South Zilker Park Groundwater Tracing November 2013 and February 2014 Data Report DR-16-11

November 1, 2016

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Suggested Citation: Hauwert, N, and J. M. Sharp. 2016. South Zilker Park Groundwater Tracing November 2013 and February 2014: City of Austin Watershed Department Data Report DR-16-11,

South Zilker Park Groundwater Tracing November 2013 and February 2014

Executive Summary

Two traces were conducted from a creek site south Zilker Park, near the intersection of Robert E. Lee Road and Barton Hills Drive, in South Austin Texas, where upstream perennial spring flow from the Buda Limestone is lost in alluvial gravel deposits at the Little Zilker swallet just downstream of Robert E. Lee Road. Historically Little Zilker Creek flowed directly into Barton Springs pool, but was diverted along an artificial drainage into Barton Creek/Lady Bird Lake downstream of Old Mill Springs. The 240 m (800 ft) long portion that still potentially channels runoff into Barton Springs Pool is called South Zilker tributary in this report.

The initial trace in December 2013 injected only one pound of pyranine and was not detected at any monitoring site. Organic-rich sediment can sorb small masses of organic dyes like pyranine unless a sufficient mass of dye is used, and apparently the initial dye mass was insufficient. A follow up injection of 4 pounds of pyranine in February 2014 was impacted by an unforecast rain later that evening that flushed a portion of the dye through surface drainage to the Colorado River within 12 hours of injection. The rain had the positive effect of reactivating dried springs in South Zilker tributary where the tracer was recovered. The pyranine was not detected in receptors placed at Main Barton Springs, Eliza, Old Mill, or Upper Barton Springs. On April 14, 2014 the flow in South Zilker tributary was 62% of the 0.59 l/s (9.3 gal/min) that recharged from Little Zilker Creek into Little Zilker swallet. The South Zilker tributary spring flow is itself subsequently lost to the Georgetown Formation of the Edwards Aquifer and overlying alluvium within 60 m (200 ft) of Main Barton Springs and 44 feet higher than the pool elevation. It is assumed the tracer discharged from Barton Springs below the detection limit, although a follow up trace using a higher mass of pyranine or similar mass of a more conservative tracer would be needed for direct demonstration. These traces potentially provided an opportunity to examine local flow paths to Barton Springs and provide advance information in the case of an accidental spill in this area.

Background

Zilker Park, located in South Austin, Texas contains Barton Springs, a cluster of spring outlets including Main Barton Springs that discharges within a dammed pool in Barton Creek, Eliza Springs, Old Mill, and Upper Barton Springs. Differences in injected tracer breakthroughs and water quality between the various spring outlets show that the springs are derived from different sources or different combinations of sources along groundwater flow paths that converge in Zilker Park (Hauwert et al, 2004a, 2004b). The Colorado River or Lady Bird Lake is the regional base level for spring and creek discharge is north of and adjacent to Zilker Park, so the area of interest for shallow groundwater flow is relatively local.

Little Zilker Creek is located on the south side of Zilker Park and has perennial flow upstream of Robert E. Lee Road (Figure 1). The source of baseflow is Little Zilker Spring, which discharges from the Buda Limestone perched over the Del Rio Clay. This geological contact is about 18 to 21 m (60 to 70 ft) higher in elevation than the top of the Edwards Aquifer. Geological faulting in the area has caused the elevation of specific rock layers to vary across specific rock blocks. Spring and runoff generated flow in Little Zilker Creek has generally been observed to be completely lost a short distance after flowing beneath Robert E. Lee Road, just east of Barton Hills Drive. The swallet located just downstream of Robert E. Lee Road is generally capable of infiltrating the entire tributary flow, even under observed stormwater conditions. From April 30, 2013 through October 16, 2013, the discharge of Little Zilker Creek varied from 0.03 to 2.3 l/s (0.5 to 36 gal/min), based on flow measurements collected by UT student Marilyn Kohut and myself using a Marsh McBirney flow meter. Flood flows of the tributary result in higher discharge rates. A hand-dug well located about 30 m (100 ft) west of Little Zilker Spring apparently taps the same water source as the spring and at times discharges to Little Zilker Creek. On October 16, 2013, Marilyn Kohut measured that the flowing well and Little Zilker Spring together discharged at 1.8 l/s (28 gal/min.)

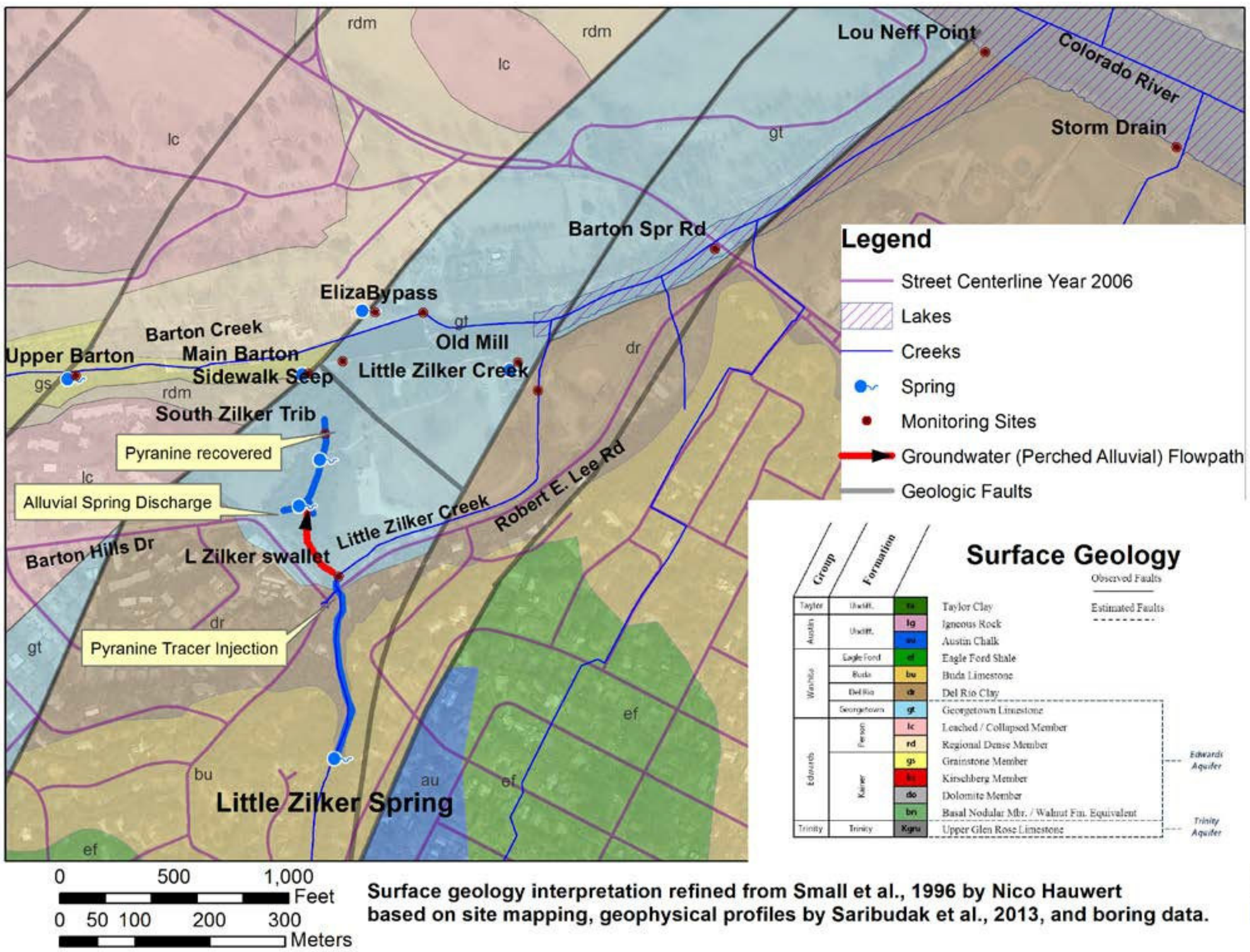

Figure 1. Zilker Park Trace Study Area, Surface Geology, Monitoring Sites, and Tracing Results

The creek referred to as "Little Zilker" in this report has experienced anthropogenic changes over time. On 1940 aerial photographs, Little Zilker Creek appears to flow directly into Barton Springs pool but was later artificially diverted downstream of Old Mill Springs. The swallet on Little Zilker Creek is located in the vicinity of the historical channel diversion. The un-named 200 m (650 feet)-long segment of the original creek that continues to drain into Barton Springs pool is informally identified as South Zilker tributary, for the purposes of this report. It has also been referred to as the "Diving Board Tributary." In the 1920's, a dam was constructed across Barton Creek to create Barton Springs pool. In 1960, Longhorn Dam was constructed creating Lady Bird Lake. Except for intervals where Lady Bird Lake water levels are lowered, the Colorado River water backs into Barton Creek as far upstream as Barton Springs Dam and into the bypass tunnel.

For the purposes of preparing for accidental spills over the Edwards Aquifer, it is advantageous to know the fate of the constant flow of Little Zilker Creek and local groundwater flow paths near Barton Springs. Towards this purpose, a geophysical survey of portions of Zilker Park was conducted by Dr. Mustafa Saribudak in 2010 (Saribudak et al., 2013). Dr. Saribudak found that natural potential anomalies, which are measured as electrical potential between two points, correspond with areas of focused groundwater flow. Direct groundwater tracing is a further step to connect recharge and discharge sites. The only previously known local dye trace injected in Zilker Park is a 61 m (200 feet) trace from an existing well (state well #58-49-903) to Main Barton Springs (Senger, 1983). The water within this Edwards Aquifer well is typically at a depth of about 7 m (23 ft). Perched alluvial groundwater can be seen discharging at an elevation slightly higher than the water table of the Edwards Aquifer within South Zilker tributary and sidewalk seeps south of Barton Springs pool.

Methods

Pyranine dye was selected for this trace. Pyranine has been shown safe for human ingestion and aquatic life at the concentrations range of less than 10 parts per billion (Smart, 1984; Field et al., 1995). Based on limited data, Aley (2002) reported that pyranine is less likely to be recovered on charcoal and extracted than sodium fluorescein, eosine, rhodamine wt or sulforhodamine b. Its detection limit is also one or two orders of magnitude higher than fluorescein or eosine. Because of background concentrations of the four primary dyes and the intention to reserve them for planned long-distance tracing, pyranine was selected for this trace.

A proposal for groundwater tracing was prepared by UT student Marilyn Kohut on October 3, 2013 and submitted to the Barton Springs/Edwards Aquifer Conservation District for approval to satisfy requirements for authorization in their Rules and Bylaws, 3-1.2. Approval for the 2014 retrace were received from BS/EACD on February 11, 2014. City of Austin Watershed Protection salamander biologist Laurie Dries helped to insure compliance with federal endangered species permit. Austin Parks and Recreation and Texas Commission on Environmental Quality staff were also notified. Tracer receptors, or mesh nylon bags containing activated coconut charcoal and plastic water vials, were provided by Ozark Underground Laboratory (OUL) in Protem, Missouri. The charcoal receptor serves to continuously sorb pyranine dye dissolved in water discharging through a monitored site. Water samples were collected and held by the lab for possible verification and in some cases to document the tracer concentration breakthrough in greater detail, in the case that dye is initially detected on a corresponding site charcoal receptor. OUL also conducted all of the dye analysis for this study from charcoal receptors and grab water samples submitted to them.

Tracer Injections

On November 19, 2013 at 10:30 am, 0.5 kg (1 pound) of pyranine was poured in Little Zilker Creek just upstream and beneath Robert E Lee Road at Barton Hills Drive by Nico Hauwert of City of Austin Watershed Protection Dept. and Professor John Sharp of the University of Texas Department of Geological Sciences (Figure 2). The creek flow and dye completely infiltrated within 9 m (30 ft) of Robert E Lee Road in a pool just downstream. UT undergraduate student Marilyn Kohut conducted the majority of this tracing study by monitoring the tracer and measuring flow in Little Zilker Creek. No pyranine was detected at any of the monitored sites associated with the November 2013 injection. It is most likely that the initial injection mass was too small for successful recovery and that sorption on sediment and dilution diminished the dye concentrations below the detection limit. For this reason it is reasonably appropriate to step up tracer masses when working near sensitive locations such as large water supply systems or endangered species habitat.

Figure 2. November 19, 2013 photos showing the tracer injection site in Little Zilker Creek upstream of Robert E. Lee Road (left photo) and the downstream swallet pool colored green with pyranine dye.

In 2014, UT student David Comer continued Marilyn Kohut's 2013 research on Little Zilker Creek. A follow up trace was conducted by lead investigator and Watershed Protection staff member David Comer as a University of Texas Geological Sciences class project, under supervision from University of Texas Department of Geological Sciences professor Dr. John Sharp. On February 25, 2014 at 8:30am, 1.8 kg (4 pounds) of pyranine were poured at the same site by UT students David Comer and Sam Lillard, with Nico Hauwert of CoA Watershed Protection (Figure 3). Monitoring was conducted by David Comer and other Watershed Protection Dept. staff. Charcoal receptors were placed at Main Barton Springs, Eliza, Old Mill Springs. While duplicate receptors and grab samples were collected, to save costs they were often not analyzed unless pyranine dye was detected on the primary charcoal receptor. An autosampler installed at Old Mill Springs collected samples at 4 hour intervals from Feb. 25 to 29, 2014. Barton Springs pool was drawn down that week for spring cleaning. Unexpectedly, about 0.8 inches of rainfall fell over Zilker Park from the evening of February 25 through February 27, causing runoff and much of the dye to be discharged into Barton Creek and Town Lake. The rain also activated spring flow from gravels in the South Zilker tributary.

A charcoal receptor placed in the South Zilker tributary (Figure 1) from February 26, 2014 until February 28, 2014 contained 1.80 ppb pyranine. The replacement charcoal receptor placed in the tributary from February 28, 2014 through March 7, 2014 contained 2.02 ppb of pyranine. A water sample from the South Zilker tributary collected on February 28, 2014 at 3:07 pm detected no pyranine at a detection limit of 0.01 ppb. Pyranine was not detected in a water sample collected at Lou Neff Point in the mouth of Barton Creek at the Colorado River at on February 28, 2014 at 4:55 pm. Charcoal receptors placed in Main Barton, Eliza, and Old Mill Springs from November 20, 2013 until December 3, 2013; January 17, 2014 through February 14, 2014; February 14, 2014 through February 28, 2014 did not detect pyranine. No pyranine was detected in charcoal receptors placed in Main Barton Springs, Eliza Springs, Old Mill Springs, Upper Barton Springs, Colorado River Storm Drain, Sidewalk Seep at south side of Barton Springs pool, or Barton Springs Pool Bypass. On April 9, 2014 between 5 to 6 pm, David Comer compared the flow entering the swallet downstream of Robert E. Lee Road (0.59 l/s; 9.3 gal/min) to flow in the South Zilker tributary to Barton Springs pool (0.37 l/s; 5.8 gal/min).

Figure 3. Pyranine was reinjected into the culvert under Robert E. Lee Road on February 25, 2014 at 8:30am. Signs were placed to alert the public for the cause of the green tracer. Flow did not extend beyond the swallet pool at the time of injection.

Figure 4. Photos taken of the Little Zilker Creek swallet and channel downstream near Old Mill Springs on February 26, 2014. Note the green tint of pyranine dye that was washed downstream by floodwaters in the evening of Tuesday February 25 and morning of February 26, 2014. The stormwaters likely washed a large portion of the injected dye downstream to the Colorado River before it could infiltrate into the Little Zilker Creek swallet as planned. The 2 cm (0.8 in) rain did activate springflow in the South Zilker tributary so that monitoring was initiated there February 26, 2014.

Discussion
No dye was detected in the South Zilker tributary associated with the November 19, 2013 injection of pyranine, but pyranine was detected in the South Zilker tributary on two consecutive receptors following the February 25, 2014 injection of the same dye. This is the short tributary segment that still potentially discharges runoff directly into Barton Springs pool. A filled gravel paleochannel, about 120 m (400 ft) long, connects the swallet on Little Zilker Creek to the dissected short South Zilker tributary to Barton Springs pool. The subsequent success after initial recovery failure is attributed to the increase in injected pyranine dye from one pound in the first injection to four pounds in the second injection. The effective mass of tracer injected in February 2014 was reduced to less than four pounds due to the unexpected runoff event later in the day. Loss of dye from groundwater transport through organic-rich sediment, photodecay from exposure to sunlight in exposed drainages, and dilution from other sources to Barton Springs can easily account for the fact that the pyranine was not detected in any of the four Barton Springs monitored in this study. On February 28, 2014, water samples collected from the South Zilker tributary did not detect pyranine, even though corresponding charcoal receptors did detect pyranine. This difference may be because charcoal monitoring is a continuous accumulation of pyranine, while a water sample is a discrete sample. Also the tracer may travel in a pulse, varying in response to time since injection and rain-even flushing, such that dye can be missed in discrete water samples but appear in the water at other times. In theory, the trace can be repeated with greater dye mass to further increase the confidence of the results, but such additional tracing must be weighed against the potential risks of higher than desirable dye concentrations for aquatic life and recreational swimmers. These results support a fairly intuitively obvious conclusion, that the abrupt loss of flow in the Little Zilker Creek follows a 120 m (400 ft)-long covered alluvial channel where, after discharges from alluvial gravel springs, subsequently infiltrates into the alluvium and/or Georgetown Formation of the Edwards Aquifer and discharges locally at Barton Springs. It is possible that the seeps observed along the sidewalk in Barton Springs pool represent discharge from the alluvial deposits and South Zilker tributary, but its proximity to Edwards Aquifer discharge at Barton Springs are so close as to be indistinguishable (no chemical analysis was conducted to differentiate these waters).

The discharge point for creek flow at the Little Zilker Creek swallet is constrained by a lower elevation of about 145 m (476 ft) msl. Main Barton Springs has a submerged cave in the pool at an elevation of about 128 m (420 ft) msl and a pool elevation of about 132 m (432 ft) msl (Saribudak et al., 2013). The Barton Springs pool sidewalk seeps have an elevation of about 133 m (435 ft) msl. The point of flow (and tracer) loss on South Zilker tributary swallet is about 145 m (476 ft) msl, or about 13 m (44 ft) above the normal pool level, based on City of Austin two feet interval contour coverages. The Colorado River water elevation at the mouth of Barton Creek is about 131 m (430 ft) msl.

The tracer was also carried via flood runoff on Little Zilker Creek directly into the Colorado River on February 25, 2014, as evident from the colored pools along Little

Zilker Creek downstream of the injection swallet. Normally the surface transport of dye is also documented at downstream monitoring sites. No dye was measured in water samples collected February 28, 2014 at Lou Neff Point in the mouth of Barton Creek at the Colorado River or in receptors placed there Feb. 28 to March 7, 2014. The receptors placed at the site between December 20, 2013 to February 28, 2014, which may have detected the dye (see Figure 4), were missing. Similarly, no receptors were recovered from Barton Springs Road bridge in 2014. It is possible that boaters or fishermen passing by the monitoring sites thought the charcoal receptors were litter. Also no receptors were recovered from Little Zilker Creek after the February 25, 2014 injection, since the creek was obviously dyed with high concentrations (see Figure 4) and handling the receptors by the monitoring team or laboratory posed an unnecessary risk of cross-contamination. The Little Zilker Creek receptors were left in place.

Conclusion

The presence of injected pyranine tracer in the South Zilker tributary, the similarity of flow loss at the Little Zilker Creek and flow gain in South Zilker tributary indicate that flow lost at the Little Zilker Creek swallet infiltrates into gravel that was deposited as a paleochannel associated with the 1940's natural channel of Little Zilker Creek to Barton Springs pool. The tracer results were significant because they show flow going towards Barton Springs pool and within 60 m (200 ft) of the pool, even though tracer was not directly detected in any of the four Barton Springs or sidewalk seeps. This flow is assumed to discharge at one of the Barton Springs or seeps within the pool, the local regional base level of the Colorado River. Other than the known Barton Springs, there is no perched discharge to Barton Creek flowing at a comparable rate of 0.38 to 0.57 l/s (6 to 9 gal/min). The dye was not detected at seeps in Barton Springs pool or four of the monitored Barton Springs outlets presumably because an insufficient mass of dye was used to overcome the sorption by organic-rich sediment, dilution by Barton Springs flow, and limitations of pyranine tracer properties compared to more conservative tracers such as fluorescein and eosine. The South Zilker tributary was the only groundwater discharge site where the pyranine tracer was detected in this study.

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Appendix A
Ozark Underground Laboratory Results

OUL #	Site	Date/Time Placed	Date/Time Collected	Pyranine Peak nm	Conc. ppb
X3168	Little Zilker Creek	11/23/13 12:18	12/3/13 9:05	ND	
X4251	Little Zilker Creek	12/3/13 9:07	12/20/13 11:30	ND	
X4252	Little Zilker Creek	12/3/13 9:07	12/20/13 11:30	ND	
X2827	South Zilker Trib.	11/8/13 15:00	11/19/13 9:10	ND	
X2832	South Zilker Trib.	11/19/13 9:10	11/20/13 17:20	ND	
X2833	South Zilker Trib.	11/20/13 17:24	11/21/13 16:05	ND	
X2834	South Zilker Trib.	11/21/13 16:08	11/22/13 16:01	ND	
X2834Dup	South Zilker Trib.	11/21/13 16:08	11/22/13 16:01	ND	
X3163	South Zilker Trib.	11/20/13 17:24	11/26/13 13:18	ND	
X3164	South Zilker Trib.	11/24/13 13:58	11/26/13 13:20	ND	
X3165	South Zilker Trib.	11/26/13 13:20	12/3/13 11:00	ND	
X4246	South Zilker Trib.	12/3/13 11:02	12/20/13 12:20	ND	
X4972	South Zilker Trib.	**Water Sample**	2/28/14 15:06	ND	
X4854	South Zilker Trib.	2/26/14 15:00	2/28/14 15:07	501.0	1.80
X4990	South Zilker Trib.	2/28/14 15:07	3/7/14 13:15	500.8	2.02
X6027P	South Zilker Trib.	4/9/14 17:20	4/25/14 14:34	ND	
X6028P	South Zilker Trib.	4/9/14 17:20	4/25/14 14:34	ND	
X2831	Sidewalk Seep	11/8/13 15:40	11/19/13 8:38	ND	
X3166	Sidewalk Seep	11/26/13 10:37	12/3/13 10:05	ND	
X4253	Sidewalk Seep	12/3/13 10:07	12/20/13 13:50	ND	
X4853	Sidewalk Seep	2/26/14 15:15	2/28/14 15:40	ND	
X4989	Sidewalk Seep	2/28/14 15:40	3/7/14 10:10	ND	
X4852	Bypass	2/21/14 16:00	2/28/14 17:45	ND	
X4988	Bypass	2/28/14 17:45	3/7/14 11:42	ND	
W8915P	Main Barton	6/5/13 13:45	6/27/13 15:30	ND	
W8916P	Main Barton	6/5/13 13:47	6/27/13 15:32	ND	
W8917P	Main Barton	6/5/13 13:50	6/27/13 15:35	ND	
W8925P	Main Barton	6/27/13 15:30	7/23/13 10:50	ND	
W8926P	Main Barton	6/27/13 15:32	7/23/13 10:52	ND	
W8927P	Main Barton	6/27/13 15:35	7/23/13 10:55	ND	
X1502	Main Barton	7/23/13 10:50	8/16/13 15:20	ND	
X1503	Main Barton	7/23/13 10:52	8/16/13 15:22	ND	
X1504	Main Barton	7/23/13 10:55	8/16/13 15:25	ND	
X1517	Main Barton	8/16/13 15:20	10/4/13 16:15	ND	
X1518	Main Barton	8/16/13 15:22	10/4/13 16:17	ND	
X1519	Main Barton	8/16/13 15:25	10/4/13 16:20	ND	
X1527	Main Barton	10/4/13 16:15	10/11/13 16:20	ND	
X1528	Main Barton	10/4/13 16:17	10/11/13 16:22	ND	
X1529	Main Barton	10/4/13 16:20	10/11/13 16:25	ND	
X2922	Main Barton	10/11/13 16:20	10/23/13 16:50	ND	
X2923	Main Barton	10/11/13 16:22	10/23/13 16:52	ND	
X2924	Main Barton	10/11/13 16:25	10/23/13 16:55	ND	
X2931	Main Barton	10/23/13 16:50	11/8/13 15:55	ND	
X2932	Main Barton	10/23/13 16:52	11/8/13 15:57	ND	
X2933	Main Barton	10/23/13 16:55	11/8/13 16:00	ND	

OUL #	Site	Date/Time Placed	Date/Time Collected	Pyranine Peak nm	Conc. ppb
X2904	Main Barton	11/8/13 15:55	11/13/13 16:45	ND	
X2905	Main Barton	11/8/13 15:57	11/13/13 16:47	ND	
X2906	Main Barton	11/8/13 15:55	11/19/13 8:46	ND	
X2907	Main Barton	11/13/13 16:45	11/20/13 17:25	ND	
X2908	Main Barton	11/13/13 16:47	11/20/13 17:27	ND	
X3304	Main Barton	11/20/13 17:25	12/3/13 10:14	ND	
X3305	Main Barton	11/20/13 17:27	12/3/13 10:14	ND	
X4234	Main Barton	12/3/13 10:12	12/20/13 13:55	ND	
X4238	Main Barton	12/3/13 10:14	12/20/13 14:00	ND	
X4241	Main Barton	12/20/13 14:00	1/17/14 16:45	ND	
X4845	Main Barton	1/17/14 16:45	2/14/14 15:25	ND	
X4848	Main Barton	2/14/14 15:25	2/28/14 13:25	ND	
X4993	Main Barton	2/28/14 13:25	3/7/14 10:10	ND	
X7125	Main Barton	5/30/14 12:27	6/9/14 17:02	ND	
X7591	Main Barton	6/9/14 17:00	6/27/14 14:50	ND	
W8912P	Eliza	6/5/13 13:30	6/27/13 15:20	ND	
W8913P	Eliza	6/5/13 13:32	6/27/13 15:22	ND	
W8914P	Eliza	6/5/13 13:35	6/27/13 15:25	ND	
W8922P	Eliza	6/27/13 15:20	7/23/13 10:40	ND	
W8923P	Eliza	6/27/13 15:22	7/23/13 10:42	ND	
W8924P	Eliza	6/27/13 15:25	7/23/13 10:45	ND	
X1498	Eliza	7/23/13 10:40	8/16/13 15:10	ND	
X1499	Eliza	7/23/13 10:42	8/16/13 15:12	ND	
X1501	Eliza	7/23/13 10:45	8/16/13 15:15	ND	
X1508	Eliza	8/16/13 15:10	9/27/13 16:33	ND	
X1509	Eliza	8/16/13 15:12	9/27/13 16:35	ND	
X1510	Eliza	8/16/13 15:15	9/27/13 16:37	ND	
X1514	Eliza	9/27/13 16:33	10/4/13 16:35	ND	
X1515	Eliza	9/27/13 16:35	10/4/13 16:37	ND	
X1516	Eliza	9/27/13 16:37	10/4/13 16:40	ND	
X1524	Eliza	10/4/13 16:35	10/11/13 16:35	ND	
X1525	Eliza	10/4/13 16:37	10/11/13 16:37	ND	
X1526	Eliza	10/4/13 16:40	10/11/13 16:40	ND	
X2918	Eliza	10/11/13 16:35	10/23/13 17:05	ND	
X2919	Eliza	10/11/13 16:37	10/23/13 17:07	ND	
X2921	Eliza	10/11/13 16:40	10/23/13 17:10	ND	
X2928	Eliza	10/23/13 17:05	11/6/13 17:25	ND	
X2929	Eliza	10/23/13 17:07	11/6/13 17:27	ND	
X2930	Eliza	10/23/13 17:10	11/6/13 17:30	ND	
X2937	Eliza	11/6/13 17:25	11/13/13 16:15	ND	
X2938	Eliza	11/6/13 17:27	11/13/13 16:17	ND	
X2939	Eliza	11/6/13 17:30	11/13/13 16:20	ND	
X2909	Eliza	11/8/13 15:20	11/19/13 8:17	ND	
X2910	Eliza	11/13/13 16:15	11/20/13 17:10	ND	
X2911	Eliza	11/13/13 16:17	11/20/13 17:12	ND	

OUL #	Site	Date/Time Placed	Date/Time Collected	Pyranine Peak nm	Conc. ppb
X3302	Eliza	11/20/13 17:10	12/3/13 9:52	ND	
X3303	Eliza	11/20/13 17:12	12/3/13 9:52	ND	
X4233	Eliza	12/3/13 9:46	12/20/13 13:35	ND	
X4237	Eliza	12/3/13 9:52	12/20/13 13:40	ND	
X4239	Eliza	12/20/13 13:40	1/17/14 16:30	ND	
X4844	Eliza	1/17/14 16:30	2/14/14 15:15	ND	
X4847	Eliza	2/14/14 15:15	2/28/14 14:00	ND	
X4992	Eliza	2/28/14 14:00	3/7/14 10:30	ND	
X7124	Eliza	5/30/14 12:17	6/9/14 16:47	ND	
X7590	Eliza	6/9/14 16:45	6/27/14 14:30	ND	
W8918P	Old Mill	6/5/13 14:02	6/27/13 15:10	ND	
W8919P	Old Mill	6/5/13 14:04	6/27/13 15:12	ND	
W8928P	Old Mill	6/27/13 15:10	7/23/13 10:30	ND	
W8929P	Old Mill	6/27/13 15:12	7/23/13 10:32	ND	
X1505	Old Mill	7/23/13 10:30	8/16/13 15:00	ND	
X1506	Old Mill	7/23/13 10:32	8/16/13 15:02	ND	
X1511	Old Mill	8/16/13 15:00	9/27/13 16:18	ND	
X1512	Old Mill	8/16/13 15:02	9/27/13 16:20	ND	
X1521	Old Mill	9/27/13 16:18	10/4/13 16:00	ND	
X1522	Old Mill	9/27/13 16:20	10/4/13 16:02	ND	
X1530	Old Mill	10/4/13 16:00	10/11/13 16:00	ND	
X1531	Old Mill	10/4/13 16:02	10/11/13 16:02	ND	
X2925	Old Mill	10/11/13 16:00	10/23/13 16:35	ND	
X2926	Old Mill	10/11/13 16:02	10/23/13 16:37	ND	
X2934	Old Mill	10/23/13 16:35	11/6/13 18:00	ND	
X2935	Old Mill	10/23/13 16:37	11/6/13 18:02	ND	
X2912	Old Mill	11/6/13 18:00	11/13/13 15:55	ND	
X2913	Old Mill	11/6/13 18:02	11/13/13 15:57	ND	
X2914	Old Mill	11/8/13 14:45	11/19/13 7:57	ND	
X2915	Old Mill	11/13/13 15:55	11/20/13 16:50	ND	
X2916	Old Mill	11/13/13 15:57	11/20/13 16:52	ND	
X3308	Old Mill	11/26/13 11:00	12/3/13 9:25	ND	
X3308D	Old Mill	11/26/13 11:00	12/3/13 9:25	ND	
X3306	Old Mill	11/20/13 16:50	12/3/13 9:30	ND	
X3307	Old Mill	11/20/13 16:52	12/3/13 9:30	ND	
X4235	Old Mill	12/3/13 9:27	12/20/13 13:10	ND	
X4242	Old Mill	11/20/13 16:50	1/17/14 16:00	ND	
X4243	Old Mill	11/20/13 16:52	1/17/14 16:02	ND	
X4846	Old Mill	1/17/14 16:00	2/14/14 15:05	ND	
X4849	Old Mill	2/14/14 15:05	2/28/14 14:30	ND	
X4994	Old Mill	2/28/14 14:30	3/7/14 10:56	ND	
X7126	Old Mill	5/30/14 11:32	6/9/14 16:30	ND	
X7592	Old Mill	6/9/14 16:28	6/27/14 14:20	ND	
X2917	Upper Barton	11/8/13 16:50	11/19/13 9:32	ND	
X3310	Upper Barton	11/20/13 17:42	11/26/13 13:30	ND	

OUL #	Site	Date/Time Placed	Date/Time Collected	Pyranine Peak nm	Conc. ppb
X3309	Upper Barton	11/24/13 14:07	11/26/13 13:30	ND	
X3311	Upper Barton	11/26/13 13:33	12/3/13 11:10	ND	
X3311D	Upper Barton	11/26/13 13:33	12/3/13 11:10	ND	
X4236	Upper Barton	12/3/13 11:12	12/20/13 14:40	ND	
X4850	Upper Barton	2/21/14 15:00	2/28/14 15:20	ND	
X4995	Upper Barton	2/28/14 15:20	3/7/14 11:20	ND	
X7127	Upper Barton	5/30/14 12:42	6/9/14 17:19	ND	
X7593	Upper Barton	6/9/14 17:17	6/27/14 15:10	ND	
X2828	Barton Springs Road	11/15/13 16:35	11/19/13 10:00	ND	
X3161D	Barton Springs Road	11/19/13 10:05	11/26/13 12:29	ND	
X3161	Barton Springs Road	11/19/13 10:05	11/26/13 12:29	ND	
X3162	Barton Springs Road	11/26/13 12:31	12/3/13 9:15	ND	
X4244	Barton Springs Road	12/3/13 9:17	12/20/13 11:45	ND	
X4245	Barton Springs Road	12/3/13 9:17	12/20/13 11:45	ND	
X2829	Lou Neff Point	11/15/13 17:30	11/19/13 11:55	ND	
X3158D	Lou Neff Point	11/19/13 11:58	11/26/13 13:00	ND	
X3158	Lou Neff Point	11/19/13 11:58	11/26/13 13:00	ND	
X3159	Lou Neff Point	11/26/13 13:02	12/3/13 10:45	ND	
X4249	Lou Neff Point	12/3/13 10:47	12/20/13 12:40	ND	
X4250	Lou Neff Point	12/3/13 10:47	12/20/13 12:40	ND	
X4973	Lou Neff Point	**Water Sample**	2/28/14 16:55	ND	
X4991	Lou Neff Point	2/28/14 16:00	3/7/14 12:45	ND	
X2830	Storm Drain	11/15/13 17:10	11/19/13 11:43	ND	
X3167	Storm Drain	11/26/13 12:55	12/3/13 10:40	ND	
X4247	Storm Drain	12/3/13 10:42	12/20/13 12:30	ND	
X4248	Storm Drain	12/3/13 10:42	12/20/13 12:30	ND	
X4851	Storm Drain	2/21/14 13:55	2/28/14 16:15	ND	
X4987	Storm Drain	2/28/14 16:15	3/7/14 12:23	ND	
W8921P	COA Control	6/27/13 15:00	6/27/13 16:00	ND	
W8930P	COA Control	7/23/13 10:30	7/23/13 11:00	ND	
X1507	COA Control	8/16/13 14:15	8/16/13 15:30	ND	
X1513	COA Control	9/27/13 13:30	9/27/13 17:00	ND	
X1523	COA Control	10/4/13 14:45	10/4/13 17:00	ND	
X1532	COA Control	10/11/13 14:00	10/11/13 16:35	ND	
X2927	COA Control	10/23/13 15:25	10/23/13 17:00	ND	
X2936	COA Control	11/6/13 16:30	11/8/13 16:30	ND	
X2903	COA Control	11/13/13 14:35	11/13/13 16:50	ND	
X2902	COA Control	11/20/13 16:15	11/20/13 17:30	ND	
X4996	COA Control	3/7/14 10:00	3/7/14 13:30	ND	
X7594	COA Control	6/27/14 11:00	6/27/14 16:00	ND	