Gardenside Spring Springshed Delineation

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Under the direction of James C. Currens, Kentucky Geological Survey,
KRPG 0905

Introduction

The Kentucky Geological Survey (KGS) was approached by the Friends of Wolf Run, in cooperation with the Gardenside Neighborhood Association, in March of 2015 regarding the source of groundwater flow from Gardenside Spring (GSS). Friends of Wolf Run, a volunteer conservation organization, in conjunction with several neighborhood associations is currently engaged in remediation and water quality monitoring efforts within the South Elkhorn basin. As Gardenside Spring discharges into the basin, knowledge regarding water source would be useful in remediation efforts. While water quality data was available; no data regarding springshed location or areal extent was known to exist.

Background

Gardenside Spring is located in Gardenside Park and discharges into the Wolf Run tributary of the South Elkhorn Creek Basin. The park is located within the Inner Bluegrass Physiographic region (Appendix, Map 1) typified by low-relief rolling hills (Blair, 2009). Karst is prevalent throughout the region and the surface watershed of Wolf Run abuts the groundwater basin of McConnell Springs. Interaction between surface and subsurface watersheds are common and karst groundwater basins regularly cross surface watershed divides (Currens and Paylor, 2009). The spring is located within the Ordovician-age Lexington Limestone, which has two principal facies, the Grier and Tanglewood Limestone members. These are interfingered by the minor shale and limestones of the Millersburg, Devils Hollow, and Brannon members, and Macedonia Bed. The Lexington Limestone is overlain by the Clays Ferry Formation. The spring rises along a contact of interbedded minor shales (Blair, 2009; Fig. 1) within the Tanglewood. Down cutting of Wolf Run, immediately up - and downstream of the spring, has been slowed by this minor shale. The immediate area surrounding the spring is dominated by ridges capped by the silty, weather resistant Brannon member.

Land-use is residential and commercial, however, the presence of a karst springs discharging into Wolf Run create the potential for land-uses outside of the surface watershed to influence water quality. Wolf Run is considered impaired for fecal coliform and Gardenside Spring is considered impaired for E.Coli and has a total maximum daily load of 216 colonies/100 ml (Ormsbee et al., 2013). Water quality analyses of Gardenside Spring were conducted during a prior study of the South Elkhorn Basin (Blair, 2009).

Regional groundwater basin delineation has shown downgradient groundwater flow to the northwest aligned with regional structure (Currens, 1996). This is seen in the adjacent McConnell Springs and Kenton's Blue Hole groundwater basins. Prior tracer tests within the region connect features to the north, south, west, and east of Gardenside Spring to McConnell Springs or Kenton's Blue Hole.

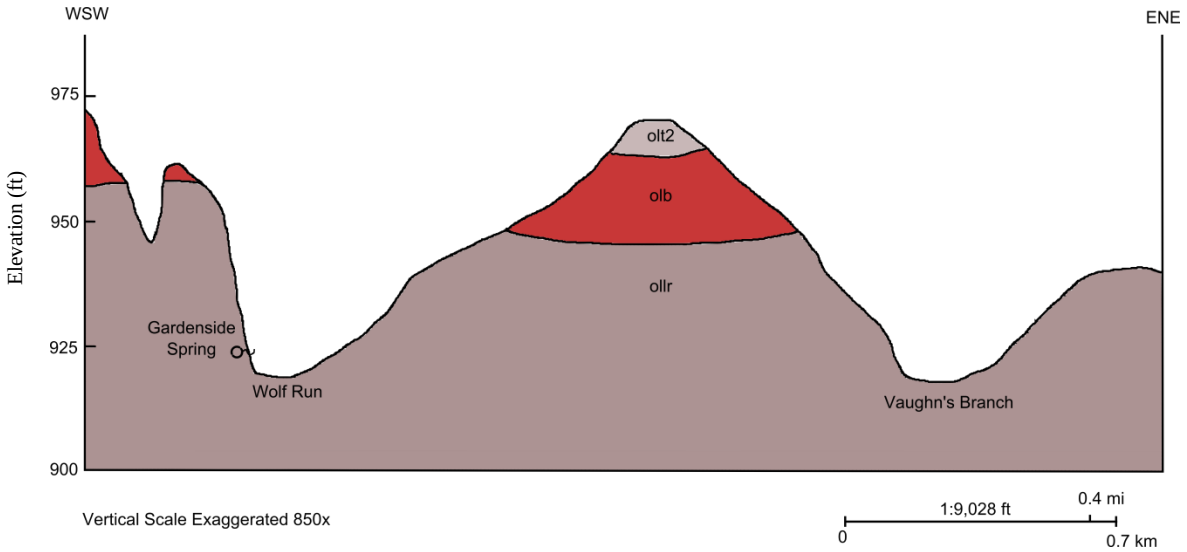

Fig. 1 – Topographic profile and geologic cross-section (A – A', Map 1; Olt2 – Tanglewood Limestone Member, Olb – Brannon Member, Ollr – Lower Lexington Limestone)

Methods

A review of prior work, and surface and ground water basin maps was conducted by (Blair, 2009; Currens, 1996). Given the prevalence of karst within the study area the spring was expected to be conduit flow. A search for tracer injection points was conducted using aerial (current and historical) photography, lidar, and topographic maps. Depression identification was limited by lidar resolution. Contact with landowners within the Gardensprings neighborhood was conducted with the aid of the neighborhood association. Letters were distributed asking residents to contact the researchers regarding the history of flooding and direct knowledge of karst features.

Suspected features were inspected on the ground to confirm identification and areas obscured by vegetation were investigated by foot. The study was initially focused on two localities: a large sinkhole spanning the residential bloc between Stonewall and Fredericksburg Roads, and the topographically delineated tributary watershed to the immediate south of Wolf Run. No tracer tests located within these areas were recovered and the study area was expanded north past Mason-Headley Road, west to Cross Keys Park, and east south east to Clays Mill/Harrodsburg Road. The watershed of Wolf Run upstream of GSS was topographically delineated using Lidar data in ArcGIS (Map. 1). The reach upstream of GSS was walked from Gardenside Park to Clays Mill Road.

Spring discharge, temperature, conductivity, dissolved oxygen, and pH were monitored from July to Oct 2015 using an YSI multiprobe and Marsh-McBirney Flo-Mate. Weekly measurements were conducted over the summer dry period to establish base flow conditions. Two storm events were monitored; one at a 24-hr interval, the other using a HOBO data logger at 30-minute intervals. Temperature and conductivity were also monitored within the pond and Wolf Run Branch at Cross Keys Park. Daily precipitation data was gathered from NOAA. As precipitation data is based on zip code it likely includes precipitation outside of the Wolf Run drainage. Springshed extent was estimated using the unit base flow assessment for the Inner Bluegrass Region established by Paylor and Currens (2001). Previous water quality analysis

work was reviewed. Fluoride and caffeine were focused upon as potential indicators of artificial recharge.

Qualitative Dye Injections

Background monitoring for fluorescent tracers were conducted at Gardenside Spring, along Wolf Run, Kenton's Blue Hole, and McConnell Springs for one week prior to tracer tests. Five locations were identified as injection points and a total of five groundwater and one surface water injections were conducted between June and November 2015. Activated charcoal dye receptors were placed at seven locations: Wolf Run Branch at Cross Keys Park, Wolf Run at the Beacon Hill Road Bridge, Wolf Run at Gardenside Park (upstream of the spring), Wolf Run at Wolf Run Park, Gardenside Spring, Kenton's Blue Hole, and McConnell Springs. Monitoring sites varied from five to six depending on injection location. Dye receptors were oven dried within 24 hours of recovery then treated with Smart solution (1 – propanol ammonium hydroxide) for approximately thirty minutes. The resulting solution was then decanted and analyzed using a Varian Carie Eclipse scanning fluorometer.

The first tracer test was conducted at a suspected swallow hole adjacent to a natural gas meter on the Garden Springs Elementary school grounds. Twenty-five grams of sodium fluorescein was injected as powder. Conditions were dry and the dye was followed by 10 gallons of water. A second tracer test was conducted during a storm event, because of ambiguous results from the first. One-hundred grams of Sulforhodamine B was injected at Garden Springs Elementary, followed by 5 gallons of water. Conversations with residents suggested a small area within the Stonewall Road sink drained rapidly and 75 grams of eosine was injected in an animal burrow taking water within the Stonewall Road sink, followed by 5 gallons of water. Rainfall was consistent over the day and heavy at times; total rainfall was 0.9 inches at Bluegrass airfield.

A third test was conducted at a repaired cover collapse sink at the intersection of Yorktown and Della drive, and at one of two suspected swallow holes along the reach of Vaughn's Branch within the Picadome Golf Course. A two-hundred and fifty milliliter solution of Rhodamine WT was injected into an animal burrow at the location of the repaired cover collapse. The swallow hole along Vaughn's Branch was injected with 150 grams of eosine. This reach is ephemeral and was flowing and the swallow hole was actively taking water. Rainfall was consistent across the day and heavy at times and the storm total was 0.9 inches at Bluegrass Airfield. The final tracer test was conducted at the Clays Mill box culvert over Wolf Run where 125 grams of sulforhodamine b were poured into the surface flow. Wolf run was at moderate flow and the ephemeral reach between Clays Mill Road and Harrodsburg Road was flowing.

Results

Map and ground investigation confirmed one previously unrecognized significant sink at the intersection of Clays Mill Road and Harrodsburg Road. Additionally, two suspected swallow holes were identified along Vaughn's Branch; one was confirmed (Map 1). Several potential examples of "anthrokarst" and likely surface expressions of underlying epikarst were also located but could not be confirmed.

Spring discharge varied from 0.05 to 0.89 cubic feet per second (cfs). Lowest discharge (taken as baseflow) occurred in July and August, and agrees with the prior work of Blair (2009). Highest discharge was associated with a precipitation event of 2.33 inches on September 30th (Fig. 2).

Determination of lag time was limited by the sampling interval of discharge and precipitation data but can be determined to be 24 hours or less. Springshed extent was estimated at 0.10 mi^2 using a baseflow of 0.05 cfs.

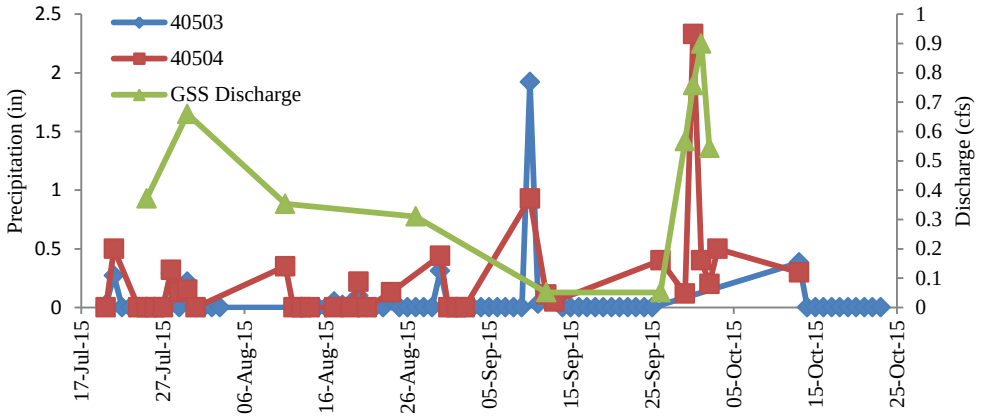

Fig. 2 – Daily Precipitation (NOAA, 2015) and Gardenside Spring Discharge

Dissolved oxygen, temperature, and conductivity ranged from 6.46 – 7.02 mg/L, 15.3 - 16.6° celcius, and 431.6 – 518 µs/cm, respectively, pending flow condition. Dissolved oxygen and conductivity rose with increasing discharge, while conductivity decreased (Fig. 3 and Fig. 4). PH varied from 6.38 to 6.71; no trend in pH was apparent from the collected data (Fig. 3).

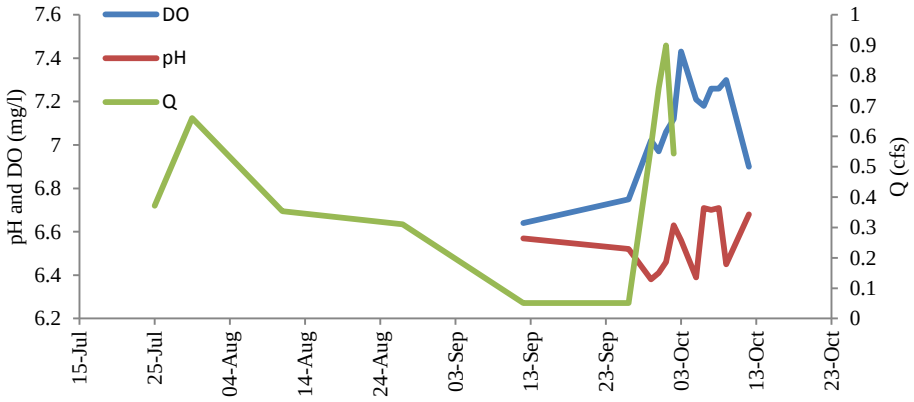

Fig. 3 - Gardenside Spring, Discharge, Dissolved Oxygen, and pH

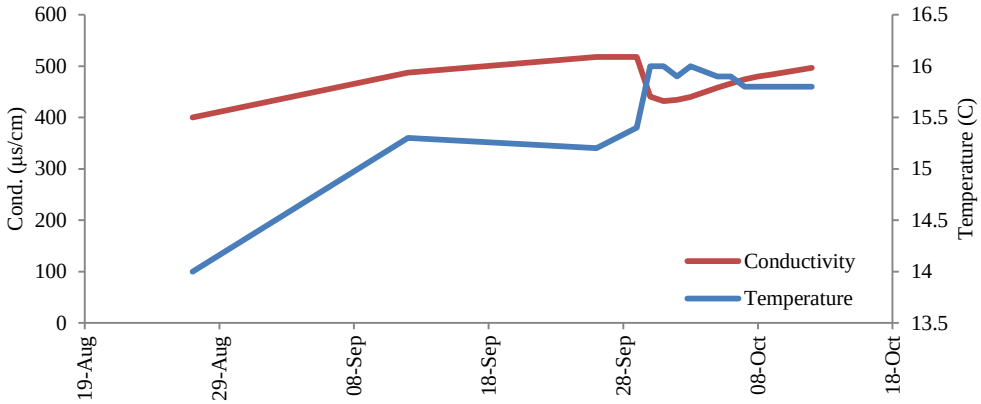

Fig. 4 - Gardenside Spring, Temperature, and Conductivity, 25 Aug – 13 Oct.

Of the six tracer tests conducted, only the eosine trace from the western most Vaughn's Branch swallet was recovered at McConnell Springs. Serendipitously, this trace also tested positive for sodium fluorescein. Lexington - Fayette Urban County Government was contacted and the source of the fluorescein is likely a test for leaking municipal sewers. Prior water quality work reported fluoride at 0.254 mg/L and caffeine was reported equivalent to 742 ng/L (Blair, 2009).

Discussion and Conclusion

The chemograph response of the discharge from the spring is characteristic of piston displacement of conduit stores. The piston displacement is indicated by the shift from higher conductivity and lower temperature to lower conductivity and higher temperature, in warm weather. Conversely, the perennial flow from the spring coupled with the small estimated recharge area, indicate a reservoir (porous media or conduit) capable of sustaining base flow during dry periods. Base flow sustained by artificial recharge (municipal water, lawn maintenance, or sewage) is also a possibility. While fluoride values fell below recommended levels for municipal water fluoridation for tooth decay prevention (CDC, 2015), caffeine levels were close to 2x the arbitrary threshold (400 ng/L) suggested by Sauve (2012) as a proxy for sewage contamination. While not conclusive, in combination with the impairment of Wolf Run and Gardenside Spring by fecal coliform, specifically E. Coli for the spring, the potential for baseflow maintenance by artificial recharge cannot be eliminated.

While not directly related to the task of springshed delineation, the ephemeral reach of Wolf Run between Clays Mill and Harrodsburg roads is an interesting case of karst groundwater basin evolution and groundwater/surfacewater interaction. Under most flow conditions, the swallet at Southbend Road is pirating close to one-hundred percent of baseflow from Wolf Run, carrying it to McConnell Springs, where it is returned to Wolf Run at Preston's Cave Spring. A roughly linear line of features (including the confirmed sinkhole at the intersection of Clays Mill and Harrodsburg Road) points from Wolf Run to McConnell Springs and is likely evidence for the up-dip migration of a karst conduit. This is likely analogous to the migration of a knick point in a

surface stream. Downstream of the ephemeral reach, Wolf Run returns to gaining and the wetland floodplain maintained by Friends of Wolf Run likely acts to maintain base flow.

Although no individual water sinks or areas were connected to Gardenside Spring by tracer tests, the successful inflow test from Vaughn's Branch to McConnell Springs adjusts the McConnell Springs groundwater basin to the west, further constraining the possible area of the Gardenside groundwater basin. The results of that trace, combined with prior tests to the east (swallet along Wolf Run at Southbend Road; Map 1), the southeast (Kay's Spring; Map 1), and the west, southwest (Kenton's Bluehole; Map 1) limits the areal extent likely to include the springshed. Because it is very close to GSS, the large sink between Fredrickburg and Stonewall Road should be considered a suspected recharge area. No drain has been found in the sink, despite multiple searches, but the lack of flooding in the sink is indicative of a significant capacity for drainage. This could be a product of diffuse recharge to epikarstic storage. However, the failed tracer, whether a product of a failure to penetrate the sediment column or monitoring the wrong spring must be reconciled before a definitive conclusion can be made.

References

Blair, R. J, Ray, J., Webb, J., Blanset, J., and Goodmann, P. 2009 Assessment of Nonpoint Source Impacts on Groundwater Quality in South Elkhorn Creek Basin, Central Kentucky (BMU1, Round 2), Kentucky Division of Water

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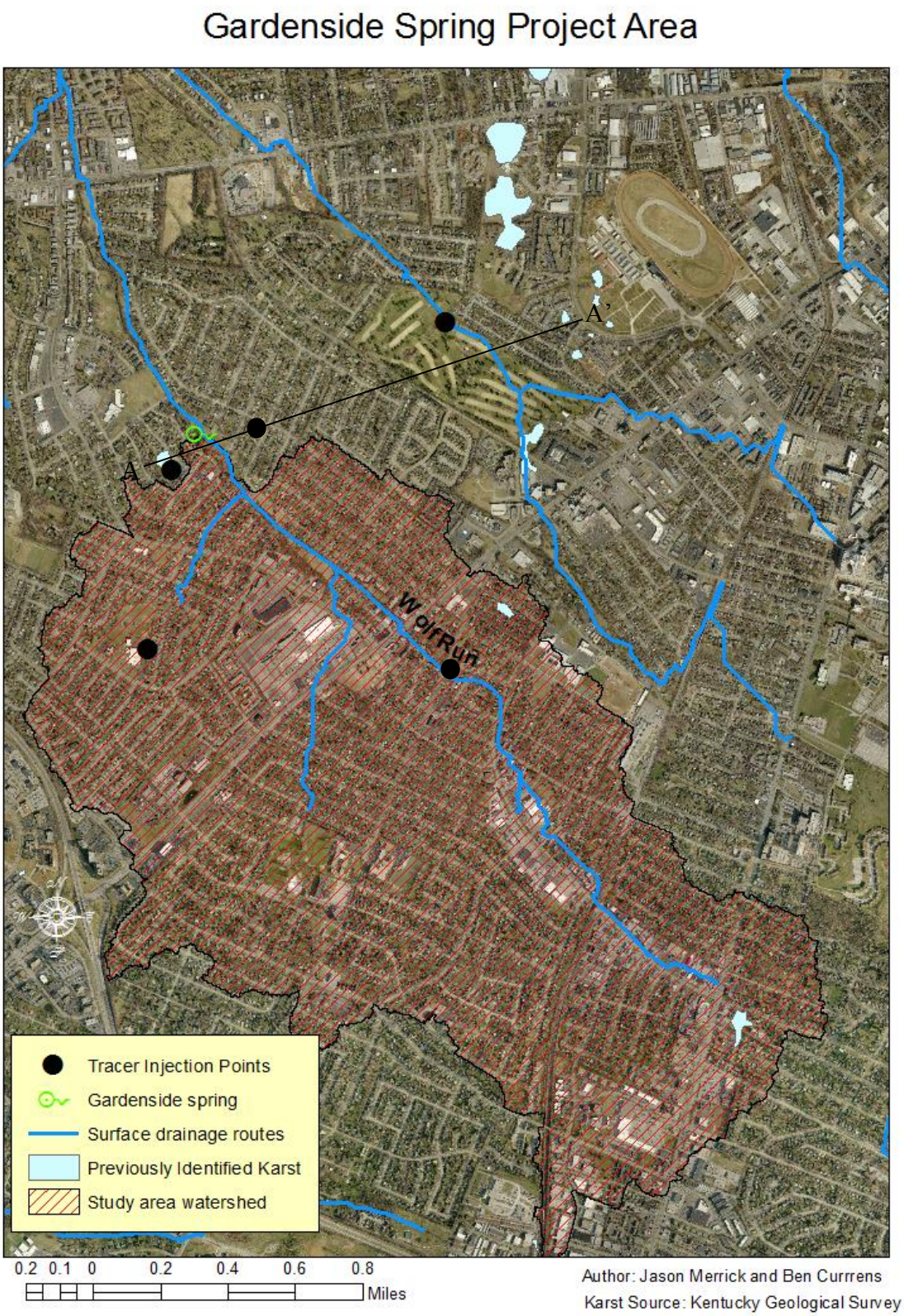
Center for Disease Control, 2015, Fluoridation FAQS, CDC http://www.cdc.gov/fluoridation/faqs/#fluoride3

Ormsbee, L., 2013, Total Maximum Daily Load for Fecal Coliform and *E.Coli*, 9 Stream Segments and 2 Springs within the South Elkhorn Creek Watershed, Fayette, Franklin, Jessamine, Scott, and Woodford Counties, Kentucky, Kentucky Division of Water

Paylor, R., and Currens, J. 2001, Mapping karst groundwater basins in the Inner Bluegrass as a nonpoint-source management tool, in Beck, B.F. and Herring, J.G., eds: Geotechnical and Environmental Applications of Karst Geology and Hydrology.

Sauvé, Sébastien, Aboulfadl, Khadija, Dorner, Sarah, Payment, Pierre, Deschamps, Guy, and Michèle Prévost, 2012, Fecal coliforms, caffeine and carbamazepine in stormwater collection systems in a large urban area. Chemosphere 86:118–123

Appendix



Map 1 - Map of study area.

GROUNDWATER TRACE
INJECTION REPORT FORM

Circle √, X, or underline wherever possible

INJECTION SITE LOCATION

Reporters: Currens & Currens Report date: 12-3-2015
Field ID: _____ Trace serial No: _____
Site name: Wolfe Run @ Clays Mill Rd Type of karst feature: ephemeral surface drainage
County: Fayette Quadrangle: Lexington Corridor or project: Gardenside
✗ Geodetic location: N latitude: ____ ° ____ ' ____ . __ " W Longitude: ____ ° ____ ' ____ . __ "
UTM location: Zone _____, easting _____, northing _____
Elevation: _____, Accuracy est. _____ GPS Topo Other _____

Additional forms completed for this location:

Spring Inspection	Cover-Collapse Report
Bug Sheet	Karst Feature Inventory

TRACER INJECTION

Weather or field conditions: Dye Traced injected at dusk to avoid citizen complaints. Was poured directly in Wolfe Run less than 20 Ft. downstream of Boxculvert
Date of injection: 12-3-2015 Time (military) of injection: 17:30 est
Amount of tracer: 125 gm Batch or lot no. (Optional): _____

Tracer Used

1 ☐ Eosine-Y (Acid Red 87)
2 ☐ Rhodamine WT (Acid Red 388)
3 ☐ Sodium Fluorescein (Acid Yellow 73)
4 ☐ Solophenyl (Direct Yellow 96)
5 ☒ Sulforhodamine B (Acid Red 52)
6 ☐ Tinopal CBS-X (Fabric Brightener 351)
7 ☐ Other tracer (specify) _____

Tracer Recovery

Name of positive spring(s): Wolfe Run @ Gardenside Park AKGWA ID No. _____
Detector placement: date 12-2-2015 Time (Military): Not recorded
Detector recovery: date 12 Time (Military): _____
Other positive sites? Wolfe Run at Wolfe Run Park
For a complete list of all monitored sites, see the Monitoring Report dated: _____

Comment or Interpretation:

McConnel Spring was negative, as was Gardenside Spring

GROUNDWATER TRACE
INJECTION REPORT FORM

Circle √, X, or underline wherever possible

INJECTION SITE LOCATION

Reporters: Currens & Currens Report date: Nov 20, 2015
Field ID: none Trace serial No: none
Site name: 1801 Yorktown Type of karst feature: Macropore over a repaired collapse
County: Fayette Quadrangle: Lex West Corridor or project: Garden Spr
Geodetic location: N latitude: 38 ° 02 ' 11 " W Longitude: -84° 32' 31 "
Decimal Deg ~~UTM location: Zone~~ Lat, ~~easting~~ 38.036644, ~~northing~~ Lon -84.542017
Elevation: 940, Accuracy est. ____ GPS Topo Other ____

Additional forms completed for this location:

Spring Inspection	Cover-Collapse Report
Bug Sheet	Karst Feature Inventory

TRACER INJECTION

Weather or field conditions: Heavy rain Total Rain at BG Airport was 0.9 inches

Date of injection: Nov 19, 2015 Time (military) of injection: 16:00 est
Amount of tracer: 250 mL Batch or lot no. (Optional): NA

Tracer Used

1 ☐ Eosine-Y (Acid Red 87)
2 ☒ Rhodamine WT (Acid Red 388)
3 ☐ Sodium Fluorescein (Acid Yellow 73)
4 ☐ Solophenyl (Direct Yellow 96)
5 ☐ Sulforhodamine B (Acid Red 52)
6 ☐ Tinopal CBS-X (Fabric Brightener 351)
7 ☐ Other tracer (specify) _____

Tracer Recovery

Name of positive spring(s): _____ AKGWA ID No. _____
Detector placement: date _____ Time (Military): _____
Detector recovery: date _____ Time (Military): _____
Other positive sites? _____
For a complete list of all monitored sites, see the Monitoring Report dated: _____

Comment or Interpretation:

This site was known to me as the location of a cover collapse that had been repaired. If the tracer could be transported past the soil then it would wash into the stone & thence into the conduit. Elev Garden Spring is 908

GROUNDWATER TRACE
INJECTION REPORT FORM

Circle √, X, or underline wherever possible

INJECTION SITE LOCATION

Reporters: Currens & Currens Report date: Nov 2015
Field ID: ____ Trace serial No: ____
Site name: Pinedome West Type of karst feature: Swallow hole on S bank of
County: Fayette Quadrangle: Leq West Corridor or project: Garden Sp Vaughns Br
Geodetic location: N latitude: 38° 07' 20" W Longitude: 84° 31' 51.6"
Decimal ~~UTM location: Zone~~ Lat, ~~easting~~ _____, ~~northing~~ Lon _____
Elevation: 915, Accuracy est. _____ GPS (Topo) Other _____

Additional forms completed for this location:

Spring Inspection	Cover-Collapse Report
Bug Sheet	Karst Feature Inventory

TRACER INJECTION

Weather or field conditions: Heavy rain for past 3 hours
Total storm accumulation at B.G. Airport 0.9 inches
Date of injection: 11-19-2015 Time (military) of injection: 16:10 est
Amount of tracer: 150 grams Batch or lot no. (Optional): _____

Tracer Used

1 [X] Eosine-Y (Acid Red 87)
2 [ ] Rhodamine WT (Acid Red 388)
3 [ ] Sodium Fluorescein (Acid Yellow 73)
4 [ ] Solophenyl (Direct Yellow 96)
5 [ ] Sulforhodamine B (Acid Red 52)
6 [ ] Tinopal CBS-X (Fabric Brightener 351)
7 [ ] Other tracer (specify) _____

Tracer Recovery

Name of positive spring(s): _____ AKGWA ID No. _____
Detector placement: date _____ Time (Military): _____
Detector recovery: date _____ Time (Military): _____
Other positive sites? _____
For a complete list of all monitored sites, see the Monitoring Report dated: _____

Comment or Interpretation:

Swallow hole on south side of Vaughns Branch at the western end of Pinedome (formerly Big Elm) Golf Course

GROUNDWATER TRACE
INJECTION REPORT FORM

Circle √, X, or underline wherever possible

INJECTION SITE LOCATION

Reporters: J. Curran R. Curran Report date: 2 Jul

Field ID: _____ Trace serial No: _____

Site name: Crash Spring, Slem Type of karst feature: Sink. Swallow hole

County: Fayette Quadrangle: _____ Corridor or project: _____

Geodetic location: N latitude: ____° ____' ____." W Longitude: ____° ____' ____."

UTM location: Zone _____, easting _____, northing _____

Elevation: _____, Accuracy est. _____ GPS Topo Other _____

Additional forms completed for this location:

Spring Inspection	Cover-Collapse Report
Bug Sheet	Karst Feature Inventory

TRACER INJECTION

Weather or field conditions: 2 1.5" rain prior to injection, 10 gal water sinking from, 100g SRB follow by 5 gal water

Date of injection: 2 Jul Time (military) of injection: 1220 Est

Amount of tracer: 100 g Batch or lot no. (Optional): _____

Tracer Used

1 ☐ Eosine-Y (Acid Red 87)
2 ☐ Rhodamine WT (Acid Red 388)
3 ☐ Sodium Fluorescein (Acid Yellow 73)
4 ☐ Solophenyl (Direct Yellow 96)
5 ☒ Sulforhodamine B (Acid Red 52)
6 ☐ Tinopal CBS-X (Fabric Brightener 351)
7 ☐ Other tracer (specify) _____

Tracer Recovery

Name of positive spring(s): _____ AKGWA ID No. _____

Detector placement: date _____ Time (Military): _____

Detector recovery: date _____ Time (Military): _____

Other positive sites? _____

For a complete list of all monitored sites, see the Monitoring Report dated: _____

Comment or Interpretation:

_____

_____

GROUNDWATER TRACE
INJECTION REPORT FORM

Circle √, X, or underline wherever possible

INJECTION SITE LOCATION

Reporters: Curren & Curren Report date: 12-18-2015
Field ID: _____ Trace serial No: _____
Site name Garden Spr. Sch Type of karst feature: possible swallow hole
County: Fayette Quadrangle: Lex W Corridor or project: Garden Springs
Geodetic location: N latitude: ____° ____'____.__" W Longitude: ____° ____'____.__"
UTM location: Zone _____, easting _____, northing _____
Elevation: _____, Accuracy est._____ GPS Topo Other_____

Additional forms completed for this location:

Spring Inspection	Cover-Collapse Report
Bug Sheet	Karst Feature Inventory

TRACER INJECTION

Weather or field conditions: Rain

Date of injection: 6-20-15 Time (military) of injection: 7:30 AM
Amount of tracer: 25 gm Batch or lot no. (Optional): _____

Tracer Used

1 ☐ Eosine-Y (Acid Red 87)
2 ☐ Rhodamine WT (Acid Red 388)
3 ☒ Sodium Fluorescein (Acid Yellow 73)
4 ☐ Solophenyl (Direct Yellow 96)
5 ☐ Sulforhodamine B (Acid Red 52)
6 ☐ Tinopal CBS-X (Fabric Brightener 351)
7 ☐ Other tracer (specify) _____

Tracer Recovery

Name of positive spring(s): None AKGWA ID No. _____
Detector placement: date 6-19-15 Time (Military): _____
Detector recovery: date 6-26-15 Time (Military): _____
Other positive sites? _____
For a complete list of all monitored sites, see the Monitoring Report dated: _____

Comment or Interpretation:

Trace was lost possibly due to too little rain

GROUNDWATER TRACE
INJECTION REPORT FORM

Circle √, X, or underline wherever possible

INJECTION SITE LOCATION

Reporters: Currens + Currens Report date: Dec 3, 2015
Field ID: _____ Trace serial No: _____
Site name: Stonewall Type of karst feature: animal ~~burrow~~ burrow spring
County: Fayette Quadrangle: Lexington W Corridor or project: Cardin
Geodetic location: N latitude: 38 ° 02' 03 " W Longitude: 84 ° 32' 45 "
Decmal Dg ~~UTM location: Zone 16~~, easting 38.034228, northing -84.545907
Elevation: _____, Accuracy est. _____ GPS Topo Other _____
Additional forms completed for this location: 960 Stonewall Rd, Lexington Ky

Spring Inspection	Cover-Collapse Report
Bug Sheet	Karst Feature Inventory

TRACER INJECTION

Weather or field conditions: Rain

Date of injection: June 30, 2015 Time (military) of injection: 8:27 edst
Amount of tracer: 25 gms Batch or lot no. (Optional): _____

Tracer Used

1 ☒ Eosine-Y (Acid Red 87)
2 ☐ Rhodamine WT (Acid Red 388)
3 ☐ Sodium Fluorescein (Acid Yellow 73)
4 ☐ Solophenyl (Direct Yellow 96)
5 ☐ Sulforhodamine B (Acid Red 52)
6 ☐ Tinopal CBS-X (Fabric Brightener 351)
7 ☐ Other tracer (specify) _____

Tracer Recovery

Name of positive spring(s): _____ AKGWA ID No. _____
Detector placement: date _____ Time (Military): _____
Detector recovery: date _____ Time (Military): _____
Other positive sites? _____
For a complete list of all monitored sites, see the Monitoring Report dated: _____

Comment or Interpretation:

Trace was not recovered. Possible unmonitored spring, too little dye, or poor communication of small hole with groundwater

University of Kentucky, Kentucky Geological Survey

Groundwater Trace Monitoring and Analysis Data Report

PAGE 1 of __

Project or Area: Gardensick Spring Field Personnel: b. Currens Date of Field Work: 30 may – 1 June

VISIT RECORD		FIELD TASKS						ANALYSIS RESULTS								
Time: 24-hr Clock	Location: Name or ID No.	Hang			Collect			Charcoal				Cotton		Water		
		Rig Gumdrop	Char.	Cotton	Char.	Cotton	Pull Gumdrop	Fluor.	R WT	SRB	Eosine	DY	OB	Time	Conc.	Comment
~~9:15~~	Wolf Creek #1	X	X													
~~9:20~~	Beacon Hill RD #1	X	X													
	Gardensick Spr #1	X	X													
9:15	Wolf Creek #1		X		X											No dye found
9:25	Gardensick Spr #1		X		X											No dye found
9:32	Beacon Hill RD #1		X		X											No dye found
10:51	McConnell Spr	X	X													
11:15	Keenons Blue Hole	X	X													
11:32	Beacon Hill RD		X		X											
11:42	Gardensick Spring	X	X		X											
11:50	Wolf Creek Perch		X		X											

EXPLANATION

√- Bug changed or task performed. **BM** Bug missing. **BD** Bug destroyed / Bug not changed. **NA** Not Applicable. **NR** Not recovered.
"-" Negative (< 1 ppb) + Positive (> 1 ppb). **"B-"** Negative Background. **"B+"** Positive Background. **X** Ambiguous. **ND** Not Determined.

Signatures are Required:

Person Delivering Receptors: _____; Date_____ Person Receiving Trace Receptors: _____; Date_____

Person Preparing Receptor: _____; Date_____ Person Conducting Analysis: _____; Date _____

University of Kentucky, Kentucky Geological Survey

Groundwater Trace Monitoring and Analysis Data Report

PAGE 2 of __

Project or Area: Gardnside Field Personnel: b. Curtis, J. Curtis Date of Field Work: 8 Jan 15

VISIT RECORD		FIELD TASKS						ANALYSIS RESULTS								
Time: 24-hr Clock	Location: Name or ID No.	Hang			Collect			Charcoal				Cotton		Water		
		Rig Gumdrop	Char.	Cotton	Char.	Cotton	Pull Gumdrop	Fluor.	R WT	SRB	Eosine	DY	OB	Time	Conc.	Comment
10:51	Mr Lonal Spr	✓														
11:15	Kendon's Blue	✓														
	Hole															
11:32	Beacon Hill 120		✓		✓											
11:42	Gardnside Spr	✓	✓		✓											
11:50	Wolf Creek		✓		✓											

EXPLANATION

√- Bug changed or task performed. **BM** Bug missing. **BD** Bug destroyed / Bug not changed. **NA** Not Applicable. **NR** Not recovered.

"-" Negative (< 1 ppb) + Positive (> 1 ppb). **"B-"** Negative Background. **"B+"** Positive Background. **X** Ambiguous. **ND** Not Determined.

Signatures are Required:

Person Delivering Receptors: _____; Date_____ Person Receiving Trace Receptors: _____; Date_____

Person Preparing Receptor: _____; Date_____ Person Conducting Analysis: _____; Date _____

University of Kentucky, Kentucky Geological Survey

Groundwater Trace Monitoring and Analysis Data Report

PAGE 2 of __

Project or Area: _____ Field Personnel: _____ Date of Field Work: 19 Jun

VISIT RECORD		FIELD TASKS						ANALYSIS RESULTS								
Time: 24-hr Clock	Location: Name or ID No.	Hang			Collect			Charcoal				Cotton		Water		
		Rig Gumdrop	Char.	Cotton	Char.	Cotton	Pull Gumdrop	Fluor.	R WT	SRB	Eosine	DY	OB	Time	Conc.	Comment
14:40	McConnell Spr		X					—			—					Char. missing
15:03	K. Blue Hole		X		X			—			—					
15:11	Wolf Creek #3		X		X			—			—					
15:20	G. Side Spr #1, 3		X		X			—			—					
15:21	G. Side Spr #2, 2		X		X			—			—					
15:27	B. Hill #3		X		X			—			—					
13:30	McConnel Spr #2		X		X			—			—					Trace on 20 Jun
13:52	Kearns Blue Hole #2		X		X											
14:01	Wolf Creek #4		X		X											
14:09	GS Spr 1, #4		X		X											
14:11	GS Spr 2, #3		X		X											
14:17	Bacon Hill #4		X		X			—			—					

EXPLANATION

√- Bug changed or task performed. **BM** Bug missing. **BD** Bug destroyed / Bug not changed. **NA** Not Applicable. **NR** Not recovered.
"-" Negative (< 1 ppb) + Positive (> 1 ppb). **"B-"** Negative Background. **"B+"** Positive Background. **X** Ambiguous. **ND** Not Determined.

Signatures are Required:

Person Delivering Receptors: _____; Date_____ Person Receiving Trace Receptors: _____; Date_____

Person Preparing Receptor: _____; Date_____ Person Conducting Analysis: _____; Date _____

University of Kentucky, Kentucky Geological Survey

Groundwater Trace Monitoring and Analysis Data Report

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Project or Area: _____ Field Personnel: B. Currens Date of Field Work: 26 Jun

VISIT RECORD		FIELD TASKS						ANALYSIS RESULTS								
Time: 24-hr Clock	Location: Name or ID No.	Hang			Collect			Charcoal				Cotton		Water		
		Rig Gumdrop	Char.	Cotton	Char.	Cotton	Pull Gumdrop	Fluor.	R WT	SRB	Eosine	DY	OB	Time	Conc.	Comment
10:08	McC. Spr		√		√			√			√					
10:28	Kenton's Blue Hole		√		√			↓			↓					
10:36	Wolf Creek		√		√			↓			↓					
10:44	Coordinate Spr 1		√		√			↓			↓					
10:45	Coordinate Spr 2		√		√			√			↓					
10:52	Beaver Hill		√		√			√			√					
8:08	Wolf Creek		√		√											
7:45	Beaver Hill		√		√											
7:52	GSS #1		√		√											
7:57	GSS #2		√		√											
7:37	Kenton's Blue Hole		√		√											
7:18	McC. Spr		√		√											

EXPLANATION

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"-" Negative (< 1 ppb) + Positive (> 1 ppb). **"B-"** Negative Background. **"B+"** Positive Background. **X** Ambiguous. **ND** Not Determined.

Signatures are Required:

Person Delivering Receptors: _____; Date_____ Person Receiving Trace Receptors: _____; Date_____

Person Preparing Receptor: _____; Date_____ Person Conducting Analysis: _____; Date _____

University of Kentucky, Kentucky Geological Survey

Groundwater Trace Monitoring and Analysis Data Report

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Project or Area: Gardenside Field Personnel: B Currens Date of Field Work: July 21, 2015

VISIT RECORD		FIELD TASKS						ANALYSIS RESULTS								
Time: 24-hr Clock	Location: Name or ID No.	Hang			Collect			Charcoal				Cotton		Water		
		Rig Gumdrop	Char.	Cotton	Char.	Cotton	Pull Gumdrop	Fluor.	R WT	SRB	Eosine	DY	OB	Time	Conc.	Comment
	Wolf Creek							~			—					
	Kenton's Bluff							~			—					
	Beacon Hill							~			—					
	GSS #1							—			—		B+			
	GSS #2							~			—		B+			
	KBSF rescan							~	.		—					

EXPLANATION

√- Bug changed or task performed. **BM** Bug missing. **BD** Bug destroyed / Bug not changed. **NA** Not Applicable. **NR** Not recovered.
"-" Negative (< 1 ppb) + Positive (> 1 ppb). **"B-"** Negative Background. **"B+"** Positive Background. **X** Ambiguous. **ND** Not Determined.

Signatures are Required:

Person Delivering Receptors: _____; Date_____ Person Receiving Trace Receptors: _____; Date_____

Person Preparing Receptor: _____; Date_____ Person Conducting Analysis: _____; Date _____

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GROUNDWATER TRACE MONITORING AND ANALYSIS DATA REPORT

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Project or Area: Garden Spring Field Personnel: Cumm, + Cumm Date of Field Work: Nov 18, 2015

VISIT RECORD		FIELD TASKS						ANALYSIS RESULTS								
Time: 24-hr Clock	Location: Name or I. D. #	Hang			Collect			Charcoal				Cotton		Water		
		Rig Gum Drop	Char.	Cotton	Char.	Cotton	Pull Gum Drop	Fluor.	R Wt.	S R B	Eosine	D Y	O B	Time	Conc.	Comment
13:00	McConnel Spr	✓	✓													
13:20	Garden Spr 1															Heavy Rain
	~~Stallfeeder Hill Spr~~															
13:40	Crosskey Lk	✓	✓													
13:32	Wolf Run	✓	✓													
	at Mouth															
13:25	Garden Spr 2	✓	✓													
13:40	Kenson = 13:41	✓	✓													
14:08	GSS perh	✓	✓													

EXPLANATION

√- Bug changed or Task performed: **BM**- Bug Missing: **BD**- Bug destroyed: / -Bug not changed: **NA**- Not App.: **NR**- Not Recovered

- Negative (< 1 ppb) **+** Positive (> 1 ppb) **B**- Negative Background: **B+** Positive Background **X** - Ambiguous **ND**- Not Determined

SIGNATURES ARE REQUIRED:

Person Delivering Receptors: _____; Date_____ Person Receiving Trace Receptors: _____; Date_____

Person Preparing Receptor: _____; Date_____ Person Conducting Analysis: _____; Date _____

University of Kentucky, Kentucky Geological Survey

Groundwater Trace Monitoring and Analysis Data Report

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Project or Area: Boardside Springs Field Personnel: B. Curran Date of Field Work: 21 NOV

VISIT RECORD		FIELD TASKS						ANALYSIS RESULTS								
Time: 24-hr Clock	Location: Name or ID No.	Hang			Collect			Charcoal				Cotton		Water		
		Rig Gumdrop	Char.	Cotton	Char.	Cotton	Pull Gumdrop	Fluor.	R WT	SRB	Eosine	DY	OB	Time	Conc.	Comment
done 11-22 10:20	GSS #1		✓		✓											None
10:35	McConnell Spr		✓		✓						++					
21 NOV 15											—					
8:42	Wolfrun @ GSS				✓		✓				—					
8:50	GSS		✓		✓						—					None
8:52	GSS		✓		✓						—					
9:02	Wolf Run		✓		✓						—					Now
9:09	Cross Keys				✓		✓				—					Now
9:29	Keen's BR (Kentons Blt)				✓		✓				—					Now
9:38	McC Spr		✓		✓						++					

EXPLANATION

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"-" Negative (< 1 ppb) + Positive (> 1 ppb). **"B-"** Negative Background. **"B+"** Positive Background. **X** Ambiguous. **ND** Not Determined.

Signatures are Required:

Person Delivering Receptors: _____ ; Date_____ Person Receiving Trace Receptors: _____ ; Date_____

Person Preparing Receptor: _____ ; Date_____ Person Conducting Analysis: _____ ; Date _____

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Project or Area: Gardenside Spr Field Personnel: B. Curry & D. Haslam Date of Field Work: 2 Dec 2015

VISIT RECORD		FIELD TASKS						ANALYSIS RESULTS								
Time: 24-hr Clock	Location: Name or ID No.	Hang			Collect			Charcoal				Cotton		Water		
		Rig Gumdrop	Char.	Cotton	Char.	Cotton	Pull Gumdrop	Fluor.	R WT	SRB	Eosine	DY	OB	Time	Conc.	Comment
14:55	McL Spr		✓		✓											V. High Flow
15:22	WR @ GSS	✓	✓													
15:23	GSS		✓		✓											
15:25	GSS		✓		✓											
15:40	WR @ WR		✓		✓											
15:48	Cross Keys	✓	✓													
	12 Dec 2015															
~~19:00~~ 13:33	McL Spr				✓		✓			+						Fluorescein
14:30	WR @ GSS				✓		✓			++						
14:31	GSS (Spr)				✓		✓			−						Nil
14:32	GSS				✓		✓			−						
14:43	WR @ WR				✓		✓			++						
14:54	Cross Keys				✓		✓			−						

EXPLANATION

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"-" Negative (< 1 ppb) + Positive (> 1 ppb). **"B-"** Negative Background. **"B+"** Positive Background. **X** Ambiguous. **ND** Not Determined.

Signatures are Required:

Person Delivering Receptors: _____ ; Date _____ Person Receiving Trace Receptors: _____ ; Date _____

Person Preparing Receptor: _____ ; Date _____ Person Conducting Analysis: _____ ; Date _____

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Groundwater Trace Monitoring and Analysis Data Report

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Project or Area: Gardenside Spring Field Personnel: Ben Currens Date of Field Work: Dec 2-18-15

VISIT RECORD		FIELD TASKS						ANALYSIS RESULTS								
Time: 24-hr Clock	Location: Name or ID No.	Hang			Collect			Charcoal				Cotton		Water		
		Rig Gumdrop	Char.	Cotton	Char.	Cotton	Pull Gumdrop	Fluor.	R WT	SRB	Eosine	DY	OB	Time	Conc.	Comment
	Gardenside Spr #1							—	—	—	—					
	" " #2							—	—	—	—					
	Wolf Run Park							B+	—	—	—					
	McConnell Spr							+			B+					

EXPLANATION

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Signatures are Required:

Person Delivering Receptors: _____; Date_____ Person Receiving Trace Receptors: _____; Date_____

Person Preparing Receptor: _____; Date_____ Person Conducting Analysis: _____; Date _____