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2007 BENTHIC BIOLOGICAL ASSESSMENT OF THE LOWER MILL RIVER, HAMDEN/NEW HAVEN, CT

Prepared For:

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INTRODUCTION

The purpose of this study is to provide aquatic resource management information concerning resumption of water withdrawals from Lake Whitney and possible alterations to stream flows in the downstream Mill River.. The study provides quantitative and qualitative information about general habitat characteristics and benthic macroinvertebrate community structure at five locations along the lower Mill River in Hamden and New Haven, CT. In 2006, station 5 was dropped from the study due to tidal influences at this downstream station. This study summarizes survey results from 2007. In April 2005 the new water treatment facility which draws water from Lake Whitney went online, and this study represents the third year of post-operational data collection. The water treatment facility was operating mostly in a testing mode in 2005, and withdrawals were generally near the low end of the expected range, averaging 16 percent of the maximum allowed withdrawal. 2006 operations consisted of higher but still very moderate withdrawal rates, averaging 31% of the maximum allowed withdrawal. The most significant flow alteration in 2006 occurred as a result of lowering the water level of Lake Whitney for a water supply construction project. This resulted in downstream flows exceeding natural inflow during the drawdown period, followed by a period of minimum downstream releases after the project while the reservoir refilled. 2007 operations consisted of lower withdrawal rates, averaging only 28% of the maximum allowed withdrawal. In 2007 Lake Whitney was drawn down for dam inspection and maintenance on two occasions (June and October), for a total of 12 days. It is intended that a review of all data collected in 2005, 2006 and 2007, as well as future operational years will be conducted to evaluate any potential impacts to Mill River from the water withdrawal in Lake Whitney. Ultimately, post-operation data will be compared to pre-operation data collected in 1998 and 2000 to 2004. This investigation facilitates that analysis, but focuses on extending the post-operational database.

METHODS

General methods were consistent with previous years, beginning in 2000. Samples were collected on June 15 and August 17, 2007, at the peak of the tidal outflow (low tide). Sampling locations (Figure 1) were the same as previous years, except in 2006 station 5 was eliminated from the monitoring program due to the tidal influences and to focus on more detailed chironomid analysis at more relevant upstream stations. Sampling stations were longitudinal stretches, ranging from 85 to 300 ft in length (~25-90 m). Each sampling station was characterized for general habitat and instream water quality at representative sites. A single sample per site was used to determine water quality features on the day of sampling. Flow values were daily means from SCCRWA flow records from the Whitney Dam.

Aquatic habitat was evaluated in a qualitative to semi-quantitative way. This was a modified version of the USEPA Rapid Bioassessment Protocol (Physical Characterization / Water Quality

Assessment) (Barbour et al. 1999). Aquatic habitat characterization included features such as surrounding land use, canopy cover, flow, and substrate composition for each sampling station. Water quality was assessed in a quantitative way with in situ determinations of water temperature, dissolved oxygen content, conductivity, turbidity, and pH at each sampling station.

Timed (two minutes) D-frame dip-net sampling was used to collect macroinvertebrates. This method is commonly used as a multi-habitat rapid bioassessment technique (Barbour et al. 1999). Riffle habitats were sampled at stations where riffle habitat is available, although at higher flows some of these areas could be characterized as run habitats. Macroinvertebrates were captured in the net by dislodging the substrate up to 1 ft (0.3 m) upstream of the dip-net. Two subsamples per sampling station were collected. Each subsample consisted of a two-minute collection, itself comprised of four 30-second collection efforts at four nearby locations within the site. Subsamples were preserved in 70% ethanol for laboratory analysis. Macroinvertebrates were sorted, identified to the lowest practical taxonomic level, and counted. Samples were collected during the period of low tide on both sampling dates.

After a 2005 test run with a subset of the total sample collection, Chironomidae samples were identified in 2006 and 2007 to the lowest practical taxonomic division, typically the genus or species level, to further facilitate water quality analysis. Although the main focus of this monitoring program is on the impacts of changing flows, flow can affect water quality, and pollution tolerance of individual species varies within the Chironomidae family.

The two macroinvertebrate subsamples were analyzed separately, but combined into a single sample per station for data analysis. Variability among subsamples was evident, as is expected for such samples, but was not striking. Numerical analysis included relative abundance and dominance patterns on taxonomic and feeding group bases, species richness and diversity. Species richness was expressed as number of taxa (S). Species diversity quantifies the degree of dominance (or lack thereof) of taxa within a community; it measures the distribution of individuals among taxa present. When one or a few taxa dominate a community, diversity is low. The Hilsenhoff Biotic Index (HBI), based on a quality value of 0-10 assigned to each taxon multiplied by the abundance of each corresponding taxon and divided by the total number of individuals was calculated for each station. Modified HBI calculations were completed for all data collected from 2000-2007. The index was modified to include non-arthropod species (Mandeville 2002).

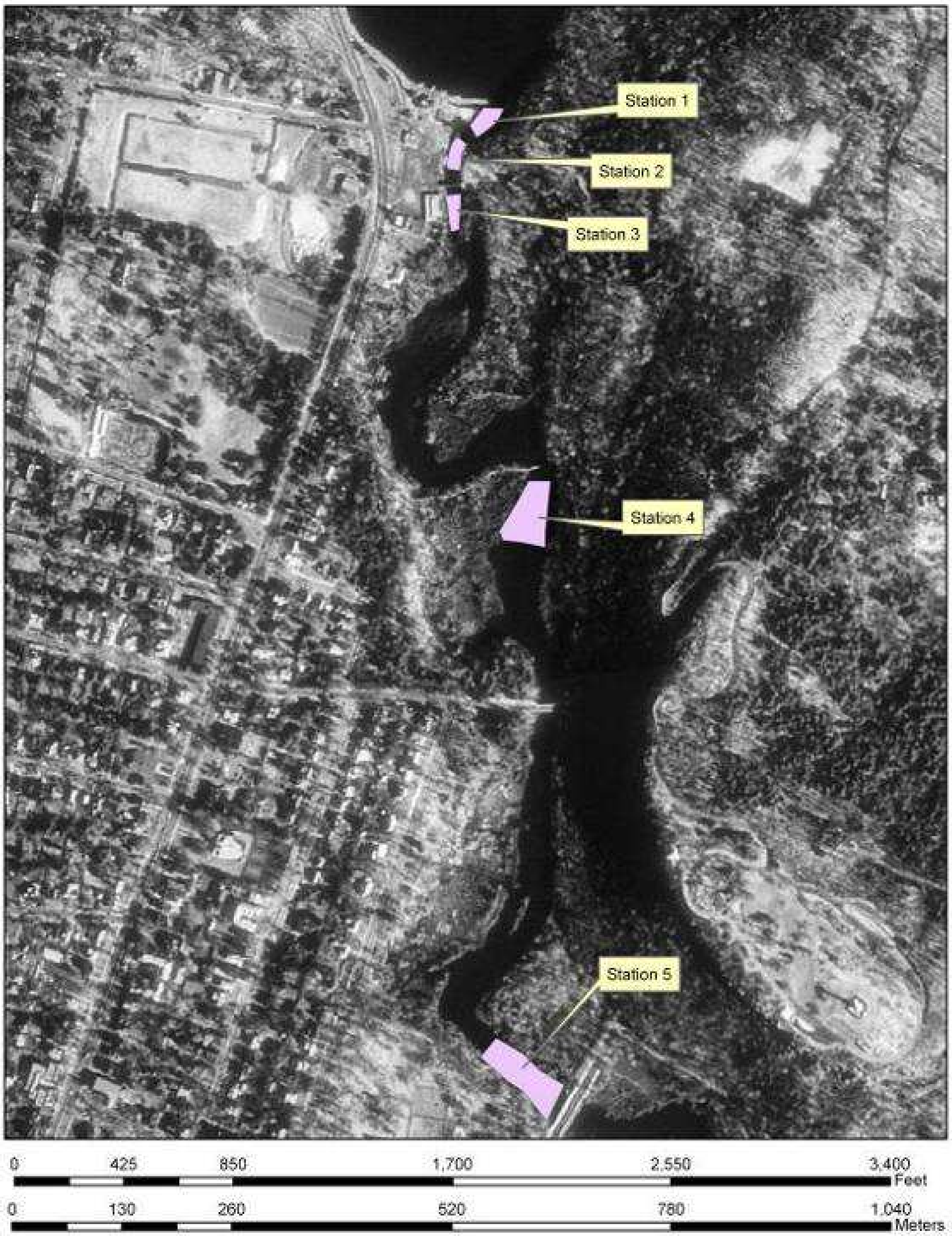

Figure 1. Locations of the five established sampling stations along the Lower Mill River in Hamden (stations 1-4) and New Haven (station 5). Station 5 was eliminated as an active biological sampling station in 2006.

RESULTS

Habitat Characterization

Predominant land use (forest and residential) and sources of pollution (storm pipes discharging at several locations between stations 2 and 4) were the same in 2007 as in all previous surveys (Table 1). Sources of pollution to the lower Mill River include a number of combined sewer overflows (CSOs), the closest to the study area being located at East Rock Road between Stations 4 and 5. CSOs can have strong but intermittent water quality impacts in the tidal areas of the river. Canopy cover reached its maximum at station 3 and its minimum at station 1. Major shore or bank erosion was not observed.

Flow is estimated by the SCCRWA using automated lake level measurements at the Lake Whitney spillway. Flows on the day of the survey are not necessarily an indication of antecedent conditions, however, and SCCRWA flow records were consulted to categorize the hydrological conditions for two and a half months before each sampling. Based on factors such as tidal influence and watershed hydrologic characteristics, a wide range of flow conditions might be anticipated at any given time within the study area. Tidal influences are apparent at stations 3 and 4 as water level fluctuations. Variation in flow from Lake Whitney is the more dominant current influence at stations 1 and 2. Under low flow conditions, salinity influences at station 4 are measurable (CH2MHILL 2008). However, while water level changes with tide are evident at station 3, saltwater does not intrude this far upstream. In 2007 the average daily spring flow in the 10-week period preceding the June 15 sampling (143 mgd) was larger than the average daily summer flow preceding the August 17 sampling (38 mgd) (Table 2), as expected. Flows in the spring of 2007 were higher than any previously observed average daily 10 week flow preceding sampling since the inception of the study program. April of 2007 was the 2nd wettest April in the 96 year period of record of rainfall measurements at Lake Whitney. In contrast, flows in the summer of 2007 were the 2nd lowest observed since study inception. Total rainfall for the period of June – September was below average for 2007, and late summer was characterized by an extended period of little rainfall.

The abundance and distribution of aquatic vegetation was similar to pre-operational years. The amount of filamentous algae and rooted aquatic plants varied among sampling locations in 2007 and is likely a function of varied flow. In 2007, the abundance of aquatic macrophytes as percent cover at each station was similar at all stations. Station 4 was influenced by tidal activity involving saltwater intrusion as described in the water quality monitoring report for 2007 (CHSMHILL 2008).

Average stream depth and width were similar to previous years. Stream width and depth were both on the lower end of the observed range for stream width and depth due to lower flows at the time of sampling. Tide influenced stream depth at Station 4. However, as sampling at station 4 was conducted under low tide conditions, observed fluctuations were minor in comparison with possible changes over the tidal cycle.

Inorganic substrates were generally coarser at the upstream sites (Stations 1 and 2) and progressively decreased in mean particle size in the downstream direction (Table 1). Fine-grained substrate such as silt was observed only at the most downstream station (i.e., Station 4). Data from previous years suggest particle transport is occurring during large storm events, but the amount of transport has not been examined.

Detritus (e.g., logs, wood, leaf litter) was present at relatively low levels, indicating periodic flushing as would be expected in this large watershed. Most stations had similar percentages of detritus. Station 4 had the greatest amount of detritus, but the relative amount was minimal in comparison with inorganic substrates. However, general amounts of detritus, both fine and coarse, appeared to be sufficient to support abundant populations of macroinvertebrates at all stations.

Vegetation levels in 2007 were similar to those in previous survey years. Our experiences from previous years is that species tolerant of high flow such as attached moss and filamentous green algae (Chlorophyta: Chlorophyceae) comprised the majority of the vegetation at the upstream stations (1 and 2), but presence of rooted macrophytes (mostly narrow-leaved pondweeds) was noted in the upstream area during some samplings. Filamentous algal abundance at stations 1 and 2 increased between June and August samplings, perhaps in response to decreasing flows. During previous years, filamentous algae abundance typically decreased between June and August. Stations 1 and 2 experienced an overall decrease in macrophyte abundance between June and August related to a narrow river channel under decreased flows.

Waterlilies (*Nymphaea* sp., a freshwater species that prefers slow-flowing to lentic waters) were observed at the downstream stations. All the taxa of vascular plants encountered in the lower Mill River in 2007 were common taxa, tolerant of conditions such as low light, high nutrients, and salinity gradients (Crow and Hellquist 1980). Total plant coverage at the sites was within the typical ranges observed for temperate lotic systems (Allan 1995).

In general, habitat structure was suitable for macroinvertebrates at all stations in 2007. Substrate structural complexity (i.e., spatial heterogeneity) provides a diverse habitat for invertebrates, creating “niches” dominated by different food resources and hence varied invertebrate species, and/or providing crevices that protect invertebrates from predation or complete dislodgement by strong currents (Hixon & Menge 1991; Allan 1995). Macrophytes also contribute to increased spatial heterogeneity by providing a substrate rich in food resources (epiphytic algae and detritus covering the plants) (Diehl & Kornijów 1998). Physical substrate (cobble and gravel substrate) and/or macrophyte cover was sufficient to potentially support a rich and diverse macroinvertebrate community at all stations, although the quality of that habitat was not as high at station 4 as at stations 1-3.

Selected water quality parameters were assessed in 2007 during both sampling events (Table 2). Assessed water quality in 2007 was slightly different than previous years for some parameters. The pH of most samples was slightly basic to basic (Table 2). Stations 1 and 3 had August pH values slightly higher than any value measured previously. pH values in 2007 increased between June and August at all stations, but remained within the life compatible 4.5 – 9.5 range for most aquatic biota (Wetzel 2001b). Dissolved oxygen levels were above the Connecticut Water Quality Standard of 5 mg/L at all stations in June and August except for station 4 in August. In August, station 4 dissolved oxygen levels at the surface and bottom were 5.0 and 3.5 mg/L respectively. Dissolved oxygen levels of 5.0 mg/L are considered adequate to support aquatic life but values dropping below 5.0 mg/L begin to stress aquatic life. A more comprehensive study of dissolved oxygen levels at station 4 indicates that the seasonal average at station 4 is under 5.0 mg/L (CH2MHILL 2008).

In August 2007, the salinity levels at Station 4 were higher than salinity levels in June; however, they were lower than measured salinities from 2005 or 2006. Water temperature in 2007 was within the range from previous years. Water temperature in August was higher than in June, which is typical.

Specific conductivity was comparable between stations during June, but was considerably higher at station 4 during August. Saltwater influence from the recent tide was undoubtedly responsible and was likely due to saltwater intrusion under lower flows. There is evidence of saltwater intrusion at lower flows, extending upstream of Station 4 (CH2MHill 2001).

Turbidity varied among stations and dates to some degree, but was generally low to moderate at the time of sampling. Very high turbidity is known from the Mill River system upstream of Lake Whitney, but the lake acts as a detention basin and minimizes downstream transport of particles much of the time.

Table 1. - Lower Mill River habitat characterization. Data are for the June and August sampling events in 2007.

	Stn 1		Stn 2		Stn 3		Stn 4		Stn 5	
Parameters	**Jun 1**	**Aug 17**	**Jun 1**	**Aug 17**	**Jun 1**	**Aug 17**	**Jun 1**	**Aug 17**	**Jun 1**	**Aug 17**
Length of Segment	85 ft (26 m)		150 ft (46 m)		300 ft (91 m)		300 ft (91 m)		300 ft (91 m)	
Watershed/Bank Features										
predominant surrounding land use	forest/residential		forest/residential		forest/residential		forest/residential		forest/residential	
canopy cover	open		some shade (<40%)		mod. Shade (30-80%)		some shade (<40%)		some shade (<40%)	
dominant riparian vegetation	shrubs		shrubs		trees		trees/shrubs		trees	
bank stability [1]	stable		stable		stable		stable		stable	
other notable features	near dam		near dam		downstream of dam		tidal influence		tidal influence	
In-stream Features										
general habitat type (%)										
riffle	100	100	90	90	80	100	-	-	-	-
run	-	-	10	10	20	-	75	40	-	-
pool	-	-	-		-	-	25	60	-	-
estimated stream width (ft):	80	40	70	20	110	65	130	90	-	-
estimated stream depth (ft):										
riffle	1.4	0.5	1.4	0.8	0.6	0.3	-	-	-	-
run	-	-	1.0	1.0	0.8	-	3.0	3.0	-	-
pool	-	-	-	-	-	-	3.5	3.0	-	-
inorganic substrate composition[2]										
bedrock	-	-	-	-	-	-	-	-	-	-
boulder (>256 mm)	10	10	10	10	0	5	5	5	-	-
cobble (64-256 mm)	80	75	70	60	30	20	10	10	-	-
gravel (2-64 mm)	10	15	20	25	55	55	30	30	-	-
sand (0.06-2 mm)	-	-	-	5	15	25	40	30	-	-
silt (0.004-0.006 mm)	-	-	-	-	-	-	15	25	-	-
clay (<0.004 mm)	-	-	-	-	-	-	-	-	-	-
organic substrate composition[2]										
detritus[3]	0	5	5	10	10	15	10	20	-	-
aquatic macrophytes (total)	50	50	75	55	40	40	40	50	-	-
filamentous algae	100	100	40	60	75	80	20	20	-	-
water lilies (*Nymphaea, Nuphar*)	-	-	-	-	-	5	25	40	-	-
pondweeds (*Potamogeton spp*) [4]	-	-	60	40	15	15	30	35	-	-
moss	-	-				-		-		
waterweed (*Elodea canadensis*)	-	-			10	-	25	5	-	-
tidal influence	No	No	No	No	No	No	Yes	Yes	-	-

(1) stable = minimal evidence of erosion or bank failure
(2) percent coverage
(3) logs, wood, coarse particulate organic matter
(4) narrow-leaved species.

Table 2. Water quality ranges and flows at the sampling locations in 2007. Pre-operation data is also presented as a range of values over all pre-operation years.

	Station 1					
Parameter	Pre-operation Range		Jun 15 2007		Aug 17 2007	
	Jun	Aug				
water temperature (°C)	17.9-23.2	19.8-26.7	19.6		24.3	
dissolved oxygen (mg/L)	8.3-9.7	5.7-9.4	9.8		7.9	
dissolved oxygen (% saturation)	99-112	71-108	107.4		94.0	
specific conductivity (µS/cm)	189-282	194-270	202		226	
turbidity (NTU)	1.0-3.2	1.6-5.6	2.1		2.6	
pH (SU)	7.2-8.5	6.8-8.4	7.1		8.7	
Flow (mgd) (Average over prior 10 weeks)	88-140	42-97	143		38	
	Station 2					
	Pre-operation Range		**Jun 15 2007**		**Aug 17 2007**	
	Jun	Aug				
water temperature (°C)	17.7-23.2	19.7-26.4	19.6		24.4	
dissolved oxygen (mg/L)	8.0-10.4	7.3-9.0	9.4		6.7	
dissolved oxygen (% saturation)	94-120	86-111	103.2		80.3	
specific conductivity (µS/cm)	190-284	192-268	202		227	
turbidity (NTU)	1.0-7.9	1.2-7.8	2.4		2.6	
pH (SU)	7.2-8.5	7.6-8.8	7.4		8.6	
Flow (mgd) (Average over prior 10 weeks)	88-140	42-97	143		38	
	Station 3					
	Pre-operation Range		**Jun 15 2007**		**Aug 17 2007**	
	Jun	Aug				
water temperature (°C)	17.6-23.3	19.7-26.7	19.5		24.2	
dissolved oxygen (mg/L)	7.9-10.2	5.9-9.3	8.8		6.8	
dissolved oxygen (% saturation)	93-117	73-109	95.9		81.6	
specific conductivity (µS/cm)	189-290	194-265	203		228	
turbidity (NTU)	1.2-3.8	1.6-4.8	2.2		2.8	
pH (SU)	7.2-8.6	7.6-8.2	7.4		8.5	
Flow (mgd) (Average over prior 10 weeks)	88-140	42-97	143		38	
	Station 4					
	Pre-operation Range		**Jun 15 2007**		**Aug 17 2007**	
	Jun	Aug	**Surface**	**Bottom**	**Surface**	**Bottom**
water temperature (°C)	17.8-23.5	19.7-30.2	19.2	19.2	24.1	24.1
dissolved oxygen (mg/L)	7.9-11.8	6.1-8.9	7.8	8.3	5.0	3.5
dissolved oxygen (% saturation)	92-134	72-117	84.5	89.5	60.0	41.8
specific conductivity (µS/cm)	189-290	194-7013	205	204	305	548
turbidity (NTU)	1.2-4.6	1.9-8.4	2.8	-	3.7	-
pH (SU)	7.3-8.8	7.2-8.3	7.3	7.2	7.9	7.7
Salinity (ppt)	-	-	-	-	0.15	0.27
Flow (mgd) (Average over prior 10 weeks)	88-140	42-97	143	143	38	38

Macroinvertebrates

This investigation focused on the invertebrate community as an indicator of conditions downstream of Lake Whitney. Invertebrates have long been used as indicators of environmental quality, and will reflect water quantity effects to the extent that water quantity affects water quality (e.g., dilution, runoff). In the extremes, water quantity can also affect invertebrates by altering the substrate (scouring or drying/oxidation), through dislodgment of biota with downstream transport, and through reduced available habitat under dry conditions. Most effects of water quantity are indirect, however, necessitating a considerable database to allow an analysis that accounts for other potentially influential factors. An initial survey of the Mill River downstream of Lake Whitney was conducted in 1998, from which it was determined that invertebrates might provide suitable indication of the impact of changing flow as a consequence of the re-activation of Lake Whitney as a water supply.

2007 raw data for benthic macroinvertebrates has been analyzed in several ways relevant to questions of flow impacts. Total benthic macroinvertebrate abundance in 2007 (Figure 3) varied considerably within and among stations. The obvious conclusion for 2007 as well as previous years, supported visually, is that invertebrates are more abundant at stations 1-3 than at station 4. There are both physical and chemical habitat changes between stations 3 and 4 that are more likely to be responsible for this difference than any variation in flow. The primary influence is tidal, with slower water velocities, changing direction of flow, and oscillating salinity at station 4.

In 2007 there was an increase in invertebrate abundance at stations 1 and 2, compared to 2006. However, abundance was still lower than 2005 for both stations. Compared to 2006, invertebrate abundance at station 3 in 2007 increased in June and decreased in August. 2007 invertebrate abundance at Station 4 increased in June and August compared to 2006 values. In 2005 we witnessed the largest numbers of invertebrates since the inception of the study program at stations 1 and 2 (Figures 3 and 4). In 2006 and 2007, abundance levels were within the range of values observed previously for stations 2-4 (Figure 4). In 2007, June invertebrate abundance at station 1 was the 2nd highest since study inception. Macroinvertebrate abundance was greatest at stations 1-3, and decreased at station 4, similar to previous years. Macroinvertebrate abundance increased between the June and August sampling events at stations 2 and 4, and decreased between sampling events at stations 1 and 3.

Taxonomically, the assemblage of invertebrates in the Mill River downstream of Lake Whitney exhibits variable richness (Figure 5), with between 7 and 21 taxa identified at each station for both sampling occasions in 2007. The findings in 2007 are comparable to previous years where the number of taxa present at each station varied between 6 and 28. 2007 richness has a wider range of values compared to the two previous years with the treatment facility online. Richness in 2005 ranged between 6 and 17 taxa, while 2006 richness ranged between 10 and 16 taxa. This assessment excludes the Chironomidae, which have only been identified below the family level at all stations beginning in 2006, and will be addressed separately.

A cumulative look at the abundance of invertebrates within the more common taxa encountered in 2005, 2006 and 2007 (Figure 6), indicates that the most common taxon (the caddisfly *Macrostemum*) is by far the most abundant. The next two most abundant taxa are the midges in the family Chironomidae, and an oligochete worm, *Nais communis.* The 15 most abundant taxa are shown in Figure 6, with the next 10 most abundant lumped together and the remaining 30 taxa lumped into yet another category for graphic comparison. Adding a third year of post-operational data resulted in midges becoming the 2nd most abundant and *Nais communis* becoming the 3rd most abundant invertebrate taxon collected. In addition, more taxa are present due to collection of 16 taxa in 2007 that had not been collected in 2005 or 2006.

The common taxa observed in any one year were also encountered in the other years. In 2005, two new taxa were collected, Donacia (leaf beetles) and Neophylax (caddisfly). Donacia was not observed in 2006 or 2007, but Neophylax was again collected in the 2006 and 2007 samples. In 2005, one specimen of Neophylax was collected at Station 5, while in 2006 specimens were collected at Stations 1 and 4, but only in June. Note that Station 5 was not sampled in 2006. In 2007, Neophylax was collected at stations 1, 2 and 3 but only in June. Of the 16 new taxa collected in 2007, only 3 were represented by more than 10 individuals when stations and sampling dates were combined. In previous years we found that less common taxa were not consistently observed over time or space. Rare taxa tend to be patchily distributed, and patchiness may be exacerbated by spatial habitat heterogeneity. Therefore, absence of such rare taxa in some samples or years may not mean that the taxa were not present in the lower Mill River system.

An alternative way to evaluate the macroinvertebrate data is to organize them by feeding groups. These groups have ecological meaning in terms of food resources and energy flow, and may be affected by flow insofar as flow affects food delivery from upstream, the growth of periphyton, and the accumulation of organic detritus. 2007 feeding group data varied between stations and among sampling dates (Figures 7-10). Stations 1-3 were dominated by collectors, filter feeders and shredders, while collectors and predators were most abundant at station 4. General patterns of feeding group abundance between post-operational years (2005-2007) appear similar, although slight shifts are present based on specific species occurrences.

Hilsenhoff Biotic Index values at each station were calculated and graphed against the10-week average flows prior to sampling for each year (Figures 11-15). The graphs do not include the HBI values for the September 2004 sampling event due to the Lake Whitney drawdown for upgrades to the dam related to the new treatment facility. Values for all years ranged from 4.65-8.21 at Station 1, 3.66-7.04 at station 2, 4.72-7.19 at station 3, 5.46-9.01 at station 4 and 5.86-7.41 at station five (Table 3).

To assess the impacts of the water treatment facility on the invertebrate community in the Mill River, pre-operation and post-operation data were grouped separately and graphed against the flows for each sampling occasion. Flow was graphed against taxonomic richness, total individuals, evenness and diversity (Figures 16-19). Diversity values are affected by the number of taxa present at each station, while evenness is a normalized measure of diversity that puts all values on a scale of zero (low) to one (high). Pre-operation and post-operation data is similar for taxonomic richness and diversity. Evenness between pre and post-operation data is similar, although post-operational data appears to be slightly higher. Total number of individuals varies between data sets. Four of the five highest numbers of individuals at any station or date have occurred since the water treatment facility went online. Although slight differences in the data may be suggested visually, no trend in flow impacts is apparent.

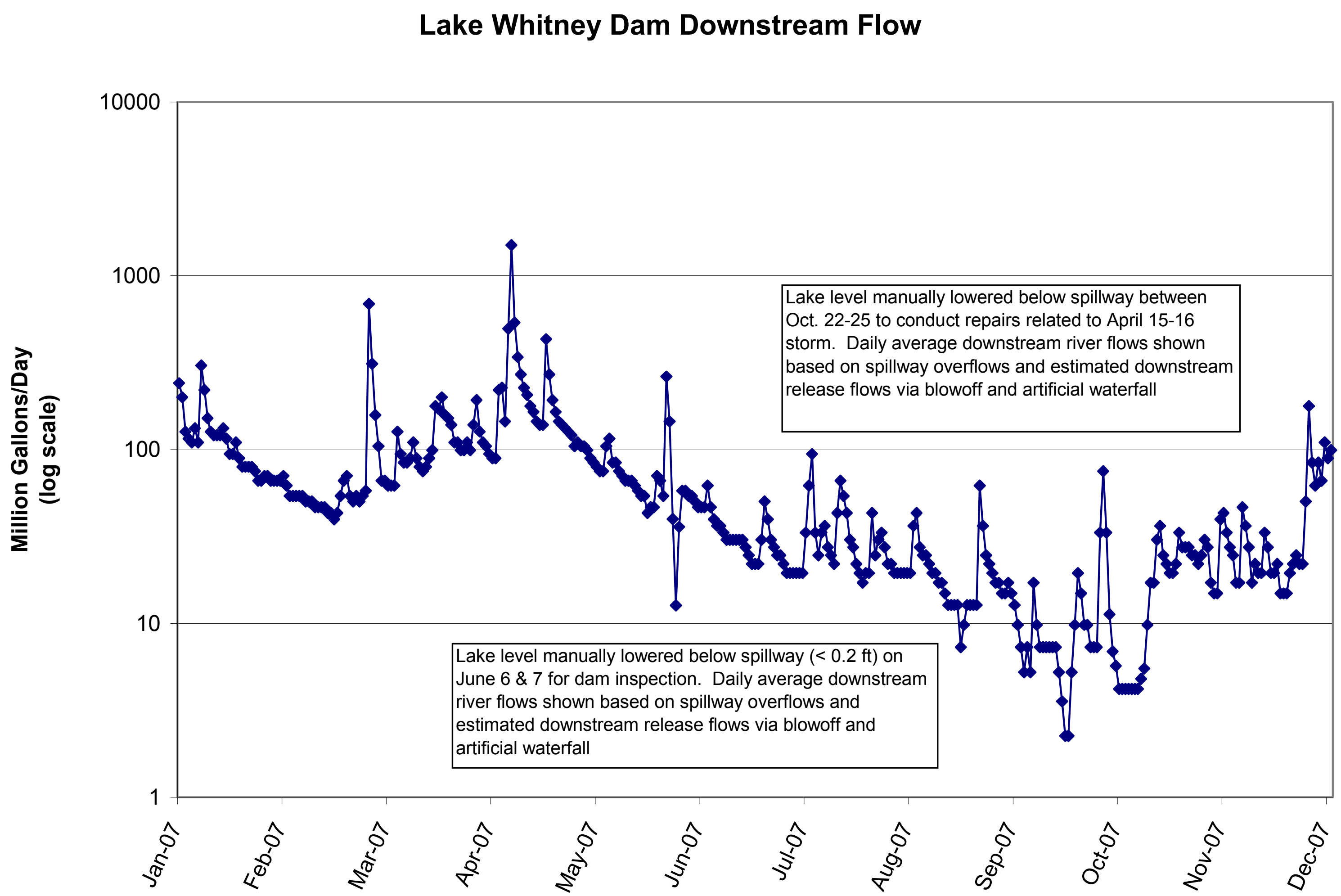

Figure 2. Mill River flows in 2007 measured at the Lake Whitney spillway.

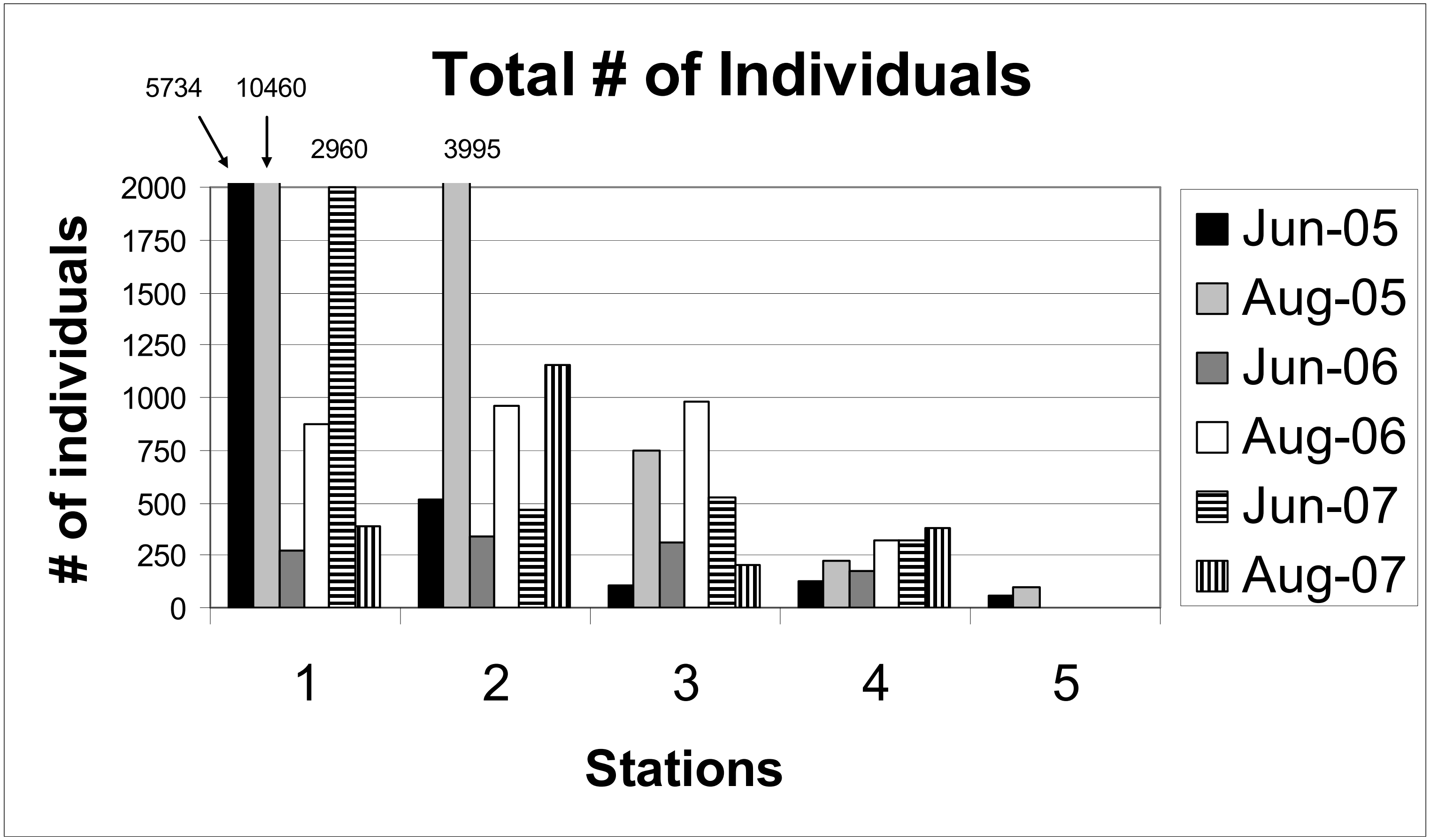

Figure 3. 2005, 2006 and 2007 benthic macroinvertebrate abundance over space and time in the Mill River, downstream of Lake Whitney. Macroinvertebrate abundance is based on two timed, two minute D frame net samples.

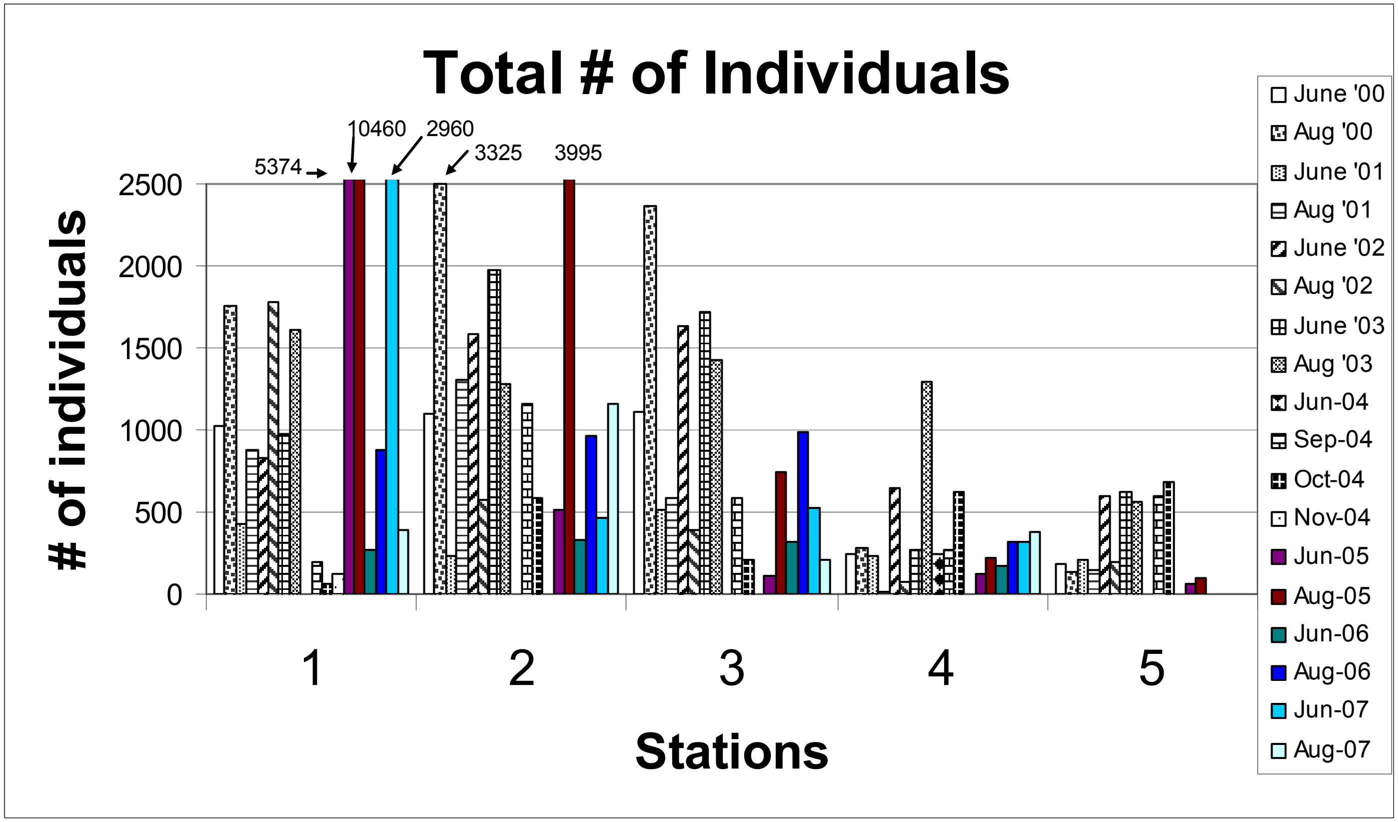

Figure 4. Total number of invertebrates over space and time in the Mill River, downstream of Lake Whitney for all years. These values are based on two timed, two minute D frame net samples.

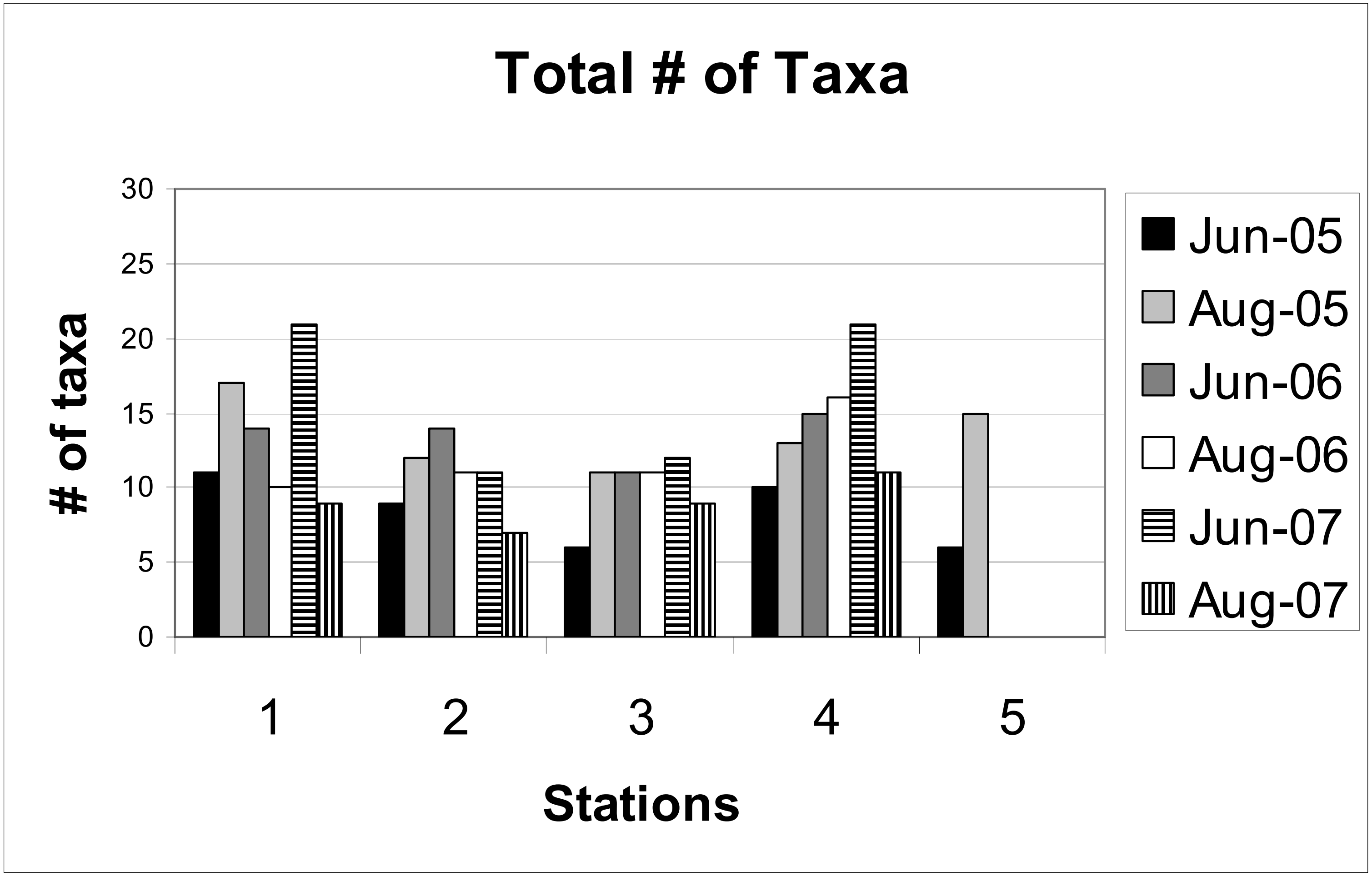

Figure 5. 2005, 2006 and 2007 benthic macroinvertebrate taxa abundance over space and time in the Mill River, downstream of Lake Whitney. Macroinvertebrate abundance is based on two timed, two minute D frame net samples.

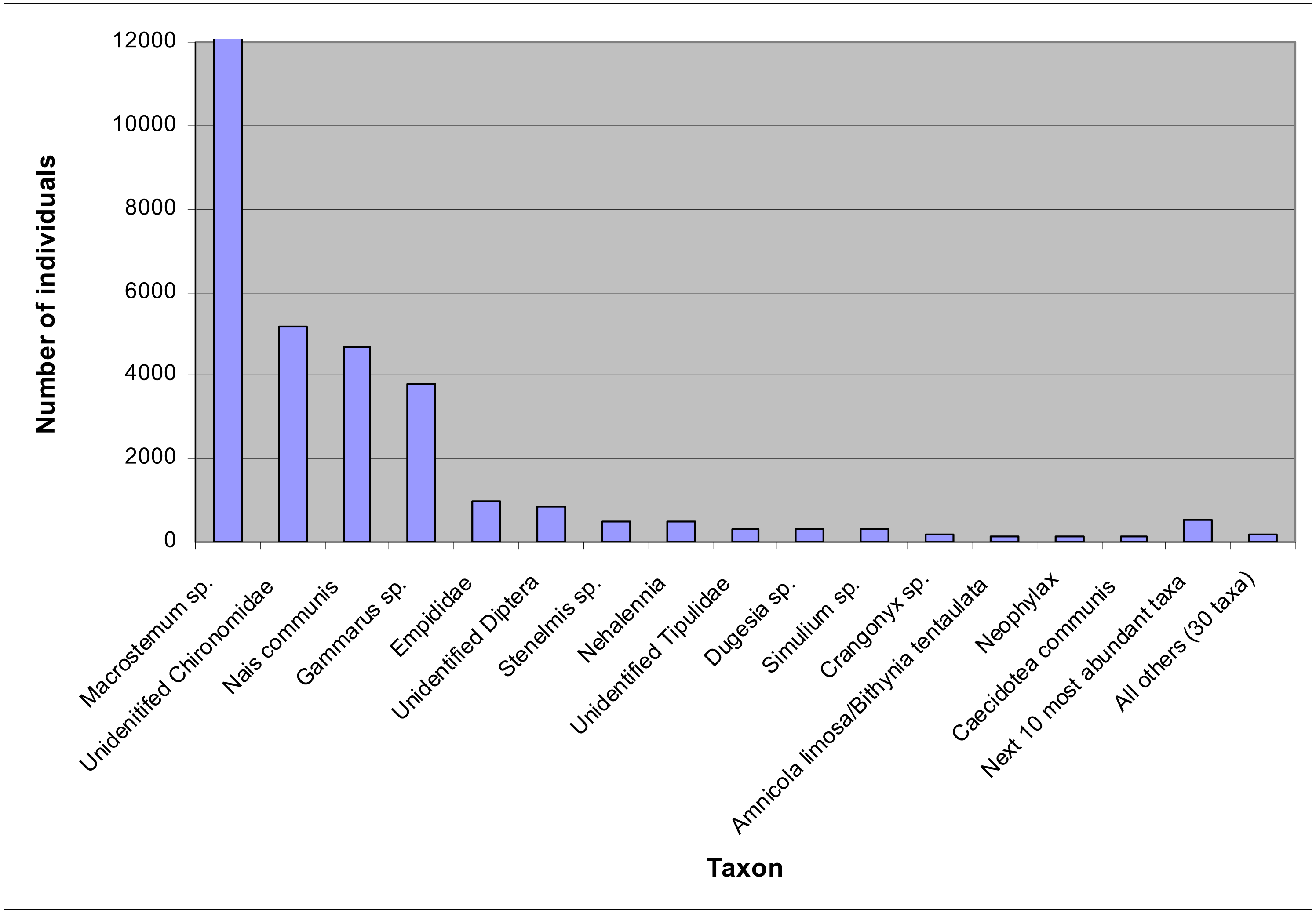

Figure 6. Pooled invertebrate abundance data for 2005, 2006 and 2007 in the Mill River, downstream of Lake Whitney. The 15 most abundant invertebrate taxa are graphed, after which the next 10 most abundant are grouped and the remaining individuals are grouped (30 taxa).

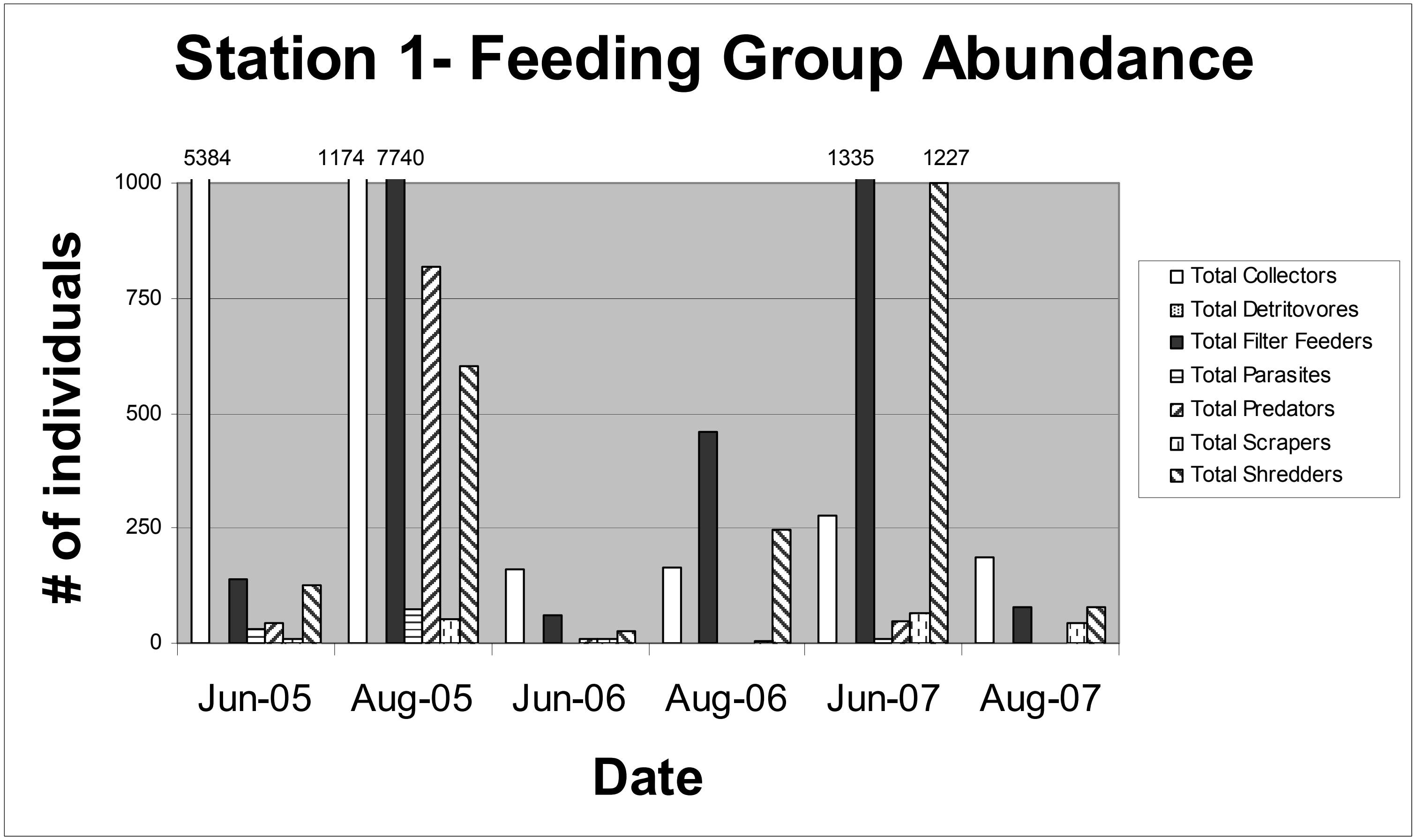

Figure 7. Feeding group presence at Station 1 in 2005, 2006 and 2007.

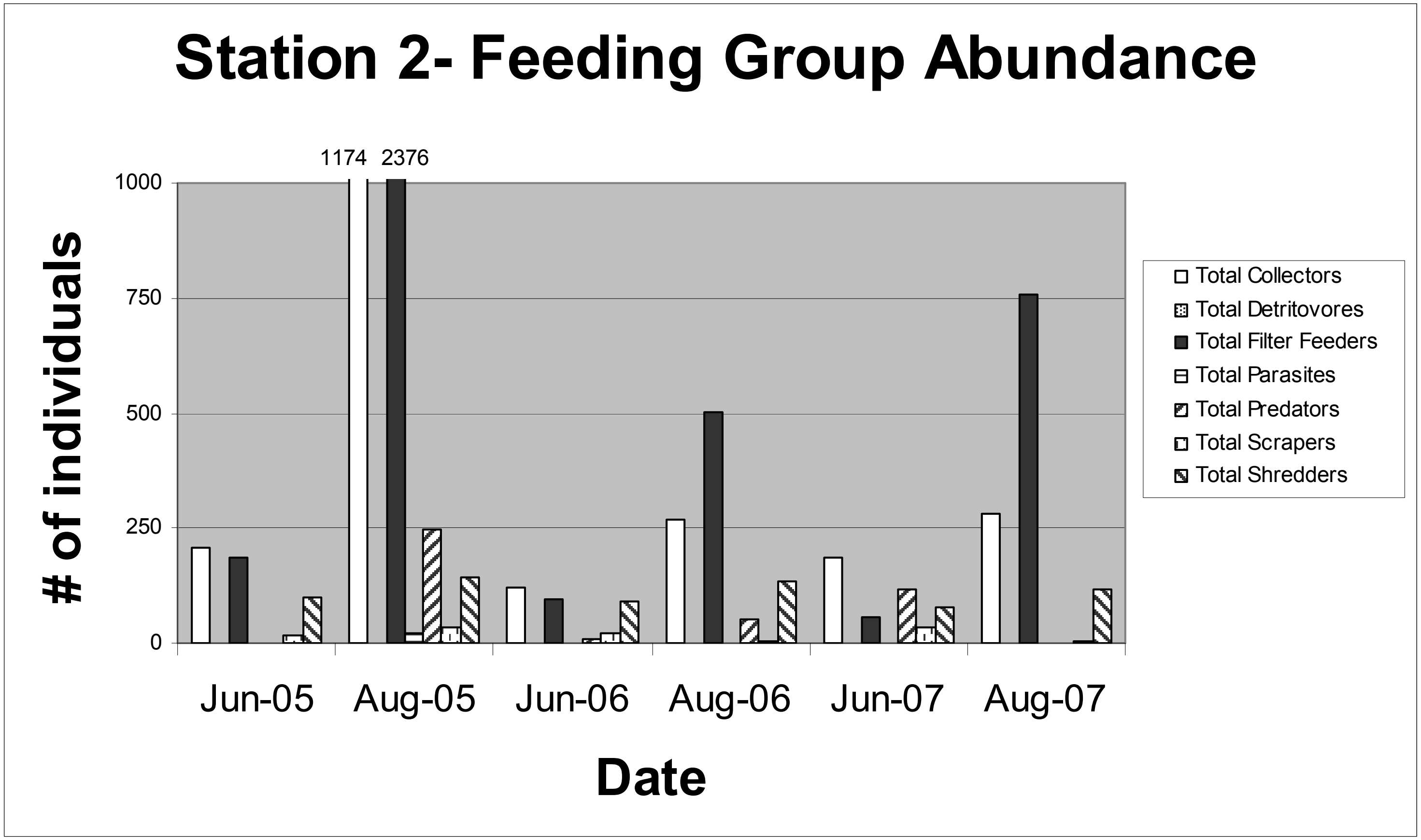

Figure 8. Feeding group presence at Station 2 in 2005, 2006 and 2007.

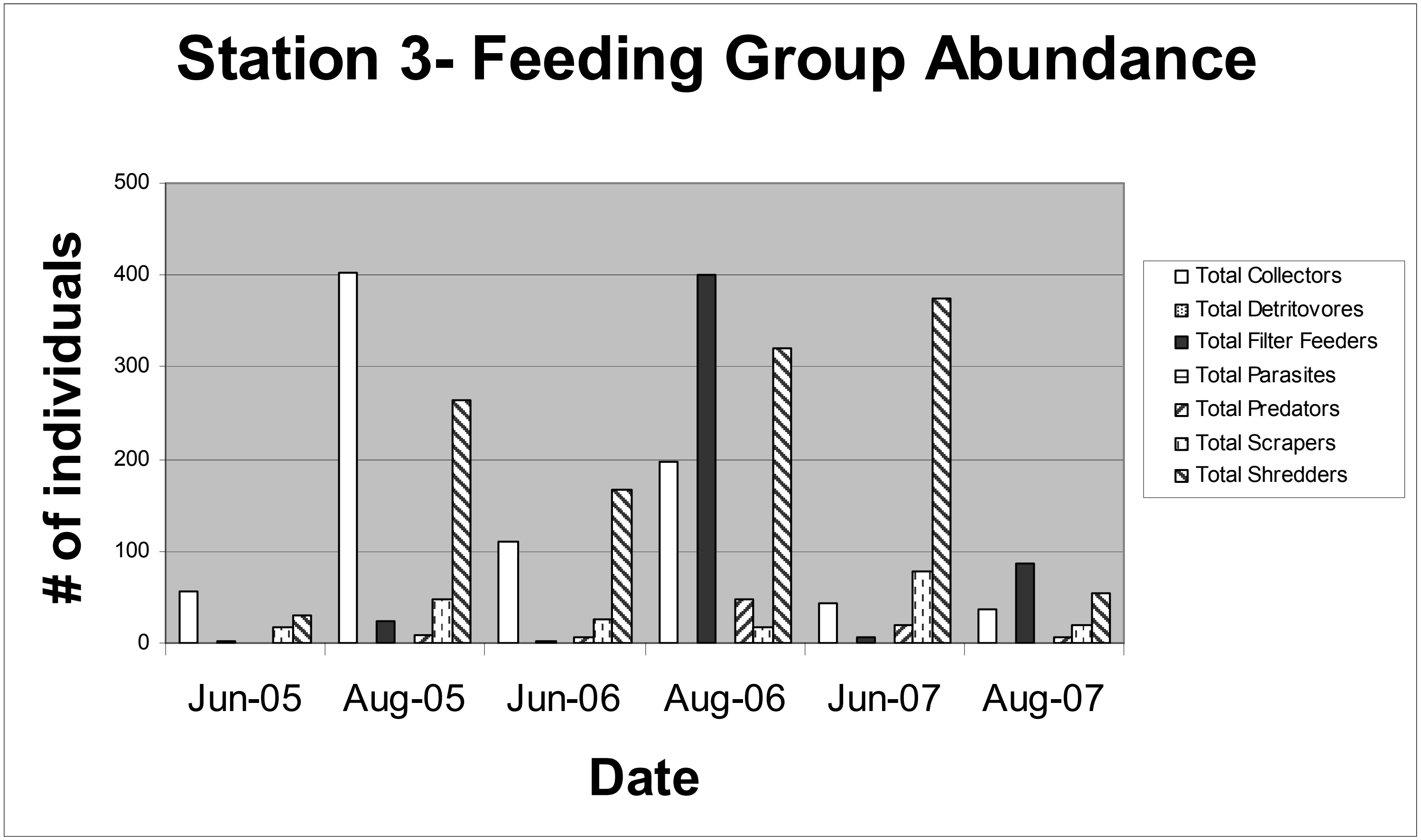

Figure 9. Feeding group presence at Station 3 in 2005, 2006 and 2007.

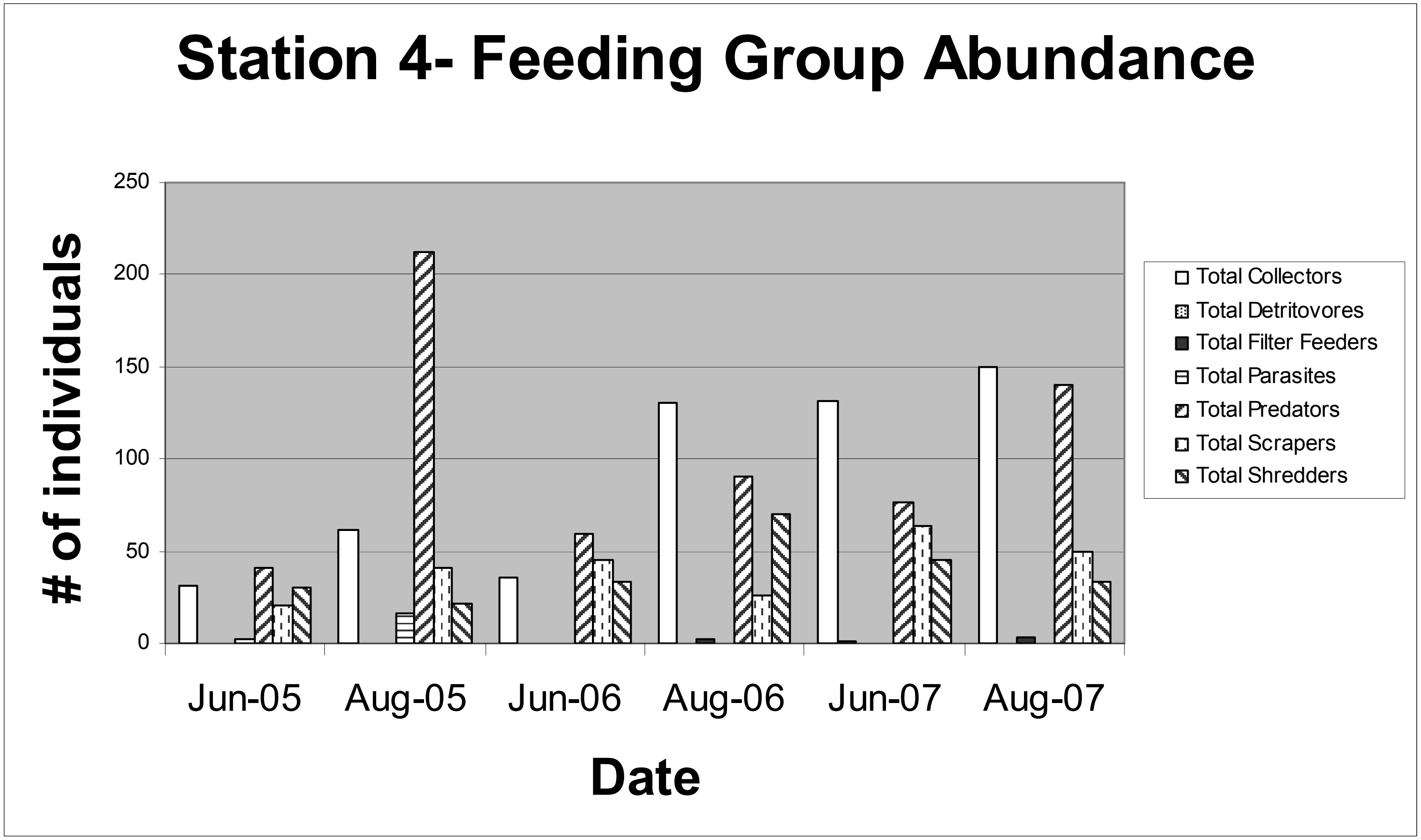

Figure 10. Feeding group presence at Station 4 in 2005, 2006 and 2007.

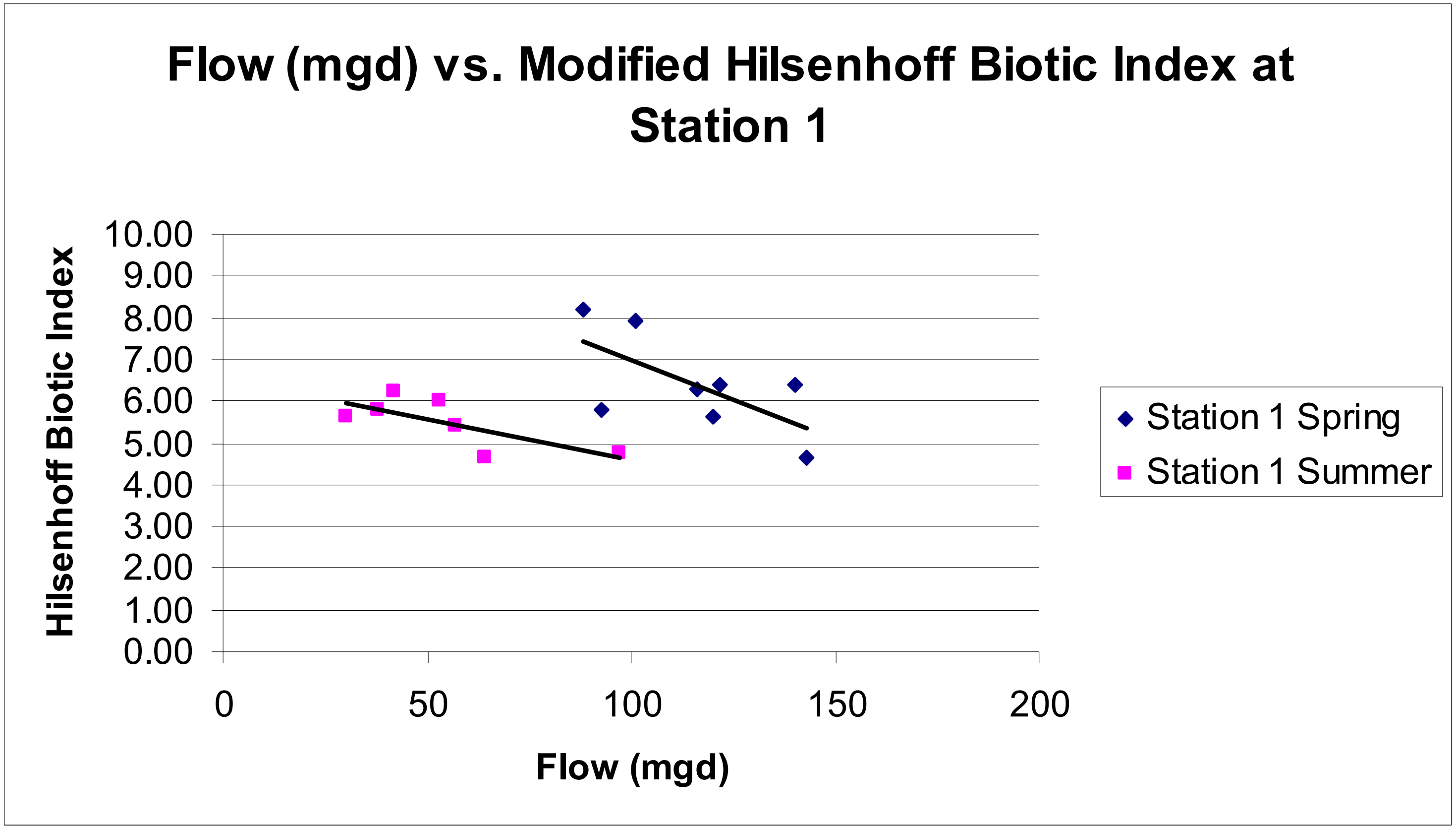

Figure 11. A graph of HBI values vs. average flow for 10 weeks prior to macroinvertebrate sampling for 2000-2007 at station 1. Flow values are based on water flow over the dam, downstream releases and blowoff.

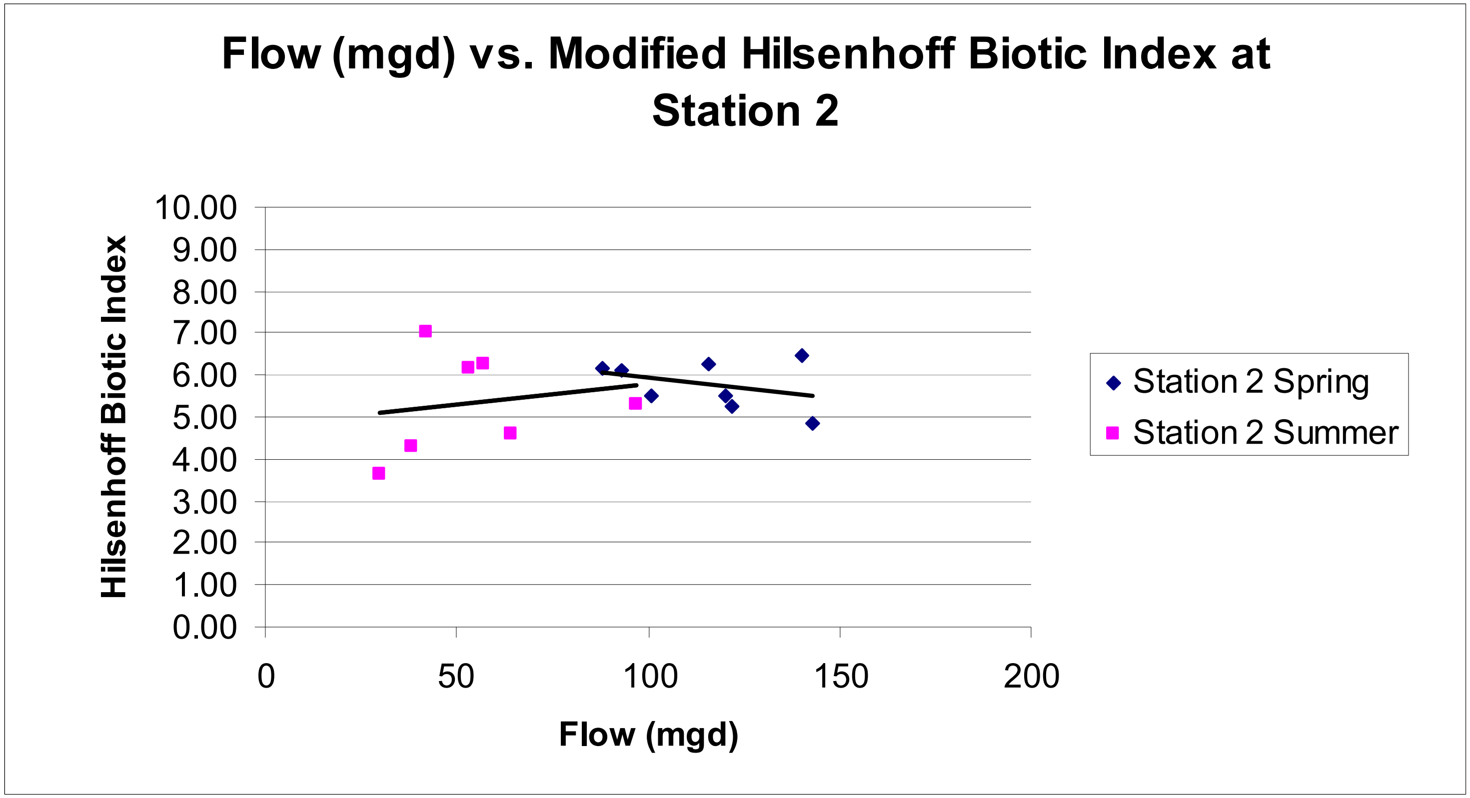

Figure 12. A graph of HBI values vs. average flow for 10 weeks prior to macroinvertebrate sampling for 2000-2007 at station 2. Flow values are based on water flow over the dam, downstream releases and blowoff.

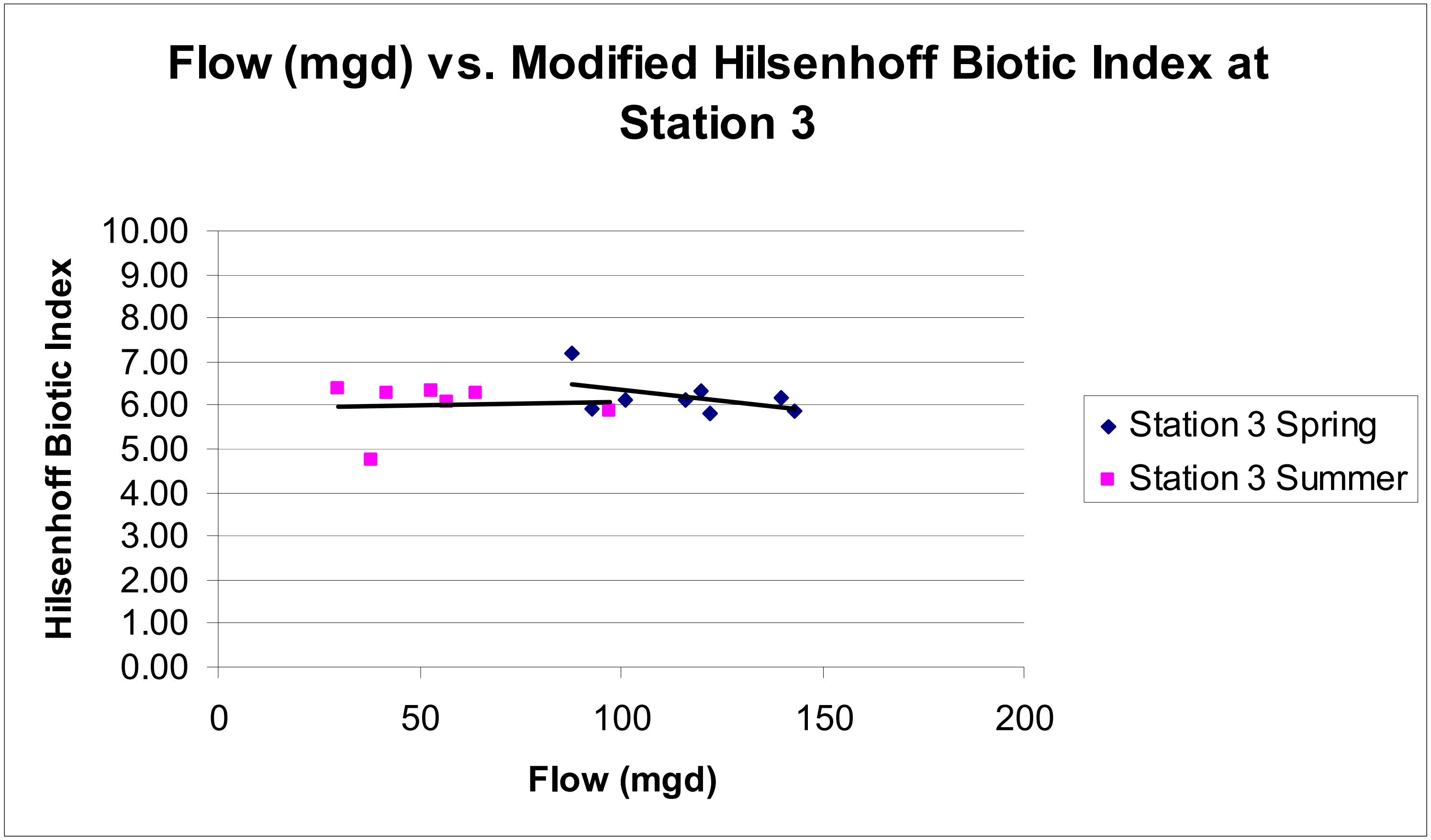

Figure 13. A graph of HBI values vs. average flow for 10 weeks prior to macroinvertebrate sampling for 2000-2007 at station 3. Flow values are based on water flow over the dam, downstream releases and blowoff.

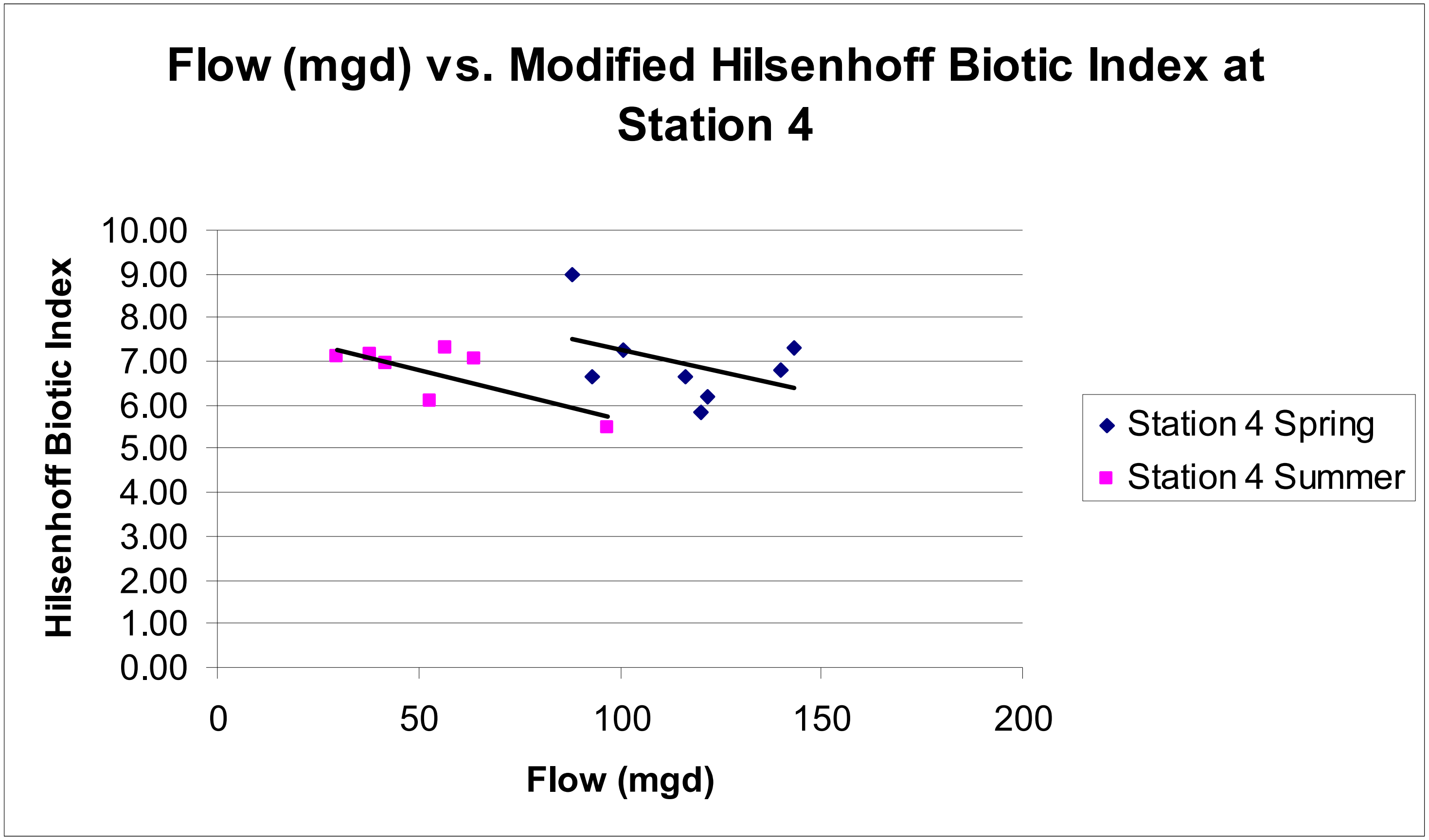

Figure 14. A graph of HBI values vs. average flow for 10 weeks prior to macroinvertebrate sampling for 2000-2007 at station 4. Flow values are based on water flow over the dam, downstream releases and blowoff.

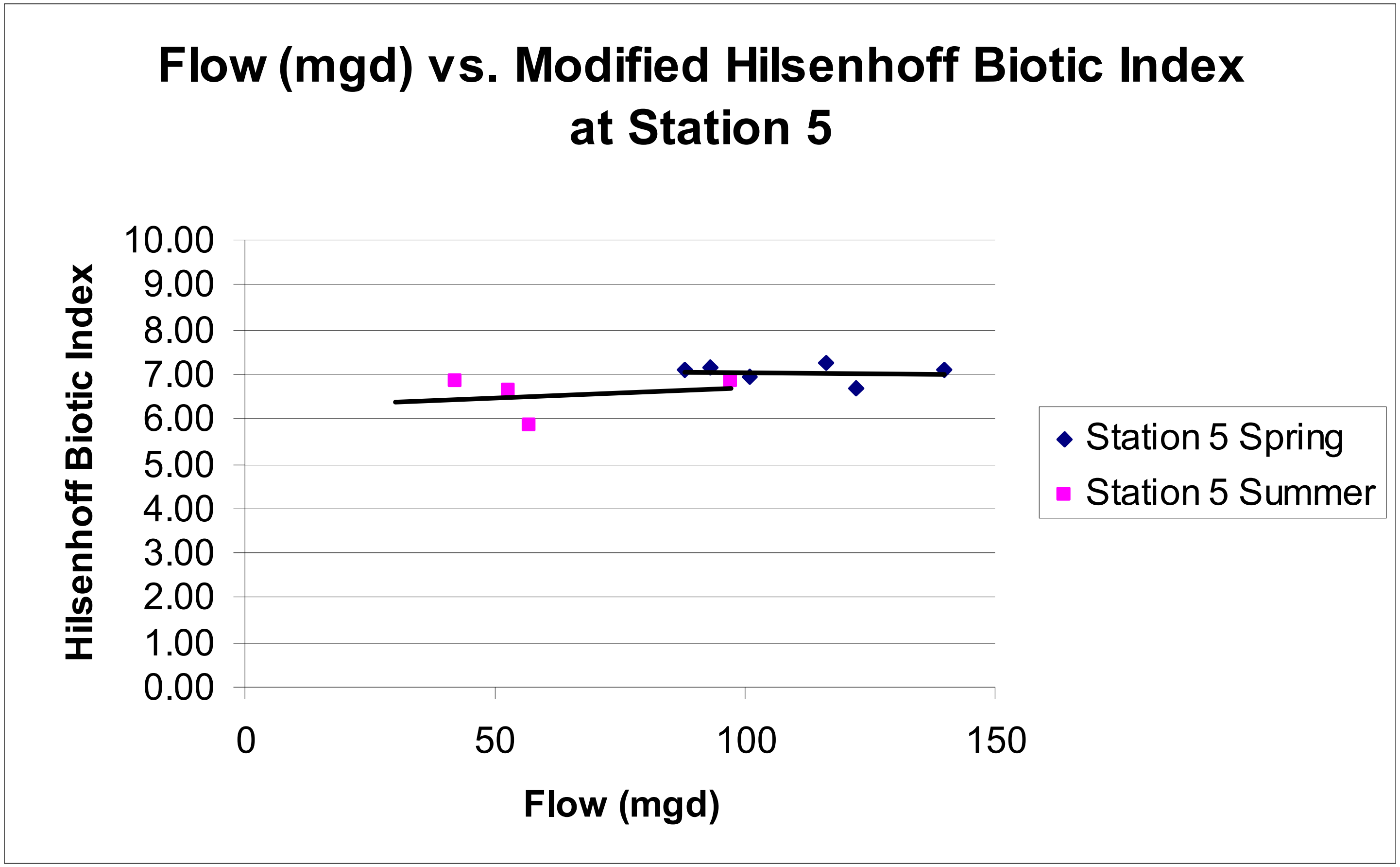

Figure 15. A graph of HBI values vs. average flow for 10 weeks prior to macroinvertebrate sampling for 2000-2005 at station 5. Flow values are based on water flow over the dam, downstream releases and blowoff.

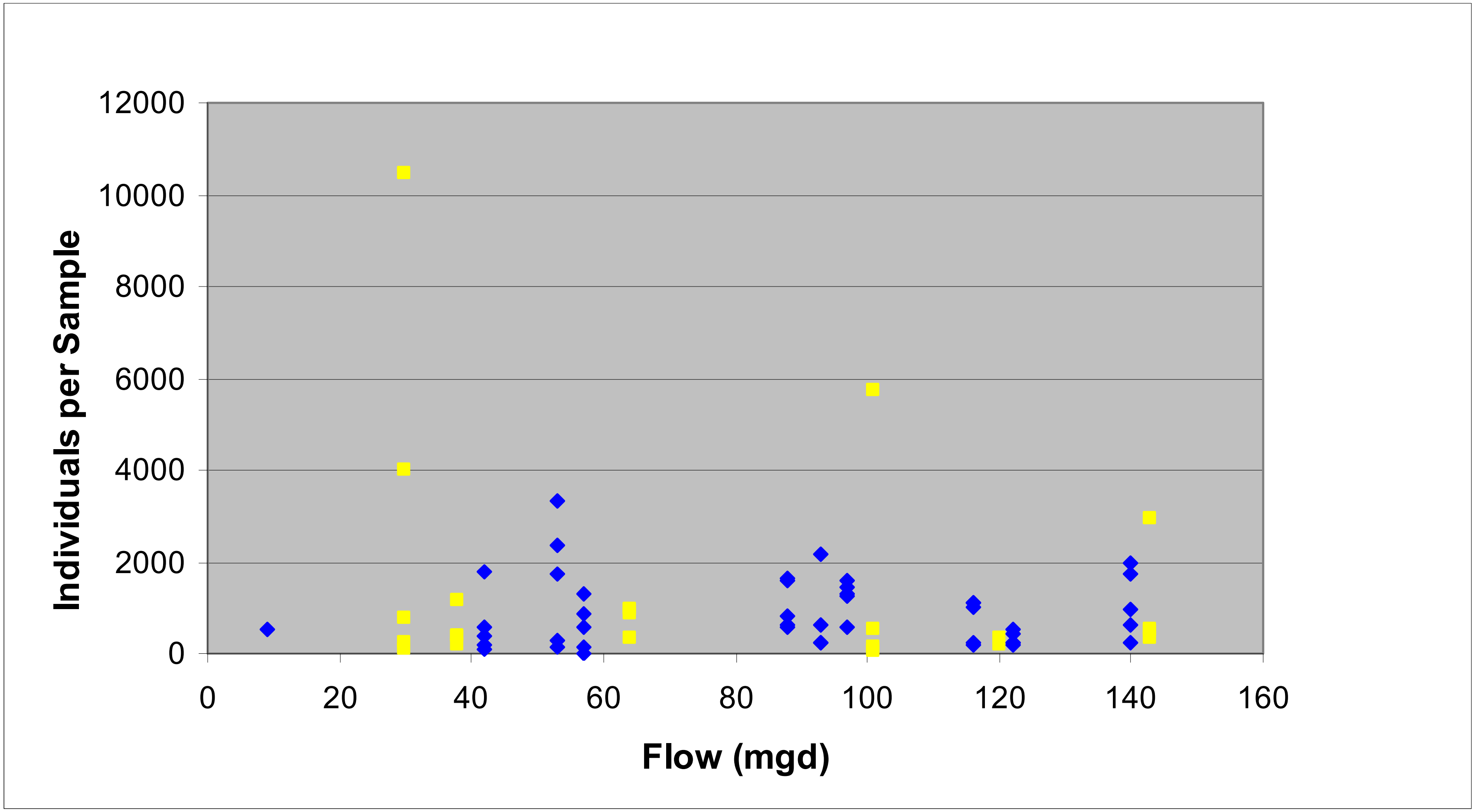

Figure 16. A graph of average flow for 10 weeks prior to macroinvertebrate sampling vs. total number of individuals for 2000-2007 invertebrate data. Pre-operation data is blue and post-operation data is yellow. Flow values are based on water flow over the dam, downstream releases and blowoff.

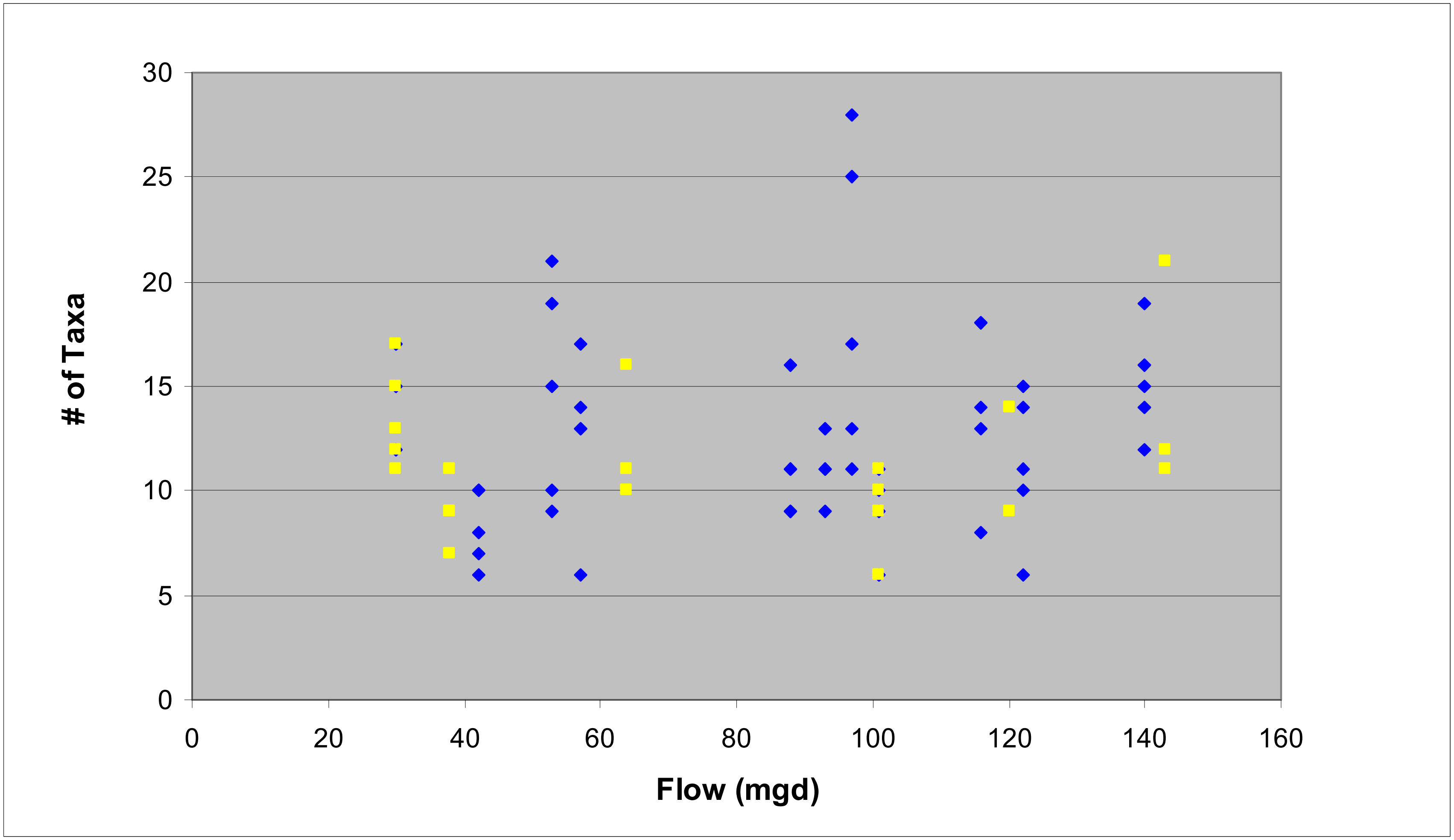

Figure 17. A graph of average flow for 10 weeks prior to macroinvertebrate sampling vs. number of taxa for 2000-2007 invertebrate data. Pre-operation data is blue and post-operation data is yellow. Flow values are based on water flow over the dam, downstream releases and blowoff.

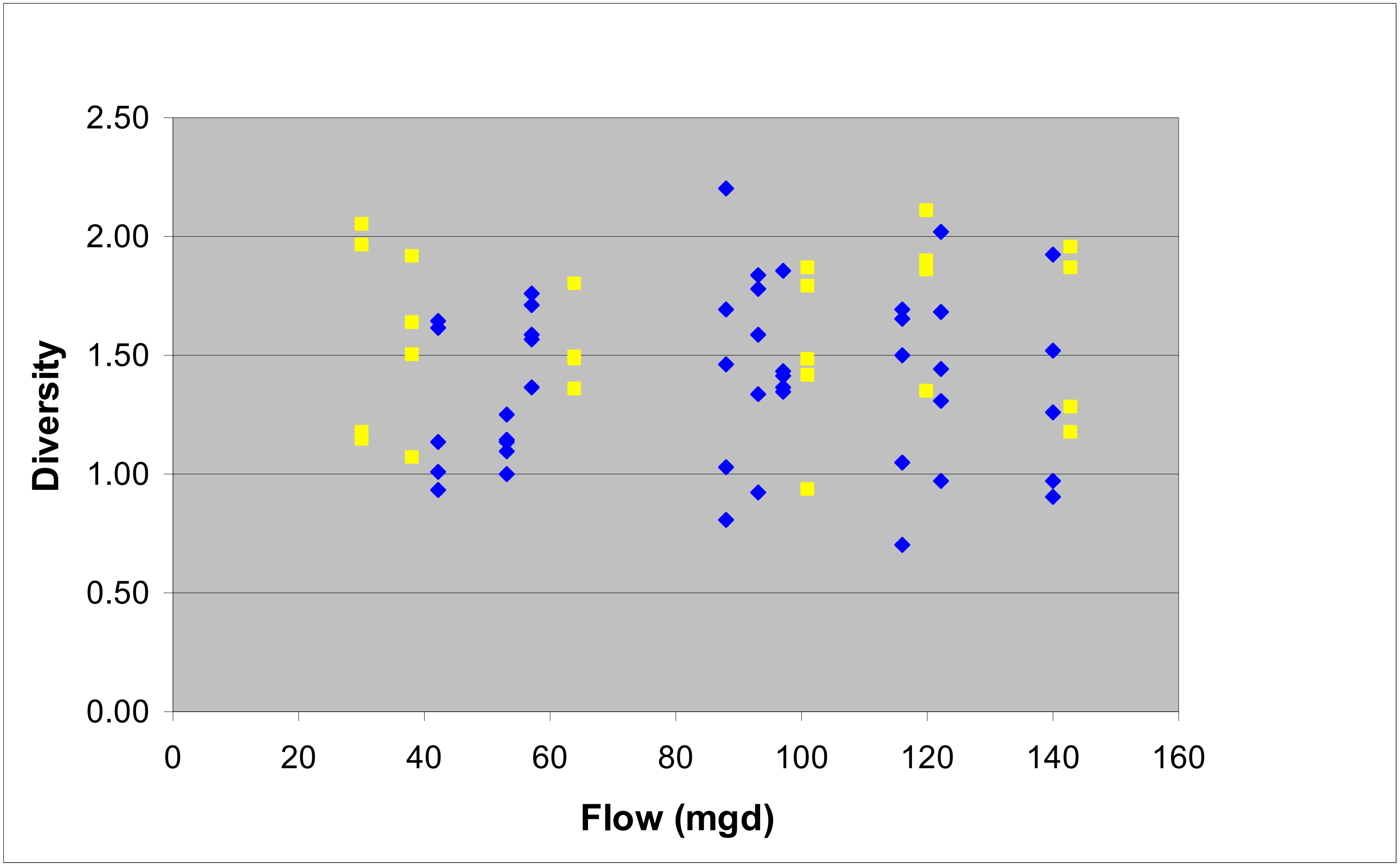

Figure 18. A graph of average flow for 10 weeks prior to macroinvertebrate sampling vs. diversity for 2000-2007 invertebrate data. Pre-operation data is blue and post-operation data is yellow. Flow values are based on water flow over the dam, downstream releases and blowoff.

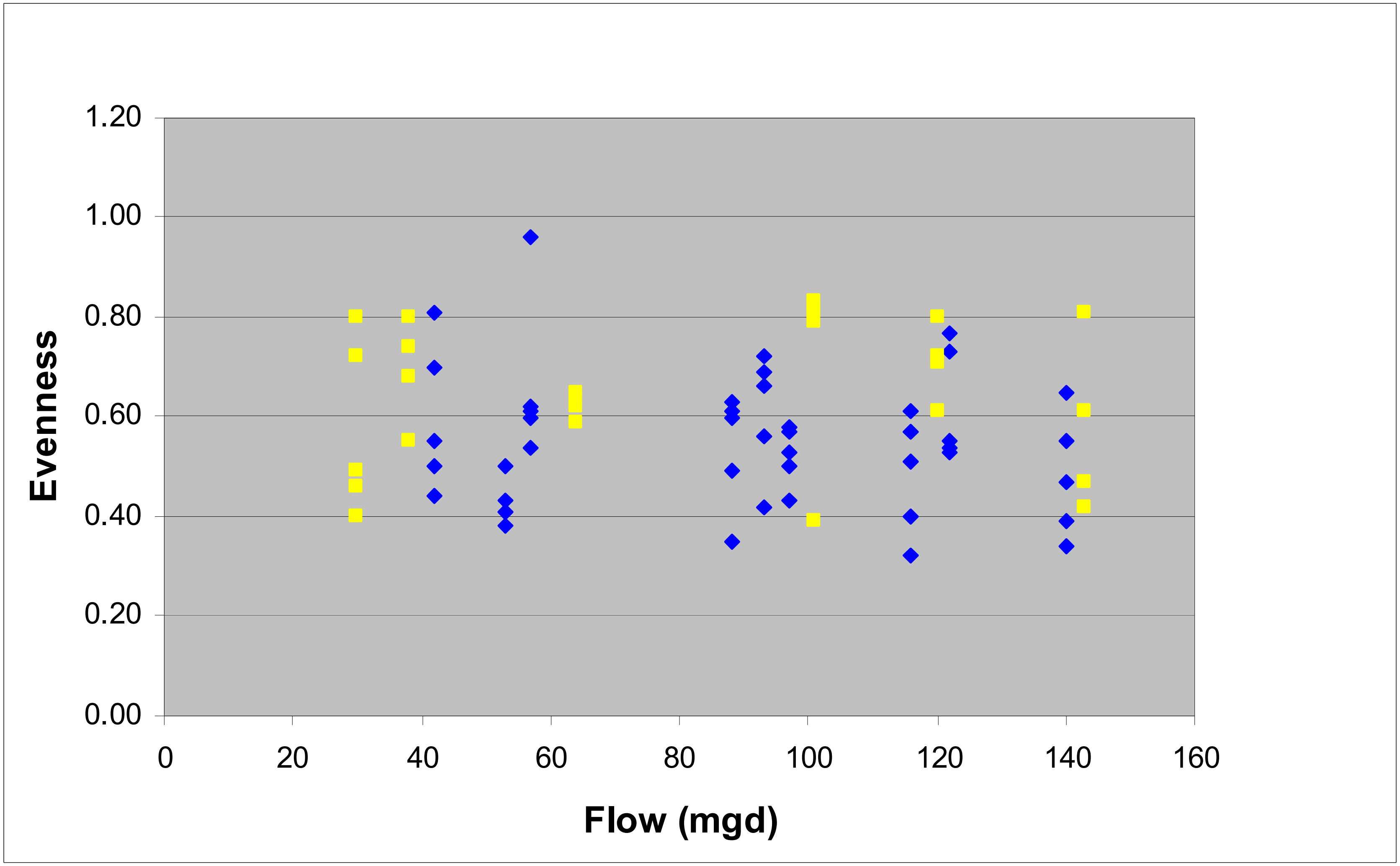

Figure 19. A graph of average flow for 10 weeks prior to macroinvertebrate sampling vs. evenness for 2000-2007 invertebrate data. Pre-operation data is blue and post-operation data is yellow. Flow values are based on water flow over the dam, downstream releases and blowoff.

Table 3. Tabular results of the Modified Hilsenhoff Biotic Index values for 2000-2007 at each station and the corresponding flows. Flow data for September 2004 are not available due to the Lake Whitney drawdown for maintenance.

	2000		2001		2002		2003		2004		2005		2006		2007	
	June	August	June	August	June	August	June	August	June	September	June	August	June	August	June	August
Station 1	6.31	6.00	6.40	5.39	8.21	6.25	6.37	4.75	5.79	6.83	7.91	5.61	5.65	4.65	4.63	5.8
Station 2	6.27	6.18	5.24	6.25	6.18	7.04	6.44	5.32	6.13	6.04	5.51	3.66	5.49	4.62	4.86	4.29
Station 3	6.13	6.33	5.81	6.08	7.19	6.25	6.20	5.85	5.90	5.58	6.13	6.39	6.34	6.30	5.88	4.72
Station 4	6.67	6.08	6.21	7.29	9.01	6.95	6.81	5.46	6.66	6.76	7.23	7.09	5.82	7.07	7.31	7.16
Station 5	7.25	6.62	6.69	5.86	7.10	6.83	7.10	6.85	7.14	7.41	6.93	6.91	*	*	*	*
Flow (mgd)	116	53	122	57	88	42	140	97	93		101	30	120	64	143	38

* Station 5 was eliminated from the sampling program in 2006

Table 4. Modified HBI values with suggested water quality designation and degree of organic pollution. Table taken from Mandeville 2002.

Biotic Index	Water Quality	Degree of Organic Pollution
0.00-3.50	Excellent	No apparent organic pollution
3.51-4.50	Very Good	Possible slight organic pollution
4.51-5.50	Good	Some organic pollution
5.51-6.50	Fair	Fairly significant organic pollution
6.51-7.50	Fairly Poor	Significant organic pollution
7.51-8.50	Poor	Very significant organic pollution
8.51-10.00	Very Poor	Severe organic pollution

2007 Lower Mill River Chironomid Taxonomic Study

Analysis of Mill River chironomids from all 2007 samples collected at stations 1-4 during June and August was conducted to assess variability in responses to hydrologic changes among subclassifications of chironomids beyond family level. Previous identification to just the family level was consistent with the methods used for other invertebrates. Further identification of chironomids involves addition sample preparation and examination at higher magnification, which was performed on a subset of previous samples in 2005 to assess potential richness increases. On the advice of a member of the Whitney Environmental Study Team that provides oversight for the overall environmental monitoring program, the SCCRWA agreed to expand sample analysis going forward to include this more detailed assessment of chironomids, although there is no pre-operational data to which these new data can be compared. Identifications followed Epler (2001) a recent and standard references for this group, with consideration of Simpson and Bode (1980), an older but more regionally appropriate text.

The results presented in Table 4 demonstrate moderate taxonomic richness and fairly consistent composition between stations and dates. There were a total of eight (8) taxa identified in 2007, representing four sub-families of the Chironomidae. Only three species occurred in a majority of samples. The dominant taxon varied slightly between stations and sampling dates but three taxa were the most common. The three most common chironomids in the June 2007 samples, in order of abundance were, *Dicrotendipes neomodestus, Cricotopus trifascia*, and *Polypedilum flavum*. All three taxa are common, and were also the dominant species encountered during the 2006 analysis. In August, the same three taxa were the dominants but there was a slight shift in abundance. The most common taxon present was *Polypedilum flavum*, followed by *Cricotopus trifascia*, and *Dicrotendipes neomodestus*. *Cardiocladius obscurum* and *Cricotopus intersectus* were the other two chironomid species found in at least half the samples, but at much lower numbers than the other three mentioned here. Remaining chironomid taxa were found at low densities in just a few samples. Compared to 2006, 2007 chironomid species richness (8 taxa vs. 14 taxa) and total number of individuals decreased; however the dominant species in both years were the same.

The ecological indications of virtually all encountered species were of minimal water quality preference (found in a wide range of chemical conditions), high tolerance for elevated nutrients and organic matter (eutrophic conditions), and wide tolerance of current speed with a general preference for moderate to high velocities. The ecological indications of the chironomid species present in the Mill River downstream of the Lake Whitney dam are entirely consistent with observed conditions.

Table 5. Tabular results of the 2006 and 2007 Chironomid analysis.

		1-Jun-06				17-Aug-06				19-Jun-07				15-Aug-07			
		Stations				Stations				Stations				Stations			
Taxon	WQ Tolerance	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Chironominae																	
Chironomini																	
Chironomus riparius	10					2											
Dicrotendipes neomodestus	8				1	28	80	15	18	42	1	11		12	5	6	5
Glyptotendipes lobiferus	10			5	2	3	6	10	14		3			8	10		
Paratendipes albimanus	6					6	8										
Polypedilum flavum	6	30	40	55	8	52	48	24	30	8	11	1		6	31	5	7
Polypedilum braseniae	6				1												
Polypedilum sp.	6							1									
Tanytarsini																	
Paratanytarsus sp.	6							1									
Rheotanytarsus exiguus group	6				3		3	4		13					5		1
Orthocladiinae																	
Cardiocladius obscurum	6												12	2	2	2	
Cricotopus trifascia	6	5	3	17	2	10		30	22				23	10	14	9	7
Cricotopus intersectus	7		5		2	4	6	12		2	3			1	4		
Cricotopus tibialis	7		1														
Cricotopus sylvestris	7		3	1													
Eukiefferiella tirolensis	8	8															
Tanypodinae																	
Procladius sp.	9											2					

DISCUSSION

Hydrologic conditions in 2007 varied between sampling events, but flows did not appear to have a negative impact on the benthic ecology of the river. Channel width and depth at each station were comparable to the range of values measured previously. In April 2007, a nor'easter was responsible for raising the river level to the base of the covered bridge. High flows exceeding 1 billion gallons per day related to the nor'easter may have scoured the bottom and washed invertebrates downstream, but invertebrate abundance was still high in June. Although August sampling occurred after a dry period, there was still an adequate amount of suitable benthic habitat available for macroinvertebrates and other aquatic organisms. One point of interest during the August sampling event was the presence of blue crabs at all stations. ENSR was able to collect and/or visually observed more than 20 adult blue crabs in the Mill River at station 1. ENSR has never observed blue crabs as far upstream as station 1, and has never seen such high numbers of blue crabs, yet salinity values were not elevated.

Differences in macroinvertebrate taxonomic composition between the upstream (stations 1 through 3) and downstream stations (station 4) may be ascribed mostly to differences in physical habitat and salinity exposure. Freshwater invertebrate tolerance to salinity is not well known, but some of the taxa found in the lower Mill River during previous years (e.g., scuds, damselflies, chironomid midges, beetles, and pulmonate snails) are found in relatively high numbers in moderately saline lakes (Colburn 1988; Alcocer et al. 1998).

The strikingly high invertebrate abundance at Stations 1 and 2 in 2005 was followed by a return to more typical densities in 2006. Initial recolonization of new substrates at station 1 in 2005, along with favorable flows and velocities after a period of diversion at Stations 1 and 2, likely resulted in the observed increases in abundance. It is possible however, that these inflated values could not be sustained long-term and declined in 2006, especially with elevated water velocities as experienced during multiple large storms and elevated summer downstream flows associated with a drawdown of the reservoir. High numbers of invertebrates were again present in the June 2007 sample at station 1. Although average spring flows 10 weeks preceding sampling were the highest recorded since study inception, and a large April nor'easter resulted in increased flows and velocities, the 5^{th} highest invertebrate abundance for any station on any date occurred in June 2007. Rapid recolonization ability or adaptations to withstand high flows may be responsible for increased abundance of some species after high flow events.

No clear patterns are apparent in the 2007 feeding group analysis. Collectors, filter feeders and shredders were the dominant feeding groups in June for station 1. Station 2 was dominated by collectors and predators in June, but shredder and filter feeder abundance decreased substantially compared to station 1. Changes between June and August samplings varied between stations and may be related to changes in habitat or water quality, although no significant differences were noted on the days of sampling. Feeding groups that were abundant at one station were not necessarily abundant at the next downstream station even when the stations are very close (e.g., stations 1 and station 2). Major shifts in feeding groups tend to be related to shifts in individual species abundance. *Macrostemum sp.*, a filter feeding caddisfly, was the most abundant taxon at station 1 in June and at station 2 in August. The first appearance of *Macrostemum* in the study area in great numbers (>500) occurred in 2003, and it has been abundant in each of the subsequent years.

In general, the macroinvertebrate assemblages observed in the Mill River were indicative of intermediate stream community health. The taxa collected at the four stations located along the Mill River may be commonly found in a range of environments (e.g., worms, scuds, prosobranch snails, caddisflies, mayflies). HBI values at stations 1-3 were within the fair category for most years while stations 4 and 5 were within the fairly poor category (Table 3). Most taxa found were typical of urban freshwater habitats (Walsh et al. 2001), where water quality impacts are common. Midges (Diptera, Chironomidae) and worms (Oligochaeta, *Nais communis*), which were common invertebrates, can be found in a variety of freshwater habitats (Wetzel 2001c), but their dominance in a community is often regarded as a sign of degraded conditions. However, the most common invertebrate again in 2007, *Macrostemum sp*., is less tolerant of pollution. The data show decreased numbers of *Macrostemum* in the downstream direction, indicating less favorable habitat or water quality conditions, such as dissolved oxygen and salinity. Dissolved oxygen (DO) monitoring conducted by SCCRWA has indicated that low flows in late summer/early fall lead to DO values consistently <5mg/L at station 4. In June, *Macrostemum* were only present at stations 1 and 2, but they were present at all stations in August.

This study represents the third year of post-operational macroinvertebrate data related to the withdrawal of water in Lake Whitney. As such, although we have attempted to make comparisons, not enough data have been collected to facilitate longer term comparisons among sites or within sites over time as they relate to the activation of the water treatment facility. Initial impressions from these data should be tempered with the larger data set that will be generated over the course of the planned study. Comparisons of flow and pre and post-operational data available thus far do not suggest any impacts of the water treatment facility going online.

As noted in the summary report for the 2000-2004 pre-operational monitoring program, changes in the invertebrate community over time may be a consequence of many environmental factors, including the desiccation of the stream during the dry summer months, changes in water quality, altered food abundance and quality, and predation effects. Flow is only one factor, and is likely to have more indirect effects at low levels. Variability in flow, inducing instability, may also be a potent factor in structuring the benthic macroinvertebrate community of the lower Mill River, and is linked to water quality issues (including dilution of contaminants from upstream and salinity from downstream), altered physical habitat, and available food resources. One water quality issue that may be present in the Mill River but not detected in the water chemistry results is the impact of sewage inputs into Mill River. During the August 2007 sampling event, the strong smell of sewage was present at station 3 in the vicinity of the Whitneyville Sewage Pump Station in Hamden.. This was the result of a leak in the pressurized sanitary sewer first reported by SCCRWA environmental staff in 2002, which discharged to a stormwater outfall adjacent to the Mill River. The Greater New Haven Water Pollution Control Authority (GNHWPCA) assumed ownership of the pump station from the Town of Hamden WPCA in 2005 and in the fall of 2007 conducted extensive repairs to a sewer serving the pump station.

Reduced flow may decrease invertebrate density and diversity (Gørtz 1998; Brunke et al. 2001), but flow interacts closely with the physical structure of the habitat. Streams with relatively low flow but a high degree of habitat heterogeneity (coarse detritus, rocks, submerged vegetation) may still support high invertebrate density, taxonomic richness and diversity (Brunke et al. 2001). Increased vegetation cover may be expected at lower flow regimes, thus counterbalancing (at least in part) the potentially negative effects of decreased flow by increasing substrate heterogeneity. Relatively rapid response of invertebrate communities suggests that recovery will occur within months after a drought period. In the Mill River, macroinvertebrate density tends to increase slightly with decreasing flow.

Effects of increased salinity on the lower Mill River invertebrate assemblages are difficult to predict, but would seem likely to be more severe than minor changes in flow. Reduced freshwater flow could increase salinity effects. Most of the taxa found in this survey may withstand small increases in salinity, with invertebrate communities shaped more by physical habitat characteristics than those fluctuations in salinity (Alcocer et al. 1998). However, effects of possible tide-related bursts in salinity, exacerbated by lower flow or removal of tide gates, could shift the community to a taxa-poor, low-diversity assemblage dominated by high salinity tolerant taxa (Wolfram et al. 1999). The current community at station 4, where salinity exposure is periodically elevated, already exhibits this condition. The upstream portion of the lower Mill River (stations 1 through 3) appears unlikely to be significantly affected by tide-driven salinity bursts, because of its higher elevation.

LITERATURE CITED

Alcocer J., E. Escobar, A. Lugo, & L. Peralta, 1998. Littoral benthos of the saline crater lakes of the basin of Oriental, Mexico. *International Journal of Salt Lake Research* 7: 87-108

Allan J. D., 1995. Stream Ecology – Structure and Function of Running Waters. Chapman & Hall, London, UK.

Barbour M. T., J. Gerritsen, B. D. Snyder, & J. B. Stribling, 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. Second edition. EPA 841-B-99-002. USEPA, Office of Water. Washington, DC.

Beckett D. C., P. A. Lewis, & J. H. Green, 1998. Where have all the Crangonyx gone? The disappearance of the amphipod Crangonyx pseudogracilis, and subsequent appearance of Gammarus nr. fasciatus, in the Ohio River. *The American Midland Naturalist* 139: 201-209

Brown K. M., 1991. Mollusca: Gastropoda. Pp. 285-314 in: Ecology and Classification of North American Freshwater Invertebrates, J. H. Thorp & A. P. Covich editors. Academic Press, San Diego, CA.

Brunke M., A. Hoffman, & M. Pusch, 2001. Use of mesohabitat specific relationships between flow velocity and river discharge to assess invertebrate minimum flow requirements. *Regulated Rivers: Research & Management* 17: 667-676

CH2M Hill, 2001. 2001 monitoring of Mill River dissolved oxygen and salinity – Hamden and New Haven, CT. Report for the SCCRWA.

CH2M Hill, 2002. 2002 Water Quality Monitoring, Mill River, Hamden and New Haven, CT. Report for the SCCRWA.

CH2M Hill, 2005. 2005 Water Quality Monitoring, Mill River, Hamden and New Haven, CT. Report for the SCCRWA.

CH2MHill, 2008. 2007 Water Quality Monitoring, Mill River, Hamden and New Haven, CT. Report for the SCCRWA.

Colburn E. A., 1988. Factors influencing species diversity in saline waters of Death Valley, USA. *Hydrobiologia* 158: 215-226

Crow G. E., and C. B. Hellquist, 1980. Aquatic Vascular Plants of New England. Part 1 through 8. Series of bulletins published by the New Hampshire Agricultural Experiment Station, University of New Hampshire. Durham, NH.

Diehl S., & R. Kornijów, 1998. Influence of submerged macrophytes on trophic interactions among fish and macroinvertebrates. Pp. 24-46 in: The Structuring Role of Submerged Macrophytes in Lakes; E. Jeppesen, Ma. Søndergaard, Mo. Søndergaard, and K. Christoffersen Editors. Springer-Verlag, New York, NY.

ENSR, 1998. Aquatic biological assessment of the Lower Mill River – Hamden, Connecticut. Final Report to the SCCRWA, 1998.

ENSR, 2000. Benthic biological assessment of the Lower Mill River – Hamden / New Haven (CT). Final report to the SCCRWA, 2000.

ENSR, 2001. Benthic biological assessment of the Lower Mill River – Hamden / New Haven (CT). Final report to the SCCRWA, 2001.

Epler, J. H. 2001. Identification manual for the larval chironomidae (Diptera) of North and South Carolina. USEPA Region IV, Atlanta Ga.

Gørtz P., 1998. Effects of stream restoration on the macroinvertebrate community in the River Esrom, Denmark. *Aquatic Conservation: Marine and Freshwater Ecosystems* 8: 115-130

Hixon M. A., & B. A. Menge, 1991. Species diversity: prey refuges modify the interactive effects of predation and competiiton. *Theoretical Population Biology* 39: 178-200

Lombardo P., 1997. Predation by Enallagma nymphs (Odonata, Zygoptera) under different conditions of spatial heterogeneity. *Hydrobiologia* 356: 1-9

Merritt R. W., & K. W. Cummins (editors), 1996. An Introduction to the Aquatic Insects of North America, third Edition. Kendall/Hunt Publishing, Dubuque, IA.

Peckarsky B. K., P. R. Fraissinet, M. A. Penton, & D. J. Conklin Jr., 1993. Freshwater Macroinvertebrates of Northeastern North America. Cornell Univ. Press, Ithaca, NY.

Pip E., 1986. The ecology of freshwater gastropods in the central Canadian region. *Nautilus* 100: 56-66

Rozan T. F., & G. Benoit, 2001. Mass balance of heavy metals in New Haven Harbor, Connecticut: predominance of nonpoint sources. *Limnology and Oceanography* 46: 2032-2049

Sabo M. J., C. F. Bryan, W. E. Kelso, & D. A. Rutherford, 1999. Hydrology and aquatic habitat characteristics of a riverine swamp: I. Influence of flow on temperature and water chemistry. *Regulated Rivers: Research & Management* 15: 505-523

Simpson, K. & R. Bode. 1980. Common larvae of Chironomidae (Diptera) from New York State streams and rivers. Bull. # 439, NY State Museum, Albany, NY.

Thorp J. H., & A. P. Covich (editors), 1991. Ecology and Classification of North American Freshwater Invertebrates. Academic Press, San Diego, CA.

Walsh C. J., A. K. Sharpe, P. F. Breen, & J. A. Sonneman, 2001. Effects of urbanization on streams of the Melbourne region, Victoria, Australia. I. Benthic macroinvertebrate communities. *Freshwater Biology* 46: 535-551

Wetzel R. G., 2001a. Oxygen. Chapter 9 in: Limnology - Lake and River Ecosystems, 3rd edition. Academic Press, San Diego, CA.

Wetzel R. G., 2001b. The inorganic carbon complex. Chapter 11 in: Limnology - Lake and River Ecosystems, 3rd edition. Academic Press, San Diego, CA.

Wetzel R. G., 2001c. Littoral and profundal benthic communities of lakes. Pp. 702-705 in: Limnology - Lake and River Ecosystems, 3rd edition. Academic Press, San Diego, CA.

Wolfram G., K. Donabaum, M. Schagerl, & V. A. Kowarc, 1999. The zoobenthic community of shallow salt pans in Austria – preliminary results on phenology and the impact of salinity on benthic invertebrates. *Hydrobiologia* 408/409: 193-202

APPENDIX A

2005-2007 Benthic Macroinvertebrate Data

ENSR | AECOM

					13-Jun-05					23-Aug-05				
					Stations					Stations				
					1	2	3	4	5	1	2	3	4	5
Class	**Order**	**Family**	**Genus/Species**	**Feeding Group**										
Annelida	Hirudinea	Glossiphoniidae	Glossiphonia complanata	Parasite										
Annelida	Hirudinea	Glossiphoniidae	Placobdella sp.	Parasite										
Annelida	Hirudinea		Hirudinia	Parasite	30					53	10			
Annelida	Oligochaeta	Lumbriculidae	Unidentified Lumbriculidae	Collector										
Annelida	Oligochaeta	Naididae	Nais communis	Collector	4127	55		17		367	7	13		
Annelida	Oligochaeta	Oligochaeta	Unidentified Oligochaeta	Collector						20				
Annelida	Oligochaeta	Tubificidae	Limnodrilus hoffmeisteri	Collector										
Annelida	Oligochaeta	Tubificidae	Unidentified Tubificidae	Collector										
Annelida	Polychaeta	Ampherididae	Unidentified Ampherididae	Detritivore										
Annelida	Polychaeta	Capitellidae	Heteromastus filiformis	Detritivore										
Annelida	Polychaeta	Spionidae	Marenzellaria viridis	Filter Feeder										
Annelida	Polychaeta	Spionidae	Polydora sp.	Detritivore										
Arachnida	Trombidiformes	Lebertiidae	Lebertia sp.	Predator								1	3	
Arachnoidea	Hydracarina	Arrenuridae	Unidentified Arrenuridae	Parasite				2					3	
Bivalvia	Veneorida	Pisidiidae	Pisidium sp.	Filter Feeder										
Branchiopoda	Cladocera		cladocera	Collector										
Crustacea	Amphipoda	Corophiidae	Corophium sp. (juvenile)	Filter Feeder										
Crustacea	Amphipoda	Crangonyctidae	Crangonyx sp.	Shredder	77	18				67				
Crustacea	Amphipoda	Gammaridae	Gammarus sp.	Shredder	50	82	30	30	12	247	137	264	15	14
Crustacea	Cumacea	Nannasticidae	Almyracuma proximoculi	Shredder										
Crustacea	Decapoda	Palaemonidae	Paleomonetes vulgaris	Shredder										8
Crustacea	Decapoda	Palaemonidae	Paleomonetes paludosus	Shredder										
Crustacea	Decapoda	Portunidae	Carcinus maenus	Shredder										1
Crustacea	Isopoda	Asellidae	Caecidotea communis	Collector										
Crustacea	Isopoda	Asellidae	Lirceus/Acellus sp. (communis)	Shredder										
Hydrozoa	Hydroida	Hydridae	Hydra sp.	Predator										
Insecta	Coleoptera	Brachyceridae	Brachycerus sp.	Collector					2			1		
Insecta	Coleoptera	Chrysomelidae	Donacia	Shredder									7	2
Insecta	Coleoptera	Coleoptera	Unidentified Coleoptera	Predator										
Insecta	Coleoptera	Curculionidae	Unidentifed Curculionidae	Shredder										
Insecta	Coleoptera	Dryopidae	Helichus sp.	Predator										
Insecta	Coleoptera	Elmidae	Stenelmis sp.	Scraper	10	16	18	3		20	24	48	20	1
Insecta	Coleoptera	Haliplidae	Peltodytes	Shredder										
Insecta	Coleoptera	Hydrophilidae	Berosus sp.	Predator		2		2		20			3	1
Insecta	Coleoptera	Psephenidae	Unidentified Psephenidae	Predator										
Insecta	Diptera	Atrichopogon	Atrichopogon	Predator	10			3						1
Insecta	Diptera	Ceratopognidae	Unidentified Ceratopognidae	Predator										
Insecta	Diptera	Chironomidae	Unidenitifed Chironomidae	Collector	1130	139	35	14	22	747	1087	385	48	23
Insecta	Diptera	Diptera	Unidentified Diptera	Collector	127	15	21			40	80	4	7	1
Insecta	Diptera	Empididae	Empididae	Predator						533	227			
Insecta	Diptera	Empididae	Hemerodromia sp.	Filter Feeder										
Insecta	Diptera	Simuliidae	Simulium sp.	Filter Feeder	50	39				33				
Insecta	Diptera	Tabanidae	tabanidae	Predator	33									
Insecta	Diptera	Tachinidae	Ceracia	Parasite										
Insecta	Diptera	Tipulidae	Unidentified Tipulidae	Shredder						287	7	1		
Insecta	Ephemeroptera	Baetidae	Baetis sp	Collector					2				6	6
Insecta	Ephemeroptera	Caenidae	Caenis sp.	Collector										
Insecta	Ephemeroptera	Ephemerellidae	Unidentified Ephemerellidae	Collector										
Insecta	Ephemeroptera	Heptageniidae	Stenonema sp.	Scraper										
Insecta	Ephemeroptera	Oligoneuridae	Isonychia sp.	Collector										
Insecta	Hemiptera	Aphididae	aphididae	Predator									133	
Insecta	Hemiptera	Hemiptera	Unidentified Hemiptera	Predator										
Insecta	Heteroptera	Gerridae	Unidentified Gerridae	Predator										
Insecta	Heteroptera	Gerridae	Rheumatobates sp.	Predator										1
Insecta	Heteroptera	Mesoveliidae	Mesovelia sp.	Predator										
Insecta	Heteroptera	Veliidae	Microvelia	Predator										
Insecta	Neuroptera	Sisyridae	Sisyira sp.	Predator										
Insecta	Odonata	Calopterygidae	Calopteryx spp	Predator										
Insecta	Odonata	Coenagrionidae	Argia sp.	Predator										
Insecta	Odonata	Coenagrionidae	Ischnura/Enallagma sp.	Predator										
Insecta	Odonata	Coenagrionidae	Nehalennia	Predator				36	16				73	34
Insecta	Odonata	Cordulegastridae	Epitheca	Predator										
Insecta	Odonata	Corduliidae	Didymops sp.	Predator										
Insecta	Odonata	Corduliidae	Somatochlora sp.	Predator										
Insecta	Odonata		Anisoptera (juvenile)	Predator										
Insecta	Odonata		zygoptera fragments	Predator										
Insecta	Trichoptera	Brachycentridae	Brachycentrus sp.	Filter Feeder										
Insecta	Trichoptera	Brachycentridae	Micrasema sp.	Filter Feeder										
Insecta	Trichoptera	Glossosomatidae	Glossosoma	Scraper										
Insecta	Trichoptera	Hydropsychidae	Hydropsyche sp.	Filter Feeder										
Insecta	Trichoptera	Hydropsychidae	Macrostemum sp.	Filter Feeder	90	145	3			7707	2376	24		3
Insecta	Trichoptera	Hydropsychidae	Parapsyche sp.	Filter Feeder										
Insecta	Trichoptera	Hydroptilidae	Agraylea sp.	Parasite						20	10	1	13	
Insecta	Trichoptera	Hydroptilidae	Orthotrichia sp.	Predator										
Insecta	Trichoptera	Hydroptilidae	Oxyethira sp.	Predator										
Insecta	Trichoptera	Leptoceridae	Ceraclea sp.	Collector										
Insecta	Trichoptera	Leptoceridae	Mystacides sp.	Collector										
Insecta	Trichoptera	Leptoceridae	Triaenodes sp.	Shredder										
Insecta	Trichoptera	Limnephilidae	Rossiana sp.	Scraper										
Insecta	Trichoptera	Limnephilidae	Unidentified Limnephilidae	Scraper										
Insecta	Trichoptera	Philopotamidae	Chimarra spp	Filter Feeder										
Insecta	Trichoptera	Psychomyiidae	Psychomyia sp.	Collector										
Insecta	Trichoptera	Uenoidae	Neophylax	Shredder										1
Malacostraca	Amphipoda	Hyalellidae	Hyalella azteca	Collector										
Malacostraca	Decapoda	Cambaridae	Orconectes limosus	Shredder										
Malacostraca	Decapoda	Cambaridae	Unidentified Cambaridae	Shredder			1		2					
Maxillopoda	Sessilia	Balanidae	Balanus improvisus	Filter Feeder										
Mollusca	Bivalvia	Sphaeriidae	Unidentified Sphaeriidae	Scraper										
Mollusca	Gastropoda	Ancylidae	Ferrissia rivularis	Scraper										
Mollusca	Gastropoda	Gastropoda	Unidentified Gastropoda	Scraper										
Mollusca	Gastropoda	Hydrobiidae	Amnicola limosa/Bithynia tentaulata	Scraper						33			13	
Mollusca	Gastropoda	Hydrobiidae	Pomatiopsis sp.	Scraper										
Mollusca	Gastropoda	Lymnaeidae	Lymnaea columella	Scraper										
Mollusca	Gastropoda	Physidae	Physa sp.	Scraper				3					8	3
Mollusca	Gastropoda	Planorbidae	Gyraulus circumstriatus	Scraper										
Mollusca	Gastropoda	Planorbidae	Gyraulus deflectus	Scraper										
Mollusca	Gastropoda	Planorbidae	Gyraulus parvus	Scraper										
Mollusca	Gastropoda	Planorbidae	Helisoma sp.	Scraper				15			10			
Mollusca	Gastropoda	Pleuroceridae	Pleurocera sp.	Scraper										
Mollusca	Gastropoda	Valvatidae	Valvata tricarinata	Scraper										
Nemertea	Nemertea	Nemertea	Unidentified Nemertea	Predator						33				
Turbellaria	Tricladida	Dugesiidae	Dugesia sp.	Predator						233	20	7		
				Total Individuals	5734	511	108	125	56	10460	3995	749	352	100
				Total Taxa	11	9	6	10	6	17	12	11	14	15

					1-Jun-06				1-Aug-06			
					Stations				Stations			
					1	2	3	4	1	2	3	4
Class	**Order**	**Family**	**Genus/Species**	**Feeding Group**								
Annelida	Hirudinea	Glossiphoniidae	Glossiphonia complanata	Parasite								
Annelida	Hirudinea	Glossiphoniidae	Placobdella sp.	Parasite								
Annelida	Hirudinea		Hirudinia	Parasite								
Annelida	Oligochaeta	Lumbriculidae	Unidentified Lumbriculidae	Collector								
Annelida	Oligochaeta	Naididae	Nais communis	Collector	14	2			5			
Annelida	Oligochaeta	Oligochaeta	Unidentified Oligochaeta	Collector				4				
Annelida	Oligochaeta	Tubificidae	Unidentified Tubificidae	Collector								
Annelida	Oligochaeta	Tubificidae	Limnodrilus hoffmeisteri	Collector								
Annelida	Polychaeta	Ampherididae	Unidentified Ampherididae	Detritivore								
Annelida	Polychaeta	Capitellidae	Heteromastus filiformis	Detritivore								
Annelida	Polychaeta	Spionidae	Marenzellaria viridis	Filter Feeder								
Annelida	Polychaeta	Spionidae	Polydora sp.	Detritivore								
Arachnida	Trombidiformes	Lebertiidae	Lebertia sp.	Predator							5	
Arachnoidea	Hydracarina	Arrenuridae	Unidentified Arrenuridae	Parasite								
Bivalvia	Veneorida	Pisidiidae	Pisidium sp.	Filter Feeder								2
Branchiopoda	Cladocera		cladocera	Collector								
Crustacea	Amphipoda	Corophiidae	Corophium sp. (juvenile)	Filter Feeder								
Crustacea	Amphipoda	Crangonyctidae	Crangonyx sp.	Shredder	4	5	6	1				
Crustacea	Amphipoda	Gammaridae	Gammarus sp.	Shredder	10	83	161	31	241	117	316	70
Crustacea	Cumacea	Nannasticidae	Almyracuma proximoculi	Shredder								
Crustacea	Decapoda	Palaemonidae	Paleomonetes vulgaris	Shredder								
Crustacea	Decapoda	Palaemonidae	Paleomonetes paludosus	Shredder								
Crustacea	Decapoda	Portunidae	Carcinus maenus	Shredder								
Crustacea	Isopoda	Asellidae	Caecidotea communis	Collector	34	36	0	1	4	0	4	6
Crustacea	Isopoda	Asellidae	Lirceus/Acellus sp. (communis)	Shredder								
Hydrozoa	Hydroida	Hydridae	Hydra sp.	Predator								
Insecta	Coleoptera	Brachyceridae	Brachycerus sp.	Collector								8
Insecta	Coleoptera	Chrysomelidae	Donacia	Shredder								
Insecta	Coleoptera	Coleoptera	Unidentified Coleoptera	Predator								
Insecta	Coleoptera	Curculionidae	Unidentifed Curculionidae	Shredder								
Insecta	Coleoptera	Dryopidae	Helichus sp.	Predator								
Insecta	Coleoptera	Elmidae	Stenelmis sp.	Scraper	8	2	20	44	5	4	8	18
Insecta	Coleoptera	Haliplidae	Peltodytes	Shredder								
Insecta	Coleoptera	Hydrophilidae	Berosus sp.	Predator	7	1	7		1			
Insecta	Coleoptera	Psephenidae	Unidentified Psephenidae	Predator								
Insecta	Diptera	Atrichopogon	Atrichopogon	Predator								
Insecta	Diptera	Ceratopogonidae	Probezzia	Predator				1				
Insecta	Diptera	Ceratopognidae	Unidentified Ceratopognidae	Predator								
Insecta	Diptera	Chironomidae	Unidenitifed Chironomidae	Collector	61	66	86	24	134	216	142	107
Insecta	Diptera	Diptera	Unidentified Diptera	Collector	50	15	24	5	22	51	30	4
Insecta	Diptera	Empididae	Empididae	Predator						49	42	
Insecta	Diptera	Empididae	Hemerodromia sp.	Filter Feeder								
Insecta	Diptera	Simuliidae	Simulium sp.	Filter Feeder	6	1	1		44	37		
Insecta	Diptera	Tabanidae	tabanidae	Predator								
Insecta	Diptera	Tachinidae	Ceracia	Parasite								
Insecta	Diptera	Tipulidae	Unidentified Tipulidae	Shredder	3	3	0	0	4	17	4	
Insecta	Ephemeroptera	Baetidae	Baetis sp	Collector				1				2
Insecta	Ephemeroptera	Caenidae	Caenis sp.	Collector								
Insecta	Ephemeroptera	Ephemerellidae	Unidentified Ephemerellidae	Collector								
Insecta	Ephemeroptera	Heptageniidae	Stenonema sp.	Scraper								
Insecta	Ephemeroptera	Oligoneuridae	Isonychia sp.	Collector								
Insecta	Hemiptera	Aphididae	aphididae	Predator	1						1	
Insecta	Hemiptera	Gelastocoridae	Gelastocoris	Predator								1
Insecta	Hemiptera	Hemiptera	Unidentified Hemiptera	Predator								
Insecta	Heteroptera	Gerridae	Rheumatobates sp.	Predator								1
Insecta	Heteroptera	Gerridae	Unidentified Gerridae	Predator								
Insecta	Heteroptera	Mesoveliidae	Mesovelia sp.	Predator								
Insecta	Heteroptera	Veliidae	Microvelia	Predator								
Insecta	Neuroptera	Sisyridae	Sisyira sp.	Predator								
Insecta	Odonata	Calopterygidae	Calopteryx spp	Predator								
Insecta	Odonata	Coenagrionidae	Nehalennia	Predator				50				80
Insecta	Odonata	Coenagrionidae	Ischnura/Enallagma sp.	Predator								
Insecta	Odonata	Coenagrionidae	Argia sp.	Predator		2		3				2
Insecta	Odonata	Cordulegastridae	Epitheca	Predator								
Insecta	Odonata	Corduliidae	Epicordulia	Predator				5				6
Insecta	Odonata	Corduliidae	Somatochlora sp.	Predator								
Insecta	Odonata	Corduliidae	Didymops sp.	Predator								
Insecta	Odonata		Anisoptera (juvenile)	Predator								
Insecta	Odonata		zygoptera fragments	Predator								
Insecta	Trichoptera	Brachycentridae	Brachycentrus sp.	Filter Feeder								
Insecta	Trichoptera	Brachycentridae	Micrasema sp.	Filter Feeder								
Insecta	Trichoptera	Glossosomatidae	Glossosoma	Scraper								
Insecta	Trichoptera	Hydropsychidae	Macrostemum sp.	Filter Feeder	56	92	1		416	468	401	
Insecta	Trichoptera	Hydropsychidae	Hydropsyche sp.	Filter Feeder								
Insecta	Trichoptera	Hydropsychidae	Parapsyche sp.	Filter Feeder								
Insecta	Trichoptera	Hydroptilidae	Agraylea sp.	Parasite						1	22	2
Insecta	Trichoptera	Hydroptilidae	Oxyethira sp.	Predator								
Insecta	Trichoptera	Hydroptilidae	Orthotrichia sp.	Predator								
Insecta	Trichoptera	Leptoceridae	Ceraclea sp.	Collector								
Insecta	Trichoptera	Leptoceridae	Mystacides sp.	Collector								
Insecta	Trichoptera	Leptoceridae	Triaenodes sp.	Shredder								
Insecta	Trichoptera	Limnephilidae	Rossiana sp.	Scraper								
Insecta	Trichoptera	Limnephilidae	Unidentified Limnephilidae	Scraper				1				
Insecta	Trichoptera	Philopotamidae	Chimarra spp	Filter Feeder								
Insecta	Trichoptera	Psychomyiidae	Psychomyia sp.	Collector								
Insecta	Trichoptera	Uenoidae	Neophylax	Shredder	11			1				
Malacostraca	Amphipoda	Hyalellidae	Hyalella azteca	Collector								
Malacostraca	Decapoda	Cambaridae	Orconectes limosus	Shredder								
Malacostraca	Decapoda	Cambaridae	Unidentified Cambaridae	Shredder								
Maxillopoda	Sessilia	Balanidae	Balanus improvisus	Filter Feeder								
Mollusca	Bivalvia	Sphaeriidae	Unidentified Sphaeriidae	Scraper								
Mollusca	Gastropoda	Ancylidae	Ferrissia rivularis	Scraper								
Mollusca	Gastropoda	Gastropoda	Unidentified Gastropoda	Scraper								
Mollusca	Gastropoda	Hydrobiidae	Amnicola limosa/Bithynia tentaulata	Scraper	1	18	7				10	
Mollusca	Gastropoda	Hydrobiidae	Pomatiopsis sp.	Scraper								
Mollusca	Gastropoda	Lymnaeidae	Lymnaea columella	Scraper								
Mollusca	Gastropoda	Physidae	Physa sp.	Scraper								5
Mollusca	Gastropoda	Planorbidae	Gyraulus parvus	Scraper								
Mollusca	Gastropoda	Planorbidae	Helisoma sp.	Scraper								2
Mollusca	Gastropoda	Planorbidae	Gyraulus deflectus	Scraper								
Mollusca	Gastropoda	Planorbidae	Gyraulus circumstriatus	Scraper								
Mollusca	Gastropoda	Pleuroceridae	Pleurocera sp.	Scraper								
Mollusca	Gastropoda	Valvatidae	Valvata tricarinata	Scraper								
Nemertea	Nemertea	Nemertea	Unidentified Nemertea	Predator								
Turbellaria	Tricladida	Dugesiidae	Dugesia sp.	Predator	3	7				1		

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				15-Jun-07				17-Aug-07			
				Stations				Stations			
				1	2	3	4	1	2	3	4
Class	**Order**	**Family**	**Genus/Species**								
Annelida	Hirudinea	Glossiphoniidae	Glossiphonia complanata								
Annelida	Hirudinea	Glossiphoniidae	Placobdella sp.								
Annelida	Hirudinea		Hirudinia								
Annelida	Oligochaeta	Lumbriculidae	Unidentified Lumbriculidae								
Annelida	Oligochaeta	Naididae	Nais communis	8			36	4			17
Annelida	Oligochaeta	Oligochaeta	Unidentified Oligochaeta				9				
Annelida	Oligochaeta	Tubificidae	Unidentified Tubificidae	2							
Annelida	Oligochaeta	Tubificidae	Limnodrilus hoffmeisteri								
Annelida	Polychaeta	Ampherididae	Unidentified Ampherididae								
Annelida	Polychaeta	Capitellidae	Heteromastus filiformis								
Annelida	Polychaeta	Spionidae	Marenzellaria viridis								
Annelida	Polychaeta	Spionidae	Polydora sp.				1				
Arachnida	Trombidiformes	Lebertiidae	Lebertia sp.		2						
Arachnoidea	Hydracarina	Arrenuridae	Unidentified Arrenuridae								
Bivalvia	Veneorida	Pisidiidae	Pisidium sp.			8					
Branchiopoda	Cladocera		cladocera								10
Crustacea	Amphipoda	Corophiidae	Corophium sp. (juvenile)								
Crustacea	Amphipoda	Crangonyctidae	Crangonyx sp.	20		3					
Crustacea	Amphipoda	Gammaridae	Gammarus sp.	1165	11	370	45	80	117	54	27
Crustacea	Cumacea	Nannasticidae	Almyracuma proximoculi	2							
Crustacea	Decapoda	Palaemonidae	Paleomonetes vulgaris								
Crustacea	Decapoda	Palaemonidae	Paleomonetes paludosus								
Crustacea	Decapoda	Portunidae	Carcinus maenus								
Crustacea	Isopoda	Asellidae	Caecidotea communis	2		1	3		30		
Crustacea	Isopoda	Asellidae	Lirceus/Acellus sp. (communis)								
Hydrozoa	Hydroida	Hydridae	Hydra sp.								
Insecta	Coleoptera	Brachyceridae	Brachycerus sp.								
Insecta	Coleoptera	Chrysomelidae	Donacia								
Insecta	Coleoptera	Coleoptera	Unidentifed Coleoptera								
Insecta	Coleoptera	Curculionidae	Unidentifed Curculionidae								
Insecta	Coleoptera	Dryopidae	Helichus sp.								
Insecta	Coleoptera	Elmidae	Stenelmis sp.	55	33	49	1	24	3	17	50
Insecta	Coleoptera	Haliplidae	Peltodytes								7
Insecta	Coleoptera	Hydrophilidae	Berosus sp.	2	24	1	1				
Insecta	Coleoptera	Psephenidae	Unidentified Psephenidae								
Insecta	Diptera	Atrichopogon	Atrichopogon								
Insecta	Diptera	Ceratopogonidae	Probezzia								
Insecta	Diptera	Ceratopognidae	Unidentified Ceratopognidae								
Insecta	Diptera	Chironomidae	Unidenitifed Chironomidae	108	40	18	47	156	237	31	67
Insecta	Diptera	Diptera	Unidentified Diptera	137	144	25	9	28	13	6	10
Insecta	Diptera	Empididae	Empididae		89	19				1	
Insecta	Diptera	Empididae	Hemerodromia sp.								
Insecta	Diptera	Simuliidae	Simulium sp.	87	9						
Insecta	Diptera	Tabanidae	tabanidae								
Insecta	Diptera	Tachinidae	Ceracia	8							
Insecta	Diptera	Tipulidae	Unidentified Tipulidae	2							
Insecta	Ephemeroptera	Baetidae	Baetis sp								
Insecta	Ephemeroptera	Caenidae	Caenis sp.	5			4				
Insecta	Ephemeroptera	Ephemerellidae	Unidentified Ephemerellidae								
Insecta	Ephemeroptera	Heptageniidae	Stenonema sp.				1				
Insecta	Ephemeroptera	Oligoneuridae	Isonychia sp.								
Insecta	Hemiptera	Gelastocoridae	Gelastocoris								
Insecta	Hemiptera	Hemiptera	Unidentified Hemiptera								
Insecta	Heteroptera	Gerridae	Rheumatobates sp.							3	
Insecta	Heteroptera	Gerridae	Unidentified Gerridae								
Insecta	Heteroptera	Mesoveliidae	Mesovelia sp.				4				
Insecta	Heteroptera	Veliidae	Microvelia	2			4			1	
Insecta	Neuroptera	Sisyridae	Sisyira sp.	3							
Insecta	Odonata	Calopterygidae	Calopteryx spp								
Insecta	Odonata	Coenagrionidae	Nehalennia				67				140
Insecta	Odonata	Coenagrionidae	Ischnura/Enallagma sp.								
Insecta	Odonata	Coenagrionidae	Argia sp.								
Insecta	Odonata	Cordulegastridae	Epitheca								
Insecta	Odonata	Corduliidae	Epicordulia								
Insecta	Odonata	Corduliidae	Somatochlora sp.								
Insecta	Odonata	Corduliidae	Didymops sp.								
Insecta	Odonata		Anisoptera (juvenile)								
Insecta	Odonata		zygoptera fragments								
Insecta	Trichoptera	Brachycentridae	Brachycentrus sp.								
Insecta	Trichoptera	Brachycentridae	Micrasema sp.								
Insecta	Trichoptera	Glossosomatidae	Glossosoma								
Insecta	Trichoptera	Hydropsychidae	Macrostemum sp.	1248	47			76	740	87	3
Insecta	Trichoptera	Hydropsychidae	Hydropsyche sp.						17		
Insecta	Trichoptera	Hydropsychidae	Parapsyche sp.								
Insecta	Trichoptera	Hydroptilidae	Agraylea sp.	13			1				30
Insecta	Trichoptera	Hydroptilidae	Oxyethira sp.								
Insecta	Trichoptera	Hydroptilidae	Orthotrichia sp.								
Insecta	Trichoptera	Leptoceridae	Ceraclea sp.								
Insecta	Trichoptera	Leptoceridae	Mystacides sp.								
Insecta	Trichoptera	Leptoceridae	Triaenodes sp.								
Insecta	Trichoptera	Limnephilidae	Rossiana sp.								
Insecta	Trichoptera	Limnephilidae	Unidentified Limnephilidae								
Insecta	Trichoptera	Philopotamidae	Chimarra spp								
Insecta	Trichoptera	Psychomyiidae	Psychomyia sp.								
Insecta	Trichoptera	Uenoidae	Neophylax	38	67	3					
Malacostraca	Amphipoda	Hyalellidae	Hyalella azteca				23				17
Malacostraca	Decapoda	Cambaridae	Orconectes limosus								
Malacostraca	Decapoda	Cambaridae	Unidentified Cambaridae								
Maxillopoda	Sessilia	Balanidae	Balanus improvisus								
Mollusca	Bivalvia	Sphaeriidae	Unidentified Sphaeriidae								
Mollusca	Gastropoda	Ancylidae	Ferrissia rivularis				1				
Mollusca	Gastropoda	Gastropoda	Unidentified Gastropoda								
Mollusca	Gastropoda	Hydrobiidae	Amnicola limosa/Bithynia tentaulata	12	2	24	3	8		3	
Mollusca	Gastropoda	Hydrobiidae	Pomatiopsis sp.								
Mollusca	Gastropoda	Lymnaeidae	Lymnaea columella								
Mollusca	Gastropoda	Physidae	Physa sp.				32	8			
Mollusca	Gastropoda	Planorbidae	Gyraulus parvus				24				
Mollusca	Gastropoda	Planorbidae	Helisoma sp.			5	1				
Mollusca	Gastropoda	Planorbidae	Gyraulus deflectus					4			
Mollusca	Gastropoda	Planorbidae	Gyraulus circumstriatus								
Mollusca	Gastropoda	Pleuroceridae	Pleurocera sp.								
Mollusca	Gastropoda	Valvatidae	Valvata tricarinata								
Nemertea	Nemertea	Nemertea	Unidentified Nemertea								
Turbellaria	Tricladida	Dugesiidae	Dugesia sp.	42							