Natural Gas Pipelines in Lycoming County, Pennsylvania

A Technical Appendix

Prepared for: **The League of Women Voters of Pennsylvania**

For Use in: **Pipelines in Pennsylvania: A Case Study of a Community and its County: Lycoming County**

Funded by: **US Department of Transportation PHMSA Technical Assistance Grant #DTPH56-11-G-PHPT20**

Prepared by: **Schmid & Company, Inc., Consulting Ecologists**
1201 Cedar Grove Road
Media, Pennsylvania 19063-1044
www.schmidco.com

24 January 2013

Table of Contents

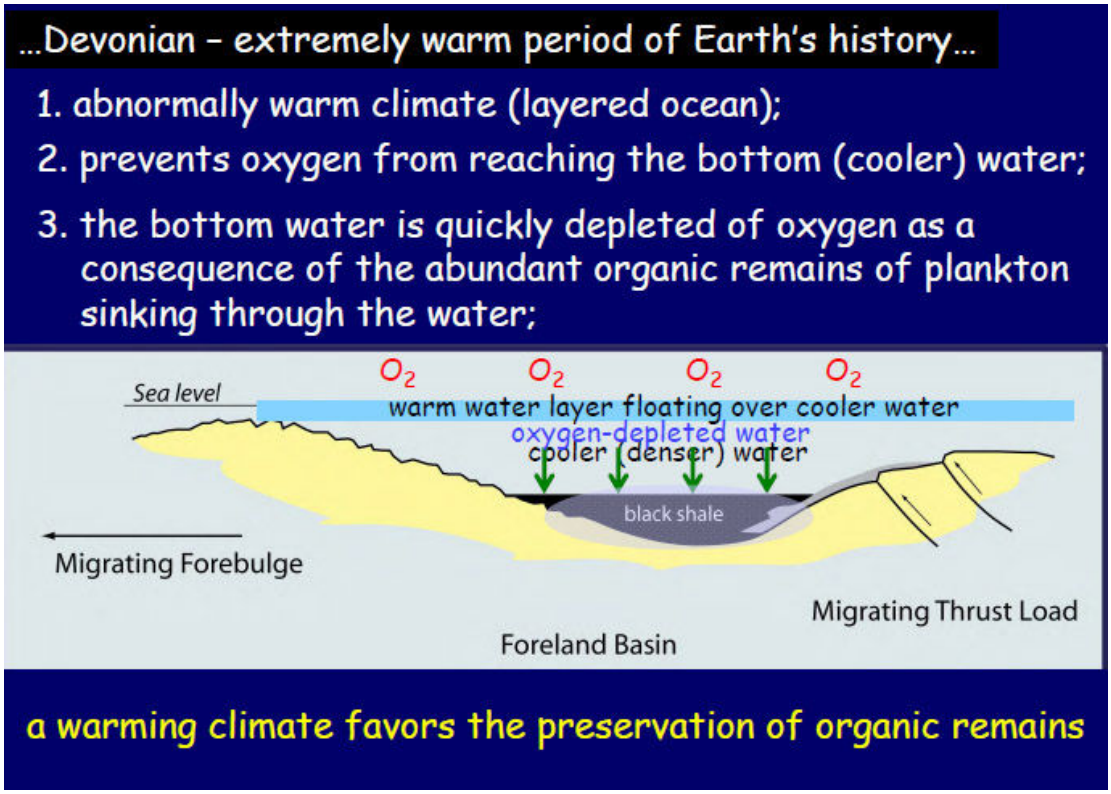
Page

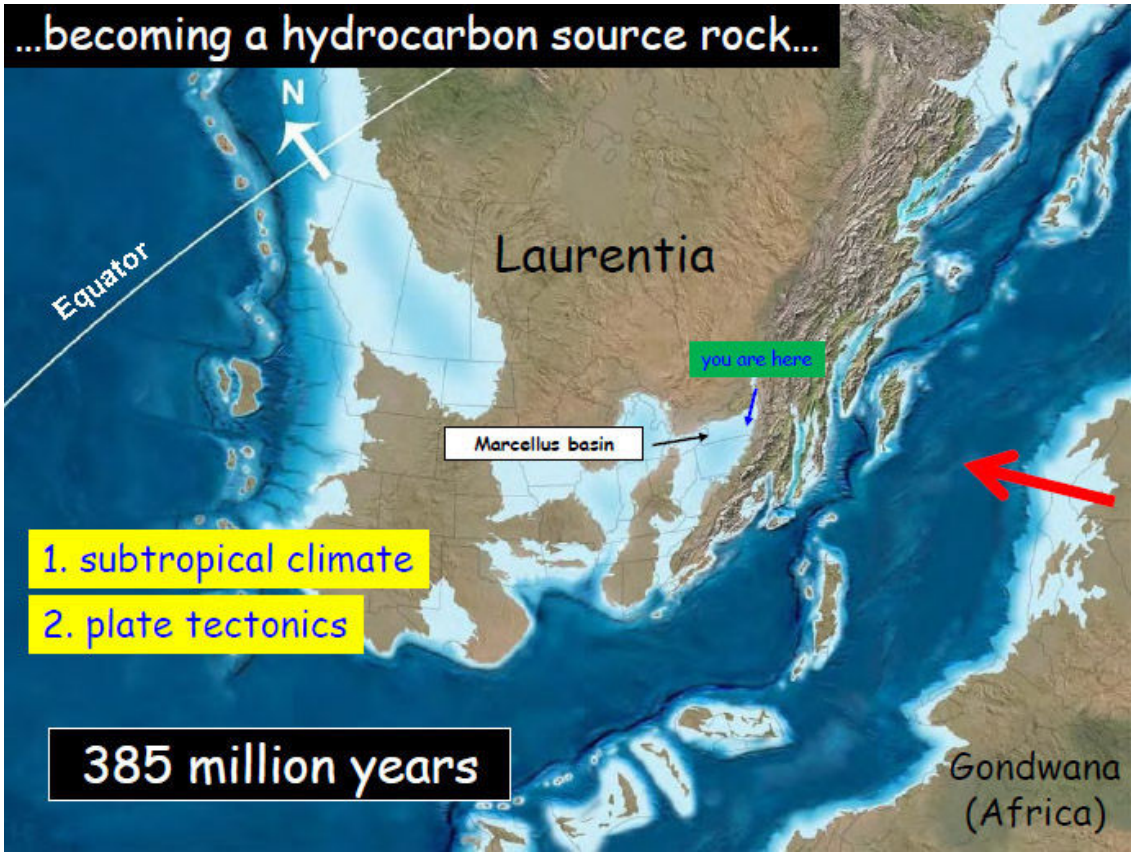
Page

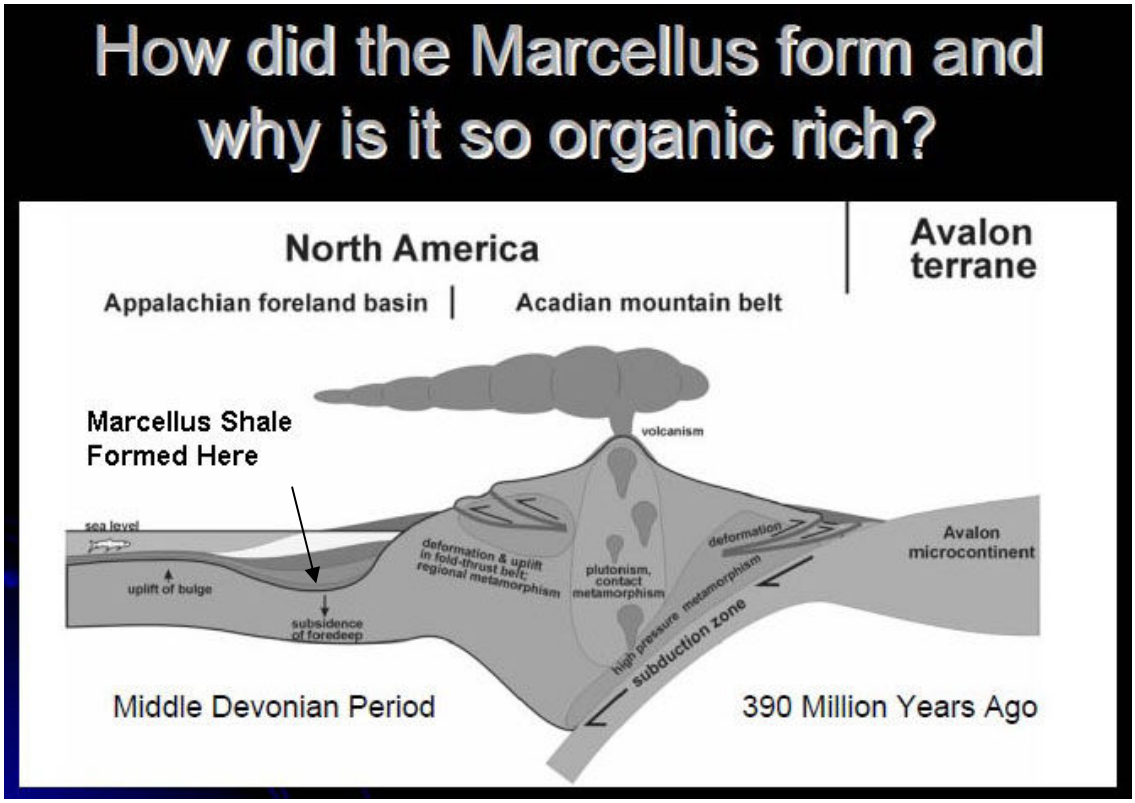
Resource Background on Pennsylvania Natural Gas

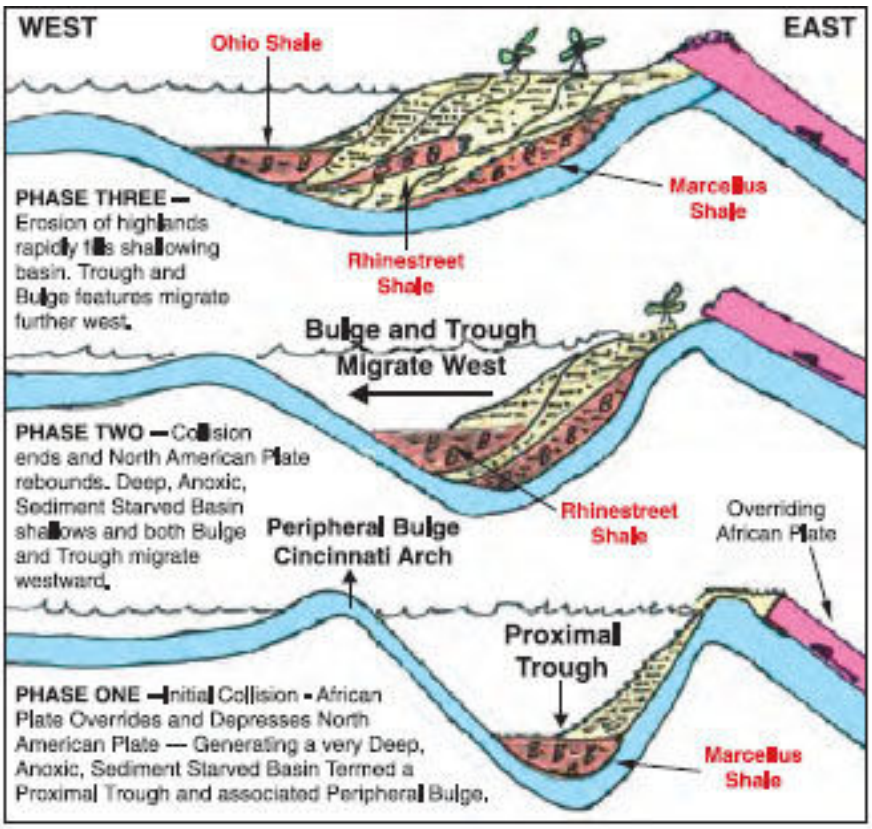
Natural gas has been used in Pennsylvania as a fuel yielding light and heat for two centuries. Gas also is a source of raw material for numerous organic chemical products including plastics and agricultural fertilizer. Natural gas is a relatively clean-burning fossil fuel that is colorless and odorless, except when pungent odors have been added to it for safety. (It is called "natural" gas to distinguish it from the "town" gas generated from coal in coke ovens. Town gas was piped locally for lighting and cooking during the nineteenth and early twentieth centuries.) Natural gas consists primarily of methane (CH_4). It may also contain other hydrocarbons, several of which currently have higher economic value than methane. Natural gas may require processing to remove impurities before marketing. When released to the atmosphere, methane is a much more potent contributor to global warming than carbon dioxide, and significant quantities are known to escape as gas is produced, transported, and distributed to end users. Escaping gas cannot be seen by the human eye except when burning, but can be recorded by infrared photography.

Natural gas is the end result of ancient accumulations of organic material from marine algae on the ocean floor hundreds of millions of years ago, long before the age of dinosaurs. The organic material was compressed to form rock, and its chemical composition was altered by temperature and pressure deep underground to yield methane and other hydrocarbons. Depending on pressure and temperature, those hydrocarbons today consist chiefly of natural gas, crude oil, or mixtures of these substances.



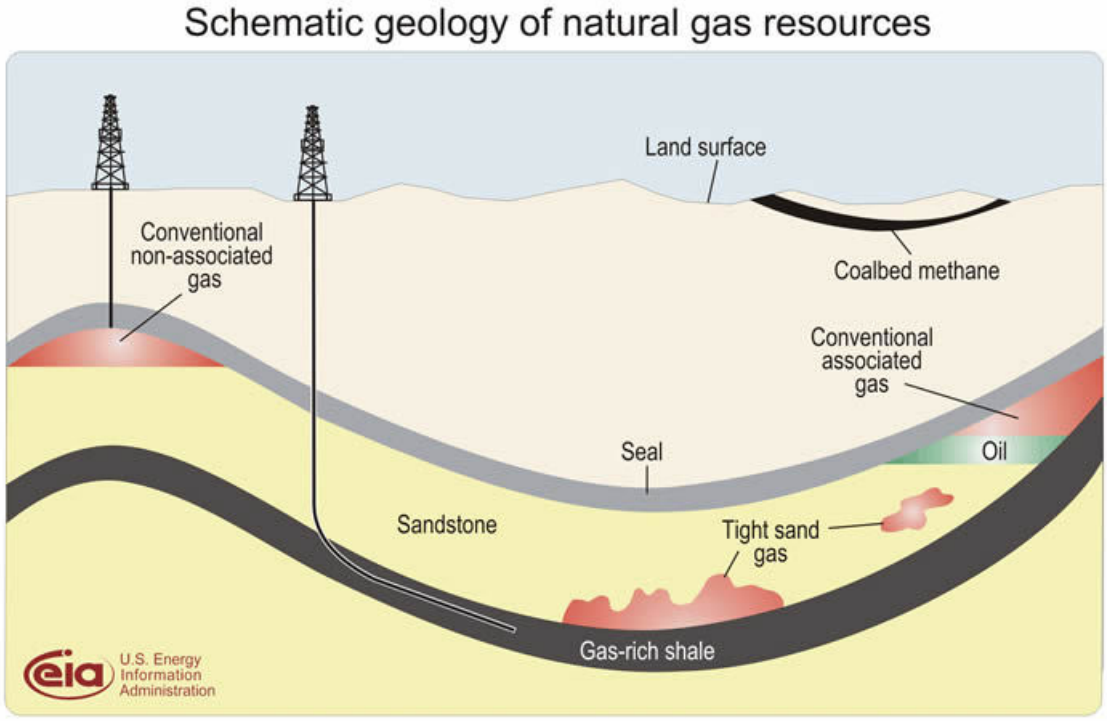

...becoming a hydrocarbon source rock...
N
Equator
Laurentia
you are here
Marcellus basin
1. subtropical climate
2. plate tectonics
385 million years
Gondwana
(Africa)


How did the Marcellus form and why is it so organic rich?
North America
Avalon terrane
Appalachian foreland basin
Acadian mountain belt
Marcellus Shale Formed Here
volcanism
sea level
uplift of bulge
subsidence of foredeep
deformation & uplift in fold-thrust belt; regional metamorphism
plutonism, contact metamorphism
deformation
high pressure metamorphism
subduction zone
Avalon microcontinent
Middle Devonian Period
390 Million Years Ago



Phanerozoic Eon (543 mya to present)	Cenozoic Era (65 mya to today)	Quaternary (1.8 mya to today) Holocene (10,000 years to today) Pleistocene (1.8 mya to 10,000 yrs) Tertiary (65 to 1.8 mya) Pliocene (5.3 to 1.8 mya) Miocene (23.8 to 5.3 mya) Oligocene (33.7 to 23.8 mya) Eocene (54.8 to 33.7 mya) Paleocene (65 to 54.8 mya)
	Mesozoic Era (248 to 65 mya)	Cretaceous (144 to 65 mya) Jurassic (206 to 144 mya) Triassic (248 to 206 mya)
	Paleozoic Era (543 to 248 mya)	Permian (290 to 248 mya) Carboniferous (354 to 290 mya) Pennsylvanian (323 to 290 mya) Mississippian (354 to 323 mya) Devonian (417 to 354 mya) Silurian (443 to 417 mya) Ordovician (490 to 443 mya) Cambrian (543 to 490 mya) Tommotian (530 to 527 mya)
Precambrian Time (4,500 to 543 mya)	Proterozoic Era (2500 to 543 mya)	Neoproterozoic (900 to 543 mya) Vendian (650 to 543 mya) Mesoproterozoic (1600 to 900 mya) Paleoproterozoic (2500 to 1600 mya)
	Archaean (3800 to 2500 mya)	
	Hadean (4500 to 3800 mya)	

Oil and gas often escape from the original rocks in which they formed. Gas can reach the surface through natural cracks and fractures in the rock. Gas and oil typically rise upward to collect underground in porous rock such as sandstone where less permeable adjacent rock layers may trap them in reservoirs. These reservoirs are tapped by the conventional oil and gas wells that have been drilled vertically downward from the surface since the 1860s. Drilled wells represent preferred pathways for gas reaching the earth surface. Many old wells were not capped, and well caps may leak over time. Recovery of the less concentrated natural gas remaining behind in deep shales requires a combination of much newer, "unconventional" technologies in larger industrial operations than conventional wells.

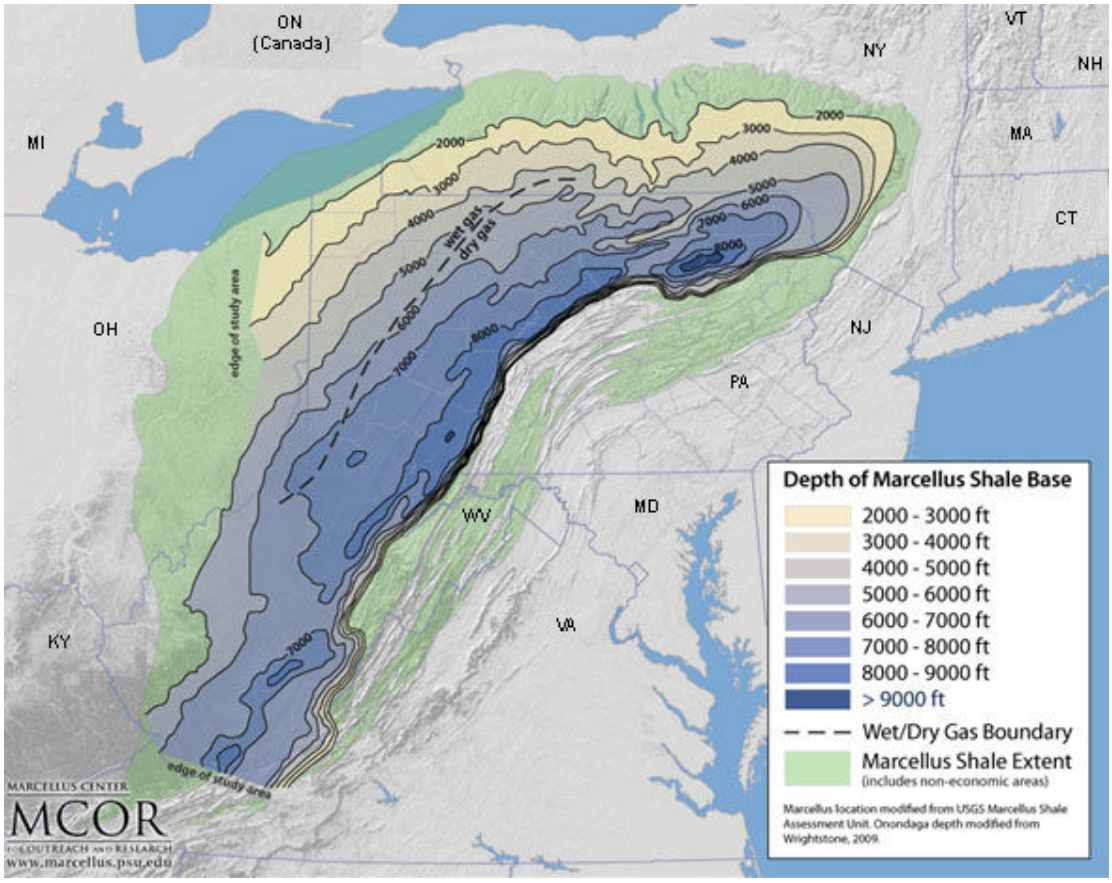


At present public attention in Pennsylvania is focused on gas in the Marcellus Shale Formation. This kind of rock was named for Marcellus, New York, where it crops out at the surface and was first described scientifically. Marcellus Shale is a sedimentary rock whose thin layers of fine-grained material accumulated as mud on the ancient ocean floor. It is mostly silicon, but also contains as much as 10% organic carbon---a much lower percent carbon than coal. (High-quality coal can consist of as much as 90% carbon; coal can be burned, but shale cannot.) The Marcellus Formation consists of layers of shale up to several hundred feet thick laid down about 400 million years ago prior to formation of the Appalachian Mountains in the bed of a subtropical ocean during the Devonian period. A significant amount of its carbon has become natural gas.

Within the Marcellus Shale Formation the gas is found in tiny pores within the rock layers, and it collects in the myriad natural cracks and fractures under the significant pressure found more than a mile beneath the earth surface. If those fractures can be opened and connected with the surface, some of the gas can escape. This is what unconventional technology seeks to accomplish using large volumes of slickwater and sand under high pressure in horizontal wells deep underground. Current technology is able to extract about 10% of the gas present in the Marcellus Shale, with optimistic industry predictions ranging to 30%. At least 70% of the gas remains unrecoverable underground.

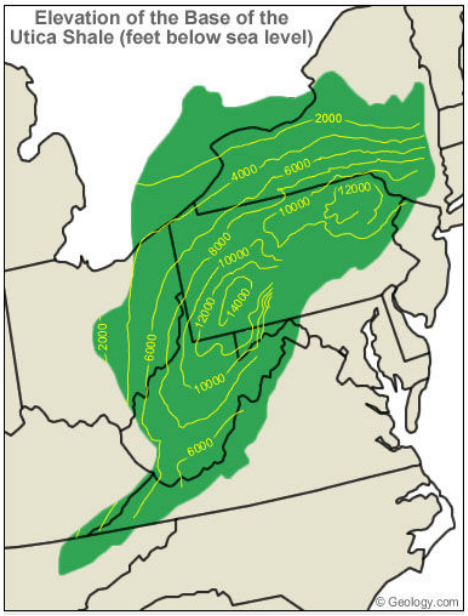
Richard Smosna examining Marcellus Shale outcrop near Bedford, Pennsylvania.
Photograph by Daniel J. Soeder, DOE.

Marcellus Shale underlies about 80,000 square miles, as shown on several maps, but only about one quarter of that land is likely to be economically productive of natural gas in the near future (www.marcellus.psu.edu/resources/PDFs/DCNR.pdf). The Marcellus Shale layer is relatively close to the ground surface along the shores of Lake Erie, and its gas was first developed for street lighting in Fredonia, New York, during the 1820s. Conventional wells have steadily produced small volumes of gas from the Marcellus Formation for many years, but commercial interest in deep Marcellus gas is a recent phenomenon that began with the import of new technology to Pennsylvania in 2004. Development interest centers in the Marcellus Shale beneath the Allegheny Plateau, north and west of the most intensively folded ridges and valleys of Appalachia.

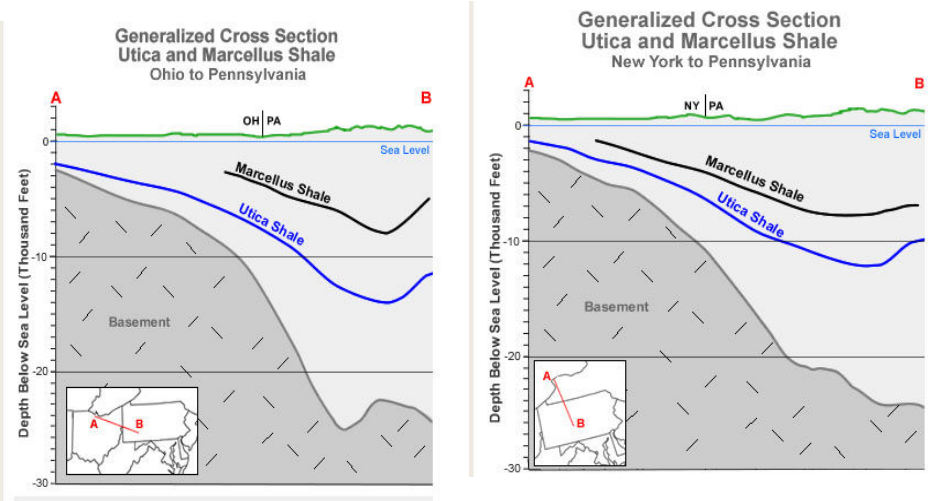


It is present beneath the majority of Pennsylvania at depths ranging from 2,000 to 9,000 feet below the surface. Shale gas collection and conveyance to market is generating a need for significant construction of new pipelines throughout the Commonwealth. A conventional (shallow vertical) Pennsylvania gas well produces about 13 Mcf (thousand cubic feet) of gas per day, about what is needed to heat one all-gas house for one month. Lycoming County Marcellus wells initially produce about 3 MMcf (million cubic feet) per day.

Beneath the Marcellus Shale lies an older, even more extensive formation known as the Utica Shale. It is a source of both crude oil and natural gas. It is less well understood and has been relatively little developed (starting in Ohio and Canada). Utica Shale was laid down in warm oceans during the Ordovician period some 50 million years before the Marcellus Shale and ranges up to 500 feet thick. Like the Marcellus, Utica Shale beds thin westward. The Utica Formation generally lies 1,800 to 5,000 feet below the Marcellus Shale, so the Marcellus resource is being developed first wherever both formations exist together. Gas resources from the Utica Shale and other organic shales may be widely developed in western Pennsylvania in the future. Utica Shale ranges from 2.3 to 4.7% carbon. About 5 to 10% of its gas currently can be recovered. Given the higher concentration of hydrocarbons other than methane in Utica Shale gas, drill rigs recently have been shifted to Ohio, away from northern Pennsylvania where the "dry" gas consists primarily of less valuable methane. The high production and resulting glut on the market for ethane and propane have caused prices for these hydrocarbons to drop during 2012.[1]



[1] http://www.post-gazette.com/stories/business/news/drillers-rattled-as-ethane-propane-prices-plunge-651245/



Natural gas also is found in the joints of coal deposits and adsorbed onto the surface of the coal itself. Coal has long been mined in Pennsylvania. The coalbeds are younger than the major organic shales, having been deposited in freshwater swamps 300 to 350 million years ago. They lie closer to the surface than the ancient marine shales. In water-saturated coalbeds, methane is generated by bacteria. Coalbed methane provides economic supplies of natural gas in some places where the coal seams are too thin to warrant mining. Coalbed methane also can seep naturally into domestic water wells, and its movement through rocks and soil can be stimulated by well drilling and by mining. Hydraulic fracturing technology has been used longer for coalbed methane production than for gas production from tight shales far underground.

Coalbed methane is relatively easily tapped by wells, because coal is found at so much shallower depth than the major organic shales. It often occurs together with groundwater that contains pollutants capable of damaging aboveground animals and plants. In coal mines, methane long has been deemed to be a serious hazard that can explode at low concentrations and can suffocate miners at higher concentrations. Canaries formerly were used underground as gas detectors, because they are sensitive to lower concentrations of methane than humans, giving the miners time to escape or to increase mine ventilation. Methane causes human asphyxiation at concentrations greater than 50% in air (500,000 ppm). Air becomes explosive at methane concentrations exceeding 5% (50,000 ppm) but lower than 15% (150,000 ppm). Highly concentrated methane becomes explosive when diluted by air to proportions within the explosive range.

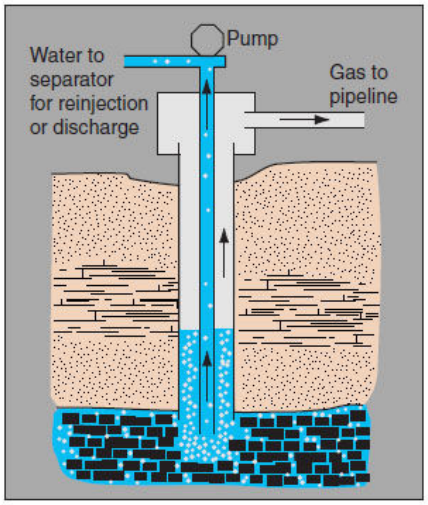
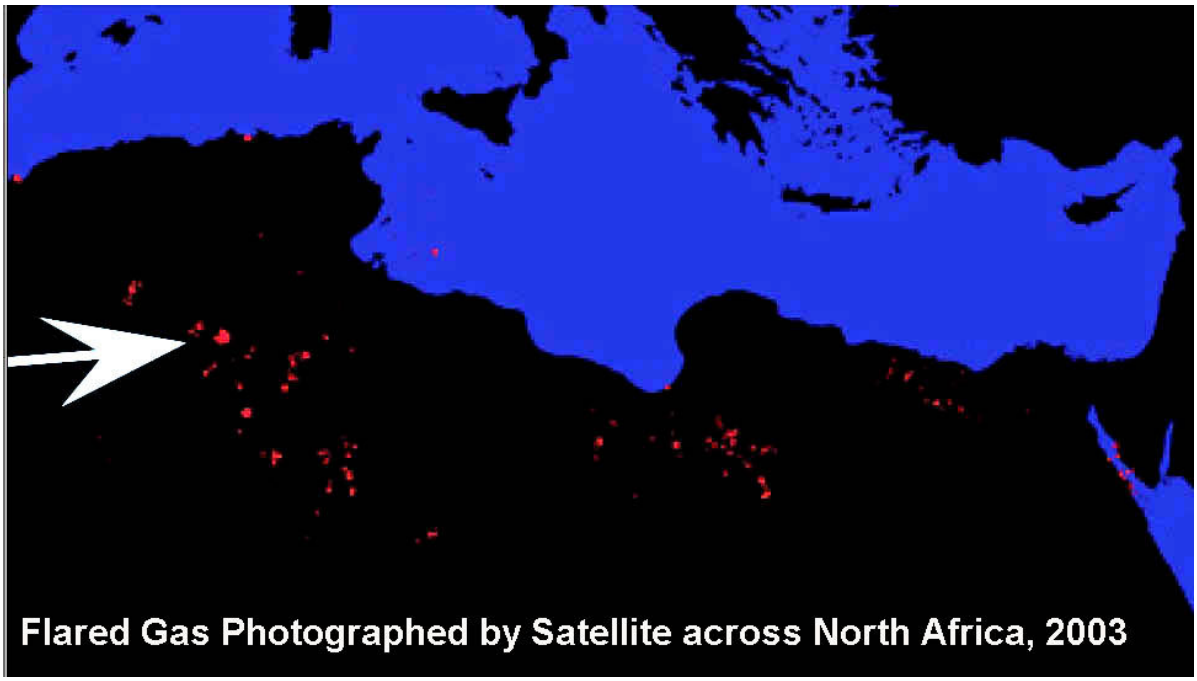


Figure 3. Diagram showing the production scheme of gas and water for a typical coal-bed methane well.

Natural gas historically was less valued as a fuel than coal or crude oil. Its energy is less concentrated per unit volume at normal atmospheric pressure. Thus it is more difficult to transport to users, and it poses a greater risk of explosion and suffocation. Vast quantities of stranded natural gas remote from end users have been disposed as waste from oil wells, wherever pipelines were not available to transport the gas to market. Typically waste gas is burned from tall pipes, to reduce the hazard of uncontrolled gas catching fire or exploding at ground level. Welded steel pipelines for gas transport have existed only since the 1920s; before then most natural gas was flared as waste in the oilfields of Pennsylvania.

Night photographs from satellites at present show major oilfields around the earth by their vast flares burning waste natural gas. More prudent oilfield management today captures the stranded gas from oil wells and returns it underground to increase oil yields if it is not otherwise used. Natural gas can be transformed into liquid fuels such as synthetic gasoline and diesel, as is being done in the major gas fields of Qatar. At present one third of the natural gas produced in the oilfields of North Dakota is flared because there is no transport to market, but it could be processed into anhydrous ammonia fertilizer.[2]

[2] http://www.businessweek.com/ap/2012-08-21/grant-delayed-to-turn-natural-gas-into-fertilizer



Since the price was deregulated by Federal law beginning in 1978, the value of gas has risen in the United States, increasing the incentive for its production, transport by pipeline, and sale. Demand for gas in the United States peaks during cold winters, given its use as a fuel for heating in more than half the nation's homes. Much gas is stored seasonally. Natural gas now is used increasingly to generate electricity, accounting for nearly one third of electric energy produced in Pennsylvania. Its price has fluctuated dramatically over the past several decades.

As shale gas from the Marcellus and other deep formations around the nation has become available, its price recently has been dropping in the United States and is now at its lowest levels in a decade, despite high prices for oil. Domestic production is at 20-year highs, and imports at 20-year lows. Marcellus Shale development is proceeding rapidly, as is the production in other deep shale gas fields across the nation, as the industry seeks to gain more gas at less cost. The domestic industry is hoping to pipe gas to seaports, liquify it there, ship it, and profit from the higher prices currently being offered by users in Europe and Asia. Several countries run millions of vehicles using compressed natural gas, while the 112,000 United States gas-fueled vehicles (<1% of its total) currently rank it 14th worldwide. At the present cost of diesel, the natural gas energy equivalent is $1.50 to $2.00 per gallon less, offering a considerable savings potential for truck fleet operators who burn gas rather than diesel or gasoline.

Lycoming County

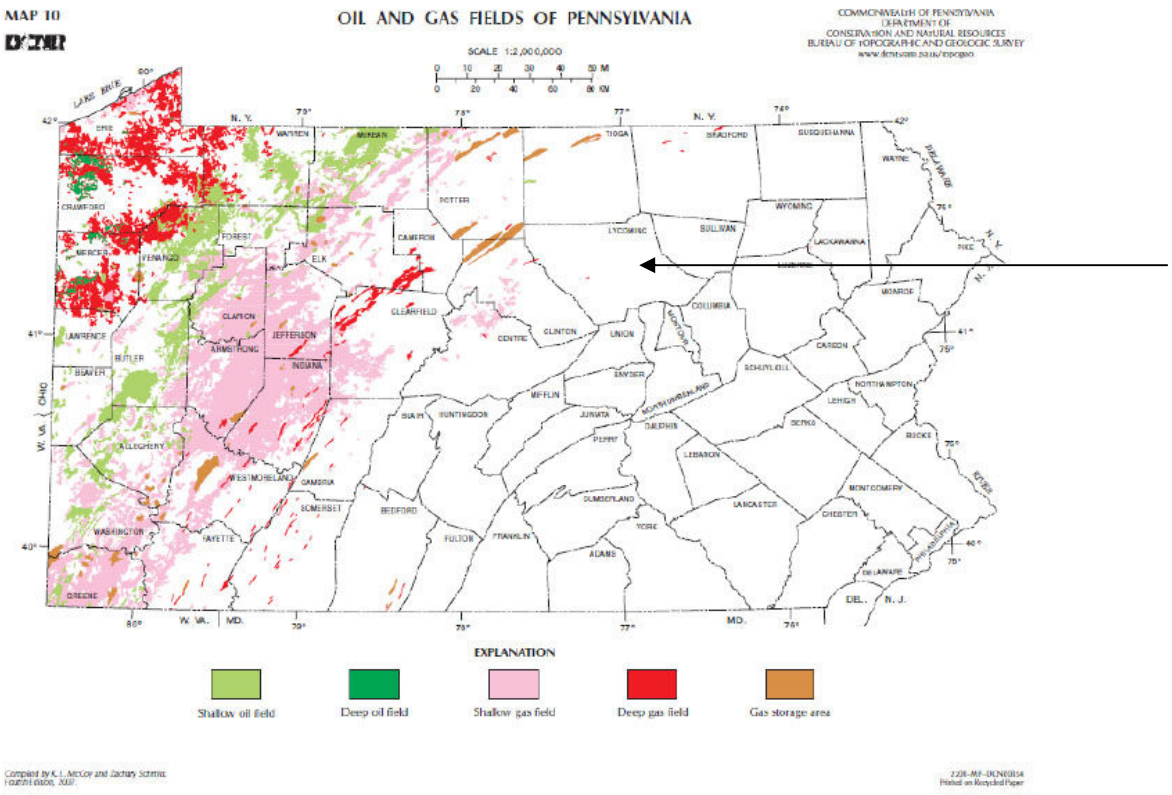
Lycoming County is located in northcentral Pennsylvania where the dissected Allegheny Plateau meets the Appalachian Mountains and the Susquehanna Lowland. Most of the County was covered by glacial ice one or more times during the past million years. Organized in 1795, the County encompasses 1,246 square miles, making it the largest Pennsylvania county by land area (Erie County is slightly larger, but much of it lies beneath Lake Erie) and a bit larger than the State of Rhode Island. Lycoming County is centrally located in the immense forest of Pennsylvania, where tree logging was the first

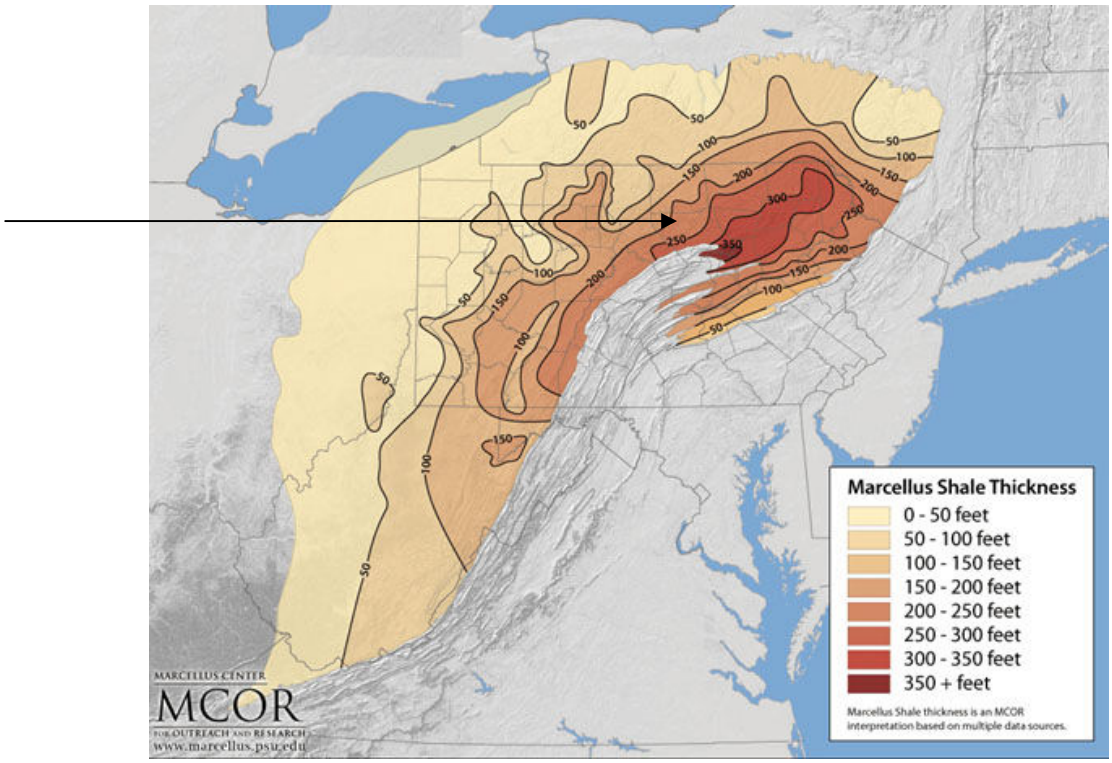
major resource exploitation, peaking during the nineteenth century. Regrowth forest today occupies nearly 80% of the County. The 2010 population of 116,111 marked

a decline of 3.3% since the 2000 census. As a whole, there are 94.5 persons per square mile in the County, about 29,000 of whom live in the City of Williamsport (incorporated 1806), the County seat. Williamsport was a primary center of the lumber industry, from which logs could be floated to market down the Susquehanna River and later transported by rail. The County Planning Department reports more than 2,200 miles of streams in Lycoming County. There are 52 municipalities, including 9 boroughs and 42 townships.

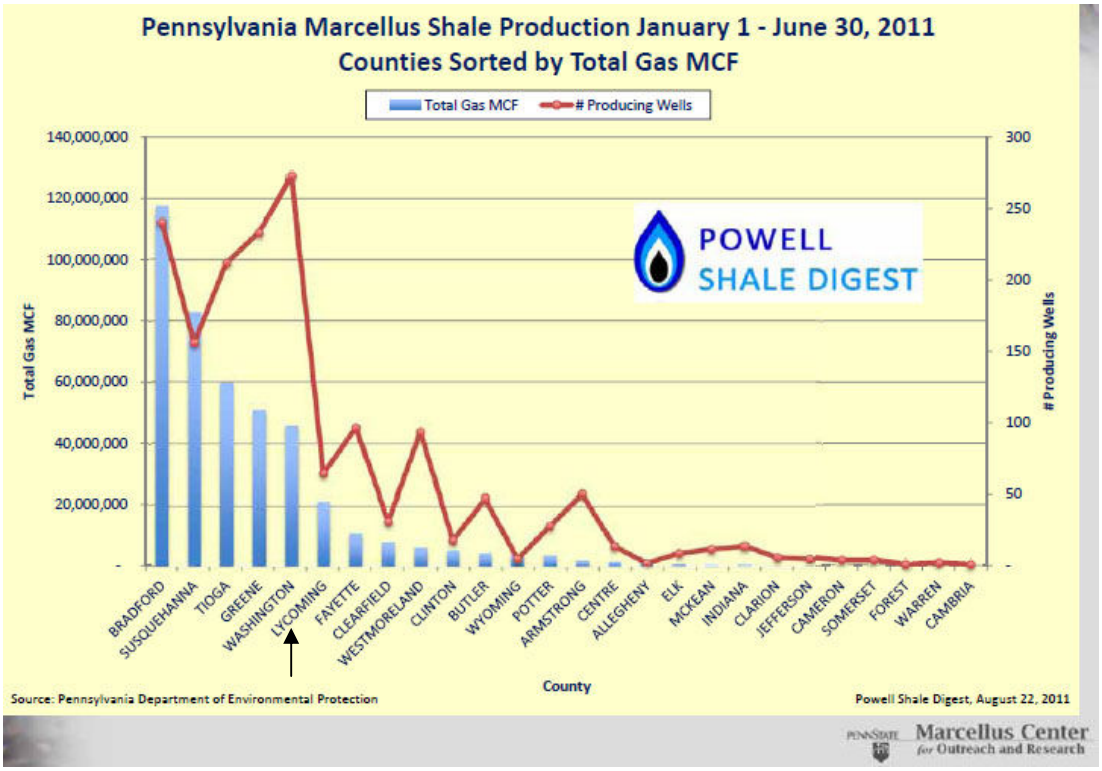
Traditional oil and gas production were minimal in Lycoming County, which lies outside the geological strata tapped by conventional vertical drilling methods. In sharp contrast, Lycoming County is located in the midst of the Marcellus Shale.

CONVENTIONAL



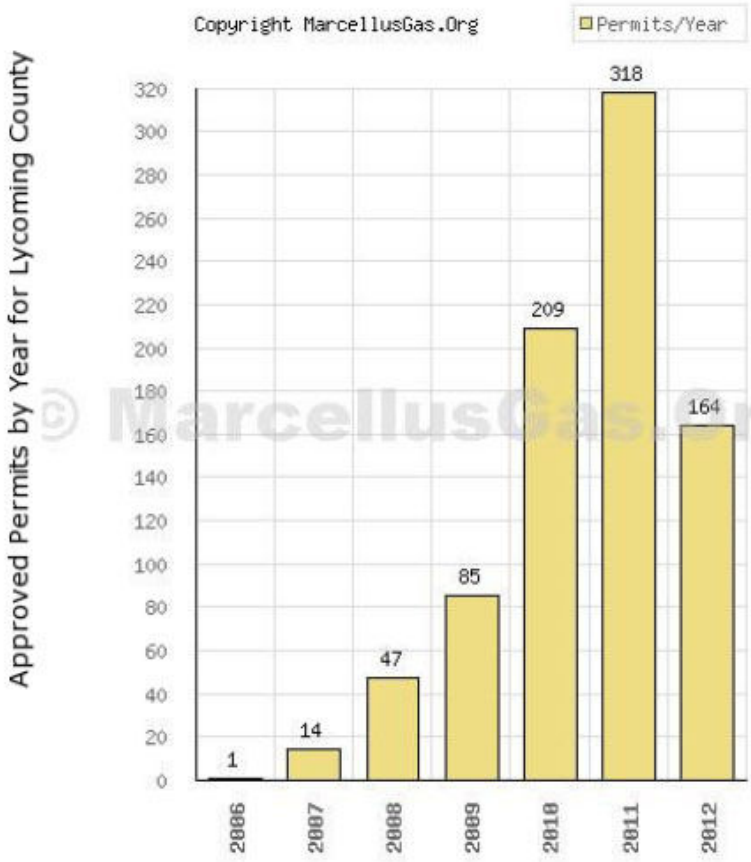


Production of more than 20 million Mcf during the first half of 2011 ranked Lycoming County sixth among the 26 Pennsylvania counties producing natural gas. Its more than 50 producing wells ranked it eighth in number of gas wells.



As of May 2012, there were 565 active (spudded) wells and 64 wells producing Marcellus Shale gas in Lycoming County among the 840 unconventional well permits (87% of which are for horizontal wells) that had been granted by the Pennsylvania Department of Environmental Protection (www.MarcellusGas.org). These wells are situated in 23 municipalities. Shale gas development has expanded the pipeline network, and will continue to do so for the foreseeable future as more wells are drilled. Permitting and gas production have expanded rapidly, generating a need for pipeline construction. The glut on the market of natural gas has led to a decrease in production and permitting during 2012 in Lycoming County and elsewhere in Pennsylvania.

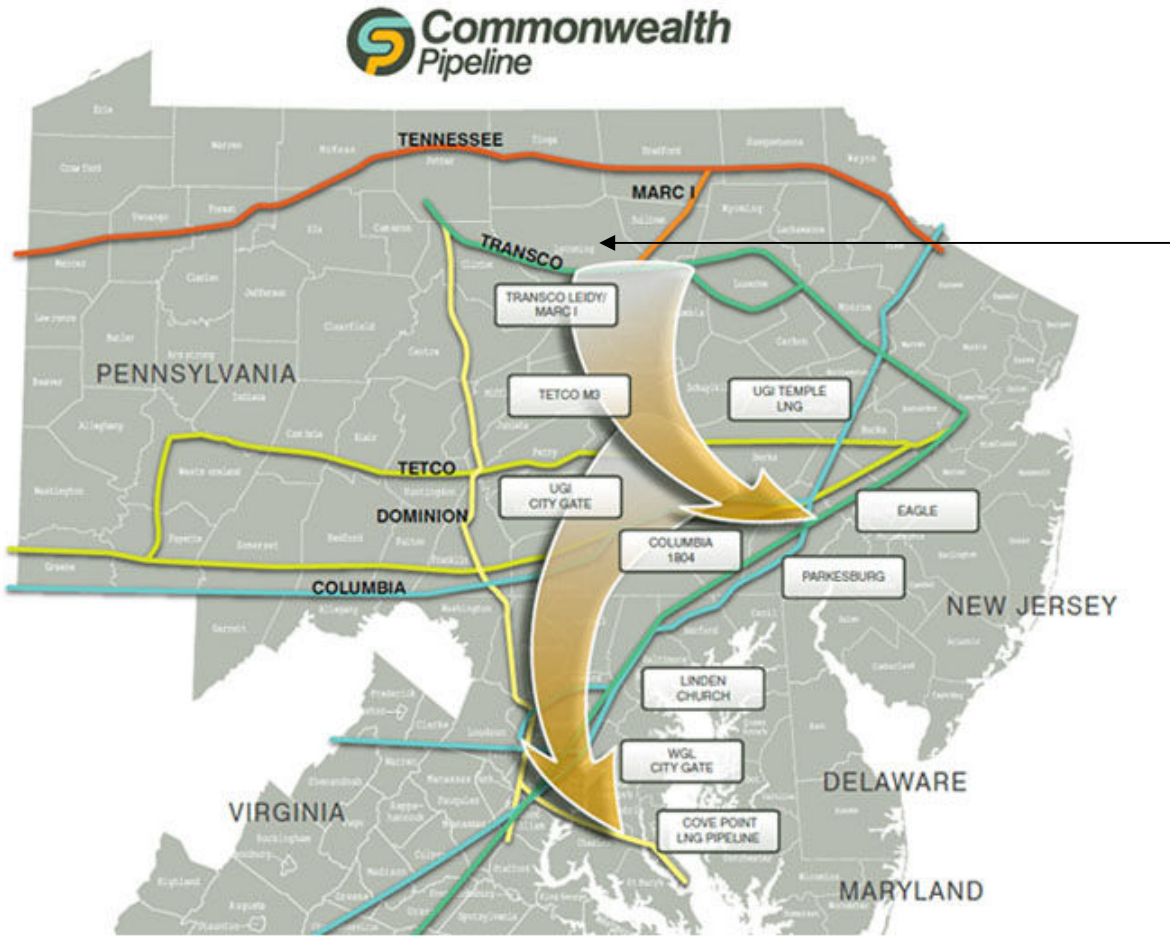
Graph: Marcellus Well Permits by Year for Lycoming County, Pennsylvania



Years in chronological order - current year represents permits approved as of May 14th, 2012

Based on data from May 14th, 2012

The nation's first major petroleum pipeline terminated in Williamsport and was 109 miles long. According to PADEP data assembled by Dr. Harvey M. Katz, a professional ichthyologist, 88 new named gathering pipelines and 18 named compressor stations (plus half a dozen more unnamed compressor stations) were in some stage of planning for construction in Lycoming County during the period January 2011 through May 2012. The named pipelines range from 1 to 39 miles in length. Pennsylvania is expected to receive as much as 25,000 miles of new pipelines, requiring clearing of as much as 150,000 acres of forest (Johnson *et al*. 2011), as well as hundreds of new compressor stations as shale gas development proceeds during the next few years**.** There is a shale gas frackwater treatment plant in Williamsport next to the Susquehanna River, but wastewater is brought to it by truck, not by pipeline. Current pipeline proposals from various operators that will affect Lycoming County are shown in the following graphics.



Market and Points of Delivery

The billion-dollar Commonwealth Project offers shippers the ability to deliver Northeast and Appalachian shale gas directly to premium Northeast and Mid-Atlantic city-gate markets. Markets include those accessible throughout central and southeastern Pennsylvania and eastern Maryland. Supplies delivered into the Commonwealth Pipeline will also have the ability to access markets in Northern Virginia through a proposed interconnect with the Dominion Cove Point LNG, LP pipeline at a location near the Washington Gas Gardiner Road Gate Station in Charles County, Maryland. Commonwealth will consider additional markets and points of delivery beyond those listed above.

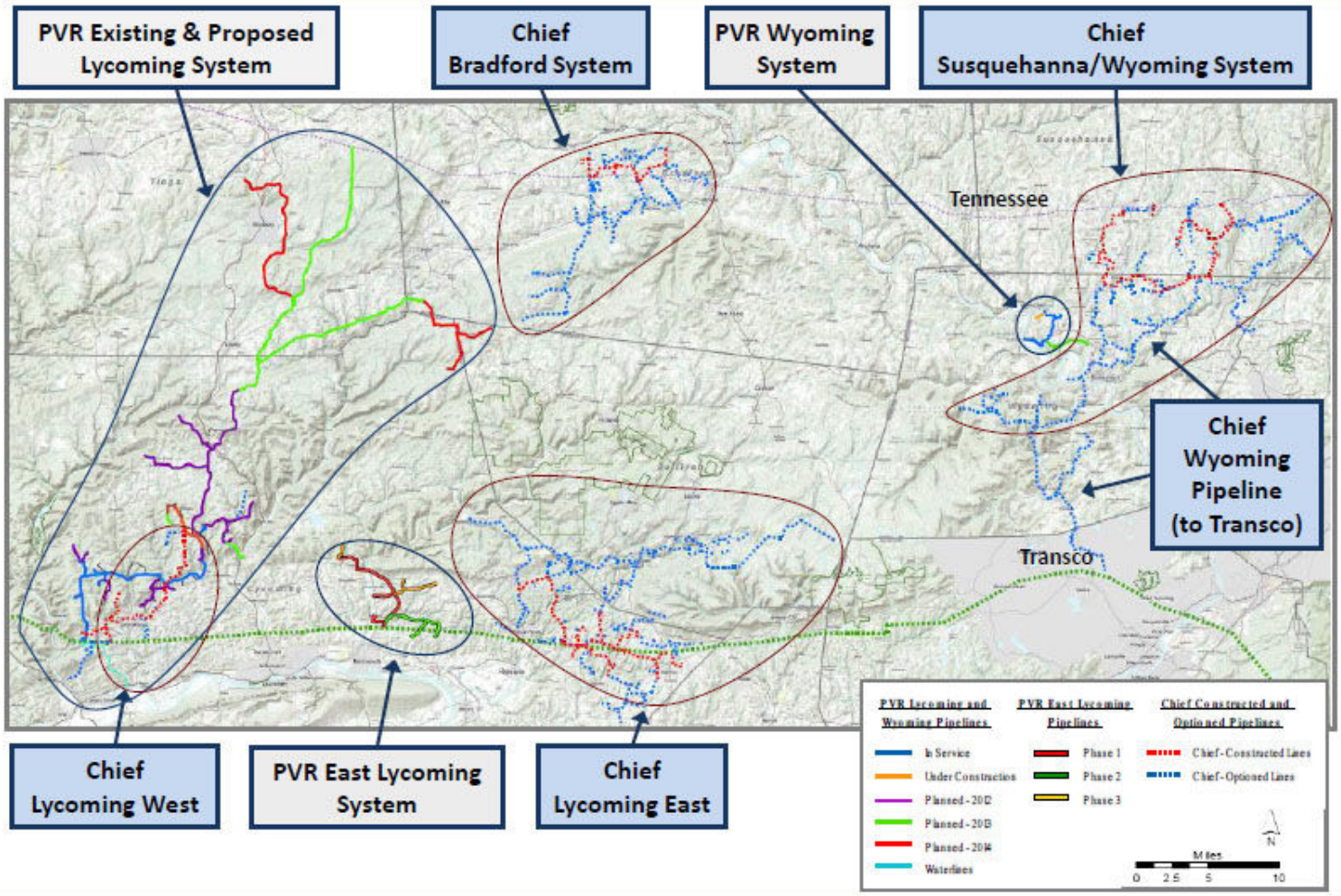
Planned Receipt and Delivery Points B= Bidirectional, D = Delivery

Possible Interconnects	
MARC I (Lycoming County, PA)	B
Transco Leidy Line	B
TETCO M3	B
Columbia 1804	B
Transco Station 195	B
UGI Temple LNG (Berks County, PA)	B
Eagle Station (Chester, PA)	
Peco, Philadelphia Gas Works	B
UGI's Gate Station (Harrisburg, PA)	D
Eastern Shore Natural Gas Co. (Parkesburg, PA)	D
BG&E's City Gate (Linden Church, MD)	D
WGL's City Gate (Prince George's County, MD)	D
Dominion Cove Point LNG Pipeline (Charles County, MD)	D

Commonwealth will be a FERC jurisdictional interstate natural gas pipeline. Commonwealth expects to request FERC for authorization to provide no-notice firm transportation service, park & loan service, and multiple interruptible services.

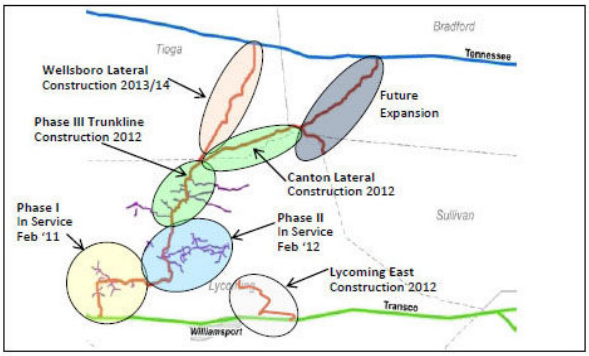
The applicability and character of Commonwealth's services will be governed by the terms and conditions of Commonwealth's FERC-approved gas tariff

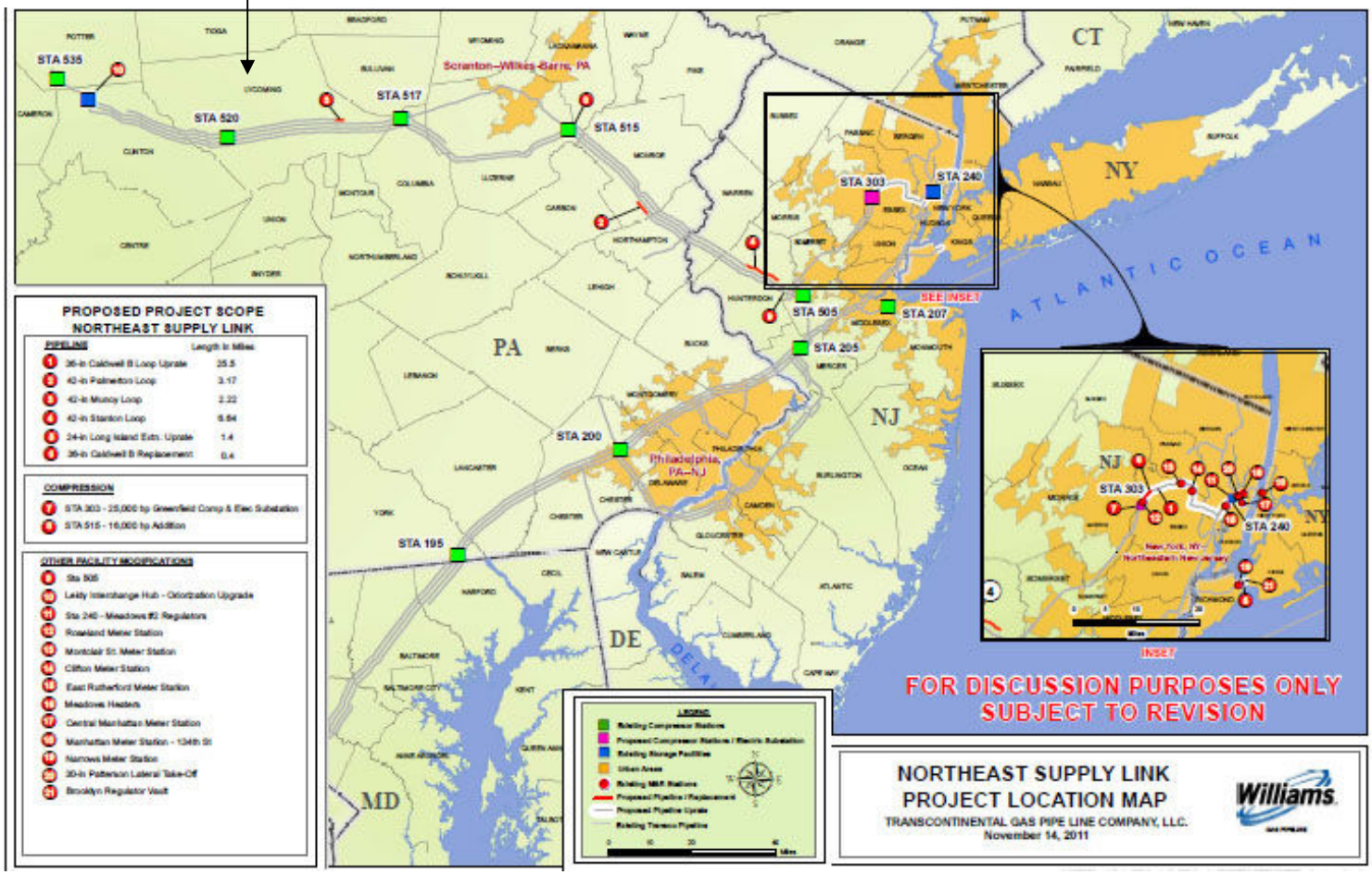
Marcellus Systems



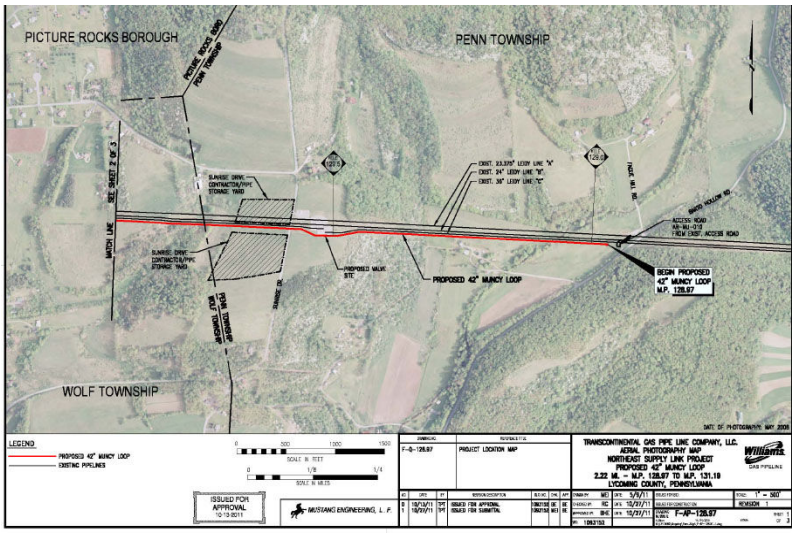
Lycoming Systems

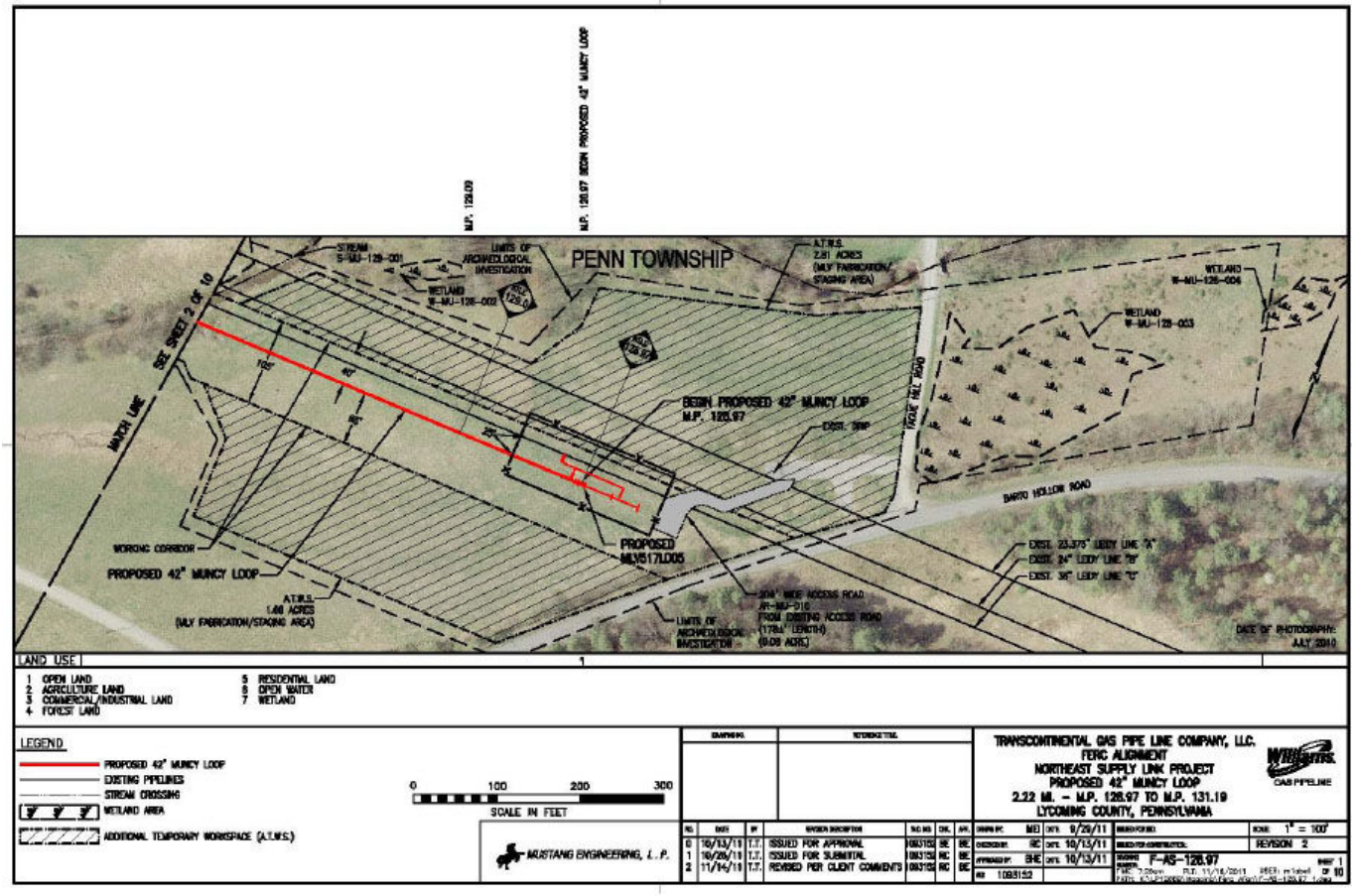
- Lycoming West System
  - First large-diameter gathering system in north-central PA Marcellus fairway (30-inch pipeline / 850 MMcfd capacity)
  - Range Resources – original anchor producer
  - Recent firm capacity agreements with Shell and Southwestern support system extension to Tennessee line
- Fresh water pipeline (JV w/ Aqua) to supply producers
- Lycoming East System (Inflection Energy)

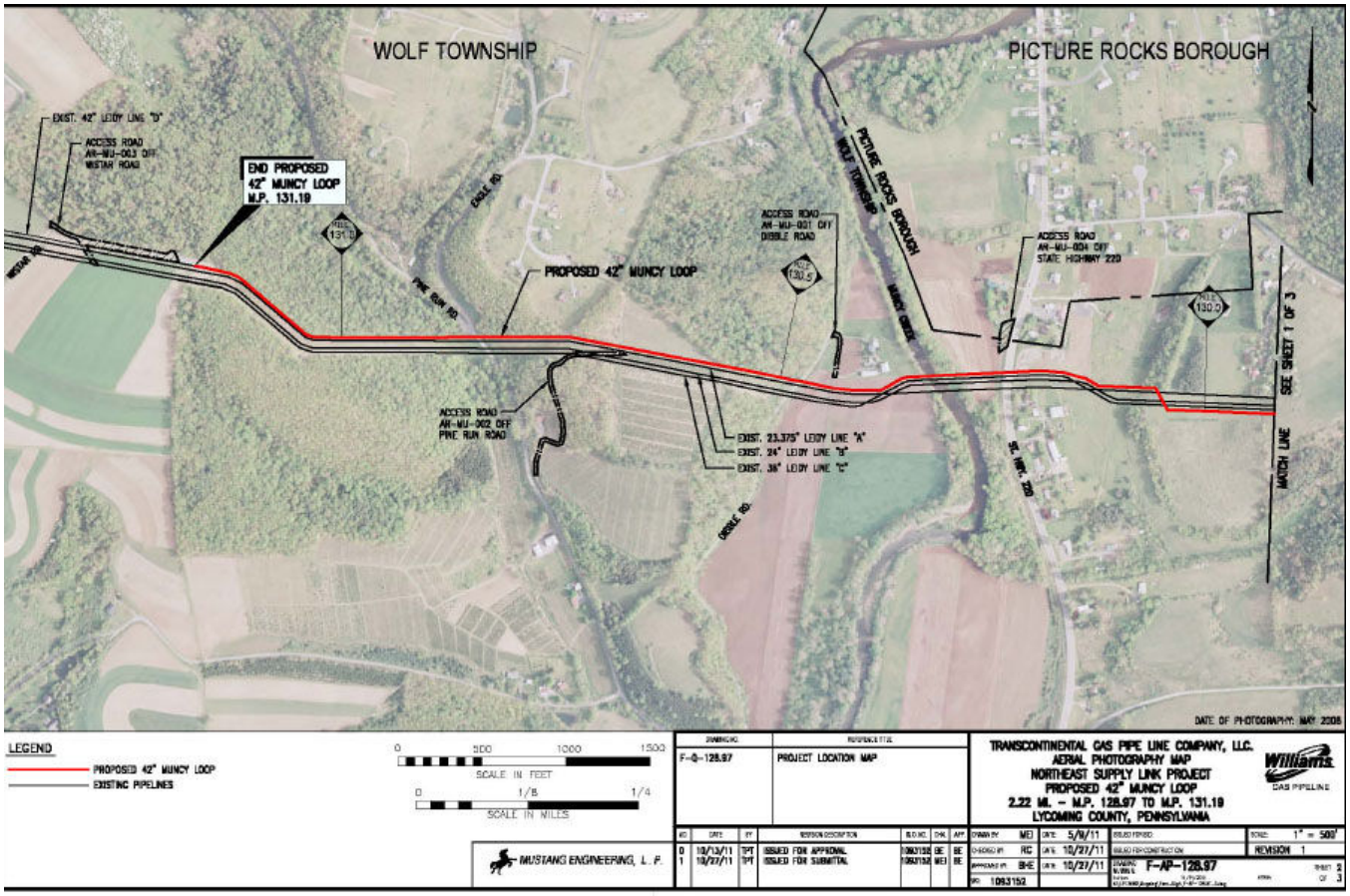


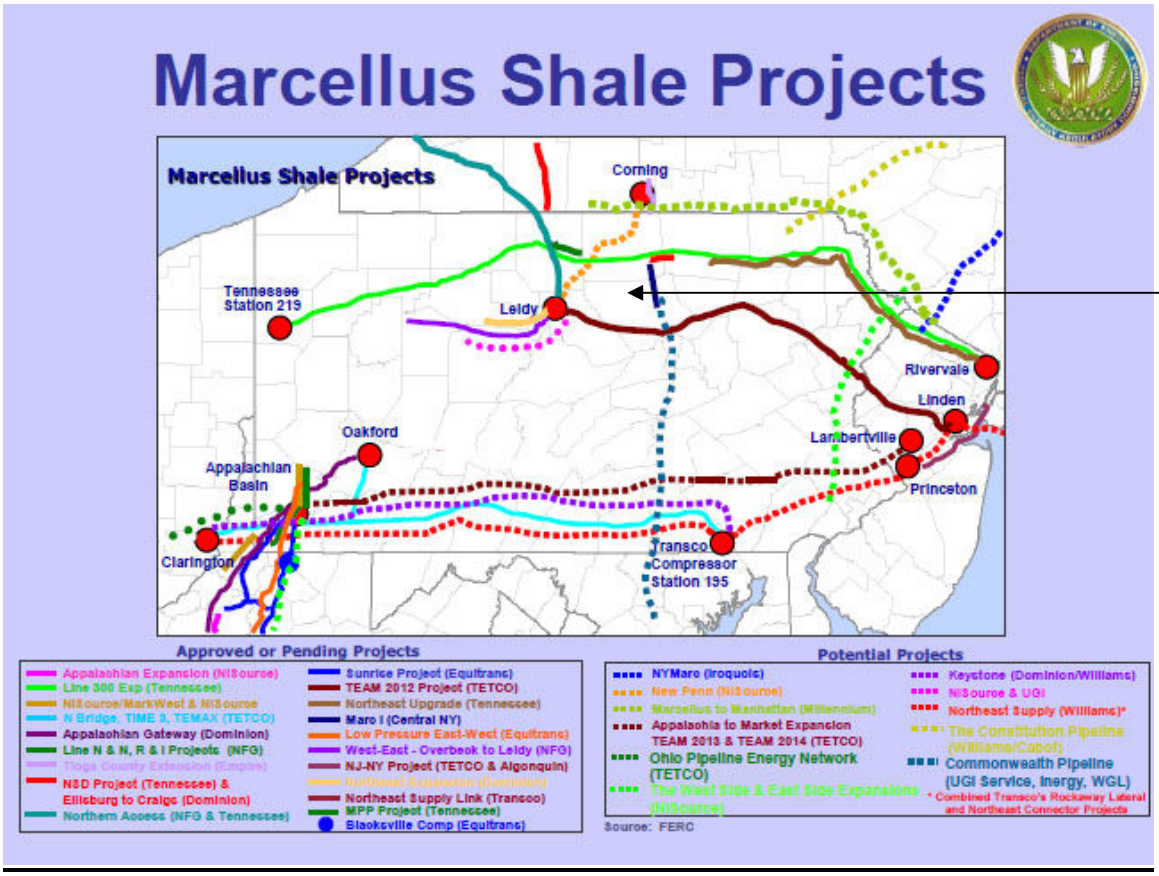


The Muncy Loop proposed by Williams will consist of construction of the Leidy Line "D" Pipeline between mile points 128.97 and 131.19. This loop consists of 2.22 miles of 42-inch pipeline parallel to the existing Leidy pipeline in Wolf and Penn townships about 14 miles east of Williamsport. An existing pig receiver and related appurtenances will be moved from MP 131.19 to MP 128.97. The 300-foot wide corridor for the Muncy Loop that was surveyed for wetlands encompassed 142 acres. The graphics below illustrate the kind of information available to the public from FERC-regulated interstate pipelines. No comparable information is available for PADEP-regulated pipelines.

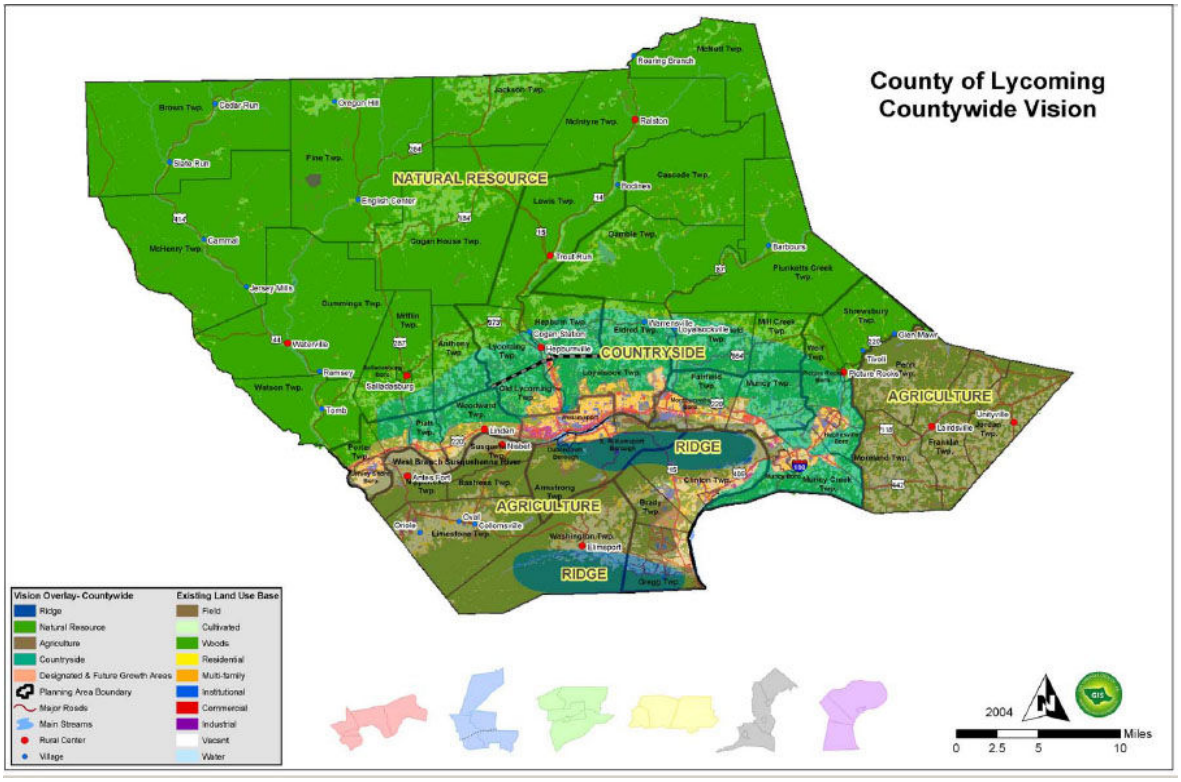



M.P. 129.09
M.P. 128.97 BEGIN PROPOSED 42" MUNCY LOOP
PENN TOWNSHIP
STREAM S-MU-129-001
WETLAND W-MU-128-002
LIMITS OF ARCHEOLOGICAL INVESTIGATION
A.T.W.S. 2.81 ACRES (MLV FABRICATION/ STAGING AREA)
WETLAND W-MU-128-004
WETLAND W-MU-129-003
SEE SHEET 2 OF 10
MATCH LINE
BEGIN PROPOSED 42" MUNCY LOOP M.P. 128.97
EXIST. SRP
WOLF HILL ROAD
BARTO HOLLOW ROAD
WORKING CORRIDOR
PROPOSED 42" MUNCY LOOP
PROPOSED MLV517L005
EXIST. 23.375" LEDDY LINE "A"
EXIST. 24" LEDDY LINE "B"
EXIST. 36" LEDDY LINE "C"
A.T.W.S. 1.66 ACRES (MLV FABRICATION/STAGING AREA)
20.0' WIDE ACCESS ROAD AR-MU-010 FROM EXISTING ACCESS ROAD (1784' LENGTH) (0.08 ACRS.)
LIMITS OF ARCHEOLOGICAL INVESTIGATION
DATE OF PHOTOGRAPHY: JULY 2010
LAND USE
1 OPEN LAND
2 AGRICULTURE LAND
3 COMMERCIAL/INDUSTRIAL LAND
4 FOREST LAND
5 RESIDENTIAL LAND
6 OPEN WATER
7 WETLAND
LEGEND
PROPOSED 42" MUNCY LOOP
EXISTING PIPELINES
STREAM CROSSING
WETLAND AREA
ADDITIONAL TEMPORARY WORKSPACE (A.T.W.S.)
0 100 200 300
SCALE IN FEET
MUSTANG ENGINEERING, L.P.
TRANSCONTINENTAL GAS PIPE LINE COMPANY, LLC.
FERC ALIGNMENT
NORTHEAST SUPPLY LINK PROJECT
PROPOSED 42" MUNCY LOOP
2.22 MI. – M.P. 128.97 TO M.P. 131.19
LYCOMING COUNTY, PENNSYLVANIA
Williams GAS PIPELINE
0 10/13/11 T.T. ISSUED FOR APPROVAL
1 10/26/11 T.T. ISSUED FOR SUBMITTAL
2 11/14/11 T.T. REVISED PER CLIENT COMMENTS
DRAWN BY: MD 9/29/11
CHECKED BY: RC 10/13/11
APPROVED BY: BHE 10/13/11
ISSUED FOR CONSTRUCTION
REVISION 2
SCALE: 1" = 100'
DRAWING F-AS-128.97
SHEET 1 OF 10


WOLF TOWNSHIP
PICTURE ROCKS BOROUGH
EXIST. 42" LEDDY LINE "D"
ACCESS ROAD AR-MU-003 OFF MISTAR ROAD
END PROPOSED 42" MUNCY LOOP M.P. 131.19
131.0
EAGLE RD.
ACCESS ROAD AR-MU-001 OFF DIBBLE ROAD
130.5
PICTURE ROCKS BOROUGH
WOLF TOWNSHIP
MARSH CREEK
ACCESS ROAD AR-MU-004 OFF STATE HIGHWAY 220
130.0
PROPOSED 42" MUNCY LOOP
PINE RUN RD.
ACCESS ROAD AR-MU-002 OFF PINE RUN ROAD
EXIST. 23.375" LEDDY LINE "A"
EXIST. 24" LEDDY LINE "B"
EXIST. 36" LEDDY LINE "C"
ST. HWY. 220
DIBBLE RD.
SEE SHEET 1 OF 3
MATCH LINE
DATE OF PHOTOGRAPHY: MAY 2008
LEGEND
PROPOSED 42" MUNCY LOOP
EXISTING PIPELINES
0 500 1000 1500
SCALE IN FEET
0 1/8 1/4
SCALE IN MILES
MUSTANG ENGINEERING, L.P.
F-0-128.97
PROJECT LOCATION MAP
TRANSCONTINENTAL GAS PIPE LINE COMPANY, LLC.
AERIAL PHOTOGRAPHY MAP
NORTHEAST SUPPLY LINK PROJECT
PROPOSED 42" MUNCY LOOP
2.22 MI. – M.P. 128.97 TO M.P. 131.19
LYCOMING COUNTY, PENNSYLVANIA
Williams GAS PIPELINE
0 10/13/11 TPT ISSUED FOR APPROVAL
1 10/27/11 TPT ISSUED FOR SUBMITTAL
DRAWN BY: MD 5/9/11
CHECKED BY: RC 10/27/11
APPROVED BY: BHE 10/27/11
ISSUED FOR CONSTRUCTION
REVISION 1
SCALE: 1" = 500'
DRAWING F-AP-128.97
SHEET 2 OF 3



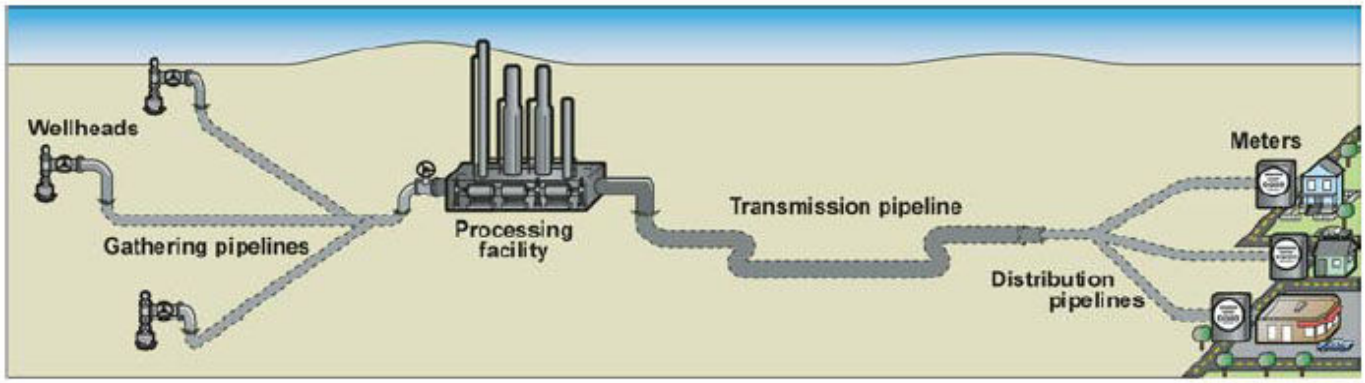
Such pipelines herald major changes for the landscape and economy of Lycoming County during the twenty-first century, especially in rural areas. Most of the county's residents currently live in the Susquehanna River valley.



Pipelines for Natural Gas Production and Use

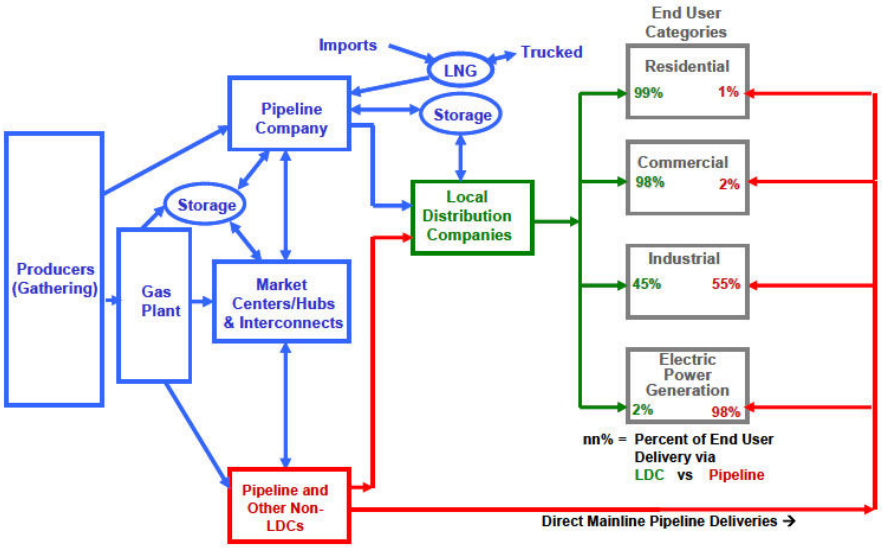
Pipelines are an intrinsic part of shale gas production and marketing. Five basic types of pipelines can be distinguished: frackwater lines, production piping, gathering lines, transmission lines, and distribution lines. Together these pipelines are needed to extract shale gas from the earth, convey it to processing stations, transmit it to market, and distribute it to end users. The types of pipes vary in size, operating pressure, construction materials, and in the way they are addressed by regulators concerned with siting, construction material standards and specifications, maintenance, inspections, and decommissioning. Each type of pipeline presents both short-term and long-term hazards to people, property, and the environment because of their capacity to leak, corrode, become brittle with age, or suddenly rupture. Once pipelines have been buried underground, they tend to be forgotten by the general public until spectacular disasters occur. The construction, operation, and ownership of pipelines are highly fragmented enterprises, and are primarily the business of the private sector in the United States. Some public entities pipe and distribute gas via retail pipelines in urban areas.

Pipeline System



Source: PHMSA.

Figure 1. Natural Gas Distribution Segments, 2006



The decentralized American system of government has adapted only slowly to the need for regulating pipelines as these transport systems expand and age, and as ever more people come to live and work near them. Responsibility is fragmented between the Federal Government and the States. Within each State, regulations have evolved historically in contrasting ways. To some extent certain gas pipelines now are treated as natural monopolies, with regulation of rate setting by public utility commissions. Other pipelines are regulated only as physical entities by permitting agencies concerned with protection of human safety, human health, or air, water, soil, and highway resources. Even for the largest pipelines, most regulatory attention has been focused on urban, as opposed to rural, areas.

The discussion of State regulation in this report concerns Pennsylvania and does not apply elsewhere. Within Pennsylvania there are significant gaps in the regulation of certain types of pipelines. The allocation of responsibility between State agencies and local municipalities currently is undergoing change as elected officials respond to the demands of the gas industry and of their constituents. Pennsylvania Act 13 of 2012 requires municipalities to allow oil, gas, and water pipelines in all zoning districts, but such provisions were deemed unconstitutional by Commonwealth Court during July 2012.

Types of Pipelines in Shale Gas Development, Transport, and Use

Frackwater Pipelines. The first type of pipeline to appear in the landscape of Lycoming County as a result of the Marcellus Shale gas industry carries not natural gas but fresh water and gas well return wastewater. Shale gas wells require immense quantities of water, about one hundred times as much as needed to develop each conventional gas well. Some (up to 80,000 gallons or so) is needed for well drilling to lubricate the drill bit and remove cuttings. Most of the water (about 5 to 8 million gallons), combined with sand and chemicals is injected each time a single shale well is hydrofractured. This water must be obtained from sources such as a surface lake or stream or a subsurface water well, and transported by truck and/or pipeline to the gas well pad, where it must be stored until needed to fracture the shale deep underground.

Water, sand, and chemicals are combined in proprietary formulas and forced at high pressure (as much as 20,000 pounds per square inch) to prop open natural fractures in the shale rock. The sand keeps small channels open so that gas can flow out through the well pipe after the water has been removed. A million gallons or more of water returned to the surface as flowback must be disposed from each well pad, because this industrial waste (like drill cuttings and drilling mud) cannot simply be released into the environment, given its potential to cause damage. As little as 20% to much as nearly 100% of the injected water is pushed back to the surface by gas in Marcellus Shale wells. This produced water typically contains high levels of total dissolved solids (70,000 to 250,000 mg/L, mostly salts from the shale) plus hydrocarbons, radioactive materials, and heavy metals. These constituents preclude re-use and reinjection from one well to the next unless some filtration is provided. Typically return water can be filtered and reused in order to reduce both cost and the potential for environmental damage. After use, any wastewater retrieved from a gas well must be disposed by industrial treatment, placed in a residual waste landfill, or injected into permanent storage underground. There are very few suitable waste injection wells in Pennsylvania. Some flowback water may not be amenable to reinjection due to high concentrations of barium and strontium and the

potential for calcite precipitation that clogs the well (NETL 2011). Smaller quantities of flowback water may continue to be returned to the surface for years. It must be separated from the marketable gas and collected for disposal.

The water produced from gas wells contains not only the diverse chemicals added by drillers to enhance its effectiveness for opening pathways for gas in the rock, but also various materials (including brine salts, strontium, bromide, and radioactive materials) that it brings up from the Marcellus Shale. Return water (flowback) poses a hazard to plants and animals if spilled on land, and to all kinds of aquatic biota in streams, wetlands, and other bodies of fresh water. It is regulated as a residual waste by the Pennsylvania Department of Environmental Protection (PADEP). Return water also has been blamed for contamination of private water supply wells, although such contamination is strongly denied by the industry. Flowback water can be filtered, with the sludge trucked to a landfill and the liquid reused in subsequent hydrofracturing. Water pipelines, as well as trucks, are used to ship filtered frackwater from the storage tanks or open pits on one well pad to the next. Increasingly, fresh water and flowback water (whether partially treated or not) are being routed through the same pipelines (whether intended or not). The PADEP has shown a tendency to view them as one and the same for regulatory purposes (*e.g.*, the proposed revision to General Permit 8 for temporary aboveground water pipelines). The US Environmental Protection Agency currently has no plans to regulate fracking water quality prior to 2014, according to November 2011 testimony to Congress.[3]

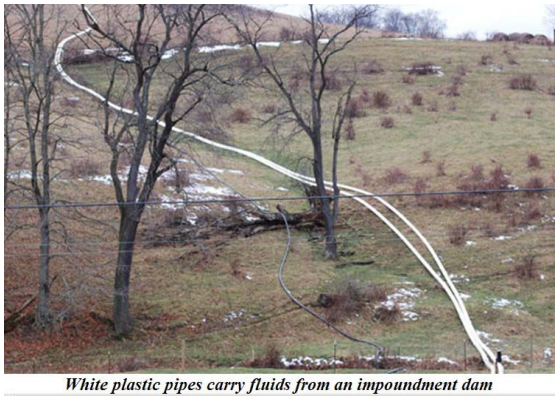
PADEP has established a general permit (WMGR 123) allowing classification of gas well return water as "dewasted" material if it meets specified concentrations limiting certain chemicals. Unlike other residual wastewater, "dewasted" water can be stored in unlined impoundments. Return water brines also are authorized (General Permit WMGR 064) for use for deicing and for dust control on roads in Pennsylvania, where they pose an underappreciated hazard to vegetation and to aquatic animals. Treated municipal wastewater has been proposed for use as fracking water, but has not yet been widely used by gas well drillers in Pennsylvania. The industry has expressed a willingness to use acid mine drainage for fracking, but has requested exemption from liability from spills and perpetual treatment. Such wastewater typically presents low pH and high sulfate, as well as storage risks.

PADEP seeks to encourage the reuse of wastewater from gas wells for hydrofracturing subsequent wells. Reuse has the advantages of lessening the quantity of water withdrawn from freshwater sources, as well as the quantity of wastewater that must be disposed. The filtration needed to improve its quality for reuse yields sludge that must be trucked to disposal sites. PADEP data show about 38% of returned frackwater to have been reused during 2011. Frackwater distribution lines that contain reused wastewater pose a greater threat to environmental resources than those lines containing only fresh water, in the event that a line becomes broken.

Increasingly pipelines are being installed in Pennsylvania to reduce the need for hundreds of large trucks to haul the water for hydrofracking to and from each well. In the spring of 2012, a joint venture between a gas producer (Penn Virginia

[3] https://library.villanova.edu/Find/Record/1396998

Resources) and an investor-owned water utility (Aqua America of Bryn Mawr) began the first phase of a 12-inch diameter steel pipeline that will supply 3 million gallons per day of Susquehanna River water to frackwater reservoirs in Lycoming County. The pipeline uses the right-of-way of gas gathering lines, potentially eliminating thousands of trips by 5,400-gallon tank trucks. (Trucks and roads still are needed to haul sand, chemicals, wastes, and equipment.) Because the project caused the sudden eviction of longtime residents of a riverside trailer park in Piatt Township, Lycoming County, it generated controversy (Thompson 2012).



White plastic pipes carry fluids from an impoundment dam

Gas companies are constructing fracking water reservoirs on hilltops to supply nearby wellpads by gravity to the extent practicable. “Temporary” aboveground or permanent underground pipelines can carry water into and out of the reservoirs, as well as to and from each well pad. Uncovered reservoirs to be used for returned frackwater require liners, whereas freshwater reservoirs do not. If produced gas well flowback water is placed in unlined or leaking reservoirs, its pollutants can be spread widely through groundwater as well as by vaporization of volatile components inimical to human health.

Clearing of forested corridors is necessary to allow heavy equipment to place the pipe sections, unless these pipelines follow existing road margins or utility corridors. Booster pumps are used as needed.

Initially the aboveground water pipelines conveying water to (and from) gas wells were simple agricultural irrigation water pipes made of aluminum sections snapped together, or glued plastic. They were laid on top of the ground for the months when

they were needed. At streams wood cribbing typically raises such pipelines above normal water level. Roads, however, typically are crossed by laying sections of the water pipes underground, usually by cutting an open trench (especially through unpaved roads); sometimes, by boring or drilling horizontally beneath the pavement. Newer above-ground pipelines consist of heavier gauge polyethylene pipe whose sections are fused together. Above-ground pipelines are constantly at risk from

Gas well water lines clog road drainage culverts in Washington County PA.

structural damage by vehicles, as well as by floodwaters and debris in floodplains. All types have experienced breakage and water loss, resulting in environmental damage.

Water pipelines carrying fresh water and produced flowback water are not regulated by the State or Federal agencies concerned with pipeline safety for natural gas, petroleum, and hazardous materials transport. Any attention that they get comes from environmental agencies or from those municipalities with applicable zoning ordinances addressing such industrial uses. Water and other pipelines affecting State roads in Lycoming County are regulated by the Pennsylvania Department of Transportation (PennDOT). Engineering plans must gain approval through a utility Highway Occupancy Permit prior to pipeline installation beneath or alongside State roads. Regardless of products carried, pipelines affecting municipal roads are supposed to gain municipal or county review and approval prior to construction.

PADEP at first elected to ignore aboveground fracking water pipelines entirely. Currently its Bureau of Dams and Waterway Management General Permit 8 authorizes aboveground frackwater pipelines as “temporary” structures, presuming that they will be removed from stream crossings after no more than one year. General permits are registered by applicants and do not receive PADEP staff review or public notice. Such permits can be renewed indefinitely, when an operator opts to construct the wells on a pad consecutively rather than all at once or returns to try to raise lagging production of gas several years after a well was first installed by additional hydrofracturing.

Some frackwater pipelines are constructed of steel and placed underground in the same trenches as gas gathering pipelines. Presumably, such underground lines are expected to

be available for use indefinitely, if and when the wells they serve require subsequent rounds of hydrofracturing or additional or deepened wells are drilled on the pad.

Production Piping. Shale gas wells are lined with sections of threaded steel piping that are screwed together to form underground "strings" of casing up to about three miles long. Each shale gas well typically contains several strings of pipes with decreasing diameter inside each other. The outer casing typically is about 30 inches in diameter; the

Installing Well Casing
Source: ChevronTexaco Corporation

innermost (production) casing, about 5 to 6 inches. Blowout containment devices and well casing of sufficient strength are required. The American Petroleum Institute has published technical specifications for commonly used equipment (http://www.api.org/publications-standards-and-statistics.aspx). At the top of the finished well the several valves and pipes collectively are called a "Christmas tree". Valves, storage tanks, and other gas handling equipment vary in their propensity to leak gas. Well construction requirements have been set forth by PADEP at 25 *Pa. Code* Chapter 78 (http://www.pacode.com/secure/data/025/chapter78/chap78toc.html) and in its (pre-Marcellus) 2001 Oil and Gas Operator's Manual (Document 550-0300-001; http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8295). Casing requirements were significantly strengthened by PADEP in 2011. The Operator's Manual recommends (but PADEP does not require) burying gas pipelines within road corridors. Currently there are few requirements for an operator to use equipment that minimizes the loss of gas to the air, but during April 2012 the US Environmental Protection Agency issued new source performance standards for air pollution control in the oil and gas industry (http://www.epa.gov/airquality/oilandgas/pdfs/20120417finalrule.pdf). Pennsylvania's 2011 Act 127 law mandates that well operators report their emissions of air pollutants annually (http://www.puc.state.pa.us/naturalgas/Act_127_Info.aspx). Current PA regulations require that gas operators investigate reports of high methane levels (25 *Pa. Code* 78.89). Concentrations of methane in well water of 7 mg/L (ppm) or greater warrant immediate contact with PADEP and the operator of nearby gas wells or pipelines (Oram 2012).

.

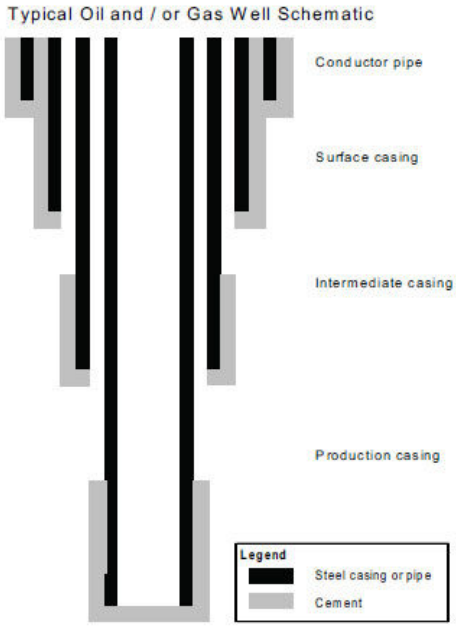
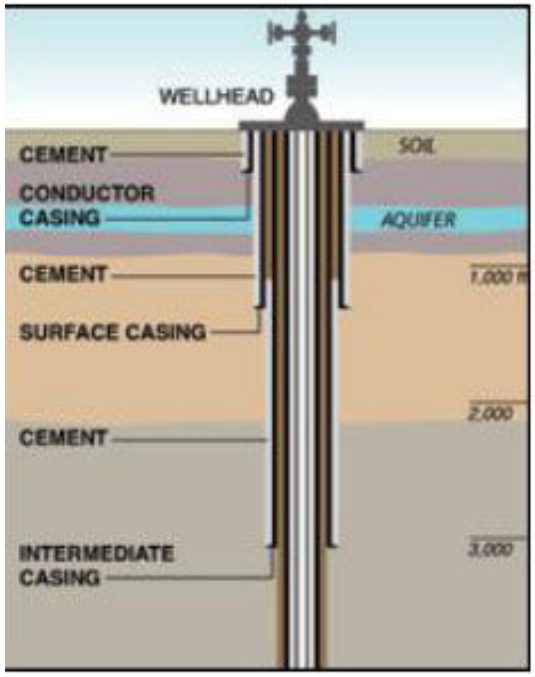


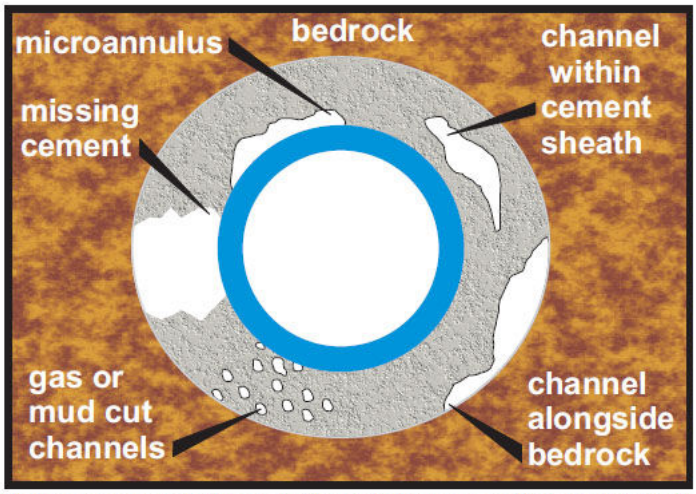
Figure 1—Typical Well Schematic



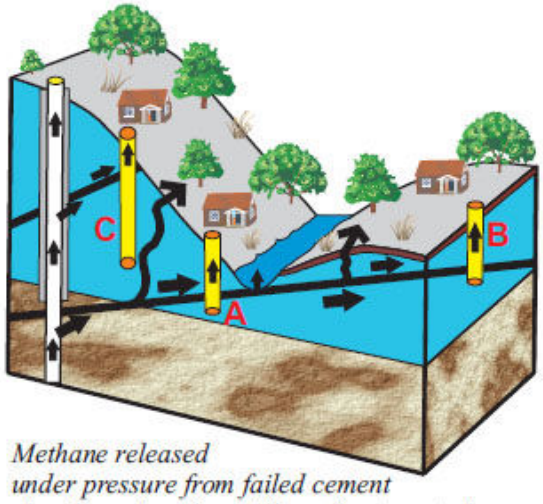
Cement typically is placed to fill the annulus between the outside of the steel pipe and the surrounding rock in the drill hole, where it is intended to block the movement of fluids between the pipe and the rock. Cement also may be placed in the gaps between successively smaller strings of pipe. Cement requirements were updated in 2011 (25 *Pa. Code* Chapter 78), but continuous cementing of the entire well still is not required. The effectiveness of cement is a critical determinant of the extent to which gas and fracking fluid will be lost outside the pipe into the atmosphere or into groundwater aquifers, drinking water wells, and streams within a mile or more of each well pad. Tiny imperfections in cement provide corridors through which natural gas and other fluids move upward under pressure into near-surface aquifers.

Available data on deep gas production wells document that about 6% of well casings typically fail to prevent pressure buildup outside the casing during their first year of operation (Bufatto et al. 2003). After 30 years some 60% of well casings typically have failed (Watson & Bachu 2009). In Pennsylvania 90 well casings were reported by PADEP in 2010 as having failed (6.2% of the total). The same percentage failure was reported in 2011 (121 failures). In January and February 2012, 19 of 262 drilled ("spudded") wells failed (7.2%). Longer-term data are not available, but the immediate and continually increasing risk to waters from installing tens of thousands of shale gas wells in Pennsylvania is obvious.

The shale gas industry in Pennsylvania is too new to have experience with the repeated hydrofracking of wells to increase production as gas pressure drops. Each hydrofracking episode poses an additional risk of failure in well casing and cement.



Types of cement channels in annular spaces that may permit upward methane migration. From Newhall (2006).



Methane released under pressure from failed cement sheaths and casings follows fractures to home-owner wells, water bodies, and the land surface.

Neither cement nor steel casing materials can reasonably be expected to maintain their integrity for more than a century. Cement shrinks and cracks. Steel undergoes accelerated corrosion under the heat and chemicals present deep underground. Long-term, of course, every manmade borehole provides a connection between the deep shale strata and the earth surface. Every such connection is a potential pathway for migration of gas, other petroleum compounds, brine, and associated fluids to the surface, given the high probability of eventual disturbance of wells by earthquakes and plate tectonics, whether the well bores were initially installed properly and then plugged successfully or not. PADEP amended its well construction regulations during 2011 to require that drillers allow cement to set for 8 hours. (Proposed New York shale gas regulations would require fluid testing of wells after cement has set for at least 7 days.) Complete cementing of the entire length of gas wells is not required in Pennsylvania, but the gas wells are supposed to be cased through aquifers (waterbearing zones) and cemented to prevent immediate contamination of water supplies by gas and other well fluids. Whether this requirement can be met consistently, even in the short run, remains to be seen. Historic failure rates in Pennsylvania and elsewhere are not reassuring.

Some 350,000 conventional wells have produced gas in Pennsylvania, according to PADEP. The locations of hundreds of thousands of inactive wells are unknown statewide (Davies 2011). Most are likely to be leaking gas at the present time. Current technology allows methane gas to be detected at low concentrations, but in the absence of regulatory requirements it is seldom utilized to locate abandoned wells.

Like unrecognized natural fractures, abandoned wells pose a hazard during shale gas development throughout the Commonwealth. If abandoned wells are encountered, control of flowback water and gas can be lost. The pipelines within wells are regulated only by those agencies tasked with overseeing well construction, namely, PADEP. Construction specifications in regulations typically lag behind advances in well engineering, and effective well cementing remains a major challenge for engineering research. Unlike most states, Pennsylvania does not require any cementing or casing of private water supply wells, which may allow the water well to be affected by shale gas development nearby. In the short term surface spills of contaminants may be a more common source of water contamination than gas casing leaks, but the casings provide an ever-growing long-term threat to Pennsylvania waters.

Methane bubbling in Little Muncy Creek, May 2011. XTO drilling in Marcellus Shale was underway nearby.

Natural gas lost from wells into the air can travel across large distances. Only recently have concentrations of such fugitive gas begun to be measured. Along the Rocky Mountain Front Range in Colorado, the measured concentration of methane and other hydrocarbons downwind from gas wells has led to estimates by the National Oceanic and Atmospheric Administration of fugitive emissions twice as high as those made by gas industry and State agency sources (Petron *et al*. 2012). Comparable work has not been performed in Pennsylvania.

Bradford County shale well spews fluids

Thursday, April 21, 2011
By Sean D. Hamill, Pittsburgh Post-Gazette

C.J. Marshall/The Daily Review

This is the natural gas well site operated by Chesapeake Energy in Leroy, Bradford County.

An equipment failure on a Marcellus Shale natural gas well in northeastern Pennsylvania late Tuesday night caused a blowout, allowing thousands of gallons of chemically laced hydraulic fracturing fluid to flow from the site for at least half a day.

More than 16 hours after the blowout began at 11:45 p.m. Tuesday, frack fluid was still spewing out of the Chesapeake Energy well in Bradford County, county and state officials said.

The above news account identified a blowout of gas and fracking fluids at Chesapeake's Atgas 2H well in Leroy Township, Bradford County, during April 2011. Just over 1 year later Chesapeake experience leakage of gas at its Morse 3H and 5H wells, also in the Towanda Creek watershed. The 2012 incident generated measurements of methane in water and air.

Traditional technology has long been used to detect gas concentrations that threaten explosions. The Office of Surface Mining action level for methane in water is 10 ppm; higher concentrations may warrant venting of water wells.[4] Portable, vehicle mounted, laser-based Cavity Ring-Down Spectrometry technology can detect low methane

[4] Kappel, William M., & E. A. Nystrom. 2012. Methane in New York groundwater, 1999-2011. US Geological Survey Open File Report 2012-1162. ofr2012-1162_508_09072012.pdf

concentrations in air to parts-per-billion accuracy, far below the detection limit of traditional combustible gas indicator meters (Ackley 2012b). On 25 July 2012 air samples were analyzed for methane in McNett and McIntyre Townships of Lycoming County, as well as in nearby sections of Bradford and Tioga Counties. Domestic well water samples also were analyzed. Low concentrations of methane from agricultural sources were accounted for during the plume investigations.

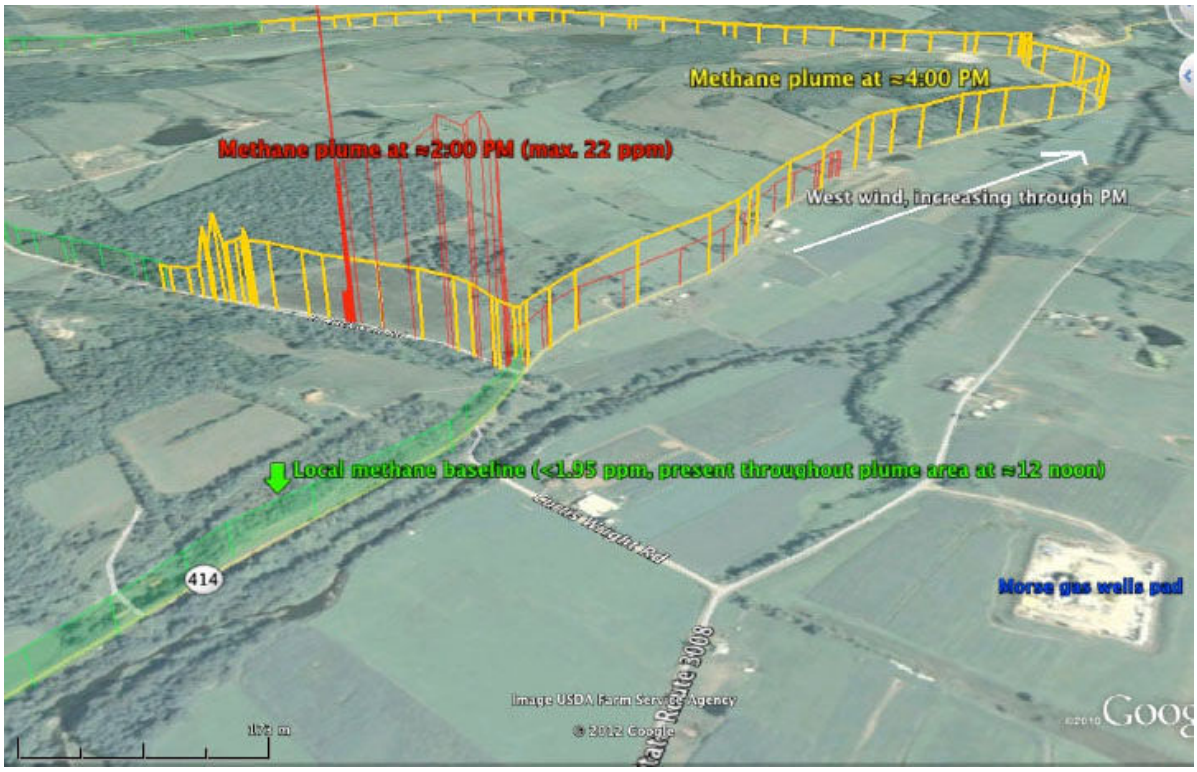
The 25 July investigation centered on Leroy Township, Bradford County, where dramatic discharges of methane at Morse Wells 2H and 5H had been reported on 22 May 2012 as causing several domestic water wells suddenly to overflow. Methane was measured in the soil, in water, and in the air. During the afternoon sampling of airborne methane plumes the wind remained light and variable. This methane originated from natural faults and fractures that apparently had been disturbed by nearby shale gas development several months before. The approximately 12,000 air sample locations taken at intervals of 3 to 4 seconds were plotted using Global Positioning System (GPS) technology on maps and aerial photographs.

Measured background methane concentrations in this vicinity were less than 1.95 ppm. The lowest concentration encountered was 1.656 ppm. Concentrations higher than 2.05 ppm in outdoor air indicate unusually high gas levels.

The July inquiry expanded and confirmed the findings from a previous survey (more than 7,500 samples) of methane in air and water on 8 June 2012 (Ackley & Payne 2012a). Methane in residential water wells here had been measured previously by PADEP and by industry contractors at 50 to100 ppm, a supersaturated condition well above saturation at normal atmospheric pressure (28 ppm). Five of the 6 domestic water wells sampled on 8 June remained supersaturated on 25 July. Airborne methane of as much as 713 ppm had been measured on 8 June just above the soil on the banks of Towanda Creek, where bubbles were visible from the Cross Road Bridge. Methane was visible in the water along hundreds of feet of Towanda Creek about 1.3 miles from the well pad.

The principal source of the methane was considered to be a reported casing leak at the pad housing Chesapeake's Morse 3H and 5H wells. The leak had occurred on 19 May 2012. On 25 July soil-air methane concentrations at 8 to 12 inches below the surface were measured as high as 940,000 ppm (94%) using a Bascom-Turner combustible gas indicator, and the gurgling sound of underground gas was audible. Gas was estimated to be escaping from the soil over an area of at least 30 acres (200 x 600 m). Near-ground-surface air concentrations spiked to 22 ppm at 2 pm. No measurements were taken in the immediate vicinity of the well pad. The plume was quite distinct at 4 pm, as shown in the following graphic, when the average plume methane concentration was 3.8 ppm. The size of this plume had not decreased over the six weeks since the prior measurements on 8 June.

These measurements in Leroy Township suggested a pattern of gas escaping to the atmosphere from faults and fractures originating at considerable depth, rather than from near the surface at the Morse wells pad where the vertical sections of the shale gas wells emerge. The area of escaping gas was expected to be larger than the area



Methane concentrations from gas exiting natural faults and fractures in Leroy Township, Bradford County, on 25 July 2012. Green bars show concentrations at background level. Yellow and red bars show elevated concentrations at two times of day (2 pm and 4 pm). This plume encompassed about 1.6 square miles and originated from a gas discharge area occupying at least 30 acres. The red spikes showing maximum concentrations are relatively distant from the presumed originating source at Morse wells 3H and 5H in the lower right corner of the view, 0.4 mile away near the intersection of Curtis Wright Road and Southside Road (State Route 3008), where a casing leak had been reported on 19 May 2012 (Ackley & Payne 2012b). Towanda Creek parallels Route 414 in the center of the oblique photograph.

actually examined during the limited measurements on 25 July. Methane plumes in soil would be expected to cause the slow death of tree roots, followed by canopy death. The implications for human health of such airborne plumes are not known.

Later on 25 July another 10-mile long plume was detected several miles to the west. It extended from north of Canton to north of Ralston. This plume was presumed to be a result of another methane migration event that reportedly began on 20 June in Union Township, Tioga County (Ackley & Payne 2012b).

Hydrofractured wells in the Marcellus Shale produce an initial rush of water to the surface when the pressure of hydraulic pumps is released. Thereafter, gas wells produce brine in lesser amounts for many years. Permanent tanks often are installed on well pads to collect the waste liquid, which is removed by truck.

EQT Corp. brine water tanks (collect residual frac water as it returns to the surface over time) in Waynesburg, PA. Photo credit - Josephine Sabillon

For a comprehensive analysis of enforcement of oil and gas regulations in several States, Sumi (2012) tabulated the onsite inspections that any careful reader of PADEP regulations would expect to be performed routinely at gas wells in the Commonwealth:

Table A6-8. Suggested inspections in DEP Oil and Gas Inspection Policy.[23]

Suggested Routine Inspections
At least once during siting a well
At least once during drilling a well
At least once during casing a well
At least once during cementing a well
At least once during completing a well
At least once during altering a well
At least once during stimulating a well.
At least once during, or within 3 months after, the time period in which the owner or operator is required to restore the site, after drilling the well
At least once prior to a well being granted inactive status.
At least once during well plugging
At least once during, or within 3 months after, the period in which the owner or operator is required to restore the site, after the well is plugged or abandoned.
At least once before the bond or other financial security is released.
At least once a year to determine whether compliance with the statutes administered by DEP has been achieved.

Table A6-8 (continued). Suggested inspections in DEP Oil and Gas Inspection Policy

Special Inspections
At least once prior to the issuance of a permit, if a waiver or exception is requested by the permit applicant.
At least once in verifying or resolving objections or determining the Department's response to objections, when objections are raised to a permit application.
At least once prior to the authorization to use an alternate method for plugging, casing or equipping the well
At least once during the periods that an alternative method for plugging, casing or equipping the well is being used or installed.
At least once when a well is being reconditioned or repaired or when casing is being replaced.
At least once a year, if there is onsite brine disposal or residual waste disposal subject to the statutes referenced in § 78.902 (relating to policy).
At least twice a year if the well is located in a gas storage reservoir or in a gas storage reservoir protective area.
If there is a violation, at least once to determine whether the violation has been corrected, or whether there is a continuing violation.
At least once, in response to a complaint.

Source: 25 Pennsylvania Code §78.901-906. "Inspection Policy Regarding Oil and Gas Wells."
http://www.pacode.com/secure/data/025/chapter78/subchapXtoc.html

In reality, PADEP inspectors do not perform many inspections of shale gas wells. In 2011, there were 8,216 active Marcellus wells to be inspected by 88 inspectors (more than 93 for each inspector), not counting the nearly 70,000 active non-Marcellus wells for which the same 88 inspectors were also responsible (but that rarely are inspected). The careful analysis for Earthworks Action concludes that no State is adequately enforcing laws and regulations that pertain to the oil and gas industry.

Gathering Pipelines. Gathering lines begin at the first point of measurement where piped gas leaves a well. Steel pipelines are constructed underground to link each well pad with gas processing facilities and compressor stations, because it is not considered economic to haul uncompressed natural gas by truck. The 70,000 active, pre-Marcellus, conventional gas wells in Pennsylvania typically are served by 6- to 8-inch diameter gathering lines that operate at low pressure (less than 200 psi). In contrast, Marcellus gas gathering lines typically are 24 inches in diameter (some are larger). They operate at pressures of up to 1,440 pounds per square inch (psi) and require compressor stations similar to those of interstate transmission pipelines. Pennsylvania

Gas gathering pipeline under construction near Warrensville, Lycoming County

A pipeline laying operation near a home in Greene County. (Michael Bryant / Staff Photographer)

Act 127 of 2011 allows the PUC to require steel pipelines to be protected from corrosion, provided they are subject to its jurisdiction; most gathering lines are not (see discussion below of Class 1 pipelines in rural areas). Operators also must protect their lines from excavation damage by enrolling them in the One Call (811) system.

Historically gathering lines have received minimal regulatory attention in Pennsylvania except in some urban areas, although shale gas gathering lines may overlap in size and pressure with major transmission lines. Only those initially sited within densely populated areas may fall within Federal purview. More than 93% of existing gathering

lines nationally are exempt from Federal regulation. There are no comprehensive maps of such lines in Pennsylvania. The recent Act 127 of 2011 failed to extend regulatory control to Class 1 areas within the Commonwealth. The Pennsylvania Public Utility Commission (PUC) now is allowed to collect information on those gathering lines within the Commonwealth that are subject to Federal authority, and is now authorized to accept responsibility for Federal inspections. The location of unconventional gas well (Marcellus) gathering lines in Class 1 (rural) areas now is to be reported to the PUC (http://www.puc.state.pa.us/naturalgas/PDF/Act127/Tele_Conf_QA-012412.pdf).

Lycoming County municipalities have been requiring zoning permit approval (either directly from the more developed municipalities or from the County in rural areas) for gathering pipelines that cross public roads or floodplains along streams shown on County aerial photographs. Lycoming County updated its zoning ordinance in 2011 to address many aspects of oil and gas development, but local ordinances typically have not been updated since the onset of shale gas. Both County and local ordinances may require revision to conform to PA Act 13 of 2012, depending on the outcome of ongoing litigation.

In Lycoming County land development approvals generally are required for permanent buildings, such as those which house compressors or metering stations along pipelines. County or local governments have been requiring engineering review of such structures as land developments, even though unable to regulate the pipelines which the structures serve outside floodplains or public roads. Where gas well access roads have crossed multiple properties, they have been considered to be municipal streets. Pipelines are not land developments, and they rarely entail the creation of new land parcels requiring subdivision review. Well pads, frackwater reservoirs, and their drainage easements in Lycoming County have not been reviewed for compliance with Act 167 stormwater requirements since passage of Act 13 of 2012.

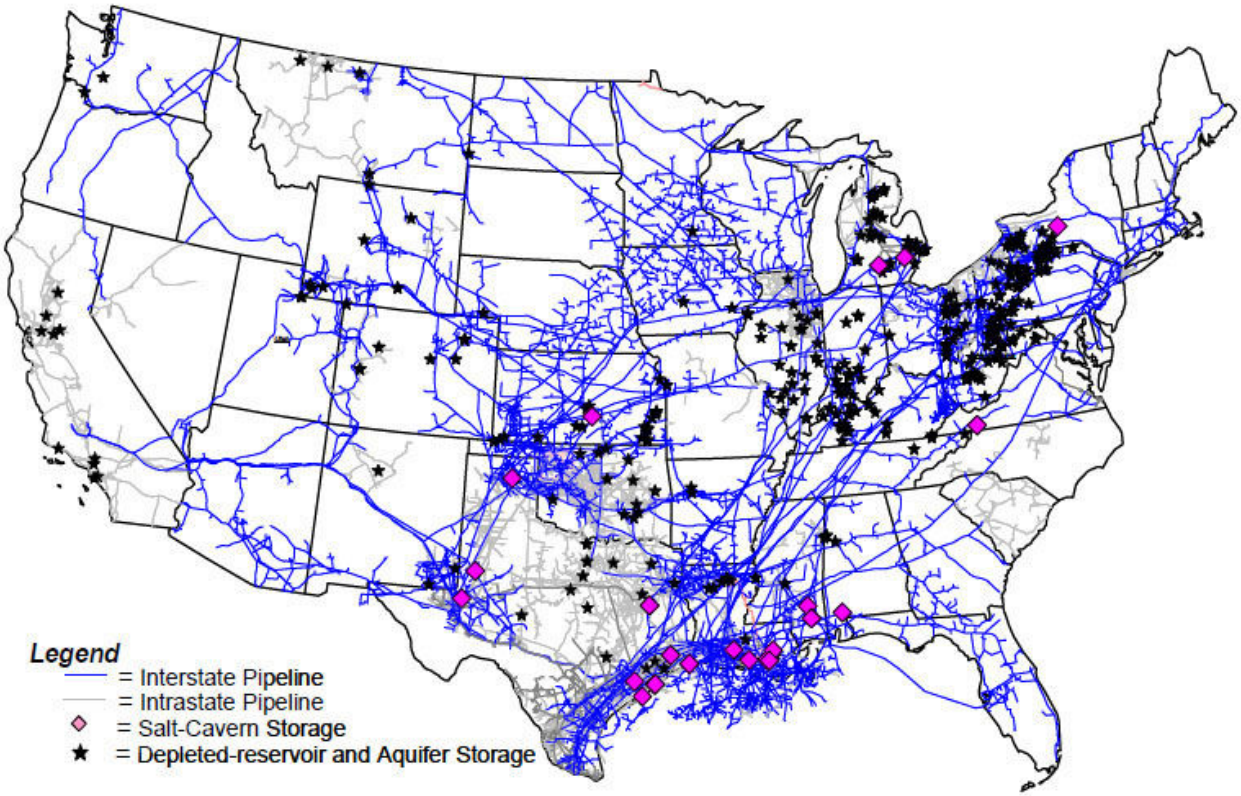
Gas operators must seek permit approval from PADEP for gathering lines to cross wetlands, streams, and other bodies of water, either by registering general permits or by seeking individual permits that require public notice (25 *Pa. Code* 105). They must seek approval from PennDOT to gain access to (67 *Pa. Code* 441) or for pipes to encroach upon (67 *Pa. Code* 459) or cross State road rights-of-way.

Some gathering lines are built close to homes. Landowners close to gathering lines have expressed concern for the unregulated construction practices that they observe. Independent contractors are hired who offer the lowest bids, and gathering line ownership may change repeatedly, along with the liability for accidental damage. It is not surprising that the thinnest available pipe is used, typically that produced in China, and no corrosion protection is required. It is not reassuring when the cut sections of pipe must be beveled in the field to accommodate fittings. Some leakage from gathering line joints is expected by PADEP, but substantial undetected leaks in fact may occur. Water testing of the pipes is not required prior to use, and gathering lines may rupture upon full pressurization. Properly calibrated monitoring devices known as “pigs” can detect leaks, but their use is not mandatory. Industry construction workers from out-of-state have expressed surprise at the absence of pipeline inspection in

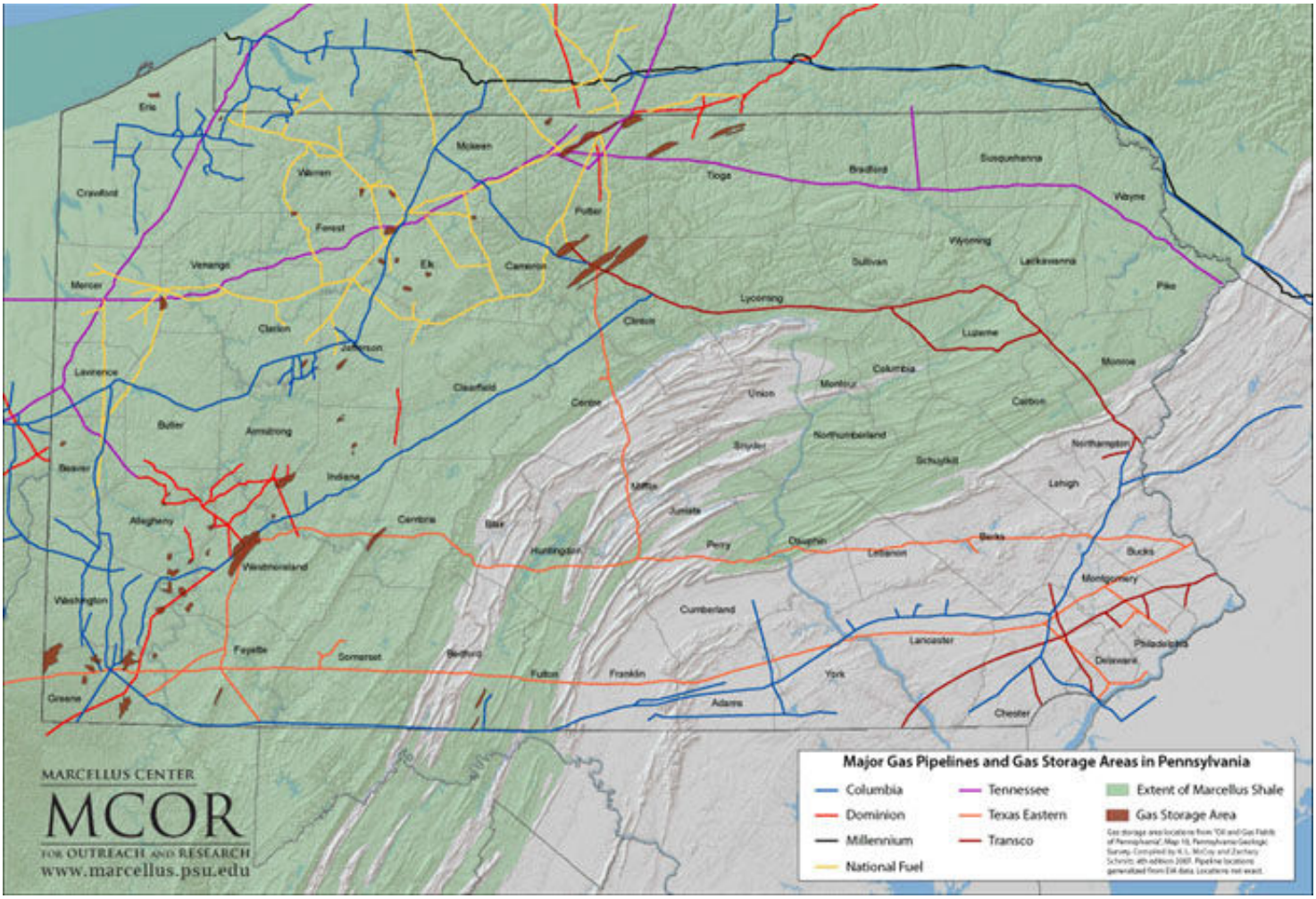
Pennsylvania. Inspections can slow construction, but also can reduce the likelihood of future explosions.

Transmission Lines. These are the relatively large lines that transmit gas at high pressure over long distances from the processing plants in the gas fields to and from underground storage reservoirs and to electric power generating plants, other large industrial users, or "city gates" for distribution to retail customers. Interstate lines and some intrastate transmission lines are federally regulated. Several of these major pipelines have transported gas from Texas, Louisiana, and Canada through Pennsylvania to markets along the eastern seaboard. Associated with these lines are large compressor stations needed to keep gas pressure high, as well as underground storage facilities. Most of these lines are involved in interstate commerce and receive some regulatory oversight from Federal agencies with respect to siting, maintenance, and decommissioning.

U.S. Underground Natural Gas Storage Facilities in Relationship to the National Natural Gas Transportation Grid, 2005



Note: EIA has determined that publication of this figure does not raise security concerns, based on the application of Federal Geographic Data Committee's Guidelines for Providing Appropriate Access to Geospatial Data in Response to Security Concerns.
Source: Energy Information Administration, GasTran Natural Gas Transportation Information System.


Major Gas Pipelines and Gas Storage Areas in Pennsylvania
Columbia
Dominion
Millennium
National Fuel
Tennessee
Texas Eastern
Transco
Extent of Marcellus Shale
Gas Storage Area
MARCELLUS CENTER
MCOR
FOR OUTREACH AND RESEARCH
www.marcellus.psu.edu

Interstate transmission lines were first regulated at the federal level by the Natural Gas Act of 1938, which addressed rate-setting, construction permits, and eminent domain. The Natural Gas Pipeline Safety Act of 1968 addressed safety requirements, which have been increased by several other laws up to the Pipeline Safety, Regulatory Certainty, and Jobs Creation Act of 2011 (http://www.gpo.gov/fdsys/pkg/PLAW-112publ90/pdf/PLAW-112publ90.pdf). Transmission lines range in diameter from 6 to 48 inches and in operating pressure from 200 to 1,500 psi. Since 1970 they have been required by FERC regulations to be constructed at minimum depths of 30" in rural areas, 36" in urban areas and along roads and railroads, and 48" beneath navigable waters. Older pipelines may persist at shallower depths. Floods during 2011 exposed transmission lines in Lycoming County.

Within many States the Federal regulatory authority is administered by State agencies, and Act 127 of 2011 empowered the PUC for the first time to take on some of that role in Pennsylvania. Approval of siting for a new interstate transmission line by the Federal Energy Regulatory Commission (FERC) grants eminent domain authority to the interstate pipeline company through a certificate of convenience and necessity. FERC regulates rates charged by interstate pipelines as public utilities. It also oversees decommissioning of transmission pipelines.

During the years of an interstate pipeline's service life, operational safety and maintenance of the pipeline plus any associated rights-of-way, facilities, and buildings used to treat and transport gas come under the purview of the Office of Pipeline Safety in the Pipeline and Hazard Materials Safety Administration (PHMSA) of the US Department of Transportation. For years this small agency has been criticized for insufficient budget and staff to regulate interstate pipeline safety. Transmission lines confined entirely within one State and not engaged in interstate commerce are not subject to Federal oversight.

In Lycoming County the major Transcontinental Pipeline of the Williams Company crosses east-west. Despite local opposition, the MARC-1 transmission pipeline link currently is being built from eastern Lycoming County into New York State. The recent increase in natural gas supplies in the eastern United States has drastically curtailed use of some interstate pipelines to convey gas from western sources, such as the Rockies Express pipeline from Colorado to Ohio.[5]

[5] http://www.platts.com/RSSFeedDetailedNews/RSSFeed/NaturalGas/6567960

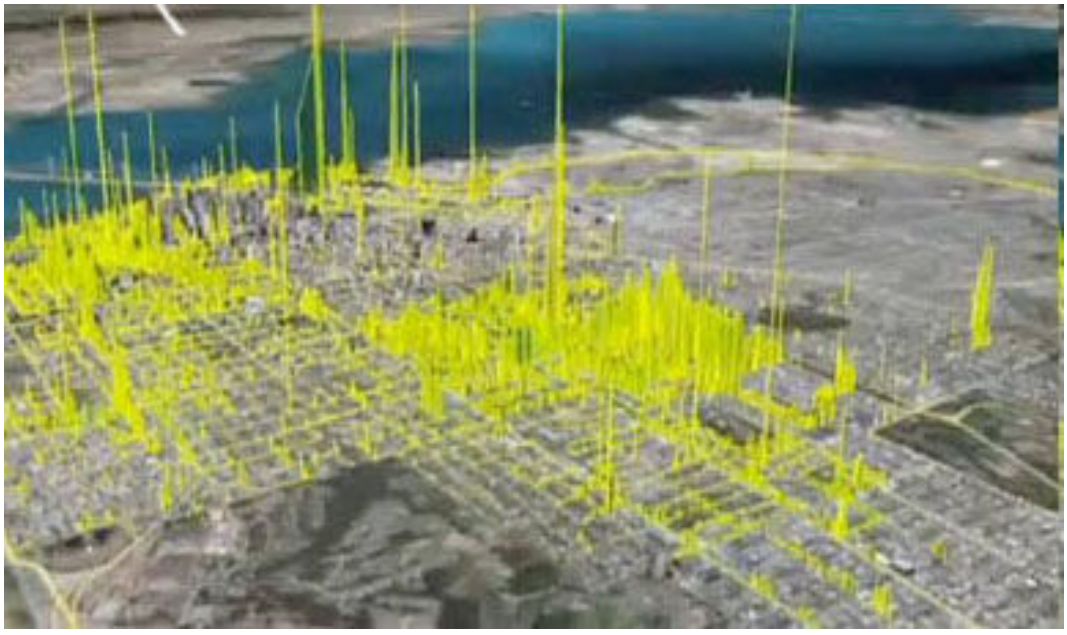
Distribution Lines. Distribution lines have various sizes and pressures that vary widely from place to place, according to their age and the preference of retail gas suppliers. Within any given area the size and pressure of distribution pipes also can vary, with regulator stations that control flows from one size or pressure pipe to another. Since 1970 distribution lines have been required to be buried at least 12" deep on private property and 18" deep along streets and roads. Older lines may be shallower.

Definitions of what is considered "low" and "high" pressure vary from State to State. In general, lines entering homes tend to have low pressure of approximately 0.4 psi (10-inch water column). Pressures from less than 5 up to 100 psi also are often considered intermediate, and many delivery systems operate within this range. Pressures above 100 psi can be considered high. Low pressure lines typically are small, but can reach 36 to 60 inches in diameter. Distribution lines in residential streets can be operated at several hundred psi, similar to major transmission pipelines.

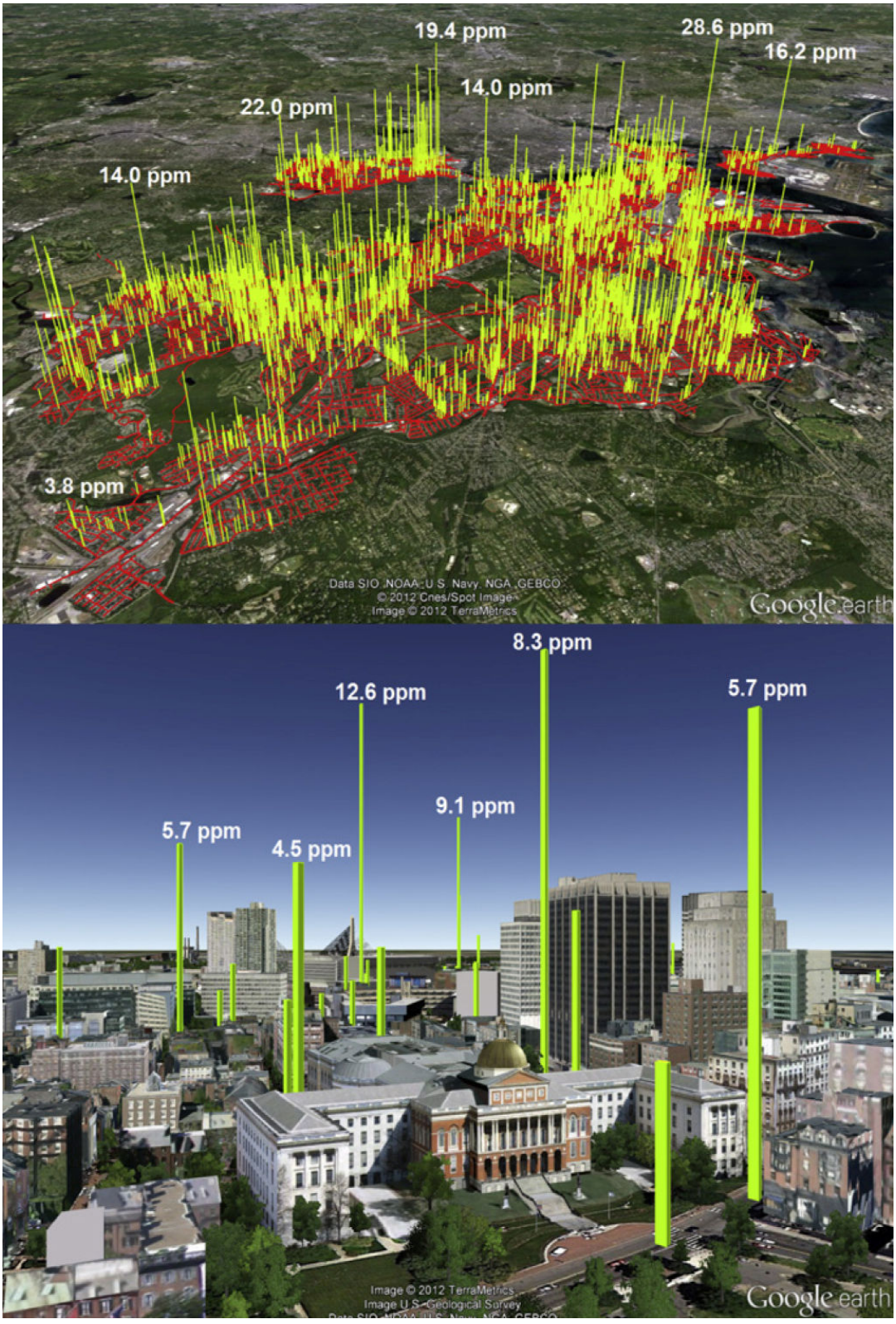
Distribution mains extend from the city gate at the terminus of a transmission pipeline where pressure is stepped down prior to the dispatch of gas into industrial, commercial, and residential neighborhoods and the characteristic "rotten egg" mercaptan odor is added. Some 47,000 miles of distribution pipelines in Pennsylvania are regulated by the Public Utility Commission (http://www.puc.state.pa.us/), which is charged with natural gas rate setting and limited review of physical structures. By law [*Pa. CSA* 66 §2205(a)(1)], utilities in Pennsylvania must maintain public safety, including the integrity of the gas distribution system at least in conformity with the standards established by the US Department of Transportation (49 *Code of Federal Regulations* 192 *et. seq.)* and by the industry (API RP 80).

In Annapolis, San Francisco, and Boston the location of natural gas distribution leaks has been mapped recently by measuring the concentrations of methane in the atmosphere by using sensors mounted in vehicles traveling public roads. The patterns of high ambient gas concentrations closely follow the pattern of distribution lines in the urban roadways. The results clearly show leaks that warrant attention by gas distributors. Consequences of such elevated methane concentrations in air for human health have been little studied.

Ambient gas concentrations in Annapolis, Maryland, 23 February 2012, as measured by R. Ackley (from http://gassafetyusa.com/blog/).



Ambient gas concentrations in San Francisco, California, as measured by Picarro, Inc. (http://www.loe.org/shows/segments.html?programID=12-P13-00002&segmentID=3)



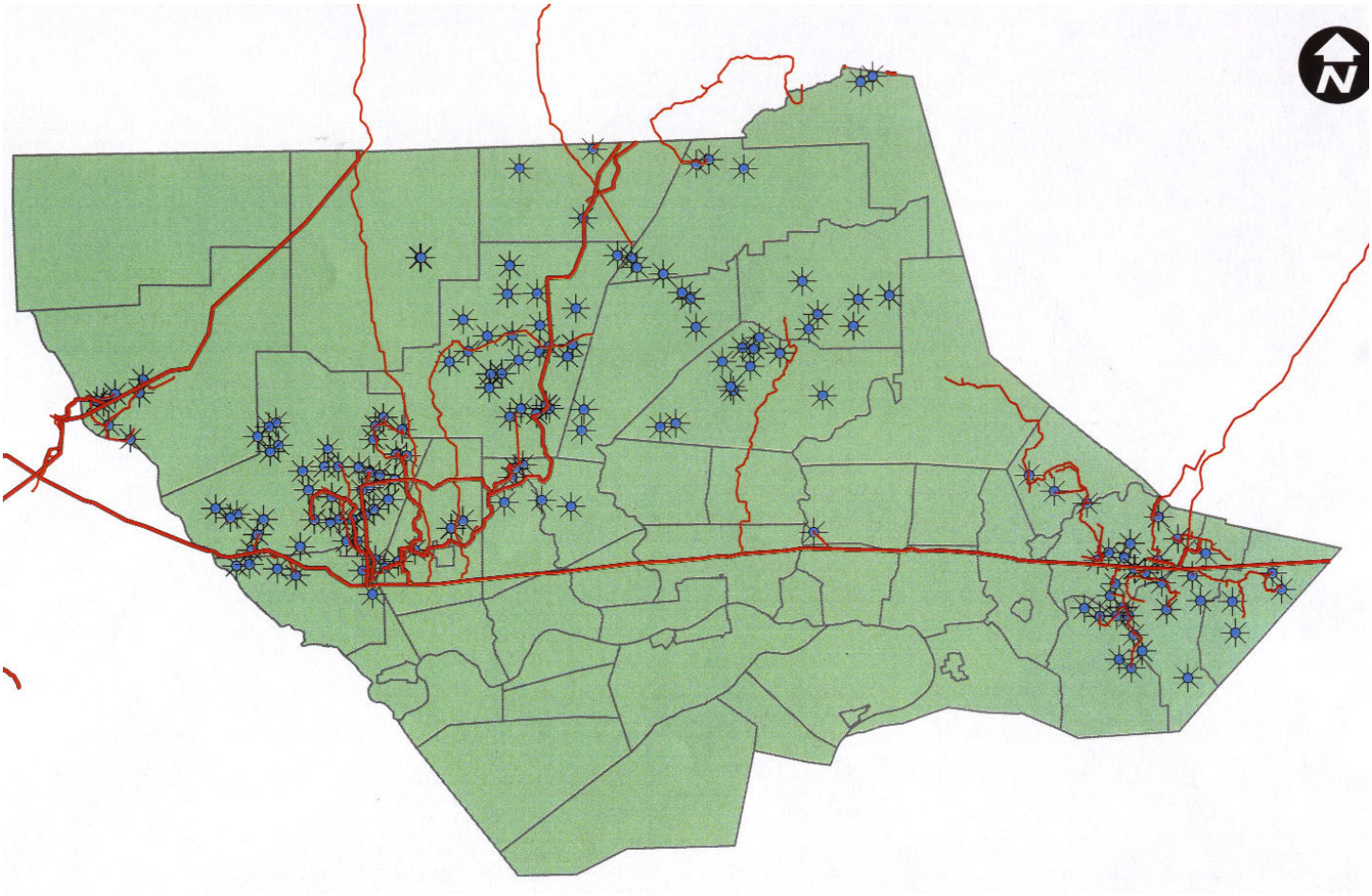
Methane concentrations in Boston MA during 2012 attributed to 3,356 pipeline leaks, as measured along 785 miles of roadways. Isotopic signatures ruled out landfills, sewers, and wetlands as potential sources (Phillips *et al*. 2013). Measured concentrations reached15 times background.

Typically the locations of distribution lines are regulated by municipal governments, and some municipal authorities market natural gas. The larger municipal distribution lines formerly were constructed of cast iron, a material that becomes brittle with age and presents risks of rupture and explosion, especially when the pipes are exposed by water eroding the supporting soils. Lives have been lost recently in Philadelphia and Allentown as a result of fires from deterioration of cast iron gas distribution pipes. Replacement is expensive and slow, and is not the responsibility of the gas production industry, but rather the private or municipal utilities. New and replacement distribution lines are equipped with automatic shutoff valves that detect changes in pressure and prevent buildup of gas in homes.

Distribution lines are operated by municipalities and by privately owned public utilities to distribute natural gas to the end users. Public utilities do not include producers of natural gas not engaged in distributing gas directly to the public for compensation (*Pa. CSA* 66 §102). The PUC oversees about 35 gas utilities in Pennsylvania. Utilities must prepare plans to deal with accidents as well as emergencies of gas shortage. They must maintain complete maps and plans of their pipelines and other facilities, but these are furnished to the PUC only upon request.

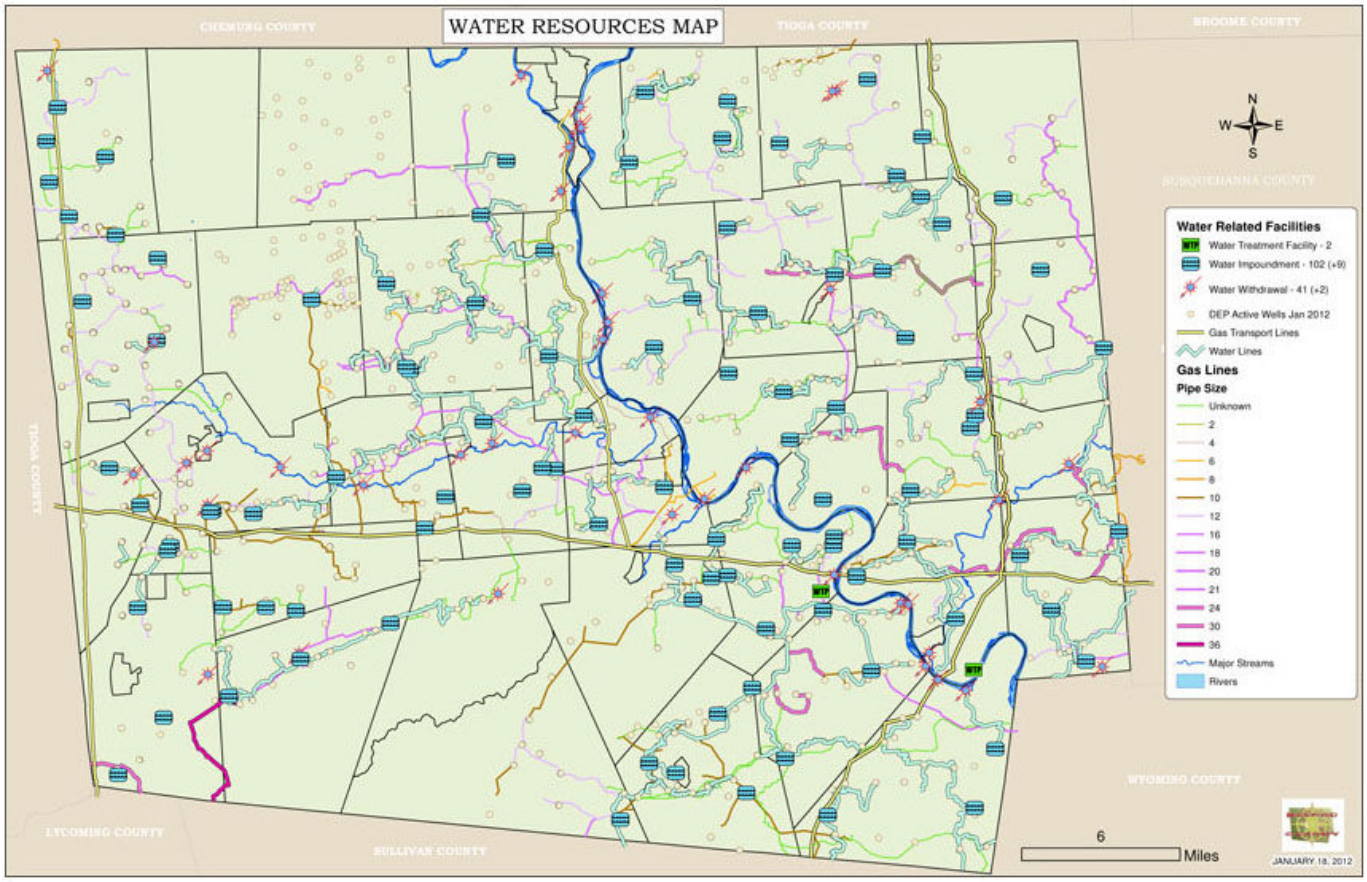
Where Are Pipelines in Lycoming County?

The Lycoming County Department of Planning & Community Development has been working to compile available information on the location of pipelines. There is no reliable procedure at present in Pennsylvania for disclosing such information to planning agencies or to the public, aside from federally regulated transmission lines for which examples were provided previously. As of April 2012 the County's admittedly incomplete inventory map shows the location of spudded wells, transmission lines, and gathering lines. As shown, the system of gathering lines does not extend to all the wells, and suggests the extent of new pipeline construction that can be anticipated in the near future. No maps of distribution lines are available.

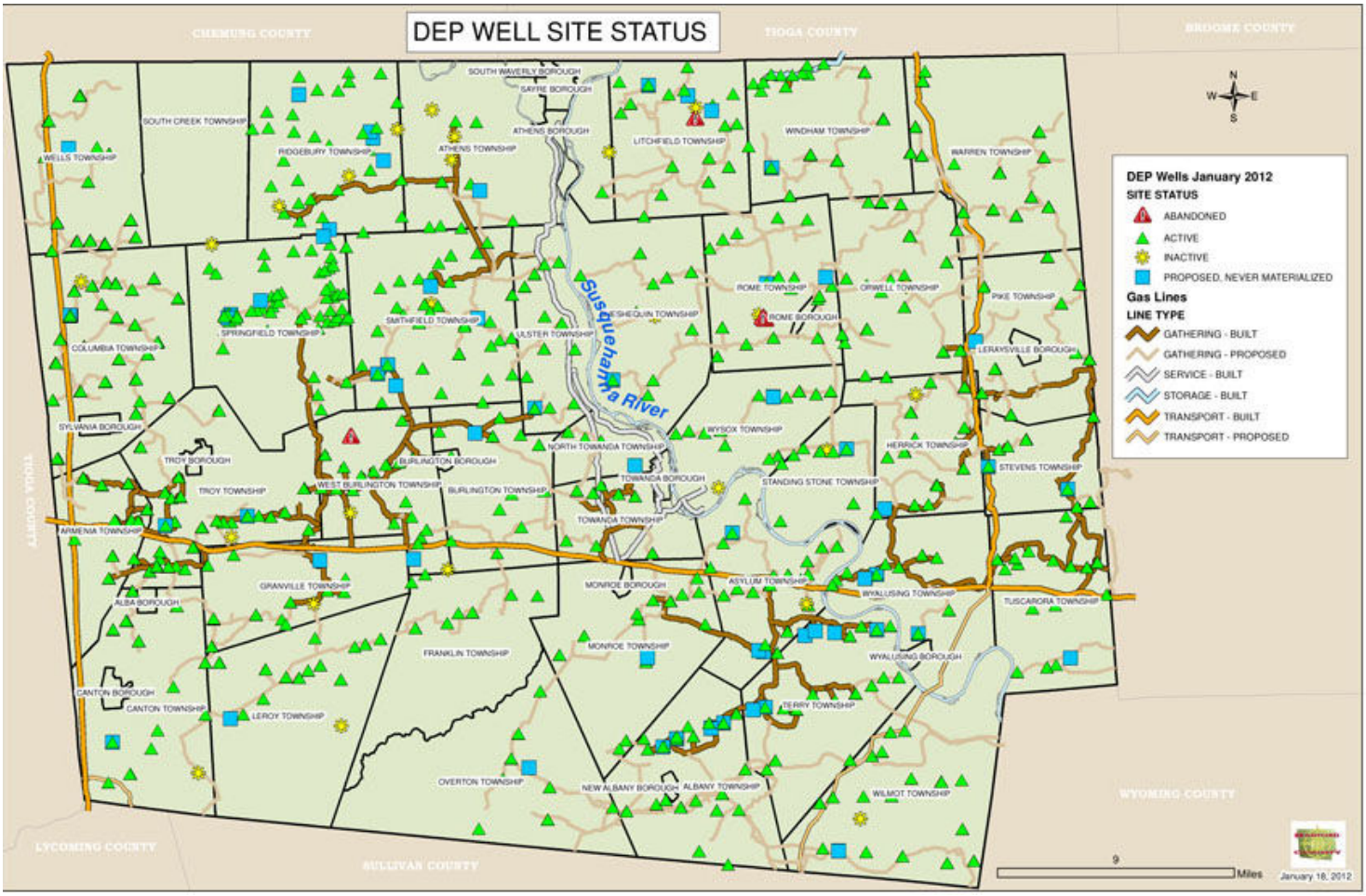


Drilled (spudded) gas wells, gas transmission lines (thick red) and gathering lines (thin red) in Lycoming County and its municipalities. Lycoming County Department of Planning & Community Development, April 2012.

Shale gas development in adjacent Bradford County has been more intensive than in Lycoming County. Bradford County planners have compiled maps showing gas-related water resources as well as fracking water pipelines, gas gathering, and transmission pipelines (no distribution lines are shown). Gas drilling has declined precipitously in Bradford County during 2012 with the declining gas prices caused by the glut of shale gas, warm winter, and weak economy. Over time the pattern of gas wells in Lycoming County can be expected to resemble that in Bradford County, where current production is about six times that in Lycoming County.



Blue rectangles (above) are frackwater reservoirs in neighboring Bradford County, Pennsylvania, January 2012 (Bradford County Planning Commission).



Gas wells and pipelines, built and proposed, in Bradford County, January 2012 (Bradford County Planning Commission).

Pipeline Safety

Two key determinants of the risks a pipeline poses to public safety are the pipeline's location and enforcement of the safety regulations governing its design, construction, operation, and maintenance. Small pipelines remote from people and operated under low pressure pose less of a threat than large pipelines under high pressure in densely populated areas and have generally been ignored at the federal and state level.

The slightly increased setback requirements between gas wells and buildings included in Act 13 of 2012 may preclude construction of gas wells in the more densely developed sections of Lycoming County, at least in the absence of waivers granted by surface landowners. Where there are no well pads, there will be little need for gathering lines. Production pipes, of course, can extend underground for miles from well pads beneath developed areas, and their rights-of-way usually are kept clear of trees.

Siting Pipelines. The procedure for siting pipelines varies dramatically among pipeline types. Only interstate and some intrastate transmission lines and all distribution lines are subject to any systematic examination of siting in Pennsylvania.

When the need for gas pipelines arises, companies propose routes. In the case of frackwater lines, well pads, intrastate pipelines, distribution lines, and gathering lines, the pipeline company basically decides where it wants to put the pipeline. The company then seeks necessary permits from Department of Environmental Protection (PADEP) and PennDOT for regulated segments and the local zoning, road, and floodplain approvals as it seeks to obtain easements and rights of way. Then it constructs the line using numerous contractors. Local jurisdictions typically become involved in a variety of matters, including emergency response in the event of accidents, after a pipeline is built, with minimal input into its siting.

In general, the federal government can only determine the siting of interstate gas transmission pipelines. It has no authority over the siting of frackwater lines or most intrastate gas pipelines, regardless of whether they are production, gathering, transmission, or distribution lines. Those intending to construct pipelines and the associated facilities for use in the interstate transportation of gas must apply to the Federal Energy Regulatory Commission (FERC) for a certificate of public necessity and convenience for siting of pipelines. That federal approval grants the power of eminent domain, by which the company can acquire land for the pipeline right-of-way whether its owner is willing to sell or not. The vast majority of new gas pipelines being proposed for Lycoming County are not interstate pipelines, so no federal agency is involved in their siting. For intrastate gathering lines, there is no state oversight, either, although the Public Utility Commission is beginning to collect information on gathering line locations, sizes, and pressures.

As remarkable as it may seem, neither federal nor state pipeline safety regulations address the issue of safely siting pipelines. Part of the reason for this disconnect is that pipeline siting is not under the jurisdiction of the agencies chartered to administer and enforce pipeline safety regulations. FERC's primary mission is to provide low-cost energy. PHMSA's primary mission is pipeline safety. The PUC in Pennsylvania has primary responsibility for energy cost regulation and only partial responsibility for the safety of some types of pipelines.

Pipelines can either leak or rupture, and these two very different types of failure should be considered when choosing routes for pipelines, although neither FERC not the PUC does this effectively at present. Because of the many tons of resulting gas released and considerably larger potential impact zones associated with ruptures, special care should be exercised in the placement of large diameter, high pressure gas pipelines. For gas pipelines capable of rupture, High Consequence Areas (HCAs) where large groups of unsheltered individuals may gather, or structures that cannot be easily evacuated, such as schools, hospitals and facilities that house the elderly, should be avoided. For pipelines that can rupture, distancing and site-specific screening, such as the placement of trees, concrete structures, and parking lots, can also play an important role in prudent pipeline placement. These screening techniques can buy some survival time by helping to block people

from the initial heat flux or by creating more distance between people and a potential rupture.

The proximity of pipelines to structures where gas can leak, collect, and build up, especially if the pipelines are not odorized to aid leak detection, is critically important. Leaking gas that builds up in a structure can result in very destructive forces upon ignition and detonation. That is why for gas distribution pipelines that cannot avoid proximity to structures, odorization of the gas as an early warning of leaks is mandatory in urban areas. Because transmission and gathering pipelines can also leak, odorant injection is required for these facilities in certain high population areas to assist in leak detection, but there are many exclusions even in such areas. As a result, most transmission and gathering pipeline miles do not transport odorized gas.

In a related siting issue, it is not uncommon for multiple pipelines to share a common right-of way. In shared pipeline rights-of-way it is incumbent on all those involved that pipeline construction, operations, maintenance, and emergency activities be communicated amongst all pipeline operators in the right-of-way. Pennsylvania currently provides pipeline operators with little incentive to build and share common pipeline infrastructure. With each company building its own systems the risk is multiplied, with little apparent thought as to how to minimize pipelines and their landscape impacts through shared facilities.

Regulating Pipeline Safety. The following paragraphs introduce the regulation of pipeline safety. In Pennsylvania regulators are involved at the Federal, State, and local level.

Federal Powers. The Federal Energy Regulatory Commission (FERC) oversees the siting of interstate pipelines. Its actions are subject to some degree of public disclosure and comment as a result of the National Environmental Policy Act (NEPA, P.L. 91-190 of 1969, as amended). New FERC pipelines are well publicized, but state and local governments have no authority to control the location or construction of such facilities beyond commenting on permit applications in the context of the formal FERC review process.

Companies wishing to expand existing interstate pipelines or construct new ones send their plans to the Federal Energy Regulatory Commission (FERC). Under Section 7 of the Natural Gas Act, 15 *U.S.Code* § 717f (c), this commission has the power to issue a "certificate of public necessity and convenience" for the construction and operation of interstate natural gas pipelines. This independent agency approves both the siting and abandonment of interstate natural gas pipelines, as well as fuel storage and liquefied natural gas facilities and pipelines. FERC also oversees environmental matters related to natural gas projects. Sample documents and guides for citizens are located on the FERC website.[6]

[6] http://www.ferc.gov/for-citizens/citizen-guides.asp

Siting carries important implications for safety, inasmuch as pipeline accidents are often caused by damage from third parties such as excavators or construction workers. Therefore, FERC has recently asked the Office of Pipeline Safety[7] (OPS), an agency that administers the Pipeline and Hazardous Material Safety Administration (PHMSA) regulatory program, to help in evaluating the location of proposed pipelines.

The FERC process begins with a pipeline company submittal of a pre-filing application to FERC. Notification to landowners, state or local agencies and other stakeholders is not legally required and therefore not made. The industry applicant, not FERC, identifies the stakeholders. The company then gives notice to state and county agencies as well as all "affected" landowners. Such notification consists of publication in the *Federal Register* and the local newspaper as well as good faith efforts to deliver necessary information by hand or mail to landowners. These include those whose land will be used by the "proposed activity," those whose land abuts the pipeline, and those within 50 feet of any proposed construction work area. If a landowner, county, and/or township fails to submit a motion to intervene by the assigned date, that potential intervenor loses the right to have FERC consider its comments, to get copies of filings, and to appeal decisions.

The company holds an "open house" to discuss the project at which time all landowners, even those in general proximity to alternate routes, should intervene. Pipeline plans change, and alternate routes can become reality. Once a certificate is issued, the pipeline companies can purchase needed land or, most often, exercise the power of eminent domain. Intervenors have the right to appeal FERC actions. A useful guide, *Knowing and Protecting Your Rights When an Interstate Gas Pipeline Comes to Your Community,*[8] was prepared to help local governments and citizens understand the process by which a "certificate of public necessity and convenience" is issued.

Some residents of Chester County, Pennsylvania, known as the "Brandywine Five", were involved in the FERC process regarding the expansion of a major interstate pipeline. The pipeline company, Transcontinental Gas Pipeline Company, LLC, was unsuccessful in securing essential permits from PADEP pursuant to 42 *U.S.Code* § 4654(a)(2), the easement was not obtained, and court costs were awarded to the residents.[9] Williams-Transco currently (mid 2012) is again seeking approval for open-cut surface crossing of Brandywine Creek and other streams, rather than drilling below the waterway and steep slopes in this densely populated area, and has encountered continued local opposition. With greater public awareness of the confluence of pipeline siting and safety, public participation such as this may aide in creating safer communities.

---

[7] http://phmsa.dot.gov/pipeline

[8] http://www.scribd.com/doc/33801163/Knowing-and-Protecting-Your-Rights-When-an-Interstate-Gas-Pipeline-Comes-to-Your-Community

[9] http://law.psu.edu/_file/aglaw/Natural_Gas/TranscontinentalGas_v_PermanentEasement_Aug_19_2010.pdf

The U.S. Department of Transportation, through its Office of Pipeline Safety (OPS) establishes the minimum safety standards for the interstate and intrastate transportation of gas by pipelines, as well as for the "pipeline facilities" used in these activities. The term "pipeline facilities" includes pipelines, rights-of-way, buildings, and equipment used in transporting gas or treating gas during its transportation. OPS can pay up to 80% of a state's costs in administering pipeline safety measures.

Congress mandated that OPS adopt safety standards, which appear at 49 *Code of Federal Regulations* 192 *et seq*. (http://phmsa.dot.gov/pipeline/regs). Among the issues which standards must address are operator qualifications, facility information and documents (for example, emergency response plans and mapping), and periodic pipeline inspections. Other mandated standards include those addressing risk analyses and integrity management programs for pipeline facilities (other than distribution pipelines) in high-density population areas, as well as a separate integrity management program for distribution pipelines.

The mandates vary depending on whether a gas pipeline is used for production, gathering, transmission, or distribution. Congress also gave PHMSA authority to adopt other safety standards on its own. This discretionary authority is broad and covers the entire range of the public safety risk areas—except for siting—related to interstate pipeline facilities and transportation: design, installation, inspection, emergency plans and procedures, testing, construction, operation, replacement, and maintenance. PHMSA does not regulate most pipelines in Class 1 rural areas, which are defined below in the subsequent section on federally regulated pipeline classification.

Regulatory Loopholes for Production and Gathering Pipelines. Federal pipeline safety regulations more or less define where unregulated production pipelines stop and where regulated gathering lines start. While many production and gathering pipelines are smaller than transmission pipelines, there are currently some in Lycoming County as large as 24 inches in diameter with maximum allowable operating pressures similar to transmission pipelines. Unlike the sometimes larger interstate pipelines and usually smaller distribution pipelines, gathering lines in Class 1 areas are not regulated for safety in Pennsylvania. Historically this regulatory gap was of less significance than at present, because gas was gathered from conventional wells through small pipes of 6 to 8 inch diameter under relatively low pressure.

Today additional scrutiny is warranted, given the capability of pipelines of much greater size and pressure to release many tons of gas upon rupture. Currently these pipelines also are exempt from federal Integrity Management rules that require some form of interstate pipeline quality inspection at a minimum of once every seven years, and clearly define how and when problems found during these inspections are reported and repaired.

State Powers – Gas Distribution Lines. Pennsylvania law directs the Public Utilities Commission to attend to safety considerations for gas distribution lines (P.L. 1578 of 2004 §308.2, http://www.legis.state.pa.us/WU01/LI/LI/CT/HTM/66/66.HTM). PHMSA OPS has certified PUC to inspect intrastate pipelines in Pennsylvania, primarily about 47,000 miles of distribution pipelines. Gas distribution lines are

largely confined to road rights-of-way, and gain some municipal oversight during land development review involving new distribution lines. No maps of distribution lines are publicly available, and reliance to locate them must be placed on operators via the One Call system when excavation is planned.

Through certification by OPS, Pennsylvania regulates and inspects certain intrastate gas pipeline operators in the Commonwealth. According to testimony provided by PUC Commissioner Chair Robert Powelson, the PUC does not have jurisdiction over the safety of all gathering and intrastate transmission lines in the Commonwealth. The PUC only inspects certain pipelines under USDOT's program that is administered by PHMSA. The federal government pays PUC to assume inspection and enforcement responsibility for the intrastate pipelines it has jurisdiction over based on Pennsylvania law[10]. Through legislative authority, the Gas Safety Division of the Bureau of Transportation and Safety within the Public Utility Commission conducts this work. The Public Utility Commission of Pennsylvania (PUC) is an independent agency funded through federal allocations and assessments on utility companies under their jurisdiction.[11] Its role is to balance the needs of consumers and utilities to ensure safe and reliable service at reasonable rates; protect the public interest; educate consumers to make independent and informed choices; further economic development; and foster new technologies and competitive markets in an environmentally sound manner.[12]

The PUC, as an agent of USDOT's Office of Pipeline Safety, enforces federal safety standards and may prescribe additional, non-conflicting ones. By Pennsylvania law, PUC requirements can be no more stringent than federal requirements. The areas of standards include the design, installation, operation, inspection, testing, construction, extension, replacement, and maintenance of the pipeline facilities. Testifying before the Consumer Affairs Committee of the Pennsylvania House of Representatives on March 8, 2011, PUC Commissioner Chair Robert Powelson noted, "Currently, there are approximately 11,000 miles of cast iron, steel, and even a small portion of wooden natural gas pipes in Pennsylvania that have reached or are reaching the end of their useful lives."[13] Further, Mr. Powelson noted that the process of recouping costs for making upgrades to the pipeline infrastructure is insufficient and results in delays. He suggested that the General Assembly adopt a funding system to encourage infrastructure replacement similar to the Distribution System Improvement Charge (DSIC) adopted in 1997 for water companies. With such a system, the costs are passed on to consumers through automatic adjustment fees assessed with quarterly surcharges.[14]

Some of these recommendations were adopted in the recent Gas and Hazardous Liquids Pipelines Act (Act 127 of 2011). For the first time the PUC is to record in its registry the mileage and location of rural gathering pipelines in Class 1 areas that serve

[10] http://wallaby.telicon.com/pa/library/2011/20110308tz.pdf
[11] http://www.puc.state.pa.us/general/pdf/Exec_Budget_Request2010-11.pdf
[12] http://www.puc.state.pa.us/
[13] http://wallaby.telicon.com/pa/library/2011/20110308tz.pdf
[14] http://wallaby.telicon.com/pa/library/2011/20110308tz.pdf

unconventional shale gas wells, although it was allocated no regulatory authority over such lines. The new PUC authority otherwise extends only to federally regulated pipelines. PUC regulations can be no more stringent than the minimum federal standards for pipelines.

The PUC is also responsible to investigate all methods or practices of pipeline companies, including reports and records. Investigators can examine property, buildings, plants, and offices as well as books, records, mail, e-mail, and other relevant documents, as needed to enforce the PUC rules and regulations.

If a violation is found, the Gas Safety Division issues a written report delineating the results of the on-sight evaluating and the specific regulations in apparent violation. The utility has 30 days in which to respond. Generally, the Gas Safety Division and the utility work together to agree on how to resolve the violation. If they cannot agree, the matter is referred to the PUC, which then resolves the issue more formally by issuing a complaint, setting a penalty, or seeking enforcement through the courts.

PADEP provides oversight of erosion and sedimentation control for gas-related development including pipelines. Before pipelines of any type are constructed, the company must complete paperwork for approval of an Erosion and Sediment Control and Stormwater Management for Oil and Gas Exploration, Production, Processing, Treatment Operations or Transmission Facilities General Permit (ESCGP-1). A plan is needed to show how land and water resources are to be protected against accelerated erosion through the use of Best Management Practices (BMPs). A PADEP fact sheet[15] outlines the process for complying with 25 *Pa. Code* Chapter 102. In addition to permitting, PADEP is also responsible for the administration and enforcement of the Clean Streams Law (35 P.S. § 691.9 *et seq.*), primarily for construction in waters and wetlands in accordance with 25 *Pa. Code* Chapter 105. In cases where construction involves a Special Protection Watershed, additional safeguards are to be established as set forth in DEP's Water Quality Antidegradation Implementation Guidance.[16] When a Corps of Engineers permit also is needed pursuant to the federal Clean Water Act (CWA), it cannot be issued prior to PADEP approval of the anticipated impacts on water quality via CWA Section 401 (http://water.epa.gov/lawsregs/guidance/wetlands/sec401.cfm).

National Pollutant Discharge Elimination System (NPDES) permits regulate discharges to protect public health and aquatic life and to assure that every facility treats wastewater. These are required by the federal Clean Water Act and the Pennsylvania Clean Streams law (http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-52060/Act%20394%20of%201937.pdf). They set pollution limits for dischargers and specify monitoring and reporting requirements.[17] For gas pipelines water pollution is to be confined to stormwater erosion and sediment associated with construction, rather than involving discharges. Loss of contents from gas-related pipelines into streams is

[15] http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-72023/5500-FS-DEP4216.pdf
[16] http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-47704/391-0300-002.pdf
[17] http://www.dep.state.pa.us/dep/deputate/waterops/redesign/Subpages/npdes.htm

not supposed to occur, but when it does, it generally constitutes pollution damaging to water quality and aquatic biota. The high conductivity associated with spills of produced water (brine) can persist for long periods.

Role of Local Government. Land use planning is generally a function of local government, which in Pennsylvania is empowered to enact ordinances regulating the zoning of land uses and the process for seeking approval prior to constructing new land developments (Pa. Municipal Land Use Code, Act of 1968, P.L. 805, No. 247, as amended). Municipal powers to regulate zoning and land development of oil and gas activities were reduced by Act 13 of 2012 amendments to the Oil and Gas Act, and authority to approve municipal requirements for oil and gas activities was assigned to the Public Utility Commission. No implementing regulations have yet appeared. Several provisions of this law affecting municipalities were overturned by Commonwealth Court as unconstitutional, and no overturn of municipal laws can proceed unless and until the Pennsylvania Supreme Court adopts the State's position on appeal.

Except by regulating siting of new pipelines, land use controls offer no protection to existing landowners. Land planning near pipelines, once constructed, should have at least three major goals:

1. Ensure communication between builders/developers/excavators and pipeline operators so everyone knows what pipelines new land uses are being planned near.

2. Put in place practices that protect pipelines from construction damage.

3. Put in place more protective planning and building codes to protect people who come to live near pipelines long after their construction.

The Municipal Research and Services Center has developed an entire website that covers these "planning near pipelines" issues. It can be found at: http://www.mrsc.org/Subjects/PubSafe/transpipes.aspx Sample ordinances are provided by the Pipeline Safety Trust at: http://www.pstrust.org/pipeinfo/localgov.htm

If Act 13 of 2012 is upheld, Pennsylvania municipalities will lack most regulatory authority for siting and safety of gas facilities, yet local governments still have to respond to pipeline emergencies. Some gas operators voluntarily adopt standard design and construction practices for regulated pipelines even where not required. They are solely responsible for maintaining unregulated lines against deterioration resulting from construction defects, corrosion, or damage. Given their legal liability for pipeline failures, it is in the operators' best interest to undertake sound construction and adequate maintenance. But long-term operators may have no input into pipeline construction.

Residents often go to local government agencies to seek answers about pipeline issues. Pipeline safety often depends on local zoning and land use decisions affecting the land along each pipeline. Over time, some rural lands that were Class 1 when

pipelines were built now have developed into areas where high consequences would result in the event of pipeline failure. (See Pipeline Classification table below.)

Because of lack of knowledge regarding pipeline locations, there is risk that schools and hospitals can be built adjacent to petroleum pipelines with potential for serious damage---greater risk than attaches to other pipeline utilities such as public water and sewer lines which usually remain out of sight and out of mind. Development can also infringe on rights-of-way directly, although pipeline companies typically object to encroachments that can be seen aboveground.

In Pennsylvania local governments theoretically retain regulatory approval authority over pipeline, storage reservoirs, and other gas-related construction activities in floodplains. Requests for floodplain encroachments are subject to county conservation district review for erosion and sediment control. Conservation districts also review interstate pipelines. They generally do not review gas well pads, access roads, or gathering pipelines. Absent the power to keep pipelines away from people, Pennsylvania municipalities must focus on keeping people away from pipelines as the years go by.

To help local governments protect both citizens and pipelines, the Pipeline Safety Trust has useful strategies and suggestions on their website.[18] Further, the Pipelines and Informed Planning Alliance (PIPA) has issued a list of recommended practices and published a report entitled *Partnering to Further Enhance Pipeline Safety In Communities Through Risk-Informed Land Use Planning: Final Report of Recommended Practices.*[19]

Rights-of Way. Because of the unique conditions of each site and the variability of pipeline requirements, right-of-way (ROW) agreements vary from location to location. To protect the public, the line itself, and other customers from loss of service, the pipeline company is responsible for maintaining a ROW that usually ranges from 25 to 100 feet wide. A ROW agreement is important because it enables workers to gain access for inspection, maintenance, testing or emergencies; authorizes maintenance of an unobstructed view for frequent aerial surveillance; and identifies an area that restricts certain activities to protect the landowner, the community through which the pipeline passes, and the pipeline itself.[20]

In examining environmental concerns related to pipeline siting in the Delaware River Watershed, Aaron M. Lien and William J. Manner suggest that gas operators collocate and simultaneously install their infrastructure. In this way, land can be minimally disrupted as water lines, gas pipelines, and/or other conduits are placed in the same right-of-way simultaneously and then covered with a roadbed.[21] But there are no such requirements in Pennsylvania. To reduce forest fragmentation,

---

[18] http://www.pstrust.org/pipeinfo/localgov.htm
[19] http://primis.phmsa.dot.gov/comm/pipa/landuseplanning.htm
[20] http://www.pipeline101.com/PipelinesYou/landowner.html
[21] www.pinchot.org/gp/Marcellus_Shale

ROW agreements can specify that a tree canopy remain intact to the maximum practicable extent. In this way, invasive species are less likely to move into open pathways that are needed for safety inspections by plane or helicopter. Inspectors walking on foot also can monitor pipeline status. Unless landowners insist, however, ROW agreements typically allow tree regrowth to be prevented.

The importance of proper siting within a right-of-way was underscored by an article in the 6 February 2011 *Dallas Post.* According to the local paper, residents of Dallas Township, Pennsylvania, filled the supervisors' meeting to voice concerns and seek answers about a planned natural gas compressor station 1,345 feet from one of the Dallas public schools.[22] The dramatic decline in land values from nearby gas production and transport activities is only slowly becoming appreciated by landowners in Pennsylvania as insurers and mortgage lenders seek to avoid risks of damage.

Regulatory Recommendations

• Looking forward, municipalities in Pennsylvania should focus on requiring disclosure of gathering pipelines, making permanent records of their location, and enacting setback ordinances providing minimum distances between new land improvements and all gas pipelines, based on the size and operating pressure of each pipeline. Primary reliance at the state level in Pennsylvania for protection from gas development activities has been placed on small setback requirements from wells and other activities (per Act 13 of 2012). Thus it would be prudent for municipal governments to prevent the construction of new development within the immediate hazard zone of all gas pipelines by implementing and strictly enforcing setbacks when development is proposed after pipeline construction. The construction of transmission pipelines and high-pressure gathering pipelines is rendering extensive strips of land unsuitable for residential, commercial, or public uses in the future. Municipalities have been slow to recognize and respond to this fact.

• The federal Office of Pipeline Safety should implement rulemaking to clarify the point where onshore regulated gas gathering lines begin (49 *CFR* Part 192.8). That point should be defined to ensure there are no unregulated gas pipelines from well pads in Class 2, 3, or 4 areas, or other "identified sites" where large groups may gather. In Pennsylvania it would make a major difference if PHMSA were to regulate also those pipelines in Class 1 (rural) areas, at least for lines of large diameter and high pressure.

• The federal Office of Pipeline Safety should implement rulemaking to include all Type A gathering lines (49 *CFR* Part 192.9) under the full requirements of the Integrity Management program (49 *CFR* Part 192 Subpart O) that currently only applies to transmission pipelines.

[22] http://www.timesleader.com/TheDallasPost/news/Proposed_natural_gas_compressor_station_is_all_the_buzz_02-06-2011.html

Pipeline Safety Design and Construction

The construction phase of pipeline installation is a critically important time to ensure the long-term integrity of a pipeline. Below are discussed the principal issues that arise during the construction phase that affect pipeline safety. These various safety precautions pertain mainly to gas transmission lines and the very few regulated gathering pipelines. Most gathering and production lines are not required to follow these standards, although good construction practices reduce risk.

Federally Regulated Pipeline Classification. For purposes of safety relative to the number of people in close proximity of a pipeline, pipelines are divided into four classes. Per 49 *CFR* 192 natural gas pipelines are classified prior to construction and periodically reclassified based on changes in population and land use. According to Karen Gentile, CATS/General Engineer of the OPS Eastern Region Office in West Trenton, classes are based on land uses extending 220 yards in each direction from the middle of the pipeline in any continuous one mile length.[23] Each building is considered to be a "dwelling unit" and apartment houses, multi-family homes, and the like are considered to be multiple buildings.[24]

The pipelines class determines design criteria for pipelines that must have sufficient wall thickness and composition to withstand anticipated pressure and loads. The higher the area class, the thicker the wall of the pipes and the stronger the pipeline material must be. Because areas frequently undergo development over time, some companies "over build" to meet specifications of locations in higher classes. In this way companies can anticipate growth and prevent additional costs related to upgrading the infrastructure at a later date. The American Petroleum Institute (API)[25] issues pipeline standards. This trade group, representing more than 400 corporations in the oil and gas industry, is also involved in advocacy, education, certification, research and statistics.[26]

FEDERAL PIPELINE CLASSIFICATION

Class Locations	Description
One	Offshore or has 10 or fewer buildings* (dwelling places) intended for human occupancy.
Two	Has greater than 10 but less than 46 buildings* intended for human occupancy.
Three	Has greater than 46 buildings* or is within 100

[23] Telephone conversation of March 17, 2010 between Roberta Winters and Karen Gentile with follow-up e-mail communication on 3/18/11 regarding OPS jurisdiction and related questions.

[24] http://edocket.access.gpo.gov/cfr_2004/octqtr/pdf/49cfr192.5.pdf

[25] http://www.api.org/Standards/

[26] http://www.api.org/aboutapi/

	yards of an area occupied by 20 or more persons on at least 5 days per week for 10 weeks in any 12 month period.
Four	Has buildings of four or more stories above ground

*within 220 yards per mile of pipeline

According to Ms. Gentile, PHSMA regulates onshore gas gathering lines in Class 2, 3, and 4 locations.[27] However, PHMSA does not extend its regulatory authority to gathering lines in Class 1 locations that are remote and sparsely populated. (These areas are the potential locations of thousands of new wells planned to extract natural gas from Marcellus Shale in Pennsylvania.) Further, the class location of pipelines also impacts their odorization. For example, pipelines with combustible gases only in Class 3 and 4 locations need to be odorized.[28]

Choosing Pipe. Pipe sections are fabricated in steel rolling mills and inspected to assure they meet government and industry safety standards. Generally between 40 and 80 feet in length, they are designed specifically for their intended location in the pipeline. A variety of soil conditions and geographic or population characteristics of the route will dictate different requirements for pipe size, strength, wall thickness and coating material. Not all pipe is steel. Some low pressure gathering, transmission, and distribution pipelines use other materials such as other metals, or nonmetallic material, such as plastic or composites. Pennsylvania lawmakers have shown more concern that gas industry pipes be constructed of Pennsylvania steel than that they meet minimum construction standards for public safety.

Pipe Burial. Mechanical wheel trenchers and backhoes are used to dig the pipe trench for pipelines installed underground. Occasionally, rock drilling and blasting are required to break rock in a controlled manner. The material that is excavated during trenching operations is temporarily stockpiled on the non-working side of the trench. This material is used again in the backfill operation. In some locations, such as river crossings, horizontal directional drilling (HDD) and boring techniques are used to place pipe underground without the need of trenching.

[27] Telephone conversation as cited on March 17, 2010 in reference to 49 *CFR* 192.5

[28] http://edocket access.gpo.gov/cfr_2010/octqtr/pdf/49cfr192.629.pdf

Trenches must be dug deep enough to allow for an adequate amount of cover when the pipe is buried. Federal regulations require that transmission pipelines and regulated Type A gathering lines be buried at least 30 inches below the surface in rural areas and deeper (36 inches) in more populated areas. In addition, the pipeline must be buried deeper in some locations, such as at road and railroad crossings (36 inches) and crossings of navigable bodies of water (48 inches). The depth may be shallower in other locations, such as when the pipe is installed in consolidated rock (18 to 24 inches). The depth of burial must be according to these regulations at the time of burial, but there is nothing that requires this depth be maintained over time. Erosion may expose pipelines not subject to frequent inspection and maintenance. Flood frequency and severity are increasing in Pennsylvania as a consequence both of increasing development and of global warming. Damage to pipelines and other gas industry facilities in floodplains can be expected to increase.

Welding of Steel Pipelines. To carry out the welding process, the pipe sections are temporarily supported along the edge of the trench and aligned. The various pipe sections are then welded together into one continuous length, using manual, semiautomatic, or automatic welding procedures. As part of the quality-assurance process, each welder must pass qualification tests to work on a particular pipeline job, and each weld procedure must be approved for use on that job in accordance with federally adopted welding standards. Welder qualification takes place before the project begins. Each welder must complete several welds using the same type of pipe as that to be used in the project. The welds are then evaluated by placing the welded material in a machine and measuring the force required to pull the weld apart. A proper weld is actually stronger than the pipe itself.

For high stress pipelines over 6 inches in diameter, a second level of quality assurance evaluates the ongoing welding operation. To do this, qualified technicians sample a certain number of welds (the sample number varies based on the population near the pipeline) using radiological techniques (*i.e.*, X-ray or ultrasonic inspection) to ensure the completed welds meet federal standards. The X-ray technician processes the film in a small, portable darkroom at the site. If the technician detects flaws, the weld is repaired or cut out, and a new weld is made. Another method of weld quality inspection employs ultrasonic technology. None of these procedures is required for gathering lines, unless the construction operator chooses to utilize them. Economic pressures make such choices unlikely.

Coatings. Several different types of coatings may be used to coat the pipe at the factory and the joints made in the field, with the most common at present being fusion bond epoxy or polyethylene heat-shrink sleeves. Prior to application, the bare pipe is thoroughly cleaned to remove any dirt, mill scale, or debris. The coating is then applied and allowed to dry. After field coating and before the pipe is lowered into the trench, the entire coating of the pipe is inspected to ensure that it is free from defects. For many years, coal tar epoxy coatings were standard. Today, Fusion Bond Epoxy (FBE) is used.[29] Older pipes, such as those made from cast iron or bare steel pipes, are more vulnerable to safety problems due to age, rusting, and/or corrosion. Public utility companies are gradually replacing such pipes with plastic in their older distribution systems.[30] Typically there is no corrosion protection provided for gathering lines.

Lowering and Backfilling. Once the pipeline is welded and coated, it is lowered into the trench. Lowering is done with multiple pieces of specialized construction equipment called sidebooms. This equipment acts in tandem to lift and lower segments of the assembled pipeline into the trench in a smooth and uniform manner to prevent damaging the pipe.

---

[29] www.ingaa.org/File.aspx?id=10751

[30] http://www.lehighvalleylive.com/news/index.ssf?/base/news-1/1297832779297570.xml&coll=3

Once the pipeline has been lowered into the ground, the trench is backfilled. To ensure that the pipe and its coating are not damaged, this is generally accomplished with either a backhoe or padding machine depending on the soil. Care must be taken to protect the pipe and coating from sharp rocks and abrasion as the backfill is returned to the trench. In areas where the ground is rocky and coarse, the backfill material is screened to remove rocks or the pipe is covered with a material to protect it from sharp rocks and abrasion. Alternatively, clean fill may be brought in to cover the pipe. Once the pipe is sufficiently covered, the coarser soil and rock can then be used to complete the backfill. As the backfill operations begin, the excavated material can be returned to the trench in reverse order, with the subsoil put back first, followed by the topsoil. Thus the topsoil can be returned to its original position.

Valves and Valve Placement. A valve is a mechanical device installed in a pipeline in order to control the flow of gas. Some valves have to be operated manually by pipeline personnel, some valves can be operated remotely from a control room, and some valves are designed to operate automatically if a certain condition occurs on the pipeline. If a pipeline should fail, how quickly the major valves can be closed and the distance between the valves are major factors that determine how much gas is released. Many types of gas-related equipment have valves, and many valves are a source of gas leaks to the atmosphere. New and replacement residential service lines are being equipped with automatic shutoff valves that respond when excess flows are sensed, thereby preventing the buildup of gas in homes when service lines experience damage.

Operating Pressure. Maximum allowable operating pressure (MAOP) is the maximum internal pressure at which a natural gas pipeline or pipeline segment may be continuously operated. MAOP is set at levels meant to ensure safety by requiring that the pressure does not cause undue stress on the pipeline. How this pressure is determined is defined in federal regulations, based on a number of different factors such as the location of the pipeline, pipe wall thickness, previous pressure tests, and the pressure ratings of various components. Operating pressures in Pennsylvania shale gas gathering lines overlap with those in major transmission lines and tend to be far higher than in traditional gathering lines serving conventional gas wells.

Testing. Generally, but with certain exceptions, all newly constructed natural gas transmission pipelines must be hydrostatically tested before they can be placed into service. The purpose of a hydrostatic pressure test is to expose any defect that might threaten the pipeline's ability to sustain its maximum operating pressure plus an additional safety margin, at the time of the hydrostatic test. A pipeline is designed to a specified strength based on its intended operating pressure.

Hydrostatic pressure testing consists of filling the pipeline with water and raising the internal pressure to a specified level above the intended operating pressure. Critical defects that cannot withstand the pressure will fail. Upon detection of such failures, the defects are repaired or the affected section of the pipeline is replaced and the test resumed until the pipeline "passes".

Hydrostatic testing is not the only means for detecting pipe defects. For example, inline inspection (ILI) technologies also are used that permit the identification of specific types of defects, such as corrosion. But because not all lines can be

inspected with ILI tools and because of the need to find types of imperfections that are not currently detected by ILI technology, hydrostatic testing is an accepted method for demonstrating the fitness of a pipeline segment for service.

Concerns During Pipeline Construction. In 2009 the federal Office of Pipeline Safety (OPS) held a workshop to go over the numerous problems they found during just 35 inspections of new, federally regulated transmission pipelines under construction. The inspectors recorded significant problems with the pipe coating, the pipe itself, the welding, the excavation methods, the testing, the design, and other aspects. The findings and presentations from this workshop can be found at: http://www.regulations.gov/search/Regs/home.html#docketDetail?R=PHMSA-2009-0060

These OPS findings call into question the current system of inspections for the construction of new interstate pipelines. This construction phase is critical for the ongoing safety of pipelines for many years to come. Gathering lines in Pennsylvania are not subject to even these minimum federal standards.

Pipeline Operation

Corrosion Protection. Unprotected steel pipelines are susceptible to corrosion, and without proper corrosion protection every steel pipeline will deteriorate more rapidly than necessary. Corrosion can weaken the pipeline and make it unsafe. Technology has been developed to allow corrosion to be controlled in many cases to extend pipeline life if applied correctly and maintained consistently. As noted below, corrosion accounts for more than half of the failures of gathering lines nationwide and for nearly 70% of those failures in Texas, where incidents are more thoroughly recorded. Here are the three common methods used to control corrosion on pipelines:

- Cathodic protection (CP) is a system that uses direct electrical current to counteract the normal external corrosion of a metal pipeline. CP is used where all or part of a pipeline is buried underground or submerged in water. On new pipelines, CP can help prevent corrosion from starting; on existing pipelines, CP can help stop existing corrosion from getting worse.

- Pipeline coatings and linings are principal tools for defending against corrosion by protecting the bare steel.

- Corrosion inhibitors are substances that can be added to a pipeline's contents to decrease the rate of attack of internal corrosion on the steel since CP cannot protect against internal corrosion.

Supervisory Control and Data Acquisition System (SCADA). A SCADA is a pipeline computer system designed to gather information such as flow rate through the pipeline, operational status, pressure, and temperature readings. Depending on the pipeline, this information allows pipeline operators to know what is happening along the pipeline, and allows quicker reactions for normal operations, and to equipment malfunctions and releases. Some SCADA systems also incorporate the ability to operate certain equipment remotely, including compressor stations and

valves, allowing operators in a control center to adjust flow rates in the pipeline as well as to isolate certain sections of a pipeline. Many SCADA systems also include leak detection systems based on the pressure and mass balance in the pipelines.

The National Transportation Safety Board found inadequate attention to SCADA procedures to be a major contributing factor in the major ruptures of interstate petroleum pipelines in San Bruno, California, and Marshall, Michigan. Inattention to written procedures and delays in recognizing and responding to the ruptures greatly increased the resulting damage in both those incidents. NTSB for years has recommended that operators perform audits of their SCADA alarm systems *prior to* major incidents and beware complacency regarding false alarms.

PHMSA statistics collected over the decade 2002-2012 suggest that remote sensors have actually detected only about 5% of oil pipeline leaks (Song 2012). Clearly, the rapid detection of and response to pipeline leaks are unsolved problems that threaten human safety, public health, and the environment.

Right-of-Way Patrols. Federal regulations require regular patrols of pipeline rights-of-way to check for indications of leaks and ensure that no excavation activities are taking place on or near the right-of-way that may compromise pipeline safety. For transmission pipelines these patrols are often accomplished by aerial surveillance.

Leakage Surveys. Federal regulations also require regular leakage surveys for all types of regulated interstate gas pipelines along the pipeline routes. Personnel walk or drive the route using specialized equipment to determine if any gas is leaking and to then quantify the size of the leak. Small leaks are a normal part of most gas pipeline systems. Collectively, the leaks from natural gas production and transmission operations contribute significantly to global warming on a worldwide scale. Operators have some economic incentive, even if no regulatory obligation, to minimize leaks.

Following spectacular environmental damage by leaks from oil transmission pipelines in Utah and Michigan, Congress directed the OPS to report on ways to improve timely leak detection. That report is due in 2013 (Weimer 2012).

Odorization. All distribution pipelines, and some transmission and gathering lines (mainly in highly populated areas), are required by Pennsylvania or federal law to be odorized so leaking gas is readily detectable by a person with a normal sense of smell. Gathering lines in Class 1 areas are not required to be odorized.

Odorizer shut-down

Contaminants in odorizer

Naturally occurring sulfurs

Distillates in pipeline

Pipewall adsorption

Oxidation in pipeline

Soil adsorption

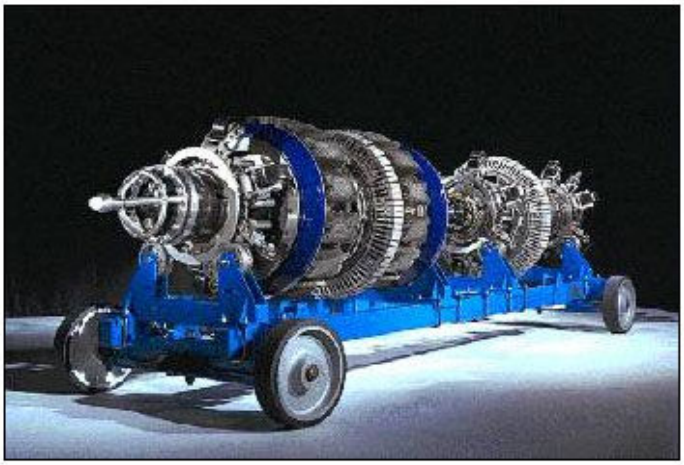
Factors Which Affect Odorant Quantity

Integrity Management. Integrity Management refers to a relatively new set of federal rules that specify how pipeline operators must identify, prioritize, assess, evaluate, repair, and validate---through comprehensive analyses---the integrity of their pipelines. Some form of Integrity Management now applies to both gas transmission (since 2004) and distribution (since 2011) pipelines. Gathering lines remain exempt from these requirements.

For gas transmission pipelines integrity management requires that lines that could affect High Consequence Areas (relatively densely populated areas) have to be re-inspected by their operators at least once every seven years. This re-inspection is done mainly with internal inspection devices called smart “pigs” (pipeline inspection gages), but may also be done through pressure tests or direct inspection. Special openings (launchers) are built into pipelines so that pigs can be inserted and removed. Once inspected the rules require that operators respond to certain anomalies found on their pipelines in certain ways within certain timeframes. In the first 5 years of this national program these rules required nearly 3,000 repairs be made to natural gas transmission pipelines that fall within High Consequence Areas. Only about 7% of the gas transmission pipelines nationwide are required to undergo these important inspections, although some companies inspect more mileage voluntarily pursuant to their own Integrity Management Programs. Most distribution lines are found in densely populated areas.

"Pig launchers"

More "Pig launchers"



Pig - Pipeline Inspection Tool
Source: Duke Energy Gas Transmission Canada

Pipeline Damage Prevention. One of the leading causes of all pipeline incidents is damage to pipelines from people digging. In fact, as shown below, for the past 10 years this has been the main cause of deaths and injuries when all types of pipelines are considered together in the United States. For this reason programs

designed to decrease damage to pipelines caused by excavation are extremely important to protect people and the environment.

Current PHMSA regulations require interstate pipeline operators to prepare a written plan to respond to worst-case instances of pipeline rupture (49 CFR 194.115). The National Transportation Safety Board has documented the inadequacy of PHMSA staff to review such plans effectively, in contrast to other agencies such as the US Coast Guard and US Environmental Protection Agency which also review plans for responding to spills of petroleum on water. It has called for PHMSA to promulgate more detailed prescriptive regulations for addressing spill emergencies because pipeline companies at present lack such guidance, and to issue an interim advisory bulletin prior to implementation of mandatory regulations. It also recommends unannounced onsite audits by PHMSA when spill response plans are being reviewed, as typically are conducted by the Coast Guard and USEPA, with required correction of deficiencies.

Inspections. To ensure that regulations are implemented, inspection and enforcement are needed. In light of the expanding natural gas pipeline infrastructure within our Commonwealth and recent fatal pipeline explosions in Philadelphia[31] and Allentown[32], this is an area of increasing concern

The Pipeline and Hazardous Materials Safety Agency (PHMSA), through its Office of Pipeline Safety (OPS) has inspection and enforcement responsibilities. While the number of inspectors throughout the country may vary, Congress authorized additional staff in the 2009-2010 budget to bring the total number of inspectors across the country to 113.[33] The primary responsibility of these OPS inspectors is the interstate pipeline system. To do their job in overseeing the pipeline

[31] http://www.pbs.org/wnet/need-to-know/the-daily-need/fatal-gas-explosion-in-philadelphia-kills-one-and-injures-five/6465/

[32] http://abcnews.go.com/Business/pennsylvania-natural-gas-explosion-leaves-dead/story?id=12883552

[33] http://primis.phmsa.dot.gov/comm/InspectionEnforcement.htm?nocache=1433

transmission system, these inspectors at the federal level rely on inspectors at the state level. As of March 2011, the PA Public Utility Commission had eight certified gas safety engineer inspectors and was seeking to obtain authorization from the legislature for twelve additional staff positions.[34]

How can so few staff inspect hundreds of thousands of miles of pipelines? Inspectors spend a great deal of their time reviewing data provided by the pipeline companies and following up with on-site inspections as needed. There are several different types of pipeline inspections as summarized on the following table.

Pipeline Inspections[35]

TYPE of INSPECTION	NATURE of INSPECTON
Standard Reviews • take about a week • done every 2-3 years • done more frequently as needed	Examine operator's records and equipment for compliance Check if required surveillance and testing is done within prescribed timeframes Review current and historical records checking maximum pressure relative to safe limits Examine emergency procedures Field visits include • measuring corrosion control equipment and testing valves, • checking instruments and equipment to protect the system from events that could put too much pressure on a pipeline • observe right of way (ROW) markers
Operations and Maintenance Manual Reviews • overview of manuals maintained by operators according to required, established procedures • more time consuming than a Standard Review	Important areas of procedural review include: • proper construction, repair, testing, and maintenance • repairing or replacing pipe, welding, valve maintenance, and testing and maintenance of overpressure protection devices • prevention of damage due to excavation activities, including right-of-way maintenance, maintaining line markers, participation in One-Call programs, and periodic surveillance of the pipeline right-of-way. • minimizing the hazards from a gas pipeline emergency
Operator Qualification (OQ) Inspections	•identify those who perform maintenance and safety-sensitive operations on a pipeline for operators •identify tasks performed by these employees or

[34] Testimony provided by PUC Commissioner Wayne Gardner on March 7, 2011 in Upper Merion Township at congressional roundtable on gas pipeline safety convened by U.S. Rep. Shuster (R-9), chair of the House Transportation subcommittee that oversees pipeline safety.

[35] http://primis.phmsa.dot.gov/comm/Inspection.htm?nocache=2674

	contractors • ensure those who are doing the jobs have knowledge and skills to perform given task through documented tests, records, and actions • observe personnel conducting tasks and assess that safety plans are implemented effectively via a series of inspection protocols
Integrity Management Inspections* • comprehensive process to prevent pipeline leaks or ruptures • conducted by a team of inspectors over a two-week period * most frequent in HCAs	• assess "integrity" of pipeline through in-line inspections, hydrostatic pressure testing, and/or direct assessment • determine any potential defects for repair • develop and implement of a set of safety management and analytical processes, i.e. an integrity management program • ensure pipeline operators have a comprehensive, well-documented process in place to protect high consequence areas (HCAs) where pipeline failure would lead to devastating results.

Other types of inspections include gas transmission operators, gas distribution operators, liquefied natural gas facilities, breakout tanks, gas storage fields, and construction.[36]

To prevent failure, pipeline integrity testing has grown increasingly more high-tech. Visual inspections look at corrosion. Hydrostatic inspections force water through pipelines at high pressure to determine if the pipeline can withstand forces above its maximum operating pressure. "Smart pigs" assess the pipeline from the inside and can measure the thickness of the pipe and identify corrosion as well as other flaws before actual leaks and ruptures occur.[37] Pigs perform inspections without stopping the flow of natural gas. Although initially used to clean pipes, mini-sensors and computerized systems allow "smart" pigs to conduct numerous tests designed to reduce pipeline hazards. Unless the pigs are accurately calibrated, however, they will not disclose defects.

The Gas Safety Division of the PA PUC conducts inspections in a manner similar to PHMSA. Wayne Gardner, a PUC Commissioner assigned to gas safety, has found pipelines to be a reliable way to transport natural gas.[38] In 2010, PUC's nine inspectors conducted about 1,200 inspections. Although some of the inspections are conducted on-site, the methodology used by the gas inspectors allows them to determine areas of interest without leaving their offices. Companies under the supervision of PUC are required to provide self-reporting. These reports provide

---

[36] http://primis.phmsa.dot.gov/comm/InspectionDetails.htm?nocache=5986

[37] http://pstrust.org/cgi-bin/search.cgi?zoom_query=Pig&zoom_per_page=10&zoom_and=0

[38] Based on the presentation by Wayne Gardner at the October 9, 2010 LWV of Southeastern PA forum on gas pipelines held at the Radnor Township Municipal Building, Wayne, PA.

insight not only into the on-going operations of facilities but also give clues about the overall attitude of the company toward critical issues such as safety. Summary reports are compiled by PUC inspectors.

Safe and secure gas pipelines are in best interest of companies who pay the monetary price for lost gas and damages. However, the frequency and nature of the testing by pipeline companies is self-determined.

Enforcement. In addition to inspection, PHMSA has an enforcement program to monitor and enforce compliance of operators to meet standards for safe, reliable, and environmentally sound practices and procedures.[39] A flow chart[40] showing the interrelationship of enforcement and inspection begins with determining whether jurisdiction occurs at the state or federal level. Actions then are divided between concerns that relate to standards and programs. Appropriate inspections and data are collected before consequences are determined. Based on the transgression, actions can include warnings, reviews, hearings, fines, and a range of other tools to ensure that operators take appropriate and timely corrective actions and prevent future failures or non-compliance issues.

During the past decade, PHMSA reports indicate that between 100 and 300 cases nationwide are initiated and resolved annually.[41] During the same period, they issued about 100 warning letters, 100 notices of amendments, between 40 and 99 notices of probable violation, between 5 and 20 corrective action orders, and a maximum of 3 notices of proposed safety orders.[42]

The PUC has jurisdiction to conduct investigations regarding all methods or practices of pipeline companies in Pennsylvania, including reports, records and other information. Investigators may look at the property, buildings, plants and offices of the pipeline companies and inspect books, records, paper, email, and documents relevant to the enforcement of the rules and regulations. If evidence is found, violation reports are written, and the gas utility is given a written citation regarding specifics of the violation.[43]

In Pennsylvania, during the 2009-2010 fiscal year, Commissioner Gardner reported that PUC conducted 3 investigations of reportable incidents involving the hit and near hit of pipelines, issued 63 warnings or letters of non compliance, and handled 190 gas safety violations. Of the 190 violations, 151 were handled with letters and 39 instances were dealt with by the enforcement staff. As a rule, once companies are cited, they tend to correct the issue and settle out of court. If no agreement is reached, the Gas Safety Division refers the problem to the PUC for formal resolution by issuing a complaint, setting a penalty, or seeking enforcement through the courts.

---

[39] http://primis.phmsa.dot.gov/comm/reports/enforce/Enforcement.html?nocache=5774

[40] http://primis.phmsa.dot.gov/comm/EnforcementFlowchart1.htm?nocache=2655

[41] http://primis.phmsa.dot.gov/comm/reports/enforce/EnfHome.html?nocache=1175

[42] http://primis.phmsa.dot.gov/comm/reports/enforce/Actions_opid_0.html?nocache=8300

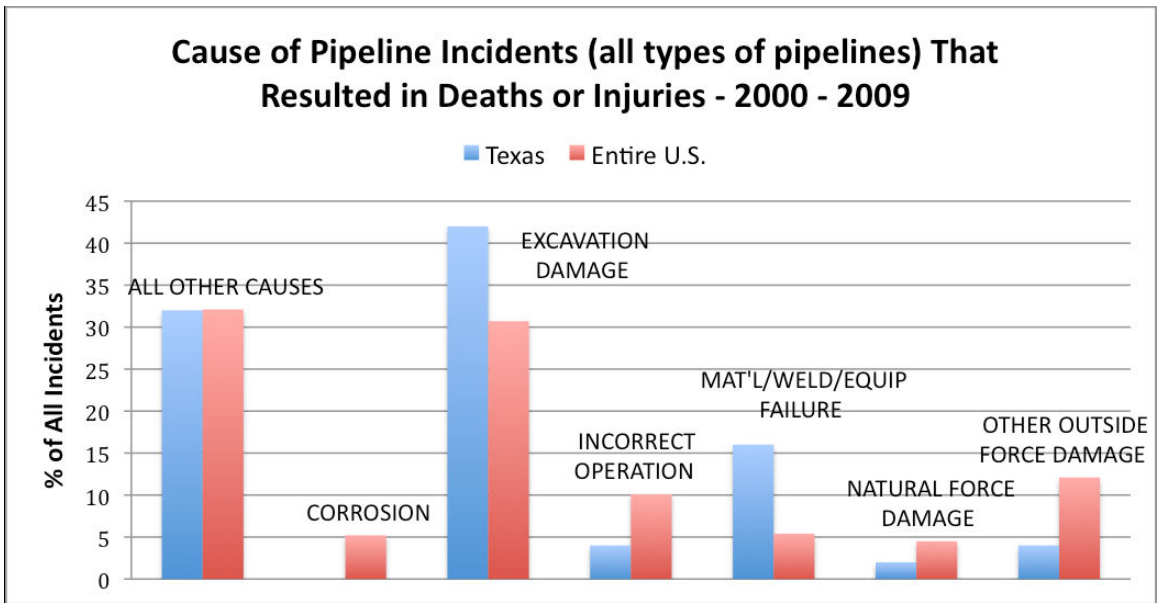
[43] http://www.puc.state.pa.us/transport/gassafe/gassafe_jurisdiction.aspx

In the case of a major event such as an explosion, fire, or significant outage, the PUC investigates and conducts a hearing. As a result, companies may be fined. For instance, an $80,000 civil fine was imposed along with an $80,000 mandated contribution to a "low income use" program for a company involved in a gas explosion. The PUC does not take a company to court to pay the damage cost for damages or settle liability issues. Other examples include a $15,000 fine for mistaken location of a gas line that resulted in a hit by an excavator and a $600,000 cumulative fine to a single company for air quality violations.[44]

Reporting of Excavation Damage and Enforcement. Pennsylvania currently has no requirements for reporting on pipeline damage and enforcement beyond those required by the federal government in high consequence areas. Even those statistics are not routinely published by the Public Utilities Commission, which recently revised its forms requiring annual reports. Thus it is instructive to summarize the major damage prevention efforts in Texas, a major location for gas production.

The Railroad Commission of Texas (RRC), which is charged with state-level regulation of oil and gas activities, has adopted regulations that require both pipeline companies and excavators to report all damage to pipelines. The reporting of incidents is tracked on a publicly accessible database which gives the RRC and the public the ability to analyze which excavators are hitting pipelines, the cause of that damage, and what penalties the RRC imposed. This publicly available database is unique in the entire nation, with many states having no ability even to track excavation damage. The federal pipeline incident tracking system lacks the data of Texas's system. Yet even the Texas Railroad Commission has been identified by an appointed reviewing agency (as well as by independent organizations) as providing inadequate recordkeeping regarding oil and gas pollution incidents and as having astonishing gaps in its regulatory authority over interstate pipelines, which are not inspected in Texas (Sunset Advisory Commission 2011, Sumi 2012).

[44] Based on comments made by Commissioner Wayne Gardner at a LWV of Southeastern PA pipeline forum held at the Radnor Township Municipal Building in Wayne, PA on October 9, 2010.



For comparison according to the federal Office of Pipeline Safety's incident database over the past ten years, Texas averages about 10 pipeline incidents per year caused by excavation damage. The RRC database shows an average of about 18,000 incidents per year. Pennsylvania data are presented in a subsequent section.

One-Call Centers. The primary tool for avoiding damages to underground facilities is timely communication between those digging (excavators) and the owners of the facilities. It is important to Call Before You Dig. One-call centers facilitate this communication process by enabling an excavator to place just one call, prior to digging, to request that all underground facilities in the area of a planned excavation be located and marked.

811®
Know what's below.
Call before you dig.

By simply dialing 811 or 1-800-545-6005, you can reach the one-call center where, at no cost to you, companies that may operate underground utilities in the area where you plan to dig will be notified. Those companies can then dispatch field crews to determine and surface mark the location of their utilities so that you can avoid hitting them when you begin your excavation. Pennsylvania law requires anyone doing excavation to call to have the location of the utilities marked at least 48 working hours before any excavation is done. Hitting underground utilities when you are digging can cause injuries, even deaths, environmental damage, and loss

of critical infrastructure and services. Strikes that don't cause immediate problems can lead to failures years later. If you don't make the call, you could be liable for damage costs and repairs, as well as subject to potential penalties. Don't take the chance---Call before you dig!

The Pipeline Safety Act of 2006 was enacted at the federal level to reduce the hazards created when pipelines were damaged by powered digging equipment. It mandated that excavators or contractors who hit a pipeline and create an emergency such as a gas leak, must call 911. It further required that all owners or operators of pipeline facilities be subject to a civil action or assessment of a $1 million penalty if they fail to respond to a location request in order to ensure accurate markings of the location of a pipeline facility. The legislation further created the One Call System – "811 Call Before You Dig." These federally mandated, non-profit centers serve as informational clearinghouses organized and governed at the state level. They are funded not by tax dollars but by operators of underground facilities including power lines, water and sewer pipes, telephone service, and energy pipelines.

The One Call system works as follows:

- The "digger" calls 8-1-1 three business days prior to beginning the excavation project and provides the location of the activity
- The One Call center notifies facility operators in the area who mark the site with designated colored flags or spray paint designating lines and pipes.
- The excavator uses the markings to avoid damaging systems and the project is safely completed.

The PA One Call System "Know What's Below" is a resource for homeowners, excavators, facility operators, emergency responders, and project owners.[45] It

[45] http://www.pa1call.org/PA811/Public/Default.aspx?

precedes the national system and was authorized by PA Act 287. It has been operating since 1972 and is funded by notification service fees to its members, supplier dues, and excavator fees.[46] Gathering lines and some intrastate lines unregulated by the PUC are presently not included in the PA One Call System.

Cities and municipal utilities, state departments of transportation, and farmers often seek exemptions, or to retain existing exemptions, from having to participate in the one call system. It is a chore to get a one-call ticket every time a new street sign is erected, ditch maintained, or field plowed. Likewise, production and gathering pipelines often seek exemptions from having to participate in responding to one-call locate requests or mapping requirements. Excavators point out that a high percentage of the incidents that cause damage to underground utilities are caused by the utilities being marked incorrectly after One-Call has been used. The excavators want to ensure that, if they are going to be held accountable for their failures to use the one-call system properly, the utilities are also held equally accountable for failures to mark pipes correctly.

Best Practices Regarding Damage Prevention. In 2000 a national organization called the Common Ground Alliance (CGA) was launched in an effort to reduce damages to all underground gas facilities in North America through shared responsibility among all stakeholders. In promoting a spirit of shared responsibility, the CGA welcomes all stakeholders who would like to be a part of the identification and promotion of best practices that lead to a reduction in damage. Any "best practices" endorsed by the CGA come with consensus support from experts representing the following stakeholder groups: Excavators, Locators, Road Builders, Electric, Telecommunications, Oil, Gas Distribution, Gas Transmission, Railroad, One Call, Public Works, Equipment Manufacturing, State Regulators, Insurers, Emergency Services, and Engineering/Design.

CGA has taken the lead nationally in developing best practices to reduce damage to underground utilities, including pipelines. The latest edition (Version 7.0) of their Best Practices manual includes 147 best practices in the following categories:

1. Planning & Design Best Practices
2. One Call Center Best Practices
3. Location & Marking Best Practices
4. Excavation Best Practices
5. Mapping Best Practices
6. Compliance Best Practices
7. Public Education Best Practices
8. Reporting & Evaluation Best Practices
9. Miscellaneous Practices

Current CGA recommendations can be examined at http://www.commongroundalliance.com/Content/NavigationMenu/Best_Practices/Best_Practices_2010/BP_8.0_Web.pdf

[46] http://www.pa1call.org/pa811/Public/About/History/Public/POCS_Content/About_Us/History.aspx?hkey=5cc3c2fc-394f-47a8-9cc7-aac867a6d997

Public Awareness. For many years, the pipeline industry has provided information to a variety of groups living and working near pipelines to ensure they know about the pipelines in their area, how to recognize and respond to a problem, and ways to prevent damage to pipelines. The American Petroleum Institute developed a series of recommended practices for pipelines operators to use to help ensure the effectiveness of these public awareness efforts.

In 2005 these recommended practices were incorporated by reference into the federal pipeline safety regulations (49 *CFR* 192.616 and 49 *CFR* 195.440), and now require that pipeline operators conduct continuing public awareness programs to provide pipeline safety information to four stakeholder audiences: the affected public, emergency officials, local public officials, and excavators.

Under these regulations, pipeline operators must provide the above groups with information about how to recognize, respond to, and report pipeline emergencies. The importance of using the one-call notification system prior to excavation is to be emphasized for all stakeholders. Emergency officials and local public officials must be provided information about the location of transmission pipelines to enhance emergency response and community growth planning. Affected municipalities, school districts, businesses, and residents must be advised of pipeline locations. Of particular significance is the requirement that operators must periodically review their programs for effectiveness and enhance the programs as necessary. These recommended practices can be reviewed at:
http://committees.api.org/pipeline/standards/docs/1162nonprintable.pdf

The National Transportation Safety Board investigates accidents in all forms of transportation systems. It has produced two major reports on recent pipeline accidents, one on the 2008 San Bruno, California, gas pipeline rupture and one on the 2010 crude oil pipeline rupture in Michigan.

In its exhaustive report on a hazardous pipeline rupture and release on 25 July 2010 that sickened 320 people and 11 cleanup employees, caused $767 million in cleanup costs, $13.2 million lost revenue to the operator, and $2.7 million to repair the pipe, the NTSB offered the following comments regarding public awareness and first-responder preparedness.

> Public knowledge of pipeline locations and the hazards associated with the materials transported is critical for successful recognition and reporting of releases, as well as the safe response to pipeline ruptures. The transportation of hazardous materials by pipeline is unlike hazardous materials transportation by railroad or highway because a pipeline is a permanent fixture. A pipeline presents a unique challenge to awareness because it is often buried. When pipeline releases occur, a properly educated public can be the first to recognize and report the emergency (National Transportation Safety Board 2012a).

It then twice makes the following recommendation to PHMSA:

> Because system-specific pipeline information is critical to the safe response to pipeline incidents, the NTSB is also concerned about the emergency officials' lack of awareness of Enbridge's pipeline. Therefore, the NTSB recommends that the

> International Association of Fire Chiefs and the National Emergency Number Association inform their members about the circumstances of the Marshall, Michigan, pipeline accident and urge their members to aggressively and diligently gather from pipeline operators system-specific information about the pipeline systems in their communities and jurisdictions. … This information should include pipe diameter, operating pressure, product transported, and potential impact radius (National Transportation Safety Board 2012b).

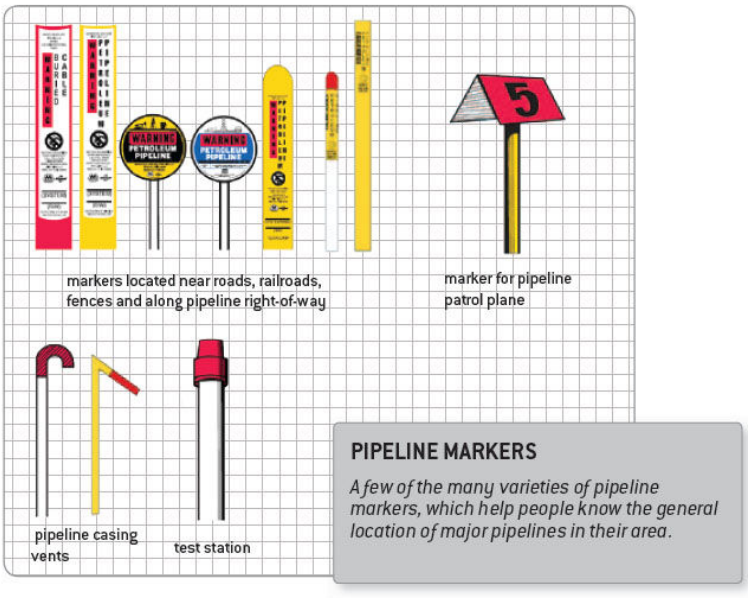
Contact information for regulators of pipelines in Pennsylvania is as follows:

Pennsylvania Public Utility Commission
Commonwealth Keystone Building
P.O. Box 3265 Harrisburg, PA 17105-3265
Chief, Gas Safety Division: Paul J. Metro
Office: 717-787-1063; Fax: 717-787-3114
E-mail: pmetro@state.pa.us

Office of Pipeline Safety - Eastern Region Office
820 Bear Tavern Road, Suite 103 W. Trenton, NJ 08628
Telephone: 609-989-2171
Director: Byron Coy
Information Contact: Alex Dankanich / Karen Gentile
Direct: 202-550-0481 / 609-989-2252
E-mail: alex.dankanich@dot.gov / karen.gentile@dot.gov

Pipeline and Hazardous Materials Safety Administration
1200 New Jersey Avenue SE East Building, Second Floor (PH)
Washington D.C. 20590-0001
Administrator: Cynthia L. Quarterman
Assistant Administrator / Chief Safety Officer: Vacant
Media Contact - Deputy Director, Office of Governmental, International and Public Affairs: Patricia Klinger
Associate Administrator for Pipeline Safety: Jeff Wiese Phone: 202-366-4595

Persons living near pipelines would be prudent to become familiar with the kinds of markers that operators use to mark their rights-of-way on the ground.



Recommendations Regarding Pipeline Operations

The League of Women Voters of Pennsylvania has adopted a position regarding extracting transporting natural gas from Marcellus Shale that includes support for:

- the maximum protection of public health and the environment by promoting comprehensive regulation and adequate staffing across government agencies in all aspects of Marcellus Shale natural gas production, site restoration, and delivery to the customer, and

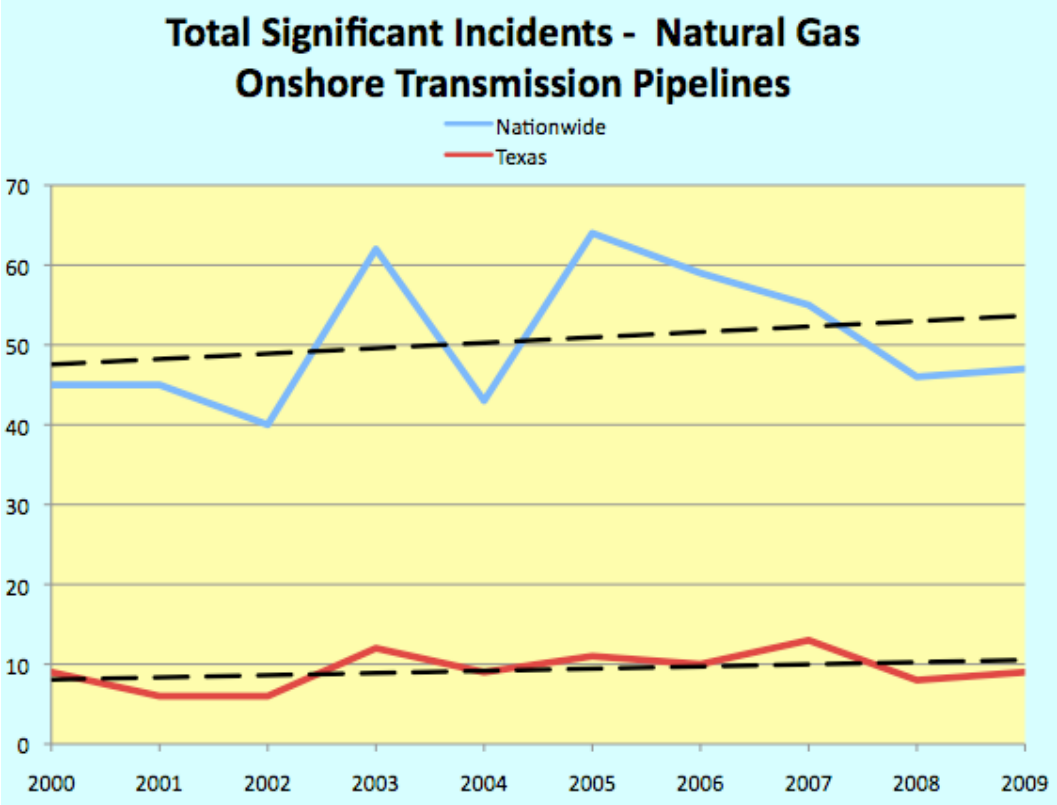
- legislation that provides for the establishment of an efficient and effective oversight system for reporting potential violations and accidents.

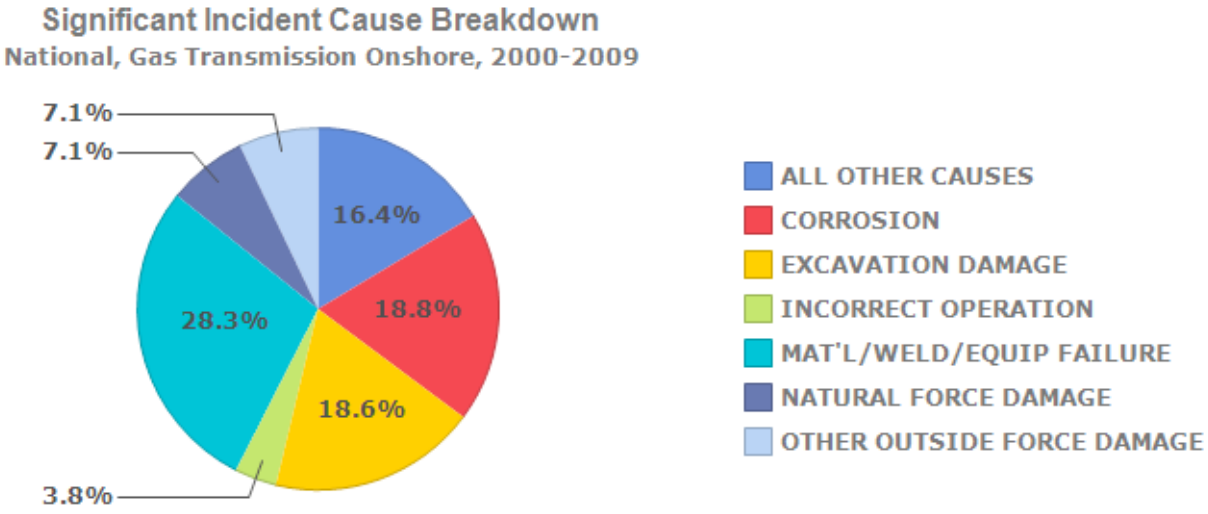
In addition, the federal Office of Pipeline Safety should undertake a study to determine the benefits and risks of odorizing gathering lines, at least in densely populated areas. That study should at a minimum address the concern of proper injection of odorant at multiple well sites, how and at what concentrations heavier than air gas components may change the need for odorants, and the apparent disconnect between the requirements for odorant in Type A gathering lines in populated areas and the various exemptions to those requirements, particularly related to gathering lines transporting gas.

Natural Gas Pipeline Risk

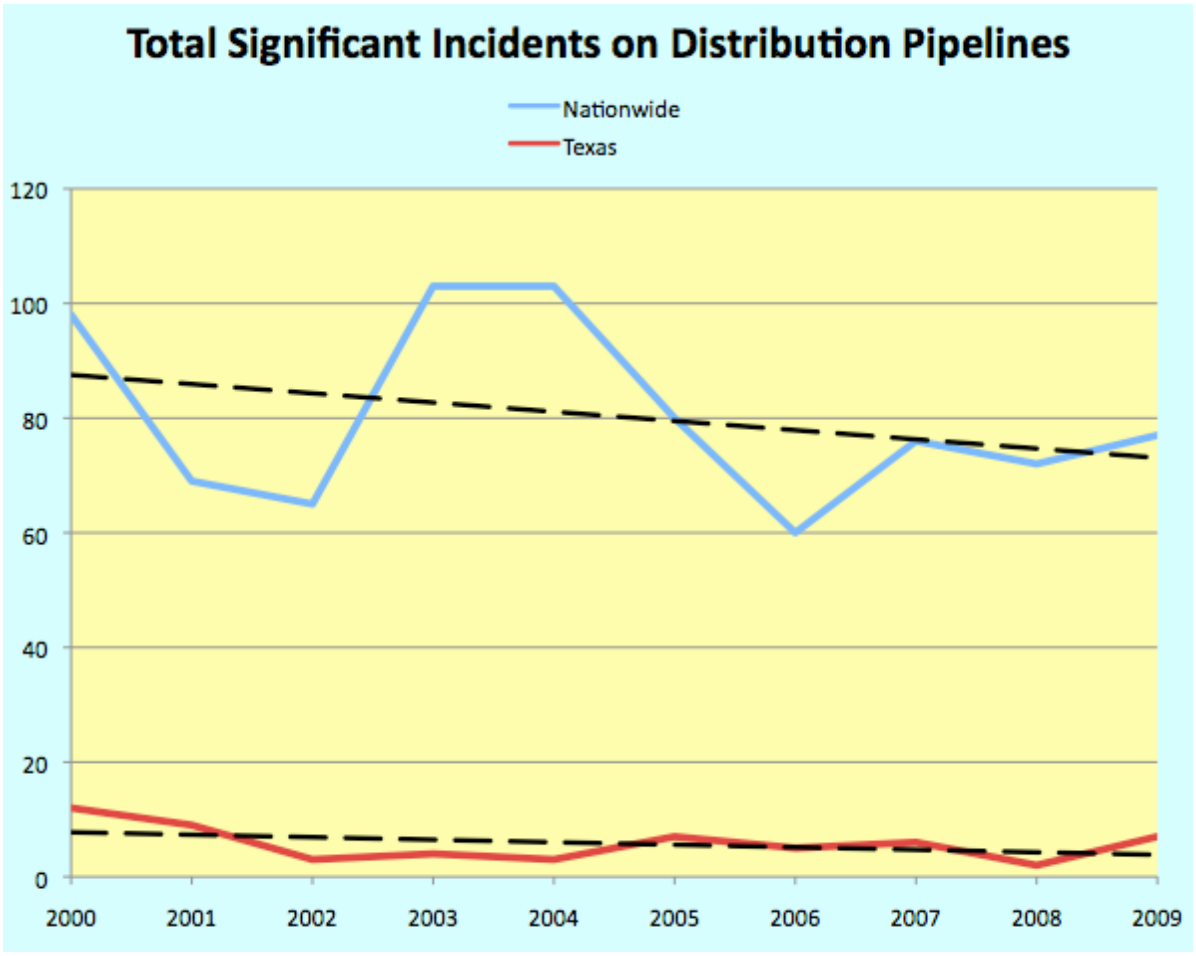
There is a growing literature on how risk is perceived differently by individuals and groups (Ropeik 2010, Ropeik & Gray 2002). Risk is made up of several different factors which need to be carefully considered when deciding how risky an activity is. Those factors include the probability that an event will occur (the chance a pipeline will rupture or leak), and the possible consequences if it does. Various measures were discussed above that pipeline operators can or are required to take to keep their pipelines safe and reduce the probability of a catastrophic event occurring.

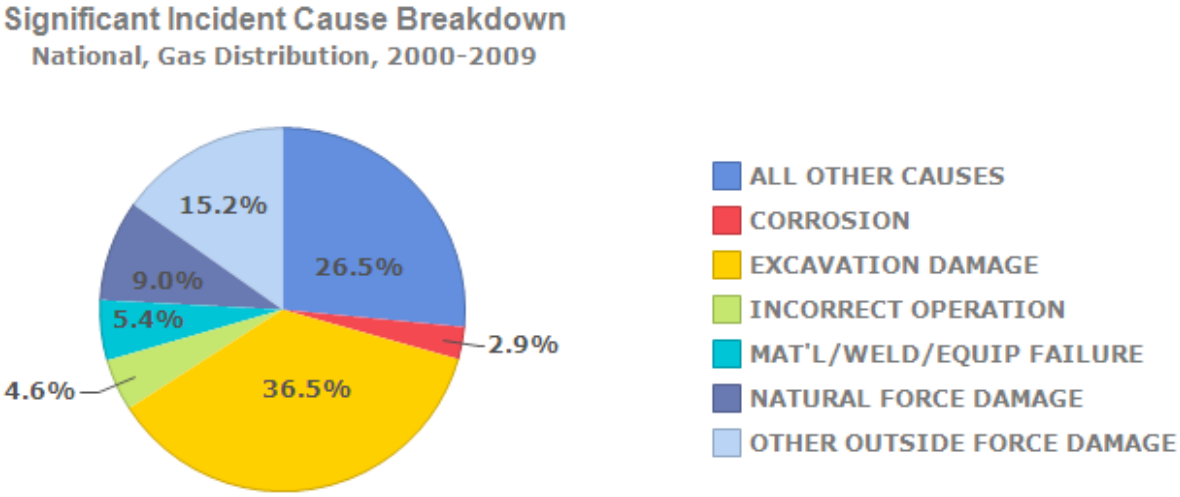
One other measure that helps shed light on the probability of an occurrence is the past incident rates for pipelines in a given area. Past performance cannot accurately forecast future incidents, but such data can provide trend lines that point to needed changes in pipeline operation, maintenance, public outreach, and regulations. Below are graphs that show the number of significant incidents occurring on the different types of pipelines in the past ten years nationwide and in Texas. These graphs also indicate the trend lines for incidents during this period. Pie charts that show the causes of the incidents also are displayed. They indicate which incidents were within the control of pipeline operators. The trends show increasing damage incidents for transmission pipelines and decreasing damage incidents for distribution pipelines over the past decade. No comparable statistics exist for gathering lines.



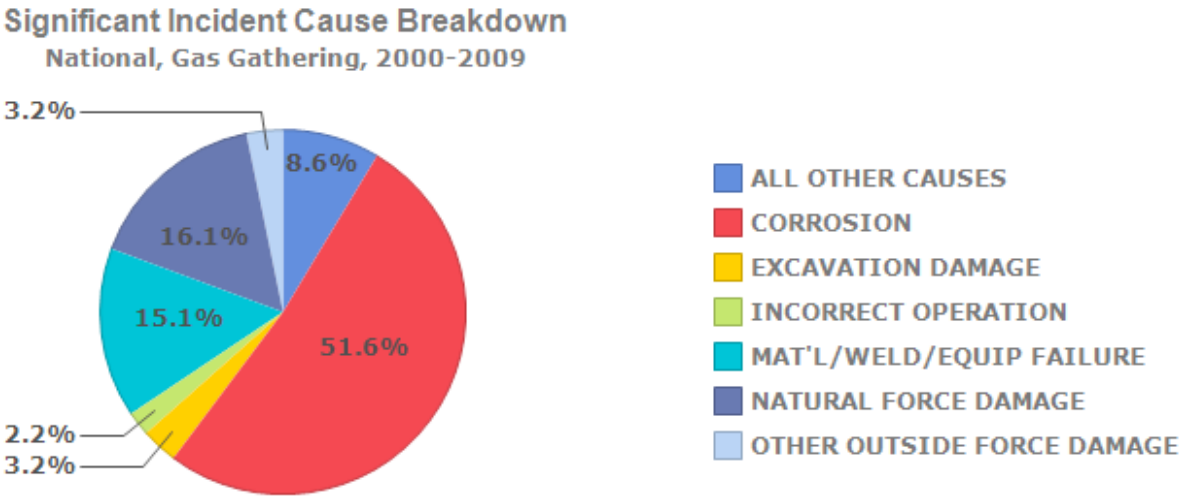


Source: PHMSA Significant Incidents Files February 17, 2010

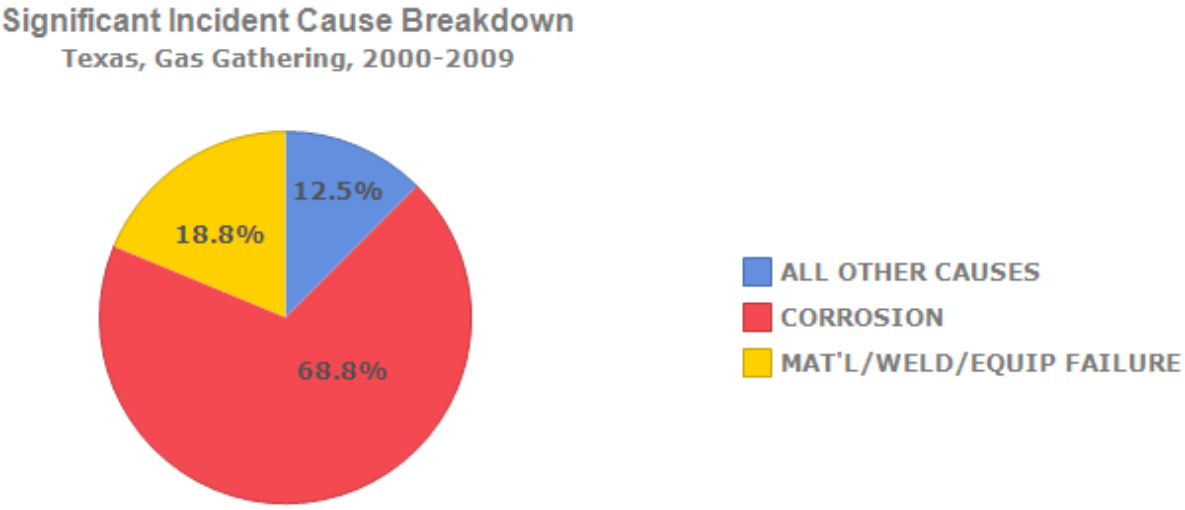




Source: PHMSA Significant Incidents Files February 17, 2010



Source: PHMSA Significant Incidents Files February 17, 2010



In Pennsylvania the miles of federally regulated pipelines in 2011 and number of significant incidents (January 2001-January 2012) were reported by PHMSA as follows:

	Pipeline Miles	Significant Incidents	Operators
Gas distribution lines*	47,143*	62	9
Gas transmission lines	10,011	26	10
Gas gathering lines	590	No data	No data
Hazardous liquids	2,638	28	6
Total	60,382*	116	

* Does not include the small retail service lines bringing gas to 2,752,264 customers.

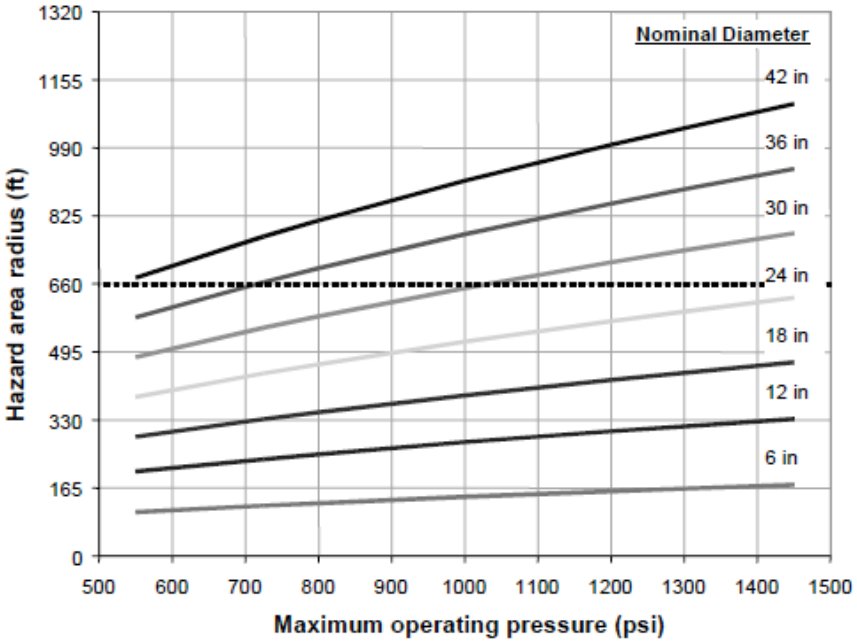
During the period 2002-2010 the Public Utility Commission reported 1,172 probable violations at gas pipelines within its purview. As in Texas, the state regulators are identifying far more probable violations than reported by PHMSA for Pennsylvania.

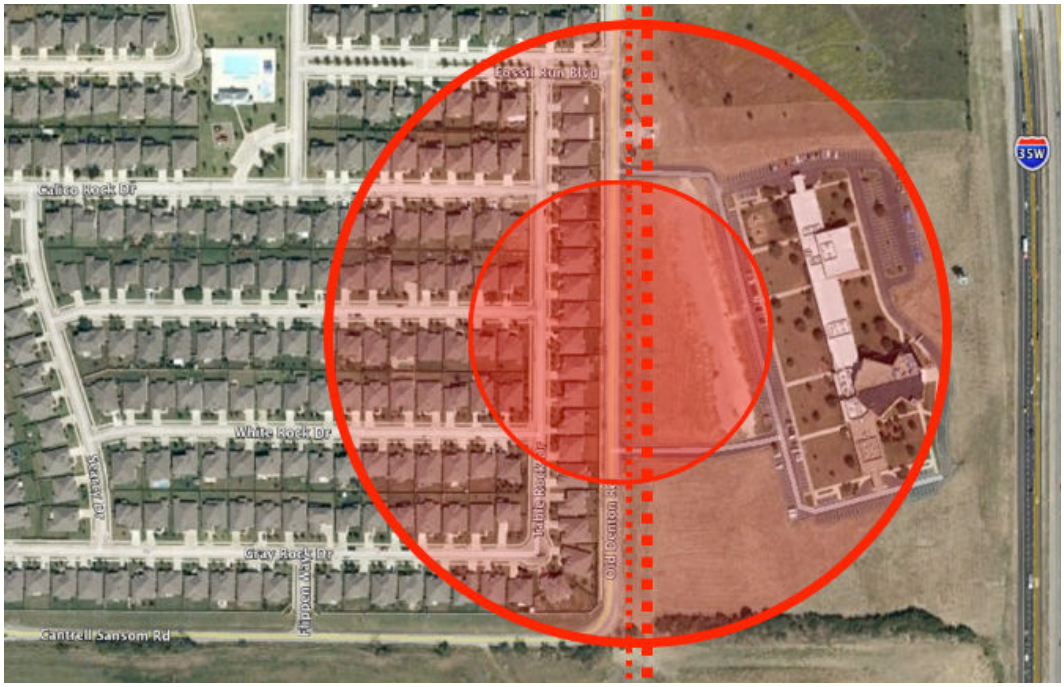
In 2000 the Gas Research Institute contracted with C-FER Technologies to produce "A Model For Sizing High Consequence Areas Associated With Natural Gas

Pipelines". That model has become instrumental in helping define potential impact zones around natural gas pipelines. The model is complex, but the basic idea is that by considering the diameter of the pipeline and the operating pressure, it is possible to predict roughly the impact area around the pipeline that could lead to human fatalities in the event of a catastrophic failure.

Below is a chart for the model that predicts these different zones. It is possible to use this graph to analyze the potential impact radius of specific pipelines. In the aerial photograph both a 30-inch diameter gas transmission pipeline and a 16-inch gas gathering pipeline occupy the same right-of-way parallel to each other. Both pipelines have a maximum allowable operating pressure (MAOP) of 1,200 pounds per square inch. Within the gathering pipeline's potential impact radius lie about 19 homes; within the transmission line's radius, about 78 homes and one large church. The model calculations are based on pipeline rupture in an open area, so there could be some temporary sheltering of the outer structures by intervening walls and trees.

The Potential Impact Radius (PIR) model illustrated below does not take into account the length of time before a pipeline's valves can be closed and the remaining gas in the pipe is released. During that time a failed pipeline can continue to act as a giant blowtorch igniting nearby structures. The resulting fire can encompass an area much larger than described by the PIR. The model may underestimate the size of impact areas for large diameter pipelines at high pressure. Pipelines, however, are not always operated at maximum allowable pressure. Thus such models must be applied carefully when adopted into local zoning ordinances.





Potential impact radii for a short segment of 30-inch transmission pipeline and 16-inch gathering line, both with maximum allowable operating pressure of 1,200 psi, using the Gas Research Institute model. Setbacks required by municipal ordinances could eliminate new land use conflicts such as these that otherwise will arise from land development subsequent to pipeline installation. From Pipeline Safety Trust.

Setbacks based on pipeline size and pressure are the most practical means of protecting the public from catastrophic pipeline failures, especially in rural areas.

In this incident of pipeline failure there was no fire or explosion. The crater was created by the pressure of the gas coming out. A section of pipe was hurled into the right background area of the photograph.

Sometimes rural areas are less fortunate. This corrosion incident occurred at Appomattox, Virginia, during 2008. The affected pipeline extends into Pennsylvania.

The actual consequences of the most significant pipeline incidents are investigated by the National Transportation Safety Board. PHMSA increased operator reporting requirements for incidents in May 2012.

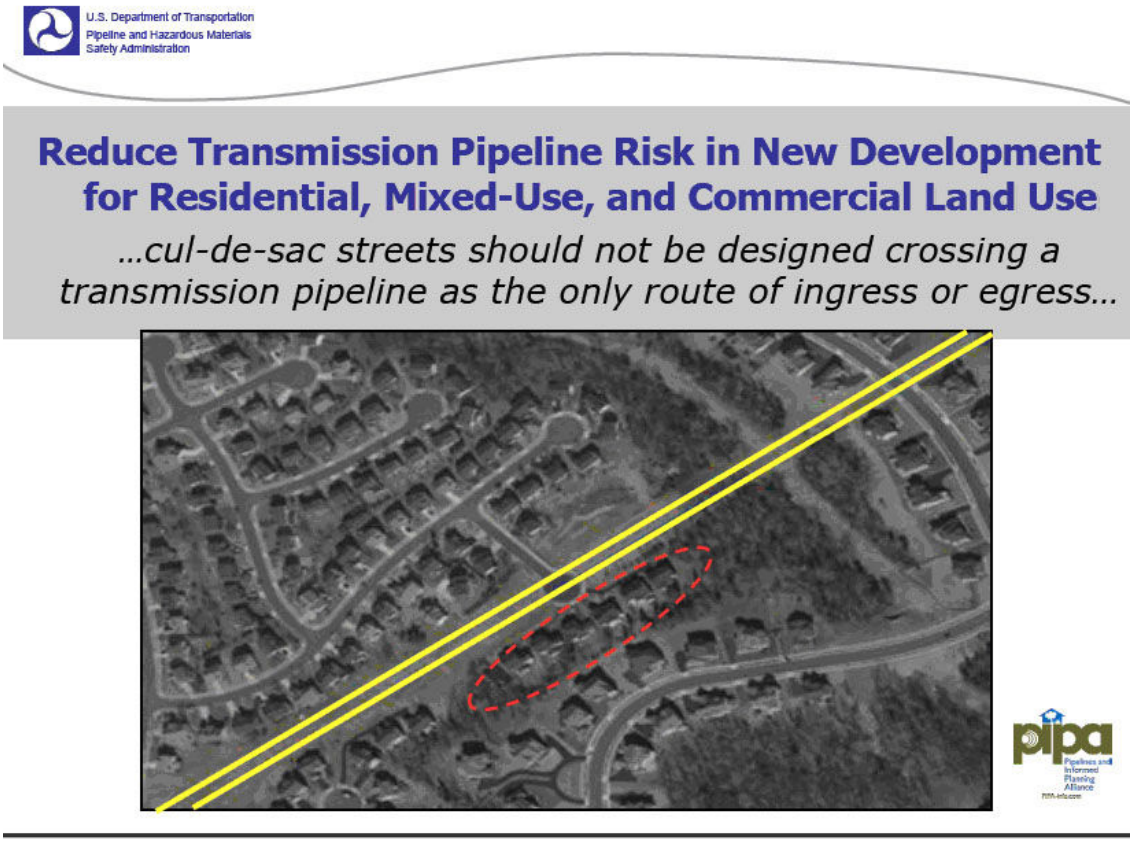
Left photo: 2010. Right photo April 2011. Eight persons dead, 58 injured, 38 homes destroyed, 70 damaged in this incident in San Bruno, California, 10 September 2010. The 30-inch pipeline was 62 years old and operated at 365 psig pressure (MAOP 400) on the day of rupture. Nearly 48 million cubic feet of gas were released.

Integrity Management (IM) may be well thought out, well managed, and well-implemented by many gas companies. The 2010 explosion in San Bruno, however, presents an example of how IM can fail as a safety program when a company's program is inadequate and regulators fail to identify its inadequacies. Pacific Gas & Electric lacked sufficient records on which to base its threat identification and operating pressures because it failed to maintain records showing the kinds of pipe or quality of welds. It chose an assessment method ("direct assessment") only valid for use when corrosion is correctly identified as the biggest threat to a segment. It chose not to use a hydrotest (a pressure test using water in the pipe) on that section of its pipeline. The direct assessment inspections of PG&E failed to identify the pipeline's shortcomings, in part because of the way its inspections were designed. As the National Transportation Safety Board pointed out, the inspections need to verify the truth of the operators' records, not just blindly trust them (http://www.pstrust.org/library/docs/NTSBReport.pdf).

Fire from the buildup of gas from a distribution line leak in a private home.

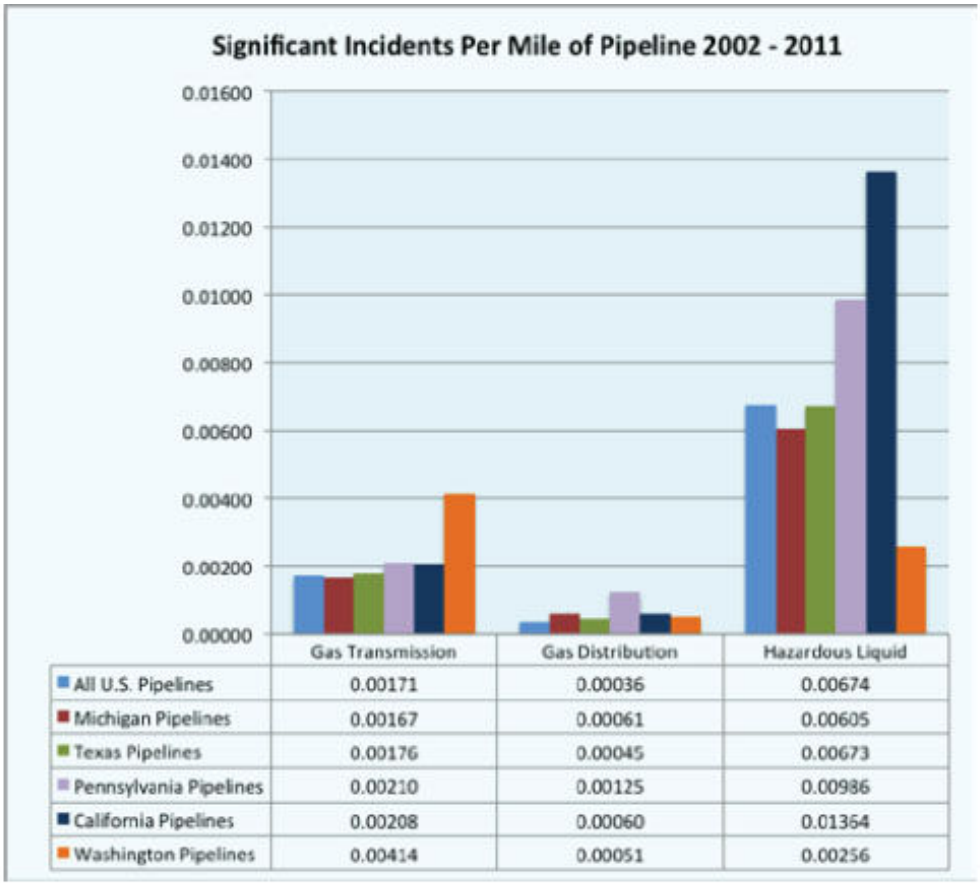
Loss of life and property from failures in gas distribution can be prevented only by continuous vigilance by regulators and the public, and by replacement of failing pipes. Current accounts of incidents are available at www.naturalgaswatch.org.

Dashed line indicates a section of natural gas pipeline, shown on the left in 1990 and on the right in 2002 aerial photographs. Damage potential has increased significantly along this section of pipeline during the interval bracketed by the photographs.



Data available from experience with significant damage incidents at federally regulated pipelines during the past decade in Pennsylvania, other states, and nationwide are summarized in the following chart. Significant incidents are those

where there is a death, an injury requiring hospitalization, property damage of $50,000 or more, liquid releases where there is an unintentional fire or explosion, or a liquid release of > 5 barrels of highly volatile liquid, or > 50 barrels of other liquids. Like other States where oil and gas are produced, the general quality of public information is not high in Pennsylvania, and many steps could be taken to increase public involvement in monitoring of pipeline safety (Sumi 2012).



	Gas Transmission	Gas Distribution	Hazardous Liquid
All U.S. Pipelines	0.00171	0.00036	0.00674
Michigan Pipelines	0.00167	0.00061	0.00605
Texas Pipelines	0.00176	0.00045	0.00673
Pennsylvania Pipelines	0.00210	0.00125	0.00986
California Pipelines	0.00208	0.00060	0.01364
Washington Pipelines	0.00414	0.00051	0.00256

Neighbor Involvement

If you have made it this far in this report then you have taken an important step to help ensure that pipelines in Lycoming County will be as safe as possible by educating yourself about how they work, who's in charge, and what needs to be done to ensure the public's safety is being looked after. Pipeline safety is like a three-legged stool with the industry, regulators, and public each serving as one leg of the stool and each playing a crucial role. If any leg of the stool falters, pipeline safety is at risk.

The natural gas industry uses its vast resources and expertise to install, operate and maintain safe pipelines. The regulators verify through inspections and data collection that the minimum safety regulations are appropriate and are being met, and where authorized, they use enforcement authority to ensure compliance. The public, including elected officials, serve as the watchdogs to push for greater

regulation and enforcement when necessary, and to make sure complacency doesn't set in.

The public can only do their part of the job if there is adequate transparency in what the industry and the regulators are doing. Adequate performance, inspection, and enforcement data need to be made easily publicly available so compliance can be verified. Adequate information about the specifications, contents, and routes of proposed pipelines also need to be easily available so people living in potentially impacted neighborhoods can decide for themselves if adequate safety precautions have been taken. The information that decision makers use to make pipeline safety decisions also needs to be available to the public so they can decide whether their officials are making decisions with full knowledge of the impacts and with the public's safety and welfare in mind. Only through verification can trust in pipeline safety grow, and only when government and industry is truly transparent is such verification possible.

Concerns with Pipeline Information Transparency

This report is based on information that is publicly available. The federal Office of Pipeline Safety (OPS) has made great strides in the past few years increasing transparency by making better incident, enforcement and inspection data available. The Texas Railroad Commission has a robust website (http://www.rrc.state.tx.us/) that includes pipeline maps, individual permits and annual reports, and information on excavation damage that is not available from the most other state pipeline regulators. Although somewhat complex to use, it shows what could be done (and done better) in Pennsylvania, where gas pipelines are to expected increase tremendously during the next several decades.

A large amount of information is publicly available and verifiable, yet there is still important information missing, which may lead to widespread public distrust of the process. With the current electronic abilities to post nearly unlimited materials online, both industry and government could create more trust by posting information that they already are required to prepare, instead of creating barriers by expecting the public to go through a formal public information request process. The gas industry in particular provides very little information about their pipelines and associated operations, maintenance, and inspection.

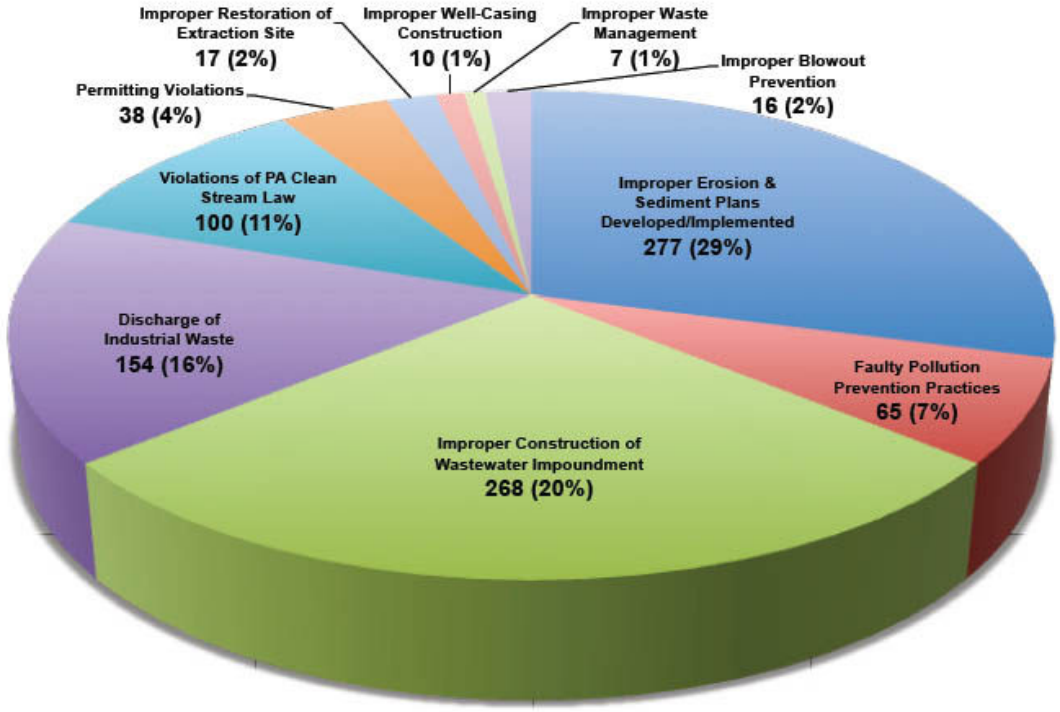
One of the very basic measures of pipeline safety is incident data. OPS has worked hard to upgrade their incident database in the past years, and now provides state-by-state breakouts of incident data including the specifics for each incident on the transmission lines they regulate. The Texas RRC provides data showing how vastly more incidents on intrastate pipelines were reported to them than were reported to OPS for interstate pipelines in Texas during the same time periods, but no specifics are provided regarding these incidents that allows analysis of safety trends or gaps in regulations.

One other concern is that often security issues are raised as a reason to prevent the public from access to important pipeline information. These concerns often appear to be overblown, and a well informed public increases safety in many ways.

Environmental Consequences

As discussed above, pipelines are involved at many steps in the drilling of deep shale gas wells and the transport of natural gas to processing plants and end users. Pipelines and associated facilities designed, constructed, and maintained in accordance with the best available management practices serve to minimize environmental damages as well as maximize resource recovery. Laws, regulations, permit reviews, and inspection requirements provide some opportunities for outside verification of pipeline conditions. But there are significant gaps in the regulatory process in Pennsylvania, and compliance is not universal.

A major report focused on potential impacts of shale gas development in the European Union pointed out the lack of systematic baseline monitoring in the United States, where most such development has occurred to date, along with the lack of centralized data on failures and incidents (Broomfield 2012). Lack of such information contributes to public concern regarding risk of damage to people and the environment. This is true of Pennsylvania in particular.



952 “serious” violations of PADEP regulations at shale gas wells by 43 drillers over a 30-month period, 2008-2010.

The Pennsylvania Land Trust Association (PALTA) in 2010 reported on 1,435 violations of Marcellus gas well permits recorded by PADEP over the 30-month period 2008 through mid 2010. These violations were produced by 43 drillers at active wells during a period when more than 3,600 permits were issued. At least two thirds of the violations (952) were deemed by PALTA as likely to entail significant impacts, primarily on water resources. Given the track record of PADEP in monitoring compliance with its permits, the statistics provided to PALTA must be regarded as a minimum estimate of actual

violations at Marcellus Shale gas wells statewide. This one-time PALTA effort to classify violations was not based on independent analysis of PADEP files or any on-ground inspections, just a thoughtful review of PADEP spreadsheets. When they were tallied by PALTA**,** the 43 permittee drilling companies averaged from 0.8 to 11.0 violations *per well***.** As shown in the figure above, more than 370 violations were reported for faulty pollution prevention and wastewater containment, more than 150 violations for illegal discharge of industrial waste, and 54 violations for improper casings and faulty blowout controls. It is extraordinary that this number of violations was *recorded*, given the minimal information currently required by PADEP in applications for Marcellus Shale gas wells and its small number of field inspectors.

Clean Water Action (2012) summarized the shale gas violations during 2011 as reported by PADEP as follows:

Total Violations for 2011	1,192
Notice of Violation Issued *(35% of total violations)*	421
Consent Order & Agreements Issued *(0.05% of total violations)*	7
Consent Assessment of Civil Penalties Issued *(6% of total violations)*	80
Violations Receiving No Enforcement Action *(63% of total violations)*	753
Violations Receiving No Fines *(93% of total violations)*	1,105
Total Fines Collected	$2,452,988

Source: PA Department of Environmental Protection website as of May 1, 2012

As of March 2012, PADEP had reported 24% (134) of the 565 active Marcellus wells in Lycoming County as having incurred 601 violations (see chart below). Available PADEP statistics do not address violations associated with gas pipelines. The most detailed information currently available on violations and enforcements of oil and gas regulations in Pennsylvania is that provided by Sumi (2012).

Pollution incidents occasionally rise to the attention of the news media. Gas-caused fires, explosions, and deaths, whether at well pads or pipelines or compressor stations or homes, often gain wide publicity. Yet there are few comprehensive records of pipeline incidents or pipeline-related pollution episodes in Pennsylvania to show which operators are most responsible and what circumstances are most likely to lead to incidents.

State lacks consistent record keeping for natural gas drilling contamination, leak incidents

BY LAURA LEGERE (STAFF WRITER)
Published: June 21, 2010

Few spills make news.

SCRANTON TIMES-TRIBUNE

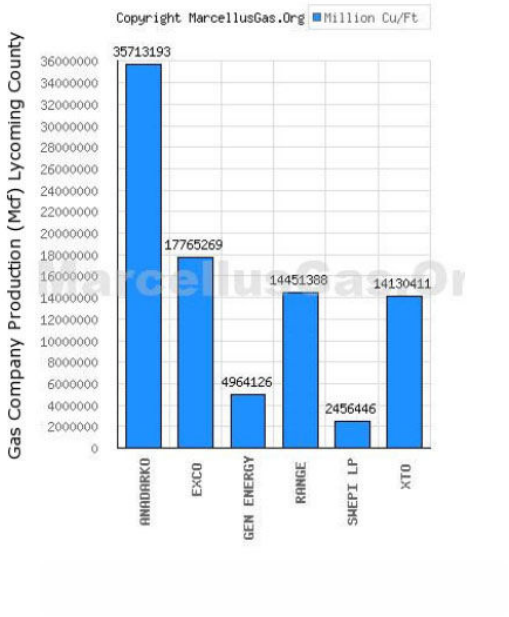
Data on well permits, production, and violations in Lycoming County also have been compiled from PADEP records by MarcellusGas.org. Gas production drives the need for gathering and transmission pipelines, and the number of violations recorded at well sites may offer some insight into the concern at various companies to comply with good construction practice in their pipeline work. As of May 2012, permits for shale gas wells had been approved in 23 municipalities in Lycoming County. Setback requirements from existing buildings in current Pennsylvania law may limit the number of wells drilled in the more densely settled parts of Lycoming County, unless surface landowners elect to allow drilling in closer proximity to their homes and other structures. All well pads will be connected to the pipeline network.

Graph: Marcellus Well Permits per Township for Lycoming County, Pennsylvania

Both well pads and pipelines can be sited in inaccessible sections of Lycoming County and other Pennsylvania municipalities. When emergencies occur such as blowouts or ruptures, experienced operator crews may have to travel long distances and require many hours to reach the broken gas facilities. Emergency response training will increase in Pennsylvania, but the need for emergency responders has grown more rapidly than response capability. Public safety has deteriorated as a result of the limited PADEP staff available to inspect gas development and transport sites before, during, and after construction.

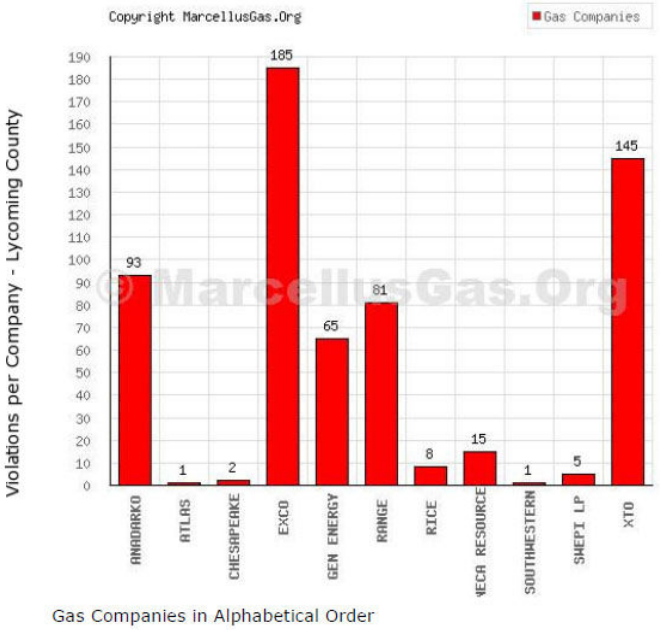
The sudden arrival and rapid growth of shale gas development have outstripped the laws and regulations of the Commonwealth and the ability of agency staff to review and inspect ongoing activities. Thus the PADEP reports of violations must be viewed as a minimum estimate of non-compliance. An industry-funded review of PADEP violation notices reported that for 190 wells drilled in 2008, there were 99 violations issued (about 52% of wells; Considine *et al*. 2012). The proportions dropped in later years: 286/710 (40%) in 2009; 428/1,405 (31%) in 2010; and 331/1,248 (27%) in the first 8 months of 2011. Such statistics may underestimate violations in Pennsylvania significantly (Connor, Galbraith & Nelson 2012). Even the sanguine, industry-sponsored Considine report demonstrates that fines for violations represent a negligible cost of well construction in Pennsylvania, and have not motivated all gas operators to avoid impacts that are deemed by the industry

Graph: Gas Production (Mcf) per Gas Company for Lycoming County, Pennsylvania



Based on data from December 31st, 2011

Graph: Violations by Gas Company for Lycoming County, Pennsylvania



Based on data from March 15th, 2012

to be readily avoidable. The industry expects adverse impacts now commonly experienced in the Pennsylvania gas fields to be avoidable altogether in New York, which is proposing much stricter shale gas regulations than currently exist in Pennsylvania, if the moratorium on shale gas development is lifted there. Serious regulation has not been implemented in Pennsylvania, and probably will not be, considering the industry's cash contributions to elected officials and lobbyists (Kaplan & Browning 2010, Browning & McNeil 2012).

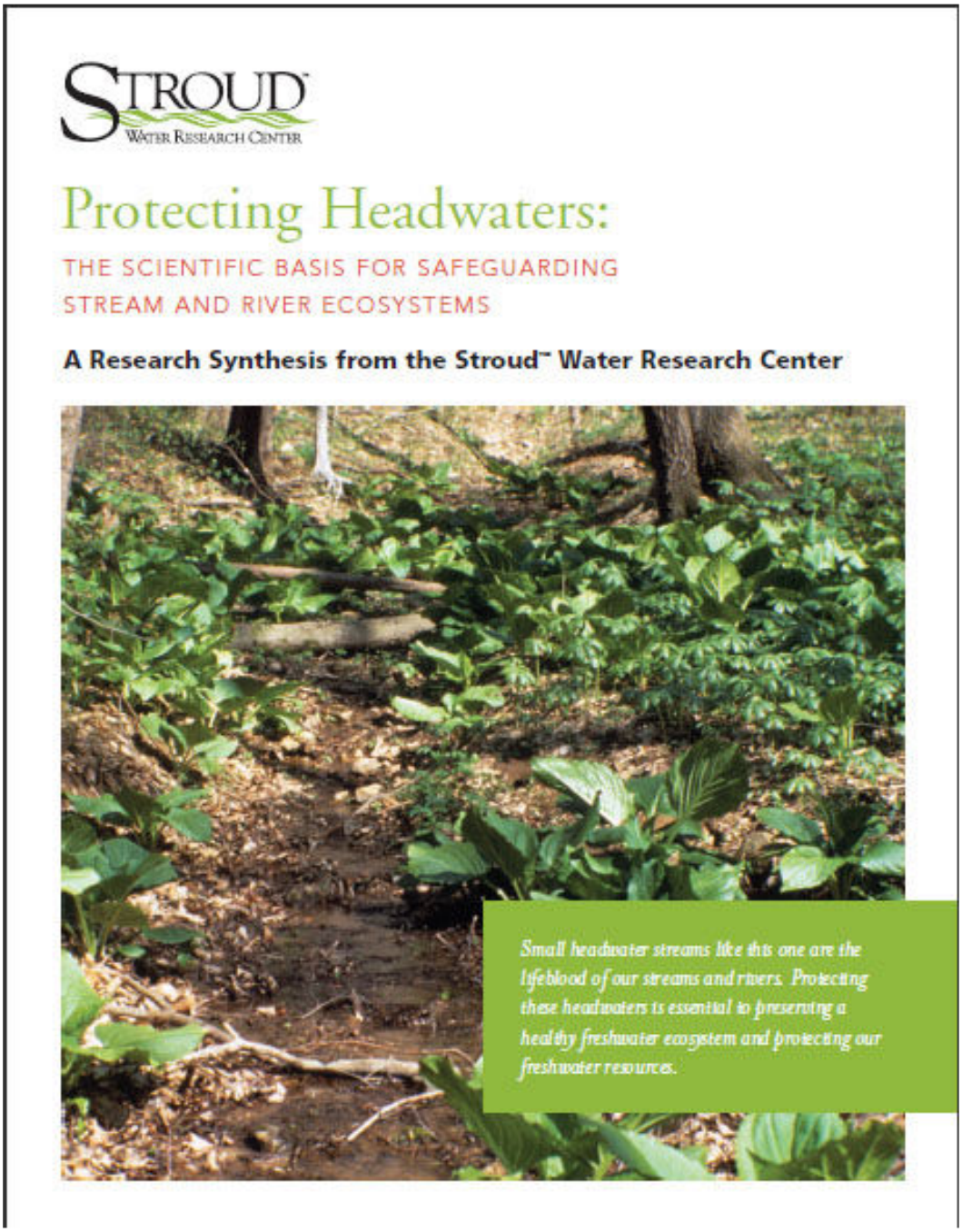
Well pad fire in Avela PA, February 2011.

This small frackwater pipeline joint failure caused loss of more than 10,000 gallons of fluid resulting in a fish kill in High Quality Brush Run watershed, Washington County, 2009. Damage to fish, salamanders, frogs, and oligochaetes here was recorded by PADEP.

Despite past experience with the boom-and-bust economic cycles of prior natural resource exploitation, Pennsylvania institutions showed limited ability to control the adverse effects of the natural gas industry during the first decade of the twenty-first century. More than 90% of the anticipated gas wells have not yet been started. Absent a major change in attitudes among the public and their elected officials, shale gas development is on its way to causing widespread, permanent environmental degradation. The technological inventiveness that makes shale gas ever more developable and economic is not being focused on eliminating its adverse impacts.

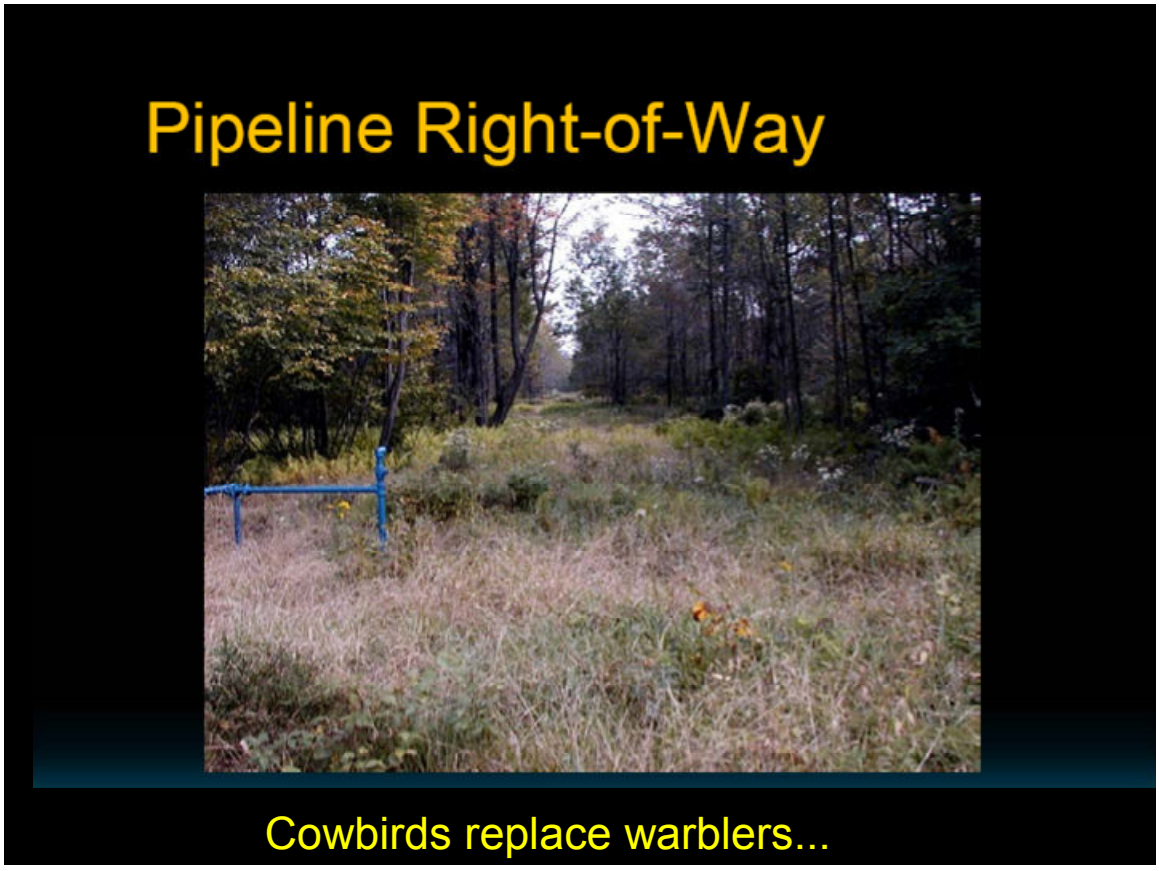
Fracking water and gathering pipelines undergo permit review (by PADEP) when they cross or encroach upon wetlands, large streams, and other bodies of water or (by PennDOT) when they encroach upon state roads. Thousands of stream crossings are being approved. How much local review they will receive is uncertain since passage of Act 13 of 2012. Soil erosion and sediment control on steep slopes are sometimes ignored. Gas wells require permit approval from PADEP for intended compliance with its regulations aimed at protecting land, air, and water resources. Well applications show well pads, access roads, return water storage facilities, and proposed well casing, but not fracking water or gathering pipelines. Actual compliance with PADEP requirements is far from complete, and enforcement efforts to date have not been fully effective. Interstate transmission pipelines garner somewhat greater scrutiny during siting, construction, operation, and abandonment. Federal requirements are summarized at http://ferc.gov/industries/gas/enviro/wetland.pdf. Distribution lines are regulated to some extent by the PUC and municipal engineers, but consistently cause damage to human life and property, especially where there are old, cast-iron mains nearing the end of their expected useful life.

Stormwater management regulations and policies for oil and gas exploration, extraction, and transport facilities operating in Pennsylvania are less comprehensive, significantly less strict, and subject to far less regulatory review than virtually any other construction or industrial activity in the state. The current regulatory process for review, approval, and operation of oil and gas exploration, extraction, and transport facilities fails to ensure design and implementation of both erosion control and stormwater management measures that are sufficient to protect water quality. This is particularly true for headwater streams, where PADEP review of encroachments and obstructions is waived in watersheds less than 100 acres, despite the growing recognition of the vital importance of headwaters to downstream fisheries and water quality.

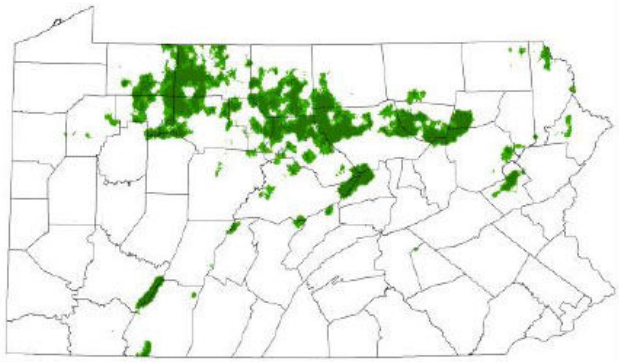


Recreational fishing, hunting, and hiking are major economic mainstays of the Endless Mountains region of Pennsylvania that includes Lycoming County. To the extent that gas development and pipeline construction disrupt streams and landscapes for decades, the tourism and outdoor recreation industries in Lycoming County are at risk of damage from landscape industrialization.

All new pipelines, except to the extent that they use existing utility corridors and road rights-of-way, necessitate clearing of corridors. Cropland and lawn can be reestablished above buried pipelines, but forest cannot. Pipeline corridors are maintained devoid of woody plants to allow access for inspection and maintenance. Even temporary, aboveground pipelines entail clearing of forest so that equipment can install and remove the pipes. This permanent fragmentation of forest is devastating for species that require large, closed-canopy stands, while forest-edge species are favored. Forest fragmentation is a major concern in the sparsely populated forests of northern Pennsylvania. At minimum, rights-of-way should be managed to prevent the spread of non-native, invasive plants into Pennsylvania forests.

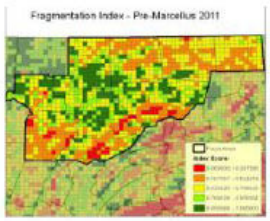


Core Forest Bird Habitat

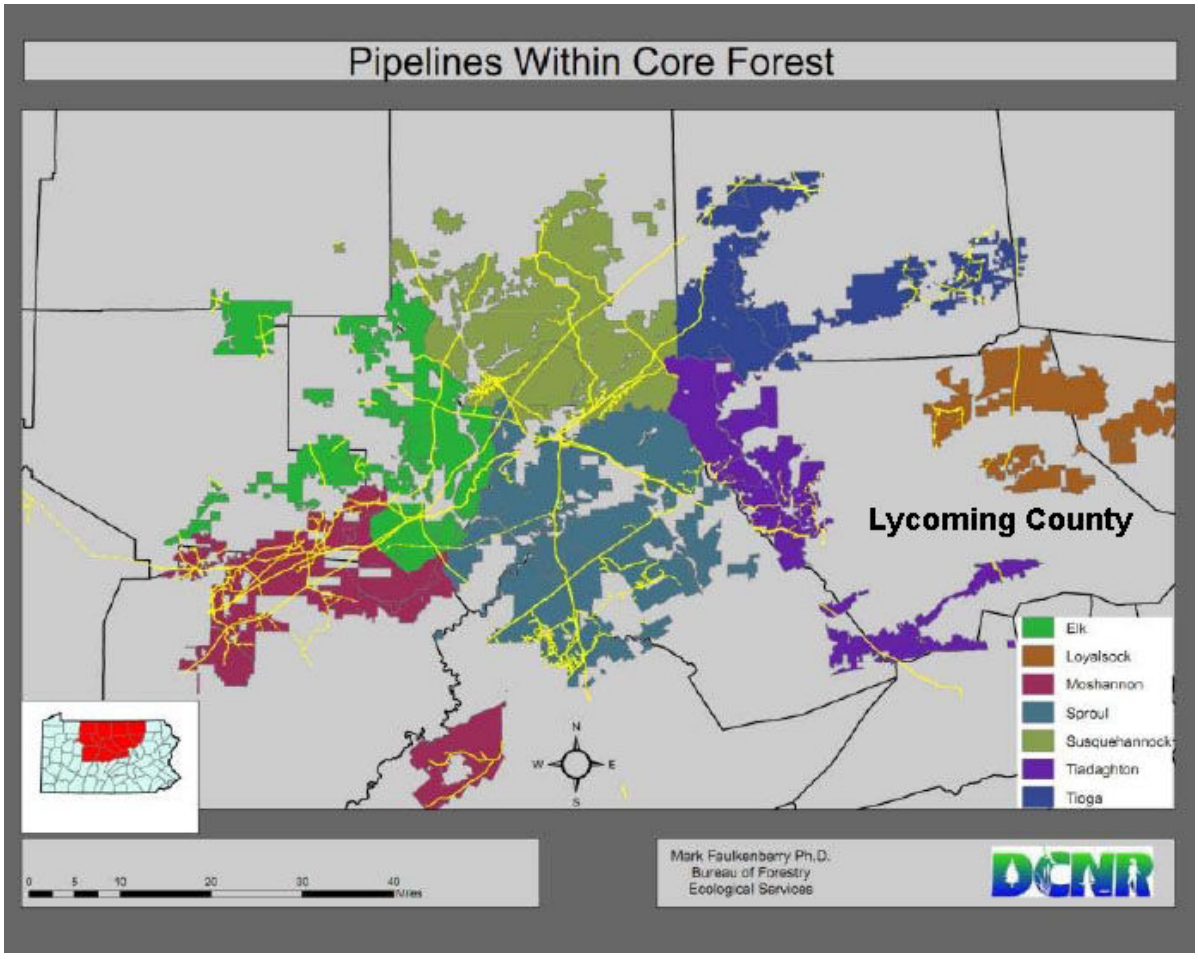


Source: 2nd PA Breeding Bird Altas point count data, 2011.
Top 10% of 12 forest interior bird populations is Core Forest (light green), top 5% is Critical Forest Bird Habitat (dark green).

- 275 blocks in study area ranked in top 5 or 10 % for state
- Mean Fragmentation scores = 0.85±0.006
- Range 0.59-1.00
- 75% >0.78



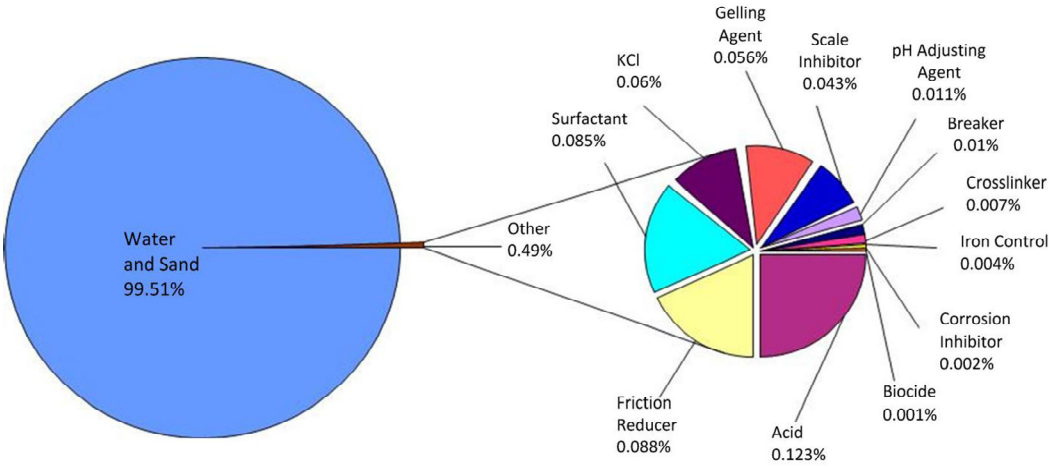
2nd PA Breeding Bird Atlas – Wilson and Brauning



The construction impacts of pipeline crossings of roads and rivers often can be minimized by using horizontal borings rather than open trenches. Some operators are more willing than others to commit to the higher cost of horizontal boring. Borings improperly performed have polluted Pennsylvania streams with drilling mud. At present pipeline crossings of streams are being authorized with minimal scrutiny of the resources at risk and with virtually no followup to determine the extent of damage to water quality or aquatic organisms. Above-ground pipelines are exposed to damage by floodwaters and debris, as well as by damage from vehicles.

Whether conveyed by truck or by pipeline, shale gas well return water contains many chemicals in toxic amounts. Some of those chemicals are naturally present in water derived from deep shale: brine many times saltier than seawater, radioactive isotopes, strontium, barium, arsenic. Other chemicals have been added to maximize the success of frackwater to release gas---such as surfactants, acids, lubricants, and biocides. Spills are common at well pads. Pipeline ruptures can wipe out stream ecosystems for miles below spills. To the extent that gas and fluids escape the well pipes that they are supposed to travel, they can damage water supply wells in addition to streams, lakes, and wetlands.

Typical Hydrofracturing Fluid



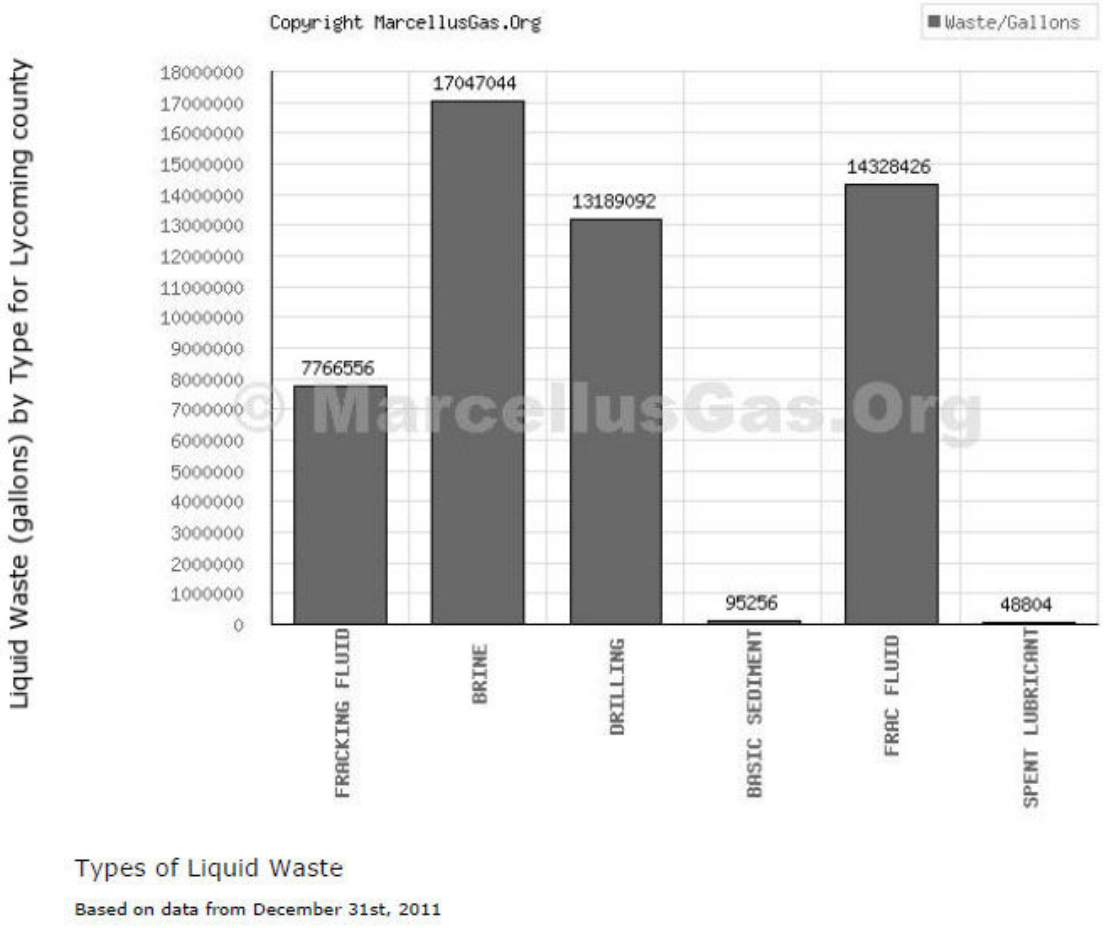
"Slickwater"

Table 1. Water quality parameters measured in Phase 1 water wells in comparison to Pennsylvania drinking water standards and to typical concentrations in Pennsylvania water wells and Marcellus wastewaters. All concentrations are reported in units of mg/L except pH.

Parameter	Drinking Water Standard[1]	Approximate Median Concentration in Typical Pennsylvania Groundwater[2]	Approximate Median Concentration in Typical Marcellus Wastewater[3]
pH	6.5 to 8.5	7.50	6.60
Total Dissolved Solids	< 500	163.0	67,300
Total Suspended Solids	-	1.0	99.0
Barium	< 2.0	0.070	686
Iron	< 0.30	0.20	39
Manganese	< 0.05	0.01	2.63
Sodium	-	6.87	18,000
Hardness	-	86.1	17,700
Strontium	-	0.26	1,080
Chloride	< 250	5.3	41,850
Sulfate	< 250	18.0	2.4 to 106
Nitrate-Nitrogen	< 10	0.50	0.1 to 1.2
Bromide	-	0.016	445
Dissolved Organic Carbon	-	<1.0	62.8
Dissolved Methane		No data available	No data available
Oil & Grease	-	<5.0	6.3

[1] Pennsylvania Department of Environmental Protection, 2006. [2] Pennsylvania State University, 2011; Davis et al., 2004; and Thurman, 1985. [3] Hayes, 2009.

Graph: Liquid Waste in Gallons, by Type: Lycoming County, Pennsylvania



During the period 18 January 2011 through 24 June 2011 the PADEP Bureau of Oil & Gas made 4,157 inspections of unconventional wells statewide yielding 633 violations.[47] Nearly half of the violations fell into one of five categories:

83 improper storage, transport, processing, or disposal of residual waste
79 ineffective erosion and sediment controls
55 insufficient capacity pits or tanks
36 absences of pollution prevention measures
36 improper well casings.

On 19 May 2011 the Bureau conducted a well site training inspection for supervisors from across the Commonwealth to evaluate inspection methods and ascertain uniformity in documentation. The site chosen was a surface coal mine in Centre County that had undergone reclamation 25 years previous. Three well pads in various stages of completion were inspected. The site included access roads, a rock borrow pit, a central frackwater impoundment, and crossings of streams and wetlands. Numerous erosion and sediment control measures were missing. Many violations were recorded throughout the site, grouped into nine categories:

Inadequate erosion and sediment (E&S) controls at various locations
Failure to maintain Best Management Practices (BMPs)
Improper installation of BMPs
Failure to register a 105 General Permit for a wetland encroachment
Failure to follow the E&S plan for the stream crossing
Clean Streams Law violations for allowing the transportation of sediment into the Waters of the Commonwealth (wetland & intermittent stream)
Failure to obtain an OG-57 waiver for building a well site closer than 100 feet to a body of water
Sediment being transported beyond the limit of disturbance
Lack of two feet of freeboard depth in the drill cutting waste pits

No conclusions were reported regarding the significance of environmental impacts from these violations. No pipelines serving the wells were mentioned. As a result of the exercise, statewide inspection forms were revised to reflect more accurately the kinds of violations observed at this site.

At every step of the process, methane and other components of natural gas are released to the atmosphere. Large quantities of gas returning to the surface with frackwater are vented or flared for convenience, although most could be captured and profitably sold. Valves, meters, and compressors leak gas to the atmosphere every time they interrupt pipeline gas flow. Energy is needed to push gas through pipelines against friction. The combustion of gas or diesel as fuel to run compressors is another significant source of air pollutants and carbon dioxide. USEPA just completed its first New Source Performance Standards for air emissions from the oil and gas industry

47 http://files.dep.state.pa.us/OilGas/OilGasLandingPageFiles/NOV/FINALMarcellusEnforcementProjectFindings.pdf).

during April 2012.[48] These include allowable emissions for pipelines and associated facilities such as processing plants and city gates.

Shale gas production, to a much greater extent than that of conventional natural gas, contributes both methane (a potent greenhouse gas) directly through leaks and other discharges and carbon dioxide (after burning) to the atmosphere. Absent

[48] 20120417finalrule.pdf

stringent application of leak-reducing controls throughout the industry, shale gas use contributes at least as much to global temperature rise as does the use of coal as a source of energy (Howarth *et al.* 2012).

Air quality effects on human health are also of significant concern. When small leaks exist or valves are periodically vented at stations, storage facilities and along pipelines, fugitive emissions are released. These include not only methane but also volatile organic compounds (VOCs) and other contaminants such as hydrogen sulfide. The process of dehydration can also result in the release of airborne chemicals that are dependent on the nature of the gas and may include benzene and toluene[49]. Many residents of Dish, Texas, continue to suffer from air quality issues believe to be related to the town's eleven compressor engines, piping, metering, and valves.[50]

The increasing availability of accurate sensors capable of locating gas leaks portends an increase in understanding of where gas is escaping, and thus a more efficient deployment of maintenance efforts to repair leaks before disasters occur. Gas producers, transporters, and distributors, need regulatory stimulus to use such technology and to make the necessary repairs promptly. If that occurs on a widespread scale, the damaging contribution of waste gas to global warming can be reduced. In areas affected by shale gas production, careful measurement of pre-development background methane concentrations in soils, water, and air should become a routine requirement.

Uncertainties currently surround the significance of elevated natural gas concentrations for human health at levels below the explosive limit. People who use gas for residential heating and cooking typically experience higher methane concentrations in their dwellings that those not using natural gas. Such consumers have a choice of fuel. People living in proximity to shale gas wells, however, may experience high gas concentrations in their well water and in the air entering their basements through cracks as a result of gas resource development imposed upon them. Passive venting of private wells is sometimes required of gas producers in Pennsylvania to reduce risk of explosion. Homeowners suddenly confronted by gas in their water supply typically switch to bottled water for human consumption. Water used for other purposes such as showering, however, typically retains elevated concentrations of methane. Given the association of normally occurring radioactive materials with the Marcellus Shale formation, natural gas may serve as a proxy for elevated levels of radon in gases escaping from shale gas wells. This situation warrants study for its implications for human health.

In addition to the pipelines themselves, compressor stations along natural gas pipelines have been a particular source of many environmental issues. Noise pollution is a serious concern as the powerful engines need to produce tens of thousands of horsepower and operate 24/7. *Arkansas in Balance: Managing the Risks of Shale Gas* notes that noise levels have been measured at 70 decibels (about the same as an up-close vacuum cleaner) on a porch of a home near a station. Such unrelenting noise can cause problems with fetal development and medical conditions including hypertension and heart disease, hearing impairment, digestive problems, and sleep disturbance.[51]

Legislative protection to date has been afforded to Pennsylvanians by requiring small setbacks from the heavy industrial activities associated with shale gas well drilling and hydrofracturing. Municipalities are still allowed to prohibit the noise-producing compressor stations needed along pipelines at intervals of about 50 miles from being built in residential zones.

Natural gas compressor stations have also been connected with water pollution, air pollution, and soil contamination. Since 2009, PADEP has received at least four reports of equipment malfunction in Bedford County at Spectra Energy's Steckman Ridge Gas Compressor Station. One report of an "emergency shutdown" on August 23, 2010, resulted in 1,629 pounds of used "lubricating oil" being sprayed onto fertile farmland and residential property.[52] The importance of proper siting within a right-of-way was underscored by an article in the 6 February 2011, *Dallas Post.* According to the local paper, residents of Dallas Township, Pennsylvania, filled the supervisors' meeting to voice concerns and seek answers about a planned natural gas compressor station 1,345 feet from one of the Dallas public schools.[53]

---

49 http://www.earthworksaction.org/airpollutionsources.cfm - VENTING
50 http://www.npr.org/templates/story/story.php?storyId=120043996
51 http://arpanel.org/content/index.php/Environment/Arkansas-in-the-Balance-Managing-the-Risks-of-Shale-Gas-Development-in-the-Natural-State.html
52 http://www.archive.org/details/Spectra-Energy-Steckman-Rige-Natural-Gas-Compressor-Station-files
53 http://www.timesleader.com/TheDallasPost/news/Proposed_natural_gas_compressor_station_is_all_the_buzz_02-06-2011.html

Public subsidies for fossil fuels over many decades have led to tremendous dependence on these energy sources, both in Pennsylvania and in the United

States. Current laws, tax codes, and regulations greatly favor coal, oil, and natural gas production at the expense of public health, public safety, and the environment. Producers and purveyors of fossil fuels are well funded by private investors. They use both campaign contributions and advertising to maintain their ability to impose impacts onto the public and the environment while extracting private profit. Despite the guarantees of Article 27 of the Pennsylvania Constitution and several implementing statutes, environmental protection, public health, and public safety are compromised by fossil fuel production and use in Pennsylvania. The public must direct its elected officials and regulating bureaucrats to force the true costs of shale gas and other fossil fuels to be charged to energy producers, so that the market incentive develops to rely upon renewable resources.

PADEP environmental permits for activities in Lycoming County are issued by the

DEP Northcentral Regional Office
208 West Third St. Suite 101
Williamsport, PA 17701
Phone: 570 327-3636 (business hours)
570 327-3636 (after hours).

Conclusion

After studying the issues discussed in this report, and after publishing several study guides to shale gas development and pipelines in Pennsylvania, the following position statement on pipelines was adopted by concurrence by the League of Women Voters of Pennsylvania on 5 June 2011.

LWVPA Position on Pipelines

The League of Women Voters of Pennsylvania recognizes that pipelines are a relatively safe and efficient means of transporting natural gas.

Based on the position adopted by the League of Women Voters of Pennsylvania on May 1, 2010, we support the maximum protection of public health and the environment in all aspects of Marcellus Shale natural gas production, site restoration, and delivery to the customer by requiring the use of best practices and promoting comprehensive regulation, communication, and adequate staffing across government agencies.

Following study of the transmission, regulation, legislation, inspection and enforcement of pipelines, the Leagues of Southeastern Pennsylvania Region (LWVSEPR) and the League of Women Voters (LWV) of Indiana County reached a consensus position to enhance the protection of the public and the environment. In addition to transparent processes, the League of Women Voters of Pennsylvania, in concurrence with the LWVSEPR and LWV of Indiana County support:

• Siting of natural gas pipelines through coordinated federal, state, regional, and local efforts that are objective and responsive to safety considerations, accurate environmental assessments, county conservation districts, land use planning

agencies, and local communities. The process should include adequate public notice of local stakeholders from the beginning of the process, convenient input venues, timelines reflective of the PA Municipal Planning Code, consistency with existing state and local regulation, and a mediation process to resolve conflict.

• Regulation for the safety of natural gas pipelines that encompasses the entire transmission system, including gathering lines, with standard location data, current, comprehensive maps that are publically accessible, on-going inspection, One Call coverage, odorization, emergency/hazard response contingencies, adequately funded maintenance plans, a reserve trust to compensate for unanticipated events, and mandated best practices to promote the integrity of the system.

• Standardized and comprehensive inspection of all natural gas pipelines by an adequate number of qualified inspectors who are continually updated in their training and employ best practices including on-site evaluations, objective information to verify self-reporting, accurate data gathered from sophisticated technological devices, and the support of local agencies such as emergency response teams and county conservation districts.

• Enforcement of regulations for all natural gas pipelines that demonstrate standardization, best practices, costly penalties that encourage compliance, and fines consistent with the nature of the violation.

• Legislation at the State level that would
  - authorize the PA Public Utility Commission (PUC) to regulate all natural gas pipelines for safety without providing the right of eminent domain for gathering lines, and
  - promote the development of a regional interstate compact for siting interstate pipelines.

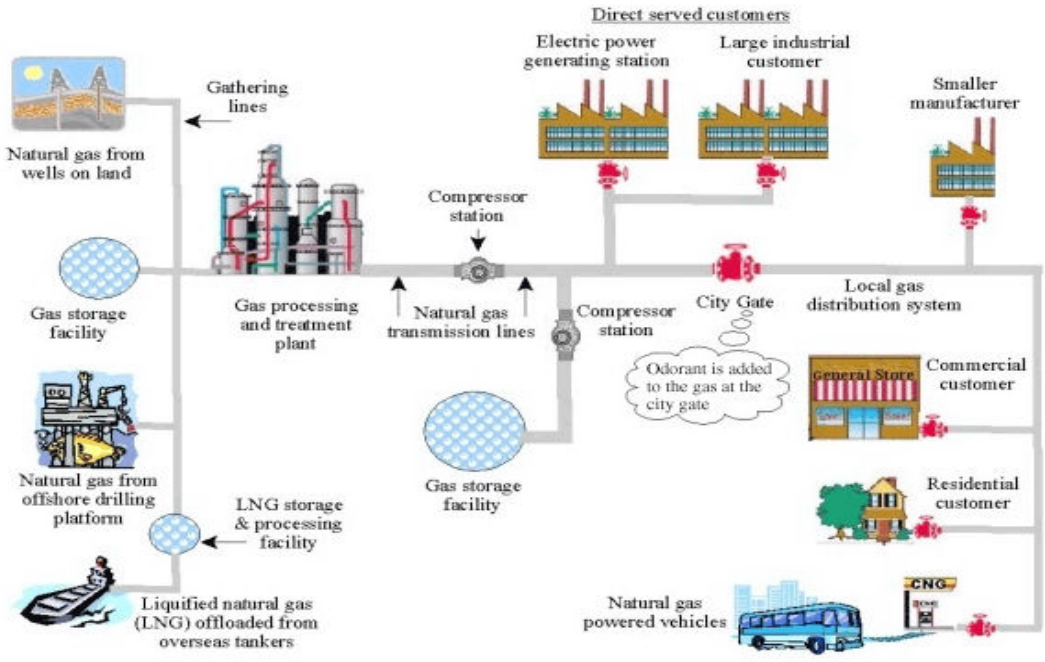
• Ordinances/zoning regulations, where and when possible, for natural gas pipelines at the local level sited and designed to protect the public, prevent environmental degradation, and reflect community or county-wide land-use planning.

• Measures to insulate regulatory agencies from political influences and other considerations provided by the natural gas companies that they are authorized to regulate. This would prevent the appearance of a conflict of interest and potential ethical concerns.

On May 1, 2010 The League of Women Voters of Pennsylvania adopted a position that supports the maximum protection of public health and the environment in all aspects of Marcellus Shale gas production and delivery to the customer.

For many years the natural gas transmission system in the United States was well summarized by the diagram below. Today, however, the glut of gas on the United States market and soaring international prices offered for gas are leading to intense activity to export liquified natural gas, rather than import it from abroad. Shale gas from Pennsylvania likely is headed for international markets as soon as the necessary infrastructure can be made operational.

The Natural Gas Transmission System



Useful Sources of Additional Information

Federal pipeline safety regulations
http://phmsa.dot.gov/pipeline/regs

http://primis.phmsa.dot.gov/comm/reports/stenforce/StateEnfDet_state_PA.html?nocache=2183

http://primis.phmsa.dot.gov/comm/StatePages/Pennsylvania.htm?nocache=3470

Integrity Management for Natural Gas Transmission pipelines:
http://primis.phmsa.dot.gov/gasimp/index.htm

Integrity management for natural gas distribution pipelines:
http://primis.phmsa.dot.gov/dimp/?nocache=9404

Pennsylvania Public Utility Commission
http://www.puc.state.pa.us/

Pennsylvania Department of Environmental Protection
http://www.portal.state.pa.us/portal/server.pt/community/oil_and_gas/6003

American Petroleum Institute
http://committees.api.org/pipeline/standards/docs/1162nonprintable.pdf

Natural Gas Supply Association for many aspects of natural gas, including the history of gas regulation
www.NaturalGas.org

Pennsylvania Citizens Marcellus Shale Commission Final Report (2011)
http://CitizensMarcellusShale.com/

Pennsylvania Governors Marcellus Shale Advisory Commission Final Report (2011)
http://www.mde.state.md.us/programs/Land/mining/marcellus/Documents/MSAC_Final_Report.pdf

Pennsylvania League of Women Voters Marcellus Shale Study Guides (2009-2011)
http://www.mde.state.md.us/programs/Land/mining/marcellus/Documents/MSAC_Final_Report.pdf

Pennsylvania Department of Conservation and Natural Resources, Bureau of Forestry. 2011. Guidelines for Administering Oil and Gas Activity on State Forest Land. Harrisburg PA. 156 p.
http://www.dcnr.state.pa.us/ucmprd2/groups/public/documents/document/dcnr_004055.pdf

Pennsylvania Marcellus News Digest (compiled weekly by League of Women Voters)
Request from Julie Kollar: juliekwren@verizon.net

Grassroots information on shale gas in Lycoming County
www.ResponsibleDrillingAlliance.org

Citizens for Pennsylvania's Future reports on Marcellus Shale gas
www.PennFuture.org (follow the Drilling & Mining tab)

Pennsylvania gas development statistics
www.MarcellusGas.org

Pipeline safety information, sample ordinances
www.PSTrust.org

Gas pipeline safety news nationwide
www.NaturalGasWatch.org

Reports and updates on Marcellus Shale gas
www.PennEnvironment.org

Frackwater report with focus on Pennsylvania
http://www.nrdc.org/energy/files/Fracking-Wastewater-FullReport.pdf

Chester County PA grassroots information on petroleum pipelines
www.PAPipelineSafety.org

Common Cause “Deep Drilling-Deep Pockets” reports on campaign contributions and lobbying by gas industry (these may be easier to Google by title than to copy links):

www.CommonCause.org/atf/cf%7Bfb3c17e2-cdd1-4df6-92bebd4429893665%7D/Marcellusshalestudy.pdf (2010 PA)

www.CommonCause.org/site/pp.a5p?c=dkLNK1MQIwG&b=7868571 (2011 national)

Current news links on energy and environment in Pennsylvania
http://StateImpact.npr.org/pennsylvania

Recent series on gas pipelines in the *Philadelphia Inquirer*
http://www.philly.com/philly/news/special_packages/inquirer/marcellus-shale/

New York Times articles on Marcellus Shale gas, fracking, etc. (Google NY Times Marcellus)

Useful information for citizens, compiled in Otsego County, New York
http://www.scribd.com/doc/70951393/GasDrillinginOtsegoCounty-InfoforCitizens-000

Arkansas Public Policy Panel reports on shale gas development
http://arpanel.org/policy/reports/natural-gas

Interstate Natural Gas Association of American (NGAA)
www.ngas.org

American Gas Association (AGA)
www.aga.org

Dig Safely
www.digsafely.com

Common Ground Alliance (CGA)
www.commongroundalliance.com

Pipeline 101 introductory information
www.pipeline101.com

Association of Oil Pipelines (AOPL)
www.aopl.org

In the Pipe – Newsletter from the Oil Pipeline Industry
www.enewsbuilder.net/aopl

References Cited

Ackley, Robert, & Bryce F. Payne 2012a. Report to the Clean Air Council on 8 June 2012 field inspection and methane sampling survey of parts of Leroy, Granville and Franklin Townships, Bradford County, Pennsylvania. Gas Safety, Inc. Southborough MA. 8 p.

Ackley, Robert, & Bryce F. Payne. 2012b. Report to Damascus Citizens for Sustainability, and Mr. Don Williams on 25 July 2012 field inspection and methane sampling survey, of parts of Leroy, Granville, and Franklin Townships, Bradford County, Pennsylvania, and Union and Liberty Townships, Tioga County, and McNett and McIntyre Townships, Lycoming County. Gas Safety, Inc. Southborough MA. 12 p.

Broomfield, Mark. 2012. Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe. Prepared for European Commission DG Environment. AEA Technology PLC. Oxford, England. 292 p. http://ec.europa.eu/environment/integration/energy/pdf/fracking%20study.pdf

Browning, James, & J. McNeil. 2012. New report: natural gas industry has spent more than $23 million to influence PA elected officials. Press release. Common Cause PA. Harrisburg PA. 1 p. www.marcellusmoney.org

Brufatto, Claudio, *et al*. 2003. From mud to cement. *Oilfield Review*. Autumn:62-76.

Clean Water Action Pennsylvania. 2012. Enforcement of Marcellus shale drilling violations by Pennsylvania Department of Environmental Protection, Jan.1, 2011-Dec.31, 2011. 6 p. www.cleanwateraction.org/pa

Connor, Kevin, R. Galbraith, & B. Nelson. 2012. The UB shale play: Distorting the facts about fracking: A review of the University at Buffalo Shale Resources and Society Institute's report on environmental impacts during Marcellus shale gas drilling. Public Accountability Initiative. Buffalo NY. 20 p. http://public-accountability.org/wp-content/uploads/UBShalePlay.pdf

Considine, Timothy, R. Watson, N. Considine, & J. Martin. 2012. Environmental impacts during Marcellus shale drilling: causes, impacts, and remedies. Shale Resources and Society Institute, State University of New York at Buffalo. Buffalo NY. 52 p. http://www.buffalo.edu/news/pdf/UBSRSI-Environmental%20Impact.pdf

Davies, R.J. 2011. Methane contamination of drinking water caused by hydraulic fracturing remains unproven. *Proceedings of the National Academy of Sciences USA* 108: E871.

Gardner, Wayne. (2011, March 7). Congressional Roundtable Testimony at U.S. Rep. Shuster's Congressional Roundtable, Upper Merion Township, PA.

Gardner, Wayne. (2010, October 9). League of Women Voters of Southeastern PA Presentation, Radnor, PA.

Gellerman, Bruce. 2012. Rampant city gas leaks. Living on Earth, Public Radio International. Air date week of 13 January 2012. http://www.loe.org/shows/segments.html?programID=12-P13-00002&segmentID=3

Howarth Robert W., R. Santoro, & A. Ingraffea. 2012. Venting and leaking of methane from shale gas development: response to Cathles *et al*. *Climatic Change,* in press. 20 p. http://news.caloosahatchee.org/docs/Report-Shale-Gas-Development.pdf

Howarth, Robert W., D. Shindell, R. Santoro, A. Ingraffea, N. Phillips, & A. Townsend-Small. 2012. Methane emissions from natural gas systems. Background paper 2011-0003 prepared for the National Climate Assessment. 8 p. http://www.eeb.cornell.edu/howarth/Howarth%20et%20al.%20--%20National%20Climate%20Assessment.pdf

Johnson, Nels, T. Gagnolet, R. Ralls, & J. Stevens. 2011. Natural gas pipelines. Excerpt from Report 2 of the Pennsylvania Energy Impacts Assessment. The Nature Conservancy, Pennsylvania Chapter. Harrisburg PA. 10 p.

Kaplan, Alex, & J. Browning. 2010. Deep drilling, deep pockets: the campaign contributions & lobbying expenditures of the natural gas industry in PA. Common Cause PA. Harrisburg PA. 23 p.

Kennedy, Lucy. (2011, January 19). Natural gas explosion in Philadelphia kills worker. Retrieved from: http://www.pbs.org/wnet/need-to-know/the-daily-need/fatal-gas-explosion-in-philadelphia-kills-one-and-injures-five/6465/

Kuprewicz, Richard, & Carl Weimer. 2010. The state of natural gas pipelines in Fort Worth. Fort Worth League of Neighborhoods. Fort Worth TX. 36 p.

Little, Lyneka, & Alan Farnham (2011, February 10) Allentown, Pa explosion leaves five dead. Retrieved from: http://abcnews.go.com/Business/pennsylvania-natural-gas-explosion-leaves-dead/story?id=12883552

Myers, Tom. 2012. Potential contaminant pathways from hydraulically fractures shale to aquifers. *Ground Water* (online). 17 April. 11 p. http://www.mde.state.md.us/programs/Land/mining/marcellus/Documents/Meyers_Tom_Potential_Contaminant_Pathways_from_Hydraulically_Fractured_Shale_to_Aquifers.pdf

National Energy Technology Lab (NETL). 2011. Sustainable management of flowback water during hydraulic fracturing of Marcellus Shale for natural gas production. US Department of Energy. DE-FE0000975. http://www.netl.doe.gov/technologies/oil-gas/Petroleum/projects/Environmental/Produced_Water/00975_MarcellusFlowback.html

National Transportation Safety Board. 2012a. Pacific Gas and Electric Company natural gas transmission line rupture and fire, San Bruno, California, September 9, 2010. Accident Report NTSB/PAR-11/01 PB 2011-916501.

Washington DC. 153 p.
http://www.ntsb.gov/doclib/reports/2011/PAR1101.pdf

National Transportation Safety Board. 2012b. Enbridge Incorporated hazardous liquid pipeline rupture and release, Marshall, Michigan, July 25, 2010. Accident Report NTSB/PAR-12/01 PB 2012-916501. Washington DC. 149 p. http://www.ntsb.gov/doclib/reports/2012/par1201.pdf

Newhall, C. 2006. Improving cement bond in the Appalachian Basin with adjustments to preflush and spacer design. Society of Petroleum Engineers Inc. (SPE 104576). 10 p.

Oram, Brian. 2012. Methane and other gases in drinking water and groundwater. B.F. Environmental Consultants, Inc. Dallas PA. http://www.water-research.net/methanegas.htm

Petron, G., *et al*. (2012), Hydrocarbon emissions characterization in the Colorado Front Range - A pilot study, *Journal of Geophysical Research.* doi:10.1029/2011JD016360, in press.
http://www.agu.org/pubs/crossref/pip/2011JD016360.shtml

Phillips, Nathan G., R. Ackley, E.R. Crosson, A. Down, L.R. Hutyra, M. Brondfield, J.D. Karr, K. Zhao, and R. B. Jackson. 2013. Mapping urban pipeline leaks: methane leaks across Boston. *Environmental Pollution* 173:1-4.
http://www.sciencedirect.com/science/article/pii/S0269749112004800

Reid, Scott M., G. Isaac, S. Mitikosh, & J. Evans. 2003. Physiological response of rainbow trout to sediment released during open-cut pipeline water crossing construction. *Water Quality Research Journal of Canada* 38(3):473-481.

Ropeik, David. 2010. How risky is it really: why our fears don't match the facts. McGraw Hill. New York NY. 280 p.

Ropeik, David, and George Gray. 2002. Risk: a practical guide for deciding what's really safe and what's really dangerous in the world around you. Houghton Mifflin. New York NY. 485 p.

Song, Lisa. 2012. Few oil pipeline spills detected by much-touted sensors. Bloomberg News. 19 September. http://www.bloomberg.com/news/2012-09-19/oil-pipeline-spills-go-undetected-by-much-touted-sensors.html

Sumi, Lisa. 2012. Breaking all the rules: the crisis in oil and gas regulatory enforcement. Earthworks Oil and Gas Accountability Project. Washington DC. 120 p.
http://www.earthworksaction.org/library/detail/breaking_all_the_rules_the_crisis_in_oil_and_gas_regulatory_enforcement

Sunset Advisory Commission. 2011. Final report, Texas Railroad Commission. Austin TX. 95 p. http://www.sunset.state.tx.us/83.htm#rc

Thompson, David. 2012. 32-unit village no more. *Williamsport Sun-Gazette*. 18 March.

U.S. Department of Transportation. (2011). Briefing: Additional Details on Standard Inspections. *PHMSA Stakeholder Communications.* Retrieved from http://primis.phmsa.dot.gov/comm/InspectionDetails.htm?nocache=5986

U.S. Department of Transportation. (2011). Briefing: Pipeline Safety Inspections. *PHMSA Stakeholder Communications.* Retrieved from http://primis.phmsa.dot.gov/comm/Inspection.htm?nocache=2674

U.S. Department of Transportation. (2011). Enforcement. *PHMSA Stakeholder Communications.* Retrieved from http://primis.phmsa.dot.gov/comm/reports/enforce/Enforcement.html?nocache=5774

U.S. Department of Transportation. (2011). Inspection. *PHMSA Stakeholder Communications.* Retrieved from http://primis.phmsa.dot.gov/comm/InspectionEnforcement.htm?nocache=1433

U.S. Department of Transportation. (2011). Inspection and Enforcement Flowchart 1. *PHMSA Stakeholder Communications.* Retrieved from http://primis.phmsa.dot.gov/comm/EnforcementFlowchart1.htm?nocache=2655

U.S. Department of Transportation. (2011). Pipeline Safety Awareness Site. Retrieved from http://www.phmsa.dot.gov/

Watson, Theresa L., & Stefan Bachu. 2009. Evaluation of the potential for gas and CO_2 leakage along wellbores. *Society of Petroleum Engineers Journal*. Paper 106817

Weimer, Carl. 2012. Pipeline safety in the Salt Lake valley. Prepared for Salt Lake City. Pipeline Safety Trust. Bellingham WA. 28 p. www.slcgov.com/oilspill

Acknowledgments and Authorship

This technical appendix was prepared for the League of Women Voters of Pennsylvania under their Technical Assistance Grant from the US Department of Transportation. It makes extensive use of the 2010 report on pipelines in Fort Worth, Texas, by Kuprewicz and Weimer for the Forth Worth League of Neighborhoods, as well as other work of the Pipeline Safety Trust. Staff of the Lycoming County Planning Department were generous in sharing information, as was Ralph Kisberg of the Responsible Drilling Alliance.

Much of the information on pipeline regulation was assembled by Roberta L. Winters. Helpful comments were provided by a number of people on sections of the appendix, and especially by Stephen P. Kunz. Responsibility for any remaining errors is that of the principal author, James A. Schmid.

Dr. Winters is an active member of the League. Dr. Schmid is a biogeographer and plant ecologist with decades of experience in environmental consulting.