MI/DEQ/WB-09/006

PROJECT REPORT
Project Number 08-02

Evaluating the Effects of a Dam Removal on the Morphology, Habitat, Aquatic Invertebrates, and Temperature, of the Iron River (Iron County, Michigan)

Iron River looking upstream from Wild River Road (June 2008)

Prepared for:
Michigan Department of Environmental Quality
Water Bureau (MDEQ-WB)
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Contact: Dean B. Premo, Ph.D., President
and
Great Lakes Environmental Center (Prime Contractor)
Contract number: 071B1001643

Date: March 24, 2009

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SUMMARY

The Iron River is one of the most productive native brook trout streams in Michigan. Just downstream from the South Branch-North Branch confluence, the Iron River was once blocked by a historic logging dam that was removed in 1976 when the Wild River Road Bridge was replaced with a 16 foot wide half arch culvert. A simple wood dam was then constructed at the upstream end of the new culvert, re-flooding part of the old impoundment. The removal of this simple wood dam in 2005 is the main subject of the current study.

Stream studies were conducted prior to removal of the wood dam including: (1) detailed longitudinal and cross sectional morphology measurements of the impounded area in 2005; (2) stream temperature monitoring in 1999-2000; (3) aquatic macroinvertebrate assessments in 2000; (4) physical habitat measurements in 1987 and (5) archived aerial photography from 1939-2000. This study was a team effort by the MDEQ-WB and White Water Associates, Inc. to assess the condition of the free-flowing Iron River in 2008 after dam removal and compare this to the available pre-dam removal information.

Removal of the wood dam now allows brook trout to access upstream spawning gravel. Aerial photographs show that since dam removal the formerly impounded area of the Iron River is returning to a more natural width and sandbars and small islands are forming. Stream morphology studies show that in the former impounded area, wetted stream width has been reduced by 29% and down-cutting has lowered the formerly impounded stream channel by an average of about 1.2 feet. This mobilized about 4,400 tons of sediment. Nevertheless, width and bottom texture were unchanged in 2008 compared to 1987, downstream of the former impoundment, and depths may even be slightly greater. The reach upstream of the former impoundment was deeper and had a coarser substrate in 2008 (after dam removal) compared to 1987 (before dam removal). This suggests that improvement from the 2005 dam removal extended further upstream than expected. However, channel depth upstream of the impoundment may have also been affected by pipeline construction activities between 1987 and 2005. Aerial photographs show that the impoundment surface area was unchanged between 1939 and 2005 suggesting that the improvement in bottom texture was likely caused by the 2005 dam removal and not from continuing improvement from the 1976 dam removal.

Benthic macroinvertebrate community condition was rated as “excellent” or “acceptable” at all four sites measured which included sites upstream, downstream and within the former impoundment. Habitat was rated “excellent” in the 3 sites outside of the former impoundment and “good” (slightly impaired) within the former impoundment.

Daily average water temperature did not change much after dam removal but the diurnal temperature variation increased by almost 5^{o} C.

INTRODUCTION

The Iron River emanates from two branches in southwest Iron County, Michigan. The South Branch flows north from Lake Ottawa for three miles to the point where it joins the North Branch. The North Branch starts east of the community of Beechwood and flows about three miles to its confluence with the South Branch. From that point, the Iron River flows southeast for about five miles to the City of Iron River. Passing through the City, it continues southeast for about seven miles to where it empties into the Brule River (the Michigan-Wisconsin boundary). The Iron River is one of the most productive native brook trout streams in Michigan even though it has been subject to a variety of severe human-caused impacts for more than a century.

Just downstream from the South Branch-North Branch confluence, the Iron River is crossed by Wild River Road. A large culvert forms the crossing. For many years, a simple wooden dam was located at the upstream end of the culvert. This impounded water up to the confluence of the South Branch-North Branch confluence and beyond. The Iron River in the vicinity of the Wild River Road dam has a gradient of about 4.1 feet per mile. This dam (and its impoundment) had potential deleterious impacts on the Iron River and was removed in 2005.

Several stream studies were conducted on the Iron River in the vicinity of the Wild River Road Dam prior to the removal of the dam. In 2004, just prior to the dam's removal, detailed longitudinal and cross sectional morphology measurements of the impounded area were obtained. Stream temperature studies and aquatic insect assessments were conducted prior to the dam's removal. In 1994, the Michigan Department of Natural Resources (MDNR) completed a report on a variety of physical and habitat measurements collected on the Iron River, with some measurements were taken in the vicinity of Wild River Road Dam (Wagner et al. 1994). The data available through these sources provide insight into the Iron River in the impounded condition. Three years have passed since the removal of the dam and the Michigan Department of Environmental Quality (MDEQ)-Water Bureau (WB) saw this as an opportunity to assess the condition of the free-flowing Iron River and compare this to the available historic information.

In 2008 (spring, summer, and fall) field work was carried out on the Iron River to collect comparable data to pre-dam removal information. This work was a team effort including the MDEQ-WB and White Water Associates, Inc. (an independent environmental contractor).

This report is organized as five sections: Introduction, Background, Methods, Results and Discussion, and Literature Cited. Three appendices augment the report each containing photographs, figures, and tables respectively. Where convenient, exhibits are contained within the report narrative.

BACKGROUND

In this section, we describe the study area on the Iron River, the history of the site with respect to impoundment, and the process of removing the wooden dam at the Wild River Road crossing.

Study Area

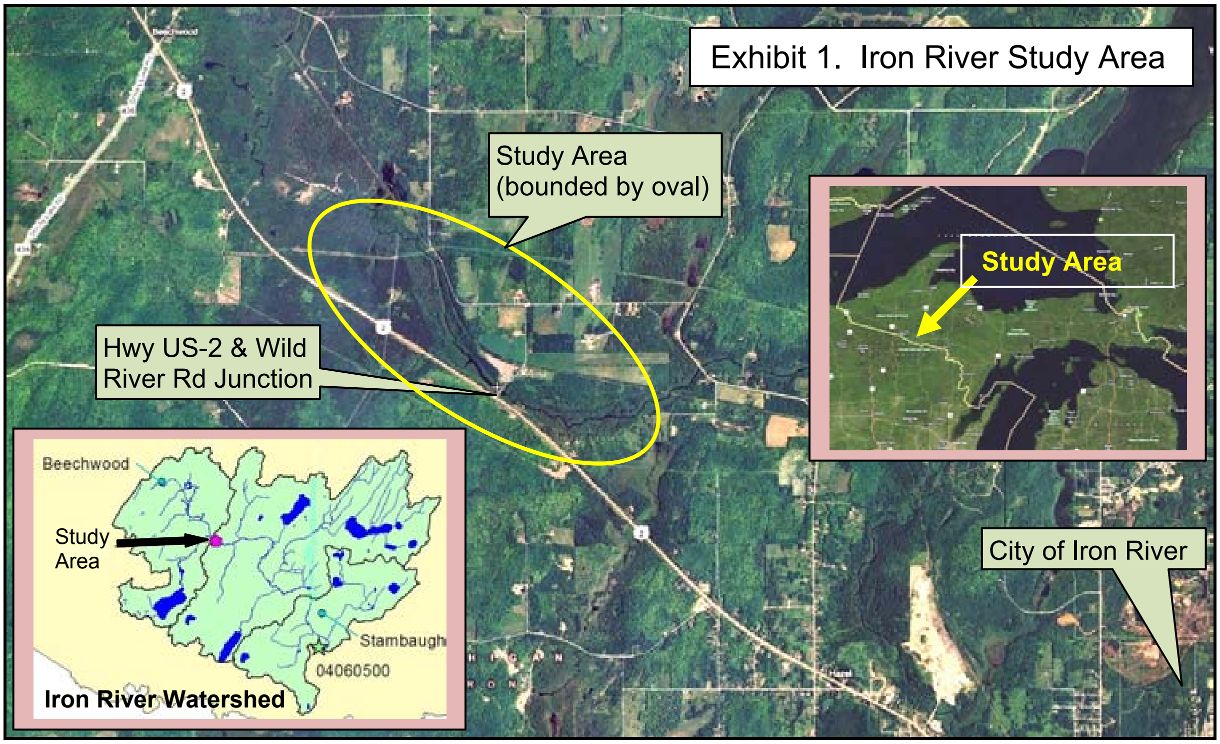
The study landscape is in western Iron County in Michigan's Upper Peninsula. The Iron River is part of the headwaters of the Menominee River watershed. Roughly 6,000 people, about 46% of Iron County's population, reside in the Iron River watershed. Most are concentrated within the Cities of Iron River and Caspian through which the Iron River passes. Land use for the Iron River watershed is distributed as 57% forested 12% agricultural, 7% wetland, 16% urban, and 8% various other classifications. There are approximately forty miles of streams that constitute the major flowing water systems in the Iron River watershed, including South Branch Iron River, Autio Creek, Holmes Creek, North Branch Iron River, Iron Lake Creek, Baker Creek, Nash Creek, Sunset Creek, Stanley Creek, and the Iron River. Along with the streams, the watershed contains a number of lakes including Bates Lake, Bennan Lake, Ice Lake, Iron Lake, Lake Nine, Lake Fifteen, Lake Sixteen, Lake Ottawa, Snipe Lake, Stanley Lake, Sunset Lake, and Wildwood Lake.[1]

Over twelve miles of the Iron River is classified as *Blue Ribbon Trout Water* by the MDNR. It supports a healthy population of naturally reproducing native brook trout. The conditions in the Iron River are ideal for brook trout. The Iron River's reputation for a strong and abundant brook trout population is well known. In fact, the MDNR has used brook trout from the Iron River as brood stock in the Department's hatchery program.

The Iron River Watershed Council (organized in 1997) is a very active group of volunteers that work to restore and maintain a healthy Iron River. Many projects have been carried out or overseen by the Council including acid mine drainage mitigation, storm water treatment, gully stabilization, agricultural buffers, improved road crossing, watershed study, development of the Iron River Watershed Comprehensive Management Plan, riparian restoration projects, river clean-up, education, and development of the Apple Blossom Trail (a three-mile long trail for walkers and bikers along the Iron River between the cities of Iron River and Caspian).

[1] *This information comes from Iron River Watershed News, a publication of The Iron River Watershed Council.*

The study area on the Iron River is located in Sections 17 and 18 T.43N-R.35.W (Iron River Township). Exhibit 1 provides an aerial view of this area. The area of actual study varies slightly with each of the several study tasks.



The stream channel morphology aspect of this study repeated a 2004 stream morphology survey conducted by Tom Berndt (Natural Resources Conservation Service) and Jim Bond (Iron River Watershed Manager). This work focused specifically on the Wild River Road dam and impoundment. The effort included a longitudinal survey of the river from the Wild River Road culvert upstream for about 900 feet. Exhibit 2 shows the Iron River in the vicinity of the Wild River Road and the area of the stream channel morphology study.

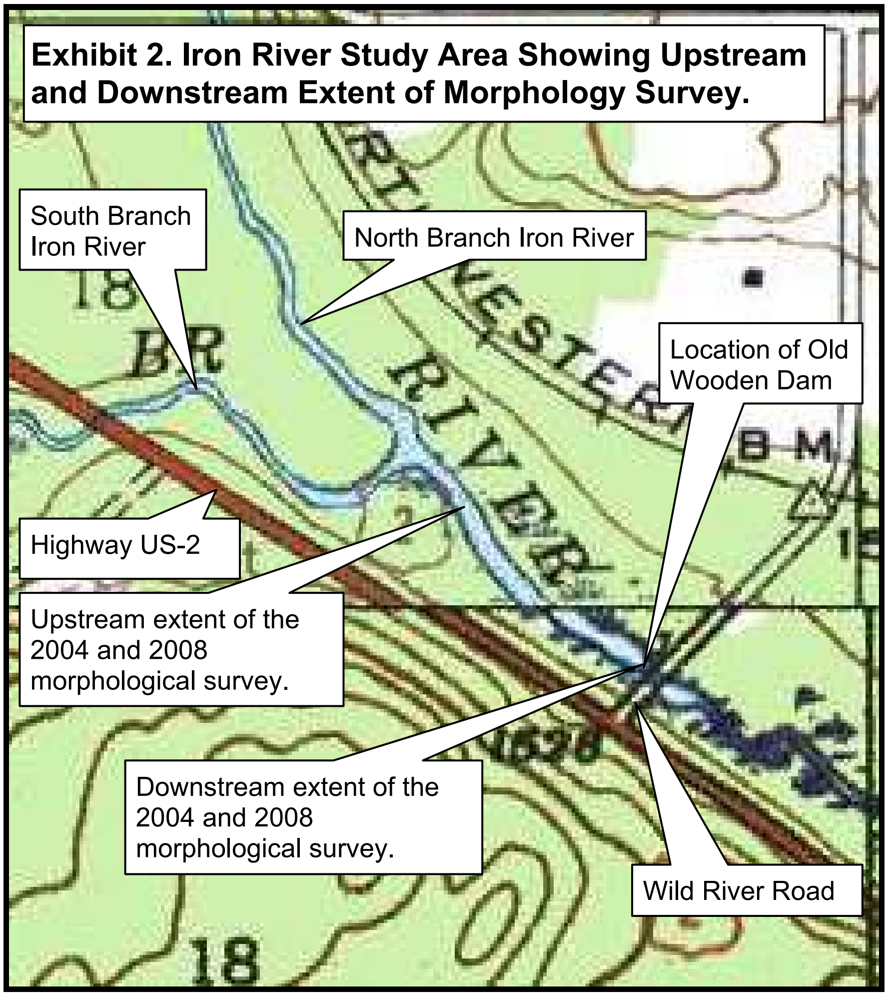
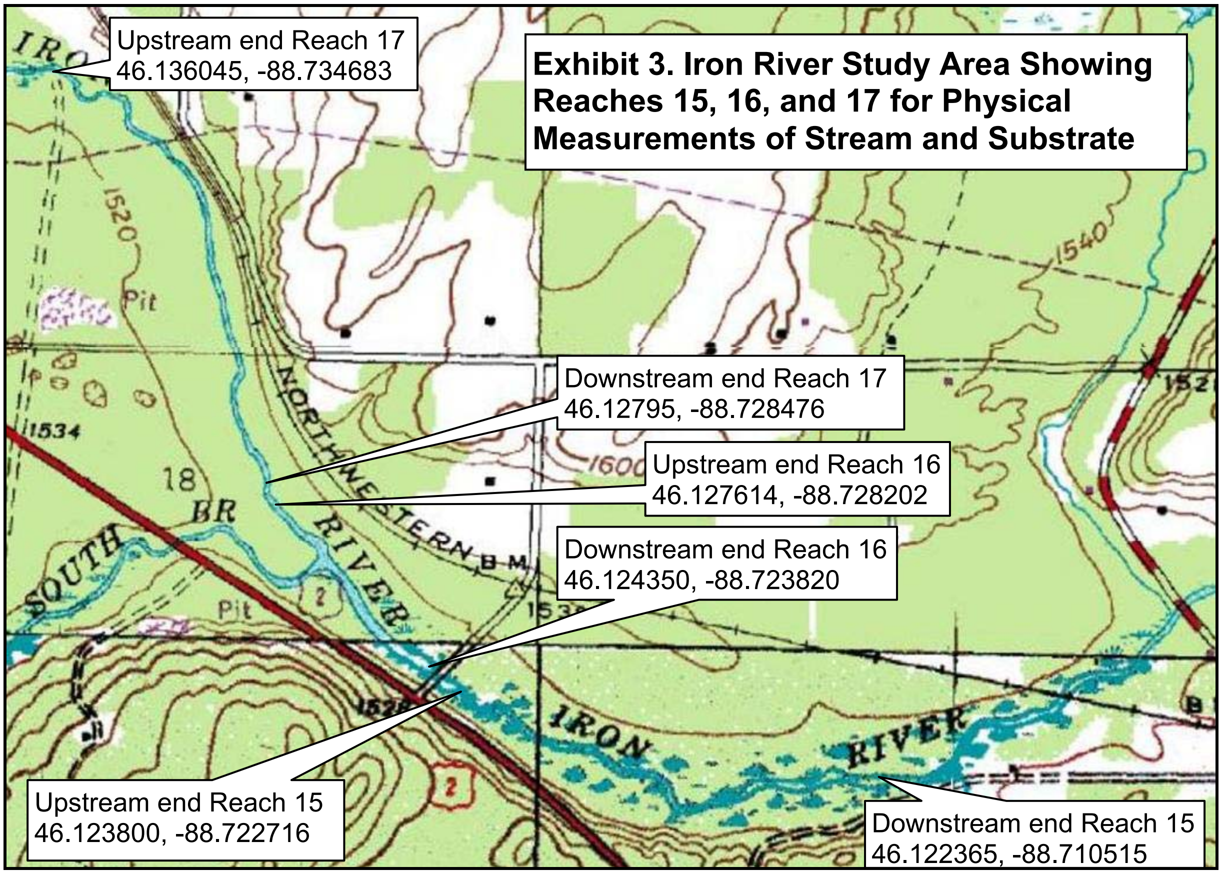
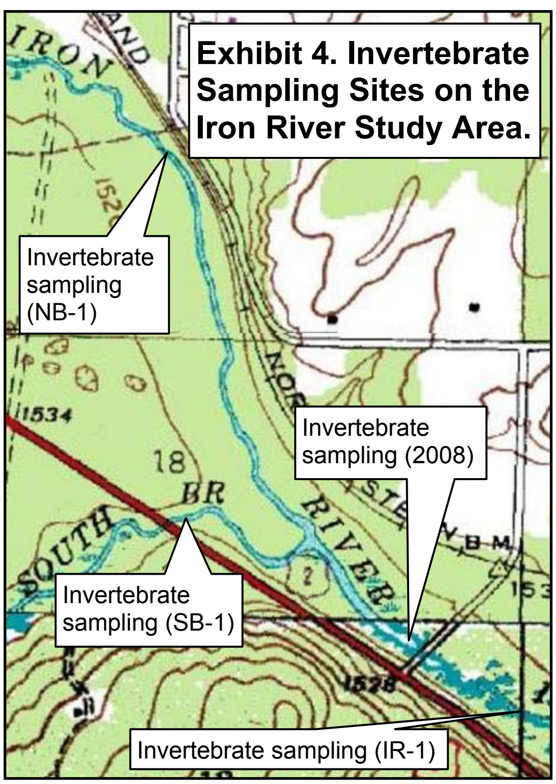


Exhibit 2. Iron River Study Area Showing Upstream and Downstream Extent of Morphology Survey.

We also repeated physical measurements of width, depth, substrate composition that were made by the MDNR on the Iron River in the late 1980s (Wagner et al. 1994). Three river reaches were examined that correspond to Reaches 15, 16, and 17 of the MDNR study except for minor modifications that allowed more specific isolation of the old impounded area. Reach 15 is downstream of the dam and is 0.65 miles long. It corresponds to Reach 15 and part of Reach 16 in the MDNR study. Reach 16 is 0.3 mile long and covers that portion of the MDNR Reach 16 that was formerly impounded. This reach's downstream point was two meters upstream of the upstream end of the Wild River Road culvert tube. Reach 17 is upstream of the formerly impounded area and is 0.625 miles long. It entirely corresponds to the MDNR Reach 17. Exhibit 3 illustrates the locations of these three stream reaches.





In 2000 and 2008, macroinvertebrates and habitat were sampled at three locations near the Wild River Road crossing. In 2008, a fourth site was sampled. This site was formerly within the impoundment prior to dam removal. These sites are shown on Exhibit 4.

For the temperature study, data was collected at two locations: (1) Iron River upstream of Wild River Road and (2) Middle Branch of the Ontonagon River upstream of Bond Falls Flowage. The Ontonagon River site served as a control site and was at the crossing of USFS 172 (Sec. 29 T46N, R38W, Ontonagon Co.). Both locations are shown on Exhibit 5 and more accurate locations are shown on individual maps (Exhibits 6 and 7).

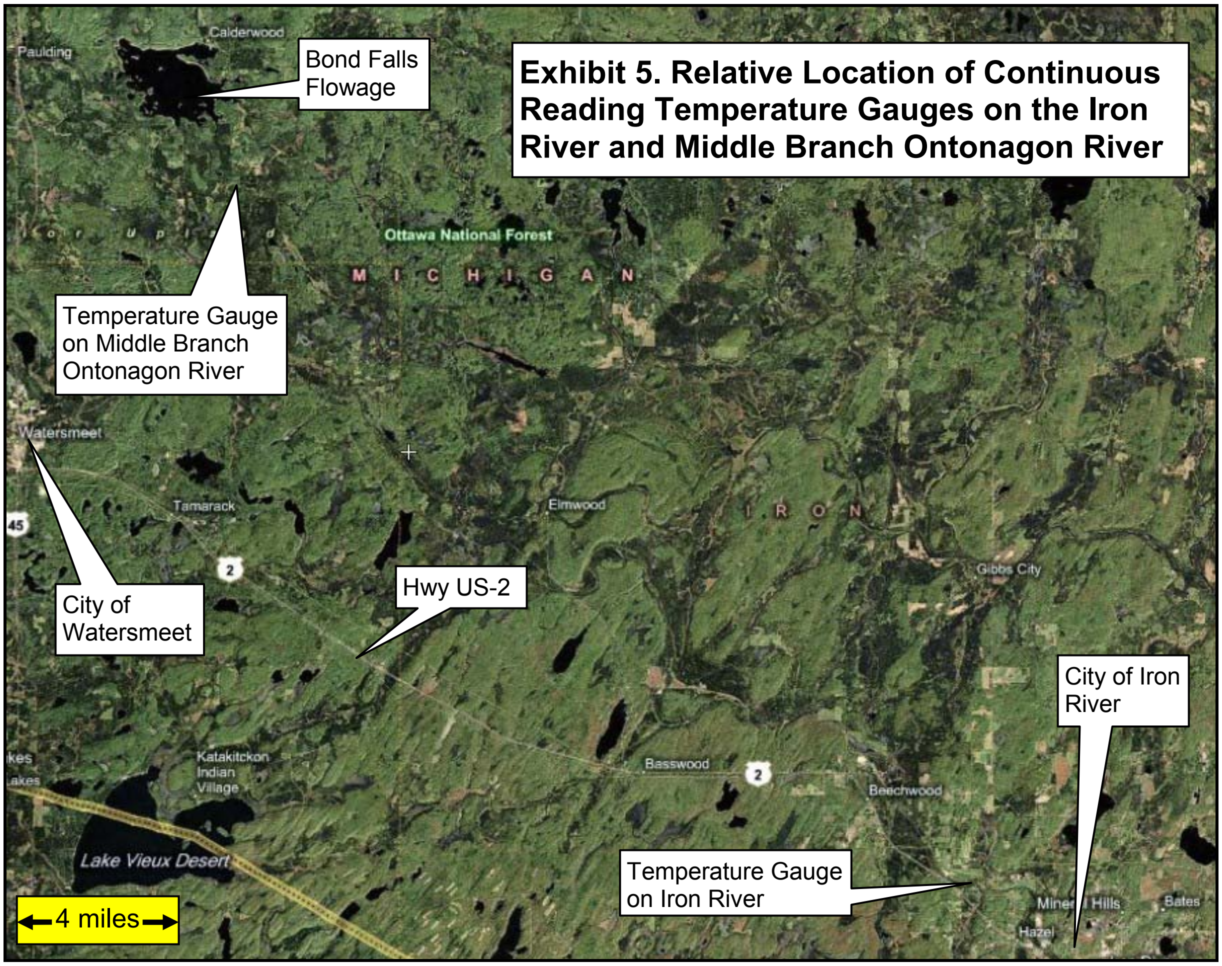


Exhibit 5. Relative Location of Continuous Reading Temperature Gauges on the Iron River and Middle Branch Ontonagon River

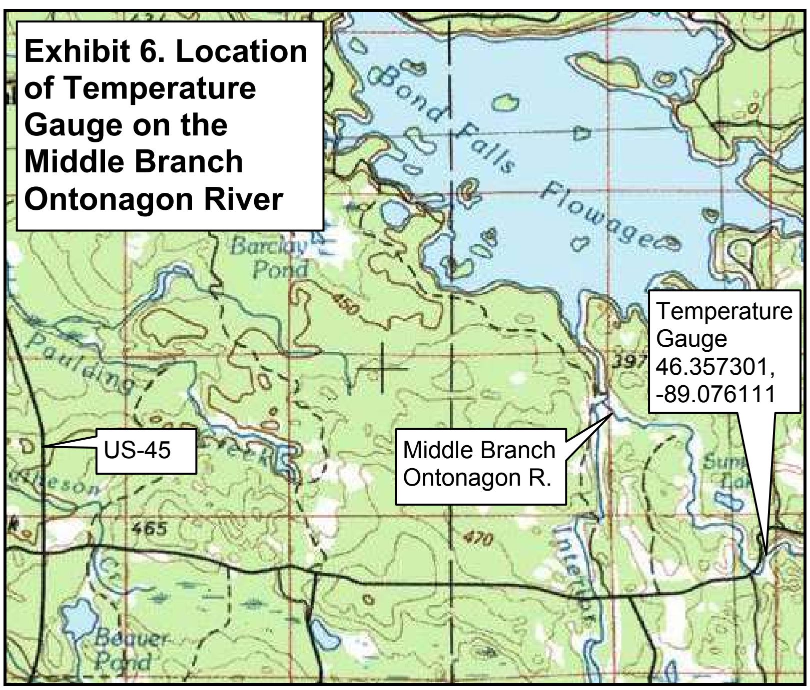


Exhibit 6. Location of Temperature Gauge on the Middle Branch Ontonagon River

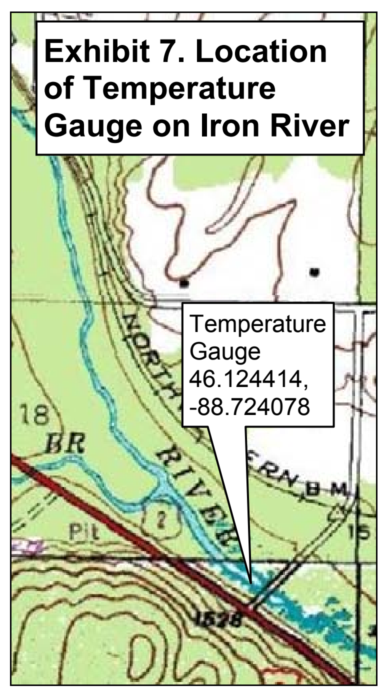


Exhibit 7. Location of Temperature Gauge on Iron River

Description of Dam Removal

A dam has been in place at the Wild River Road site for a very long time. An old "Pine Days" logging dam was removed in 1976 when the Wild River Road Bridge was replaced with a sixteen-foot-wide half arch culvert. According to Buddy Jacob (retired MDNR-Fisheries), this logging dam was located at the site of the Wild River Road and maybe extended a few feet upstream of the road. After the logging dam was removed, a simple wood dam was constructed of thick wood planks in front of the new culvert to re-flood part of the old impoundment. The removal of this simple wood dam and its impoundment in 2005 is the main subject of the current study.

Exhibit 8 shows a low-level aerial photograph of the site a couple of years prior to the removal of the wood dam. This photo is looking southeast (downstream). The location of the dam (at upstream end of culvert on Wild River Road) is indicated on the photo. In the foreground left on Exhibit 8 is the North Branch of the Iron River. Coming in from the right is the South Branch of the Iron River. The zone of influence of the dam extends a bit upstream of the coverage of this photo. As can be seen, a large pool exists immediately below Wild River Road and below this point the Iron River takes on its more typical width. This pool below Wild River Road is typical of those seen below pine logging dams where cascading pine logs and heavy flow during the river drives tended to scour out deep pools. Over the years organic sediment and other fine materials collected in the impounded area upstream of the dam. Exhibit 9 shows a canoe paddle (in 2000) pushed into the sediment beyond the blade and the thick sticky sediment on the blade after it was withdrawn.

Exhibit 8. Site of wood dam on Iron River

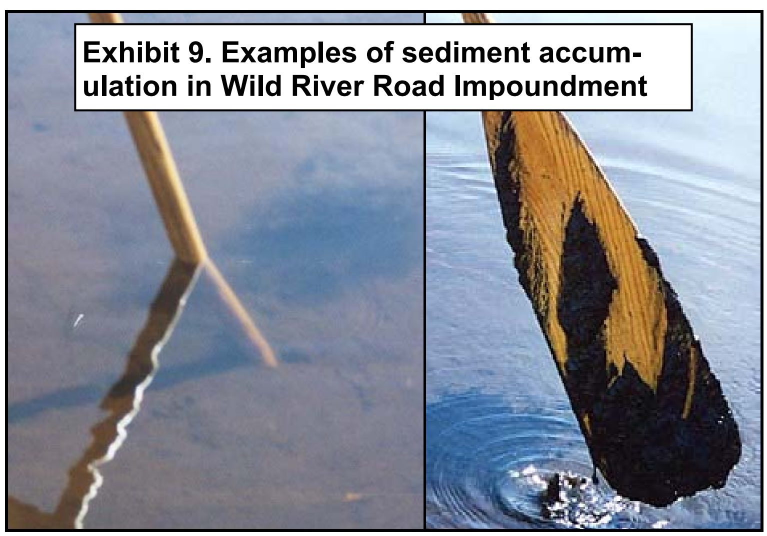


Exhibit 9. Examples of sediment accumulation in Wild River Road Impoundment

After some years of planning, discussing with the public, and obtaining the appropriate permit, the local chapter of Trout Unlimited (TU) went about removing the dam and overseeing a slow de-watering of the impoundment. This began in early summer of 2005 and continued through summer of 2006. Periodically, small portions of the upper planks were removed dropping the impoundment level by a few inches. Local TU President Dave Tiller observed that mobilization of sediment appeared to be minimal during this process and seemed to be confined to the main channel (thalweg) just a short distance in front of the dam. He saw very little sediment moved from near the stream margins. By fall of 2006, the new river banks were becoming vegetated, although still rather saturated and quaking. In addition, to natural regeneration, TU planted cedar, silver maple, and spread herbaceous wetland seeds over bare muck. Over time, more vegetation has become established and the banks are slowly becoming more stable.

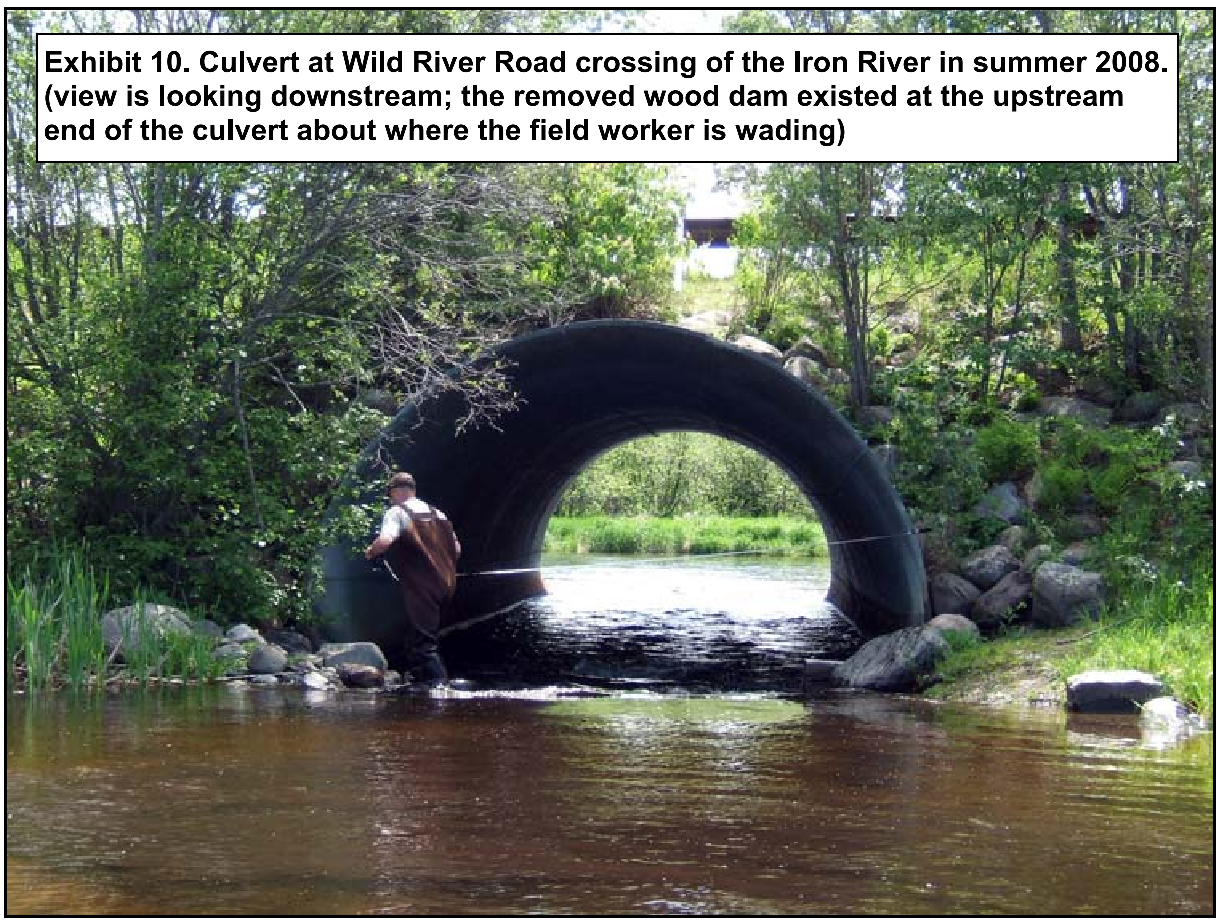


Exhibit 10. Culvert at Wild River Road crossing of the Iron River in summer 2008. (view is looking downstream; the removed wood dam existed at the upstream end of the culvert about where the field worker is wading)

METHODS

This before-and-after, upstream-downstream study examines the influence of removing the wood dam on several aspects of the Iron River ecosystem. The 2008 fieldwork was conducted from May through October. Measurements were conducted using standardized, scientifically accepted protocols. Fieldwork was carried out in accordance with the *MDEQ Quality Assurance Manual for Water, Sediment, and Biological Sampling* and project-specific work plans. Field measurements and observations were recorded on field forms, maps, and field notebook. In the case of stream temperature, data were stored electronically in continuous reading instruments. In this section, the methods are described in five subsections reflecting major project tasks: photographic documentation, stream channel morphology, physical measurements of stream and substrate, stream habitat and benthic macroinvertebrates, and temperature.

Photographic Documentation

We were able to obtain an August 15, 1939 aerial photograph (1:20,000 scale) and a May 8, 1983 aerial photograph (1:58,000 scale) for the study area from the Michigan State University aerial archive office. We obtained 1992, 1998, and 2005 aerial photography for the study area from the Michigan Geographic Data Library (Michigan Center for Geographic Information). We obtained an aerial photograph from Google Maps™ for the study area subsequent to dam removal. Through these various sources several views were available of the vicinity of the Wild River Road crossing of the Iron River before and after the removal of the wood dam. A single low level aerial photograph was available for the site taken just prior to the dam removal (Exhibit 8). No aerial photography was contracted for this project as available photographs depicted the changes. Other than the two photos of sediment in Exhibit 9, no ground level photographs were available for the impoundment before dam removal or of the dam removal process.

Stream Channel Morphology

Working upstream of the former Wild River Road dam, a longitudinal profile and eleven cross sections were surveyed by MDEQ-WB staff on June 12 and 13, 2008. This was the same reach and cross sections surveyed on March 24, 2004 by Tom Berndt (Natural Resources

Conservation Service) prior to dam removal. The 2004 survey was performed optically with a transit and survey rod. Elevations, distances and angles were recorded for each survey station and the x/y positions were determined through trigonometry. The bench mark for the 2004 survey was a paint mark on the road. The top of the upstream end of the Wild River Road culvert served as a second bench mark in 2004. The 2004 survey work did not include loop closure as verification. Eleven transects were surveyed from water's edge to water's edge in 2004 and were not monumented. The elevation of the former stream bed prior to impoundment was determined for each surveyed point in the transects by pushing the survey rod into the sediment as far as possible and then making a foresight. Sediment depth was also recorded at each survey point. The elevation of the water/sediment interface (top of sediment) was calculated by adding the sediment depth to the elevation of the former stream bed as determined from the foresight.

For the 2008 survey, the longitudinal profile was surveyed with a cloth tape placed along the stream to determine longitudinal distances. Thalweg and water surface elevations were determined at each transect and supplemental readings were made along the thalweg between transects. Transects corresponding to the 2004 stations were marked with 4 foot lengths of metal re-rod on the left bank. These locations are believed to vary by no more than about 10 feet longitudinally from the transect locations surveyed in 2004. A hand held lensatic compass graduated in increments of 2 degrees was used to record the bearing (azimuth) from the left bank along the transect to the right bank. During the survey, bearings were recorded relative to magnetic north. The location of the 2004 water's edge relative to the re-rod placed in 2008 could not be determined with the survey equipment used in 2008. Therefore, for graphing of cross sections, the location of the left water edge in 2004 relative to the left transect end as marked in 2008 was determined using best professional judgment and by applying the rule that the 2004 wetted width was within the 2008 channel width defined by an elevation of 88.77 feet.

For all transects in the 2008 survey, the foresights were taken with the rod on the stream bottom and not pushed into the sediment as in the 2004 survey. All elevations were determined with a laser level. The primary bench mark used for the 2008 survey was the top of the upstream end of the Wild River Rd. culvert (corresponds to the secondary bench mark in the 2004 survey). The paint mark in the road (primary bench mark in 2004) was no longer visible in 2008 but was remarked by Tom Berndt on June 11, 2008 from memory. This mark was used as a secondary bench mark in 2008 and served as confirmation that the 2004 and 2008 surveys could be converted to a common datum (in this report, the 2004 datum established by Tom Berndt). Since transects were not evenly spaced along the stream, each transect represented a length of stream that was equal to half the distance between the next upstream and next downstream transect.

The cross sectional area of the channel at a transect was calculated with equation 1. The average depth at a transect was calculated as the cross sectional area divided by the width.

Equation 1: $$A = \sum_{x=1}^{n} (0.5 * (L_{(x+1)} - L_{(x-1)}) * D)$$

Where: A = cross sectional area of the transect (square feet);
L_x = location of depth measurements along the cross channel transect (distance in feet from transect origin);
D = depth at the observation point L_x (feet)

The amount of sediment mobilized and transported downstream due to dam removal was calculated as the volume occupied by the channel at an elevation of 88.77 feet in 2008, minus the volume occupied by the channel at an elevation of 88.77 feet in 2004. This elevation (88.77 feet) was the water surface elevation during the 2004 survey prior to dam removal. For the 2004 survey this volume was equivalent to that actual water volume. Volume occupied by the channel was as calculated using equation 2:

Equation 2: $$V = \sum_{y=1}^{n} (A_y * 0.5 * (P_{(y+1)} - P_{(y-1)}))$$

Where: V = volume occupied by the channel (cubic feet);
A_y = cross sectional area at transect y (square ft);
P = distance measured along the channel from the culvert (former dam location) to transect y

Physical Measurements of Stream and Substrate

For this aspect of the study White Water staff repeated aspects of an earlier MDNR study (Wagner et al. 1994). Work was conducted in consultation with the MDNR (including Karen Koval, field technician in the original study) and MDEQ. Using MDNR methods, White Water staff measured the three reaches previously described in the study area subsection. Each reach was divided into 164 foot (50 m) sections. Stream width, depth, and velocity were measured at the upstream end of each 164 foot section. Stream depth and velocity were measured at the cross section middle and at one-sixth of the stream width measurement from each shore. Velocity was measured at 0.6 of stream depth with a FP101 Global Flow Probe (MDNR did not record velocity in these reaches). It should be noted that, although we slightly modified the extent of two of the three original MDNR study reaches (Reaches 15 and 16, as previously described), we retained the MDNR nomenclature of the three study reaches (15, 16, and 17). Nevertheless, all comparisons made between the MDNR study and the present study are made between identical stream reaches comprised of corresponding sets of 164 foot stream sections. This was possible because we had access to the original MDNR data (which was not reported in full in the MDNR report).

In each section, percentages of substrate types were classified using the MDNR methodology (and methods references cited therein). This involved making a visual estimate of substrate texture by scoring the percentage occurrence of six substrate types: (1) boulder (>256 mm); (2) cobble (256-64 mm); (3) pebble (64-4 mm); (4) granular (2-4 mm); (5) sand-coarse (2 to 0.25mm), (6) sand-fine (0.25 to 0.062 mm sand); (7) silt (<0.062), and (8) detritus.

The ends of each of the three reaches were marked with a handheld global positioning system (GPS) and latitude/longitude coordinates were recorded. The total reach length was measured with a forester's hip-chain (accurate to ±5 feet per mile). Stream sinuosity was calculated by dividing total reach length by valley length (as determined from straight line distance between starting and ending points using the GPS coordinates).

Stream Habitat and Benthic Macroinvertebrates

In 2000, macroinvertebrates and habitat were characterized at three locations. One site was on the North Branch of the Iron River within the upper portion of Reach 17. The second site was on the South Branch of the Iron River just downstream of US-2. The third site was located several hundred feet downstream of Wild River Road. Exhibit 4 shows these locations. Iron River Watershed manager Jim Bond applied U.S. EPA 1989 Rapid Bioassessment Protocols for Use in Stream and Rivers: Benthic Macroinvertebrates and Fish at the three stream locations. In 2008, MDEQ staff used GLEAS Procedure #51 (MDEQ 2002) at the same three sites to determine if the macroinvertebrate community is changing over time. In addition, the MDEQ added a fourth macroinvertebrate sampling site (Exhibit 4) in the previously impounded area upstream of Wild River Road.

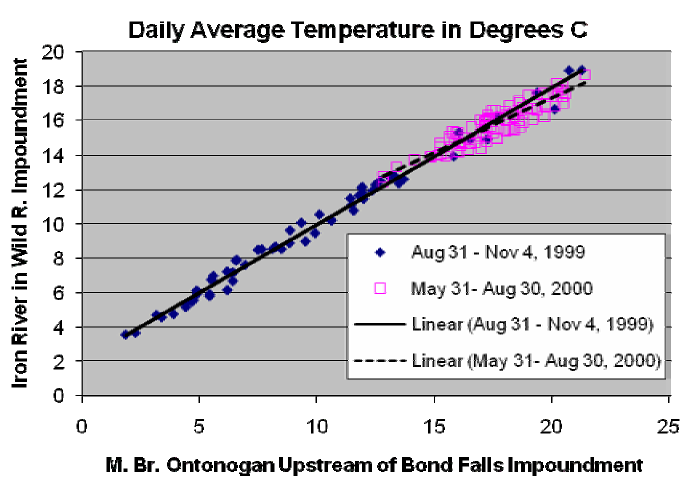
Water Temperature

In 1999 (September-November) and 2000 (May-August) White Water Associates collected continuous water temperature data (using *Ryan TempMentor*) for a location in the impounded area immediately upstream of the old dam at Wild River Road. MDEQ staff located a water temperature data set for the Middle Br. of the Ontonagon River that was taken over the same period of time. The Middle Br. Ontonagon River data were collected by the US Forest Service to assess impacts from the Bond Falls Hydropower Project. John Suppnick (MDEQ) compared the Middle Br. Ontonagon River and the Iron River temperature data sets and created the regression graph shown in Exhibit 11. These data sets were obtained before the Wild River Dam was removed. In the 2008 study, White Water repeated continuous reading temperature monitoring at both the Middle Branch Ontonagon River site and the Iron River station in the former impoundment. Using the Middle Branch Ontonagon River station as a control, the temperature regimen of the post-impoundment Iron River can be assessed. A cooling effect from dam removal would be indicated by a lowering of the slope or intercept of the regression line.

In 2008, White Water deployed Onset HOBO® Water Temp Pro v2 Temperature loggers for the period 5/31-10/31, 2008. Temperature was recorded every 60 minutes. Quality control checks of the temperature loggers were performed in the laboratory pre- and post-deployment, in the field at deployment, on two mid-season checks (mid-July and mid-September) and at collection. Pre- and post-deployment laboratory quality checks were performed to ensure each temperature logger was reading within 0.5°C of a National Institute of Standards and Technology Reference Thermometer. Readings were taken at four different temperatures over the range of temperatures expected (in pre-deployment) and over the range of temperatures recorded (in post-deployment). Temperature data were downloaded from units during mid-study checks.

Exhibit 11. Temperature Analysis for Middle Br. Ontonagon and Iron Rivers.

Analysis conducted by John Suppnick (MDEQ)



RESULTS AND DISCUSSION

This section presents and discusses results of the five project components under corresponding subsections.

Photographic Documentation

A low-level aerial photo was taken by Jim Bond (Iron River Watershed Manager) in 1999 or 2000 (prior to dam removal). This image is provided as Photo 1 (Appendix A). This photo is looking southeast (downstream). Wild River Road crosses the river near the upper part of the photograph and the wood dam is located at the upstream end of culvert on Wild River Road. In the foreground left of Photo 1 is the North Branch of the Iron River. Coming in from the right is the South Branch. The dam's influence extends a bit upstream of the coverage of this photo.

Photos 2-6 are an historical series of aerial photos of the impounded area prior to dam removal. In these photos, river flow is from the lower left to the upper right. In the photos, north direction points to the left. The North Branch of the Iron River enters the photographs from the northwest; the South Branch of the Iron River enters the photos from the west. The old impoundment appears full in these photos with little change apparent in the gross morphology of the river and impoundment from 1939 through 2005. The influence of the dam up into the North and South Branches of the Iron River can be seen. This upstream influence is more dramatic when compared with Photo 7, the same view and scale as the previous photo, but clearly post dam removal (source: Google Maps). The river is narrower and small island features have emerged. The width of the South Branch of the Iron River has greatly diminished. Apparent shallower water and green aquatic vegetation can be seen in the old impoundment (Photo 7).

Stream Channel Morphology

Figure 1 shows the location of the cross sectional transects and other features of the stream morphology survey. Table 1 summarizes the morphological data from the 2004 and the 2008 surveys. The results of the longitudinal profiles for 2004 and 2008 are compared in Figure 2 and indicate that the water surface elevation has been reduced by 1.6 feet at the culvert and that the average thalweg elevation has been reduced by an average of 0.41 feet by removal of the dam.

Full restoration of the original thalweg depth would require additional down-cutting of 0.41 feet. Average water depth along the thalweg decreased from 2.5 feet to 1.3 feet after dam removal. If the original stream bottom elevation was restored without additional lowering of water surface elevation, then the average thalweg depth would increase from the current 1.3 feet to 1.7 feet. Figure 3 summarizes the change in cross sectional area of the transect between 2004 and 2008.

The transect survey results for 2004 and 2008 are presented graphically in Figures 4-14. Dam removal reduced the average wetted stream width by about 29% from 92.7 feet before removal to 66.2 feet after removal. The overall average depth in the first 800 feet of the impoundment upstream of the culvert was 1.27 feet before dam removal and 0.81 feet after.

Wetted channel widths and average depths were expected to be changed at each transect by dam removal, but can also vary with stream flow. Therefore it is important to know whether the changes in channel morphology seen between 2004 and 2008 were due to differences in stream flow at the time that the surveys were performed. No flow measurements were made in the surveyed reach during any of the survey work. However the United States Geological Survey (USGS) stream flow gage on the Brule River at US-2 (gage #4060993) and the Middle Branch Ontonagon River near Paulding (gage #4033000), can be used as regional indicators of flow conditions during the surveys. Based on drainage area correlations to the Iron River at Wild River Road, these gages predict 22cfs and 21cfs respectively on March 24, 2004, the day of the pre-dam removal survey and 25cfs and 23cfs respectively on June 12, 2008, the day when the post dam removal survey was mostly completed. The work completed on June 13, 2008 included surveys of transects 1-6 with all other post dam removal survey work completed on June 12, 2008. A heavy rain occurred between the June 12 and June 13 survey work but measurements of the water surface elevation in the survey reach indicate that the water level had increased only 0.15 feet due to the rain. This is a minimal change from June 12 water levels. Therefore all survey work in 2004 and 2008 were considered to be under comparable flow conditions and no adjustments to the data for varying flow were made.

Survey loops were closed with an error of 0.11 feet on June 12, 2008 and 0.04 feet on June 13, 2008. The 2004 survey indicated that the elevation of the paint mark in the road was 3.84 feet higher than the bench mark set on the top of culvert. The 2008 survey indicated that the paint mark was 3.66 feet higher than the bench mark on the top of culvert. This is acceptable agreement considering that the original paint mark location was relocated from memory in 2008.

For the 800 foot length of stream surveyed, we have calculated a water volume of 89,810 cubic feet during the 2004 survey. Based on the 2008 survey the volume occupied by the channel at the 2004 water elevation of 88.77 feet was 153,086 cubic feet. The difference in these two channel volumes (63,276 cubic feet) represents the volume of sediment that was mobilized and transported from the former impoundment after dam removal. Using a specific weight of 100 pounds per cubic foot produces an estimate of about 3,164 tons of sediment mobilized. This estimate is low since it does not include the upper reach of the impoundment which, according to aerial photos, appears to have extended upstream at least 1500 feet from the road. Figure 3 shows that the amount of sediment mobilization at a given transect after dam removal was higher near the culvert and diminished in an upstream direction. We used a graphical method to estimate the volume of sediment mobilized in the un-surveyed reach to be about 24,000 cubic feet. Therefore the total sediment mobilized was about 88,000 cubic feet or 4,400 tons.

No sediment load measurements have been made for the Iron River at the Wild River Road that would allow us to determine the percentage increase in sediment load due to the dam removal and sediment mobilization. Loads measured in other small streams in Michigan indicate a wide range in values from low 10s to over 100 tons of solids per square mile of drainage per year. Most values fall within the range of 20-100 tons per square mile per year. The drainage area at the Wild River Road is 23 sq. mi. so the range in expected load if the Iron River is typical would be 460 – 2,300 tons per square mile per year. Therefore, the mobilization of 4,400 tons of sediment between the survey dates of March 2005 and June 2008 represents a substantial short term increase in load for the Iron River downstream of the Wild River Road.

Field observations indicate that the sediment mobilized was predominantly fine material. The surveyors in 2004 had little difficulty pushing the survey rod over 2 feet into the sediment. Furthermore the sediment remaining in the impoundment in 2008 was predominantly fine material as evidenced by the "jello-like" flats that were found along the channel margins and the difficulty that the 2008 surveyors had walking in the former impoundment due to soft substrate.

Physical Measurements of Stream and Substrate

In the 2008 field work, we closely duplicated the position of the transects originally established in the 1987 MDNR study by carefully measuring from the known points of origin. Despite this care, it is not likely that transects are in exactly the same place and therefore a transect by transect comparison of depth or width data is not advised. Nevertheless, occasional landmarks noted in the MDNR notes were recognizable in 2008 and allowed us to record a "distance from origin" datum. We had four such opportunities for quality control checks. In Reach 17 (upstream of the impoundment), the MDNR noted a beaver dam at 1,558 feet (475 meters) from the origin. We noted an old, apparently perennial beaver dam at 1,565 feet (477 meters) (a 0.4% difference). The MDNR noted the gas pipeline crossing at 3,402 feet (1,037 meters), whereas in the 2008 study, we marked the pipeline at 3,333 feet (1,016 meters) (a 2% difference). The terminus of Reach 17 was at a foot bridge marked at 4,472 feet (1,363) meters by the MDNR and at 4,544 feet (1,385 meters) in 2008 (a 1.6% difference). Our final check was in Reach 15 (downstream of Wild River Rd.) where the MDNR noted a boulder dam at 3,281 feet (1000 meters). We noted an island and boulders at 3,327 feet (1,014 meters) that was likely the same feature (a 1.4% difference). On average, the 2008 transects were positioned ±1.4%.

The actual physical measures of width and depth and estimates of substrate type and coverage are contained in Tables 2, 3, and 4 for Reaches 17, 16, and 15, respectively. Table 5 contains stream velocities measured in 2008 for three transect positions (left, center, right).

Table 6 provides a statistical comparison of stream widths for each of the three study reaches (1987 and 2008 data are summarized). Reach 15 (downstream of Wild River Road) did not differ significantly in stream width between 1987 and 2008. The same is true for Reach 17 (upstream of the old impoundment). The stream width of the formerly impounded area (Reach 16) was significantly narrower by 18.2 feet (5.7 meters) or 26% in 2008. Looking at the 2008 data, Reach 17 has the smallest mean stream width at 33.5 feet (10.2 meters) and Reach 15 has the next smallest at 45.6 feet (13.9 meters). With a 2008 mean width of 52.5 feet (16.0 meters), Reach 16 may tend to narrow down over time and approach the width of the flanking reaches.

Table 7 presents a comparison of stream depths for each study reach before and after dam removal. Reach 15 mean depths changed very little, although showed a slight decrease overall (generally not significant at $\alpha=0.05$). This is graphically represented in Figure 15. Reach 16 mean depths for 2008 are shown in a bar graph on Figure 16. Reach 17 mean depth changed very little, but showed a slight increase overall (generally not significant at $\alpha=0.05$). These data are graphically represented in Figure 17. In the section of Reach 17 that was about 300 feet downstream of the pipeline crossing and about 600 feet upstream of the crossing, the 2008 depths were greater than those recorded in 1987. Bill Ziegler (MDNR Fisheries) confirmed that a sediment trap was installed just downstream of the pipeline crossing during the early 1990s when additional pipeline was installed. He postulated that the pipeline work may have also elevated the upstream water level. This may account for the greater depths observed in 2008 in this section. The overall mean depth for Reach 17 was 1.07 feet (32.6 cm; ±3.8 cm 95% confidence interval) in 1987 and 1.18 feet (36.1 cm; ±6.0 cm 95% confidence interval) in 2008. The equivalent statistics for Reach 15 were 1.58 feet (48.1 cm; ±5.5 cm 95% confidence interval) in 1987 and 1.41 feet (42.9 cm; ±4.4 cm 95% confidence interval) in 2008.

An actual measure of thalweg depth was not obtained in 2008, we *post hoc* estimated thalweg depth for each reach as the deepest of the three depth measures at each 164 foot transect. These were averaged for each study reach using 2008 data and the results are presented in Table 8. The thalweg depth values derived in this way underestimate the actual thalweg depth. The 2008 average thalweg depths for each of the three study reaches differ significantly (at α=0.05) with Reach 16 (the formerly impounded reach) being the shallowest.

At 0.65 feet (19.7 cm), the average 2008 depth of Reach 16 is significantly shallower (at α=0.05) than either Reach 17 (1.18 feet) or Reach 15 (1.41 feet). Estimated thalweg depths (Table 8) in the formerly impounded reach are also shallower. The width of the formerly impounded area decreased since dam removal (from an average of 71.2 feet to 52.5 feet), but it remains significantly wider (α=0.05) than upstream (33.5 ft) and downstream reaches (45.6 ft).

Any comparisons between widths and depths measured before and after dam removal must consider whether the stream flows were comparable when measurements were made. The USGS gauges on the Middle Br. of the Ontonagon River at Paulding (Gauge #4033000) and Brule River at US-2 (Gauge #4060993) were used as indicators of regional flow conditions to predict daily flows on the Iron River at the Wild River Road crossing with drainage area correlations to these gauges for the days when field measurements were made. The predicted flows were 33 cfs and 20 cfs for July 7, 1987 and 12 cfs and 15 cfs for July 25, 2008 using the Middle Br. Ontonagon and Brule River gauges, respectively. Both gauges indicate lower flow during post dam removal measurements in 2008. Lower flows of this magnitude would produce shallower depths but probably have minimal effect on widths. At the gauges, the difference in depth for these two days would be 0.8 feet at the Middle Br. Ontonagon River and 0.20 feet at the Brule River gauge site based on an analysis of stage-discharge curves from the gauge sites. Because of this substantial difference in flow between the surveys and the potential impact on depths, we did additional analysis to estimate the potential impact of this flow difference on stream depth in the Iron River for the reach downstream of Wild River Road. We estimated flow as the average of the values predicted from the two gauges and then used Manning's equation (Grant 1989) to estimate depth differences at these flow rates. The wetted perimeter, hydraulic radius, and cross sectional area were estimated from the channel survey data. Channel slope was estimated from USGS topographical maps. The roughness coefficient was calibrated to match predicted flow. Based on this analysis, the average depth in 2008 is expected to be about three-quarters foot less than in 1987 due to reduced stream flow. Since this is greater than the depth reduction measured between 1987 and 2008 (0.17 feet), it is likely that, at equivalent flow conditions, average depth is either unchanged or has increased downstream of the dam between 1987 and 2008.

Stream velocities were not recorded in 1987. Mean stream velocities for each of the three 2008 study reaches are in Table 9. The stream velocities over the three reaches are similar. If the left, center, and right mean values are averaged for Reach 15 (0.38 fps), Reach 16 (0.33 fps), and Reach 17 (0.26 fps), differences are small. Even without data from before dam removal, it almost certain that stream velocity of Reach 16 has increased because depths and widths have reduced.

A summary of percent cover of the eight substrate types (boulder, cobble, pebble, granular, course sand, fine sand, silt, and detritus) are presented in Figures 18, 19, and 20. In Reach 15, the coarser stream substrate categories did not show dramatic change before and after dam removal. At the finer end of the scale, there was a large decrease in fine sand, but a corresponding increase in silt. Both are fine materials and probably represent similar (poor) habitat characteristics with regard to aquatic macroinvertebrates and fish. Detritus was not observed by the 1987 study but was present in 2008 as over 10% of the substrate cover. It is possible that silt and detritus increase noted in 2008 was released from the removal of the wood dam. It is also possible that the 1987 study was measuring a dynamic period in the streambed since just a decade earlier (1976) a larger and older dam was removed thus releasing materials to the downstream area of Reach 15.

Reach 16 substrate (Figure 19) was characterized entirely as "mud" in 1987. In Figure 19 we estimated that "mud" represented 50% cover by silt and 50% cover detritus. The substrate was still dominated by fine materials at the time of the 2008 study.

Reach 17 substrate (Figure 20) showed the most change in the substrate composition. There was an increase in all coarse material categories (especially evident in pebble and granular categories). There was a corresponding decrease in finer materials (with the greatest reduction in the "fine sand" category). This apparent habitat improvement might be due to the 2005 dam removal or it might be continuing improvement from the 1976 removal of the larger logging dam. Aerial photographs suggest that this dam likely had a greater upstream zone of impact than the wood dam. The MDNR 1987 study (ten years after the logging dam removal) may have been conducted before complete recovery from the 1976 dam removal.

To further probe the dynamics of Reach 17, we split the reach into two sections to examine the substrate. The "downstream section" was comprised of the 820 foot (250 m) through the 2,461 foot (750 m) transects (as measured from the South Branch of the Iron River). The "upstream section" was comprised of the 2,625 foot (800 m) through the 4,429 foot (1,350 m) transects. Figure 21 graphically displays the 2008 data. In 2008 the upstream and downstream sections were fairly similar with the upstream section being slightly coarser than the downstream section. The 1987 data (Figure 22) show that the upstream section was relatively coarser than the downstream section (that is, the downstream section was more dominated by fine materials). A clearer picture emerges when the eight substrate categories are combined into two: coarse and fine. As seen in Figure 23, both the upstream and downstream sections of the reach are improved in 2008 relative to 1987 with coarse materials dominating in both sections. The downstream section has made the most dramatic improvement since 1987 suggesting that removing the wood dam in the last few years has benefitted this section (in other words, the impoundment removed in 2005 apparently extended into the downstream half of Reach 17). In studying the dynamics of dam removal on streams, Burroughs (2007) found that on average, substrate appears to begin coarsening slightly in the former impoundment immediately following dam removal, while the downstream zone shows very little substrate coarsening. The oldest dam removal cases Burroughs studied (>30 years post-removal) showed median substrate sizes in both former impoundments and downstream zones that were larger than those of the reference zones, indicating that restoration of substrate coarseness is possible following dam removal. His data suggests, as we also apparently found, that coarsening of the substrate in the former impoundment continues for more than ten years after dam removal.

Stream sinuosity was calculated for each of the three study reaches by dividing "valley length" by the actual reach length as measured along the stream channel. All three reaches are fairly straight with Reach 17 and Reach 15 sinuosity being very similar (1.14 and 1.15, respectively). Reach 16 (formerly impounded) sinuosity approached one (1.01). In studies of the effects of dam removal on streams, Burroughs (2007) found that the sinuosity of the river channel that develops in a former impoundment is established soon after removal and then remains stable.

Stream Habitat and Benthic Macroinvertebrates

Tables 10, 11, and 12 provide the results of stream habitat and benthic macroinvertebrate assessment carried out by MDEQ-WB staff in 2008. Approximately 300 organisms were identified at each site. All four sites sampled rated "excellent" or "acceptable" in terms of macroinvertebrate community. Three of the four sites rate as "excellent" (non-impaired) in habitat. The formerly impounded area upstream of Wild River Road rated as "good" (slightly impaired). The following paragraphs provide further description of each of the sampling sites.

The South Branch Iron River at the US-2 crossing (Photo 8) had the highest habitat rating (188 of 220) with near perfect scores for most habitat metrics. The variety of hard substrates (boulder, cobble, gravel, and woody debris) and flows allow for full macroinvertebrate colonization. Macroinvertebrate sampling results indicated that this site scored "Excellent" with a very high total score of + 7. More than 50% of the taxa present were mayflies and caddisflies.

The North Br. of the Iron River at the pipeline crossing (Photo 9) had a habitat rating of "excellent" (total score of 168). This section was comprised primarily of a Pool/Glide stream type that was rather uniform in depth and flow velocity. The area upstream of the pipeline crossing may have been modified in the past as it appeared to be straightened. A great variety of macroinvertebrate taxa (42 types) were collected at this station including large numbers of physid snails, water boatmen, midges, burrowing mayflies, brachycentrid and limnephilid caddisflies. Most of these taxa are associated with fine gravel and sand, plant beds or stream edge areas.

The Iron River just upstream of Wild River Road (the old impoundment area) is depicted in Photo 10. It was lacking in a number of habitat metrics including epifaunal substrate and pool substrate composition due to sediment deposition caused by the old dam structure. In spite of these habitat impairments, this site still had a habitat metric score of "Good" and a macroinvertebrate community rating of "acceptable" with a +2 score. We encountered 31 types of macroinvertebrates including large numbers of baetid mayflies, midges, physid snails, fingernail clams, water boatmen, scuds and worms. Many of the taxa collected were mainly associated with aquatic plant beds, areas of woody debris and fine sediment common to this site.

The Iron River downstream of Wild River Road (coinciding with the upstream portion of Reach 15) is depicted in Photo 11. It showed improvements in the in-stream habitat with an overall rating of "Excellent." This stream segment had improved habitat metric scores in 10 of 14 categories (Table 12) compared to sampling station in the old impounded area. The macroinvertebrate community remained similar in total number of taxa, but increased numbers of mayfly and caddisfly families were present thus increasing the total overall macroinvertebrate score to a +3 ("Acceptable"). The most common macroinvertebrate taxa encountered were scuds, baetid mayflies, midges, and hydropsychid and brachycentrid caddisflies.

In 2000, qualitative assessments of invertebrates and habitat were conducted at three of the four stations sampled by the MDEQ-WB in 2008. These sites included the North Branch of the Iron River at the pipeline crossing, the South Branch of the Iron River at US-2, and the Iron River about 75 yards downstream of Wild River Road. These assessments were conducted with a USEPA Rapid Bioassessment Protocol and are not directly comparable to the 2008 assessments, but the data are included in Tables 13, 14, 15, and 16 for historical completeness and comparison. Table 13 shows that the three stations scored very high with respect to habitat characteristics (similar to the result of the 2008 assessment). Invertebrate taxa identified in the 2000 study are provided in Tables 14, 15, and 16 without analysis of macroinvertebrate community rating.

Water Temperature

Our 2008 temperature monitoring was intended to determine the water temperature dynamics in the Iron River and ascertain whether differences existed between the pre-dam removal and post-dam removal data. To control for year-to-year temperature differences, part of the analysis was done by regression analysis using daily average temperature data collected from the Middle Branch of the Ontonagon River and from the Iron River over the same periods of time. The entire data set (before and after, spring through fall periods) is plotted in Figure 24. No obvious before-after differences stand out from this graph. We also plotted before and after daily average temperature data for just the summer period to see if differences were revealed during the warmest part of the season. Figure 25 presents this analysis and the 2008 data set shows a somewhat higher slope, but lower intercept than the 2000 data set. Dam removal has had no dramatic effect on the daily average temperature.

In both 2000 and 2008, the Iron River was cooler on average than the Middle Branch of the Ontonagon River. Mean stream temperatures for the period of mid-June to end of August (2000) was 16.0°C (SD=1.3) for the Iron River and 17.8°C (SD=1.5) for the Ontonagon River. In 2008, Iron River and Ontonagon River means for the same period were 17.7°C (SD=3.0) and 19.6°C (SD=1.7), respectively. These means also indicate (as does interpretation of Figures 24 and 25) that 2008 water temperatures were warmer than 2000 on both the Middle Branch of the Ontonagon River and the Iron River.

Figure 26 illustrates that 2008 Iron River temperatures showed much greater daily fluctuations (greater differences in daily maximum and minimum temperatures) than the 2000 Iron River water temperatures. An increase in daily fluctuations between 2000 and 2008 did not occur in the Middle Branch of the Ontonagon River (Figure 27). The average and maximum diurnal variations (difference between high and low temperatures) are given in Exhibit 12.

Exhibit 12. Average and Maximum Diurnal Variations between Daily Maximum and Minimum Temperatures (°C)

	Iron River		Middle Branch Ontonagon River	
	2000	2008	2000	2008
Average (May 31 - Aug 31)	2.17	7.12	2.96	2.80
Maximum Diurnal (same period)	4.40	11.23	5.64	5.21
Date when maximum occurred	31-May	20-Jun	8-Jun	1-Jun

This increase in daily temperature fluctuations on the Iron River appears to be an effect of 2005 dam removal. As shown in the stream morphology portion of this study, the volume of the impounded area has been reduced and this may have also reduced the thermal inertia. Furthermore, survey data show that the surface area of the impoundment was reduced only 27% while depth decreased 36%. Reduction in surface area decreased solar heat input, but decreases in depth reduce the amount of water available to absorb the heat. Since we did not have separate temperature gauges on the South Branch and North Branch of the Iron River, we cannot determine whether this phenomenon has been influenced to a greater or lesser extent by either of these streams.

Another difference in temperature dynamics is apparent when comparing the before and after temperature data on the Iron River. Figure 26 shows that dam removal apparently shifted the time of daily maximum temperatures to earlier in the day. This kind of phase shift has been reported for water quality parameters at other small dam removal sites (Graf 2003).

Stream temperatures in small coldwater streams influence the entire aquatic ecosystem. A good indicator organism of a healthy coldwater stream in Michigan is the brook trout (*Salvelinus fontinalis*) because of its narrow range of temperature tolerance. The Iron River is a cold-water stream that provides habitat for this native species. If stream temperatures increase above those preferred by brook trout (13.9°C to 15.6°C = 57°F to 60°F) (Becker 1983), the quality of trout habitat decreases. In more extreme cases, if stream temperatures rise above the upper lethal limit of brook trout (25°C = 77°F), the habitat will be unsuitable for this species during part or all of the year. Daily maximum temperatures in the Iron River in 2000 never exceeded 20°C (68°F). In contrast, 2008 maximum temperature regularly exceeded 20°C and on two occasions exceeded 25°C (77°F).

Pre-calibration checks of the loggers against the NIST-calibrated thermometer at four temperatures showed that the units were accurate (within 0.5°C of the NIST thermometer). Field temperature checks using the same NIST thermometer were conducted on May 30, July 11, September, and October 31 and these readings were later checked against the data downloaded from the units for the same time. In all cases, temperatures recorded by the loggers were within 0.5°C of the NIST thermometers. After retrieval, laboratory checks of the loggers against the NIST thermometer at four temperatures encountered during the monitoring season (2.2, 8.7, 15.7, and 22.6 °C) showed them to be within 0.5°C of the NIST thermometer, while the difference between the two units was almost always less than 0.25°C for all four temperature values tested during this post-calibration phase.

Conclusions

Five main sources of information were used in this study to evaluate the effects of removing the old wood dam on the Iron River: (1) aerial photographs, (2) stream channel morphology, (3) physical measures of stream and substrate, (4) benthic macroinvertebrates and their habitat, and (5) water temperature.

Simple aerial photographic evidence indicates that the formerly impounded area of the Iron River is beginning to return to a more natural (pre-dam state) in terms of width and presence of sandbars and small islands. In spite of this, by comparison to upstream and downstream reaches, it still has improvement to make.

Stream channel morphology measurements support what can be observed from aerial photography. In the former impounded area, wetted stream width has been reduced by 29%. Down-cutting has lowered the former impounded stream channel by an average of about 1.2 feet. The morphological work also shows that over 4,000 tons of sediment has been mobilized since dam removal. This restored the formerly impounded reach closer to its natural riverine condition, but did not have deleterious habitat affects on downstream reaches as the mobilized sediment moves through the Iron River system.

Physical measurements of stream and substrate showed that since dam removal, upstream and downstream reaches were unchanged with respect to width. In contrast, the formerly impounded area has decreased in width since dam removal. The upstream reach became deeper, especially after considering the effects of different flow regimes during the two surveys. The downstream reach was unchanged or deeper after considering the effect from differing flow regimes during the two surveys. The post-dam removal downstream reach did not show much change in substrate composition from the pre-dam removal condition. The formerly impounded reach seems to have improved slightly (become more coarse). The upstream reach has made the greatest improvement from dam removal (coarser substrate) with much of that habitat improvement occurring in the lower half of the reach.

Direct comparison of benthic macroinvertebrates is not possible in pre-dam removal and post-dam removal conditions, but the 2008 condition rated macroinvertebrate community as excellent or acceptable at the four sites measured. Habitat was rated “excellent” in three of the four sites. The former impoundment scored “good” (slightly impaired) with respect to habitat.

Daily average water temperature data did not show an apparent affect from dam removal with respect to lowering of stream temperature. An apparent increase in diurnal temperature variation occurred after dam removal and may require further investigation to fully understand the mechanism for this.

The wood dam at the Wild River Road crossing acted as a barrier to fish movement in the Iron River. Although we did not study this aspect of the dam removal, its absence now allows brook trout access to high quality spawning areas upstream of the old dam. According to Bill Ziegler (MDNR-Fisheries), previous review showed that most of the best quality spawning gravel habitat was upstream of the dam.

An impoundment has been in place on the Iron River upstream of Wild River Road for a very long time and recovery can be expected to be slow. Restoration of the stream channel and habitat has begun and improvement is evident with no apparent deleterious effects downstream. This site provides good opportunity for further study as the slow, but dynamic process continues.

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APPENDIX A

Photographs

Photo 1. Low-level aerial photograph of the impounded area of the Iron River (looking southeast or downstream). (Photo taken approximately in 2000, before dam removal)

Photo 2. Aerial photograph (1939) of the impounded area of the Iron River prior to dam removal (River flow direction is from lower left to upper right) (Source: Michigan State University, Aerial Archive Office).

Photo 3. Aerial photograph (1983) of the impounded area of the Iron River prior to dam removal (River flow direction is from lower left to upper right) (Source: Michigan State University, Aerial Archive Office).

Photo 4. Aerial photograph (1992) of the impounded area of the Iron River prior to dam removal (River flow direction is from lower left to upper right) (Source: Michigan Geographic Data Library).

Photo 5. Aerial photograph (1998) of the impounded area of the Iron River prior to dam removal. (River flow direction is from lower left to upper right) (Source: Michigan Geographic Data Library).

Photo 6. Aerial photograph (2005) of impounded area of the Iron River taken prior to dam removal. (River flow direction from lower left to upper right) (Source: Michigan Geographic Data Library)

Photo 7. Aerial photograph of the impounded area of the Iron River after dam removal. (River flow direction from lower left to upper right) (Source: Google Maps)

Photo 8. South Branch Iron River within the macroinvertebrate sampling reach.
(Looking downstream)

Photo 9. North Branch Iron River within the macroinvertebrate sampling reach.
(Looking upstream from the pipeline crossing)

Photo 10. Iron River in area of old impoundment upstream of Wild River Road within the macroinvertebrate sampling reach.
(Looking upstream)

Photo 11. Iron River about seventy-five meters downstream of Wild River Road within the macroinvertebrate sampling reach.
(Looking downstream)

APPENDIX B

Figures

Figure 1. Layout of survey cross sections and other features of the Iron River stream morphology survey upstream of Wild River road.

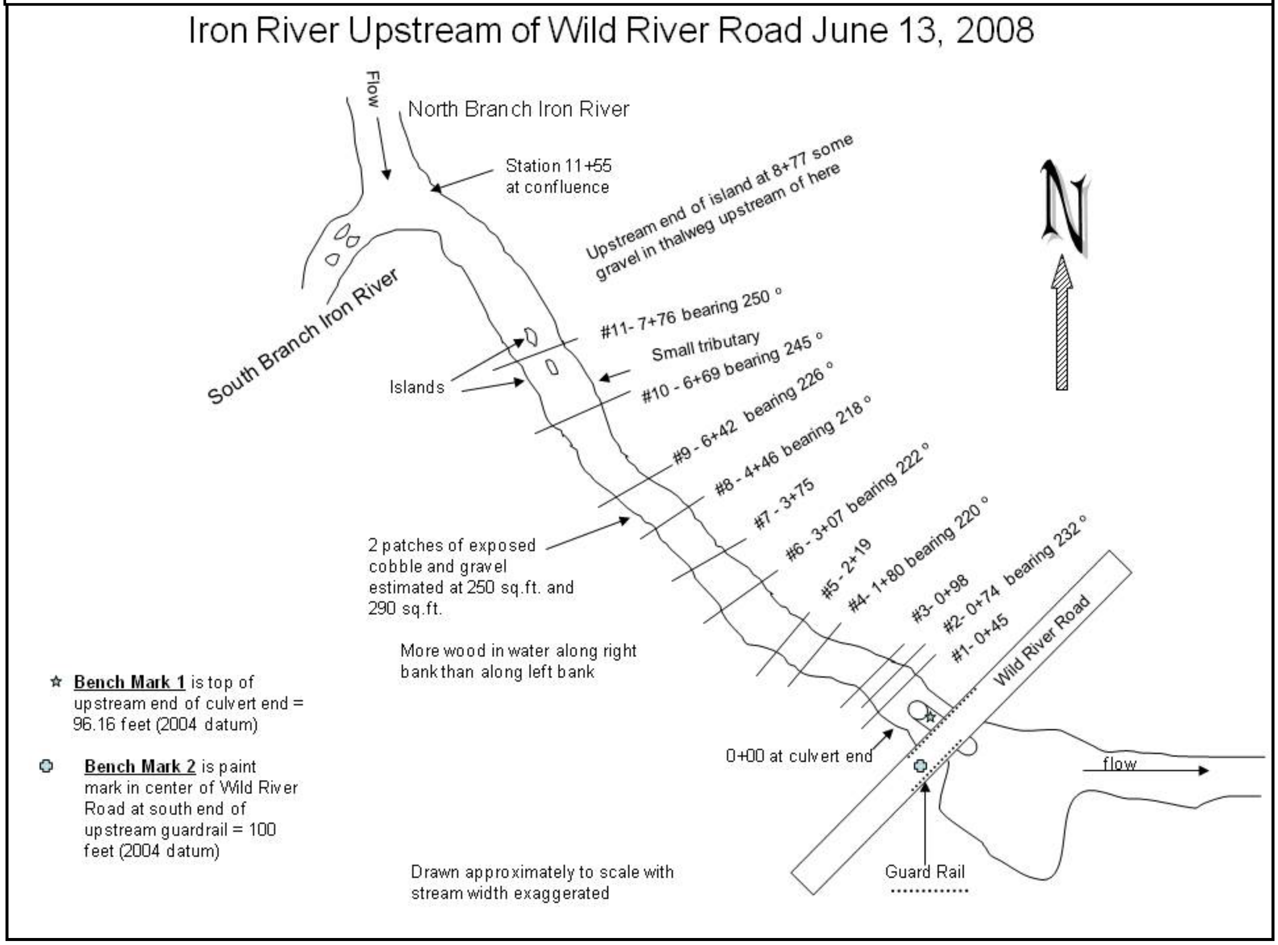


Figure 2. Longitudinal profile of water surface and thalweg before and after removal of the dam

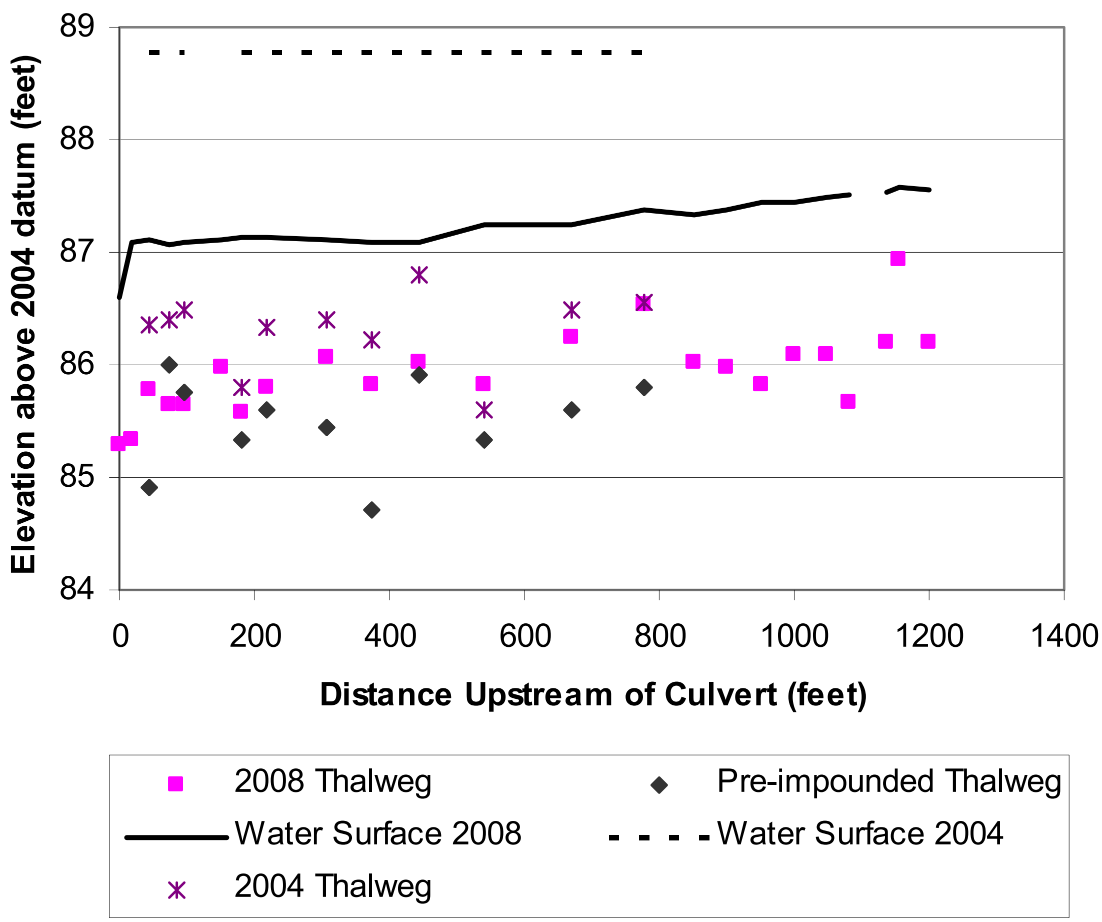


Figure 3. Change in Cross Sectional Area of the Transect Between 2004 and 2008

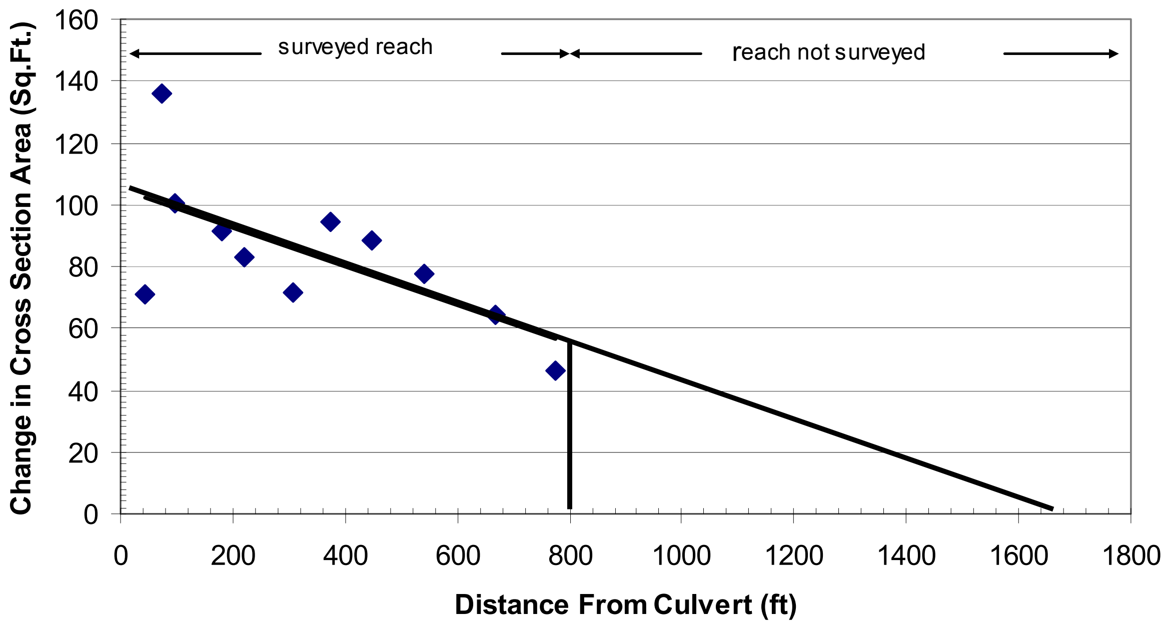


Figure 4. Transect Survey Results for 2004 and 2008 Stream Morphology Surveys

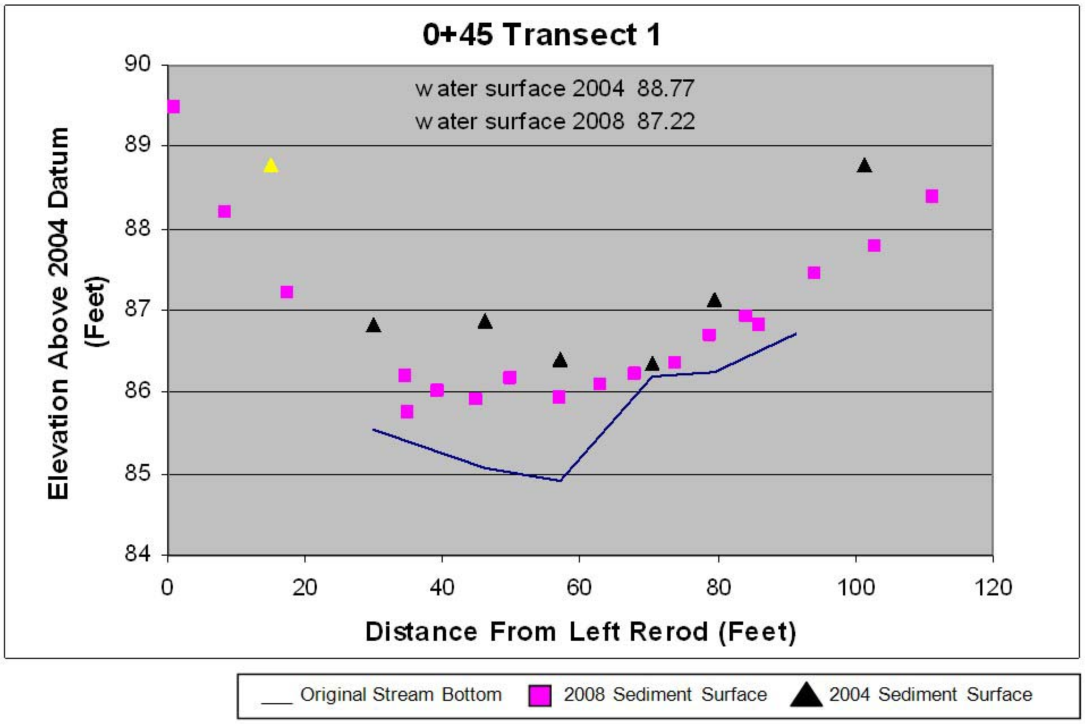


Figure 5. Transect Survey Results for 2004 and 2008 Stream Morphology Surveys

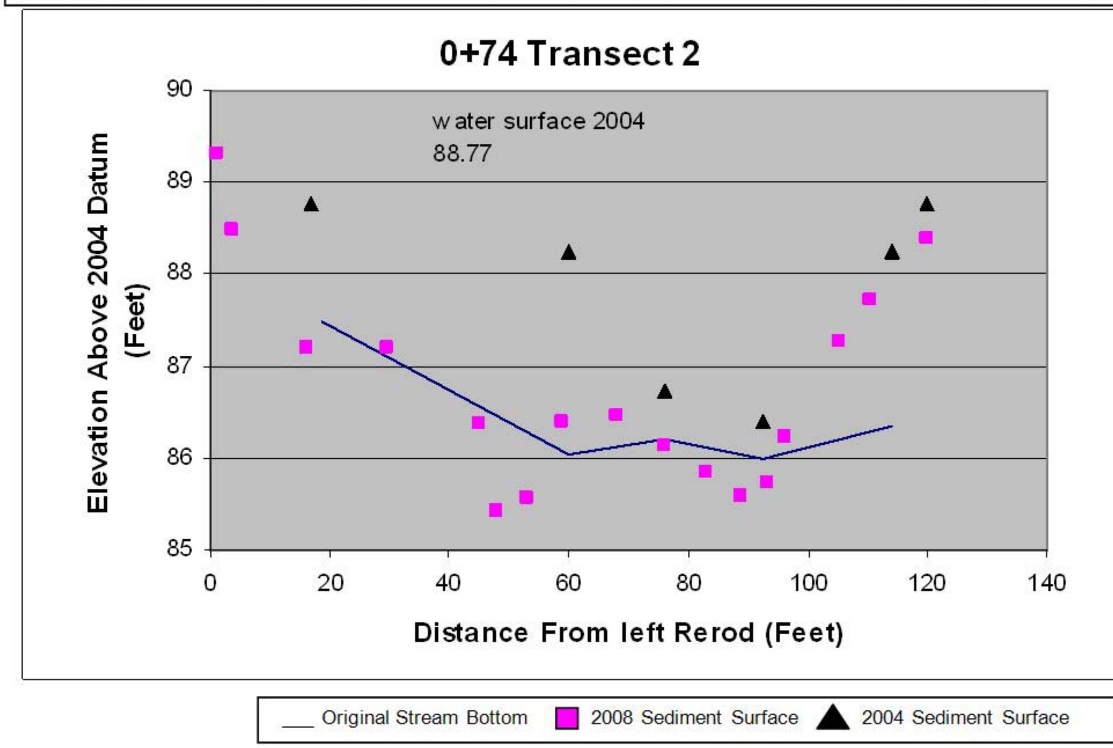


Figure 6. Transect Survey Results for 2004 and 2008 Stream Morphology Surveys

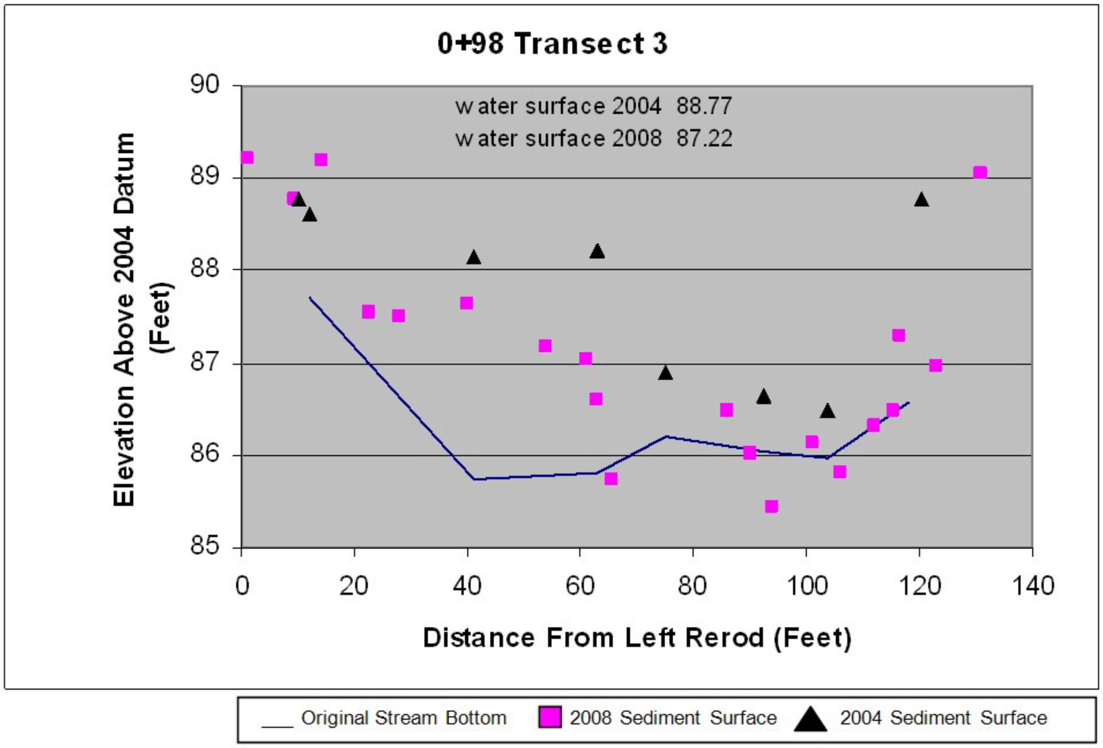


Figure 7. Transect Survey Results for 2004 and 2008 Stream Morphology Surveys

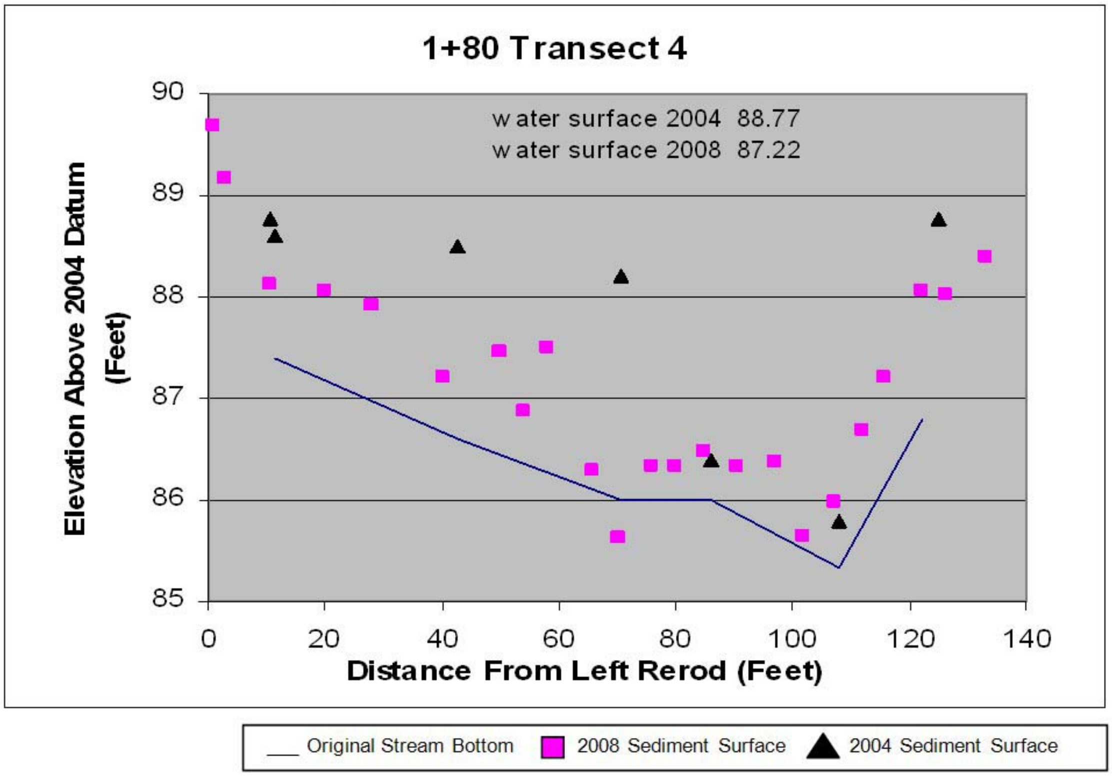


Figure 8. Transect Survey Results for 2004 and 2008 Stream Morphology Surveys

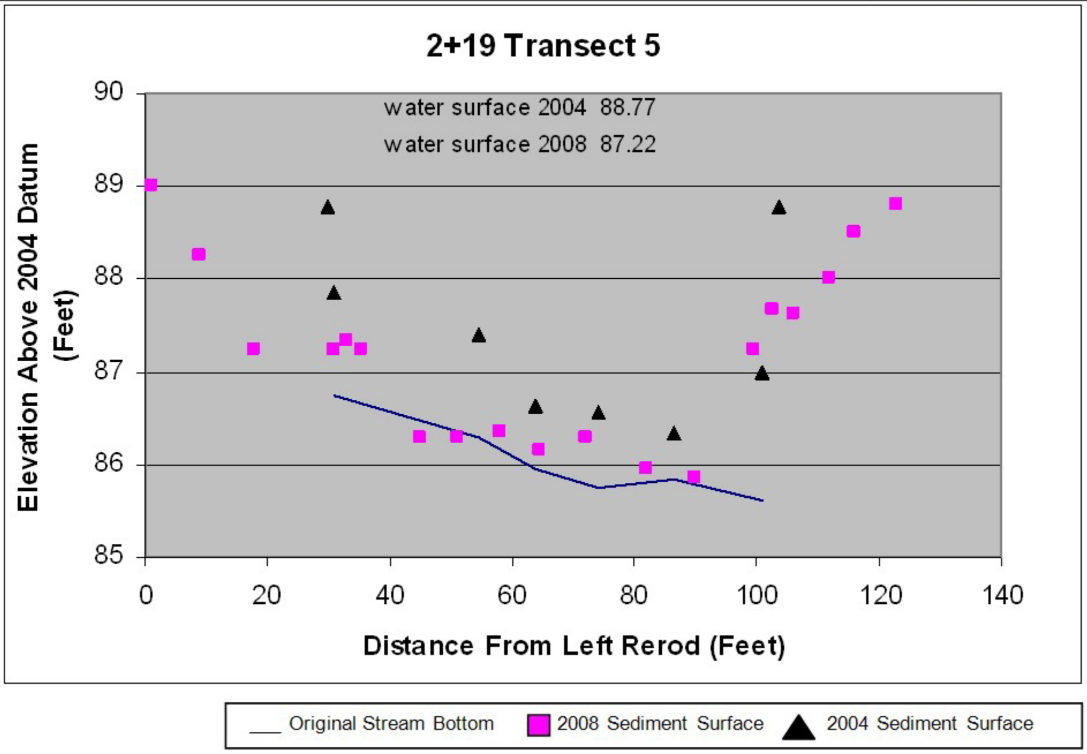


Figure 9. Transect Survey Results for 2004 and 2008 Stream Morphology Surveys

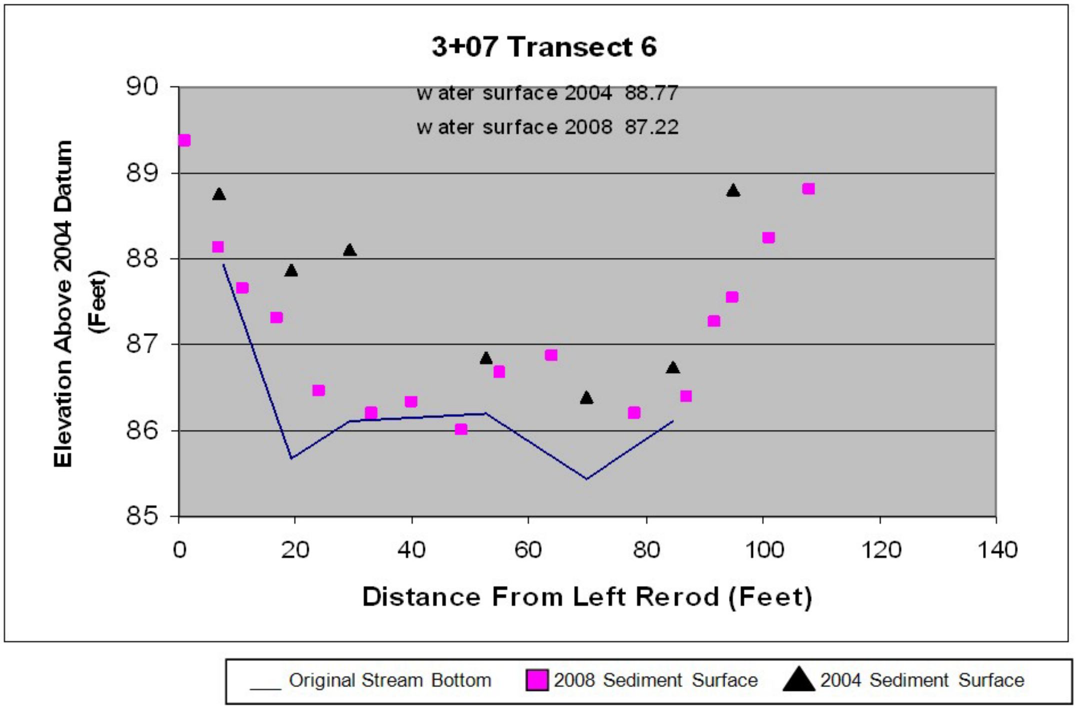


Figure 10. Transect Survey Results for 2004 and 2008 Stream Morphology Surveys

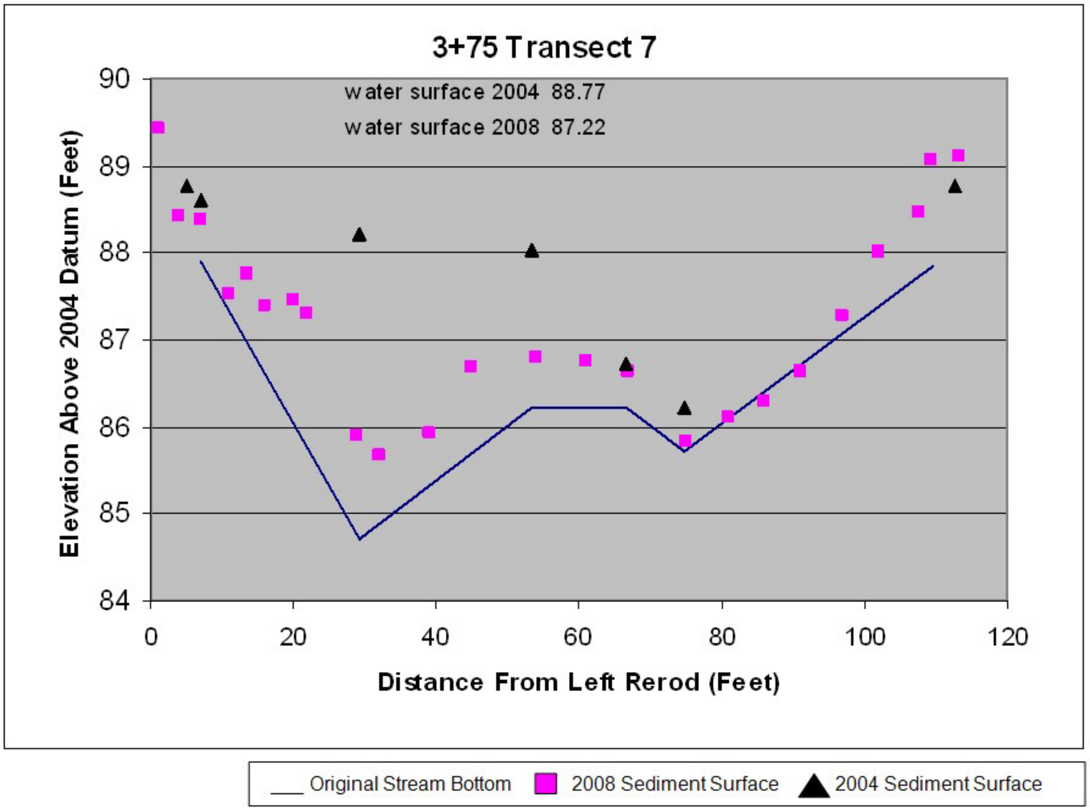


Figure 11. Transect Survey Results for 2004 and 2008 Stream Morphology Surveys

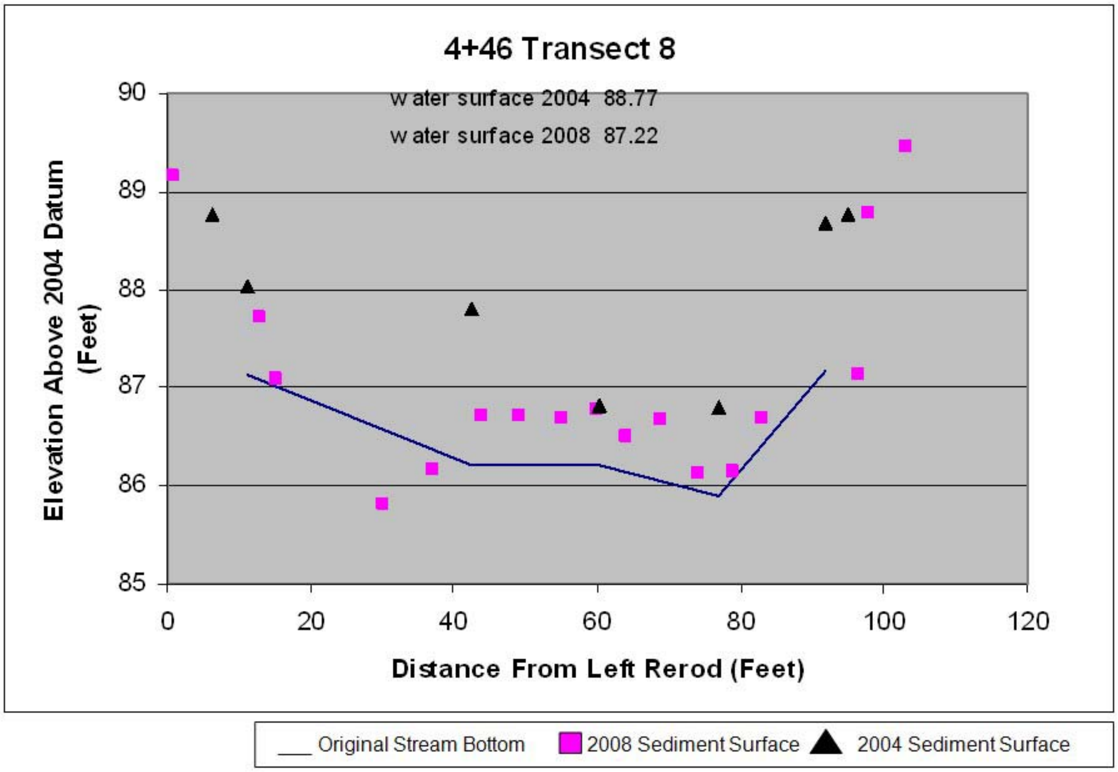


Figure 12. Transect Survey Results for 2004 and 2008 Stream Morphology Surveys

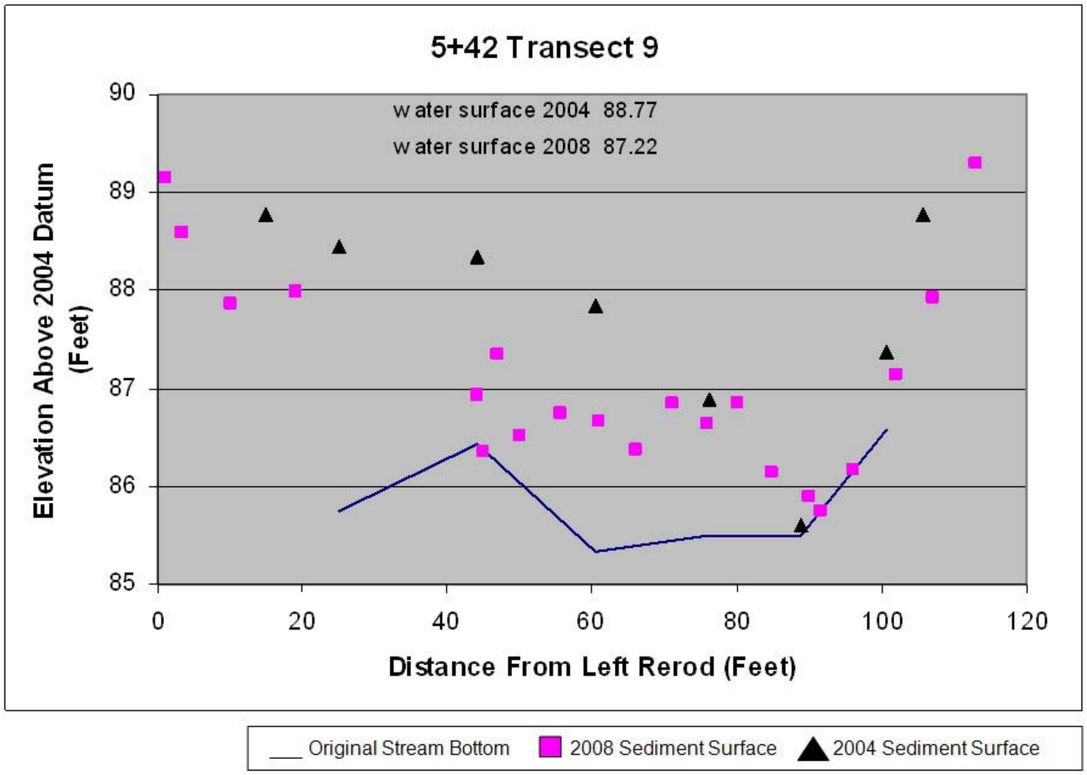


Figure 13. Transect Survey Results for 2004 and 2008 Stream Morphology Surveys

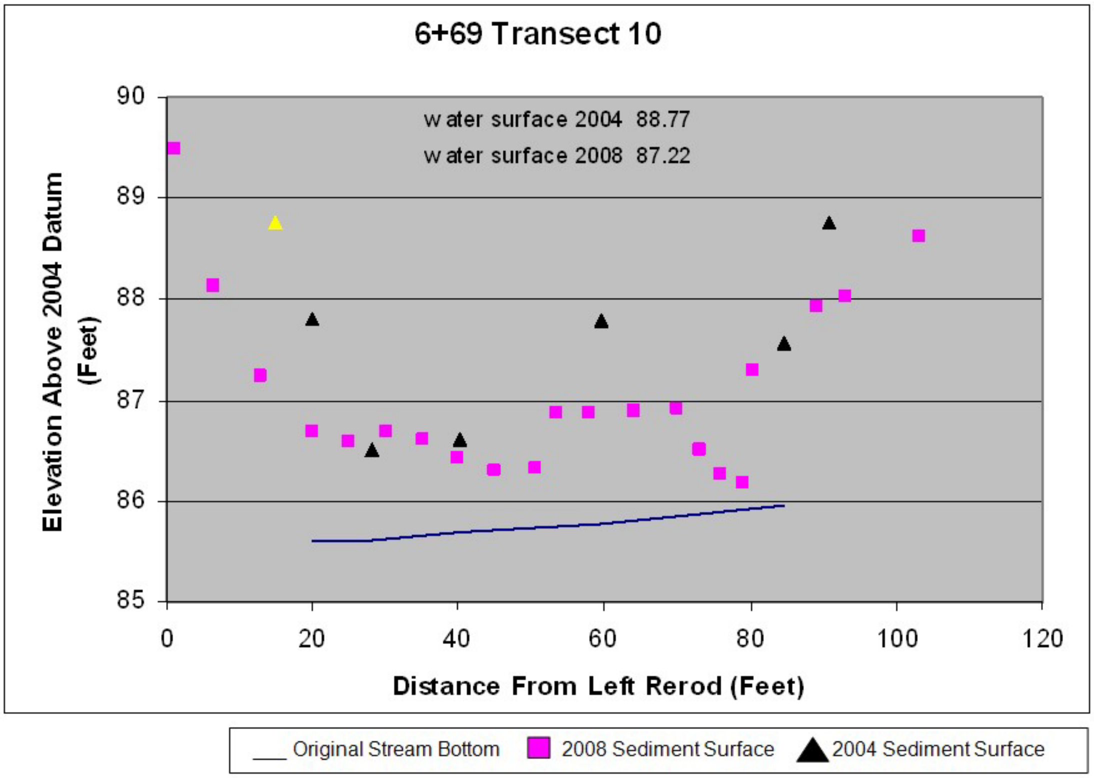


Figure 14. Transect Survey Results for 2004 and 2008 Stream Morphology Surveys

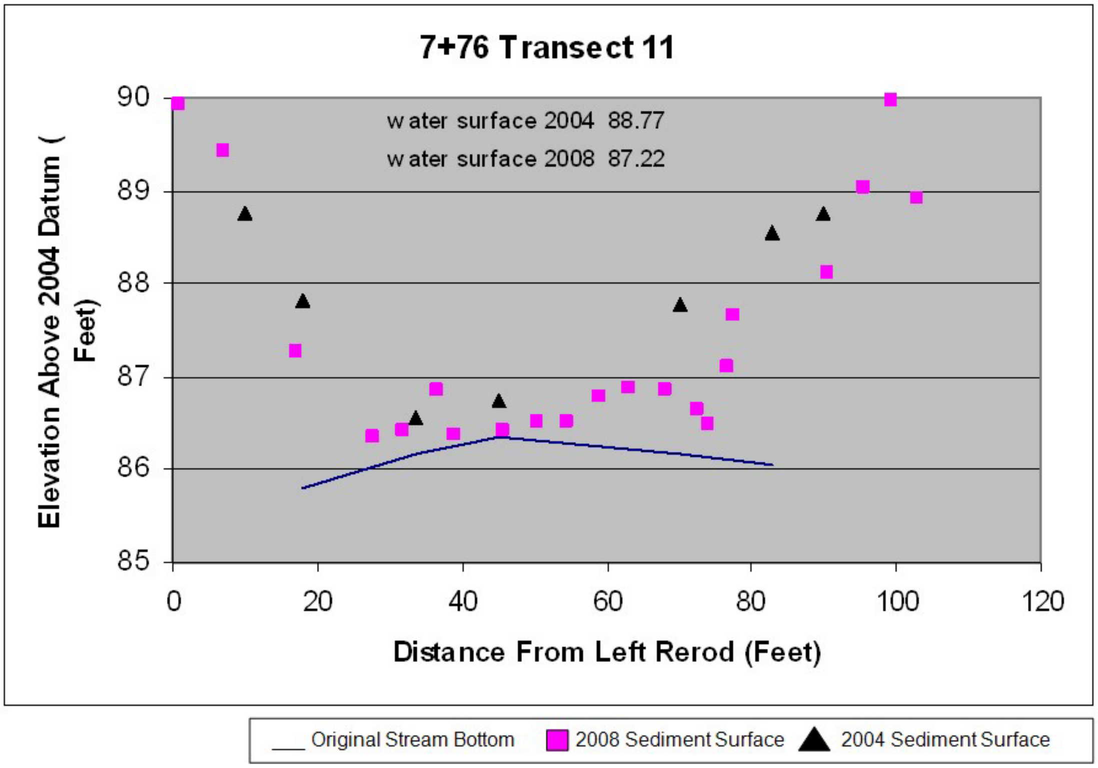


Figure 15. Reach 15 Mean Stream Depth at River Left, Center, and Right (Before and After Dam Removal)

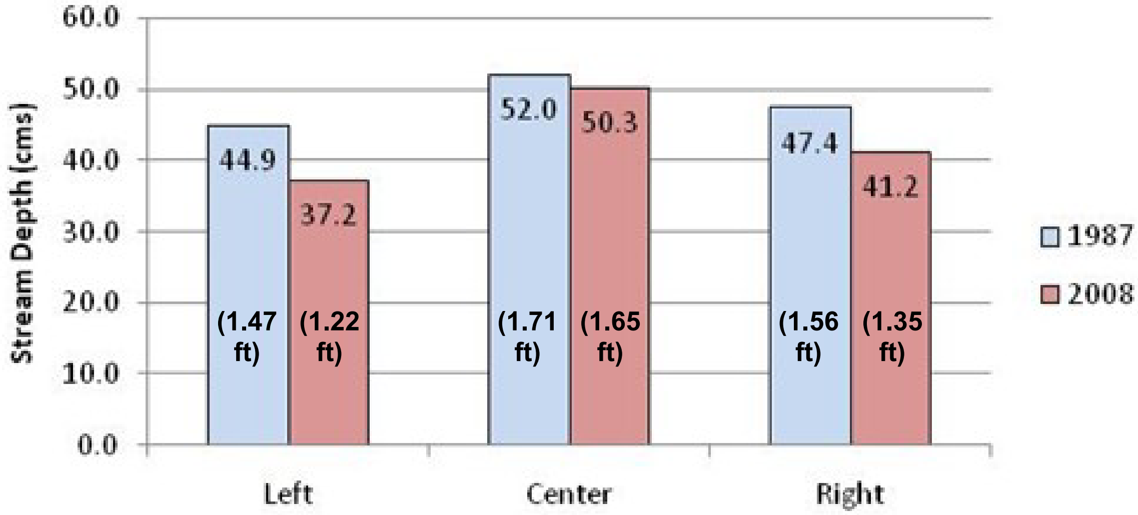


Figure 16. Reach 16 Mean Stream Depth at River Left, Center, and Right (After Dam Removal)

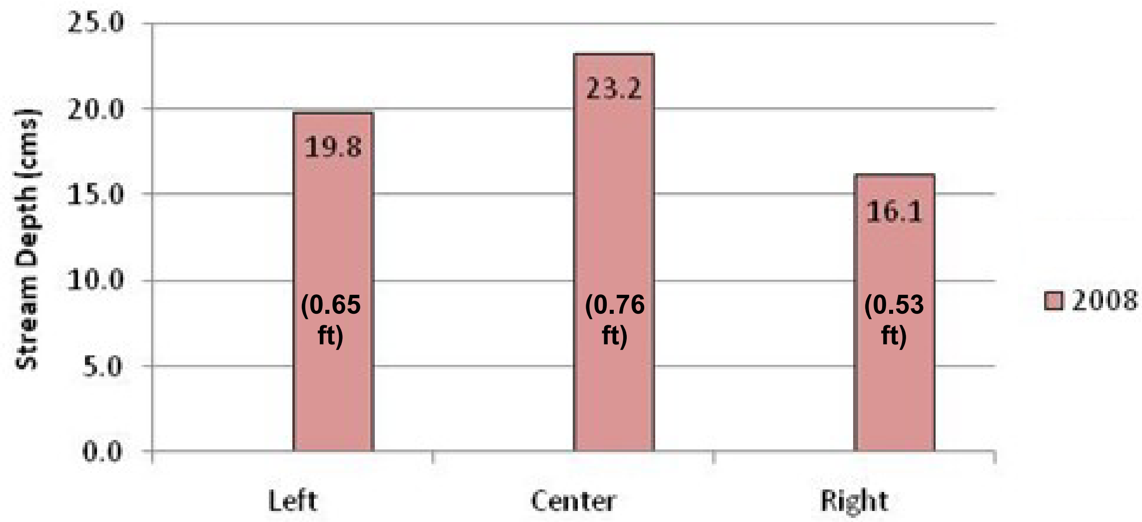
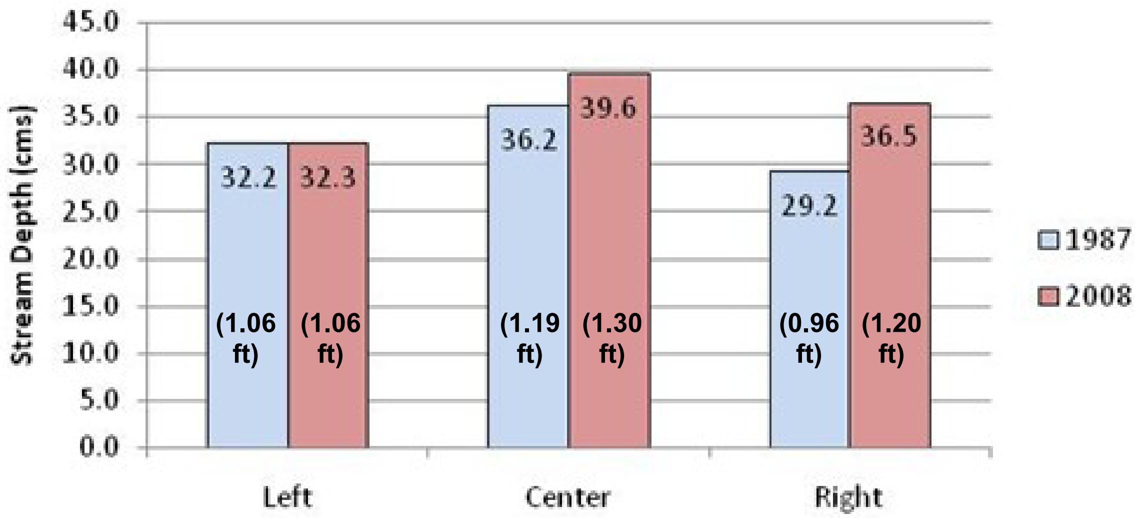
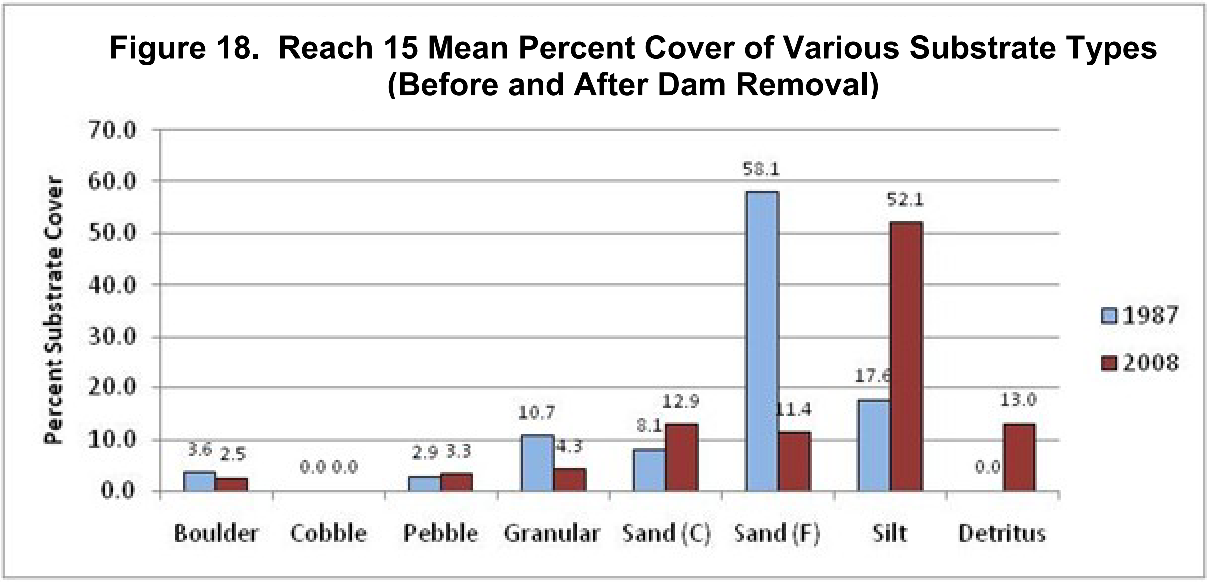


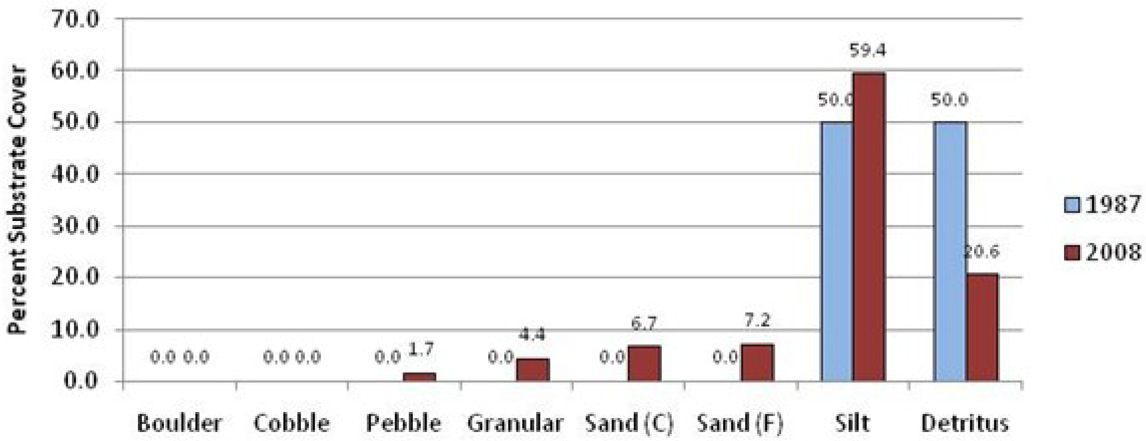
Figure 17. Reach 17 Mean Stream Depth at River Left, Center, and Right (Before and After Dam Removal)





Note: Substrate types include: boulder (>256 mm), cobble (256 to 64 mm), pebble (64 to 4 mm), granular (4 to 2 mm), sand-coarse (2 to 0.25mm), sand-fine (0.25 to 0.062 mm, silt (0.062 to 0.004 mm), and detritus (organic material of various sizes).

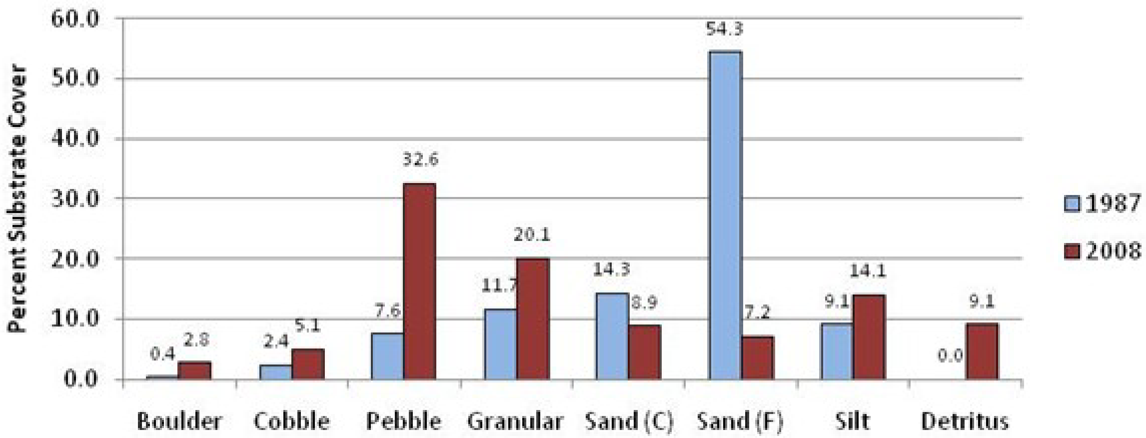
Figure 19. Reach 16 Mean Percent Cover of Various Substrate Types (Before and After Dam Removal)



Note: Substrate types include: boulder (>256 mm), cobble (256 to 64 mm), pebble (64 to 4 mm), granular (4 to 2 mm), sand-coarse (2 to 0.25mm), sand-fine (0.25 to 0.062 mm, silt (0.062 to 0.004 mm), and detritus (organic material of various sizes).

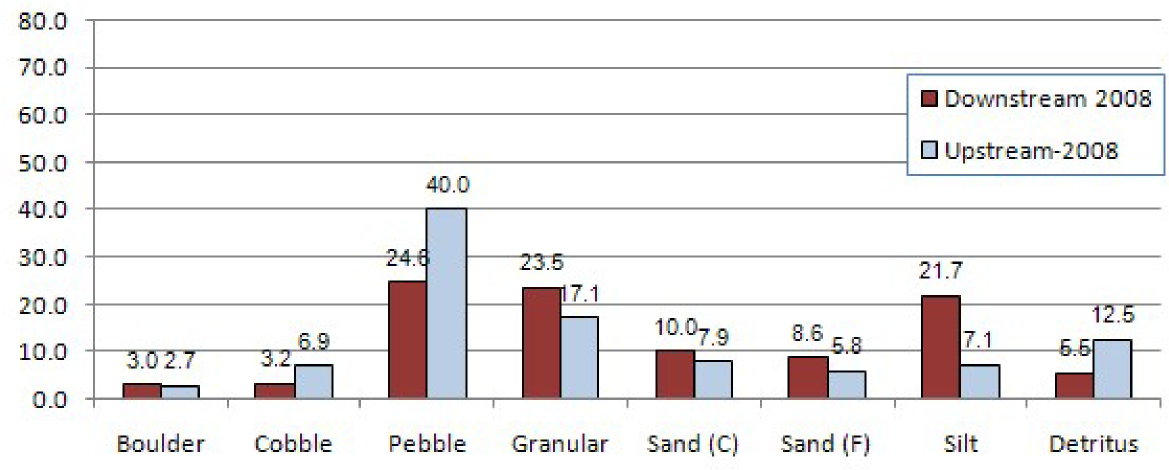
Note: In 1987, substrate was not estimated on each 50 meter transect of Reach 16 as it was impounded at the time. The substrate was simply classified as “mud.” For comparison purposes in Figure 18, “mud” was designated as 50% coverage by silt and 50% coverage by detritus.

Figure 20. Reach 17 Mean Percent Cover of Various Substrate Types (Before and After Dam Removal)



Note: *Substrate types include: boulder (>256 mm), cobble (256 to 64 mm), pebble (64 to 4 mm), granular (4 to 2 mm), sand-coarse (2 to 0.25mm), sand-fine (0.25 to 0.062 mm, silt (0.062 to 0.004 mm), and detritus (organic material of various sizes).*

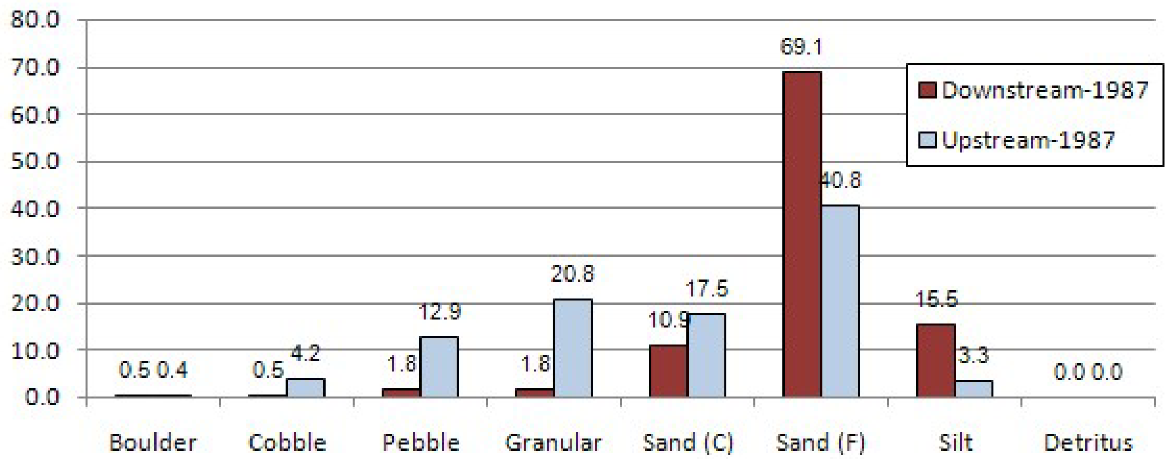
Figure 21. 2008 Percent Substrate Cover on Downstream and Upstream Sections of Reach 17



Note: Substrate types include: boulder (>256 mm), cobble (256 to 64 mm), pebble (64 to 4 mm), granular (4 to 2 mm), sand-coarse (2 to 0.25mm), sand-fine (0.25 to 0.062 mm, silt (0.062 to 0.004 mm), and detritus (organic material of various sizes).

Note: Downstream Section of Reach 17 includes 250 m through 750 m transects. Upstream Section of Reach 17 includes 800 m through 1350 meter transects.

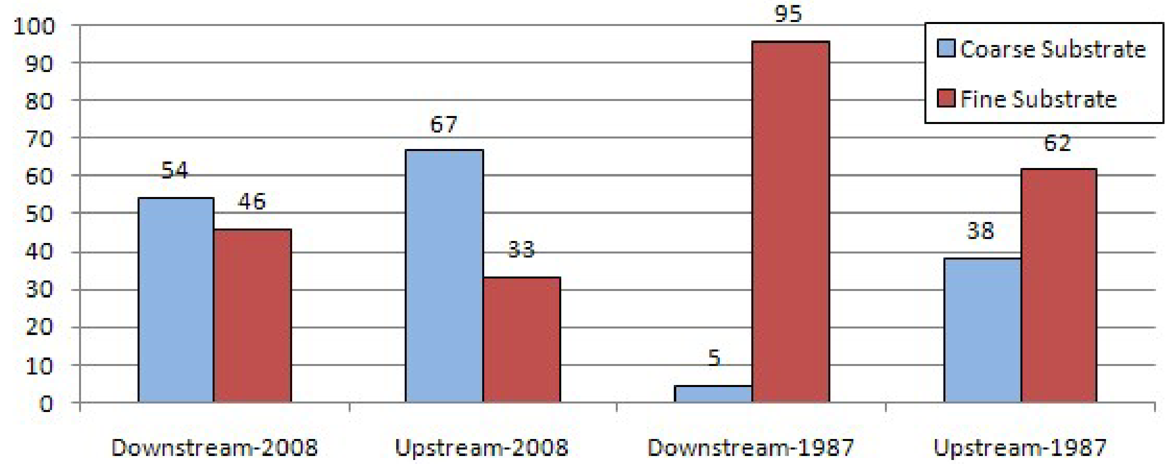
Figure 22. 1987 Percent Substrate Cover on Downstream and Upstream Sections of Reach 17



Note: Substrate types include: boulder (>256 mm), cobble (256 to 64 mm), pebble (64 to 4 mm), granular (4 to 2 mm), sand-coarse (2 to 0.25mm), sand-fine (0.25 to 0.062 mm, silt (0.062 to 0.004 mm), and detritus (organic material of various sizes).

Note: Downstream Section of Reach 17 includes 250 m through 750 m transects. Upstream Section of Reach 17 includes 800 m through 1350 meter transects.

Figure 23. **Percent Substrate Cover of Coarse and Fine Materials on Downstream & Upstream Sections of Reach 17**



Note: ***Coarse Substrate*** *includes the combination of: boulder (>256 mm), cobble (256 to 64 mm), pebble (64 to 4 mm), granular (4 to 2 mm)*
Fine Substrate *includes the combination of: sand-coarse (2 to 0.25mm), sand-fine (0.25 to 0.062 mm, silt (0.062 to 0.004 mm), and detritus (organic material of various sizes).*

Note: *Downstream Section of Reach 17 includes 250 m through 750 m transects. Upstream Section of Reach 17 includes 800 m through 1350 meter transects.*

Figure 24. Daily Average Temperature for Three Periods,
M. Br. Ontonagon vs. Iron River (Wild River Impoundment Before and After)

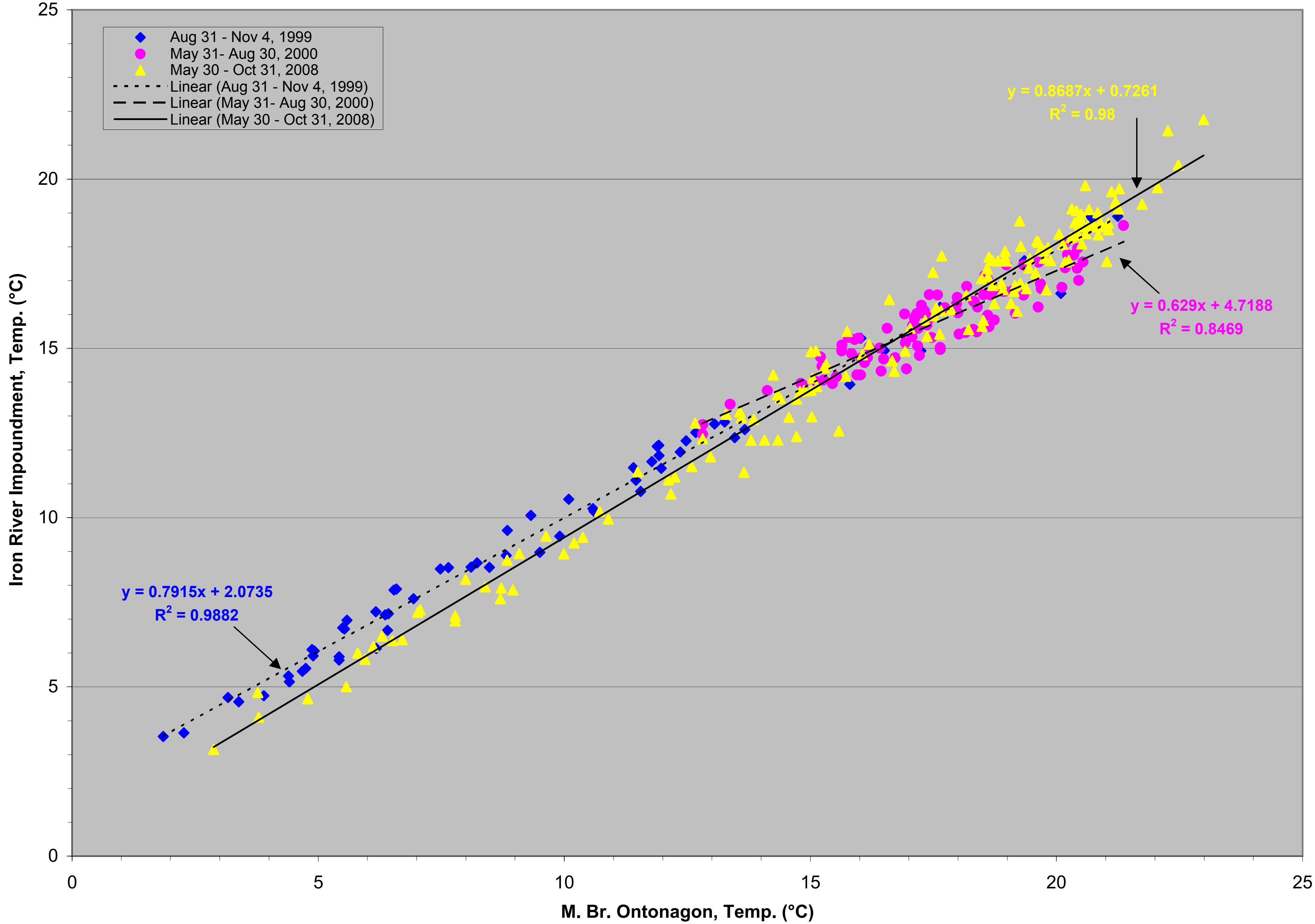
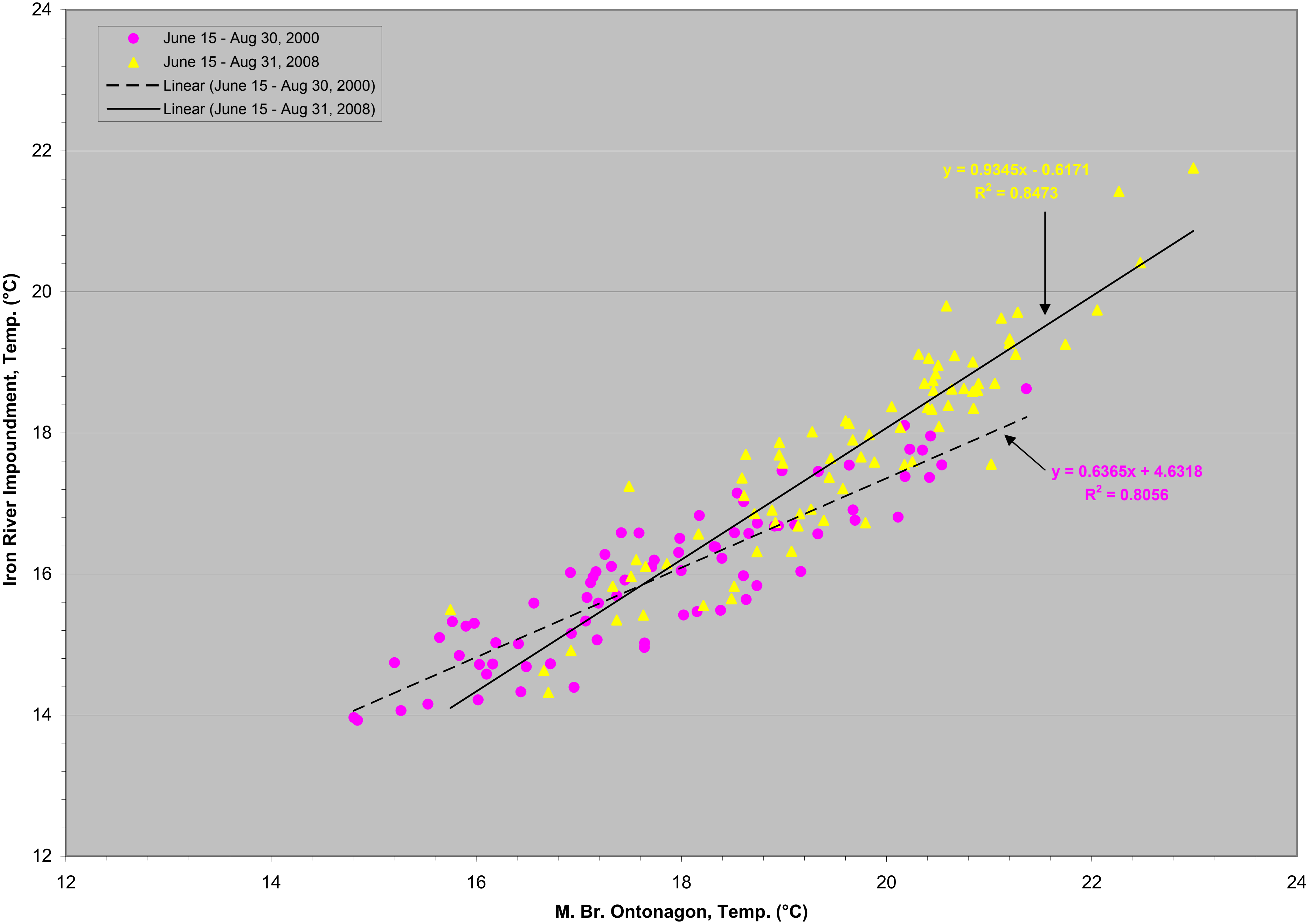


Figure 25. Daily Average Temperature for Two Warmest Weather Periods,
M. Br. Ontonagon vs. Iron River (Wild River Impoundment Before and After)



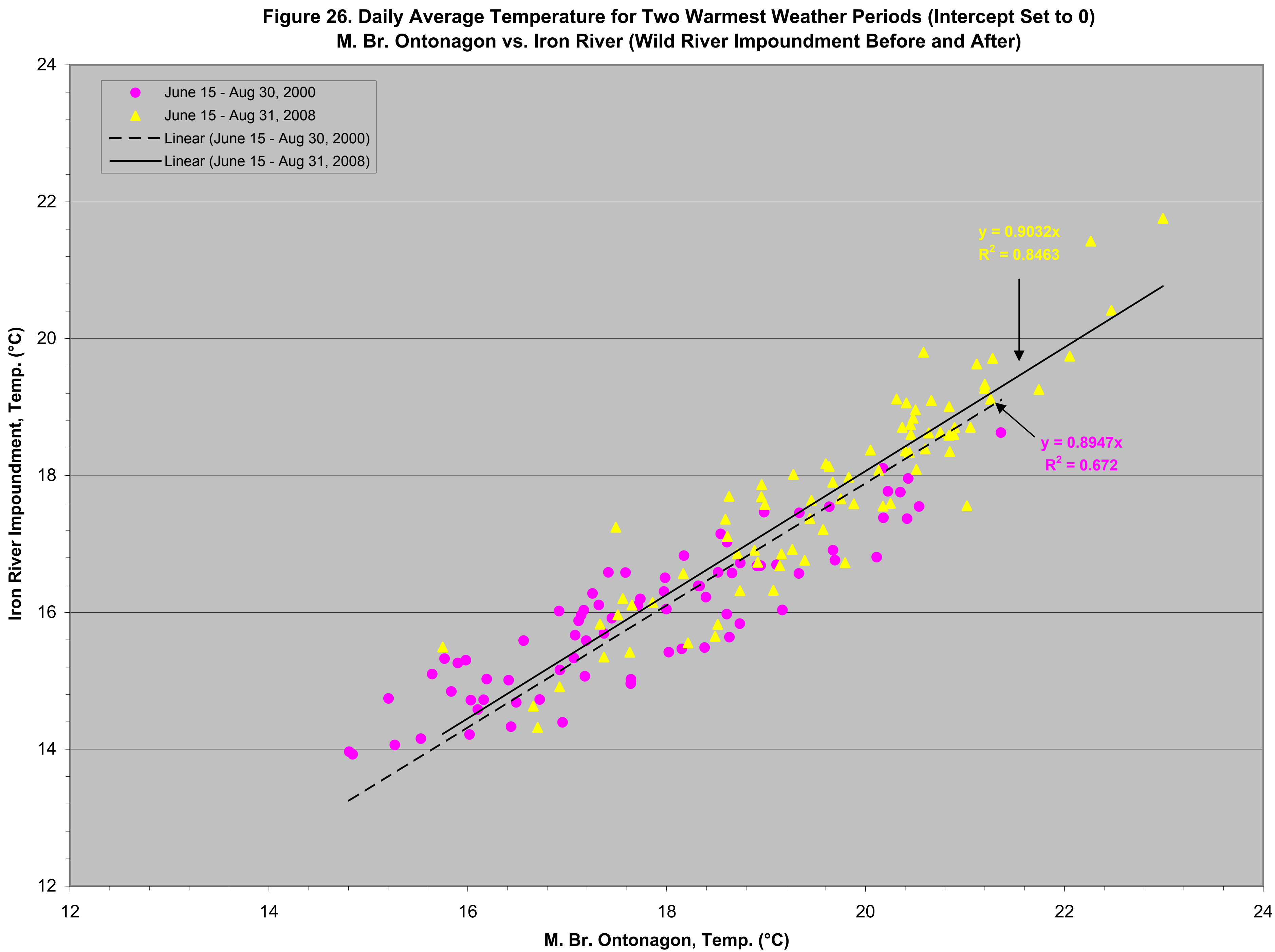
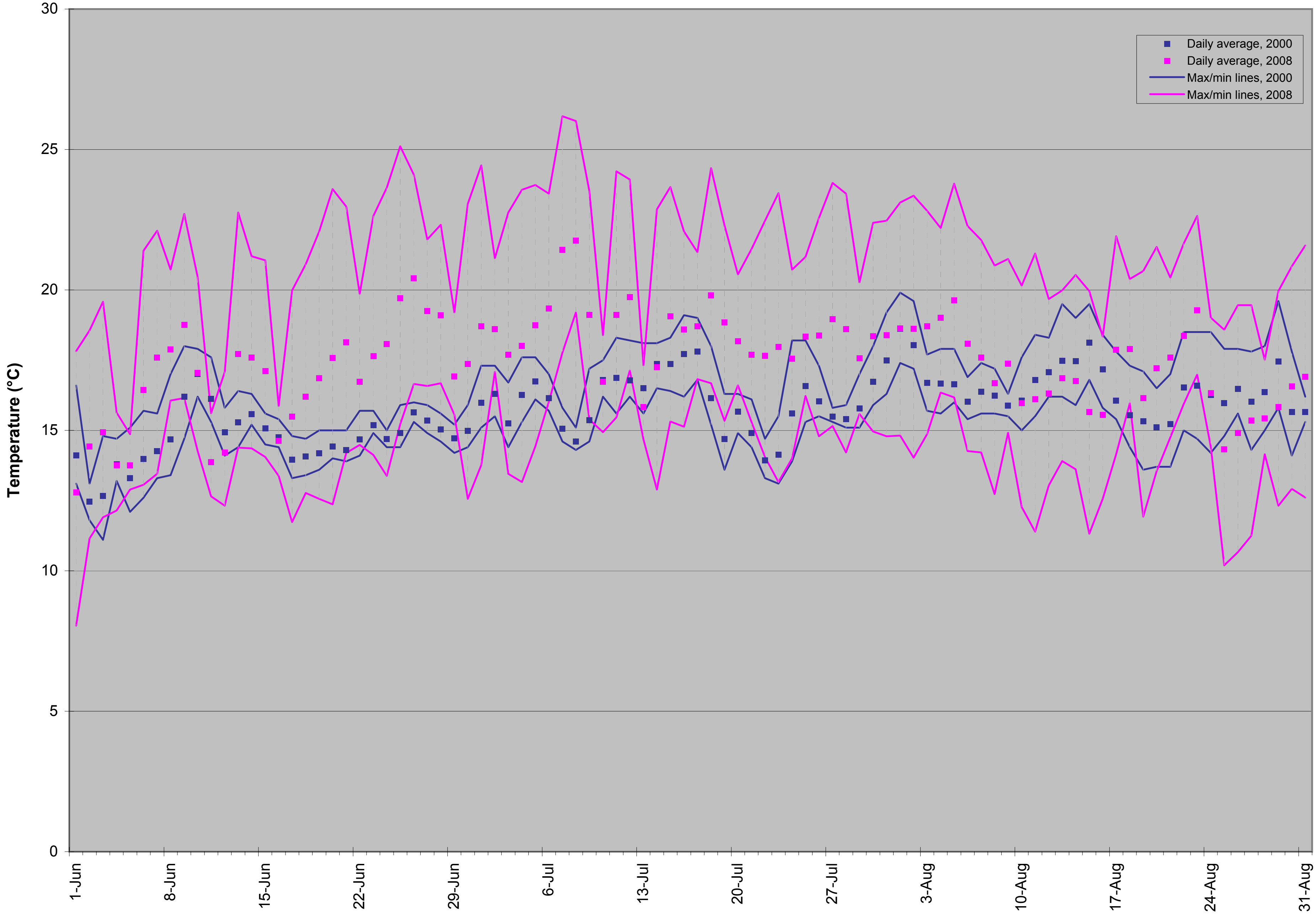


Figure 26. Daily Average Temperature for Two Warmest Weather Periods (Intercept Set to 0)
M. Br. Ontonagon vs. Iron River (Wild River Impoundment Before and After)
June 15 - Aug 30, 2000
June 15 - Aug 31, 2008
Linear (June 15 - Aug 30, 2000)
Linear (June 15 - Aug 31, 2008)
y = 0.9032x
R^2 = 0.8463
y = 0.8947x
R^2 = 0.672
Iron River Impoundment, Temp. (°C)
M. Br. Ontonagon, Temp. (°C)
12
14
16
18
20
22
24

Figure 27. Maximum, minimum, and daily average temperatures for the Iron River (2000 and 2008)



APPENDIX C

Tables

Table 1. Morphological Characteristics of an 800 Foot Reach of the Iron River Upstream of Wild River Road Dam Before and After Removal of the Dam.		
Morphological Parameters	2004 (Before Dam Removal)	2008 (After Dam Removal)
Water Elevation (feet)	88.77	87.15 (6/12/08 data only)
Average Thalweg Depth (feet)	2.5	1.3
Average Depth (feet)	1.27	0.81
Average Wetted Width (feet)	92.7	66.2
Volume occupied by the channel at 88.77 feet elevation (cubic feet)	89,810	153,086

Table 2. Stream Physical Data for Reach 17 (width in meters, depth in centimeters, substrate categories in percent)

Distance from Origin of Reach	Width 1987	Width 2008	Depth-L-1987	Depth-L-2008	Depth-C-1987	Depth-C-2008	Depth-R-1987	Depth-R-2008	Boulder-1987	Boulder-2008	Cobble-1987	Cobble-2008	Pebble-1987	Pebble-2008	Granular-1987	Granular-2008	Sand (C)-1987	Sand (C)-2008	Sand (F-1987	Sand (F-2008	Silt-1987	Silt-2008	Detritus-1987	Detritus-2008
250	10	8.6	47	36	54	39	20	10	0	5	0	0	0	0	0	5	0	5	50	5	50	75	0	5
300	14	10	47	29	29	11	12	16	0	0	0	0	0	0	0	5	0	15	70	20	30	55	0	5
350	14	13.7	10	10	8	11	26	24	0	0	0	0	0	0	0	30	0	15	80	15	20	30	0	10
400	12	9.6	34	19	20	34	40	22	0	2	0	0	0	0	0	28	0	15	80	15	20	30	0	10
450	10	9	40	14	49	19	47	50	0	10	0	15	10	15	0	30	0	10	70	5	20	10	0	5
500	15	14.5	30	46	29	0	26	70	5	10	5	20	0	15	10	30	30	5	50	5	0	10	0	5
550	12	10	39	45	41	57	36	42	0	0	0	0	0	0	0	50	20	15	70	15	10	10	0	10
600	10	12.5	43	52	50	43	34	24	0	0	0	0	0	0	0	50	20	15	70	15	10	10	0	10
650	9	11	36	10	52	50	47	52	0	2	0	0	0	80	10	10	20	5	60	0	10	3	0	0
700	10	15	31	35	35	50	31	50	0	2	0	0	0	80	0	10	20	5	80	0	0	3	0	0
750	11	11.5	38	42	36	41	26	43	0	2	0	0	10	80	0	10	10	5	80	0	0	3	0	0
800	11	10	22	42	44	43	35	40	0	10	0	20	10	60	10	5	20	5	60	0	0	0	0	0
850	9	11	38	30	40	45	28	40	5	20	0	0	15	60	30	10	30	5	20	0	0	5	0	0
900	9	11.5	41	35	45	30	35	25	0	2	10	8	0	60	30	10	30	5	20	5	10	5	0	5
950	9	8	26	40	34	50	21	40	0	0	10	0	0	80	50	0	0	0	20	0	20	0	0	20
1000	11	9	30	55	40	110	45	85	0	0	0	0	10	10	30	40	20	10	30	10	10	10	0	20
1050	7	9	58	50	57	68	40	50	0	0	0	0	10	30	0	20	0	10	90	10	0	20	0	10
1100	6	6	26	28	25	52	25	54	0	0	10	10	30	20	0	20	30	5	30	0	0	5	0	40
1150	6.5	7.4	16	26	25	40	15	25	0	0	10	10	10	30	30	20	30	5	20	0	0	5	0	30
1200	7	7.2	12	18	24	25	18	21	0	0	10	20	20	40	30	20	20	5	20	0	0	5	0	10
1250	12	11.4	39	18	30	22	12	18	0	0	0	5	10	30	10	20	0	15	80	15	0	10	0	5
1300	11	10	21	38	34	36	26	10	0	0	0	5	10	30	20	20	0	15	70	15	0	10	0	5
1350	9	9.3	17	24	32	35	27	29	0	0	0	5	30	30	10	20	30	15	30	15	0	10	0	5
Mean	10.2	10.2	32.2	32.3	36.2	39.6	29.2	36.5	0.4	2.8	2.4	5.1	7.6	32.6	11.7	20.1	14.3	8.9	54.3	7.2	9.1	14.1	0.0	9.1
STD	2.4	2.3	12.2	13.4	12.0	22.3	10.4	19.0	1.4	5.1	4.2	7.3	9.3	29.4	14.7	13.7	12.7	5.0	24.8	7.0	12.8	18.1	0.0	10.0
95%CI	1.0	0.9	5.0	5.5	4.9	9.1	4.3	7.8	0.6	2.1	1.7	3.0	3.8	12.0	6.0	5.6	5.2	2.0	10.1	2.9	5.2	7.4	---	4.1

Table 3. Stream Physical Data for Reach 16 (width in meters, depth in centimeters, substrate categories in percent)

Distance from Origin of Reach	Width 1987	Width 2008	Depth-L-1987	Depth-L-2008	Depth-C-1987	Depth-C-2008	Depth-R-1987	Depth-R-2008	Boulder-1987	Boulder-2008	Cobble-1987	Cobble-2008	Pebble-1987	Pebble-2008	Granular-1987	Granular-2008	Sand (C)-1987	Sand (C)-2008	Sand (F-1987	Sand (F-2008	Silt-1987	Silt-2008	Detritus-1987	Detritus-2008
50	35	13.7		25		22		20	0	0	0	0	0	0	0	0	0	0	0	0	50	100	50	0
100	25	21.9		40		12		20	0	0	0	0	0	0	0	0	0	0	0	0	50	75	50	25
150	25	12.5		25		21		26	0	0	0	0	0	0	0	0	0	0	0	5	50	75	50	20
200	25	21		10		26		5	0	0	0	0	0	5	0	5	0	5	0	5	50	50	50	30
250	20	15		20		40		8	0	0	0	0	0	0	0	15	0	15	0	10	50	30	50	30
300	20	14.4		15		28		37	0	0	0	0	0	5	0	10	0	15	0	10	50	30	50	30
350	15	12.7		16		20		10	0	0	0	0	0	5	0	10	0	15	0	15	50	40	50	15
400	15	11.8		15		18		9	0	0	0	0	0	0	0	0	0	5	0	10	50	60	50	25
450	15	17.2		12		22		10	0	0	0	0	0	0	0	0	0	5	0	10	50	75	50	10
Mean	21.7	15.6	--	19.8	--	23.2	--	16.1	0.0	0.0	0.0	0.0	0.0	1.7	0.0	4.4	0.0	6.7	0.0	7.2	50.0	59.4	50.0	20.6
STD	6.6	3.7	--	9.2	--	7.8	--	10.5	0.0	0.0	0.0	0.0	0.0	2.5	0.0	5.8	0.0	6.6	0.0	5.1	0.0	23.9	0.0	10.4
95%CI	2.7	1.5	--	3.8	--	3.2	--	4.3	--	--	--	--	--	1.0	--	2.4	--	2.7	--	2.1	--	9.8	--	4.3

Table 4. Stream Physical Data for Reach 15 (width in meters, depth in centimeters, substrate categories in percent)

Distance from Origin of Reach	Width 1987	Width 2008	Depth-L-1987	Depth-L-2008	Depth-C-1987	Depth-C-2008	Depth-R-1987	Depth-R-2008	Boulder-1987	Boulder-2008	Cobble-1987	Cobble-2008	Pebble-1987	Pebble-2008	Granular-1987	Granular-2008	Sand (C)-1987	Sand (C)-2008	Sand (F-1987	Sand (F-2008	Silt-1987	Silt-2008	Detritus-1987	Detritus-2008
125	11	13	80	20	78	26	46	54	0	0	0	0	10	50	20	0	20	25	50	25	0	0	0	0
175	10	13.8	22	29	71	18	71	17	10	0	0	0	0	0	30	10	0	5	60	5	0	70	0	10
225	14	10.5	47	63	49	62	56	26	20	50	0	0	0	0	20	15	0	10	60	5	0	10	0	10
275	11	12	70	38	87	37	45	44	0	2	0	0	0	0	10	10	20	10	60	8	10	70	0	0
325	12	13.5	60	12	47	62	38	84	0	0	0	0	0	0	5	0	0	0	70	0	25	100	0	0
375	14	12	47	17	54	67	50	60	0	0	0	0	0	0	0	5	0	5	70	0	30	70	0	20
425	17	17.1	22	38	59	24	52	32	0	0	0	0	0	0	20	0	10	20	60	20	10	40	0	20
475	15	15	65	32	60	70	47	70	0	0	0	0	0	0	0	0	20	20	60	20	20	40	0	20
525	13	15.5	52	8	67	54	65	47	0	0	0	0	0	0	20	0	30	20	40	20	10	40	0	20
575	11	14.5	33	10	82	50	104	40	0	0	0	0	20	0	30	0	20	20	30	20	0	40	0	20
625	13	11.5	36	50	54	43	41	12	0	0	0	0	10	0	20	20	0	15	60	5	10	40	0	20
675	13	14.0	52	80	92	77	59	20	0	0	0	0	10	0	30	20	20	15	30	5	10	40	0	20
725	14	14.2	36	47	36	66	48	62	0	0	0	0	0	0	10	0	0	8	70	5	20	75	0	12
775	15	11.8	73	46	28	81	18	43	0	0	0	0	10	15	10	10	0	8	60	5	20	50	0	12
825	12	15.5	22	53	47	38	58	23	0	0	0	0	0	0	0	0	0	15	70	15	30	60	0	10
875	15	11	19	35	36	74	52	54	0	0	0	0	0	0	0	0	0	15	70	15	30	60	0	10
925	19	12	62	55	23	58	16	20	0	0	0	0	0	0	0	0	0	5	70	5	30	70	0	20
975	22	15.5	42	18	13	33	23	60	5	0	0	0	0	5	0	0	0	5	50		45	60	0	30
1025	12	15	29	55	42	35	47	25	20	0	0	0	0	0	0	0	0	15	50	15	30	60	0	10
1075	17	22	44	22	36	28	26	40	0	0	0	0	0	0	0	0	30	15	50	15	20	60	0	10
1125	15	13	30	54	30	53	34	32	20	0	0	0	0	0	0	0	0	20	80	20	20	40	0	0
Mean	14.0	13.9	44.9	37.2	52	50.3	47.4	41.2	3.57	2.48	0	0	2.86	3.33	10.7	4.29	8.1	12.9	58.1	11.4	17.6	52.1	0	13
STD	2.90	2.54	18.3	19.5	21.7	19	19.6	19.4	7.27	10.9	0	0	5.61	11.2	11.4	6.94	11.2	6.73	13.3	7.83	12.5	22.3	0	8.41
95%CI	1.2	1.0	7.5	8.0	8.9	7.8	8.0	7.9	3.0	4.5	--	--	2.3	4.6	4.7	2.8	4.6	2.8	5.4	3.2	5.1	9.1	--	3.4

Table 5. Stream velocities at river left, center, and right for Iron River Study Reaches 17, 16, and 15.

REACH 17

Distance from origin (m)	Velocity-L 2008 (fps)	Velocity-C 2008 (fps)	Velocity-R 2008 (fps)
250	0.35	0.5	0.1
300	0.54	0.38	0.25
350	0.12	0.46	0.37
400	0.44	0.56	0.2
450	0.15	0.56	0.15
500	0.3	0	0.47
550	0	0.55	0.27
600	0.33	0.3	0
650	0	0.41	0
700	0.27	0.33	0
750	0.36	0.36	0.27
800	0.11	0.55	0.11
850	0.22	0.55	0
900	0.33	0.47	0.27
950	0.11	0.43	0.15
1000	0	0	0
1050	0	0.33	0.25
1100	0	0.47	0.27
1150	0	0.55	0.16
1200	0	0.21	0.71
1250	0.48	0.42	0.36
1300	0	0.31	0
1350	0	0.3	0.18
Mean	0.18	0.39	0.20
STD	0.18	0.16	0.18
95%CI	0.07	0.07	0.07

REACH 16

Distance from origin (m)	Velocity-L 2008 (fps)	Velocity-C 2008 (fps)	Velocity-R 2008 (fps)
50	0.75	0.3	0.45
100	0.16	0.15	0.39
150	0.14	0.64	0
200	0	1.21	0
250	0	0.57	0
300	0	0.46	1.26
350	0.25	0.53	0.25
400			
450	0	0.49	0
Mean	0.16	0.54	0.29
STD	0.26	0.31	0.43
95%CI	0.10	0.13	0.18

REACH 15

Distance from origin (m)	Velocity-L 2008 (fps)	Velocity-C 2008 (fps)	Velocity-R 2008 (fps)
125	0.41	1.55	0
175	0.35	1.26	0.4
225	0.23	0.46	0.33
275	0.55	0.47	0.41
325	0	0.47	0.27
375	0	0.47	0.3
425	0.41	0.66	0.33
475	0.1	0.47	0.1
525	0.16	0.47	0.33
575	0	0.55	0.36
625	0.36	0.66	0.55
675	0.22	0.33	0.22
725	0.1	0.36	0.21
775	0	0.55	0.3
825	0.36	0.55	0.33
875	0	0.36	0.3
925	0.41	0.55	0.55
975	0	0.66	0.41
1025	0.55	0.55	0.33
1075	0.37	0.41	0.55
1125	0.33	0.33	0.66
Mean	0.23	0.58	0.34
STD	0.19	0.30	0.15
95%CI	0.08	0.12	0.06

Table 6. Comparison of Mean Stream Width Before and After Dam Removal			
		Before Dam (1987)	After Dam (2008)
Reach 15 (Downstream of Dam)	Mean Stream Width (m)	14.1	13.9
	Standard Deviation	2.9	2.5
	95% Confidence Interval	1.2	1.0
	Number of measures (n)	21	21
Reach 16 (Within former impounded area)	Mean Stream Width (m)	21.7	16.0
	Standard Deviation	6.6	3.7
	95% Confidence Interval	2.7	1.5
	Number of measures (n)	9	9
Reach 17 (Upstream of former impounded area)	Mean Stream Width (m)	10.2	10.2
	Standard Deviation	2.4	2.3
	95% Confidence Interval	1.0	0.9
	Number of measures (n)	23	23

Table 7. Comparison of Mean Stream Depths Before and After Dam Removal

Reach	Parameter	Before Dam Removal (1987)				After Dam Removal (2008)			
		Left	Center	Right	Mean	Left	Center	Right	Mean
Reach 15	Mean Depth (cm)	44.9	52.0	47.4	48.1	37.2	50.1	41.2	42.9
(Down-stream of Dam)	Standard Deviation	18.3	21.8	19.6	19.8	19.5	19.0	19.4	19.8
	95% Confidence Interval	7.5	8.9	8.0	5	8.0	7.8	7.9	5.0
	Number of measures (n)	21	21	21	63	21	21	21	63
Reach 16	Mean Depth (cm)	NA	NA	NA	NA	19.8	23.2	16.1	19.7
(Within former impounded area)	Standard Deviation	NA	NA	NA	NA	9.2	7.8	10.5	9.3
	95% Confidence Interval	NA	NA	NA	NA	3.8	3.2	4.3	3.6
	Number of measures (n)	NA	NA	NA	NA	9	9	9	27
Reach 17	Mean Depth (cm)	32.2	36.2	29.2	32.6	32.3	39.6	36.5	36.1
(Upstream of former impounded area)	Standard Deviation	12.2	12.0	10.4	11.7	13.4	22.3	19.0	18.5
	95% Confidence Interval	5.0	4.9	4.3	2.8	5.5	9.1	7.8	4.4
	Number of measures (n)	23	23	23	69	23	23	23	69

Table 8. Average Estimated Thalweg Depths for Reaches 17, 16, and 15.						
	Reach 17 (upstream)		Reach 16 (impoundment)		Reach 15 (downstream)	
	2008	1987	2008	1987	2008	1987
Mean Depth (centimeters)	46.3	39.2	28.2	NA	58.0	62.3
Standard Deviation	18.8	9.4	8.6	NA	14.8	17.4
95% Confidence Interval	7.7	3.8	5.6	NA	6.3	7.5
The deepest measure of three measures on each 164 foot (50 m) transect (MDNR methodology) was used to calculate an average estimated thalweg depth for each reach. Since no actual thalweg depth was measured in the field, this likely underestimates actual thalweg depth (for example, the measured thalweg depth of Reach 16 was 39.6 cm (1.3 feet) as compared to the average estimated value of 28.2 cm (0.93 ft).						

Table 9. Mean 2008 Stream Velocities for Iron River Study Reaches.				
		After Dam Removal (2008)		
Reach	Parameter	Left	Center	Right
Reach 15 (Downstream of Dam)	Mean Velocity (feet per sec)	0.23	0.58	0.34
	Standard Deviation	0.19	0.30	0.15
	95% Confidence Interval	0.08	0.12	0.06
	Number of measures (n)	21	21	21
Reach 16 (Within former impounded area	Mean Velocity (feet per sec)	0.16	0.54	0.29
	Standard Deviation	0.26	0.31	0.43
	95% Confidence Interval	0.10	0.13	0.18
	Number of measures (n)	9	9	9
Reach 17 (Upstream of former impounded area)	Mean Velocity (feet per sec)	0.18	0.39	0.20
	Standard Deviation	0.18	0.16	0.18
	95% Confidence Interval	0.07	0.07	0.07
	Number of measures (n)	23	23	23

Table 10. Qualitative macroinvertebrate sampling results for Iron River in the vicinity of Wild River Road, Iron River, MI, June 2008.

TAXA	S B Iron River US-2 Crossing 6/16/2008 STATION 1	Iron River At Pipeline Crossing (u/s of Dam) 6/16/2008 STATION 2	Iron River u/s Wild River Rd Bridge 6/17/2008 STATION 3	Iron River d/s Wild River Rd Bridge 6/17/2008 STATION 4
ANNELIDA (segmented worms)				
Hirudinea (leeches)		3		
Oligochaeta (worms)	32	1	30	18
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	3	12	24	100
Decapoda (crayfish)	1		1	
Isopoda (sowbugs)	1	14	8	2
Arachnoidea				
Hydracarina		1	1	
Insecta				
Ephemeroptera (mayflies)				
Baetidae	13	10	61	23
Caenidae	1	1		2
Ephemerellidae	24	8	5	7
Ephemeridae	4	29	4	13
Heptageniidae	15	1	1	2
Leptophlebiidae	4			
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	1	4		
Cordulegastridae		1		
Gomphidae	1		1	6
Libellulidae		1		
Zygoptera (damselflies)				
Calopterygidae	3	7	3	1
Coenagrionidae		5		
Plecoptera (stoneflies)				
Perlidae	6	2		2
Hemiptera (true bugs)				
Corixidae		34	20	2
Gerridae	1	1	1	
Saldidae		1		
Megaloptera				
Corydalidae (dobson flies)	4	1		1
Sialidae (alder flies)		4		
Trichoptera (caddisflies)				
Brachycentridae	2	33	10	14
Helicopsychidae	25	10	6	7
Hydropsychidae	44	2	8	23
Lepidostomatidae		1		2
Leptoceridae	4	4		8
Limnephilidae	3	18	7	2
Molannidae		1		1
Philopotamidae	9			1
Polycentropodidae		2	2	
Uenoidae	2	2	1	1
Coleoptera (beetles)				
Dytiscidae (total)		2		
Gyrinidae (adults)		1		
Haliplidae (adults)		11	6	
Elmidae	20	6	3	5
Diptera (flies)				
Athericidae				3
Ceratopogonidae		1	1	
Chironomidae	14	19	29	10
Empididae	4			
Simuliidae	7		4	
Tabanidae		5	1	1
Tipulidae	9	1	2	5
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)	1	1	1	
Hydrobiidae	1	10	5	18
Lymnaeidae			2	
Physidae	5	28	17	2
Pelecypoda (bivalves)				
Sphaeriidae (clams)	23	17	30	1
TOTAL INDIVIDUALS	287	316	295	283

Table 11. Macroinvertebrate metric evaluation of Iron River in the vicinity of Wild River Road, Iron River, MI, June 2008.

	S B Iron River US-2 Crossing 6/16/2008 STATION 1		Iron River At Pipeline Crossing (u/s of Dam) 6/16/2008 STATION 2		Iron River u/s Wild River Rd Bridge 6/17/2008 STATION 3		Iron River d/s Wild River Rd Bridge 6/17/2008 STATION 4	
METRIC	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	32	1	42	1	31	1	30	1
NUMBER OF MAYFLY TAXA	6	1	5	1	4	0	5	1
NUMBER OF CADDISFLY TAXA	7	1	9	1	6	1	9	1
NUMBER OF STONEFLY TAXA	1	0	1	0	0	-1	1	0
PERCENT MAYFLY COMP.	21.25	0	15.51	0	24.07	1	16.61	0
PERCENT CADDISFLY COMP.	31.01	1	23.10	0	11.53	0	20.85	0
PERCENT DOMINANT TAXON	15.33	1	10.76	1	20.68	0	35.34	-1
PERCENT ISOPOD, SNAIL, LEECH	2.79	1	17.72	-1	11.19	0	7.77	0
PERCENT SURF. AIR BREATHERS	0.35	1	15.82	-1	9.15	0	0.71	1
TOTAL SCORE		7		2		2		3
MACROINV. COMMUNITY RATING		EXCELLENT		ACCEPT.		ACCEPT.		ACCEPT.

Table 12. Habitat evaluation for Iron River in the vicinity of Wild River Road, Iron River, MI, June 2008.

HABITAT METRIC	S B Iron River US-2 Crossing RIFFLE/RUN		Iron River At Pipeline Crossing (u/s of Dam) GLIDE/POOL		Iron River u/s Wild River Rd Bridge GLIDE/POOL		Iron River d/s Wild River Rd Bridge GLIDE/POOL	
Substrate and Instream Cover								
Epifaunal Substrate/ Avail Cover (20)	19		16		6		12	
Embeddedness (20)*	19							
Velocity/Depth Regime (20)*	13							
Pool Substrate Characterization (20)**			15		8		14	
Pool Variability (20)**			13		3		14	
Channel Morphology								
Sediment Deposition (20)	20		17		5		12	
Flow Status - Maint. Flow Volume (1	9		9		9		10	
Flow Status - Flashiness (10)	10		10		9		10	
Channel Alteration (20)	19		18		16		20	
Frequency of Riffles/Bends (20)*	19							
Channel Sinuosity (20)**			10		7		8	
Riparian and Bank Structure								
Bank Stability (L) (10)	10		10		9		10	
Bank Stability (R) (10)	10		10		9		10	
Vegetative Protection (L) (10)	10		10		10		10	
Vegetative Protection (R) (10)	10		10		10		10	
Riparian Veg. Zone Width (L) (10)	10		10		10		10	
Riparian Veg. Zone Width (R) (10)	10		10		10		10	
TOTAL SCORE (200):	188		168		121		160	
HABITAT RATING:	EXCELLENT (NON-IMPAIRED)		EXCELLENT (NON-IMPAIRED)		GOOD (SLIGHTLY IMPAIRED)		EXCELLENT (NON-IMPAIRED)	

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Date:	6/16/2008		6/16/2008		6/17/2008		6/17/2008	
Weather:	Cloudy		Partly Cloudy		Cloudy		Partly Cloudy	
Air Temperature:	58	Deg. F.	62	Deg. F.	55	Deg. F.	55	Deg. F.
Water Temperature:	62	Deg. F.	59	Deg. F.	54	Deg. F.	54	Deg. F.
Ave. Stream Width:	12	Feet	21	Feet	45	Feet	30	Feet
Ave. Stream Depth:	0.6	Feet	1.1	Feet	0.8	Feet	1.3	Feet
Surface Velocity:	2.1	Ft./Sec.	0.7	Ft./Sec.	0.83	Ft./Sec.	0.83	Ft./Sec.
Estimated Flow:	15.12	CFS	16.17	CFS	30.25	CFS	31.62	CFS
Stream Modifications:	None		Canopy Removal		Impounded		Impounded	
Nuisance Plants (Y/N):	N		N		N		N	
Report Number:								
STORET No.:	360164		360161		360162		360163	
Stream Name:	S B Iron River		Iron River		Iron River		Iron River	
Road Crossing/Location:	US-2 Crossing		At Pipeline Crossing (u/s of Dam)		u/s Wild River Rd Bridge		d/s Wild River Rd Bridge	
County Code:	36		36		36		36	
TRS:	43N35W18		43N35W07		43N35W18		43N35W18	
Latitude (dd):	46.12688		46.13464		46.12440		46.12375	
Longitude (dd):	-88.73109		-88.73177		-88.72398		-88.72274	
Ecoregion:	NLAF		NLAF		NLAF		NLAF	
Stream Type:	Coldwater		Coldwater		Coldwater		Coldwater	
USGS Basin Code:	4030106		4030106		4030106		4030106	

* Applies only to Riffle/Run stream Surveys
** Applies only to Glide/Pool stream Surveys

Table 13. Habitat Evaluation for Iron River in the Vicinity of Wild River Road in 2000.			
Habitat Categories (Maximum Possible Score)	North Br. Iron River at Pipeline Crossing	South Br. Iron River at US-2 Crossing	Iron River 75 Yards Downstream of Wild River Rd.
Bottom substrate (20)	13	20	11
Embeddedness (20)	16	15	14
Velocity/Depth (20)	15	15	16
Channel Alteration (15)	10	11	10
Bottom Scouring (15)	10	12	8
Pool/Riffle, Run/Bend Ratio (15)	13	11	11
Bank Stability (10)	9	10	9
Bank Vegetative Stability (10)	10	10	10
Streamside Cover (10)	10	9	8
Total Score	106	113	104
% Comparability to Reference Site	93.8	100	92

Note: Habitat characteristics were given a numericals core for each of nine categories. The total score for each site was then comparead to the site with the highest total score, designated as the "reference site" (in this case the reference site was the South Branch of the Iron River at the US-2 Crossing).

Note: Assessment Categories and Percent of Comparability given in the following table:

Assessment Categories	*Percent of Comparability*
Comparable to Reference	*≥ 90%*
Supporting	*75-88%*
Partially Supporting	*60-73%*
Non-Supporting	*≤58%*

Table 14. Aquatic Macroinvertebrates Identified in the North Branch Iron River in the Vicinity of the Pipeline Crossing in 2000.

NB-1			
Amphipod (Scuds)	43	Megaloptera (Dobsonflies, & Alderflies)	
Coleoptera (Beetles)		Corydalidae	
Elmidae	3	Sialidae	
Diptera (True Flies)		Mollusca - Fingernail Clam	
Atherixidae (Watersnipe Flies)	1	Odonata (Dragonflies & Damselflies)	
Chironomidae (Midges)	1	Anisoptera	
Culicidae (Mosquitoes)		Zygoptera	
Simulidae (Black Flies)		Oligocheata (Worms)	1
Stratiomyidae (Aquatic Soldier Flies)		Plecoptera (Stoneflies)	
Tabanidae (Horse & Deer Flies)	1	Perlidae	1
Tipulidae (Crane Flies)	4	Perlodidae	4
Ephemeroptera (Mayflies)		Pteronarcidae	
Baetidae	3	Taenipterygidae	
Baetiscidae		Trichoptera (Caddisflies)	
Emphemerellidae	6	Brachycentridae	21
Emphemeridae	1	Glossosomatidae	
Heptageniidae	1	Helicopsychidae	1
Leptophlibidae		Hydropsychidae	3
Siphonuridae		Lepidostomatidae	
Gastropod		Leptoceridae	
Hemiptera (True Bugs)		Limnephilidae	3
Corixidae		Molannidae	
Isopod (Sowbugs)	15	Philopotamidae	
Hirudinea (Leeches)		Rhycophilidae	
Lepidoptera (Moths & Butterflies)		Sericostomatidae	
Pyralidae			

Table 15. Aquatic Macroinvertebrates Identified in the South Branch Iron River in the Vicinity of the US-2 Crossing in 2000.

SB-1			
Amphipod (Scuds)	22	Megaloptera (Dobsonflies, & Alderflies)	
Coleoptera (Beetles)		Corydalidae	2
Elmidae	10	Sialidae	
Diptera (True Flies)		Mollusca - Fingernail Clam	
Atherixidae (Watersnipe Flies)	3	Odonata (Dragonflies & Damselflies)	
Chironomidae (Midges)		Anisoptera	
Culicidae (Mosquitoes)		Zygoptera	
Simulidae (Black Flies)		Oligocheata (Worms)	14
Stratiomyidae (Aquatic Soldier Flies)		Plecoptera (Stoneflies)	
Tabanidae (Horse & Deer Flies)		Perlidae	5
Tipulidae (Crane Flies)	1	Perlodidae	
Ephemeroptera (Mayflies)		Pteronarcidae	
Baetidae		Taenipterygidae	
Baetiscidae		Trichoptera (Caddisflies)	
Emphemerellidae		Brachycentridae	
Emphemeridae		Glossosomatidae	1
Heptageniidae	5	Helicopsychidae	
Leptophlibidae		Hydropsychidae	31
Siphonuridae		Lepidostomatidae	
Gastropod		Leptoceridae	
Hemiptera (True Bugs)		Limnephilidae	
Corixidae		Molannidae	
Isopod (Sowbugs)		Philopotamidae	13
Hirudinea (Leeches)		Rhycophilidae	
Lepidoptera (Moths & Butterflies)		Sericostomatidae	
Pyralidae			

Table 16. Aquatic Macroinvertebrates Identified in the Iron River about 75 Yards Downstream of the Wild River Road Crossing in 2000.

IR-1			
Amphipod (Scuds)	3	Megaloptera (Dobsonflies, & Alderflies)	
Coleoptera (Beetles)		Corydalidae	
Elmidae		Sialidae	
Diptera (True Flies)		Mollusca - Fingernail Clam	
Atherixidae (Watersnipe Flies)		Odonata (Dragonflies & Damselflies)	
Chironomidae (Midges)	4	Anisoptera	1
Culicidae (Mosquitoes)		Zygoptera	
Simulidae (Black Flies)		Oligocheata (Worms)	8
Stratiomyidae (Aquatic Soldier Flies)		Plecoptera (Stoneflies)	
Tabanidae (Horse & Deer Flies)		Perlidae	
Tipulidae (Crane Flies)	2	Perlodidae	
Ephemeroptera (Mayflies)		Pteronarcidae	
Baetidae	6	Taenipterygidae	
Baetiscidae	3	Trichoptera (Caddisflies)	
Emphemerellidae		Brachycentridae	
Emphemeridae	16	Glossosomatidae	3
Heptageniidae		Helicopsychidae	
Leptophlibidae	2	Hydropsychidae	5
Siphonuridae		Lepidostomatidae	
Gastropod	16	Leptoceridae	
Hemiptera (True Bugs)		Limnephilidae	
Corixidae		Molannidae	17
Isopod (Sowbugs)	4	Philopotamidae	
Hirudinea (Leeches)		Rhycophilidae	
Lepidoptera (Moths & Butterflies)		Sericostomatidae	
Pyralidae			