Marcellus Gas Drilling and Water Resources

Marcellus drilling involves ….

Bigger rigs

More disturbance

More water

Hydrofracturing

More wastewater

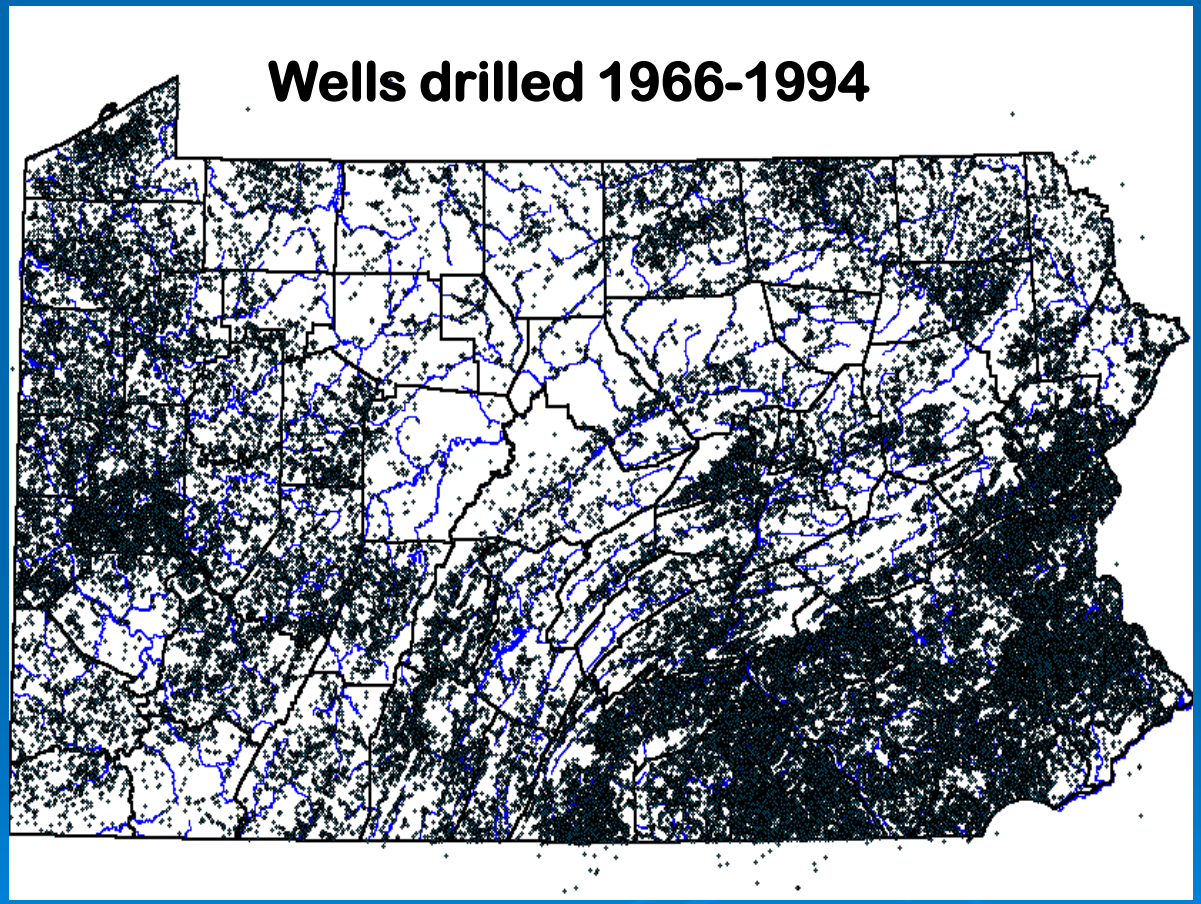
PA's abundant water resources - a blessing and a concern

83,000 miles of streams

Thousands of ponds/lakes

80 trillion gallons of groundwater

Private Water Systems in Pennsylvania

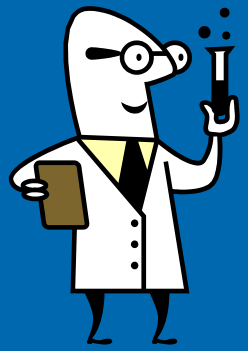


- One million homes, 3.5 million residents
- About 20,000 new wells each year
- Access groundwater
- No ownership of water

Private Water Systems in Pennsylvania

- All management is voluntary
- No statewide requirements on location or construction
- Most wells have inadequate construction
- About 40% fail at least one safe drinking water standard
- Causes = natural pollutants, well construction, nearby land use
- Most homeowners are unaware of unsafe water

Protecting Your Private Water Supply

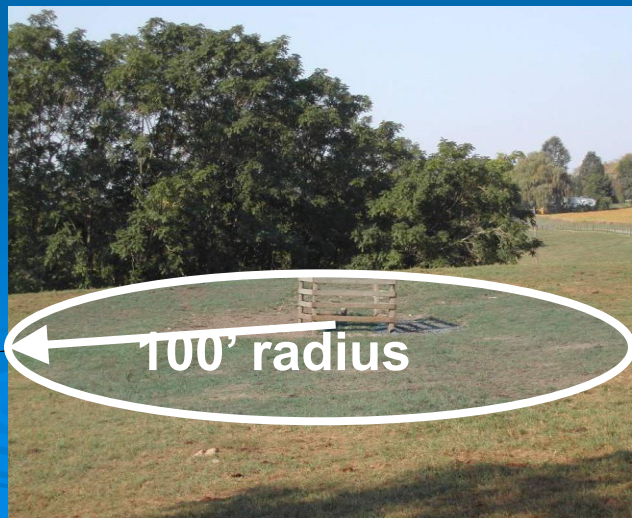


- Have your water tested by a state certified lab
  - 50% never properly tested
  - See Extension for list of certified labs or to obtain test kit
  - Routine tests for bacteria, pH, TDS
  - Focus testing on local land uses (before activity if possible)

- Properly construct water supply
  - Casing above ground, sanitary well cap, grout seal

- Create a water supply protection area

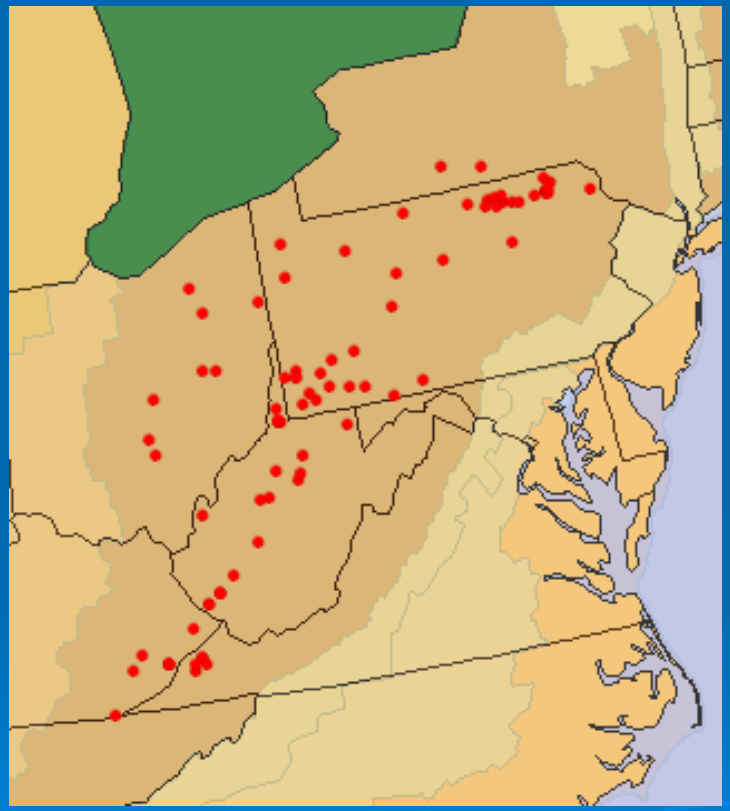
- Purchase water treatment devices carefully



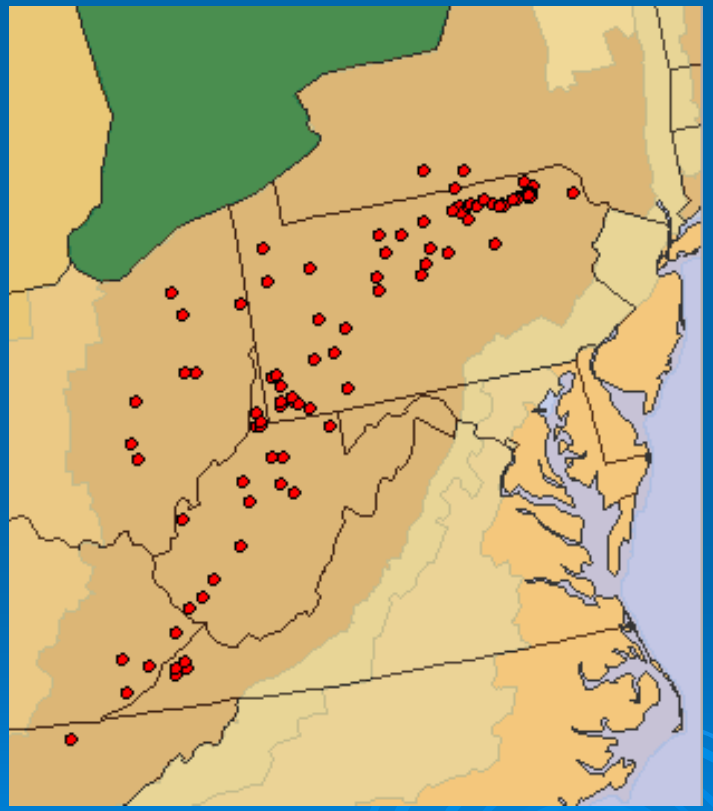
Marcellus Shale

Drilling Locations

July 3, 2009



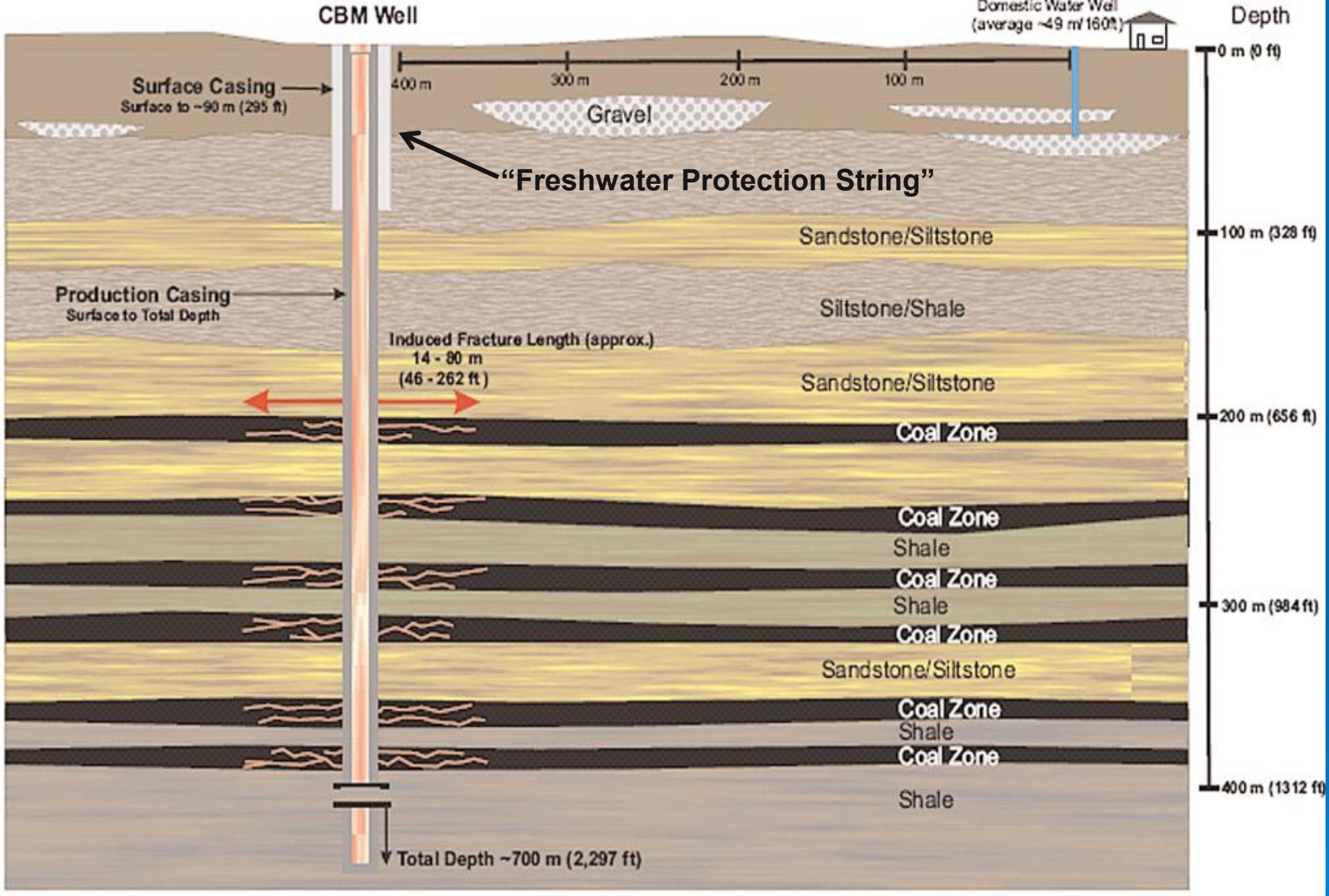
September 11, 2009



Data from Baker Hughes web site

Drill Bit and Casing

- Top hole pipe diameter = 13-16 inches, decreases as you move deeper
- Depth typically 5,000 to 10,000 feet
- Horizontal drilling parallel to shale



* **Notes**: 1. Coal Zones may represent several coal seams, ranging in thickness from 20 cm to 3.5 metres
2. Additional coal seams may exist above the depths indicated above however are not shown here as these shallower zones are not generally targeted by QRCI in this area.

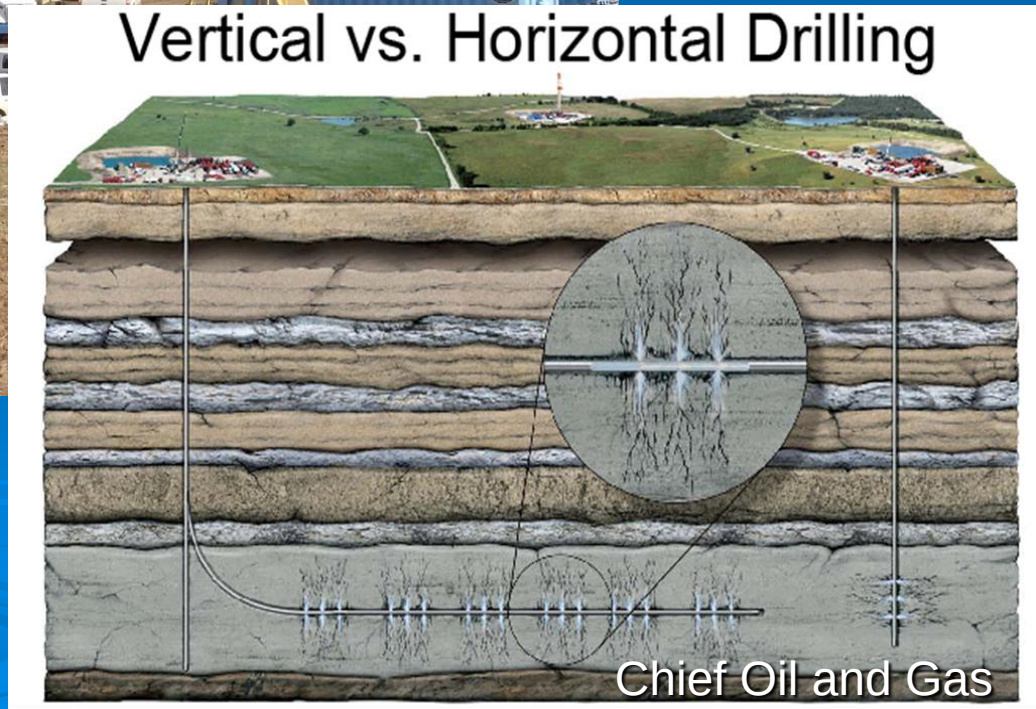
QUICKSILVER

April 2006

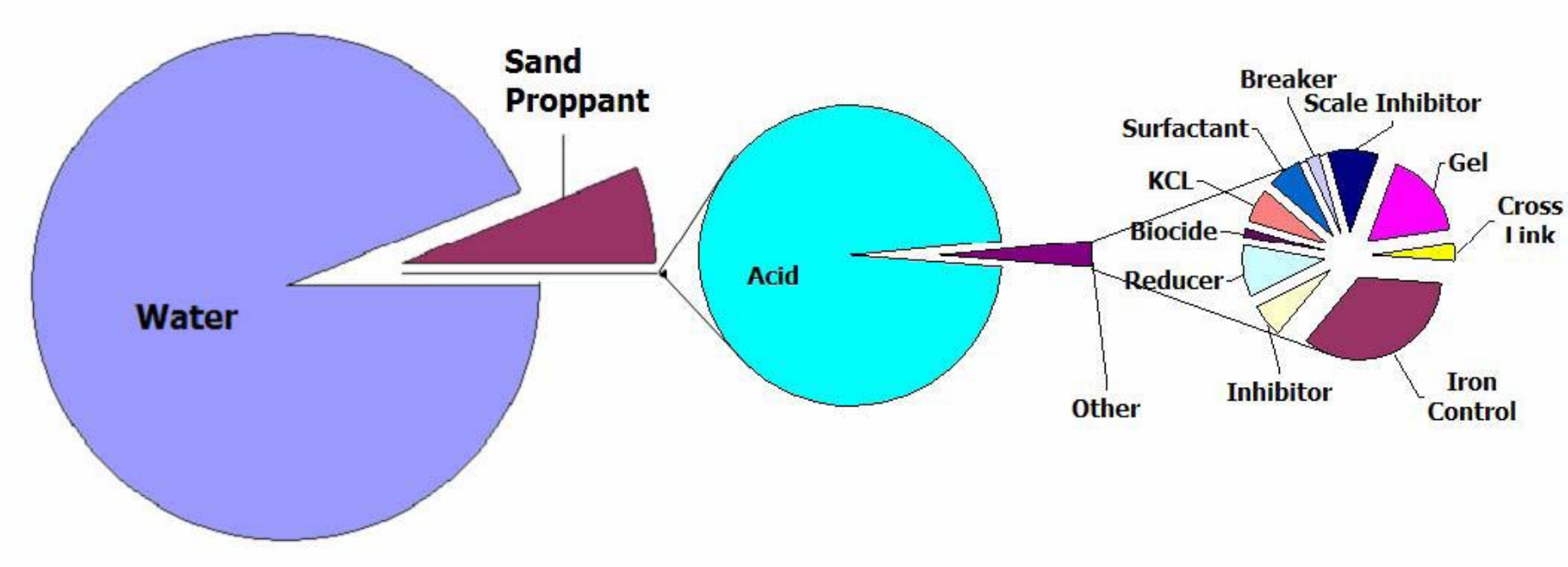
Types of Waste Fluids

- *Top hole fluid* – freshwater encountered during drilling
- *Drilling fluids*
  - *Mixed with drilling mud and cuttings*
- *Bottom hole fluids (brine)*
- *Stimulation "flow back" fluids*
- *Production fluids*

Hydrofrac in Progress



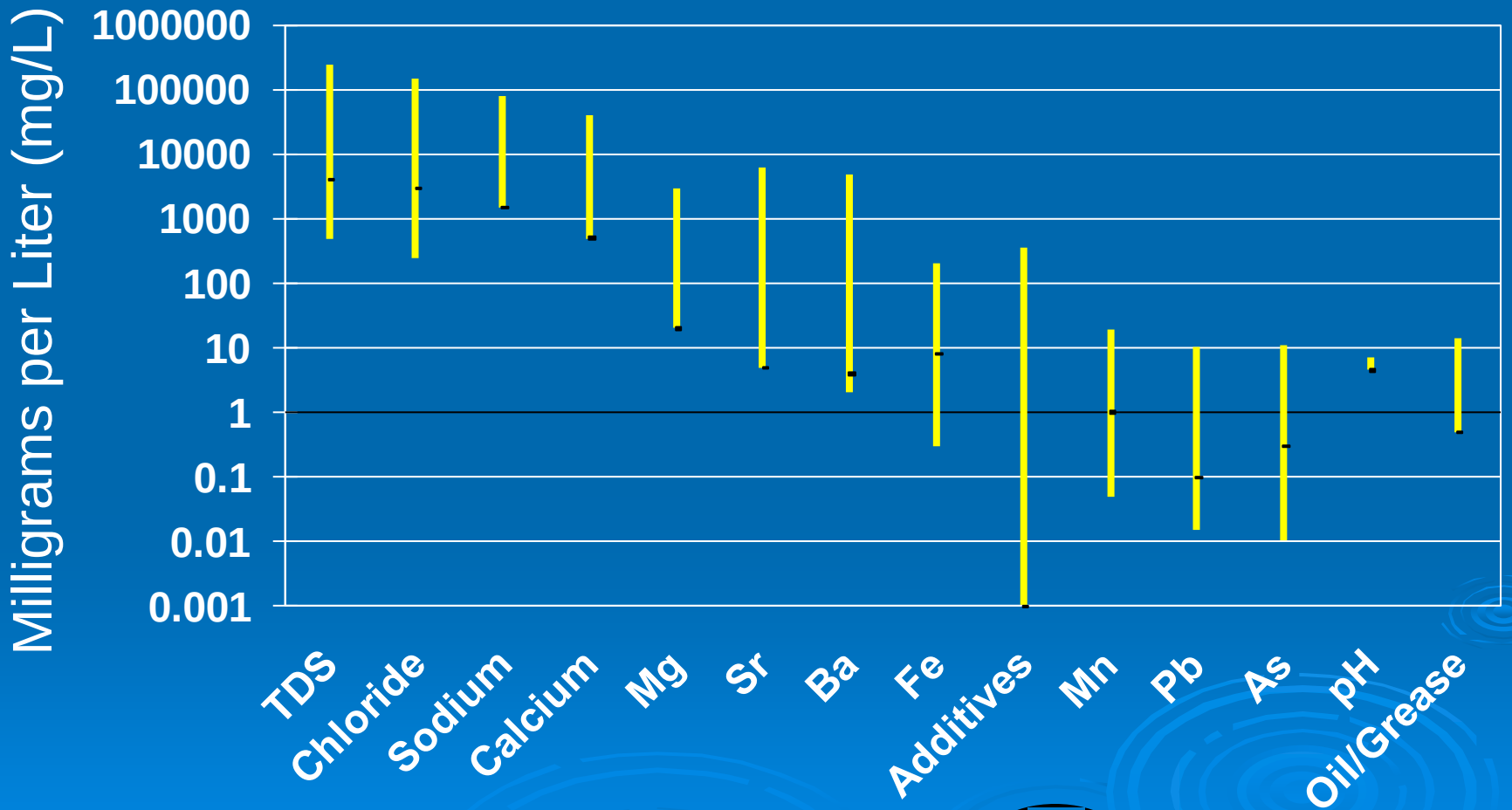
Hydrofracturing Mixtures



Source: Arthur et al. 2008. Hydraulic Fracturing Considerations for Natural Gas Wells of the Marcellus Shale. The Ground Water Protection Council , 2008 Annual Forum, Cincinnati, OH.

Wastewater Pollutants

(~20 wastewater samples)



Wastewater Treatment

- Highly mineralized water – challenging treatment
- Limited existing capacity – this will control pace of drilling
- Traditional methods
  - Dedicated facilities (western PA) – salt discharge
  - Road spreading – limited circumstances
  - UIC wells – limited number + capacity
- Marcellus exceeds current capacity
  - POTW's used as a stop-gap
- Where are we headed?
  - New treatment requirements will affect future wastewater treatment

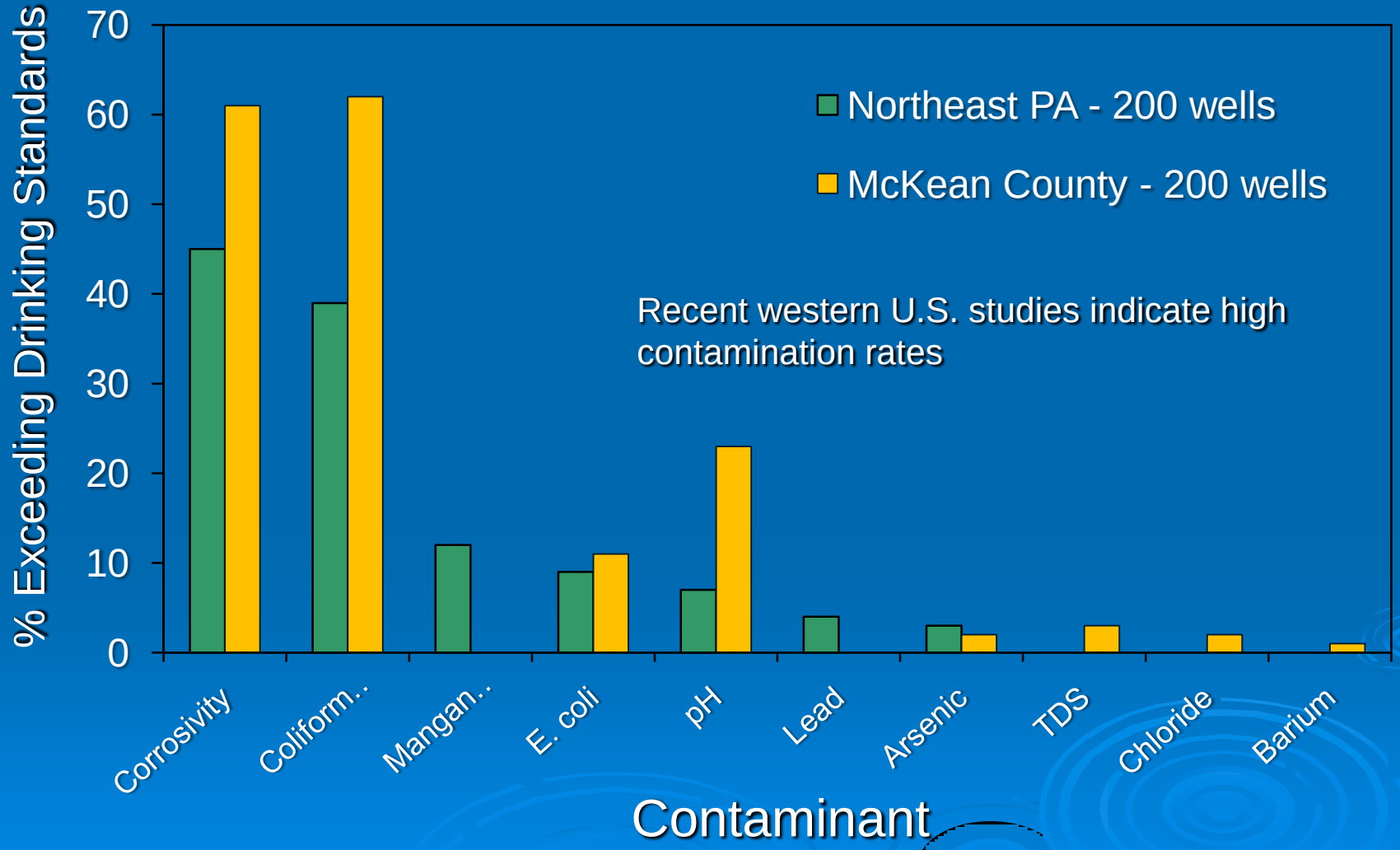
What Can Go Wrong?

- Leaking storage pits
- Inadequate freshwater protection string
- Illegal disposal
- Site spills
- Infrequent inspections
- Methane migration to groundwater

Methane Gas Migration

- Can occur naturally or due to nearby gas drilling or storage
- Odorless gas
- Symptoms
  - Effervescent water, spurting faucet, bubbling noise in well
- Simple bottle test to determine if gas is methane

Water Well Studies



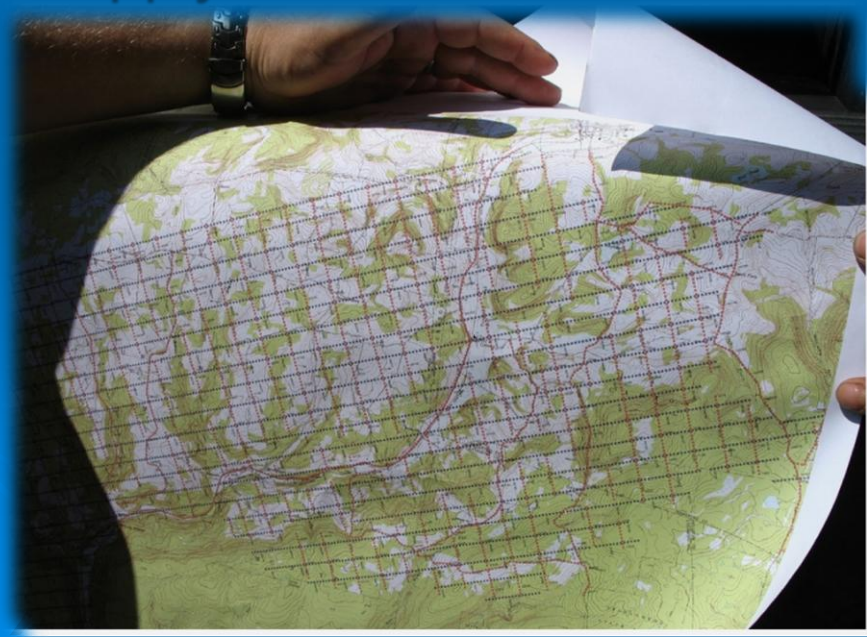
Homeowner Strategies to Protect Water Supplies

Learn When and Where Gas Wells Will be Drilled in Your Area

- eNotice – sign up to receive notice of permits by township
  - http://www.dep.state.pa.us/enotice/
- eMap – web-based GIS allows mapping of proposed well locations by permit number
  - http://www.emappa.dep.state.pa.us/emappa/viewer.htm
- eFacts – after drilling begins, monitor inspection reports, violations, etc.
  - http://www.dep.state.pa.us/efacts/default.asp

Seismic Testing

- No regulations on seismic in Pennsylvania
- Stipulate setback distances to water supply
- Arrange for a well/spring yield test before allowing seismic testing close to a water supply
- Make sure shot holes are properly abandoned to prevent groundwater contamination



Pre-Drilling Survey
(If you are within 1,000 ft of gas well)

- Voluntary test arranged by energy company through a state-certified water testing lab
  - No standard list of parameters
- You will likely be contacted by the lab to schedule a visit
- Allow access for pre-drilling sample collection
- Ask for identification – confirm relation to unbiased lab
- Provide as much information as you can about your water supply
- Arrange to receive a copy of results if possible

Do Your Own Water Testing?

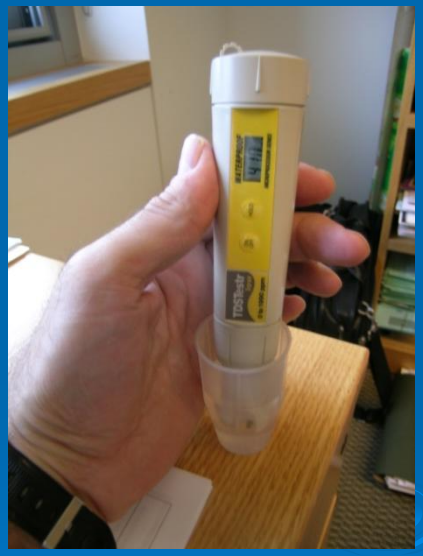
- If your water supply is >1,000 ft from the gas well, you will need to arrange for your own water testing (if you desire)
- Some homeowners within 1,000 ft may also wish to confirm results collected by gas company
- Third party collection of water samples is critical

Pre-Drill Testing Strategies
(Homeowner Perspective)

- "Gotta Have It" – critical indicators
  - Total dissolved solids, pH, barium, chloride
- Excellent additions
  - Methane, TSS, iron, manganese, total organic carbon
- Good additions
  - Sr, Pb, As, oil/grease, MBAS (surfactants), coliform bacteria, hardness
- "If You Can Afford It" - additions
  - BTEX (benzene, toluene, ethylbenzene, xylenes)
  - VOC's
  - Na, Ca

During and After Drilling
(Homeowner Perspective)

- Impacts (if they occur) are often transient, short-lived
- One time (grab) sampling provides only a snapshot
- Continuous TDS monitoring
  - Daily monitoring of raw water with inexpensive total dissolved solids meter or conductance meter
  - Significant increases warrant grab sampling



- Post-drilling test to document conditions within six months

What About Quantity?

Reduction in well or spring yield is unlikely

Documentation of pre-existing well or spring yield (gallons per minute) would require measurement by an independent water well contractor (NGWA certified) or hydrogeologist

Photo courtesy of Todd Giddings, PA Ground Water Association

What to Watch Out For

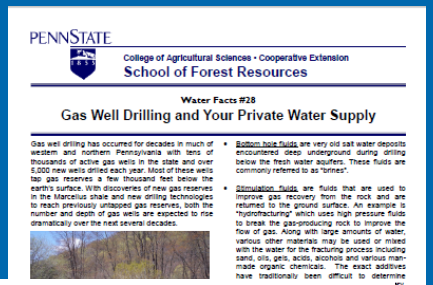
- Erosion and sediment problems in surface water
- Changes in well and spring water appearance
  - Sediment during construction or drilling
  - Effervescence, spurting faucet, foaming
- Changes in drinking water taste
  - Metallic (iron, manganese), salty (chloride)
- Changes in water odor
- Changes in well or spring yield

Water Resource Lease Guidelines

- Setback distances to water supplies
  - Don’t waive the 200 foot setback
- Pre and post testing
  - Certified lab, parameters, delivery of results
  - Receipt of pre-drilling results BEFORE drilling begins
- Well or spring yield test prior to drilling
- Testing of other nearby water supplies, streams, ponds
- Access to water resources on property?

Educational Resources
Gas Drilling and Water Resources

Publications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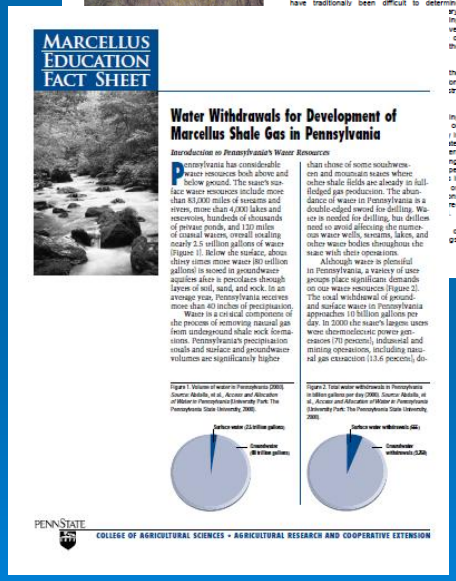
Water Facts #28
Gas Well Drilling and Your Private Water Supply

Gas well drilling has occurred for decades in much of western and northern Pennsylvania with tens of thousands of active gas wells in the state and over 5,000 new wells drilled each year. Most of these wells tap gas reserves a few thousand feet below the earth's surface. With discoveries of new gas reserves in the Marcellus shale and new drilling technologies to reach previously untapped gas reserves, both the number and depth of gas wells are expected to rise dramatically over the next several decades.


MARCELLUS EDUCATION FACT SHEET

Water Withdrawals for Development of Marcellus Shale Gas in Pennsylvania

Introduction to Pennsylvania's Water Resources

Pennsylvania has considerable water resources both above and below ground. The state's surface water resources include more than 83,000 miles of streams and rivers, more than 4,000 lakes and reservoirs, hundreds of thousands of private ponds, and 120 miles of coastal waters, overall totaling nearly 2.5 trillion gallons of water (Figure 1). Below the surface, about ninety times more water (80 trillion gallons) is stored in groundwater aquifers akin to percolates through layers of soil, sand, and rock. In an average year, Pennsylvania receives more than 40 inches of precipitation.

Water is a critical component of the process of removing natural gas from underground shale rock formations. Pennsylvania's precipitation totals and surface and groundwater volumes are significantly higher than those of some southwestern and mountain states where other shale fields are already in full-fledged gas production. The abundance of water in Pennsylvania is a double-edged sword for drilling. Water is needed for drilling, but drillers need to avoid affecting the numerous water wells, streams, lakes, and other water bodies throughout the state with their operations.

Although water is plentiful in Pennsylvania, a variety of user groups place significant demands on our water resources (Figure 2). The coal withdrawal of groundand surface water in Pennsylvania approaches 10 billion gallons per day. In 2000 the state's largest users were thermoelectric power generators (70 percent), industrial and mining operations, including natural gas extraction (13.6 percent), do-

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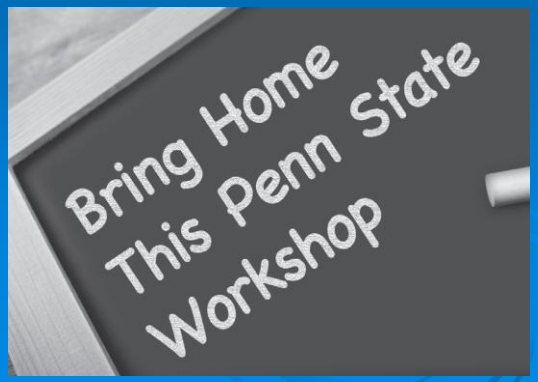
Web sites / webinars

Presentations

Portable Classroom DVD



- Gas drilling and your private water supply
- Water stipulations for gas leases
- Treatment options for gas waste fluids
- Gas well drilling and water resources


Questions?