles west of Clearwater. Plum Creek has been channelized throughout its entire reach. There is one biological monitoring station (09UM028) that was sampled for fish in 2009 (Figure 19). Plum Creek was assessed in 2019 as part of the TALU assessment process for assessing channelized streams. The UAA process determined that Plum Creek should be assessed under the modified use criteria, which resulted in a new fish impairment. The fish stream class is class 7 (Low Gradient).

Data and Analyses

Chemistry

Water chemistry data is limited to the samples that were collected during the fish sample in 2009.

Table 5. Water chemistry data collected on Plum Creek.

Parameter	Sample Count	Applicable Standard	Avg. Results	Min. Results	Max. Results
Dissolved oxygen (DO)	1	5.0 mg/L	8.95	8.95	8.95
Inorganic nitrogen (nitrate and nitrite)	1	N/A	0.2	0.2	0.2
pH	1	N/A	8.46	8.46	8.46
Phosphorus	1	0.100 mg/L	0.11	0.11	0.112
Specific conductance	1	N/A	543	543	543
Temperature, water	1	N/A	17.8	17.8	17.8
Total suspended solids	1	30.0 mg/L	24.8	24.8	24.8
Transparency, tube with disk	1	N/A	54.5	54.5	54.5
Volatile suspended solids	1	N/A	7.2	7.2	7.2

Nutrients – Phosphorus

Phosphorus values from the limited dataset on Plum Creek, shows that the average TP is just above the Central Region River Nutrient standard (0.100 mg/L) with an average value of 0.11 mg/L (Table 5). Although the dataset is limited to one sample, there is evidence that TP can become elevated during the summer months, but more samples would be needed to make a final determination of phosphorus as a stressor. The SID staff have attempted to collect more grab samples on Plum Creek, but due to critically low water levels, no other samples have been able to be collected.

Dissolved Oxygen

DO data for Plum Creek is limited to one sample, which showed that DO levels were meeting the standard (8.95 mg/L) (Table 5). However, there is not enough data to make an official determination on the DO levels within Plum Creek due to low water levels.

Total Suspended Solids

TSS data for Plum Creek is also limited to one sample (24.8 mg/L), which was just below the standard of 30 mg/L (Table 5). TSS does not appear to be a stressor to the aquatic life in Plum Creek, but due to the limited TSS data due to low water levels, TSS is an inconclusive stressor at this time.

Conductivity

Specific conductivity was limited to one sample (Table 5), but does not appear to be a stressor. However, more data would be need to make a final determination.

Temperature

Temperature data was limited to one sample (Table 5), but does not appear to be a stressor. However, more data would be need to make a final determination.

Habitat

Habitat was classified as poor on Plum Creek, through the MSHA evaluation at the fish sample (Figure 21).

Figure 21. MSHA habitat scores for Plum Creek.

Due to the historic channelization of Plum Creek, and poor MSHA score, the assessment of Plum Creek was brought into the Use Attainability Analysis (UAA) process. It was determined that the habitat of Plum Creek has degraded to a point where it cannot support good quality habitat for aquatic life, as a result of channelization. Therefore, Plum Creek was assessed using the modified use TALU criteria.

Although the MSHA score was low overall, substrate and channel morphology scored particularly low as noted in Figure 21. Substrate was the first low scoring component of the MSHA score, as indicated by the dominance of sand. Healthy fish communities need coarse substrate in order to build nests and spawn. Excessive fine sediment also affects juvenile fishes, as the sediment is stirred into the water column creating TSS, it can easily tear sensitive juvenile fish gills. Similarly, many sensitive macroinvertebrates also have specialized gills that are used to breathe DO. Excessive fine sediments can damage these gills, similar to juvenile fishes, making the creek uninhabitable for sensitive species.

Channel morphology was another low scoring component of the MSHA evaluation. The MSHA indicated that there was no channel depth variability, fair sinuosity, and no channel development (no riffles or pools). Fish and macroinvertebrates need channel depth variability to use as cover from predation and refuge during high precipitation events. No change in the channel depth combined with fair sinuosity and poor channel development impedes the fish and macroinvertebrates ability to inhabit the creek throughout the summer, especially during high flow events, which can flush these communities downstream. The lack of good channel morphology is caused by the channelization of the creek, as the manipulation of the channel has been designed to move water quickly, by mechanically removing channel sinuosity, pools, and riffles. Lack of habitat is a direct stressor to the aquatic life in Plum Creek.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology of Plum Creek, and the entire subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests to cultivated fields and the channelization of the natural streams and wetlands. Plum Creek has been straightened along the entire length of the AUID. Historically, Plum Creek was comprised of multiple wetlands and small stream channels.

Starting from Mund Lake and ending in Maria Lake, the historical stream channel was channelized to drain the landscape. This new channel cut through multiple wetlands, creating a direct connection between the two lakes. This channel alteration accelerates stream flow, resulting in higher flows during precipitation events which achieves the agricultural land use drainage goals, but causes instability. Water leaves the landscape quickly, resulting in periods of higher flow than what would have naturally occurred. As the landscape drains, water that was once held in the upstream wetlands is flushed downstream, carrying low DO water throughout the reach. Then, as these flows quickly drain, the flow regime quickly transitions to intermittent, reaching stagnant conditions starting early in the summer (Figure 22, Figure 23). Although 2021 was a dry summer, Plum Creek was already mostly dry by the end of May.


Figure 22. Plum Creek on 6/10/21, showing an almost dry channel with only 1 inch of water in the channel.

Figure 23. Plum Creek intermittent flow at the end of June 2021.

Due to the channelization of Plum Creek, the creek does not have a natural stream pattern that can be assessed for stability. Utilizing the biological monitoring sampling pictures and MSHA evaluations of stream bank condition, the banks appear to be stable and not actively eroding. The current channel size is most likely much larger than the historic stream channels that existed prior to the channelization, and is showing signs that the channel is receiving excess sediment from the banks or the landscape, as sand was the only substrate noted within the MSHA evaluation. It is possible that this excess sediment would have historically settled out within the wetlands that made up most of the riparian pre-settlement, but due to the channelization, the sediment is flushed downstream during precipitation events. Therefore, due to the altered hydrology and geomorphology of Plum Creek causing the channel to dry up, it is considered to be a direct stressor within Plum Creek.

Connectivity

The culvert crossing by 09UM028 off CR45 does not appear to be a fish barrier.

Stressor signals from biology

Fish

Fish were sampled in 2009 as part of the cycle I monitoring effort. A total of three fish species were collected, with the Central Mudminnow being the most dominate. The Central Mudminnow is one of the most pollution tolerant fish species within the State of Minnesota. All of the other fish species that were collected are also considered tolerant of pollutants (Creek Chub, Johnny Darter).

Tolerance index values (TIV) were calculated for Plum Creek using the fish community. The TSS TIV found that the fish community has an 83% probability of coming from a stream that is meeting the TSS standard. No fish species that are considered to be tolerant or sensitive of elevated TSS were found within any of the fish samples, indicating a weak TSS signal from the biology. Therefore, the fish community response to TSS is weak, and inconclusive at this time.

DO TIV scores were also calculated for Plum Creek using the fish communities. These TIV scores found that the fish community within Plum Creek is very tolerant to low DO, as the score indicated that, on average, there was only a 2% chance that the fish community the was collected within the creek would come from a stream that was meeting the DO standard. Most of the fish collected within the sample are considered to be either tolerant or very tolerant of low DO, indicating that low DO has the potential to be a stressor to the fish community within Plum Creek.

Phosphorus tolerance of the fish community was also investigated in Plum Creek using the fish species characteristics. One of the fish collected within the sample was considered to be tolerant of elevated phosphorus. As for sensitive species, no fish that are sensitive or intolerant of elevated phosphorus were found in the sample. The presence of elevated phosphorus tolerant species and the absence of intolerant species indicates that phosphorus may be a stressor to the fish community within Plum Creek. However, due to only one species having a sensitivity to phosphorus, the fish community response to phosphorus is weak, and is therefore inconclusive.

Macroinvertebrates

Macroinvertebrates were not able to be sampled during the 2009 monitoring effort due to dry stream conditions, and 09UM028 was not sampled for fish or macroinvertebrates in 2019.

Composite conclusion from biology

The fish TIVs are indicating that low DO is a stressor to the aquatic life within Plum Creek, however, the limited DO dataset indicates that DO is at healthy levels.

The TIVs indicate that TSS and phosphorus do not appear to be stressors to the aquatic life within Plum Creek.

The habitat and geomorphology are heavily altered within Plum Creek, and are the direct stressors to the aquatic life within Plum Creek.

Conclusions about stressors

The fish TIVs indicate that DO is a stressor to the fish community within this section of Plum Creek, however, this may be the result of the low DO tolerant fish species also having the ability to survive in streams with poor habitat and altered hydrology. Therefore, altered hydrology is the direct stressor to the biology in Plum Creek. Poor sinuosity, poor channel development, and fine sediment were noted within the MSHA assessment. These are the result of channel over widening and the creation of a new channel through large wetlands. Sensitive fish and macroinvertebrates require coarse substrate and good channel morphology to survive and reproduce. However, good sinuosity and the pools and riffles that naturally occur within streams and rivers, do not exist in this section of Plum Creek due to the channel alteration. As for the substrate in Plum Creek, due to creating a channel through several wetlands, sand has covered all of the coarse substrates that would exist naturally.

As a result of channelization, the altered geomorphology and habitat of Plum Creek is impeding the ability of intolerant fish species from surviving in the creek.

Recommendations

Maintaining compliance with the Buffer Law will help avoid erosion issues. Most of the creek has a nice wide buffer, although there are places where cattle have access to the creek, and if fenced out, it may help stabilize the substrate.

Stream restoration to a smaller channel with a sinuous pattern would be a way to improve habitat. This would require a cooperative effort between landowners and local government units, as the additional land that would be needed for a restoration project is privately owned.

More chemistry data could be collected to confirm that phosphorus, DO, and TSS are not stressors to the aquatic life within Plum Creek.

Upper Clearwater River Subwatershed

The Upper Clearwater Subwatershed covers 33,950 acres, located in Watkins (Figure 24). Over half of the streams within the subwatershed have been straightened.

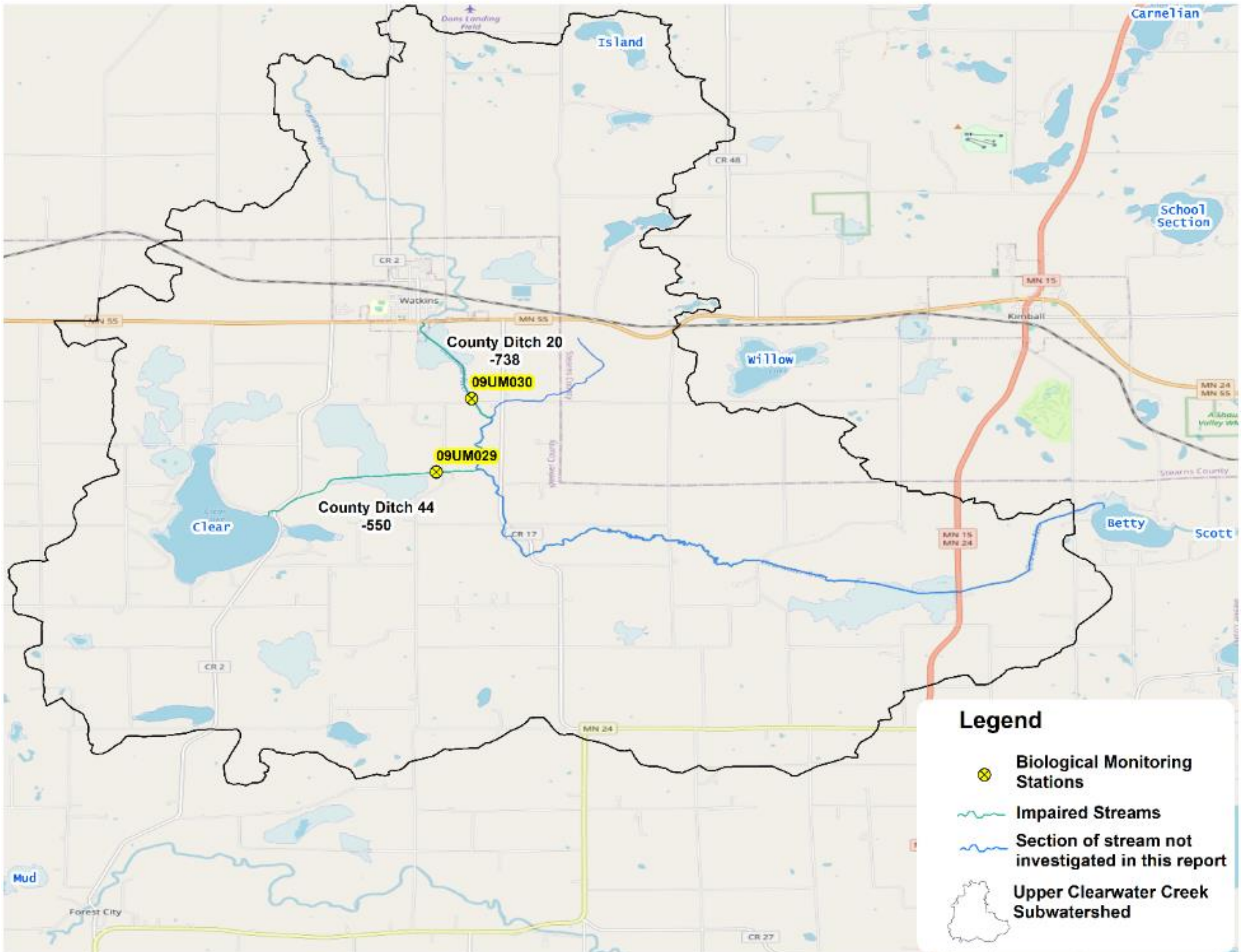


Figure 24. Biological monitoring stations within the Upper Clearwater River Subwatershed.

The land use within the Upper Clearwater River Subwatershed is dominated by cropland (73.4%), followed by rangeland (9.3%), and barren land (5.3%) (Figure 25).

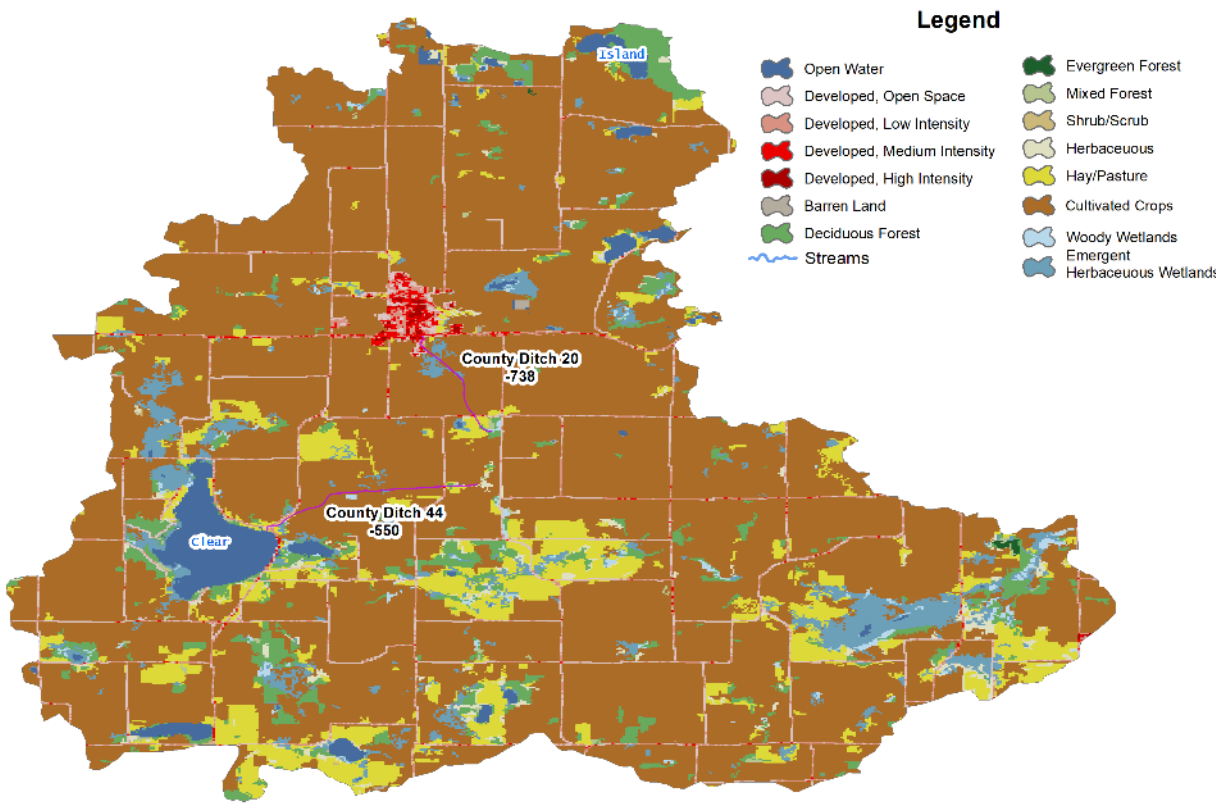


Figure 25. Land use within the Upper Clearwater River Subwatershed. Credit: NLCD 2016.

County Ditch 44 (07010203-550)

Impairment: County Ditch 44 (AUID -550) flows for 2 miles from Clear Lake to the Clearwater River, just south Watkins. County Ditch 44 has been channelized throughout the entire reach. There is one biological monitoring station (09UM029) that was sampled for fish and macroinvertebrates in 2009 (Figure 24). County Ditch 44 was assessed in 2019 as part of the TALU assessment process for assessing channelized streams. The UAA process determined that County Ditch 44 should be assessed under the general use criteria, due to fair habitat scores. This assessment resulted in new fish and macroinvertebrate impairments. The fish stream class is class 6 (Northern Headwaters), and the macroinvertebrate stream class is class 5 (Southern Streams Riffle/Run).

Data and Analyses

Chemistry

Water chemistry data has been collected in multiple locations (S002-714, S003-407, S003-912, and S011-224) on County Ditch 44 (Table 6). The dataset ranges throughout various years from 1981 through 2016. Data from 2002 through 2016 were used to aid in SID process of the biological impairments from the 2009 sampling effort on County Ditch 44.

Table 6. Water chemistry data collected on County Ditch 44 from 2002-2016. Data available at https://webapp.pca.state.mn.us/surface-water/search.

Parameter	Count of Samples	Applicable Standard	Avg. Result	Min. Result	Max. Result
Ammonia-nitrogen	2	N/A	0.32	0.14	0.5
Chlorophyll a, uncorrected for pheophytin	12	N/A	33.59	1.1	111
Dissolved oxygen (DO)	23	5.0 mg/L	9.14	3.17	16.94
Inorganic nitrogen (nitrate and nitrite)	11	N/A	9.08	0.47	47.7
pH	23	N/A	8.02	6.85	9.12
Phosphorus	18	0.100 mg/L	0.19	0.07	0.46
Specific conductance	24	N/A	727.17	358.2	1,716
Temperature, water	24	N/A	19.43	8.07	27.7
Total suspended solids	14	30.0 mg/L	18.86	2	45.2
Transparency, tube with disk	2	N/A	38	18	58
Volatile suspended solids	2	N/A	11.5	8.2	14.8

Nutrients – Phosphorus

Phosphorus values from the County Ditch 44, shows that the average TP is almost double the Central Region River Nutrient standard (0.100 mg/L) with an average value of 0.19 mg/L (Table 6). In addition, a maximum value of 0.46 mg/L was collected, and 73.7% of the phosphorus values across the dataset were above the standard, indicating that there is strong potential for eutrophication to occur within County Ditch 44. Due to the elevated phosphorus values, phosphorus is considered to be a direct stressor to the aquatic life within County Ditch 44.

Chlorophyll-a

Chlorophyll-*a* values are elevated within the dataset with a maximum value of 111.0 mg/L (Table 6). However, it is likely that this elevated sample contained duckweed within the sample, as duckweed is prevalent within the channel throughout the summer (Figure 27).

Dissolved Oxygen

Twenty-three DO samples have been collected from 2002 through 2016 on County Ditch 44. Seven of the 23 samples were below the DO standard of 5.0 mg/L. These data also indicate that the DO levels within County Ditch 44 are unstable, with DO values ranging from 3.17 mg/L to 16.94 mg/L (Table 6). This fluctuation in DO levels further indicates that eutrophication may be occurring in County Ditch 44. Due to the unstable DO levels, and the strong potential for eutrophication to occur, DO is considered to be a direct stressor to the aquatic life within County Ditch 44.

Total Suspended Solids

The TSS dataset for County Ditch 44 indicates that TSS levels may be elevated at times, as 26.7% of the samples were above standard of 30 mg/L, but the average value was below the standard at 18.33 (Table 6). Therefore, TSS does not appear to be a definitive stressor to the aquatic life in County Ditch 44, but due to the presence of elevated values in the dataset, TSS does have the potential to be a direct stressor to the aquatic life.

Conductivity

Specific conductivity was within range throughout the dataset on County Ditch 44, except for one elevated value of 1716 µS (Table 6). Therefore, conductivity does not appear to be a stressor to the aquatic life within County Ditch 44 at this time.

Temperature

Temperature data was within range throughout the dataset on County Ditch 44 (Table 6), and does not appear to be a stressor to the aquatic life within County Ditch 44 at this time.

Habitat

Habitat was classified as fair on County Ditch 44, through the MSHA evaluations (Figure 26).

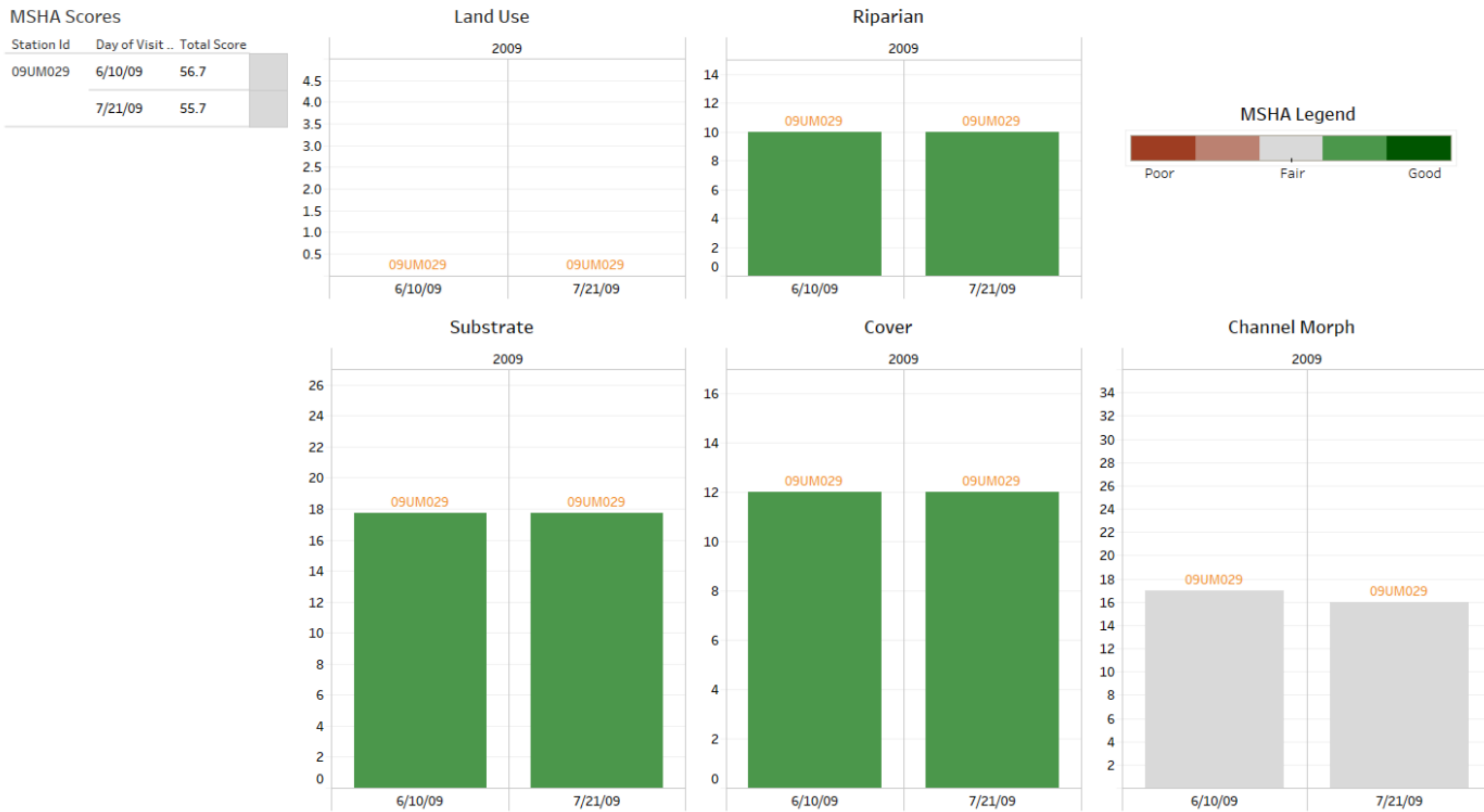


Figure 26. MSHA habitat scores for County Ditch 44.

Due to the historic channelization of County Ditch 44, and fair MSHA score, the assessment of County Ditch 44 was brought into the UAA process. It was determined that the habitat of County Ditch 44 has not degraded to a point where it cannot support good quality habitat for aquatic life, as a result of channelization. Therefore, County Ditch 44 was assessed using the general use TALU criteria.

Although the average MSHA score was fair overall, substrate and channel morphology scored particularly low, which lowered the overall MSHA score (Figure 26). Substrate was the first low scoring component of the MSHA score, as indicated by the dominance of clay and silt. Healthy fish communities need coarse substrate in order to build nests and spawn. Excessive fine sediment also affects juvenile fishes, as the sediment is stirred into the water column creating TSS, it can easily tear sensitive juvenile fish gills. Similarly, many sensitive macroinvertebrates also have specialized gills that are used to breathe DO. Excessive fine sediments can damage these gills, similar to juvenile fishes, making the ditch uninhabitable for sensitive species. Gravel was present within the channel, but was sparse. This could indicate that the stream channel historically had coarse substrate, but has been removed through the excavation.

Channel morphology was another low scoring component of the MSHA evaluation. The MSHA indicated that there was fair channel depth variability, poor sinuosity, and moderate channel stability. Fish and macroinvertebrates need channel depth variability to use as cover from predation and refuge during high precipitation events. Minimal change in the channel depth combined with fair sinuosity impedes the fish and macroinvertebrates ability to inhabit the creek throughout the summer, especially during high flow events**,** which can flush these communities downstream. The lack of good channel morphology is caused by the channelization of the creek, as the manipulation of the channel has been designed to move water quickly, by mechanically removing channel sinuosity, pools, and riffles. Lack of habitat is a direct stressor to the aquatic life in County Ditch 44.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology of County Ditch 44, and the entire subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests to cultivated fields and the channelization of the natural streams and wetlands. County Ditch 44 has been straightened along the entire length of the AUID. Historically, the stream channel that now makes up County Ditch 44, did not exist. The channel flowed north from Clear Lake, and flowed into the Clearwater River, just south of Watkins. The new channel was excavated to straighten the channel straight east, which allowed a large wetland complex to be filled in, and converted to agriculture. This channel alteration accelerates stream flow, resulting in higher flows during precipitation events which achieves the agricultural land use drainage goals, but causes instability. Water leaves the landscape quickly, resulting in periods of higher flow than what would have naturally occurred. As the landscape drains, the flow regime quickly transitions to low flow, reaching stagnant conditions starting early in the summer (Figure 27).

Figure 27. Stagnant flow in County Ditch 44 starting in June.

Due to the channelization of County Ditch 44, the ditch does not have a natural stream pattern that can be assessed for stability. Utilizing the biological monitoring sampling pictures and MSHA evaluations of stream bank condition, the banks appear to be stable and not actively eroding. The current channel size is most likely similar in size to the historic stream channels that existed prior to the channelization, but the new channel is much shorter, which drains the channel quickly. Historically, the water coming out of Clear Lake would travel a longer route to the Clearwater River, but due to the new ditch channel, the water reaches the Clearwater River much faster. In addition, County Ditch 44 originates in Clear Lake, which has a nutrient impairment with an approved TMDL, and due to the ditched channel, this nutrient rich water has a direct route to the Clearwater River, which may also explain the elevated TP levels within the ditch. In addition, chlorophyll-*a* data was collected at the confluence of County Ditch 44 and the Clearwater River (Figure 28), and although the data were meeting standards at that time, this has the potential to become a future eutrophication impairment. Due to these hydrologic and geomorphic alterations of the historical stream channel, altered hydrology is considered to be a direct stressor to the aquatic life within County Ditch 44.

Figure 28. Clearwater River just downstream of the confluence of the Clearwater River and County Ditch 44.

Connectivity

The culvert crossing by 09UM029 off 677th Ave does not appear to be a fish barrier.

Stressor signals from biology

Fish

Fish were sampled twice in 2009 as part of the cycle I monitoring effort. A total of three fish species were collected, with White Suckers being the most dominate. White Suckers are one of the most pollution tolerant fish species within the state of Minnesota. All of the other fish species that were collected are also considered tolerant of pollutants.

TIVs were calculated for County Ditch 44 using the fish community. The TSS TIV found that the fish community has an average of 64% probability of coming from a stream that is meeting the TSS standard. No fish species that are considered to be tolerant or sensitive of elevated TSS were found within any of the fish samples, indicating a weak TSS signal from the biology. Therefore, the fish community response to TSS is weak, and therefore, is inconclusive at this time.

DO TIV scores were also calculated for County Ditch 44 using the fish communities. This calculation indicated that the fish community has an average probability of 83% of coming from a stream that was meeting the DO standard. One of the fish species collected within the two samples is considered to be tolerant of low DO, while the other two species do not have a documented sensitivity to low DO. Therefore, the fish community response to DO is weak, and therefore, is inconclusive at this time.

Phosphorus tolerance of the fish community was also investigated in County Ditch 44 using the fish species characteristics. One of the fish collected within the samples was considered to be tolerant of elevated phosphorus. As for sensitive species, no other fish that are sensitive or intolerant of elevated phosphorus were found in the sample. The presence of elevated phosphorus tolerant species and the absence of intolerant species indicates that phosphorus may be a stressor to the fish community within County Ditch 44. However, due to only one species having a sensitivity to phosphorus, the fish community response to phosphorus is weak, and is therefore inconclusive.

Macroinvertebrates

Macroinvertebrates were also sampled in 2009 as part of the cycle I watershed monitoring effort. In 2009, 84% of the macroinvertebrate community that was sampled was comprised of taxa that are considered to be tolerant of pollutants, and 63.2% of the community was considered to be very tolerant of pollutants. *Physa* and *Stagnicola* snails dominated the sample, and are both considered to be tolerant taxa.

TSS taxa tolerance was investigated using the macroinvertebrate communities. In the 2009 sample, no intolerant taxa, 18 tolerant taxa, and 9 very tolerant taxa were collected (Table 7). Overall, the macroinvertebrate community within County Ditch 44 indicates that TSS is a stressor to the macroinvertebrate community.

DO tolerance was also investigated using the macroinvertebrate communities. In 2009, 1 very intolerant, 3 intolerant taxa, 18 tolerant taxa, and 11 very tolerant taxa were collected (Table 7). Although there is are a few intolerant taxa present, tolerant and very tolerant taxa dominated the sample, and indicate that low DO has the potential to be a stressor to the macroinvertebrate community within County Ditch 44. This low DO signature by the macroinvertebrate community may further suggest that low DO is a stressor to the fish community.

The final tolerance indicator that was investigated within the macroinvertebrate community was phosphorus tolerance. In the 2009 sample, 1 intolerant taxa, 23 tolerant taxa and 13 very tolerant taxa were collected (Table 7). These tolerance indicators within the macroinvertebrate community indicate that phosphorus is a stressor to the macroinvertebrate community within County Ditch 44, and may further suggest the elevated phosphorus is a stressor to the fish community.

Table 7. Macroinvertebrate tolerance index values for County Ditch 44.

Parameter	Taxa Tolerance	2009 Sample
DO	# Intolerant	3
	# Tolerant	18
	# Very Intolerant	1
	# Very Tolerant	11
Phosphorus	# Intolerant	1
	# Tolerant	23
	# Very Intolerant	0
	# Very Tolerant	13
TSS	# Intolerant	0
	# Tolerant	18
	# Very Intolerant	0
	# Very Tolerant	9

Composite conclusion from biology

The TSS, DO, and phosphorus TIVs were inconclusive for fish, but did indicate that TSS, DO, and, phosphorus are direct stressors to the macroinvertebrate community.

The habitat and geomorphology are heavily altered within County Ditch 44, and are also direct stressors to the aquatic life within the ditch.

Conclusions about stressors

The fish samples were limited to three total species collected, which limited the ability to utilize the TIVs. However, the macroinvertebrate TIVs were able to be used, which indicated that TSS, DO, and phosphorus all have the potential to the stressor to the aquatic life within County Ditch 44, with DO and phosphorus having the strongest signals. The elevated TP and unstable DO levels within the chemistry dataset collected on County Ditch 44 further indicate that TP and DO are stressors to the aquatic life within the ditch.

Altered hydrology and geomorphology have also impacted the aquatic life within County Ditch 44, by removing habitat, increasing the amount of nutrients drained from the landscape and from Clear Lake to the downstream Clearwater River, and altering the historic flow conditions. Good quality habitat such as coarse substrate, good channel development, and good depth variability are critical for the survival of sensitive fish and macroinvertebrates. Sensitive fish species like the Hornyhead Chub utilize coarse substrate to build nests for spawning. Similarly, sensitive macroinvertebrate taxa use coarse substrate, aquatic vegetation, and woody debris as attachment surfaces to avoid floating downstream, which allows them to feed. These important habitat types have been removed by the ditching process. In addition to the TP and DO stressors as indicated by the macroinvertebrate TIVs and the chemistry dataset, the channel alteration has accelerated the amount of nutrients flowing downstream. The historic stream channel was much longer, which would have allowed some of the nutrients to be consumed by aquatic vegetation growth, but due to the shortened channel, the nutrients quickly flow through the ditch and end up in the Clearwater River. Therefore, the aquatic life within County Ditch 44 experience the elevated nutrients and poor DO conditions due to the altered hydrology. Similarly, the stream flow within the channel would have historically flowed slower and had a longer stream channel, but it now drains quickly. It is difficult for aquatic life to survive without constant water flow, with periods of dry or stagnant conditions.

County Ditch 20 (07010203-738)

Impairment: County Ditch 20 (AUID -738) flows for 1.4 miles from Hwy 55 to Unnamed Creek, 2 miles south of Watkins. County Ditch 20 has been channelized throughout the entire reach. There is one biological monitoring station (09UM030) that was sampled for fish and macroinvertebrates in 2009 (Figure 24). County Ditch 20 was assessed in 2019 as part of the TALU assessment process for assessing channelized streams. The UAA process determined that County Ditch 20 should be assessed under the modified use criteria. This assessment resulted in new fish and macroinvertebrate impairments. The fish stream class is class 6 (Northern Headwaters), and the macroinvertebrate stream class is class 5 (Southern Streams Glide/Pool).

Chemistry

Water chemistry data has been collected in multiple locations (S003-404, S003-406, and S011-225) on County Ditch 20 (Table 8). The dataset ranges throughout various years from 1981 through 2021. Data from 2002 through 2021 were used to aid in SID of the biological impairments from the 2009 sampling effort on County Ditch 20.

Table 8. Water chemistry data collected on County Ditch 20 from 2002-2021. Data available at https://webapp.pca.state.mn.us/surface-water/search.

Parameter	Count of Samples	Applicable Standard	Avg. Result	Min. Result	Max. Result
Ammonia-nitrogen	3	N/A	0.39	0.29	0.59
Chlorophyll a, uncorrected for pheophytin	7	N/A	19.01	3	51
Dissolved oxygen (DO)	72	5.0 mg/L	7.77	0.24	20.16
Inorganic nitrogen (nitrate and nitrite)	41	N/A	6.96	0.22	19.2
pH	67	N/A	7.73	6.91	8.69
Total Phosphorus	64	0.100 mg/L	0.42	0.07	4.69
Specific conductance	59	N/A	758.56	7.69	1,487
Temperature, water	73	N/A	14.59	0.03	23.6
Total suspended solids	60	30.0 mg/L	12.45	1.6	201
Transparency, tube with disk	4	N/A	84.75	39	100

Nutrients – Phosphorus

Phosphorus values from County Ditch 20, shows that the average TP is over four times the Central Region River Nutrient standard (0.100 mg/L) with an average value of 0.42 mg/L (Table 8). In addition, a maximum value of 4.69 mg/L was collected, and 94.2% of the phosphorus values across the dataset were above the standard, indicating that there is strong potential for eutrophication to occur within County Ditch 20. Due to the elevated phosphorus values, phosphorus has a strong potential to be a direct stressor to the aquatic life within County Ditch 20.

Dissolved Oxygen

Seventy-two DO samples have been collected from 2002 through 2021 on County Ditch 20. Of the 72 samples, 20 were below the DO standard of 5.0 mg/L. These data also indicate that the DO levels within County Ditch 20 are unstable, with DO values ranging from 0.24 mg/L to 20.16 mg/L (Table 8). This fluctuation in DO levels further indicates that eutrophication may be occurring in County Ditch 20. Due to the unstable DO levels, and the strong potential for eutrophication to occur, DO is considered to be a direct stressor to the aquatic life within County Ditch 20.

Total Suspended Solids

The TSS dataset for County Ditch 20 indicates that TSS levels may be elevated at times, but only 6.6% of the samples were above standard of 30 mg/L (Table 8). The average value was below the standard at 12.32. Therefore, TSS does not appear to be a definitive stressor to the aquatic life in County Ditch 20, but due to the presence of elevated values in the dataset with a maximum value of 201.0 mg/L, TSS does have the potential to contributing root cause that is stressing the aquatic life within County Ditch 20.

Conductivity

Specific conductivity was within range throughout the dataset on County Ditch 20, except for one elevated value of 1487 µS (Table 8). Therefore, conductivity does not appear to be a stressor to the aquatic life within County Ditch 20 at this time.

Temperature

Temperature data was within range throughout the dataset on County Ditch 20 (Table 8), and does not appear to be a stressor to the aquatic life within County Ditch 44 at this time.

Habitat

Habitat was classified as fair on County Ditch 20, through the MSHA evaluation at the fish sample (Figure 29).

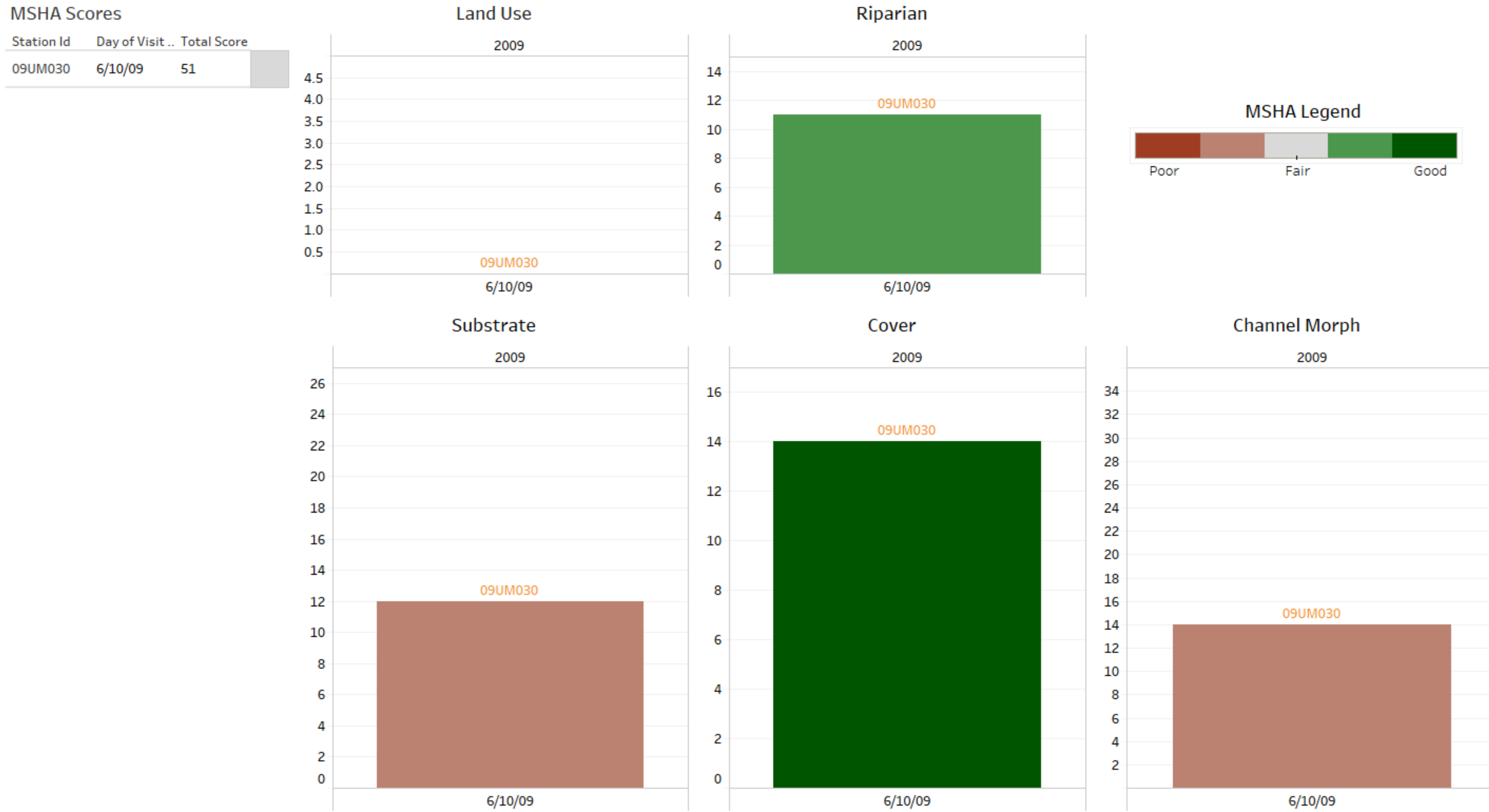


Figure 29. MSHA habitat scores for County Ditch 20.

Due to the historic channelization of County Ditch 20, and poor MSHA score, the assessment of County Ditch 20 was brought into the UAA process. It was determined that the habitat of County Ditch 20 has degraded to a point where it cannot support good quality habitat for aquatic life, as a result of channelization. Therefore, County Ditch 20 was assessed using the modified use TALU criteria.

Although the average MSHA score was poor overall, substrate and channel morphology scored particularly low, which lowered the overall MSHA score (Figure 29). Substrate was the first low scoring component of the MSHA score, as indicated by the dominance of sand and silt. Healthy fish communities need coarse substrate in order to build nests and spawn. Excessive fine sediment also affects juvenile fishes, as the sediment is stirred into the water column creating TSS, it can easily tear sensitive juvenile fish gills. Similarly, many sensitive macroinvertebrates also have specialized gills that are used to breathe DO. Excessive fine sediments can damage these gills, similar to juvenile fishes, making the creek uninhabitable for sensitive species.

Channel morphology was another low scoring component of the MSHA evaluation. The MSHA indicated that there was fair channel depth variability, poor sinuosity, and fair channel development (no riffles, and poorly defined pools). Fish and macroinvertebrates need channel depth variability to use as cover from predation and refuge during high precipitation events. Minimal change in the channel depth combined with fair sinuosity impedes the fish and macroinvertebrate's ability to inhabit the creek throughout the summer, especially during high flow events, which can flush these communities downstream. The lack of good channel morphology is caused by the channelization of the creek, as the manipulation of the channel has been designed to move water quickly, by mechanically removing channel sinuosity, pools, and riffles. Lack of habitat is a direct stressor to the aquatic life in County Ditch 20.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology of County Ditch 20, and the entire subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests to cultivated fields and the channelization of the natural streams and wetlands. County Ditch 20 has been straightened along the entire length of the AUID. Historically, the stream channel that now makes up County Ditch 20, was part of a small tributary to the Clearwater River which flowed out of Clear Lake (Figure 30).

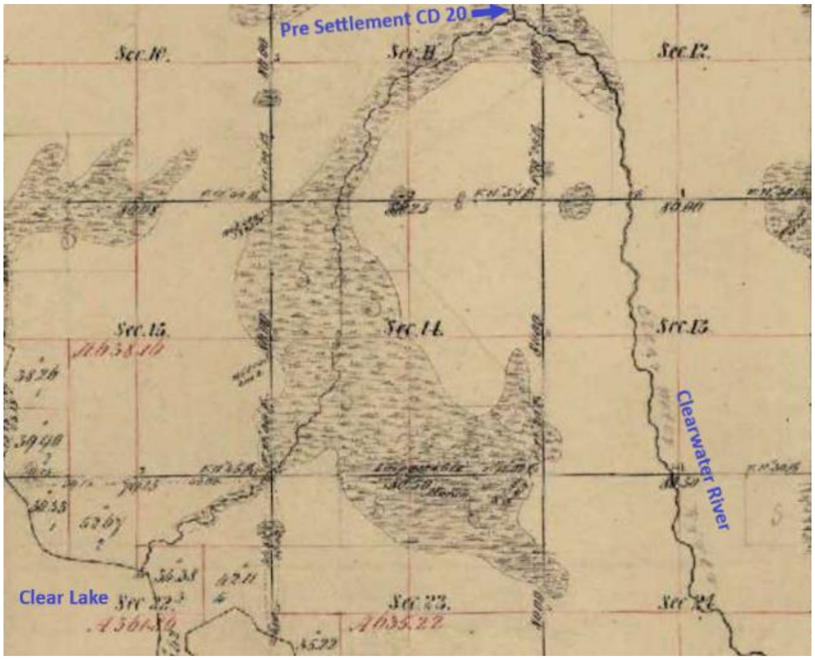


Figure 30. Historic plat map of the Clearwater River.

After settlement, the headwaters of the Clearwater River were channelized to form County Ditch 40 and County Ditch 20. County Ditch 40, as explained in the previous section, was excavated straight east of Clear Lake, and now drains quickly to the present-day Clearwater River channel. County Ditch 20**,** however, was historically a small tributary to the original Clearwater River channel but has now been excavated to drain 12.75 sq. miles of the landscape (Figure 31), which includes an additional 9.74 sq. miles that was not historically connected to the original small tributary (Figure 32).

Figure 31. County Ditch 20 current drainage area. Credit: USGS Stream Stats.

Figure 32. County Ditch 20 current drainage area, with additional drainage area from channelization denoted in blue. Credit: USGS Stream Stats.

This channel alteration accelerates stream flow, resulting in higher flows during precipitation events, which achieves the agricultural land use drainage goals, but causes instability. Water leaves the landscape quickly, resulting in periods of higher flow than what would have naturally occurred. As the landscape drains, the flow regime quickly transitions to low flow, reaching stagnant conditions starting early in the summer (Figure 33).

Figure 33. Stagnant flow conditions within County Ditch 20, early summer 2021.

Due to the channelization of County Ditch 20, the ditch does not have a natural stream pattern that can be assessed for stability. Utilizing the biological monitoring sampling pictures and MSHA evaluations of stream bank condition, the banks appear to be stable and not actively eroding. The current channel size is most likely much larger than the historic stream channels that existed prior to the channelization, due to the large drainage area of the ditch. This large drainage area, and unstable flow conditions caused by the channelization of County Ditch 20, has inhibited the ability for sensitive fish and macroinvertebrates to inhabit the ditch. Therefore, the altered hydrology and geomorphology of County Ditch 20 is a direct stressor to aquatic life.

Connectivity

The culvert crossing by 09UM030 off 380th Street does not appear to be a fish barrier. However, there is a pool just downstream of the culvert which does indicate that there may be a barrier. Looking at aerial photography (Figure 34), it does appear that this bend in the ditch channel can back up at times, which may be caused by beaver activity. No beaver activity was noted by SID staff, so connectivity as a stressor to the aquatic life within County Ditch 20 is inconclusive at this time.

Figure 34. Plunge pool on the downstream end of the culvert crossing off 380th Street.

Stressor signals from biology

Fish

Fish were sampled in 2009 as part of the cycle I monitoring effort. A total of seven fish species were collected, with Central Mudminnows being the most dominate. Central Mudminnows are one of the most pollution tolerant fish species within the state of Minnesota. All of the other fish species that were collected are also considered tolerant of pollutants.

TIVs were calculated for County Ditch 20 using the fish community. The TSS TIV found that the fish community has an average of 79% probability of coming from a stream that is meeting the TSS standard. No fish species that are considered to be tolerant or sensitive of elevated TSS were found within any of the fish samples, indicating a weak TSS signal from the biology. Therefore, the fish community response to TSS is weak, and therefore, is inconclusive at this time.

DO TIV scores were also calculated for County Ditch 20 using the fish communities. This calculation indicated that the fish community has an average probability of 2% of coming from a stream that was meeting the DO standard. Five of the fish species collected within the sample are considered to be tolerant of low DO, and four of those species are also considered to be very tolerant of low DO. None of the species that were collected were sensitive or intolerant to low DO. Therefore, the fish community response to DO indicates that DO is a stressor to the fish community within County Ditch 20.

Phosphorus tolerance of the fish community was also investigated in County Ditch 20 using the fish species characteristics. Four of the fish collected were considered to be tolerant of elevated phosphorus, and two of those species were also considered to be very tolerant of elevated phosphorus. As for sensitive species, no other fish that are sensitive or intolerant of elevated phosphorus were found in the sample. None of the species that were collected were sensitive or intolerant to elevated phosphorus. Therefore, the presence of elevated phosphorus tolerant species and the absence of intolerant species indicates that phosphorus is a stressor to the fish community within County Ditch 20.

Macroinvertebrates

Macroinvertebrates were also sampled in 2009 as part of the cycle I watershed monitoring effort. Ninety four percent of the macroinvertebrate community that was sampled in 2009 was comprised of taxa that are considered to be tolerant of pollutants, and 43% of the community was considered to be very tolerant of pollutants. *Oligochaeta* worms and *Simulium* (Blackflies) dominated the sample, and are both considered to be tolerant taxa.

TSS taxa tolerance was investigated using the macroinvertebrate communities. In the 2009 sample, no intolerant taxa, 11 tolerant taxa, and 5 very tolerant taxa were collected (Table 9). Overall, the macroinvertebrate community within County Ditch 20 indicates that TSS is a stressor to the macroinvertebrate community.

DO tolerance was also investigated using the macroinvertebrate communities. In 2009, 1 very intolerant, 1 intolerant taxa, 13 tolerant taxa, and 7 very tolerant taxa were collected (Table 9). Although there are a few intolerant taxa present, tolerant and very tolerant taxa dominated the sample, and indicate that low DO has the potential to be a stressor to the macroinvertebrate community within County Ditch 20.

The final tolerance indicator that was investigated within the macroinvertebrate community was phosphorus tolerance. In the 2009 sample, no intolerant taxa, 17 tolerant taxa and 12 very tolerant taxa were collected (Table 9). These tolerance indicators within the macroinvertebrate community indicate that phosphorus is a stressor to the macroinvertebrate community within County Ditch 20.

Table 9. Macroinvertebrate tolerance index values for County Ditch 20.

Parameter	Tolerance	2009 Sample
DO	# Intolerant	1
	# Tolerant	13
	# Very Intolerant	1
	# Very Tolerant	7
Phosphorus	# Intolerant	0
	# Tolerant	17
	# Very Intolerant	0
	# Very Tolerant	12
TSS	# Intolerant	0
	# Tolerant	11
	# Very Intolerant	0
	# Very Tolerant	5

Composite conclusion from biology

The TSS TIV was inconclusive for fish, but did indicate that DO, and phosphorus are stressors to the fish community. Similarly, the macroinvertebrate TIVs indicated the DO and Phosphorus are stressors to the macroinvertebrate community, but also indicated that TSS is a contributing stressor.

The habitat, hydrology, and geomorphology are heavily altered within County Ditch 20, and are direct stressors to the aquatic life within the ditch.

Conclusions about stressors

The TIVs from the biological sample that was collected on County Ditch 20, indicated that TSS, DO, and phosphorus are stressors to the aquatic life within County Ditch 20. The chemistry dataset also indicated that the DO levels within the ditch are unstable, and the phosphorus levels were severely elevated. Although the average TSS value was below the standard, there were elevated values within the dataset that indicated that TSS may be a stressor. Due to the chemistry data and TIVs from the biological sample, TSS, DO, and phosphorus are all direct stressors to the aquatic life within County Ditch 20.

Altered hydrology and geomorphology have also impacted the aquatic life within County Ditch 20, by removing habitat, increasing the amount of nutrients drained from the landscape to the downstream Clearwater River, and altering the historic flow conditions, by increasing the amount of land that is drained though the ditch. Good quality habitat such as coarse substrate, good channel development, and good depth variability are critical for the survival of sensitive fish and macroinvertebrates. Sensitive fish species like the Hornyhead Chub utilize coarse substrate to build nests for spawning. Similarly, sensitive macroinvertebrate taxa use coarse substrate, aquatic vegetation, and woody debris as attachment surfaces to avoid floating downstream, which allows them to feed. These important habitat types have been removed by the ditching process.

Threemile Creek Subwatershed

The Threemile Creek Subwatershed covers 12,075 acres, located just north of South Haven (Figure 35). Almost half of the streams within the subwatershed have been straightened.

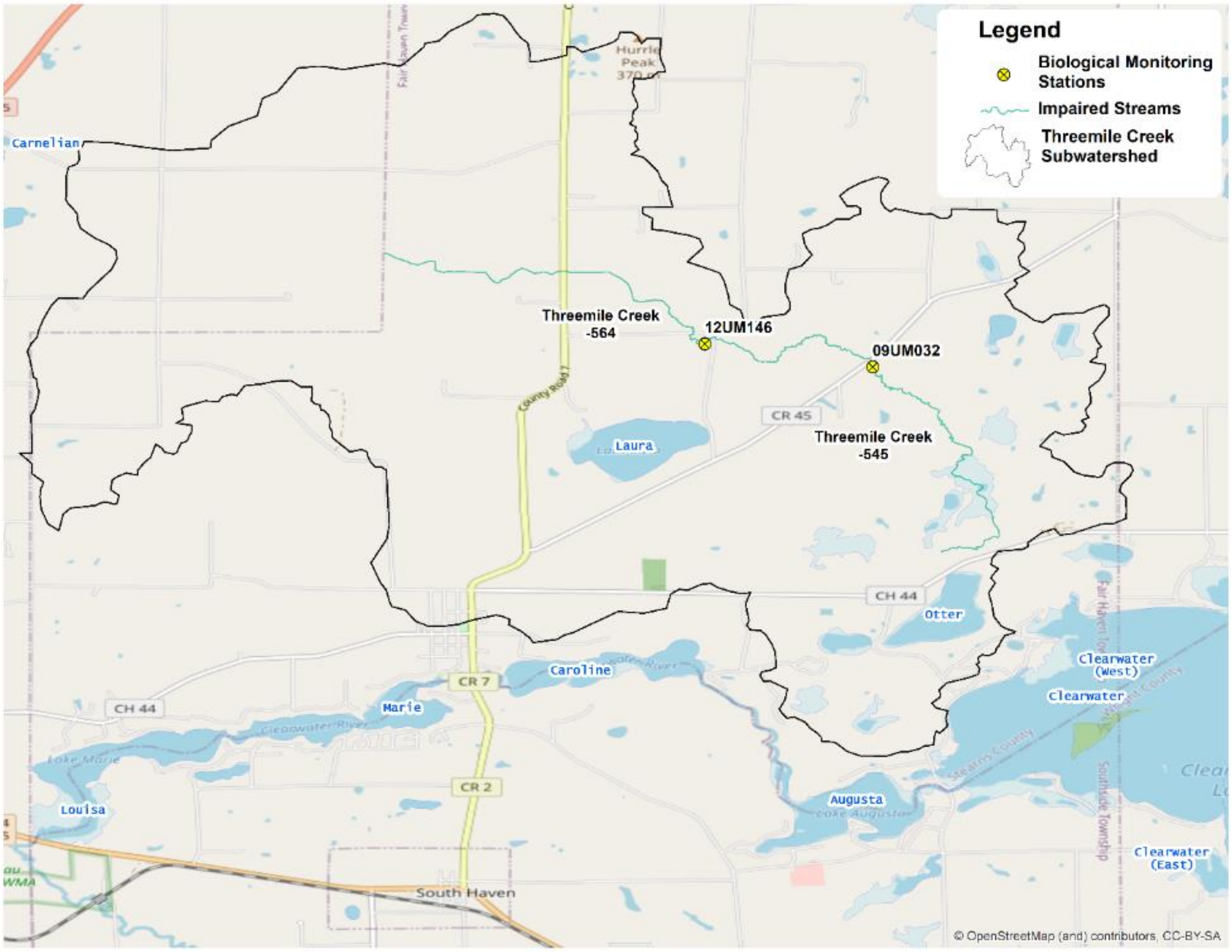


Figure 35. Biological monitoring stations within the Threemile Creek Subwatershed.

The land use within the Threemile Creek Subwatershed is dominated by cropland (56.7%), followed by wetlands (15.5%), and forest land (14.8%) (Figure 36).

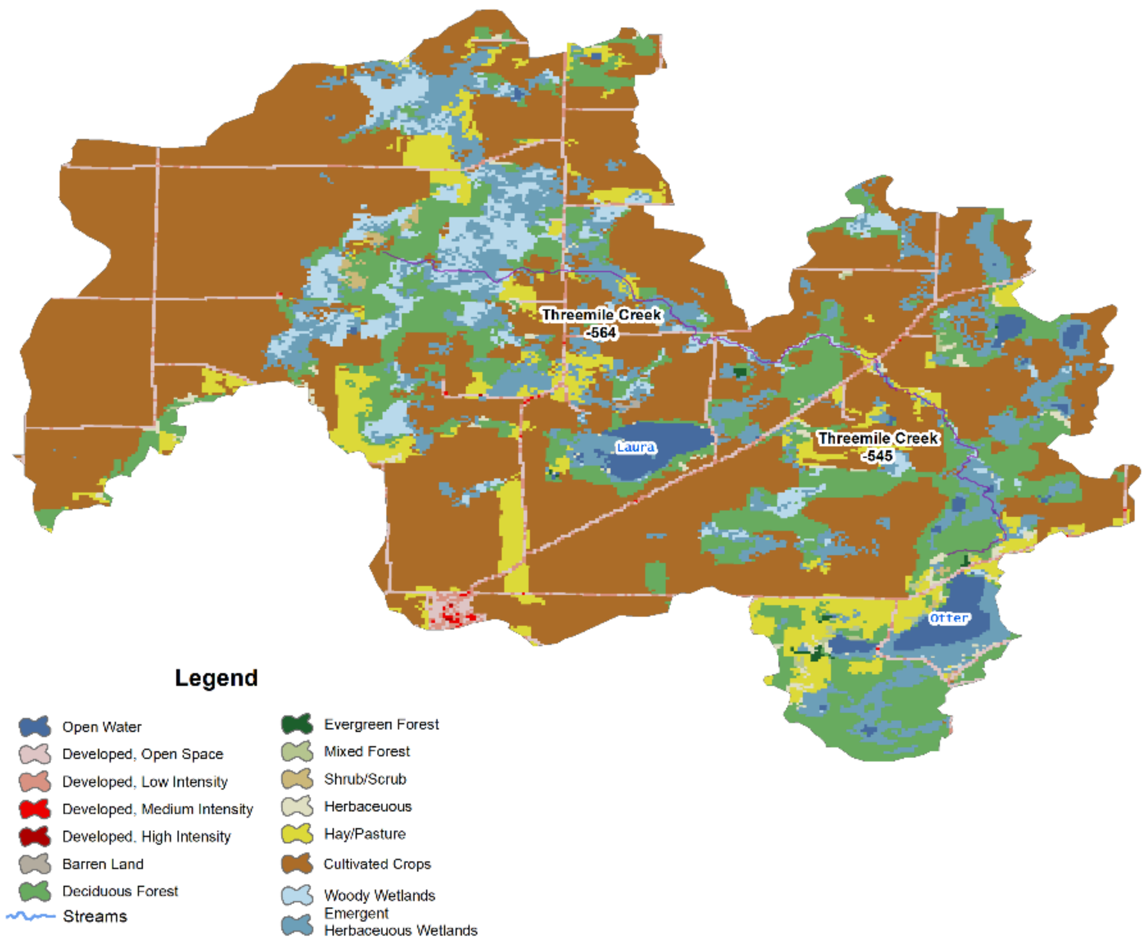


Figure 36. Land use within the Threemile Creek Subwatershed. Credit: NLCD 2016.

Threemile Creek (07010203-545)

Impairment: Threemile Creek (AUID -545) flows for 3.4 miles from the outlet of Laura Lake to just upstream of Otter Lake, 2.7 miles east of South Haven. Threemile Creek remains natural throughout the entire reach. There is one biological monitoring station (09UM032) that was sampled for fish and macroinvertebrates in 2009, 2012, 2013, and 2019 (Figure 35). Threemile Creek was assessed as a coldwater stream in 2021, which resulted in a new fish impairment. The fish stream class is class 11 (Northern Coldwater), and the macroinvertebrate stream class is class 9 (Southern Coldwater).

Threemile Creek (07010203-564)

Impairment: Threemile Creek (AUID -564) flows for 3 miles from just west of CR 1 to the confluence with the outlet of Laura Lake, 3 miles north of South Haven. Threemile Creek is mostly natural, with one short section that is channelized. There is one biological monitoring station (12UM146) that was sampled for fish and macroinvertebrates in 2012 (Figure 35). Threemile Creek was assessed as a coldwater stream in 2021, which resulted in new fish and macroinvertebrate impairments. The fish stream class is class 11 (Northern Coldwater), and the macroinvertebrate stream class is class 9 (Southern Coldwater).

Data and Analyses

The two AUIDs (-545 and -564) that are impaired on Twelvemile Creek are connected in close proximity, and therefore, will be discussed together for the purposes of this report.

Chemistry

Water chemistry data has been collected on both AUIDs in 2009, 2012, 2013, 2019, and 2021 (Table 10).

Table 10. Water chemistry data collected on Threemile Creek. Data available at https://webapp.pca.state.mn.us/surface-water/search.

AUID	EQuIS Code	Parameter	Sample Count	Applicable Standard	Avg. Results	Min. Results	Max. Results
07010203-545	S011-227	Dissolved oxygen (DO)	13	7.0 mg/L	8.71	8.03	9.11
07010203-545	S011-227	Inorganic nitrogen (nitrate and nitrite)	5	N/A	1.86	1.58	2.2
07010203-545	S011-227	Nitrate + Nitrite Nitrogen, Total	3	N/A	2.27	1.9	2.5
07010203-545	S011-227	pH	13	N/A	7.87	7.68	8.36
07010203-545	S011-227	Phosphorus	5	0.100 mg/L	0.04	0.02	0.104
07010203-545	S011-227	Specific conductance	13	N/A	618.35	460.5	667
07010203-545	S011-227	Temperature, water	13	N/A	15.18	11.4	17.6
07010203-545	S011-227	Total suspended solids	1	10.0 mg/L	1.8	1.8	1.8
07010203-545	S011-227	Transparency, tube with disk	6	N/A	100	100	100
07010203-564	S012-271	Dissolved oxygen (DO)	9	7.0 mg/L	8.54	5.67	9.98
07010203-564	S012-271	Nitrate + Nitrite Nitrogen, Total	3	N/A	2.53	2.2	2.8
07010203-564	S012-271	pH	9	N/A	8.02	7.71	8.22
07010203-564	S012-271	Phosphorus	4	0.100 mg/L	0.045	0.02	0.062
07010203-564	S012-271	Specific conductance	9	N/A	640.89	555	680
07010203-564	S012-271	Temperature, water	9	N/A	15.94	10.38	23.5
07010203-564	S012-271	Total suspended solids	1	10.0 mg/L	14	14	14
07010203-564	S012-271	Transparency, tube with disk	2	N/A	100	100	100
07010203-564	S012-271	Volatile suspended solids	1	N/A	4	4	4

Nutrients – Phosphorus

Phosphorus values from the dataset on Threemile Creek shows that the average TP value for each station is well below the Central Region River Nutrient standard (0.100 mg/L) with average values of 0.04 mg/L and 0.045 mg/L (Table 10). Although the values are primarily low, there was one elevated sample during the fish sample in 2009. Overall, phosphorus does not appear to be a stressor within Threemile Creek at this time, however, there is a potential for phosphorus to become elevated at times, as noted in the 2009 sample.

Dissolved Oxygen

DO levels within Threemile Creek appear to be stable, with 96% of the DO values meeting the coldwater DO standard of 7.0 mg/L (Table 10). Therefore, DO does not appear to be a stressor to the aquatic life within Threemile Creek at this time.

Total Suspended Solids

TSS data for Threemile Creek is also limited to one sample for each station, which indicated that the TSS levels are below the standard (AUID -545) or just above (AUID-564) the standard of 10 mg/L (Table 10). However, due to the limited dataset, TSS is an inconclusive stressor at this time.

Conductivity

Specific conductivity values were within range in Threemile Creek (Table 10), and are not considered to be a stressor.

Temperature

Temperature values from the dataset that was collected in Threemile Creek were within range for a coldwater stream (Table 10). Additional data was also collected by MPCA biological monitoring staff, which further indicated that temperatures were stable and cold enough to support a coldwater biological community. Therefore, temperature is not considered a stressor at this time.

Habitat

Habitat was classified as fair/good on Threemile Creek, through the MSHA evaluations during the fish and macroinvertebrate samples (Figure 37).

MSHA Scores

Station Id	Day of Visit ..	Total Score
09UM032	6/11/09	65.5
	7/20/09	67.5
	7/10/12	55.15
	8/21/13	70.4
	6/20/19	64
	8/19/19	50.4
12UM146	6/18/12	68.9

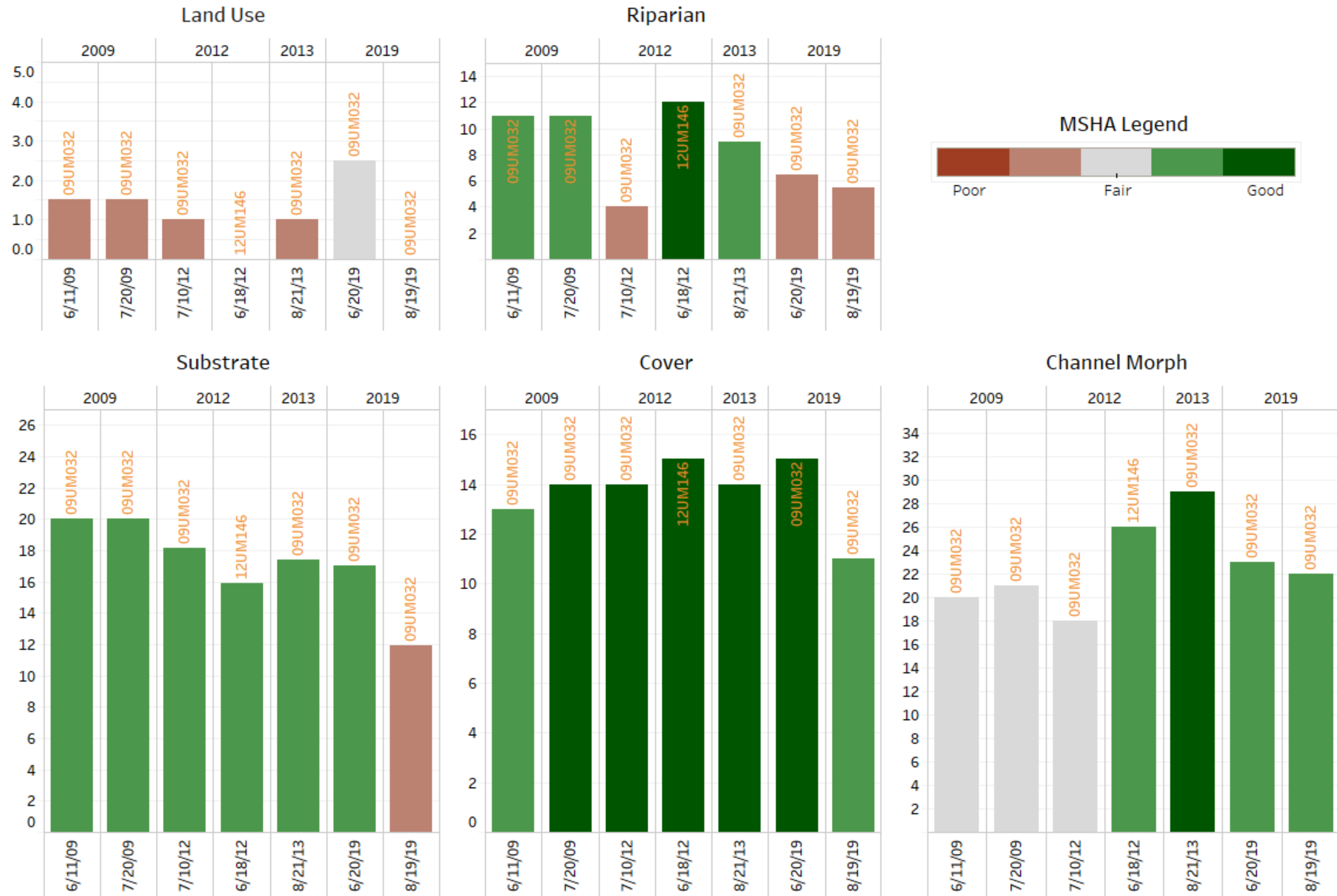


Figure 37. MSHA habitat scores for Threemile Creek.

Several MSHA categories such as substrate, cover, and channel morphology scored well, while the land use and riparian categories scored poorly (Figure 37). Substrate, cover, and channel morphology are especially important to fish and macroinvertebrates, and due to these categories scoring well, the MSHA scores indicate that there is sufficient habitat to support healthy fish and macroinvertebrate communities within the creek. Therefore, habitat is not considered to be a stressor to the aquatic life within Threemile Creek.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology within the Threemile Creek Subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests to cultivated fields and the channelization of the natural streams and wetlands. The sections of Threemile Creek that were sampled for biology have remained natural, and have not been straightened. However, the entire headwaters portion of the creek flowing into the upstream section of Threemile Creek (-564) have been channelized (Figure 38).

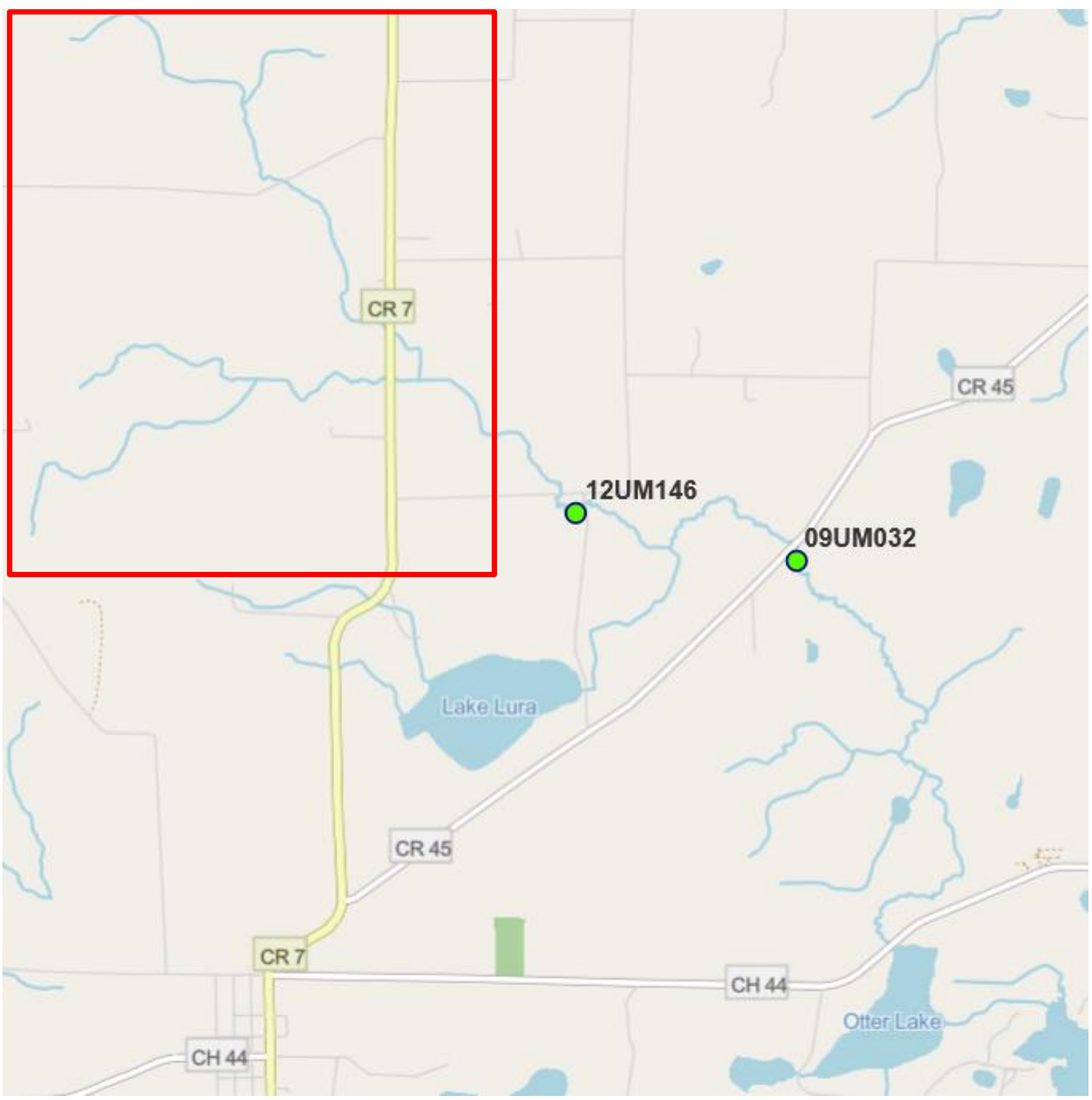


Figure 38. Current Threemile Creek stream channel with ditched channels providing additional flow outlined in red.

This channel alteration within the headwaters was cut through several wetlands, which has caused a greater volume of water to flow into Threemile Creek at a higher velocity than what would have naturally occurred. Due to the additional stream power caused by the additional water and higher velocity, the banks of the creek have eroded (Figure 39, Figure 40), causing the channel to over-widen, as noted by the evidence of point bars, which would not exist if the channel were narrower and had the ability to self-clean.

Figure 39. Eroding stream bank on the -564 reach of Threemile Creek.

Figure 40. Eroding stream bank on the -545 reach of Threemile Creek.

This over-widening has been further complicated in the downstream section of Threemile Creek, where the culvert crossing under CR 45 has been used as a cattle crossing, allowing the cattle to use the stream as a corridor, further over-widening the stream (Figure 41, Figure 42, Figure 43).

Figure 41. Channel erosion caused by cattle trampling, downstream of CR 45.

Figure 42. Channel erosion caused by cattle trampling, upstream of CR 45.

Figure 43. Cattle gate connected to the CR 45 culvert, using the culvert for cattle passage under CR 45.

In addition to the increase in water volume caused by the channelization of the headwaters in Threemile Creek, the over-widening and channelization of the creek has also caused periods of low flow within the channel. As the landscape drains, the flow transitions to low flow and receives very little water contribution from the landscape (which may also explain the low nutrient levels within the creek). The only water that is available to the aquatic life within the creek is through groundwater seeps, which helps to maintain cold water temperatures, but the overall depth at constriction points is limited to only a few inches during the summer months (Figure 44).

Figure 44. Shallow riffle located downstream of 35th Ave.

Due to the over-widened stream channel and altered flow patterns, altered hydrology and geomorphology are the direct stressors to the fish community within Threemile Creek.

Connectivity

The culvert crossings by 09UM032 and 12UM146 do not appear to be a fish barrier, however, the culvert crossing off 160th Street upstream of 12UM146 is perched. This culvert was replaced within the past few years, but unfortunately it was not installed deep enough. This is a fish barrier, and the elevated outflow of the culvert has carved a large plunge pool on the downstream end of the culvert. Silt and detritus were carved out of the channel, creating the pool, and these sediments have moved downstream for approximately 100ft, filling in the pools and runs with ~1ft of sediment (Figure 45).

Figure 45. Perched culvert off 160th St.

Stressor signals from biology

Fish

Fish were sampled four times from 2009 through 2013 at 09UM032 and once at 12UM146 in 2012 as part of the cycle I monitoring effort. Fish were sampled again at 09UM032 as part of the cycle II monitoring effort. Throughout the samples, 5 to 10 fish species were collected, with Central Mudminows dominating most samples. The Central Mudminnow is one of the most pollution tolerant fish species within the state of Minnesota. Although the samples were dominated by fish that are considered to be tolerant, several sensitive species were also collected within the sample (Blacknose Shiner, Iowa Darter). No coldwater fish were collected within any of the samples on Threemile Creek.

The lack of coldwater fish within Threemile Creek may be attributed to the historical range of coldwater fishes, as it is difficult to determine the historical distribution of coldwater fishes within this portion of the State. The Mississippi River- St. Cloud Watershed is the lower distribution limit of our knowledge of the historical presence of coldwater fishes, such as Brook Trout. The headwaters of Threemile Creek have been carved into wetlands that are close in proximity to other coldwater streams in the watershed (Luxemburg Creek), which could also indicate that the historical channel may not have been cold, but the channelization has supplied coldwater to the creek. It is also very possible that Threemile Creek did not historically contain coldwater fishes due to there not being a source population of coldwater fishes within nearby connected streams or rivers, which could migrate into Threemile Creek. Furthermore, the presence of Otter Lake and Clearwater Lake at the outlet of the creek would be warm water barriers to the coldwater fishes, and Otter Lake would also have lower DO due to the wetland riparian, which would also be difficult for these fishes to navigate.

Macroinvertebrates

Macroinvertebrates were sampled twice in 2009 at 09UM032 and once at 12UM146 in 2012 as part of the cycle I monitoring effort. Macroinvertebrates were sampled again at 09UM032 as part of the cycle II monitoring effort. The sample within the upstream station produced an IBI score that was below the impairment threshold, and the downstream station produced IBI scores that were above the impairment threshold. All of the samples contained macroinvertebrate taxa that are considered to be coldwater taxa, which are found within coldwater streams. These coldwater taxa may have migrated from Luxemburg Creek.

Water levels were low during the 2012 sample at 12UM146. These low water levels combined with the over-widened stream channel and excessive sediment migrating downstream of the culvert off 160th Street, could explain the poor IBI scores.

Composite conclusion from biology

The habitat and geomorphology are altered within Threemile Creek, and are the direct stressors to the aquatic life within Threemile Creek.

Coldwater fish may not have existed in Threemile Creek historically, and due to the absence of source populations of coldwater fishes, it will be difficult for Threemile Creek to meet the fish coldwater IBI standards without the manual reintroduction of coldwater fishes.

Recommendations

Threemile Creek is no longer managed as a trout stream by the DNR, and further restoration of the creek to support a coldwater fishery would be difficult. Stabilizing the stream banks, condensing the stream channel to allow it to self-clean, and removing the cattle from the downstream riparian along with a new culvert under CR 45 that would allow for cattle passage separate from the stream crossing would all make the biggest impacts to the creek.

County Ditch No 3 Subwatershed

The County Ditch No 3 Subwatershed covers 10,252 acres, located just east of St. Cloud (Figure 46). Almost all of the streams (91.6%) within the subwatershed have been straightened.

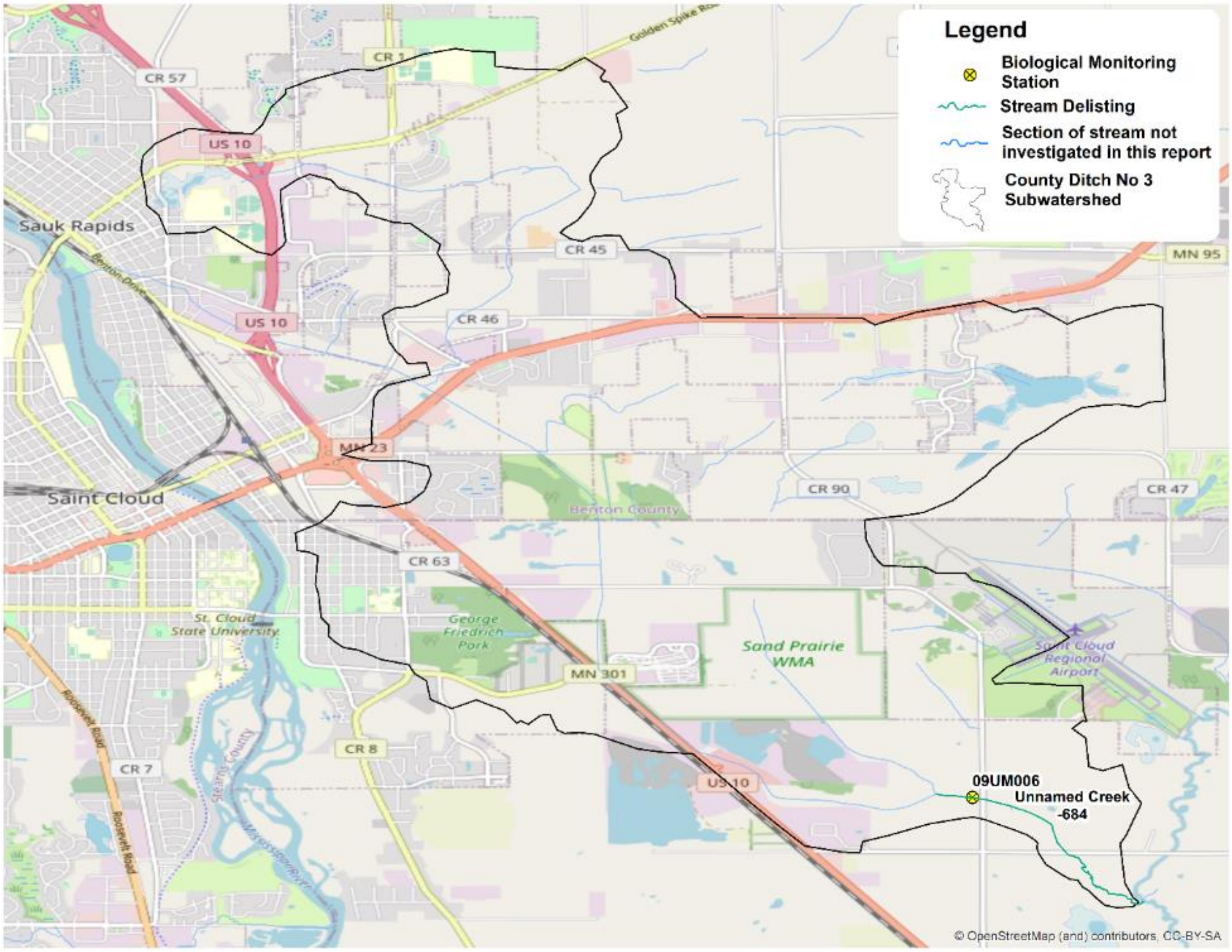


Figure 46. Biological monitoring station within the County Ditch No 3 Subwatershed.

The land use within the County Ditch No 3 Subwatershed is dominated by developed land (26.5%), followed by cropland (24.3%), and wetlands (22.6%) (Figure 47).

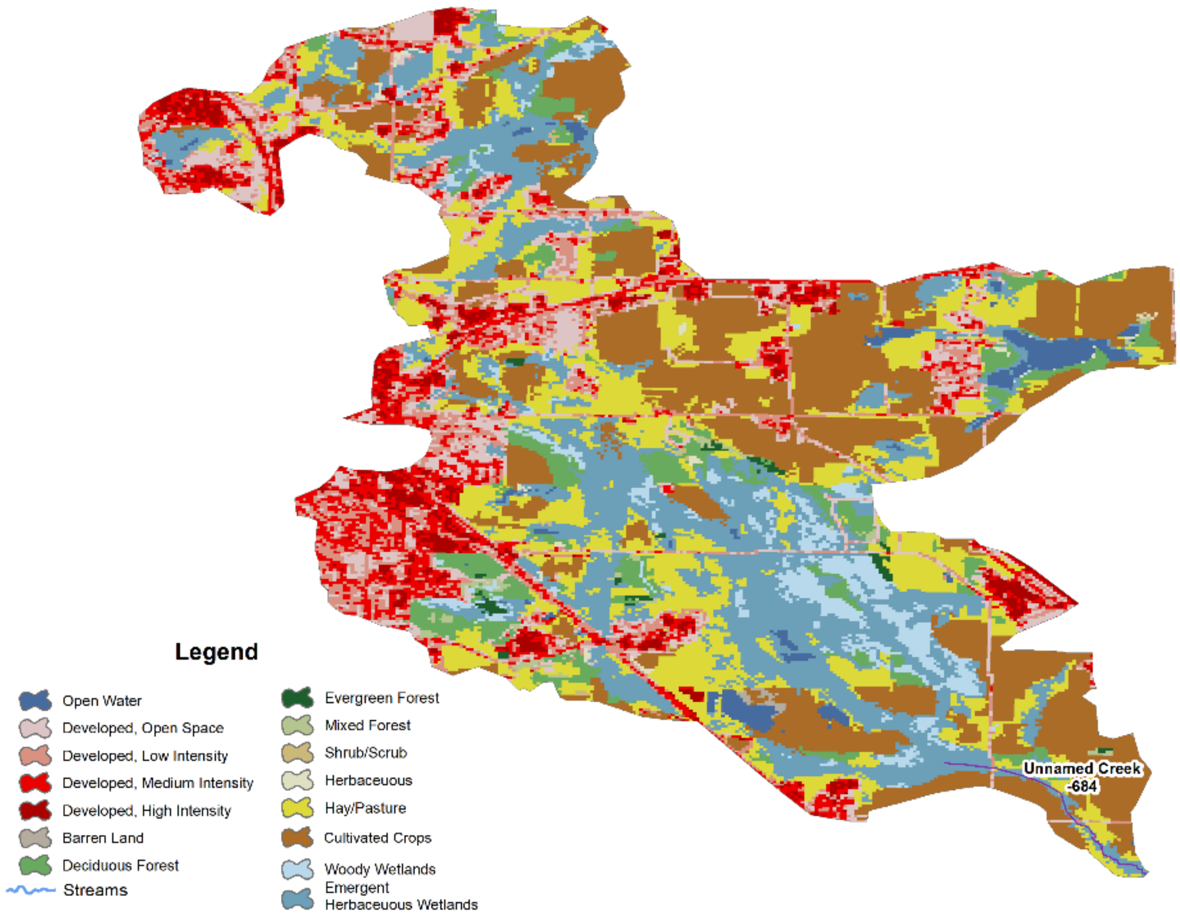


Figure 47. Land use within the County Ditch No 3 Subwatershed. Credit: NLCD 2016.

Unnamed Creek (07010203-684)

Delisting: Unnamed Creek (AUID -684) flows for 1.7 miles from just west of CR 7 to the confluence with the Elk River, six miles southeast of St. Cloud. Half of Unnamed Creek has been channelized. There is one biological monitoring station (09UM006) that was sampled for fish and macroinvertebrates in 2009, and then repeated in 2019 (Figure 46). Fish were listed on the impaired waters list in 2002, and macroinvertebrates were listed in 2006. The fish stream class is class 7 (Low Gradient), and the macroinvertebrate stream class is class 6 (Southern Forest Streams Glide/Pool). After the 2019 sampling, the fish and macroinvertebrate IBI scores vastly improved which prompted a delisting for both communities. Due to the improved scores, SID staff investigated the creek to try to determine the cause of the improved scores. As part of this investigation, it was discovered that the culvert had been replaced at the 45th Ave SE crossing (Figure 48).

Figure 48. Culvert crossing replacement at the 45th Ave SE crossing from June 2009 to July 2019.

Prior to this replacement, excessive fine sediments were noted in the MSHA scores at the fish sample in 2009 and it was also noted that there was a pool of backed up water that had formed at the culvert, due to it being undersized. After the culvert was replaced, the 2019 sampling photos indicated that the backup of water at the culvert, which created the pool, had disappeared. In 2020, SID staff installed a water level logger within the stream to determine if the culvert replacement had restored perennial flow within the stream (Figure 49).

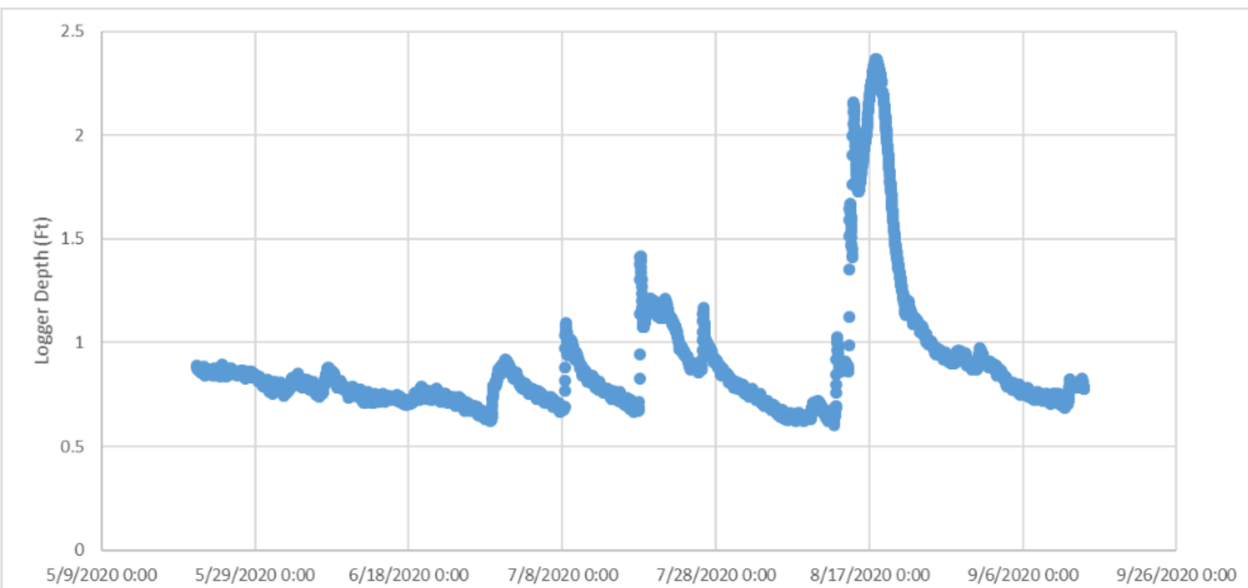


Figure 49. Logger level data collected on Unnamed Creek in 2020.

These data indicated that the water is no longer backed up at the culvert, and the creek now has perennial flow through the summer. Although the 2019 MSHA scores were similar to the score from 2009, there is evidence that the channel is starting to self-clean due to the restored flow conditions.

Overall, it was determined that lack of perennial flow, and the resulting poor habitat are the direct stressors to the biological communities in 2009, and the replacement of the culvert has helped to mitigate this issue, which in turn has helped to delist Unnamed Creek from the impaired waters list.

St. Francis River, West Branch Subwatershed

The St. Francis River, West Branch Subwatershed covers 11,724 acres, located just east of St. Cloud (Figure 50). Almost all of the streams (91.6%) within the subwatershed have been straightened.

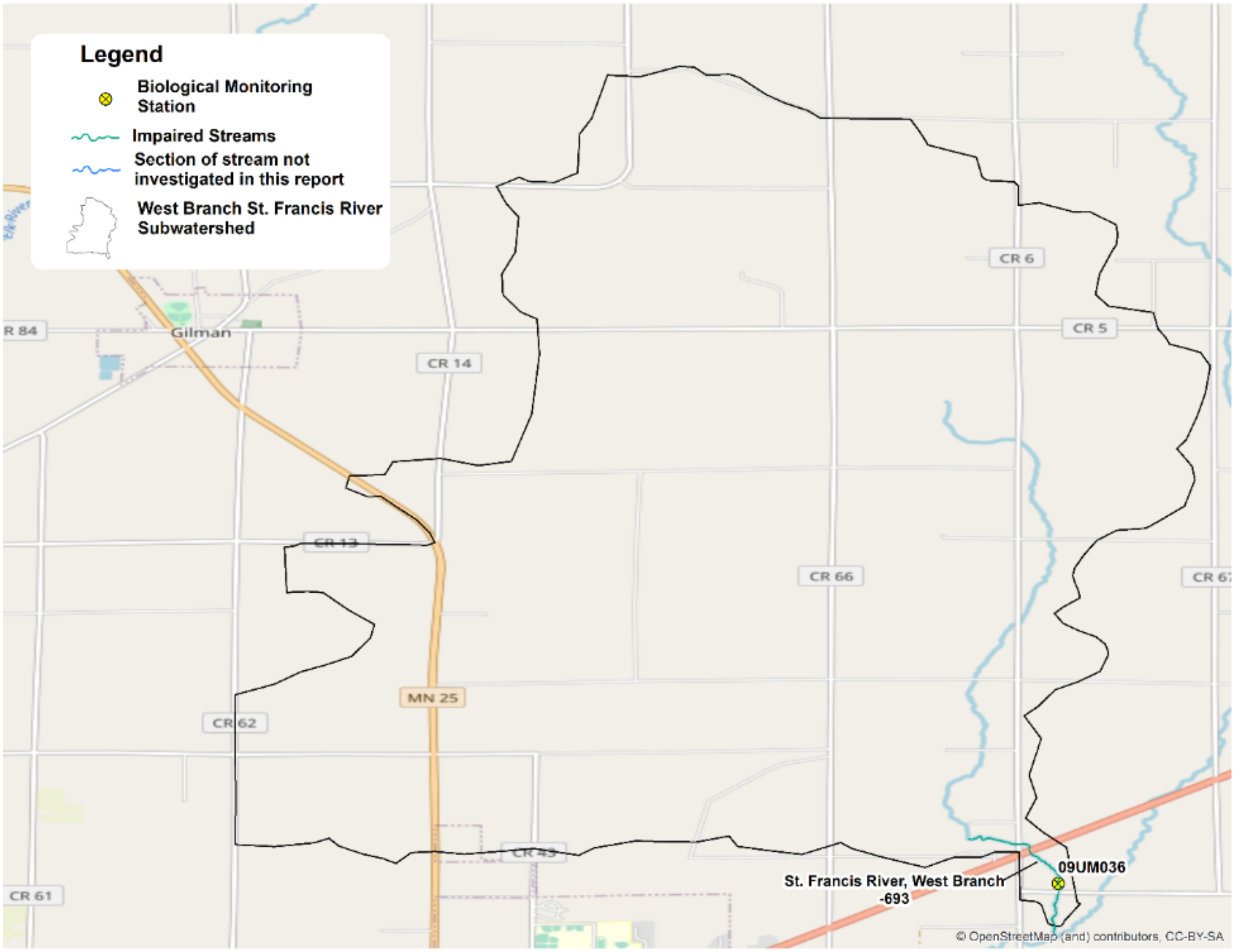
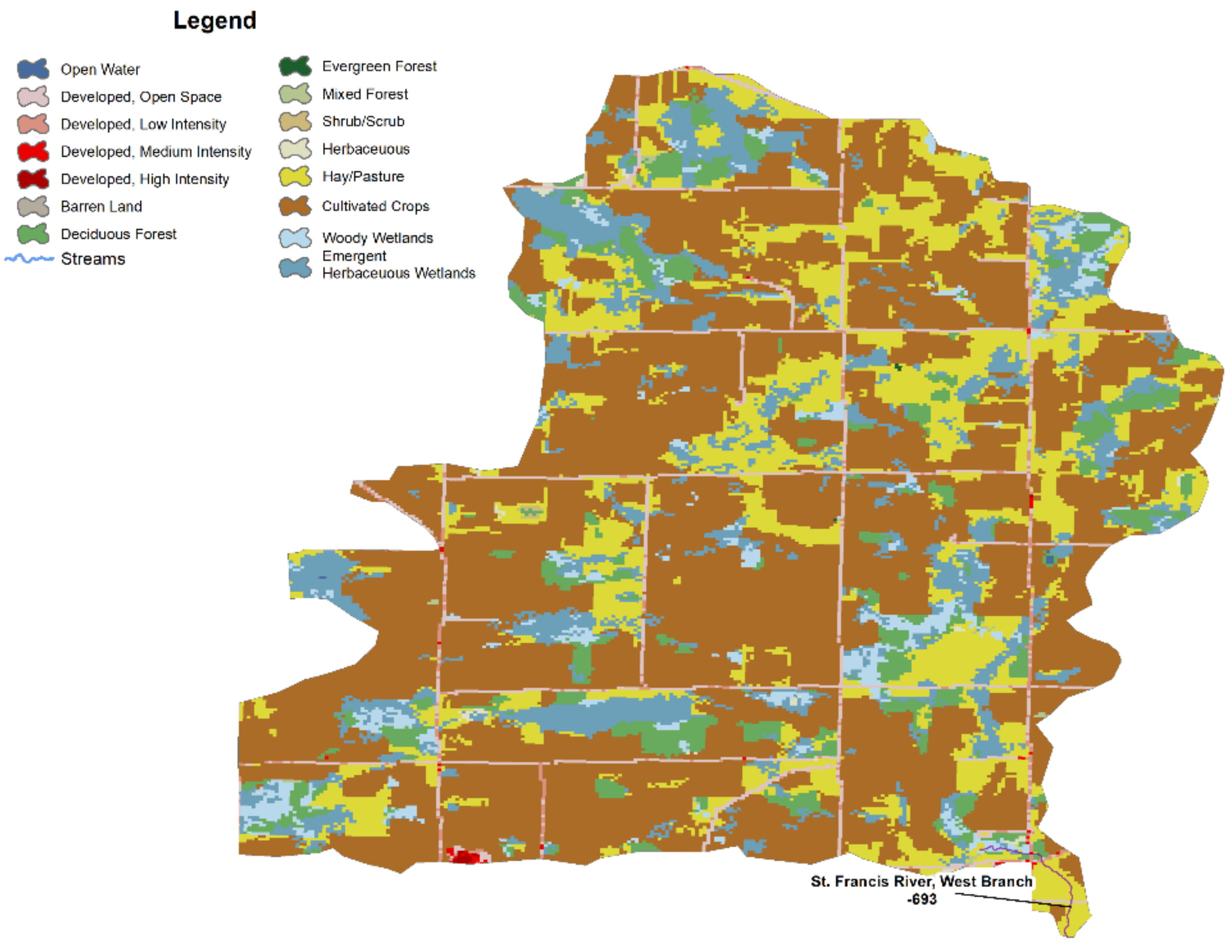


Figure 50. Biological monitoring station within the St. Francis River, West Branch Subwatershed.

The land use within the St. Francis River, West Branch Subwatershed is dominated by cropland (57.1%), followed by rangeland (18.5%), and wetlands (14.2%) (Figure 51).

Figure 51. Land use within the St. Francis River, West Branch Subwatershed. Credit: NLCD 2016.



St. Francis River, West Branch (07010203-693)

Impairment: The St. Francis River, West Branch (AUID -693) flows for 1.1 miles from just west of CR 6 to the confluence with the St. Francis River, 2.5 miles northeast of Foley. The St. Francis River, West Branch has remained natural and has not been channelized. There is one biological monitoring station (09UM036) that was sampled for fish and macroinvertebrates in 2009 and then repeated in 2019 and 2020 (Figure 50). St. Francis River, West Branch was assessed in 2019, which resulted in new fish and macroinvertebrate impairments. The fish stream class is class 6 (Northern Headwaters), and the macroinvertebrate stream class is class 4 (Northern Forest Streams Glide/Pool).

Chemistry

Water chemistry data has been collected from one station (S011-228) on the St. Francis River, West Branch (Table 11). This dataset was collected in 2009, 2019, and 2020, and was used to aid in the SID process of the biological impairments.

Table 11. Water chemistry data collected on the St. Francis River, West Branch. Data available at https://webapp.pca.state.mn.us/surface-water/search

Parameter	Count of Samples	Applicable Standard	Avg. Result	Min. Result	Max. Result
Dissolved oxygen (DO)	5	5.0 mg/L	8.97	7.51	11.81
pH	5	N/A	7.96	7.65	8.26
Phosphorus	3	0.100 mg/L	0.08	0.06	0.125
Specific conductance	5	N/A	390.08	322.5	415.6
Temperature, water	5	N/A	20.54	16.05	24.7
Total suspended solids	2	30.0 mg/L	5.8	5	6.6
Transparency, tube with disk	2	N/A	100	100	100

Nutrients – Phosphorus

Phosphorus values from the St. Francis River, West Branch shows that the average TP is well under the Central Region River Nutrient standard (0.100 mg/L) with an average value of 0.08 mg/L (Table 11). However, a maximum value of 0.125 mg/L was collected, and 33.3% of the phosphorus values across the dataset were above the standard, indicating that there is potential for eutrophication to occur within the St. Francis River, West Branch. Due to the presence of elevated phosphorus values within a portion of the dataset, phosphorus is considered to be a secondary stressor to the aquatic life within the St. Francis River, West Branch.

Dissolved Oxygen

Five DO samples have been collected from 2009, 2019, and 2020 on the St. Francis River, West Branch. All of the DO samples were above the DO standard of 5.0 mg/L (Table 11), which indicates that DO is not a stressor within the St. Francis River, West Branch at this time.

Total Suspended Solids

The TSS dataset for the St. Francis River, West Branch indicates that TSS levels are low, as all of the samples were below the standard of 30 mg/L, with an average value of 5.8 mg/L (Table 11). Therefore, TSS is not considered to be a stressor to the aquatic life within the St. Francis River, West Branch, at this time.

Conductivity

Specific conductivity was within range throughout the dataset on the St. Francis River West Branch (Table 11), and therefore, conductivity does not appear to be a stressor to the aquatic life within the St. Francis River West Branch at this time.

Temperature

Water temperatures were within range throughout the dataset on the St. Francis River West Branch (Table 11), and therefore, water temperature does not appear to be a stressor to the aquatic life within the St. Francis River West Branch at this time.

Habitat

Habitat was classified as fair on the St. Francis River, West Branch, through the MSHA evaluations at the fish and macroinvertebrate samples (Figure 52).

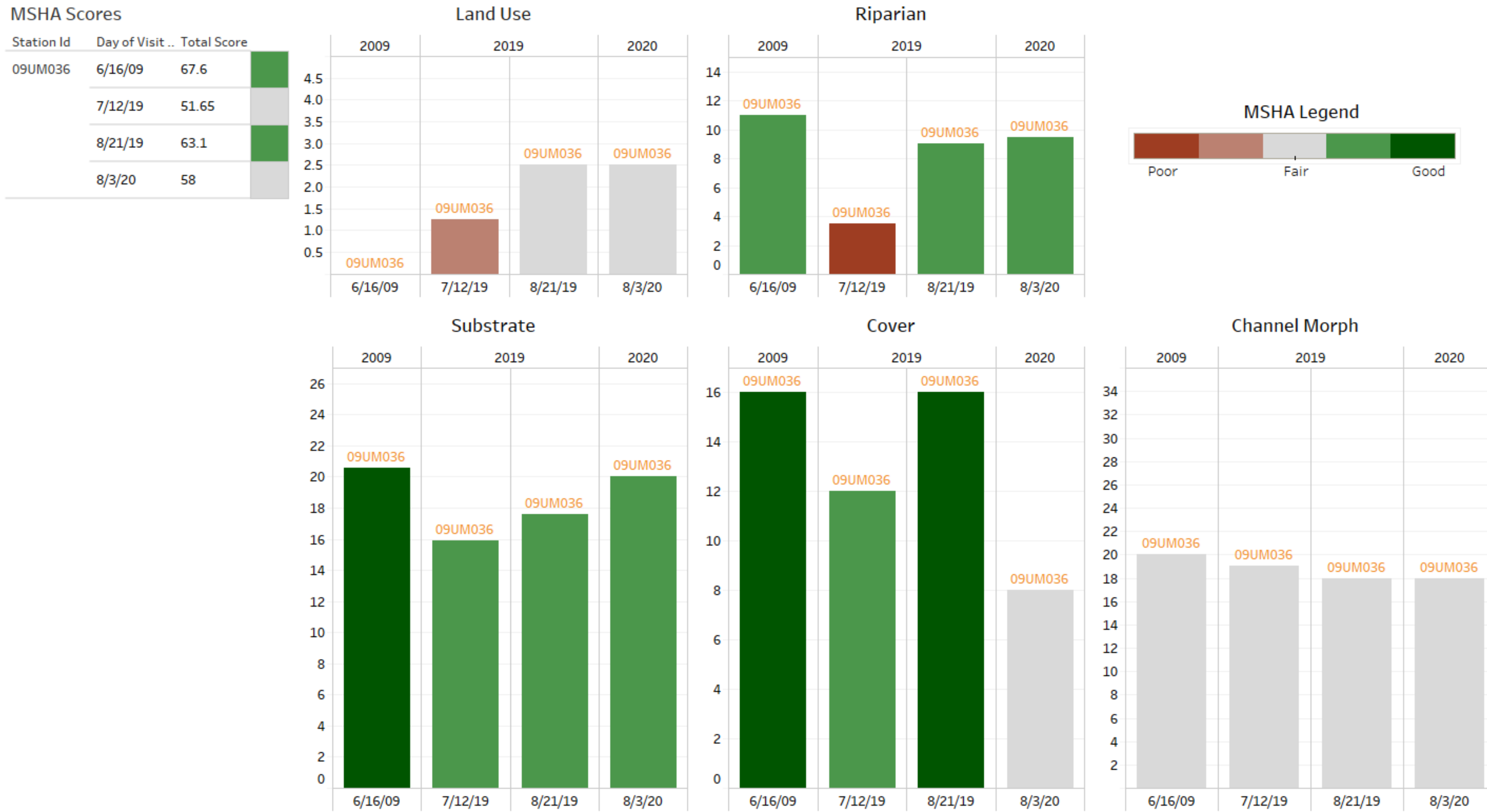


Figure 52. MSHA habitat scores for the St. Francis River, West Branch.

Although the average MSHA score was fair, all of the MSHA categories scored fairly well. Channel morphology was the lowest scoring category, but still indicated that the river has good depth variability and channel stability, which are indicators of good habitat for aquatic life. Therefore, habitat is not considered to be a stressor to the aquatic life in the St. Francis River, West Branch.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology of the St. Francis River, West Branch, and the entire subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests to cultivated fields and the channelization of the natural streams and wetlands. Although the section of river that was sampled for biology (09UM036) has not been channelized, most of the upstream portions of the river have been straightened.

Due to the channelization within the headwaters of the St. Francis River, West Branch, the historic slow moving sinuous channel is now a straight ditched channel. This channel alteration accelerates stream flow, resulting in higher flows during precipitation events which achieves the agricultural land use drainage goals, but causes instability. Water leaves the landscape quickly, resulting in periods of higher flow than what would have naturally occurred. As the landscape drains, the flow regime quickly transitions to low flow, reaching stagnant conditions starting early in the summer (Figure 53, Figure 54).

Figure 53. Dry stream channel on the upstream side of CR 52.


Figure 54. Dry stream channel on the downstream side of CR 52.

Utilizing the biological monitoring sampling pictures and MSHA evaluations of stream bank condition, the banks appear to be stable when the land surrounding the river is not being actively pastured. However, in 2019, the riparian of the river channel by the biological monitoring station was actively pastured, and the stream banks were noted as heavily eroding and the riparian scores dropped significantly. In 2020, the stream banks recovered when the land was not being actively pastured. Active erosion from cattle trampling can remove coarse habitat and fill in important geomorphic features such as pools and riffles. In order to avoid further degradation of the St. Francis River, West Branch, it would be beneficial for the cattle to have limited access to the river.

The current channel size has most likely not changed since settlement, due to the stream remaining natural. However, the channel is receiving more water, and receiving that water at a higher velocity, than what would have existed naturally due to the channelization in the headwaters. This has caused unstable flow conditions, and although the MSHA habitat scores indicated that fair/good habitat was available to the aquatic life within the river, the assessment also indicated that there was a lack of flow. Throughout most of the biological samples in 2009, 2019, and 2020, flow was recorded as slow flow and areas of no flow. In 2020, the SID staff installed a level logger to determine the duration of the dry/no flow periods in the river throughout the summer. These data indicated that water levels were critically low from June through July 2020 (Figure 55).

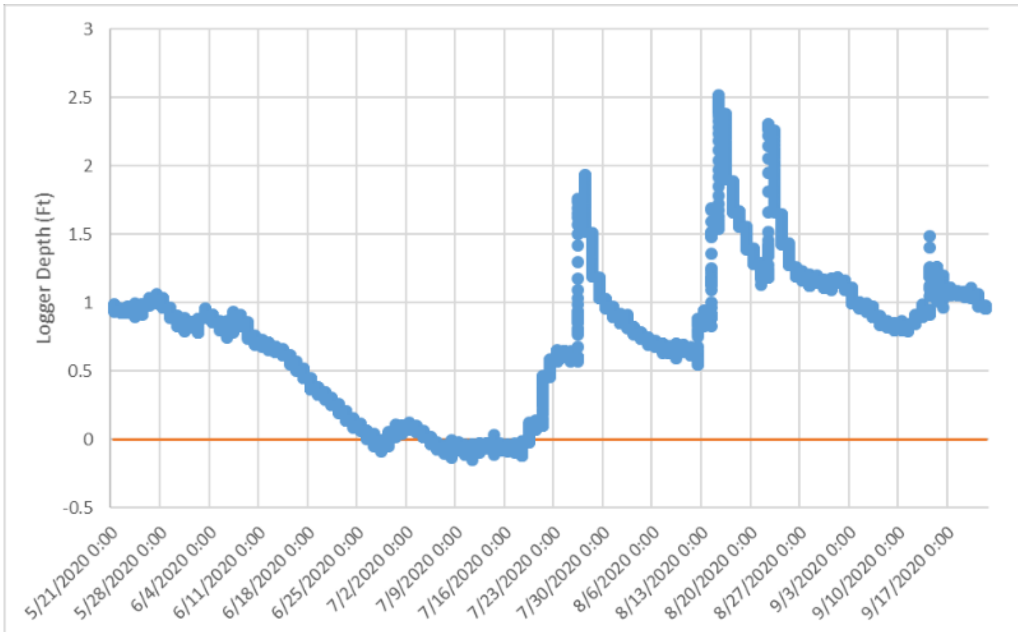


Figure 55. Level logger data collected on the St. Francis River, West Branch.

The unstable flow conditions caused by the channelization in the headwaters of the river has inhibited the ability for sensitive fish and macroinvertebrates to inhabit the St. Francis River, West Branch, and therefore, the altered hydrology and geomorphology of the river is a direct stressor to aquatic life.

Connectivity

The culvert crossing by 09UM036 off CR 52 does not appear to be a fish barrier, however, there is an impoundment in the Sherburne National Wildlife Refuge that is located on the St. Francis River downstream of the confluence of the St. Francis River and the St. Francis River, West Branch. This was identified as a connectivity barrier to the St. Francis River fish community within the cycle I SID report (MPCA 2013), and due to the impoundment being downstream of the St. Francis River, West Branch, connectivity is also considered to be a direct stressor to the fish community in the St. Francis River, West Branch.

Stressor signals from biology

Fish

Fish were sampled in 2009 as part of the cycle I monitoring effort, and then sampled again in 2019 as part of the cycle II monitoring effort. Eight fish species were collected in 2009 and a total of nine fish species were collected, with Central Mudminnows dominating both samples. Central Mudminnows are one of the most pollution tolerant fish species within the state of Minnesota. All of the other fish species that were collected are also considered tolerant of pollutants.

TIVs were calculated for the St. Francis River, West Branch using the fish community. The TSS TIV found that the fish community had a 75% probability of coming from a stream that is meeting the TSS standard from the 2009 sample, and an 83% probability from the 2019 sample. No fish species that are considered to be tolerant or sensitive of elevated TSS were found within any of the fish samples, indicating a weak TSS signal from the biology. Therefore, the fish community response to TSS is weak, and therefore, is inconclusive at this time.

DO TIV scores were also calculated for the St. Francis River, West Branch using the fish communities. This calculation indicated that the fish community from 2009 had a probability of 3% of coming from a stream that was meeting the DO standard. Similarly, the fish community from 2019 had a 7% probability of coming from a stream that was meeting the DO standard. Six of the fish species collected within the 2009 sample and three of fish species collected in the 2019 sample were considered to be tolerant of low DO. Three of the species from the 2009 sample and two of the fish species from the 2019 sample were considered to be very tolerant to low DO. None of the species that were collected were sensitive or intolerant to low DO. Therefore, the fish community response to DO indicates that DO is a stressor to the fish community within the St. Francis River, West Branch. However, the chemistry dataset indicates that DO levels are good within the river, which maybe further indication that DO is not a stressor, but the lack of flow is the limiting factor, as the DO tolerant fish species are also tolerant of low flow.

Phosphorus tolerance of the fish community was also investigated in the St. Francis River, West Branch using the fish species characteristics. Five of the fish collected in 2009 and two of the fish collected in 2019 were considered to be tolerant of elevated phosphorus, and two of those species collected in 2009 were also considered to be very tolerant of elevated phosphorus. As for sensitive species, no fish that are sensitive or intolerant of elevated phosphorus were found in either sample. Therefore, the presence of elevated phosphorus tolerant species and the absence of intolerant species indicates that phosphorus is a stressor to the fish community within the St. Francis River, West Branch. Due to these TIV scores and the elevated TP values within the dataset, phosphorus is considered a secondary stressor.

Macroinvertebrates

Macroinvertebrates were also sampled in 2009 as part of the cycle I watershed monitoring effort, and resampled in 2019 and 2020 as part of the cycle II watershed monitoring effort. An average of 83% of the macroinvertebrate community was comprised of taxa that are considered to be tolerant of pollutants, and an average of 51% of the community was considered to be very tolerant of pollutants. *Hyalella, Polypedilum,* and *Oligochaeta* taxa dominated the samples, which are all considered to be tolerant taxa.

TSS taxa tolerance was investigated using the macroinvertebrate communities. Within the three samples that have been collected on the St. Francis River, West Branch, only one sample yielded several intolerant taxa, while all of the samples were dominated by tolerant and very tolerant taxa (Table 12). Overall, the macroinvertebrate community within the St. Francis River, West Branch indicates that TSS is a stressor to the macroinvertebrate community. However, the TSS data from the chemistry dataset indicates that TSS is low within the river. Therefore, it is most likely that the low flow conditions within the river were the cause of the dominance of the tolerant taxa, and could explain the presence of the intolerant taxa in 2019, when there was more flow in the channel and the cattle were not pastured in the area in 2019.

DO tolerance was also investigated using the macroinvertebrate communities. The DO tolerance within the macroinvertebrate samples on the St. Francis River, West Branch contained a mixture of intolerant and tolerant taxa (Table 12). These taxa indicate that DO is not a stressor with the presence of several intolerant taxa, and in 2019, three very intolerant taxa. Therefore, the macroinvertebrate community indicates that DO is not a stressor on the St. Francis River, West Branch at this time.

The final tolerance indicator that was investigated within the macroinvertebrate community was phosphorus tolerance. Similar to the TSS indicators, within the three samples that have been collected on the St. Francis River, West Branch, only one sample yielded several intolerant taxa, while all of the samples were dominated by tolerant and very tolerant taxa (Table 12). Therefore, the presence of elevated phosphorus tolerant species and the absence of intolerant species indicates that phosphorus is a stressor to the macroinvertebrate community within the St. Francis River, West Branch. Due to these TIV scores and the elevated TP values within the dataset, phosphorus is considered a secondary stressor.

Table 12. Macroinvertebrate tolerance index values for the St. Francis River, West Branch.

Parameter	Tolerance	2009 Sample	2019 Sample	2020 Sample
DO	# Intolerant	1	5	2
	# Tolerant	16	11	17
	# Very Intolerant	0	3	0
	# Very Tolerant	8	5	6
Phosphorus	# Intolerant	0	2	0
	# Tolerant	14	16	16
	# Very Intolerant	0	0	0
	# Very Tolerant	9	7	10
TSS	# Intolerant	0	4	0
	# Tolerant	10	13	12
	# Very Intolerant	0	0	0
	# Very Tolerant	6	5	7

Composite conclusion from biology

The dam within the Sherburne National Wildlife Refuge is a connectivity barrier to the fish community within the St. Francis River, West Branch.

The TIVs within the fish and macroinvertebrate samples on the St. Francis River, West Branch indicate that low DO and TSS are not stressors, but elevated phosphorus is a secondary stressor.

The habitat, hydrology, and geomorphology are heavily altered within the headwaters of the St. Francis River, West Branch, and have caused unstable flow conditions within the river. Therefore habitat, hydrology, and geomorphology are the direct stressors to the fish and macroinvertebrates in the St. Francis River, West Branch.

Recommendations

Stream restoration to the original stream channel with a sinuous pattern would be a way to improve habitat. This would require a cooperative effort between landowners and local government units, as the additional land that would be needed for a restoration project is privately owned.

Limiting cattle access to the river will help avoid future erosion issues, while also preserving the limited good quality habitat that remains.

Rice Lake-St. Francis River Subwatershed

The Rice Lake-St. Francis River Subwatershed covers 21,153 acres, located 8.5 miles northeast of Becker (Figure 56). Just over half of the streams (53.8%) within the subwatershed have been straightened.

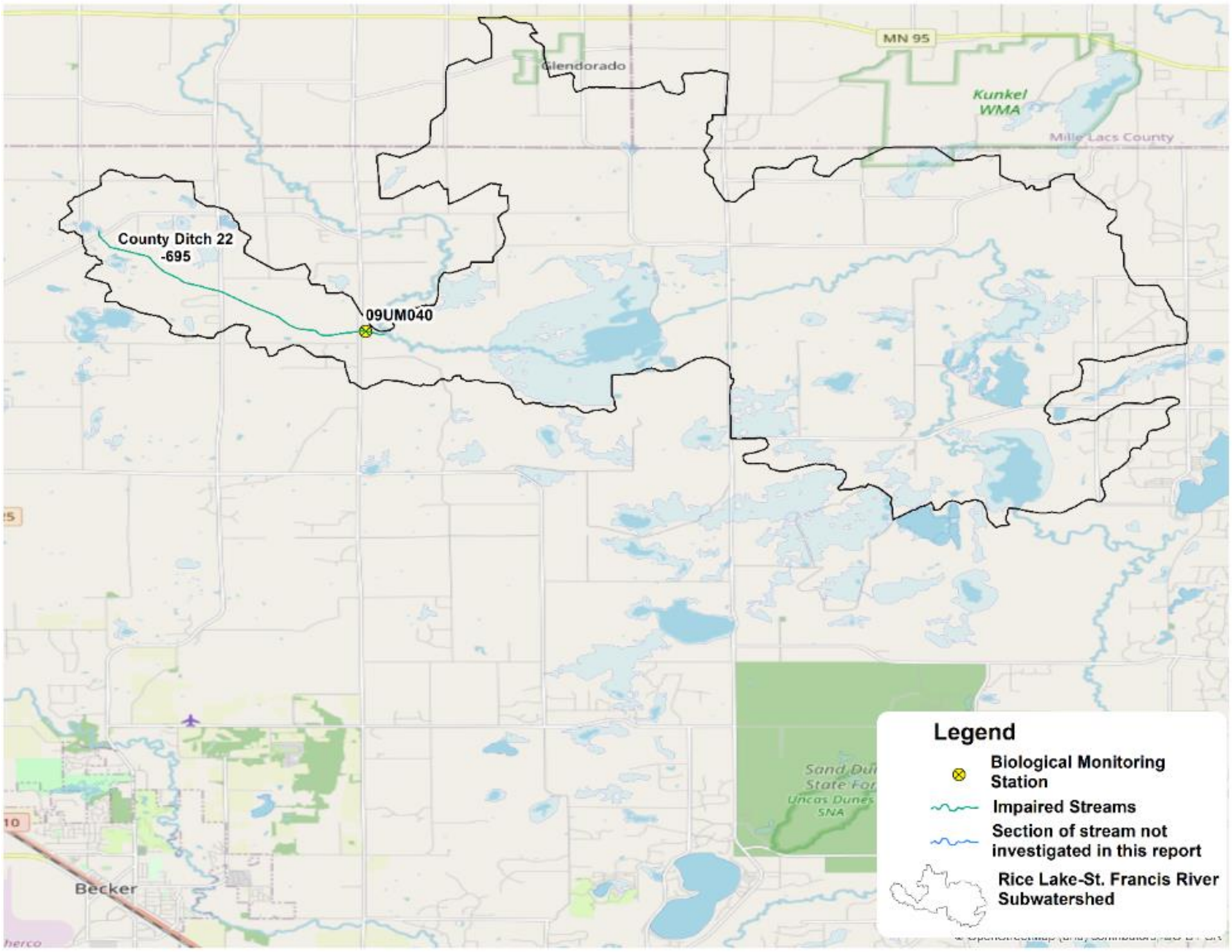


Figure 56. Biological monitoring station within the Rice Lake-St. Francis River Subwatershed.

The land use within the Rice Lake-St. Francis River Subwatershed is dominated by wetlands (40.4%), followed by rangeland (22.4%), and cropland (14.8%) (Note: The hay/pasture within the Land use map are most likely prairie/oak savannah within the Sherburne National Wildlife Refuge) (Figure 57).

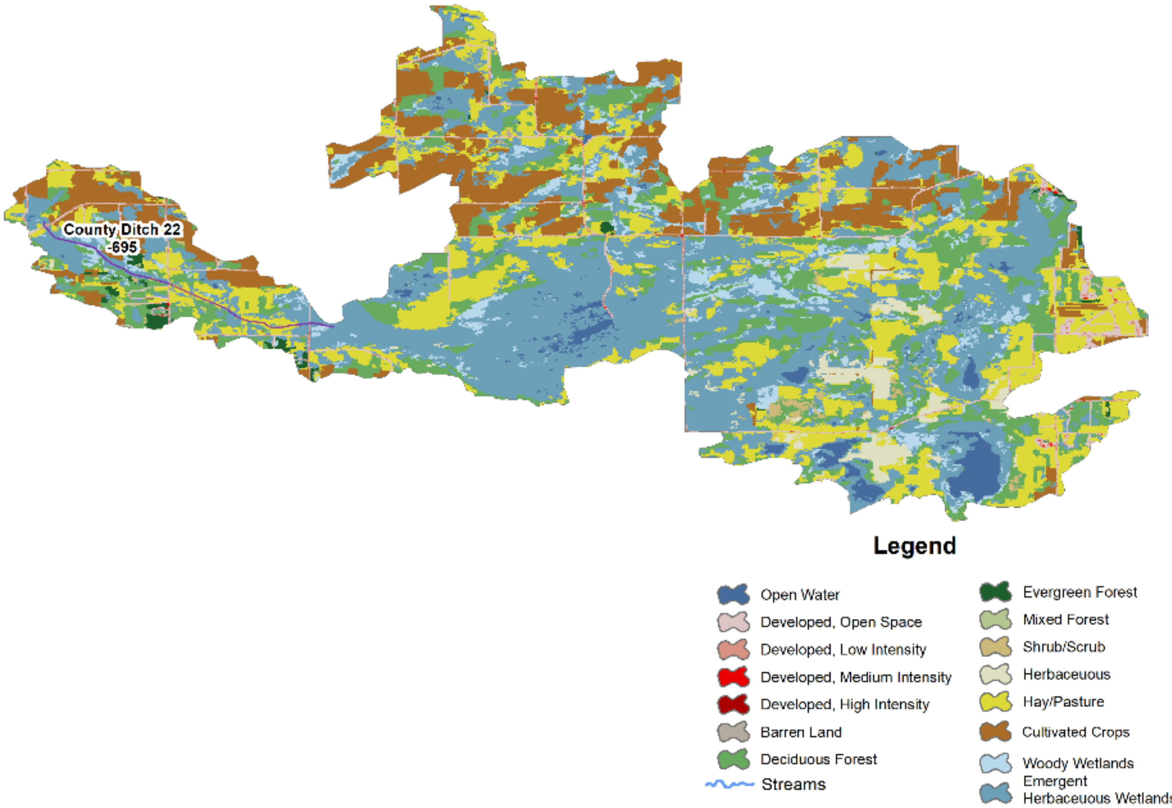


Figure 57. Land use within the Rice Lake-St. Francis River Subwatershed. Credit: NLCD 2016.

County Ditch 22 (07010203-695)

Impairment: County Ditch 22 (AUID -695) flows for 3.7 miles from just upstream of CR 3, to the confluence with the St. Francis River, 1.5 miles south of Santiago. County Ditch 22 has been channelized throughout the entire reach. There is one biological monitoring station (09UM040) that was sampled for fish in 2009 (Figure 56). Macroinvertebrates were attempted to be sampled in 2009 as well, however, dry stream conditions impeded the sample. County Ditch 22 was assessed in 2019, as part of the TALU assessment process for assessing channelized streams. The UAA process determined that County Ditch 22 should be assessed under the modified use criteria. This assessment resulted in a new fish impairment. The fish stream class is class 7 (Low Gradient).

Data and Analyses

Chemistry

Water chemistry data is limited to the samples that were collected during the fish sample in 2009 (Table 13).

Table 13. Water chemistry data collected on County Ditch 22.

Parameter	Count of Samples	Applicable Standard	Avg. Result	Min. Result	Max. Result
Dissolved oxygen (DO)	1	5.0 mg/L	5.39	5.39	5.39
Inorganic nitrogen (nitrate and nitrite)	1	N/A	0.97	0.97	0.97
pH	1	N/A	7.33	7.33	7.33
Phosphorus	1	0.100 mg/L	0.17	0.17	0.17
Specific conductance	1	N/A	343	343	343
Temperature, water	1	N/A	13.9	13.9	13.9
Total suspended solids	1	30.0 mg/L	89.1	89.1	89.1
Transparency, tube with disk	1	N/A	33.2	33.2	33.2
Volatile suspended solids	1	N/A	31.6	31.6	31.6

This dataset was limited due to dry stream conditions. SID staff attempted to collect more data on County Ditch 22 in 2021, but the ditch dried up in June, and the staff were not able to collect any more information. Due to the limited nature of the dataset, stressor determinations on the common chemical parameters were not completed. However, this does further indicate that lack of flow is a stressor to the fish community in County Ditch 22, and will be discussed below in further detail.

Habitat

Habitat was classified as poor on County Ditch 22, through the MSHA evaluation at the fish sample (Figure 58). Due to the historic channelization of County Ditch 22, and poor MSHA score, the assessment of County Ditch 22 was brought into the UAA process. It was determined that the habitat of County Ditch 22 has degraded to a point where it cannot support good quality habitat for aquatic life, as a result of channelization. Therefore, County Ditch 22 was assessed using the modified use TALU criteria.

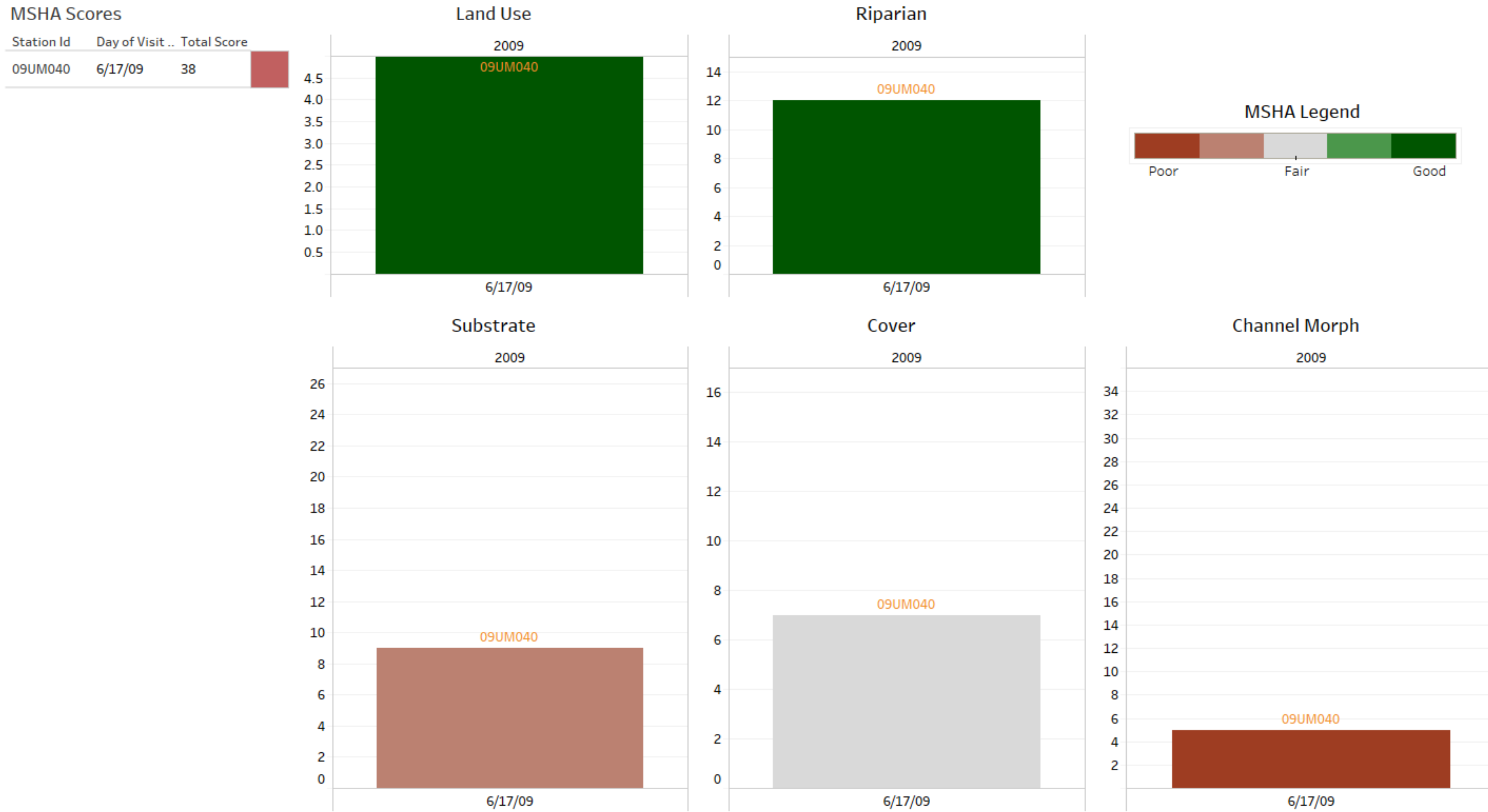


Figure 58. MSHA scores for County Ditch 22.

Although the average MSHA score was low overall, two categories scored particularly low as noted in Figure 58. Substrate was the first low scoring component of the MSHA score, as indicated by the dominance of sand and silt. Healthy fish communities need coarse substrate in order to build nests and spawn. Excessive fine sediment also affects juvenile fishes, as the sediment is stirred into the water column creating TSS, it can easily tear sensitive juvenile fish gills. Similarly, many sensitive macroinvertebrates also have specialized gills that are used to breathe DO. Excessive fine sediments can damage these gills, similar to juvenile fishes, making the creek uninhabitable for sensitive species.

Channel morphology was another low scoring component of the MSHA evaluation. The MSHA indicated that there was no channel depth variability, poor sinuosity, and no channel development (no riffles or pools). Fish and macroinvertebrates need channel depth variability to use as cover from predation and refuge during high precipitation events. No change in the channel depth combined with poor sinuosity and poor channel development impedes the fish and macroinvertebrates ability to inhabit the creek throughout the summer, especially during high flow events, which can flush these communities downstream. The lack of good channel morphology is caused by the channelization of the creek, as the manipulation of the channel has been designed to move water quickly, by mechanically removing channel sinuosity, pools, and riffles. Lack of habitat is a direct stressor to the aquatic life in County Ditch 22.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology of County Ditch 22, and the entire subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests to cultivated fields and the channelization of the natural streams and wetlands. County Ditch 22 has been straightened along the entire length of the AUID. Historically, County Ditch 22 was comprised of multiple wetlands, however, a new channel was created to drain the landscape. This channel alteration accelerates stream flow, resulting in higher flows during precipitation events, which achieves the agricultural land use drainage goals, but causes instability. Water leaves the landscape quickly, resulting in periods of higher flow than what would have naturally occurred. As the landscape drains, water that was once held in the upstream wetlands is flushed downstream, carrying low DO water throughout the reach. Then, as these flows quickly drain, the flow regime quickly transitions to intermittent, reaching stagnant conditions in early June (Figure 59).


Figure 59. County Ditch 22 almost dry in early June 2021.

Due to the channelization of County Ditch 22, the ditch does not have a natural stream pattern that can be assessed for stability. Utilizing the biological monitoring sampling pictures and MSHA evaluations of stream bank condition, the banks appear to be stable and not actively eroding. The current channel size is most likely much larger than the historic stream channels that existed prior to the channelization, due to the channel not existing previously. The ditch is also showing signs that the channel has excess sediment loads, which are most likely a result of creating a channel through a wetland. This excess sediment would have historically settled out within the wetlands, but due to the channelization, the sediment is flushed downstream during precipitation events. Therefore, altered hydrology and the lack of perennial flow has played a role in stressing the aquatic life in County Ditch 22, and is considered a direct stressor.

Connectivity

In 2009, the culvert crossing by 09UM040 off CR 11 was undersized when the fish and macroinvertebrate samples were collected (Figure 60).

Figure 60. Culvert crossing off CR 11 in 2009.

However, since 2009 the culvert has been replaced with a properly sized culvert, and is no longer a connectivity barrier (Figure 61).

Figure 61. Culvert crossing off CR 11 in 2021.

Stressor signals from biology

Fish

Fish were sampled in 2009 as part of the cycle I monitoring effort. A total of three fish species were collected, with the Central Mudminnow being the most dominate. The Central Mudminnow is one of the most pollution tolerant fish species within the state of Minnesota. All of the other fish species that were collected are also considered tolerant of pollutants (Fathead Minnow, White Sucker).

TIVs were calculated for County Ditch 22 using the fish community. The TSS TIV found that the fish community has a 77% probability of coming from a stream that is meeting the TSS standard. No fish species that are considered to be tolerant or sensitive of elevated TSS were found within any of the fish samples, indicating a weak TSS signal from the biology. Therefore, the fish community response to TSS is weak, and therefore, is not considered a stressor to the fish community in County Ditch 22 at this time.

DO TIV scores were also calculated for County Ditch 22 using the fish communities. This calculation indicated that the fish community has an average probability of only 2% of coming from a stream that was meeting the DO standard. Most of the fish collected within the sample are considered to be either tolerant or very tolerant of low DO, indicating that low DO is a stressor to the fish community within County Ditch 22. However, due to only three total fish species collected within County Ditch 22, the fish community response to DO is weak, and therefore, is not considered a stressor to the fish community in County Ditch 22 at this time.

Phosphorus tolerance of the fish community was also investigated in County Ditch 22 using the fish species characteristics. Most of the fish collected within the sample are considered to be tolerant of elevated phosphorus, and no fish that are sensitive or intolerant of elevated phosphorus were found the sample. The presence of elevated phosphorus tolerant species and the absence of intolerant species indicates that phosphorus may be a stressor to the fish community within County Ditch 22. However, due to only three total fish species collected within County Ditch 22, the fish community response to phosphorus is weak, and therefore, is not considered a stressor to the fish community in County Ditch 22 at this time.

Macroinvertebrates

Macroinvertebrates were not able to be sampled during the 2009 monitoring effort, due to dry stream conditions.

Composite conclusion from biology

The fish TIVs are indicating that low DO and elevated phosphorus are stressors to the aquatic life within County Ditch 22. However, due to the limited number of fish species collected and the lack of chemistry data, lower confidence was placed in the TIV metrics.

The habitat, hydrology and geomorphology are heavily altered within County Ditch 22. These alterations have caused unstable flow conditions within the ditch, and are the direct stressors to the fish within County Ditch 22. In addition, macroinvertebrates were not able to be sampled due to the stream being dry, which is further indication that altered hydrology is a stressor to the fish community within County Ditch 22.

Recommendations

Stream restoration to a smaller channel with a sinuous pattern would be a way to improve habitat. This would require a cooperative effort between landowners and local government units, as the additional land that would be needed for a restoration project is privately owned.

Rice Creek Subwatershed

The Rice Creek Subwatershed covers 29,319 acres, located in Foley (Figure 62). Over half of the streams (62.3%) within the subwatershed have been straightened. Only reaches with a biological impairment (A small tributary stream (Unnamed Creek, -743)) will be discussed in this report.

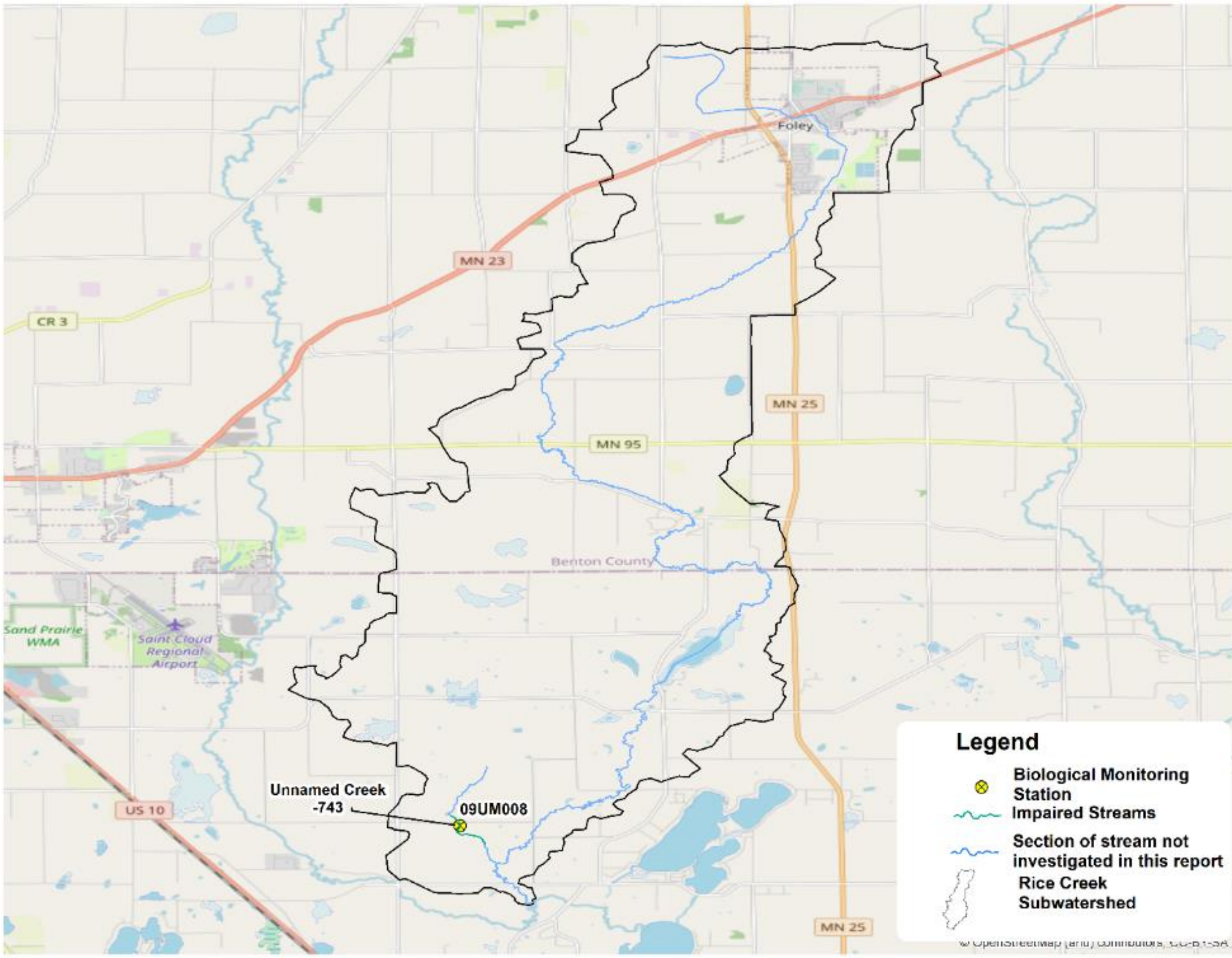


Figure 62. Biological monitoring station within the Rice Creek Subwatershed.

The land use within the Rice Creek Subwatershed is dominated by cropland (49.7%), followed by rangeland (16.8%), and wetlands (15.5%) (Figure 63).

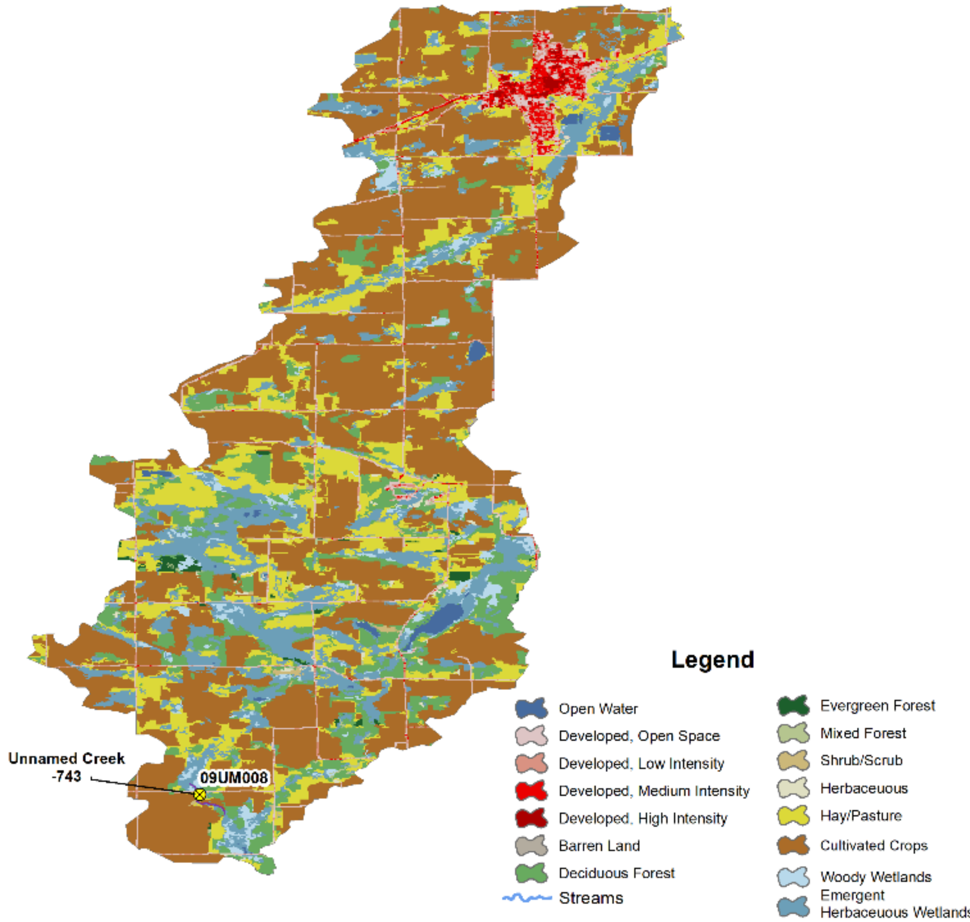


Figure 63. Land use within the Rice Creek Subwatershed. Credit: NLCD 2016.

Unnamed Creek (07010203-743)

Impairment: Unnamed Creek (AUID -743) flows for ¾ of a mile from just upstream of 47th Street SE, to just upstream of 57th Street, 2.6 miles northeast of Clear Lake. Unnamed Creek has been channelized throughout the entire reach. There is one biological monitoring station (09UM008) that was sampled for fish and macroinvertebrates in 2009 (Figure 62). Unnamed Creek was assessed in 2019, as part of the TALU assessment process for assessing channelized streams. The UAA process determined that Unnamed Creek should be assessed under the modified use criteria. This assessment resulted in a new fish impairment. The fish stream class is class 7 (Low Gradient).

Data and Analyses

Chemistry

Water chemistry data is limited to the samples that were collected during the fish sample in 2009.

Table 14. Water chemistry data collected on Unnamed Creek.

Parameter	Count of Samples	Avg. Result	Min. Result	Max. Result
Ammonia-nitrogen	1	0.1	0.1	0.1
Dissolved oxygen (DO)	1	6.26	6.26	6.26
Inorganic nitrogen (nitrate and nitrite)	1	1.2	1.2	1.2
pH	1	7.68	7.68	7.68
Phosphorus	1	0.175	0.175	0.175
Temperature, water	1	17.7	17.7	17.7
Total suspended solids	1	59.8	59.8	59.8

Although the dataset is limited to one sample, phosphorus and TSS were elevated. The phosphorus value was almost double the Central Region River Nutrient standard (0.100 mg/L) with a value of 0.175 mg/L (Table 14). Similarly, the TSS value was almost double the standard of 30 mg/L at 59.8 mg/L. This indicates that phosphorus and TSS have the potential to be stressors within Unnamed Creek, however, the perched culvert off 57th Street SE is most likely the direct stressor.

Habitat

Habitat was classified as poor on Unnamed Creek, through the MSHA evaluation at the fish sample (Figure 64).

Figure 64. MSHA habitat scores for Unnamed Creek.

Due to the historic channelization of Unnamed Creek, and poor MSHA score, the assessment of Unnamed Creek was brought into the UAA process. It was determined that the habitat of Unnamed Creek has degraded to a point where it cannot support good quality habitat for aquatic life, as a result of channelization. Therefore, Unnamed Creek was assessed using the modified use TALU criteria.

Although the average MSHA score was low overall, substrate and channel morphology scored particularly low as noted in Figure 64. Substrate was the first low scoring component of the MSHA score, as indicated by the dominance of silt, detritus, and sludge. Healthy fish communities need coarse substrate in order to build nests and spawn. Excessive fine sediment also affects juvenile fishes, as the sediment is stirred into the water column creating TSS, it can easily tear sensitive juvenile fish gills. Similarly, many sensitive macroinvertebrates also have specialized gills that are used to breathe DO. Excessive fine sediments can damage these gills, similar to juvenile fishes, making the creek uninhabitable for sensitive species.

Channel morphology was another low scoring component of the MSHA evaluation. The MSHA indicated that there was poor channel depth variability, fair sinuosity, and no channel development (poorly defined riffles or pools). Fish and macroinvertebrates need channel depth variability to use as cover from predation and refuge during high precipitation events. No change in the channel depth combined with fair sinuosity and poor channel development impedes the fish and macroinvertebrates ability to inhabit the creek throughout the summer, especially during high flow events which can flush these communities downstream. The lack of good channel morphology is caused by the channelization of the creek, as the manipulation of the channel has been designed to move water quickly, by mechanically removing channel sinuosity, pools, and riffles. Lack of habitat is a direct stressor to the aquatic life in Unnamed Creek.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology of Unnamed Creek, and the entire subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests to cultivated fields and the channelization of the natural streams and wetlands. Historically, Unnamed Creek was a small sinuous stream that flowed into Rice Creek, before eventually flowing into the Elk River. Although the modern-day channel still flows into Rice Creek, Unnamed Creek has been straightened along the entire length of the AUID. This channel alteration accelerates stream flow, resulting in higher flows during precipitation events which achieves the agricultural land use drainage goals, but causes instability. Water leaves the landscape quickly, resulting in periods of higher flow than what would have naturally occurred. As the landscape drains, water that was once held in the upstream wetlands is flushed downstream, carrying low DO water throughout the reach. Then, as these flows quickly drain, the flow regime quickly transitions to low flow.

Due to the channelization of Unnamed Creek, the creek does not have a natural stream pattern that can be assessed for stability. Utilizing the biological monitoring sampling pictures and MSHA evaluations of stream bank condition, the banks appear to be stable and not actively eroding. The current channel size is most likely similar to the historic stream channel that existed prior to the channelization, but is showing signs that the channel is receiving excess sediment from the banks or the landscape, as fine substrates dominated the MSHA substrate category. Cattle also have access to the stream and have altered the channel though cattle trampling. This was noted in the MSHA scores as sludge (cattle manure) was one of the most dominate substrate types. Due to the channel alteration and the cattle access to the creek, altered hydrology and geomorphology is considered to be a direct stressor to the fish community within Unnamed Creek.

Connectivity

The culvert crossing off 47th Street E does not appear to be a fish barrier, but there is another field crossing that is located at the downstream end of the sampling reach that does appear to be a barrier. The stream channel is over-widened on the downstream side of the field crossing culvert, which indicates that it is shallow since it is not contained in a defined channel (Figure 65).

Figure 65. Aerial photo of the sampling reach on Unnamed Creek, with the field crossing outlined in red. Credit Google Earth.

The stream banks were altered during the channelization process, and then the banks have eroded due to cattle trampling which had led to an over-widened channel. The over-widening of the stream channel has led to low water below the culvert, which blocks fish passage.

Looking further downstream on Rice Creek, there is a perched culvert just south of 57th Street SE off a small private road (Figure 66), and there was also a beaver dam at the bridge crossing off 57th Street SE, both of which are fish barriers.


Figure 66. Perched culvert off 57th Street SE.

The perched culvert and beaver dam were present in 2009 when the biological monitoring crews were sampling fish and macroinvertebrates. These barriers prompted the sampling crews to relocate their original sampling location on Rice Creek to the downstream side of the perched culvert on 57th Street SE. Although Rice Creek is slightly larger than Unnamed Creek, the biological monitoring station that was sampled below the perched culvert on Rice Creek allowed for the comparison of fish samples between Rice Creek and Unnamed Creek, to help identify if connectivity is a direct stressor to the fish community within Unnamed Creek.

The fish sample from Unnamed Creek yielded 5 total species, and the fish sample from Rice Creek yielded 21 total species (Table 15).

Table 15. Comparison of the fish species collected on each side of the perched culvert.

Unnamed Creek		Rice Creek	
Fish Species	**Number**	**Fish Species**	**Number**
central mudminnow	33	white sucker	22
brook stickleback	4	green sunfish	21
creek chub	2	yellow perch	19
fathead minnow	1	hornyhead chub	12
johnny darter	1	creek chub	11
		common shiner	9
		blackside darter	6
		black bullhead	5
		logperch	5
		rock bass	5
		bluntnose minnow	4
		Iowa darter	4
		johnny darter	4
		tadpole madtom	4
		spotfin shiner	3
		bluegill	2
		central mudminnow	1
		central stoneroller	1
		mottled sculpin	1
		pumpkinseed	1
		yellow bullhead	1

The vast difference in the number of fish species between the two samples indicates that there is a fish passage issue on Unnamed Creek, and the robust sample from Rice Creek indicates that there is a source population of sensitive species that would be available to colonize Unnamed Creek, if the barriers were removed. Due to these barriers, connectivity is considered to be the direct stressor to the fish community within Unnamed Creek.

Stressor signals from biology

Fish

As noted above, fish were sampled in 2009 as part of the cycle I monitoring effort. A total of five fish species were collected, with the Central Mudminnow being the most dominate (Table 15). The Central

Mudminnow is one of the most pollution tolerant fish species within the state of Minnesota. All of the other fish species that were collected are also considered tolerant of pollutants.

TIVs were calculated for Unnamed Creek using the fish community. The TSS TIV found that the fish community has an 80% probability of coming from a stream that is meeting the TSS standard. No fish species that are considered to be tolerant or sensitive of elevated TSS were found within any of the fish samples, indicating a weak TSS signal from the biology. Therefore, the fish community response to TSS is weak, and therefore, is inconclusive at this time.

DO TIV scores were also calculated for Unnamed Creek using the fish communities. This calculation indicated that the fish community has an average probability of only 3% of coming from a stream that was meeting the DO standard. All of the fish species that were collected within Unnamed Creek are considered to be very tolerant of low DO, indicating that low DO has the potential to be a stressor to the fish community within Unnamed Creek.

Phosphorus tolerance of the fish community was also investigated in Unnamed Creek using the fish species characteristics. All of the fish collected within the sample were considered to be tolerant of elevated phosphorus, and two of those species were considered to be very tolerant of elevated phosphorus. As for sensitive species, no fish that are sensitive or intolerant of elevated phosphorus were found the sample. The presence of elevated phosphorus tolerant species and the absence of intolerant species indicates that phosphorus has the potential be a stressor to the fish community within Unnamed Creek.

Macroinvertebrates

Macroinvertebrates were also sampled in 2009 as part of the cycle I watershed monitoring effort. This sample produced a macroinvertebrate community that is meeting standards, and is not impaired at this time. In 2009, 68% of the macroinvertebrate community was comprised of taxa that are considered to be tolerant of pollutants, and an average of 9% of the community was considered to be very tolerant of pollutants. Hyalella, and Baetis taxa dominated the samples, which are considered to be tolerant taxa. Although the macroinvertebrates are meeting standards within Unnamed Creek, the TIV scores were calculated using the macroinvertebrate community to help identify potential stressors to the fish community. However, the TIV scores for TSS, DO, and phosphorus all contained healthy mixtures of taxa that are considered to be both intolerant and tolerant to the respective parameters (Table 16). Since these TIV scores do no indicate that the chemical parameters are stressors, this is further indication that habitat and connectivity are the primary stressors to the fish community within Unnamed Creek.

Table 16. Macroinvertebrate tolerance index values for Unnamed Creek.

Parameter	Tolerance	2009 Sample
DO	# Intolerant	7
	# Tolerant	5
	# Very Intolerant	4
	# Very Tolerant	1
Phosphorus	# Intolerant	3
	# Tolerant	7
	# Very Intolerant	0
	# Very Tolerant	3
TSS	# Intolerant	1
	# Tolerant	4
	# Very Intolerant	0
	# Very Tolerant	1

Composite conclusion from biology

The fish TIV scores indicated that DO may be a stressor, but the macroinvertebrate TIV scores indicate that DO, TSS, and phosphorus are not stressors due to a healthy mixture of intolerant and tolerant taxa.

The habitat and geomorphology are heavily altered within Unnamed Creek, and are direct stressors to the aquatic life within Unnamed Creek.

Perched culverts and beaver dams are barriers to fish passage from Rice Creek to Unnamed Creek, and are direct stressors to the fish community within Unnamed Creek.

Recommendations

Maintaining compliance with the Buffer Law will help avoid erosion issues. Most of the creek has a nice wide buffer, although there are places where cattle have access to the creek. If fenced out, it may help stabilize the substrate and stream banks.

Managing beaver activity and replacing the culverts at the private field crossing by the biological monitoring stations and at the private road crossing south of 57 Street SE with Aquatic Organism Passage Program (AOP) certified culverts would allow fish to access the entire length of Unnamed Creek.

Stream restoration to a smaller channel with a sinuous pattern would be a way to improve habitat. This would require a cooperative effort between landowners and local government units, as the additional land that would be needed for a restoration project is privately owned.

Snake River Subwatershed

The Snake River Subwatershed covers 28,443 acres, located just east of Becker (Figure 67). Almost all of the streams (86.9%) within the subwatershed have been straightened.

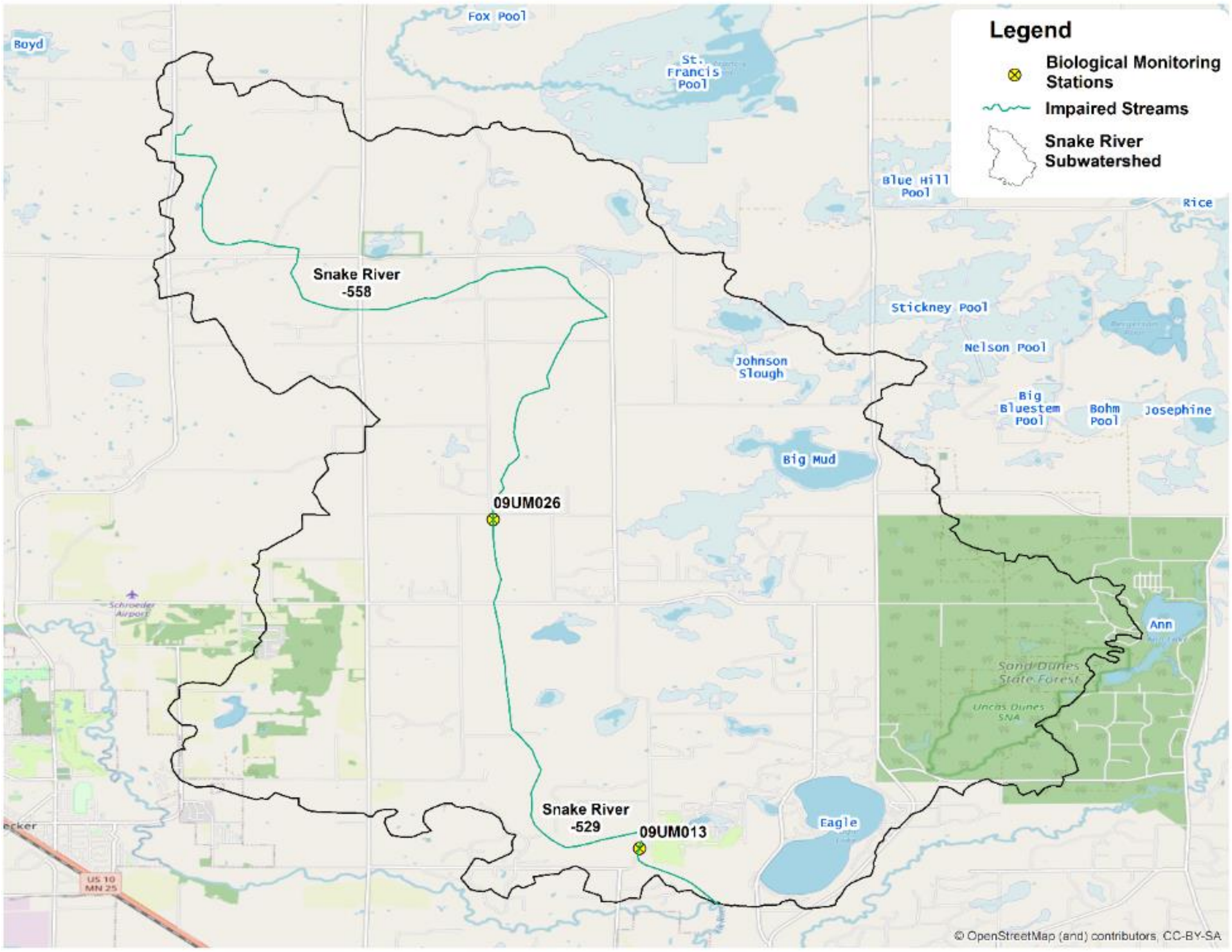


Figure 67. Biological monitoring stations within the Snake River Subwatershed.

The land use within the Snake River Subwatershed is dominated by forestland (32.0%), followed by wetlands (23.3%), and cropland (18.0%) (Figure 68).

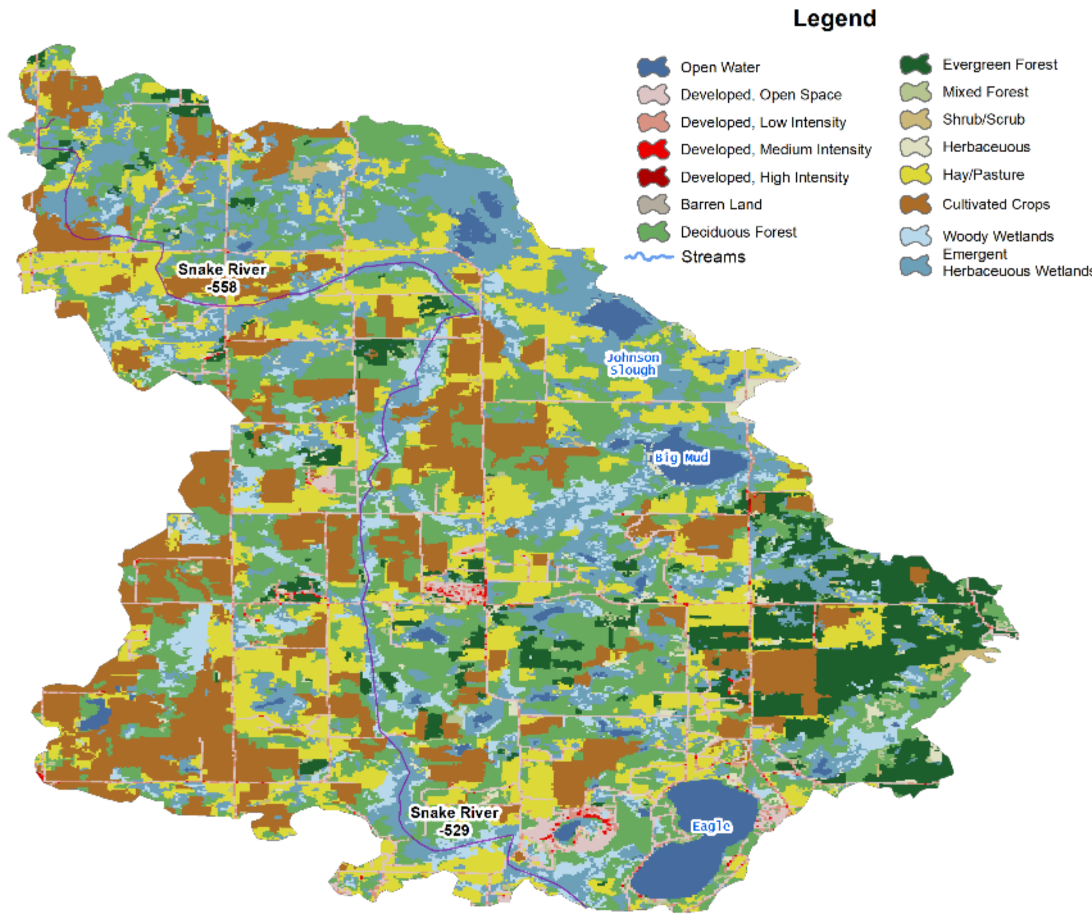


Figure 68. Land use within the Snake River Subwatershed. Credit: NLCD 2016.

Snake River (07010203-558)

Impairment: The Snake River (Sherburne County Ditch #34) (AUID -558) flows for 11.4 miles from the headwaters, off 150th Ave, 2.3 miles southwest of Santiago to the confluence with the downstream portion of Snake River, just downstream of 112th Street SE. The Snake River has been channelized throughout the entire reach. There is one biological monitoring station (09UM026) that was sampled for fish and macroinvertebrates in 2009, and then repeated in 2019 (Figure 67). The Snake River was assessed in 2021, which determined that the Snake River has cold water temperatures, and should be held to coldwater stream standards. This assessment resulted in a new fish impairment. The fish stream class is class 11 (Northern Coldwater) and the macroinvertebrate stream class is class 9 (Southern Coldwater).

Snake River (07010203-529)

Impairment: The Snake River (AUID -529) flows for 2.8 miles from just downstream of 112th Street SE, to the confluence with the outlet of Eagle Lake, just southwest of Eagle Lake. The Snake River has been channelized throughout the entire reach. There is one biological monitoring station (09UM013) that was sampled for fish and macroinvertebrates in 2009, and then repeated in 2019 (Figure 67). The Snake River was assessed in 2021, which determined that the Snake River has cold water temperatures, and should be held to coldwater stream standards. This assessment resulted in a new fish impairment. The fish stream class is class 11 (Northern Coldwater) and the macroinvertebrate stream class is class 9 (Southern Coldwater).

Data and Analyses

The two AUIDs (-558 and -529) that are impaired on the Snake River are connected in close proximity, and therefore, will be discussed together for the purposes of this report.

Chemistry

Water chemistry data has been collected on both AUIDs from 2007 through 2013, and 2019 to 2020 (Table 17).

Table 17. Water chemistry data collected on Snake River. Data available at https://webapp.pca.state.mn.us/surface-water/search.

AUID	Parameter	Sample Count	Applicable Standard	Avg. Result	Min. Result	Max. Result
07010203-529	Dissolved oxygen (DO)	63	7.0 mg/L	9.76	3.4	12.14
07010203-529	Inorganic nitrogen (nitrate and nitrite)	16	N/A	1.44	0.16	1.87
07010203-529	pH	61	N/A	8.06	6.6	8.7
07010203-529	Phosphorus, Total	26	0.100 mg/L	0.102	0.04	0.122
07010203-529	Specific conductance	63	N/A	421.88	238	460
07010203-529	Temperature, water	63	N/A	15.34	3.5	29
07010203-529	Total suspended solids	22	10.0 mg/L	9.27	2	20
07010203-529	Transparency, tube with disk	99	N/A	74.15	25	100
07010203-529	Volatile suspended solids	2	N/A	6.3	5.6	7
07010203-558	Dissolved oxygen (DO)	6	7.0 mg/L	7.66	6.06	8.48
07010203-558	Inorganic nitrogen (nitrate and nitrite)	4	N/A	1.34	1.1	1.6
07010203-558	pH	6	N/A	7.81	7.61	8.15
07010203-558	Phosphorus, Total	4	0.100 mg/L	0.06	0.06	0.075
07010203-558	Specific conductance	6	N/A	408.1	333.4	444
07010203-558	Temperature, water	6	N/A	16.38	13.1	20.4
07010203-558	Total suspended solids	4	10.0 mg/L	6.25	2.8	9.6
07010203-558	Transparency, tube with disk	6	N/A	88.92	70	100
07010203-558	Volatile suspended solids	1	N/A	4	4	4

Nutrients – Phosphorus

Phosphorus values from the dataset on the Snake River shows that the average TP value was just above the Central Region River Nutrient standard (0.100 mg/L) at -529 with an average value of 0.102 mg/L and below the standard at -558 with an average value of 0.06 mg/L (Table 17). The phosphorus values at -529 were elevated within 15% of the samples, which indicates that phosphorus has the potential to be a stressor to the aquatic life within the short downstream portion of the Snake River.

Dissolved Oxygen

DO levels within the Snake River appear to be stable, with all but two samples (one sample from each reach) meeting the coldwater DO standard of 7.0 mg/L (Table 17). Therefore, DO does not appear to be a stressor to the aquatic life within the Snake River at this time. Within the cycle I SID report (MPCA 2013), the Snake River was suggested to be a potential source of low DO to the downstream reach of the Elk River. This report indicated that the low DO readings within the Elk River near the confluence with the Snake River, and the fish species that were collected at the same location indicated that the Snake River was negatively impacting the Elk River. However, the data was inconclusive to determine if low DO was affecting the fish community. Due to the majority of the DO samples meeting the coldwater DO standard, it is more likely that the Snake River is contributing sediment to the Elk River, which is impacting the biology, than contributing low DO.

Total Suspended Solids

The TSS dataset for the Snake River indicated that 45% of the TSS samples exceeding the coldwater standard of 10.0 mg/L on reach -529 and all of the four samples were below the standard on reach -558 (Table 17). The TSS values on -529 indicate that TSS has the potential to be a stressor within the river.

Conductivity

Specific conductivity values were within range within the Snake River (Table 17), and are not considered to be a stressor.

Temperature

Temperature values were within range for a coldwater stream within the dataset that was collected in the Snake River (Table 17). Additional data was also collected by MPCA biological monitoring staff, which further indicated that temperatures were stable and cold enough to support a coldwater biological community. Therefore, temperature is not considered a stressor at this time.

Habitat

Habitat was classified as fair/poor on the Snake River, through the MSHA evaluations during the fish and macroinvertebrate samples (Figure 69).

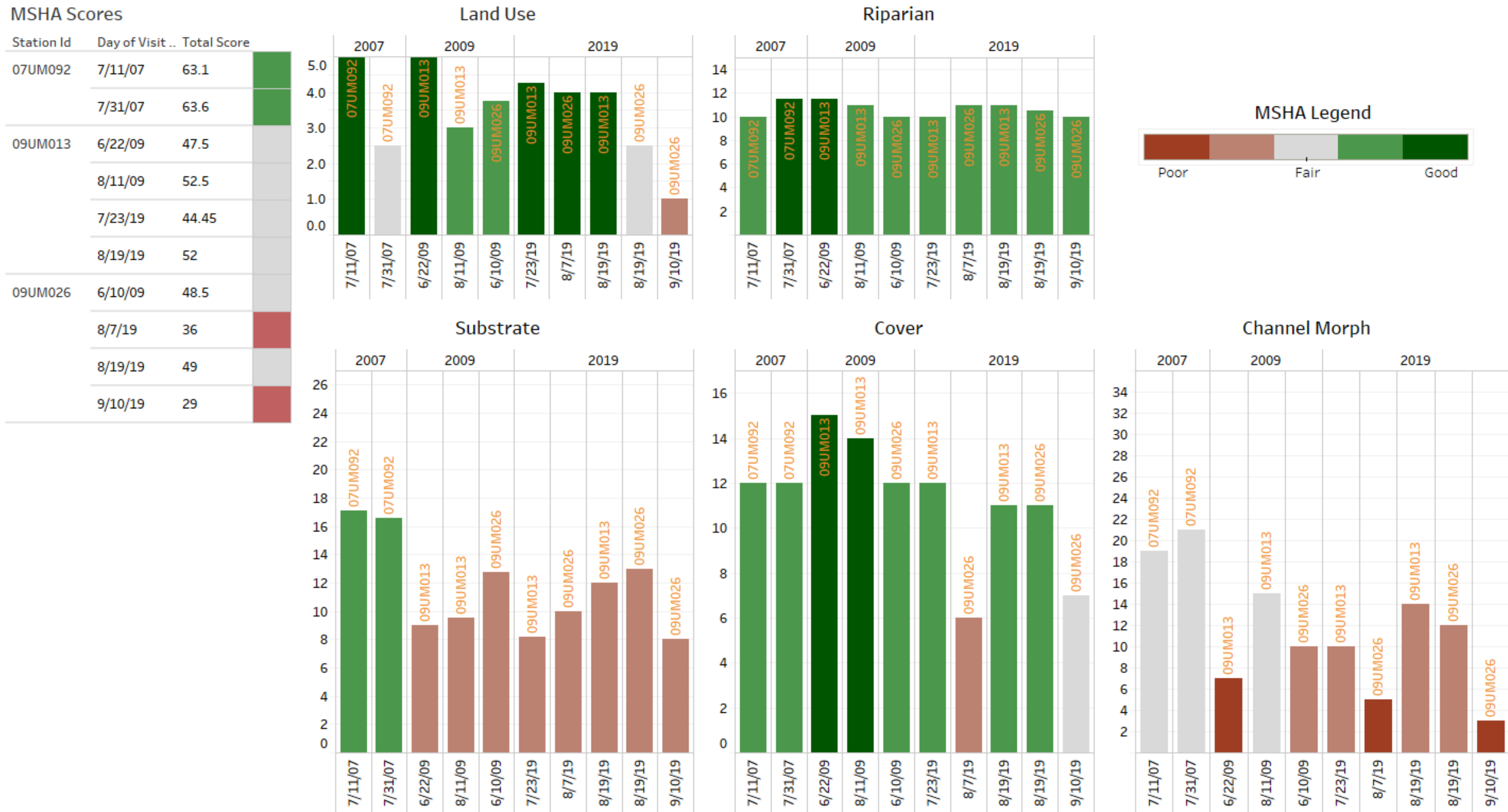


Figure 69. MSHA habitat scores for the Snake River.

Although the average MSHA score was fair/poor overall, substrate and channel morphology scored particularly low as noted in Figure 69. Substrate was the first low scoring component of the MSHA score, as indicated by the dominance of sand and silt. Coldwater fishes, such as the Brook Trout, require exceptionally clean coarse substrate in order to build nests and spawn. Excessive fine sediment also affects juvenile fishes. As the sediment is stirred into the water column creating TSS, it can easily tear sensitive juvenile fish gills. Similarly, many sensitive macroinvertebrates also have specialized gills that are used to breathe DO. Excessive fine sediments can damage these gills, similar to juvenile fishes, making the creek uninhabitable for sensitive species.

Channel morphology was another low scoring component of the MSHA evaluation. The MSHA indicated that there was no sinuosity, and poor channel development (no riffles or pools). Fish and macroinvertebrates need deep pool habitats to use as cover from predation and refuge during high precipitation events. Although the channel depth varied throughout the reach, the ditching process has removed all sinuosity and pool habitat within the river. This lack of pool habitat impedes the fish and macroinvertebrates ability to inhabit the creek throughout the summer, especially during high flow events, which can flush these communities downstream. The lack of good channel morphology is caused by the channelization of the river, as the manipulation of the channel has been designed to move water quickly, by mechanically removing channel sinuosity, pools, and riffles. Lack of habitat is the direct stressor to the aquatic life within the Snake River.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology of the Snake River, and the entire subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests to cultivated fields and the channelization of the natural streams and wetlands. The entire length of the Snake River has been straightened, including AUIDs -558 and -529.

Utilizing the pictures that were taken during the fish samples and MSHA evaluations of stream bank condition, the banks appear to be stable and not actively eroding. Although the banks are stable within the river, there is evidence of excessive sediment within the channel. Silt, detritus, and muck are present along the banks of the river throughout both AUIDs (Figure 70).

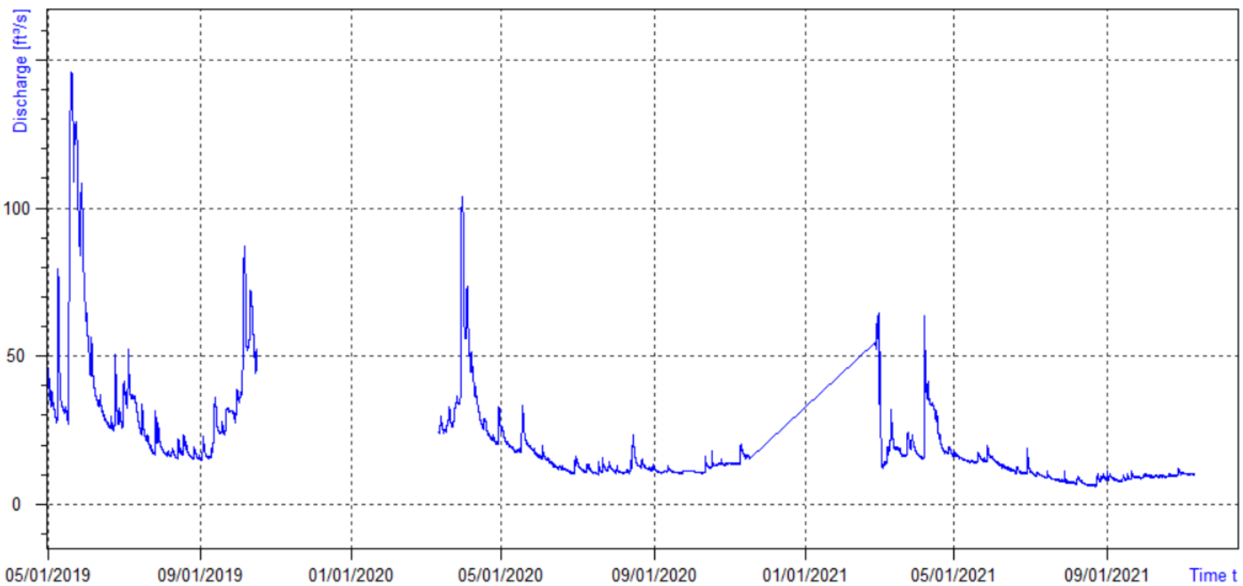
Figure 70. Excessive sedimentation at 09UM013 (left) and at 09UM026 (right).

Due to the stable banks, and minimal erosion within the channel, the excessive sedimentation is most likely the result of the historic channelization of the river, which straightened the river by dredging a new channel through multiple historic wetlands (Figure 71).

Figure 71. 1939 aerial photo of the channelization of the Snake River. Photo available at https://geo.lib.umn.edu/Sherburne/y1939/BJL-9-7.jpg.

Looking at the 1939 historic aerial photograph of the area (Figure 71), remnants of the small sinuous channel can be seen. This smaller channel through the wetlands would have allowed the channel to self-clean during high flow events. However, due to the new channel being much larger than the historic channel, sediment is only transported during the spring time thaw, as all of the other events throughout the summer can be contained within the new larger channel, as noted by the stream gage data that was collected off the 185th Ave SW crossing, starting in 2019 (Figure 72).

Figure 72. Discharge data collected on the Snake River collected from 2019-2021.



In addition to the over-sized channel contributing to the sediment issues within the Snake River, beaver activity is prevalent throughout the subwatershed. Current and historic dams can be found throughout the Snake River, and not only create connectivity barriers for fish, but also hold back sediment, and divert flow into the banks (Figure 73 and Figure 74).

Figure 73. Overview of one of the old beaver dams within the Snake River, showing the TSS coming from the banks.

Figure 74. Closer view of the old beaver dam, showing the velocity fish barrier and the suspended sediment.

Due to the geomorphic changes within the river caused by altered hydrology and beaver activity leading to excess sedimentation, altered hydrology and geomorphology is considered to be a direct stressor to the aquatic life within the Snake River.

Connectivity

The culvert crossings by 09UM026 and 09UM013 are slightly undersized and could become plugged with sediment, but are currently open and do not appear to be perched. However, there are multiple beaver impoundments on the Snake River, and there are multiple small tributaries that flow into the Snake River in the headwaters portion of the subwatershed, which may provide coldwater refuge for coldwater fish and macroinvertebrates, that are isolated by perched culverts (Figure 75). As the smaller culverts are replaced in the future, there may be an opportunity to reconnect the small tributaries to the Snake River with AOP certified culverts. Connectivity is considered to be a direct stressor to the aquatic life within the Snake River due to the beaver activity.

Figure 75. Perched culverts on small tributary streams flowing into the Snake River.

Stressor signals from biology

Fish

Fish were sampled once at 09UM026 and twice at 09UM013 in 2009 as part of the cycle I monitoring effort. Fish were sampled again at 09UM026 and 09UM013 as part of the cycle II monitoring effort. On average, 11 fish species were collected at 09UM026 and an average of 17 fish species were collected at 09UM013. Blacknose Shiner and the Northern Redbelly Dace were the most prevalent fish species collected at 09UM026, and the Blacknose Shiner, White Sucker, and the Johnny Darter were the most prevalent species collected at 09UM013. These communities contained a healthy mixture of tolerant and intolerant fish species, but only one cool water species was collected (Mottled Sculpin). Due to the lack of coldwater fishes, the Snake River reaches -558 and -529 were listed for fish on the impaired waters list. In addition, the Snake River is no longer managed as a trout stream by the DNR due to the lack of habitat, beaver activity, lack of angler access, and the fact that the river serves as a public drainage ditch.

TIVs were calculated for the Snake River using the fish community. The TSS TIV found that the fish community had an average probability of 82% of coming from a stream that is meeting the TSS standard. Within the samples collected at 09UM026, two of the fish species that were collected are considered to be sensitive of elevated TSS, and no other species had a sensitivity to TSS. As for the samples collected at 09UM013, one intolerant species, three sensitive species, and one tolerant species were found within the samples. Therefore, the fish community response to TSS indicates that TSS is not a stressor to the fish community.

DO TIV scores were also calculated for the Snake River using the fish communities. This calculation indicated that the fish community has an average probability of 35% of coming from a stream that was meeting the DO standard. However, all of the fish samples collected at 09UM026 and 09UM013 contained a healthy mixture of fish species that are considered to be tolerant and intolerant to low DO. Therefore, the fish community response to DO indicates that DO is not at stressor to the fish community within the Snake River.

Phosphorus tolerance of the fish community was also investigated within the Snake River using the fish species characteristics. Across all of the fish samples an average of two sensitive, five tolerant, and three very tolerant species were collected within the samples. This presence of sensitive and tolerant species indicates that there is a healthy mixture of species and that phosphorus is not a stressor to the fish community within the Snake River.

Macroinvertebrates

Macroinvertebrates were also sampled in 2009 at 09UM026 and 09UM013 as part of the cycle I watershed monitoring effort, and resampled at both locations as part of the cycle II monitoring effort. These samples produced a macroinvertebrate community that was meeting standards at both -558 and -559, which are not impaired for macroinvertebrates at this time. In 2009, an average of 74% of the macroinvertebrate community was comprised of taxa that are considered to be tolerant of pollutants, and an average of 17% of the community was considered to be very tolerant of pollutants. *Hyalella,* and *Baetis* taxa dominated the samples, which are considered to be tolerant taxa. Similarly, in 2019 an average of 79% of the macroinvertebrate community was comprised of taxa that are considered to be tolerant of pollutants, and an average of 11% of the community was considered to be very tolerant of pollutants. *Baetis* and *Gammarus* taxa dominated the samples, which are considered to be tolerant taxa. Although the macroinvertebrates are meeting standards within the Snake River, the TIV scores were calculated using the macroinvertebrate community to help identify potential stressors to the fish community. However, the TIV scores for TSS, DO, and phosphorus all contained healthy mixtures of taxa that are considered to be both intolerant and tolerant to the respective parameters (Table 18). Since these TIV scores do not indicate that the chemical parameters are stressors, this is further indication that habitat and altered hydrology are the primary stressors to the fish community within the Snake River.

Table 18. Macroinvertebrate tolerance index values for the Snake River.

Parameter	Tolerance	2009 Sample at 09UM026	2009 Sample at 09UM013	2019 Sample at 09UM013	2019 First Sample at 09UM026	2019 Second Sample at 09UM026
DO	# Intolerant	10	8	5	9	4
	# Tolerant	4	11	6	0	1
	# Very Intolerant	7	5	3	6	4
	# Very Tolerant	0	4	3	0	1
Phosphorus	# Intolerant	5	3	3	1	2
	# Tolerant	10	17	9	5	3
	# Very Intolerant	1	0	0	0	0
	# Very Tolerant	5	10	5	2	2
TSS	# Intolerant	2	1	2	0	0
	# Tolerant	6	14	9	6	7
	# Very Intolerant	0	0	0	0	0
	# Very Tolerant	3	4	4	1	2

Composite conclusion from biology

The habitat and altered hydrology/geomorphology are heavily altered within the Snake River, and are direct stressors to the aquatic life within the Snake River.

Beaver dams are barriers to fish passage throughout the Snake River, and therefore, connectivity is a direct stressor to the fish community within the Snake River.

Recommendations

Restoration of the Snake River to support a coldwater fishery would require significant channel alterations. The current river channel is over-widened and lacks the habitat complexity that is required to support a healthy coldwater fishery. This could be achieved by restoring the river to the narrow and sinuous channel that existed prior to the channelization, which would make the greatest impact to the aquatic life within the river, but would be costly, and would require a change in the current management of the river channel as a ditch. Due to the Snake River being an active ditch that can be legally cleaned out, any restoration activities would require the public drainage authorities to abandon the Snake River from current ditch plans, and remove the channel from active ditch management.

Therefore, due to the high cost of a stream restoration project and the ditch management changes needed to restore the Snake River, implementing an active beaver management plan across the entire length of the Snake River may be the most cost-effective way to address the fish impairment within both sections of the Snake River.

Big Lake-Elk River Subwatershed

The Big Lake-Elk River Subwatershed covers 19,844 acres, located just east of Becker (Figure 76). Just over half of the streams (52%) within the subwatershed have been straightened. The drainage area of Unnamed Creek, which will be discussed in this section is around 6,800 acres.

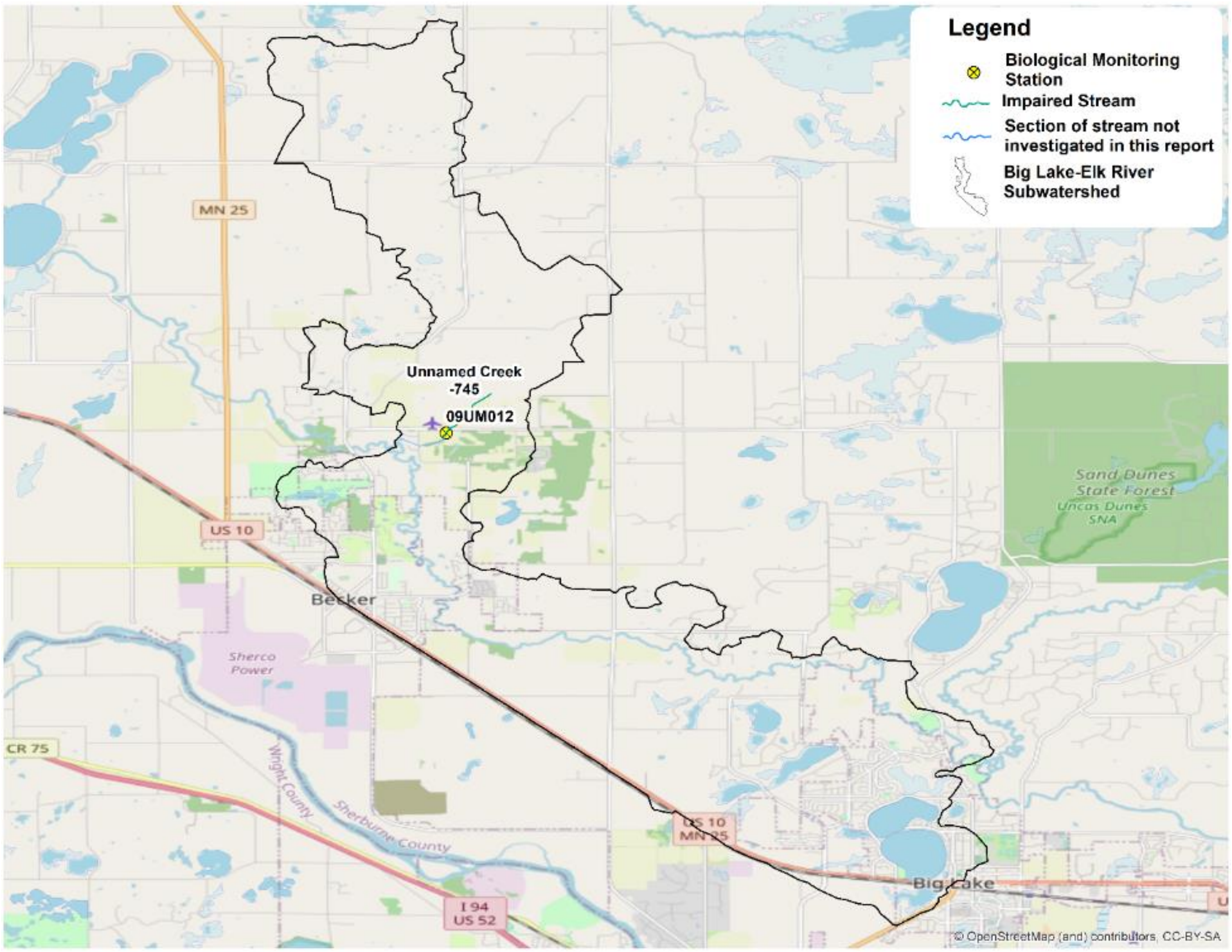


Figure 76. Biological monitoring station within the Big Lake-Elk River Subwatershed.

The land use within the Big Lake-Elk River Subwatershed is dominated by cropland (31.4%), followed by forestland (21.4%), and developed land (16.8%) (Figure 77).

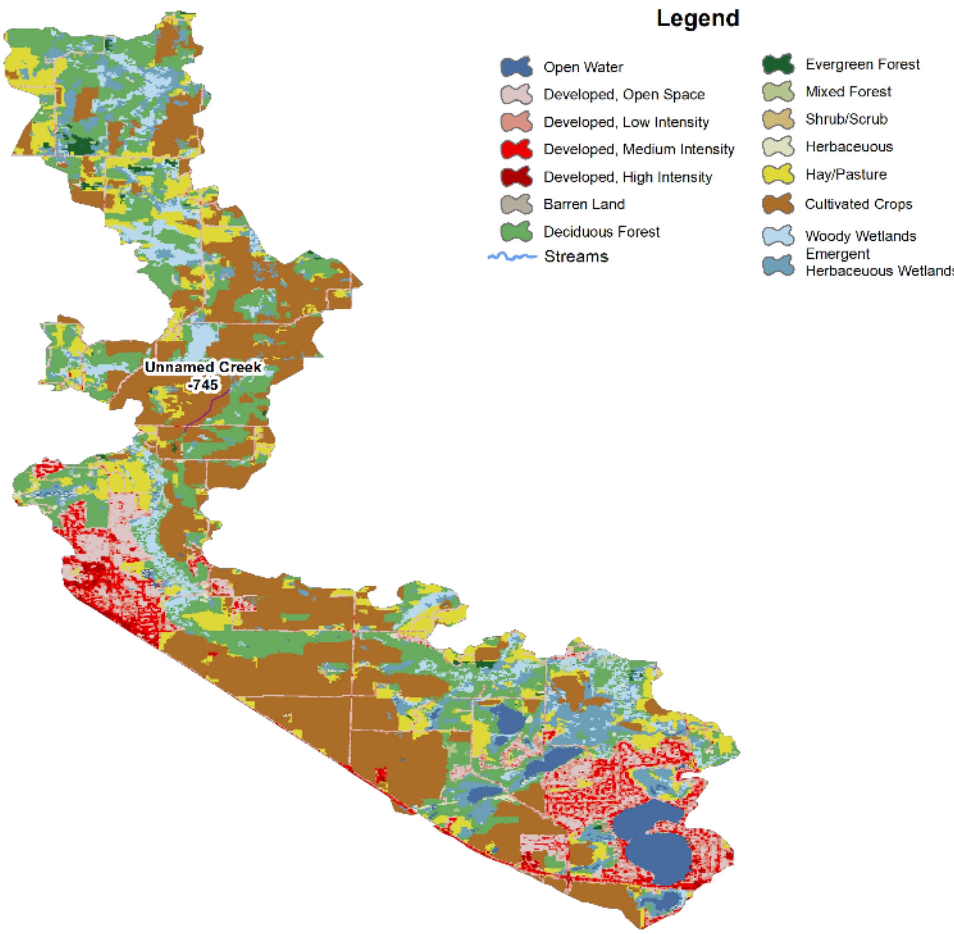


Figure 77. Land use within the Big Lake-Elk River Subwatershed. Credit: NLCD 2016.

Unnamed Creek (07010203-745)

Impairment: Unnamed Creek (also known as Sherburne County Ditch #19) (AUID -745) flows for 0.8 of a mile from south of 82nd Street SE, to the just south of 97th Street. Unnamed Creek has been channelized throughout the entire reach. There is one biological monitoring station (09UM012) that was sampled for fish and macroinvertebrates in 2009 (Figure 76). Unnamed Creek was assessed in 2019, as part of the TALU assessment process for assessing channelized streams. The UAA process determined that Unnamed Creek should be assessed under the modified use criteria. This assessment resulted in a new fish impairment. The fish stream class is class 6 (Northern Headwaters) and the macroinvertebrate stream class is class 6 (Southern Forest Streams Glide/Pool).

Chemistry

Water chemistry data has been collected from one station (S011-212) on Unnamed Creek (Table 19). This dataset was collected in 2009 and 2021, and was used to aid in the SID process of the biological impairments.

Table 19. Water chemistry data collected on Unnamed Creek. Data available at https://webapp.pca.state.mn.us/surface-water/search.

Parameter	Count of Samples	Applicable Standard	Avg. Result	Min. Result	Max. Result
Dissolved oxygen (DO)	6	5.0 mg/L	9.63	8.85	11.73
Inorganic nitrogen (nitrate and nitrite)	3	N/A	1.45	1.3	1.6
pH	6	N/A	8.05	7.86	8.17
Phosphorus	3	0.100 mg/L	0.067	0.02	0.164
Solids, Suspended Volatile	5	N/A	4.6	2	9.8
Specific conductance	6	N/A	501.02	471	523
Temperature, water	6	N/A	16.22	14.16	19.3
Total suspended solids	5	30.0 mg/L	13.6	1.2	23.6
Transparency, tube with disk	2	N/A	79	58	100

Nutrients – Phosphorus

Phosphorus values from Unnamed Creek, shows that the average TP is below the Central Region River Nutrient standard (0.100 mg/L) with an average value of 0.067 mg/L (Table 19). Although the average TP value was below the standard, one of the samples was above the standard at 0.164 mg/L. Altogether, the dataset is limited to three samples, which indicates that elevated phosphorus may be a stressor, but is inconclusive due to the limited dataset.

Dissolved Oxygen

DO data from Unnamed Creek is limited to six samples, but indicates that the DO levels within the Creek are within range (Table 19). Low DO does not appear to be a stressor to the aquatic life within Unnamed Creek.

Total Suspended Solids

The TSS dataset for Unnamed Creek indicates that TSS levels are low within the creek, with all five samples occurring below the standard of 30 mg/L (Table 19). Therefore, TSS does not appear to be a stressor to the aquatic life within Unnamed Creek.

Conductivity

Specific conductivity was within range throughout the dataset on Unnamed Creek (Table 19). Therefore, conductivity does not appear to be a stressor to the aquatic life within Unnamed Creek at this time.

Temperature

Temperature data was within range throughout the dataset on Unnamed Creek (Table 19), and does not appear to be a stressor to the aquatic life within Unnamed Creek at this time.

Habitat

Habitat was classified as poor on Unnamed Creek, through the MSHA evaluations at the 2009 and 2021 fish samples (Figure 78).

Figure 78. MSHA habitat scores for Unnamed Creek.

Due to the historic channelization of Unnamed Creek, and poor MSHA score, the assessment of Unnamed Creek was brought into the UAA process. It was determined that the habitat of Unnamed Creek has degraded to a point where it cannot support good quality habitat for aquatic life, as a result of channelization. Therefore, Unnamed Creek was assessed using the modified use TALU criteria.

Although the average MSHA score was poor overall, land use, substrate, and channel morphology scored particularly low, which lowered the overall MSHA score (Figure 78). Substrate scored poorly due to the dominance of sand and silt. Healthy fish communities need coarse substrate in order to build nests and spawn. Excessive fine sediment also affects juvenile fishes, as the sediment is stirred into the water column creating TSS, it can easily tear sensitive juvenile fish gills. Similarly, many sensitive macroinvertebrates also have specialized gills that are used to breathe DO. Excessive fine sediments can damage these gills, similar to juvenile fishes, making the creek uninhabitable for sensitive species.

Channel morphology was another low scoring component of the MSHA evaluation. The MSHA indicated that there was fair channel depth variability, poor sinuosity, and fair channel development (no riffles, and poorly defined pools). Fish and macroinvertebrates need channel depth variability to use as cover from predation and refuge during high precipitation events. Minimal change in the channel depth combined with fair sinuosity impedes the fish and macroinvertebrates ability to inhabit the creek throughout the summer, especially during high flow events which can flush these communities downstream. The lack of good channel morphology is caused by the channelization of the creek, as the manipulation of the channel has been designed to move water quickly, by mechanically removing channel sinuosity, pools, and riffles. Lack of habitat is a direct stressor to the aquatic life in Unnamed Creek.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology of Unnamed Creek, and the entire subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests to cultivated fields and the channelization of the natural streams and wetlands. Unnamed Creek has been straightened along almost the entire length of the AUID, with a small portion of the creek at the confluence with the Elk River remaining natural.

Historically, Unnamed Creek was a small stream channel that flowed into the Elk River. After the channelization of the creek, the drainage area was doubled, with the creek now draining 10.6 square miles (Figure 79).

Figure 79. Plat map of the pre-settlement channel compared to the current steam channel.

This channel alteration accelerates stream flow, resulting in higher flows during precipitation events which achieves the agricultural land use drainage goals, but causes instability. Water leaves the landscape quickly, resulting in periods of higher flow than what would have naturally occurred. Due to the channelization of Unnamed Creek, the ditch does not have a natural stream pattern that can be assessed for stability. Utilizing the biological monitoring sampling pictures and MSHA evaluations of stream bank condition, the banks appear to be mostly stable, but are showing signs of active erosion. The current channel size is most likely much larger than the historic stream channels that existed prior to the channelization, due to the large drainage area of the ditch. This large drainage area, and unstable flow conditions caused by the channelization of Unnamed Creek has inhibited the ability for sensitive fish and macroinvertebrates to inhabit the ditch, and therefore, the altered hydrology and geomorphology of Unnamed Creek is a direct stressor to aquatic life.

Connectivity

The culvert crossing by 09UM012 off 97th Street, and the next downstream crossing off 145th Ave SE do not appear to be a fish barrier.

Stressor signals from biology

Fish

Fish were sampled in 2009 as part of the cycle I monitoring effort and resampled in 2021 as part of the cycle II monitoring effort. The 2009 sample contained a total of seven fish species, with Central Mudminnows being the most dominate, and the 2021 sample contained a total of six fish species, with Creek Chubs being the most dominate. All of the fish sampled within the 2009 sample were considered to be tolerant, and the 2021 fish sample was dominated by tolerant fish species, but also contained a sensitive species (Smallmouth Bass).

The TSS and phosphorus TIV values from the 2009 fish sample were weak due to the limited number of fish collected within the sample. However, the DO TIV scores were able to be calculated. The fish community within the 2009 sample indicated that DO may be a stressor as only DO tolerant and very DO tolerant fish species were collected. The TIV score also indicated that there was only a 5.5% probability that the fish that were collected within Unnamed Creek would come from a stream that is meeting the DO standard. Therefore, the fish TIV scores indicate that DO has the potential to be a stressor within Unnamed Creek, however, due to the DO data within the dataset showing values above the standard, it is likely that the fish species that are present within the creek are also tolerant of poor habitat, further indicating that poor habitat is the direct stressor.

The TIV scores for the 2019 fish sample were slightly higher than the 2009 sample, providing more evidence that DO is not a stressor within Unnamed Creek.

Macroinvertebrates

Macroinvertebrates were also sampled in 2009 as part of the cycle I watershed monitoring effort. Seventy-two percent of the macroinvertebrate community that was sampled in 2009 was comprised of taxa that are considered to be tolerant of pollutants, and 14% of the community was considered to be very tolerant of pollutants. *Ceratopsyche* dominated the sample, which is considered to be a sensitive taxa. Due to the presence of sensitive taxa, the macroinvertebrate sample produced an IBI score that was above the impairment threshold, and is meeting standards at this time.

Although the macroinvertebrates are meeting standards, TIV indicators were calculated using the macroinvertebrate sample in an attempt to help identify potential stressors to the fish community. TSS taxa tolerance was the first TIV investigated using the macroinvertebrate community. In the 2009 sample, no very intolerant taxa, one intolerant taxa, seven tolerant taxa, and three very tolerant taxa were collected (Table 20). Overall, the macroinvertebrate community within Unnamed Creek indicates that TSS has the potential to be a stressor to the fish community, with the sample being dominated by tolerant taxa. However, with the limited TSS dataset indicating that TSS within Unnamed Creek is below the threshold, more data would need to be collected to make a final determination.

DO tolerance was also investigated using the macroinvertebrate communities. In 2009, seven very intolerant, two intolerant taxa, two tolerant taxa, and one very tolerant taxa were collected (Table 20). The combination of very intolerant and tolerant taxa within the macroinvertebrate sample indicates that DO is not a stressor to the fish community within Unnamed Creek.

The final tolerance indicator that was investigated within the macroinvertebrate community was phosphorus tolerance. In the 2009 sample, four intolerant taxa, seven tolerant taxa and four very tolerant taxa were collected (Table 20). These tolerance indicators within the macroinvertebrate community indicate that phosphorus is not a stressor to the fish community within Unnamed Creek.

Table 20. Macroinvertebrate tolerance index values for Unnamed Creek.

Parameter	Tolerance	2009 Sample
DO	# Intolerant	7
	# Tolerant	2
	# Very Intolerant	5
	# Very Tolerant	1
Phosphorus	# Intolerant	4
	# Tolerant	7
	# Very Intolerant	0
	# Very Tolerant	4
TSS	# Intolerant	1
	# Tolerant	7
	# Very Intolerant	0
	# Very Tolerant	3

Composite conclusion from biology

The habitat, hydrology, and geomorphology are heavily altered within Unnamed Creek, and are direct stressors to the aquatic life within the ditch. However, due to the improvement within the 2021 fish sample, with the presence of the sensitive species, Smallmouth Bass, this reach is currently under review for a potential correction to the original impairment, and may be removed from the impaired waters list.

Recommendations

The impairment status of this reach is currently under review as the fish sample from 2021 is meeting the modified use standards. Therefore, it would be prudent to determine if this reach will be removed from the impaired waters list in the future. The MPCA staff are currently reviewing the fish data, and will make recommendations on the future impairment status of Unnamed Creek within the 2023 assessment cycle.

Tibbits Brook Subwatershed

The Tibbits Brook Subwatershed covers 24,205 acres, located in Zimmerman (Figure 80). Almost all of the streams (91.5%) within the subwatershed have been straightened.

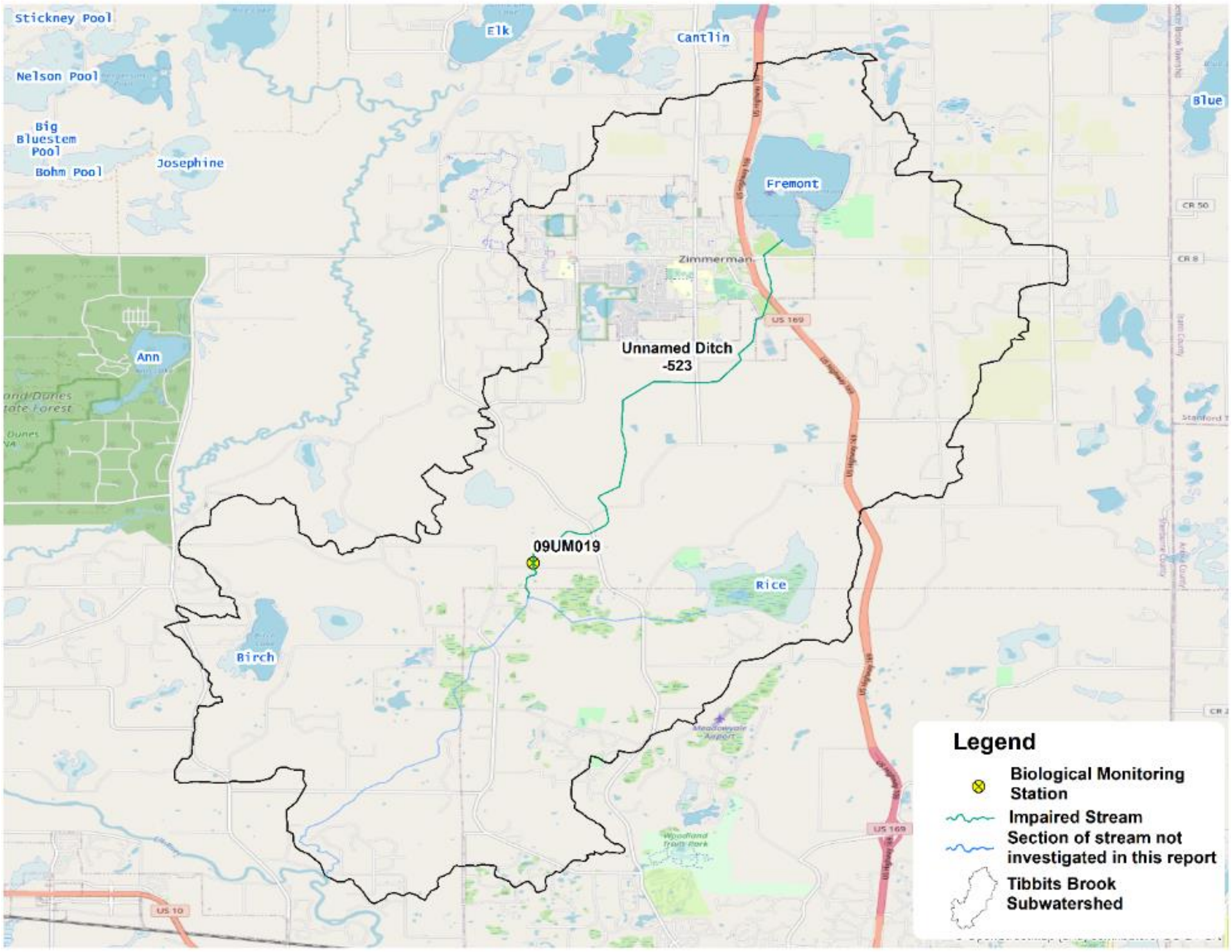


Figure 80. Biological monitoring station within the Tibbits Brook Subwatershed.

The land use within the Tibbits Brook Subwatershed is dominated by wetlands (26.2%), followed by forestland (26.1%), and rangeland (23.3%) (Figure 81).

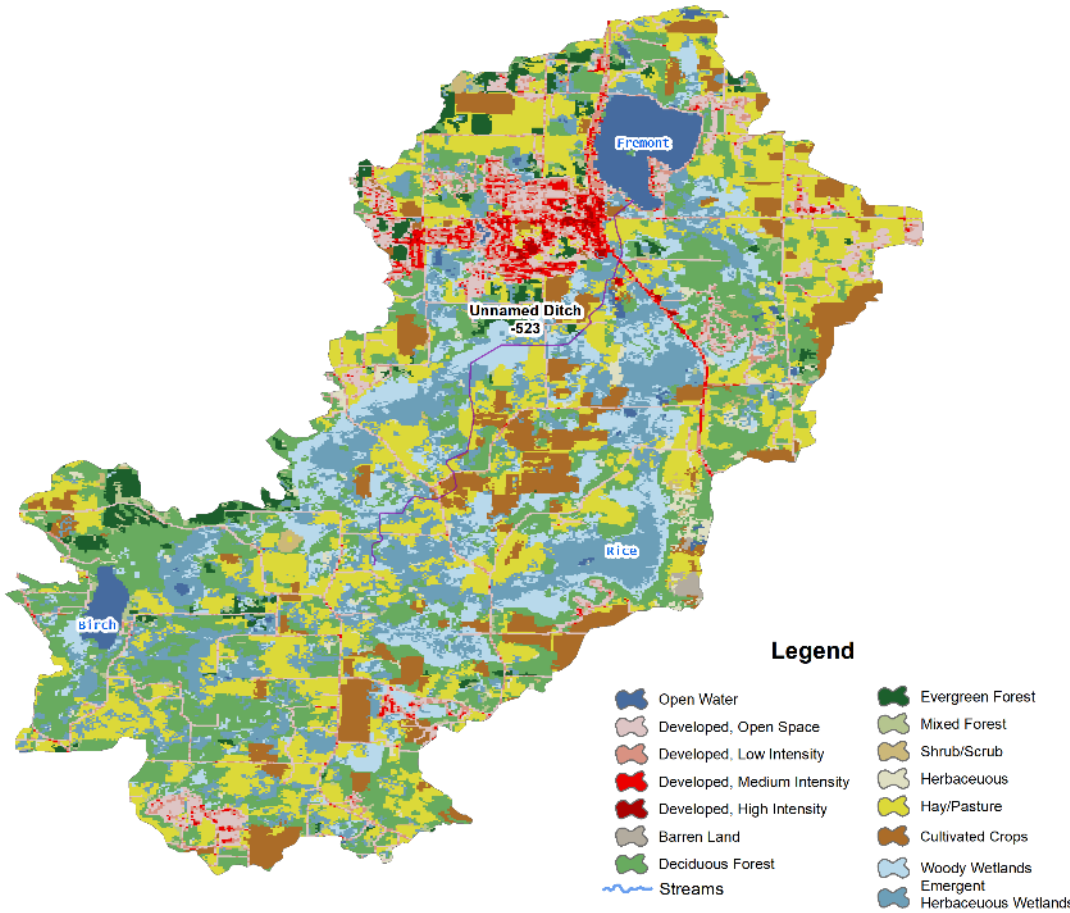


Figure 81. Land use within the Tibbits Brook Subwatershed. Credit: NLCD 2016.

Unnamed Ditch – Sherburne County Ditch #1 (07010203-523)

Impairment: Unnamed Ditch - Sherburne County Ditch #1 (AUID -523) flows for 5.9 miles from Fremont Lake to Tibbets Brook, 5 miles southwest of Zimmerman. Unnamed Ditch - Sherburne County Ditch #1 has been channelized throughout the entire reach. There is one biological monitoring station (09UM019) that was sampled for fish in 2009 and sampled for macroinvertebrates in 2010 (Figure 80). Unnamed Ditch - Sherburne County Ditch #1 was assessed in 2019, as part of the TALU assessment process for assessing channelized streams. The UAA process determined that Unnamed Ditch - Sherburne County Ditch #1 should be assessed under the modified use criteria. This assessment resulted in a new macroinvertebrate impairment. The fish stream class is class 6 (Northern Headwaters) and the macroinvertebrate stream class is class 6 (Southern Forest Streams Glide/Pool).

Data and Analyses

Chemistry

Water chemistry data that has been collected on Unnamed Ditch - Sherburne County Ditch #1 (S011-215) is limited to the samples that were collected by the biological monitoring crews in 2009 and 2010 (Table 21).

Table 21. Water chemistry data collected on Unnamed Ditch - Sherburne County Ditch #1. Data available at https://webapp.pca.state.mn.us/surface-water/search.

Parameter	Count of Samples	Applicable Standard	Avg. Result	Min. Result	Max. Result
Dissolved oxygen (DO)	2	5.0 mg/L	8.4	5.61	11.18
Inorganic nitrogen (nitrate and nitrite)	1	N/A	0.56	0.56	0.56
pH	2	N/A	7.72	7.27	8.17
Phosphorus	1	0.100 mg/L	0.11	0.11	0.106
Specific conductance	2	N/A	453.5	424	483
Temperature, water	2	N/A	15.05	12.9	17.2
Total suspended solids	1	30.0 mg/L	5.4	5.4	5.4
Transparency, tube with disk	2	N/A	100	100	100

Although the dataset is limited, phosphorus appears to be elevated. The phosphorus value was right at the Central Region River Nutrient standard (0.100 mg/L) with a value of 0.106 mg/L (Table 21). This indicates that phosphorus has the potential to be a stressor within Unnamed Ditch - Sherburne County Ditch #1, however, the stream habitat is most likely the direct stressor. All of the other parameters within the dataset were below the respective thresholds, but due to the limited samples within the dataset, the chemical parameters are inconclusive stressors to the aquatic life within Unnamed Ditch - Sherburne County Ditch #1 at this time. Although the dataset for Unnamed Ditch – Sherburne County Ditch #1 is limited, there are data further downstream on Tibbits Brook (S005-538) that indicate that TP is elevated in Tibbits Brook and may also impact Unnamed Ditch - Sherburne County Ditch #1.

Habitat

Habitat was classified as poor on Unnamed Ditch - Sherburne County Ditch #1, through the MSHA evaluation at the fish sample (Figure 82).

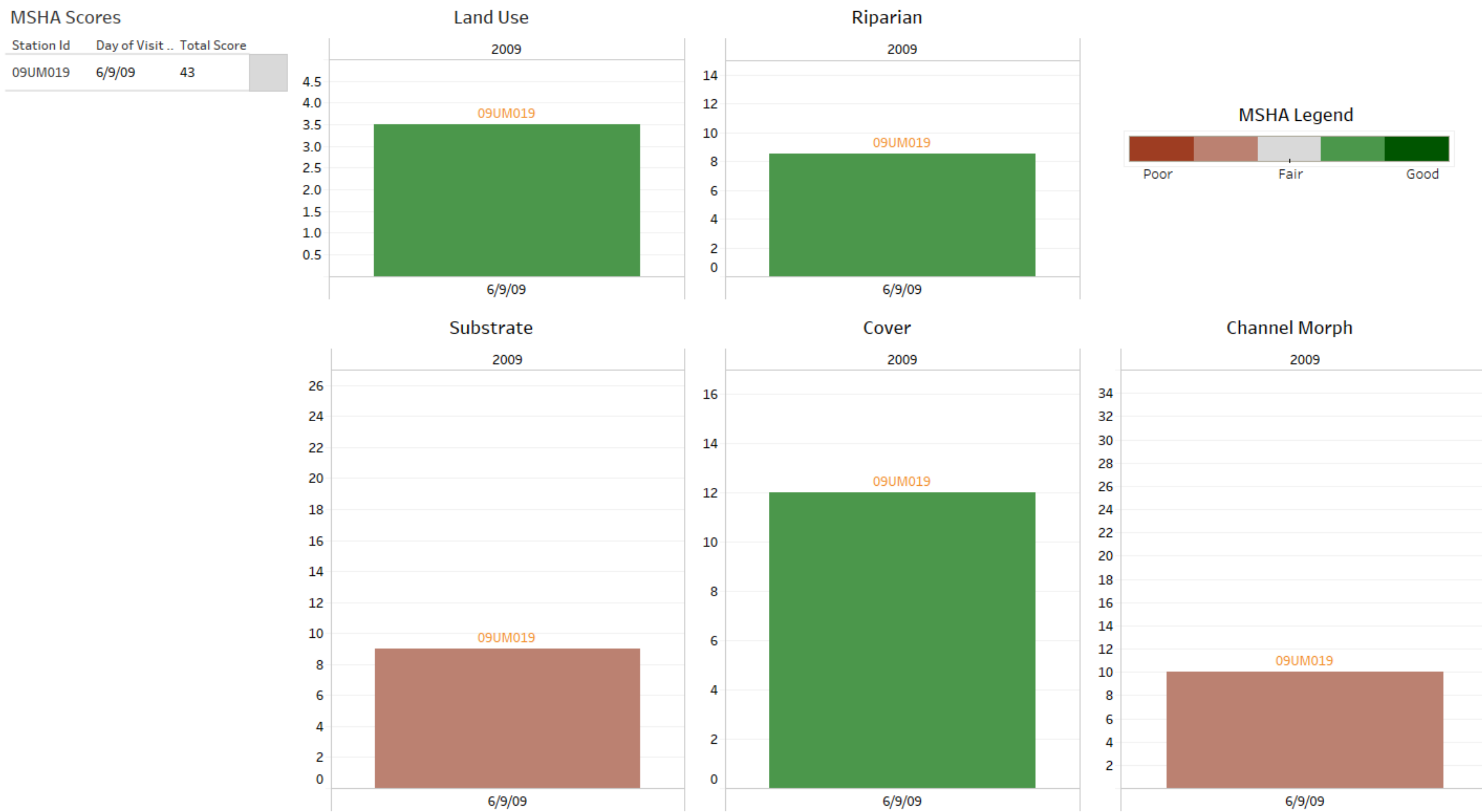


Figure 82. MSHA habitat scores for Unnamed Ditch - Sherburne County Ditch #1.

Due to the historic channelization of Unnamed Ditch - Sherburne County Ditch #1, and poor MSHA score, the assessment of Unnamed Ditch - Sherburne County Ditch #1 was brought into the UAA process. It was determined that the habitat of Unnamed Ditch - Sherburne County Ditch #1 has degraded to a point where it cannot support good quality habitat for aquatic life, as a result of channelization. Therefore, Unnamed Ditch - Sherburne County Ditch #1 was assessed using the modified use TALU criteria.

Although the average MSHA score was low overall, substrate and channel morphology scored particularly low as noted in Figure 82. Substrate was the first low scoring component of the MSHA score, as indicated by the dominance of sand and silt. Healthy fish communities need coarse substrate in order to build nests and spawn, and macroinvertebrates need coarse substrate as an attachment surface, which helps them to avoid drifting downstream, allowing them to feed. Excessive fine sediment also affects juvenile fishes, as the sediment is stirred into the water column creating TSS, which can easily tear sensitive juvenile fish gills. Similarly, many sensitive macroinvertebrates also have specialized gills that are used to breathe DO. Excessive fine sediments can damage these gills, similar to juvenile fishes, making the creek uninhabitable for sensitive species.

Channel morphology was another low scoring component of the MSHA evaluation. The MSHA indicated that there was fair channel depth variability, poor sinuosity, and fair channel development (no riffles and poorly developed pools). Fish and macroinvertebrates need channel depth variability to use as cover from predation and refuge during high precipitation events. No change in the channel depth combined with poor sinuosity and fair channel development impedes the fish and macroinvertebrates ability to inhabit the creek throughout the summer, especially during high flow events which can flush these communities downstream. The lack of good channel morphology is caused by the channelization of the creek, as the manipulation of the channel has been designed to move water quickly, by mechanically removing channel sinuosity, pools, and riffles. Lack of habitat is the direct stressor to the aquatic life in Unnamed Ditch - Sherburne County Ditch #1.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology of Unnamed Ditch - Sherburne County Ditch #1, and the entire subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests to cultivated fields and the channelization of the natural streams and wetlands. Unnamed Ditch - Sherburne County Ditch #1 has been straightened along the entire length of the AUID. Historically, the stream channel that now makes up Unnamed Ditch - Sherburne County Ditch #1, did not exist. The new channel was excavated to drain 16 square miles, which drained multiple wetlands and allowed the land to be tilled up and utilized for agriculture. This channel alteration accelerates stream flow, resulting in higher flows during precipitation events which achieves the agricultural land use drainage goals, but causes instability. Water leaves the landscape quickly, resulting in periods of higher flow than what would have naturally occurred. As the landscape drains, the flow regime quickly transitions to low flow, reaching low flow conditions later in the summer (Figure 83).

Due to the channelization of Unnamed Ditch - Sherburne County Ditch #1, the ditch does not have a natural stream pattern that can be assessed for stability. Utilizing the biological monitoring sampling pictures and MSHA evaluations of stream bank condition, the banks appear to be stable and not actively eroding. Therefore, the excessive sand and silt do not appear to be the product of eroding banks, but are remnants of the wetlands that existed prior to settlement. Due to these hydrologic and geomorphic alterations of Unnamed Ditch - Sherburne County Ditch #1, with the creation of a channel that did not exist historically, altered hydrology is considered to be a direct stressor to the aquatic life within Unnamed Ditch - Sherburne County Ditch #1.

Figure 83. Water levels within Unnamed Ditch - Sherburne County Ditch #1 in the spring and mid-summer.

Connectivity

The culvert crossing by 09UM019 off CR 32 does appear to be a barrier under low flow conditions. In June of 2021 SID staff noted that fish were trapped in the pool just downstream of the culvert and were not able to pass through. The water depth within the ditch appears to have been significantly higher during the 2009 fish sample, compared to the visit to the ditch by SID staff in 2021. Therefore, due to the fish yielding an IBI score that was above the threshold, and not currently impaired, it would be beneficial to replace this culvert with an AOP culvert to avoid future impairment.

Stressor signals from biology

Fish

Fish were sampled in 2009 as part of the cycle I monitoring effort. A total of 11 fish species were collected, with Fathead Minnows being the most dominate. The Fathead Minnow is one of the most pollution tolerant fish species within the state of Minnesota. A majority of the other fish species that were collected are also considered tolerant of pollutants, however, Pearl Dace, which are a sensitive species, were also collected within the sample. Due to this mixture of fish species, the fish sample produced an IBI score that was above the modified use threshold, and is not impaired at this time.

Although the fish are not impaired within Unnamed Ditch - Sherburne County Ditch #1, TIVs were calculated for Unnamed Ditch - Sherburne County Ditch #1 using the fish community to aid in the identification of potential stressors to the macroinvertebrate community. The TSS TIV found that the fish community has a 54% probability of coming from a stream that is meeting the TSS standard. One of the fish species that was collected is considered to be tolerant to elevated TSS and one other species is considered to be sensitive of elevated TSS. Due to only two fish species having a sensitivity to TSS, the TSS signal from the fish community is weak, and therefore is currently inconclusive.

DO TIV scores were also calculated for Unnamed Ditch - Sherburne County Ditch #1 using the fish communities. This calculation indicated that the fish community has an average probability of only 9% of coming from a stream that was meeting the DO standard. Seven of the fish collected within the sample are considered to be tolerant of low DO and five of those species are also considered to be very tolerant of low DO, indicating that low DO has the potential to be a stressor to the fish community. This response from the fish community may indicate that low DO is a stressor to the macroinvertebrate community within Unnamed Ditch - Sherburne County Ditch #1.

Phosphorus tolerance of the fish community was also investigated in Unnamed Ditch - Sherburne County Ditch #1 using the fish species characteristics. Four of the fish collected within the sample was considered to be tolerant of elevated phosphorus, and three species were considered to be very tolerant of elevated phosphorus. As for sensitive species, no fish that are sensitive or intolerant of elevated phosphorus were found the sample. The presence of elevated phosphorus tolerant species and the absence of intolerant species indicates that phosphorus may be a stressor to the fish community within Unnamed Ditch - Sherburne County Ditch #1. This response from the fish community may indicate that elevated phosphorus is a stressor to the macroinvertebrate community within Unnamed Ditch - Sherburne County Ditch #1.

Macroinvertebrates

Macroinvertebrates were sampled in 2010 as part of the cycle I watershed monitoring effort. Eighty-six percent of the macroinvertebrate community was comprised of taxa that are considered to be tolerant of pollutants, and 48% of the community was considered to be very tolerant of pollutants. *Caenis* (44% of the total sample) and *Hyalella* (9% of the total sample) taxa dominated the samples, which are both considered to be tolerant taxa.

TSS taxa tolerance was also investigated using the macroinvertebrate community within Unnamed Ditch - Sherburne County Ditch #1. In the sample, one intolerant, five tolerant, and one very tolerant taxa were collected (Table 22). Therefore, due to the dominance of tolerant taxa, the macroinvertebrate community within Unnamed Ditch - Sherburne County Ditch #1 indicates that TSS has the potential to be a stressor.

DO tolerance was also investigated using the macroinvertebrate community. The DO tolerance within the macroinvertebrate sample on Unnamed Ditch - Sherburne County Ditch #1 contained nine tolerant taxa and three very tolerant taxa (Table 22). No intolerant or very intolerant taxa were collected within the sample. Therefore, the macroinvertebrate community indicates that DO has the potential to be a stressor to the aquatic life within Unnamed Ditch - Sherburne County Ditch #1.

The final tolerance indicator that was investigated within the macroinvertebrate community was phosphorus tolerance. Similar to the other indicators, nine tolerant taxa, six very tolerant taxa were collected within the sample (Table 22). As for intolerant taxa, one intolerant taxa and no very tolerant taxa were collected within the sample. Therefore, the presence of elevated phosphorus tolerant species and the absence of intolerant species indicates that phosphorus has the potential to be a stressor to the macroinvertebrate community within Unnamed Ditch - Sherburne County Ditch #1.

Table 22. Macroinvertebrate tolerance index values for Unnamed Ditch - Sherburne County Ditch #1.

Parameter	Tolerance	2010 Sample
DO	# Intolerant	0
	# Tolerant	9
	# Very Intolerant	0
	# Very Tolerant	3
Phosphorus	# Intolerant	1
	# Tolerant	9
	# Very Intolerant	0
	# Very Tolerant	6
TSS	# Intolerant	1
	# Tolerant	5
	# Very Intolerant	0
	# Very Tolerant	1

Composite conclusion from biology

The habitat, hydrology, and geomorphology are heavily altered in Unnamed Ditch - Sherburne County Ditch #1. This degraded habitat, which is caused by the creation of a new stream channel through a series of wetlands, is the direct stressor to the macroinvertebrates within Unnamed Ditch - Sherburne County Ditch #1.

The culvert on CR 32 has the potential to impede fish movement, and could cause a future fish impairment.

The TIVs within the fish and macroinvertebrate samples on Unnamed Ditch - Sherburne County Ditch #1 indicate that low DO and elevated phosphorus are stressors, but more chemistry data is needed to make a final determination.

Conclusions about stressors

The fish and macroinvertebrate TIVs indicate that low DO and elevated phosphorus have the potential to be stressors to the macroinvertebrate community within Unnamed Ditch - Sherburne County Ditch #1, however, this may be the result of the tolerant fish and macroinvertebrate species also having the ability to survive in streams with poor habitat and altered hydrology. The most dominant macroinvertebrate taxa sampled within the biological sample were *Caenis* (44%) and *Hyalella* (9%). Hyalella, similar to the Central Mudminnow, have adapted to survive in streams with low DO levels (Irving et al. 2004). Other taxa within the macroinvertebrate sample were also tolerant of low DO, including the *Caenis* mayfly, which is specifically adapted to survive in low DO streams with silty sediments, using specialized operculate gill coverings (Mackie 2004).

Channelization has also impacted habitat within Unnamed Ditch - Sherburne County Ditch #1, as indicated by the MSHA score. Poor sinuosity, fair channel development, and fine sediment were noted within the MSHA assessment. Fine sediments can prohibit sensitive fish species from colonizing within a stream, and only one sensitive fish species was collected within the fish sample. Hornyhead Chubs are a sensitive fish species which were found in other nearby streams, but were not collected within Unnamed Ditch - Sherburne County Ditch #1. Hornyhead Chubs, and similar fish species, require clean coarse gravel in which to spawn. Fine sand and silt were the most dominant substrate types within Unnamed Ditch - Sherburne County Ditch #1, as indicated by the MSHA score. This sediment would have historically settled out within the wetlands, but due to the channelization, the sediment is flushed downstream during precipitation events. This process has caused the gravel beds to become embedded in fine sediment. This loss of spawning habitat prohibits the ability for more sensitive fish species to spawn and survive within Unnamed Ditch - Sherburne County Ditch #1. Similarly, macroinvertebrates are also sensitive to habitat degradation. In general, mayflies have specialized gills that require clean water that is free of floating fine sediment. However, *Caenis* mayflies are specially adapted to survive in streams with fine sediments, using operculate plates to guard the gills from the abrasive sediment (Mackie 2004). *Caenis* were abundant within the macroinvertebrate sample in Unnamed Ditch - Sherburne County Ditch #1, and very few sensitive taxa were collected. The prevalence of *Caenis* within the macroinvertebrate sample, and the low presence of gravel spawning fishes, combined with the absence of sensitive macroinvertebrate taxa indicates that poor habitat caused by altered hydrology and geomorphology is the direct stressor to the macroinvertebrates within Unnamed Ditch - Sherburne County Ditch #1.

Recommendations

Compliance with the Buffer Law will help avoid erosion issues. Also, due to elevated TP values collected downstream on Tibbits Brook, there is a potential for TP to be a stressor to the fish and macroinvertebrates within the ditch, and nice wide buffers will help to reduce the amount of TP that is entering the ditch.

As funds are available, replacing the culvert off CR 32 with an AOP approved culvert would be advantageous to avoid a future fish impairment.

Silver Creek Subwatershed

The Silver Creek Subwatershed covers 33,356 acres, located just north of Maple Lake (Figure 84). Just over half of the streams (55.4%) within the subwatershed have been straightened.

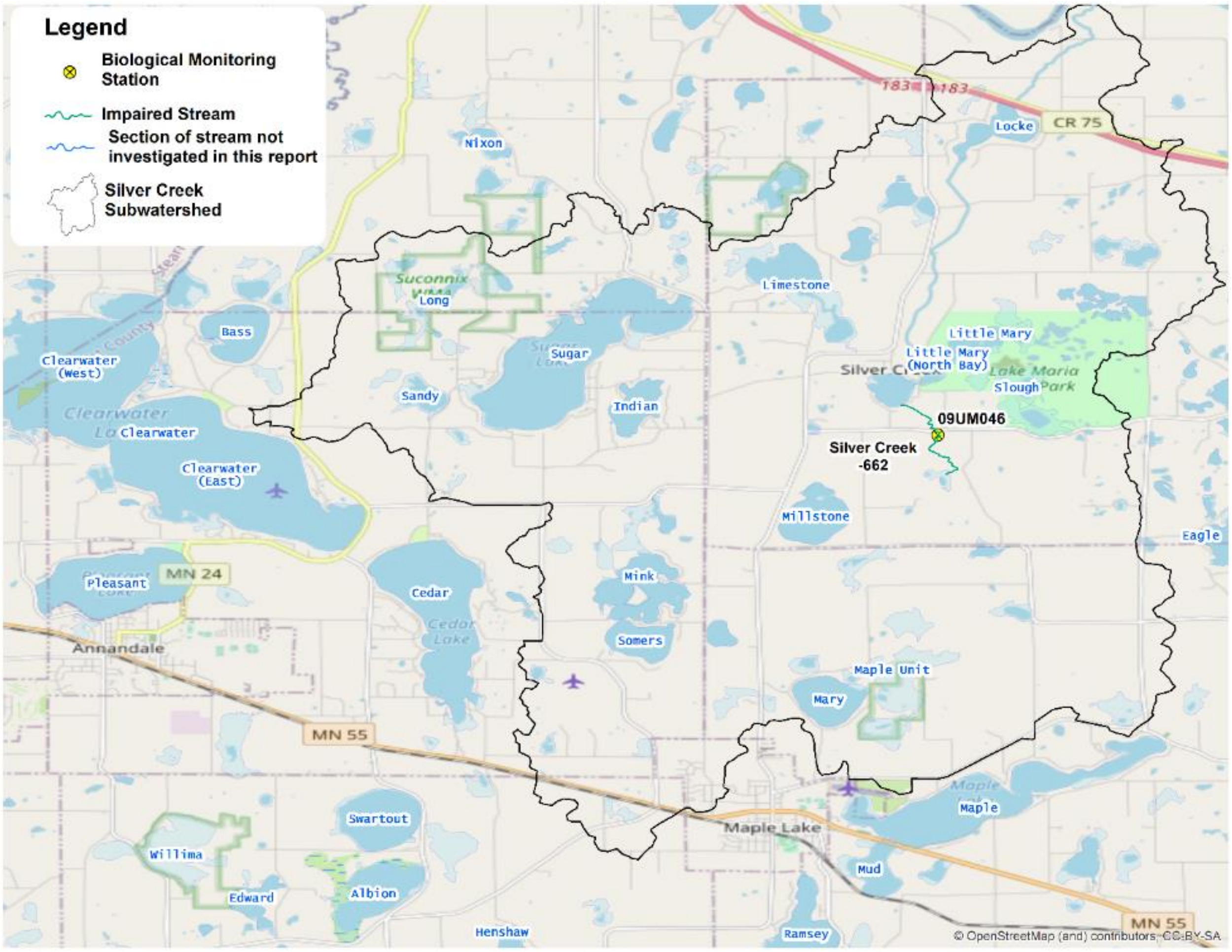


Figure 84. Biological monitoring station within the Silver Creek Subwatershed.

The land use within the Silver Creek Subwatershed is dominated by cropland (42.8%), followed by forestland (16.8%), and rangeland (13.4%) (Figure 85).

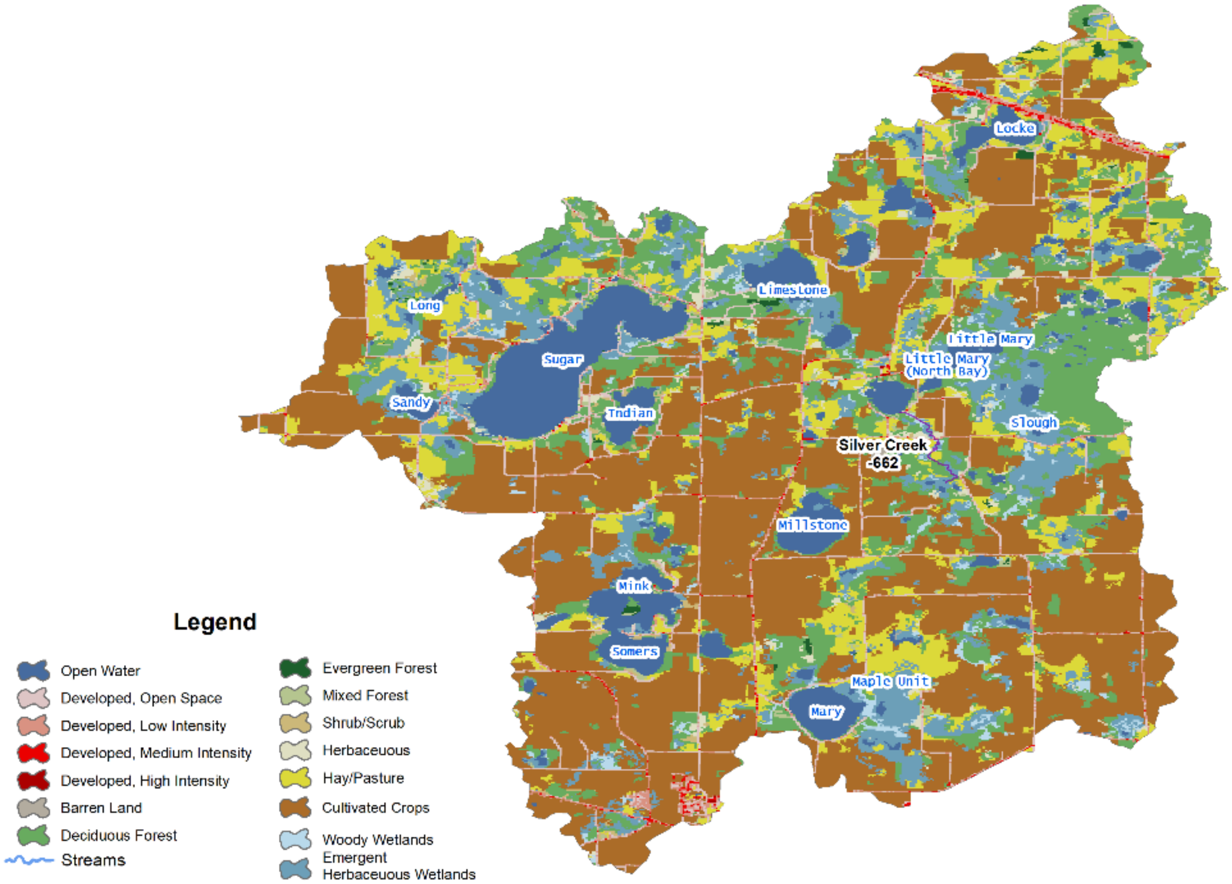


Figure 85. Land use within the Silver Creek Subwatershed. Credit: NLCD 2016.

Silver Creek (07010203-662)

Impairment: Silver Creek (AUID -662) flows for 1.5 miles from a small wetland a ½ mile south of CR 39 NW to Silver Lake, in the town of Silver Creek. Silver Creek has not been channelized, and remains natural. There is one biological monitoring station (09UM046) that was sampled for fish and macroinvertebrates in 2009 (Figure 84). Silver Creek was assessed in 2011, which resulted in fish and macroinvertebrate impairments. The fish stream class is class 7 (Low Gradient) and the macroinvertebrate stream class is class 6 (Southern Forest Streams Glide/Pool).

Data and Analyses

Chemistry

Water chemistry data that has been collected on Silver Creek (S004-534, S011-236) from 2007-2009 (Table 23).

Table 23. Water chemistry data collected on Silver Creek. Data available at https://webapp.pca.state.mn.us/surface-water/search.

Parameter	Count of Samples	Applicable Standard	Avg. Result	Min. Result	Max. Result
Dissolved oxygen (DO)	1	5.0 mg/L	9.17	9.17	9.17
pH	1	N/A	8.1	8.1	8.1
Phosphorus	25	0.100 mg/L	0.24	0.1	0.455
Specific conductance	1	N/A	468	468	468
Temperature, water	1	N/A	11.8	11.8	11.8
Total suspended solids	1	30.0 mg/L	4	4	4
Transparency, tube with disk	10	N/A	64	60	100

The water chemistry dataset is limited to one sample for almost all parameters, except phosphorus and transparency tube readings. Therefore, phosphorus was the only parameter included in this analysis. The average phosphorus value was over double the Central Region River Nutrient standard (0.100 mg/L) with a value of 0.240 mg/L (Table 23), and the maximum value was four times the standard at 0.455 mg/L. In addition to the phosphorus data that was collected on AUID -662, additional phosphorus data has been collected on several AUIDs upstream of -662, as shown in Table 24.

Table 24. Phosphorus data collected on the AUIDs upstream of -662.

AUID	EQuIS Code	Parameter	Count of Samples	Avg. Result	Min. Result	Max. Result
07010203-663	S004-533	Phosphorus	17	0.44	0.07	0.86
07010203-665	S004-532	Phosphorus	14	0.34	0.09	1.08
07010203-666	S004-531	Phosphorus	17	0.22	0.05	0.426

These data further indicate that elevated phosphorus is present within Silver Creek, with values as high as 0.860 mg/L and 1.08 mg/L. Overall the elevated phosphorus values throughout the headwaters of Silver Creek indicates that phosphorus has strong potential to be a direct stressor through elevated phosphorus and through eutrophication.

Habitat

Habitat was classified as poor on Silver Creek, through the MSHA evaluation at the fish sample (Figure 86).

Figure 86. MSHA habitat scores for Silver Creek.

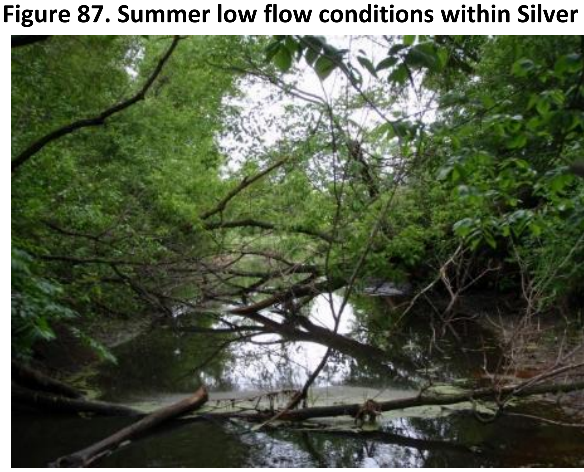
Although the average MSHA score was low overall, substrate and channel morphology scored particularly low as noted in Figure 86. Substrate was the first low scoring component of the MSHA score, as indicated by the dominance of sand, silt, muck, and detritus. Healthy fish communities need coarse substrate in order to build nests and spawn, and macroinvertebrates need coarse substrate as an attachment surface, which helps them to avoid drifting downstream, allowing them to feed. Excessive fine sediment also affects juvenile fishes, as the sediment is stirred into the water column creating TSS, which can easily tear sensitive juvenile fish gills. Similarly, many sensitive macroinvertebrates also have specialized gills that are used to breathe DO. Excessive fine sediments can damage these gills, similar to juvenile fishes, making the creek uninhabitable for sensitive species.

Channel morphology was another low scoring component of the MSHA evaluation. The MSHA indicated that there was fair channel depth variability and fair channel development (no riffles and poorly developed pools). Fish and macroinvertebrates need channel depth variability to use as cover from predation and refuge during high precipitation events. No change in the channel depth combined with poor sinuosity and fair channel development impedes the fish and macroinvertebrates ability to inhabit the creek throughout the summer, especially during high flow events, which can flush these communities downstream. Due to the poor substrate and channel morphology, lack of habitat is a direct stressor to the aquatic life in Silver Creek.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology of Silver Creek, and the entire subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests to cultivated fields and the channelization of the natural streams and wetlands. The section of Silver Creek that was sampled has remained natural, but the majority of the upstream portions of the creek have been straightened. This channel alteration accelerates stream flow, resulting in higher flows during precipitation events, which achieves the agricultural land use drainage goals, but causes instability. Water leaves the landscape quickly, resulting in periods of higher flow than what would have naturally occurred. As the landscape drains, the flow regime quickly transitions to low flow, reaching low flow conditions later in the summer (Figure 87).

Figure 87. Summer low flow conditions within Silver Creek.



In addition to the lack of stable flow within Silver Creek, the lack of good channel morphology as noted in the MSHA assessment, is caused by the channelization in the headwaters of the creek, as the manipulation of the channel has been designed to move water quickly. Due to the additional water volume draining into Silver Creek, the stream channel has over-widened which has caused sediment from the banks to fill in coarse substrate that would have existed prior to the channelization. This over-widening also reduces the stream power within the creek, which would have naturally carried fine sediment downstream, further complicating the sediment issues within Silver Creek.

Due to the channelization in the headwaters of Silver Creek, and the resulting altered flow and habitat conditions, altered hydrology and geomorphology is considered to be a direct stressor to the aquatic life within Silver Creek.

Connectivity

The culvert crossing by 09UM046 off 90th Street NW does not appear to be a barrier, however, there is a dam that is located on the farthest downstream section of Silver Creek (AUID -557) off Curtis Ave (Figure 88).

Figure 88. Dam structure downstream of Curtis Ave on Silver Creek.

The effects of this dam on the aquatic life within Silver Creek have been well documented in the cycle I SID report (MPCA 2013) for -577, which also apply to all of Silver Creek upstream of -577, including -662.

Another section of Silver Creek (-555) was sampled for fish and macroinvertebrates (07UM091) in 2007 and 2019. The 2019 samples produced passing fish and macroinvertebrate scores, however, the fish community was comprised of fish that thrive within lakes (Table 25).

Table 25. Fish species collected at 07UM091.

Fish Species	Number Captured
white sucker	30
spottail shiner	13
yellow perch	12
northern pike	11
fathead minnow	3
central mudminnow	2
yellow bullhead	2
black crappie	1
bluegill	1
common shiner	1
green sunfish	1

Although several of these fish species are commonly found within streams, there is a notable lack of stream fishes from the list. This is further indication that the dam on Silver Creek is a connectivity barrier, and is a direct stressor to the fish community within Silver Creek.

Stressor signals from biology

Fish

Fish were sampled in 2009 as part of the cycle I monitoring effort. A total of three fish species were collected, with Central Mudminnow being the most dominate. The Central Mudminnow is one of the most pollution tolerant fish species within the state of Minnesota. All three fish that were collected within the sample are considered to be tolerant, which resulted in an IBI score of 0.

TIVs were calculated for Silver Creek using the fish community. The TSS TIV found that the fish community has an 83% probability of coming from a stream that is meeting the TSS standard. However, none of the fish within the sample were sensitive or tolerant of elevated TSS, so the fish TSS TIV analysis is inconclusive.

DO TIV scores were also calculated for Silver Creek using the fish communities. This calculation indicated that the fish community has an average probability of only 2% of coming from a stream that was meeting the DO standard. Two of the fish collected within the sample are considered to be tolerant of low DO and one of the species is considered to be very tolerant of low DO, indicating that low DO has the potential to be a stressor to the fish community. This response from the fish community may indicate that low DO is a stressor to the aquatic life within Silver Creek.

Phosphorus tolerance of the fish community was also investigated in Silver Creek using the fish species characteristics. Two of the fish collected within the sample were considered to be tolerant of elevated phosphorus. As for sensitive species, no fish that are sensitive or intolerant of elevated phosphorus were found the sample. The presence of elevated phosphorus tolerant species and the absence of intolerant species indicates that phosphorus may be a stressor to the fish community within Silver Creek.

Macroinvertebrates

Macroinvertebrates were sampled in 2009 as part of the cycle I watershed monitoring effort. Seventy-nine percent of the macroinvertebrate community was comprised of taxa that are considered to be tolerant of pollutants, and 53% of the community was considered to be very tolerant of pollutants. *Physa* snails and *Hyalella* taxa dominated the samples, which are both considered to be tolerant taxa.

TSS taxa tolerance was also investigated using the macroinvertebrate community within Silver Creek. In the sample, 1 very intolerant, 2 intolerant, 10 tolerant, and 4 very tolerant taxa were collected (Table 26). Therefore, due to the dominance of tolerant taxa, the macroinvertebrate community within Silver Creek indicates that TSS has the potential to be a stressor.

DO tolerance was also investigated using the macroinvertebrate community. The DO tolerance within the macroinvertebrate sample on Silver Creek contained 2 very intolerant, 2 intolerant, 15 tolerant, and 3 very tolerant taxa (Table 26). Due to the dominance of tolerant taxa, DO has the potential to be a stressor to the aquatic life within Silver Creek.

The final tolerance indicator that was investigated within the macroinvertebrate community was phosphorus tolerance. Similar to the other indicators, 1 very intolerant, 2 intolerant, 16 tolerant, and 10 very tolerant taxa were collected within the sample (Table 26). Therefore, the dominance of elevated phosphorus tolerant species and the low numbers of intolerant taxa, indicates that phosphorus has the potential to be a stressor to the macroinvertebrate community within Silver Creek.

Table 26. Macroinvertebrate tolerance index values within Silver Creek.

Parameter	Tolerance	Value
DO	# Intolerant	2
	# Tolerant	15
	# Very Intolerant	2
	# Very Tolerant	3
Phosphorus	# Intolerant	2
	# Tolerant	16
	# Very Intolerant	1
	# Very Tolerant	10
TSS	# Intolerant	2
	# Tolerant	10
	# Very Intolerant	1
	# Very Tolerant	4

Composite conclusion from biology

The habitat, hydrology, and geomorphology have been impacted by the channel alterations in the headwaters of the creek, and are direct stressors to the aquatic life within Silver Creek.

The dam on the downstream reach of Silver Creek is a barrier, and impedes fish movement into Silver Creek from the Mississippi River. Therefore, connectivity is a direct stressor to the fish community.

The TIVs within the fish and macroinvertebrate samples on Silver Creek indicate that low DO, elevated phosphorus, and TSS are stressors. Phosphorus values are significantly elevated within the dataset for

Silver Creek and several upstream sections of the creek, indicating that phosphorus is a direct stressor to the aquatic life. The DO and TSS datasets are limited, and are therefore, inconclusive at this time.

Recommendations

Maintaining compliance with the Buffer Law will help avoid erosion issues.

As funds are available, removing the dam off Curtis Ave would be advantageous for fish passage, but may cause undercutting within the channel.

Reducing the nutrient input into Silver Creek through runoff and tile outlets would make the biggest impact to the creek.

References

Cormier S., S. Norton, G. Suter and D. Reed-Judkins. 2000. Stressor Identification Guidance Document. U.S. Environmental Protection Agency, Washington D.C., EPA/822/B-00/025. http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/biocriteria/upload/stressorid.pdf

Irving, E.C., K. Liber, and J.M. Culp. 2004. Lethal and Sublethal Effects of Low Dissolved Oxygen Condition on Two Aquatic Invertebrates, *Chironomus tentans* and *Hyalella azteca*. Environmental Toxicology and Chemistry. Vol 23 6:1561-1566.

LeFevra, N.J., A. Plevan, P. Conrad, B. Peichel, P. Votruba, A. Persons, and M. Wettlaufer. 2014. Upper Mississippi River Bacteria TMDL Study and Protection Plan. Emmons & Olivier Resources, Inc. 142.

Mackie, G. 2004. Applied Aquatic Ecosystem Concepts. Kendall/Hunt Publishing Company. 2nd Ed. 320-321.

Minnesota Department of Natural Resources (DNR). 2003. Habitat Improvement Progress Report Luxemburg Creek. Minnesota Department of Natural Resources, St. Paul, Minnesota.

Minnesota Department of Natural Resources (DNR). Watershed Health Assessment Framework. Accessed 1/6/2022 from https://arcgis.dnr.state.mn.us/ewr/whaf2/

Minnesota Pollution Control Agency (MPCA). 2013. Mississippi River-St. Cloud Stressor Identification Report. Minnesota Pollution Control Agency, St. Paul, Minnesota. https://www.pca.state.mn.us/sites/default/files/wq-ws3-07010203c.pdf

Rosgen, D. 2009. Watershed Assessment of River Stability and Sediment Supply (WARSSS). Second Edition. Wildland Hydrology. Fort Collins, CO.

Rosgen, D. 2014. River Stability Field Guide. Second Edition. Wildland Hydrology. Fort Collins, CO.