WAUKEGAN RIVER NATIONAL MONITORING PROGRAM

Illinois State Water Survey
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BIOLOGICAL AND PHYSICAL MONITORING OF WAUKEGAN RIVER RESTORATION EFFORTS IN BIOTECHNICAL BANK PROTECTION AND POOL/RIFFLE CREATION, 1996

by

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TABLE OF CONTENTS

BACKGROUND

The National Nonpoint Source Watershed Monitoring Program (NSWMP) documents the environmental benefits resulting from the Best Management Practices implemented by the Environmental Protection Agency (EPA) 319 Program of Nonpoint Pollution Control. The Illinois EPA and the Illinois Department of Natural Resources (IDNR) agreed to jointly monitor the effectiveness of stream rehabilitation practices implemented on the Waukegan River.

The Biological Stream Characterization Work Group states that in the summer, low stream flows place significant stress upon fish communities and contribute to a general reduction in the quality and availability of stream habitat. Urban streams have much greater areas of impervious surface so that little infiltration occurs. Therefore summer low flows are more frequent and severe in urban streams such as the Waukegan River.

On the South Branch of the Waukegan River, protocols of the NSWMP were followed to detail the response of the stream fishery, the macroinvertebrate populations, and the instream physical habitat. The environmental quality of these three monitoring areas was judged by the Index of Biological Integrity (IBI) for fisheries, the Macroinvertebrate Biotic Index (MBI) for macroinvertebrates, and the Potential Index of Biologic Integrity (PIBI) for instream habitat.

The monitoring plan divided the stream reach into an upstream control (S2) and a downstream bank erosion site (S1) for biotechnical stabilization and instream habitat enhancement (Figure 1). This reach was chosen because no large ravine system transported urban runoff into the stream between Sl and S2.

These monitoring efforts were performed by stream biologists from the Illinois EPA and the Illinois DNR. The project was monitored three times per year in the spring, summer, and fall seasons of 1994, 1995, and 1996. The yearly monitoring documented the aquatic resources for one year before attempting any bank stabilization and instream habitat enhancement.

Between the sampling seasons of 1994 and 1995, the Second National Nonpoint Source Watershed Conference was held in Chicago. Installation of lunkers and bank revegetation at Sl coincided with the Conference so attendees could participate in the construction. Illinois EPA and Illinois DNR stream biologists gave field demonstrations of the monitoring techniques used in this National Watershed Monitoring effort.

During the spring, summer, and fall of 1995, the National Watershed Monitoring Program documented the response of aquatic resources to the lunker installation.

In the winter of 1995-1996, a series of seven loose stone weirs was constructed to simulate natural riffles through the Sl rehabilitation reach and downstream. Spring, summer, and fall monitoring in 1996 documented the effect of the new pool/riffle sequences on aquatic resources.

The stream fishery went from three species to five species with the lunkers applications and to nine species with the pool/riffle rehabilitation at Sl. The larger numbers of gamefish and pollution-intolerant fish species increased the IBI from 26 to 35 after the addition of pool and riffles. A degraded inner-city stream became a moderate (average) aquatic resource.

In 1996, the MBI indicated poor water quality at S2 with a value of 8.3 but better water quality in the pool and riffle site since Sl remained in the nonlimited Classification at 7.0 with the same streamwaters as S2. Water quality measurements found ammonia levels up to 0.5 milligrams per liter (mg/1) in streamwaters at both Sl and S2. The MBI indicates that water quality did not limit or degrade aquatic resources in 1994 or 1995.

Fish numbers increased from an average of 13 to 64 with lunker habitat enhancement at Sl. The average number of fish per Station increased to 75 with the addition of pool/riffles.

The upstream control (S2) remained a limited aquatic resource with 1-2 species for the entire period and an IBI of 28 or less. Between 1994 and 1996, the average number of fish per sample varied between 5 and 23.

The physical habitat evaluations found deeper pools at Sl while S2 remained very shallow. However, PIBI scores remained constant and similar (41-42) for Sl and S2 for all three years. The PIBI scores are predicated on the absence of claypan or silt-mud Substrates and the percentage of pools and stream width. The Sl and S2 physical habitat had very little silt or claypan Substrate initially. Pool percentage decreased while mean stream width increased. Habitat variables such as pool depth and riffle function do not contribute to PIBI scores even though they are extremely important in small streams.

Acknowledgments

This project has been successfully completed with the active participation of Scott Tomkins, John Lesnak, and Wally Matsunaga, Illinois Environmental Protection Agency; and Steve Pescitelli, Dave Day, and Randy Sauer, Illinois Department of Natural Resources, Office of Resource Conservation. The nature of stream restoration projects requires Cooperation of the State agencies managing and regulating aquatic resources. Linda Dexter typed the manuscript and the final report, and Eva Kingston edited the manuscript.

Any opinions, findings, and conclusions or recommendations expressed in this report are solely those of the authors.

Figure 1. Urban watershed of Waukegan River and stream monitoring sites

INTRODUCTION

The Waukegan Park District has implemented an innovative stream restoration program with funding from the 319 Nonpoint Pollution Program of the Illinois EPA and USEPA. The stormwater runoff had created severe bank erosion so that city sewer lines were exposed, park bridges were destroyed, and public access to downstream lands was limited (Figure 2).

Stream Channel erosion in city parks results when stormwater runoff from streets, parking lots, and buildings enters the steep stream Channel on the Lake Michigan bluff. The river falls from 730 feet above mean sea level (msl) to 580 msl, with the steepest lands located in Washington and Powell Parks.

The Waukegan River has a 7,640-acre watershed, which is largely urbanized (Figure 3). Over 80 percent of the city of Waukegan lies in the watershed. With a population of 60,000, Waukegan has the greatest population density in Lake County. Washington Park and Powell Park are located in the older highly urbanized area where very few stormwater detention basins were constructed before 1970, as is the case with many older cities.

The Waukegan Park District requested that the Illinois State Water Survey develop stream stabilization practices that would protect city infrastructure and restore the recreational and environmental benefits of park lands. The Water Survey chose biotechnical bank stabilization where riparian revegetation is combined with structural stabilization. The structural elements tested were bank covers (lunkers) and interlocking concrete jacks (a-jacks) as seen in Figure 4. These urban stream restoration techniques were chosen to resist high velocity runoff while increasing riparian habitat for stream fisheries.

Projects on the North Branch of the Waukegan River

Initial installation of lunkers and a-jacks occurred in Powell Park in May of 1991. Lunkers with stone were installed on the North Branch of the Waukegan River in Washington Park in August of 1991 (Figure 5). Willows, dogwood, grosses, and wetland plants were planted in lower, middle, and upper zones of the streambank at both lunker installations. In October of 1992, lunkers, stone, dogwoods, and willows were installed where Channel erosion had damaged the access road to Washington Park.

Projects on the South Branch of the Waukegan River

In September of 1994, a severe bank erosion site on the South Branch of the Waukegan River in Washington Park was stabilized with lunkers, a-jacks, stone, dogwoods, willows, and grasses during the Second National Nonpoint Pollution Conference Workshop in Chicago. Smaller bank erosion sites on the South Branch were stabilized with coir coconut fiber rolls, willows, and grasses.

After monitoring the South Branch for two years following the National Watershed Monitoring Protocols of the USEPA, aquatic biota was still limited by a lack of water depth in pools, limited cobble Substrates, and limited stream aeration, even though the streambanks were stable and vegetated.

In 1996, a series of six pool-and-riffle complexes was recreated by the construction of low stone weirs in this channelized reach of the South Branch. In two locations, the weirs were placed over main sewer lines where Channel incision had exposed the concrete culverts.

The National Watershed Monitoring Protocols are being followed in the continued monitoring of the South Branch to determine the environmental benefits resulting from the formation of pools and cobble riffles. The initial results of the 1996 monitoring reveal a doubling of pool depth, increased boulder Substrate, and greater fishery diversity.

PROJECT DESIGN: NORTH BRANCH OF THE WAUKEGAN RIVER

Key factors in selecting the lunker technique were the lack of instream habitat, bank erosion of park property, and the high velocity urban runoff. Fish surveys by the Illinois DNR Streams Program found desirable gamefish in the Washington Park location: bass, Channel catfish, and salmon. Since lunkers had proved stable on larger watersheds with steep topography in both Illinois and Wisconsin, they were the best possible choice for the Waukegan urban parks. In addition, maintenance costs from vandalism are limited once the Vegetation is established. All Vegetation was selected to endure heavy foot traffic along the streambank.

The a-jacks and lunkers were positioned below the streambed elevation to minimize any future instability resulting from Channel degrading. The backhoe excavated a trench along the base of the eroding bank. Each lunker is held in position with nine 6 foot (ft) lengths of 5/8 inch (in.) diameter rebar, which is driven into the streambed. Initially willow cutting and small rootballs were placed into the trench behind the lunkers with a geofabric mesh called fibredam that reduces soil movement through the lunker structure while roots Systems are developing. Riprap of 10 in. average diameter and soil were placed behind and above the lunker.

The bank was then sloped over the lunkers and seeded with annual rye as the primary matrix and timothy as the secondary matrix. The final seed matrix depends upon the landowner. For example, parks may chose a turf grass on the upper bank along the foot trail while the use of wet prairie grasses and flowers would be more appropriate in a nature preserve.

After the initial growth of grasses and willows, additional rooted stock of red osier dogwood was planted near the water's edge. Root masses of willow and dogwood minimize any soil loss above the lunkers. Both excelsior blankets and wood chips were used as mulch.

The project had two main components:

1. To develop urban biotechnical stream restoration on three major bank erosion sites: two sites in Washington Park and one site in Powell Park.

2. To conduct two training Workshops for Park District and city personnel, with hands-on installation of biotechnical bank protection techniques.

At the Powell Park site (Figure 2), the Channel had eroded across the floodplain and was attacking a low terrace, where seeps from the adjacent bluffs kept the bank soils unstable. Since the stream depth was very shallow (0.5 ft), the site had structural

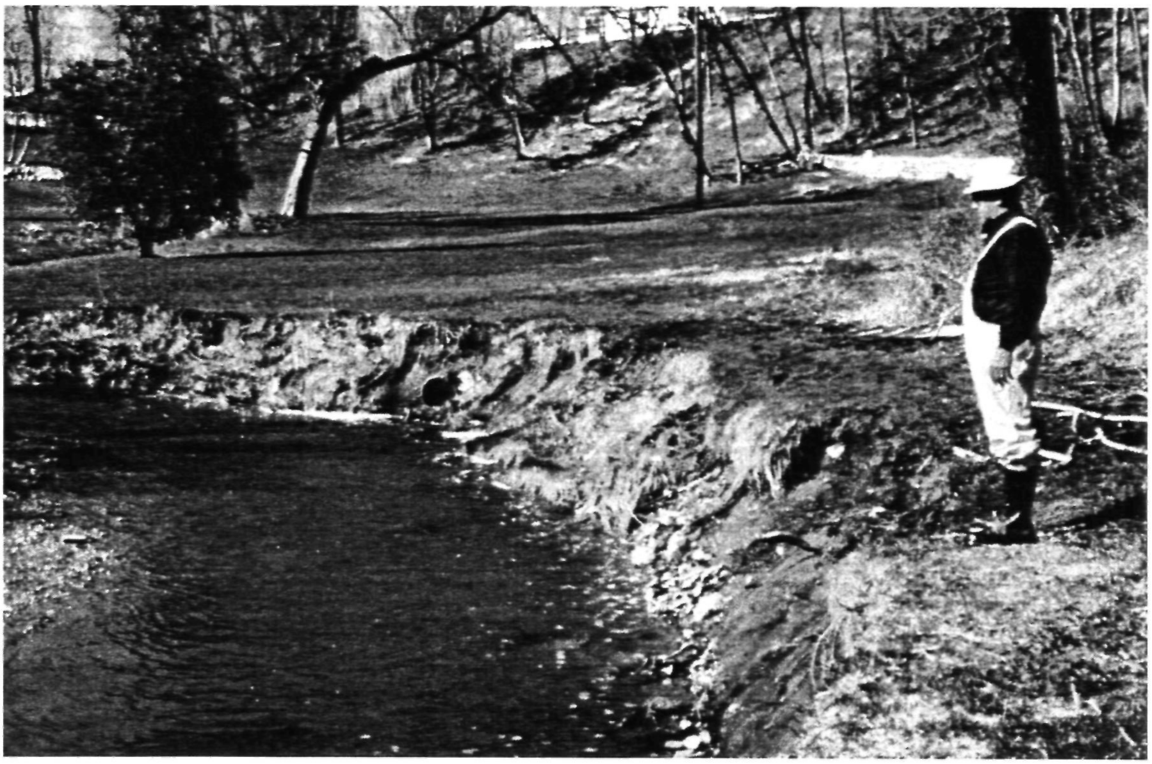


Figure 2. A major erosion site in Powell Park

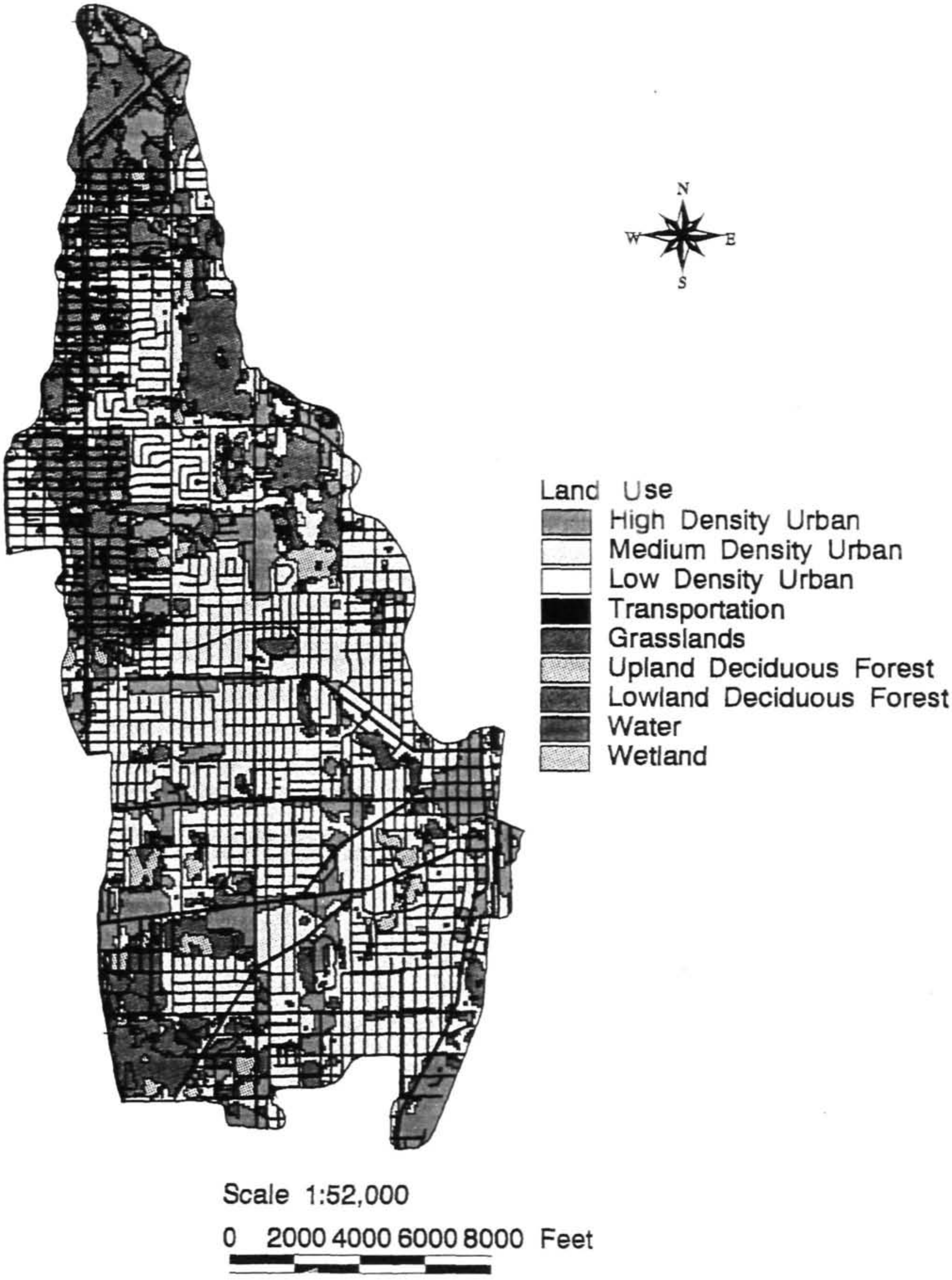
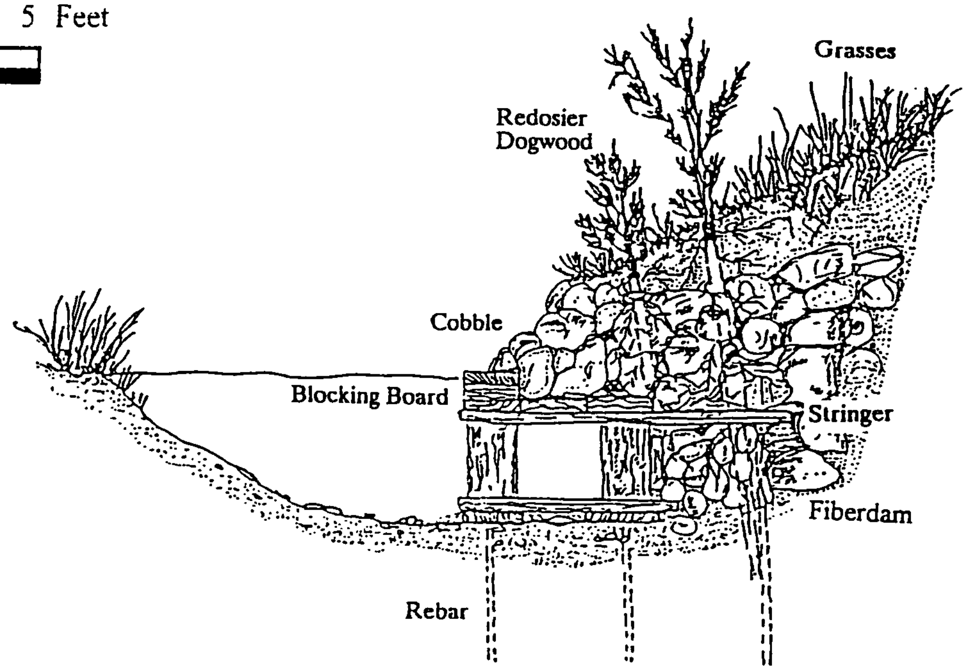


Figure 3. Waukegan River basin land use.

(Scale 1 inch = 2.5ft.)

0 2.5 5 Feet

Lunker Installation Design



A-Jack Design and Installation

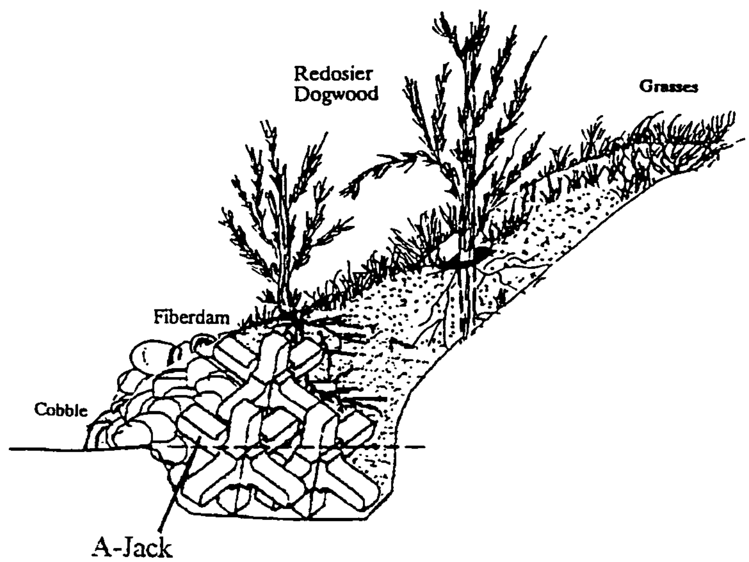


Figure 4. Lunker and a-jack structures.

Figure 5. Installations of lunkers, stone and woody species

used to stabilize the waterline and upper bank. The Vegetation included willows and dogwood with bulrush, arrowhead, and a waterways mix of grasses for the upper bank.

PROJECT DESIGN: SOUTH BRANCH OF THE WAUKEGAN RIVER

Major bank erosion resulted from Channel scour of the fill material over a major sewer line on the South Branch of Waukegan River (Sl on Figure 6). The stream was eroding a new Channel through the middle of Washington Park following the sewer line. Smaller erosion sites occurred downstream to the junction of the North and South Branches of the Waukegan River.

The major restoration effort was the Installation of lunker and a-jack bank structures at the severe erosion site in late September 1994. Construction coincided with a stream restoration Workshop at the EPA Second National Nonpoint Pollution Monitoring Workshop in Chicago. Three minor bank stabilizations used coconut fiber rolls and riparian Vegetation.

At the major bank erosion site, Channel scour was eroding across the floodplain into the best parklands. Since the stream depth was very shallow (O.S ft), the site was stabilized with structural components of a-jacks and lunkers of recycled plastic lumber. These structural components would not deteriorate if exposed to air during low flow periods. Plastic lunkers were placed in the meander down to the sewer line crossing. Downstream of the lunkers, the bank length was stabilized with triple rows of a-jacks. Upstream of the lunkers, riprap and Vegetation were the stabilization elements.

The project follows two main programs:

1. To design and implement biotechnical stream restoration on one major and three minor bank erosion sites in a 1000 ft reach of Washington Park. To seed grasses and plant small cuttings in less severe sites with bare soils.

    A. Structural bank stabilization materials

        1. Lunkers (Figure 4) in 8 and 4 ft sections.
        2. A-jacks (Figure 4) in the 2 ft diameter size.
        3. Pit run stone in the 8 in. to 12 in. diameter range.
            a. Approximately a 30 in. deep layer behind the lunkers.
            b. A surface layer of stone over the exposed a-jacks.
        4. 5/8 in. rebar was in 6 ft lengths, of which 4 ft was embedded in the streambed.

    B. Plant materials

        1. Rooted stock and cuttings of willows.
        2. Rooted stock of red osier dogwood.
        3. Annual rye and a waterways mixture of grasses.

WASHINGTON PARK

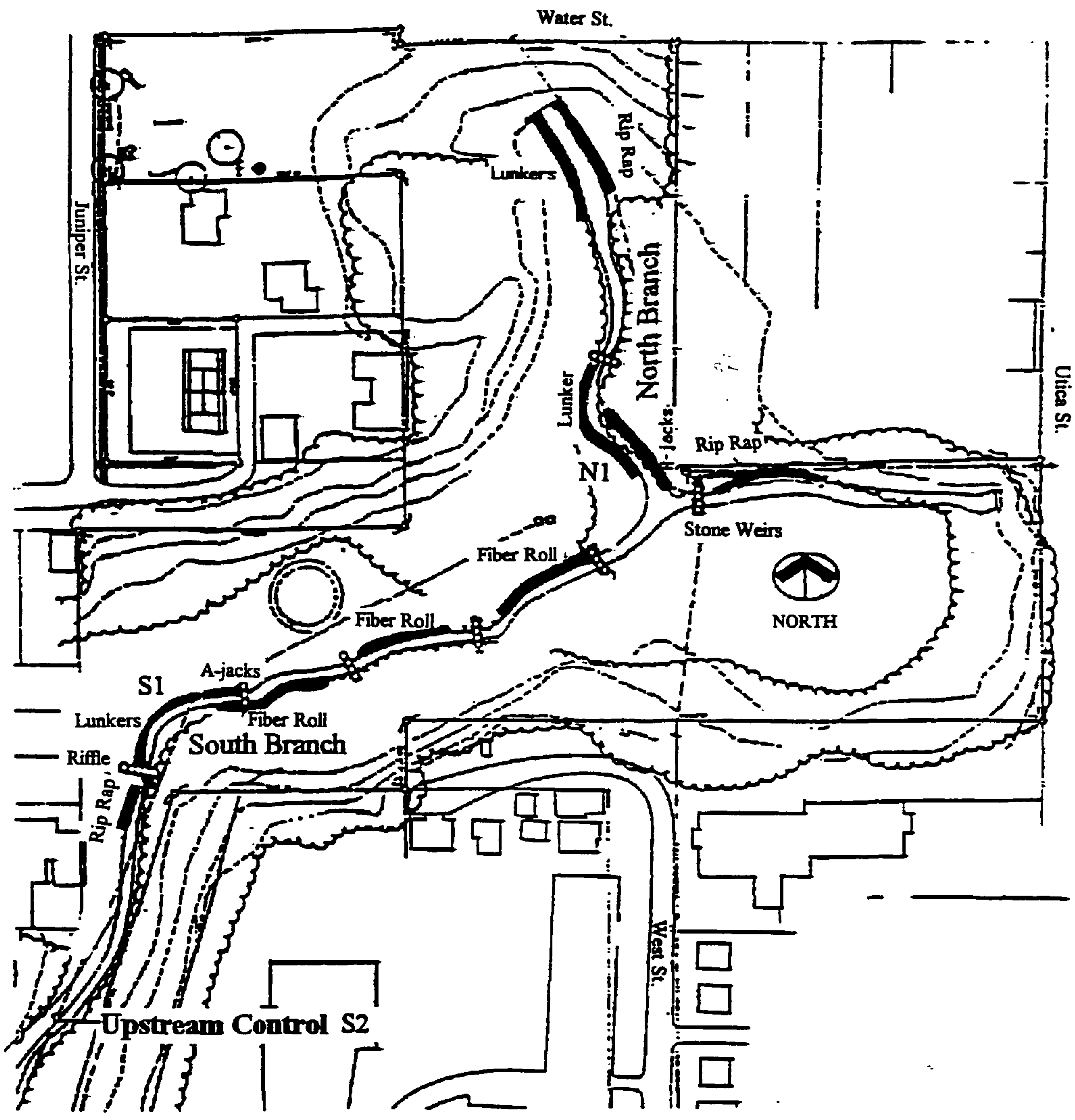


Figure 6. Map showing placement of erosion control techniques.

C. Installation steps

1. Excavate a trench along the toe of the severely eroding bank. Hand trenching will be required so that the excavator does not accidentally damage the sewer line.
2. Place the lunkers and a-jacks in the trench along the vertical wall of the eroding bank.
3. Place fiberdam behind the lunkers.
4. Place stone behind the lunkers.
5. Place trench fill over the lunkers and a-jacks.
6. Slope bank soils over the trench fill.
7. Place stone over the a-jacks layer.
8. Plant red osier dogwood with a-jacks layer and above lunkers.
9. Place erosion matting on exposed bank soils.
10. Plant annual rye and waterways mix.

At three other bank sites, over 200 ft of minor bank erosion were protected with entrenched coconut fiber rolls (Figure 7). The rolls were placed in shallow trenches and fastened to the streambed with rebar. Small willow cuttings were driven through the fiber rolls into the bank soils. Additional grass seeding and willow cuttings were placed on smaller areas of exposed bank within the reach. Where shading limited bank growth, small trees and shrubs were cut back.

Fiber rolls were installed with difficulty because the streambed contained broken concrete. The rebar had to be driven with a gasoline-powered jackhammer in order to hold the fiber roll. Willow cuttings were forced into the bank soils. Since the fiber rolls and plantings were installed in early November, little plant growth has occurred.

The sites have remained stable since 1994. Both the dogwood and grass seedlings regrew quickly. Willow cuttings have responded less quickly to the planting efforts and may need restaking in the spring.

2. To conduct a training Workshop during the Illinois EPA's National Nonpoint Pollution Monitoring Conference in Chicago. Personnel from both private and government agencies were involved in hands-on installation of bank protection techniques.

More than 120 Workshop participants visited the site from states as far away as North Carolina, New York, Arkansas, and California (Figure 8). The site was divided into various stages of installation so that the installation process was apparent. The Workshop group was divided into eight teams who toured the site individually. Waukegan Park director, Greg Petry, explained the park district interests to the group. Each group worked on the lunker installation and handled the a-jack assembly.

The Waukegan Park District, Illinois EPA, and Illinois DNR were pleased with urban biotechnical streambank measures, which were highly successful in reducing streambank erosion, re-establishing riparian Vegetation, and saving park infrastructure. However even with the introduced underwater habitat of lunkers, the biological response was limited in the diversity and numbers of aquatic biota. Sample results and summary tables are in Appendix A.

Figure 7. Fiber rolls installed at toe of streambank.

Figure 8. Workshop participants check out site in various stages of installation.

After monitoring the South Branch of the Waukegan River in 1994 and 1995, shallow pool depths were found to limit the habitat suitability for stream fisheries during low summer flows. The stream Channel was similar to a ditch with a uniform streambed without a clearly defined pool and riffle pattern. In addition, the ditchlike characteristics of the channelized reach limited stream aeration and promoted deposition of fine organic materials in the shallow pools.

The Illinois EPA and Waukegan Park District decided to recreate a deeper pool and cobble riffle sequence by constructing low stone weirs in the South Branch of the Waukegan River. The locations and height of the stone weirs were based upon the designs of Dr. Robert Newbury, a Canadian hydrologist who had developed this technique of stream restoration (Figures 9 and 10).

The distance between riffles was based upon the banldull Channel width, approximately 5-7 banldull widths. The relative height of each stone weir was determined by dividing the total streambed fall in the demonstration reach by the number of weirs located in the length of the demonstration area. The localized rise in the streambed at each weir creates a larger and deeper pool since all of the streambed fall occurs in 20 percent of the demonstration area length.

Following the upstream-downstream design plan of USEPA's National Watershed Monitoring Protocols, five stone weirs were constructed in the 600 ft. downstream treatment reach of the South Branch of the Waukegan River (Figure 11). Rock weirs were located over two main sewer lines where Channel incision had exposed and degraded the concrete cap over the sewers. One sewer was located in the monitored area where lunkers had also been installed in 1994. The other exposed sewer protected by a stone weir was located just downstream of the junction of the North and South Branches of the Waukegan River. One additional stone weir was constructed upstream of the North Branch lunker site constructed in 1992.

The size of the crest stone in the weir was determined by the depth of water at each weir elevation and the need to bury a portion of the crest stone in the streambed. Water depth before weir construction varied from 0.1 to 1 ft between proposed weir locations with increases in water elevation ranging from 0.3 to 1 ft. Crest stone diameters averaged about 2.5 ft for the granite boulders but were highly variable. The height of the uppermost weir was lower to minimize upstream deposition of bedload since there would be no upstream weir to promote pool scour. The height of the most downstream weir was lower to reduce downstream scour where no weir would provide a deeper pool to reduce bank erosion.

The stone backface of the weir extended downstream for a distance of 20 times the height of the crest stone above the streambed. The front face of the weir extended upstream four times the height of the crest stone. The backfill had a median diameter of 1 ft, within the 1.5 to 0.5 ft diameter of stone specified by Dr. Newbury.

As is common for this technique, some of the weirs settled slightly after the January and April rains; so that approximately 30 tons of small 6-12 in. diameter stone were added to the backface of three weirs. No stone was added after the large May storms of l996.

The mean annual flood flow was estimated at 40 cubic feet per second (cfs) from U.S. Geological Survey (USGS) records of nearby streams. However, runoff from the highly urbanized city made higher streamflows likely since nearby streams with USGS gaging stations do not have watersheds with the population densities of Waukegan. Peak

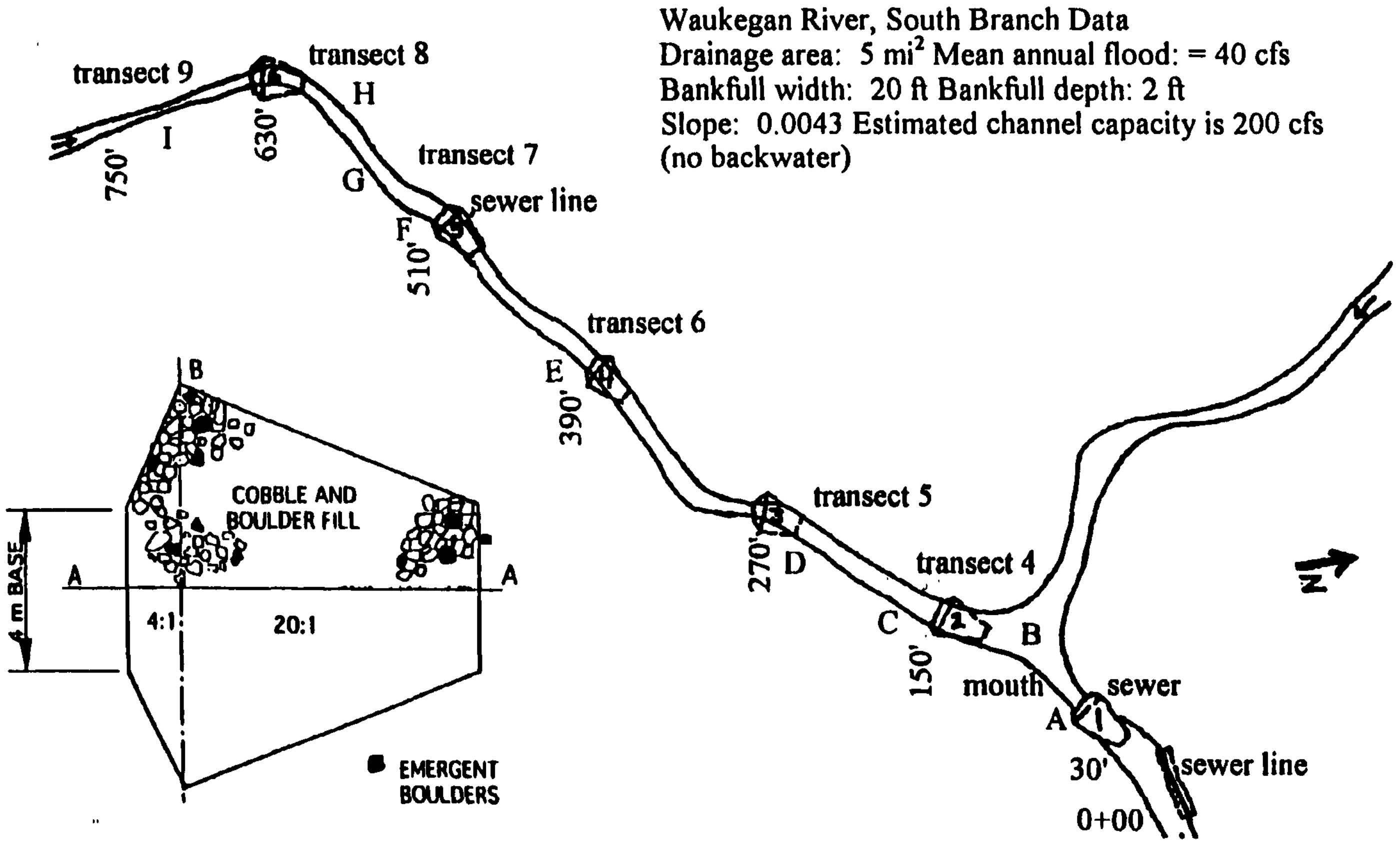


Figure 9. Plan view of stone weirs on South Branch Waukegan River.

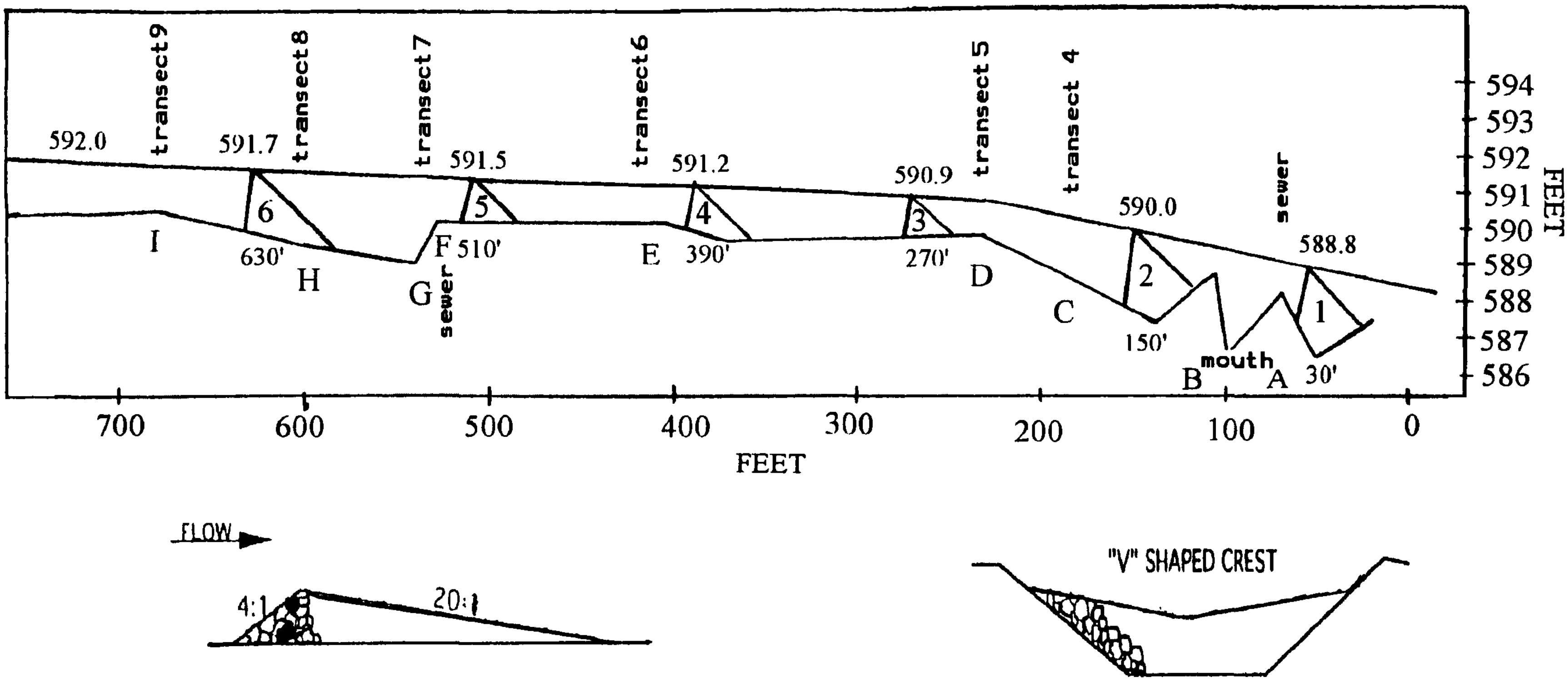


Figure 10. Longitudinal profile of stone weirs.

Figure 11. A tractor moves the large boulders of one of the stone weirs in Washington Park.

flood flows in Waukegan have varied from 30 to 60 cfs during the spring floods of 1996. However, urban debris from Shopping carts to plastic garbage sacks have covered the doppler sensor during several of the larger floods. Appendix B presents recorded 1996 peak discharges. Appendix C contains data from two Waukegan rain gauges for 1996.

The cost for 210 tons of granite boulders for the seven stone weirs was $10,000. A large track hoe was contracted for the majority of the weir Installation at a cost of $1,350. The Waukegan Public Works Department contributed a track loader to transport the granite boulders down the steep ravine bluffs. The Waukegan Park District contributed a rubber-tired backhoe for additional boulder transport to stream locations and some boulder placement in the stream Channel. The track front-end loader was used for 2.5 days at cost of $1,100. The backhoe was used for four days at a cost of $800. Total cost for equipment and materials was $13,250.

STREAM MONITORING

The upstream control lies 500 ft upstream of the restored pool/riffle reach. No large ravine Systems transport stormwater in the stream Channel between the upstream control and the downstream Station. The intensive monitoring of fisheries, benthos, and instream habitat was concentrated in the upper 200 ft of the control reach.

For the National Watershed Monitoring effort, Sl and S2 monitoring stations were located in the downstream treatment reach and the upstream control reach, respectively. These South Branch stations were monitored three times in 1994 before any restoration efforts began and three times in 1995 after lunkers were installed at the most severe bank erosion site in late 1994 during the Second Annual National Watershed Monitoring Conference. As a part of the continuing monitoring efforts of the Illinois EPA and Illinois DNR, the South Branch sites were monitored three times in 1996 after pool and riffle restoration in early 1996.

Additional monitoring sites (Nl and N2) on the North Branch of the Waukegan River have been monitored but do not follow National Watershed Monitoring Protocols. Nl is a wooden lunker site in Washington Park while the N2 site has lunkers of recycled plastic lumber and concrete a-jacks in Powell Park.

Methodology

Fundamental to the evaluation of stream stabilization and habitat enhancement techniques is measurement of the biological response of aquatic species. Biological stream site characterization with the Index of Biological Integrity (IBI) has been the Standard in the Waukegan River monitoring.

Since 1984, a team of stream biologists from the Illinois DNR and the Illinois EPA has developed this stream Classification system based upon the attributes of the logic fish communities (Hite and Bertrand, 1989, Table 1).

The Biological Stream Characterization Work Group has reviewed the 12 IBI metrics used to evaluate streams based upon their stream fisheries (Bertrand, Hite, and Day, 1996). These 12 metrics encompass trophic condition, abundance, and condition of the fish Community. The index accounts for changes in species richness and allows comparison of fish Community composition with the maximum known values for similar sized streams (Table 2).

Stream size is estimated from the Horton-Strahler stream Classification system (Strahler, 1957). When evaluated on a 1:24,000 USGS map (7.5 minute), this system designates unbranched tributaries as first order. Where two first-order streams join, a second-order stream is formed as where the North Branch and South Branch of the Waukegan River join in Washington Park.

Where watershed land use and drainage have increased runoff rates, stream order must be estimated by discharge measurements and Channel geometry. In such cases, bankfull width, bankfull depth, and discharge of natural streams in the region will determine the stream order Classification for the stream segment. Such natural streams must serve as the template for the Classification of modified stream Channels in the urbanized watersheds of northeastern Illinois.

Table 1. Biological Stream Characterization (BSC) Criteria for the Classification of Illinois Streams

Biotic Metric	Unique Aquatic Resource A	Highly Valued Aquatic Resource B	Moderate Aquatic Resource C	Limited Aquatic Resource D	Restricted Aquatic Resource E
FISHERY					
Index of Biotic Integrity(IBI)or Altenate (A1BI)	51-60	41-50	31-40	21-30	<20
Sport Fishery Value		Good fishery for walleye. sauger, smallmouth, spotted, or largemouth bass, northern pike, white bass, crappie, catfish, rock bass, or put and take trout fishery.	Smaller species of sport fish predominate in sport catch. Bulhead/sunfish carp fishery. Diverse forage fish Community may be present.	Carp or other less desirable species support fishery. Few if any fish of other species caught.	No sport fishery. Few fish of any species.
Spawning or Nursery Value		Tributary to an "A" stream, or used as nursery by above sport fish species.	Nursery or rearing area for common sport fish. Young of year or juveniles of above species common in fish samples.	Few ifany young of year or juveniles ofany sport species present.	No young of year or juveniles of sport species
MACROINVERTEBRATES					
Macroinveitebrate Biotic Index (MBI)	N/A	N/A	N/A	>7.5<10.0	>10.0
Community Structure	N/A	N/A	N/A	Predominant macroinveitebrate taxa/individuals consist of facuhative and/or moderate organisms. Intolerant Organismsare sparseor may be absent.	Intolerant organisms absent, benthic Community consists of nearly all tolerant forms,or no aquatic macroinvertebrates may be present
Species Richness	N/A	N/A	N/A	Notably lower than expected for geographic area, stream size, or available habitat, usually limited to a moderate or few number of taxa.	Restricted to few taxa, or no taxa present.

Table 2. Index of Biotic Integrity (IBI) Metrics Used to Assess Fish Communities in Second-Order Streams in Northeastern Illinois (Bertrand, Hite, and Day, 1996)

Category	Metrie	Scoring criteria		
		5	3	1
Species richness and composition	1. Total number of fish species		6-10	
	2. Number and identity of darter species		2	
	3. Number and identity of sunfish species		1	
	4. Number and identity of sucker species		2	
	5. Number and identity of intolerant species		2-3	
	6. Proportion of individuals as green sunfish	<5%	5-20%	>20%
Trophic composition	7. Proportion of individuals as omnivores	<20%	20-45%	>45%
	8. Proportion of individuals as insectivorous cyprinids	>45%	45-20%	<20%
	9. Proportion of individuals as piscivores (top carnivores)	<5%	5-1%	<1%
Fish abundance	10. Number of individuals in sample		350-700/hr	
	11. Proportion of individuals as hybrids	0%	>0-1%	>1%
	12.. Proportion of individuals with disease, tumors, fin damage, and skeletal anomalies	0-2%	>2-5%	>5%

Rehabilitation techniques on the South and North Branches of the Waukegan River will be evaluated as if the two branches were second-order streams. See Table 2 for the IBI scoring criteria for a second-order stream in northeastern Illinois.

Stream Fisheries

Collection. Each monitoring site consisted of a single pool and the two adjacent riffles. The sites ranged from 120 to 200 ft in length. Blocking seines isolate the sites at both the upper and lower areas.

Fish collection equipment includes a backpack electrofishing unit, which stuns fish and brings them to the surface. The fish survey crew consisted of the backpack shocker Operator and a single netter. Electrofishing normally requires 10-15 minutes depending on habitat and pool depth. Time must be accurately observed to calculate the catch per unit effort.

Larger fish were identified on site and returned to the stream. Smaller fishes were stored in 95 percent ethanol and identified at a later date by an Illinois DNR fishery biologist. Fish species were identified and examined for disease and condition.

IBI Stream Evaluation

IBI assesses the health of a fish community using 12 fish community metrics. Each metric is scored as a 1, 3, or 5, with a possible score of 60 for sites of exceptional quality. Six of the 12 metrics do not have criteria established for scoring. Of these, expectations (and scoring) vary with stream size and region for the five metrics that measure species richness and composition. The other metric without fixed criteria evaluates abundance (catch-per-unit of effort or CPUE) and also has expectations that "vary with stream size and other factors." Fisheries Professionals applying IBI have thus been delegated the responsibility to define species richness criteria based upon geographic considerations, and CPUE criteria based upon stream size and "other factors" such as catch efficiency of gear used in collecting fish samples.

Species richness scoring criteria can be derived through use of the maximum species richness line (MSR) described by Fausch et al. (1984) in their examination of regional applications of IBI. The MSR line is essentially a plot of the maximum number of species found in samples versus stream size (Figure 12).

The Horton-Strahler method of stream ordering was employed as a measure of stream size. Thousands of stream samples were examined in an effort to find samples where a large number of species reflected undisturbed conditions prior to modification by humans - the "pristine" conditions against which deterioration of fish communities could be measured. Samples of undisturbed sites were not available for all stream sizes within each major watershed of the State, but enough were found to establish the MSR slope. Once the MSR line is plotted for a particular region, deviation from this line is given a score by trisecting the area beneath the line. Samples with numbers in the zone closest to the line are valued at 5, those in the next zone 3, and samples with numbers in the lowest zone area scored at 1 (Figure 13).

In the example shown (Figure 13), a fish sample from a sixth-order stream location with 20 species would be scored a 3 for the total species parameter; a sample from a

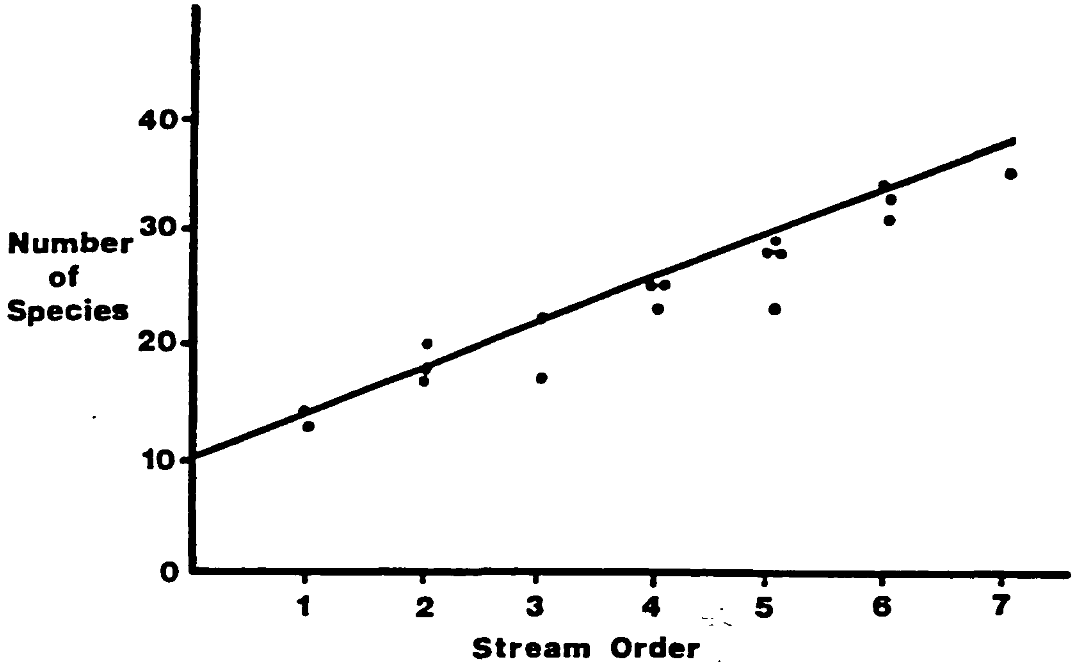


Figure 12. Plot of Maximum Species Richness (MSR) line using maximum number of species in samples from streams of different sizes.

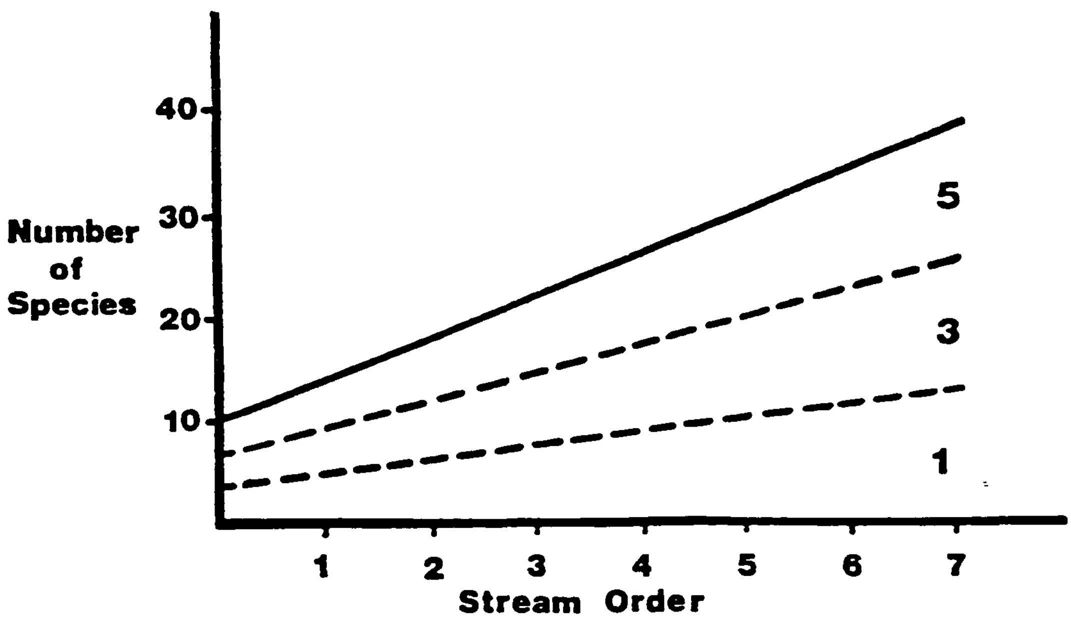


Figure 13. Zones (dashed lines) beneath MSR line used to define IBI scoring criteria.

fourth-order stream with 20 species would score 5. Limits of the zones beneath the MSR lines become criteria for the five species richness metrics (Figures 13 and 14) as applied to designated regions of the state.

Through testing of these criteria and comparison with other areas in Illinois, watersheds displaying similar MSR lines were grouped together. Watersheds with fisheries data too sparse to develop MSR lines were grouped with adjacent watersheds where data were available. This grouping produced distinct Illinois regions with unique criteria for application of IBI to fishery data.

The abundance metric varies with method of sampling, gear, and sometimes with stream size; it is scored as a catch-per-unit of effort (CPUE) value. Scoring criteria for this metric have evolved since initial development and application of IBI in 1982. The large number of rotenone and electrofishing samples on second-/fifth-order streams collected in the past five years provided ample data to refine scoring applied to different sized streams.

Macroinvertebrate Surveys

Aquatic macroinvertebrates as defined by Weber (1973) are invertebrates large enough to be seen by the naked eye and retained on a U.S. Standard 30 sieve (0.595 millimeters or mm). They will spend at least part of their life cycle within or upon aquatic Substrates. Invertebrates included in this group are typically annelids, macrocrustaceans, aquatic insects, and mollusks (Isom, 1978) and are commonly useful in water quality monitoring as indicator species (Resh and Unzicker, 1975).

At each sampling site, Substrates are sampled at three locations with a Hess bottom sampler and a 500 micron net. The Hess sampler is firmly pressed into the sediment to ensure a tight seal.

Cobble are scrubbed with a nylon brush within the sampler and removed. The remaining bed material is stirred vigorously and allowed to clear three times for thoroughness.

The screened material is removed from the Hess sampler and preserved in 95 percent ethanol. Invertebrates are picked from the screened materials and identified to genus.

Macroinvertebrate data are interpreted by an examination of Community attributes: Community structure, taxa richness, and use of the Macroinvertebrate Biotic Index (MBI). The MBI provides a summation or average of tolerance values assigned to each taxon collected and is weighted by its abundance. Low values indicate high water quality (for example, the rural Franklin Creek Lunker project had an MBI of 5.5). High values indicate degraded water quality.

This index has a 0-11 scale rather than the 0-5 scale proposed by Hilsenhoff (1977, 1982) for Wisconsin streams. The Illinois EPA has also assigned tolerance rating for Turbellaria, Annelida, Decapoda, and Molluska. The MBI is calculated by the following equation:

$$\mathbf{MBI = \Sigma(n\mathit{i}\ t\mathit{i}) / N}$$

where ni = number of individuals of each taxon

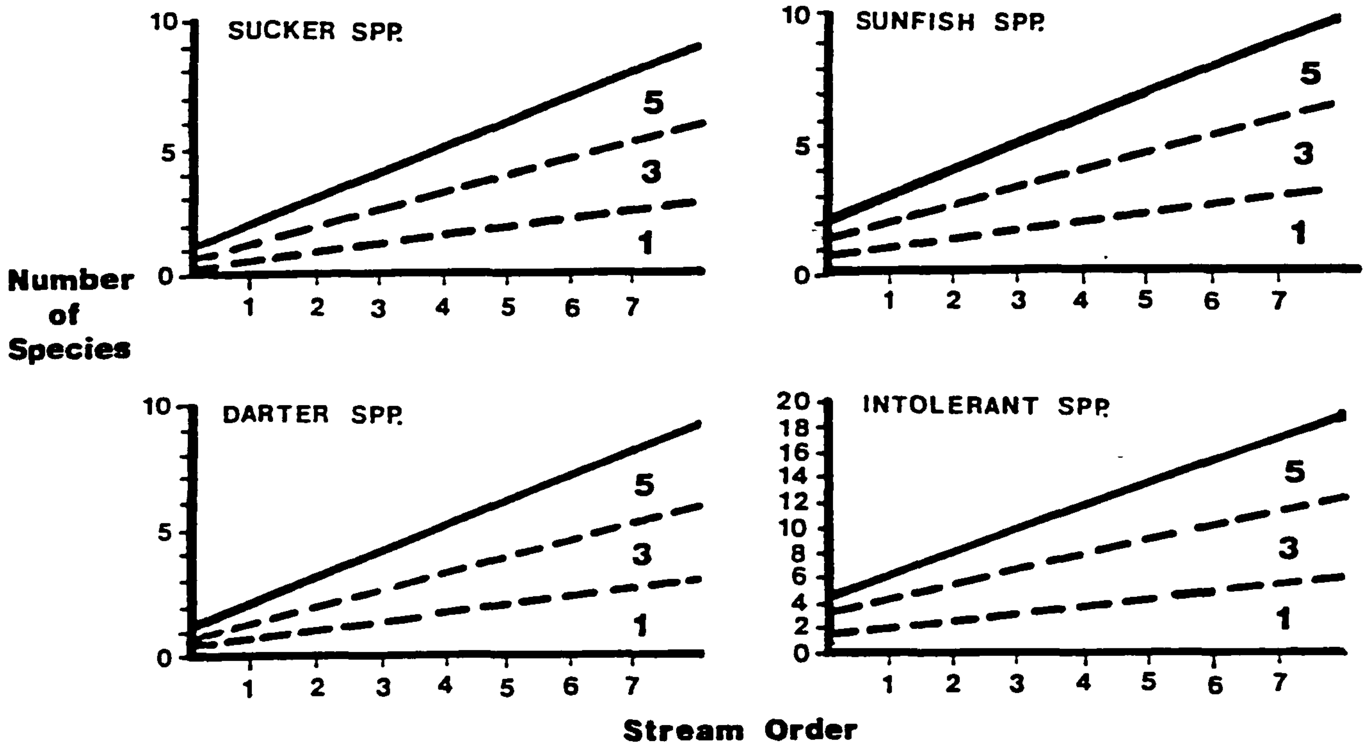


Figure 14. MSR lines and scoring criteria zones for species richness metrics.

ti = tolerance value for each taxon
N = total number of individuals

Instream Habitat Monitoring

The instream habitat monitoring follows the guidelines of the Illinois EPA Potential Index of Biological Integrity (PIBI). The PIBI was the result of multiple regression analysis of the data generated by the wadable stream transect methodology.

Using the wadable transect methodology, the sampling site is divided into 10 segments of equal length bounded by 11 transects. Habitat variables are defined within each of the 10 stream segments. These habitat variables are stream width; stream depth; streambed Substrate; instream cover; percentage of riffles, pools and runs, and shade canopy; and stream discharge.

Stream width is determined by direct measurement at each of the 11 transects. Stream depth and bottom substrate are determined at one ft intervals along each transect. The extent of shade canopy, pool, riffle, and run is estimated from Observation of each of the 10 stream segments. Stream discharge is measured at one ft intervals along one transect. The entire procedure for wadable transect surveys is given later in this section.

Regression analysis of habitat data generated by Illinois basins surveys found the percent of silt-mud Substrate, the percent of claypan Substrate, the percent of pool habitat, and the mean stream width accounted for the greatest variance in IBI values. The following equation predicted the IBI values of selected Illinois streams with the greatest accuracy:

$$\text{PIBI} = 40.1 - (0.126 * \text{silt-mud}) - (0.123 * \text{claypan}) + (0.0424 * \text{pool}) + (0.0916 * \text{width})$$

For typical Illinois streams, the PIBI values will range from 35 to 50 for third- to sixth-order streams. Smaller streams will have lower PIBI values. This trend is similar to IBI values for smaller streams since they have fewer species and less abundance than larger streams with similar habitat.

Wadable Streams Transect Methodology

Summary

The transect assessment procedures used in wadable streams in conjunction with Illinois EPA/Illinois DNR Cooperative Intensive Basin surveys, special studies, or with selected elements of the Biological Stream Characterization (BSC) effort, combines the habitat approach of Gorman and Karr (1978) with information on additional metrics important to stream quality (e.g., pool/riffle development, instream cover, and shading).

Stream habitat is measured along dimensions considered important to fish and applicable to many stream types. This methodology employs placement of transects along the study areas with depth and Substrate measured at equally spaced intervals at each transect (calculation of habitat diversity or HD may be accomplished if desired by placement of habitat components into discrete categories with diversity calculated by the Shannon-Weiner equation on total observations within a combination of habitat dimensions). Use of the habitat transect approach allows calculation of mean depth and width and determination of substrate composition for the study reach. Quantification of pool/riffle development, instream cover, and shading is accomplished in incremental fashion in conjunction with recording data from each transect. A complete list of metrics recorded with the 11-transect approach is provided in Table 3. A summary of the steps employed when the transect approach is used in conjunction with the assessment of fish communities is provided below:

1. Following placement of block seines or completion of fish sampling, measure the length of the fish sampling reach.

2. Determine the transect interval and location of first (or last transect).

3. Place flags or markers at the proper transect locations.

4. Estimate mean stream width.

5. Determine transect increments based on stream width.

6. Using the appropriate field sheets, initiate recording depth and Substrate type at the first downstream transect (transect 1), and continue procedure measures in an upstream direction through transect 11 (see Figure 15);

7. Record estimates of instream cover and other metrics for each of the 10 segments as moving upstream.

Limitations of Methodology

Because fish Community structure may be affected by seasonal changes in fish distribution and stream flow regime, five situations were listed by Gorman and Karr (1978) as limitations and/or considerations when evaluating stream habitat to predict fish Community diversity.

1. Habitat measurements must not be made in stream environments uninhabitable by fishes (e.g., water too shallow).

2. Habitat should be sampled in flowing streams; habitat assessments are preferably conducted when streams are at or near base flow, or low flow conditions. When streams are partially dried or pooled, fish are restricted to pools and habitat assessments may predict lower fish diversity or biotic integrity than will actually occur.

3. Streams excessively choked with filamentous algae should not be included in habitat diversity analysis for prediction of biotic integrity (or habitat diversity). Gorman and Karr found HD in such areas predicted a higher fish species diversity than occurred.

4. The stream habitat and fish community must be in relative equilibrium with fishes using their optimum habitat. Migration of fishes in search of spawning areas will impact resident fish Community structure. Fluctuating stream stages typically found in spring months may similarly invalidate habitat relationships with fish Community composition.

5. Sampling of fish communities should be avoided when short-term chemical changes have impacted or devastated fish communities. Biotic integrity will be much lower than predicted by habitat assessment in such instances.

Table 3. Field Metrics Evaluated in IEPA 11-Transect Stream Habitat

Field metrics	11-Transect
SUBSTRATE (%)	
Silt - Mud (<0.063mm)	X
Sand (0.063-2mm)	X
Fine Gravel (0.08 - 0.3 inches)	X
Medium Gravel (0.2 - 0.6 inches)	X
Coarse Gravel (0.6 - 2.5 inches)	X
Small Cobble (2.5 - 5 inches)	X
Large Cobble (5-10 inches)	X
Boulder (> 10 inches)	X
Bedrock	X
Claypan - Compacted Soil	X
Plant Detritus	X
Vegetation	X
Submerged Logs	X
Other (e.g., cutvert)	X
Bottom Substrate	X
Deposition	
Pool Substrate	
Substrate Stability	
HYDRAULIC/MORPHOMETRY FEATURES	
Channel Alteration	
Channel Sinuosity	
Discharge (cfs)	X
Hydrologic Diversity	
Mean Depth (ft)	X
Mean Velocity @ Q	X
Mean Reach Velocity	X
Mean Width of Water (ft)	X
Pool Quality	
Pool Variability	
Pool (%)	X
Riffle (%)	X
Water Level Trend	X
Water Level	X
Width/Depth Ratio	
RIPARIAN FEATURES	
Bank Vegetative Stability	
Immediate Watershed	
Shading/Canopy (%)	X
OTHER	
Instream Cover Total (%)	X
Aquatic Vegetation	X
Boulders	X
Brush-debris Jams	X
Logs	X
Rock Ledge	X
Submerged Tree Roots	X
Submerged Terrestrial Vegetation	X
Undercut Bank	X
POTENTIAL INDEX OF BIOTIC INTEGRITY (PEBI)	X

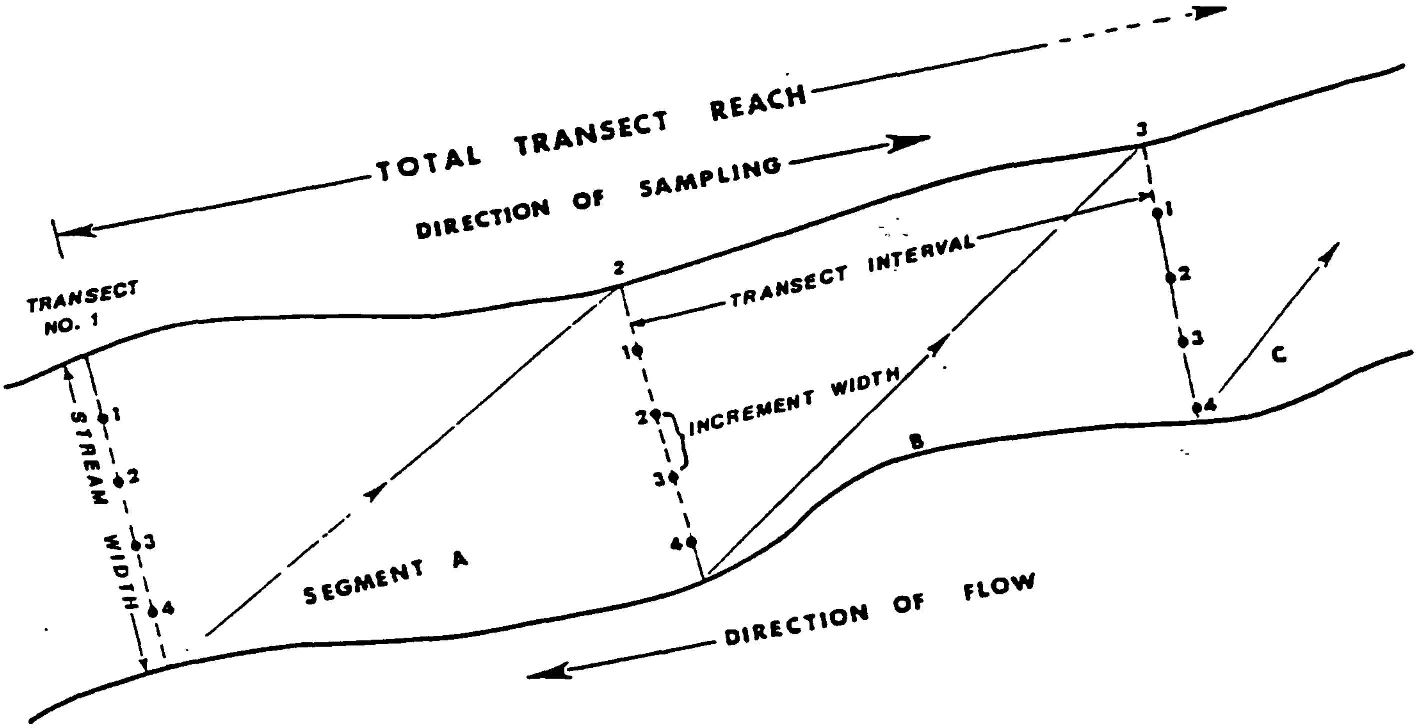


Figure 15. Schematic diagram of IEPA habitat quality assessment procedura for wadable streams. Sampling is initiated at the right edge of the water (REW) at Transect 1. Depth, velocity, and Substrate measurements start at the proper increment width from REW (Point 1 in the figure) and sampling proceeds across transect. Additional transects are taken at 10 yard intervals moving upstream.

Procedurefor Wadable Streams

1. Selection of Study Reach

Selection of a stream reach for assessing habitat quality is largely determined by study objectives. The primary objectives for acquiring habitat data in most stream evaluations are: 1) to document stream habitat quality, 2) to determine biotic potential, and 3) to compare biotic potential with actual aquatic life use attainment documented in fishery surveys.

2. Fish Station Length

Station length is defined as the length of the study area sampled by fishery biologists. This length is determined by measuring the distance between block nets, electroseine sampling, or the total distance sampled in electrofishing or seining surveys. Station length is measured in the thalweg or center of flow.

3. Determination of Total Transect Reach and Transect Interval

Habitat quality metrics are measured at 11 transects in all Illinois EPA Cooperative Stream Surveys. The total *transect reach* (distance from the first to last transect) should be established in the area of the fishery survey. The distance between habitat transects is defined as the *transect interval.*

For fishery study areas shorter or longer than 100 yards, the study area may be divided into 10 segments of equal transect intervals. The study area should include at least one riffle/pool sequence whenever possible. The length of the fish sampling reach, transect reach, and transect interval is recorded on the Habitat Transects Field Sheet.

Transect locations may be marked temporarily with wire flags or flagging tape. The first transect should be placed across a riffle area at the upstream end of the study area with subsequent transects located at appropriate intervals in a downstream direction. If a riffle is not available at the upper end of the study reach, it may be necessary to place the initial transect across a riffle at the downstream end of the sample area and proceed with placement of transects in an upstream direction. Regardless of the direction in which transects are placed, the first transect at the downstream end of the study reach is always designated as number one.

Habitat metrics are recorded at equal increments across each transect with increment width or spacing for the study area determined by mean (x) stream width (see Table 4 below). Mean stream width is determined by a few measurements of stream width at representative points. Once increment spacing is determined, the same increment width is used for each transect.

Table 4. Transect Increment Spacing as Determined by Mean Stream Width

Mean stream width x (ft)	Increment spacing
x < 10	1
x > 10 but < 30	2
x > 30 but < 60	3
x > 60 but < 100	5
x > 100	10

Instream Habitat Measurements

Using a fiberglass measuring tape or wire tagline, transect 1 is placed perpendicular to the opposite shore and generally 90 degrees to the direction of flow. Measurement of stream width, depth, velocity, and Substrate is initiated at transect 1, starting from the right downstream bank (Figure 15).

HABITAT VARIABLES

1. Stream Width

Stream width is determined by measuring the distance between the right downstream water edge to the left downstream water edge. Stream width is recorded to the nearest foot (1.0 ft) on the Habitat Transects Field Sheet. To provide consistency in measurement, protruding logs, boulders, stumps, or debris surrounded by water are included in the measurement of the water surface. Any solid accumulation of inorganic sediment particles protruding above the water and more than 1.0 ft in width is considered an island and is not included in the measurement of stream width. The stream width measurement ends when, on approaching the shoreline, any material is not completely surrounded by water and water is only pocketing between the material (Platts et al., 1983).

Following recording of stream width on the field sheet, depth, velocity, and Substrate type are recorded at each sample point or transect increment. Measurements are initiated at Transect 1 at the appropriate increment width from the right downstream edge (REW) of the water (e.g., if the increment width is 3 ft, the first measurement is started 3 ft from the REW).

2. Water Depth

Water depth between the water surface and substrate is measured with a USGS top setting wading rod or fiberglass level rod to the nearest tenth of a foot (0.1 ft).

Mean stream depth for a transect is determined by dividing the sum of depth measurements by the number of measurements plus 1. This accounts for the zero depths at the stream edge (Platts et al., 1983). The mean depth for the sampling reach is calculated by summing all the depth measurements in the reach and dividing by the number of measurements plus the number of transects. For example, if 10 depth measurements were made at each of 11 transects, the mean depth would equal the sum of the depths divided by 110+11.

3. Stream Velocity

Stream velocity is the speed of water movement over a given distance and is typically measured in feet per second (ft/sec) or meters per second (m/sec). Velocity, a function of many variables such as gradient, bottom Substrate (roughness), and runoff from precipitation, is an important hydrological variable that affects the physical, biological, and chemical components of stream quality.

Velocity measurements are recorded in conjunction with the measurement of stream discharge. Velocity is determined using a Price AA current meter, pygmy meter, or Gurley meter at 0.6 of total depth (v_x = 0.6d). The habitat field sheet allows the investigator to record total revolutions and time in seconds for each measurement; stream velocity may be computed in the field or in the office and is recorded to the nearest hundredth foot per second (0.01 ft/sec).

Mean velocity

The mean or average stream velocity is a fiinction of where velocity measurements are taken and the method used for computation. For EPA stream habitat assessment surveys two mean velocity measurements may be recorded:

- *Mean Velocity @ Q.* The average stream velocity at the discharge transect is determined by totaling all velocity measurements taken at the discharge transect and dividing that value by the total number of measurements.

- *Mean Velocity for the Sampling Reach.* The average velocity in the habitat reach is determined by dividing stream discharge by mean width x depth.

$$V = cfs/(W \times D)$$

4. Substrate

Substrate is defined as the mixture of particles comprising the streambed (Bovee, 1982). A total of ten Substrate types and four instream cover metrics (including "other") have been developed to record Substrate and bottom type in Illinois streams. The ten Substrate categories listed in Table 5 are predicated on particle sizes modified from Lane (1947).

At each transect point the predominant Substrate is noted and the numerical code recorded on the field form. Considerable judgment is necessary in recording Substrate type. It is necessary to always use the size categories provided on the field sheet. Intermixtures of various materials or particle sizes are probably the most difficult to judge. Normally if you have an intermixture of materials, each will be predominant at one or more sample points on the transect. However, if a nearly equal intermixture of sand, gravel, and detritus is noted across nine transect points, it would be practical to code three points as sand, three points as gravel, and three as detritus.

5. Instream Cover

Cover is defined as something that fish can hide under or behind (Bovee, 1982). Instream cover and Substrate function similarly in stream environments by affording fish and macroinvertebrates sanctuaries for specific life processes. Instream cover, as measured by these habitat assessment procedures, applies mainly to fish beyond the juvenile stage while Substrate provides essentially the same function to benthic macroinvertebrates and certain life stages of fish (e.g., eggs and larvae).

Instream cover typically encountered in Illinois streams consists of logs, snags, brush-debris jams, aquatic Vegetation, rock ledges, and undercut banks (Table S). For the purpose of this habitat methodology, roots and filamentous algae extending into the stream are considered Vegetation and may be included in the estimate of instream cover. Boulders may also be considered instream cover if they are of a size, shape, and location in the stream to afford fish cover.

Table 5. Substrate and Bottom Type Categories Used in the IEPA Transect Habitat Assessment Procedure

Code	Substrate	Particle size
1	Silt/mud	<0.062 mm
2	Sand	0.062 - 2 mm
3.1	Fine gravel	2 - 8 mm (0.08 - 0.3 in.)
3.2	Medium gravel	8 - 16 mm (0.3 - 0.6 in.)
3.3	Coarse gravel	16-64 mm (0.6-2.5 in.)
4.1	Small cobble	64 - 128 mm (2.5 - 5 in.)
4.2	Medium cobble	128-256 mm (5-10 in.)
5	Boulder	256-4000 mm (> 10 in.)
6	Bedrock	Solid rock
	Bottom tvpe	
7	Claypan - compacted soil	
8	Plant detritus	
9	Vegetation	
10	Submerged logs	
11	Other	

6. Pool/Riffle Development

Pools

A pool is defined as that area of a stream that has slow velocity and is usually deeper than a riffle or a run (Platts et al., 1983). A pool frequently exhibits a streambed concave in shape and a water surface gradient near zero. Pools in meandering and straight Channels are topographic low areas, usually several Channel widths long, produced by scour at high flow; pools are generally associated with point bars and contain relatively fine-grained bed material (Keller and Melhorn, 1978).

Riffles

A riffle is defined as that section of a stream where velocity is fast, stream depth relatively shallow, and water surface gradient relatively steep; Channel profile is usually straight to convex (Platts et al., 1983). Riffles are usually topographic high areas produced by the accumulation of coarse-grained material; ideally, the inflection point of the thalweg is located on riffles between successive pools (Keller and Melhorn, 1978).

Run

To further quantify the characteristics of a stream, Platts et al. (1983) have defined a run as that length of stream that does not form distinguishable pools or riffles but has a rapid nonturbulent flow. A run is usually too deep to be a riffle and too fast to be a pool; it is like a low incline plane where all water flows at the same fast pace, but not fast enough to cause surface rippling. Channel form under a run is usually very uniform and the plane flat.

Slack Area

Many low-gradient Midwest streams are intermittent in nature and have sections which cannot be distinguished as riffles, runs, or pools, particularly during periods of low flow. Long sections of the stream which may have been considered a run or riffle at a higher stream stage (and discharge) may at low flow have no measurable velocity and not have the characteristics typical of pools (depth and concave shape). Many other sections of the stream along shorelines, between Islands or bars, or adjacent to pools may also not be distinguishable as riffles, runs, or pools; such shallow areas with no velocity may be termed "slack areas".

Pool/Riffle Ratio

The pool/riffle ratio is the length or percent of riffle divided into the length or percent pool obtained for the study area. This ratio reflects the stream's capability of providing resting and feeding pools for fish and riffles to produce their food and support their spawning (Platts et al., 1983).

Estimating Percentage of Instream Cover, Pool, and Riffle

Percentage of instream cover, pool, and riffle was estimated by type for each of the 10 segments.

Segment Approach

The preferred method used to estimate instream cover, pool, or riffle requires the investigator to estimate the area (square feet) of each cover type, pool, or riffle by segment. All values for each segment are added together and percent instream cover, pool, or riffle for the study reach is determined. Two forms (IEPA Stream Habitat Supplemental Form A and B) are used to facilitate quantification of instream cover, pool and riffle.

7. Canopy-Percent Shaded

Solar radiation and the resulting heat load are important factors that regulate biological activity in all aquatic environments. Canopy or the percent shaded area is determined by estimating the percent of the stream surface shaded between 1000 and 1600 hours.

8. Stream Discharge

Stream discharge is an extremely important variable affecting the carrying capacity and dilution of contaminants in water and all biotic communities in lotic environments. As stream flow is directly related to stream size, it is an important metric in the evaluation of biotic potential.

Field Discharge Measurement Procedures

Discharge measurement methods follow established USGS procedures and guidelines (Buchanan and Somers, 1969). An outline of the methodology is provided below.

1. Select an area of stream best suited for a discharge measurement (e.g., straight reach, free of obstructions with a flat streambed profile.)

2. String a tag line or measuring tape across the stream at a right angle to the direction of flow.

3. Determine spacing of the verticals (increments), generally using 25 to 30 sections. Fewer sections may be used if the cross section is smooth and there is good velocity distribution. Space the partial sections so that no section has more than 10 percent of the total discharge in it. Note: equal increment spacing across the entire cross section is not recommended unless the discharge is well distributed. Decrease the increments as depths and velocities become greater. The minimum increment spacing is 0.3 fr for the pygmy meter and 0.5 fr for the Price AA meter.

4. Record necessary information on the USGS Discharge Measurement Notes field sheet as shown in Appendix E-5, or on the optional IEPA Stream Discharge Measurement form.

5. Select a current meter, pygmy or type AA, based on criteria listed below. Note: do not change meter during discharge measurement.

Depth, ft	Meter	Velocitv method
2.5 and above	Type AA	0.2 and 0.8
1.5-2.5	Pygmy or Type AA	0.6
0.3-1.5	Pygmy	0.6

6. Identify streambank, when facing downstream, as LEW (left edge of water) or REW (right edge of water). Record beginning and ending times of discharge measurement.

7. Stand from 1 to 3 in. downstream from the tag line and 18 in. or more from the wading rod. Keep the wading rod in a vertical position and the meter parallel to the direction of flow while observing the velocity.

8. Record the distance from initial point and depth.

9. Take the velocity measurement. Normally the 0.6 method is used (at depths greater than 2.5 feet the 0.2 and 0.8 method is used). When the setting rod is adjusted to read the depth of water, the meter is positioned automatically for the 0.6 depth method. Count the number of revolutions for a period of 40-70 seconds. Start the stopwatch with the first click counting zero not one. End the count on a convenient number given on the meter rating table column heading. Note: If a 0.6 depth velocity cannot be taken, a surface velocity divided by 1.15 can be used.

Discharge Calculation

1. Determine width for each partial section (sampling location) by using the following equation:

$$W_x = [b_{(x+1)} - b_{(x-1)}]1/2$$

Where W_x is the width at location x, $b_{(x+1)}$ is the distance from initial point to next location and $b_{(x-1)}$ is the distance from initial point to preceding location. Widths for edge of water locations are determined by dividing the distance from initial point to next location (beginning of cross section) or preceding location (end of cross section) by 2. The sum of all individual widths should equal the total width of the stream.

2. Multiply width by depth to get area for each partial section.

3. Multiply area by velocity (from proper rating table) to get discharge for each partial section.

4. Total area equals the sum of all partial areas.

5. Total discharge equals the sum of all partial discharges.

6. Mean velocity is determined by the equation:

$$V = Q/A$$

where V is the mean velocity, Q is total discharge, and A is total area.

MONITORING EVALUATIONS

Stream Fisheries Evaluations

The S2 control or reference site has remained consistently low in numbers of species and abundance. The only abundant species was stickleback during the spring spawning runs. The IBI values at S2 were 28 or below. Pollution-tolerant species such as goldfish have lowered IBI scores since no fish at a site during sampling will give a 28 score. Only 2-4 species were found during any year with population numbers ranging from 15 to 17 individuals for each year.

Without any habitat enhancement in 1994, five more species were found at Sl than at the S2 control. All five species were limited to a single individual (see Table 6). The IBI values at both stations were similar in 1994 and 1995 after lunker installation at Sl. During 1995, the number of fish species remained eight at Sl, however, population counts quadrupled without counting the spawning sticklebacks. Most of the population increase resulted from increases of fathead minnow and white sucker at Sl during 1995.

After the pool and riffle construction in 1996, the IBI value for Sl rose to 35 while S2 remained at 28. The increase of fish species to 16 accounted for this increase since both bluegill and coho salmon fry made their first appearances on the South Branch. The single largemouth bass Observation in 1994 increased to 12 individuals in 1996.

Other new species, long nose dace, green sunfish, and black bullhead, moved into the newly created habitat at S1. Populations numbers for Sl remained nearly identical for 1995 and 1996. In the S2 control, fish populations remained severely limited in both fish species and numbers.

Macroinvertebrate Survey Evaluations

The MBI uses aquatic invertebrate populations to determine water pollution effects in streams, and scores above 7.5 indicate poor water quality. During 1994 and 1995, the MBI remained at 7 or below at all sampling stations. However, in the spring sample of 1996, the MBI rose to a high of 9.50 at the S2 control site.

At the Sl pool and riffle site downstream, the MBI reached a high of 8.4, which also indicates water pollution effects. In contrast, both sampling stations on the North Branch had MBI values below 7, which indicates high water quality. Water chemistry samples did not reveal higher levels than those of 1994 or 1995. The North Creek sites had MBI values indicating no limitations as the result of water pollution.

The MBI values for S2 remained higher than Sl during the summer and fall sampling dates. At S2, MBI values were near the 7.5 level, which indicates water quality limitations. The Sl Station had MBI values at 6.3 or below, which were similar to the North Branch sites.

These MBI differences result from water quality effects on stations only 400 ft apart and receiving the same streamflows. The fall sampling date was two days after a small stormwater flood event with a peak flow of 80 cfs. Stormwater in the South Branch had elevated ammonia levels above 0.5 mg/1. Oxygen levels were between 5.5 and 4.5 mg/1 in the South Branch from S2 and Sl to the last riffle downstream on the South

Table 6. Comparison of Mean Station Values of Indices for Sl and S2,1994-1996

Index	1994 S1	1994 S2	1995 S1 Lunker	1995 S2	1996 S1 Riffles	1996 S2
IBI	25.82	22.18	25.33	26.00	34.67	28.00
MBI	6.64	7.26	6.26	6.31	6.99	8.26
PIBI	41.51	41.93	41.93	41.79	41.34	41.65
Fish species and abundance						
Coho					2	
Bluegill					9	
Largemouth bass	1				12	
Longnose dace					44	
Mottled sculpin			4		2	
Fathead minnow	4	2	64	4	16	
Creek chub	1		8		8	
Golden shiner	1	2	17		2	
White sucker			24	7	28	
Black bullhead					3	
Green sunfish					8	
Mosquito fish	27	13	20	4	2	1
Goldfish	1				1	
Brook stickleback			1		1	
Ninespine stickleback	1				3	
Threespine stickleback	1		53	54	84	15
Species	8	3	8	4	16	2
Abundance without stickleback	35	17	138	15	136	1
Abundance with stickleback	37	17	191	69	224	16

Branch. North Branch sites had better water quality with ammonia levels below 0.1 mg/1 and dissolved oxygen above 7.5 mg/1.

The MBI values indicate water quality effects on invertebrate populations over a longer time period. Grab samples for water chemistry represent water quality at a particular instant in the flow regime. The MBI values and water chemistry values were typical of high quality water at the North Branch sites even though a fish kill was visible along the banks in the September 1996 sampling.

Spring MBI values are generally higher and indicate longer term water quality effects including low water temperatures on aquatic invertebrate populations. As invertebrate populations respond to higher water temperatures, the species numbers and abundance increased.

Overall the MBI mean values for Sl and S2 were similar in 1994 and 1995 (Table 6). However at the S2 control site in 1996, aquatic macroinvertebrate populations suffered greater water pollution effects with the same streamflow and water quality than the pool and riffle complex at S1.

Instream Habitat Evaluations

Habitat evaluations of the wadable transects of the Sl and S2 sites were performed simultaneously with the fishery surveys and macroinvertebrate surveys. Of the habitat criteria measured, maximum pool depth, instream cover of undercut bank (lunkers in 1995) and boulders (riffles), and Substrates of cobble and boulders had the greatest increases (Table 7). Especially important for this urban stream was the increase of pool depth and therefore fish carrying capacity during low streamflows.

The increase of cobble and boulder Substrate along the turbulent backface of riffles is an important habitat feature. This well scoured cobble lies adjacent to deeper scour holes, which formed just below the riffles. Additional habitat improvement occurred where lunkers formed undercut banks downstream of the riffles' turbulent flows.

This table of habitat variables does not weight the value of one habitat feature with hydraulic features of water depth and velocity. Although this habitat complex is difficult to quantify, stream fishery in natural streams is most closely associated with this multiple habitat and hydraulic parameter matrix.

The predicted IBI (PIBI) from the Standard equation is based upon mean width, pool percentage, and silt or hardpan clay Substrates. Such parameters were most significant of larger streams in downstate Illinois, but small urban streams in northeastern Illinois appear to respond to other features. Note that the PIBI values for Sl and S2 remain essentially unchanged and constant all three years (Table 6).

Despite the habitat alterations of both lunkers and weir construction, the four variables of special importance in PIBI calculations were not affected significantly. If the IBI based upon fishery response maintains or improves at Sl, then additional habitat features for PIBI calculations will be suggested for small urban streams in northeastern Illinois.

Table 7. Instream Habitat Characteristics of the .Waukegan River, Annual Means

Characteristics	S1 (Treatment) 1994	S1 (Treatment) 1995	S1 (Treatment) 1996	S2 (Control) 1994	S2 (Control) 1995	S2 (Control) 1996
Hydraulics						
Pool (%)	34.92	29.40	20.77	23.38	8.22	0.14
Riffle (%)	5.58	0.36	4.80	14.35	32.34	46.02
Run (%)	59.50	70.24	74.43	62.27	59.44	53.84
Maximum depth (ft)	0.90	1.50	2.50	1.03	0.53	0.40
Mean depth (ft)	0.27	0.55	0.86	0.20	0.31	0.15
Wetted volume (ft^3)	491	838	2,117	419	310	459
Substrate						
Boulder (%)	8.09	11.47	13.99	1.75	1.25	0.73
Instream cover						
Boulder (%)	4.90	5.48	12.87	1.69	2.04	0.91
Undercut bank (%)	0.19	8.12	2.44	0.06	0.10	0.00
Rock ledge (%)	0.17	7.96	8.11	0.00	0.00	0.00
Total cover (%)	8.90	27.57	28.17	5.62	2.59	1.15

SUMMARY

1. The stream fisheries abundance increased after lunker installation at S1, but IBI values remained similar to S2 and Sl values before lunker installation. The IBI values increased after weir construction formed a series of pool and riffles at S1.

2. The IBI values increased even though the 1996 MBI values for macroinvertebrates indicated significant water pollution effects on the S2 control and to a lesser extent at S1.

3. The PIBI scores did not significantly change for Sl after habitat enhancement efforts. Both Sl and S2 PIBI scores remained very similar all three years. If IBI scores continue to be higher at Sl and PIBI scores remain constant, other habitat variables will be suggested for PIBI calculations on small urban streams in northeastern Illinois.

4. The major habitat modification was the increase of maximum pool depth and the increase of boulder instream cover. The increase in pool depth is seen most clearly in Figure 16 where the light blue indicates the increase of pool depth. Figure 17 reveals the increase of boulder instream cover.

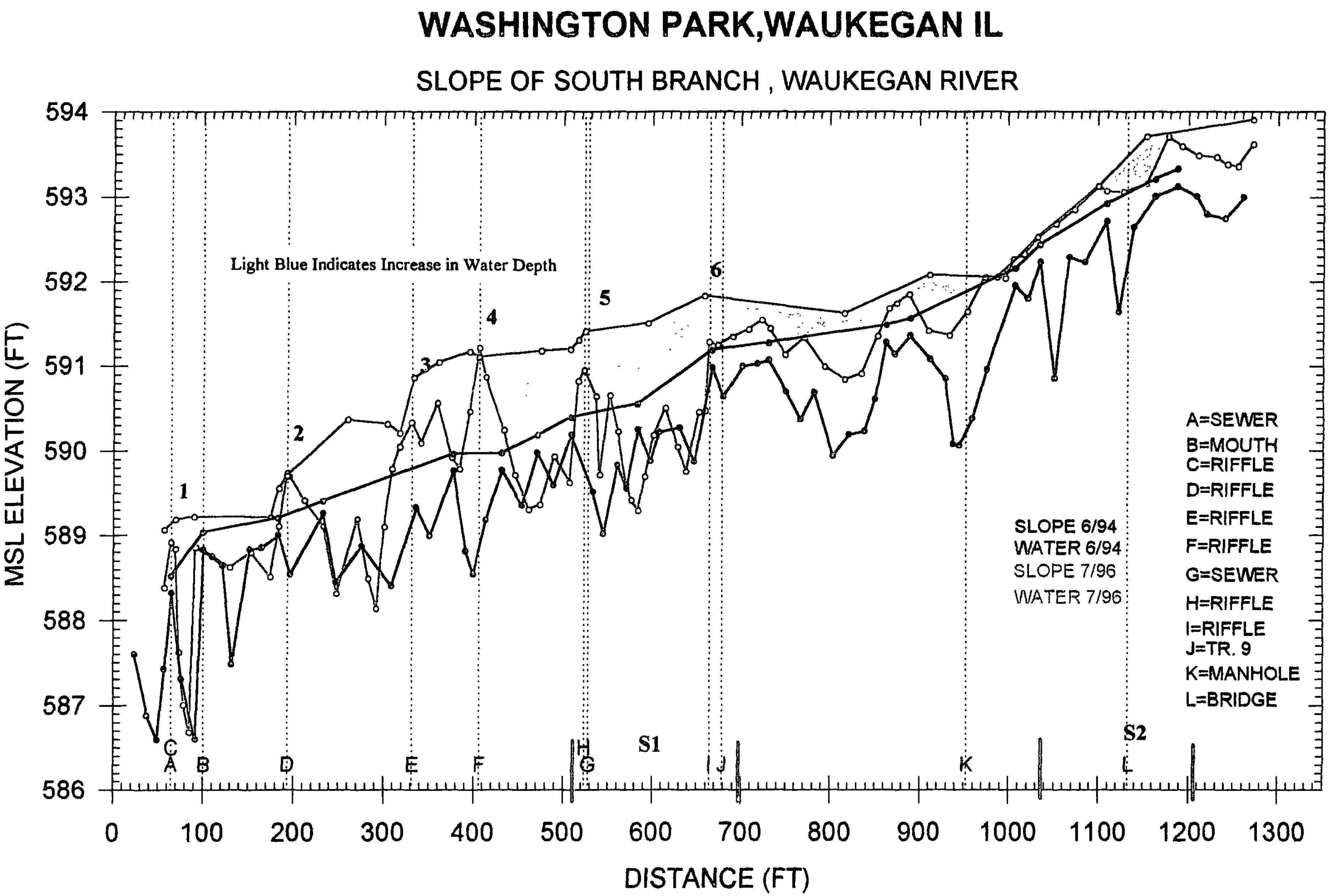


Figure 16. Profile of streambed and low summer flows before and after weir construction.

Figure 17. Large cobbles provide increased habitat for stream fisheries and increased reaeration of stormwater

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APPENDIX A.

MONITORING DATA

Table A1. Waukegan River, Mean Values of the 1994 to 1996 Fish Samples

		IBI	Taxa	Individuais
1994 Samples		24.36	2.3	8
1995 Samples		26.67	3.6	39
1996 Samples		32.83	5.4	66
Spring Samples		28.33	4.0	67
Summer Samples		28.03	3.3	20
Fall Samples		27.50	4.2	26
1994	S1	25.82	3.3	13
	S2	22.18	1.7	6
	N1	27.27	3.0	9
	N2	22.18	1.3	2
1995	S1	25.33	4.6	64
	S2	26.00	1.3	23
	N1	28.00	6.3	49
	N2	27.33	2.0	20
1996	S1	34.67	8.7	75
	S2	28.00	0.7	5
	N1	36.67	7.7	161
	N2	32.00	4.7	23

Table A2. Waukegan River, Mean Values of the 1994 to 1996 Benthic Macroinvertebrate Samples

		MBI	Taxa	Individuais/ m^2
1994 Samples		6.88	8.5	1,556
1995 Samples		6.27	10.1	2,104
1996 Samples		6.97	8.6	2,108
Spring Samples		7.26	6.1	730
Summer Samples		6.58	10.6	3,066
Fall Samples		6.29	10.6	1,972
1994	Sl	6.64	10.3	1,772
	S2	7.26	8.7	685
	Nl	7.10	8.0	1,504
	N2	6.53	7.0	2,262
1995	Sl	6.26	11.0	1,598
	S2	6.31	10.3	1,339
	Nl	6.10	10.7	3,495
	N2	6.43	8.3	1,982
1996	Sl	6.99	9.3	2,019
	S2	8.26	7.7	854
	Nl	6.31	8.3	2,890
	N2	6.33	9.0	2,671

Table A3. Waukegan River, Mean Values of the 1994 to 1996 Habitat Samples

			Discharge (cfs)	Mean width (ft)	Mean depth (ft)
1994 Samples		41.85	0.20	9.86	0.36
1995 Samples		41.69	0.55	11.33	0.45
1996 Samples		41.43	3.49	15.12	0.65
Spring Samples		41.10	3.62	13.88	0.53
Summer Samples		41.64	0.27	11.12	0.42
Fall Samples		42.25	0.36	11.32	0.51
1994	S1	41.51	0.15	8.97	0.27
	S2	41.93	0.13	12.79	0.20
	N1	41.66	0.24	8.94	0.65
	N2	42.29	0.28	8.74	0.30
1995	S1	41.93	0.27	9.12	0.55
	S2	41.79	0.29	15.61	0.31
	N1	41.40	0.84	9.69	0.73
	N2	41.65	0.79	10.91	0.40
1996	S1	41.34	1.60	13.91	0.86
	S2	41.65	1.39	17.64	0.15
	N1	41.23	6.02	14.54	0.90
	N2	41.52	4.95	14.39	0.68

Table A4. Fish Collected Using a Backpack Shocker, Waukegan River, June 5,1996

ID Code	Common name	Stations S1	S2	N1	N2
NA	Alewife			3	
3088	Black bullhead	1		2	
3120	Bluegill			15	6
NA	Coho salmon	2			10
3069	Creek chub	7			1
3065	Fathead minnow	1		2	
3011	Gizzard shad			9	13
3022	Goldfish				1
3116	Green sunfish				1
3068	Longnose dace	35		5	
3156	Mottled sculpin	1		2	
NA	Ninespine stickleback	3		6	
NA	Threespine stickleback	48		383	
3073	White sucker			1	
	Total number	98	0	428	32
	Total species	8	0	10	6
	Station length (ft)	180	160	170	180
	Time: minutes	30	28	32	15
	Species metric	3	1	3	3
	Sucker metric	1	1	1	1
	Sunfish metric	1	1	3	5
	Darter metric	1	1	1	1
	Intolerant metric	3	1	1	1
	Green metric	5	5	5	5
	Hybrid metric	5	5	5	5
	Omnivore metric	5	5	5	3
	Ins. cyprinid metric	3	1	1	1
	Carnivore metric	1	1	1	1
	Condition factor	5	5	5	5
	Abundance factor	1	1	5	1
	IBI	34.00	28.00	36.00	32.00

Table A5. Fish Collected Using a Backpack Shocker, Waukegan River, July 11, 1996

ID Code	Common name	Stations S1	S2	N1	N2
3088	Black bullhead	1		1	
3120	Bluegill	2		10	9
NA	Coho salmon			2	2
3065	Fathead minnow				3
3037	Golden shiner	2			
3022	Goldfish				2
3116	Green sunfish			2	
3068	Longnose dace	7		11	
3156	Mottled sculpin	1		1	
NA	Threespine stickleback	32	15	23	7
3073	White sucker				11
	Total number	45	15	50	34
	Total species	6	1	7	6
	Station length (ft)	180	160	170	160
	Time: minutes	20	20	28	26
	Species metric	3	1	3	3
	Sucker metric	1	1	1	1
	Sunfish metric	3	1	5	3
	Darter metric	1	1	1	1
	Intolerant metric	1	1	3	1
	Green metric	5	5	5	5
	Hybrid metric	5	5	5	5
	Omnivore metric	5	5	5	5
	Ins. cyprinid metric	1	1	3	1
	Carnivore metric	1	1	1	1
	Condition factor	5	5	5	5
	Abundance factor	1	1	1	1
	IBI	32.00	28.00	38.00	32.00

Table A6. Fish Collected Using a Backpack Shocker, Waukegan River, September 11,1996

ID Code	Common name	Stations S1	S2	N1	N2
3088	Black bullhead	1			
3120	Bluegill	7		1	
3109	Brook stickleback	1			
3069	Creek chub	1			1
3065	Fathead minnow	15		1	
3022	Goldfish	1			
3116	Green sunfish	8		1	
3126	Largemouth bass	12		1	
3068	Longnose dace	2		1	
3107	Mosquitofish	2	1		
3156	Mottled sculpin			1	
NA	Threespine stickleback	4			
3073	White sucker	28			1
	Total number	82	1	6	2
	Total species	12	1	6	2
	Station length (ft)	170	160	170	170
	Time: minutes	28	18	19	19
	Species metric	5	1	3	1
	Sucker metric	1	1	1	1
	Sunfish metric	5	1	5	1
	Darter metric	1	1	1	1
	Intolerant metric	1	1	1	1
	Green metric	3	5	3	5
	Hybrid metric	5	5	5	5
	Omnivore metric	5	5	5	5
	Ins. cyprinid metric	1	1	1	5
	Carnivore metric	5	1	5	1
	Condition factor	5	5	5	5
	Abundance factor	1	1	1	1
	IBI	38.00	28.00	36.00	32.00

Table A7. Benthic Macroinvertebrates (individuals/m^2) Collected Using a Hess Sampler, Waukegan River, June 5, 1996

ID Code	Taxon	Tolerance rating	Stations S1	S2	N1	N2
1306	*Hydropsyche*	5.0				4
2495	*Sphaerium*	5.0	8		12	
258	*Caecidotea intermedius*	6.0			31	27
602	*Caenis*	6.0	4			
1963	Chironomidae	6.0	27	12	113	172
197	Erpobdellidae	8.0	4		8	
152	Glossiphoniidae	8.0				4
31	OLIGOCHAETA	10.0	67	82	35	59
	MBI		8.43	9.50	6.73	6.90
	Total taxa		5	2	5	5
	Total individuals/m^2		110	94	199	266
	Percent intolerant (<6)		7.3	0.0	6.0	1.5
	Percent moderate (6-8)		31.8	12.8	76.4	76.3
	Percent tolerant (>8)		60.9	87.2	17.6	22.2

Table A8. Benthic Macroinvertebrates (individuals/m^2) Collected Using a Hess Sampler, Waukegan River, July 11, 1996

ID Code	Taxon	Tolerance rating	Stations S1	S2	N1	N2
341	*Gammarus*	3.0		4	27	8
.831	*Calopteryx*	4.0			4	
2497	*Corbicula*	4.0		8		
1865	*Pedicia*	4.0				16
1306	*Hydropsyche*	5.0				4
2495	*Sphaerium*	5.0	12	12	20	
258	*Caecidotea intermedius*	6.0	8	8	466	250
1963	Chironomidae	6.0	4,442	505	2,681	3,487
840	*Lestes*	6.0	4	133		8
2	TURBELLARIA	6.0	35	67		
1952	*Simulium*	6.0			4	
2151	Ephydridae	8.0				4
197	Erpobdellidae	8.0	16	12	129	20
2331	*Physella*	9.0	67	23		8
31	OLIGOCHAETA	10.0	286	646	243	106
1687	Dytiscidae	-	12			12
	MBI		6.26	7.86	6.31	6.09
	Total taxa		9	10	8	11
	Total individuals/m^2		4,882	1,418	3,574	3,923
	Percent intolerant (<6)		0.2	1.7	1.4	0.7
	Percent moderate (6-8)		92.6	51.1	91.8	96.4
	Percent tolerant (>8)		7.2	47.2	6.8	2.9

Table A9. Benthic Macroinvertebrates (individuals/m^2) Collected Using a Hess Sampler, Waukegan River, September 11, 1996

ID Code	Taxon	Tolerance rating	Stations S1	S2	N1	N2
341	*Gammarus*	3.0	20		235	55
743	*Aeshna*	4.0			4	
831	*Calopteryx*	4.0			12	4
1865	*Pedicia*	4.0	4			12
825	*Tramea*	4.0	31	4		
2144	Dolichopodidae	5.0	4			
1771	Elmidae	5.0	43	4		
1306	*Hydropsyche*	5.0			51	239
2495	*Sphaerium*	5.0	8			
258	*Caecidotea intermedius*	6.0	35	27	4,411	3,213
1302	*Cheumatopsyche*	6.0			4	
1963	Chironomidae	6.0	70	219	74	153
2146	Empididae	6.0				4
2340	*Gyraulus*	6.0		27		
873	*Ischnura*	6.0	677	262		
2	TURBELLARIA	6.0		67		
197	Erpobdellidae	8.0	27	8	74	27
152	Glossiphoniidae	8.0	8	16	4	12
2331	*Physella*	9.0	106	211	8	35
31	OLIGOCHAETA	10.0	27	204	16	70
1687	Dytiscidae	-	4		4	
	MBI		6.27	7.41	5.88	6.01
	Total taxa		14	11	12	11
	Total individuals/m^2		1,064	1,049	4,897	3,824
	Percent intolerant (<6)		10.3	0.8	6.2	8.1
	Percent moderate (6-8)		77.2	59.6	93.3	89.2
	Percent tolerant (>8)		12.5	39.6	0.5	2.7

Table A10. Habitat Characteristics of Waukegan River Samples Collected June 5, 1996

Characteristics	Stations S1	S2	N1	N2
Hydraulics				
Mean width (ft)	16.18	22.18	17.36	19.55
Mean depth (ft)	0.98	0.23	1.11	0.65
Discharge (cfs)	4.43	3.88	16.06	13.24
Pool (%)	20.45	0.00	0.00	2.51
Riffle (%)	3.96	35.16	10.28	35.16
Run (%)	75.59	64.84	89.72	62.33
Shade (%)	36.00	25.00	76.00	27.00
Substrate				
Silt/mud (%)	7.50	1.75	19.55	3.94
Sand (%)	13.13	9.21	35.19	11.82
Fine gravel (%)	23.75	25.57	26.26	15.76
Medium gravel (%)	20.62	27.19	6.15	8.37
Coarse gravel (%)	2.50	26.63	1.12	17.74
Small cobble (%)	2.50	6.58	0.56	10.34
Large cobble (%)	11.88	0.88	0.00	12.32
Boulder (%)	15.00	2.19	11.17	14.78
Bed rock (%)	0.00	0.00	0.00	0.00
Claypan (%)	1.88	0.00	0.00	4.93
Other (%)	1.24	0.00	0.00	0.00
Instream cover				
Boulder (%)	13.82	0.50	1.83	1.34
Undercut bank (%)	0.00	0.00	9.79	0.00
Rock ledge (%)	10.35	0.00	0.38	9.15
Submerged tree roots (%)	0.00	0.00	0.00	0.00
Brush-debris jam (%)	0.00	0.00	0.00	0.05
Logs(%)	0.00	0.00	0.03	0.00
Aquatic Vegetation (%)	0.00	0.00	0.00	0.00
Submerged terrestrical veg (%)	0.00	0.00	0.00	0.00
Other (%)	0.00	0.00	0.34	0.00
Total instream cover (%)	24.17	0.50	12.37	10.54
PIBI	41.27	41.91	39.23	40.89
Total reach surface area (avg. W x avg. L)	2,880	3,549	2,898	3,584
Total wetted usable area (avg. W x avg. L x avg. D)	2,822	816	3,217	2,329

Table A11. Habitat Characteristics of Waukegan River Samples Collected July 11, 1996

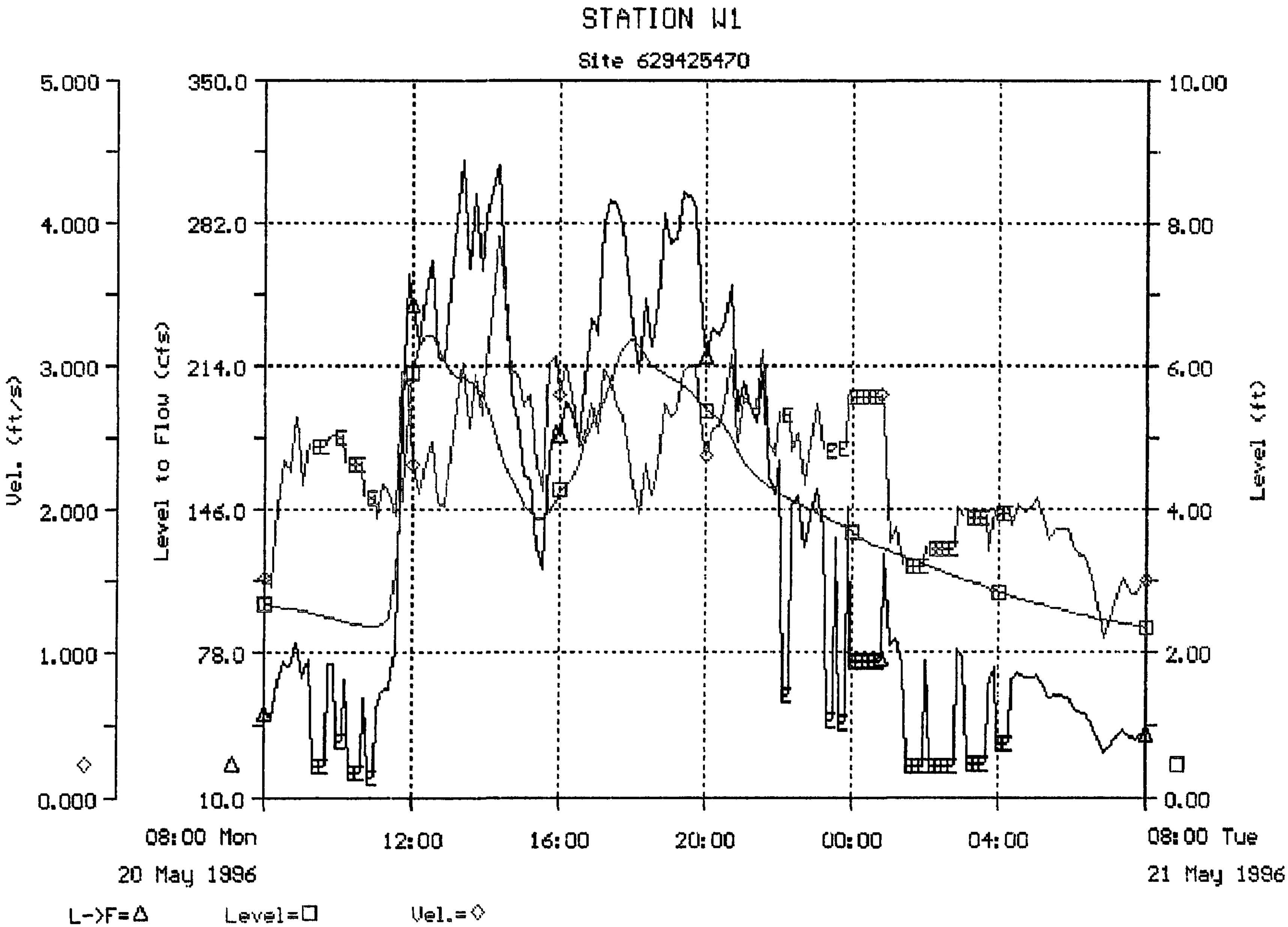
Characteristics	Stations S1	S2	N1	N2
Hydraulics				
Mean width (ft)	11.18	15.55	12.18	10.91
Mean depth (ft)	0.82	0.12	0.73	0.47
Discharge (cfs)	0.20	0.20	0.62	0.66
Pool (%)	11.26	0.00	60.13	20.32
Riffle (%)	6.20	68.07	8.88	9.58
Run (%)	82.54	31.93	30.99	70.10
Shade (%)	41.62	51.35	65.89	70.35
Substrate				
Silt/mud (%)	0.87	0.00	8.13	0.91
Sand (%)	18.26	5.61	39.04	8.18
Fine gravel (%)	14.78	20.63	24.39	16.36
Medium gravel (%)	14.78	44.38	3.25	9.09
Coarse gravel (%)	9.57	26.25	3.25	11.82
Small cobble (%)	1.74	2.50	0.00	22.73
Large cobble (%)	7.82	0.63	3.25	10.92
Boulder (%)	26.96	0.00	12.19	15.45
Bed rock (%)	0.00	0.00	0.00	0.00
Claypan (%)	5.22	0.00	0.81	4.54
Other (%)	0.00	0.00	5.69	0.00
Instream cover				
Boulder (%)	9.73	1.00	4.23	10.07
Undercut bank (%)	3.26	0.00	6.70	0.00
Rock ledge (%)	0.00	0.00	3.44	6.67
Submerged tree roots (%)	0.00	0.00	0.23	0.12
Brush-debris jam (%)	0.31	0.00	0.00	0.30
Logs (%)	0.00	0.00	0.00	0.00
Aquatic Vegetation (%)	9.63	0.00	0.00	14.43
Submerged terrestrical veg (%)	0.00	0.00	0.00	40.69
Other (%)	0.00	0.72	1.86	1.21
Total instream cover (%)	22.93	1.72	16.46	74.12
PIBI	40.85	41.52	42.64	41.29
Total reach surface area (avg. W x avg. L)	1,963	2,512	2,150	1,650
Total wetted usable area (avg. W x avg. L x avg. D)	1,610	301	1,570	775

Table A12. Habitat Characteristics of Waukegan River Samples Collected September 11, 1996

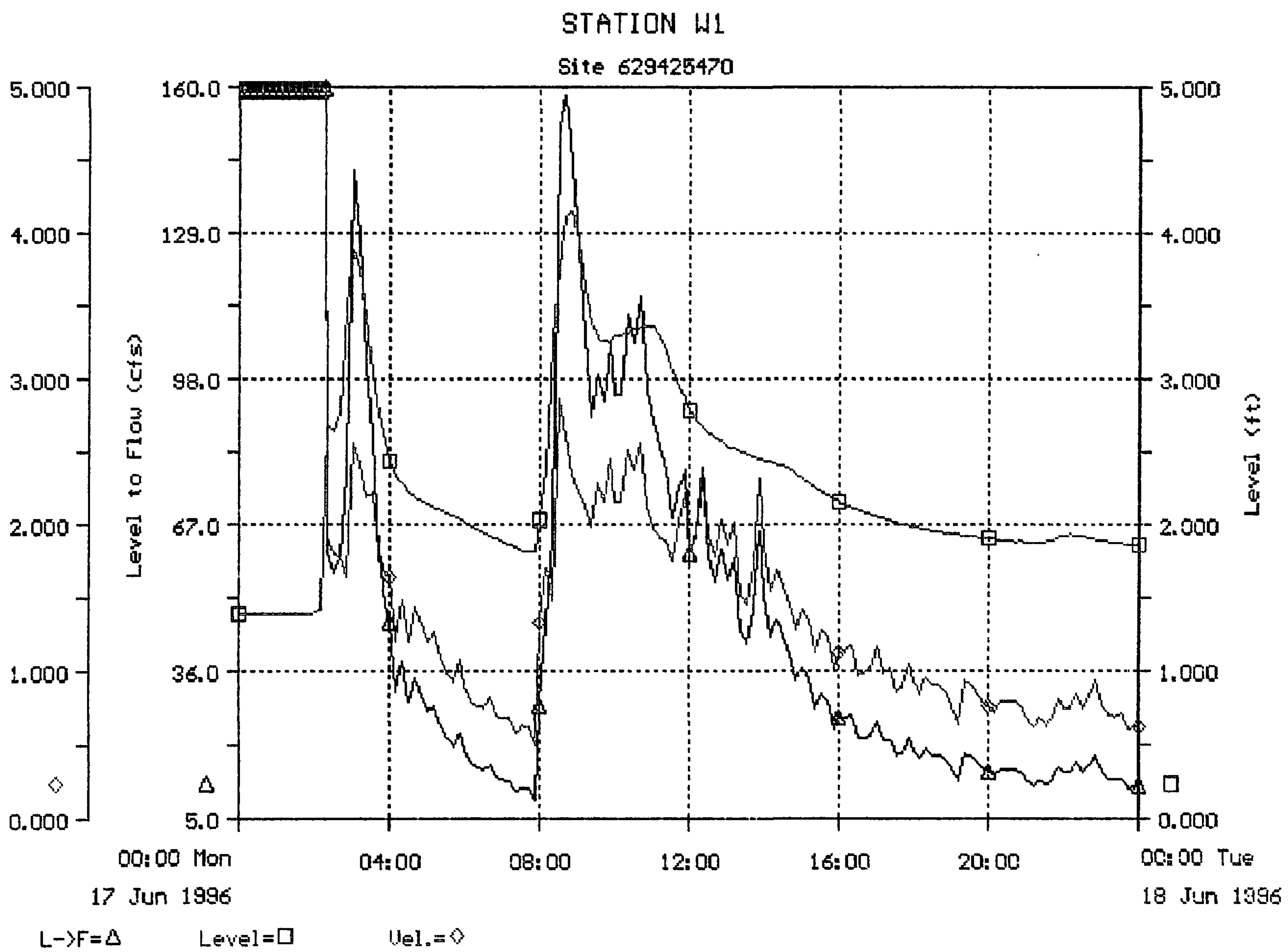
Characteristics	Stations S1	S2	N1	N2
Hydraulics				
Mean width (ft)	14.36	15.18	14.09	12.72
Mean depth (ft)	0.79	0.11	0.86	0.93
Discharge (cfs)	0.16	0.09	1.37	0.95
Pool (%)	30.60	0.42	25.27	26.07
Riffle (%)	4.25	34.84	5.80	9.64
Run (%)	65.15	64.74	68.93	64.29
Shade (%)	28.5	71.50	62.10	47.00
Substrate				
Silt/mud (%)	6.57	0.00	5.04	0.00
Sand (%)	26.28	24.34	34.53	8.67
Fine gravel (%)	28.47	52.63	29.50	14.17
Medium gravel (%)	7.30	19.74	11.51	17.32
Coarse gravel (%)	8.76	1.34	4.32	29.14
Small cobble (%)	5.84	1.95	5.04	16.54
Large cobble (%)	16.79	0.00	4.32	6.30
Boulder (%)	0.00	0.00	0.00	0.79
Bed rock (%)	0.00	0.00	5.04	7.09
Claypan (%)	0.00	0.00	0.00	0.00
Other (%)	0.00	0.00	0.70	0.00
Instream cover				
Boulder (%)	15.06	1.23	4.76	7.83
Undercut bank (%)	4.07	0.00	5.84	0.46
Rock ledge (%)	13.99	0.00	0.41	9.41
Submerged tree roots (%)	0.00	0.00	2.57	0.23
Brush-debris jam (%)	1.97	0.00	0.83	0.23
Logs(%)	0.21	0.00	0.21	0.00
Aquatic Vegetation (%)	0.00	0.00	0.00	0.00
Submerged terrestrical veg (%)	2.10	0.00	0.00	0.55
Other (%)	0.00	0.00	0.00	0.83
Total instream cover (%)	37.40	1.23	14.62	19.54
PIBI	41.89	41.51	41.83	42.37
Total reach surface area (avg. W x avg. L)	2,431	2,376	2,414	2,167
Total wetted usable area (avg. W x avg. L x avg. D)	1,920	261	2,076	2,016

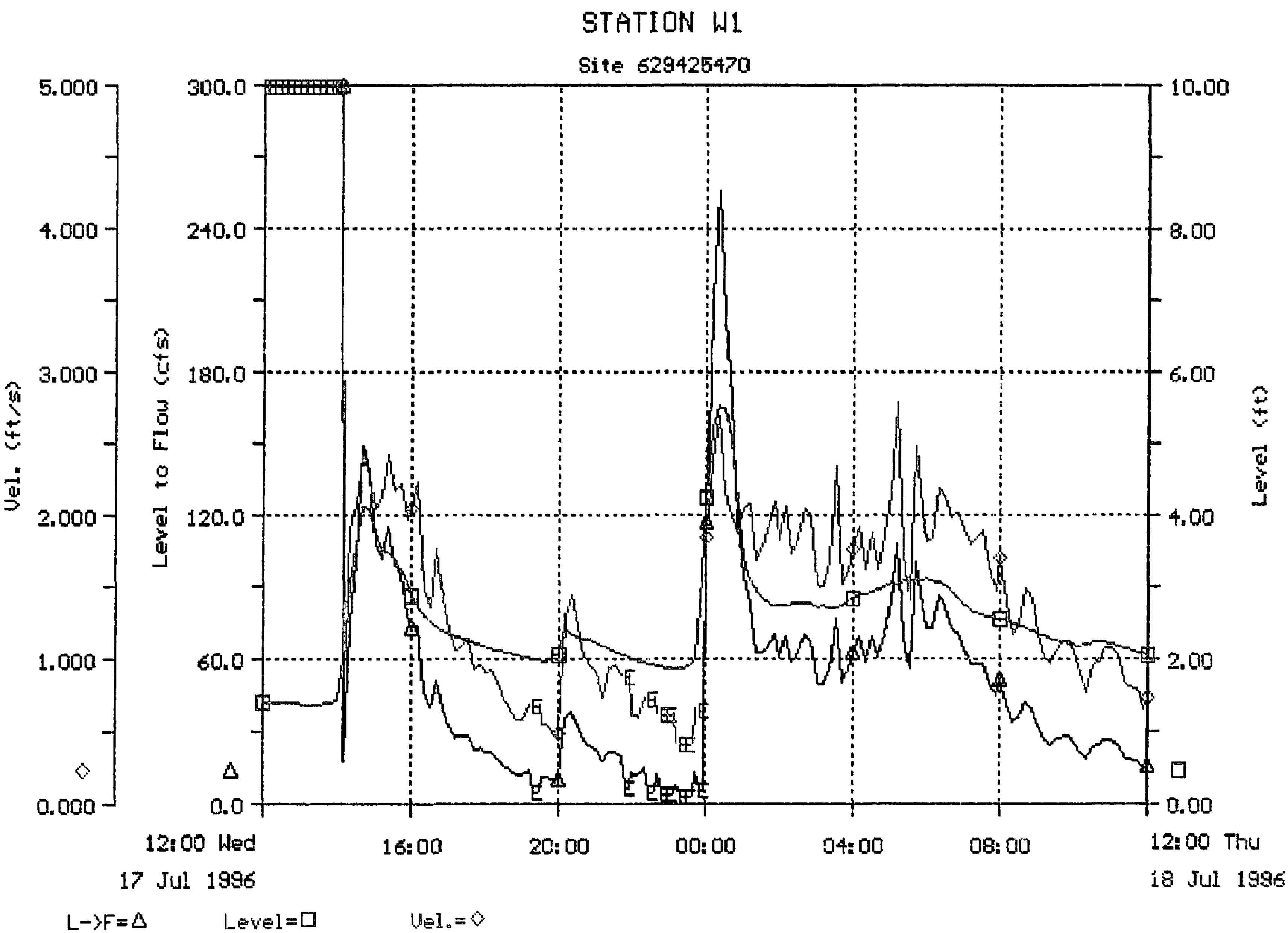
APPENDIX B.

FLOW DATA



STATION W1
Site 629425470
5.000
4.000
3.000
2.000
1.000
0.000
Vel. (ft/s)
350.0
282.0
214.0
146.0
78.0
10.0
Level to Flow (cfs)
10.00
8.00
6.00
4.00
2.00
0.00
Level (ft)
08:00 Mon
20 May 1996
12:00
16:00
20:00
00:00
04:00
08:00 Tue
21 May 1996
L->F=Δ
Level=□
Vel.=◇

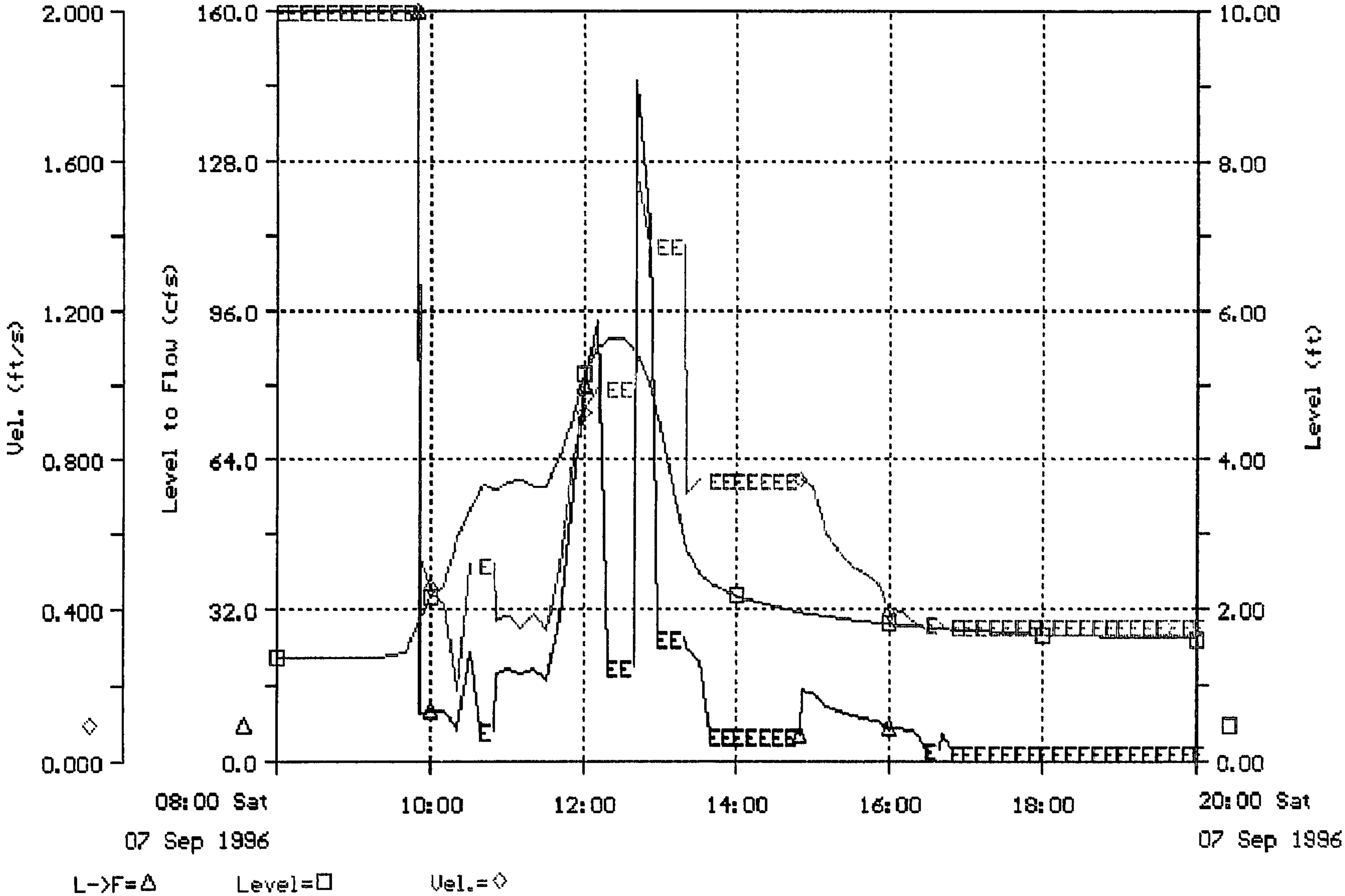

STATION W1
Site 629425470
Vel. (ft/s)
5.000
4.000
3.000
2.000
1.000
0.000
Level to Flow (cfs)
160.0
129.0
98.0
67.0
36.0
5.0
Level (ft)
5.000
4.000
3.000
2.000
1.000
0.000
00:00 Mon
17 Jun 1996
04:00
08:00
12:00
16:00
20:00
00:00 Tue
18 Jun 1996
L->F=Δ
Level=□
Vel.=◇

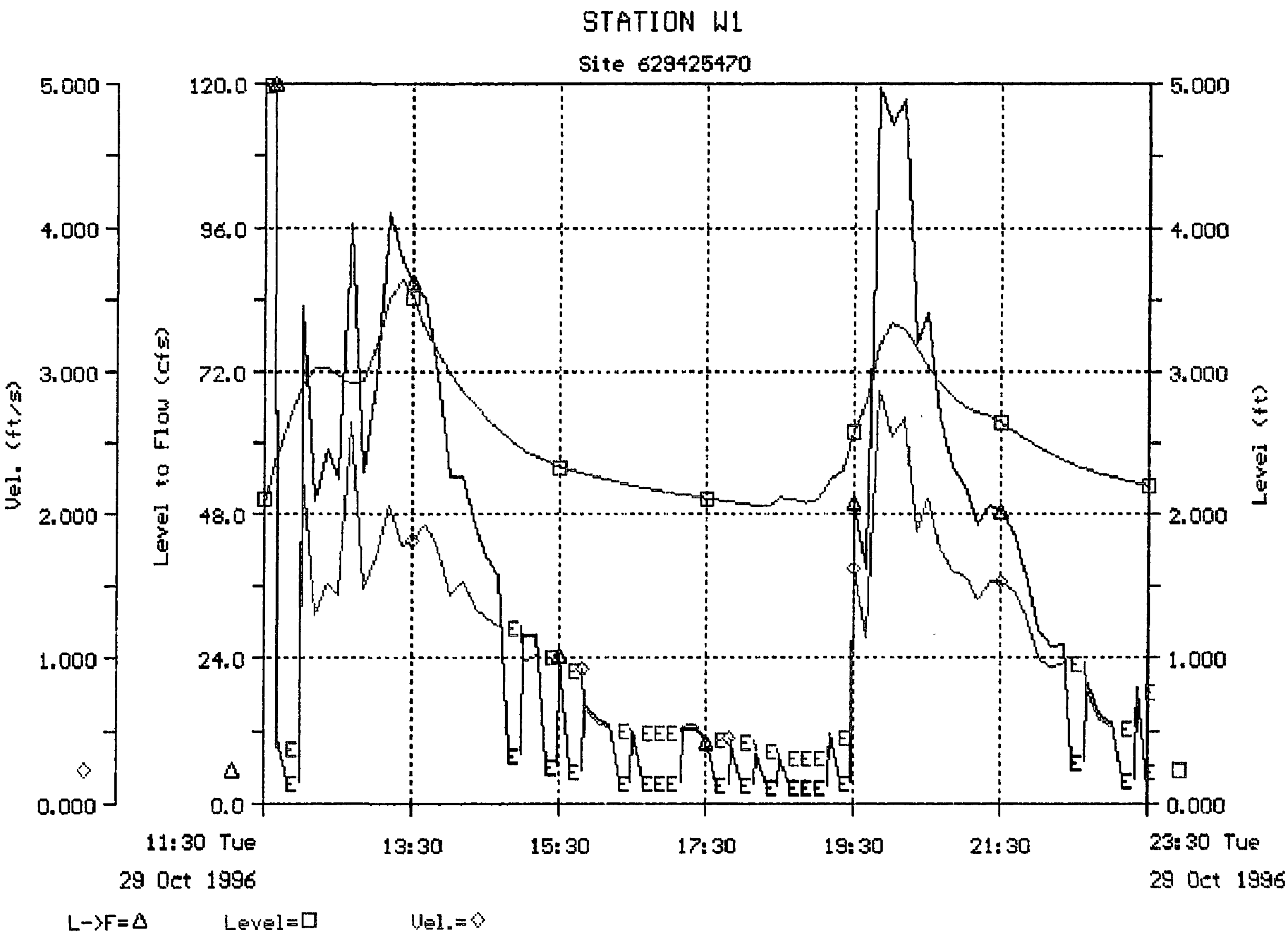


STATION W1
Site 629425470
Vel. (ft/s)
Level to Flow (cfs)
Level (ft)
5.000
4.000
3.000
2.000
1.000
0.000
300.0
240.0
180.0
120.0
60.0
0.0
10.00
8.00
6.00
4.00
2.00
0.00
12:00 Wed
17 Jul 1996
16:00
20:00
00:00
04:00
08:00
12:00 Thu
18 Jul 1996
L->F=Δ
Level=□
Vel.=◇

STATION W1

Site 629425470




STATION W1
Site 629425470
Vel. (ft/s)
Level to Flow (cfs)
Level (ft)
5.000
4.000
3.000
2.000
1.000
0.000
120.0
96.0
72.0
48.0
24.0
0.0
11:30 Tue
29 Oct 1996
13:30
15:30
17:30
19:30
21:30
23:30 Tue
29 Oct 1996
L->F=△
Level=□
Vel.=◇

MONTHLY SUMMARY   Site #629425470   STATION W1

Wed 0l May 1996 00:00 - Fri 31 May 1996 00:00

Part A Level

Date	Minimum Level (ft)	Maximum Level (ft)	Average Level (ft)
Wed Ol May 1996			
Thu 02 May 1996			
Fri 03 May 1996			
Sat 04 May 1996			
Sun 05 May 1996			
Mon 06 May 1996			
Tue 07 May 1996	1.48 @ 00:00	1.53 @ 15:20	1.50
Wed 08 May 1996	1.46 @ 10:50	1.78 @ 13:20	1.53
Thu 09 May 1996	1.46 @ 03:10	2.71 @ 07:30	1.83
Fri 10 May 1996	1.89 @ 00:00	4.28 @ 04:40	2.40
Sat 11 May 1996	1.69 @ 23:40	1.89 @ 00:10	1.77
Sun 12 May 1996	1.60 @ 23:10	1.69 @ 00:20	1.64
Mon 13 May 1996	1.55 @ 20:50	1.60 @ 00:50	1.58
Tue 14 May 1996	1.50 @ 17:20	1.83 @ 19:50	1.56
Wed 15 May 1996	1.57 @ 01:40	3.87 @ 05:10	2.03
Thu 16 May 1996	1.64 @ 23:50	1.74 @ 00:10	1.69
Fri 17 May 1996	1.60 @ 23:00	2.12 @ 03:50	1.71
Sat 18 May 1996	1.47 @ 23:30	1.61 @ 13:50	1.54
Sun 19 May 1996	1.40 @ 23:40	1.48 @ 00:50	1.44
Mon 20 May 1996	1.41 @ 00:10	6.45 @ 12:20	4.17
Tue 21 May 1996	1.80 @ 23:40	3.64 @ 00:10	2.28
Wed 22 May 1996	1.63 @ 20:30	1.79 @ 00:10	1.70
Thu 23 May 1996	1.63 @ 04:50	2.90 @ 10:30	1.98
Fri 24 May 1996	1.74 @ 10:50	2.58 @ 12:50	1.87
Sat 25 May 1996	1.67 @ 23:10	1.80 @ 15:00	1.72
Sun 26 May 1996	1.62 @ 16:20	1.78 @ 21:00	1.66
Mon 27 May 1996	1.62 @ 07:10	2.60 @ 09:50	1.78
Tue 28 May 1996	1.63 @ 10:50	3.36 @ 16:30	2.02
Wed 29 May 1996	1.74 @ 23:30	2.19 @ 00:10	1.87
Thu 30 May 1996	1.63 @ 23:30	1.74 @ 00:20	1.69
Fri 31 May 1996	1.55 @ 20:00	1.64 @ 00:40	1.60
Monthly results	1.40 @ 23:40 Sun 19 May	6.45 @ 12:20 Mon 20 May	1.87

MONTHLY SUMMARY   Site #629425470   STATION W1

Wed 0l May 1996 00:00 - Fri 31 May 1996 00:00

Part B Velocity

Date	Minimum Velocity (ft/s)	Maximum Velocity (ft/s)	Average Velocity (ft/s)
Wed 01 May 1996			
Thu 02 May 1996			
Fri 03 May 1996			
Sat 04 May 1996			
Sun 05 May 1996			
Mon 06 May 1996			
Tue 07 May 1996	0.16 @ 21:50	0.22 @ 17:30	0.19
Wed 08 May 1996	0.13 @ 22:00	0.34 @ 13:00	0.24
Thu 09 May 1996	0.23 @ 15:50	1.36 @ 22:20	0.53
Fri 10 May 1996	-0.10 @ 09:00	2.83 @ 04:50	1.04
Sat 11 May 1996	0.29 @ 23:40	0.53 @ 04:30	0.41
Sun 12 May 1996	0.26 @ 09:30	0.32 @ 12:50	0.29
Mon 13 May 1996	0.25 @ 16:30	0.28 @ 15:10	0.27
Tue 14 May 1996			
Wed 15 May 1996	-0.62 @ 05:20	1.76 @ 07:20	0.68
Thu 16 May 1996	0.27 @ 20:50	0.43 @ 06:50	0.35
Fri 17 May 1996	0.26 @ 23:30	0.88 @ 03:50	0.39
Sat 18 May 1996	0.19 @ 09:30	0.38 @ 14:00	0.27
Sun 19 May 1996	0.13 @ 17:30	0.23 @ 13:30	0.17
Mon 20 May 1996	0.20 @ 00:40	3.91 @ 14:20	2.46
Tue 21 May 1996	0.56 @ 22:40	2.66 @ 00:50	1.11
Wed 22 May 1996	0.32 @ 21:00	0.71 @ 03:10	0.51
Thu 23 May 1996	0.31 @ 01:00	2.67 @ 10:30	1.07
Fri 24 May 1996	0.44 @ 10:00	2.26 @ 12:50	0.71
Sat 25 May 1996	0.33 @ 20:50	0.60 @ 14:40	0.47
Sun 26 May 1996	0.28 @ 09:40	0.61 @ 20:40	0.43
Mon 27 May 1996	0.30 @ 22:50	2.04 @ 10:10	0.69
Tue 28 May 1996	0.23 @ 12:50	3.16 @ 16:50	1.32
Wed 29 May 1996	0.35 @ 20:20	1.18 @ 01:20	0.64
Thu 30 May 1996	0.26 @ 16:20	0.54 @ 04:00	0.37
Fri 31 May 1996	0.20 @ 13:50	0.40 @ 06:20	0.25
Monthly results	-0.62 @ 05:20 Wed 15 May	3.91 @ 14:20 Mon 20 May	0.82

MONTHLY SUMMARY   Site #629425470   STATION W1

Wed 0l May 1996 00:00 - Fri 31 May 1996 00:00

Level to Flow Part A

Date	Minimum Flow Rate (cfs)	Maximum Flow Rate (cfs)	Average Flow Rate (cfs)	Total Flow (cf)
Wed 01 May 1996				
Thu 02 May 1996				
Fri 03 May 1996				
Sat 04 May 1996				
Sun 05 May 1996				
Mon 06 May 1996				
Tue 07 May 1996	2.11 @ 21:50	2.96 @ 17:30	2.54	9135.59
Wed 08 May 1996	1.71 @ 22:00	5.90 @ 13:00	3.71	53445
Thu 09 May 1996	3.74 @ 15:50	44.11 @ 22:20	12.52	600925
Fri 10 May 1996	-2.87 @ 09:00	180.95 @ 04:50	47.12	1413496
Sat 11 May 1996	4.63 @ 23:40	9.72 @ 04:30	7.31	52623
Sun 12 May 1996	3.99 @ 09:30	4.96 @ 12:50	4.44	29299
Mon 13 May 1996	3.55 @ 16:30	3.97 @ 15:10	3.77	6793.36
Tue 14 May 1996				
Wed 15 May 1996	-31.39 @ 05:20	54.81 @ 07:20	20.96	213833
Thu 16 May 1996	4.23 @ 20:50	6.98 @ 06:50	5.65	23730
Fri 17 May 1996	3.83 @ 23:30	20.03 @ 03:50	6.51	250118
Sat 18 May 1996	2.54 @ 18:40	5.67 @ 14:00	3.85	187122
Sun 19 May 1996	1.55 @ 17:30	2.85 @ 13:30	2.10	42920
Mon 20 May 1996	3.82 @ 00:40	311.99 @ 13:20	170.16	1.32e+07
Tue 21 May 1996	9.97 @ 22:40	125.38 @ 00:50	29.02	2229081
Wed 22 May 1996	4.94 @ 21:00	12.20 @ 03:10	8.45	623814
Thu 23 May 1996	4.72 @ 01:00	96.65 @ 10:30	27.57	1819543
Fri 24 May 1996	7.34 @ 10:00	68.95 @ 12:50	14.36	1232283
Sat 25 May 1996	5.30 @ 20:50	10.56 @ 14:40	7.91	536442
Sun 26 May 1996	4.26 @ 09:40	10.61 @ 20:40	6.97	192442
Mon 27 May 1996	4.79 @ 22:50	60.85 @ 10:10	14.88	723037
Tue 28 May 1996	3.59 @ 12:50	130.47 @ 16:50	40.62	2120595
Wed 29 May 1996	5.92 @ 20:20	26.81 @ 01:20	12.54	1060883
Thu 30 May 1996	3.96 @ 16:20	8.92 @ 04:00	5.97	182562
Fri 31 May 1996	2.82 @ 15:00	6.04 @ 06:20	3.67	30802
Monthly results	-31.39 @ 05:20 Wed 15 May	311.99 @ 13:20 Mon 20 May	28.73	2.68e+07

MONTHLY SUMMARY Site #629425470 STATION W1

Sat 0l Jun 1996 00:00 - Sun 30 Jun 1996 00:00

Part A Level

Date	Minimum Level (ft)	Maximum Level (ft)	Average Level (ft)
Sat Ol Jun 1996	1.52 @ 12:50	3.89 @ 21:40	1.84
Sun 02 Jun 1996	1.70 @ 19:40	3.14 @ 23:40	1.97
Mon 03 Jun 1996	1.70 @ 00:00	2.82 @ 00:10	1.88
Tue 04 Jun 1996	1.68 @ 05:40	2.48 @ 11:10	2.00
Wed 05 Jun 1996	1.67 @ 00:00	1.87 @ 00:10	1.75
Thu 06 Jun 1996	1.61 @ 17:30	3.98 @ 23:50	1.93
Fri 07 Jun 1996	1.82 @ 00:00	3.66 @ 00:10	2.14
Sat 08 Jun 1996	1.70 @ 23:50	1.82 @ 00:30	1.76
Sun 09 Jun 1996	1.67 @ 19:30	4.07 @ 23:50	1.77
Mon 10 Jun 1996	1.77 @ 23:20	3.80 @ 00:10	2.10
Tue 11 Jun 1996	1.65 @ 23:30	1.77 @ 00:10	1.71
Wed 12 Jun 1996	1.57 @ 18:10	1.66 @ 00:10	1.62
Thu 13 Jun 1996	1.51 @ 00:00	1.58 @ 06:30	1.55
Fri 14 Jun 1996	1.44 @ 21:40	1.52 @ 00:10	1.48
Sat 15 Jun 1996	1.38 @ 20:10	1.45 @ 07:50	1.43
Sun 16 Jun 1996	1.38 @ 21:00	1.41 @ 08:50	1.40
Mon 17 Jun 1996	1.39 @ 00:10	4.15 @ 08:50	2.31
Tue 18 Jun 1996	1.75 @ 08:00	2.98 @ 09:20	1.95
Wed 19 Jun 1996	1.63 @ 23:40	1.83 @ 00:10	1.70
Thu 20 Jun 1996	1.54 @ 22:20	1.63 @ 00:30	1.59
Fri 21 Jun 1996	1.53 @ 12:00	2.98 @ 14:00	1.68
Sat 22 Jun 1996	1.47 @ 22:30	1.60 @ 00:20	1.54
Sun 23 Jun 1996	1.42 @ 18:20	3.17 @ 23:30	1.51
Mon 24 Jun 1996	1.49 @ 23:10	2.74 @ 00:10	1.67
Tue 25 Jun 1996	1.42 @ 15:40	1.50 @ 00:10	1.48
Wed 26 Jun 1996	1.45 @ 17:20	1.48 @ 10:40	1.47
Thu 27 Jun 1996	1.35 @ 14:00	1.47 @ 07:30	1.43
Fri 28 Jun 1996	1.35 @ 13:40	1.50 @ 15:40	1.41
Sat 29 Jun 1996	1.33 @ 16:20	1.56 @ 20:40	1.42
Sun 30 Jun 1996	1.40 @ 05:10	1.72 @ 18:40	1.47
Monthly results	1.33 @ 16:20 Sat 29 Jun	4.15 @ 08:50 Mon 17 Jun	1.70

MONTHLY SUMMARY   Site #629425470   STATION W1

Sat 01 Jun 1996 00:00 - Sun 30 Jun 1996 00:00

Part B Velocity

Date	Minimum Velocity (ft/s)	Maximum Velocity (ft/s)	Average Velocity (ft/s)
Sat 01 Jun 1996	0.18 @ 07:10	3.42 @ 22:10	1.66
Sun 02 Jun 1996	0.37 @ 15:40	3.21 @ 23:40	0.89
Mon 03 Jun 1996	0.29 @ 23:10	2.10 @ 01:00	0.68
Tue 04 Jun 1996	0.29 @ 01:20	2.16 @ 09:40	1.07
Wed 05 Jun 1996	0.27 @ 16:50	0.74 @ 02:00	0.49
Thu 06 Jun 1996	0.29 @ 08:20	2.65 @ 23:40	0.88
Fri 07 Jun 1996	0.51 @ 23:30	3.15 @ 00:40	1.17
Sat 08 Jun 1996	0.33 @ 21:00	0.63 @ 04:00	0.49
Sun 09 Jun 1996	0.27 @ 04:30	2.56 @ 23:30	0.54
Mon 10 Jun 1996	0.38 @ 00:00	2.80 @ 01:20	1.00
Tue 11 Jun 1996	0.25 @ 21:10	0.51 @ 00:20	0.39
Wed 12 Jun 1996	0.23 @ 21:30	0.37 @ 13:40	0.28
Thu 13 Jun 1996	0.14 @ 21:00	0.28 @ 07:30	0.21
Fri 14 Jun 1996	0.12 @ 19:30	0.19 @ 06:50	0.15
Sat 15 Jun 1996	0.10 @ 12:00	0.15 @ 03:30	0.13
Sun 16 Jun 1996			
Mon 17 Jun 1996	0.50 @ 07:50	2.87 @ 08:30	1.34
Tue 18 Jun 1996	0.43 @ 22:20	2.55 @ 09:20	0.84
Wed 19 Jun 1996	0.26 @ 23:10	0.67 @ 01:50	0.43
Thu 20 Jun 1996	0.20 @ 20:00	0.39 @ 09:20	0.26
Fri 21 Jun 1996	0.20 @ 11:00	2.24 @ 14:20	0.58
Sat 22 Jun 1996	0.15 @ 23:00	0.35 @ 02:00	0.23
Sun 23 Jun 1996	0.12 @ 18:40	2.62 @ 23:20	0.61
Mon 24 Jun 1996	0.14 @ 00:00	2.22 @ 00:20	0.69
Tue 25 Jun 1996	0.09 @ 18:20	0.17 @ 11:00	0.14
Wed 26 Jun 1996	0.08 @ 13:20	0.13 @ 10:10	0.11
Thu 27 Jun 1996	0.07 @ 11:10	0.11 @ 08:50	0.09
Fri 28 Jun 1996	0.07 @ 12:20	0.12 @ 15:30	0.08
Sat 29 Jun 1996	-0.11 @ 17:50	0.15 @ 20:20	0.08
Sun 30 Jun 1996	0.06 @ 10:00	0.23 @ 18:40	0.11
Monthly results	-0.11 @ 17:50 Sat 29 Jun	3.42 @ 22:10 Sat 01 Jun	0.67

MONTHLY SUMMARY   Site #629425470   STATION W1

Sat 0l Jun 1996 00:00 - Sun 30 Jun 1996 00:00

Level to Flow Part A

Date	Minimum Flow Rate (cfs)	Maximum Flow Rate (cfs)	Average Flow Rate (cfs)	Total Flow (cf)
Sat 01 Jun 1996	2.54 @ 07:10	168.86 @ 21:30	61.69	1591663
Sun 02 Jun 1996	6.17 @ 21:20	130.42 @ 23:40	21.31	1815605
Mon 03 Jun 1996	4.70 @ 23:10	65.64 @ 00:10	14.31	1167800
Tue 04 Jun 1996	4.67 @ 01:20	60.55 @ 09:40	25.31	1731053
Wed 05 Jun 1996	4.45 @ 16:50	13.72 @ 02:00	8.48	595052
Thu 06 Jun 1996	4.75 @ 08:20	148.24 @ 23:50	27.31	1409032
Fri 07 Jun 1996	9.26 @ 23:30	137.91 @ 00:30	31.66	2716536
Sat 08 Jun 1996	5.35 @ 21:00	11.27 @ 04:00	8.37	668121
Sun 09 Jun 1996	4.35 @ 04:30	145.72 @ 23:50	13.46	613940
Mon 10 Jun 1996	6.56 @ 00:00	134.92 @ 00:10	26.78	2281963
Tue 11 Jun 1996	3.93 @ 21:10	8.76 @ 00:20	6.50	382060
Wed 12 Jun 1996	3.36 @ 21:30	5.42 @ 13:40	4.23	106698
Thu 13 Jun 1996	1.83 @ 21:00	4.09 @ 07:30	2.95	141546
Fri 14 Jun 1996	1.50 @ 19:30	2.58 @ 06:50	1.94	60628
Sat 15 Jun 1996	1.23 @ 12:00	1.86 @ 11:00	1.54	30441
Sun 16 Jun 1996				
Mon 17 Jun 1996	9.05 @ 07:50	158.36 @ 08:40	43.11	3388539
Tue 18 Jun 1996	7.46 @ 22:20	96.06 @ 09:20	18.81	1613830
Wed 19 Jun 1996	4.02 @ 23:10	11.91 @ 01:50	7.09	476116
Thu 20 Jun 1996	2.84 @ 23:50	5.78 @ 09:20	3.84	112774
Fri 21 Jun 1996	2.74 @ 11:00	70.71 @ 14:20	12.63	507856
Sat 22 Jun 1996	1.99 @ 23:00	5.09 @ 02:00	3.20	111464
Sun 23 Jun 1996	1.47 @ 18:40	98.36 @ 23:30	20.14	265810
Mon 24 Jun 1996	1.82 @ 00:00	71.97 @ 00:10	15.18	510176
Tue 25 Jun 1996	1.21 @ 18:20	2.13 @ 11:00	1.77	27690
Wed 26 Jun 1996	1.05 @ 13:20	1.65 @ 10:10	1.34	13661
Thu 27 Jun 1996	0.89 @ 13:40	1.36 @ 08:50	1.07	18021
Fri 28 Jun 1996	0.83 @ 14:10	1.56 @ 15:30	1.02	32521
Sat 29 Jun 1996	-1.33 @ 17:50	2.15 @ 20:20	1.01	19434
Sun 30 Jun 1996	0.78 @ 10:00	3.79 @ 18:40	1.68	28203
Monthly results	-1.33 @ 17:50 Sat 29 Jun	168.86 @ 21:30 Sat 01 Jun	16.55	2.24e+07

MONTHLY SUMMARY Site #629425470 STATION W1

Mon 01 Jul 1996 00:00 - Wed 31 Jul 1996 00:00

Part A Level

Date	Minimum Level (ft)	Maximum Level (ft)	Average Level (ft)
Mon 01 Jul 1996	1.42 @ 20:10	1.50 @ 00:00	1.45
Tue 02 Jul 1996	1.47 @ 18:20	1.53 @ 12:40	1.49
Wed 03 Jul 1996	1.48 @ 21:10	1.53 @ 11:50	1.50
Thu 04 Jul 1996	1.50 @ 23:40	1.53 @ 11:00	1.52
Fri 05 Jul 1996	1.46 @ 19:30	1.52 @ 07:50	1.50
Sat 06 Jul 1996	1.44 @ 20:10	1.50 @ 00:40	1.47
Sun 07 Jul 1996	1.43 @ 20:40	1.50 @ 00:00	1.46
Mon 08 Jul 1996	1.49 @ 21:20	1.54 @ 01:50	1.51
Tue 09 Jul 1996	1.48 @ 02:10	1.55 @ 20:20	1.51
Wed 10 Jul 1996	1.40 @ 17:50	1.55 @ 00:50	1.49
Thu 11 Jul 1996	1.42 @ 17:20	1.48 @ 12:20	1.45
Fri 12 Jul 1996	1.42 @ 09:50	1.55 @ 15:30	1.47
Sat 13 Jul 1996	1.38 @ 20:30	1.49 @ 05:00	1.45
Sun 14 Jul 1996	1.42 @ 17:00	3.72 @ 19:00	1.65
Mon 15 Jul 1996	1.47 @ 14:00	3.22 @ 16:30	1.68
Tue 16 Jul 1996	1.36 @ 21:10	1.58 @ 00:10	1.46
Wed 17 Jul 1996	1.37 @ 00:20	4.25 @ 00:00	1.83
Thu 18 Jul 1996	1.70 @ 00:00	5.54 @ 00:20	2.35
Fri 19 Jul 1996	1.57 @ 00:00	1.71 @ 02:10	1.63
Sat 20 Jul 1996	1.50 @ 18:30	1.57 @ 00:20	1.54
Sun 21 Jul 1996	1.47 @ 20:20	1.50 @ 00:10	1.49
Mon 22 Jul 1996	1.42 @ 18:20	1.56 @ 09:00	1.47
Tue 23 Jul 1996	1.40 @ 20:50	1.51 @ 06:00	1.45
Wed 24 Jul 1996	1.42 @ 01:10	1.70 @ 17:20	1.46
Thu 25 Jul 1996	1.42 @ 23:30	1.50 @ 14:20	1.45
Fri 26 Jul 1996	1.38 @ 17:50	1.42 @ 00:20	1.40
Sat 27 Jul 1996	1.39 @ 16:40	2.02 @ 19:00	1.50
Sun 28 Jul 1996	1.48 @ 07:00	1.81 @ 13:40	1.62
Mon 29 Jul 1996	1.41 @ 20:10	1.54 @ 00:10	1.46
Tue 30 Jul 1996	1.40 @ 19:40	1.44 @ 02:40	1.42
Wed 31 Jul 1996	1.39 @ 02:20	1.62 @ 16:20	1.44
Monthly results	1.36 @ 21:10 Tue 16 Jul	5.54 @ 00:20 Thu 18 Jul	1.54

MONTHLY SUMMARY   Site #629425470   STATION W1

Mon 01 Jul 1996 00:00 - Wed 31 Jul 1996 00:00

Part B Velocity

Date	Minimum Velocity (ft/s)	Maximum Velocity (ft/s)	Average Velocity (ft/s)
Mon 01 Jul 1996	0.06 @ 09:50	0.06 @ 09:50	0.06
Tue 02 Jul 1996	0.06 @ 17:50	0.06 @ 17:50	0.06
Wed 03 Jul 1996	0.07 @ 11:40	0.07 @ 11:40	0.07
Thu 04 Jul 1996			
Fri 05 Jul 1996			
Sat 06 Jul 1996			
Sun 07 Jul 1996	-0.06 @ 12:30	0.16 @ 16:40	0.02
Mon 08 Jul 1996	0.09 @ 14:20	0.11 @ 14:00	0.10
Tue 09 Jul 1996			
Wed 10 Jul 1996			
Thu 11 Jul 1996			
Fri 12 Jul 1996			
Sat 13 Jul 1996			
Sun 14 Jul 1996	0.56 @ 21:50	2.48 @ 19:30	1.38
Mon 15 Jul 1996	0.19 @ 15:00	1.68 @ 16:20	0.57
Tue 16 Jul 1996			
Wed 17 Jul 1996	0.43 @ 23:10	2.43 @ 14:40	1.22
Thu 18 Jul 1996	0.19 @ 21:30	2.78 @ 05:10	1.08
Fri 19 Jul 1996	0.13 @ 05:10	0.24 @ 00:20	0.18
Sat 20 Jul 1996			
Sun 21 Jul 1996			
Mon 22 Jul 1996			
Tue 23 Jul 1996			
Wed 24 Jul 1996	0.06 @ 19:30	0.21 @ 17:20	0.13
Thu 25 Jul 1996			
Fri 26 Jul 1996			
Sat 27 Jul 1996	0.37 @ 19:20	0.53 @ 18:40	0.44
Sun 28 Jul 1996	0.16 @ 18:50	0.27 @ 16:00	0.22
Mon 29 Jul 1996			
Tue 30 Jul 1996			
Wed 31 Jul 1996	0.09 @ 17:20	0.09 @ 14:20	0.09
Monthly results	-0.06 @ 12:30 Sun 07 Jul	2.78 @ 05:10 Thu 18 Jul	0.86

MONTHLY SUMMARY   Site #629425470   STATION Wl

Mon 01 Jul 1996 00:00 - Wed 31 Jul 1996 00:00

Level to Flow Part A

Date	Minimum Flow Rate (cfs)	Maximum Flow Rate (cfs)	Average Flow Rate (cfs)	Total Flow (cf)
Mon 01 Jul 1996	0.77 @ 09:50	0.77 @ 09:50	0.77	463.42
Tue 02 Jul 1996	0.74 @ 17:50	0.74 @ 17:50	0.74	444.26
Wed 03 Jul 1996	0.91 @ 11:40	0.91 @ 11:40	0.91	547.85
Thu 04 Jul 1996				
Fri 05 Jul 1996				
Sat 06 Jul 1996				
Sun 07 Jul 1996	-0.75 @ 12:30	1.92 @ 16:40	0.30	1070.66
Mon 08 Jul 1996	1.24 @ 14:20	1.50 @ 14:00	1.37	1643.83
Tue 09 Jul 1996				
Wed 10 Jul 1996				
Thu 11 Jul 1996				
Fri 12 Jul 1996				
Sat 13 Jul 1996				
Sun 14 Jul 1996	11.44 @ 21:50	107.13 @ 19:30	47.84	545363
Mon 15 Jul 1996	2.79 @ 15:00	48.56 @ 16:20	14.24	213671
Tue 16 Jul 1996				
Wed 17 Jul 1996	8.17 @ 23:10	149.11 @ 14:40	42.43	1323805
Thu 18 Jul 1996	3.26 @ 21:30	256.75 @ 00:20	37.83	3019046
Fri 19 Jul 1996	2.01 @ 05:10	3.89 @ 00:20	2.91	61149
Sat 20 Jul 1996				
Sun 21 Jul 1996				
Mon 22 Jul 1996				
Tue 23 Jul 1996				
Wed 24 Jul 1996	0.76 @ 19:30	3.45 @ 17:20	1.90	5708.56
Thu 25 Jul 1996				
Fri 26 Jul 1996				
Sat 27 Jul 1996	6.86 @ 18:30	10.79 @ 18:50	9.02	48697
Sun 28 Jul 1996	2.43 @ 18:50	4.63 @ 16:00	3.72	26784
Mon 29 Jul 1996				
Tue 30 Jul 1996				
Wed 31 Jul 1996	1.06 @ 14:20	1.19 @ 17:20	1.13	1350.39
Monthly results	-0.75 @ 12:30 Sun 07 Jul	256.75 @ 00:20 Thu 18 Jul	28.88	5249743

MONTHLY SUMMARY   Site #629425470   STATION W1

Thu 01 Aug 1996 00:00 - Sat 31 Aug 1996 00:00

Part A Level

Date	Minimum Level (ft)	Maximum Level (ft)	Average Level (ft)
Thu 01 Aug 1996	1.39 @ 21:30	1.45 @ 00:10	1.41
Fri 02 Aug 1996	1.38 @ 23:00	1.43 @ 13:00	1.40
Sat 03 Aug 1996	1.36 @ 17:20	1.39 @ 02:50	1.38
Sun 04 Aug 1996	1.31 @ 19:20	1.38 @ 04:20	1.35
Mon 05 Aug 1996	1.33 @ 00:10	1.92 @ 03:20	1.49
Tue 06 Aug 1996	1.38 @ 00:10	3.84 @ 01:00	2.00
Wed 07 Aug 1996	1.46 @ 15:20	1.81 @ 17:30	1.61
Thu 08 Aug 1996	1.45 @ 14:10	1.77 @ 17:50	1.59
Fri 09 Aug 1996	1.39 @ 15:30	1.59 @ 16:40	1.45
Sat 10 Aug 1996	1.38 @ 16:40	1.43 @ 18:40	1.40
Sun 11 Aug 1996	1.38 @ 19:50	1.41 @ 12:20	1.39
Mon 12 Aug 1996	1.38 @ 01:30	1.44 @ 15:40	1.41
Tue 13 Aug 1996	1.36 @ 16:10	1.52 @ 18:20	1.42
Wed 14 Aug 1996	1.34 @ 17:20	1.47 @ 22:30	1.39
Thu 15 Aug 1996	1.40 @ 12:30	1.45 @ 00:10	1.42
Fri 16 Aug 1996	1.35 @ 23:50	1.41 @ 00:10	1.38
Sat 17 Aug 1996	1.35 @ 22:30	1.40 @ 11:10	1.38
Sun 18 Aug 1996	1.35 @ 16:10	1.84 @ 21:30	1.42
Mon 19 Aug 1996	1.41 @ 14:00	1.76 @ 00:00	1.48
Tue 20 Aug 1996	1.40 @ 23:40	1.79 @ 00:20	1.50
Wed 21 Aug 1996	1.41 @ 01:50	1.72 @ 16:50	1.51
Thu 22 Aug 1996	1.40 @ 17:40	2.74 @ 18:50	1.65
Fri 23 Aug 1996	1.53 @ 23:40	2.52 @ 00:10	1.74
Sat 24 Aug 1996	1.44 @ 00:00	1.53 @ 00:10	1.49
Sun 25 Aug 1996	1.39 @ 19:40	1.46 @ 09:30	1.43
Mon 26 Aug 1996	1.40 @ 00:10	1.45 @ 09:50	1.43
Tue 27 Aug 1996	1.42 @ 00:40	1.49 @ 13:10	1.47
Wed 28 Aug 1996	1.45 @ 23:50	1.50 @ 13:50	1.47
Thu 29 Aug 1996	1.42 @ 23:00	1.47 @ 11:00	1.45
Fri 30 Aug 1996	1.41 @ 23:30	1.53 @ 07:10	1.48
Sat 31 Aug 1996	1.39 @ 19:50	1.43 @ 10:50	1.41
Monthly results	1.31 @ 19:20 Sun 04 Aug	3.84 @ 01:00 Tue 06 Aug	1.48

MONTHLY SUMMARY   Site #629425470   STATION W1

Thu Ol Aug 1996 00:00 - Sat 31 Aug 1996 00:00

Part B Velocity

Date	Minimum Velocity (ft/s)	Maximum Velocity (ft/s)	Average Velocity (ft/s)
Thu 01 Aug 1996			
Fri 02 Aug 1996			
Sat 03 Aug 1996			
Sun 04 Aug 1996			
Mon 05 Aug 1996	0.07 @ 10:00	0.35 @ 05:00	0.17
Tue 06 Aug 1996	0.08 @ 23:30	2.47 @ 05:20	0.86
Wed 07 Aug 1996	0.12 @ 22:20	0.49 @ 17:30	0.26
Thu 08 Aug 1996	0.15 @ 15:30	0.30 @ 16:50	0.21
Fri 09 Aug 1996			
Sat 10 Aug 1996			
Sun 11 Aug 1996			
Mon 12 Aug 1996			
Tue 13 Aug 1996			
Wed 14 Aug 1996			
Thu 15 Aug 1996			
Fri 16 Aug 1996			
Sat 17 Aug 1996			
Sun 18 Aug 1996	0.11 @ 20:30	0.25 @ 23:50	0.18
Mon 19 Aug 1996			
Tue 20 Aug 1996	0.20 @ 02:20	0.36 @ 00:10	0.27
Wed 21 Aug 1996	0.12 @ 15:10	0.24 @ 16:20	0.18
Thu 22 Aug 1996	0.09 @ 18:00	1.80 @ 23:50	1.08
Fri 23 Aug 1996	0.41 @ 03:20	1.87 @ 00:10	0.72
Sat 24 Aug 1996			
Sun 25 Aug 1996			
Mon 26 Aug 1996			
Tue 27 Aug 1996			
Wed 28 Aug 1996			
Thu 29 Aug 1996			
Fri 30 Aug 1996			
Sat 31 Aug 1996			
Monthly results	0.07 @ 10:00 Mon 05 Aug	2.47 @ 05:20 Tue 06 Aug	0.62

MONTHLY SUMMARY Site #629425470 STATION W1

Thu 01 Aug 1996 00:00 - Sat 31 Aug 1996 00:00

Level to Flow Part A

Date	Minimum Flow Rate (cfs)	Maximum Flow Rate (cfs)	Average Flow Rate (cfs)	Total Flow (cf)
Thu 01 Aug 1996				
Fri 02 Aug 1996				
Sat 03 Aug 1996				
Sun 04 Aug 1996				
Mon 05 Aug 1996	0.98 @ 10:00	5.89 @ 03:10	3.04	27369
Tue 06 Aug 1996	1.21 @ 23:30	126.71 @ 00:50	26.27	1639105
Wed 07 Aug 1996	1.92 @ 22:20	8.83 @ 17:30	4.40	89777
Thu 08 Aug 1996	2.40 @ 15:10	5.10 @ 16:50	3.49	39765
Fri 09 Aug 1996				
Sat 10 Aug 1996				
Sun 11 Aug 1996				
Mon 12 Aug 1996				
Tue 13 Aug 1996				
Wed 14 Aug 1996				
Thu 15 Aug 1996				
Fri 16 Aug 1996				
Sat 17 Aug 1996				
Sun 18 Aug 1996	1.56 @ 20:30	3.95 @ 23:50	2.94	7050.32
Mon 19 Aug 1996				
Tue 20 Aug 1996	3.27 @ 02:20	6.37 @ 00:10	4.64	16695
Wed 21 Aug 1996	1.81 @ 15:10	3.95 @ 17:00	2.88	27603
Thu 22 Aug 1996	1.11 @ 18:00	56.55 @ 23:50	31.37	470509
Fri 23 Aug 1996	8.78 @ 03:20	55.15 @ 00:10	17.88	268186
Sat 24 Aug 1996				
Sun 25 Aug 1996				
Mon 26 Aug 1996				
Tue 27 Aug 1996				
Wed 28 Aug 1996				
Thu 29 Aug 1996				
Fri 30 Aug 1996				
Sat 31 Aug 1996				
Monthly results	0.98 @ 10:00 Mon 05 Aug	126.71 @ 00:50 Tue 06 Aug	17.38	2586058

MONTHLY SUMMARY   Site #629425470   STATION W1

Sun 01 Sep 1996 00:00 - Mon 30 Sep 1996 00:00

Part A Level

Date	Minimum Level (ft)	Maximum Level (ft)	Average Level (ft)
Sun 01 Sep 1996	1.36 @ 23:50	1.43 @ 12:10	1.40
Mon 02 Sep 1996	1.33 @ 20:20	1.38 @ 09:20	1.36
Tue 03 Sep 1996	1.34 @ 00:10	1.43 @ 11:20	1.39
Wed 04 Sep 1996	1.38 @ 17:00	1.42 @ 13:20	1.40
Thu 05 Sep 1996	1.40 @ 20:40	1.45 @ 11:00	1.42
Fri 06 Sep 1996	1.37 @ 20:00	1.42 @ 10:50	1.40
Sat 07 Sep 1996	1.37 @ 00:20	5.66 @ 12:20	1.93
Sun 08 Sep 1996	1.47 @ 13:40	2.65 @ 14:50	1.65
Mon 09 Sep 1996	1.51 @ 22:00	1.58 @ 00:10	1.53
Tue 10 Sep 1996	1.44 @ 14:20	1.53 @ 17:10	1.50
Wed 11 Sep 1996	1.42 @ 07:40	1.52 @ 16:00	1.46
Thu 12 Sep 1996	1.44 @ 06:00	1.47 @ 07:20	1.45
Fri 13 Sep 1996	1.43 @ 19:30	1.48 @ 10:00	1.45
Sat 14 Sep 1996	1.43 @ 00:20	1.47 @ 23:40	1.45
Sun 15 Sep 1996	1.43 @ 20:20	1.50 @ 04:40	1.47
Mon 16 Sep 1996	1.45 @ 00:10	1.52 @ 15:40	1.48
Tue 17 Sep 1996	1.44 @ 18:30	1.48 @ 00:40	1.46
Wed 18 Sep 1996	1.45 @ 00:30	1.50 @ 18:40	1.48
Thu 19 Sep 1996	1.47 @ 17:00	1.49 @ 01:30	1.48
Fri 20 Sep 1996	1.44 @ 21:40	1.48 @ 04:50	1.47
Sat 21 Sep 1996	1.40 @ 03:40	1.46 @ 08:00	1.45
Sun 22 Sep 1996	1.42 @ 02:40	1.50 @ 08:50	1.46
Mon 23 Sep 1996	1.44 @ 02:20	1.51 @ 22:20	1.46
Tue 24 Sep 1996	1.46 @ 23:30	1.51 @ 04:20	1.48
Wed 25 Sep 1996	1.41 @ 23:20	1.46 @ 00:20	1.44
Thu 26 Sep 1996	1.39 @ 08:20	4.23 @ 11:10	2.10
Fri 27 Sep 1996	1.61 @ 17:30	2.24 @ 00:10	1.77
Sat 28 Sep 1996	1.54 @ 23:20	1.60 @ 00:10	1.57
Sun 29 Sep 1996	1.51 @ 19:50	1.55 @ 04:20	1.53
Mon 30 Sep 1996	1.47 @ 23:20	1.52 @ 10:30	1.50
Monthly results	1.33 @ 20:20 Mon 02 Sep	5.66 @ 12:20 Sat 07 Sep	1.51

MONTHLY SUMMARY   Site #629425470   STATION W1

Sun Ol Sep 1996 00:00 - Mon 30 Sep 1996 00:00

Part B Velocity

Date	Minimum Velocity (ft/s)	Maximum Velocity (ft/s)	Average Velocity (ft/s)
Sun 01 Sep 1996			
Mon 02 Sep 1996			
Tue 03 Sep 1996			
Wed 04 Sep 1996			
Thu 05 Sep 1996			
Fri 06 Sep 1996			
Sat 07 Sep 1996	0.19 @ 10:20	1.57 @ 12:40	0.59
Sun 08 Sep 1996	-0.13 @ 14:10	2.05 @ 15:00	0.95
Mon 09 Sep 1996			
Tue 10 Sep 1996			
Wed 11 Sep 1996			
Thu 12 Sep 1996			
Fri 13 Sep 1996			
Sat 14 Sep 1996			
Sun 15 Sep 1996			
Mon 16 Sep 1996			
Tue 17 Sep 1996			
Wed 18 Sep 1996			
Thu 19 Sep 1996			
Fri 20 Sep 1996			
Sat 21 Sep 1996			
Sun 22 Sep 1996			
Mon 23 Sep 1996			
Tue 24 Sep 1996			
Wed 25 Sep 1996			
Thu 26 Sep 1996	0.41 @ 21:30	2.57 @ 10:40	1.26
Fri 27 Sep 1996	0.16 @ 11:10	0.68 @ 01:00	0.42
Sat 28 Sep 1996			
Sun 29 Sep 1996			
Mon 30 Sep 1996			
Monthly results	-0.13 @ 14:10 Sun 08 Sep	2.57 @ 10:40 Thu 26 Sep	0.99

MONTHLY SUMMARY Site #629425470 STATION W1

Sun 01 Sep 1996 00:00 - Mon 30 Sep 1996 00:00

Level to Flow Part A

Date	Minimum Flow Rate (cfs)	Maximum Flow Rate (cfs)	Average Flow Rate (cfs)	Total Flow (cf)
Sun 01 Sep 1996				
Mon 02 Sep 1996				
Tue 03 Sep 1996				
Wed 04 Sep 1996				
Thu 05 Sep 1996				
Fri 06 Sep 1996				
Sat 07 Sep 1996	6.10 @ 16:40	145.06 @ 12:40	28.63	498086
Sun 08 Sep 1996	-2.89 @ 14:10	63.41 @ 14:50	24.05	245327
Mon 09 Sep 1996				
Tue 10 Sep 1996				
Wed 11 Sep 1996				
Thu 12 Sep 1996				
Fri 13 Sep 1996				
Sat 14 Sep 1996				
Sun 15 Sep 1996				
Mon 16 Sep 1996				
Tue 17 Sep 1996				
Wed 18 Sep 1996				
Thu 19 Sep 1996				
Fri 20 Sep 1996				
Sat 21 Sep 1996				
Sun 22 Sep 1996				
Mon 23 Sep 1996				
Tue 24 Sep 1996				
Wed 25 Sep 1996				
Thu 26 Sep 1996	8.94 @ 21:30	128.84 @ 11:00	45.38	1987620
Fri 27 Sep 1996	2.66 @ 11:10	16.05 @ 00:20	9.13	76698
Sat 28 Sep 1996				
Sun 29 Sep 1996				
Mon 30 Sep 1996				
Monthly results	-2.89 @ 14:10 Sun 08 Sep	145.06 @ 12:40 Sat 07 Sep	35.18	2807731

MONTHLY SUMMARY   Site #629425470   STATION W1

Tue 01 Oct 1996 00:00 - Thu 31 Oct 1996 00:00

Part A Level

Date	Minimum Level (ft)	Maximum Level (ft)	Average Level (ft)
Tue 01 Oct 1996	1.46 @ 21:20	1.48 @ 10:40	1.48
Wed 02 Oct 1996	1.44 @ 10:40	1.61 @ 14:30	1.50
Thu 03 Oct 1996	1.45 @ 20:00	1.50 @ 00:10	1.47
Fri 04 Oct 1996	1.41 @ 20:10	1.48 @ 10:30	1.45
Sat 05 Oct 1996	1.43 @ 20:50	1.48 @ 08:30	1.46
Sun 06 Oct 1996	1.44 @ 00:20	1.53 @ 14:00	1.48
Mon 07 Oct 1996	1.44 @ 09:00	1.51 @ 23:50	1.46
Tue 08 Oct 1996	1.50 @ 01:50	1.54 @ 22:00	1.52
Wed 09 Oct 1996	1.50 @ 13:40	1.54 @ 21:30	1.52
Thu 10 Oct 1996	1.53 @ 23:00	1.81 @ 06:30	1.60
Fri 11 Oct 1996	1.43 @ 19:00	1.53 @ 00:10	1.48
Sat 12 Oct 1996	1.47 @ 00:10	1.52 @ 03:20	1.49
Sun 13 Oct 1996	1.48 @ 00:30	1.52 @ 00:00	1.50
Mon 14 Oct 1996	1.50 @ 05:10	1.56 @ 23:40	1.53
Tue 15 Oct 1996	1.52 @ 15:40	1.57 @ 00:30	1.54
Wed 16 Oct 1996	1.53 @ 05:50	1.91 @ 23:50	1.60
Thu 17 Oct 1996	1.63 @ 17:50	2.10 @ 08:50	1.77
Fri 18 Oct 1996	1.59 @ 19:30	1.75 @ 00:10	1.63
Sat 19 Oct 1996	1.51 @ 15:00	1.63 @ 16:50	1.58
Sun 20 Oct 1996	1.58 @ 18:00	1.61 @ 08:50	1.60
Mon 21 Oct 1996	1.59 @ 00:30	1.73 @ 16:00	1.63
Tue 22 Oct 1996	1.61 @ 11:20	2.58 @ 21:40	1.77
Wed 23 Oct 1996	1.67 @ 23:00	2.07 @ 00:10	1.79
Thu 24 Oct 1996	1.63 @ 23:20	1.68 @ 00:50	1.65
Fri 25 Oct 1996	1.59 @ 18:10	1.63 @ 07:10	1.62
Sat 26 Oct 1996	1.59 @ 19:30	1.62 @ 02:40	1.61
Sun 27 Oct 1996	1.55 @ 03:10	1.61 @ 06:20	1.59
Mon 28 Oct 1996	1.59 @ 17:00	1.61 @ 09:10	1.60
Tue 29 Oct 1996	1.60 @ 00:40	3.65 @ 13:20	2.11
Wed 30 Oct 1996	1.73 @ 23:30	2.15 @ 00:10	1.83
Thu 31 Oct 1996	1.69 @ 00:00	1.74 @ 00:20	1.71
Monthly results	1.41 @ 20:10 Fri 04 Oct	3.65 @ 13:20 Tue 29 Oct	1.60

MONTHLY SUMMARY Site #629425470 STATION W1

Tue 01 Oct 1996 00:00 - Thu 31 Oct 1996 00:00

Part B Velocity

Date	Minimum Velocity (ft/s)	Maximum Velocity (ft/s)	Average Velocity (ft/s)
Tue 01 Oct 1996			
Wed 02 Oct 1996			
Thu 03 Oct 1996			
Fri 04 Oct 1996			
Sat 05 Oct 1996			
Sun 06 Oct 1996			
Mon 07 Oct 1996			
Tue 08 Oct 1996			
Wed 09 Oct 1996			
Thu 10 Oct 1996			
Fri 11 Oct 1996			
Sat 12 Oct 1996			
Sun 13 Oct 1996			
Mon 14 Oct 1996			
Tue 15 Oct 1996			
Wed 16 Oct 1996			
Thu 17 Oct 1996	0.14 @ 19:00	0.14 @ 17:30	0.14
Fri 18 Oct 1996			
Sat 19 Oct 1996			
Sun 20 Oct 1996			
Mon 21 Oct 1996			
Tue 22 Oct 1996	-0.19 @ 20:10	2.02 @ 21:30	0.80
Wed 23 Oct 1996			
Thu 24 Oct 1996			
Fri 25 Oct 1996			
Sat 26 Oct 1996			
Sun 27 Oct 1996			
Mon 28 Oct 1996			
Tue 29 Oct 1996	0.34 @ 18:30	2.87 @ 19:50	1.30
Wed 30 Oct 1996	0.24 @ 09:40	0.67 @ 01:00	0.43
Thu 31 Oct 1996			
Monthly results	-0.19 @ 20:10 Tue 22 Oct	2.87 @ 19:50 Tue 29 Oct	1.10

MONTHLY SUMMARY Site #629425470 STATION W1

Tue 01 Oct 1996 00:00 - Thu 31 Oct 1996 00:00

Level to Flow Part A

Date	Minimum Flow Rate (cfs)	Maximum Flow Rate (cfs)	Average Flow Rate (cfs)	Total Flow (cf)
Tue 01 Oct 1996				
Wed 02 Oct 1996				
Thu 03 Oct 1996				
Fri 04 Oct 1996				
Sat 05 Oct 1996				
Sun 06 Oct 1996				
Mon 07 Oct 1996				
Tue 08 Oct 1996				
Wed 09 Oct 1996				
Thu 10 Oct 1996				
Fri 11 Oct 1996				
Sat 12 Oct 1996				
Sun 13 Oct 1996				
Mon 14 Oct 1996				
Tue 15 Oct 1996				
Wed 16 Oct 1996				
Thu 17 Oct 1996	2.13 @ 17:30	2.25 @ 19:00	2.19	2630.64
Fri 18 Oct 1996				
Sat 19 Oct 1996				
Sun 20 Oct 1996				
Mon 21 Oct 1996				
Tue 22 Oct 1996	-5.38 @ 20:10	61.45 @ 21:30	23.43	196785
Wed 23 Oct 1996				
Thu 24 Oct 1996				
Fri 25 Oct 1996				
Sat 26 Oct 1996				
Sun 27 Oct 1996				
Mon 28 Oct 1996				
Tue 29 Oct 1996	7.68 @ 18:30	119.36 @ 19:50	46.42	1504006
Wed 30 Oct 1996	4.27 @ 09:40	14.95 @ 01:00	8.86	37227
Thu 31 Oct 1996				
Monthly results	-5.38 @ 20:10 Tue 22 Oct	119.36 @ 19:50 Tue 29 Oct	37.68	1740649

APPENDIX C.

RAINGAGE DATA

STATION: WAUKEGAN 2 WNW, IL (Station ID:: 119029) YEAR: 1996
Precipitation (in)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	0	0	0	0	0	0	0	0	.05
2	0	0	0m	0	0	0m	0	0	0	0	0	0
3	.05	0	0	0	0	.80	.03	0	0	0	0	0
4	0	0	0	0	0	.05	0	0	0	0	0	.05
5	0	0	.10	0	0	.60	0	.06	0	0	0	0
6	0	0	0	0	0	.05	0	1.15	0	0	0	.10
7	0m	0	.25	0	.25	.90	0	0	0	0	.10	0
8	.02	0	0	0	.20	.20	0	.03	.05	.05	0	0
9	0	0	0	0	.35	0	0	0	0	0	0	0
10	0	0	0	0	1.15	.32	0	0	0	.10	0	0
11	.06	0	0	0	0	0	0	0	0	0	0	.28
12	.07	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	.25	0	0	.05	0	0	0	0	0
14	0	0	0	0m	.60	0	0	0	0	0	0	0
15	0	0	0	1.00	0	0	.42	0	0	0	0	0
16	0	0	0	.20	0	0	.05	0	0	0	0	0
17	0	0	0m	0	0	.40	0	0	0	.10	0	0
18	.75	0	0	0	0	.90	2.40	0	0	0	0	0
19	0	.08	0	0	1.97	.74	.11	.10	0	0	0	0
20	0	0	0	.28	1.60	0	0	.07	0	0	0	0
21	0	0	0	0	0	0m	0	0	0	0	.48	0
22	0	0	0	0	0	.16	0	0	.08	0	.02	0
23	0	0	0	0	.45	0	0	.62	0	0	0	.15
24	.02	0	0	0	0	.60	0	0	.10	.05	0	.20
25	0	0	.48	0	0m	0	0	0	0	0	.10	0
26	0	.30	0	0	0m	0	0	0	0	0	0	.20
27	0	.45	0	.07	.15	0	0	0	1.55	0	0	.10
28	0	0	0	0	.55	0	0m	0	0	0	.01	0
29	0	0	0	.35	0	0	.30	0	0	0	0	0
30	.12		0	.50	0	0	.02	0	0	1.15	.02	.02
31	0		.06		0		0	0		0		.01
Sum	1.09	0.83	0 .89	2.65	7.27	5.72	3.38	2.03	1.78	1.45	0.73	1.16

Note: Om means omitted data.

STATION: WAUKEGAN 2, IL (Station ID: 119030) YEAR: 1996
Precipitation (in)-

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0m	0m	0m	0	0	0	0	.02	0	0	0	0
2	0m	0m	0m	0	0	.67	.01	0	0	0	0	0
3	0m	0m	0m	0	0	.49	.05	0	0	0	0	0m
4	0m	0m	0m	0	.05	0	0	0	0	0	.01	.34
5	0m	0m	0m	0	0	.35	0	.07	0	0	0	0m
6	0m	0m	0m	0	.03	.06	0	0	0	0	0	0
7	0m	0m	0m	0	.08	.78	0	0	0	0	.15	.03
8	0m	0m	0m	0	0	.02	0	0	0m	.53	0	0
9	0m	0m	0m	0	0m	.05	0	0	3.01	0	0	0
10	0m	0m	0m	0	0m	.60	.01	0	0	.12	0	0
11	0m	0m	0m	0	1.40	0	0	0	0	0	0	0
12	0m	0m	0m	0	0	0	0	0	0	0	0	.05
13	0m	0m	0m	0	0	0	.06	0	0	0	0	0
14	0m	0m	0m	0	0	0	0	0	0	0	0	0
15	0m	0m	0m	1.10	0m	0	.59	0	0	0	0	0
16	0m	0m	0m	0	.47	0	.66	0	0	0	0	0
17	0m	0m	0m	0	.09	.33	0	0	0	0m	.05	0
18	0m	0m	0m	0	0	.83	0	0	0	.17	0	0
19	0m	0m	0m	.11	0	.42	2.35	.15	0	0	0	0
20	0m	0m	0m	0	1.35	0	0	.05	0	0	0	0
21	0m	0m	0m	0	2.55	0	0	.02	0	0	.17	0
22	0m	0m	0m	0	0	.10	0	0	0	.02	0	0
23	0m	0m	0m	.58	0	0	0	.48	0	0m	0	0
24	0m	0m	0m	0	.52	.28	0	0	0	.34	0m	0m
25	0m	0m	0m	0	0	0	.07	0	0	0	0	0
26	0m	0m	0m	0	0m	0	0	0	0	0	0	.40
27	0m	0m	0m	0	0m	0	0	0	.50	0	0	0
28	0m	0m	0m	0	.51	0	.08	0	0	0	0	0
29	0m	0m	0m	0	.46	0	.05	0	0	0	0	0
30	0m		0m	.95	0	0	0	0	0	1.32	.02	0
31	0m		0m		0		0	0		0		0
Sum	0m	0m	0m	2.74	7.51	4.98	3.93	0.79	3.51	2.50	0.40	0.82

Note: 0m means omitted data.