Final Report

Biological Monitoring in the Whitewater River Watershed National Monitoring Program Project

(Whitewater Watershed Project: 2004-2006 Fish, Benthic Macroinvertebrate and Habitat Assessments)

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by

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Executive Summary

Three related, but separate, projects were undertaken within the Whitewater River watershed during 2004, 2005, and 2006. During 2004, stream sites that were surveyed during 1998 were revisited to assess any potential changes in fish, invertebrates, or physical habitats that may have occurred during the 6-year period. In 2005, an intensive, longitudinal survey of the South Branch Whitewater River was conducted to document the biota and physical habitats at 22 stream sites evenly spaced throughout the entire length of this stream. During 2006, the filling of stream pool habitats by fine sediments was examined at 25 sites within the Whitewater River watershed and the adjacent Garvin Brook watershed.

During 2004, fish assemblages at most stream sites on upper reaches of the main branches of the Whitewater River were rated as poor or very poor, whereas sites on the lower reaches and the smaller tributaries received higher ratings. Relationships between the fish index of biotic integrity and various stream habitat variables suggest that the best coldwater fish assemblages in the Whitewater River watershed were found in shallow (e.g., < 40 cm) stream sites with more riffle than run habitat, good riparian buffer, and lack of cover for large fish.

Invertebrate assemblages generally were rated as fair to poor throughout the Whitewater River watershed in 2004. Relationships between the invertebrate index of biotic integrity and various stream habitat variables suggest that the best invertebrate assemblages in the Whitewater River watershed were found in larger streams with clean substrate, good pool-riffle

habitat, and non-shaded streambed with long grasses overhanging the banks.

When examined together, stream size, the abundance of fine sediments, abundance of riffle and run habitats, buffer width, and the type of riparian vegetation influence the types and abundances of fish and invertebrates in these streams. Although observable changes in agriculture and development have occurred within the watershed in the years between 1998 and 2004, these changes have not yet had any significant effects on either the habitats or biota of streams in this area.

Many patterns were apparent after examining 22 sites along the length of the South Branch Whitewater River during 2005. Basically, upstream sites had poor fish habitat and poor fish assemblages. Upstream sites 1 through 11 all had fair or poor habitat ratings, whereas downstream sites 12 through 22 mostly had good habitat ratings. The change in habitat rating between sites 11 and 12 was dramatic. The fish index of biotic integrity rated sites on the South Branch Whitewater River as very poor to good. Most of the sites on upper reaches were rated as poor or very poor, whereas sites on the lower reaches received fair or good ratings. Fine sediments, embeddedness, and lack of instream cover and riparian buffers were the factors most likely affecting fish communities in this stream segment. In contrast, downstream sites had much better fish habitat and fish assemblages, the result of higher flows of cold water, reduced fines and embeddedness, wider riparian buffers, and better instream habitat. Invertebrate samples collected from South Branch sites received fair to very poor ratings by the invertebrate index of biotic integrity. Invertebrate habitat was limited at many locations, especially at the upper sites, and diversity was poor throughout the entire stream.

The filling of stream pools with fine sediments was examined in 25 pools in streams in and near the Whitewater River watershed during 2006. Pools varied in the extent of volume lost to fine sediment accumulations, ranging from <5 to >93% of total pool volume lost to fines. Middle Branch Whitewater pools had the lowest volume loss to fines (<11%), whereas Trout Valley Creek pools had the most extensive losses (>70%). There was no apparent pattern of volume loss from upstream to downstream sites within a stream. Turbidities produced by disturbing pool sediments suggested that upstream pools were dominated by finer sediments (silts, clays) and downstream pools were dominated by coarser sediments (sands, gravel). Pool loss to fine sediments, whether historical or ongoing, reduces the capacity of the stream to support abundant, sustainable trout populations.

General Introduction

This report summarizes information on fish, benthic macroinvertebrate, and habitat assessments conducted for the Whitewater Watershed Project during the period June-August 2004, 2005, and 2006. Data collected during these three field seasons and herein described represent three related, but separate, studies. These studies are a continuation and expansion of work begun in 1994 to collect baseline information on the biological and physical integrity of streams within the watershed. During 2004, stream sites within the Whitewater Watershed that were assessed for their physical and biological characteristics in 1998 were reassessed for comparison to the 1998 findings. During 2005, an intensive, longitudinal survey of the physical and biological characteristics of the South Branch Whitewater River was undertaken. During 2006, filling of stream pools by fine sediments was assessed at stream sites in the Whitewater River and Garvin Brook watersheds.

This report is separated into three chapters, with each chapter detailing the procedures and findings for a single field season. Each chapter is written to stand alone as a separate report, if necessary, so methodologies and certain other items common to all years’ studies appear in each chapter.

Budget

The funding for this work was provided by the Minnesota Pollution Control Agency through a USEPA Section 319 program grant. The funds were provided as part of the Whitewater River Watershed National Monitoring Project. The contract (CFMS #A61340) budget was $55,504 for the period June 6, 2004 through September 30, 2006. Grant payments were made in the amounts of $24,977 on July 29, 2004 and July 21, 2005 with a final payment of $832.61 on December 11, 2006. The remaining contract balance of $4,717.39 was not needed to complete the project.

Chapter 1: **Whitewater Watershed Project: 2004 Fish, Benthic Macroinvertebrate, and Habitat Assessments, and a Comparison to 1998 Findings**

Introduction

Fish, benthic macroinvertebrate, and habitat assessments were conducted at 42 stream sites within the Whitewater Watershed during June-August 1998 (Mundahl 1999). Most stream sites had fair to good fish habitat ratings, although poor and excellent ratings also were observed. Fish assemblage assessment with the coldwater index of biotic integrity (IBI) indicated that sites rated from very poor to good, with poorer ratings largely the result of too few coldwater fishes and too many warmwater fishes. Invertebrate assemblage assessment rated most sites throughout the Watershed as having moderate impairment, largely the result of too few species overall and specifically too few sensitive species that feed by scraping algae off coarse substrates or by shredding leaves or other large pieces of vegetation. The highest-quality fish and invertebrate assemblages were found in narrow, shallow streams with cool to cold water, coarse substrates, extensive riffles, and little fine sediment (sand, silt, clay). These conditions were most often associated with streams with wide, wooded buffers.

The objective of the present study was to re-examine in 2004 the same stream sites that were surveyed in 1998, to assess any changes which may have occurred at these stream locations during the intervening 6-year period. During this time period, residential and commercial development continued within the watershed, with several new developments occurring nearby or between various stream sites. In addition, changes in farm practices were observed near many stream sites, specifically increases in row-crop agriculture and expanded livestock grazing. It was hypothesized that these changes may result in measurable changes in the abundance of instream fine sediments and embeddedness, and ultimately in altered macroinvertebrate and fish assemblages.

Methods

Field Work

During the period June to August 2004, 38 stream sites were sampled for fish, invertebrates, and stream habitat (Table 1-1; sites within each stream are listed in upstream to downstream order). Of these sites, 35 were located within the Whitewater Watershed and three were on streams in adjacent watersheds (Garvin Brook, East Indian Creek). Four of the 42 sites examined in 1998 were not examined in 2004, because of lack of access in 2004: one site on East Indian Creek (EIC-2), one site on the Middle Branch Whitewater River (MWR-4), and two sites on the South Branch Whitewater River (SWR-2 and SWR-6).

Fish at each site were sampled with a backpack electrofisher. All fish captured within a 150-m stream segment (downstream to upstream, single pass) were identified, counted, and released. Specimens of uncertain identity were retained for later identification.

Invertebrates were collected in triplicate kick net samples at each stream site. Each sample was the combination of organisms collected by kicking the substrate for 30 sec in each of two sections (fast and slow) of a single riffle. Invertebrate samples were preserved in ethanol and later sorted, identified, and counted in the laboratory.

Habitat at each stream site was examined in two ways. First, a simple fish habitat rating index designed for assessing streams in Wisconsin (Simonson et al. 1993) was used. Instream and riparian features were examined, scored, and used to produce a fish habitat rating for each site.

Additional, more detailed habitat assessments also were conducted at each of the sites. Assessments were based on protocol developed for use in Wisconsin (Simonson et al. 1993). Additional protocols developed to examine grazing impacts in the west, but appropriate here, also were used (Platts et al. 1982). Sampling at each sites was conducted using a modification of the transect method (Simonson et al. 1993). Habitats at each sites were sampled across each of 13 transects spaced approximately two to three mean stream widths apart.

Along each transect, several instream habitat features were assessed, and riparian conditions were recorded. Instream measures were taken at four, evenly spaced points along each transect. At each point, depth was measured using a wading rod, and velocity measured at 0.6 of the depth using a Marsh-McBirney model 2000 flow meter. Dominant substrate composition was visually estimated according to a modification of the Wentworth Scale (clay, silt, sand, gravel, cobble, boulder). Embeddedness, the percent of large substrates such as cobbles covered by fine materials, was visually estimated on a five-category scale: <5%, 5-25%, 25-50%, 50-75%, and >75% (Platts et al. 1983).

Other instream measures were estimated visually within a reach one mean stream width in length, centered on the transect

(Simonson et al. 1993). The percentage of the stream shaded by the canopy at noon, the percentage of riffle, pool, and run, and the percent of the reach providing cover for fish 200 mm or larger, were estimated to the nearest 5%. Cover for fish included overhanging bank vegetation, woody debris, instream vegetation, boulders, and water >60 cm deep.

Riparian measures were made on only one stream bank per transect, alternating the side measured with each transect. Width of the riparian buffer was measured to the nearest meter. Average length of vegetation overhanging the stream was measured to the nearest 0.1 meter. The percentage of bank vegetation as grass, forb, tree, and shrub, and the percentage of bank as bare soil, were estimated visually to the nearest 5% for each category. Data collected from all transects were averaged to determine overall site values.

Data analysis

Fish data were used to calculate an Index of Biotic Integrity (IBI) score and rating for each site. For ease of comparison, all stream sites were assessed with a coldwater version of the IBI (Mundahl and Simon 1998).

Invertebrate data were used to calculate Benthic Index of Biotic Integrity (B-IBI) scores and ratings for each site (Wittman and Mundahl 2003). Scores for the triplicate samples for each site were averaged to produce a single value and rating for that site.

Physical stream habitat variables were compared statistically to one another and to the two biotic indexes with multiple regression models. In addition, several habitat variables and the coldwater IBI data collected in 2004 were compared with paired t tests to data collected from the same sites in 1998 to assess possible changes during the 6-year period between investigations.

Results and Discussion

General Fish Habitat

Fish habitat rating index scores of stream sites examined in 2004 ranged from a low of 28 (poor rating) to a high of 91 (excellent rating), averaging 61.6 (good rating; Table 1-2). Habitat scores for the same sites in 1998 ranged from a low of 4 (poor rating) to a high of 89 (excellent rating), averaging 56.7 (fair rating; Table 1-2). Most (>80%) sites received fair or good fish habitat ratings in both years. Habitat scores did not change significantly (paired t-test: $t = 1.39$, $P = 0.17$) between 1998 and 2004, and the rating distribution changed only slightly (Fig. 1-1). However, fish habitat rating scores within the Whitewater River watershed have been improving steadily during the past decade (1996 mean = 49.8 [fair rating], 1997 mean = 53.9 [fair rating], 1998 mean = 58.3 [fair rating], 2004 mean = 61.6 [good rating]).

Fish

During 2004, 23 species of fish were collected from 38 stream sites, whereas 22 species were collected from 41 sites in 1998 (Table 1-3). Three species (brown trout, longnose dace, white sucker) each were collected at more than 20 sites in 2004, whereas two species (bigmouth shiner, pumpkinseed) were found at only a single location. The total number of fish collected in 2004 was 6,488, with each site averaging 171 fish (range = 3 to 364 fish/site) (Table 1-4). In 1998, 12,343 were collected, with each site averaging 301 fish (range = 59 to 788 fish/site). Fish numbers in 1997 were 18,309 total and 436 fish/site (range = 21 to 1,253 fish/site). An average of 6 species (range = 2-13) was collected per site in 2004, compared to an average of 7 species (range = 1 to 14) collected per site during 1998.

Fish data collected in 2004 from each of the sites were used in calculating a coldwater IBI score for each site. The coldwater IBI rated sites within the Whitewater River watershed as very poor to excellent. Most of the sites on upper reaches of the main branches were rated as poor or very poor, whereas sites on the lower reaches and the smaller tributaries received higher ratings (Table 1-5). IBI scores averaged 46.6 (fair) in 2004 compared to an average of 45.7 (fair) in 1998. There was no significant difference (paired t-test: $t = 0.25$, $P = 0.80$) in IBI scores between 1998 and 2004. Compared to 1998, more sites in 2004 were rated excellent, but more also were rated as very poor (Fig. 1-2). In general, IBI scores in both years were reduced by too many warmwater species (minnows and benthic species such as darters) and too few brook trout and brown trout (especially as top carnivores).

Invertebrates

Invertebrate samples collected in 2004 contained a limited diversity of taxa, and this poor diversity was reflected in poor B-IBI scores. The B-IBI rated stream sites as fair to very poor, with no apparent trend based on stream or site location along a stream (Table 1-6). Overall, the stream sites surveyed averaged a B-IBI score of 18.8 (poor).

In 1998, invertebrate samples were assessed with a different tool, the rapid bioassessment protocol or RBP (Plafkin et al.

1989), which is not directly comparable to the B-IBI. However, the RBP rated >70% of stream sites as moderately impaired in 1998, closely matching the >70% rated as poor by the B-IBI in 2004 (Fig. 1-3). During 1998 and 2004, RBP and B-IBI scores were reduced by low numbers of taxa (especially mayflies, stoneflies, caddisflies), and high dominance by individual taxa, such as amphipods.

Habitat variables vs. coldwater IBI

Multiple regression analysis indicated the presence of several relationships between various instream and riparian habitat variables and the coldwater IBI (Table 1-7). Coldwater IBI score was inversely correlated with depth, % run, and % fish cover, and positively correlated with lack of embeddedness, % riffle, buffer width, and fish habitat rating score. These relationships suggest that the best coldwater fish assemblages in the Whitewater River watershed were found in shallow (e.g., < 40 cm) stream sites with more riffle than run habitat, good riparian buffer, and lack of cover for large fish. A similar assessment in 1998 indicated good coldwater assemblages in shallow (< 40 cm), narrow (< 5 m), and cold (< 17°C) stream sites with higher current velocities and good riparian buffers (Mundahl 1999).

Habitat variables vs. B-IBI

Habitat variables showed generally weaker relationships with B-IBI scores than they did with coldwater IBI scores (Table 1-7). B-IBI scores were inversely correlated with % run habitat, % bare bank, and % shaded, and positively correlated with flow, stream width, lack of embeddedness, % riffle and pool habitats, and length of overhanging bank vegetation. These relationships suggest that the best invertebrate assemblages in the Whitewater River watershed were found in larger streams with clean substrate, good pool-riffle habitat, and non-shaded streambed with long grasses overhanging the banks. In 1998, the best invertebrate assemblages were found in streams with < 20% fines, > 30% riffle habitat, mean depth < 30 cm, and a riparian buffer width > 80 m (Mundahl 1999).

Coldwater IBI vs. B-IBI

Although both biotic indexes displayed many correlations with the various habitat variables measured, they showed no correlation to one another (Table 1-7). The two indexes responded in similar ways to % fines, embeddedness, % riffle/run/pool, and % bare bank, but responded differently to the majority of the remaining habitat variables. This lack of a relationship between the coldwater IBI and the B-IBI may be worrisome, but the preponderance of poor invertebrate assemblages, and the lack of good and excellent ones, may hinder the detection of the actual relationship between these two indexes. Further comparison of these indexes outside the Whitewater River watershed, where invertebrate assemblages may be better, is warranted.

Correlations among habitat variables

In addition to relationships among the biological and physical habitat variables, many trends were apparent among several of the physical variables themselves (Table 1-7). For example, fish habitat rating scores were negatively correlated with % fines, % run habitat, and % bare bank, and positively correlated with lack of embeddedness, % riffle and pool habitats, buffer width, and length of overhanging bank vegetation. Cover for large fish was negatively correlated with lack of embeddedness and % riffle habitat, and positively correlated with flow, stream width, and depth. As expected, % fines and embeddedness were highest in stream sections dominated by run habitats and lowest in riffle-dominated areas. Shaded stream sections also had the shortest overhanging bank vegetation and the highest % bare bank. Wider buffers tended to be associated with shallower streams with more riffles, fewer runs, more shading, and less cover for large fish.

It was expected that several key habitat variables may have changed between 1998 and 2004, so these were compared between the two years (Table 1-8). Buffer widths remained unchanged between 1998 and 2004, as did % fines. Embeddedness actually declined marginally (higher value associated with lower embeddedness) in 2004, but % bare bank increased by >40% in 2004.

Conclusions

Analysis of stream habitat and biota within the Whitewater River watershed during summer 2004 produced two general conclusions. First, there are clear relationships among the biota and stream habitats within this region. Stream size, the abundance of fine sediments, abundance of riffle and run habitats, buffer width, and the type of riparian vegetation influence the types and abundances of fish and invertebrates in these streams. Similar conclusions have been reached by previous investigators working within this system (see overview by Mundahl 2001). Second, although observable changes in agriculture and development have occurred within the watershed in recent years, these changes have not yet had a noticeable effect on the habitats or biota of streams in this area. Cox and Vondracek (1998) observed that land use outside the stream riparian corridors appears to have little effect on streams within the Whitewater River watershed, as long as the riparian zone is protected. Apparently the riparian corridors continue to insulate the streams of the Whitewater from recent changes within the basin.

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Table 1-1. Locations of fish and invertebrate sampling sites in and near the Whitewater River watershed, 1998 and 2004. X indicates collection made.

Site	Location	Year 1998	Year 2004
East Indian Creek			
EIC-1	T109N R10W NW28	X	X
EIC-2	T109N R10W NE27	X	
Garvin Brook			
GB-1	T106N R8W SE5	X	X
GB-2	T106N R8W NW4	X	X
Trout Valley Creek			
TVC-1	T108N R9W NW17	X	X
TVC-2	T108N R9W SW8	X	X
TVC-3	T108N R9W NW5	X	X
Beaver Creek			
BC-1	T108N R10W NW19	X	X
BC-2	T108N R10W SE16	X	X
Trout Run			
TR-2	T107N R10W NE29	X	X
TR-3	T107N R10W NE29	X	X
TRT-1	T107N R10W NE29	X	X
North Branch Whitewater River			
NWR-1	T108N R12W SE26	X	X
NWR-2	T108N R12W SW25	X	X
NWR-3	T108N R12W SE25	X	X
NWR-4	T108N R11W SW30	X	X
NWR-5	T108N R11W NW31	X	X
NWR-6	T108N R11W NW32	X	X
NWR-7	T108N R11W SE32	X	X
NWR-8	T107N R11W SE1	X	X
NWR-9	T107N R10W NW9	X	X
Middle Branch Whitewater River			
MWR-1	T106N R11W SE6	X	X
MWR-2	T107N R11W SW33	X	
MWR-3	T107N R11W SE33	X	X

Table 1-1. - continued

Site	Location	Year 1998	2004
MWR-4	T107N R11W SW30	X	
MWR-5	T107N R11W NE34	X	X
MWR-6	T107N R11W NW35	X	X
MWR-7	T106N R11W SE3	X	X
MWR-8	T107N R11W NE35	X	X
MWR-9	T107N R11W SE26	X	X
South Branch Whitewater River			
SWR-1	T106N R11W SW17	X	X
SWR-2	T106N R11W NE22	X	
SWR-3	T106N R11W NW23	X	X
SWR-4	T106N R11W NE23	X	X
SWR-5	T106N R11W NE23	X	X
SWR-6	T107N R10W NW25	X	X
SWR-8	T107N R10W SW24	X	X
SWR-9	T107N R10W SE14	X	X
SWR-10	T107N R10W NW11	X	X
Tributary of S. Branch Whitewater R.			
SWT-1	T107N R10W SE1	X	X
SWT-2	T107N R10W NW12	X	X
SWT-3	T107N R10W NE12	X	X

Table 1-2. Fish habitat rating scores for the 36 stream sites assessed in both 1998 and 2004. Site numbers are as listed in Table 1-1.

Site	1998	2004
EIC-1	76	66
GB-1	63	86
GB-2	71	91
TVC-1	77	69
TVC-3	56	61
BC-1	79	80
BC-2	72	91
TR-2	75	63
TR-3	75	75
TRT-1	65	71
NWR-1	32	46
NWR-2	70	71
NWR-3	33	49
NWR-4	37	48
NWR-6	48	37
NWR-7	75	80
NWR-8	55	74
NWR-9	69	78
MWR-1	51	39
MWR-3	49	45
MWR-5	48	48
MWR-6	64	71
MWR-7	24	32
MWR-8	82	73
MWR-9	55	67
SWR-1	89	51
SWR-3	23	51
SWR-4	4	28
SWR-5	22	31
SWR-7	86	56
SWR-8	55	68
SWR-9	55	69
SWR-10	66	66
SWT-1	51	53
SWT-2	65	70
SWT-3	80	64

Table 1-3. Fish species collected at stream sites in and near the Whitewater River watershed, June-August 1998 (41 sites) and 2004 (38 sites).

Family/scientific name	Common name	Number of sites 1998	2004
Petromyzontindae			
Lampetra appendix	American brook lamprey	4	2
Salmonidae			
Oncorhynchus mykiss	Rainbow trout	4	5
Salmo trutta	Brown trout	26	28
Salvelinus fontinalis	Brook trout	4	8
Umbridae			
Umbra limi	Central mudminnow	1	0
Cyprinidae			
Campostoma anomalum	Central stoneroller	17	7
Luxilus cornutus	Common shiner	7	4
Notropis dorsalis	Bigmouth shiner	10	1
Notropis ludibundus	Sand shiner	0	5
Phoxinus erythrogaster	Southern redbelly dace	10	4
Pimephales notatus	Bluntnose minnow	7	3
Pimephales promelas	Fathead minnow	2	3
Rhinichthys atratulus	Blacknose dace	17	12
Rhinichthys cataractae	Longnose dace	26	22
Semotilus atromaculatus	Creek chub	24	17
Catostomidae			
Catostomus commersoni	White sucker	29	24
Gasterosteidae			
Culaea inconstans	Brook stickleback	26	18
Cottidae			
Cottus bairdi	Mottled sculpin	10	8
Cottus cognatus	Slimy sculpin	8	9
Centrarchidae			
Lepomis cyanellus	Green sunfish	6	6
Lepomis gibbosus	Pumpkinseed	0	1
Lepomis macrochirus	Bluegill	0	3
Percidae			
Etheostoma flabellare	Fantail darter	21	15
Etheostoma nigrum	Johnny darter	19	16
Etheostoma caeruleum	Rainbow darter	2	0

Table 1-4. Fish collected in 150-m sections (single-pass with backpack electrofisher) at stream sites in and near the Whitewater River watershed, June-August 2004. Site numbers are as listed in Table 1-1.

	Stream sites								
Common name	NWR-1	NWR-2	NWR-3	NWR-4	NWR-5	NWR-6	NWR-7	NWR-8	NWR-9
American brook lamprey									8
Rainbow trout						1	1		
Brown trout	5	11	3	6	1	20	30	122	33
Brook trout									
Central stoneroller									
Common shiner									
Bigmouth shiner									
Sand shiner									
Southern redbelly dace									
Bluntnose minnow									
Fathead minnow									
Blacknose dace									4
Longnose dace	1	2		2	1	20	16	8	46
Creek chub	12	6	10	6	2	13			
White sucker	37	78	99	119	83	79	88	39	13
Brook stickleback	3							1	
Green sunfish									
Pumpkinseed									
Bluegill			1						
Fantail darter		3	1	6	2	28	2		1
Johnny darter	14	7	61	55	81	32	26		
mottled sculpin									
slimy sculpin								29	15
TOTALS	72	107	175	194	170	193	163	199	120

Table 1-4. - extended

Common name	Stream sites MWR-1	MWR-3	MWR-5	MWR-6	MWR-7	MWR-8	MWR-9	TRT-1	TR-2
American brook lamprey									
Rainbow trout							2		
Brown trout				5	50	53	15	1	54
Brook trout					86			13	7
Central stoneroller	1	26	7						
Common shiner									
Bigmouth shiner									
Sand shiner		2	5						
Southern redbelly dace	6	38							
Bluntnose minnow									
Fathead minnow	16	2	2						
Blacknose dace	15	12	33	10					
Longnose dace		16	27	34			15		
Creek chub	43	30	35	20					
White sucker	44	133	112	64		4	31		
Brook stickleback	1	18		2					
Green sunfish									
Pumpkinseed									
Bluegill									
Fantail darter		3	5	2					
Johnny darter	6	30	62	43					
mottled sculpin		4		98	149	200	121	89	233
slimy sculpin									
TOTALS	132	314	288	278	285	257	184	103	294

Table 1-4. - extended

	Stream sites								
Common name	TR-3	SWR-1	SWR-3	SWR-4	SWR-5	SWR-7	SWR-8	SWR-9	SWR-10
American brook lamprey									
Rainbow trout						8	2		
Brown trout	65					14	13	28	94
Brook trout	6								
Central stoneroller		33	36	8	1				
Common shiner			3	1	8				
Bigmouth shiner				2					
Sand shiner			1						
Southern redbelly dace		1	1		6				
Bluntnose minnow		36	2	2					
Fathead minnow									
Blacknose dace		33	34	22	51			6	
Longnose dace		1	6	5	18	1	5	127	1
Creek chub		33	37	6	25				1
White sucker		9	73	13	12	36	3	103	30
Brook stickleback		2	5	22	3			2	
Green sunfish								1	1
Pumpkinseed									
Bluegill			10					2	
Fantail darter		37	1	1	4			24	
Johnny darter		22	2	13	14			9	
mottled sculpin	87								
slimy sculpin						76	135		1
TOTALS	158	207	211	95	142	135	158	302	128

Table 1-4. - extended

	Stream sites								
Common name	SWT-1	SWT-2	SWT-3	BC-1	BC-2	TVC-1	TVC-2	TVC-3	EIC-1
American brook lamprey					8				
Rainbow trout									
Brown trout				78	120	5	3	11	20
Brook trout						62	8	1	65
Central stoneroller									
Common shiner								1	
Bigmouth shiner									
Sand shiner									
Southern redbelly dace									
Bluntnose minnow									
Fathead minnow									
Blacknose dace		2	22					30	2
Longnose dace						8	4		
Creek chub									
									4
White sucker									
Brook stickleback	8	1			4	5	29	1	3
Green sunfish	6		3		1			12	
Pumpkinseed	1								
Bluegill									
Fantail darter									
Johnny darter									
mottled sculpin									
slimy sculpin				113	85				
TOTALS	15	3	25	191	218	80	44	56	94

Table 1-4. - extended

	Stream sites	
Common name	GB-1	GB-2
American brook lamprey		
Rainbow trout		
Brown trout	117	68
Brook trout		
Central stoneroller		
Common shiner		
Bigmouth shiner		
Sand shiner		
Southern redbelly dace		
Bluntnose minnow		
Fathead minnow		
Blacknose dace		
Longnose dace		
Creek chub		
White sucker		
Brook stickleback		4
Green sunfish		
Pumpkinseed		
Bluegill		
Fantail darter		
Johnny darter		
mottled sculpin		
slimy sculpin	247	262
TOTALS	364	334

Table 1-5. Coldwater IBI scores for Whitewater River watershed fish collections in 1998 and 2004. Site numbers as listed in Table 1-1. Scoring: 0-5 = very poor, 10-30 = poor, 35-65 = fair, 70-100 = good, 105-120 = excellent.

Site	1998	2004
EIC-1	90	90
GB-1	95	100
GB-2	95	95
TVC-1	100	105
TVC-2	25	90
TVC-3	35	50
BC-1	100	100
BC-2	85	95
TR-2	95	90
TR-3	95	100
TRT-1	95	100
NWR-1	15	15
NWR-2	15	15
NWR-3	20	20
NWR-4	15	15
NWR-5	20	15
NWR-6	20	20
NWR-7	10	30
NWR-8	35	60
NWR-9	50	35
MWR-1	0	5
MWR-3	15	5
MWR-5	10	10
MWR-6	25	25
MWR-7	90	105
MWR-8	45	70
MWR-9	45	60
SWR-1	5	0
SWR-3	0	0
SWR-4	5	0
SWR-5	5	0
SWR-7	60	60
SWR-8	40	70
SWR-9	20	20
SWR-10	60	50
SWT-1	80	0
SWT-2	65	0
SWT-3	55	50

Table 1-6. Benthic IBI scores for Whitewater River watershed invertebrate collections in 2004. Values are means of triplicate samples collected at each site. Site numbers as listed in Table 1-1. Scoring: 0-5 = very poor, 10-25 = poor, 30-45 = fair, 50-60 = good, 65-100 = excellent.

Site	B-IBI
EIC-1	21.7
GB-1	20
GB-2	31.7
TVC-1	15
TVC-2	23.3
TVC-3	10
TVC-4	0
BC-1	11.7
BC-2	16.7
TR-2	35
TR-3	18.3
TRT-1	15
NWR-1	5
NWR-2	6.7
NWR-3	5
NWR-4	10
NWR-5	18.3
NWR-6	21.7
NWR-7	20
NWR-8	41.7
NWR-9	28.3
MWR-1	18.3
MWR-3	25
MWR-5	23.3
MWR-6	21.7
MWR-7	13.3
MWR-8	13.3
MWR-9	20
SWR-1	35
SWR-3	20
SWR-4	38.3
SWR-5	0
SWR-7	23.3
SWR-8	16.7
SWR-9	25
SWR-10	25
SWT-1	13.3
SWT-2	15
SWT-3	13.3

Table 1-7. Correlation matrix for biotic and physical variables measured in the Whitewater River watershed, 2004.

	CW IBI	*B-IBI*	*Flow*	*width*	*depth*	*CV*	*% fines*	*embed*
CW IBI	1.0000							
B-IBI	-0.0096	1.0000						
Flow	-0.0606	0.3939	1.0000					
width	-0.0714	0.2646	0.7877	1.0000				
depth	-0.3644	0.1409	0.4547	0.3539	1.0000			
CV	0.1055	0.2294	0.7154	0.3307	0.2091	1.0000		
% fines	-0.1591	-0.1557	-0.1185	-0.0670	0.1742	-0.0602	1.0000	
embed	0.5912	0.2651	0.1661	0.0763	-0.2912	0.1843	-0.7335	1.0000
% shaded	0.1467	-0.2333	-0.0747	0.1501	-0.2539	-0.1548	-0.1891	0.2185
% riffle	0.3398	0.2858	0.3451	0.2141	-0.3355	0.3086	-0.7177	0.7260
% run	-0.3161	-0.3579	-0.1001	0.0003	0.2265	0.0043	0.6061	-0.6901
% pool	0.1217	0.2636	-0.2108	-0.2170	0.0095	-0.3563	-0.1585	0.2806
fish cov	-0.4934	0.1879	0.4153	0.3853	0.9466	0.1205	0.1301	-0.3244
buffer	0.3108	-0.0382	0.0269	0.1406	-0.2588	-0.1228	-0.0722	0.1285
overhang	-0.0862	0.2668	0.0483	-0.1929	0.4292	0.1338	0.1554	-0.0971
bare bank	-0.1668	-0.3540	0.0097	0.1713	-0.2753	-0.0591	0.1162	-0.2580
fish habitat	0.4385	0.2046	0.2119	0.0400	0.0562	0.1675	-0.5316	0.6363

	% shaded	*% riffle*	*% run*	*% pool*	*fish cov*	*buffer*	*overhang*	*bare bank*
% shaded	1.0000							
% riffle	0.1171	1.0000						
% run	-0.0315	-0.7847	1.0000					
% pool	-0.0819	0.1535	-0.7298	1.0000				
fish cov	-0.2144	-0.3510	0.2481	-0.0056	1.0000			
buffer	0.3382	0.2846	-0.2481	0.0986	-0.2433	1.0000		
overhang	-0.5313	-0.1056	-0.0788	0.2402	0.3324	-0.1762	1.0000	
bare bank	0.4885	-0.0436	0.1554	-0.1820	-0.1951	0.3183	-0.6922	1.0000
fish habitat	-0.0409	0.5513	-0.6496	0.4204	-0.0438	0.2934	0.2709	-0.3652

Table 1-8. Change in select stream habitat variables in the Whitewater River watershed, 1998 to 2004. Values are means and the results of paired t-tests.

Variable	1998	2004	t value	P value
Buffer width (m)	59	58	0.26	0.80
% fines	31.7	32.2	0.14	0.89
Embeddedness	1.91	2.22	1.89	0.07
% bare bank	24	34	2.87	0.01

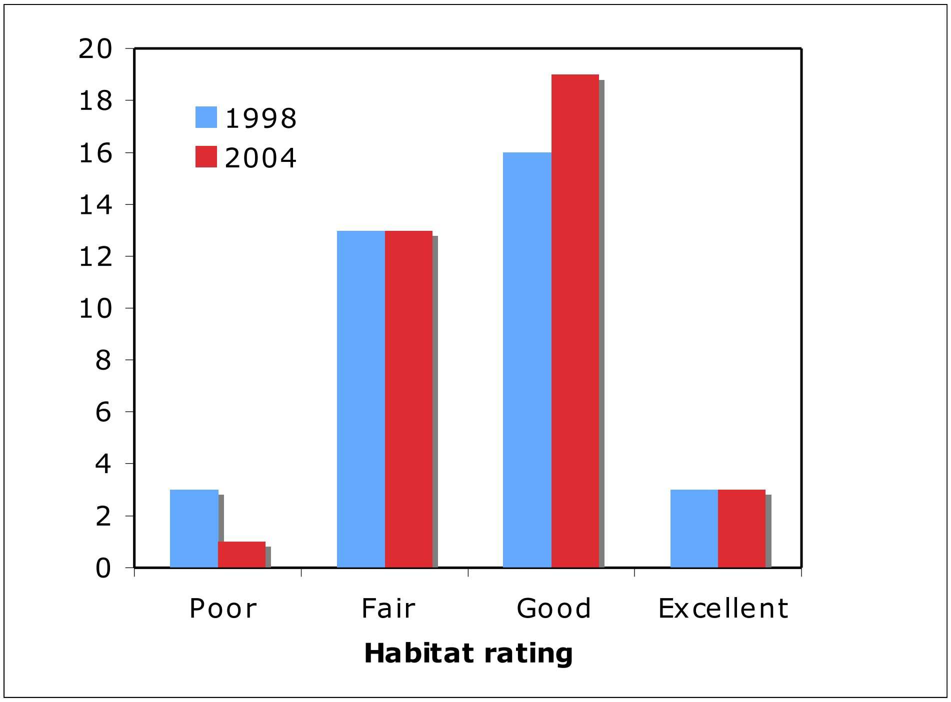

Figure 1-1. Distribution of fish habitat ratings among Whitewater River watershed sites, 1998 and 2004.

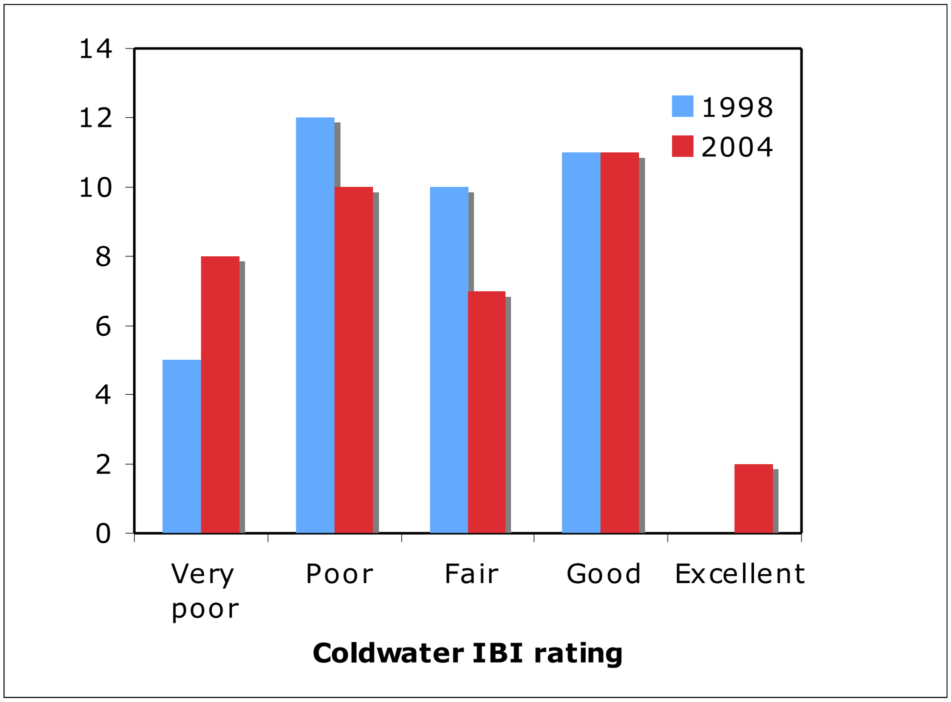

Figure 1-2. Distribution of coldwater IBI ratings among Whitewater River watershed sites, 1998 and 2004.

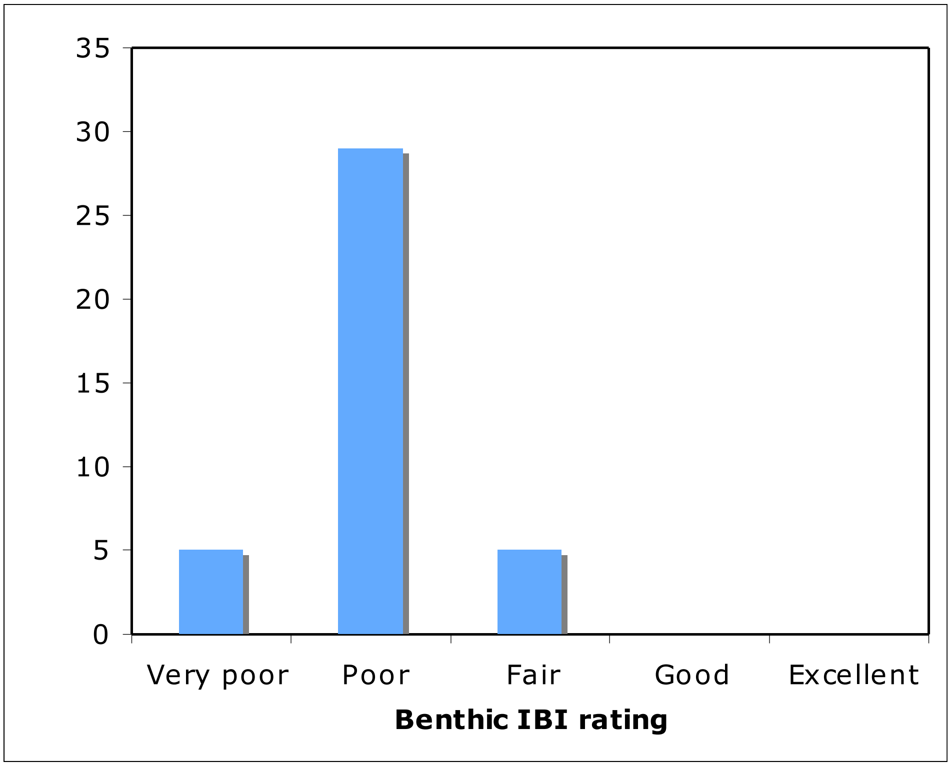

Figure 1-3. Distribution of benthic IBI ratings among Whitewater River watershed sites, 2004.

Chapter 2: **Whitewater Watershed Project: 2005 Longitudinal Assessment of Fish, Benthic Macroinvertebrate, and Habitats of the South Branch Whitewater River**

Introduction

Since 1994, investigations of the habitat and biota associated with streams in the Whitewater River watershed in southeastern Minnesota have demonstrated a wide range of conditions throughout the watershed (Mundahl 2001). Streams range from high-quality coldwater systems with excellent fish assemblages and excellent habitat, to very poor warmwater systems with disturbed habitats and impaired invertebrate and fish assemblages. In any given year, as many as 38 stream sites within the watershed have been assessed. However, typically no more than 9 or 10 sites have been assessed on any one stream within the watershed. While this degree of coverage has been satisfactory for baseline studies and generalized monitoring of watershed conditions, it does not allow for detection of finer-scale changes along a given stream that may result from changes in geology, development, or agricultural practices.

The South Branch Whitewater River is the longest stream within the Whitewater River system, extending from its headwaters in wetlands northwest of Eyota to its confluence with the Whitewater River mainstem at Elba. Most management and monitoring attention has been focused on the lower, coldwater section of the river, which begins northwest of Utica and continues to the mouth. Fish, benthic invertebrates, and habitat have been examined at stream sites on this lower section on nearly a yearly basin during the past decade, whereas similar efforts on stream sites in the upper section have been sporadic

(Mundahl 2001). No more than 10 stream sites have been examined along the South Branch during any one year, and their irregular spacing left large sections unmonitored.

The objective of this project was to more thoroughly assess the fish and benthic invertebrate assemblages and habitats of the South Branch Whitewater River, by examining these variables at a large number of sites spaced fairly evenly along the length of the entire stream. It was hypothesized that fish and invertebrate assemblages and habitat would change dramatically between the upper and lower sections, with very little change within either section.

Methods

Field Work

During the period June to August 2005, 22 stream sites were sampled for fish, invertebrates, and stream habitat (Table 2-1; sites are listed in upstream to downstream order). Special efforts were made to space sites fairly evenly along the stream, although inaccessibility in some locations (due to topography and private property restrictions) created some minor difficulties. All sites that had been examined in previous years, with one exception, were included in this effort. The one exception was a site immediately east of Dover, previously accessed through a horse pasture which had now been transformed into an active sand and gravel quarry.

Fish at each site were sampled with a backpack electrofisher. All fish captured within a 150-m stream segment (downstream to upstream, single pass) were identified, counted, and released. Specimens of uncertain identity were retained for later identification.

Invertebrates were collected in triplicate kick net samples at each stream site. Each sample was the combination of organisms collected by kicking the substrate for 30 sec in each of two sections (fast and slow) of a single riffle. Invertebrate samples were preserved in ethanol and later sorted, identified, and counted in the laboratory.

Habitat at each stream site was examined in two ways. First, a simple fish habitat rating index designed for assessing streams in Wisconsin (Simonson et al. 1993) was used. Instream and riparian features were examined, scored, and used to produce a fish habitat rating for each site.

Additional, more detailed habitat assessments also were conducted at each of the sites. Assessments were based on protocol developed for use in Wisconsin (Simonson et al. 1993). Additional protocols developed to examine grazing impacts in the west, but appropriate here, also were used (Platts et al. 1982). Sampling at each sites was conducted using a modification of the transect method (Simonson et al. 1993). Habitats at each sites were sampled across each of 13 transects spaced approximately two to three mean stream widths apart.

Along each transect, several instream habitat features were assessed, and riparian conditions were recorded. Instream measures were taken at four, evenly spaced points along each transect. At each point, depth was measured using a wading rod, and velocity measured at 0.6 of the depth using a Marsh-McBirney model 2000 flow meter. Dominant substrate composition was visually estimated according to a modification of the Wentworth Scale (clay, silt, sand, gravel, cobble, boulder). Embeddedness, the percent of large substrates such as cobbles covered by fine materials, was visually estimated on a five-category scale: <5%, 5-25%, 25-50%, 50-75%, and >75% (Platts et al. 1983).

Other instream measures were estimated visually within a reach one mean stream width in length, centered on the transect (Simonson et al. 1993). The percentage of the stream shaded by the canopy at noon, the percentage of riffle, pool, and run, and the percent of the reach providing cover for fish 200 mm or larger, were estimated to the nearest 5%. Cover for fish included overhanging bank vegetation, woody debris, instream vegetation, boulders, and water >60 cm deep.

Riparian measures were made on only one stream bank per transect, alternating the side measured with each transect. Width of the riparian buffer was measured to the nearest meter. Average length of vegetation overhanging the stream was measured to the nearest 0.1 meter. The percentage of bank vegetation as grass, forb, tree, and shrub, and the percentage of bank as bare soil, were estimated visually to the nearest 5% for each category. Data collected from all transects were averaged to determine overall site values.

Data analysis

Fish data were used to calculate an Index of Biotic Integrity (IBI) score and rating for each site. For ease of comparison, all stream sites were assessed with a coldwater version of the IBI (Mundahl and Simon 1998).

Invertebrate data were used to calculate Benthic Index of Biotic Integrity (B-IBI) scores and ratings for each site (Wittman and Mundahl 2003). Scores for the triplicate samples for each site were averaged to produce a single value and rating for that site.

Physical stream habitat variables were compared statistically to one another and to the two biotic indexes with multiple regression models. In addition, longitudinal changes in several habitat variables and the two biotic indexes were examined graphically to detect any obvious patterns.

Results and Discussion

General Fish Habitat

Fish habitat rating index scores of the 22 South Branch Whitewater River stream sites examined in 2005 ranged from a low of 14 (poor rating) to a high of 80 (good rating), averaging 53 (fair rating; Fig. 1-1). Sites 1 through 11 all had fair or poor habitat ratings, whereas sites 12 through 22 mostly had good habitat ratings (Fig. 1-1). The change in habitat rating between sites 11 and 12 was dramatic.

Fish

Eighteen species of fish were collected from the 22 sites on the South Branch Whitewater River during 2005 (Table 2-2). No species was found at all sites, but white sucker (21 sites) and longnose dace (19 sites) were the species most frequently encountered. Brown trout, blacknose dace, creek chub, and Johnny darter also were very common, with each collected at 14 sites. Four species (American brook lamprey, rainbow trout, emerald shiner, common carp) were each found at only a single location. The total number of fish collected was 9,171, with each site averaging 417 fish (range = 49 to 926 fish/site) (Table 2-3). An average of 8 species (range = 2 to 12) was collected per site, with upstream sites having more species than downstream sites (Fig. 2-2).

The coldwater IBI rated sites on the South Branch Whitewater

River as very poor to good (Fig. 2-3). Most of the sites on upper reaches were rated as poor or very poor, whereas sites on the lower reaches received fair or good ratings. IBI scores averaged 26 (poor) for the entire stream. There was a significant difference (t-test: t = 5.03, P << 0.001) in IBI scores between sites 1 through 11 (mean IBI = 5) and sites 12 through 22 (mean IBI = 46). This improvement in IBI score was largely the result of a loss of several minnow and shiner species and the appearance of sculpin as the stream became colder.

Invertebrates

Invertebrate samples collected from South Branch sites received fair to very poor ratings by the B-IBI (Fig. 2-4). Invertebrate habitat was limited at many locations, especially at the upper sites, and diversity was poor throughout the entire stream. Although B-IBI scores improved steadily through the first seven upstream sites, there were no further improvements in invertebrate assemblages throughout the remaining 15 sites downstream, and assemblages may actually have worsened (Fig. 2-4).

Habitat variables vs. coldwater IBI

Multiple regression analysis indicated the presence of numerous strong relationships between instream and riparian habitat variables and the coldwater IBI (Table 2-4). Coldwater IBI score in the South Branch was inversely correlated with % fines and % run habitat, and positively correlated with flow, width, depth, current velocity, lack of embeddedness, % riffle and pool habitat, fish cover, buffer width, and fish habitat rating score. These relationships suggest that the best coldwater fish assemblages in the South Branch Whitewater River watershed were found at the larger stream sites with greater depth and flow, with more riffles and pools than run habitat, low embeddedness and fines, good riparian buffer, and cover for large fish. Designated trout waters comprise the lower half of the South Branch, with steeper gradients, rocky substrates, and a riparian buffer consisting of a portion of the Whitewater Wildlife Management Area.

Habitat variables vs. B-IBI

Habitat variables displayed fewer, and generally weaker, relationships with B-IBI scores on the South Branch than they did with coldwater IBI scores (Table 2-4). B-IBI scores were inversely correlated with depth, cover for large fish, and overhanging bank vegetation, and positively correlated with current velocity, % shading by trees, and % bare bank. These relationships suggest that the best invertebrate assemblages in the South Branch Whitewater River were found in small, shallow stream sections with tree-lined banks and little shoreline vegetation. Considering that the best invertebrate assemblages within the South Branch were rated as only fair, the level of confidence in the preceding statement is not high. While trees along the shore can contribute allochthonous materials for invertebrate detritivores and shredders, they also inhibit algal growth, which in turn limits grazers. Banks with bare soil also can contribute fines to streams, increasing embeddedness and limiting habitat for invertebrates.

Coldwater IBI vs. B-IBI

Both the coldwater IBI and the B-IBI displayed many correlations with the various habitat variables measured, but they showed no correlation to one another (correlation coefficient = -0.10; Table 2-4). The two indexes responded in opposite ways to nearly all habitat variables except for current velocity. This apparent lack of a relationship between the coldwater IBI and the B-IBI probably is related to the overall poor quality of invertebrate assemblages in the South Branch.

Additional patterns and correlations

In addition to the relationships described above, many other interesting patterns and correlations were apparent among the physical and biological variables. For example, two physical variables exhibited expected longitudinal patterns within the South Branch. Discharge or flow displayed its greatest increase downstream from site 12, where groundwater inputs add cold water to the system, improving its suitability as habitat for trout (Fig. 2-5). In a related pattern, % fines were high until a dramatic decline below site 11, coincident with increasing stream gradient and increasing discharge (Fig. 2-6).

The abundance of fine sediments at South Branch sites also displayed strong, negative relationships to both the fish habitat rating index (Fig. 2-7) and the coldwater IBI (Fig. 2-8). Percent fines explained 59% and 63% of the variability in the fish habitat rating index and the coldwater IBI, respectively. These similar relationships between fines and these two indexes is not surprising, given the strong relationship between the indexes (Fig.2-9).

Many correlations were apparent among the physical variables measured at South Branch sites in 2005. For example, fish habitat rating scores were negatively correlated with % fines, % run habitat, and % bare bank, and positively correlated with lack of embeddedness, % riffle and pool habitats, and buffer width. Cover for large fish was negatively correlated with % fines, and positively correlated with flow and stream width. As expected, % fines and embeddedness were highest in stream sections dominated by run habitats and lowest in riffle-dominated areas, and were strongly related to buffer width. Shaded stream sections also were negatively correlated with overhanging bank vegetation and positively correlated with % bare bank. Wider buffers tended to be associated with wider and deeper stream sections with more riffles and fewer runs.

Conclusions

Many patterns became apparent after examining 22 sites on the South Branch Whitewater River. Basically, upstream sites had poor fish habitat and poor fish assemblages. Fine sediments, embeddedness, and lack of instream cover and riparian buffers were the factors most likely affecting fish communities in this stream segment. In contrast, downstream sites had much better fish habitat and fish assemblages, the result of higher flows of cold water, reduced fines and embeddedness, wider riparian buffers, and better instream habitat. The change between these two stream segments was dramatic, and occurred over a short stream distance. This shift took place just to the north and east of the City of St. Charles.

In contrast to the dramatic longitudinal changes in habitat and fish assemblages, invertebrate assemblages were consistently poor. Even improved habitat and cold water did nothing to improve the invertebrate communities compared to those in upstream reaches. Either some, as yet unknown, problem continues to suppress invertebrates (but not fish) in the lower sections of the South Branch, or invertebrates may need help recolonizing the coldwater section of the South Branch. The isolation of this stream region from potential sources of recolonizing invertebrates has likely prevented a better invertebrate assemblage from developing here.

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Table 2-1. Locations of fish and invertebrate sampling sites, South Branch Whitewater River, 2005. Sites are listed in upstream to downstream order. Additional site names used in previous studies are included. Sampling dates also are included.

Stream site	Location	Date
1	N 43° 59.455' W 92° 13.786'	7/19/05
2	N 43° 59.215' W 92° 13.077'	7/29/05
3	N 43° 58.619' W 92° 10.770'	8/5/05
4 (SWR-1)	N 43° 58.829' W 92° 9.630'	8/9/05
5 (SWR-3)	N 43° 58.223' W 92° 7.077'	7/19/05
6 (SWR-4)	N 43° 58.280' W 92° 6.892'	7/29/05
7 (SWR-5)	N 43° 58.445' W 92° 6.245'	7/22/05
8	N 43° 58.305' W 92° 5.441'	8/8/05
9	N 43° 58.509' W 92° 4.379'	7/15/05
10	N 43° 58.667' W 92° 3.897'	8/4/05
11	N 43° 59.435' W 92° 3.069'	8/4/05
12	N 44° 0.485' W 91° 59.937'	8/5/05
13	N 44° 0.798' W 91° 59.016'	8/2/05
14	N 44° 1.068' W 91° 57.451'	7/15/05
15	N 44° 1.506' W 91° 58.327'	8/10/05
16	N 44° 1.567' W 91° 58.325'	8/10/05
17 (SWR-7)	N 44° 2.912' W 91° 58.719'	7/11/05
18 (SWR-8)	N 44° 3.106' W 91° 58.520'	7/11/05
19 (SWR-9)	N 44° 4.233' W 91° 58.762'	6/7/05
20	N 44° 4.741' W 91° 59.253'	7/18/05
21 (SWR-10)	N 44° 5.407' W 91° 59.901'	6/13/05
22	N 44° 5.476' W 92° 0.254′	8/12/05

Table 2-2. Fish species collected at 22 stream sites on the South Branch Whitewater River, June-August 2005.

Family/scientific name	Common name	Number of sites
Petromyzontindae		
Lampetra appendix	American brook lamprey	1
Salmonidae		
Oncorhynchus mykiss	Rainbow trout	1
Salmo trutta	Brown trout	14
Cyprinidae		
Campostoma anomalum	Central stoneroller	11
Cyprinus carpio	Common carp	1
Luxilus cornutus	Common shiner	8
Notropis atherinoides	Emerald shiner	1
Notropis ludibundus	Sand shiner	10
Phoxinus erythrogaster	Southern redbelly dace	5
Pimephales notatus	Bluntnose minnow	9
Rhinichthys atratulus	Blacknose dace	14
Rhinichthys cataractae	Longnose dace	19
Semotilus atromaculatus	Creek chub	14
Catostomidae		
Catostomus commersoni	White sucker	21
Gasterosteidae		
Culaea inconstans	Brook stickleback	13
Cottidae		
Cottus cognatus	Slimy sculpin	7
Percidae		
Etheostoma flabellare	Fantail darter	12
Etheostoma nigrum	Johnny darter	14

Table 2-3. Fish collected from 22 sites on the South Branch Whitewater River, 2005. Site numbers as listed in Table 2-1.

	Stream sites						
Taxa	1	2	3	4	5	6	7
Petromyzontidae							
American brook lamprey							
Salmonidae							
Rainbow trout							
Brown trout							1
Cyprinidae							
Central stoneroller		118	91	105	143	39	6
Common shiner		16	27	11	23	3	
Sand shiner		1	6	9		10	12
Emerald shiner							
Common carp							
Southern redbelly dace		18	15	6	1		
Bluntnose minnow			20	51	1	2	
Blacknose dace	16	72	43	22	1	36	62
Longnose dace		8	9	1	4	22	22
Creek chub	19	92	81	88	81	76	84
Catostomidae							
White sucker		79	63	68	203	53	41
Gasterosteidae							
Brook stickleback	336	23	1	5	7		
Percidae							
Fantail darter		16	6	6	2	16	9
Johnny darter		3	2	29	22	35	24
Cottidae							
slimy sculpin							
TOTALS	371	446	364	401	488	292	261

Table 2-3. - extended

Taxa	Stream sites 8	9	10	11	12	13	14	15	16
Petromyzontidae									
American brook lamprey									
Salmonidae									
Rainbow trout									
Brown trout		1		2	34	12	53	115	62
Cyprinidae									
Central stoneroller	6	117	135	1	11				
Common shiner	10	19	7						
Sand shiner	22	3	9	3	1				
Emerald shiner									
Common carp									
Southern redbelly dace			1						
Bluntnose minnow	11	19	10	3	2				
Blacknose dace	8	61	25	55	71	24			
Longnose dace	4	21	3	11	36	285	10		
Creek chub	147	119	163	73	42	20			
Catostomidae									
White sucker	82	191	126	57	173	49	36	76	11
Gasterosteidae									
Brook stickleback	1	4	1	4	15				
Percidae									
Fantail darter	3	48	6	4					
Johnny darter	45	47	53	51	56	16			
Cottidae									
slimy sculpin					1		827	485	587
TOTALS	339	650	539	264	442	406	926	676	660

Table 2-3. - extended

Taxa	Stream sites					
	17	18	19	20	21	22
Petromyzontidae						
American brook lamprey						1
Salmonidae						
Rainbow trout		1				
Brown trout	11	54	7	41	28	65
Cyprinidae						
Central stoneroller						
Common shiner						
Sand shiner						
Emerald shiner						2
Common carp					10	
Southern redbelly dace						
Bluntnose minnow						
Blacknose dace			1			
Longnose dace	15	39	26	96	5	18
Creek chub	7					
Catostomidae						
White sucker	52	56	27	17	6	26
Gasterosteidae						
Brook stickleback	1		2			8
Percidae						
Fantail darter			9	1		
Johnny darter	1		6			
Cottidae						
slimy sculpin	170	626	211			
TOTALS	257	776	289	155	49	120

Table 2-4. Correlation matrix for biotic and physical variables measured in the South Branch Whitewater River, 2005.

	CW IBI	*BIBI*	*Flow*	*width*	*depth*	*CV*	*% fines*	*embed*
CW IBI	1.0000							
BIBI	-0.1010	1.0000						
Flow	0.6023	0.0241	1.0000					
width	0.6917	0.0215	0.8626	1.0000				
depth	0.3749	-0.3258	0.5698	0.4544	1.0000			
CV	0.4180	0.3589	0.7732	0.6079	0.0520	1.0000		
% fines	-0.7191	0.0569	-0.4719	-0.6252	-0.2552	-0.2988	1.0000	
embed	0.4465	-0.1147	0.2484	0.3986	0.1919	0.1981	-0.6309	1.0000
% shaded	-0.0212	0.4246	-0.2272	-0.1999	-0.5606	0.0631	0.1094	-0.0080
% riffle	0.4594	0.1519	0.4375	0.5490	0.0026	0.5968	-0.6172	0.6700
% run	-0.5246	0.0710	-0.4202	-0.5266	-0.1643	-0.3765	0.7286	-0.8171
% pool	0.3509	-0.2823	0.1888	0.2530	0.2544	-0.0619	-0.5482	0.6189
fish cov	0.4778	-0.3854	0.3601	0.4313	0.2324	0.1628	-0.4386	-0.0231
buffer	0.5858	0.0435	0.4802	0.5276	0.4939	0.2271	-0.5270	0.6287
overhang	-0.1749	-0.4870	-0.1250	-0.2023	0.3490	-0.4342	-0.0613	0.0027
bare bank	-0.2681	0.4994	-0.1370	-0.1834	-0.5636	0.2373	0.4485	-0.2489
fish habitat	0.7041	-0.0290	0.4932	0.6237	0.2763	0.3933	-0.7708	0.7205

	% shaded	*% riffle*	*% run*	*% pool*	*fish cov*	*buffer*	*overhang*	*bare bank*
% shaded	1.0000							
% riffle	-0.0805	1.0000						
% run	0.2117	-0.8169	1.0000					
% pool	-0.2451	0.2396	-0.7537	1.0000				
fish cov	-0.1202	0.2628	-0.2311	0.1018	1.0000			
buffer	-0.0802	0.3149	-0.4415	0.3683	-0.2125	1.0000		
overhang	-0.3722	-0.2997	0.1335	0.1211	-0.0507	0.1518	1.0000	
bare bank	0.5917	-0.0719	0.2066	-0.2719	-0.2075	-0.3704	-0.6935	1.0000
fish habitat	-0.2736	0.6964	-0.8033	0.5382	0.1707	0.6868	-0.0732	-0.3693

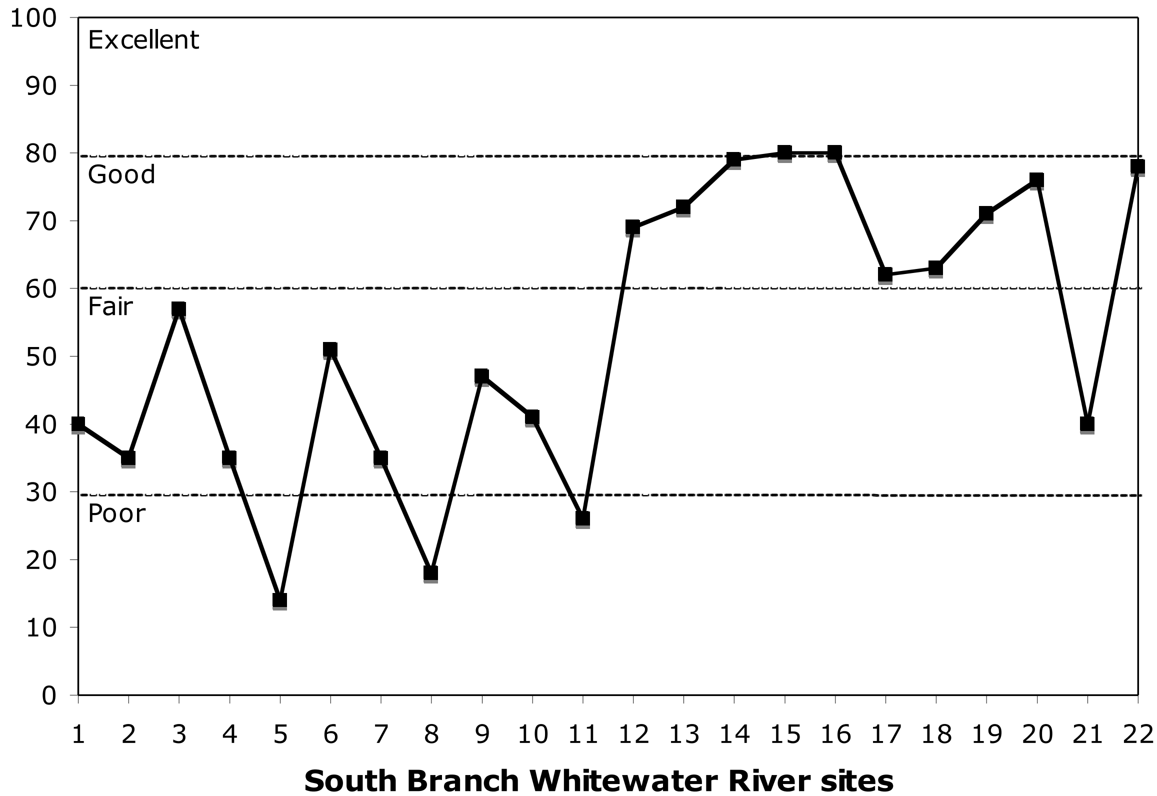

Figure 2-1. Fish habitat rating index scores for 22 sites on the South Branch Whitewater River, 2005. Site numbers as listed in Table 2-1.

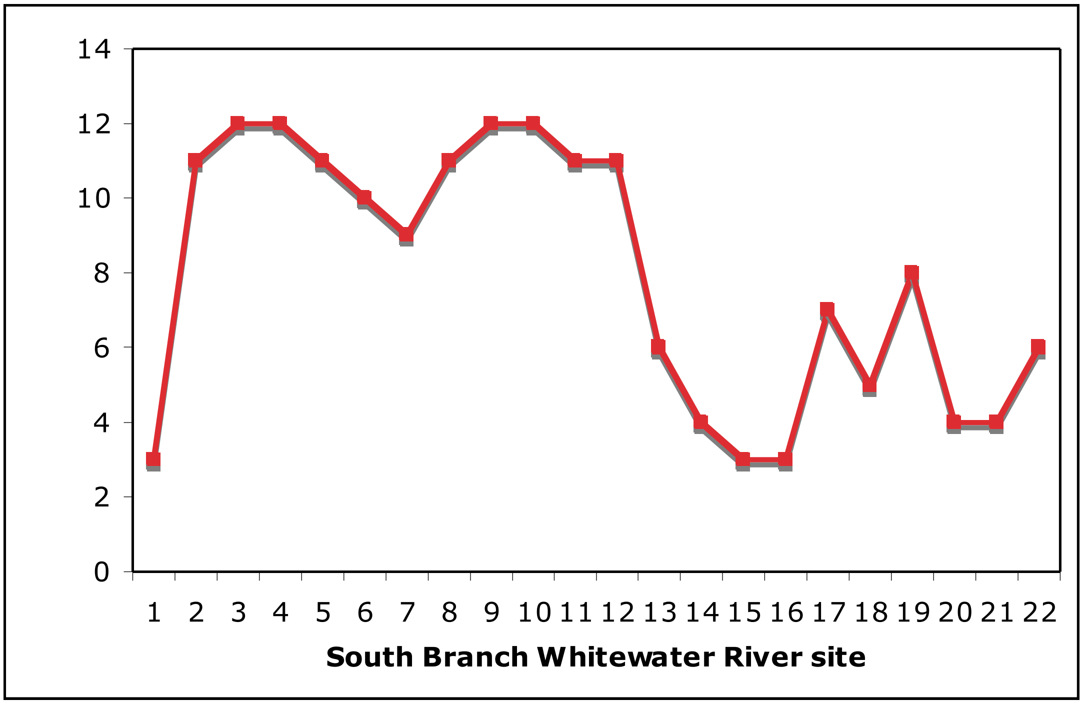

Figure 2-2. Number of fish species collected at each of 22 sites on the South Branch Whitewater River, 2005. Site numbers as listed in Table 2-1.

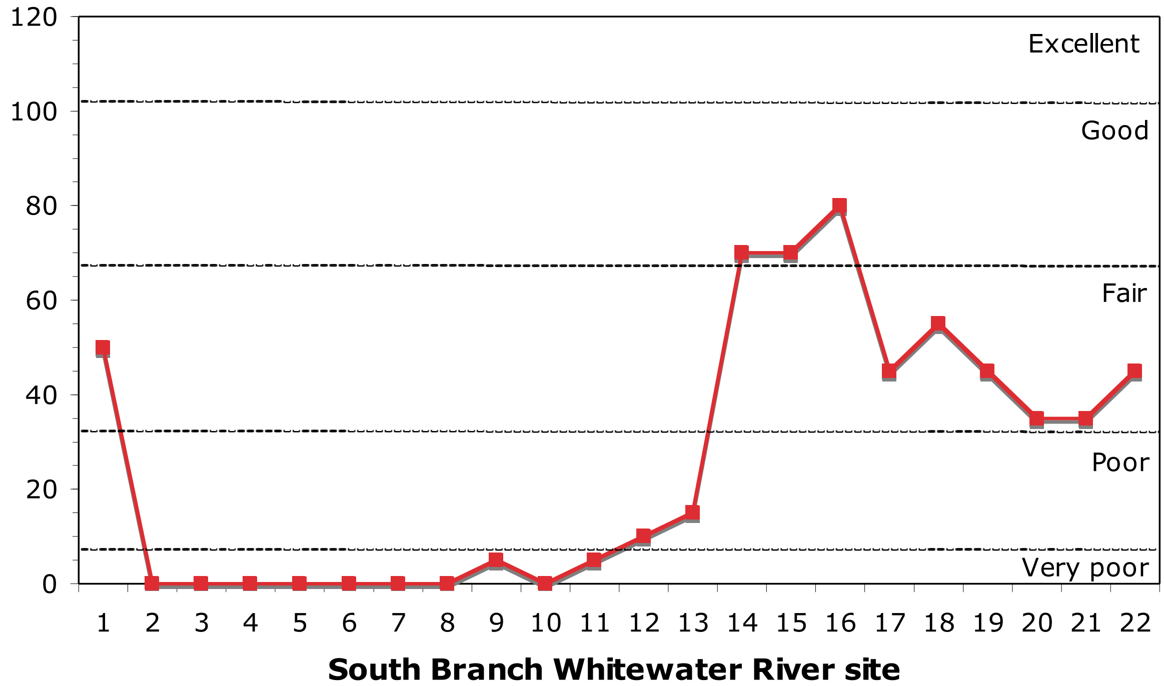

Figure 2-3. Coldwater IBI scores for 22 sites on the South Branch Whitewater River, 2005. Site numbers as listed in Table 2-1.

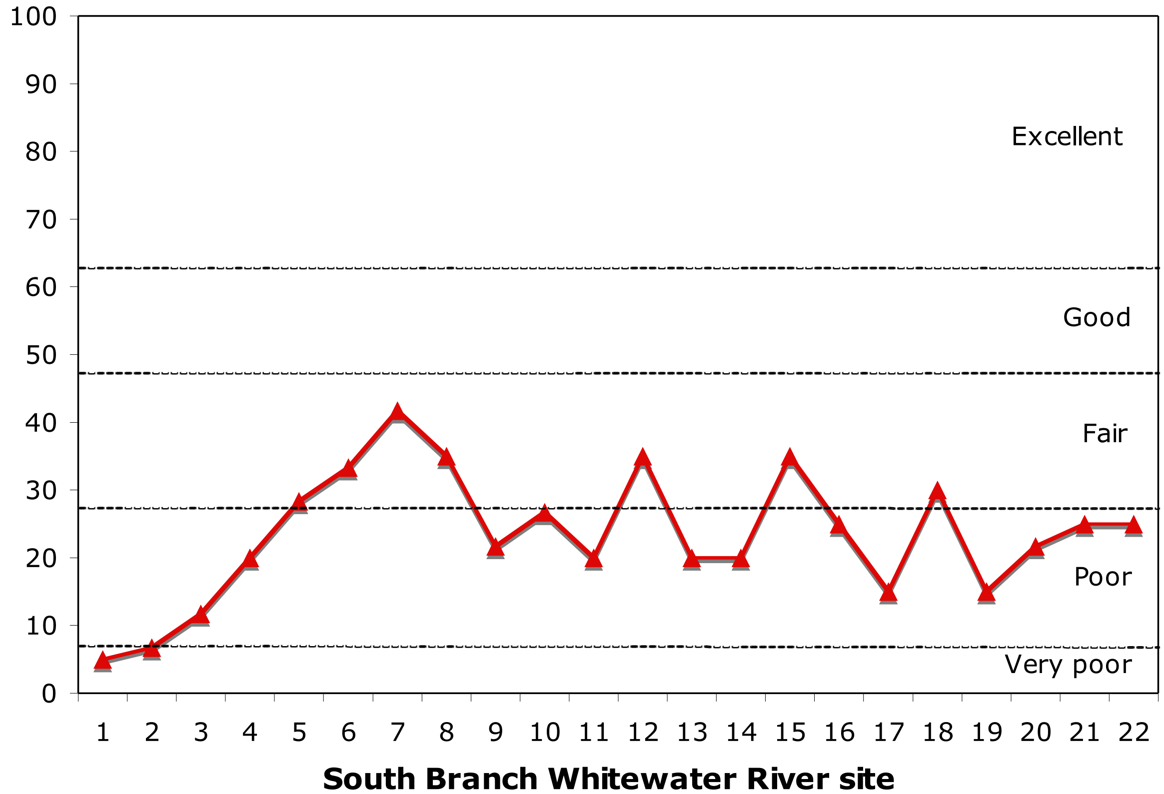

Figure 2-4. Benthic IBI scores for 22 sites on the South Branch Whitewater River, 2005. Site numbers as listed in Table 2-1.

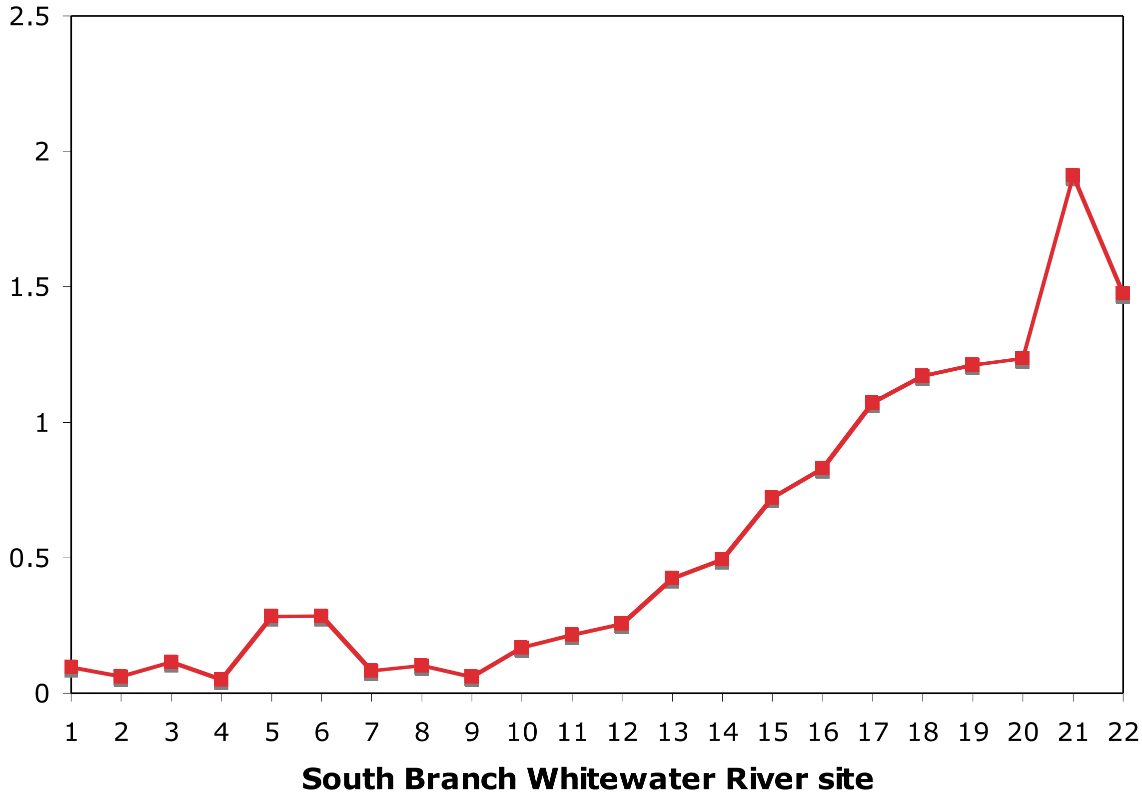

Figure 2-5. Estimated discharge at 22 sites on the South Branch Whitewater River, 2005. Site numbers as listed in Table 2-1.

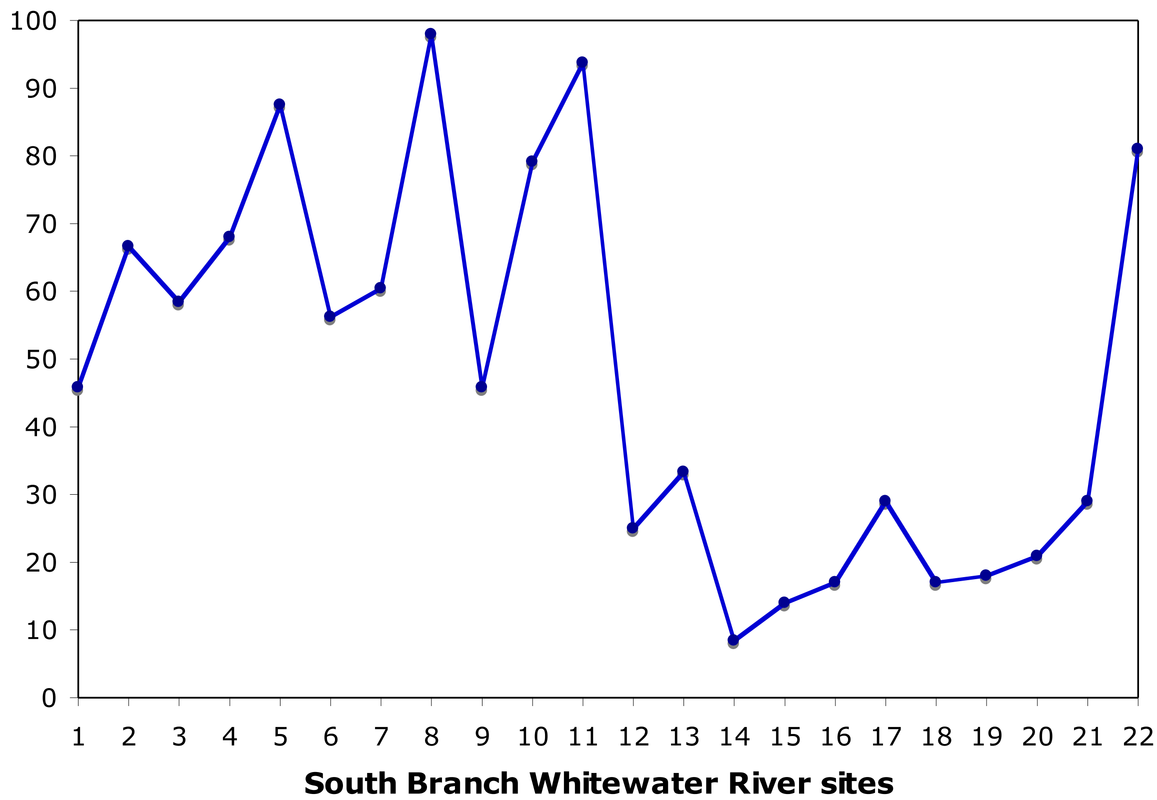

Figure 2-6. Percent abundance of fine sediments at 22 sites on the South Branch Whitewater River, 2005. Site numbers as listed in Table 2-1.

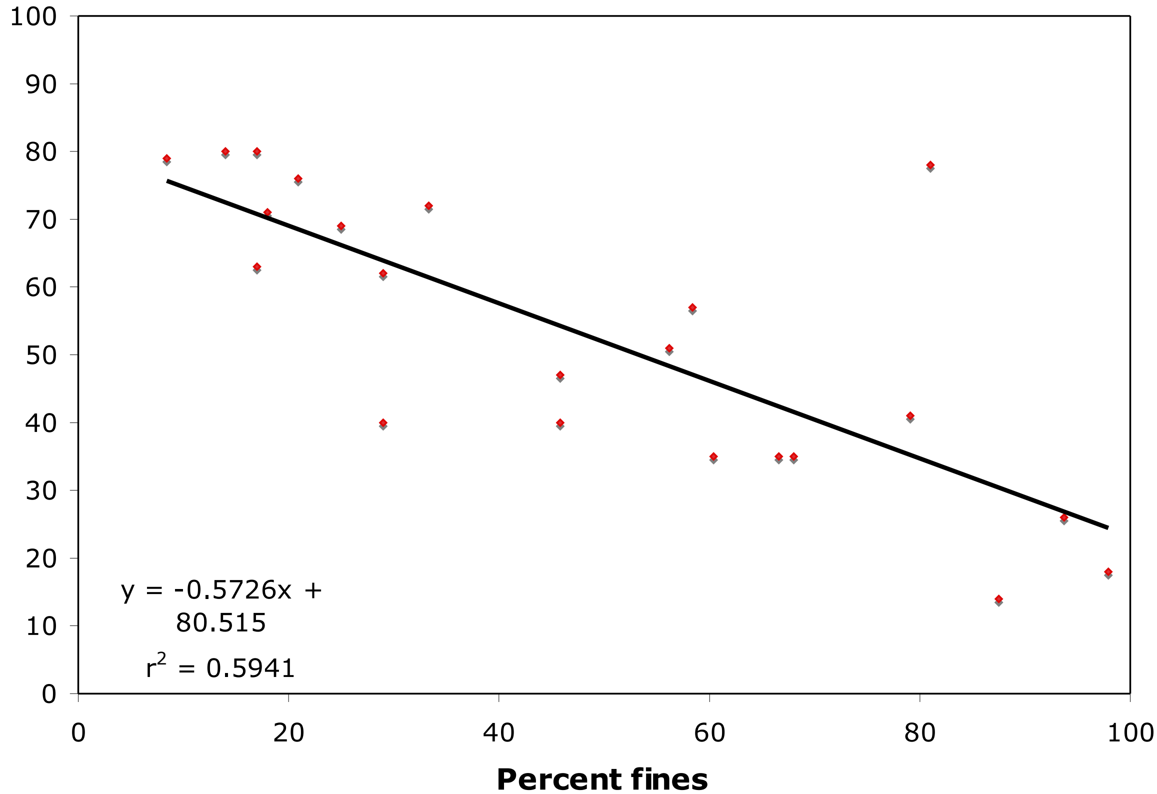

Figure 2-7. Relationship between the abundance of fine sediments and the fish habitat rating index at 22 sites on the South Branch Whitewater River, 2005.

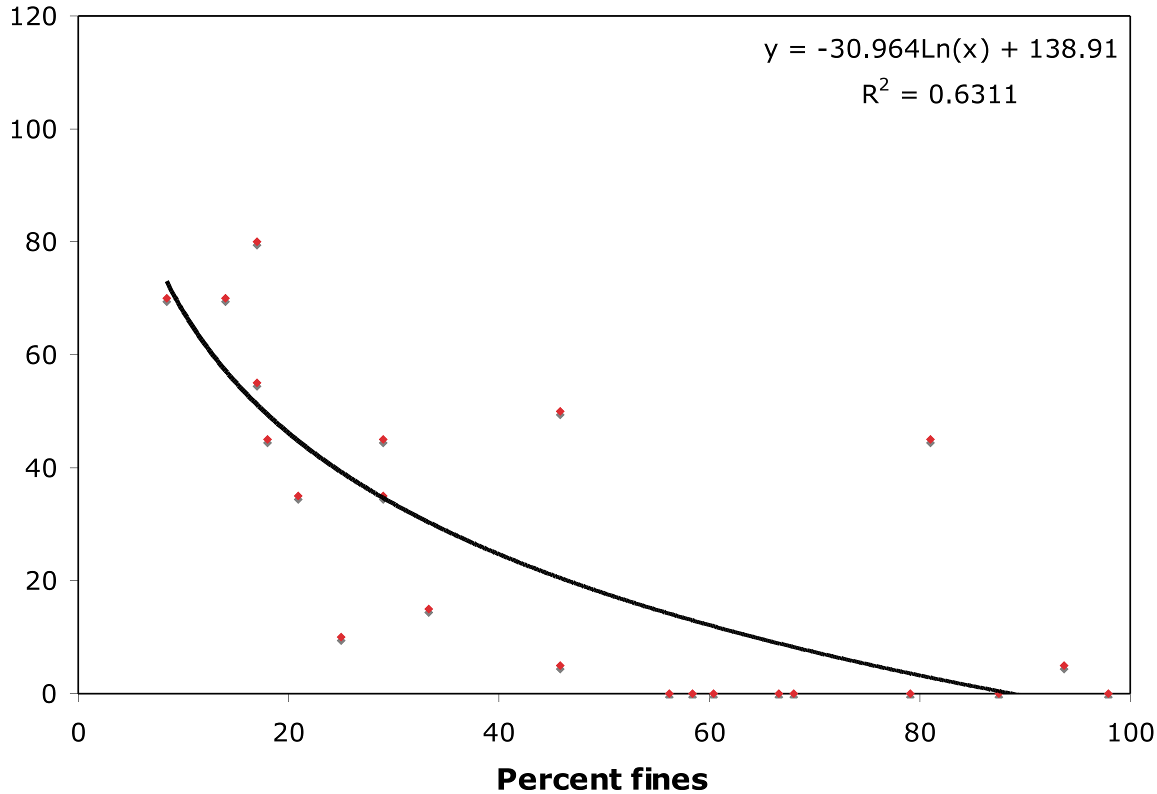

Figure 2-8. Relationship between abundance of fine sediments and the coldwater IBI at 22 sites on the South Branch Whitewater River, 2005.

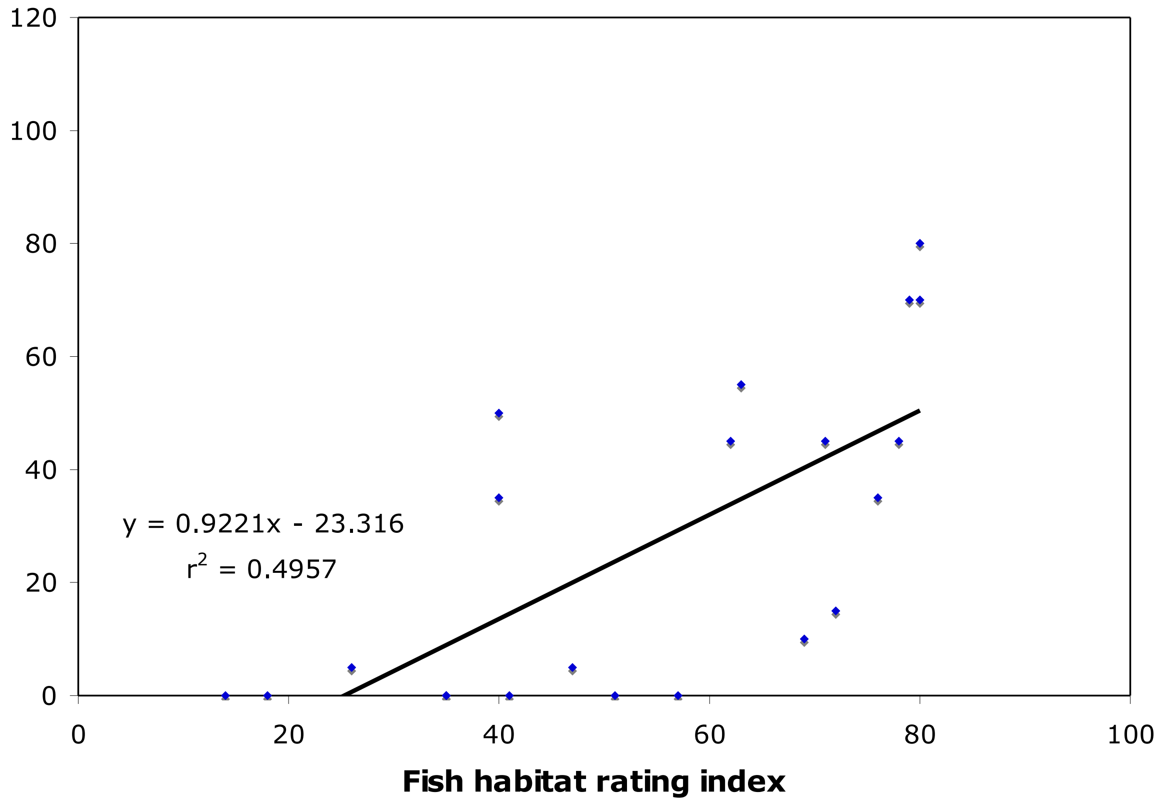

Figure 2-9. Relationship between the fish habitat rating index and the coldwater IBI at 22 sites on the South Branch Whitewater River, 2005.

Chapter 3: **A Preliminary Assessment of Stream Pool Filling by Fine Sediments in the Whitewater River Watershed**

Introduction

Casual observations over the past decade have suggested that pool habitats within the streams of the Whitewater River watershed were being filled with fine sediments eroded from the watershed. The possible loss of pool habitats within these streams can be problematic, since pools are important habitats for adult trout within this region (White and Brynildson 1967). In fact, much effort and money has been expended in southeastern Minnesota to improve stream habitats for trout, including increasing the area and depth of pools (Thorn et al. 1997). Various habitat assessments and trout habitat models indicate that the abundance and biomass of adult trout can be maximized when pools comprise 75% of a stream's reach length, and when 25% of pool area is >60 cm in depth (Thorn 1988a, 1988b, 1992, Thorn et al. 1997).

Despite the importance of pool habitats to trout, and the importance of the trout fishery within the streams of the Whitewater River watershed, no systematic assessment of pool habitats within these streams has been conducted previously. Consequently, this study was initiated as a preliminary assessment of pool habitats within streams of the Whitewater River watershed. This study had two basic objectives: 1) to examine the extent to which fine sediments had filled pools throughout the watershed, and 2) to assess the size of fine sediments within these pools.

Methods

A variety of pools in streams throughout the Whitewater River watershed were selected for assessments of fine sediment accumulations (Table 3-1). These included 12 pools in the three major branches of the Whitewater River, and 7 pools in smaller streams tributary to the Whitewater River. In addition, 6 pools were examined in Garvin Brook, a stream in a watershed adjacent to that of the Whitewater. No pools were examined in the mainstem of the Whitewater River downstream from Elba, MN, nor in the upper, warmwater sections of the North Branch and Middle Branch.

Pools were assessed during base flow conditions in June and July 2006. No assessments were conducted after significant rainfall events that might have elevated flows and/or increased suspended sediment transport.

Each pool was examined and assessed for sediment accumulation in a systematic fashion. Pool length was measured along the thalweg to the nearest meter. Five, equally spaced transects were established in each pool and measured to the nearest 0.1 m. Water depth was measured (nearest cm) at five equidistant points along each transect. At each point where water depth was measured, a copper rod (1.25-cm diameter, 2.45 m long) was pushed into the soft bottom sediments by one person, until hard substrates were encountered. The water level was marked on the rod prior to its removal from the sediments to determine total pool depth. Sediment depth was determined by subtracting water depth from total pool depth. Total volume for the entire pool, as well as water volume and sediment volume, was determined as the product of pool length, width, and the appropriate depth measurements.

The size of fine sediments accumulated in each pool was assessed indirectly by measuring turbidity at the outflow of that pool. This process was selected over direct particle size measurement because of the difficulty in collecting a representative mix of sediments from throughout an entire pool. Turbidity was measured with a turbidity meter for triplicate grab water samples collected at the downstream end of the pool prior to disturbance of bottom sediments. Turbidity also was measured for triplicate samples collected from the same location after pool sediments were disturbed by two individuals vigorously kicking sediments throughout the pool.

Results and Discussion

Pools assessed ranged in size from 23 to 469 m^3 in total volume (Table 3-2). Loss of pool volume to filling by fine sediments was highly variable, ranging from <5 to >93%. Although the limited number of pools sampled in any one stream makes the statement of generalities somewhat difficult, some patterns appear to emerge. For example, Middle Branch Whitewater sites appeared to have the least filling by fine sediments, whereas Trout Valley Creek pools had a very high proportion of their volume filled by fines (Figure 3-1). North Branch, Middle Branch, and Trout Run pools had similar, low (<15%) volume losses, and South Branch and Beaver pools had higher losses (>25%). Trout Valley Creek pools had very high volume losses (>70%) that exceeded all other streams in the watershed. Pools in Garvin Brook had highly variable volume losses (Table 3-2), but averaged higher losses than all Whitewater streams except Trout Valley Creek (Figure 3-1).

Turbidities measured at pool outlets prior to sediment disturbance were very low in most cases, with only a few sites having base flow turbidities >10 NTU (Table 3-3). Only in Garvin

Brook was there a pattern in these base flow turbidities among sites, with a general increase in turbidity from upstream to downstream locations.

Following disturbance of bottom sediments, turbidities measured at most sites were significantly higher than pre-disturbance values, usually by an order of magnitude or higher (Table 3-3). Turbidities were generally highest at the upstream sites within a stream, with disturbance turbidities declining at downstream sites (Figure 3-2). All Whitewater watershed streams followed this pattern; only Garvin Brook displayed a different upstream-downstream pattern.

The pattern of post-disturbance turbidities is suggestive of the sizes of fine sediments accumulated in stream pools. Fine sediments in the upper pools of a stream appeared to be mostly silts and/or clays that, when disturbed, remained in the water column and were carried out of the pool, contributing to high, post-disturbance turbidities. Lower pools within a stream often had bottom sediments dominated by sand that, when disturbed, fell quickly back to the stream bottom, contributing little to post-disturbance turbidities.

Conclusions

Pools in streams within the Whitewater River watershed displayed high variability in the extent to which they have filled with fine sediments. Some streams (e.g., Middle Branch) have lost little pool volume to fines, whereas others (e.g., Trout valley Creek) have lost the majority of their volume. Significant loss of pool volume certainly will reduce the ability of these streams to support abundant, sustainable trout populations.

It is not possible from this study to determine whether pools are accumulating fine sediments currently, or if accumulations observed today are historical. Regardless, volume lost to fines is volume unavailable to support fish or other biota.

The apparent pattern of fine sediment sizes accumulated in pools from upstream (silts and clays) to downstream (sand) is in agreement with expectations based on stream power and sediment movement. Upper stream sections, with their lower flow volumes and reduced stream power, would not be capable under normal circumstances of flushing fine silt and clay particles out of pools. In contrast, the higher flow volumes and greater stream power in lower stream sections would flush out the finer sediments, leaving behind only the larger sands and gravels.

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Minnesota streams. North American Journal of Fisheries Management 17: 860-872.

White, R.J., and O.M. Brynildson. 1967. Guidelines for management of trout stream habitat in Wisconsin. Wisconsin Department of Natural Resources, Technical Bulletin 39.

Table 3-1. Locations of pools in the Whitewater River and Garvin Brook drainages where sediment accumulations were assessed during summer 2006.

Stream/site	Location	Coordinates

N. Br. Whitewater		
1	Fairwater	N 44° 5.625' W 92° 3.563'
2	upstream of Elba	N 44° 5.219' W 92° 1.693′
M. Br. Whitewater		
1	Hwy. 9	N 44° 1.385′ W 92° 6.853′
2	above Quincy	N 44° 1.994′ W 92° 6.412′
3	at Quincy	N 44° 2.113' W 92° 6.179'
4	Group Camp	N 44° 3.345' W 92° 3.234'
5	below WSP	N 44° 4.061' W 92° 2.558'
S. Br. Whitewater		
1	west of St. Charles	N 43° 58.219' W 92° 7.054'
2	St. Charles park west	N 43° 58.450' W 92° 4.472'
3	St. Charles Brookwood Park	N 43° 58.620' W 92° 3.940'
4	below Crystal Springs	N 44° 4.619' W 91° 59.279'
5	east of Elba	N 44° 5.452' W 91° 59.921'
Trout Valley Creek		
1	upper	N 44° 9.494' W 91° 55.849'
2	mid	N 44° 10.050' W 91° 55.891'
3	lower	N 44° 11.316' W 91° 55.814'
4	below lower	N 44° 11.776' W 91° 56.445'
Beaver Creek		
1	upper	N 44° 8.653' W 92° 3.398'
2	lower	N 44° 9.184' W 92° 1.558'
Trout Run		
1	lower	N 44° 2.878′ W 92° 2.780′
Garvin Brook		
1	Farmer's Park	N 43° 59.874' W 91° 48.783'
2	west of Stockton	N 44° 0.830' W 91° 47.698'
3	Hwy 23 in Stockton	N 44° 1.488' W 91° 46.192'
4	Bronk forestry unit	N 44° 3.335' W 91° 44.853'
5	Hwy 23 south of MN City	N 44° 4.267' W 91° 45.865'
6	in MN City	N 44° 5.581' W 91° 44.899'

Table 3-2. Volume assessments of stream pools (m^3) and loss of pool volume to fine sediment filling.

Stream/site	Total pool volume	Water volume	Sediment volume	% pool loss

N. Br. Whitewater				
1	351.00	323.70	27.30	7.78
2	168.94	135.15	33.79	20.00
M. Br. Whitewater				
1	23.30	19.55	3.75	16.09
2	28.36	24.24	4.12	14.53
3	48.23	45.90	2.33	4.83
4	177.19	164.28	12.91	7.29
5	138.70	125.40	13.30	9.59
S. Br. Whitewater				
1	29.90	21.92	7.98	26.69
2	48.13	35.20	12.93	26.86
3	61.47	32.80	28.67	46.64
4	96.90	84.66	12.24	12.63
5	218.40	170.56	47.84	21.90
Trout Valley Creek				
1	90.35	50.98	39.37	43.57
2	86.26	12.58	73.68	85.42
3	56.17	22.88	33.29	59.27
4	107.01	7.07	99.95	93.40
Beaver Creek				
1	91.56	78.81	12.75	13.93
2	86.69	53.46	33.23	38.33
Trout Run				
1	48.83	42.56	6.27	12.84
Garvin Brook				
1	66.37	60.67	5.70	8.59
2	62.75	47.78	14.98	23.87
3	146.03	46.01	100.02	68.49
4	52.41	39.39	13.02	24.84
5	469.66	105.33	364.34	77.58
6	158.76	119.36	39.40	24.82

Table 3-3. Mean (±SD) turbidities (NTU) at pool outlets before and after disturbance of pool sediments.

Stream/site	Turbidity before	Turbidity after
N. Br. Whitewater		
1	3.22 (0.42)	97 (71)

2	3.70 (0.13)	42 (14)
M. Br. Whitewater		
1	1.21 (0.07)	149 (25)
2	1.80 (0.42)	115 (18)
3	5.43 (0.08)	103 (116)
4	2.52 (0.22)	80 (29)
5	3.17 (0.46)	51 (62)
S. Br. Whitewater		
1	5.73 (0.22)	272 (109)
2	4.88 (0.77)	125 (27)
3	4.78 (0.29)	115 (48)
4	2.23 (0.07)	24 (10)
5	3.38 (0.26)	11 (3)
Trout Valley Creek		
1	1.73 (0.36)	364 (43)
2	9.00 (0.13)	142 (36)
3	13.4 (4.8)	117 (38)
4	11.0 (3.5)	15 (3)
Beaver Creek		
1	2.7 (0.4)	266 (74)
2	6.2 (2.9)	78 (36)
Trout Run		
1	24.2 (2.4)	303 (45)
Garvin Brook		
1	0.8 (0.1)	83 (28)
2	0.8 (0.2)	168 (85)
3	2.5 (0.3)	176 (52)
4	7.3 (0.6)	68 (38)
5	19.0 (2.0)	350 (108)
6	18.7 (0.6)	47 (8)

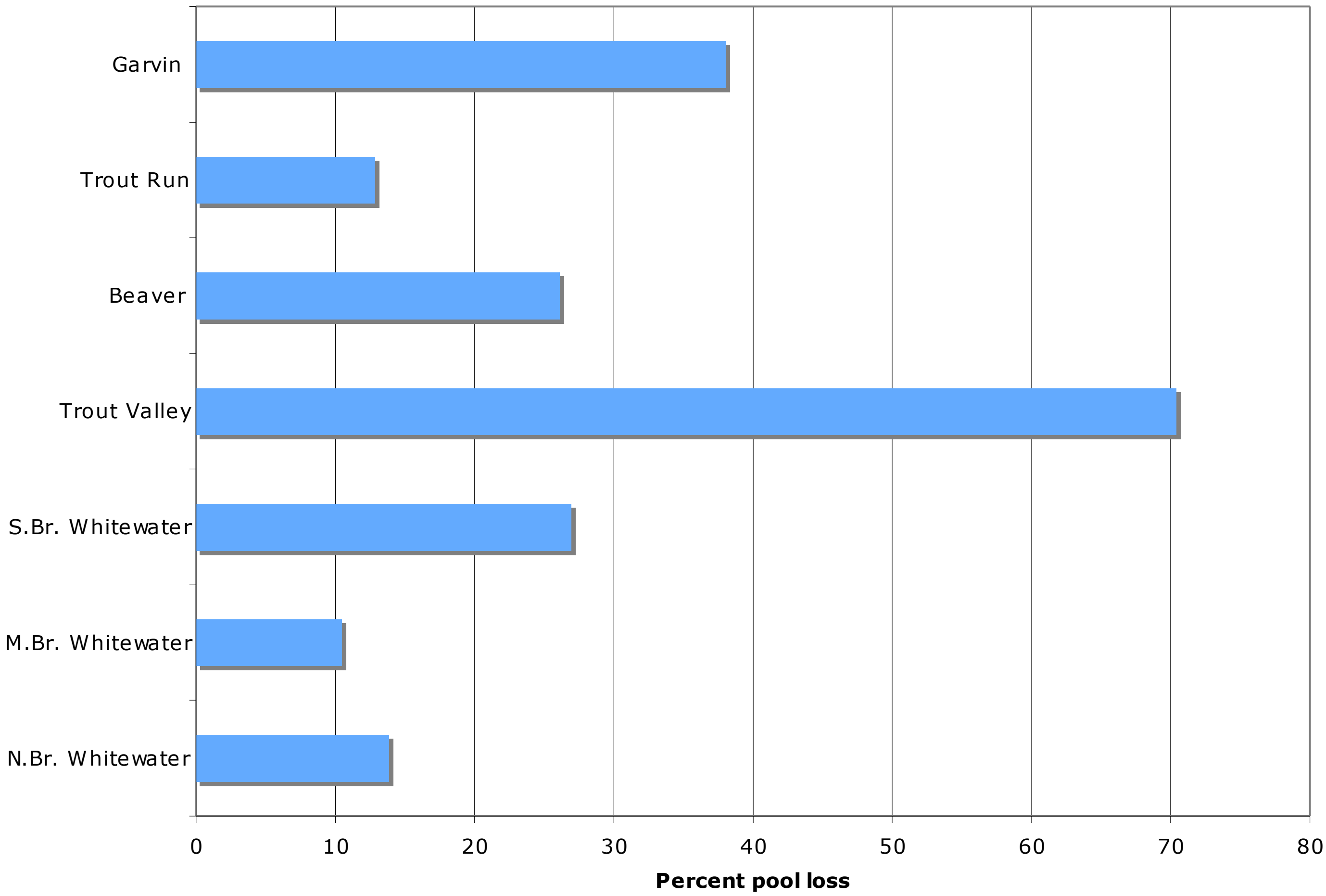

Figure 3-1. Mean loss of total pool volume to filling by fine sediments in streams in and near the Whitewater River watershed, summer 2006.

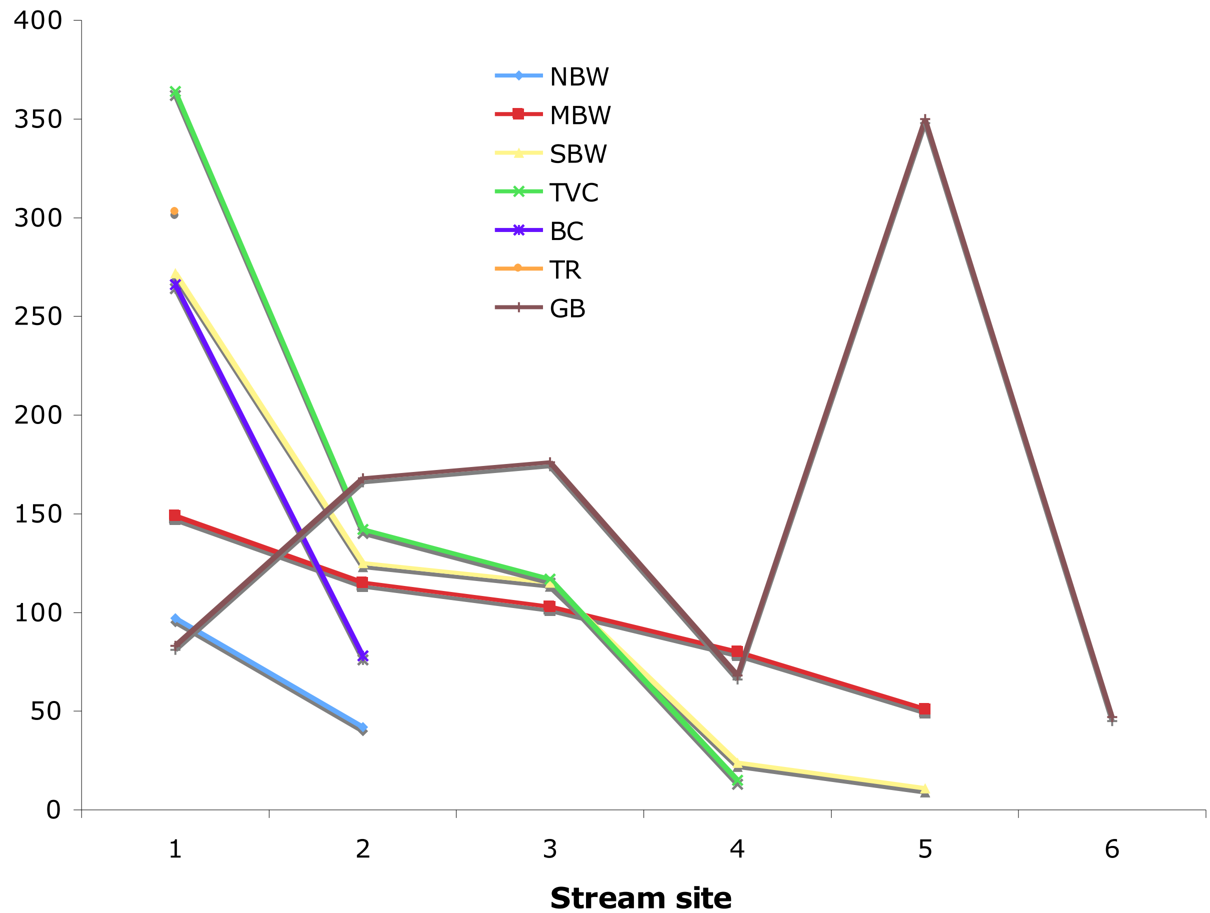

Figure 3-2. Mean turbidity at pool outlets after disturbance of pool sediments, summer 2006. Stream sites are shown in upstream (1) to downstream (6) order. NBW – North Branch Whitewater; MBW – Middle Branch Whitewater; SBW – South Branch Whitewater; TVC – Trout Valley Creek; BC – Beaver Creek; TR – Trout Run; GB – Garvin Brook.