GROUND WATER (DYE) TRACING IN MURFREESBORO FOR PLANNING BEST MANAGEMENT PRACTICES FOR STORMWATER RUNOFF, PREDICTING SINKHOLE FLOODING PROBLEMS, AND TO AID IN CHEMICAL SPILL RESPONSE

Prepared for:

The City of Murfreesboro

Water and Sewer Department

Prepared by:

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May 5th, 2011

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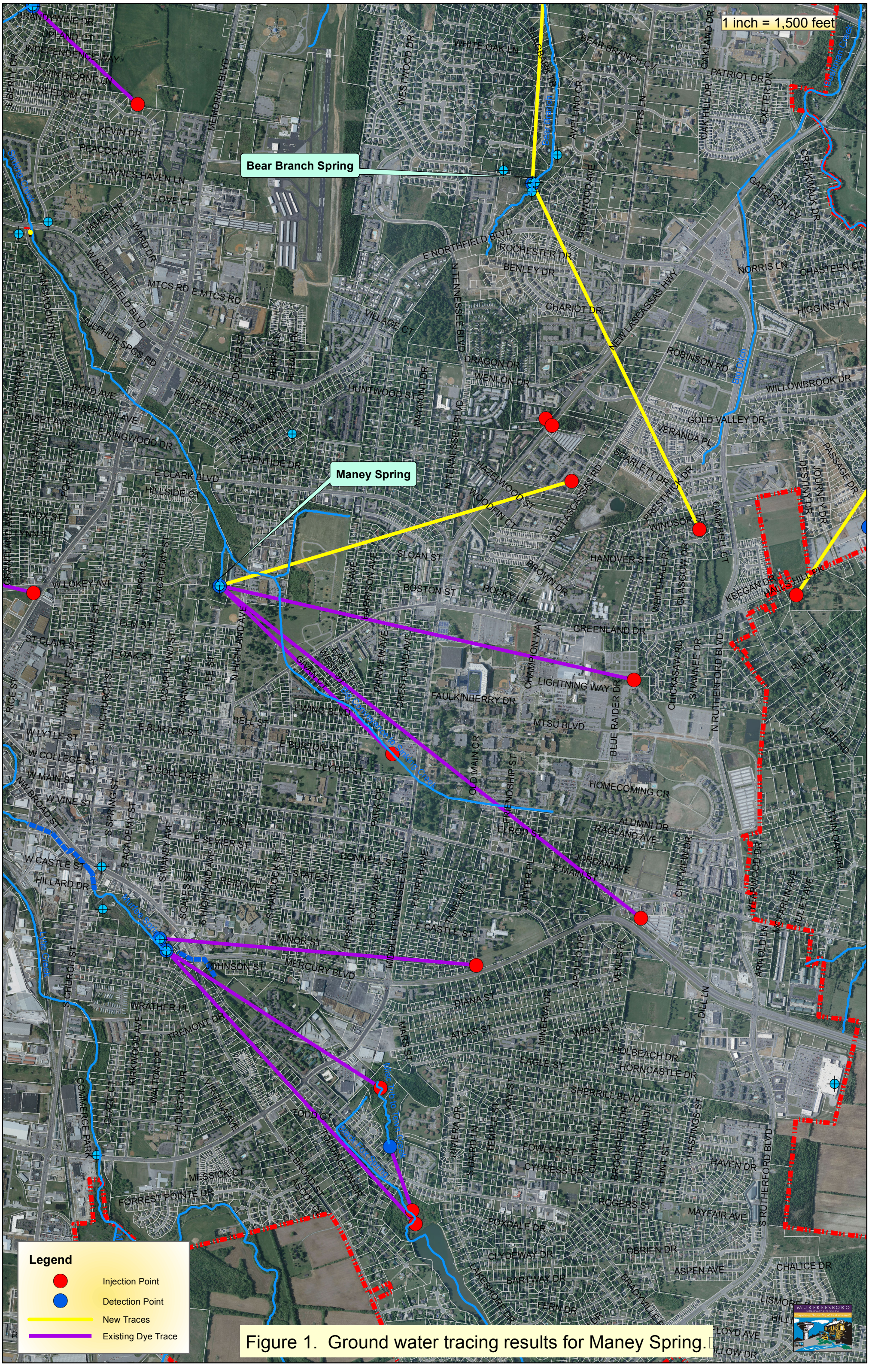

Figure 1. Ground water tracing results for Maney Spring.

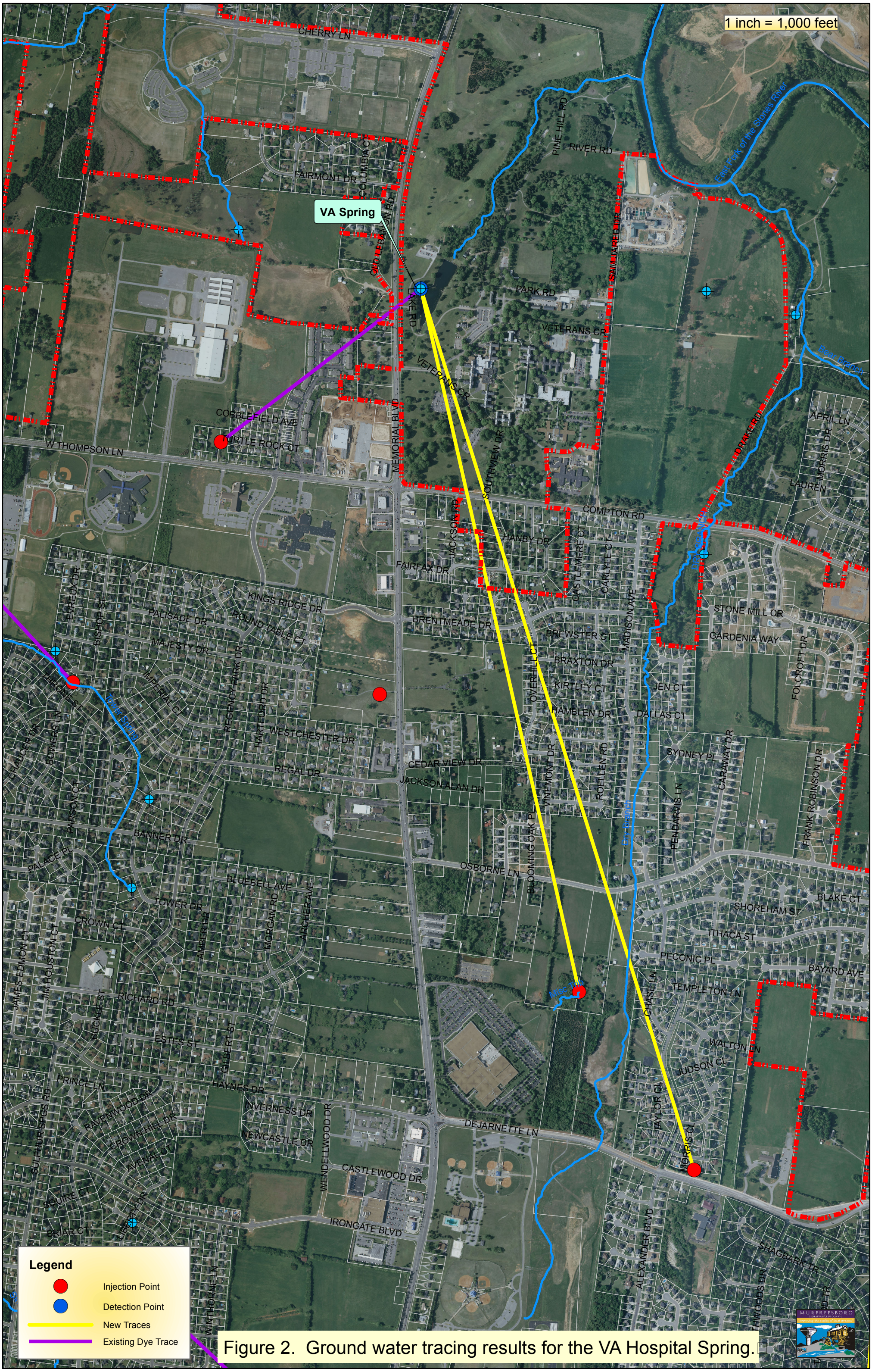

Figure 2. Ground water tracing results for the VA Hospital Spring.

1 inch = 1,000 feet

Bushman Spring

Bushman Creek

Big Ditch

Legend

- Injection Point
- Detection Point
- New Traces
- Existing Dye Trace

Figure 3. Ground water tracing results for Bushman Spring.

1 inch = 1,000 feet

Boiling Springs

Legend

- Injection Point
- Detection Point
- New Traces
- Existing Dye Trace

Figure 4. Ground water tracing results for Boiling Springs.

1 inch = 1,500 feet

Lufkin Spring

Ayers Spring

Bear Branch Spring

Bushman Spring

Maney Spring

Legend

- Injection Point
- Detection Point
- New Traces
- Existing Dye Trace

Figure 5. Ground water tracing results for Lufkin Spring.

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GROUND WATER (DYE) TRACING IN MURFREESBORO FOR PLANNING BEST MANAGEMENT PRACTICES FOR STORMWATER RUNOFF, PREDICTING SINKHOLE FLOODING PROBLEMS, AND TO AID IN CHEMICAL SPILL RESPONSE

EXECUTIVE SUMMARY

A total of 13 ground water (dye) traces were conducted for this project although three of them were repeated because positive results did not occur the first time. This was due to the wrong spring being monitored. Eight of the traces were successful. Valuable information now exists to provide the City with important information regarding the surface drainage basin of five large springs within the Urban Growth Boundary. Past traces conducted by the author of this report, combined with the new traces, now makes possible an accurate delineation of the entire watersheds of the VA Hospital Spring, Maney Spring, and Bushman Spring. Two successful traces to Boiling Spring that runs into Puckett Creek have made it possible to delineate much of its watershed based on topographic highs and other springs in the area. Only one successful trace was conducted to Lufkin Spring which is believed to be the resurgence of Bear Branch which sinks and re-surfaces at least twice along its pathway. Ayers Spring, Old Fort Park Spring, Bear Spring, and River Rock Spring were monitored for dye during the tracing activities, but only Bear Spring ever showed the presence of the injected dyes. As a result, there is presently no information regarding the drainage basins of these springs. In addition to these springs, there are several other significant springs within the Urban Growth Boundary for which there is no information regarding their recharge areas. It is recommended that this work be continued in the next fiscal year to provide more information for the City, particularly for those springs showing elevated levels of *e-coli.*

INTRODUCTION AND PURPOSE

Rutherford County is underlain by cavernous rock in which rain waters and contaminants rapidly enter the ground through sinkholes with little or no filtration. Murfreesboro has been experiencing unprecedented growth that has led to increasing amounts of storm water runoff that is often laden with chemicals applied to yards and fluids that leak from cars. In addition, the increased growth has resulted in more trucks carrying hazardous chemicals and gasoline that if spilled, would quickly disappear into a sinkhole without any prior knowledge as to which spring the chemicals are going to emerge. This would result in killing of aquatic species in our surface streams and endangering our water supplies (Percy Priest Lake). Ground water tracing from sinkholes to springs using non-toxic dyes enables the delineation of surface watersheds that provide water to the subterranean streams that feed springs. Therefore, the primary purpose for conducting the ground water tracing was to determine the surface drainage basins of several

springs that have elevated levels of *e-coli* to help ascertain potential sources of the contamination. The secondary purpose was to aid in the development of best management practices for storm water runoff to lessen its impact on spring and surface water quality. These same results will enable rapid response to a hazardous waste or substance spills along highways or an underground storage tank leak. Waiting to conduct a ground water trace after a spill occurs can become very costly and causes very bad "press" when officials have to say that they do not know where the spilled substance is going to re-emerge at the surface. Most spilled or leaked contaminants are petroleum products that float on water. If it is known which spring is hydrologically connected to the spill site, the chemicals can be readily absorbed by floating absorption tubes set up around the spring orifice.

Murfreesboro's rapid growth has also led to some homes being built within shallow, large diameter sinkholes that tend to fill with water during large storm events as a result of increased runoff from paved surfaces and rooftops. The ground water tracing results will enable city personnel to determine the elevation difference between the sinkhole bottom and the spring to which it drains. If the bottom is close to the spring elevation, the water table simply rises quickly from the bottom of sinkholes during large storms. If there is approximately 25 feet of difference between a sinkhole bottom and spring, flooding can likely be prevented by the construction of drainage wells in sinkholes that do not drain quickly.

STUDY AREA

The study area is located nearly entirely within the Murfreesboro Urban Growth Boundary in the upper Stones River watershed. Figures 1 through 5 show the location of the springs involved in the study and the tracing results. Traces conducted for this study are shown in yellow and past traces are shown in purple. Maney (Oakland Mansion) Spring (Figure 1) forms the head of Sinking Creek which flows into the West Fork of the Stones River. The VA Hospital Spring (Figure 2) flows into the lake formed by Walter Hill dam on the East Fork of the Stones River. The spring water enters the lake below the city's water intake. Bushman Spring (Figure 3) forms the head of Bushman Creek which also flows into the East Fork. The confluence of Bushman Creek and the East Fork are several miles upstream of the water intake.

Lufkin Spring (Figure 5) forms the head of Bear Branch during the dry season. Nearby Ayers Spring (Figure 5) forms the head of Dry Branch during dry conditions. The flow of these two springs combine and within a short distance enters the East Fork of the Stones River just above the city's water intake on Walther Hill dam. Boiling Spring (Figure 4) is commonly the head of Puckett Creek during the dry season. Puckett Creek joins Overall Creek which then flows into the West Fork of the Stones River.

HYDROGEOLOGIC SETTING

Rutherford County is located in the Central Basin physiographic province, which is underlain by limestones of Ordovician age that have been gently upwarped to form the Nashville Dome. The first detailed geologic map of Rutherford County was made by Galloway in 1919. Detailed geology maps now exist for the entire County. The oldest rocks exposed in Rutherford County are those of the Murfreesboro Limestone Formation, which is approximately 400 feet thick. Above the Murfreesboro Limestone is the Pierce Formation (Figure 6), a shaly, thin-bedded limestone that confines water beneath it in the Murfreesboro Aquifer and perches water above it in the Ridley Limestone. The Ridley Limestone underlies most of the area of investigation, and it is the most karstic (cavernous) limestone in Rutherford County. Proprietary files of the Tennessee Cave Survey show that a majority of the 124 caves discovered and explored in Rutherford County occur in the Ridley Limestone aquifer. Snail Shell Cave near Rockvale is the largest with over nine miles of passage. All of the springs involved in this study are believed to emerge near the contact between the impermeable Pierce Formation and the overlying Ridley Limestone or the upper Ridley Limestone and the underlying Lower Ridley Confining Unit.

The first documented dye tracing in the Rutherford County occurred in the area of Snail Shell Cave as part of the State's proposal for the Superconducting Super Collider (Crawford, 1988). Crawford conducted two traces in the study area as part of his investigation. Since then, approximately 110 ground water traces have been conducted in the County by the author of this report. Five previously funded projects by the Rutherford County Planning Commission, two grants from the City of Murfreesboro, four MTSU Faculty Research Grants, and a grant from the Rutherford County Board of Education have enabled important discoveries to be made regarding

ground water flow directions, causes for sinkhole flooding, and potential sources of spring water contamination. This research has resulted in a number of publications (Ogden and Scott, 1997; Ogden et.al., 1998; Ogden et.al., 1999; Ogden and Powell, 1999; Ogden, 2000; Ogden et.al., 2001; Ogden et.al., 2002, Ogden, et.al., 2003, James, et.al, 2004, Ogden, et.al., 2006, and James, et.al, 2006). Josh Upham, of Murfreesboro's Water and Sewer Department, has diligently updated the statewide GIS ground water tracing database he and the author created for TDEC-Ground Water Management Section in 2003. The author has conducted approximately 30 new traces in Rutherford County since 2003.

GROUND WATER TRACING METHODS

The ground water tracing was performed using three fluorescent dyes: sulphorhodamine B (SRB), eosine, and fluorescein. These tracing agents are non-toxic and routinely approved for use by various divisions of the Tennessee Department of Environment and Conservation. Prior to conducting the traces, the Tennessee Underground Injection Control Program was notified in writing as required for their dye tracing registration program (see Appendix A). The injected tracing agents were detected by using activated charcoal packets that absorb and concentrate the dye levels in the water. The charcoal packets, called "traps", were suspended in the waters expected to receive the dyes on a stiff wire connected to a concrete base. Prior to tracing, some of the traps were placed in the spring waters for approximately a week to test for background concentrations. The dyes are common coloring agents and frequently found as "contaminants" in the ground water. Once background levels were determined, new packets were set out immediately prior to injection. After injection of the tracing agents, the packets were changed at approximately 7 day intervals and sent to the laboratory for analysis. Crawford Hydrology Lab, located at Western Kentucky University, was used to perform the analyses, which were done by a scanning spectrofluorophotometer.

GROUND WATER TRACING RESULTS

A total of thirteen traces were conducted for this project of which eight were successful. Three of the thirteen were repeated due to the wrong spring being monitored for dye. The following is

a discussion of the results by spring basin. Past traces were conducted by the author to three of the springs. These are shown on the figures in red to provide a better overview of the springs' watersheds. Appendix B provides the results from the laboratory.

Maney Spring

Maney Spring is located on the property of the historic Oakland Mansion (Figure 1 and Photograph 1). The spring forms the beginning of Sinking Creek. The author previously performed three traces to this spring so it was not originally intended to be included in the present study. One pound of sulphorhodamine B was injected into a sinkhole located within the College Grove Apartments complex on February 1st, 2011, and was expected to be detected at Bear Spring or Lufkin Spring. It was not, so the trace was repeated on March 18th with two pound of fluorescein (Photograph 2), and this time Maney Spring was monitored. The dye was detected there. With these four traces, it is possible to delineate with significant accuracy the entire watershed that provides recharge to the spring. This includes much of the MTSU campus, Evergreen Cemetery by the former hospital, sinkholes near the Slick Pig restaurant, and the area just north of Greenland Drive and west of Old Lascassas Road.

Photograph 1. Maney Spring.

Photograph 2.Site of fluorescein trace to Maney Spring.

VA Hospital Spring

The VA Hospital Spring is the source of the water for the lake on the hospital property (Figure 2 and Photograph 3). The spring emerges from Black Cat Cave which has been mapped by members of the Tennessee Cave Survey. The cave was used as a "speakeasy" bar during Prohibition. Two previous traces were conducted by the author to this spring for the Rutherford County Board of Education, so it was not intended to be included in the present study. On February 1st, 2011, 1½ pounds of sulphorhodamine B were injected into a sinkhole (Photograph 4) that receives most of the storm water runoff from the State Farm Insurance headquarters located at the corner of DeJarnette Lane and Memorial Blvd. One and a half pounds of fluorescein were injected shortly after that into a sinkhole (Photograph 5) located on the north side of DeJarnette near the northern end of the Murfreesboro Airport runway. Ayers Spring (Photograph 6) or Lufkin Spring (Photograph 7) was expected to receive the dyes. The laboratory results proved negative so the traces were repeated on February 24th, and the VA Hospital Spring was monitored. This time, both traces were positive. A third trace was conducted on the 24th using one pound of eosine dye from a sinkhole located near the intersection of Memorial Blvd. and

Photograph 3. VA Hospital Spring.

Photograph 4. Sulphorhodamine B trace to the VA Hospital Spring.

Osborne Lane. The eosine was never detected at any of the three monitored springs. The past traces to the VA Hospital Spring combined with the two new traces enables a very accurate delineation of the surface watershed that contributes ground water flow to the spring. Storm water runoff from numerous businesses along Memorial Blvd. contribute ground water flow to the spring, as well as, the northern section of the airport and portions of the MTSU horse arena.

Photograph 5. Fluorescein trace to the VA Hospital Spring.

Photograph 6. Ayers Spring.

Photograph 7. Lufkin Spring.

Bushman Spring

Bushman Springs forms the head of Bushman Creek (Figure 3 and Photograph 8) and is one of the largest springs in the County. Based on many previous dye traces by the author, the spring basin has a large drainage area including portions of Veals Road and Bradyville Pike in

vicinity of Mt. Herman Church. Much of the drainage to sinkholes and karst windows along Flat Rock Road also go to the spring. No traces to the spring had been conducted to the spring from within the Murfreesboro City limits. Therefore, dye was injected into two sinkholes along Halls Hill Pike. On March 18th, one pound of eosine was injected into a sinking stream located along Halls Hill Pike about a quarter mile past the intersection of Flat Rock Road. Then, on March 4th, one pound of sulphorhodamine B was injected into a sinkhole on the south side of Halls Hill Pike across the road from The Grove Apartments. Both dyes were detected at the spring. The new information demonstrates that much of the drainage from the northeast side of MTSU provides recharge to the spring. It is likely that the three campus storm water detention ponds slowly leak water that eventually appears at Bushman Spring. In addition, storm water runoff from the new apartments, subdivisions, and businesses located along Halls Hill Pike east of Rutherford Blvd., and distant upgradient areas within the basin, contribute to the flow of the spring.

Photograph 8. Bushman Spring

Boiling Springs

Boiling Springs is located in Evergreen Farms subdivision on the east side of Puckett Creek about a mile downstream from where the creek goes under New Salem Road/Route 99 (Figure 4 and Photograph 9). No previous tracing had been conducted to this spring. River Rock Spring, located at the intersection of Route 99 and River Rock Blvd., was also monitored for dye while tracing in this part of Murfreesboro. On February

Photograph 9. Boiling Springs.

Photograph 10. Sinkhole used for fluorescein trace to Boiling Springs.

24th, one pound of fluorescein was injected into a sinkhole in the Amber Glen subdivision (Photograph 10). Then, one pound of eosine was injected into a sinkhole located immediately east of Salem Cove subdivision. Both of the dyes were detected at Boiling Spring, and no dye was detected at River Rock Spring. Boiling Spring is not believed to have a large drainage basin compared to the other springs previously discussed. Much of the spring flow is likely storm water runoff from the subdivisions where the dye injections took place and nearby surrounding areas.

Lufkin Spring

Lufkin Spring is a large spring and likely is the resurgence of the surface flow of Bear Branch with sinks and re-appears as springs along its course (Figure 5-Photograph 7). Although tracing from sinking areas along the stream course would have been easy to conduct to Lufkin Spring, it was felt that sinkholes in the upper reaches of the Bear Branch Basin would provide more valuable information. Therefore, on February 1st, 1½ pounds of eosine were injected into a sinkhole along New Lascassas Road near the Pet Safari Resort. Then, one pound of sulphorhodamine B was injected into the College Grove Apartments sinkhole previously discussed. The following day, 1½ pounds of fluorescein were injected

Photograph 7. Lufkin Spring.

into a sinkhole located in Scotland Acres north of Greenland Drive. A spring located at the head of Bear Branch, called Bear Spring, was monitored for dye along with Lufkin Spring and Bushman Spring. The first two traces were never detected at any of the monitored springs. The fluorescein injected within Scotland Acres was detected at Bear Spring and at Lufkin Spring. The flow of Bear Springs sinks throughout most of the year. Therefore, this trace proves that sink points along Bear Branch are connected to Lufkin Spring. A major spring along Bear Creek located downstream of Bear Spring was discovered after the project ended. Future tracing in this area will likely show many areas that drain to it. Although only one successful trace was conducted to Lufkin Spring, it demonstrate the very large size of the basin in which numerous subdivisions and businesses are located.

SUMMARY AND CONCLUSIONS

In cavernous limestone regions, storm water runoff commonly enters sinkholes before reaching a stream channel. The water entering the sinkholes travels through subterranean pathways to emerge at springs usually located a mile or more away. The purpose of this investigation was to delineate surface basins that provide recharge to some of the springs in Murfreesboro that show elevated levels of *e-coli* contamination. A total of 13 ground water (dye) traces were conducted for this project although three of them were repeated because positive results did not occur the first time. This was due to the wrong spring being monitored. Eight of the traces were successful. Valuable information now exists to provide the City with important information regarding the surface drainage basin of five large springs within the Urban Growth Boundary. Past traces conducted by the author of this report, combined with the new traces, now makes possible an accurate delineation of the entire watersheds of the VA Hospital Spring, Maney Spring, and Bushman Spring. Two successful traces to Boiling Spring that runs into Puckett Creek have made it possible to delineate much of its watershed based on topographic highs and other springs in the area. Only one successful trace was conducted to Lufkin Spring and Bear Spring. The flow of Bear Springs soon sinks in the channel of Bear Branch most of the year. As a result, this trace demonstrates the interconnection of sink points along the branch to Lufkin Spring. Ayers Spring, Old Fort Park Spring, and River Rock Spring were monitored for dye during the tracing activities. None of these ever showed the presence of

the injected dyes. In addition to helping determine the sources of spring water contamination, the results of this investigation can be used to predict sinkhole flooding potential in areas planned for new development. They also can be used for emergency response should a tanker truck overturn and spill toxic and hazardous chemicals into a sinkhole.

RECOMMENDATIONS

This project was initially conceived as a Phase I project since there are many other significant springs in Murfreesboro in which their drainage basin is completely or only partially know. A Phase II project of similar scope is recommended to solve present problems and help prevent them in other spring basins. It is also recommended from a flooding perspective, that the City consider the possibility of removing the dam on the upper section of Bushman Creek located on the eastern edge of Baskinbrook subdivision. The dam has likely raised the water table in the area by about 6 feet. The subdivision and nearby areas are presently not far above the watertable. Removal of the dam would lower the level of the watertable and lessen the chances of sinkhole flooding from large storm events.

ACKNOWLEDGEMENTS

The author would like to thank Josh Upham and Bruce Ross for all their help in the field. Josh Upham also prepared the figures in the report that show the ground water tracing results and provided all of the photographs. In addition, the author would like to thank Kyle Wiseman, a geology student at MTSU, who helped conduct three of the traces as part of a special research project.

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APPENDIX A

Dye Tracing Registration Form submitted to the

Tennessee Department of Environment and Conservation-UIC Program

APPENDIX B

Summary of Laboratory Results

Tennessee Department of Environment & Conservation
Dye Trace Registration

Owner/Operator of Facility Necessitating Trace:

Name: Murfreesboro Water + Sewer Dept. Attn: Robert Haley

Mailing Address: 220 NW Broad St., P.O. Box 1477

City, State, Zip Code: Murfreesboro, TN 37127

Phone: (615) 848-3200 County Rutherford

Person/Company Performing Trace:

Name: Albert E. Ogden

Mailing Address: 6478 Jones Lane,

City, State, Zip Code: Murfreesboro, TN 37127

Phone: (615) 907-0004

Property Owner at Injection Site:

Name: Various owners on private land

Mailing Address:

City, State, Zip Code:

Reason for Trace: to help determine sources of spring water contamination

If State or Federal Agency Oversight, Give Agency: NONE

Dyes to be Used with Approximate Amounts and Respective Injection Locations:

fluorescein, eosine, + sulphrhodamine B approximately 1 pound of dye will be used during each injection

CN-1112 RDA 2474

(continued on reverse)

Type Receptors or Visual: charcoal

Background Test: yes

Describe Injection Point(s) and Include Photocopy of Topographic Map with Locations Latitude and Longitude:

see attached Map.
coordinated on attached page

Anticipated Injection Date: February and March, 2011

Public Water Systems: List Surface Water Intakes, Wells or Springs within 2 Miles of the Injection Point(s):

No public water supply intakes within 2 miles
Everyone in the study area uses public water
so NO wells or springs are utilized for drinking

Is the Area Served by a Public Water System? Yes

Estimate Percentage of Private Well/Spring Use Versus Public Water Use:

No wells or springs are utilized for drinking

Submitted by: Albert E. Ogden

Phone: (615) 907-0004

Date: 1/12/11

Mail or Fax the Completed Form to:

Tennessee Division of Water Supply
Ground Water Management Section
Attn: Scotty Sorrells
6th Floor, L & C Tower
401 Church Street
Nashville, Tennessee 37243-1549
Phone: (615) 532-0191; Fax: (615) 532-0503

There are currently no regulations requiring dye trace registration in Tennessee, unless there is the potential to impact a public water system. This registry is designed to avoid cross contamination and re-performing the same or similar trace. The dye tracing registry allows the Department to make informed responses to water pollution inquiries so that dye traces are not mistakenly identified as pollution to waters of the state.

Riverrock Spring: 86.431, 35.817; **Boiling Spring:** 86° 27'52", 35 °49'34"

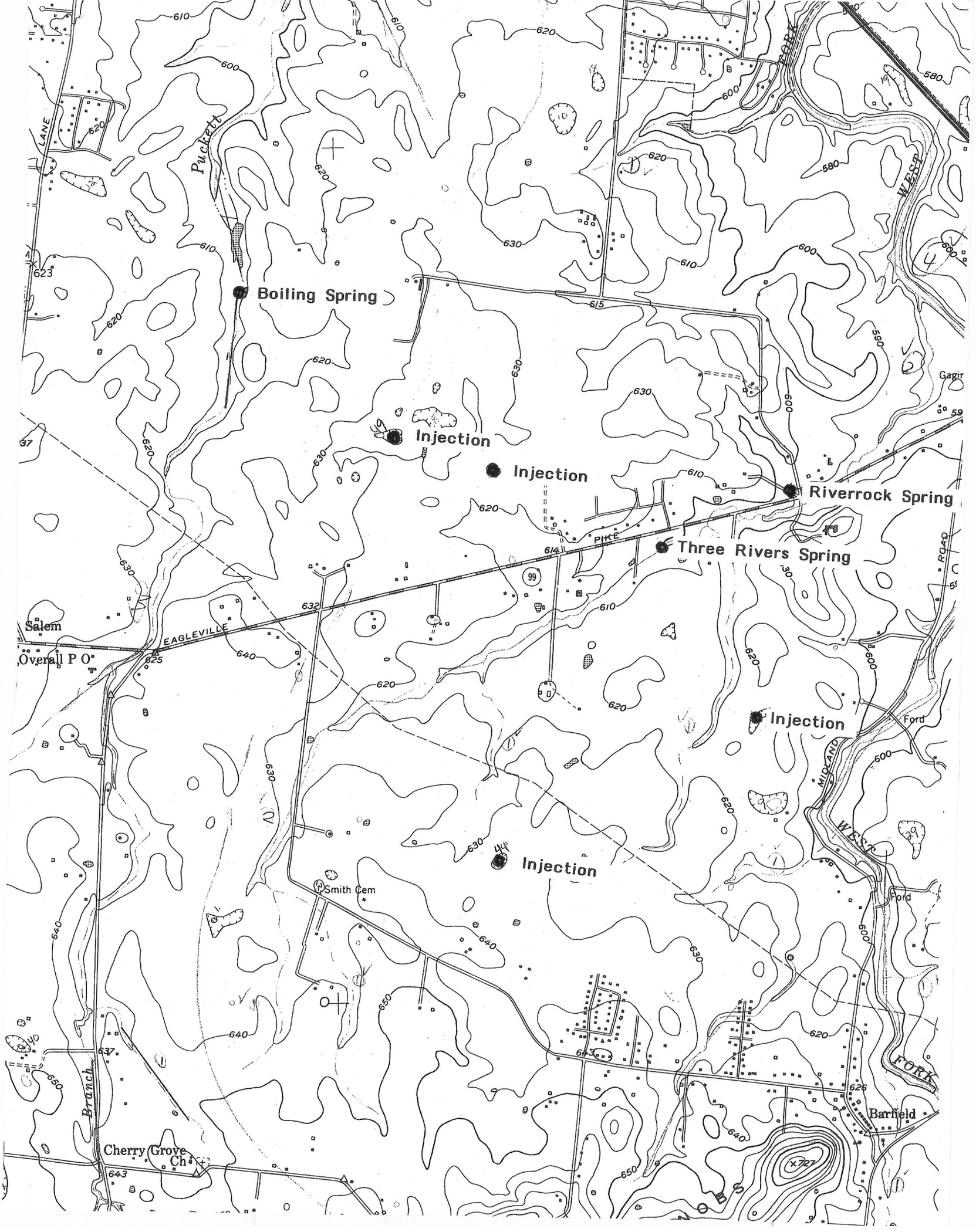
Injection Points: 86.451, 35.824 and 86.455, 35.819

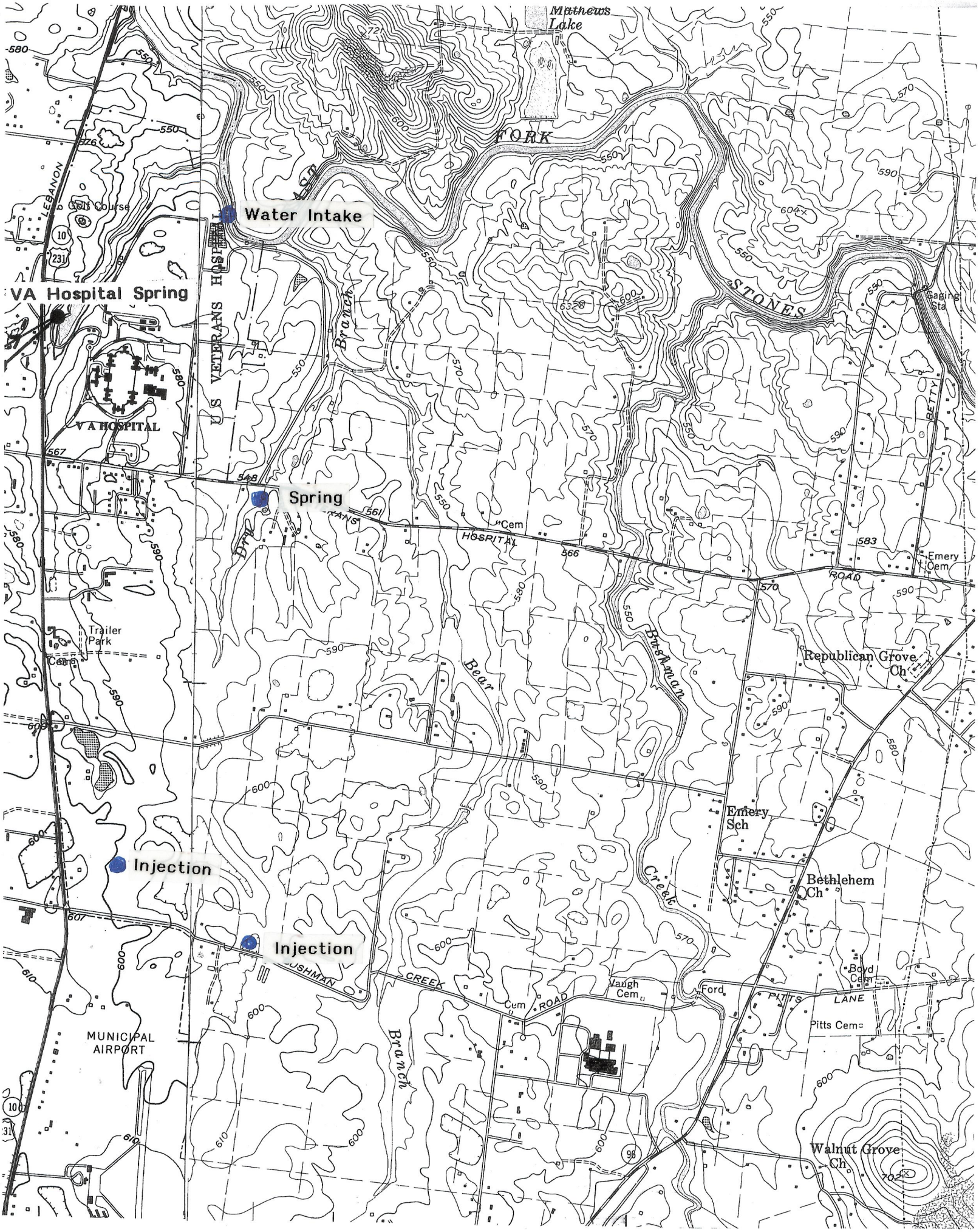
Three Rivers Spring: 86.411, 35.813

Injection Points: 86.442, 35.797 and 86° 25'57", 35° 48'20"

Bear Spring: 86.365, 35.876

Injection Points: 86° 21'51", 35° 51'53" and 86° 22'20", 35° 52'28"


Boiling Spring
Injection
Injection
Riverrock Spring
Three Rivers Spring
Injection
Injection
Salem
Overall P O
EAGLEVILLE
PIKE
Smith Cem
Cherry Grove Ch
Barfield
Ford
Ford
Gagir
Pucketts
LANE
Branch
WEST
FORK
MIDLAND
ROAD
623
614
632
625
643
626
727


Water Intake
VA Hospital Spring
Spring
Injection
Injection
Mathews Lake
FORK
STONES
Branch
US VETERANS HOSPITAL
V A HOSPITAL
Golf Course
LEBANON
Trailer Park
Cem
HOSPITAL
ROAD
Emery Cem
Republican Grove Ch
Bushman Creek
Bear
Emery Sch
Bethlehem Ch
Boyd Cem
Vaugh Cem
Ford
PITTS LANE
Pitts Cem
MUNICIPAL AIRPORT
Walnut Grove Ch
Gaging Sta
BETTY

CRAWFORD HYDROLOGY LAB * HOFFMAN ENVIRONMENTAL RESEARCH INSTITUTE

* *Hydrogeologists, Geologists, Environmental Scientists* * *Karst Geophysical Subsurface Investigations*

* *Karst Groundwater Investigations* * *Fluorescent Dye Analysis*

Western Kentucky University
Bowling Green, KY 42101
(270) 745-9224
E-mail: Crawford.Hydrology@wku.edu

LABORATORY REPORT SHEET

FLUORIMETRIC ANALYSIS RESULTS

Mufreesboro City Project

Analysis requested by:

Albert Ogden

FLUORESCEIN	EOSINE	SULPHORHODAMINE B
Color Index: Acid Yellow 73	**Color Index:** Acid Red 87	**Color Index:** Acid Red 52
Dye Receptor: Activated Charcoal	**Dye Receptor:** Activated Charcoal	**Dye Receptor:** Activated Charcoal
Analysis by: Spectrofluorophotometer	**Analysis by:** Spectrofluorophotometer	**Analysis by:** Spectrofluorophotometer

CHARCOAL SAMPLES

					FLUORESCEIN PQL in Eluent: 0.005 ppb; PQL in Water: 0.010 ppb; λ in Eluent: 516.0 nm; λ in Water: 510.2 nm			EOSINE PQL in Eluent: 0.005 ppb; PQL in Water: 0.010 ppb; λ in Eluent: 540.2 nm; λ in Water: 534.4 nm			SULPHORHODAMINE B PQL in Eluent: 0.005 ppb; PQL in Water: 0.005 ppb; λ in Eluent: 577.0 nm; λ in Water: 582.2 nm			
Lab ID	Event	Date Collected	Feature Name	TIME	Peakfit	Results	Conc in ppb	Peak Center (nm)	Results	Conc in ppb	Peak Center (nm)	Results	Conc in ppb	Peak Center (nm)	Comments
EL-001-0	01	02/08/11	Lufkin Spring	NA		+	0.309	514.6	ND			ND			
EL-001-0	02	03/01/11	Lufkin Spring	NA		+	0.140	512.2	ND			ND			
EL-001-0	03	03/28/11	Lufkin Spring	NA		+	0.373	515.0				ND			
EL-002-0	01	02/08/11	Ayers Spring	NA		B	0.073	509.4,POR	ND			ND			
EL-002-0	02	03/01/11	Ayers Spring	NA		+?	0.111	511.4	ND			ND			
EL-003-0	01	02/08/11	Pond Spring	NA		B	0.015	508.0,POR	ND			ND			
EL-004-0	01	02/08/11	Pond Side Spring	NA		ND	0.013	NPI	ND			ND			
EL-005-0	01	02/08/11	Bushmun Spring	NA		B	0.029	508.2,POR	ND			ND			
EL-005-0	03	03/26/11	Bushmun Spring	NA		ND			++	2.045	539.8	ND			
EH-005-0	04	04/10/11	Bushmun Spring	NA		ND			+++	8.709	540.4	+?	0.567	572.6	
EL-006-0	01	02/08/11	Bear Spring #1	NA		+?	0.267	514.4	ND			ND	0.070	NPI	
EL-007-0	01	02/08/11	Bear Creek Upstream	NA		B	0.027	508.0,POR	ND			ND			
EL-008-0	01	02/08/11	Bear Creek Downstream	NA		B	0.042	508.8,POR	ND			ND			
EH-009-0	02	03/01/11	VA Spring	NA		+	22.765	516.2	ND			+	53.020	576.4	
EH-009-0	03	03/08/11	VA Spring	NA		+	21.088	515.8	ND			+	17.594	575.6	
EH-010-0	02	03/01/11	Boiling Spring	NA	x	+?	10.984	515.5	+?	242.930	541.3	ND			
EL-011-0	02	03/01/11	River Rock Spring	NA		B	0.054	508.8,POR	ND			ND			
EH-012-0	03	03/25/11	Maney Spring	NA		+?	1.664	517.2				+?	1.489	572.4	
EL-013-0	03	03/30/11	Old Fort Spring	NA		+?	0.139	514.0				ND			
EL-013-0	04	04/07/11	Old Fort Spring	NA		B	0.066	510.2,POR	ND			ND			

Approved by L.Bledsoe on 04/25/11

For Al Ogden Mufreesboro City Project

Peakfit needed for acurate results

Comments: **No background monitoring conducted for these locations.**

DUP = Field Duplicate
B = Background
ND = No Detection
IB = Initial Background
NS = No Sample Recovered
GS = Grab Sample
NPI = No Peak Identified
POR = Peak Out of Range
Q = Lab Duplicate
+ = Positive
?+ = Questionable Positive, needs two hits in a row to equal +
Peakfit Utilized

ND Below Quantitation Limit
B Background
NS No Sample

\+ Positive
++ Very Positive
+++ Extremely Positive

Created 4/25/2011