WATER RESOURCES ISSUES RELATED TO SHALE GAS DEVELOPMENT

Protection of drinking water

Fracking chemicals

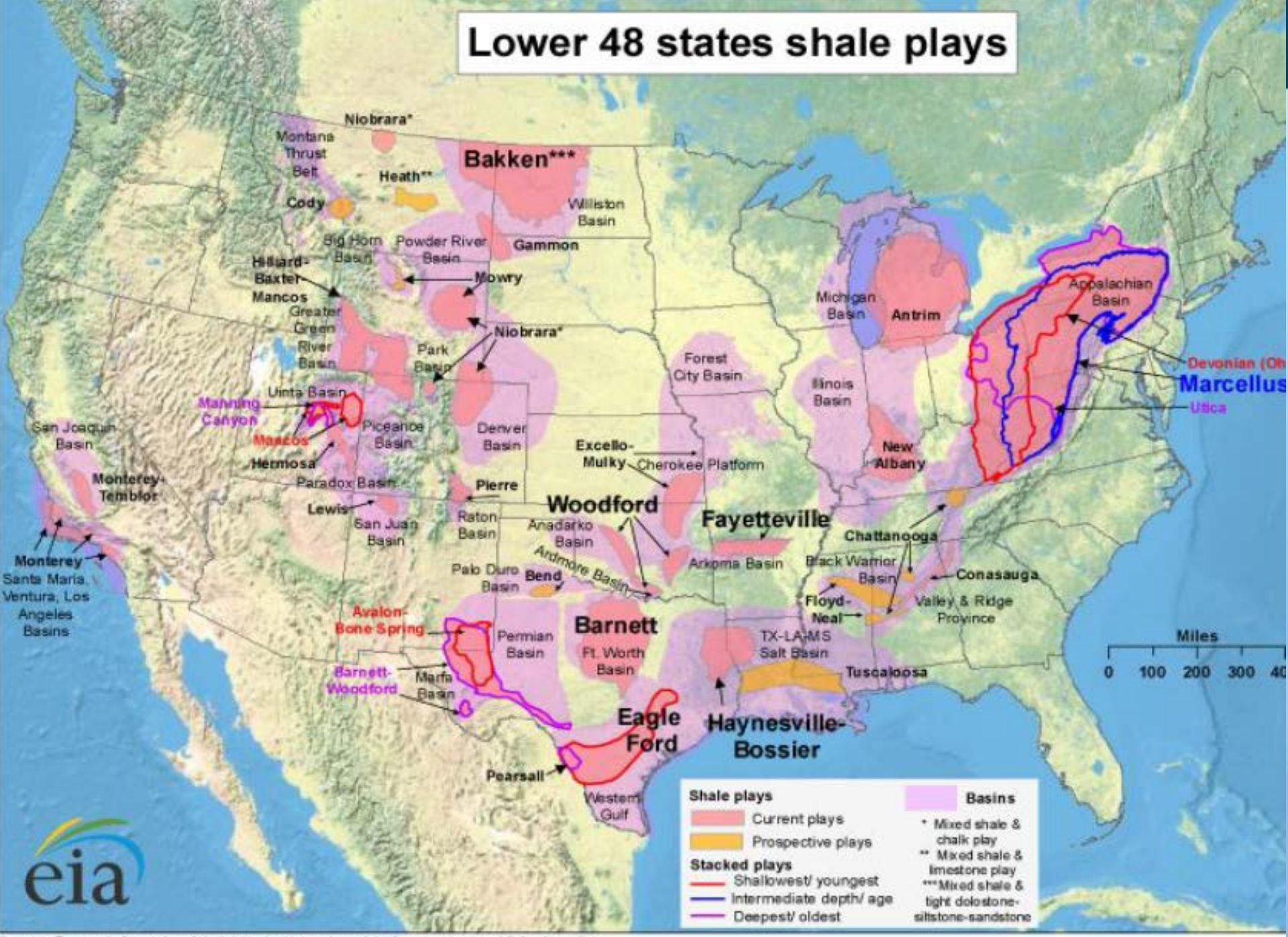
Adequate wastewater treatment

Impact of water withdrawals

Surface water impacts

Regulations and enforcement

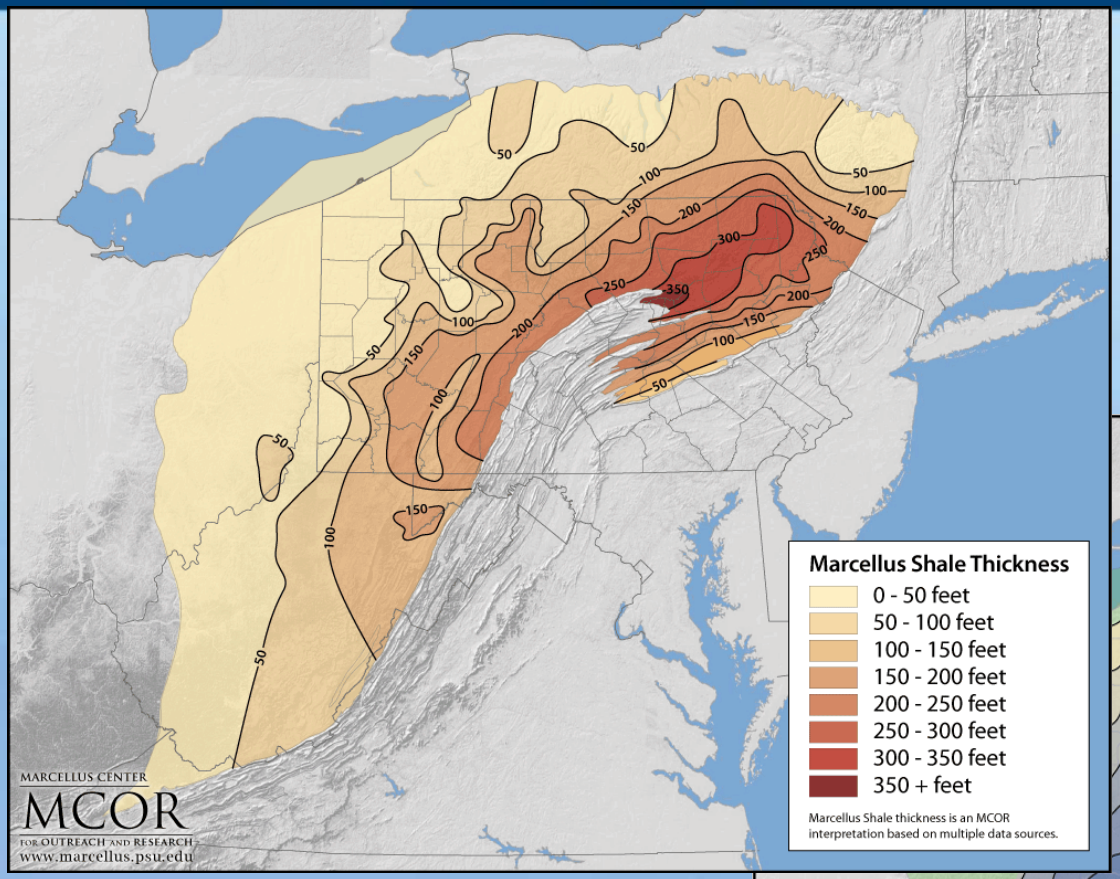
Lower 48 states shale plays



eia

Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

Marcellus


Marcellus Shale Thickness
0 - 50 feet
50 - 100 feet
100 - 150 feet
150 - 200 feet
200 - 250 feet
250 - 300 feet
300 - 350 feet
350 + feet
Marcellus Shale thickness is an MCOR interpretation based on multiple data sources.
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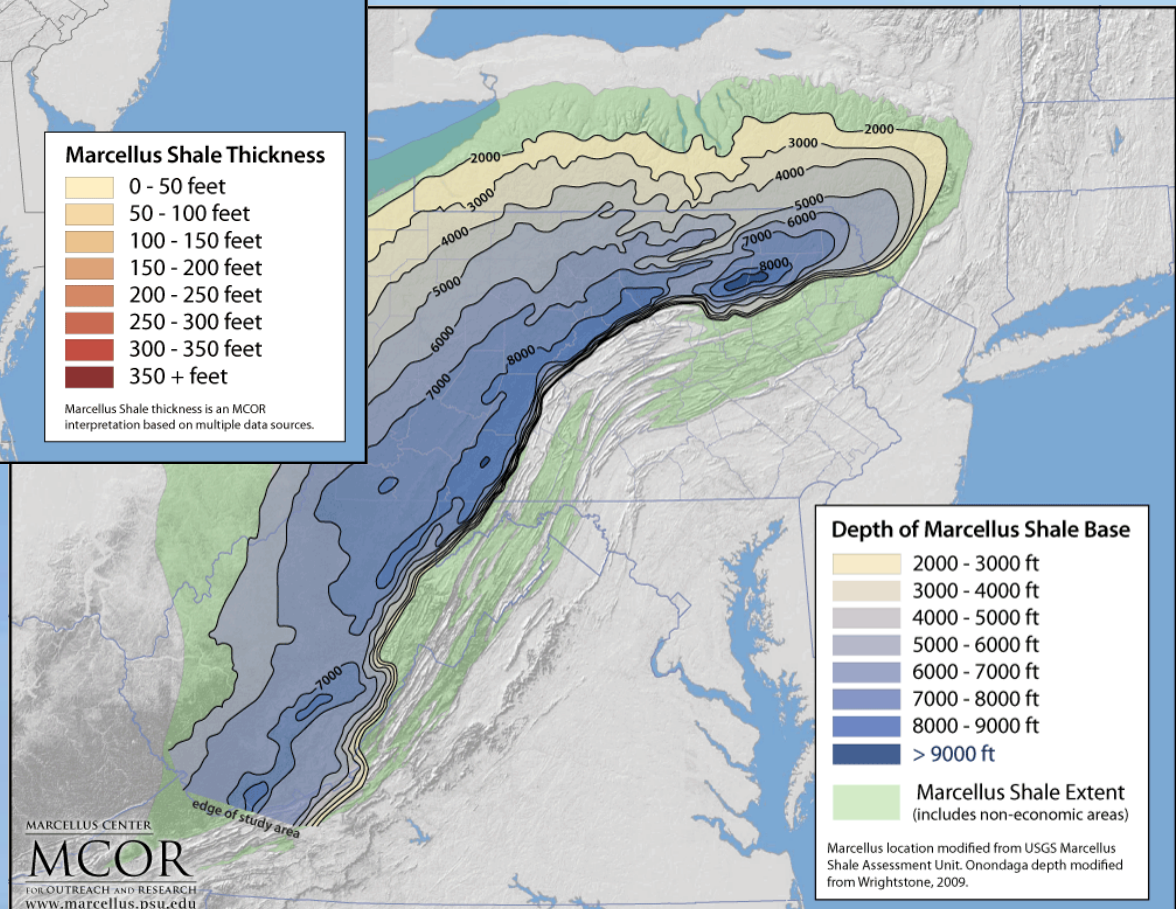
FOR OUTREACH AND RESEARCH
www.marcellus.psu.edu


Depth of Marcellus Shale Base
2000 - 3000 ft
3000 - 4000 ft
4000 - 5000 ft
5000 - 6000 ft
6000 - 7000 ft
7000 - 8000 ft
8000 - 9000 ft
> 9000 ft
Marcellus Shale Extent
(includes non-economic areas)
Marcellus location modified from USGS Marcellus Shale Assessment Unit. Onondaga depth modified from Wrightstone, 2009.
edge of study area
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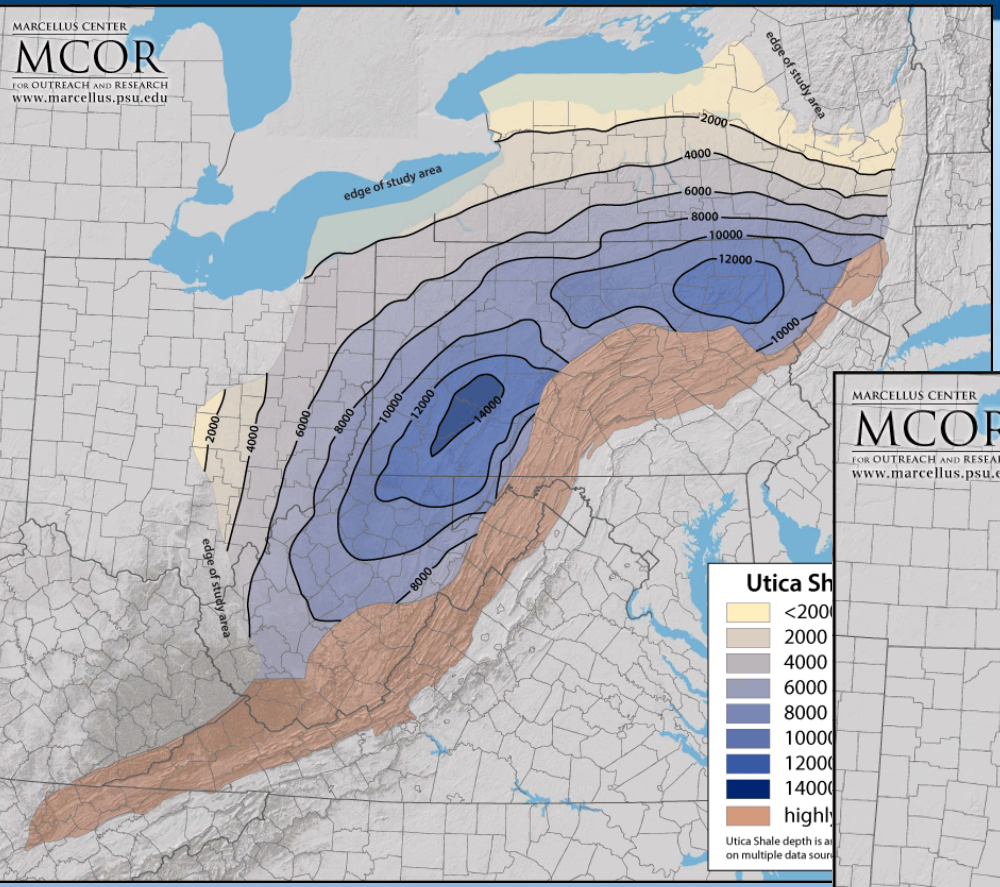
Utica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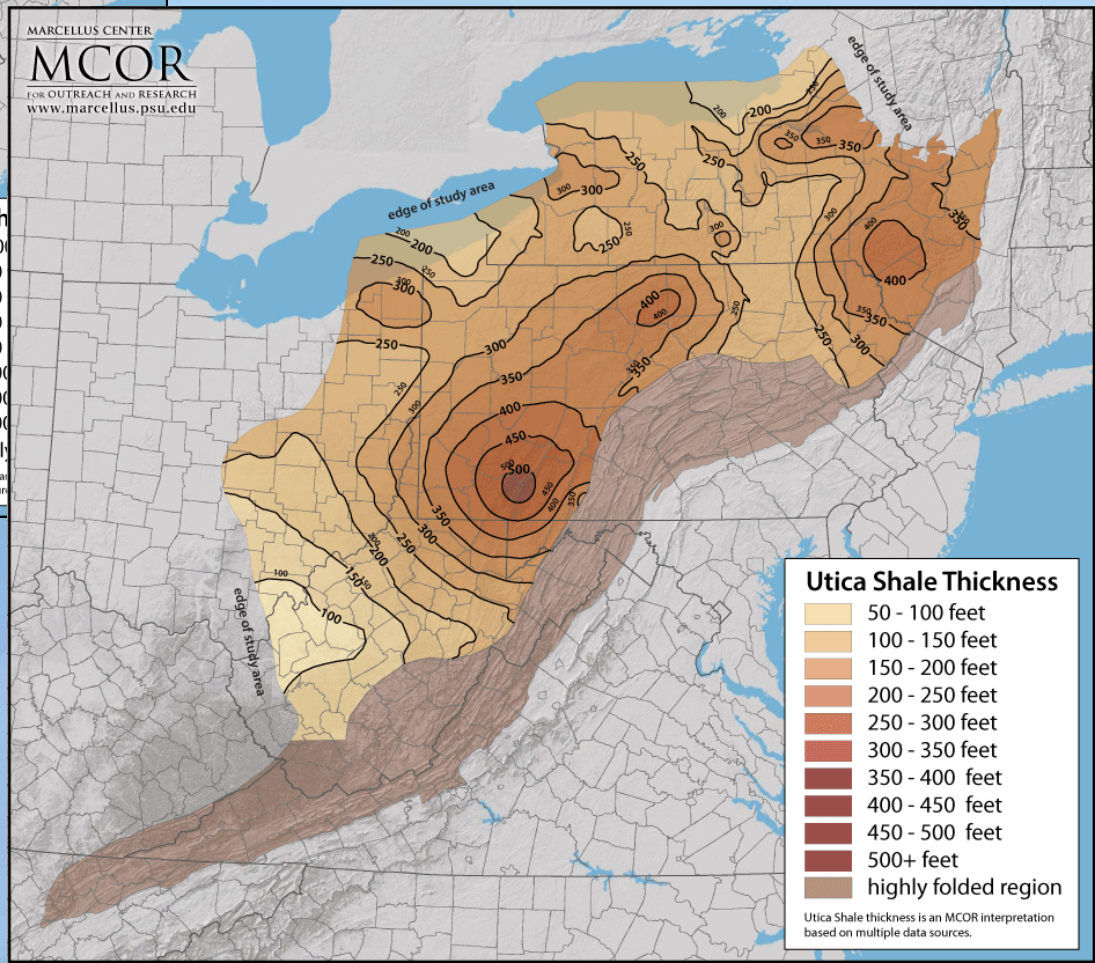
edge of study area
2000
4000
6000
8000
10000
12000
14000
Utica Sh
<200
2000
4000
6000
8000
10000
12000
14000
highly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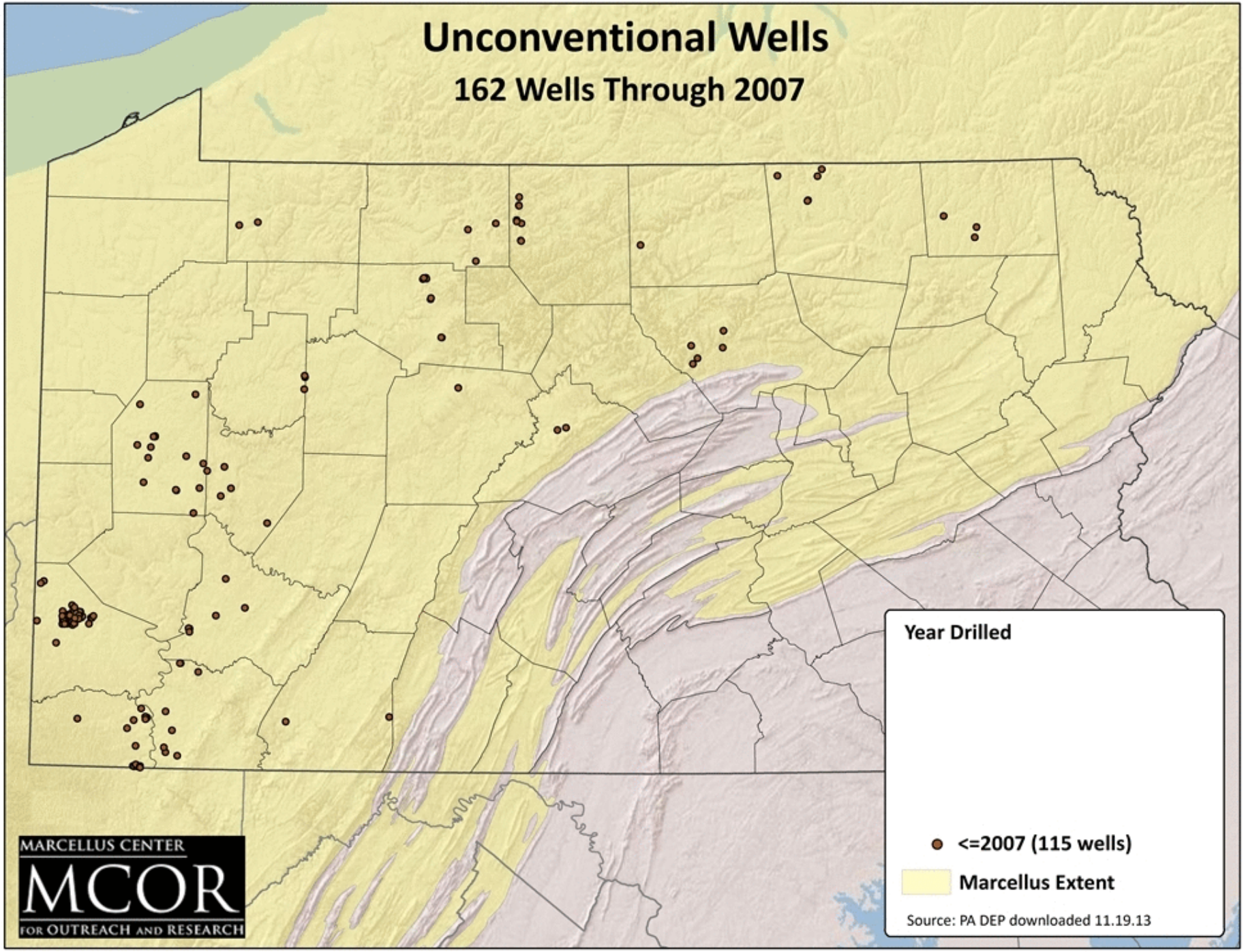
edge of study area
Utica Shale Thickness
50 - 100 feet
100 - 150 feet
150 - 200 feet
200 - 250 feet
250 - 300 feet
300 - 350 feet
350 - 400 feet
400 - 450 feet
450 - 500 feet
500+ feet
highly folded region
Utica Shale thickness is an MCOR interpretation based on multiple data sources.


Unconventional Wells
162 Wells Through 2007
Year Drilled
<=2007 (115 wells)
Marcellus Extent
Source: PA DEP downloaded 11.19.13
MARCELLUS CENTER
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FOR OUTREACH AND RESEARCH

Potential Concerns / Problems

- Surface water impacts from well site, roads & pipeline construction (sediment, nutrients)

- Groundwater impacts from brines, stimulation fluids, production fluids
- Surface or groundwater impacts from spills or containment failures (drilling mud, recovered stimulation fluids & production fluids)
- Methane gas migration

Seismic Testing

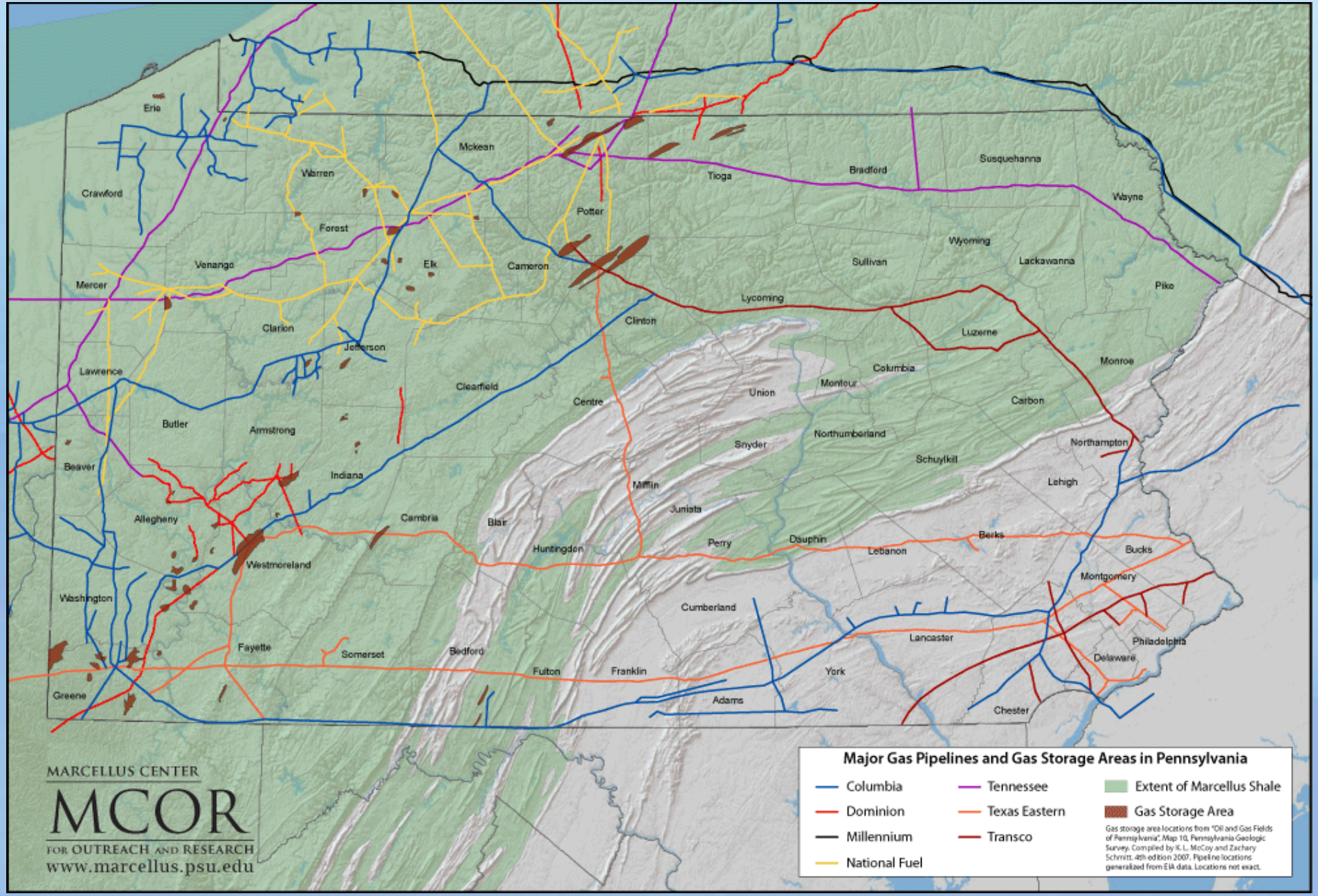
Earth Disturbance

- Roads, drilling pads


Earth Disturbance

Penn State **Extension**

Pipelines

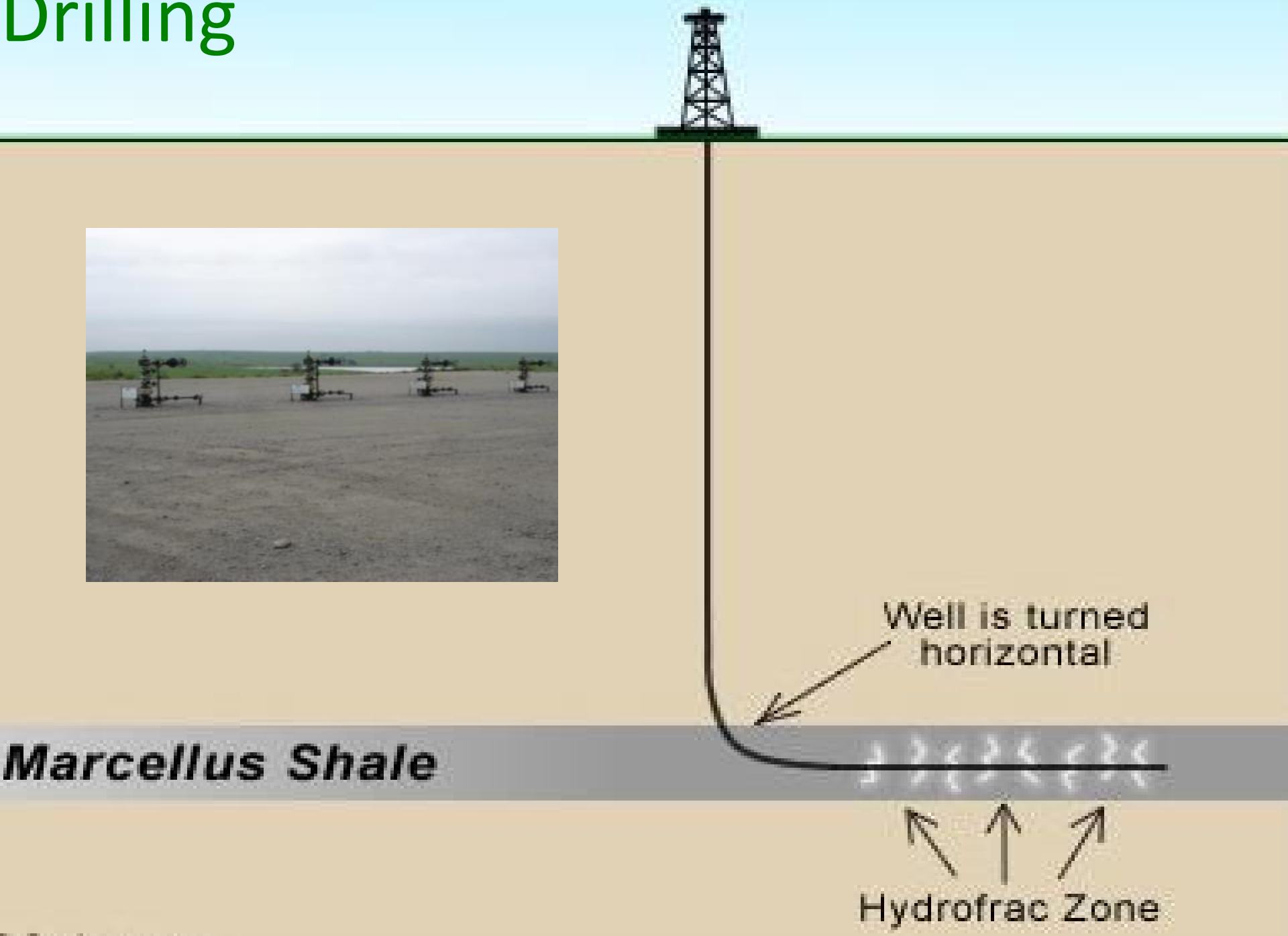


Rigs

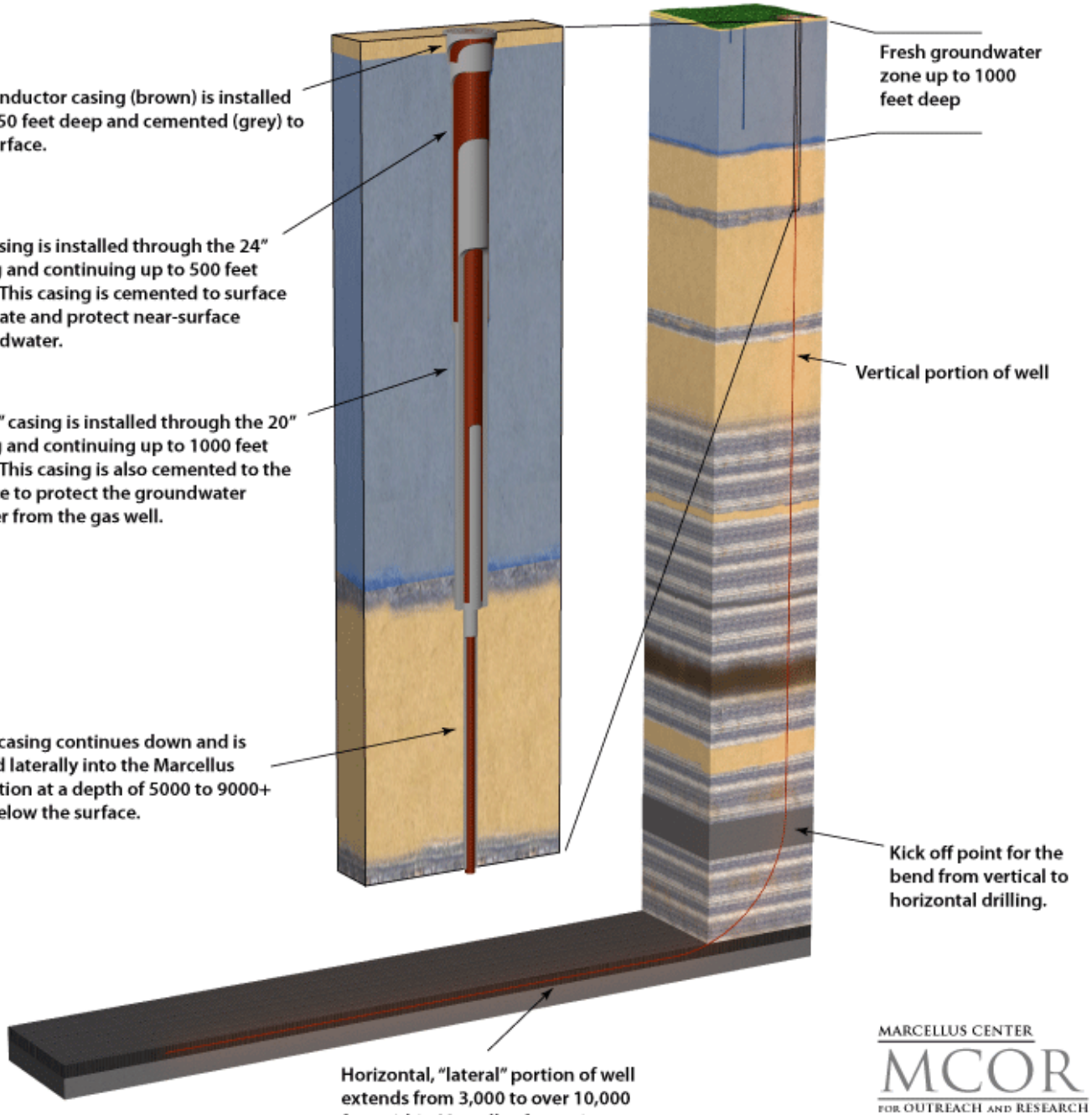
Surface

Deep & Horizontal

Drilling



Cross-Section of Typical Horizontal Marcellus Well



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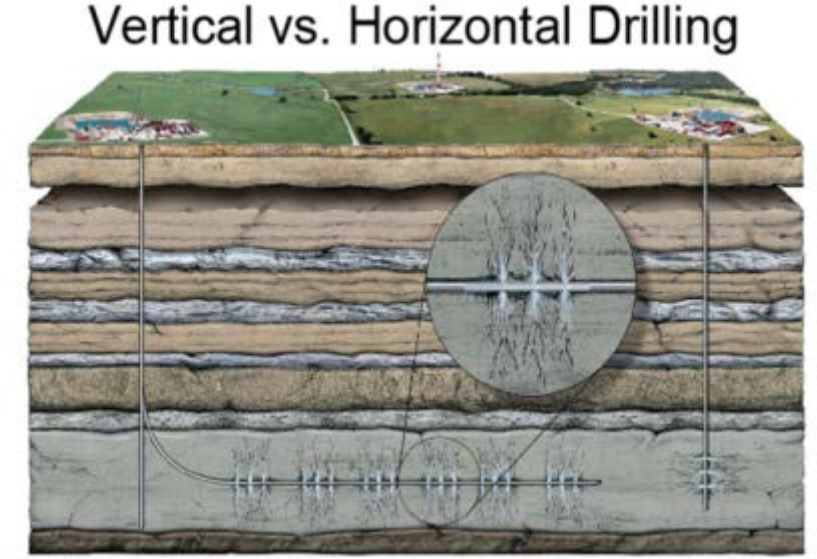
Freshwater Use for Drilling

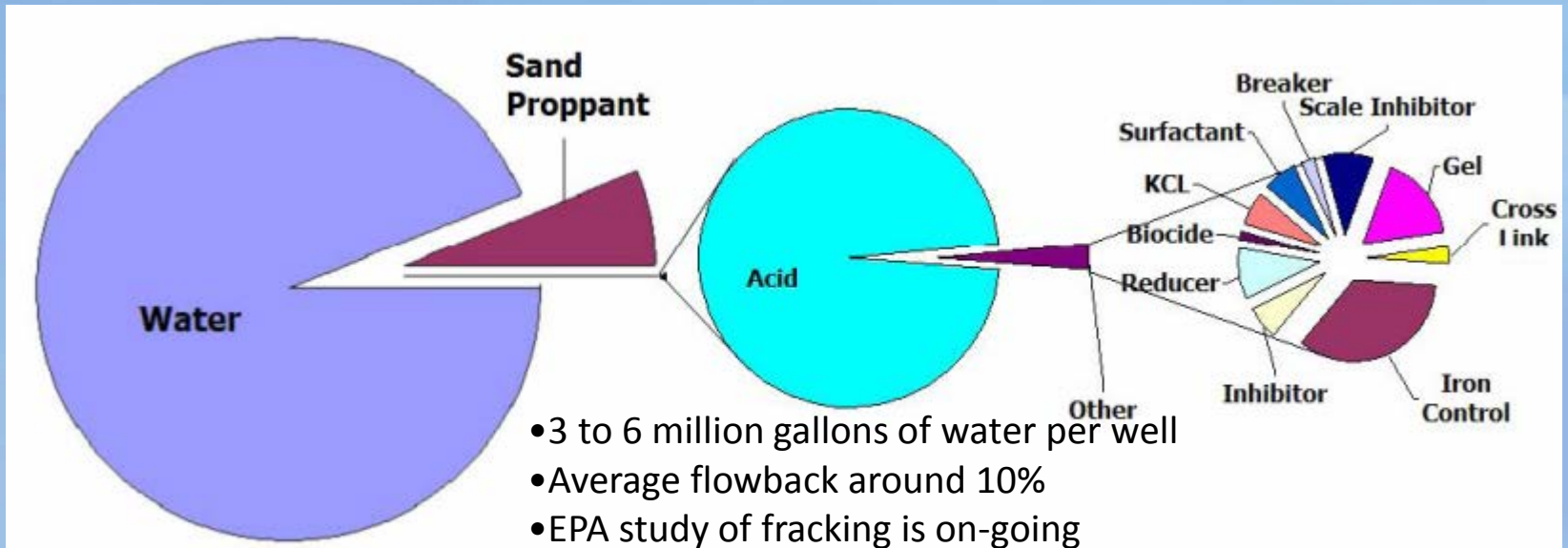
- Typically 3 to 5 million gallons per well
- Access to water = landowner control
- Allocation of water = state control
  - Basin commissions, DEP, Clean Streams Law

- Water withdrawals
  - Purchase water from communities
  - Large rivers and impoundments
  - Small streams and groundwater
  - Incentives – wastewater

- Biggest concerns
  - Withdrawals in western PA
  - Illegal withdrawals – enforcement
  - “loss of water”

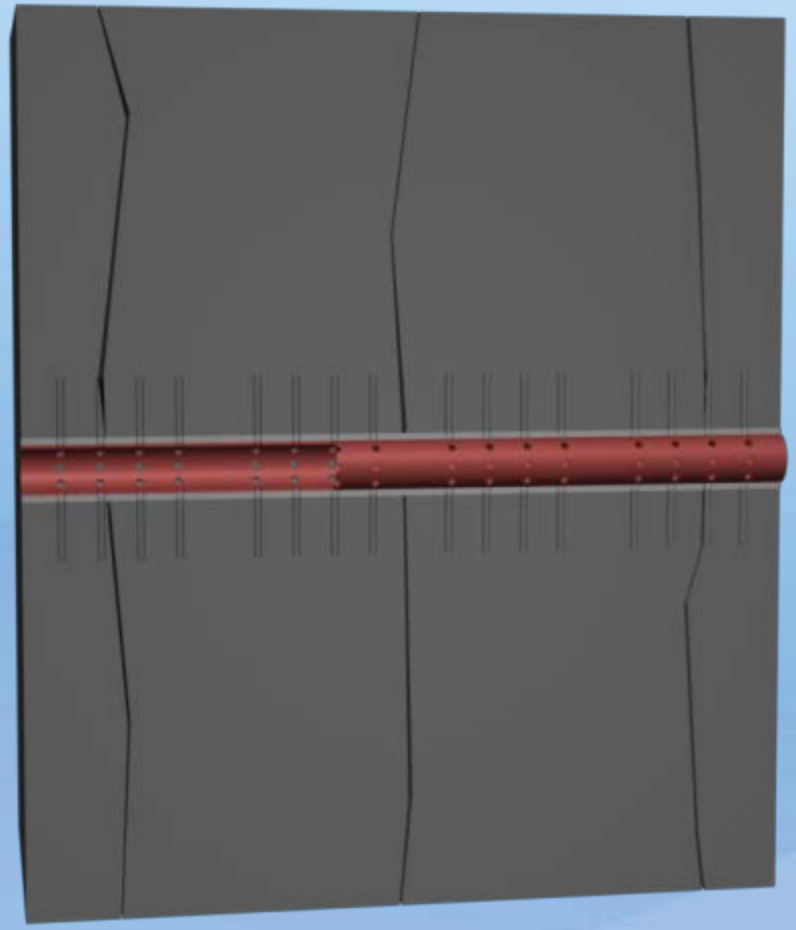
Hydraulic Fracturing



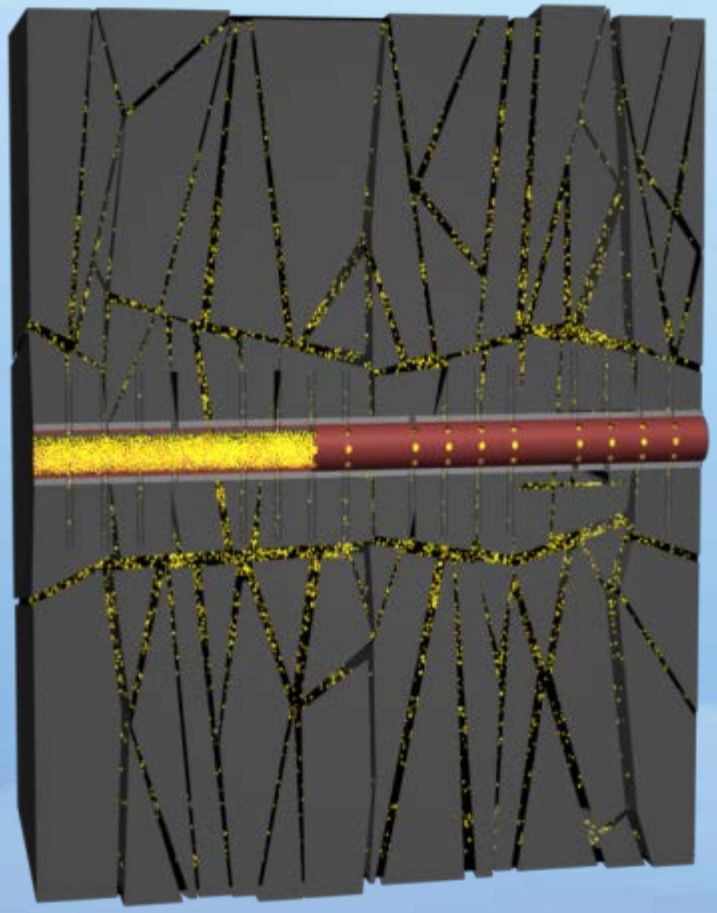


- 3 to 6 million gallons of water per well
- Average flowback around 10%
- EPA study of fracking is on-going

Pre and Post Hydraulic Fracturing



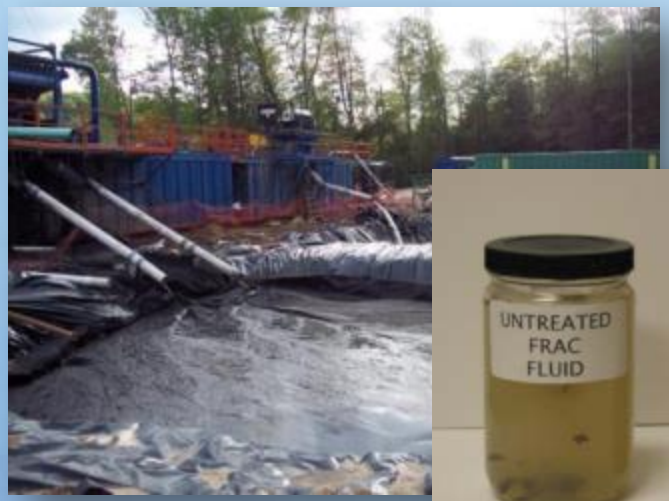
Every 300-500 feet of casing is perforated to inject fluids into the shale for hydraulic fracturing.



Approximately 0.5 to 1 million gallons of fluids are injected into each stage.

Types of Waste Fluids

Drilling Fluids

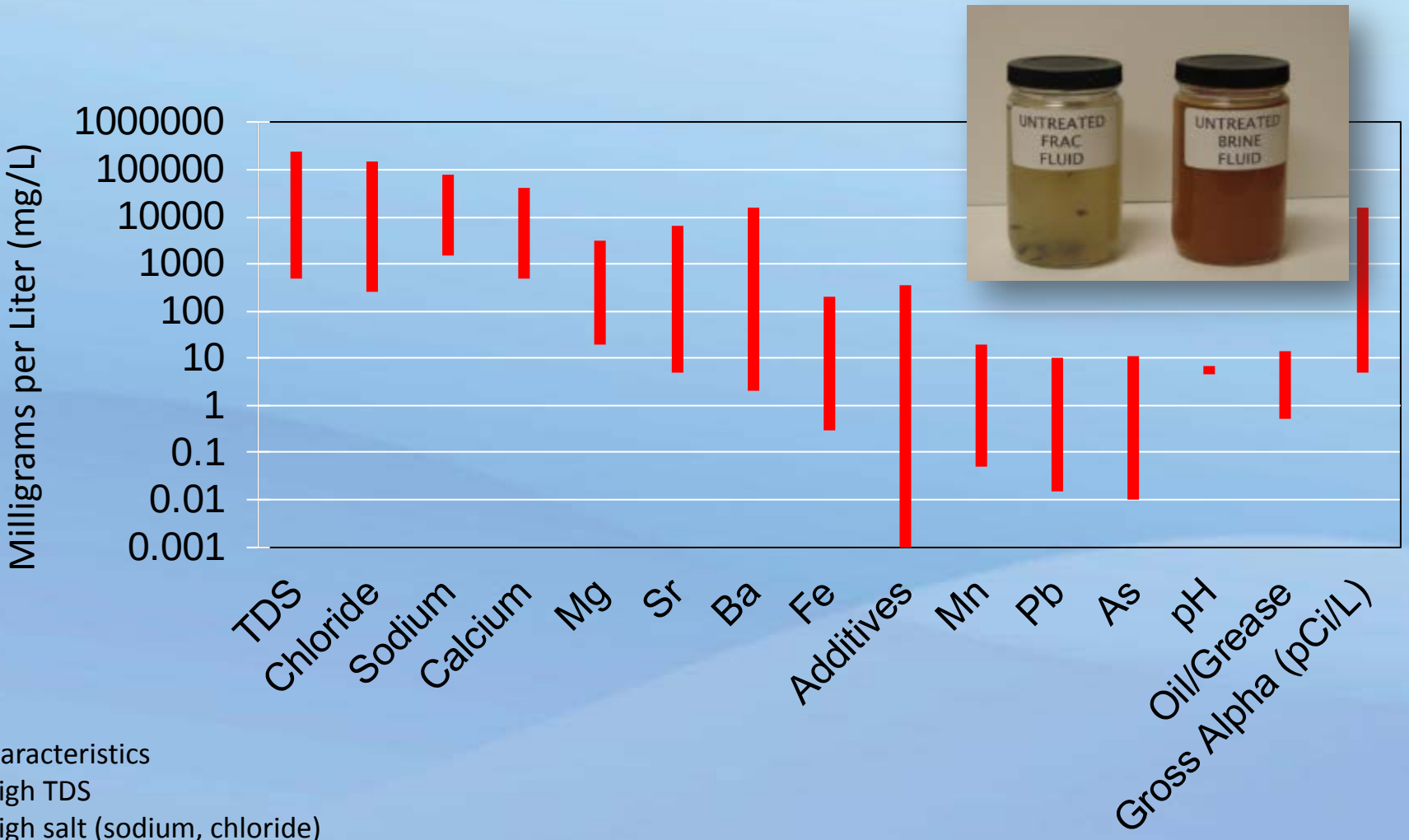


Brine

Flow-Back / Frac Return

Production Fluids

Typical Wastewater Concentrations

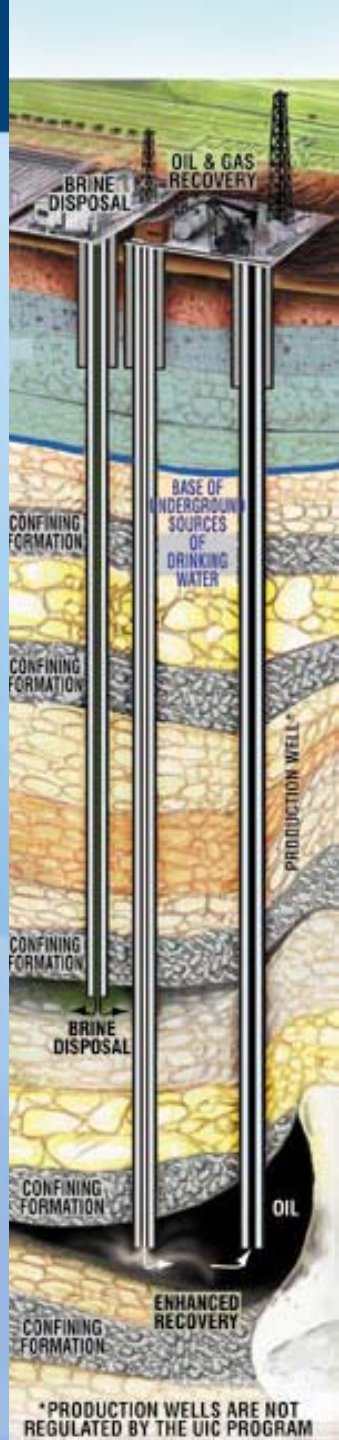


Characteristics
- High TDS
- High salt (sodium, chloride)
- High metals (barium, etc.)
- Organic carbons

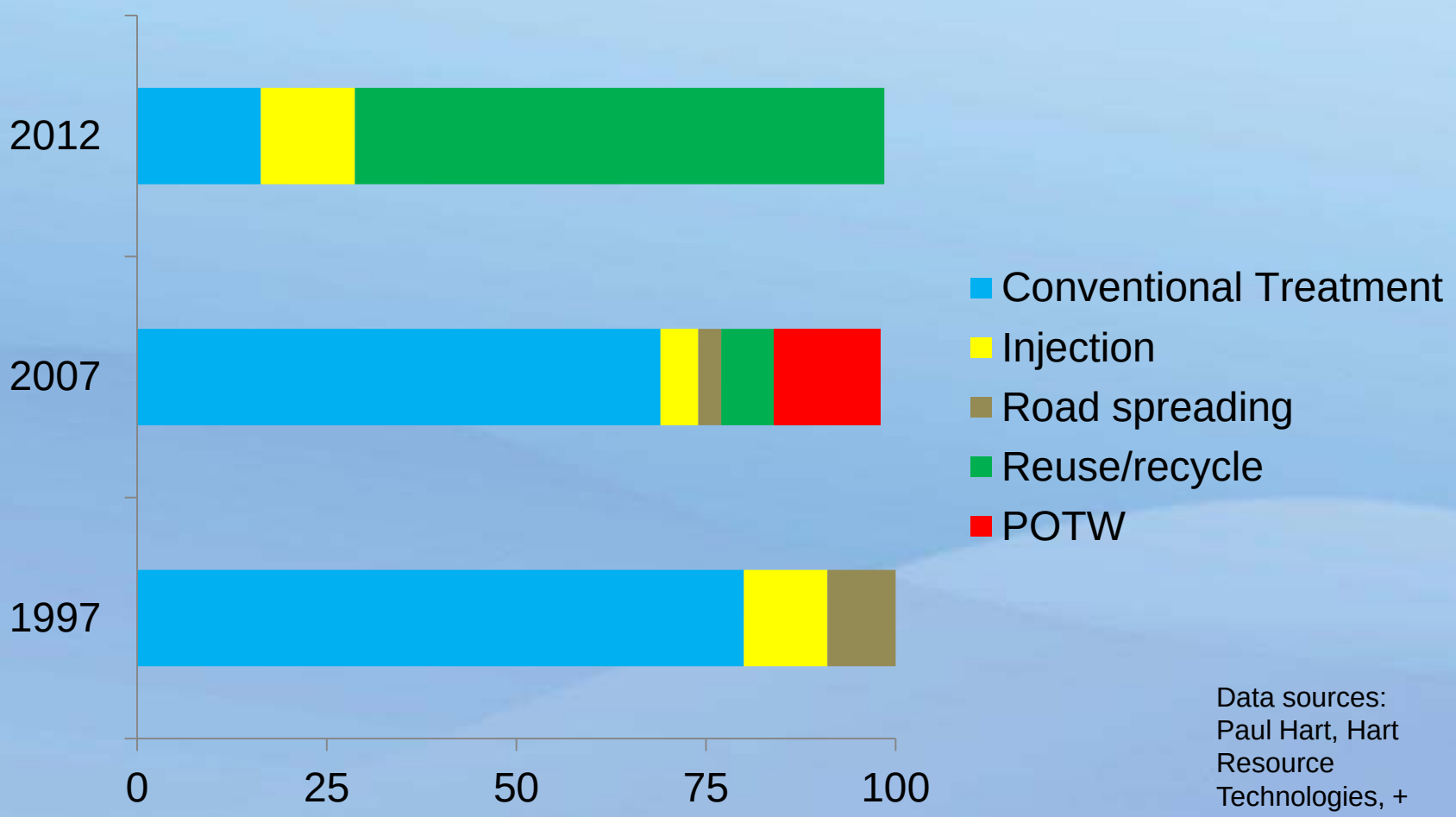
Photo courtesy – Paul Hart, Hart Resource Technologies, Inc

Wastewater Options

- Conventional treatment – treatment and discharge
  - Treatment facilities or POTW's
- Deep injection wells – limited in PA
- Reuse / recycling
  - Directly dilute and reuse
  - Basic treatment then dilute
- Membrane filtration
  - Requires some pre-treatment
  - Reuse or discharge to stream
- Distillation
  - Produces clean water but $$
  - Reuse or discharge to stream



Changing Wastewater Treatment

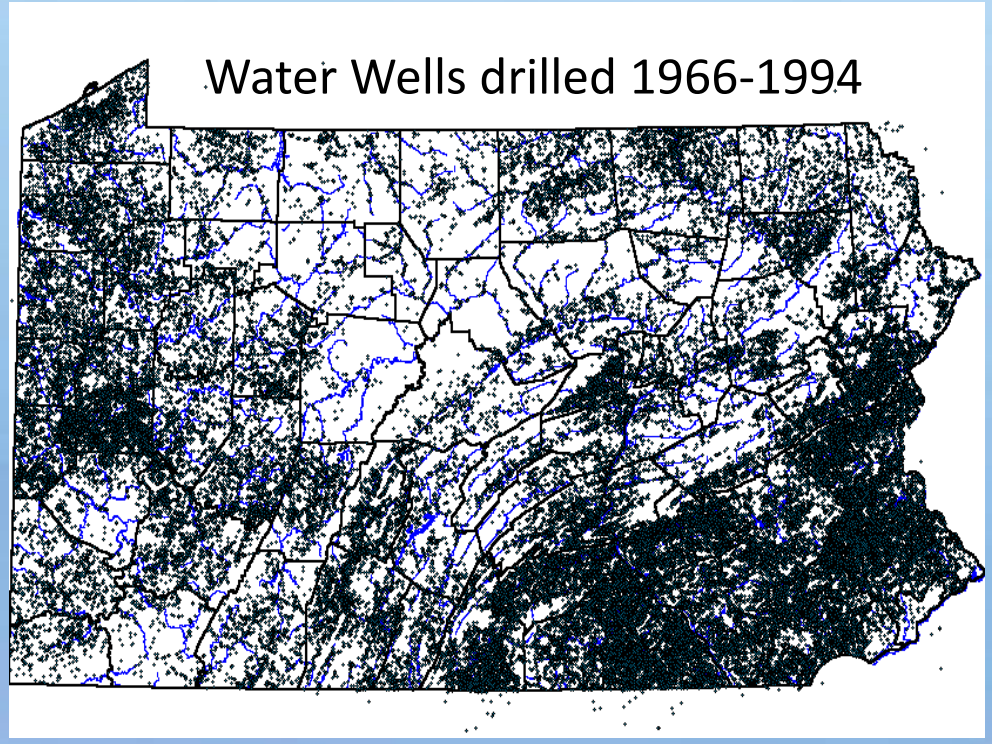


Data sources:
Paul Hart, Hart Resource Technologies, + PA DEP

Restored Well Site

Picture courtesy Fortuna Energy

Groundwater Issues



High density of groundwater wells in Pennsylvania

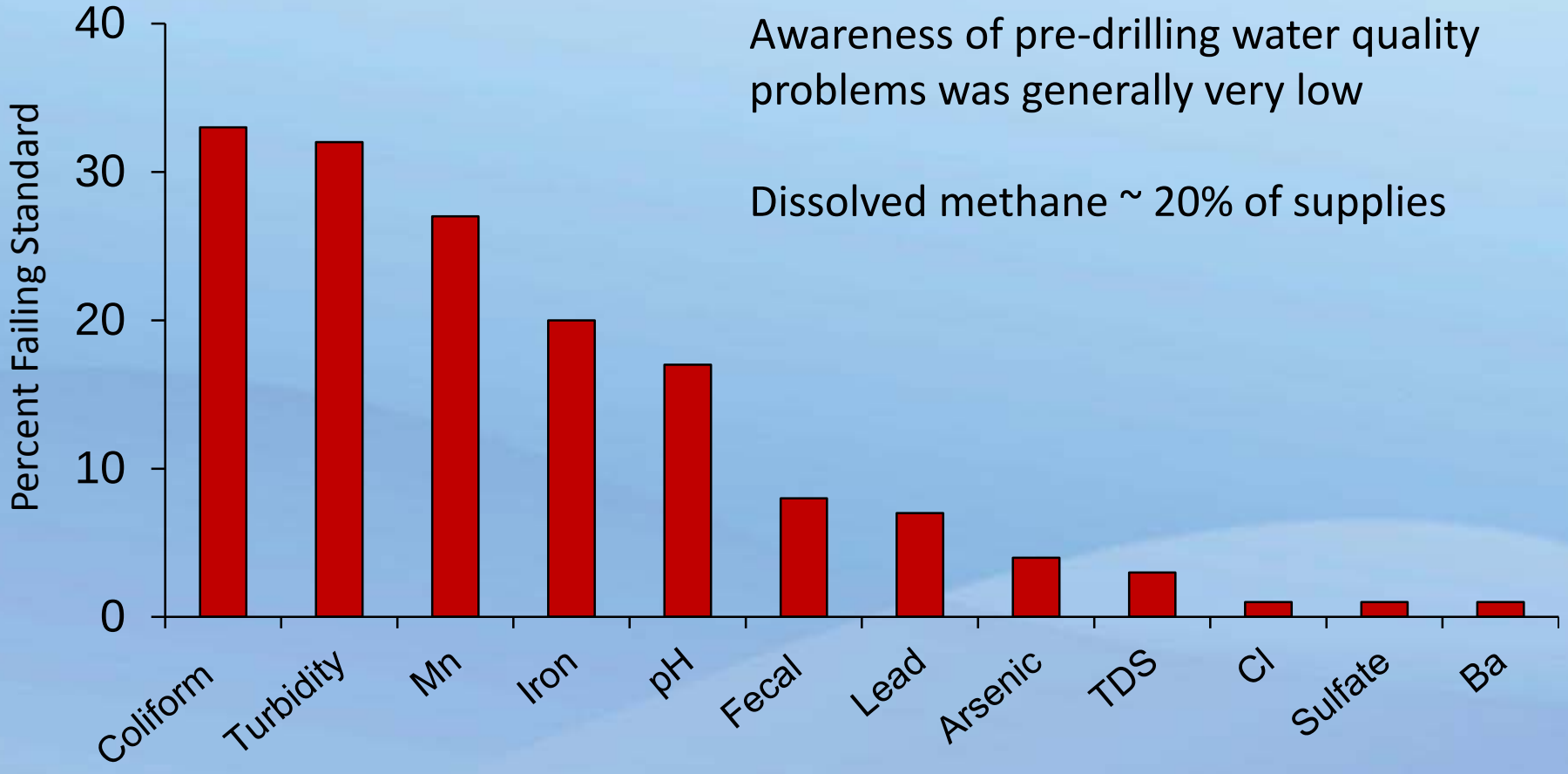
Many never tested

Poor well construction

METHANE IN WATER

- Can occur naturally in groundwater or migrate from gas wells
- Detected in ~20% of water wells
- Gas well casing and cementing critical to prevent methane migration
- No drinking water standard - saturation concentration in groundwater = 28 mg/L at atmospheric pressure
- Symptoms = effervescent or cloudy water, spurting faucets, bubbling sound in well

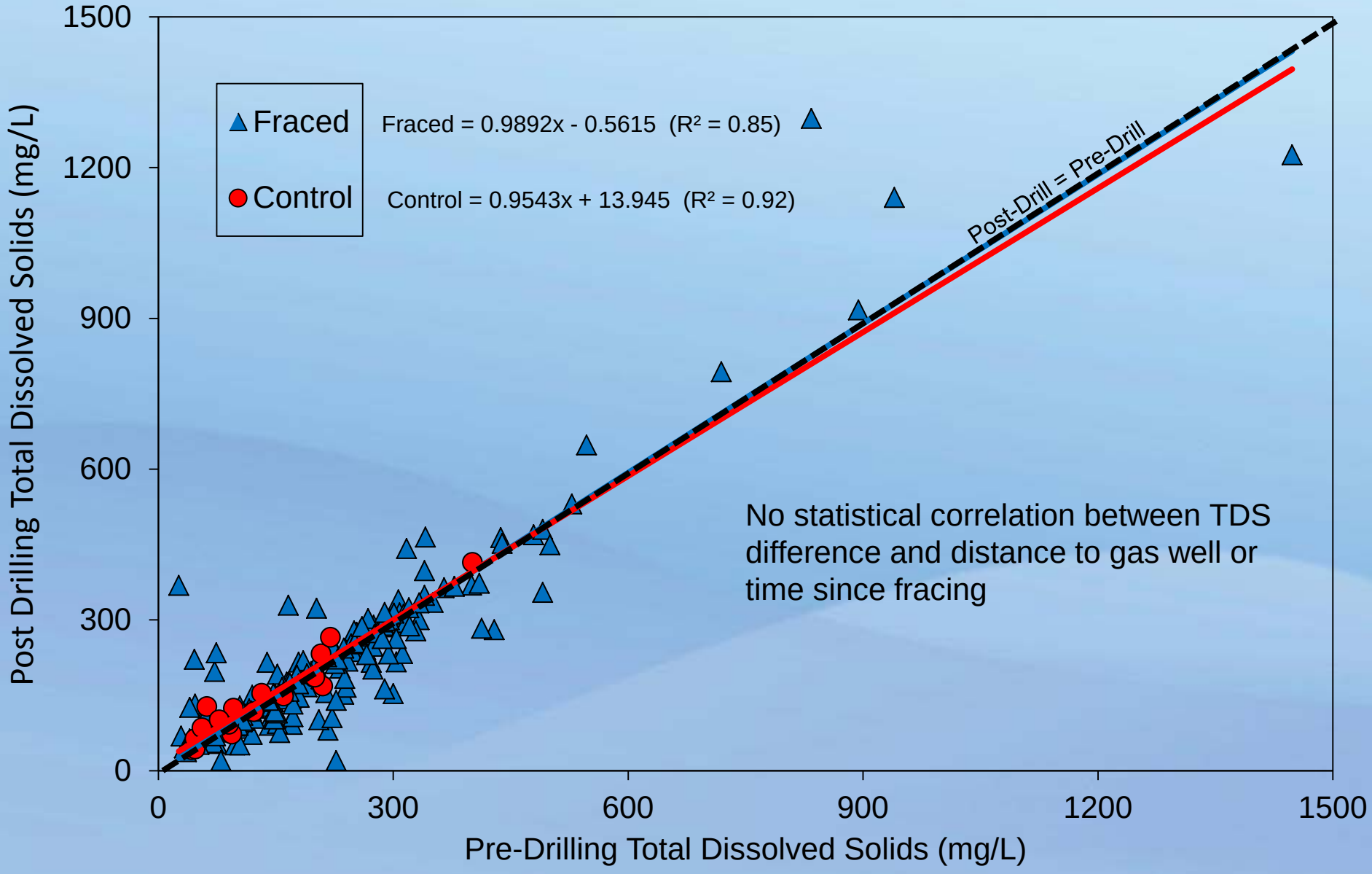
Pre-Drilling Water Quality Issues



Awareness of pre-drilling water quality problems was generally very low

Dissolved methane ~ 20% of supplies

Total Dissolved Solids

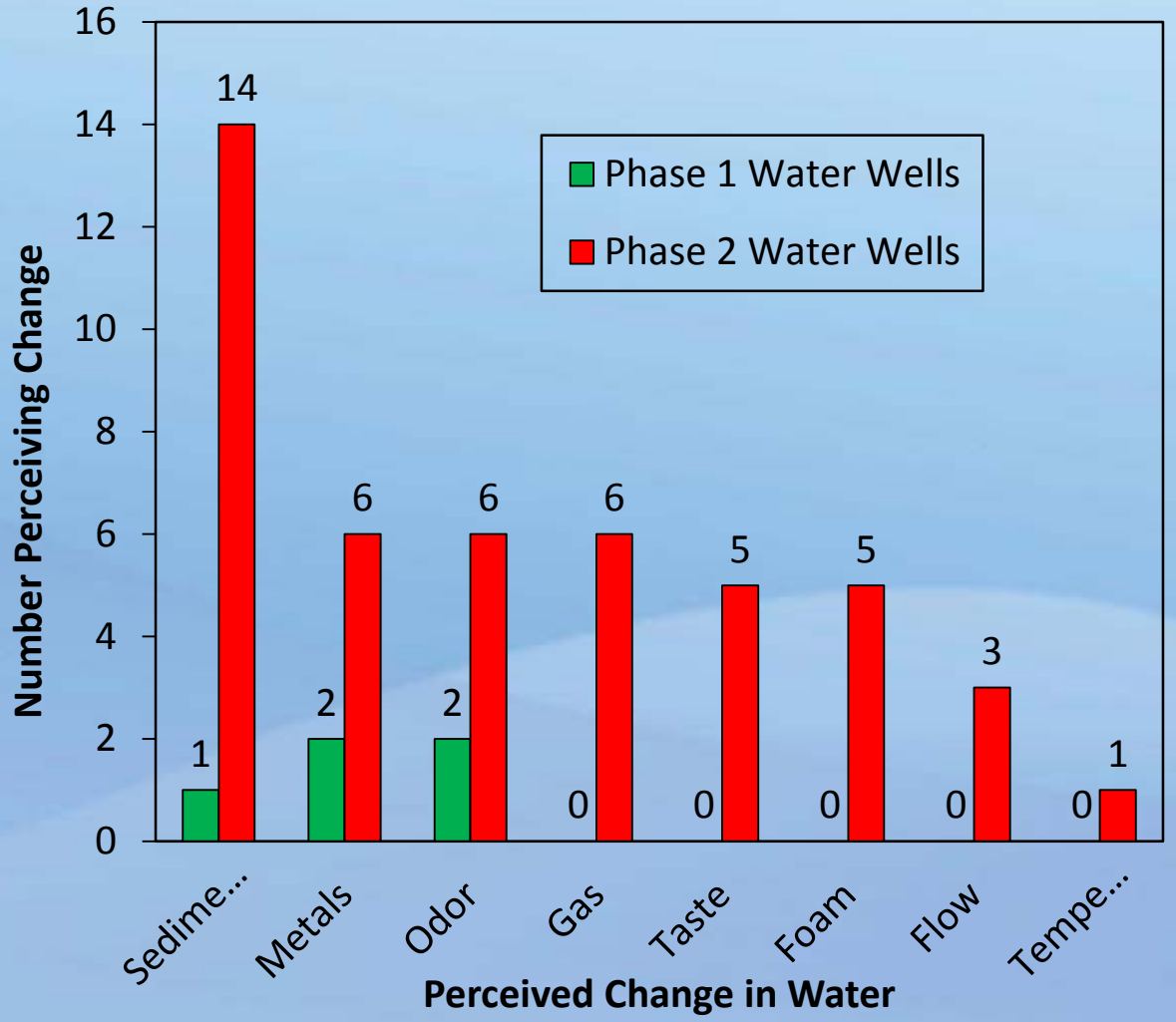


Water Supply Complaints

- Perceived changes reported by 12% of Phase 1 and 17% of Phase 2 well owners

- 82% of perceived changes and 100% of those who filed DEP complaints were within 3,000 feet of nearest Marcellus well

- Most complaints either could not be evaluated or could not be confirmed – some problems could be intermittent?

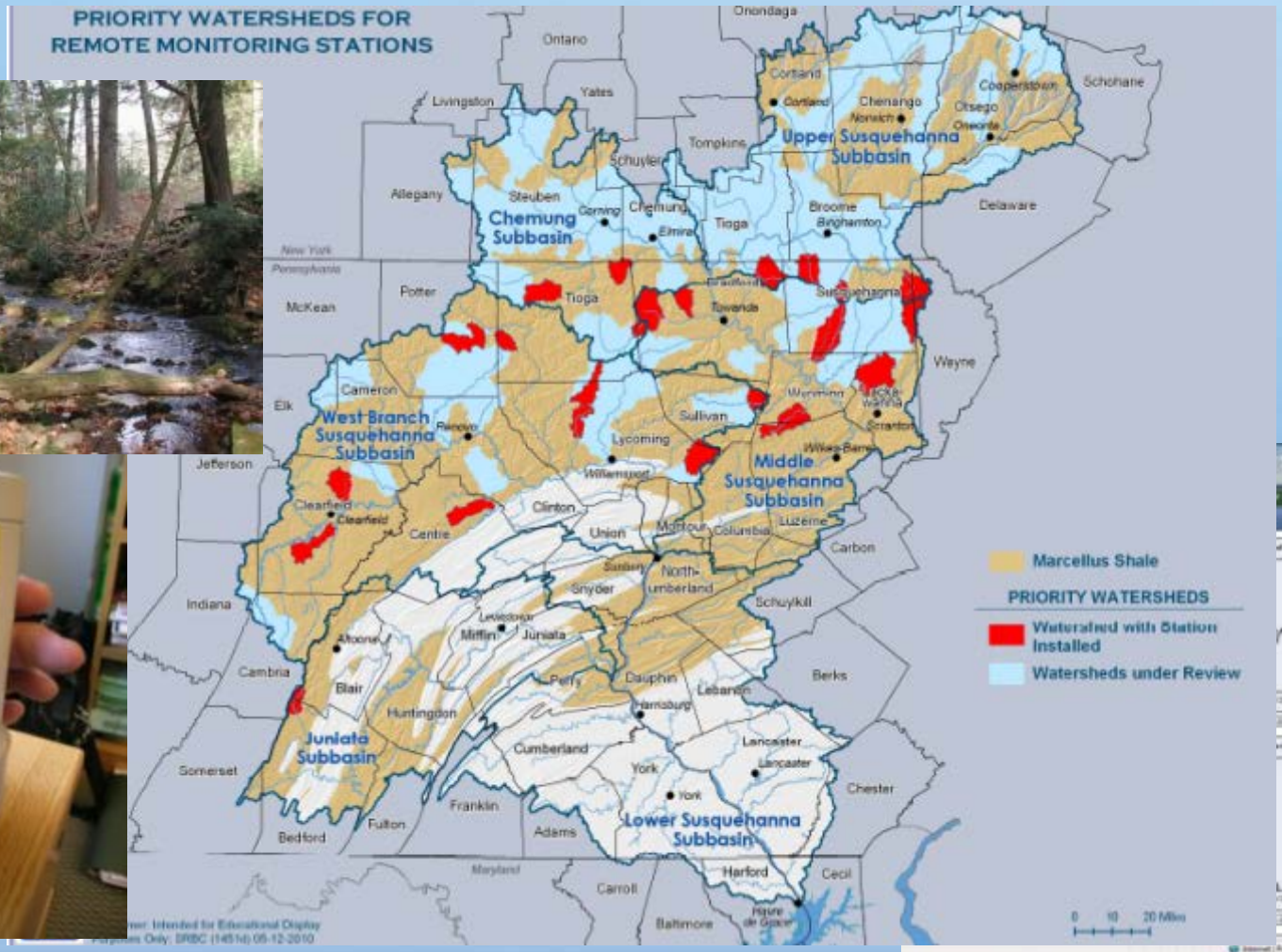


Protecting Surface Water During Drilling

- Clean Streams Law
  - Broad authority to regulators to protect water quality
- River Basin Commissions
- Oil and Gas Act
  - Setbacks (typically 100 feet)
- Erosion and Sedimentation Plans
- Stream encroachment permits
- Site restoration plans

SURFACE WATER MONITORING

No presumed responsibility, many volunteer networks



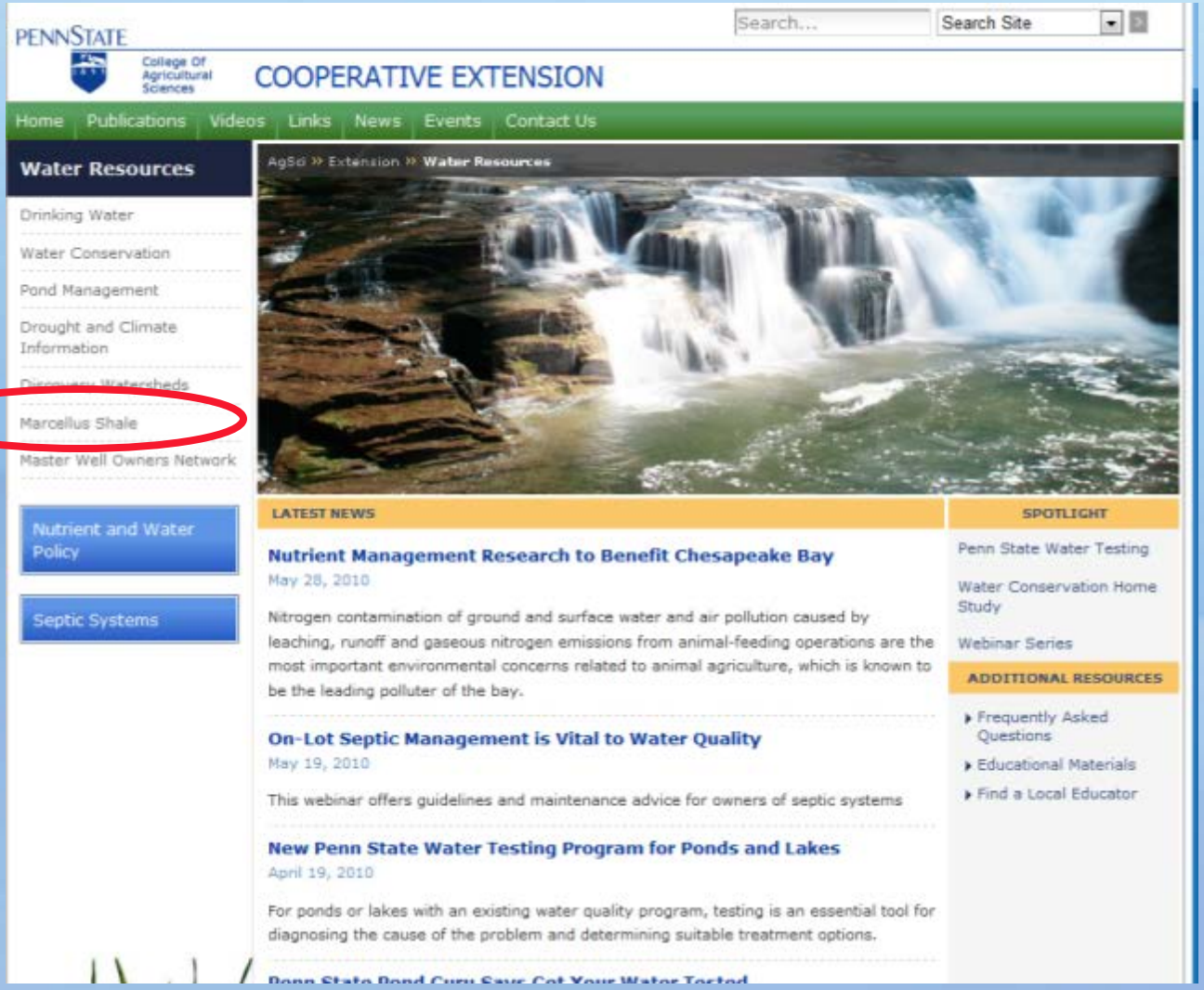
Additional Actions to Protect Water

- Leasing stipulations
  - Greater setbacks to water
  - Use of tanks vs. pits for wastewater
  - Pre + post-drilling testing of ALL water
  - Water flow measurements (before seismic)
  - Proper retirement of seismic holes
  - Access to water (and payment)
  - No surface lease?

- Voluntary water testing and documentation

- Reporting obvious problems (sediment, tastes, odors, loss of water, etc.) and report problems to DEP and gas drilling company

Penn State Cooperative Extension Resources



http://extension.psu.edu/water