Ecological Characterization of the Blanco River Basin, Texas –First Year Results and Plans For Second Year

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The Nature Conservancy of Texas

By

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Table of Contents

1.0 Title: Introduction

1.1 Background

The Blanco River is a major stream in the Edwards Plateau region of Central and West Texas. The Edwards Plateau comprises about 24 million acres and includes diverse eco-regions including the granitic Central Basin (encompassing Burnet, Llano, and Burnet Counties) and the Stockton Plateau on the west portion. To the east and south, the Balcones Escarpment forms a distinct boundary for the plateau but also blends into the Cross-timbers and Central Tallgrass eco-region on the northeast and east and the Chihuahuan Desert eco-region to the southwest. The Blanco River, comprising about 600 square miles of drainage area (Figure 2.1), runs through the eastern portion of the Balcones Escarpment (Kendall, Blanco, Comal, and Hays Counties) and is a primary tributary of the San Marcos River which in turn feeds into the Guadalupe River at Gonzales, Texas.

The Nature Conservancy of Texas --- sharing the views of local citizens—has long seen the Blanco River as a "jewel of Central Texas streams"! The Conservancy identified a portion of the Blanco River watershed (about 400 square miles) as a Conservation Area in July 2002 in an eco-regional assessment of the Edwards Plateau. The designation includes both terrestrial and aquatic portions of the watershed but emphasizes the aquatic designation of the main stem and major tributaries. However, data gaps in water science information ---particularly in aquatic biology --- were seen as a limitation to progress in Conservation Area planning.

1.2 Purpose

The Nature Conservancy of Texas has developed a partnership with Texas State University – San Marcos, Texas to fill these important data gaps so that the Conservation Area planning may be successfully completed. These data gaps include specific information on aquatic habitat but also on the hydrological processes of rainfall-runoff, spring flow from local aquifers, and base-flow definition in the River and its tributaries. In addition, it was recognized that socio-economic analyses must be a part of the planning process. Under the direction of the International Institute For Sustainable Water Resources, Texas State University – San Marcos, a team of faculty and students was assembled from four Departments (Aquatic Biology, EARDC, Geography, Sociology) and from the facilities of the Edwards Aquifer Research & Data Center.

This report represents the first year interim report of this team. It should be recognized that this report is a work in progress ---- data collection and analysis is continuing for some study elements and is just beginning for others. A final report will be completed in 2006.

1.3 Acknowledgements

The University and the Conservancy gratefully acknowledge the support of the following institutions who provided monetary support for this project:

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Graduate Students included Mr. Brad Littrell, Mr. Mike Cave, Mr. David Pendergrass, Mr Eric Dedden, Aquatic Biology; Mr. Dennis Fowler and Ms Stephanie Stiefel, Geography. Hannes Wagner, Geography Student, University of Kiel, Germany provided valuable start-up support for the SWAT 2000 watershed modeling work described in Chapter 6.

Staff from the Nature Conservancy of Texas are providing valuable consultation and support and the efforts of Dr. Jim Bergan, Mr. Gary Aamon, Ms. Lacey Halstead, and Mr. Steve Jester is gratefully acknowledged.

2.0 Title: Sampling Locations

Sites in the Blanco River watershed were chosen for their suitability to the aquatic biology needs of this study. Hydrologic measurements were made at a cross-section at each site as well as in the specific locations designated by biology field team members. For the cross-section discharge measurements, 25-35 individual measurements of velocity were taken over the channel width at each cross-section. Hydrology data was collected using a SonTek Handheld acoustic Doppler velocimeter. Velocity measurements taken at spot aquatic habitat sites were also made using this velocimeter.

A total of ten (10) sites were chosen for this study. The site name along with its latitude and longitude location are provided in Table 2.1 and selected locations are shown in figure 2.1.

Table 2.1 Sampling locations.

Site Number and Name	**Latitude**	**Longitude**	**Elevation**
1. Hammonds Ranch	30.103450	97.915710	1430
2. Blanco Reservoir	30.05984	98.26585	1320
3. Turner Ranch	30.083920	98.322330	1138
4. Narrows Ranch	30.053990	98.285070	1053
5. University Camp	29.985040	98.04820	758
6. Way Ranch	30.006670	97.975130	748
7. Post Road	29.937310	97.897310	587
8. Martindale Road	29.870980	97.915710	535
9. Cypress Creek	29.996740	98.097760	856
10. Little Blanco R.	30.041080	98.252370	1001

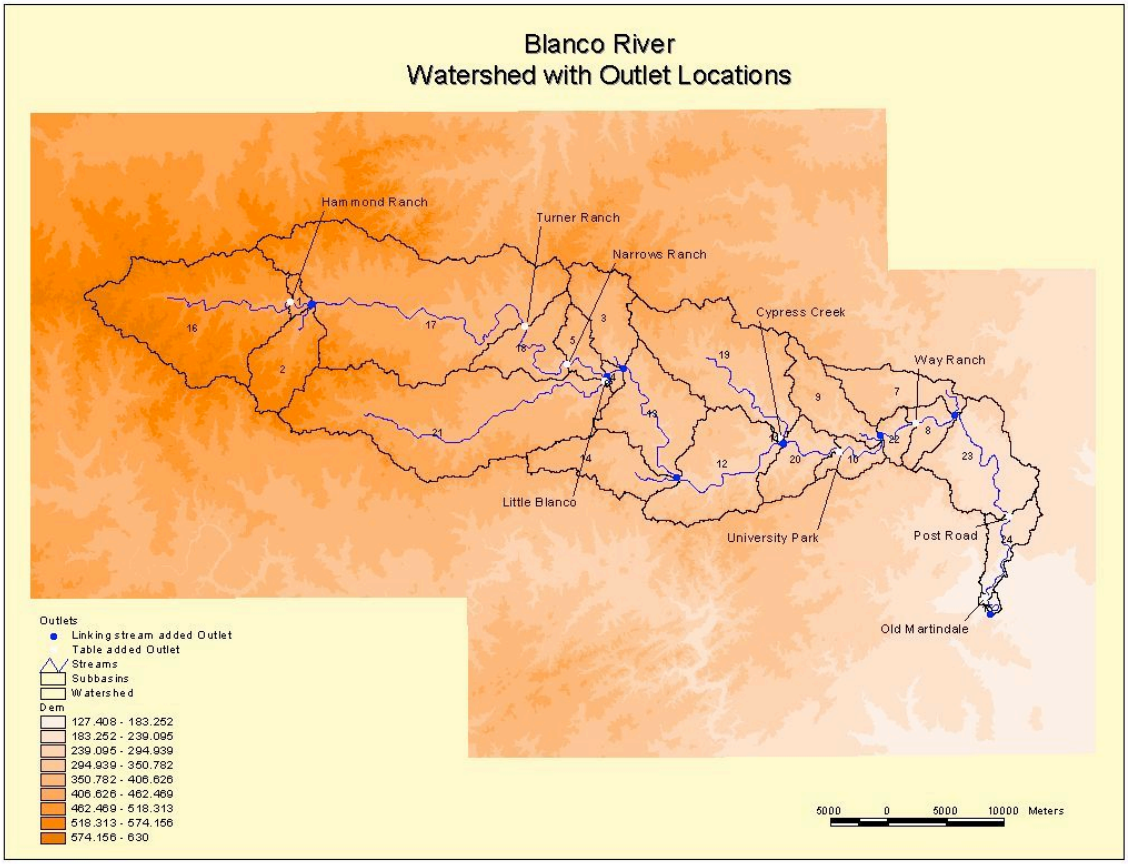

Figure 2.1. Map of the Blanco Watershed illustrating selected sampling locations.

Specific site locations were determined using the following criteria: biological and socio-economically important factors important to The Nature Conservancy, stream segments identified as ecologically important to Texas Parks and Wildlife Department (TPWD), sites previously sampled by TPWD and USGS where historically data are available, and site accessibility. Specific criteria involving site location were that sampling include the upper reaches of the Blanco River near the City of Blanco to assess the effect of instream dams on abiotic and biotic factors in the Blanco River, the Blanco River near the City of Wimberley to assess the effect of point source pollution, and the Little Blanco River (TPWD reference stream) to assess biota, habitat, and water quality in major tributaries of the Blanco River. In the lower reaches of the Blanco River, sites were selected to include the lower reaches within the Edward's Aquifer recharge zone to assess the effect of high natural stream flow variability on the Blanco River, and downstream of Five-Mile Dam to assess dam effects on assemblage fragmentation between biota upstream and those downstream in the Blanco and San Marcos rivers. Other sites were selected to allow unrestricted access for diel monitoring on abiotic and biotic factors.

Nine sites were chosen within the Blanco River watershed to quantify water quality, macroinvertebrates, and fish assemblage structures on both a spatial and temporal scale. Eight sites were chosen along the longitudinal axis of the main river channel. An attempt was made to space these sites equally along the river to provide a broad and even coverage from headwaters to its confluence with the San Marcos River. One site was also chosen on each of the two major tributaries to the Blanco – the Little Blanco River and Cypress Creek. Water chemistry, macroinvertebrate, and fish assemblage data area to be collected at these sites quarterly.

Each site has undergone sampling on a seasonal schedule over the first year, and this is expected to continue during the second year. At each site, a stream segment (~100 m) was delineated. From this segment, all habitat types (pool, runs, riffles) were sampled from a downstream to upstream direction. For each habitat, fish assemblages were collected, identified, and released. Macroinvertebrates were collected and returned to the lab for identification. Water quality data (pH, dissolved oxygen, water temperature, and water turbidity) was measured. Hydrologic data was collected at every habitat location as well as along a full cross-section at each sampling location.

3.0 Title: Assessment of macroinvertebrates in the Blanco River drainage

3.1 Objectives

Urbanization often imposes environmental stressors on the structure and function of stream invertebrates (Paul and Meyer 2001, Palmer et al. 2002, McKinney 2002, Brasher 2003). For instance, habitat loss, decline in water quality and increased hydrologic variability often accompany watershed development and can reduce invertebrate taxonomic richness and disrupt invertebrate life cycles (Ebersole et al. 1997, Townsend et al. 2000, Smith and Wood 2002). Ultimately, dysfunction in the invertebrate community leads to instability in the overall aquatic ecosystem (Vannote et al. 1988, Tilman 1999, Dodds 2002, Covich et al. 2004). As water quality diminishes and fisheries decline, local economies can suffer losses in recreation revenue and real estate value. Tracking the health of stream invertebrate populations can be used to assess the integrity of a river (Death and Winterbourn 1995, Barbour et al. 1999). Comparisons of invertebrate assemblages across time can reveal positive or negative responses to environmental changes and inform water management policy (Barbour et al. 1999). The objectives of this element of the Blanco River Project are to 1) describe the spatio-temporal distribution of macroinvertebrate community structure 2) quantify the drifting patterns of macroinvertebrates at up-,mid- and downstream sites, 3) use rapid bioassessment (RBA) metrics to assess the water quality of the Blanco River and 4) examine the impact of anthropogenic stressors (e.g. nutrient inputs, flow alterations, recreational activity) on the community structure of Blanco River macroinvertebrates. To characterize the structure of the aquatic macroinvertebrate assemblages in the Blanco River and provide a snapshot of the river's viability, we employed the following procedures.

3.2 Methods

Invertebrate communities exhibit patterns of organization that vary across different scales of space and time (Vannote et al. 1980, Minshall 1988). To improve the accuracy of our description of Blanco River macroinvertebrate assemblages, we sampled the longitudinal dimension (the length of the stream) by sampling at upstream, midstream and downstream sites. The lateral and vertical dimensions were obtained by sampling a variety of habitats at each site (e.g. submerged leaf packs, snags, water surface and benthos) and the temporal dimension was captured by sampling seasonally and during a 24 hr period at selected sites. Comparing the upstream and downstream data should permit examination of large-scale patterns (the whole stream) while individual sites will allow analysis of the smaller scales of spatial distributions (stream sections and microhabitats). Likewise, temporal assemblage patterns should be observable at seasonal and diel resolutions.

A Hess sampler at sites 3, 7 and 8 and drift nets at sites 1, 5 and 8 provided quantification of the Blanco River macroinvertebrates. Substrate characteristics prevented the use of the Hess sampler at other sites. All sites also were sampled with a D-net and by visual inspection and handpicking of substrate to account for taxa that may not be found in the cobble or were less likely to drift. Blanco reservoir (site 2) was not sampled due to typically low numbers of taxa associated with benthic reservoir habitats. Samples were stored on site in 70% ethanol and taken to the lab where they were washed in a 60 μ sieve and picked under a microscope from the surrounding detritus. Insects were keyed to genus, with dipterans keyed to family only. Non-insect taxa were keyed to the lowest reasonable resolution (Merritt and Cummins 1996, Thorp and Covich 2001). Initially, all individuals were counted from every collection to inform cost-benefit estimates regarding sub-sampling procedures. These sub-sampling procedures are currently being developed.

Once the organisms are counted, population structure will be analyzed with metrics prescribed by the EPA's Rapid Bioassessment Protocols (Barbour et al. 1999). Multivariate analysis will also be employed to assess the impact of anthropogenic stressors on macroinvertebrate community structure and function in the Blanco River. The variables examined will be derived from data sets regarding fish, hydrology and chemistry obtained from other elements of the Blanco River Project. Sampling will be completed in October, 2004, and data assessment has already begun.

3.3 Results

Initial evaluations have yielded the following results. Table 3.1 lists all taxa tabulated in the lab through August, 2004. They are organized by Ephemeroptera-Plecoptera-Trichoptera (EPT) taxa (the most pollution intolerant orders), Diptera (generally the order least intolerant of disturbance) and "other" insects and "non-insect" taxa. The current total number of taxa is 105 with some families still to be keyed to genus. This is nearly double the number of taxa found in local reference stream data from 1992 (Bayer et al. 1992). If taken to the resolution of most of the reference stream taxa (i.e. species), the number of macroinvertebrate taxa in the Blanco River would likely be greater. This difference might be explained by the larger number of samples we collected and the multidimensional approach we used. This illustrates the value of sampling as many spatial and temporal scales as possible when gathering baseline data and performing bioassessments (Minshall and Robinson 1998). High taxonomic diversity is often associated with high habitat heterogeneity (Townsend 2000, Vinson and Hawkins 1998). A greater variety of niches in the Blanco River means a greater variety of invertebrates can fill them. Since habitats usually experience increased homogenization with increased urbanization (Ebersole 1997, Paul and Meyer 2001), the high diversity of the Blanco River may reflect minimal impact on habitat heterogeneity at this stage of development in the Blanco watershed.

Relative abundance of higher taxonomic groupings at upstream, midstream and downstream sites in January 2004, are displayed in Figure 3.1. Samples were not quantitative, but may illustrate a distribution where EPT taxa account for more than 35% of the total taxa throughout the river. At no site did a single group display high dominance, an indicator of ecological imbalance (Barbour et al. 1999).

To collect quantitative measurements at sites 1, 5 and 8, drift nets were deployed to capture small-scale temporal changes in macroinvertebrate abundance. Figure 3.2 illustrates the diel drifting patterns for Site 8 on May 27-28, 2004. Abundance was clearly higher for the nighttime hours and this is consistent with on-site observations during other dates and at different sites. The drift samples were dominated by mayfly and caddisfly taxa. Both the timing of the abundance peaks and the taxonomic composition are consistent with drift literature (Muller 1974, Smock 1976, Allan 1995, Ramirez and Pringle 2001).

3.4 Plans for Year 2

Many samples remain to be picked and counted and further analysis is required before any firm statements can be made regarding the viability of the Blanco River or structural patterns in its invertebrate population. The objectives for the second year are to 1) complete sampling, 2) finalize sub-sampling procedure, 3) pick and count remaining samples and 4) perform graphical and statistical analysis of all data.

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TABLE 3.1.--Macroinvertebrate taxonomic composition of the Blanco River from October 2003-August 2004. Taxa are listed to highest resolution employed through August 2004. Totals are given at the end of each column.

Insects (EPT)	***Insects (Diptera)***	***Insects (Other)***	***Non-Insects***
Ephemeroptera (mayflies)	Calamoceratidae	Odonata (dragon/damselflies)	Nematamorpha
Ephemeridae	Chironomidae	Calopterygidae	
Tricorythidae	Simuliidae	*Calopteryx*	Nematoda
Tricorythodes	Tabanidae	*Hetaerina*	
Leptohyphes	Stratiomyidae	Coenagrionidae	Platyhelminthes
Caenidae	Culicidae	*Argia*	Turbellaria
Caenis	Ceratopogonidae	*Enallagma*	
Heptageniidae	Tipulidae	*Amphiagrion*	Annelida
Stenonema	Empididae	Gomphidae	Oligochaeta
Isonychiidae		*Phyllogomphoides*	Hirudinea
Isonychia	Sum=9	*Erpetogomphus*	
Leptophlebiidae		Libellulidae	Arachnida
Neochoroterpes		*Nannothemis*	Hydrachnida
Paraleptophlebiidae		Corduliidae	
Thraulodes		*Epitheca*	Pelecypoda
Choroterpes		*Macromia*	Corbiculiidae
Traverella		Aeshnidae	
Baetidae			Gastropoda
Fallceon		Coleoptera (beetles)	Lymnaeidae
Procloeon		Elmidae	Planorbidae
Camelobaetidius		*Macrelmis*	Physidae
Paracloeodes		*Neoelmis*	
Baetodes		*Stenelmis*	Crustacea
Centroptilum		*Microcylloepus*	Amphipoda
Barbaetis		*Rhizelmis*	Cambaridae
Callibaetis		*Dubiraphia*	Conchostraca
Apobaetis		*Cylloepus*	Cladocera
		Heterelmis	Copepoda
Plecoptera (stoneflies)		*Narpus*	
Perlidae		Dryopidae	Sum=16
Perlesta (Banks)		*Postelichus*	
		Helichus	
Trichoptera (caddisflies)		Lutrochidae	
Philopotamidae		*Lutrochus*	
Chimarra		Gyrinidae	
Dolophilodes		Haliplidae	
Polycentropodidae		*Peltodytes*	
Polycentropus		Dytiscidae	
Polyplectropus		*Celina*	
Glossosomatidae		Hydrophilidae	
Anagapetus		*Hydrobius*	
Hydroptilidae		*Berosus*	
Hydroptila		Psephenidae	
Ochrotrichia		*Ectopria*	
Oxyethira			
Neotrichia		Hemiptera (true bugs)	
Mayatrichia		Corixidae	
Hydropsychidae		*Trichocorixa* (Kirkaldy)	
Cheumatopsyche		Belostomatidae	
Hydropsyche		Naucoridae	
Leptoceridae		*Ambrysus* (Stal)	
Mystacides		*Cryphocricos*	
Oecetis		Pleidae	
Nectopsyche		Notonectidae	
Helicopsychidae		Veliidae	
Helicopsyche		*Rhagovelia* (Mayr)	
Hydrobiosidae		Gerridae	
Atopysche		*Metrobates* (Uhler)	
Limnephilidae		*Trepobates* (Uhler)	
		Macroveliidae	
Sum=39		*Macrovelia* (Uhler)	
		Megaloptera (dobsonflies)	
		Corydalus	
		Lepidoptera (moths)	
		Pyralidae	
		Sum=41	

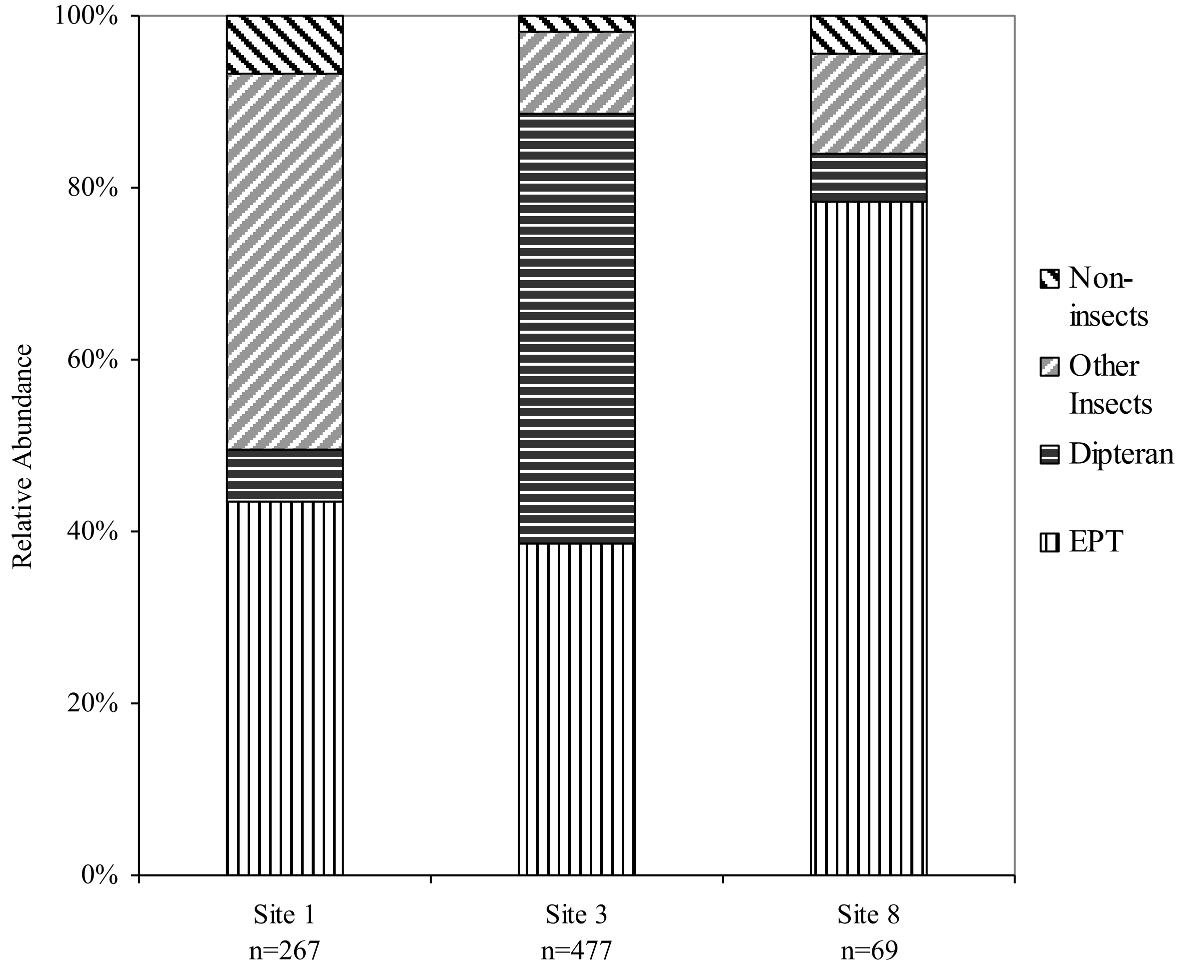

FIGURE 3.1.--Relative abundance of EPT, dipteran, insect and non-insect macroinvertebrates collected from three sites (up-, mid-, and downstream) in the Blanco River by dip netting in January, 2004. Total n across all three sites is 813.

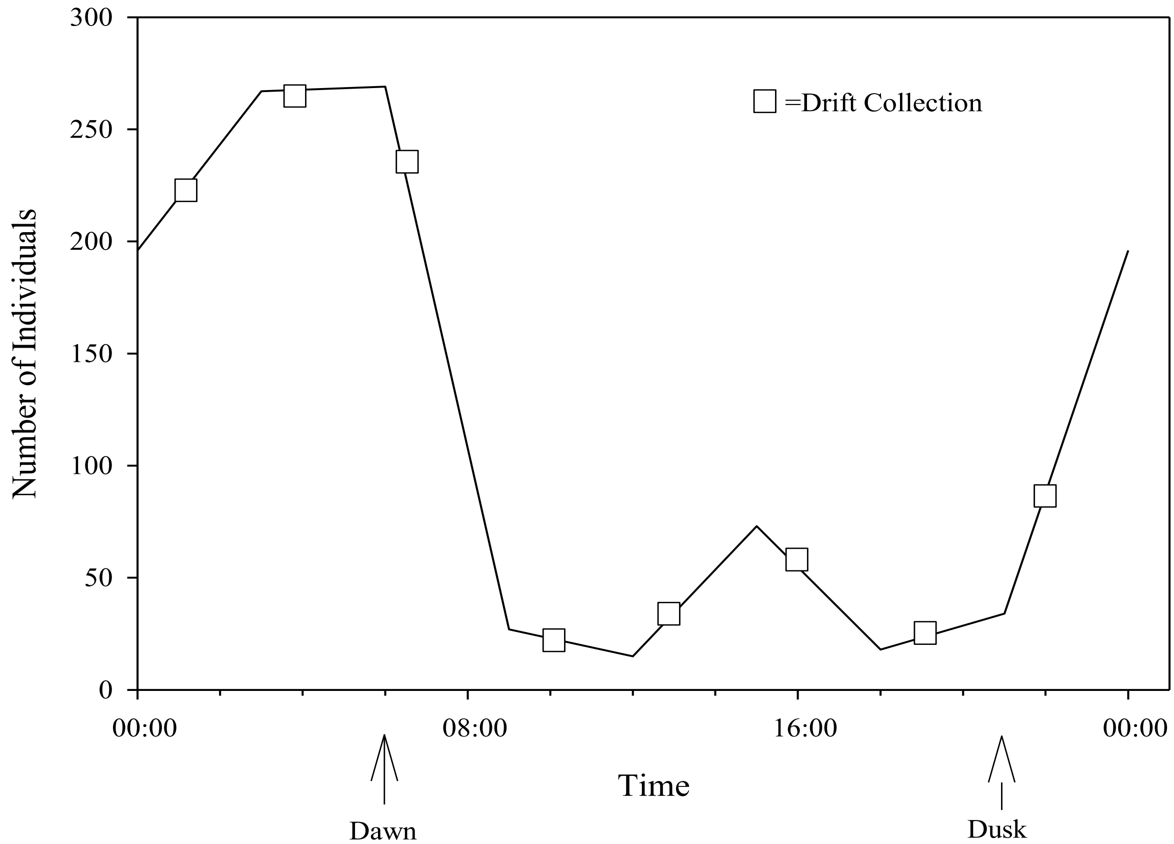

FIGURE 3.2.--Diel changes in macroinvertebrate abundance for drift samples collected in 3 hour intervals at site 8 on May 27-28, 2004.

4.0 Title: Assessment of fishes in the Blanco River drainage

4.1 Objectives

Objectives of the Blanco River fish assemblage study are to determine spatial and temporal patterns in assemblage composition and population structure of fishes within the Blanco River drainage. Patterns in assemblage structure will be correlated to a variety of physical (e.g., stream width, substrate, and dams), chemical (e.g., dissolved oxygen, specific conductance, and point source pollution) and biological (e.g., nutrients, macroinvertebrates, and macrophytes) factors. Provided herein are results of Year 1 sampling efforts.

4.2 Methods

Fishes were collected quarterly from October 2003 through August 2004 from eight Blanco River sites (sites 1 through 8) and two tributary sites (e.g., Little Blanco River and Cypress Creek). At each site, fish were sampled with a Smith-Root Model-14 backpack electroshocker and seines (1.2 by 1.8 m, 6 mm mesh size; 1.8 by 2.4 m, 9.5 mm mesh size) from all habitats (i.e., pools, runs, riffles, and backwater). Gillnets were used additionally at Site 2, which is a small, mainstem reservoir on the Blanco River. Fish were identified to species, counted, measured (total length of the first 30 individuals of each species), and released. Temperature (°C), conductivity (uS), pH, and dissolved oxygen (mg/L) were measured at each site (data present elsewhere in this report). Habitat type, width, length, percent substrate, percent cover, percent vegetation, depth (cm), and current velocity (cm/s) were measured for each habitat sampled. Depth and current velocity estimates are not available at this time.

4.3 Results

In Year 1, 15,262 fishes representing 10 families, 20 genera, and 32 species were collected (Table 4.1). The most abundant taxa across sites and time were the blacktail shiner *Cyprinella venusta* (47%, relative abundance), Texas shiner *Notropis amabilis* (13%), western mosquitofish *Gambusia affinis* (11%), central stoneroller *Campostoma anomalum* (4.9%), redbreast sunfish *Lepomis auritus* (4.7%), and mimic shiner *Notropis volucellus* (4.7%). Among the 32 species, one species (Guadalupe roundnose minnow *Dionda nigrotaneniata*) is endemic to the Guadalupe River drainage and four species (burrhead chub *Macrhybopsis marconis,* gray redhorse *Moxostoma congestum*, Guadalupe bass *Micropterus treculi*, and Texas logperch *Percina carbonaria*) are endemic to drainages of Texas. Six species (see Table 4.1) are non-native to the Guadalupe River drainage. Two species previously reported in the Blanco River and not collected during this study were the American eel *Anguilla rostrata* and headwater catfish *Ictalurus lupus*. The American eel persists in the Blanco River according to angler reports. The headwater catfish previously was reported extirpated from the Guadalupe River drainage.

The Blanco River fish assemblage was not homogenous throughout its course. Spatially, mean similarity index (Renkonen Similarity Index for species richness and abundance) was 51% (range: 14 to 80%) among sites. Notable fish assemblage heterogeneity existed among mainstem sites (sites 1 through 8), Little Blanco River site, and Cypress Creek site, and between upper mainstem sites (sites 1 through 3) and lower mainstem sites (sites 4 through 8). In general, cyprinids (minnows) were the most abundant group of fishes in mainstem sites and Cypress Creek whereas centrarchids (sunfishes and bass) were more abundant in Little Blanco River. Likewise, cyprinids typical of spring-run streams were more abundant in Cypress Creek than in the mainstem of the Blanco River. Among mainstem sections, sites in the lower Blanco River had 11 species not found in the upper Blanco River. The Narrows (Site 4) is a natural barrier and probably limits upstream movement of some fishes such as the mimic shiner and orangethroat darter (*Etheostoma spectabile*). However, other fishes (i.e., *Astyanax mexicanus, Macrhybopsis marconis,* and *Fundulus notatus*) might be inhibited from moving upstream from sites 7 and 8 because of a low-head dam (Five Mile Dam). Trends in spatial and temporal differences will be assessed in greater detail with data obtained from Year 2.

Fish assemblages changed substantially through time within each site. Mean similarity index was 58% (range: 40 to 81%) for all sites. Cypress Creek fish assemblage was the most persistent (similarity index: 81% across four sampling dates) whereas Site 8 was the most temporally variable site (similarity index: 40%). As with spatial differences, temporal differences especially in lower reaches of the Blanco River were attributed to migrant species, those moving from the San Marcos River during certain times of the year. However, most of the temporal variability was associated with life history characteristics (i.e., timing of reproduction, mode of egg dispersion) of the most abundant taxa.

4.4 Plans for Year 2

Sites 1 through 8, Little Blanco River, and Cypress Creek will be sampled seasonally (four times) within Year 2. Once collections are made, spatial and temporal patterns in fish assemblages, species population structure, and fish habitat associations will be fully explored with univariate and multivariate analyses.

Table 4.1. Relative abundance of fish species and habitat parameters measured at 10 sites within the Blanco River watershed from October 2003 through August 2004. Parenthetical "I" indicates introduced species within the Blanco River drainage.

		Sites									
Common name	Scientific name	1	2	3	4	5	6	7	8	Little Blanco River	Cypress Creek
spotted gar	*Lepisosteus oculatus*				<0.1	<0.1					
central stoneroller	*Campostoma anomalum*	9.9		3.9	11	0.3	1	6.5	2.9	0.6	15.5
blacktail shiner	*Cyprinella venusta*	77	37.2	31.5	38.5	56.2	41.9	68.1	29.4	3.6	34.6
common carp	*Cyprinus carpio* (I)		0.1		<0.1						
Guadualupe roundnose minnow	*Dionda nigrotaneniata*									4.5	0.4
burrhead chub	*Macrhybopsis marconis*								0.1		
Texas shiner	*Notropis amabilis*	2.1	18.5	36.7	16.7	11.9	0.3	5.9	29.4	2.2	17.1
sand shiner	*Notropis stramineus*					18.1	5	0.1			
mimic shiner	*Notropis volucellus*				1.9	4.7	2	8.8	15.8		
fathead minnow	*Pimephales promelas* (I)						0.1				
bullhead minnow	*Pimephales vigilax*		11.5		0.6						
gray redhorse	*Moxostoma congestum*		3.2	0.2	0.1						0.5
Mexican tetra	*Astyanax mexicanus* (I)							0.1	0.2		
yellow bullhead	*Ameiurus natalis*										0.2
channel catfish	*Ictalurus punctatus*	0.5	0.2	0.8		0.2	0.5	0.1	0.1		
flathead catfish	*Pylodictis olivaris*					<0.1					
blackstripe minnow	*Fundulus notatus*							1.2	0.2		
western mosquitofish	*Gambusia affinis*	4.5	6.1	0.5	19.4	4.1	39.3	0.8	9.3	22.3	6.4
redbreast sunfish	*Lepomis auritus* (I)	2.2	8.9	13.9	3.7	1.8	1.2	2.3	2.2	16.5	14.1
green sunfish	*Lepomis cyanellus*	0.1	0.2	1.8		0.1		0.1		5.1	
warmouth	*Lepomis gulosus*	0.1	0.1								0.1
bluegill	*Lepomis macrochirus*	1.1	8.6	0.2		0.4		0.4	2	26.9	
longear sunfish	*Lepomis megalotis*	1.9	0.5	6.8	6.2	0.9	0.2	0.1	0.3	3.4	2.7
redear sunfish	*Lepomis microlophus*		0.1	0.3						0.3	
western spotted sunfish	*Lepomis miniatus*						<0.1				
sunfish (juvenile)	*Lepomis* sp.	0.3	3.8	0.7	0.9	0.1	0.6	0.1	0.2	2	0.7
smallmouth bass	*Micropterus dolomeiu* (I)			0.2		0.4	0.1			0.1	0.5
largemouth bass	*Micropterus salmoides*	0.4	1	0.7	0.6					4.7	0.1
Guadualupe bass	*Micropterus treculi*			0.4					0.2		
orangethroat darter	*Etheostoma spectabile*					0.4	5.6	3.7	3.3	7.6	3.4
Texas logperch	*Percina carbonaria*				0.2			0.1	0.2	0.1	
dusky darter	*Percina sciera*								0.1		
Rio Grande cichlid	*Cichlosoma cyanoguttatum* (I)		0.2	1.3		0.4	2	1.7	4.1		3.6
	Total number of individuals	2,528	1,106	1,092	806	1,593	2,031	1,922	2,656	685	843
Mesohabitat	% riffle			17			29	26	13	5	41
	% run	100		23	84	100	65	56	44	44	44
	% pool		100	47	16			17	38	49	11
	% backwater			13			6		5	2	3
Substrate	% gravel	2		19	4	27	35	38	38	74	1
	% cobble	2		41	5	13	3	6	52	14	22
	% bedrock	70	50	13	91	60	49	28	1		47
	% silt	26	50	26			5	28	10	1	8
	% detritus			2			9			11	23
Cover	% LWD	<1		2		2	3	1	4	2	4
	% veg	5.3	30	10	11	1	3	19	26	14	7
	% boulder	<1		<1	3	2			<1	2	1

5.0 Title: Water quality in the Blanco River drainage

5.1 Objectives

The objectives of the Blanco River water quality study are to assess chemical character including nutrient and other ion concentrations, to establish baseline conditions for specific areas of the river, and to quantify the chemical contributions of major tributaries. Water chemistry data will also be compared with fish and invertebrate assemblages in order to find spatial and temporal ecological patterns in the Blanco River.

5.2 Methods

Beginning in November 2003, study sites 1, 2, 3, 5, 6, 7, 8, and the Cypress Creek site in Wimberley were sampled monthly for water quality. An additional water quality sampling site near the bridge on Valley View Road was added in January 2004. Zero or no flow conditions at the Narrows (Site 4) and Little Blanco sites frequently prevented meaningful sampling. Site 8 was additionally sampled on 30 June 2004 following a storm flow event. Temperature, pH, dissolved oxygen, and specific conductivity were measured with a Hydrolab™ Minisonde calibrated one day prior to each sampling event. Whole water samples were collected at each site in 1 L bottles (placed on ice), and were analyzed in the laboratory for turbidity and alkalinity. Turbidity was determined using a Fisher Scientific turbidometer. Alkalinity was measured by potentiometric titration to pH 4.8 using 0.02 N H_2SO_4 according to Wetzel and Likens (2000). Beginning in March 2004, additional monthly samples were filtered in the field with 0.7 µm glass fiber filters and frozen immediately until analysis of NO_3-N and soluble reactive phosphorus could be performed in the laboratory. NO_3-N was analyzed by second-derivative UV spectroscopy (Crumpton, Isenhart, and Mitchell, 1992). Soluble reactive phosphorus (PO_4-P) was determined using the ascorbic acid method (APHA, 1989). Two thermistors, programmed to record water temperature every 6 minutes, were placed at study sites 1 and 8 in November 2003. In January 2004, additional thermistors were placed at Site 3 and at the Valley View Road site. Stored data were retrieved every four months. Calcium and magnesium analyses were performed by the Edwards Aquifer Research and Data Center using standard atomic absorption methods (APHA, 1989). Another Hydrolab™ Minisonde with data-logging capabilities was deployed above Site 1 on August 13 for a period of one week. The Minisonde recorded temperature, pH, dissolved oxygen, and specific conductivity every ten minutes. Collected dissolved oxygen and pH data proved unreliable (a problem with the internal circulator), but equipment issues were resolved and seasonal re-deployment is planned. Historical flow data collected by the United States Geological Survey from stations on the Blanco and available on their website were compiled (USGS, 2004).

5.3 Results

A total of 91 water quality samples were recorded from November 2003 to October 2004. Median water temperatures varied by site between 20 and 25 ºC. Cypress Creek was found to have a lower median temperature than the Blanco (Figure 5.1). In addition, median specific conductance and alkalinity were higher at Cypress Creek than at any sites on the Blanco (Figure 5.2). Calcium and alkalinity values related positively to one another (Figure 5.3). Dissolved oxygen concentrations were normally between 8 and 10 mg/L for all sites and were found to be lower at higher temperatures (Figure 5.4). Turbidity values generally ranged between 1 and 4 NTU, with the exception of Site 2, the Blanco Reservoir, which had a median turbidity of 10.2 NTU (Figure 5.5). Median monthly flows from 78 years of record were highest in April and May and lowest in August and September (Figure 5.6). Table 5.1 contains median values for three months of measured NO_3-N and soluble reactive phosphorus concentration data. Valley View Road and Cypress Creek study sites had the highest median concentrations of both of these nutrients.

5.4 Plans for Year 2

Monthly sampling at regular sites will continue into year 2 of the project, with the possibility of sampling new sites as well as further post-storm event sampling.
A thermistor will be placed directly in the spring near Valley View Road in order to better characterize the subsurface flow so important to the Blanco River. Seasonal deployment of the remote Hydrolab unit will begin Fall 2004. Regular chemical analysis may expand to include additional anions, including chloride and sulfates. Archived chemical data available from the USGS will be compared with and integrated into data from this study.

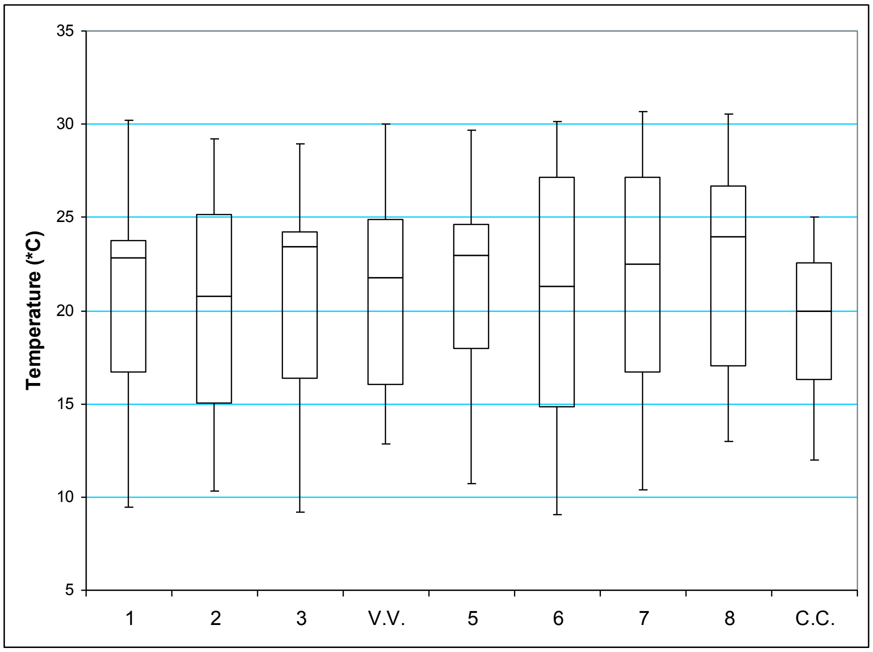

Figure 5.1. Box-plot diagrams of water temperature from study sites on the Blanco River and Cypress Creek (V.V. = Valley View Road; C.C. = Cypress Creek).

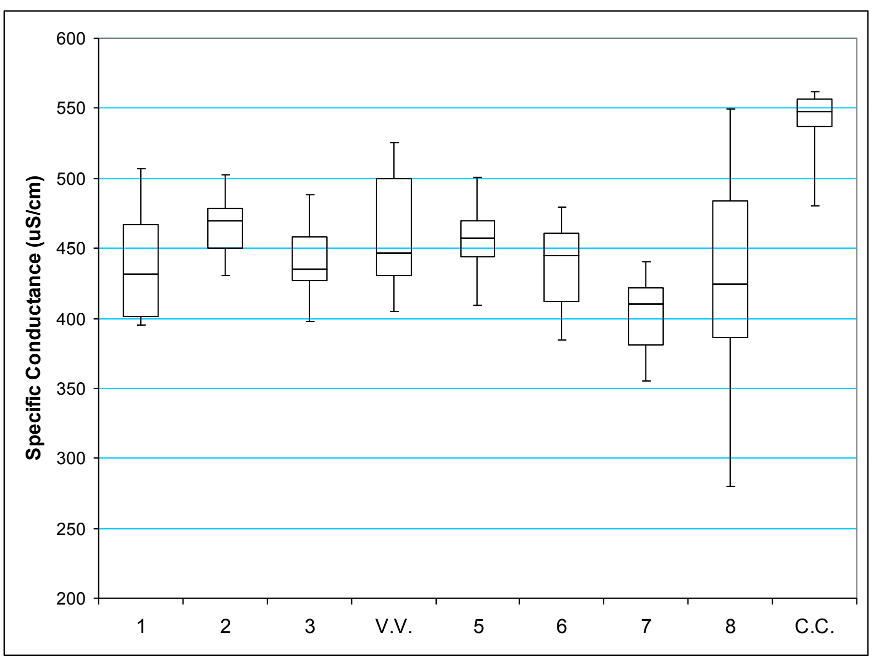

Figure 5.2. Box-plot diagrams of specific conductance from study sites on the Blanco River and Cypress Creek (V.V. = Valley View Road; C.C. = Cypress Creek).

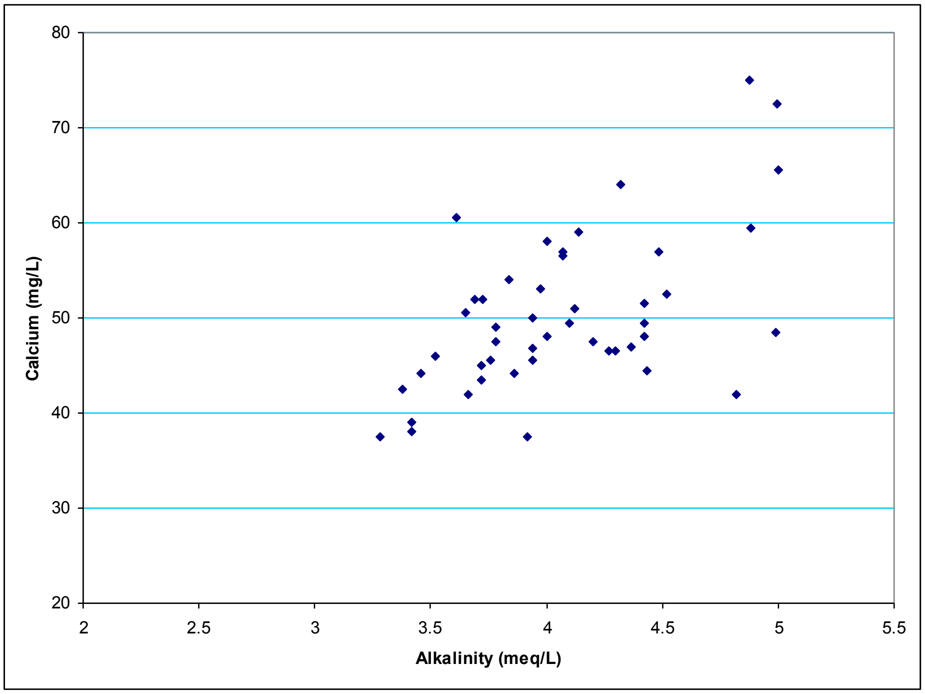

Figure 5.3. Calcium and alkalinity concentrations from study sites on the Blanco River and Cypress Creek.

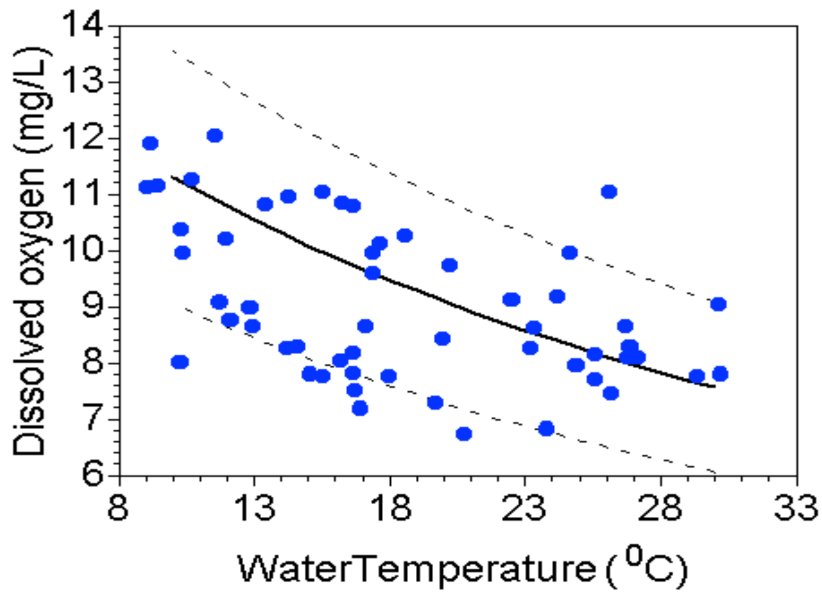

Figure 5.4. Dissolved oxygen and water temperature from Blanco River, Little Blanco, and Cypress Creek study sites. The solid line represents 100% saturation, and the upper and lower dashed lines represent 120 and 80% saturation, respectively.

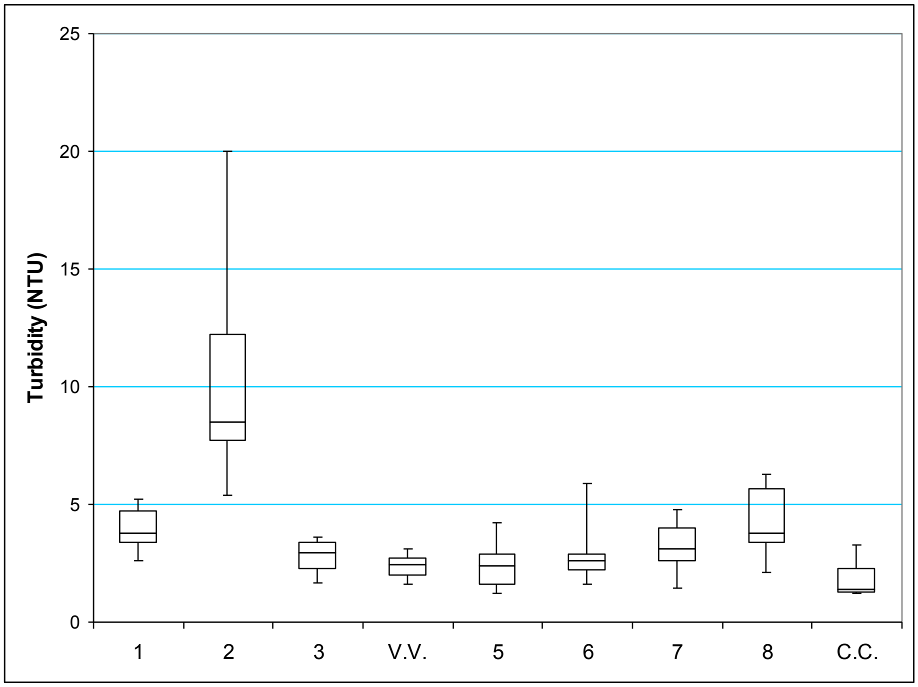

Figure 5.5. Box-plot diagrams of turbidity from study sites on the Blanco River and Cypress Creek. (V.V. = Valley View, C.C. = Cypress Creek).

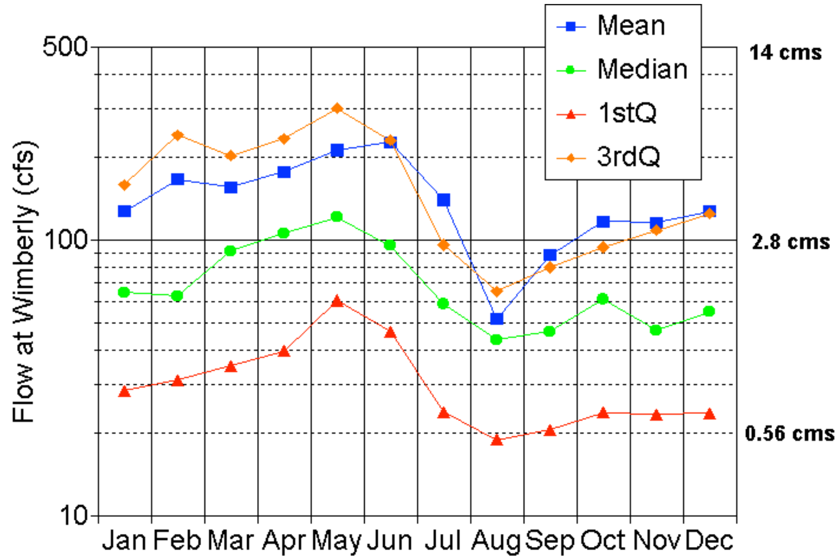

Figure 5.6. Average monthly flows from 78 years of data collected by the United States Geological Survey.

Table 5.1. Median concentrations of NO_3-N and soluble reactive phosphorus by site.

Site	Median NO_3-N (ug/L)	Median SRP (ug/L)
Site 1	119.3	4.9
Site 2	184.3	5.2
Site 3	304.5	4.1
Valley View Rd.	334.5	9.1
Site 5	299.5	4.2
Site 6	244.4	4.1
Site 7	186.8	3.8
Site 8	274.5	5.2
Cypress Creek	324.5	7.8

6.0 Watershed Modeling Using SWAT2000

6.1 Overview of SWAT

SWAT (Soil and Water Assessment Tool) is a watershed scale model that predicts the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions over long periods of time (Srinivasan et al., 1995). It provides us with the ability to model hydrologic systems and watersheds and to express the results of these models in a GIS. The model pulls together large, varied data sets, and the GIS interface allows for a user friendly explanation of the model results, meaning that the results are displayed graphically rather than through data tables. From a research standpoint, integrating the study of hydrological systems with GIS provides challenging opportunities and the promise of improved hydrological models.

Rather than relying solely on regression equations to describe the relationship between input and output variables, SWAT requires specific information about weather, soil properties, topography, vegetation, and land management practices occurring in the watershed. The physical processes associated with water movement, sediment movement, crop growth, nutrient cycling, etc. are directly modeled by SWAT using this input data.

SWAT sub-divides watersheds into smaller basins to improve modeling capabilities in small yet distinct watershed areas. The physical processes are modeled separately for each small basin and then routed through the entire watershed. This increases accuracy and gives a much better physical description of the watershed.

SWAT has fit the purpose of our study well, incorporating the detail necessary for accurate prediction. Data collection is a labor and cost intensive, but necessary to achieve an acceptable level of accuracy. The use of SWAT has decreased the need for continuous detailed data collection over time while producing an accurate prediction of watershed response.

SWAT has many advantages. It can operate on various amounts of data. With little data, the model will interpret where necessary. As more data becomes available, it is incorporated into the model, improving accuracy. Another advantage is that the model is physically based and does not rely on less accurate regression equations. The model can also be updated. SWAT interfaces into GIS so effective maps of multiple different scenarios can be created.

6.2 Development of the Blanco River Basin SWAT Model

In order to develop a watershed model using SWAT, critical data must first be collected. The model created simulates particular attributes about an individual watershed based on these collected data. The first step in creating a watershed involves the use of a DEM grid. The DEM is a grid storing location coordinates with elevation. For the Blanco River Basin SWAT model, 34 DEM grids were downloaded from the Texas Natural Resources Information System website (http://www.tnris.state.tx.us/digital.htm) and merged into one continuous DEM encompassing the entire river basin. The continuous DEM was then preprocessed in order to remove any sinks, define the projection, and choose the units of measurement. The following map shows one continuous grid used for watershed delineation.

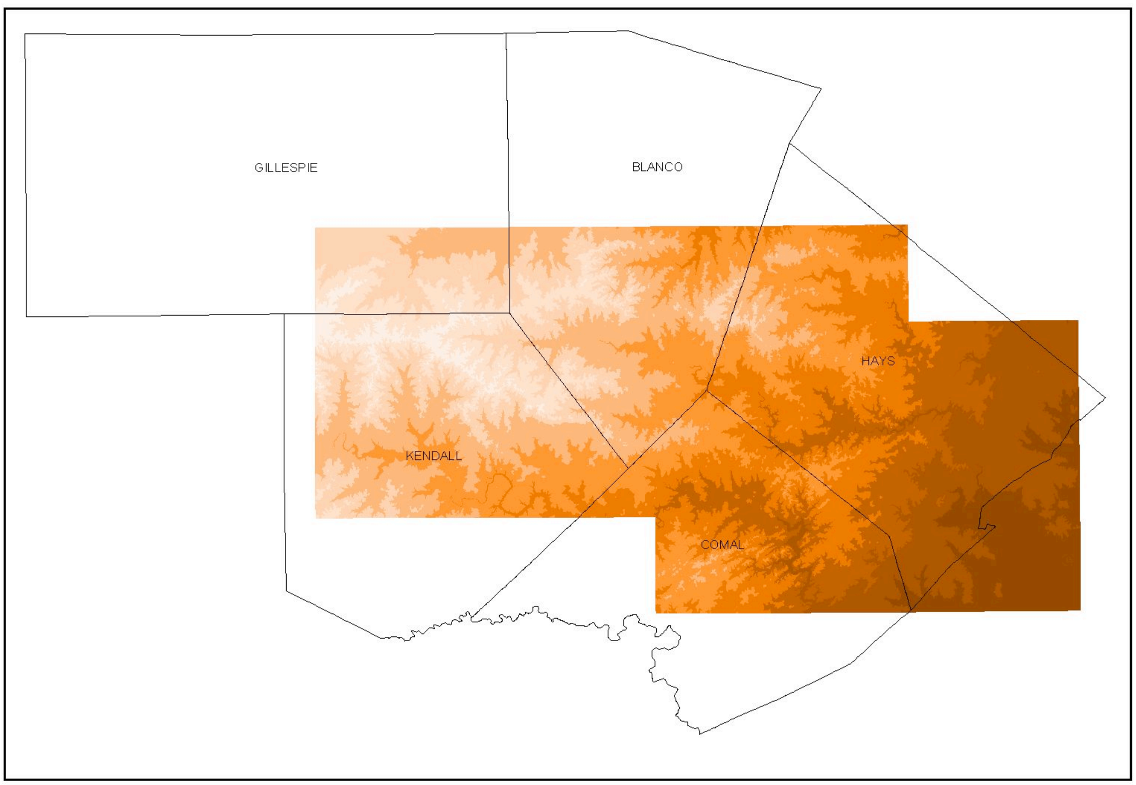

Figure 1.1 Example of a continuous grid created from merged DEMs.

Then, the watershed, subbasins, and stream network were created by SWAT. The subbasins were located at sampling sites (red circles) and at each tributary channel (green circles) along the river. The sampling sites were located using a GPS unit and include: Hammond Ranch, Turner Ranch, Narrows Ranch, Little Blanco, Cypress Creek, University Park, Way

Ranch, Post Road, and Old Martindale. This process created 24 subbasins within the Blanco River basin.

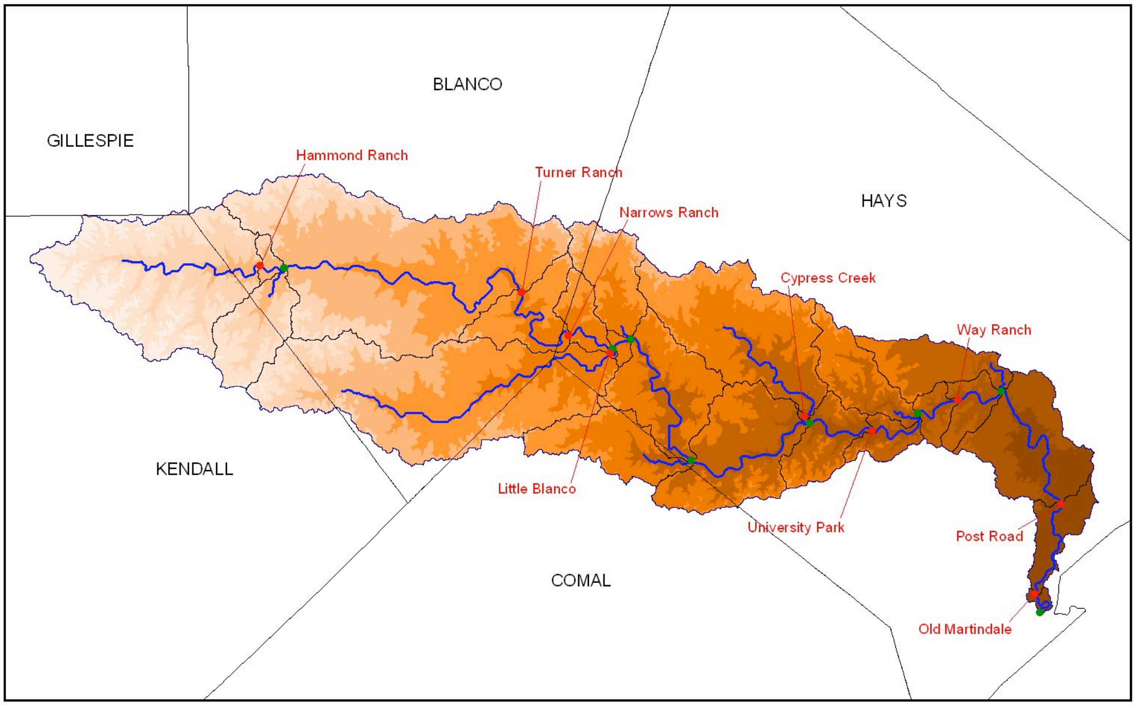

Figure 1.2 SWAT image of the Blanco watershed showing the sampling sites (red circles) and channel (green line).

After that, land use and soil data were collected in order to create Hydrological Response Units (HRUs). HRUs split the subbasin according to land use and soil type. This allows for loadings to be calculated for each HRU first, then for each subbasin based on the results. Land use data was acquired from the Texas Natural Resources Information System website (ftp://ftp.tnris.state.tx.us/Land_Resources/Landuse_Landcover/Decimal_Degrees/). Soil data was acquired from the United States Department of Agriculture's *State Soil Geographic Database* (STATSGO). Both the land use and soil data was then properly projected, clipped with the study area and converted to grid format. Once in grid format, SWAT is able to create HRUs through individual reclassification of each layer followed by an overlay. The following table shows the HRU details of Subbasin #16, the head waters, as an example of the re-classification and overlay results.

			% of Subbasin Area	% of Watershed Area
SUBBASIN # 16				11.75
HRUs:				
	76	Range-Grasses-->RNGE/TX076	4.11	0.48
	77	Range-Grasses-->RNGE/TX042	0.75	0.09
	78	Range-Grasses-->RNGE/TX371	6.69	0.79
	79	Range-Grasses-->RNGE/TX628	0.87	0.10
	80	Forest-Evergreen-->FRSE/TX076	27.95	3.28
	81	Forest-Evergreen-->FRSE/TX042	4.72	0.55
	82	Forest-Evergreen-->FRSE/TX371	32.75	3.85
	83	Forest-Evergreen-->FRSE/TX628	13.70	1.61
	84	Forest-Mixed-->FRST/TX076	0.01	0.00
	85	Forest-Mixed-->FRST/TX371	0.07	0.01
	86	Agricultural Land-Generic-->AGRL/TX076	2.44	0.29
	87	Agricultural Land-Generic-->AGRL/TX042	4.90	0.58
	88	Agricultural Land-Generic-->AGRL/TX371	0.94	0.11
	89	Agricultural Land-Generic-->AGRL/TX628	0.09	0.01

Table 1.1 List of HRUs for Subbasin 16 as generated by SWAT.

The next process involves weather generation. For this step, the location of precipitation and temperature gage stations within the watershed are collected. The daily precipitation and daily minimum/maximum temperatures were downloaded from the National Oceanic and Atmospheric Administration's (NOAA) *National Climatic Data Center (NCDC)* (http://www.ncdc.noaa.gov/oa/climate/stationlocator.html). The precipitation gage stations used for the Blanco River basin were: Blanco, San Marcos, Fischer Store, and Wimberley 1 NW (Figure 1.3).

The weather simulation was aided with the Blanco weather gage station and data provided with SWAT. Weather data for a twelve year period was used in order to simulate a ten year SWAT model. The first two years of weather data are needed in order for SWAT to properly simulate weather conditions. In other words, the first two years are a data preparation period so the model does not start with a dry watershed (due to lack of precipitation data).

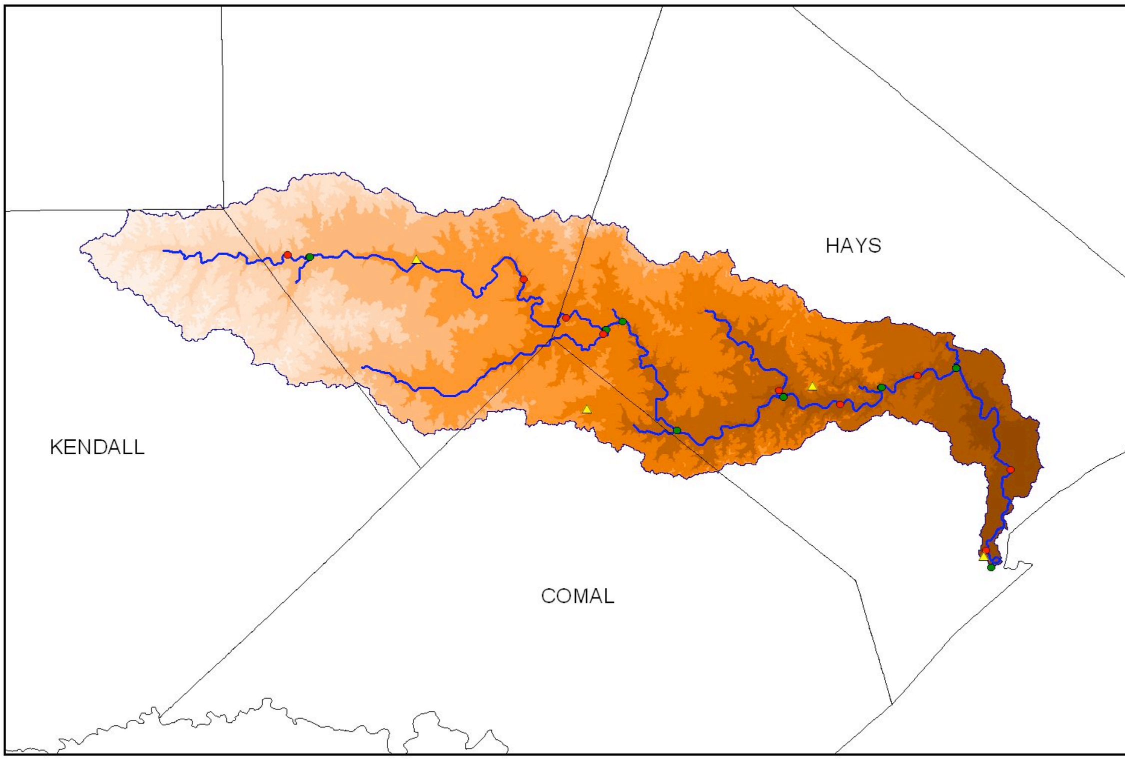

Figure 1.3. SWAT map of the Blanco watershed showing the locations of the precipitation gage stations (yellow triangles) within the watershed in relation to the sampling sites (red circles) and tributary channels (green circles).

6.3 Blanco River Basin SWAT Model Results

With the accumulation of the above mentioned data, it was time to run the SWAT model. After setting the proper parameters, we were able to run the Blanco River basin SWAT model and view the results. Several files created by SWAT recorded the watershed, HRU and subbasin values for key parameters. With these files it is possible to create custom graphs and maps according to the parameters measured. The following map shows one possibility to visualize the water yield (mm) for each subbasin.

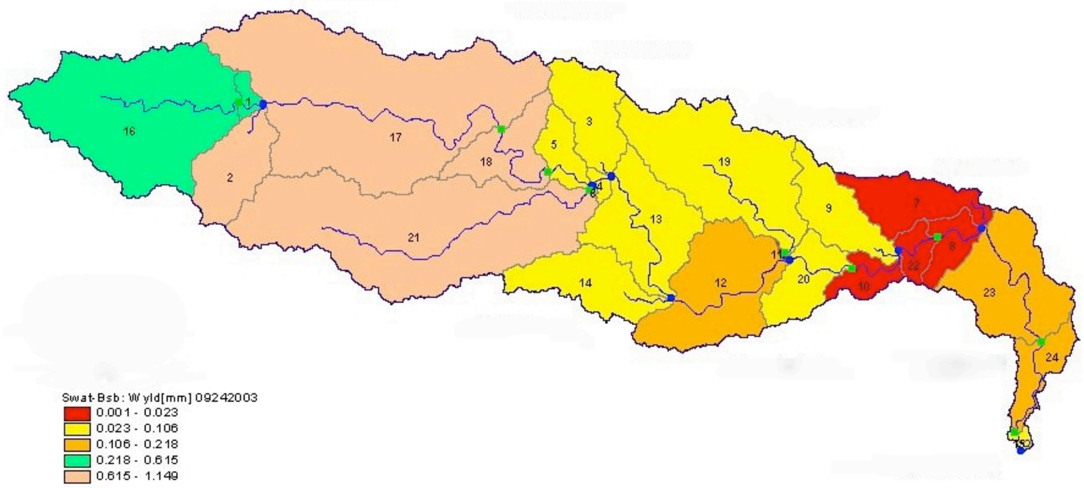

Figure 1.4 SWAT generated map illustrating the range of precipitation throughout the watershed. The colors represent water yield in millimeters as follows: red, 0.001 – 0.023; yellow, 0.023 – 0.106; orange, 0.106 – 0.218; green, 0.218 - .0615; tan, 0.615 – 1.149.

6.4 Comparison of SWAT model to measured data

The most effective method to demonstrate the accuracy of the SWAT model is by comparing the discharge data generated by the model with the discharges measured by the USGS. This is accomplished by overlaying the plots of discharge from the two sources and comparing the trends. When models are used to generate results, the data rarely match perfectly without parameter adjustment. What is important at this stage of model development is that SWAT is able to mimic the trends in the data.

The following graphs demonstrate the average monthly stream flow measured by SWAT (blue line) and the USGS (red line). Two USGS stream flow gage stations were used for data input:

Blanco River at Wimberley: USGS #08171300

Blanco River near Kyle: USGS #08171000

The data shown correspond to the time frame from January of 1996 to December of 1998. These years were chosen for model accuracy assessment, because they include the driest and wettest years of the past decade.

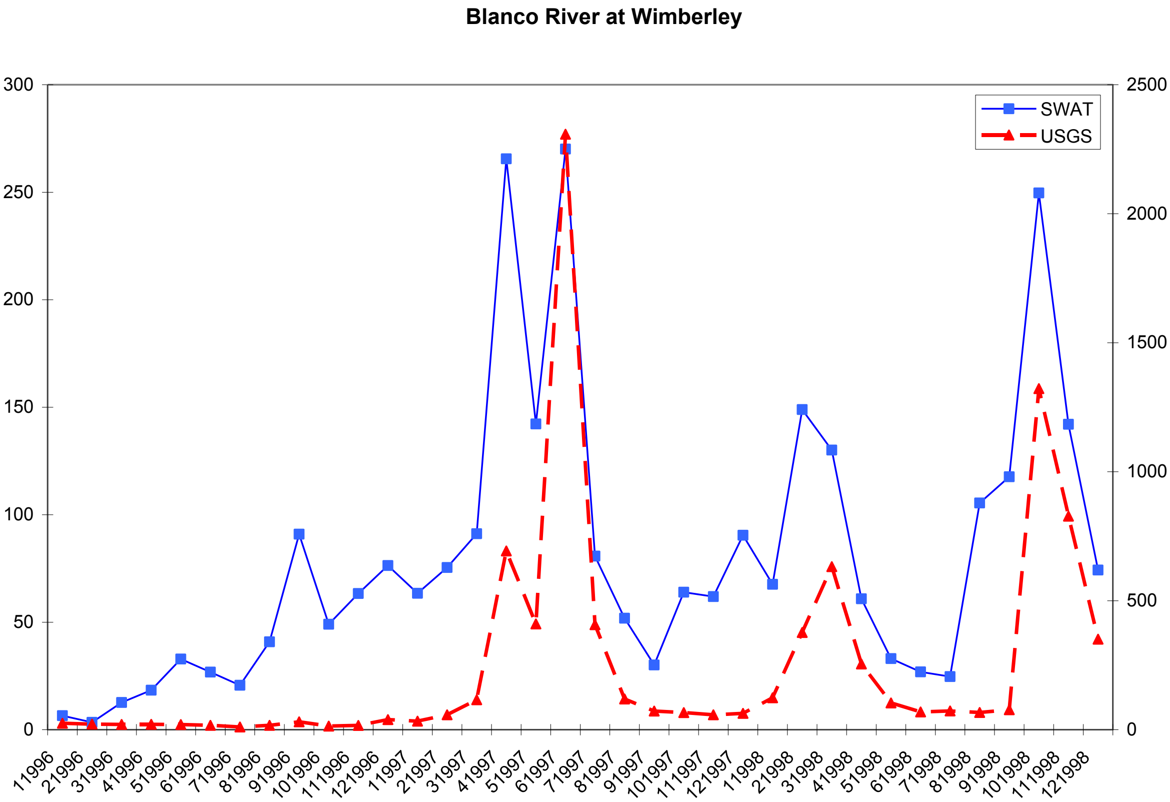

Figure 1.5 Comparison of discharge data generated by SWAT with that measured by the USGS on the Blanco River at Wimberley. The blue line shows the SWAT results, and the red line is the USGS gaging station data. The graph shows the monthly average flow data from January, 1996, to January, 1999. 1996 was the driest year of the past decade while the 1997-1998 period was the wettest of the past decade.

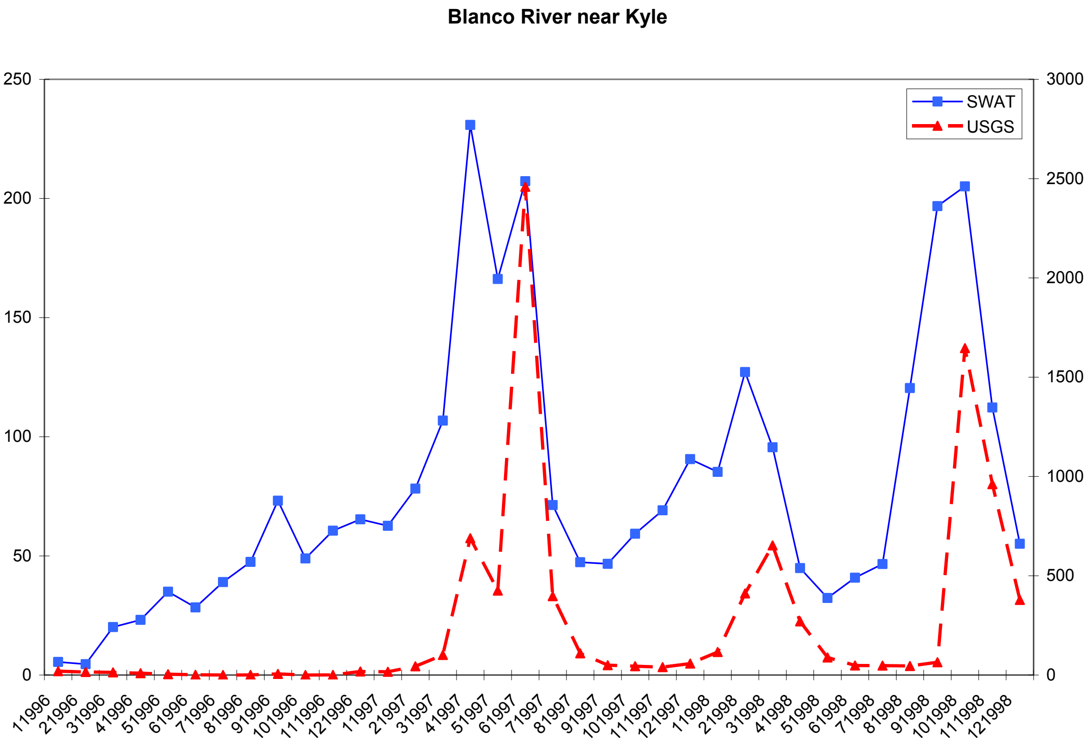

Figure 1.6 Comparison of discharge data generated by SWAT with that measured by the USGS at the Blanco River gauge near Kyle. The blue line shows the SWAT results, and the red line is the USGS gaging station data. The graph shows the monthly average flow data from January, 1996, to January, 1999. 1996 was the driest year of the past decade while the 1997-1998 period was the wettest of the past decade.

6.5 Governing Equations for Blanco River Swat Modeling

The following equations are the governing equations used by SWAT to generate data. These are the equations which may be used to improve the model simulation during year 2 of the project. The equations presented are taken from the Soil and Water Assessment Tool (SWAT) Theoretical Documentation Version 2000.

CITATION INFO: S.L. Nietsch, J.G. Arnold, J.R. Kiniry, J.R. Williams, K.W. King (J.G. Arnold et.al.). Grassland, Soil and Water Research Laboratory-Agricultural Research Service. Published 2002 by Texas Water Resources Institute, College Station Texas.

This publication provides the complete set of equations used within SWAT to determine how all physical processes within the river and its watershed are determined and calibrated. The equations presented here are those specific to the needs of the overall creation and calibration of the Blanco River model itself and factors that are of immediate concern to its aquatic in habitants, specifically fish and macro invertebrates.

Water Temperature

To calculate water temperature SWAT uses an equation developed by Stefan and Prued'homme (1993).

$$T_{water} = 5.0 + 0.75\overline{T_{av}}$$

where T_{water} is the water temperature for the day in degrees Celsius, and T_{av} is the average temperature on the day in degrees Celsius.

This equation is used to calculate the average daily temperature for a well mixed stream. Water temperature is necessary to model in-stream biological and water quality processes.

Surface Runoff

The SCS curve number equation, developed in the 1950's, is used by SWAT to provide "a constant basis for estimating the amounts of runoff under varying land use and soil types (Rallison and Miller, 1981).

$$Q_{surf} = \frac{\left(R_{day} - I_a\right)^2}{\left(R_{day} - I_a + S\right)}$$

where Q_{surf} is the accumulated runoff or rainfall excess (mm H_20), R_{day} is the rainfall depth for the day (mm H_20), I_0 is the initial abstractions which includes surface storage, interception and infiltration prior to runoff (mm H_20), and S is the retention parameter (mm H_20). The retention parameter varies spatially due to changes in soils, land use, management, and slope, and temporarily due to fluctuations in soil water content. The retention parameter is defined as:

$$S = 25.4\left(\frac{1000}{CN} - 10\right)$$

Runoff will occur only when $R_{day} > I_a$. This ensures that runoff will not occur until the rainfall amount exceeds the infiltration capacity of the rural area.

Surface Runoff in Urban areas

The Blanco River has two centers of high population density that are considered as "urban areas" or "places" (US Census, 2000) within its watershed: Wimberley (including Wood Creek) and San Marcos. Further, development between these two areas is occurring at a rapid rate and forecasted to do so for some time. Because of this is it is important to look at how SWAT models for runoff in areas such as this that have greater amounts of impervious coverage.

SWAT uses the composite curve number for disconnected impervious/pervious areas. These equations were developed by the Soil Conservation Service Engineering Division (1986) and are reproduced here.

$$CN_c = \frac{CN_p\left(1 - imp_{tot} + \frac{imp_{dcon}}{2}\right) + 98\left(\frac{imp_{dcon}}{2}\right)}{1 - imp_{con}} \qquad \text{if } imp_{tot} \leq 0.30$$

$$CN_c = \frac{CN_p\left(1 - imp_{tot}\right) + 98 imp_{dcon}}{1 - imp_{con}} \qquad \text{if } imp_{tot} > 0.30$$

where CN_c is the composite moisture condition II curve number, CN_p is the pervious moisture condition II curve number, imp_{tot} is the fraction of the HRU area that is impervious (both directly connected and disconnected), imp_{con} is the fraction of the HRU area that is impervious and hydraulically connected to the drainage system, imp_{dcon} is the fraction of the HRU area that is impervious but not hydraulically connected to the drainage system.

Runoff Volume

The Green-Ampt Mein-Larson equation is included within SWAT to aid in determining the quantity surface runoff from a given precipitation event.

$$f_{\inf,i} = K_e\left(1 + \frac{\Psi_{wf}\Delta\Theta_v}{F_{\inf,t}}\right)$$

where $f_{\inf}$ is the infiltration rate at time t (mm/hr), K_e is the effective hydraulic conductivity (mm/hr), Ψ_{wf} if the wetting front matric potential (mm), $\Delta\Theta_v$ is the change in volumetric moisture content across the wetting front (mm/mm), and F_{inf} is the cumulative infiltration at time t (mm H_20).

Transmission Losses

Since the Blanco River is located within the arid/semi-arid climate of the central Texas Hill country it is important to include the how SWAT calculates water loss to transmission. The prediction equation for the volume of runoff after transmission losses is as follows:

$$vol_{Qsurf,f} = \begin{cases} 0 & vol_{Qsurf,i} \le vol_{thr} \\ a_x + b_x vol_{Qsurf,i} & vol_{Qsurf,i} > vol_{thr} \end{cases}$$

where $vol_{Qsurf,f}$ is the volume of run-off after transmission losses (m^3), a_x is the regression intercept for a channel of length L and width W (m^3), b_x is the regression slope for a channel of length L and width W, $vol_{Qsurf,f}$ is the volume of run-off prior to transmission losses (m^3), and vol_{thr} is the threshold volume for a channel of length L and width W (m^3). The threshold volume is

$$vol_{thr} = -\frac{a_x}{b_x}$$

This quantity of runoff after accounting for transmission losses will provide an idea of how much water can reach the river under different rainfall scenarios. By adjusting the relative amounts of urban and rural surface runoff, we will alter the transmission losses of the precipitation as it travels to the river. This series of changes will help predict how river flow may change under increased urbanization.

Potential Evaporation

SWAT calculates potential evaporation (PET) several different ways depending on the information imputed within the model that directly affects PET of the particular area in question. In the case of the Blanco River Model, the Priestly-Taylor method was used (as opposed to the Penmen-Monteith or the Hargreaves method). The information relating to PET included within this model that were air temperature (inputted manually), solar radiation and relative humidity (calculated by SWAT defaults). When these three factors are included, SWAT automatically uses the Priestly-Taylor method:

$$\lambda E_o = \alpha_{pet} \frac{\Delta}{\Delta + \gamma} \left(H_{net} - G \right)$$

where λ is the latent heat of vaporization (MJ/kg), E_o is the potential evapotranspiration (mm/d), α_{pet} is a coefficient, Δ is the slope of the saturation vapor pressure-temperature curve, de/dT (kPa/°C), γ is the psychrometric constant (kPa/°C), H_{net} is the net radiation (MJ/m^{2}d), and G is the heat flux density to the ground (MJ/m^{2}d).

It is important to mote that the in arid and semi-arid regions the Priestly-Taylor Method may underestimate the PET. However, in order to compensate for this the Penmen-Monteith method would have to be used. The Penmen-Monteith method, which would better account for these drier conditions, requires that wind speed, an environmental variable not available from the weather gauging stations in the Blanco River watershed, be included into the model.

Dissolved Oxygen

Dissolved oxygen (DO) is one of the most important indicators of both the quality of water in surface water feature and it is vital for the not just the feeding and reproduction of aquatic species, but is crucial for their survival. SWAT calculates DO on two different levels. First it determines the DO concentration of surface runoff from rainfall:

$$Ox_{surf} = Ox_{sat} - \kappa_1 cbod_{surq} \frac{t_{ov}}{24}$$

where Ox_{surf} is the dissolved oxygen concentration in surface runoff (mg O_2/L), Ox_{sat} is the saturation oxygen concentration (mg O_2/L), κ_1 is the CBOD deoxygenation rate (1/day), $cbod_{surq}$ is the CBOD concentration in surface runoff (mg CBOD/L), and t_{ov} is the time of concentration for overland flow (hr). For loadings from HRUs, SWAT assumes κ_1=1.047 1/day.

Once DO is within a surface water body its levels are affected by temperature, amount of dissolved solids present, and atmospheric pressure. SWAT account for these factors with the following equation:

$$Ox_{sat} = \exp\left[-139.34410 + \frac{1.575701\times10^5}{T_{wat,\mathrm{K}}} - \frac{6.642308\times10^7}{\left(T_{wat,\mathrm{K}}\right)^2} + \frac{1.243800\times10^{10}}{\left(T_{wat,\mathrm{K}}\right)^3} - \frac{8.621949\times10^{11}}{\left(T_{wat,\mathrm{K}}\right)^4}\right]$$

where Ox_{sat} is the equilibrium saturation oxygen concentration at 1.00 atm (mg O_2/L), and $T_{wat,K}$ is the water temperature is Kelvin (273.15+°C). The constants in the equation were developed by APHA (American Public Health Association) in 1985.

6.6 Plans for Year 2

The hydrology plans for year 2 consist primarily of working with the SWAT model to improve its accuracy. We will be incorporating the field data that has been taken. As real data is incorporated into the model, we expect an increase in the accuracy of the discharge data. We will be looking at the governing equations, specifically at the fitted parameters within the equations given in part 1.6 of this report. The parameters will be adjusted where necessary. This will make the model more specific to the Blanco watershed and better reflective of the specific field conditions. Data has been gathered so far on a broad scale for information soil parameters, and this may be updated with more specific information.

We will continue to use the discharge data from the past decade to calibrate the SWAT model. Once we are satisfied with the results produced by SWAT to model the past 10 years, including the driest and wettest years, we will begin a scenarios of scenario runs. The scenarios will simulate the flow conditions through the Blanco watershed under conditions of increased and/or decreased urbanization in different parts of the watershed. Through these scenarios we hope to predict how the flow in the Blanco watershed may change in the future.

7.0 Title: Survey of the Blanco River for *Graptemys caglei* (Proposed study)

7.1 Overview

Although well known from the Guadalupe and San Antonio rivers, the occurrence of Cagle's map turtle's in the San Marcos and Blanco rivers has been poorly documented. David Haynes (Pers. Comm.) saw a single specimen supposedly captured at Spring Lake but no *Graptemys* was observed there during our studies that began in 1994: over 4,000 turtles were collected and marked. The consensus is that the turtle does not occur in the upper reaches of the San Marcos River or the Blanco River.

In the summer of 2003, two individuals of Cagle's map turtle were collected from the Blanco River in an area approximately half way between San Marcos and Wimberley. As these two individuals were collected within one minute of each other, the population levels may be significantly high.

7.2 Significance

The occurrence of Cagle's map turtle in the middle sections of the Blanco River implies that the turtle probably occurs in the San Marcos River as well. Activities on the Guadalupe River basically associated with habitat destruction, with concomitant loss of nesting areas, will probably increase. Fewer nesting sites offer a smaller window of opportunity for more intense egg predation by raccoons, opossums, foxes, and skunks. A stable and healthy population of Cagle's map turtle in the Blanco River offers a protection-site counter to its currently perceived distribution.

7.3 Action and Results

We propose to survey the Blanco River at least twice each season during a 12 month period. Individuals will be captured with hand-held nets, baited hoop traps, or by snorkeling once individuals are observed. Captured animals will be weighed, their sex determined, eggs palpated in season, and measured. Individuals will be marked by drilling holes in peripheral plates and by having a PIT implanted. Blood will be collected from a tail vein by conventional technique to use for genetic studies and to ascertain the prevalence of blood parasites. If possible, "age" will be estimated by counting growth rings on the horny plates. A Garmin V Deluxe GPS unit will be used to determine locality. Turtles will be photographed and released at the site of capture.

These data can then be used to assess population size, distribution, and habitat requirements within the river. Additional information on population demographics and morphological parameters can also be determined. Blood and tissue samples collected during this stage can then be used in future genetic investigations.

8.0 Title: Resident survey of the Blanco River basin

8.1 Overview

The research design for the resident survey has been finalized, and the project team is awaiting final institutional (Texas State University) approval of the survey instrument and sampling plan. Both elements of the project received substantial input from university faculty and representatives from The Nature Conservancy of Texas and eventual approval is anticipated.

The survey instrument has been designed to elicit responses on a wide variety of issues from property owners throughout the study area. More specifically, the instrument will afford the opportunity to gauge attitudes/opinions about natural resources and conservation measures. Data will be collected through a mail-questionnaire design. At present, the sampling plan calls for distribution of questionnaires to approximately 3,000 property owners throughout the study area. The sample will be stratified on the basis of county.

The survey instrument has been developed with a format that includes both fixed-choice and open-ended questions, though the clear majority of questions follow a fixed-choice response structure. One of the more interesting aspects of the instrument is its focus on respondent attitudes concerning natural resource issues *in the present*, as well as respondent attitudes toward those same issues as they are likely to be *in the future* (i.e., ten years from now).

When distributed, respondents will be encouraged to return completed surveys within approximately one month. A self-addressed, postage-paid return envelope will be included with all mailed survey forms. Responses will be returned to a designated location at Texas State University.

The questionnaire format has been designed so as to facilitate the ease of data entry. Upon completion of the data entry phase of the project, the data will be processed (using SPSS software). In addition to frequency distributions on all fixed-choice responses, the data analysis will provide a variety of cross-tabulations ---- something that should prove to be very valuable in assessing attitude variation by specific sub-group (e.g., comparison of long term and recent resident attitudes of a variety of issues).

As noted above, the project team is currently awaiting institutional review/approval of the final survey instrument. Upon receipt of the approval, the survey instrument and mailing pieces (i.e., outgoing/return envelopes) will go to press.

9.0 Title: Plans for the Cypress Creek Watershed Groundwater and Habitat Assessment (Proposed study)

9.1 Introduction

During 2003-2004, the Blanco River Assessment Project was funded by the Nature Conservancy of Texas and conducted by the Texas State University at San Marcos Aquatic Biology Department. Water quality, macroinvertebrates and fish were assessed in a total of 8 sites within the Blanco River Watershed. In addition, hydrological and sociological aspects were also investigated. During this time, it was recognized that Cypress Creek plays a key role in contributing to the aquatic habitat of the Blanco River Watershed.

9.2 Statement of Problem

The Village of Wimberley determined that management of water resources is important to the health and welfare of citizens and the economy. Wimberley's natural beauty and attractiveness for both tourism and residential development is centered on the Cypress Creek and the Blanco River. Both of these waterways are supported by the spring flow from the Trinity Aquifer. All drinking water in the Wimberley Valley, except those on rainwater collection systems, comes from local groundwater. Portions of the incorporated City are in the Edward's Aquifer Recharge Zone. All of Wimberley is within the Contributing Zone for the Edward's Aquifer.

During September of 2000, Jacob's Well, in Wimberley Texas, stopped flowing. Jacob's Well is a natural spring flowing into Cypress Creek three miles northwest of Wimberley in west central Hays County (at 30°02' N, 98°08' W). It issues from an inclined shaft forty meters deep along a fault line in the Edwards Plateau. Jacob's Well is the source of Cypress Creek, which rises about a mile west of Mount Sharp in western Hays County (at 30°06' N, 98°14' W) and runs southeast for 14½ miles to its mouth on the Blanco River in Wimberley (at 29°59' N, 98°06' W). The stream is intermittent in its upper reaches. Live oak and Ashe juniper trees grow in the primarily limestone and chalk soils found along its banks. This area is one of the most prolific springs in Central Texas. The cause of the September 2000 cessation of flow is unknown; however, drought and increased pumping in recent years are two possible causes. Over the past few decades, pumping has increased significantly in the area in conjunction with explosive development throughout the Wimberley Valley. For this reason, Wimberley Valley now puts enormous pressure on the Trinity Aquifer, which is the region's main source of groundwater and the source of Jacob's Well.

Because of the significance of Jacob's Well and Cypress Creek to the economy of the City of Wimberley, it is necessary that a study specifically addressing Cypress Creek be conducted in order to develop a baseline scientific database dealing with annual spatial and temporal variations, as well as correlations between aquifer levels, springflow and the local ecosystem.

9.3 Proposed objectives

During the second year of the Blanco River Assessment Project, a detailed evaluation of aquifer levels in the Trinity Aquifer—in relation to springflow and habitat—will be performed in the small, spring-fed Cypress Creek Watershed. The Cypress Creek Watershed Groundwater and Habitat Assessment will consist of the following: 1) The Hays Trinity Groundwater Conservation District will locate up to 15 new monitoring wells in or near Cypress Creek and the major springs—Jacob's Well and Blue Hole. A program of monthly measurement will be set up at each well. Springflow measurements will be taken at key points in the watershed, using the FlowTracker™ system, including incremental contributions from individual springs. In addition, fish and macroinvertebrate collections will be made, and relationships between springflow, aquifer level and habitat measures will be prepared for inclusion in the final Blanco River Assessment Project Report.

9.4 Approach

An assessment which will contribute to the Blanco River Assessment Project Final Report will be conducted specifically addressing Cypress Creek. Fish and macroinvertebrates will be collected seasonally from approximately 5 sites along the course of the Cypress Creek over the course of 12 to 14 months. This will be done using the USEPA Rapid Bioassessment Protocols outlined in document EPA 841-B-99-002: Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Macroinvertebrates, and Fish, Second Edition. This data will be correlated with springflow, measured using the FlowTracker™, and aquifer levels, using measurements taken from 15 monitoring wells in or near Cypress Creek and the major springs—Jacob's Well and Blue Hole. In addition, water quality data will also be collected using the Hydrolab™ and water samples will be analyzed concurrently using the laboratory facilities at Edward's Aquifer Research and Data Center (EARDC). This will allow spatial and temporal relationships between springflow, aquifer levels and vertebrate and invertebrate communities to be determined within the Cypress Creek subwatershed.