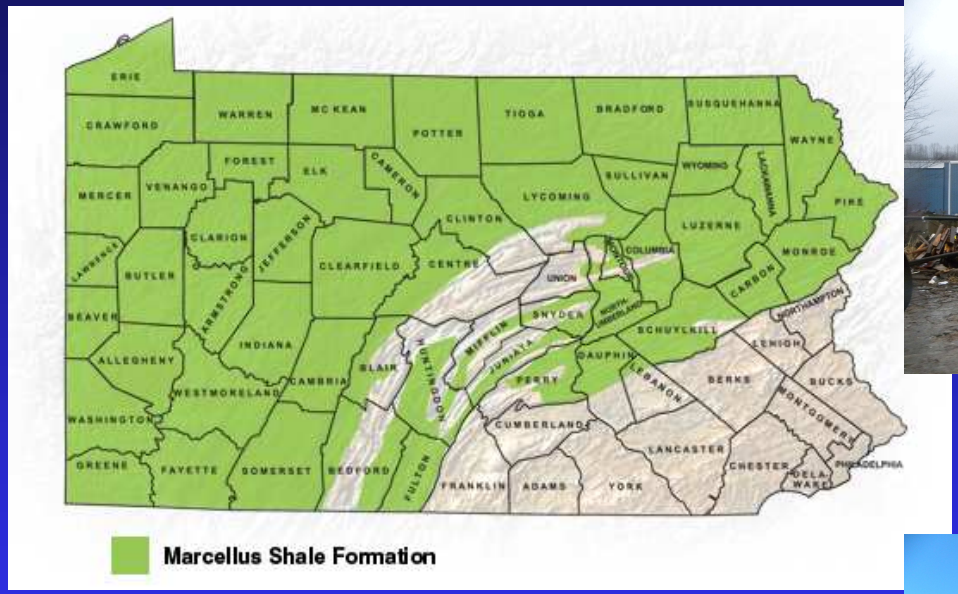
Getting The Waters Tested

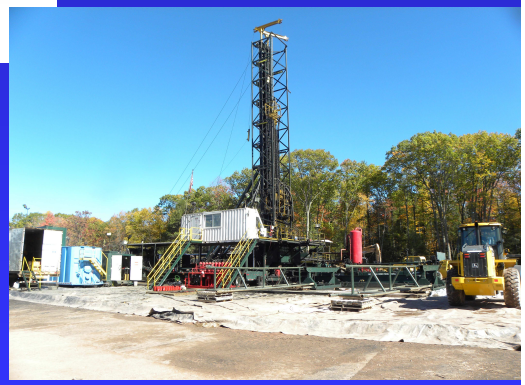
The Marcellus Shale Factor- Columbia County, PA

Water Resources



Old Issues

Environment



New Issues

Presented by:

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

Accredited Geothermal Installer

Laboratory Director, Center for Environmental Quality
Wilkes University
http://www.wilkes.edu/water

and

B.F. Environmental Consultants Inc.

http://www.bfenvironmental.com

Center for Environmental Quality

Non-profit/ equal opportunity employer, is operated and managed within the Department of Environmental Engineering and Earth Sciences at Wilkes University

Outreach Programs

- Environmental and Professional Education and Training
- Applied Research- Product Development
- Community and Business Outreach Programs

Website: http://www.wilkes.edu/water

B.F. Environmental Consultants Inc.

- Professional Consulting Services in the areas of water quality, soils, stormwater, geology, aquifer analysis, and land-development.
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FREE

TECHNICAL ASSISTANCE
FOR
WATERSHEDS!!!

C-SAW

(Consortium for Scientific Assistance to Watersheds)

Funding provided by Growing Greener and the
in-kind support of the partners

http://www.pnercd.org

CSAW
Consortium for Scientific Assistance to Watersheds

Pocono Northeast
Resource Conservation & Development Council

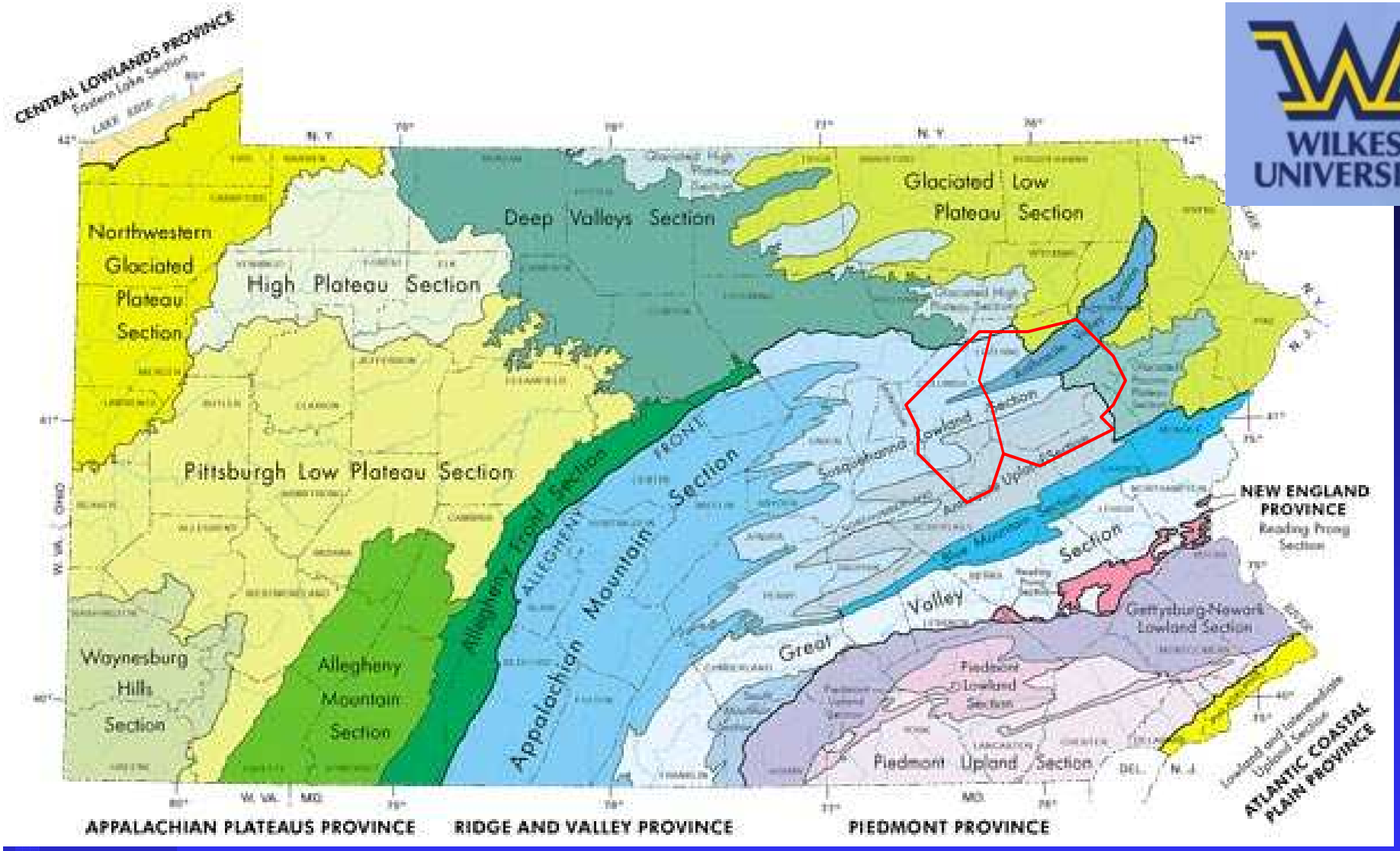
Pennsylvania is... Growing Greener

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, 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**

Background

- Geology/ Hydrology

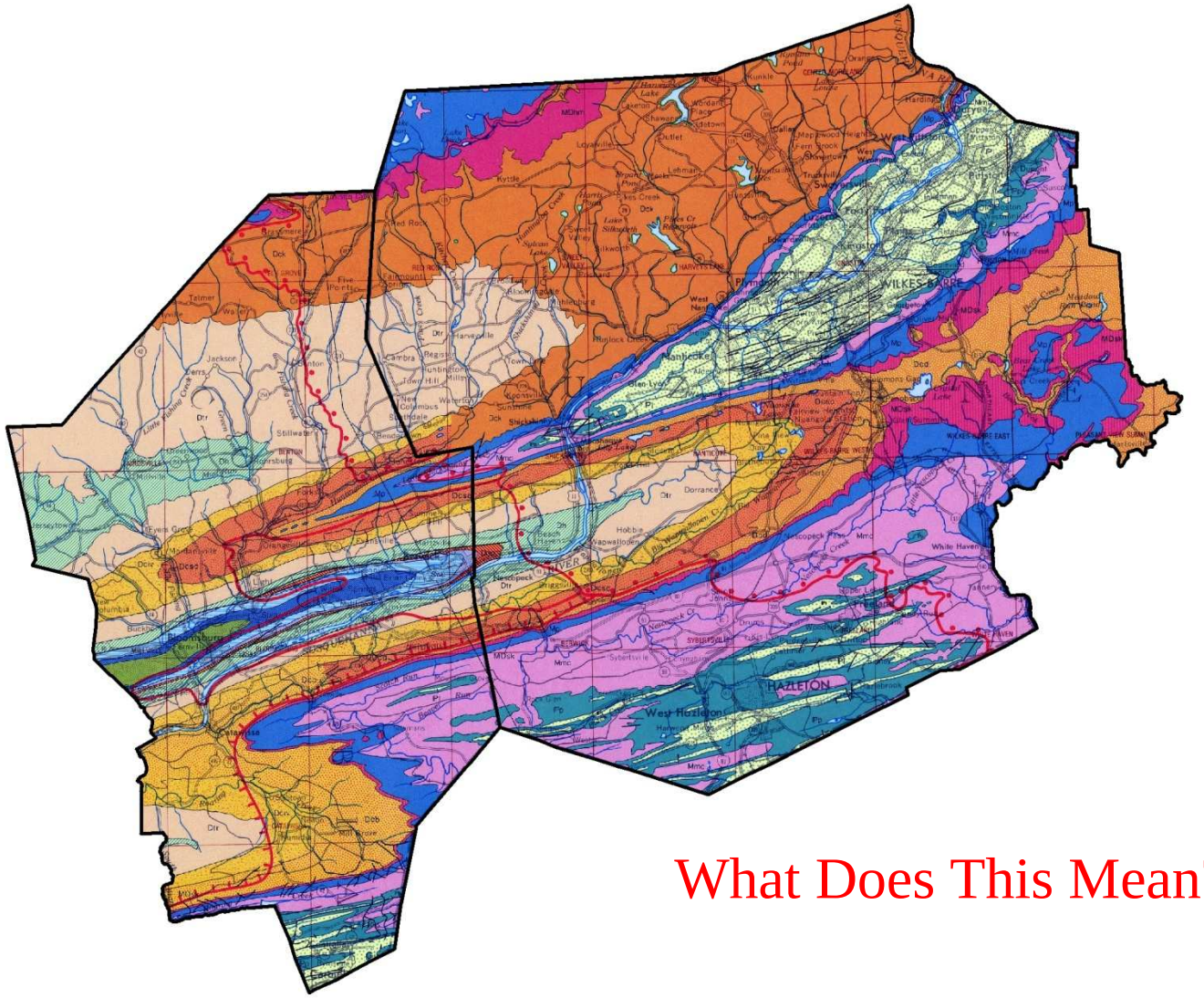


Columbia and Luzerne Counties were glaciated and they are within the Appalachian Plateau and the Ridge and Valley Provinces

Source: DCNR - http://www.dcnr.state.pa.us/topogeo/map13/map13.aspx

WILKES UNIVERSITY

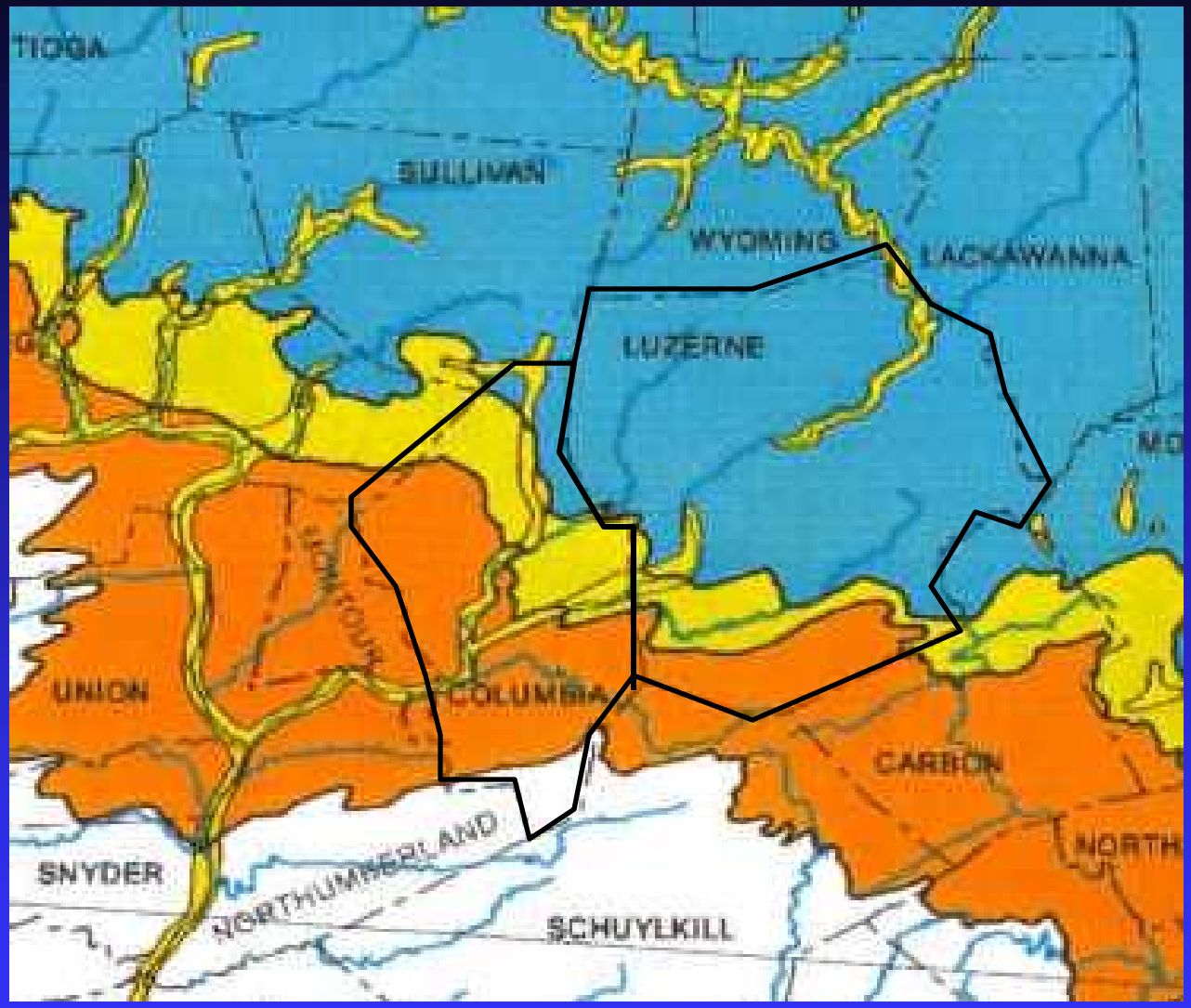
G E O L O G Y



What Does This Mean?

Source: Luzernecounty.org

GLACIATION



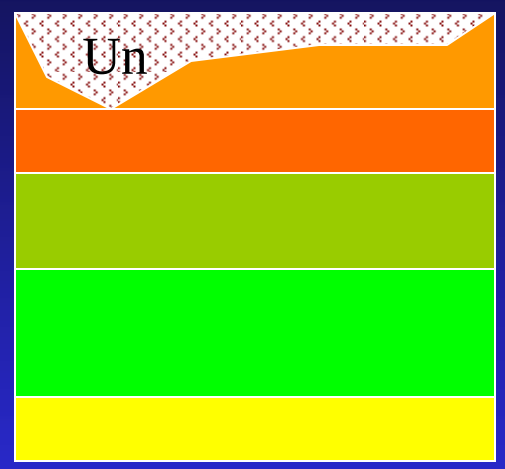
Wisconsinan (17,000 to 22,000 yrs)
Late-Illinoian (132,000 – 198,000 yrs)
Pre-Illinoian (> 770,00 yrs)

Source: DCNR - http://www.dcnr.state.pa.us

Appalachian Plateau Province

- Broad to Narrow Valleys
- Rounded Hills and Valleys Associated with Glaciation
- Valleys filled by glacial fluvial material

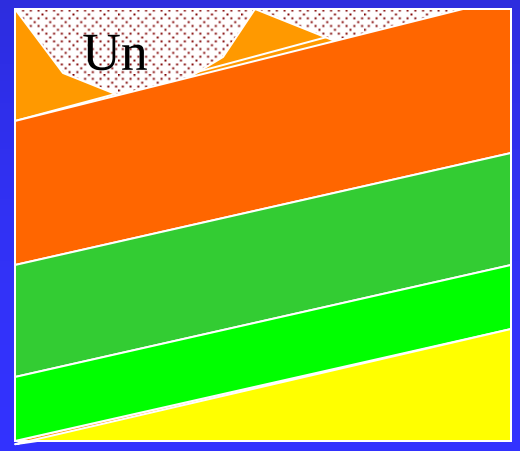
Unconsolidated Material (Un)



Younger (Y)

Older (O)

Y ← O

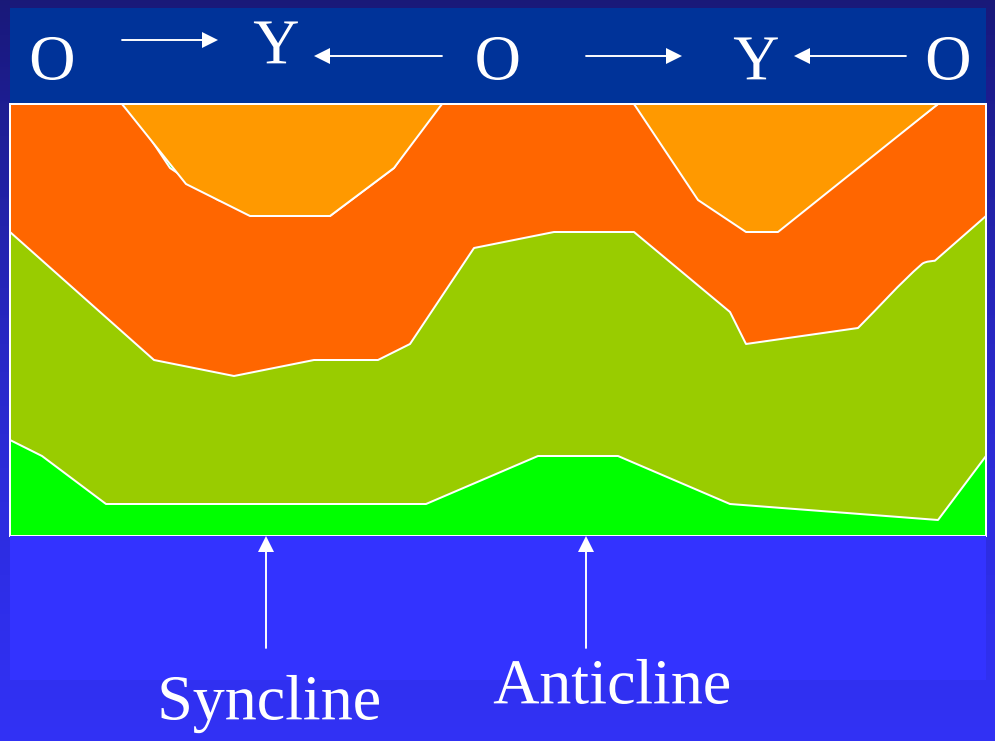


Y

O

Ridge and Valley Province

- Bedrock has been folded into a series of anticline and synclinal structures.



Edge Ridge and Valley Province – Rt 309- Dallas, PA

B.F. Environmental Consultants Inc.
Environmental Scientists, Hydrogeologists, & Environmental Education Specialists
Located in Northeastern Pennsylvania
water reuse hydrogeology soil testing

Mahantango Formation

Source: flickr.com/photos/ (ID –stillriverside)- Site Milford, PA

Marcellus Shale Photo

Main Fracture Orientation

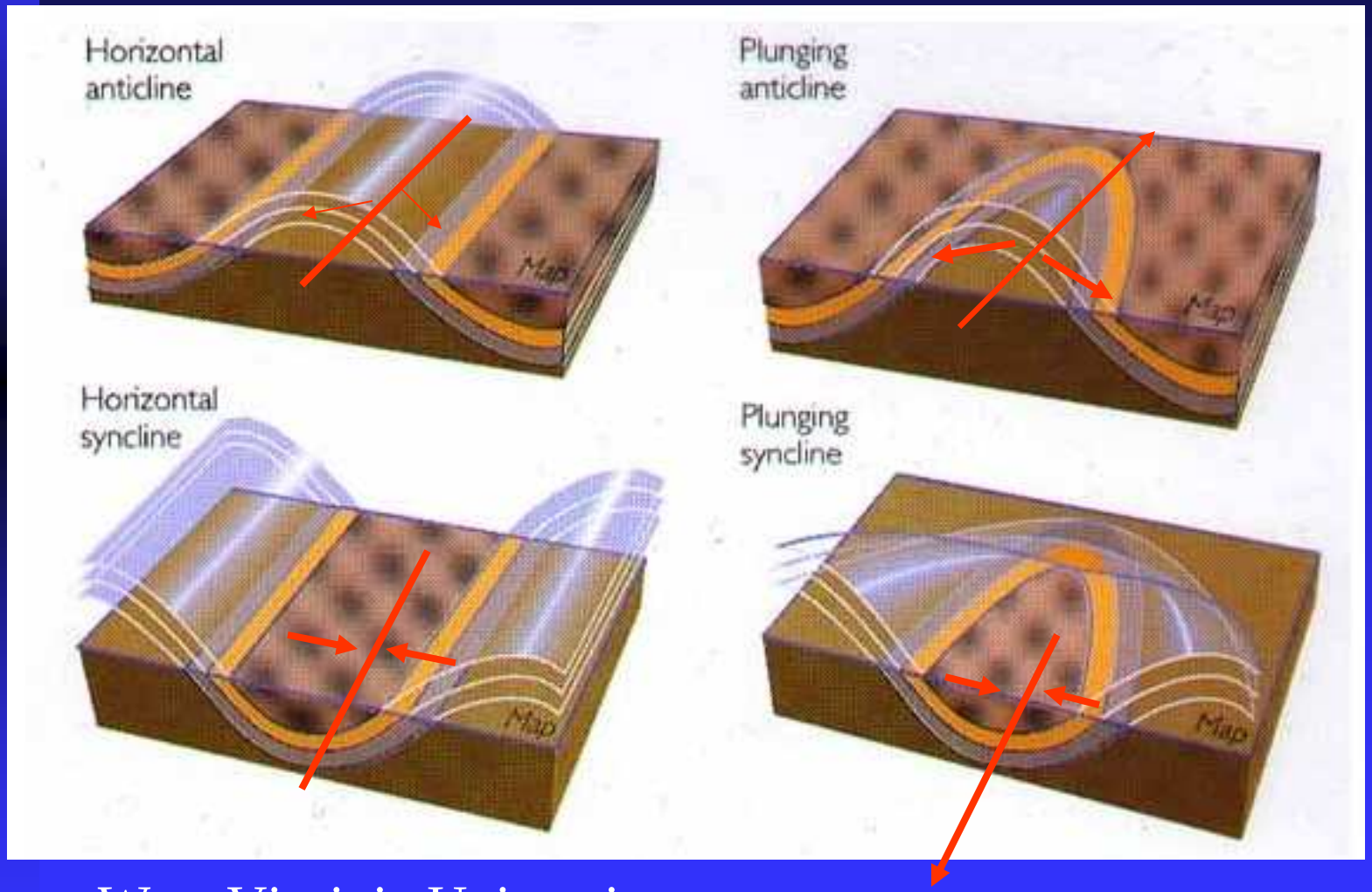
Outcrops Along the Southeastern Border of Pike County Along Route 209

Geological Sequence – Northeast PA

OLDER

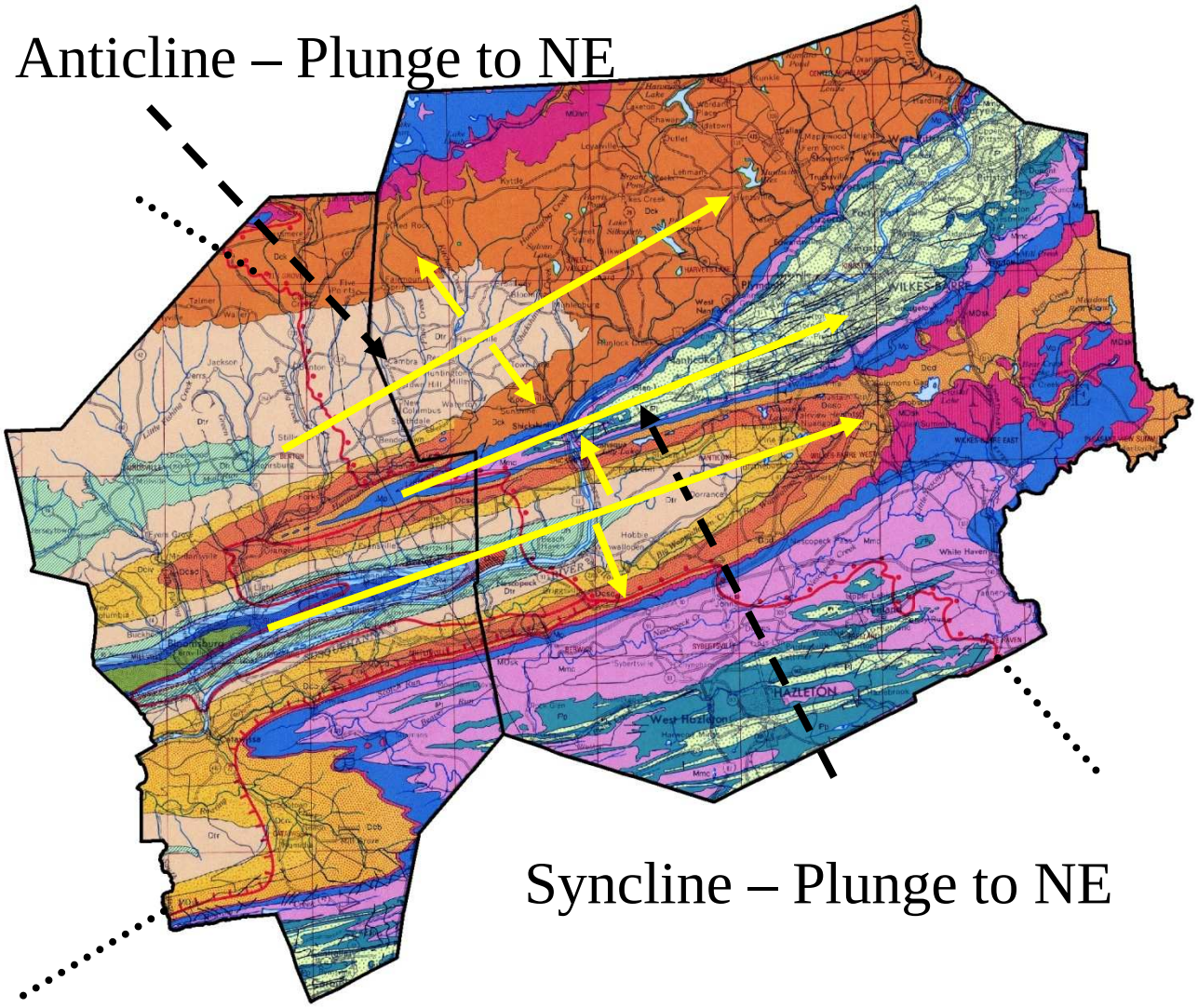
Time	Period	Deposit or Rock Type
0 to 1.8 million years	Quaternary – Glaciation	sand, silt, clay, and gravel
1.8 to 290 million	Tertiary to Permian	**Not present (eroded and weathered)**
290 – 320 million	Pennsylvanian	**Llewellyn (coal) and Pottsville (minor coal)**
320 – 354 million	Mississippian	**Mauch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

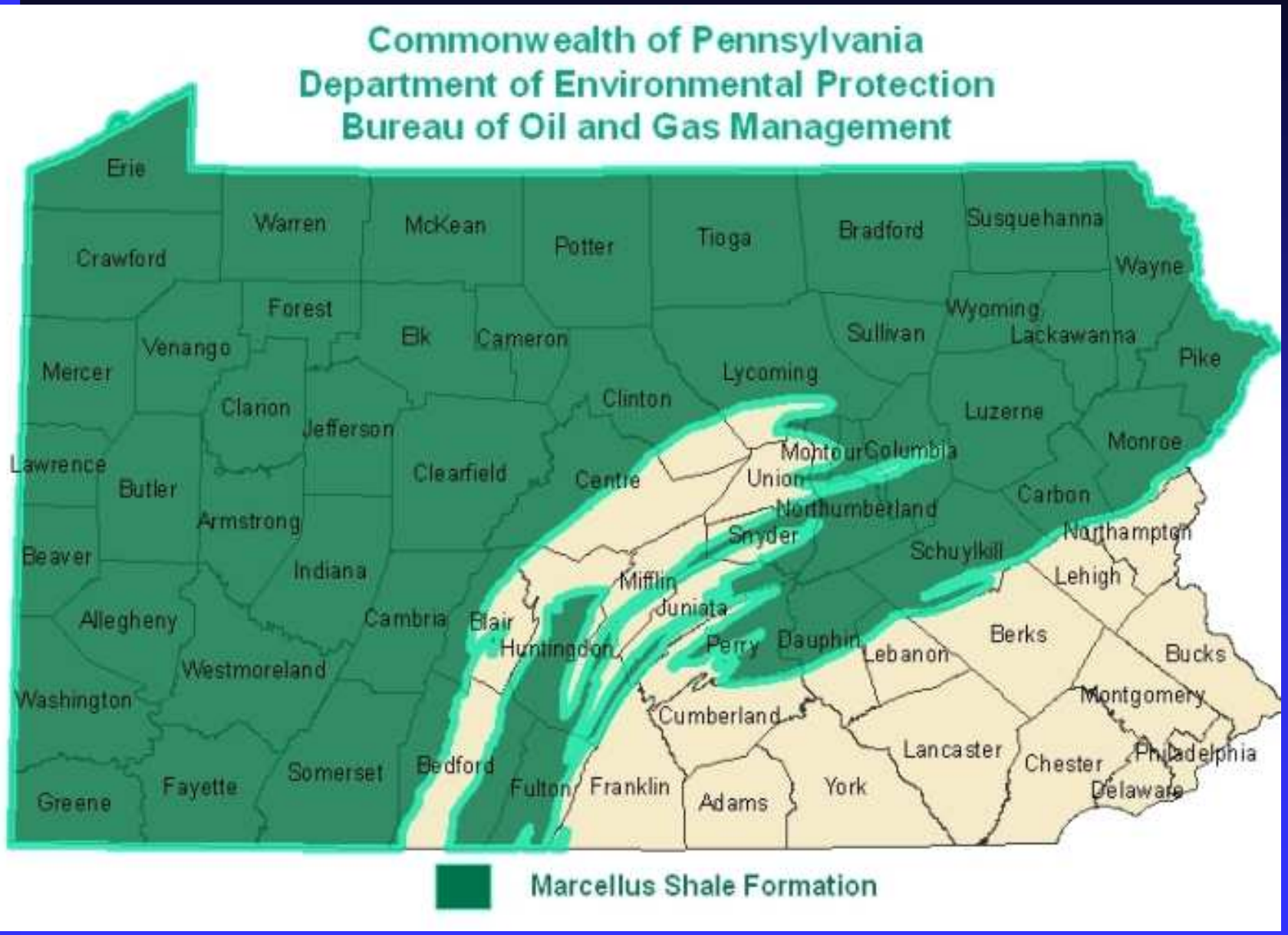
Plunging Anticlines / Synclines



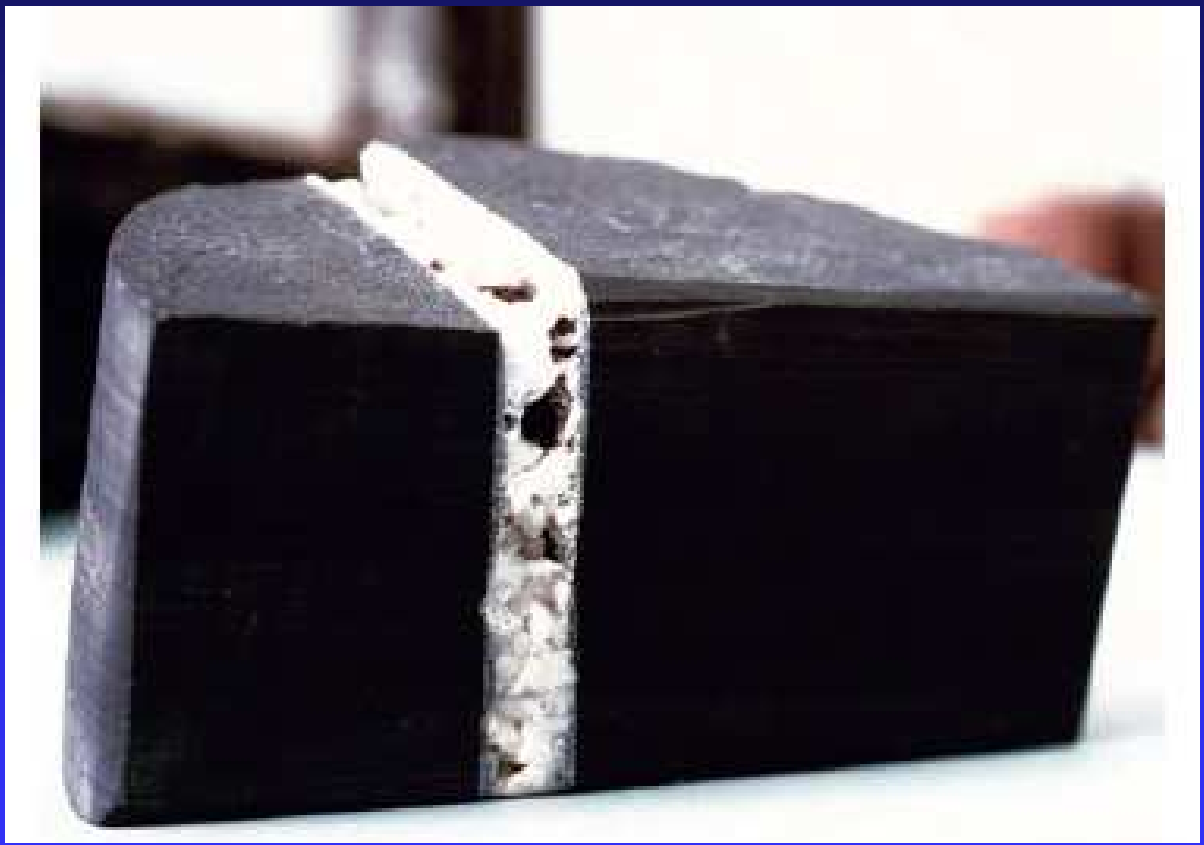
Source: West Virginia University
http://www.geo.wvu.edu

Geology of Columbia and Luzerne County



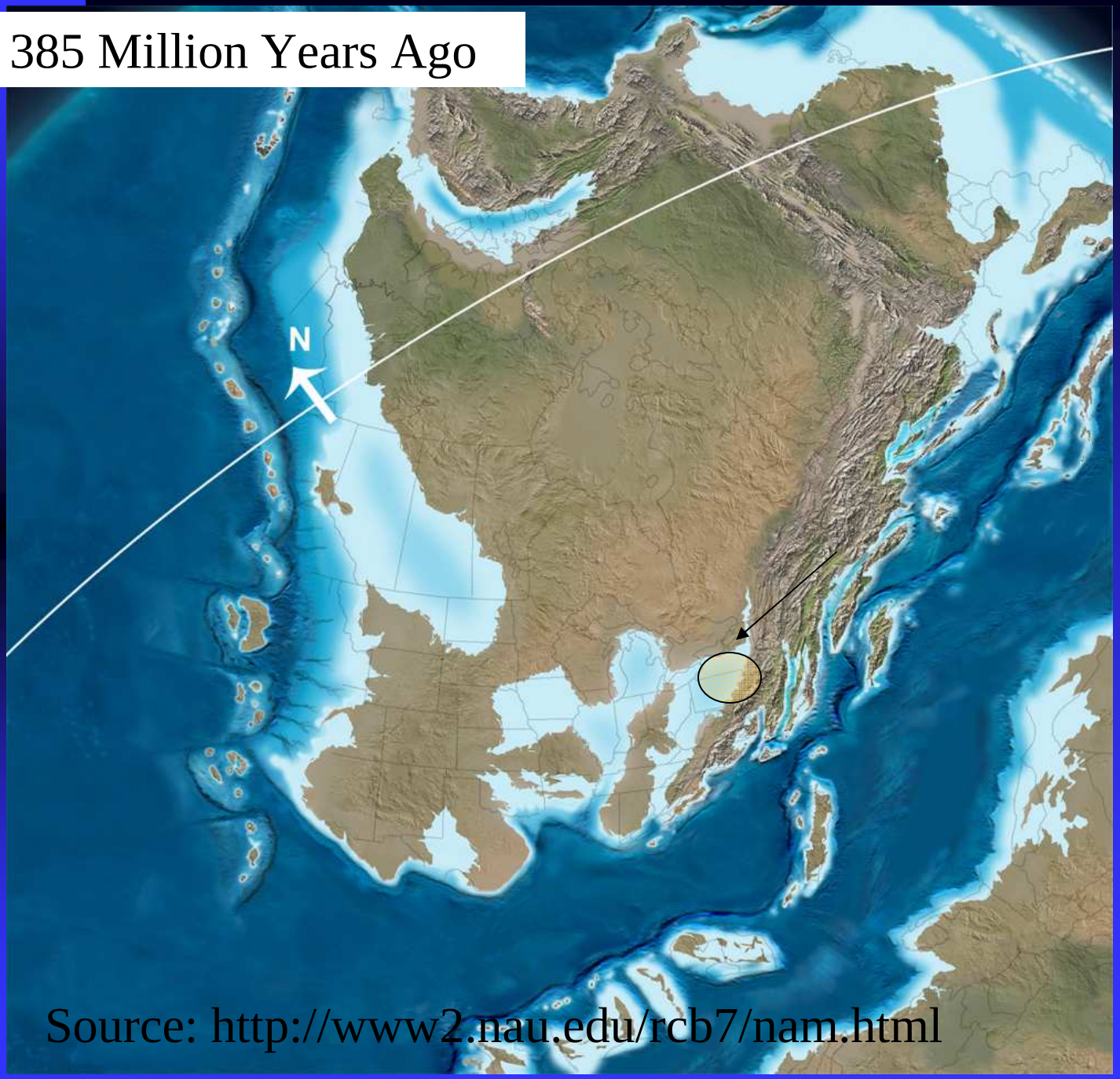

Commonwealth of Pennsylvania
Department of Environmental Protection
Bureau of Oil and Gas Management
Erie
Warren
McKean
Potter
Tioga
Bradford
Susquehanna
Wayne
Crawford
Forest
Elk
Cameron
Sullivan
Wyoming
Lackawanna
Pike
Venango
Mercer
Clanon
Jefferson
Clinton
Lycoming
Luzerne
Monroe
Lawrence
Butler
Clearfield
Centre
Union
Carbon
Armstrong
Northumberland
Snyder
Northampton
Beaver
Indiana
Schuylkill
Lehigh
Mifflin
Juniata
Allegheny
Cambria
Blair
Huntingdon
Perry
Dauphin
Lebanon
Berks
Bucks
Westmoreland
Washington
Cumberland
Montgomery
Lancaster
Chester
Philadelphia
Delaware
Greene
Fayette
Somerset
Bedford
Fulton
Franklin
Adams
York
Marcellus Shale Formation

Marcellus Shale



This is Causing all the Concern?

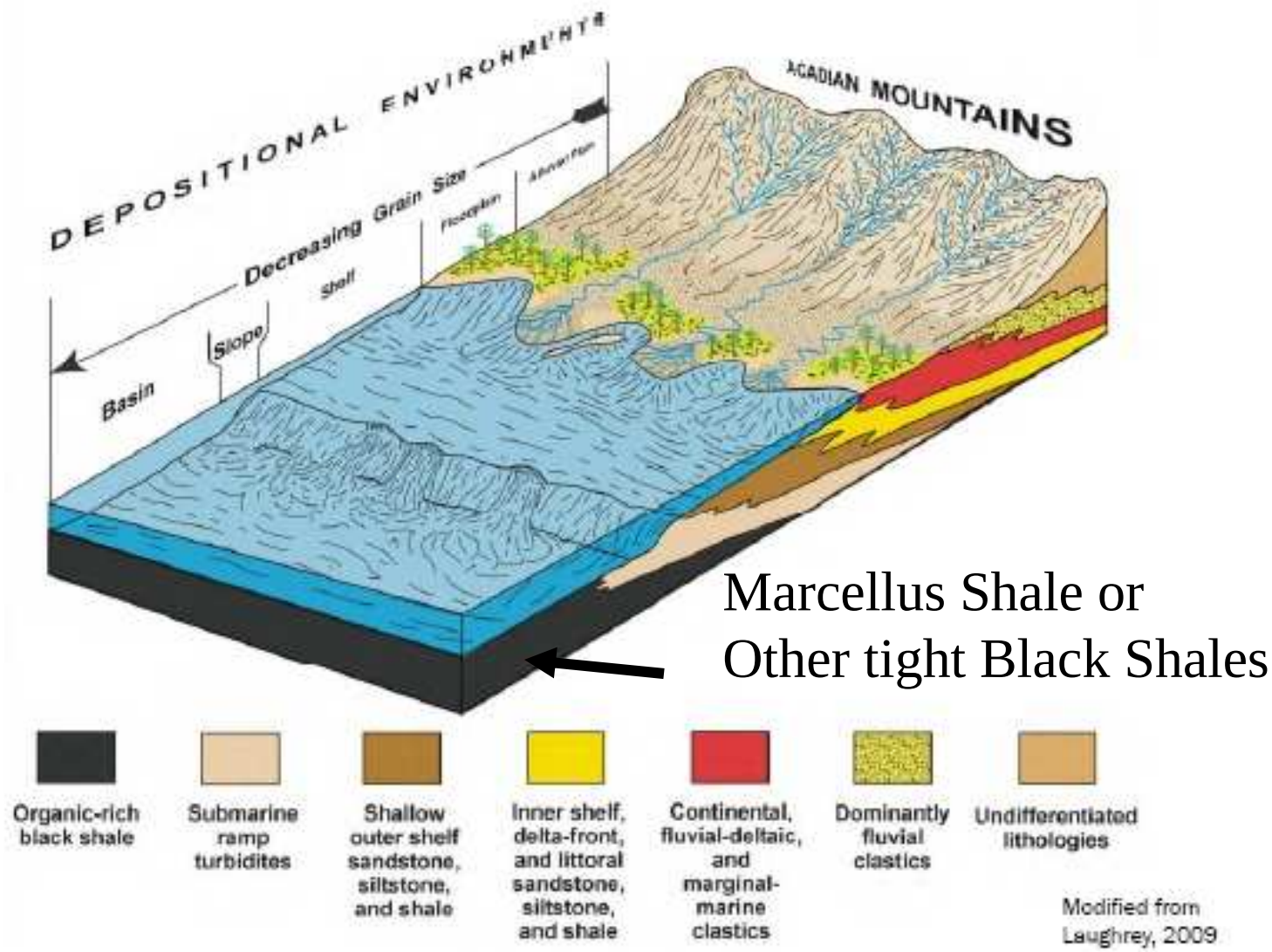
385 Million Years Ago



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

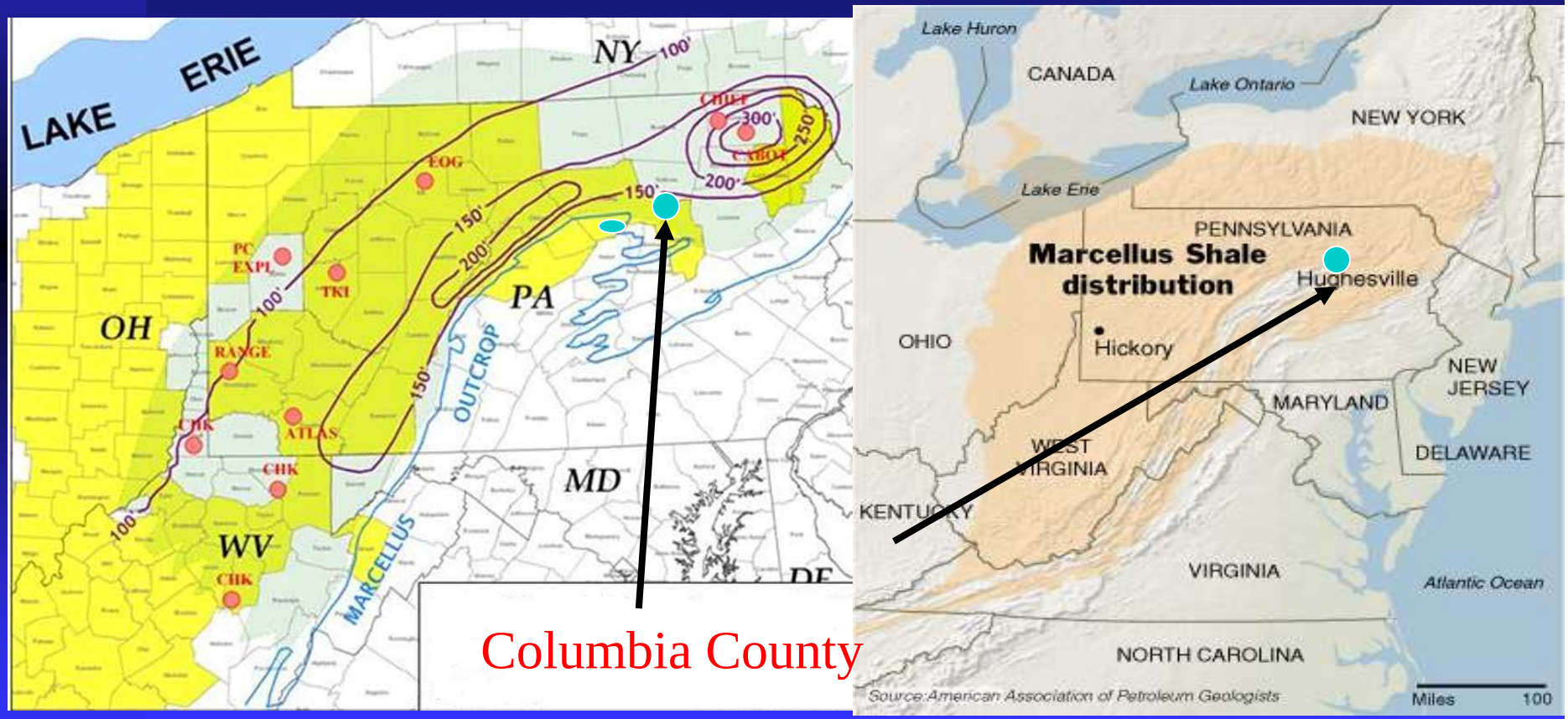
Barkley, 2009

DEVONIAN DEPOSITIONAL ENVIRONMENTS



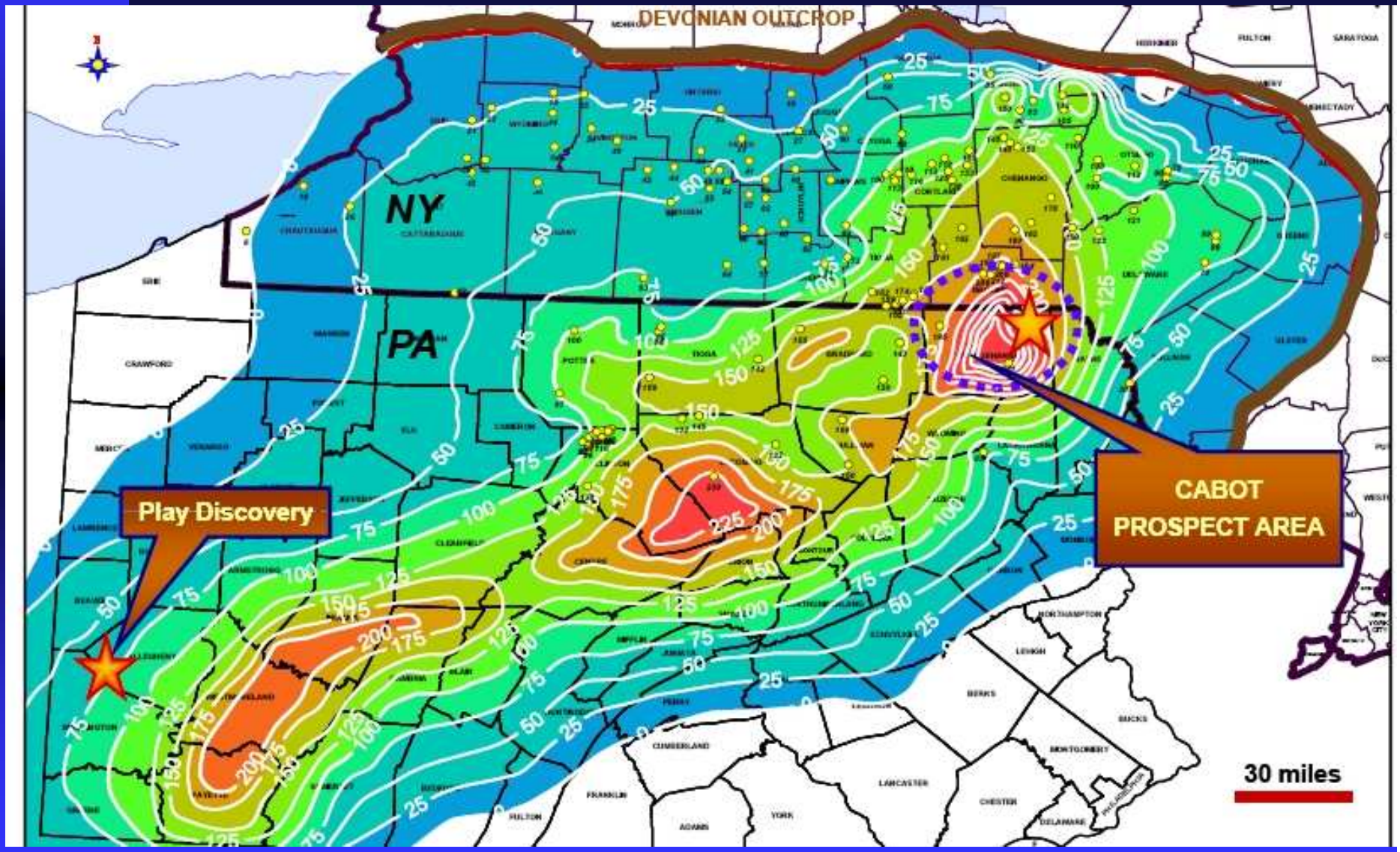
Modified from Laughrey, 2009

Marcellus Shale- Natural Gas Play
50 to 200 trillion cubic feet



Shale may be 150+ feet thick- The Grapevine is saying 200 to 300 feet

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



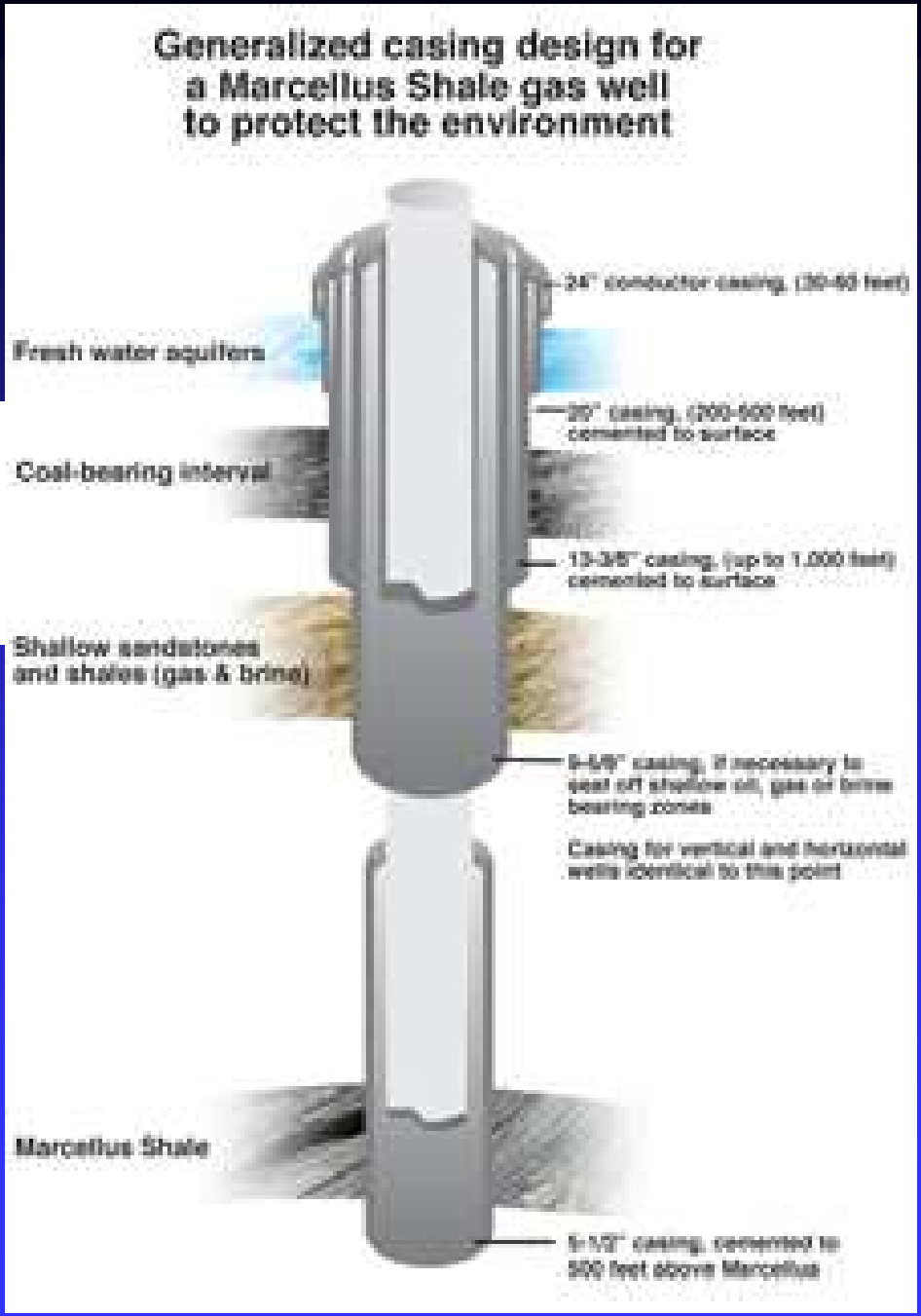
Source- Cabot – Marcellus Shale Thickness Map

- Marcellus Shale Development
  - Drilling
  - Casing
  - Cement
  - What are the weaknesses?
  - What are the contaminants of concern?
  - Where to monitor?

Marcellus Shale Drilling Site

Pads can be 5+ acres – but one pad may support drilling multiple horizontal wells.

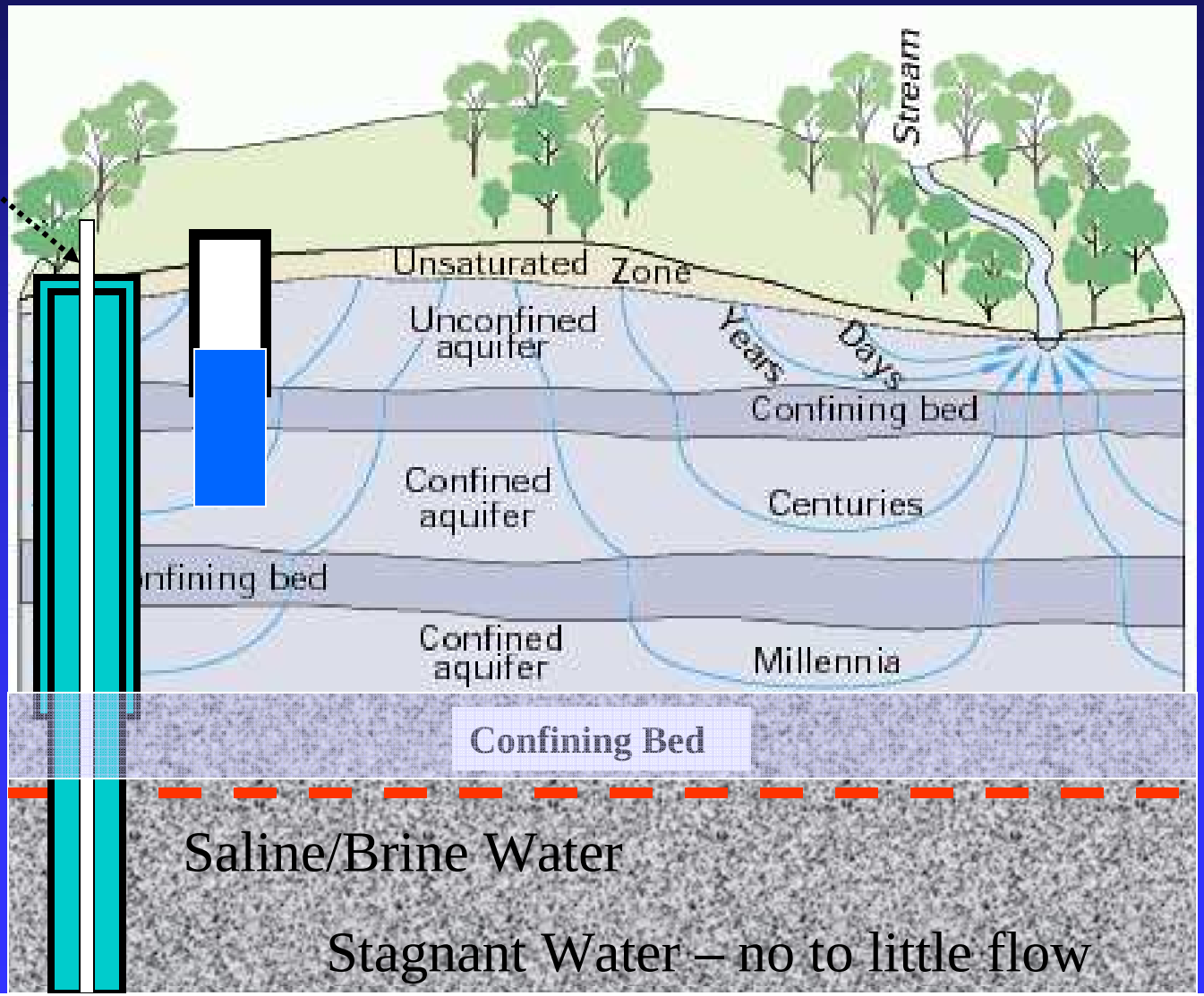
Multiple Grouted Casing Used in Drilling Process



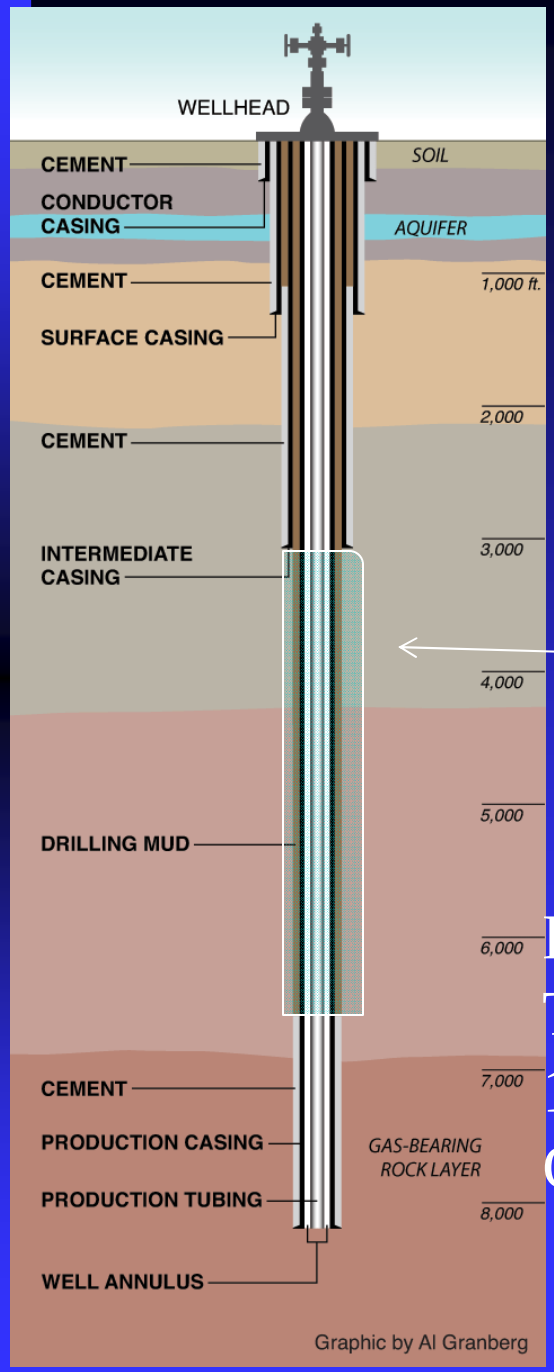
Protective Casing – Do it Right !

Photos do not show centralizers – very critical

Properly Constructed Wells and Ideal Natural Gas Wells



Sea Level

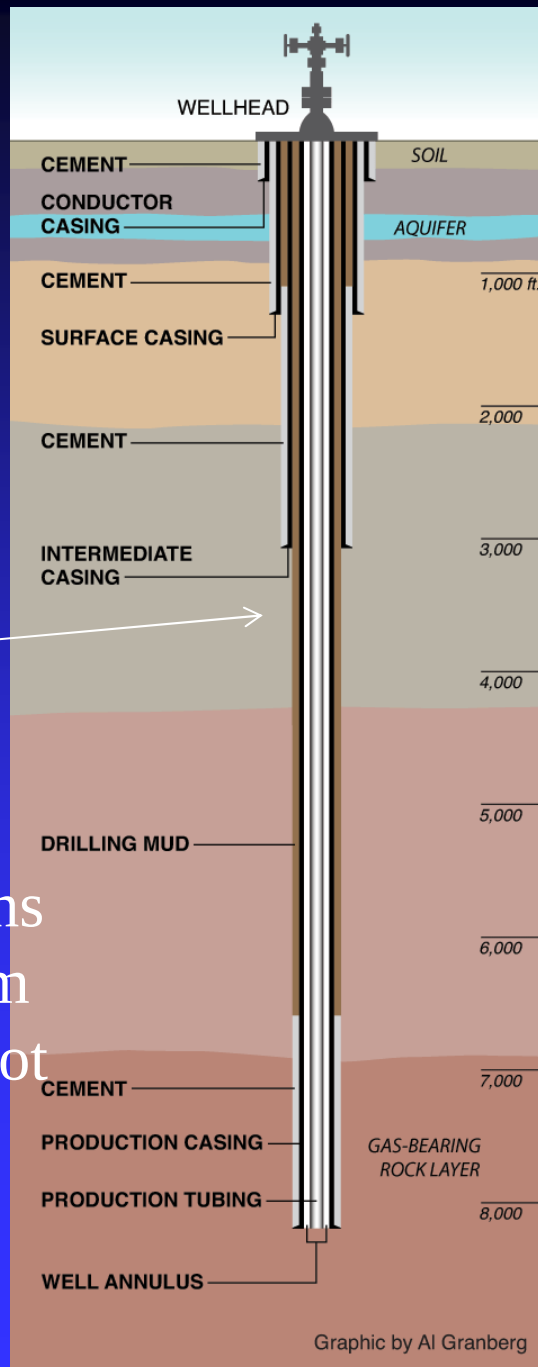


Typical Well

Additional Cemented Zones

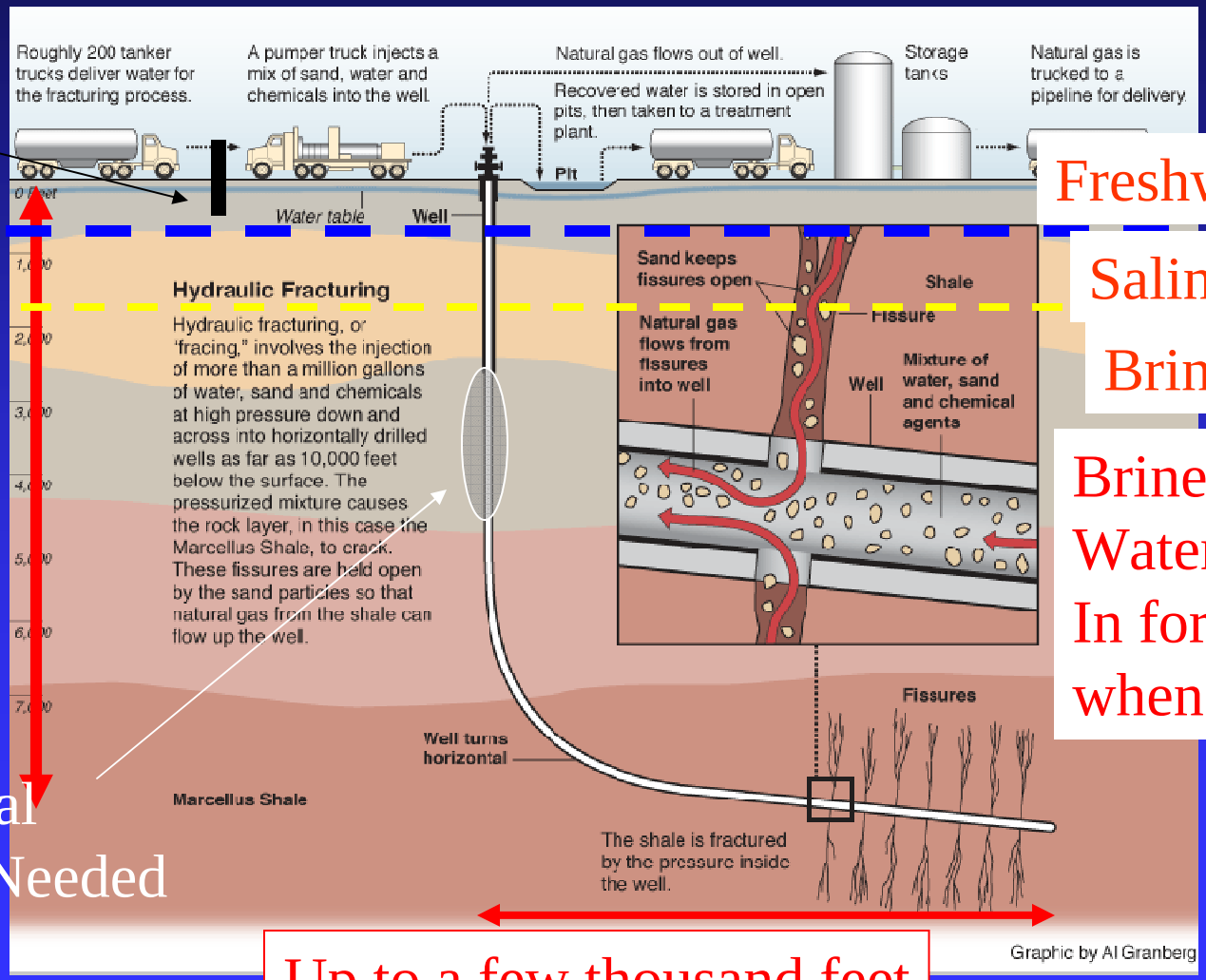
This Zone should be cemented

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



Getting to The Natural Gas

Freshwater Well



Freshwater

Saline

Brine

Brine / connate Water- Trapped In formation when deposited

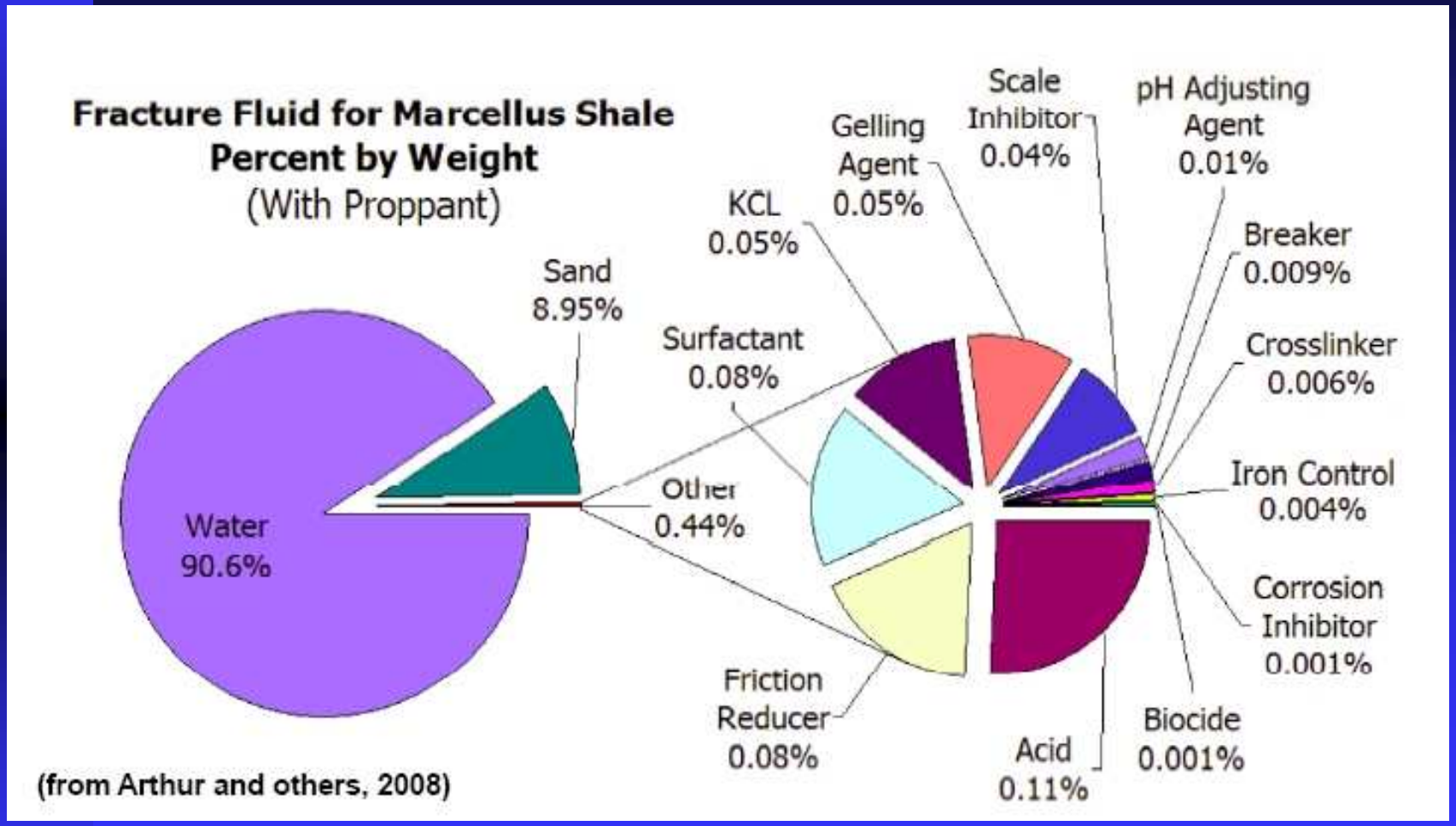
5000 to 7000 feet

Additional Cement Needed

Up to a few thousand feet

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.



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 probably 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.

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		

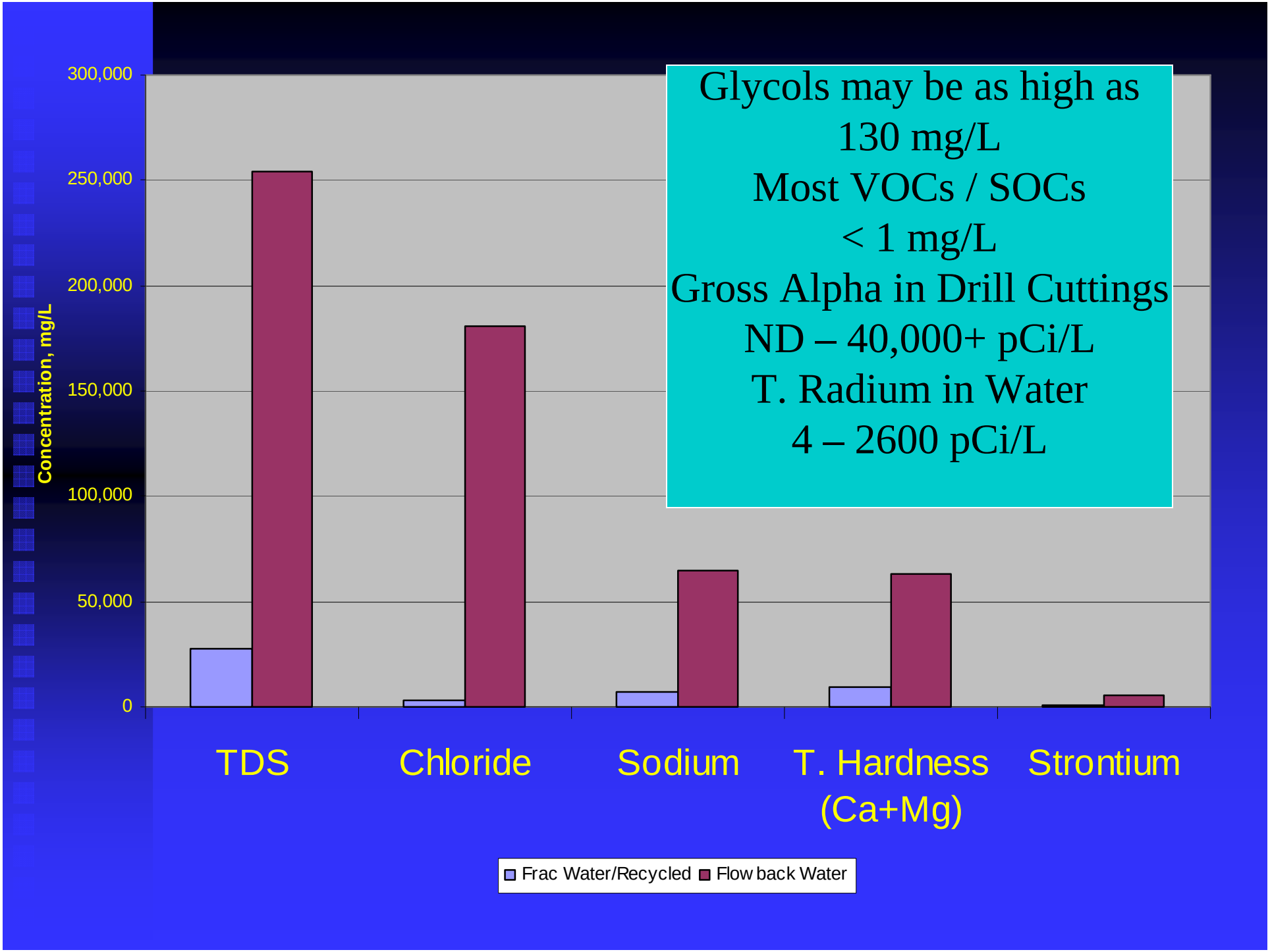
May contain elevated levels of trace metals, nitrogen, bromide, uranium, and hydrocarbons. Most of the dissolved solids includes chloride and sodium.

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

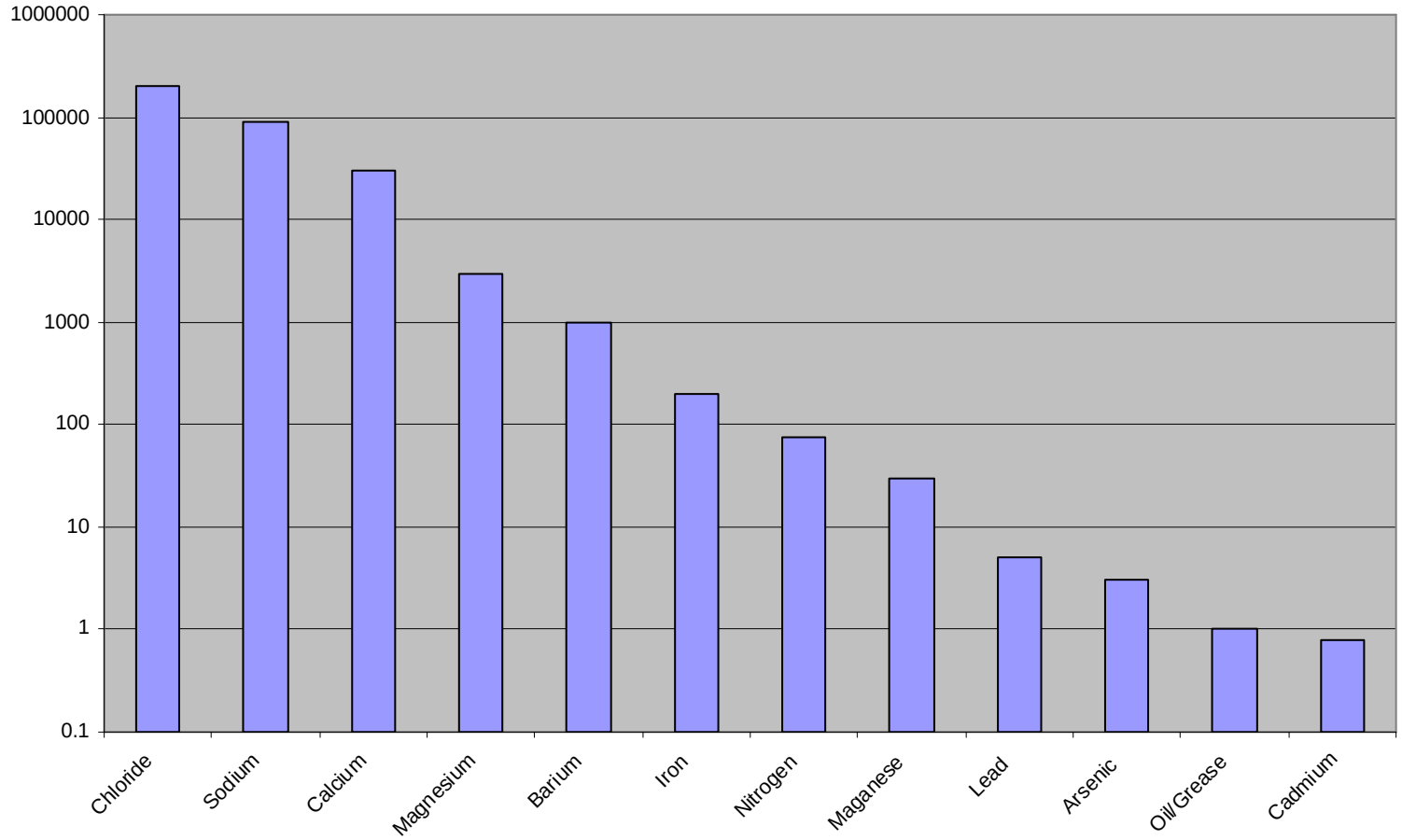
Available Frac Water (Includes Recycled) Chemistry

Parameter	Units	Concentration	PWS	MultipleAbove 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- 150**
Gross Beta	mrem/yr (Sr)	38.65	4	10
Radium 228	pCi/L	18.55	5	**4 – 500**
Radium 226	pCi/L	69.63	5	**14 - 500**

http://www.prochemtech.com/- updated by Brian Oram


Glycols may be as high as
130 mg/L
Most VOCs / SOCs
< 1 mg/L
Gross Alpha in Drill Cuttings
ND – 40,000+ pCi/L
T. Radium in Water
4 – 2600 pCi/L
Concentration, mg/L
300,000
250,000
200,000
150,000
100,000
50,000
0
TDS
Chloride
Sodium
T. Hardness (Ca+Mg)
Strontium
Frac Water/Recycled
Flow back Water

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

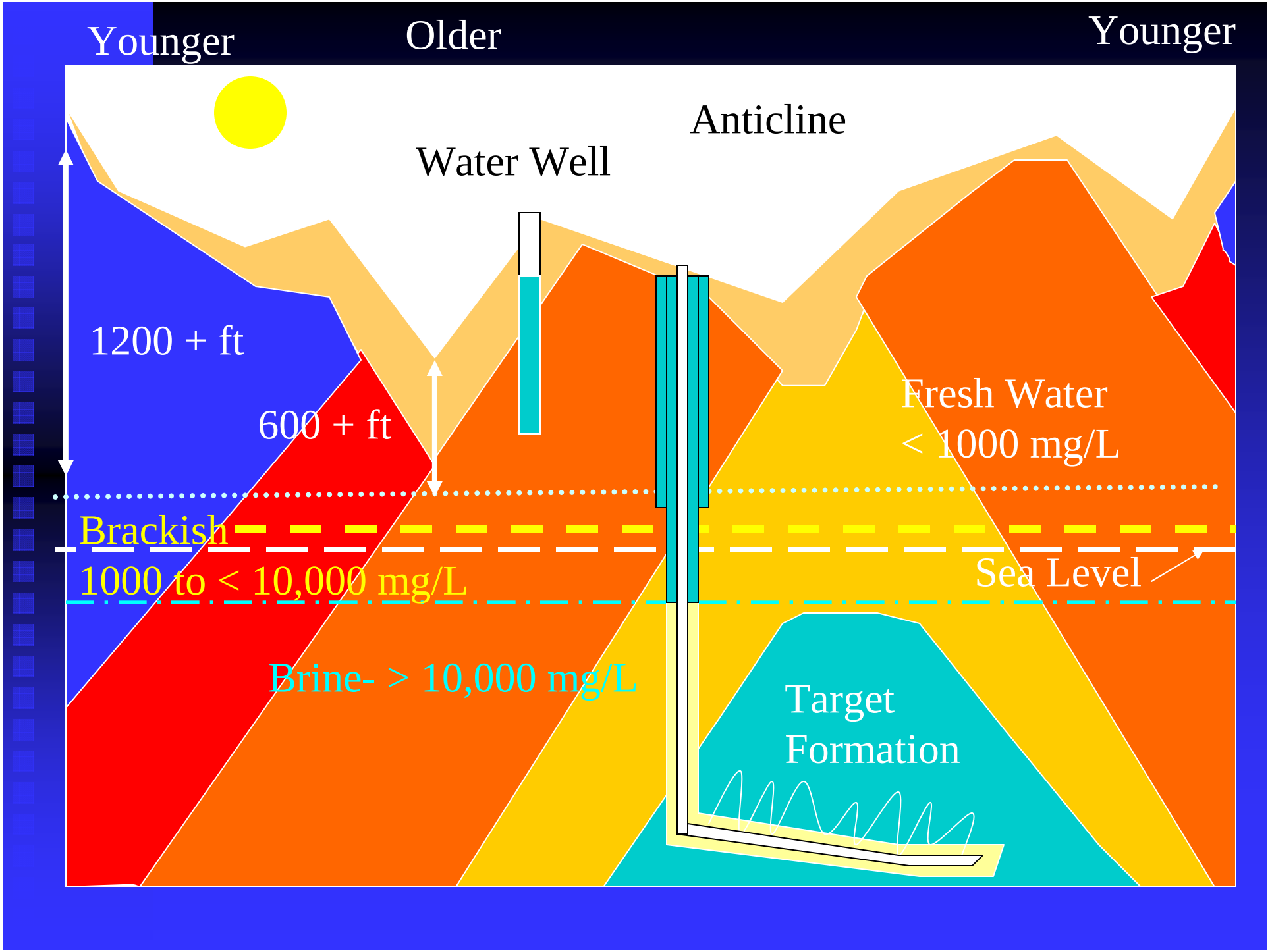


More Data can be found at http://www.bfenvironmental.com

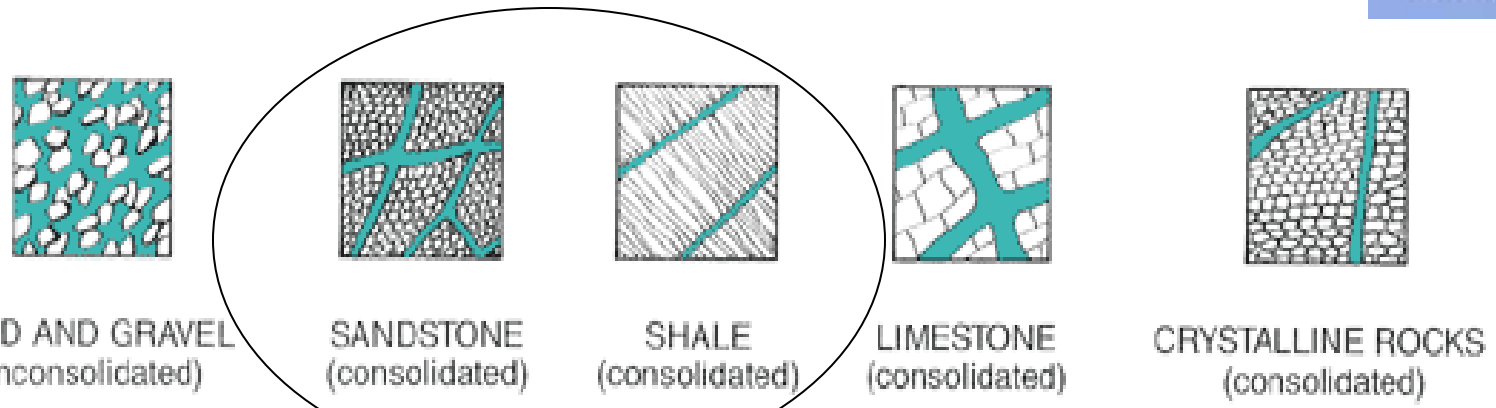
Researching other parameters

Concerns Related to Marcellus Shale

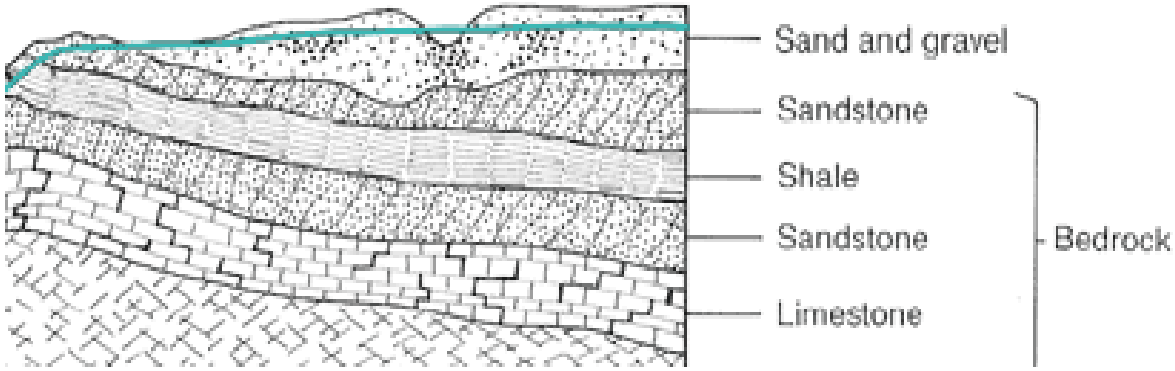
- In general, the concerns are related to the following:
  - Surface Spills and Releases Near Surface
  - Methane Gas Migration
  - Pushes and Slugs associated with Improper Cementing and not Properly Sealing the Existing Confining Layers
  - Improper Disposal of Brines
  - Freshwater Aquifer Contamination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


Younger
Older
Younger
Anticline
Water Well
1200 + ft
600 + ft
Fresh Water
< 1000 mg/L
Brackish
1000 to < 10,000 mg/L
Sea Level
Brine- > 10,000 mg/L
Target
Formation

Primary Aquifers in PA



Most Common Aquifers



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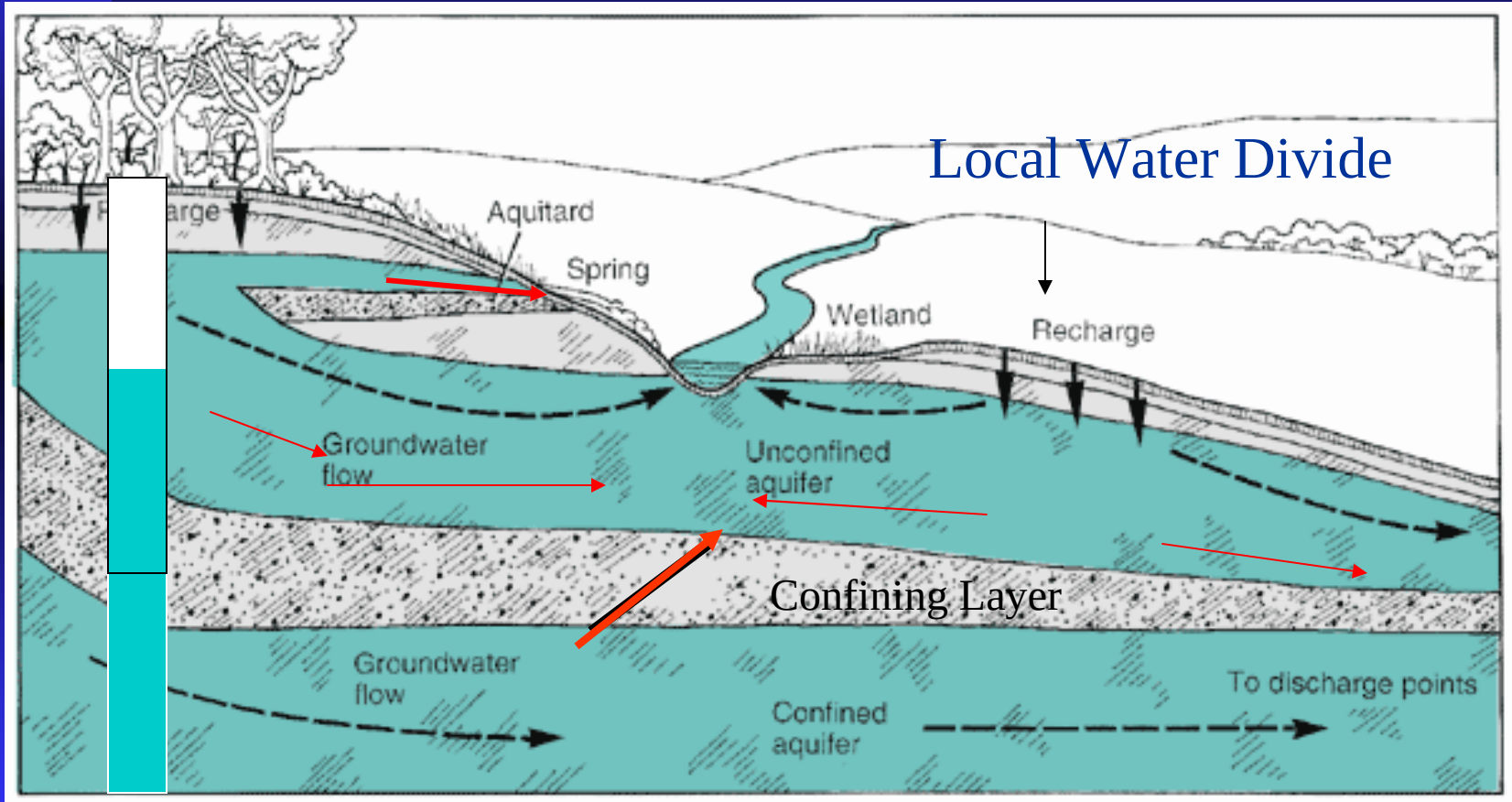
Surfacewater & Groundwater

They Are Related and Connected !



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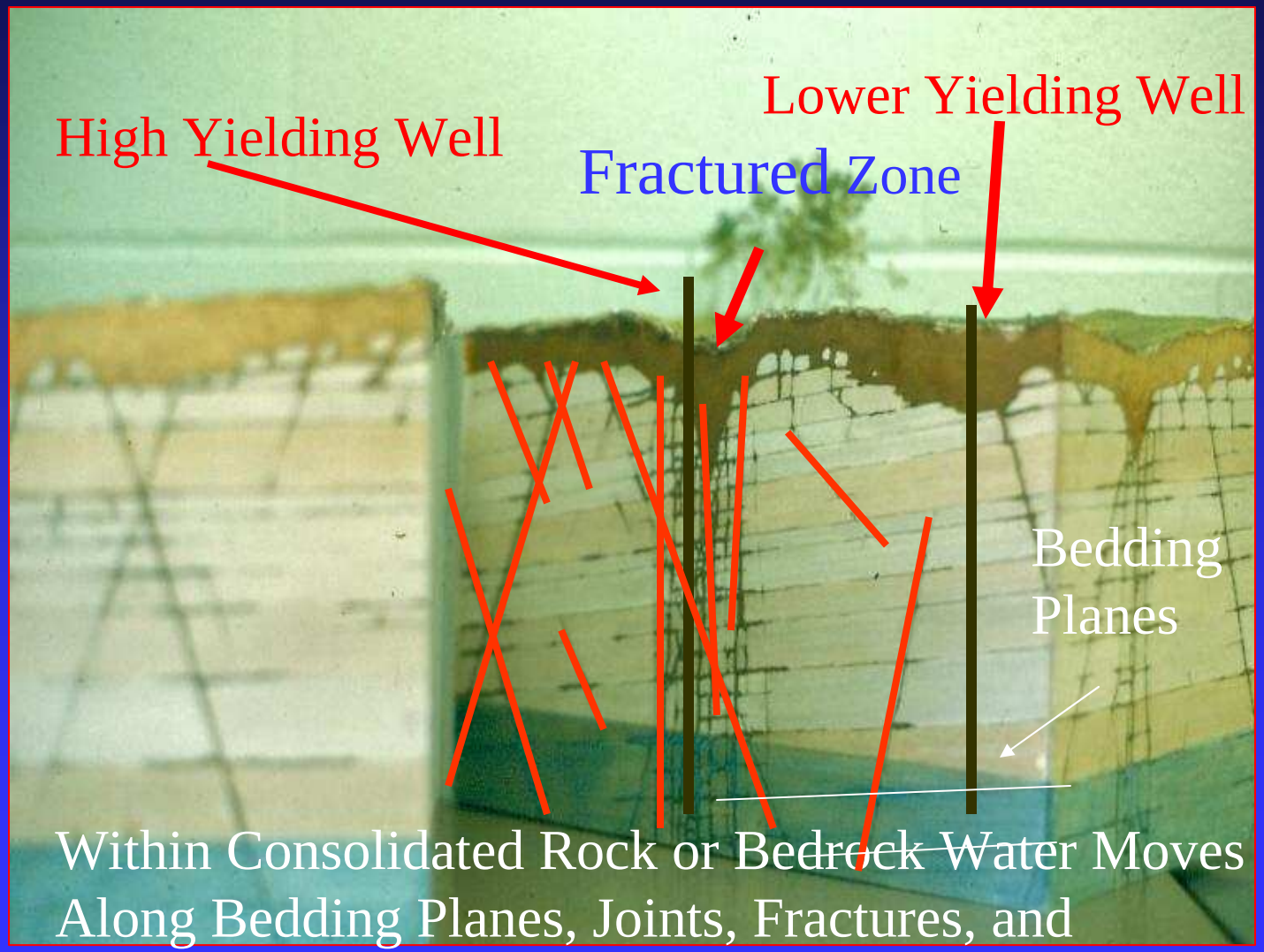
Bedrock Fractures and Fractured Zones



Within Consolidated Rock or Bedrock Water Moves Along Bedding Planes, Joints, Fractures, and Faults.

Private Wells/ Springs/ Water Systems in Pennsylvania

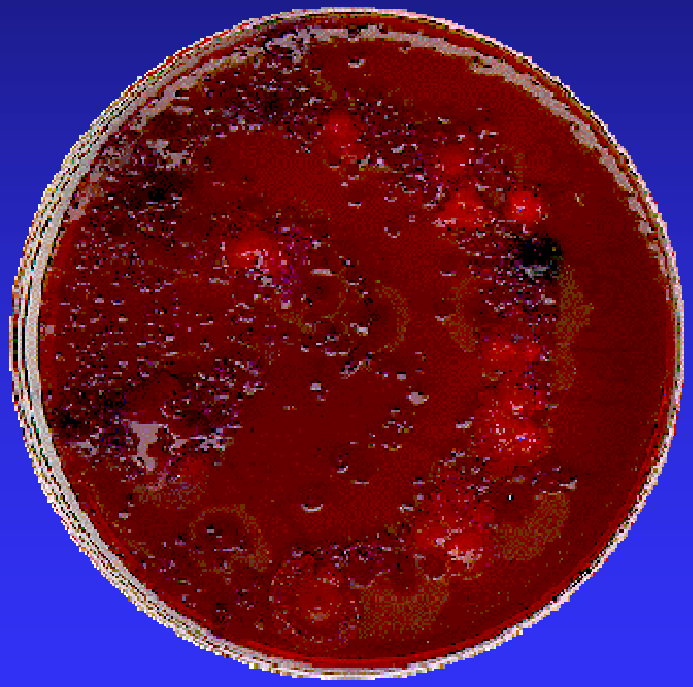
What ?

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

Groundwater Northeast Pennsylvania

Based on the geology of Northeast PA, 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 Elevated Sulfates

Methane – Yes Baseline Levels can be High - Predrilling

Air Quality Issues – Radon In Air !

Before Marcellus Shale Development What was the Quality of Private Well Water? Personal Observations

Impacts from Road Salt, Old Landfills, Gas Stations, Saline Water (1981 - 1985)

Bacterial Contamination and Well Construction Issues (1985)

Methane Gas Present in Wells in Northern Tier of PA and in parts of Columbia and Luzerne County, PA(Oram,1989).

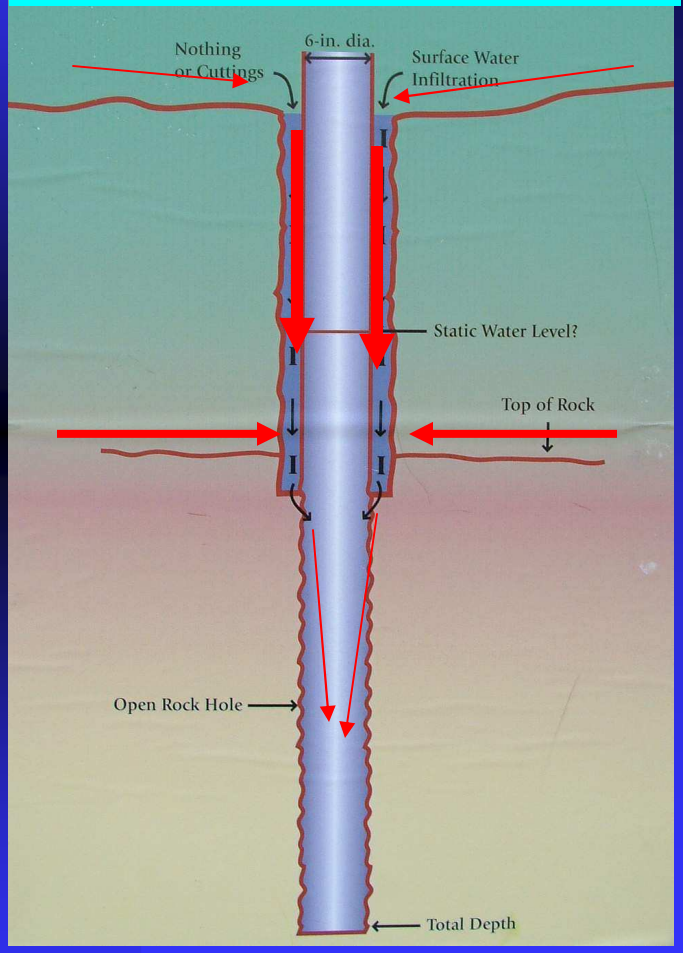
Testing Conducted by Wilkes University in throughout the United States indicates that 30 to over 50% may be contaminated – Mostly by Total Coliform Bacteria (1989 – 2011). Locally – it tends to be about 40 to 50%.

Most Contamination appears to be associated with Total Coliform Bacteria

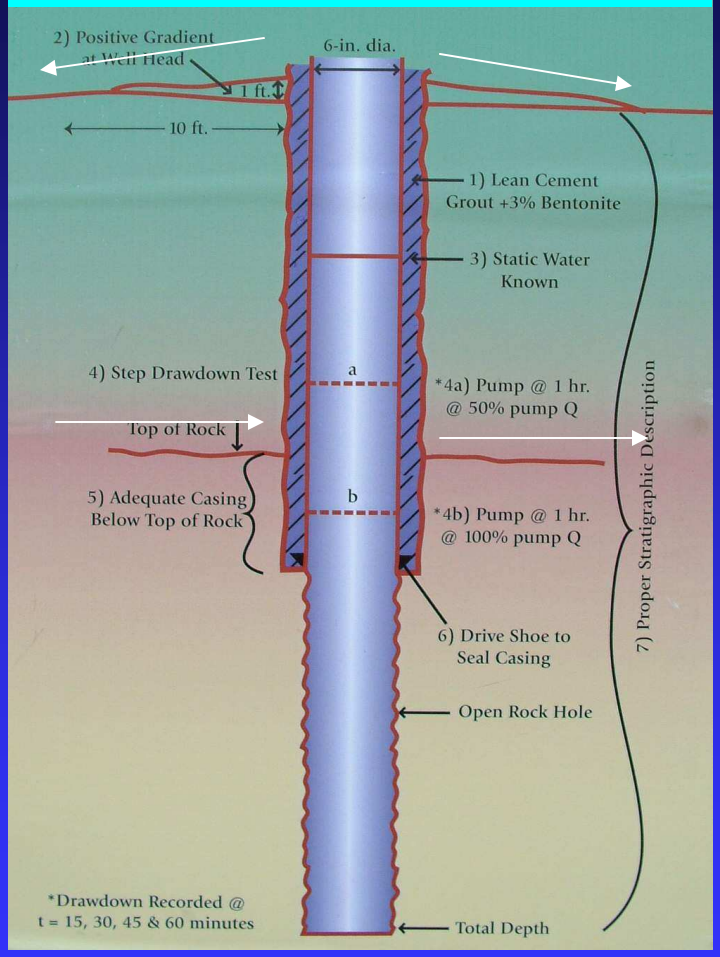
- Insects, Larvae and Nests / Egg Masses
- Mouse Colonies
- Snakes
- Beehives
- Mud - when casing to close to ground

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

An Ungrouted Residential Well

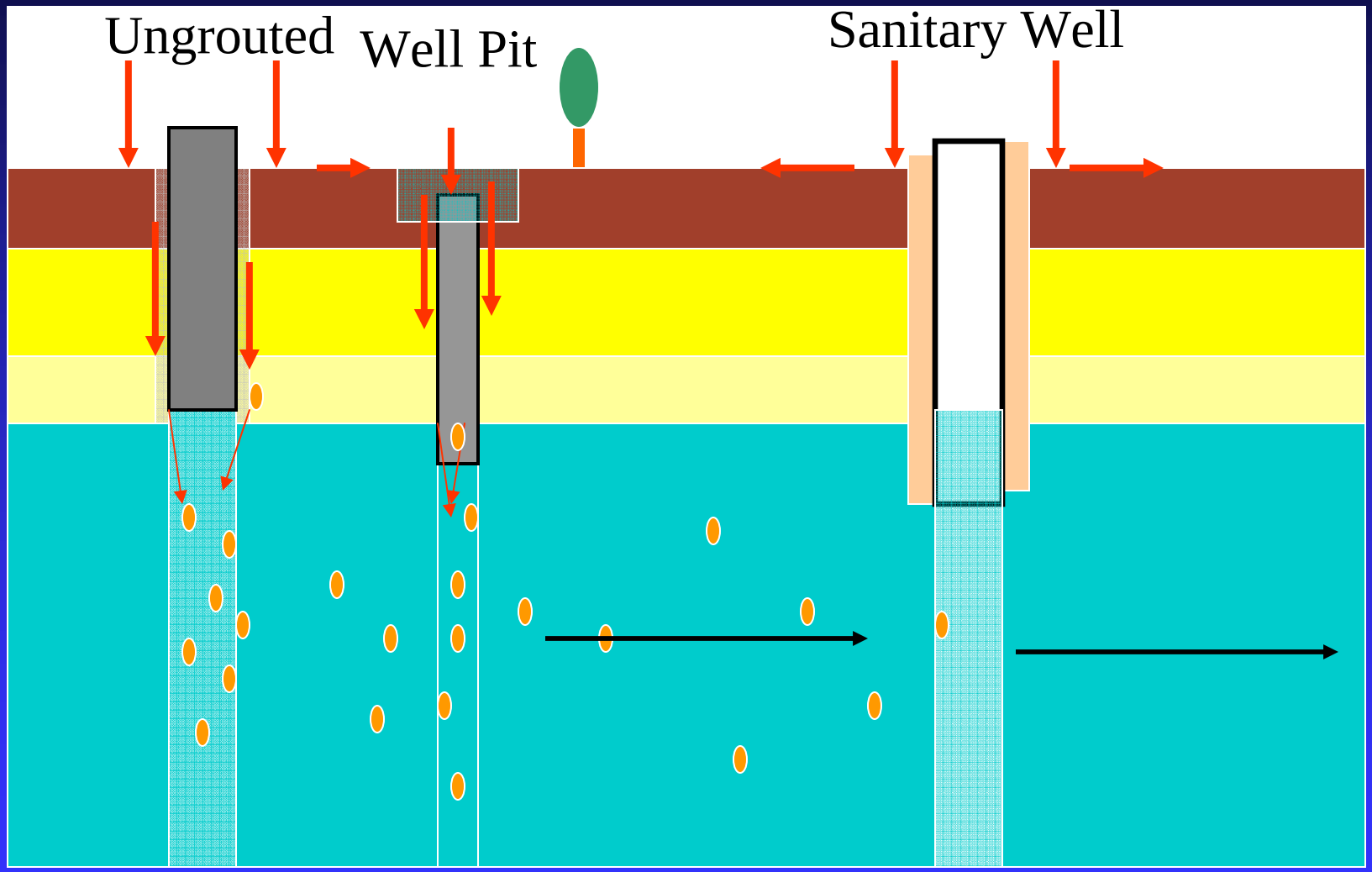


A Properly Grouted Well

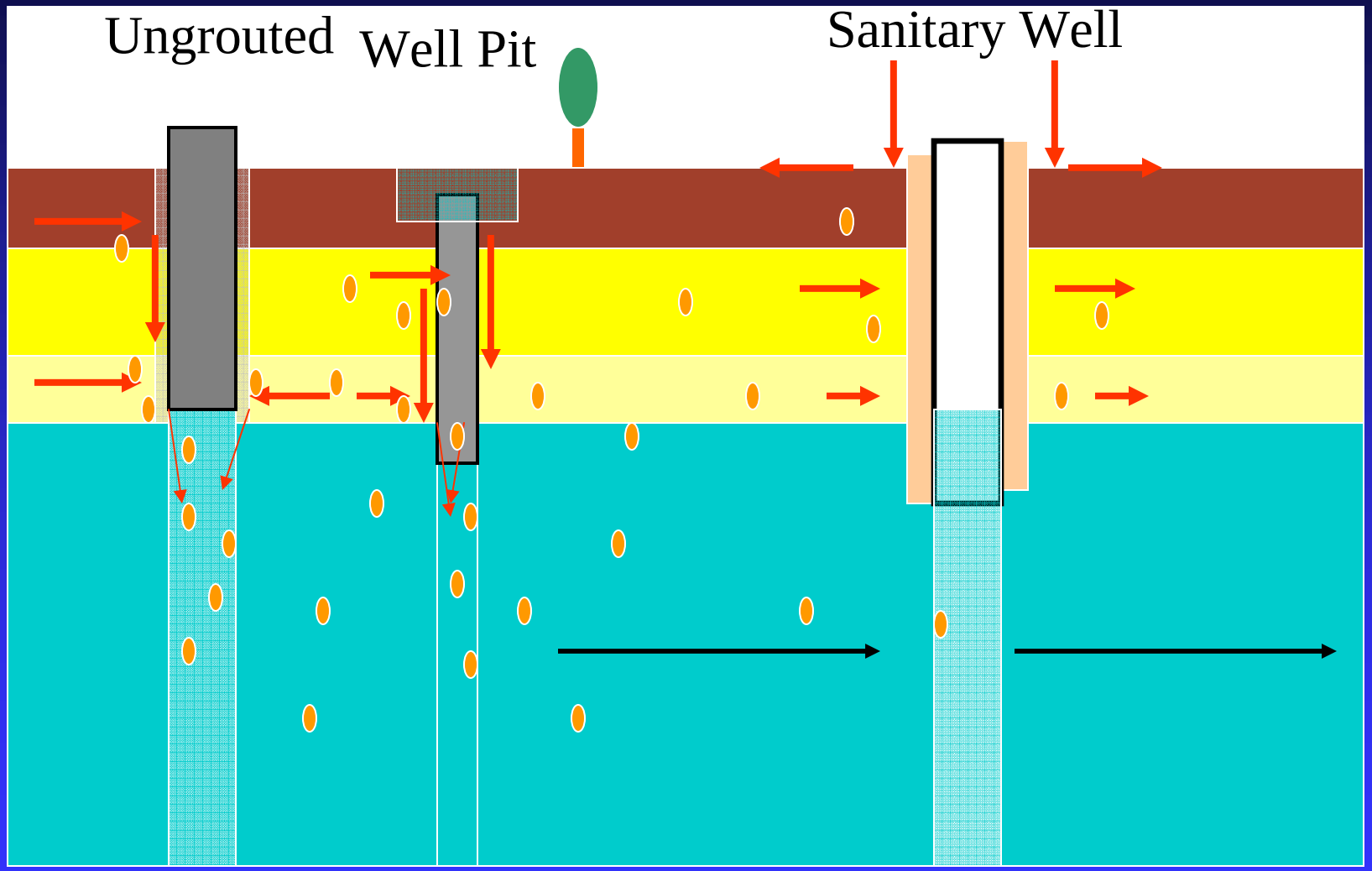


Source: Pennsylvania State University – Master Well Owner Program - Carbon County Groundwater Guardians (edited by Mr. Brian Oram)

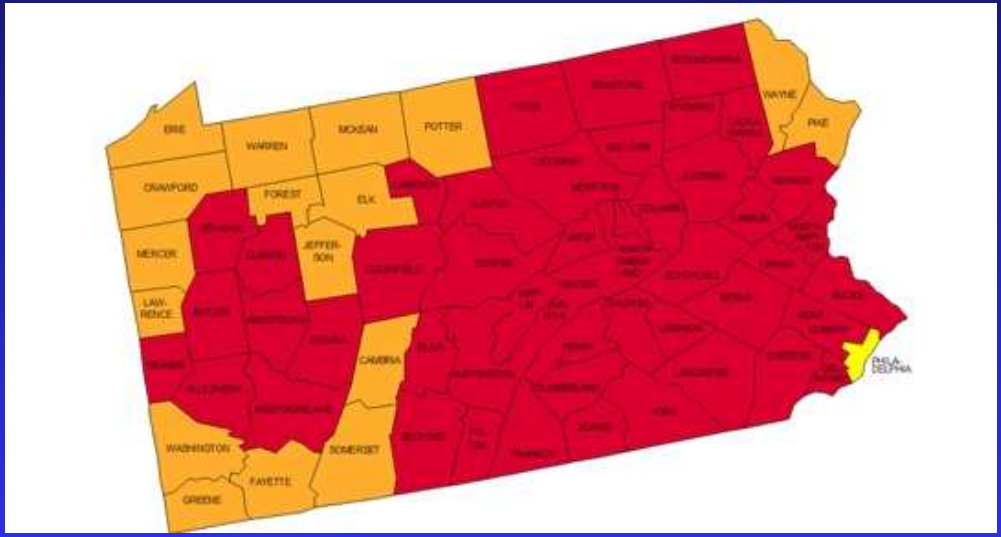
How Contaminants Can Get In to the Aquifer (Surface)



How Contaminants Can Get In to the Aquifer (Subsurface)



Radon (In Air)- PA



Columbia County and Many Other Counties are in the Red Zone – Suggests indoor air radon levels greater than 4 pCi/L

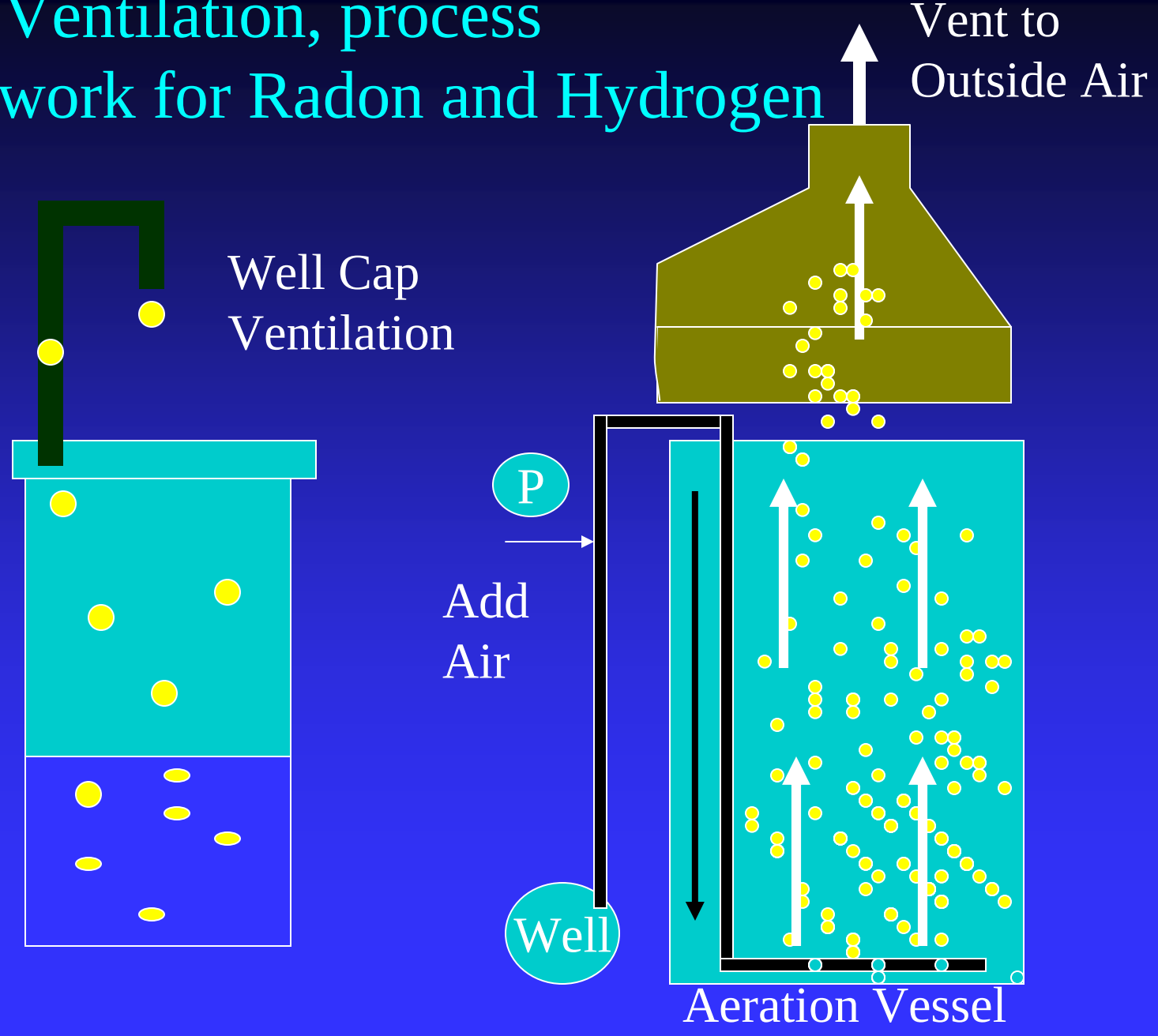
Methane in Water

- 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

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
- Primary treatment options would include ventilation or aeration systems.

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



- Baseline Testing – Documenting Conditions
- Citizen Database- Track Change
- Making Improvements – The Real Work !

Three Step Process

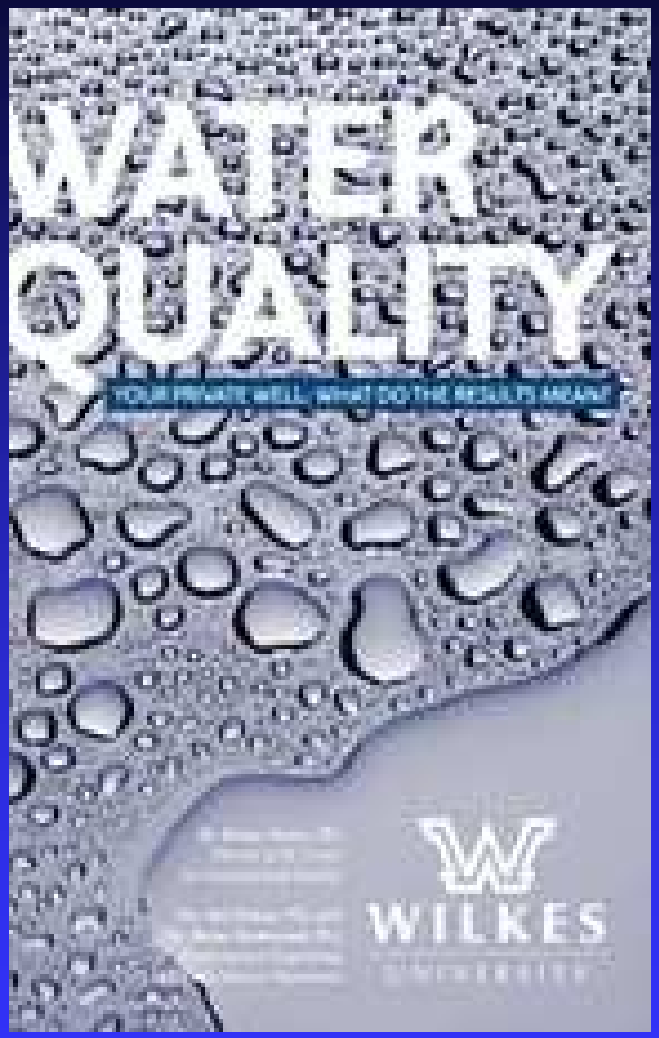
Step 1: Baseline Testing- Education and Need Good Data

- 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
  - Educating Private Well Owners and Explaining Results

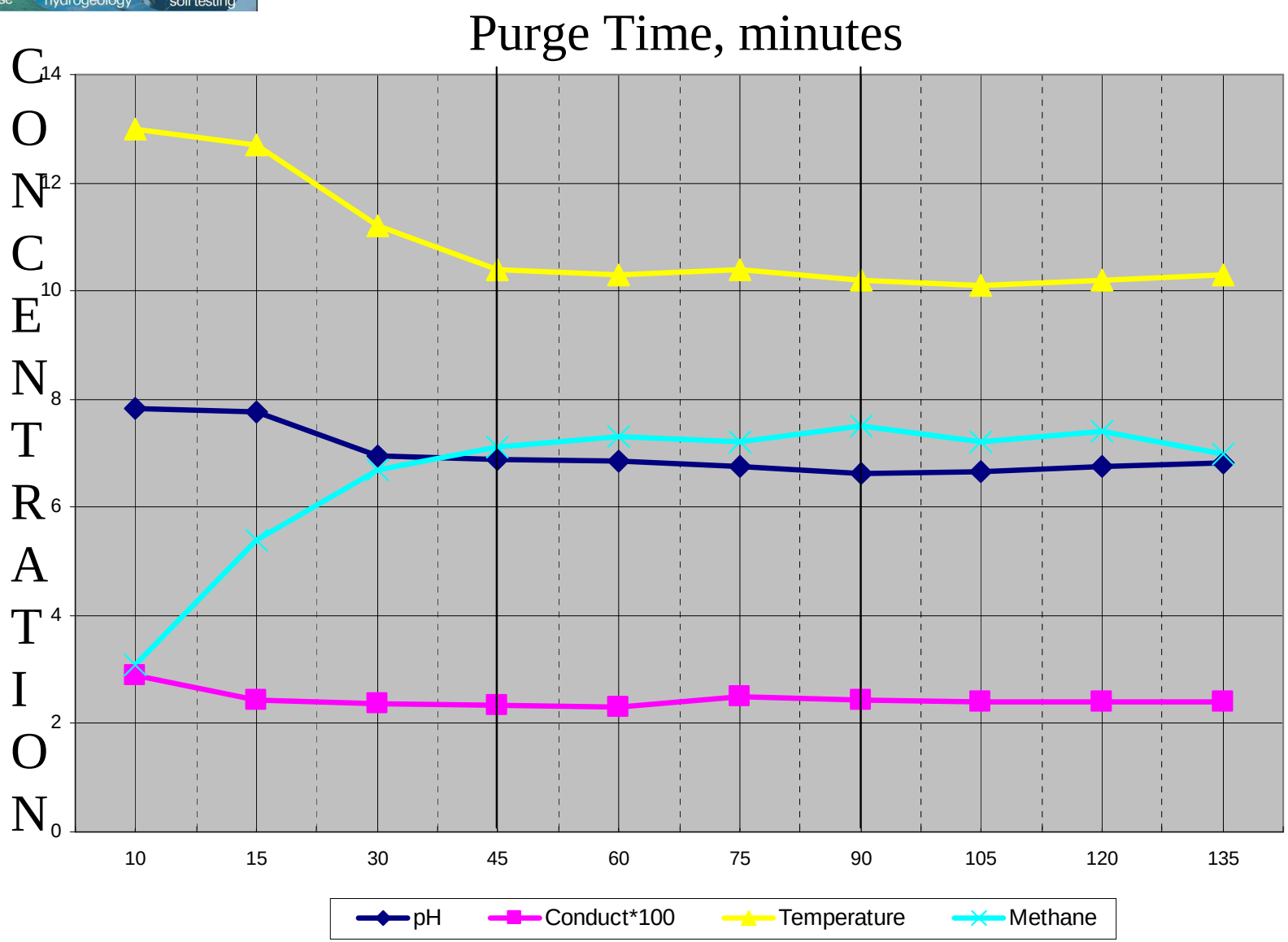
Education

- Conducted Free Workshops and Fairs
- Updated Website

  http://www.wilkes.edu/water
- Created a New Free Community Resource
- Added Informational Water Testing – Saline Water Screening Program



Schedule a Free Training Session – Go to Our Website



1 WBV = 45 minutes

Copyright Mr. Brian Oram, PG

Chain-of-Custody

- Sampling Procedures
- Sampling Operations
  - Short-Term
  - Long- Term
- Sample Transport
- Receipt, Storage, Transport
- Sample Analysis
- Procedures for Data

Their water is Red!

Chain of Custody is Not Just a Third Party Sampler – Much More – Begins at the Lab

Step 2: Citizen Database

- Provide a Central Location to Store Baseline Pre-Drilling and/or Post-Drilling Water Quality Data for the Region – Provided by Citizens. **All raw data is confidential.**
- Document Quality by Geological Formation- Conduct Vulnerability Analysis
- Identify Existing Regional Issues or Concerns (Pre-drilling)
- Provide an Un-Biased Community Resource
- Provide a Mechanism to Track Temporal, Spatial, and other Geospatial Variation in Water Quality.
- Aid in Conducting Vulnerability Analysis
- Supplement the Database with Other Data Sources – Currently I am adding all the data from the Dimock PADEP Investigation.

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 and/or zip code and mailing address for the well – either from the citizen or direct from laboratory – This raw data will NOT be released or viewable – Privacy is Critical.

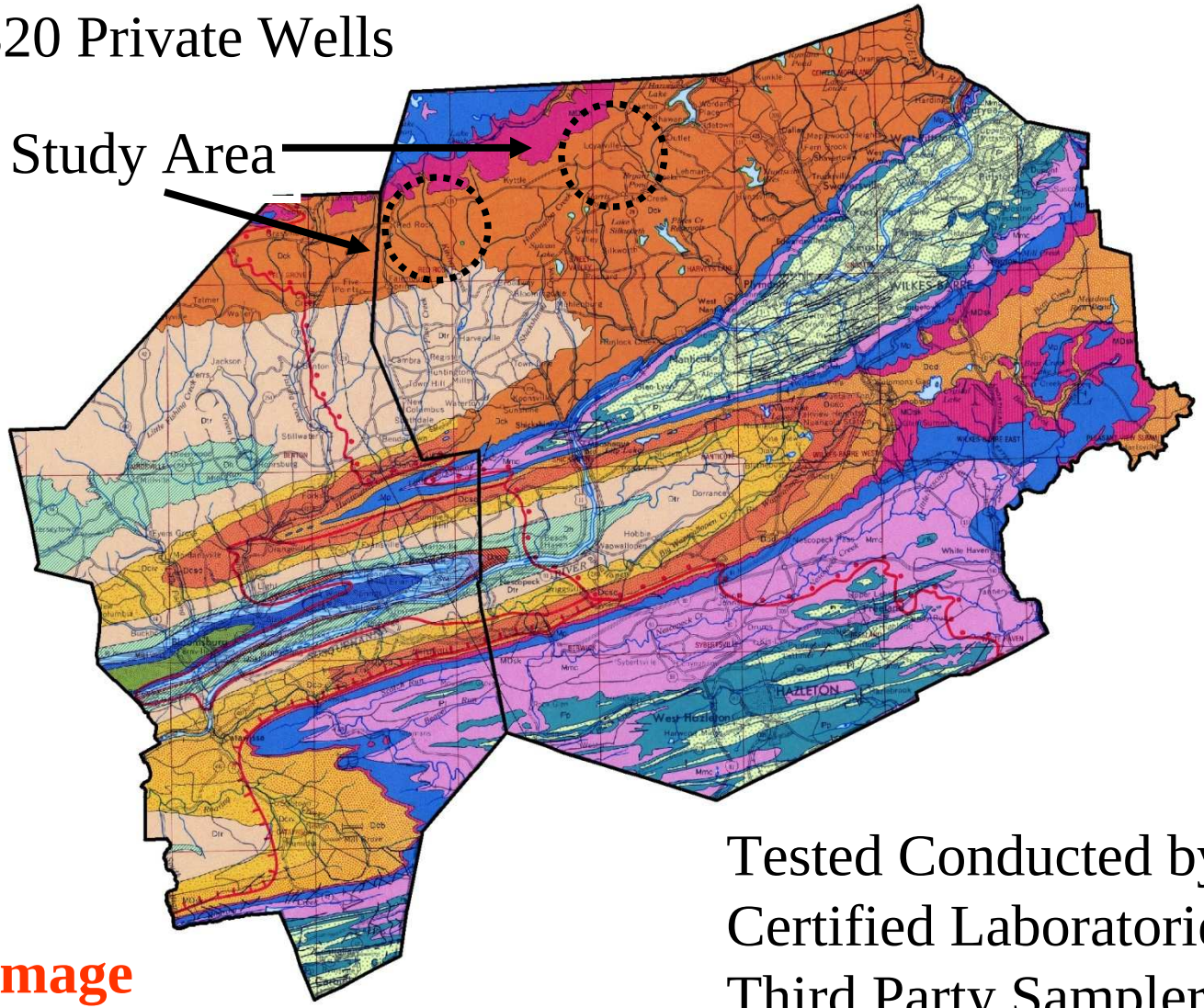
3. The water sample must be collected ahead of any water treatment system.

4. other conditions – Learn More at the Wilkes University Website.

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

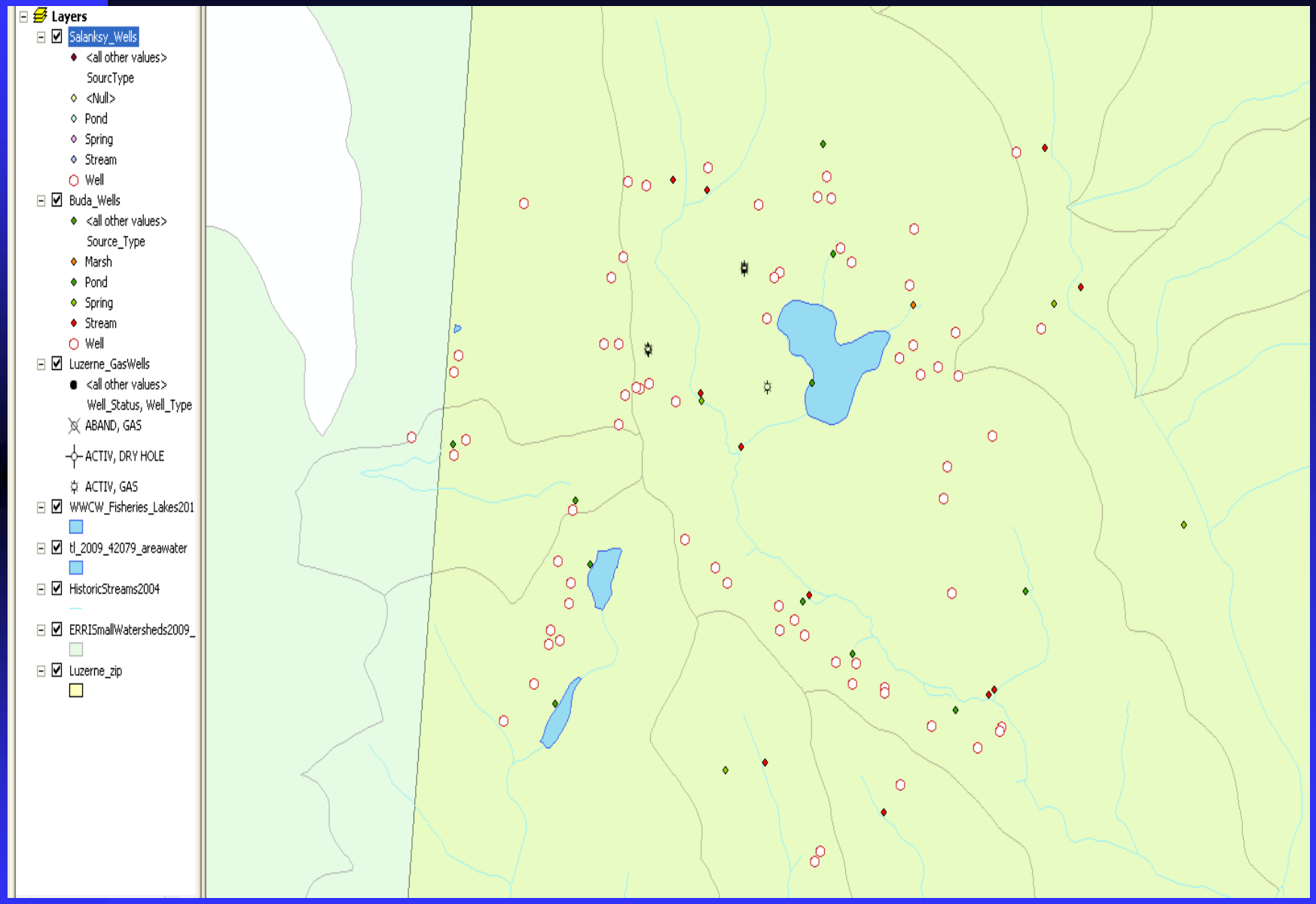
WATER QUALITY DATABASE
CONSENT & INFORMATION

Recent Baseline Testing in Luzerne County, PA
320 Private Wells



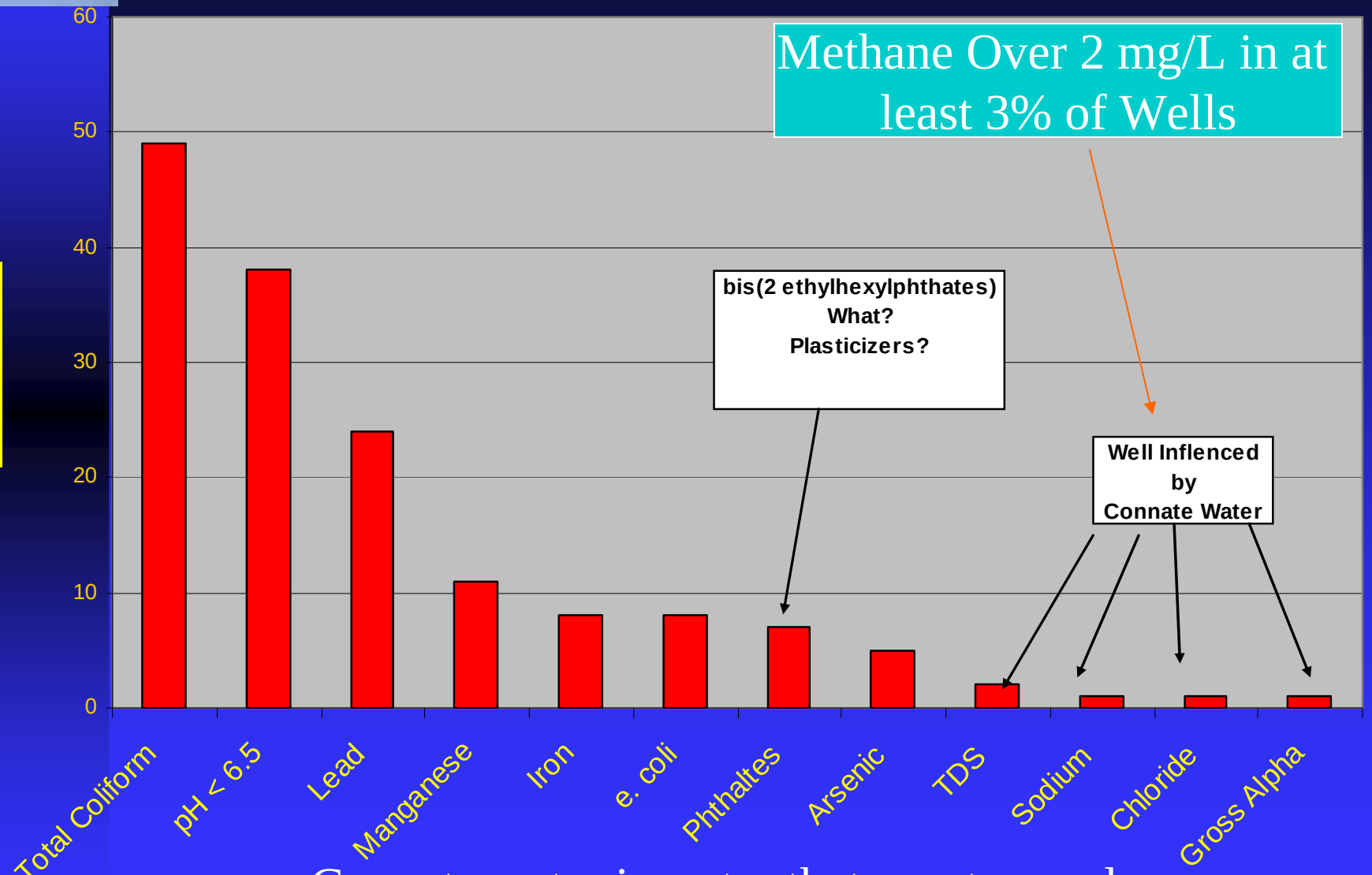
Tested Conducted by
Certified Laboratories
Third Party Samplers
Not Wilkes University

Image Source: Luzernecounty.org



Preliminary – Screenshots – Add Hydrology, Roads, other GIS Layers (Internal Screenshot – Not available to general public)

Source – Wilkes University Database



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

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
- Highest in the database – Now – about 7 mg/L – I am in the process of adding baseline data that is approaching 20 mg/L (predrilling)

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.

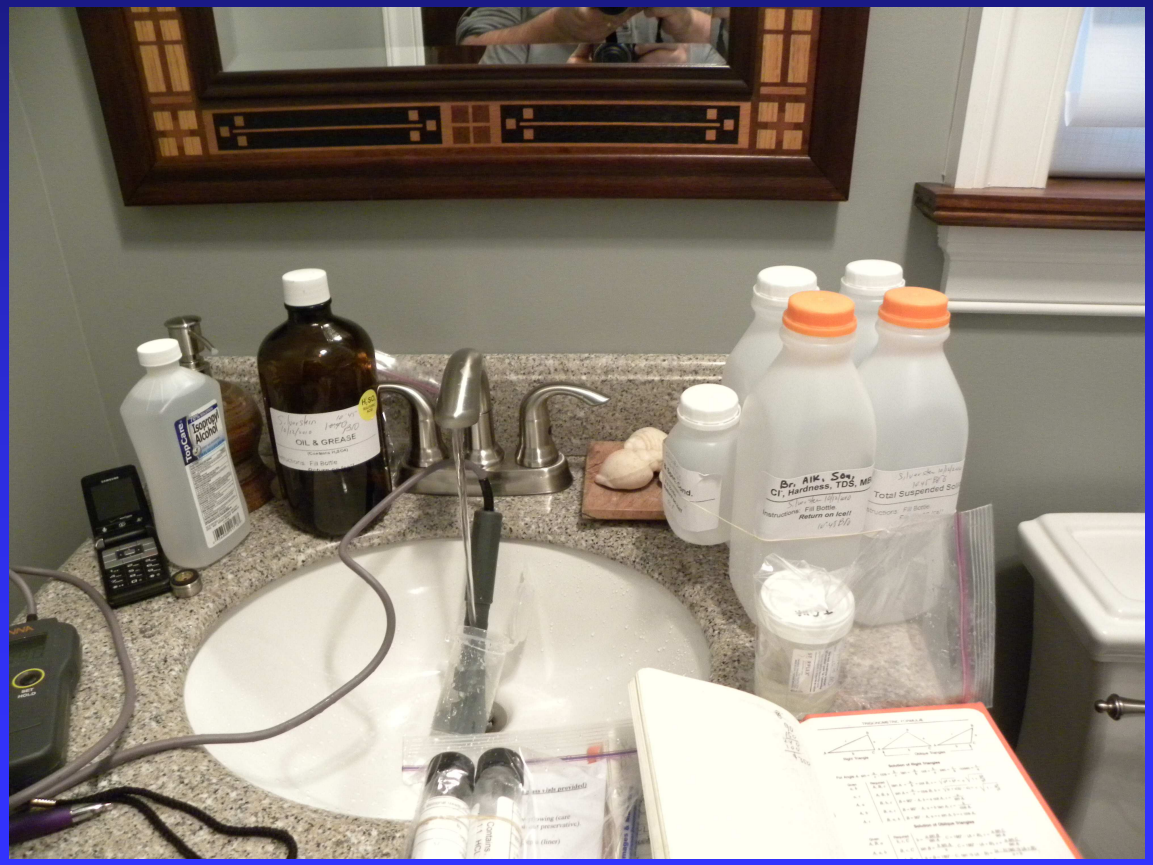
Make sure to test for total coliform, standard plate count, and Nuisance Bacteria.

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?
  - Possibly the Black Coil Pipe used in wells and delivery lines for private homes.

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 Soilds, 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?

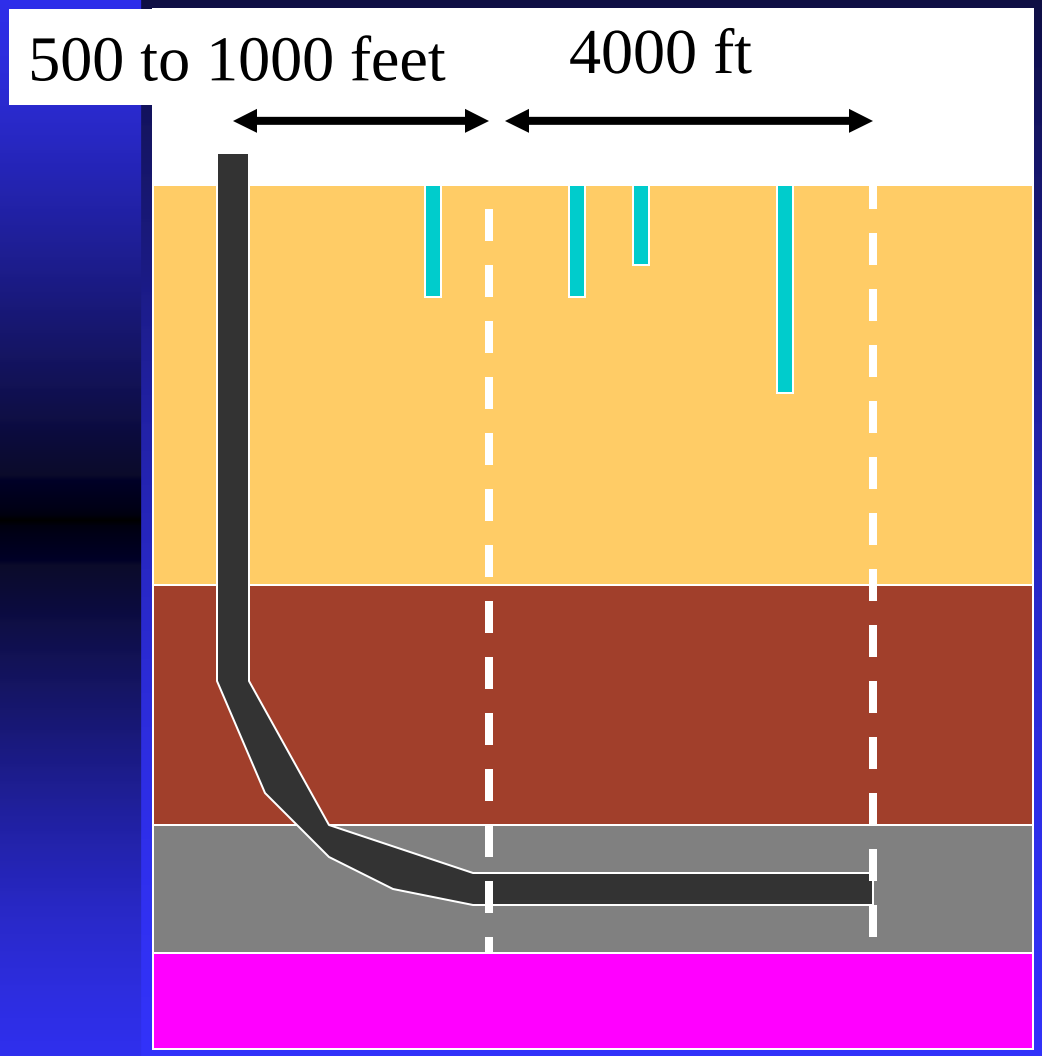
Quarry

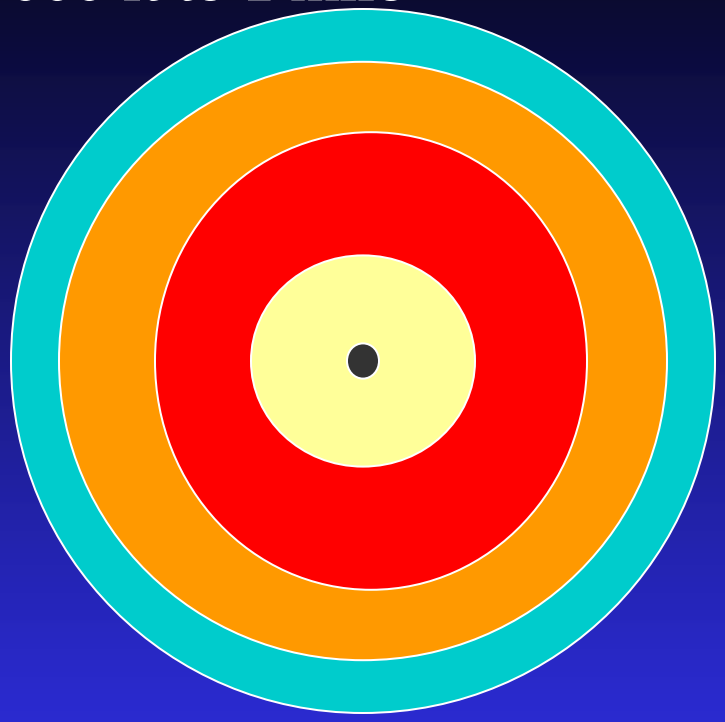
Mixed Hazards

Saline Seep

Salt Spring, Susquehanna County
(You can light the gas- Back to 1800s)

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





Mud/ Methane Migration (up to 1000 ft)

Methane Pushes (2500 feet)

Area Above Lateral

1000 ft Buffer

This is More Opinion/ Judgment- not fact.

Copyright- Brian Oram, 2010

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.

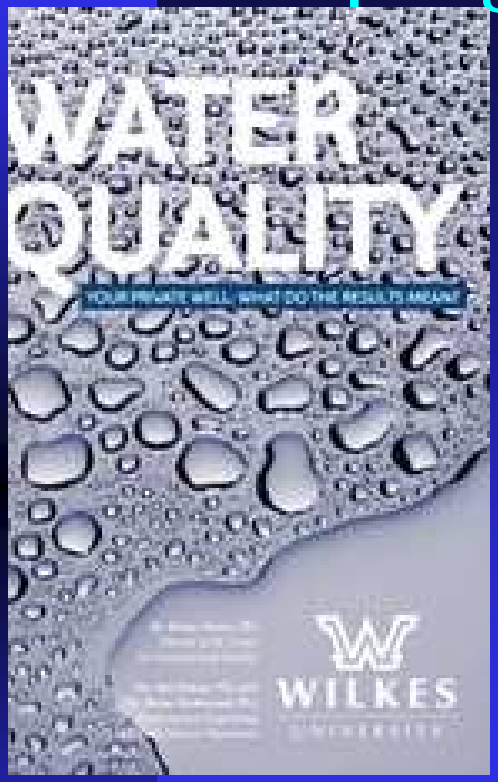
- Testing Package # 3 Recommendations

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

It may be advisable to add Glycols 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)

Step 3:New Community Resource Helping To Take Action



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- Screening Testing Post Drilling

Add Your Data to the Citizen Database

Other Projects

- Developing Low Cost Water Monitoring Equipment with Remote Reading Capacity for Citizen Scientists.
- Assisting with the Development of Stream and Watershed Based Monitoring Programs.
- Developing and Training Citizen Scientists
- Working on Sourcewater Protection Projects
- Educating Private Well Owners

Step 4:New Program to Help Private Well Owners (Fixing Problem Wells)

- Pocono Northeast RC&D Council – Private Well Assistance Program
  - Education
  - Outreach/Training
  - Funding Need Repairs – via a 1 % loan program- terms up to 20 yrs.
  - http://www.pnesolutions.org

Recent Site Tour- Towanda, PA

It is Critical to Get in the Field - Keep Your Eyes Open

Certificate of Completion

Training Event

Getting The Waters Tested The Marcellus Shale Factor

3/17/2011

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

Accredited Geothermal Installer

Laboratory Director, Center for Environmental Quality
Wilkes University
http://www.wilkes.edu/water

and

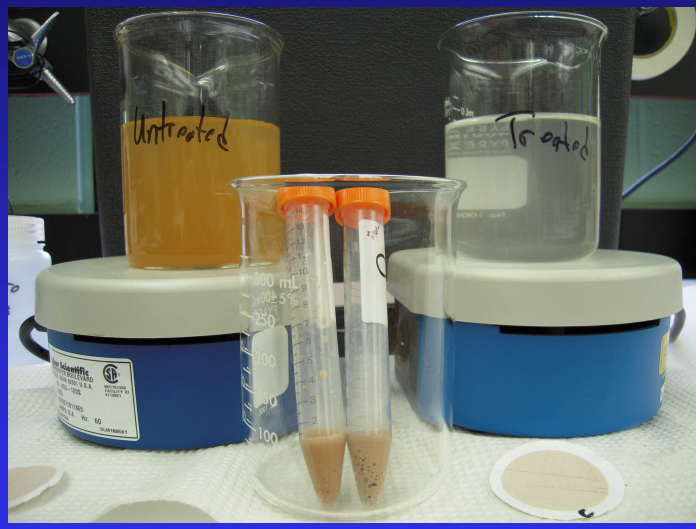
B.F. Environmental Consultants Inc.

http://www.bfenvironmental.com

Mine Water Treatment System

BEFORE

POW Process



AFTER

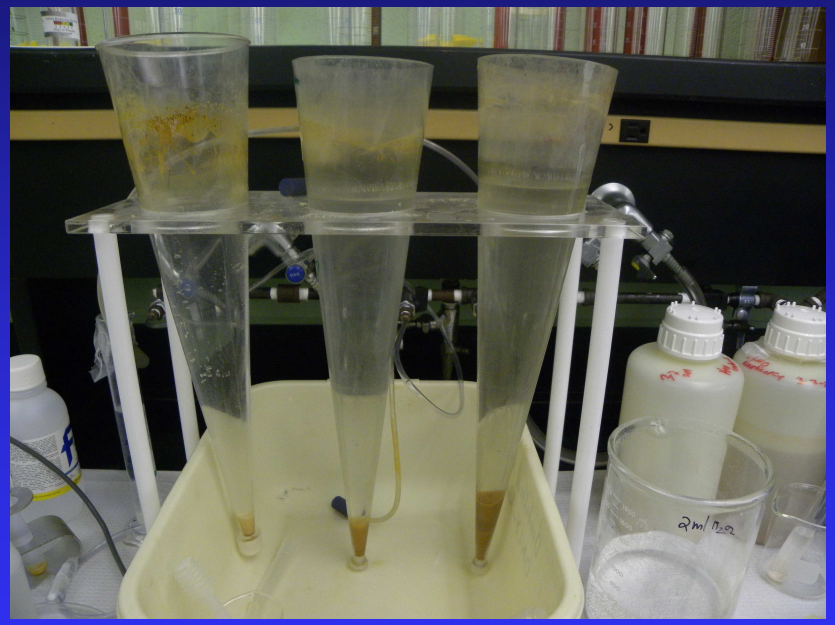
iCONSERVE PENNSYLVANIA

B.F. Environmental Consultants Inc.
Environmental Scientists, Hydrogeologists, & Environmental Education Specialists
Located in Northeastern Pennsylvania
water reuse hydrogeology soil testing

GreenNEPA STEWARD

Production Water Treatment-Modified POW Process for Brines

Before



After

iCONSERVE PENNSYLVANIA

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water reuse hydrogeology soil testing

GreenNEPA STEWARD

Injection Wells – Class II

Class II wells inject fluids associated with oil and natural gas production. Most of the injected fluid is salt water (brine), which is brought to the surface in the process of producing (extracting) oil and gas.

Regulated by:

EPA - http://www.epa.gov/safewater/uic/wells_class2.html

Does the UIC Program regulate hydraulic fracturing?

Sometimes. The UIC Program regulates the following activities:

- Well injection of fluids into a formation to enhance oil and gas production (Class II wells).
- Fracturing used in connection with Class II and Class V injection wells to "stimulate" (open pore space in a formation).
- Hydraulic fracturing to produce methane from coal beds in Alabama.
- Hydraulic fracturing that uses diesel in the mixture.

Note: Class V wells are shallow wells that inject water into or above a freshwater aquifer. http://www.epa.gov/ogwdw000/uic/