2003-2004 Door Peninsula Baseline Monitoring Report

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ABSTRACT

The Door Peninsula located in the northern half of the Lakeshore basin features many miles of streams that range from intermittent warmwater streams to spring-fed coldwater streams. The ecological landscape of the area is classified as Northern Lake Michigan Coastal and is the result of glaciation and the influence of Lake Michigan on the area. Beneath the glacial drift is Niagara limestone that is buried up to 100 feet in the southern part of the Peninsula to exposed along the Green Bay shoreline in northern Door County. Soils on the Peninsula include lacustrine soils that are poorly drained shallow sands over bedrock or sand dune and ridge complexes near Lake Michigan, to sandy-loams in northern Door County, and silt to heavy clays in southern sections of the peninsula. Shallow bedrock areas have been shown to be susceptible to groundwater contamination. The silts and clays are highly erodible and can negative impact water quality if erosion occurs.

The purpose of the study described in this report was to measure environmental quality in streams located in the watersheds of the Door Peninsula by using the Hilsenhoff Biotic Index (HBI) for invertebrates and the Index of Biotic Integrity (IBI) for fish (Lyons 1992). By quantifying the type and number of fish species, macroinvertebrates and plants as well as evaluating the physical habitat of a stream, we can judge the quality of the stream and compare that stream to other streams across the state. Standard, Statewide sampling protocols were followed in this survey.

During this two year survey that sampled 33 sites on 29 streams, a variety of physical, chemical and biological characteristics were measured. By measuring a combination of biological, chemical and physical parameters, trends in watershed health can be better understood than if a single individual metric was used.

We believe that the data collected shows that flow is not a problem for resident biological communities in most streams. Flow in Three Springs Creek, Geisel Creek and Larson Creek appeared to negatively impact the fishery in them. Several others, Smith Creek, Fish Creek (Lake Michigan) also had low flow, but fish populations were not as impacted as in the other three streams.

Throughout the watershed, large-scale habitat varied greatly from stream to stream. The diversity of habitat was reflected by the diversity of organisms found in surveyed streams as measured by HBI and IBI metrics.

During this survey we captured 6,141 individual fish representing 28 species. Fish IBI ratings ranged from very poor at six sites, poor at ten sites, fair at fourteen sites, good at two sites and was not collected at one site.

Distribution of the catch was not evenly divided among the streams and sites surveyed. The streams that were sampled could be broken into three zones, those north of Sturgeon Bay, south of Sturgeon Bay that flow toward Green Bay and south of Sturgeon Bay that flow into Lake Michigan. When these three zones are compared there is a marked difference in the number of fish captured and the species diversity within each zone.

Natural reproduction of Lake Michigan trout and salmon was noted in several streams that we surveyed. Although reproduction was modest in most streams, it appeared that in Stony Creek steelhead are reproducing at a higher rate.

HBI scores, stream temperatures and dissolved oxygen levels indicate that water quality in the streams surveyed is fair to very good despite several streams falling below the 5 ppm standard for DO in warmwater streams.

Based on the collected data, it is recommended that:

- Resource agencies and land owners should actively utilize streambank protection programs (CRP, CREP) to maximize stream bank protection in those streams that exhibit bank erosion.

- Agencies should encourage the use of land practices that hold and slowly release water into streams to improve stream flows.

- DNR Fisheries should continue to evaluate natural reproduction of Lake Michigan trout and salmon in tributaries to Lake Michigan to determine their magnitude.

- DNR should do additional work utilizing continuous temperature and DO monitors to more fully determine the extent of water quality problems in the watershed.

INTRODUCTION

The Door Peninsula located in the northern half of the Lakeshore basin features many miles of streams that range from intermittent warmwater streams to spring-fed coldwater streams (Figure 1).

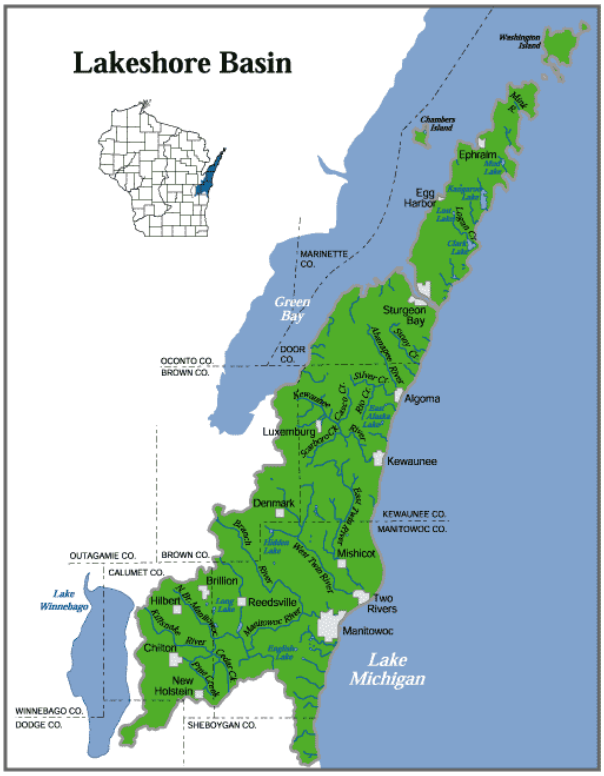


Figure 1. The Lakeshore Basin map (Courtesy of the Lakeshore Basin Partners website, Pat Robinson site administrator).

The ecological landscape of the area is classified as Northern Lake Michigan Coastal and is the result of glaciation and the influence of Lake Michigan on the area (WNDR 2001). Beneath the glacial drift is Niagara limestone that is buried up to 100 feet in the southern part of the Peninsula to exposed along the Green Bay shoreline in northern Door County. Soils on the Peninsula include lacustrine soils that are poorly drained shallow sands over bedrock or sand dune and ridge complexes near Lake Michigan, to sandy-loams in northern Door County, and silt to heavy clays in southern sections of the peninsula. Shallow bedrock areas have been shown to be susceptible to groundwater contamination. The silts and clays are highly erodible and can negative impact water quality if erosion occurs.

Vegetation varies from boreal forest in the north along the Lake Michigan shoreline, to maple-basswood-beach forest in the south. Wetlands are scattered throughout the area and can be large in size. Land use on the Peninsula varies greatly as well, with large farming operations found in the Red River and Ahnapee River watersheds to

recreational lands in the Upper Sturgeon Bay watershed to the north. Since the Door Peninsula is a highly desirable location for recreation, it experiences a high demand for development that places pressure on the natural resources of the area.

Upper Sturgeon Bay Watershed

The Upper Sturgeon Bay Watershed encompasses all of Door County located north of the Sturgeon Bay Ship Canal. Soils in the northern part of the watershed are shallow, sandy loams located over dolomite bedrock (WDNR 1995). In southern portions of the watershed along the Lake Michigan shoreline, soils are poorly drained silt-loams. Projections indicate that development will be increasing in this area and could negatively impact the 16 streams and 16 lakes greater than 10 acres found in this basin.

Streams in this basin have water quality classifications that range from Limited Aquatic Life (LAL) to Cold Water 1 (WDNR 1995). Many streams are first order streams that receive ground water inputs and flow through forested landscapes while others drain large wetland complexes. Little fisheries information exists on the streams in this basin except for information collected during the 1970's to determine if Lake Michigan trout and salmon that were found in tributary streams were displacing native, reproducing brook trout (Avery 1974). Avery found a remnant brook trout population in Whitefish Bay Creek.

Red River/Sturgeon Bay Watershed

This watershed covers the southern half of Door County as well as those waters in Brown and Kewaunee Counties that drain into Green Bay (WDNR 1995). Soils in the northern half of the basin are shallow with many areas having exposed bedrock. Soils in southern sections of the basin consist of silts and clays that can be highly erodible.

Within this basin there are 15 streams that contain 55.9 miles of water (WDNR 1995). These streams range in classification from limited aquatic life streams (five) with seasonal flows to cold water class 1 and 2 streams (one). All streams are less than ten miles in length and many are flow limited. Because of limited seasonal flow and the impact of non-point source pollution, forage fisheries dominate most streams. However, many of the streams that are directly tributary to Green Bay experience spring fish runs and can be important spawning areas. Streams with flowing springs or spring ponds in headwater areas have the greatest potential for gamefish, but their current status is unknown.

Stony Creek Watershed

The Stony Creek watershed is a small watershed that is located in Door County and the northeast corner of Kewaunee County south of Sturgeon Bay along the Lake Michigan shoreline. The watershed has shallow, somewhat permeable soils over fractured dolomite that causes this watershed to be susceptible to groundwater contamination (WDNR 1995).

There are five streams in this watershed that cover 33 miles, but a single stream, Stony Creek is the major water of the basin. The lower section of Stony Creek is classified as a warmwater sport fishery, with the remainder of stream miles in the watershed classified as forage fisheries. However, most steams in this watershed experience seasonal migrations of Lake Michigan trout and salmon and Avery (1974) found native brook trout in Bear Creek.

Ahnapee River Watershed

The Ahnapee Watershed is located in northern Kewaunee County and south central Door County (WDNR 1995). Soils in this watershed are variable and range from level to very steep, from sandy loams in the north to clay-silt-loams in the south and can be shallow to deep over fractured dolomite. Non-point point source pollution in the watershed is likely degrading surface and ground water within the basin.

Water resources in the basin include a large wetland, four lakes greater than ten surface acres in size and nine streams covering 57 miles (WDNR 1995). Two streams the Ahnapee River and Silver Creek have dams on them that isolate the lower river from the upper river. Stream classifications range from limited aquatic life in the upper section of Silver Creek (LFF) to Cold Water 1 and 2 in Silver and Three-Mile Creeks.

Many species of fish are found in the Ahnapee River including smallmouth and largemouth bass, northern pike and trout and salmon that make seasonal runs up the river from Lake Michigan. Several streams in this watershed have experienced fish kills and during the investigations, many large northern pike were observed (Hogler 1994).

Study Rationale

The purpose of the study described in this report was to measure environmental quality in streams located in the watersheds of the Door Peninsula by using the Hilsenhoff Biotic Index (HBI) for invertebrates and the Index of Biotic Integrity (IBI) for fish (Lyons 1992). By quantifying the type and number of fish species, macroinvertebrates and plants as well as evaluating the physical habitat of a stream, we can judge the quality of the stream and compare that stream to other streams across the state. These types of studies are also called biological monitoring or bioassessment.

METHODS

Sampling locations were selected on most of the named streams in the area sampled. Most streams had one sampling location, but larger streams, such as Hibbards Creek in Door County, and the Ahnapee River and Silver Creek in Kewaunee County had multiple sampling locations based on their size at the rate of 1 for every five miles of perennial water.

Survey locations began at the first upstream riffle above a road crossing that was at least 10 times the mean stream width (MSW) away from a bridge. The end point of the survey location was determined by assessing MSW. For streams that had a MSW of less than 2.9 meters, the station length was 100 meters, for streams with a MSW of between 2.9 meters and 23 meters; the station length was 35 times the MSW and for streams with a MSW of greater that 23 meters the station was 800 meters in length. Transects within the sampling station were marked starting 1 MSW above the station starting point and then every three MSW thereafter following Wisconsin DNR wadable stream protocol (WDNR 2002). Data was collected at each station following standard procedures for water characteristics and large-scale channel and basin characteristics (Simonson et al. 1994). Variables include stream name, waterbody code, location, air and water temperature, dissolved oxygen, flow, channel size, transect size and spacing, gradient, order, distances between bends, riffles and pools and a generalized stream map. Gradient and sinuosity were determined by plotting starting and ending points using GIS and using measuring tools to determine the value of these variables. All sampling was conducted during the open water portion of 2003-04 from June through September.

Discharge

Stream flow and depth were measured at 10 equally spaced locations along a transect at each sample site using a Swoffer current meter. Stream discharge in Cubic Meters per Second (CMS) was calculated by multiplying velocity by depth by the distance between measurement points, and then summing the products along the transect.

Habitat Assessment

Habitat along each of the 12 transects per site were evaluated using standard procedures (Simonson et al. 1994). The host of variables measured included depth and width parameters, bottom characteristics, plant growth, percent shading from vegetation, fish cover, streambank erosion and surrounding land use.

Biological Assessments

Biological assessment work included collecting stream invertebrates and fish. Collected invertebrates were sent to UW-Steven's Point for identification and calculation of the Hilsenhoff Biotic Index (HBI) which relates species diversity, abundance and pollution sensitivity to water quality. Invertebrate samples were collected following standard invertebrate collection procedures.

Fish were sampled using electrofishing gear and techniques during the summer. In the small streams, a backpack shocker was used to capture fish, while in larger streams, a stream shocker was used. DC current was used to capture the fish regardless of the gear type.

One upstream pass was made and all fish observed were collected with small nets. Fish were identified and the number of each species tallied. Unidentifiable fish were taken to the office to be identified. One gram of MS-222 per 5 gallons of water was used to anesthetize unidentified fish, which were then transferred into 10% formalin to be preserved for later identification and as a reference for future collections.

The Index of Biotic Integrity (IBI) based on the fish community at each sampling location was calculated. Similar to the HBI, IBI relates community structure to community health and water quality.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen readings were taken with a YSI meter each visit to the stream to get a snapshot of the current condition of the stream. To get a better sense of stream condition, hobo samplers that measured continuous stream temperatures and YSI Sondes units that measured continuous stream temperatures and dissolved oxygen were also employed at selected stream locations.

RESULTS

Upper Sturgeon Bay Watershed

Fish Creek

Fish Creek is a 2.4 km stream that flows into Green Bay in the village of Fish Creek. Headwaters of the creek are found in a large wetland complex that drains the western edge of the Niagara Escarpment (Door County SWD 2000). The area drained by this river is 5.18 km^2.

The survey site was located just upstream of State Highway 42 above a wooden bridge in a village park (N45.1246, W-087.2387 to N45.1236, W-087.2389). The survey section averaged 3.3 meters in width and was 102 meters in length. Fish Creek has a gradient of 2.8 meters per kilometer and a sinuosity of 1 to 1.12. The study reach of the river ran through 100 percent wooded parkland (Figure 2).

Figure 2. An upstream view from the start of the survey site on Fish Creek. This view was what was observed throughout the entire survey site.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was 0.008 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled was mostly run, with small pools found between the runs. Habitat features ranged from 3 to 7 meters in length for pools, and 6.5 to 31.0 meters in length for runs. No riffle areas were noted. Bank erosion within 5 meters of the creek was common throughout the survey section and ranged from 10 to 60% of the stream bank. It appeared that at one time this section of creek was channelized. Fish cover was limited to large woody vegetation found in and near the pools.

The bottom sediments were dominated by silt and clay although large areas of detritus and wood were encountered (Figure 3). The soft sediments found at this location were indicative of the bank erosion and channelization that was observed at this site.

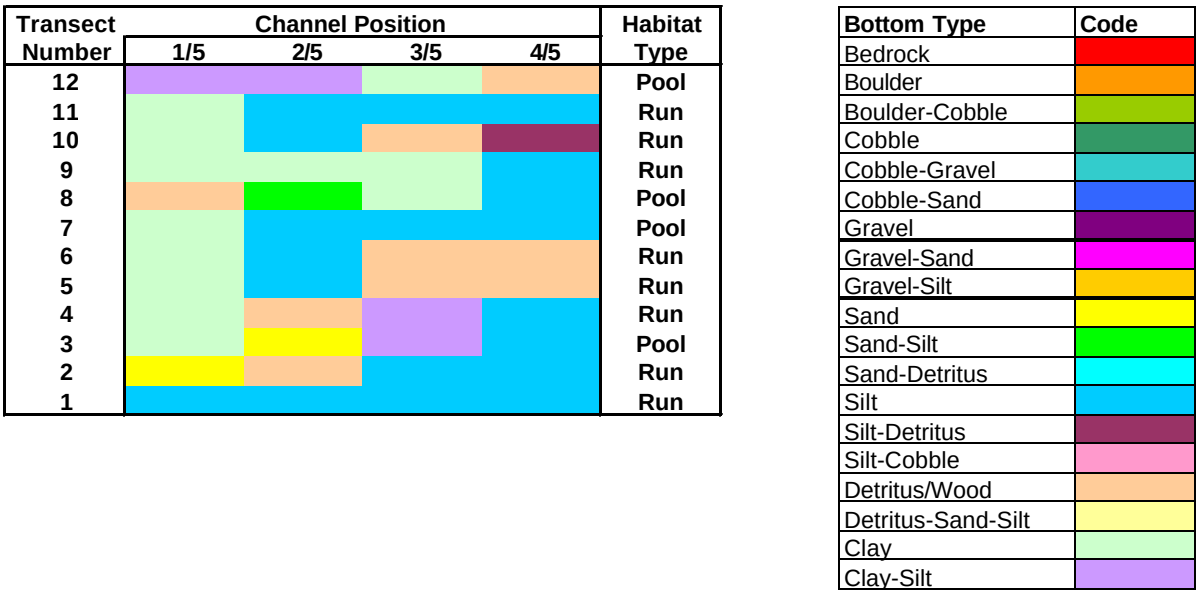


Figure 3. Bottom sediment map and key for the survey site upstream of Highway 42 on Fish Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were not collected from this location because it lacked suitable riffle habitat for the collection of invertebrates.

A single upstream pass was made on Fish Creek with a backpack electroshocker to capture fish. The entire section was shocked in 14 minutes without any fish being captured or observed.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected at this location each time the site was visited during July 2003. During the July 8 habitat assessment trip, DO was 8.00 mg/l with a stream water temperature 20.2 C. Air temperature was 19.3 C. By July 16, DO had declined to 4.46 mg/l which is less than the state standard of 5 mg/l for surface water. Stream water temperature was 17.6 C and the air temperature was 21.0 C.

Ephraim Creek

Ephraim Creek is a 1.6 km stream that flows into Green Bay in the village of Ephraim. The area drained by this river is 5.18 km^2 (Door County SWD 2000).

The survey site was located just upstream of Brookside Lane (N45.1454, W-087.1789 to N45.1446 W-087.1785). The survey section averaged 2.2 meters in width and was 92

meters in length. The creek has a gradient of 0.4 meters per kilometer and a sinuosity of 1 to 1.26 (Door County SWD 2000). The study reach of the river ran through 100 percent wooded land (Figure 4).

Figure 4. Looking upstream from the start of the survey site on Ephraim Creek. Note the clay sediment in the water caused by waders in the stream.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was 0.007 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of small runs, riffles and pools with small pools being the dominant feature. Habitat features ranged from 3 to 12 meters in length for pools, 3.0 to 9.6 meters in length for runs and 1.0 to 6.3 meters for riffles. Bank erosion within 5 meters of the creek was common throughout the survey section and ranged from 0 to 80% of the stream bank. Fish cover was limited to large woody vegetation found in and near the pools. The downed trees occurred singlely or in many cases as a mass of multiple logs.

Gravel and large areas of woody debris dominated the bottom sediments in the surveyed section of Ephraim Creek (Figure 5). Cobble, sand and clay were also noted during the habitat assessment.

Figure 5. Bottom sediment map and key for the survey site upstream of Brookside Lane on Ephraim Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were not collected from this location because it lacked suitable riffle habitat for the collection of invertebrates.

A single upstream pass was made on Ephraim Creek with a backpack electroshocker to capture fish. The entire section was shocked in 14 minutes with three brown trout captured. The three trout ranged in length from 165 mm to 172 mm and were most likely recently stocked into Ephraim harbor. No other fish were observed during shocking. The calculated IBI rating for the fish community of Ephraim Creek was poor.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected at this location each time the site was visited during July 2003. During the July 8 habitat assessment trip, the DO was 10.1 mg/l and the stream water temperature was 14.2 C. Air temperature was 22.5 C. On July 16, DO was 10.6 mg/l indicating excellent water quality. Stream water temperature was 12.0 C and the air temperature was 21.5 C.

Three Springs Creek

Three Springs Creek is 3.68 km intermittent stream that drains wetland and has a12.95 km^2 watershed (Door County SWD 2000). The stream enters Lake Michigan in North Bay.

The survey site was upstream of Highway ZZ (N45.1856, W-087.0782 to N45.1869 W-087.0787). Mean stream width was not calculated for this stream because low flow caused the stream to have a stream width that varied in width from 0.015 m to 0.9 m. Many of the runs in the stream were dry when surveyed. The survey section was 92 meters in length. This 1st. order stream had a gradient of 2.1 meters per kilometer and a sinuosity of 1 to 1.12 (Door County SWD 2000). The study reach of the river ran through a landscape of meadows, shrubs and forest (Figure 6).

Figure 6. Looking upstream on Three Springs Creek. Grassland was replaced by shrubs and trees as one proceeded upstream. The stream channel upstream was dry in many places.

Discharge

Water level was judged to be normal or slightly below normal for the date of the survey and water clarity was rated clear. Flow was 0.0 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of runs and pools. Habitat features ranged from 4.1 to 12 meters in length for pools and 1.0 to 14.3 meters in length for runs. No riffle areas were observed. Very little bank erosion within 5 meters of the creek was noted, although because of low water, bare soil was common throughout the survey section.

Protocols for assessment of habitat along survey transects were followed when stream widths allowed for non-overlapping assessment squares otherwise a single assessment was made in the center of the stream. Sand and silt dominated the bottom sediments in

the surveyed section of Three Springs Creek (Figure 7). One small area of detritus was also noted.

Transect Number	Channel Position 1/5	2/5	3/5	4/5	Habitat Type
12					Run
11					Pool
10					Pool
9					Run
8					Run
7					Run
6					Run
5					Run
4					Run
3					Run
2					Pool
1					Pool

Bottom Type	Code
Bedrock	
Boulder	
Boulder-Cobble	
Cobble	
Cobble-Gravel	
Cobble-Sand	
Gravel	
Gravel-Sand	
Gravel-Silt	
Sand	
Sand-Silt	
Sand-Detritus	
Silt	
Silt-Detritus	
Silt-Cobble	
Detritus-Wood	
Detritus-Sand-Silt	
Clay	
Clay-Silt	

Figure 7. Bottom sediment map and key for the survey site upstream of Highway ZZ on Three Springs Creek. Transect 1 is the furthest downstream sampling location. Multiple habitat assessments were only made on transects that had a stream width great enough to prevent overlapping assessment squares.

Biological Assessment

Invertebrates were not collected from this location because it lacked suitable riffle habitat for the collection of invertebrates.

Fish were not collected from this location because most of the stream channel was dry and pools had very low dissolved oxygen.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected at this location on July 9. During the July 9 habitat assessment trip, DO was 3.84 mg/l and stream water temperature was 19.0 C. Air temperature was 18.6 C.

Piel Creek

Piel Creek is a 4 km, 1st order stream that drains a large wetland complex before entering Kangaroo Lake (Door County SWD 2000). It has many spring holes along the soft bottomed stream channel. Historic water chemistries indicate low phosphorus levels and high alkalinites in this stream.

The survey location on Piel Creek was upstream of County Highway EE (N45.0692, W-087.1683 to N45.0701, W-087.1699), averaged 5.0 meters in width, and was 170 meters in length. The gradient was 1.2 meters per kilometer and the stream sinuosity was 1 to 1.2 (Door County SWD 2000). The study reach of the river ran through nearly 100 percent woodland with the remainder wetland (Figure 8).

Figure 8. An upstream view of Piel Creek from the start of the survey station. Note the large amount of woody debris in the stream.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated as stained. Flow was 0.03 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of runs and pools. No riffle areas were observed. Habitat feature length was not measured on this stream due to the soft channel bottom and large piles of woody debris that created safety issues for the survey crew. Very little bank erosion within 5 meters of the creek was noted, although bare soil along the stream bank was common throughout the survey section. Fish habitat was provided by woody debris. In many cases, the large piles of wood spanned the entire stream channel in others, a single tree provided cover.

Silt was the dominant bottom sediment observed on Piel Creek (Figure 9). Other bottom sediment material included detritus and wood. No areas of rock were observed in the stream channel.

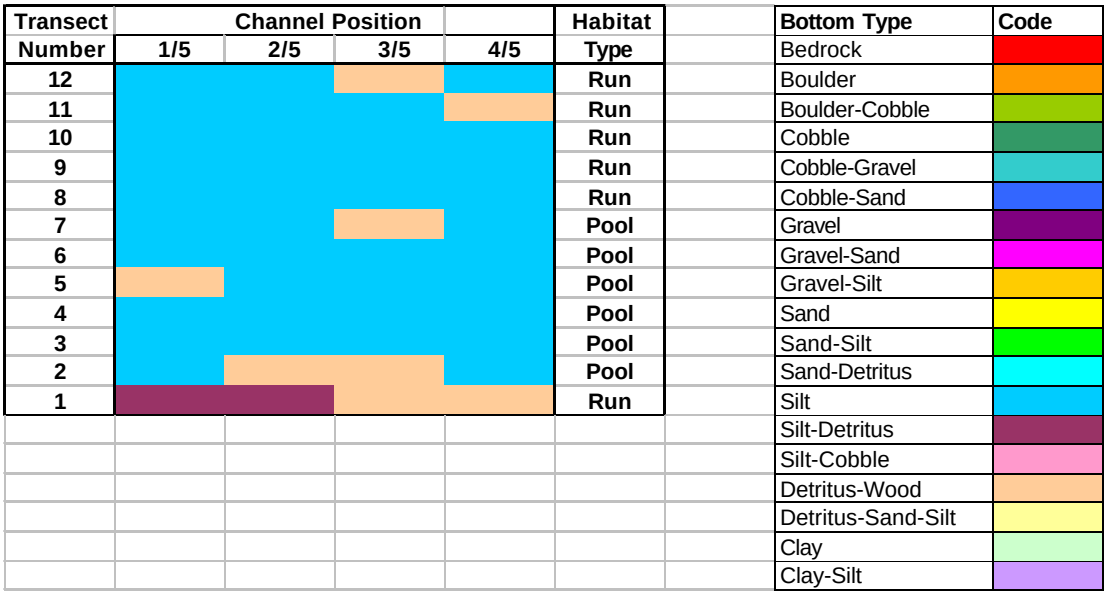


Figure 9. Bottom sediment map and key for the survey site upstream of Highway EE on Piel Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were not collected from this location because it lacked suitable riffle habitat for the collection of invertebrates.

Fish were not collected from this location because of the hazardous conditions that the soft stream channel presented to those operating electroshocking equipment. Although the stream was not electroshocked, small (young-of-year) northern pike were observed in the creek during habitat assessment.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected at this location on July 9. During the July 9 habitat assessment trip, DO was 9.07 mg/l and stream water temperature was 12.3 C. Air temperature was 22.5 C.

Hibbards Creek (County A)

Hibbards Creek is an 11.84 km long stream that drains wetland and flows through agricultural land before entering Lake Michigan. Much of the stream corridor is forested resulting in good habitat and water quality, with 4.48 km of the stream being classed as Class 2 Trout Waters.

This survey location on Hibbards Creek was upstream of County Highway A (N44.9857, W-087.1923 to N44.9875, W-087.1940), had an average width of 7.8 meters, and was 272 meters in length. At this location, the stream had a gradient of 1.4 meters per

kilometer and a sinuosity of 1 to 1.15 (Door County SWD 2000). The study reach of the river ran through nearly 100 percent woodland with the remainder wetland and lawn (Figure 10).

Figure 10. An upstream view of Hibbards Creek above County Highway A.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated as clear. Flow was 0.12 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained nearly an equal mixture of runs, riffles and pools. Habitat feature length ranged from 2.8 meters to 18.6 meters for riffles, 9.4 meters to 44.4 meters for pools and 6.0 meters to 22.2 meters for runs. Very little bank erosion within 5 meters of the creek was noted, although bare soil along the stream bank was common throughout the survey section. Woody debris and boulders provided habitat for fish in the surveyed section of stream.

Cobble was the dominant bottom sediment type observed in this section of Hibbards Creek and was observed on nearly every transect (Figure 11). Small, scattered patches of gravel were encountered in several of the riffle areas. Other sediment types that were observed included sand and detritus/wood but in substantially lower abundance than either cobble or gravel.

Figure 11. Bottom sediment map and key for the survey site upstream of Highway A on Hibbards Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were collected at the first riffle upstream of County A. Results indicate caddis flies, may flies and beetles dominated the invertebrate community. The calculated HBI score was 3.616, which indicates that water quality at this site is very good.

Fish were collected during a single upstream transit of the survey section. A total of 410 individual fish representing 11 species were captured (Table 1). The IBI score for this survey section was 50 indicating a good fish community.

Table 1. The species and abundance of fish captured from electroshocking in Hibbards Creek at County A.

Species	Abundance
Chinook Salmon	1
Central Mudminnow	3
Northern Pike	1
Hornyhead Chub	125
Common Shiner	214
Blacknose Dace	37
Longnose Dace	2
Creek Chub	7
White Sucker	17
Pumpkinseed Sunfish	1
Mottled Sculpin	2
Total	**410**

Common shiner and hornyhead chub were the dominant species of fish captured during the survey (Table 1). Substantially fewer blacknose dace and white sucker were collected during shocking. The gamefish that were captured, Chinook salmon and northern pike, were young-of-year fish and may be representative of the water quality and the variety of habitat available for fish in Hibbards Creek.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected by a continuous monitor and during visits for habitat assessment and the fisheries survey.

Instantaneous DO and temperature information were collected at this location on July 7 and July 14. During the July 7 habitat assessment trip, DO was 9.96 mg/l, stream water temperature was 19.1 C and the air temperature was 18.6 C. On July 14, the DO was 8.67 mg/l, stream water temperature was 19.1 C and the air temperature was 22.5 C.

The continuous monitor at this location showed daily dissolved oxygen problems (Figure 12). In fact, dissolved oxygen levels were depressed throughout the sampling period except for short periods in the middle of the day when photosynthesis brought levels to slightly above the 6 mg/l water quality standard. Dissolved oxygen levels were as low as 4.0 and as high as 7.6 mg/l. These daily fluctuations put tremendous stress on the aquatic organisms that may inhabit the stream. Water temperatures ranged from 18 to 26 degrees C with a mean temperature of 22.6 degrees C. pH was normal with a mean of 8.4. Specific conductivity values ranged from 557 to 602 uS/cm.

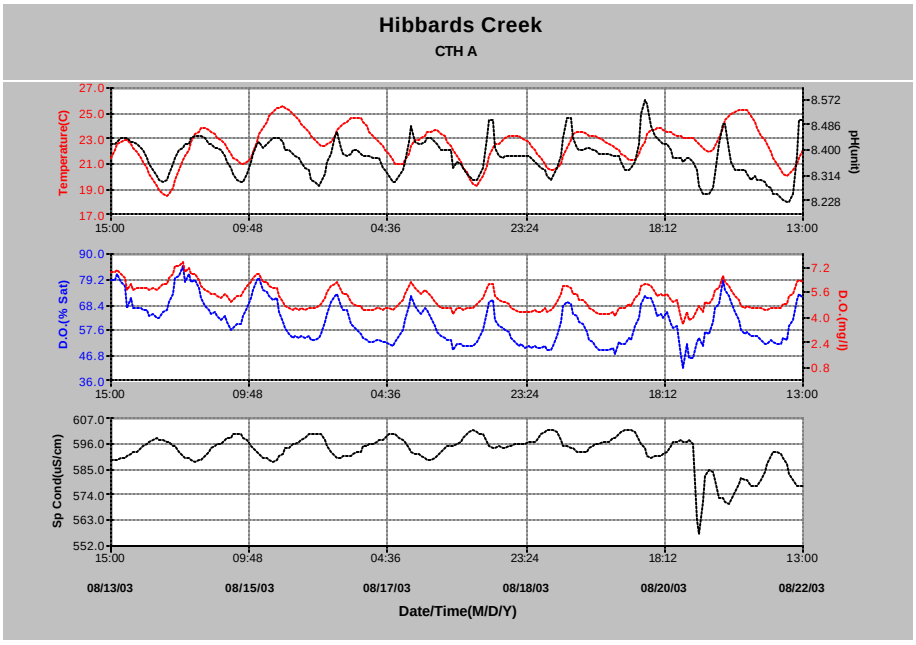


Figure 12. Continuous monitor data collected at County Highway A on Hibbards Creek.

Hibbards Creek (Fairview Road)

This survey location on Hibbards Creek was upstream of Fairview Road (N45.0326, W-087.2036 to N45.0331, W-087.2039). The study section averaged 2.8 meters in width, and was 92 meters in length. The stream had a gradient of 4.2 meters per kilometer and a sinuosity of 1 to 1.19 (Door County SWD 2000). The study reach of the river ran through a woodland, shrub and grassland corridor (Figure 13).

Figure 13. An upstream view of Hibbards creek at Fairview Road. Note in the foreground water cress (*Rorippa nasturtium aquaticum*) and that at the tree line the stream splits with the major channel on the right.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated as clear. Flow was 0.04 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained twice as many meters of riffles as runs or pools with 40.9 meters of riffles, 26.6 meters of pools and 17.3 meters of run measured. Habitat feature length ranged from 3.0 meters to 22.6 meters for riffles, 9.4 meters to 17.2 meters for pools and 4.2 meters to 13.1 meters for runs. Very little bank erosion within 5 meters of the creek was noted, although bare soil along the stream bank was common throughout the survey section especially in a recently logged section of the survey site. There was abundant woody debris in the creek that provided cover for fish in the deeper areas of the stream.

Gravel and cobble were the dominant bottom sediment types observed in this section of Hibbards Creek (Figure 14). Small, scattered patches of sand or detritus/wood were encountered across transects that were adjacent to logged areas of the streambank.

Figure 14. Bottom sediment map and key for the survey site upstream of Fairview Road on Hibbards Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were not collected from this location on Hibbards Creek because it is likely that result, the HBI score, would have been similar to the information collected at County A.

Fish were collected during a single upstream transit of the survey section. A total of 21 individual fish representing 4 species were captured (Table 2). Central mudminnow was the most common species followed by coho salmon.

Table 2. The species and abundance of fish captured during electroshocking in Hibbards Creek at Fairview Road.

Species	Abundance
Coho Salmon	6
Rainbow Trout (Steelhead)	2
Brook Trout	1
Central Mudminnow	12
Total	**21**

The measured lengths of the trout and salmon, 74-83 mm for coho, 37-45 mm for the rainbow trout and the 85 mm brook trout indicated that these were young-of year fish

and that this headwater area must be an important spawning location. The IBI score for this survey section was 30 indicating a fair fishery community although the captured species indicate that a high value fish resource exists at this location.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information was collected by a continuous monitor and during visits for habitat assessment and the fisheries survey.

Instantaneous DO and temperature information were collected at this location on July 7 and July 14. During the July 7 habitat assessment trip, DO was 9.95 mg/l, stream water temperature was 16.2 C and the air temperature was 27.2 C. On July 14, the DO was 10.3 mg/l, stream water temperature was 15.9 C and the air temperature was 27.5 C.

Continuous monitors at Fairview Road showed dissolved oxygen dropped below the state standard for a period of time in late evening-early morning hours on ½ of the days the monitoring equipment was deployed (Figure 15). Hibbards Creek at Fairview Road is classified as a warm water stream and needs to remain above 5 mg/l to meet state water quality standards. Dissolved oxygen levels ranged from 4.1 to 8.4 mg/l. Water temperatures ranged from 14 to 23 degrees C with a mean of 18.8 degrees C. pH was normal with a mean of 8.4. Specific conductivity values ranged from 480 to 560 uS/cm.

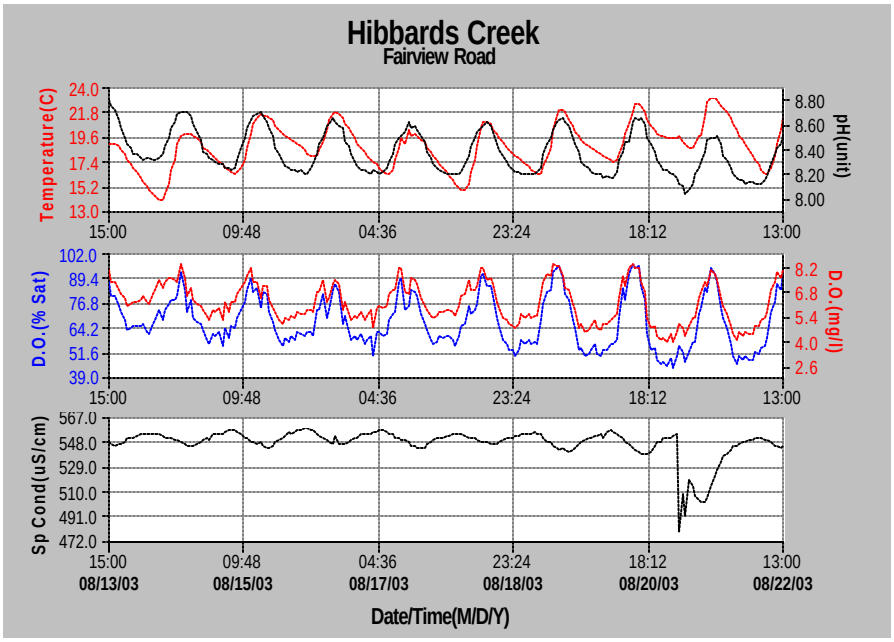


Figure 15. Continuous monitoring data collected at Fairview Road on Hibbards Creek.

Logan Creek (Highway 57)

Logan Creek is a 8.64 km creek that flows out of Lost Lake and empties into Clark Lake. Much of the stream corridor is lowland cedar and black ash although cropland, pasture

and orchards are also found adjacent to the creek (Door County SWD 2000). Most of the stream is classified as a warmwater forage fishery although the lower 2 km are classed as either Class 1 or 2 trout waters based on historic accounts of a self-sustaining brook trout population.

This survey location on Logan Creek was upstream of State Highway 57 (N44.9579, W-087.2181 to N44.9596, W-087.2192), averaged 5.9 meters in width and was 204 meters in length. Logan Creek drains a 31.1 km^2 watershed. The gradient was 3.4 meters per kilometer, and the sinuosity was 1 to 1.31 (Door County SWD 2000). The study reach of the river ran through meadow-shrub habitat in lower sections and was all woodland by the end of the study section (Figure 16).

Figure 16. Looking upstream on Logan Creek just above State Highway 57.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated as clear. Flow was 0.118 cubic meters per second (CMS) at this site. A second flow reading was conducted 150 meters upstream from the start of the survey section. Flow at this location was calculated to be 0.0001 cubic meters per second. Located between the two flow locations is a large spring.

Habitat

The section of river sampled contained a mixture of riffles, runs, and pools with 90.0 meters of riffles, 68.6 meters of pools and 50.9 meters of run. Habitat feature length ranged from 1.5 meters to 27.5 meters for riffles, 1.5 meters to 26.2 meters for pools and 1.1 meters to 23.0 meters for runs. Very little bank erosion within 5 meters of the creek was noted, although bare soil along the stream bank was common in survey

sections that were upstream of the spring. Undercut banks provided cover for fish in the deeper areas of the stream.

Sand and sand mixtures were the dominant bottom sediments in lower and upper sections of the survey site, with cobble and gravel the most abundant sediments in middle sections (Figure 17). Small areas of boulder or detritus/wood were also encountered.

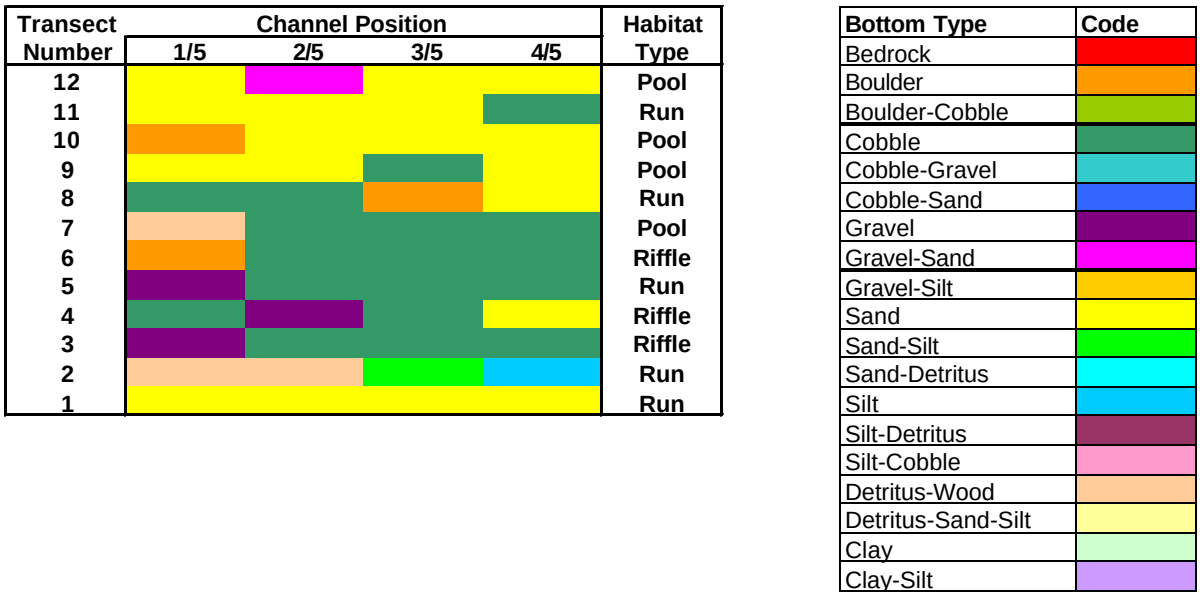


Figure 17. Bottom sediment map and key for the survey site upstream of State Highway 57 on Logan Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were not collected from this location on Logan Creek.

Fish were collected during a single upstream transit of the survey section. A total of 31 individual fish representing five species were captured (Table 3). Iowa darter and central mudminnow were the most common species followed by yellow perch. The IBI score for this site was 20 yielding a rating of poor for the fish community.

Table 3. The species and abundance of fish captured during electroshocking in Logan Creek above State Highway 57.

Species	Abundance
Bowfin	4
Central Mudminnow	7
Northern Pike	3
Iowa Darter	12
Yellow Perch	5
Total	**31**

The captured northern pike ranged in length from 83 mm to 114 mm which may indicate that these are young-of-year fish. The five yellow perch ranged in length from 58 mm to 69 mm and the length of the captured bowfin ranged from 76 mm to 83 mm.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information was collected through continuous monitors and during visits for habitat assessment and the fisheries survey.

Instantaneous DO and temperature information was collected at this location on July 1 and July 16. During the July 1 habitat assessment trip, DO was 6.47 mg/l, stream water temperature was 9.8 C and the air temperature was 19.3 C. DO and temperature taken above the spring site was 10.6 mg/l and 14.1 C. respectively. On July 16, the DO was 7.22 mg/l, stream water temperature was 11.2 C and the air temperature was 19.3 C.

Continuous monitors on Logan Creek at STH 57 showed daily dissolved oxygen problems (Figure 18). Dissolved oxygen routinely fell below the cold water state standard of 6 mg/l., with readings ranging from a low of 4.5 and to as high as 9.7 mg/l. Water temperature ranged from 8.7 to 14 degrees C with a mean of 10.2 degrees C. pH values ranged from 6.7 to 7.2 with a mean of 6.8. Specific conductivity values ranged from 581 to 628 uS/cm with a mean of 610 uS/cm.

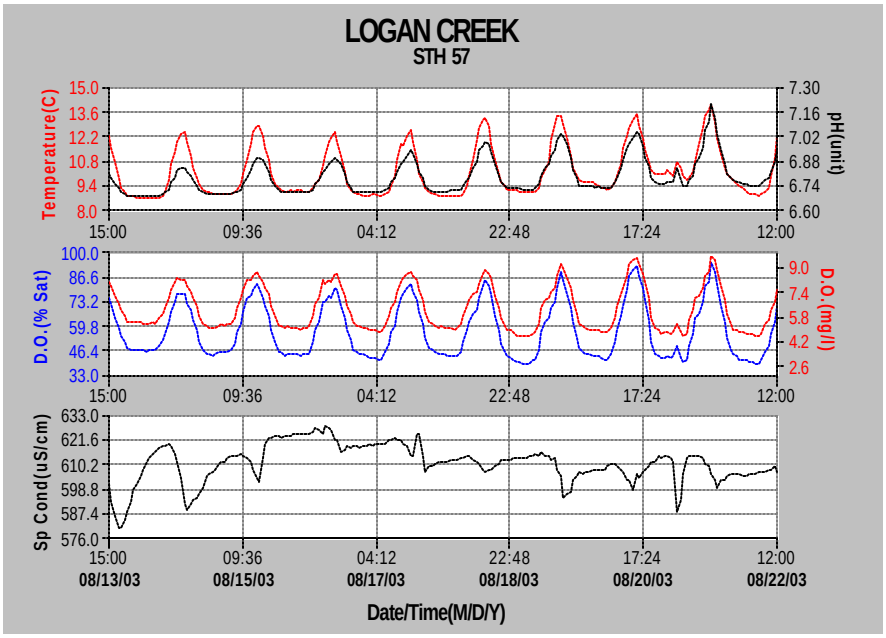


Figure 18. Continuous monitoring data collected on Logan Creek at State Highway 57.

Logan Creek (Highway T)

This survey location on Logan Creek was upstream of Highway T (N44.9711, W-087.2441 to N44.9717, W-087.2446), averaged 2.8 meters in width and was 92 meters

in length. The gradient was 2.4 meters per kilometer, and the sinuosity was 1 to 1.4 (Door County SWD 2000). The study reach of the river ran through meadow-wetland habitat in lower sections and was all woodland by the end of the study section (Figure 19).

Figure 19. Looking upstream of Highway T on Logan Creek. Note the wetland plants in the foregrounds that give way to woodland upstream.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated as clear. Flow was 0.0087 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of riffles, runs, and pools with 21.5 meters of riffles, 53.0 meters of pools and 16.7 meters of run. Habitat features ranged in length from 3.3 meters to 17.5 meters for pools and 2.7 meters to 10.0 meters for runs. A single 21.5 meter riffle was also measured. Bank erosion or bare soil was noted along many transects in this survey site. Overhanging vegetation provided cover for fish in the deeper areas of the stream.

Silt, detritus or sand (Figure 20) dominated bottom sediments in the lower 2/3 of the site. In general, the areas with silt were associated with areas of stream bank erosion or bare soil. Gravel was the dominant bottom substrate in upper sections of the survey site.

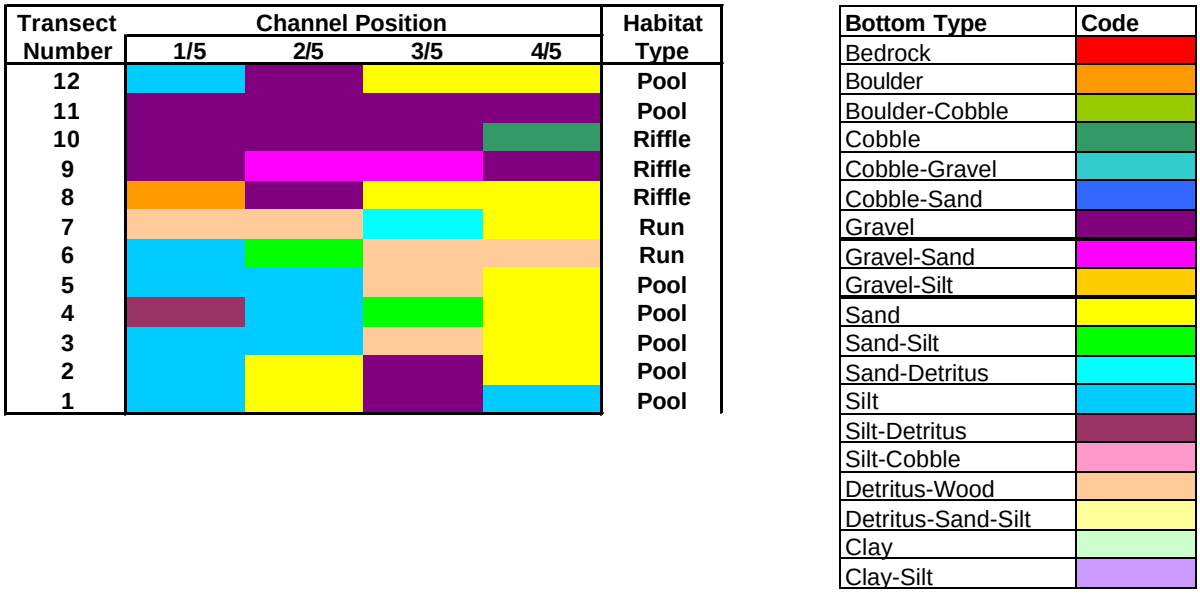


Figure 20. Bottom sediment map and key for the survey site upstream of Highway T on Logan Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were not collected from this location on Logan Creek.

Fish were collected during a single upstream transit of the survey section. A total of 59 individual fish representing three species were captured (Table 4). Central mudminnow was the most common species captured with substantially fewer Iowa darter and yellow perch collected. However, a large pool that was upstream of the end of the survey site contained many yellow perch that were shocked for identification, but not collected. The IBI score for this site was 30, which gave this site a fish rating of fair.

Table 4. The species and abundance of fish captured during electroshocking in Logan Creek above State Highway 57.

Species	Abundance
Central Mudminnow	54
Iowa Darter	2
Yellow Perch	3
Total	**59**

Dissolved Oxygen and Temperature

Instantaneous DO and temperature information were collected at this location on July 2 and July 16. During the July 2 habitat assessment trip, DO was 8.7 mg/l, stream water temperature was 16.4 C and the air temperature was 22.8 C. On July 16, the DO was 9.26 mg/l, stream water temperature was 15.4 C and the air temperature was 19.9 C.

Geisel Creek

Geisel Creek is a 8.4 km long stream that drains a 25.9 km^2 watershed that is primarily agricultural or wetland before entering Dunes Lake (Door County SWD 2000). The creek is classified as a limited aquatic life stream and has a history of fish kills and poor water quality.

The survey location on Geisel Creek was upstream of Dunn Road (N44.8939, W-087.2656 to N44.8947, W-087.2658), averaged 1.92 meters in width and was 92 meters in length. The stream had a gradient of 1.8 meters per kilometer, and a sinuosity of 1 to 1.16 at this location (Door County SWD 2000). The study reach of the river ran through meadow and shrub land (Figure 21).

Figure 21. Looking upstream at the abundant shrub cover on Geisel Creek above Dunn Road.

Discharge

Water level was judged to be normal for the date of the habitat survey and water clarity was rated as stained. Flow was 0.031 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of riffles, runs, and pools with 24.2 meters of riffles, 25.7 meters of pools and 57.6 meters of run. Habitat features ranged in length from 1.3 m to 5.7 meters for riffles, 2.2 meters to 13.4 meters for pools and 4.1 meters to 42.4 meters for runs. A small amount of bank erosion or bare soil was noted along most transects in this survey site. Overhanging vegetation, undercut banks and woody debris provided cover for fish in the deeper areas of the stream.

Sand and cobble were the dominant substrates in this section of surveyed stream (Figure 22). Substrates encountered at lower frequency included gravel or boulder and a small amount of a sand-silt mixture.

Figure 22. Bottom sediment map and key for the survey site upstream of Dunn Road on Geisel Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were not collected from this location on Geisel Creek. At the time electroshocking, only a small pool at the very start of the station contained water from which a single brook stickleback was captured. The remainder of the station was dry.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment visit.

Instantaneous DO and temperature information were collected at this location on June 30. At this time, DO was 7.82 mg/l, and the stream water temperature was 18.0 C.

Lilly Bay Creek

Lilly Bay Creek is a 11.2 km stream that drains a 28.49 km^2 watershed before entering Lake Michigan (Door County SWD 2000). Lower sections of the river are classified as Class 2 trout water while upper reaches of the creek are intermittent. Lower reaches of the creek are forested with upper reaches bordered by agricultural land or grassland.

The survey location on Lilly Bay Creek was upstream of North Lake Michigan Road (N44.8498, W-087.2741 to N44.8494, W-087.2755), averaged 3.5 meters in width and was 125 meters in length. The gradient was 3.6 meters per kilometer, and the sinuosity was 1 to 1.35 (Door County SWD 2000). The study reach of the river ran through meadow and woodland (Figure 23).

Figure 23. Looking upstream at the downed cedar that was common throughout the survey site on Lilly Bay Creek.

Discharge

Water level was judged to be normal for the date of the habitat survey and water clarity was rated as clear. Flow was 0.019 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained an equal mixture of runs and pools with 59.3 meters of pools and 69.3 meters of run. No riffles were encountered. Habitat feature ranged in length from 8.8 meters to 22.5 meters for pools and 7.0 meters to 36.2 meters for runs. Bare soil was common along stream banks but erosion of the bank was not noted despite the bare soil. Undercut banks and woody debris provided cover for fish in the deeper areas of the stream.

Silt was the dominant substrate in this section of surveyed stream (Figure 24). Less common substrates included sand, detritus/wood and a small patch of cobble. Soft bottom sediments were encountered along nearly every transect at this site.

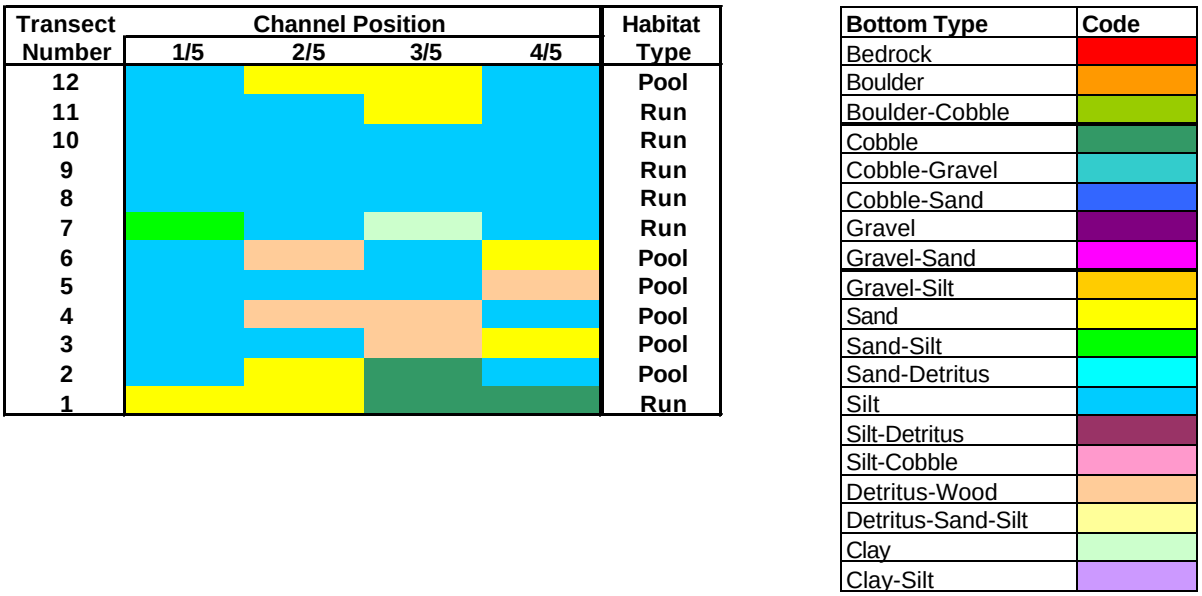


Figure 24. Bottom sediment map and key for the survey site upstream of N. Lake Michigan Road on Lilly Bay Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were not collected from this location on Lilly Bay Creek.

Electroshocking was difficult at this location because of soft bottom sediments and resulted in only one brook stickleback being captured. This resulted in an IBI rating of poor for the fish in this section of Lilly Bay Creek. However, before electroshocking began, several young-of-year northern pike were observed in a pool downstream of the survey site which indicates that Lily Bay Creek can and does support a more diverse fish than was captured during electroshocking.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment and fishery survey visits to Lilly Bay Creek.

Instantaneous DO and temperature information were collected at this location on June 30 and July 15. On June 30, DO was 8.42 mg/l, the stream water temperature was 16.4 C and the air temperature was 18.5 C. On July 15, DO was 7.77 mg/l, the stream water temperature was 18.1 and the air temperature was 22.0 C.

Red River/Sturgeon Bay Watershed

Smith Creek

Smith Creek is a 4 km stream that flows through agricultural land before entering Green Bay (WDNR 1995). Upper reaches of the stream are intermittent which limits the potential fish community in that portion of the stream to species that are tolerant to warm water and low dissolved oxygen levels. Lower sections provide access to migratory fish such as white sucker and smelt that move upstream from Green Bay.

The survey location on Smith Creek was upstream of Town Hall Road (N44.6323, W-087.7587 to N44.6318, W-087.7592), averaged 1.42 meters in width and was 94 meters in length. The stream had a gradient of 2.1 meters per kilometer, and a sinuosity of 1 to 1.27. The study reach of the river ran through meadow and woodland (Figure 25).

Figure 25. An upstream view of Smith Creek that was typical of of the habitat along the stream corridor.

Discharge

Water level was judged to be normal for the date of the habitat survey and water clarity was rated as clear. Flow was 0.005 cubic meters per second (CMS) at this site.

Habitat

The dominant habitat feature in the surveyed section of river was pool with substantially fewer riffles or runs. Habitat feature ranged in length from 4.6 meters to 21.6 meters for pools, 1.0 meters to 9.3 meters for riffles and 5.4 meters to 7.4 meter for runs. Bare soil and bank erosion was common throughout the survey site. The shallow water that was encountered during the survey did not provide cover for fish.

Cobble, gravel or sand were the dominant substrates in this section of surveyed stream (Figure 26). Substrates encountered at lower a frequency included boulder, clay or mixtures of cobble, gravel and sand.

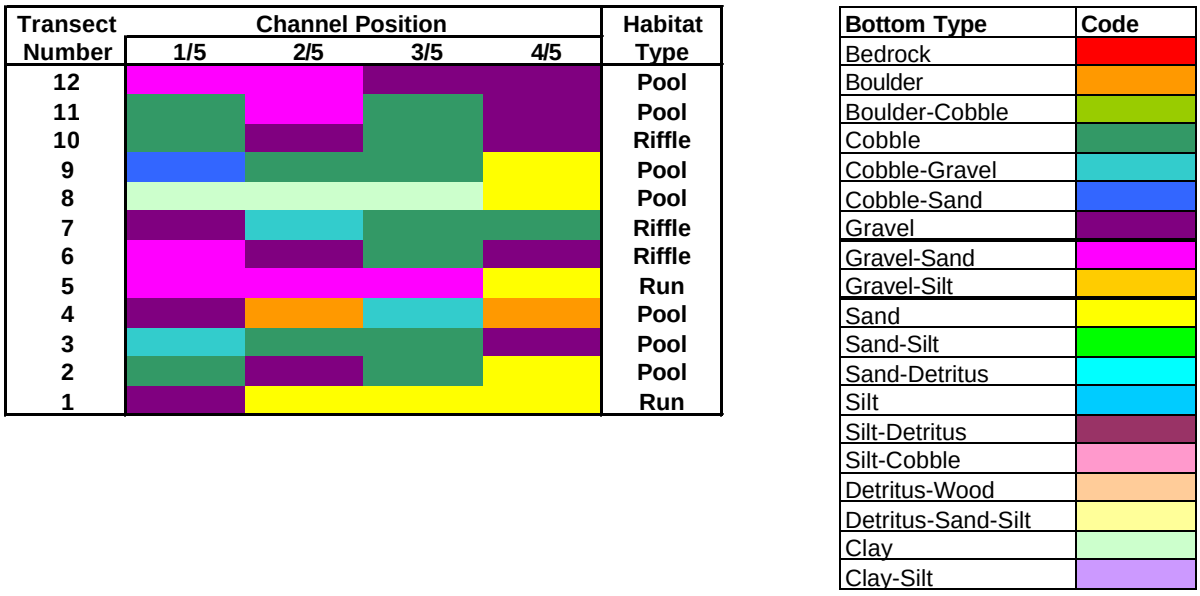


Figure 26. Bottom sediment map and key for the survey site upstream of Town Hall Road on Smith Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were not collected from this location on Smith Creek.

Before electroshocking began, many young-of-year white sucker were observed in the pool downstream of the survey site as well as several dead adult white sucker. Electroshocking resulted in two young-of-year white sucker captured because most of the small suckers were smaller than the mesh openings of the dip nets. This resulted in an IBI rating of very poor for the fishery of Smith Creek.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment visit to Smith Creek on June 18. On that date, DO was 7.81 mg/l and the stream temperature was 20.0 C.

Red River

Red River is 13.8 km stream that drains an agricultural watershed before entering Green Bay (WDNR 1995). It is classified as a limited aquatic life stream because of intermittent flows and poor water quality. The erodible clay soils in this watershed cause the stream to be very turbid during runoff events (Gansberg 1994). Lower reaches below State Highway 57 likely support a forage fishery derived from migratory runs of fish from Green Bay.

The survey location on Red River was upstream of County Highway A (N44.6594, W-087.7280 to N44.6591, W-087.7271), averaged 3.1 meters in width and was 105 meters in length. The gradient was 3.68 meters per kilometer, and had a sinuosity of 1 to 1.27 at this survey site. The study reach of the river ran through meadow and shrubs (Figure 27).

Figure 27. Looking upstream at Red River from above County Highway A. Just upstream of this location is a small waterfall.

Discharge

Water level was judged to be normal for the date of the habitat survey and water clarity was rated as stained. Flow was 0.21 cubic meters per second (CMS) at this site.

Habitat

The dominant habitat feature in the surveyed section of river was riffle with substantially fewer runs. No pools were observed. Habitat feature ranged in length from 19.9 meters to 29.1 meters for riffles and 5.6 meters to 12.1 meter for runs. Bare soil and bank erosion were not seen at this location. Boulders provided cover for fish in this survey section although shallow water limited their effectiveness as cover.

Bedrock was the most common substrate along transects in lower sections of this survey site. Boulders were common in middle transects and finally in upper transects, cobble was the dominant substrate (Figure 28).

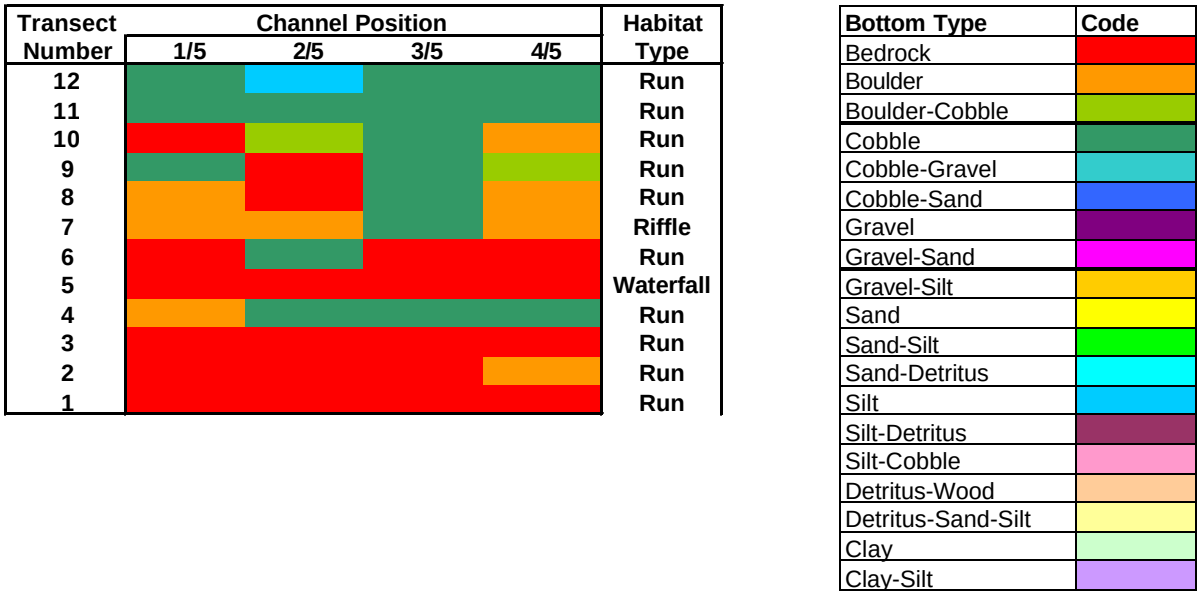


Figure 28. Bottom sediment map and key for the survey site upstream of County Highway A on Red River. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were not collected from this location on Red River.

Before electroshocking began, many young-of-year fish were observed in the pool downstream of the survey site. Electroshocking resulted in two blacknose dace and one brook stickleback being captured. Other small fish were not captured because they were smaller than the mesh openings of the dip nets. The IBI score was 15 indicating the fish community found in Red River was very poor.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment visit to Red River on June 18. On that date, DO was 8.91 mg/l and the stream temperature was 20.1 C.

Renard Creek

Renard Creek is a 9.6 km stream that drains a 15.54 km^2 watershed (Door County SWD 2000). The upper reaches of the stream flow through agricultural land with little stream bank canopy while lower reaches are wooded and flow through low density residential land. The water quality of the stream has been negatively impacted by sediment and nutrient enrichment and its fish commnity has been dominated by warmwater forage species (WDNR 1995).

The survey location on Renard Creek was upstream of Shoemaker Road (N44.7172, W-087.7011 to N44.7176, W-087.7001). The Renard Creek survey section averaged 1.9 meters in width and was 96 meters in length. The gradient was 6.6 meters per kilometer, and the sinuosity was 1 to 1.53. The study reach of the river ran through meadow and woodland (Figure 29).

Figure 29. Stream width being measured on Renard Creek.

Discharge

Water level was judged to be normal for the date of the habitat survey and water clarity was rated as clear. Flow was 0.041 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of runs, riffles and pools with 43.9 meters of riffles, 21.2 meters of run and 26.3 meters of pools. Habitat feature ranged in length from 5.0 meters to 16.5 meters for riffles, 6.1 meters to 12.2 meters for pools and 4.1 meters to 6.7 meter for runs. Bare soil and bank erosion was slight in this survey location. Boulders and over hanging vegetation provided cover for fish in this stream section although shallow water limited their effectiveness as cover.

Gravel was the most common substrate at this location (Figure 30). Lesser amounts of boulder, cobble or sand were encountered on Renard Creek.

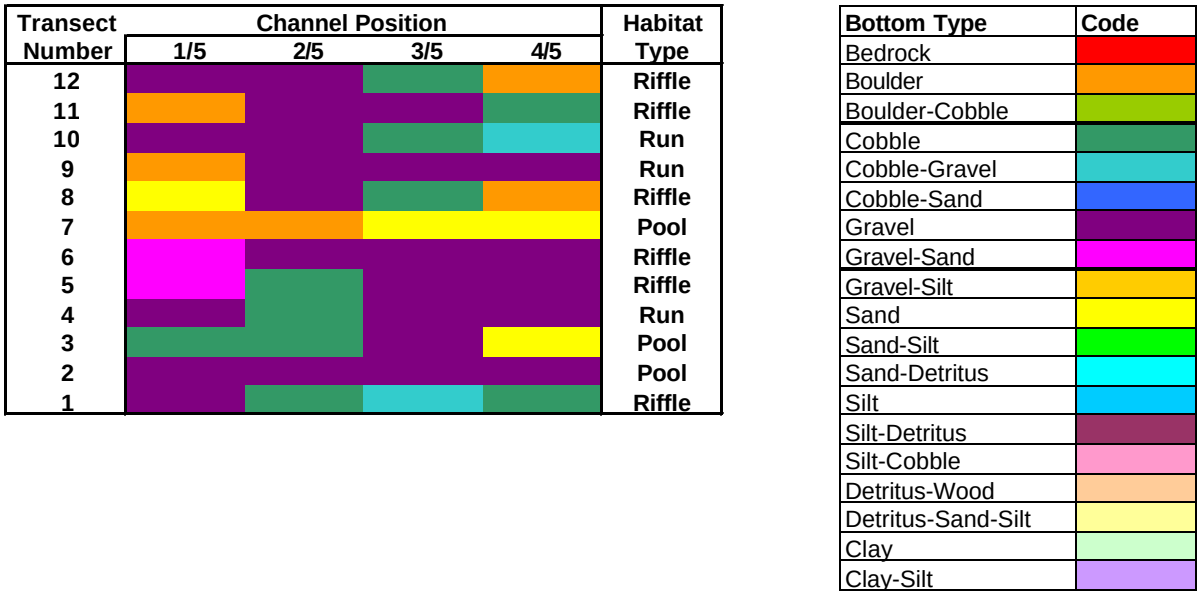


Figure 30. Bottom sediment map and key for the survey site upstream of Shoemaker Road on Renard Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were collected from the first upstream riffle at this location on Renard Creek. Results indicate that a diverse community of invertebrates are found in the stream with stoneflies, mayflies and several species of Dipterans dominating community. The HBI score was 4.682 indicating that water quality was good at this location.

Fish were collected during a single upstream transit of the survey section. A total of 18 individual fish representing seven species were captured (Table 5). The IBI score for this survey section was 10 indicating a very poor fish community.

Table 5. The species and abundance of fish captured from electroshocking in Renard Creek at Shoemaker Road.

Species	Abundance
Central Mudminnow	1
Bluntnose Minnow	11
Fathead Minnow	1
Blacknose Dace	1
Pearl Dace	2
Brook Stickleback	1
Mottled Sculpin	1
Total	**18**

Bluntnose minnow was the dominant species of fish captured during the survey with substantially fewer individuals of other species collected during shocking.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected with a continuous monitor and during the habitat assessment visit.

Instantaneous DO and temperature information were collected at this location on June 19. At this time, DO was 9.88 mg/l, and the stream water temperature was 13.2 C.

Continuous monitoring of Renard Creek at Shoemaker Road showed several dissolved oxygen water quality violations (Figure 31). During six of twenty-six nights dissolved oxygen levels fell below 5 mg/l for short periods of time in the late evening hours, but quickly rebounded. This is extremely stressful to aquatic life. Nutrient enrichment and algal photosynthesis and respiration when higher temperatures depress oxygen solubility cause these diurnal fluctuations. Water temperature ranged from 12 to 21 degrees C with a mean of 17 degrees C. pH was normal with a mean of 8.2 and specific conductivity was also normal for this type of stream with a mean of 812 uS/cm.

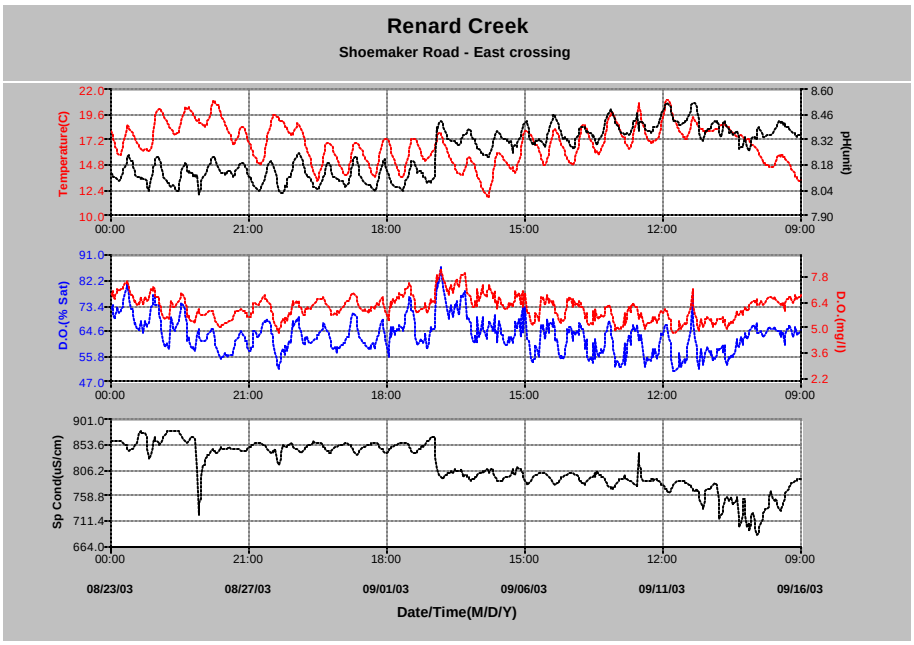


Figure 31. Continuous monitoring data collected at Shoemaker Road on Renard Creek.

Sugar Creek

Sugar Creek is a 16 km stream that drains a 36.26 km^2 watershed (Door County SWD 2000). Upper reaches flow intermittently through wetland while lower reaches are rocky and have perennial flow. Sugar Creek is classified as a warmwater forage fishery throughout its entire length (WDNR 1995).

The survey location on Sugar Creek was upstream of Gardner Road (N44.7633, W-087.6616 to N44.7586, W-087.6594). The Sugar Creek survey section averaged 2.7 meters in width although some transects reached 10 meters width in wetland areas. Through the 95 meter study section, the creek had a gradient of 3.4 meters per kilometer, and a sinuosity of 1 to 1.33. The study reach of the river ran through a shrub-meadow-wetland complex (Figure 32).

Figure 32. Looking upstream at the thick wetland and shrub vegetation that was common throughout the study site on Sugar Creek above Gardner Road.

Discharge

Water level was judged to be normal for the date of the habitat survey and water clarity was rated as clear. Flow was 0.035 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of runs, riffles and pools with 39.4 meters of riffles, 28.9 meters of run and 30.9 meters of pools encountered. Habitat feature ranged in length from 1.0 meters to 17.5 meters for riffles, 3.3 meters to 8.2 meters for pools and 2.0 meters to 8.0 meter for runs. Bare soil and bank erosion was slight in this survey location and did not appear to cause sedimentation in the creek. Over hanging vegetation provided cover for fish in this stream section although shallow water limited their effectiveness as cover.

Cobble was the most common substrate at this location (Figure 33). Lesser amounts of gravel, boulder or sand were encountered on Sugar Creek. Several areas of detritus were also noted.

Figure 33. Bottom sediment map and key for the survey site upstream of Gardner Road on Sugar Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were collected from the first upstream riffle at this location on Sugar Creek. Results indicate that amphipods and beetles dominated the invertebrate community. The HBI score was 4.763 indicating that the water quality was good at this location.

Fish were collected during a single upstream transit of the survey section. A total of 31 individual fish representing six species were captured (Table 6). The IBI score for this survey section was 35 indicating a fair fish community.

Table 6. The species and abundance of fish captured from electroshocking in Sugar Creek at Gardner Road.

Species	Abundance
Central Mudminnow	8
Creek Chub	2
Blacknose Dace	1
Pearl Dace	18
Brook Stickleback	1
Johnny Darter	1
Total	**31**

Pearl dace was the dominant species of fish captured during the survey followed by central mudminnow. Other species were collected in substantially lower number.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment visit and with a continuous monitor.

Instantaneous DO and temperature information were collected at this location on June 19. At this time, DO was 8.7 mg/l, and the stream water temperature was 19.0 C.

A continuous monitor at Gardner Road showed that Sugar Creek maintained good water quality throughout the monitoring period (Figure 34). Dissolved oxygen ranged from 5.3 to 8.8 mg/l with normal diel swings. Water temperature ranged from 11 to 22 degrees C with a mean of 17 degrees C. pH was normal with a mean of 8.2. Specific conductivity was also normal for this type of stream with a mean value of 723 uS/cm. Five rain events during the sampling period documented a temporary lowering of conductivity, water temperature, and dissolved oxygen levels although levels quickly rebounded.

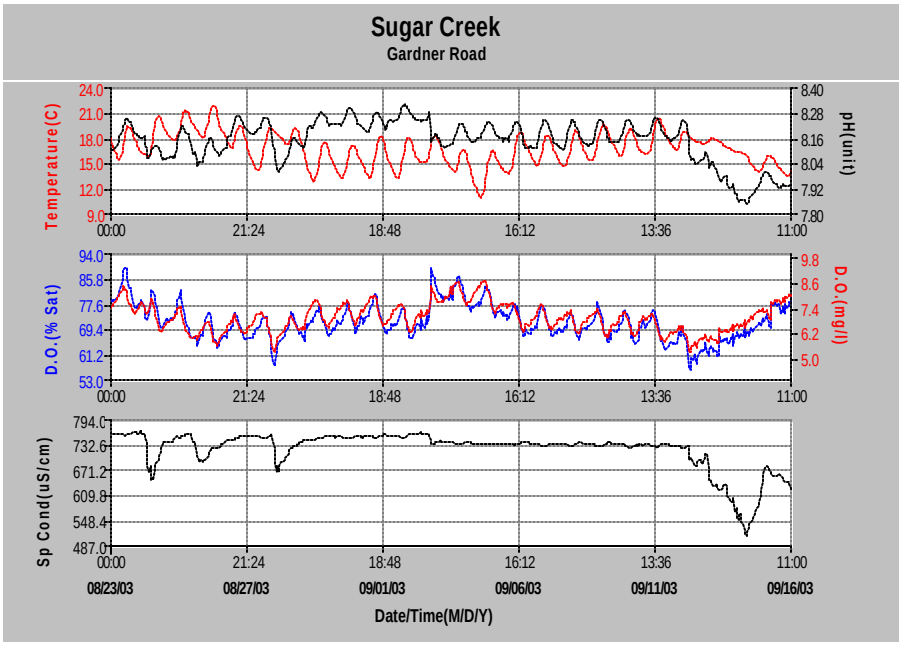


Figure 34. Continuous monitoring data collected at Gardner Road on Sugar Creek.

Kayes Creek

Kayes Creek is a 11.2 km creek that drains a series of springs and flows through Gardner State Wildlife Area before entering Little Sturgeon Bay (Door County SCD 2000). Lower stream sections are classified as either a warmwater forage or sport

fishery with upper sections classified as trout water. Agricultural runoff contributes sediment and nutrients to Kayes Creek that negatively affect water quality in the stream.

The survey location on Kayes Creek was upstream of Fox Lane (N44.8092, W-087.5866 to N44.8083, W-087.5869). The Kayes Creek survey section averaged 6.2 meters in width and was 225 meters in length. Kayes Creek has a gradient of 1.5 meters per kilometer, and a sinuosity of 1 to 1.28 at this location. The study reach of the river ran through meadow and pasture (Figure 35).

Figure 35. Looking upstream at the meadow-pasture that was common throughout the survey site on Kayes Creek.

Discharge

Water level was judged to be normal for the date of the habitat survey and water clarity was rated as clear. Flow was 0.019 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of runs, riffles and pools although runs were the dominant habitat feature. The study site contained 31.4 meters of riffles, 62.9 meters of pool and 131.9 meters of run. Habitat feature ranged in length from 22.0 meters to 40.9 meters for pools, 27.5 meters to 62.0 meter for runs and the single riffle was 31.4 meters in length. Bare soil and bank erosion was common throughout the survey site. Woody debris and boulders provided cover for fish in this stream section and were found in or near pools.

Sand was the most common substrate at this location (Figure 36). Lesser amounts of silt, clay or cobble were encountered on Kayes Creek. Several small areas of gravel or boulder were also noted at this location.

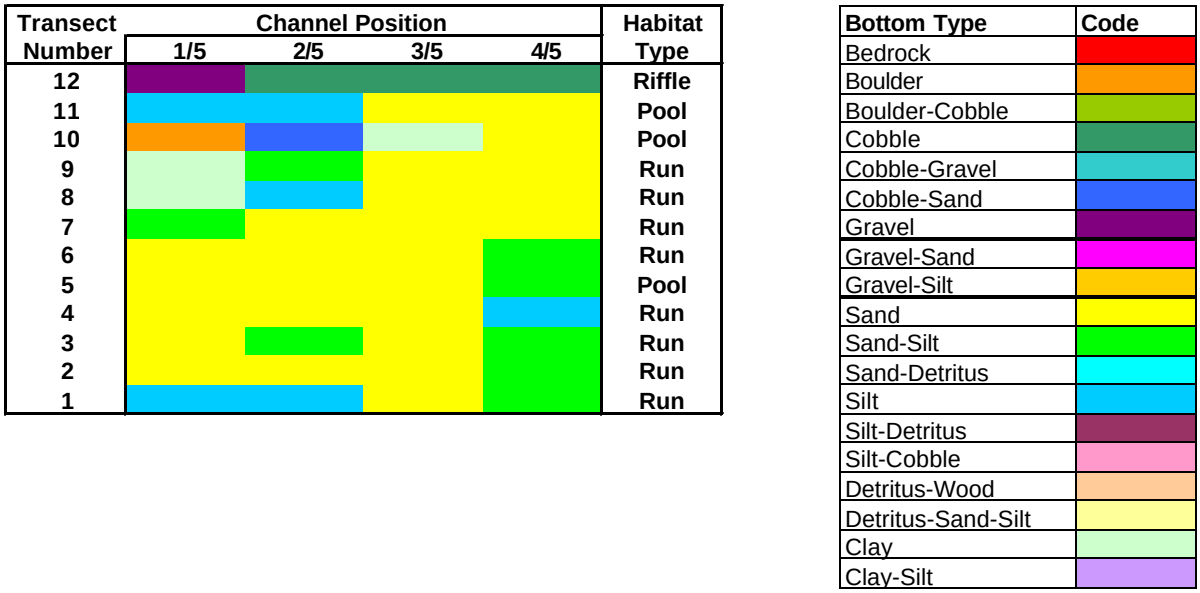


Figure 36. Bottom sediment map and key for the survey site upstream of Fox Lane on Kayes Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were collected from the first upstream riffle at this location on Kayes Creek. Results indicate that isopods and amphipods dominated the invertebrate community. The HBI was 6.165 indicating that water quality was fair at this location.

Fish were collected during a single upstream transit of the survey section. A total of 120 individual fish representing five species were captured (Table 7). The IBI score for this survey section was 20 indicating a poor fish community.

Table 7. The species and abundance of fish captured from electroshocking in Kayes Creek at Fox Lane.

Species	Abundance
Central Mudminnow	115
Northern Pike (yoy)	1
Northern Redbelly Dace	2
Fathead Minnow	1
Black Bullhead	1
Total	**120**

Central mudminnow was the dominant species of fish captured during the survey. Other species were collected in substantially lower number. The captured northern pike was 115 mm in length and the black bullhead was 145 mm in length.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment visit and with the use of a continuous monitor.

Instantaneous DO and temperature information were collected at this location on June 26. At this time, DO was 8.76 mg/l, and the stream water temperature was 24.0 C.

Continuous monitoring on Kayes Creek at Fox Lane showed almost daily dissolved oxygen problems (Figure 37). Dissolved oxygen routinely fell below the 5 mg/l state standard in the late evening hours and during rainfall events. Dissolved oxygen dropped as low as 3.5 mg/l however, quickly rebounded during daylight photosynthesis periods. Water temperature ranged from 13 to 32 degrees C with a mean of 20.7 degrees C. This stream gets much warmer than Renard Creek or Sugar Creeks (high of 22 degrees C in Sugar Creek). The mean pH of 7.8 was somewhat lower in Kayes Creek than in Renard and Sugar but still in the normal range for this type of stream. Specific conductivity in Keyes Creek ranged from 395 to 633 with an average of 582 uS/cm.

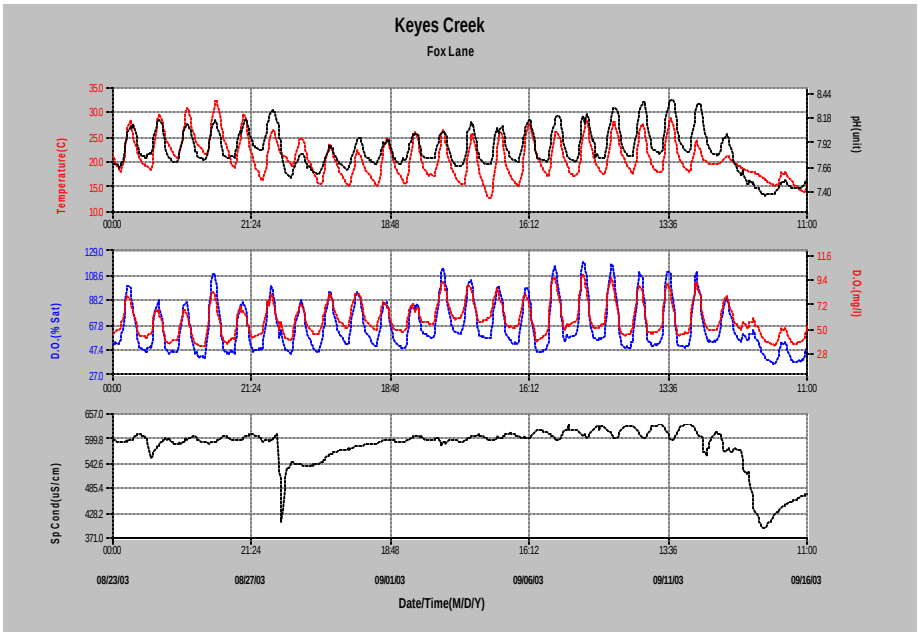


Figure 37. Continuous monitoring data collected at Fox Road on Kayes Creek.

Malvitz Creek

Malvitz Creek is a small, 1.6 km creek that is intermittent in years with low precipitation (Door County SWD 2002). Lower reaches are classified as a forage fishery, although in high water years the creek can experience runs of sport and forage fish from Green Bay. Upper reaches are classified as having limited aquatic life (WDNR 1995).

The survey location on Malvitz Creek was upstream of County Highway C (N44.8198, W-087.5525 to N44.8192, W-087.5523). The survey section averaged 2.0 meters in width and was 92 meters in length. Malvitz Creek has a gradient of 3.3 meters per kilometer, and a sinuosity of 1 to 1.3 at this location. The study reach of the river ran through meadow-shrub-woodland landscape (Figure 38).

Figure 38. A typical view of Malvitz Creek looking upstream above County Highway C.

Discharge

Water level was judged to be normal for the date of the habitat survey and water clarity was rated as clear. Flow was 0.019 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of runs, riffles and pools although riffles were the dominant habitat feature. The study site contained 73.2 meters of riffles, 5.0 meters of pool and 18.7 meters of run. Habitat features ranged in length from 1.0 meters to 57.3 meters for riffles, 2.0 meters to 3.0 meters for pools, and 2.6 meters to 12.0 meters for runs. Bare soil was common throughout the survey site although

erosion did not appear to be a problem. Shallow water depth did not allow for fish cover although over-hanging vegetation was common throughout the survey site.

Cobble was the most abundant substrate at this location although other hard substrates such as boulder, gravel or bedrock were also commonly encountered (Figure 39). Lesser amounts of sand or detritus were measured at this location despite the abundance of bare soil along the stream bank.

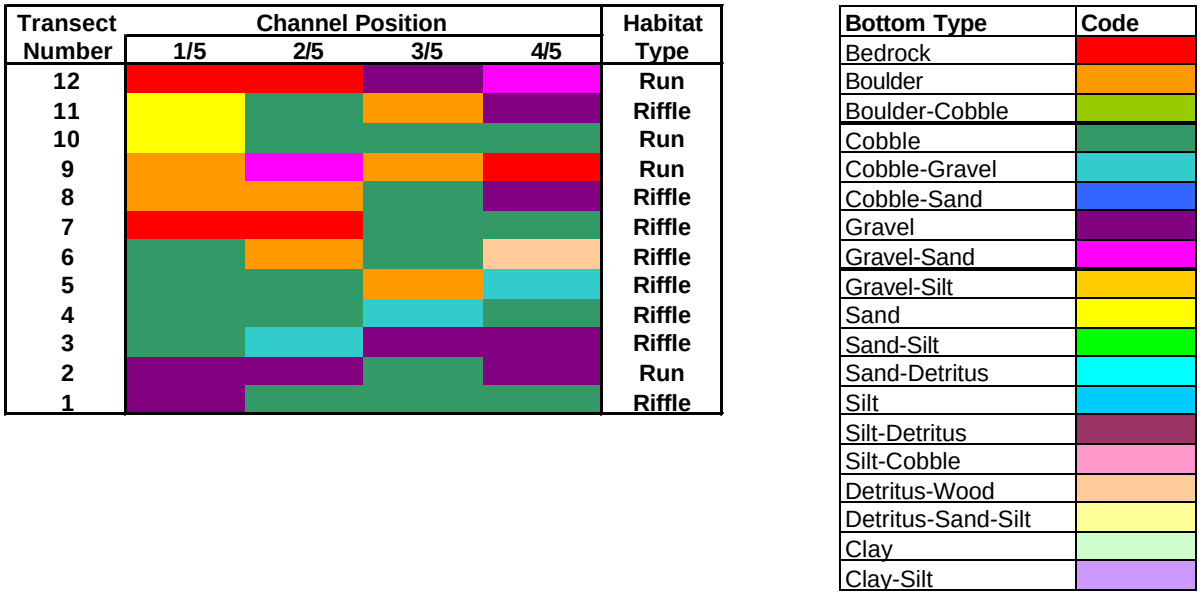


Figure 39. Bottom sediment map and key for the survey site upstream of County Highway C on Malvitz Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were collected from the first upstream riffle at this location on Malvitz Creek. Results indicate that isopods dominated the invertebrate community with substantially fewer beetle and amphipods collected. The HBI score was 7.169 indicating that water quality was fair at this location.

Fish were collected during a single upstream transit of the survey section. A total of 4 individual fish representing two species were captured. The captured fish included a single northern pike that was 91 mm in length and three yellow perch that ranged from 41 mm to 45 mm in length. The IBI score for this survey section was 40 indicating a fair fish community. Also noted at this site were frogs and numerous small crayfish.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the fisheries assessment visit to the survey site. On July 15, DO was 8.12 mg/l, the stream water temperature was 19.9 C and the air temperature was 21.5 C.

Larson Creek

Larson Creek is a 6.4 km that originates in a wetland and flows though agricultural land before entering Green Bay (Door County SWD 2000). The creek can be intermittent and is classified as a warm water forage fishery (WDNR 1995). Non point source pollution from agricultural lands negatively impact the water quality of the creek.

The survey location on Larson Creek was upstream of Eliason Road (N44.8568, W-087.4672 to N44.8559, W-087.4670). The survey section averaged 1.9 meters in width and was 92 meters in length. Larson Creek has a gradient of 8.8 meters per kilometer, and a sinuosity of 1 to 1.22 at this location. The study reach of the river ran through a meadow and shrub landscape (Figure 40).

Figure 40. Thick, overhanging grass was common throughout the survey site on Larson Creek.

Discharge

Water level was judged to be normal for the date of the habitat survey and water clarity was rated as clear. Flow was 0.001 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of runs, riffles and pools although runs were the dominant habitat feature. The study site contained 7.1 meters of riffles, 15.3 meters of pool and 75.7 meters of run. Habitat features ranged in length from 1.0 meter to 4.1 meters for riffles, 2.9 meters to 8.3 meters for pools, and 6.1 meters to 21.0 meters for runs. It appears this section of stream had been channelized within the past

20 years. Bare soil or erosion was uncommon at this site although undercut banks were present along several transects. Over hanging vegetation and undercut banks provided cover for fish in this stream section.

Sand, gravel or clay were the most abundant substrates at this location (Figure 41). Other substrates such as boulder, cobble or detritus were also encountered although in lower amounts during the survey.

Figure 41. Bottom sediment map and key for the survey site upstream of Eliason Road on Larson Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were collected from the first upstream riffle at this location on Larson Creek. Results indicate that isopods dominated the community. The HBI score was 7.111 indicating fair water quality at this location.

Fish were collected during a single upstream transit of the survey section. One central mudminnow was captured during electroshocking.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat and fisheries assessment visits.

Instantaneous DO and temperature information were collected at this location on July 3 and 15. On July 3, DO was 8.5 mg/l, the stream water temperature was 20.2 C and the air temperature was 22.1 C. During the fisheries assessment on July 15, DO was 8.27 mg/l, the stream water temperature was 19.2 C and the air temperature was 21.5 C.

Stony Creek Watershed

Clay Banks Creek

Little historic information exists for this small, intermittent stream that flows through agricultural and low density residential land before entering Lake Michigan south of Sturgeon Bay.

The survey location on Clay Banks Creek was upstream of Hornspier Road (N44.7576, W-087.3528 to N44.7580, W-087.3528). The survey section on Clay Banks Creek averaged 1.8 meters in width and was 99 meters in length. Clay Banks Creek has a gradient of 2.0 meters per kilometer, and a sinuosity of 1 to 1.13 at this location. The study reach of the river ran through 100 percent woodland (Figure 42).

Figure 42. Field staff measuring habitat on Clay Banks Creek. The bare soil banks that can be seen in this picture were common throughout the site.

Discharge

Water level was judged to be 0.25 meters above normal for the date of the habitat survey and water clarity was rated as clear. Flow was 0.025 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of runs, riffles and pools although runs were the dominant habitat feature in the study site. The study site contained 15.2 meters of riffles, 20.2 meters of pool and 63.5 meters of run. Habitat features ranged in

length from 4.4 meters to 10.8 meters for riffles, 0.3 meters to 8.5 meters for pools, and 0.2 meters to 25.2 meters for runs. Bare soil or erosion was commonly observed at this site. Undercut banks provided a limited amount of cover for fish in this stream section.

Sand was the most abundant substrate encountered at this location (Figure 43). Other substrates such as clay, cobble, detritus/wood and boulder were also encountered at this site although in lower frequency.

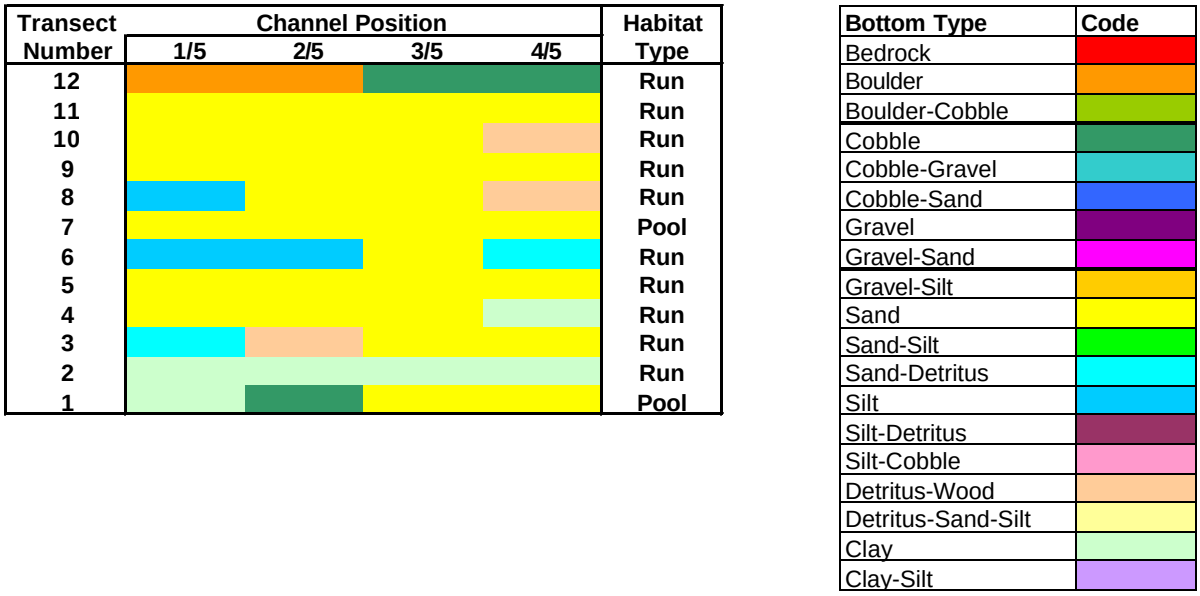


Figure 43. Bottom sediment map and key for the survey site upstream of Hornspier Road on Clay Banks Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were not collected at this location on Clay Banks Creek.

Fish were collected during a single upstream transit of the survey section. A total of 62 mottled sculpin and 4 brook stickleback were captured during electroshocking. The collected species fish resulted in a IBI score of 40 indicating a fair fish community.

Dissolved Oxygen and Temperature

Instantaneous DO and temperature information were collected at this location on August 4 and 7 during habitat and fisheries assessment visits. On August 4, DO was 8.27 mg/l, the stream water temperature was 14.7 C and the air temperature was 20 C. During the fisheries assessment on August 7, DO was 8.66 mg/l, the stream water temperature was 15 C and the air temperature was 22.8 C.

Woodward Creek

Woodward Creek is a 6.4 km creek that drains a 12.95 km^2 watershed before entering Lake Michigan. Upper reaches can be intermittent, while lower reaches that have a more stable base flow experience migratory runs of Lake Michigan fish (Door County 2000). The stream is classified as a warmwater forage fishery (WDNR 1995).

The survey location on Woodward Creek was upstream of County Highway U (N44.7334, W-087.3564 to N44.7337, W-087.3570). The survey section on Woodward Creek averaged 1.7 meters in width and was 92 meters in length. Woodward Creek has a gradient of 8.4 meters per kilometer, and a sinuosity of 1 to 1.56 at this location. The study reach of the river ran through a meadow-shrub woodland landscape (Figure 44).

Figure 44. Field staff measuring feature length on Woodward Creek.

Discharge

Water level was judged to be 0.15 meters above normal for the date of the habitat survey and water clarity was rated as clear. Flow was 0.026 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of runs, riffles and pools although runs were the dominant habitat feature in the study site. The study site contained 9.4 meters of riffle, 26.5 meters of pool and 63 meters of run. Habitat features ranged in length from 4.2 meters to 5.2 meters for riffles, 2.1 meters to 6.5 meters for pools, and 2.1 meters to 20.3 meters for runs. Bare soil or erosion was commonly observed at this site. Undercut

banks and woody debris provided a limited amount of cover for fish in this stream section.

Sand was the most abundant substrate encountered at this location (Figure 45). Other substrates such as clay, gravel, detritus/wood or boulder were also encountered at this site although in lower frequency.

Figure 45. Bottom sediment map and key for the survey site upstream of County U on Woodward Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were collected at the first upstream riffle at this location on Woodward Creek. Results indicate that isopods, beetles and caddis flies dominated the invertebrate community. The HBI score was 5.497 indicating that water quality was good at this location.

Fish were collected during a single upstream transit of the survey section. A total of 49 brook stickleback, 3 white sucker and 27 creek chub were captured during electroshocking. The collected species fish resulted in an IBI score of 40 indicating a fair fish community.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat and fisheries assessment visits.

Instantaneous DO and temperature information were collected at this location on August 4 and 7. On August 4, DO was 8.19 mg/l, the stream water temperature was 17.6 C and the air temperature was 24.2 C. During the fisheries assessment on August 7, DO was 7.98 mg/l, the stream water temperature was 18.3 C and the air temperature was 23.2 C.

Schuyler Creek

Schuyler Creek is 6.4 km stream that is classified as a warm water forage fishery. It flows through agricultural land and woodland before entering Lake Michigan.

The survey location on Schuyler Creek was upstream of Midway Road (N44.7119, W-087.3625 to N44.7127, W-087.3629). The survey section on Schuyler Creek averaged 2.0 meters in width and was 92 meters in length. Woodward Creek has a gradient of 2.4 meters per kilometer, and a sinuosity of 1 to 1.06 at this location. The study reach of the river ran through a meadow and shrub landscape before becoming mostly woodland (Figure 46).

Figure 46. Field staff measuring stream width on Schuyler Creek. Dense vegetation was common throughout the survey site.

Discharge

Water level was judged to be 0.1 meter above normal for the date of the habitat survey and water clarity was rated as stained. Flow was 0.016 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of runs, riffles and pools although run was the dominant habitat feature in the study site. The study site contained 6.5 meters of riffle, 14.7 meters of pool and 37.1 meters of run. Habitat feature ranged in length from 6.5 meters to 22.2 meters for riffles, 14.7 meters for the single pool, and 3.5 meters to 27.0 meters for runs. Bare soil or erosion was uncommonly observed at this site. Undercut banks, over hanging vegetation and boulders provided cover for fish in this stream section.

Gravel and sand were the most abundant substrates encountered at this location (Figure 47). Other substrates such as cobble or boulder were also encountered at this site although in lower frequency.

Figure 47. Bottom sediment map and key for the survey site upstream of Midway Road on Schuyler Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were not collected from this location.

Fish were collected during a single upstream transit of the survey section. A total of 8 brook stickleback were captured during electroshocking. The collected species fish resulted in an IBI score of 20 indicating a poor fish community.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat and fisheries assessment visits.

Instantaneous DO and temperature information were collected at this location on August 5 and 7. On August 5, DO was 9.23 mg/l, the stream water temperature was 17.1 C and the air temperature was 21.6 C. During the fisheries assessment on August 7, DO was 8.25 mg/l, the stream water temperature was 18.9 C and the air temperature was 23 C.

Bear Creek

Bear Creek is a 6 km, high gradient stream that drains a 12.95 km^2 watershed of glacial drift before entering Lake Michigan (Door County SWD 2000). Although the stream is classed as a warm water forage fishery, Avery (1974) documented that Lake Michigan trout were spawning successfully in the creek. During high water years, other Lake Michigan fish run up Bear Creek and use it for spawning.

The survey location on Bear Creek was upstream of Shiloh Road (N44.7039, W-087.3769 to N44.7036, W-087.3776). The survey section on Bear Creek averaged 1.8 meters in width and was 93.3 meters in length. Bear Creek has a gradient of 6.3 meters per kilometer, and a sinuosity of 1 to 1.43 at this location. The study reach of the river ran through a meadow and shrub landscape (Figure 48).

Figure 48. Thick meadow vegetation was common in lower reaches of the study site on Bear Creek before giving way to shrubs in upper reaches.

Discharge

Water level was judged to be 0.15 meters above normal for the date of the habitat survey and water clarity was rated as stained. Flow was 0.0179 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of runs, riffles and pools although runs were the dominant habitat feature in the study site. The study site contained 16.7 meters of riffle, 4.0 meters of pool and 72.6 meters of run. Habitat features ranged in length from 3.8 meters to 8.1 meters for riffles, 4 meters for the single pool, and 4.5 meters to 38.8 meters for runs. The stream channel was braided at several locations, but survey work was conducted on what was judged the main channel. Bare soil or erosion was uncommonly observed at this site. Undercut banks, over hanging vegetation and boulders provided cover for fish in this stream section.

Cobble and gravel were the most abundant substrates encountered at this location (Figure 49). Other substrates such as sand and boulder were also encountered at this site although in lower frequency.

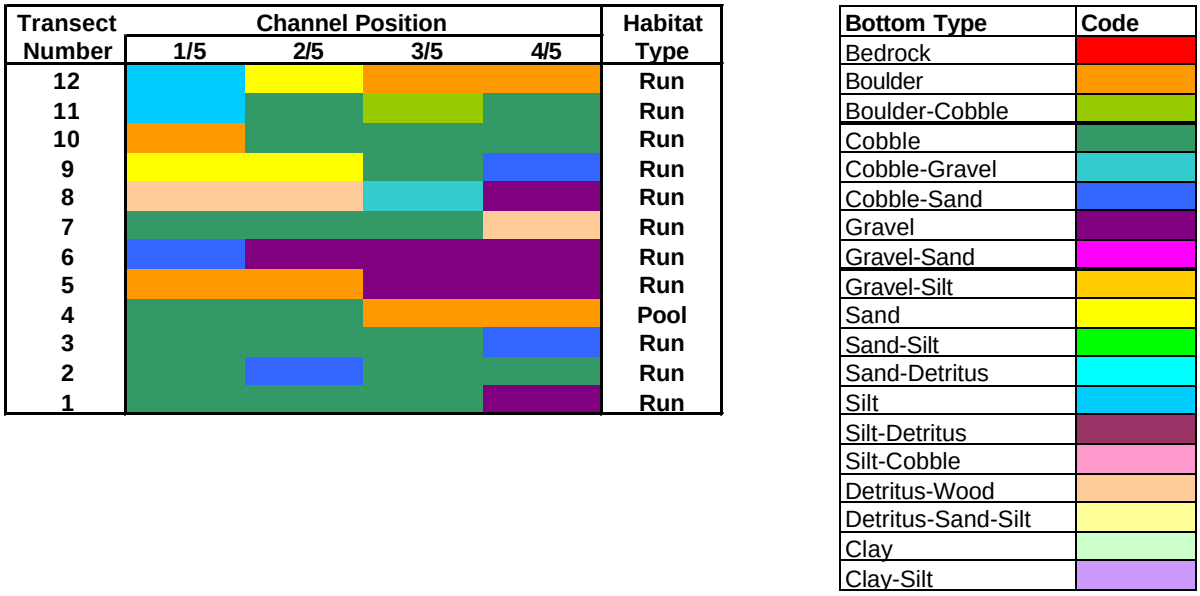


Figure 49. Bottom sediment map and key for the survey site upstream of Shiloh Road on Bear Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were collected from the first riffle upstream of the beginning of the survey site. Results indicate that amphipods, mayflies and beetles were the dominant invertebrate groups collected from this location. The HBI score was 3.680 indicating that water quality was very good at this location.

Fish were collected during a single upstream transit of the survey section. A total of 44 fish of four different species were captured during electroshocking (Table 8).

Table 8. The species and abundance of fish captured from electroshocking in Bear Creek at Shiloh Road.

Species	Abundance
Central Mudminnow	1
Rainbow Trout	3
Brook Stickleback	18
Mottled Sculpin	22
Total	**44**

Mottled sculpin and brook stickleback dominated the catch. The captured rainbow trout ranged in length from 81 mm to 130 mm and are most likely naturally reproduced recruits. The collected species resulted in an IBI score of 45 indicating a fair fish community.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat and fisheries assessment visits to this site.

Instantaneous DO and temperature information were collected at this location on August 5 and 7. On August 5, DO was 8.86 mg/l, the stream water temperature was 17.6 C and the air temperature was 26.2 C. During the fisheries assessment on August 7, DO was 8.46 mg/l, the stream water temperature was 18.0 C and the air temperature was 22.9 C.

Stony Creek (Rosewood Road)

Stony Creek is a 21.9 km, low gradient stream that drains a 60.32 km^2 watershed before entering Lake Michigan (Door County SWD 2000). The upper 17.6 km of the stream is classified as a warmwater forage fishery and can be slow moving with low DO. Lower sections are classified as a Cold Water 2 and are faster flowing with good DO. During high water years, Lake Michigan fish run up Stony Creek.

This survey location on Stony Creek was upstream of Rosewood Road (N44.6829, W-087.4034 to N44.6850, W-087.4040). The survey section on Stony Creek averaged 7.8 meters in width and was 272 meters in length. Stony Creek has a gradient of 4.9 meters per kilometer, and a sinuosity of 1 to 1.42 at this location. The study reach of the river ran through a woodland-shrub landscape (Figure 50).

Figure 50. An upstream look at Stony Creek from above Rosewood Road showing the wooded stream bank and stained water.

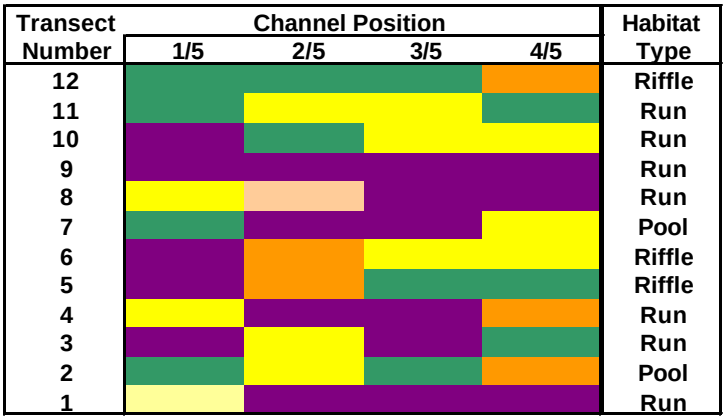
Discharge

Water level was judged to be 0.1 meters above normal for the date of the habitat survey and water clarity was rated as stained. Flow was 0.23 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of runs, riffles and pools. The study site contained 66.3 meters of riffle, 96.6 meters of pool, and 105 meters of run. Habitat features ranged in length from 5.6 meters to 16.8 meters for riffles, 6.5 meters to 21.0 meters for pools, and 4.1 meters to 31.9 meters for runs. Bare soil was observed along most transects although erosion was uncommonly observed at this site. Boulders and macrophytes provided cover for fish in this stream section.

Gravel, cobble or sand were the most abundant substrates encountered at this location (Figure 51). Other substrates such as boulder or wood/detritus were also encountered at this site although in much lower frequency.



Bottom Type	Code
Bedrock	
Boulder	
Boulder-Cobble	
Cobble	
Cobble-Gravel	
Cobble-Sand	
Gravel	
Gravel-Sand	
Gravel-Silt	
Sand	
Sand-Silt	
Sand-Detritus	
Silt	
Silt-Detritus	
Silt-Cobble	
Detritus-Wood	
Detritus-Sand-Silt	
Clay	
Clay-Silt	

Figure 51. Bottom sediment map and key for the survey site upstream of Rosewood Road on Stony Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were collected from the first riffle upstream of the beginning of the survey site. Results indicate that beetles, caddis flies and isopods dominated the invertebrate community at this site. The HBI score for this location was 5.219 which indicates that water quality was good.

Fish were collected during a single upstream transit of the survey section. A total of 191 fish of twelve different species were captured during electroshocking (Table 9).

Table 9. The species and abundance of fish captured from electroshocking in Stony Creek at Rosewood Road.

Species	Abundance
Rainbow Trout	72
Central Mudminnow	8
Hornyhead Chub	9
Common Shiner	9
Fathead Minnow	2
Blacknose Dace	6
Longnose Dace	6
Creek Chub	14
White Sucker	17
Bluegill	1
Johnny Darter	9
Mottled Sculpin	38
Total	**191**

Rainbow trout dominated the catch, with fewer mottled sculpin, white sucker and creek chub captured. The collected species fish resulted in an IBI score of 45 indicating a fair fishery for this location of Stony Creek.

The captured rainbow trout ranged in length from 45 mm to 215 mm and are most likely naturally reproduced recruits, although one rainbow had an adipose left ventral fin clip indicating it was a Ganaraska strain steelhead. It appears from the length frequency that two year classes were present in the sample (Figure 52). The YOY fish ranged in length from 45 mm to 85 mm and averaged 61 mm in length. Age 1 fish ranged in length from 140 mm to 215 mm and had an average length of 175 mm.

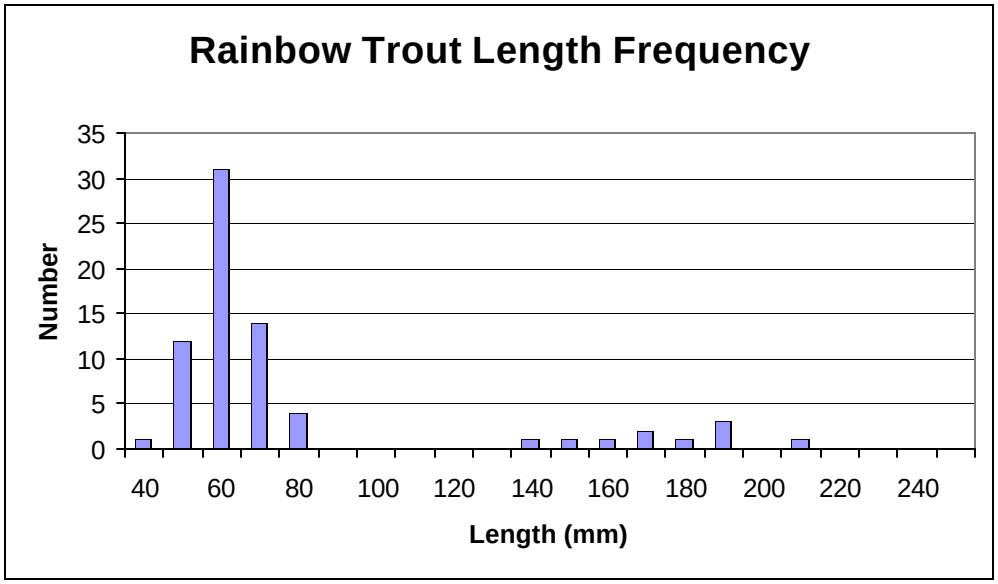


Figure 52. Rainbow trout (steelhead) length frequency for trout captured in Stony Creek upstream of Rosewood Road.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment visit and with the use of a continuous monitor at this location.

Instantaneous DO and temperature information were collected at this location on July 21. The DO was 5.72 mg/l, the stream water temperature was 22.4 C and the air temperature was 23.1 C.

Water temperature collected by using a continuous monitor at this site indicated that stream temperature ranged from a low 55 F to a high of 76 F (Figure 53).The mean average stream water temperature during the summer of 2004 was 66 F. State water temperature standards were not exceeded at this location.

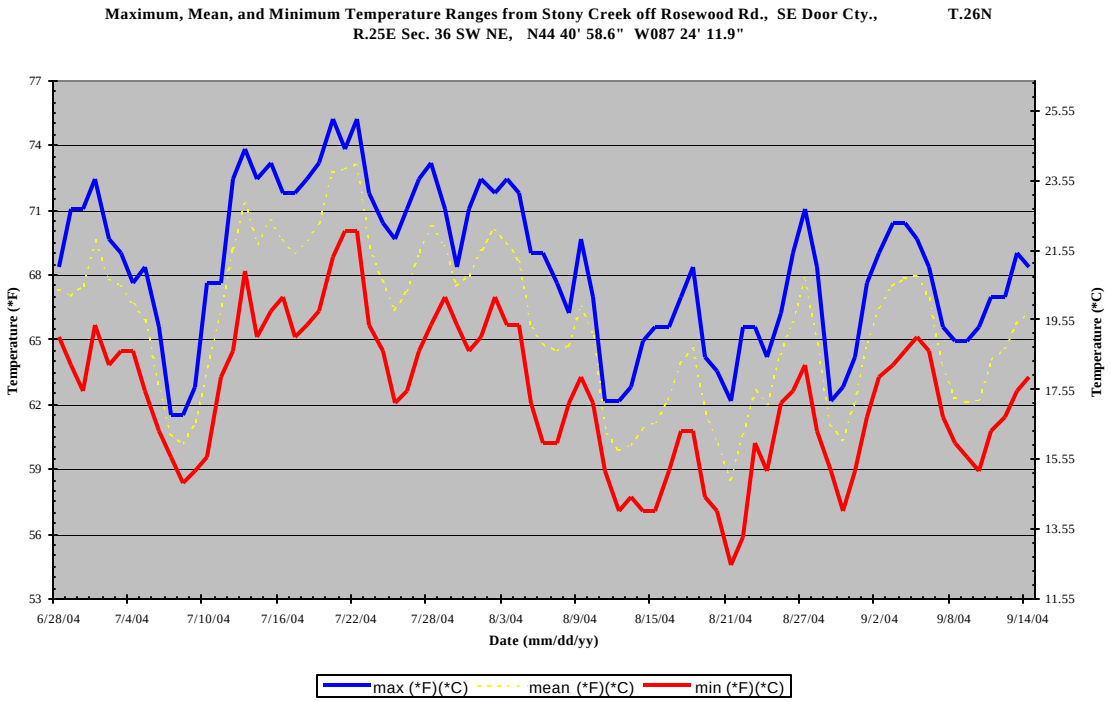


Figure 53. Continuous stream temperature readings from Stony Creek at Rosewood Lane from June 28 through September 14, 2004.

Stony Creek (Maplewood Road)

This survey location on Stony Creek was upstream of Maplewood Road (N44.7410, W-087.4550 to N44.7418, W-087.4563). The survey section on Stony Creek averaged 4.88 meters in width and was 170 meters in length. Stony Creek has a gradient of 0.67 meters per kilometer, and a sinuosity of 1 to 1.29 at this survey site. The study reach of the river ran through a shrub-woodland-grassland landscape (Figure 54).

Figure 54. An upstream look at Stony Creek from above Maplewood Road showing the dense shrub cover encountered at the lower end of the survey location.

Discharge

Water level was judged to be 0.1 meters above normal for the date of the habitat survey and water clarity was rated as stained. Flow was 0.06 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained 45.2 meters of pool and 127.3 meters of run. Habitat features ranged in length from 6.0 meters to 19.5 meters for pools, and 17.0 meters to 44.2 meters for runs. Bare soil was observed along most transects although erosion was uncommon. However, where erosion was noted, it was substantial. Overhanging vegetation and woody debris provided cover for fish in this stream section.

Gravel, sand or silt were the most abundant substrates encountered at this location (Figure 55). Other substrates such as cobble, boulder or wood/detritus were also encountered at this site although in lower frequency. Soft bottom sediments were associated with areas in which bank erosion was noted.

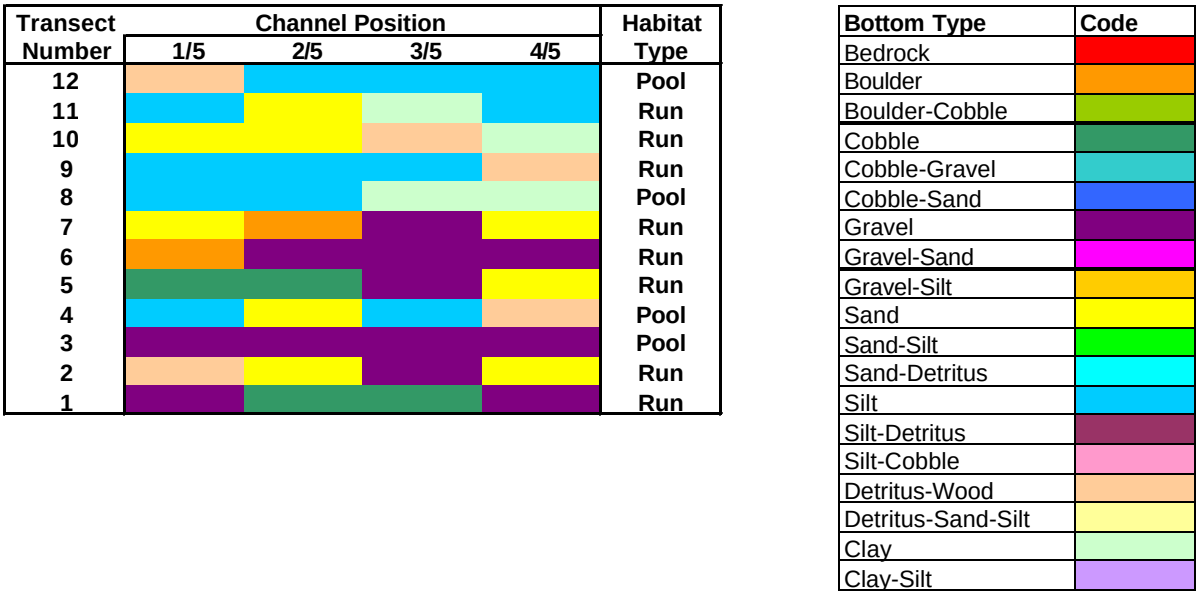


Figure 55. Bottom sediment map and key for the survey site upstream Maplewood Road on Stony Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were collected from the first upstream riffle at this location. Isopods and amphipods dominated the invertebrate community at this location, with substantially fewer dipterans captured. The HBI score at Maplewood Road was 6.71 which indicates that water was fairly poor and likely indicates low stream flow at this location.

Fish were collected during a single upstream transit of the survey section. A total of 186 fish of five different species were captured during electroshocking (Table 10).

Table 10. The species and abundance of fish captured from electroshocking in Stony Creek at Maplewood Road.

Species	Abundance
Central Mudminnow	32
Northern Pike	6
Brook Stickleback	145
Pumpkinseed Sunfish	2
Johnny Darter	1
Total	**186**

Brook stickleback dominated the catch, with substantially fewer individuals from other species captured. The collected species fish resulted in an IBI score of 35 indicating a fair fish community for this location on Stony Creek.

The captured northern pike ranged in length from 94 mm to 132 mm in length and were likely YOY fish.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment visit on July 14. At this time the DO was 5.60 mg/l, the stream water temperature was 21.1 C and the air temperature was 24.3 C.

A continuous temperature meter was placed just upstream of our survey site at Highway O. At this location temperature ranged from 40 F to 105 F (Figure 56). The average stream temperature was 63 F. High maximum stream temperatures measured on August 6 and August 14 through August 24 could be indicative of extremely low or no flow periods which allowed stream temperatures to rise.

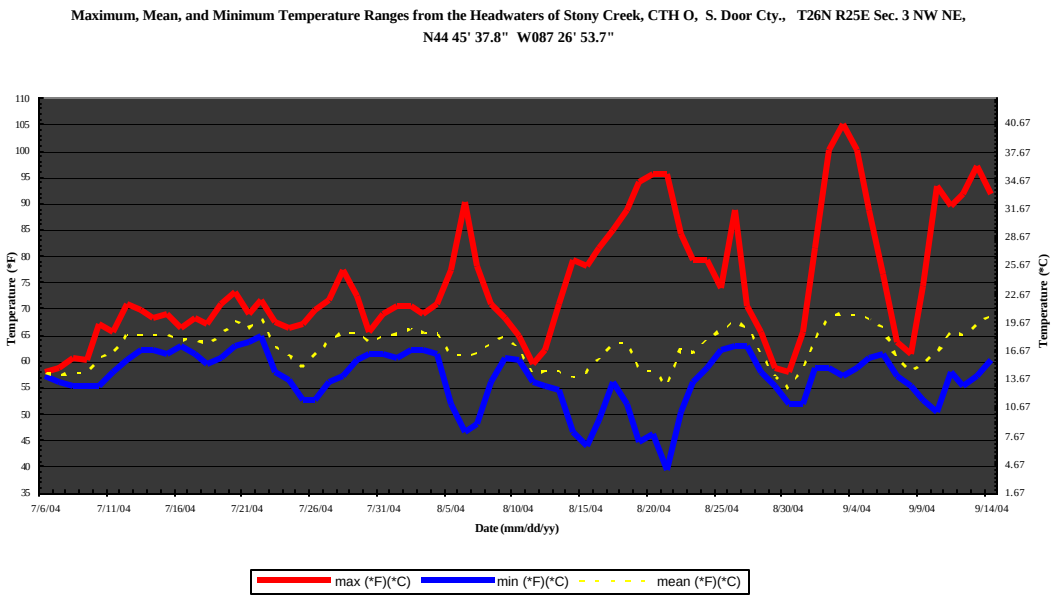


Figure 56. Continuous stream water temperatures recorded at Highway O on Stony Creek from July 6 through September 14, 2004.

Kolstad Creek

Kolstad Creek is a 4.8 km low gradient stream that drains wetland and agricultural land before entering Stony Creek. The survey location on Kolstad Creek was upstream of Maplewood Road (N44.7336, W-087.4247 to N44.7345, W-087.4250). The survey section on Kolstad Creek averaged 7.0 meters in width, but because it was a channel through a wetland with highly variable width, transects were established every 8 meters resulting in a survey station that was 92 meters in length. Kolstad Creek has a gradient of 0.04 meters per kilometer, and a sinuosity of 1 to 1.35. The study reach of the river ran through 100 percent shrub/wetland landscape (Figure 57).

Figure 57. Looking upstream on Kolstad Creek at the shrub/wetland complex that was common throughout the survey station.

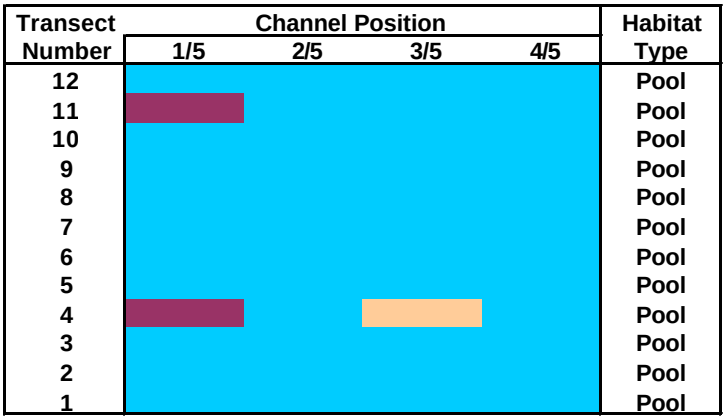
Discharge

Water level was judged normal for the date of the habitat survey and water clarity was rated as stained. Flow was 0.02 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled was one large pool that had little visible flow. The stream bottom was very soft making surveying difficult. Aquatic vegetation was common throughout the site. Bare soil was observed along most transects although erosion was uncommon. Overhanging vegetation and emergent macrophytes provided cover for fish in this stream section.

Nearly all the bottom sediment was silt, with only one transect having a small amount of detritus/wood for a substrate (Figure 58).



Bottom Type	Code
Bedrock	
Boulder	
Boulder-Cobble	
Cobble	
Cobble-Gravel	
Cobble-Sand	
Gravel	
Gravel-Sand	
Gravel-Silt	
Sand	
Sand-Silt	
Sand-Detritus	
Silt	
Silt-Detritus	
Silt-Cobble	
Detritus-Wood	
Detritus-Sand-Silt	
Clay	
Clay-Silt	

Figure 58. Bottom sediment map and key for the survey site upstream of Maplewood Road on Kolstad Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were not collected from this location.

Fish were collected during a single upstream transit of the survey section. A total of 7 brook stickleback were captured during electroshocking. The IBI score for this site was 20 that resulted in a fishery rating of poor.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment visit on July 19. At this time the DO was 4.57 mg/l, the stream water temperature was 17.3 C and the air temperature was 24.0 C.

Kramer Creek

Kramer Creek is a 3.2 km moderate gradient stream that drains wetland and agricultural land before entering Stony Creek. The survey location on Kramer Creek was upstream of Maplewood Road (N44.7408, W-087.4326 to N44.7417, W-087.4320). The survey section on Kramer Creek averaged 3.2 meters in width resulting in a survey station that was 102 meters in length. Kramer Creek has a gradient of 2.65 meters per kilometer, and a sinuosity of 1 to 1.03. The study reach of the river ran through a woodland shrub landscape (Figure 59).

Figure 59. Looking upstream on a wooded section of Kramer Creek.

Discharge

Water level was judged normal for the date of the habitat survey and water clarity was rated as stained. Flow was 0.048 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled was one large run. Bare soil was common throughout the survey section, but erosion was judged slight except on two transects where silt was common. Overhanging vegetation and woody debris provided cover for fish in this stream section.

The bottom sediment of this survey section was primarily sand. Lesser amounts of silt, gravel or cobble were encountered in the survey reach of this stream (Figure 60).

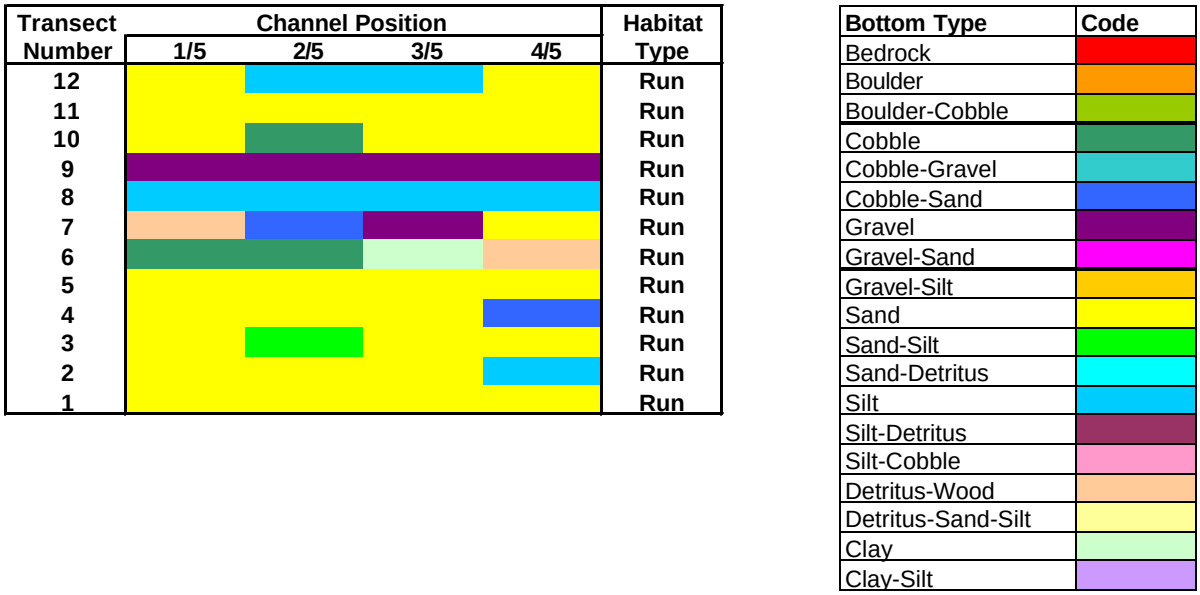


Figure 60. Bottom sediment map and key for the survey site upstream of Maplewood Road on Kramer Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were not collected from this location.

Fish were collected during a single upstream transit of the survey section. A total of 34 individuals representing six species were captured during shocking (Table 11). The IBI score for this site was 30 that resulted in a fishery rating of fair.

Table 11. The species and abundance of fish captured from electroshocking in Kramer Creek at Maplewood Road.

Species	Abundance
Central Mudminnow	12
Fathead Minnow	3
Creek Chub	2
White Sucker (YOY)	5
Brook Stickleback	1
Johnny Darter	11
Total	**34**

Central mudminnow and johnny darter were the most abundant fish captured, with other species captured in lower number (Table 11).

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment visit on July 15. At this time the DO was 7.42 mg/l, the stream water temperature was 17.2 C and the air temperature was 24.0 C.

Silver Creek (Lake Michigan Tributary)

Silver Creek is an 8 km stream that drains a 9.62 km^2 watershed before entering Lake Michigan. The upper section of the watershed is wetland that has been ditched with lower sections of the watershed agricultural in nature (Door County SWD 2000). The stream is classified as a warm water forage fishery although runs of Lake Michigan trout and salmon commonly occur.

The survey location on Silver Creek was upstream of Jackson Road (N44.6611, W-087.4097 to N44.6619, W-087.4103). The survey section on Silver Creek averaged 2.7 meters in width resulting in a survey station that was 92 meters in length. Silver Creek has a gradient of 0.53 meters per kilometer, and a sinuosity of 1 to 1.16. The study reach of the river ran through 100 percent meadow (Figure 61).

Figure 61. The dense meadow was common throughout the survey station upstream of Jackson Road on Silver Creek.

Discharge

Water level was judged normal for the date of the habitat survey and water clarity was rated as turbid. Flow was measured at 0.0 cubic meters per second (CMS) at this site, but visual evidence indicated that flow was present in the stream.

Habitat

The section of river sampled contained a mixture of runs and pools with 48.9 meters of pools and 36.0 meters of run. No riffles were encountered. Habitat features ranged in length from 5.5 meters to 14.0 meters for pools and 2.0 meters to 13.0 meters for runs. Bare soil and erosion was uncommon in the surveyed section of river. Overhanging vegetation and undercut banks provided cover for fish in the deeper areas of the stream.

The bottom sediment of this survey section was primarily gravel, although silt was also commonly observed. Lesser amounts of cobble, boulder or sand were encountered in the survey reach of this stream (Figure 62).

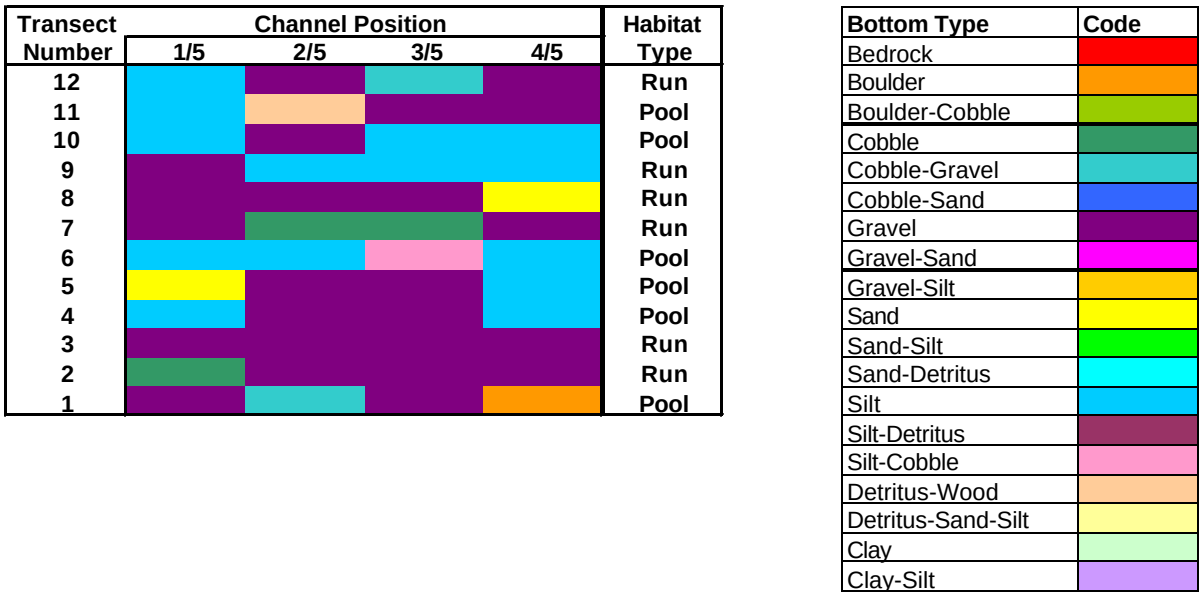


Figure 62. Bottom sediment map and key for the survey site upstream of Jackson Road on Silver Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were collected from a gravel run at this location. Results indicate that caddis flies, beetles and isopods were the dominant invertebrates collected from this location. Based on the collected invertebrates, the HBI score was 5.168 at this location indicating that water quality was good.

Fish were collected during a single upstream transit of the survey section. A total of 2,846 individuals representing ten species were captured during shocking (Table 12). Because of the number of fish observed, many fish were not netted and the number captured was a subsample of the total number observed. The IBI score for this site was 55 that resulted in a fish community rating of good.

Table 12. The species and abundance of fish captured from electroshocking in Silver Creek at Jackson Road.

Species	Abundance
Rainbow Trout (Steelhead)	2
Central Mudminnow	2,523
Fathead Minnow	48
Southern Redbelly Dace	1
Creek Chub	59
White Sucker	81
Brook Stickleback	113
Pumpkinseed Sunfish	1
Johnny Darter	15
Mottled Sculpin	3
Total	**2,846**

Central mudminnow dominated the catch, with substantially fewer brook stickleback, and white sucker captured (Table 12). It is likely the two rainbow trout captured were produced in the stream because measured lengths of 65 mm and 70 mm, made them much smaller than stocked steelhead.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment visit on July 29. At this time the DO was 4.67 mg/l, the stream water temperature was 18.0 C and the air temperature was 21.2 C.

A continuous temperature meter was placed in the stream at this location on June 29 and operated through September 14. During the months of operation, stream temperature ranged from 52 F to 73 F (Figure 63). The average stream temperature during this survey period was 62F.

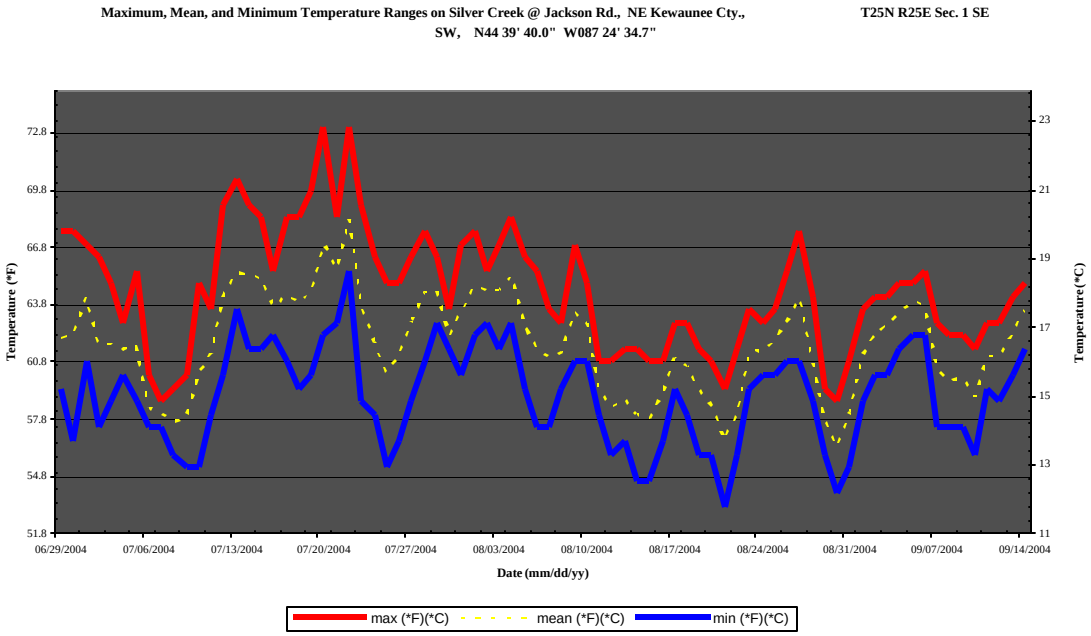


Figure 63. Stream temperature at Jackson Road on Silver Creek from July 7 through September 15, 2004.

Ahnapee River Watershed

Ahnapee River

The Ahnapee River is a 22.4 km stream that drains a 304.2 km^2 watershed before entering Lake Michigan in the City of Algoma (WDNR 1995). Headwaters originate from spring ponds and there is a 65 acre impoundment on the main channel. Lower sections of the Ahnapee River located in the city of Algoma have been dredged for navigation. The Ahnapee River is classified as a warmwater sportfishery for its entire length and experiences seasonal runs of Lake Michigan trout and salmon up to the dam in Forestville.

The survey location on the Ahnapee Rivers was upstream of Door County Highway H (N44.7482, W-087.5366 to N44.7505, W-087.5354). The survey section on the Ahnapee River averaged 8.54 meters in width resulting in a survey station that was 306 meters in length. The Ahnapee River has a gradient of 1.08 meters per kilometer, and a sinuosity of 1 to 1.27. The study reach of the river ran through a meadow-woodland-shrub landscape (Figure 64).

Figure 64. This upstream facing photo on the Ahnapee River shows the typical meadow-woodland-shrub landscape found at this survey site.

Discharge

Water level was judged normal for the date of the habitat survey and water clarity was rated as clear. Flow was measured at 0.19 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of runs, riffles and pools but was dominated by runs. There were 174.2 meters of runs, 72.1 meters of riffles and 65.5 meters of pools. Habitat features ranged in length from 6.2 meters to 46.5 meters for riffles, 16.1 meters to 49.4 meters for pools and 6.2 meters to 117.0 meters for runs. In several locations the stream channel was braided and a small manmade rock “dam” was encountered in the survey section. Bare soil and erosion were uncommon in the surveyed section of river. Boulders and submerged macrophytes provided cover for fish in the deeper areas of the stream.

The bottom sediment of this survey section was primarily gravel and silt although sand was also commonly observed. Lesser amounts of cobble or wood/detritus were encountered in the survey reach of this stream (Figure 65).

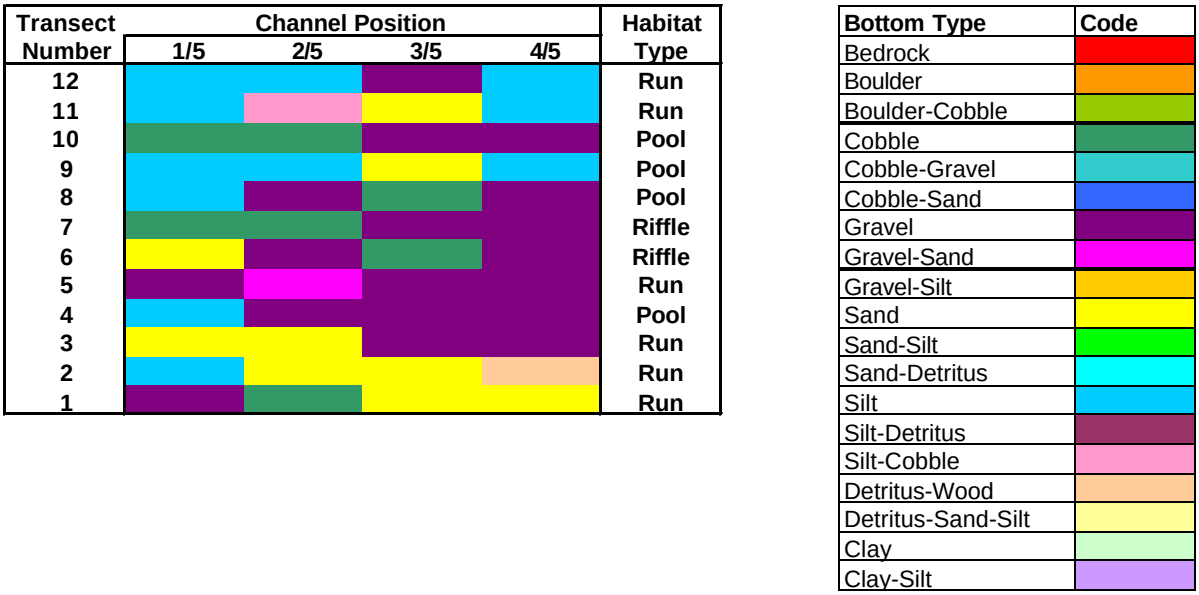


Figure 65. Bottom sediment map and key for the survey site upstream of County H on the Ahnapee River. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were not collected at this location.

Fish were collected during a single upstream transit of the survey section. A total of 384 individuals representing thirteen species were captured during shocking (Table 13). The IBI score for this site was 40 but only resulted in a fish community rating of fair.

Table 13. The species and abundance of fish captured from electroshocking in the Ahnapee River at Highway H.

Species	Abundance
American Brook Lamprey	2
Central Mudminnow	129
Common Shiner	40
Southern Redbelly Dace	6
Bluntnose Minnow	12
Fathead Minnow	1
Blacknose Dace	2
Creek Chub	2
Pearl Dace	29
White Sucker	32
Brook Stickleback	70
Johnny Darter	26
Mottled Sculpin	33
Total	**384**

Central mudminnow dominated the catch, with substantially fewer brook stickleback and individuals of other species captured (Table 13).

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat and fisheries assessment visits as well as with the use of a continuous monitor.

On July 14 the DO was 9.28 mg/l, the stream water temperature was 14.5 C and the air temperature was 20.7 C. On July 20 the DO was 10.5 mg/l, the water temperature was 16.7 C and the air temperature was 30.5 C.

A continuous stream water temperature monitor was placed at this location on June 29 and operated through September 15 (Figure 66). During the time period that the monitor operated stream water temperature ranged from 50 F to 70 F. The average stream temperature during this time period was 60 F.

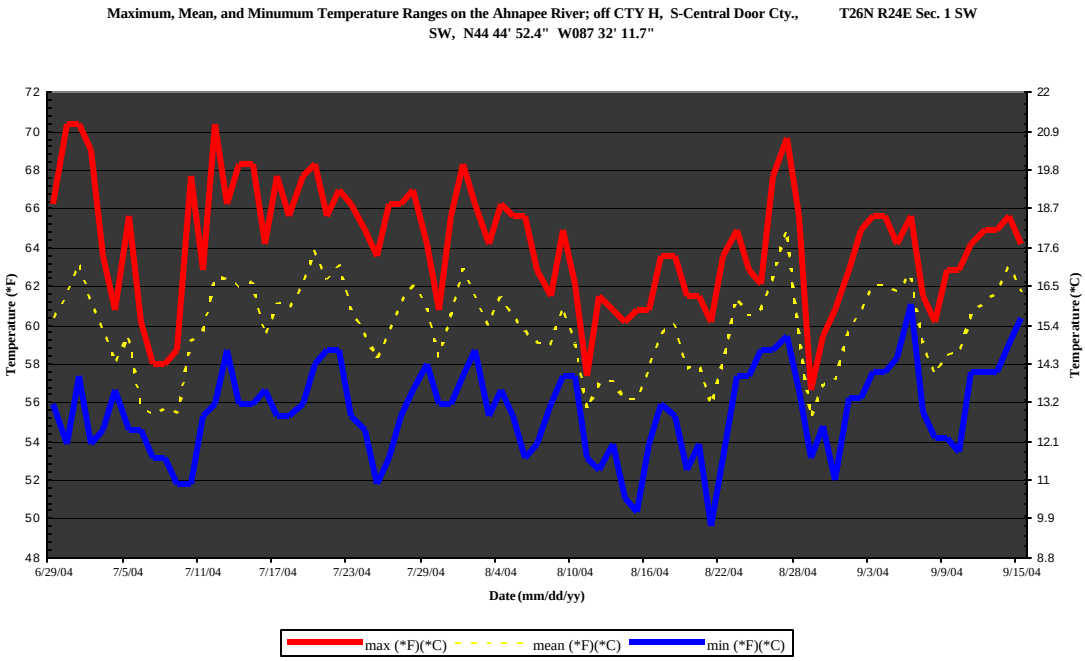


Figure 66. Continuous stream temperature data collected at Highway H on the Ahnapee River from June 29 through September 15, 2004.

Silver Creek (Kewaunee County Highway S)

Silver Creek is 20.48 km stream that is the largest tributary to the Ahnapee River and it has a 5.7 acre impoundment on its main channel. The lower 2.4 km are classified as supporting warmwater sport fish with the remainder of the stream classified as having forage fisheries (WDNR 1995). Excessive nutrient and sediment loading has resulted in fair to poor water quality and has caused several fish kills.

The survey location at this site on Silver Creek was upstream of Kewaunee County Highway S (N44.6179, W-087.4890 to N44.6199, W-087.4910). The survey section on Silver Creek averaged 9.2 meters in width resulting in a survey station that was 306 meters in length. Silver Creek has a gradient of 0.36 meters per kilometer, and a sinuosity of 1 to 1.20. The study reach of the river ran through either a meadow-woodland or a meadow-shrub landscape (Figure 67).

Figure 67. Measuring stream width on Silver Creek upstream of Highway S.

Discharge

Water level was judged normal for the date of the habitat survey and water clarity was rated as clear. Flow was measured at 0.07 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of runs, riffles and pools but was dominated by runs. There were 169.5 meters of runs, 64.0 meters of riffles and 60.2 meters of pools. Habitat features ranged in length from 3.2 meters to 16.3 meters for riffles, 7.0 meters to 15.0 meters for pools and 7.8 meters to 68.0 meters for runs. Bare soil and erosion were uncommon in the surveyed section of river, although several upstream transects had substantial bare soil and erosion. Fish cover was not measured at this site because of shallow water (<200 mm), however, boulders and submerged macrophytes were common throughout the survey site.

The bottom sediment of this survey section was primarily cobble or gravel with scattered boulders (Figure 68). Lesser amounts of sand or silt were encountered in the survey reach of this stream.

Figure 68. Bottom sediment map and key for the survey site upstream of County S on Silver Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were collected from a riffle at this location. Results indicate that isopods dominated the invertebrate community with substantially fewer dipterans and other invertebrates collected. The HBI score for this location was 7.627 which indicates poor water quality.

Fish were collected during a single upstream transit of the survey section. A total of 906 individuals representing eight species were captured during shocking (Table 14). The IBI score for this site was 15 which resulted in a fishery rating of very poor.

Table 14. The species and abundance of fish captured from electroshocking in Silver Creek at Highway S.

Species	Abundance
Central Mudminnow	111
Fathead Minnow	1
Blacknose Dace	342
Creek Chub	87
White Sucker	208
Brook Stickleback	89
Johnny Darter	67
Mottled Sculpin	1
Total	**906**

Blacknose dace and white sucker dominated the catch, with substantially fewer central mudminnow and fish from other species captured (Table 14).

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment visit.

On August 3, the DO was 8.67 mg/l, the stream water temperature was 21.2 C and the air temperature was 19.6 C.

Silver Creek (Black Ash Road)

The survey location at this site on Silver Creek was upstream of Black Ash Road (N44.6358, W-087.5463 to N44.6365, W-087.5470). The survey section on Silver Creek averaged 3.5 meters in width resulting in a survey station that was 92 meters in length. Silver Creek has a gradient of 1.83 meters per kilometer, and a sinuosity of 1 to 1.29. The study reach of the river ran through a meadow-woodland landscape (Figure 69).

Figure 69. Looking upstream on Silver Creek at Black Ash Road.

Discharge

Water level was judged normal for the date of the habitat survey and water clarity was rated as clear. Flow was measured at 0.04 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of runs, riffles and pools. There were 41.2 meters of riffles, 15.2 meters of pools and 36.2 meters of runs. Habitat features ranged in length from 5.0 meters to 17.6 meters for riffles, 4.5 meters to 10.7 meters for pools and 4.9 meters to 16.0 meters for runs. Bare soil and erosion were noted at several locations on this survey site, however they did not appear to be severe. Fish cover was limited at this site because of shallow water (<200 mm), however, boulders and over-hanging vegetation provided some cover for fish at this location.

The bottom sediment of this survey section was primarily cobble or gravel with scattered boulders (Figure 70). Lesser amounts of sand or silt were encountered in the survey reach of this stream.

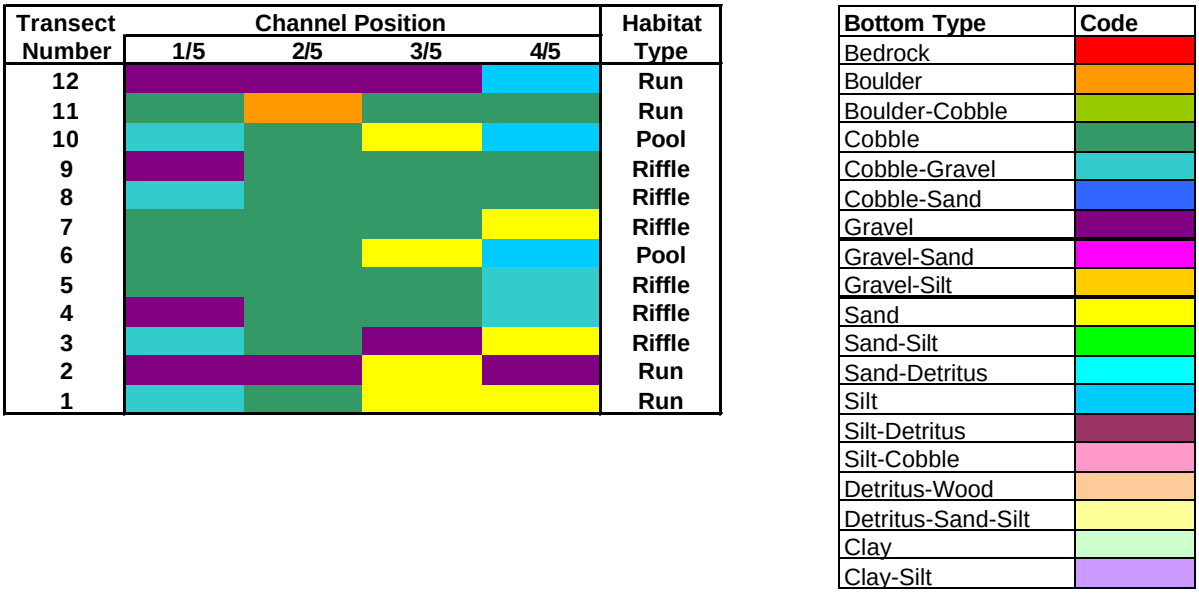


Figure 70. Bottom sediment map and key for the survey site upstream of Black Ash Road on Silver Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were not collected from this location because results should be similar to those at the downstream site.

Fish were collected during a single upstream transit of the survey section. A total of 211 individuals representing nine species were captured during shocking (Table 15). The IBI score for this site was 30 that resulted in a fish community rating of fair.

Table 15. The species and abundance of fish captured from electroshocking in Silver Creek Black Ash Road.

Species	Abundance
Central Mudminnow	11
Southern Redbelly Dace	4
Fathead Minnow	3
Blacknose Dace	88
Creek Chub	64
White Sucker	13
Brook Stickleback	11
Johnny Darter	11
Mottled Sculpin	6
Total	**211**

Blacknose dace and creek chub dominated the catch, with substantially fewer individuals of other species captured (Table 15).

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment visit to this site.

On August 3, the DO was 9.94 mg/l, the stream water temperature was 20.7 C and the air temperature was 24.8 C.

Rio Creek

Rio Creek is 12.8 km stream that is tributary to Silver Creek. The entire stream is classified as a forage fishery (WDNR 1995). Excessive nutrient and sediment loading has resulted in fair to poor water quality and has caused several fish kills. Despite being classed as a forage fishery, large northern pike have been noted during fish kill investigations, which indicates that the stream can support gamefish (Hogler 1994).

The survey location on Rio Creek was upstream of Kewaunee County Highway S (N44.6181, W-087.5244 to N44.6168, W-087.5703). The survey section on Rio Creek averaged 3.1 meters in width resulting in a survey station that was 92 meters in length. Rio Creek has a gradient of 0.34 meters per kilometer, and a sinuosity of 1 to 1.16. The study reach of the river ran through 100 percent woodland (Figure 71).

Figure 71. Upstream of Highway S, Rio Creek flows through woodland that shades the stream and adds wood to the stream .

Discharge

Water level was judged normal for the date of the habitat survey and water clarity was rated as clear. Flow was measured at 0.03 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained runs, riffles and pools but was dominated by runs. There were 5.0 meters of riffles, 4.3 meters of pools and 92.7 meters of runs. Habitat features ranged in length from 5.9 meters to 47.2 meters for runs, with the single riffle and pool having a length of 5.0 meters and 4.3 meter, respectively. Bare soil was noted throughout the survey station, but erosion was uncommon and slight. Fish cover was not measured at this site because of shallow water (<200 mm), however, woody debris occurred throughout the site.

The bottom sediments of this survey section were dominated by sand (Figure 72). Clay, detritus/wood, or silt was also seen but in lower abundance. Only one small patch of gravel was noted in the survey reach of this stream.

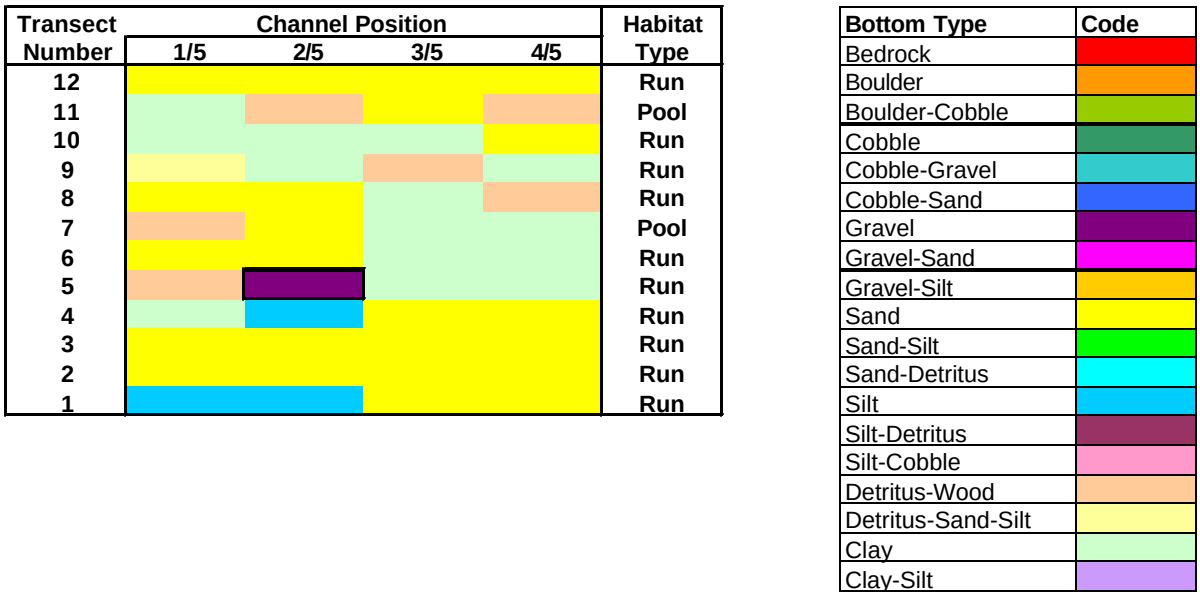


Figure 72. Bottom sediment map and key for the survey site upstream of Highway S on Rio Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were not collected from this location because a suitable riffle could not be found.

Fish were collected during a single upstream transit of the survey section. A total of 152 individuals representing seven species were captured during shocking (Table 16). The IBI score for this site was 35 that resulted in a fish community rating of fair.

Table 16. The species and abundance of fish captured from electroshocking in Rio Creek at Highway S.

Species	Abundance
Central Mudminnow	4
Fathead Minnow	17
Blacknose Dace	15
Creek Chub	16
White Sucker	19
Brook Stickleback	80
Johnny Darter	1
Total	**152**

Brook stickleback dominated the catch, with substantially fewer individuals of other species captured (Table 16).

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment visit to this site.

On August 4, the DO was 6.2 mg/l, the stream water temperature was 19.3 C and the air temperature was 20.1 C.

Silver Creek (Brussels)

Silver Creek is 8.4 km stream that is tributary to the Ahnapee River Door County SCW 2000). The stream drains agricultural land on the eastern edge of the Niagara Escarpment and is classified as having a cold water fishery in the lower 0.3 km and limited aquatic life in the remainder of the stream, although the fish community is not well known (WDNR 1995). It is believed that excessive nutrient and sediment loading and low flow has resulted in fair to poor water quality in Silver Creek, although the headwaters of this stream are spring fed.

The survey location on Silver Creek was upstream of Stevenson Pier Road (N44.7601, W-087.5400 to N44.7593, W-087.5413). The survey section on Silver Creek averaged 5.74 meters in width resulting in a survey station that was 204 meters in length. Silver Creek has a gradient of 1.01 meters per kilometer, and a sinuosity of 1 to 1.33. The study reach of the river ran through a meadow-shrub-woodland complex (Figure 73).

Figure 73. Looking upstream of Stevenson Pier Road on Silver Creek.

Discharge

Water level was judged normal for the date of the habitat survey and water clarity was rated as clear. Flow was measured at 0.10 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained mixture of pools and runs. There were 77.9 meters of pools and 137.0 meters of runs. Habitat features ranged in length from 7.0 meters to 32.3 meters for pools and 10.2 meters to 61.6 meters for runs. The stream channel was braided at several locations resulting in several mid-channel islands. Bare soil was noted at several locations scattered throughout the survey site, but erosion was not noted. Fish cover at this location included overhanging vegetation, woody debris and submerged macrophytes.

Sand or silt that was found throughout the site dominated the bottom sediment of this survey section (Figure 74). Cobble, boulder, gravel or woody debris were found in downstream sections of the survey site and were localized in the thalweg of the stream.

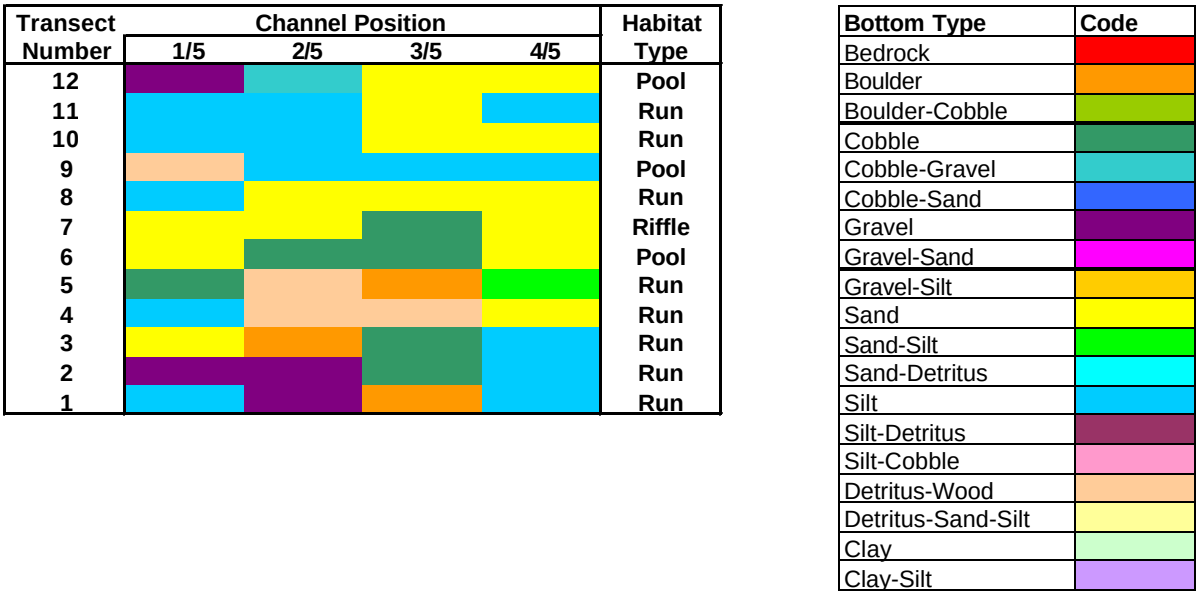


Figure 74. Bottom sediment map and key for the survey site upstream of Stevenson Pier Road on Silver Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were collected from this location and the results indicate that caddis flies, amphipods and beetles dominated the invertebrate community. The HBI score for this location was 4.663 which indicates that water quality is good.

Fish were collected during a single upstream transit of the survey section. A total of 211 individuals representing seven species were captured during shocking (Table 17). The IBI score for this site was 25 that resulted in a fish community rating of poor.

Table 17. The species and abundance of fish captured from electroshocking in Silver Creek at Stevenson Pier Road.

Species	Abundance
Central Mudminnow	69
Fathead Minnow	2
Pearl Dace	34
Creek Chub	6
Brook Stickleback	82
Johnny Darter	2
Mottled Sculpin	2
Total	**211**

Brook stickleback and central mudminnow dominated the catch, with substantially fewer pearl dace and fish of other species captured (Table 17).

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment visit to this site. On July 12, the DO was 9.07 mg/l, the stream water temperature was 12.9 C and the air temperature was 20.0 C.

A continuous stream temperature meter was placed at this site on July 30 and was operated through September 15. At this site, water temperature ranged from 46 F to 67 F (Figure 75). The average stream temperature during the sample period was 57 F.

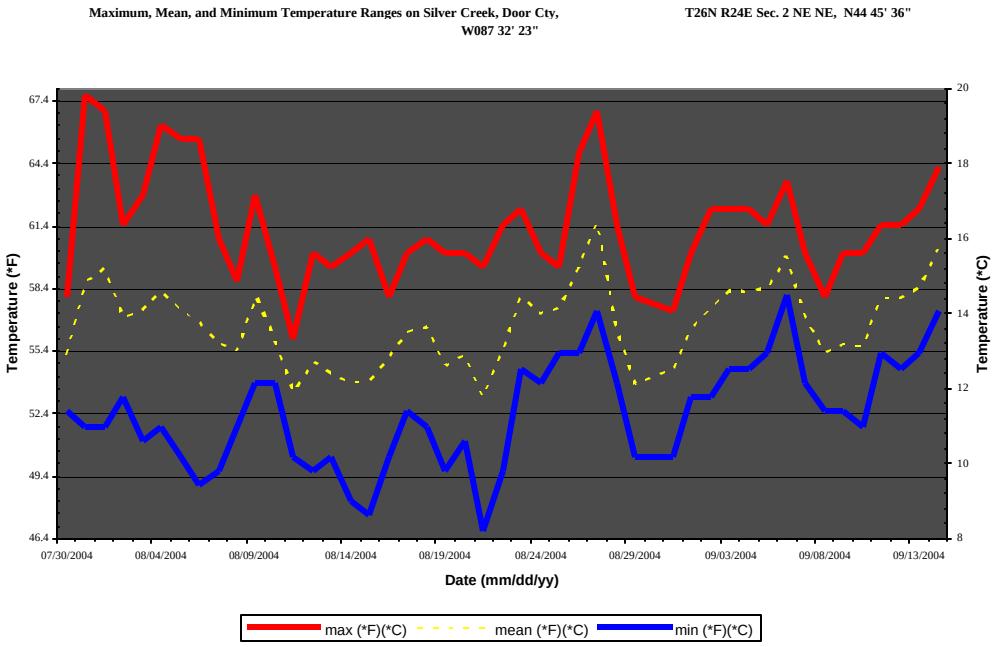


Figure 75. Stream water temperature on Silver Creek at Stevenson's Pier Road from July 30 through September 15, 2004.

Three Mile Creek

Three Mile Creek is a 4.5 km intermittent stream that flows out of Krohns Lake and empties into Lake Michigan. Lower sections of stream near Lake Michigan are classified as forage fisheries with upper sections near Krohns Lake classified as cold water. Low flow and agricultural runoff is believed to affect the water quality and fisheries of the stream.

The survey location on Three Mile Creek was upstream of Longfellow Road (N44.5854, W-087.4642 to N44.5850, W-087.4653). The survey section on Three Mile Creek averaged 2.7 meters in width resulting in a survey station that was 92 meters in length. Three Mile Creek has a gradient of 14.5 meters per kilometer, and a sinuosity of 1 to 1.16. The study reach of the river ran through a cedar woodland (Figure 76).

Figure 76. A view of the wooded Three Mile Creek upstream of Longfellow Road.

Discharge

Water level was judged normal for the date of the habitat survey and water clarity was rated as clear. Flow was measured at 0.01 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of riffles, pools and runs. There were 39.4 meters of riffle, 23.0 meters of pools and 28.1 meters of runs. Habitat features ranged in length from 4.0 meters to 15.5 meters for riffles, 4.4 meters to 18.6 meters for pools and 4.8 meters to 12.3 meters for runs. Many downed trees that occurred singly or in piles of multiple trees crossed the stream channel. Bare soil and stream bank erosion were common throughout the survey site. Fish cover was limited in this stream because of shallow water (< 200 mm) but woody debris was common and boulders were scattered throughout the stream channel at this site.

Cobble, sand or boulder were the most common bottom sediments at this location (Figure 77). Lesser amounts of clay, silt and woody debris were encountered at this site on Three Mile Creek.

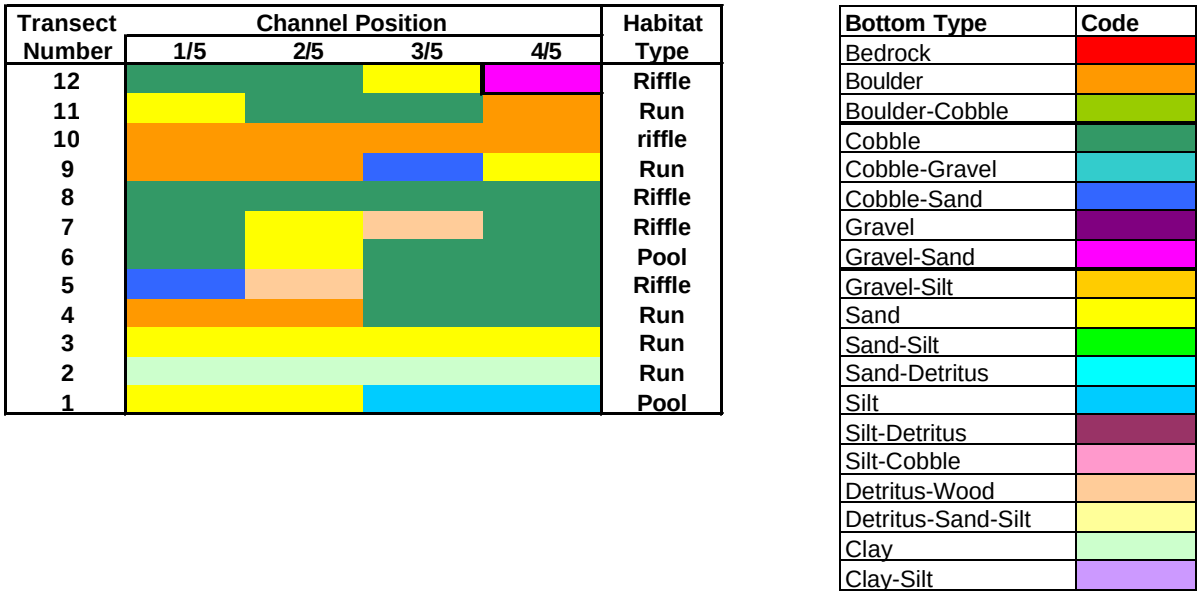


Figure 77. Bottom sediment map and key for the survey site upstream Longfellow Road on Three Mile Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were collected from this location and the results indicate that mayflies, caddis flies and amphipods dominated the community. The HBI score was 3.710 which indicates very good water quality at this location.

Fish were collected during a single upstream transit of the survey section. A total of 45 individuals representing eight species were captured during shocking (Table 18). The IBI score for this site was 30 that resulted in a fish community rating of fair.

Table 18. The species and abundance of fish captured from electroshocking in Three Mile Creek at Longfellow Road.

Species	Abundance
American Brook Lamprey	2
Rainbow Trout	1
Central Mudminnow	10
Fathead Minnow	2
Blacknose Dace	1
Creek Chub	9
Brook Stickleback	3
Mottled Sculpin	17
Total	**45**

Mottled sculpin and central mudminnow were the most abundant species caught, with fewer individuals of other species captured (Table 18). The single rainbow trout that was captured was 80 mm in length. We do not know if its parents were from Lake Michigan or Krohns Lake which receives an annual stocking of rainbow trout.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information were collected during the habitat assessment visit to this site.

On August 4, the DO was 7.59 mg/l, the stream water temperature was 18.4 C and the air temperature was 24.1 C.

Mashek Creek

Mashek Creek is a 8 km intermittent stream that is tributary to Lake Michigan. Little is know about the water quality or fishery of the stream, but records indicate that during high water Lake Michigan trout and salmon migrate into the stream.

The survey location on Mashek Creek was upstream of Lakeshore Drive (N44.5032, W-087.4868 to N44.5029, W-087.4882). The survey section on Mashek Creek averaged 3.3 meters in width resulting in a survey station that was 92 meters in length. Mashek Creek has a gradient of 10.09 meters per kilometer, and a sinuosity of 1 to 1.16. The study reach of the river ran through shrub-woodland (Figure 78).

Figure 78. An upstream view of Mashek Creek upstream of Lakeshore Drive.

Discharge

Water level was judged normal for the date of the habitat survey and water clarity was rated as clear. Flow was measured at 0.01 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled contained a mixture of riffles, pools and runs. There were 25.0 meters of riffle, 49.2 meters of pools and 27.1 meters of runs. Habitat features ranged in length from 1.0 meter to 10.6 meters for riffles, 3.3 meters to 15.9 meters for pools and 2.9 meters to 8.6 meters for runs. Bare soil and stream bank erosion was common throughout the survey site. Fish cover was limited in this stream because of shallow water (< 200 mm).

Gravel or cobble were the most common bottom sediments at this location (Figure 79). Lesser amounts of sand, boulder or silt were encountered at this site on Mashek Creek.

Figure 79. Bottom sediment map and key for the survey site upstream Lakeshore Drive on Mashek Creek. Transect 1 is the furthest downstream sampling location.

Biological Assessment

Invertebrates were collected from this location and the results indicate that isopods, mayflies and caddis flies were the dominant invertebrates collected from this location. The HBI score was 5.945 which indicates water quality was fair.

Fish were collected during a single upstream transit of the survey section. A total of 110 individuals representing five species were captured during shocking (Table 19). The IBI score for this site was 25 that resulted in a fish community rating of poor.

Table 19. The species and abundance of fish captured from electroshocking in Mashek Creek at Lakeshore Drive.

Species	Abundance
Rainbow Trout	25
Blacknose Dace	1
Creek Chub	51
White Sucker	31
Brook Stickleback	2
Total	**110**

Creek chub, white sucker and rainbow trout were the most abundant species caught, with fewer individuals of other species captured (Table 19). The 25 captured rainbow trout ranged in length from 65 mm to 95 mm with an average length of 77 mm (Figure 80). We suspect these rainbow trout were naturally produced in this stream.

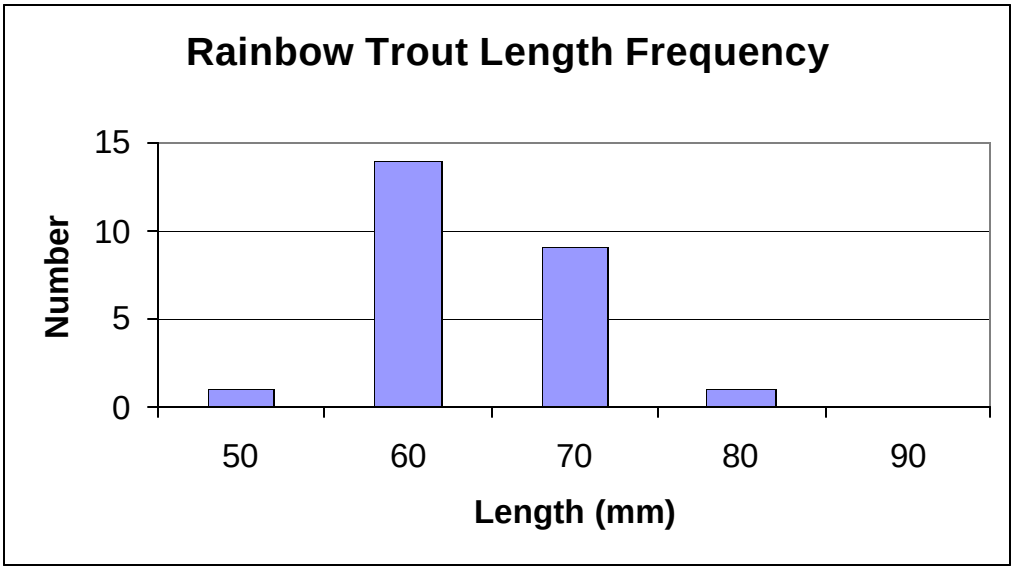


Figure 80. Rainbow Trout length frequency from fish captured in Mashek Creek.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature information was collected during the habitat assessment visit to this site.

On August 4, the DO was 8.4 mg/l, the stream water temperature was 19.7 C and the air temperature was 19.2 C.

DISCUSSION

During this two year survey that sampled 33 sites on 29 streams, a variety of physical, chemical and biological characteristics were measured. By measuring a combination of biological, chemical and physical parameters, trends in watershed health can be better understood than if a single individual metric was used.

Chemical monitoring in this study consisted of collection of instantaneous dissolved oxygen and temperature measurements collected at each site or continuous temperature and dissolved oxygen collected at a subset of the sites. Biological samples that were collected as a part of this study included macroinvertebrates for the Hilsenhoff's Index (HBI) and fish for the Index of Biotic Integrity (IBI). Habitat assessments were also conducted at each study site. Stream flow was measured and discharge was calculated for each location.

Most of the streams that were sampled were less than 10 km in length and had a stream gradient less than 5 meters per kilometer. Most had continuous flow, but several streams were dry during a portion of the study. A variety of large and small scale habitats and biological communities were noted on the surveyed streams.

Discharge

Measured flow and the resulting calculated discharge during the study most likely represented low flow or base flow conditions for the streams that were sampled. Flow ranged from 0 (dry) on Three Springs and Geisel Creeks to 0.2 CMS on Red River, Stony Creek and the Ahnapee River.

Weather conditions during the two years of the study varied greatly. 2003 was a very dry year, while 2004 was very wet during May. Because of this difference in weather, the year that a stream was studied could have influenced flow. Streams surveyed in 2003, including all those which flow into Green Bay and those from Bear Creek north that flow in Lake Michigan may have had lower base flows than those surveyed in 2004.

However, we believe that the data collected shows that flow is not a problem for resident biological communities in most streams. Flow in Three Springs Creek, Geisel Creek and Larson Creek appeared to negatively impact the fishery in them. Several others, Smith Creek, Fish Creek, Silver Creek (Lake Michigan) also had low flow, but fish populations were not as impacted as in the other three streams.

Habitat

Three types of habitat were measured during the survey, which included large-scale stream features: runs, pools and riffles; small-scale habitat: bottom type and fish cover; and adjacent land use: buffer type and width.

Throughout the watershed, large-scale habitat varied greatly from stream to stream. Although runs, pools and riffles occurred equally across the basin, only Hibbards Creek (County A), Sugar Creek Stony Creek (Rosewood) and Three Mile Creek had an equal distribution of habitat. Most streams sampled were dominated by one habitat type. Streams that were dominated by runs included Geisel, Kayes, Larson, Clay Banks, Woodward, Schuyler, Bear, Stony (Maplewood), Kramer, Silver (Ahnapee), Rio and Silver (Brussels) Creeks and the Ahnapee River. Most of these streams had bottom sediments dominated by sand or gravels.

Pools dominated Ephraim, Logan (Highway T), Smith, Kolstad, Silver (Lake Michigan) and Mashek Creeks. These streams either had low flows or sediments dominated by silt or sand.

Riffles dominated Hibbards (Fairview), Renard, Malvitz, Silver (Black Ash) Creeks and Red River. Many of these streams had cobble, boulder or bedrock for bottom sediments.

Other streams such as Fish Creek, Piel Creek and Lily Bay had streams that were co-dominated by pools and runs with little riffle habitat. These streams had low flow or silt sediments.

Sand, gravel and cobble were the most common sediments observed during the survey. Lesser amounts of silt, bedrock, boulder or clay were observed across the basins that were surveyed, but where seen, did make-up a large portion of a stream's bottom substrate.

The variety in bottom substrate has allowed a diverse community of invertebrate and fish species to exist in the watershed. This was reflected in HBI and IBI scores. Shallow water in runs and riffles along with limited pool depth most likely limits the abundance of warm water gamefish such as smallmouth bass and northern pike in the watershed.

Stream corridors were well buffered with 10 meters of forest, meadow or shrubs buffers at most study locations. Most of the streams in northern Door County have buffers much greater than the measured 10 meters, while streams south of Sturgeon Bay were bounded by agricultural land uses and buffers were more limited. Some streams such as Fish Creek and Smith Creek had bank erosion that has caused deposits of silt or clay in the stream channel.

Biological Assessments

Results from the 2003 and 2004 Hilsenhoff Biotic Index samples showed fair to very good water quality at the locations that were sampled. In streams with the greatest amount of groundwater inflows, Hibbards Creek and Bear Creek water quality as measured by HBI scorers were very good. In streams that drained wetlands or had some groundwater inputs water quality was good and in streams that were surface water fed, water quality was fair.

Fish IBI ratings ranged from very poor at six sites, poor at ten sites, fair at fourteen sites, good at two sites and data was not collected at one site. However, there is concern with the IBI ratings. Despite the fact that intolerant species or naturally reproduced trout and salmon were captured in several streams during this survey, these sites only had fair ratings. The lack of warm water gamefish was also very noticeable and was likely caused by swings in dissolved oxygen level, lack of pool habitat or from periodic episodes of low water or flow.

During this survey we captured 6,141 individual fish representing 28 species (Table 20). One site, Silver Creek (Lake Michigan) however, accounted for 46% of the total catch with 2,846 individuals captured.

The five most abundant species in order were central mudminnow, brook stickleback, blacknose dace, creek chub and white sucker (Table 20). The most common gamefish were rainbow trout and northern pike.

Table 20. Species list and abundance by zone for fish captured during the 2003 and 2004 survey.

Group	COMMON NAME	SCIENTIFIC NAME	South-Green Bay	South-Lake Michigan	North of Sturgeon Bay	Total
Lampreys	American brook lamprey	*Lampetra appendix*		4		4
Bowfins	Bowfin	*Amia calva*			4	4
Trouts	Coho salmon	*Oncorhynchus kisutch*			6	6
	Chinook salmon	*Oncorhynchus tshawytscha*			1	1
	Rainbow trout	*Oncorhynchus mykiss*		103	2	105
	Brown trout	*Salmo trutta*			3	3
	Brook trout	*Salvelinus fontinalis*			1	1
Mudminnows	Central mudminnow	*Umbra limi*	125	2910	76	3111
Pikes	Northern pike	*Esox lucius*	2	6	7	15
Minnows	Hornyhead chub	*Nocomis biguttatus*		9	125	134
	Common shiner	*Luxilus cornutus*		49	214	263
	Northern redbelly dace	*Phoxinus eos*	1	15		16
	Southern redbelly dace	*Phoxinus erythrogaster*		11		11
	Bluntnose minnow	*Pimephales notatus*	11	12		23
	Fathead minnow	*Pimephales promelas*	2	79		81
	Blacknose dace	*Rhinichthys atratulus*	3	455	37	495
	Longnose dace	*Rhinichthys cataractae*		6	2	8
	Creek chub	*Semotilus atromaculatus*	2	342	7	351
	Pearl dace	*Margariscus margarita*	20	63		83
Suckers	White sucker	*Catostomus commersoni*		377	17	394
Bullhead-Catfishes	Black bullhead	*Ameiurus melas*	1			1
Sticklebacks	Brook stickleback	*Culaea inconstans*	3	682	1	686
Sunfishes	Pumpkinseed	*Lepomis gibbosus*		2	1	3
	Bluegill	*Lepomis macrochirus*		1		1
Perches	Iowa darter	*Etheostoma exile*			14	14
	Johnny darter	*Etheostoma nigrum*	1	128		129
	Yellow perch	*Perca flavescens*	3		8	11
Sculpins	Mottled sculpin	*Cottus bairdi*	1	184	2	187
TOTAL			175	5438	528	6141

Distribution of the catch was not evenly divided among the streams and sites surveyed (Table 20). The streams that were sampled could be broken into three zones, those north of Sturgeon Bay, south of Sturgeon Bay that flow toward Green Bay and south of Sturgeon Bay that flow into Lake Michigan. When these three zones are compared,

there is a marked difference in the number of fish captured and the species diversity within each zone.

The zone south of Sturgeon with streams flowing into Green Bay was the least diverse and had the fewest fish captured during surveys (Table 20). It is likely that many of these streams experience low flows, warm water temperatures and low dissolved oxygen levels. Fish that live in these streams must be tolerant to wide swings in environmental conditions that may occur on a regular basis. Indeed, mudminnows was the dominant specie in these streams.

Streams south of Sturgeon Bay that flow into Lake Michigan had the greatest number of individual fish and the most species present during our surveys (Table 20). These streams have greater flow, are much longer in length, have adequate dissolved oxygen and a greater diversity of habitat. Coupled with being biologically productive, these streams can support many species and individuals can exist in these streams.

Streams north of Sturgeon Bay were nearly as diverse as southern streams flowing into the lake, but had substantially fewer individuals (Table 20). These streams were generally short, had cool to cold waters and had simple habitats. Species that live here must tolerate cool water temperatures and low stream productively.

Water Quality

Temperature and DO measurements along with invertebrate and fish sampling were used to evaluate water quality within the watershed. Several trends in stream temperature and dissolved oxygen levels were observed. Although stream temperatures remained below 20 C for most streams surveyed, Kayes Creek was notably warmer. Streams in northern Door County that were fed by groundwater were much cooler than other streams. Streams draining towards Green Bay were the warmest.

Dissolved oxygen levels varied throughout the watershed. Seven streams had periods in which they fell below the 5 ppm state standard for warm water streams. In most streams these DO lows occurred during periods of respiration (night) and once plants began to produce oxygen, DO levels rebounded in the streams. However, DO does appear to be low in Three Springs Creek, Kolstad Creek and Silver Creek (Lake Michigan) for reasons other than diel oxygen swings. Low flow and stagnate conditions may be the cause of low DO in Three Springs and Kolstad Creeks, while high fish biomass may account for the low DO in Silver Creek. Surrounding land use may also contribute excess nutrients to streams south of Sturgeon Bay and thereby negatively impact water quality in them.

HBI scores indicate that water quality in the streams surveyed ranged from poor to very good. Streams that were surrounded by poor land use or that had low flows had the worst water quality, while well buffered, groundwater fed streams had the best water quality.

CONCLUSIONS

- We believe that the data collected shows that flow is not a problem for resident biological communities in most streams. Flow in Three Springs Creek, Geisel Creek and Larson Creek appeared to negatively impact the fishery in them. Several others, Smith Creek, Fish Creek (Lake Michigan) also had low flow, but fish populations were not as impacted as in the other three streams.

- Throughout the watershed, large-scale habitat varied greatly from stream to stream. The diversity of habitat was reflected by the diversity of organisms found in surveyed streams as measured by HBI and IBI metrics.

- During this survey we captured 6,141 individual fish representing 28 species. Fish IBI ratings ranged from very poor at six sites, poor at ten sites, fair at fourteen sites, good at two sites and data was not collected at one site.

- Distribution of the catch was not evenly divided among the streams and sites surveyed. The streams that were sampled could be broken into three zones, those north of Sturgeon Bay, south of Sturgeon Bay that flow toward Green Bay and south of Sturgeon Bay that flow into Lake Michigan. When these three zones are compared there is a marked difference in the number of fish captured and the species diversity within each zone.

- Natural reproduction of Lake Michigan trout and salmon was noted in several streams that we surveyed. Although reproduction was modest in most streams, it appeared that in Stony Creek steelhead are reproducing at a higher rate.

- HBI scores, stream temperatures and dissolved oxygen levels indicate that water quality in the streams surveyed is fair to very good despite several streams falling below the 5 ppm standard for DO in warmwater streams.

RECOMMENDATIONS

- Actively utilize streambank protection programs (CRP, CREP) to maximize stream bank protection in those streams that exhibit bank erosion.

- Encourage the use of land practices that hold and slowly release water into streams to improve stream flows.

- Continue to evaluate natural reproduction of Lake Michigan trout and salmon in tributaries to Lake Michigan to determine their magnitude.

- Do additional work utilizing continuous temperature and DO monitors to more fully determine the extent of water quality problems in the watershed.

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