Item 5F
BCWMC 3-21-13
Full Report

A Biotic Index Evaluation of Bassett Creek and Plymouth Creek: 2012

Prepared by
Bassett Creek Watershed Management Commission

March 2013

A Biotic Index Evaluation of Bassett Creek and Plymouth Creek: 2012

Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 Executive Summary

During 2012, the Bassett Creek Watershed Management Commission (BCWMC) conducted biological monitoring of Plymouth Creek and Bassett Creek to evaluate the water quality of the streams (Figure 1). The BCWMC has conducted biological monitoring of Plymouth Creek and Bassett Creek at regular intervals since 1980 (1980, 1983, 1991, 1995, 2000, 2003, 2006, 2009, and 2012). In addition, biological samples were collected from the Sweeney Lake Branch and the Main Stem east of Zane Avenue in 1996. These historical data were compared with 2012 data to determine changes in the stream's biological community over time.

Biological indices, such as the Hilsenhoff Biotic Index (HBI) and Invertebrate Community Index (ICI), have been used to evaluate the water quality of Plymouth Creek and Bassett Creek. The HBI, used since 1980, is a measure of organic and nutrient pollution, which causes lower dissolved oxygen levels. The ICI is a measure of a wider range of pollutants and has been used since 1995. Low HBI scores are indicative of good water quality. Conversely, low ICI scores are indicative of poor water quality. Figure 8 shows the HBI and ICI results from 1995 – 2012, and Figure 9 shows the HBI results from 1980 – 2012.

A severe drought reduced stream flow and stream depth in Bassett Creek and Plymouth Creek later in 2012. The North Branch of Bassett Creek dried up and was not sampled. The 2012 drought provided ideal conditions for single species to dominate the macroinvertebrate community at locations most severely impacted by reduced flow and water depth (i.e., Plymouth Creek, Sweeney Lake Branch, and the upstream Main Stem locations). The species that capitalized on the habitat changes, *Gammarus* and Planaria, are species that live on the stream bottom and are tolerant of low flow and low water levels.

Because *Gammarus* and Planaria can survive and thrive under adverse habitat conditions (low flow and low water levels), they have low ICI tolerance values (a numerical value assigned to level of pollution tolerance, with low values indicating higher tolerance). Their low ICI tolerance values coupled with the high numbers of these organisms resulted in lower average ICI values than had been previously observed at all locations except the Main Stem at Irving Avenue—the most downstream location of the Main Stem. While the reduced ICI values indicate a poorer macroinvertebrate community, they are due to climatic changes, a variable that cannot be managed. In addition, literature suggests that both *Gammarus* and Planaria require relatively clean water to survive—

indicating that despite the lowered ICI numbers, water quality in areas where they proliferate is good (Hyman 1951; Gerhardt 2011; Maltby 1994).

The 2012 HBI results indicate the water quality of Bassett Creek and Plymouth Creek was:

- Very good at Plymouth Creek and the Main Stem at Rhode Island Avenue, which is the most upstream location on the Main Stem.
- Good at the Main Stem at Zane Avenue, Dresden Lane, and Irving Avenue.
- Fair at the Sweeney Lake Branch.

The only location with a significant change in HBI since the last monitoring period was the most upstream location on the Main Stem at Rhode Island Avenue. Here, there was significant improvement in water quality. Although not significant, improved water quality was also seen at Plymouth Creek, the Sweeney Lake Branch, and the Main Stem east of Zane Avenue. Degradation was seen at the Main Stem of Bassett Creek at Dresden Lane and Irving Avenue. Water quality improvements are attributed to reductions in stormwater runoff during the 2012 drought. This reduced the quantity of oxygen-demanding materials added to the stream. The drought also, however, reduced flow and oxygen in the stream, leading to the areas of water quality degradation.

The Minnesota Pollution Control Agency (MPCA) is developing a Macroinvertebrate Index of Biological Integrity (MIBI) to identify biologically impaired rivers and streams. When available, the BCWMC can apply the MIBI to all or some of the macroinvertebrate data collected to date. Once MIBI scores are computed for Plymouth Creek and Bassett Creek, the BCWMC will know whether the streams meet the MPCA impairment standard.

Based on the results of the 2012 monitoring program, the Commissioners will consider:

- Continuing management efforts of Bassett Creek and Plymouth Creek, including installation of BMPs to protect and, if possible, to improve the water quality of the stream as opportunities become available.
- Sampling all stations again in 3 to 5 years to maintain the long-term monitoring record and assess stream water quality changes.
- Continuing flow and water quality monitoring from the Watershed Outlet Monitoring Program (WOMP) sample station located on the Main Stem at Irving Avenue to evaluate physical and chemical parameters impacting the stream's plants and animals..
- Using the Macroinvertebrate Index of Biological Integrity (MIBI), when finalized by the MPCA, to assess the biological community of Bassett Creek and Plymouth Creek; the MIBI will replace the HBI and ICI that were used from 1980 to 2012.

- Applying the MIBI (when finalized) to all or some of the macroinvertebrate data collected from Bassett Creek and Plymouth Creek from 1980 to 2012 to determine whether the streams have met the MPCA impairment standard.

2.0 Introduction

During 1980, 1983, 1991, 1995, 2000, 2003, 2006, 2009, and 2012, benthic macroinvertebrates (bottom-dwelling organisms) were collected from Plymouth Creek and Bassett Creek (Sweeney Lake Branch, North Branch, and Main Stem) to evaluate water quality and detect changes in water quality over time. In addition, samples were collected from the Sweeney Lake Branch and the Main Stem east of Zane Avenue in 1996. This report presents the results of the 2012 benthic macroinvertebrate monitoring. Macroinvertebrate data and biotic index calculations are included in Appendix A and Appendix B. Biotic index values from 1980 through 2012 are depicted graphically in Appendix C.

Evaluating benthic macroinvertebrates in a stream provides a long-term assessment of its water quality. The two biotic indices described in this report use biological indicator organisms to evaluate stream water quality. The types of organisms living on the stream bottom depend on the available habitat, which is affected by water quality. Water quality is degraded when pollutants enter a stream; organic pollutants and nutrients cause a loss of oxygen. Low flow (less physical aeration) during dry climatic conditions also causes low oxygen concentrations. Organisms that are sensitive to low oxygen concentrations are only able to survive in the highest quality of water (i.e., well-oxygenated). There are tolerant macroinvertebrate species that can survive in low oxygen conditions, and their presence indicates low water quality (i.e., organic pollution or dry climatic conditions). Other stressors, such as high suspended solids concentration or high metals concentrations, can also affect the macroinvertebrate community.

This report uses two biotic indices, the Hilsenhoff Biotic Index (HBI) and the Invertebrate Community Index (ICI). Both indices provide an indication of the water quality at a sample location based on the characteristics of the resident macroinvertebrate community. The HBI is an indicator of organic pollution or dry climatic conditions that produce low oxygen levels in the stream, while the ICI is an indicator of a broader range of pollutants.

3.0 Methods

Monitoring for the presence or absence of biological indicator organisms provides *indirect* evidence of transitory changes in stream water quality related to stormwater runoff. Benthic macroinvertebrates are exposed to all of the temporal variations in stream water quality and reflect the quality of the passing water. The presence of pollution-tolerant organisms and/or the absence of pollution-sensitive organisms demonstrate the adverse water-quality impacts of urban runoff. These organisms are periodically collected in the same location from the creek bottom (or substrate). This methodology provides better results than using grab water quality samples and is more economical than multi-event stormwater quality sampling. The BCWMC currently performs benthic macroinvertebrate monitoring on a three-year cycle.

3.1 Sampling Locations and Methods

Benthic macroinvertebrate samples were collected from Plymouth Creek and Bassett Creek (North Branch, Main Stem, and Sweeney Lake Branch) during 2012 on the dates indicated below. The sampling locations are identified as follows (Figure 1):

- Plymouth Creek at Industrial Park Boulevard in Plymouth (October 2).
- North Branch of Bassett Creek at 32nd Avenue North and Adair Avenue in Crystal (October 2). The stream was dry and no samples were collected in 2012.
- Main Stem of Bassett Creek at Rhode Island Avenue in Golden Valley (October 2).
- Main Stem of Bassett Creek east of Zane Avenue in Golden Valley (October 2).
- Main Stem of Bassett Creek at Dresden Lane in Golden Valley (October 2).
- Main Stem of Bassett Creek at Irving Avenue in Minneapolis (October 2).
- Sweeney Lake Branch of Bassett Creek at Turner's Crossroad in Golden Valley (October 3).

The same locations were regularly monitored from 1980 through 2012 with three exceptions:

1. The North Branch sample site was located just north of where the North Branch joins the Main Stem in 1980, 1983, and 1991. In 1995, this location had silted in and was no longer a representative habitat for the stream. An alternate site was located a short distance upstream at 32nd Avenue North and Adair Avenue where the habitat was characteristic of the stream. Macroinvertebrates were collected at the 32nd Avenue and Adair Avenue site in 1995, 2000, 2003, 2006, 2008, 2009, and 2012.

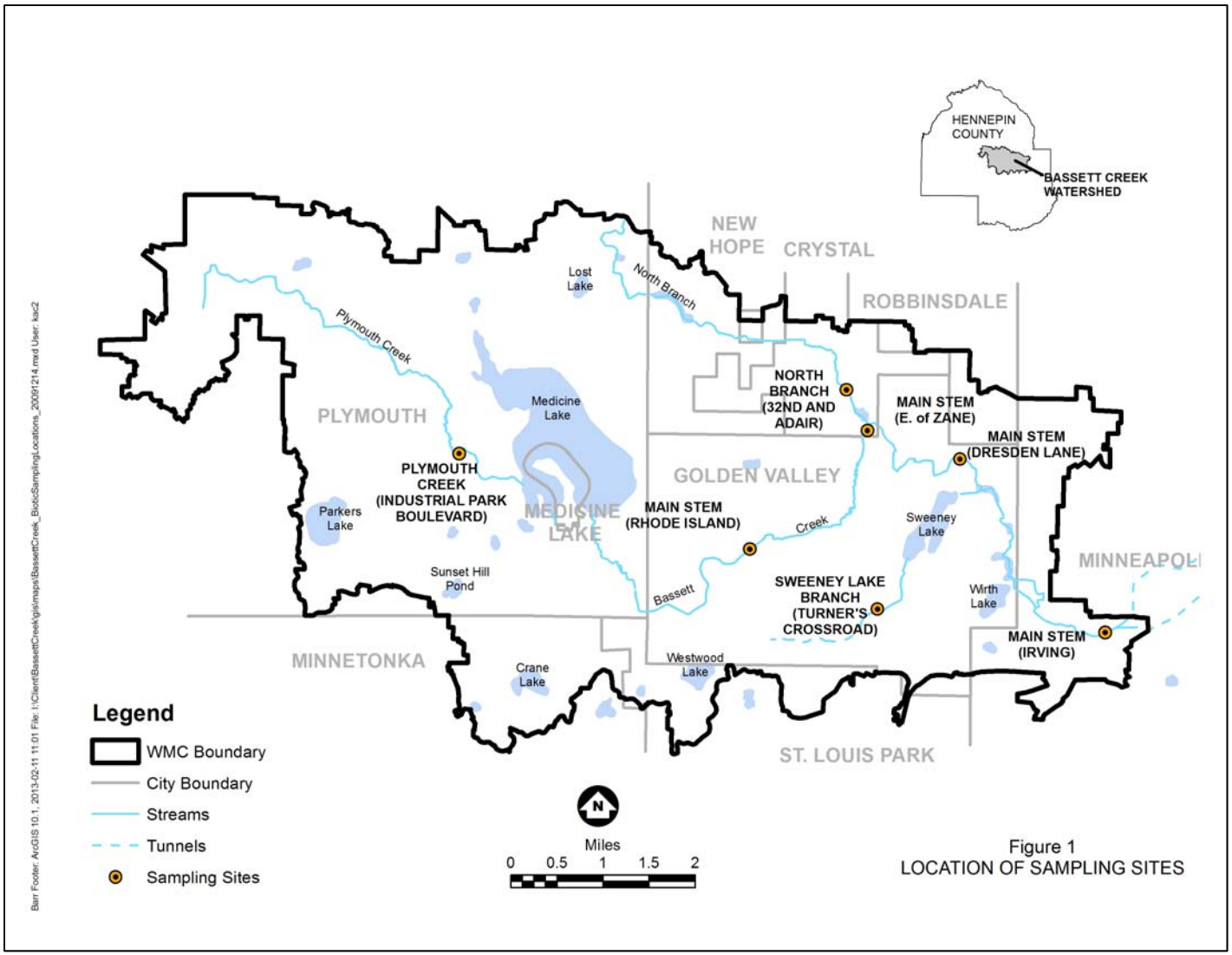


Figure 1 Location of Sampling Sites

2. The most downstream Main Stem sample site was located at Dupont Avenue from 1980 through 2003. The location was moved slightly upstream to Irving Avenue in 2003 due to access problems at Dupont Avenue. The Irving Avenue sample site is located near the WOMP sample station.

3. The Main Stem site at Dresden Lane was added by the MPCA in 2008 to collect additional data because fish Index of Biotic Integrity (IBI) scores indicate that it is impaired. The Dresden Lane location is downstream from where the North Branch joins the Main Stem of Bassett Creek and upstream from the Irving Avenue sample site.

Table 1 summarizes the years in which biological samples were collected from Plymouth Creek and Bassett Creek locations.

Table 1 1980-2012 Summary of Years with Biological Data

Sample Location	Years with Sampling Data
Plymouth Creek at Industrial Boulevard	1980, 1983, 1991, 1995, 2000, 2003, 2006, 2009, 2012
North Branch of Bassett Creek north of Zane (1980-2000) or 32nd and Adair (2003-2012)	1980, 1983, 1991, 1995, 2000, 2003, 2006, 2008[1], 2009, 2012[2]
Main Stem of Bassett Creek at Rhode Island	1980, 1983, 1991, 1995, 2000, 2003, 2006, 2008[1], 2012
Main Stem of Bassett Creek East of Zane Avenue	1980, 1983, 1991, 1995, 1996, 2000, 2003, 2006, 2012
Main Stem of Bassett Creek at Dresden Lane	2008[1], 2012
Main Stem of Bassett Creek at Dupont (1980-2000) or Irving Avenue (2003-2012)	1980, 1983, 1991, 1995, 2000, 2003, 2006, 2008[1], 2012
Sweeney Lake Branch of Bassett Creek at Turner's Crossroad	1980, 1983, 1991, 1995, 1996, 2000, 2003, 2006, 2009, 2012

[1]Monitored by the Minnesota Pollution Control Agency

[2]The North Branch of Bassett Creek was dry in 2012 and no data were collected.

At each sample location, macroinvertebrate samples were collected from riffle areas (areas with fast-moving water) where the substrate was composed of gravel and small stones. Samples were collected by disturbing the creek bottom and allowing dislodged macroinvertebrates to drift into a D-frame aquatic net positioned downstream. Rocks and other substrate materials were also examined for macroinvertebrates. Macroinvertebrates were collected for a total of 30 minutes at each sample location and later identified in the laboratory.

3.2 Biological Indicators

Biological indicators can be used to evaluate stream water quality and provide an estimate of impact from pollutants entering the stream during storm events. Biological indicators also evaluate the changes in dissolved oxygen due to changes in climatic conditions (i.e., declining oxygen conditions

during dry periods that result in low flows). There are a variety of biological indices that can be used to assess the water quality of a stream. As noted, this study uses the Hilsenhoff Biotic Index (HBI) and the Invertebrate Community Index (ICI).

3.3 Hilsenhoff Biotic Index (HBI)

The HBI has been used to evaluate biological data from Bassett Creek and Plymouth Creek since 1980. It should be noted that the HBI can only be used when at least 100 macroinvertebrates are collected and, hence, was not used in Plymouth Creek monitoring events during 1980 and 1983.

Small streams such as Plymouth Creek and Bassett Creek usually have a low diversity of organisms because of their size, regardless of water quality. Even though small streams have fewer types of organisms than larger streams, research indicates that the HBI provides a good indication of water quality. The HBI is described as "a measure of organic and nutrient pollution, which causes lower dissolved oxygen levels" (Hilsenhoff, 1987). The HBI uses tolerance values assigned to species of arthropods (aquatic insects, amphipods and isopods) that are sensitive to different levels of dissolved oxygen in the stream water. The tolerance values indicate the species' ability to survive in low-oxygen conditions and the values range from 0 to 10. The lower the value, the less tolerance the species has for low dissolved oxygen conditions. A tolerance value of 0 is assigned to a species collected only in unaltered streams of very high water quality, and a value of 10 is assigned to species known to occur in severely polluted or significantly disturbed streams. Intermediate values are assigned to species known to occur in streams with varying degrees of water quality.

To produce an overall HBI value for a stream the average of the HBI tolerance values is weighted by organism abundance in the riffle community. Hence, the HBI score provides an indication of average oxygen conditions in the stream as well as the stream's water quality based upon the degree of organic pollution.

Table 2 provides a general guide for using the HBI values to determine water quality and the degree of organic pollution of a stream.

Table 2 Water Quality and Degree of Pollution Indicated by HBI Values

HBI Value	Water Quality	Degree of Organic Pollution
0.00 – 3.50	Excellent	No apparent organic pollution
3.51 – 4.50	Very good	Possible slight organic pollution
4.51 – 5.50	Good	Some organic pollution
5.51 – 6.50	Fair	Fairly significant organic pollution
6.51 – 7.50	Fairly poor	Significant organic pollution
7.51 – 8.50	Poor	Very significant organic pollution
8.51 – 10.00	Very poor	Severe organic pollution

3.4 Invertebrate Community Index (ICI)

A second index, the ICI, was used with the 1995 through 2012 data as a second opinion. The ICI uses macroinvertebrates from both fast- and slow-water habitats and provides an indication of a wider range of pollutants. It is calculated like the HBI, but uses tolerance values derived from the ICI (DeShon, 1995).

The ICI tolerance values were derived from the abundance of each macroinvertebrate and the quality of the streams in which they were found (DeShon 1995). The scale for the ICI ranges from 0 to 60, with a score of 60 indicating the highest quality water. Like the HBI, the numeric scores are grouped according to water-quality categories, ranging from poor to exceptional. Those categories are not used here, however, because they specifically reference Ohio stream sites. For Plymouth Creek and Bassett Creek, an ICI-based index is used as a relative measure for comparison with the HBI. For example, when HBI and ICI values measured at the Main Stem of Rhode Island Avenue in 2008 were compared, the HBI value of 5.2 and the ICI value of 29.4 were approximately midway in the range of values for the respective indices. Both values indicated the stream community was comprised of organisms tolerant of a moderate level of pollutants.

To produce an overall ICI value for a stream the average of the ICI tolerance values are weighted by organism abundance in the community. Hence, the ICI score provides an indication of the average water quality conditions in the stream. Because the ICI is based upon a wide range of pollutants it provides a broader view of the stream's water quality than the HBI.

4.0 Results and Discussion

4.1 2012 Drought Impacts

A severe drought later in 2012 reduced stream flow and stream depth in Bassett Creek and Plymouth Creek. August through October 2012 precipitation totaled 2.63 inches at the Bassett Creek WOMP station (MCES 2013), which is 7.18 inches below normal (National Weather Service 2012). The total rainfall from August through October 2012 was substantially lower than the total rainfall observed during this period at the Bassett Creek WOMP location in 2000, 2003, 2006, 2008, and 2009 (Figure 2) (MCES 2012, MCES 2013). The reduced rainfall during this August through October 2012 period also resulted in lower average daily stage (water depth) and lower average daily flow than observed in 2000, 2003, 2006, 2008, and 2009 (Figures 3 and 4) (MCES 2012, MCES 2013). The North Branch of Bassett Creek dried up; hence, macroinvertebrates could not be sampled. The change in macroinvertebrate habitat resulting from reduced rainfall, reduced stream depth, and reduced stream flow during the summer through fall period caused changes in the 2012 macroinvertebrate communities of Plymouth Creek, the Sweeney Lake Branch, and the Main Stem of Bassett Creek.

4.1.1 Sweeney Lake Branch

In the Sweeney Lake Branch of Bassett Creek, the 2012 macroinvertebrate community was dominated by Planaria (pictured to the right), which comprised 71 percent of the total number of macroinvertebrates found in the stream (Figure 5). Planaria, also known as flatworm, lives on the stream bottom and can thrive in shallow waters and low-flow conditions. Planaria requires relatively clean water to survive (Hyman 1951). Higher numbers of Planaria were observed in 2012 than in previous years in the Sweeney Lake Branch of Bassett Creek (Figure 6). The large number of Planaria observed in 2012 is attributed to drought conditions which created ideal conditions and favored dominance by this species. **The dominance of Planaria in the Sweeney Lake Branch of Bassett Creek indicates the stream was relatively clean during 2012.**

Planaria, pictured above, dominated the Sweeney Lake Branch macroinvertebrate community in 2012.

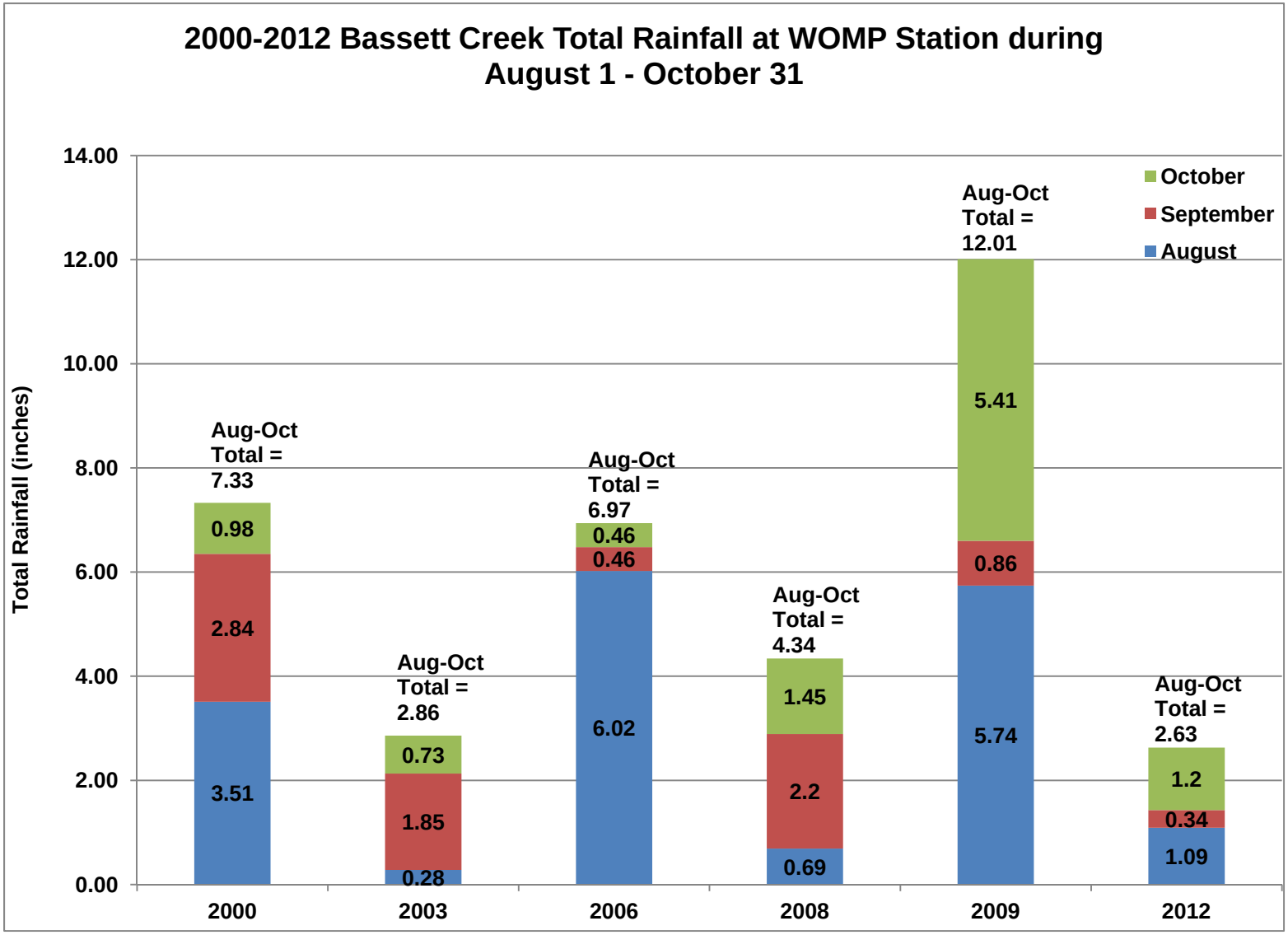


Figure 2. 2000-2012 Bassett Creek Total Rainfall at WOMP Station during August 1-October 31

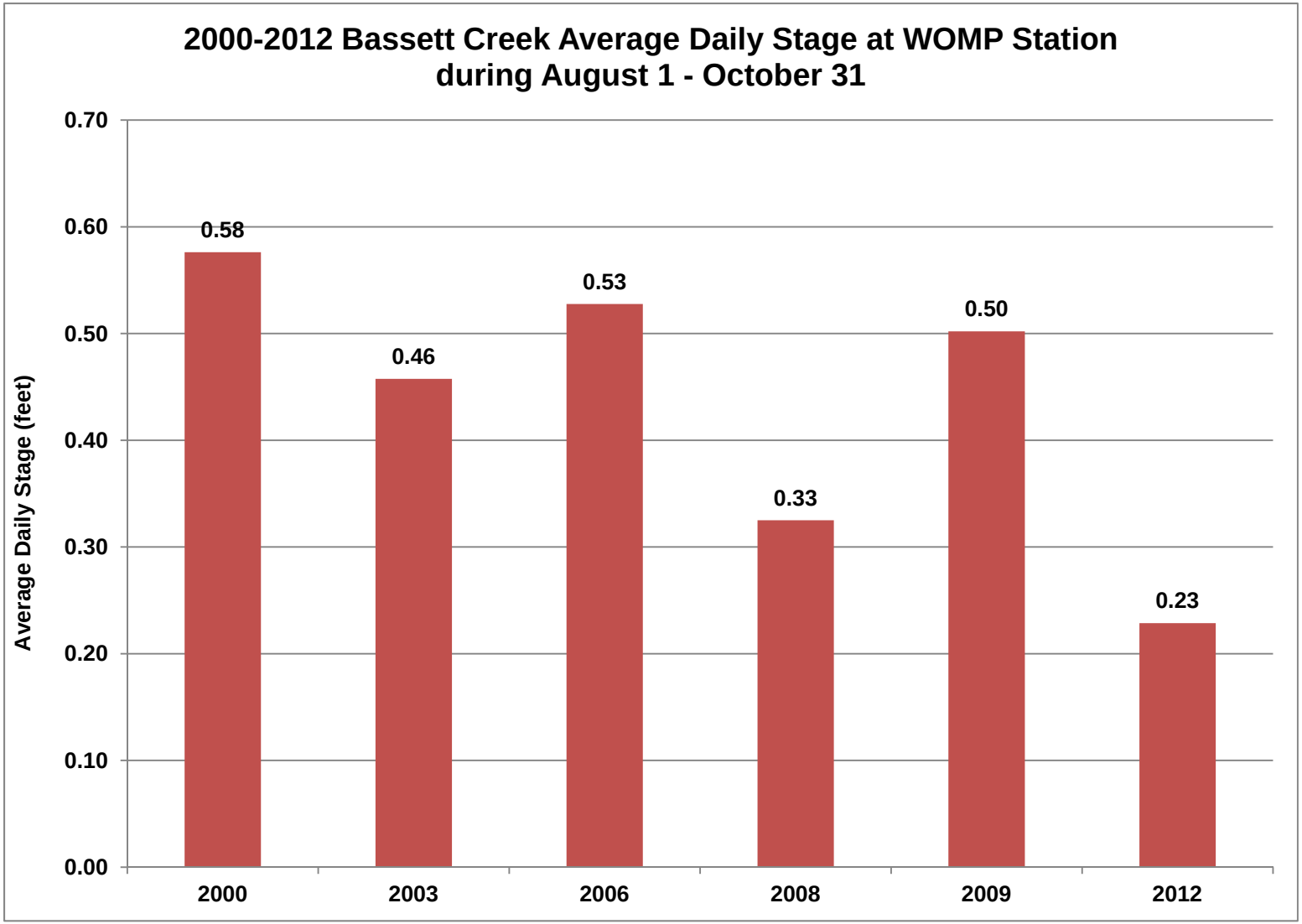


Figure 3. 2000-2012 Bassett Creek Average Daily Stage at WOMP Station during August 1-October 31

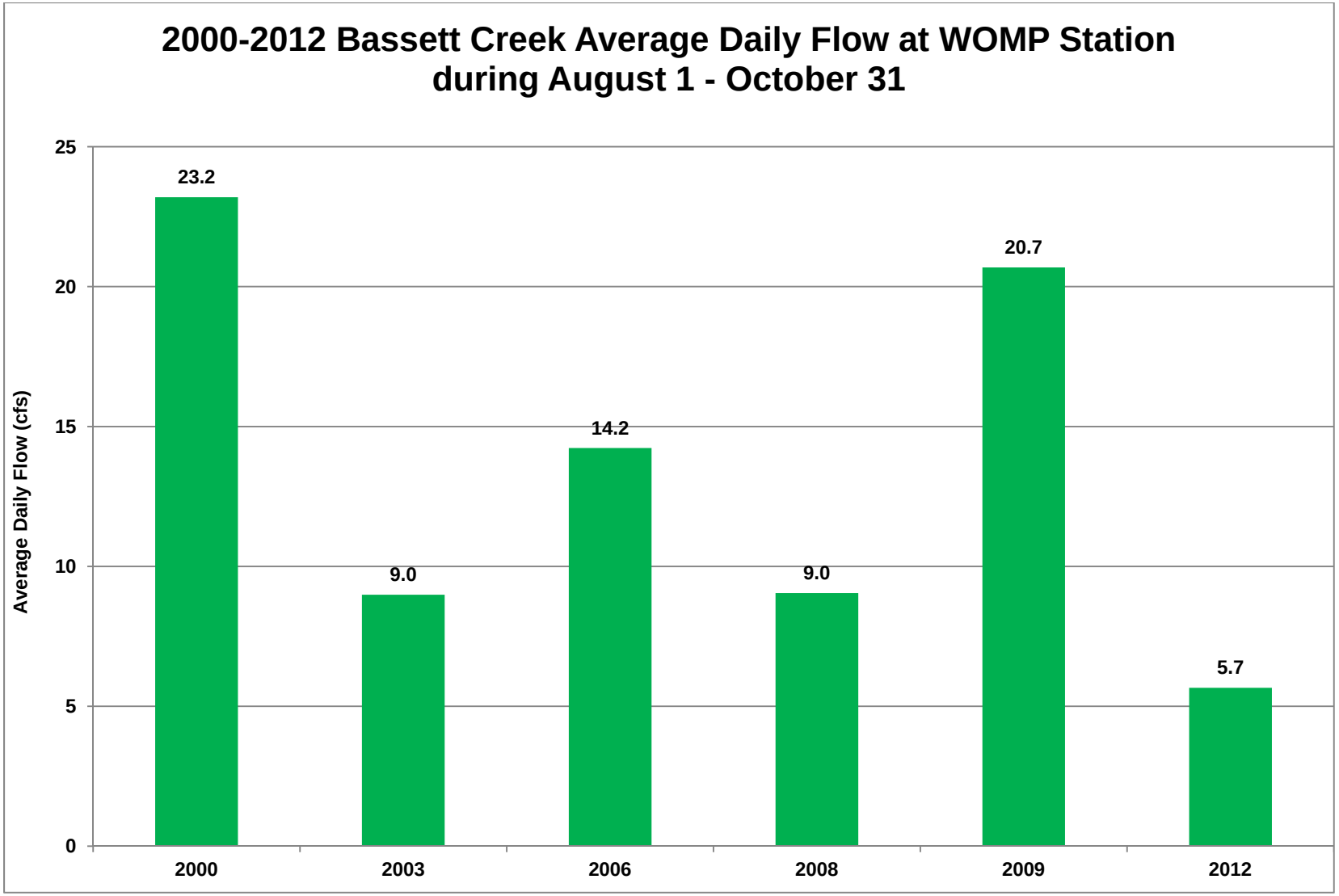


Figure 4. 2000-2012 Bassett Creek Average Daily Flow at WOMP Station during August 1-October 31

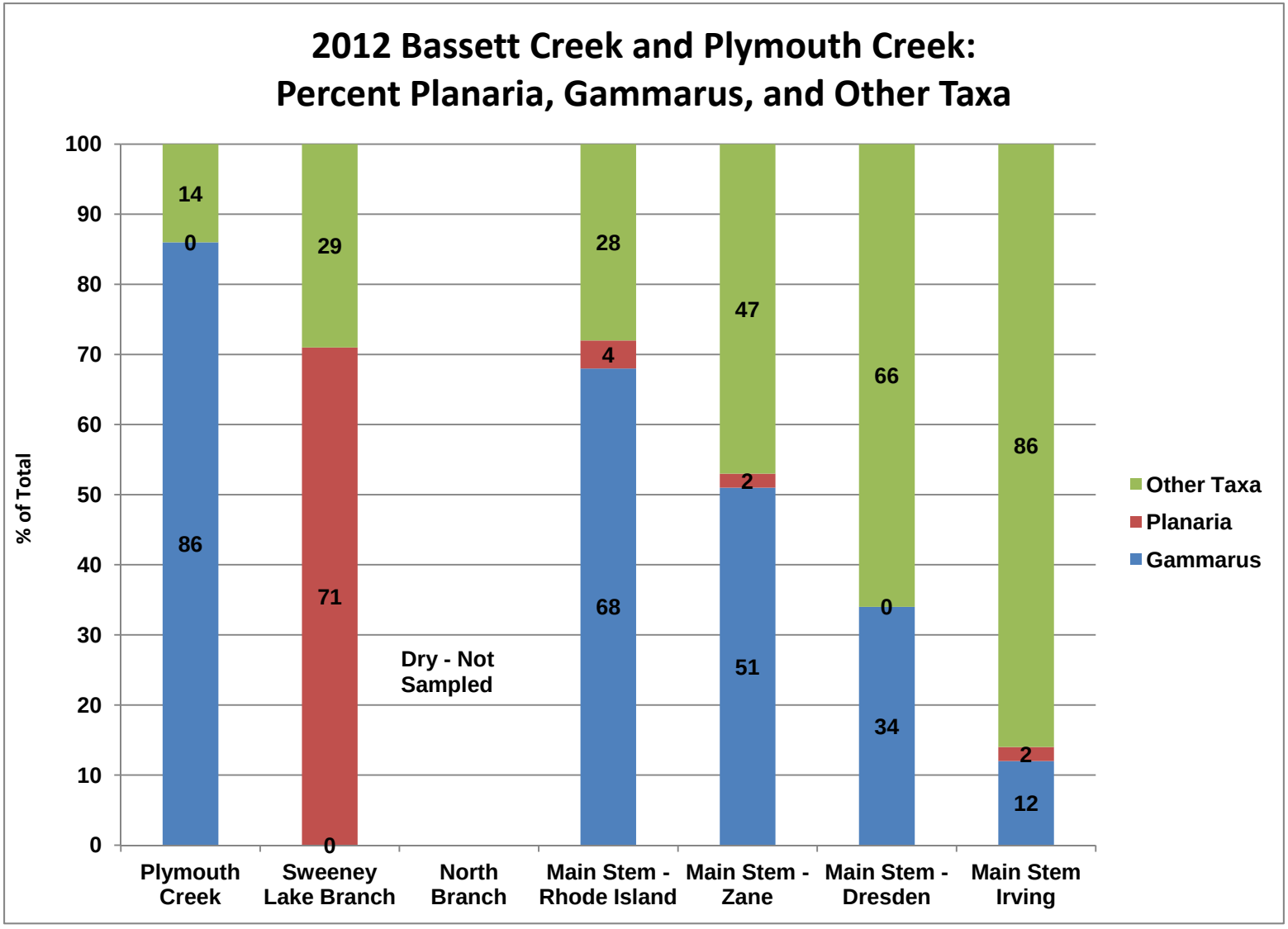


Figure 5. 2012 Bassett Creek and Plymouth Creek: Percent Planaria, Gammarus, and Other Taxa

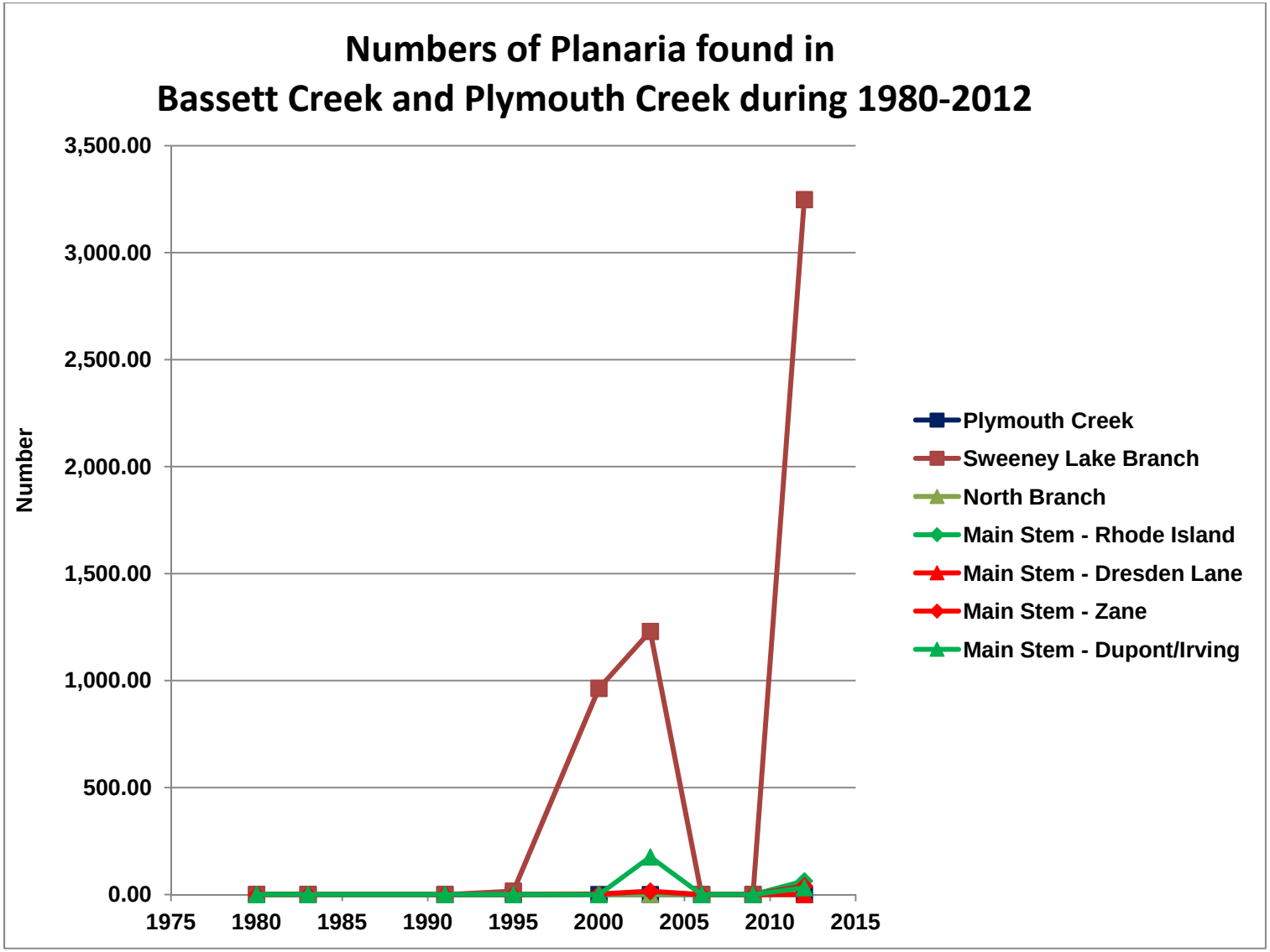


Figure 6. Numbers of Planaria found in Bassett Creek and Plymouth Creek during 1980-2012

4.1.2 Plymouth Creek

In Plymouth Creek, the 2012 macroinvertebrate community was dominated by *Gammarus*, a small crustacean that comprised 86 percent of the total number of macroinvertebrates found in the stream (Figure 5). *Gammarus* lives on the stream bottom and can thrive in shallow waters and low-flow conditions. It requires relatively clean water to survive (Gerhardt 2011; Maltby 1994). *Gammarus* dominance has not been observed previously in Plymouth Creek (Figure 7). The large number of *Gammarus* observed in 2012 is attributed to drought conditions which created ideal conditions and favored dominance by this species. **The dominance of *Gammarus* in Plymouth Creek indicates the stream was relatively clean during 2012.**

***Gammarus*, pictured above, dominated Plymouth Creek and the upstream reaches of the Main Stem of Bassett Creek invertebrate communities in 2012.**

4.1.3 Main Stem of Bassett Creek

Gammarus also dominated the upstream reaches of the Main Stem of Bassett Creek, the portion of the creek most impacted by the 2012 drought. In the Main Stem of Bassett Creek, the percent of the macroinvertebrate community comprised by *Gammarus* was highest at the most upstream location and gradually diminished from upstream to downstream locations. The percent of the total number of macroinvertebrates comprised by *Gammarus* was 68 percent at Rhode Island Avenue, 51 percent at Zane Avenue, 34 percent at Dresden Lane, and 12 percent at Irving Avenue (Figure 5) (locations shown in Figure 1). The data show that as flow increased from upstream to downstream Bassett Creek locations, the presence of *Gammarus* decreased while the presence of other macroinvertebrates increased. *Gammarus* dominance has not been observed previously in the Main Stem of Bassett Creek (Figure 7). The large number of *Gammarus* observed in 2012 is attributed to drought conditions which created ideal conditions and favored dominance by this species. **The dominance of *Gammarus* in the upstream reaches of Bassett Creek indicates the stream was relatively clean during 2012.**

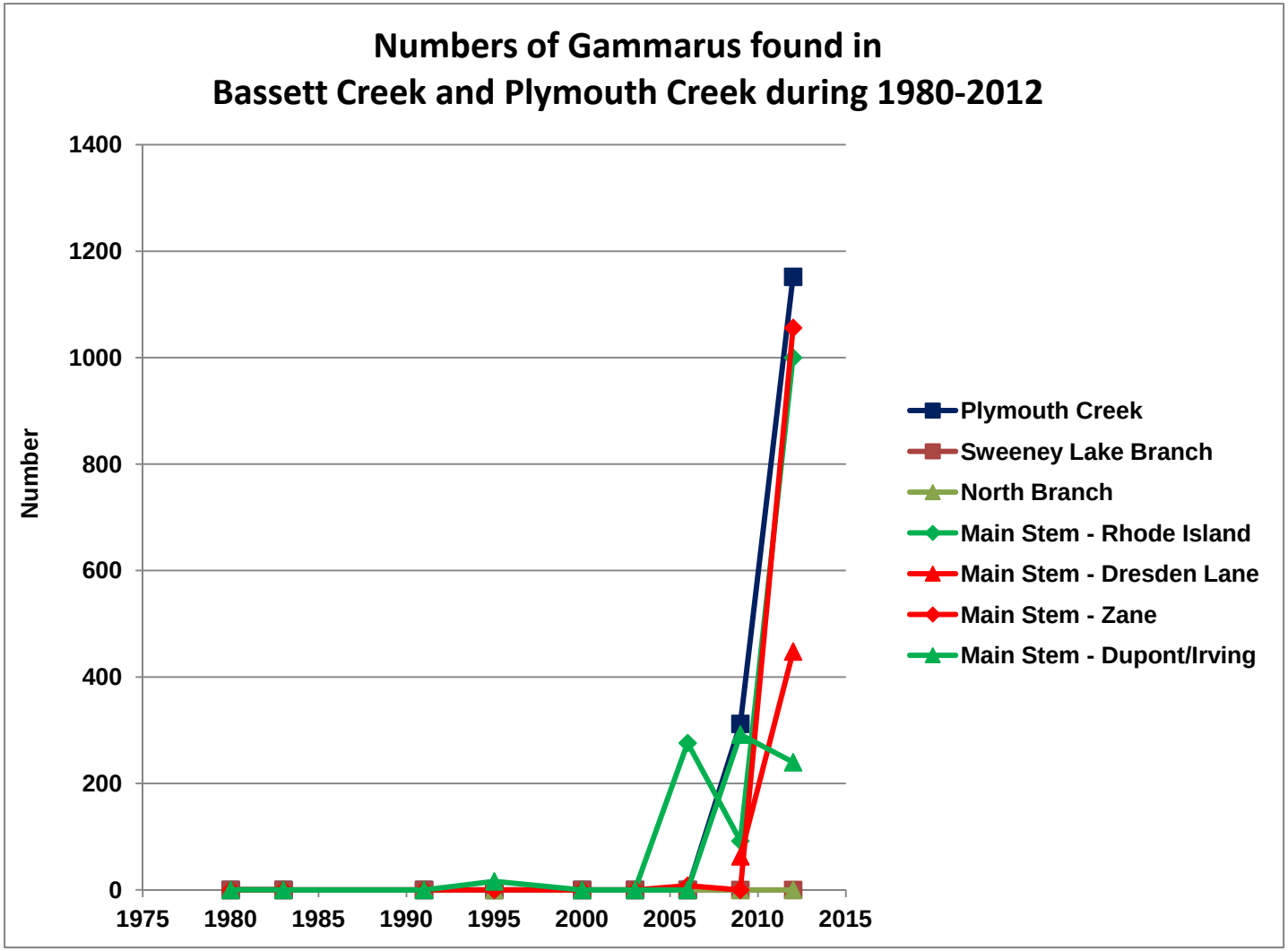


Figure 7. Numbers of Gammarus found in Bassett Creek and Plymouth Creek during 1980-2012

4.1.4 North Branch of Bassett Creek

The sampling location was dry due to drought conditions. Thus, monitoring was not performed.

4.1.5 Drought Impacts on ICI

Because *Gammarus* and Planaria are able to thrive under unfavorable flow conditions, the ICI tolerance scores for these organisms are lower than ICI scores of species that are more sensitive to poor habitat conditions whether from low flow or poor water quality. On a scale of 0 to 60, with increasing scores indicating increased sensitivity to unfavorable water quality and/or flow conditions, *Gammarus* has an ICI score of 16 and Planaria has an ICI score of 23. The drought provided ideal conditions for *Gammarus* and Planaria, resulting in high numbers. This reduced ICI scores in Plymouth Creek, Sweeney Lake Branch, and the upstream reaches of Bassett Creek. However, as noted previously, literature suggests that both *Gammarus* and Planaria require relatively clean water to survive—indicating that despite the lowered ICI numbers, water quality in these areas is good.

The high numbers of *Gammarus* in 2012 lowered ICI scores in Plymouth Creek and the upstream reaches of the Main Stem of Bassett Creek below values observed in previous years. 2012 ICI scores from Plymouth Creek and the Main Stem locations at Rhode Island Avenue, east of Zane Avenue, and Dresden Lane ranged from 17 to 27 (Table 3) when *Gammarus* comprised 34 to 86 percent of the macroinvertebrate communities. 2008 and 2009 ICI scores from these same locations ranged from 29 to 32 when *Gammarus* comprised 21 to 22 percent of the macroinvertebrate community (Table 3) (Barr 2010).

Just as high numbers of *Gammarus* in Plymouth Creek and the upper reaches of Bassett Creek resulted in reductions in ICI scores during 2012, high numbers of Planaria in the Sweeney Lake Branch resulted in a reduced ICI score. The Sweeney Lake Branch had an ICI score of 25 in 2012 compared with scores of 29 to 39 in previous years (Table 2). Planaria comprised 71 percent of the macroinvertebrate community in 2012. In previous years, Planaria comprised from 0 to 62 percent of the macroinvertebrate community (Barr 1981; Barr 1984; Barr 1992; Barr 1996; Barr 2001; Barr 2004; Barr 2007; Barr 2010).

4.2 HBI and ICI

The HBI and ICI-based indices at each sample location for 1995 through 2012 are shown in Figure 8. In this figure, the HBI scale is on the left side and the ICI scale on the right. The indices are scaled to **indicate improving water quality with increasing bar height**. Figure 9 shows a graphical comparison of the HBI values at all stations since biomonitoring started in 1980. Water quality changes were evaluated using historical and current HBI data for Bassett and Plymouth Creeks. These results are summarized in Table 3. Water quality changes were determined to be statistically significant when the chronological differences in HBI values exceeded 0.84 (Narf et al. 1984).

The 2012 results for the HBI data shown on Table 3 and Figure 9 include:

- The 2012 HBI evaluation of the Main Stem of Bassett Creek indicates water quality was very good at the most upstream location, Rhode Island Avenue.
- The 2012 HBI evaluation indicates Plymouth Creek water quality was very good.
- The 2012 HBI evaluation indicates water quality was good at the Main Stem of Bassett Creek at Zane Avenue, Dresden Lane, and Irving Avenue.
- The 2012 HBI evaluation indicates the water quality of the Sweeney Lake Branch of Bassett Creek was fair.
- The water quality at the most upstream location of the Main Stem at Rhode Island Avenue showed a significant improvement (i.e., significant increase in oxygen concentrations) between 2008 and 2012 (1.00 HBI units). The improvement is likely due to 2012 reductions in stormwater runoff which reduced the quantity of oxygen-demanding materials added to the stream.
- Water quality changes between 2008-2009 and 2012 were not significant at Plymouth Creek and the Sweeney Lake Branch of Bassett Creek. Although not significant, the changes indicated an improvement in water quality (i.e., increased oxygen concentrations). This is likely due to 2012 reductions in stormwater runoff which reduced the quantity of oxygen-demanding materials added to the stream.
- The Main Stem at Zane Avenue was not sampled during 2008-2009. Water quality changes between 2006 and 2012 were not significant, but indicated an improvement (i.e., increased oxygen concentrations). This is likely due to 2012 reductions in stormwater runoff which reduced the quantity of oxygen-demanding materials added to the stream.
- Water quality changes between 2009 and 2012 at the Main Stem of Bassett Creek at Dresden Lane and Irving Avenue were not significant, but indicated degradation (i.e., decreased oxygen concentrations). This degradation, indicated by an increased HBI score, is likely due to the reduced flow that occurred during the 2012 drought (Figure 4). The data indicate that 2012 reductions in stormwater runoff, which reduced the quantity of oxygen-demanding

materials added to the stream, were offset by oxygen reductions resulting from reduced flow. The net change was a reduction in stream oxygen levels which resulted in a higher HBI score in 2012.

Table 3 Summary of HBI and ICI Based Indices for Stations Located on Bassett and Plymouth Creeks

	HBI[1]												ICI[2]								
STATION	**09/19/80**	**09/08/83**	**09/24/91**	**10/12/95**	**10/08/96**	**9/28/00**	**10/3/03**	**10/3/06**	**8/19/08**	**9/17/08**	**10/3/09**	**10/02/12**	**10/12/95**	**10/08/96**	**09/28/00**	**10/03/03**	**10/03/06**	**8/19/08**	**9/17/08**	**10/3/09**	**10/02/12**
Main Stem at Rhode Island Ave.	5.5	6.1	6.0	4.7	**NS**	5.2	5.3	5.0	5.2	**NS**	**NS**	4.2	39.1	**NS**	40.4	39.7	37.7	29.4	**NS**	**NS**	19.7
Change from previous sampling (HBI only)		0.62	-0.14	-1.3**		0.50	0.10	-0.35	0.26			-1.0**									
Main Stem east of Zane Ave.	5.5	6.0	5.2	5.8	5.0	5.2	5.2	5.1	**NS**	**NS**	**NS**	4.6	41.1	41.7	39.9	39.8	42.0	**NS**	**NS**	**NS**	27.4
Change from previous sampling (HBI only)		0.48	-0.78	0.58	-0.80	-0.6/0.2	0.00	-0.10				-0.49									
Main Stem at Dupont or Irving Ave.	6.0	6.5	6.5	5.1	**NS**	5.7	5.3	5.1	4.9	**NS**	**NS**	5.3	35.1	**NS**	38.6	35.9	38.1	39.3	**NS**	**NS**	37.9
Change from previous sampling (HBI only)		0.48	-0.02	-1.36**		0.60	-0.40	-0.20	-0.19			0.38									
North Branch immediately north of Main Stem or at 32nd & Adair	5.7	7.2	5.1	5.2	**NS**	4.6	5.4	5.5	5.6	**NS**	7.6	**NS**	34.5	**NS**	39.6	34.9	39.1	34.3	**NS**	22.5	**NS**
Change from previous sampling (HBI only)		1.52**	-2.1**	0.12		-0.60	0.82	0.10	0.06		2.04**										
Sweeney Lake Branch at Turner's Cross.	4.3	5.1	5.3	7.2	5.6	4.5	5.7	6.3	**NS**	**NS**	6.4	6.1	34.2	38.5	29.3	35.1	32.4	**NS**	**NS**	28.6	24.8
Change from previous sampling (HBI only)		0.84	0.18	1.88**	-1.60**	-2.7**/ -0.9**	1.20**	0.60			0.13	-0.33									
Plymouth Creek at Industrial Park Blvd.	**NS**	**NS**	6.3	5.5	**NS**	5.3	6.5	5.1	**NS**	**NS**	4.8	4.3	40.8	**NS**	40.8	33.9	41.2	**NS**	**NS**	32.4	16.7
Change from previous sampling (HBI only)				-0.76		-0.20	1.20**	-1.40**			-0.29	-0.56									
Main Stem at Dresden Lane	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	4.8	**NS**	5.4	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	29.1	**NS**	26.4
Change from previous sampling (HBI only)												0.61									

[1]HBI range = 0 (very high water quality) to 10 (severely polluted or significantly disturbed streams). The HBI is an average of species tolerance values and indicates the average water quality of the stream.

[2]ICI range = 0 (poor water quality) to 60 (excellent water quality. Like the HBI, it is an average of species tolerance values. The ICI indicates the average water quality of the stream. When compared to the HBI, the ICI provides a second opinion of the stream's water quality.

**** Indicates significant difference** from previous sample period; differences greater than **0.84 (positive= degradation)** or less than **-0.84 (negative=improvement)** are considered statistically significant.
NS Not Sampled

For the Main Stem east of Zane Avenue and Sweeney Lake Branch at Turner's Crossroad on 9/28/2000, **the first value** is the difference from 10/12/1995 and the second value is the difference from 10/8/1996.

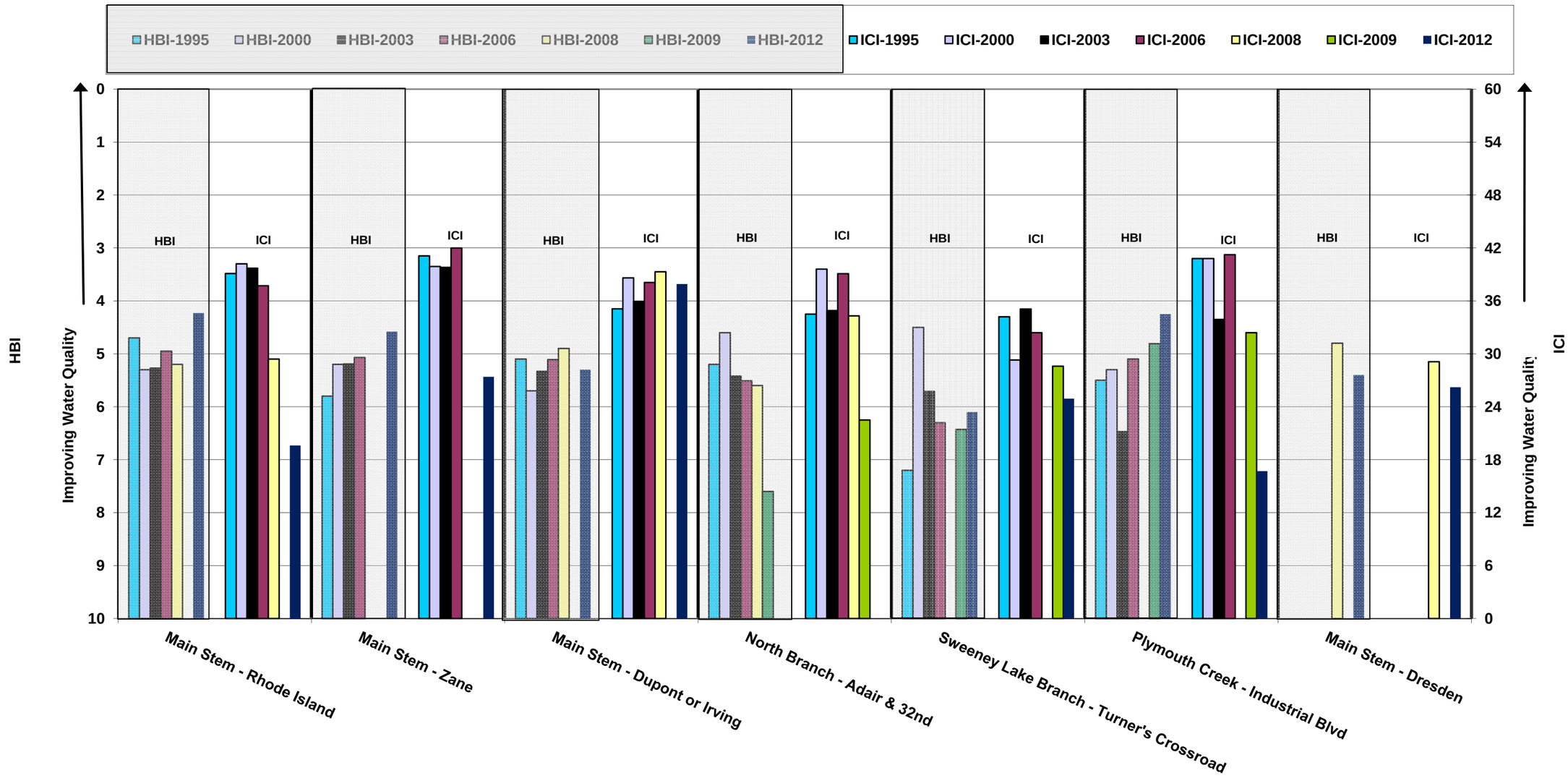


Figure 8. Summary of HBI and ICI Based Indices

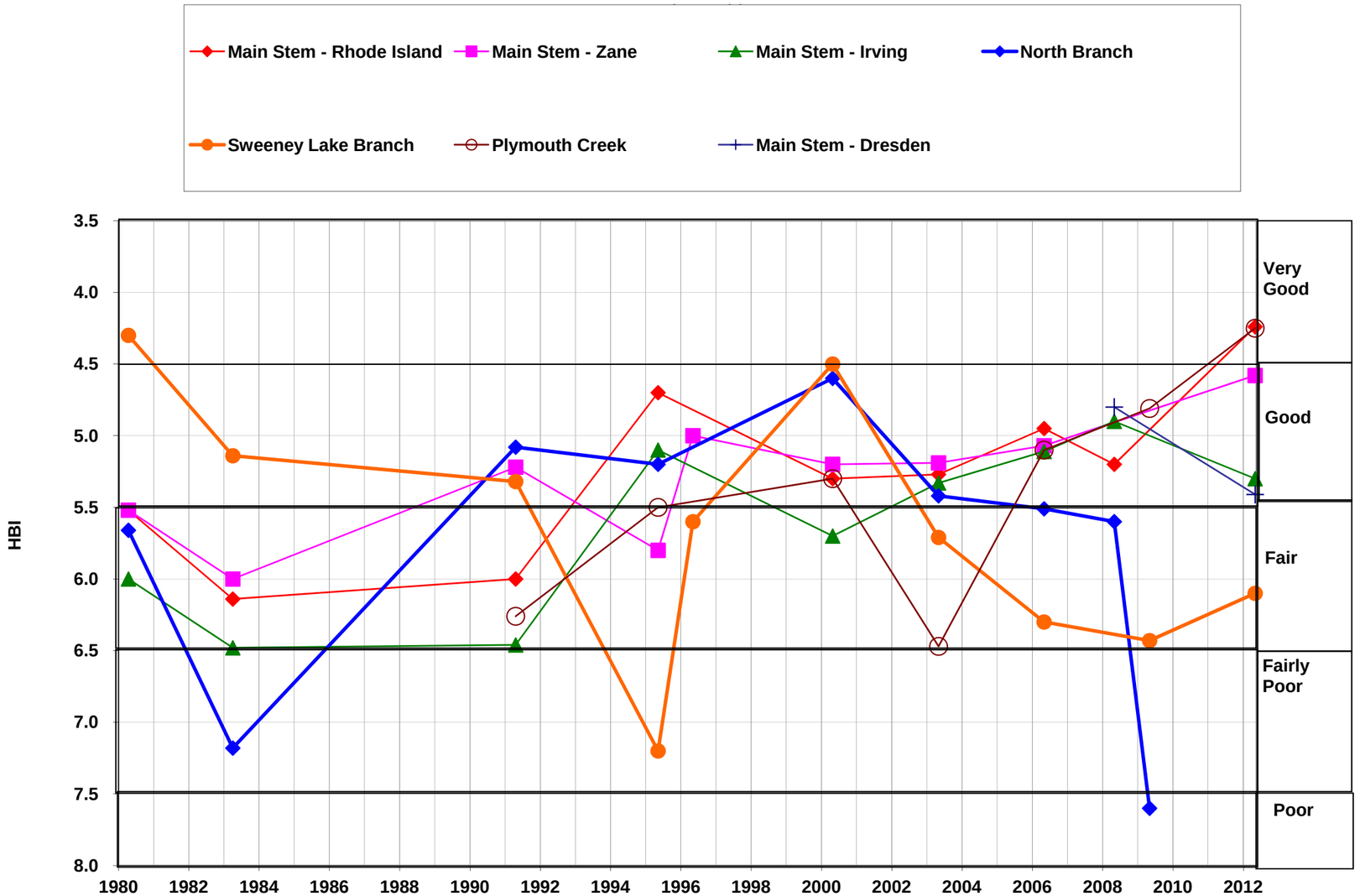


Figure 9. HBI Summary of Stream Water Quality from 1980-2012

5.0 Macroinvertebrate Index of Biological Integrity (MIBI)

The Minnesota Pollution Control Agency (MPCA) is developing a Macroinvertebrate Index of Biological Integrity (MIBI) to identify biologically impaired rivers and streams. Because of the variations among Minnesota's watercourses—geographical location (northern or southern), size (rivers and streams), and water temperature (cold or warm)—the MPCA has developed eight draft MIBIs that are subject to change during the finalization process. Geographic locations of the eight MIBIs are shown in Figure 10. The MIBI applicable to Plymouth Creek and Bassett Creek is Class 5 – Southern Streams (Riffle/Run Habitats), shown in Table 4. This MIBI uses seven metrics to determine the stream MIBI score:

- Taxa (organism types such as family or species) richness of climbers—the number of organism types (family, species) that typically climb on aquatic plants and sometimes rocks
- Relative percentage of taxa adapted to cling to substrate in swift-flowing waters
- Relative abundance (%) of dominant five taxa in sample
- HBI_MN—a MPCA-modified version of the original HBI
- Relative percentage of insect taxa
- Taxa richness of Odonata—the number of organism types (family, species) that are Odonata (dragonflies and damselflies)
- Taxa richness of Plecoptera—the number of organism types (family, species) that are Plecoptera (stoneflies)
- Relative percentage of taxa with HBI_MN tolerance values equal to or greater than 6
- Taxa richness of Trichoptera—the number of organism types (family, species) that are Trichoptera (caddisflies)

The MPCA is currently developing a MIBI generation tool that will allow stakeholders, such as the Bassett Creek Watershed Management Commission (BCWMC), to generate MIBI scores. When available, the BCWMC can apply the tool to all or some of the macroinvertebrate data collected to date. Once MIBI scores are computed for Plymouth Creek and Bassett Creek, the BCWMC will know whether the streams meet the MPCA impairment standard. According to Table 4, the impairment threshold for Bassett and Plymouth Creek is a MIBI score of 35.9.

Table 4 Invertebrate Class 5 - Southern Streams (Riffle/Run Habitats)

Classification Criteria:

Sites within this class are representative of the Eastern Broadleaf forest, Prairie Parklands, and Tall Aspen Parklands ecological provinces, as well as streams in HUC 07030005. Sites included in this class have watershed areas less than 500 square miles.

Examples:

Ashley Creek, Beaver Creek, Cedar River, Chippewa River, Clearwater River, Cobb River, Deer Creek, Elk River, , Le Sueur River, Okabena Creek, Otter Creek, Pomme de Terre River, Redwood River, Rice Creek, Rock River, Root River, Wells Creek, Yellow Medicine River, and Zumbro River.

Biocriteria:

Upper C.L. 48.5

Threshold 35.9

Lower C.L. 23.3

Metric Name	Category	Response	Metric Description
ClimberCh	Habitat	Decrease	Taxa richness of climbers
ClingerChTxPct	Habitat	Decrease	Relative percentage of taxa adapted to cling to substrate in swift flowing water
DomFiveChPct	Composition	Increase	Relative abundance (%) of dominant five taxa in subsample (chironomid genera treated individually)
HBI_MN	Tolerance	Increase	A measure of pollution based on tolerance values assigned to each individual taxon, developed by Chirhart
InsectTxPct	Composition	Decrease	Relative percentage of insect taxa
Odonata	Richness	Decrease	Taxa richness of Odonata
Plecoptera	Richness	Decrease	Taxa richness of Plecoptera
PredatorCh	Trophic	Decrease	Taxa richness of predators
Tolerant2ChTxPct	Tolerance	Increase	Relative percentage of taxa with tolerance values equal to or greater than 6, using MN TVs
Trichoptera	Richness	Decrease	Taxa richness of Trichoptera

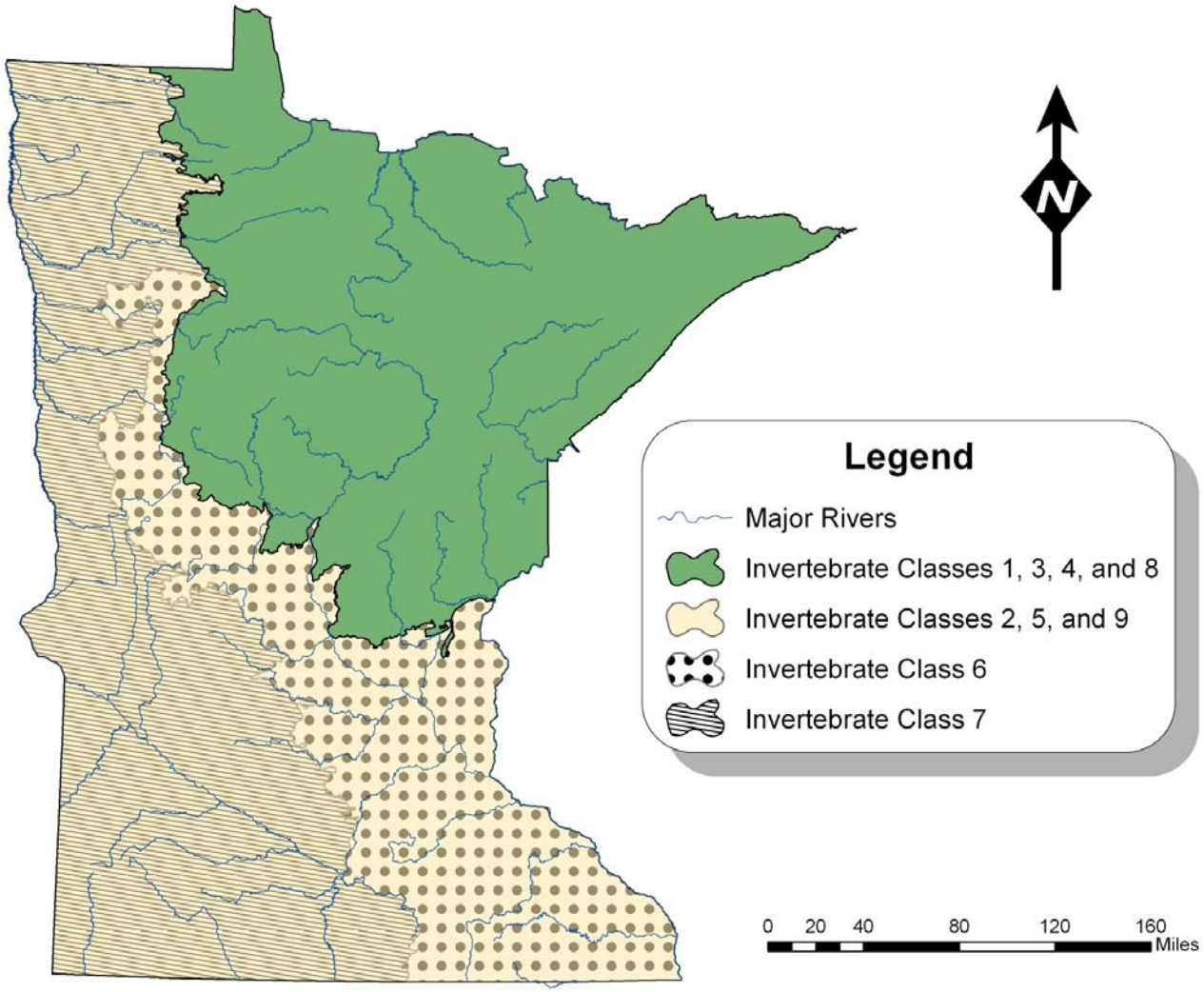


Figure 10.Locations of Invertebrate Classes for MIBI

6.0 Recommendations

Based on the results of the 2012 monitoring program, the Commissioners will consider:

- Continuing its management efforts of Bassett Creek and Plymouth Creek, including installation of BMPs to protect and, if possible, to improve the water quality of the stream, as opportunities become available.
- Sampling all stations again in 3 to 5 years to maintain the long-term monitoring record and assess stream water quality changes.
- Continuing flow and water quality monitoring from the Watershed Outlet Monitoring Program (WOMP) sample station located on the Main Stem at Irving Avenue to evaluate physical and chemical parameters impacting the stream's biota.
- Using the Macroinvertebrate Index of Biological Integrity (MIBI) when finalized by the MPCA to assess the biological community of Bassett Creek and Plymouth Creek; the MIBI will replace the use of the HBI and ICI used from 1980 to 2012.
- Applying the MIBI (when finalized) to all or some of the macroinvertebrate data collected from Bassett Creek and Plymouth Creek from 1980 to 2012 to determine whether the streams have met the MPCA impairment standard.

7.0 References

Barr Engineering Company. 1981. A Biotic Index Evaluation of Bassett Creek and Plymouth Creek: 1980. Prepared for Bassett Creek Flood Control Commission.

Barr Engineering Company. 1984. A Biotic Index Evaluation of Bassett Creek and Plymouth Creek: 1983. Prepared for Bassett Creek Flood Control Commission.

Barr Engineering Company. 1992. A Biotic Index Evaluation of Bassett Creek and Plymouth Creek during 1991. Prepared for Bassett Creek Watershed Management Commission.

Barr Engineering Company. 1996. A Biotic Index Evaluation of Bassett Creek and Plymouth Creek: 1995. Prepared for Bassett Creek Watershed Management Commission.

Barr Engineering Company. 2001. A Biotic Index Evaluation of Bassett Creek and Plymouth Creek: 2000. Prepared for Bassett Creek Watershed Management Commission.

Barr Engineering Company. 2004. A Biotic Index Evaluation of Bassett Creek and Plymouth Creek: 2003. Prepared for Bassett Creek Watershed Management Commission.

Barr Engineering Company. 2007. A Biotic Index Evaluation of Bassett Creek and Plymouth Creek: 2006. Prepared for Bassett Creek Watershed Management Commission.

Barr Engineering Company. 2010. A Biotic Index Evaluation of Bassett Creek and Plymouth Creek: 2008-2009. Prepared for Bassett Creek Watershed Management Commission.

DeShon, J.E. 1995. Development and Application of the Invertebrate Community Index (ICI). Pages 217-243 in W.S. Davis and T.P. Simon (editors*). Biological Assessment and Criteria, Tools for Water Resource Planning and Decision Making*. Lewis Publishers, Boca Raton, Florida.

Gerhardt, Almut. 2011. GamTox: *A Low-Cost Multimetric Ecotoxicity Test with Gammarus spp. For In and ExSitu Application*. International Journal of Zoology, Volume 2011, Article ID 574536, 7 pages.

Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. *The Great Lakes Entomologist.* 20(1):31-39.

Hilsenhoff, W.L. 1982. *Using a biotic index to evaluate water quality in streams*. Technical Bulletin Wisconsin Department of Natural Resources 132. 22 pages.

Hyman, L.HY. 1951. The Invertebrates: *Platyhelminthes* and *Rhynchocoela* the *acoelomate Bilateria*. McGraw-Hill, London and New York.

Maltby, L. 1994. Stress, Shredders, and Streams: Using Energetics to Assess Water Quality. In: Sutcliffe, D.W. (ed), *Water Quality and Stress Indicators in Marine and Freshwater Systems: Linking Levels of Organisation*. Amblesidae, UK. Freshwater Biological Association, pp. 98-110 (FBA Special Publications, 4).

Metropolitan Council Environmental Services. 2012. WOMP Data from the Bassett Creek Irving Avenue Location for 2000 through 2011.

Metropolitan Council Environmental Services. 2013. WOMP Data from the Bassett Creek Irving Avenue Location for 2012.

Narf, R.P., E.L. Lange and R.C. Wildman. 1984. *Statistical procedures for applying Hilsenhoff's Biotic Index*. Journal of Freshwater Ecology. 2:441-448.

National Weather Service. 2012. 2012 WFO Monthly/Daily Climate Data. Downloaded on 1/28/2013 from http://climate.umn.edu/doc_prelim_lcd_msp.htm

Appendices

Appendix A

Bassett Creek and Plymouth Creek Macroinvertebrate Data

2012 Bassett Creek and Plymouth Creek Data Macroinvertebrate Data
For insects, all numbers refer to larvae unless otherwise noted.

Taxa	**Plymouth Creek 2 Oct. 2012** (Number in sample extrap-olated from subsampling)	**Main Stem, Irving Ave. 2 Oct. 2012** (Number in sample extrap-olated from subsampling)	**Main Stem, Dresden Ave. 2 Oct. 2012** (Number in sample extrap-olated from subsampling)	**Main Stem, Zane Ave. 2 Oct. 2012** (Number in sample extrap-olated from subsampling)	**Sweeney Lake Branch 3 Oct. 2012** (Number in sample extrap-olated from subsampling)	**Main Stem, Rhode Island 2 Oct. 2012** (Number in sample extrap-olated from subsampling)	**North Branch 32nd and Adair Avenue 2 Oct. 2012**
INSECTA							**DRY**
Ephemeroptera: Mayflies							**No Samples Collected**
Baetidae							
Baetis flavistriga		16	56	200			
Baetis undet. (small or broken)			4			8	
Caenidae							
Caenis			4				
Maccaffertium		16					
Stenacron		376	76	40			
Odonata: Dragonflies, damselflies							
Calopterygidae							
Calopteryx		1	10	2			
Coenagrionidae							
Ishnura	12		84		8		
Enallagma			48		8		
Undet. immature Coenagrionidae			16			8	
Hemiptera: True Bugs							
Belostomatidae							
Belostoma	4		2				
Corixidae							
Hesperocorixa			4				
Undetermined			24				
Gerridae							
Rheumatobates adult			8		8		
Nepidae							
Ranatra	1						
Pleidae							
Neoplea			16				
Trichoptera: Caddisflies							
Hydropsychidae							
Cheumatopsyche	4	440	92	136	320		
Hydropsyche alhydra		16	12				
Hydropsyche betteni		16	12	56	16	24	

2012 Bassett Creek and Plymouth Creek Data Macroinvertebrate Data
For insects, all numbers refer to larvae unless otherwise noted.

Taxa	Plymouth Creek 2 Oct. 2012 (Number in sample extrap-olated from subsampling)	Main Stem, Irving Ave. 2 Oct. 2012 (Number in sample extrap-olated from subsampling)	Main Stem, Dresden Ave. 2 Oct. 2012 (Number in sample extrap-olated from subsampling)	Main Stem, Zane Ave. 2 Oct. 2012 (Number in sample extrap-olated from subsampling)	Sweeney Lake Branch 3 Oct. 2012 (Number in sample extrap-olated from subsampling)	Main Stem, Rhode Island 2 Oct. 2012 (Number in sample extrap-olated from subsampling)	North Branch 32nd and Adair Avenue 2 Oct. 2012
Hydropsyche sparna			4				
Undetermined (too small)				16			
Leptoceridae							
Nectopsyche			4	8			
Coleoptera: Beetles							
Dytiscidae							
Liodessus adults	4		8		8		
Elmidae							
Dubiraphia larvae						8	
Macronychus		8					
Stenelmis larvae		584	32	216		32	
Stenelmis adults		96	28	88			
Hydrophilidae							
Tropisternus adults	2						
Scirtidae							
Scirtes					32		
Diptera: True Flies							
Tipulidae							
Limonia	10				8		
Tipula		1				28	
Chironomidae							
Chironomus			8				
Dicrotendipes	8		12		8		
Glyptotendipes					136		
Microtendipes			16			8	
Parachironomus					8		
Phaenopsectra			8			8	
Polypedilum	4		28	8	240	16	
Stenochironomus						8	
Stictochironomus			4				
Tanytarsini							
Tanytarsus			16				
Corynocera	4						
Rheotanytarsus		16		8		24	
Orthocladiinae							

2012 Bassett Creek and Plymouth Creek Data Macroinvertebrate Data
For insects, all numbers refer to larvae unless otherwise noted.

Taxa	Plymouth Creek 2 Oct. 2012 (Number in sample extrap-olated from subsampling)	Main Stem, Irving Ave. 2 Oct. 2012 (Number in sample extrap-olated from subsampling)	Main Stem, Dresden Ave. 2 Oct. 2012 (Number in sample extrap-olated from subsampling)	Main Stem, Zane Ave. 2 Oct. 2012 (Number in sample extrap-olated from subsampling)	Sweeney Lake Branch 3 Oct. 2012 (Number in sample extrap-olated from subsampling)	Main Stem, Rhode Island 2 Oct. 2012 (Number in sample extrap-olated from subsampling)	North Branch 32nd and Adair Avenue 2 Oct. 2012
Corynoneura			12				
Cricotopus			4	8			
Hydrobaenus	4						
Rheocricotopus			4	8			
Tvetenia		8		8			
Undetermined			4	8			
Tanypodiinae							
Conchapelopia					8		
Culicidae							
Anopheles			32		8		
Undetermined larva			4				
Undetermined pupa			16				
Simulium sp.		40		144	224	28	
Athericidae							
Atherix		16	4	8	16	8	
Undet. Higher Diptera puparium			8				
ANNELIDA: Segmented Worms							
Oligochaetes: Aquatic earthworms							
Undet. Oligochaetes		16	8		24	8	
Hirudinea: Leeches							
Erpobdella punctata (probable)	2	1		2	32		
Erpobdella punctata					1	2	
Helobdella stagnalis			2		16		
Placobdella					8		
Undetermined small leech	4					4	
MOLLUSCA: Clams and Snails							
Gastropoda: Snails							
Campeloma			1				
Fossaria	4						
Ferrissia	4		52	8			
Gyraullus	24						
Helisoma	12						
Physa	32		80		80		
Undet. Operculate snail			1				

2012 Bassett Creek and Plymouth Creek Data Macroinvertebrate Data
For insects, all numbers refer to larvae unless otherwise noted.

Taxa	**Plymouth Creek 2 Oct. 2012** (Number in sample extrap-olated from subsampling)	**Main Stem, Irving Ave. 2 Oct. 2012** (Number in sample extrap-olated from subsampling)	**Main Stem, Dresden Ave. 2 Oct. 2012** (Number in sample extrap-olated from subsampling)	**Main Stem, Zane Ave. 2 Oct. 2012** (Number in sample extrap-olated from subsampling)	**Sweeney Lake Branch 3 Oct. 2012** (Number in sample extrap-olated from subsampling)	**Main Stem, Rhode Island 2 Oct. 2012** (Number in sample extrap-olated from subsampling)	**North Branch 32nd and Adair Avenue 2 Oct. 2012**
Pelecypoda: Clams							
Undet large clam		1	2				
Pisidium			4			16	
Sphaerium			5	12		80	
PORIFERA (sponges)							
Undet. sponge colony fragments		12			4	88	
TURBELLARIA: Flatworms							
Dugesia-type planarian		32		40	3248	64	
BRYOZOA: Moss animalcules							
Undet. Colonies or fragments					numerous		
CRUSTACEA							
Amphipoda							
Talitridae: Hyalella	40				80		
Gammaridae: Gammarus	1152	240	448	1056		1000	
Decapoda: crayfish							
Orconectes	1	1	1			1	
ISOPODA: Sowbugs							
Caecidotea			8				
Total Organisms	**1,332**	**1,953**	**1,336**	**2,080**	**4,549**	**1,471**	

Appendix B

Bassett Creek and Plymouth Creek Biotic Index Calculations

2012 Bassett Creek and Plymouth Creek Invertebrate Study Results
BIOTIC INDEX CALCULATIONS FOR HILSENHOFF BIOTIC INDEX (HBI) AND INVERTEBRATE COMMUNITY INDEX (ICI)
Samples collected on October 2-3, 2012

						10/02/12					Dry	10/02/12				
			Station:	Tolerance Values		Plymouth Creek - Industrial Blvd					North Branch: 32nd and Adair	Main Stem: Zane Ave.				
Taxa	Taxa	Taxa		HBI (10-0)	ICI (0-60)	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum	No. Speci-mens	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum
INSECTA																
	Coleoptera															
		Elmidae		4												
			Stenelmis (adults)	5	41.7	0					0	88	88	440	88	3,670
			Stenelmis (larvae)	5	41.7	0					0	216	216	1,080	216	9,007
	Diptera															
		Chironomidae		6												
			Chironominae		11.4											
			Dicrotendipes	8	26.6	8	8	64	8	213						
			Polypedilum sp.	6	30.4	4	4	24	4	121	0	8	8	48	8	243
			Corynocera	7		4	4	28								
			Hydrobaenus	8		4	4	32								
			Rheotanytarsus	6	39.9	0					0	8	8	48	8	319
		Orthocladiinae														
			Cricoptopus (Cricotopus)	7	34.4	0					0	8	8	56	8	275
			Rheocricotopus	6	30.4	0					0	8	8	48	8	243
			Tvetenia	5	46.4							8	8	40	8	371
			Undetermined orthoclad	6	36.6	0					0	8	8	46	8	293
		Athericidae														
			Atherix	2	41.3	0					0	8	8	16	8	330
		Simuliidae		6	31.3											
			Simulium sp.	7	31.3							144	144	1,008	144	4,507
		Tipulidae														
			Limonia	6		6	10	60								
	Ephemeroptera															
		Baetidae		4												
			Baetis flavistriga (nymphs)	4	42.6	0					0	200	200	800	200	8,520
		Heptageniidae		4												
			Stenacron (larvae)	7	41.1	0					0	40	40	280	40	1,644
	Odonata															
		Calopterygidae		5												
			Calopteryx	5	37.9	0					0	2	2	10	2	76

2012 Bassett Creek and Plymouth Creek Invertebrate Study Results
BIOTIC INDEX CALCULATIONS FOR HILSENHOFF BIOTIC INDEX (HBI) AND INVERTEBRATE COMMUNITY INDEX (ICI
Samples collected on October 2-3, 2012

						10/02/12					Dry	10/02/12				
			Station:	Tolerance Values		Plymouth Creek - Industrial Blvd					North Branch: 32nd and Adair	Main Stem: Zane Ave.				
Taxa	Taxa	Taxa		HBI (10-0)	ICI (0-60)	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum	No. Speci-mens	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum
		Coenagrionidae		9												
			Ischnura	9	na	12	12	108			0	0				
	Trichoptera															
		Hydropsychidae		4												
			Hydropsyche betteni (larvae)	6	43.4	0					0	56	56	336	56	2,432
			Undetermined Hydropsyche species, too small	4	43.4	0					0	16	16	64	16	695
			Cheumatopsyche (larvae)	5	42.5	4	4	20	4	170	0	136	136	680	136	5,780
		Leptoceridae														
			Nectopsyche	3	45.8							8	8	24	8	366
		Gammaridae		4												
			Gammarus	4	15.8	1,152	1,152	4,608	1,152	18,202	0	1,056	1,056	4,224	1,056	16,685
		Talitridae		8												
			Hyalella	8	26.2	40	40	320	40	1,048	0	0				
	Decapoda															
		Astacidae														
			Orconectes	na	30.9	1			1	31	0	0				
ANNELIDA																
	Hirudinea			0					0		0	0				
			Erpodbella punctata	na	8.8	2			2	18	0	2			2	18
MOLLUSCA																
	Gastropoda															
		Ancylidae														
			Ferrisia	na	28.7	4			4	115	0	8			8	230
		Lymnaeidae		0					0		0	0				
			Fossaria	na	44.6	4			4	178						
		Physidae														
			Physa	na	14.3	32			32	458	0	0				
		Planorbidae														
			Gyraulus	na	27.0	24			24	648						

2012 Bassett Creek and Plymouth Creek Invertebrate Study Results
BIOTIC INDEX CALCULATIONS FOR HILSENHOFF BIOTIC INDEX (HBI) AND INVERTEBRATE COMMUNITY INDEX (ICI)
Samples collected on October 2-3, 2012

Taxa	Taxa	Taxa	Station:	Tolerance Values		10/02/12 Plymouth Creek - Industrial Blvd					Dry North Branch: 32nd and Adair	10/02/12 Main Stem: Zane Ave.				
				HBI (10-0)	ICI (0-60)	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum	No. Speci-mens	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum
			Helisoma	na	24.0	12			12	288						
		Sphaeriidae		na	32.0											
			Sphaerium	na	31.5							12			12	378
TURBELLARIA				na	23.0											
		Tricladida														
			Dugesia type	na	23.0							40			40	920
					Total Specimens	1,332	1,238	5,264	1,287	21,489	0	2,080	2,018	9,248	2,080	57,002
								HBI		ICI				HBI		ICI
			Index Value					4.25		16.70				4.58		27.40
			Water Quality					Very Good						Good		

NOTES:

F: FAMILY TOLERANCE VALUE
S: SPECIES (SPP) TOLERANCE VALUE
G: GENUS TOLERANCE VALUE
A: AVERAGE OF MANY SPECIES

2012 Bassett Creek and Plymouth Creek Invertebrate Study Results
BIOTIC INDEX CALCULATIONS FOR HILSENHOFF BIOTIC INDEX (HBI) AND INVERTEBRATE COMMUNITY INDEX (ICI)
Samples collected on October 2-3, 2012

Taxa	Taxa	Taxa	Station:	Tolerance Values		10/02/12 Main Stem: Dresden Lane					10/02/12 Main Stem: Rhode Island Ave.				
				HBI (10-0)	ICI (0-60)	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum
INSECTA															
	Coleoptera														
		Elmidae		4											
			Dubiraphia (larvae)	6	31.5	0					8	8	48	8	252
			Stenelmis (adults)	5	41.7	28	28	140	28	1,168	0				
			Stenelmis (larvae)	5	41.7	32	32	160	32	1,334	32	32	160	32	1,334
	Diptera														
		Chironomidae		6											
			Chironominae		11.4										
			Chironomus	10	11.4	8	8	80	8	91	0				
			Dicrotendipes	8	26.6	12	12	96	12	319					
			Microtendipes	6	43.7	16	16	96	16	699	8	8	48	8	350
			Phaenopsectra spp.	7	32.7	8					8	8	56	8	261
			Polypedilum sp.	6	30.4	28	28	168	28	850	16	16	96	16	486
			Stenochironomus	5	38.2	8	8	40	8	306					
			Stictochironomus	9	36.1	4	4	36	4	144					
		Tanytarsini													
			Tanytarsus	6	38.9	16	16	96	16	622	0				
			Rheotanytarsus	6	39.9	0					24	24	144	24	958
		Orthocladiinae													
			Cricoptopus (Cricotopus)	7	34.4	4	4	28	4	138	0				
			Rheocricotopus	6	30.4	4	4	24	4	122	0				
			Corynneura	7	38.9	12	12	84	12	467	0				
			Undetermined orthoclad	6	36.6	4	4	23	4	146	0				
		Athericidae													
			Atherix	2	41.3	4	4	8	4	165	8	8	16	8	330
		Simuliidae		6	31.3										
			Simulium sp.(used value for Simulium vittatum)	7							28	28	196	28	876
		Tipulidae		3											
			Tipula (larva)	4	17.0	0					28	28	112	28	476
	Ephemeroptera														
		Baetidae		4											
			Baetis flavistriga (nymphs)	4	42.6	56	56	224	56	2,386	0				
			Unidentifiable Baetis (nymphs)	4	41.1	4	4	16	4	164	8	8	32	8	329
		Caenidae		7											
			Caenis (larvae)	7	41.6	4	4	28	4	166	0				
		Heptageniidae		4											

2012 Bassett Creek and Plymouth Creek Invertebrate Study Results
BIOTIC INDEX CALCULATIONS FOR HILSENHOFF BIOTIC INDEX (HBI) AND INVERTEBRATE COMMUNITY INDEX (ICI)
Samples collected on October 2-3, 2012

Taxa	Taxa	Taxa	Station:	Tolerance Values		10/02/12 Main Stem: Dresden Lane					10/02/12 Main Stem: Rhode Island Ave.				
				HBI (10-0)	ICI (0-60)	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum
			Stenacron (larvae)	7	41.1	76	76	532	76	3,124	0				
	Odonata														
		Calopterygidae		5											
			Calopteryx	5	37.9	10	10	50	10	379	0				
		Coenagrionidae		9											
			Enallagma (nymphs)	9	23.2	48	48	432	48	1,114	0				
			Ischnura	9	na	84	84	756			0				
			Undetermined, very small	9	23.2	16	16	144	16	371	8	8	72	8	186
	Trichoptera														
		Hydropsychidae		4											
			Hydropsyche betteni (larvae)	6	43.4	12	12	72	12	521	0				
			Hydropsyche sparna	4	40.6	4	4	16	4	162	0				
			Cheumatopsyche (larvae)	5	42.5	92	92	460	92	3,910	0				
		Leptoceridae													
			Nectopsyche	3	48.8	4	4	12	4	183					
CRUSTACEA															
	Amphipoda														
		Gammaridae		4											
			Gammarus	4	15.8	448	448	1,792	448	7,078	1,000	1,000	4,000	1,000	15,800
	Decapoda														
		Astacidae													
			Orconectes		30.9	1			1	31	1			1	31
	Isopoda														
		Asellidae													
			Caecidotea	na	18.8	8			8	150					
	Hirudinea			na	15.1	0					0				
			Helobdella stagnalis	na	10.8	2			2	22	0				
			Erpobdella punctata		8.8						2			2	18
	Gastropoda			na		1									
		Ancylidae													
			Ferrisia	na	28.7	52			52	1,492	0				
		Physidae		na											
			Physa	na	14.3	80			80	1,144	0				
	Pelecypoda														
		Sphaeriidae		na	32.0										
			Pisidium		32.5	4			4	130	16			16	520
			Sphaerium		31.5	5			5	158	80			80	2,520

2012 Bassett Creek and Plymouth Creek Invertebrate Study Results
BIOTIC INDEX CALCULATIONS FOR HILSENHOFF BIOTIC INDEX (HBI) AND INVERTEBRATE COMMUNITY INDEX (ICI)
Samples collected on October 2-3, 2012

Taxa	Taxa	Taxa	Station:	Tolerance Values		10/02/12 Main Stem: Dresden Lane					10/02/12 Main Stem: Rhode Island Ave.				
				HBI (10-0)	ICI (0-60)	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum
TURBELLARIA					23.0										
		Tricladida													
			Dugesia type	na	23.0						64			64	1,472
			Total Specimens			1,336	1,030	5,573	1,098	28,952	1,471	1,184	5,020	1,347	26,504
						Main Stem: Dresden Lane					Main Stem: Rhode Island Ave.				
								HBI		ICI			HBI		ICI
			Index Value					5.41		26.37			4.24		19.68
			Water Quality					Good					Very Good		

NOTES:
F: FAMILY TOLERANCE VALUE
S: SPECIES (SPP) TOLERANCE VALUE
G: GENUS TOLERANCE VALUE
A: AVERAGE OF MANY SPECIES

2012 Bassett Creek and Plymouth Creek Invertebrate Study Results
BIOTIC INDEX CALCULATIONS FOR HILSENHOFF BIOTIC INDEX (HBI) AND INVERTEBRATE COMMUNITY INDEX (ICI)
Samples collected on October 2-3, 2012

Taxa	Taxa	Taxa	Station:	Tolerance Values		10/02/12 Main Stem: Irving Avenue					10/03/12 Sweeney Lake Branch: Turner's Crossroad				
				HBI (10-0)	ICI (0-60)	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum
INSECTA															
	Coleoptera														
		Elmidae		4											
			Macronychus	4	42.8	8	8	32	8	342					
			Stenelmis (adults)	5	41.7	96	96	480	96	4,003	0				
			Stenelmis (larvae)	5	41.7	584	584	2,920	584	24,353	0				
	Diptera														
		Chironomidae		6											
			Chironominae	na	11.4										
			Dicrotendipes	8	na						8	8	64	8	213
			Parachironomus	10	35.2						8	8	80	8	282
			Glypotendipes	na	22.5						136			136	3,060
			Polypedilum sp.	6	30.4	0					240	240	1,440	240	7,289
		Tanytarsini													
			Rheotanytarsus	6	39.9	16	16	96	16	638	0				
		Orthocladiinae													
			Tvetenia	5		8	8	40	8	371	0				
		Tanypodiinae													
			Chonchapelopia	6	34.3						8	8	48	8	274
		Athericidae													
			Atherix	2	41.3	16	16	32	16	661	16	16	32	16	661
		Simuliidae		6	31.3										
			Simulium sp	7	31.3	40	40	280	40	1,252	224	224	1,568	224	7,011
		Tipulidae		3	na										
			Limonia	6	na						8	8	48		
			Tipula (larva)	4	17.0	1	1	4	1	17					
	Ephemeroptera														
		Baetidae		4	na										
			Baetis flavistriga (nymphs)	4	42.6	16	16	64	16	682	0				
		Heptageniidae		4											
			Stenacron (larvae)	7	41.1	376	376	2,632	376	15,454	0				
	Odonata														
		Calopterygidae		5											
			Calopteryx	5	37.9	1	1	5	1	38	0				
		Coenagrionidae		9											
			Enallagma (nymphs)	9	23.2	0					8	8	72	8	186
			Ischnura	9	na	0					8	8	72		

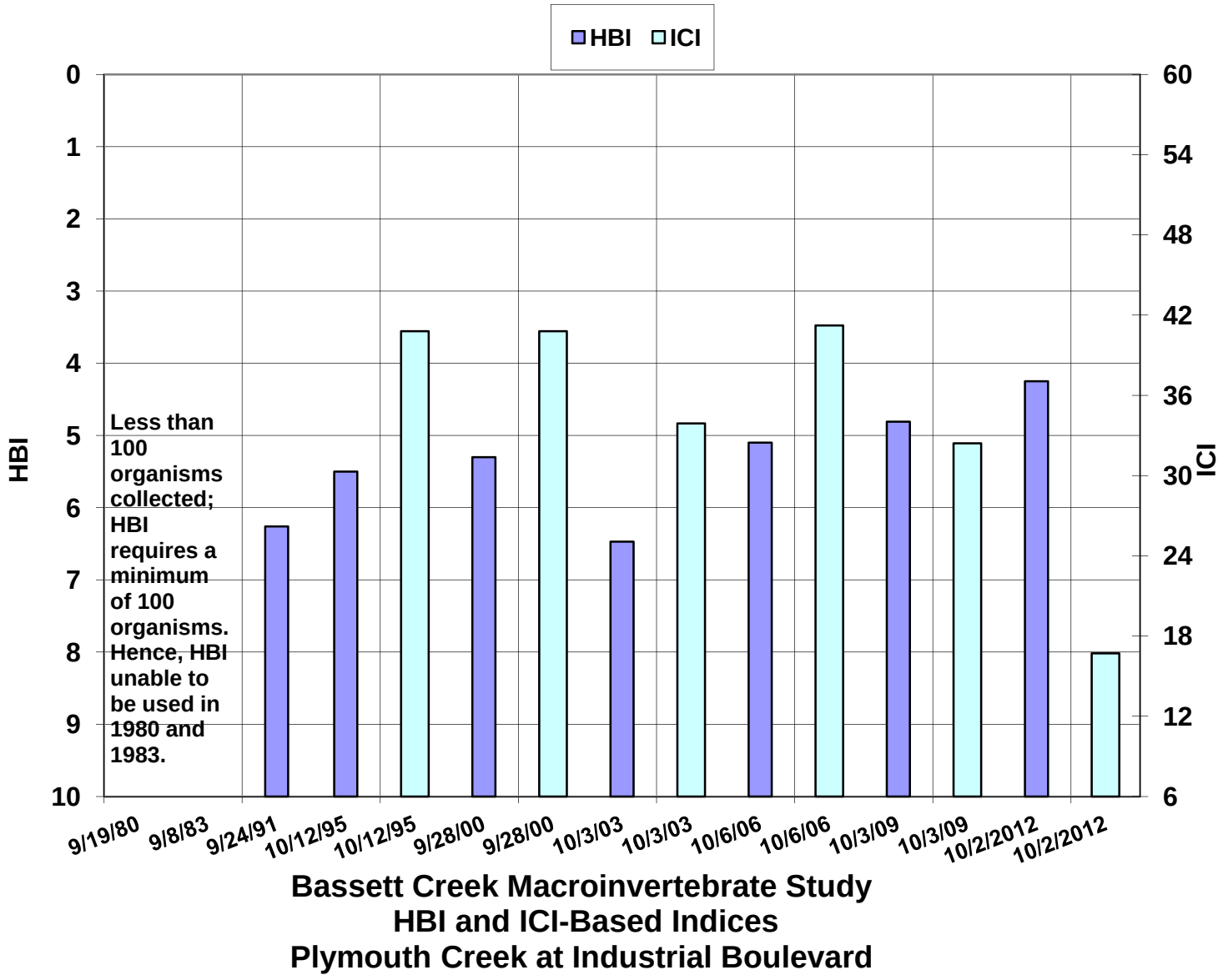
2012 Bassett Creek and Plymouth Creek Invertebrate Study Results
BIOTIC INDEX CALCULATIONS FOR HILSENHOFF BIOTIC INDEX (HBI) AND INVERTEBRATE COMMUNITY INDEX (ICI)
Samples collected on October 2-3, 2012

Taxa	Taxa	Taxa	Station:	Tolerance Values		10/02/12 Main Stem: Irving Avenue					10/03/12 Sweeney Lake Branch: Turner's Crossroad				
				HBI (10-0)	ICI (0-60)	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum	No. Speci-mens	No. Spec. w/ HBI Tol. Values	HBI Sum	No. Spec. w/ ICI Tol. Values	ICI Sum
	Trichoptera														
		Hydropsychidae		4	na										
			Hydropsyche betteni (larvae)	6	43.4	16	16	96	16	695	16	16	96	16	695
			Cheumatopsyche (larvae)	5	42.5	440	440	2,200	440	18,700	320	320	1,600	320	13,600
CRUSTACEA															
	Amphipoda														
		Gammaridae		4	na										
			Gammarus	4	15.8	240	240	960	240	3,792	0				
		Talitridae		8	na										
			Hyalella	8	26.2	0					80	80	640	80	2,096
	Decapoda														
		Astacidae													
			Orconectes		30.9	1			1	31	0				
ANNELIDA															
	Hirudinea			na	15.1	0					0				
			Helobdella stagnalis	na	10.8	0					16			16	173
			Erpodbella punctata	na	8.8	1			1	9	33			33	290
			Placobdella	na	27.1						8			8	217
MOLLUSCA															
	Gastropoda			na											
		Physidae		na											
			Physa	na	14.3	0					80			80	1,144
TURBELLARIA				na	23										
		Tricladida													
			Dugesia type	na	23.0	32			32	736	3,248			3,248	74,704
			Total Specimens			1,953	1,858	9,841	1,892	71,773	4,549	944	5,760	4,449	111,894
								HBI		ICI			HBI		ICI
			Index Value					5.30		37.94			6.10		25.15
			Water Quality					Good					Fair		

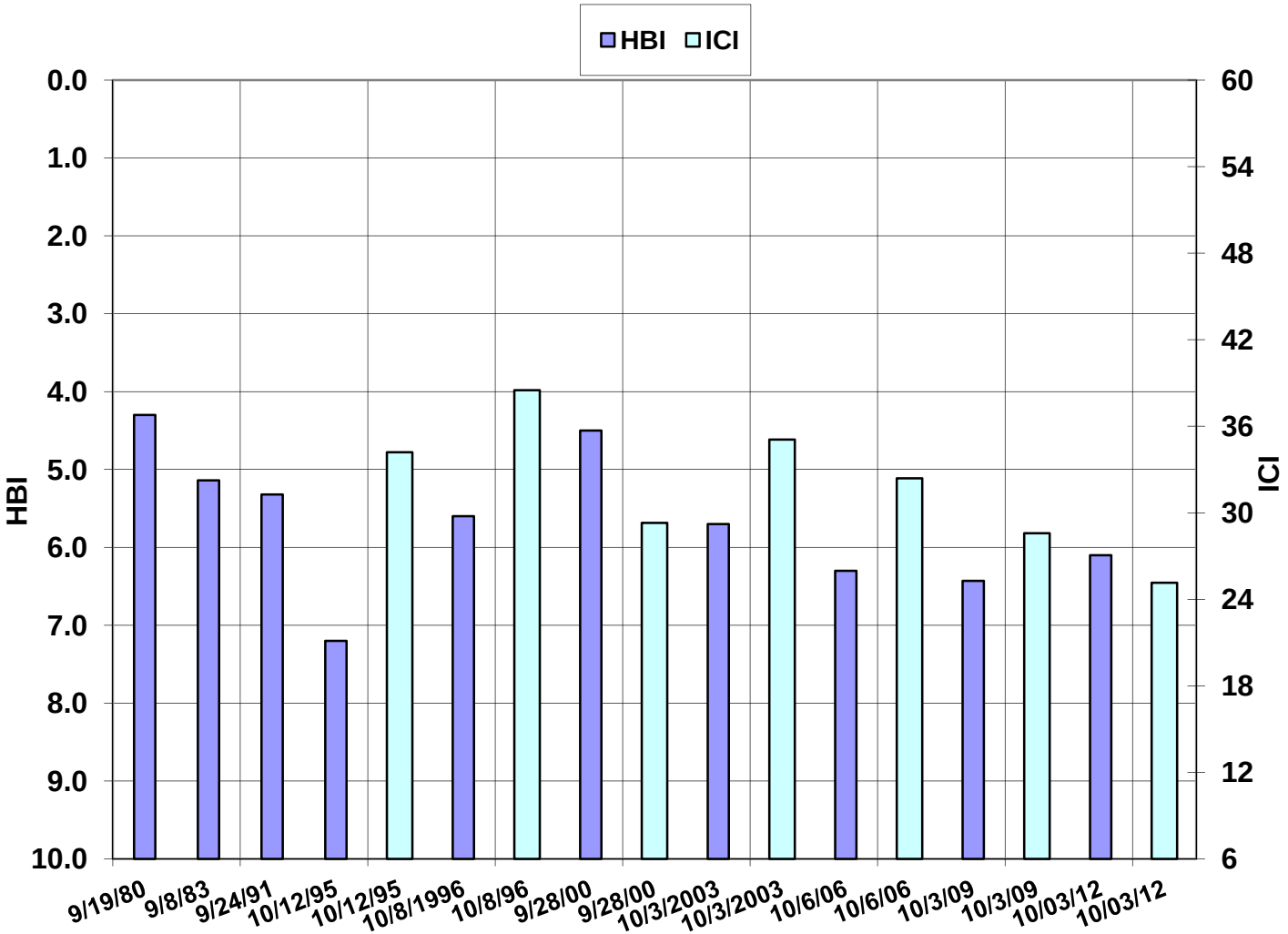
NOTES:
F: FAMILY TOLERANCE VALUE
S: SPECIES (SPP) TOLERANCE VALUE
G: GENUS TOLERANCE VALUE
A: AVERAGE OF MANY SPECIES

Appendix C

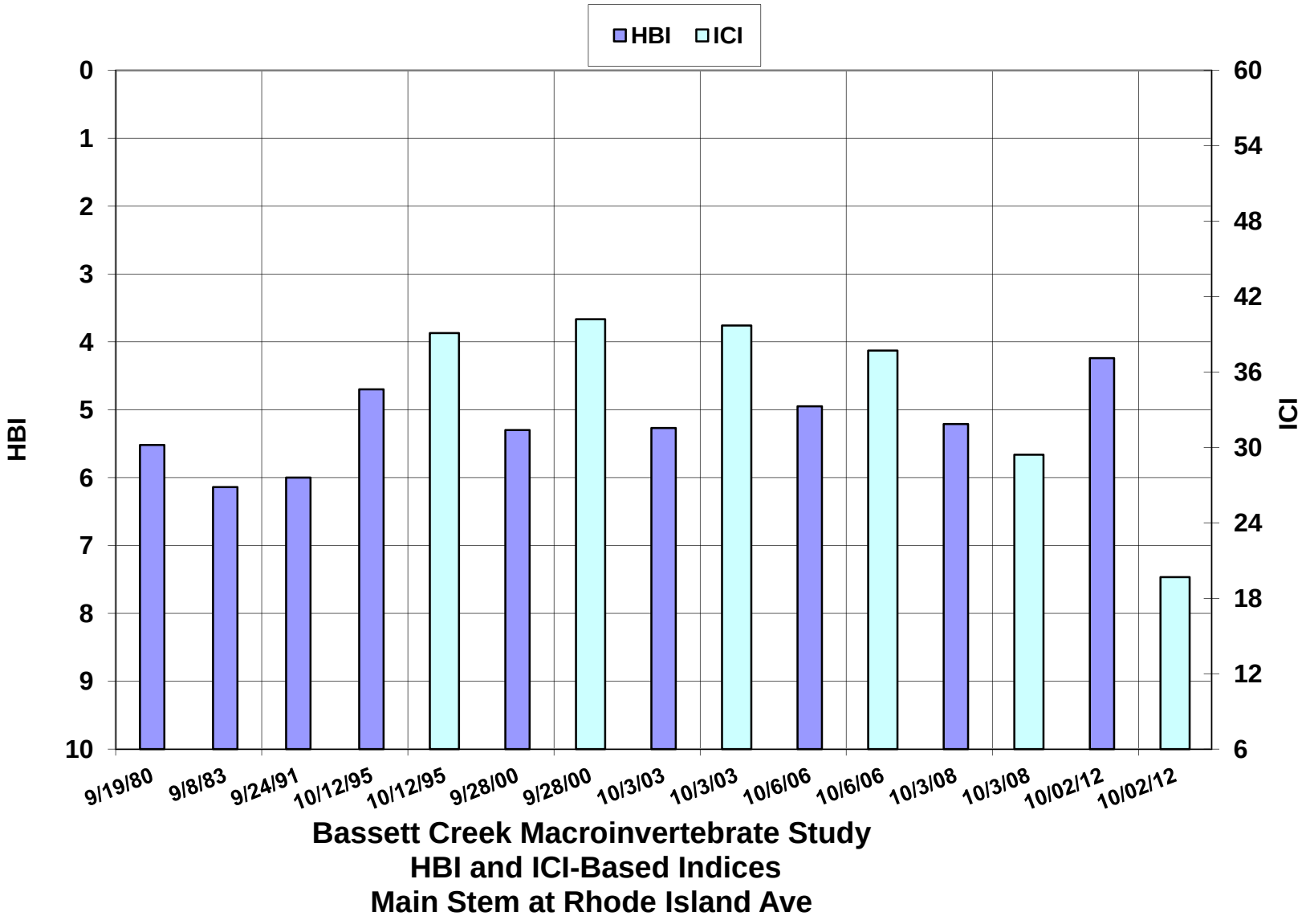
HBI and ICI Graphs

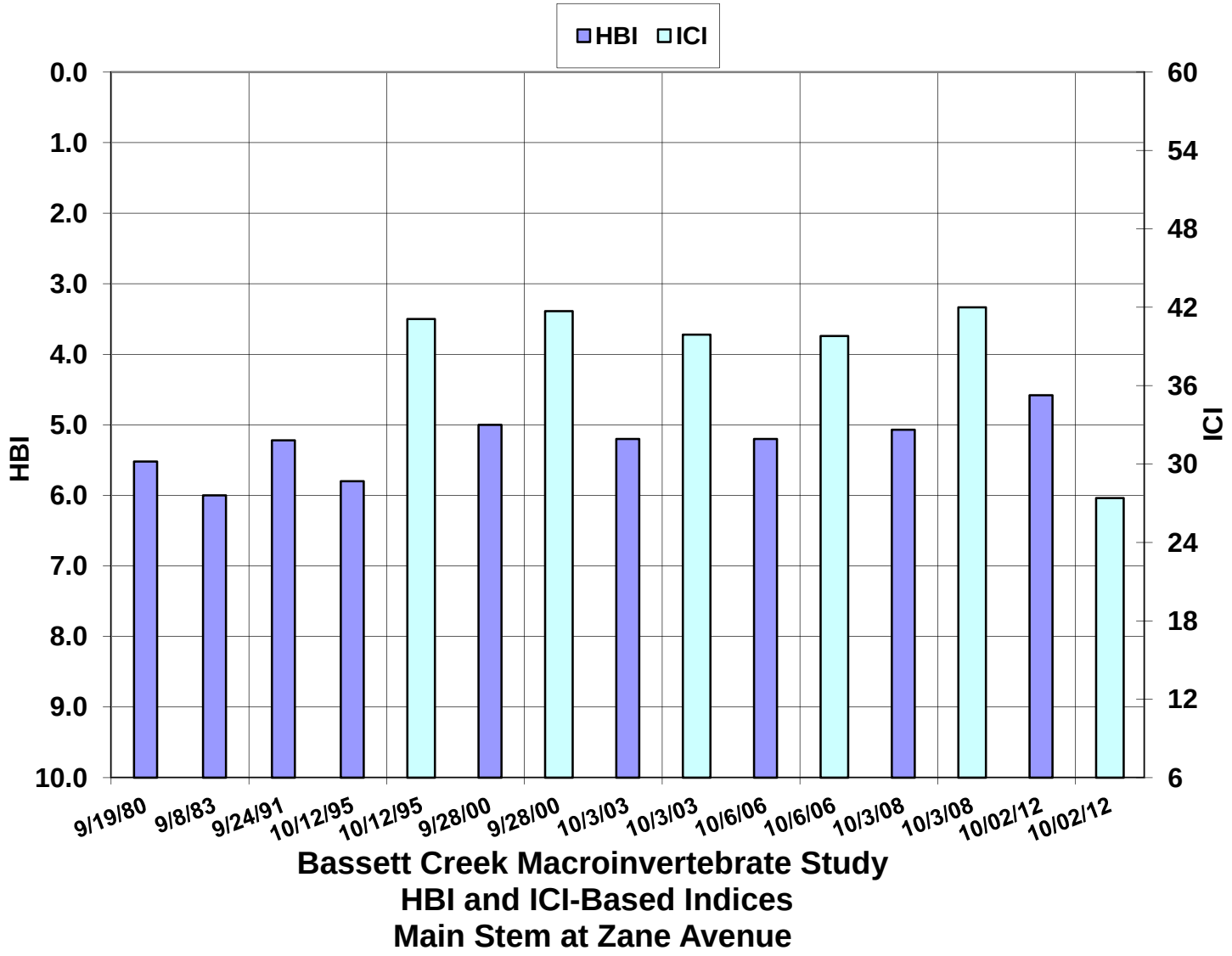


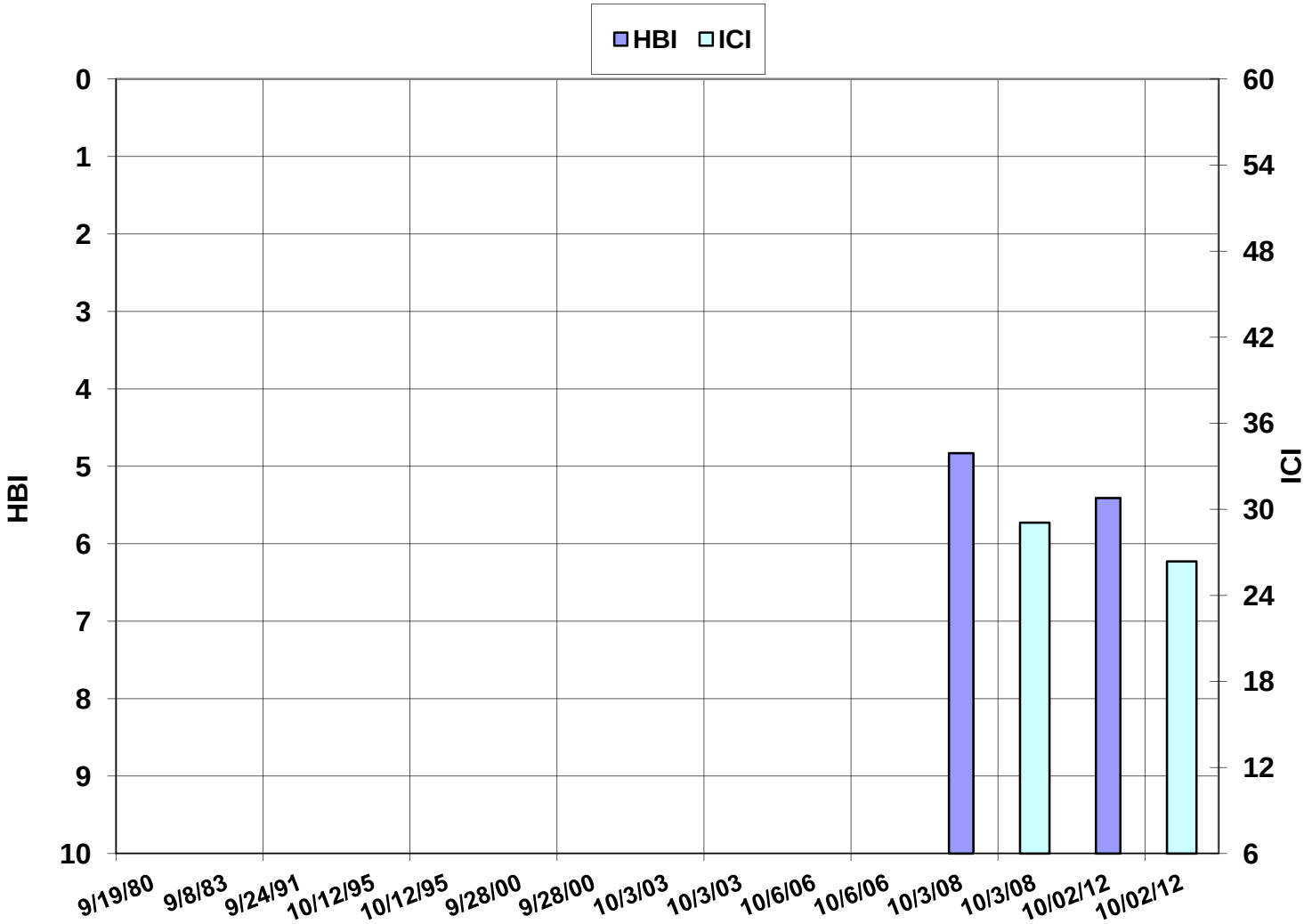
Bassett Creek Macroinvertebrate Study
HBI and ICI-Based Indices
Plymouth Creek at Industrial Boulevard



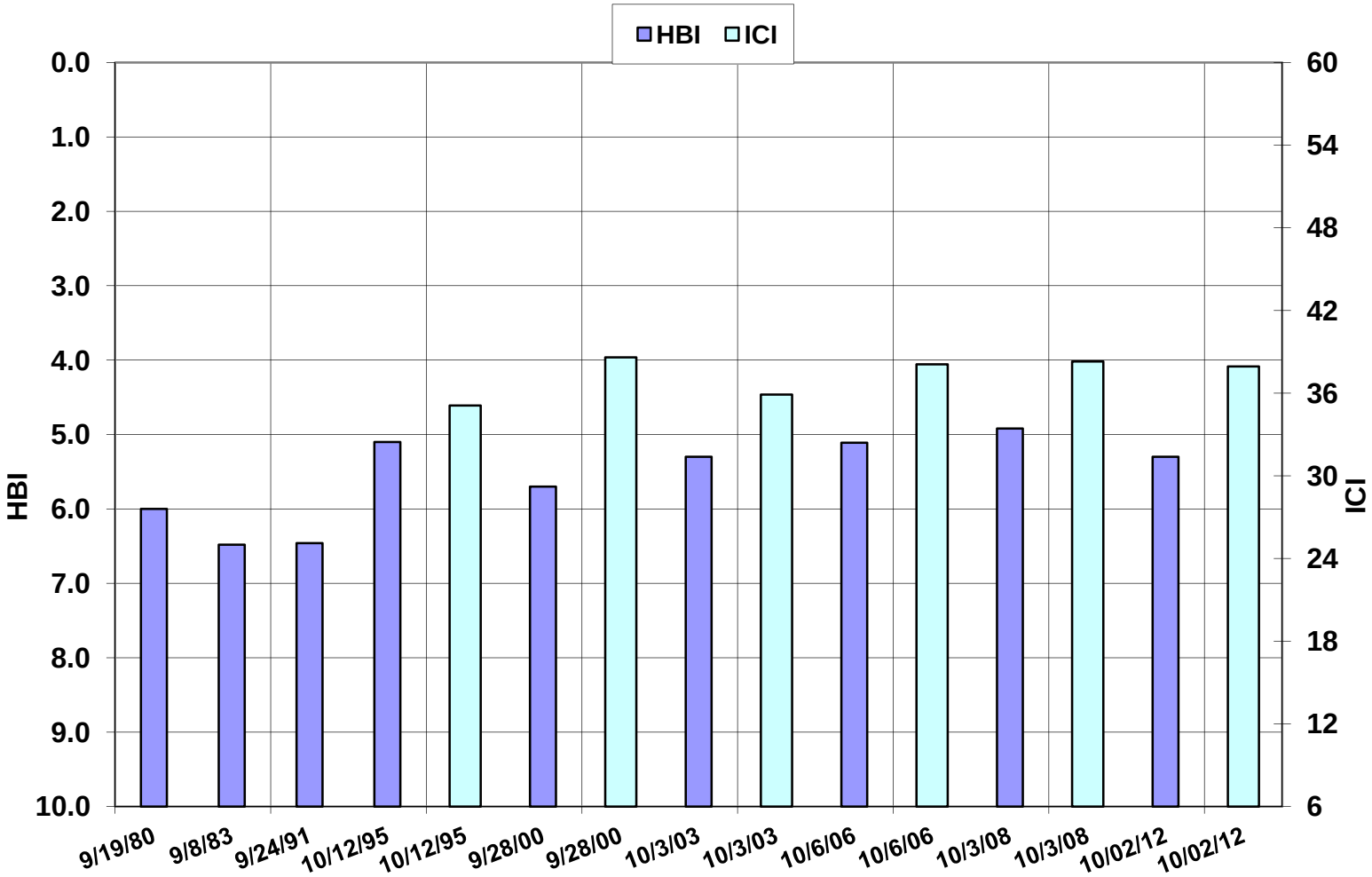
Bassett Creek Macroinvertebrate Study
HBI and ICI-Based Indices
Sweeney Lake Branch at Turner's Crossroad


HBI
ICI
0
1
2
3
4
5
6
7
8
9
10
60
54
48
42
36
30
24
18
12
6
9/19/80
9/8/83
9/24/91
10/12/95
10/12/95
9/28/00
9/28/00
10/3/03
10/3/03
10/6/06
10/6/06
10/3/08
10/3/08
10/02/12
10/02/12
Bassett Creek Macroinvertebrate Study
HBI and ICI-Based Indices
Main Stem at Rhode Island Ave


HBI
ICI
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
60
54
48
42
36
30
24
18
12
6
9/19/80
9/8/83
9/24/91
10/12/95
10/12/95
9/28/00
9/28/00
10/3/03
10/3/03
10/6/06
10/6/06
10/3/08
10/3/08
10/02/12
10/02/12
Bassett Creek Macroinvertebrate Study
HBI and ICI-Based Indices
Main Stem at Zane Avenue



Bassett Creek Macroinvertebrate Study
HBI and ICI-Based Indices
Main Stem at Dresden Lane



Bassett Creek Macroinvertebrate Study
HBI and ICI-Based Indices
Main Stem at Dupont Avenue (1980-2000) and Irving Avenue (2003-2012)