

East Twin River Baseline Monitoring Report

By Steve Hogler and Jim Cahow

MWBC = 84,000

ABSTRACT

Streams in the East Twin Watershed flow southeastward through southern Kewaunee County and northern Manitowoc County to the City of Two Rivers where it enters Lake Michigan. The 101,196 acre watershed is split nearly evenly between Kewaunee and Manitowoc Counties with 42,932 acres (42.5%) in Kewaunee County and 58,264 acres (57.5%) in Manitowoc County.

Streams within the watershed range from those that are intermittent to perennial named streams. Classifications of these streams are also widely variable with multiple classifications found on some streams. Of the 98.9 stream miles in the basin, 67.9 miles have had their biological use classified. In this watershed 12.5 miles of stream are classified as trout waters, 26.9 miles are classed as warmwater sport fisheries, 13.6 miles as warmwater forage fisheries, 9.9 miles as limited forage fisheries and 5 miles of limited aquatic life.

Fish surveys have been conducted infrequently on the East Twin River, but those studies have found a wide variety of gamefish which range from trout in upper reaches, to smallmouth bass and northern pike in middle reaches to Lake Michigan species in the areas nearest to the lake.

Results from the survey indicate that although HBI and IBI ratings have changed little since earlier surveys, it appears that native warmwater gamefish species are nearly absent or low in abundance in many surveyed sections. The absence of gamefish from upper sections of the watershed may be due to low flow conditions or habitat loss, in middle sections due to deep pool loss and in lower sections due to low dissolved oxygen.

Brook trout populations in Tisch Mills Creek have dramatically increased since earlier surveys while those in the East Twin River remain stable and those in Krok Creek have declined. Increases are mostly likely due to improved water quality, while declines most likely are due to changes in flow patterns.

Water quality within the watershed is generally good as indicated by dissolved oxygen levels greater than 5 PPM and cool temperatures. However, water quality in the East Twin River below the dam in Mishicot appears to be impaired with high stream temperatures and dissolved oxygen levels below 5 PPM.

Streams within this system are well buffered and feature a variety of large-scale and small-scale habitats for aquatic organisms. Large gamefish habitat however is limited.

It is recommended that resource managers use the results from the survey to design protection or enhancement strategies for each stream and then enact these strategies

with the assistance of local partners. These strategies should use streambank protection programs (CRP, CREP) to maximize stream bank protection.

INTRODUCTION

Streams in the East Twin Watershed flow southeastward through southern Kewaunee County and northern Manitowoc County to the City of Two Rivers where it enters Lake Michigan (Figure 1). The 101,196 acre watershed is split nearly evenly between Kewaunee and Manitowoc Counties with 42,932 acres (42.5%) in Kewaunee County and 58,264 acres (57.5%) in Manitowoc County (WCD 1966 and 1968).

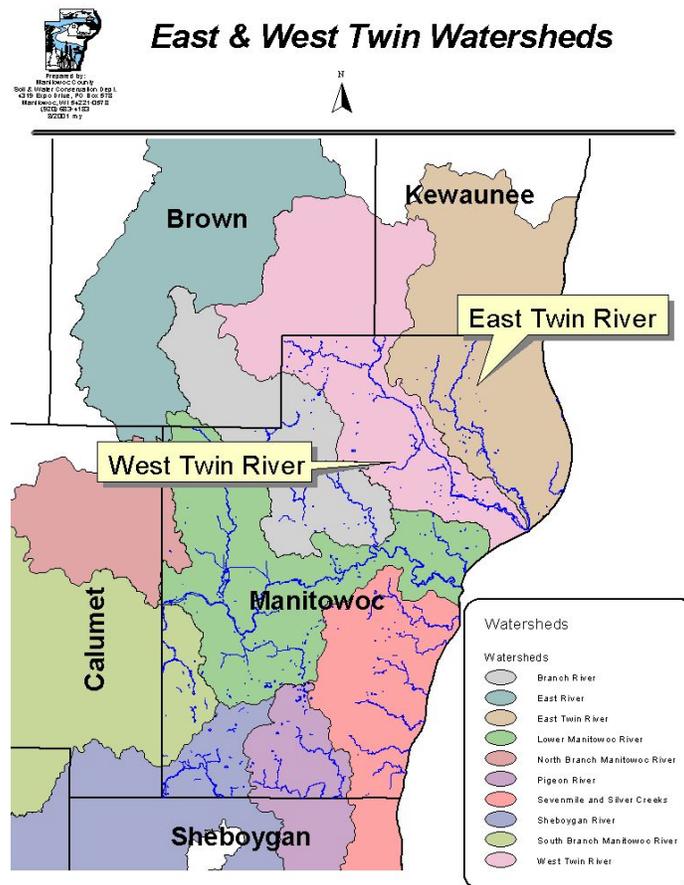


Figure 1. Location of the East Twin River Watershed in Kewaunee and Manitowoc Counties.

Soils in the watershed range from poorly drained organic soils in the north, to gently sloping clays in the central basin to well drained sandy loams near Lake Michigan. Most of the clay-loam soils are fine textured and easily erodible, which can lead to water quality impacts.

The predominate landuse in the watershed is agriculture, although a substantial amount of land is forested (Table 1). Other activities account for only sixteen percent of the landuse in the watershed.

Table 1. Landuse activities in the East Twin River Watershed.

| Activity | Acreage | Percent Landuse |
|-------------------------------------|----------------|------------------------|
| Agriculture | 68,784 | 68% |
| Non-Cropland | 8,467 | 8% |
| Wetlands | 1,196 | 2% |
| Woodlands | 16,266 | 16% |
| Other (urban, mining, roads, water) | 5,683 | 6% |
| Total | 101,196 | 100% |

Within the East Twin River watershed, there are three lakes that have 108 surface acres of water and twenty-two streams with a total of 98.9 miles of water. The three lakes, Engledinger, Heidmann and Shea are impacted by surrounding use. Elevated phosphorus levels in the lakes have resulted in the classification of mesotrophic for Heidmann Lake, with the other two lakes classified as eutrophic (WDNR 1995). Historical records indicate each lake has had winterkill problems, but none recently. The exact status of the fish community in each lake is unknown, but records indicate they are lakes with a largemouth bass-northern pike-bluegill mixture.

Streams within the watershed range from those that are intermittent to perennial named streams. Classifications of these streams are also widely variable with multiple classifications found on some streams. Of the 98.9 stream miles in the basin, 67.9 miles have had their biological use classified. In this watershed 12.5 miles of stream are classified as trout waters, 26.9 miles are classed as warmwater sport fisheries, 13.6 miles as warmwater forage fisheries, 9.9 miles as limited forage fisheries and 5 miles of limited aquatic life (WDNR 1995). Unclassified streams have the default classification of warmwater sportfisheries.

Historical information about streams in this watershed can provide a basis for comparison to our current work. Earlier surveys indicate that the East Twin River and its tributaries support a variety of fish species (Table 2). This list should be viewed cautiously, because of the limited data on fish distribution of non-game species from early surveys that did not collect this type of information.

East Twin River

The East Twin River is a large, low gradient stream (2.7 to 3.3 feet per mile) that flows 34.5 miles through mostly agricultural land on its way to Lake Michigan. Upper sections in Kewaunee County are slightly stained and classified as either Class 1 or Class 2 trout waters (WDNR 1995). Stream corridors are well buffered by forests and numerous groundwater seeps are present. Stream bottom sediments range from all sand to all silt with bedrock and gravel present in some streams (WCD 1966).

Table 2. Species list for fish captured in the East Twin River watershed during Fago's collection (1985) and during baseline monitoring in 2001. The species list from Fago includes both the East and West Twin River basins. An "X" denotes that a species was present in the survey.

| Group | COMMON NAME | SCIENTIFIC NAME | Found during 1974-1983 Survey | Found in 2001 Survey |
|--------------------|--------------------------------|---------------------------------|-------------------------------|----------------------|
| Lampreys | American brook lamprey | <i>Lampetra appendix</i> | X | X |
| | Sea lamprey | <i>Petromyzon marinus</i> | X | |
| Herrings | Alewife | <i>Alosa pseudoharengus</i> | X | |
| | Gizzard shad | <i>Dorosoma cepedianum</i> | X | |
| Trouts | Coho salmon | <i>Oncorhynchus kisutch</i> | X | |
| | Chinook salmon | <i>Oncorhynchus tshawytscha</i> | X | |
| | Rainbow trout | <i>Oncorhynchus mykiss</i> | X | |
| | Brown trout | <i>Salmo trutta</i> | X | X |
| | Brook trout | <i>Salvelinus fontinalis</i> | X | X |
| Smelts | Rainbow smelt | <i>Osmerus mordax</i> | X | |
| Mudminnows | Central mudminnow | <i>Umbra limi</i> | X | X |
| Pikes | Northern pike | <i>Esox lucius</i> | X | X |
| Minnows | Largescale stoneroller | <i>Camptostoma oligolepis</i> | X | X |
| | Goldfish | <i>Carassius auratus</i> | X | |
| | Redside dace | <i>Clinostomus elongatus</i> | X | X |
| | Lake chub | <i>Couesius plumbeus</i> | X | |
| | Common carp | <i>Cyprinus carpio</i> | X | X |
| | Brassy minnow | <i>Hybognathus hankinsoni</i> | | X |
| | Hornyhead chub | <i>Nocomis biguttatus</i> | X | X |
| | Golden shiner | <i>Notemigonus crysoleucas</i> | X | X |
| | Emerald shiner | <i>Notropis atherinoides</i> | X | |
| | Common shiner | <i>Luxilus cornutus</i> | X | X |
| | Blacknose shiner | <i>Notropis heterolepis</i> | X | |
| | Spottail shiner | <i>Notropis hudsonius</i> | X | |
| | Rosyface shiner | <i>Notropis rubellus</i> | | X |
| | Spotfin shiner | <i>Cyprinella spilopterus</i> | | X |
| | Sand shiner | <i>Notropis stramineus</i> | X | X |
| | Mimic shiner | <i>Notropis volucellus</i> | X | |
| | Northern redbelly dace | <i>Phoxinus eos</i> | X | |
| | Southern redbelly dace | <i>Phoxinus erythrogaster</i> | X | X |
| | Finescale dace | <i>Phoxinus neogaeus</i> | | X |
| | Bluntnose minnow | <i>Pimephales notatus</i> | X | X |
| | Fathead minnow | <i>Pimephales promelas</i> | | X |
| | Blacknose dace | <i>Rhinichthys atratulus</i> | X | X |
| | Longnose dace | <i>Rhinichthys cataractae</i> | X | X |
| Creek chub | <i>Semotilus atromaculatus</i> | X | X | |
| Pearl dace | <i>Margariscus margarita</i> | X | X | |
| Suckers | White sucker | <i>Catostomus commersoni</i> | X | X |
| | Silver redbhorse | <i>Moxostoma anisurum</i> | X | X |
| | Golden redbhorse | <i>Moxostoma erythrurum</i> | X | X |
| | Shorthead redbhorse | <i>Moxostoma macrolepidotum</i> | X | |
| | Greater redbhorse | <i>Moxostoma valenciennesi</i> | | X |
| Bullhead-Catfishes | Black bullhead | <i>Ameiurus melas</i> | X | X |
| | Yellow bullhead | <i>Ameiurus natalis</i> | X | |
| | Channel catfish | <i>Ictalurus punctatus</i> | X | X |
| | Stonecat | <i>Noturus flavus</i> | X | X |
| | Tadpole madtom | <i>Noturus gyrinus</i> | X | X |
| Trout-Perches | Trout perch | <i>Percopsis omiscomaycus</i> | X | |
| Sticklebacks | Brook stickleback | <i>Culaea inconstans</i> | X | X |
| Temperate basses | White bass | <i>Morone chrysops</i> | X | |
| Sunfishes | Rock bass | <i>Ambloplites rupestris</i> | X | X |
| | Green sunfish | <i>Lepomis cyanellus</i> | X | X |
| | Pumpkinseed | <i>Lepomis gibbosus</i> | X | X |
| | Bluegill | <i>Lepomis macrochirus</i> | | X |
| | Smallmouth bass | <i>Micropterus dolomieu</i> | X | X |
| | Largemouth bass | <i>Micropterus salmoides</i> | X | |
| | Black crappie | <i>Pomoxis nigromaculatus</i> | X | |
| Perches | Iowa darter | <i>Etheostoma exile</i> | X | X |
| | Johnny darter | <i>Etheostoma nigrum</i> | X | X |
| | Yellow perch | <i>Perca flavescens</i> | X | X |
| | Logperch | <i>Percina caprodes</i> | X | X |
| | Blackside darter | <i>Percina maculata</i> | X | X |

| | | | | |
|----------|-----------------|-----------------------------|---|---|
| | Walleye | <i>Stizostedion vitreum</i> | X | |
| Sculpins | Mottled sculpin | <i>Cottus bairdi</i> | X | X |
| | Slimy sculpin | <i>Cottus cognatus</i> | X | |

Lower sections of the East Twin River (Manitowoc County) flow through mostly agricultural land, although some sections are buffered by grass. Most of the urban development along the river is in the lowest sections in the city of Two Rivers and the village of Mishicot. A dam in Mishicot blocks fish movement in the river. However the dam does prevent further upstream migration of sea lamprey and allows for easier lamprey treatment in the East Twin. Bottom sediments in the lower sections of the East Twin range from sand to cobble, although silt can be present in depositional portions of the river (Weber et al. 1966).

Invertebrate rankings in the East Twin River range from fair to very good for the Hilsenhoff Biotic Index (Gansberg 1995). Habitat evaluation scores ranged from fair to good. Both indexes indicate good water quality. This is markedly different than water quality measurements in the 1930's and 1940's when poor water commonly reduced Dissolved Oxygen Levels (D.O.) to near zero resulting in many fish kills (Bartz 1938 and 1944). Construction of an improved sewage treatment plant in Mishicot, and restricting discharge from a dairy certainly has led to improved water quality in the river.

Fish surveys have been conducted infrequently on the East Twin River, but those studies have found a wide variety of gamefish which range from trout in upper reaches, to smallmouth bass and northern pike in middle reaches to Lake Michigan species in the areas nearest to the lake (Fago 1985, Hogler 2000). Forage species are abundant throughout the system. A large fish kill in 1982 as result of a sea lamprey treatment killed at least 21,000 fish (Bregge 1983). Minnows, suckers and bullheads were the most commonly killed species with substantially fewer gamefish noted.

Johnson Creek

Johnson Creek is a small, 2.4 mile tributary that enters the East Twin River below the dam in Mishicot. This stream flows through agricultural land and is considered to be extremely fertile. It is classified as a limited forage fishery.

Jambo Creek

Jambo Creek is a nine mile long, low gradient stream that flows southward through agricultural and forested land before joining with the East Twin River. The first three miles of Jambo Creek above it's confluence with the East Twin River are considered to be Class II brown trout waters (WDNR 1995). However, biologists believe that because of agricultural runoff this section of river is not meeting its full potential use. The upper 6 miles are considered to be a limited forage fishery or limited aquatic life stream because of low flows and warm summer temperatures. Habitat evaluations from areas of the stream classified as trout waters in 1994, ranged from fair to excellent, with invertebrate HBI scores indicating excellent water quality (Gansberg 1995). Habitat scores in upper sections of the river (non-trout waters) were fair.

Electrofishing surveys conducted on Jambo Creek by Schultz (1968), Belonger (1975) and Peeters (1983), in similar locations, found that stocked brown trout dominated the fishery. No evidence of natural reproduction by trout was found. Each survey found a limited number of gamefish, mostly a mixture northern pike and smallmouth bass. Most

of the fish captured were common shiners, white sucker, creek chub and sculpin. Other species of cyprinids similar to those collected by Fago (1985) were also captured during each survey.

Tisch Mills Creek

Tisch Mills Creek is an 8 mile long creek that is low gradient. The headwaters of the creek are in Kewaunee County where it drains a large amount of wetland. Upper sections of Tisch Mills Creek are classified a warmwater forage fishery because of low flow and poor habitat in these stream sections (WCC 1968). The lower 1 ½ miles of Tisch Mills Creek are classified as Class II brown trout waters because of improved flow and habitat. Recent invertebrate surveys had similar results, with scores of good for habitat and very good for water quality in sections classified as trout waters and fair in other sections of the river (Gansberg 1995).

Electroshocking surveys by Schultz and Wiegert (1964 and 1965) found that stocked trout clipped from previous seasons had survived well and showed good growth rates. Northern pike, white sucker, black side darter, pearl dace, longnose dace, common shiners and sculpin were common with rock bass classified as present. Bank and pool cover, and food abundance were considered good. The bottom type was classified as mostly gravel with some rock and rubble. Silt was a minor component of the bottom. Belonger (1974) noted similar fish species, although the number of northern pike was greatly reduced. However, he did note a shift in bottom type with less gravel observed and more sand, silt and detritus in the make-up of the bottom.

Krok Creek

Kroc Creek is a small, shallow 4 mile long tributary to the East Twin River. Flow is sluggish and the water is stained (Hacker 1957). Bottom material consisted of 80% silt, and the remainder was sand and gravel. Creek chub and pearl dace were the most commonly captured fish with white sucker, brook stickleback and sea lamprey occasionally captured.

Sampling by Gansberg (1995) found that habitat was fair, and that HBI scores indicted water quality as good.

Study Rationale

The purpose of the study described in this report was to measure environmental quality in streams located in the East Twin River Watershed 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 the main stem of the East Twin River and each major tributary at the rate of 1 for every five miles of perennial water (Figure 2). These sites included eight on the East Twin River and one each on Jambo Creek, Tisch Mills Creek, Kroc Creek and an unnamed tributary. We measured 10 times the mean stream width (MSW) away from a bridge or other man made structure to determine the starting point delineated sampling stations. The end point was then 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 than 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 2000). 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 2001 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 Marsh/McBirney instrument. 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, stream bank erosion and surrounding land use.

Biological Assessments

Biological assessment work included collecting stream invertebrates and fish. Collected invertebrates were sent to UW-Stevens 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 from streams that had riffle areas following standard invertebrate collection procedures.

Fish were sampled using electrofishing techniques during the summer. In the small streams surveyed a backpack shocker was used, while in the 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 collecting all fish observed 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

Hobo 8 Remote Sensing Temperature Data Loggers were deployed to record diurnal (diurnal = daily cycles of maximum and minimum) temperature regime data information at six locations. In addition to the standard temperature data collected, YSI 600 xlm remote sensing sondes were used to document diurnal swings in temperature, dissolved oxygen and pH at four locations on the East Twin River.

RESULTS

East Twin River at Steiners Corner

This site was located just downstream of the village of Mishicot (N44-13.279, W087-37.384 to N44- 13.431, W087- 37.435). The survey section averaged 12 meters in width and was 420 meters in length (Appendix 1). The gradient was 1.4 meters per kilometer and had a sinuosity of 1 to 1.4. The study reach of the river ran through agricultural and some residential lands and was mostly run with several pools located at stream bends (Figure 3).

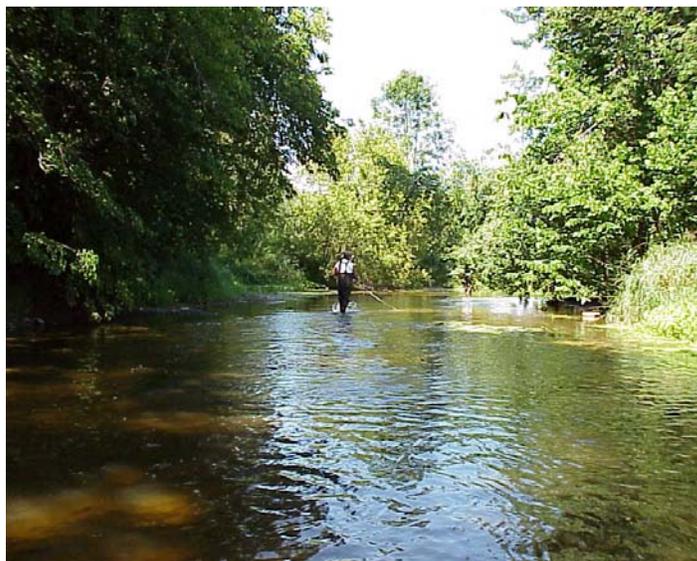


Figure 3. Looking upstream from Steiners Corners on August 14, 2001. Note that the stream is wide and shallow at this location.

Discharge

Water level was judged to be normal for the date of the survey and water clarity was rated clear. Flow was 0.42198 cubic meters per second (CMS) at this site.

Habitat

The section of river sampled was mostly run, with several large pools and one riffle area. Fish cover was limited to a small area of large woody debris and overhanging vegetation. Habitat features ranged from 11 meters (smallest run) to 128 meters (largest pool).

The bottom sediments were dominated by gravel, although large areas of sand were encountered (Figure 4). Sand in the lower transects of the station was replaced by gravel, followed by an increase in sand-silt combinations as we moved upstream.

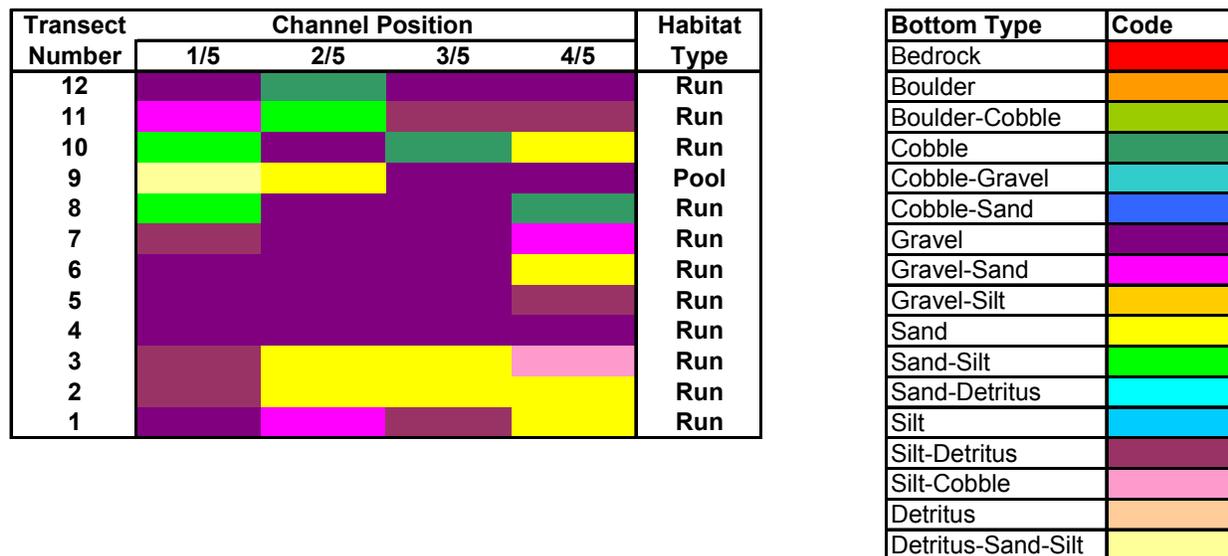


Figure 4. Bottom sediment map and key for transects at the Steiners Corner station. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were collected from a riffle 100 meters above the downstream end of the station. Samples produced a Hilsenhoff Biotic index of 4.98 indicating that water quality at this site was good (Table 3).

Table 3. Habitat, Hilsenhoff (HBI) and Fish Biotic Index (IBI) for sample locations collected during 1994 and 2001 on the East Twin River and its tributaries.

| River | Location | Stream Class. | 1994 | | 2001 | |
|---------------|-----------------|---------------|--------------|----------------|----------------|--------------|
| | | | Habitat Fall | HBI Fall | HBI | IBI |
| E. Twin | Steiners Corner | WWSF | | | 4.98-Good | 65-Excellent |
| | Rockledge | WWSF | | | 3.76-V. Good | 75-Excellent |
| | Tapawingo | WWSF | | | 4.17-V. Good | 75-Excellent |
| | Hwy 163 | WWSF | | | 4.10-V. Good | 65-Excellent |
| | Sandy Bay | WWSF | | | 5.39-Good | 70-Excellent |
| | Hwy B | WWSF | | | 5.19-Good | 45-Fair |
| | CTH J | WWSF | | | 4.15-V. Good | 40-Fair |
| | E. Townline | COLD II | 186-Fair | 4.36-V. Good | 4.15-V. Good | 50-Good |
| Tisch Mills | CTH BB | COLD II | 138-Fair | 2.89-Excellent | 3.05-Excellent | 55-Good |
| Unnamed Trib. | Hwy J | Default | | | 4.03-V. Good | 40-Fair |
| Krok Creek | HWY 29 | WWFF | | | | 40-Fair |
| Jambo Cr. | Jambo Cr. | COLD II | 132-Fair | 3.71-Excellent | 3.65-V. Good | 29-Poor |

Electroshocking in the East Twin River at Steiners Corners captured 2299 individual fish representing 27 species in the 420 meters of river that was sampled (Table 4). This resulted in an IBI score of 65 and a rating of excellent (Table 3).

Table 4. Fish species and abundance collected from electroshocking at Steiners Corner in the East Twin River, July 2001.

| Species | Number |
|------------------------|-------------|
| Central Mudminnow | 1 |
| Northern Pike | 1 |
| Largescale Stoneroller | 4 |
| Carp | 4 |
| Brassy Minnow | 24 |
| Hornyhead Chub | 251 |
| Common Shiner | 994 |
| Rosyface Shiner | 8 |
| Sand Shiner | 193 |
| Southern Redbelly Dace | 1 |
| Bluntnose Minnow | 568 |
| Fathead Minnow | 10 |
| Creek Chub | 10 |
| White Sucker | 70 |
| Silver Redhorse | 7 |
| Shorthead Redhorse | 1 |
| Black Bullhead | 1 |
| Channel Catfish | 1 |
| Madtom | 1 |
| Rock Bass | 47 |
| Green Sunfish | 19 |
| Pumpkinseed Sunfish | 3 |
| Smallmouth Bass | 59 |
| Johnny Darter | 12 |
| Yellow Perch | 1 |
| Logperch | 4 |
| Blackside Darter | 4 |
| Total | 2299 |

Three forage species, common shiner, bluntnose minnow and hornyhead chub dominated the catch (Table 4). Smallmouth bass were the most common gamefish and rock bass the most abundant panfish collected during the survey at this location.

Temperature and Dissolved Oxygen

Figure 5 documents the diurnal temperature, dissolved oxygen, and pH for the East Twin River below the Mishicot impoundment near Steiner's Corner Road during August of 2001. The dissolved oxygen profile shows that there are dramatic swings in the amount of D.O. each day, with some values below levels (5.0 mg/l) needed to support sensitive aquatic organisms. Temperature and pH appeared to be normal for the river and time of year.

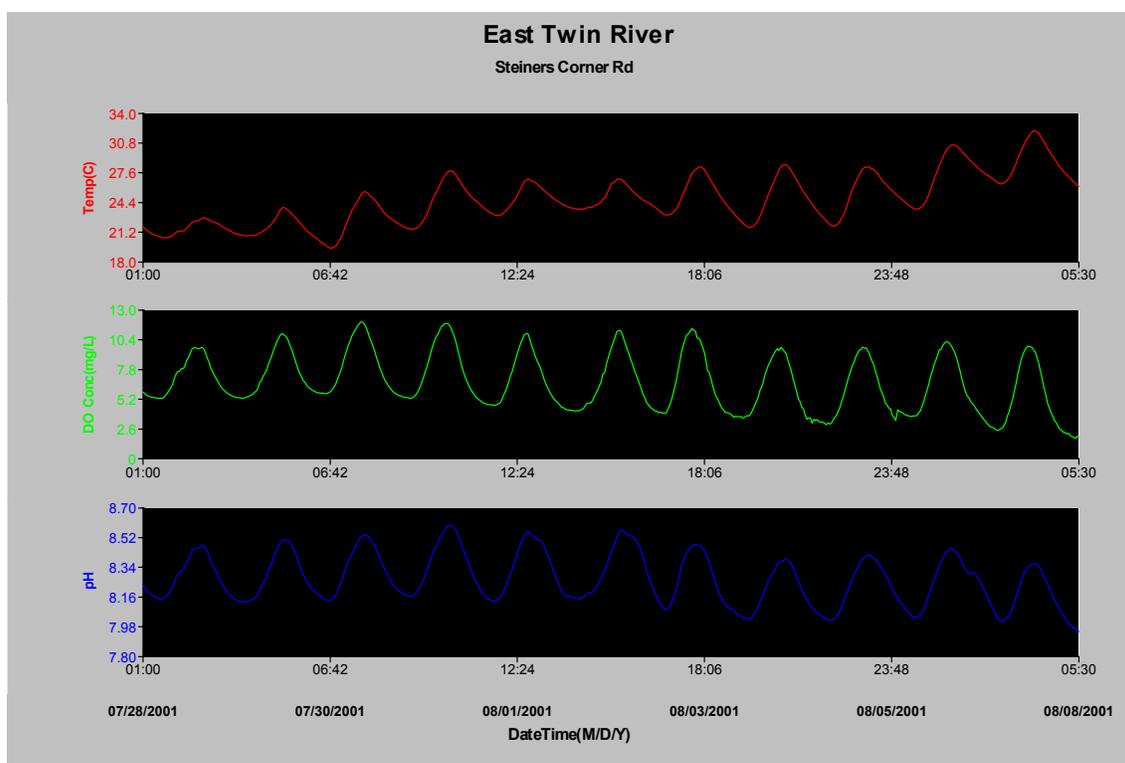


Figure 5. Diurnal temperature, dissolved oxygen, and pH for the East Twin River below the Mishicot impoundment near Steiner's Corner Road during August of 2001.

East Twin River at Rockledge Road

This site was located just upstream of the village of Mishicot millpond (N44-15.663, W087- 39.596 to N44- 15.855, W087- 39.706). The survey section averaged 12 meters in width and was 420 meters in length (Appendix 1). The gradient was 2.2 meters per kilometer and had a sinuosity of 1 to 1.1. The study reach of the river ran through agricultural land and was mostly run with several large pools located at stream bends (Figure 6).



Figure 6. Looking upstream on the East Twin River from the Rockledge Road bridge.

Discharge

Water level was judged normal for the time of the survey and water clarity was rated as slightly turbid. Flow was 0.3911 cubic meters per second (CMS) at this site.

Habitat

Runs and several large pools dominated the stream features of this section, with only one riffle area noted. Habitat features ranged from 1 meter (smallest pool) to 123 meters (longest run). Most features ranged in length from 30 to 40 meters in length. Fish cover in this section of stream consisted of large boulders and overhanging grass.

Sand, gravel, or a sand-gravel combination dominated the bottom type of the section (Figure 8). These combinations were very common in the middle transects of the site. However, several large pockets of boulders and cobble were encountered while. Soft sediments, silt and detritus were uncommon at this station.

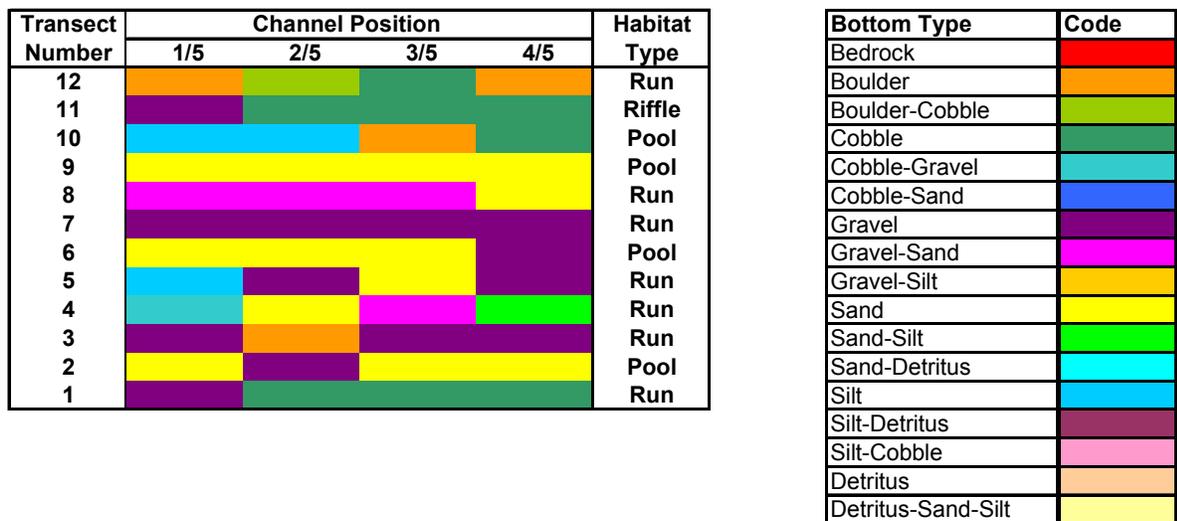


Figure 8. Bottom sediment map and key for transects at the Rockledge Road station. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were collected from a riffle just before the upstream end of the station. Samples produced a Hilsenhoff Biotic index of 3.76 indicating that water quality at this site was very good (Table 3).

The entire river section was electroshocked with a stream shocker to collect a representative subsample of fish. A total of 902 individual fish representing 24 species were collected (Table 5). This resulted in an IBI score of 75 and an IBI rating of excellent for the fisheries community in this section of the East Twin River (Table 3).

Table 5. Fish species and abundance collected from electroshocking at Rockledge Road on the East Twin River, July 2001.

| Species | Number |
|------------------------|--------|
| American Brook Lamprey | 4 |
| Central Mudminnow | 35 |
| Northern Pike | 1 |
| Largescale Stoneroller | 50 |
| Hornyhead Chub | 58 |
| Common Shiner | 312 |
| Rosyface Shiner | 15 |
| Southern Redbelly Dace | 6 |
| Bluntnose Minnow | 3 |
| Fathead Minnow | 17 |
| Blacknose Dace | 84 |
| Creek Chub | 22 |
| White Sucker | 161 |
| Silver Redhorse | 1 |

Table 5. (Cont.)

| | |
|-------------------|-----|
| Greater Redhorse | 5 |
| Brook Stickleback | 16 |
| Rock Bass | 2 |
| Green Sunfish | 5 |
| Bluegill | 1 |
| Johnny Darter | 79 |
| Yellow Perch | 1 |
| Logperch | 7 |
| Blackside Darter | 17 |
| Total | 902 |

The fishery at this location was dominated by common shiner and white sucker. Blacknose dace and johnny darter were also commonly captured. One small northern pike and the four species of panfish were captured in the limited pool habitat.

Temperature and Dissolved Oxygen

Figure 9 documents the diurnal temperature, dissolved oxygen, and pH for the East Twin River downstream of Rockledge Road during August 2001. Maximum diurnal temperatures continue to be above those that can support trout and other cold water species.

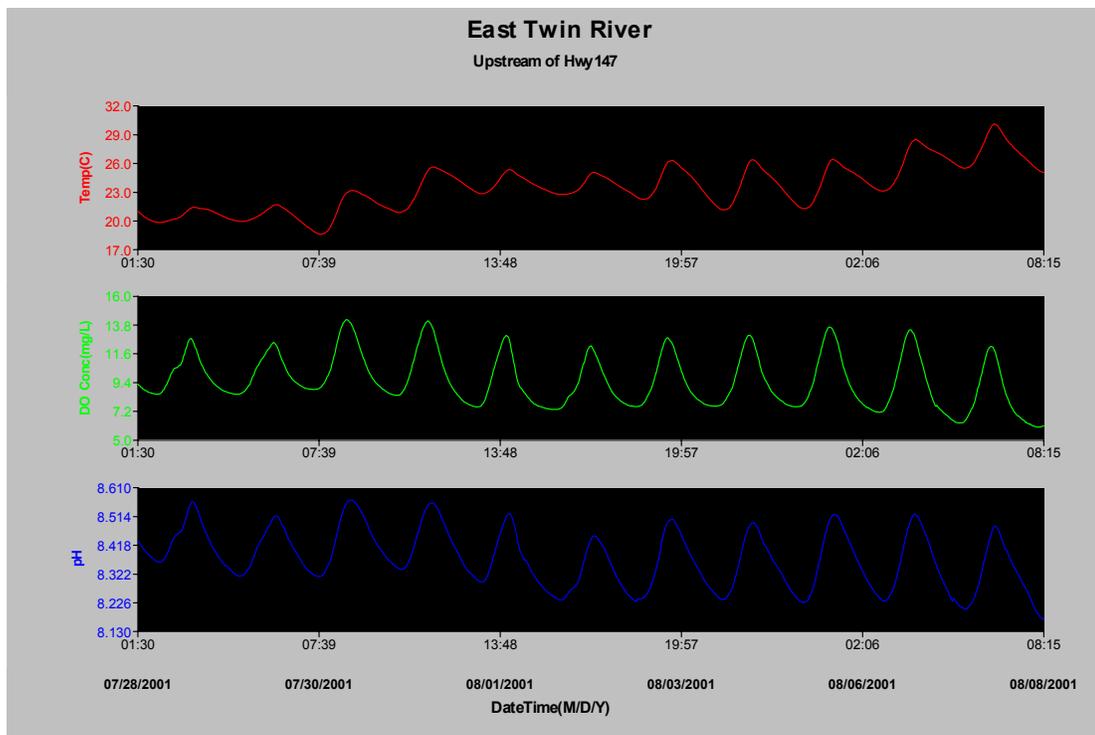


Figure 9. Diurnal temperature, dissolved oxygen, and pH for the East Twin River downstream of Rockledge Road during August 2001.

Despite the increase in stream temperature during the monitored time period, dissolved oxygen levels were consistently above 7 PPM indicating excellent water quality.

East Twin River at Tapawingo Road

This site was located downstream of Tapawingo Road, and ran through Camp Tapawingo (N44-16.855, W087-39.788 to N44-17.025, W087-39.549). The survey section averaged 15.76 meters in width and was 467 meters in length (Appendix 1). The gradient was 1.9 meters per kilometer and had a sinuosity of 1 to 1.4. The study reach of the river flowed through a mostly wooded area and had nearly equal amounts of run, riffle and pool habitat (Figure 10). One large island was found in the study section.



Figure 10. The East Twin River looking downstream from Tapawingo Road on June 13, 2002. Most of the site was forested as can be seen from this photograph.

Discharge

Water level was normal for the time of the survey and water clarity was slightly turbid. Flow was 0.2936 cubic meters per second (CMS) at this site.

Habitat

Only eleven transects were measured at this station because the twelfth would have been too near a bridge resulting in biased data. Runs, riffles and pools were found in nearly equal amounts in this study section. Feature size ranged from 12 meters (smallest run) to 99 meters (largest riffle), but most features were about 30 meters in length. Abundant large woody debris provided most of the measured fish habitat in the station, but overhanging vegetation and large boulder habitat were also present.

Bottom type in this section was dominated by gravel followed by sand (Figure 11). Sand-Silt or Sand-detritus sediments were encountered in pools or wide runs, but were not widespread throughout the remainder of section.

| Transect Number | Channel Position | | | | Habitat Type | Bottom Type | Code |
|-----------------|------------------|-----|-----|-----|--------------|--------------------|------|
| | 1/5 | 2/5 | 3/5 | 4/5 | | | |
| 12 | | | | | | Bedrock | |
| 11 | | | | | Run | Boulder | |
| 10 | | | | | Run | Boulder-Cobble | |
| 9 | | | | | Run | Cobble | |
| 8 | | | | | Riffle | Cobble-Gravel | |
| 7 | | | | | Run | Cobble-Sand | |
| 6 | | | | | Run | Gravel | |
| 5 | | | | | Run | Gravel-Sand | |
| 4 | | | | | Run | Gravel-Silt | |
| 3 | | | | | Run | Sand | |
| 2 | | | | | Pool | Sand-Silt | |
| 1 | | | | | Run | Sand-Detritus | |
| | | | | | | Silt | |
| | | | | | | Silt-Detritus | |
| | | | | | | Silt-Cobble | |
| | | | | | | Detritus | |
| | | | | | | Detritus-Sand-Silt | |

Figure 11. Bottom sediment map and key for transects at the Tapawingo Road station. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were collected from a small riffle 125 meters downstream from the upstream end of the station. The sample yielded a HBI score of 4.17 indicating water quality was very good at this site (Table 3).

Electroshocking captured 955 individual fish representing 18 species at this station (Table 6). These results gave the station an IBI score of 75, which rates the fish community of this stream section as excellent (Table 3).

Table 6. Fish species and abundance collected from electroshocking at Tapawingo Road on the East Twin River, July 2001.

| Species | Number |
|------------------------|--------|
| Central Mudminnow | 8 |
| Largescale Stoneroller | 39 |
| Hornyhead Chub | 75 |
| Common Shiner | 372 |
| Rosyface Shiner | 10 |
| Southern Redbelly Dace | 106 |
| Bluntnose Minnow | 11 |
| Blacknose Dace | 6 |
| Longnose Dace | 7 |

Table 6. (Cont.)

| | |
|-------------------|------------|
| Creek Chub | 39 |
| White Sucker | 127 |
| Greater Redhorse | 5 |
| Brook Stickleback | 2 |
| Rock Bass | 7 |
| Green Sunfish | 7 |
| Smallmouth Bass | 3 |
| Johnny Darter | 109 |
| Blackside Darter | 22 |
| Total | 955 |

Common shiner, southern redbelly dace, white sucker and johnny darter were the dominant species collected at this site. The smallmouth bass captured here were young-of-year fish and ranged in length from 45 mm to 50 mm. Few panfish were collected at this site.

Temperature and Dissolved Oxygen

Continuous monitoring of temperature and dissolved oxygen was not conducted at this location.

East Twin River at County Highway AB

This site was located just upstream of County Highway AB, and ran through mostly pasture land (N44-18.466, W087- 38.647 to N44-18.609, W087- 38.559). The survey section averaged 9.4 meters in width and was 315 meters in length (Appendix 1). The gradient was 1.9 meters per kilometer and had a sinuosity of 1 to 1.09. The study reach of the river was predominantly run, with several small pools and only one riffle (Figure 12).



Figure 12. Looking upstream from the Highway AB bridge over the East Twin River.

Discharge

Water level was normal for the time of the survey and water clarity was slightly turbid. Flow was 0.2211 cubic meters per second (CMS) at this site.

Habitat

Runs were the most common stream feature in this section of river. Fewer pools and only one riffle were encountered in the study reach. Feature size ranged from 3.4 meters (smallest pool) to 55.5 meters (largest run), but most features were about 15 meters in length. Large woody debris and boulders provided most of the fish habitat measured in the station, but the total amount of fish habitat was limited to three small areas of the study section.

Gravel, sand or gravel-sand combinations dominated bottom substrate in this section (Table 13). Other than the two boulder patches in transect 10 and 11 and the silt in transect 3, the bottom was flat and fairly monotypic.

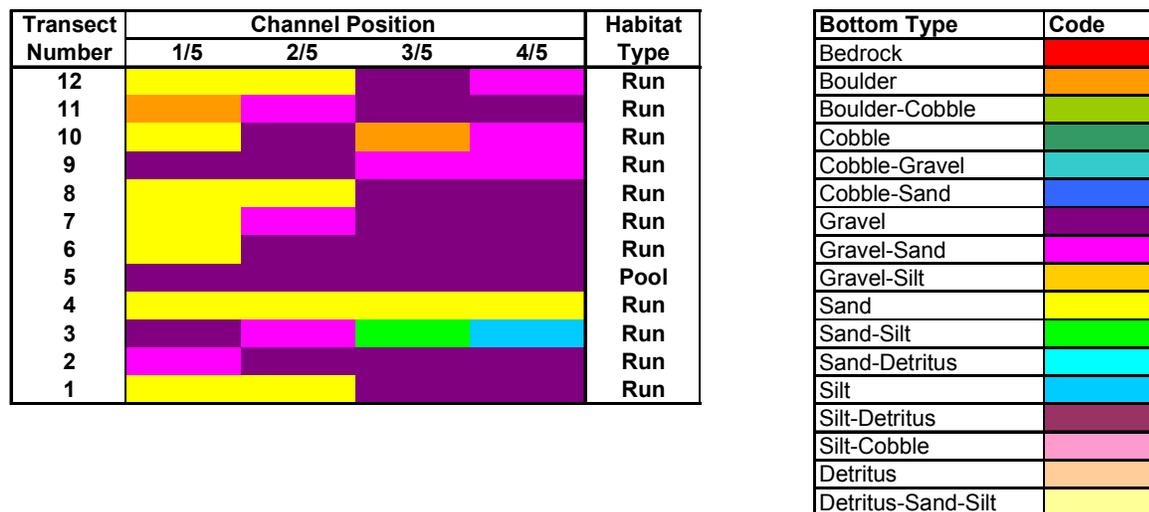


Figure 13. Bottom sediment map and key for transects at the County Highway AB station. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were collected from a small riffle 100 meters upstream from the lower end of the station adjacent to a sheep pasture. The sample yielded a HBI score of 4.10 indicating water quality was very good at this site (Table 3).

Electroshocking captured 655 individual fish representing 20 species at this station (Table 7). These results gave the station an IBI score of 65, which rates the fish community of this stream section as excellent (Table 3).

Table 7. Fish species and abundance collected from electroshocking at County Highway AB on the East Twin River, August 2001.

| Species | Number |
|------------------------|---------------|
| American Brook Lamprey | 1 |
| Central Mudminnow | 21 |
| Largescale Stoneroller | 3 |
| Hornyhead Chub | 34 |
| Common Shiner | 269 |
| Rosyface Shiner | 2 |
| Southern Redbelly Dace | 91 |
| Bluntnose Minnow | 27 |
| Fathead Minnow | 1 |
| Longnose Dace | 1 |
| Creek Chub | 21 |
| White Sucker | 151 |
| Golden Redhorse | 4 |
| Brook Stickleback | 2 |
| Green Sunfish | 3 |
| Iowa Darter | 1 |
| Johnny Darter | 10 |
| Logperch | 1 |
| Blackside Darter | 11 |
| Mottled Sculpin | 1 |
| Total | 655 |

Three forage species, common shiner, white sucker and southern redbelly dace, dominated the fish community at this location (Table 7). Other forage species were captured in substantially lower numbers. No gamefish and only one panfish were captured at this site.

Temperature and Dissolved Oxygen

Continuous monitoring of temperature and dissolved oxygen was not conducted at this location, but monitoring did occur approximately 3 kilometers upstream from this location upstream of County Highway BB just outside of Tisch Mills.

Figure 14 documents the diurnal temperature, dissolved oxygen, and pH for the East Twin River near Tisch Mills during August of 2001. The diurnal temperatures approached 30 degrees Centigrade, which is well beyond those capable of supporting trout and some species of gamefish. Dissolved oxygen levels dropped below 5 mg/L following a minor runoff event and probably drop much lower with heavier runoff events or during drought conditions with warmer than average summer temperatures.

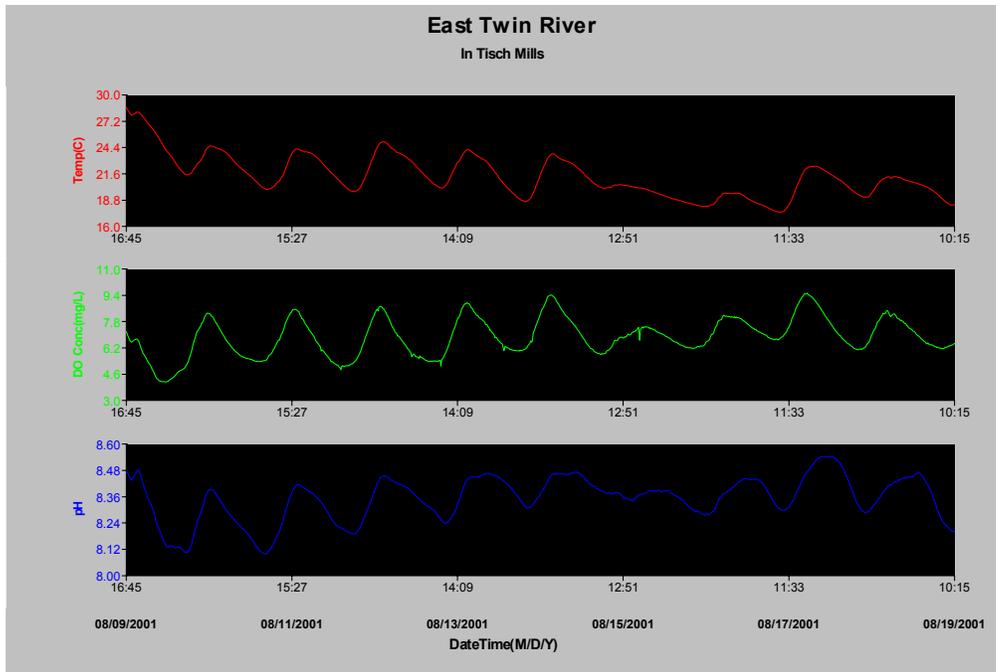


Figure 14, diurnal temperature, dissolved oxygen, and pH for the East Twin River near Tisch Mills during August of 2001.

East Twin River at Sandy Bay Road

This site was located just upstream of Sandy Bay Road, and ran through mostly pasture land on one bank and meadow on the opposite bank (N44-21.410, W087-36.029 to N44-21.585, W087-35.016). The survey section averaged 8.5 meters in width and was 297.5 meters in length (Appendix 1). The gradient was 5.1 meters per kilometer and had a sinuosity of 1 to 1.07. The study reach of the river was a series of pools and runs (Figure 15). No riffle areas were encountered at this site.



Figure 15. The East Twin River, looking upstream from the bridge on Sandy Bay Road. Stream bank use by pasturing cows was observed at this location.

Discharge

Water level was normal for the time of the survey and water clarity was slightly turbid. Flow was 0.1175 cubic meters per second (CMS) at this site.

Habitat

Runs and pools were the most common stream features in this section of river. No riffle areas were noted. Feature size ranged from 17.9 meters (smallest run) to 146.3 meters (largest run), but most features were about 25 meters in length. Boulders and a small area of aquatic vegetation provided most of the fish habitat measured in the station. However, the total amount of fish habitat was limited to just four small areas of the study section.

Sand, sand/detritus or sand/silt mixtures dominated the bottom substrate at this location (Figure 16). Few locations along the stream transects contained substantial amounts of hard substrates in the form of gravel, cobble or boulders which limited the amount of fish habitat available at this site.

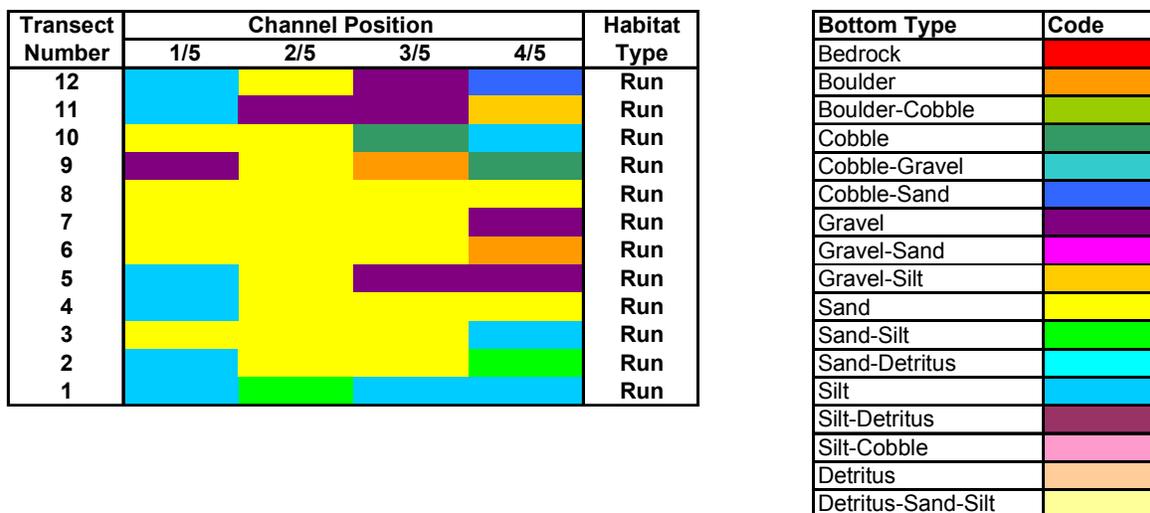


Figure 16. Bottom sediment map and key for transects at the Sandy Bay Road station. Transect 1 is the furthest downstream sampling location.

Bare soil and stream bank erosion was noted at most transects in this study section. Pasturing of cattle along the stream bank was the likely cause for the impacted banks in this section of river.

Biological Assessments

Invertebrates were collected from a small riffle just at the downstream edge of this station adjacent to a cow pasture. The sample yielded a HBI score of 5.39 indicating water quality was good at this site (Table 3). An increased gradient at the location the sample was collected at most likely allowed for the establishment of a more diverse

population of invertebrates and masked the effects of sedimentation that was apparent throughout the remainder of the study site.

Electroshocking captured 2,679 individual fish representing 21 species at this station (Table 8). These results gave the station an IBI score of 70, which rates the fish community of this stream section as excellent (Table 3).

Table 8. Fish species and abundance collected from electroshocking at Sandy Bay Road on the East Twin River, August 2001.

| Species | Number |
|------------------------|---------------|
| American Brook Lamprey | 2 |
| Central Mudminnow | 12 |
| Largescale Stoneroller | 24 |
| Hornyhead Chub | 300 |
| Golden Shiner | 1 |
| Common Shiner | 1160 |
| Rosyface Shiner | 10 |
| Sand Shiner | 1 |
| Southern Redbelly Dace | 796 |
| Finescale Dace | 8 |
| Fathead Minnow | 33 |
| Blacknose Dace | 13 |
| Longnose Dace | 11 |
| Creek Chub | 92 |
| Pearl Dace | 1 |
| White Sucker | 155 |
| Brook Stickleback | 4 |
| Rock Bass | 24 |
| Bluegill | 2 |
| Johnny Darter | 22 |
| Blackside Darter | 8 |
| Total | 2,679 |

Five forage species, common shiner, southern redbelly dace, hornyhead chub, white sucker and creek chub dominated the fish community at this site with all other species occurring in substantially lower numbers. The 24 rock bass and 2 bluegill captured at this location were young-of-year or age 1 fish.

Temperature and Dissolved Oxygen

Continuous monitoring of temperature and dissolved oxygen was not conducted at this location.

East Twin River at County Highway B

This site was located just upstream of County Highway B, and ran through mostly meadow and woodland (N44-23.461, W087-36.083 to N44-23.463, W087-36.125). The survey section averaged 4.0 meters in width and was 140 meters in length (Appendix

1). The gradient was 6.5 meters per kilometer and had a sinuosity of 1 to 2.5. The study reach of the river was a series of pools and runs with one small riffle (Figure 17).



Figure 17. The East Twin River, looking upstream from the bridge on County Highway B.

Discharge

Water level was normal for the time of the survey and water clarity was clear. Flow was 0.1529 cubic meters per second (CMS) at this site.

Habitat

Runs and pools were the most common stream features in this section of river. Only one riffle area was noted. Feature size ranged from 1.2 meters (smallest riffle) to 41.7 meters (largest run), but most features were much smaller and were 10 to 20 meters in length. Overhanging vegetation provided the entire measured fish habitat in the station and was limited to just four locations.

The make-up of the bottom sediments changed as one moved upstream. The gravel and sand-gravel mixture found along early transects was replaced by a sand-detritus mixture and finally silt and detritus (Figure 18). Land use that surrounds this site must be affecting stream habitat because eroded banks, bare soil and the amount of soft sediment in the stream. Bottom sediments were also covered with *Cladophora sp.* and many diatoms indicating nutrient enrichment.

| Transect Number | Channel Position | | | | Habitat Type | Bottom Type | Code |
|-----------------|------------------|-----|-----|-----|--------------|--------------------|------|
| | 1/5 | 2/5 | 3/5 | 4/5 | | | |
| 12 | | | | | Pool | Bedrock | |
| 11 | | | | | Run | Boulder | |
| 10 | | | | | Run | Boulder-Cobble | |
| 9 | | | | | Run | Cobble | |
| 8 | | | | | Run | Cobble-Gravel | |
| 7 | | | | | Run | Cobble-Sand | |
| 6 | | | | | Run | Gravel | |
| 5 | | | | | Run | Gravel-Sand | |
| 4 | | | | | Run | Gravel-Silt | |
| 3 | | | | | Run | Sand | |
| 2 | | | | | Run | Sand-Silt | |
| 1 | | | | | Riffle | Sand-Detritus | |
| | | | | | | Silt | |
| | | | | | | Silt-Detritus | |
| | | | | | | Silt-Cobble | |
| | | | | | | Detritus | |
| | | | | | | Detritus-Sand-Silt | |

Figure 18. Bottom sediment map and key for transects at the County Highway B station. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were collected from a small riffle just at the downstream edge of this station just above the County B Bridge. The sample yielded a HBI score of 5.19 indicating water quality was good at this site despite abundant filamentous algae and diatoms (Table 3).

Electroshocking captured 204 individual fish representing 12 species at this station (Table 8). These results gave the station an IBI score of 45, which rates the fish community of this stream section as fair (Table 3).

Table 8. Fish species and abundance collected from electroshocking at County Highway B on the East Twin River, August 2001.

| Species | Number |
|------------------------|------------|
| Central Mudminnow | 12 |
| Hornyhead Chub | 19 |
| Common Shiner | 48 |
| Southern Redbelly Dace | 24 |
| Bluntnose Minnow | 1 |
| Blacknose Dace | 3 |
| Creek Chub | 30 |
| White Sucker | 51 |
| Brook Stickleback | 2 |
| Johnny Darter | 2 |
| Blackside Darter | 1 |
| Mottled Sculpin | 11 |
| Total | 204 |

White sucker and common shiner were the most common species collected followed by creek chub and southern redbelly dace (Table 8). No gamefish or panfish were captured at this site, although stocked brown trout were observed at this location.

Temperature and Dissolved Oxygen

Figure 19, documents the diurnal temperature for a section of the East Twin River at County Highway B approximately 5-6 miles downstream from the headwaters of the river. Since stocked brown trout were observed in the sampling station and appeared to have survived and grown 1-2 years since stocking, this would indicate that temperature and dissolved oxygen levels did not preclude survival of coldwater species during the immediate years preceding the survey. Temperature never exceeded 22 C. during the survey period.

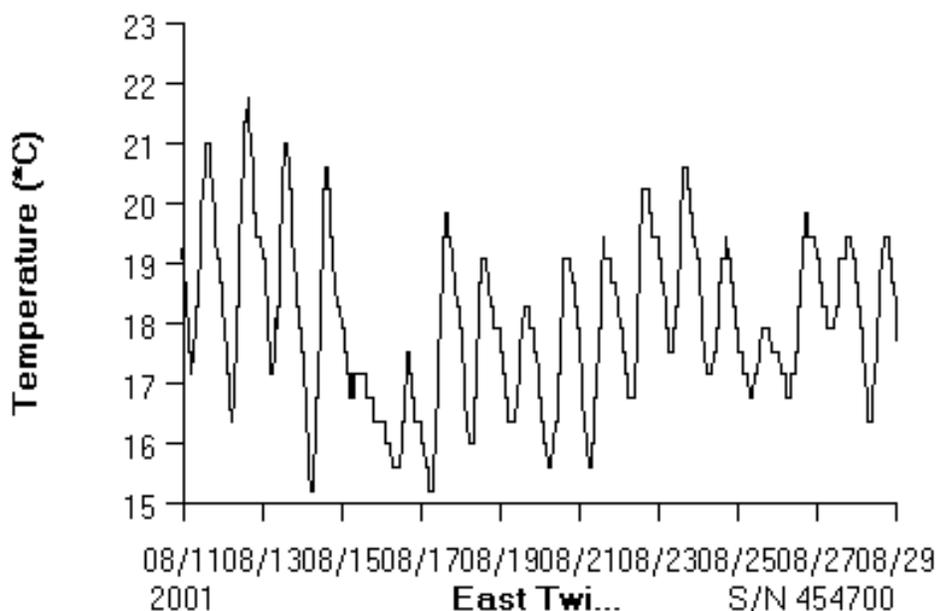


Figure 19, diurnal temperature for a section of the East Twin River at CTH B, upstream of confluence with un-named tributary flowing out of East Krok, August 2001.

Continuous monitoring of dissolved oxygen levels was not conducted at this site during the survey.

East Twin River at County Highway J

This site was located just upstream of County Highway J, and ran through mostly meadow, shrubs and woodland (N44-24.020, W087-36.855 to N44-24.048, W087-36.894). The survey section averaged 4.0 meters in width and was 140 meters in length (Appendix 1). The gradient was 2.2 meters per kilometer and had a sinuosity of 1 to 1.5.

The study reach of the river was a series of pools and runs without any riffles (Figure 20).



Figure 20. The East Twin River, looking upstream from the bridge on County Highway J.

Discharge

Water level was normal for the time of the survey and water clarity was clear. Flow 0.1110 cubic meters per second (CMS) at this site.

Habitat

This stream section was a series of small runs and pools occurring in near equal amounts. No riffle areas were encountered. Feature size ranged from 6.0 meters to 23 meters, but most features were 10 to 15 meters in length. Woody debris and overhanging vegetation provided the fish habitat at this site. Bank erosion was noted at every transect.

The bottom sediments at this site were dominated by sand. Small pockets of detritus, silt and gravel were encountered but in many cases, these also had sand in the mixture.

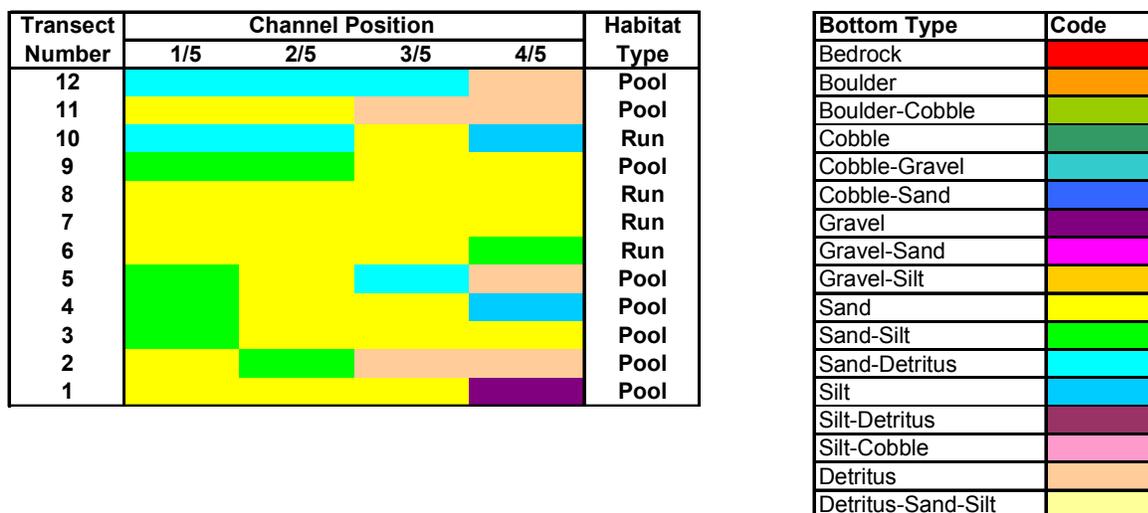


Figure 21. Bottom sediment map and key for transects at the County Highway J station. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were collected from a small riffle downstream of the County J Bridge below the study section. The sample yielded a HBI score of 4.15 indicating water quality was very good at this site (Table 3). Some filamentous algae and diatoms were noted at the collection location.

Electroshocking captured 221 individual fish representing 14 native species at this station (Table 9). These results gave the station an IBI score of 40, which rates the fish community of this stream section as fair (Table 3). Additionally, two stocked brown trout were captured during electroshocking but were not used to calculate the IBI score.

Table 9. Fish species and abundance collected from electroshocking at County Highway J on the East Twin River, August 2001.

| Species | Number |
|------------------------|------------|
| American Brook Lamprey | 2 |
| Brown Trout | 2 |
| Central Mudminnow | 21 |
| Hornyhead Chub | 13 |
| Common Shiner | 29 |
| Southern Redbelly Dace | 18 |
| Bluntnose Minnow | 4 |
| Blacknose Dace | 5 |
| Longnose Dace | 1 |
| Creek Chub | 48 |
| Pearl Dace | 5 |
| White Sucker | 44 |
| Brook Stickleback | 2 |
| Johnny Darter | 18 |
| Mottled Sculpin | 11 |
| Total | 221 |

Creek chub and white sucker were the most abundant species captured during electroshocking at this location. Common shiner and central mudminnow were also commonly caught. No native gamefish or panfish were captured. Two stocked brown trout were captured at this site.

Temperature and Dissolved Oxygen

Figure 22, documents the diurnal temperature for a section of the East Twin River at Krok Road, approximately 2 kilometers upstream of Highway J during August of 2001. Maximum diurnal temperatures reached 24 Centigrade. The section of the East Twin River between Highway 29 and Krok Road lacks adequate buffer widths and composition which results in a lack of forest canopy. This lack of forest canopy resulted in more sunlight reaching the stream and increased water temperatures in the stream.

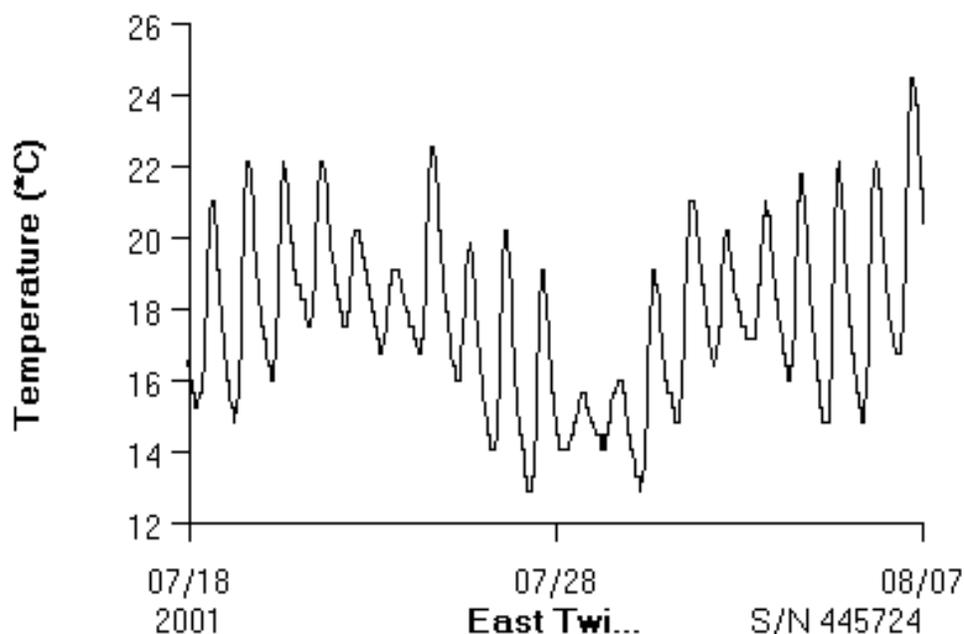


Figure 22. Diurnal temperatures for the East Twin River at Krok Road, approximately 2 kilometers upstream of County Highway J, during August of 2001.

Continuous dissolved oxygen monitoring was not conducted at this location.

East Twin River at Townline Road

This site was located just upstream of Townline Road, and ran through mostly shrubs and woodland (N44-26.706, W087-38.659 to N44-26.759, W087-38.723). The survey section averaged 4.0 meters in width and was 140 meters in length (Appendix 1). The gradient was 2.2 meters per kilometer and had a sinuosity of 1 to 1.1. The study reach

of the river consisted of one long run, several small runs and pools and one riffle (Figure 23).



Figure 23. The East Twin River, looking upstream from the bridge on Townline Road.

Discharge

Water level was normal for the time of the survey and water clarity was clear. Flow was 0.0255 cubic meters per second (CMS) at this site.

Habitat

This stream section contained one long run and a series of small runs, riffles and pools. Feature size ranged from 2.0 meters (smallest riffle) to 88 meters (longest run), but most features were 5 to 10 meters in length. Bank erosion was noted at several transects in this study site.

Similar to the study site at Highway J, the bottom sediments at this site were dominated by sand, or sand mixtures (Figure 24). Some small deposits of detritus and gravel were encountered, but they were not widespread at the site.

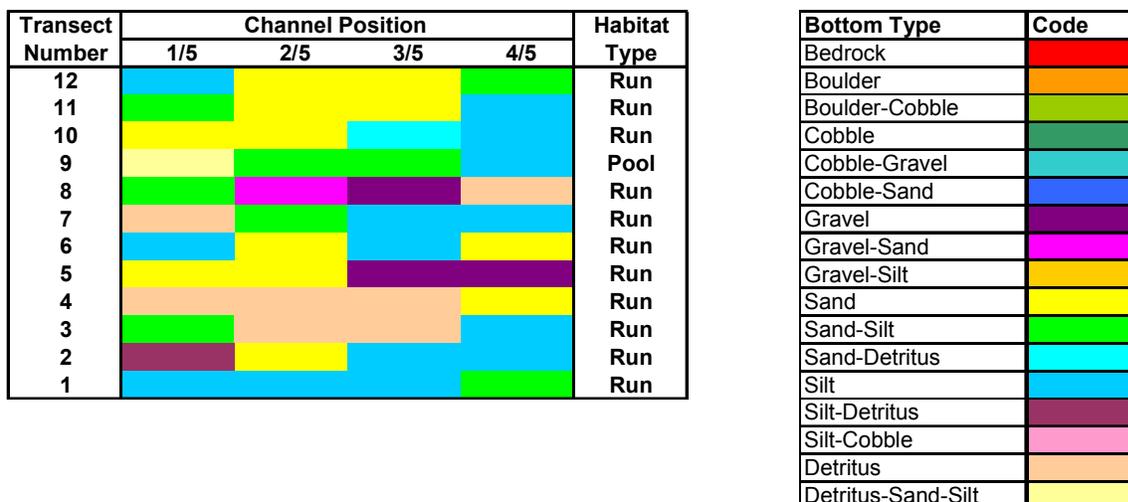


Figure 24. Bottom sediment map and key for transects at the Townline Road station. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were collected from a marginal riffle at the downstream limit of the study section. The sample yielded a HBI score of 4.15 indicating water quality was very good at this site (Table 3).

Electroshocking captured 78 individual fish representing 9 native species at this station (Table 10). These results gave the station an IBI score of 50, which rates the fish community of this stream section as good (Table 3).

Table 10. Fish species and abundance collected from electroshocking at Townline Road on the East Twin River, July 2001.

| Species | Number |
|------------------------|-----------|
| American Brook Lamprey | 2 |
| Brook Trout | 3 |
| Central Mudminnow | 8 |
| Longnose Dace | 1 |
| Pearl Dace | 10 |
| White Sucker | 1 |
| Brook Stickleback | 11 |
| Johnny Darter | 1 |
| Mottled Sculpin | 41 |
| Total | 78 |

Mottled sculpin was the most common fish captured at this location followed by brook stickleback and pearl dace. Also captured at this location were 3 native brook trout. Their lengths were 74 mm, 190 mm and 211 mm. This was the first survey at this location to catch brook trout. It is likely their range expanded from either Tisch Mills Creek or Krok Creek.

Temperature and Dissolved Oxygen

Figure 25 documents the diurnal temperature, dissolved oxygen, and pH for more than two weeks in the headwaters of the East Twin River, near East Townline Road during August of 2001. This stream segment was found to have summer diurnal temperatures which seldom increased above 20 Centigrade (Figure 25). Dissolved oxygen levels did drop below 6 mg/L during the study; but averaged closer to 7 mg/L for the majority of the period monitored. This short section of the stream has good stream buffers and along with a dense forest canopy, helped to maintain colder water temperatures with good D.O. levels.

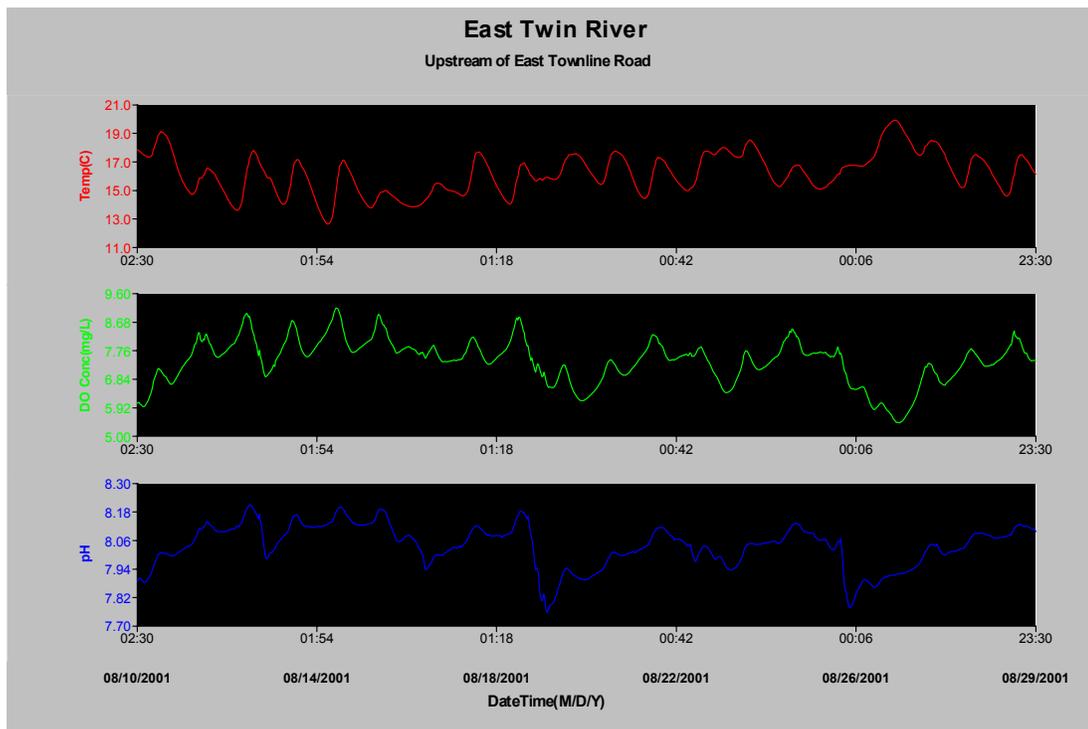


Figure 25. Diurnal temperature, dissolved oxygen, and pH for the East Twin River at East Townline Road, August of 2001.

Jambo Creek at Jambo Creek Road

This site was located just upstream of Jambo Creek Road, and ran through mostly shrubs and woodland (N44-15.743, W087-40.882 to N44-15.832, W087-40.900). The survey section averaged 5.4 meters in width and was 189 meters in length (Appendix 1). The gradient was 1.6 meters per kilometer and had a sinuosity of 1 to 1.1. The study reach of the river was most pool and run with a lesser amount of riffle (Figure 26).



Figure 26. Jambo Creek, looking upstream from the bridge on Jambo Creek Road.

Discharge

Water level was normal for the time of the survey and water clarity was slightly stained. Flow was 0.0287 cubic meters per second (CMS) at this site.

Habitat

This stream section began with a series of riffles and runs, followed by several large pools that were separated by runs. One pool appeared to have been enlarged mechanically. Feature size ranged from 7.9 meters (smallest run) to 43 meters (longest pool), but most features were 15 to 25 meters in length. Slight bank erosion was noted at lower transects at this site.

Cobble and boulder bottom substrates were common at this site. Several large areas of silt and sand were also encountered. Even in run areas, current was not strong enough to remove the deposited silt from the stream. Gravel deposits were infrequent and scattered throughout the site.

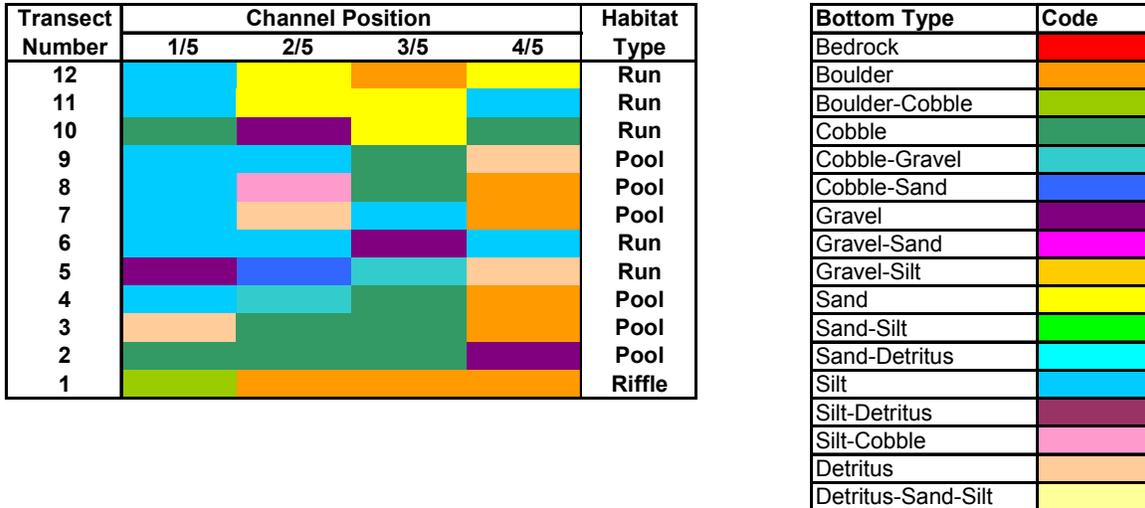


Figure 27. Bottom sediment map and key for transects at the Jambo Creek location. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were collected from a good riffle at location of the first habitat transect. The sample yielded a HBI score of 3.65 indicating water quality was very good at this site (Table 3).

Electroshocking captured 25 individual fish representing 9 native species at this station (Table 11). These results gave the station an IBI score of 29, which rates the fish community of this stream section as poor (Table 3). Additionally, two stocked brown trout were captured during electroshocking but were not used to calculate the IBI score.

Table 11. Fish species and abundance collected from electroshocking at Jambo Creek Road on Jambo Creek, August 2001.

| Species | Number |
|------------------------|-----------|
| American Brook Lamprey | 2 |
| Brown Trout | 2 |
| Central Mudminnow | 7 |
| Northern Pike | 2 |
| Fathead Minnow | 1 |
| Creek Chub | 2 |
| White Sucker | 3 |
| Johnny Darter | 5 |
| Blackside Darter | 2 |
| Mottled Sculpin | 1 |
| Total | 27 |

Fish abundance and diversity at this location was low given the variety of habitat and the invertebrate community that were found in the study section. The dredged pool or some other water quality event must have reduced fish numbers in this section of river.

The two northern pike were 202 mm and 215 mm in length, while the two captured brown trout that were most likely recently stocked at this location were 235 mm and 245 mm in length.

Temperature and Dissolved Oxygen

Figure 28, documents the diurnal temperature for Jambo Creek at Jambo Creek Road, during August of 2001. Water temperatures during the monitoring ranged from 16 C. to 24 C. (Figure 28). The observed temperature regime could limit the success of coldwater species in the section of river.

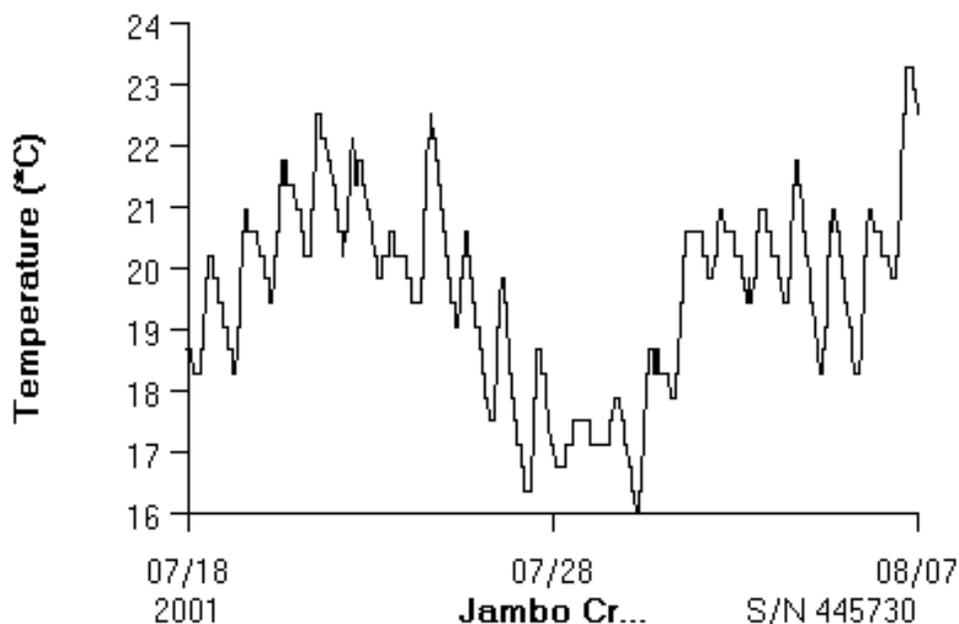


Figure 28. Diurnal temperature for Jambo Creek at Jambo Creek Road, during the August of 2001.

Dissolved oxygen levels were not monitored at this location during the study period.

Tisch Mills Creek at County Highway BB

This site was located just upstream of County Highway BB, and ran through mostly woodland with some shrubs (N44-19.660, W087-38.206 to N44-19.738, W087-38.068). The survey section averaged 7.0 meters in width and was 245 meters in length (Appendix 1). The gradient was 1.2 meters per kilometer and had a sinuosity of 1 to 1.5. The study reach of the river was mostly runs and pools with few riffles (Figure 29).



Figure 29. Looking upstream at Tisch Mills Creek from County Highway BB.

Discharge

Water level was normal for the time of the survey and water clarity was clear. Flow was 0.0296 cubic meters per second (CMS) at this site.

Habitat

This stream section began with a series of riffles and pools. Following the beginning series of features, several large pools were encountered that were separated by runs. Feature size ranged from 2.7 meters (smallest riffle) to 80.8 meters (longest run), but most features were 25 meters in length. One island and one large downfall of trees were encountered at this site. Fish cover at this location included undercut banks, overhanging vegetation and large woody debris. Most riffles were too shallow to have boulders classified as fish habitat.

The bottom sediments at this location were extremely rocky. Most of the transects contained gravel, cobble, boulders and a small amount of bedrock. Sand was common but silt and detritus were uncommon except in pools or where deposited behind obstructions in the river.

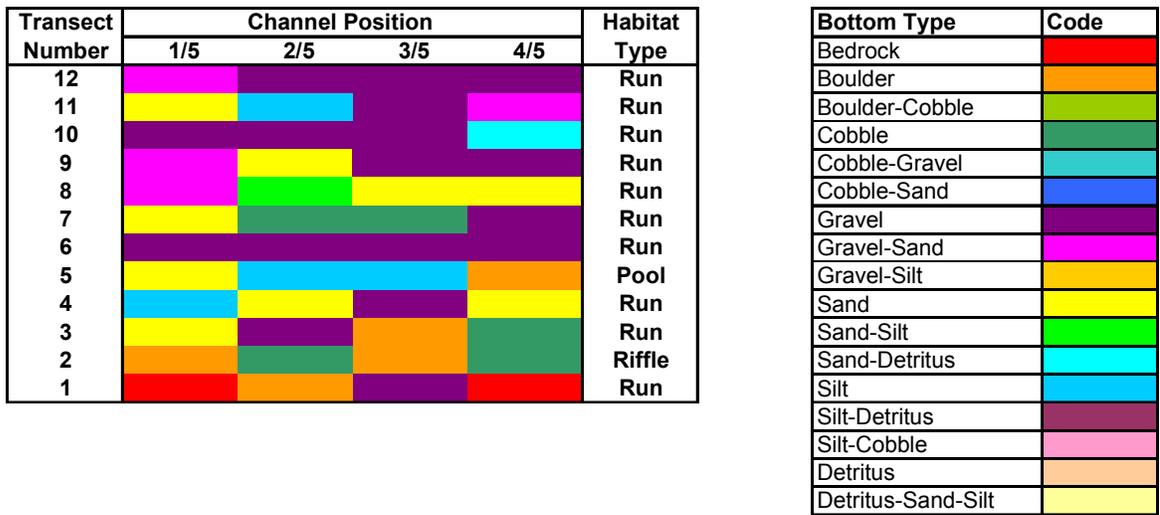


Figure 30. Bottom sediment map and key for transects at the Tisch Mills Creek location. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were collected from a good riffle at location of the first habitat transect. The sample yielded a HBI score of 3.05 indicating water quality was excellent at this site (Table 3).

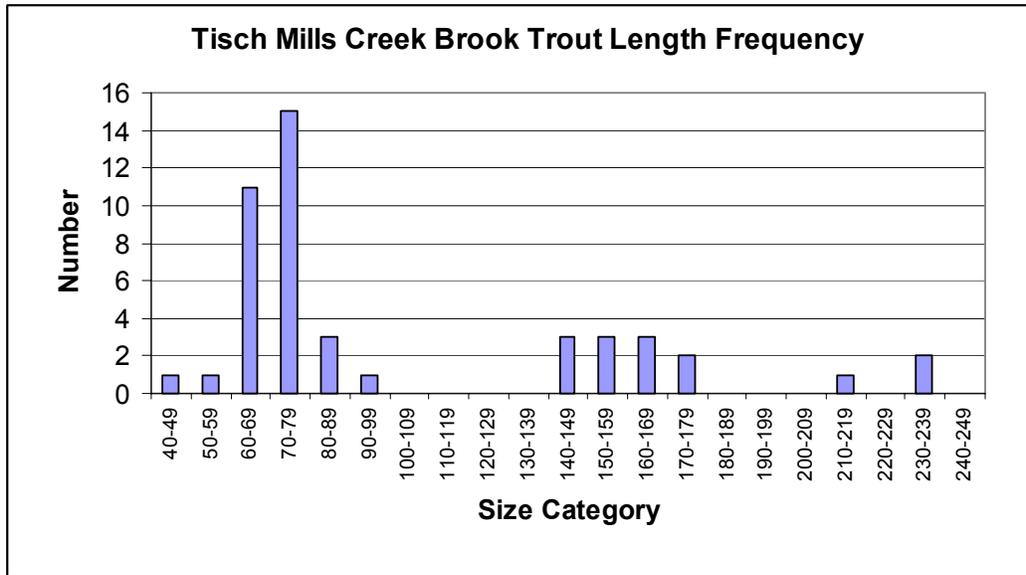
Electroshocking captured 211 individual fish representing 11 native species at this station (Table 11). These results gave the station an IBI score of 55, which rates the fish community of this stream section as good (Table 3). Additionally, two stocked brown trout were captured during electroshocking but were not used to calculate the IBI score.

Table 12. Fish species and abundance collected from electroshocking at Highway BB on Tisch Mills Creek, August 2001.

| Species | Number |
|------------------------|------------|
| American Brook Lamprey | 1 |
| Brown Trout | 2 |
| Brook Trout | 46 |
| Central Mudminnow | 16 |
| Southern Redbelly Dace | 9 |
| Blacknose Dace | 32 |
| Longnose Dace | 25 |
| Creek Chub | 36 |
| Pearl Dace | 6 |
| White Sucker | 5 |
| Green Sunfish | 1 |
| Mottled Sculpin | 34 |
| Total | 213 |

Brook Trout, creek chub, mottled sculpin and blacknose dace were the most common species captured during electroshocking (Table 12). The brook trout length frequency appears to indicate that three age classes of trout are utilizing this section of stream (Table 13). The 2 captured stocked brown trout had lengths of 235 mm and 265 mm.

Table 13. Brook Trout length frequency collected from Tisch Mills Creek during August 2001.



Temperature and Dissolved Oxygen

Figure 31 documents the diurnal temperature for Tisch Mills Creek at CTH during August of 2001. Although the maximum diurnal temperature approached 24 Centigrade (the upper preferred limit for brown trout), trout were common in the stream segment sampled.

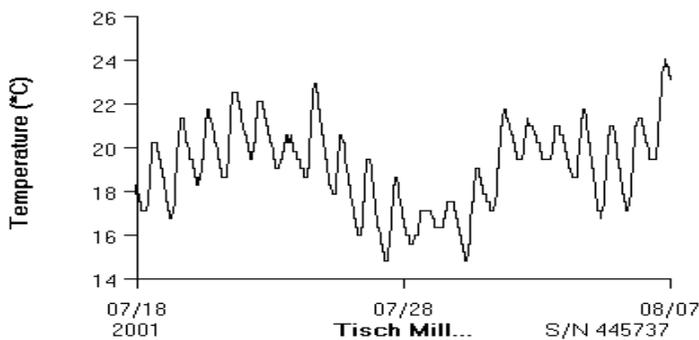


Figure 31. Diurnal temperature for Tisch Mills Creek at CTH BB during August of 2001.

Dissolved oxygen was not monitored at this site during the survey.

Krok Creek at Highway 29

This site was located just upstream of Highway 29, and ran through mostly shrubs, woodland and some wetland (N44-26.616, W087-37.758 to N44-26.664, W087-37.768). The survey section averaged 4.0 meters in width and was 140 meters in length (Appendix 1). The gradient was 2.2 meters per kilometer and had a sinuosity of 1 to 1.5. The study reach of the river was mostly runs and pools with a lesser amount of riffle (Figure 32).



Figure 32. Looking upstream on Krok Creek from the downstream end of the survey station.

Discharge

Water level was normal for the time of the survey and water clarity was slightly stained. Flow was 0.0464 cubic meters per second (CMS) at this site.

Habitat

This stream section began with a large pool and a small riffle. Following the beginning series of features, several large pools that were separated by runs were encountered. Feature size ranged from 4 meters (smallest run) to 54 meters (longest run), but most features were much smaller and ranged in length from 5 to 10 meters. Some bank erosion was noted at this site and fish cover was in the form of large woody debris. One old cattle crossing and culvert was encountered at this location.

Sand or mixtures of silt or detritus and sand dominated the bottom sediments (Figure 33). Detritus was also commonly encountered, but rock substrates were uncommon.

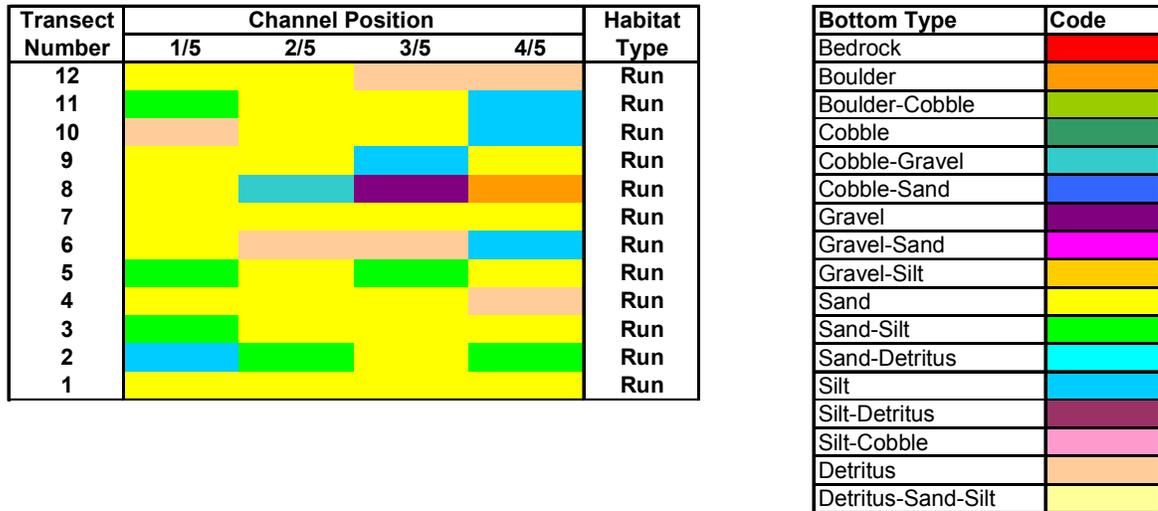


Figure 33. Bottom sediment map and key for transects at the Krok Creek location. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were not collected from this station because a suitable riffle location was not found.

Electroshocking captured 113 individual fish representing seven species at this station (Table 13). These results gave the station an IBI score of 40, which rates the fish community of this stream section as fair (Table 3).

Table 12. Fish species and abundance collected from electroshocking at Highway BB on Tisch Mills Creek, August 2001.

| Species | Number |
|------------------------|------------|
| American Brook Lamprey | 1 |
| Central Mudminnow | 8 |
| Creek Chub | 25 |
| Pearl Dace | 22 |
| Brook Stickleback | 6 |
| Johnny Darter | 4 |
| Mottled Sculpin | 47 |
| Total | 113 |

Mottled sculpin, creek chub and pearl dace were the most common fish captured at this location (Table 12). Other species were captured in lower numbers. No gamefish or panfish were collected at this location.

Temperature and Dissolved Oxygen

Figure 34 documents the diurnal temperature for Krok Creek at Highway 29 during August of 2001. Maximum diurnal temperatures reached 24 C, which is beyond recommended preferred temperatures for brook trout and brown trout.

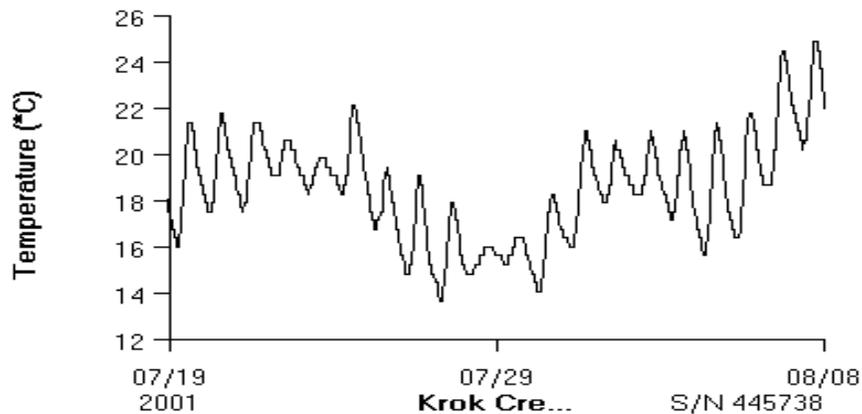


Figure 34. Diurnal temperature for Krok Creek at Highway 29 during August of 2001.

Dissolved oxygen was not monitored at this location.

Unnamed Tributary to the East Twin River at County Highway J

The unnamed tributary site was located just upstream of County Highway J, and ran through mostly meadow and shrubs (N44-24.005, W087-36.095 to N44-24.060, W087-36.112). The survey section averaged 4.0 meters in width and was 140 meters in length (Appendix 1). The gradient was 2.2 meters per kilometer and had a sinuosity of 1 to 1.4. The study reach of the river consisted of runs and pools without any riffles (Figure 35).

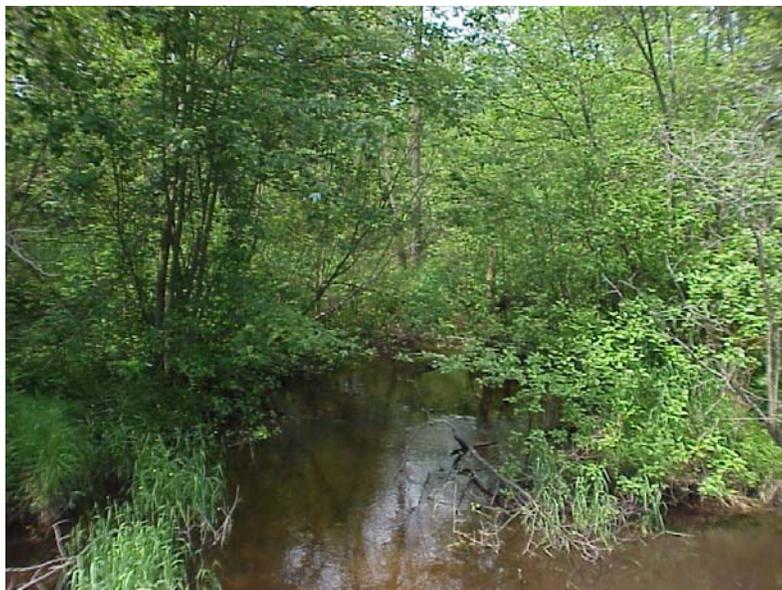


Figure 35. Looking upstream of an unnamed tributary to the East Twin River at County Highway J.

Discharge

Water level was normal for the time of the survey and water clarity was clear. Flow was 0.0259 cubic meters per second (CMS) at this site.

Habitat

This stream section was mostly runs separated by pools. No riffles were encountered at this site. Feature size ranged from 12.8 meters (smallest run) to 55.5 meters (longest run), but most features ranged in length from 20 to 25 meters. Some bank erosion was noted at this site and fish cover was in the form of large woody debris.

Sand and detritus dominated the bottom sediments of this location (Table 36). Some silt and gravel substrates were encountered but were uncommon.

| Transect Number | Channel Position | | | | Habitat Type | Bottom Type | Code |
|-----------------|------------------|-----|-----|-----|--------------|--------------------|------|
| | 1/5 | 2/5 | 3/5 | 4/5 | | | |
| 12 | | | | | Run | Bedrock | |
| 11 | | | | | Run | Boulder | |
| 10 | | | | | Run | Boulder-Cobble | |
| 9 | | | | | Run | Cobble | |
| 8 | | | | | Run | Cobble-Gravel | |
| 7 | | | | | Run | Cobble-Sand | |
| 6 | | | | | Run | Gravel | |
| 5 | | | | | Run | Gravel-Sand | |
| 4 | | | | | Run | Gravel-Silt | |
| 3 | | | | | Run | Sand | |
| 2 | | | | | Run | Sand-Silt | |
| 1 | | | | | Run | Sand-Detritus | |
| | | | | | | Silt | |
| | | | | | | Silt-Detritus | |
| | | | | | | Silt-Cobble | |
| | | | | | | Detritus | |
| | | | | | | Detritus-Sand-Silt | |

Figure 36. Bottom sediment map and key for transects at the unnamed tributary location. Transect 1 is the furthest downstream sampling location.

Biological Assessments

Invertebrates were collected from a riffle just below the downstream start of the study section. The sample yielded a HBI score of 4.03 indicating water quality was very good at this site (Table 3).

Electroshocking captured 105 individual fish representing 11 native species at this station (Table 13). These results gave the station an IBI score of 40, which rates the fish community of this stream section as fair (Table 3).

Table 13. Fish species and abundance collected from electroshocking at an unnamed tributary to the East Twin River above County Highway J, July 2001.

| Species | Number |
|------------------------|------------|
| American Brook Lamprey | 2 |
| Central Mudminnow | 2 |
| Common Shiner | 4 |
| Southern Redbelly Dace | 15 |
| Blacknose Dace | 1 |
| Creek Chub | 50 |
| Pearl Dace | 3 |
| White Sucker | 2 |
| Brook Stickleback | 7 |
| Johnny Darter | 11 |
| Mottled Sculpin | 8 |
| Total | 105 |

Creek chub dominated the catch, with substantially fewer southern redbelly dace, and johnny darters captured (Table 13). No gamefish or panfish were collected at this location.

Temperature and Dissolved Oxygen

Figure 37 documents the diurnal temperature during August of 2001 for an unnamed tributary that joins the East Twin River less than a mile south of the County Highway J crossing. Diurnal temperatures never exceeded 20 C., which indicates the potential of this tributary to carry over trout. Dissolved oxygen levels were not monitored.

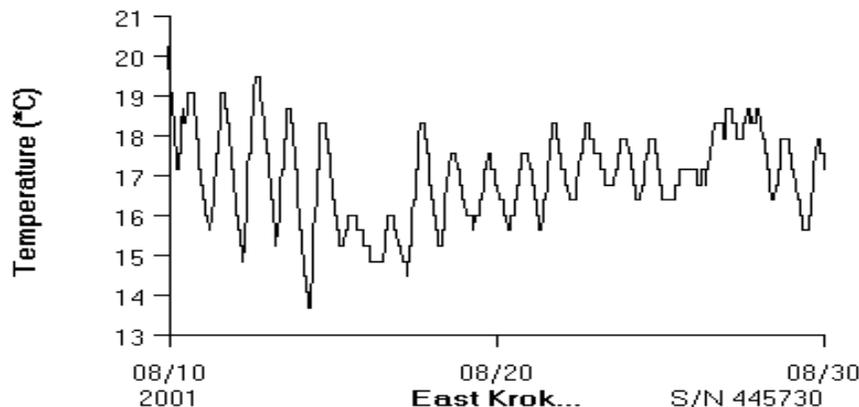


Figure 37. Diurnal temperature for an unnamed tributary flowing out of East Krok and joining the East Twin River less than a mile south of the County Highway J crossing, during the August of 2001.

Mussel Distribution

During the course of this survey, we had the opportunity to collect additional data that did not correspond with the standardized procedures for baseline monitoring. Because we were interested in the management of the whole watershed and its biota, we began to collect mussel shells when it became apparent that a large number of mussel species inhabited the East Twin River Watershed and that these species were not being evaluated as part of the standard survey. Although far from complete, the following observations were made on mussels that we collected.

Threeridge – *Amblema plicata*

Threeridges were noted in three different locations. Their abundance or population density was low when encountered. They were not identified in any of the headwater sections of the East Twin or any of its tributaries.

Steiners Corners Road

A few threeridges were noted up and downstream of this road crossing and are most likely representative of this short stretch of river below the Mishicot impoundment that has a greater gradient that prevents smothering of mussels.

Highway 147

The largest concentration of these mussels was noted 150 meters upstream of Highway 147 just below or along side of the plunge pool at the old low head dam structure. Approximately a dozen were located in a couple square meters on the left side of a sand delta adjacent to the plunge pool.

Camp Tapawingo

One specimen was noted in front of the camp.

Wabash Pigtoe – *Fusconaia flava*

Wabash Pigtoes were noted throughout most of the river, with the exception of headwater areas and small tributaries, and were the second most common mussel encountered during the summer survey period. Densities in some areas approached 8-10 per square meter.

Spike – *Elliptio dilatata*

Spikes were common throughout most of the river, with the exception of headwater areas and small tributaries. The elongate shell form with well developed pseudocardinal and lateral teeth and obvious purple nacre helped confirm the identification of this species from dead specimens rapidly in the field.

Crude abundance estimates were difficult to make since Spikes share a similar external morphology with the Eastern Elliptio, *Elliptio complanata* and the Cylindrical Papershell, *Anodontoides ferussacianus* which also occur within the East Twin River and can not be

easily identified without sacrificing live specimens. If greater effort is exerted collecting shells in future surveys a more accurate characterization of density can be made.

White Heelsplitter – *Lasmiogona complanata*

White Heelsplitters were also common in all the larger, lower sections of the river from Tisch Mills downstream.

Pocketbook – *Lampsilis ovata*

Pocketbooks were encountered in the larger lower sections of the river from Tisch Mills downstream. The large thick rounded to ovate shell set this mussel apart from most of the other species encountered.

Fingernail Clams – *Sphaerium transversum*

Fingernail clams were the most common and widely distributed mussel in the system. Distribution was far greater than that of any of the other mussels and included some of the headwaters and tributary streams. The uniform small size (usually around a half an inch) and evenly rounded shell made for easy identification of this species in the field from dead or live specimens.

Cylindrical Papershell – *Anodontooides ferussacianus*

This mussel was identified in the lower sections of the watershed from Tisch Mills downstream. An accurate characterization of distribution and density was not accomplished for this species. This species shares a similar external morphology with other mussels making it difficult to distinguish between them with living specimens. Adequate numbers of dead specimens were not collected at each site making further characterization of distribution and density impossible.

Eastern Elliptio – *Elliptio complanata*

An accurate characterization of distribution and density was not accomplished for this species. This mussel was identified from a lone dead specimen recovered upstream of Steiners Corner Road in the Village of Mishicot. Externally this mussel resembles the Cylindrical Papershell; but, this specimen has well developed pseudocardinal and lateral teeth that can only be observed in the dead specimen. Adequate numbers of dead specimens were not collected at each site making further characterization of distribution and density impossible.

Snails

Numerous kinds of Gastropods (snails) were also noted in the different river sections, but no efforts were made to collect and identify them.

DISCUSSION

A combination of biological, chemical and physical data may show trends of watershed health better than an individual metric. Chemical monitoring was very limited in this study with the best data being continuous dissolved oxygen and temperature from selected sites and continuous temperature data from the other sites. Biological samples were also collected as a part of this study which 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. Through this sampling effort, we hope that the collected data will be used to help make management decisions that will improve the condition of the watershed.

Discharge

Measured flow and the resulting calculated discharge during the study most likely represented low flow or base flow conditions for the East Twin River and its tributaries. Discharge on the East Twin River ranged from a low of 0.0255 CMS at Townline Road to a high of 0.420 CMS at Steiners Corner. This range of discharge is expected given that Townline Road was our most upstream location and Steiners Corner, our most downstream location. Flow was not judged a problem on the mainstream East Twin River.

Discharge on the tributaries ranged from 0.0287 CMS on Jambo Creek to 0.0464 CMS on Krok Creek. Streams exhibited continuous, although low flow throughout the survey and were most likely not limiting to the biological communities that inhabited them.

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, runs comprised 59.3% (991 meters of the 3,043 meters measured) pools 32.6% and riffles 8.1% of the total measured large-scale habitat features. This distribution of stream features was observed at sites on the East Twin River and on tributaries when each group of data was pooled. Individual sites showed greater variation with sites ranging from having no riffle areas, Steiners Corners and Sandy Bay Road to those dominated by runs, Rockledge Road and Krok Creek. However, it must be noted that pools were generally shallow and less than 0.25 meters in depth reducing their suitability for holding fish during temperature extremes.

Gravel and sand dominated bottom type in the mainstem East Twin River although substrates of all other types (except bedrock) were encountered. In tributaries, sand dominated the bottom substrate except for Jambo Creek were gravel dominated. Tributaries also had more soft sediments present. The variety in the bottom substrate lead to a diversity of invertebrate and fish species in the watershed as rated by HBI and IBI scores (Table 3). Fish cover for adult gamefish (northern pike and smallmouth bass)

was extremely limited at all sample locations. This lack of cover, when coupled with the lack of pool depth most likely limits the abundance of gamefish in the watershed.

Stream corridors of the East Twin River are well buffered with 10 meters of forested or grassland buffers at most study locations. Even sites with less buffer have at least 5 meters of buffer. Along stream corridors in Kewaunee County, buffers are forested and as the river travels southward through Manitowoc County grassy buffers increasingly predominate. Two sites, Sandy Bay Road and County B show the need for improved buffers because of degraded stream habitat or bank erosion.

Biological Assessments

Results from the 2001 Hilsenhoff Biotic Index samples showed good to excellent water quality at all sample locations. Data from 1994 (Gansberg 1995) indicated that water quality on the East Twin River ranged from very good to excellent at sample locations nearby the current study locations. Direct comparisons should be made with caution because sampling locations between 1994 and 2000 were not be identical, however, results from 2000 as compared to those collected in 1994, appear to indicate that the HBI hasn't changed substantially.

A total of 43 species of fish were captured during the surveys on the East Twin River system (Table 2). Although historical surveys had identified 58 species in the system, a number species that were not collected are Lake Michigan species and are more likely to be captured in sections of the lower East Twin River that were not surveyed. Fish IBI ratings ranged from poor on Jambo Creek to excellent at the five lowest sites on the East Twin River (Table 3). However, there is concern with the IBI ratings because they reflect that few warmwater gamefish and intolerant species were captured during this survey. This most likely is due to swings in dissolved oxygen level, or from habitat loss caused by past land practices that encouraged erosion and sedimentation.

Two species of special concern, redbreast dace and greater redhorse were captured during this survey but in limited numbers. Fago (1985) did not catch redbreast dace during his survey work in the East Twin River system. Since redbreast dace are reported to be sensitive to sedimentation (Becker 1980) water quality may be showing a slight improvement since the 1980's.

Brook trout range expansion into Tisch Mills Creek was documented during this survey. A good population of trout with at least three age classes was captured in the creek. The brook trout population in the upper East Twin River appeared to be similar to the one encountered by Fago (1985), however, the current survey did not capture any brook trout in Krok Creek as did Fago.

Many species of mussel and snail were collected during this survey which is an indication of good water quality. More work needs to be done to determine the species and distribution of these organisms in the watershed.

Water Quality

Hobo temperature recorders or YSI sondes temperature-DO recorders and invertebrate and fish sampling were used to evaluate water quality within the watershed. Several trends in stream temperature and dissolved oxygen levels were observed. First, as would be expected with increased river width and decreased shading, temperatures increased and dissolved oxygen decreased the farther downstream they were measured (Figures 5, 9, 14,19, 22, 25).

The dam in Mishicot accentuated this trend by the creation of a millpond, which allowed East Twin River water to warm to a greater extent than would naturally occur. Temperature data collected at Rockledge Road just above the millpond exhibited ranges in temperature from 20 to 26 C during the sampling period (Figure 9). A sondes recorder set the same time below Steiners Corners Road had temperature swings from 20 to 30 C (Figure 5). The higher upper temperature found at Steiners Corner might inhibit some species of fish from inhabiting that section of river.

Of greater concern however, are the differences that were measured in dissolved oxygen between the two sample locations, which are located less than 5 km apart. DO at Rockledge Road ranged from 7 to 13 PPM (Figure 5). During the same period, DO at Steiners Corners ranged from 3 PPM to 10 PPM. A DO less than 5 PPM is in violation of State Standards for waters containing a sport fishery. During this survey, Steiners Corners site had the only DO readings below 5 PPM. The most likely cause of the decline in dissolved oxygen is the millpond, although the Mishicot Sewage Treatment Plant discharges nearby and could contribute to the problem. Low DO in this section of river may explain the low abundance of gamefish that were captured at the Steiners Corner site.

The second trend that was apparent was the cool water temperatures that were found in the upper East Twin River and in all tributaries (Figures 19,22,25,28,31,34,37). Most temperatures ranged from 13 to 22 C and along with the suitable habitat that was encountered at most locations, trout should have been more abundant in these areas of the watershed. Past land practices or other activities must have eliminated native trout from the system over time.

Summary

The data that was collected, although providing detailed information about the Watershed, does little to simplify the complicated environmental interactions that could allow for identification of trends or to identify streams that are at risk and that need to be protected. A model for the East Twin River Watershed developed by Robinson (2002) uses matrix math to score and rank complex variables and generates a model output that ranks each sub-watershed as to the extent it has been impacted by land use. Ward (Manitowoc LCD personal communication) and his technical work group for this watershed has identified five risk factors that could influence water quality, habitat and aquatic life in the East Twin River basin (Table 14).

Table 14. Land use risk factors for the East Twin River that could affect water quality and aquatic life.

| Risk Factor | Unit Measure |
|--------------------|------------------------------------|
| Channel Density | lineal feet per subwatershed acre |
| Buffer Needs | acres needed per subwatershed acre |
| Cropland | acres per subwatershed acre |
| Cropland >6% slope | acres per subwatershed acre |
| High Runoff Soils | acres per subwatershed acre |

The selected variables describe the ease of sediment and nutrient delivery to the receiving water. In this model, a stream that flows through steeply sloping, erodable cropland that has no buffers would rank high as to having the greatest risk to negative impacts from land use, while a stream flowing through a flat, well buffered forest would rank very low.

The model was used to score and rank each water relative to others in the basin based on land use impacts reflected by the stream HBI score (Figure 38). The sub-watersheds

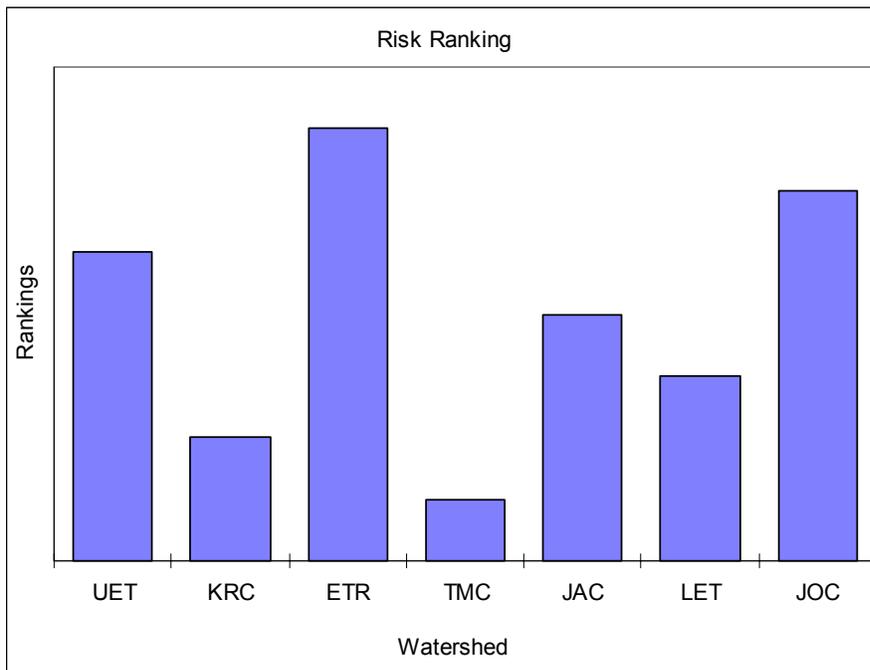


Figure 38. Relative risk ranking to land use impacts of each sub-watershed in the East Twin River basin. The sub-watersheds in the East Twin River basin are the Upper East Twin (UET), Krok Creek (KRC), the East Twin River from the Mishicot Dam to the confluence with Krok Creek (ETR), Tisch Mills Creek (TMC), Jambo Creek (JAC), the Lower East Twin River from Lake Michigan to Mishicot dam (LET) and Johnson Creek (JOC).

identified as those being at greatest risk to land use were the East Twin River (ETR), Johnson Creek (JOC) and the Upper East Twin River (UET). Tisch Mills Creek (TMC) and Krok Creek had the lowest risk associated with land use.

To be useful to managers, the model should then identify streams that have high quality resources but face risks because of potential sediment or nutrient delivery due to poor land use in the watershed. By seeing the risk to the resource, managers can design protection strategies to maintain environmental quality or enhancement strategies to improve degraded systems.

When IBI rankings were added as a measure of ecosystem quality to the risk assessments for the watershed, the East Twin River, upper East Twin and Tisch Mills Creek were identified as priority areas (Figure 39).

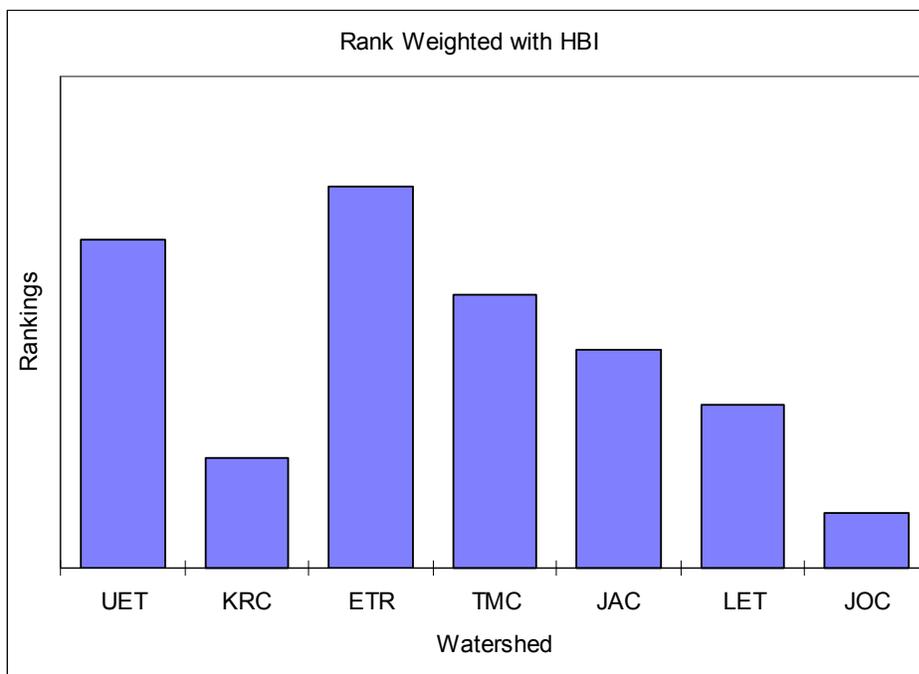


Figure 39. Relative risk ranking based on land use impacts to each sub-watershed as reflected by HBI scores. The sub-watersheds in the East Twin River basin are the Upper East Twin (UET), Krok Creek (KRC), the East Twin River from the Mishicot Dam to the confluence with Krok Creek (ETR), Tisch Mills Creek (TMC), Jambo Creek (JAC), the Lower East Twin River from Lake Michigan to Mishicot dam (LET) and Johnson Creek (JOC).

The East Twin River, which ranked high in the risk assessment portion of the model, also ranked high when the risk to current aquatic life was considered (both the UET and ETR sections). This indicates that protection of the resources of the East Twin River should be classified as a high priority in this watershed. Management strategies should be designed to protect the high quality resources already present in the river.

Tisch Mills Creek although ranking low in the risk assessment portion of the model, had a moderate ranking when the current population of invertebrates was factored into the model. This indicates that this stream has a medium priority and is in need of management strategies that would protect the resource that currently exists.

Johnson Creek, which ranked high in risk assessment, scored poorly when HBI scores were added indicating that management strategies should be geared toward restoration rather than protection because resources had already been impacted by non-point source pollution.

CONCLUSIONS

- Although HBI and IBI ratings have changed little since earlier surveys, it appears that native warmwater gamefish species are nearly absent or low in abundance in many surveyed sections of the East Twin River. The absence of gamefish from upper sections of the watershed may be due to low flow conditions or habitat loss, in middle sections due to deep pool loss and in lower sections due to low dissolved oxygen.
- Brook trout populations in Tisch Mills Creek have dramatically increased since earlier surveys while those in the East Twin River remain stable and those in Krok Creek have declined. Increases are mostly likely due to improved water quality, while declines most likely are due to changes in flow patterns. Very few stocked brown trout were encountered during this survey.
- Water quality within the watershed is generally good as indicated by dissolved oxygen levels greater than 5 PPM and cool temperatures. However, water quality in the East Twin River below the dam in Mishicot appears to be impaired with high stream temperatures and dissolved oxygen levels below 5 PPM. Most likely this is due to presence of the dam and millpond in Mishicot.
- Streams within this system are well buffered and feature a variety of large-scale and small-scale habitats for aquatic organisms. Large gamefish habitat however is limited.

RECOMMENDATIONS

- Use the results from the assessment model to design protection or enhancement strategies for each stream and then enact these strategies with the assistance of local partners such as County LCD offices, USDA, river friends groups.
- Activity utilize streambank protection programs (CRP, CREP) to maximize stream bank protection.

- Implement a plan that seeks to improve the water quality in the lower East Twin River below Mishicot.
- Evaluate the current stocking of brown trout into streams within this watershed because of native brook trout populations and the low abundance of brown trout captured during the survey.
- Collect detailed information on the distribution of mussels and snails in the watershed.
- Do additional work in Jambo Creek to determine why fish populations were depressed despite a very good invertebrate score.

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