2011 Summary of Tracing for Pit Springs and Four Points in and near the Balcones Canyonlands Sam Hamilton and Bull Creek Preserves

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Abstract

Two traces were conducted to understand the source of groundwater to a significant spring on Bull Creek (Pit Spring) and determine the direction of groundwater migration, approximate flow velocities, and what springs are downgradient of the proposed Four Points Jollyville Transmission Main shaft in the vicinity of Four Points Drive and Riverplace Blvd.. Results indicate that approximately half of the water discharging from Pit Springs is re-emerging surface water that sinks into alluvial sediment hundreds of feet upstream of the spring and daylights from numerous discharge points along the east bank of the creek channel. The remaining spring water discharges from openings in the bedrock floor comprised of the uppermost portion of the Glen Rose formation. Preliminary results of the Four Points trace indicate that groundwater in the area of the proposed shaft migrates northeastward. However, record drought conditions dried up springs and adjacent creeks during the summer of 2011 preventing completion of monitoring for this trace. Monitoring will continue once flow return to the springs and creeks.

Background

Infrastructure related to Water Treatment Plant 4 is proposed near and below the Balcones Canyonlands Sam Hamilton west and Bull Creek Preserves. Greater understanding of groundwater in these areas will help provide data to protect significant resources within the preserve, particularly springs and the aquatic species associated with the springs. Groundwater tracing is a commonly used technique to achieve reliable understanding of groundwater movement in karst systems (Hauwert et al, 2004, Quinlan, 1990, Aley, 1999)

Two related but separate traces were conducted in and adjacent to the Bull Creek Preserve. One trace was performed in the vicinity of Pit Spring and the other in the Four Points area near Riverplace Blvd. and Four Points Dr.. Groundwater level data is generally sparse in the area. However, piezometers installed in the Edwards formation for the geotechnical program of the Jollyville Transmission Main provide data that help estimate possible directions of groundwater movement. A previous tracing study using multiple dyes injected into boreholes located on uplands on the original Bull Creek plant site detected dyes in springs to the north, northwest and east of the site, essentially radiating from the topographic higher uplands. Results also indicate movement of water

from the Edwards into the underlying Walnut formation as indicted by tracer detections in spring discharging from the Walnut (CoA, in preparation).

Pit Spring is located on the main channel of Bull Creek upstream of Tributary 7 in the Bull Creek Preserve (Franklin tract). It discharges a significant volume of water into Bull Creek (0.6 cfs in May and November 2010) and is an important site for the rare Jollyville Plateau Salamander (*Eurycea tonkawa*). Flow in Bull Creek commonly drops to zero a few hundred feet upstream of Pit Spring (Photo 1) and increases dramatically downstream of the spring. In the area of flow loss upstream of the spring, the creek bed is composed of alluvial sediment but it transitions to Glen Rose limestone bedrock for several hundred feet upstream of the spring and through part of the spring reach. Spring water discharges from numerous outlets at the bank edge through alluvial deposits (Photo 2). Additional water discharges from open fractures oriented N35-45E and small solutional openings in the channel bottom (Photo 3).

The source of this groundwater in Pit Spring is assumed to be from infiltrated rainfall falling on the topographically high ground to the east. However, it is possible that the creek flow loss upstream could partially re-emerge in Pit Spring. Recent groundwater investigations indicate a strong downward gradient for water in all formations (Edwards, Walnut, and Glen Rose) in the upper Bull Creek basin (Black & Veatch, 2010). Determining if surface water loss in Bull Creek upstream is re-emerging in Pit Spring versus migrating into deeper formations is important in evaluating potential groundwater impacts of the proposed Jollyville Transmission Main and may have implications for groundwater inflows to the tunnel during construction.

The proposed Four Points shaft is located west of the intersection of River Place Blvd. and Four Points Rd. This area is geologically underlain by the Edwards, Walnut, and Glen Rose Formations. The Edwards commonly contains karst features, including caves, sinkholes, and solution enlarged fractures, ranging in size from millimeters to tens of feet. The karst openings allow rapid recharge of surface water and movement of groundwater from recharge points to springs. Groundwater migration to springs can be primarily through solution-enlarged conduits in the subsurface. Analysis of outcrops and cores suggest that regional dip for the bedrock is approximately 1 degree or less to the north and northeast (CoA, unpublished data 2010). Limited water level data suggest that groundwater migrates generally in a northeast direction in the Four Points area although there is likely a groundwater divide in the general area of RM 620 separating water moving eastward toward Bull Creek and westward toward Lake Travis (unpublished data, 2010). Locally, shallow groundwater may migrate radially from topographic high ground, as indicated by tracing on the original Bull Creek Plant site (CoA, in preparation).

The Four Points shaft is potentially upgradient of several springs in the headwaters of Bull Creek to the north and east. The closest springs approximately 1,500-2,000 ft away appear to discharge from the Edwards near the contact with the underlying Walnut Formation. Further downgradient, generally northeast, other springs discharge from the Walnut and Glen Rose Formations.

The proposed Four Points shaft will be 36 ft in diameter and over 200 feet deep. Excavation through the Edwards has the potential to intercept conduits carrying groundwater to springs. Mitigation strategies are proposed to minimize groundwater impacts and data from these tracer studies on how rapidly groundwater migrates and which springs could be impacted will assist in evaluating their success in protecting groundwater resources.

Methods

The study area includes undeveloped land for the Balcones Canyonlands Preserve managed by the City of Austin, Travis County and private preserves. In addition, springs and channels in private preserves in the Bull Creek headwaters in the Four Points area were monitored along with sites in the upper reaches of Panther Hollow and adjacent to the current Water Treatment Plant 4 site at RR 620 and Bullick Hollow Road.

For the Pit Spring trace, environmentally safe organic eosine dye was injected into flowing water of Bull Creek approximately 100-200 ft upstream of where flow ceases and approximately 1,600 ft upstream of the spring (Photo 4). An autosampler was calibrated to inject a total of one pound of dye mixed into five gallons of water over a 24 hours period (Photo 5). This approached was taken to assure keeping dye concentrations at Pit Spring would remain below a 24 hour average of 2 ppm to protect the salamanders from potential dye toxicity (Smart, 1984; Field et al, 1995). Monitoring points included alluvial and bedrock spring outlets over a 100 foot reach of the creek where spring discharge is most pronounced and sites downstream.

Pit Spring monitoring locations include (Photo 6):

- Three spring alluvial outlets on east creek bank
- Two channel spring sites where water discharges from bedrock
- One channel site downstream the two bedrock channel monitored springs
- Two channel locations downstream of the spring with the most downstream site also having an autosampler to supplement grab and charcoal samples.

Pit Spring sampling frequency:

- Receptors changed daily for first week and weekly for up to 6 weeks
- Grab water samples collected with each charcoal receptor
- Autosampler collected water samples at intervals of 2 hrs for first 2 days, 4 hrs for 3 days, and 6 hours for 2 days following dye injection

Dye injection was on December 8, 2010 and monitoring ended January 18, 2011

For the Four Points trace, an existing monitoring well inside the proposed location of the shaft at the Four Points site was used as a point to introduce environmentally safe fluorescein dye to the water table. The well was completed with 11.5 ft of casing and as an open hole to a depth of 90 ft below ground surface or approximately 5 feet into the Walnut formation. The water table at the time of injection was approximately 81.2 ft below ground surface. Approximately 20 gallons of non-potable water from Lake Austin was used to wet the inside of the well casing to reduce attenuation of the dye. A

peristaltic pump transferred three pounds of dye mixed into five gallons of water from a carboy into the well (Photo 7). Approximately 250 gallons of non-potable water were used to flush the dye down the well and into the rock formation.

Since the Four Points injection site is located on or very close to an apparent groundwater divide, monitoring attempted to cover all reasonable directions of groundwater migration to the north, east, south, and west (Photo 8). However, access was not granted for two springs on a private preserve north of the site. Channel sites were monitored downstream of these springs.

Four Points monitoring locations include (Photo 8):

- Two monitoring wells adjacent to the proposed shaft location
- Three monitoring wells along Riverplace Blvd. south of Four Points Dr.
- Set of springs east of four points in the 3M private preserve
- Powerline Spring on the original Bull Creek plant site.
- Lanier Spring on the north side of Bull Creek in the BCP
- Ribelin Spring (on Tributary 8) in the Sam Hamilton Reserve east (managed by Travis County) on the east side of the original Bull Creek site.
- Two channel sites in Tributary 8 near the upper end of the Sam Hamilton east Reserve
- Channel of Bull Creek at the upstream and downstream of the original Bull Creek site.
- Channel of Bull Creek downstream of Lanier Spring.
- Bull Creek downstream of Pit Spring (approximately 2.2 miles NE)
- Three channel sites adjacent to the current water treatment plant site in unnamed tributaries to Lake Travis
- Two springs and one channel site near the head of Panther Hollow south of the injection site.
- Additionally, a spring and channel sites were added in November in a newly acquired tract (Gass property) along the main channel of Bull Creek between the existing Sam Hamilton Reserve west and a private preserve along Four Points Dr..

Frequency:

- Receptors were changed every two days for first week and then weekly. Frequency was reduce to every three to four weeks as drought reduced spring and creek flows.
- Grab water samples were collected with each charcoal receptor

Dye injection was on March 2, 2011 and monitoring continues in December. Fall rains have caused springs the creeks to resume flow as of late December and monitoring resumed although results of these samples are not yet available.

Monitoring used a combination of charcoal receptors and grab water samples. Several specific spring outlets and channel sites were monitored. Receptors will be secured using a combination of paper clips and string attached to roots or rocks and small rock bolts in the bedrock channel.

Overall climatic conditions include lower than average rainfall during the Pit Springs trace and much lower than average rainfall during the Four Points trace. In fact, central Texas has been designated as under Exceptional Drought as of early summer 2011 (Texas Water Development Board, 2011). This caused many creek reaches and springs to dry up during the monitoring period. The creek hydrograph serves an indicator of general hydraulic conditions affecting groundwater movement over the monitoring period.

Water and charcoal samples were analyzed by the Ozark Underground Laboratory.

Results

Pit Spring Trace

Dye injected in Bull Creek upstream of Pit Spring has been detected in the spring and confirms that water lost from the channel upstream is re-emerging at the spring. Dye was detected in all three monitored alluvial discharge points and all points downstream of those points, including PSC3 (Photo 6). However, at two monitoring points in the channel where water visibly discharges from bedrock and that are upstream of bank spring outlets, dye was only detected following rain events that cause short-term creek flow across the monitoring area from upstream. There was no surface flow from upstream at the time samples were collected. Dye was detected in charcoal, which was possibly carried downstream from the injection site but also in water in the 100 ppt range, low enough to indicate discharge of water containing dye from underground through the bedrock. Another possible source was dye leaching from bedrock surfaces or leaves exposed to dye during brief storm-related surface flow events. Dye was still present in detectable concentrations in both charcoal receptors and water six weeks after injection when monitoring ended. Dye in water concentrations were kept below the 2 ppm concentration limit to protect aquatic life. Detection of dye is best illustrated from samples collected downstream of Pit Spring (Figure 1).

First arrival of dye was approximately 15 hours following injection. Velocity, assuming straight line flow path, is approximately 107 ft/hr or 2,560 ft/d. Peak concentration occurred approximately 55 hours following injection.

Pit Spring appears to have two different water sources, re-emerging surface water and groundwater. The re-emerging surface water primarily discharges from the alluvial springs on the east side of the creek channel. Maidenhair ferns on the east bank indicate that the discharge zone extends for several hundred feet and possibly downstream of the last monitoring site for this study. Creek flow rapidly declines in a reach approximately 1,600 ft upstream of Pit Spring (upstream of a concrete grade crossing) and will be referred to as the channel recharge area. In this area, the channel is composed entirely of recent unconsolidated alluvial material in this area whereas the channel in the spring area is bedrock at the upstream end and bedrock covered with recent alluvium at the downstream end. Although not measured, the channel elevation appears to drop 2-3 ft between the channel recharge area and spring. Based on the results of this study and physical evidence in the creek suggests that the current creek channel has cut into an old abandoned creek channel (paleochannel) that roughly parallels the creek along the east

side. Over time that the current channel has filled with unconsolidated alluvium and hides the paleochannel. The creek water likely enters the channel alluvium and then passes into the paleochannel to migrate downstream to discharge back into the creek. The exact path of this channel is unknown. Source area for the Glen Rose groundwater discharging directly into the channel is not known but currently assumed to be rainwater infiltrating in adjacent uplands.

Four Points Trace

Dye injected in the Four Points well has been detected in multiple wells generally northeast of the injection point (Photo 9). There have not been confirmed dye hits in any springs or channel sites. Dry conditions in 2011 caused many sites to dry up by early summer. However, monitoring wells completed into the Edwards (JT-101A, 112, 113, 114, 115, and 128) continued to have water (Photo 8).

Dye was first detected in JT112, approximately 140 ft ENE of the injection well, within 46 hours of injection. This equals a travel time equates to a velocity of approximately 3 ft/hr or 72.9 ft/d. This velocity is comparable to that determined from tracing on the original plant site in 2007 (COA in preparation). Dye was also detected in JT128 only 35 ft away from the injection well with first arrival between 46 and 97 hours following injection. These travel times equate to much slower velocities than to JT-112. First arrival velocities were found to be between 0.8 ft/hr (18.3 ft/d) or 0.4 ft/h (8.7 ft/d). Faster groundwater migration velocity to JT112, northeast of the injection well, than to JT128, north of the injection well, suggests a preferential direction of groundwater movement that may be based on regional dip of the geologic units.

Additionally, dye was detected in wells JT113, 114, and 115, 2,000 ft, 3,000, ft and 4,000 ft respectively away from the injection well. First arrival of dye at these wells is unclear at this time because of inconsistent initial detection of dye. However, detecting dyes in randomly drilled wells as sampled here is unusual. Such consistent hits may be due to 1) strong preferred direction of groundwater movement along regional formation dip, 2) formation characteristics similar to porous media rather than conduit-dominated (Photo 10), 3) cross contamination from another monitoring site, or 4) dye from another source or a combination of these factors.

There have been unconfirmed hits of the same dye (eosine) used on the Four Points injection in Bull Creek downstream of Pit Spring, in JT101 northwest of the injection well, and two sites adjacent to WTP4. These detections are considered unconfirmed because they have not been verified in follow-up samples. Additionally, eosine (used in other nearby traces) has been detected in a number of sites, including 3M, Bull Creek downstream of Pit Spring, Bull Creek adjacent to the original plant site, two sites in Panther Hollow, Ribelin Spring 2, and adjacent to WTP4. The Bull Creek and Ribelin Spring detections are likely related to tracer studies conducted in 2007 and 2010. Since the other detections, such as adjacent to the WTP4 site, have not been consistently detected in follow-up samples they are likely due to other dye sources or environmental conditions. Dye traveling over 3,500 ft in this aquifer would likely be present in spring

water for many weeks. These dyes are used in many common products which could get into surface or groundwater.

Excavation of the Four Points shaft in the fall of 2011 essentially followed well JT-129 down. Dye was encountered at the water table at the contact between the Edwards and Walnut formation (Photos 10 and 11). In addition, the excavation uncovered the bottom of JT-128 and showed heavily stained rock (Photo 12).

Conclusions

Tracing confirmed that water discharging from Pit Springs has two sources; one is re-emerging surface water and the other is groundwater discharging from the upper part of the Glen Rose formation. Surface water from upper Bull Creek sinks into alluvium approximately 1,600 ft upstream of the spring and discharges from alluvium at a number of points on the east side of the channel. Glen Rose water discharges from solution-enlarged trace fossils in the rock and fractures in the channel.

Tracers at the Four Points shaft site have been detected in monitoring wells northeast of the injection well suggesting that regional dip may be a strong factor in groundwater migration direction. Record drought in 2011 suspended monitoring at all surface sites. Detection of dye in many monitoring wells and observations of the Edwards/Walnut contact in the Four Points shaft suggests that the basal Edwards in this area has characteristics more like a porous media aquifer rather than a conduit-dominated aquifer. Continued monitoring during 2012 of creeks and springs for tracers from the 4 Points injection should refine these preliminary results and which springs might be downgradient from the Four Points shaft.

References

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Photo 1. Bull Creek upstream of Pit Spring under low baseflow conditions. Note bedrock channel bottom and no surface flow upstream of the spring.



Photo 2. Pit Spring has numerous outlets from the alluvial sediments on the east side of the channel.



Photo 3. Pit Spring also discharges water from fractures and small solution openings on the channel bottom.

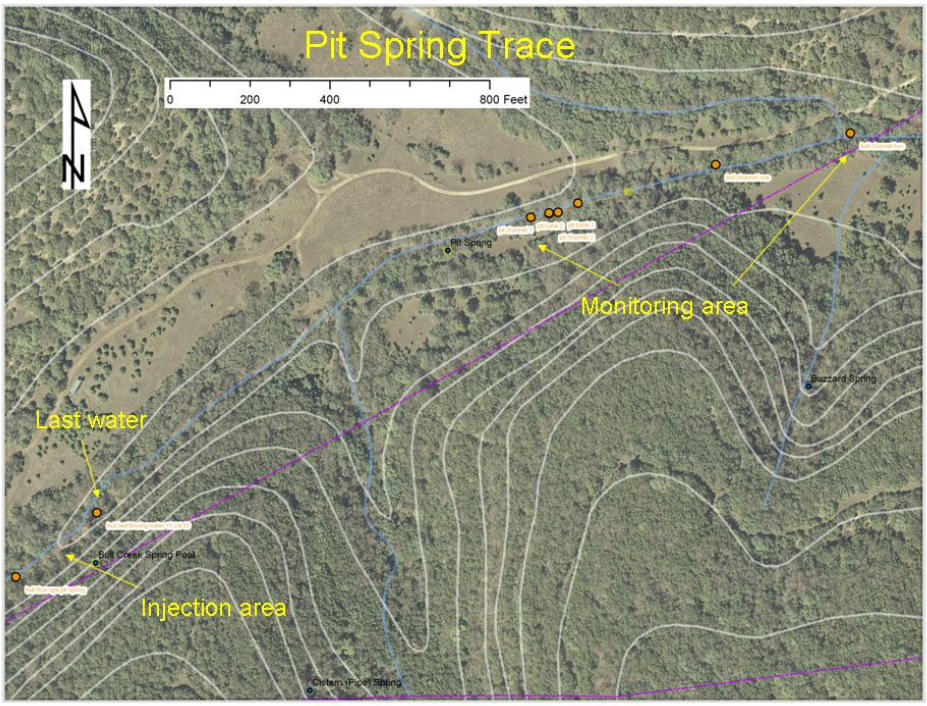

Photo 4. Aerial image of the Bull Creek preserve west of Old Lampasas Trail. The monitoring area includes separate spring outlets and the main creek channel. The injection area is approximately 1,600 ft upstream of the spring and the area of last water, as of November 24, 2010, is similar to that that observed in May and October 2010.



Photo 5. Dye injection set-up immediately after injection of dye in Bull Creek channel approximately 1,600 ft upstream of Pit Springs in December 2010.

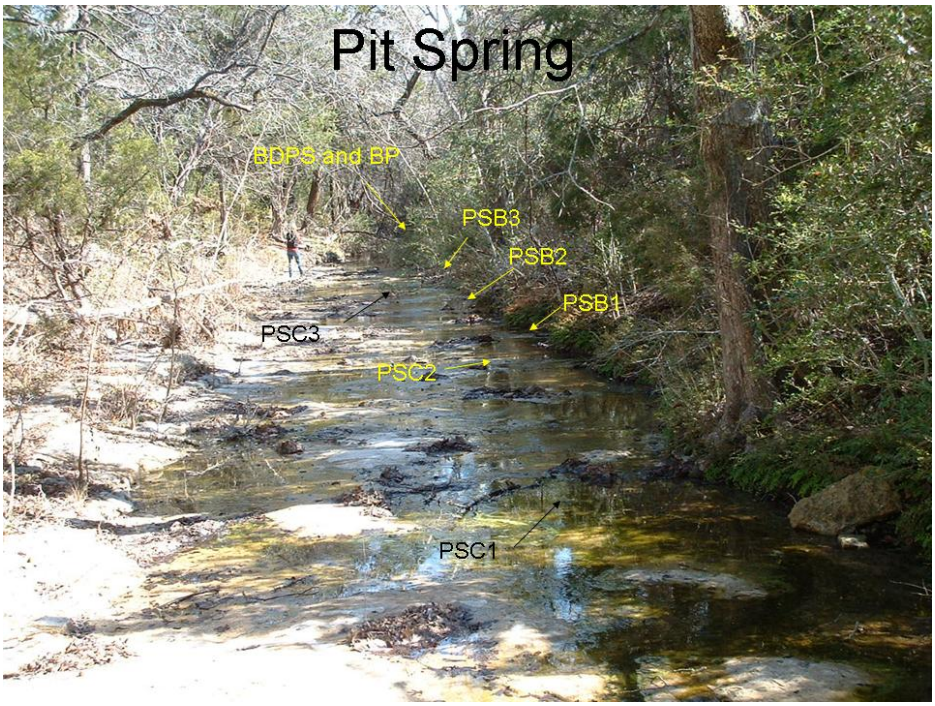

Photo 6. Pit Spring area in January 2011 showing general location of spring outlets monitored for tracing.



Photo 7. Injection of dye into JT-129 in March 2011. Lake Austin water from the tank in the background was used to wash dye down the well and into the rock formation.

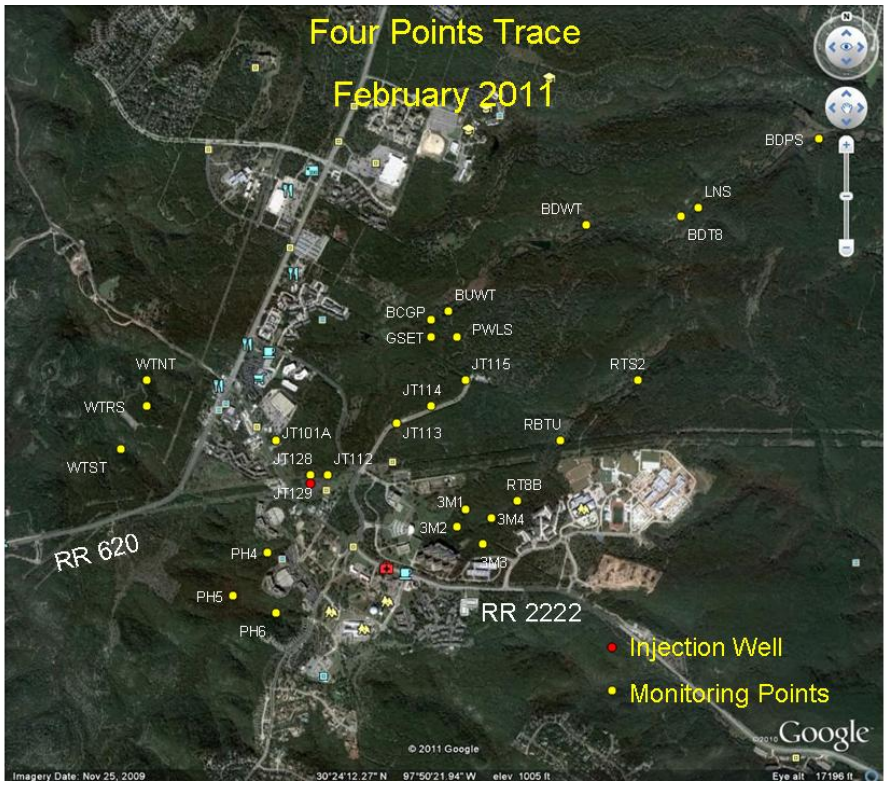

Photo 8. Aerial image of the Four Points area showing location of injection point and monitoring sites.

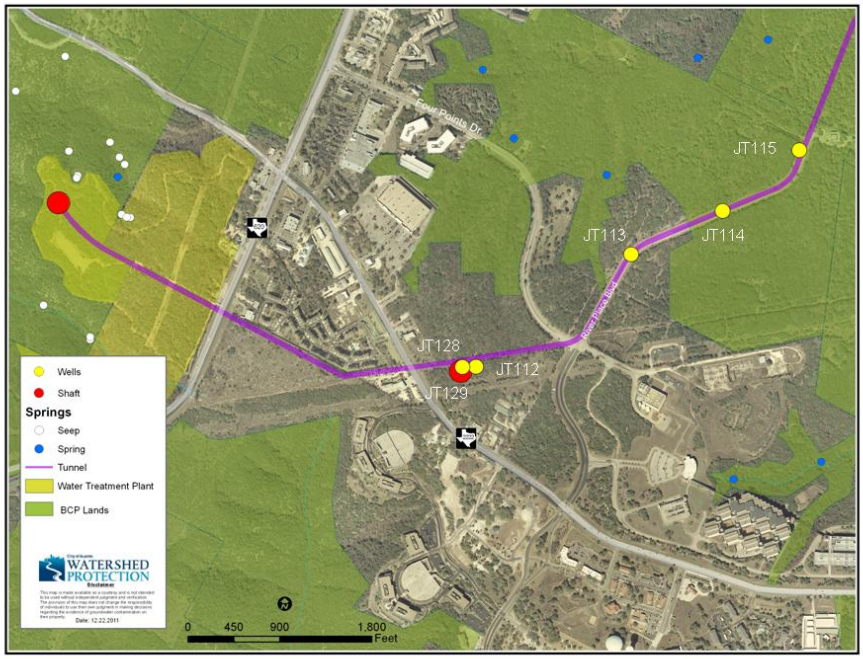

Photo 9. Aerial image of Four Points area showing injection well JT-129 (inside current 4 Points shaft) and confirmed detections in monitoring wells.



Photo 10. Edwards/Walnut contact in the 4 Points shaft. Contact is along sub-horizontal line in the middle of the image. Water discharges from several discrete points such as the oxidized zone on the left and un-oxidized “notch” on the right.



Photo 11. Excavation of the Four Points shaft encountered dye at the water table at the Edwards/Walnut contact.



Photo 12. Excavation of the Four Points shaft exposed the injection well (JT-129) as it advanced downward. The rock in the center shows the well bore and rock stained by the fluorescein dye.

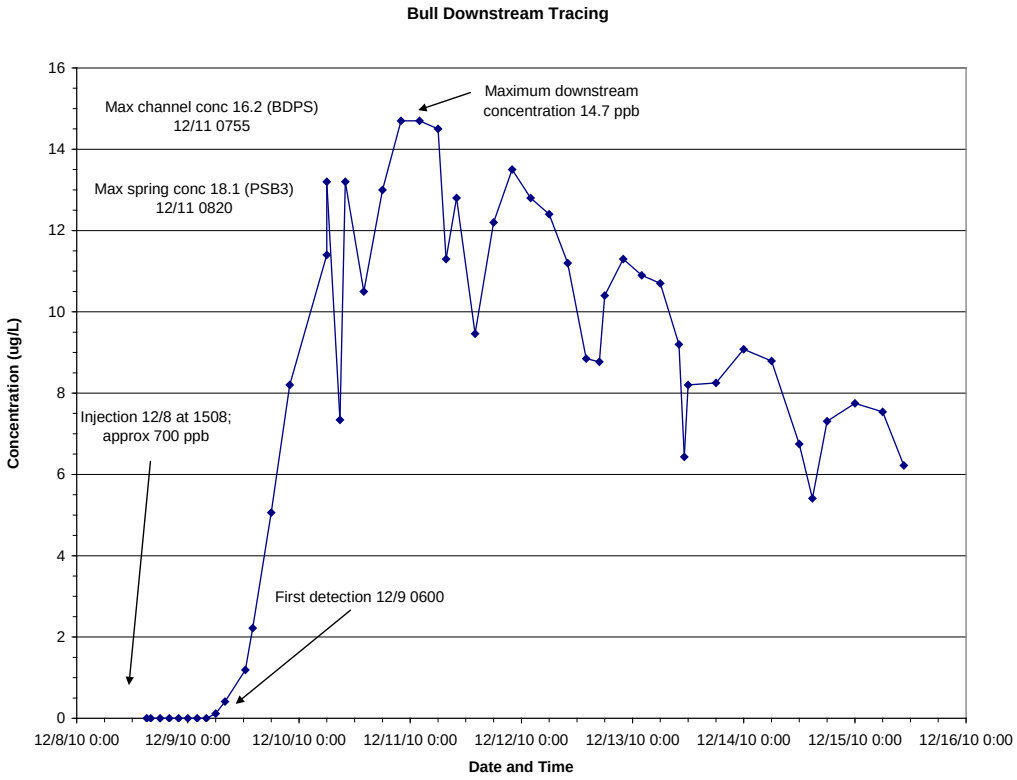

Figure 1. Chart showing injection and detection of dye downstream of Pit Springs in December 2010.