Assessment of Arsenic Attenuation in Public and Domestic Supply Wells

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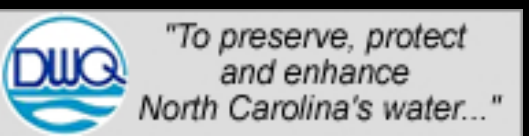

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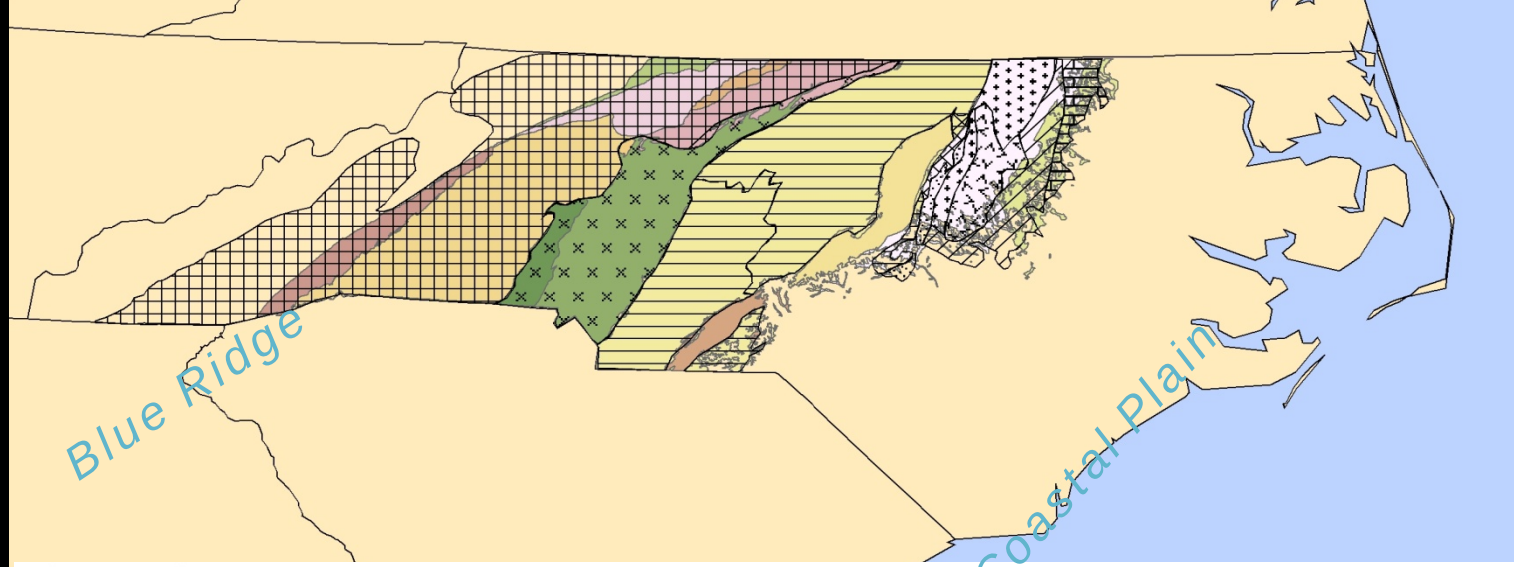
Piedmont Geology of NC



Legend

NC Terranes
(after Hibbard and others, 2002)

- Carolina Terrane
- Charlotte Terrane
- Crabtree Terrane
- Falls Lake Terrane
- Late Prot. Granitoid
- Piedmont Zone
- Raleigh Terrane
- Roanoke Rapids Terrane
- Spring Hope Terrane

Piedmont Geologic Belts
(from 1985 NC Geologic Map)

- Carolina Slate Belt
- Charlotte Belt
- Chauga Belt
- Dan River Triassic Basin
- Davie Triassic Basin
- Eastern Slate Belt
- Inner Piedmont Belt
- Kings Mt Belt
- Milton Belt
- Raleigh Belt
- Sanford-Durham Tri Basin
- Sauratown Mts Anticlinori
- Smith River Allochthon
- Undif Coastal Plain
- Wadesboro Triassic Basin

Overview of the Piedmont Aquifer System

Saprolite – Highly weathered parent material, often bears relict features such as primary rock textures.

Transition Zone – Weathering zone between saprolite and bedrock, generally more transmissive than the overlying saprolite zone.

Fractured Bedrock – Igneous or metamorphic rocks. Groundwater is transmitted to discharge areas or wells *via* fracture network. Highly transmissive, but little storage. Connectivity to overlying regolith determines available water.

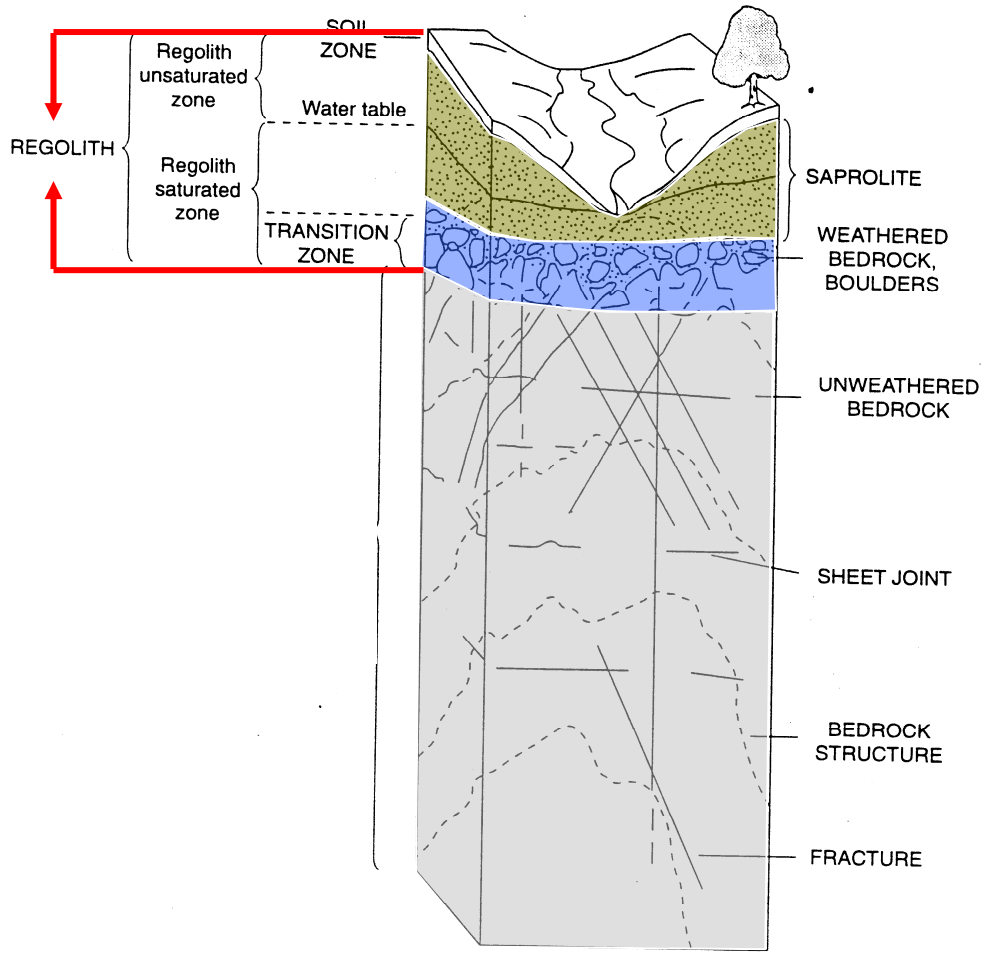
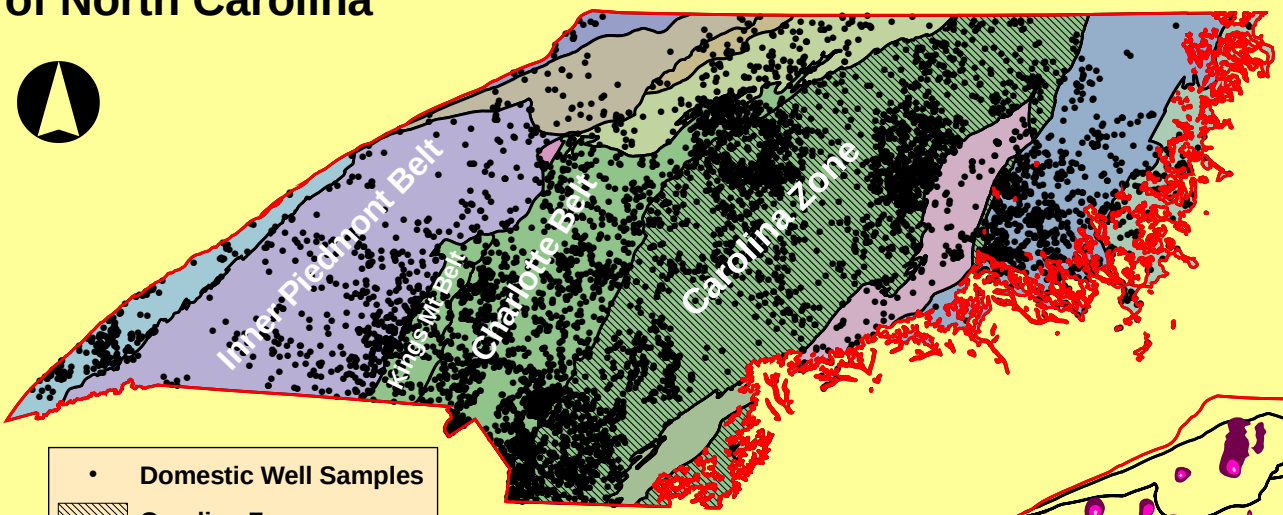
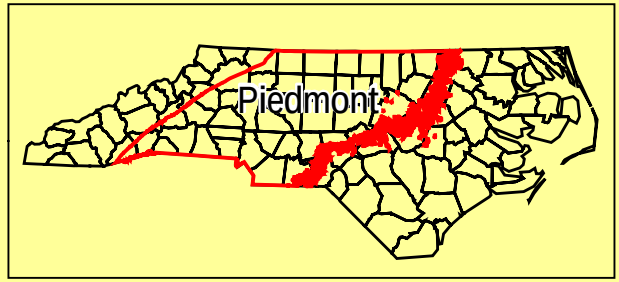


Figure 2. Principal components of the ground-water system in the Piedmont physiographic province of North Carolina (from Harned and Daniel, 1992).

High Probability zones are spatially correlative with volcanic and volcaniclastic rocks of the Carolina Zone.

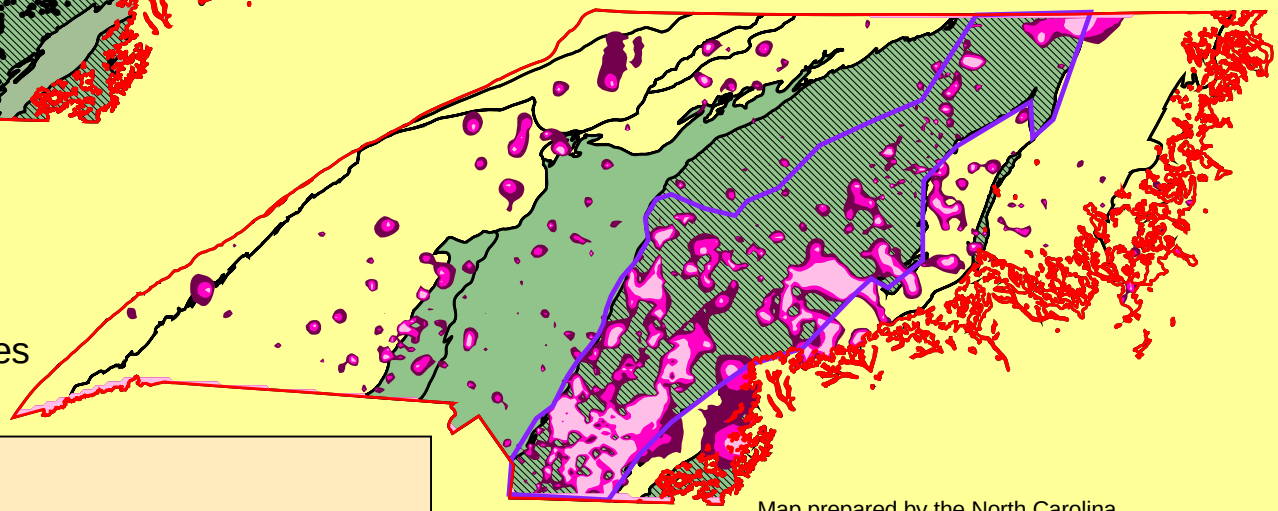
Arsenic in the Piedmont of North Carolina





- Domestic Well Samples
- Carolina Zone
- Carolina Terrane

60 30 0 60 Miles



Legend

Probability to Exceed 1 ug/L

- 75% Probability
- 50% Probability
- 25% Probability

- Carolina Zone
- Carolina Terrane
- Carolina Zone Volcanic and Volcaniclastic Rocks

Map prepared by the North Carolina Department of Environment and Natural Resouces, Division of Water Quality, Aquifer Protection Section

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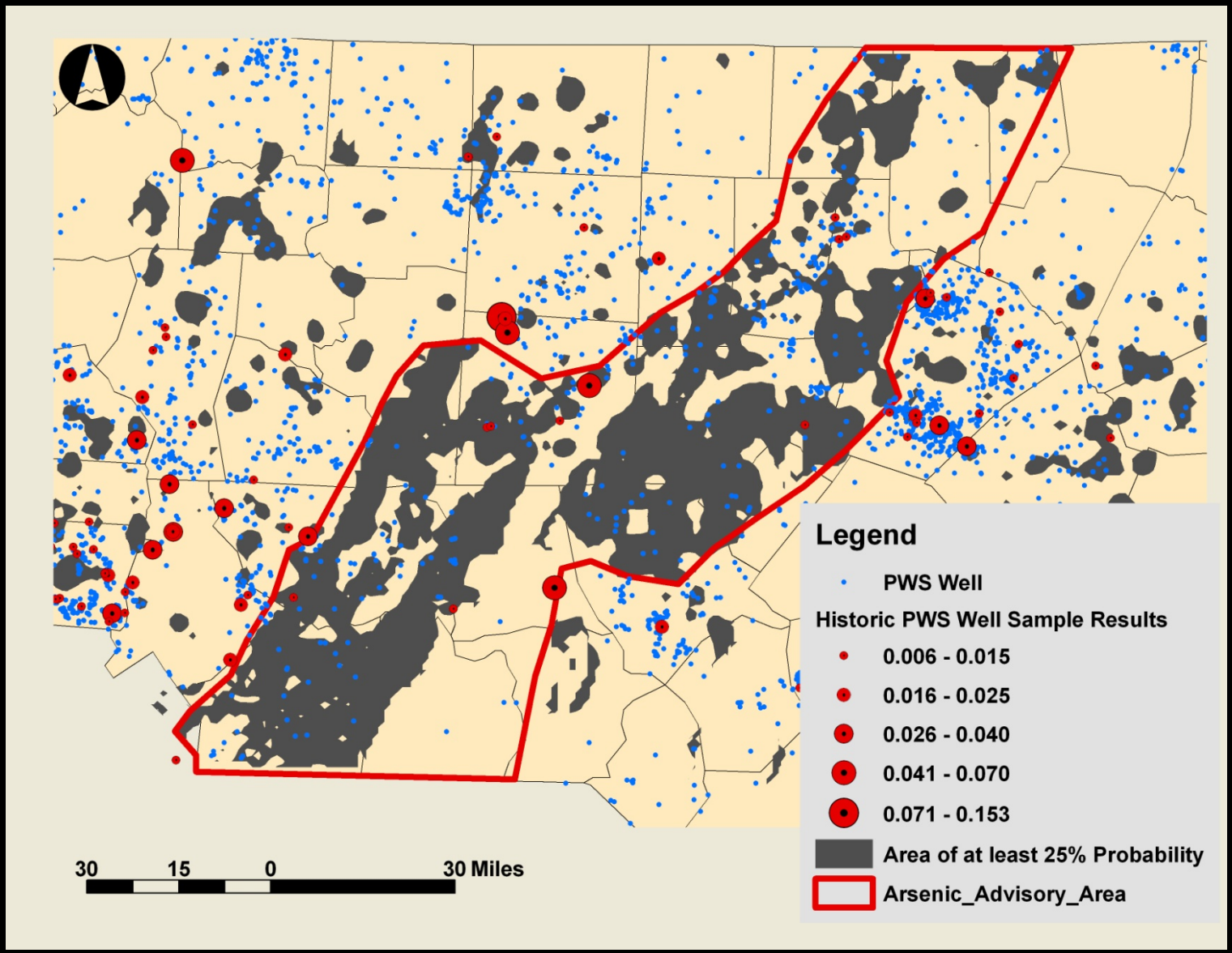
Public Water Supply Wells In the Piedmont



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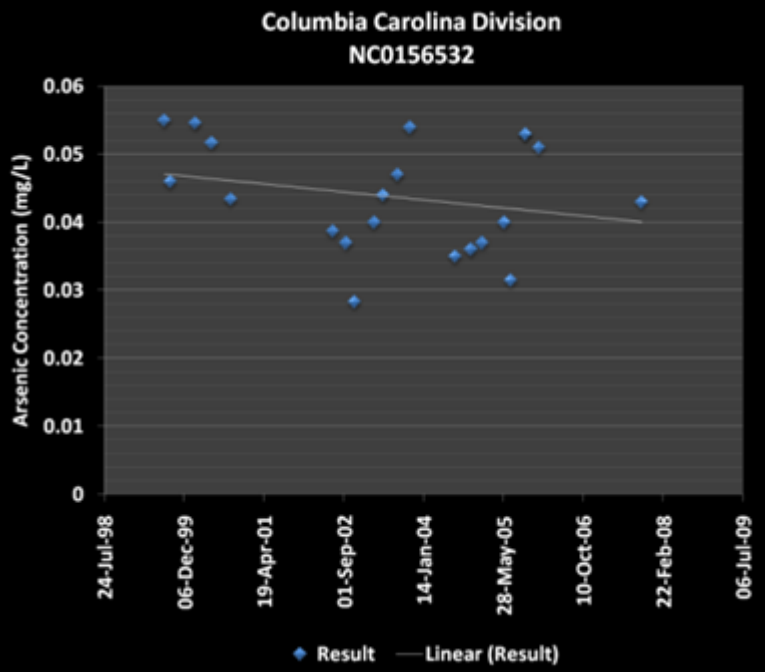
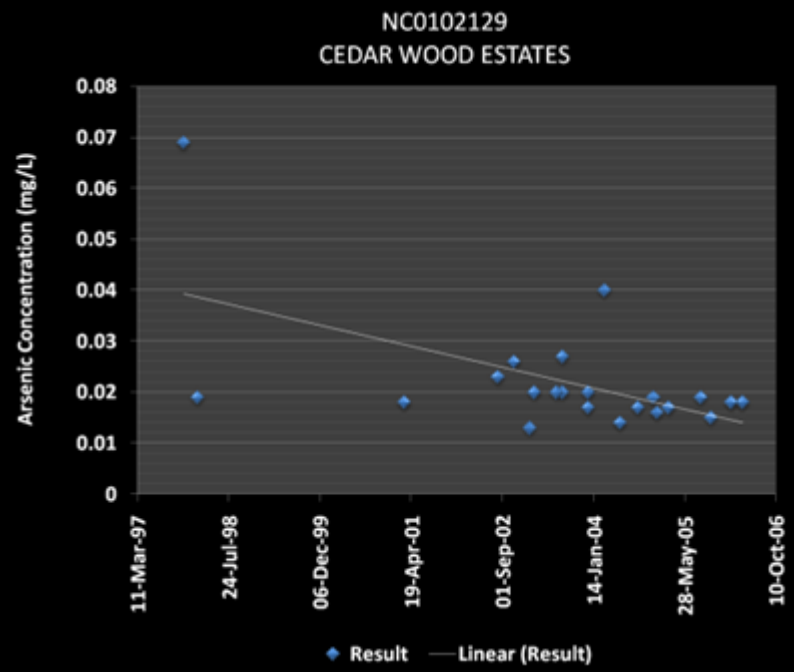
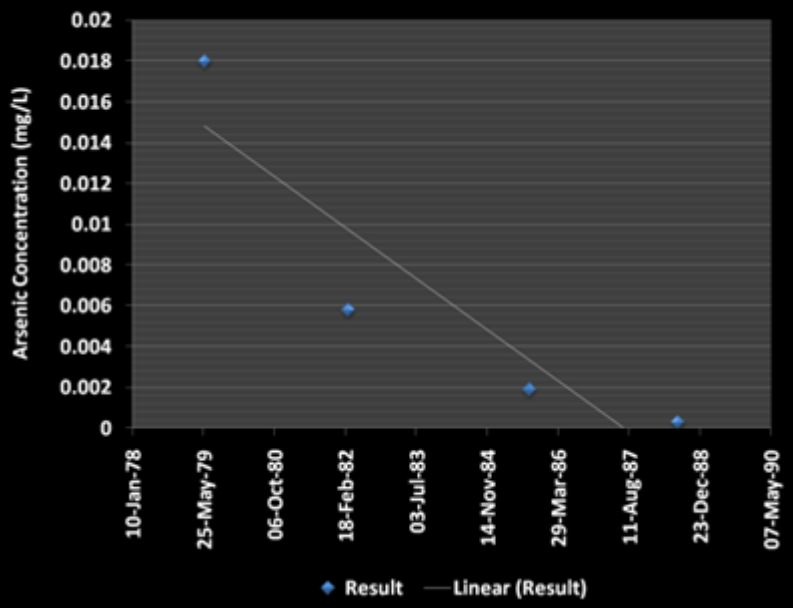
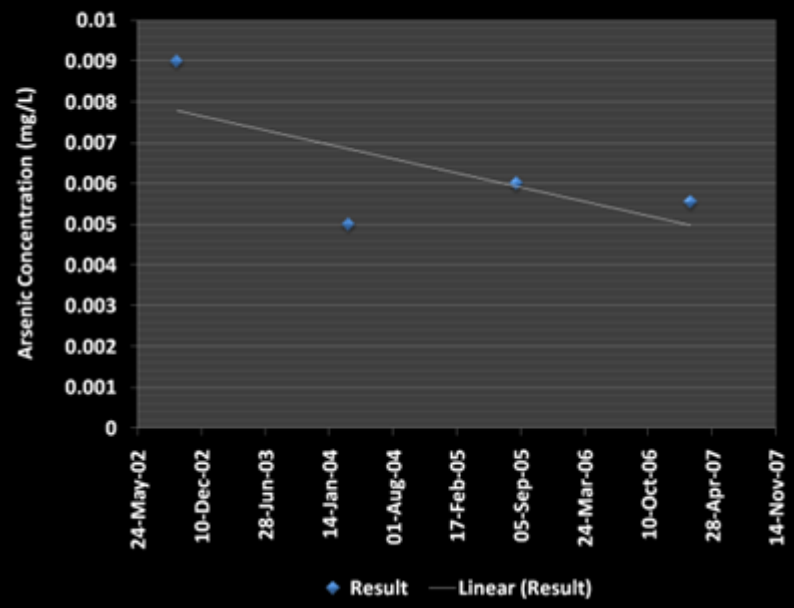
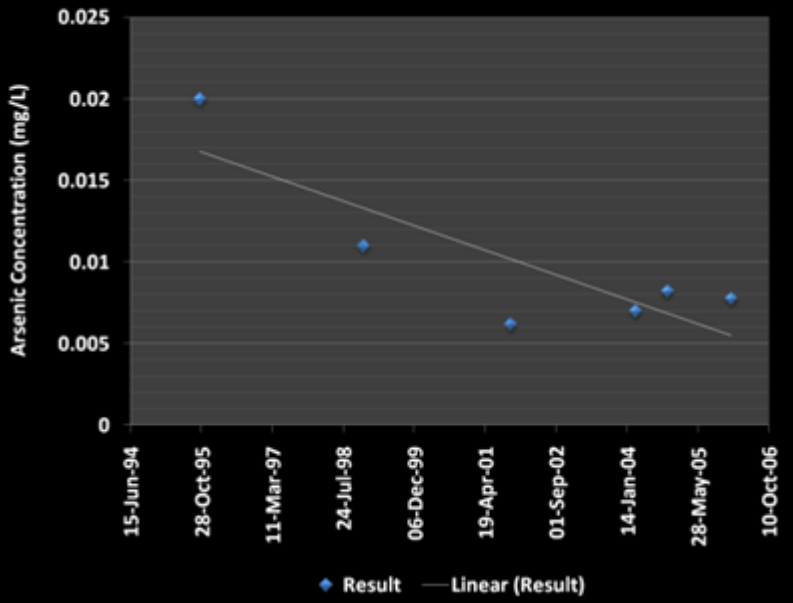

Columbia Carolina Division
NC0156532
Arsenic Concentration (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0
24-Jul-98
06-Dec-99
19-Apr-01
01-Sep-02
14-Jan-04
28-May-05
10-Oct-06
22-Feb-08
06-Jul-09
Result
Linear (Result)


NC0102129
CEDAR WOOD ESTATES
Arsenic Concentration (mg/L)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
11-Mar-97
24-Jul-98
06-Dec-99
19-Apr-01
01-Sep-02
14-Jan-04
28-May-05
10-Oct-06
Result
Linear (Result)

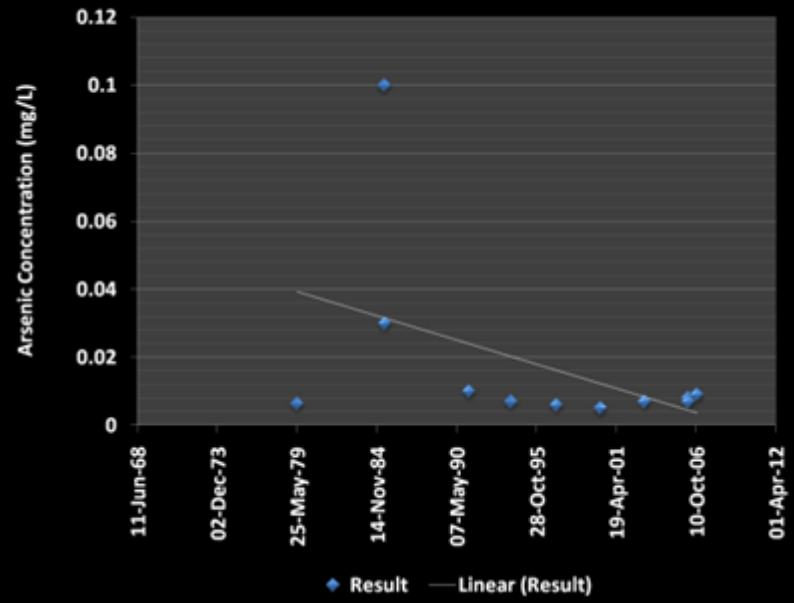

NC0160137
EASTWOOD FOREST MHP
Arsenic Concentration (mg/L)
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
10-Jan-78
25-May-79
06-Oct-80
18-Feb-82
03-Jul-83
14-Nov-84
29-Mar-86
11-Aug-87
23-Dec-88
07-May-90
Result
Linear (Result)


NC0136362
CREEKSIDE ESTATE
Arsenic Concentration (mg/L)
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
24-May-02
10-Dec-02
28-Jun-03
14-Jan-04
01-Aug-04
17-Feb-05
05-Sep-05
24-Mar-06
10-Oct-06
28-Apr-07
14-Nov-07
Result
Linear (Result)

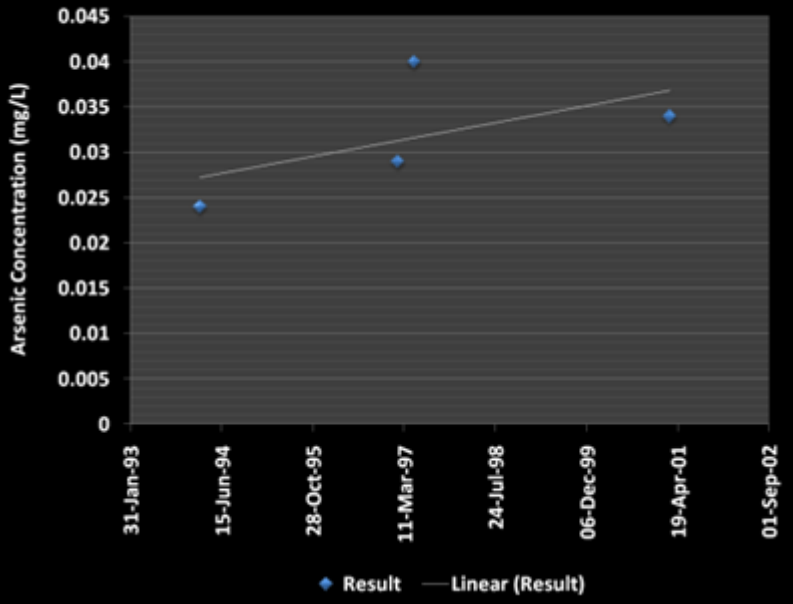
NC0276631
FARMER ELEMENTARY SCHOOL



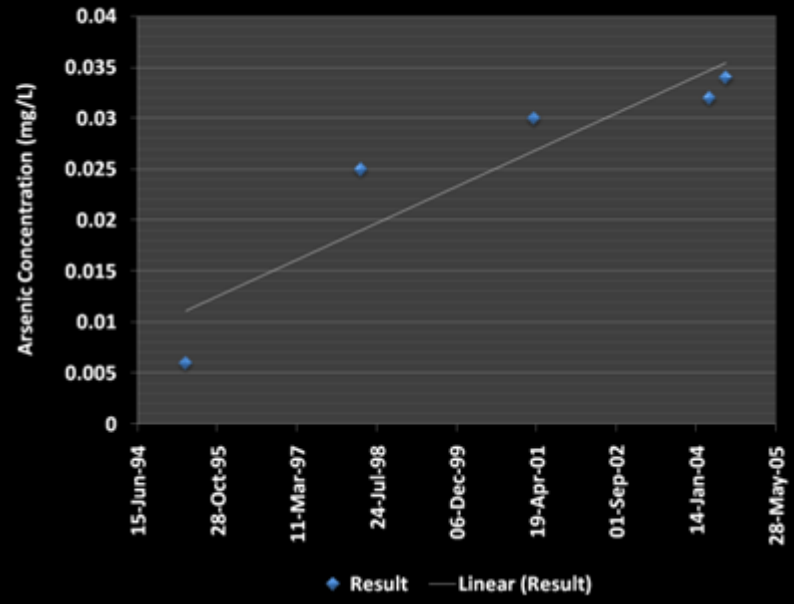
NC0123045
LAWNDALE, TOWN OF

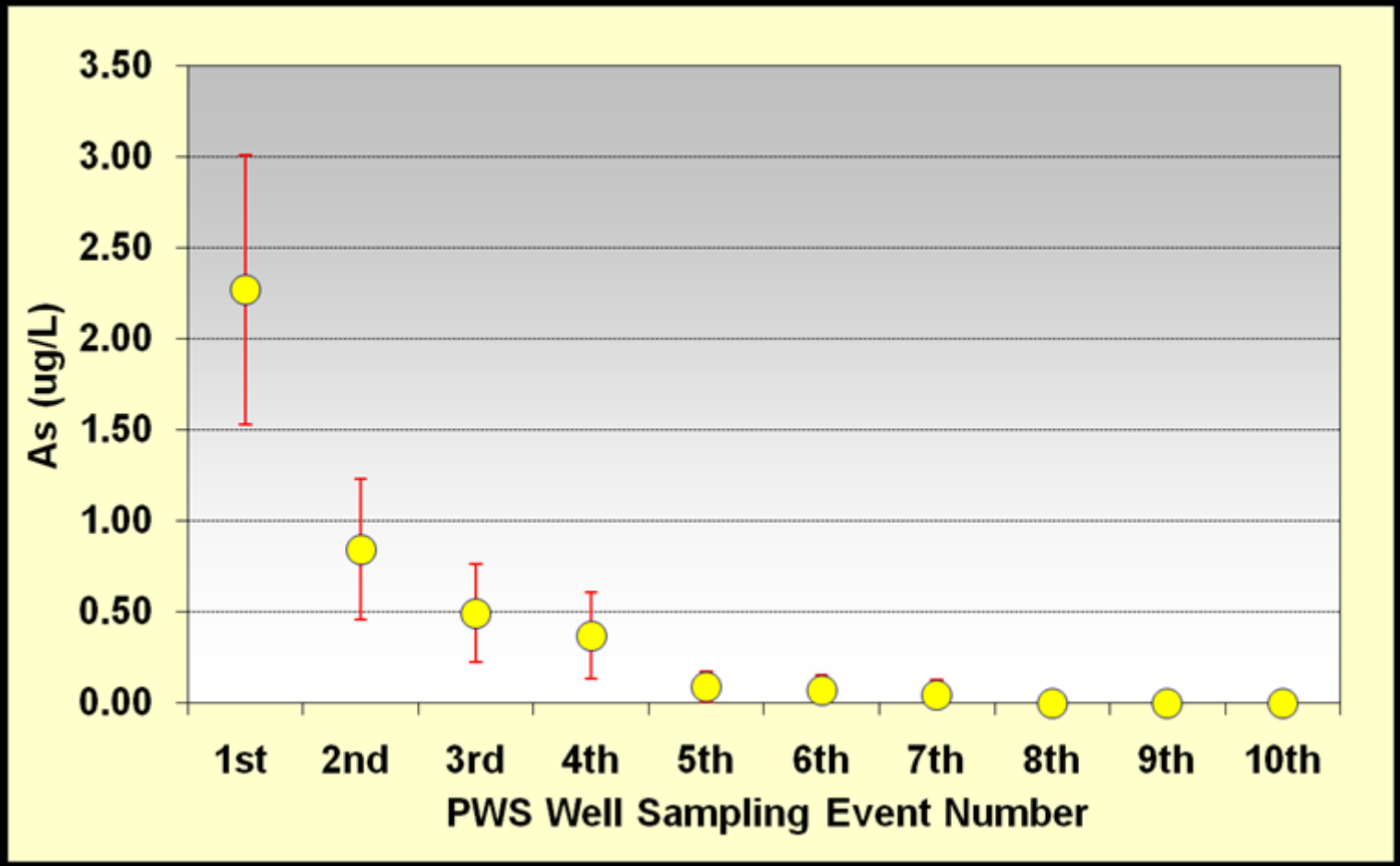


NC0190401
NEW SALEM ELEM SCHOOL

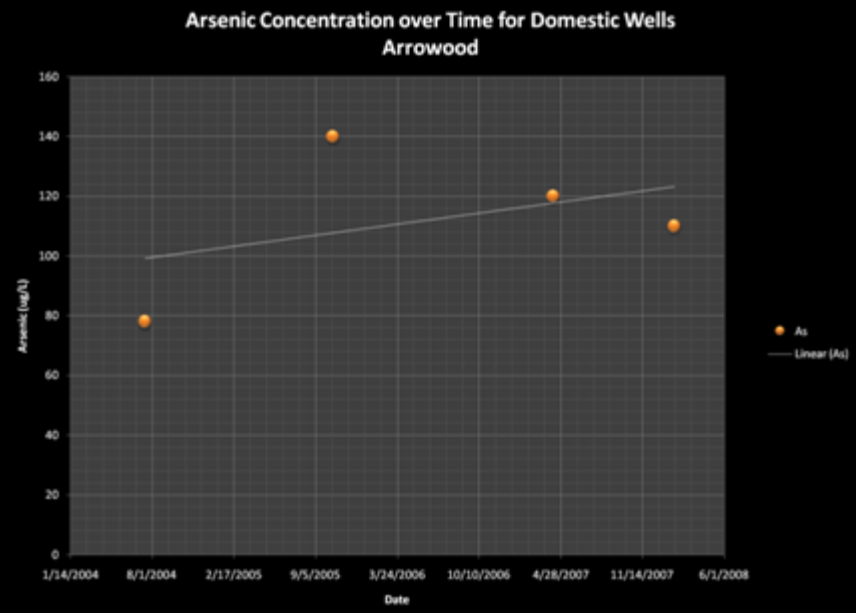


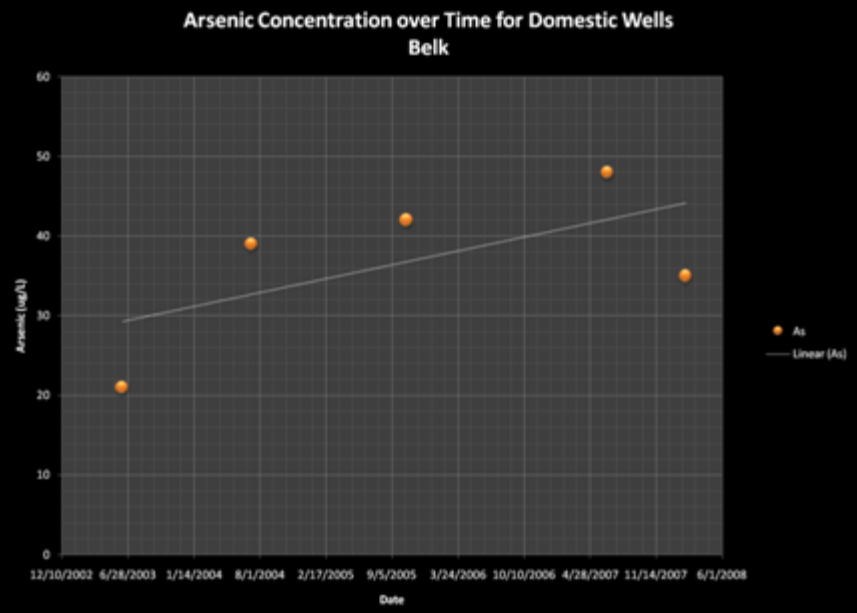
NC0106107
SUGAR MOUNTAIN UTILITY

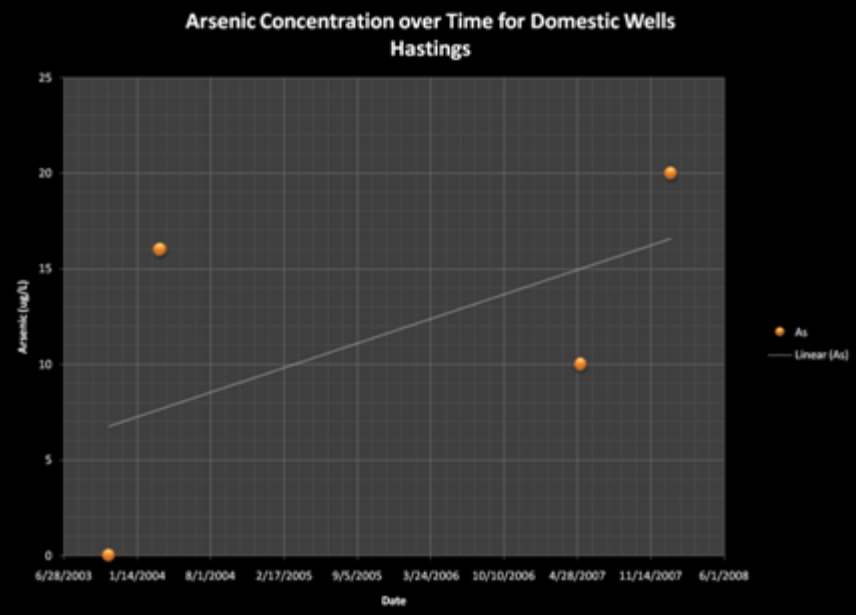


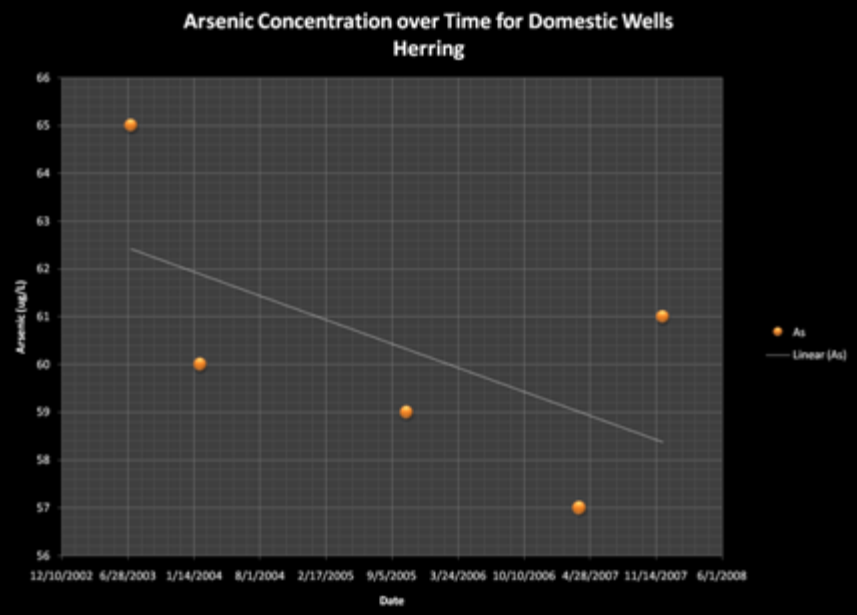


Domestic Well Temporal

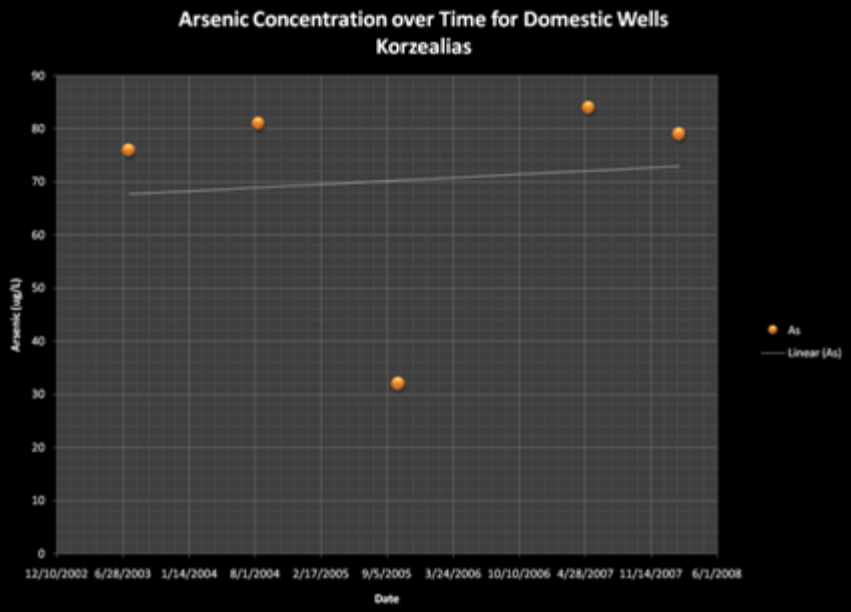


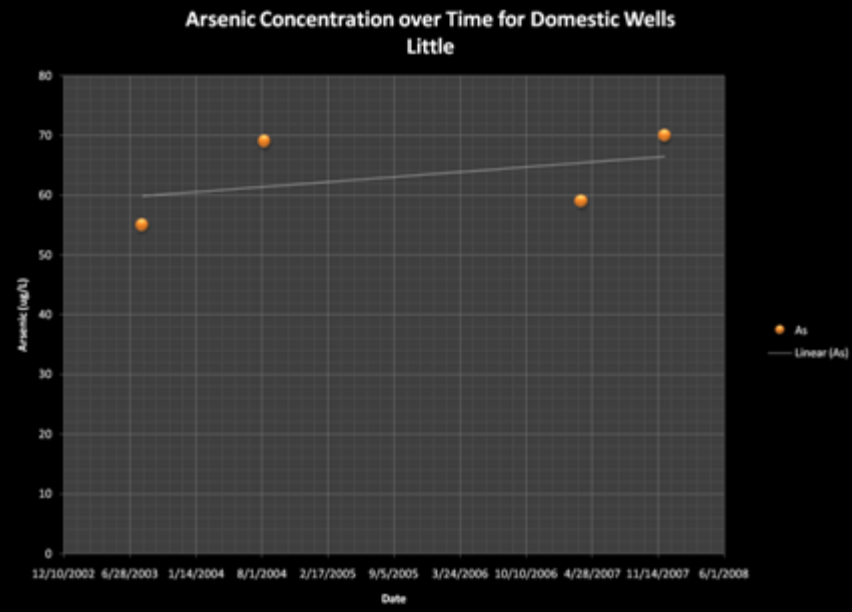


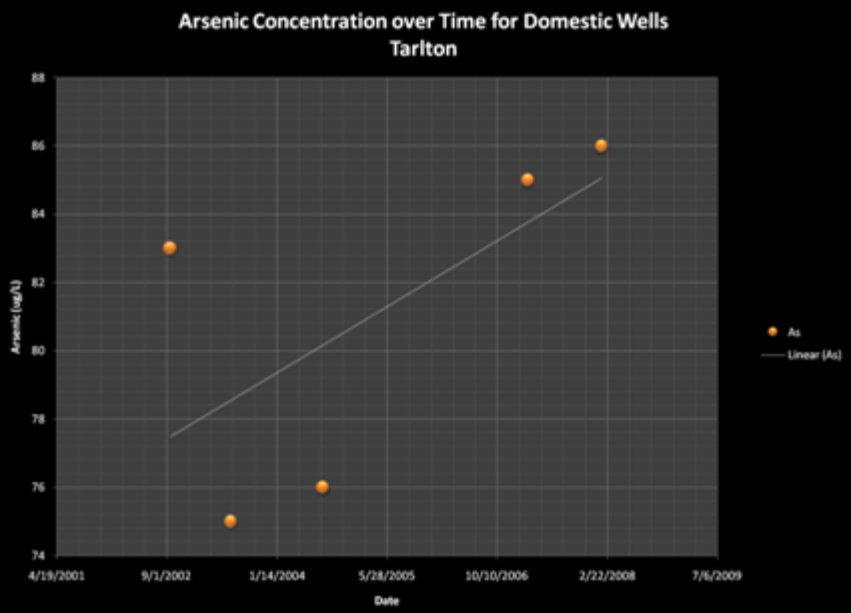


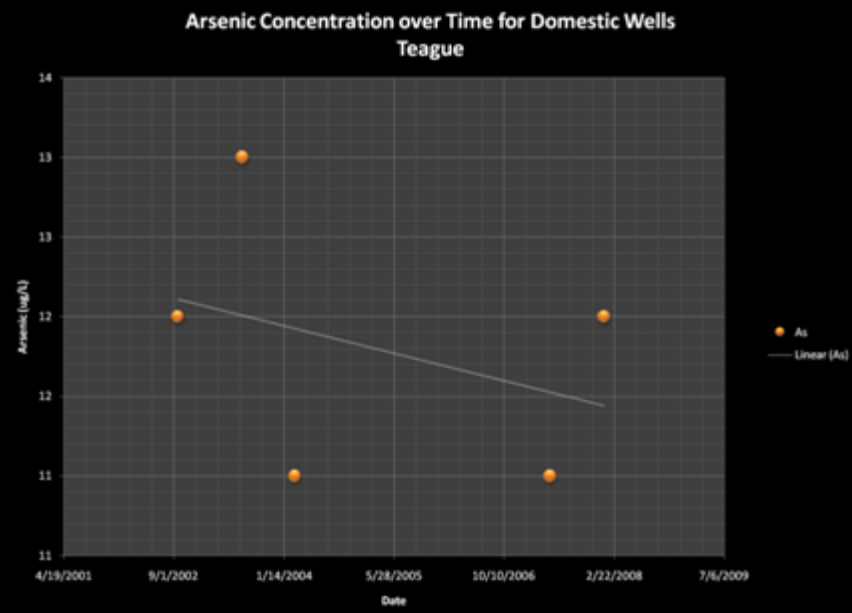


Domestic Well Temporal

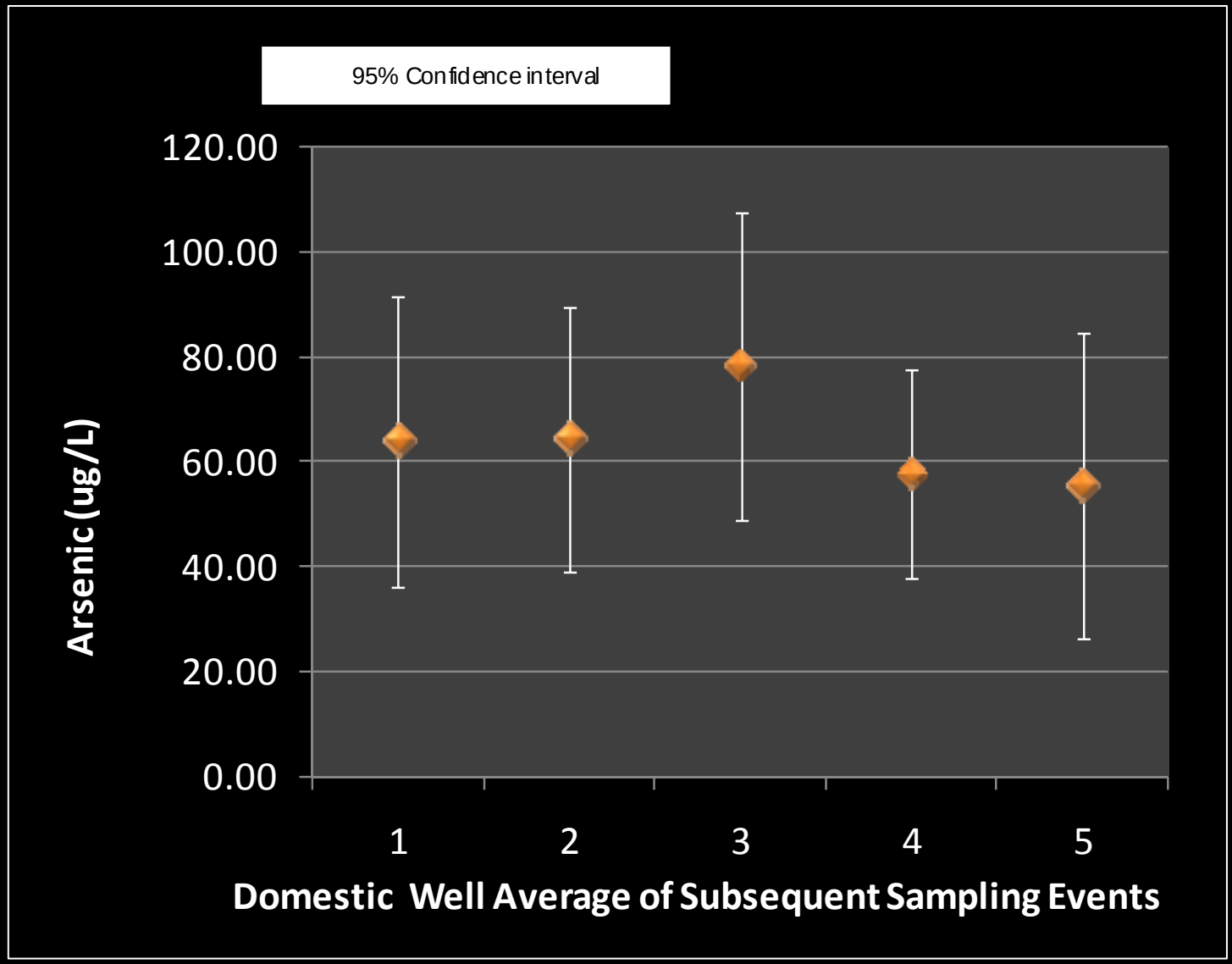








Composite of Domestic Wells From 2004 to 2008



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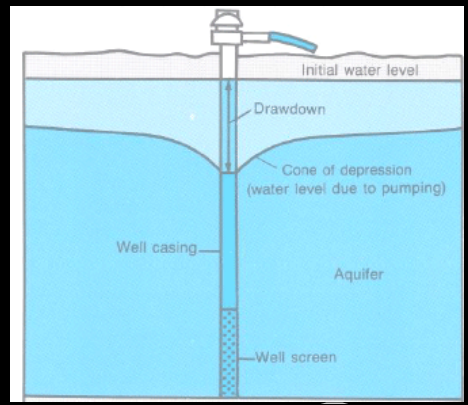
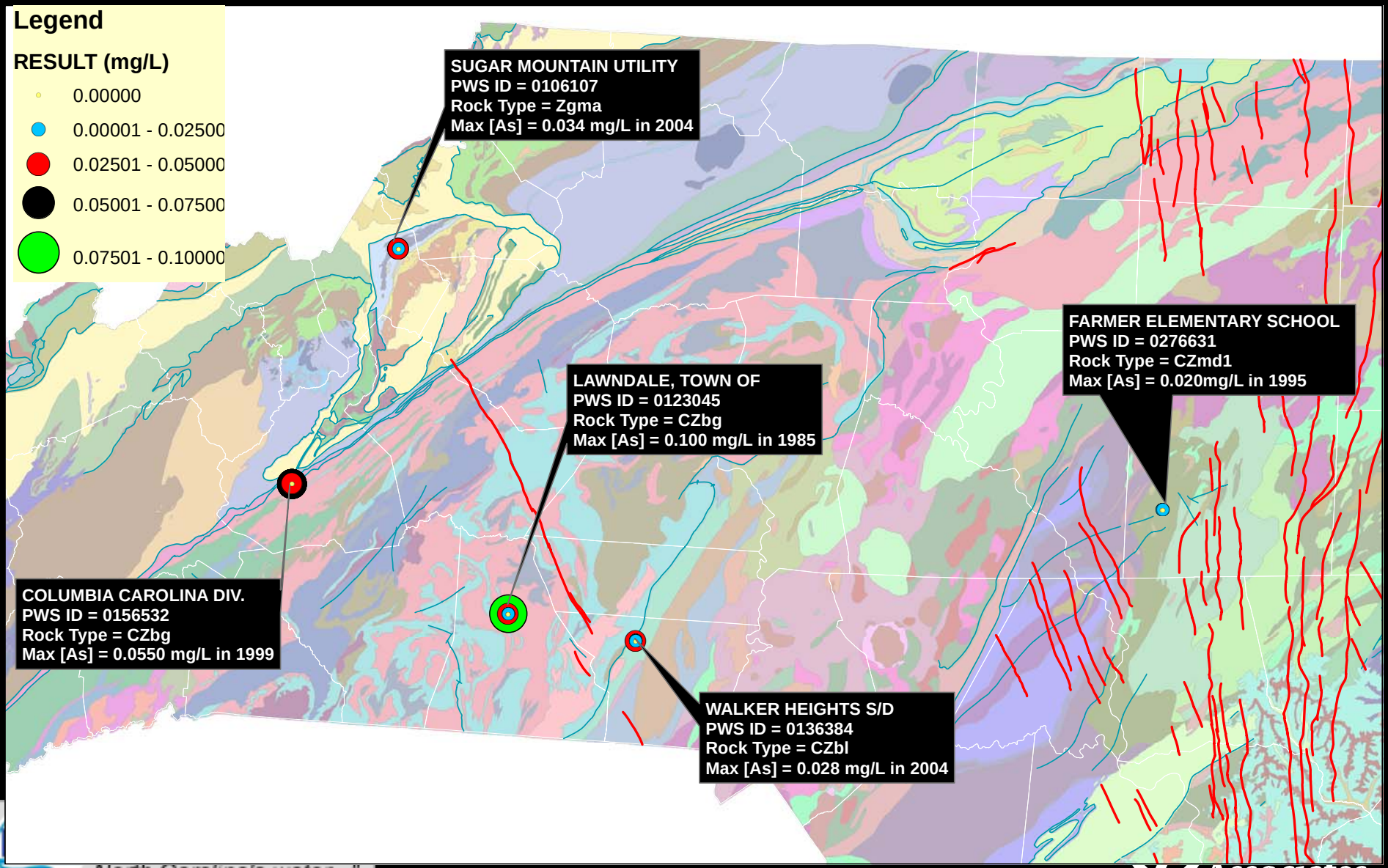
Public Wells vs. Private Wells

- Well characteristics: larger diameter (8”), greater yields, somewhat deeper
- Regulated by PWS if 15 or more connections (as of 2006 must meet MCL of 10 ppb, oversight of siting, operation, & sampling)
- Requires system design to meet daily flow requirements (400 gpd/house), results in much greater (15+times more) pumping
- Engineered design, water management plans and trained operators in some cases.

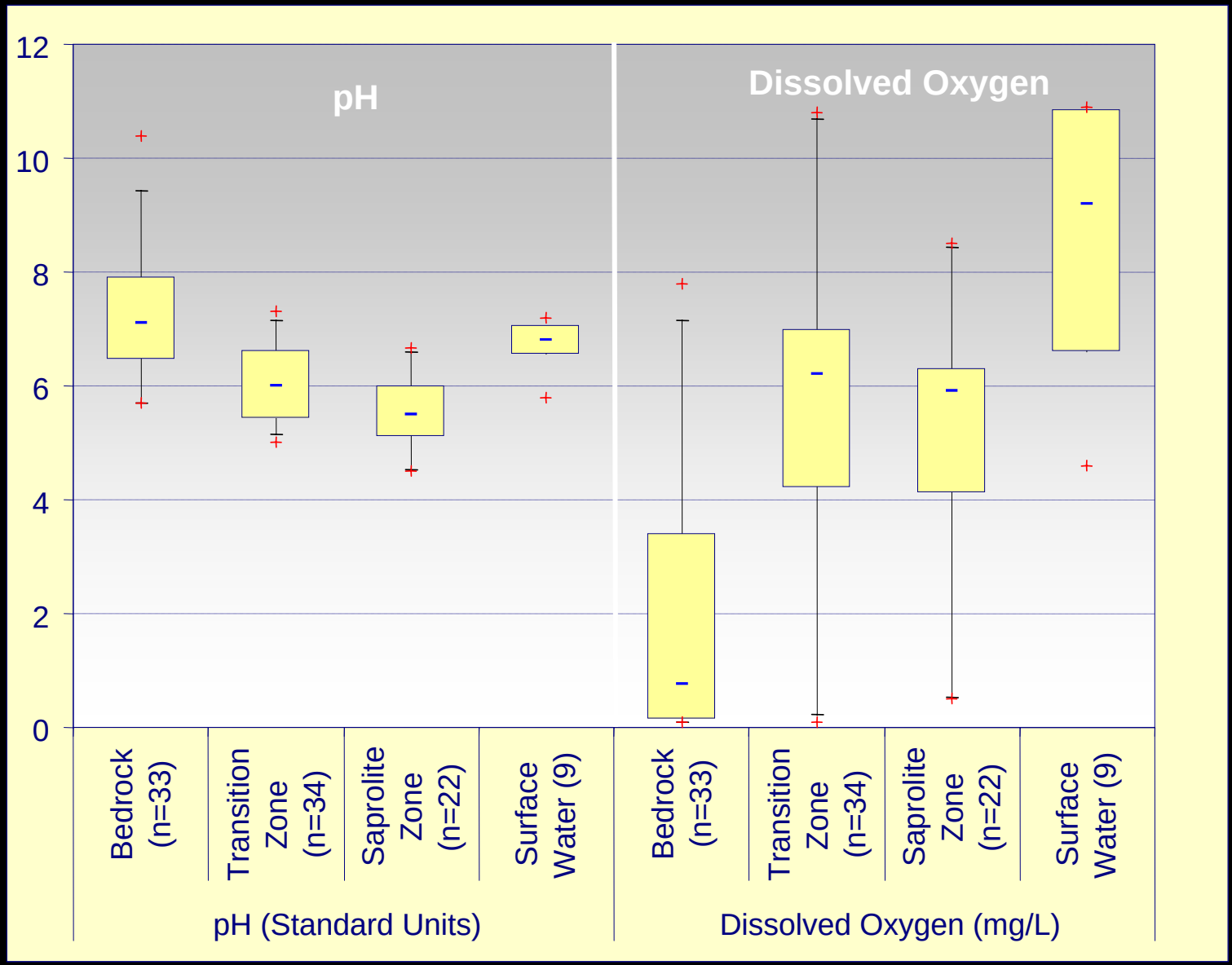
- Wells commonly 6” with lower yields, somewhat more shallow
- Low pumping rate (400 gpd)
- Generally not regulated
- Limited maintenance and sampling



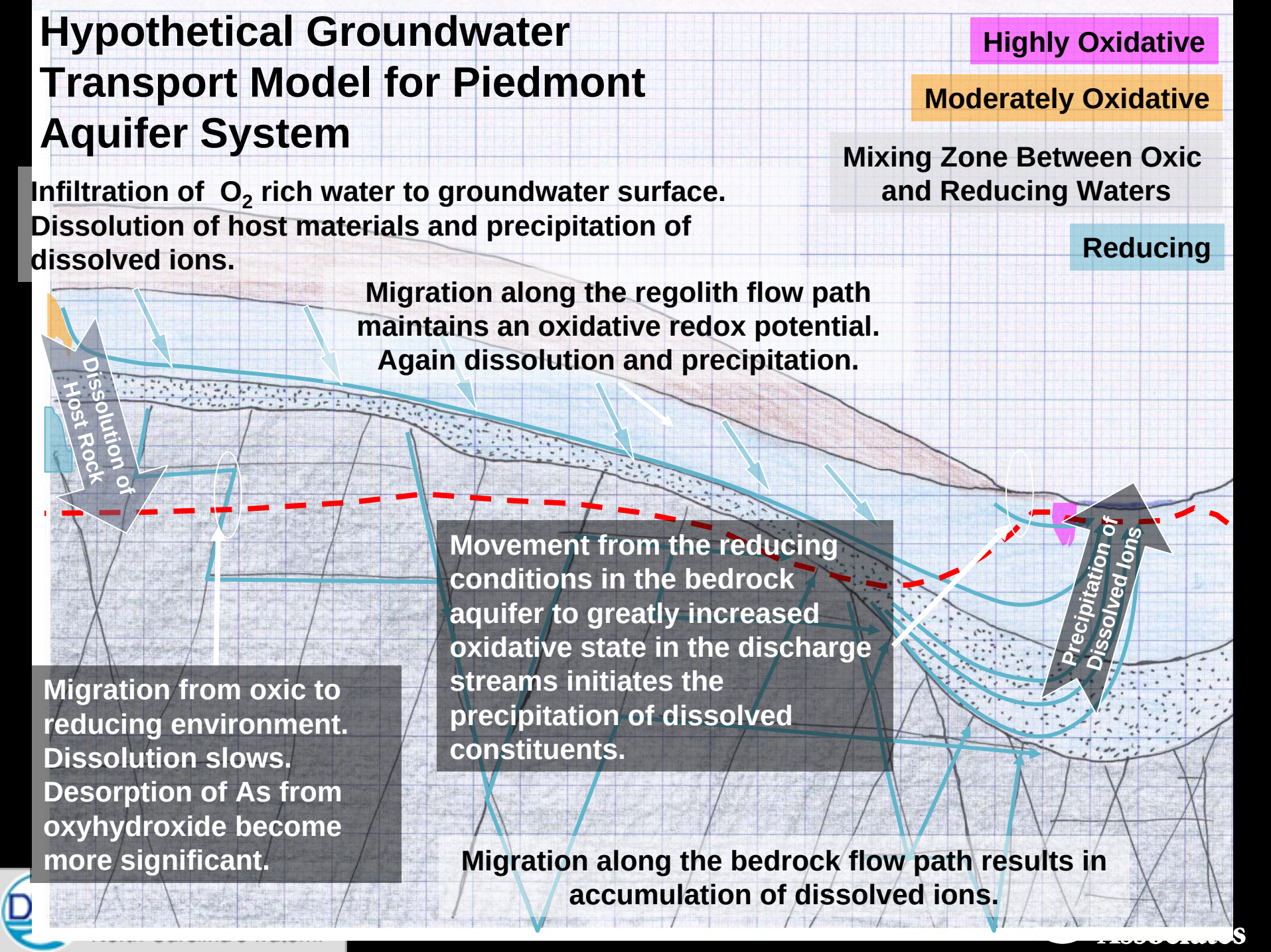
Map of PWS Wells Locations



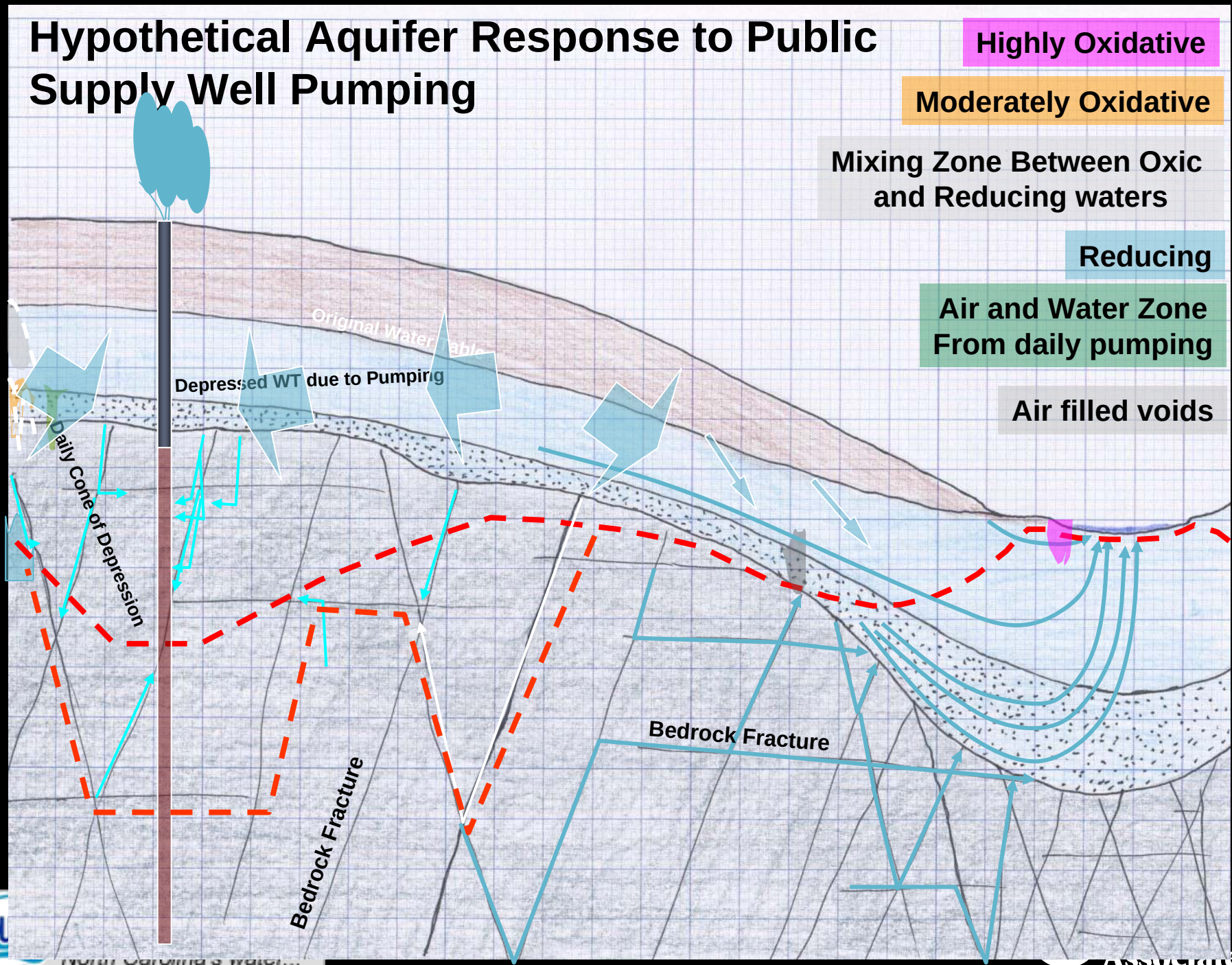
pH and Dissolved Oxygen Data from Four Hydrogeologic Characterization Sites Located in the NC Piedmont.



Hypothetical Groundwater Transport Model for Piedmont Aquifer System



Hypothetical Aquifer Response to Public Supply Well Pumping



Public Wells vs. Private Wells Dealing with Arsenic

- If >MCL, system forced to address problem by regulation
- Treatment can include blending multiple wells, taking problem wells offline, centralized treatment, well rehabilitation, and even drilling more wells to have less connections to avoid regulation
- Sometimes similar treatment strategies, but public systems have more resources for analysis of problems, enacting solutions, and maintenance.

- Private well owner's choice to treat or not
- Little guidance available
- Treatment often based on financial ability and concern of well owner when trying to address tasteless, odorless contaminant, who's health impact may be years to decades away
- POE/POU treatment systems often complex to well owner
- Treatment systems get little maintenance

Lots of variables, but maybe the hydrogeology also helps explain some of the attenuation

Conclusion

- Based on data review, public and private well systems behave differently with respect to arsenic concentrations
  - Private wells show some variability, but have relatively consistent concentrations over time
  - Public well concentrations tend to attenuate over time
- Many factors are potentially involved to explain these differences, including possible alteration of the in situ geochemical environment
- Widespread exposure to arsenic via private wells in North Carolina demands further investigation of geochemical mechanisms associated with arsenic release and possible attenuation and treatment