Natural Gas, Range Resources and the Marcellus Shale

RANGE RESOURCES

I. Big Picture

II. How Do We Do It?

III. Issues and Concerns

Range Resources

- Natural gas production company
- Included in S&P 500
- Committed to Pennsylvania
- Regional Headquarters in Washington County
- Pioneered Marcellus Shale, 2004
- More than $1 billion invested in Pennsylvania
- Employs more than 250 Pennsylvanians, thousands of indirect jobs

CELEBRATING OVER 25 YEARS IN PENNSYLVANIA
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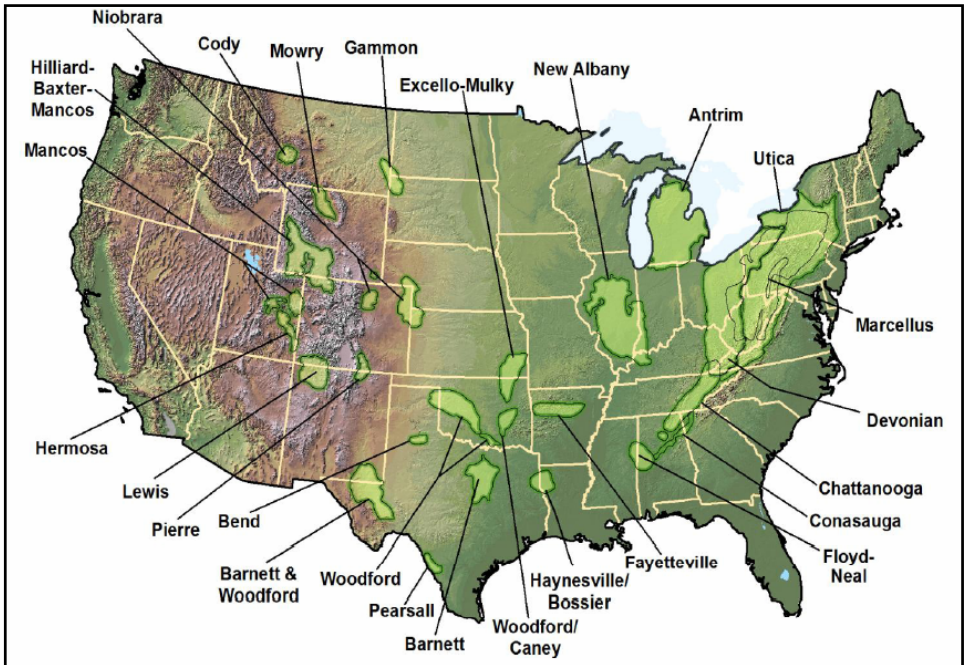
What is the Marcellus Shale?

- Large, natural gas rich, shale formation spanning tens of million of acres
- Actual piece of Marcellus Shale core sample
- Natural gas and hydrocarbons are trapped inside the solid shale



U.S. Department of Energy, U.S. Shale Basins

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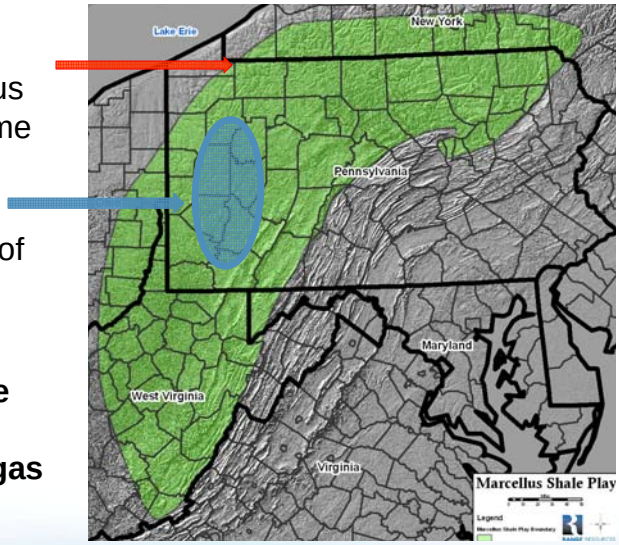
Marcellus Shale Formation

(compared to aerial extent of Barnett Shale in Texas)

ot all of the Marcellus will produce the same

arnett provides 5% of US natural gas

ost experts believe that Pennsylvania has more natural gas than Saudi Arabia has oil



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Marcellus is a World Class Discovery

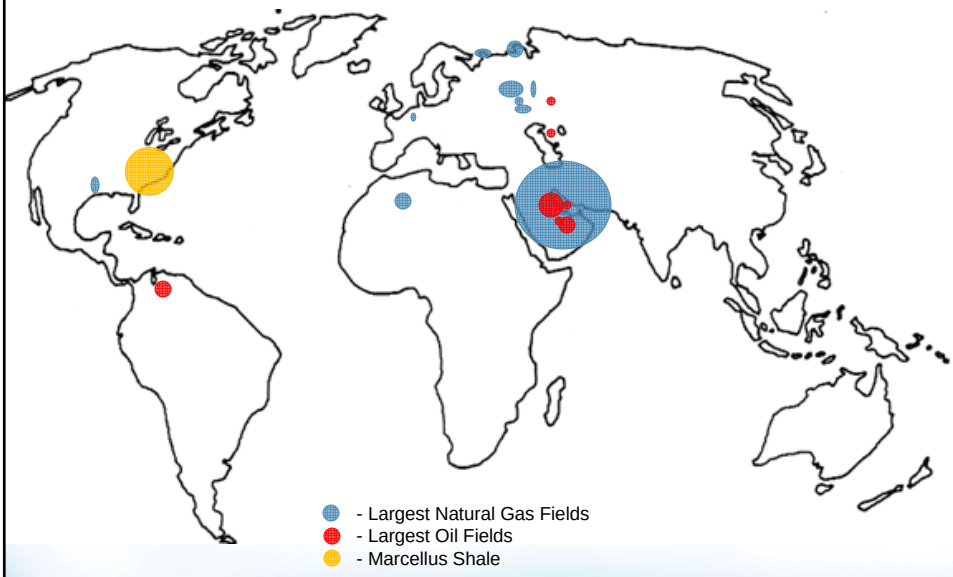
f estimated recoverable reserves are accurate at 50 Tcf- 500 Tcf, how does the Marcellus stack up against the largest oil and gas fields in the world?

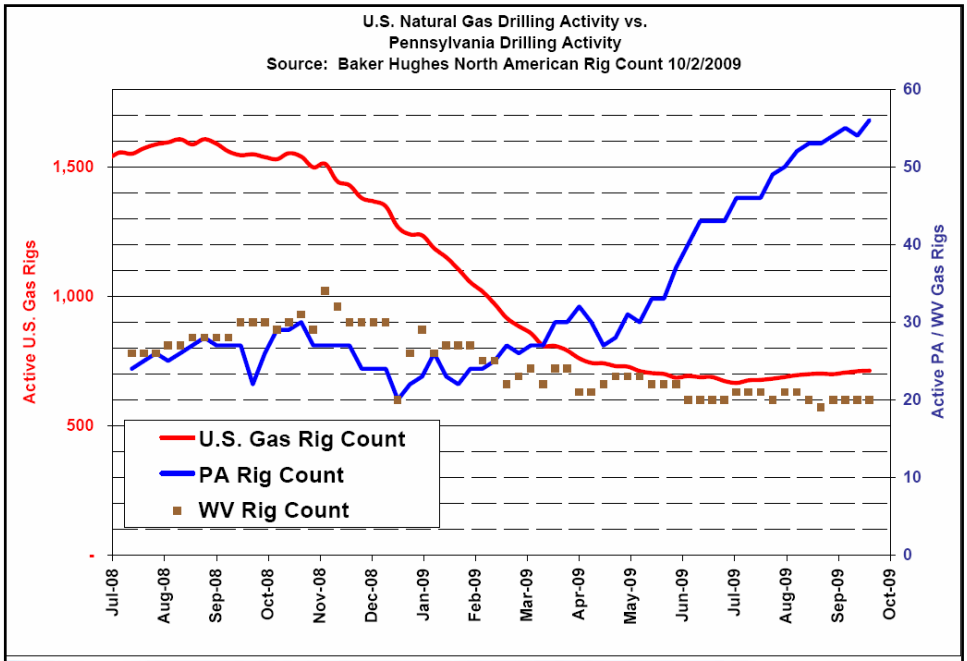
World's Largest Oil Fields			
Field, Country	**Discovery**	**Gb**	**Tcfe**
Ghawar, Saudi Arabia	1948	80	**480**
Burgan, Kuwait	1938	60	**360**
Bolivar Coastal, Venezuela	1917	32	**192**
Sufaniya, Saudi Arabia	1951	30	**180**
Rumiala, Iraq	1953	20	**120**
Ahwaz, Iran	1958	17	**102**
Marun, Iran	1964	16	**96**
Kirkuk, Iraq	1927	16	**96**
Romashkino, Russia	1948	16	**96**
Tengiz, Kazakhstan	1979	15	**90**

World's Largest Natural Gas Fields			
Field, Country	**Discovery**	**Tcf**	**Gboe**
North Field-South Pars, Qatar-Iran	1976	**1400**	233
Urengoy, Russia	1966	**222**	37
Yamburg, Russia	1969	**138**	23
Hassi R'Mel, Algeria	1956	**123**	20
Shtokman, Russia	1989	**110**	18
Zapolyarnoye, Russia	1965	**95**	16
Hugoton, USA	1926	**81**	13
Groningen, Netherlands	1959	**73**	12
Bonavenko, Russia	1971	**70**	12
Medvezhye, Russia	1967	**68**	11

Source: IPC Petroleum Consulting, Inc.

Top 10 Largest, Oil and Gas Fields





Marcellus Drilling Activity

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Why Natural Gas?

- Secure
- Abundant
- Domestic
- Clean
- Versatile
- No subsidies

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Beyond the Flame

Natural Gas drives other industries as feedstock

- Plastics
- Glass
- Metals
- Chemicals
- Fertilizers
- Pharmaceuticals
- And many more

According to Natural Gas Supply Association

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Energy Security

National Security

- We have a growing **100-year supply** of natural gas
- We have an opportunity to stop exporting hundreds of billions of dollars to other countries
- This is a once in a generation opportunity and maximizing this resource will not happen by accident

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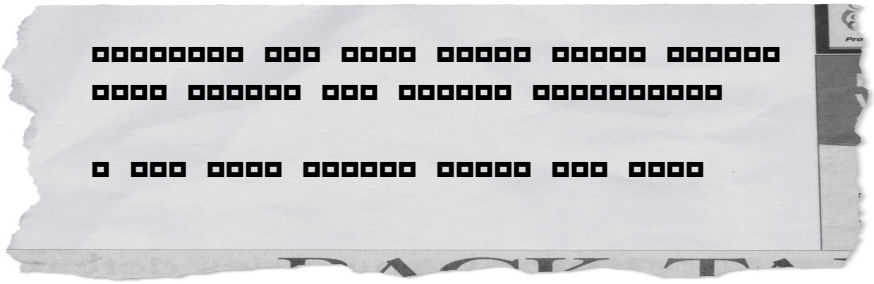
Natural Gas from US Shales



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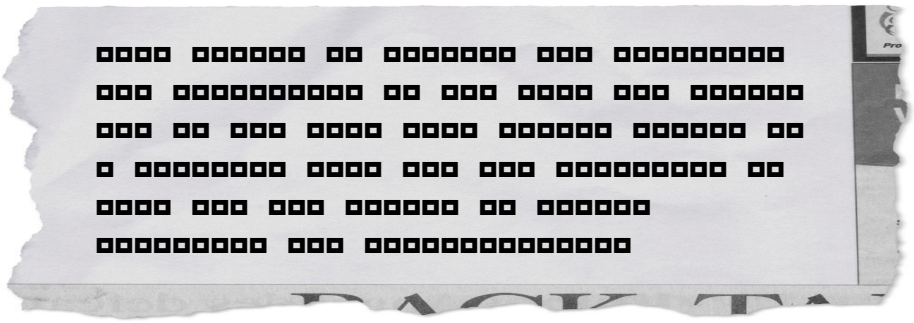
New Natural Gas Means Energy Security



According to The Wall Street Journal: Potential Gas Committee June 2009 and Energy Information Association, Annual Outlook, 2009

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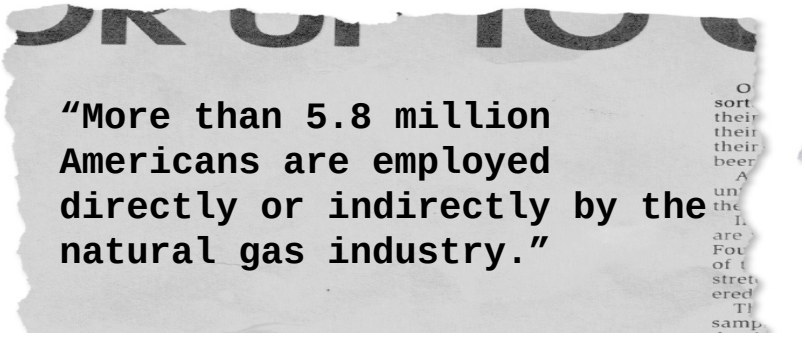
Gas is the Future, says *Wall Street Journal*


"More than 5.8 million Americans are employed directly or indirectly by the natural gas industry."

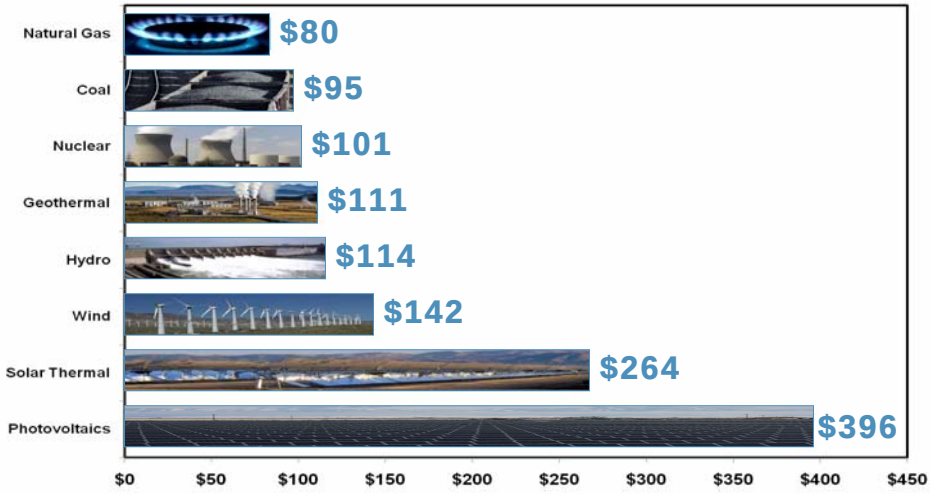
According to Wall Street Journal, January 15, 2009 "Energy Jobs: Blue is the New Green, Gas Lobby Says"

EIA Touts "Cleaner Electricity"

- 900 of the next 1,000 new power generation plants in the U.S. will be natural gas fired
- Natural gas does not contribute significantly to smog – low nitrogen oxides levels and virtually no particulate matter
- Could reduce acid rain causing emissions – virtually no sulfur dioxide and up to 80% less nitrogen oxides than coal
- New, high efficiency natural gas-fired power stations produce 70% less greenhouse gas emissions than existing brown coal-fired generators, and less than half the greenhouse gas emissions of the latest technology black coal-fired power stations.

According to Natural Gas Supply Association, Energy Information Association, Environmental Protection Agency, and Gas Research Institute

Total Cost of New Generating Technologies in 2016 per Megawatt Hour (2007 dollars)



According to the Institute for Energy Research, in Fall 2009 issue of "Technology Review, published by M.I.T."

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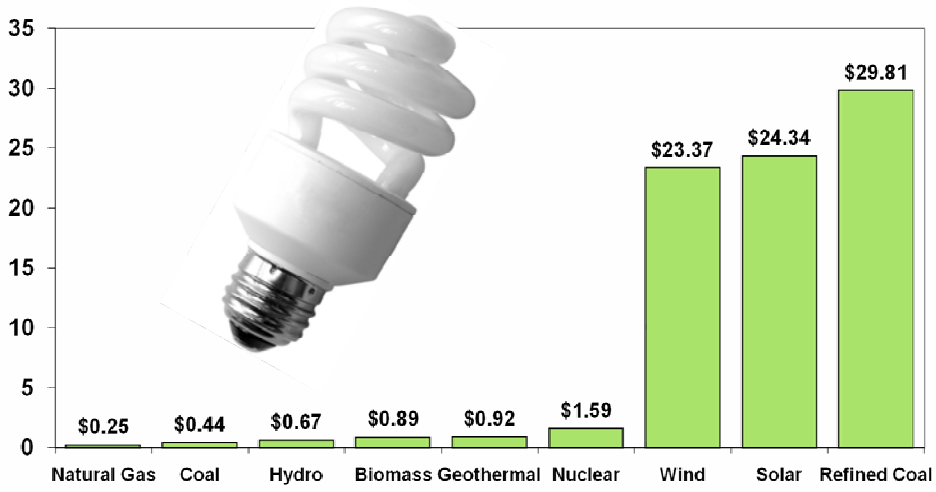
Subsidized Dollars Per Megawatt Hour



Energy Information Administration, *Federal Financial Interventions and Subsidies in Energy Markets 2007*

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EIA Touts "Cleaner Transportation"

- 90-97% less carbon monoxide
- 25% less carbon dioxide
- 35-60% less nitrogen oxide
- 50-75% less from other non-methane hydrocarbons
- Fewer carcinogenic emissions & virtually no particulate emissions

According to Natural Gas Supply Association, Energy Information Association, Environmental Protection Agency, and Gas Research Institute

Fleet Conversions Gaining Ground

Heating Up Fleets

Natural Gas Vehicles

- 8 million NGVs worldwide, growing 26% annually since 2001
- 65 million NGVs by 2020, reduce oil demand by 7 million barrels per day
- CNG is 1/3rd the price on an energy-equivalent basis

AT&T converting 8,000 fleet vehicles in the US

According to Oil and Gas Journal, week of February 16, 2009

We Can Make it Happen

- Of the 8 million NGVs worldwide, only 150,000 are in the US
- Natural gas is roughly one-third the price at the pump
- If we converted every vehicle in the U.S. today, we still have a **60-year domestic supply** to meet all of our natural gas needs

According to Oil and Gas Journal, week of February 16, 2009

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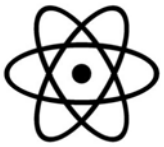
Key to Clean Energy Future

The United States needs to build 420 Gigawatts of generating capacity over the next 20 years to replace aging capacity and meet our growing need for electricity. At that rate, the U.S. would have to build **840 new power plants over the next 20 years** simply to keep up with demand.



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Economic Impact Study

Marcellus Shale report from economists and industry experts at Penn State

2010

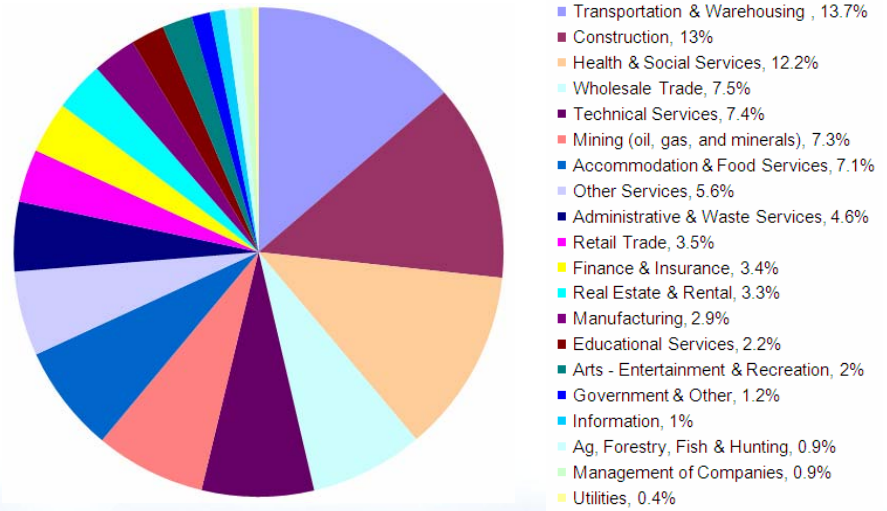
- $8 billion annual impact and 110,000 jobs
- $800 million in state/local tax revenue

2020

- $265 billion cumulative impact and 176,000 jobs
- $15 billion state/local tax revenue

***30 percent tax revenue remains local**

Broad Based Job Creation



According to 2009 Penn State University Marcellus Shale Economic Impact Study

Job Creation

Each horizontal drilling rig can drill about 15 wells per year and support 150 full-time, family-sustaining jobs

Average Salary $85,000

industry salaries have increased 16% per year in recent more years

- **Advanced or Technical Degree** - geologists, engineers, environmental specialists, attorneys, Ph D
- **College or Continued Education** - land specialists, accountants, IT, office
- **High School or No Training** - heavy equipment operators, truck drivers, welders, general labor

According to the Southwest Pennsylvania Economy League Study on Oil and Gas in Pennsylvania

Field-Based Careers

Technical Careers

Landowner Wealth

"Pa. homeowners net $1.2M in gas-drilling royalties"

Associated Press
March 9, 2009

- Depending on gas prices and other variables, each well could generate $3 million, or more in royalties
- Industry wide had paid landowners more than $4 billion in lease and royalty payments
- Spin-off effect
- Lease and royalties for entire Marcellus from the industry could reach $2.75 billion annually by 2020

PaMarcellus.com

- Educational
- Videos
- Fact Sheets
- More

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I. Big Picture

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III. Issues and Questions

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Marcellus Shale Development

State-of-the-art Technology - Proven Approach - Industry Expertise

Preparation → Drilling → Completion & Production → Reclamation

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Preparation

Geoscientists determine drilling locations

- Surface, sub-surface maps
- 3-D seismic measurements
- State-of-the-art Technology

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Seismic Survey

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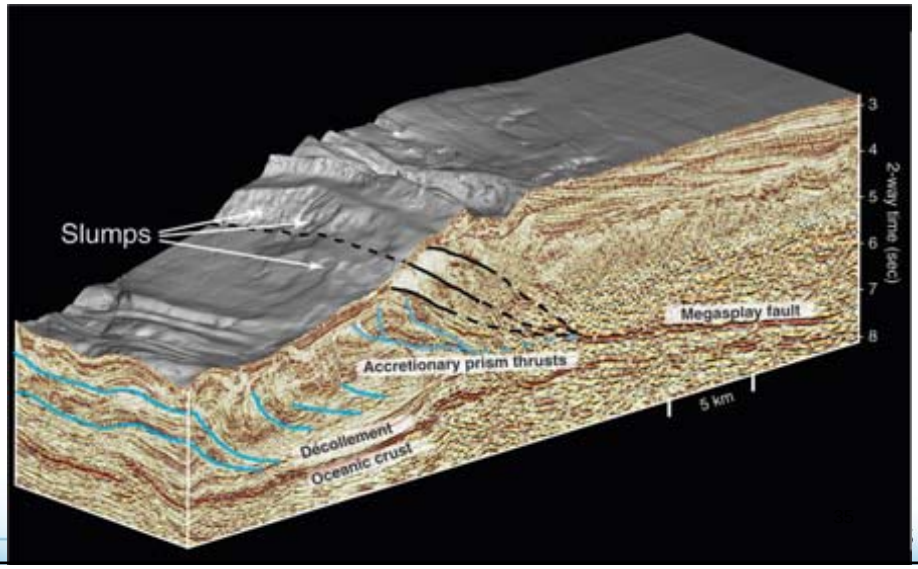
Example of 3-D Image



Leases are Acquired

- Oil & gas owners (frequently the surface owner) are offered compensation for leasing rights to their property
- In addition to initial lease payment, oil & gas owners also receive royalties on natural gas sold from the property

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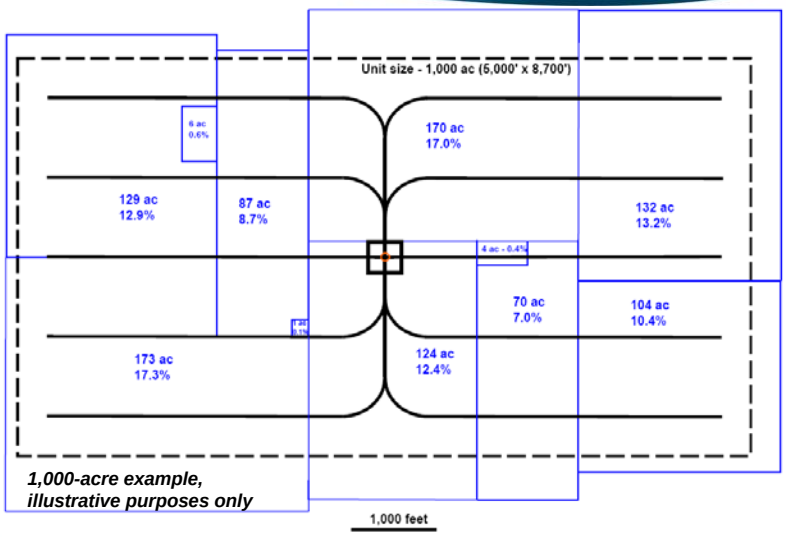
Pooling Leases



1,000-acre example, illustrative purposes only

Royalties are divided in proportion to the percentage of land that each land tract contributes to the total unit

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Site Preparation

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Drilling

- State-of-the-art technology
- Multiple wells, single site
- Footprint is 3-5 acres

Range's pioneering spirit continues…Patterson 315 was the first "walking" Marcellus Shale drilling rig

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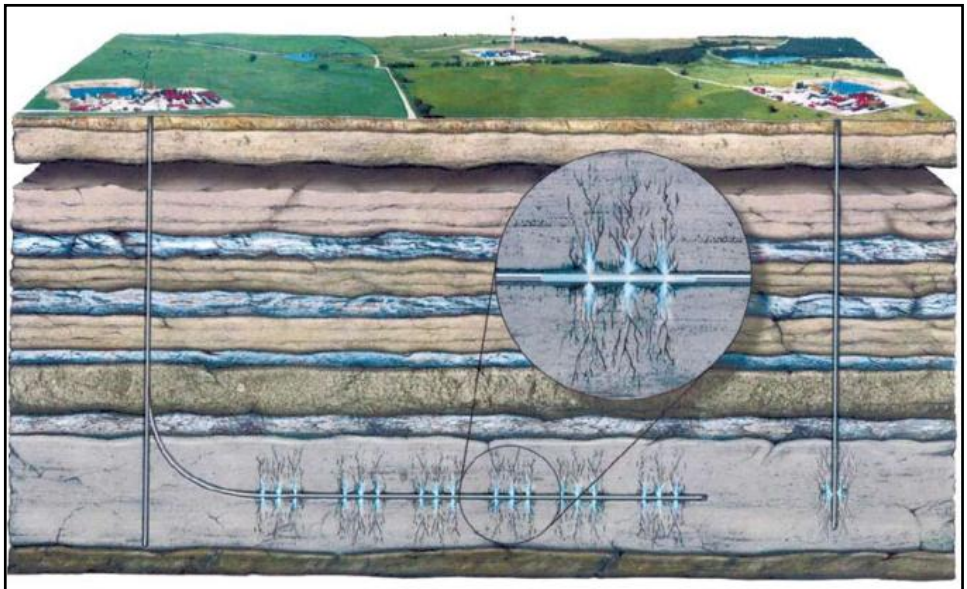

Horizontal Technology

John Perez Graphics

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Horizontal Technology

- Drill 5,000-8,000’ vertical up to 3,000’ horizontal
- Roughly 2 miles of drilling, spot-on accuracy
- Reduce surface disturbance, with less environmental impact

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...all to drill an 8.5” hole

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How Do You "Drill Horizontal"

Small bend in drilling motor assembly, roughly 1-2°, drills the curve over the course of 900', at a rate of 10° per 100' to achieve a 90° turn horizontally.

It's not abrupt, rather a gradual sweeping motion.

Weatherford drilling technology

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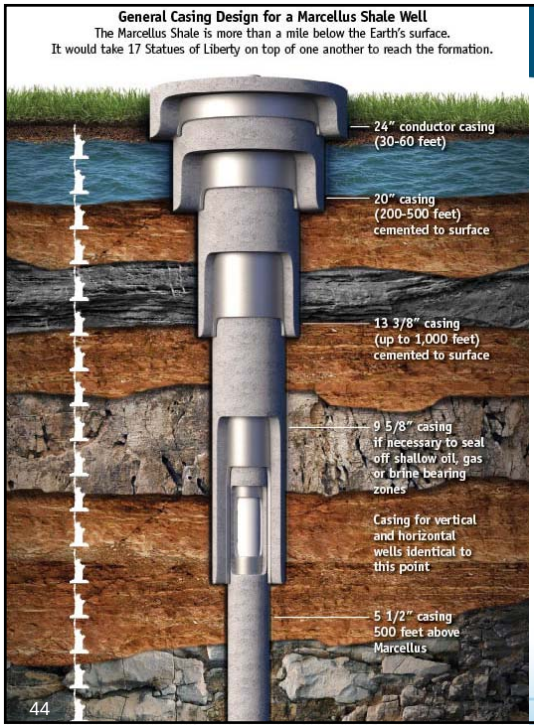

Water Protection

"The simple reality is that stimulation using this technique does not impact ground-water bearing zones." –

Robert W. Watson PhD PE is Emeritus Associate Professor of Petroleum and Natural Gas Engineering and Environmental Systems Engineering at The Pennsylvania State University

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Steel Casings that Protect Water

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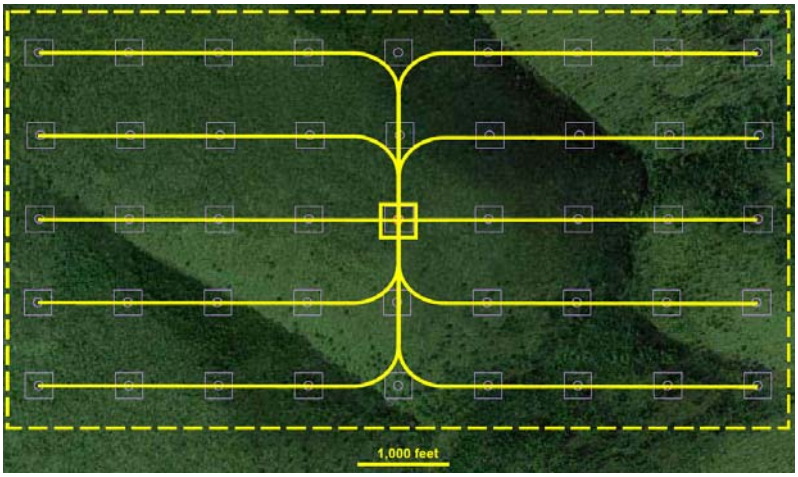
Horizontal Drilling



Total surface disturbance during drilling, including access road, drilling pad and required pipeline infrastructure:

- **Horizontal (yellow) develop 1,000 acres per pad with 1% surface disturbance**
- **Vertical (purple) on 1,000-foot spacing develop 23 acres per well with 19% total surface disturbance**

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Horizontal

- Greatly reduce surface impact
- Minimize disturbance
- Decrease construction time

Vertical

- More costly
- More surface disturbance
- Longer construction time

General representation for visualization purposes

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Drilling

RANGE RESOURCES

Drilling

RANGE RESOURCES

Drilling

RANGE RESOURCES

Drilling

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Completion

Hydraulic fracture stimulation injects fresh water and sand at high pressure, fracturing the rock and safely releasing the gas

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Completions

RANGE RESOURCES

Completions Van

RANGE RESOURCES

Command Central

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Completions

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Completions

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Water Impoundment

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Water Transfer

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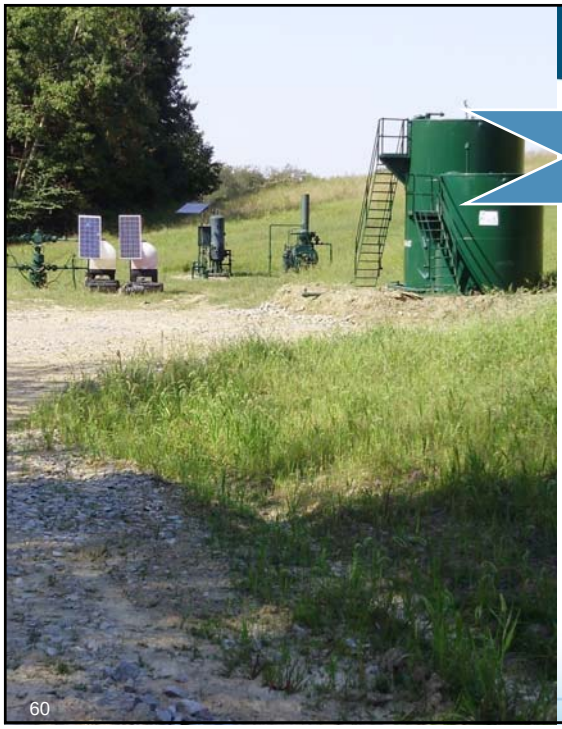

Production

- Following frac, water is flowed back and gas flow is tested to ensure proper completion
- Small footprint – wellhead, separator, produced water tanks

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Production, roughly size of a 1-2 car garage

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Production, roughly size of a 1-2 car garage

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Reclamation

Work hard to restore property to a condition the same as or better than before the process began

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Partial Reclamation

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Partial Reclamation

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Final Reclamation

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Reclamation, often difficult to find after

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Reclamation, often difficult to find after

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Reclamation, often difficult to find after

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Renz #1H, Washington County, Pennsylvania

First Modern Marcellus Well, initial reclaim

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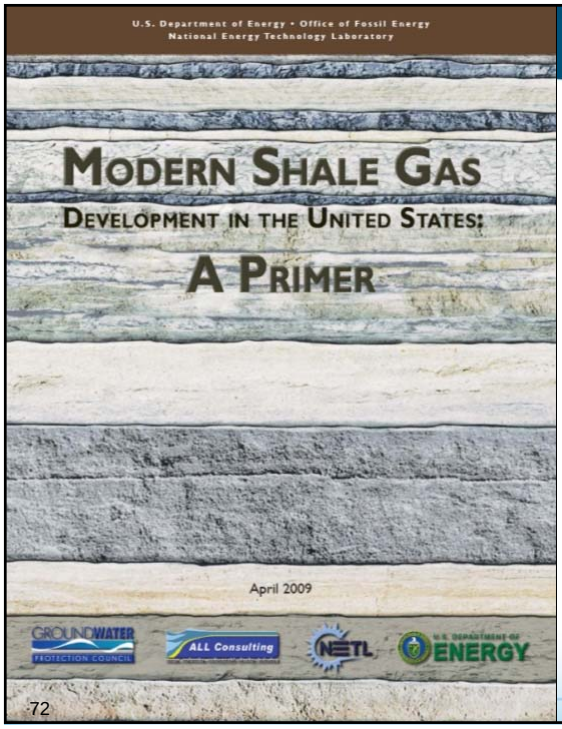

Modern Drilling is Safe and Environmentally Responsible

Exhaustive Study

- **Developed by the United States Department of Energy, The National Energy Technology Laboratory, and the Groundwater Protection Council**
- **Overall, very supportive of shale development**
- **116 page primer on shale gas development**
- **Detailed analysis of benefits, questions, concerns, and potential impacts**
- **Including evaluation of immediate and long term environmental impacts**

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U.S. Department of Energy • Office of Fossil Energy
National Energy Technology Laboratory

STATE OIL AND NATURAL GAS REGULATIONS DESIGNED TO PROTECT WATER RESOURCES

May 2009

GROUNDWATER PROTECTION COUNCIL

NETL

U.S. DEPARTMENT OF ENERGY

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Water Regulations are Safe, Sound and Robust, especially in Pennsylvania

Exhaustive Study

- Developed by the United States Department of Energy, The National Energy Technology Laboratory, and the Groundwater Protection Council
- Specific to water related regulations, safeguards, and advances in new technologies
- In short, Pennsylvania has among the very best environmental and water regulations in the United States and the world for that matter

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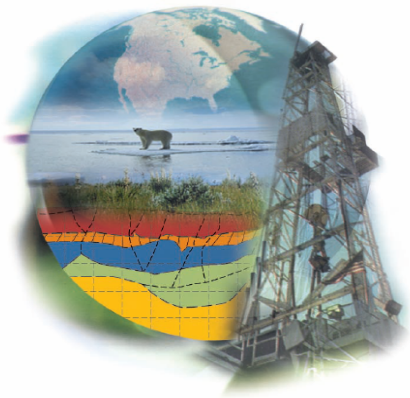
U.S. DEPARTMENT of ENERGY
OFFICE of FOSSIL ENERGY



ENVIRONMENTAL BENEFITS of ADVANCED OIL and GAS EXPLORATION and PRODUCTION TECHNOLOGY

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Modern Technology is Environmentally Responsible and Beneficial

Exhaustive Study

- Developed by the United States Department of Energy
- Comprehensive look at proven advances in state-of-art oil and natural gas production technologies and how these new technologies help to protect and preserve the environment
- These advances are well regulated and ensure that our energy needs are met with excellence in environmental protections and safeguards

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Stringent Environmental Regulations and Protections

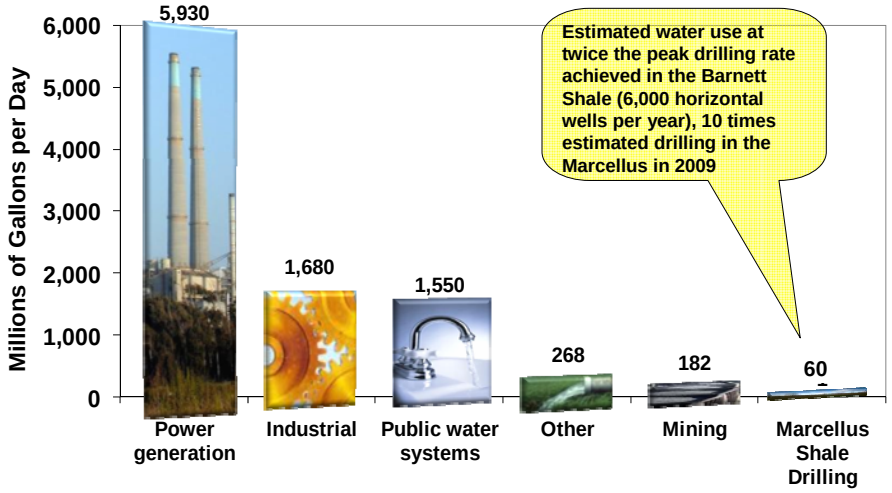
- National experts refer to Pa regulations as "protections with teeth"

SUSQUEHANNA RIVER BASIN COMMISSION

Delaware River Basin Commission

Pennsylvania is blessed with great natural resources and has more surface water than almost anywhere. Water usage is regulated through the drilling permit, which is approved by the DEP.

How Our Water Usage Stacks Up



Source: USGS, Pennsylvania Water Consumption

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How Our Water Usage Stacks Up

According to SRBC estimates, at double the peak drilling level in the Barnett Shale or 10 times greater than expected Marcellus drilling in 2009, water use would only represent half of what is used for recreational purposes in PA like golf courses and ski resorts

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Water supply sources

- Larger streams and rivers
  - Pennsylvania has abundant water supplies
  - Water can be safely withdrawn at reasonable rates during all but the very driest periods
  - Susquehanna and Delaware River Basin Commissions have regulated water withdrawal for many years; no such regulation presently exists in the Ohio River basin
  - Industry and DEP have agreed to adopt SRBC rules; DEP is approving all water management plans
  - Protection of downstream uses
- Municipal water supplies
- Acid mine drainage

Ground Water Protection

- PA casing and cementing regulations among toughest in the U.S.
- 1,000' rebuttable presumption rule; DEP aggressively investigates all claims
- DEP issued only 80 orders to repair or replace water supplies impacted by drilling in past 15 years; 32,000 oil and gas wells drilled; 0.25% incident rate; all impacted water supplies replaced by drillers
- In comparison, Penn State 2009 study indicates over 40% of PA's 1.2 million private water wells and springs do not meet safe drinking water standards; common causes of contamination are on-lot septic systems, agricultural practices, poor well construction
- PA currently updating casing and cementing regulations

Water Requirements for Marcellus

- Water requirements for drilling are insignificant; drilling mud systems are reused
- Fracing a typical horizontal well requires 3-5 million gallons
- Is that a lot of water?
  - 4 million gallons is 1.84 inches of water over an area of 80 acres
  - PA receives about 40 inches of rainfall per year
  - If the productive area of the Marcellus takes 50 years to drill, annual water use over the productive area would be 0.037 inches of water per year or less than 1/10th of 1 percent of annual rainfall

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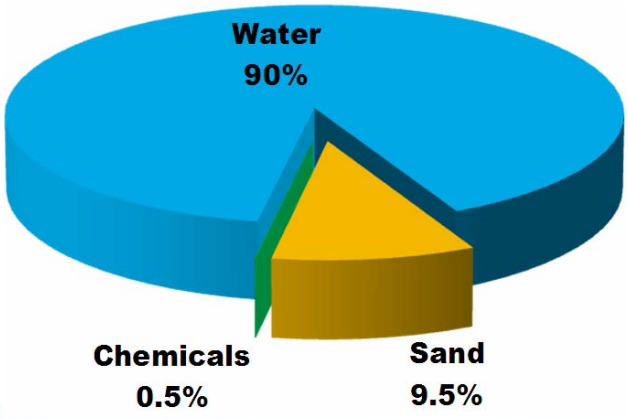
Frac Mixture

What goes into the well?



Primarily fresh water, with some sand, and a very small proportion of common chemicals, representing 0.5% of the mix. The chemicals are in very small quantities, low concentrations, used in highly supervised environments, and injected through multiple layers of cemented steel casings

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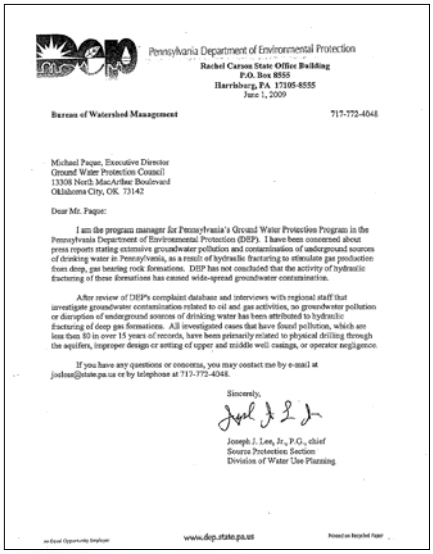
Safe and Proven

More than 30 state and federal regulatory agencies have extensively studied this industry, including hydraulic fracturing technology and have ***zero*** confirmed cases of groundwater contamination in its 60-year history.

Safe and Proven

According to the DEP, based on the last 15 years in Pennsylvania when **35,000 wells** were drilled with the same technology, the likelihood of negative groundwater impacts from all other industry related activities is **0.2%,** typically from a human or mechanical error with no impacts on health.



Pennsylvania Department of Environmental Protection
Rachel Carson State Office Building
P.O. Box 8555
Harrisburg, PA 17105-8555
June 1, 2009

Bureau of Watershed Management 717-772-4048

Michael Paque, Executive Director
Ground Water Protection Council
13308 North MacArthur Boulevard
Oklahoma City, OK 73142

Dear Mr. Paque:

I am the program manager for Pennsylvania's Ground Water Protection Program in the Pennsylvania Department of Environmental Protection (DEP). I have been concerned about press reports stating extensive groundwater pollution and contamination of underground sources of drinking water in Pennsylvania, as a result of hydraulic fracturing to stimulate gas production from deep, gas bearing rock formations. DEP has not concluded that the activity of hydraulic fracturing of these formations has caused wide-spread groundwater contamination.

After review of DEP's complaint database and interviews with regional staff that investigate groundwater contamination related to oil and gas activities, no groundwater pollution or disruption of underground sources of drinking water has been attributed to hydraulic fracturing of deep gas formations. All investigated cases that have found pollution, which are less than 80 in over 15 years of records, have been primarily related to physical drilling through the aquifers, improper design or setting of upper and middle well casings, or operator negligence.

If you have any questions or concerns, you may contact me by e-mail at joelose@state.pa.us or by telephone at 717-772-4048.

Sincerely,

Joseph J. Lee, Jr., P.G., chief
Source Protection Section
Division of Water Use Planning

www.dep.state.pa.us

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Completion Fluids

Same mixtures can be found in grocery stores and pharmacies and have been safely used for generations, mostly in products that are applied directly to the skin or consumed.

Frac Fluids

The industry invests millions of dollars for scientists to develop greener and even more environmentally friendly formulas. Many of which are organically-based.

Typical additives used in frac water

Additive type	Main compound	Purpose	Common use
Friction reducer	Polyacrylamide	Reduces friction between fluid and pipe	Water treatment; soil conditioner; some children's toys
Biocide	Glutaraldehyde	Eliminates bacteria in the water that produce corrosive byproducts	Disinfectant; sterilize medical and dental equipment and surfaces
Scale inhibitor	Ethylene glycol or alcohol	Prevents scale deposit in the pipe	Automotive anti-freeze, household cleaners, de-icing agent
Oxygen scavenger	Ammonium bisulfite	Removes oxygen from the water to protect the pipe from corrosion	Cosmetics, food and beverage processing, water treatment
Diluted Acid	Hydrochloric Acid	Help dissolve cement and minerals and help initiate fractures	Swimming pool chemical and cleaner

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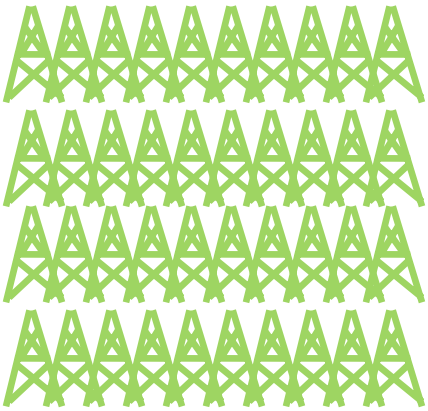
Water Treatment

Industry waste water contains about 9% salt, primarily sodium and calcium chloride commonly referred to as fresh brine or comparable to table salt.

Water can be treated at approved facilities or recycled through water transfer lines and fresh water impoundments.

How Much Salt?



15,000 Marcellus gas wells = salt dumped on Pennsylvania roads annually

Shared Vision for Water Treatment

- The DEP and industry are working together to explore wastewater disposal options for the long term
- Range recycles 100% of our water in our core operating areas
- Industry now recycles more than 60% of all water and is increasing efforts to do more
- Many long-term treatment technologies are already being applied

Water Disposal Solution

There won't be a "silver bullet" or single technology, the solution will consist of a portfolio of disposal options, many of which are already being utilized including:

-deep well injection
-recycling of flow back water
-zero liquid evaporation, crystallization, and land filling

Is there adequate regulation?

Act 223 - The Oil & Gas Act of 1984

- **Primary statute regulating oil and gas drilling activity**
- **Details permitting and operations requirements for the following:**
  - **Well drilling permits**
  - **Well registration and identification**
  - **Inactive status of wells**
  - **Well location restrictions**
  - **Well site restoration**
  - **Site restoration requirements**
  - **Casing and cementing requirements – Protection of fresh groundwater**
  - **Plugging requirements**
  - **Protection of water supplies**
  - **Reporting requirements**
  - **Bonding**
  - **Enforcement and remedies**

PA Code 25, Chapter 78

- Detailed regulations promulgated under Act 223.

Act 214 - Coal and Gas Resources Coordination Act of 1984

- This Act covers governs placement of wells and special regulations in areas containing active coal mines and unmined coal seams.

Act 359 - Oil and Gas Conservation Law of 1961

- Governs spacing of deep wells which penetrate the Onondaga Formation (directly beneath the Marcellus Shale).

PA Code 25, Chapter 102

- Regulations with respect to erosion and sedimentation control for earth disturbance activities.
- Basis for Erosion and Sedimentation Control Manual for oil & gas development (well pads, pipelines, impoundments).
- Requires ESCGP-1 for earth disturbance over 5 acres; applies to all Marcellus wells, pipelines and water impoundments.

PA Code 25, Chapter 105

- Requires permits for stream and wetland crossings.
- Requires permits for stream and wetland encroachments.
- Requirements for dam permits for impoundments if the impoundment is to be used for collection/storage of flowback and/or produced water.
- Construction Guidelines for the construction of impoundments

Federal Clean Water Act and Pennsylvania Clean Streams Law

- These are the laws that allow Pennsylvania to enact the permitting requirements described above associated with Chapter 102 and Chapter 105.

PA Code 25, Chapter 287, Residual Waste

- regulates disposal of wastes from drilling or completion operations
- regulates transportation of wastes from drilling or completion operations and the record keeping
- annual chemical analysis of the waste stream.

Act 220 - Water Resources Planning Act 0f 2002

- **Under Act 220, the PADEP has mandated that operators submit a comprehensive Water Management Plan for all Marcellus Shale wells prior to conducting hydro-fracturing operations on wells.**

Title 40 of the Code of Federal Regulations, Part 112

- **Mandates Oil Pollution Prevention and regulates by requiring Spill Prevention Control and Contingency Plans**

SRBC - Susquehanna River Basin Commission

- **Interstate Compact Commission that regulates all water usage within the Susquehanna River Basin in PA (and other states).**
- **Requires reports, plans and procedures to be filed and followed prior to any activity on a wellsite in the SRBC area. Also includes significant fees for water consumptive use.**

US Army Corps of Engineers

- **ACOE performs a review of the stream/wetland crossing General Permit applications submitted to the PADEP when impacts from the crossings exceed thresholds defined by the ACOE.**

Inconveniences?

Construction process

- Dirty
- 24-hour operations
- Truck traffic
- Noise and lights
- Some road damages
- Temporary

How Loud Is It?

Technical Study Results

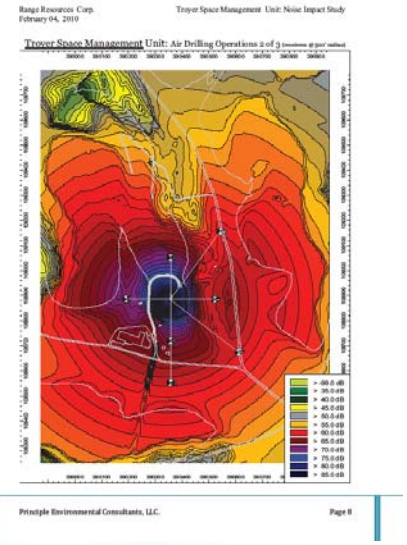
- Noise is temporary
- From 200-600 feet comparable to normal speech at 3 feet
- Roughly 65 dBA
- Similar to highway sounds or other construction projects
- More than likely, it's louder inside your house

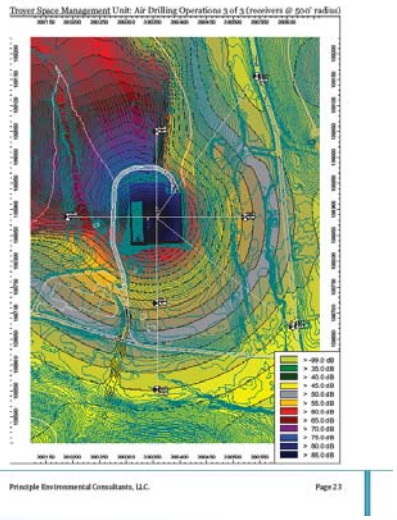
Noise

- Range is conducting noise studies in various townships
- **Most recent example is Cecil Township**
- Rigs were pulled from site; soundproofing walls erected to mitigate site noise
- Range investigating other ways to comply with sound requirements contained in municipal ordinances

Sound Walls

RANGE RESOURCES





RANGE RESOURCES

What About the Roads?

- Nearby roads may be damaged or dirtied
- 100% legally liable for any and all repairs
- Roads are cleaned
- Roads are bonded in accordance with state regulations
- Tax-free road improvements

RANGE RESOURCES

Washington County Road

RANGE RESOURCES

Still in Early Development

- Help transform the nation's energy future
- Cleaner, greener tomorrow
- Jobs, wealth creation, and long-term economic boost
- Many, many years to accomplish goals

Murrysville, Pa

Issues / Concerns

- Site is proposed; work to begin late 2010/early 2011
- Range will work with municipality on traffic routes/construction schedule
- Full contact information to be provided
- Public updates as information becomes available

RANGE RESOURCES

Thank You

724-743-6700

MyRangeResources.com

PaMarcellus.com

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