# Preliminary Analysis of Barton Springs Site-Specific Flow Data
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## Abstract

*Data for flow and substrate velocity were collected for Eliza, Old Mill, and Upper Barton springs and compared to United States Geological Survey (USGS) discharge data for the Barton Springs Complex. There was a strong positive correlation between the combined USGS discharge data and flow for Eliza Spring and Old Mill Spring. The positive correlation existed between the USGS discharge data and Upper Barton Spring flow but was weaker. Velocity at the substrate was compared to the total flow for each site. Substrate velocity was not explained well by the flow at Old Mill and portions of Upper Barton Spring. The substrate velocity is probably influenced by other conditions not measured.*

## Introduction

Natural variation in rainfall, as well as anthropogenic modifications, such as groundwater withdrawals for wells and impervious cover, affect the amount of water discharging from the Barton Springs Complex. Decreased spring flow is correlated with decreased water quality at Barton Springs (City of Austin 2006, 2009). Low flow is correlated with decreased dissolved oxygen in the water, sometimes to levels documented to increase mortality in the Barton Springs Salamander, *Eurycea sosorum* (Woods et al. 2010). Temperature and conductivity also increase during low flow conditions. Pollutants may also become concentrated when there is less water flowing from the springs. Fewer *E. sosorum* are found during count surveys conducted in low flow conditions (City of Austin 2012). Salamanders need sufficient flow to sustain high water quality at the spring sites. Low water velocities at the substrate may increase sediment deposition. However, very high velocities at the substrate level can negatively impact salamanders by flushing vegetation, the salamanders, and the invertebrates that they prey upon out of suitable habitat.

For this study, we assessed differences in flow rate at spring sites inhabited by *E. sosorum*. The combined discharge of three springs (Main, Eliza, and Old Mill springs) has been measured daily by United States Geological Survey (USGS) since March 1978. We measured the flow rate at three of the springs where *E. sosorum* are found (Eliza, Old Mill, and Upper Barton springs). We compared our measurements for each of the spring sites to measurements of combined spring discharge from USGS to assess what relationship existed between the datasets, if any. We also assessed whether the flow rate could be used as to determine the substrate velocity in salamander habitat.

## Methods

Discharge and substrate velocity data has been collected during salamander surveys (City of Austin Field Sampling Database project #26) at individual spring sites within the Barton Springs complex (Eliza, Old Mill, and Upper Barton Springs) since 2008. These data were collected monthly using a Marsh-McBirney flow meter unless a salamander survey was not conducted or if no measurable flow was observed at the individual spring.

Eliza Spring was measured approximately 1.5–2.5 feet upstream of the outflow pipe in the spring pool. The substrate was approximately 2–3 inches of large gravel atop concrete and the water level is normally around 2 feet deep. Old Mill Spring was measured a few feet upstream of the constructed waterfall at the end of the stream flowing from the spring pool. The substrate was a couple inches of large gravel and cobble atop either a clay channel bottom or the large limestone blocks that construct the waterfall. Upper Barton Spring was measured in multiple locations (downstream, midstream and section V). Discharge from Upper Barton Spring is a combination of all flowing discharge points at the site on that date. The discharge points vary greatly in width/depth/substrate at each sampling date and can be reviewed in the notes from each sampling date.

A linear regression was applied to each of the individual spring sites in relation to the USGS combined discharge for Barton Springs (USGS 08155500 Barton Spgs at Austin, TX).

Additionally, water velocity at the substrate (substrate velocity) was measured to determine how site discharge relates to velocity in salamander habitat. Eliza Spring substrate velocities were measured on the bare concrete at each of the 15 vents around the base of the amphitheater. Old Mill Spring substrate velocities were measured in five locations along the Old Mill Stream either on gravel and cobble or clay. Substrate velocities at Upper Barton Spring were measured along the bottom of the outflow channels on natural substrate. For each sampling date, substrate velocities were averaged for each site sampled.

Average substrate velocities at each site were plotted against site specific discharge. A linear regression was applied to each of the average substrate velocities in relation to discharge of individual spring sites.

### Results and Discussion

Linear regressions comparing individual spring sites to the USGS combined discharge for Barton Springs are shown in Figures 1-3. The regression equations and $R^2$ values are located on each of the site specific graphs. The discharge from Eliza Spring (Figure 1, $R^2$=0.879) and Old Mill Spring (Figure 2, $R^2$=0.915) had a strong relationship to the USGS measurements, while Upper Barton Spring had less variation in the flow explained by the USGS measurements (Figure 3, $R^2$=0.553). Given the strong relationship between the USGS data and the data collected for this report, it may be possible to use the regression equations to predict discharge for Eliza and Old Mill springs. Zero flow (no discharge) conditions at the individual spring sites occur at different levels of USGS combined discharge. Eliza Spring never stopped flowing even when USGS discharge decreased to 14 $ft^3/s$ (Figure 1). The discharge at Old Mill Spring was at or near 0 when the measured USGS combined discharge was approximately 20 $ft^3/s$ or less (Figure 2). Upper Barton Spring discharge stopped flowing when USGS combined discharge decreased to 44 $ft^3/s$ (Figure 3). The maximum discharge for Eliza and Old Mill were both approximately 14 $ft^3/s$, while Upper Barton Spring only exceeded 3 $ft^3/s$ during one measurement. Upper Barton Spring is a smaller spring and it occurs at a higher elevation than the other springs measured, so it is the first spring to stop flowing when the water table lowers. There are also different source areas contributing recharge and flow paths through the aquifer to each spring (Hauwert 2004, Saribudak et al. 2013), so it is possible that differing rainfall totals in the Barton Springs recharge zone could lead to greater flow rates at some spring sites but not others for the same time period. Another possibility is that given the small range of discharges for Upper Barton Springs (0-3.1 $ft^3/s$), small errors that occur when measuring velocity could have a larger effect on the data for this spring site.

Linear regressions plotting average substrate velocity against discharge for each site are shown in Figures 4–6. The regression equations and $R^2$ values are located on each of the site specific graphs. Site-specific discharge and substrate velocity are strongly positively correlated for Eliza Spring (Figure 4, $R^2$=0.896) and the downstream outflow of Upper Barton Spring (Figure 6, $R^2$=0.854), but not for Old Mill (Figure 5, $R^2$=0.366) or the upstream and midstream outflows of Upper Barton Spring (Figure 6, $R^2$=0.193 upstream, $R^2$=0.544 midstream). The stronger relationship at Eliza Spring may be due to a difference in methodology for this site. The other spring sites had substrate velocity measured at the outflow channels, whereas Eliza substrate velocity was measured at the vents where the water exited the ground.

The relationship between site-specific discharge and velocity differed for each of the spring sites. For example, at a site-specific discharge of 2 $ft^3/s$ at each site, based on the regression (Figures 4–6), the substrate velocity at Eliza Spring would be 0.184 $\pm$ 0.039 ft/s, Old Mill would be 0.693 $\pm$ 0.209 ft/s, and Upper Barton Spring would be 1.035 $\pm$ 0.208 ft/s downstream, 0.763 $\pm$ 0.263 ft/s midstream, and 0.202 $\pm$ 0.189 ft/s upstream. Because the spring pool at Eliza is relatively flat, substrate velocity is unlikely to change from the effects of gravity on a slope. The substrate velocity in Eliza Spring always remained below 1.5 ft/s, which is lower than the maximum substrate velocity at the other sites, even though the range of discharges at Old Mill and Eliza Spring were similar, and Eliza discharge was much higher than Upper Barton Springs. Old Mill and Upper Barton springs were measured in areas that had varying slopes that could increase the velocity. Old Mill, which had mean substrate velocities up to 3.65 ft/s, has a relatively steep slope that can increase the velocity. The velocity may also differ within the stream based on the slope and stream width in different areas. At Upper Barton Spring, the slope and width of each of the three outflows is also expected to change the substrate velocity. The flow rate at each of the three outflows would be lower than the site-specific rate for Upper Barton Spring. To more accurately assess the relationship between substrate velocity and flow rate at Upper Barton Spring, the outflow-specific flow, not the total Upper Barton Spring flow, would need to be used to compare to the substrate velocity. Other variables not evaluated in this study could affect the substrate velocity, such as the type and size of substrate present.

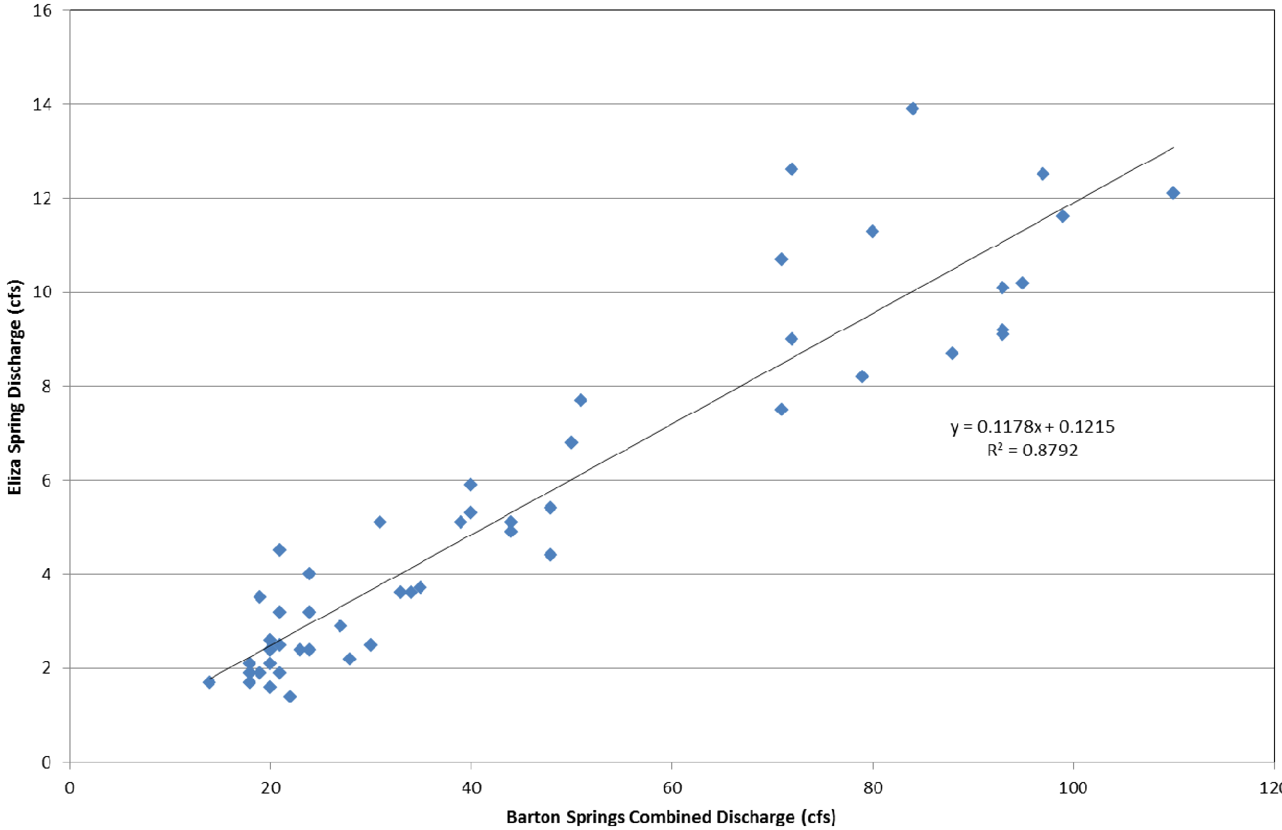


Figure 1. Eliza spring flow based on Eliza Spring pool measurements versus Barton Springs combined discharge. CFS = $ft^3/s$

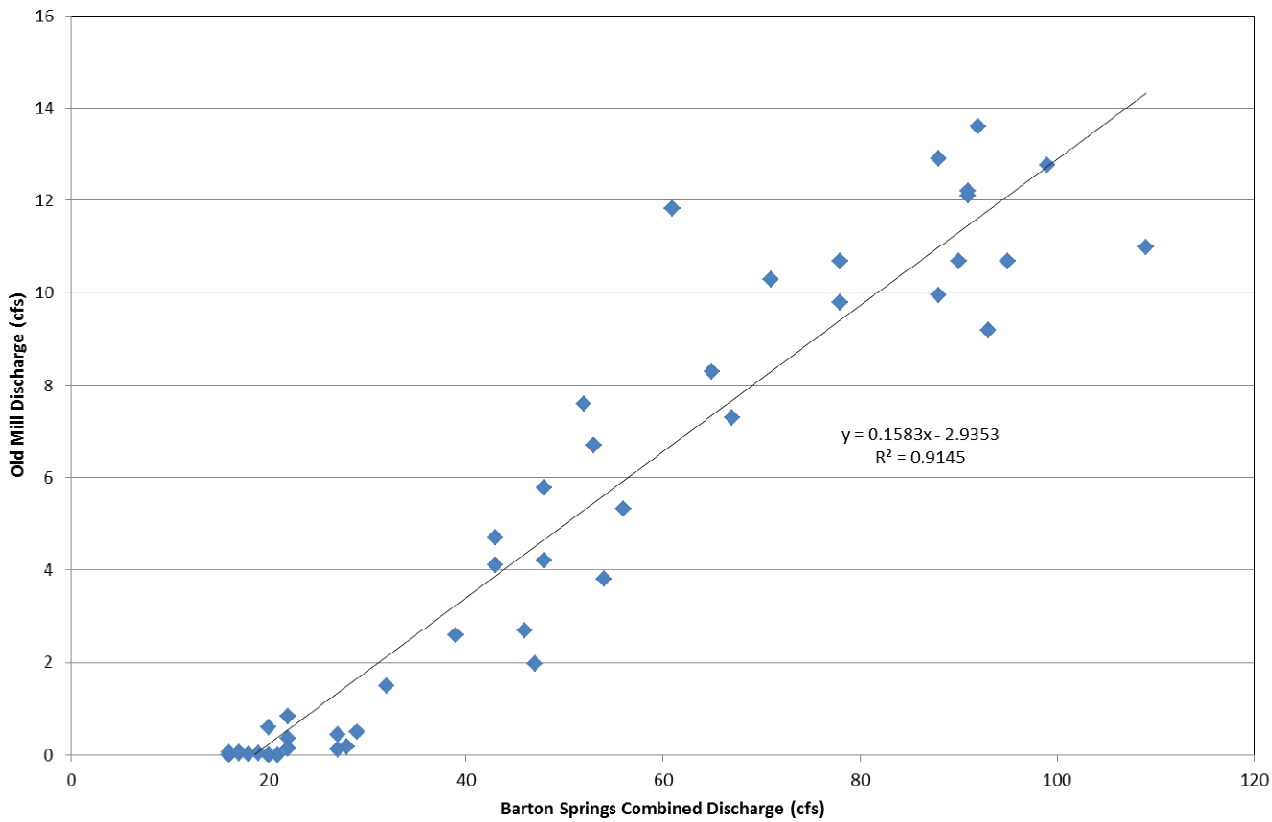


Figure 2. Old Mill flow measured in the Old Mill stream versus Barton Springs combined discharge. CFS = $ft^3/s$.

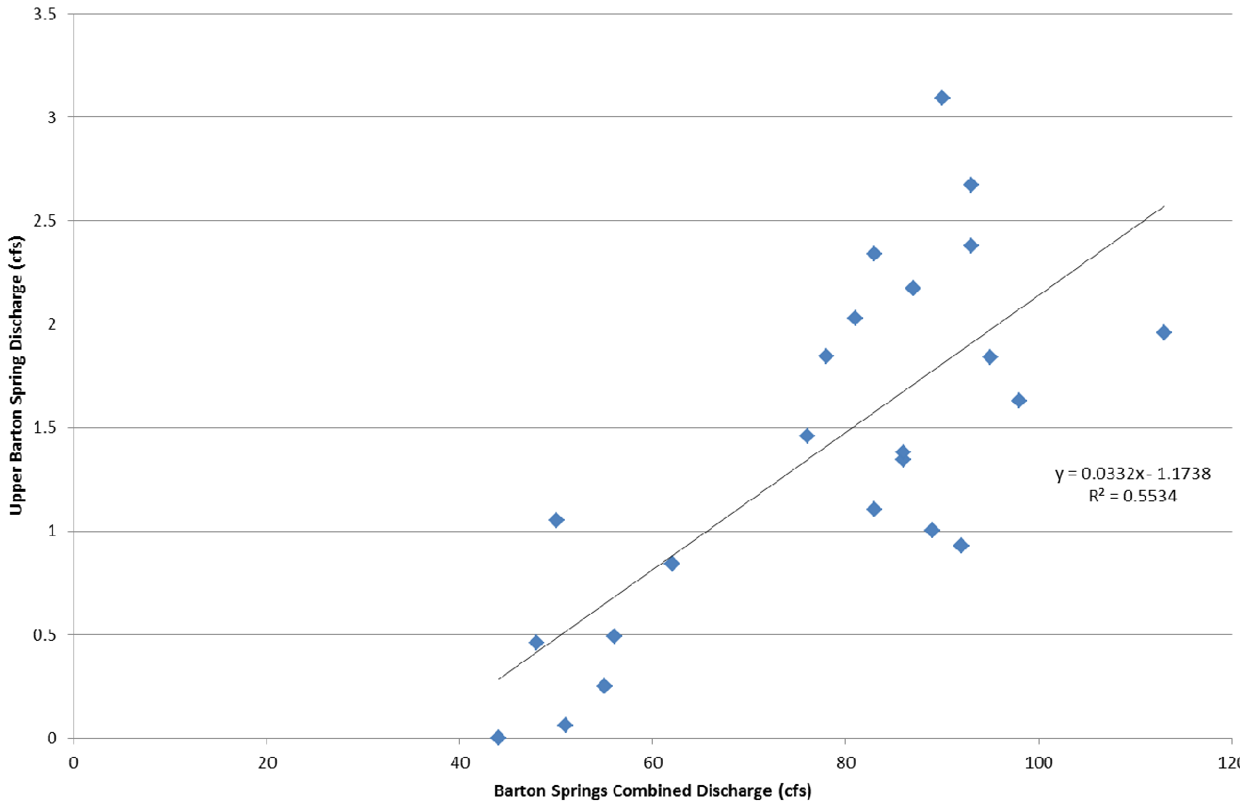


Figure 3. Upper Barton Spring flow measured at the spring outlets versus Barton Springs combined discharge. CFS = $ft^3/s$.

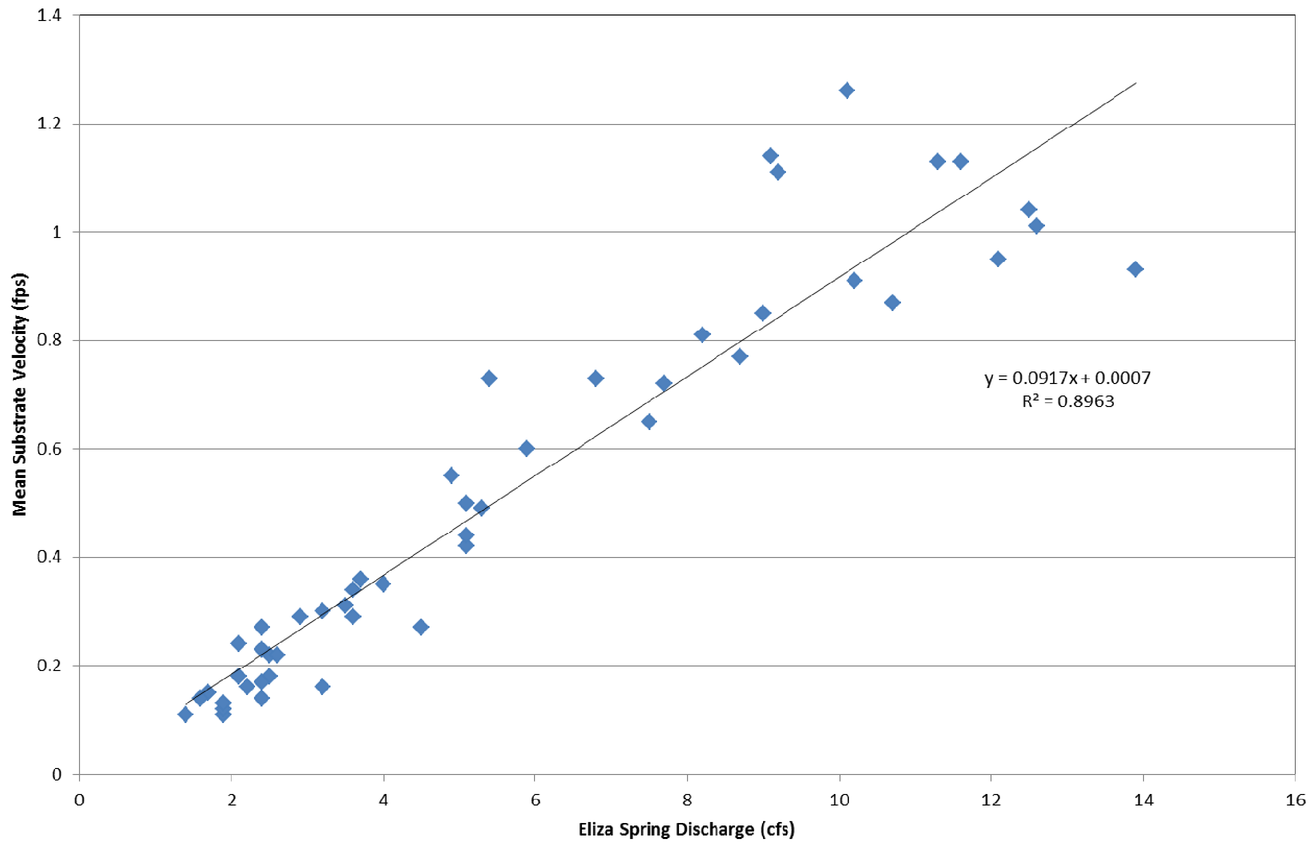


Figure 4. Mean velocity at the substrate in Eliza Spring measured at vents around the perimeter of the spring pool. CFS = $ft^3/s$. FSP = ft/s.

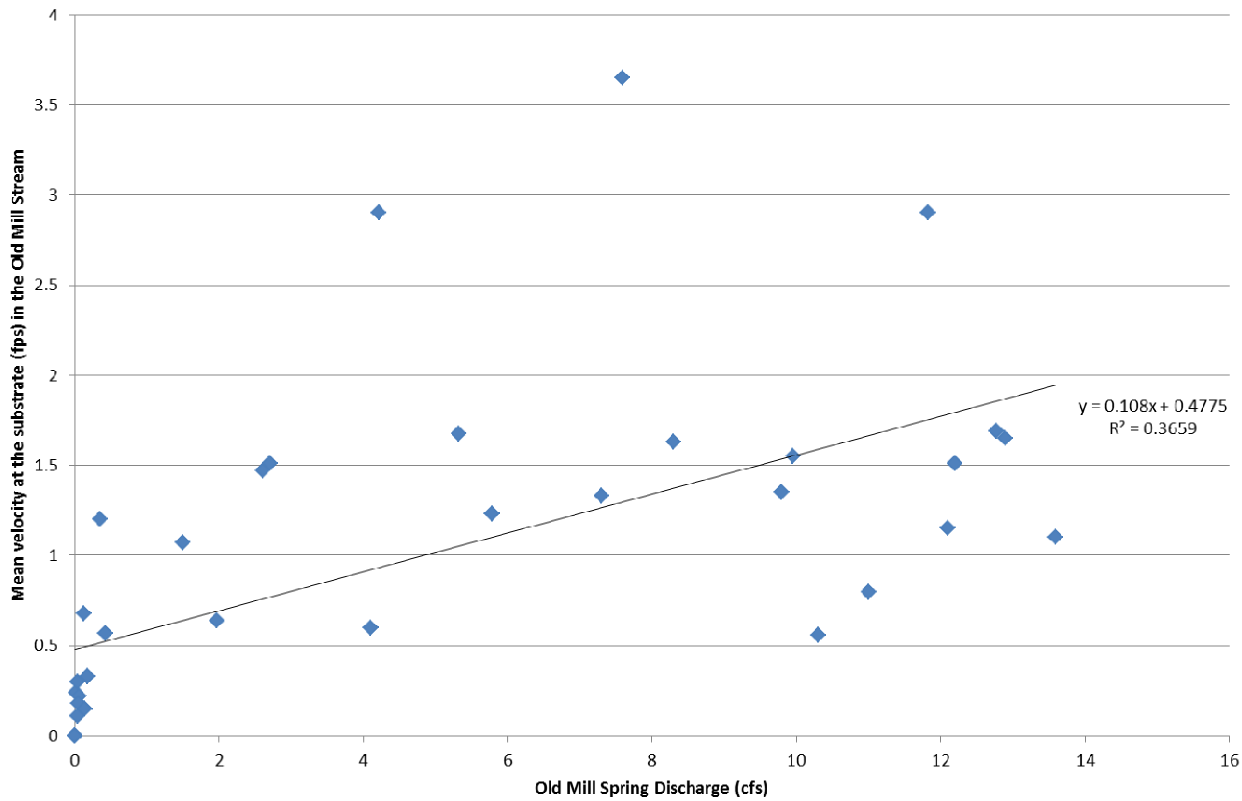

Figure 5. Mean velocity at the substrate in Old Mill stream as measured in the channel center along the length of the stream. CFS = $ft^3/s$. FSP = ft/s.

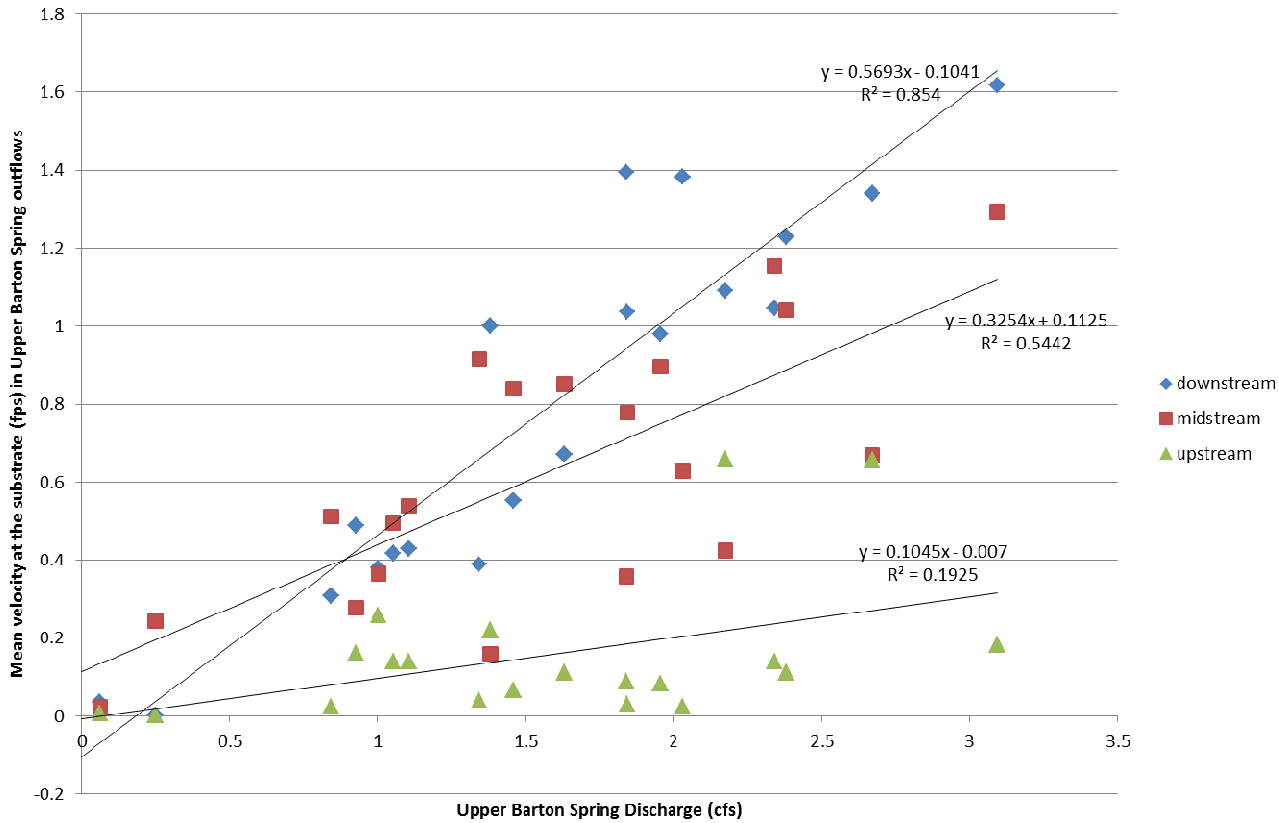


Figure 6. Mean velocity at the substrate in Upper Barton Spring as measured in each of the three outflows. CFS = $ft^3/s$. FSP = ft/s.

## References


City of Austin. 2006. Effects of Low Spring Discharge On Water Quality at Barton, Eliza, and Old Mill Springs, Austin, Texas by David A. Johns, P.G. SR-06-05.

City of Austin. 2009. Barton Springs Salamanders, Spring Discharge and Dissolved Oxygen. An Update to DR-07-07 BSS&ABS Salamander Data Report 2006 and SR-04-06 Some Water Quality Threats to the BBS at Low Flows by Martha A. Turner, P.E. SR-09-02

City of Austin. 2012. Variation in abundances of *Eurycea sosorum* and *Eurycea waterlooensis* (Plethodontidae: Hemidactyliini: *Eurycea*: Notiomolge), with examination of influences of flow regime and drought by Laurie A. Dries. SR-12-16

Hauwert N, D Johns, B Hunt, J Beery, B Smith, J Sharp. 2004. *Flow Systems of the Edwards Aquifer Barton Springs Segment Interpreted from Tracing and Associated Field Studies*: from Edwards Water Resources In Central Texas, Retrospective And Prospective Symposium Proceedings, May 21, 2004 San Antonio, Hosted by the South Texas Geological Society and Austin Geological Society. 18 p.

Saribudak M, NM Hauwer, A Hawkins. 2013. Geophysical signatures of Barton Springs (Parthenia, Zenobia and Eliza) of the Edwards Aquifer, Austin, Texas. Carbonate Evaporates. 28(1):75-87.

Woods HA, MFF Poteet, PD Hitchings, RA Brain, BW Brooks. 2010. Conservation physiology of the plethodontid salamanders *Eurycea nana* and *E. sosorum*: response to declining dissolved oxygen. Copeia. 2010:540-553.