technical memo

Project Name	Brown's Creek Biological Assessments	**Date**	04/03/2024
To / Contact info	BCWD Board of Managers		
Cc / Contact info	Karen Kill, District Administrator		
From / Contact info	Mike Majeski, Conservation Biologist		
Regarding	Macroinvertebrate Data Summary_2015-2023		

Background

The BCWD has been conducting routine fish and macroinvertebrate assessments since 2015 to monitor changes in the biological community of Brown's Creek following implementation of numerous water quality projects in the watershed (see implementation activity under Stream Management, Goal A of the 2017-2026 Watershed Management Plan). The goals of BCWD's routine fish and macroinvertebrate assessments are to develop a more robust understanding of the variability of species composition over time and to develop a long-term trend analysis of changes to the biological community in Brown's Creek in response to on-going water quality projects implemented in the watershed. Macroinvertebrate assessments have been conducted annually as populations and species diversity can change quickly due to changes in their environment, in part due to their short life spans and sensitivities to changes in water quality. Conversely, fish have longer lifespans and populations are generally slower to respond to changes in their environment compared to macroinvertebrates. The last fish survey was conducted in 2021 by MNDNR fisheries staff.

The Minnesota Pollution Control Agency (MPCA) has been using this data to assess the watershed's specific water quality standards and designated uses as part of their long-term Intensive Watershed Monitoring Plan. As part of MPCA's biological assessment, fish and macroinvertebrate-based indices of biological integrity (IBI) have been developed to track long-term trends in the biological community of each watershed studied. Fish and macroinvertebrate IBI's are based on the number and diversity of fish and macroinvertebrate species present in a stream compared to what the stream is expected to support. The following is a summary of macroinvertebrate data collected from 2015-2023.

2023 Macroinvertebrate Assessment

Macroinvertebrates were sampled from three sites along Brown's Creek including the Headwaters, Middle Reach, and Gorge (Figure 1). In 2023, the sampling was only conducted in the fall (September) based on input and recommendations from MPCA staff. The fall period is when most macroinvertebrate sampling is conducted since the overall macroinvertebrate community is better represented in the fall (e.g., more species are present in the fall compared to the spring).

Macroinvertebrate specimens were sent to RMB for taxonomic identification to the genus level, and a subsequent report was completed by RMB summarizing the macroinvertebrate IBI scores and results from the 2015-2023 surveys (Appendix A). Key findings from the macroinvertebrate surveys are provided below.

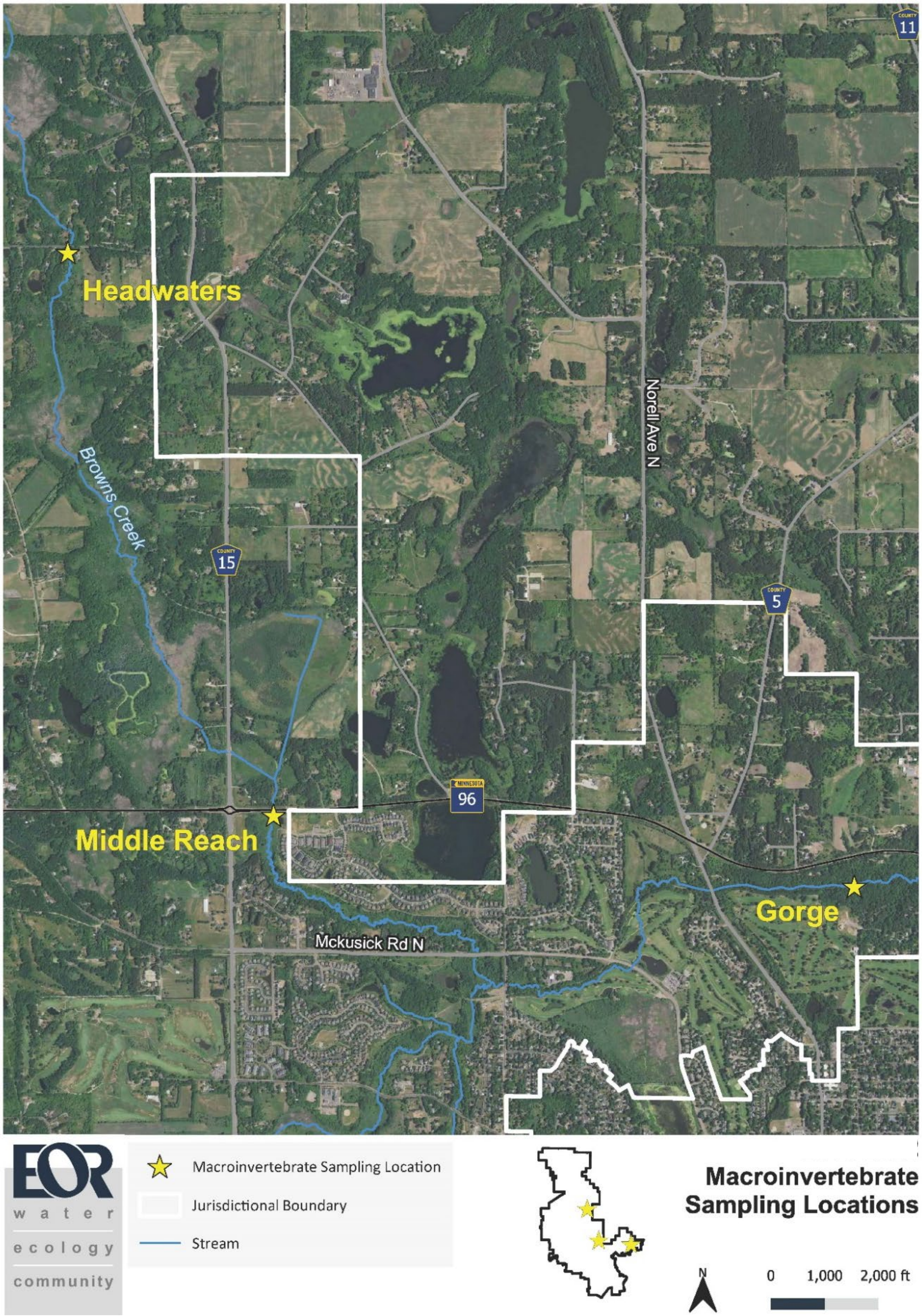


Figure 1. Macroinvertebrate sampling locations in the BCWD, 2015-2023

Key Findings

- Data collected from 2015-2023 indicates an overall upward (improving) trend in stream health and macroinvertebrate community quality.

- The calculated IBI scores from all 3 sites from 2015-2023 indicate a stable and improving macroinvertebrate community since 2015, with most macroinvertebrate IBI scores occurring between the General Use and Exceptional Use thresholds for the Southern Coldwater Streams region (Figure 2). In particular, the Gorge IBI scores have improved the most during the study and have remained above the Exceptional Use threshold since 2019. Of the 17 samples that have scored above the Exceptional Use Threshold over the course of the project, 14 of those samples have occurred since 2019. Most notably, all three fall 2019 samples were above the Exceptional Use Threshold.

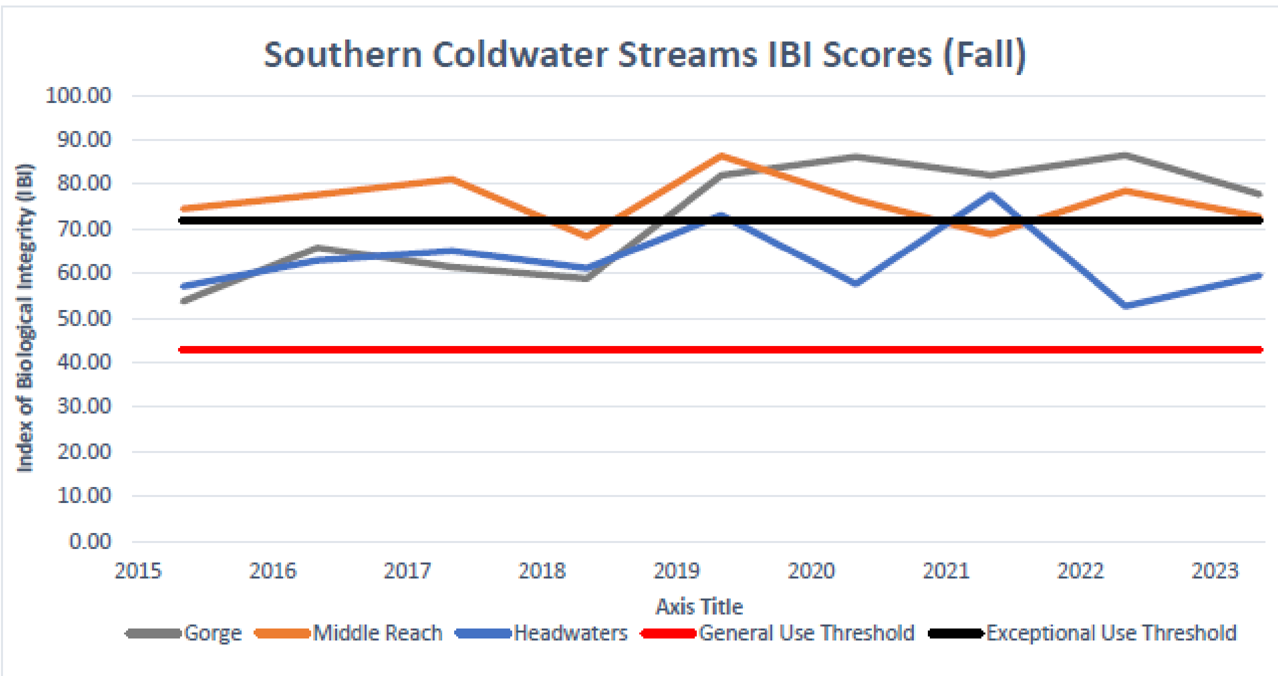


Figure 2. Fall season IBI scores from Brown's Creek and associated General Use and Exceptional Use thresholds. Source: RMB Macroinvertebrate Stream Monitoring Assessment 2015-2023 (Figure 6, Appendix A)

- The total number of taxa sampled from 2015-2023 indicates a diversity of species present across all 3 sites (140 unique taxa to date), with the three most dominant taxa having a medium-level tolerance to pollution. However, good numbers of intolerant taxa (species intolerant of pollution) are also present which indicates the stream provides ample habitat and water quality to support these sensitive species.

- The Perlodid stonefly has been collected every year from the Gorge site, indicating the creek provides ample habitat and oxygen levels for this pollution intolerant species. Perlodid stoneflies were also collected from the Middle Reach from 2020-2022.
- The average pollution tolerance score has decreased since 2015, indicating the creek is supporting a greater number of species that are considered intolerant to pollution (Figure 3). This trend is also reflective in the population size of intolerant species, with the number of pollution intolerant specimens steadily increasing since 2015 (Figure 4). Pollution intolerant taxa are present in good numbers at all 3 sampling sites and suggest Brown's Creek is providing suitable habitat and water quality for macroinvertebrates throughout the creek corridor.

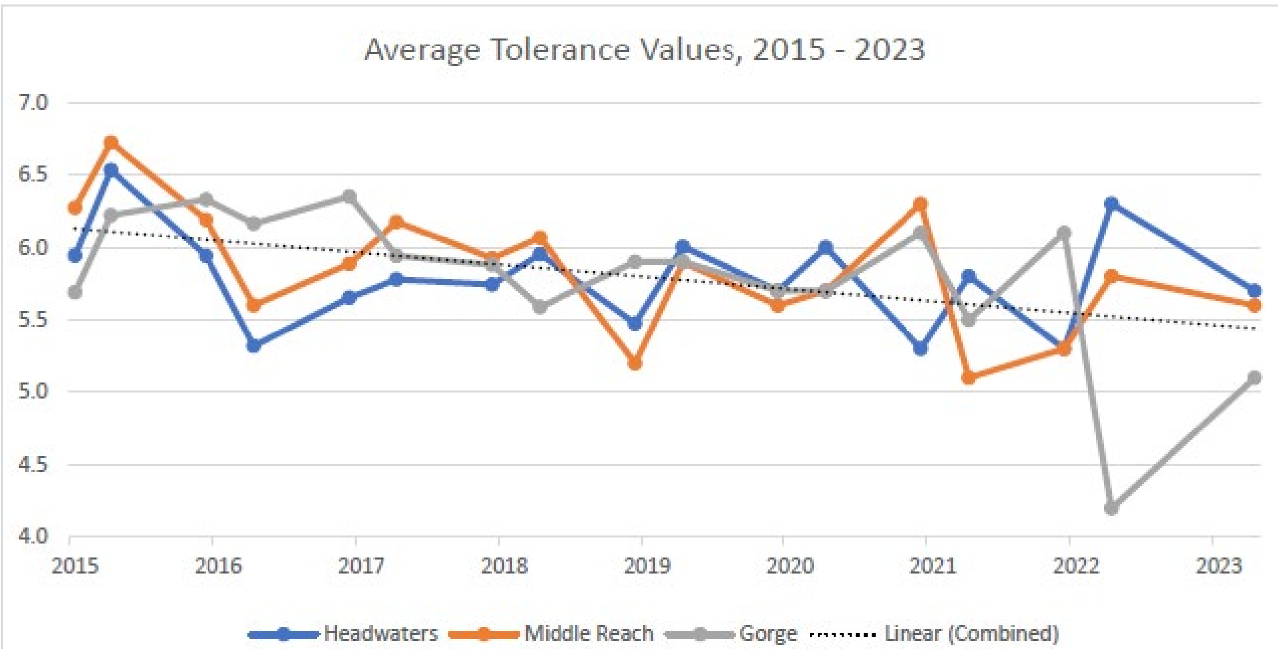
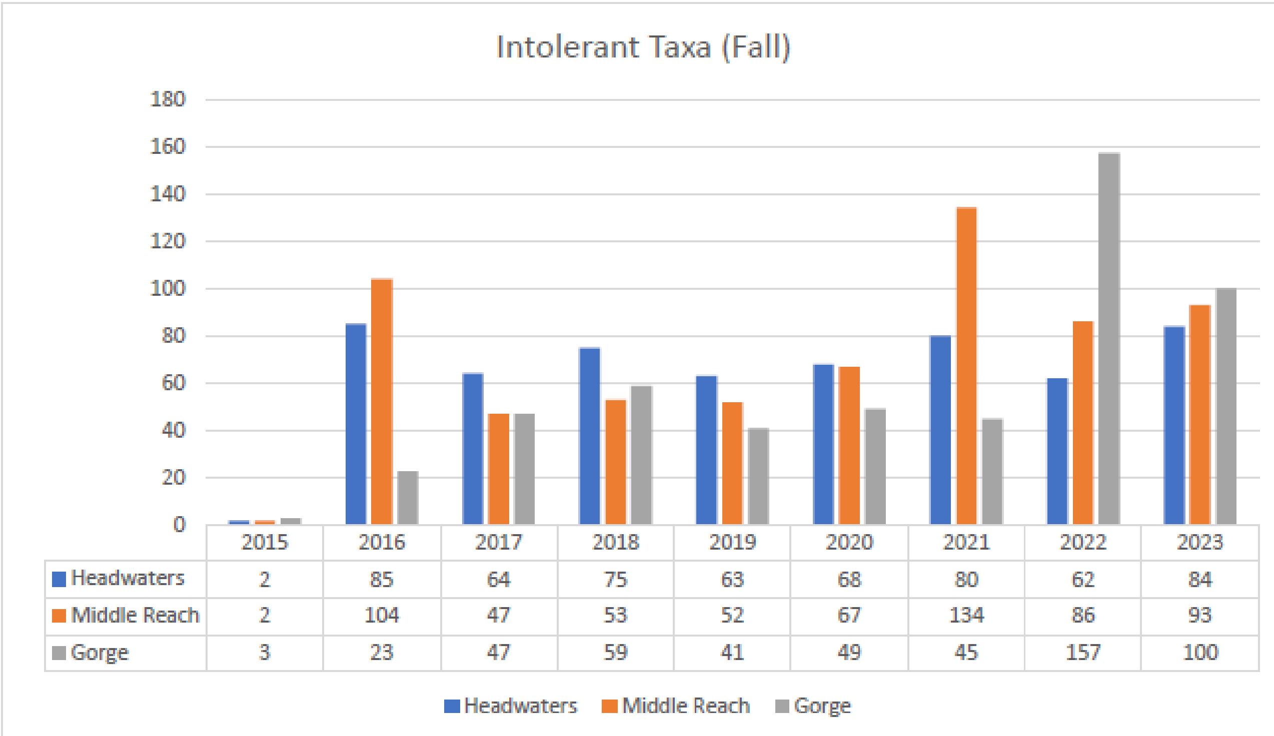


Figure 3. Average pollution tolerance values for Brown's Creek macroinvertebrates from 2015-2023. Source: Source: RMB Macroinvertebrate Stream Monitoring Assessment 2015-2023 (Figure 4, Appendix A)



	2015	2016	2017	2018	2019	2020	2021	2022	2023
Headwaters	2	85	64	75	63	68	80	62	84
Middle Reach	2	104	47	53	52	67	134	86	93
Gorge	3	23	47	59	41	49	45	157	100

Figure 4. Comparison of total numbers of intolerant taxa collected in Brown's Creek from 2015-2023 (Fall samples only). Source: RMB Macroinvertebrate Stream Monitoring Assessment 2015-2023 (Figure 9, Appendix A)

Appendix A

RMB Report: Macroinvertebrate Stream Monitoring Assessment 2015-2023

Macroinvertebrate Stream Monitoring Assessment 2015 – 2023

Emmons & Olivier Resources, Inc.

April 2nd, 2024

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Introduction

Macroinvertebrates provide a valuable insight into the health of a stream ecosystem since most taxa require specific conditions to survive and thrive. Stream parameters like temperature, flow speed, substrate type, dissolved oxygen, and pollution inputs can all impact which invertebrates will be found at a site. Evaluating the invertebrate community in a stream or river can reveal impacts to the aquatic ecosystem and trends in the water quality.

From 2015 – 2022, aquatic macroinvertebrates were collected in May or June and September from Brown's Creek in Washington County, Minnesota. In 2023, aquatic macroinvertebrates were collected September only. The Minnesota Pollution Control Agency (MPCA) Index of Biotic Integrity (IBI) was calculated for all stream sites to assess the water quality and compare sites. Samples were collected along the stream reach at the Headwaters, Middle Reach, and Gorge sites to evaluate how the quality changes along the gradient (Figure 1). Brown's Creek is located within the Southern Coldwater Streams invertebrate class (Figure 2). Samples were repeated each year beginning in 2015 to evaluate changes over time. The collection of this data is essential for compiling a baseline dataset of

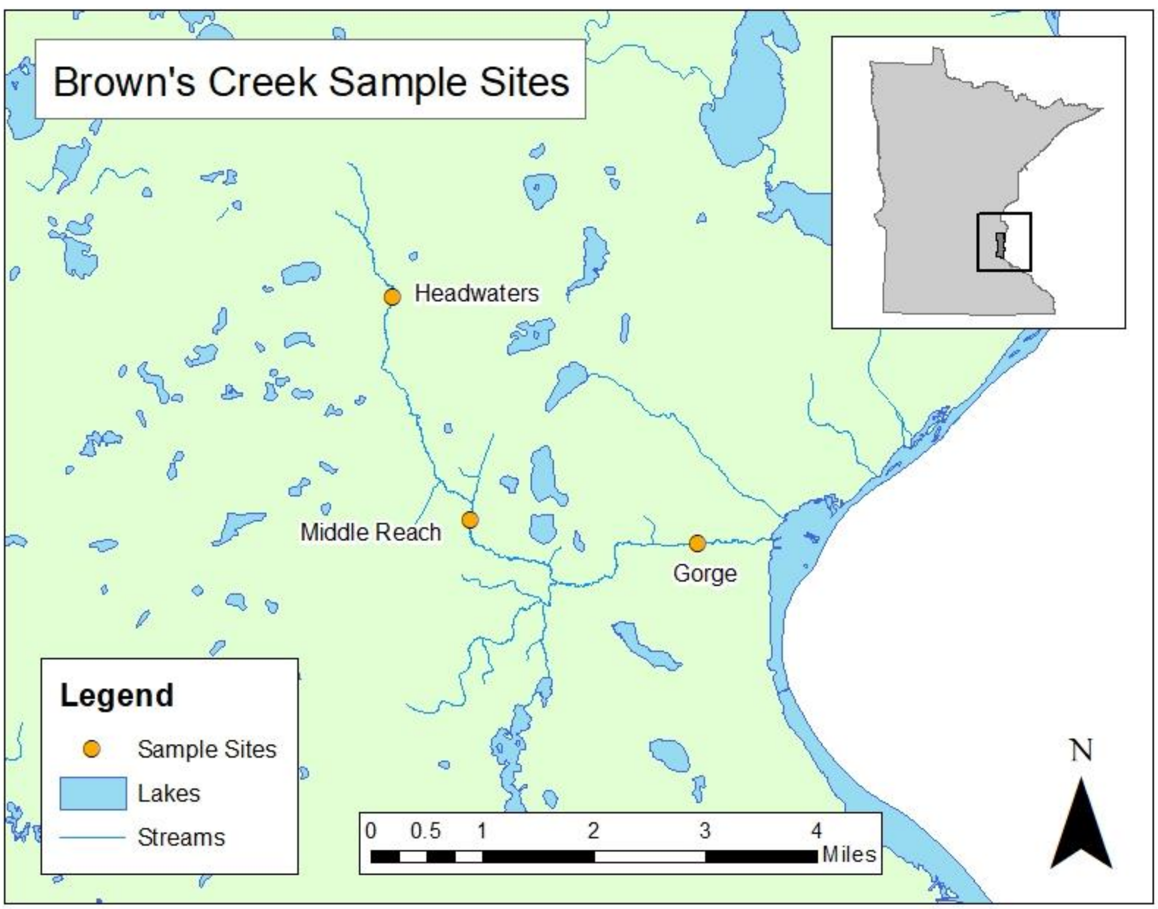


Figure 1: Macroinvertebrate monitoring sites in Brown's Creek, 2015-2023

invertebrates found in this region, which can be used for assessments of impacts or future restoration projects on this stream.

Methods

Sample Collection

The aquatic macroinvertebrate samples collected from 2015 – 2023 were located at the Headwaters, Middle Reach, and Gorge sites of Brown's Creek. Samples were collected with a D-frame net following the MPCA's Standard Operating Procedure (SOP) for multi-habitat collection of stream invertebrates (MPCA). They were then preserved and delivered to RMB Environmental Laboratories, Inc. (RMBEL) in Detroit Lakes, MN for laboratory processing and data analysis.

Laboratory Processing

The macroinvertebrate samples were processed following MPCA methods, including sorting random subsamples to a target specimen count of 300. All taxa were enumerated and identified to genus level, with leeches and snails identified to species where possible. Representative taxa were retained in a project collection for internal quality control. Subsample picking and taxa identifications were both held to 95% efficiency in internal quality control checks.

Data Management and Assessment

The final data for each sample was entered into a spreadsheet and sent to Joel Chirhart at the MPCA to run the IBI database calculations. RMBEL staff used the macroinvertebrate community data to calculate general invertebrate metrics to accompany the IBI values and facilitate comparison among sites along the stream gradient and across years. Sites were mapped in ArcMap to regionally compare the samples, which are within the Southern Coldwater Streams invertebrate class (Class 9). These classes are derived from the Minnesota Department of Natural Resources (DNR) Ecological Classification System provinces and were developed based on major climate zones, native vegetation, and biomes.

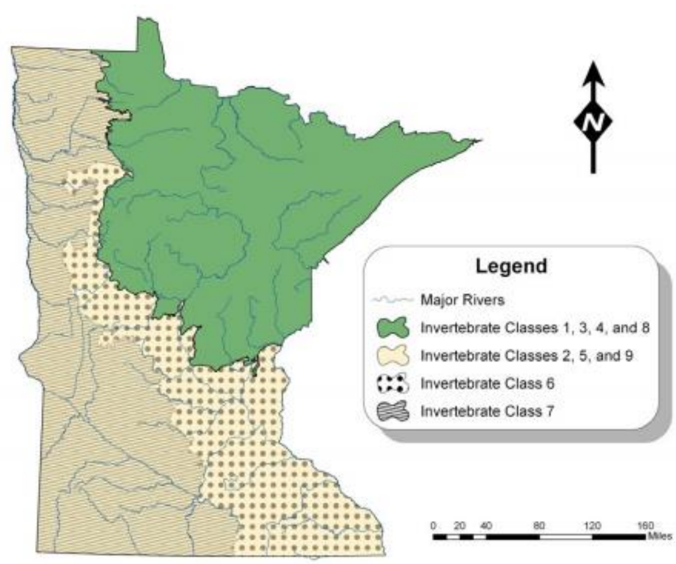


Figure 2: Map of Minnesota Pollution Control Agency invertebrate classes (MPCA)

Results

Macroinvertebrate Metrics

Macroinvertebrate metrics can provide a general overview of the health of a stream ecosystem relating to which taxa are dominant in a sample and how many taxa are intolerant to pollution impacts. Overall taxa richness is a common metric for water quality, since unimpacted stream systems typically show much more diversity than those with heavy impacts. The taxa richness values in this report include only unique taxa, and specimens that are immature or damaged and left at a higher taxonomic level were omitted from the metric. This may present some discrepancies from previous reports sent, in which all taxa were included in the richness values, regardless of whether they were unique to the rest of the community composition. Evaluating certain taxa groups that generally prefer specific conditions can give an idea of whether the stream quality is higher or lower than other sites. These include Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), which typically are found in unpolluted waters, as well as Chironomidae (midges) which tend to dominate in highly impacted sites. Additionally, the presence of taxa that are intolerant to pollution can indicate higher quality waters. These metrics are explained in Table 1; they have been calculated for all the samples throughout this project and are listed in Tables 2 – 7.

Table 1. Explanations of the macroinvertebrate metrics

Metric	Explanation	Response
Taxon Richness	**The total number of taxa found in the sample (genus level, family level for Chironomidae)**	**Higher numbers indicate better water quality and habitat quality**
EPT Richness	**The total number of Ephemeroptera (mayflies), Plecoptera (Stoneflies), and Trichoptera (caddisflies) in the sample. These taxa are considered generally intolerant to pollution.**	**Higher numbers indicate better water quality and habitat quality**
Plecoptera Richness	**The total number of Plecoptera (stoneflies) taxa in the sample. Plecoptera are intolerant to pollution and are clean water indicators.**	**Higher numbers indicate better water quality and habitat quality**
Percent Chironomidae	**Generally, the more chironomids in a sample, the more impacted the site is.**	**Lower numbers indicate better water quality and habitat quality**
Average Tolerance	**The average tolerance value of all the taxa in the sample on a 0-10 scale, with 0 being intolerant to organic pollution and 10 being tolerant to organic pollution**	**Lower numbers indicate better water quality and habitat quality**
Intolerance	**Number of taxa with tolerance values less than or equal to 4**	**Higher numbers indicate better water quality and habitat quality**

2015 Results

This macroinvertebrate survey began in 2015 with two samples collected per year at the Headwaters, Middle Reach, and Gorge sites of Brown's Creek. Overall, there were 53 unique taxa found in the samples this year. Most of the samples showed high taxon richness values, with the most diversity found at the Headwaters and Middle Reach sites (Table 2). All samples had at least two taxa in the EPT group, which represent higher quality water. Plecoptera (stonefly) richness is a metric that can indicate unimpacted streams. Only one immature stonefly specimen was found at the Gorge site during this year of sampling. Stoneflies typically prefer to live in fast, cold waters with riffles, and even a stream with moderate impacts can be unsuitable for them.

The percent Chironomidae metric showed results from 0% up to only 11.7% in 2015. This taxa group tends to dominate in heavily impacted streams, so this low proportion of the community means that there are minimal high-impact pollutant sources affecting the stream. The average tolerance values of all taxa found in each sample were predominantly greater than 5.0, which indicates that most of the taxa are tolerant to higher levels of pollution or other impacts to the streams.

Every sample in 2015 included intolerant taxa in the community, which are specimens with a tolerance value of 4 or less. Even though most of the samples had dominating species with high tolerance values, the presence of intolerant taxa indicates the sites are also providing suitable conditions.

Table 2. Metrics for each sample site in 2015

Site	Taxon Richness	EPT Richness	Plecoptera Richness	Percent Chironomidae	Average Tolerance	Intolerance
Headwaters	**39**	**8**	**0**	**8.1%**	**6.1**	**2**
June	28	7	0	11.7%	5.9	2
September	18	4	0	1.1%	6.5	1
Middle Reach	**27**	**6**	**0**	**1.2%**	**6.5**	**2**
June	21	4	0	4.3%	6.3	2
September	28	5	0	0.0%	6.7	1
Gorge	**22**	**4**	**1**	**1.3%**	**5.8**	**4**
June	16	3	0	1.5%	5.7	3
September	11	2	1	0.9%	6.2	2

2016 Results

In 2016, the samples had a total of 55 different taxa found. The taxon richness values for each sample were mostly above 20, which represents a diverse community of invertebrates (Table 3). Only the Gorge sample from September showed a lower taxa richness than the other samples, with only 15 unique taxa. The EPT richness was also found to be high, with every sample having at least 3 different taxa from one of those insect groups. The Plecoptera richness was comparable to the 2015 samples, with only the Gorge site having stoneflies present, but they were found in both the May and September samples this year.

The percent Chironomidae was low again for the samples in 2016, with the highest only reaching 14.2%. However, the average tolerance values were slightly above 5.0 again, indicating the domination of tolerant taxa in the samples. Like 2015, each of the samples displayed intolerant taxa, so each site does not show the high impact levels that would prevent those species from occurring there.

Table 3. Metrics for each sample site in 2016

Site	Taxon Richness	EPT Richness	Plecoptera Richness	Percent Chironomidae	Average Tolerance	Intolerance
Headwaters	**36**	**8**	**0**	**6.0%**	**5.6**	**3**
May	20	4	0	7.6%	5.9	1
September	28	6	0	4.5%	5.3	3
Middle Reach	**36**	**7**	**0**	**6.8%**	**5.8**	**3**
May	20	3	0	14.2%	6.2	1
September	23	5	0	1.4%	5.6	3
Gorge	**27**	**3**	**1**	**11.6%**	**6.2**	**2**
May	21	3	1	12.2%	6.3	1
September	15	3	1	1.1%	6.2	1

2017 Results

The macroinvertebrate samples taken in 2017 again showed high-quality water overall, with 60 unique taxa found across all the sites (Table 4). The taxon richness was higher for most of the samples than in previous years, and all sites had several EPT taxa present. Plecoptera were again found only at the Gorge site, but in both the spring and fall samples. The Chironomidae proportion was higher in some of the sites this year than in previous years, with the most being present in the Headwaters sample from May. However, most of the midge taxa found were *Diamesa* and *Parametriocnemus*, which both have moderate tolerance values of 5.0 and 5.2, respectively. Midges that dominate in heavily impacted streams tend to have tolerance values much higher than those found in this sample. The average tolerance values for the samples were like previous years in the 5.5 – 6.5 range, and each site had some intolerant taxa found.

Table 4. Metrics for each sample site in 2017

Site	Taxon Richness	EPT Richness	Plecoptera Richness	Percent Chironomidae	Average Tolerance	Intolerance
Headwaters	**31**	**6**	**0**	**33.2%**	**5.7**	**4**
May	18	3	0	51.5%	5.7	2
September	23	4	0	4.8%	5.8	3
Middle Reach	**37**	**8**	**0**	**8.9%**	**6.1**	**5**
May	19	3	0	19.6%	5.9	2
September	28	6	0	1.3%	6.2	4
Gorge	**34**	**6**	**1**	**20.5%**	**6.1**	**3**
May	20	3	1	34.5%	6.4	1
September	27	5	1	11.7%	5.9	3

2018 Results

The metrics for 2018 sample sites show high stream quality, most like 2017 than previous years, and the samples included 64 different taxa across all samples (Table 5). All samples showed exceptionally high taxon richness values, with the Gorge site being at a similar level to the other sites. All sites had at least two EPT taxa present, and again the only Plecoptera specimens found this year were at the Gorge site in both samples. The percent Chironomidae metric was slightly lower across most of the sites compared to previous years. Like 2017, the highest percent Chironomidae value was in the May Headwaters sample, but again the community consisted mostly of moderate-tolerance species. The average tolerance values are like previous years, and all samples had some intolerant taxa present this year, so the sites also provide suitable conditions for these species.

Table 5. Metrics for each sample site in 2018

Site	Taxon Richness	EPT Richness	Plecoptera Richness	Percent Chironomidae	Average Tolerance	Intolerance
Headwaters	**35**	**6**	**0**	**18.7%**	**5.9**	**4**
May	24	2	0	35.8%	5.7	2
September	26	5	0	4.9%	6.0	3
Middle Reach	**37**	**6**	**0**	**7.3%**	**6.0**	**4**
May	21	3	0	13.8%	5.9	2
September	25	4	0	0.9%	6.1	3
Gorge	**36**	**8**	**1**	**11.5%**	**5.7**	**5**
May	27	6	1	17.9%	5.9	3
September	24	5	1	5.4%	5.6	3

2019 Results

In 2019, the samples included 58 unique taxa and showed an ongoing trend of high stream quality (Table 6). The taxon richness values continue to show high levels of diversity throughout Brown's Creek. The May Headwaters community had a richness level higher than any sample in this project so far with over 30 unique taxa. The Middle Reach and Gorge sites showed diversity like previous years. All samples had at least 3 unique EPT taxa present, with the Gorge site showing the only Plecoptera specimens. However, this year both *Isoperla* and *Haploperla* were found at this site, which have moderately low tolerance values of 4.2 and 4.0, respectively.

The Chironomidae proportion was slightly higher in 2019 than in previous years in the Headwaters and Middle Reach sites with half to two-thirds of the May samples comprised of midges. This level of community domination would generally indicate a higher level of impact, although the majority of the Chironomidae community was again represented by *Diamesa*. The average tolerance values are also slightly lower than in previous years with all the samples remaining below 6.0, and all sites included intolerant taxa. This indicates that the stream community is stable and continuing to support the species that are intolerant to stream impacts.

Table 6. Metrics for each sample site in 2019

Site	Taxon Richness	EPT Richness	Plecoptera Richness	Percent Chironomidae	Average Tolerance	Intolerance
Headwaters	**39**	**8**	**0**	**40.3%**	**5.7**	**4**
May	32	4	0	67.0%	5.5	2
September	23	6	0	16.9%	6.0	3
Middle Reach	**32**	**9**	**0**	**28.4%**	**5.6**	**5**
May	19	3	0	54.8%	5.2	3
September	20	7	0	4.0%	5.9	4
Gorge	**31**	**9**	**2**	**11.3%**	**5.9**	**4**
May	24	6	1	25.3%	5.9	3
September	17	5	1	1.8%	5.9	2

2020 Results

In 2020, the samples included 54 unique taxa and showed an ongoing trend of high stream quality (Table 7). The taxon richness values continue to show high levels of diversity throughout Brown's Creek. All samples had at least 3 unique EPT taxa present. The Middle Reach and Gorge sites both showed Plecoptera specimens. This is the first year that Plecoptera has been found in the Middle Reach which could represent higher water quality in that area than in years past.

The average tolerance values for the samples were similar to 2019, with numbers falling between the 5.6 – 6.0 range which are slightly lower than in previous years. Each site had some intolerant taxa found which indicates that the stream community is stable and continuing to support the species that are intolerant to stream impacts.

This year there was a higher number of taxa with moderately low tolerance values ranging from 4.1 to 4.5. *Isoperla (TV=4.2)* was found in both Middle Reach and Gorge, *Ptilostomis (TV=4.4)* and *Pycnopsyche (TV=4.5)* were found in Headwaters, and *Antocha (TV=4.1)* was found in Gorge. A higher number of taxa with moderately low tolerance values is another indicator of good water quality.

The Chironomidae proportion was lower in 2020 compared to 2019 where we saw the highest numbers of any year sampled. Similar to 2019, the majority of the Chironomidae community was again represented by *Diamesa,* which has a moderate tolerance value compared to other midges.

Table 7. Metrics for each sample site in 2020

Site	Taxon Richness	EPT Richness	Plecoptera Richness	Percent Chironomidae	Average Tolerance	Intolerance
Headwaters	**36**	**7**	**0**	**23.8%**	**5.8**	**2**
May	22	3	0	35.9%	5.7	2
September	25	6	0	11.4%	6.0	3
Middle Reach	**32**	**10**	**1**	**18.1%**	**5.7**	**5**
May	16	6	1	28.5%	5.6	3
September	22	5	0	18.1%	5.7	3
Gorge	**29**	**7**	**1**	**14.2%**	**5.7**	**5**
May	20	5	1	21.1%	5.7	2
September	22	7	1	6.6%	5.7	5

2021 Results

In 2021, the samples included 52 unique taxa and showed an ongoing trend of high stream quality (Table 8). The taxon richness values continue to show high levels of diversity throughout Brown's Creek. All samples had at least 4 unique EPT taxa present. The Gorge site showed Plecoptera specimens for both sample occurrences.

The average tolerance values for the samples in 2021 were similar to 2020, with numbers falling between the 5.6 – 6.0 range which are slightly lower than in previous years. Each site had some intolerant taxa found which indicates that the stream community is stable and continuing to support the species that are intolerant to stream impacts.

This year again there was a higher number of taxa with moderately low tolerance values ranging from 4.1 to 4.5. *Ptilostomis (TV=4.4)* was found in Headwaters. *Isoperla (TV=4.2), Pycnopsyche (TV=4.5)* and *Antocha (TV=4.1)* were found in Gorge. A higher number of taxa with moderately low tolerance values is another indicator of good water quality.

The Chironomidae proportion was lower in 2021 compared to 2020 and substantially lower to 2019 where we saw the highest numbers of any year sampled. The majority of the Chironomidae community was represented by *Polypedilum,* which has a high tolerance value compared to other midges. The second highest number of midges were represented by Diamesa which has a lower tolerance value and has been the most prevalent genus found in past years. The lower Chironomidae numbers this year are a good sign since most of MN had experienced low water conditions over the summer of 2021. Lower water conditions usually result in warmer water temperatures which helps Chironomidae development. EPT richness remained stable from Spring to fall sampling and increased in the Middle Reach which is similar to past years and a great sign that taxa can maintain richness even in low water conditions.

Table 8. Metrics for each sample site in 2021

Site	Taxon Richness	EPT Richness	Plecoptera Richness	Percent Chironomidae	Average Tolerance	Intolerance
Headwaters	**28**	**8**	**0**	**6.0%**	**5.5**	**5**
May	20	5	0	9.7%	5.3	4
September	21	5	0	2.4%	5.8	3
Middle Reach	**40**	**9**	**0**	**15.6%**	**5.7**	**5**
May	25	4	0	30.8%	6.3	3
September	24	7	0	3.1%	5.1	3
Gorge	**28**	**7**	**1**	**14.7%**	**5.8**	**3**
May	22	5	1	24.9%	6.1	2
September	16	5	1	4.5%	5.5	2

2022 Results

In 2022, the samples included 50 unique taxa and showed an ongoing trend of high stream quality (Table 9). The taxon richness values continue to show high levels of diversity throughout Brown's Creek. All samples had at least 5 unique EPT taxa present. All samples had at least 20 unique taxa with the highest being 28 representing a heathy and diverse community of invertebrates. The Gorge site showed Plecoptera specimens for both sample occurrences. Middle Reach showed plecoptera specimens for its spring sample.

The average tolerance values were like years past for Headwaters and Middle Reach. Gorge site had a normal average tolerance in the spring; but showed a much lower average tolerance value for its fall sample due to the abundance of the caddisfly Glossosoma (TV=1.1), Protoptila (TV=1.4) and riffle beetle Optioservus (TV=3.1). Each site had at least 5 intolerant taxa which indicates that the stream community is stable and continuing to support the species that are intolerant to stream impacts. The Chironomidae proportion was average for Headwaters which typically shows higher numbers than the other two sites. The majority of the Chironomidae community was represented by Diamesa (TV=5.0), which has a lower tolerance value and has been the most prevalent genus found in past years. Middle Reach and Gorge came back with lower-than-average Chironomidae numbers which are similar to 2015 where we had the lowest numbers of all year's sampled.

Table 9. Metrics for each sample site in 2022

Site	Taxon Richness	EPT Richness	Plecoptera Richness	Percent Chironomidae	Average Tolerance	Intolerance
Headwaters	**32**	**7**	**0**	**26.2%**	**6.0**	**8**
May	25	5	0	41.4%	5.3	6
September	22	5	0	10.8%	6.3	6
Middle Reach	**37**	**10**	**1**	**4.5%**	**5.6**	**7**
May	25	8	1	5.1%	5.3	5
September	28	7	0	4.0%	5.8	6
Gorge	**33**	**10**	**1**	**3.9%**	**5.1**	**8**
May	26	7	1	3.5%	6.1	5
September	20	8	1	4.2%	4.2	7

2023 Results

In 2023, the samples included 44 unique taxa and showed an ongoing trend of high stream quality (Table 10). The taxon richness values continue to show high levels of diversity throughout Brown's Creek. All samples had at least 5 unique EPT taxa present. All samples had at least 20 unique taxa with the highest being 26 representing a heathy and diverse community of invertebrates. The Gorge and Middle Reach sites showed Plecoptera specimens for each sample occurrence.

The average tolerance values were like years past for all three sites. Each site had at least 3 intolerant taxa which is consistent with past years indicating that the stream community is stable and continuing to support the species that are intolerant to stream impacts.

The Chironomidae proportion was average for Headwaters which typically shows higher numbers than the other two sites. The majority of the Chironomidae community was represented by Tvetenia Bavarica Group (TV=5.0), which has a lower tolerance value than other midges. Middle Reach and Gorge came back with lower-than-average Chironomidae numbers.

Table 10. Metrics for each sample site in 2023

Site	Taxon Richness	EPT Richness	Plecoptera Richness	Percent Chironomidae	Average Tolerance	Intolerance
Headwaters						
September	20	5	0	10.3%	5.7	3
Middle Reach						
September	26	7	1	4.0%	5.6	**3**
Gorge						
September	21	8	1	5.4%	5.1	4

2015 – 2023 Comparisons

General macroinvertebrate metrics are best used in combination to determine the health of a stream ecosystem. However, a few of the metrics can give an overall glimpse into how stream health is changing over time. The taxa richness represents how many unique specimens are present in a sample, which is an indication of biological community stability. Streams with high taxa richness are better able to respond to and recover from impacts to the water quality. In this project, the taxa richness for all samples ranges from 11 to 32, and over the years of this project, the communities present appear to be stable and showing an increasing trend in richness (Figure 3). This indicates that the stream ecosystem is healthy and successfully recovering from any disturbances or impacts that may have occurred in the years prior to the survey. Several of the 2015 samples did not meet the target specimen count of 300 specimens when the entire sample was sorted, and this can affect the metric results. However, even with these low counts, the spring samples still showed a high taxa richness that is comparable to the community sampled in the following years. The Headwaters sample from May 2019 showed 32 unique taxa, which was higher than in any of the previous samples, indicating that the stream has a very stable and diverse community present. Samples from 2021 showed lower taxa richness than 2019 but remained comparable with earlier years of sampling. 2022 showed continued improvement. We had a record low for average tolerance from the fall Gorge site which also resulted in a record high in IBI scoring from that same site. The total tolerance comparison across all years shows a strong increase in intolerant taxa along with a decrease in tolerant taxa. Decreasing tolerance values along with stable taxa richness and lower Chironomidae numbers are all great indicators that conditions are improving for Brown's Creek. When comparing 2023's results with past numbers for taxa richness, average tolerance and IBI scoring; consistent stable numbers appear to be the trend which is a great sign that no new impairments have been introduced to Brown's Creek and the stream seems to be maintaining a health macroinvertebrate community.

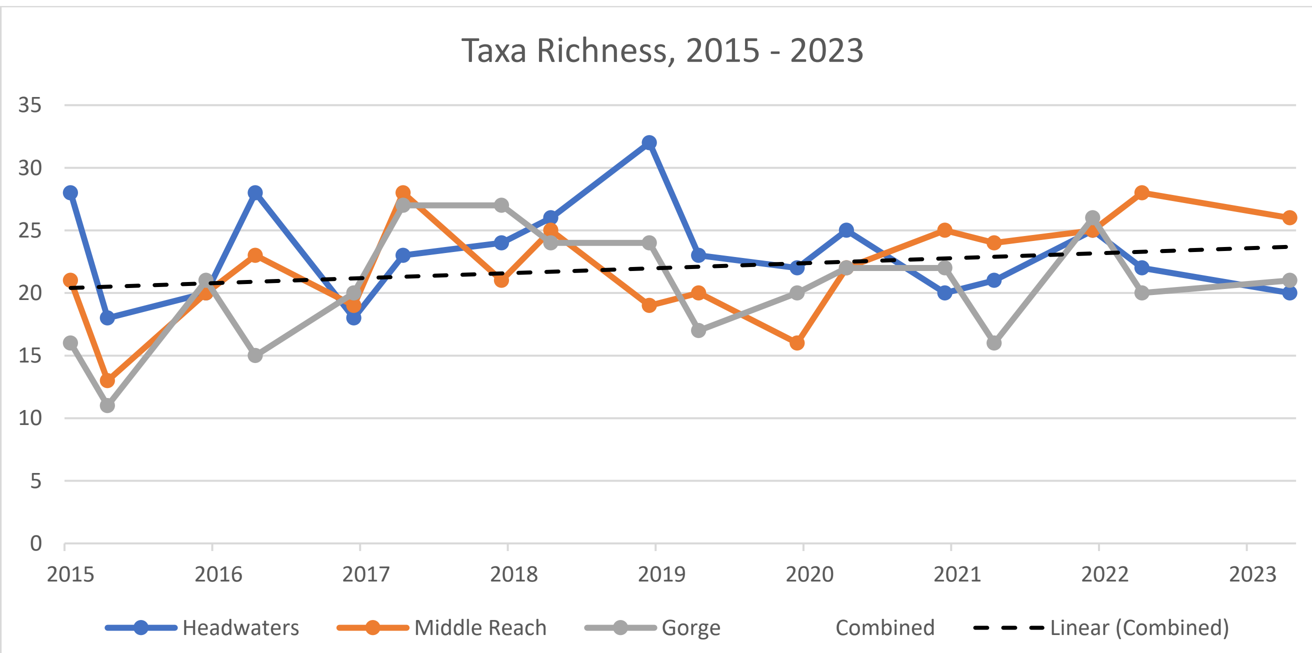


Figure 3: Taxa richness values for Brown's Creek samples from 2015 to 2023

The average tolerance value metrics can also give a good insight into stream health since it consists of a weighted average calculation. The Brown's Creek samples show an interesting pattern over the course of the years surveyed (Figure 4). In 2015, there were high values across the sites, and then some fluctuation in the tolerance values over the rest of the years. Natural fluctuations in community composition can occur year to year and are a normal occurrence in this tolerance range of 5.5 to 6.5. There is a slight decreasing trend developing over the years, showing that the stream community can support more specimens that are intolerant to impacts. This is an indication of good water quality and a stable aquatic ecosystem. The Headwaters and Middle Reach sites tend to follow the same pattern throughout the sample period, indicating similar conditions at those two sites.

However, the Gorge samples follow a different pattern, showing a higher tolerance score in 2016 and 2017 when the other two sites showed much lower scores. This could be due to a disturbance or impact occurring to Brown's Creek between the Middle Reach and Gorge sample sites. However, the disturbance is not severe enough to have strongly altered the other metrics in the Gorge samples, so the stream community is able to recover before reaching this last sample site. In 2020 & 2021, we see more consistent taxa in Headwaters and Middle Reach. Gorge showed more variation than in years past when compared with the other two sites; this could be due to low water levels in the fall. There is a down trend in average tolerance values and it seems that the numbers of intolerant taxa have been rising year after year which is a great sign that conditions are improving. Even thou numbers of unique taxa have declined since 2018 in Brown's creek, the taxa with lower tolerance values have been increasing. As conditions improve in Brown's creek it allows taxa with lower tolerance values a chance to rebound and increase their populations from past numbers.

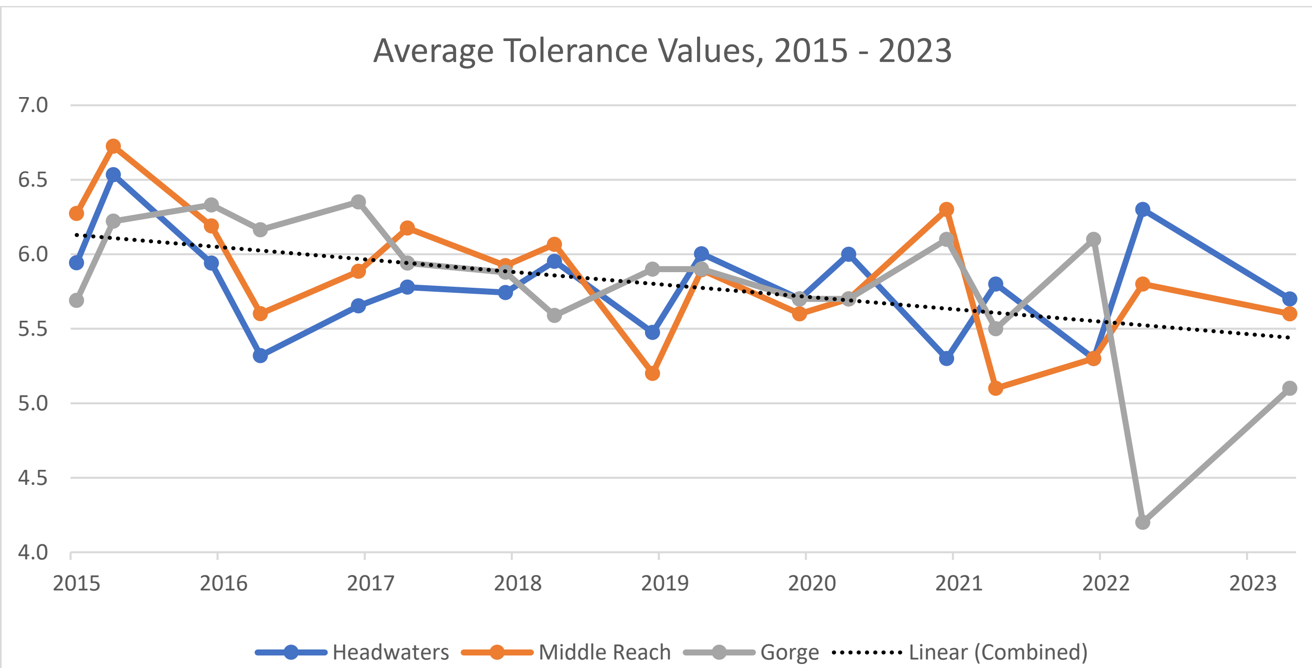


Figure 4: Average tolerance values for Brown's Creek samples from 2015 to 2023

Index of Biological Integrity (IBI)

The MPCA has developed a state-wide method of evaluating stream health using aquatic macroinvertebrates. This index gives each sample a numerical value that can be used to compare one site to another. It can also be used to monitor individual sites over time to determine whether the stream condition is improving or declining.

Due to the geographic differences throughout Minnesota and the variability in stream types, the state has been divided up into three regions that comprise nine different invertebrate stream classes (Figure 2). Each class has a different IBI calculation that best represents the invertebrate communities typically found within the region. They are based primarily on region, watershed size, thermal regime, and stream gradient (MPCA). The study area in this project is located within the Southern Coldwater Streams invertebrate class.

Tiered Aquatic Life Uses (TALU)

Stream health throughout Minnesota is evaluated for its capacity to sustain aquatic life, including the macroinvertebrates, fish, plants, and other organisms. The MPCA developed models with threshold IBI values that represent how well the stream can sustain aquatic life. These include *Exceptional Use* for high-quality streams, *General Use* for streams with light impacts, and *Modified Use* for areas with heavy impacts to the streams (Table 7). Each invertebrate stream class has different threshold levels based on the invertebrate communities typically found in that region. In this project, almost all samples were above the General Use Threshold, and several were above the Exceptional Use Threshold.

Table 11: Tiered Aquatic Life Uses as determined by the MPCA (MPCA 2014)

Use Category	Description
Exceptional Use	**Evident changes in structure due to loss of some rare native taxa; shifts in relative abundance; ecosystem level functions fully maintained**
General Use	**Overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes**
Modified Use	**Sensitive taxa markedly diminished; conspicuously unbalanced distribution of major taxonomic groups; ecosystem function shows reduced complexity and redundancy**

Table 12: Index of Biological Integrity (IBI) scores for Brown's Creek samples from 2015 to 2023

Sample Date		Headwaters	Middle Reach	Gorge
2015	June	53	64.6	62.2
	September	57.1	74.5	53.8
2016	May	51.7	44.8	41
	September	63	77.7	65.8
2017	May	49.8	56.1	35.2
	September	65.1	81.1	61.4
2018	May	53.8	66.6	52.4
	September	61.2	68.4	58.9
2019	May	49.9	48.9	51
	September	73.1	86.4	82
2020	May	63.3	64.5	53.2
	September	57.6	76.6	86.2
2021	May	72.5	43.3	48.4
	September	77.8	68.9	82
2022	May	59.1	75.1	78
	September	52.7	78.5	86.5
2023				
	September	59.5	72.7	77.8

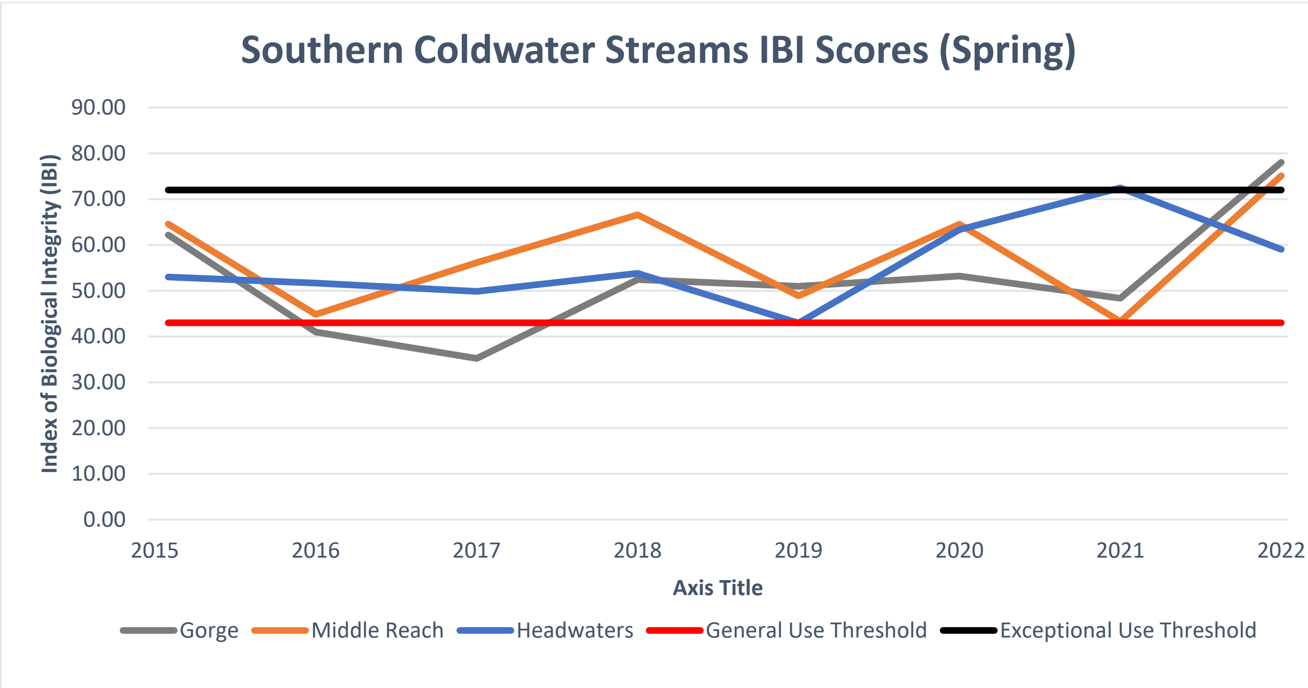


Figure 5: IBI scores, General Use Threshold, and Exceptional Use Threshold for Brown's Creek samples within the Southern Coldwater Streams class in spring 2015 - 2022

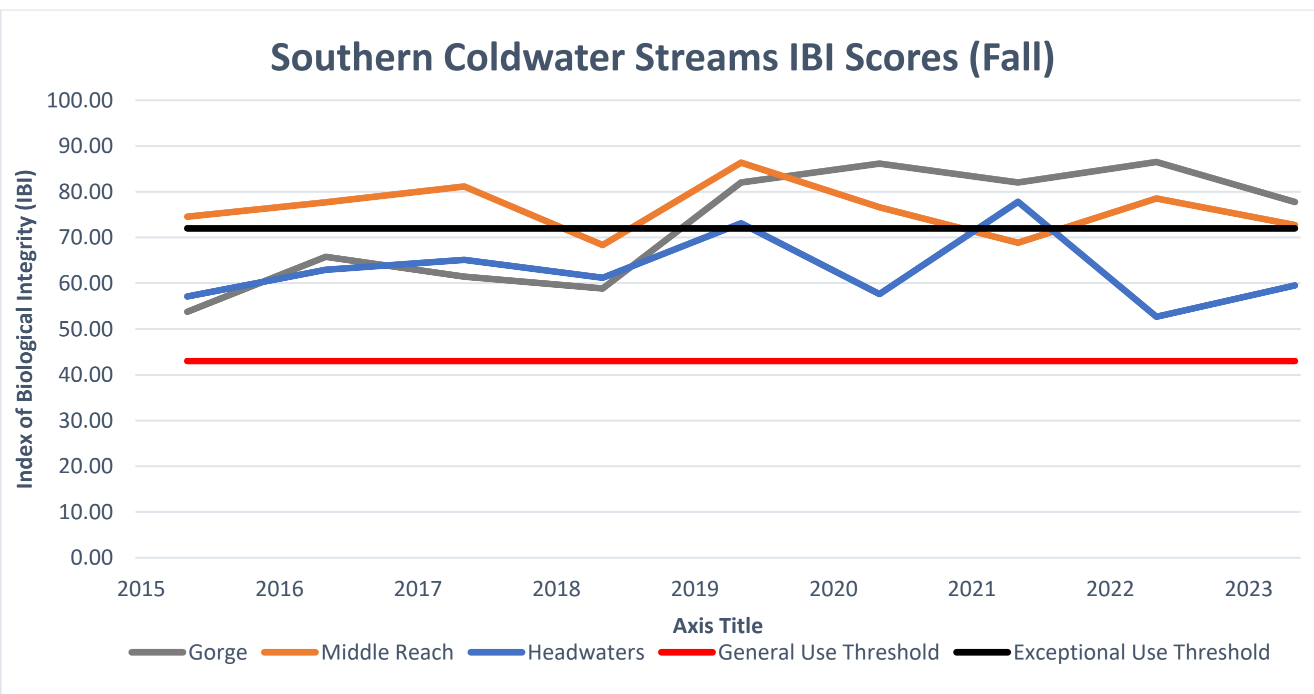


Figure 6: IBI scores, General Use Threshold, and Exceptional Use Threshold for Brown's Creek samples within the Southern Coldwater Streams class in fall 2015 - 2023

Southern Coldwater Streams region represents areas in the southern portions of Minnesota with deciduous broadleaf forests. This invertebrate class has an IBI General Use Threshold of 43 and an Exceptional Use Threshold of 72. In this project, almost all samples met the General Use Threshold, and several of the Middle Reach & Gorge samples exceeded the Exceptional Use Threshold as well as all the sites in September of 2019 (Table 7, Figure 5). The highest score was 86.5 from the September 2022 sample of the Gorge site and the lowest was 35.2 from the May 2017 sample of the Gorge site. There are natural fluctuations in the invertebrate community, causing the IBI scores to change over time. The samples taken in the fall of each year usually show a higher score than the spring samples, but overall, the scores are between the General and Exceptional Use Thresholds, indicating a stable aquatic community. Some of the samples in 2015 fell below the total specimen count of 265 recommended for the IBI calculation, which can affect the score outcome. However, even with the low counts, the IBI scores from 2015 still appear comparable to the results in the later years of this project.

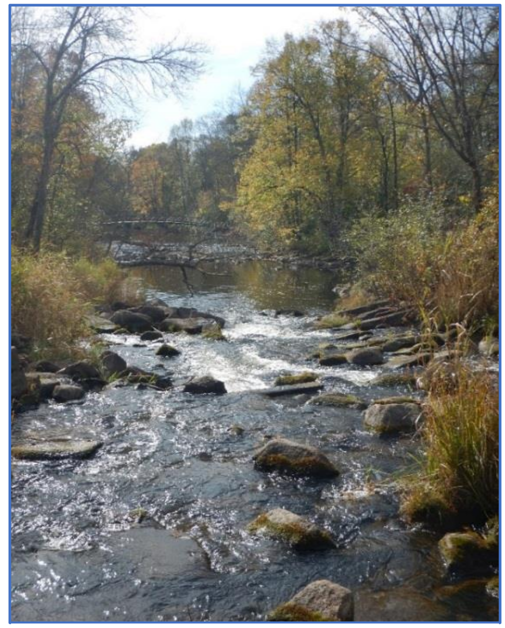
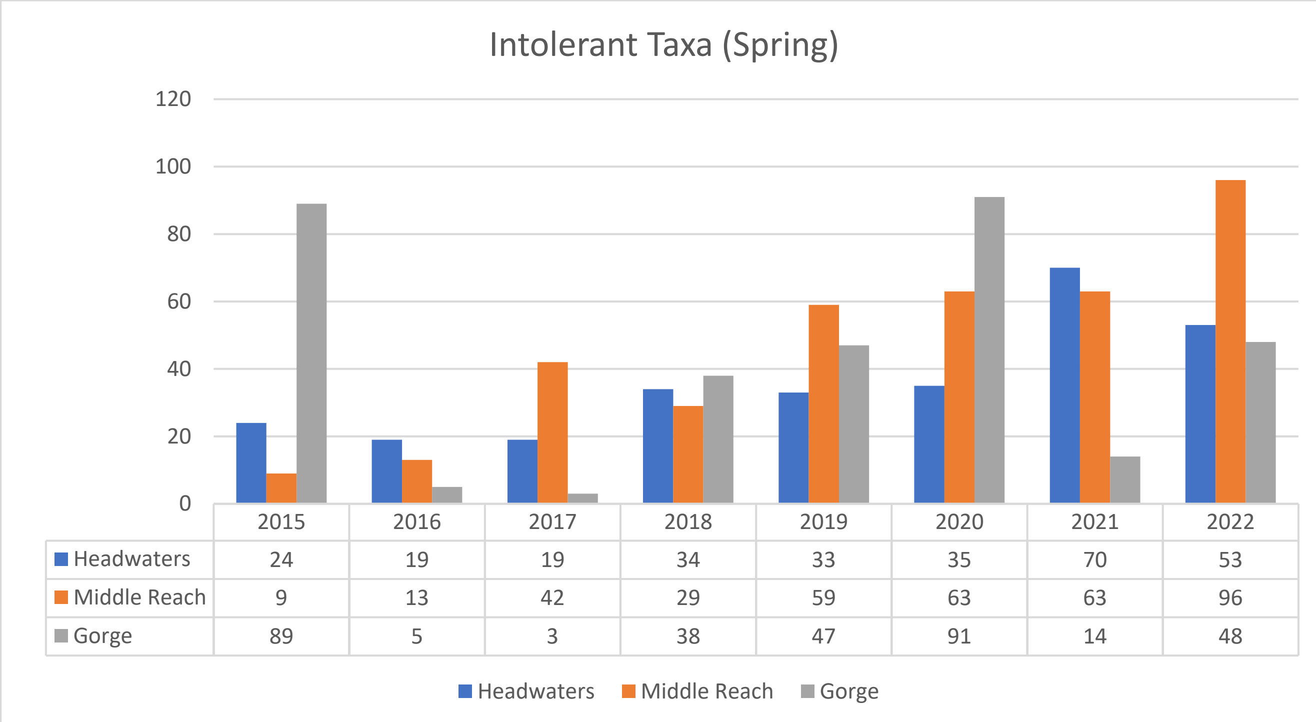
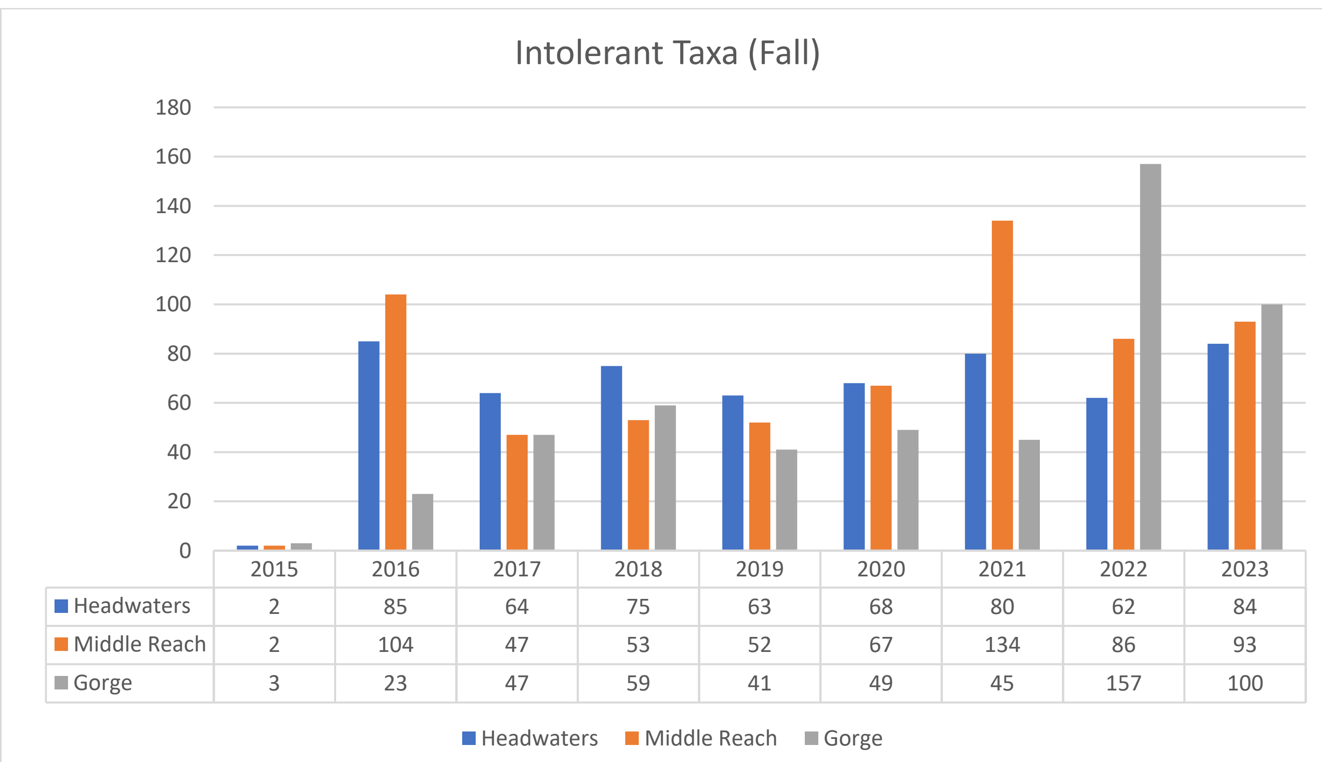


Figure 7: Example of a Southern Coldwater Stream sample site

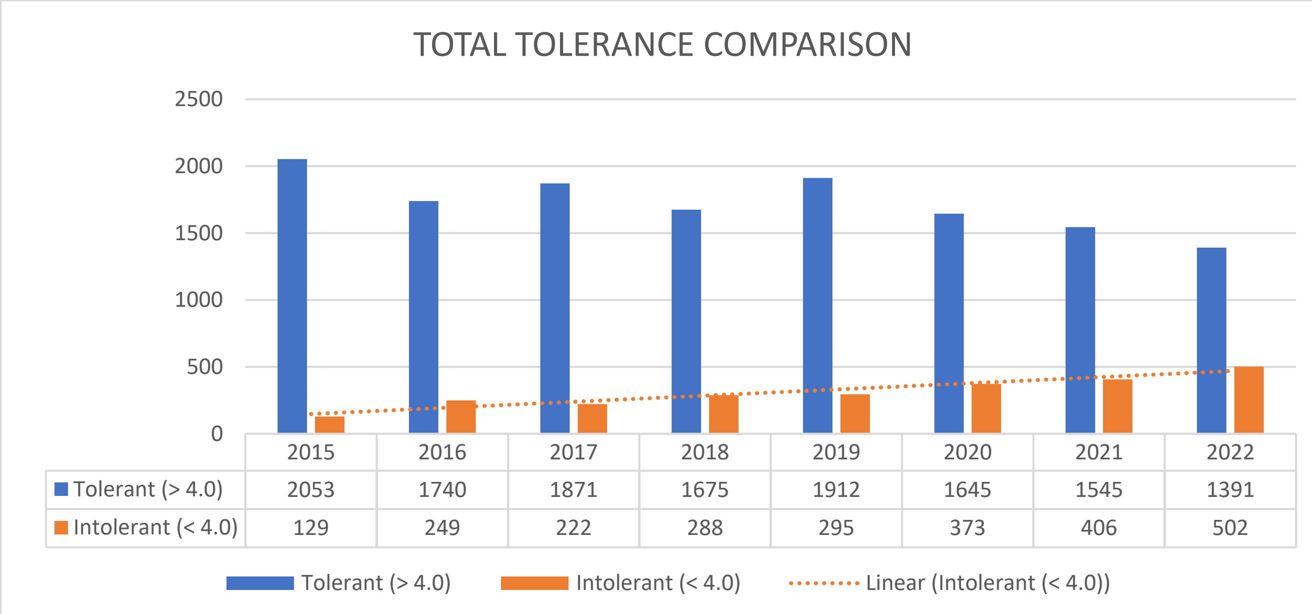


	2015	2016	2017	2018	2019	2020	2021	2022
Headwaters	24	19	19	34	33	35	70	53
Middle Reach	9	13	42	29	59	63	63	96
Gorge	89	5	3	38	47	91	14	48



	2015	2016	2017	2018	2019	2020	2021	2022	2023
Headwaters	2	85	64	75	63	68	80	62	84
Middle Reach	2	104	47	53	52	67	134	86	93
Gorge	3	23	47	59	41	49	45	157	100

Figure 8 & 9: Comparison of Intolerant taxa spring vs fall for Brown's Creek 2015 - 2023



	2015	2016	2017	2018	2019	2020	2021	2022
Tolerant (> 4.0)	2053	1740	1871	1675	1912	1645	1545	1391
Intolerant (< 4.0)	129	249	222	288	295	373	406	502

Figure 10: Comparison of Tolerant from Intolerant Taxa for Brown's Creek 2015 - 2022

Discussion

General Metrics

The macroinvertebrate communities sampled throughout this project included a wide variety of species, and the sample sites showed a range of metric results. Overall, there were 140 unique taxa across all the years of sampling, meaning that the Brown's Creek sites have diverse communities with seasonal fluctuations in the community composition (Appendix 1). The most prevalent taxa overall were scuds (*Gammarus*), blackflies (*Simulium*), and mayflies (*Baetis*). These taxa have medium-level tolerance values, so they are often found in higher densities in streams with moderate impacts. The dominance of tolerant taxa like these can cause the average tolerance value of a sample to be high. Most of the samples in this project had an average tolerance value between 5 and 7, with the lowest being 5.2 in the May 2019 Middle Reach sample and the highest being 6.7 in the September 2015 Middle Reach sample.

Despite the prevalence of tolerant species, all the samples included some intolerant taxa, indicating that the level of impacts on the streams was not high enough to prevent the sensitive species from living there. The next most abundant taxon was a riffle beetle (*Optioservus*) which is intolerant to impacts with a tolerance value of only 3.1. The abundance of these riffle beetles indicates that the stream is clean and fast enough to support a strong community of intolerant taxa. Intolerant taxa are any species with a tolerance value (TV) of 4 or less. In this project, these included the riffle beetle *Optioservus* (TV = 3.1), caddisflies *Neophylax* (TV = 3.2), *Glossosoma* (TV = 1.1) and Protoptila

(TV=1.4). This combination of taxa shows that while these streams likely have some urbanization impact, they also have pockets of good microhabitat and sufficient oxygen.

The EPT metric evaluates the diversity of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) in the samples. These insect groups are generally indicators of less impacted waters since they contain many intolerant species. In this project, the EPT values ranged from 2 to 7 unique taxa in each sample. While there are no definitive thresholds with this metric, sites with few or no EPT taxa likely have a substantial number of impacts and may be targeted for management practices to improve the watersheds that flow into these sites. The Plecoptera subset of the EPT metric is also evaluated since the stonefly group contains mostly intolerant species, and typically they require high-quality, well-oxygenated water. Two unique stonefly species were found during this project (*Isoperla* and *Haploperla*), and they have only been found in the Gorge & Middle Reach Sites. This group of insects is typically not very diverse in stream samples without strong riffles present to keep the water full of dissolved oxygen.

The Chironomidae fraction of a sample can also indicate general water quality. Even though this group is very diverse and includes midge species with tolerance values ranging from 0 to 10, generally they only dominate a sample at a site with heavy pollution impacts. The samples in this project ranged from 0% to 67% Chironomidae present, with some of the largest proportions seen in the May 2019 samples. Since most healthy streams have a diverse community of macroinvertebrates, the high numbers of midges seen in the spring samples initially seems like an indication of impact. However, with the change in community throughout the year and with such low Chironomidae proportions in the fall samples, Brown's Creek likely has minimal pollution impacts affecting the water quality, especially when looking at all the metrics in combination.

Invertebrate Stream Classes

Minnesota is divided up into invertebrate stream classes based on three geographic regions so the IBI values can be compared to streams within similar regions. These regions include Northern Forest Streams, Southern Streams, and Prairie Streams. The regions are then further divided based on whether the sample was taken from a site with riffle habitats present or only with glides and pools. This survey was located within the Southern Coldwater Streams class. Samples were taken from 3 dominant habitat types in a given reach per season (Either from riffles, pools, runs, glides, undercut banks, leaf packs, or wood debris.)

Each stream class has unique threshold values indicating the level of support for biological communities living there. The highest tier is the Exceptional Use Threshold which represents the highest quality streams that are providing maximum support for aquatic organisms. The next level is the General Use Threshold, which is the target level for streams that are healthy and functioning despite any impacts to them. The lowest level is the Modified Use Threshold, which represents streams with heavy impacts that may be struggling to adequately support the aquatic communities living in them. Sites with IBI scores at or below the Modified Threshold should be prioritized over others for management practices or restorations to improve the stream health.

The Brown's Creek sites within the Southern Coldwater Streams region have been regularly fluctuating with the seasonal sampling over the years of this project. Most IBI scores fall between the General and Exceptional Use Thresholds. The pattern across the three sites shows increased scores in the fall with numbers closer to the Exceptional Use Threshold. The Spring samples show slightly lower scoring with numbers closer to the general use threshold. This pattern is normal for most streams with fall samples showing a better display of a stream's true macro community. With improving IBI scoring occurring over the summer, it's unlikely that any major pollution impacts are occurring along Brown's Creek between the sample points.

Limitations and Future Projects

This project contained a few limitations that may have affected some of the resulting data and statistics. During laboratory processing, some of the 2015 samples were completely sorted with the total number of specimens falling below the required 265 count needed for best application of the MPCA IBI calculation. This can slightly skew the resulting IBI score for those sites, but the taxa and tolerance values are still accurate and representative of the sample.

Further monitoring of these sites is recommended to continue establishing the baseline data for these aquatic communities. Each site is dynamic and seasonally changing, so continuing to collect data helps to eliminate the differences due to natural fluctuations in invertebrate communities. Additionally, if there are suspected pollution inputs to a stream or restoration projects in progress, monitoring before and after these impacts is recommended to assess how the biological community is affected.

Literature Cited

MPCA. 2014. Development of a macroinvertebrate-based Index of Biological Integrity for assessment of Minnesota's rivers and streams. Minnesota Pollution Control Agency, Environmental Analysis and Outcomes Division, St. Paul, MN.

MPCA. 2014. Development of biological criteria for tiered aquatic life uses: Fish and macroinvertebrate thresholds for attainment of aquatic life use goals in Minnesota streams and rivers. Minnesota Pollution Control Agency, Environmental Analysis and Outcomes Division, St. Paul, MN.

Appendix 1: Project Taxa List

Order	Family	Genus	Species
Acari/Hydracarina			
	Sperchontidae	*Sperchon*	
	Limnesiidae	*Limnesia*	
Amphipoda	Crangonyctidae	*Crangonyx*	
	Gammaridae	*Gammarus*	*lacustris*
	Hyalellidae	*Hyalella*	
Coleoptera	Dytiscidae	*Agabus*	
		Ilybius	
		Liodessus	
		Uvarus	
	Elmidae	*Macronychus*	
		Optioservus	
		Stenelmis	
	Gyrinidae	*Gyrinus*	
	Haliplidae	*Peltodytes*	
	Hydraenidae	*Hydraena*	
	Hydrophilidae	*Enochrus*	
		Hydrobius	
		Hydrochara	
		Hydrochus	
		Tropisternus	
	Scirtidae	*Scirtes*	
Collembola			
Decapoda	Cambaridae		
Diptera	Ceratopogonidae	*Bezzia/Palpomyia*	
		Ceratopogon	
		Dasyhelea	
		Mallochohelea	
	Chironomidae	*Brillia*	
		Cardiocladius	
		Chaetocladius	
		Cladotanytarsus	
		Conchapelopia	
		Corynoneura	
		Cricotopus	
		Cryptochironomus	
		Diamesa	
		Diplocladius	
		Eukiefferiella	

		Eukiefferiella	*claripennis gr.*
		Eukiefferiella	*devonica gr.*
		Eukiefferiella	*tirolensis gr.*
		Limnophyes	
		Meropelopia	
		Micropsectra	
		Microtendipes	
		Nanocladius	
		Orthocladius (Orthocladius)	*lignicola*
		Orthocladius (Symposiocladius)	
		Paracricotopus	
		Parametriocnemus	
		Paratanytarsus	
		Paratendipes	
		Polypedilum	
		Prodiamesa	
		Rheocricotopus	
		Rheotanytarsus	
		Saetheria	
		Stenochironomus	
		Tanytarsus	
		Thienemanniella	
		Thienemannimyia gr.	
		Tvetenia	
		Tvetenia	*bavarica gr.*
		Zavrelimyia	
	Dixidae	*Dixa*	
	Empididae	*Chelifera*	
		Hemerodromia	
		Neoplasta	
		Metachela	
	Ephydridae		
	Limoniidae	*Antocha*	
		Helius	
		Molophilus	
	Pediciidae	*Dicranota*	
	Simuliidae	*Simulium*	
		Prosimulium	
	Stratiomyidae	*Odontomyia*	
	Syrphidae	*Chrysogaster*	
	Tabanidae	*Chrysops*	
	Tipulidae	*Antocha*	

		Dicranota	
		Hexatoma	
		Limnophila	
		Limonia	
		Ormosia	
		Pedicia	
		Pilaria	
		Tipula	
Ephemeroptera	Baetidae	*Baetis*	
Gastropoda	Ancylidae	*Ferrissia*	
	Lymnaeidae	*Stagnicola*	
	Physidae	*Aplexa*	
		Physa	*acuta*
		Physa	*gyrina*
		Physella	
	Planorbidae	*Gyraulus*	*parvus*
		Micromenetus	
	Valvatidae	*Valvata*	*perdepressa*
Hemiptera	Belostomatidae	*Belostoma*	
	Corixidae	*Hesperocorixa*	
		Sigara	
	Gerridae	*Aquarius*	
		Gerris	
	Nepidae	*Ranatra*	
	Pleidae	*Neoplea*	
	Veliidae	*Microvelia*	
Hirudinida	Erpobdellidae	*Dina*	*parva*
	Erpobdellidae	*Erpobdella*	*punctata*
	Glossiphoniidae	*Glossiphonia*	*complanata*
		Helobdella	*stagnalis sp. group*
		Placobdella	
Isopoda	Asellidae	*Caecidotea*	
		Oniscus	
Lepidoptera	Pyralidae		
Mermithida	Mermithidae		
Odonata	Aeshnidae	*Aeshna*	
		Boyeria	
Odonata	Calopterygidae	*Calopteryx*	
	Coenagrionidae		
Plecoptera	Chloroperlidae	*Haploperla*	
	Perlodidae	*Isoperla*	
Trichoptera	Brachycentridae	*Brachycentrus*	

	Glossosomatidae	*Glossosoma*	
		Protoptila	
	Hydropsychidae	*Ceratopsyche*	
		Cheumatopsyche	
		Hydropsyche	
		Parapsyche	
	Hydroptilidae		
	Lepidostomatidae	*Lepidostoma*	
	Leptoceridae	*Oecetis*	
	Leptoceridae	*Triaenodes*	
	Limnephilidae	*Anabolia*	
		Limnephilus	
		Pycnopsyche	
	Philopotamidae	*Chimarra*	
	Phryganeidae	*Ptilostomis*	
	Polycentropodidae	*Polycentropus*	
	Psychomyiidae	*Lype*	
	Rhyacophilidae	*Rhyacophila*	
	Uenoidae	*Neophylax*	
Tricladida			