Bull Creek Update Report 2010

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Abstract: *Bull Creek ranks highest in overall health out of all sampled creeks in the City of Austin and is home to the Jollyville Salamander, an indigenous caddisfly and two endangered bird species. This report is the result of 12 years (1996-2008) of physical, chemical and biological monitoring of five Bull Creek sites. Results of spatial and temporal analyses identify increases in conductivity, dissolved salts, pH, E-coli and pollution tolerant taxa coupled with a decrease in sensitive taxa at various sites throughout the Bull Creek watershed. These findings are most likely the result of land-use changes and resulting increased impervious cover despite the amount preserve land in the watershed. Management strategies designed to mitigate the effects of urbanization are necessary to maintain sensitive species and recreational uses.*

Introduction

Bull Creek, located within Travis County, encompasses a drainage area of 24.7 square miles, the majority of which (16.3 square miles) lies atop the northern portion of the Edwards Aquifer recharge zone. The mouth of the Creek drains directly into Lake Austin, which supplies the City of Austin (COA) with drinking water. Bull Creek contains environmentally sensitive terrestrial and aquatic habitat and is home to a number of rare and endangered species (Geismer 2001). It contains habitat for the endangered Golden-Cheeked Warbler (*Dendroica chrysoparia)* and Black-Capped Vireo (*Vireo atricapilla)* (Geismer 2001) and is home to the Jollyville Salamander (*Eurycea tonkawae)*, considered a species of concern under the Endangered Species Act (Geismer 2001), and to a caddisfly (*Austrotinodes texensis),* that is assumed to be endemic to karst springs/runs of the Edwards Plateau ecoregion (Bowles 1995).

Currently there are no waste water discharges in the Bull Creek watershed; however there are two active Texas land application permits (TLAP) in the watershed. Permit 11363-001 is for Balcones Water Reclamation Plant which is upstream ~ 1 mile from Tributary 6 (#151) and permit 12929-001 is for Pickfair Water Reclamation Plant which would enter tributary 4. No monitoring occurs on this tributary and the next sample location that would be affected by run-off from this TLAP would be in Saint Edwards Park.

Site Selection and Description

Currently (2006 land use data), fifty nine percent of the Bull Creek watershed is developed: 33% residential, 5% business, 1% civic, 11% parks, and 9% roadways (Figure 1). As of 2000 the population in the Bull Creek watershed was ~ 44,000 and at current growth rates it is estimated that by 2030 the population will be near 70,000 (COA-WPD Masterplan, 2001)

Sites are selected based on several factors:

- Drainage area and representation of targeted land uses is used to locate a general area;
- Road crossings are then used to locate viable access points;
- Riffles are the primary physical unit required for the bioassessment method used by the City of Austin so it is important that comparable riffles are selected based on substrate size, dimensions of the riffle and amount of appropriate cover.

<u>Tributary Sites</u>

Tributary 5 (#1164) is located on COA's BCCP property on Hanks Tract and is upstream of the confluence with Tributary 6. Land use within this tributary's catchment is predominantly park/preserve but has quite a bit of single family residential and commercial development and an overall impervious cover of 21%.

Tributary 6 (#151) is also located on the BCCP property known as the Hanks Tract and is upstream of the confluence with Tributary 5. This tributary flows through several subdivisions with the Balcones Country Club golf course located in the upper two-thirds of the catchment. Land use in this tributary is predominantly single family residential with an overall impervious cover of 31%.

<u>Main Stem Sites</u>

Bull upstream tributary 7 (#349) is located in the BCCP property known as the Franklin Tract. This site is on the main stem of Bull Creek downstream of its confluence with Tributary 8 and directly adjacent to the discharge of Pit Spring. Land use within this tributary is predominantly park/preserve with an overall impervious cover of 17%.

St. Edwards Park monitoring site (#920) is located in the park, ¼ mile upstream of the park dam, off Spicewood Springs Road, west of Loop 360. Land use within this tributary's catchment is primarily a mix of park/preserve and single family residential with an overall impervious cover of 23.55 percent.

Loop 360 (#350) is located at the most downstream crossing of Loop 360 upstream of the Lower Bull Creek District Park, approximately 1 mile upstream of Bull Creek's confluence with Lake Austin/the Colorado River. Land use within this site's catchment is a mix of park/preserve, residential and commercial development with an overall impervious cover of 26%.

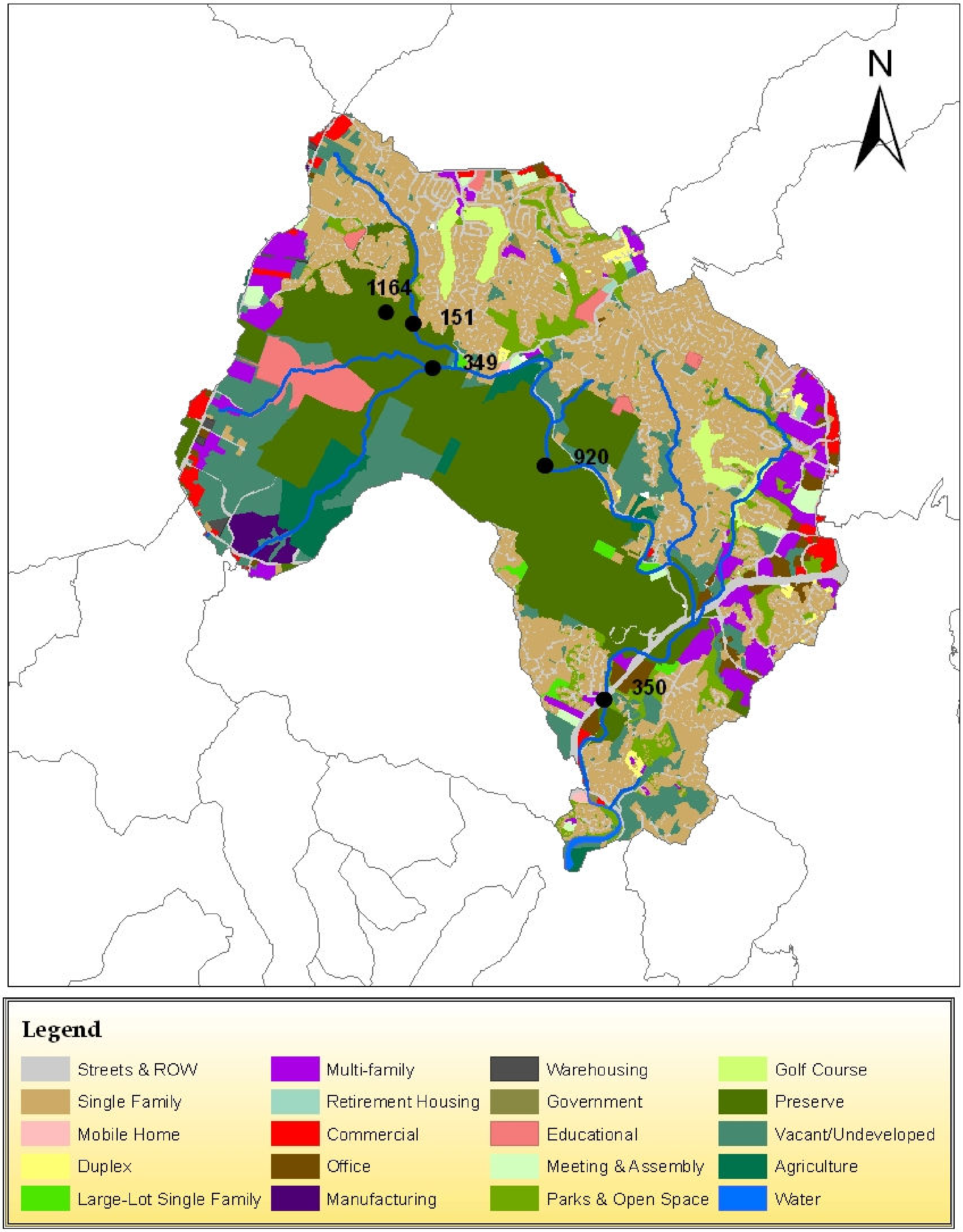

Figure 1. Bull Creek watershed land use map, black dots represent sampling sites along Bull Creek. Upper most is Tributary 5 (#1164), Tributary 6 (#151), Bull above Tributary 7 (#349), Saint Edwards Park (#920) and Loop 360 (#350). Bull above Tributary 7 is considered reference condition for the watershed, and sites 1164, 151 and 349 are all located within the Bull Creek Preserve.

Methods and Analysis

For details concerning City of Austin habitat, biological, and water quality sampling protocols refer to City of Austin WRE standard operating procedures (SOP) sections 3, 5, and 6 respectively (City of Austin 2010).

The most recent City of Austin Environmental Integrity Index (EII) score was calculated for each watershed in Austin. The EII score is a combination of a water quality, sediment, contact recreation, non-contact recreation, physical integrity, aquatic life, algae cover, benthic macroinvertebrate, diatom, and fish community scores. Watersheds are not sampled for EII every year and scores ranged from 2006 to 2008 depending on the watershed. Scores were ranked, compared between watersheds, and placed in categories. EII scores range from 0 to 100 and are grouped in the following categories:

0-12.5 = Very Bad	12.6-25 = Bad	25.1-37.5 = Poor	37.6-50 = Marginal
50.1-62.5 = Fair	62.6-75 = Good	75.1-87.5 = Very Good	87.6-100 = Excellent

Physical Habitat Monitoring

Habitat data were collected twice a year in May/June and August/September beginning in 1997. Data consisted of both visual assessment and measured components. Intensive habitat surveys (EPA Habitat Quality Index, Barbour et al 1999)) included assessment of bank stability, vegetative protection, channel alteration, flow within the channel, embeddedness, epifaunal substrate, frequency of riffles, riparian zone width, sediment deposition, and the number of velocity/depth categories. Habitat data was compiled and placed into a matrix to calculate the Habitat Quality Index (HQI) for each site. The overall HQI score was plotted against time and categorized into marginal (<113), suboptimal (113-166), or optimal (>166).

Intensive habitat parameters (SOP section 6.5, pg. 61) were measured about 6 times at each site during the index period at the riffle and reach scale from 2004-2008. Means were calculated for riffle length, riffle area, canopy cover, wetted width, reach length, number of riffles, number of runs, and number of pools at each site to evaluate among site variability. Pebble counts were performed at each site to determine particle size distribution of the streambed sediments.

Water Quality Monitoring

Water quality data, collected in accordance with COA standard methods (COA SOP section 3.0), consisted of the following parameters: alkalinity, ammonia, calcium, chloride, conductivity, discharge, dissolved oxygen, *Esherichia coli* (*E. coli*), fecal coliform, magnesium, nitrate/nitrite, orthophosphorus, pH, phosphorus, potassium, sodium, sulfate, total kjeldahl nitrogen, total suspended solids, turbidity, and water temperature. Spatial analysis of water quality parameters used only data collected from 1998 to 2008.

Biological Monitoring

Benthic macroinvertebrates and Diatoms were collected twice a year during the May/June and Aug/Sept sampling events in accordance with City of Austin standard procedures (COA SOP, section 5.3). Benthic macroinvertebrates were collected using a 600µm mesh surber sampler (1ft^2). Three surber samples were collected and composited from riffle locations that represent the bottom, middle and top portions of the sample area. Sub-sampling was performed if necessary to obtain 200 (± 20%) individuals. Macroinvertebrates were sorted in the field, preserved in 70% ethyl alcohol and identified to the lowest practical level, usually genus by City of Austin taxonomists.

Diatoms were collected from three rocks representing the bottom, middle and top portions of the sample riffle habitat. Periphyton was scrubbed from a defined area of 47cm^{2}from each rock, composited and preserved with 10% buffered formalin, and sent out for processing and identification by a 3rd party taxonomist (B. Winsborough).

Standard benthic macroinvertebrate and diatom metrics were calculated from raw taxa lists and used to evaluate qualitative spatial and temporal patterns (COA SOP section 5.3 and 5.4)). Analysis performed on the benthic macroinvertebrate metrics and the diatom metrics were for data collected from 1998 to 2008 on Bull Creek. Analyses were done separately for the benthic macroinvertebrate metrics in the summer and the spring. The summer samples were collected in June, July, August, or September and the spring samples were collected in March, April, or May.

The following invertebrate biological metrics were used:

EPT richness is the total number of distinct genera within Order Ephemeroptera, Order Plecotpera and Order Trichoptera. This metric shows a decline in genera as impairments increase of physiochemical factors that negatively affect member of these orders. Taxa belonging to these orders are considered to be pollution sensitive (TCEQ 1999).

Percent of total benthic organisms as the functional feeding group: collectors. This metric looks at the ratio of the number of individuals in the collector-gatherer functional feeding group (FFG) to the total number of organisms (N) * 100. Collector-gatherers ingest fine particulate organic matter (FPOM) as their primary food resource. This FFG can be affected due to physiochemical impairments such as organic enrichment, which can lead to an increase in FPOM (TCEQ 1999). Increases in nutrient loads can cause this FFG to become predominate in the aquatic community.

Number of taxa also called taxa richness, the total number of benthic macroinvertebrate taxa. Taxa are identified to genus, except for Chironomidae which are only taken to family or sub-family in the case of Tanypodinae. Non-insect taxa are left at several different levels of taxonomy. Once all organisms are identified they are counted and low taxa richness reflects a low biotic integrity.

TCEQ qualitative aquatic life use (ALU) score compiles 12 metrics: taxa richness, EPT richness, Hilsenhoff biotic index (HBI), percent Chironomidae, percent dominate taxa, percent dominate functional feeding group, percent predators, ratio of intolerant to tolerant taxa, percent of total Trichoptera as Hydropsychidae, number of non-insect taxa, percent of total organisms as collector-gatherers and percent of total organisms as Elmidae. These 12 metrics are calculated and then are scored on a scale: > 36 Excellent; 36-29 High; 28-22 Intermediate; < 22 Limited (TCEQ 1999, 2007).

The following diatom biological metrics were used:

Cymbella Richness compiles number of taxa in the Cymbella, Encyonema, Encyonemopsis, and Reimeria genera" (COA 2008). A decrease in cymbelloid taxa indicates a decrease in sensitive taxa (Gilroy and Makosky 2008).

Percent Motile Taxa compiles Navicula, Nitzschia, Surrirella, Craticula, Diadesmis, Luticola, Sellaphora, Hippodonta, Tryblionella, Geisselaria genera as percentage of the total number of organisms (COA 2008). Percent motile taxa (PMT) are used to measure siltation because the more mobile taxa are capable of surviving a siltation event by moving upwards to avoid settling silt. Increasing PMT values indicates an increase in siltation (Gilroy and Makosky 2008)

Pollution Tolerance Index (PTI) rates diatom taxa by their sensitivity to pollution on a scale of increasing sensitivity, where 1 is least sensitive and 4 is the most sensitive (Gilroy and Makosky 2008).

Spatial Analysis

The distribution of water quality, benthic macroinvertebrate and diatom data was checked for normality by the Shapiro-Wilk test in SAS. Analysis of Variance (ANOVA) was carried out on the parameters with a normal distribution while a Kruskal-Wallis test was performed on the non-normally distributed parameters to examine whether or not a difference existed between sites for a given parameter. To compare means for each parameter a Tukey-HSD multiple comparison test was performed on parameters where a significant difference existed according to an ANOVA. The minimum p-value multiple comparison test was performed on parameters where a significant difference existed according to a Kruskal-Wallis test. All alpha levels for determining significance were set to 0.05 for this analysis. Means for water quality (non-censored), benthic macroinvertebrate, and diatom data were calculated using PROC MEANS in SAS, while the Kaplan-Meier technique was used to calculate means for censored data. Only significant trends were presented in this report.

Temporal Analysis

Normally distributed water quality, benthic macroinvertebrate, and diatom data was analyzed for temporal trends using least squares regression with the PROC REG procedure in SAS, while data that was non-normal was ranked first and then analyzed using least squares regression. Water quality data that contained values below detection level were analyzed using Cox's proportional hazards regression in SAS using the PROC PHREG procedure. Alpha levels for determining significance were set to 0.1 for temporal analysis.

Results & Discussion

Overview of Bull Creek Watershed

Bull Creek is evaluated as part of the City of Austin's Environmental Integrity Index (EII), a program that combines biological, physical and chemical measures to compare all area creeks (45 catchments) on a biannual basis. Bull Creek was most recently evaluated in 2007 when it scored highest of all creeks sampled for overall watershed EII score (Figure 2).

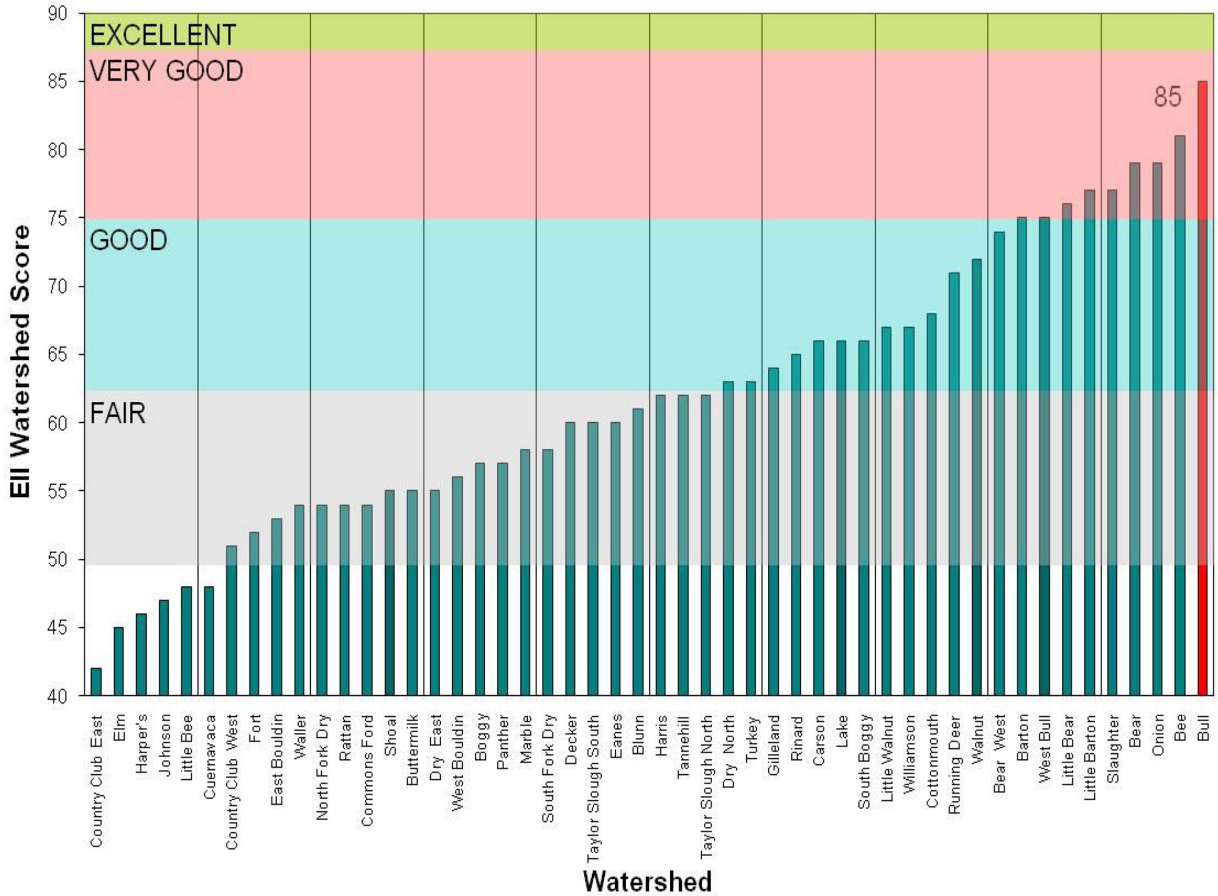

Figure 2. 2007 EII watershed scores for all watersheds, with Bull Creek in red.

Physical Habitat Overview

The EPA's visually based Habitat Quality Index (HQI) scored all Bull Creek sites in the sub-optimal to optimal range over the sampling period of 1997-2008 (Figure 3). Loop 360 is the only location that continually scored in the suboptimal range, primarily due to the bridge and park use in the area. In addition to the HQI, quantitative habitat surveys (WRE SOP section 6.5) were conducted twice a year from 2005-2008 to understand spatial variation among study sites and for interpretation of biological data. In general, habitat physical measures were similar with little variation between upstream and downstream site conditions. Stream habitat type was fairly consistent among study sites, with all sites having 2-3 each of riffle, run and pool habitats per site reach. Bed substrate size, as measured using a 100 point pebble count, was dominated by gravel (11-65mm) at all sampling locations. There were no major differences in instream cover, woody debris, roots, undercut banks and aquatic vegetation between sampling sites. The only notable contrasts were the lack of any canopy cover at Loop 360 and reach length, which was established based on bankfull width (20x Bankfull width), and increased from upstream to downstream, going from 485 ft at Tributary 5 up to 1688 ft at Loop 360.

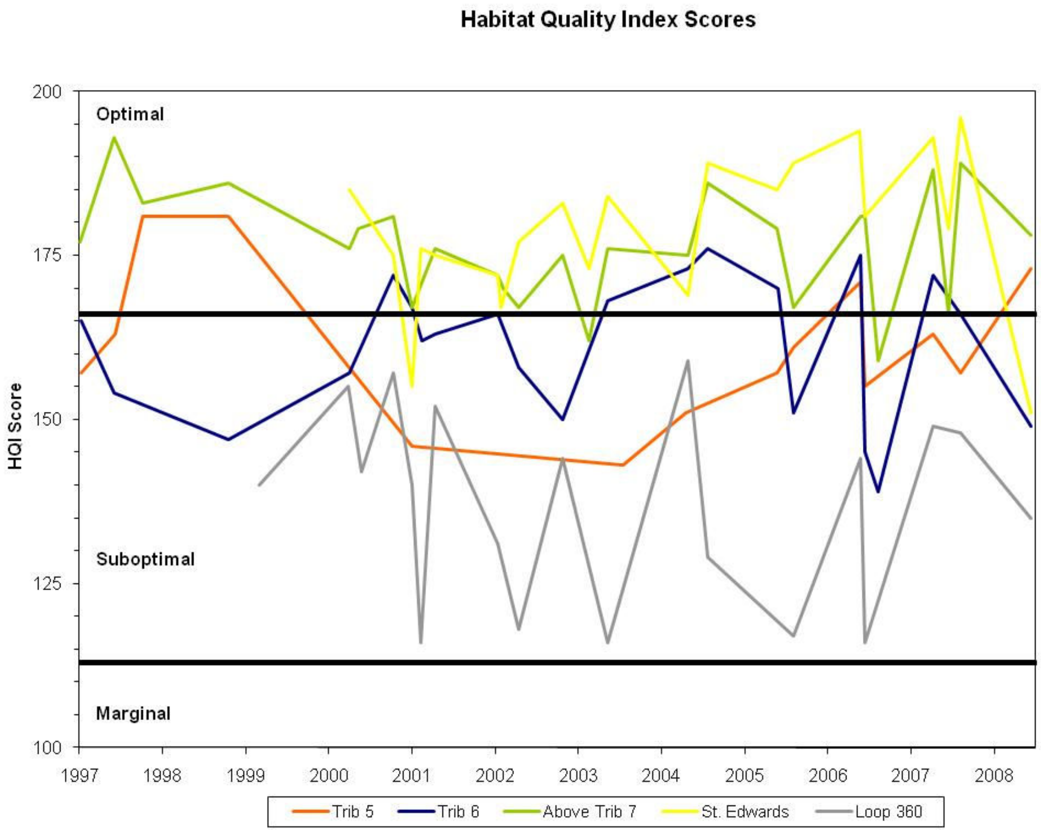

Figure 3. Habitat Quality Index (HQI) scores for Bull Creek sites (1997-2008).

Water Chemistry Spatial Trends

There were significant spatial differences in temperature, pH, dissolved oxygen and conductivity among sampling sites on Bull Creek (Figures 4). The significant increase in water temperature at Loop 360 (Figure 4a) is likely due to the lack of canopy cover at this site, and from the decrease in spring/groundwater influences at this most downstream site (Figure 1). pH values generally increased from upstream to downstream (Figure 4b) but all sites were within the Texas Commission on Environmental Quality (TCEQ) surface water standards range for receiving bodies of Lake Austin, of 6.5-9.0 (TCEQ 2009a). Measurements of dissolved oxygen showed some differences among sites (Figure 4c) but all mean values exceeded the TCEQ minimum 24-hour average dissolved oxygen level of 5mg/L (TCEQ 2009a). Conductivity varied significantly among sites with the most notable increase occurring at Tributary 6 (Figure 4d). This increase is correlated to high levels of dissolved salts of calcium, magnesium, potassium, sodium and chloride ions (Table 1). Although the Tributary 6 monitoring site is located within the Balcones Canyonlands Conservation Preserve, urbanization upstream of the preserve area, with impervious cover of 31.29%, is probably the source of these dissolved salts. Past studies performed by The City of Austin showed that increases in urbanization caused changes to groundwater chemistry, particularly increases in ion concentrations (COA *draft* 2007).

There were minimal differences in concentration of Fecal Coliforms (col/100mL) and *E. coli* (MPN/100mL) among sites with only the farthest downstream site, Loop 360, showing higher values than the other sites (Table 1). Although mean *E. coli* levels are above the contact recreation maximum value of 126 MPN/100mL for Loop 360,the rest of the sites on Bull are well below that threshold. *E. coli* contamination at Saint Edwards and Loop 360 is of particular concern due to their heavy use as recreational areas for swimming and wading (Cooke 1985, Dudley *et al* 1976, Schiff and Kinney 2001). Higher E. coli values at the downstream sites that are in public parks appear to be related to both park use (by humans and dogs) and possibly urban wildlife (Sejkora et al. 2010). It is also possible that these increasing values are related to accidental sewage overflows. Since 1998 twenty five surface water sewage spills, ranging from 500- 84,000 gallons, have been recorded within the watershed. A more detailed account of bacteria issues in Bull creek can be found in SR 08 02 (Herrington and Scoggins 2008) and will be reviewed again in January of 2011 in an update report.

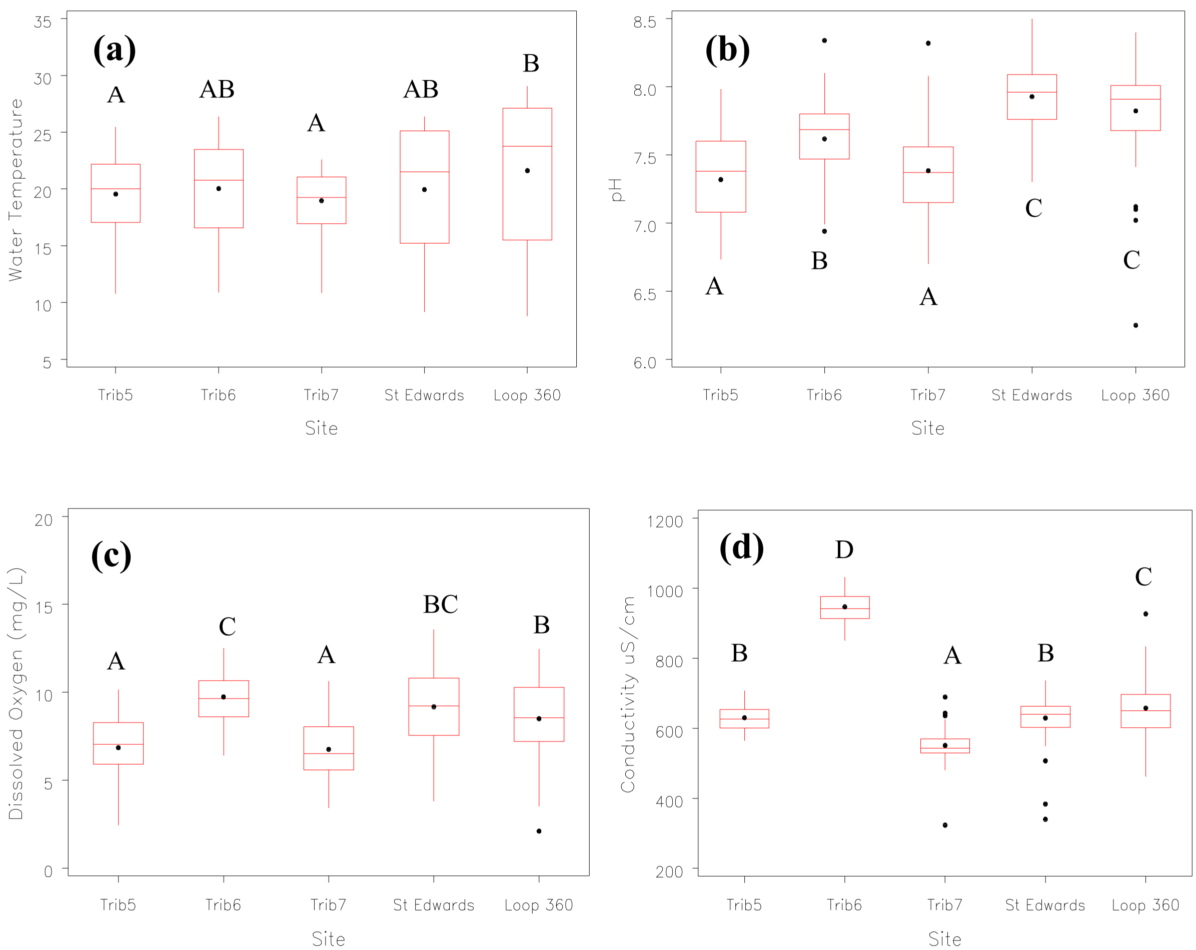

Figure 4. Water temperature (a), pH (b), 24-hour average dissolved oxygen (c) and conductivity (d) ranges for Bull Creek sampling locations (1996-2008). Dots within the boxes indicate means, the lines inside the box are medians, boxes indicate 25th and 75th percentile of range, and dots outside the boxes are 1.5 times the interquartile range. Same letters indicate no statistical difference.

Table 1. Mean ± Standard Deviation for parameters collected at Bull Creek study sites (1997-2008). Superscript letters indicate significant differences among study sites. The Kaplan-Meier survival analysis technique is used to establish the mean and standard deviation for ammonia data which was below detection approximately 50% of the time.

Parameter	Trib 5	Trib 6	Above Trib 7	St. Edwards	Loop 360
Ammonia as N	0.035 ± 0.036^{C}	0.032 ± 0.042^{BC}	0.023 ± 0.029^{ABC}	0.024 ± 0.021^{AB}	0.018 ± 0.019^{A}
Calcium (Ca)	98.84 ± 8.07^{B}	117.10 ± 9.93^{C}	87.12 ± 7.85^{A}		
Chloride	23.24 ± 7.67^{B}	77.17 ± 10.62^{E}	15.72 ± 2.50^{A}	40.22 ± 6.77^{C}	49.23 ± 14.66^{D}
E Coli	52 ± 49^{AB}	92 ± 81^{AB}	39 ± 46^{A}	43 ± 45^{A}	190 ± 256^{B}
Fecal Coliform	70 ± 74^{A}	58 ± 60^{A}	34 ± 48^{A}	111 ± 151^{AB}	199 ± 272^{B}
Discharge (cfs)	0.73 ± 0.91^{A}	0.83 ± 0.81^{A}	0.96 ± 0.90^{A}	6.97 ± 6.28^{B}	5.76 ± 8.66^{B}
Magnesium (Mg)	16.12 ± 1.76^{A}	25.24 ± 2.41^{B}	15.82 ± 1.00^{A}		
Potassium (K)	0.85 ± 1.01^{A}	2.28 ± 0.75^{B}	0.91 ± 1.05^{A}		
Sodium (Na)	11.55 ± 3.97^{A}	43.62 ± 10.31^{B}	8.22 ± 1.48^{A}		
Sulfate (SO_4)	20.39 ± 3.02^{A}	81.70 ± 14.63^{D}	17.84 ± 3.40^{A}	41.60 ± 8.17^{B}	62.89 ± 25.14^{C}

Benthic Macroinvertebrate Spatial Trends

Spatial analysis of the benthic macroinvertebrate community data consisted of surveys from 1998 – 2008 and included all seasons. Total number of taxa identified (135) was evenly distributed between sites (Tributary 6 = 79, Above Tributary 7 = 68, St. Edwards =75, and Loop 360 = 80) except for Tributary 5 (22) which was only sampled during summer while all other locations had sampling in all seasons. Tributary 5 was represented graphically but not included in any spatial comparisons due to this sampling disparity. A full taxa list is provided in Appendix A and is color coded by season.

There were few spatial differences in the distribution of benthic macroinvertebrate taxa among sampling sites (Figure 5). EPT taxa richness decreases from upstream to downstream with Loop 360 having the lowest values (Figure 5a). Taxa belonging to the EPT orders are considered to be pollution sensitive where a decrease could indicate impairment of physiochemical factors and an overall reduction in water quality (TCEQ 1999). There was a significant increase in the percentage of collector functional feeding group macroinvertebrates downstream, with Loop 360 having the highest values and Above Trib 7, our reference site, having the lowest values (Figure 5b). Collector-gatherers ingest fine particulate organic matter (FPOM) and can become dominant as a result of organic enrichment (TCEQ 1999). Number of taxa at study sites was relatively similar, with no significant difference in means among sites and all with means in the 20-25 taxa range (Figure 5c). The TCEQ qualitative aquatic life use score (ALU) demonstrated slight variations among sites with mean scores falling in the intermediate range (22-28), with values going from limited to excellent (Figure 5d). Large variability in ALU scores is possibly due to dewatering and/or low flow effects during drought conditions. In general, the benthic macroinvertebrate measures showed minimal differences among study sites.

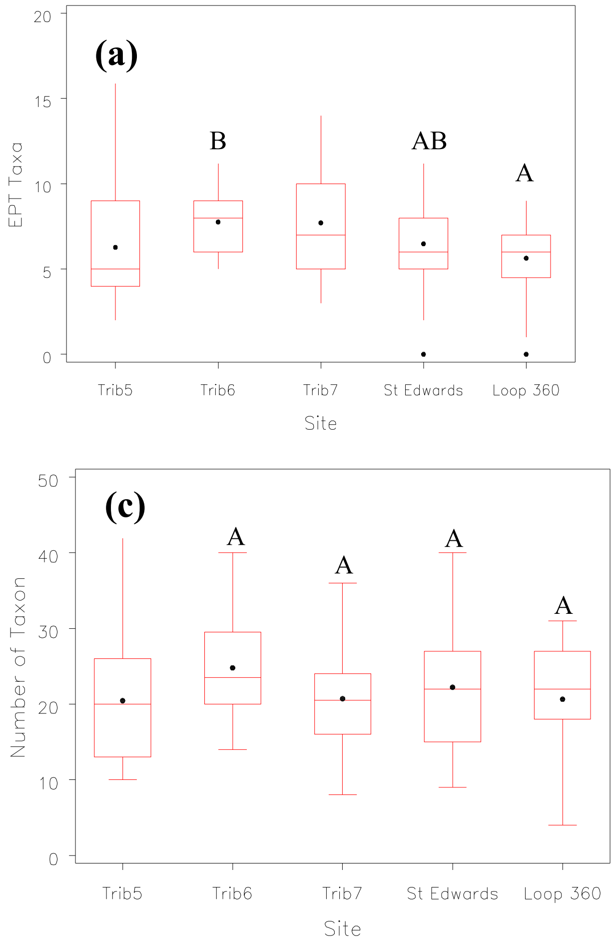

Figure 5. Benthic macroinvertebrate metrics scores at 5 study sites during sampling period: EPT Taxa, (a), Percent Collectors (b), Number of Taxa (c), and TCEQ qualitative aquatic life use score (d). Note: For description of box plots see Figure 4 titles. Also, Trib 5 results are shown, but not included in statistical comparison.

Diatom Sampling Spatial Trends

Some spatial differences in Bull Creek diatom populations were found among sampling locations, but with no distinct spatial trends (Figure 6). The decrease in Cymbelloid diatoms at Tributary 6 (Figure 6a) appears to correlate with the increases in dissolved salts documented at that site (Figure 4d, Table 1). A decrease in the number of cymbelloid taxa could indicate environmental stress and an overall reduction in water quality. However, when compared to all other Austin creeks, Bull Creek sites, including Trib 6, are above the EII *Cymbella* richness average of 2.29. Increases in percent motile taxa (Figure 6b) indicate a rise in siltation but only one site (St. Edwards) was notably different (higher) than the other sites. Significant differences in the pollution tolerance index (PTI) were noted at Tributary 6 (Figure 6c) and could again be linked to an increase in conductivity and other stressors. Overall, among the Bull Creek sampling sites, the diatom community shows a subtle pattern of better ecological health at the reference site, Above trib 7, and the most downstream site, Loop 360. This can be most clearly seen in the PTI index (Figure 6c), but does not appear to correlate with other environmental measures (water chemistry, benthic macroinvertebrates, or habitat).

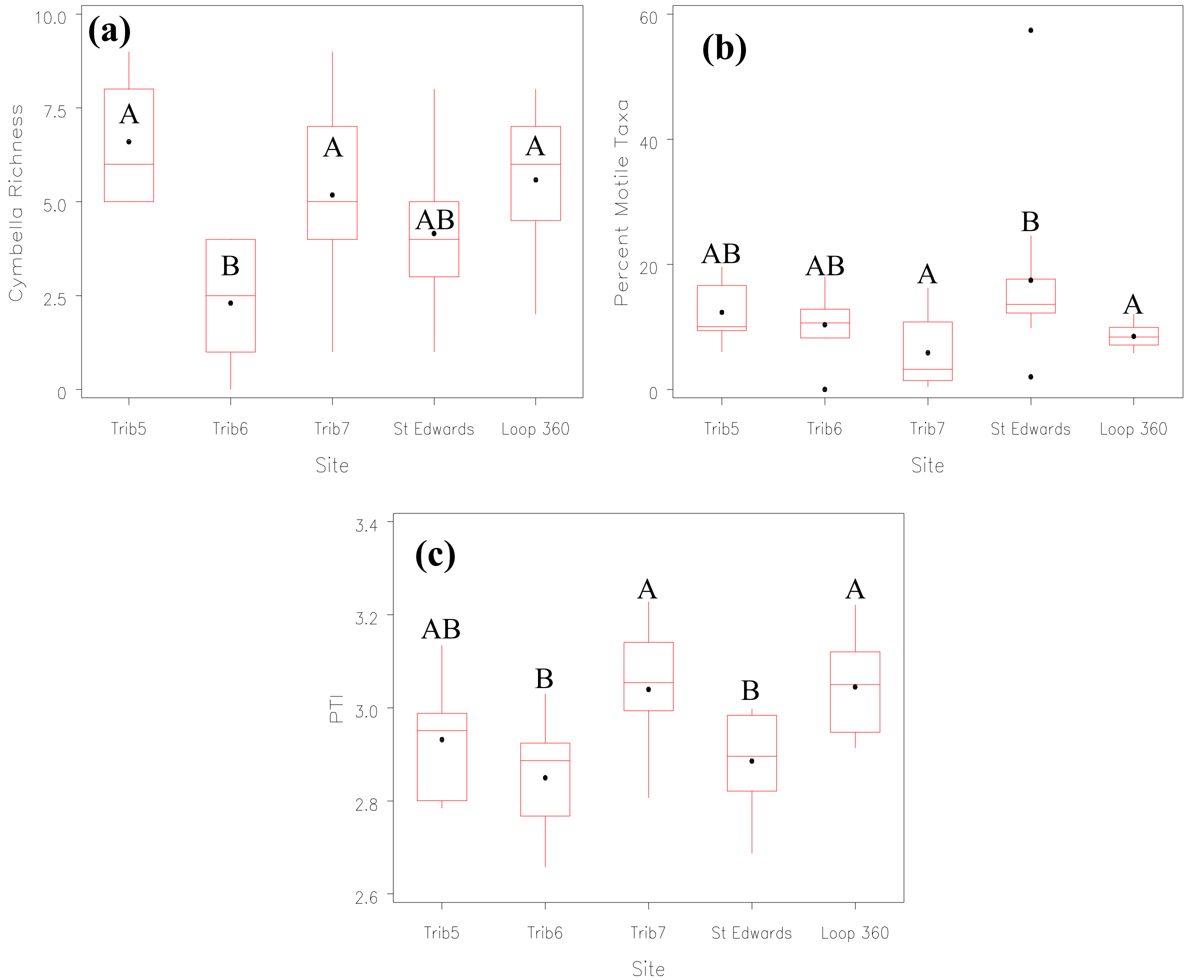

Figure 6. Distribution of diatom community metrics from 5 Bull Creek study sites during study period: Cymbella Richness (a), Percent Motile Taxa (b), and Pollution Tolerance Index (c), Note: For description of box plots see Figure 4 title.

Water Quality, Benthic Macroinvertebrate and Diatom Temporal Trends

Although the most recent EII score ranks Bull Creek as the highest out of all currently sampled creeks by the City of Austin (Figure 2), the temporal trends over the past decade elude to a negative shift in water quality (Figure 7-10). Since 1996, Tributary 5 has experienced a significant increase in conductivity (Figure 7a), chloride (Figure 7b) and sodium (Figure 7c). This change in water chemistry has corresponded to a decrease in the number of macroinvertebrate taxa (Figure 7d). These same water chemistry parameters were also significantly higher for Tributary 6 in the spatial comparison (Figure 4d and Table 1) and indicate a potential link. There have also been significant shifts in alkalinity, although that measure has not been collected since 2005 (Figure 8a), and a reduction in pollutant tolerant taxa (EPT) in Tributary 6 since 1996 (Figure 8b). There is a significant increase in percentage of collector functional feeding group macroinvertebrates for the downstream sites (Saint Edwards and Loop 360) (Figure 9). This steady upward trend corresponds to a 16% increase in impervious cover in the watershed during that period. More recently Bull Creek has experienced increases in the concentration of *E. coli* at Loop 360, particularly at the end of our study period in 2007 and 2008 (Figure 10). As mentioned previously, this phenomonen has been looked at in detail in SR-08-02 (Herrington and Scoggins) and is currently being studied to determine sources and temporal dynamics. Only Above Trib 7 has shown no indication of impairment for any of the spatial or temporal analyses performed. There have been significant increases in the number of pollution sensitive diatom taxa (cymbella richness, Figure 11a) and a corresponding decrease in the number of pollution tolerant benthic macroinvertebrate taxa over time (Figure 11b), indicating an overall increase in water quality at this site during our study period.

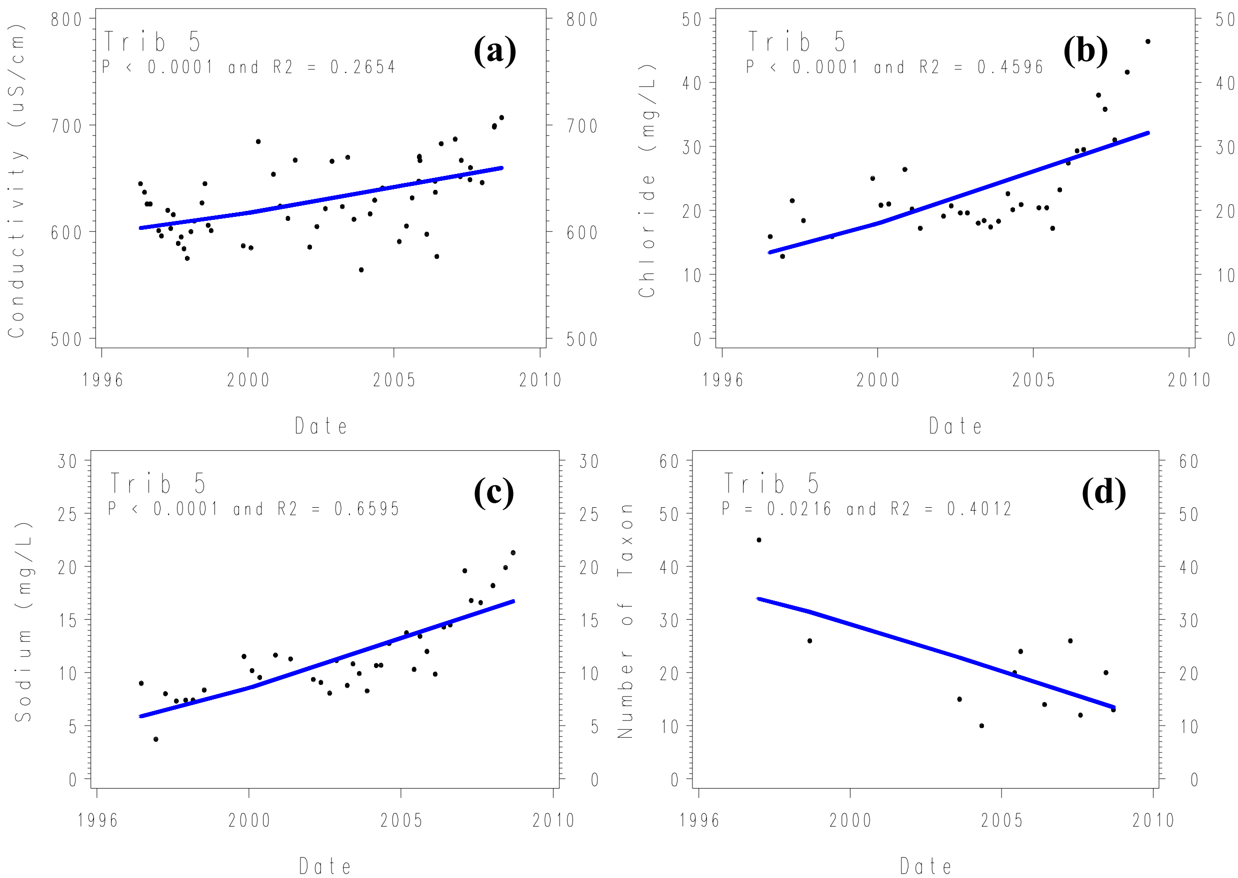

Figure 7. Regression analysis of Tributary 5 on Bull Creek through study period: conductivity (a), chloride (b), sodium (c), and macroinvertebrate Taxa (d). Dots represent actual data points fitted with a trend line ($\alpha = 0.1$).

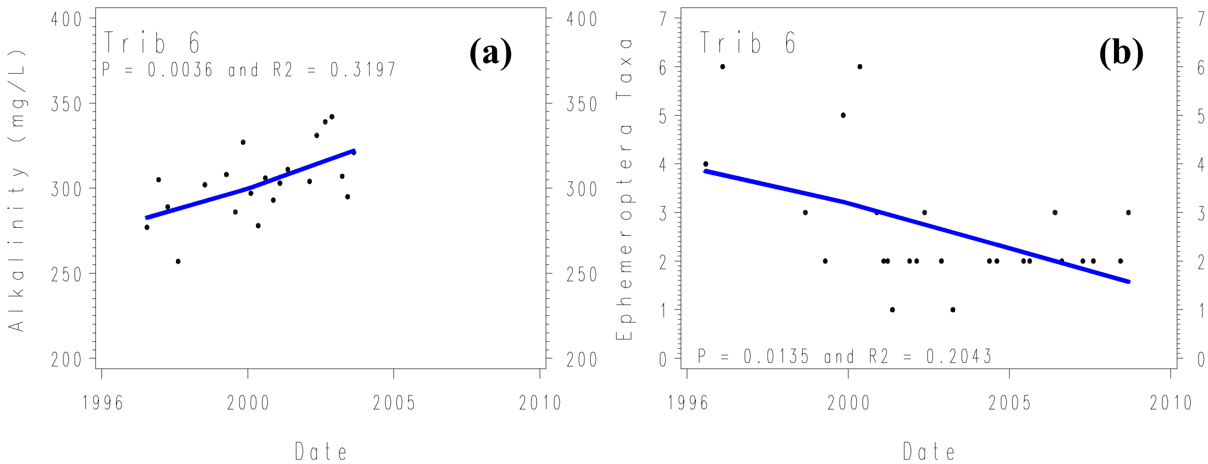

Figure 8. Regression analysis of Tributary 6 on Bull Creek through study period: alkalinity (a) and Ephemeroptera taxa (b). Dots represent actual data points fitted with a trend line (α = 0.1).

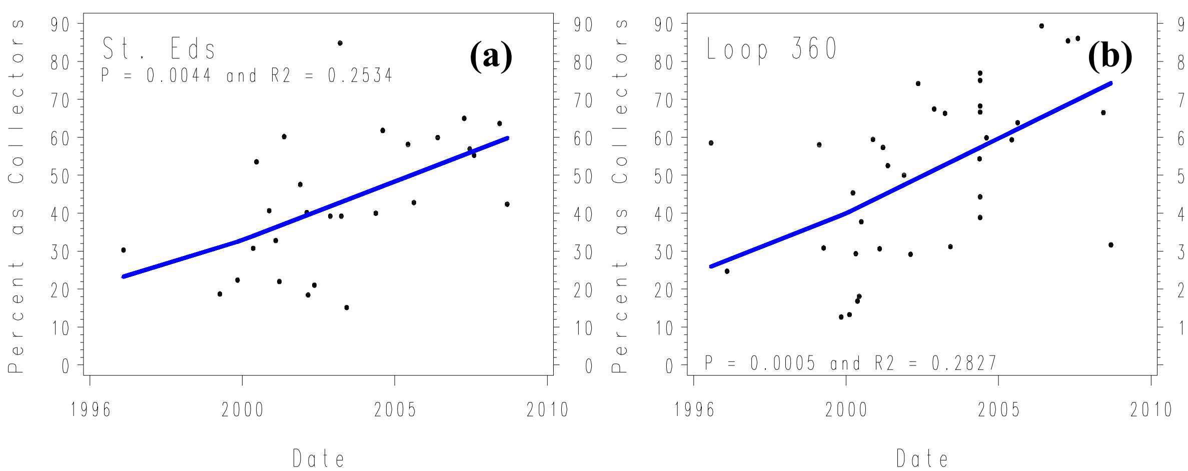

Figure 9. Regression analysis of percent of macroinvertebrates as collectors for Bull Creek sites Saint Edwards Park (a) and Loop 360 (b) through study period. Dots represent actual data points fitted with a trend line (α = 0.1).

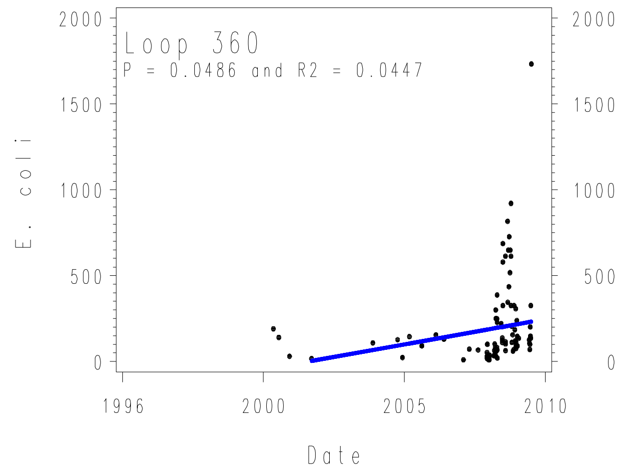

Figure 10. Regression analysis of Loop 360 *E. coli* (MPN/100mL) on Bull Creek through study period. Dots represent actual data points fitted with a trend line (α = 0.1).

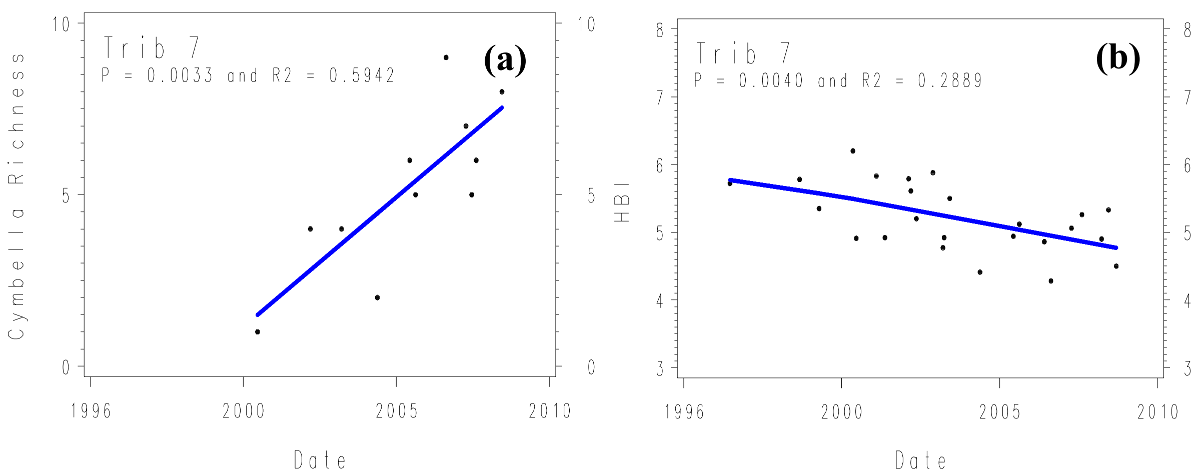

Figure 11. Regression analysis of the Bull Creek Above Tributary 7 site through study period: cymbella richness (a) and hilsenhoff biotic index (HBI) (b). Dots represent actual data points fitted with a trend line (α = 0.1).

Summary

Currently Bull Creek ranks highest out of all sampled creeks in the City of Austin; however, spatial differences between sites coupled with temporal shifts over the past decade indicate negative changes in the watershed, particularly in the headwater tributaries:

- Significant differences in pH and conductivity between sites corresponded to increased loading of dissolved salts and suggest that the rise in urbanization influences has started to negatively impact the water chemistry of Trib 5 and Trib 6.
- The decrease in EPT richness at Tributary 6 and corresponding increase in the percentage of collector macroinvertebrates at Saint Edwards Park and Loop 360 again indicate impairment and an overall reduction in water quality (TCEQ 1999).
- Tributary 5 a formerly pristine headwater site located in “Hanks Tract” has seen a shift in impervious cover from less than 4.8 percent in 1995 (Geismer, E. 2001) to 21 percent in 2006. These changes in land-use correlate with significant increases in conductivity, chloride and sodium and an overall reduction in the number of macroinvertebrate taxa.
- Tributary 6, also impacted by increases in impervious cover, has had a significant shift in alkalinity and a reduction in pollutant tolerant taxon. These headwater sites are of specific concern as they are home to the endemic Jollyville Salamander.
- As you move downstream to Saint Edwards Park and Loop 360 sampling sites we see a significant increase in percentage of collector functional feeding group macroinvertebrates over time. This increase in collector macroinvertebrates indicates impaired water quality due to organic enrichment.
- Only Above Tributary 7 has shown no indication of impairment for any of the spatial or temporal analyses performed. There have been significant increases in the number of pollution sensitive taxon and a decrease in the number of pollution tolerant taxon over time, indicating an increase in water quality.
- Although this study found some evidence of a negative shift in the Bull Creek watershed, many City of Austin watershed health measures, including the habitat quality index, The TCEQ aquatic life use score, the number of macroinvertebrate taxa, and the three diatom community metrics, all continue to indicate an overall healthy creek.

Recommendations

- Continue monitoring changes to Bull Creek within the framework of the Environmental Integrity Index (EII) sampling plan. Currently, EII sampling collects water quality four times per year and biology/habitat yearly during biannual surveys (every other year). This sampling method will continue to track long term trends both spatially and temporally.
- Tributary 5 (#1164) should be considered for a special study. The documented increase in conductivity and the ions chloride and sodium should be investigated with the intent of locating the source(s) and dynamics of these changes and suggesting management solutions.
- Continue monitoring the elevated *E. coli* levels at Loop 360 and quantify its relationship to Lower Bull Creek District Park closures; specifically, the role of dogs functioning as vectors and other potential sources of pathogens in lower Bull Creek (COA 2008b).
- Continue to collaborate with and support the Jollyville Salamander research team to understand ecological implications of watershed changes in Bull Creek.

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Appendix A Bull Creek Benthic Macroinvertebrates

PARAMETER	**151**	**151**	**151**	**151**	**349**	**349**	**349**	**349**	**920**	**920**	**920**	**920**	**350**	**350**	**350**	**350**	**1164**
ALLOGNOSTA														1			
AMBRYSUS		2		2													
ANOPHELES							1										3
AQUARIUS				1													
ARCHILESTES														1			
ARGIA	286	18	51	173	192	23	54	109	437	67	35	140	87	55	5	24	81
ATHERICIDAE								6									
AUSTROTINODES																	1
BAETIS		22												15			
BAETODES									3				10				
BASIAESCHNA					1									1			
BEROSUS		1	1	6	1			1		12	1	9	6	39	25	22	
BEZZIA / PALPOMYIA	5		2	8	15		2	7	3	1	1	2	3		3	2	6
BOYERIA																	1
BRECHMORHOGA MENDAX	58	2	2	18	69	4		15	47	3	3	10	24	4		1	10
CAECIDOTEA								5									
CAENIS	1	33	2	30	9	4		10	2	1			5	2	1	1	
CALLIBAETIS				1	2												5
CALOPARYPHUS	117	3	3	11	41	1	2	6	81	4	9	31	5	2		4	34
CAMELOBAETIDIUS	4				18			4	47	10	5	44	216	34	2	136	
CARABIDAE													1				
CERATOPOGONIDAE	1				4			1				1	1				3
CHEUMATOPSYCHE	394	5	80	185	326	1	9	263	1132	31	46	277	57	36	9	96	35
CHIMARRA	8				78			4	263	15	25	44	16	30	2	7	2
CHIRONOMIDAE	407	74	521	271	152	16	49	184	194	148	387	252	137	134	446	115	429
CINCINNATIA CINCINNATIENSIS								2					56	38	1	12	
COLLEMBOLA			1						3			4					
CORBICULA FLUMINEA	1								50		6	8	30	9	2	24	
CORYDALUS	2				1				10								
CYPHON											1						

PARAMETER	151	151	151	151	349	349	349	349	920	920	920	920	350	350	350	350	1164
DASYHELEA					6												10
DECAPODA		3															
DIPTERA (MIDGE/FLY)	1																
DIXIDAE								1									
DUGESIA	296	45	65	192	16	3	1	3	93	9	12	63	280	31	9	242	33
DYTISCUS					1		1	1									
ELMIDAE									1					75			
ENALLAGMA	5	2		2					3					7			
EPHYDRIDAE				1													
EPITHECA (EPICORDULIA) PRINCEPS	1												1				
ERETES															2		
ERPETOGOMPHUS	2			1	1			2	6					2			
ERYTHEMIS										3		1		1		1	
EUPARYPHUS	24		7	14	7		2	3	12		5	16	1		2	1	12
FALLCEON	564	162	636	1288	305	21	76	443	471	143	295	1229	683	214	104	717	297
FERRISSIA	1							1									
GASTROPODA													3	2			
GYRAULUS								1	6			1	13	2		4	
HAEMATOPOTA			3														
HELICHUS									1								
HELICOPSYCHE	127	30	32	172	22		2	31	4	12	22	34	29	13		11	
HELISOMA ANCEPS	1				6	1			6			11	16				2
HELOCHARES (ADULT)													3				
HEMERODROMIA	1	2			13			1				2				2	1
HEPTAGENIIDAE													1				
HETAERINA	18	1		3	9				20	3	2	4	3			2	4
HETERELMIS									1								
HETEROSTERNUTA		1															
HEXACYLLOEPUS										2		2				1	
HEXAGENIA		3		1													
HIRUDINEA	1									1		3	18	4	1	1	
HOLORUSIA	1			1													
HYALELLA	249	94	5	196	26	1			20	3	8	26	45	45	13	209	45
HYDATICUS			17			1	1	1		1	1	1		2			

PARAMETER	151	151	151	151	349	349	349	349	920	920	920	920	350	350	350	350	1164
HYDRACARINA	11	16	43	76	72		13	25	22	3	14	35	36	3	6	12	5
HYDROPHILUS			1												1		
HYDROPORUS				1													
HYDROCHUS										3							
HYDROCHARA																	1
HYDROPTILA	70	8	18	86	35	1	3	28	7	2	17	71	6	10	3	15	3
LACCOPHILUS				1													
LEPTOCERIDAE		1															
LEPTOHYPHES		17												3			
LEUCOTRICHIA	2																
LIBELLULA																1	
LUTROCHUS LUTEUS									7			3					
LYMNAEIDAE								16									
MACRELMIS	2				3				98		1	3	11			4	2
MACROVELIA									3			1					
MARILIA	37	13	35	34	18			9		3	2	2	1			1	27
MAYATRICHIA									2	1							
MELANOIDES TUBERCULATUS													12				
MESOVELIA		1												1			
METROBATES				2													2
MICROCYLLOEPUS PUSILLUS	21	2		2	11				798	7	2	218	110	4		15	1
MOLOPHILUS			1														
NECTOPSYCHE	28	2	1	56	6	2		20					2	1		16	6
NEMATODA								5									
NEMOTELUS									1								
NEOCHOROTERPES													1				
NEOCYLLOEPUS									1	4							
NEOELMIS	2				1				28	7		18	43	10		3	
NEOTRICHIA				1					1								
NEUROCORDULIA					1	2					2						
OCHROTRICHIA				2													
OECETIS	10	1		3	3			2	5	3	4	8	2				
OLIGOCHAETA	6	13	3	12	15	3	45	32	36	7	1	12	38	66	10	89	9
ORDOBREVIA												1		1			

PARAMETER	151	151	151	151	349	349	349	349	920	920	920	920	350	350	350	350	1164
OSTRACODA	20		37	145	2				44		10	114	30	2	7	47	30
OXYTHERIA		1												5			
PELTODYTES														1			
PERITHEMIS									1				4				
PERLESTA			4	5	1		35	48		1	79	121		4	13	9	
PETROPHILA (MOTH)	14				1			1	22				6			2	5
PHYLLOICUS ORNATUS		2	1	3	45	1	1	10			1						10
PHYSELLA	1		1	13	14	1	32	140	14	2	34	345	12	51	3	10	9
PLANORBELLA								4				1					
PLANORBIDAE										2			3	18		1	
PLAUDITUS (FORMERLY PSEUDOCLOEON)								63		4	25	32		27		1	
POLYCENTROPUS / CERNOTINA		2		2	17				3							1	
PROBEZZIA												1					
PROCAMBARUS				1	1									1			1
PSEPHENUS	529	77	25	171	325			169			1	4	7	8		4	1
PSYCHODIDAE								1									
RHAGOVELIA	105	14	1	112	32	2	1	28	52			33	9	1		6	16
SALDIDAE	2				2									1			
SIMULIUM	184	131	179	426	24	7	159	59	37	96	20	152	11	88	17	12	2
SMICRIDEA	3			1	1		1		1		1	5			1		
SPHAERIUM (CLAM)													1				
STENELMIS	6	1	5	5	7		1	7	23	4	1	26	14	24	1	21	
STENONEMA / MACCAFFERTIUM	3	9			6			10	2	1				2			9
STYGOBROMUS								1									
STRATIOMYS				1													
SURAGINA CONCINNA	13	14	8		85		2	15	1	1	1	1					10
TABANUS WHITNEYOMYIA ATYLOTUS COMPLEX	1			4	1	1			1	2		1					
TANYPODINAE	58	1	6	40	54	1	3	31	32	6	17	55	37	6	2	20	20
THRAULODES										2				1		1	
TIPULA	3	1	1		3		1	3		2			1	2			
TIPULIDAE				1													
TREPOBATES				1	1			1									2

PARAMETER	151	151	151	151	349	349	349	349	920	920	920	920	350	350	350	350	1164
TRICORYTHODES	189	7	1	96	72				458	65	15	69	71	21		10	1
UNIDENTIFIED DIPTERA GENUS (PUPA)					1				1								
VACUPERNIUS PACKERI									1				1				
XIPHOCENTRON		1			2												7

Winter Fall Spring

Appendix B Bull Creek Diatoms

GENUS SPECIES	151	349	350	920	1164
ACHNANTHES AMOENA			2		
ACHNANTHES BIASOLETTIANA	138	918	105	331	292
ACHNANTHES EXIGUA	2		1	4	
ACHNANTHES HUNGARICA				19	
ACHNANTHES LANCEOLATA	55		2	10	6
ACHNANTHES THERMALIS	1	1	12	1	6
ACHNANTHIDIUM AFFINIS		35			2
ACHNANTHIDIUM MINUTISSIMUM	795	1363	2210	1674	939
ACHNANTHIDIUM MINUTISSIMUM V GRACILLIMA	2	68	2	3	7
ADLAFIA BRYOPHILA		2		3	4
ALGAE BLUE-GREEN					
ALGAE FLAGELLATE					
AMPHIPLEURA PELLUCIDA		14	12	12	13
AMPHORA (SEMINAVIS) STRIGOSA	3				
AMPHORA CF. NORMANI	2				
AMPHORA INARIENSIS	84	2	18	60	6
AMPHORA LIBYCA	4			1	11
AMPHORA MONTANA	12	1	4	3	3
AMPHORA OVALIS	85	4	7	13	2
AMPHORA OVALIS V LIBYCA				17	2
AMPHORA OVALIS V OVALIS	52		12	1	2
AMPHORA PEDICULUS	397	25	49	767	29
AMPHORA VENETA	1			2	
BACILLARIA PARADOXA	3		2		
BRACHYSIRA BREBISSONII					5
BRACHYSIRA NEOEXILIS (SERIANS)	3	7		2	
BRACHYSIRA VITREA		75	26	43	68

GENUS SPECIES	151	349	350	920	1164
CALONEIS ALPESTRIS		2			
CALONEIS BACILLUM	1	6	4	12	6
CALONEIS SCHUMANNIANA		1		6	
CALONEIS SILICULA	6			3	2
CAMPYLODISCUS HIBERNICUS	1				
CAMPYLODISCUS LEVANDERI	8				
COCCONEIS PEDICULUS	481	3	178	304	41
COCCONEIS PLACENTULA	1032	12	39	117	30
COCCONEIS PLACENTULA V EUGLYPTA	61		8	32	14
CRATICULA CUSPIDATA	2				
CRATICULA HALOPHILA			6		
CYCLOTELLA MENEGHINIANA	15		9	9	4
CYCLOTELLA PSEUDOSTELLIGERA					7
CYMATOPLEURA ELLIPTICA		2	1		
CYMBELLA AFFINIS	25	36	101	83	9
CYMBELLA AMPHICEPHALA					5
CYMBELLA CESATII					4
CYMBELLA CYMBIFORMIS		16	8	8	8
CYMBELLA EXCISA		79		16	
CYMBELLA EXILLIS		18		26	
CYMBELLA HUSDTEDTII V STIGMATA	6	20	14		2
CYMBELLA HUSTEDTII	1		1	1	2
CYMBELLA LAEVIS	7	58	4	16	43
CYMBELLA NEOCISTULA		18	4	11	
CYMBELLA TUMIDULA			2		
CYMBELLA TURGIDULA		6	20	16	
DENTICULA KUETZINGII	81	159	182	94	103
DENTICULA KUETZINGII V RUMRICHAE		1			
DENTICULA SUBTILIS			2	2	
DIADESMIS CONTENTA		1			
DIATOM COUNT	500		500	500	
DIATOMA VULGARIS			4		
DIPLONEIS ELLIPTICA	3	14	2	28	5
DIPLONEIS MARGINESTRIATA					1

GENUS SPECIES	151	349	350	920	1164
DIPLONEIS OBLONGELLA		13			41
DIPLONEIS PUELLA	3	8		8	14
ENCYONEMA DELICATULA	4	413	360	50	100
ENCYONEMA ELGINENSE		2			
ENCYONEMA EVERGLADIANUM	11	152	143	28	151
ENCYONEMA GAEUMANNII		3	14	86	16
ENCYONEMA GRACILE			2		
ENCYONEMA HEBRIDICUM		127		1	
ENCYONEMA MINUTUM	1	9	8	16	26
ENCYONEMA NORVEGICUM					1
ENCYONEMA PERPUSILLA		3			
ENCYONEMA SILESIACUM	296	40	182	154	42
ENCYONEMOPSIS SILESIACUM		9		16	
ENCYONOPSIS MICROCEPHALA	8	125	377	206	144
EPITHEMIA ARGUS			2		
EPITHEMIA SOREX			2		
EPITHEMIA TURGIDA	2	11	14	4	4
EUCOCCONEIS FLEXELLA		66		2	7
EUNOTIA ARCUS		38			
EUNOTIA BILUNARIS	1	4			
EUNOTIA FLEXUOSA		64			
EUNOTIA MINOR		4			7
EUNOTIA PECTINALIS	8	106		7	50
EUNOTIA PRAERUPTA		6			
FALLACIA PYGMAEA				3	
FALLACIA SUBHAMULATA				1	
FRAGILARIA ACUS		11	1	13	2
FRAGILARIA CAPUCINA	12	92	109	191	11
FRAGILARIA CONSTRUENS V VENTER			3	4	6
FRAGILARIA FASCICULATA			1		
FRAGILARIA TENERA		49	13	14	3
FRAGILARIA ULNA	95	248	120	198	33
FRAGILARIA VAUCHERIAE	10			2	
FRUSTULIA WEINHOLDII					4

GENUS SPECIES	151	349	350	920	1164
GEISSLERIA CUMMEROWII			2	6	6
GOMOPHONEMA SP 100					1
GOMPHONEMA ACUMINATUM		8	1	1	
GOMPHONEMA AFFINE	24	143	18	14	18
GOMPHONEMA ANGUSTATUM	58	122	19	255	8
GOMPHONEMA ANGUSTUM	6	75	5	18	13
GOMPHONEMA AUGUR	1				
GOMPHONEMA CLAVATUM				6	4
GOMPHONEMA GRACILE			5	8	
GOMPHONEMA INSIGNE	2		2		
GOMPHONEMA INTRICATUM V VIBRIO		66	16		11
GOMPHONEMA MCLAUGHLINII	2	15	2		6
GOMPHONEMA MEXICANUM	6		1	3	
GOMPHONEMA MINUTUM			2	2	
GOMPHONEMA PARVULUM	109	11	8	60	2
GOMPHONEMA PUMILUM		4			
GOMPHONEMA RHOMBICUM	244	187	6	24	21
GOMPHONEMA TRUNCATUM				3	1
GOMPHONEMA VIBRIOIDES		8			
GOMPHOSPHENIA REICHELTII (G. GROVEII)		2			
GYROSIGMA NODIFERUM	11			2	14
GYROSIGMA NODOSA	1				1
KOBAYASIELLA SUBTILISSIMA					24
LUTICOLA MUTICA					2
MASTOGLOIA ELLIPTICA	1	15			
MASTOGLOIA SMITHII		25	1	6	
MASTOGLOIA SMITHII V LACUSTRIS		166	2	22	
MELOSIRA LINEATA	3			2	
MELOSIRA SP 100	2				
MELOSIRA VARIANS	4			3	6
MERIDION CIRCULARE	14			14	
NAVICULA ANTONII			12		
NAVICULA ATOMUS	5				
NAVICULA CRYPTOCEPHALA	3	14	6	20	5

GENUS SPECIES	151	349	350	920	1164
NAVICULA CRYPTOTENELLA	11	7	79	134	33
NAVICULA ERIFUGA		4		1	2
NAVICULA INGENUA	1	1			
NAVICULA KOTSCHYI	10	5	15	125	41
NAVICULA LANCEOLATA V PHYLLEPTA	2		16	63	12
NAVICULA LEPTOSTRIATA		4			
NAVICULA LIBONENSIS				2	
NAVICULA MENISCULUS	12		9	20	4
NAVICULA MINIMA	5	10	8	4	2
NAVICULA PSEUDOARVENSIS	1				
NAVICULA PSEUDOBRYOPHILA		1			
NAVICULA RADIOSA	68	95	13	47	36
NAVICULA RECENS	1	2	2	3	3
NAVICULA SALINICOLA			27	10	
NAVICULA SANCTAECRUCIS				2	
NAVICULA SCHROETERII					4
NAVICULA SP. 101				1	
NAVICULA SP. 102				4	
NAVICULA STROEMII	15	23	44	156	41
NAVICULA SUBMINISCULA	1	1		12	
NAVICULA SUBRHYNCHOCEPHALA				1	
NAVICULA SYMMETRICA	1				
NAVICULA TENELLOIDES	3				
NAVICULA TRIDENTULA				2	
NAVICULA TRIPUNCTATA	49	2	1	52	1
NAVICULA VENETA	13	4	4	28	6
NAVICULA VIRIDULA	4	1			
NAVICULA VIRIDULA V ROSTELLATA	2				
NITSCHIA LANCEOLATA V MINUTULA	3			1	
NITZSCHIA AMPHIBIA	52	106	81	144	60
NITZSCHIA AMPHIBIOIDES		35	22	14	37
NITZSCHIA CLAUSII	4				
NITZSCHIA DISSIPATA	19	1	8	148	8
NITZSCHIA FILIFORMIS			1		

GENUS SPECIES	151	349	350	920	1164
NITZSCHIA FONTICOLA	2				
NITZSCHIA FRUSTULUM	56	1	9	13	8
NITZSCHIA GRACILIS				1	
NITZSCHIA INCONSPICUA	146	1	42	49	4
NITZSCHIA LINEARIS			2	4	2
NITZSCHIA MICROCEPHALA	19		10	7	7
NITZSCHIA PALEA	7		12	26	6
NITZSCHIA PUMILA			2		
NITZSCHIA RECTA				1	
NITZSCHIA SERPENTIRAPHE		4			
NITZSCHIA SOLITA			1		
NITZSCHIA SP. 100					1
NITZSCHIA TROPICA	3	4	2		1
PACHYDIPLAX LONGIPENNIS	2				
PINNULARIA GIBBA		4			
PINNULARIA MICROSTAURON		4		2	
PINNULARIA VIRIDIS		2			
PLEUROSIGMA SALINARUM	1			2	
PLEUROSIRA LAEVIS	9				
PSAMMOTHIDIUM SUBATOMOIDES	7	8		1	4
REIMERIA SINUATA	57		11	8	
RHOICOSPHENIA CURVATA	45		8	44	
RHOPALODIA BREBISSONII	1				
RHOPALODIA GIBBA	2	19	8	8	2
SELLAPHORA LAEVISSIMA			2	28	11
SELLAPHORA PUPULA	1	3		13	4
SELLAPHORA RECTANGULARIS					2
SELLAPHORA SEMINULUM			2		
STAURONEIS SMITHII					2
STAUROSIRA CONSTRUENS			3		
STAUROSIRELLA PINNATA	2			1	
SURIRELLA ANGUSTA	1				
SURIRELLA BIFRONS					3
SURIRELLA BREBISSONII	2			1	

GENUS SPECIES	151	349	350	920	1164
SURIRELLA OVALIS	1				
SYNEDRA NANA		12	5	16	
SYNEDRA ULNA	26	202	38	76	158
TERPSINOE MUSICA	12				
THALASSIOSIRA WEISSFLOGII					2
TRYBLIONELLA APICULATA	4	1		2	3