Macroinvertebrate Assessment of Allens Creek and the Brazos River, Austin County, Texas

Charles R. Wood
Thomas L. Arsuffi
M. Katherine Cauble

Department of Biology-Aquatic Station
Southwest Texas State University
San Marcos, TX 78666

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Introduction

The construction of a reservoir along Allens Creek has been proposed by Houston Lighting and Power (HL&P) and the Texas Water Development Board. An assessment of the aquatic community including macroinvertebrates and fishes at the reservoir site and downstream within the Allens Creek watershed was requested by the Texas Water Development Board. Assessment of basic biological information such as species composition, distribution, density, secondary productivity and trophic structure, can provide useful insights into the structure and function of an ecosystem. The use of rapid bioassesment (RBA) protocols as outlined by the Environmental Protection Agency (EPA) can be used in conjunction with basic biological information to assess the effects of non-point source pollution on the structure of aquatic communities. Macroinvertebrates are an important structural component of river systems and have been widely used to evaluate the amount of environmental stress in streams (Klemm, 1990). In September of 1993, a study of the macroinvertebrate communities at six sites on Allens Creek and the Brazos River was initiated. The objectives of the study were to determine the taxonomic composition, density, functional feeding group (FFG) composition, macroinvertebrate secondary production and the distribution of the macroinvertebrate community in both benthic and snag habitats. Rapid Bioassessment Protocol III (Plafkin et al., 1989) was also used to evaluate environmental conditions at the Allens Creek and the Brazos River sample sites.

Study Area

Allens Creek and the portion of the Brazos River into which it flows is located in Austin County, Texas. Sample sites were located along a 22 km section of Allens Creek and the Brazos River (Fig. 1). Allens Creek is a first order stream with its headwaters located in the town of Sealy. Sample sites 1-4 were located in Allens Creek. Sample site 5 was located at the confluence of Allens Creek and the Brazos River. Sample site 6 is located 2 km downstream of site 5 on the Brazos River. At sample sites 5 and 6, the Brazos River is a fifth order river system.

Austin County is located in the Blackland Prairie ecoregion of southeastern Texas. Riparian vegetation along Allens Creek and the Brazos River is dominated by Post Oak (*Quercus stellata*) and Black Jack Oak (*Quercus marilandica*). Canopy cover along Allens Creek ranged from moderate (40-60%) to heavily canopied (60-100%). The Brazos River has very little canopy cover at our sample sites. Large amounts of woody debris are found in both Allens Creek and the Brazos River. The woody debris in the rivers forms debris dams or snags which provide additional habitat for macroinvertebrates. In our study, both benthic and snag habitats were sampled monthly to determine the density, diversity, secondary productivity and distribution of the macroinvertebrates.

The streambed of Allens Creek and the Brazos River is predominately sandy silt over a hard clay pack and lacks substantial macrophyte or periphyton growth. The streambed of Allens Creek is very smooth, with only a few deeper pools and some scattered riffles with gravel substrate.

Location and Description of Macroinvertebrate Sample Sites for Allens Creek and the Brazos River

Site 1 - This site is located where Mixville Road crosses Allens Creek. Site 1 is 1.2 km east of the Mixville Road and state highway 36 intersection at the first bridge that crosses Allens Creek. The stream at site 1 is 3 m wide with steep banks and a moderate canopy cover (40-60%). The streambed at this site is a series of gravel bottomed riffles and benthic samples were collected from the riffles.

Site 2 - This site is located on HL&P property. The turnoff for site 2 is 4 km south of Mixville Road on state highway 36. The sample site is located 0.5 km to the east on HL&P lease property at a collapsed wooden bridge. The creek at this site ranges from 3-5 m wide with a sandy bottom, heavy canopy cover (60-100%) and steep banks. Ten meters downstream from the bridge is a 5 m long series of gravel bottom riffles. Benthic and snag habitat samples were collected from a section of the stream that stretched from 5 m upstream to 20 m downstream of the bridge. Benthic samples were collected from riffles when flows permitted. The snag habitats that were sampled are located 5-20 m downstream from the collapsed bridge.

Site 3 - This site is located on HL&P property. The turnoff for site 3 is 4 km south of the site 2 turnoff on state highway 36. This site is 0.75 km east of the state highway 36 turnoff where a wooden bridge crosses Allens Creek. The stream at this site is 3-5 m wide, heavily canopied (60-100%) and has a sandy bottom. Snag habitats were found 15 m upstream and where the bridge crosses Allens Creek. Benthic sample were collected from a section of the streambed that stretched from 15 m upstream to 5 m downstream of the bridge.

Site 4 -. This site is 1.2 km north of the FM 1093 and FM 1458 intersection where FM 1458 crosses Allens Creek. The creek is 5-6 m wide with a sandy, clay bottom, very steep banks and is moderately to heavily canopied (50-80%). Samples were collected from a section of the streambed that stretched from where FM 1458 crosses Allens creek to 10 m downstream. Snag habitats were located in the center of the creek 8 m and 10m downstream from the bridge.

Site 5 - Site 5 is located at the confluence of Allens Creek and the Brazos River. This site is located 5 km upstream from where FM 1093 crosses the Brazos River. The width of the creek at site 5 varies from 3-25 m wide depending on the discharge regimes of Allens Creek and the

Brazos River. The stream bottom at site 5 is a sandy-clay mix interspersed with small gravel bottom riffle areas during low flow periods. The canopy cover at this site is less than 1% and the bank walls are very steep. Samples were collected in Allens Creek from a section of streambed from the confluence to 15 m upstream.

Site 6 - Site 6 is 6.4 km east of Wallis, Texas where FM 1093 crosses the Brazos River. The width of the Brazos River at site 6 varies between 70-100 m wide and has a deep central channel. The riverbed is composed of a layer of sandy silt over hard packed clay and sand. Canopy cover is less than 1% at site 6 and the banks of the river are very steep. Numerous snags have formed in this section of the river. Samples were collected from snag and benthic habitats in a section of the river that stretched from 0.5 km upstream of the FM 1093 bridge to 0.75 km downstream of the FM 1093 bridge.

Materials and Methods

Macroinvertebrate Community

Beginning in September of 1993, samples were collected monthly when possible along Allens Creek and the Brazos River to determine taxonomic composition, density, trophic structure and functional feeding group composition (FFG) of the macroinvertebrate community. In late October of 1993, we were unable to gain access to sample sites 2-4 because new lock sets were placed on HL&P lease properties along Allens Creek. Repeated attempts were made to contact the individuals leasing the property, but to no avail. HL&P was contacted, but did not provide a key until late spring of 1994. Sampling resumed in June of 1994; however, the new key only fit the lock at site 2. Sites 3 and 4 were still inaccessible.

We used Hester-Dendy multi-plate samplers to sample macroinvertebrates associated with snag habitats. To do this we attached 4 multi-plate samplers to the woody debris at sites with snag habitats and retrieved them every 30-40 days. Multi-plate samplers were returned to the lab for sorting and identification of the macroinvertebrates which colonized the plates. Four quantitative benthic macroinvertebrate samples were also collected at each site during the same time period using a Hess sampler to collect in the shallow riffles or a Ponar grab to collect at the deeper river sites. Samples from benthic and snag habitats were preserved in 80% ETOH and returned to the lab for sorting and identification. Invertebrates were identified to the lowest possible level using Merritt and Cummins (1984) for insects, and Pennak (1989) and Thorp and Covich (1991) for non-insect taxa. Trophic structure of the macroinvertebrate community was assessed by assigning functional feeding group (FFG) designations to macroinvertebrate taxa as described by Merritt and Cummins (1984). Functional feeding group classifications for insect taxa were assigned using Merritt and Cummins (1984). Non-insect taxa were assigned a FFG using Thorp and Covich

(1991). Secondary production for the dominant taxa in both benthic and snag habitats was determined. Standing stock biomass and production estimates were calculated using direct biomass determination or size group counts and length-weight relationships. Direct invertebrate biomass was determined by drying the specimens at 60 °C for 24 hours, cooling them in a desiccater to room temperature and then weighing with a micro-balance. Length to weight relationships were used to determine biomass estimates for Chironomidae (Diptera) and *Hydropsyche* (Trichoptera: Hydropsychidae). Specimen length and headcapsule width were measured using a binocular microscope fitted with on ocular micrometer. Specimens were then dried as described for the direct biomass determination and weighed. Biomass relationships between length and weight were determined as described by Smock (1980). Macroinvertebrate secondary production was calculated using the instantaneous growth method ($P=g\Delta t\overline{B}$), where P represents production, g is the instantaneous growth rate, Δt is the time period and $\overline{B}$ is the standing stock biomass for the time period (Benke, 1984 ; Waters, 1977).

Water Quality and Physical Characteristics

Rapid Bioassessment (RBA) protocol III for stream macroinvertebrates following US Environmental Protection Agency guidelines was used to evaluate environmental conditions on Allens Creek (Plafkin et al., 1989) (Appendix A; Table A1). Mill Creek, Austin County, Texas (located in the Brazos River Basin) was used as the unimpaired reference site (Bayer et al., 1992). Mill Creek is similar to Allens Creek in that it is a sandy bottom stream within the Blackland Prairie ecoregion (Bayer et al., 1992). The riparian vegetation along Mill Creek is also dominated by Post Oak and Black Jack Oak (Bayer et al., 1992).

Basic water quality parameters consisting of dissolved oxygen, and temperature were collected monthly at each of the six sample sites. Dissolved oxygen and temperature were collected using an Orion Model 840 meter. The general habitat characteristics such as bank height, stream width, canopy cover and substrate composition were determined at each site by visual observation.

Results

Macroinvertebrate Community

Thirty-two macroinvertebrate taxa were identified from benthic and snag habitats in Allens Creek and the Brazos River. In both benthic and snag habitats, insect taxa made up 78% of all organisms collected, with the remaining 22% divided among Amphipoda (4%), Annelida (7%), Bivalvia (4%), Decapoda (7%) and other minor taxa. The relative abundance for the dominant taxa in both benthic and snag habitats were determined (Fig. 2). Benthic habitats were dominated by Annelida (11%), Chironomidae (Diptera) (50%), *Baetis* (Ephemeroptera: Baetidae) (8%) and *Popenaias* (Bivalvia: Unionidae) (6%) (Tables 1-3). The dominant taxa for snag habitats were Chironomidae (Diptera) (73%), *Hydropsyche* (Trichoptera: Hydropsychidae) (10%), *Leptohyphes* (Ephemeroptera:

Tricorythidae) (5%), *Argia* (Odonata: Coenagrionidae) (3%) (Tables 4-5). Chironomidae (Diptera) were the most numerous organisms in both snag and benthic habitats with densities ranging from 9 -1613 organisms / m^2 Chironomidae (Diptera) (Tables 1-5).

Overall macroinvertebrate densities were greatest in the snag habitats, reaching a maximum density of 2274 organisms / m^2 at site 6 in October of 1993 (Fig. 3). Macroinvertebrate densities at site 6 snag habitats decreased in November of 1993 to 865 organisms / m^2. Snag habitats at site 6 were dominated by two taxa, Chironomidae (Diptera) and *Hydropsyche* (Trichoptera: Hydropsychidae) throughout the fall 1993 sample period (Tables 4 & 5). Snag habitats at site 4 showed an increase in the total macroinvertebrate density from 94 organisms / m^2 in October to 578 organisms / m^2 in November of 1993 (Fig. 3). The large increase in November of 1993 at site 4 was due to a 74% increase in Chironomidae (Diptera) collected and a 100% increase in the number of *Leptohyphes* (Ephemeroptera: Tricorythidae) and Ceratopogonidae (Diptera) (Tables 4 & 5).

Benthic macroinvertebrates reached a maximum density of 1155 organisms / m^2 at site 1 in October of 1993 (Fig. 3). Benthic macroinvertebrate densities at site 1 in October of 1993 were 24-28% greater than the September and November collection dates. In October of 1993, *Hydropsyche* (Trichoptera: Hydropsychidae), *Baetis* (Ephemeroptera, Baetidae) and *Stenelmis* (Coleoptera: Elmidae) all increased by more than twice their September and November 1993 densities at site 1 (Tables 1-3). Benthic invertebrate densities at site 5 also exhibited increases during the October 1993 sample period (Fig. 4). This was largely due to a 68% increase in Chironomidae (Diptera) densities (Tables 1-3). Macroinvertebrate densities at sites 2 and 3 showed a decline from September to October (Fig. 4). Site 6 macroinvertebrate densities declined from September to November of 1993 (Fig. 4).

Of the macroinvertebrates collected in Allens Creek and the Brazos River during the fall of 1993, 58% belonged to the collector-gatherers, 19% were predators, 11% were collector-filterers, 11% were scrapers and less than 1% of the macroinvertebrates collected were facultative shredders (Figs. 5-9). No obligate shredders were identified from Allens Creek or the Brazos River during this sampling period.

Standing stock biomass and macroinvertebrate secondary productivity were calculated for both benthic and snag habitats for the fall 1993 sample period. Snag habitat standing stock biomass exceeded that of the benthic habitat at all sites (Figs. 10 & 11). At sites 2, 4 and 6 the standing stock biomass was more than 50% greater in snag habitats than in benthic habitats (Fig. 10). Standing stock biomass for the snag habitats at site 3 was only 10% greater than the benthic habitats. We attribute reduced standing stock biomass at site 3 to a period of reduced flow. During the low flow period, snag habitats became emergent and were unavailable for colonization by macroinvertebrates.

Invertebrate secondary productivity in snag habitats exceeded that of the benthic habitats. Chironomidae (Diptera) accounted for the largest portion of the invertebrate secondary production at sites 2, 3 and 4 was 82%, 73% and 89% respectively (Fig. 11). Site 2 snag production was 104% greater than the benthic production. Chironomidae (Diptera) accounted for 2040 mg/m^2/month of the snag production and 108 mg/m^2/month of the benthic production (Fig. 11). Site 3 snag production was 6% greater than the benthic habitat. Chironomidae (Diptera) accounted for 217 mg/m^2/month of the production in the snag habitat and 180 mg/m^2/month of the production in the benthic habitat (Fig. 11). Snag habitat production at site 4 was 25% greater than the benthic production. Chironomidae (Diptera) accounted for 324 mg/m^2/month of the snag habitat production at site 4 (Fig. 11). In the snag habitats at collection site 6 the invertebrate secondary production was dominated by Chironomidae (Diptera) and *Hydropsyche* (Trichoptera: Hydropsychidae) (Fig. 11). Site 6 snag habitat was 99% more productive than the benthic habitat. *Hydropsyche* (Trichoptera: Hydropsychidae) and Chironomidae (Diptera) accounted for 3010 mg/m^2/month and 2715 mg/m^2/month of snag production (Fig. 11).

Water Quality and Physical Characteristics

Water quality conditions of Allens Creek and the Brazos River over the fall 1993 sampling period ranged from slightly to moderately impaired (Tables 6-10; Appendix A; Table A2). There was a temporal component to water quality changes in that some sites changed status from slightly impaired in one month to moderately impaired the next or vice versa.

Dissolved oxygen levels were generally higher during the November 1993 sampling dates than during September and October (Fig. 12). Temperatures in Allens Creek and the Brazos River showed a gradual decrease from September through November (Fig. 12). The increase in dissolved oxygen through this time period can be attributed to a drop in the water temperature (Fig. 12). Dissolved oxygen levels and temperature varied greatly among sample sites in Allens Creek and the Brazos River (Fig. 12).

Discussion

Distinct differences in macroinvertebrate densities were observed in both benthic and snag habitats during the fall of 1993. At sites 1 and 5, there was a dramatic increase in macroinvertebrate density between September and October. At site 1, this may be attributed to a change in the riparian and stream conditions during the first two months of the study. The week before samples were first collected in September of 1993, Austin County officials cleared the stream banks of brush and many of the large trees along the upper reaches of

Allens Creek for flood control. Consequently, riparian cover at site 1 was reduced changing the stream from being heavily to moderately shaded. Algae and periphyton which were not present during the September collection date, were now apparent growing on the visible gravel substrate in the riffle areas at this site. Also after the riparian vegetation had been clear-cut, coarse particulate organic matter (CPOM) from brush piles that remained along the banks was introduced into the streambed by wind and runoff. Macroinvertebrate densities of *Hydropsyche* (Trichoptera: Hydropsychidae), *Baetis* (Ephemeroptera, Baetidae) and *Stenelmis* (Coleoptera: Elmidae) all increased after the new periphyton growth was observed and additional CPOM was introduced into the stream. *Hydropsyche* (Trichoptera: Hydropsychidae) and *Baetis* (Ephemeroptera, Baetidae) are collector-gatherer taxa which gather or collect CPOM as a food source. *Stenelmis* (Coleoptera: Elmidae) is a scraper which removes periphyton from the surface of macrophytes or substrate. The increase in available food resources (i.e. periphyton and CPOM) provided the necessary conditions for macroinvertebrate densities to increase at site 1.

Site 5 macroinvertebrate densities also increased during the October 1993 sample period. Heavy rains prior to the October sample period increased the water level at site 5 and expanded the width of Allens Creek from 3 m wide during the September sample period to 12 m in October. Site 5 is a backwash area that catches most of the debris washed down from Allens Creek during high flows and prevents them from washing directly into the Brazos River. The increased water levels at this site increased the amount of benthic habitat available for macroinvertebrate colonization. Invertebrates that are washed from the upper reaches of Allens Creek become trapped at this site and would have rapidly colonized the newly inundated habitat. Chironomidae (Diptera), which accounted for much of the increase in macroinvertebrate densities, are known to have life histories that promote high turnover rates and rapid colonization of habitat (Hauer and Benke, 1991; Merritt and Cummins, 1984). Chironomidae (Diptera) life history characteristics along with the addition of drifting individuals from the upper reaches of Allens Creek, would have accounted for the rapid colonization of the newly inundated habitat and increase in macroinvertebrate densities at site 5. Benthic macroinvertebrate densities decreased from October to November 1993 at all other sample sites. The decrease in macroinvertebrate density during this time can be attributed to exceptionally heavy rains which scoured the predominately sandy substrates.

Snag habitats make an important contribution to the structure and function of the macroinvertebrate community in many streams (Benke et al., 1984; Jacobi and Benke, 1991). Benke et al. (1984) showed that in the coastal blackwater rivers of the southeastern U.S. snag habitats may only account for 6% of the potential invertebrate habitat spatially. However, macroinvertebrate standing stock biomass, annual production and densities in snag habitats are 16-50% greater than adjacent benthic habitats. In our study, the macroinvertebrate standing stock biomass, secondary production and invertebrate densities in snag habitats in Allens Creek and the Brazos River exceeded that of benthic habitats by 10% to more than 50%. Similarly, Benke et al. (1984) in a study of the Setilla River found that invertebrate production in snag habitats exceeded that of the adjacent benthic habitats by 84%. From this we conclude that where snag habitats are present in Allens Creek and the Brazos River, they are important structural components of the habitat.

The River Continuum Concept (RCC) as proposed by Vannote et al. (1980) defines longitudinal changes in the trophic structure of lotic systems from the headwaters to larger rivers. RCC defines first order streams trophic structure as shredder dominated, where coarse particulate organic matter derived (leaves, twigs, buds etc.) from the riparian environment is the primary source of food. Shredder taxa are macroinvertebrates with mouth parts designed to tear, rip or in some manner breakdown large organic matter (Cummins and Klug, 1979). Shredders were completely absent from snag and benthic habitats in Allens Creek and the Brazos River. Scraper taxa are another important FFG in the RCC. Scrapers are invertebrates which rasp or scrape periphyton from the surface of rocks or macrophytes (Cummins and Klug, 1979). Allens Creek lacks any substantial macrophyte or periphyton growth in most of the sample sites and as a result only three scraper taxa were found in this system. The dominant functional feeding group composition for snag and benthic habitats in Allens Creek and the Brazos River are collector-gatherer and collector-filterer taxa which utilize fine particulate organic matter (FPOM). The FPOM that the collector-gatherer and collector-filterer taxa utilize as a source of energy is composed of organic matter which is 50 μm-1 mm in size and can be gathered or filtered from the water column. Chironomidae (Diptera) was the most abundant collector-gatherer taxa in both benthic and snag habitats. Predator taxa were also an important component of benthic and snag habitats in Allens Creek and the Brazos River. Benke et al. (1984) found a similar trophic structure in which collector-gatherers, collector-filterers and predators were the dominant functional feeding groups for benthic and snag habitats of the Setilla River in the Coastal Plains of Georgia.

Allens Creek and the Brazos River in Austin County are relatively high stress environments for macroinvertebrates. Rapid fluctuations in the water level, temperature and substrate can make the environment unsuitable for all but the most tolerant invertebrate species. In addition, at most of the sample sites in Allens Creek and the Brazos River, old car batteries, chemical containers and appliances of all types can be found in and along the stream and its banks. These could represent sources of contamination. At site 5, which is below the Wallis wastewater treatment facility, foul smelling water and tar-like residues have been found on several sampling trips. Results from the RBA assessment indicate a slightly impaired to moderately impaired system for Allens Creek and the Brazos River. This indicates that some impact from the wastewater outfall from the cities of Sealy and Wallis as well as the agricultural and ranching activities along Allens Creek and the Brazos River may be affecting the water quality and community structure.

Table 1: Benthic macroinvertebrates from Allens Creek and the Brazos River during the September 1993 sampling period.

		COLLECTION SITE					
		1	2	3	4	5	6
TAXON	FFG						
AMPHIPODA							
Hyalella azteca	FS						
ANNELIDA							
Annelida	CG	9	38	21	56		54
Hirudinoidea	P	6					
BIVALVIA							
Unionidae *Popenaias*	CF	153	9	21			43
COLEOPTERA							
Elmidae *Stenelmis*	SC	91	3			3	
Dytiscidae							
Hydravatus	P						
Celina	*P*				9		
Haliplidae *Peltodytes*	SC				26		
Hydrophilidae *Tropisternus*	P						
Psephenidae *Psephenus*	P						
DECAPODA							
Cambaridae *Cambarellus*	P						
Palaemonidae *Palaemonetes*	P				12	6	
DIPTERA							
Ceratopogonidae	P	3		6	18		22
Chironomidae	CG	153	44	106	294	12	261
Stratiomyidae *Stratiomys*	P	3		144			
Tipulidae *Rhabdomastix*	P	3		6		3	
Simuliidae *Simulium*	CF						
EPHEMEROPTERA							
Baetidae *Baetis*	CG	18			35		
Leptophlebiidae *Thraulodes*	CF	6					
Tricorythidae *Leptohyphes*	CG	3	9		68		
GASTROPODA							
	SC			3	9		

Table 1 Continued.

		COLLECTION SITE					
		1	2	3	4	5	6
TAXON	FFG						
HEMIPTERA							
Corixidae *Neocrixa*	P				3		
Gerris	P				15		
Rheumatobates	P		3				
Veliidae *Rhagavelia*	P				6		
HYDRACHNOIDEA							
Hydrachnidae *Hydrachna*	P						
LIMNOPHILA							
Ancylidae *Hebetancylus*	SC	3					
ODONATA							
Coenagrionidae *Argia*	P						
Corduliidae *Neurocordullia*	P	3					
Gomphidae *Erpetogomphus*	P	3	6				
Macromiidae *Didymops*	P						
TRICHOPTERA							
Hydropsychidae *Hydropsyche*	CF	91					
TOTAL # OF INDIVIDUALS m^{-2}		547	112	306	550	24	380
TOTAL # OF TAXA		15	7	7	12	4	4

Functional Feeding Group Composition (FFG): P = Predators, CG = Collector-gatherers, CF = Collector-filterers, SC = Scrapers, FS = Facultative Shredders

Table 2: Benthic macroinvertebrates from Allens Creek and the Brazos River during the October 1993 sampling period.

		COLLECTION SITE					
		1	2	3	4	5	6
TAXON	FFG						
AMPHIPODA							
Hyalella azteca	FS	3					
ANNELIDA							
Annelida	CG		38				
Hirudinoidea	P	3					
BIVALVIA							
Unionidae *Popenaias*	CF	74	3	12		3	22
COLEOPTERA							
Elmidae *Stenelmis*	SC	270	3	3		3	
Dytiscidae							
Hydravatus	P						
Celina	*P*						
Haliplidae *Peltodytes*	SC						
Hydrophilidae *Tropisternus*	P					3	
Psephenidae *Psephenus*	P						
DECAPODA							
Cambaridae *Cambarellus*	P						
Palaemonidae *Palaemonetes*	P	3				9	
DIPTERA							
Ceratopogonidae	P			12			11
Chironomidae	CG	94	35	109		62	120
Stratiomyidae *Stratiomys*	P						
Tipulidae *Rhabdomastix*	P					3	
Simuliidae *Simulium*	CF						
EPHEMEROPTERA							
Baetidae *Baetis*	CG	303		26			
Leptophlebiidae *Thraulodes*	CF	18				3	
Tricorythidae *Leptohyphes*	CG	9	6	3		9	
GASTROPODA							
	SC	3		3			

Table 2 Continued.

		COLLECTION SITE					
		1	2	3	4	5	6
TAXON	FFG						
HEMIPTERA							
Corixidae *Neocrixa*	P	3					
Gerridae							
Gerris	*P*						
Rheumatobates	P		3	12			
Veliidae *Rhagavelia*	P						
HYDRACHNOIDEA							
Hydrachnidae *Hydrachna*	P						
LIMNOPHILA							
Ancylidae *Hebetancylus*	SC			3			
ODONATA							
Coenagrionidae *Argia*	P						
Corduliidae *Neurocordullia*	P						
Gomphidae *Erpetogomphus*	P		3				
Macromiidae *Didymops*	P						22
TRICHOPTERA							
Hydropsychidae *Hydropsyche*	CF	373					
TOTAL # OF INDIVIDUALS m^{-2}		1155	91	182	0	94	174
TOTAL # OF TAXA		12	7	9	0	8	4

Functional Feeding Group Composition (FFG): P = Predators, CG = Collector-gatherers, CF = Collector-filterers, SC = Scrapers, FS = Facultative Shredders

Table 3 : Benthic macroinvertebrates from Allens Creek and the Brazos River during the November 1993 sampling period.

		COLLECTION SITE					
		1	2	3	4	5	6
TAXON	FFG						
AMPHIPODA							
Hyalella azteca	FS						
ANNELIDA							
Annelida	CG	32			3	3	
Hirudinoidea	P	9					
BIVALVIA							
Unionidae *Popenaias*	CF	79					
COLEOPTERA							
Elmidae *Stenelmis*	SC	38					3
Dytiscidae							
Hydravatus	P						
Celina	P						
Haliplidae *Peltodytes*	SC						
Hydrophilidae *Tropisternus*	P						
Psephenidae *Psephenus*	P					3	
DECAPODA							
Cambaridae *Cambarellus*	P				9		
Palaemonidae *Palaemonetes*	P	3				3	
DIPTERA							
Ceratopogonidae	P	12					
Chironomidae	CG	194			54	12	9
Stratiomyidae *Stratiomys*	P						
Tipulidae *Rhabdomastix*	P						
Simuliidae *Simulium*	CF	6					
EPHEMEROPTERA							
Baetidae *Baetis*	CG	129			3	6	
Leptophlebiidae *Thraulodes*	CF	3					
Tricorythidae *Leptohyphes*	CG	50			32	6	3
GASTROPODA							
	SC						

Table 3 Continued.

		COLLECTION SITE					
		1	2	3	4	5	6
TAXON	FFG						
HEMIPTERA							
Corixidae *Neocrixa*	P						
Gerridae							
Gerris	*P*						
Rheumatobates	P						
Veliidae *Rhagavelia*	P						
HYDRACHNOIDEA							
Hydrachnidae *Hydrachna*	P				3		
LIMNOPHILA							
Ancylidae *Hebetancylus*	SC						
ODONATA							
Coenagrionidae *Argia*	P						
Corduliidae *Neurocordullia*	P						
Gomphidae *Erpetogomphus*	P	3			3		
Macromiidae *Didymops*	P						
TRICHOPTERA							
Hydropsychidae *Hydropsyche*	CF	71					
TOTAL # OF INDIVIDUALS m^{-2}		629	0	0	106	32	15
TOTAL # OF TAXA		13	0	0	7	6	3

Functional Feeding Group Composition (FFG): P = Predators, CG = Collector-gatherers, CF = Collector-filterers, SC = Scrapers, FS = Facultative Shredders

Table 4 : Snag habitat macroinvertebrates from Allens Creek and the Brazos River during the October 1993 sampling period.

			COLLECTION SITE		
		2	3	4	6
TAXON	FFG				
AMPHIPODA					
Hyalella azteca	FS				
ANNELIDA					
Annelida	CG	3	32		
Hirudinoidea	P				
BIVALVIA					
Unionidae *Popenaias*	CF		5		
COLEOPTERA					
Elmidae *Stenelmis*	SC	24	5		5
Dytiscidae					
Hydravatus	P				
Celina	*P*				
Haliplidae *Peltodytes*	SC				
Hydrophilidae *Tropisternus*	P				
Psephenidae *Psephenus*	P				
DECAPODA					
Cambaridae *Cambarellus*	P	3			
Palaemonidae *Palaemonetes*	P				
DIPTERA					
Ceratopogonidae	P	13	5		3
Chironomidae	CG	1156	247	86	1613
Stratiomyidae *Stratiomys*	P				
Tipulidae *Rhabdomastix*	P		5		
Simuliidae *Simulium*	CF				
EPHEMEROPTERA					
Baetidae *Baetis*	CG				
Leptophlebiidae *Thraulodes*	CF				
Tricorythidae *Leptohyphes*	CG				
GASTROPODA					
	SC		11	3	

Table 4 Continued.

		COLLECTION SITE			
		2	3	4	6
TAXON	FFG				
HEMIPTERA					
Corixidae *Neocrixa*	P				
Gerridae					
Gerris	*P*				
HEMIPTERA (cont.)					
Rheumatobates	P				
Veliidae *Rhagavelia*	P				
HYDRACHNOIDEA					
Hydrachnidae *Hydrachna*	P			3	3
LIMNOPHILA					
Ancylidae *Hebetancylus*	SC				
ODONATA					
Coenagrionidae *Argia*	P				
Corduliidae *Neurocordullia*	P				
Gomphidae *Erpetogomphus*	P				
Macromiidae *Didymops*	P				3
TRICHOPTERA					
Hydropsychidae *Hydropsyche*	CF			3	648
TOTAL # OF INDIVIDUALS m^{-2}		1199	312	94	2274
TOTAL # OF TAXA		5	7	4	6

Functional Feeding Group Composition (FFG): P = Predators, CG = Collector-gatherers, CF = Collector-filterers, SC = Scrapers, FS = Facultative Shredders

Table 5: Snag habitat macroinvertebrates from Allens Creek and the Brazos River during the November 1993 sampling period.

		COLLECTION SITE			
		2	3	4	6
TAXON	FFG				
AMPHIPODA					
Hyalella azteca	FS			3	
ANNELIDA					
Annelida	CG				
Hirudinoidea	P				
BIVALVIA					
Unionidae *Popenaias*	CF				
COLEOPTERA					
Elmidae *Stenelmis*	SC				
Dytiscidae					
Hydravatus	P			3	
Celina	*P*				
Haliplidae *Peltodytes*	SC			3	
Hydrophilidae *Tropisternus*	P				
Psephenidae *Psephenus*	P				
DECAPODA					
Cambaridae *Cambarellus*	P			3	
Palaemonidae *Palaemonetes*	P			3	
DIPTERA					
Ceratopogonidae	P			46	
Chironomidae	CG			250	379
Stratiomyidae *Stratiomys*	P				
Tipulidae *Rhabdomastix*	P			3	
Simuliidae *Simulium*	CF				

Table 5 Continued.

		COLLECTION SITE			
		2	3	4	6
TAXON	FFG				
EPHEMEROPTERA					
Baetidae *Baetis*	CG				
Leptophlebiidae *Thraulodes*	CF			3	35
Tricorythidae *Leptohyphes*	CG			185	11
GASTROPODA					
	SC				
HYDRACHNOIDEA					
Hydrachnidae *Hydrachna*	P				
LIMNOPHILA					
Ancylidae *Hebetancylus*	SC				
ODONATA					
Coenagrionidae *Argia*	P			78	
Corduliidae *Neurocordullia*	P				
Gomphidae *Erpetogomphus*	P				
Macromiidae *Didymops*	P				
TRICHOPTERA					
Hydropsychidae *Hydropsyche*	CF				441
TOTAL # OF INDIVIDUALS m^{-2}	0	0	0	578	865
TOTAL # OF TAXA	0	0	0	11	4

Functional Feeding Group Composition (FFG): P = Predators, CG = Collector-gatherers, CF = Collector-filterers, SC = Scrapers, FS = Facultative Shredders

Table 6 : RBA protocol III metrics for benthic habitats in Allens Creek and the Brazos River, September 1993.

	SAMPLE SITES					
	Macroinvertebrate Metric Scores					
Metric	1	2	3	4	5	6
Taxa Richness	38%	18%	18%	32%	10%	33%
FBI (Modified)	95%	155%	77%	135%	104%	153%
FFG % Similarity Index	70%	10%	0%	20%	189%	0%
EPT:Chironomidae	163%	63%	0%	181%	0%	0%
% Contribution (Dom. Family)	42%	71%	86%	97%	185%	125%
EPT Index	33%	3%	0%	18%	0%	0%
Community Similarity Index	2.46	3.86	4.28	2.25	7.25	7.80
Metric Criteria Score	26	18	12	22	20	14
% Comparison to Reference	62%	43%	29%	52%	48%	33%
Impairment Level	Slightly Impaired	Moderately impaired	Moderately impaired	Slightly Impaired	Moderately impaired	Moderately impaired

Table 7 : RBA protocol III metrics for benthic habitats in Allens Creek and the Brazos River, October 1993.

	SAMPLE SITES					
	Macroinvertebrate Metric Scores					
Metric	1	2	3	4	5	6
Taxa Richness	31%	18%	23%	NA	21%	10%
FBI (Modified)	95%	171%	126%	NA	123%	131%
FFG % Similarity Index	70%	94%	81%	NA	94%	0%
EPT:Chironomidae	325%	54%	78%	NA	60%	0%
% Contribution (Dom. Family)	48%	76%	109%	NA	119%	125%
EPT Index	33%	8%	17%	NA	17%	0%
Community Similarity Index	2.08	7.43	3.00	NA	3.38	7.75
Metric Criteria Score	26	24	26	NA	24	14
% Comparison to Reference	62%	57%	62%	NA	57%	33%
Impairment Level	Slightly Impaired	Slightly Impaired	Slightly Impaired	NA	Slightly Impaired	Moderately impaired

NA = No data available

Table 8 : RBA protocol III metrics for benthic habitats in Allens Creek and the Brazos River, September 1993.

	SAMPLE SITES					
	Macroinvertebrate Metric Scores					
Metric	1	2	3	4	5	6
Taxa Richness	33%	NA	NA	18%	15%	8%
FBI (Modified)	116%	NA	NA	124%	119%	139%
FFG % Similarity Index	36%	NA	NA	0%	0%	189%
EPT:Chironomidae	210%	NA	NA	146%	185%	93%
% Contribution (Dom. Family)	56%	NA	NA	93%	68%	109%
EPT Index	33%	NA	NA	17%	17%	8%
Community Similarity Index	1.85	NA	NA	4.14	5.66	10.00
Metric Criteria Score	24	NA	NA	20	20	26
% Comparison to Reference	57%	NA	NA	48%	48%	62%
Impairment Level	Slightly Impaired	NA	NA	Moderately impaired	Moderately impaired	Slightly Impaired

NA = No data available

Table 9 : RBA protocol III metrics for snag habitats in Allens Creek and the Brazos River, October 1993.

	SAMPLE SITES			
		Macroinvertebrate Metric Scores		
Metric	2	3	4	6
Taxa Richness	13%	18%	10%	15%
FBI (Modified)	160%	158%	148%	115%
FFG % Similarity Index	189%	144%	94%	1%
EPT:Chironomidae	0%	0%	12%	106%
% Contribution (Dom. Family)	175%	143%	166%	129%
EPT Index	0%	0%	8%	8%
Community Similarity Index	5.60	4.00	7.75	4.67
Metric Criteria Score	20	20	20	20
% Comparison to Reference	48%	48%	48%	48%
Impairment Level	Moderately impaired	Moderately impaired	Moderately impaired	Moderately impaired

Table 10 : RBA protocol III metrics for snag habitats in Allens Creek and the Brazos River, November 1993.

		SAMPLE SITES		
		Macroinvertebrate Metric Scores		
Metric	2	3	4	6
Taxa Richness	NA	NA	28%	10%
FBI (Modified)	NA	NA	150%	74%
FFG % Similarity Index	NA	NA	94%	0%
EPT:Chironomidae	NA	NA	159%	208%
% Contribution (Dom. Family)	NA	NA	79%	93%
EPT Index	NA	NA	17%	25%
Community Similarity Index	NA	NA	2.64	7.50
Metric Criteria Score	NA	NA	26	18
% Comparison to Reference	NA	NA	62%	43%
Impairment Level	NA	NA	Slightly Impaired	Moderately impaired

NA = No data available

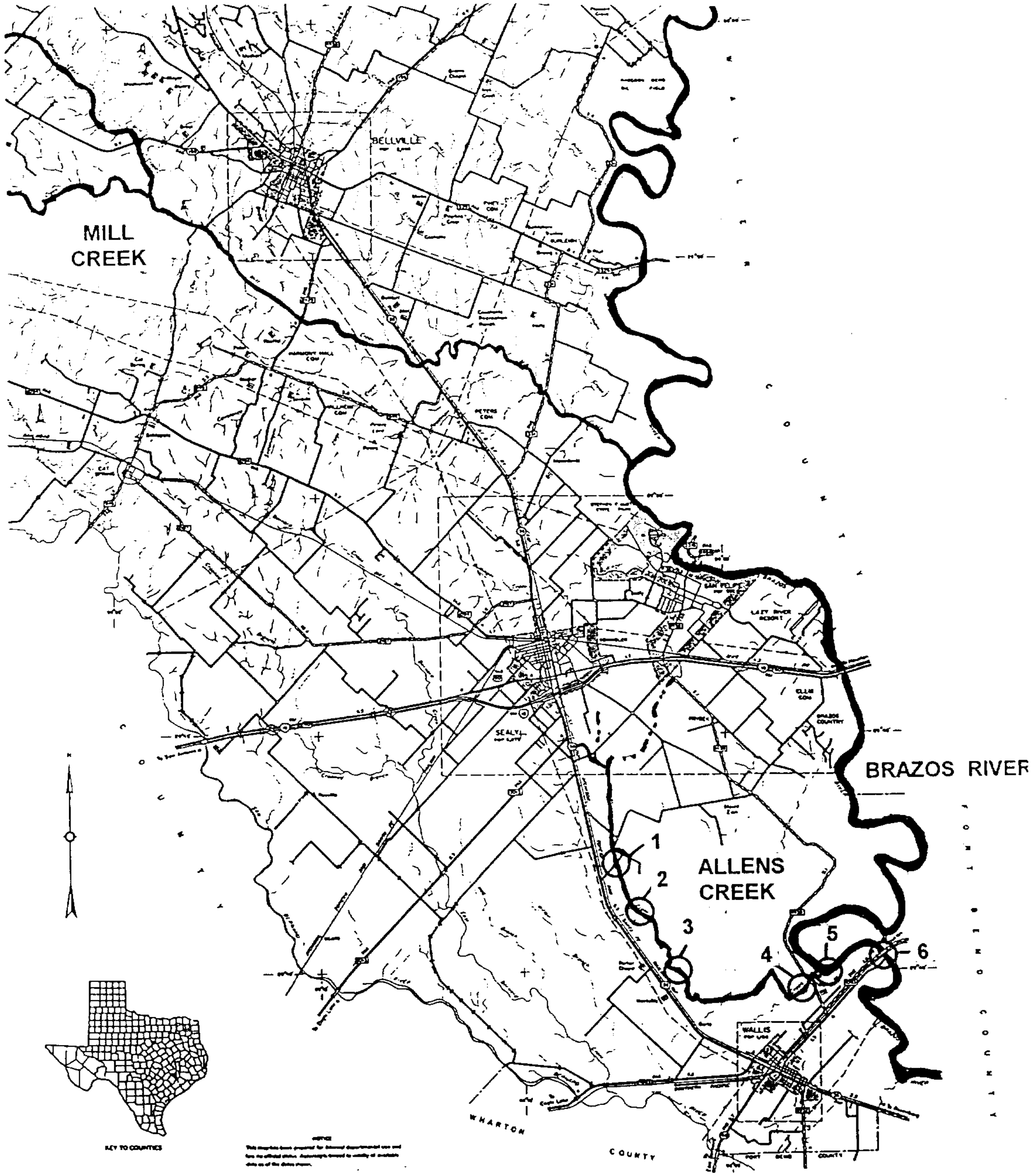


Figure 1: Map of the Allens Creek and Brazos River study area showing sample collection sites 1 - 6. Mill Creek in central Austin county was selected as the unimpaired RBA reference site.

Figure 2: Relative abundance for snag and benthic sites along Allens Creek for the fall 1993 sample period. Taxa that represented less than 1% of the organisms sampled were grouped and represented by the designation "Other".

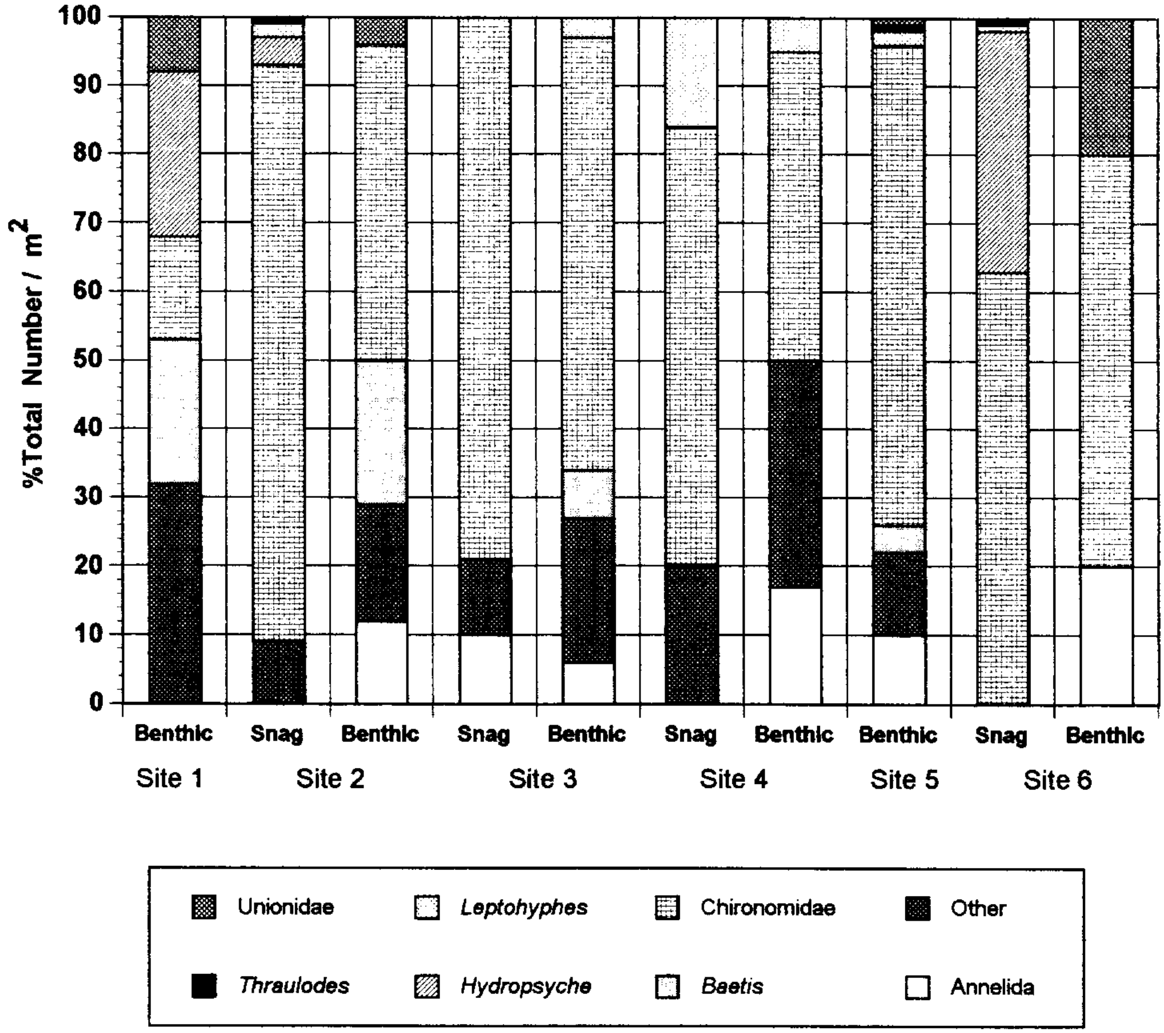


Figure 3: Snag habitat macroinvertebrate densities for Allens Creek and the Brazos River fall during the fall 1993 sample period. Plate samplers were attached to snag habitats in September and first retrieved in October. Sample sites 2 and 3 were not accessible during the November sampling period.

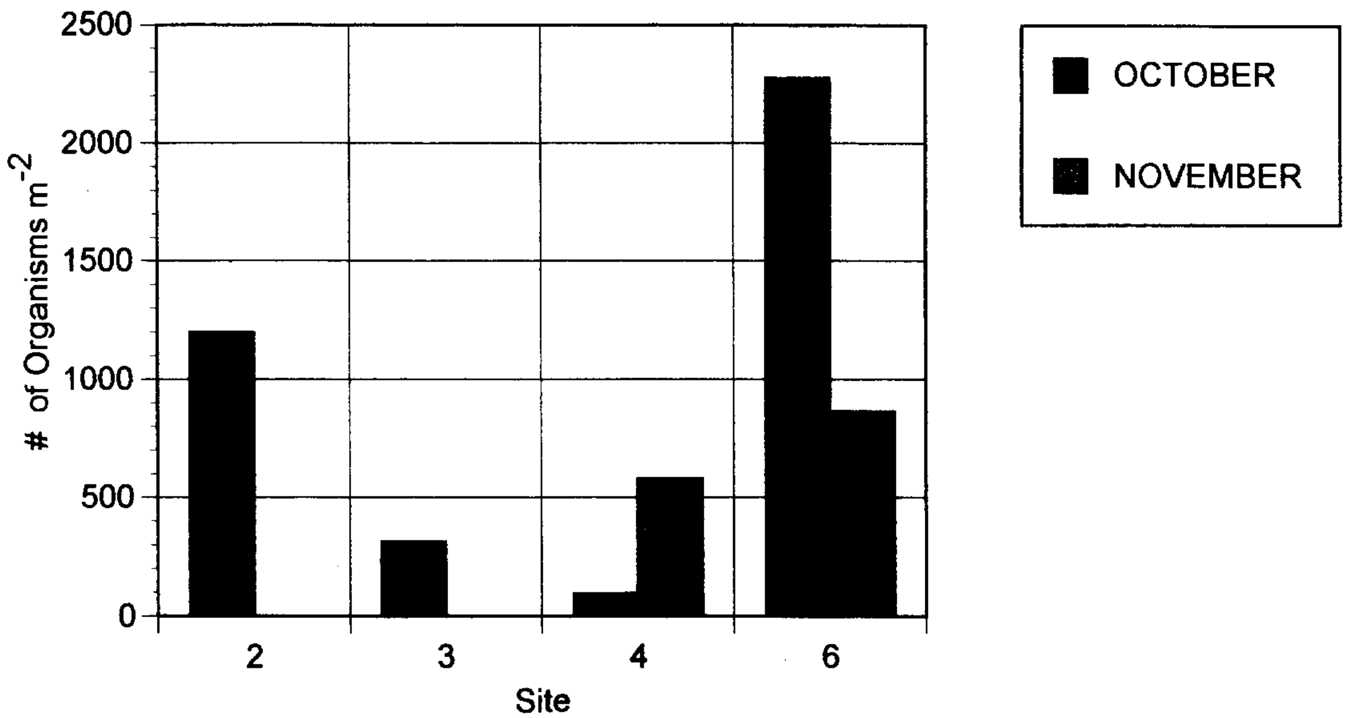


Figure 4: Benthic macroinvertebrate densities for Allens Creek and the Brazos River during the fall 1993 collection period. Side 4 was not sampled.

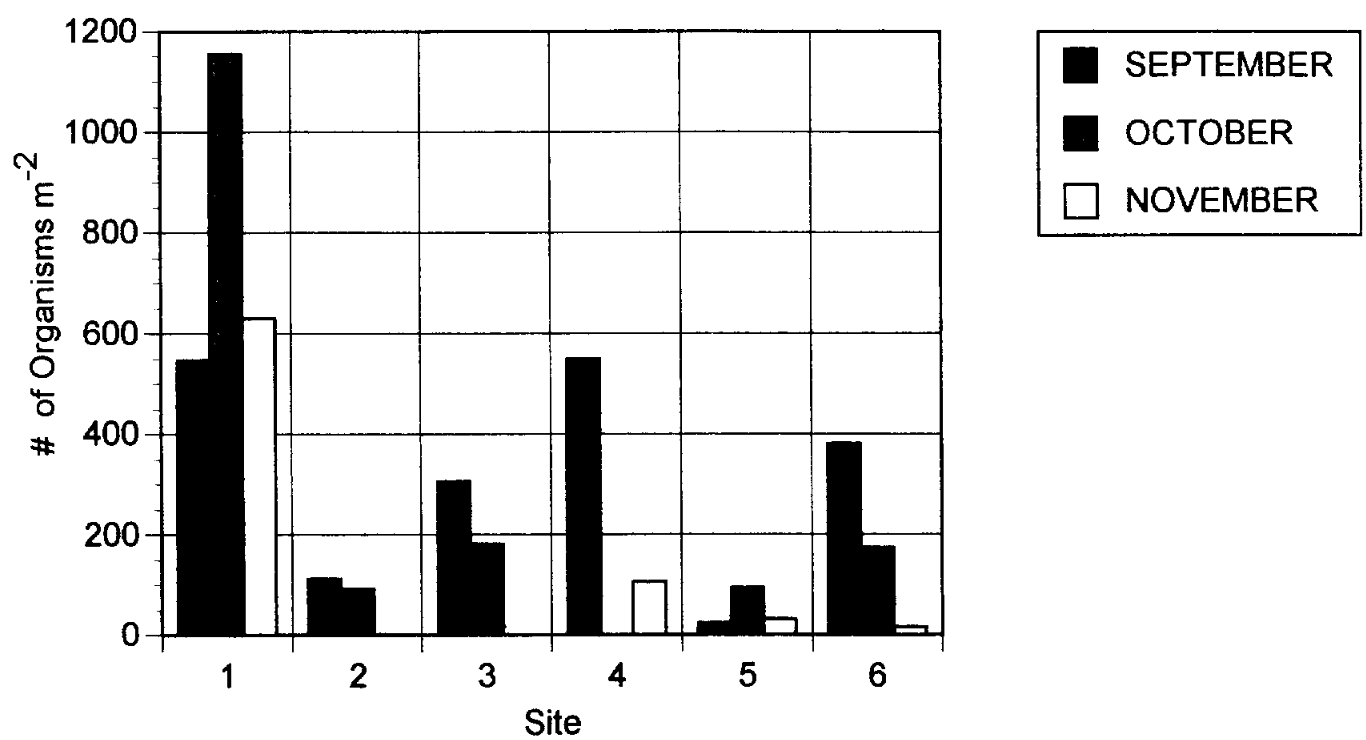


Figure 5: Functional feeding group (FFG) composition for benthic habitats in September 1993.

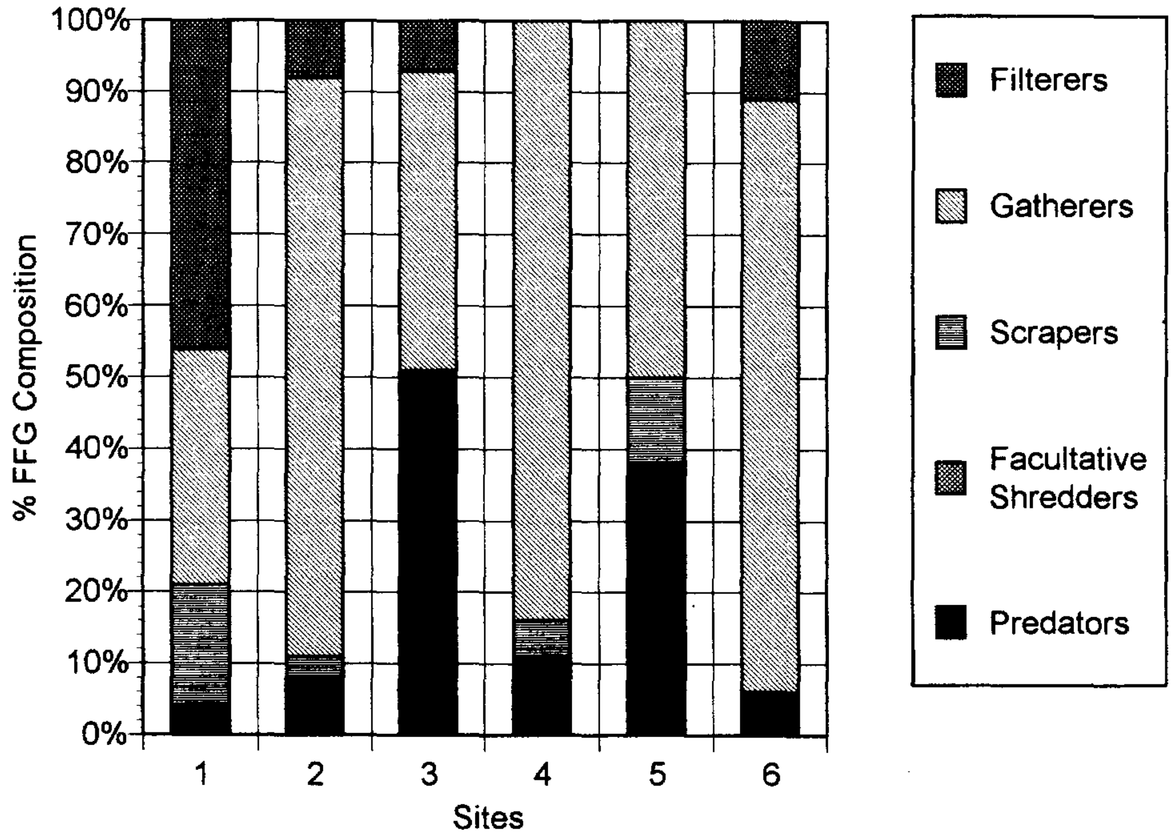


Figure 6: Functional feeding group (FFG) composition for benthic habitats in October 1993. Site 4 was not sampled due to high flows.

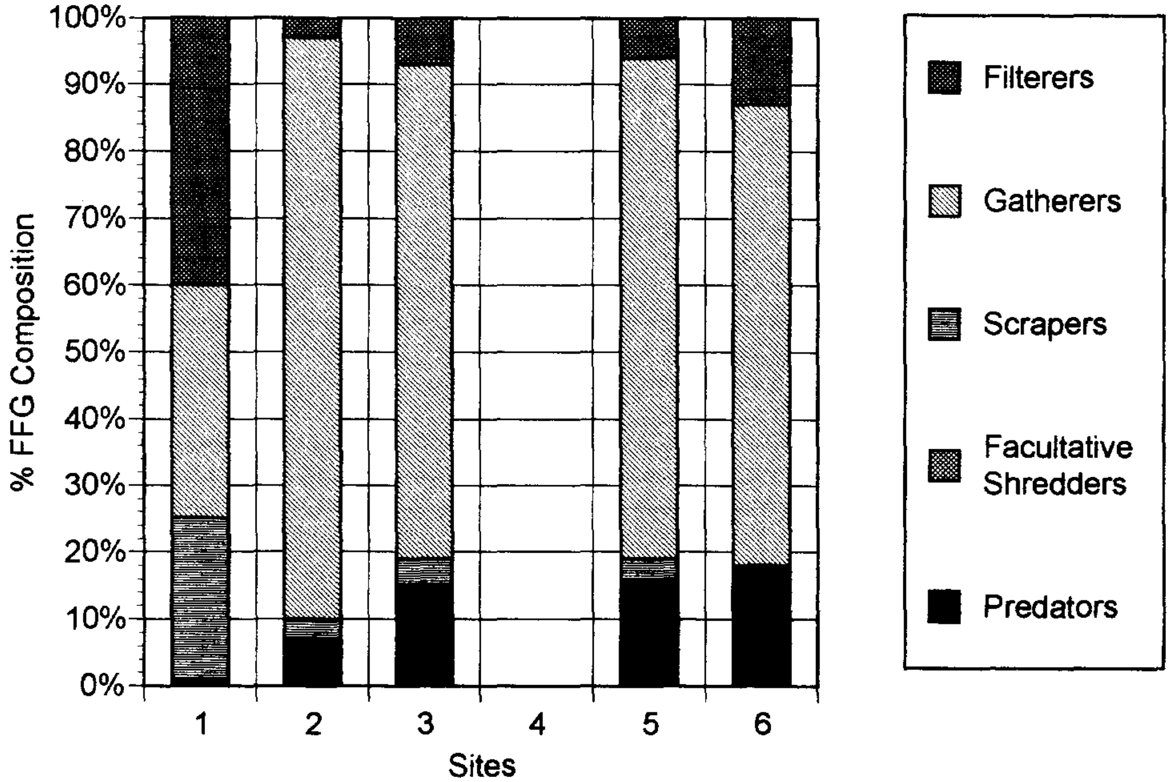


Figure 7: Functional feeding group (FFG) composition for benthic habitats in November 1993. Sites 2 and 3 were not accessible at this time.

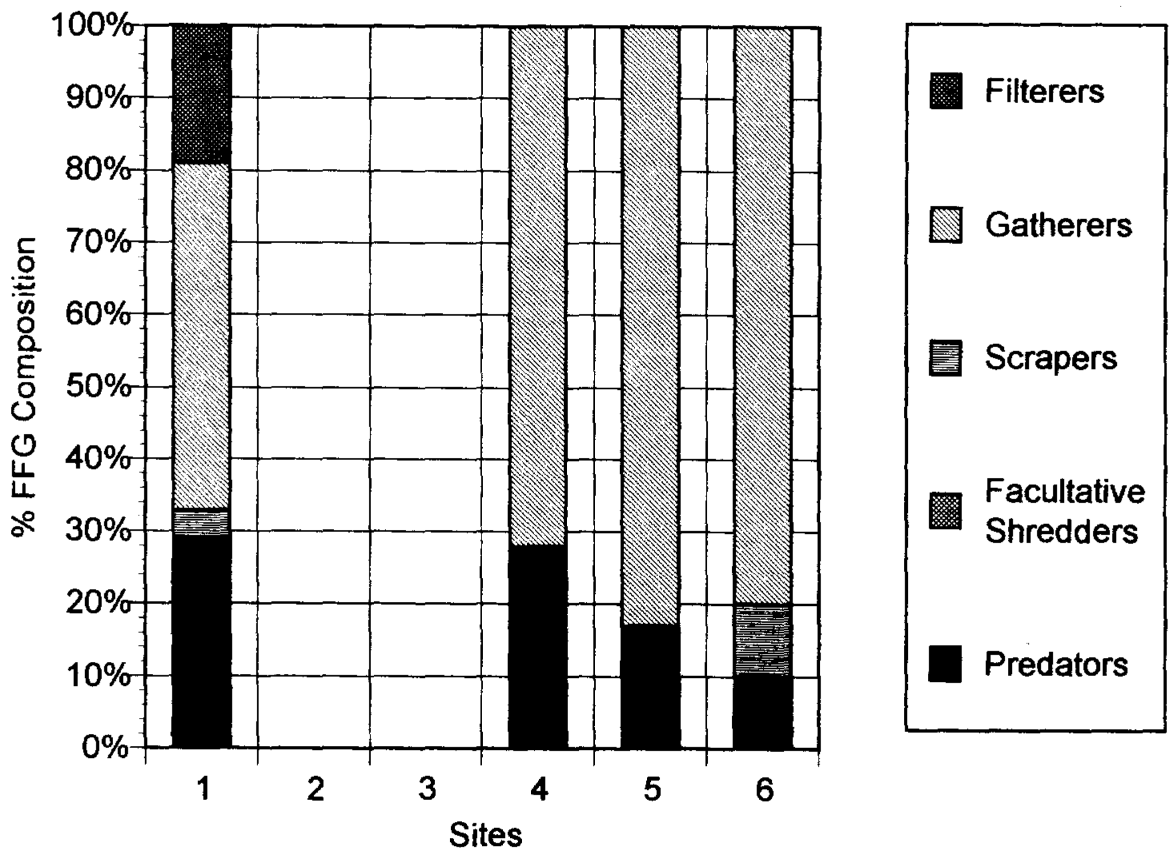


Figure 8: Functional feeding group (FFG) composition for snag habitat in October 1993.

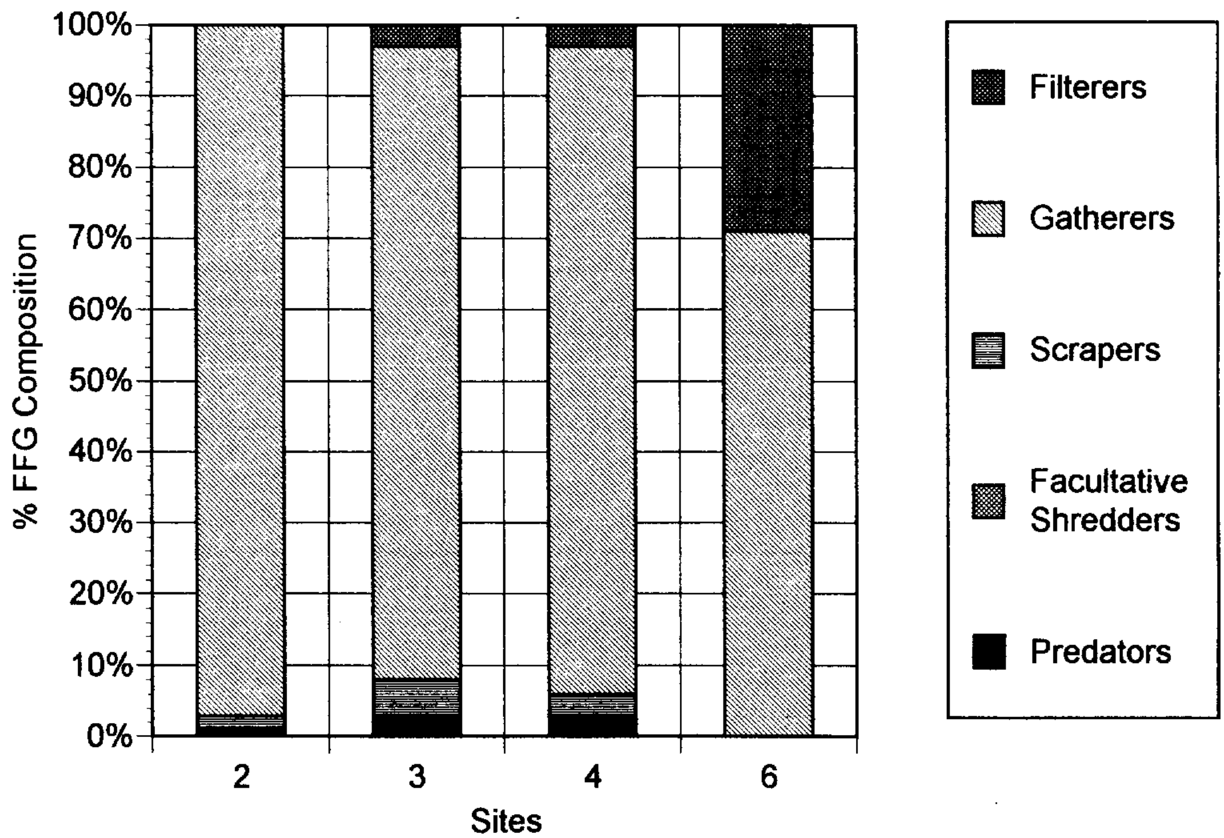


Figure 9: Functional feeding group (FFG) composition for snag habitats in November 1993. Sites 2 and 3 were not accessible at this time.

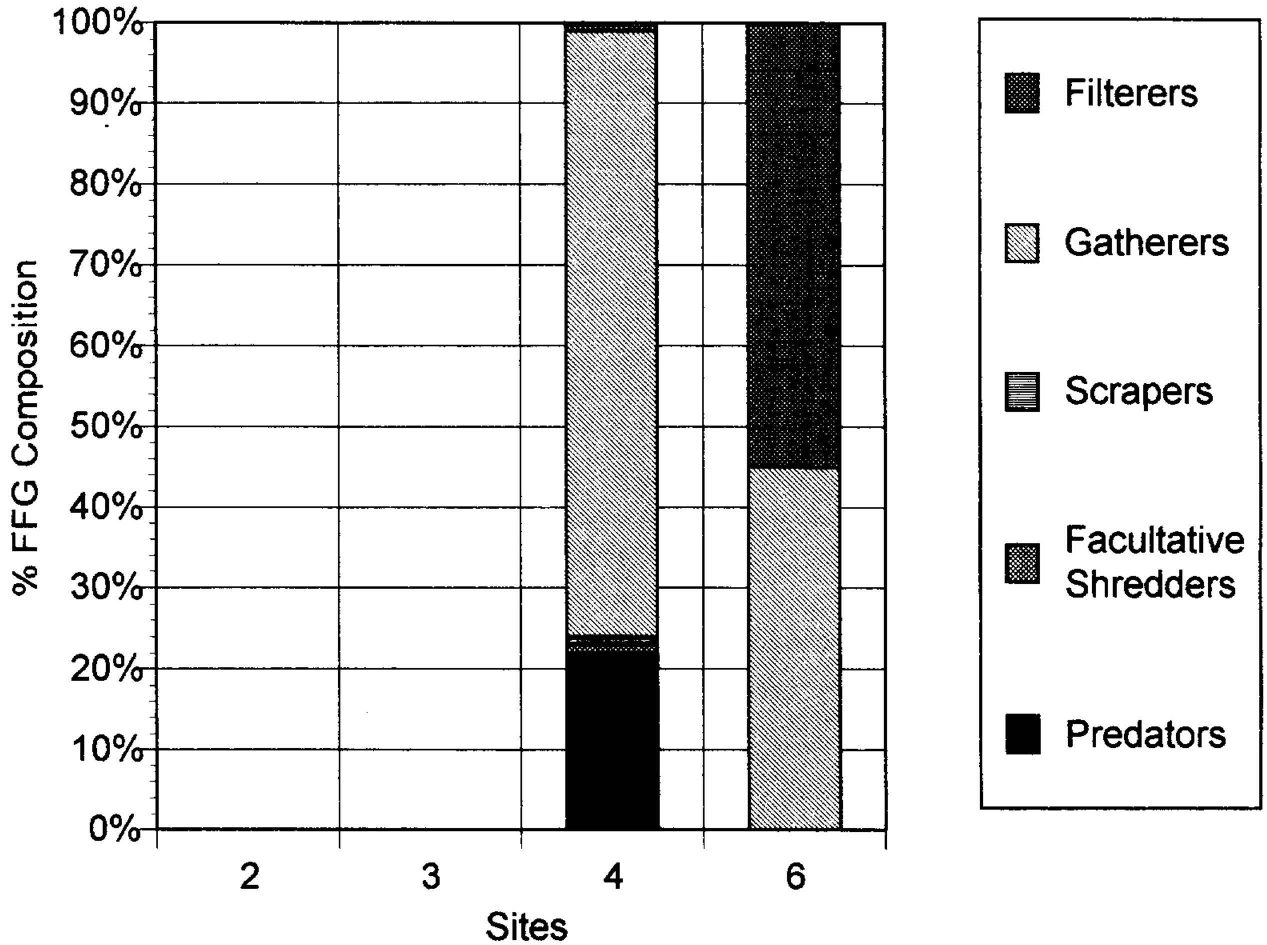


Figure 10: Standing stock biomass for dominant taxa in snag and benthic habitats in Allens Creek and the Brazos River from September through November of 1993.

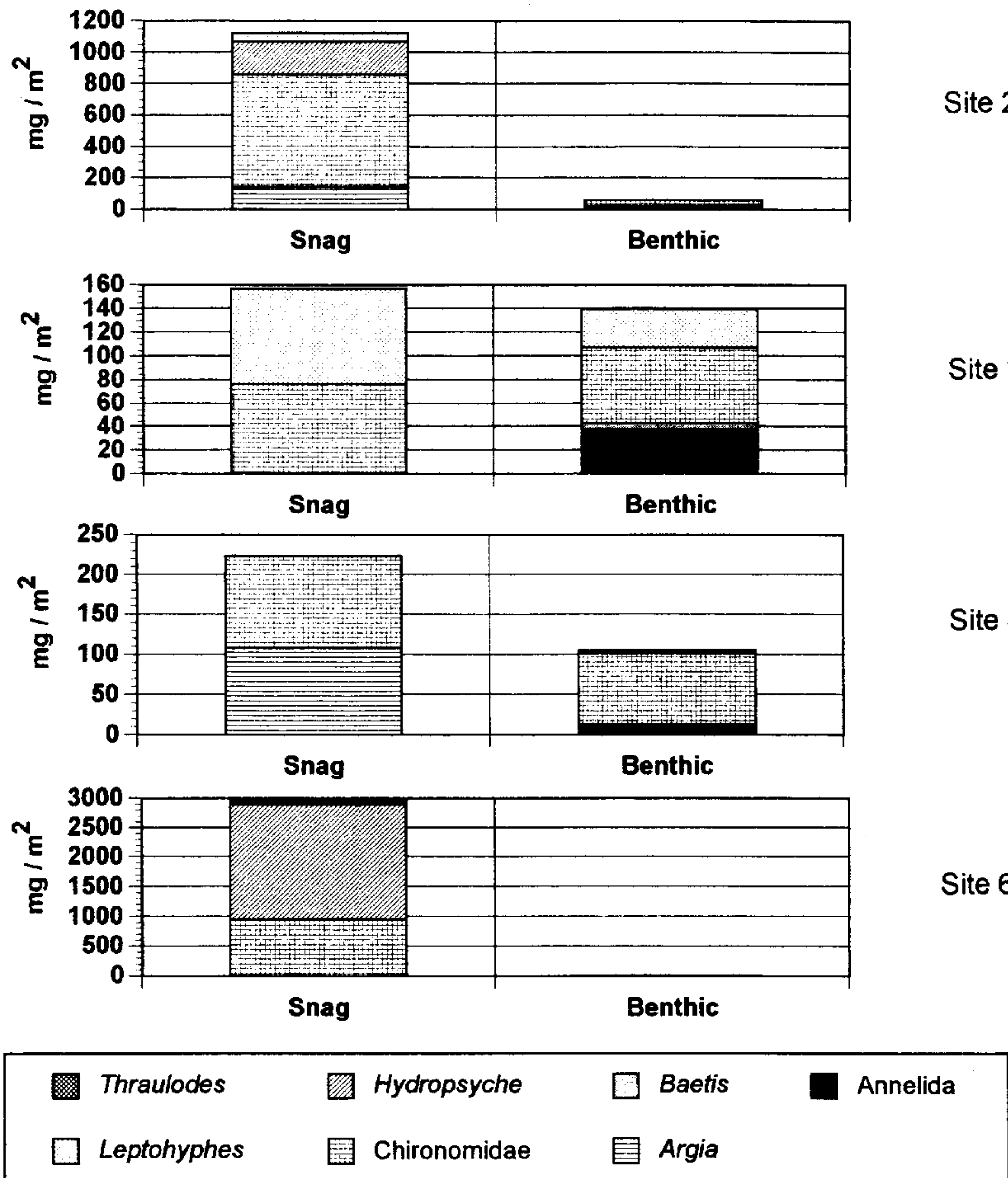


Figure 11: Secondary production for dominant taxa in snag and benthic habitats in Allens Creek and the Brazos River for September through November of 1993.

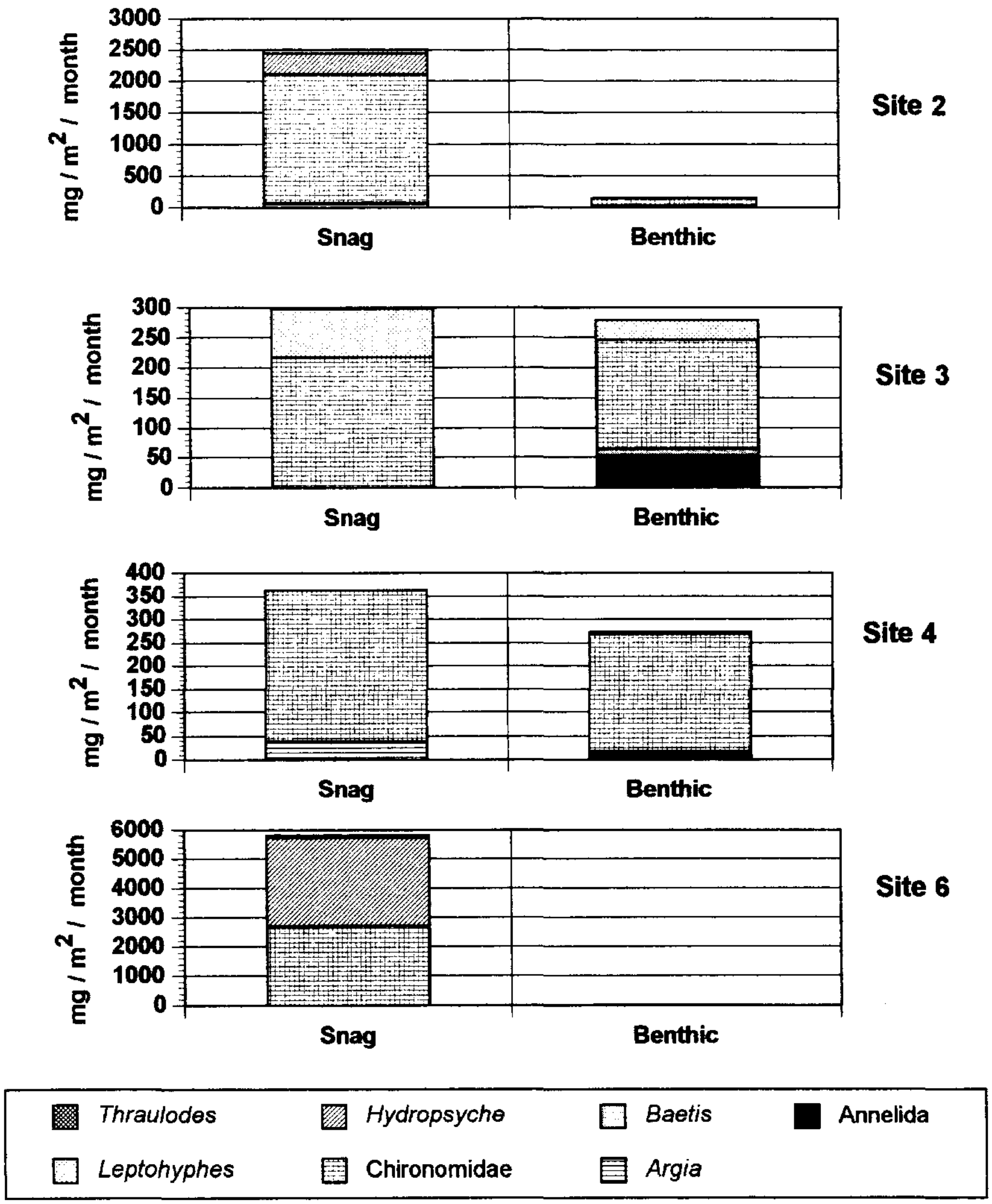
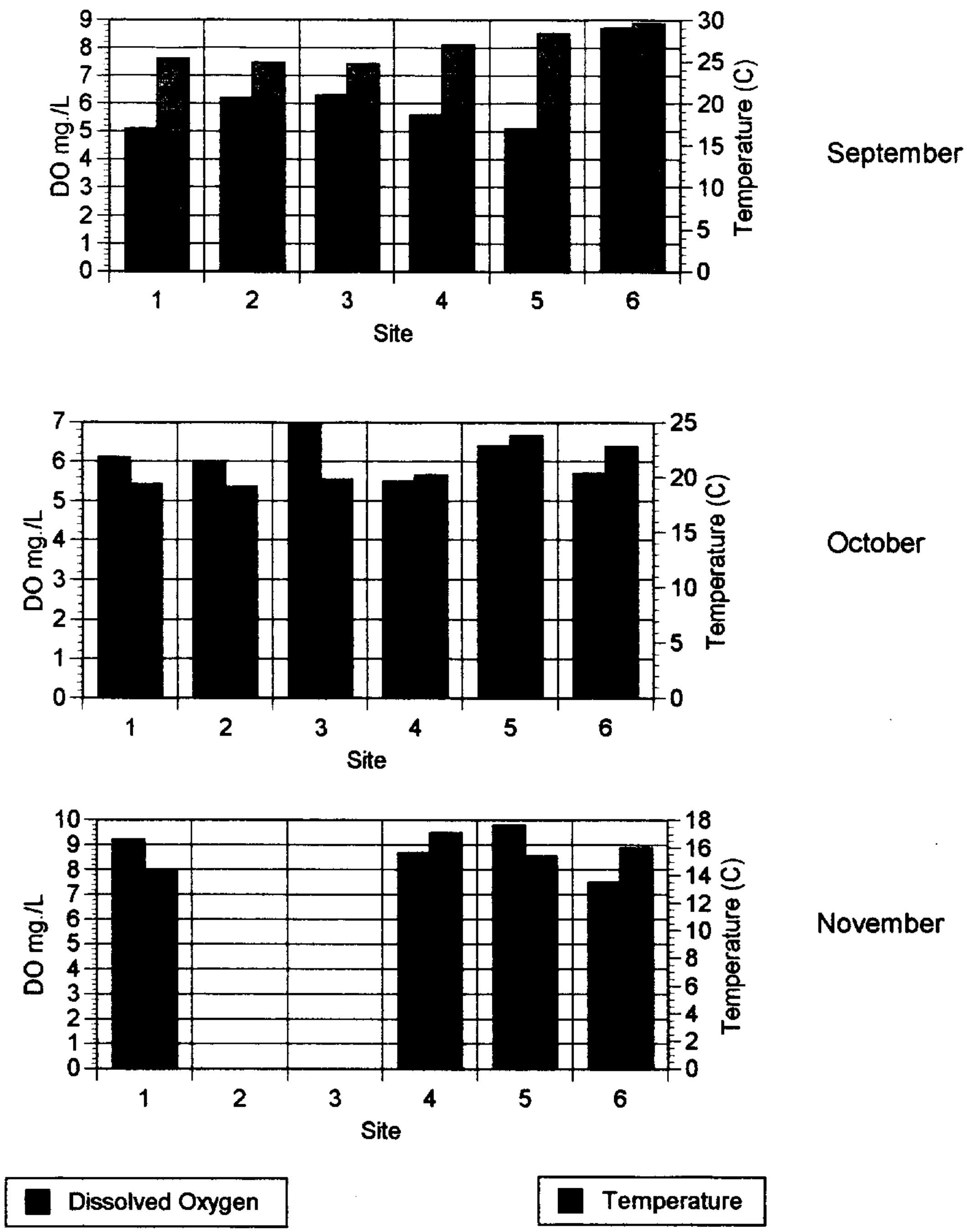


Figure 12: Dissolved oxygen and temperature recordings for fall 1993 in Allens Creek and the Brazos River.



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Appendix A

RBA Metrics

Table A1: Equations for RBA protocol III analysis as adapted from Plafkin et al. 1989.

$$\textbf{1. Taxa Richness} = \left(\frac{\text{\# of Families at Sample Site}}{\text{\# of Families at Reference Site}} \right) \times 100$$

2. Hilsenhoff Biotic Index or Family Biotic Index (FBI) (modified)

$$= \left(\frac{\text{FBI \# at Reference Site}}{\text{FBI \# at Study Site}} \right) \times 100$$

3. Functional Feeding Group % Similarity Index

To calculate the FFG % Similarity Index

A. Calculate % FFG composition of each FFG at both the reference site and the sample site to be compared.

$$= \left(\frac{\text{Total \# of individuals in FFG}}{\text{Total \# of individuals in Sample}} \right) \times 100$$

B. List the percent contribution of each FFG for the sample site and the reference site.

FFG	SAMPLE SITE	REFERENCE SITE
Scrapers	75%	{20%}
Filterers	{20%}	30%
Shredders	{5%}	50%

C. Take the lowest score for each FFG (Numbers in brackets from the example table above). Then sum all the lowest scores. The result is the Functional Feeding Group % Similarity.

ex. 20 + 20 + 5 = 45%

Table A1: Continued

4. Ratio of EPT (Ephemeroptera, Plecoptera, Trichoptera) and Chironomidae (Diptera) abundance

$$= \left(\frac{\frac{\sum \text{EPT Individuals}}{\sum \text{EPT} + \sum \text{Chironomidae Individuals}} \text{ at Sample Site}}{\frac{\sum \text{EPT Individuals}}{\sum \text{EPT} + \sum \text{Chironomidae Individuals}} \text{ at Reference Site}} \right) \times 100$$

5. % Contribution of Dominant Family

$$= \left(\frac{\frac{\text{\# of Individuals in Dominant Family}}{\text{Total \# of Individuals in Sample}} \text{ at Sample Site}}{\frac{\text{\# of Individuals in Dominant Family}}{\text{Total \# of Individuals in Sample}} \text{ at Reference Site}} \right) \times 100$$

6. EPT Index

$$= \left(\frac{\text{\# of Taxa For Ephemeroptera + Plecoptera + Trichoptera at Sample Site}}{\text{\# of Taxa For Ephemeroptera + Plecoptera + Trichoptera at Reference Site}} \right) \times 100$$

7. Community Similarity Index

$$= \left(\frac{\text{Total \# of Taxa at Reference Site - Total \# of Taxa Common to Both Sites}}{\text{Total \# Taxa at Sample Site}} \right) \times 100$$

Table A2: RBA protocol III impairment levels as modified from Plafkin et al. 1989.

% Comparison to Reference Score	Level of Impairment	Attributes
>83%	Nonimpaired	Comparable to the best situation to be expected within an ecoregion. Balanced trophic structure. Optimum community structure.
51-82%	Slightly Impaired	Community structure less than expected. Composition lower than expected due to loss of some intolerant forms. Percent contribution of tolerant forms increases.
20-50%	Moderately Impaired	Fewer species due to loss of most intolerant forms. Reduction in EPT index.
<20%	Severely Impaired	Few species present. If high densities of organisms, then dominated by one or two taxa.

A Fisheries Inventory and Assessment of Allens Creek and the Brazos River, Austin County, Texas

Gordon W. Linam
Jeffrey C. Henson
Mark A. Webb

River Studies Report No. 12

Resource Protection Division
Texas Parks and Wildlife Department
Austin, Texas

December 1994

Texas Water Development Board
Interagency Contract Number 93-483-364

INTRODUCTION

Allens Creek Reservoir is a proposed 8,250 acre reservoir located on Allens Creek, a small tributary of the Brazos River in Austin County, Texas. The project would impound water from the Allens Creek watershed as well as water diverted and pumped from the Brazos River (HDR Engineering, Inc. *et al.* 1994). Originally, Allens Creek Reservoir was proposed by the Houston Lighting and Power Company (HL&P) as a cooling lake for a nuclear power plant (URS/Forrest and Cotton, Inc. 1977). HL&P eventually abandoned plans for the power plant and subsequently the Brazos River Authority obtained an option to purchase the reservoir site from HL&P. The reservoir, if built, could serve as a water storage facility for the Trans-Texas Water Program (HDR Engineering, Inc. *et al.* 1994).

To assist in future environmental impact evaluations, the Texas Parks and Wildlife Department conducted a pre-impoundment survey of the fish community at the proposed Allens Creek Reservoir site and nearby Brazos River.

STUDY AREA

Allens Creek originates southeast of Sealy, Texas (Austin County), and flows south for about 16 km before making a strong turn to the east, emptying into the Brazos River after another 6 km. The proposed reservoir is located about 3 km north of Wallis, Texas (Figure 1).

Six sampling stations were selected within the study area (Table 1). One station was located upstream, two within, and three downstream of the proposed reservoir.

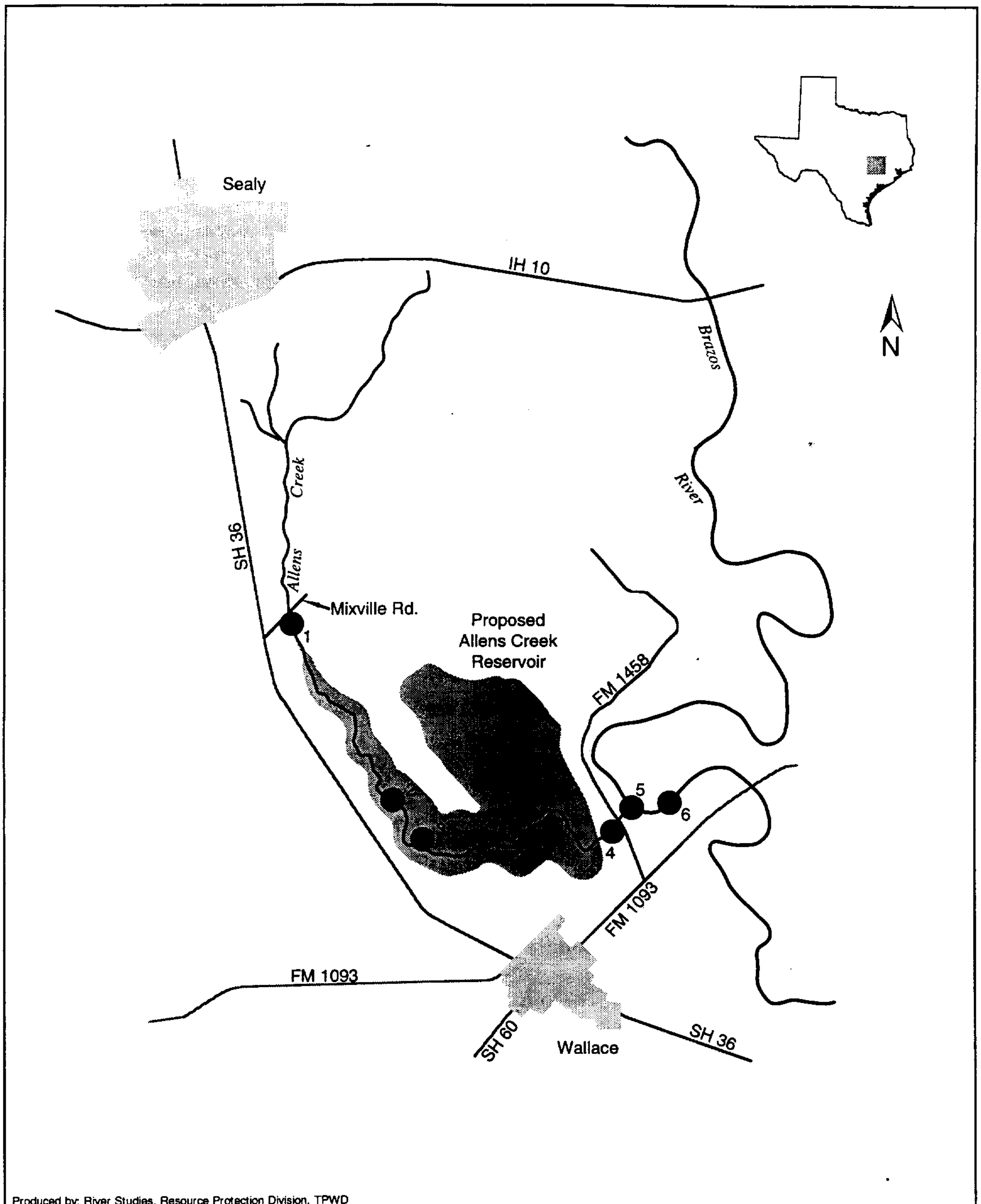

Figure 1. Sample stations on Allens Creek and Brazos River (Austin County, Texas). See Table 1 for station descriptions.

Table 1. Sample station descriptions for Allens Creek and the Brazos River, Texas (Austin County).

Station 1:	Allens Creek at Mixville Road. GPS: 29°42'15"N 96°07'45"W
Station 2:	Allens Creek at private road off from SH 36 on Houston Power and Light property. GPS: 29°40'2"N 96°06'19"W
Station 3:	Allens Creek at private road off from SH 36 on Houston Power and Light property. The private road is located across from the Christ Our Redeemer Church Academy. GPS: 29°39'20"N 96°06'00"W
Station 4:	Allens Creek at FM 1458. GPS: 29°39'56"N 96°02'49"W
Station 5:	Allens Creek at mouth. GPS: 29°39'56"N 96°02'49"W
Station 6:	Brazos River between Allens Creek and FM 1093.

The upstream station (Station 1) was established at Mixville Road, about 8 km south of Sealy. This site consisted of turbid, shallow pools (typically less than 0.3 m deep) and riffles. Substrate was sand and clay. Much of the stream bank had been recently cleared for pastureland. Woody debris, undercut banks, and root wads were prevalent and provided abundant fish habitat.

The two stations within the proposed reservoir, Stations 2 and 3, are located on HL&P property. Both stations are accessed by private roads off of SH 36. Entrance to Station 2 is through a gate located about 5 km south of Mixville Road. A large, white, abandoned two-story house on the east side of SH 36 identifies the gate leading into the station. The gate into Station 3 is about 2 km south of the gate for Station 2, and is located just across from the Christ Our Redeemer Church Academy. These stations were characterized by sand and clay substrate and very heavy canopy cover from mixed hardwood trees and willows. The stream was clear and shallow. In September, many of the pools at Station 3 were widely separated by long stretches of dry stream bed. Mean depth of most pools was about 0.3 m or less and maximum depth was about 1 m. The predominant land use within this portion of the watershed was cattle grazing.

Stations 4-6 are located downstream of the proposed reservoir. Station 4 was located at FM 1458. Station 5 was the most downstream station on Allens Creek and consisted of the first and second pools upstream from its confluence with the Brazos River. The downstream reach of Allens Creek was turbid and had very soft sand/silt substrate. Willows dominated the stream bank cover. Very little instream cover was noted. The major land uses in the immediate vincinity of these stations were cattle grazing and hay production. Station 6 was located in the Brazos River just downstream from the mouth of Allens Creek. Sand was the dominant substrate in this area; however, gravel bars were also present. Snag habitat was scattered throughout the river but was not very abundant.

MATERIALS AND METHODS

Fish and physicochemical measurements were collected at five sampling stations in Allens Creek and one station in the Brazos River. Sampling was conducted on September 7-8, 1993, and again on November 16-17, 1993. Fish were collected at each station in Allens Creek with straight seines and a backpack electrofisher. Boat electrofishing was also employed at Station 5 during the November effort. Brazos River fish samples were collected with straight seines and a boat-mounted electrofisher. Habitats were sampled in proportion to their occurrence.

Physicochemical parameters were measured at each station with a Hydrolab Scout and included: dissolved oxygen, pH, conductivity, and temperature. General physical features such as substrate, turbidity, water depth, and riparian attributes were noted while sampling.

The Index of Biotic Integrity (IBI) was used to evaluate the fish community (Karr *et al.* 1986), though the metrics and scoring criteria were modified to rate the Allens Creek and Brazos River fish community. Metrics and scoring criteria were developed from a study of minimally disturbed Texas streams (Bayer *et al.* 1992). Trophic and tolerance designations follow that developed by Linam and Kleinsasser (unpublished manuscript).

All sample stations but Station 1 are within the Western Gulf Coastal Plain Region. Station 1 lies just within the boundary of the South Central and Southern Humid, Mixed Land Use Region (Omernik and Gallant 1989). Since regional boundaries were coarsely established and the stream characteristics and fish community at Station 1 were very similar to the other stations downstream, the same IBI metrics and scoring criteria were used for all stations (Table 2).

Eight of the original IBI metrics developed by Karr *et al.* (1986) were employed in this study. The number of darter species and the number of sucker species were eliminated because only one darter species and no suckers were collected from the minimally disturbed streams sampled in the Western Gulf Coastal Plain Region (Bayer *et al.* 1992). Number of cyprinid species excluding common carp (*Cyprinus carpio*) and number of catfish species were used in their place. These modifications were previously employed in Texas during a study of the Trinity River (Kleinsasser and Linam 1989). Catfish were used based upon suggested modifications by Karr *et al.* (1986) and because they were well represented in collections from the minimally disturbed streams in this region. Cyprinid species was selected because cyprinids were fairly common in the minimally disturbed streams from this region and because this family is considered to have many species which serve as good indicators of water quality (Ramsey 1968). Also, Hughes and Gammon (1987) used cyprinids as a target group in an IBI study of the Willamette River, citing their responsiveness to deterioration of habitat structure (Minckley 1973; Moyle 1976).

Table 2. Metrics, scoring criteria, and integrity classes used to evaluate the fish community in Allens Creek and the Brazos River.

	Scoring criteria		
METRIC	5	3	1
1. Total number of fish species	>10	5-10	<5
2. Number of cyprinid species (excluding common carp)	>2	2	<2
3. Number of catfish species	>2	2	<2
4. Number of sunfish species	>3	2-3	<2
5. Number of intolerant species	≥1	-	0
6. Proportion of individuals as tolerant species (excluding western mosquitofish)	<26%	26-50%	>50%
7. Proportion of individuals as omnivores	<9%	9-16%	>16%
8. Proportion of individuals as invertebrate feeders	>64%	34-64%	<34%
9. Proportion of individuals as piscivores	>2%	1-2%	0%
10. Number of individuals in sample*			
a. Individuals/seine haul	>174	88-174	<88
b. Individuals/minute shocked	>6	4-6	<4
11. Proportion of individuals as introduced species	<2%	2%	>2%
12. Proportion of individuals with disease or other anomaly	<0.6%	0.6-1%	>1%

IBI Score	Integrity Class
58-60	Excellent
48-52	Good
40-44	Fair
28-34	Poor
12-22	Very Poor
	No Fish

* Rating calculated as a mean of a and b

The scoring criteria for number of intolerant species was adjusted such that this metric can either receive a score of five or one, since only one intolerant species was collected from the minimally disturbed streams in this region. The proportion of individuals as tolerant species (excluding western mosquitofish, *Gambusia affinis*) was substituted for proportion of individuals as green sunfish (*Lepomis cyanellus*). Karr *et al.* (1986) selected green sunfish as a species that tends to overpopulate disturbed areas, but offered proportion of tolerant individuals as an alternate metric. Western mosquitofish are tolerant, but were excluded since there does not appear to be a relationship between water quality and their abundance. They are common in both perturbed and unperturbed systems, and were often the most abundant species in the minimally disturbed streams sampled. Their inclusion would have reduced the sensitivity of this metric.

In other modifications, the proportion of individuals as invertebrate feeders was substituted for proportion of insectivorous cyprinids, following the guidance of Karr *et al.* (1986). The proportion of individuals as hybrids was replaced with the proportion of individuals as introduced species. Introduced species may impact the native species present, and their presence is often an indication of deteriorating stream conditions.

RESULTS AND DISCUSSION

Physicochemical measurements are reported in Table 3. All measured parameters were within ranges capable of supporting a diverse fish community. Conductivity in Allens Creek increased substantially between Stations 3 and 4

Table 3. Physicochemical measurements recorded in Allens Creek and the Brazos River during September and November, 1993.

SEPTEMBER

	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Date	9/8/93	9/8/93	9/8/93	9/7/93	9/7/93	9/7/93
Time	0902	1204	1454	1813	1107	1430
Temperature (°C)	23.07	25.22	25.85	26.23	26.43	30.03
Dissolved Oxygen (mg/L)	3.63	5.81	5.74	9.74	5.09	8.60
Conductivity (μmhos/cm)	573	512	576	750	755	1160
pH	7.65	8.04	8.13	7.66	7.90	8.21

NOVEMBER

	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Date	11/16/93	11/16/93	11/16/93	11/16/93	11/17/93	11/17/93
Time	0937	1050	1220	1441	1134	1301
Temperature (°C)	17.63	17.84	17.14	16.72	14.52	17.21
Dissolved Oxygen (mg/L)	7.58	8.43	8.82	7.25	8.50	8.02
Conductivity (μmhos/cm)	226	299	190	268	132	637
pH	7.66	7.97	8.12	8.16	8.35	8.19

(possibly due to the City of Wallis sewage treatment plant), but was even higher in the Brazos River (nearly twice the highest values recorded in Allens Creek during September, and more than twice the values recorded in November). Temperature was also slightly higher in the Brazos River (during September), likely due in part to the dense canopy cover over Allens Creek.

November 1993 physicochemical measurements were recorded during a major thunderstorm associated with a cold front moving through the area. Runoff caused the creek to rise and deposition of sediment was observed at the mouths of channels entering the creek. Measurements reported for the sample period reflect those conditions. Water temperature was considerably cooler and conductivity was up to six times lower than in September.

Forty-four fish species were collected from Allens Creek and the Brazos River (Tables 4 and 5). Western mosquitofish was the most abundant fish species at all but two sampling stations in Allens Creek. Pirate perch (*Aphredoderus sayanus*) slightly outnumbered it at Station 2 in September, whereas longear sunfish (*Lepomis megalotis*) outnumbered it there in November. Red shiner (*Cyprinella lutrensis*) was the most abundant species at Station 5 in November, and dominated both collections in the Brazos River.

Red shiner was the dominant cyprinid at Stations 4, 5, and 6 during September and at Stations 5 and 6 in November; however, bullhead minnow (*Pimephales vigilax*) displaced it as the most numerous cyprinid at Station 4 in November. No one cyprinid species dominated the three upstream stations, but blacktail shiner was the most

Table 5. Fishes collected with seines and electrofishing gear from Allens Creek and the Brazos River during November 1993.

Species	Common Name	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Lepisosteus oculatus	Spotted gar				1		6
Lepisosteus osseus	Longnose gar						1
Amia calva	Bowfin	1				1	
Dorosoma cepedianum	Gizzard shad	1			1	5	17
Dorosoma petenense	Threadfin shad						2
Cyprinella lutrensis	Red shiner			1	22	204	1694
Cyprinella venusta	Blacktail shiner	16	8	3	3	1	1
Cyprinus carpio	Common carp	4	2			9	
Hybognathus nuchalis	Mississippi silvery minnow		3	1		1	1
Lythrurus fumeus	Ribbon shiner						
Macrhybopsis aestivalis	Speckled chub						
Macrhybopsis storeriana	Silver chub						
Notemigonus crysoleucas	Golden shiner						
Notropis buchanani	Ghost shiner					1	3
Notropis shumardi	Silverband shiner				20	16	137
Opsopoedus emiliae	Pugnose minnow					1	
Pimephales vigilax	Bullhead minnow	3	2	7	62	85	312
Carpiodes carpio	River carpsucker	2	5		5	3	11
Ictiobus bubalus	Smallmouth buffalo		1		1	1	1
Minytrema melanops	Spotted sucker						
Ameiurus melas	Black bullhead		1				
Ameiurus natalis	Yellow bullhead	2	5	1			
Ictalurus furcatus	Blue catfish						1
Ictalurus punctatus	Channel catfish	2	2		1	4	11
Noturus gyrinus	Tadpole madtom	1					
Pylodictis olivaris	Flathead catfish						1
Aphredoderus sayanus	Pirate perch	3	6	3	1		
Gambusia affinis	Western mosquitofish	55	15	147	78	124	47
Menidia beryllina	Inland silverside						
Elassoma zonatum	Banded pygmy sunfish				1		
Lepomis cyanellus	Green sunfish	3	9	5	8	7	4
Lepomis gulosus	Warmouth	13	5	1	19	1	2
Lepomis humilis	Orangespotted sunfish				1	1	2
Lepomis hybrid	Sunfish hybrid						
Lepomis macrochirus	Bluegill	23	2		26	8	4
Lepomis megalotis	Longear sunfish	32	24	22	8	5	5
Lepomis microlophus	Redear sunfish						
Lepomis sp. (juvenile)	Juvenile sunfish						1
Micropterus punctulatus	Spotted bass			1			
Micropterus salmoides	Largemouth bass	1					
Pomoxis annularis	White crappie				2	2	2
Pomoxis nigromaculatus	Black crappie						
Etheostoma gracile	Slough darter	2	1	1	3		
Aplodinotus grunniens	Freshwater drum						6
Mugil cephalus	Striped mullet						1
Mugil curema	White mullet						

Table 4. Fishes collected with seines and electrofishing gear from Allens Creek and the Brazos River during September 1993.

Species	Common Name	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Lepisosteus oculatus	Spotted gar			1		16	3
Lepisosteus osseus	Longnose gar						1
Amia calva	Bowfin			1			
Dorosoma cepedianum	Gizzard shad		4	1	1		39
Dorosoma petenense	Threadfin shad					5	1
Cyprinella lutrensis	Red shiner	2	1	2	212	128	1120
Cyprinella venusta	Blacktail shiner	8	8	10	66	34	
Cyprinus carpio	Common carp	1	3	5	5	2	3
Hybognathus nuchalis	Mississippi silvery minnow			1			
Lythrurus fumeus	Ribbon shiner	5				5	
Macrhybopsis aestivalis	Speckled chub						1
Macrhybopsis storeriana	Silver chub						1
Notemigonus crysoleucas	Golden shiner	3			1	1	
Notropis buchanani	Ghost shiner						
Notropis shumardi	Silverband shiner					5	363
Opsopoedus emiliae	Pugnose minnow					1	
Pimephales vigilax	Bullhead minnow	8	1	4	48	7	266
Carpiodes carpio	River carpsucker	1	3	5	18		47
Ictiobus bubalus	Smallmouth buffalo				1		
Minytrema melanops	Spotted sucker		1				
Ameiurus melas	Black bullhead				1		
Ameiurus natalis	Yellow bullhead	3	38	24	2		
Ictalurus furcatus	Blue catfish						20
Ictalurus punctatus	Channel catfish	3	1	11	9		47
Noturus gyrinus	Tadpole madtom	1		1			
Pylodictis olivaris	Flathead catfish			1			22
Aphredoderus sayanus	Pirate perch	7	37	28	5	6	
Gambusia affinis	Western mosquitofish	215	35	508	3861	463	551
Menidia beryllina	Inland silverside					2	
Elassoma zonatum	Banded pygmy sunfish						
Lepomis cyanellus	Green sunfish	2	21	21	50	13	16
Lepomis gulosus	Warmouth	7	9	3	24	42	
Lepomis humilis	Orangespotted sunfish				1		
Lepomis hybrid	Sunfish hybrid				2		
Lepomis macrochirus	Bluegill	29	13	20	53	50	2
Lepomis megalotis	Longear sunfish	19	20	13	8	2	
Lepomis microlophus	Redear sunfish				2		
Lepomis sp. (juvenile)	Juvenile sunfish						
Micropterus punctulatus	Spotted bass						
Micropterus salmoides	Largemouth bass	1	1	4	1		
Pomoxis annularis	White crappie			1	4	18	1
Pomoxis nigromaculatus	Black crappie					2	
Etheostoma gracile	Slough darter	9			6	1	
Aplodinotus grunniens	Freshwater drum						
Mugil cephalus	Striped mullet						5
Mugil curema	White mullet						2

numerous cyprinid in most upstream collections. This shift in cyprinid abundance between Stations 3 and 4 may be related to factors including conductivity, turbidity, and siltation. As noted previously, conductivity substantially increased between Stations 3 and 4, turbidity was greater in the downstream reach, and substrate composition changed from clay and sand to very soft sand/silt. Allens Creek was nearly dry at Station 3 in September and was reduced to enduring pools to a point just upstream of Station 4. In-channel springs and the City of Wallis sewage treatment plant contributed to flow at Station 4; however, flow was scarcely apparent at its mouth (which was almost completely silted in). Red shiners and bullhead minnows appear better suited than many freshwater fishes (including blacktail shiners) to such physicochemical conditions providing them a possible advantage over other cyprinids in the lower reach and Brazos River (Paloumpis 1958; Minckley 1973; Pflieger 1975; Matthews and Hill 1977; Robison and Buchanan 1984; Cross and Moss 1987; Rutledge and Beitinger 1989).

River carpsucker (*Carpiodes carpio*) was collected at each station and was the most abundant of the three sucker species collected. River carpsucker are one of two sucker species listed as tolerant for purposes of IBI in Texas (Linam and Kleinsasser unpublished manuscript) and seem to prefer waters that are turbid much of the time as it is replaced in clearer waters by other suckers (Pflieger 1975). Smallmouth buffalo (*Ictiobus bubalus*) were collected at most of the stations, but in much lower numbers than river carpsucker.

Six catfish species were collected during this survey. Channel catfish (*Ictalurus* *punctatus*) and yellow bullhead (*Ameiurus natalis*) were the two most common catfish species. Channel catfish were documented from each station but were most abundant from Station 4 downstream (including the Brazos River); whereas, yellow bullhead was the most common catfish species in the upstream reach of Allens Creek.

Collections made during this survey also documented eleven centrarchid species including banded pygmy sunfish (*Elassoma zonatum*), six *Lepomis* species, two black basses, and two crappies. Banded pygmy sunfish, redear sunfish (*Lepomis microlophus*), spotted bass (*Micropterus punctulatus*), and black crappie (*Pomoxis nigromaculatus*) were each only collected from one station (all in Allens Creek); whereas, orangespotted sunfish (*Lepomis humilis*) were only collected from Station 4 downstream (including the Brazos River). The others were fairly evenly distributed.

Other fish families collected include: Lepisosteidae (two species); Amiidae (one species - only from Allens Creek); Clupeidae (two species); Aphredoderidae (one species - only from Allens Creek); Atherinidae (one species - only from Allens Creek); Percidae (one species - only from Allens Creek); Sciaenidae (one species - only from the Brazos River); and Mugilidae (two species - only from the Brazos River).

During September, Station 3 received an excellent IBI integrity class rating; Stations 1 and 4, good to excellent; Stations 5 and 6, fair to good; and Station 2, fair (Table 6). Station 1 did not receive an excellent rating because of the low number of individuals collected and the moderately high proportion of fish with disease or anomalies. Station 4 rated less than excellent because of the absence of intolerant species and the moderate proportion of piscivores collected. Station 5 did not rate higher because of the absence of catfish and intolerant species, the moderately high proportion of tolerant species, and the low number of individuals collected. Station 6 only had a moderate number of sunfish species, no intolerant species, a high proportion of tolerant species, a moderate proportion of piscivores, and a moderate number of individuals in the collection. Station 2 only received a fair rating due to a moderate number of catfish species, absence of intolerant species, moderately high proportion of tolerant species, imbalanced trophic structure, modest number of fish collected, and moderately high proportion of introduced species.

Integrity classes declined at all stations in Allens Creek (except Station 2 which remained as fair) during November; while, the Brazos River station increased from a fair to good integrity class to good. The changes in Allens Creek were likely due to the rising stream conditions which rendered sampling less effective than in September. This is supported by the species richness data in that the disparity in the number of species collected from each station increased downstream as rising waters exhibited an increasing effect on sampling efficiency. Species richness at Station 5 did not follow this trend since the high waters provided the opportunity to boat electrofish. In November, Stations 1, 4, and 6 received good integrity class ratings, Station 3 fair to good, and Stations 2 and 5 fair (Table 7). Less than expected numbers of fish were collected at each station. Besides low collection numbers contributing to the less than excellent rating, Station 1 only yielded a moderate number of cyprinid and sunfish species, a moderately high proportion of tolerant individuals, and a moderately high proportion of introduced species. Station 4 had a low number of catfish species,

Table 6. IBI ratings for the Allens Creek and Brazos River stations sampled during September 1993.

Metric	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
1. Total number of fish species	18 (5)	16 (5)	21 (5)	22 (5)	20 (5)	20 (5)
2. Number of cyprinid species (excluding common carp)	5 (5)	3 (5)	4 (5)	4 (5)	7 (5)	5 (5)
3. Number of catfish species	3 (5)	2 (3)	4 (5)	3 (5)	0 (1)	3 (5)
4. Number of sunfish species	4 (5)	4 (5)	4 (5)	6 (5)	4 (5)	2 (3)
5. Number of intolerant species (bonus)	1 (3)	0 (-)	1 (3)	0 (-)	0 (-)	0 (-)
6. Proportion of individuals as tolerant species (excluding western mosquitofish)	15 (5)	28 (3)	11 (5)	9 (5)	31 (3)	51 (3)
7. Proportion of individuals as omnivores	3 (5)	25 (3)	7 (5)	1 (5)	1 (5)	6 (5)
8. Proportion of individuals as invertebrate feeders	94 (5)	59 (3)	88 (5)	97 (5)	88 (5)	92 (5)
9. Proportion of individuals as piscivores	3 (5)	16 (5)	5 (5)	2 (5)	11 (5)	2 (5)
10. Number of individuals in sample						
a. Individuals/seine haul	38 (1)	8 (1)	85 (3)	1052 (5)	83 (3)	374 (5)
b. Individuals/minute electrofishing	4 (3)	10 (5)	10 (5)	10 (5)	3 (3)	3 (3)
Mean	(2)	(3)	(4)	(5)	(3)	(4)
11. Proportion of individuals as introduced species	0 (5)	1.5 (3)	0.8 (5)	0.1 (5)	0.2 (5)	0.1 (5)
12. Proportion of individuals with disease or other anomaly	0.9 (3)	0.5 (3)	0.3 (5)	0 (5)	0 (5)	0 (5)
Total IBI score	53	41	57	55	47	50
Integrity class	Good	Fair/Good	Excellent	Excellent	Good	Good/Excellent

Table 7. IBI ratings for the Allens Creek and Brazos River stations sampled during November 1993.

Metric	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
1. Total number of fish species	17 (5)	16 (5)	12 (5)	19 (5)	20 (5)	24 (5)
2. Number of cyprinid species (excluding common carp)	2 (3)	3 (5)	4 (5)	4 (5)	7 (5)	6 (5)
3. Number of catfish species	3 (5)	3 (5)	1 (1)	1 (1)	1 (1)	3 (5)
4. Number of sunfish species	3 (5)	4 (5)	3 (3)	5 (5)	5 (5)	5 (5)
5. Number of intolerant species (bonus)	1 (3)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
6. Proportion of individuals as tolerant species (excluding western mosquitofish)	30 (3)	32 (3)	4 (5)	32 (3)	51 (3)	77 (1)
7. Proportion of individuals as omnivores	7 (5)	21 (3)	1 (5)	3 (5)	5 (5)	2 (5)
8. Proportion of individuals as invertebrate feeders	82 (5)	64 (3)	95 (5)	86 (5)	93 (5)	97 (5)
9. Proportion of individuals as piscivores	11 (5)	15 (5)	4 (5)	11 (5)	2 (5)	1 (3)
10. Number of individuals in sample						
a. Individuals/seine haul	9 (1)	7 (1)	22 (1)	10 (1)	33 (1)	724 (5)
b. Individuals/minute electrofishing	7 (5)	4 (3)	5 (5)	20 (5)	14 (5)	2 (3)
Mean	(3)	(2)	(3)	(3)	(3)	(4)
11. Proportion of individuals as introduced species	2.4 (1)	2.2 (1)	0 (5)	0 (5)	1.9 (3)	0 (5)
12. Proportion of individuals with disease or other anomaly	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)
Total IBI score	48	42	47	47	45	48
Integrity class	Good	Fair/Good	Good	Good	Good	Good

no intolerant species, and a moderately high proportion of tolerant individuals. Station 6 yielded no intolerant species, a high proportion of tolerant individuals, and a moderate proportion of piscivores. Station 3 rated fair to good because of the low number of catfish species, moderate number of sunfish species, and absence of intolerant species. Station 2 rated fair due to the absence of intolerant species, moderately high proportion of tolerant species, imbalanced trophic structure, and moderately high proportion of introduced species. Station 5 also rated fair, due to the low number of catfish species, absence of intolerant species, high proportion of tolerant individuals, moderate proportion of piscivores, and moderately high proportion of introduced species.

SUMMARY

The impoundment of streams has immediate obvious effects on the terrestrial ecosystem which is inundated, but perhaps less obvious effects on the aquatic environment. Fish species with specific habitat requirements associated with lotic systems are often replaced with species more suited for lentic environments. Allens Creek, as well as the Brazos River station, have rich fish faunas typical of streams in the Western Gulf Coastal Plain with species richnesses comparable to minimally disturbed streams sampled within this region (Bayer *et al.* 1992). Integrity classes for the fish communities at Stations 2 and 3 (which lie within the proposed impoundment) rated as fair and good to excellent, respectively, over the two sampling periods.

Stream reaches downstream of impoundments may also be affected as stream flow decreases and the overall hydrological pattern is altered. The fish community at

Stations 4 and 5 rated good and fair, respectively, over the two sampling periods; whereas, the Brazos River station rated fair to good.

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