What are the potential water quality impacts of Barton Creek water entering Barton Springs Pool?

Chris Herrington, PE

City of Austin
Watershed Protection Department

April 2011
DR-11-01

Data Included

Parameters with data available at both Main Barton Springs (primarily site #35) and from Barton Creek above Barton Springs Pool (site # 879 and 53) and at least one detected value in Barton Creek were selected, yielding a total of 25 parameters for analysis. Data from other parameters were either all non-detect (no statistical basis for analysis) or had no matching data at the other site. Data collected by the USGS and the City of Austin (COA) available in the COA Field Sampling Database was used. Mean daily flow data was extracted from the USGS gages at Barton Springs (08155500) and Barton Creek Above Barton Springs Pool (08155400). No datasonde data exists for Barton Creek downstream of Lost Creek Blvd, although extensive datasonde data exists for Barton Springs.

Period of Record

Data was included from January 2005 to present (April 2011). This period provides sufficient data for statistical analyses reflecting likely current conditions and covers the last 2 full cycles of Barton Springs recession (Figure 1). Barton Creek above Barton Springs discharge is low and frequently dry, yielding no discharge for 38% of the 2005-present time frame and a median flow of 1 ft^3/s (Figure 2). Approximately 81% of the 2005-present time period yielded mean daily creek flows less than 40 ft^3/s. Some years do maintain sustained creek flows, as demonstrated in 2007 when annual median mean daily flow was 31 ft^3/s.

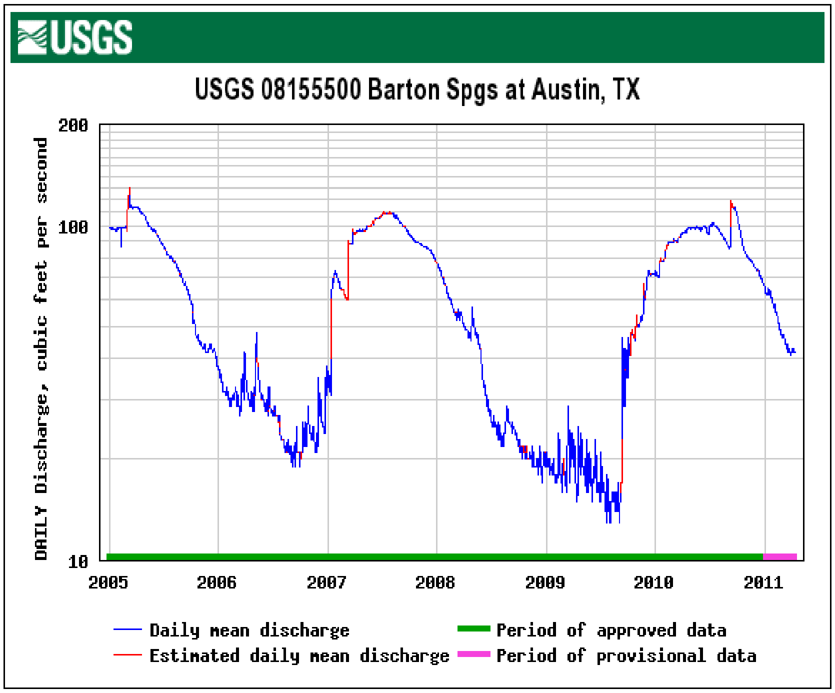

Figure 1. Barton Springs (08155500) mean daily flow data, January 2005 to present.

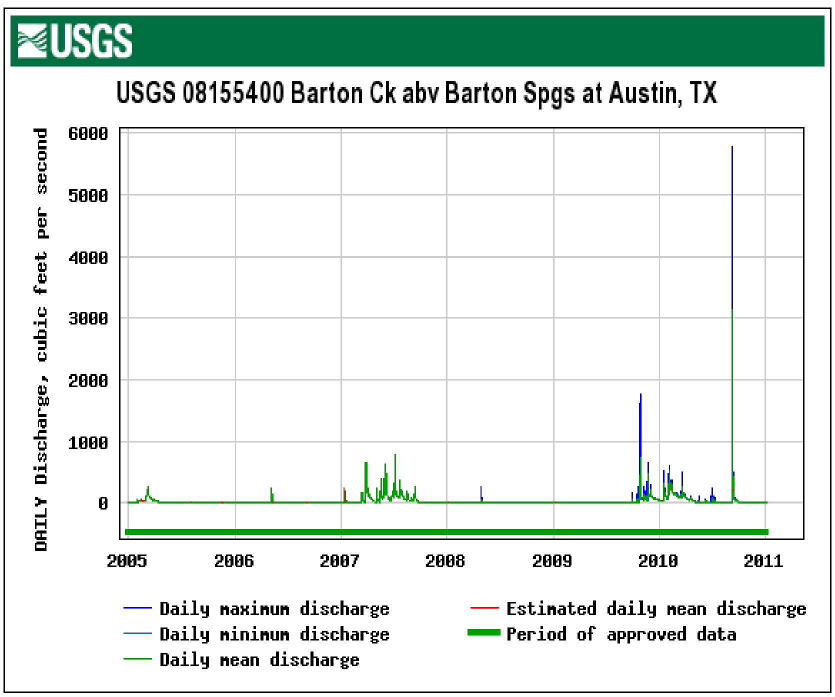

Figure 2. Barton Creek above Barton Springs (0815400) mean daily flow data, January 2005 to present.

Analysis Groups

Data were separated into groupings for statistical analysis. Some parameters (chloride, sulfate, conductivity) are known to be affected by variations in Barton Springs discharge (Johns 2006, Herrington and Hiers 2009), particularly at Barton Springs flows less than 40 ft^3/s. Using the flow type designation in the FSDB, storm or base flow conditions were identified. Six non-unique analysis groups were included in the analysis.

- Creek, non-storm
- Creek, storm
- Springs, non-storm all spring discharges
- Springs, storm all spring discharges
- Springs, non-storm discharges ≤ 40 ft^3/s
- Springs, storm discharges ≤ 40 ft^3/s

Results

Summary statistics, accounting for non-detect data points by Kaplan-Meier methods where appropriate, were calculated for each analysis group. Non-parametric multiple comparison testing (REGWQ) was conducted to test for significant differences ($\alpha \le 0.05$) between groups, again accounting for non-detect data by survival analysis methods. Groups with the same letter are not significantly different.

Alkalinity, mg/L as CaCO3

Alkalinity is significantly lower (up to 55%) in creek stormwater than average non-storm concentration in springs. There is no baseflow alkalinity measures in Barton Creek during non-storm conditions.

Group	N	Mean	Std	REGWQ
Creek, Storm	9	120.2	44.1	D
Spring, NonStorm	103	267.2	11.9	A
Spring, Storm	31	255.3	12.2	BC
Spring, LowBase	37	261.4	9.8	AB
Spring, LowStorm	8	251.3	8.7	C

Ammonia as N, mg/L

Ammonia is significantly higher in creek stormwater than any other condition.

Group	N	Mean	Std	REGWQ
Creek, NonStorm	14	0.035	0.049	A
Creek, Storm	8	0.055	0.042	B
Spring, NonStorm	177	0.016	0.01	A
Spring, Storm	30	0.021	0.01	A
Spring, LowBase	77	0.014	0.01	A
Spring, LowStorm	8	0.023	0.01	A

Conductivity, µS/cm

Conductivity was calculated using grab measurements. Conductivity is significantly lower in Barton Creek under all conditions. Conductivity is significantly higher in non-storm, low flow conditions at the springs versus all other conditions. Average conductivity from spring datasonde data for the 2005-present time period is generally consistent with grab samples although no attempt was made at baseflow separation in the datasonde data for this phase of the analysis. For all flows, average conductivity is 667 (+/- 29) µS/cm and for low flow only periods is 695 (+/- 18) µS/cm.

Group	N	Mean	Std	REGWQ
Creek, NonStorm	18	597.0	73.9	C
Creek, Storm	15	406.9	166.8	C
Spring, NonStorm	259	673.0	30.6	B

Spring, Storm	30	663.7	37.1	B
Spring, LowBase	125	694.0	22.8	A
Spring, LowStorm	7	653.9	54.3	B

Copper, µg/L
No baseflow copper samples from Barton Creek are available. Barton Creek copper concentrations are significantly higher than Barton Springs under all conditions, although Barton Creek stormwater concentrations are lower than any measured concentrations at the Nature Center Well, even after filtration (see Liza's draft report).

Group	N	Mean	Std	REGWQ
Creek, Storm	8	2.46	1.45	A
Spring, NonStorm	47	0.55	0.82	B
Spring, Storm	2	0.90	0.14	B
Spring, LowBase	17	0.31	0.29	B
Spring, LowStorm	1	0.80	.	B

Dissolved Oxygen, mg/L
There are no dissolved oxygen field measurements in Barton Creek stormwater, although DO in stormwater is not projected to be problematic due to turbulence. Field, grab measures of DO were used although Barton Springs datasonde average DO for all flow conditions 5.8 (+/- 0.9) mg/L, and low flows 4.8 (+/- 0.3) mg/L, were slightly higher than grab measures. Barton Creek yields significantly higher DO than Barton Springs under all conditions.

Group	N	Mean	Std	REGWQ
Creek, NonStorm	18	8.61	2.84	A
Spring, NonStorm	267	5.95	1.16	B
Spring, Storm	33	6.29	1.19	B
Spring, LowBase	127	5.15	0.92	C
Spring, LowStorm	8	4.66	0.44	C

E. coli bacteria, mpn/dL
No stormwater E. coli measures are available from Barton Creek although numbers are expected to be high and in excess of contact recreation standards during runoff events. Barton Springs should be closed during storm runoff events for safety. Creek non-storm conditions are not different from Barton Springs storm-influenced conditions.

Group	N	Mean	Std	REGWQ
Creek, NonStorm	14	52.3	42.0	A
Spring, NonStorm	79	22.2	40.7	B
Spring, Storm	30	217.9	448.6	A
Spring, LowBase	43	21.3	34.6	B
Spring, LowStorm	7	534.3	857.2	A

Iron, µg/L
There is extremely limited iron data from Barton Creek and only in stormwater. Despite a substantially higher concentration of iron in creek stormwater, there is no significant difference between conditions when accounting for censored observations by survival analysis methods. A Canadian review of iron toxicity concluded that concentrations of iron less than 1,000 µg/L are sufficient to protect aquatic life from detrimental effects (Phippen et al 2008).

Group	N	Mean	Std	REGWQ
Creek, Storm	2	662.5	233	A

Spring, NonStorm	45	23.53	57.4	A
Spring, Storm	2	92	67.9	A
Spring, LowBase	17	13.85	15.7	A
Spring, LowStorm	1	44	.	

Lead, µg/L
There is no baseflow data for lead in Barton Creek, and the majority of data in low flow conditions at Barton Springs are less than detection limits. Barton Creek stormwater concentrations are significantly higher than Barton Springs in all conditions. TCEQ screening criteria for dissolved lead chronic effects is 2 µg/L. Unfiltered samples for lead have been demonstrated to yield artificially high values because of acid-extraction from particulate matter by previous WPD experimentation in highly turbid samples. All creek samples are for total lead while samples from Barton Springs are mixed with both total and dissolved samples.

Group	N	Mean	Std	REGWQ
Creek, Storm	8	3.228	3.51	A
Spring, NonStorm	47	0.17	0.69	B
Spring, Storm	2	0.21	0.21	B
Spring, LowBase	17	0.08	.	B
Spring, LowStorm	1	0.06	.	B

Nitrate/Nitrite as N, mg/L
Barton Creek yields lower concentrations of nitrate/nitrite than Barton Springs, and is not significantly different under non-storm conditions.

Group	N	Mean	Std	REGWQ
Creek, NonStorm	13	0.93	0.73	B
Creek, Storm	8	0.52	0.17	C
Spring, NonStorm	184	1.40	0.14	B
Spring, Storm	30	1.56	0.11	A
Spring, LowBase	78	1.47	0.09	AB
Spring, LowStorm	8	1.56	0.17	A

Organic Carbon, mg/L
There is no organic carbon data available from Barton Creek during baseflow conditions, and limited data from Barton Springs during storm-influenced conditions. Barton Creek stormwater concentrations of organic carbon are significantly higher than Barton Springs under any condition.

Group	N	Mean	Std	REGWQ
Creek, Storm	8	7.98	3.78	A
Spring, NonStorm	47	1.14	1.71	B
Spring, Storm	2	6.00	6.08	B
Spring, LowBase	17	0.85	0.78	B
Spring, LowStorm	1	10.30	.	B

Orthophosphorus as P, mg/L
Barton Creek concentrations of orthophosphorus are not significantly different from Barton Springs except under low spring flow storm conditions, although Barton Creek stormwater is more variable than other analysis groups.

Group	N	Mean	Std	REGWQ
Creek, NonStorm	16	0.012	0.012	B

Creek, Storm	8	0.022	0.028	B
Spring, NonStorm	177	0.011	0.007	B
Spring, Storm	30	0.014	0.004	AB
Spring, LowBase	78	0.011	0.007	B
Spring, LowStorm	8	0.018	0.002	A

pH

Barton Creek pH is significantly higher than Barton Springs pH. Only instantaneous measures were included at Barton Springs in the analysis. Barton Springs datasondes yield generally consistent mean values for all data (7.079 +/- 0.1) and in low flow conditions (7.103 +/- 0.1).

Group	N	Mean	Std	REGWQ
Creek, NonStorm	18	7.558	0.24	A
Creek, Storm	7	7.814	0.21	A
Spring, NonStorm	282	7.048	0.34	BC
Spring, Storm	32	6.95	0.13	C
Spring, LowBase	130	7.107	0.18	C
Spring, LowStorm	8	6.95	0.22	B

Phosphorus as P, mg/L

Total phosphorus measurements are only available in Barton Creek during USGS-sampled storm conditions as WPD routinely measures orthophosphorus but not total phosphorus. Barton Creek total phosphorus concentrations are significantly higher than Barton Springs in all conditions.

Group	N	Mean	Std	REGWQ
Creek, Storm	16	0.072	0.07	A
Spring, NonStorm	101	0.010	0.01	B
Spring, Storm	60	0.010	0.01	B
Spring, LowBase	49	0.010	0.01	B
Spring, LowStorm	16	0.020	0.01	B

Sulfate, mg/L

There is only 1 creek sulfate measurement for the period of record, yielding a value of 30.8 mg/L. Barton Springs averages in non-storm conditions (36.3 mg/L +/- 7.0) and in non-storm low spring flows (39.3 mg/L +/- 2.6) are generally consistent.

Total Kjeldahl Nitrogen as N, mg/L

Barton Creek stormwater TKN values are significantly higher than Barton Springs in all conditions. No baseflow Barton Creek samples are available.

Group	N	Mean	Std	REGWQ
Creek, Storm	8	0.72	0.38	A
Spring, NonStorm	61	0.08	0.08	B
Spring, Storm	30	0.11	0.03	B
Spring, LowBase	29	0.05	0.05	B
Spring, LowStorm	8	0.10	0.03	B

Total Suspended Solids, mg/L

Barton Creek TSS is significantly higher in stormwater than any condition at Barton Springs. Low spring flow non-storm influenced conditions are worse than Barton Creek baseflow conditions.

Group	N	Mean	Std	REGWQ
Creek, NonStorm	14	2.23	2.03	B
Creek, Storm	15	78.40	76.81	A
Spring, NonStorm	280	1.28	1.34	B
Spring, Storm	32	4.80	8.15	B
Spring, LowBase	128	1.21	1.02	B
Spring, LowStorm	9	6.11	12.75	B

Turbidity (NTU)

No NTU turbidity measures during storm flow conditions are available from instantaneous data at either site. Barton Creek baseflow turbidity (NTU) is significantly higher than Barton Springs during non-storm conditions.

Group	N	Mean	Std	REGWQ
Creek, NonStorm	10	1.49	0.77	A
Spring, NonStorm	161	1.16	3.23	B
Spring, LowBase	68	0.45	0.56	B

Water Temperature, C

Temperature comparisons were made from instantaneous samples. There are no stormwater Barton Creek temperature measurements. Barton Creek baseflow conditions are not significantly different from Barton Springs under most conditions. Seasonal extremes for Barton Creek could be considered relative to Barton Springs with current data. Additional temperature predictions for Barton Creek, relative to seasonal climate shifts, could be extrapolated from correlation with local air temperature for comparison to Barton Springs datasonde data if there are significant temperature concerns.

Group	N	Mean	Std	REGWQ
Creek, NonStorm	18	23.94	6.06	AB
Spring, NonStorm	326	21.26	0.8	BC
Spring, Storm	35	20.34	1.53	C
Spring, LowBase	151	21.57	0.52	AB
Spring, LowStorm	8	21.68	0.13	A

Zinc, µg/L

There is no baseflow data for zinc, and very limited storm-influenced data for Barton Springs. Barton Creek stormwater yields significantly higher zinc than Barton Springs in all conditions. TCEQ screening criteria for chronic effects is 83 µg/L, and thus Barton Creek stormwater is not likely to be of concern.

Group	N	Mean	Std	REGWQ
Creek, Storm	8	11.94	8.60	A
Spring, NonStorm	47	2.28	3.50	B
Spring, Storm	2	1.50	0.71	B
Spring, LowBase	17	2.30	2.72	B
Spring, LowStorm	1	1.00	.	B

Results—Pesticides
Pesticides included in the assessment generally had very limited detected values and needed qualitative analyses. Of the 6 pesticides with data meeting the criteria, none appear likely to be problematic if Barton Creek flowed through Barton Springs pool based on a singular sample of Barton Creek stormwater from 2005. Imazaquin was detected at the highest concentration but is well below toxicity levels. Malathion was detected at a higher concentration in Barton Creek than in Barton Springs and is highly toxic, but detected values appear to be less than lowest available effects concentrations.

Imazaquin (Scepter):
- Imidazole herbicide with low toxicity to humans
- LC50 for rainbow trout is > 280,000 µg/L, and LC50 for *Daphnia magnia* is > 280,000 µg/L (EPA 1986).
- 17 samples from Barton Springs, all non-detect with typical detection limit < 0.04 µg/L.
- 1 sample from Barton Creek, a detected value of 0.95 µg/L from a storm in 2005.

Malathion
- General use organophosphate insecticide
- Malathion is highly toxic to insects (LC50 > 200 µg/L)
- 40 samples in Barton Springs, all non-detect with typical detection limit < 0.03 µg/L
- 1 sample from Barton Creek, a detected value of 0.29 µg/L from a storm in 2005.
- EPA safe drinking water lifetime health advisory is 100 µg/L
- *Xenopus* larva exhibited abnormal effects at malathion concentrations > 1,000 µg/L but not at 1 µg/L (Webb and Crain 2006). Malathion yielded no statistically significant effects on larva of *Rana palustris* at 15 µg/L (Budischak et al 2008).

Propoxur
- Carbamate insecticide
- Acute LC50 fish toxicity within 3,000-10,000 µg/L; *Daphnia magna* EC50 of 11 µg/L (EPA 1997)
- EPA safe drinking water lifetime health advisory is 3 µg/L.
- 16 samples in Barton Springs, all non-detect with detection limits ranging from <0.01 to 0.06 µg/L
- 1 sample from Barton Creek, a detected value in creek at 0.02 µg/L in a storm in 2005.

Atrazine
- Triazine herbicide
- 41 samples from Barton Springs with 10 non-detects (all LCRA lab with higher detection limits). Average detected value in Barton Springs = 0.033 µg/L (std dev = 0.059)
- 1 sample from Barton Creek, a detect of 0.02 µg/L from a storm in 2005.

Carbaryl (Sevin)
- General use carbamate insecticide
- 86 samples in Barton Springs, one detected value of 0.01 µg/L with detection limits varying from 0.01 to 1 µg/L.
- 1 sample from Barton Creek, a detect value of 0.015 µg/L from a storm in 2005

Sulfometuron-methyl

- General use urea herbicide
- LC50 in bluegill sunfish > 12,500 µg/L, but fathead minnow embryo hatch stage affected at 710 µg/L. *Daphnia magnia* LC50 is > 1,000,000 µg/L (EPA 1984).
- 17 samples in Barton Springs, all non-detect with detection limits typically 0.06 µg/L.
- 1 sample from Barton Creek, a detected value of 0.01 µg/L from a storm in 2005.

Conclusions

Maximum differences between Barton Creek and Barton Springs under any condition should be evaluated for biological relevance (see table 1). If the maximum difference in concentration has the potential for negative biologic impacts, then creek/spring mixing scenarios may be evaluated to determine if dilution will be sufficient to mitigate negative impacts.

Barton Creek is likely to improve conductivity, dissolved oxygen, and nitrate/nitrite concentrations in Barton Springs by conventional water quality assessment. Changes in alkalinity, copper, iron, organic carbon, orthophosphorus, pH, sulfate, turbidity and zinc are not likely to be biologically relevant given the magnitude of differences and comparison to available effect criteria. Barton Creek stormwater inputs of phosphorus could increase algal growth depending on the ultimate residence time of creek stormwater in Barton Springs Pool. Barton Creek supports human contact recreation during non-storm influenced conditions, although Barton Springs should be closed for safety during stormwater runoff events as creek concentrations are expected to be elevated. Water temperature may need to be re-evaluated for the specific conditions under which the project will be conducted for a more seasonally accurate comparison.

Ammonia, lead and TSS may need closer examination although significantly higher differences in these parameters are observed only during creek stormwater conditions. Barton Creek stormwater from large events enters the pool currently when the bypass capacity is exceeded.

Table 1. Maximum difference by constituent between average Barton Creek and average Barton Springs concentrations under any conditions. Highlight parameters indicate potential concerns although high creek concentrations are from storm-influenced conditions.

Parameter (unit)	Creek	Springs
Alkalinity (mg/L as CaCO3)	120.2	267.2
Ammonia as N (mg/L)	0.055	0.014
Conductivity (µS/cm)	406.9	694.0
Copper (µg/L)	2.46	0.31
Dissolved Oxygen (mg/L)	8.61	4.66
E. coli* (mpn/dL)	52.3	21.3
Iron (µg/L)	662.5	13.85
Lead (µg/L)	3.228	0.008
Nitrate/Nitrite as N (mg/L)	0.52	1.56
Organic Carbon (mg/L)	7.98	0.85
Orthophosphorus as P (mg/L)	0.022	0.011
pH	7.814	6.95
Phosphorus as P (mg/L)	0.072	0.010
Sulfate (mg/L)**	30.8	39.3
Kjeldahl Nitrogen as N (mg/L)	0.72	0.05
Suspended Solids (mg/L)	78.4	1.21
Turbidity (NTU)	1.49	0.45
Water Temperature (deg C)	23.94	20.34
Zinc (µg/L)	11.94	2.28

*Creek storm conditions would exceed contact recreation standards; difference reflects minimum average concentrations in springs.
**Only one measure in Barton Creek.

Pesticides are unlikely to be problematic based on the singular storm samples available from Barton Creek, although additional sampling is needed to confirm a lack concern especially for malathion given it's toxicity to aquatic invertebrates.

References

Budischak, S.A., and L.K. Belden, W.A. Hopkins. 2008. Effects of malathion on embryonic development and latent susceptibility to trematode parasites in ranid tadpoles. Environmental Toxicology and Chemistry 27(12): 2496-2500.

Johns, D. 2006. Effects of low spring discharge on water quality at Barton, Eliza and Old Mill Springs, Austin, Texas. City of Austin Watershed Protection and Development Review Department. SR-06-05. 15pp.

Herrington, C., and S. Hiers. 2009. Temporal Trend Analysis of Long-term Monitoring Data at Karst Springs, 2009. City of Austin Watershed Protection Department. SR-10-06. 43 pp.

Phippen, B., and C. Horvath, R. Nordin, N. Nagpal. Ministry of Environment Province of British Columbia Ambient Water Quality Guidelines for Iron. Prepared for Science and Information Branch, Water Stewardship Division, Ministry of Environment.

U.S. Environmental Protection Agency. March 20, 1986. Pesticide Fact Sheet Number: 83. US EPA, Office of Pesticide Programs, Registration Div., Washington, DC.

U.S. Environmental Protection Agency (EPA). 2007. Reregistration eligibility decision (RED): Propoxur. EPA738-R-97-009. 154 p.

U.S. Environmental Protection Agency. (1984). Oust Herbicide (Sulfometuron methyl). Environmental Effects Branch. Washington, D.C.

Webb, C.M., and D. A. Crain. 2006. Effects of ecologically relevant does of malathion on developing Xenopus laevis tadpoles. Bios 77(1): 1-6.