Water Issues Surrounding Gas Drilling

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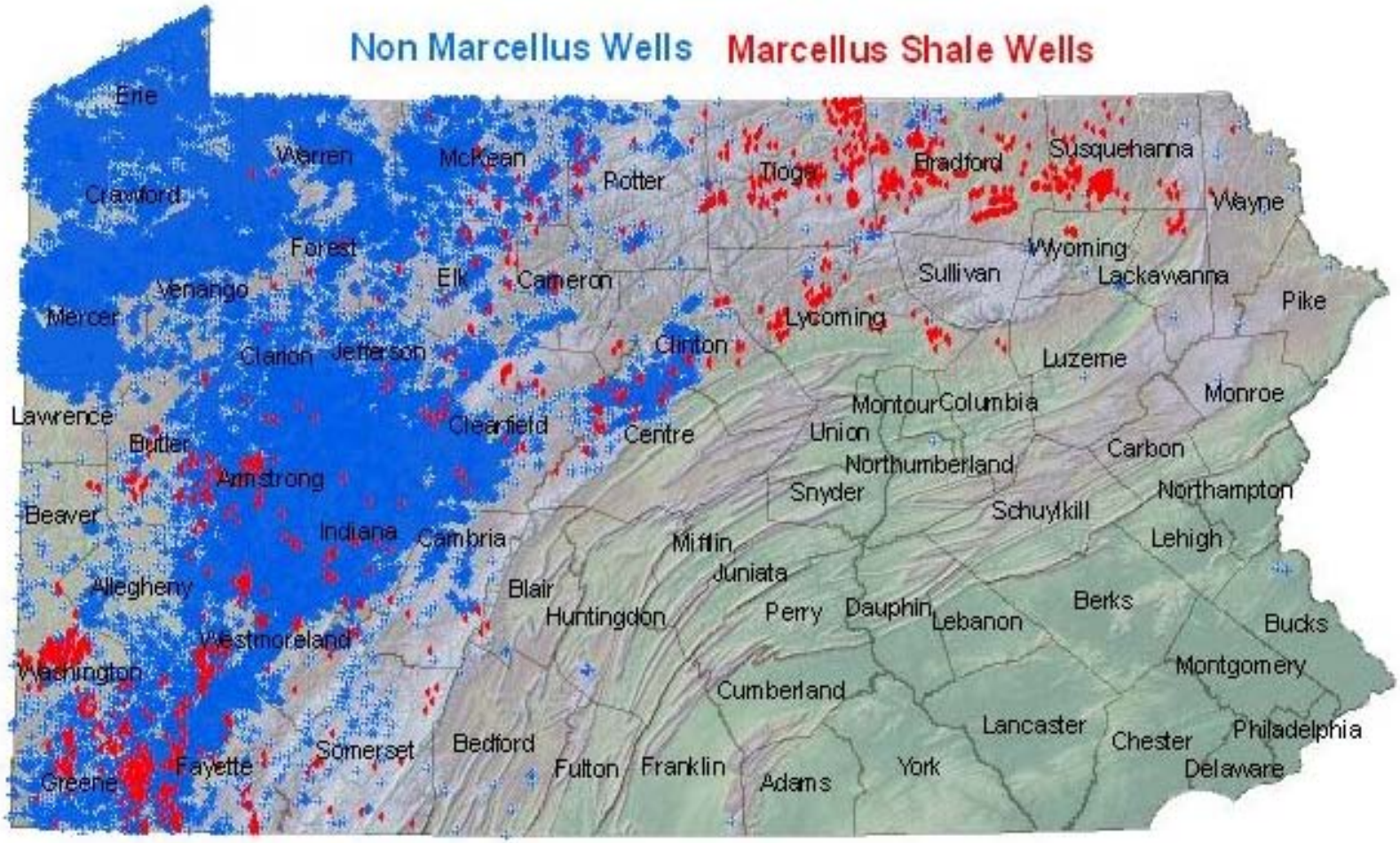
Department of Environmental Protection
Bureau of Oil and Gas Management
Active Oil and Gas Wells



Map from PA DEP – Marcellus Shale web page

as of 11/20/2009

Water Resources Issues

Impact of water withdrawals

Hydrofracturing chemicals

Adequate wastewater treatment

Protection of drinking water

Regulations and enforcement

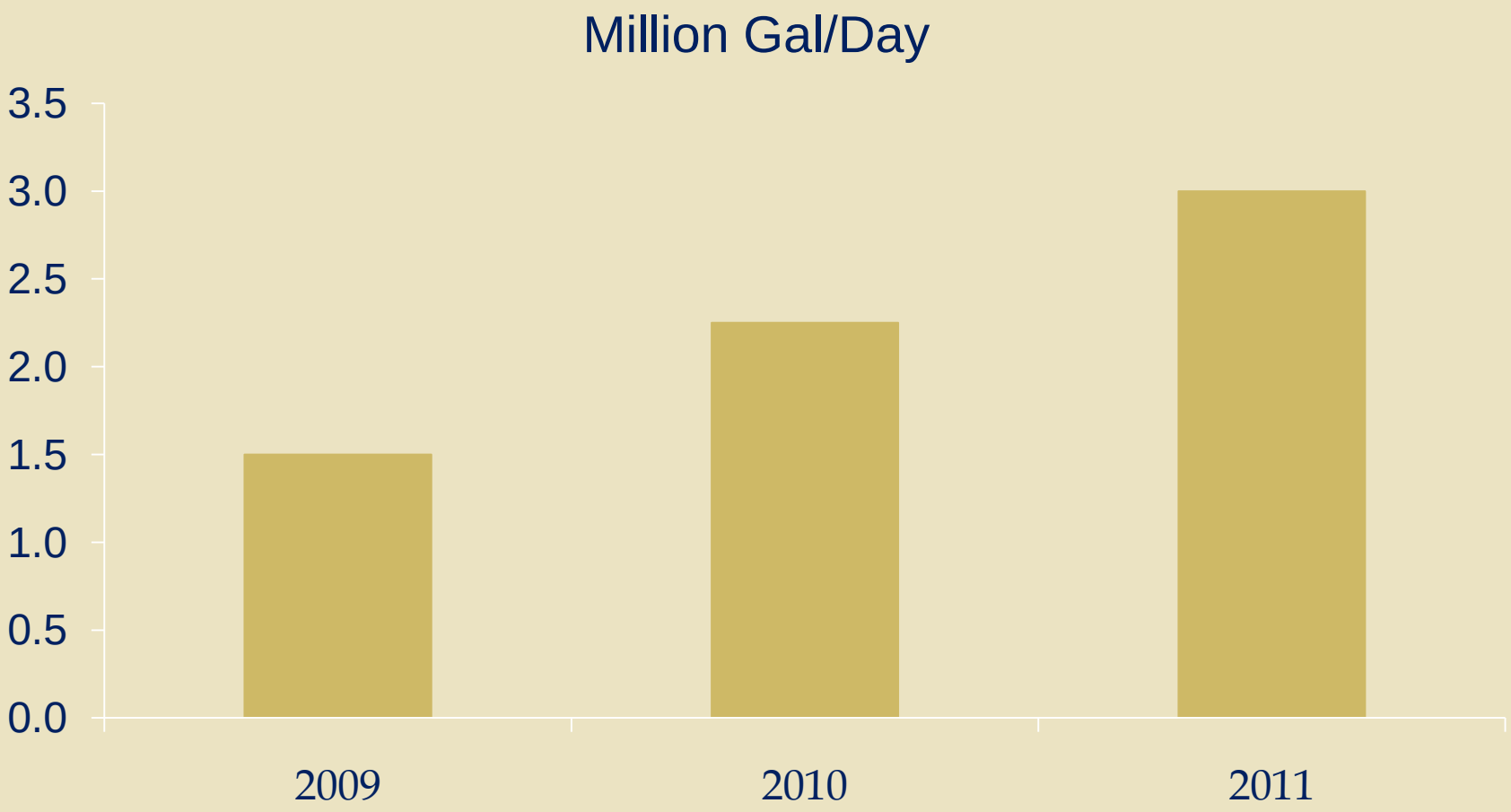
Why is Wastewater an Issue?

- Rapid expansion of industry in PA – outside traditional drilling area
- Concentration and range of pollutants in waste fluids
- Variability of wastewater chemistry in time and space
- Volume of waste fluids from Marcellus wells - multiple hydrofractures per gas well?
- Limited existing treatment infrastructure
- Limited assimilative capacity of streams
- Lack of traditional options for treatment/disposal

Types of Waste Fluids

- *Top hole fluid* – freshwater encountered during drilling
- *Drilling fluids*
- *Bottom hole fluids (brine)*
- *Stimulation "flow back" fluids (major source of waste fluids from Marcellus wells)*
- *Production fluids -??*

Predicted Volumes of Waste Fluids



Based on updated industry estimates from Paul Hart, Hart Resource Technologies, Inc. as of 10/28/09

Wastewater Pollutants

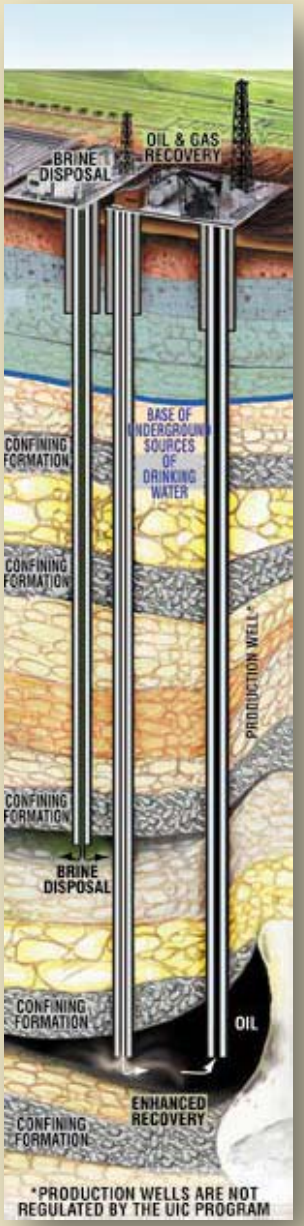
(~20 wastewater samples)

Traditional Treatment
Permitted Waste Facilities

- Remove solids, oil/grease, metals, etc.
- Discharge salt water to receiving stream
- Advantages
  - Inexpensive – pennies per gallon
  - Availability in western PA
- Disadvantages
  - Limited capacity
  - Rely on dilution for salts
  - Transportation for eastern PA
  - Time to permit, build new facilities
- Road application also permitted under certain conditions for certain waste fluids

Deep Well Injection

- EPA Underground Injection Control (UIC) program
- Requirements
  - Porous formation to accept fluid (limited in PA)
  - Confining layer free of faults or fractures
  - Plugged or absent orphan gas wells
  - Controlled injection pressure
  - Double containment – casing
- Unlike other states, very few in PA
- Some Marcellus waste fluids go to surrounding state's UIC wells for disposal
- Costly to develop but more expected in PA
  - Injectivity testing proceeding on ~13 wells currently



U.S. EPA Image

UIC Disposal in Pennsylvania

Current Class II UIC Wells

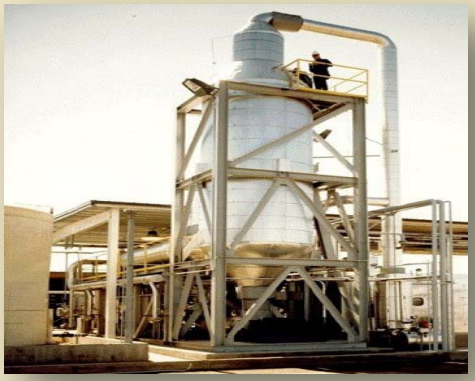
Facility Name	County	Formation	Volume (barrels/month)
Columbia Gas	Beaver	Huntersville/Oriskany	21,000
EXCO-North Coast	Clearfield	Oriskany	4,260
CNX Gas	Greene	Mine Void	150,000
Range Resources*	Erie	Gatesburg	20,000
XTO Energy #	Indiana	Balltown	3,600
Cottonwood	Somerset	Oriskany	27,000
EXCO-North Coast	Clearfield	Oriskany	4,200
Dominion	Somerset	Huntersville/Oriskany	30,000

*=Only commercial facility , #= Recently Plugged

Newer Treatment Options

- POTW's
  - Readily available with capacity ($)
  - Damage to treatment (toxicity)
  - Poor treatment efficiency/removal
  - Accumulation in sludge - hazardous
  - Interfere with existing downstream water users
  - Now scaled back

- Advanced treatment (evaporators, membranes)
  - Produce effluent that will meet new proposed state regulations on discharges
  - Time for permitting, construction
  - Treated water reusable (zero discharge?)
  - Costly ($0.25 or more per gallon)
  - Large solid waste residual

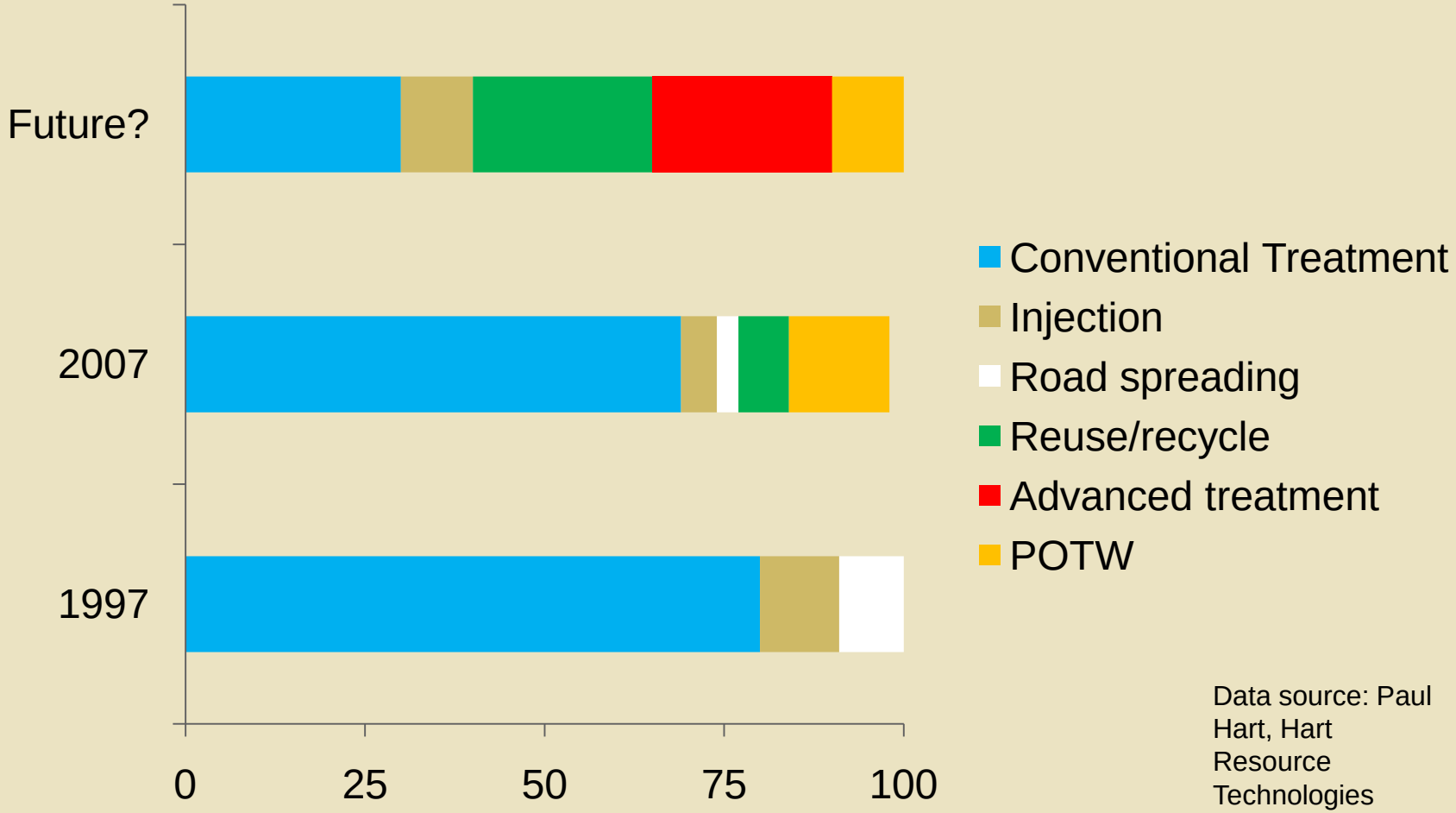


Pictures courtesy of Paul Hart, Hart Resource Technologies

Dilution and Reuse

- Frac flowback – perhaps 1 million gallons per well
  - Immediate re-use of relatively clean initial return fluids
- Remaining fluids may undergo conventional treatment to get to a moderate TDS and hardness
- The 1 million gallons of untreated or partially treated fluids are then diluted with 2 million gallons of freshwater for use on the next well
- Advantages
  - Potentially zero discharge
  - Low cost – no need for additional infrastructure
  - Less transportation of waste fluids
- Disadvantages
  - Challenge for frac process – changing chemistry
  - Still may need treatment for long-term production fluids

Changing Treatment and Disposal of Gas Drilling Wastewaters



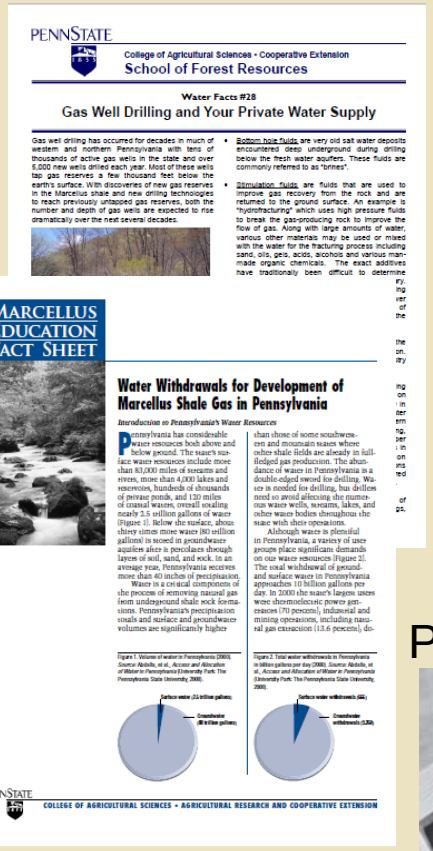
Data source: Paul Hart, Hart Resource Technologies

Homeowner Strategies
Water Resource Protection

- Learn when and where drilling will occur using DEP web sites
- Stipulate access and use of water on site
- Stipulate water protections in leases (testing, setbacks, etc.)
- Cooperate with pre-drill testing (ask for ID, request copy of results)
- Watch for obvious signs of contamination – report to DEP
- Arrange for comprehensive water test through a state-certified laboratory before drilling
- Arrange for water quantity measurement by water well contractor

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.

- Bottom hole fluids are very old salt water deposits encountered deep underground during drilling below the fresh water aquifers. These fluids are commonly referred to as "brines".
- Stimulation fluids are fluids that are used to improve gas recovery from the rock and are returned to the ground surface. An example is "hydrofracturing" which uses high pressure fluids to break the gas-producing rock to improve the flow of gas. Along with large amounts of water, various other materials may be used or mixed with the water for the fracturing process including sand, oils, gels, acids, alcohols and various man-made organic chemicals. The exact additives have traditionally been difficult to determine

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 thirty times more water (80 trillion gallons) is stored in groundwater aquifers like a pancake 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 total withdrawal of groundwater and 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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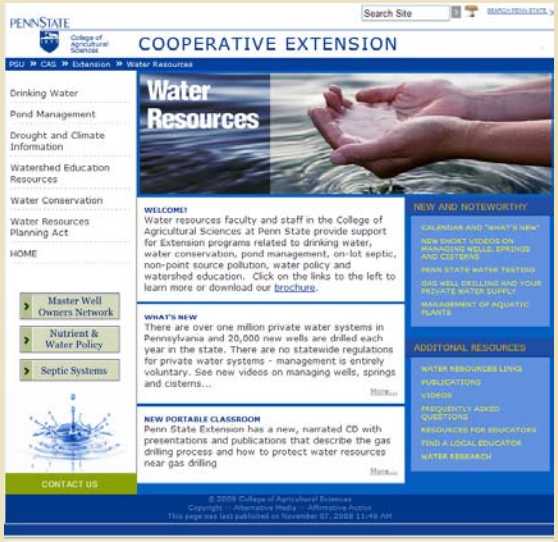
Web sites / webinars



FACT-BASED INFORMATION
natural gas
exploration & drilling
http://naturalgas.psu.edu

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