# BOARDMAN RIVER FEASIBILITY STUDY

## A Report on the Boardman River Fisheries Habitat Survey & Data Collection

DRAFT

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**Submitted by:**

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# ACKNOWLEDGMENTS

This report, is an integral part of the engineering feasibility study being performed for the Boardman River Dams Committee (BRDC) to evaluate a full range of alternatives for the Boardman River considering environmental, economic, engineering, and societal impacts.

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# TABLE OF CONTENTS

## Section — Page



## Tables



## Figures

# PURPOSE

In the earlier ECT report on the Boardman River fisheries, existing data, it was noted that information on the state of fisheries habitat in the Boardman River was limited. In order to inform the decision-making process for the state of the Boardman River dams, additional fisheries habitat data was collected, summarized and discussed in the context of evaluating alternatives for the fates of the Boardman River dams.

# INTRODUCTION

During the review of existing data on Boardman River fisheries and fisheries habitat, fisheries habitat information was identified as nearly absent and of high priority for additional collection. Existing data on stream morphology and fisheries habitat is limited to one sample location near Ranch Rudolph (conducted by the MDNR). Some fish habitat data of limited use is also available for the river segment from Union Street Dam downstream to Lake Michigan (conducted by USFWS). Additionally, the US Army Corp of Engineers (USACE) conducted detailed sediment and stream morphology sampling during 2007. However, this sampling effort focused on subsampling conditions at approximately seven sites in the mainstem of the Boardman River (*J. Selegean, USACE, personal communication*). Therefore, a comprehensive survey of conditions within the entire mainstem Boardman River was lacking.

Information on stream morphology is critical to understanding the current impacts of the existing Boardman River dams, understanding the status and distribution of current fisheries habitat in the river, and for making predictions about the likely consequences of various dam management alternatives.

The alternating pattern of bedforms (riffles, runs and pools) in mixed sand-gravel streams is seen as a way rivers self-adjust to regulate energy expenditure, and are very important to the biological productivity of streams. Dams cause aggradation upstream of dams and degradation downstream of dams, decreasing gradient in both cases, and subsequently reducing the bedform diversity through replacement of riffles and pools with runs. Upstream of dams, coarser gravel substrates are often replaced by finer sand and silt sediments, while downstream of dams, sediment transport is impeded and gravel substrates are often coarsened and include cobbles and boulders. The composition and distribution of these substrates within rivers are also critically important to stream biota. Finer sediment such as sand is generally poor quality habitat for aquatic insects, and often unsuitable spawning substrate for many species of fish. Collecting data on the locations and quantities of bedforms and substrates in the mainstem of the Boardman River is critical to understanding the current fishery conditions in the river, understanding current impacts of the dams, and for predicting outcomes of various dam management alternatives. This information has also proven useful in predicting the spatial extents of the impacts of dams, for predicting spatial extents of changes following dam removal, and for making predictions of the amount of sediment that could be mobilized following a dam removal.

In order to provide this information, a survey of fisheries habitat in the entire mainstem Boardman River, from the confluence of the North and South Branches downstream to Lake Michigan, was conducted during August and September 2007. This survey included; delineating the river channel into bedform types (run, riffle, or pool), recording the location, length and average width of each bedform unit; and qualitative characterization of the amounts of aquatic vegetation, wood debris, and deeper water depths (>2.5 ft.) (important sources of fish cover), as well as the streambed substrate composition of each bedform unit. Additionally, streambed substrate composition was also characterized quantitatively, by measuring substrate at random locations within each river segment.

# METHODS

This survey was conducted by a crew of three people, in two canoes, floating the river segments of the mainstem Boardman River on August 4, 2007 (the confluence of the North and south Branches of the Boardman River downstream to Brown Bridge Dam), August 5, 2007 (Brown Bridge Dam downstream to Shumsky's Boat Launch), September 8, 2007 (Shumsky's Boat Launch downstream to Boardman Dam impoundment, and Sabin Dam downstream to Union Street Dam Impoundment), and September 9, 2007 (Union Street Dam downstream to Lake Michigan). The river was surveyed during low flow conditions (required for the accurate delineation of bedform types).

Bedform delineation and qualitative observations were derived through independent visual observation and evaluation, and then rectified through group consensus. Bedform delineation involved the categorization of the stream into bedforms following the criteria developed by Hicks and Watson (1985). The length (along the thalweg), and widths of each bedform were measured, as well as periodically recording latitude and longitudes of selected bedforms for mapping purposes. Measurements of river widths and bedform lengths were made using a Nikon Laser Rangefinder (+/- 0.5 M accuracy).

Quantitative streambed substrate size composition measurements were made using a modified pebblecount method (Wolman 1954, Kondolf and Li 1992). 100 streambed particles were sampled systematically (instead of randomly) along each transect (randomly selected), the intermediate axis was measured and assigned a size class code (from a modified Wentworth scale) (Wentworth 1922, Cummins 1962) (Table 1). Median substrate size ($D_{50}$) for a transect was calculated after excluding "organic" or "trash" designations which did not have corresponding size classes.

Table 1. Size classes and codes used to denote particle composition (Cummins 1962).

| Size Code | Size Class (mm) | Particle |
|---|---|---|
| 0 | | Trash |
| 1 | | Organic |
| 2 | 0.00024 - 0.004 | Clay |
| 3 | 0.04 - 0.062 | Silt |
| 4 | 0.062 - 2 | Sand |
| 5 | 2 - 4 | Very Fine Gravel |
| 6 | 4 - 8 | Fine Gravel |
| 7 | 8 - 16 | Medium Gravel |
| 8 | 16 - 32 | Coarse Gravel |
| 9 | 32 - 64 | Very Coarse Gravel |
| 10 | 64 - 128 | Small Cobble |
| 11 | 128 - 256 | Large Cobble |
| 12 | 256 - 512 | Small Boulder |
| 13 | >512 | Medium Boulder |

## RESULTS & DISCUSSION

For consistency with existing Boardman River Dams reports, in this report the Boardman River is divided into 10 segments. These segments are based on the spatial extents of impacts of the dams, and possible spatial extents of impacts from dam management alternatives (Table 2) (Figure 1).

This report focuses on characterization of habitat conditions in the riverine segments of the Boardman River (segments 1, 3, 6 and 8), and delineation of the spatial extents of the impoundments (segments 2, 5, and 7).

Table 2. Descriptions of the 10 spatial segments of the Boardman River, in relation to fisheries and spatial extents of impact from the Boardman River Dams.

| Segment # | Description |
|---|---|
| 1 | From Union Street Dam downstream to Lake Michigan, and Hospital (Kids) Creek |
| 2 | Union Street Dam impoundment, also known as Boardman Lake |
| 3 | From Sabin Dam downstream to Union Street Dam impoundment, or Boardman Lake |
| 4 | Sabin Dam impoundment, also known as Sabin Pond, upstream to Boardman Dam |
| 5 | Boardman Dam impoundment, also known as Boardman Pond or Keystone Pond |
| 6 | From Brown Bridge Dam downstream to Boardman Dam impoundment |
| 7 | Brown Bridge Dam impoundment, also known as Brown Bridge Pond |
| 8 | From the confluence of the North and South Branches of the Boardman River, also known as the Forks, downstream to the Brown Bridge Dam impoundment |
| 9 | North Branch of the Boardman River |
| 10 | South Branch of the Boardman River |

Figure 1

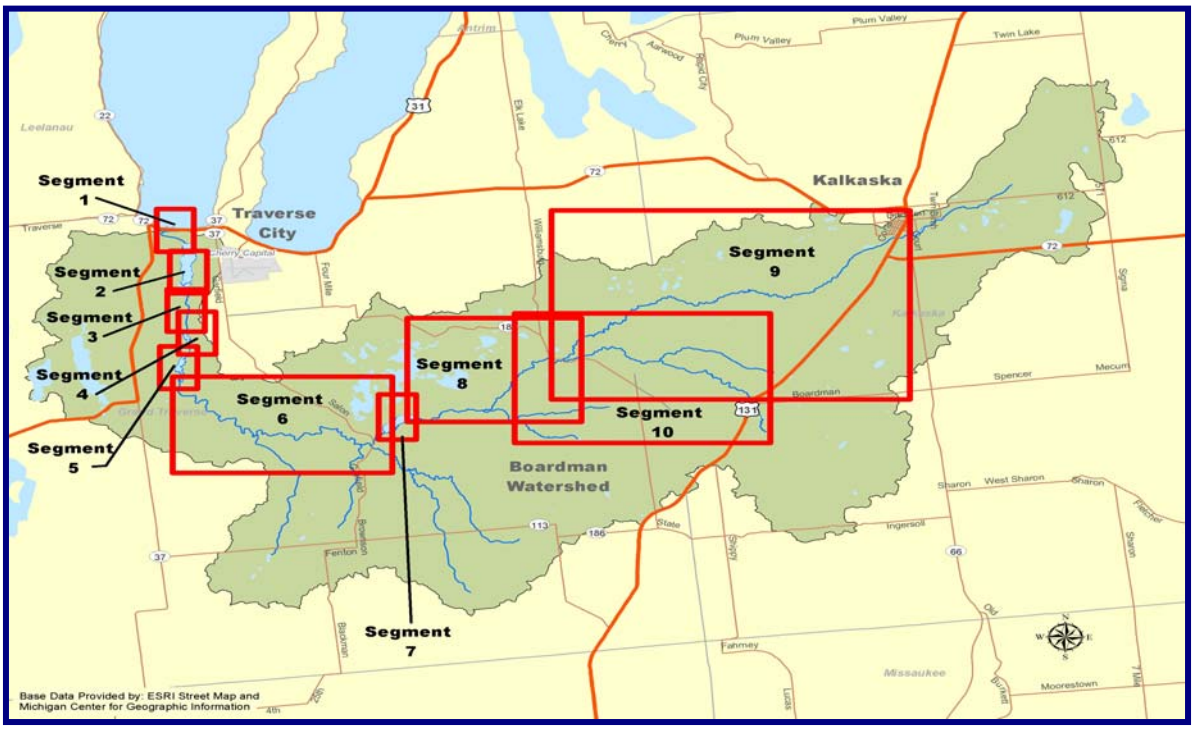
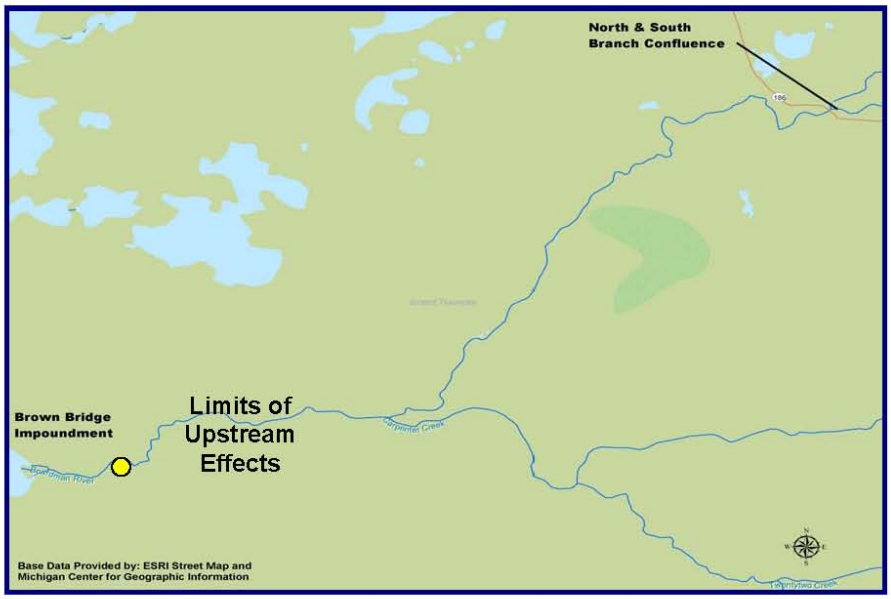


Table 3. Fisheries habitat summary statistics for the four riverine segments of the Boardman River.

| | Segment 1 | Segment 3 | Segment 6 | Segment 8 |
|---|---|---|---|---|
| Total Length (m) | 1865 | 3540 | 22144 | 9686 |
| Width (m) | | | | |
| *Mean* | 20.7 | 31.8 | 17.2 | 11.4 |
| *Standard Deviation* | 6.0 | 19.2 | 3.8 | 2.3 |
| Proportion Run Bedform | 0.96 | 1.00 | 0.73 | 0.57 |
| Proportion Riffle Bedform | 0.00 | 0.00 | 0.23 | 0.37 |
| Proportion Pool Bedform | 0.04 | 0.00 | 0.04 | 0.06 |
| % Area Deep Water (>2.5 ft) | | | | |
| *Mean* | 56 | 60 | 23 | 23 |
| *Standard Deviation* | 34 | 15 | 24 | 23 |
| % Wood Debris | | | | |
| *Mean* | 4 | 10 | 11 | 16 |
| *Standard Deviation* | 2 | 5 | 7 | 12 |
| % Aquatic Vegetation | | | | |
| *Mean* | 24 | 18 | 17 | 14 |
| *Standard Deviation* | 19 | 6 | 13 | 10 |
| Total Segment - % Clay | | | | |
| *Mean* | 0 | 0 | 2 | 1 |
| *Standard Deviation* | 0 | 0 | 6 | 2 |
| Total Segment - % Silt | | | | |
| *Mean* | 0 | 0 | 5 | 5 |
| *Standard Deviation* | 0 | 0 | 2 | 4 |
| Total Segment - % Sand | | | | |
| *Mean* | 32 | 68 | 16 | 35 |
| *Standard Deviation* | 21 | 25 | 10 | 20 |
| Total Segment - % Gravel | | | | |
| *Mean* | 45 | 32 | 58 | 50 |
| *Standard Deviation* | 17 | 25 | 18 | 18 |
| Total Segment - % Cobble | | | | |
| *Mean* | 16 | 0 | 15 | 8 |
| *Standard Deviation* | 7 | 0 | 10 | 11 |
| Total Segment - % Boulders | | | | |
| *Mean* | 6 | 0 | 3 | 1 |
| *Standard Deviation* | 2 | 0 | 4 | 3 |

Figure 2


**Segment 8:**
From the confluence of the North and South Branches of the Boardman River, also known as the Forks, downstream to the Brown Bridge Impoundment



*Segment 8*

This river segment starts at the confluence of the North and South Branches of the Boardman River (N44°40.487', W85°23.741') (Figure 2). The survey of fisheries habitat began approximately 535 m. downstream at the "Forks" canoe launch (N44°40.403', W85°24.091'), on Brown Bridge Rd, just west of County Rd. 605. This river segment ends downstream at Brown Bridge Pond. The upstream boundary of the formal reservoir or "pond" is at (N44°39.010', W85°29.411'), but impoundment effects were observed upstream an additional 2012 meters upstream to (N44°38.991', W85°28.465'). This will serve as the boundary between river segments 8 and 7, and is predicted to be the upstream extent of the impoundment caused by Brown Bridge Dam. Total length of river in this segment is 10,721 m. The condition of fisheries habitat in this river segment is important to the Boardman River Dams project, because it serves as the best available reference for what habitat conditions in the mainstem Boardman River would be, if not for the presence of the dams.

Average width of the river in this segment was 11.4 m (Table 3). River segment 8 had the lowest percentage of run habitat, as predicted by the absence of dam impacts, with 57% run, 37% riffle, and 6% pool. Approximately one quarter of the stream provided water depths of 2.5 ft. or greater. Percentage of stream containing wood material was 16% and was the highest of the river segments. Percentage of the stream covered by aquatic vegetation was 14%, the lowest of the river segments, and possibly explained by the narrower river width and direct sunlight shading from the forest canopy. Average composition of streambed substrates from qualitative observations, were: 1% clay, 5% silt, 35% sand, 50% gravel, 8% cobble, and 1% boulders.

Quantitative measurements of streambed substrate composition were taken at 4 run bedforms, 5 riffles and 1 pool in river segment 8. Median substrate size for run bedforms in segment 8 was sand (1.031 mm), which also comprised 41% of the composition (Figure 3). Runs were comprised of 11% silt, and 48% was gravel, cobble, and boulders. Segment 8 riffle median substrate size was fine gravel (6 mm), and contained 27% sand, 11% silt, and 62% gravel, cobble and boulders (Figure 3). Median substrate size of the pool bedform in segment 8 was sand (1.031 mm), which also comprised 40% of the composition (Figure 3). The pool bedform was also comprised of 19% silt, and 41% was gravel, with no cobble or boulders.

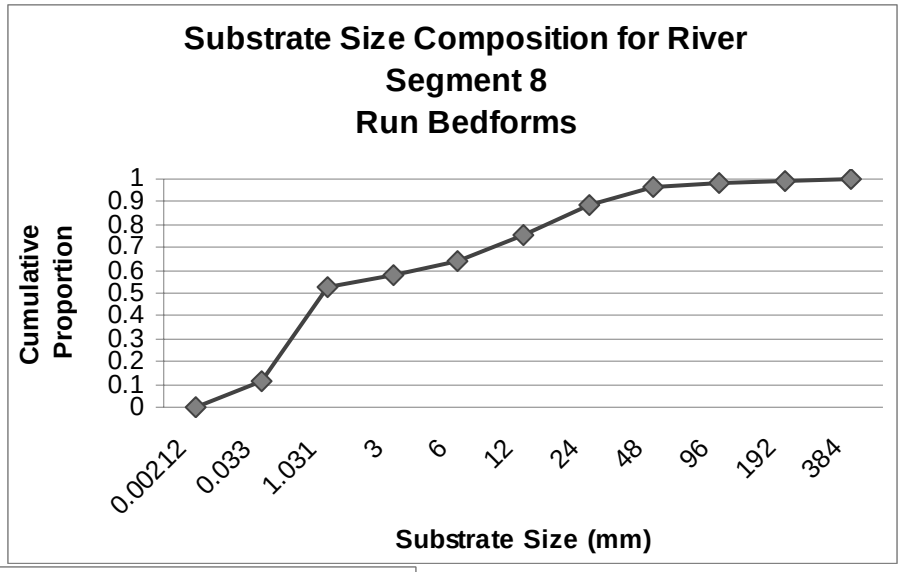
Overall, this river segment appears to provide good quality fisheries habitat, with balanced and diverse compositions of bedforms and substrates (Appendix A).

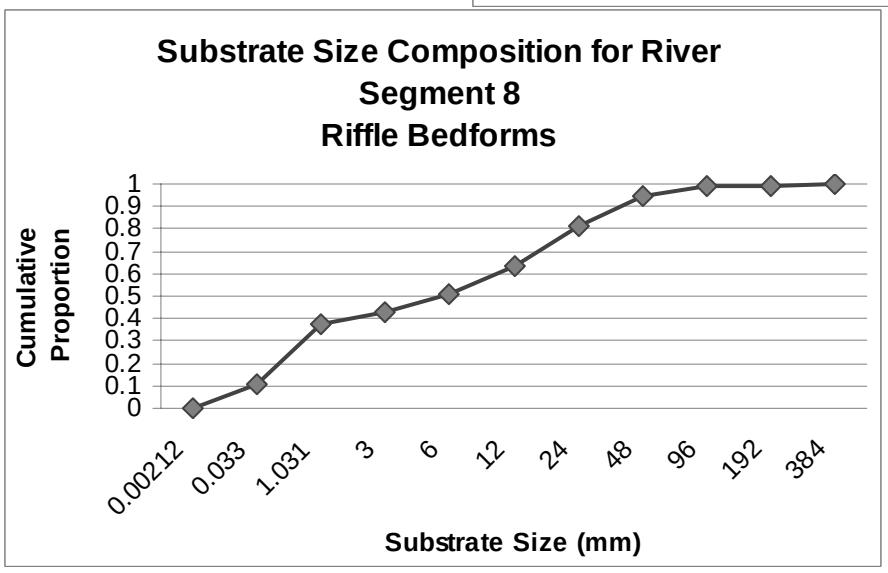
To examine whether the fisheries population surveys conducted by the Michigan Department of Natural Resources were conducted at sampling sites that were representative of the habitat conditions of the entire river segment, comparisons were made between the conditions measured in the vicinity of the MDNR sample sites and the average conditions seen within the entire river segment (Table 4). For river segment 8, individual sampling sites at "Forks", "Ranch Rudolph" and "Sheck's Campground" did differ from the overall segment characteristics. However, taken as a whole, the three sampling sites average out to represent the segment fairly well.

Table 4. Fisheries habitat summary statistics for river segment 8 and three MDNR fish sampling sites within segment 8.

| | Segment 8 | Shecks | Ranch Rudolph | Forks |
|---|---|---|---|---|
| Total Length (m) | 9686 | 980 | 323 | 282 |
| Width (m) | | | | |
| *Mean* | 11.4 | 12.9 | 9.7 | 10.8 |
| *Standard Deviation* | 2.3 | 1.5 | 2.1 | 0.5 |
| Proportion Run Bedform | 0.57 | 0.22 | 1.00 | 0.45 |
| Proportion Riffle Bedform | 0.37 | 0.74 | 0.00 | 0.55 |
| Proportion Pool Bedform | 0.06 | 0.04 | 0.00 | 0.00 |
| % Area Deep Water (>2.5 ft) | | | | |
| *Mean* | 23 | 21 | 20 | 8 |
| *Standard Deviation* | 23 | 18 | 18 | 15 |
| % Wood Debris | | | | |
| *Mean* | 16 | 15 | 16 | 15 |
| *Standard Deviation* | 12 | 5 | 3 | 6 |
| % Aquatic Vegetation | | | | |
| *Mean* | 14 | 14 | 18 | 4 |
| *Standard Deviation* | 10 | 10 | 8 | 5 |
| Total Segment - % Clay | | | | |
| *Mean* | 1 | 1 | 0 | 1 |
| *Standard Deviation* | 2 | 3 | 0 | 3 |
| Total Segment - % Silt | | | | |
| *Mean* | 5 | 10 | 3 | 2 |
| *Standard Deviation* | 4 | 6 | 3 | 2 |
| Total Segment - % Sand | | | | |
| *Mean* | 35 | 35 | 32 | 26 |
| *Standard Deviation* | 20 | 15 | 25 | 15 |
| Total Segment - % Gravel | | | | |
| *Mean* | 50 | 34 | 47 | 63 |
| *Standard Deviation* | 18 | 6 | 3 | 6 |
| Total Segment - % Cobble | | | | |
| *Mean* | 8 | 18 | 13 | 6 |
| *Standard Deviation* | 11 | 18 | 8 | 8 |
| Total Segment - % Boulders | | | | |
| *Mean* | 1 | 3 | 5 | 3 |
| *Standard Deviation* | 3 | 3 | 5 | 5 |

Figure 3. Streambed substrate size cumulative frequency distributions, for river segment 8.



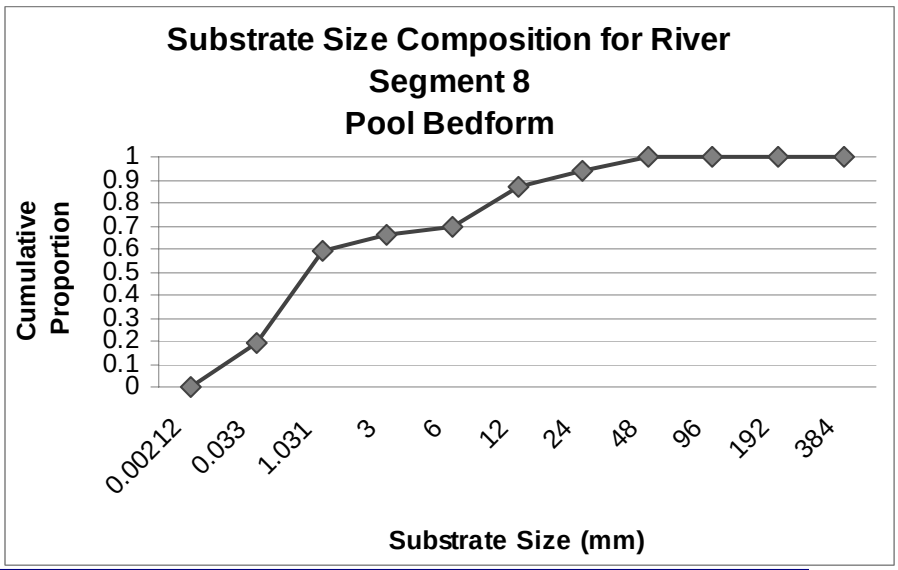
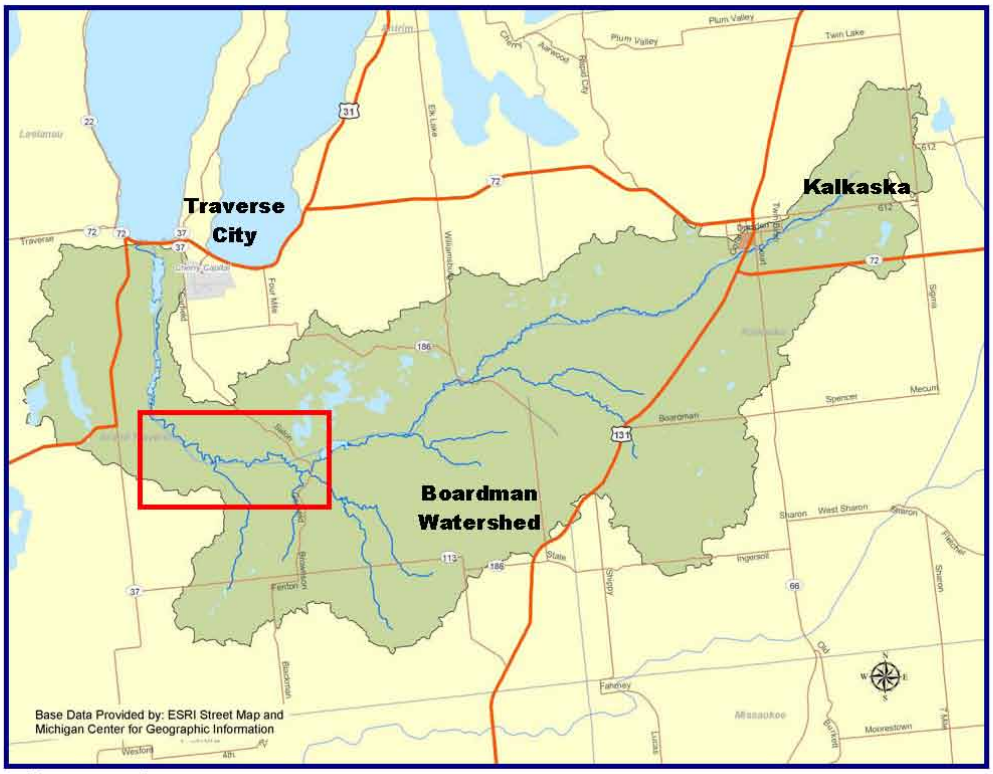
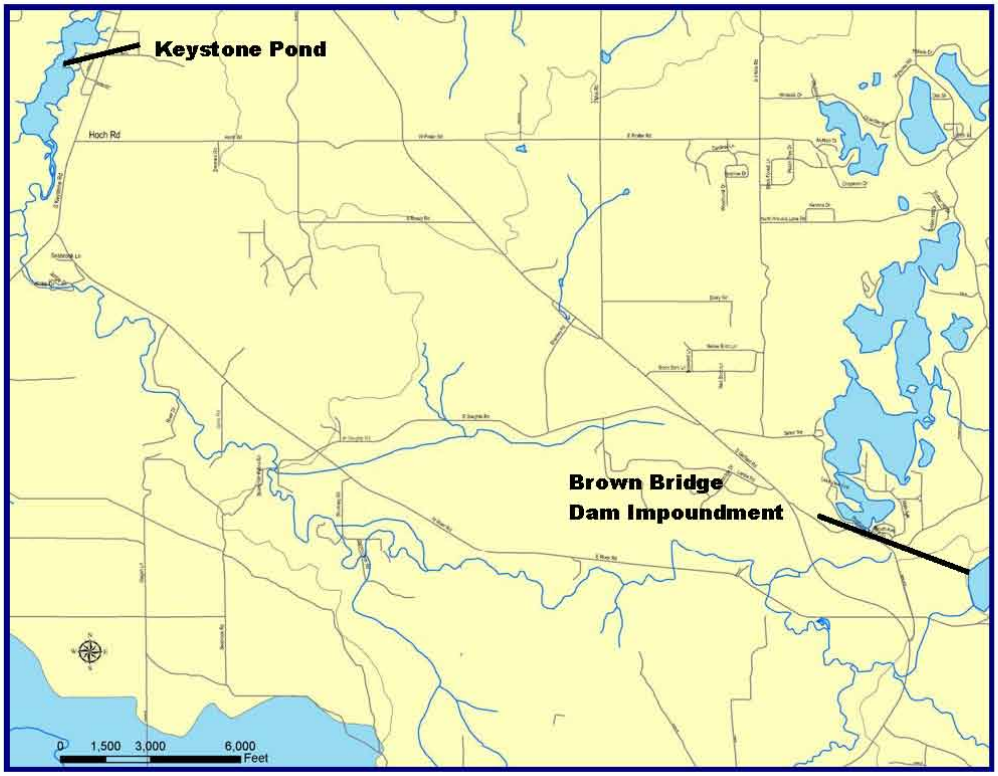



Figure 4




**Segment 6:**
From Brown Bridge Dam downstream to Boardman Dam impoundment



*Segment 6*

This river segment starts at the downstream side of Brown Bridge Dam (N44°38.573', W85°30.604') and extends downstream for 22,144 m. before reaching the upstream extent of impoundment effects from Boardman Dam (N44°40.870', W85°37.694'). The formal Boardman Dam reservoir or "pond" starts approximately 274 m. downstream at (N44°40.991', W85°37.625') (Figure 4). This is the longest freeflowing segment of the mainstem Boardman River. This fisheries habitat in this segment is known to be impacted by the presence of Brown Bridge Dam. This dam impedes the transport of sediment in the Boardman River, reducing the sediment delivered to river segment 6. Brown Bridge Dam is also known to warm water temperatures in segment 6, by approximately 8° F on average (Lessard & Hayes 2003). Analysis of bedforms and substrate compositions, collected as part of this project, suggests that Brown Bridge Dam impacts river morphology significantly for at least 2 km downstream (based on high occurrence of run bedforms low percentages of sand) (Appendix B).

Average width of the river in this segment was 17.2 m (Table 3). River segment 6 had a higher percentage of run habitat than segment 8, with 73% run, 23% riffle, and 4% pool. Approximately one quarter of the stream provided water depths of 2.5 ft. or greater. Percentage of stream containing wood material was 11%. Percentage of the stream covered by aquatic vegetation was 17%. Average composition of streambed substrates from qualitative observations, were: 2% clay, 5% silt, 16% sand, 58% gravel, 15% cobble, and 3% boulders.

Quantitative measurements of streambed substrate composition were taken at 6 run bedforms, 4 riffles and 2 pools in river segment 6. Median substrate size for run bedforms in segment 6 was fine gravel (6 mm) (Figure 5). Runs were comprised of 12% silt, 21% sand and 55% was gravel, cobble, and boulders, with a well-mixed composition of substrates. Segment 6 riffle median substrate size was medium gravel (12 mm), and contained 8% silt, 23% sand and 69% gravel, cobble and boulders (Figure 5). Median substrate size the pool bedforms in segment 6 was very fine gravel (3 mm)(Figure 5). The pool bedform was also comprised of 6% silt, 42% sand and 52% was gravel, cobble and boulders (Figure 5).

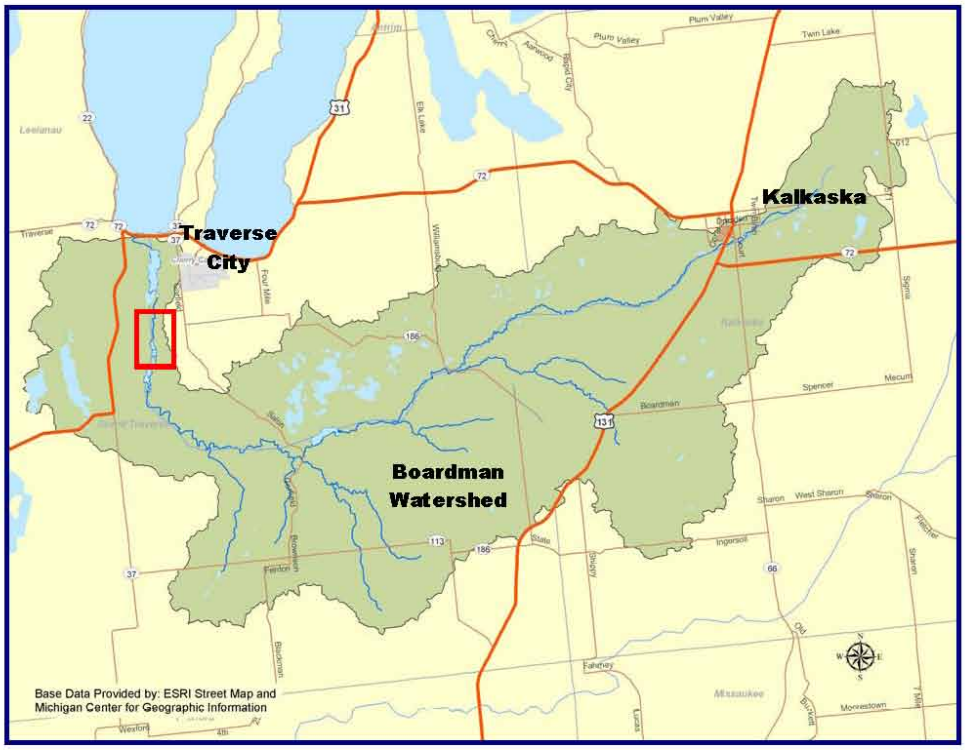
River segment 6, with the exception of water temperature, provides good fisheries habitat. As predicted, the presence of Brown Bridge Dam has several impacts on fisheries habitat, due to the lack of sediment transport. Principally, there is a higher percentage of run bedforms and fewer riffles. Also, substrate composition is noticeably coarser on average. Percentages of sand are decreased and gravel, cobble and boulders are more frequent. Wood debris is also predicted to decrease downstream of dams, due to the dams impeded the downstream migration of wood debris overtime. River segment 6 had lower percentages of wood debris than observed in river segment 8.

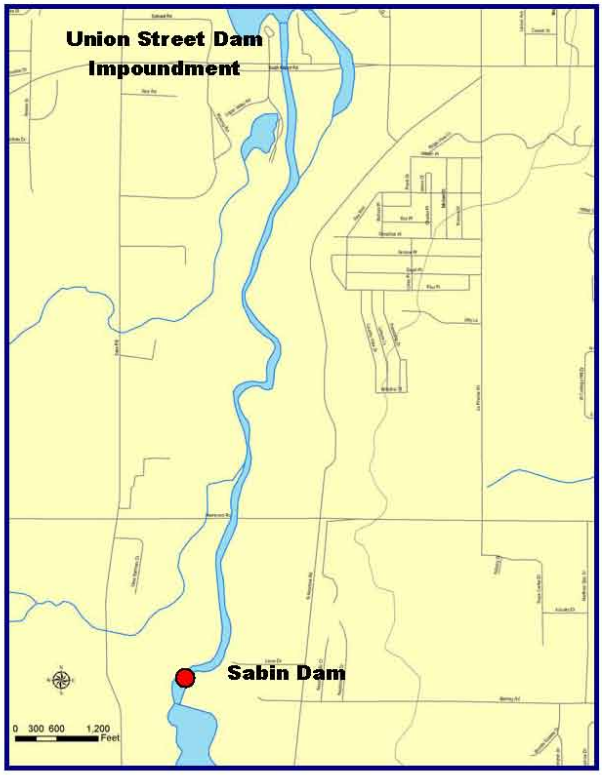
To examine whether the fisheries population surveys conducted by the Michigan Department of Natural Resources were conducted at sampling sites that were representative of the habitat conditions of the entire river segment, comparisons were made between the conditions measured in the vicinity of the MDNR sample sites and the average conditions seen within the entire river segment (Table 5). For river segment 6, individual sampling sites at "Brown Bridge Rd", "Shumsky's" and "Beitner Rd." did differ from the overall segment characteristics. Brown Bridge Rd fish sampling site was significantly different than the overall river segment. It was wider, almost entirely riffle bedform, had higher percentages of deep water due to higher percentages of pool bedforms, and had much coarser streambed substrates. Shumsky's fish sampling site was fairly similar to the overall segment, but had much lower percentages of deep water, and much higher percentages of aquatic vegetation. Beitner Rd fish sampling site was the most representative of the overall river segment characteristics, but also had much lower percentages of run bedforms and higher percentages of riffle.

Table 5. Fisheries habitat summary statistics for river segment 6 and three MDNR fish sampling sites within segment 6.

| | Segment 6 | Beitner Rd | Shumsky's | Brown Bridge Rd. |
|---|---|---|---|---|
| Total Length (m) | 22144 | 270 | 255 | 388 |
| Width (m) | | | | |
| *Mean* | 17.2 | 16.7 | 17.5 | 21.0 |
| *Standard Deviation* | 3.8 | 1.9 | 3.5 | 2.8 |
| Proportion Run Bedform | 0.73 | 0.43 | 0.73 | 0.00 |
| Proportion Riffle Bedform | 0.23 | 0.38 | 0.27 | 0.92 |
| Proportion Pool Bedform | 0.04 | 0.19 | 0.00 | 0.08 |
| % Area Deep Water (>2.5 ft) | | | | |
| *Mean* | 23 | 25 | 10 | 40 |
| *Standard Deviation* | 24 | 25 | 0 | 49 |
| % Wood Debris | | | | |
| *Mean* | 11 | 7 | 19 | 14 |
| *Standard Deviation* | 7 | 3 | 11 | 0 |
| % Aquatic Vegetation | | | | |
| *Mean* | 17 | 7 | 40 | 5 |
| *Standard Deviation* | 13 | 8 | 28 | 0 |
| Total Segment - % Clay | | | | |
| *Mean* | 2 | 2 | 0 | 3 |
| *Standard Deviation* | 6 | 3 | 0 | 4 |
| Total Segment - % Silt | | | | |
| *Mean* | 5 | 5 | 5 | 3 |
| *Standard Deviation* | 2 | 0 | 0 | 4 |
| Total Segment - % Sand | | | | |
| *Mean* | 16 | 20 | 13 | 10 |
| *Standard Deviation* | 10 | 5 | 11 | 7 |
| Total Segment - % Gravel | | | | |
| *Mean* | 58 | 62 | 50 | 48 |
| *Standard Deviation* | 18 | 8 | 14 | 32 |
| Total Segment - % Cobble | | | | |
| *Mean* | 15 | 10 | 25 | 30 |
| *Standard Deviation* | 10 | 0 | 14 | 14 |
| Total Segment - % Boulders | | | | |
| *Mean* | 3 | 2 | 8 | 8 |
| *Standard Deviation* | 4 | 3 | 11 | 4 |

Figure 6




**Segment 3:**
From Sabin Dam downstream to Union Street Dam impoundment, or Boardman Lake

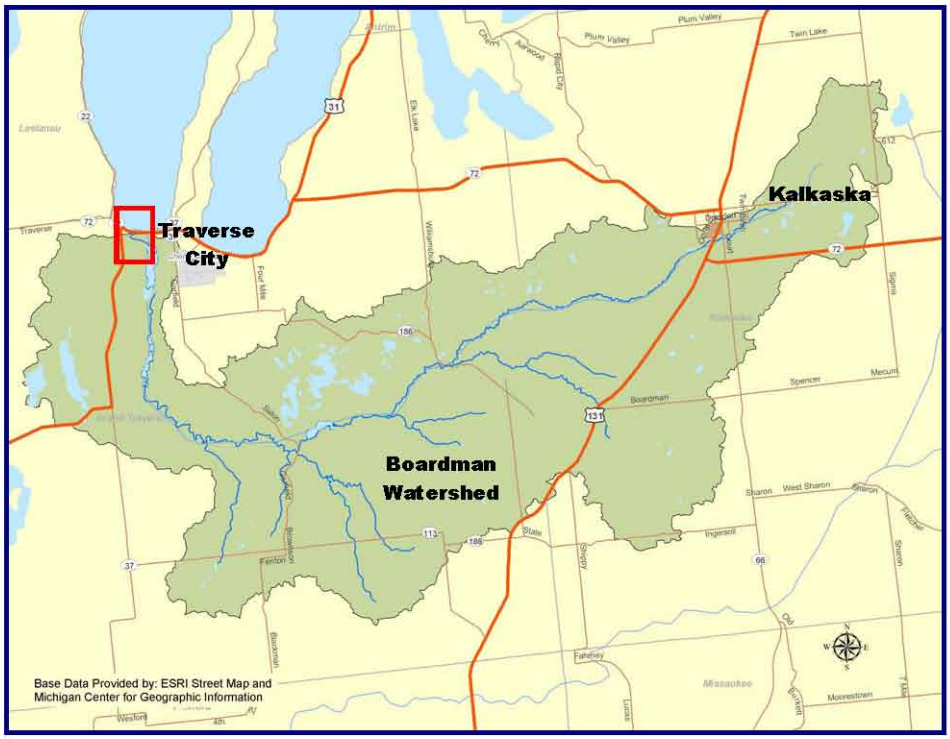
*Segment 3*

River segment 3 starts at Sabin Dam (N44°42.461', W85°37.374') and extends downstream to Union Street Dam Impoundment (also known as Boardman Lake) (Figure 6). During this survey, impacts on fisheries habitat due to Sabin Dam were observed for a distance approximately 860 m downstream of Sabin Dam (Appendix C). At this point, impoundment effects on fisheries habitat were evident from the Union Street Dam. This entire river segment is therefore determined to be impacted by Boardman River dams. This survey proceeded from Sabin Dam downstream to Airport Rd (N44°44.016', W85°36.986'), a distance of 3540 m.

Immediately downstream of Sabin Dam the river is very wide (54 m), and gravel was abundant (60%). After approximately 860 m downstream, the river was impounded by Union Street Dam. The river was narrower (~20 m) and sand was the most dominate substrate (80-85%). The river was deep (~70% was >2.5 ft. deep) and aquatic vegetation was abundant (~20%). Segment 3 was entirely run bedform, and wood debris averaged 10%. No cobble or boulders were seen and silt was scarce.

This river segment, while seriously impaired from natural conditions, does provide some unique fisheries habitat. The short gravel-filled section downstream of Sabin Dam likely provides some limited spawning habitat for fish requiring gravel for spawning. The rest of this river segment provides ample deep water habitat, some wood debris, and ample aquatic vegetation. In combination, this segment probably provides ample protective cover for certain fish species and larger-sized individual fish.

Figure 7





**Segment 1**:
From Union Street Dam downstream to Lake Michigan and Hospital (Kids) Creek

*Segment 1*

This river segment starts at Union Street Dam (N44°45.707', W85°37.391') and extends downstream to the river's confluence with the waters of Lake Michigan (N44°45.925', W85°36.860') (Figure 7). Fisheries habitat was surveyed from Union Street Dam downstream to the M31 highway bridge (N44°45.889', W85°36.875'), a distance of 1865 m. There is also a fish migration weir in this river segment, located at (N44°45.876', W85°37.592'). This river segment flows through downtown Traverse City, and is channelized along its entire course. The impeded sediment transport due to Union Street Dam, the channelized stream channel, and the impoundment effects from Lake Michigan have impacted this entire river segment.

Average width of the river in this segment was 20.7 m (Table 3). River segment 1 was 96% run, and 4% pool bedforms. Approximately 56% of the stream provided water depths of 2.5 ft. or greater. Percentage of stream containing wood material was low, at 4%. Percentage of the stream covered by aquatic vegetation was 24%. Average composition of streambed substrates, from qualitative observations, were: 0% clay, 0% silt, 32% sand, 45% gravel, 16% cobble, and 6% boulders. Similar to river segment 3, this segment downstream of Union Street Dam was quite wide and dominated by gravel, cobble and boulders. The remainder of segment 1 was narrower and contained larger percentages of sand substrate (Appendix D).

River segment 1 can be viewed as impaired from natural conditions over its entire length. However, this river segment also receives migrations of fish from Lake Michigan. The occurrence of coarse gravel and cobble in this segment likely provides opportunity for some of these migratory fish to spawn here. This segment also provides some cover for limited resident fish, in the form of deepwater and ample aquatic vegetation. During the survey of this river segment, rainbow trout, Chinook salmon, carp, drum, smallmouth bass and sea lamprey were observed.

## IMPLICATIONS

*Zone Boundaries*

Bedform mapping has proven useful as a means of accurately predicting the furthest upstream extent of impoundment effects of dams, in mixed sand-gravel streams in Michigan (Burroughs and Hayes 2007). This upstream extent of impoundment effects will also be the furthest upstream extent in which incision would occur if a dam was removed or drawn down.

As part of this effort to collect additional fish habitat data, bedform mapping was conducted. The furthest upstream extents of the impoundment effects of the Boardman River dams were documented: Brown Bridge Dam impoundment was N44°38.991', W85°28.465' and Boardman Dam impoundment was N44°40.870', W85°37.694'. Sabin Dam causes impoundment effects all the way upstream to Boardman Dam. Union Street Dam's upstream extent extends upstream to within 860m of Sabin Dam. However, due to the low gradient of this section, during different flow conditions, these effects could extend further upstream to Sabin Dam.

*Habitat Quality and Sediment Management Considerations*

Fish habitat quality below Brown Bridge Dam is primarily negatively affected by the warmer water temperatures caused by the dam. Physical characteristics of the stream channel are relatively high quality. The diversity of bedforms is slightly lower (with more run bedforms) than upstream of Brown Bridge Dam, as expected from the lowering of gradient downstream of the dam. However, while lower than upstream, riffles and pools are still abundant. Due to Brown Bridge Dam preventing sediment transport from upstream, substrate composition is highly diverse in this river segment, and coarser than observed upstream. If water temperature impacts from Brown Bridge Dam were alleviated, this river segment of the Boardman River would be expected to become high quality fish habitat. However, this data also indicates that if dam removal is considered for Brown Bridge Dam, it would be highly desirable to prevent sediment from moving downstream. If excessive amounts of sediment were transported downstream into this river segment, fish habitat quality would be negatively impacted.

Sabin Dam impounds sediment and water upstream to Boardman Dam and the river channel is currently impacted (run bedforms and sand substrate are dominant). If Boardman Dam were to be removed, sediment could be allowed to move downstream without significant impact to the existing fish habitat.

Downstream of Sabin Dam, the streambed is dominated by gravel for a short section before abruptly changing to mostly sand. The river channel is low gradient immediately downstream of Sabin Dam due to the dam and then low gradient all the way to Airport Road and the Boardman Lake proper due to the impoundment effects of Union Street Dam. If dam removal were considered for Sabin Dam, some sediment should be allowed to move downstream. This would cause streambed aggradation downstream of the dam and serve to increase the gradient of this river segment.

Downstream of Union Street Dam, the stream is channelized to protect the infrastructure of downtown Traverse City. Substrate is overly coarse downstream of the dam, and then approximately halfway downstream through this river segment, turns to mostly sand due to impoundment effects from Lake Michigan. To protect the infrastructure surrounding the stream channel in this river segment, sediment should not be allowed to be transported through this segment, if dam removal is considered for Union Street Dam.

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# APPENDICES

Appendix A. Fisheries habitat raw data, from Boardman River segment 8, Forks Canoe Launch downstream to Brown Bridge Dam impoundment, surveyed 8-4-2007.

*1=riffle, 2=run, 3=pool, 4=rapid, 7=gorge*

| Unit | Location | Bedform | Length (m) | Top Width (m) | % >2.5ft. Deep | % Wood | % Aquatic Vegetation | % Clay | % Silt | % Sand | % Gravel | % Cobble | % Boulders | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | start: Forks Boat Launch | 2 | 35.5 | 11.5 | 30 | 5 | 0 | 0 | 0 | 5 | 70 | 15 | 10 | |
| 2 | N44°40.403' W85°24.091' | 1 | 108 | 10.5 | 0 | 20 | 5 | 5 | 5 | 25 | 55 | 10 | 0 | |
| 3 | | 2 | 90 | 10.5 | 0 | 15 | 10 | 0 | 2 | 38 | 60 | 0 | 0 | |
| 4 | | 1 | 48 | 10.5 | 0 | 15 | 0 | 0 | 0 | 35 | 65 | 0 | 0 | |
| 5 | | 2 | 16 | 13.5 | 40 | 35 | 0 | 0 | 0 | 40 | 60 | 0 | 0 | |
| 6 | | 1 | 24.5 | 13 | 0 | 5 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | |
| 7 | | 3 | 18.5 | 10 | 45 | 30 | 0 | 0 | 0 | 60 | 40 | 0 | 0 | |
| 8 | | 3 | 60 | 12.5 | 45 | 40 | 0 | 0 | 0 | 50 | 50 | 0 | 0 | |
| 9 | | 1 | 53 | 11 | 0 | 5 | 0 | 0 | 0 | 25 | 75 | 0 | 0 | |
| 10 | | 2 | 161 | 10 | 25 | 30 | 20 | 0 | 10 | 40 | 50 | 0 | 0 | |
| 11 | 44 40.587 85 24.269 EPE22 | 1 | 33.5 | 13 | 0 | 5 | 20 | 0 | 0 | 20 | 80 | 0 | 0 | |
| 12 | | 2 | 140 | 10 | 45 | 30 | 15 | 0 | 0 | 60 | 40 | 0 | 0 | |
| 13 | | 2 | 235 | 12.5 | 35 | 35 | 15 | 0 | 5 | 35 | 60 | 0 | 0 | |
| 14 | | 1 | 22 | 12.5 | 0 | 20 | 10 | 0 | 10 | 30 | 60 | 0 | 0 | |
| 15 | | 2 | 114 | 10 | 10 | 25 | 10 | 0 | 0 | 25 | 75 | 0 | 0 | |
| 16 | | 3 | 49 | 15 | 30 | 5 | 0 | 0 | 0 | 25 | 75 | 0 | 0 | |
| 17 | | 2 | 75 | 10 | 30 | 15 | 15 | 0 | 5 | 55 | 40 | 0 | 0 | |
| 18 | | 3 | 44 | 12.5 | 30 | 25 | 15 | 0 | 5 | 55 | 40 | 0 | 0 | |
| 19 | | 1 | 47 | 10 | 0 | 0 | 10 | 0 | 0 | 15 | 85 | 0 | 0 | |
| 20 | | 2 | 228 | 10 | 25 | 30 | 15 | 0 | 5 | 40 | 55 | 0 | 0 | |
| 21 | 44 40.541 085 24.792 | 1 | 49 | 15.5 | 0 | 0 | 5 | 0 | 0 | 5 | 95 | 0 | 0 | |
| 22 | Upstream of Ranch Rudolph | 3 | 20 | 10 | 40 | 25 | 15 | 0 | 5 | 70 | 25 | 0 | 0 | |
| 23 | | 3 | 20.5 | 10 | 70 | 30 | 35 | 0 | 5 | 70 | 25 | 0 | 0 | |
| 24 | | 3 | 29 | 10 | 60 | 25 | 15 | 0 | 5 | 70 | 25 | 0 | 0 | |
| 25 | | 2 | 83.5 | 10 | 70 | 30 | 25 | 0 | 5 | 60 | 35 | 0 | 0 | |
| 26 | | 2 | 146 | 10 | 30 | 50 | 25 | 0 | 10 | 45 | 45 | 0 | 0 | |
| 27 | | 3 | 24 | 14.5 | 50 | 0 | 20 | 0 | 15 | 60 | 25 | 0 | 0 | |
| 28 | | 3 | 37 | 10 | 70 | 30 | 15 | 0 | 15 | 65 | 20 | 0 | 0 | |
| 29 | | 2 | 145 | 10 | 40 | 50 | 15 | 0 | 10 | 70 | 20 | 0 | 0 | |
| 30 | | 1 | 23 | 15 | 0 | 0 | 40 | 0 | 5 | 45 | 50 | 0 | 0 | |
| 31 | | 2 | 70 | 8 | 40 | 20 | 15 | 0 | 0 | 45 | 65 | 0 | 0 | |
| 32 | | 3 | 23.5 | 11 | 40 | 25 | 5 | 0 | 5 | 50 | 45 | 0 | 0 | |
| 33 | | 2 | 84 | 10 | 65 | 20 | 15 | 0 | 5 | 75 | 20 | 0 | 0 | |
| 34 | | 3 | 70 | 10.5 | 65 | 5 | 20 | 0 | 15 | 65 | 20 | 0 | 0 | |
| 35 | | 2 | 155 | 8 | 40 | 35 | 20 | 0 | 5 | 50 | 45 | 0 | 0 | |
| 36 | | 3 | 20 | 10 | 50 | 15 | 20 | 0 | 5 | 55 | 40 | 0 | 0 | |
| 37 | | 2 | 200 | 8 | 30 | 25 | 10 | 0 | 5 | 45 | 45 | 5 | 0 | |
| 38 | | 2 | 172 | | | | | | | | | | | |
| 39 | | 2 | 272 | | | | | | | | | | | |
| 40 | | 2 | 147 | 10 | 0 | 5 | 5 | 0 | 5 | 25 | 70 | 0 | 0 | |
| 41 | 44 40.165 085 25.334 | 1 | 95 | 13 | 0 | 5 | 10 | 0 | 0 | 20 | 70 | 10 | 0 | |
| 42 | | 2 | 164 | 8 | 20 | 10 | 30 | 5 | 5 | 35 | 45 | 10 | 0 | |
| 43 | | 1 | 161 | 13 | 0 | 10 | 10 | 0 | 0 | 25 | 65 | 10 | 0 | |
| 44 | | 3 | 26 | 10 | 80 | 0 | 5 | 10 | 0 | 70 | 15 | 0 | 5 | |
| 45 | | 3 | 35 | 7 | 30 | 5 | 5 | 0 | 5 | 45 | 50 | 0 | 0 | |
| 46 | | 1 | 63 | 9 | 0 | 5 | 5 | 0 | 0 | 30 | 50 | 20 | 0 | |
| 47 | | 2 | 82 | 12 | 20 | 20 | 10 | 0 | 0 | 30 | 50 | 20 | 0 | |
| 48 | | 1 | 34 | 8 | 0 | 10 | 15 | 0 | 0 | 15 | 80 | 5 | 0 | |
| 49 | | 3 | 23 | 13 | 70 | 15 | 5 | 0 | 10 | 40 | 50 | 0 | 0 | |
| 50 | | 2 | 344 | 11.5 | 20 | 20 | 30 | 0 | 5 | 35 | 45 | 10 | 5 | |
| 51 | 44 39.813 085 25.733 | 1 | 251 | 14 | 0 | 20 | 40 | 0 | 10 | 15 | 70 | 5 | 0 | |
| 52 | | 2 | 34 | 15 | 25 | 25 | 15 | 0 | 5 | 65 | 25 | 0 | 5 | |
| 53 | | 1 | 447 | 12 | 0 | 20 | 35 | 0 | 10 | 10 | 55 | 20 | 5 | |
| 54 | | 2 | 161 | 10.5 | 5 | 15 | 40 | 0 | 5 | 10 | 50 | 30 | 5 | |
| 55 | Riffle starts wood bridge/horse crossing at RR | 1 | 219 | 15 | 0 | 10 | 15 | 0 | 5 | 15 | 40 | 40 | 0 | |
| 56 | | 2 | 157 | 9 | 5 | 10 | 25 | 0 | 5 | 45 | 45 | 5 | 0 | |
| 57 | | 2 | 40 | 8 | 40 | 10 | 10 | 0 | 0 | 30 | 45 | 15 | 10 | |
| 58 | at Ranch Rudolph Bridge | 2 | 126 | 12 | 15 | 5 | 20 | 0 | 5 | 20 | 50 | 20 | 5 | |
| 59 | | 1 | 49 | 10 | 5 | 5 | 10 | 0 | 0 | 10 | 65 | 20 | 5 | |
| 60 | | 2 | 241 | 10 | 5 | 10 | 20 | 0 | 5 | 30 | 60 | 5 | 0 | |
| 61 | Downstream RR | 1 | 134 | 12 | 0 | 5 | 10 | 0 | 5 | 10 | 55 | 25 | 5 | |

Appendix A. Fisheries habitat raw data, from Boardman River segment 8, Forks Canoe Launch downstream to Brown Bridge Dam impoundment, surveyed 8-4-2007. (Continued)

*1=riffle, 2=run, 3=pool, 4=rapid, 7=gorge*

| Unit | Location | Bedform | Length (m) | Top Width (m) | % >2.5ft. Deep | % Wood | % Aquatic Vegetation | % Clay | % Silt | % Sand | % Gravel | % Cobble | % Boulders | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 62 | 44 39.272 085 26.419 | 2 | 423 | 10 | 15 | 10 | 25 | 5 | 5 | 35 | 45 | 5 | 5 | |
| 63 | | 2 | 318 | 7 | 15 | 20 | 15 | 10 | 5 | 30 | 35 | 15 | 5 | |
| 64 | | 3 | 18 | 14 | 60 | 20 | 10 | 0 | 0 | 30 | 70 | 0 | 0 | |
| 65 | | 2 | 311 | 12 | 5 | 10 | 10 | 0 | 5 | 25 | 50 | 20 | 0 | |
| 66 | | 1 | 721 | 15 | 0 | 5 | 25 | 5 | 5 | 15 | 25 | 45 | 5 | |
| 67 | Sheck Bridge 44 39.098 085 27.304 | 2 | 61 | 11.5 | 30 | 15 | 5 | 0 | 15 | 40 | 35 | 10 | 0 | |
| 68 | | 3 | 39 | 12 | 40 | 5 | 5 | 0 | 5 | 50 | 40 | 5 | 0 | |
| 69 | | 2 | 159 | 13 | 15 | 10 | 20 | 0 | 15 | 35 | 35 | 10 | 5 | |
| 70 | | 1 | 274 | 17 | 0 | 5 | 5 | 0 | 10 | 10 | 35 | 35 | 5 | |
| 71 | | 2 | 135 | 13 | 15 | 5 | 5 | 10 | 5 | 20 | 40 | 20 | 5 | |
| 72 | | 1 | 60 | 15 | 0 | 0 | 5 | 0 | 5 | 5 | 75 | 15 | 0 | |
| 73 | | 2 | 91 | 10 | 25 | 15 | 5 | 0 | 5 | 20 | 65 | 10 | 0 | |
| 74 | | 1 | 74 | 13 | 0 | 5 | 10 | 0 | 5 | 15 | 60 | 20 | 0 | |
| 75 | | 2 | 106 | 10 | 10 | 5 | 10 | 0 | 10 | 30 | 45 | 10 | 5 | |
| 76 | | 1 | 617 | 18 | 0 | 5 | 20 | 0 | 5 | 10 | 40 | 40 | 5 | 40 foot run in between |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | this is the upstream boundary of the Brown Bridge Dam impoundment effects | | | | | | | | | | | | | |
| 77 | **44 38.991 085 28.465** | 2 | 417 | 15 | 25 | 35 | 20 | 5 | 10 | 25 | 50 | 10 | 0 | |
| 78 | 44 38.988 085 28.468 | 2 | 567 | 10 | 50 | 15 | 25 | 0 | 10 | 70 | 15 | 5 | 0 | |
| 79 | | 2 | 442 | 20 | 50 | 10 | 25 | 0 | 15 | 80 | 5 | 0 | 0 | |
| 80 | Braids | 2 | 324 | 30 | 5 | 10 | 15 | 0 | 10 | 90 | 0 | 0 | 0 | |
| 81 | ENDING GPS 44 39.010 085 29.411 EPE16 | 2 | 262 | 19 | 5 | 5 | 0 | 0 | 5 | 95 | 0 | 0 | 0 | 44 38.904 085 29.018 |

Appendix B. Fisheries habitat raw data, from Boardman River segment 6, Brown Bridge Dam downstream to Boardman Dam impoundment, surveyed 8-5-2007 and 9-8-2007.

*1=riffle, 2=run, 3=pool, 4=rapid, 7=gorge*

| Unit | Location | Bedform | Length (m) | Top Width (m) | % >2.5ft. Deep | % Wood | % Aquatic Vegetation | % Clay | % Silt | % Sand | % Gravel | % Cobble | % Boulders | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | start: Brown Bridge Dam | 2 | 132 | 19 | 0 | 10 | 5 | 0 | 5 | 5 | 0 | 0 | 5 | zebra mussels 90% |
| 2 | N44°38.573' W85°30.604' | 2 | 320 | 18 | 5 | 15 | 20 | 0 | 5 | 5 | 35 | 20 | 5 | zebra mussels 30% |
| 3 | | 3 | 31 | 19 | 75 | 10 | 5 | 5 | 5 | 15 | 25 | 40 | 10 | Road culvert pool |
| 4 | | 1 | 357 | 23 | 5 | 10 | 5 | 0 | 0 | 5 | 70 | 20 | 5 | |
| 5 | | 2 | 87 | 16 | 0 | 15 | 5 | 0 | 5 | 10 | 80 | 5 | 0 | |
| 6 | | 1 | 80 | 19 | 0 | 15 | 5 | 0 | 5 | 5 | 85 | 5 | 0 | |
| 7 | | 2 | 349 | 20 | 15 | 25 | 20 | 5 | 5 | 15 | 60 | 15 | 0 | Under second road bridge |
| 8 | | 3 | 36 | 18 | 80 | 5 | 10 | 0 | 5 | 25 | 25 | 40 | 5 | |
| 9 | | 1 | 109 | 17 | 0 | 5 | 45 | 0 | 0 | 0 | 75 | 25 | 0 | |
| 10 | | 2 | 33 | 21 | 0 | 30 | 40 | 0 | 5 | 5 | 85 | 5 | 0 | |
| 11 | | 2 | 185 | 22 | 20 | 30 | 35 | 0 | 10 | 5 | 70 | 15 | 0 | |
| 12 | | 1 | 139 | 16 | 0 | 10 | 10 | 0 | 5 | 5 | 75 | 15 | 0 | *downstream extent of dam impacts ?* |
| 13 | | 2 | 117 | 22 | 30 | 40 | 50 | 0 | 5 | 20 | 60 | 15 | 0 | |
| 14 | | 1 | 53 | 25 | 5 | 15 | 40 | 0 | 5 | 15 | 80 | 0 | 0 | |
| 15 | | 2 | 500 | 18 | 25 | 15 | 15 | 0 | 10 | 10 | 65 | 15 | 0 | railroad tracks |
| 16 | | 1 | 80 | 26 | 0 | 5 | 15 | 0 | 5 | 15 | 80 | 0 | 0 | |
| 17 | | 3 | 45 | 12 | 50 | 5 | 30 | 0 | 5 | 20 | 60 | 10 | 5 | |
| 18 | | 1 | 104 | 24 | 5 | 5 | 30 | 0 | 5 | 15 | 65 | 15 | 0 | |
| 19 | | 2 | 302 | 17 | 30 | 5 | 30 | 0 | 5 | 15 | 70 | 10 | 0 | lots of culvert dumps |
| 20 | | 3 | 36 | 19 | 65 | 20 | 10 | 0 | 10 | 35 | 45 | 10 | 0 | |
| 21 | 44 38.489  085 31.786 | 2 | 424 | 22 | 30 | 30 | 40 | 0 | 10 | 15 | 65 | 10 | 0 | |
| 22 | | 3 | 25 | 10 | 80 | 10 | 10 | 0 | 5 | 20 | 35 | 35 | 5 | |
| 23 | | 3 | 56 | 10 | 80 | 10 | 10 | 0 | 5 | 20 | 35 | 35 | 5 | |
| 24 | | 3 | 33 | 14 | 35 | 10 | 5 | 0 | 0 | 5 | 70 | 25 | 0 | |
| 25 | Riffle/pool | 7 | 30 | 18 | 30 | 5 | 5 | 0 | 5 | 30 | 60 | 5 | 0 | |
| 26 | | 2 | 67 | 13 | 15 | 10 | 5 | 0 | 5 | 30 | 60 | 5 | 0 | |
| 27 | 44 38.552  85 31.969 | 1 | 61 | 18 | 10 | 10 | 10 | 0 | 5 | 40 | 55 | 0 | 0 | BB Road crossing east of Garfield |
| 28 | | 3 | 32 | 15 | 65 | 5 | 10 | 5 | 5 | 15 | 30 | 25 | 20 | |
| 29 | | 2 | 84 | 11 | 15 | 5 | 5 | 10 | 5 | 5 | 50 | 25 | 5 | Dismusebeta Cabin |
| 30 | | 1 | 78 | 16 | 0 | 5 | 10 | 0 | 0 | 10 | 35 | 50 | 5 | |
| 31 | | 2 | 480 | 13 | 15 | 20 | 5 | 10 | 5 | 15 | 60 | 20 | 0 | |
| 32 | | 3 | 50 | 10 | 80 | 10 | 5 | 35 | 5 | 25 | 15 | 15 | 5 | |
| 33 | | 2 | 501 | 13 | 20 | 20 | 15 | 10 | 5 | 25 | 30 | 30 | 0 | |
| 34 | | 1 | 494 | 13 | 0 | 5 | 15 | 5 | 5 | 15 | 40 | 35 | 0 | |
| 35 | | 3 | 65 | 17 | 40 | 0 | 5 | 15 | 5 | 10 | 30 | 30 | 10 | |
| 36 | | 1 | 279 | 15 | 5 | 5 | 10 | 5 | 5 | 25 | 35 | 30 | 0 | |
| 37 | | 2 | 86 | 19 | 10 | 5 | 5 | 5 | 0 | 15 | 60 | 20 | 5 | |
| 38 | Car bridge over water | 1 | 456 | 17 | 5 | 5 | 5 | 5 | 5 | 15 | 40 | 30 | 5 | with pool 24 meters |
| 39 | | 2 | 262 | 15 | 20 | 10 | 5 | 15 | 5 | 20 | 30 | 25 | 5 | |
| 40 | 44 38.764  085 33.024 | 1 | 76 | 16 | 0 | 5 | 10 | 0 | 5 | 25 | 55 | 15 | 0 | |
| 41 | | 2 | 35 | 12 | 20 | 10 | 10 | 10 | 5 | 25 | 40 | 20 | 0 | |
| 42 | | 1 | 52 | 14 | 15 | 5 | 5 | 10 | 5 | 35 | 30 | 20 | 0 | |
| 43 | | 3 | 44 | 18 | 50 | 5 | 0 | 40 | 0 | 25 | 35 | 0 | 0 | |
| 44 | | 2 | 321 | 15 | 30 | 5 | 15 | 5 | 5 | 30 | 30 | 25 | 5 | |
| 45 | | 3 | 38 | 16 | 20 | 5 | 5 | 15 | 0 | 20 | 35 | 20 | 10 | |
| 46 | | 1 | 335 | 16 | 0 | 15 | 25 | 0 | 0 | 10 | 55 | 25 | 10 | Braided |
| 47 | | 2 | 391 | 18 | 35 | 15 | 25 | 0 | 5 | 15 | 60 | 20 | 0 | |
| 48 | | 3 | 20 | 12 | 60 | 0 | 10 | 0 | 5 | 30 | 50 | 15 | 0 | |
| 49 | | 2 | 135 | 15 | 30 | 25 | 30 | 0 | 5 | 30 | 50 | 10 | 5 | |
| 50 | | 3 | 60 | 13 | 75 | 20 | 10 | 0 | 5 | 35 | 45 | 5 | 10 | |

Appendix B. Fisheries habitat raw data, from Boardman River segment 6, Brown Bridge Dam downstream to Boardman Dam impoundment, surveyed 8-5-2007 and 9-8-2007 (Continued)

*1=riffle, 2=run, 3=pool, 4=rapid, 7=gorge*

| Unit | Location | Bedform | Length (m) | Top Width (m) | % >2.5ft. Deep | % Wood | % Aquatic Vegetation | % Clay | % Silt | % Sand | % Gravel | % Cobble | % Boulders | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | | 2 | 648 | 16 | 40 | 20 | 15 | 5 | 5 | 20 | 55 | 10 | 5 | |
| 52 | | 1 | 58 | 17 | 0 | 5 | 40 | 0 | 5 | 10 | 60 | 25 | 0 | |
| 53 | | 2 | 224 | 12 | 30 | 5 | 20 | 0 | 5 | 30 | 50 | 15 | 0 | |
| 54 | | 3 | 39 | 14 | 80 | 5 | 10 | 0 | 5 | 25 | 35 | 25 | 10 | |
| 55 | | 2 | 516 | 14 | 15 | 10 | 35 | 0 | 5 | 15 | 60 | 15 | 5 | |
| 56 | | 1 | 157 | 18 | 0 | 5 | 25 | 0 | 5 | 10 | 60 | 20 | 5 | |
| 57 | | 2 | 328 | 17 | 15 | 5 | 30 | 0 | 5 | 20 | 50 | 25 | 0 | |
| 58 | | 1 | 175 | 14 | 10 | 10 | 25 | 0 | 5 | 5 | 65 | 25 | 0 | |
| 59 | | 2 | 356 | 22 | 40 | 20 | 30 | 0 | 10 | 20 | 55 | 15 | 0 | |
| 60 | | 3 | 41 | 15 | 80 | 5 | 20 | 0 | 10 | 20 | 55 | 10 | 5 | |
| 61 | | 2 | 957 | 19 | 35 | 25 | 30 | 0 | 5 | 15 | 60 | 15 | 5 | |
| 62 | Downstream BB Dam to | 2 | 313 | 14 | 20 | 15 | 5 | 0 | 5 | 15 | 65 | 15 | 0 | |
| 63 | Shumsky's Pull out | 1 | 69 | 15 | 10 | 5 | 60 | 0 | 5 | 5 | 40 | 35 | 15 | |
| 64 | 44 38.898 085 35.026 | 2 | 186 | 20 | 10 | 20 | 20 | 0 | 5 | 20 | 60 | 15 | 0 | |
| 65 | start: Shumsky's boat launcl | 2 | 160 | 23.5 | 5 | 15 | 35 | 0 | 5 | 5 | 80 | 10 | 0 | |
| 66 | N44°39.054' W85°35.454' | 1 | 140 | 20 | 0 | 10 | 40 | 0 | 5 | 10 | 70 | 10 | 5 | |
| 67 | | 2 | 218 | 22.5 | 0 | 10 | 15 | 0 | 5 | 10 | 75 | 10 | 0 | |
| 68 | | 2 | 229 | 15 | 15 | 15 | 10 | 0 | 5 | 15 | 75 | 5 | 0 | |
| 69 | | 3 | 80 | 17 | 60 | 15 | 5 | 0 | 5 | 10 | 75 | 10 | 0 | |
| 70 | | 1 | 43 | 18 | 5 | 20 | 5 | 0 | 5 | 15 | 80 | 5 | 0 | |
| 71 | | 2 | 135 | 13.5 | 15 | 20 | 10 | 0 | 5 | 15 | 70 | 10 | 0 | |
| 72 | | 2 | 273 | 16 | 10 | 15 | 10 | 0 | 5 | 10 | 75 | 10 | 0 | Narrow/fast |
| 73 | | 2 | 75 | 17.5 | 10 | 10 | 30 | 0 | 10 | 10 | 70 | 10 | 0 | slow |
| 74 | | 1 | 73 | 17 | 0 | 5 | 10 | 0 | 5 | 5 | 90 | 0 | 0 | |
| 75 | | 2 | 95 | 20.5 | 25 | 15 | 20 | 0 | 10 | 10 | 75 | 5 | 0 | |
| 76 | | 1 | 35 | 19 | 0 | 15 | 20 | 0 | 10 | 10 | 75 | 5 | 0 | |
| 77 | | 2 | 115 | 22 | 40 | 15 | 45 | 0 | 5 | 15 | 75 | 5 | 0 | |
| 78 | | 3 | 38.5 | 15.5 | 70 | 10 | 5 | 0 | 0 | 10 | 70 | 15 | 5 | |
| 79 | | 1 | 32.5 | 14 | 10 | 5 | 5 | 0 | 0 | 5 | 80 | 15 | 0 | trib comes in |
| 80 | | 2 | 257 | 13 | 20 | 10 | 30 | 0 | 5 | 10 | 70 | 10 | 5 | very small trib |
| 81 | | 2 | 121 | 14.5 | 20 | 10 | 30 | 0 | 5 | 10 | 75 | 10 | 0 | meandering |
| 82 | | 3 | 18 | 10 | 85 | 5 | 5 | 0 | 5 | 35 | 30 | 25 | 5 | |
| 83 | | 2 | 198 | 16 | 60 | 10 | 20 | 0 | 5 | 15 | 70 | 10 | 0 | multiple small pools |
| 84 | | 1 | 199 | 18 | 5 | 10 | 30 | 0 | 5 | 10 | 65 | 15 | 5 | 20ft run between; clay nugget |
| 85 | 44 39.516 085 35.999 | 2 | 936 | 16.5 | 15 | 10 | 25 | 5 | 5 | 10 | 65 | 10 | 5 | |
| 86 | | 2 | 252 | 18 | 20 | 20 | 15 | 0 | 15 | 10 | 70 | 5 | 0 | |
| 87 | | 3 | 47 | 17 | 40 | 10 | 0 | 0 | 5 | 60 | 35 | 0 | 0 | spring seep |
| 88 | | 2 | 227 | 20 | 10 | 15 | 20 | 0 | 5 | 10 | 70 | 10 | 5 | |
| 89 | | 1 | 53.5 | 14.5 | 10 | 5 | 10 | 5 | 5 | 10 | 60 | 15 | 5 | |
| 90 | | 2 | 764 | 18 | 15 | 15 | 20 | 0 | 5 | 5 | 75 | 10 | 5 | little riffle 20ft; private green metal bridge; little stream trib cold; shoreline all spring seeps and f |
| 91 | | 2 | 237 | 18.5 | 35 | 20 | 15 | 0 | 5 | 10 | 75 | 10 | 0 | 44 39.826 085 36.937 |
| 92 | | 2 | 234 | 23.5 | 10 | 10 | 25 | 0 | 5 | 20 | 55 | 15 | 5 | |
| 93 | | 1 | 73 | 23.5 | 0 | 5 | 30 | 0 | 0 | 5 | 85 | 10 | 0 | |
| 94 | | 2 | 396 | 19 | 10 | 10 | 15 | 0 | 5 | 10 | 65 | 15 | 5 | |
| 95 | | 1 | 68.5 | 12.5 | 10 | 5 | 0 | 0 | 5 | 15 | 65 | 15 | 0 | Wicksall Bridge |
| 96 | | 2 | 123 | 15.5 | 10 | 10 | 5 | 0 | 5 | 10 | 65 | 15 | 5 | |
| 97 | | 1 | 47.5 | 18.5 | 0 | 5 | 5 | 0 | 5 | 5 | 55 | 30 | 5 | |
| 98 | | 3 | 51 | 15 | 85 | 5 | 5 | 0 | 5 | 30 | 30 | 25 | 10 | |
| 99 | | 1 | 60 | 19 | 5 | 5 | 20 | 0 | 5 | 10 | 60 | 15 | 10 | |
| 100 | | 2 | 173 | 15 | 20 | 5 | 10 | 0 | 5 | 30 | 50 | 10 | 5 | 44 40.125 085 37.185 island |
| 101 | riffle | 7 | 124 | 33 | 5 | 10 | 10 | 0 | 5 | 10 | 70 | 10 | 5 | |

Appendix B. Fisheries habitat raw data, from Boardman River segment 6, Brown Bridge Dam downstream to Boardman Dam impoundment, surveyed 8-5-2007 and 9-8-2007 (Continued)

*1=riffle, 2=run, 3=pool, 4=rapid, 7=gorge*

| Unit | Location | Bedform | Length (m) | Top Width (m) | % >2.5ft. Deep | % Wood | % Aquatic Vegetation | % Clay | % Silt | % Sand | % Gravel | % Cobble | % Boulders | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 102 | | 2 | 318 | 20.5 | 10 | 10 | 15 | 0 | 5 | 10 | 65 | 15 | 5 | habitat improvement |
| 103 | | 1 | 74 | 23 | 5 | 5 | 10 | 0 | 0 | 5 | 80 | 10 | 5 | |
| 104 | | 1 | 163 | 20 | 5 | 5 | 10 | 0 | 5 | 15 | 70 | 10 | 0 | |
| 105 | 44 40.343 085 37.226 | 2 | 129 | 18 | 20 | 5 | 60 | 0 | 5 | 10 | 70 | 5 | 10 | |
| 106 | | 1 | 285 | 18.5 | 10 | 5 | 30 | 0 | 5 | 5 | 65 | 15 | 10 | |
| 107 | | 3 | 41.5 | 12.5 | 60 | 5 | 5 | 0 | 5 | 40 | 25 | 10 | 20 | |
| 108 | | 1 | 207 | 18 | 0 | 10 | 5 | 0 | 5 | 15 | 60 | 15 | 5 | |
| 109 | | 3 | 51.5 | 17.5 | 50 | 5 | 5 | 0 | 5 | 25 | 55 | 10 | 5 | |
| 110 | | 1 | 103 | 18 | 0 | 5 | 0 | 0 | 5 | 15 | 70 | 10 | 0 | |
| 111 | end: Bietner Launch | 2 | 115 | 14.5 | 25 | 10 | 15 | 5 | 5 | 20 | 60 | 10 | 0 | |
| 112 | 44 40.476 085 37.809 | 1 | 166 | 21 | 5 | 10 | 10 | 0 | 5 | 10 | 65 | 15 | 5 | |
| 113 | start: Beitner Road | 2 | 102 | 19.5 | 30 | 10 | 5 | 0 | 5 | 10 | 70 | 10 | 5 | Before rapids |
| 114 | N44°40.492' W85°37.810' | 4 | 695 | 17.5 | 10 | 10 | 10 | 0 | 5 | 10 | 30 | 35 | 20 | Rapids |
| 115 | | 2 | 547 | 14 | 35 | 15 | 5 | 0 | 5 | 15 | 40 | 35 | 5 | Oleson Bridge |
| 116 | end: 44 41.096 085 37.617 | 2 | 513 | 26 | 10 | 20 | 5 | 0 | 0 | 20 | 80 | 0 | 0 | Incision and impoundment affects 44 40.879 085 37.701 |

**Comments:**
GPS coordinates for beitner road are off, errored to the north and slightly to the west. Coordinates for the impoundment effects boundary also appear off, and should be N44 40.870' W85 37.694'.
Effects of Brown Bridge Dam, on river morphology, extend downstream, for probably 1.9km, based on observations on stream width and % sand.
tease out characteristics of the fish abundance sites.

Appendix C. Fisheries habitat raw data, from Boardman River segment 3, Sabin Dam downstream to Airport Rd/Boardman Lake, surveyed 9-8-2007.

*1=riffle, 2=run, 3=pool, 4=rapid, 7=gorge*

| Unit | Location | Bedform | Length (m) | Top Width (m) | % >2.5ft. Deep | % Wood | % Aquatic Vegetation | % Clay | % Silt | % Sand | % Gravel | % Cobble | % Boulders |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | start: Sabin Dam to airport | 2 | 861 | 54 | 45 | 10 | 15 | 0 | 0 | 40 | 60 | 0 | 0 |
| 2 | N44°42.520' W85°37.352' | 2 | 526 | 22 | 60 | 5 | 15 | 0 | 0 | 85 | 15 | 0 | 0 |
| 3 | downstream is airport rd | 2 | 2153 | 19.5 | 75 | 15 | 25 | 0 | 0 | 80 | 20 | 0 | 0 |

**Comments:**

lots of gravel immediately downstream of Sabin Dam, then overwhelmingly sand
by the time the effects of Sabin Dam dissapeared, impoundment effects from Union Street Dam were evident - this entire segment is impacted
lots of deep water, very deep holes, some eelgrass-like vegetation, and some amount of wood debris
smallmouth bass were sighted

Appendix D. Fisheries habitat raw data, from Boardman River segment 1, Union Street Dam downstream to Lake Michigan, surveyed 9-9-2007.

*1=riffle, 2=run, 3=pool, 4=rapid, 7=gorge*

| Unit | Location | Bedform | Length (m) | Top Width (m) | % >2.5ft. Deep | % Wood | % Aquatic Vegetation | % Clay | % Silt | % Sand | % Gravel | % Cobble | % Boulders | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | start: Union Street Dam | 2 | 443 | 23.5 | 75 | 5 | 60 | 0 | 0 | 20 | 55 | 20 | 5 | |
| 2 | | 2 | 172.5 | 29.5 | 0.5 | 5 | 30 | 0 | 0 | 15 | 65 | 15 | 5 | water inputs; tributaries/tubes |
| 3 | | 3 | 69.5 | 14.5 | 75 | 0 | 5 | 0 | 0 | 60 | 20 | 10 | 10 | Bridge crossing |
| 4 | Channelized | 2 | 240 | 24 | 50 | 5 | 10 | 0 | 0 | 60 | 25 | 10 | 5 | |
| 5 | Channelized | 2 | 287.5 | 16 | 20 | 5 | 15 | 0 | 0 | 15 | 60 | 20 | 5 | Bridge |
| 6 | Channelized | 2 | 328 | 13.5 | 90 | 5 | 15 | 0 | 0 | 15 | 45 | 30 | 10 | Boat docks |
| 7 | end M31 | 2 | 324 | 24 | 80 | 0 | 30 | 0 | 0 | 40 | 45 | 10 | 5 | Boat launch/72 Bridge |