

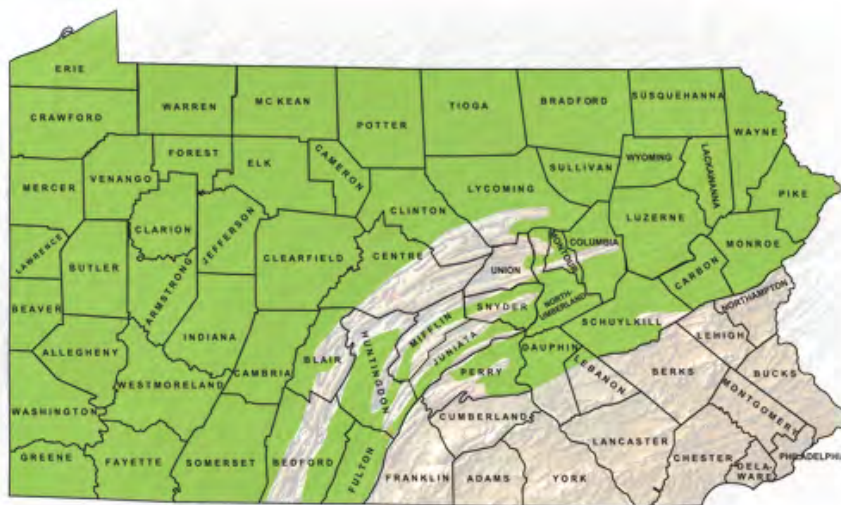
Getting The Waters Tested The Marcellus Shale Factor



Water Resources



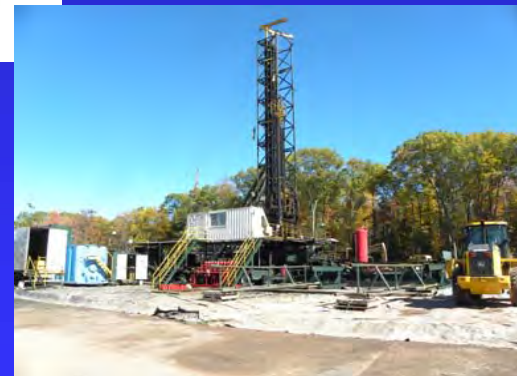
Environment



Marcellus Shale Formation



Old Issues



New Issues



Presented by:

Mr. Brian Oram, Professional Geologist (PG),
Soil Scientist, Licensed Well Driller, IGSHPA

B.F. Environmental Consultants Inc.

<http://www.bfenvironmental.com>

And

Water Research Center

<http://www.water-research.net>





B.F. Environmental Consultants Inc.



- Professional Consulting Services in the areas of water quality, soils, stormwater, geology, aquifer analysis, and land-development.
- Baseline – Chain-of-Custody
- Expert Testimony
- Water Treatment Process/ Product Development
- <http://www.bfenvironmental.com>

B.F. Environmental Consultants Inc.

Environmental Scientists, Hydrogeologists, & Environmental Education Specialists
Located in Northeastern Pennsylvania

water reuse

hydrogeology

soil testing

Water-Research Center

Education and Outreach Program funded by
B.F. Environmental Consultants Inc.



Outreach Programs

- Environmental and Professional Education and Training for Citizens and Local Municipalities
- Water Quality Help Guides – Information Library
- Community and Business Outreach Programs
- Low Cost – Informational Water Testing Program with National Laboratory
- Citizen Monitoring Programs

Website: <http://www.water-research.net>

Target Audience

- Stakeholders
- Community Advocates and Scientists
- Municipal and Local Officials
- Water Supplies and State Regulators

What is the Marcellus Shale Factor?

- We have been educating private wellowners for 20+ years- but it was difficult to get citizens to test their well water. It looks clear – I am not sick – It is fine.
- The Marcellus Shale Factor – Baseline Testing for Natural Gas Development is conducting Testing and Citizens are be told they have a Problem NOW.
- Based on Private Well Construction and Placement - Some Private Wells may be the pathways for Contamination.
- **WE NEED TO PROTECT OUR SOURCE WATER- not just from Marcellus Shale Development and other hazards, but from “us” and our past.**
- **How do we track an unregulated activity – such as: Private Wells and Identify Zones or Areas that are Vulnerable to Contamination.**
- **This lead to the idea for creating the Citizen Groundwater / Surfacewater Database**

WE Support the Citizen Groundwater Database at
Wilkes University !



Goals

- Private Well Water Quality for the Region
- Existing Problems in Region
- Brief Introduction to Marcellus Shale and Importance of Proper Well Construction
- Review of Hydraulic Fracturing
- The Citizen Groundwater Database
- Well Monitoring and Purging
- Chain-of-Custody
- Baseline Testing – What Parameters?
- Educating the Community



Private Wells/ Water Systems in Pennsylvania



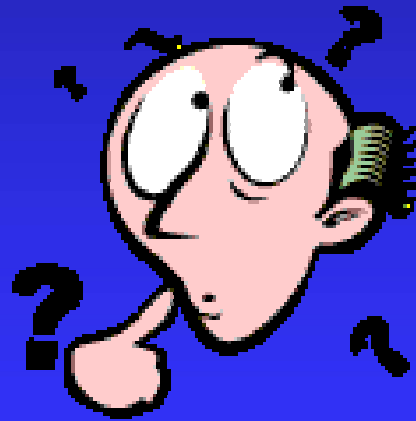
What ?



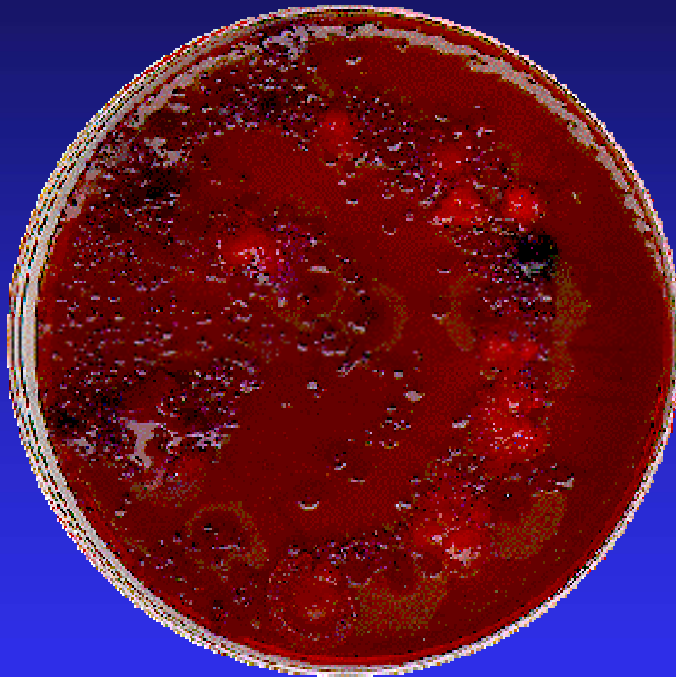
County	# of homes served by private water systems			Avg. Change in homes served by private water systems per year	% of all homes served by public water	% of all homes served by private water system
	1980	1990	2000			
Bradford	13,443	16,865	20,287	+342	37	63
Carbon	6,594	12,235	17,876	+564	55	45
Lackawanna	9,952	12,745	15,538	+279	86	14
Luzerne	19,994	24,662	29,330	+467	82	18
Monroe	21,129	37,246	53,363	+1612	32	68
Pike	9,441	16,875	24,309	+743	45	55
Sullivan	2,147	4,727	7,307	+258	13	87
Susquehanna	9,423	15,212	21,001	+579	25	75
Tioga	9,126	11,888	14,650	+276	35	65
Wayne	9,913	19,097	28,281	+918	33	67
Wyoming	7,236	8,657	10,078	+142	27	73
Region	118,398	180,209	242,020	+562	43	57

Our Groundwater is Pure and
Regulated?

Information We Know Without
Compiling the Baseline Water
Quality Data



Based on the geology of the NEPA and my 20 years experience, the **common** water quality problems are as follows:



Corrosive Water

Low pH

Soft Water (low hardness) to
Moderate Hardness

Iron and Manganese

Discolored Water – Reddish
to Brown Tints

Total Coliform Bacteria

Sulfur Odors and
Methane- Biogenic Gas
(Tends to be < 10 mg/L)

Radon Gas

Contamination by VOCs, SOCs,
Glycols, Saline Water (< 3 %), and Radionuclides
are NOT COMMON!

This is Drinking Water in PA?



Corrosion



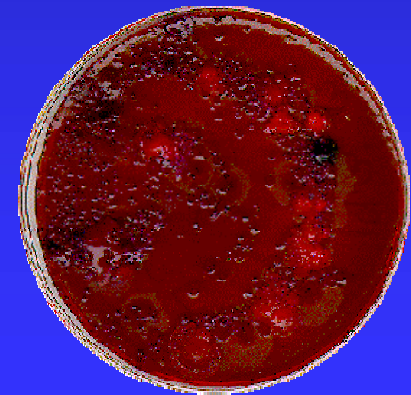
Iron / Manganese



Sediment / Gases



Bacteria





Drinking Water Regulations

The Safe Drinking Water Act (SDWA), passed in 1974 and amended in 1986 and 1996, gives the Environmental Protection Agency (EPA) the authority to set drinking water standards.

These standards are divided into two broad categories: Primary Standards (NPDWR) and Secondary Standards (NSDWR).

Primary Standards (NPDWR)

National Primary Drinking Water Regulations

Primary standards protect drinking water quality by limiting the levels of specific contaminants that can adversely affect public health and are known or anticipated to occur in water. They take the form of Maximum Contaminant Levels or Treatment Techniques.

There are over 100 chemical and biological primary drinking water standards, which include: trace metals, disinfection agents, disinfection by-products, radiological, microbiological agents, and organic chemicals.

Examples: Arsenic, Lead, MTBE, total coliform, *Giardia*, Trihalomethanes, Asbestos, Copper, Benzene, Trichloroethane, etc.

Secondary Standards

National Secondary Drinking Water Regulations

These standards were established more for cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor or color) in drinking water.

The secondary standards include: aluminum, chloride, color, corrosivity, fluoride, foaming agents, iron, manganese, odor, pH, silver, sulfate, total dissolved solids, and zinc.

Private Wells Not Regulated

- Private Wells Are Not Regulated under Safe Drinking Water Act
 - ◆ EPA – NO
 - ◆ PADEP – NO
 - ◆ County – Very Few Counties in PA
 - ◆ Townships – some have basic ordinance on placement- some have comprehensive requirements

Most Townships Only Requirement

- Well is 100 feet from septic disposal area
- Well is 50 feet from septic tank
- Well is 10 feet from property
- That is ALL Folks !
- No Water Testing
- No Construction Requirements

Private Wells - The Facts

- Are they Regulated?
 - ◆ Not really – no state-wide construction standard
 - ◆ Not Classified as a Regulated Source
- Are they Permitted?
 - ◆ May be the Licensed Well Driller Submitted a Log
 - ◆ Maybe a permit issued at the local level
- Are they Tested?
 - ◆ Not required- Data not stored
- Do we know where they are located?
 - ◆ Maybe +/- a few hundred feet.
 - ◆ PaGWIS - PA Groundwater Information System

Factor - Private Wells / Landowners



1. Concerns about groundwater quality
2. Concerns related to surfacewater quality.
3. They have never tested the water
4. They had testing done, but no one explained the results.
5. There is no program to help fix existing problems.

Some Believe Their Water is PURE H₂O
- It is not.

Before Marcellus Shale Development

What was the Quality of Private Well Water?

A USGS survey found that 70% of private wells were contaminated. This contamination could result in acute or chronic health concerns (1996).

Testing Conducted under my supervision at Wilkes University in through out the United States indicates that 30 to over 50 % may be contaminated – Mostly by Total Coliform Bacteria (1989 – 2011).

PSU – Master Well Owner Network suggests that 33 to 50 % of Private Well Owners in PA may have some Form of contamination.

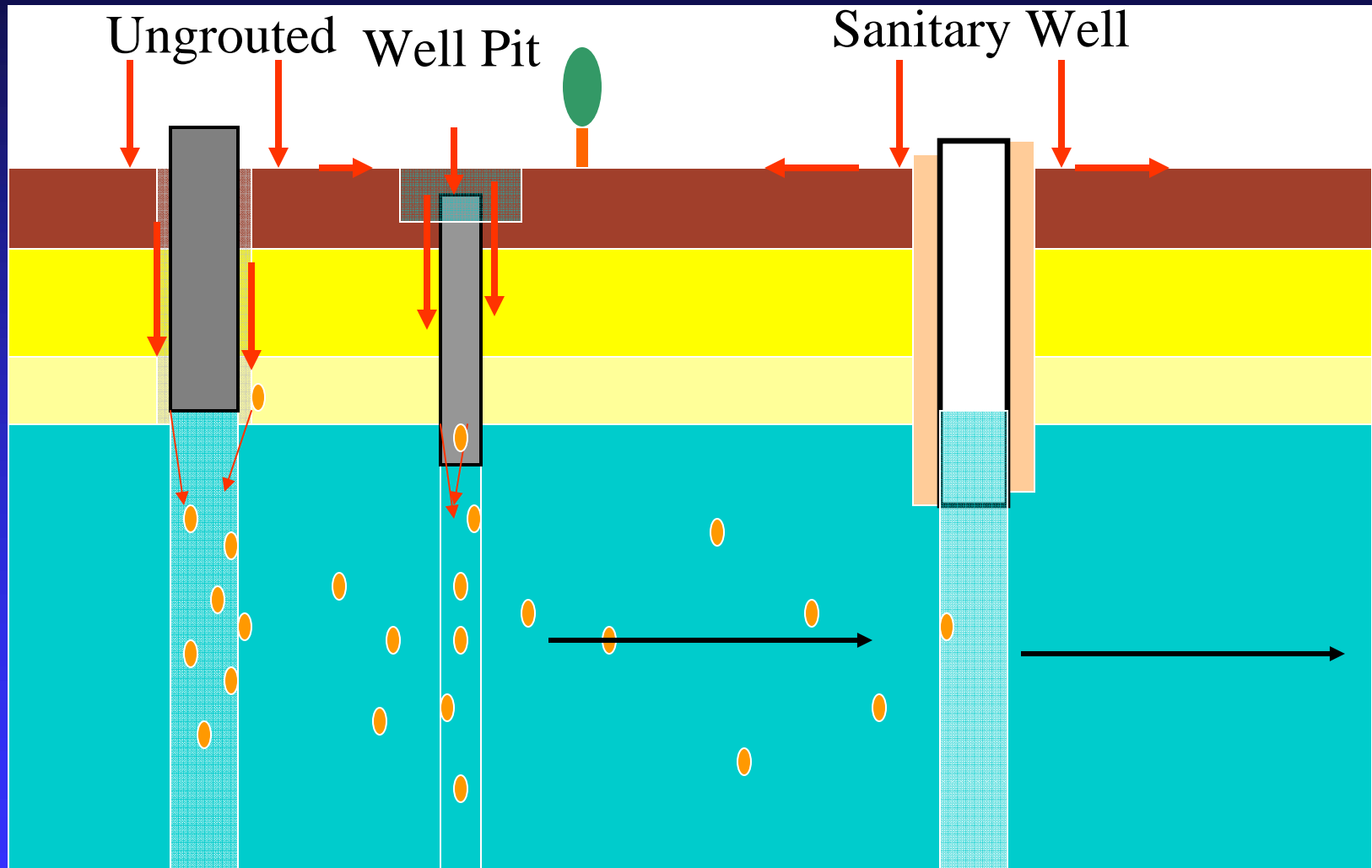
Most Contamination appears to be associated with Total Coliform Bacteria



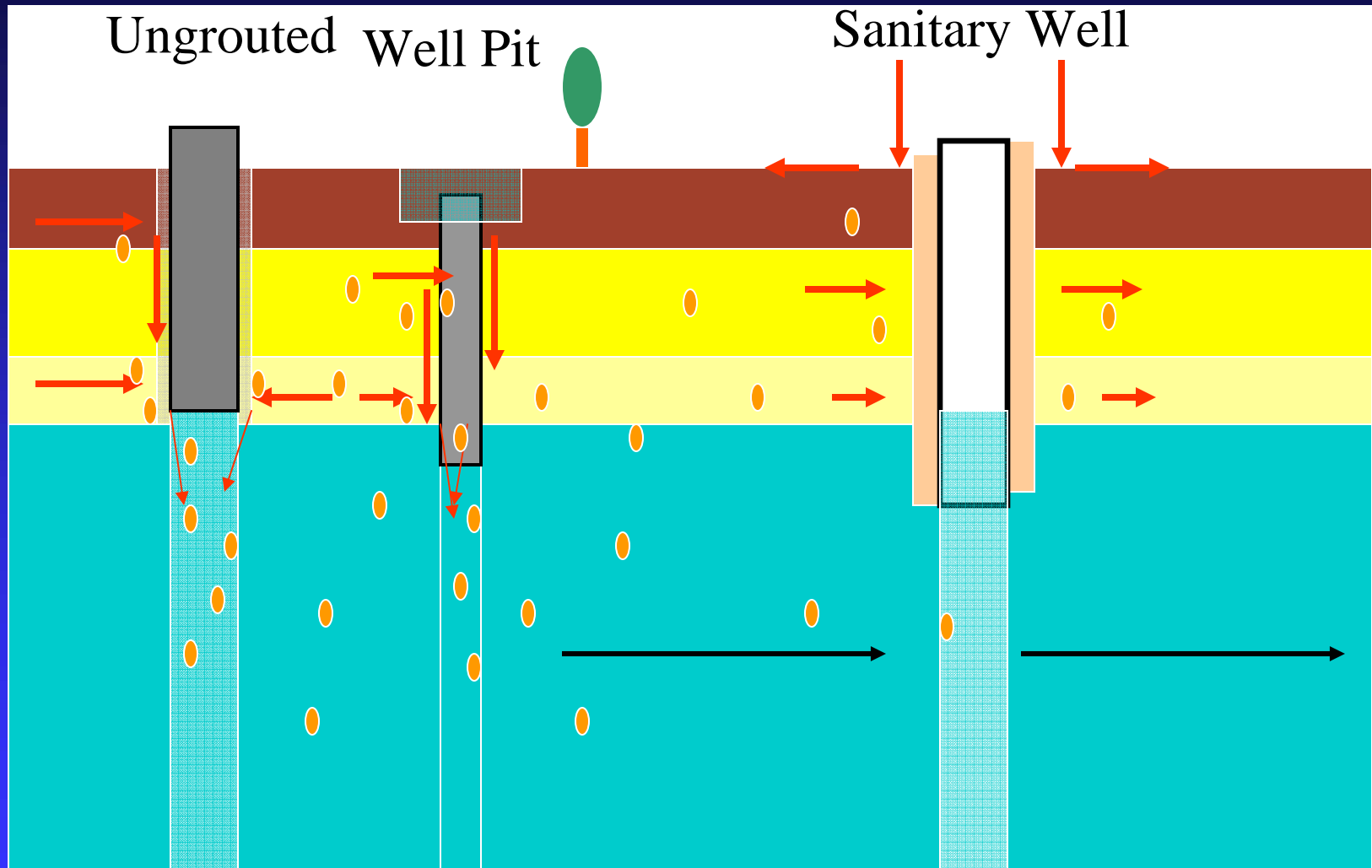
- Insects, Larvae and Nests / Egg Masses
- Mouse Colonies
- Snakes
- Beehives
- Mud - when casing to close to ground

Therefore – In some cases - the Private Wells are Facilitating Groundwater Contamination.

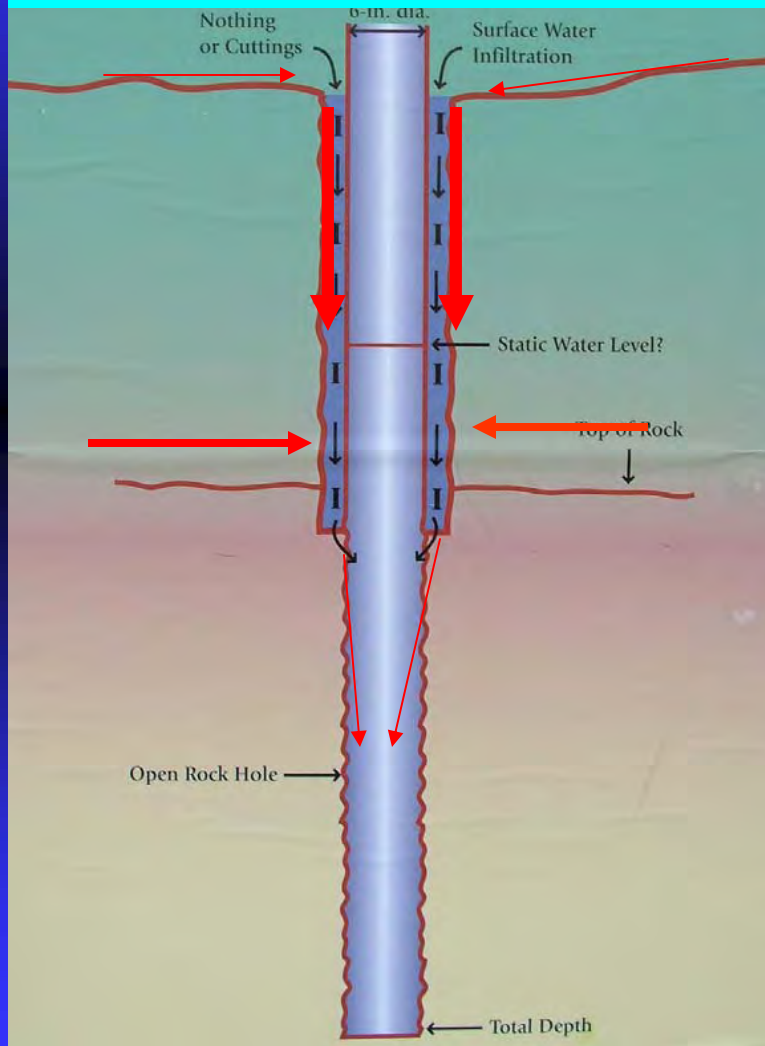
How Contaminants Can Get In to the Aquifer (Surface)



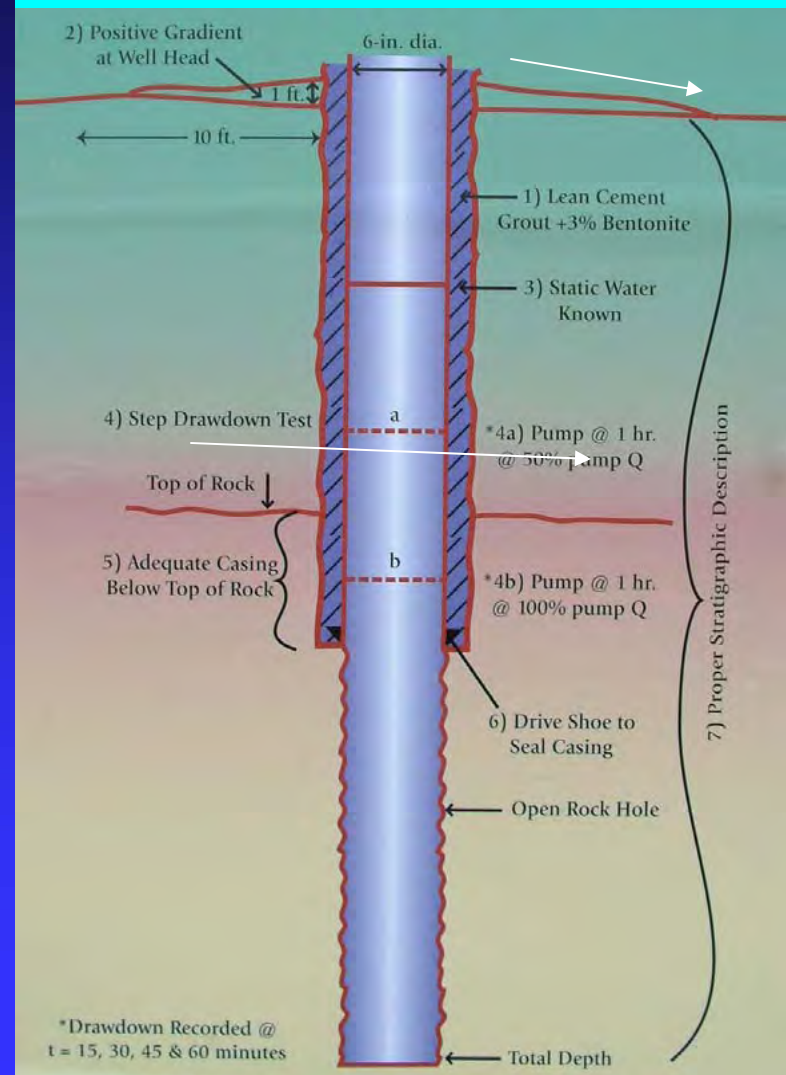
How Contaminants Can Get In to the Aquifer (Subsurface)



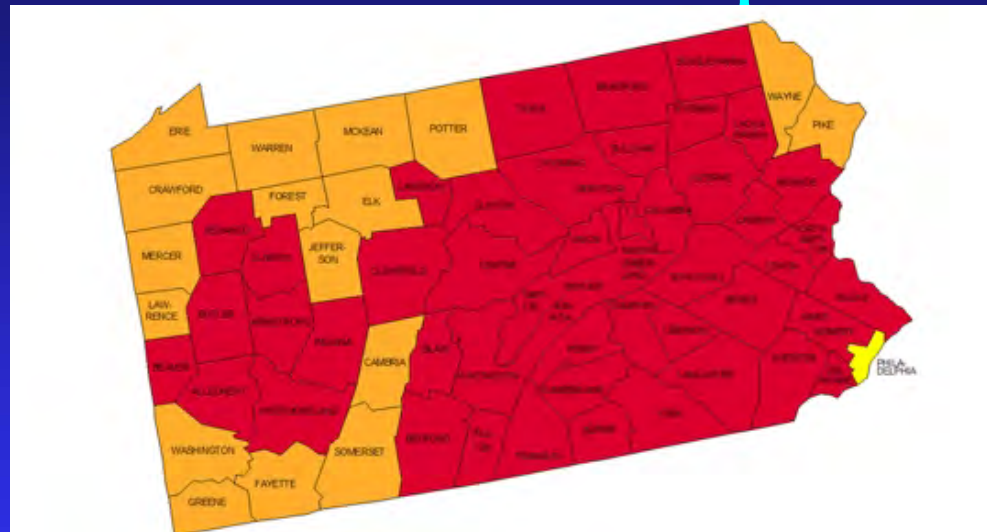
An UngROUTED Residential Well



A Properly Grouted Well



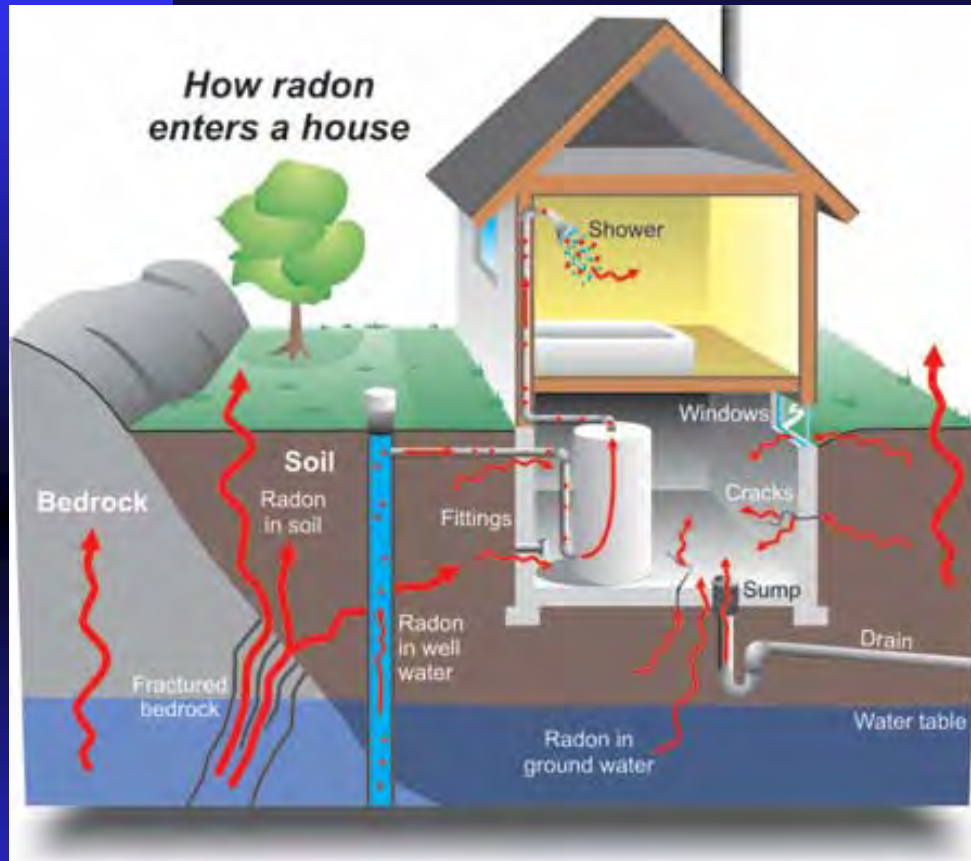
Radon (In Air)- PA Recommend < 4 pCi/L



Susquehanna County – 48 % < 2 pCi/L, but 31 % > 4 pCi/L

Bradford County – 38 % < 2 pCi/L, but 43 % > 4 pCi/L

Radon Exposure



Radon in Water – no Standard, but proposed range 300 to 4000 pCi/L

Recent testing in Susquehanna/ Luzerne County at 577 to 2200 pCi/L – 100% over 300 pCi/L

Recommendations

1. Test indoor radon in air levels.
2. If radon in air > 2 pCi/L- test the radon level in the water.
3. Add to Community Baseline Testing Program

Methane in Water

- Methane has been a hidden issue in NEPA.
- The gas is colorless, tasteless, and odorless and there are no known health effects.
- Potential concerns relate to flammability/explosiveness of gas.
- Background – appears to range from non-detect to over 20+ mg/L (highly variable) in Northeast Pennsylvania.
- I light my first well water sample in about 1989- thanks to methane gas.

Methane Gas



Video from Salt Springs State Park – Fall 2010, by Brian Oram

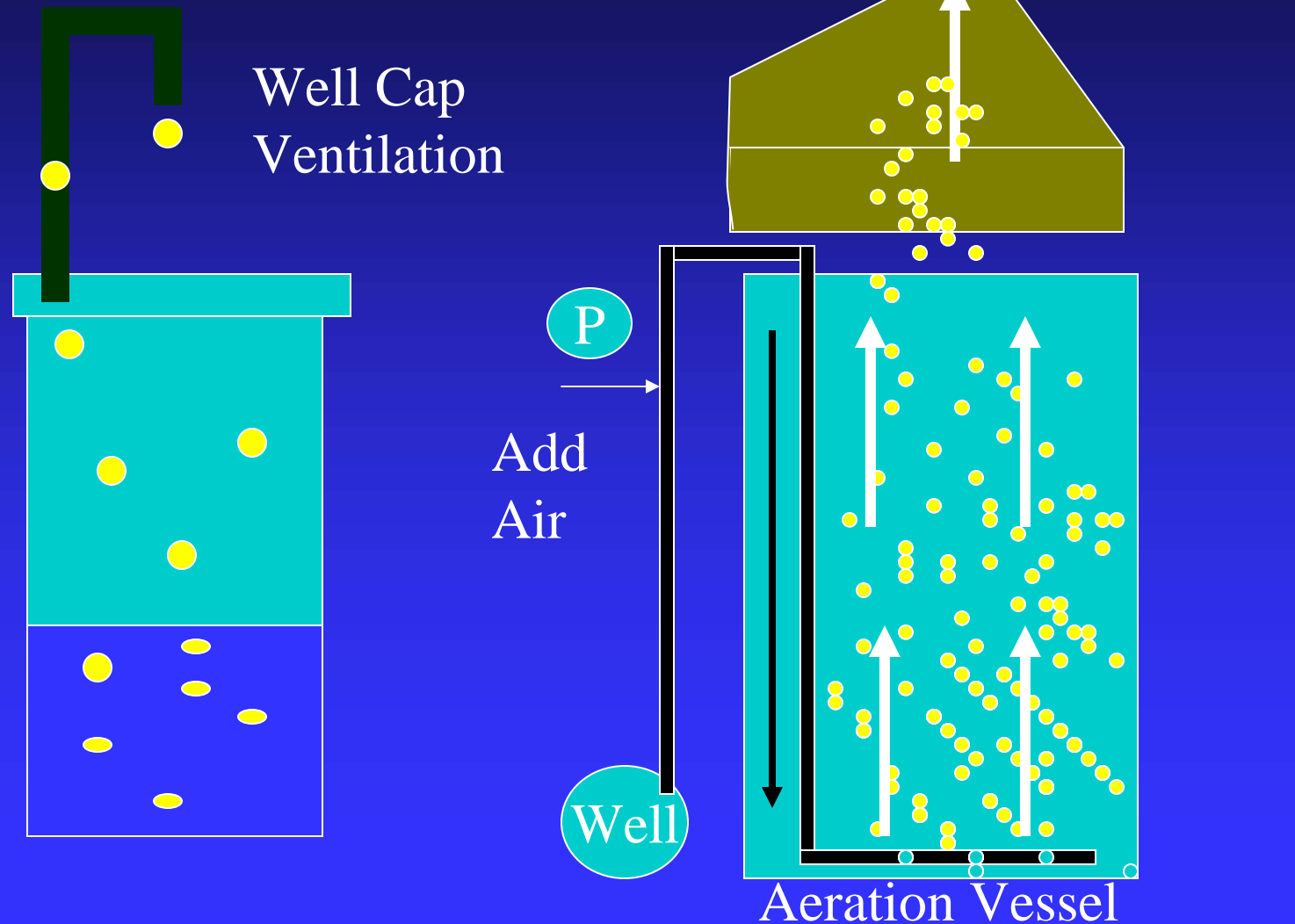
<http://www.friendsofsaltspringspark.org>

“At the base of the gorge is a bubbling salt spring, traces of an 1850s woolen mill, and mid-19th century farmhouses and barns.”

Methane (a little more)

- The Coal regions and northern portion of NEPA, and areas associated with the Mahantango / Marcellus Shale may have elevated levels of methane.
- No drinking water limit, but Office of Surface Mines recommends monitoring for concentrations from 10 to < 28 mg/L and immediate action for concentrations > 28 mg/L
- My Recommendations:
 - ◆ < 2 mg/L – Monitor annually with passive venting
 - ◆ > 2 to 7 mg/L – Real-Time Monitoring and Isotopic Analysis – “Like fingerprinting the source of the gas”- with passive venting.
 - ◆ > 7 mg/L to < 10 mg/L – active venting
 - ◆ > 10 mg/L – Treatment with active venting

Methane Ventilation, process will also work for Radon and Hydrogen Sulfide



New Methane Removal System



Problems with Iron, Manganese, and Sulfur – May be Bacterially Related



In Northeastern PA- “Nuisance Bacteria may be associated with an Odor, Iron, Manganese, or Sulfur problem. Up to 50% of the time.

Make sure to test for total coliform, standard plate count, and Nuisance Bacteria.



Marcellus Shale- What is it?

Dr. Sid Halsor
Holding a Core Sample from
About 7800 feet



Marcellus Shale



This is Causing all the Concern?

Geological Sequence

Time	Period	Deposit or Rock Type
0 to 1.8 million years	Quaternary – Glaciation	sand, silt, clay, and gravel
1.8 to 290 million	Tertiary to Permian	Not present (eroded and weathered)
290 – 320 million	Pennsylvanian	Llewellyn (coal) and Pottsville (minor coal)
320 – 354 million	Mississippian	Mauch Chunk Pocono and Spechty Kopf
354 - 417 million	Devonian	Catskill Formation Trimmers Rock Formation Mahantango Formation Marcellus Formation (Black Shale)- Target Onondaga Formation
417 – 443 million	Silurian	(calcareous sandy shale)

OLDER
↓

385 Million Years Ago



Source: <http://www2.nau.edu/rcb7/nam.html>

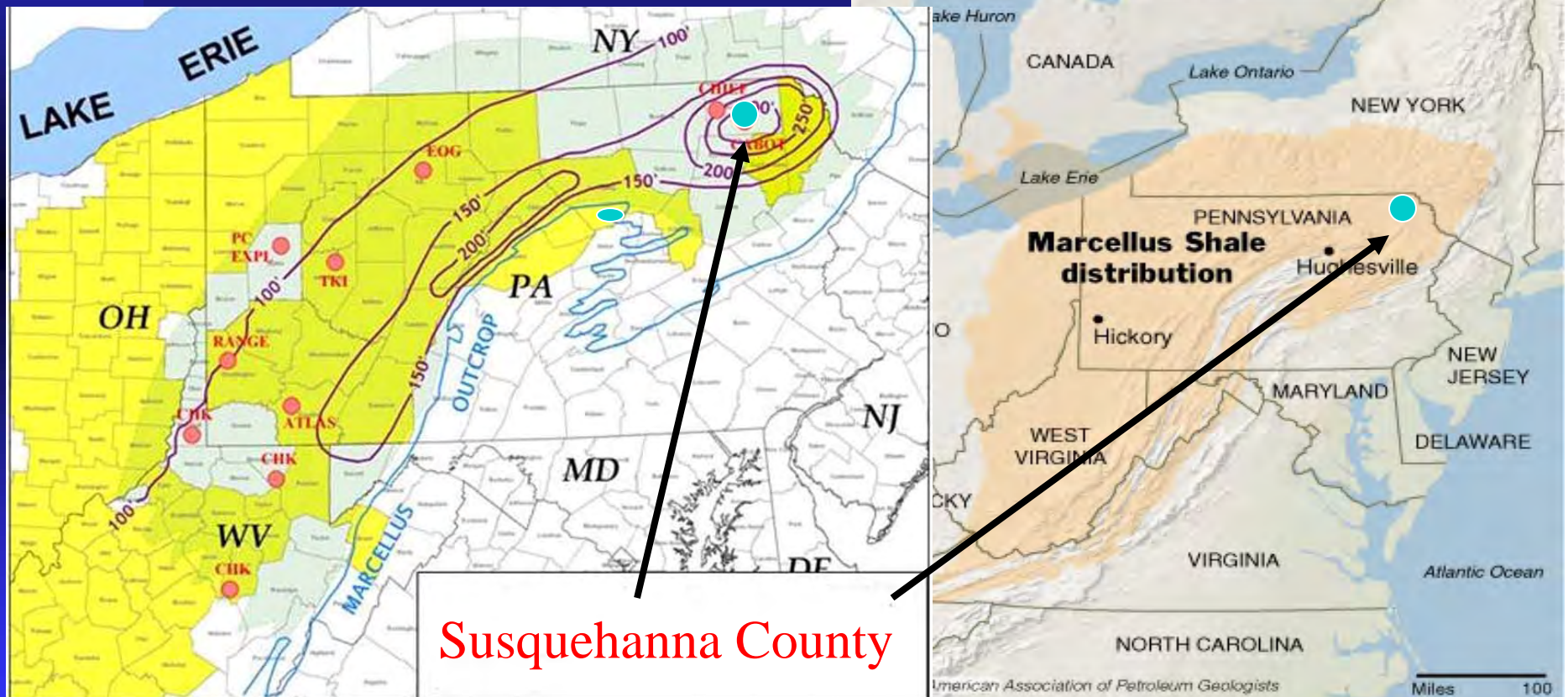
Looking Back 400 million Years



Barkley, 2009

Marcellus Shale- Natural Gas Play

84 to 500 trillion cubic feet



Susquehanna County

Shale may be 300+ feet thick.

■ Marcellus Shale Development

- ◆ Drilling
- ◆ Casing
- ◆ Cement
- ◆ What are the weaknesses?
- ◆ What are the contaminants of concern?
- ◆ Where to monitor?

Marcellus Shale Drilling Site

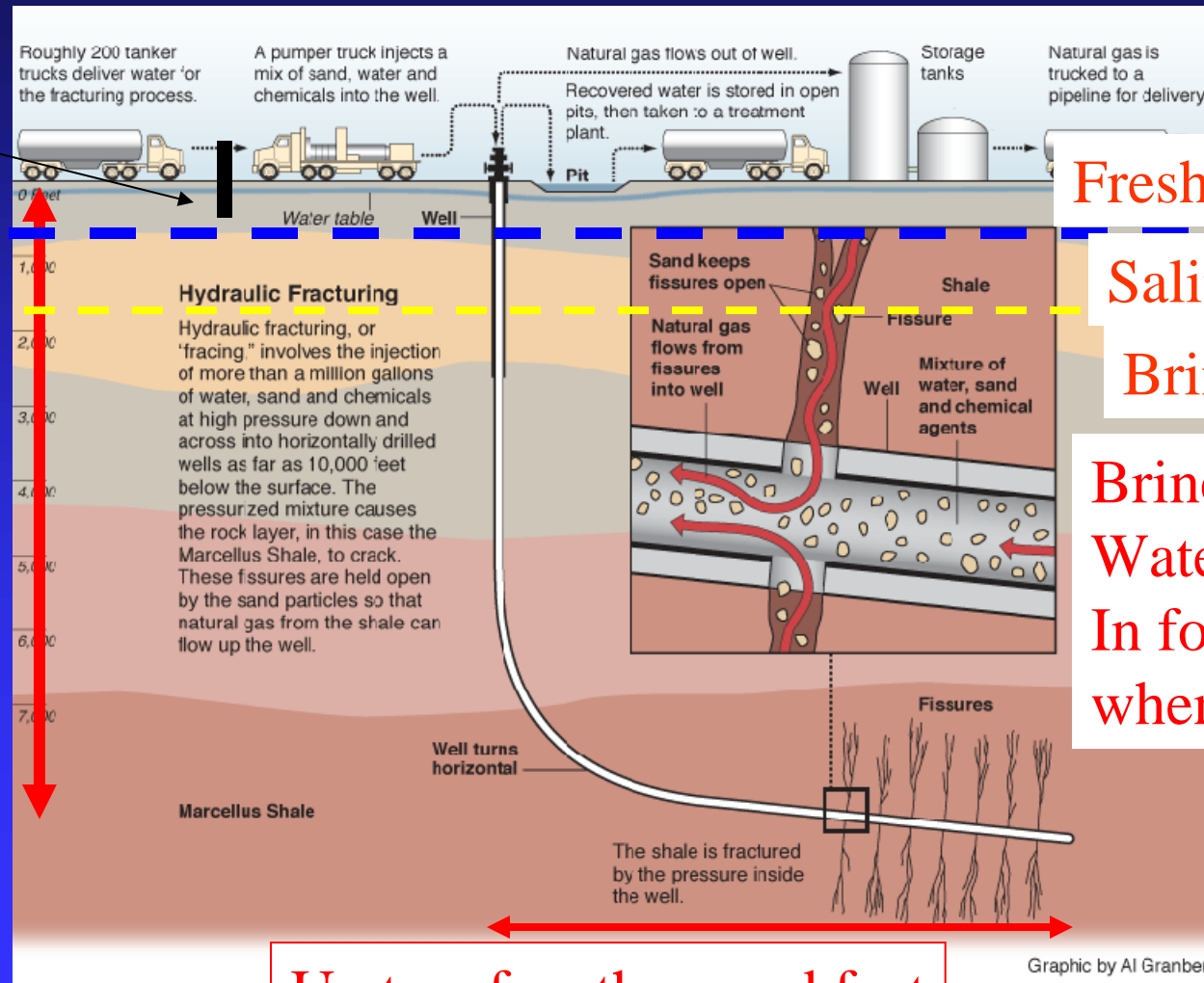


Total disturbed pads areas can be 5 acres – but one pad may support drilling multiple horizontal wells.

Getting to The Natural Gas

Freshwater
Well

5000 to
7000 feet



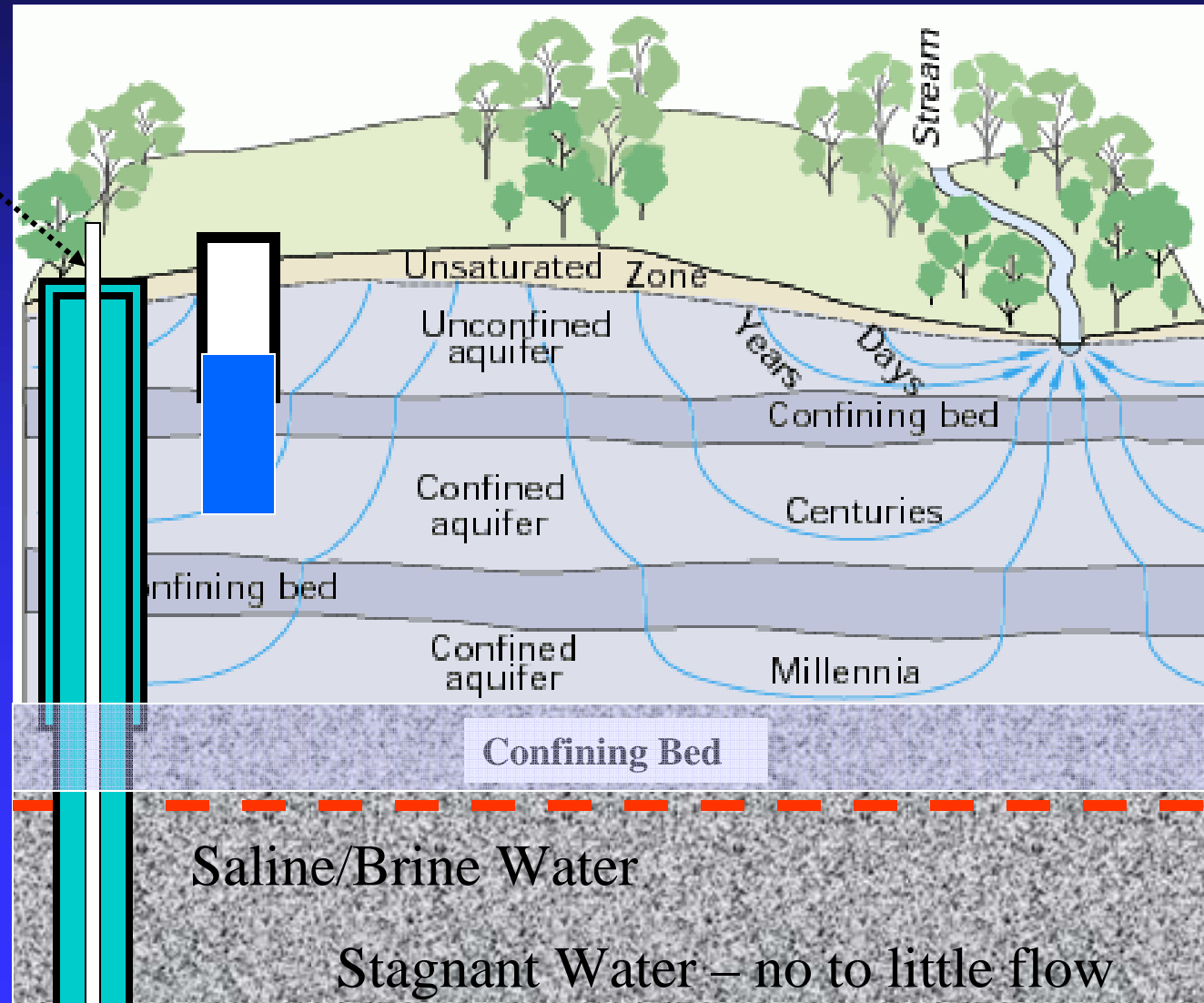
Freshwater

Saline
Brine

Brine / connate
Water- Trapped
In formation
when deposited

Up to a few thousand feet

Properly Constructed Wells and Ideal Natural Gas Wells



Sea Level

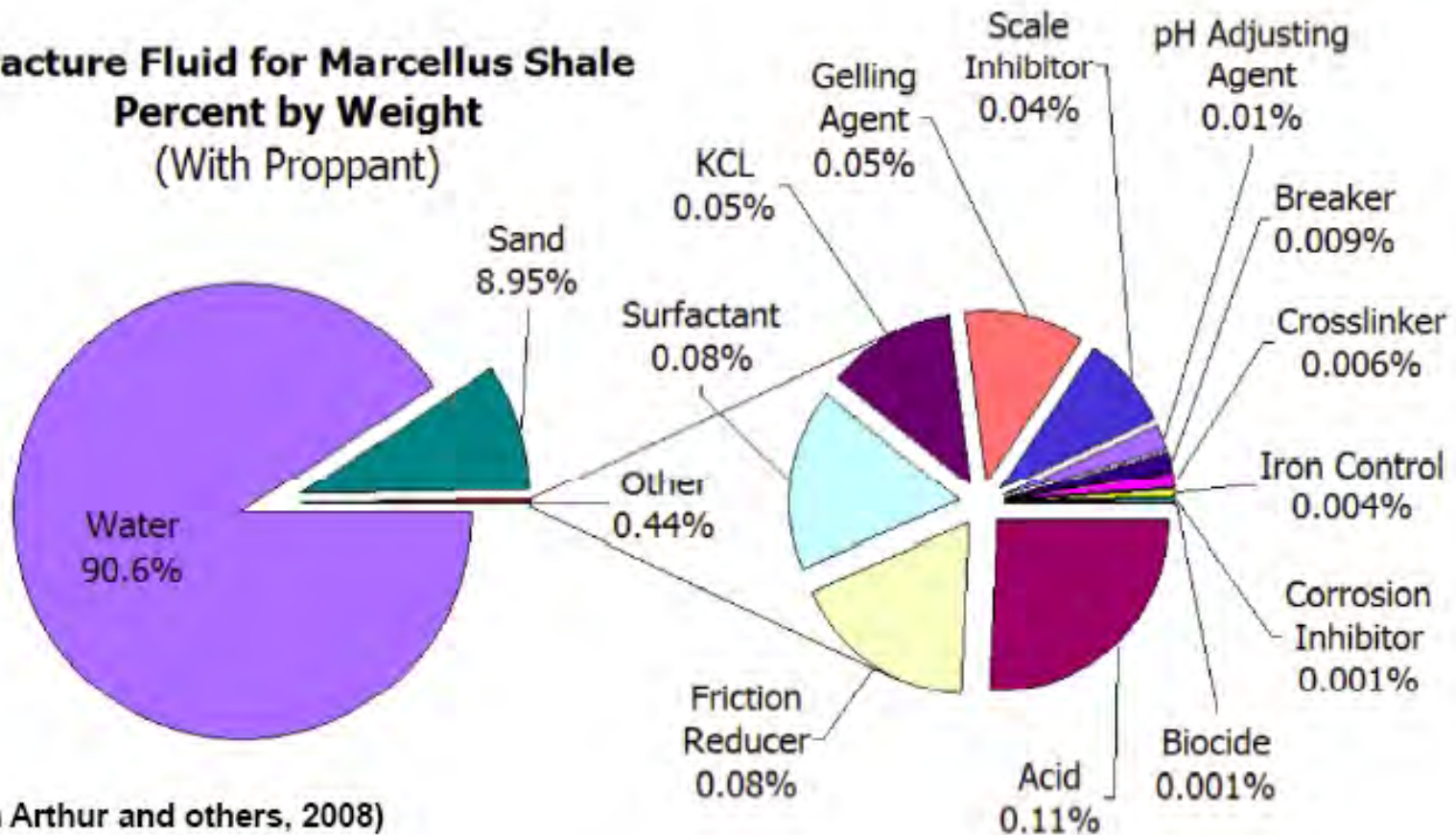
Protective Casing – Do it Right !



Types of Fluids - Associated with Marcellus Shale

- Top hole fluids – typically the water from the freshwater aquifer. This water from the first 600 to 1200 feet.
- Bottom hole fluids – brine or connate water.
- Stimulation Fluids – fluid used to improve recovery (frac process)- includes biocides and other chemicals.
- Production Fluids – water produced along the natural gas release – similar to bottom hole fluid.

**Fracture Fluid for Marcellus Shale
Percent by Weight
(With Proppant)**



(from Arthur and others, 2008)

Arthur et. al., 2008 – All Consulting – “ Natural Gas Wells of the Marcellus Shale”, Presented at Groundwater Protection Council 2008 Annual Forum.

Active Marcellus Production Site – Frac Fluid Chemistry

Typically Frac Water is comprised of clean water with a low probability for scale formation, but treated effluents and other sources being evaluated.

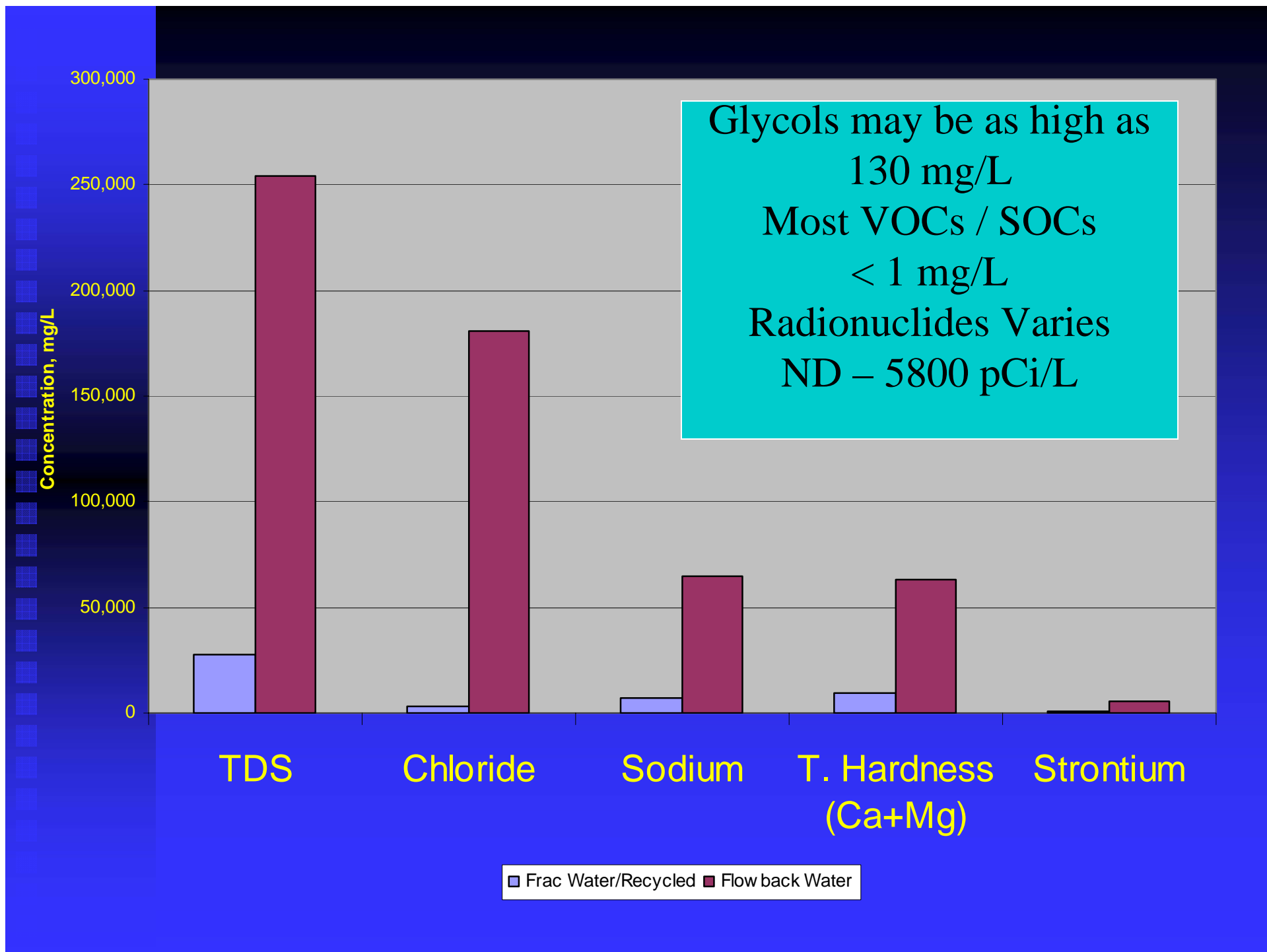
The components include:

Friction Reducer – anionic polymer high molecular weight
(hold frac sand and other particles)

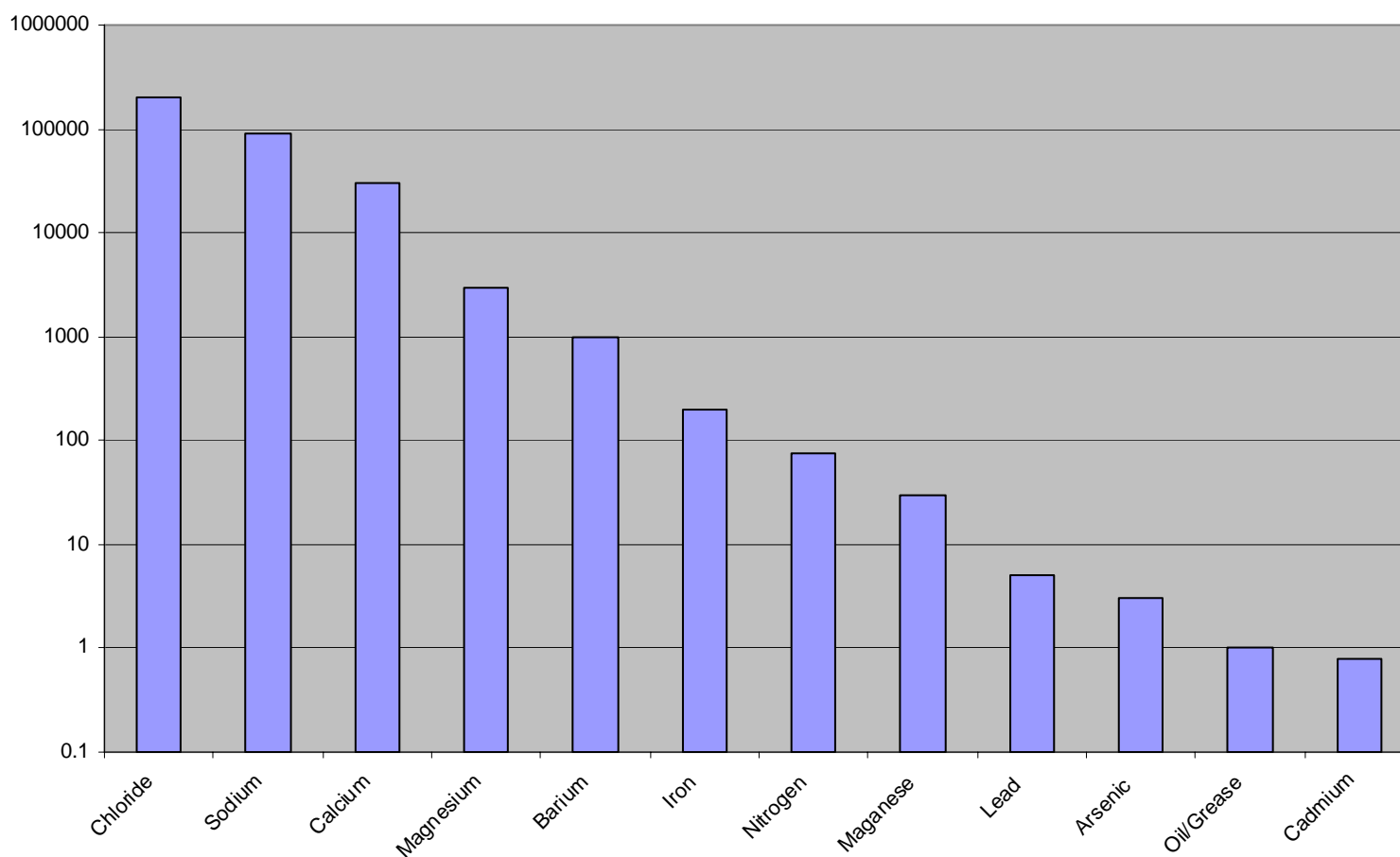
Wetting Agent- nonionic surfactant – reduce surface tension and improve frac water flowback.

Biocides- control growth or regrowth of microorganisms.

Scale Inhibitor – phosphate based chemicals to inhibit precipitate formation and scale formation.



Approximate Flowback Water - Wastewater Chemistry Concentration - mg/L (Source: PSU and Marcellus Shale Coalition)



More Data can be found at <http://www.bfenvironmental.com>

Concerns Related to Marcellus Shale

- In general, the concerns are related to the following:
 - ◆ Surface Spills and Releases Near Surface
 - ◆ Methane Gas Migration
 - ◆ Pushes and Slugs associated with Improper Cementing and not Properly Sealing the Existing Confining Layers
 - ◆ Improper Disposal of Brines
 - ◆ Freshwater Aquifer Contamination by brine water and drilling fluids/ muds.
 - ◆ Drilling fluids may contain environmental contaminations (metals and organics).

Frac Water Chemical Disclosures

- FracFocus''- <http://fracfocus.org/>. - the hydraulic fracturing chemical registry website.
- This website is a joint project of the Ground Water Protection Council Interstate Oil and Gas Compact

General Geology- Susquehanna County

Private Well

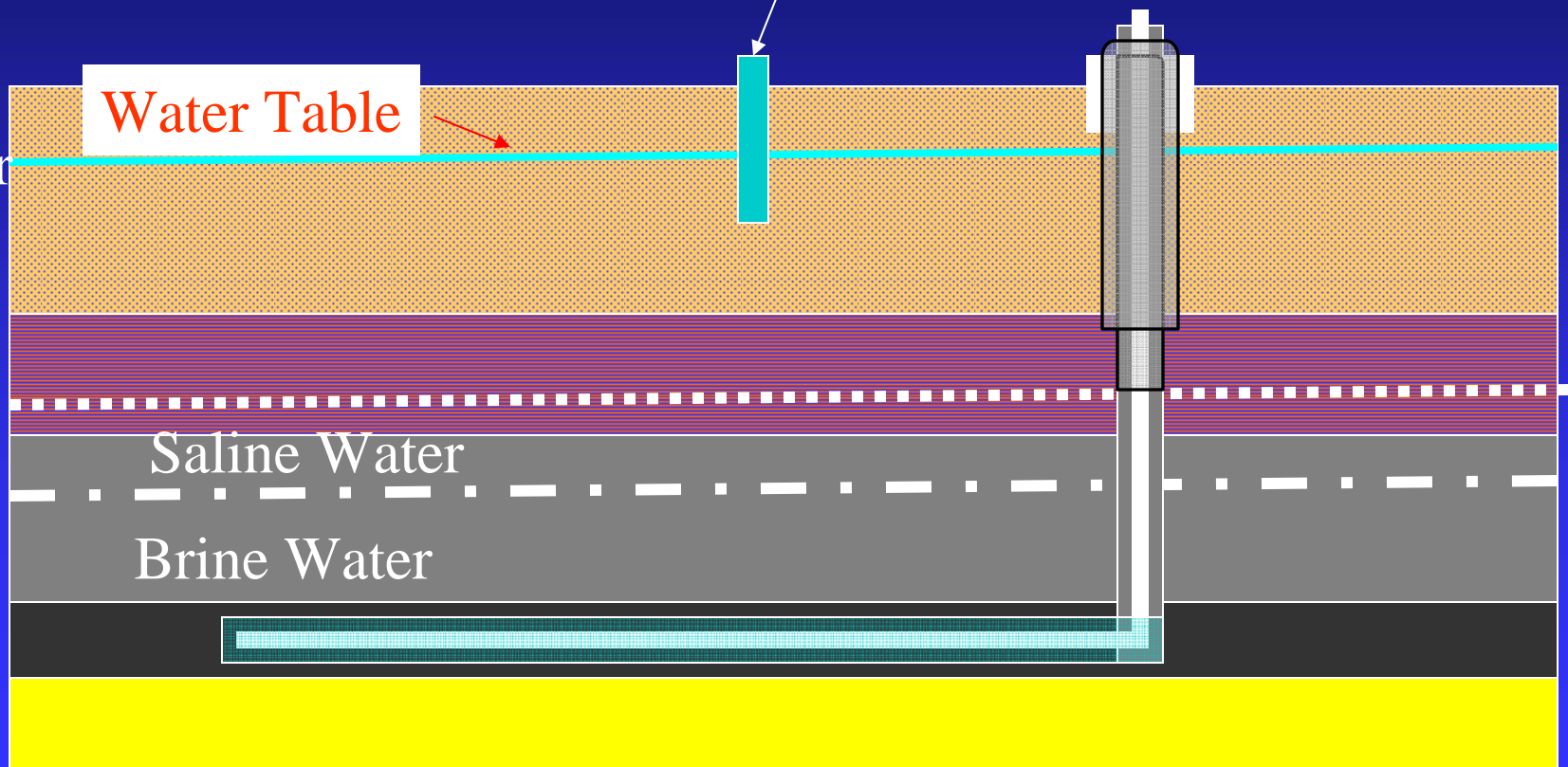
Water Table

Younger

Saline Water

Brine Water

Older



■ Citizen Database



Goal of the Database

- Provide a Central Location to Store Baseline Pre-Drilling and/or Post-Drilling Water Quality Data for the Region
- Document Quality by Geological Formation
- Identify Existing Regional Issues or Concerns
- Provide an Un-Biased Community Resource
- Provide a Mechanism to Track Temporal, Spatial, and other Geospatial Variation in Water Quality.



Citizen Database at Wilkes University- Guidelines for Submission

II. Guidelines for Data Submission

1. Third Party Samplers following chain-of-custody to certified laboratory.
2. Submit detailed reports from certified laboratory with a GPS position for the well.
3. The water sample must be collected ahead of any water treatment system.
4. other conditions – Learn More at the Wilkes University Website.

Learn More –
<http://www.wilkes.edu/water>



Recent Baseline Testing in Luzerne County, PA 320 Private Wells

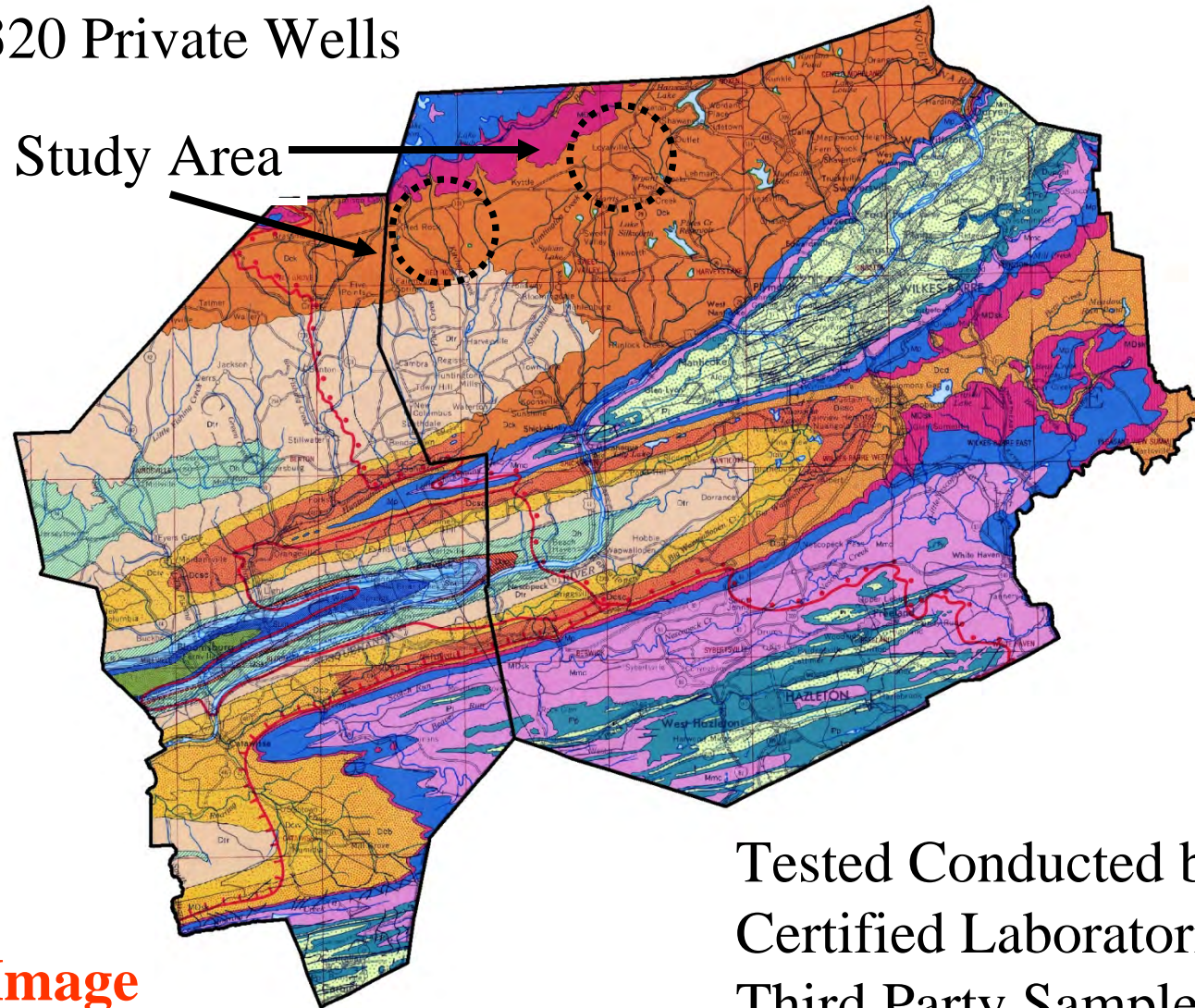
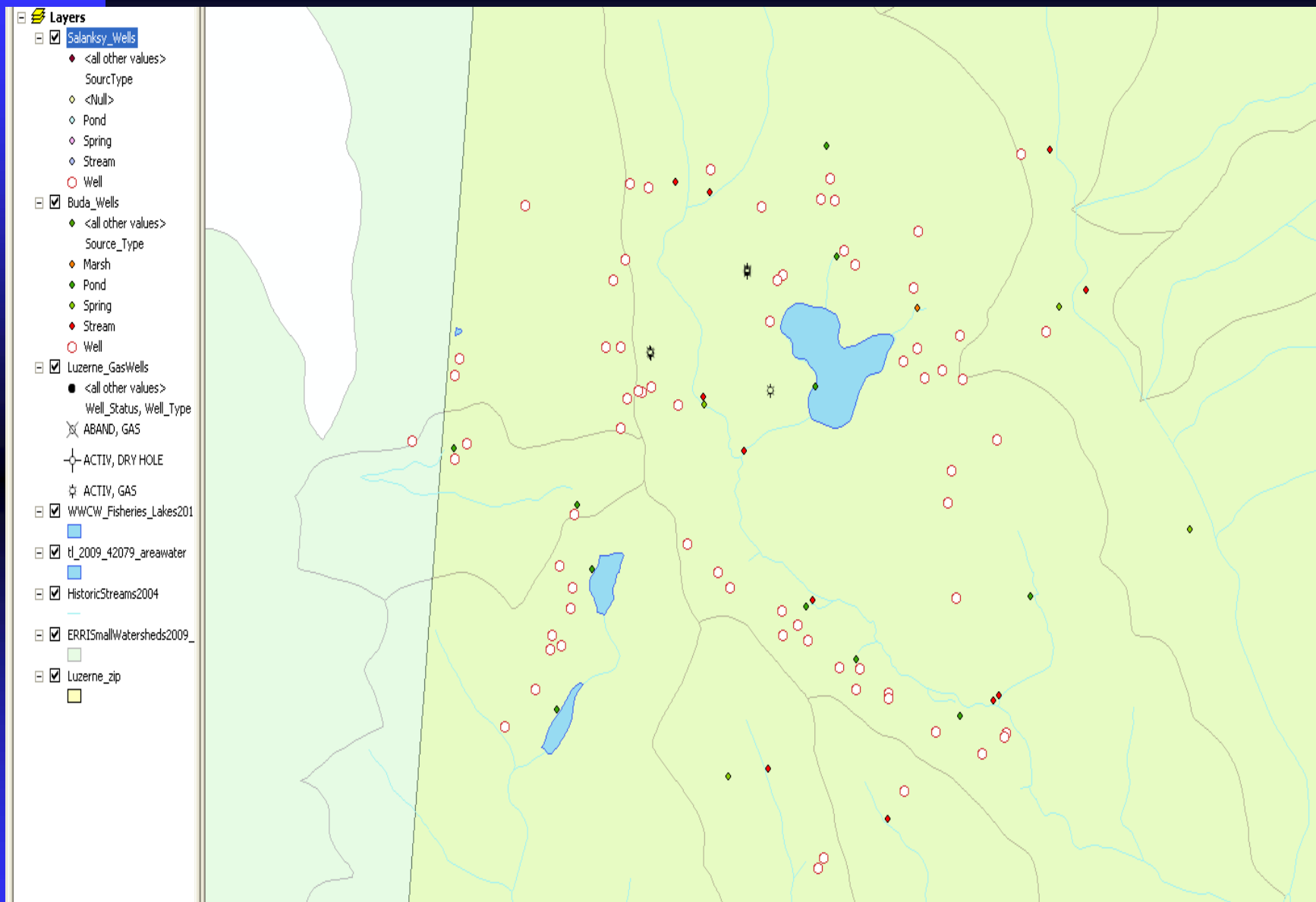


Image
Source: Luzernecounty.org

Tested Conducted by
Certified Laboratories
Third Party Samplers
Not Wilkes University

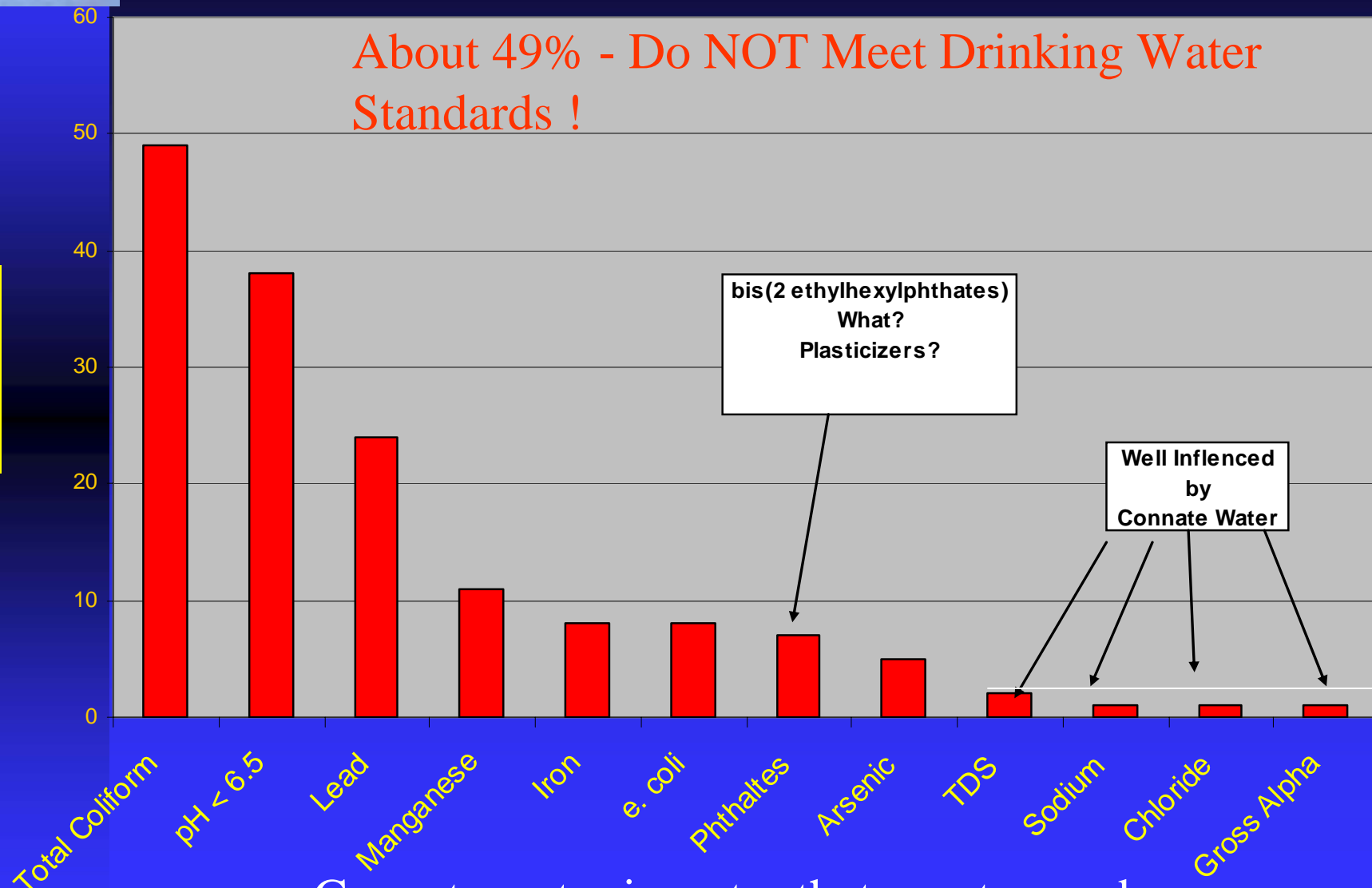


Preliminary – Screenshots – Add Hydrology, Roads, other GIS Layers

Source – Wilkes University Database

About 49% - Do NOT Meet Drinking Water Standards !

Percent Exceeded



Connate water is water that was trapped in formation when material was deposited.

What are Phthalates?

- Used as Plasticizers- is a substance which when added to a material, usually a plastic, makes it flexible and easier to handle.
- Bis(2thylhexylphthalte) (DEHP) – DW Standard – 6 ppb – GI problems, possible endocrine disruptor and carcinogen.
- Recent Testing – Highest Value was 60 ppb.
- How did this get in the aquifer?

How ? Not Sure – Here are Some Ideas

- Trace Level or near Detection Limit may be related to contamination during field sampling or laboratory testing, but this does not appear to account for levels at or above the drinking water standard.

Other Sources

- Private Wells Not Regulated and there are no plumbing codes.
- Sources – PVC plastic piping used in the home.
- Sources – Drop Pipe and Delivery Piping used in the well.

This is only a hypothesis.

Sometimes we also see hits for **Vinyl Chloride** and **Toluene**

(What the electric Tape !!!!)

The Marcellus Shale Factor- The Truth about Private Wells

- In 1996 – we knew 50% of Private Wells in PA were contaminated – But What Did We DO?
- The Marcellus Shale Factor or the Development of this resource is NOW bringing this problem to the surface.
- Baseline Testing is being conducted and more problems with groundwater quality are being identified.
- What do we do now? What is the Risk? What are the pathways to Contamination/ Impact? How should Risk be Managed?
- What to Test For as Part of Baseline Testing?
- Some Private Wells may be the pathway to Contamination.

Baseline Testing

■ Baseline Testing

- ◆ Proper Well Purging, Field Monitoring, and Sampling
- ◆ Documenting Existing Conditions and Well or Water Source Information
- ◆ Chain-of-Custody Protocols
- ◆ Using a Certified Lab / Using Certified Methods
- ◆ Picking Water Quality Parameters



Entrance Photo



Locate Well



Look for Treatment (Bypass System)



Work as a Team

Look for Treatment



What we have no treatment ?
Make Sure to By-Pass Treatment Systems

Look for Treatment



Reverse Osmosis Unit – Basement Closet on the Floor



System in Garage – Two Rooms Away from the Pressure Tank

Wellbore Volume- Volume of Water in Storage (WBV)

Well Depth from Drillers Log – 300 feet

Well Diameter – 6 inches

Static Water Level (no pumping) – 51 feet

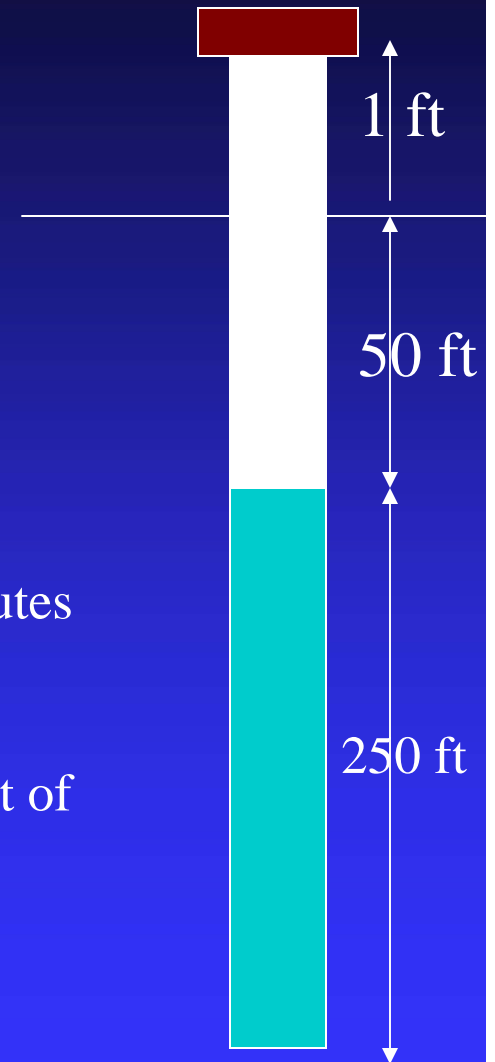
Water Column in the Well – 250 feet

Water in the Well ($250 \text{ ft} * 1.5 \text{ g/ft} = 375 \text{ gallons}$)

1 – Wellbore Volume – 375 gallons

If pump produces 5 gallons per minute, it will take 75 minutes to purge wellbore volume

Normally – we attempt to purge 3 wellbore volumes as part of a monitoring effort.



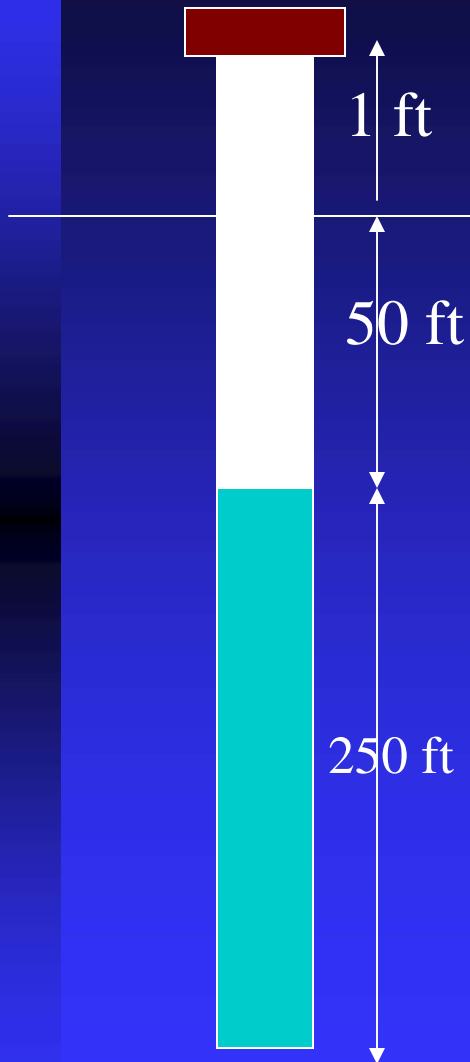


I Got to Lose Weight !

Make sure to complete the Following:

1. Take Notes and Record Observations
2. Label Each Container Name, Site ID, Date, Time, Parameters, Your Initials, Preservation
3. Prepare Chain-of-Custody
4. Record Field Water Quality Data

Estimating Specific Capacity



Specific Capacity =
Gpm/ft of drawdown

gpm = 5 gpm

Static Water Level – 50 feet

Dynamic Level – 200 feet

$Sc = (5 \text{ gpm} / (150 \text{ ft})) =$

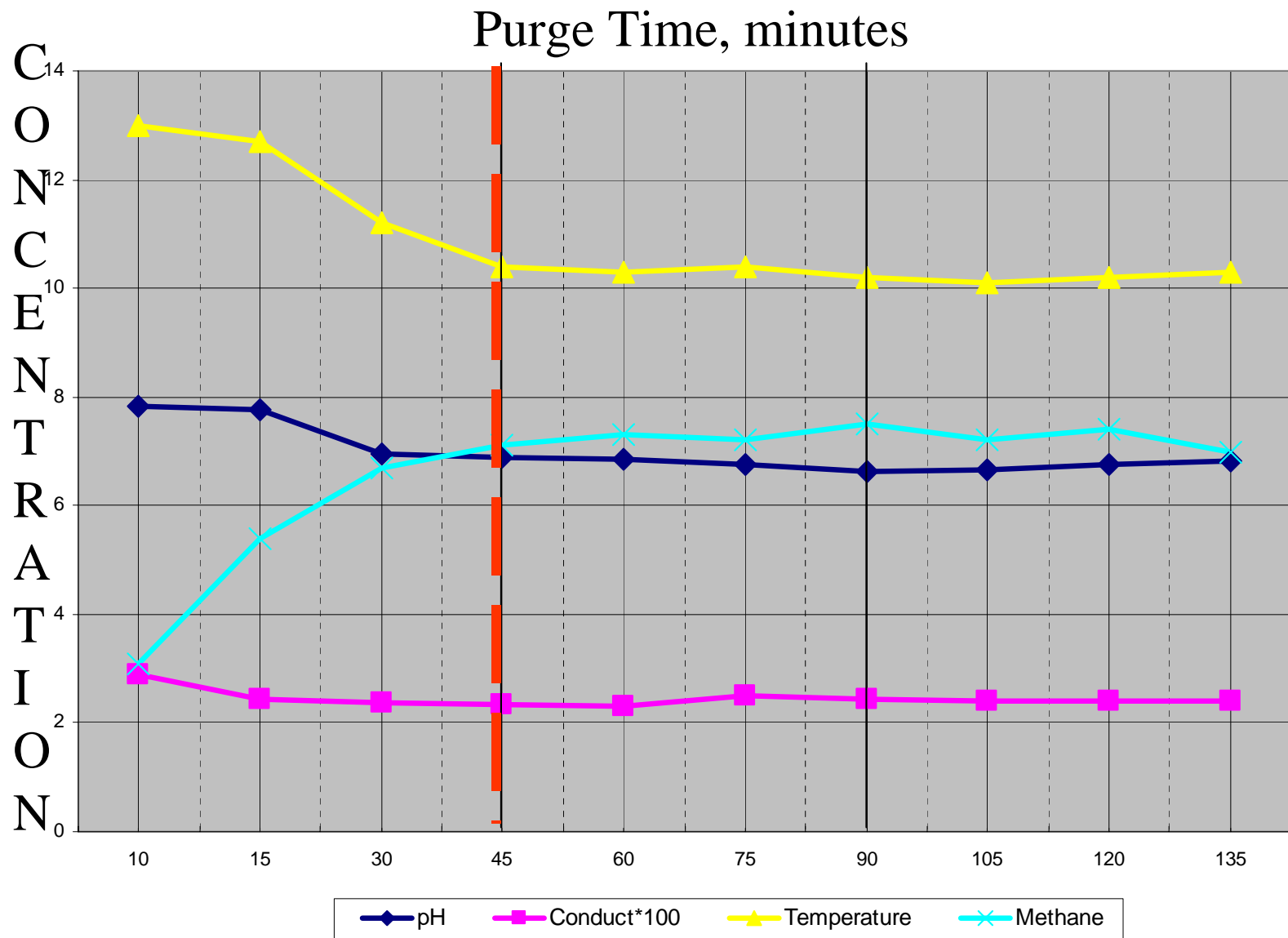
$Sc = 0.03 \text{ gpm/ft drawdown}$

Less head pressure

More methane will
be released.



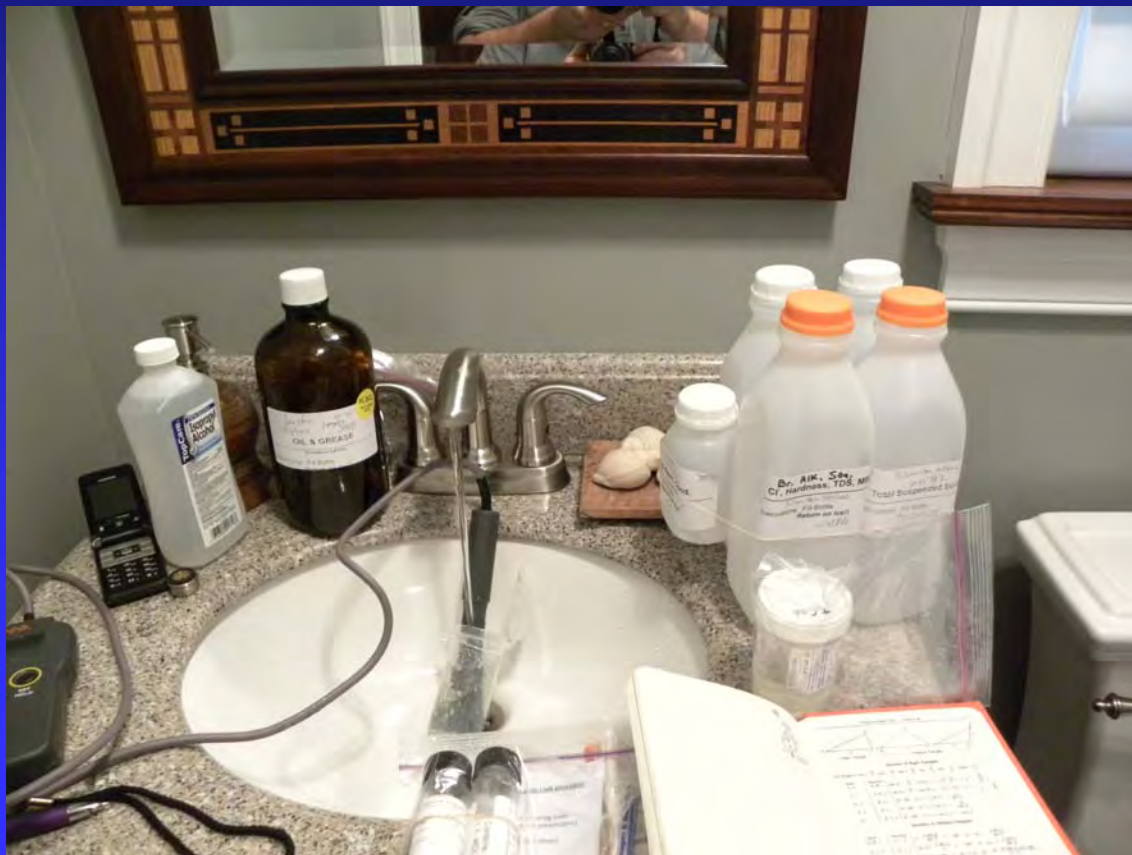
Methane



1 WBV = 45 minutes

What Parameters

■ Baseline Testing



Suggested Baseline- For Citizens from PADEP (11/2010)

- Alkalinity, Chloride, Conductivity, Hardness, Oil and Grease, pH, Sulfate, Total Dissolved Solids, Total Suspended Solids, Total Solids
- Barium, Calcium, Iron, Magnesium, Manganese, Potassium, Sodium, Strontium
- Ethane/Methane
- Total Coliform / E. coli

Other Recommendations at:

<http://www.wilkes.edu/water> (Fact Sheet - Recommended Baseline)

Baseline Testing – Oram's Recommendations for Citizens

- Where are you located?
- What is your surrounding land-use?
- Do you have any water quality problems-
such as discolored water, odors, or staining?
- Do you have a water treatment system?
- What is the source of your water?
 - ◆ Well, Spring, Cistern, etc

Same Baseline Parameters?



Quarry



Mixed
Hazards



Saline Seep

Suggested Baseline- For Citizens

- Testing Package # 1 Recommendations

Total Coliform with e. coli confirmation, chloride, sodium, bromide, barium, pH, total dissolved solids, MBAS, iron, manganese, and methane/ethane.

- Testing Package # 2 Recommendations

Package # 1- plus T. Hardness, Magnesium, Selenium, Strontium, Conductivity, Calcium, Zinc, Alkalinity, Arsenic, Nitrate, Total Suspended Solids, Sulfate, Oil & Grease, and 21-VOCs/MTBE.

- Testing Package # 3 Recommendations

Package #1 and # 2 - plus Potassium, Sulfide, Ammonia, Acidity, Nickel, Gross, Alpha/Beta, Lead, and Uranium.

It may be advisable to add Glycols, Radon in water, and other organics and inorganics. Depending on surrounding land-use, use of geothermal wells, and past history.

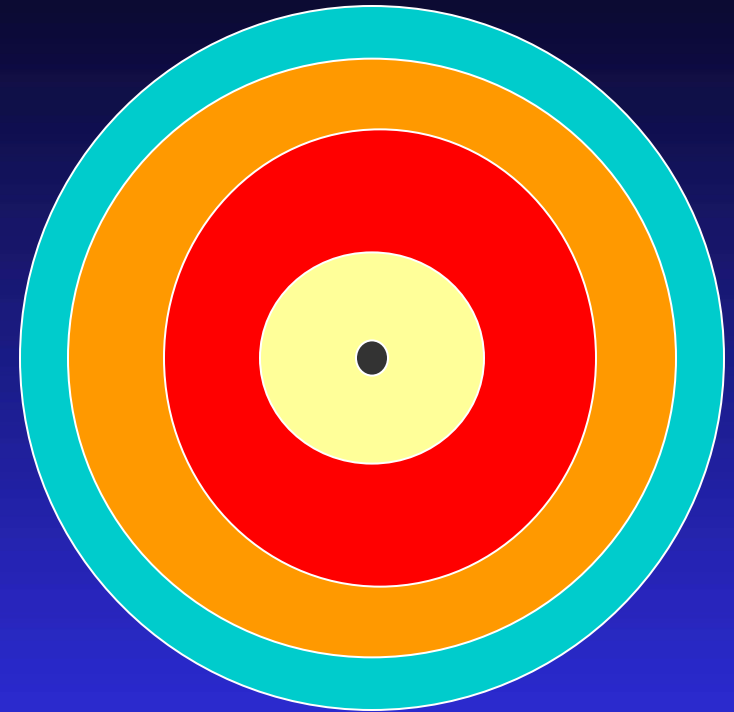
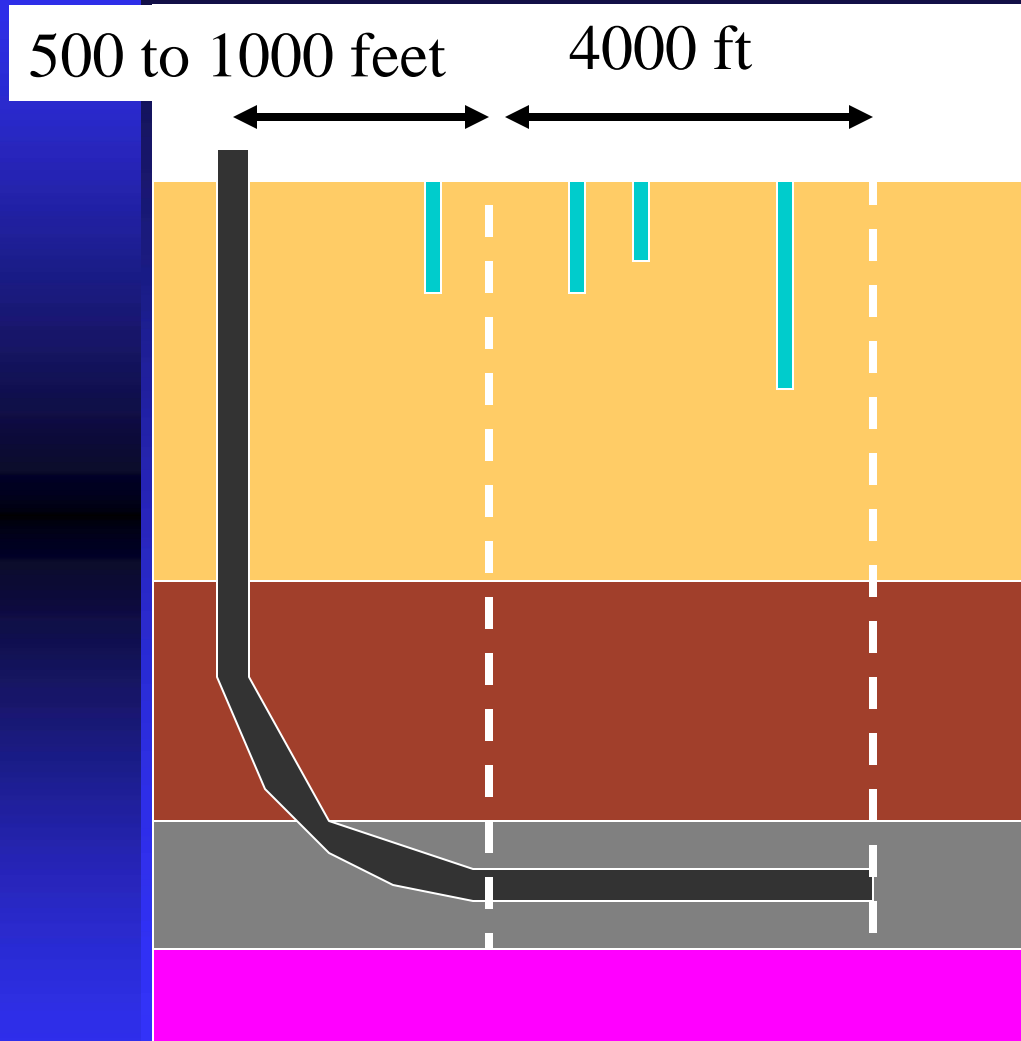
<http://www.wilkes.edu/water> (Fact Sheet - Recommended Baseline)

Suggestions for Baseline Testing

- Bacterial Series
- General Water Quality (pH, alkalinity, hardness, turbidity)
- Secondary Drinking Water Standards
- Oil/Grease
- Volatile Organics and regulated SOCs (Maybe MTBE)
- Radionuclides (Alpha/Beta – Maybe Uranium),
- Gases – Methane/ Ethane/ Propane – Add Radon !
- Major Cations / Anions
 - ◆ Plus Bromide, Sulfide, Potassium, Sodium, Aluminum,
 - ◆ Selenium, Strontium, Arsenic, Lithium (?), Lead (?), Mercury (?), Silver (?)

Companies need to take a few extra steps – they are assumed responsible.

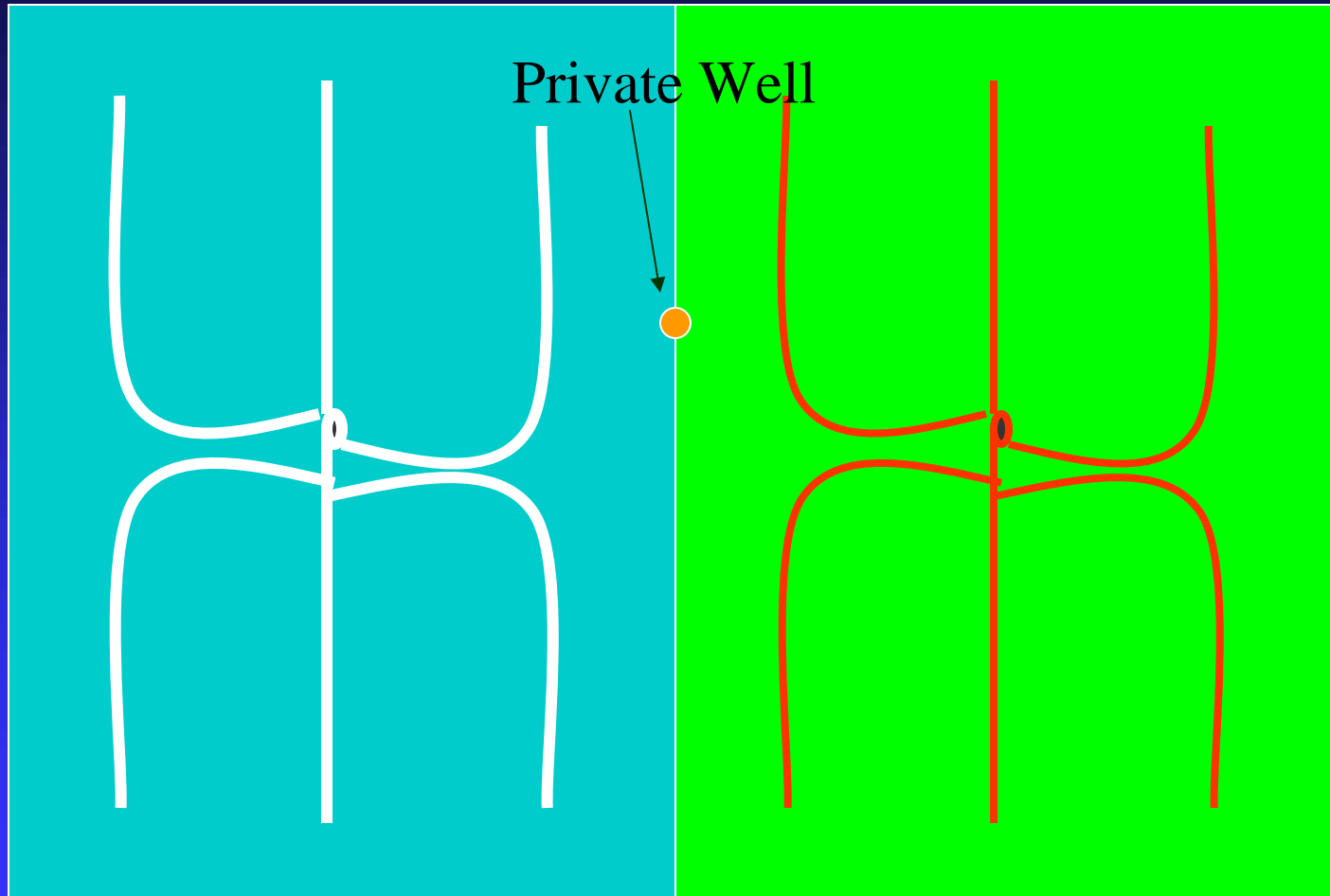
In general – I could see a radius from 3000 ft to 1 mile



- Yellow square: Mud/ Methane Migration (up to 1000 ft)
- Red square: Methane Pushes (2500 feet)
- Orange square: Area Above Lateral
- Cyan square: 1000 ft Buffer

This is More Opinion/ Judgment- not fact.

My Primary Concern with Respect to Radius
and Assumed Liab is “Who is Responsible”



Company A

Company B



Citizen Database at Wilkes University- Guidelines for Submission

II. Guidelines for Data Submission

1. Third Party Samplers following chain-of-custody to certified laboratory.
2. Submit detailed reports from certified laboratory with a GPS position for the well.
3. The water sample must be collected ahead of any water treatment system.
4. other conditions – Learn More at the Wilkes University Website.

Learn More –
<http://www.wilkes.edu/water>





New Community Resource



Download a Free Copy (pdf) or Link to a copy at <http://www.wilkes.edu/water>

Also:

1. We are Working on a Regional Citizen Water Quality Database.
2. We provide informational water testing- not Certified Test



Add Your Data to the Citizen Database- Contact Mr. Brian Oram at brian.oram@wilkes.edu

What Citizens Can Do?

- Be active in Proposed Legislation.
- Push for Local Zoning/ Subdivision Ordinances
- Private Well Construction and Siting Standards
- Getting Marcellus Shale related infrastructure added to deeds for parcels.
- Get a copy of the well permit at a local office.
- Self Monitoring
 - ◆ Baseline Testing- Certified, Chain-of-Custody
 - ◆ Post Testing Using Informational Water Test Services –
<http://www.water-testing-kits.com>
 - ◆ Self Monitoring – Easy to Use Monitoring Equipment and
Citizen Monitoring Programs
<http://www.bfenvironmental.com>

Recent Site Tour- Towanda, PA



I took both photos – First Time on the Drilling Platform

Certificate of Completion

Training Event

Getting The Waters Tested The Marcellus Shale Factor

9/1/2011

1 – hour PDH or 0.1 CEUS

Presented by

Mr. Brian Oram, PG

B.F. Environmental Consultants Inc

15 Hillcrest Drive

Dallas, PA 18612

More Online Training @

<http://www.bfenvironmental.com>





Presented by:

Mr. Brian Oram, Professional Geologist (PG),
Soil Scientist, Licensed Well Driller, IGSHPA

B.F. Environmental Consultants Inc.

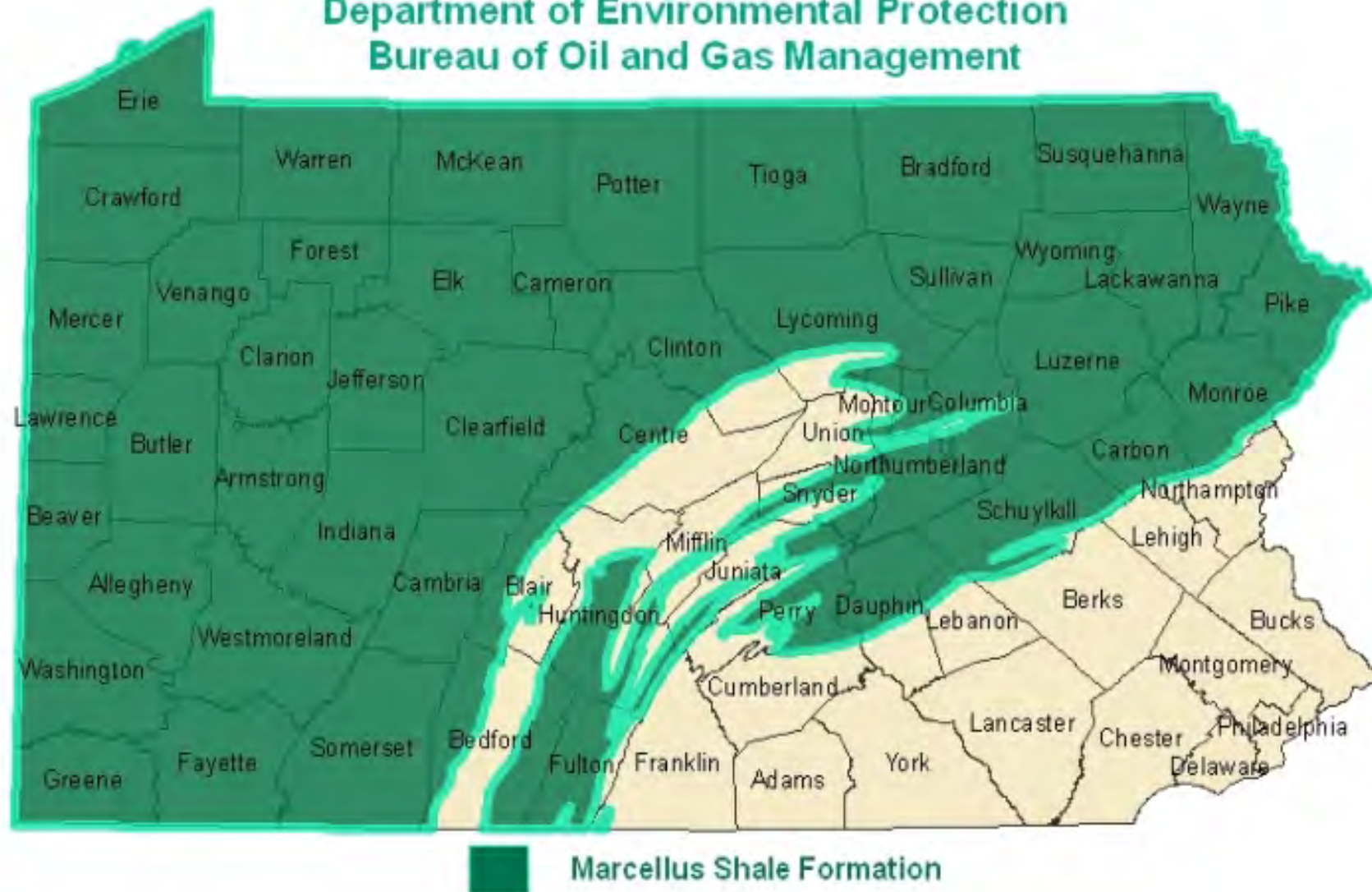
<http://www.bfenvironmental.com>

And

Water Research Center

<http://www.water-research.net>

Commonwealth of Pennsylvania
Department of Environmental Protection
Bureau of Oil and Gas Management





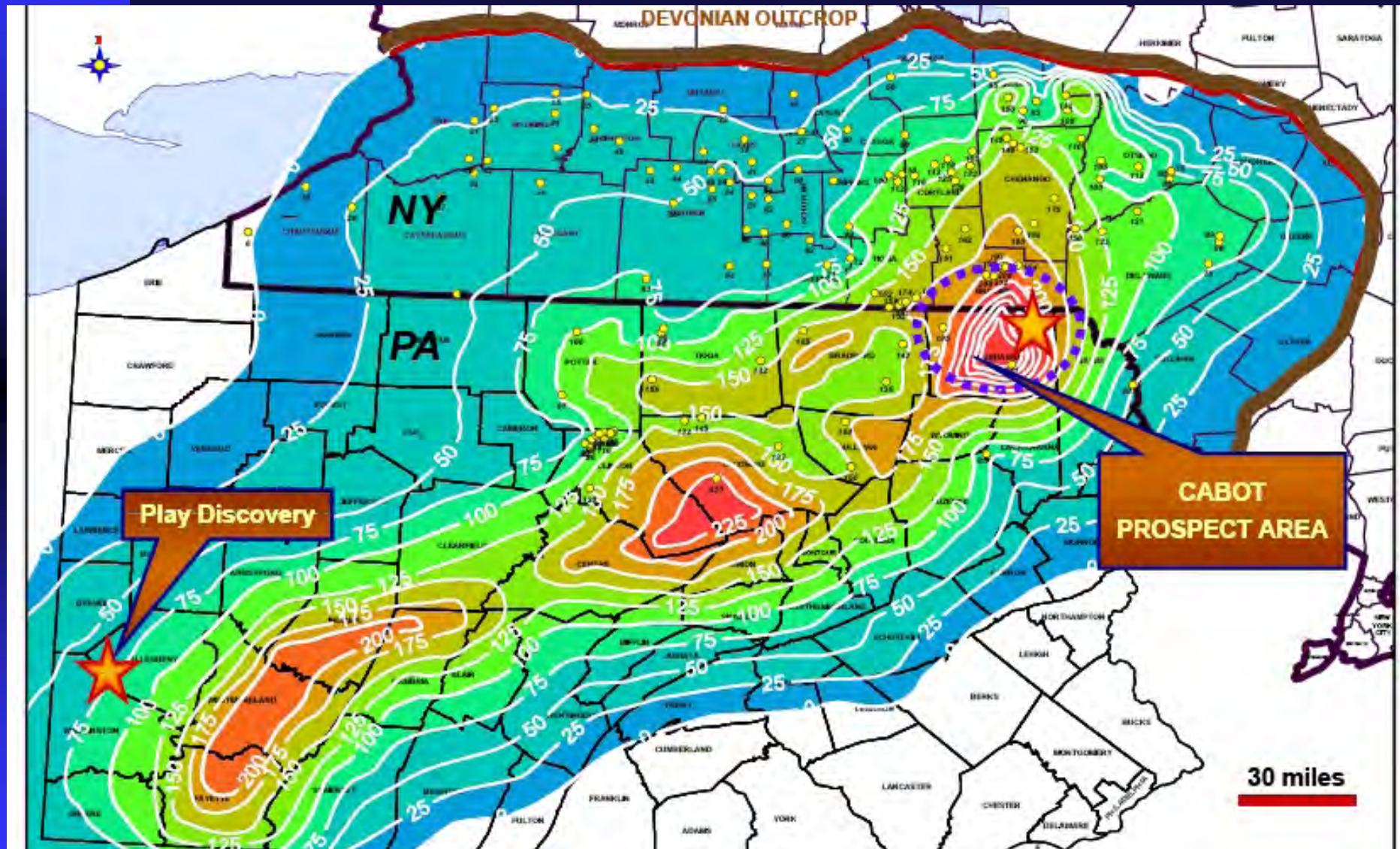
Marcellus Shale Photo



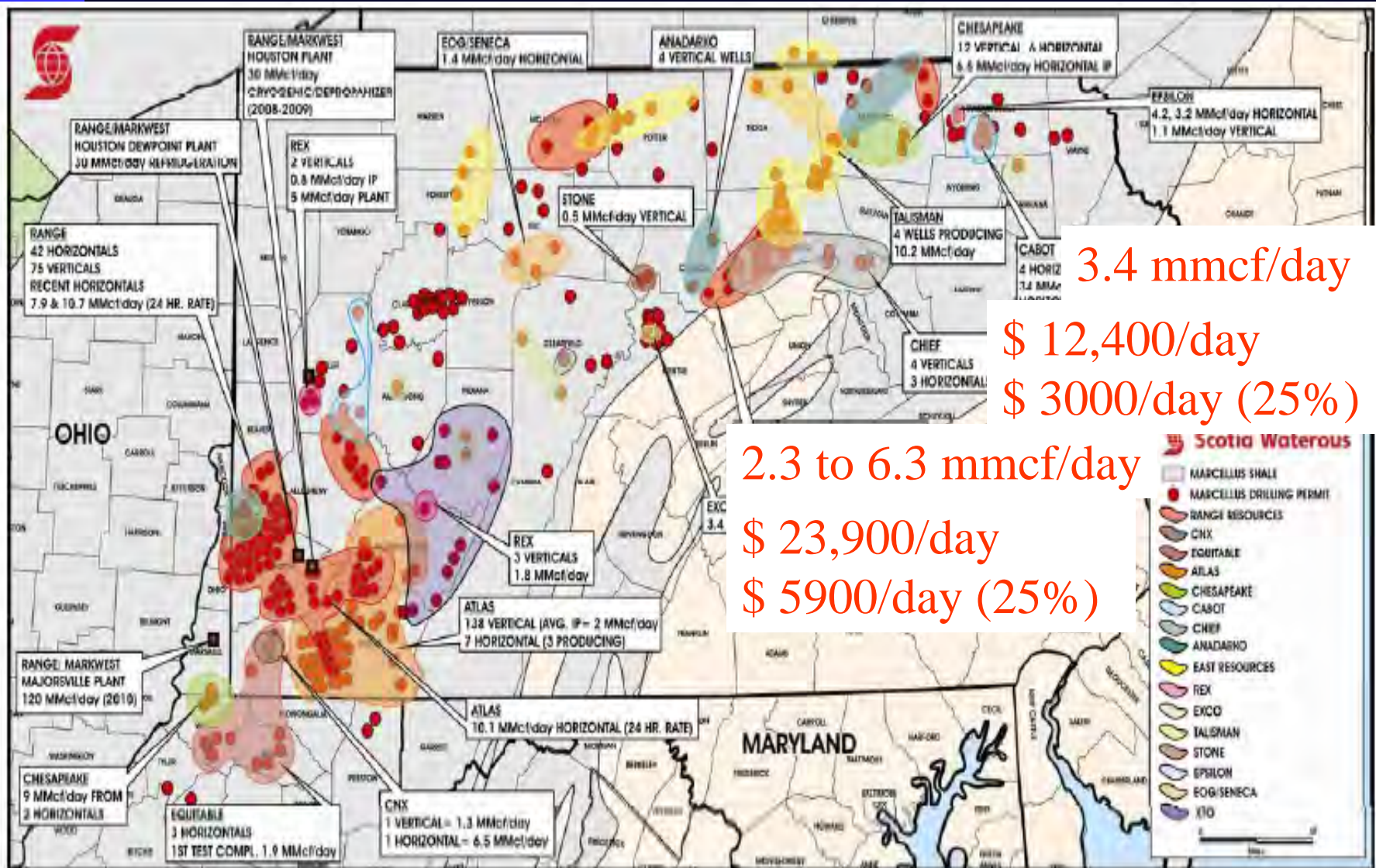
Outcrops Along the
Southeastern Border
of Pike County
Along Route 209

Main Fracture Orientation

This is why the term – Fairway is being used to describe the play.



Source- Cabot – Marcellus Shale Thickness Map



3.4 mmcf/day
 \$ 12,400/day
 \$ 3000/day (25%)

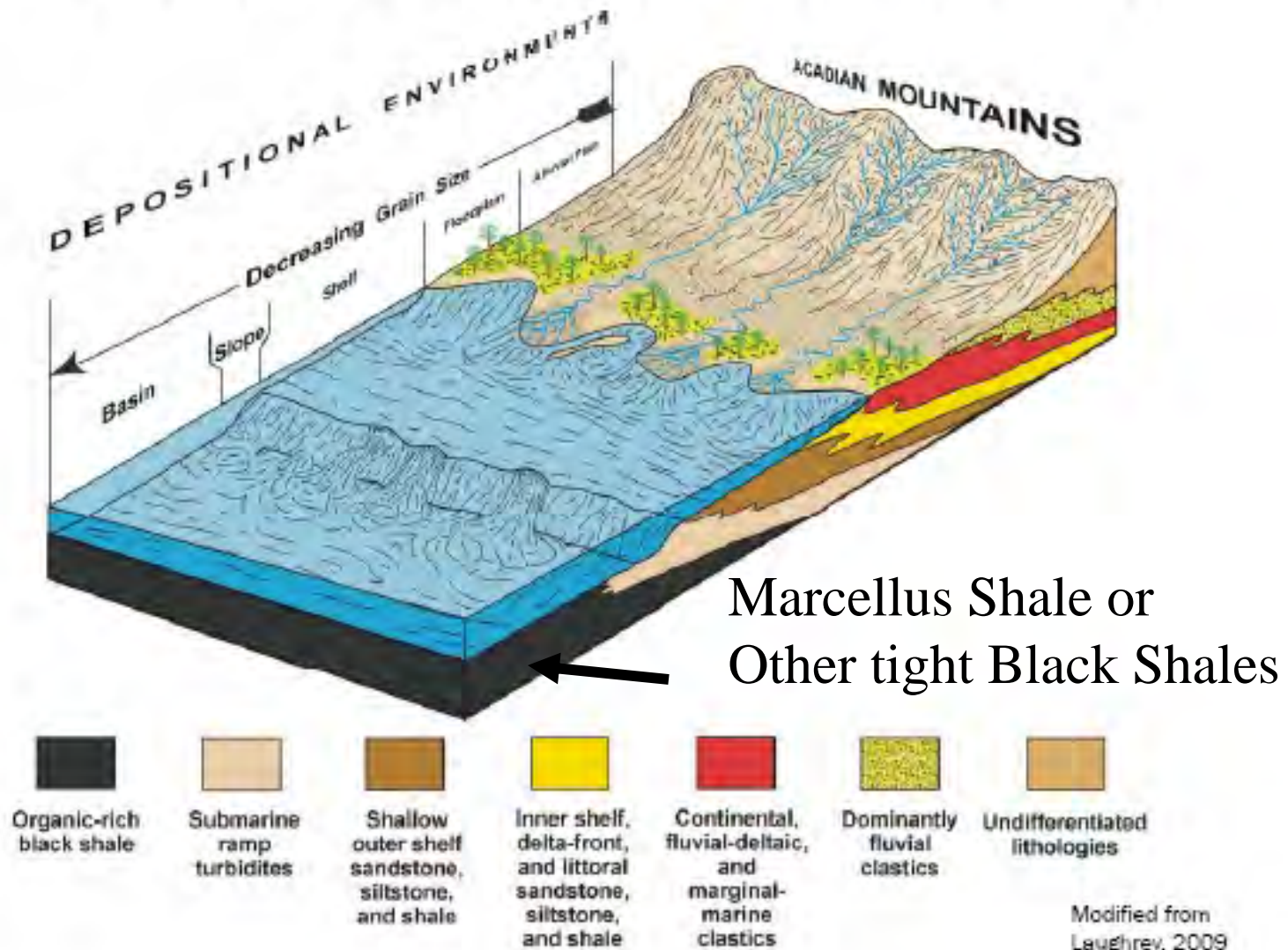
2.3 to 6.3 mmcf/day
 \$ 23,900/day
 \$ 5900/day (25%)

Source: DUG Conference Presentation

1 *MMcf* = 1000 *MMBtu*

\$3.64 per *MMBtu*

DEVONIAN DEPOSITIONAL ENVIRONMENTS



Flowback Water Chemistry

Flowback water is generated from drilling and it is what gets produced from the first 5% of water returned after a well is started

Parameter	Frac 1	Frac 2	Frac 3	Frac 4
barium mg/l	3,310	2,300	7.75	4,300
calcium mg/l	14,100	5,140	683	31,300
iron mg/l	52.5	11.2	211	134.1
magnesium mg/l	938	438	31.2	1,630
manganese mg/l	5.17	1.9	16.2	7.0
strontium mg/l	6,830	1,390	4.96	2,000
dissolved solids mg/l	175,268	69,640	6,220	248,428
suspended solids mg/l	416	48	490	330
chemical oxygen demand mg/l	600	567	1,814	2,272

May contain elevated levels of trace metals, nitrogen, bromide, uranium, and hydrocarbons. Most of the dissolved solids includes chloride and sodium.

Source: <http://www.prochemtech.com/>

Production Water

Produced water is wasted water that accompanies oil extraction and is high in saline. Typically, separated stored on site and then hauled to treatment/disposal facility.

Parameter	Result	Parameter	Result
pH	4.79	conductivity mmhos	366,600
total oil/grease mg/l	9	chemical oxygen demand mg/l	2,332
surfactants mg/l	105.7	barium mg/l	690
calcium mg/l	23,200	iron mg/l	160
magnesium mg/l	2,240	manganese mg/l	10.1
strontium mg/l	732	dissolved solids mg/l	224,300
suspended solids mg/l	33		

May contain elevated levels of trace metals, nitrogen, bromide, uranium, and hydrocarbons. Most of the dissolved solids includes chloride and sodium.

Source: <http://www.prochemtech.com/>

Multiple Grouted Casing Used in Drilling Process

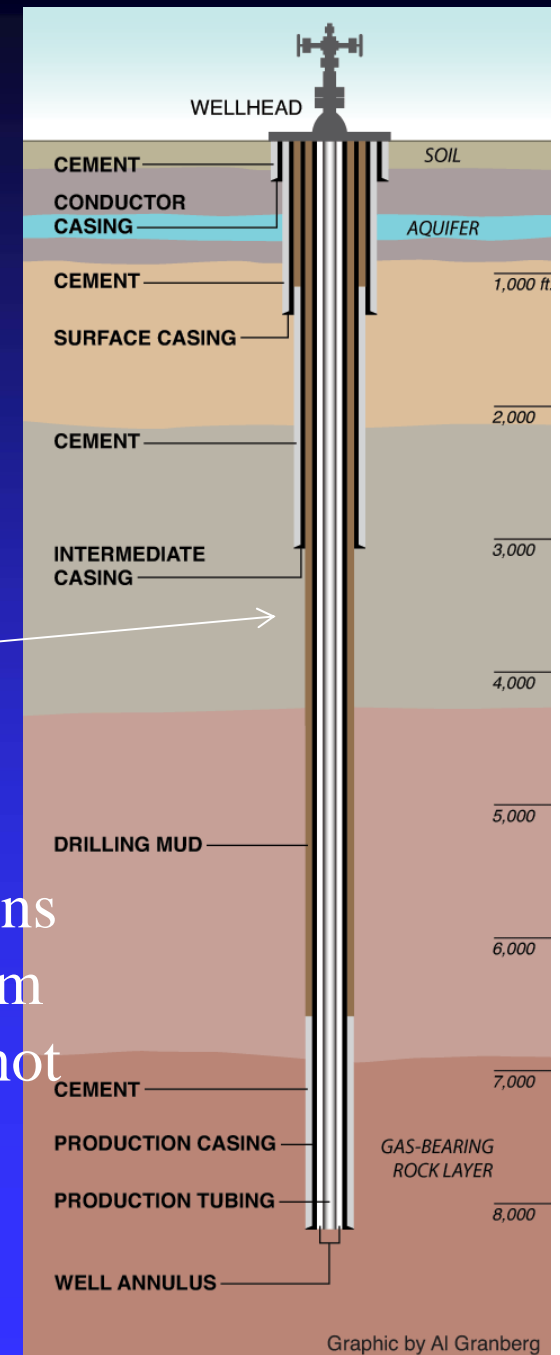
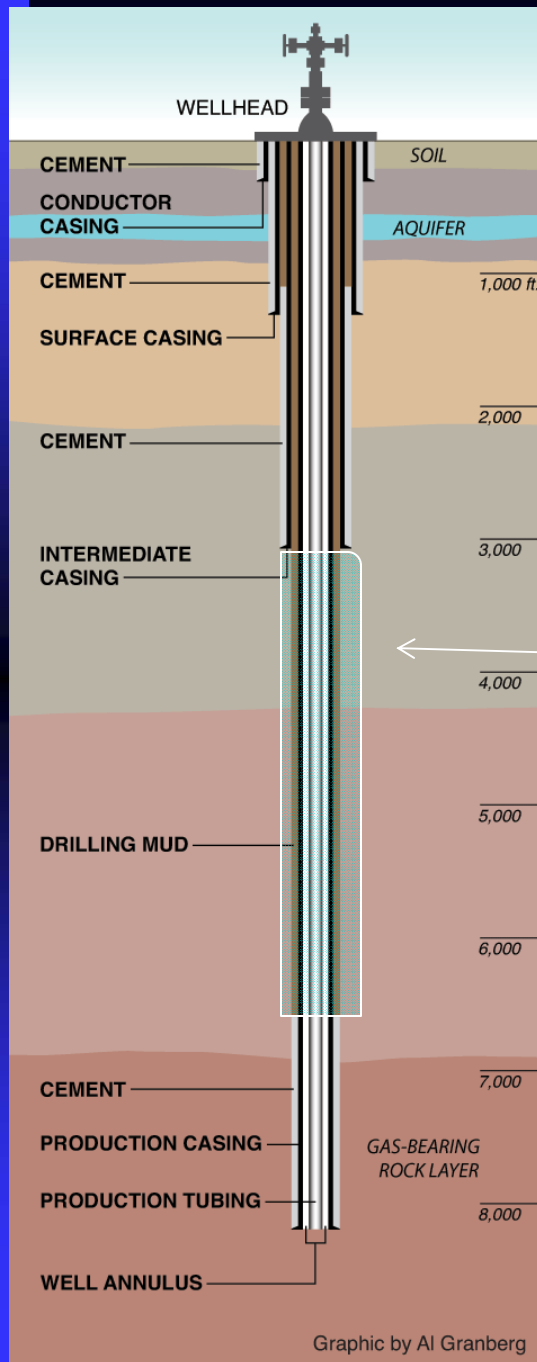


Typical Well

Additional Cemented Zones

This Zone should be cemented

Even after new regulations
There may be a zone from
1500 to 2000 feet thick not
Cemented.



Available Frac Water (Includes Recycled) Chemistry

Parameter	Units	Concentration	PWS	Multiple Above PWS Standard
Aluminum	mg/L	1.2	0.2	6
Arsenic	mg/L	0.014	0.01	1.4
Barium	mg/L	410	2	205
Iron	mg/L	17	0.3	56
Manganese	mg/L	0.89	0.05	17.8
Hardness	mg/L	1750	500	3.5
T. Dissolved Solids	mg/L	31324	500	62
Nirate @ N	mg/L	90.1	44	2
pH	su	6.73	6.5 - 8.5	oK
Bromide	mg/L	61.8	0.01	6180
Chloride	mg/L	27000	250	108
Gross Alpha	pCi/L	223.3	15	15
Gross Beta	mrem/yr (Sr)	38.65	4	10
Radium 228	pCi/L	18.55	5	4
Radium 226	pCi/L	69.63	5	14

<http://www.prochemtech.com/>



Photo Document Sampling Site, Purging, and Monitoring Process



Suggestions for Baseline Testing

- Bacterial Series
- General Water Quality (pH, alkalinity, hardness, turbidity)
- Secondary Drinking Water Standards
- Oil/Grease
- Volatile Organics and regulated SOCs (Maybe MTBE)
- Radionuclides (Alpha/Beta – Maybe Uranium),
- Gases – Methane/ Ethane/ Propane – Add Radon !
- Major Cations / Anions
 - ◆ Plus Bromide, Sulfide, Potassium, Sodium, Aluminum,
 - ◆ Selenium, Strontium, Arsenic, Lithium (?), Lead (?), Mercury (?), Silver (?)

Companies need to take a few extra steps – they are assumed responsible.