

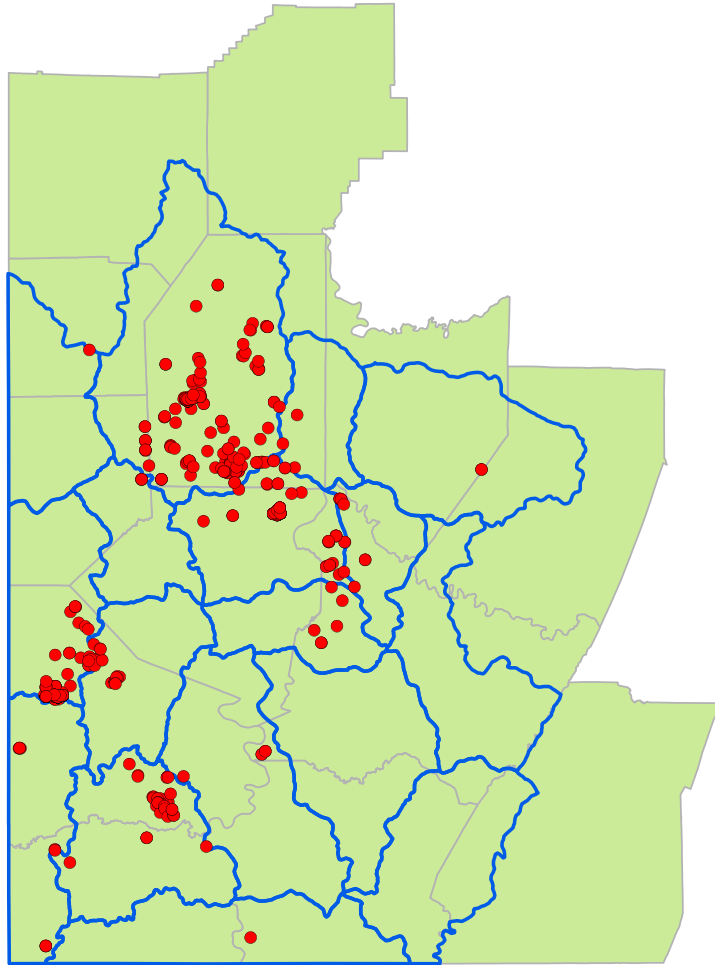
Assessing Well Water Quality in Southwestern Pennsylvania

John F. Stolz



Duquesne University



Well Water Survey in the Southwestern Pennsylvania Basin



<u>County</u>	<u># of Samples</u>
Butler	289
Washington	257
Allegheny	65
Westmoreland	42
Beaver	12
Greene	11
Fayette	7
Lawrence	4
Armstrong	2
Jefferson	1

● Water Quality Samples  Watersheds of Interest  Pennsylvania Counties selection

0 5 10 20 30 40
Miles

The survey questionnaire consisted of six questions

Do you have well water and where is your well located?

What kind of well is it (e.g. artesian, rotary, cable tool)?

Do you know how deep the well is and have you noticed a change in your well depth?

Have you noticed any change in water quality (taste, smell, color) and if so when?

Have you noticed any change in the water flow or quantity?

Have you had the water tested and would you be willing to share those results?

Water Analyses:

Taps preflushed

Sterile 1 L French square bottles

Sterile 60 ml French square bottles with nitric acid

YSI – on site temperature, DO, pH, specific conductivity

**IC – Bromide, Chloride, Fluoride, Phosphate, Nitrate,
Nitrite, Sulfate (Arsenate, Arsenite)**

ICP-MS – EPA 200.8

(ICP-OES – EPA 200.8)

**Field Analysis
(YSI Multi-meter)**

Temperature
Dissolved Oxygen
pH
Pressure
Specific Conductance
Conductance
Total Dissolved Solids
*calculated from SpC

**Anions
(Ion Chromatography)**

Fluoride
Chloride
Nitrite
Bromide
Nitrate
Phosphosphate
Sulfate

**VOC Analysis
(VaporTech Inc.)**

Methane
Ethane
Ethene
Propane
Propylene
Butane

**Cations
(ICP-MS – U.Pitt)**

Lithium (Li)
Boron (B)
Sodium (Na)
Magnesium (Mg)
Aluminum (Al)
Silicon (Si)
Phosphorus (P)
Potassium (K)
Calcium (Ca)
Titanium (Ti)
Vanadium (V)
Chromium (Cr)
Manganese (Mn)
Iron (Fe)
Cobalt (Co)
Nickel (Ni)
Copper (Cu)
Zinc (Zn)
Arsenic (As)
Selenium (Se)
Rubidium (Rb)
Strontium (Sr)
Molybdenum (Mo)
Silver (Ag)
Cadmium (Cd)
Tin (Sn)
Antimony (Sb)
Barium (Ba)
Tungsten (W)
Lead (Pb)
Uranium (U)

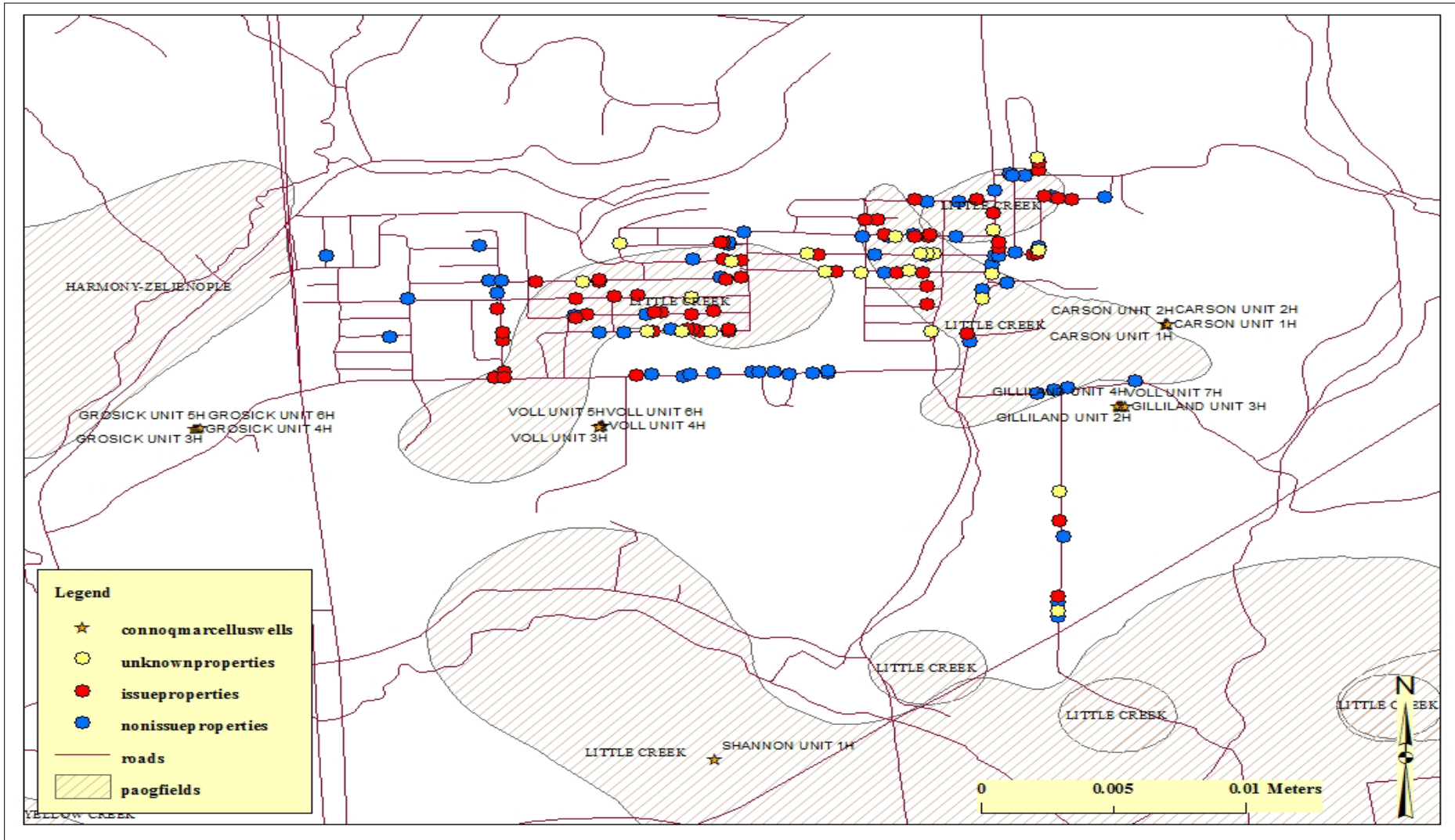
Mapping (GIS)

ArcGIS
PA DEP File Review
PASDA



The Set Up For Field Analysis: YSI, GPS, Cooler, Vials

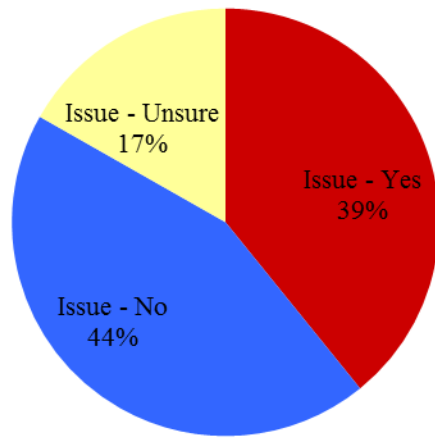
Survey Results For Butler County Community



~500 abandoned wells (Lytle 1976),
Conventional activity as late as 1985

Grey areas are gas fields

Households with Quality and/or Quantity Issues



143 households surveyed

33 households sampled

57 samples analyzed

Findings:

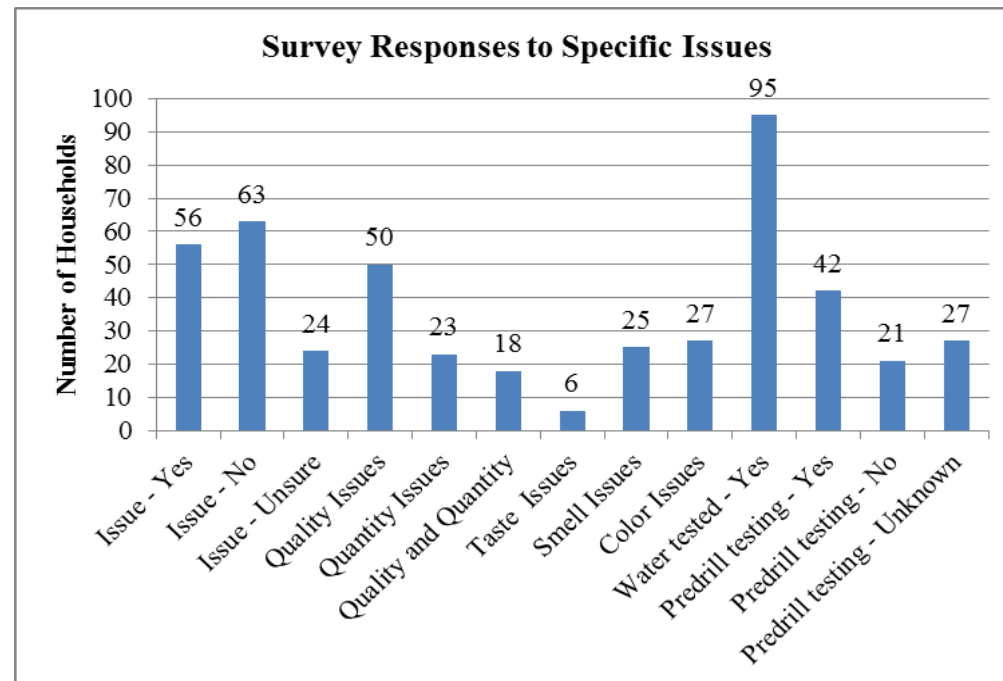
56 respondents indicated changes in water quality or quantity

Color and smell most common

25 homes with Manganese above SMCL

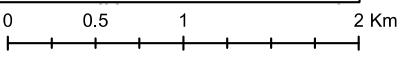
Only 2 homes with total coliforms,
1 home with both TC and *E.coli*

Contamination included Na, Ca, Mg, Sr, Ba, Cl, Br, Fe, Mn, and methane

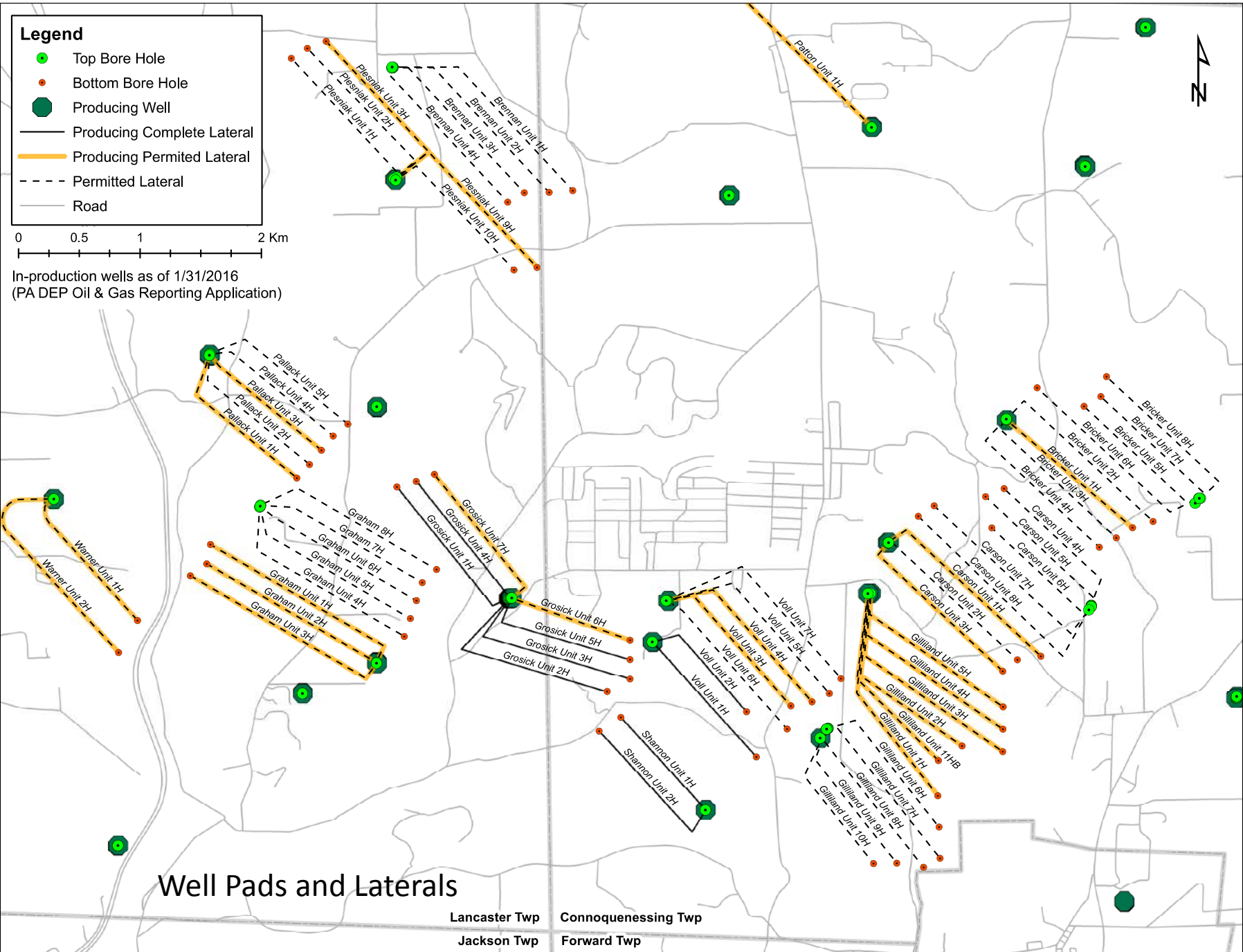


Legend

- Top Bore Hole
- Bottom Bore Hole
- Producing Well
- Producing Complete Lateral
- Producing Permitted Lateral
- - - Permitted Lateral
- Road



In-production wells as of 1/31/2016
(PA DEP Oil & Gas Reporting Application)



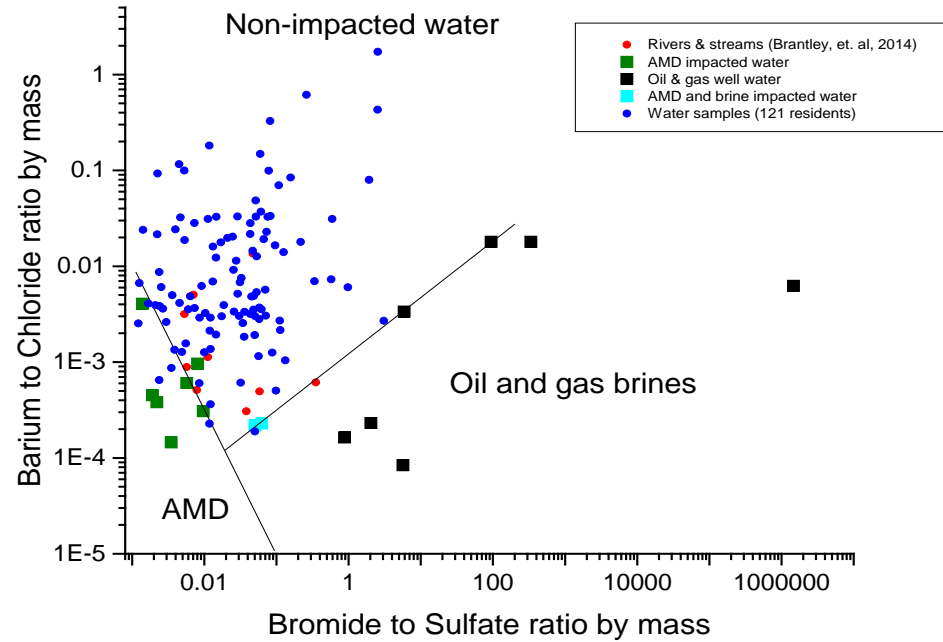
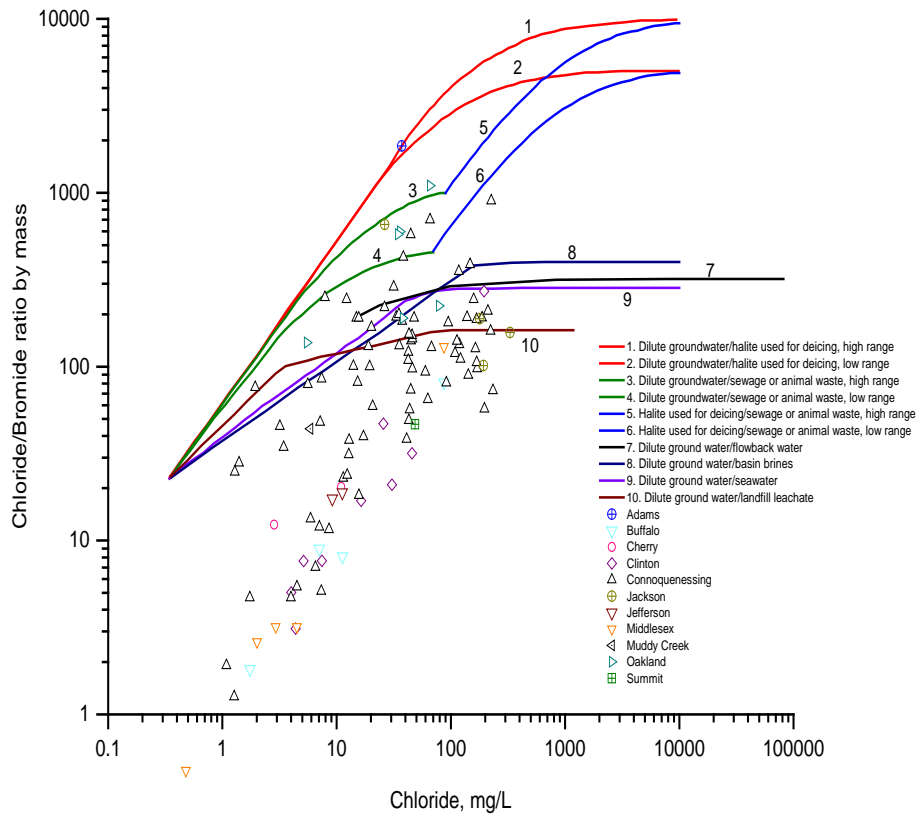
Well Pads and Laterals

Lancaster Twp Connoquenessing Twp
Jackson Twp Forward Twp

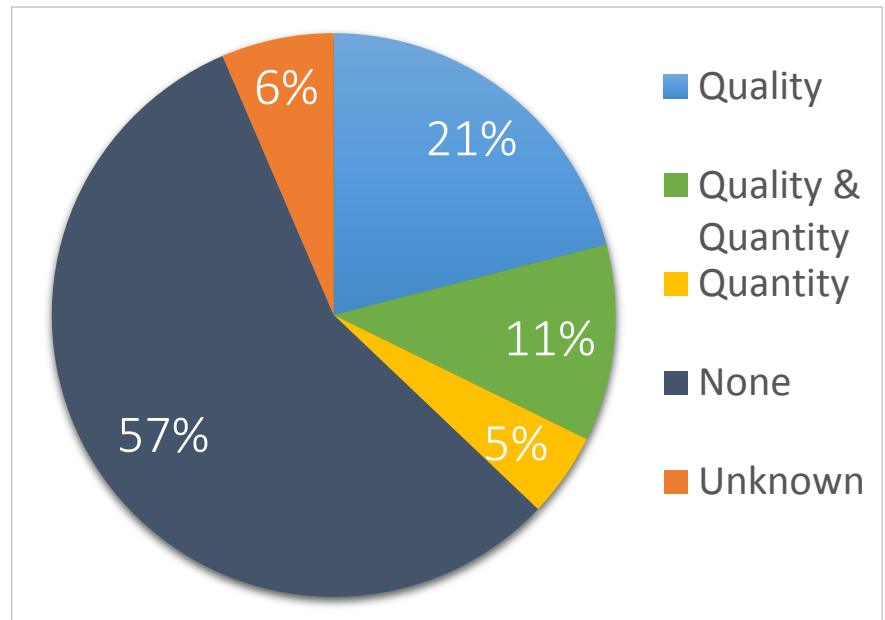
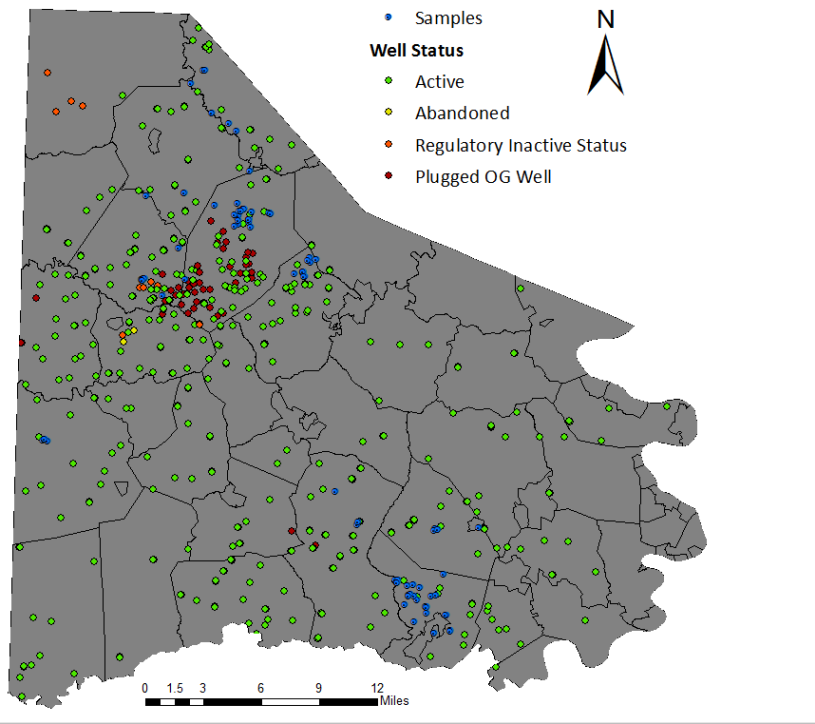
Conclusions from Butler Community Study

1. Survey indicate 56 out of 143 with issues
2. 25 homes with manganese in excess of SMCL
3. Light hydrocarbons in some wells (3 of 6 tested)
4. Well depths ranged from 60 – 900 ft
5. Extended monitoring of 2 wells ~670' apart but different depths are not “connected”
6. Legacy activities include shallow gas and oil wells, strip mining (AMD)
7. 12 pads and 34 laterals within 2 mile radius since 2009
8. Wells stimulated with 3-6.2 million gallons of fluids and 2-4 million tons of proppant
9. PA DEP file review show violations including failed casings

Combined Data Set for Butler County – 2012-15

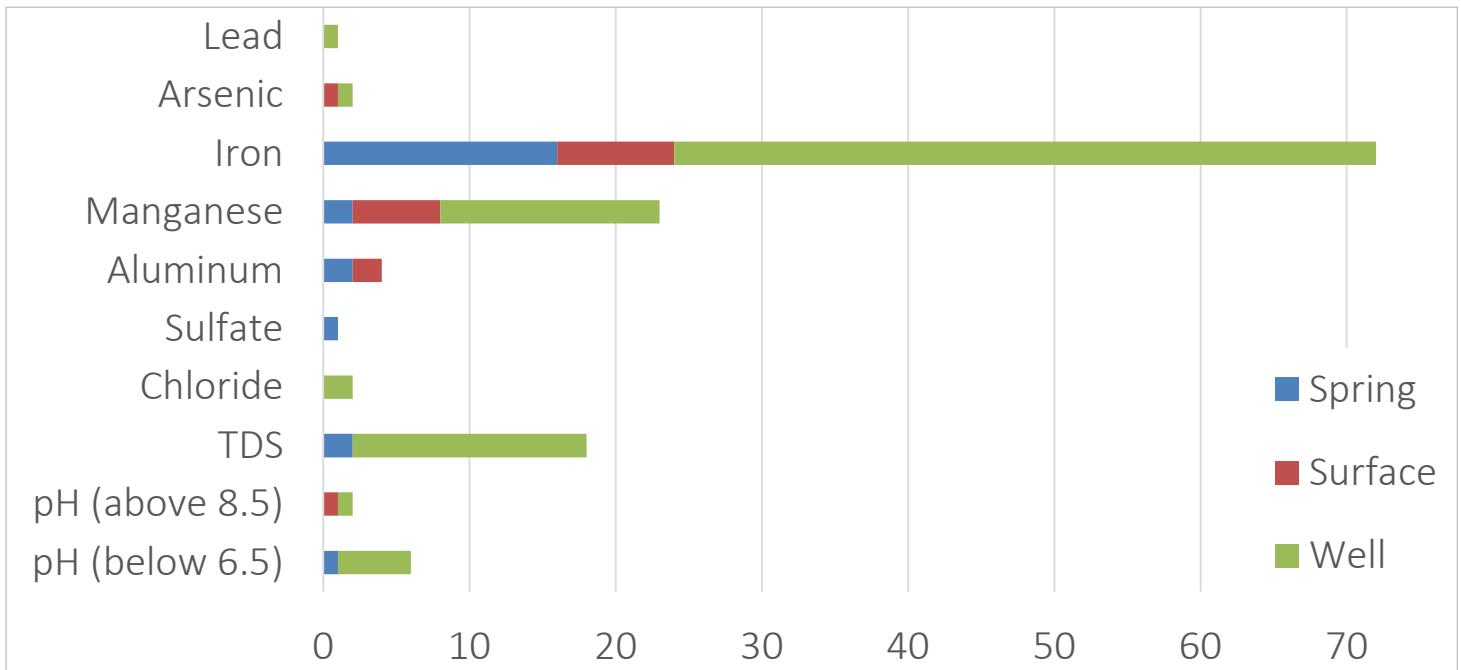


S. Mayes

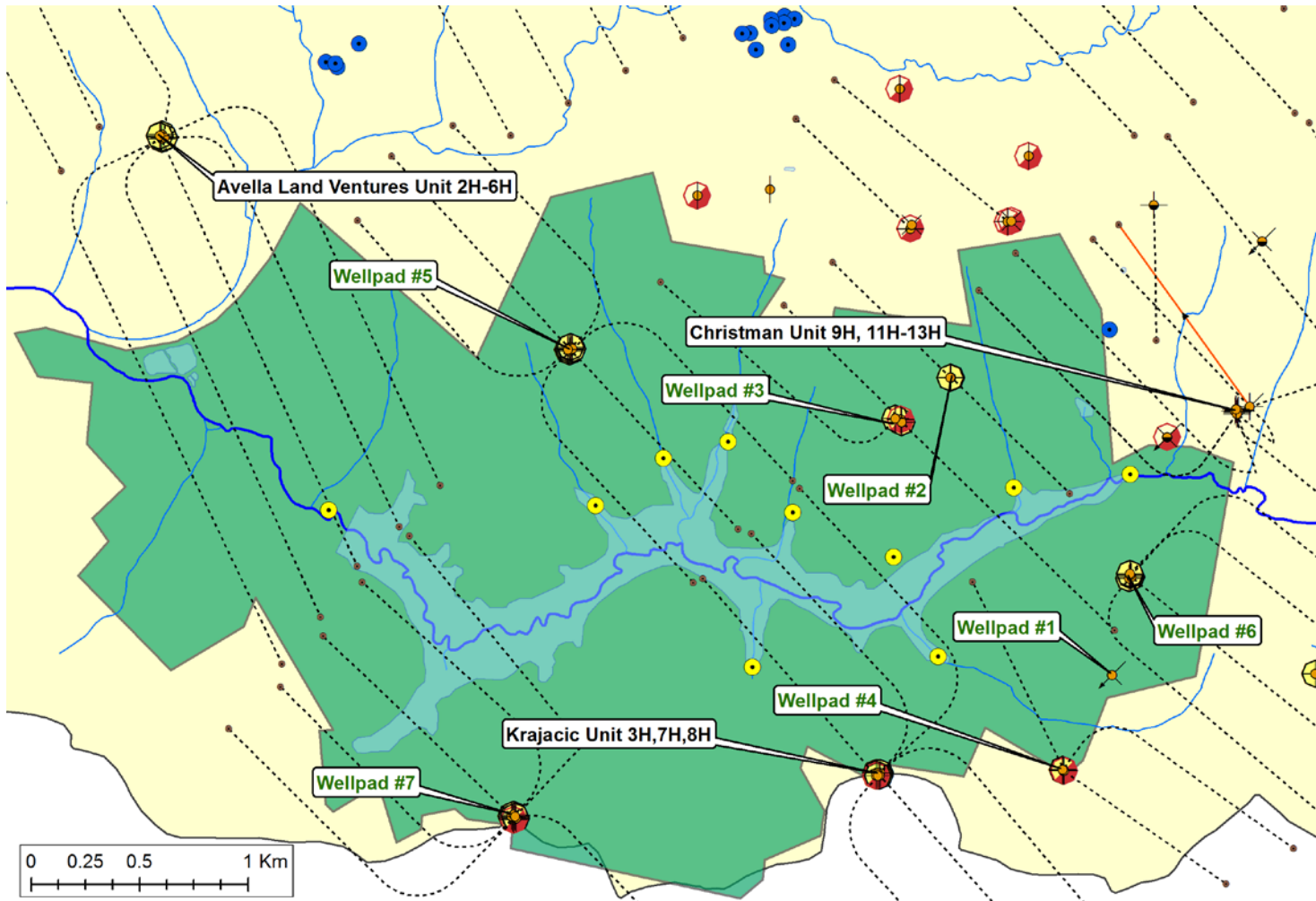


Washington County

99 homes surveyed



Cross Creek County Park – Washington County

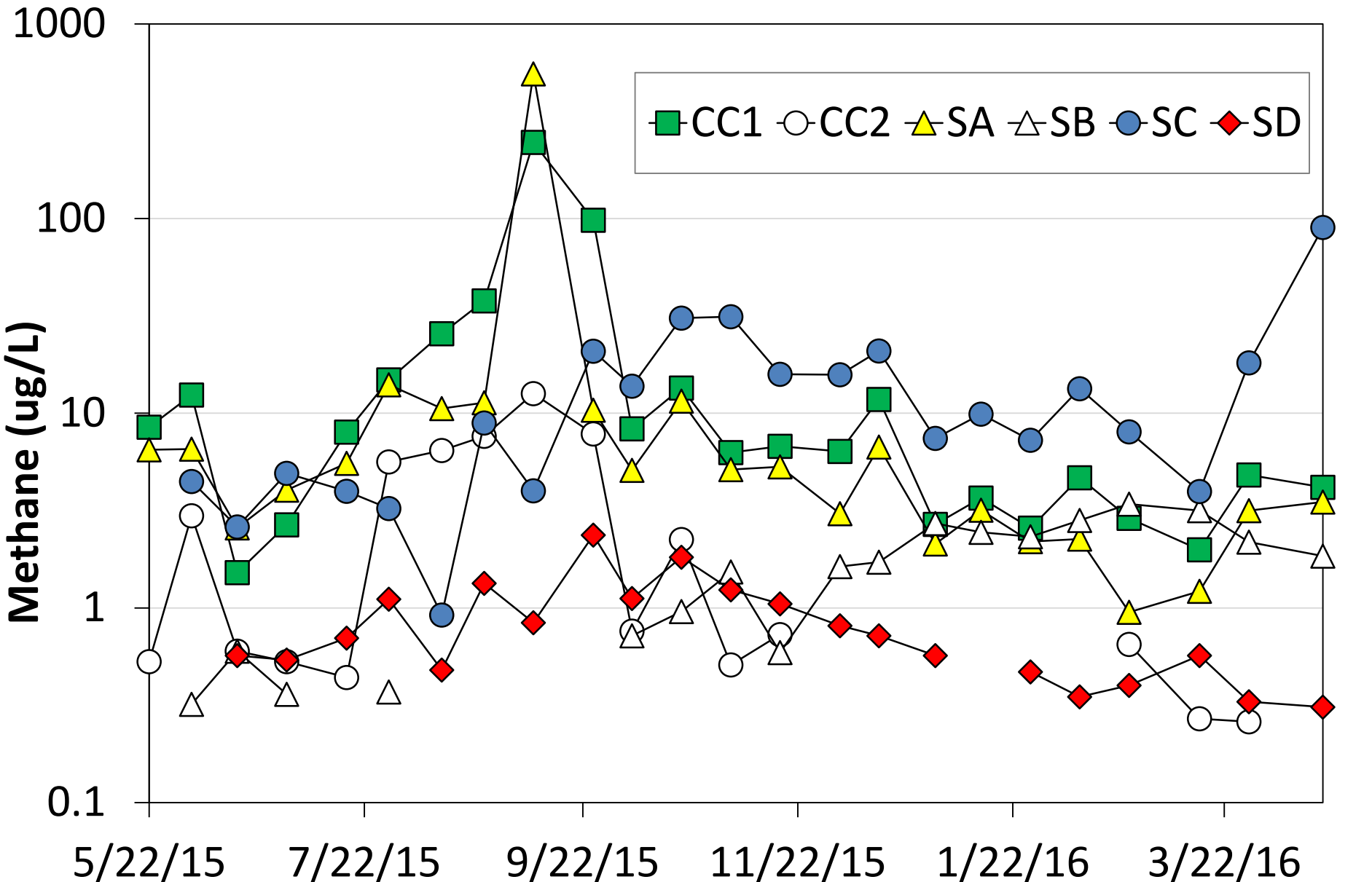


Legend Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet

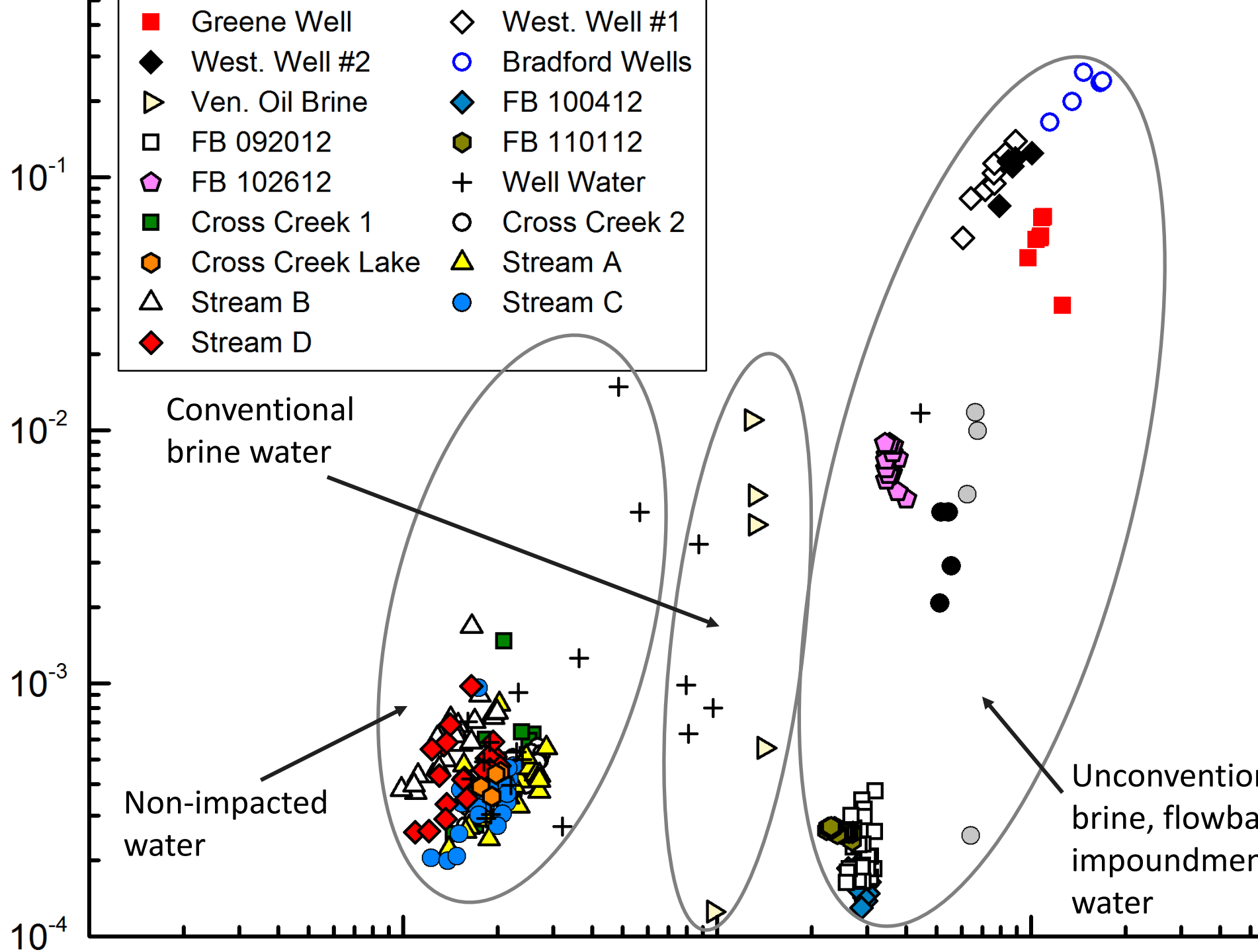
- | | | | |
|-------------------------|-------------------------|--------------------|----------------|
| ● Active Oil/Gas H-W | ● Active Oil/Gas V-W | ● Bottom Bore Hole | — Cross Creek |
| ● Plugged Oil/Gas H-W | ● Plugged Oil/Gas V-W | ● Producing Well | — Other Stream |
| ● Active Gas H-W | ● Active Gas V-W | ● Violation | ■ Waterbody |
| ● Unknown Gas H-W | ● Plugged Gas V-W | --- Active Lateral | ■ AML |
| ● Plugged Gas H-W | ● Reg. Inactive Gas V-W | — Plugged Lateral | ■ CCCP |
| ● Reg. Inactive Gas H-W | ▲ Compressor Station | — Road | ■ CCW |

- List of Abbreviations**
- (AML) Abandoned Mine Lands
 - (CCW) Cross Creek Watershed
 - (CCCP) Cross Creek County Park
 - (H-W) Horizontal Well
 - (V-W) Vertical Well

Methane levels at the 5 Sites at Cross Creek Lake



T Umstead





092012-015

092012-001

092012-002

092012-007

092012-014

092012-02A

Distinct

Conductivity ($\mu\text{S}/\text{cm}^3$), pH, and anion data (mg/L), for flowback, impoundment water, coal mine effluent, freshwater stream samples, conventional, and unconventional oil well brine.

	Flowback Water			Impoundment Water		Coal Mine Effluent		Freshwater Stream	
	FB 092012	FB 102612	FB 110112	IMP1	IMP2	MDG	WP	Fonner Run	Bates Fork
Spec. Cond.	15,270	8,380	5,200	102,860	61,480	6,400	3,250	387	476
pH	11.9	4.5	7.7	5.4	5.7	7.5	6.6	7.5	7.5
Fluoride	BDL	BDL	BDL	BDL	BDL	BDL	0.03	0.06	0.05
Chloride	68.5	4,541	242	30,700	27,700	1,240	545	1.3	6.00
Nitrite	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Bromide	20.5	31.5	6.5	255	226	14.25	0.05	BDL	BDL
Nitrate	BDL	BDL	BDL	BDL	BDL	1.8	0.4	0.1	0.5
Sulfate	460	11	531	8.6	10.2	3,830	350	25.1	24.5

	Conventional oil well brine				
	KM6	KM10Q	KM14Q	KM41	KMWB6
Specific Conductance	95,600	74,300	81,850	120,500	38,500
pH (1:10)	6.5	6.6	6.9	6.7	6.8
Fluoride	BDL	BDL	BDL	BDL	BDL
Chloride	37,586	33,583	27,344	34,862	17,548
Nitrite	BDL	BDL	BDL	BDL	BDL
Bromide	744	543	363	575	178
Nitrate	BDL	BDL	BDL	BDL	BDL
Sulfate	84	BDL	BDL	BDL	195

	Unconventional oil well brine			
	PW 092012	PW 100412	PW 102612	PW 110112
Specific Conductance	97,763	95,292	183,385	110,857
pH	6.9	6.6	6.6	6.7
Fluoride	BDL	BDL	BDL	BDL
Chloride	96,939	93,857	88,490	134,312
Nitrite	BDL	BDL	BDL	BDL
Bromide	439	183	927	329
Nitrate	BDL	BDL	BDL	BDL
Sulfate	568	791	3.3	692

BDL - below detection limit



Biogas: methanogenesis from food waste, agriculture (beef cattle, dairy, chicken, swine), human.

2-8 Tcf annually from just cow and pig waste

Conclusions

- 1) Water quality in wells in Southwestern Pennsylvania were assessed using a home owner survey, water sample analyses (e.g., anions, cations, light weight hydrocarbons), PA DEP file reviews, and GIS mapping (including legacy activity).
- 1) Flowback and produced water from unconventional gas wells, produced water from conventional oil wells, coal mine effluent, and fresh water streams and lakes, were also collected and analyzed.
- 2) Results from the more than 750 well and surface water samples analyzed over the past five years indicate that there is high quality source water in Southwestern PA.
- 3) Iron and manganese, however, were the most common contaminants of concern.
- 4) Cl^-/Br^- to Cl and $\text{SO}_4^{2-}/\text{Cl}^-$ to Br^- molar ratio analyses in particular, were found to be quite informative as they revealed discernible differences between the different sources.
- 5) Current extractive activities (conventional and unconventional gas) can exacerbate legacy issues as well as present new challenges to drinking water sources.

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