BIG SOUTH BRANCH PERE MARQUETTE RIVER WATERSHED HABITAT IMPROVEMENT DEMONSTRATION PROJECT

Prepared for: **PERE MARQUETTE WATERSHED COUNCIL, INC.**
P.O. BOX 212
BALDWIN, MICHIGAN 49304
Phone: (231) 745-7692

Prepared by: **MAINSTREAM RESOURCES**
P.O. BOX 96
AUBURN, MICHIGAN 48611
Phone: (989) 662-2240

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EXECUTIVE SUMMARY

The Pere Marquette Watershed Council, a 501(c)3, non-profit conservation organization received a $750,000 grant from the Great Lakes Fishery Trust in 1998 in order to affect and evaluate habitat improvements in the Big South Branch Pere Marquette (Big South Branch) watershed. The overarching project goal is to *"increase spawning opportunities for salmonids, adding to the naturally reproduced population in Lake Michigan."*

An interdisciplinary consultant team was assembled by project manager, Mainstream Resources, to identify the factors currently limiting anadromous salmonid production in the Big South Branch watershed. In August of 1998 the consultant team presented their findings to the Project Advisory Team which was comprised of representatives from state and federal resource management agencies and the Watershed Council.

The streams in the Big South Branch watershed have abnormally high sand bedloads, flashy flow regimes and diminished groundwater inflows. In order to increase recruitment of anadromous salmonids, the consultant team recommended the construction of gravel bars (spawning riffles), stabilization of eroding stream banks, instream sediment removal and the addition of large woody debris. The consensus was that these measures should be installed in the upper watershed and within tributaries in order to maximize benefit and to produce measurable results within the five-year project timeframe.

The stream habitat improvement measures were installed beginning in the fall of 1999 and were, for the most part, completed by summer 2000. A variety of biological and physical parameters were monitored over the five-year project period in order to evaluate the effectiveness of these measures.

The gravel bars that were constructed on the Big South Branch and its tributaries are sustaining chinook salmon and steelhead spawning at levels higher than the reference (natural) riffles. Estimates indicate that, on average, one migrant chinook salmon is produced for every 1.7 square feet of installed gravel. Over a period of twenty years, the estimated production cost per chinook migrating to Lake Michigan is estimated to be $0.09. The constructed gravel bars are supporting higher densities and a greater diversity of aquatic insects than the naturally occurring sandy substrates in these streams.

The innovative sediment removal measures employed during the project were successful at cost effectively managing sediment upstream of installed gravel bars. The Stream Sweeper™ was very efficient at removing large volumes of sediment from streams and depositing them in a thin veneer on uplands up to 1000 feet away from the stream. Cut-off oxbows, once dredged, proved to be very effective at removing excess bedload during high flow events.

Both traditional and soft (biotechnical) stream bank stabilization measures were effective at halting the delivery of sediment from eroding stream banks. Large woody debris additions provided refugia for fingerling anadromous salmonids, however, it proved difficult to add volumes of wood sufficient to significantly alter channel morphometry.

It is recommended that, at a minimum, an additional six years of monitoring be conducted in order to document return runs of anadromous salmonids. Increasing run sizes documented over time would be the best indicator of long-term success. Perpetual maintenance protocols should be established to assure that these investments continue to function optimally.

There remain a number of long-term, systemic challenges in the upper reaches of this watershed. Flashy flow regimes, resulting from historic drainage, are generating considerable stream bank erosion within the Beaver Creek watershed. These problems should be addressed collaboratively by watershed stakeholders in order to improve and maintain stream health over the long-term.

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Project Advisory Team

Michigan Department of Natural Resources

Rich O'Neal
Dan Pearson
Tom Rozich
Steve Sutton

Contractors

Knoop Excavating
Tom Knoop

Barron & Sons
Chuck Barron

USDA/Natural Resources Conservation Service

Fred Kirchner

United States Forest Service

Jim Cline
Joe Kelly
Tom Moris
Pat Fowler
Les Russell
Diane Walker
Tom Walter
Mike Joyce

Chuck Bassett, Fisheries Biologist
Hiawatha National Forest

Pere Marquette Watershed Council Volunteers

Jay Barnhart
Jim Bos
Paul Bigford
Bill Farr
Rick Conney
Dave Gibbs
Bob Kennedy
Fred McLane
Bob Nicholson
Dick Schwikert, Project Coordinator
Chuck Smith

Project Consultant Team

Field Crew

Brett Fishbach
Kris Snyder
Matt Kerr
Matt Heiman
Dan Swallow
Jody Brown
Stephanie Ogren
Dan O'Keefe
Christy Stricker
Casey Smith
Kam Truhn
Andy Carl
Aimee Genung
Amanda Bosak
Liz Bioniemi

Michigan Water Research Center
Central Michigan University

Dr. Scott McNaught
Jenny Estabrook

Mainstream Resources

Dave Cozad, Project Manager
Dr. Robert King
Gaylord Alexander
Glenn Vande Water
Ron Brown
Sam Noffke

Central Michigan University
Biology Graduate Student Research

Dr. Donna King, Advisor
Matt Kerr
Matt Heiman
Aimee Genung
Andy Carl

Education Consultants

Dr. Claudia Douglass
Douglass Consulting

Marsha Barter
Mason-Lake-Oceana ISD

Ruby Creek Conservation and Recreation Club Members

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

Page

LIST OF FIGURES

Page

1.0 INTRODUCTION

The Pere Marquette Watershed Council (Watershed Council), a 501(c)3, non-profit conservation organization received a $750,000 grant from the Great Lakes Fishery Trust in 1998 in order to affect and evaluate habitat improvements in the Big South Branch Pere Marquette (Big South Branch) watershed. The overarching project goal is to: "*increase spawning and recruitment opportunities for salmonids, adding to the naturally reproduced population in Lake Michigan*".

The Watershed Council contracted with Mainstream Resources to manage and implement the five-year demonstration project. A project advisory committee comprised of representatives of the US Forest Service, Michigan DNR Fisheries Division, USDA/Natural Resource Conservation Service and the consultant team was convened to guide development of the project. An interdisciplinary consultant team assembled by Mainstream Resources surveyed the Big South Branch watershed during the summer of 1998 and presented their findings in a report entitled "*Comprehensive Surface Resource Assessment: Big South Branch Pere Marquette River*" (Mainstream Resources 1998).

The assessment report identified diminished groundwater inflow, flashy stream flows, abnormally high sand bedload and a paucity of good spawning gravel as priority challenges in the Big South Branch watershed. The consultant team and advisory committee agreed that the stabilization of eroding stream banks within the mid- to upper Big South Branch watershed would not achieve the project goal. The consensus was that if a measurable result was to be achieved within the five-year project timeframe, habitat improvements would need to be implemented in the upper watershed and tributary streams.

The consultant team developed habitat improvement plans that included the stabilization of eroding stream banks, instream sediment removal measures and the introduction of coarse substrates (constructed gravel spawning riffles). These measures were proposed in order to affect the re-establishment of normal pool-riffle sequencing, improved channel integrity and more diverse instream habitats typified by clean gravel riffles, increased pool depths and the retention of large woody debris in treatment areas. These improved instream habitat conditions will favor increased opportunities for anadromous salmonid spawning and recruitment.

2.0 WATERSHED DESCRIPTION

The Big South Branch Pere Marquette River originates in Newaygo and Oceana counties, draining 166,796 acres and flowing 48 miles before its confluence with the Pere Marquette River main stem (US Forest Service 1976). The Big South Branch is a fourth order system from the confluence of Beaver and Winnepesaug creeks downstream.

The watershed is predominantly forested with regions of agricultural activity, particularly in the headwaters (Mainstream Resources 1998). There is virtually no manufacturing or light industrial uses within the watershed, but it does sustain a considerable amount of mixed-use recreation by transient and seasonal/weekend users.

The majority of the population within the watershed is dispersed. The largest landowner in the watershed is the US Forest Service, which manages the resources for multiple uses.

Average summer stream discharge at the confluence with the main stem Pere Marquette River is approximately 150 cfs (USFWS flow data). Discharge at flood stage, however, is several times this flow. Litter and debris were found 4'-5' high in trees in the lower Beaver Creek and upper Big South Branch reaches. This flashy flow regime is a result of the local geology and man-induced drainage in the upper reaches of the watershed.

Groundwater yield and storage in the drainage basin is relatively low because of low infiltration rates, low soil permeability and high timber stand volume. These factors limit groundwater recharge and, in turn, diminish the accrual of groundwater to streams. Agricultural drainage activities in the upper watershed significantly compound this problem. The result is depressed summer base flows and elevated summer water temperatures.

Sedimentation is the most significant treatable problem in the Big South Branch watershed. The effects of sediment on fish populations and overall stream productivity are well documented (Alexander and Hansen 1982, 1983, 1986, 1988). The highest priority for the treatment of these sediment problems is in the upper watershed, in both the main stem and tributaries. All sources, including stream banks, road crossings and drains should be identified and prioritized in developing treatment protocols.

As well, once sediment sources have been treated, a plan should be developed for the removal of accumulated sand and bedload. Erosion control measures alone will not be sufficient to produce a measurable change in either habitat conditions or fish production, due to the abnormally high sand loads currently found in these streams. Even in those reaches of high gradient stream that appear to have high quality substrates (Washington Road to Hawley Bridge, Walhalla), these gravels and cobbles are plugged (embedded) with sand to the extent that the reproductive success of spawning salmonids is limited.

Due to the aforementioned challenges, habitat improvement measures need to be carefully planned and designed in order to assure success. In watersheds such as the Big South Branch, the effects of habitat restoration may only be localized due to larger systemic problems.

2.1 Stream Reach Descriptions

The following stream reach descriptions are provided for locations in the upper

Big South Branch watershed where either habitat improvement measures were constructed or ongoing monitoring occurred.

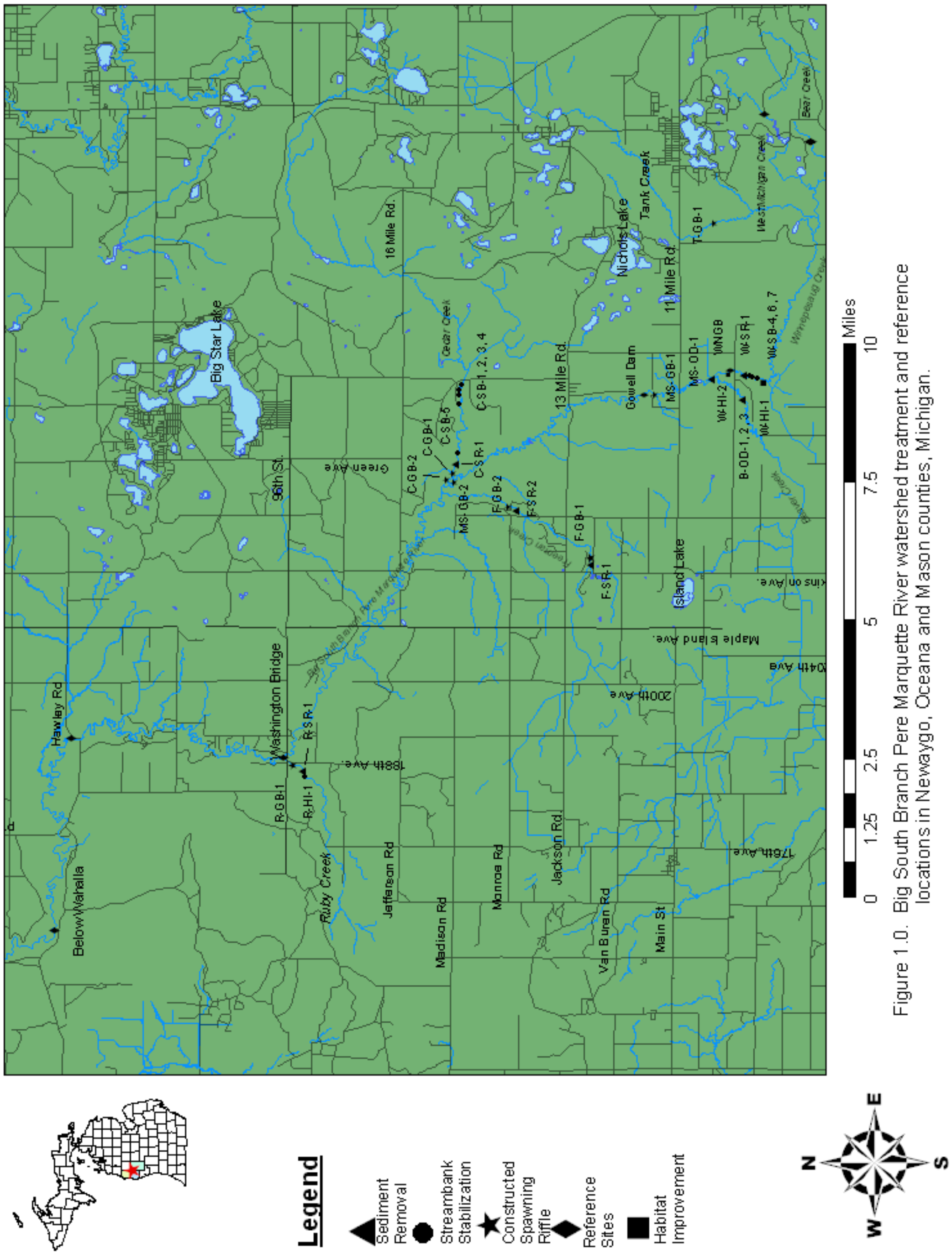

Figure 1.0. Big South Branch Pere Marquette River watershed treatment and reference locations in Newaygo, Oceana and Mason counties, Michigan.

Source: The Michigan Geographic Data Library.

2.1.1 West Michigan Creek

West Michigan Creek is first order (headwater) stream that originates at the outfall of Bass Lake (T15N, R13W, Sec. 16), two miles northwest of the town of Brohman in Newaygo County. Stream width varies from 10 to 15 feet with an average depth of one foot. While this stream does harbor a nominal number of trout and is spring-fed, water temperatures are adversely impacted by the impoundment upstream.

2.1.2 Bear Creek

Bear Creek is a first order stream that lies immediately south of West Michigan Creek. This stream originates from a spring approximately 1,000 feet upstream of our sampling station (T15N, R13W, Sec. 21). Bear Creek sustains a significant population of brook trout. Channel width varies from 10 to 25 feet with an average depth of one foot or less.

2.1.3 Tank Creek

The headwaters of Tank Creek are found in northwest Newaygo County, Michigan, immediately east of Bitely, Michigan (Figure 1). The stream flows south acquiring the flow from the outlet of Woodland Lake prior to its confluence with Winnepesaug Creek. The constructed riffle is located in Section 17 approximately 0.25 miles east of Croswell Avenue (T15N, R13W). The stream channel has a predominantly sandy bottom with an average width of 25.6 feet and an average depth of 1.8 feet. Average summer discharge was estimated to be 27 cfs. Land cover in the Tank Creek floodplain is dominated by lowland conifers and hardwoods (The Michigan Geographic Data Library 2002).

2.1.4 Beaver Creek

Beaver Creek flows southeasterly from its source in Oceana County to its confluence with Winnepesaug Creek approximately one mile south of 10 Mile Road and one mile west of Warner Road (T15N, R14W, Sec. 14NW). Steam width in the reach immediately upstream of the confluence varies from 15 to 30 feet and depth varies from 1 to 4 feet. In reaches not impacted by agricultural activity, the floodplain is typically dominated by lowland hardwoods.

2.1.5 Winnepesaug Creek

Winnepesaug Creek at 10 Mile Road is a third order stream located four miles west of the village of Woodland Park in northwest Newaygo County (T15N, R14W, Sec. 11, Figure 1). Winnepesaug Creek is the result of the convergence of three headwater streams (Tank Creek, Bear Creek and West Michigan Creek), which drain the Woodland Park and Bitely area.

Winnepesaug Creek converges with Beaver Creek north of 10 Mile Road to form the Big South Branch Pere Marquette River. Winnepesaug Creek at 10 Mile Road has a channel width of 43 feet and an average depth of 1.1 feet. Discharge at Winnepesaug Creek at 10 Mile Road is approximately 45 cfs. Bottom sediments at this location vary between sand and sand-impacted gravel. Land cover types within the riparian zone of Winnepesaug Creek include lowland hardwoods and shrub/scrub wetlands (The Michigan Geographic Data Library 2002.).

2.1.6 Upper Big South Branch Pere Marquette River

The Big South Branch Pere Marquette River originates at the confluence of Winnepesaug and Beaver Creeks, 4.5 miles west of the town of Woodland Park, Michigan and flows northwest 26 miles to converge with the main stem of the Pere Marquette River. At the confluence, the Big South Branch contributes approximately thirty per cent of the Pere Marquette's total discharge.

The Pere Marquette River flows west from this point approximately 13.4 miles to Ludington, Michigan where the river flows into Pere Marquette Lake and then into Lake Michigan. The Pere Marquette River is the largest free-flowing tributary to Lake Michigan on the Michigan side.

Constructed Riffle #1 (MS-GB-1) was completed in November 1999 and is located approximately one mile downstream from the convergence of the Winnepesaug and Beaver Creek, one quarter mile south of Hayes Road (the old Gowell Dam)(T15N, R14W, Sec. 2, Figure 1). The streambed at this site is dominated by sand overlying clay with sand-impacted gravel substrates. Average stream width is 42.2 feet and average depth is 2.1 feet. Average summer discharge at this riffle was estimated to be 68 cfs. riparian land cover at MSGB-1 is mainly lowland hardwood (The Michigan Geographic Data Library 2002.).

Constructed Riffle #2 (MS-GB-2) was completed in January 2000 and is located approximately three miles downstream from MS-GB-1 and 0.25 miles upstream of the Cedar Creek outlet (T16N, R14W, Sec. 21, Figure 1). Average summer discharge at this site was estimated to be 85 cfs with an average channel width of 43.8 feet and average depth of 2.3 feet. Sand and sand-impacted gravel dominate the streambed at this location and riparian land cover is typified by lowland hardwoods (The Michigan Geographic Data Library 2002.).

Figure 2.1. Looking upstream at the constructed gravel bar at Big South Branch Pere Marquette River Station No. 2 (MS-GB-2), Newaygo County, Michigan.

2.1.7 Upper and Lower Freeman Creek

Freeman Creek is a second order stream that originates south of School Section Lake and flows west eight miles to its confluence with the Big South Branch Pere Marquette River. Headwater sections of Freeman Creek are dominated by agricultural land and the river is channelized in some sections. The riparian zone within the lower reaches of Freeman Creek is dominated by lowland hardwoods. The streambed is comprised of sand with outcroppings of sand-impacted gravel at both sites.

The upper Freeman Creek riffle, was constructed in August 2000, is located 0.25 miles north of Garfield Street and 0.5 miles south of the town of Troy, Michigan (T16N, R14W, Sec. 32, Figure 1). The upper Freeman Creek channel has an average stream width of 11 feet and an average depth of one foot.

The lower Freeman Creek riffle is located off U.S. Forest Service Road 5367, one mile north of the town of Troy, Michigan, Newaygo County, Michigan. The lower Freeman Creek riffle was constructed in October of 1999 and has an average depth of 12 feet and an average width of 1.7 feet. Average summer discharge at the lower Freeman Creek riffle was estimated to be 12 cfs

2.1.8 Cedar Creek

Cedar Creek originates at Pickerel Lake northeast of the town of Lilley, Michigan and flows westerly 10.5 miles to converge with the Big South Branch Pere Marquette River. The upper Cedar Creek riffle (C-GB-1) was constructed in February 2000 and is located 1.5 miles east of Osborn Road and one mile south of 16 Mile Road (T16N, R14W, Sec. 16 and 21, Figure 1).

The upper Cedar Creek site has an average width of 50.3 feet and an average depth 1.4 feet while the lower Cedar Creek site has an average stream width of 30 feet and an average depth of 1.5 feet. Average summer stream discharge in this reach was estimated to be 48 cfs. Land use/cover throughout the Cedar Creek sub-watershed is typified by a mix of lowland scrub-shrub, conifers and upland hardwoods (The Michigan Geographic Data Library 2002.).

The lower Cedar Creek riffle (C-GB-2) is located 900 feet downstream of (C-GB-1) and 800 feet upstream from the Big South Branch confluence (T16N, R14W, Sec. 16, Figure 1). This riffle was constructed in November 2001. Stream sediments at both Cedar Creek sites are predominately sand and sand-impacted gravel throughout this reach (Figure 2.2).

Figure 2.2. Looking downstream at the lower Cedar Creek (C-GB-2) constructed riffle, Newaygo County, Michigan.

2.1.9 Washington Road – Big South Branch Pere Marquette River

Washington Road (T17N, R15W, Sec. 34) crosses the Big South Branch Pere Marquette River, seven miles north of the town of Walkerville ten miles upstream from the confluence of the Big South Branch and the main stem of the Pere Marquette River (Figure 1).

The river, at this location, is a fourth order stream with an average width of 50 feet. The streambed within this reach is comprised mainly of sand and sand impacted gravel with several outcroppings of gravel and cobble (riffles) which are well utilized by salmonids for spawning. The riparian zone within this reach has a fair number of seasonal and year-round homes. The floodplain is constrained by higher stream banks in many reaches of the Big South Branch from Washington Road to the confluence with the main stem Pere Marquette.

2.1.10 Ruby Creek

The headwaters of Ruby Creek are located in northeast Oceana County, Michigan, seven miles north of Walkerville (Figure 1). The stream flows east 2.75 miles and joins the Big South Branch Pere Marquette River north of Washington Bridge. The study reach is located off U.S. Forest Service Road 5148 at the Ruby Creek Interpretive Center, approximately 0.25 miles upstream from the Big South Branch (T16N, R15W, Sec. 3, Figure 1). The riffle was constructed in May 2000 and has a predominantly gravel bottom with an average width of 17.0 feet and an average depth of 0.7 feet. Average discharge estimates at this location were estimated at 12.3 cfs. Land use/cover in the Ruby Creek floodplain is dominated by lowland conifers and hardwoods (The Michigan Geographic Data Library 2002.) (Figure 2.3).

Figure 2.3. Looking downstream at the Ruby Creek constructed riffle located at the Ruby Creek Interpretive Center, Oceana County, Michigan.

2.1.11 Hawley Road – Big South Branch Pere Marquette River

The Hawley Road natural gravel bar is located seven miles south of the town of Walhalla in Mason County (T17N, R15W, Sec. 15) immediately downstream of Hawley Bridge. The site is approximately nine miles upstream of the confluence of the Big South Branch with the main stem of the Pere Marquette River. The river at this location is a fourth order stream with average depth of 3.0 feet and an average width of 51.0 feet. The streambed within this reach is composed of sand-impacted gravel and sand throughout the 1000 foot-long electrofishing station.

2.1.12 Walhalla Road -- Big South Branch Pere Marquette River

The Big South Branch natural gravel bar at the Walhalla Road site is located 5.5 miles south of the town of Wahalla, Michigan, in Mason County (T17N, R15W, Sec. 9) on U.S. Forest Service Road 5167. The site is approximately five miles upstream of the confluence of the Big South Branch with the main stem of the Pere Marquette River. The river at this location is a fourth order system with an average depth of 3.0 feet and average width of 60 feet. The streambed is comprised of sand-impacted gravel and sand throughout the 1000 foot-long electrofishing station.

3.0 HABITAT IMPROVEMENT MEASURES

A variety of stream habitat improvements were implemented, consistent with the findings stated in the CSRA (Mainstream Resources 1998). The following site-specific data summarize the extent of these habitat improvements (Table 3.1).

Project costs by component were as follows:

Project Management and Planning	200,000.00
Construction	
Gravel bars	189,235.00
Sediment removal	27,425.00
Bank stabilization	18,940.00
Channel manipulations	1,400.00
Monitoring and evaluation	250,000.00
Education	53,000.00
Ruby Creek Interpretive Center	27,000.00
Total Project Cost	$767,000.00

Table 3.1. Stream habitat improvement data, Big South Branch Pere Marquette River Demonstration Project.

Measure	Stream	Surface Area	Stream Order	Site (Date Const.)
Constructed riffle	Upper Freeman Cr.	3,333 sq. ft.	2nd	F-GB-1 (8/00)
Constructed riffle	Lower Freeman Cr.	9,697 sq. ft.	2nd	F-GB-2 (10/99)
Constructed riffle	Tank Creek	8,568 sq. ft.	2nd	T-GB-1 (3/00)
Constructed riffle	Ruby Creek	3,720 sq. ft.	2nd	R-GB-1 (5/00)
Constructed riffle	Upper Cedar Creek	13,150 sq. ft.	3rd	C-GB-1 (2/00)
Constructed riffle	Lower Cedar Creek	9,300 sq. ft.	3rd	C-GB-2 (11/01)
Constructed riffle	Big South Branch-1	9,744 sq. ft.	4th	MS-GB-1 (11/99)
Constructed riffle	Big South Branch-2	16,550 sq. ft.	4th	MS-GB-2 (1/00)
Sediment removal	Ruby Creek	900 sq. ft.	2nd	R-SR-1 (9/01)
Sediment removal	Winnepesaug Creek	14,239 sq. ft.	3rd	W-SR-1(10/99)
Sediment removal	Cedar Creek	20,250 sq. ft.	3rd	C-SR-1 (11/99)
Oxbow sediment Removal	Beaver Creek 1-3	2,806 sq. ft.	3rd	B-OD-1-3 (10/00)
Oxbow sediment Removal	Big South Branch	6,210 sq. ft.	4th	MS-OD-1 (10/01)
Large woody debris Additions	Winnepesaug Ck.-1	19,375 sq. ft.	3rd	W-HI-1 (4/00)
Large woody debris Additions	Winnepesaug Ck.-2	50,439 sq. ft.	3rd	W-HI-2 (4/00)
Channel Manipulations	Ruby Creek	1,380 sq. ft.	2nd	R-HI-1 (6/00)
Stream bank Stabilization	Cedar Creek (5)	6,726 sq. ft.	3rd	C-1-5 (6/01)
Stream bank Stabilization	Winnepesaug Ck. (3)	5,884 sq. ft.	3rd	W-4-7 (6/00)

3.1 Constructed Spawning Riffles

Spawning riffles (gravel bars) were constructed at eight locations within the Big South Branch Pere Marquette watershed. Design parameters and guidance for the construction of these gravel bars was provided by Chuck Bassett, US Forest Service Fisheries Biologist on the Hiawatha National Forest in Escanaba, Michigan. Mr. Bassett has been successfully constructing and evaluating gravel bars in Michigan’s upper peninsula streams over the past fifteen years.

The gravel bars are constructed by placing large volumes of screened, washed gravel (0.5” –3” diameter) and cobble (4”-8” diameter) in stream channels which lack sufficient spawning substrates (Figures 3.1, 3.2). All aggregate used should be round, not angular, in nature. The gravel and cobble should be carefully installed with heavy equipment (typically a hydraulic excavator and front-end loader) to a thickness of one to two feet (Figures 3.3, 3.4, 3.5).

Stream banks should be armored at the onset with cobble to prevent lateral excursion of the channel over time. This armor should extend both upstream and downstream of the gravel bar. Sills comprised of cobble should be placed several stream widths apart within the gravel bar to stabilize the introduced gravel. Site-specific spacing is dependant upon gradient and desired velocity. The downstream-most sill should be particularly well constructed so that head cutting at the upper end of the plunge pool does not ultimately compromise the gravel bar. The total length of stream manipulated as a result of gravel bar construction was estimated to be 2,407 feet or approximately 0.28% of the total stream length in the watershed (Table 3.2).

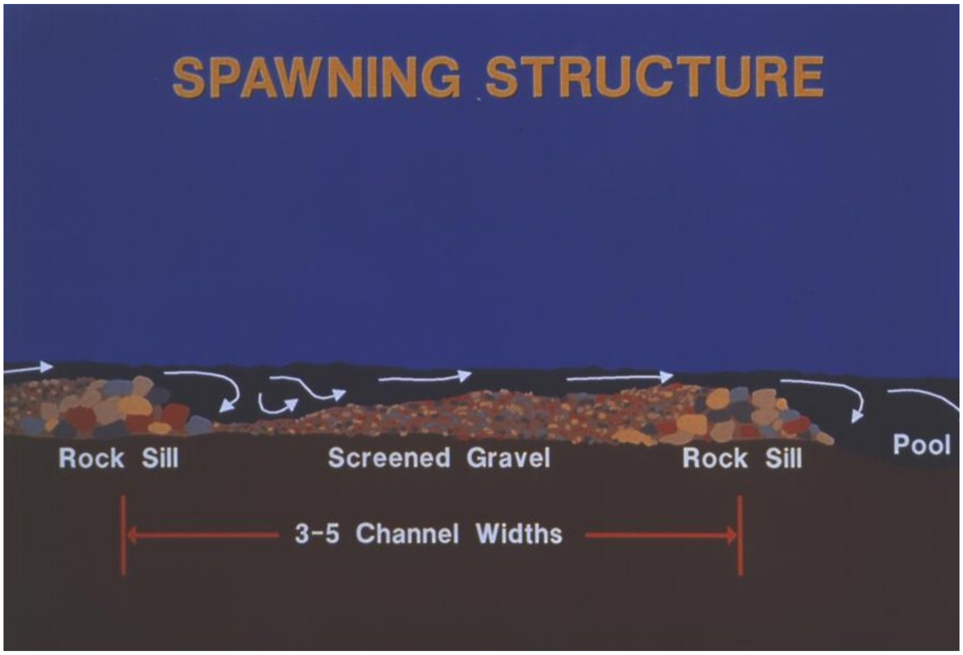

Figure 3.1. Longitudinal profile of a constructed spawning structure (Bassett 1999).

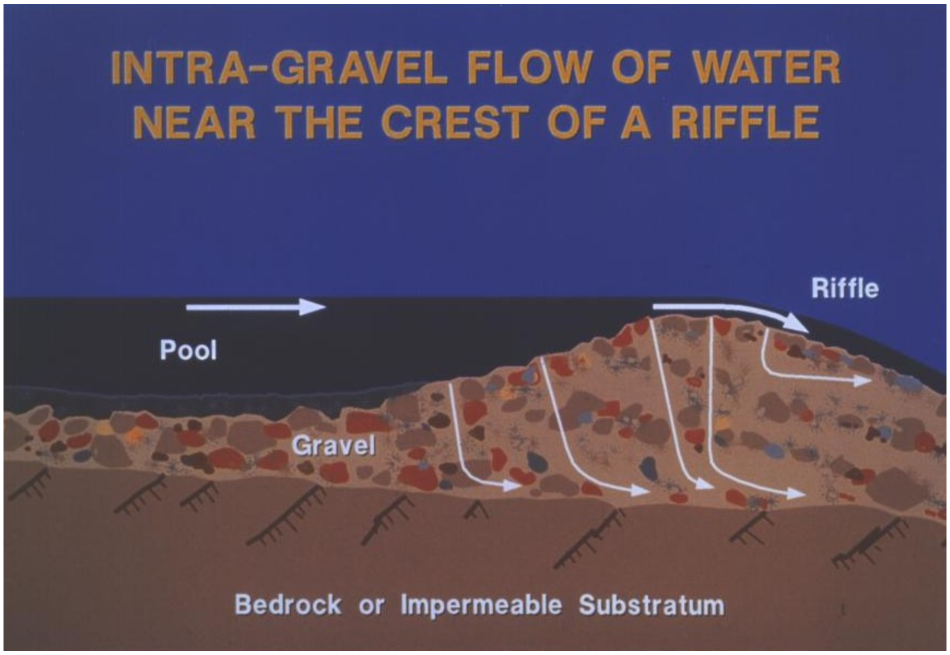

Figure 3.2. Depiction of intra-gravel flow within a riffle (Bassett, 1999).

Table 3.2. Lineal extent of stream manipulated by constructed gravel bars in the Big South Branch Pere Marquette River, Newaygo and Oceana Counties, Michigan.

Constructed Gravel Bars	River Length (ft)	Gravel Bar Lengths (ft)	Percent By Creek	Date Constructed
Tank Creek	38,527	357	0.93%	3/00
Big South 1	253,283	232	0.22%	11/99
Big South 2	--	331	--	2/00
Upper Cedar Creek	101,406	263	0.57%	3/00
Lower Cedar Creek	--	310	--	11/01
Upper Freeman Creek	81,547	303	0.81%	8/00
Lower Freeman Creek	--	363	--	10/99
Ruby Creek	33,198	248	0.75%	9/00
Balance of Watershed	348,755	--	--	
Total Watershed Length (ft)	856,716	--	--	
Total GB Length (ft)	--	2407		--
% Of Total Watershed	--	0.28%		--

Figures 3.3 and 3.4. Construction of Big South Branch Pere Marquette Station 1 (MS-GB-1)(top) and Tank Creek (T-GB-1)(bottom) gravel bars.

Figure 3.5. Placement of gravel during construction of Big South Branch Pere Marquette Station 2 (MS-GB-2) gravel bar.

3.2 Sediment removal

Sediment traps were installed upstream of the constructed riffles on Ruby, Winnepesaug, and Cedar creeks. These sediment traps were created by doubling the cross-sectional area of the stream channel via dredging (Avery 1996). This increase in cross-sectional area results in diminished velocities, which in turn, allows the bedload to settle out in the trap. As a result of intercepting this bedload, the reach of stream immediately downstream of the trap realizes improved habitat quality and productivity (Alexander and Hansen 1983).

3.2.1 Traditional sediment removal

The Ruby Creek sediment trap was constructed with a backhoe in September 2001 and has a total length of 45 feet and a storage capacity of approximately 60 cubic yards. This trap has been cleaned annually, each fall, since construction. The sediment trap is located approximately 220 feet upstream of the constructed gravel bar (R-GB-1) (T16N, R15W, Sec. 3NW).

3.2.2 Large scale sediment removal

The Winnepesaug and Cedar Creek sediment removal efforts were conducted on a considerably larger scale through the use of the Michigan Council of Trout Unlimited's Stream Sweeper™. This amphibious suction dredge enabled the removal of large volumes of sediment from both of these streams without disrupting the riparian zone.

Sediment was pumped approximately 800 feet to upland sites where it was fanned out over broad areas without the need for double or triple handing these spoils (Figures 3.6, 3.7).

Figures 3.6 and 3.7. The Stream Sweeper™ dredges sand (top) and pumps sediments approximately 800 feet to an upland site (bottom).

Figure 3.8. By moving the disposal pipeline at appropriate intervals, spoil can be deposited in thin veneers on the upland allowing for rapid revegetation.

Both the Winnepesaug and Cedar Creek sediment traps have not required maintenance dredging since their construction in October and November 1999, respectively. The Winnepesaug sediment trap is 491feet long and 29 feet wide (14,239 sq. ft.) and is located at T15N, R14W, Sec. 14. This basin has the capacity to store approximately 1,500 cubic yards of sediment.

The Cedar Creek sediment trap is located 650 feet upstream (T16N, R14W, Sec. 22) of the Upper Cedar Creek gravel bar and is 450 feet long 45 feet (20,250 sq. ft.). Wide. The sediment storage capacity of this trap is approximately 2700 cubic yards.

3.2.3 Oxbow Sediment Removal

Sediment traps were also constructed utilizing four cut-off oxbows within the Big South watershed. Three of these sediment traps were constructed on Beaver Creek and a fourth was constructed on the Big South Branch Pere Marquette River.

The Beaver Creek oxbow sediment traps are located south of 10 Mile Road, one mile west of Warner Road (T15N, R14W, Sec. 14NW). Oxbow A was dredged to a length of 26 feet and width of 30 feet (780 sq. ft.). Oxbow B was dredged to a length of 26 feet and a width of 23 feet (598 sq. ft.) and Oxbow C was dredged to a length of 32 feet and a width of 22 feet (704 sq. ft.).

The oxbow sediment trap on the Big South Branch is located approximately 0.25 miles downstream of the confluence of Winnepesaug and Beaver creeks (T15N, R14W, Sec. 11). The trap is 230 feet long and 40 feet wide (9200 sq. ft.). The three sediment traps on Beaver Creek and the Big South Branch were constructed in October 2000 and October 2001 respectively and have been monitored annually to determine their filling rates.

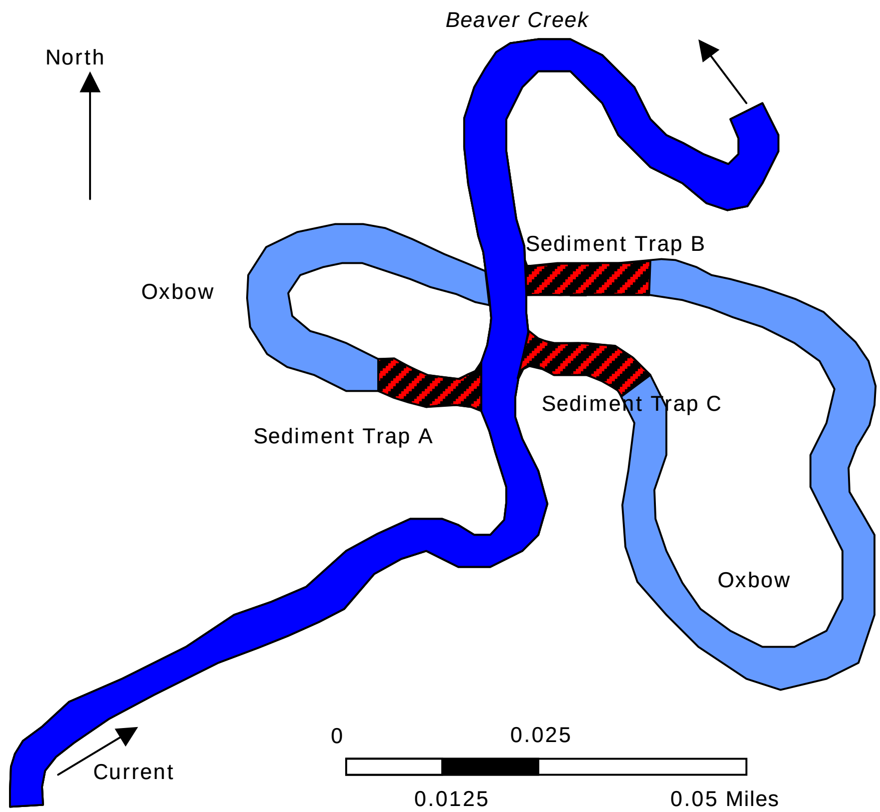

Figure 3.9. Schematic diagram of the three Beaver Creek oxbow sediment traps located immediately upstream of 10 Mile Road, Newaygo County, Michigan.

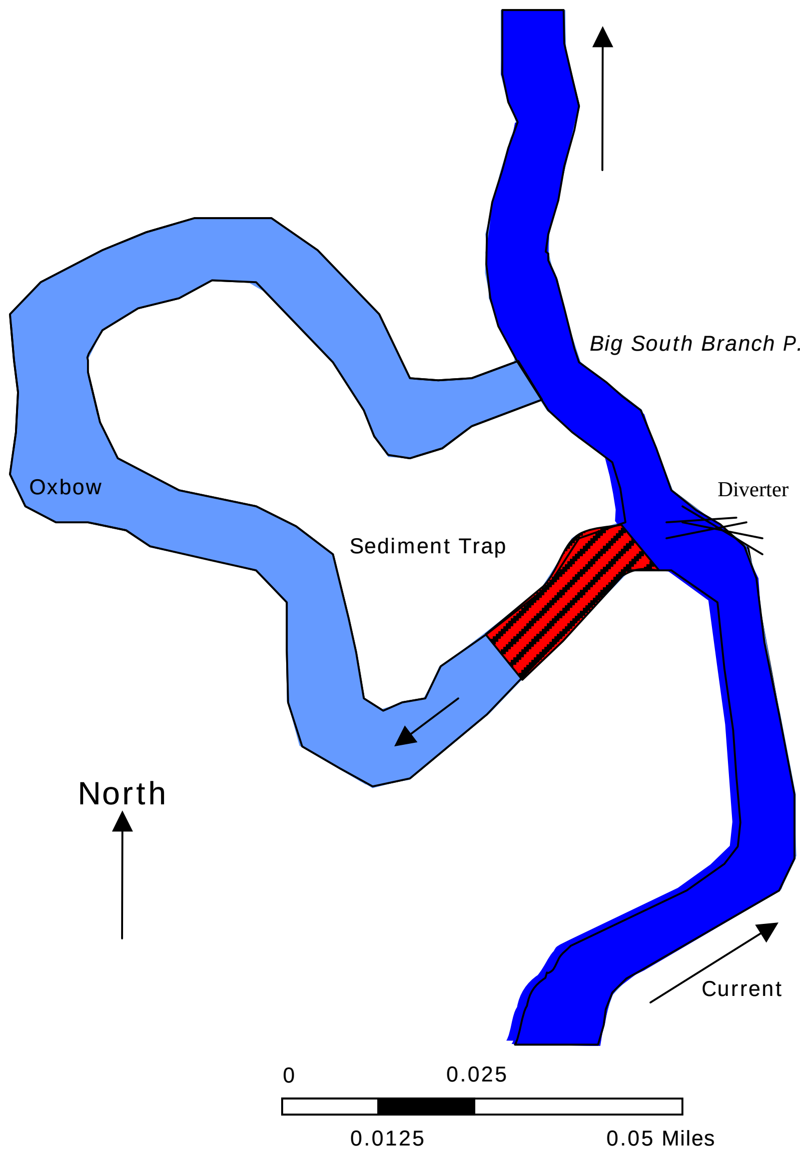

Figure 3.10. Schematic diagram of the Big South Branch Pere Marquette River oxbow sediment trap located downstream of the confluence of Beaver and Winnepesaug creeks, Newaygo County, Michigan.

Figure 3.11. Big South Branch Pere Marquette River oxbow in June 2003 looking west. At times of high water, flow is from foreground to background. The vegetation in the foreground cover sediment that was deposited during spring floods in 2002, while the fresh sand in the background accrued during spring 2003.

3.3 Large Woody Debris Additions

3.3.1 Winnepesaug Creek

Large woody debris was added at two Winnepesaug Creek locations in the form of whole trees. These additions of wood into the stream were undertaken in order to increase the amount of nursery habitat available for fingerling salmonids. It was hoped that this woody debris would also serve to narrow and deepen the channel through sediment deposition and bed scour. Winnepesaug Creek Habitat Improvement Site No. 1 (W-HI-1) is located T15N, R14W, Sec. 14. Winnepesaug Creek Habitat Improvement Site No.2 (W-HI-2) is located at T15N, R14W, Sec 11 SW 1/4, SE 1/4 immediately downstream of the Winnepesaug Creek natural riffle.

3.4 Channel Manipulations

3.4.1 Ruby Creek

Channel manipulations at Ruby Creek were completed in fall 2001 and is located in the northeast Oceana County, Michigan, seven miles north of the village of Walkerville, Michigan (Figure 1). The channel manipulation site is west of Forest Service Road 5148 at the Ruby Creek Interpretive Center (T16N, R15W, Sec. 3, Figure 1).

In order to improve channel morphometry, cobble was used to constrict the stream over an approximately 80 foot reach of Ruby Creek. Paired rock deflectors were used to scour pools and gravel was added to provide an improved substrate for macroinvertebrates and fish.

3.5 Stream Bank Stabilization

3.5.1 Cedar Creek

A total of five stream bank stabilization projects were carried out on Cedar Creek, in an area approximately two miles north of Wolgamot Corners on Osborn Road in Newaygo County. Four of the five Cedar Creek stream bank stabilization treatments were located immediately west of Osborn Road on private property (T16N, R14W, Sec. 23). The toe of each of these banks was stabilized with fieldstone, while the upper bank was terraced with red pine stop logs, seeded and brushed-in (Figure Nos. 3.12 and 3.13).

The fifth stream bank treatment site was located approximately one mile west of Osborn Road on U.S. Forest Service property (T16N, R14W, Sec. 15/22). This bank was treated in this same manner.

Stabilization of the stream banks at Cedar Creek was accomplished through a combination of traditional and biotechnical measures. The toe of the bank was secured, in each instance, with fieldstone. Following stabilization of the toe, soil was moved over the top of the rock to the normal waterline to facilitate revegetation. Wooden stakes were then used to secure red pine logs in a terrace-like fashion on the upper slope. These logs serve to collect leaf litter, secure brush, reduce slumping and restrict foot traffic on the bank. Adapted grasses (big bluestem, little bluestem, tall fescue and creeping red fescue) were seeded on all slopes and sod from the local landscape was placed in critical portions of the slope to accelerate the revegetation process. Shrubs such as willows, ninebark, black locust, red osier dogwood, and silky dogwood were planted as either bare-root stock or cuttings in order to reestablish woody vegetation on these banks.

Figures 3.12. and 3.13. Streambank stabilization at Cedar Creek before (top) and after (bottom) using a combination of traditional and soft treatments.

3.5.2 Winnepesaug Creek

Streambank stabilizations were carried out at three locations on Winnepesaug Creek. All three stream treatments were located 3.5 miles east of the community of Volney, 0.5 miles south of 10 Mile Road in Newaygo County, Michigan (T15N, R14W, Sec.14) and were accomplished with bioengineering techniques.

Stabilization of the stream banks at Winnepesaug Creek was accomplished by securing the toe of the bank with whole pine tree revetments. Wooden posts were then used to secure red pine logs in a terrace-like fashion on the upper slope. These logs served to collect leaf litter, provide shading, reduce slumping and restrict foot traffic on the bank. Adapted grasses (big bluestem, little bluestem, tall fescue and creeping red fescue) were planted on all slopes and sod from the local landscape was placed in critical portions of the slope to accelerate the re-vegetation process. Shrubs such as willows, ninebark, black locust, red osier dogwood, and silky dogwood were planted as either bare-root stock or cuttings in order to reestablish woody vegetation on these banks. In the instance of the bank shown in Figure Nos. 3.14 and 3.15, once the slope was stabilized, native vegetation reestablished rather quickly.

Figures 3.14. An eroding Streambank on Winnepesaug Creek prior to receiving bioengineering (soft) stabilization treatments.

Figures 3.15. Winnepesaug Creek stream bank after receiving bioengineering (soft) treatments. Note the native vegetation which has established on the upper slope.

4.0 MONITORING METHODS

4.1 Temperature and Water Chemistry

Water temperature recording devices were placed at eleven locations throughout the watershed. Temperatures were measured with HOBO® data loggers using one-hour recording intervals. The HOBO®s were downloaded twice annually to a laptop computer and the data were manipulated using an Excel® spreadsheet.

Water samples were collected from twelve stations located throughout the watershed at the onset (October 1998) and conclusion (July 2002) of the study to detect any remarkable changes in water chemistry conditions. Water samples were collected within a six-hour period in the field iced and transported immediately to the Michigan Water Research Institute for lab analysis. The Institute analyzed these samples for the following parameters: nitrate-nitrogen, total phosphorus, soluble reactive phosphorus, turbidity, total dissolved solids. The following parameters were measured in the field with standard Hach kit and an automated water sampler: pH, alkalinity, conductivity, dissolved oxygen and total hardness.

4.2 Stream Channel Morphometry

Monumented survey stations were constructed at each sediment removal and constructed spawning riffle site for purposes of measuring changes in channel morphometry. These monuments were constructed encasing a 4' section of 5/8" diameter steel rebar in a 4" diameter concrete filled PVC pipe. Each monument was installed within the floodplain above top-of-bank. Duplicate benchmarks were established at each monument in order to establish reference elevations for the long-term measurement of stream channel morphometry.

Stream channel cross-sections were surveyed annually at each of the sediment removal and constructed spawning riffle sites, beginning in the summer of 1999 and continuing through the summer of 2002, in order to track changes in channel morphometry. Elevations were recorded at one-foot intervals across the stream channel using a surveyor's transit. Velocity data were also recorded at one-foot intervals across the channel using a Marsh-McBirney Flo-Mate® Model 2000 portable current meter. Discharge estimates were calculated annually at each transect was using these channel cross-section and velocity data.

These data were used to map channel cross-sections at each transect in order to determine changes in channel cross-section over time.

4.3 Macroinvertebrate Monitoring

Aquatic macroinvertebrates were quantitatively sampled annually at eight constructed riffles (C-GB-1, C-GB-2, F-GB-2, MS-GB-1, MS-GB-2, R-GB-1, T-GB-1, W-NGB) from 1999 through 2002. This procedure was chosen to evaluate aquatic macroinvertebrate communities within and upstream of the constructed riffles because aquatic macroinvertebrates are good indicators of localized water quality conditions due to their limited migration patterns and life cycles of one to three years generally.

At each sampling location a total of fourteen substrate cores were collected using an acrylic coring device with a diameter of 125 mm (Figure 4.1). All cores were extracted from a depth of 100 mm. Seven cores were collected across the channel in a stratified-random fashion within the constructed riffle (gravel treatment samples) at each site. An additional seven cores were collected upstream of the constructed riffles at each site in natural substrates (upstream control).

All core samples were placed in re-sealable plastic containers, preserved with denatured ethanol and transported immediately back to the lab. In the lab each sample was immediately examined and additional preservative was added, as needed. The macroinvertebrates were hand sorted from the sediments with dissecting microscopes in the lab. All macroinvertebrates were identified to the lowest possible taxon (Merritt and Cummins 1996, McCafferty1983).

Concurrent with the collection of these macroinvertebrate cores, duplicate sediment cores were collected for purposes of analyzing the epilithic and detrital components of the sediments. This work was conducted by graduate students at Central Michigan University under the direction of Dr. Donna King. Additional information regarding these studies is included in section 5.1.3 of this report.

Figure 4.1. Sediment cores being taken at Cedar Creek, Newaygo County, Michigan, July 2002.

4.4 Spawning observations

Spring and fall redd surveys (spawning observations) were conducted in order to develop an index of anadromous salmonid spawning activity at each of the constructed riffles and at three reference riffles within the Big South Branch watershed. Weekly spawning observations were initiated in early February and continued through early May to monitor spring steelhead (*Oncorhynchus mykiss)* runs. Fall Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kitusch*) and brown trout (*Salmo trutta*) spawning observations were conducted weekly from early September through mid-December.

A variety of data were systematically recorded during each observation. The locations of spawning salmonid adults were recorded, together with the size and location of each observable spawning bed (redd). This information was recorded on data sheets and also on scaled maps of the riffle areas. Redds were separated into three categories:

- Active Redds – Redds that had fish present on them during the spawning observation.

- Active Redds without fish – Redds that showed freshly worked gravel, but did not have fish present on them during the current observation. These redds did have fish on them during the previous week's observation.
- Inactive Redds - Redds where the gravel still appeared "worked", but without visual confirmation of a spawning fish using the redd for more than a 7 day period.

The areal extent of disturbed gravel associated with each redd was estimated from mapping data. The cumulative area disturbed by spawning fish was calculated for each riffle (species-specific) annually and compared across all samples.

4.5 Electrofishing Surveys

Electrofishing surveys were conducted annually in May and June in order to develop an index of anadromous salmonid fingerling production at eight constructed riffles and four reference sites. One-pass electrofishing surveys were carried out using either a Smith-Root Backpack Electrofishing Units (Figure 4.2) or a Smith-Root stream boat Shocker (230 volts AC) and a crew of four technicians. Survey work was accomplished by sweeping the entire 1000-foot reach in synchrony, progressing upstream from the downstream limit of the sample site. Fish collected during the survey (Figure 4.3) were placed in a flow-through reservoir and processed periodically to reduce mortality. Each fish was measured (total length) to the nearest millimeter, and weighed to the nearest gram using an Ohaus electronic scale. Length-frequency relationships were used to establish age classes for salmonids. Scales samples were also collected.

Figure 4.2. An electrofishing survey crew utilizing two backpack units on Ruby Creek, Oceana County, Michigan.

Figure 4.3. Fingerling steelhead collected during the 2001 electrofishing survey on Cedar Creek, Newaygo County, Michigan.

4.6 Habitat Mapping

Instream habitat characteristics were recorded along 30 and 100 foot-wide transects at selected riffle, sediment removal and habitat improvement sites. At each site, the transects were located at the pre-established survey monuments. The instream habitat along each transect was quantified and mapped.

5.0 RESULTS AND DISCUSSION

5.1 AQUATIC MACROINVERTEBRATES

5.1.1 Macroinvertebrate Density

Quantitative macroinvertebrate density estimates (number per square foot) were calculated at each constructed gravel bar area prior to and after their construction. Macroinvertebrates were generally found to be present in greater densities within the constructed gravel bar reaches (i.e. treatments) than in the natural sediments (i.e. controls) at most locations (Figures 5.1-5.8). The streambed types (substrates) in the Big South Branch and its tributaries are dominated by sand, which is not as desirable for macroinvertebrates, as the gravels, which were added to promote spawning success by salmonids.

Remarkable increases in density had occurred at four of the constructed gravel bar sites by spring 2002 (Table 5.1). Tank Creek showed a 4.9% increase in aquatic macroinvertebrate density, Upper Cedar Creek a 73% increase, MS-GB-1 a 113% increase, and MS-GB-2 a 186% increase in macroinvertebrate densities over the 1999 values (preconstruction).

Increases in macroinvertebrate densities were not observed at all sites. Lower Freeman Creek, and Ruby Creek displayed decreases in density of 75% (Figure 5.6) and 52% (Figure 5.4) respectively, after the construction of the gravel bars. While the density estimates for the gravel bar sediments are higher than the controls at these two sites, all values were lower in 2002 than in 1999. Both of these gravel bars were inundated with sand during 2001, which probably accounts for some of the observed reduction in macroinvertebrate densities.

Table 5.1. Macroinvertebrate densities (numbers / square foot ±1 SD) from the constructed gravel bars within the Big South Branch Pere Marquette River and local tributaries. Preconstruction values are indicated here with italics.

	Treatment			
	1999	**2000**	**2001**	**2002**
Ruby	*496.45 +/- 41.56*	1253.44 +/- 98.24	318.99 +/- 28.95	242.26 +/- 20.74
Lower Freeman	*2222.74 +/- 378.50*	956.93 +/- 199.99	1053.55 +/- 119.11	576.98 +/- 34.40
Tank	*675.22 +/- 91.55*	586.16 +/- 104.59	325.89 +/- 40.42	708.50 +/- 73.29
Upper Cedar	*1082.29 +/- 192.91*	3089.81 +/- 338.88	283.64 +/- 26.50	1869.15 +/- 127.21
Lower Cedar	--	--	*587.12 +/- 178.11*	570.74 +/- 69.62
Big South - 1	*361.84 +/- 68.69*	912.77 +/- 135.72	1651.89 +/- 198.31	772.49 +/- 115.46
Big South - 2	*312.30 +/- 40.40*	661.87 +/- 73.65	481.08 +/- 65.48	894.05 +/- 69.60

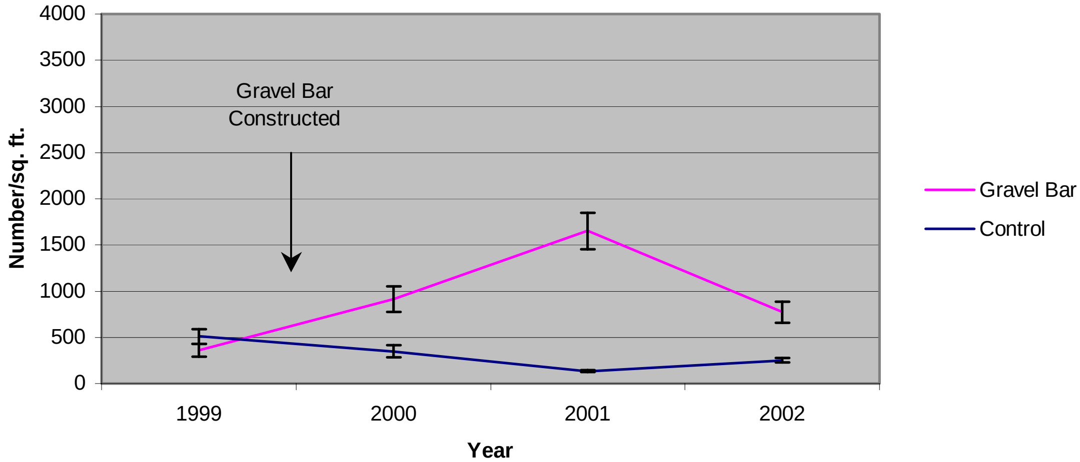

Figure 5.1 Macroinvertebrate densities (numbers / sq. ft. +/- 1SD) at the Big South Branch Station 1, Newaygo County, Michigan.

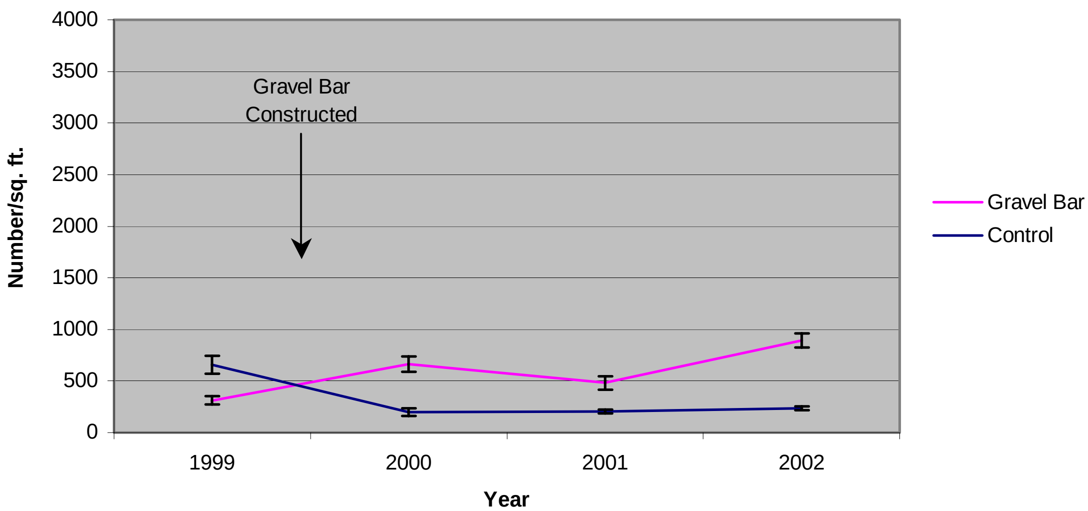

Figure 5.2 Macroinvertebrate densities (numbers / sq. ft. +/- 1SD) at the Big South Branch Station 2, Newaygo County, Michigan.

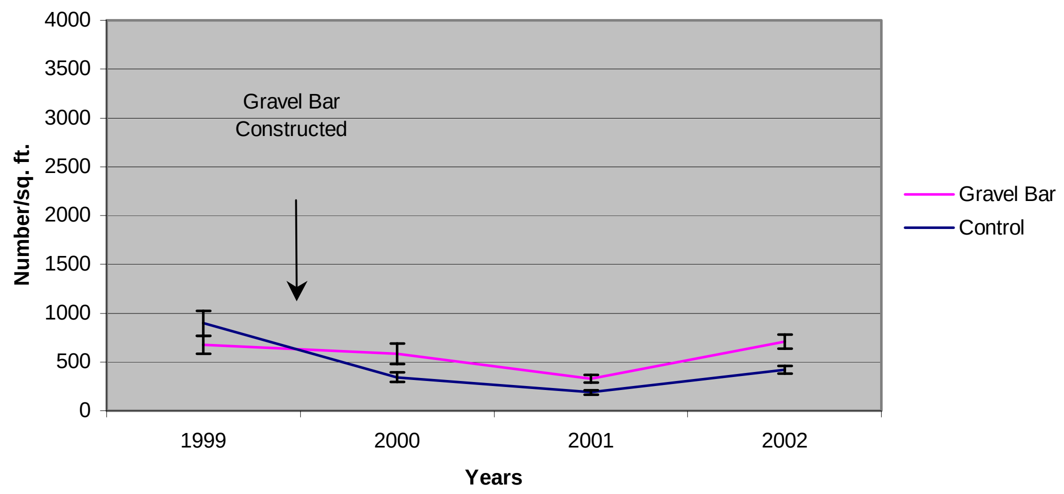

Figure 5.3 Macroinvertebrate densities (numbers / sq. ft. +/- 1SD) at Tank Creek, Newaygo County, Michigan.

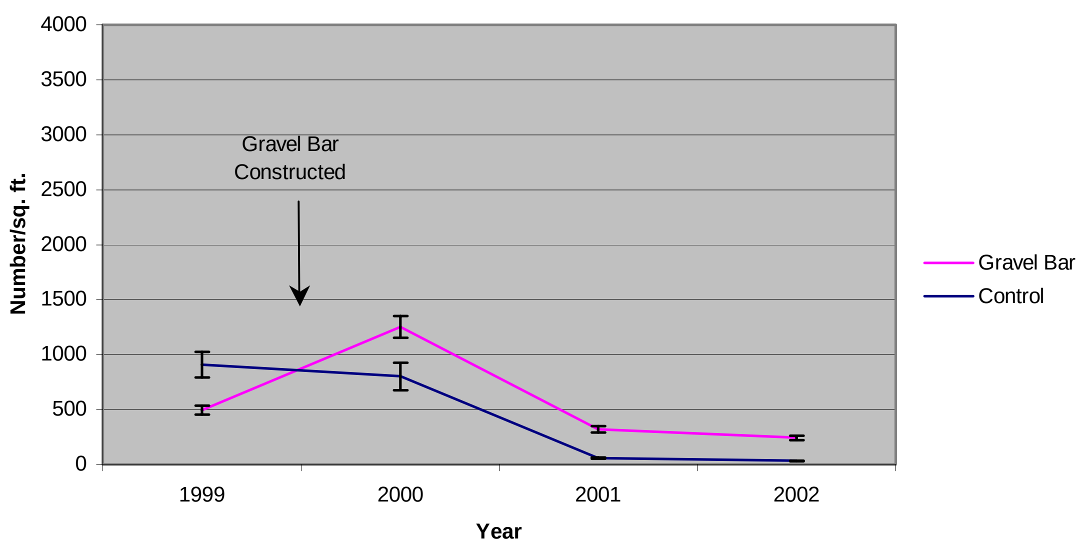

Figure 5.4 Macroinvertebrate densities (numbers / sq. ft. +/- 1SD) at Ruby Creek, Oceana County, Michigan.

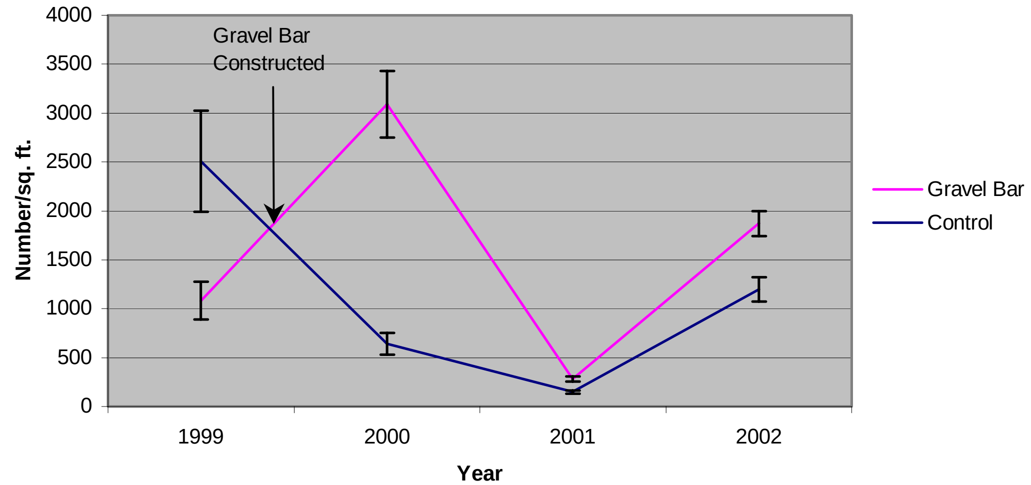

Figure 5.5 Macroinvertebrate densities (numbers / sq. ft. +/-1SD) at Upper Cedar Creek, Newaygo County, Michigan.

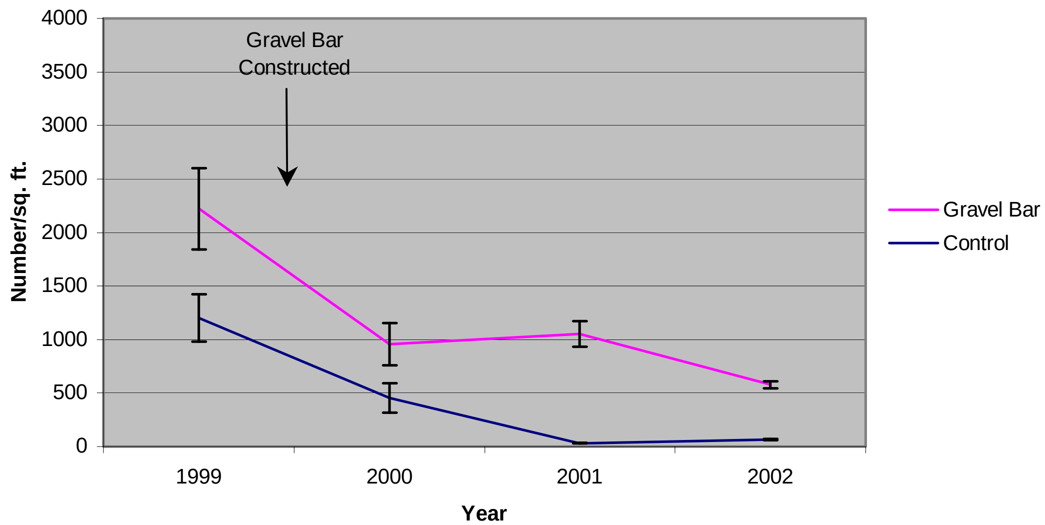

Figure 5.6 Macroinvertebrate densities (numbers / sq. ft. +/- 1SD) at Lower Freeman Creek, Newaygo County, Michigan.

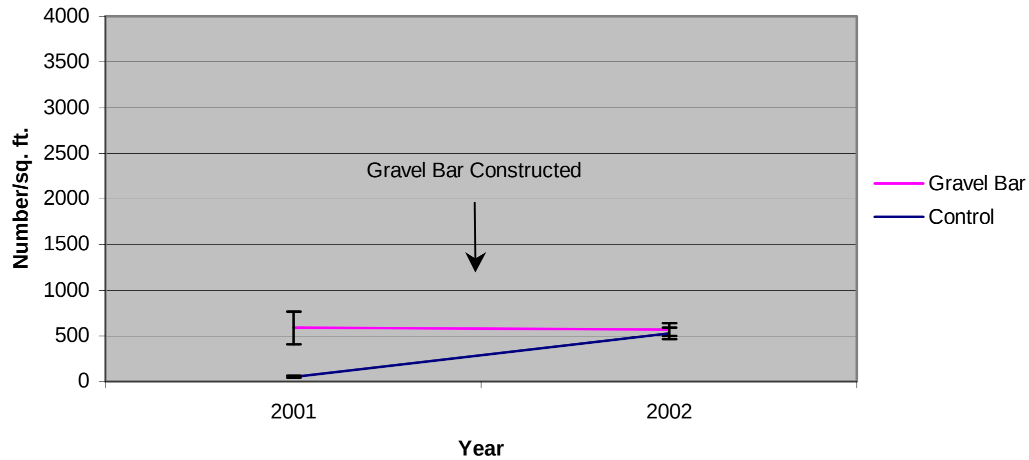

Figure 5.7. Macroinvertebrate densities (numbers / sq. ft. +/- 1SD) at Lower Cedar Creek, Newaygo County, Michigan.

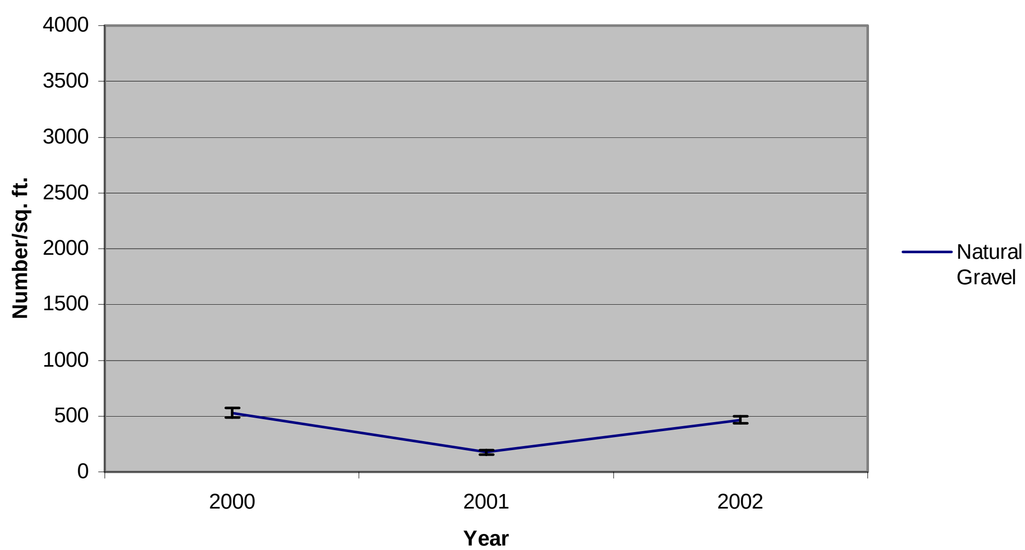

Figure 5.8 Macroinvertebrate densities (numbers / sq. ft. +/- 1SD) at Winnepesaug Creek, Newaygo County, Michigan.

The Lower Freeman Creek riffle has a sediment trap immediately upstream of the gravel bar. This trap was very effective at trapping sand, however, a dam failure in 2001 on private property, approximately one mile upstream, caused excessive sand bedload to move rapidly downstream. Sand filled the sediment trap quickly and continued downstream completely covering the gravel bar with several inches of sand. This catastrophic event would explain the lower densities in 2001 and 2002 at Freeman Creek.

Ruby Creek did not have a sediment trap in place when the gravel bar was constructed. In 2001, about one year after construction, the gravel bar at Ruby Creek was approximately 80% covered by a thin layer of sand. A small sediment trap was constructed about 200 yards upstream of the gravel bar on Ruby Creek in 2001. By spring 2002, most of the sand on the gravel bar had been transported downstream by the water current. Although most of the sand had been removed from the gravel bars at these two sites by the spring 2002 macroinvertebrate sampling date, the macroinvertebrate communities had not yet completely recovered.

5.1.2 Macroinvertebrate Types

The gravel bars (i.e., treatments) had a higher number of different macroinvertebrate taxa after construction than the sandy substrates (i.e., controls) (Table 5.2). The gravel bars ranged from 12 to 26 taxa per site while the control (sandy) sediments ranged from 7 to 16 taxa with the natural substrate ranging from 19 to 24 taxa. The data indicate that gravels added at gravel bars can support higher macroinvertebrate diversities than the sandy substrates, but are similar to the reference (natural) gravel bar at Winnepesaug Creek. The additional taxa observed in the gravel bar substrates include mayflies (Ephemeroptera), caddisflies (Trichoptera), stoneflies (Plecoptera), hellgrammites (Megaloptera), and riffle beetles (Coleoptera), which are forage for fish.

Table 5.2. Macroinvertebrate species composition (number of taxa) within the natural (Winnepesaug Cr.), control, and constructed gravel bar sections of the Big South Branch during 1999-2002. Gravel bars were constructed between the 1999 and 2000 sampling dates, with the exception of Lower Cedar. Italicized, bolded values were data taken prior to construction.

	1999		**2000**		**2001**		**2002**	
Location	**Control**	**Const.**	**Control**	**Const.**	**Control**	**Const.**	**Control**	**Const.**
Winnepesaug (Reference)	--		24		21		19	
Ruby	***22***	***20***	17	25	7	23	7	19
Lower Freeman	***20***	***18***	8	15	9	24	9	21
Upper Cedar	***17***	***18***	13	20	8	20	14	20
Lower Cedar	**--**	**--**	--	--	***9***	***10***	16	17
Big South #1	***19***	***18***	11	20	14	17	10	18
Big South #2	***20***	***22***	11	16	11	21	10	26
Tank	***18***	***17***	16	12	14	22	12	25

5.1.2.1 Upper Cedar Creek

The Upper Cedar Creek sediments had a macroinvertebrate species composition of 18 taxa in 1999 (pre-construction). The five dominant taxa consisted of Chironomidae (79%), Amphipoda (6%), Oligochaeta (5%), Brachycentridae (2%) and Tipulidae (1%) (Figure 5.9a). The "Other" category consisted of 13 taxa, which were found at low occurrences (less than 1% of the total sample). A list of t taxa collected at C-GB-1 can be found in Appendix B1.

In 2000 the species composition at this site increased to twenty taxa with the structure of the dominant macroinvertebrates starting to change (Figure 5.9b). Chironomidae were reduced to 55% of the total collection with, two taxa of Trichopterans (Hydropsychidae, 35% and Glossosomatidae 1%) now comprising 36% of the organisms collected during 2000. Ephemeropterans also started to colonize this site with the presence of Baetidae (3%).

In 2001 the species composition at Upper Cedar Creek remained steady at twenty taxa. Eight taxa were found making up more than one percent of the total sample (Figure 5.9c). The dominant taxa also changed from Chironomidae in 1999 and 2000 to Isopoda, which comprised 52% of the sample. The Chironomidae comprised 15% of the sample and was second most dominant taxa. The Trichopterans and Ephemeropterans found remained similar to the 2000 taxa numbers, however the family Ephemerellidae was identified, while no Baetidae were found in 2001.

The 2002 sample species indicated the presence of 20 taxa (Table 5.2), with Isopoda decreasing to 35% of the total sample and Chironomidae increasing to 20% (Figure 5.9d).

The macroinvertebrate community is exhibiting an increase in species composition (from 18 to 20 taxa) over the four-year study period. The community shifted from one that was almost strictly Dipteran dominated (80%) in 1999 to a more diverse assemblage that is made up of four taxa, which comprise 78% of the community (Figure 5.9).

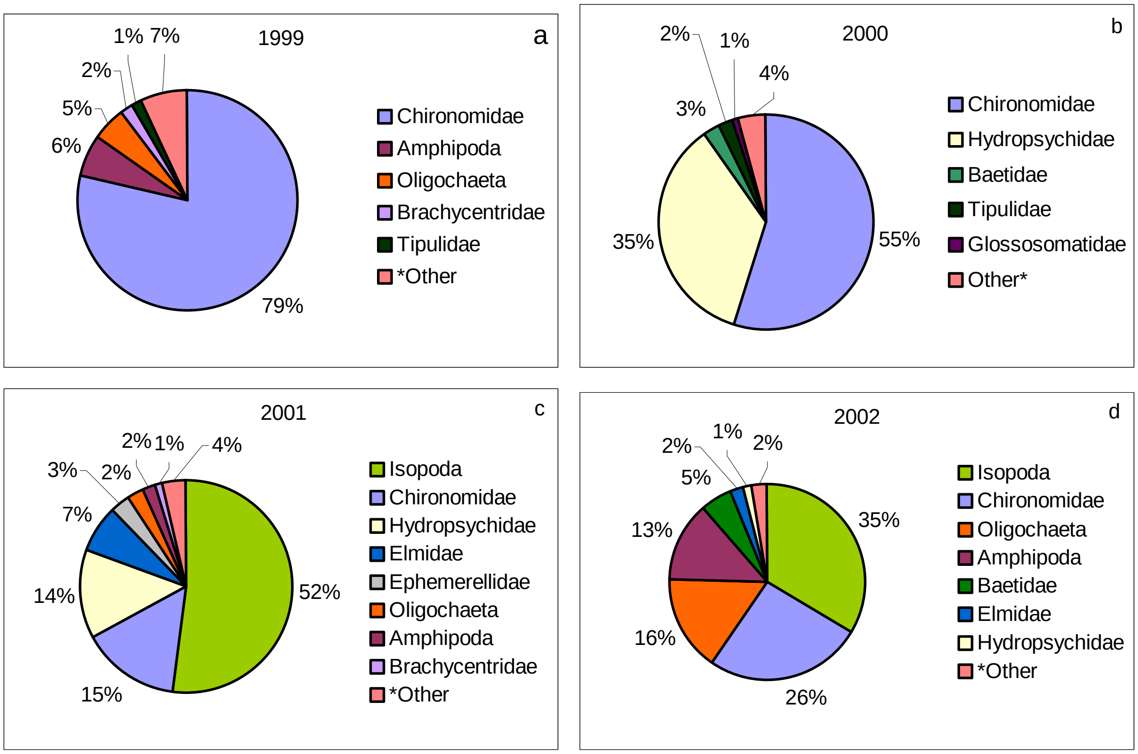

Figure 5.9. Macroinvertebrate species composition of Upper Cedar Creek gravel bar (C-GB-1) Newaygo County, Michigan.

5.1.2.2 Lower Cedar Creek

The Lower Cedar Creek sediments had a macroinvertebrate species composition of 10 taxa in 2001 (pre-construction) dominated by the two taxa of Diptera, the families Chironomidae and Simulidae, which made up 98% of the total sample (Figure 5.10a). A list of the taxa found at this site is provided in Appendix B2.

In the 2002 sample at this site, species composition increased dramatically from ten to eighteen taxa following gravel bar construction (Figure 5.10b). The dominant taxon was the dipteran Chironomidae, which was reduced from 97% in 2001 to 58% in 2002.

Increases in species diversity at this site over time indicate an improvement in substrate quality. The macroinvertebrate community at this site has shifted very rapidly from a dipteran dominated community to one made up of Hydropsychidae (9%), Isopoda (9%), Amphipoda (8%), Baetidae (8%), Elmidae (2%), Oligochaeta (1%) and Glossosomatidae (1%).

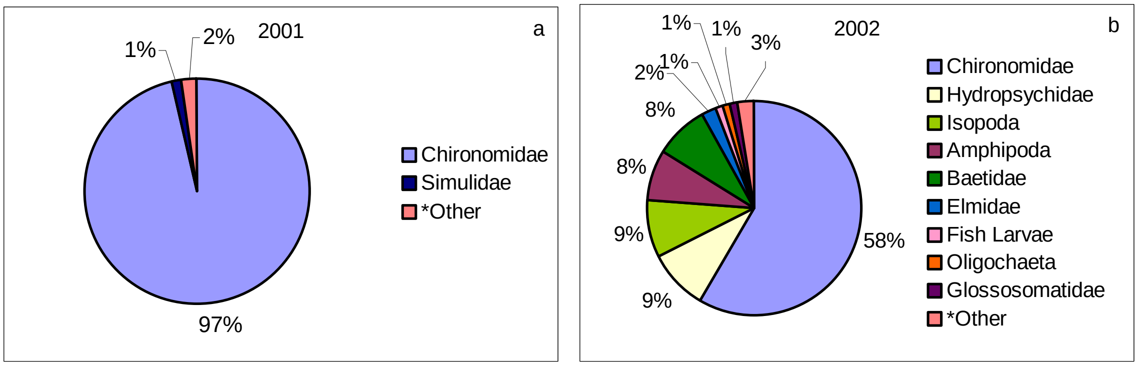

Figure 5.10. Macroinvertebrate species composition of Lower Cedar Creek gravel bar (C-GB-2) Newaygo County, Michigan.

5.1.2.3 Tank Creek

Seventeen taxa were observed in the 1999 (pretreatment) macroinvertebrate sample (Table 5.2) with the dominant taxa being Amphipoda (47%) and Chironomidae (32%), Elmidae (9%), Ceratopogonidae (2%), Brachycentridae (2%), Baetidae (1%), Ephemeridae (1%) and Athericidae (1%) (Figure 5.11a). A list of the taxa identified in the Tank Creek samples can be found in Appendix B3.

Species composition decreased during the summer of 2000 falling to twelve taxa. Amphipoda increased to 64% of the sample, while Chironomidae decreased to 21%. Other dominant taxa include Hydropsychidae (4%), Heptageniidae (3%), Gastropoda (2%), Baetidae (2%) and Tipulidae (2%) (Figure 5.11b). Five taxa made up the remaining two percent of the total catch.

In the 2001 samples the species composition (Table 5.2) (Figure 5.11c) increased to twenty-two taxa. Chironomidae made up seventy-one percent of the total macroinvertebrates collected in this sample, while Heptageniidae (7%), Hydropsychidae (3%), Philopotamidae (3%), Oligochaeta (2%), Elmidae (2%), Ephemerellidae (2%), Cheumatopsychidae (2%), Amphipoda (1%) and Gastropoda (1%) composed the remainder of the dominant taxa..

A total of twenty-five taxa were identified in the 2002 sample. Of these twenty-five taxa, eight were dominant with Chironomidae comprising 65% of the sample. The remaining six dominant taxa consisted of Amphipoda (15%), Elmidae (4%), Philopotamidae (3%), Leptophlebidae (3%), Baetidae (2%), Perlidae (1%) and Oligochaeta (1%) (Figure 5.11d).

Species composition at the Tank Creek gravel bar has increased from 17 to 25 over this four-year period. The most significant shift in the macroinvertebrate communities was the increasing presence of the family Chironomidae and decreasing numbers of amphipods. The presence of the stonefly family Perlidae in the 2002 sample is noteworthy.

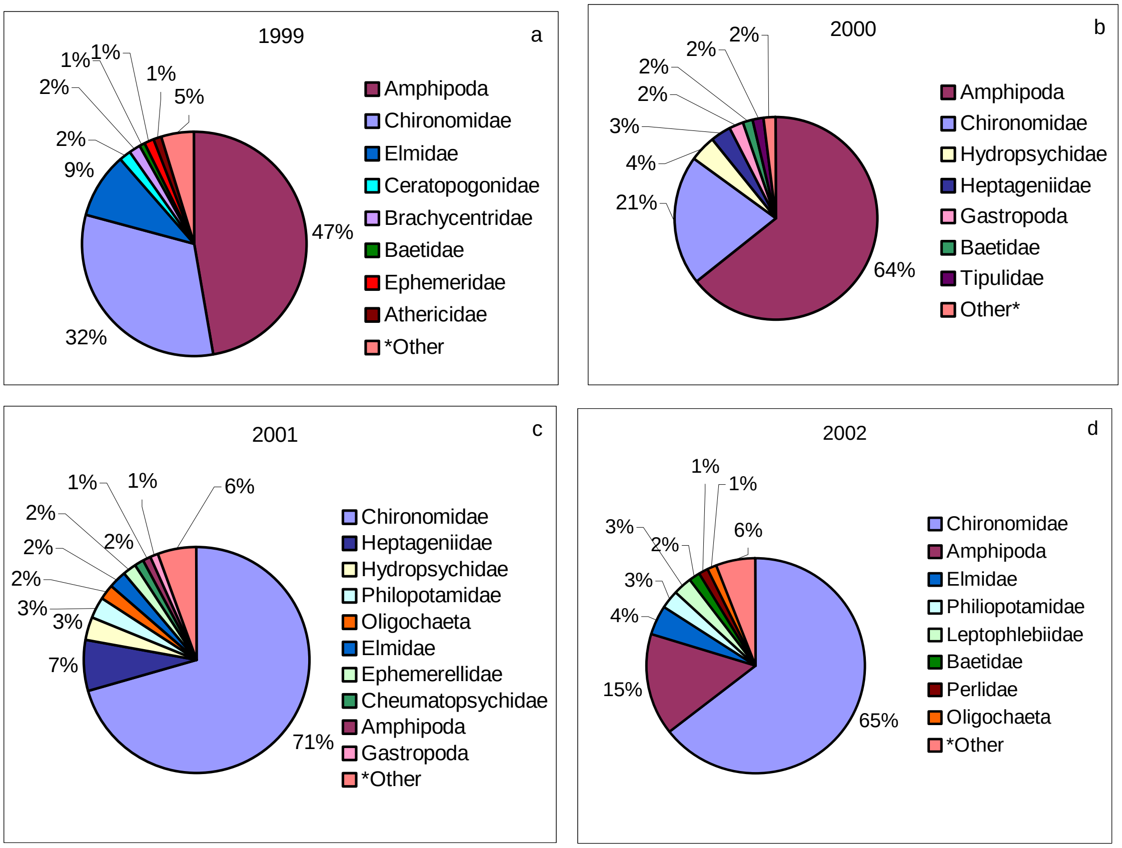

Figure 5.11. Macroinvertebrate species composition of Tank Creek gravel bar (T-GB-1), Newaygo County, Michigan.

5.1.2.4 Lower Freeman Creek

Eighteen taxa were found at the Lower Freeman Creek gravel bar in the 1999 (preconstruction) sample (Table 5.2). Three taxa dominated the macroinvertebrate sample: Chironomidae (71%), Diptera (22%) and Brachycentridae (3%) (Figure 15.12a)

Following construction of the gravel bar in the fall of 1999, the insect community began to become more diverse (Figure 5.12b). Chironomidae still dominated the collection comprising 83% of the total collection, followed by Amphipoda (4%), Elmidae (4%), Tipulidae (3%), Hydropsychidae (1%), Heptageniidae (1%) and Baetidae (1%).

Twenty-four taxa were collected in the 2001 sample. Chironomidae decreased from the previous year by 30%, making up 53% of the total collection. Hydropsychidae and Tipulidae both increased to 14% of the total sample followed by Elmidae (9%), Ephemerellidae (4%) and Helicopsychidae (1%) (Figure 5.12c). (Appendix B4).

During the 2002 field season twenty-one taxa were collected (Table 5.2). The most abundant taxa, Chironomidae was reduced in occurrence (41%) while the other taxa present were Elmidae (22%), Hydropsychidae (13%), Baetidae (11%), Amphipoda (4%), Heptageniidae (2%), Helicopsychidae (2%), Limnephilidae (1%) and Brachycentridae (1%).

The macroinvertebrate community at the Lower Freeman Creek gravel bar shows a shift from a dipteran (Chironomidae and others) dominated community in 1999 to a more diverse community over this four-year period. During 2000, Trichopterans (Hydropsychidae), Ephemeropterans (Heptageniidae and Baetidae) and Coleopterans (Elmidae) start to increase in occurrence. This is a function of the increase in habitat quality as a result of the addition of gravel and cobble to construct the gravel bar. The shift in the insect community is positive in the respect that these constructed gravel bars are able to provide the forage base necessary for juvenile salmonids during the early stages of their life cycle following emergence.

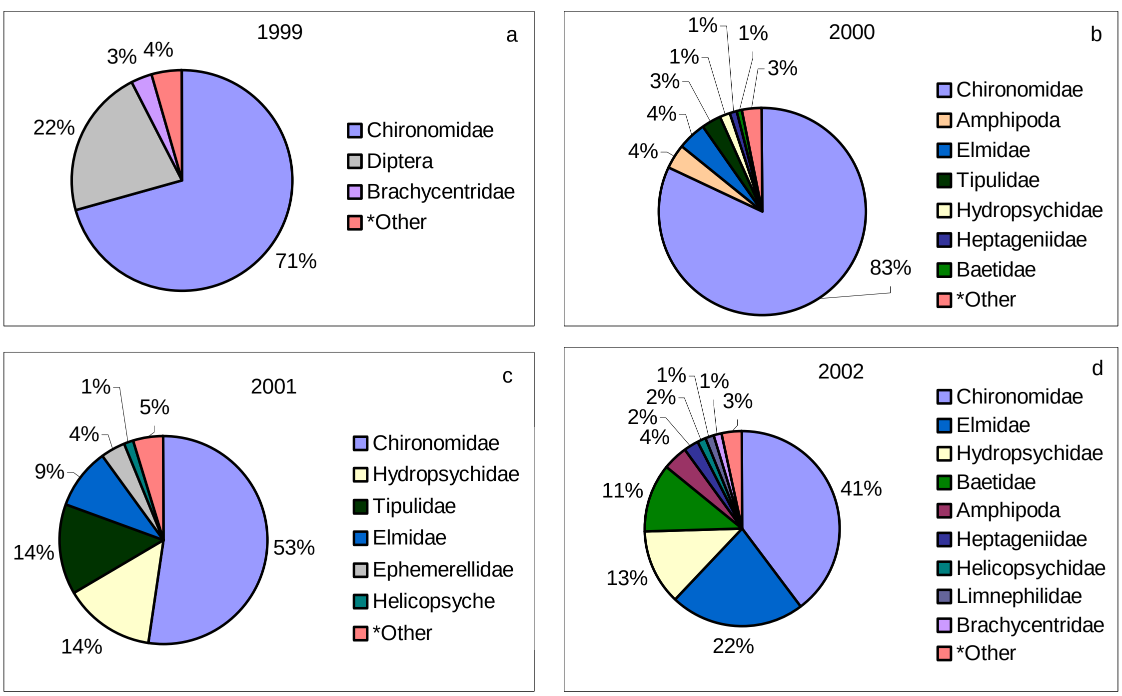

Figure 5.12. Macroinvertebrate species composition of Lower Freeman Creek gravel bar (F-GB-2), Newaygo County, Michigan.

As previously noted, a dam failure upstream of the gravel bar occurred in April 2001. An excessive sand bedload smothered the lower Freeman gravel bar prior to collection of the 2001 samples and the macroinvertebrate community continued to be impacted in 2002.

5.1.2.5 Ruby Creek

Twenty taxa were collected at Ruby Creek in the 1999 macroinvertebrate sample, of which eight were found to be dominant (Table 5.2)(Figure 5.13a). The dominant taxa were Chironomidae (46%), Elmidae (30%), Amphipoda (8%), Trichoptera (4%), Diptera (3%), Glossosomatidae (3%), Brachycentridae (1%) and Hydropsychidae (1%) with the remaining twelve taxa comprising 4% of the total collection each (Figure 5.13a).

Six taxa were found to be dominant out of the twenty-five collected in 2000 (Figure 5.13b) These taxa were: Chironomidae (42%), Elmidae (20%), Amphipoda (12%), Glossosomatidae (9%), Hydropsychidae (3%) and Tipulidae (1%) . The sample was collected immediately shortly after the gravel bar was constructed.

Chironomidae occurrence in the 2001 sample had increased to 53%. The remaining taxa included: Glossosomatidae (10%), Ephemerellidae (5%), Elmidae (5%), Heptageniidae (4%), Hydropsychidae (3%), Nemouridae (3%), Tipulidae (3%), Limnephilidae (3%), Oligochaeta (2%), Leuctridae (2%), Nematoda (1%), Simuliidae (1%) (Figure 5.13c). In 2001 the Ruby Creek gravel bar was approximately 80% covered by a thin layer of sand. This sand suppressed aquatic macroinvertebrate diversity. A small sediment trap was constructed about 200 yards upstream of the gravel bar in the fall of 2001.

The 2002 collection was found to be similar to the 2001 collection with 13 dominant taxa out of 19 total taxa counted (Table 5.2)(Figure 5.13d). Chironomidae comprised 50% of the sample, followed by Elmidae (14%), Baetidae (4%), Nematoda (4%), Leuctridae (4%), Heptageniidae 3%), Oligochaeta (2%), Limnephilidae (2%), Polycentropodidae (2%), Glossosomatidae (2%), Empididae (2%), Ephemerellidae (1%), Simuliidae (1%) (Figure 5.13d)(Appendix B5).

Although most of the excess sand bedload on the gravel bar had been transported downstream prior to the 2002 macroinvertebrate sampling, the macroinvertebrate communities had not yet fully recovered from these impacts.

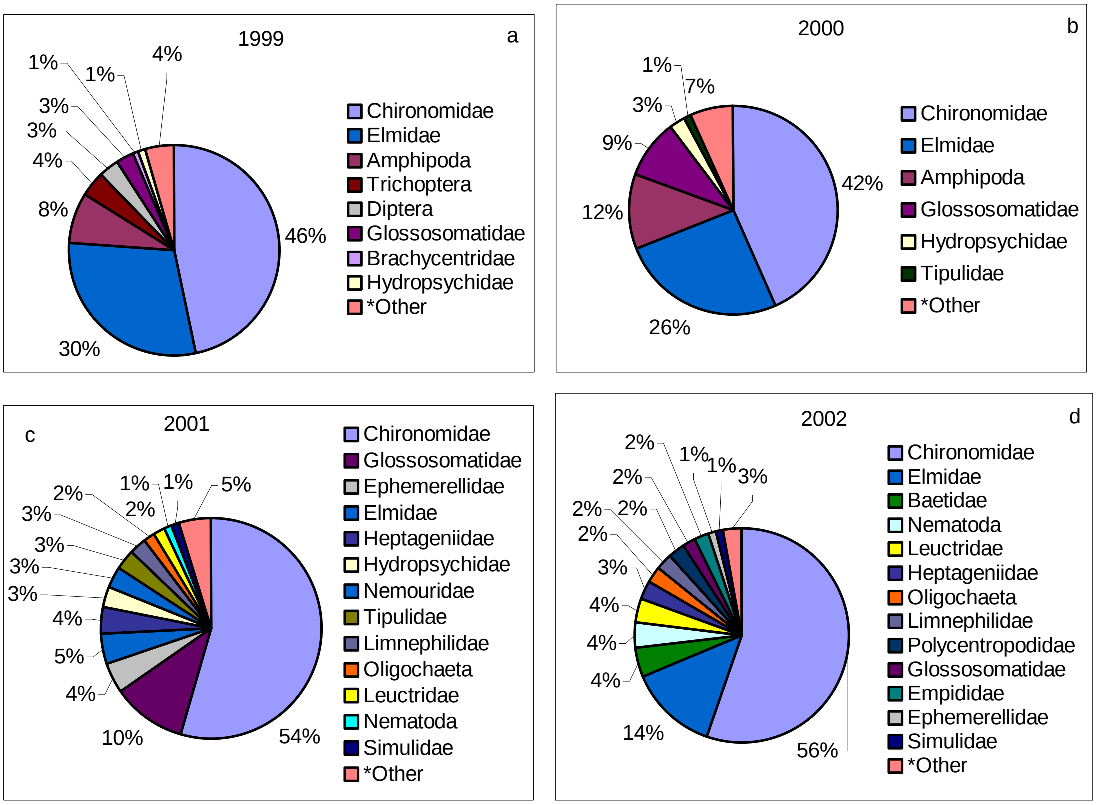

Figure 5.13. Macroinvertebrate species composition of Ruby Creek gravel bar (R-GB-1), Oceana County, Michigan.

5.1.2.6 Big South Branch Pere Marquette River Station #1 (MSGB-1)

A total of eighteen taxa, seven of which were dominant were collected in the 1999 sample at MSGB-1 (prior to the construction of the gravel bar) (Table 5.2)(Figure 5.14a). The dominant taxa present were Chironomidae (82%), Amphipoda (3%), Baetidae (2%), Elmidae (2%), Limnephilidae (2%), Oligochaeta (2%) and Tipulidae (1%) (Figure 5.14a). A list of the taxa collected can be found in Appendix B6.

During the summer of 2000, immediately after the site was constructed, twenty taxa were identified in the macroinvertebrate samples (Table 5.2). Of the twenty taxa collected only four were found to have occurrences greater than one percent. Chironomidae was found to have the greatest abundance (64%,). Hydropsychidae was determined to be the second most abundant in the sample (24%) followed by Tipulidae (5%), Elmidae (1%) and “Other” (6%)(Figure 5.14b).

In the 2001 macroinvertebrate sample seventeen taxa were identified (Figure 5.14c). A shift from a chironomid dominated community to a simulid dominated community was found. The genera *Simuliium* comprised 65% of the total collection while Chironomidae were reduced to 31%. The other dominant macroinvertebrate was the stonefly, Capniidae, which comprised only 1% of the total collection.

The number of dominant taxa was lower in the 2002 sample as only Chironomidae (91%) and Oligochaeta (4%) were found at abundances above one percent of the total sample (Figure 5.14d). Eighteen taxa were found in the benthic sample with the other sixteen making up only 5% of the total collection.

The number of species found in 1999 during the pretreatment collections equaled the 2002 collections two and a half years later. However, the number of dominant taxa decreased throughout the study suggesting a possible sediment impaction problem within this gravel bar. There is no sediment trap immediately upstream of the gravel bar at this site.

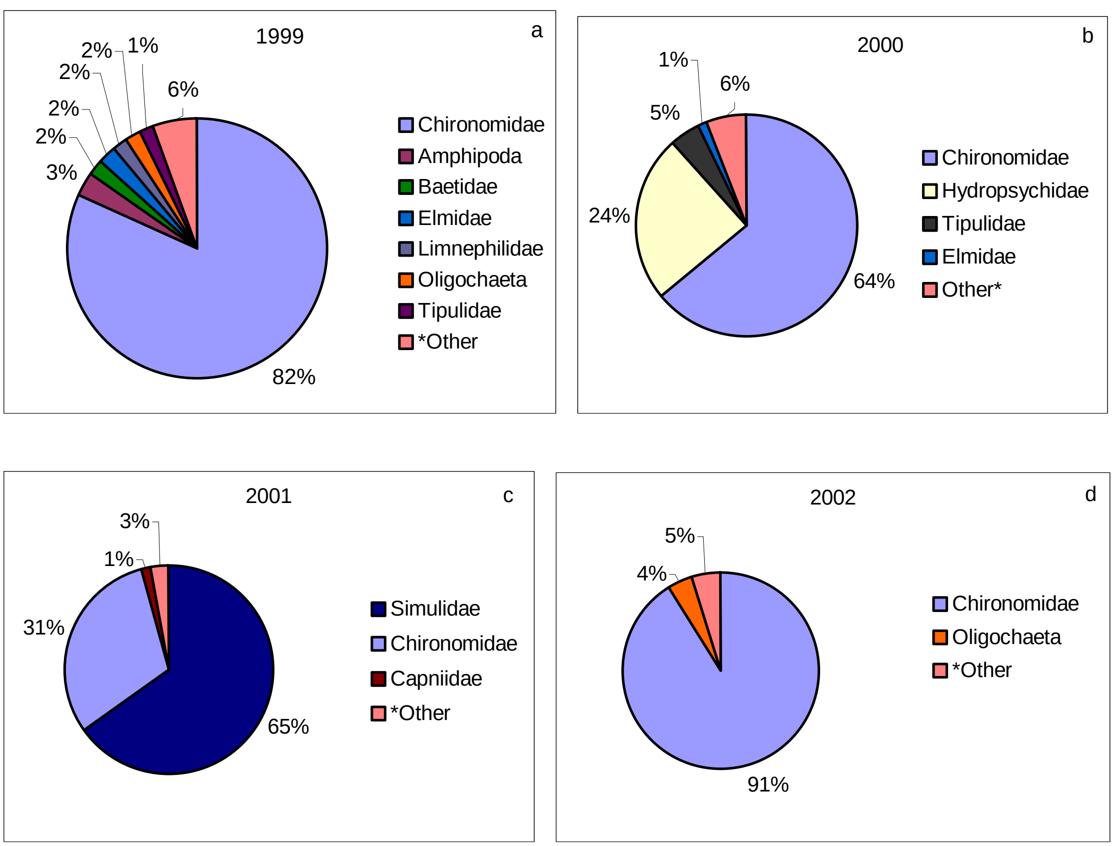

Figure 5.14. Macroinvertebrate species composition of the Big South Branch Station 1 (MS-GB-1), Newaygo County, Michigan.

5.1.2.7 Big South Branch Pere Marquette River Station #2 (MSGB-2)

Preconstruction macroinvertebrate sampling in 1999 revealed a total of twenty-two taxa of which eight taxa were determined to be dominant (greater than one percent of the total collection) including: Chironomidae (62%), Pelecypoda (10%), Tipulidae (7%), Gastropoda (4%), Oligochaeta (4%), Hydracarina (4%), Elmidae (2%), Decapoda (1%) (Figure 5.15a) (Appendix B7).

The total taxa were reduced during the 2000 field season to sixteen taxa Table 5.2). Seven of the sixteen were determined to be dominant. Chironomidae fell to 45% of the sample with Hydropsychidae also making up 45% of the 2000 macroinvertebrate sample. The remaining five taxa, which were determined to have occurrences over 1%, were: Baetidae (3%), Isonychidae (1%), Elmidae (1%), Heptageniidae (1%), Tipulidae (1%)(Figure 5.15b).

In the 2001 collection, The species composition was comprised of 21 taxa (Table 5.2). Chironomidae increased in occurrence to 85% of the sample. The remaining dominant taxa were: with Isopoda (3%), Hydracarina (2%), Hydropsychidae (2%), Helicopsychidae (1%), Psychomyiidae (1%) (Figure 5.15c).

There were a total of 26 taxa observed in the 2002 sample, with eleven being dominant (Figure 5.15d).

In 1999 this site was dominated primarily by dipterans (Chironomidae and Tipulidae), snails, clams and aquatic worms. After the construction of the gravel bar in 2000 the community structure started to change. In 2000 trichopterans and ephemeropterans started to inhabit the gravel areas, indicating an increase in habitat (substrate) quality in the stream reach. By 2002, the macroinvertebrate community had became even more diverse with taxa increasing from 22 to 26. This change in diversity and species composition was expected and it is also expected that the macroinvertebrate community at this site will continue to evolve. There is no sediment trap upstream of this gravel bar.

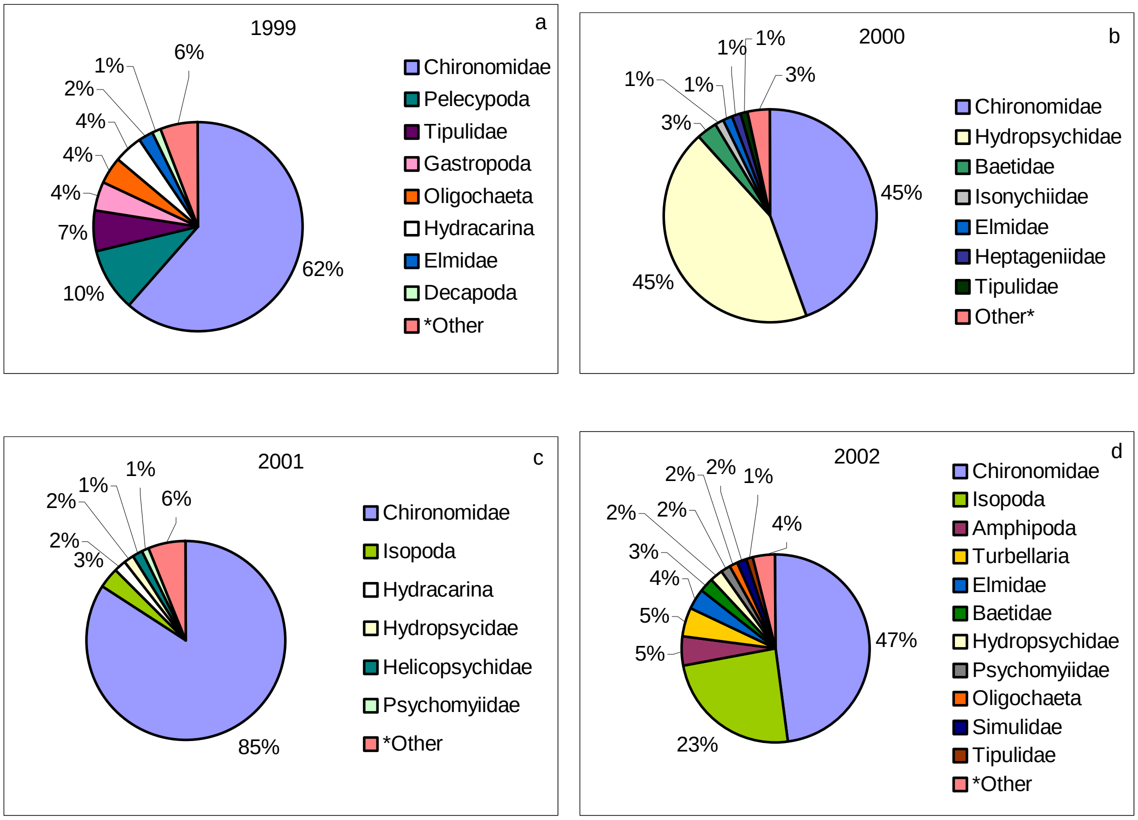

Figure 5.15. Macroinvertebrate species composition of Big South Branch Station 2 (MS-GB-2), Newaygo County, Michigan.

5.1.2.8 Winnepesaug Creek

Throughout the study period, species composition at the Winnepesaug Creek natural gravel bar has been high. This is indicative of improved substrate quality and a mature macroinvertebrate community, which includes a mix of individuals from the orders Trichopteran (caddisflies), Ephemeroptera (mayflies) and Plecoptera (stoneflies).

In the 2000 sample, twenty-four taxa were collected for the entire site with twelve taxa showing dominance (Table 5.2)(Figure 5.16a). Similar to the constructed gravel bars, Chironomidae dominated comprising 39% of the sample. The other dominant taxa included: Polycentropodidae (14%), Amphipoda (12%), Elmidae (10%), Psychomyiidae (7%), Baetidae (4%), Gastropoda (3%), Tipulidae (1%), Tabanidae (1%), Hydropsychidae (1%), Oligochaeta (1%) and Helicopsychidae (1%).

In the 2001 sample there were 21 total taxa and nine were dominant. Chironomids comprised the largest fraction of the sample (51%), followed by Gastropoda (17%), Elmidae (5%), Capniidae (5%), Ephemerellidae (4%), Helicopsychidae (4%), Tipulidae (3%), Oligochaeta (2%), Hydropsychidae (2%) (Figure 5.16b).

In the 2002 sample, total taxa collected at the site dropped to nineteen with ten dominating the sample. These dominant taxa were Chironomidae (35%), Amphipoda (21%), Gastropoda (11%), Elmidae (9%), Helicopsycidae (6%), Brachycentridae (4%), Oligochaeta (3%), Baetidae (3%), Limnephilidae (2%), Brachycentridae (1%) and Other (5%) (Appendix B8).

These species composition data from the Winnepesaug Creek samples are representative of mature natural gravel bar macroinvertebrate communities. Similar species compositions should evolve over time at the constructed gravel bars within the Big South Branch Pere Marquette River Watershed. The rate at which these macroinvertebrate communities evolve will vary from site to site. In order for substrate quality to be maintained over time, periodic monitoring and maintenance is of paramount importance. If velocities remain elevated and sand and organic inputs to the gravel bar are kept to a minimum, total number of macroinvertebrate taxa and species diversity will increase on the constructed gravel bars over time to more closely resemble the communities depicted in Figure 5.16.

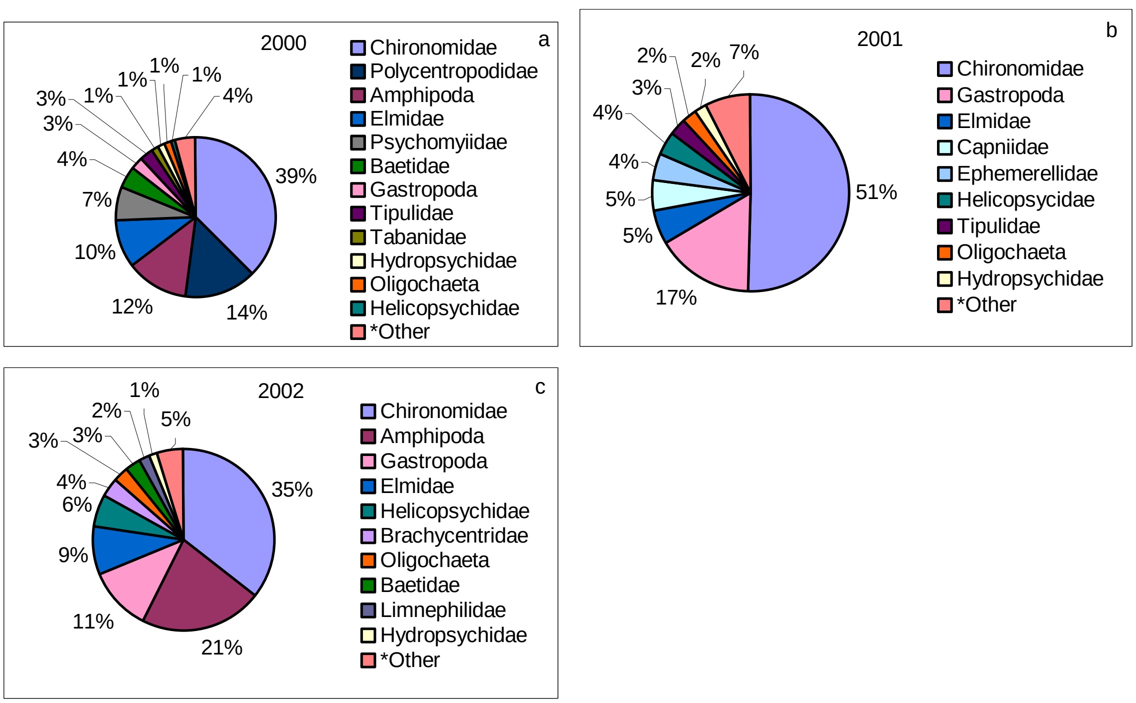

Figure 5.16. Macroinvertebrate species composition of Winnepesaug Creek natural riffle, Newaygo County, Michigan.

5.1.3 Graduate Student Research Projects

Four graduate students at Central Michigan University, under the direction of Dr. Donna King, have undertaken research projects, the results of which will shed considerable light on questions relating to the structure and function of constructed gravel bars. Each of these graduate students were employed as field biologists and, thus, had active involvement in various aspects of the construction and monitoring phases of the demonstration project. Summaries of their work are provided below.

Matt Kerr, Master's Student, Central Michigan University
Advisor, Dr. Donna King

Mr. Kerr studied the drift of macroinvertebrates (fish food) and detritus (potential macroinvertebrate food) off the newly constructed gravel bars and developing gravel bars (1999-2001). He has monitored drift upstream and downstream of the Freeman, Cedar and Winnepesaug gravel bars over 24-hour periods three times a summer and determined numbers, diversity, and biomass (AFDM) of macroinvertebrates and particle sized estimates of AFDM of detritus. Mr. Kerr's unpublished data indicate that macroinvertebrate drift increased downstream of gravel bars. Mr. Kerr's research was conducted from 1999-2001and is currently processing samples and writing his thesis.

Matt Heiman, Master's Student, Central Michigan University,
Advisor, Dr. Donna King

Mr. Heiman is determining salmonid egg survival and mortality within the constructed gravel bars. He also evaluated habitat quality for eggs by estimating the epilithon/detritus composition of sediments, which also allowed for estimates of gravel bar impaction by inorganic and organic particles over time. His research was conducted on the Freeman, Cedar, and Winnepesaug Creek gravel bars during 1999 and 2000. Mr. Heiman shared electrofishing data generated at these sites with Mainstream Resources and fellow graduate students, thus facilitating the development of this report and their research. Mr. Heiman is currently data processing and writing his thesis, while working for the Leelanau Conservancy.

Aimee Genung, Master's Student, Central Michigan University
Advisor, Dr. Donna King

Ms. Genung is studying macroinvertebrate colonization of constructed gravel bars. Her study sites were at the Upper Freeman Creek gravel bar (F-GB-2), the Upper Cedar Creek gravel bar (C-GB-1) and the Winnepesaug Creek natural gravel bar. She collected sediment samples from both upstream and within the gravel bars and has determined numbers, diversity, and biomass (AFDM) of the macroinvertebrate taxa. She has also quantified the accumulation of organic and inorganic sediments within these riffles over time by epilithon/detritus estimates from both above and within the gravel bars.

Ms. Genung has contributed data generated through her research with Mainstream Resources and fellow graduate students, thus facilitating the development of this report and their research. Preliminary findings from these unpublished data indicate that macroinvertebrate densities are higher within the constructed riffles as compared to upstream (control) sites. As well, her findings indicate that sediment inputs to these constructed gravel bars appear to adversely impact macroinvertebrate communities (pers. comm., A. Genung, 2003). Ms. Genung's field research was conducted in 2001 and 2002.

Andy Carl, Master's Student, Central Michigan University
Advisor, Dr. Donna King.

Mr. Carl is studying the rates of decomposition of Chinook salmon (AFDM) and the fungal and macroinvertebrate communities associated with this process. He is also addressing the effects of Chinook decomposition on macroinvertebrate abundance and diversity, as well as, nutrient fluxes within the Tank Creek and reference (Cedar) constructed gravel bars. He is also examining the sediment composition (organic and inorganic) and macroinvertebrate (numbers, diversity, and biomass) within the sediments of Tank Creek gravel bars. Mr. Carl's field research took place in the fall of 2002 through the summer of 2003. He is currently processing his samples.

Through the interest and initiative of these graduate students and Dr. Donna King, we will soon be able to substantially expand our understanding of the structure and function of gravel bars. The insights that will be derived from this research will enable managers to better plan and implement the construction of gravel bars. As well, these findings should assist managers in the development of protocols for the maintenance of constructed gravel bars.

Our thanks are extended to Central Michigan University, Dr. Donna King, Ms. Genung and Messrs. Carl, Heiman and Kerr. The in-kind value of their contributions to this project is substantial and is perhaps surpassed only by the ongoing value which will be derived by resource managers who apply their findings in the development and maintenance of gravel bars in the future.

5.2 Anadromous Salmonid Electrofishing Surveys

5.2.1 Chinook Salmon Fingerlings

Spring electrofishing surveys were conducted annually in order to determine the composition of the fish communities (Table 5.3) and to develop an index of anadromous salmonid fingerling (Figure 5.17) production at eight constructed gravel bars and four reference sites. The data indicate that, overall, chinook fingerling densities have increased since construction of the gravel bars (Table 5.4). As well, chinook fingerling densities at treatment sites are, on average, higher than those observed at reference sites (Figure Nos. 5.18 and 5.19). Field electrofishing data are presented in Appendix C.

Figure 5.17. Chinook salmon fingerling collected during the spring 2002 electrofishing survey (total length 63mm (2.48”).

Table 5.3. Total number of fish taxa collected during annual spring electrofishing Surveys, Big South Branch Pere Marquette River watershed.

Natural Riffles	**1999**	**2000**	**2001**	**2002**
Winnepesaug Creek	18	--	--	12
Gowell	21	21	15	15
Walhalla	16	14	11	15
Hawley	16	12	16	16
West Michigan Creek	--	9	12	13
Bear Creek	--	6	5	4
Constructed Riffles	**1999**	**2000**	**2001**	**2002**
Tank Creek	9	10	11	14
Big South 1	15	14	18	11
Big South 2	16	13	14	9
Upper Cedar Creek	6	10	--	18
Lower Cedar Creek	--	--	11	17
Upper Freeman Creek	10	9	2	--
Lower Freeman Creek	11	13	1	10
Ruby Creek	11	11	12	12

Table 5.4. Chinook fingerling densities (number / acre) from May electrofishing surveys in the Big South Branch Watershed, Michigan. 1999 represents pre-construction data and 2000-2002 represent post-construction data. *Lower Cedar Creek gravel bar was constructed in November 2001.

Treatment	**1999**	**2000**	**2001**	**2002**
Upper Cedar	3.31	0	0	66.25
Big South 1	0	0	58.11	31.29
Big South 2	0	0	23.68	0
Tank	0	0	91.51	208.44
Ruby	9.52	82.51	88.96	104.73
Lower Cedar*	0	0	0	0
Lower Freeman	0	0	0	0
Upper Freeman	0	0	0	0
Reference	**1999**	**2000**	**2001**	**2002**
Gowell	12.19	0.97	6.09	6.09
Winnepesaug	3.03	0	0	6.09
Hawley	6.94	1.24	2.48	12.44
Walhalla	11.84	1.86	0	4.25

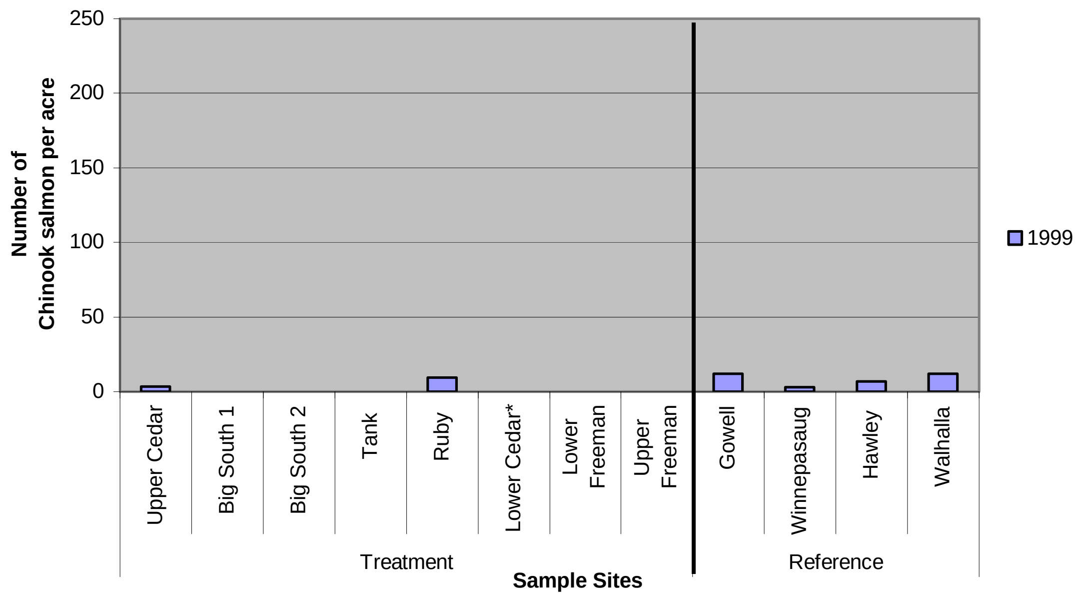

Figure 5.18. Chinook salmon fingerling densities (fingerlings per acre) from spring electrofishing surveys prior to gravel bar construction at treatment and reference sites in the Big South Branch Pere Marquette River watershed. *Lower Cedar gravel bar was not constructed until November 2001.

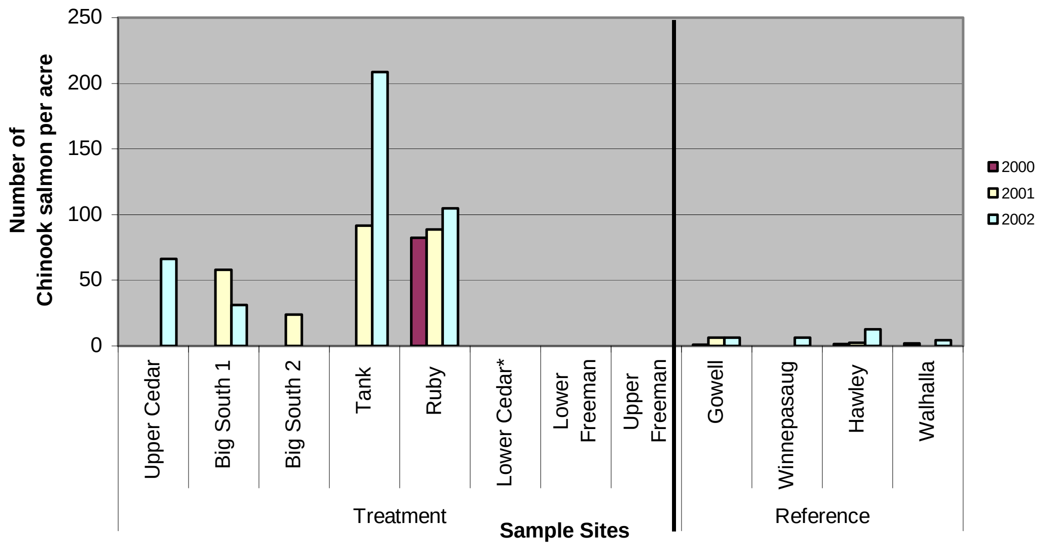

Figure 5.19. Chinook salmon fingerling densities (fingerlings per acre) from spring electrofishing surveys at treatment and reference sites in the Big South Branch Pere Marquette River watershed. *Cedar GB-2 gravel bar was not constructed until November 2001

5.2.2 Steelhead Fingerlings

Observed steelhead fingerling densities were considerably lower than those of Chinook salmon (Table 5.5). This is due, in part, to the fact that steelhead emerge from their redds later than Chinook salmon. At the onset of the project, spring electrofishing surveys were conducted in May and early June and were designed to target chinook salmon. Beginning in 2001, a second follow-up electrofishing survey was conducted, in early June, in order to create an index of steelhead fingerling production. These June surveys did result in higher estimates of steelhead fingerlings (Figure Nos. 5.20, 5.21 and 5.22).

Table 5.5 Steelhead fingerling densities (number / acre) from May electrofishing surveys in the Big South Branch watershed, Newaygo Co., Michigan. 1999 represents pre-construction data and 2000-2002 data are post-construction. †Big South Branch sites were completed prior to 2000 steelhead spawning season. *Lower Cedar Creek gravel bar was constructed in November 2001.

Treatment	**1999**	**2000**	**2001**	**2002**
Upper Cedar	0	3.31	0	13.25
Big South 1	0	31.29†	0	0
Big South 2	0	209.92†	0	0
Tank	0	0	0	0
Ruby	0	0	0	3.17
Lower Cedar*	0	0	0	18.73
Lower Freeman	0	0	0	0
Upper Freeman	0	0	0	0
Reference	**1999**	**2000**	**2001**	**2002**
Gowell	0	7.94	0	0
Winnepesaug	0	0	0	0
Hawley	0	0	3.11	0
Walhalla	0	0	0	0

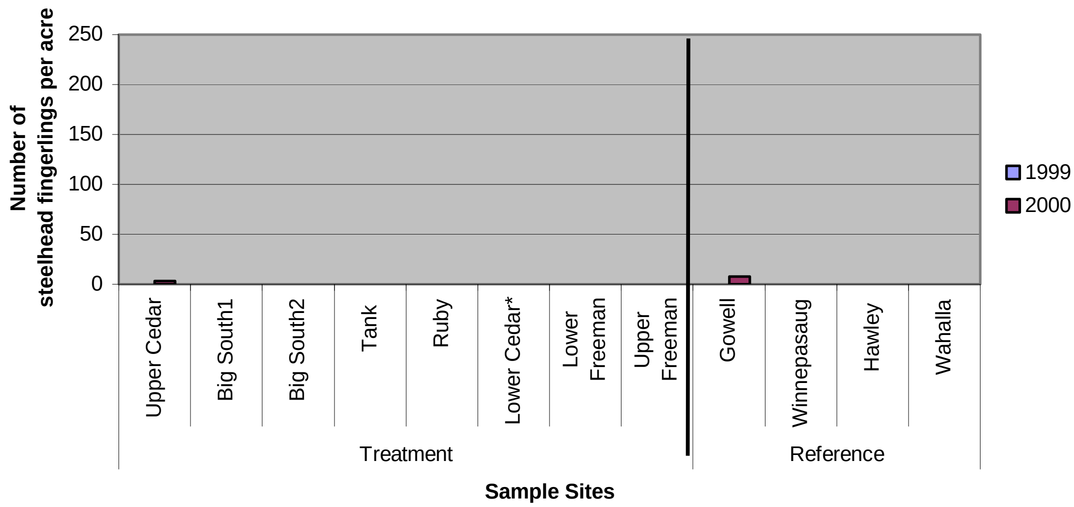

Figure 5.20 Fingerling steelhead density estimates (fingerlings per acre) from May and June electrofishing surveys prior to gravel bar construction at treatment and reference sites in the Big South Branch Pere Marquette River watershed. *Lower Cedar Creek gravel bar was not constructed unitl November 2001.

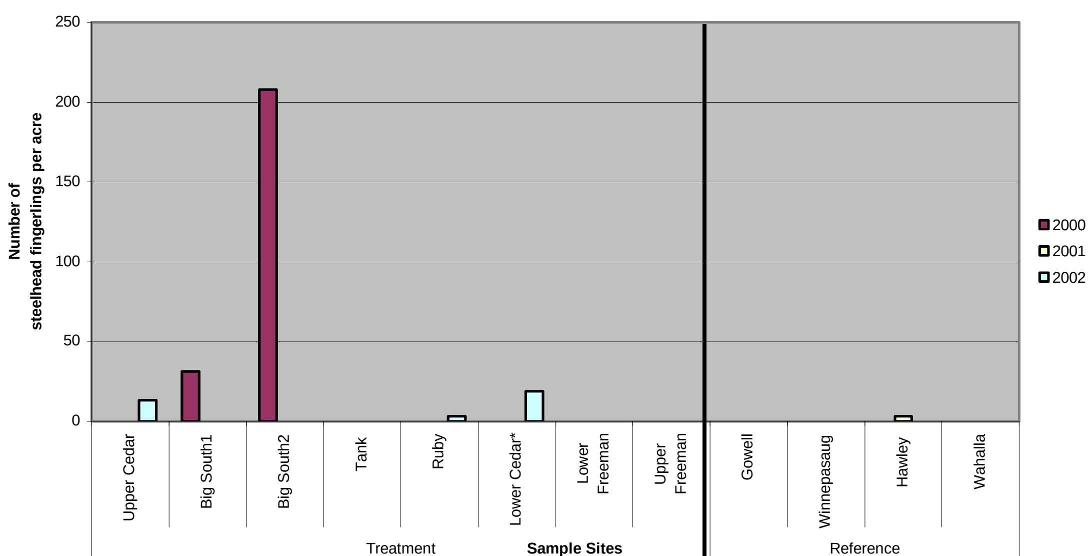

Figure 5.21. Fingerling steelhead density estimates (fingerlings per acre) from May electrofishing surveys at treatment and reference sites in the Big South Branch Pere Marquette River watershed. *Lower Cedar Creek gravel bar was not constructed unitl November 2001.

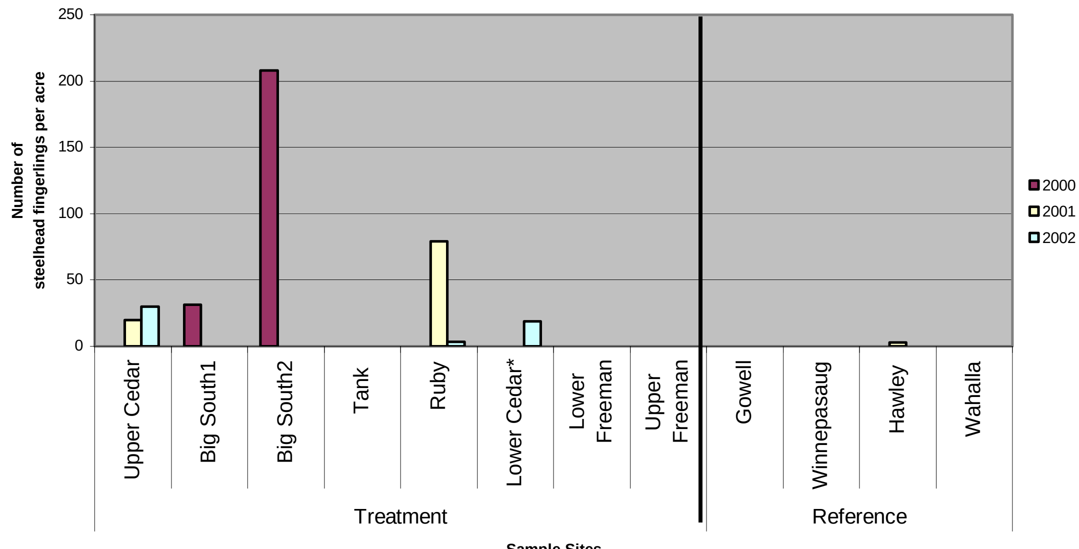

Figure 5.22. Fingerling steelhead density estimates (fingerlings per acre) from May and June electrofishing surveys at treatment and reference sites in the Big South Branch Pere Marquette River watershed. *Lower Cedar Creek gravel bar was not constructed unitl November 2001.

5.2.3 Reference Gravel Bar Electrofishing Surveys

5.2.3.1 Winnepesaug Creek

The 1999 electrofishing survey at Winnepesaug Creek resulted in the collection of 18 total taxa from 299 fish (Table 5.3). Of the 18 taxa recorded two were salmonids (Chinook salmon and brown trout). Chinook fingerling densities were calculated to be 3.03 per acre (Table 5.3).

In 2002, 12 taxa were collected during the electrofishing survey from a sample of 186 fish. One Chinook salmon fingerling was collected. No steelhead fingerlings were collected at this site (Table 5.3). The most abundant non-salmonid species collected included blacknose dace, redhorse, longnose dace, common shiner, creek chub, blackside darter, bluegill, central mudminnows, mottled sculpins, pumpkinseed and the Johnny darter. Other species found less frequently were white suckers, green sunfish, burbot, rock bass, largemouth bass, American brook lamprey and yellow perch.

5.2.3.2 Gowell Dam

A total of twenty-one taxa were collected below Gowell Dam during the 1999 electrofishing survey (Table 5.3) from a total sample of 700 fish. Of the twenty-one taxa collected in 1999, two brown trout and 14 Chinook salmon were collected. Chinook fingerling densities were calculated at 12.19 salmon during the 1999 sampling period.

In the following year (2000) chinook densities decreased dramatically to 0.87 salmon per acre and steelhead densities were calculated to be 7.84 per acre (Table 5.4). In 2001 and 2002, 15 total taxa were collected at this site.

The 2001 survey resulted in the collection of seven chinook salmon. Three Chinook salmon were collected during the 2002 electrofishing survey. No steelhead or brown trout were collected at this site during either the 2001 or 2002 field seasons (Table 5.5).

The non-salmonids commonly collected at this location throughout the study included blacknose dace, longnose dace, common shiner, white sucker, Johnny darter, blackside darter, central mudminnow, mottled sculpin and bluegill. Other species found less frequently were brown bullhead, largemouth bass, pumpkinseed, pearl dace, common shiner, carp, blacknose shiner, green shiner, redhorse, yellow perch, bluntnose shiner, American pickerel, burbot, rock bass, green sunfish, sea lamprey, bowfin, fine scale dace, northern pike, tadpole madtom and northern red-bellied dace.

5.2.3.3 Walhalla Road

The initial electrofishing survey was carried out in 1999 and resulted in 16 taxa being collected (Table 5.3) in a sample of 259 fish. Of the 259 fish collected, eight brown trout, one rainbow trout, and nineteen fingerling Chinook salmon comprised 10.8% of the total fish collected. Chinook fingerling density estimates of 11.82 per acre were calculated (Table 5.4).

The 2000 electrofishing survey resulted in a total of 14 taxa being collected from a sample of 323 fish. The sample included two brown trout, two rainbow trout and two fingerling chinook salmon (1.86 per acre).

During the 2001 sampling period, only one brown trout was collected out of the total sample of 94 fish. The final electrofishing survey in 2002 resulted in the collection of 15 taxa out of a total sample of 412 fish. The sample included seven chinook salmon. No fingerling steelhead were collected at this site (Table 5.5).

Non-salmonid species collected included blacknose dace, longnose dace, common shiner, redhorse, Johnny darter and burbot. Other species found in lower numbers were creek chub, white sucker, trout-perch, blackside darter, mottled sculpin, sunfish, American brook lamprey, sea lamprey, brown bullhead, pumpkinseed, rock bass, central mudminnow, and bluegill.

5.2.3.4 Hawley Road

A total of sixteen taxa were collected during the 1999 electrofishing survey (Table 5.3), totaling 312 fish. Of the 16 taxa collected two were salmonids (three rainbow trout and 11 fingerling chinook salmon (Table 5.4).

Total taxa decreased in the 2000 electrofishing sample. Twelve taxa were collected of which, seven brown trout and two fingerling chinook salmon were the only salmonids collected

A total of 16 taxa were represented in the 2001 electrofishing sample. Two rainbow trout, one brown trout and five chinook salmon fingerlings were collected.

Five brown trout and 20 chinook salmon accounted for 12 percent of the total sample of 210 fish. No fingerling steelhead were collected at this site therefore no densities were calculated (Table 5.5).

The most abundant non-salmonid species collected were blacknose dace, longnose dace, creek chub, common shiner, redhorse and Johnny darter. Other species found in fewer numbers included carp, white sucker, blackside darter, central mudminnow, burbot, mottled sculpin, green sunfish, American brook lamprey, sea lamprey, black crappie, yellow perch and bluegill.

5.2.3.5 West Michigan Creek

Electrofishing surveys carried out in 2000 resulted in the collection of nine taxa (Table 5.3), in a total sample of 203 fish. A total of 12 taxa in a sample of 113 fish were collected in 2001.

In 2002 the total sample size increased to 345 representing 13 taxa. One brook trout was collected in 2002. No fingerling Chinook salmon (Table 5.4) or steelhead (Table 5.5) were collected at this site throughout the course of this project

The most abundant non-salmonid species were blacknose dace, longnose dace, creek chub, common shiner, Johnny darter, mottled sculpin, northern red-bellied dace and mudminnow. Other species found in fewer numbers included, pearl dace, white sucker, bluegill, warmouth, sea lamprey, brook stickleback, green sunfish, northern brook lamprey, American brook lamprey and yellow perch.

5.2.3.6 Bear Creek

The 2000 electrofishing survey resulted in a total of 101 fish representing six different taxa. Fifty-three percent of the fish collected at this site in 2000 were brook trout. The total fish collected during the 2001 and 2002 surveys were 133 and 85 fish respectively. No Chinook fingerlings (Table 5.4) or steelhead (Table 5.5) were collected at this location throughout the entire study. As previously noted Bear Creek originates as Springs approximately 1000 feet upstream of the electrofishing station.

Other non-salmonids collected at this location included mottled sculpin, Johnny darter, mudminnow, brook stickleback, northern red-bellied dace, pearl dace and American brook lamprey.

5.2.4 Constructed Gravel Bars

5.2.4.1 Tank Creek

During the 1999 electrofishing survey 116 fish were collected representing nine different taxa (Table 5.3). The only salmonids found during the Tank Creek survey were three brook trout. During the 2000 electrofishing survey no salmonids were collected (177 fish and 10 taxa).

The 2001 sample included 19 chinook salmon fingerlings and the 2002 sample included 41 chinook and one coho salmon fingerling. No steelhead were collected during the electrofishing samples throughout the study (Table 5.5). As well, no steelhead were observed spawning at this site at any time during the study.

5.2.4.2 Big South Branch Pere Marquette River Station #1 (MS-GB-1)

Sixty-six total fish representing 15 taxa were collected during the 1999 electroshocking survey at this site (Table 5.3). The 2000 sample was comprised of a total of 105 fish with 14 total taxa represented. Surveys for the next two years increased in total fish (150 and 163 respectively) but the taxa collected was found to increase to 18 during the 2001 season and fell to 11 during the 2002 season. No fingerling salmonids were collected at this site in 1999 (Table Nos. 5.4 and 5.5).

In the 2000 sample steelhead fingerlings were collected at densities of 31.29 fish per acre. However no Chinook salmon were collected during this year. In 2001 and 2002 no steelhead were collected at MS-GB-1, however, chinook salmon production increased during that period. During the 2001 field season Chinook salmon fingerling densities were found to be 58.11 fish per acre. These densities decreased during the 2002 season to 31.29 fingerlings per acre (Figures Nos. 5.21 and 5.22).

5.2.4.3 Big South Branch Pere Marquette River Station #2

In the 1999 electrofishing sample of 118 fish, 16 different taxa (Table 5.3) were collected. The 2000 electrofishing sample was comprised of a total of 315 fish. In 2001 and 2002, both the number of taxa represented (14 and 9 respectively) as well as the total number of fish collected (126 and 109 respectively) decreased at this site.

In the 1999 electrofishing sample, prior to the gravel bar construction, no chinook salmon (Table 5.4) or steelhead (Table 5.5) were collected. Electrofishing surveys in 2000 indicated steelhead fingerling densities of 207.92 fingerlings per acre (Figure 5.20). However no more steelhead fingerlings were collected at this location throughout the remainder of the project term. The first year in which chinook salmon fingerlings were collected was in 2001, when they were found at densities of 23.68 fingerlings per acre (figure 5.19).

5.2.4.4 Upper Cedar Creek

Forty-nine total fish were collected during the 1999 electroshocking survey, representing six different taxa (Table 3). Three months after construction of the gravel bar, the electrofishing sample was comprised of 135 fish representing 10 taxa. The 2002 electrofishing sample included 286 fish representing 18 taxa (Table 5.3)

Chinook fingerling densities in the 1999 electrofishing sample were 3.31 fingerlings per acre (table 5.4). In 2000, steelhead fingerling density was 3.31 fingerlings per acre (Table 5.5). Chinook fingerling densities were for 58.11 fingerlings per acre but no steelhead were collected at this site in the spring of 2001 or 2002 so densities for both years were zero. Chinook fingerling densities decreased slightly in 2002 to 31.29 fingerlings per acre.

5.2.4.5 Upper Freeman Creek

In 1999, prior to the construction of the gravel bar, a total of 117 fish were collected representing ten different taxa electrofishing survey. Ninety-four fish from nine different taxa (Table 3) were collected during the 2000 electrofishing survey (May) a three months prior to construction of the gravel bar. As previously noted, in 2001 a dam failure upstream deposited substantial volumes of sediment throughout the riffle section. As a result, only two fish representing two taxa were collected during the 2001 electrofishing survey. Anadromous salmonid fingerlings were never collected at this site and no observations of anadromous spawning were made (Table 5.4 and 5.5). This riffle has sustained resident trout spawning activity on an annual basis.

5.2.4.6 Lower Freeman Creek

During preconstruction electrofishing in 1999, 190 fish representing eleven taxa were collected. The gravel bar was constructed in October 1999 and in the spring of 2000 seventy-three fish were collected representing 13 taxa (Table 5.3). In 2001 the system was inundated with sediment due to the dam failure and only one fish was collected during the survey. Numerous dead fish were observed in the sediments deposited over the riffle. The fish community started to rebound in 2002 when the survey recorded a total of 43 fish representing ten taxa. No fingerlings were collected at this site throughout the entire study, and only two steelhead redds were observed over the four-year observation period (Table 5.4 and 5.5). The mouth of Freeman Creek is a broad, flat delta of sand that appears to be impassible during the fall of the year. This passage challenge most likely precludes chinook salmon spawning.

5.2.4.7 Ruby Creek

During the 1999 electrofishing survey, a total of 191 fish were collected representing eleven different taxa (Table 5.3). In the 2000 electrofishing sample, a total of 155 fish were collected from 11 different taxa. In 2001, 141 fish were collected from 12 different taxa. The 2002 electrofishing survey yielded 194 fish from 12 different taxa.

No steelhead fingerlings were collected at Ruby Creek from 1999 to 2001. The first year steelhead fingerlings were documented in Ruby Creek was the final year of the study when densities of steelhead reached 3.17 fingerlings per acre (Table 5.5). Chinook salmon fingerlings, on the other hand, were very plentiful in Ruby Creek during spring. Prior to the construction of the gravel bar in 1999, chinook fingerlings were found at 9.52 fingerlings per acre. After the construction, fingerling densities increased dramatically to 82.51, 88.86 and 104.73 fingerlings in 2000, 2001 and 2002 respectively (Table 4.5).

5.2.4.8 Lower Cedar Creek

Lower Cedar Creek was added as an electrofishing and spawning riffle location during the summer of 2001 in anticipation of riffle construction in the fall of the year. The pre-construction electrofishing survey resulted in the collection of 128 fish, including four brown trout, representing 11 taxa (Table 5.3). After riffle construction, fish surveys in 2002 found 17 taxa and a total of 241 fish. One brown trout and one rainbow trout were collected during this post construction survey.

No steelhead fingerlings were collected at Lower Cedar Creek during the 2002 collection survey, however, the gravel bar was newly constructed in November 2001 and considerable steelhead spawning was observed prior to the electrofishing survey.

Even though fingerling steelhead estimates have been consistently low at gravel bars (Table 5.5), steelhead have been consistently observed using the constructed gravel bars for spawning since their creation. Accordingly, we recognize that the actual number of fingerlings produced during from the redds is difficult to estimate. It is recommended that surveys continue to determine the fingerling production from artificial gravel bars using in combination with electro shocking, traps and perhaps, drift nets to achieve a better estimate of fingerling production.

Fingerling chinook salmon density estimates have increased over the course of monitoring at five of the eight constructed gravel bars, indicating that chinook will utilize these riffles for spawning (Table 5.4). The most productive gravel bars for chinook fingerling production were found to be Tank Creek and Ruby Creek. The constructed gravel bars have consistently produced higher densities of chinook salmon fingerlings than the reference or natural riffles.

5.2.5 Cost Effectiveness of Constructed Gravel Bars

The chinook salmon and steelhead fingerlings produced on the constructed gravel bars provide direct evidence that this demonstration project has *"increased spawning and recruitment opportunities for salmonids, adding to the naturally reproduced population in Lake Michigan"*. The scientific literature indicates that naturally reproduced fish have a greater fitness than those propagated in hatcheries (Unwin 1997). Therefore, it behooves us to explore ways in which we can supplement existing opportunities for natural reproduction.

As with any natural resource management tool, cost effectiveness should be one of the key factors considered prior to construction of gravel bars. While these analyses hinge on limited information and a variety of assumptions, which will vary, based upon the site-specific conditions in the subject watershed, the exercise is nonetheless valid.

Egg production (mean fecundity) in spawning chinook salmon females was estimated to be 5,073 (Rounsefell 1957, Major and Mighell 1969, Beacham and Murray 1993, Beland 1996 and Unwin 1997). When multiplied by the average number of redds observed over the three-year monitoring period (597 redds), an average annual estimate of egg production at these six riffles is 3,028,581. It is assumed that 908,574 (30%) of those eggs are successfully fertilized and deposited in the redds (Healy 1991).
If we assume that 10.7% (Major and Mighell 1969) of those fertilized eggs survive to out-migrate, that results in an annual production of 97,217 migrants. Over twenty years these riffles would produce 1,944,349 migrants.

Construction costs for the six gravel bars (61,032 sq. ft.) supporting chinook salmon reproduction totaled $176,219. Maintenance costs over a 20-year period were estimated to be $20,400 bringing total gravel bar costs over the twenty-year period to $196,619. This equates to a cost per naturally produced migrant of $0.09. Michigan DNR Fisheries Division estimates their chinook salmon cost at plant-out for hatchery reared fingerlings to be $0.11 (pers. comm., M. Wolgamood, MDNR 2003).

It is important to note that no two streams or watersheds are alike. Accordingly, the cost effectiveness of constructed gravel bars will vary. The Big South Branch Pere Marquette River has spawning runs of both steelhead and chinook salmon. There is, however, a paucity of optimal spawning habitat available for these fish. In situations like this, the construction of gravel bars will serve to augment the current levels of natural reproduction.

5.3 Percent Disturbed Gravel As An Index Of Spawning Activity

Gravel disturbed during spawning activities was mapped and quantified during weekly spawning observations to create an index of salmonid spawning activity in both constructed gravel bars and reference riffles. The disturbed gravel data can be found in Appendix D for both steelhead and chinook salmon. The redd observation data for both steelhead and chinook salmon can also be found in Appendix E.

5.3.1 Steelhead

Only Washington Bridge and Winnepesaug Creek showed disturbances due to spring steelhead spawning activity (Figure 15.22). Gravel bars constructed prior to the spring 2000 spawning run included, Lower Freeman Creek, Tank Creek, Upper Cedar Creek, Big South Station #1 (MS-GB-1) and Big South Station #2 (MS-GB-2). Of the sites constructed before the spring 2000 spawning run, three of the five sites exhibited spawning activity as follows: Lower Freeman Creek (3.8%), Upper Cedar Creek (12.5%) and MSGB-2 (20.3%)(Figure 13.2). Tank Creek has not sustained historic steelhead runs and no significant steelhead spawning has been observed in Freeman Creek.

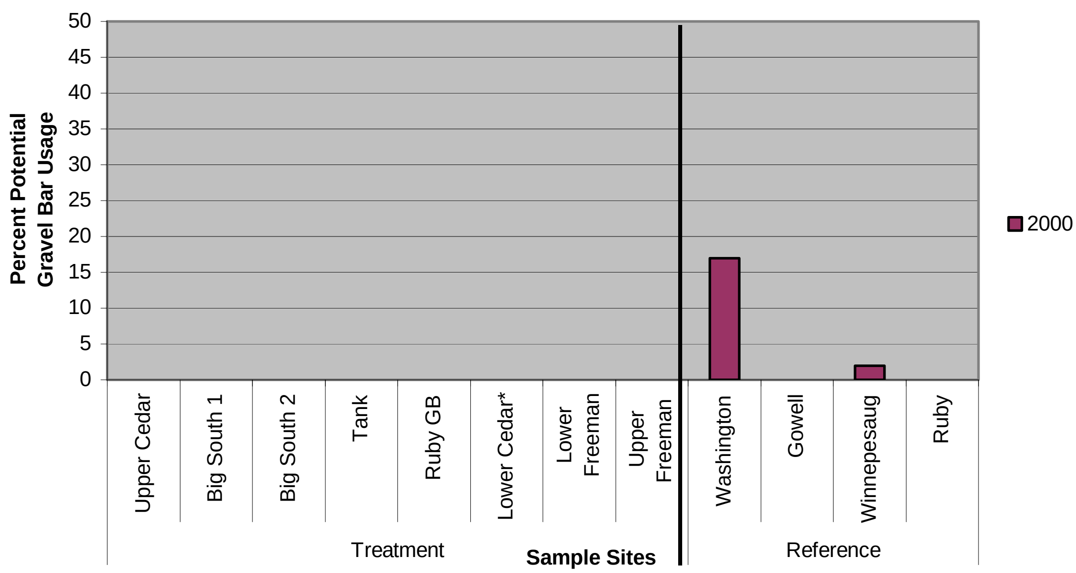

Figure 5.23. Percent gravel bar usage during the spring steelhead spawning runs prior to gravel bar construction in the Big South Branch Pere Marquette River watershed. *Lower Cedar Creek gravel bar was constructed in November 2001.

It is important to note that spring high water makes steelhead spawning observations very difficult. Extremely high tannin concentrations and turbidity in the waters of the Big South Branch watershed compound this problem. As a result of these conditions, these indices of steelhead spawning result in underestimates.

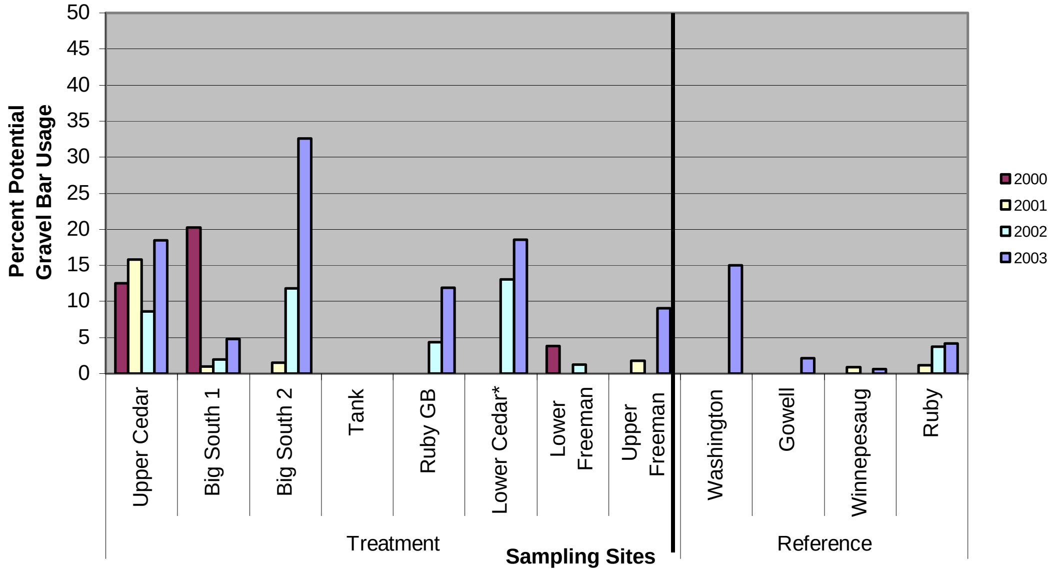

Figure 5.24. Percent gravel bar usage during the spring Steelhead spawning runs in the Big South Branch Pere Marquette River watershed from 2000 - 2003. *Lower Cedar Creek gravel bar was constructed in November 2001.

5.3.2 Chinook Salmon

Preconstruction redd surveys were conducted in 1999 at eight potential gravel bar areas and four reference locations. During these fall 1999 pretreatment redd observations, three out of four reference locations exhibited gravel bar usage (from 4.0% to 12% of the total riffle area) (Figure 5.25).

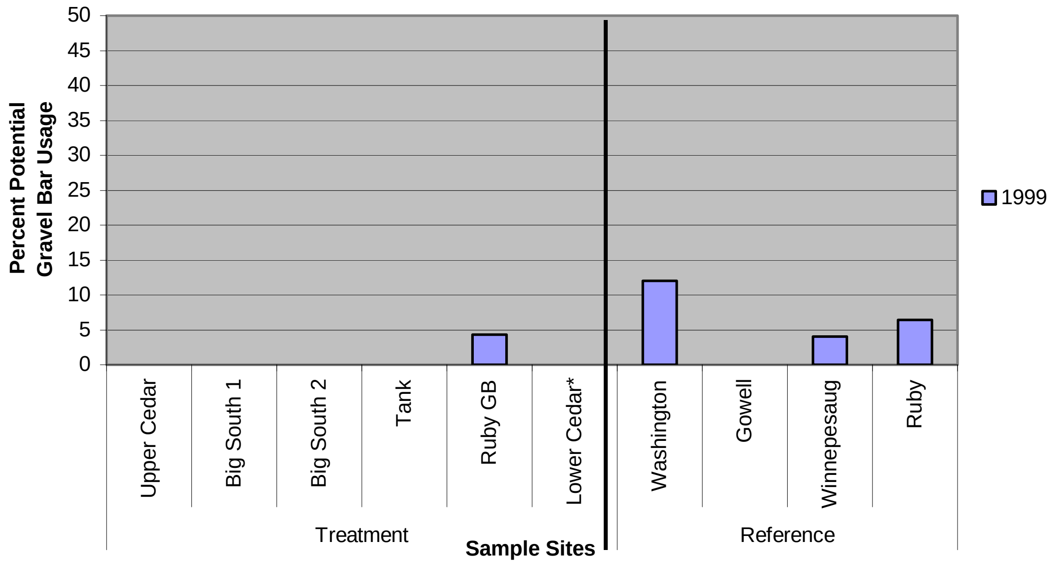

Figure 5.25 Percent gravel bar usage by Chinook salmon prior to gravel bar construction in the Big South Branch Pere Marquette River watershed. *Lower Cedar Creek gravel bar was constructed November 2001.

Chinook salmon spawning activity increased at all constructed gravel bar sites in 2000. At these constructed gravel bars, gravel usage ranged from 8.6% to 43.0% of the total surface area (Figure 5.26).

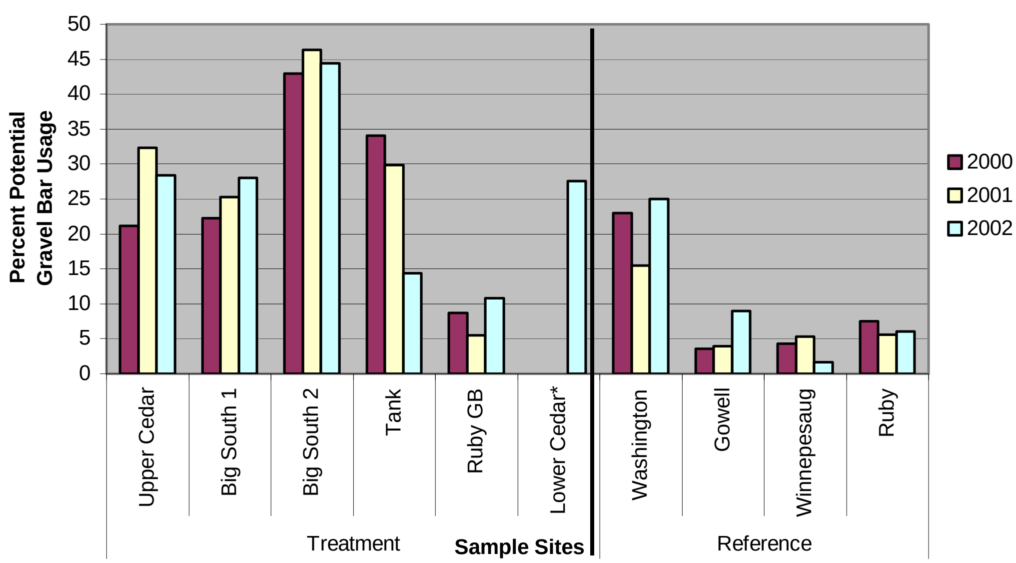

Figure 5.26. Percent gravel bar usage during the fall Chinook Salmon spawning runs in the Big South Branch Pere Marquette River watershed 1999 - 2002. *Lower Cedar Creek gravel bar was constructed November 2001.

The fall 2001 Chinook salmon spawning run showed increases in gravel bar usage for Upper Cedar Creek (32.4%), MSGB-1 (25.2%) and MSGB-2 (46.3%)(Figure 5.26). During the fall 2002 Chinook spawning run, results were mixed with gravel bar usage up at some constructed riffles and diminished at others.

Overall, the data indicate that constructed gravel bars are sustaining significant chinook salmon and steelhead spawning activity. Data generated by weekly spawning observations are provided in Appendix E and composite spawning maps for both spring and fall runs are provided in Appendix F.

Only the Ruby Creek and Upper Cedar Creek treatment sites had appreciable spawning activity prior to the construction of these riffles. Overall redd densities at the treatment sites were greater than those observed at the reference riffles in the case of both chinook salmon and steelhead.

5.4. Sediment Removal

5.4.1 Oxbow Sediment Removal

Sediment was removed from three cut-off oxbows on Beaver Creek and one cut-off oxbow on the Big South Branch Pere Marquette River. The Beaver Creek oxbows were dredged in November 2000, resulting in the removal of a total of 408.62 cubic yards of sediment. The oxbow on the Big South Branch Pere Marquette River was dredged in the fall of 2001, resulting in the removal of 830.4 cubic yards of sediment.

Table 5.6. Beaver Creek and Big South Pere Marquette River oxbow filling rates (cu. yd.) from January 2001 through June 2002. *Indicates sediment in cubic yards dredged out of the oxbow. (–) Indicates oxbow is losing sediment.

Dates	Oxbow A	Oxbow B	Oxbow C	B.S.P.M Oxbow
Nov. 2000	75.32*	135.73*	197.57*	--
Jul. 2001	-7.18	86.72	134.99	--
Fall 2001	--	--	--	830.4*
Jan.2002	5.48	11.57	-3.28	--
Jun. 2002	-12.15	5.73	9.58	517.9
Total Fill	-13.85	104.02	141.29	517.9

5.4.1.1. Beaver Creek Oxbow A

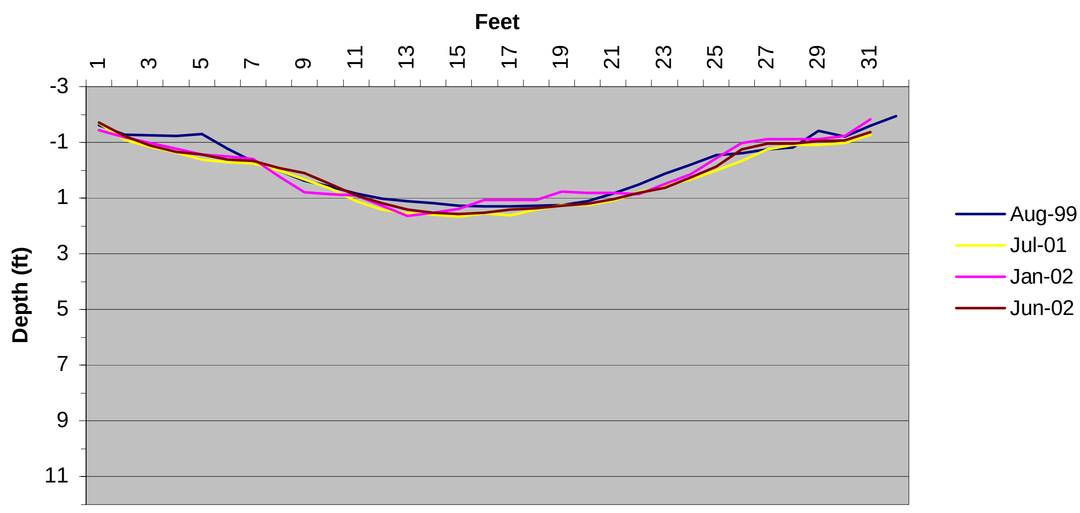

Figure 5.27. The upstream transect for the Beaver Creek oxbow diverter sediment trap (B-OD-A-T2), Newaygo County, Michigan.

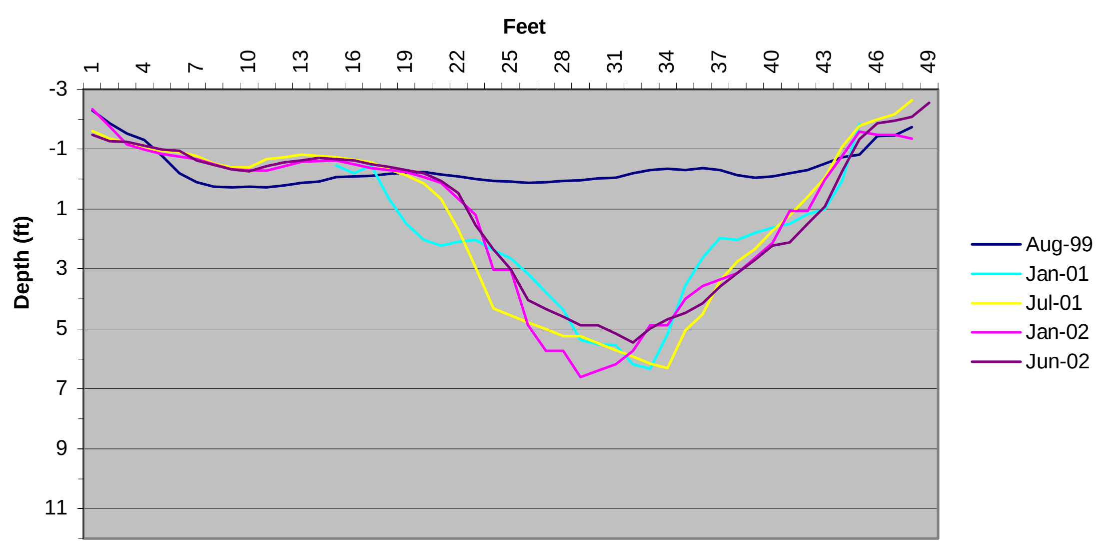

Figure 5.28. The downstream dredged section of the Beaver Creek oxbow diverter sediment trap (B-OD-A-T1), Newaygo County, Michigan.

5.4.1.2. Beaver Creek Oxbow B

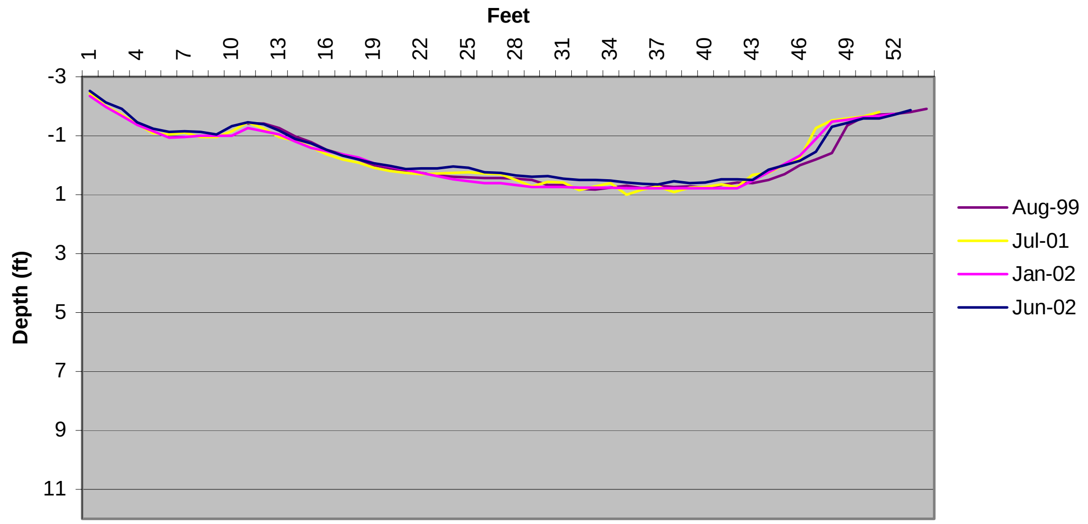

Figure 5.29 The upstream transect for the Beaver Creek oxbow diverter sediment trap (B-OD-B-T2), Newaygo County, Michigan.

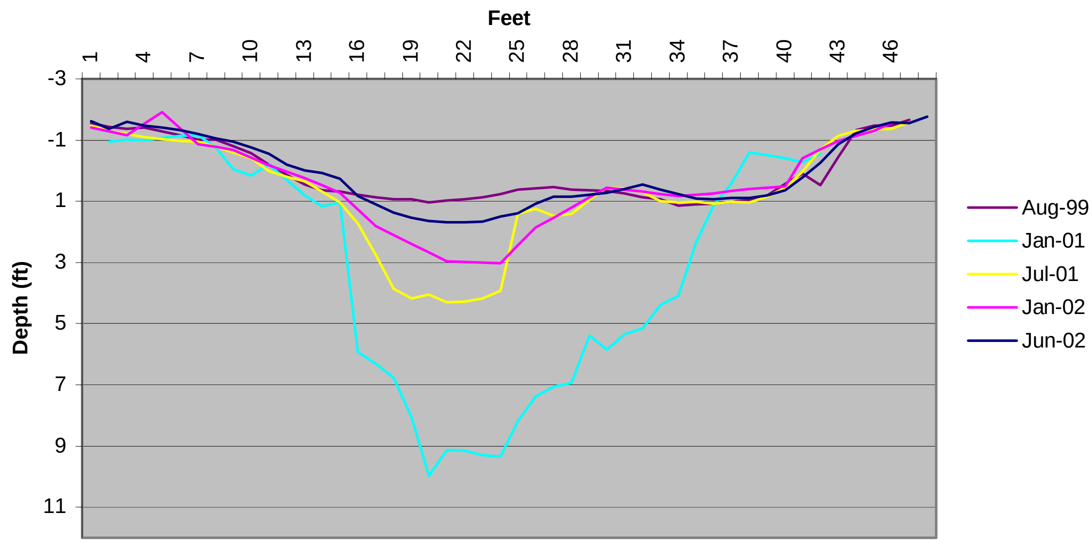

Figure 5.30 The downstream transect for the Beaver Creek oxbow diverter sediment trap (B-OD-B-T1), Newaygo County, Michigan.

5.4.1.3. Beaver Creek Oxbow C

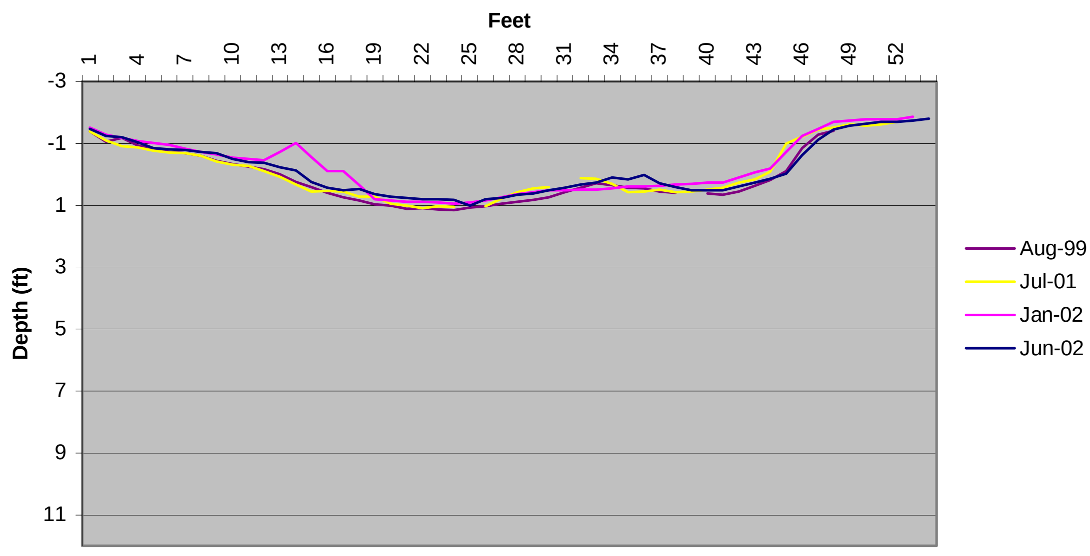

Figure 5.31 The upstream transect for the Beaver Creek oxbow diverter sediment trap (B-OD-C-T2), Newaygo County, Michigan.

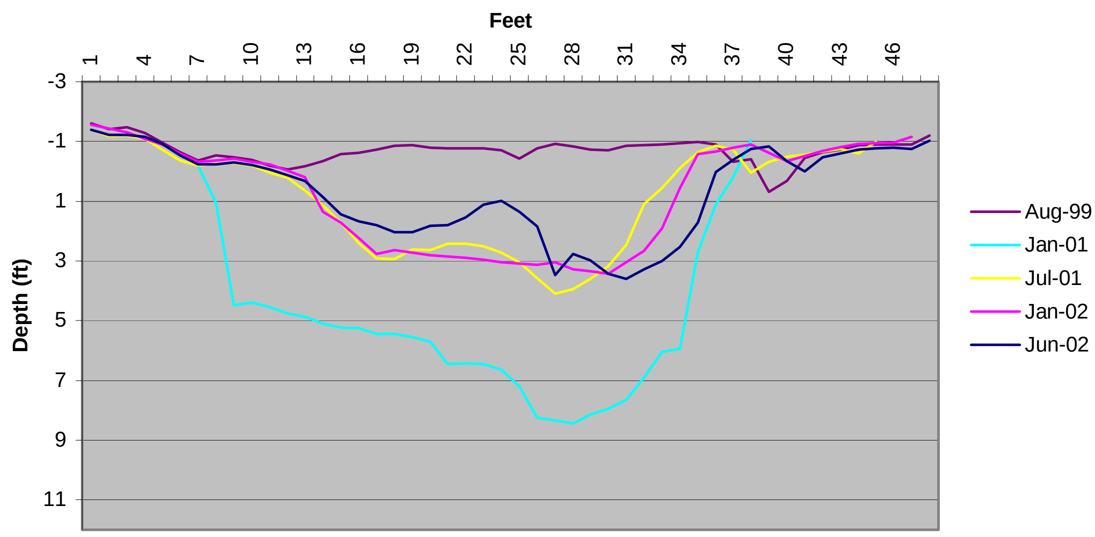

Figure 5.32 The downstream transect for the Beaver Creek oxbow diverter sediment trap (B-OD-C-T1), Newaygo County, Michigan.

5.4.1.4. Mainstream Big South Branch Pere Marquette Oxbow (MS-OD-1)

The Big South Branch oxbow (MS-OD-1) was 230 feet long and averaged 32 feet in width. Two transects were monitored at this oxbow to estimate filling rates (Figure Nos. 5.33 and 5.34). Figure 3.11 is a photograph of the east (inlet) side of this oxbow.

During the fall of 2001, 830.4 cubic yards were excavated from the 230-foot section of MS-OD-1. Nine months later, in June 2002, following spring high water events it was determined that the oxbow had collected 517.9 cubic yards of sediment, 62% of the total volume dredged the previous fall.

Oxbows B, C and MSOD-1 are very efficient at collecting stream sediments. It appears as though the orientation of the oxbows (perpendicular to the stream channel) and the hydraulics within the river channel at the entrance to the oxbow are important factors in determining their sediment trapping efficiency. It is optimal if the oxbows are configured such that during high water events water flows through the oxbow readily. This is the case with MS-OD-1. In the instance of Oxbows B and C, removal of the sediment “plug” at the inlet of the oxbow created this desired condition.

Oxbows B, C and MSOD-1 collected the 64%, 68% and 62% of their total sediment during the first spring high water period. With Oxbow C and B only accumulating between 3% and 12% more sediment throughout the next year, respectively. Suggesting sediment trapping efficiency decreases very rapidly after the first spring and should be cleaned annually in the fall to maximize sediment removal from the stream.

Cutoff oxbows provide an excellent means of removing sediment from streams that have high bedloads and flashy flow regimes. The Stream Sweeper™ performs this work very economically and avoids the damage typically inflicted on riparian zones by traditional land-based construction equipment. The Stream Sweeper™ pumps the sediment to suitable upland locations where natural vegetation reestablishes quickly.

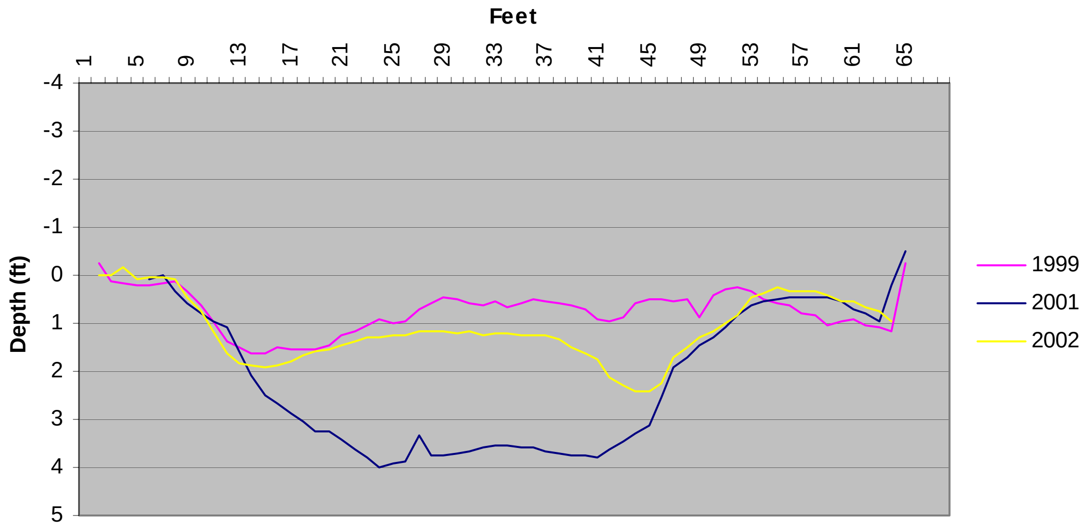

Figure 5.33. The downstream transect within the dredged section of the Big South Branch Pere Marquette River oxbow sediment trap #1(MSOD-1-T1), Newaygo County, Michigan.

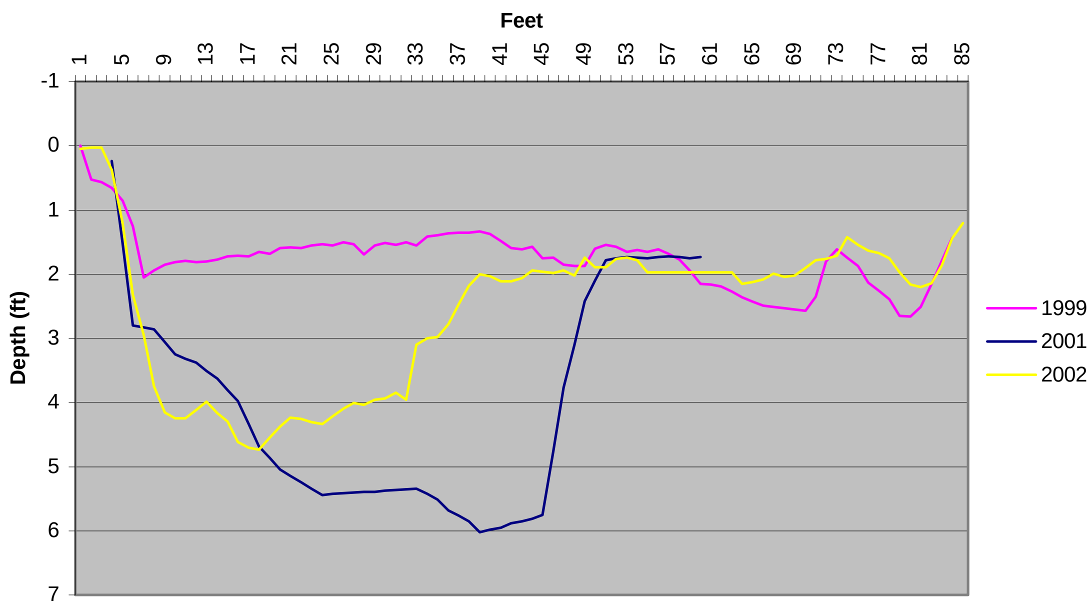

Figure 5.34 The upstream transect within the dredged section of the Big South Branch Pere Marquette River oxbow sediment trap #1 (MSOD-1-T2), Newaygo County, Michigan.

5.4.2. Winnepesaug and Cedar Creek Sediment Removal

The Winnepesaug Creek sediment trap was constructed in October 1999. An estimated 1,500 cubic yards of sediment were removed from the trap. This sediment removal site is approximately 491 feet long and 29 feet wide. The basin was designed and constructed to be considerably larger than traditional sediment traps.

The Cedar Creek sediment trap is 450 feet long and 45 feet long. Approximately 2,700 cubic yards of sediment were dredged from this trap.

The Cedar Creek basin continues to function well today, while the Winnepesaug basin completed filling in May 2003. These larger basins provide a cost –effective means of managing sediment and serve to preclude coarse-grained sediments from moving downstream of the basin. As with all sediment removal measures, long-term maintenance plans should be developed in advance of basin construction.

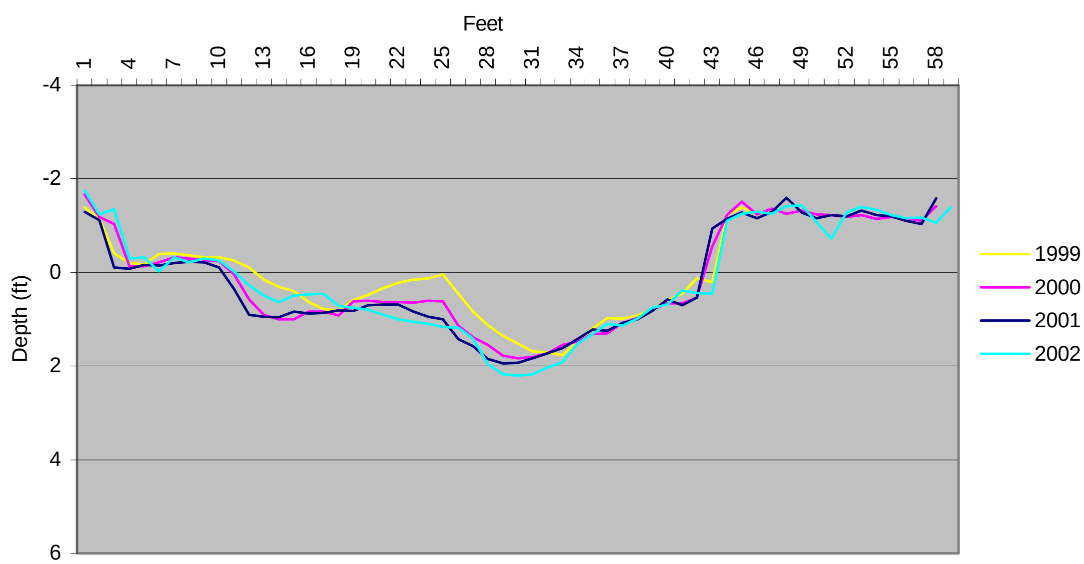

Figure 5.35 Horizontal cross-section of the Winnepesaug Creek sediment removal location, transect #1, during the 1999 - 2002 field seasons, Newaygo County, Michigan.

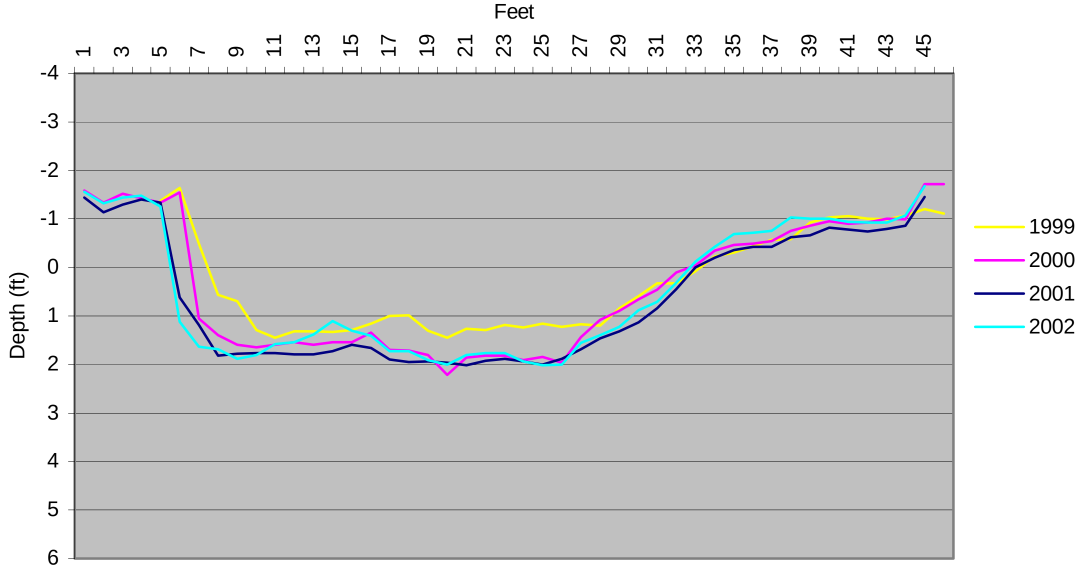

Figure 5.36. Horizontal cross-section of the Winnepesaug Creek sediment removal location, transect #2, during the 1999 - 2002 field seasons, Newaygo County, Michigan.

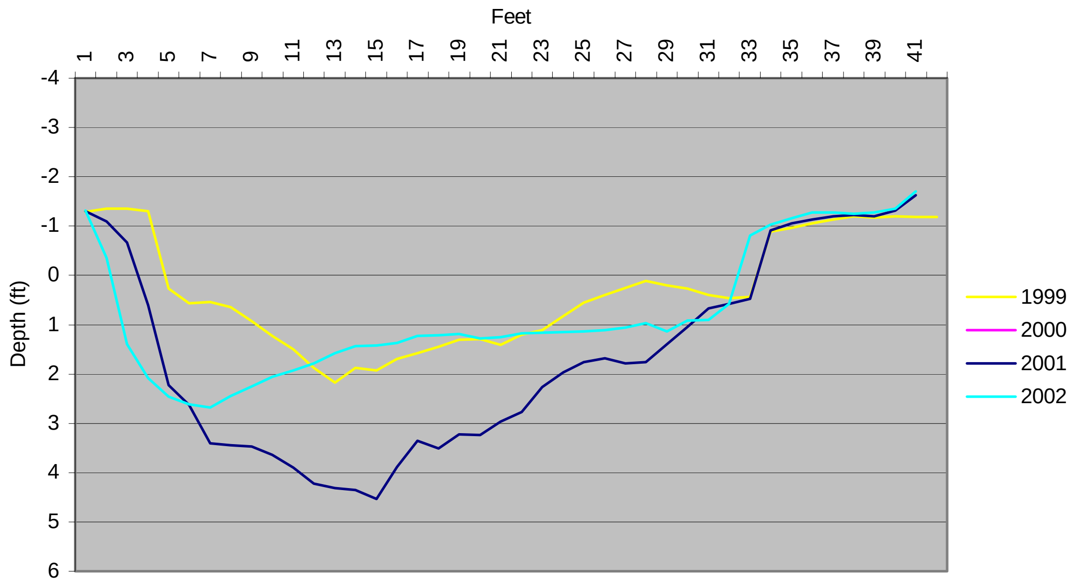

Figure 5.37. Horizontal cross-section of the Winnepesaug Creek sediment removal location, transect #3, during the 1999 - 2002 field seasons, Newaygo County, Michigan.

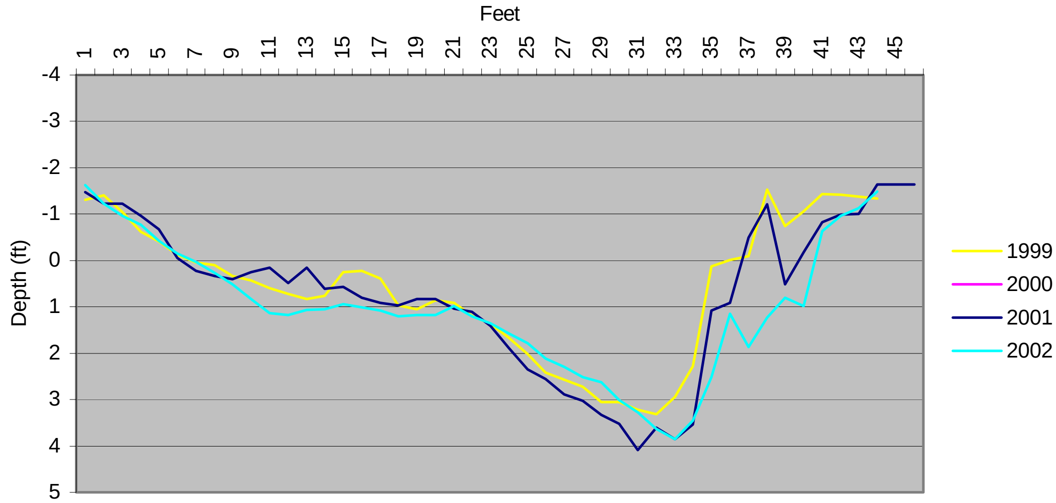

Figure 5.38. Horizontal cross-section of the Winnepesaug Creek sediment removal location, transect #4, during the 1999 - 2002 field seasons, Newaygo County, Michigan.

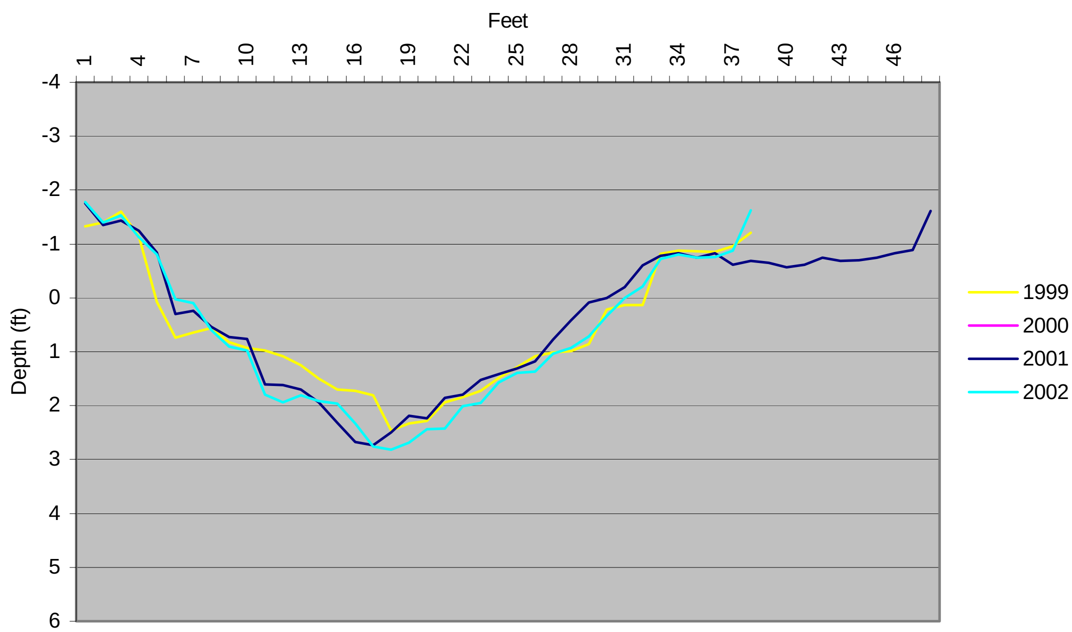

Figure 5.39. Horizontal cross-section of the Winnepesaug Creek sediment removal location, transect #5, during the 1999 - 2002 field seasons, Newaygo County, Michigan.

5.5. Instream Habitat Improvement Measures

5.5.1 Winnepesaug Creek Habitat Improvement Reach No. 1.(W-HI-1)

Whole trees were added to two reaches of Winnepesaug Creek in order to affect channel narrowing and deepening and to provide additional cover for fish. Channel cross-section surveys were conducted annually in these reaches to determine the effects of this work.

At the upper habitat improvement site (W-HI-1), some narrowing and deepening was observed at Transect 1. The effect is very localized, however.

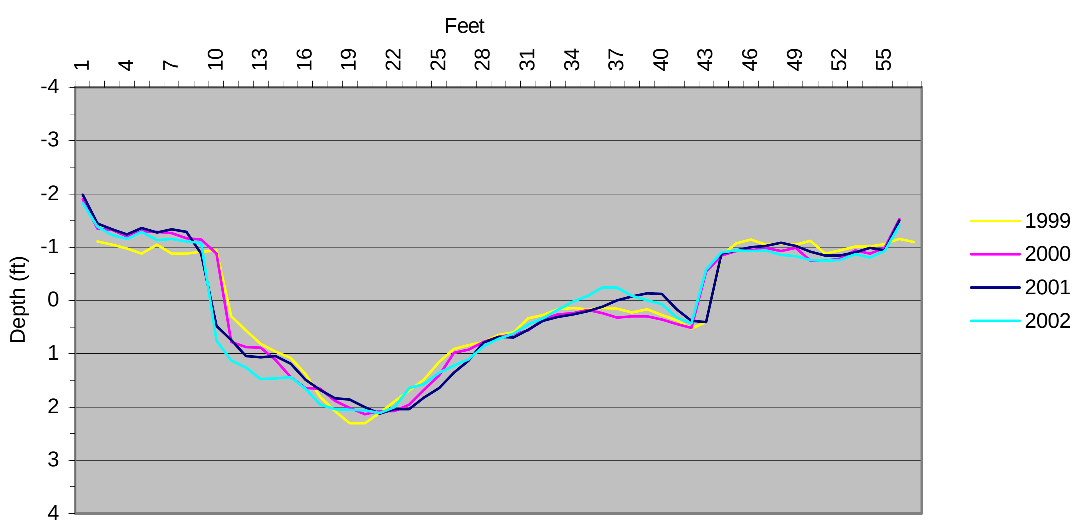

Figure 5.40. Cross-sections from the Winnepeasaug Creek Habitat Improvement #1, transect #1, during the 1999 - 2002 field seasons, Newaygo County, Michigan.

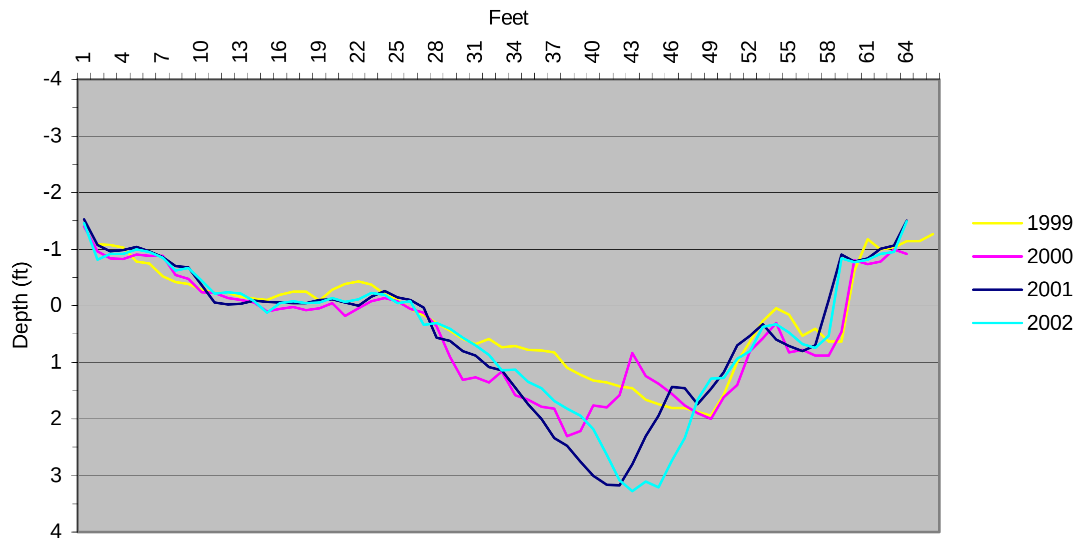

Figure 5.41. Cross-sections from the Winnepeasaug Creek Habitat Improvement #1, transect #2, during the 1999 - 2002 field seasons, Newaygo County, Michigan.

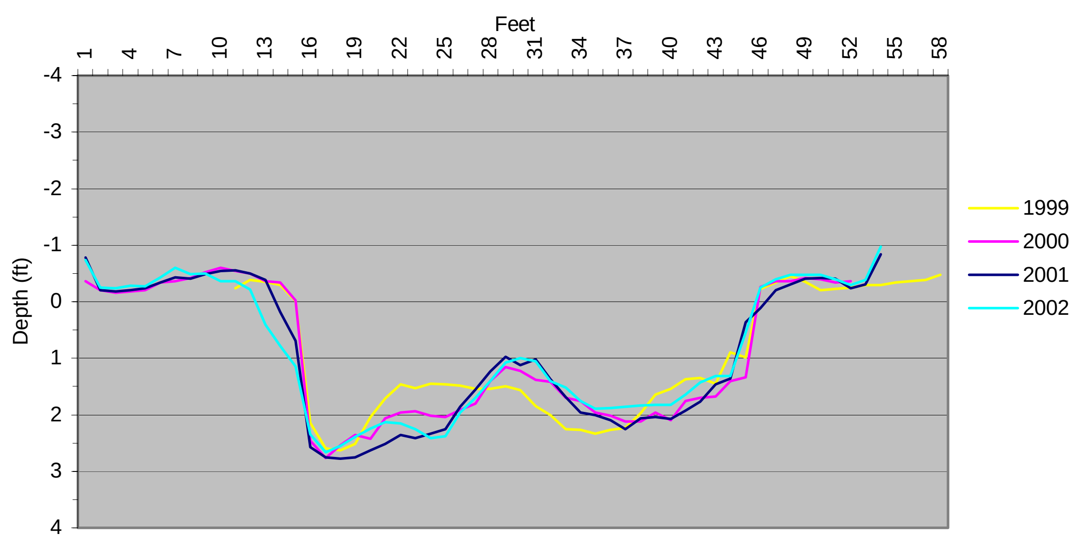

Figure 5.42. Cross-sections from the Winnepeasaug Creek Habitat Improvement #1, transect #3, Newaygo County, Michigan.

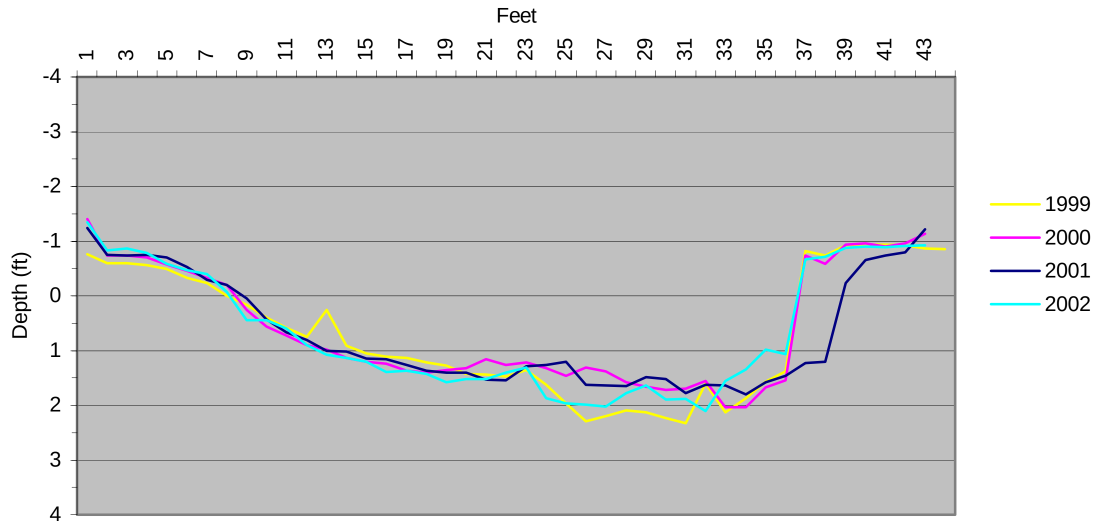

Figure 5.43. Cross-sections from the Winnepeasaug Creek Habitat Improvement #1, transect #4, Newaygo County, Michigan.

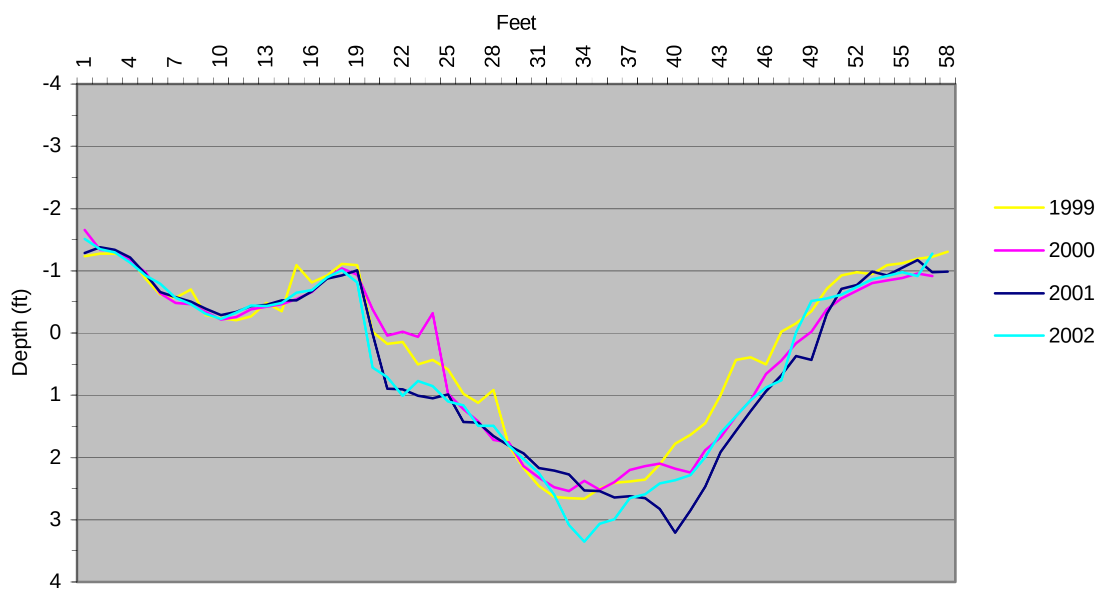

Figure 5.44. Cross-sections from the Winnepeasaug Creek Habitat Improvement #1, transect #5, Newaygo County, Michigan.

5.5.2 Winnepesaug Creek Habitat Improvement Reach No. 2 (W-HI-2)

At WH-I-2, the channel shows a positive response to the addition of whole trees in Transect 2. Again, the response is very localized.

The selective addition of whole trees is advantageous in most streams. Natural stream systems in forested landscapes would typically have 20% of their surface area comprised of wood. Irrespective of whether enough trees can be added to affect a change in channel cross-section, these larger woody debris additions create habitat for fish and macroinvertebrates. Electrofishing surveys at W-HI-2 revealed that chinook salmon fingerlings from the riffles upstream were utilizing the installed trees as refugia.

It is often difficult to find an adequate number of trees within the riparian zone to create an optimal outcome. Since it takes, on average, fifty years for a riparian zone tree to mature to the point where it will naturally fall into a Michigan stream, prudence should be used when cutting these trees.

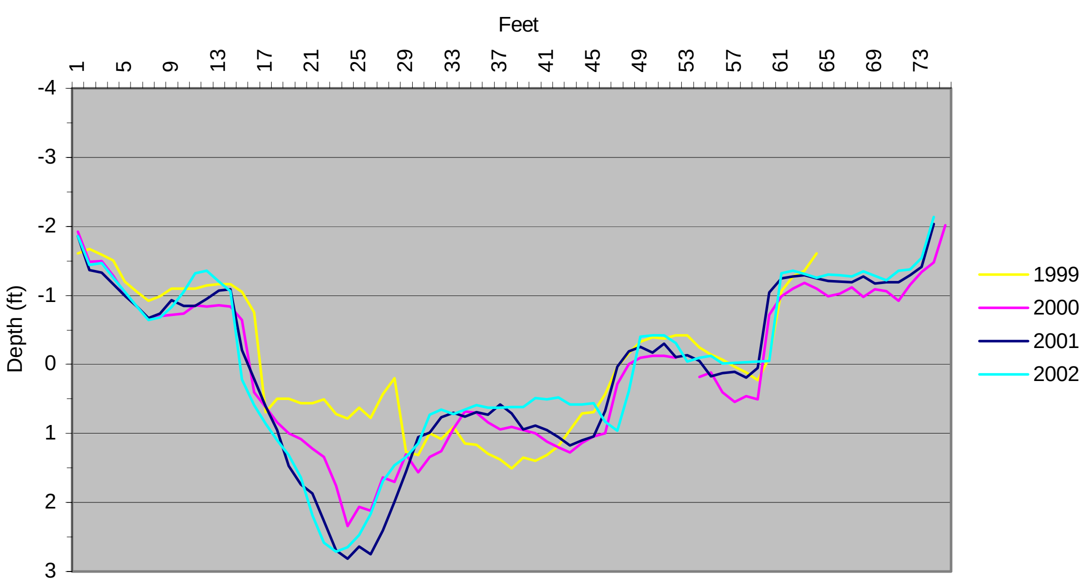

Figure 5.45. Cross-sections from the Winnepesaug Creek Habitat Improvement #2, transect 1, Newaygo County, Michigan.

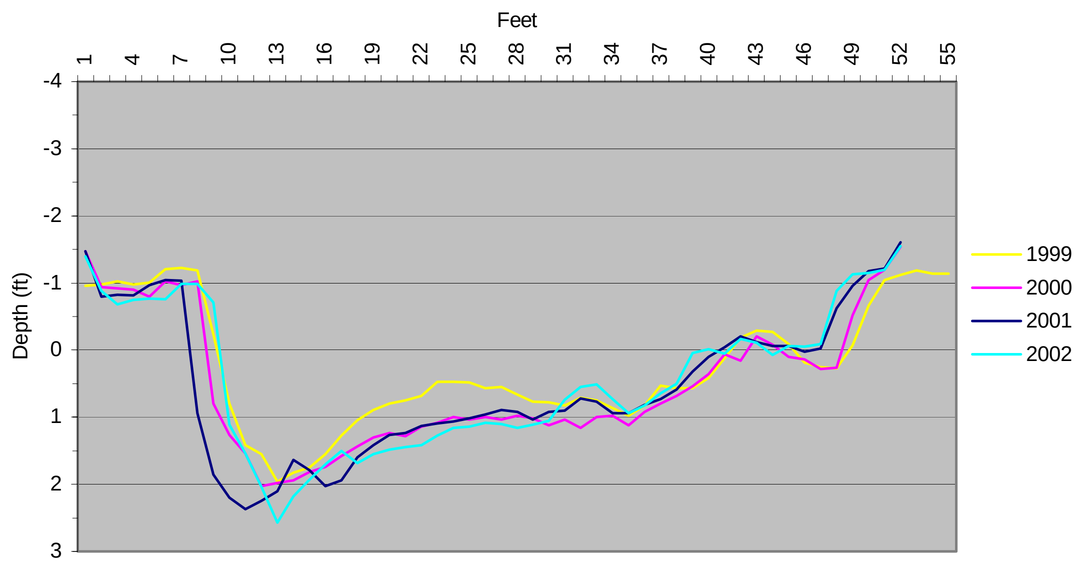

Figure 5.46. Cross-sections from the Winnepesaug Creek Habitat Improvement #2, transect 2, Newaygo County, Michigan.

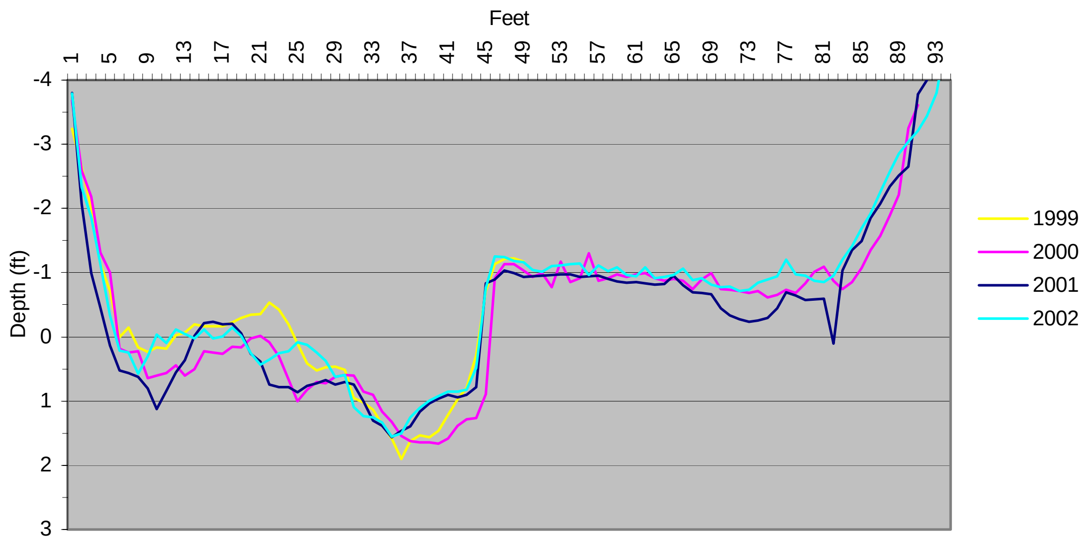

Figure 5.47. Cross-sections from the Winnepesaug Creek Habitat Improvement #2, transect 3, Newaygo County, Michigan.

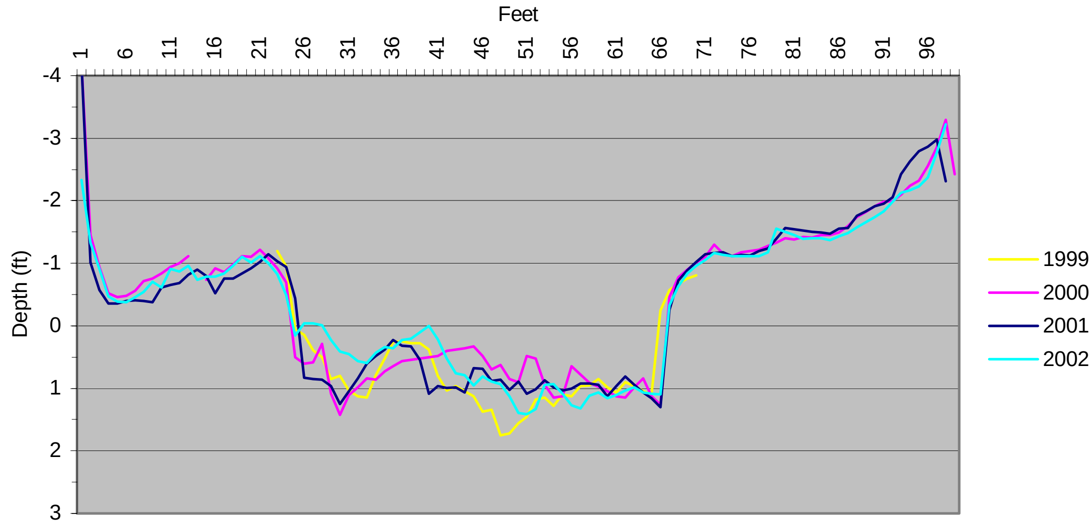

Figure 5.48. Cross-sections from the Winnepesaug Creek Habitat Improvement #2, transect 4, Newaygo County, Michigan.

5.6. Habitat Mapping

Qualitative stream habitat surveys indicate that fine sediments comprised a majority of the streambed in the Big South Branch stream reaches, prior to manipulation. Fine substrates were defined as sediments less than 1 mm in diameter, while course substrates were designated as those larger than 1 mm.

Woody cover was defined to be any woody debris that could be used by aquatic organisms for cover. Woody debris was found to be very rare at all sites comprising less than 8% of the total for all site

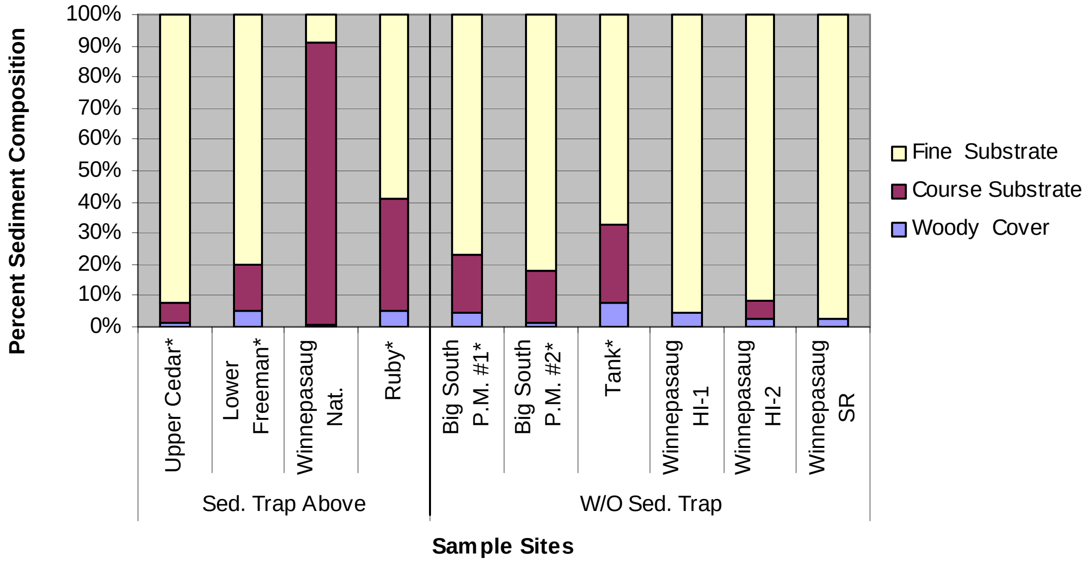

Figure 5.49. Streambed composition at the Big South Branch Pere Marquette River sampling locations during 1999. Asterik (*) denotes constructed gravel bars. Fine substrate is defined by sand, silt and detritial material. Course substrates are gravel, cobble and boulders. Woody Cover is any w oody structure w ithin the streambed.

Table 5.7. Streambed composition in the Big South Branch Pere Marquette River in 1999. * denotes constructed gravel bars.

Sites with Sediment Trap	Woody Cover	Course Substrate	Fine Substrate
Upper Cedar*	1.24%	6.35%	92.41%
Lower Freeman*	5.00%	15.05%	79.95%
Winnepesaug Nat.	0.94%	90.35%	8.72%
Ruby*	5.13%	35.92%	58.95%
Sites without Sediment Trap	**Woody Cover**	**Course Substrate**	**Fine Substrate**
Big South P.M. #1	4.38%	18.55%	77.07%
Big South P.M. #2	1.06%	16.70%	82.23%
Tank*	7.65%	25.22%	67.12%
Winnepesaug HI-1	4.71%	0.00%	95.29%
Winnepesaug HI-2	2.35%	6.23%	91.42%
Winnepesaug SR	2.83%	0.00%	97.17%

Post-construction habitat mapping showed slightly different substrate compositions from 1999. Fine substrates declined for all sites where gravel bars were constructed, due to the course gravel substrates that were added (Figure 30 and Table 15). The natural gravel bar at Winnepesaug Creek showed an increase in fine sediments from 8.7% to 45.3 %. The three other locations, Winnepesaug habitat improvement 1, 2 and Sediment removal all continued to have the reaches dominated by over 90% fines sediments regardless of the woody cover placed in the stream to create habitat and increase flow velocities.

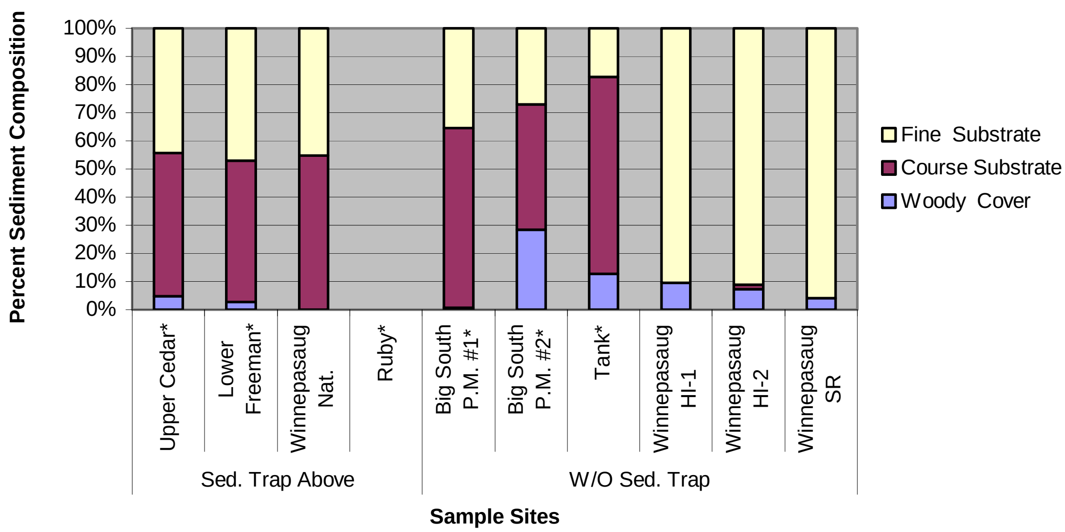

Figure 5.50. Streambed composition at the Big South Branch Pere Marquette River sampling locations in 2000. Asterisk (*) denotes constructed gravel bars. Fine substrate is defined as sand, silt and detritial material. Coarse substrates are gravel, cobble and boulders. Woody Cover is any woody structure within the streambed.

Table 5.8. Streambed composition in the Big South Branch Pere Marquette River in 2000. * denotes constructed gravel bars.

Sites with Sediment Trap	Woody Cover	Coarse Substrate	Fine Substrate
Upper Cedar*	4.70%	51.08%	44.22%
Lower Freeman*	2.65%	50.30%	47.05%
Winnepesaug Nat.	0.00%	54.74%	45.26%
Ruby*	0.00%	0.00%	0.00%
Sites without Sediment Trap	**Woody Cover**	**Coarse Substrate**	**Fine Substrate**
Big South P.M. #1*	0.77%	63.87%	35.36%
Big South P.M. #2*	38.20%	59.94%	36.25%
Tank*	12.65%	70.02%	17.34%
Winnepesaug HI-1	9.59%	0.00%	90.41%
Winnepesaug HI-2	7.26%	1.68%	91.06%
Winnepesaug SR	4.07%	0.00%	95.93%

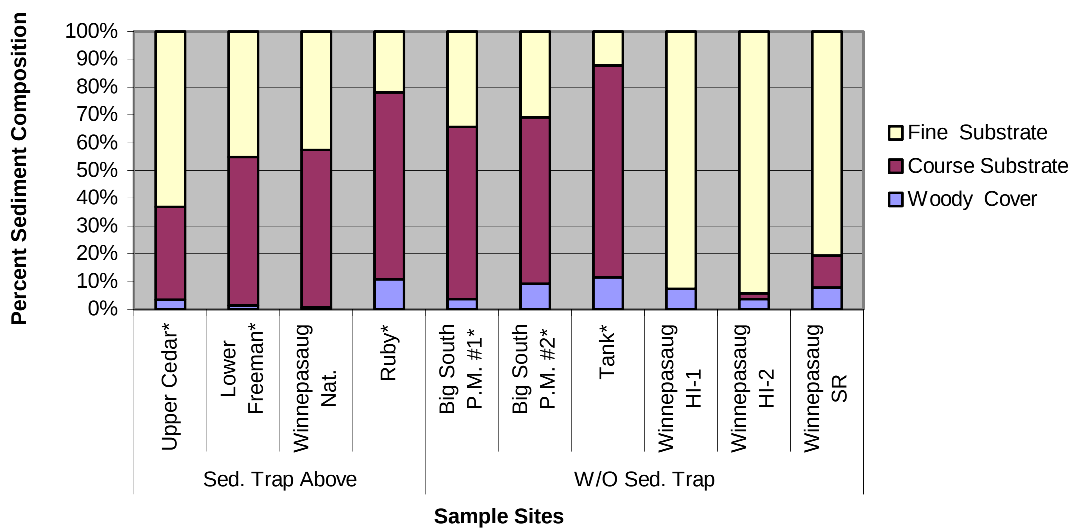

Figure 5.51. Streambed composition at the Big South Branch Pere Marquette River sampling locations during 2001. Asterisk (*) denotes constructed gravel bars. Fine substrate is defined as sand, silt and detritial material. Coarse substrates are gravel, cobble and boulders. Woody Cover is any woody structure within the streambed.

Table 5.9. Streambed composition in the Big South Branch Pere Marquette River in 2001. * denotes constructed gravel bars.

Sites with Sediment Trap	Woody Cover	Coarse Substrate	Fine Substrate
Upper Cedar*	3.45%	33.32%	63.23%
Lower Freeman*	1.42%	53.46%	45.12%
Winnepesaug Nat.	0.73%	56.70%	42.58%
Ruby*	10.77%	67.30%	21.93%
Sites without Sediment Trap	**Woody Cover**	**Coarse Substrate**	**Fine Substrate**
Big South P.M. #1*	3.66%	62.01%	34.33%
Big South P.M. #2*	9.33%	59.88%	30.79%
Tank*	11.50%	76.34%	12.16%
Winnepesaug HI-1	7.40%	0.00%	92.60%
Winnepesaug HI-2	3.69%	2.06%	94.26%
Winnepesaug SR	7.84%	11.56%	80.60%

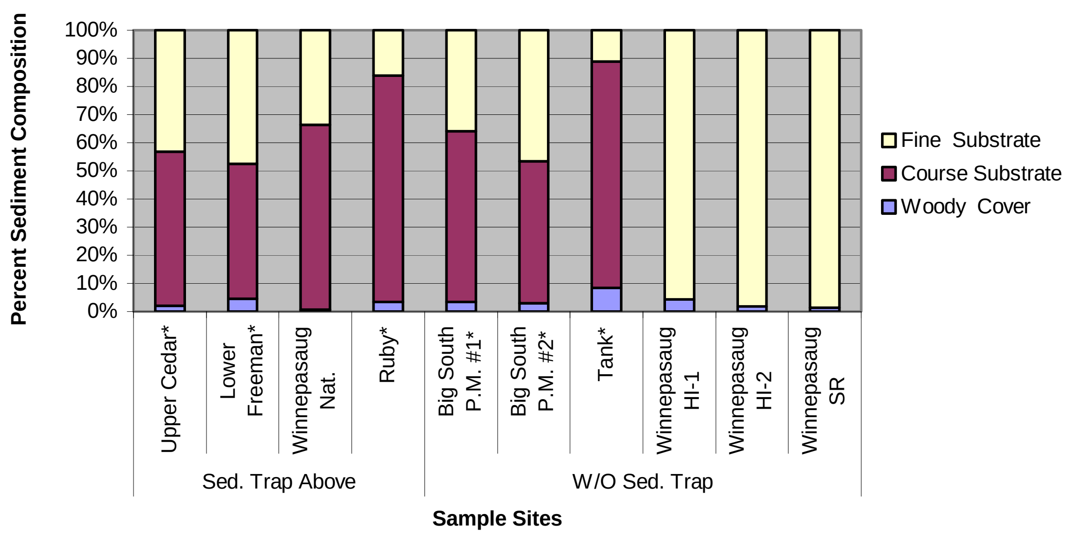

Figure 5.52. Streambed composition at the Big South Branch Pere Marquette River sampling sites in 2002. Asterisk (*) denotes constructed gravel bars. Fine substrate is defined as sand, silt and detritial material. Coarse substrates are gravel, cobble and boulders. Woody Cover is any woody structure within the streambed.

Table5.10. Streambed composition at the Big South Branch Pere Marquette River in 2002. * denotes constructed gravel bars.

Sites with Sediment Trap	Woody Cover	Coarse Substrate	Fine Substrate
Upper Cedar*	1.94%	54.98%	43.08%
Lower Freeman*	4.64%	47.84%	47.52%
Winnepesaug Nat.	0.79%	65.64%	33.57%
Ruby*	3.43%	80.34%	16.23%
Sites without Sediment Trap	**Woody Cover**	**Coarse Substrate**	**Fine Substrate**
Big South P.M. #1*	3.51%	60.67%	35.81%
Big South P.M. #2*	2.85%	50.61%	46.54%
Tank*	8.49%	80.33%	11.18%
Winnepesaug HI-1	4.30%	0.00%	95.70%
Winnepesaug HI-2	1.72%	0.00%	98.28%
Winnepesaug SR	1.34%	0.00%	98.66%

6.0 RUBY CREEK INTERPRETIVE CENTER

The Ruby Creek Recreation and Conservation Club developed a plan for and Constructed a 4,000 square foot pavilion at the site of the former Michigan DNR Ruby Creek Fish Rearing Station. The Club negotiated a 20-year special use agreement with the DNR to enable this project. The facility includes the interpretive pavilion, fishing and observation platform, public restrooms and an interpretive trail along Ruby Creek.

Figure 6.1 Ruby Creek Interpretive Center, Newaygo County, Michigan.

Figure 6.2. Michigan DNR Fisheries Biologist Rich O'Neal (left) congratulates Ruby Creek project chair John Carr, PMWC board member Dave Gibbs and Ruby Creek member O.J. Thomann at the Interpretive Center dedication.

7.0 CLASSROOM CURRICULUM AND FIELD WATER QUALITY TESTING

Dr. Claudia Douglass of Douglass Consulting collaborated with Marsha Barter of The Mason-Lake-Oceana Intermediate School District's Math-Science Center in developing both classroom and field curricula focusing on water quality monitoring in the Pere Marquette watershed. These curricula are currently being utilized by 3rd through 12th grade students in ten local school districts within the watershed. These curricula have been adopted as part of the core science curriculum in the ten districts serviced by the Mason-Lake-Oceana ISD's Math-Science center.

Copies of the curricula were distributed to the Great Lakes Fishery Trust in September 2002.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Constructed riffles have provided a substrate that is much more suitable for stream flora and fauna. These coarse substrates are more stable environments, provide more favorable velocities and they are more aesthetically pleasing.

Gravel substrates that were added to the Big South Branch and its tributaries to promote spawning success of salmonids are supporting a higher density and a higher diversity of taxa of macroinvertebrates than the naturally existing sandy substrates.

The lower densities of macroinvertebrates observed in the 2002 samples at the Lower Freeman Creek and Ruby Creek gravel bars illustrate the negative impact that excess sand bedload can have on macroinvertebrate communities.

The constructed riffles are all sustaining salmonid spawning activity at levels higher than the reference riffles, with respect to both chinook salmon and steelhead. Spring electrofishing surveys indicate that the eggs deposited in these constructed riffles by spawning salmonids are successfully hatching. Chinook salmon and steelhead fingerlings were readily visible at constructed riffles. As well, chinook salmon successfully reproduced in Tank Creek where there is no previous record of successful spawning.

In order to determine the contribution of these fish to the Great Lakes, there is a need to observe and document returning runs of fish, which were produced on these riffles. The first potential returning run of chinook salmon would spawn this fall (2003).

It is our recommendation that, at a minimum, three additional years of redd mapping be conducted, together with an additional three years of spring electrofishing and fry trapping. This would allow for the observation of three consecutive returning runs of chinook and one to two returning steelhead runs.

It would be more desirable to conduct a total of six years (2003-2008) of sampling to be able to incorporate data from a larger number of returning runs of anadromous salmonids. As with all fish populations, there is a considerable amount of natural variability within and between year classes. Accordingly, longer data sets are more likely to provide information, which is conclusive.

Cutoff oxbows can be efficient sand traps in flashy streams with high bedloads. It is important to note that, in many instances, these stream features can provide for the storage of significant volumes of sediment.

The Stream Sweeper™ provides an excellent means of removing sand bedload from streams. It is most cost effectively utilized in situations where large volumes of spoils can be pumped to nearby (1000 feet or less) uplands. When dispersed in a thin veneer, natural vegetation reestablishes quickly.

A number of new and ongoing activities should be undertaken by the project partners, including:

1. Periodic monitoring and maintenance of gravel bars, sediment removal and stream bank stabilization sites should be performed in order to assure that these improvements remain intact and productive. The effectiveness of riffles is being diminished over time by the accumulation of sediments. As well, spawning fish regularly redistribute the gravel and cobble in these riffles. Left unattended, the integrity of these measures will be diminished. Annual maintenance costs should not be high, so long as observations and maintenance activities are conducted in a timely manner.

2. The sediment removal sites will ultimately fill and become non-functional. The Ruby Creek sediment trap, in particular, requires frequent maintenance and our data indicate that timely maintenance of this trap significantly improves the quality of gravels downstream. By monitoring both the habitat quality within the constructed gravel bars and the level of spawning activity they sustain over time, determinations could be made as to when and to what extent the other sediment removal sites should be maintained.

3. Poaching has been an ongoing problem at each of the gravel bars. To date there has been no effective enforcement. Unquestionably, this poaching is having an adverse impact on the numbers of fish produced on these gravel bars. Continued communication with MDNR and US Forest Service staff will be needed in order to remedy this problem.

4. Ongoing monitoring (six additional years) of spawning activity is desirable. Increasing numbers of returning spawners at these gravel bars would serve as a good indicator of long-term success. Additional electrofishing, fry trapping, fecundity estimates and egg mortality studies would provide more accurate fingerling production estimates.

5. Long-term treatment of systemic problems in the upper watershed desperately need to be addressed. Flashy flow regimes, as a result of historic drainage and land use, are generating considerable stream bank erosion and sedimentation within the Beaver Creek watershed. These impacts are transmitted downstream throughout the Big South Branch main stem. These problems should be addressed collaboratively by watershed stakeholders in order to substantially improve stream health over the long-term.

6. Within the context of integrated watershed management, it would be appropriate to explore the value of increased timber cutting as a way to increase ground water yield. It is important to note that all cutting adjacent to riparian zones would need to be undertaken with great caution. Best management practices should be utilized in all instances.

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