

# Bull Creek Study Data Report

City of Austin  
Watershed Protection Department

July 2006

DR-07-02

## **Introduction**

The 11.4 mile long Bull Creek encompasses a drainage area of 31.9 square miles, the majority of which lies atop the northern portion of the Edwards Aquifer recharge zone. Bull Creek contains habitat for the endangered golden-cheeked warbler and black-capped vireo, as well as the sensitive Jollyville Salamander.

Major study objectives include:

1. Evaluation of spatial and temporal changes in aquatic life and habitat, and in water quality.
2. To provide early-warning signals of surface water contamination or document recovery in Bull Creek Watershed.
3. Assess the aquatic life use support of each mainstem site using benthic and habitat data.
4. Compare water quality data to TCEQ screening levels and standards to identify concerns

This report presents information on the data collected in 2004 and 2005, the last two complete years of data when the data was analyzed in 2006, as well as trend analysis on data from 1997 to early 2006.

Data analysis methods included:

- Data screening for QC flags, locations, and parameters
- Time series plots for water quality, benthic and habitat parameters by site
- Linear regressions of value vs. time for parameters
- ANOVA or box plots for site differences for bug metrics
- Assess the aquatic life use support for mainstem sites using benthic and habitat data
- Comparison of water quality data to TCEQ screening levels and standards

## Data Screening

In order to assess the usefulness of the data that was collected, the parameters which failed a QC check are listed in Table 1. Four parameters failed some of the checks. Consideration should be given to the reasons for the failures for e coli bacteria and TSS, as most of the data is unusable.

Table 1. Parameters which failed the QC Check and were rejected (2004 data)

Sum of COUNT	Flag		Grand Total	% rejected	Reasons
	OK	Rejected			
AMMONIA AS N	42	20	62	32%	Standard=0.02/.03 variability Standard=0.02/.03 standards
E COLI BACTERIA	18	44	62	71%	
ORTHOPHOSPHORUS AS P	52	10	62	16%	
TOTAL SUSPENDED SOLIDS	22	39	61	64%	
Grand Total	134	113	247		

The list of site visits, parameter types, and parameters in Tables 2, 3, and Table 1 in Appendix A indicates that QAPP was being followed appropriately.

Table 2. Sites Visited in 2004 and 2005

SITE VISITS	2004		2005	Grand Total	Comments
Barrow Preserve Spring			1	1	Salamander
Bull Creek @ Bull Creek Dist Park (Lakewood Dr)			1	1	Spill/Spring
Bull Creek @ Loop 360 First Crossing	4		8	12	In QAPP
Bull Creek @ St. Edwards Park above dam	4		7	11	In QAPP
Bull Creek Above Tributary 7 (Franklin)	6		6	12	In QAPP
Bull Creek Above West Bull Creek	3		1	4	Dropped in 2005
Bull Creek Tributary 5 Riffle 4	1			1	Dropped in 2005
Bull Creek Tributary 5 Riffle 6	5		1	6	Dropped in 2005
Little Stillhouse Hollow Spring			1	1	Salamander
Spicewood Tributary Below Spicewood Spring			1	1	Salamander
Stillhouse Hollow Spring			1	1	Salamander
Tributary 5 Below Hanks Tract Property Line	4		8	12	In QAPP
Tributary 6 @ Bull Creek (EG)	4		6	10	In QAPP
West Bull Creek @ Jester Blvd	3		1	4	Dropped in 2005
West Bull Creek Above Bull Creek (EK)	3		1	4	Dropped in 2005
Grand Total	37		44	81	

## Time Series Plots

Time series plots were done for

- field parameters: flow, conductivity, and dissolved oxygen
- core lab parameters: nitrate, ammonia, total suspended solids, e coli, and othophosphorus
- major ions: chloride, sodium, and sulfate
- benthic parameters: number of taxa, number of invertebrates, percent dominance, TCEQ Qualitative Aquatic Life Use Score, and TCEQ Quantative Aquatic Life Use Score
- habitat parameters: embeddedness rating, and sediment deposition rating

## Trends

Linear regressions of value vs. time were done for most parameters using the data from 1997 – early 2006. The results are shown in Table 4. Of greatest interest are the declines in salamander counts at Tributaries 5 and 6.

## **Aquatic Life Use Support**

The aquatic life use support is assessed using the TCEQ Qualitative Aquatic Life Use Score. The point score ranges are: < 22 limited, 22-28 Intermediate, 29-36 High, and > 36 Exceptional.

Habitat data will be included in the assessment in the future. The scores for 2004 and 2005 were:

<b>Site</b>	<b>2004</b>	<b>2005</b>
Tributary 5 Below Hanks Tract Property Line	Intermediate	Intermediate
Tributary 6 @ Bull Creek (EG)	High	High
Bull Creek Above Tributary 7 (Franklin)	Intermediate	High
Bull Creek @ St. Edwards Park above dam	High	High
Bull Creek @ Loop 360 First Crossing	Intermediate	High

### Comparison of water quality data to TCEQ screening levels and standards

The only parameter above TCEQ screening levels was total lead at Loop 360. The concentrations were not above the EPA MCL for drinking water.

SITE	Flow	PARAMETER	VALUE	UNITS	FILTER	date	EPA MCL	TCEQ RBEL
Bull Creek @ Loop 360 First Crossing	S	LEAD	7.29	UG/L	Total	3/20/2006	15	4.98
Bull Creek @ Loop 360 First Crossing	S	LEAD	5.42	UG/L	Total	6/1/2005	15	4.98

Table 3. Parameter Types at Sites in 2004 and 2005

Count of Site Visits	Parameter Type														
	Alkalinity/Hardness/pH	Bacteria Pathogens	Benthic Macroinver.	Channel Assessment	Clarity	Environmental Conditions	Flow/Rainfall	Grain Size Substrate Char.	Habitat Evaluation	Major Ions	Metals	Nutrients	Oxygen	Solids Conductivity	Spatial
SITE															
Barrow Preserve Spring			1												
Bull Creek @ Bull Creek Dist Park (Lakewood Dr)	1	1								1		1			
Bull Creek @ Loop 360 First Crossing	7	7	3	2	3	7	7	1	4	2		7	7	7	2
Bull Creek @ St. Edwards Park above dam	7	7	3	2	3	7	7	2	3			7	7	7	4
Bull Creek Above Tributary 7 (Franklin)	7	7	3	4	2	7	10	4	5	7		7	7	7	6
Bull Creek Above West Bull Creek	4	4			1	4	4					4	4	4	2
Bull Creek Tributary 5 Riffle 4			1				1		1						1
Bull Creek Tributary 5 Riffle 6	4	4	2		1	4	4		2			4	4	4	2
Little Stillhouse Hollow Spring			1												

Spicewood Tributary Below Spicewood Spring			1												
Stillhouse Hollow Spring			1												
Tributary 5 Below Hanks Tract Property Line	8	7	3	1	4	8	9	1	3	7		7	8	8	
Tributary 6 @ Bull Creek (EG)	7	7	3	1	2	7	7	1	3	7	1	7	7	7	1
West Bull Creek @ Jester Blvd	4	4			1	4	4					4	4	4	1
West Bull Creek Above Bull Creek (EK)	4	4			1	4	4					4	4	4	1

# Time Series Plots – Core Field

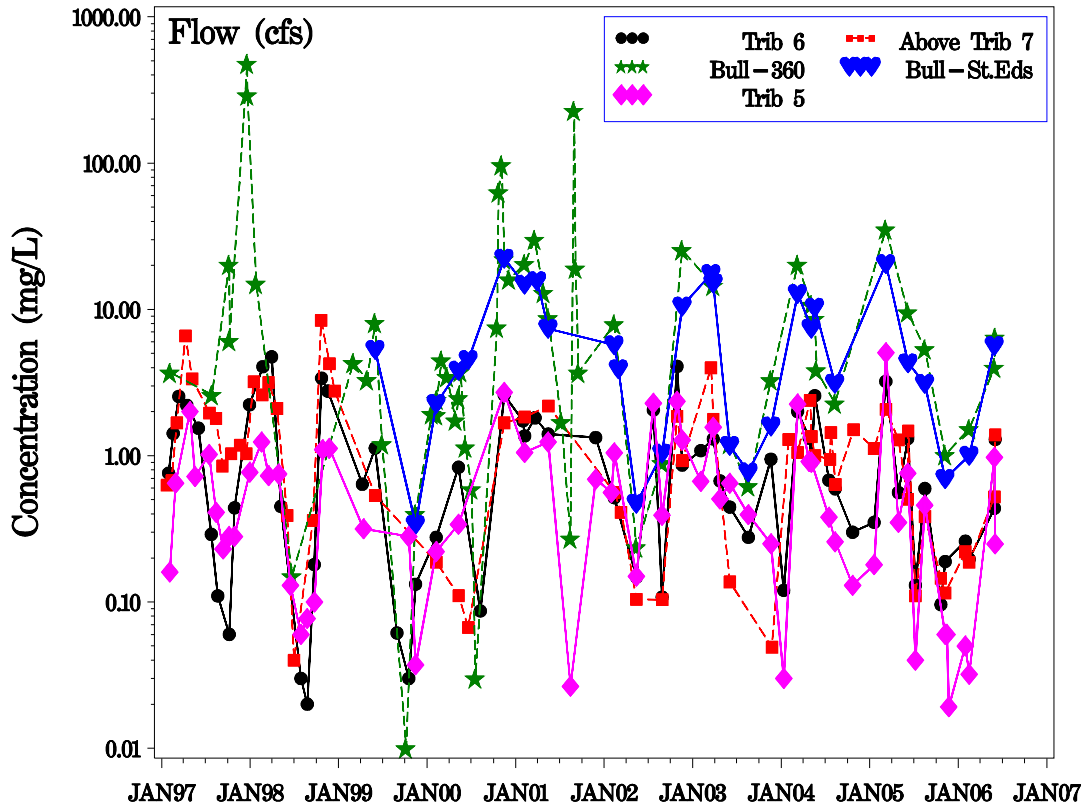
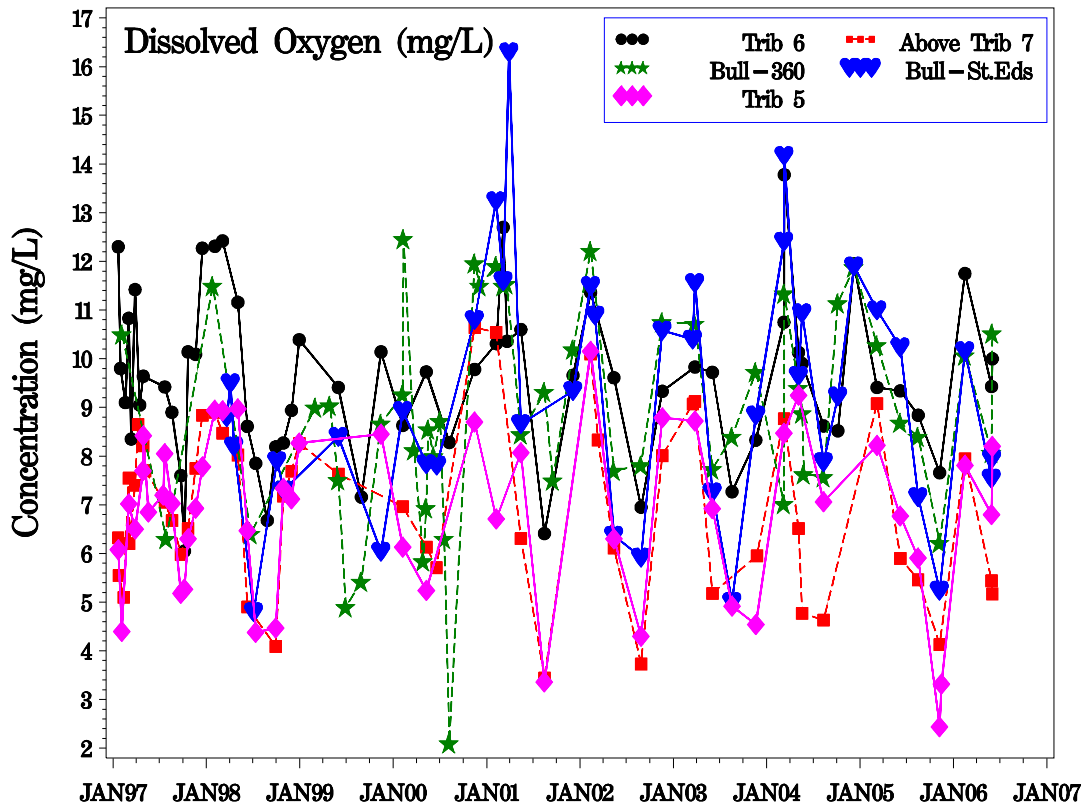
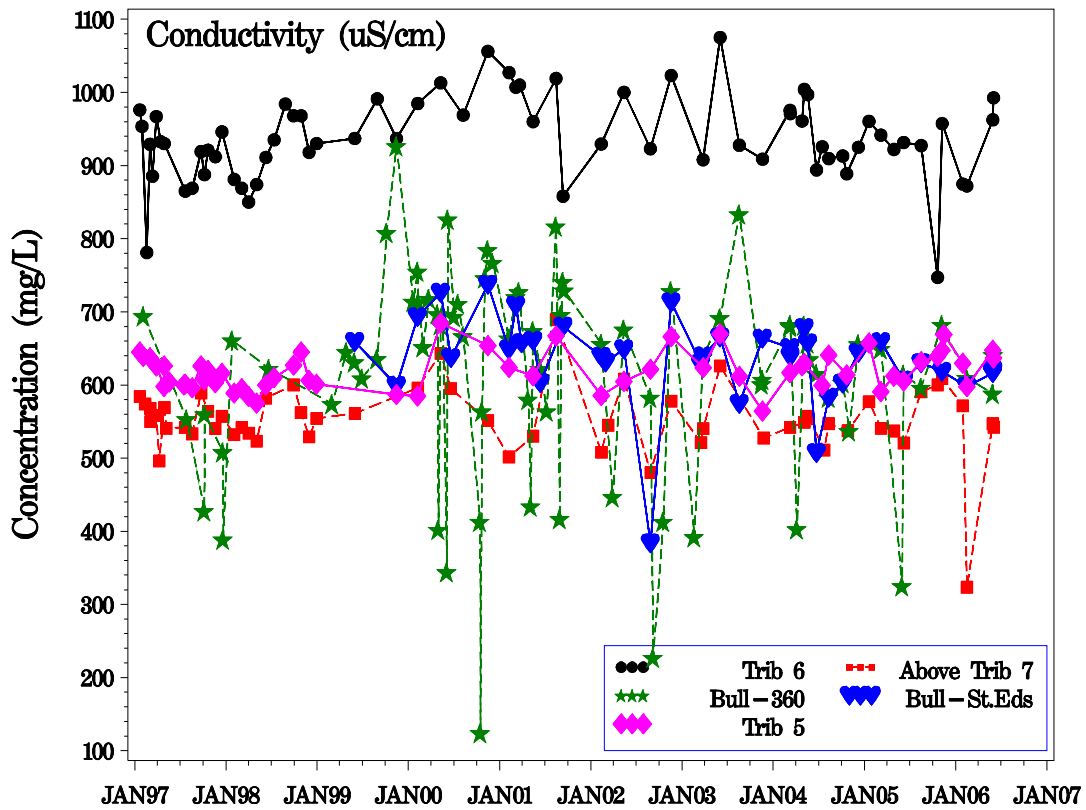
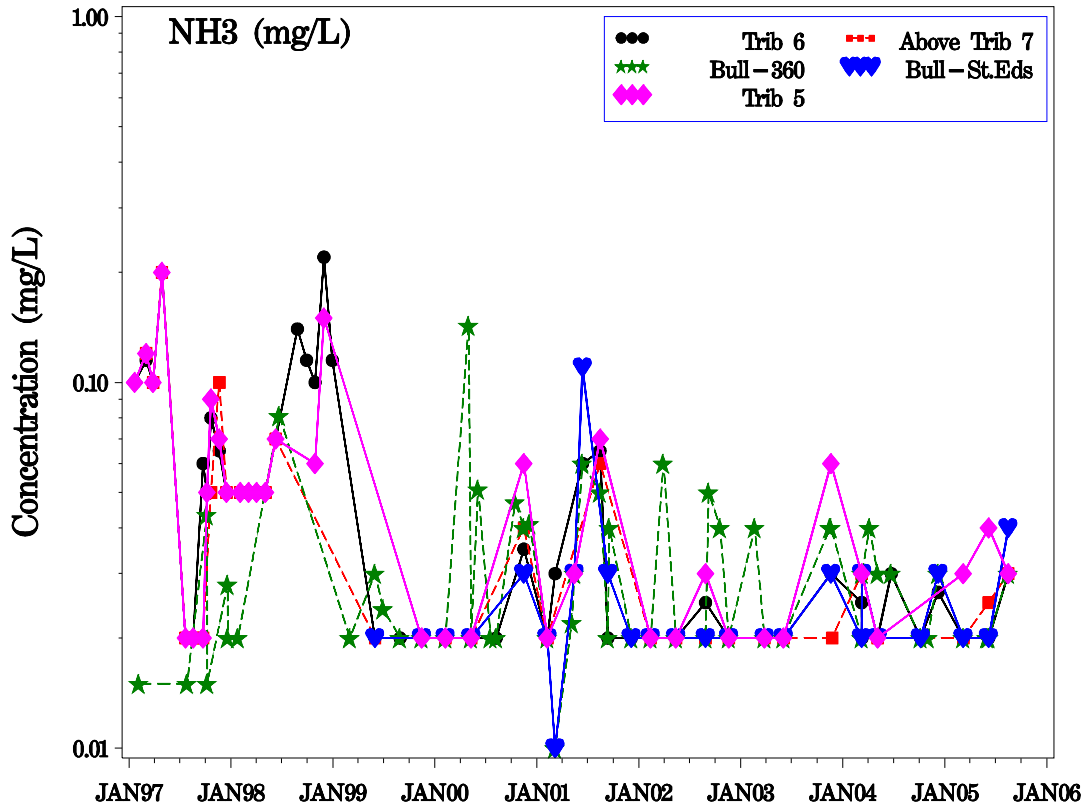
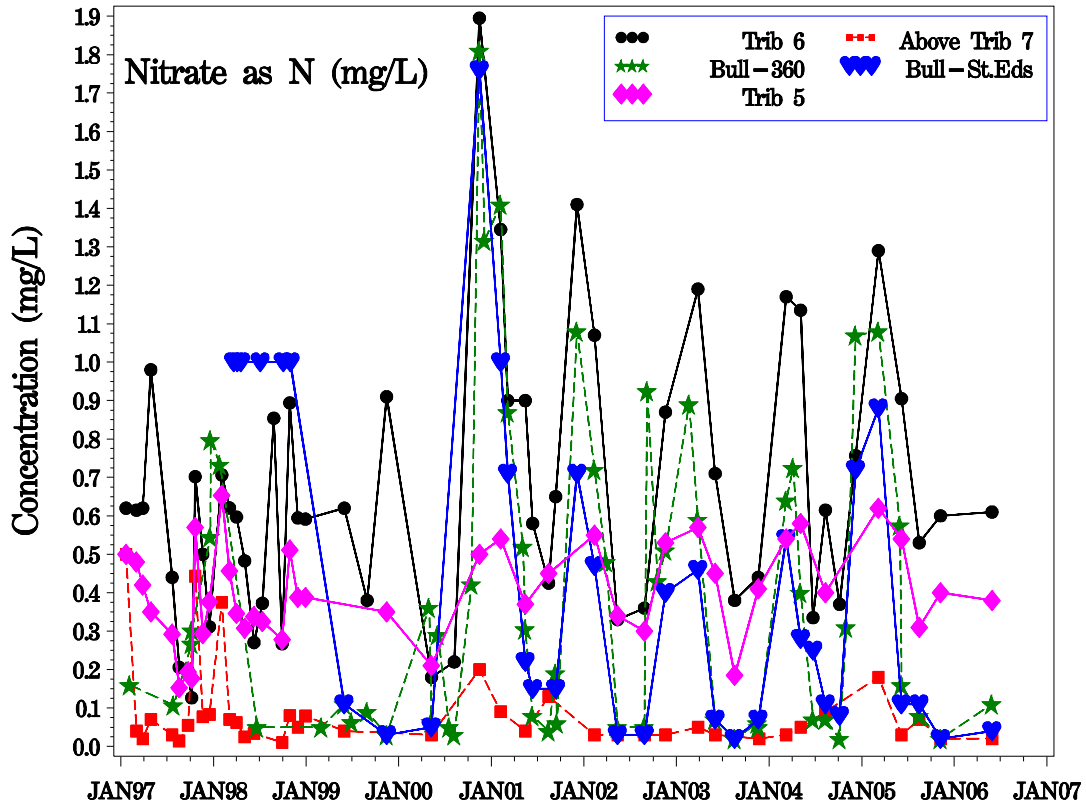
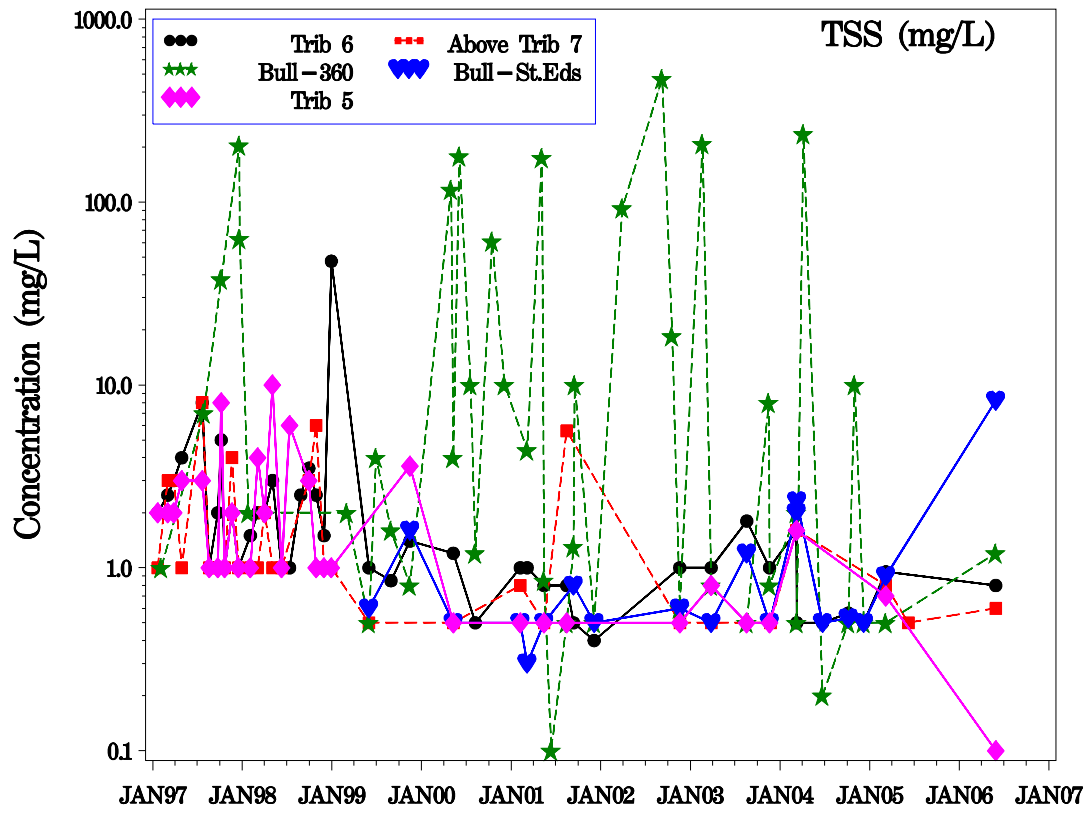


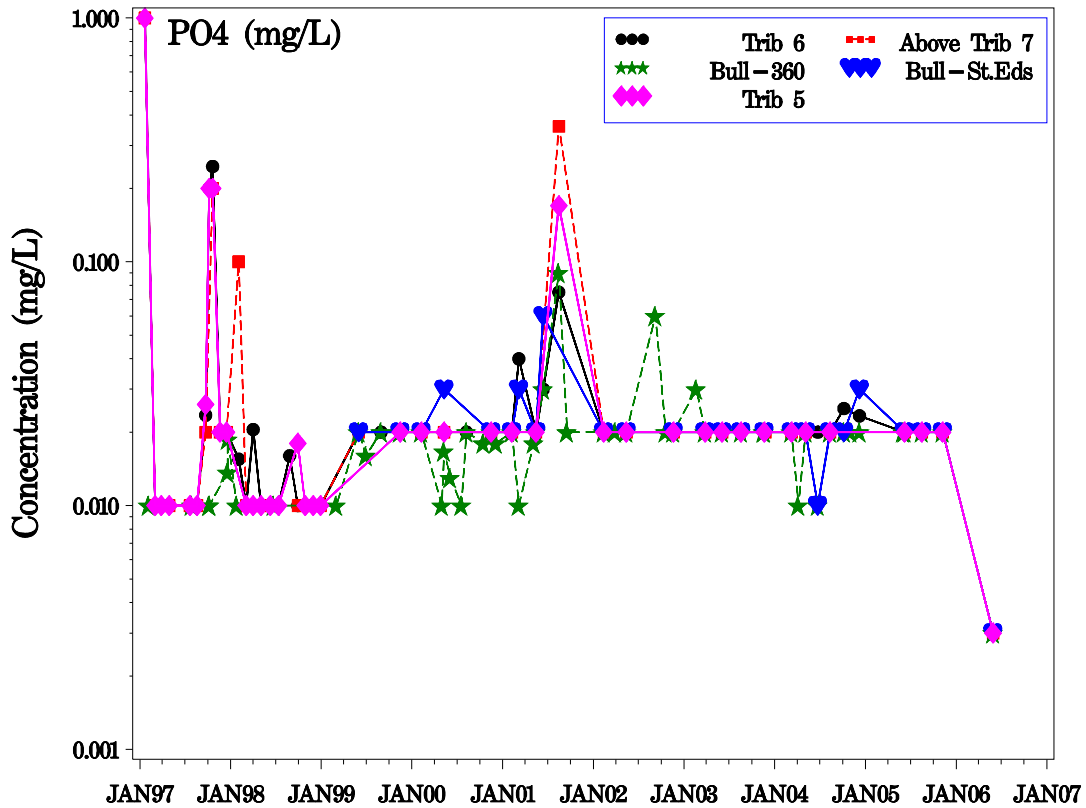
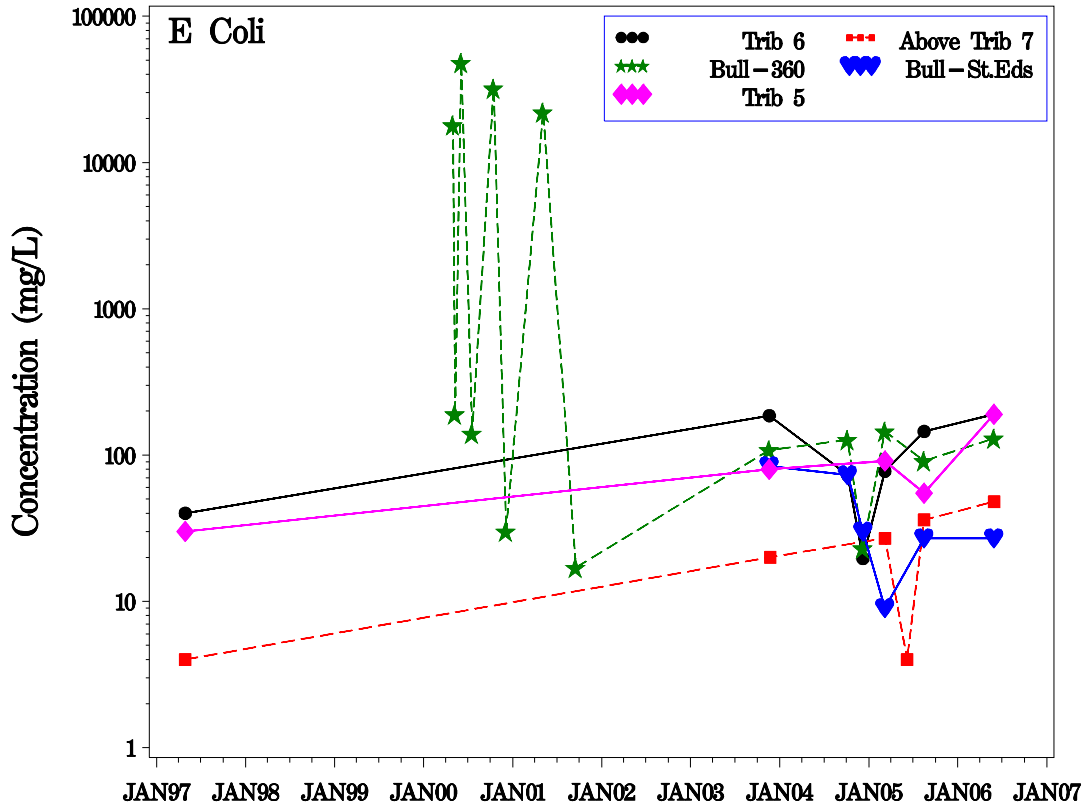
Figure 1.



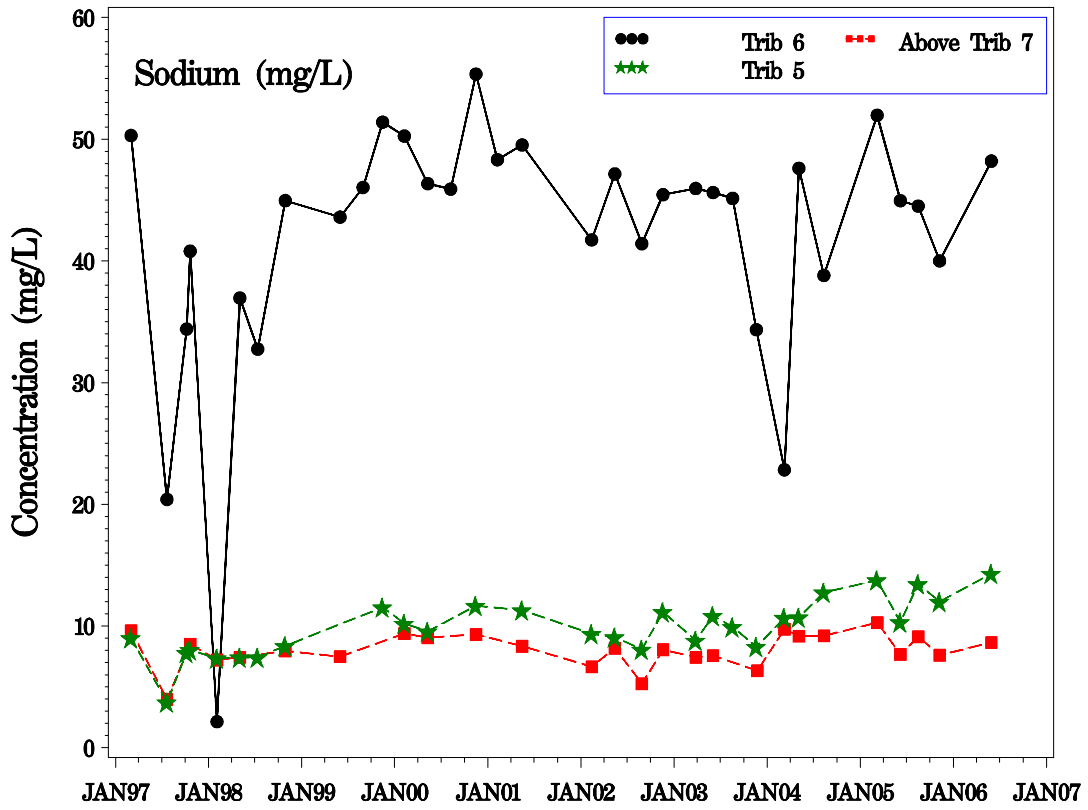
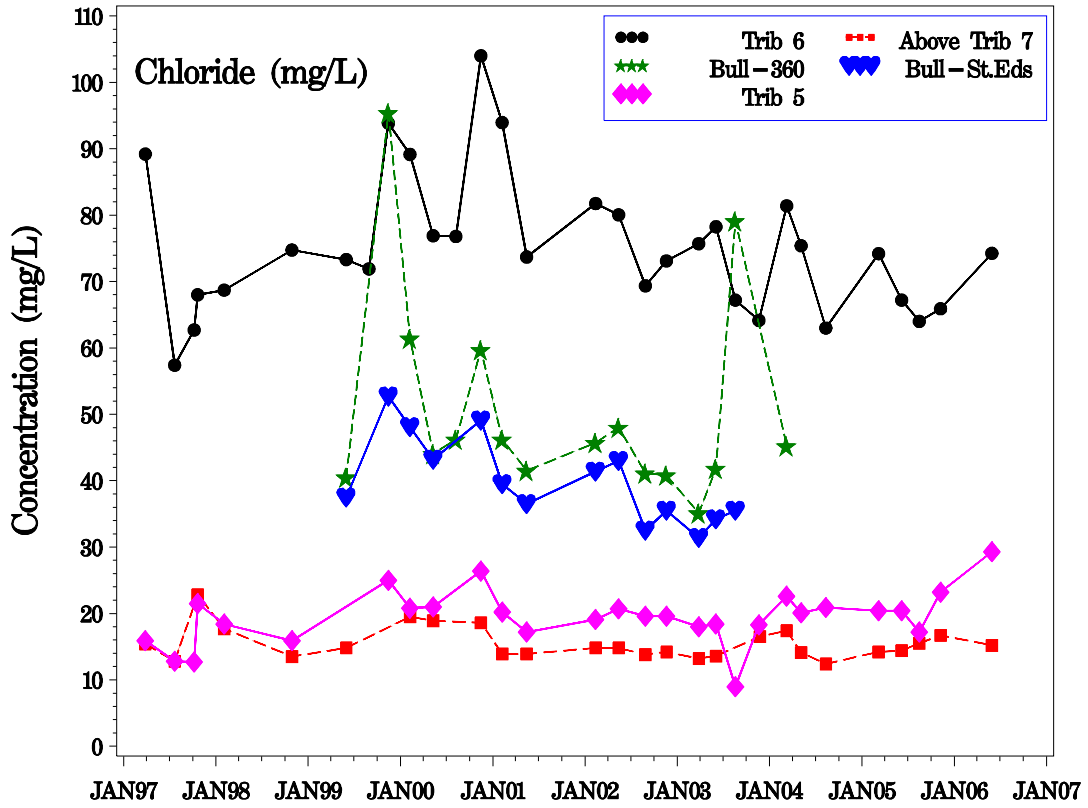
Core Lab

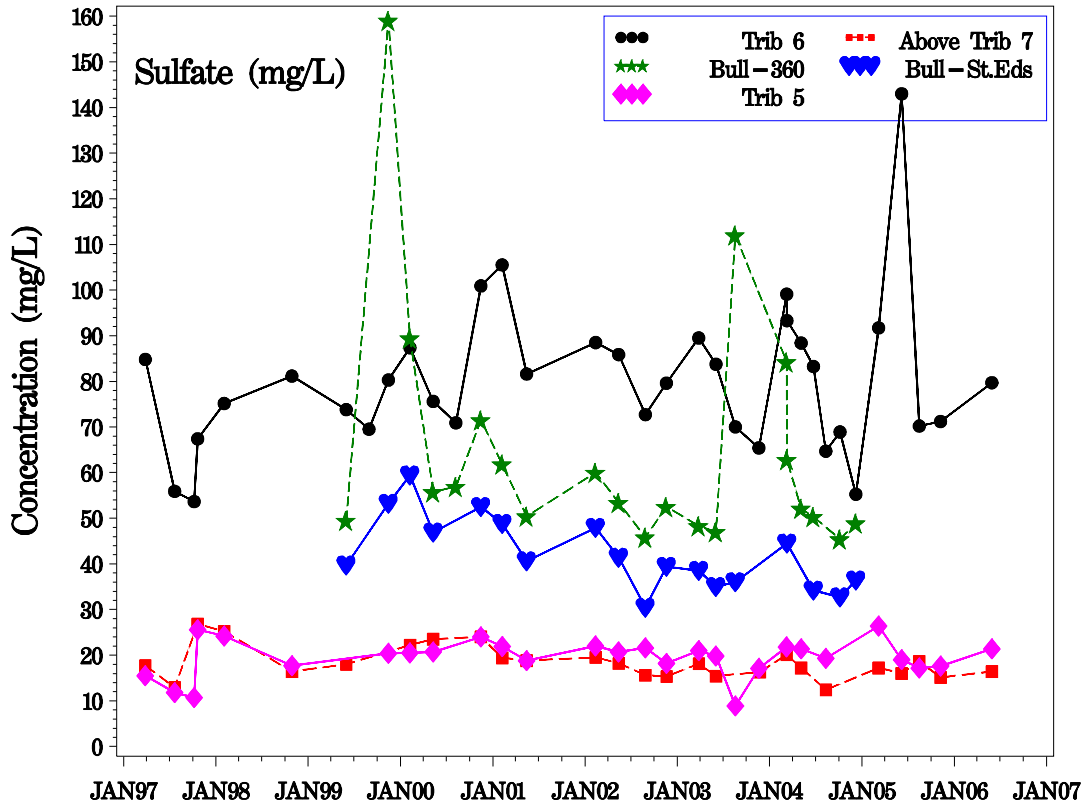




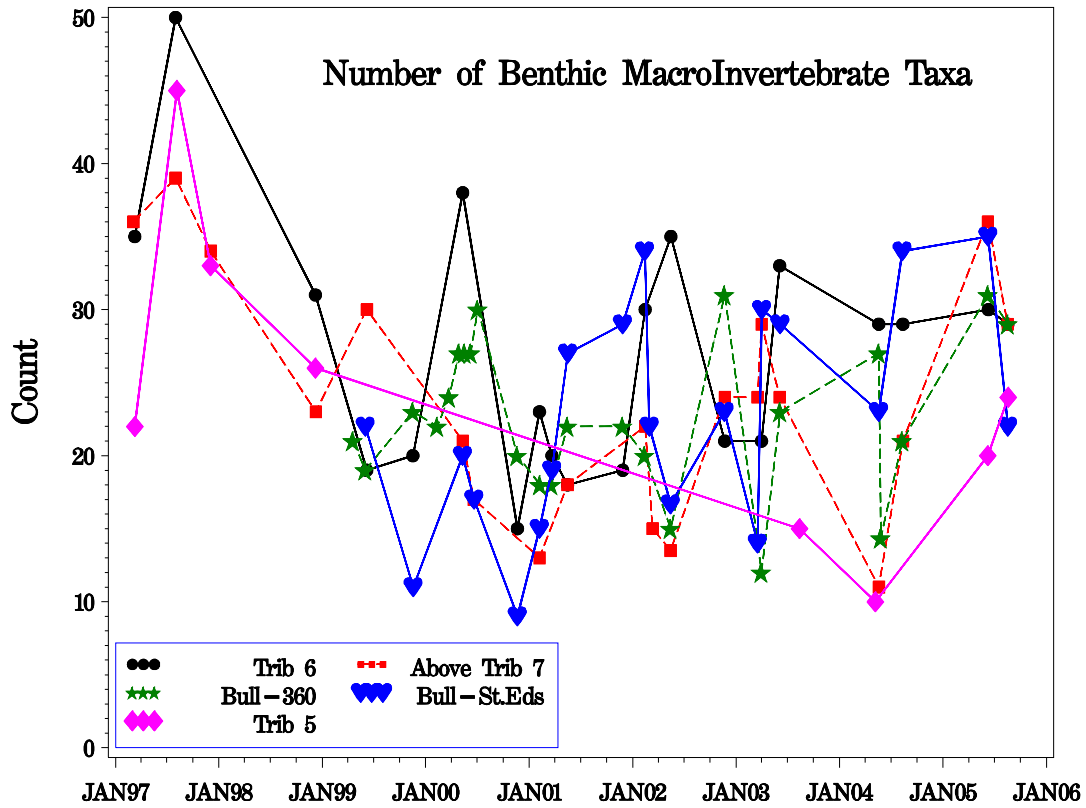


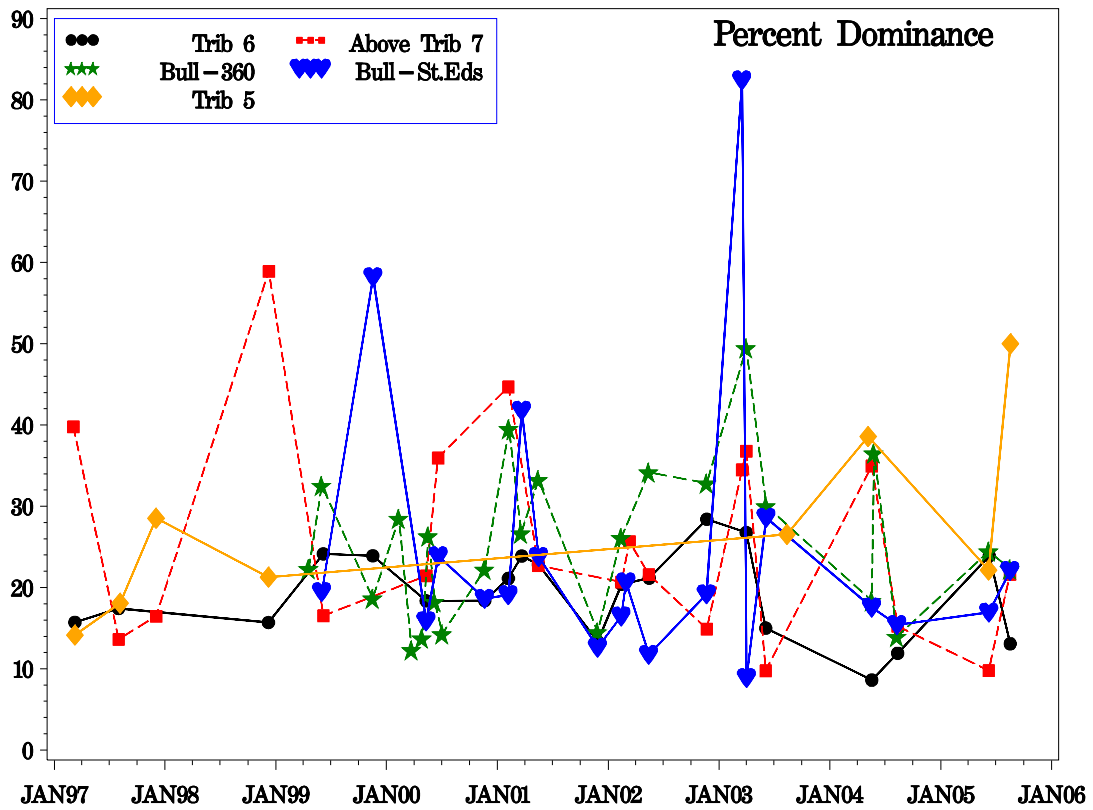
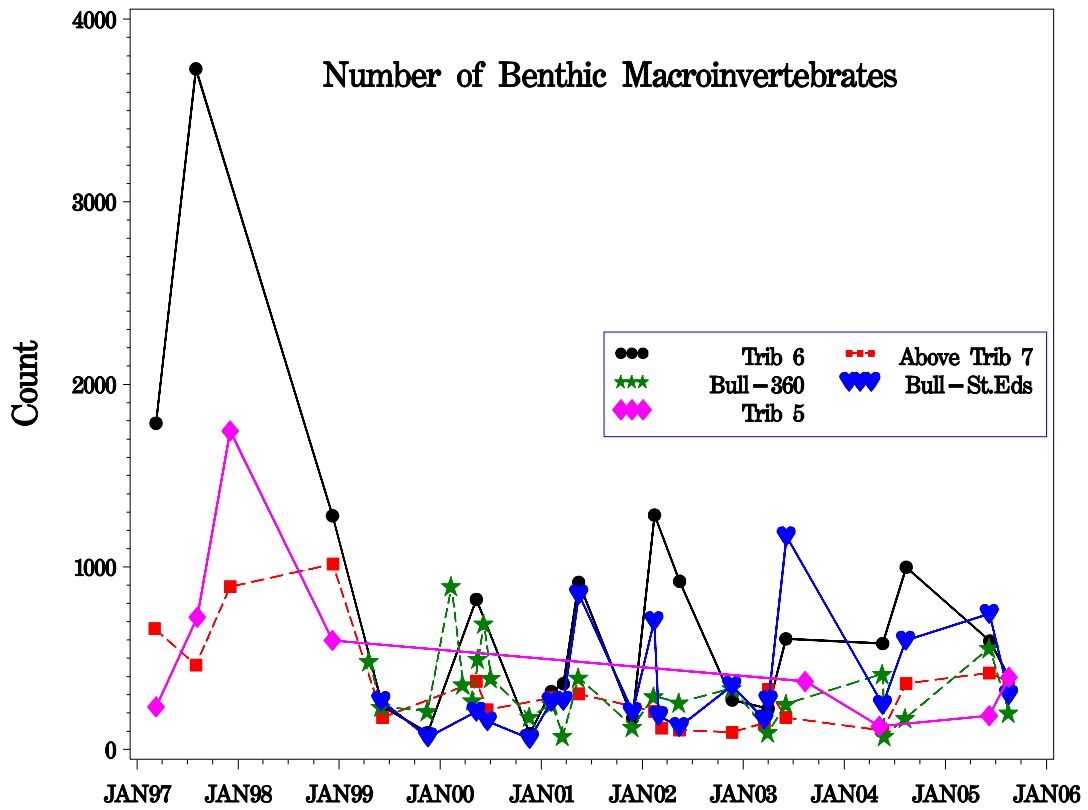
Ions

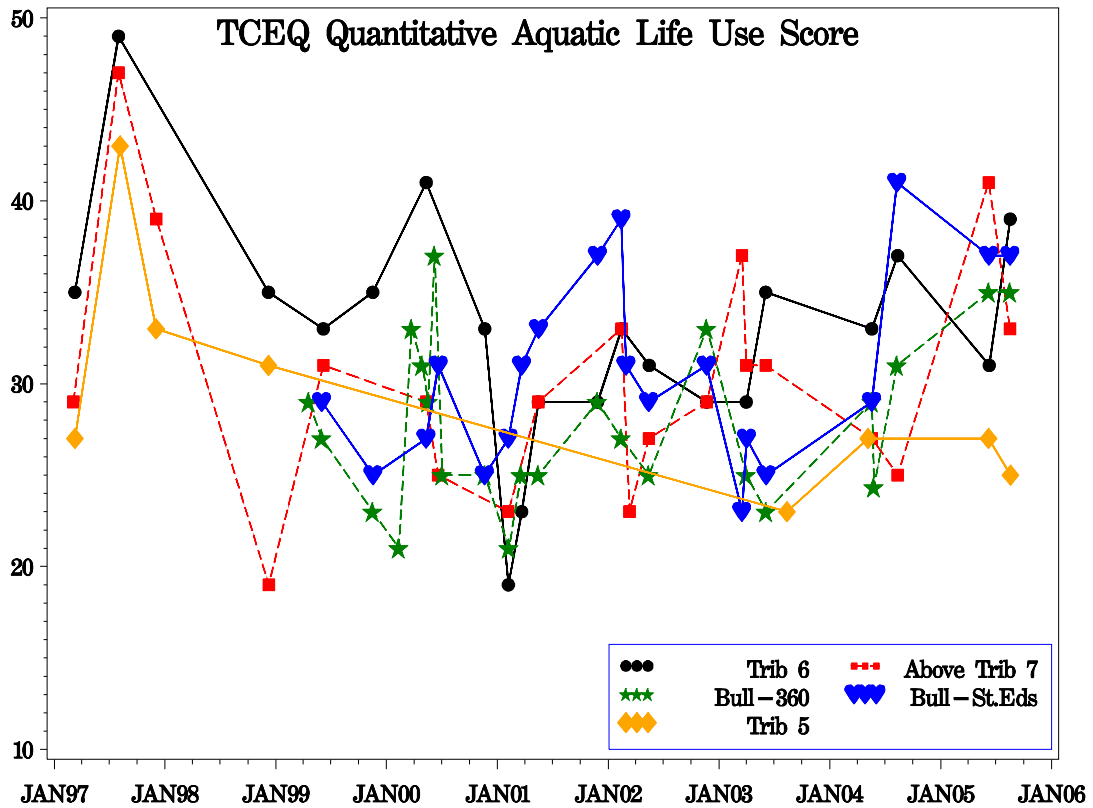
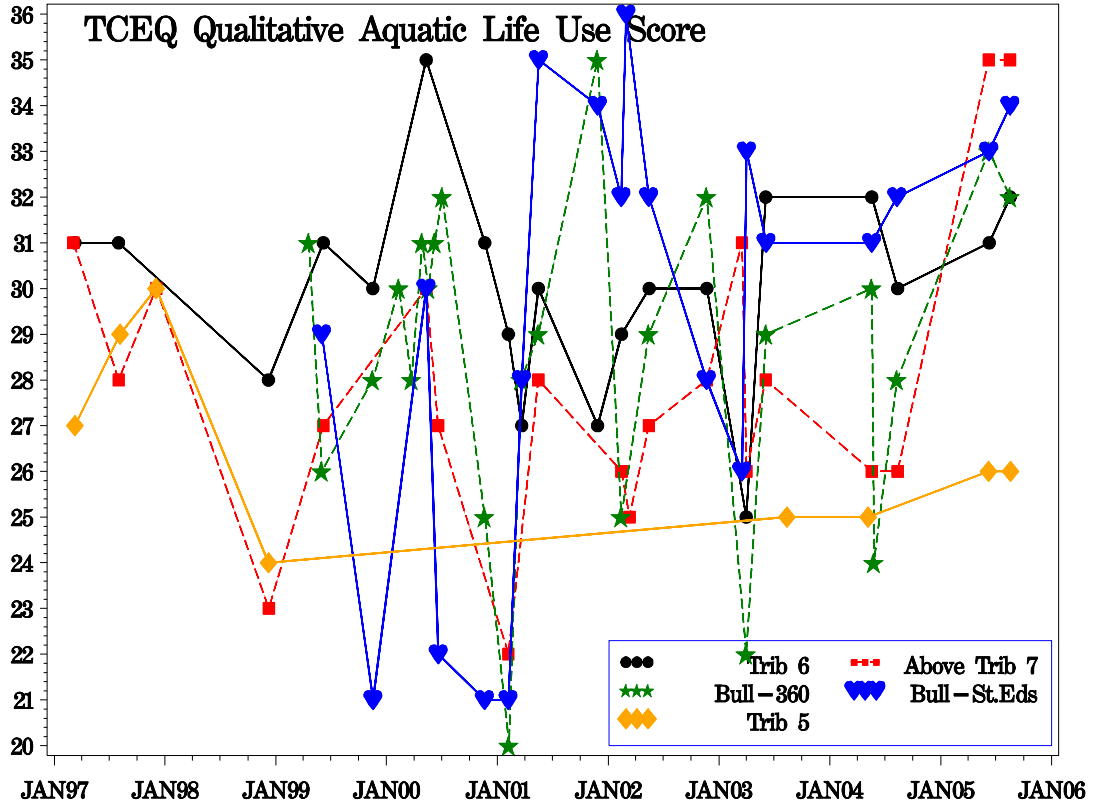




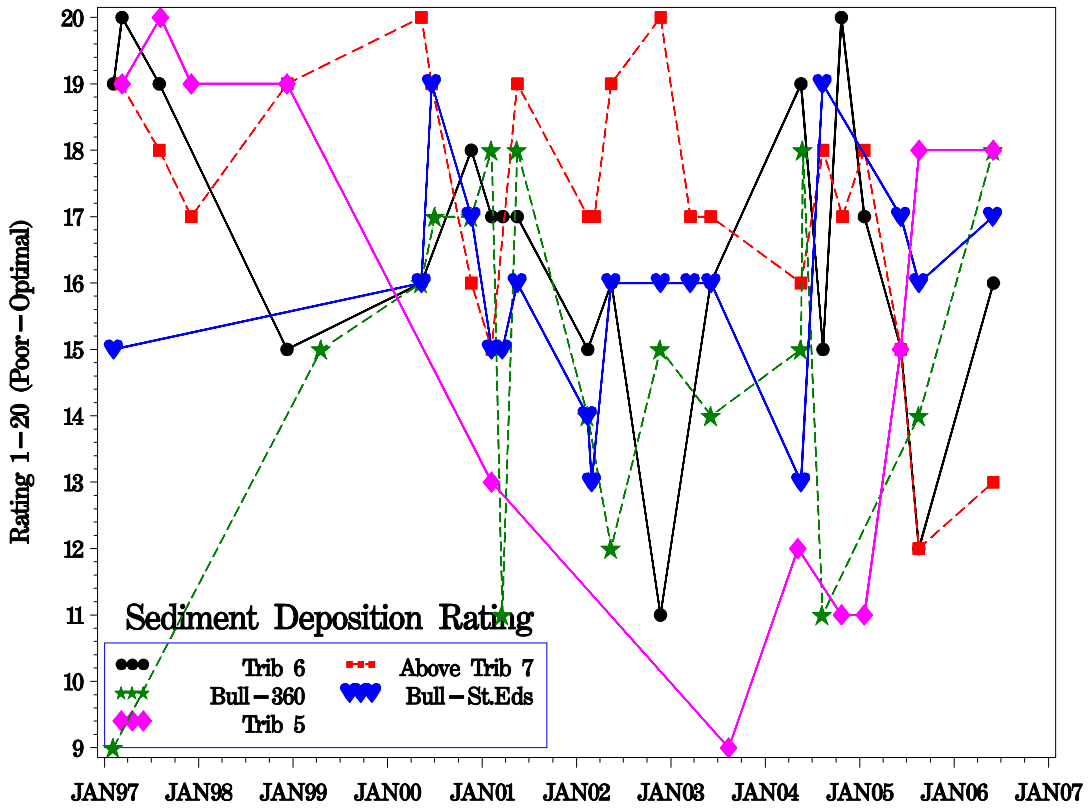
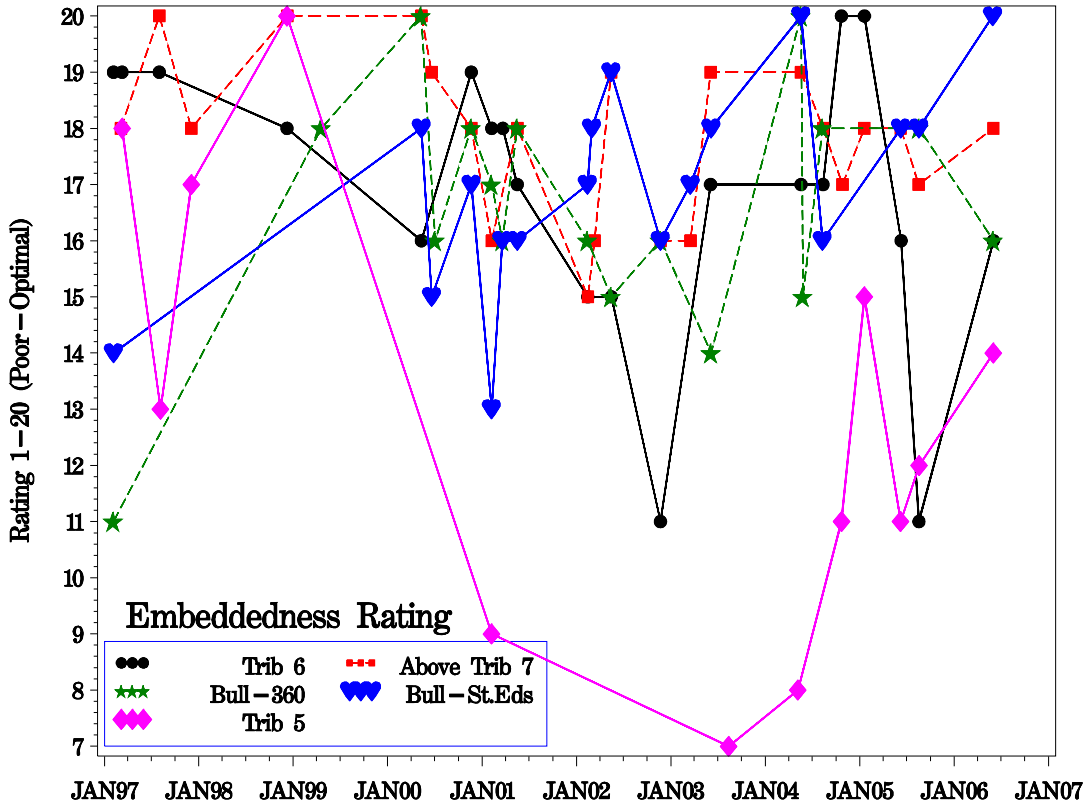
**Benthic**





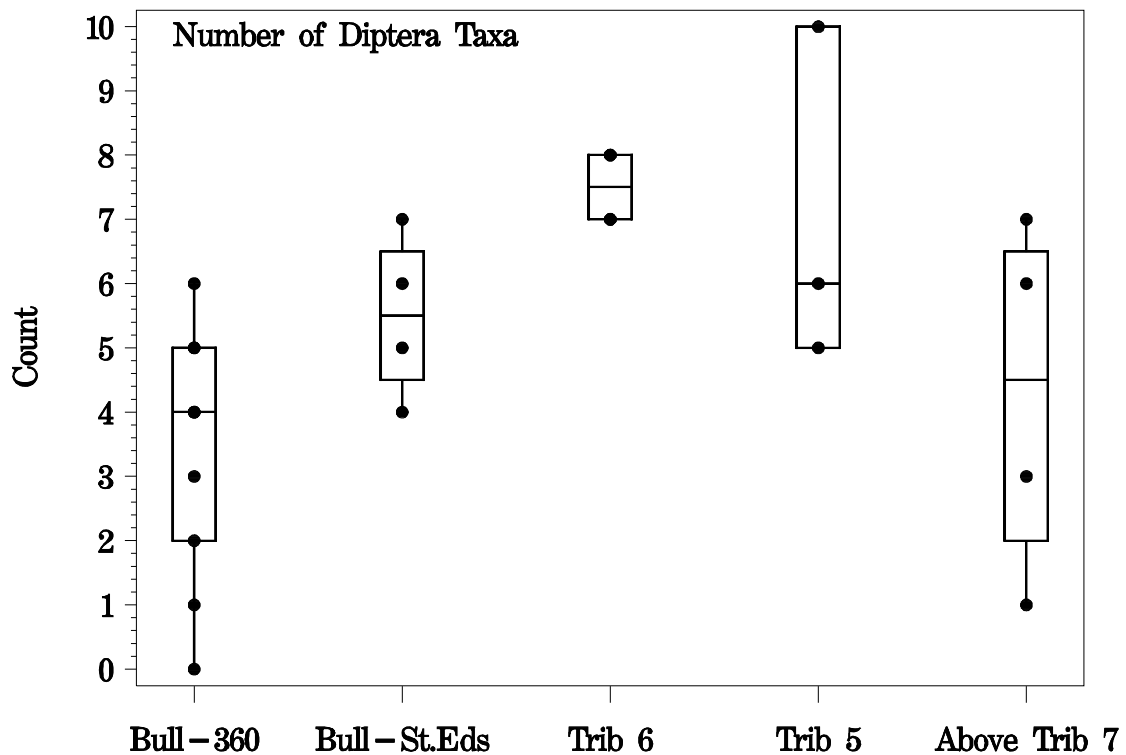


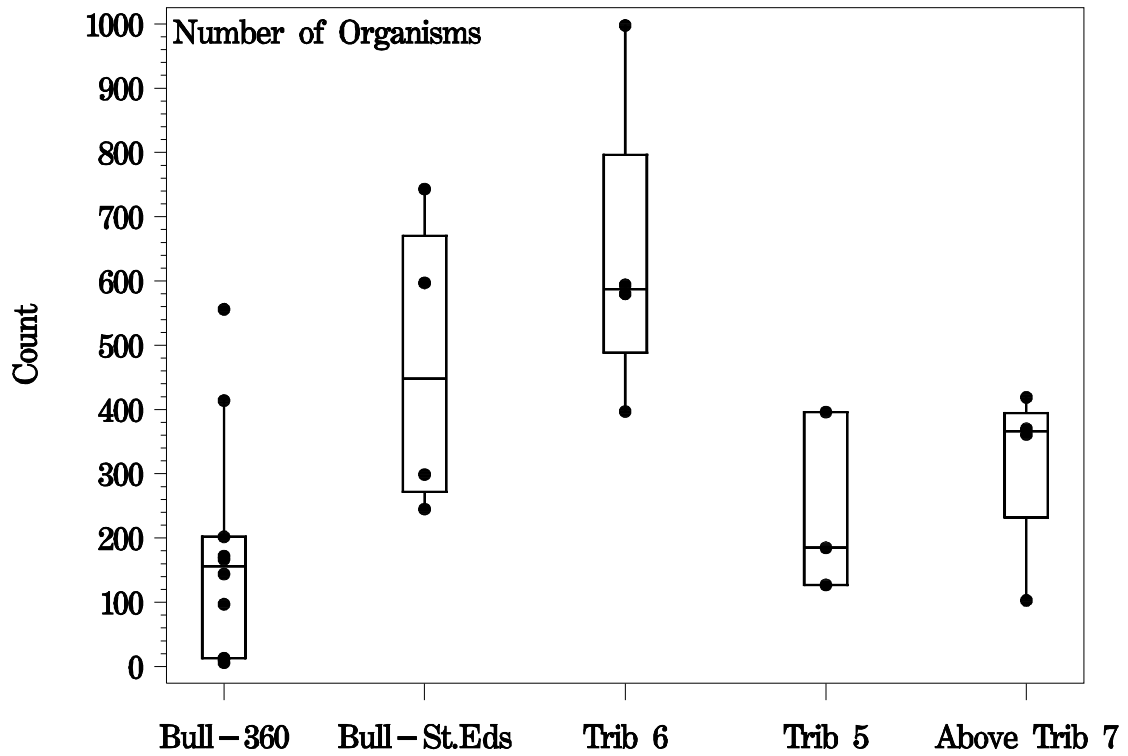
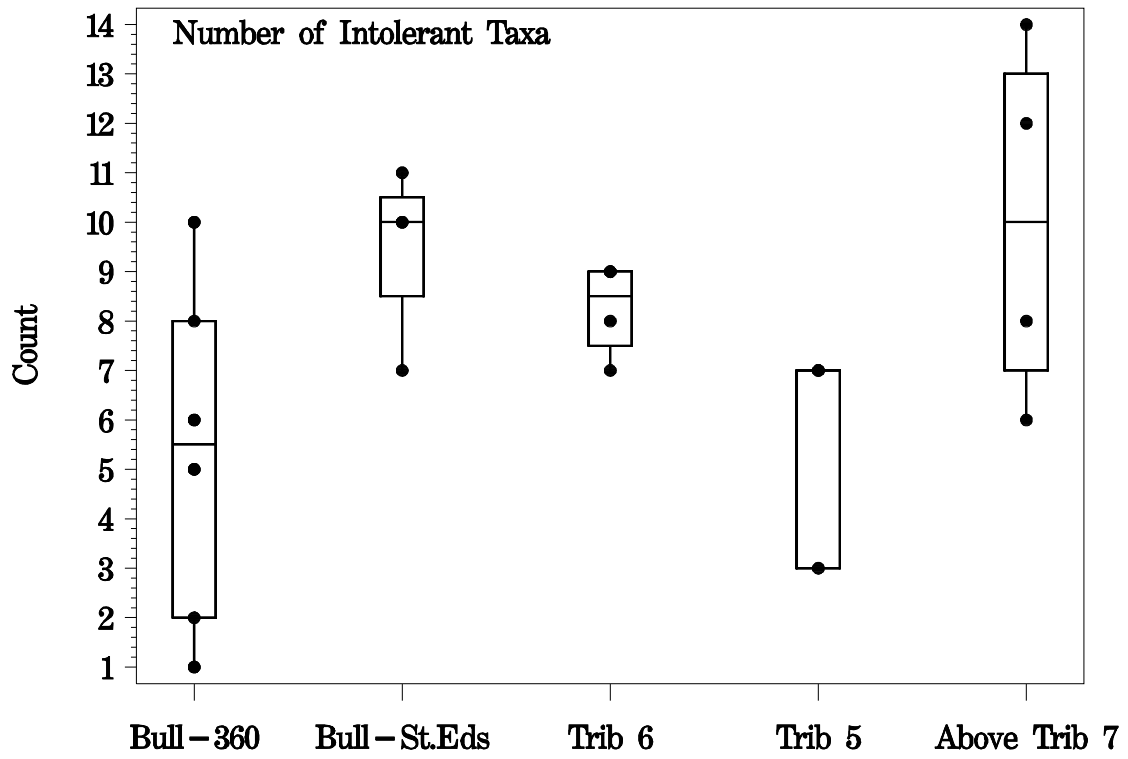
Habitat

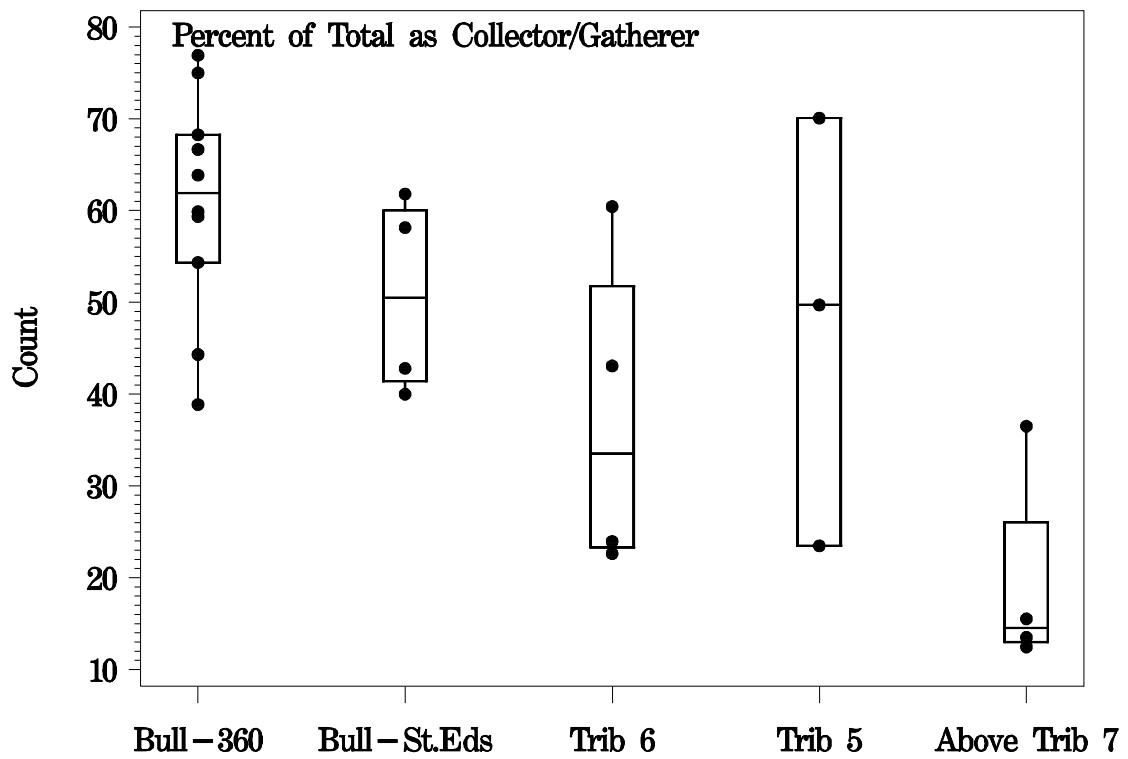
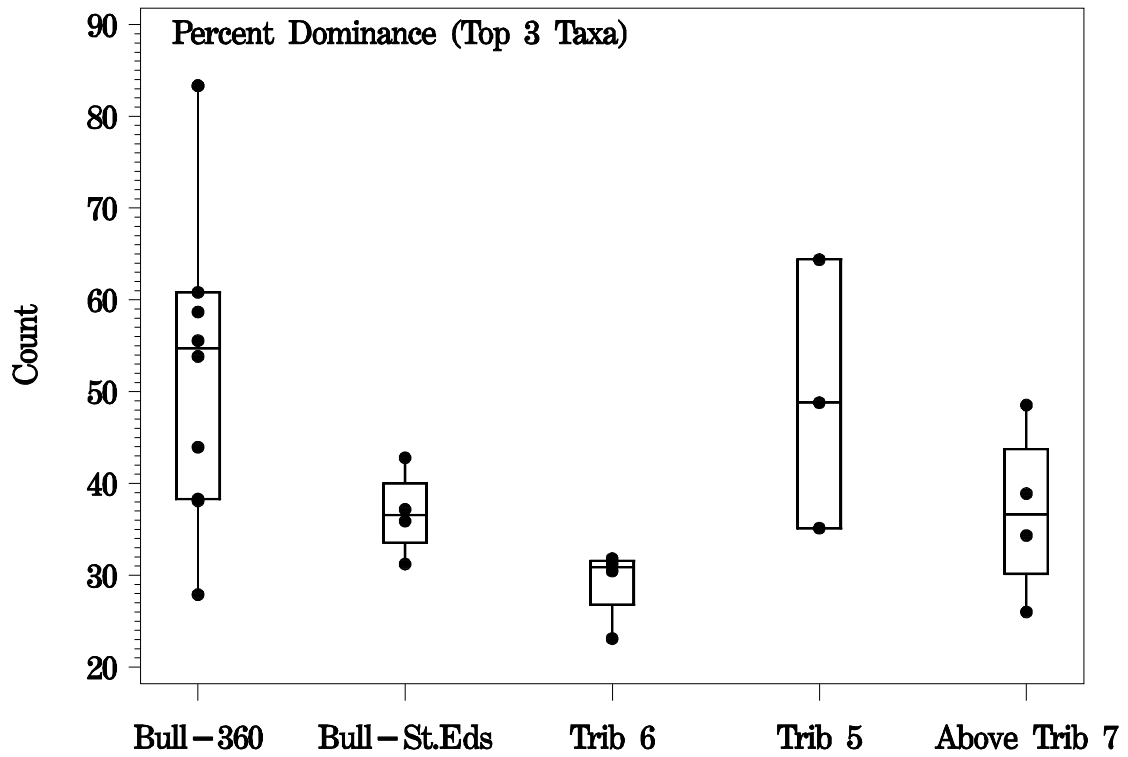


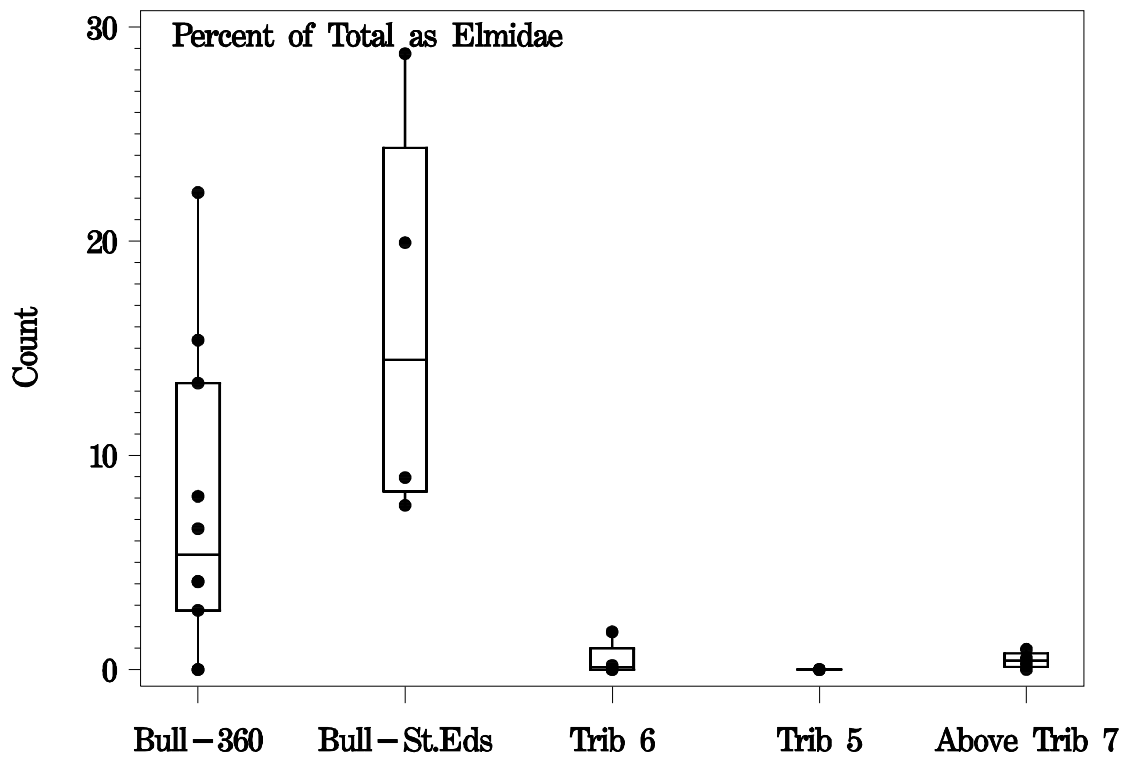
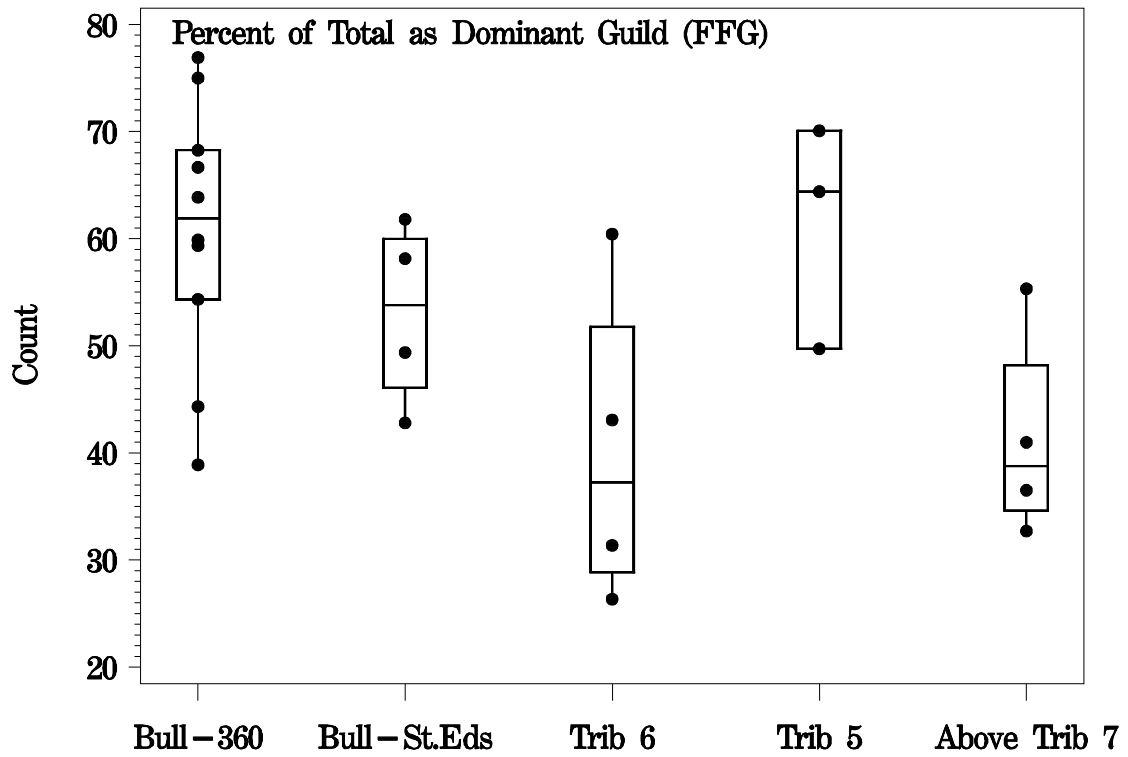
## Significant Site Differences for Benthic Macroinvertebrate Metrics for 2004 - 2007 Data

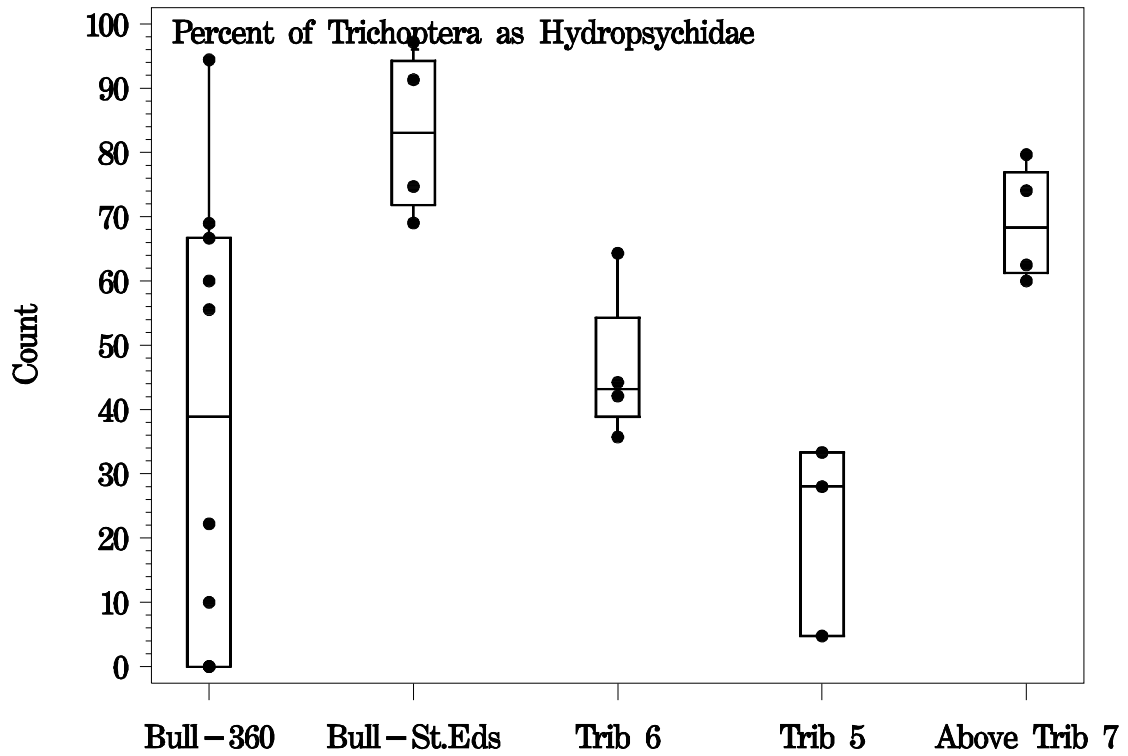
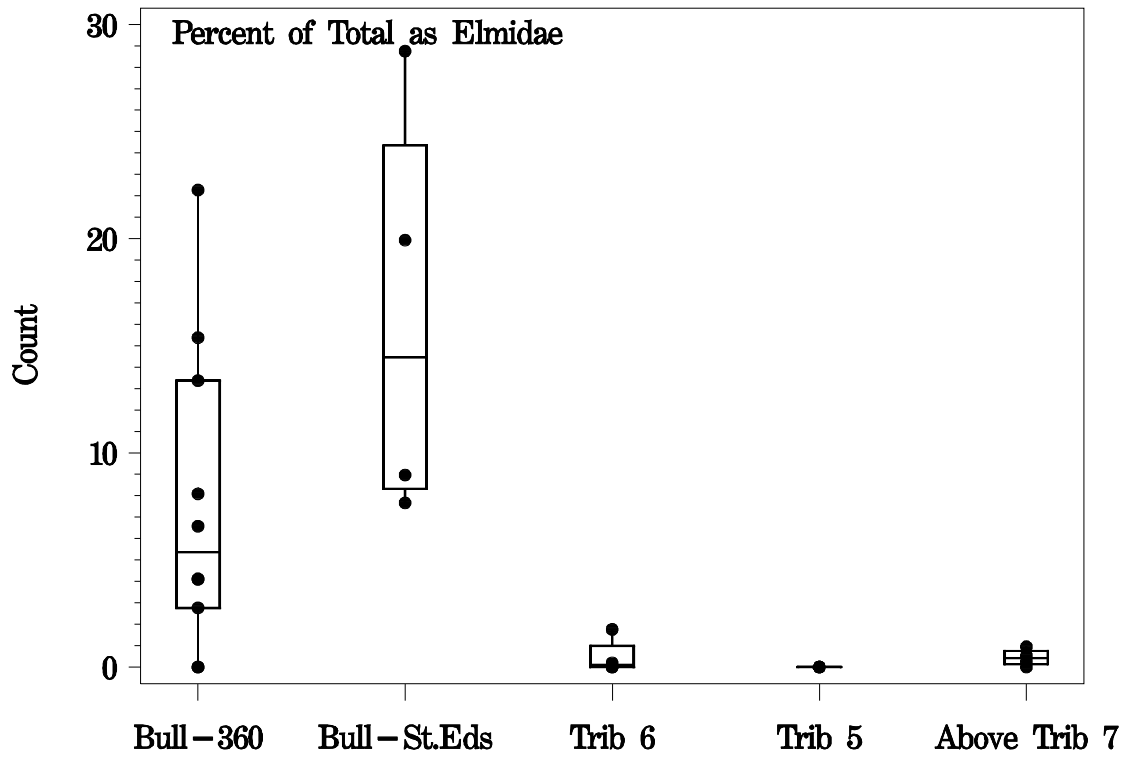
PARAMETER	UNITS	ProbF
NUMBER OF DIPTERA TAXA	None	0.0105
NUMBER OF INTOLERANT TAXA	None	0.0454
NUMBER OF ORGANISMS	None	0.0070
PERCENT DOMINANCE (TOP 3 TAXA)	(%) Percent	0.0363
PERCENT OF TOTAL AS COLLECTOR/GATHERER	(%) Percent	0.0017
PERCENT OF TOTAL AS DOMINANT GUILD (FFG)	(%) Percent	0.0232
PERCENT OF TOTAL AS ELMIDAE	(%) Percent	0.0048
PERCENT OF TOTAL AS GRAZERS (PI AND SC)	(%) Percent	0.0195
PERCENT OF TRICHOPTERA AS HYDROPSYCHIDAE	(%) Percent	0.0190
TCEQ QUANTITATIVE AQUATIC LIFE USE SCORE	None	0.0272

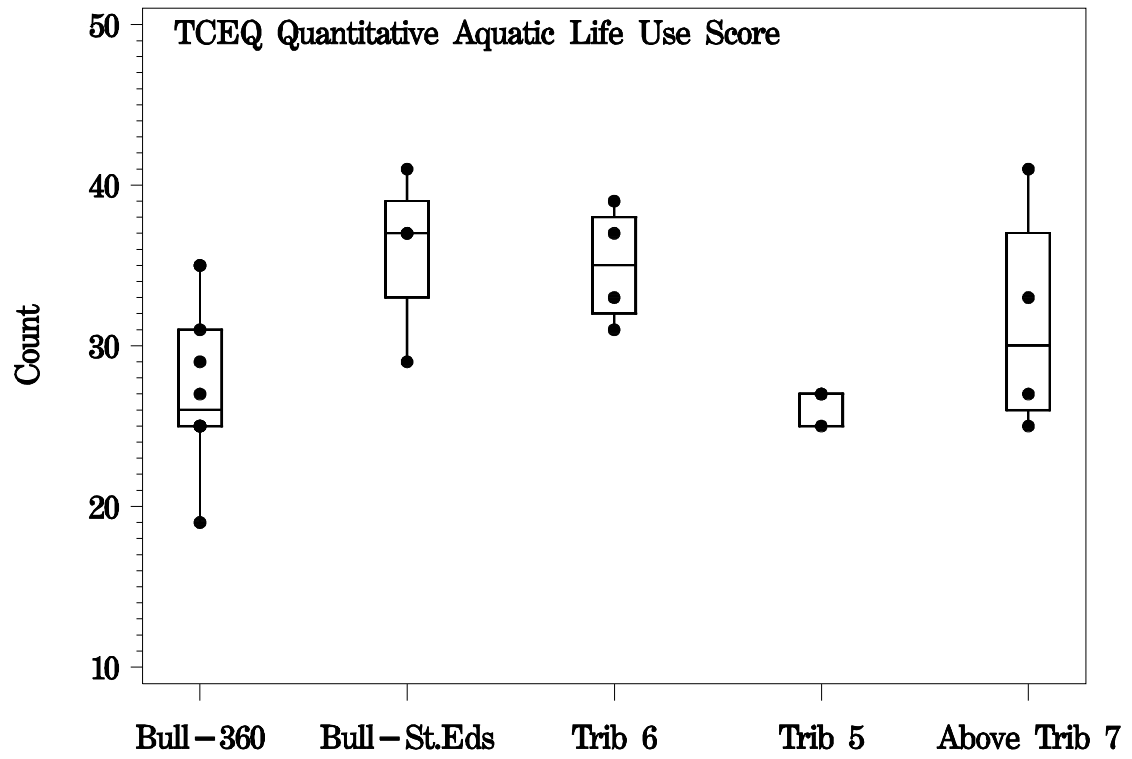












## Trends

Parameters which had significant regressions over time are listed in Table 4. For benthic macroinvertebrates only the calculated metrics were examined. For each site the parameters which were decreasing are listed first followed by those which are increasing.

**Table 4. Parameters with significant regressions over time (1997 – 2006)**

Site	Parameter Type	Parameter	UNITS	Estimate	Prob>t	Direction
Trib. 6 @ Bull Creek	Calculated Metrics	NUMBER OF EPHEMEROPTERA TAXA	None	-0.00081	0.0272	Down
	Calculated Metrics	NUMBER OF NONINSECT TAXA	None	-0.00181	0.0064	
	Nutrients	AMMONIA AS N	MG/L	-0.00002	0.0000	
	Salamanders	SALAMANDER <1 INCH	Count	-0.00029	0.0006	
	Salamanders	SALAMANDER >2 INCHES	Count	-0.00157	0.0000	
Bull Creek above Trib. 7	Major Ions	SODIUM	MG/L	0.00333	0.0440	Up
	Nutrients	NITRATE/NITRITE AS N	MG/L	0.00009	0.0207	
	Solids/Conductivity	VOLATILE SUSPENDED SOLIDS	MG/L	0.00031	0.0405	
	Calculated Metrics	PERCENT OF TOTAL AS CHIRONOMIDAE	(%) Percent	-0.00838	0.0207	Down
	Calculated Metrics	PERCENT OF TOTAL AS DOMINANT GUILD (FFG)	(%) Percent	-0.00845	0.0013	
	Calculated Metrics	PERCENT OF TOTAL AS FILTERERS	(%) Percent	-0.01592	0.0012	
	Calculated Metrics	HILSENHOFF BIOTIC INDEX	None	-0.00025	0.0235	
	Calculated Metrics	NUMBER OF ORGANISMS	None	-0.13602	0.0129	
	Habitat Evaluation	SEDIMENT DEPOSITION	Rating 1-20(Poor-Optimal)	-0.00112	0.0105	
	Major Ions	POTASSIUM	MG/L	-0.00071	0.0281	Up
	Major Ions	SULFATE	MG/L	-0.00154	0.0240	
	Nutrients	AMMONIA AS N	MG/L	-0.00002	0.0016	
	Salamanders	SALAMANDER >2 INCHES	Count	-0.00230	0.0005	
Alkalinity/Hardness/pH	ALKALINITY (AS CaCO3)	MG/L	0.01661	0.0065		
Calculated Metrics	RATIO OF INTOLERANT TO TOLERANT ORGANISMS	(%) Percent	0.00040	0.0431		
Calculated Metrics	EPT/EPT+CHIRONOMIDAE	Ratio	0.00016	0.0016		
Flow/Rainfall	FLOW VELOCITY	Feet per second	0.00197	0.0004	Up	
Salamanders	SALAMANDER 1-2 INCHES	Count	0.00198	0.0133		
Salamanders	SALAMANDER <1 INCH	Count	0.00234	0.0001		
Bull Creek @ Loop 360 First Crossing	Calculated Metrics	PERCENT OF TOTAL AS FILTERERS	(%) Percent	-0.01843	0.0002	Down
	Calculated Metrics	NUMBER OF ORGANISMS	None	-0.10258	0.0361	
	Solids/Conductivity	VOLATILE SUSPENDED SOLIDS	MG/L	-0.00574	0.0086	
	Alkalinity/Hardness/pH	PH	Standard units	0.00007	0.0367	

	Calculated Metrics	PERCENT OF TOTAL AS COLLECTOR/GATHERER	(%) Percent	0.01624	0.0005		
Bull Creek @ St. Edwards Park above Pool	Calculated Metrics	HILSENHOFF BIOTIC INDEX	None	-0.00043	0.0074	Down	
	Major Ions	CHLORIDE	MG/L	-0.00869	0.0066		
	Major Ions	SULFATE	MG/L	-0.00788	0.0024		
	Nutrients	NITRATE/NITRITE AS N	MG/L	-0.00026	0.0011		
	Calculated Metrics	PERCENT OF TOTAL AS EPT	(%) Percent	0.01687	0.0084	Up	
	Calculated Metrics	NUMBER OF DIPTERA TAXA	None	0.00138	0.0285		
	Calculated Metrics	NUMBER OF INTOLERANT TAXA	None	0.00236	0.0089		
	Calculated Metrics	NUMBER OF TAXON	None	0.00584	0.0255		
	Calculated Metrics	TCEQ QUALITATIVE AQUATIC LIFE USE SCORE	None	0.00388	0.0184		
	Habitat Evaluation	EMBEDDEDNESS	Rating 1-20(Poor-Optimal)	0.00146	0.0036		
	Solids/Conductivity	TOTAL SUSPENDED SOLIDS	MG/L	0.00115	0.0365		
	Trib. 5 below Hanks Tract Property Line	Calculated Metrics	NUMBER OF EPHEMEROPTERA TAXA	None	-0.00106	0.0017	Down
		Calculated Metrics	NUMBER OF EPT TAXA	None	-0.00238	0.0214	
Calculated Metrics		NUMBER OF NONINSECT TAXA	None	-0.00174	0.0254		
Nutrients		AMMONIA AS N	MG/L	-0.00002	0.0029		
Salamanders		SALAMANDER 1-2 INCHES	Count	-0.00090	0.0000		
Salamanders		SALAMANDER <1 INCH	Count	-0.00030	0.0159		
Salamanders		SALAMANDER >2 INCHES	Count	-0.00194	0.0000		
Solids/Conductivity		TOTAL SUSPENDED SOLIDS	MG/L	-0.00091	0.0171		
Clarity		TURBIDITY	NTU	0.00096	0.0491	Up	
Flow/Rainfall		FLOW VELOCITY	Feet per second	0.00082	0.0493		
Habitat Evaluation		LEAF LITTER	(%) Percent	0.00651	0.0002		
Major Ions		SODIUM	MG/L	0.00157	0.0000		
Solids/Conductivity		CONDUCTIVITY	uS/cm	0.00607	0.0091		

## SITE DESCRIPTIONS

### Tributary 6 (WPD#151)

The site monitored on Tributary 6 is located on the COAs BCCP property known as the Hanks Tract and is upstream of the confluence with Tributary 5. This tributary flows through the Spicewood at Balcones, Balcones Village, Spicewood Estates and Estates of Brentwood subdivisions and the Balcones Country Club Golf Course is included in the upper two thirds of the drainage area. Although the majority of the tributary is surrounded by residential neighborhoods, the BCCP preserve land buffers the lower third. Impervious cover is greater than 15%, therefore the site is classified as developed, or urban (1995 estimate of 16.2 % impervious cover with an increase to 24.8% in 2003). This site is located in known Jollyville Plateau salamander habitat.

### Tributary 5 (WPD#1164)

Tributary 5 is also located on BCCP property on Hanks tract. Tributary 5. (DUDB # 1164) flows through the Canyon Creek residential neighborhood, although there is a wide rural area (buffer) from the neighborhood to the creek. Impervious cover was estimated at less than 4.8% in 1995 and it was classified as undeveloped or rural. The impervious cover has increased ( according to the most recent data) to 19.2% in 2003 and is now classified as urban or developed. The site that is monitored is upstream of the confluence with Tributary 6. This site was previously described as known Jollyville salamander habitat.

### Bull Creek above Tributary 7 (WPD#349)

Bull Creek above Tributary 7 is a mainstem site located in the COAs BCCP property known as the Franklin Tract. Although this is a mainstem site, it has all the characteristics of the Canyon sites, a small, shady, spring fed, low flow canyon with a large riparian buffer, for comparisons in this report, it will be included in the Canyon sites. The site monitored is upstream of the confluence with Tributary 7, downstream of the confluence with Tributary 8 and directly adjacent to where Pit Spring discharges. Impervious cover is less than 15% and the site is classified as rural (undeveloped, 3.3% impervious cover in 1995 increase to 13.61% in 2003) This site is located in known Jollyville Plateau salamander habitat.

### Bull Creek at Loop 360 (WPD#350)

This site is located downstream of the first Loop 360 crossing in the mainstem of Bull Creek and consists mainly of large areas of bedrock substrate with gullies and cobble deposits. The site does not support a large in-stream vegetated area. The banks of Bull Creek in this area are constructed cement skirts from the Loop 360 roadway and some flat, previously disturbed vegetated areas,. Directly upstream of the Loop 360 site is greenbelt. This site is classified as urban. Impervious cover in the subwatershed has increased from 18.8% in 1995 to 21.94 % in 2003.

### Bull Creek at St. Edwards Park (WPD#920)

The site is located in the mainstem of Bull Creek in St. Edwards Park on Spicewood Springs Road, west of Loop 360 in Northwest Austin. One fourth of a mile upstream of the park dam and one fourth of a mile downstream of the low water crossing on Spicewood Springs Road. The site includes a large braided riffle with islands, bedrock and cobble deposits. A large amount of the filamentous algae *Chara* is usually present, mixed with other aquatic vegetation (*Nitella*, *Justicia americana*) at the site. The park consists of a large riparian buffer with native and non-native trees and shrubs, and fields of wildflowers. This site

supports large populations of butterflies, dragonflies and damselflies in addition to a large population of fish and amphibians. 1995 impervious cover estimates of 3.3% in the subwatershed contributed to the rural characteristics of this site. The 2003 impervious cover estimates are 18.87%, changing the classification of this subwatershed to urban or developed.

## RESULTS

### Tributary 6 (DB #151)

As is illustrated in the previous graphs Tributary 6 has higher conductivity, chloride, sodium and sulfate concentrations (Figures xxx) than all other sites monitored on Bull Creek. The site has a significant temporal increase in sodium. The site appears to have higher, more variable, significantly increasing Nitrate/Nitrite as N concentrations (Figure x) than other sites on Bull Creek. Several large cladophora blooms have been documented as originating from this tributary, with the most recent being in 2007. These blooms could be attributed to the higher nutrient concentrations. Volatile suspended solids show a significant increase through 2003, however, monitoring of this parameter has not been conducted since. Significant temporal decreases in salamander populations (larvae and large adults) are noted for the time period 1997-2006, along with decreases in the sensitive Ephemeroptera taxa and noninsect taxa. (Table 4). These changes may be attributed to decreasing water quality and algae blooms.

### Tributary 5 (#1164)

Significant temporal increases in flow, turbidity, conductivity and sodium, accompanied by significant temporal decreases in the sensitive Ephemeroptera, Plecoptera and Trichoptera taxa and decimation of the salamander populations (larvae, juvenile and adults) are evident at this site. In addition, significant temporal decreases in embeddedness and sediment deposition habitat scores were evident through 2005, with improvement noted but not significant from 2006-2007. Increasing impervious cover (1995 -4.8% to 2003 – 19.2%) along with construction accidents and inadequate (or failures of) best management practices (BMP) during this time period were at least partially responsible. This increase in ions, decrease in viable habitat and decrease in biological productivity has removed this site from the excellent category, and we can no longer refer to this site as a reference for comparison purposes.

### Bull Creek Above Tributary 7 (#349)

A significant increase in flow and alkalinity are noted at this site, although no alkalinity measurements are recorded after 2003. A significant increase in the salamander population both in larvae and juveniles has occurred since 1997, along with an improvement in Hilsenhoff Biological Index Scores. Although the large adult salamander population, number of macroinvertebrate filterers and number of benthic organisms has shown a decrease, this site continues to be the home of the largest known population of Jollyville salamanders (*Eurycea Tonkawa*) and an abundant diverse population of macroinvertebrates. Excellent habitat scores, along with excellent water quality and abundant spring flow from Pit Spring continue to sustain the excellent biological diversity at this site. This site continues to be known as reference for water quality and biological life for the entire City of Austin.

#### Bull Creek At St. Edwards Park (#920)

Although embeddedness and total suspended solids have shown a significant temporal increase, over this same time period, calculated biological metrics have shown an improvement, with numbers of taxa, intolerant taxa, diptera, percent of total as Ephemeroptera, Plecoptera and Trichoptera, TCEQ Qualitative life use score all showing significant increases. An improvement in the Hilsonhoff Biological Index is also evident over this time period at this site.

#### Bull Creek at Loop 360 (#350)

Bull Creek at Loop 360 is the most downstream site that is monitored. There are minimal observable changes in water quality and biological life. The number of organisms collected has decreased over this time period, along with the number of filterers. pH and volatile suspended solids (no data since 2003) have shown significant temporal increases. These are trends that should be monitored as continuation of these increases and decreases could be cause for alarm.

## Appendix A

Table 1. Parameters

PARAMATER TYPE	PARAMETER
<b>Alkalinity/Hardness/pH</b>	ALKALINITY (AS CaCO <sub>3</sub> ) PH
<b>Bacteria/Pathogens</b>	E COLI BACTERIA FECAL COLIFORM BACTERIA
<b>Benthic Macroinvertebrates</b>	ANCYLIDAE ARGIA ARGIA IMMUNDA ARGIA MOESTA ARGIA TRANSLATA BAETODES BEROSUS (LARVAE) BEZZIA (PALPOMYIA) BRECHMORHOGA MENDAX CAENIS CALOPARYPHUS CAMELOBAETIDIUS CHEUMATOPSYCHE CHIMARRA CHIRONOMIDAE CHIRONOMINAE CHIRONOMUS CINCINNATIA CINCINNATIENSIS COLLEMBOLA CORBICULA FLUMINEA CORYDALUS CURCULIONIDAE DASYHELEA DUGESIA TIGRINA EMPIDIDAE ENALLAGMA EPITHECA (EPICORDULIA) PRINCEPS ERPETOGOMPHUS EUPARYPHUS FALLCEON QUILLERI FERRISSIA GYRAULUS HELICHUS HELICOPSYCHE HELISOMA ANCEPS HEMERODROMIA HETAERINA HOLORUSIA HYALLELA HYALLELA AZTECA HYDATICUS HYDRACARINA (ACARI)

HYDROCHARA  
 HYDROPTILA  
 LESTES  
 LIBELLULA  
 MACRELMIS  
 MACROVELIA  
 MARILIA  
 MAYATRICHIA  
 METRICHIA  
 METROBATES  
 MICROCYLLOEPUS PUSILLUS  
 NECTOPSYCHE  
 NEOCHOROTERPES  
 NEOCYLLOEPUS  
 NEOELMIS CAESA  
 NEOTRICHIA  
 NEUROCORDULIA  
 OCHROTRICHIA  
 OECETIS  
 OLIGOCHAETA  
 ORTHOCLADIINAE  
 OSTRACODA  
 OXYCERA  
 PERITHEMIS  
 PETROPHILA (MOTH LARVAE)  
 PHYLLOICUS ORNATUS  
 PHYSA (PHYSELLA)  
 POLYCENTROPUS  
 PSEPHENUS  
 RHAGOVELIA  
 SALDA  
 SALDIDAE  
 SIMULIUM  
 SMICRIDEA  
 STENELMIS  
 STENONEMA  
 SURAGINA CONCINNA  
 TABANUS  
 TANYPODINAE  
 TANYTARSINI  
 TIPULA  
 TRICORYTHODES  
 VACUPERNIUS PACKERI  
 XIPHOCENTRON

**Calculated Metrics**

EPT/EPT+CHIRONOMIDAE  
 HILSENHOFF BIOTIC INDEX  
 NUMBER OF DIPTERA TAXA  
 NUMBER OF EPHEMEROPTERA TAXA  
 NUMBER OF EPT TAXA  
 NUMBER OF INTOLERANT TAXA

	NUMBER OF NONINSECT TAXA NUMBER OF ORGANISMS NUMBER OF SURBERS NUMBER OF TAXON PERCENT DOMINANCE (TOP 1 TAXA) PERCENT DOMINANCE (TOP 3 TAXA) PERCENT OF TOTAL AS CHIRONOMIDAE PERCENT OF TOTAL AS COLLECTOR/GATHERER PERCENT OF TOTAL AS DOMINANT GUILD (FFG) PERCENT OF TOTAL AS ELMIDAE PERCENT OF TOTAL AS EPT PERCENT OF TOTAL AS FILTERERS PERCENT OF TOTAL AS GRAZERS (PI AND SC) PERCENT OF TOTAL AS PREDATOR PERCENT OF TOTAL AS TOLERANT ORGANISMS PERCENT OF TRICHOPTERA AS HYDROPSYCHIDAE RATIO OF INTOLERANT TO TOLERANT ORGANISMS TCEQ QUALITATIVE AQUATIC LIFE USE SCORE TCEQ QUANTITATIVE AQUATIC LIFE USE SCORE
<b>Channel Assessment</b>	AVERAGE BANK FULL WIDTH AVERAGE STREAM DEPTH AVERAGE STREAM WIDTH CANOPY COVER CENTER CANOPY COVER LEFT BANK CANOPY COVER RIGHT BANK LEFT BANK ANGLE LEFT BANK SIZE CLASS RIGHT BANK ANGLE RIGHT BANK SIZE CLASS STREAMBED SLOPE THALWAG DEPTH (WET) TOTAL WETTED WIDTH WOODY DEBRIS
<b>Clarity</b>	TURBIDITY
<b>Environmental Conditions</b>	WATER TEMPERATURE
<b>Flow/Rainfall</b>	BASEFLOW FLOW  FLOW SEVERITY CODE (1=NONE;2=LOW;3=NORM;4=FLOOD;5=HIGH;6=DRY)
<b>Grain Size/Substrate Characterization</b>	BEDROCK BOULDER (>180MM) COARSE GRAVEL (<22.6MM) COARSE GRAVEL (<32MM) FINE GRAVEL (<8MM) LARGE COBBLE (<180MM) MEDIUM GRAVEL (<11MM) MEDIUM GRAVEL (<16MM) SAND (1/16-2MM) SAND (< 2MM)

SILT (<1/16MM)  
SMALL COBBLE (<128MM)  
SMALL COBBLE (<90MM)  
VERY COARSE GRAVEL (<45MM)  
VERY COARSE GRAVEL (<64MM)  
VERY FINE GRAVEL (< 2.8 MM)  
VERY FINE GRAVEL (<4MM)

**Habitat Evaluation**

ACTIVE CHANNEL WIDTH  
AESTHETICS CODE (1=WILD;2=NAT.;3=COMM.;4=OFF.)  
AVERAGE BANK EROSION POTENTIAL  
AVERAGE BUFFER VEGETATION WIDTH  
AVERAGE SUBSTRATE GRAVEL OR LARGER  
BANK FULL THALWAG DEPTH  
BANK STABILITY (LEFT BANK)  
BANK STABILITY (RIGHT BANK)  
BEDROCK LEDGES  
BIOLOGICAL UNITS (POOLS)  
BIOLOGICAL UNITS (RIFFLES)  
BIOLOGICAL UNITS (RUNS)  
BOULDER (>300 MM)  
CANOPY (>5M) LEFT BANK VEG TYPE  
CANOPY (>5M) RIGHT BANK VEG TYPE  
CANOPY (>5M) WIDTH LEFT BANK  
CANOPY (>5M) WIDTH RIGHT BANK  
CANOPY COVER  
CANOPY COVER DOWNSTREAM  
CANOPY COVER UPSTREAM  
CANOPY LEFT BANK BIG DIAM (<0.3M)  
CANOPY LEFT BANK SMALL DIAM (<0.3M)  
CANOPY RIGHT BANK BIG DIAM (>0.3M)  
CANOPY RIGHT BANK SMALL DIAM (<0.3M)  
CHANNEL ALTERATION  
CHANNEL FLOW STATUS  
COBBLE (64-300 MM)  
COBBLE AND BOULDER INSTREAM COVER  
COURSE GRAVEL (15-64 MM)  
DEPTH AT 25 PERCENT OF CHANNEL  
DEPTH AT 50 PERCENT OF CHANNEL  
DEPTH AT 75 PERCENT OF CHANNEL  
DISTANCE FROM LEFT BANK TO THALWAG AT BANK FULL  
DISTANCE TO LEFT BANK (25 PERCENT OF CHANNEL)  
DISTANCE TO LEFT BANK (50 PERCENT OF CHANNEL)  
DISTANCE TO LEFT BANK (75 PERCENT OF CHANNEL)  
DOMINANT SUBSTRATE TYPE  
EMBEDDEDNESS  
EPIFAUNAL SUBSTRATE  
EROSION POTENTIAL LEFT BANK SCORE  
EROSION POTENTIAL RIGHT BANK SCORE  
FINE GRAVEL (2-15 MM)  
FREQUENCY OF RIFFLES

GROUND COVER LEFT BANK NON-WOOD HERBS/GRASSES (<0.5M)  
GROUND COVER LEFT BANK STABLE (<0.5M)  
GROUND COVER LEFT BANK WOODY SHRUBS/SAPLINGS (<0.5M)  
GROUND COVER RIGHT BANK NON-WOOD HERBS/GRASSES (<0.5M)  
GROUND COVER RIGHT BANK STABLE (<0.5M)  
GROUND COVER RIGHT BANK WOODY SHRUBS/SAPLINGS (<0.5M)  
HABITAT TYPE (1=RIFFLER,2=RUN,3=POOL)  
HYPOTENUSE ANGLE  
INSTREAM COVER  
LARGE WOODY DEBRIS  
LEAF LITTER  
LENGTH OF REACH  
MACROPHYTE OR ALGAE COVER  
MEAS 1 DOM SIZE CLASS  
(1=SILT;2=LEAF;3=GRAVEL;4=COBBLE;5=BEDROCK;6=BOULDER)  
MEAS 2 DOM SIZE CLASS  
(1=SILT;2=LEAF;3=GRAVEL;4=COBBLE;5=BEDROCK;6=BOULDER)  
  
MEAS 3 DOM SIZE CLASS (1=SILT;2=LEAF;3=GRAVEL;4=COBBLE;5=BEDROCK)  
  
MEAS 4 DOM SIZE CLASS (1=SILT;2=LEAF;3=GRAVEL;4=COBBLE;5=BEDROCK)  
  
MEAS 5 DOM SIZE CLASS (1=SILT;2=LEAF;3=GRAVEL;4=COBBLE;5=BEDROCK)  
MEASUREMENT #1 DEPTH  
MEASUREMENT #1 DISTANCE TO LEFT BANK  
MEASUREMENT #10 DEPTH  
MEASUREMENT #10 DISTANCE TO LEFT BANK  
MEASUREMENT #11 DEPTH  
MEASUREMENT #11 DISTANCE TO LEFT BANK  
MEASUREMENT #2 DEPTH  
MEASUREMENT #2 DISTANCE TO LEFT BANK  
MEASUREMENT #3 DEPTH  
MEASUREMENT #3 DISTANCE TO LEFT BANK  
MEASUREMENT #4 DEPTH  
MEASUREMENT #4 DISTANCE TO LEFT BANK  
MEASUREMENT #5 DEPTH  
MEASUREMENT #5 DISTANCE TO LEFT BANK  
MEASUREMENT #6 DEPTH  
MEASUREMENT #6 DISTANCE TO LEFT BANK  
MEASUREMENT #7 DEPTH  
MEASUREMENT #7 DISTANCE TO LEFT BANK  
MEASUREMENT #8 DEPTH  
MEASUREMENT #8 DISTANCE TO LEFT BANK  
MEASUREMENT #9 DEPTH  
MEASUREMENT #9 DISTANCE TO LEFT BANK  
NATURAL BUFFER LEFT BANK WIDTH  
NATURAL BUFFER RIGHT BANK WIDTH  
NUMBER OF MODERATELY DEFINED STREAM BENDS  
NUMBER OF POORLY DEFINED STREAM BENDS  
NUMBER OF WELL DEFINED STREAM BENDS

	<p>OTHER</p> <p>OVERALL AESTHETICS (1=WILD;2=NAT;3=COMM;4=OFF)</p> <p>PERCENT CULIVATED FIELDS AS RIPARIAN VEGETATION</p> <p>PERCENT GRASSES AS RIPARIAN VEGETATION</p> <p>PERCENT OTHER AS RIPARIAN VEGETATION</p> <p>PERCENT SHRUBS AS RIPARIAN VEGETATION</p> <p>PERCENT TREES AS RIPARIAN VEGETATION</p> <p>RIFFLE AREA</p> <p>RIFFLE LENGTH</p> <p>RIPARIAN VEGETATIVE ZONE WIDTH (LEFT BANK)</p> <p>RIPARIAN VEGETATIVE ZONE WIDTH (RIGHT BANK)</p> <p>ROOTS</p> <p>SEDIMENT DEPOSITION</p> <p>SMALL WOODY DEBRIS</p> <p>STREAM BANK SLOPE</p> <p>STREAM COVER TYPES</p> <p>SUBMERGED AQUATIC VEGETATION</p> <p>TERRESTRIAL VEGETATION</p> <p>THALWAG DISTANCE FROM LEFT BANK (WET)</p> <p>TOTAL NUMBER OF STREAM BENDS</p> <p>UNDERCUT BANKS</p> <p>UNDERSTORY LEFT BANK NON-WOOD HERBS/GRASSES</p> <p>UNDERSTORY LEFT BANK VEG TYPE (0.5-5M)</p> <p>UNDERSTORY LEFT BANK WOODY SHRUBS/SAPLINGS</p> <p>UNDERSTORY RIGHT BANK NON-WOOD HERBS/GRASSES RIGHT BANK</p> <p>UNDERSTORY RIGHT BANK VEG TYPE (0.5-5M)</p> <p>UNDERSTORY RIGHT BANK WOODY SHRUBS/SAPLINGS</p> <p>VEGETATIVE PROTECTION (LEFT BANK)</p> <p>VEGETATIVE PROTECTION (RIGHT BANK)</p> <p>VELOCITY/DEPTH REGIMES</p> <p>WETTED AREA (DOWNSTREAM)</p> <p>WETTED AREA (UPSTREAM)</p> <p>WETTED WIDTH (DOWNSTREAM)</p> <p>WETTED WIDTH (UPSTREAM)</p>
<b>Major Ions</b>	<p>CALCIUM</p> <p>CHLORIDE</p> <p>FLUORIDE</p> <p>MAGNESIUM</p> <p>POTASSIUM</p> <p>SODIUM</p> <p>SULFATE</p>
<b>Metals</b>	<p>ARSENIC</p> <p>COPPER</p> <p>IRON</p> <p>LEAD</p> <p>NICKEL</p> <p>ZINC</p>
<b>Nutrients</b>	<p>AMMONIA AS N</p> <p>NITRATE/NITRITE AS N</p>

	ORTHOPHOSPHORUS AS P
<b>Oxygen</b>	DISSOLVED OXYGEN
<b>Sample Descriptors</b>	NUMBER OF TRANSECTS TRANSECT NUMBER (ID) TRANSECT TOTAL LENGTH TRANSECTS - DISTANCE BETWEEN (TRANSECT INTERVAL)
<b>Solids/Conductivity</b>	CONDUCTIVITY TOTAL SUSPENDED SOLIDS
<b>Spatial</b>	AREA SAMPLED DEPTH UNDER WATER DRAINAGE AREA MAXIMUM POOL DEPTH MAXIMUM POOL WIDTH STREAM ORDER