City of Austin
WATERSHED PROTECTION

PCEs in Austin Surface and Ground Water

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Abstract

Despite changes in the dry cleaning industry and the high level of environmental concern and diligence in Austin, Tetrachloroethylene (PCE) contamination is still occurring in local wells and springs with the maximum concentrations found in springs. The area of contamination is widespread, occurring both north and south of the Colorado River. The concentrations have been decreasing over time. The levels, both current and past have been below the predicted no effect concentration for aquatic life of 51µg/L. However, none of the toxicological studies that set this standard used amphibians, as test species. Unfortunately, the highest current concentrations of PCE are found in springs with endangered salamanders. Peak concentrations may be caused by transport of localized pollutants to area springs under the higher conduit flow during storms.

Introduction

Toxicity

Tetrachloroethylene (PCE) has been found in Austin area springs and wells since sampling was initiated in 1984. Chronic exposure in humans to tetrachloroethylene may adversely affect the neurological system, liver, and kidneys. PCE may also cause cancer. The EPA has set the maximum contaminant level (MCL) in drinking water at 5 µg PCE/L water (USEPA 2006). The reference dose for PCE is 0.01 mg/kg/day. The maximum recorded concentration in Austin was 1.7 µg PCE/L which is below the drinking water standard. In recent years (2000-2010), the maximum recorded level was 0.8 µg PCE/L.

An evaluation of aquatic environmental risk for PCE was done in Europe by the chemical industry, summarizing the results of 39 aquatic toxicity studies. They found that:

> "For tetrachloroethylene, the evaluation of toxicity was based on eight sets of data for algae, 13 for invertebrates and 18 for fish in both marine and freshwater media. These were assessed using the environmental quality criteria recommended by the European authorities. Both acute and chronic toxicity studies were taken into account, and the appropriate assessment factors were used to define a final Predicted No-Effect Concentration (PNEC) value of 51 µg/litre." (Euro Chlor 1997).

None of the studies were done on amphibians. Unfortunately, our highest levels are found in springs with endangered or listed but precluded salamanders.

Sources/Cleanup

Tetrachloroethene is a common soil contaminant. PCEis used mainly as a solvent for dry cleaning and metal cleaning and degreasing. It is also used in smaller quantities in the production of CFC substitutes and for paint removers, printing inks, adhesives, special cleaning fluids, dye carriers and silicone lubricants (Euro Chlor 1997). With a specific gravity greater than 1, PCE will be present as a dense nonaqueous phase liquid if sufficient quantities of liquid are spilled in the environment. Because of its mobility in groundwater, its toxicity at low levels, and its density (which causes it to sink below the water table), cleanup activities are more difficult than for oil spills. Recent research has focused on the in-situ (in place) remediation of soil and ground water pollution by PCE. Instead of excavation or extraction for above-ground treatment or disposal, PCE contamination has been successfully remediated by chemical treatment or bioremediation. Bioremediation has been successful under anaerobic conditions by reductive dechlorination by *Dehalococcoides* sp. and under aerobic conditions by cometabolism by *Pseudomonas* sp. Partial degradation daughter products include trichloroethylene, cis-1,2-dichloroethene and vinyl chloride; full degradation converts PCE to ethene and chloride dissolved in water.

Comparison of Austin Levels with European levels

In European rivers, typical levels were 0.5 µg/L and worst case levels were 5 µg/L. The median and maximum levels in ground water in Austin of 0.1 and 1.7 µg/L were below the European levels and substantially below the PNEC of 51 µg/L. All Austin surface water concentrations were below detection. The half life of PCE in surface water ranges from a few hours to a few days, however its degradation in groundwater is very slow (USGS 2006).

Table 1. Laboratories for PCE

LAB	Frequency
ANALAB	26
CHEM	1
DHL	15
EPIC	6
LCRA	36
NDRC	12
NET	14
TDH	12
TNRCC	62
USGS	700
WWW	4

Table 2. Site Types for PCE Samples

SITE_TYPE	Frequency
BMP - Oil Grit Separator	3
BMP - Sed. Filt. Basin	1
BMP - Wet Pond	4
Drinking Water Tap	4
Lake	83
Sampled Product	12
Sediment	1
Soil	2
Spring	330
Storm Drain	3
Stream	26
Wastewater Plant Effluent	2
Well	417

Table 3. Sample Mediums

MEDIUM	Frequency
Artificial	1
Fish Tissue	13
Ground Water	735
Pavement Sealer	12
Pore Water	8
Sediment	15
Sewage	2
Soil	2
Surface Water	96
Tap Water	4

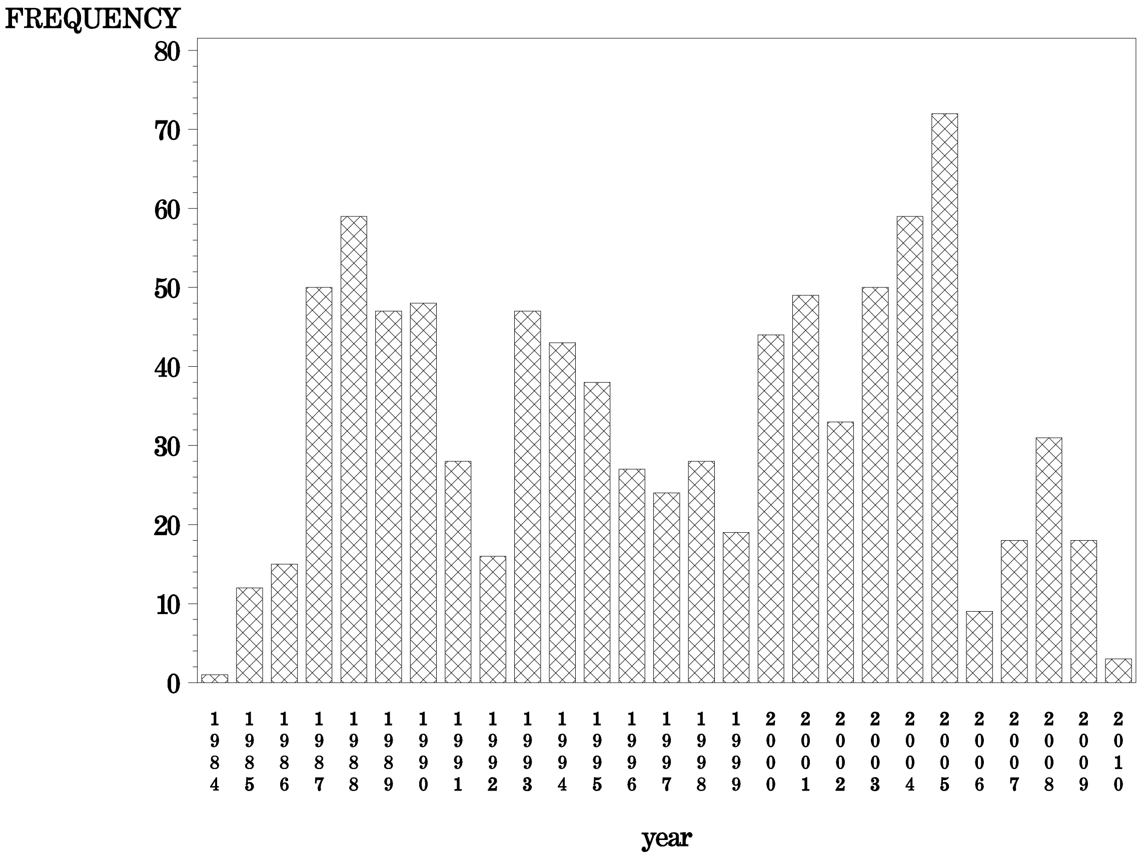

Figure 1. Sampling Frequency for PCE over time.

Sample Medium and Site Type

Austin area PCE samples were analyzed at 11 different labs (Table 1), were taken at 13 different types of sites (Table 2) in 10 different media from 1984 – 2009 (Figure 1).The most common sample media were ground and surface water (Table 3). PCE has never been detected in Austin area surface water. All the detected values are found in ground water in either springs or wells.

Detection Limits

Detection limits varied with time and laboratory. Some detection limits are too high for those samples to be of any use. The samples in surface and ground water are plotted below with all values (Figure 2a) and with the high non-detects eliminated (Figure 2b) to make the pattern of the detected data more visible. In the analyses and discussions, samples with detection limits greater than 0.2 μg/L are not used. The detection limit improves with time even when the detection limits greater than 0.2 mg/L are not considered. In 2000 the typical detection limit dropped from 0.2 μg/L to 0.1 μg/L. Then in 2002 it dropped again to 0.03 μg/L, 0.04 μg/L or 0.06 μg/L.

Changes over Time

PCE concentrations are lower in the last ten years than they were in the 1980's and 1990's (Figure2b).

Table 4. Summary statistics for sites with detected PCE

SITES with detected PCE	Site #	Freq. >DL	Freq. <DL	Flow Path /to	Watershed	Median *	Max
Springs		153	115			µg/L	µg/L
Cold Spring	9	1	5		Town Lake	0.030	0.04
Upper Barton Spring	183	43	2		Barton Creek	0.050	0.08
Backdoor Spring	160	4	1		Barton Creek	0.075	0.01
Old Mill (Sunken Gardens) Spring	422	12	13		Barton Creek	0.100	0.37
Stillhouse Hollow Spring	24	7	16		Bull Creek	0.100	0.80
Eliza Spring	428	13	11		Barton Creek	0.120	0.34
Barton Spring	35	66	40		Barton Creek	0.150	1.70
Spicewood Spring (USGS)	582	2	10		Shoal Creek	0.150	0.20
Tanglewood Spring	31	5	17		Bull Creek	0.190	0.25
Wells		26	108				
Salamander Facility @ Zilker Park Nature Center	3883	1	0	Cold	Eanes Creek	0.020	0.02
USGS Well 301314097521401 (Legend Oaks)	4237	1	0	Cold?	Williamson Creek	0.020	0.02
USGS Well 302707097461101	4243	1	0		Lake Creek	0.020	0.02
USGS Well 301432097480001 (Loop 360)	687	1	16	Sunset Valley /Barton	Barton Creek	0.030	0.02
USGS Well 301504097501401(Travis -711)	4239	3	0	Cold	Barton Creek	0.040	0.05
58-50-417 Blowing Sink Well	3996	1	5	Sunset Valley /Barton	Slaughter Creek	0.045	0.10
USGS Well 301356097473301 (Target)	686	5	20	Manchaca/ Barton	Williamson Creek	0.050	0.20
USGS Well 302537097435001	4242	1	0		Walnut Creek	0.060	0.06
USGS Well 302925097462001	4244	1	0		Lake Creek	0.090	0.09
USGS Well 301226097480701 (Mendieta)	733	1	19	Manchaca/ Barton	Williamson Creek	0.100	0.20
USGS Well 301339097483701 (Sunset Valley)	734	2	23	Sunset Valley /Barton	Williamson Creek	0.100	0.20
USGS Well 301423097495901 (Travis Country -211)	692	3	20	Cold	Barton Creek	0.100	0.20
USGS Well 302941097495901	4245	1	0		S. Brushy Creek	0.110	0.11
Deep Eddy Upstream Well	759	2	0		Town Lake	0.195	0.23
USGS Well 301336097502802 (BrushCtry&YellowRose 2)	719	1	3	Cold	Williamson Creek	0.200	1.20
USGS Well 301336097502804 (BrushCtry&YellowRose 4)	683	1	2	Cold	Williamson Creek	0.200	0.60

*detection limits of 0.2 ug/L or less were included in the calculation of the median
sites north of the Colorado River are shaded
highest two maximum concentrations for wells and springs are in red

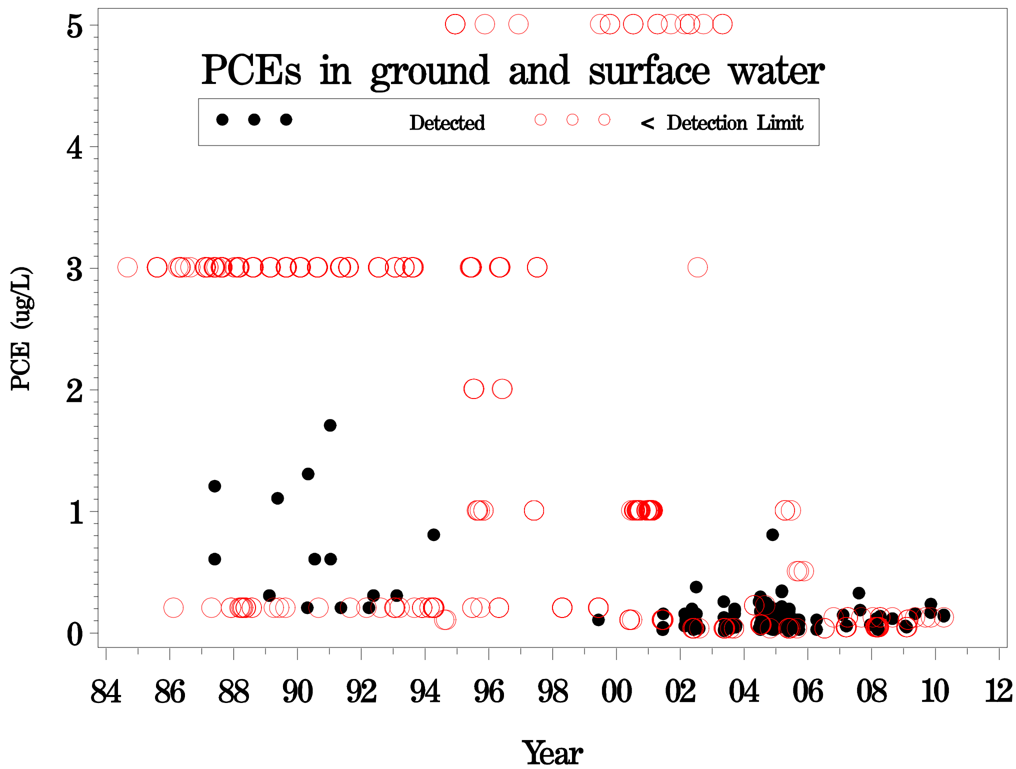

Figure 2a. PCE in ground and surface water

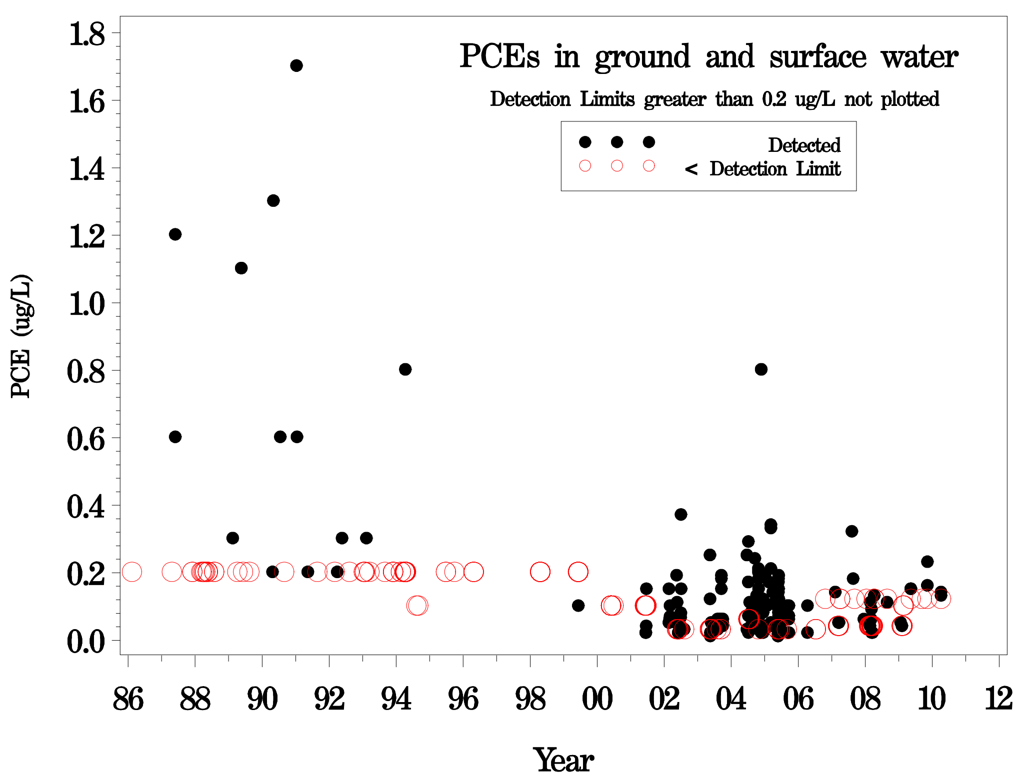

Figure 2b. PCE in ground and surface water with detection limits greater than 0.2 µnot plotted

Wells versus Springs
Concentrations are typically lower in wells than they are in springs (Table 4, Figures 3 and 4). The medians, of the site medians and maximums, are 0.75 and 0.1 µg/L for wells, versus 0.1 and 0.25 µg/L for springs. The two highest values observed in wells (sites 683 and 719) were not repeated in subsequent sampling at those sites in the following year

Stormwater
The highest detected values were found in water which is suspected of being stormwater. The determination from historical data of when water in wells and springs is storm influenced is difficult. In this case, a sample was labeled as storm influenced if

- total suspended solids (TSS) was ≥ 10 mg/L or
- fecal coliform or E. coli count was greater than 100 col. or mpn/100mL

If TSS and bacteria counts were unavailable, the specific conductivity and the changes in flow in the watershed were considered case by case. Low conductivity and a sudden increase in creek flow were taken to indicate the possibility of storm influenced flow in the spring or well. If the only indication of storm flow was increased creek flow, then the sample was not considered as storm flow. Only concentrations > 0.25 µg PCE/L were investigated for samples without TSS and bacteria counts. Almost all of the higher concentrations were storm influenced and located in the Barton Springs complex.

Time series plots for the springs with detected values are shown below for 1988-2010 and separately for 2000 – 2010 (Figure 3). Well levels are plotted in two groups for 1986-2010 since there are too many wells to see on one plot (Figure 4).

PCEs are typically higher in springs than in wells. Concentrations in both springs and wells are the highest in storm influenced water. This typically implies that pollution from surface water runoff is degrading the ground water quality with springs being the most affected. However, PCEs are not detected in surface water, in either baseflow or stormwater. It is possible that there are localized groundwater PCE pollution hotspots, which are transported primarily to springs under the higher conduit flow found during storms.

Barton Springs PCE in 2003-2005 – relationships to recharge and discharge
PCE concentrations in Barton Springs in 2003-2005 were extensively examined by USGS scientists (USGS 2006). Break-through curves at the Main Spring following storms were observed. From both storm sampling and routine sampling USGS scientists concluded that recharge flowing to Upper Barton Spring dilutes PCE levels, while recharge to the Eliza, Old Mill and the Main Spring increases concentrations. The combined flow paths to Old Mill are less contaminated then those to Eliza and the Main Spring. PCE was thought to be perched in the unsaturated zone and dissolving into recharging surface water as the water passes through that zone.

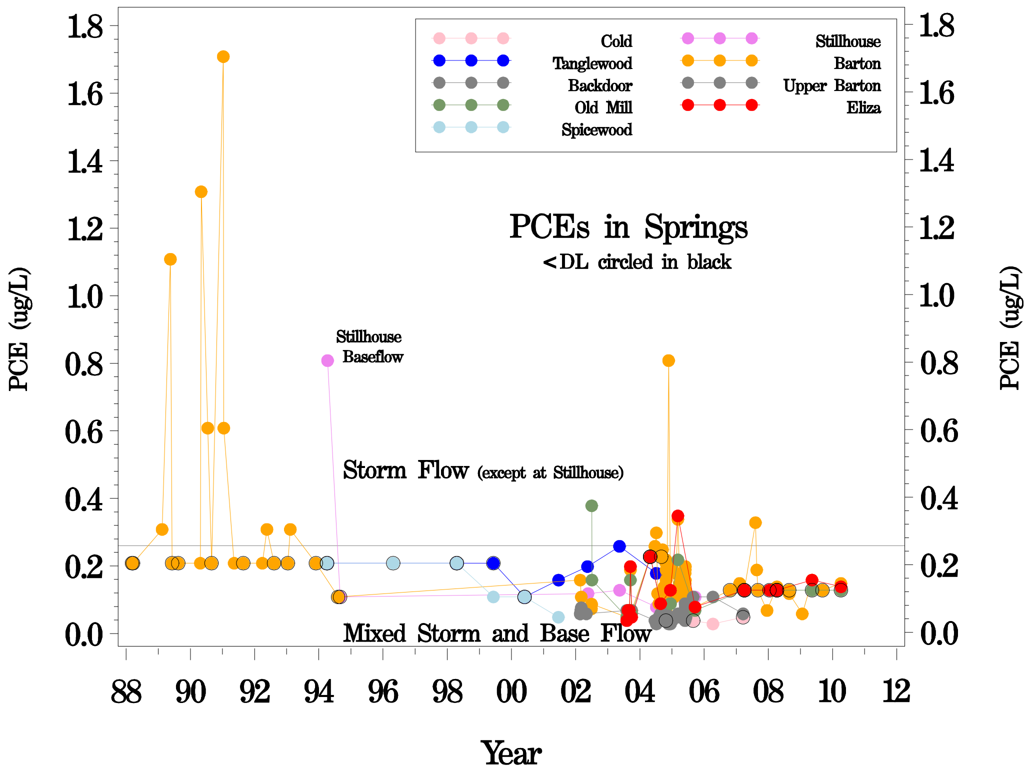

Figure 3a. Time series of detected PCE concentrations in springs. Levels above 0.26 µg/L appeared to be storm influenced with one exception.

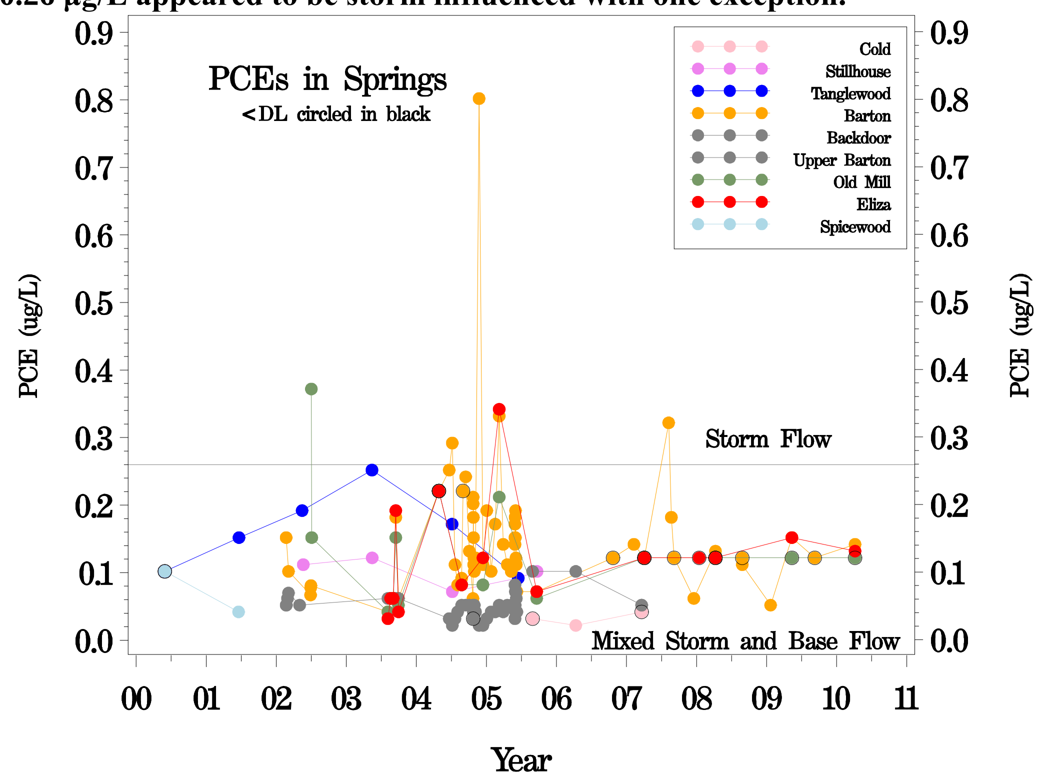

Figure 3b. Time series of detected PCE concentrations in springs since 2000.

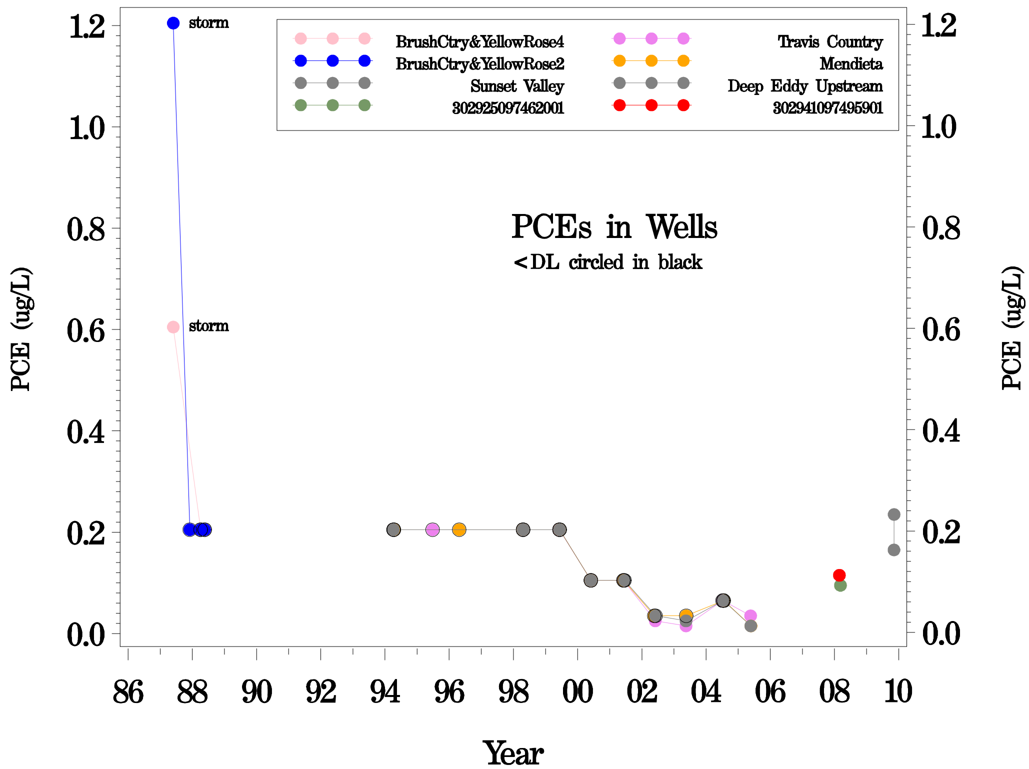

Figure 4a. Time series of detected PCE concentrations in 8 wells with detects from 1986 – 2010.

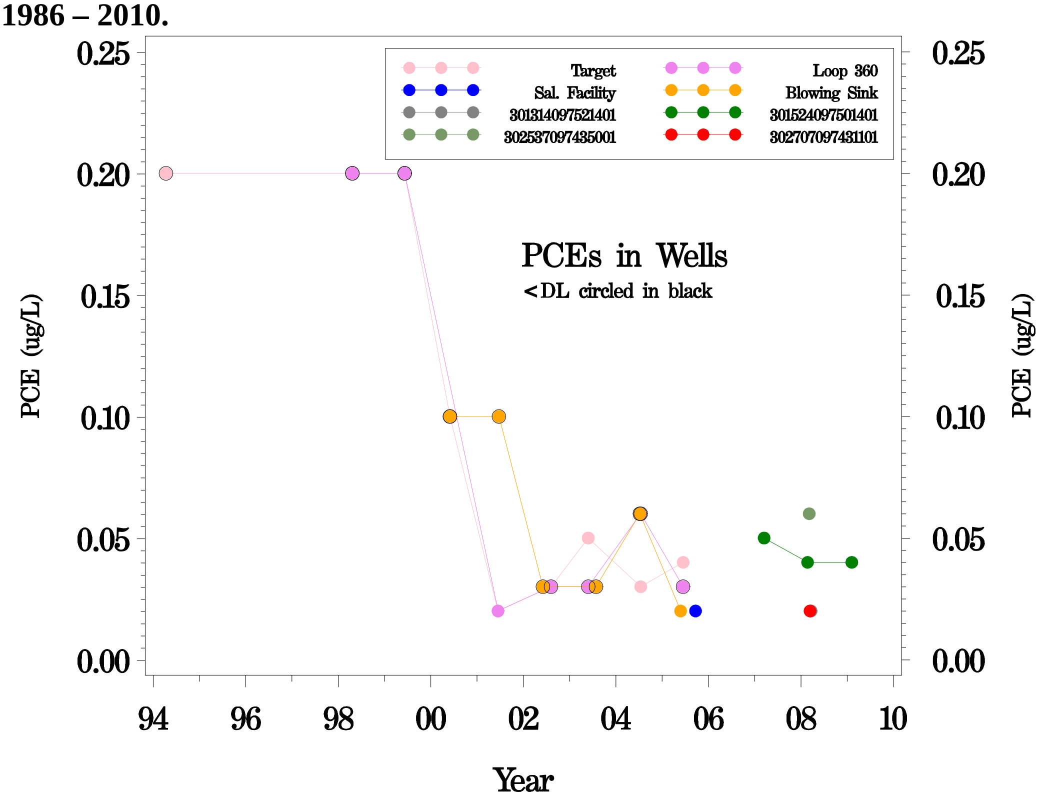

Figure 4b. Time series of detected PCE concentrations in 8 additional wells with detects from 1994 – 2010.

Sample Location
PCE has been detected in both the Barton Springs segment of the Edwards Aquifer and the Northern segment of the Edwards Aquifer (Figure 5). Sites with only non-detects, with the detection limit ≤ 0.2 are shown in Figure 6. The widespread nature of the contamination indicates multiple sources.

Plume Tracking
In order to assess the potential of the PCE data for plume tracking, and source determination, plots of site values within a single year were made. Data from the Barton Springs segment of the Edwards Aquifer where dye tracing has been used to assess flow paths was used. Only data taken after 2000 when the detection limits were lower was considered. However, the sparseness of the data, combined with detected values falling on multiple flow paths, and the highest values being found in the springs rather that in the "upstream" wells made plume tracking unrealistic. Plots of the two years, 2003 and 2005, with the most detected values are included to demonstrate that the data is insufficient for plume tracking (Figures 7 and 8).

Source Assessment
While plume tracking can not be done from the available data, the frequent detection of PC E in certain wells indicates the likelihood of a nearby source. The location of potential sources such as dry cleaners using PCE or unreported spill events could be researched further. Historical records and current chemical usage would be needed as changes to improve the environmental impact of the dry cleaning industry have been made. Locations of spills of PCE reported to the City of Austin are shown in Figure 9.

Conclusions

- PCEs are still found in Austin wells and springs with the maximum concentrations found in springs.
- The area of contamination is widespread, occurring both north and south of the Colorado River.
- The concentrations have been decreasing over time.
- The levels, both current and past have been below the predicted no effect concentration for aquatic life of 51 µg/L. However none of the toxicological studies were done on amphibians, and the highest current concentrations are found in springs with endangered salamanders.
- Peak concentrations may be caused by transport of localized pollutants to area springs under the higher conduit flow during storms.
- Source tracking would require the use of historical records

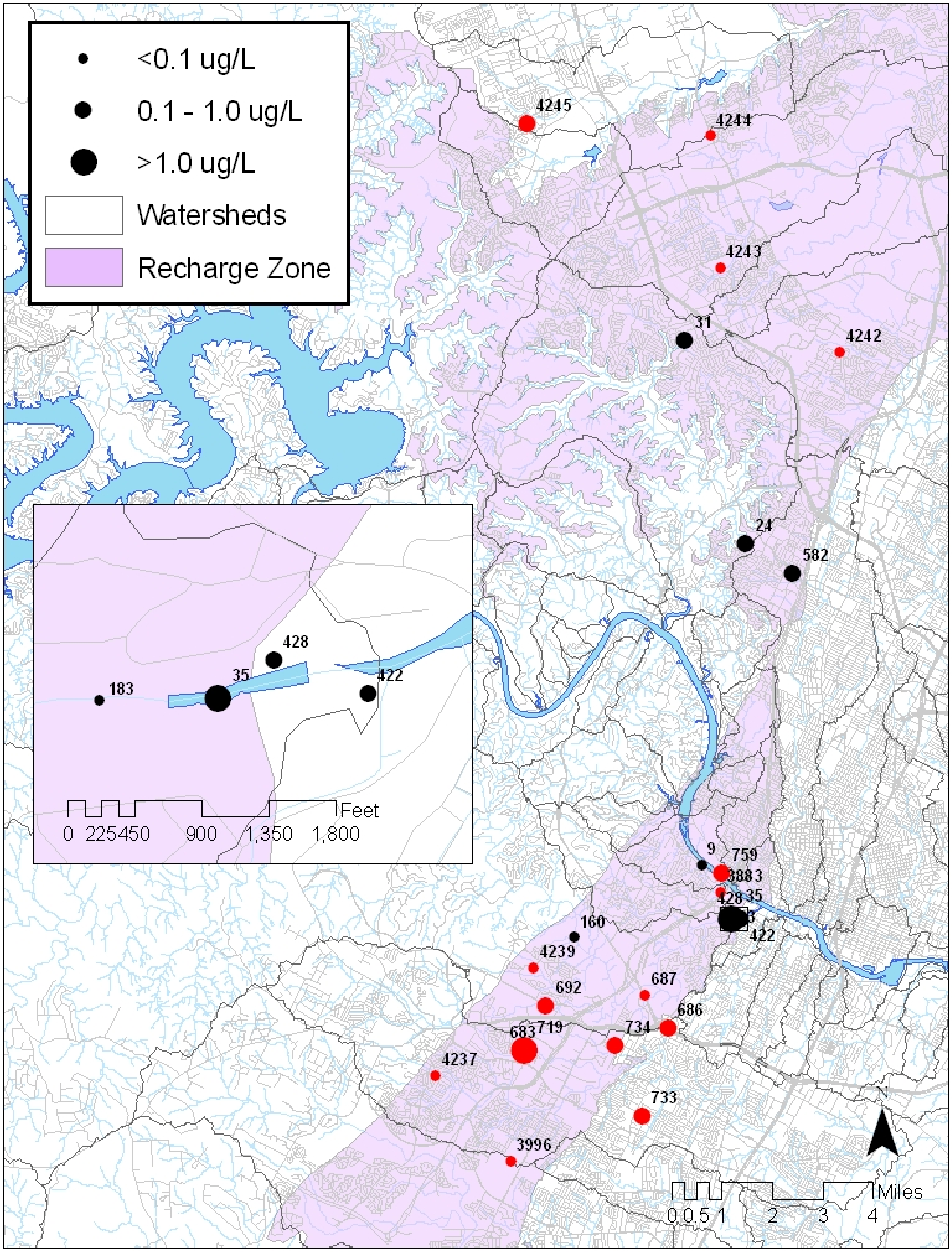

Figure 5. Locations where PCE was detected in wells (red) and springs (black). The dots are graduated in size to represent the maximum detected value of PCE at each site. The dots for the springs in the Barton Springs complex overlay each other.

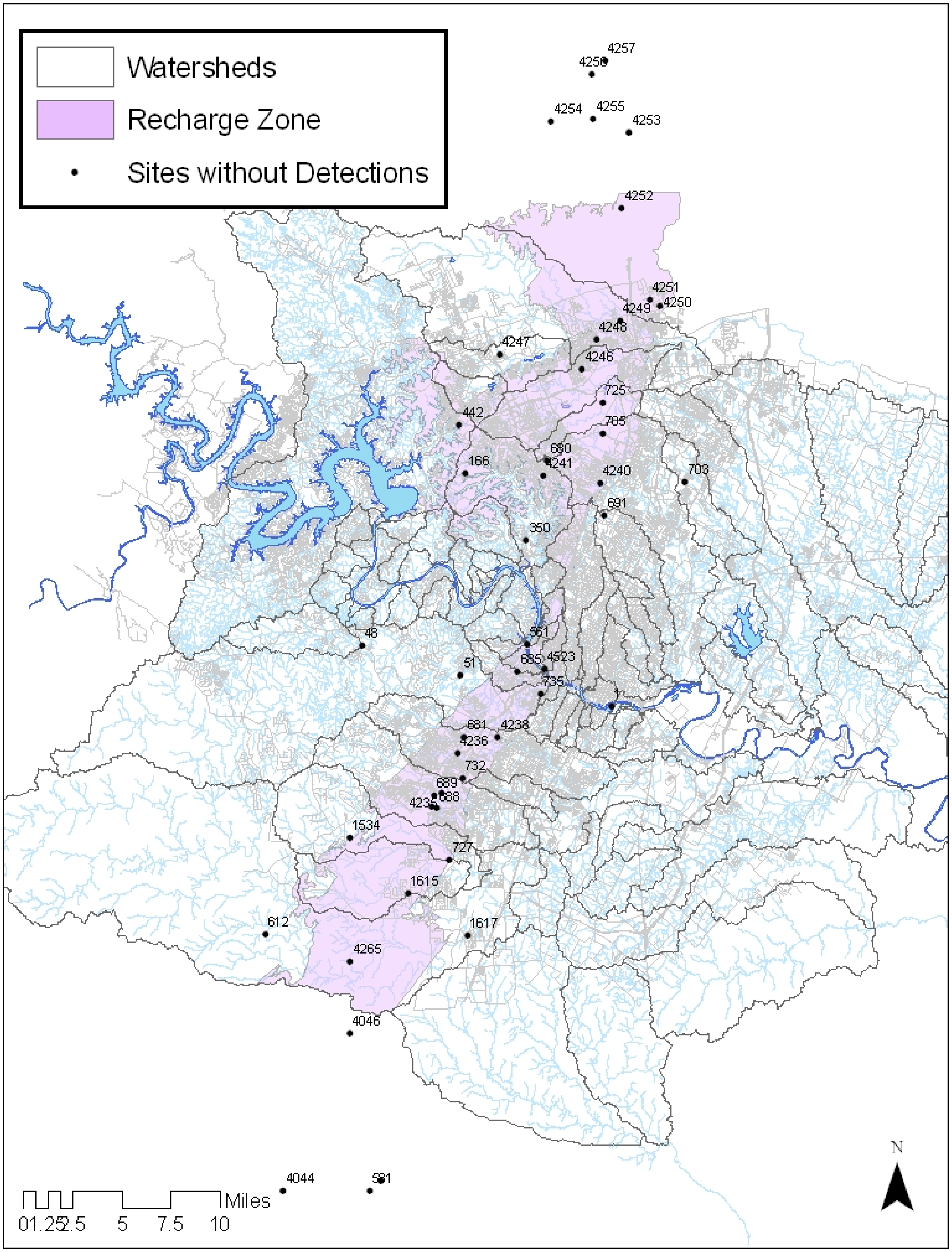

Figure 6. Locations where PCE samples were taken, the PCE concentrations was below the detection limit, and the detection limit was ≤ 0.2 µg/L.

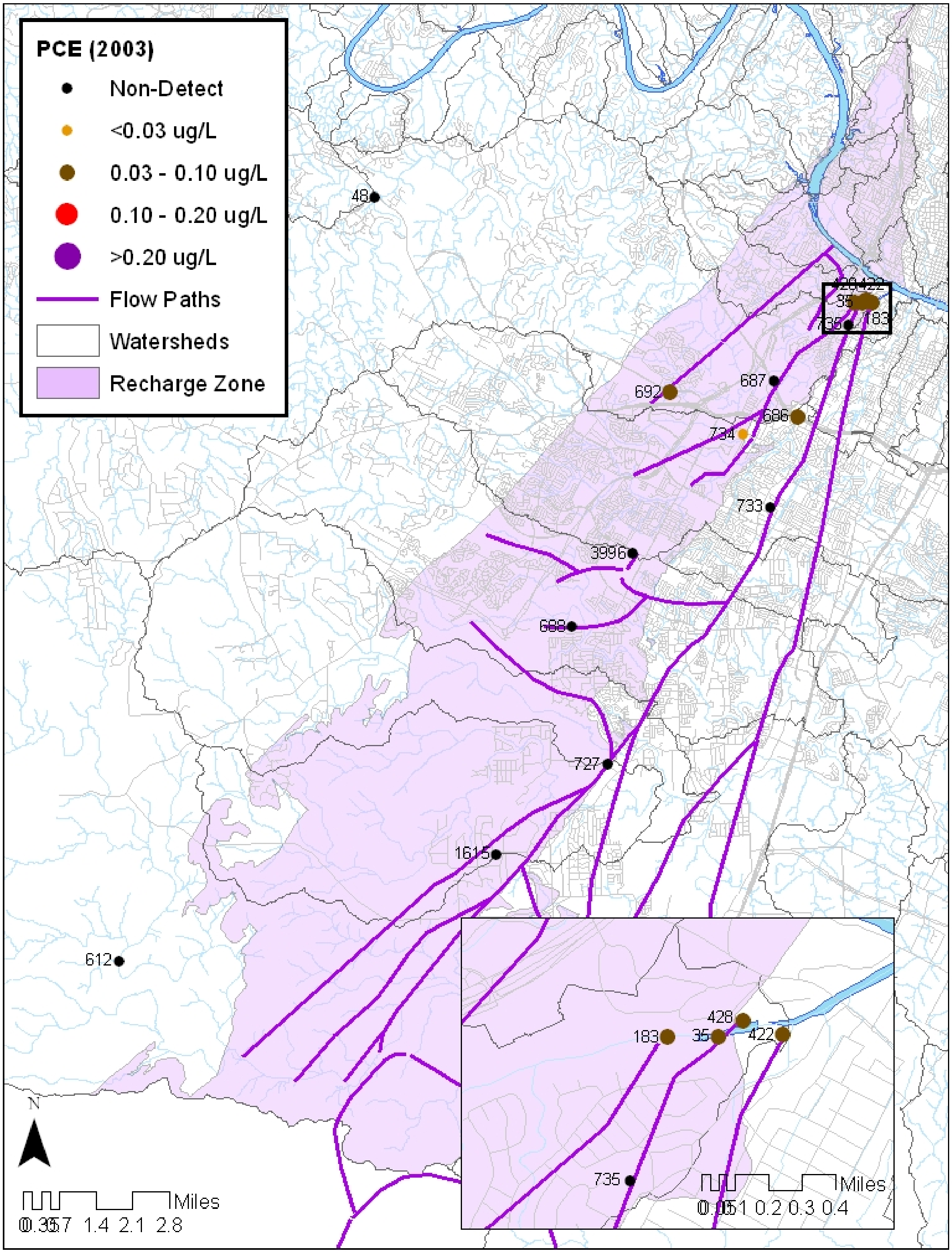

Figure 7. Sampled locations and detected values in the Barton Springs segment of the Edwards Aquifer in 2003. Flow paths are identified.

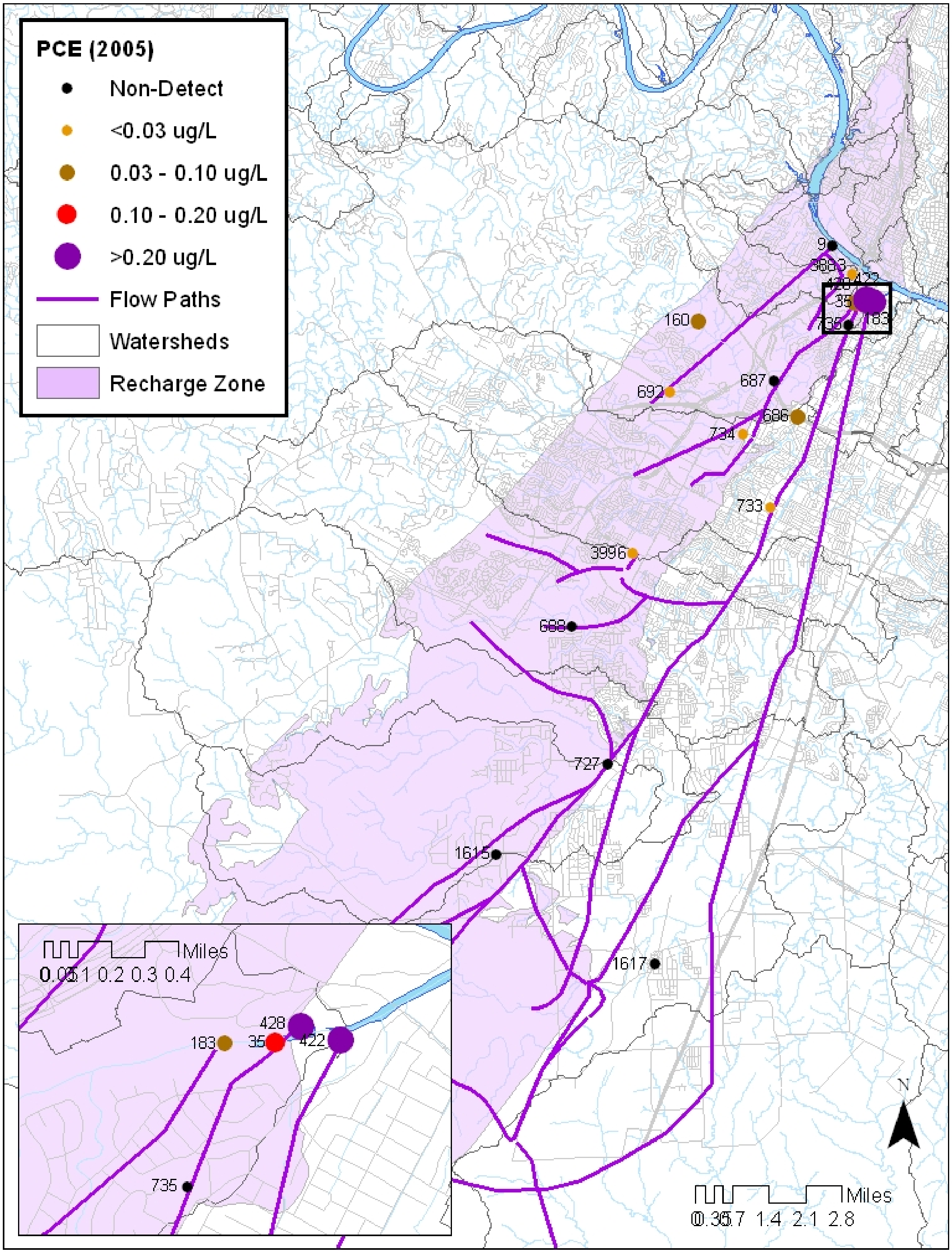

Figure 8. Sampled locations and detected values in the Barton Springs segment of the Edwards Aquifer in 2005. Flow paths are identified.

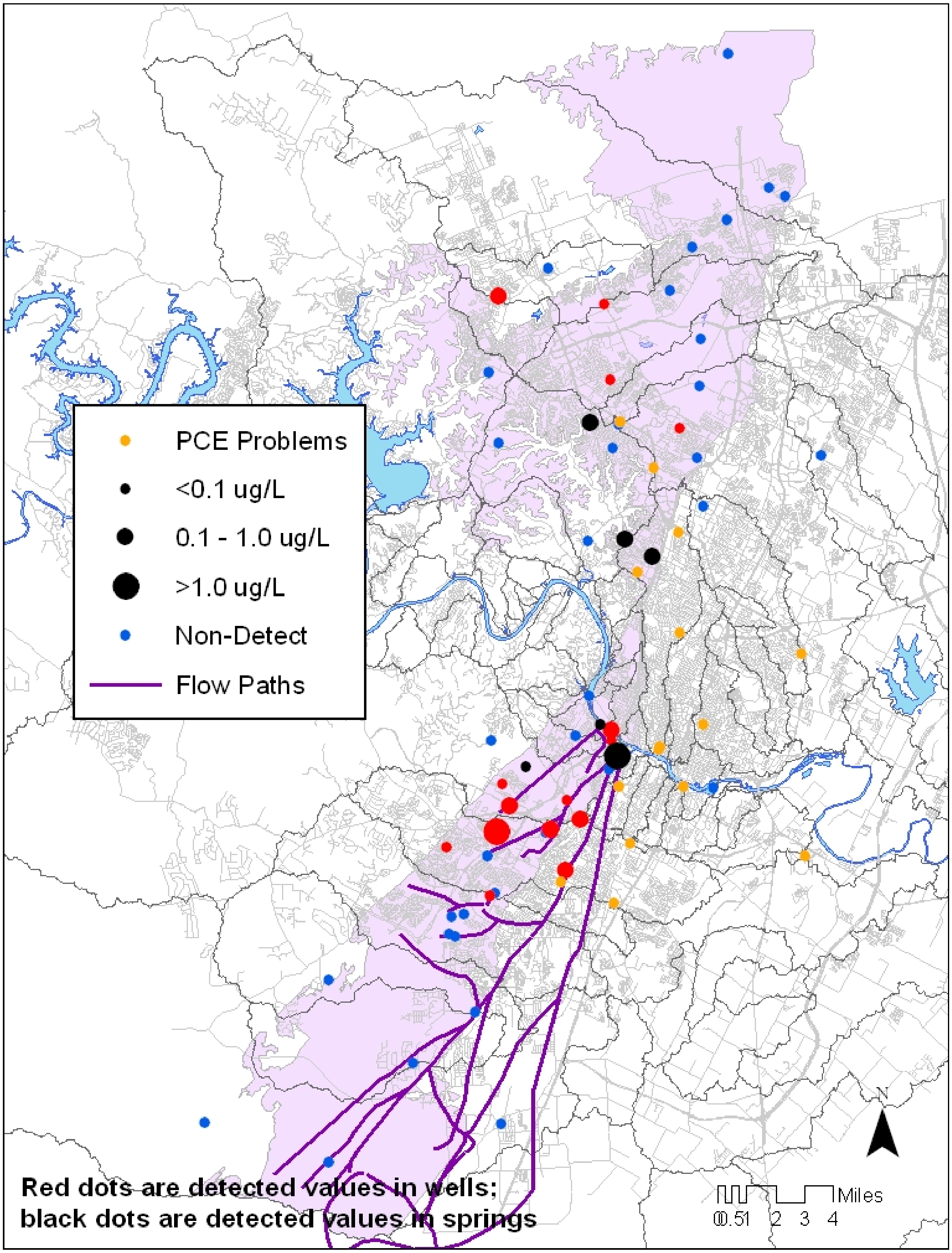

Figure 9. Location of known PCE spill locations with PCE detection in wells (red and Springs (black).

References

COA Dye Studies

Euro Chlor Risk Assessment for the Marine Environment OSPARCOM Region – North Sea, Tetrachloroethylene, June 1997 http://www.eurochlor.org/upload/documents/document75.pdf

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USGS 2006. Mahler, B. J., Garner, B.D., Musgrove, M., Guilfoyle, A.L., and Rao, M.V., Recent (2003-05) water quality of Barton springs, austin, Texas, with emphasis on factors affecting variability: U.S. Geological Survey Scientific Investigations Report 2006-5299, 83 p., 5 appendixes

Appendix A. Sampled Site without Detected PCe. Detection limit ≤0.2μg/L

SITE_NO	SITE
1	Town Lake @ Basin (AC)
48	Barton Creek @ Hwy 71 Below Little Barton
51	Barton Creek Downstream of Lost Creek Blvd
166	Schlumberger Spring 1
350	Bull Creek @ Loop 360 First Crossing
442	Kelly Hollow Spring (USGS)
561	Lake Austin @ Tom Miller Dam (AC)
581	USGS Spring 295340097554801 (Hays County)
612	Onion Creek near Driftwood (Hwy 150)
680	USGS Well 302546097455501 (Walnut Cr.)
681	USGS Well 301336097502805(BrushCtry&YellowRose 5)
685	USGS Well 301628097474001 (Rollingwood&N.Peak)
688	USGS Well 301031097515801 (Wyldwood)
689	USGS Well 301106097520501 (Slaughter Cr.)
691	USGS Well 302316097430401 (L. Walnut Cr.)
703	USGS Well 302441097385601 (Harris Branch)
705	USGS Well 302652097430501 (Walnut Cr.)
725	USGS Well 302817097430101 (Rattan Cr.)
727	USGS Well 300813097512101 (Marbridge)
732	USGS Well 301148097503501 (Gantt at Brodie&Deer)
735	USGS Well 301526097463201 (Rabb Well)
1534	Bear Creek Downstream of Bear Creek Pass (USGS)
1615	USGS Well 300646097533202 (Wolff_Turner)
1617	USGS Well 300453097503301 (Buda)
4044	USGS Well 295345098001001 (San Marcos Ranch Rd.12)
4045	USGS Well 295406097551201 (San Marcos, Gordon St)
4046	USGS Well 300041097563901 (Kyle)
4234	USGS Well 301037097521201
4235	USGS Well 301111097514001
4236	USGS Well 301256097505001
4238	USGS Well 301336097484601
4240	USGS Well 302443097431601
4241	USGS Well 302505097460901
4246	USGS Well 302947097440301
4247	USGS Well 303032097481501
4248	USGS Well 303104097431601
4249	USGS Well 303152097420301
4250	USGS Well 303230097395901
4251	USGS Well 303247097403201
4252	USGS Well 303650097415001
4253	USGS Well 304012097412101
4254	USGS Well 304046097452001
4255	USGS Well 304049097431101
4256	USGS Well 304247097431101
4257	USGS Well 304324097423001
4265	USGS Well 300350097563201
4523	Deep Eddy Downstream Well