Barton Creek Update Report 2010

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Abstract: *Barton Creek ranks 9th in overall health out of all sampled creeks in the City of Austin. Located in the environmentally sensitive Edwards Aquifer recharge and contributing zone, development has been minimized through regulations and preserves resulting in Barton Creek more closely representing a rural system. This report culminates 18 years of comprehensive water quality and ecological data collection in the watershed, characterizing the overall water quality of Barton Creek and evaluating impacts from urbanization. Spatial variation between sites was minimal while temporal patterns reveal a positive shift in water quality over time, suggesting that watersheds with increasing urbanization can maintain relatively good water quality, if certain levels of protection are provided. However, concentrations of certain pollutants continue to increase at Barton Springs, indicating that other factors than surface stream recharge are influencing groundwater quality.*

Introduction

The Barton Creek watershed is the largest contributor to Lady Bird Lake comprising a drainage area of 120 square miles. The karst topographic features along its 49.5 mile length provide 8 square miles drainage to the Edwards Aquifer Recharge Zone and 112 square miles to its contributing zone. Barton Springs, the discharge point of the Edwards Aquifer, is home to the endangered Barton Springs salamander and provides recreation opportunities to hundreds of thousands of swimmers annually. To preserve the water quality of Barton Springs and mitigate the influences of urban creeks on Lady Bird Lake, development on Barton Creek has been minimized through the Save our Springs ordinance and the formation of the City of Austin's longest greenbelt trail system starting in Zilker Park and running along the lower section of Barton Creek. As a result of these protections, the watershed more closely represents a rural system with an impervious cover of 6.1%.

In 1987 Austin City Council passed a resolution directing the Department of Environmental Protection to conduct a "full scale review and analysis of the Barton Creek Watershed" (COA, 1988). According to the 1988 Barton Creek Policy Definition Report it was a primary goal for the Austin community "to maintain existing surface water quality in Barton Creek, its tributaries, and pools" and to monitor the creek to discern changing conditions attributed to urban development.

In 1990, ERM initiated a long term, comprehensive water quality and ecological study of the Barton Creek mainstem to determine baseline water quality status. Physical, chemical and biological parameters were monitored to characterize the overall water quality of Barton Creek and to evaluate the impacts from urbanization. Initial results indicated that among the nine perennial pools studied from 1990 to 1995 the lower three, all below Barton Creek Blvd., were all significantly impacted by either elevated nitrates, total dissolved solids (TDS), total suspended solids (TSS), turbidity, or algal growth (COA 1997). Spatial trends were localized and did not coincide with any temporal shifts (COA 1997). Currently, data used in this report represents 18 years of monitoring by ERM staff, defining spatial and temporal trends along Barton Creek and developing relationships between land use and water quality.

Site Description and Selection

Barton Creek flows from the headwaters in Hays County near Dripping Springs to the mouth at Lady Bird Lake in Downtown Austin (Figure 1). Currently (2006 land use data), 32% of the Barton Creek watershed is developed: 25% residential, 2% business, 1% civic, and 4% roadways (Table 1). Undeveloped land consists predominantly of agriculture (33%) and open space (24%), which is mix of protected preserve, parks, golf courses and campgrounds.

Stark Pool (#44) is the most upstream site, located 44 stream miles above the mouth, draining an area of approximately 6 square miles. Land use within this tributary's reach is predominantly agriculture (61%) with an overall impervious cover of 2.9%.

Shield Ranch Pool (#46) is 27 miles upstream of the mouth with an intervening drainage area to Stark Pool of 65square miles. Land use in this reach is predominantly agriculture (39%) with an overall impervious cover of 3.7%.

Highway 71 Pool (#48) is located 21 stream miles from Barton's mouth, just downstream of the confluence with Little Barton Creek and upstream of the Highway 71 Bridge with a drainage area of 90 square miles. Land use within this reach is predominantly protected open space/ preserve with an overall impervious cover of 6.2%, which is primarily from the town of Bee Caves via the Little Barton Creek tributary.

Leif Johnson Pool (#50) is located 11 stream miles upstream of the creek mouth draining an area of 101 square miles. Land use within this reach is a mix of protected open space/preserve and residential development with an overall impervious cover of 10.4%.

Lost Creek pool (#51) is located nine stream miles from the Barton Creek mouth draining an area of 108 square miles. Land use within this tributary's reach is a mix of protected open space/preserve and residential development with an overall impervious cover of 10.4%.

Above Barton pool (#879) is located 1/4 mile upstream of the Barton Creek mouth draining almost the entire 120 square miles of Barton Creek. Land use within this is a mix of protected open space/ preserve, streets, and residential development with an overall impervious cover of 25.8%.

Sites are selected based on several factors:

- Drainage area and representation of targeted land uses;
- Road crossings and public greenbelt areas with access to the creek;
- Pools within riffle/ run/ pool series on the main stem of Barton Creek likely to be perennial for long term water quality sampling;

- Riffles used as the primary physical unit required for the bioassessment methods. Comparable riffles were selected based on substrate size, dimensions and amount of appropriate cover.

Table 1. Land use distribution among the 6 primary sampling sites on Barton Creek, including a summary of cumulative impervious cover. Dominant land use is highlighted bold

Description	Bar 6	Bar 5	Bar 4	Bar 3	Bar 2	Bar 1	Totals
Single Family/Duplex	6%	15%	14%	18%	24%	16%	15%
Mobile Homes	2%	2%	0%	0%	0%	0%	1%
Large-lot Single Family	20%	8%	6%	4%	2%	0%	8%
Multi-family	0%	0%	0%	1%	3%	7%	1%
Commercial	0%	0%	1%	0%	1%	9%	1%
Office	0%	0%	0%	1%	1%	8%	1%
Industrial	0%	0%	1%	0%	0%	0%	0%
Mining	0%	0%	0%	0%	0%	0%	0%
Civic	0%	0%	0%	3%	3%	2%	1%
Open Space	0%	22%	**54%**	**52%**	**33%**	**26%**	**24%**
Transportation	0%	0%	0%	0%	0%	0%	0%
Streets and Roads	2%	3%	2%	5%	6%	20%	4%
Utilities	0%	0%	0%	0%	0%	0%	0%
Undeveloped	9%	11%	12%	10%	12%	8%	11%
Agriculture	**61%**	**39%**	9%	6%	16%	2%	**33%**
Water	0%	0%	0%	0%	0%	0%	0%
Impervious Cover	2.9%	3.7%	6.2%	6.8%	10.4%	25.8%	6.1%

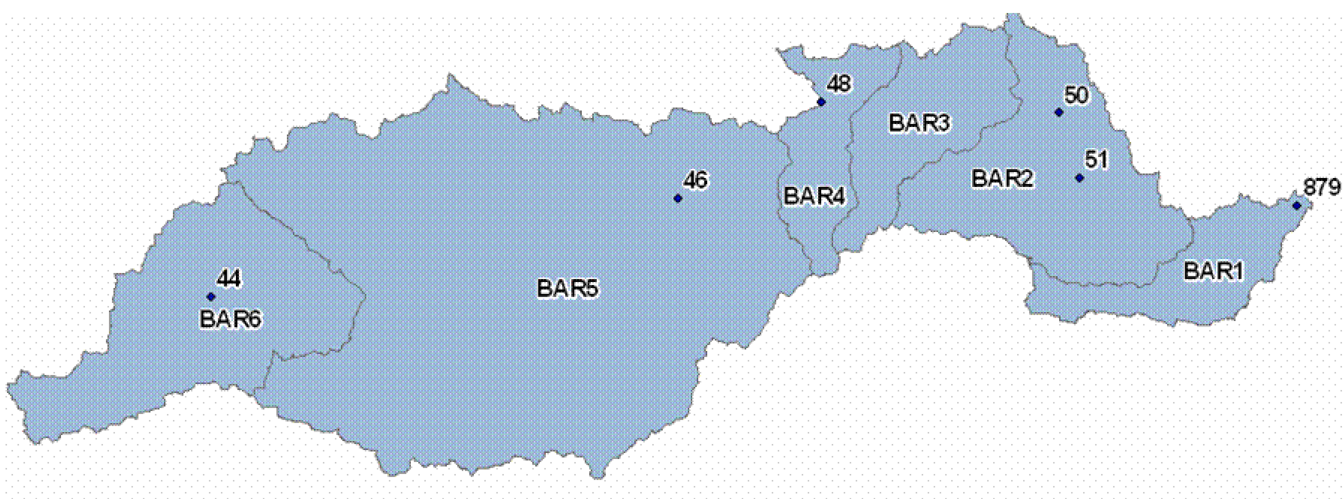


Figure 1. Barton Creek watershed reaches and primary sampling locations. Upper most site is Stark Pool (#44), followed by Shield Ranch Pool (#46), Highway 71 Pool (#48), Leif Johnson Pool (#50), Lost Creek pool (#51) and Above Barton pool (#879).

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 and compared to Barton Creek. The EII score is a combination of a water quality, sediment, contact recreation, non-contact recreation, physical integrity, aquatic life, algae cover, benthic macroinvertebrate and diatom, community scores. Watersheds were not sampled for EII every year and varied in the sampling between 2006 to 2008 depending on the subwatershed. Scores were ranked, compared between watersheds, and placed in categories. EII scores range from 0 to 100 and are grouped into the following narrative 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

A visual habitat survey (EPA Habitat Quality Index, Barbour et al 1999) was conducted from 1999 to 2009 and 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 were 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).

Water Quality Monitoring

Water quality monitoring was conducted from 1990 to 2009 and several parameters were not tested for the entire study period. 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 coliforms, magnesium, nitrate/nitrite, orthophosphorus, pH, phosphorus, potassium, sodium, sulfate, total kjeldahl nitrogen, total suspended solids, turbidity, and water temperature.

Biological Monitoring

Benthic macroinvertebrates and Diatoms were collected 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). Analyses were performed and metrics calculated for the benthic macroinvertebrate and diatom data collected between 1994 and 2008 on Barton Creek.

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 physiochemical impairments that negatively affect these orders increase. Taxa belonging to these orders are considered to be pollution sensitive (Barbour 1999).

Percent of total benthic organisms as Chironomidae (midges) calculates the ratio of the number of individuals in the family Chironomidae to the total number of organisms in the sample (N) * 100. Chironomidae are typically considered to be pollution tolerant and are ubiquitous across aquatic habitats. An increase of Chironomidae within a community often reflects environmental perturbation (Barbour 1999).

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 (Barbour 1999).

Hilsenfhoff biotic index (HBI) ranks water quality classifications and degree of organic pollution based on the pollution tolerance of benthic macroinvertebrates.

Biotic Index	**Water Quality**	**Degree of organic pollution**
0.00-3.50	Excellent	No apparent organic pollution
3.51-4.50	Very Good	Possible slight organic pollution
4.51-5.50	Good	Some organic pollution
5.51-6.50	Fair	Fairly significant organic pollution
6.51-7.50	Fairly poor	Significant organic pollution
7.51-8.50	Poor	Very significant organic pollution
8.51-10.0	Very poor	Severe organic pollution

TCEQ qualitative aquatic life use (ALU) score compiles 12 metrics: taxa richness, EPT richness, Hilsenfhoff 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 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, and Geisselaria genera asa 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 the difference among means 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 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.

Temporal Analysis

Normally distributed water quality, benthic macroinvertebrate, and diatom data were analyzed for temporal trends using least squares regression with the PROC REG procedure in SAS, while non-normally distributed data were 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 were set to 0.1 for temporal analysis.

Results & Discussion

Overview of Barton Creek Watershed

Barton 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. Barton Creek was most recently evaluated in 2006 when it scored 9th out of all creeks sampled for overall watershed EII score (Figure 2).

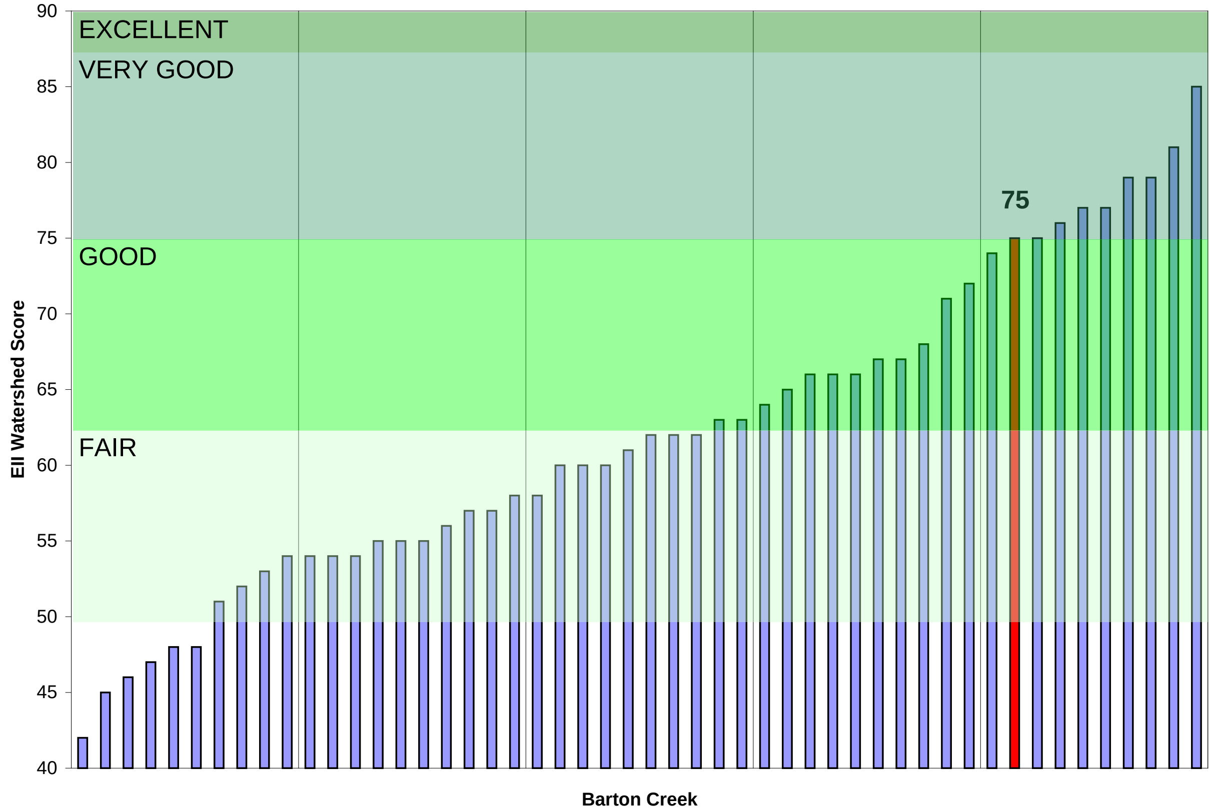


Figure 2. 2006 EII watershed scores for all watersheds, with Barton Creek in red.

Physical Habitat Overview

The EPA's visually based Habitat Quality Index (HQI) scored all Barton Creek sites in the sub-optimal to optimal range over the sampling period of 1999-2009 (Figure 3). Stark pool and above pool are the only location that continually scored in the suboptimal range. In addition to the HQI, intensive habitat surveys (WRE SOP section 6.5) were conducted once a year from 2005-2008 to understand spatial variation among study sites and for interpretation of biological data. There were no major differences in canopy cover, instream cover and the amount of large and small woody debris between sampling sites. Notable differences were narrower bankfull width at Stark and Above pool, increased frequency of undercut banks at Stark pool, a decreasing amount of roots downstream of Hwy 71, and a high concentration of terrestrial vegetation at Hwy 71, Leif Johnson, and Above pool sites. Bed substrate size, as measured using a 100 point pebble count, was dominated by coarse gravel to large cobble (22-180mm) at all sampling locations except the Leif Johnson and Above Pool sites which consisted mostly of gravel (11-64mm).

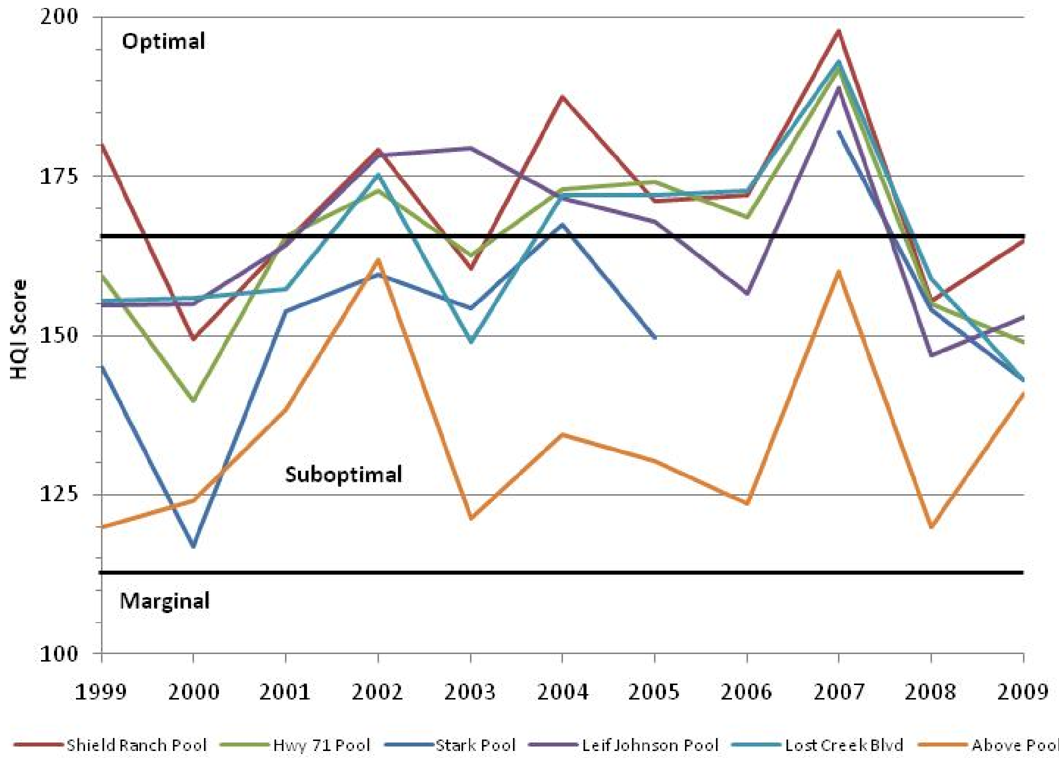


Figure 3. Habitat Quality Index (HQI) scores for Barton Creek sites (1997-2008).

Water Chemistry Spatial Trends

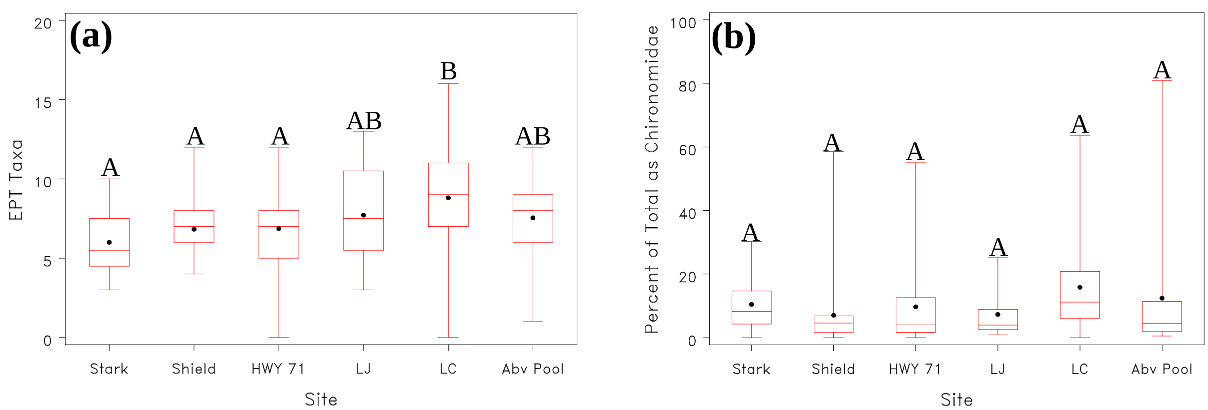
There were significant spatial differences in chloride, conductivity, dissolved oxygen (DO), nitrate, pH, sulfate, temperature and total suspended solids (TSS) among sampling sites on Barton Creek (Table 1). However, when compared to other creeks monitored by the City of Austin these differences are small, well within normal limits, and may not be ecologically relevant. As expected, fluctuations in conductivity between Barton Creek sampling sites correlated to increases in chloride and sulfate ions (Table 1) with no distinct geographical patterns. Sulfate levels at Lost Creek pool pose a potential risk as they exceed the Texas Commission on Environmental Quality (TCEQ) maximum annual average of 50 (mg/L) (TCEQ 2009a). Sulfate contamination has been linked to changes in native plant communities, increases in the concentration of methylmercury (although no COA data on Barton Creek indicate this constituent is elevated), sulfur-reducing bacteria, and lower redox conditions (Orem 2004). Measurements of dissolved oxygen showed slight differences among sites (Table 1) but all mean values exceeded the Texas Commission on Environmental Quality (TCEQ) minimum 24-hour average dissolved oxygen level of 5mg/L (TCEQ 2009a). pH values varied (Table 1) but all sites were within the TCEQ surface water standards range for receiving bodies of Lady Bird Lake, of 6.5-9.0 (TCEQ 2009a). Changes in temperature between sites can be a result of time of sampling and/or spring/groundwater influences. The variations in total suspended solid concentrations are localized with no distinct patterns and could be linked to differences in land use between the Barton Creek reaches. In general, the water chemistry data showed minimal differences among study sites.

Table 1. Mean ± Standard Deviation for parameters collected at Barton Creek study sites ranging from 1990-2008. Same superscript letters indicate no significant differences among study sites.

Parameter	Stark	Shield	HWY 71	LJ	Lost Cr.	Abv. Barton
Chloride (mg/L)	18.2 ± 1.5^{A}	30.0 ± 10.3^{BC}	25.1 ± 8.1^{B}	30.8 ± 4.8^{BC}	39.4 ± 19.4^{C}	26.9 ± 5.3^{B}
Conductivity (µS/cm)	590 ± 79^{BC}	560 ± 71^{AB}	542 ± 69^{A}	598 ± 92^{BC}	635 ± 120^{C}	597 ± 61^{AB}
Discharge (cfs)	1.6 ± 2.4^{A}	19.5 ± 27.7^{A}	28.4 ± 45.9^{A}	30.7 ± 48.2^{A}	33.9 ± 59.0^{A}	21.6 ± 37.2^{A}
DO (mg/L)	8.1 ± 2.1^{AB}	8.3 ± 2.0^{AB}	8.0 ± 1.8^{A}	8.5 ± 2.1^{AB}	8.1 ± 1.9^{A}	9.2 ± 1.9^{B}
E Coli (MPN/100mL)	90 ± 75^{A}	56 ± 56^{A}	100 ± 207^{A}	17 ± 16^{A}	48 ± 80^{A}	49 ± 35^{A}
Nitrate (mg/L)	0.06 ± 0.03^{A}	0.15 ± 0.04^{A}	0.12 ± 0.03^{A}	0.16 ± 0.03^{A}	0.19 ± 0.02^{A}	0.82 ± 0.12^{B}
Orthophosphate (mg/L)	0.02 ± 0.0^{A}	0.04 ± 0.0^{A}	0.01 ± 0.0^{A}	0.01 ± 0.0^{A}	0.01 ± 0.0^{A}	0.01 ± 0.0^{A}
pH	7.6 ± 0.4^{AB}	7.8 ± 0.4^{B}	7.9 ± 0.3^{C}	7.8 ± 0.4^{B}	7.8 ± 0.3^{B}	7.5 ± 0.3^{A}
Sulfate (mg/L)	46.2 ± 9.2^{AB}	46.8 ± 16.2^{AB}	36.4 ± 13.1^{A}	46.5 ± 5.5^{AB}	51.1 ± 24.2^{B}	39.1 ± 12.3^{A}
TKN (mg/L)	0.24 ± 0.03^{A}	0.23 ± 0.04^{A}	0.16 ± 0.01^{A}	0.19 ± 0.02^{A}	0.20 ± 0.01^{A}	0.25 ± 0.07^{A}
TSS (mg/L)	1.5 ± 0.3^{AB}	1.0 ± 0.2^{A}	2.1 ± 0.3^{BC}	2.2 ± 0.4^{AB}	2.6 ± 0.4^{C}	2.0 ± 0.4^{ABC}
Temperature (°C)	19.2 ± 6.1^{AB}	21.2 ± 7.0^{AB}	21.0 ± 6.6^{A}	21.5 ± 7.0^{AB}	21.2 ± 6.7^{B}	24.0 ± 5.3^{A}

Benthic Macroinvertebrate Spatial Differences

There were few spatial differences in the distribution of benthic macroinvertebrate taxa among sampling sites (Figure 4). The high, consistent number of environmentally sensitive EPT taxa (Figure 4a) coupled with the low percentage of pollution tolerant chironomidae species indicate low environmental impairment and overall good water quality (Barbour 1999). Number of taxa at study sites was relatively similar, with slight increases at the downstream sites (Lost Creek and Above Pool) (Figure 4c). Analysis of the TCEQ qualitative aquatic life use score (ALU) found slight variations between sites with mean scores falling in the intermediate and excellent ranges (28-3) and a reange from from limited to excellent (Figure 4d). In general, the benthic macroinvertebrate measures showed minimal differences among study sites.



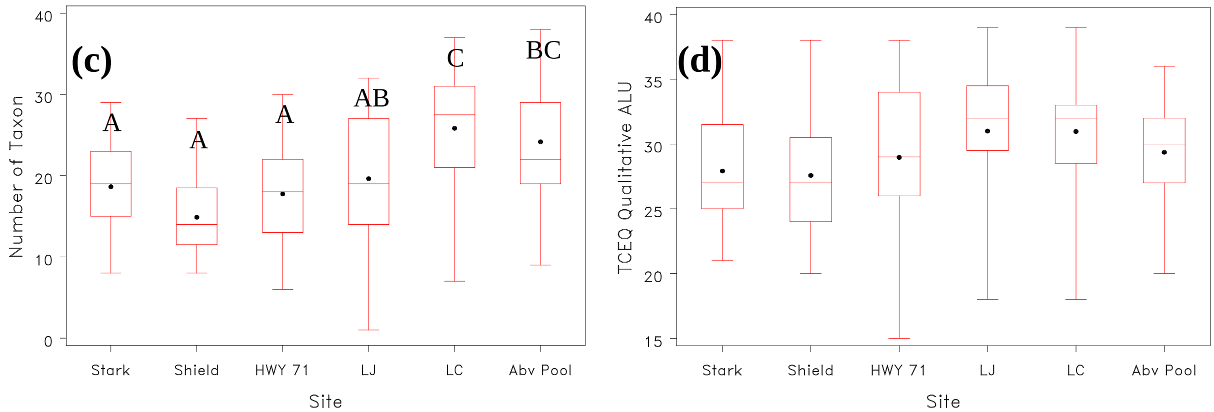


Figure 4. Benthic macroinvertebrate metrics scores at 6 study sites during sampling period: EPT Taxa, (a), Percent Chironomidae (b), Number of Taxa (c), and TCEQ qualitative aquatic life use score (d). Dots within the boxes indicate means, the lines inside the box are medians, boxes indicate 25th and 75th percentile of range, and dots outside the boxes are 1.5 times the interquartile range. Each letter corresponds to a group of sites with no statistical difference among means.

Diatom Sampling Spatial Differences

There were no significant differences in Barton Creek diatom populations between sampling sites (Figure 5). The relatively high number of cymbelloid taxa (Figure 5a) and pollution intolerant taxa (Figure 5b) combined with the low percentage of motile taxa (Figure 5c) indicates low environmental perturbation and overall good ecological health. The ability of Barton Creek to support a diatom community consisting largely of environmental sensitive taxa despite increasing watershed development provides some evidence that the programs, regulations, and projects of the City and others have been effective. .

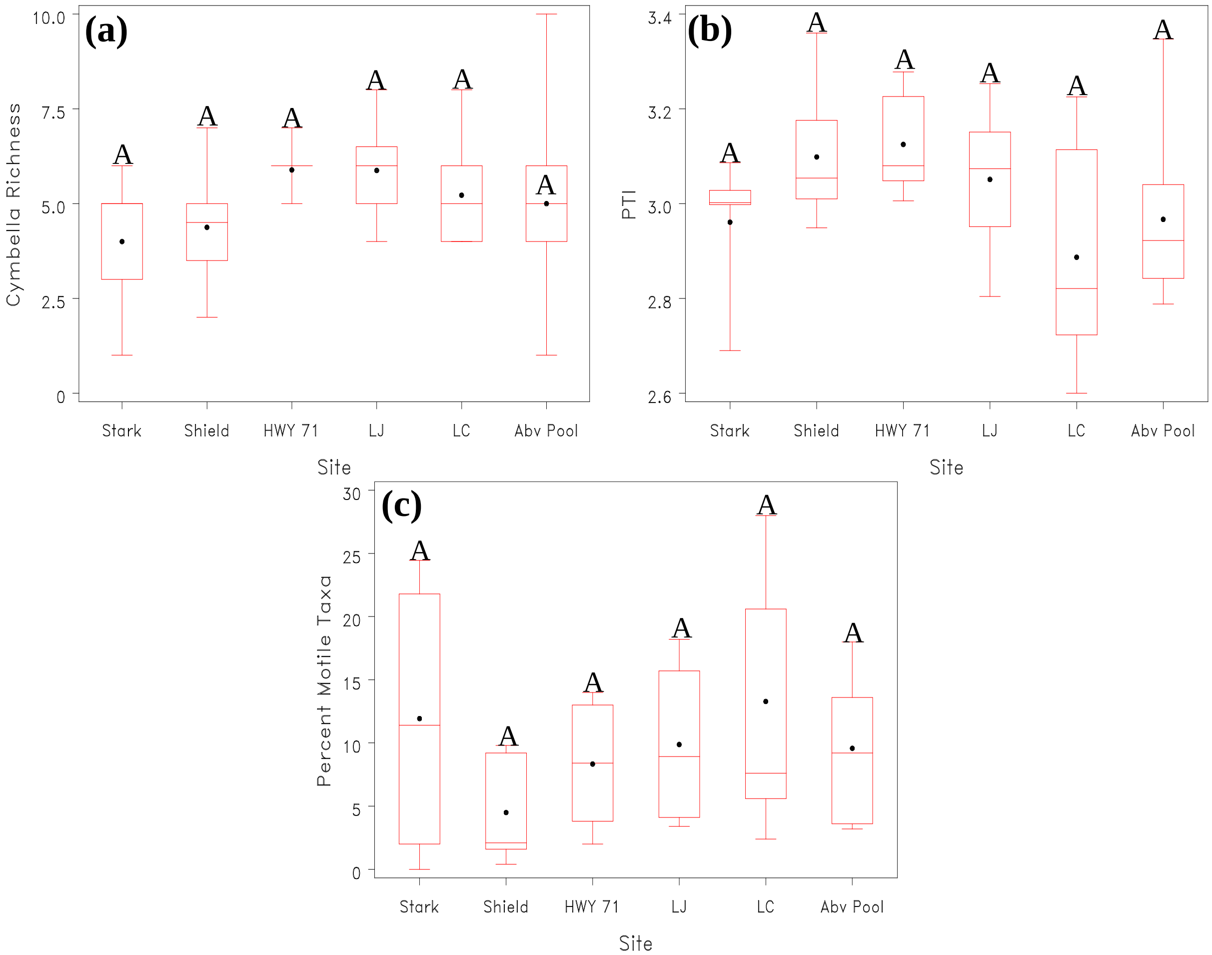


Figure 5. Distribution of diatom community metrics from 6 Barton Creek sites during study period: Cymbella Richness (a), Pollution Tolerance Index (b), and Percent Motile Taxa (c). Dots within the boxes indicate means, the lines inside the box are medians, boxes indicate 25th and 75th percentile of range, and dots outside the boxes are 1.5 times the interquartile range. Same letters indicate no statistical difference.

Water Quality and Benthic Macroinvertebrate Temporal Trends

Contrary to the rising urbanization pressure on City of Austin waterways, temporal trends of water quality and benthic macroinvertebrate in Barton Creek are positive over the past 18 years. Improvement in the macroinvertebrate community is seen at every sampling site (Figure 6-10). Macroinvertebrate assemblages are good indicators of environmental variation and reflect overall ecological integrity of an aquatic system (Barbour *et al*. 1999). Stark, Shield Ranch, and HWY 71 pools have shown positive shifts in the hilsenhoff biotic index (HBI) (Figure 6b, 7b, 8b). A decrease in HBI often indicates a reduction in nonpoint source organic pollution corresponding to improvement of water quality parameters. Kilgour *et al*. (2004) have linked the HBI to effects associated with urbanization. In other words, the decreases in HBI at these sites indicate that any urbanization in those reaches is not negatively impacting the water quality of Barton Creek. This improvement in the macroinvertebrate community has occurred despite of the significant increase in conductivity (Figure 6a, 7a, 8a). Increases in specific conductance are correlated to urban land cover and have been found to negatively impact biotic integrity (Pond 2010) particularly the EPT taxa metric (Roy *et al*. 2003). Total Suspended Solids (TSS), another factor correlated with increasing urban land cover (Pond 2010), has decreased at the Leif Johnson pool site since 1990 (Figure 10a). The macroinvertebrate community has continued to improve at Leif Johnson, Lost Creek, and Above pool sites (Figure 9b and 10) despite the increases in urbanization, measured as percent impervious cover (Figure 1), downstream. These temporal trends in Barton Creek provide evidence that with proper management watersheds flowing through urban centers can support a diverse aquatic community. However, a decline in water quality is found at Barton Springs, indicating potential domination by Onion Creek recharge, increasing in aquifer pumping, and other sources of pollutants to the aquifer such as uplands recharge (City of Austin, 2000, 2005, 2010)

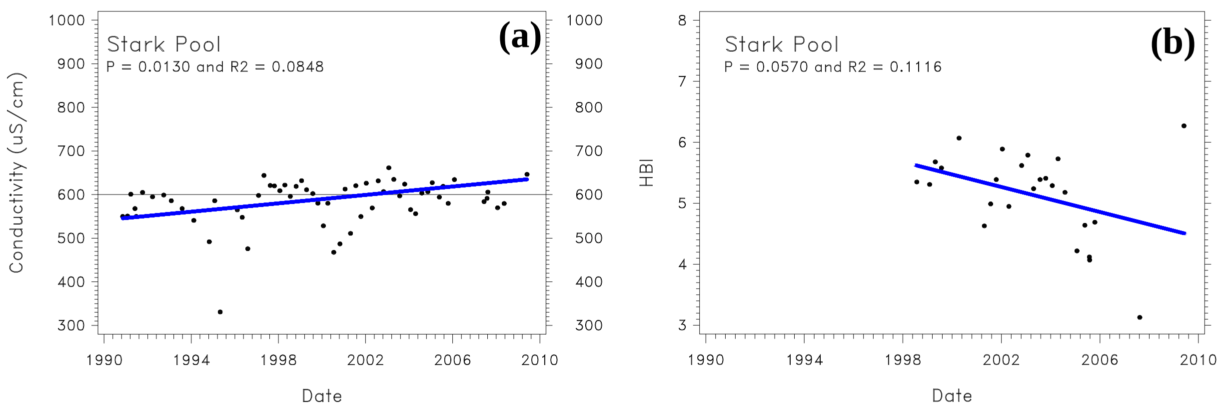


Figure 6. Regression analysis of Stark Pool at Barton Creek through study period: conductivity (a) and hilsenhoff biotic index (HBI) (b). Dots represent actual data points fitted with a trend line (α = 0.1).

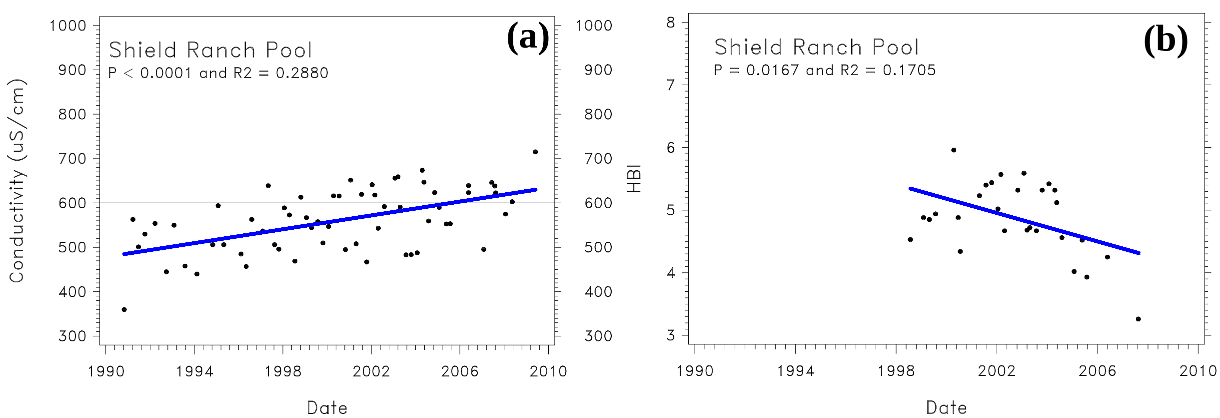


Figure 7. Regression analysis of Shield Ranch pool at Barton Creek through study period: conductivity (a) and hilsenhoff biotic index (HBI) (b). Dots represent actual data points fitted with a trend line (α = 0.1).

(a) **(b)**

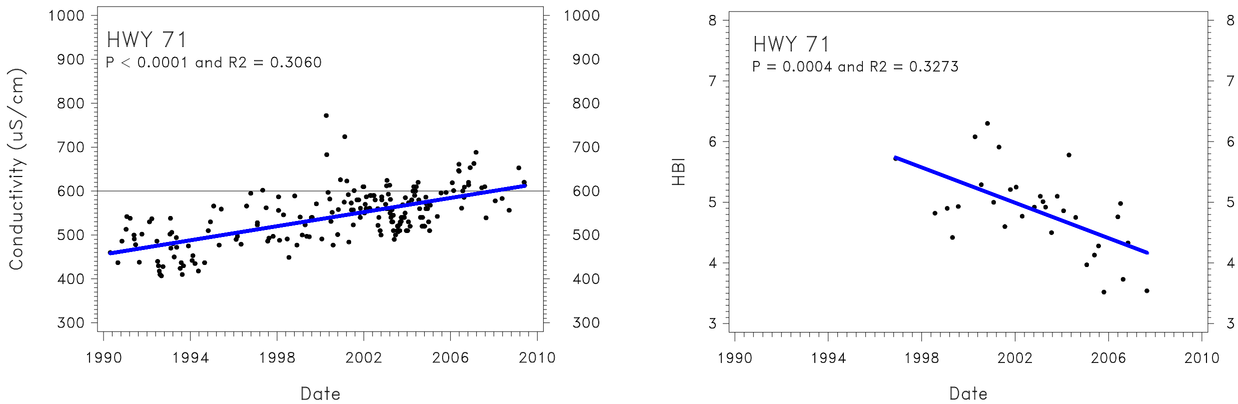


Figure 8. Regression analysis of HWY 71 Pool at Barton Creek through study period: conductivity (a) and hilsenhoff biotic index (HBI) (b). Dots represent actual data points fitted with a trend line (α = 0.1).

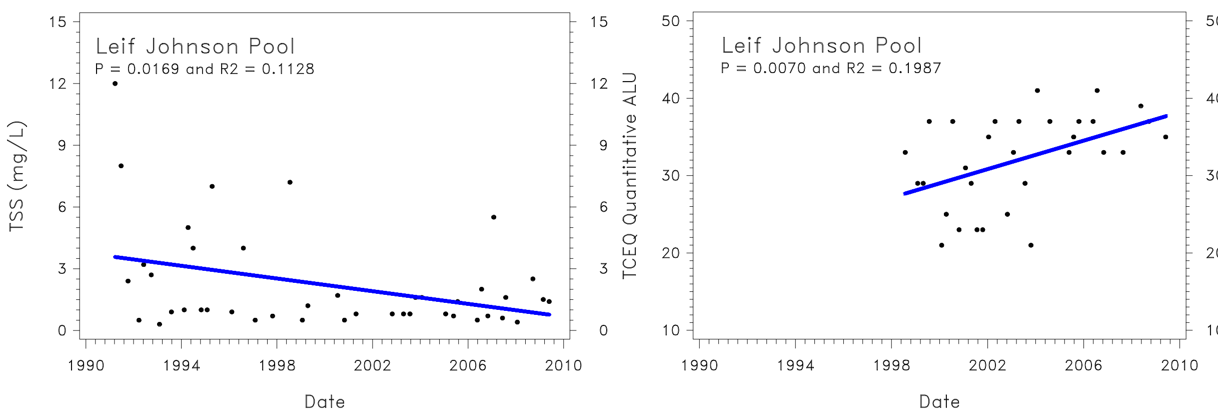


Figure 9. Regression analysis of Leif Johnson Pool at Barton Creek through study period: total suspended solids (TSS) (a) and TCEQ qualitative aquatic life use score (b). Dots represent actual data points fitted with a trend line (α = 0.1).

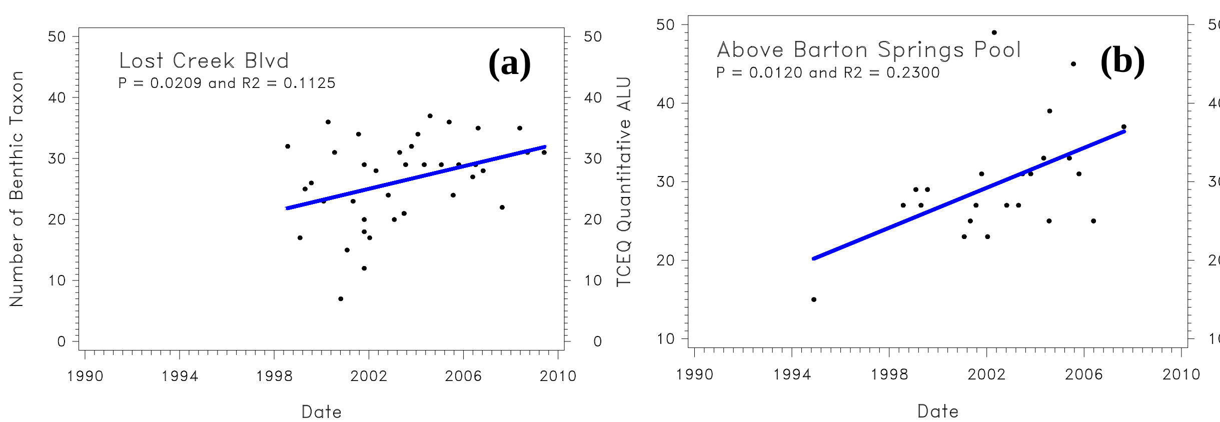


Figure 10. Regression analysis of number of benthic macroinvertebrate taxon at Lost Creek Pool (a) and TCEQ qualitative aquatic life use score at Above Pool (b) through study period. Dots represent actual data points fitted with a trend line (α = 0.1).

Summary

The following list summarizes the main conclusions from analyses performed for this study:

- Currently Barton Creek ranks ninth out of all sampled creeks in the City of Austin; however, temporal trends in the macroinvertebrate community over the past 18 years suggest improved water quality.
- The EPA's visually based Habitat Quality Index (HQI) scored all Barton Creek sites in the sub-optimal to optimal range.
- Differences in water chemistry parameters were slight and well within normal limits, suggesting minimal spatial differences between sampling sites on Barton Creek.
- Sulfate (SO_4^{2-}) levels at Lost Creek exceed the Texas Commission on Environmental Quality (TCEQ) maximum annual average of 50 (mg/L).
- Barton Creek diatom populations were stable consisting largely of environmentally sensitive taxa.
- Despite continued urbanization of the watershed, temporal trends in the macroinvertebrate community suggest improved water quality.
- Reductions in the HBI despite increasing conductivity coupled with increases in the TCEQ ALU and number of macroinvertebrate taxon demonstrate that a watershed flowing through urban areas can maintain the ecological integrity of its aquatic community.

Recommendations

- Continue monitoring changes to Barton 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 should continue to track long term trends both spatially and temporally.
- Investigate sources and impacts of elevated sulfate levels at Lost Creek; particularly in relation to native plant communities..
- Use Barton Creek as a reference ecosystem for planning of COA restoration projects, and later for their evaluation.
- Use results from these analyses to investigate sources of declines in Barton Springs water quality beyond Barton Creek surface water quality.
- Continue to collaborate with and support the Barton Springs Salamander research team to understand ecological implications of watershed changes in Barton Creek.

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