

MARCELLUS EDUCATION FACT SHEET



Water Withdrawals for Development of Marcellus Shale Gas in Pennsylvania

Introduction to Pennsylvania's Water Resources

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

Water is a critical component of the process of removing natural gas from underground shale rock formations. Pennsylvania's precipitation totals and surface and groundwater volumes are significantly higher

than those of some southwestern and mountain states where other shale fields are already in full-fledged gas production. The abundance of water in Pennsylvania is a double-edged sword for drilling. Water is needed for drilling, but drillers need to avoid affecting the numerous water wells, streams, lakes, and other water bodies throughout the state with their operations.

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

Figure 1. Volume of water in Pennsylvania (2000).
Source: Abdalla, et al., *Access and Allocation of Water in Pennsylvania* (University Park: The Pennsylvania State University, 2008).

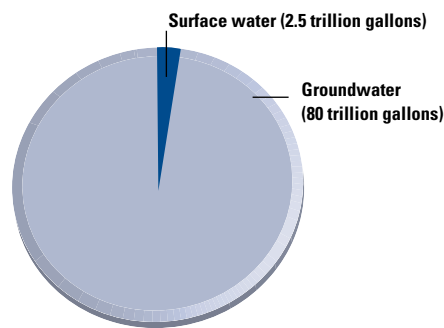
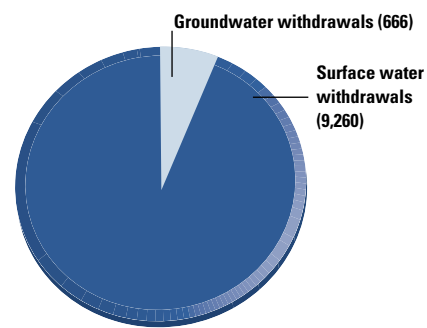


Figure 2. Total water withdrawals in Pennsylvania in million gallons per day (2000). Source: Abdalla, et al., *Access and Allocation of Water in Pennsylvania* (University Park: The Pennsylvania State University, 2008).



mestic and commercial customers (16 percent); and agricultural users (0.4 percent).

Consumptive uses remove water from a ground- or surface water source and do not directly return it to the same basin for future use. Two examples of consumptive use related to deep shale gas drilling include (1) loss of 50–70 percent of the water used for developing, or hydrofracturing (see below), the well (it remains deep underground), and (2) diversion of water from one river basin into another for drilling purposes.

It is important to put Marcellus shale drilling water withdrawals in context. The Susquehanna River Basin Commission (SRBC) estimates that basinwide total yearly water withdrawals by all gas extraction operators drilling in the Marcellus shale will equal the amount of water withdrawn currently for power production in the basin in only three days. The SRBC considers all water used in hydrofracturing to be consumptively lost to the system. Any water ultimately returned to the surface is considered a waste product, and any portion of that which is treated and discharged back into the basin is credited toward mitigation for the water withdrawal. Drilling water returned to the surface is the fracing fluid (also called drilling return water, drilling wastewater, flow-back, or produced or stimulation fluid) (see Water Quality Issues Related to Gas Drilling on p. 9).

With the recent interest in extracting gas via deep well drilling and the large water use associated with this drilling and hydrofracturing (fracing), the portion of water withdrawals related to mining is likely to rise.

The information presented here is subject to rapid change due to the fast-paced, evolving nature of gas drilling in the Marcellus shale. Check the Resources section at the end of the publication for updates. Some areas of most rapid change and uncertainty include gas well permitting requirements, the sale of water for use in drilling, and the treatment and disposal of drilling wastewater.

Pennsylvania: Site of the Country's First Oil Well

The Appalachian Plateau and western Ridge and Valley provinces in Pennsylvania have seen previous oil and gas resource development. Edwin Drake drilled the country's first oil well in 1859 in Titusville, Pennsylvania. Drake's crew struck oil about 70 feet below ground. Modern-day drillers into the Marcellus shale face many new challenges as they drill often more than a mile into the earth.

Introduction to the Marcellus Shale and Its Development for Natural Gas

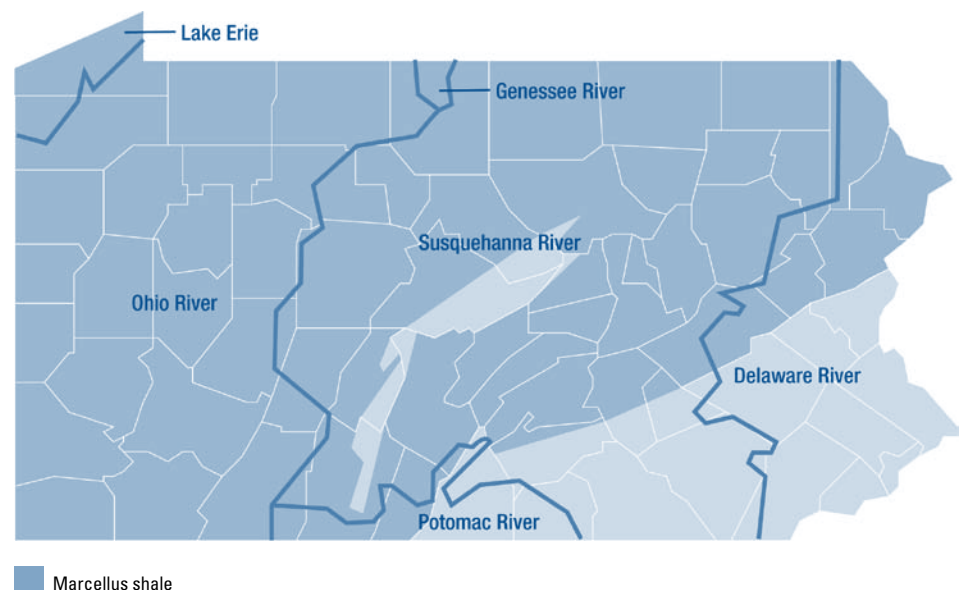
The Marcellus shale lies 4,000–8,500 feet underground beneath southern New York, western Pennsylvania, the eastern half of Ohio, and through West Virginia (Figure 3). Expanding demand for energy in the developing world and for domestically produced energy in the United States, and new drilling technologies such as horizontal drilling and hydraulic fracturing have whetted mineral exploration companies' interest in tapping the deep gas reserves in the Marcellus shale. An additional key to the interest in Pennsylvania is the location of its gas reserves relative to the large gas markets in New York, New Jersey, Virginia, and New England. However, leasing activity slowed dramatically in 2008 with

the sharp drop in energy prices and the worldwide economic slump. So how much money will eventually be put into wells in Pennsylvania, and how much gas will flow from them, remains to be seen. Gas exploration and extraction in the areas underlain by Marcellus shale is currently viewed as a speculative business. The Susquehanna River Basin Commission preliminarily estimates that up to 5,000 wells may eventually be drilled into the Marcellus shale in this river basin alone (Pennsylvania and New York).

There are varying estimates of the total and recoverable amounts of gas in the Marcellus shale. The U.S. Geological Survey estimated during the late 1970s a total of 295 trillion cubic feet (TCF), with 9 to 15 TCF recoverable. Estimates in 2008 of total gas in the field range from 168 TCF to 4,300 TCF. Geologists estimate that resource companies may be able to recover 50 to 390 TCF of gas from the Marcellus shale.

The Marcellus shale is made up of sediments high in organic material. As this organic matter decayed, methane gas formed and dispersed throughout pores in the rock. About 300 million years ago, the pressure of the gas caused northeast-to-southwest fractures to form in the shale.

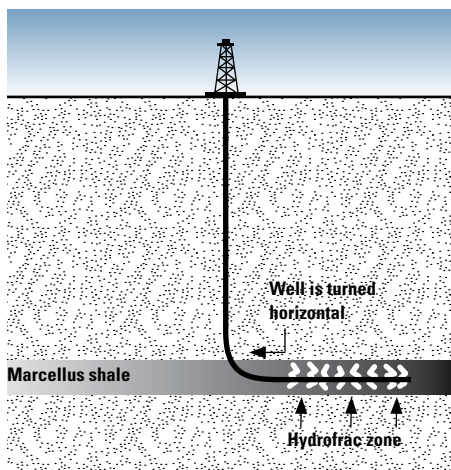
Figure 3. Distribution of Marcellus shale in Pennsylvania, with major river basins overlaid.



So a well drilled vertically into the Marcellus may cross one of these fractures, but new horizontal drilling technology can cross a number of fractures. After drilling several thousand feet into the earth, the new technology allows the bore hole to be turned 90 degrees over several hundred feet and to continue horizontal drilling for almost a mile (Figure 4). Cross-cutting multiple fractures is key to a highly productive well.

Water is a critical ingredient to extracting gas from the Marcellus shale. The drilling process itself can require up to 300,000 gallons per day per well. The shale around most new gas wells in Pennsylvania has to be hydraulically fractured to release the trapped gas so that it can be brought to the surface. Hydrofracturing uses high-pressure water, sand, and chemicals (see also Water Quality Issues Related to Gas Drilling on p. 9) to break up the gas-holding rock and improve the flow of gas to the bore hole. Hydrofracturing a deep vertical well may use 500,000 to more than one million gallons of water. Hydrofracturing a horizontal Marcellus well may use two to nine million gallons of water, typically within about one week and one time only. However, some wells may be hydrofractured several times over their productive life (typically five to twenty years

Figure 4. Drilling in the Marcellus shale takes advantage of new techniques that allow horizontal drilling for almost a mile from the vertical shaft.
Source: Geology.com.



or more). Depending on the need for refracing, these types of water withdrawals might continue further into the future, past the industry's development stage and into the gas extraction stage. These large water withdrawals may come from streams, ponds, lakes, rivers, or groundwater. They can have significant ecological effects if not done carefully. Large withdrawals could also affect nearby drinking water sources and other uses. Putting water to one use may mean that it is not available for another use, thereby increasing the potential for conflicts between water users and uses.

Pennsylvania's Oil and Gas Act protects both quantity and quality of existing water supplies. Under certain circumstances, an oil and gas company is presumed responsible for degradation of water quality in water supplies for six months following gas well drilling (see Water Quality Issues Related to Gas Drilling on p. 9). However, this act does not presume responsibility by the oil or gas well company for water quantity problems with private water supplies near active oil and gas wells. Consequently, suspected impacts to water quantity would need to be investigated by the Pennsylvania Department of Environmental Protection (DEP) and/or proved by the water supply owner. A first step would be to contact DEP and ask them to investigate the water quantity problem. Pre-drilling flow data collected by a professional drinking water supply contractor or consultant would be important in helping prove that a water quantity problem was caused by oil or gas drilling.

Water withdrawals generally exceeding 10,000 gallons per day for any average thirty-day period require registration with Pennsylvania DEP under authority of Act 220 of 2002, the Water Resources Planning Act, and implementing regulations at 25 Pa. Code Chapter 110. Water withdrawals of any amount occurring in the Susquehanna River watershed to develop gas wells in the Marcellus or Utica shale formations also require approvals from the SRBC (see The Susquehanna River Basin Commission on p. 5).

Withdrawals occurring in the Delaware River basin may also require a separate approval from the Delaware River Basin Commission (DRBC). There is no river basin commission regulating water quantity in the western third of Pennsylvania (for discussion of water quality management in the Ohio River basin, see the sidebar on p. 5), but DEP is applying SRBC "passby" guidelines in that area to ensure a consistent regulatory environment across the state. These guidelines allow for water withdrawal from a stream during times of high or normal flow but require that the withdrawal stop or decrease during times of low stream flow, usually during the late summer or early fall.

Staff from the river basin commissions are cooperating with Pennsylvania and New York state government agencies to coordinate actions and minimize duplication of effort in approving water use by gas drilling companies. However, companies must obtain the necessary state approvals as well as those of the applicable river basin commission (in areas not covered by a river basin commission, applications for well drilling and water management plans go entirely through DEP).

Institutions Governing Interstate Waters in Pennsylvania

The Delaware and Susquehanna river basins cover the eastern two-thirds of the state (Figure 3). The western third is mainly in the Ohio River basin and, to a lesser extent, the Great Lakes watershed. In the 1960s and 1970s, Pennsylvania and its neighboring states created two interstate river basin commissions by interstate compacts to manage water interests in the Delaware and Susquehanna river watersheds. The federal government is also a member of each of these compact commissions.

It is important to note, however, that these agencies approve water withdrawal projects, but landowners control access to water. Some landowners are charging drilling companies a fee for access to the water on their property. For more information, see The Sale of Water for Use in Gas Drilling on p. 8.

Delaware River Basin Commission

The Delaware River Basin Commission arose out of a longstanding interstate legal debate over rights to water within the Delaware River watershed and an out-of-basin diversion (transfer of Delaware River water to New York City, which is not in the watershed). Supreme Court decrees in 1931 and 1954 resolved the city's diversion rights and became the foundation for a more comprehensive water management agreement among the litigants when they formed the commission by interstate compact in 1961. The initial term of the compact is 100 years.

The Delaware River's east and west branches join near Hancock, New York. From there, it flows 330 miles to its mouth at the Delaware Bay. The watershed includes parts of New York, Pennsylvania, New Jersey, and Delaware. The Marcellus shale underlies more than one-third of the Delaware River basin.

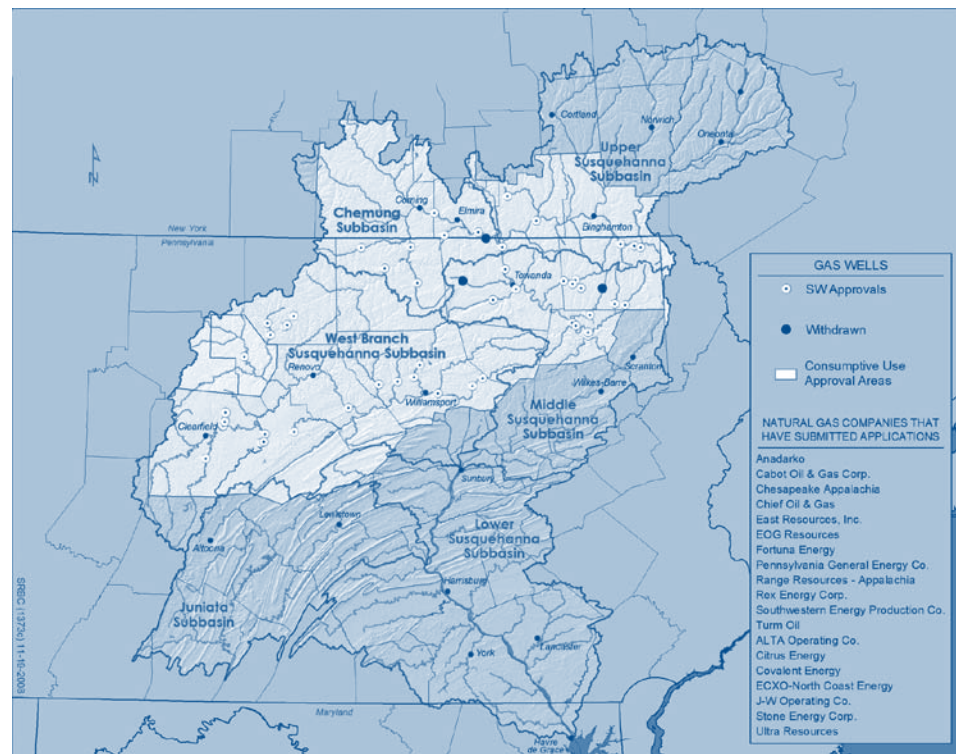
According to DRBC's Rules of Practice and Procedure, all water-related projects in the basin meeting certain thresholds must be approved, or "docketed," by the commission. The threshold for ground- and surface water withdrawals is 100,000 gallons per day as an average over any thirty-consecutive-day period, except within the Southeastern Pennsylvania Ground Water Protected Area, which is outside the Marcellus shale drilling area. In addition, no project involving the injection of pollutants into ground- or surface waters of the basin may begin without commission approval. The commission interprets this prohibition to encompass hydrofracturing of wells.

In May 2009 DRBC issued a determination, effective immediately, requiring commission approval for "any natural gas extraction project located in shale formations within the drainage area of Special Protection Waters," which includes the entire 197-mile nontidal Delaware River, from Hancock, New York, to Trenton, New Jersey. In Pennsylvania this affects all or part of Bucks, Carbon, Lehigh, Monroe, Northampton, Pike, Schuylkill, and

Wayne counties. The Marcellus shale does not occur in all of these counties, but other shale formations do. DRBC has advised at least one potential sponsor of a natural gas extraction project in the Locketong Formation in Bucks County that its project will be subject to DRBC review. The commission will propose new regulations concerning natural gas drilling in the basin, which will be subject to a public hearing and a written comment period. For more information, see www.state.nj.us/drbc/EDD5-19-09.pdf.

As of April 2009, DRBC knew of no on-site groundwater wells within the basin that have been proposed specifically to provide water for gas drilling. All natural gas-related water withdrawal applications submitted to the commission to date have been for the approval and use of surface water sources. The commission will recommend a project for approval only if it complies with the established water withdrawal review criteria, including a suitable disposal strategy for the water used in hydrofracturing (see also Water Quality Issues Related to

Figure 5. Surface water withdrawal, consumptive water use, and Approval by Rule actions taken by SRBC in 2008. Source: Susquehanna River Basin Commission.



	Surface Water Withdrawal Applications <i>Displayed as points on map</i>	Consumptive Water Use Applications <i>Displayed as areas, not as points, on map</i>	Approval by Rule (Notice of Intent Applications) <i>Not displayed on map</i>
Total Submitted in 2008	77	21	113
June Approvals	5	3	—
September Approvals	33	7	—
December Approvals	13	6	—
Total Approved in 2008	51	16	74
Pending	23	—	21
Withdrawn	3	1	16
Combined	—	4	2

Gas Drilling on p. 9). Each project is approved or denied by the commission members, not by commission staff, at a public hearing.

DRBC does not expect to issue water withdrawal approvals to individual property owners who have sold or leased natural resource rights to a gas drilling company unless the owners withdraw at least 100,000 gallons per day during any thirty-consecutive-day period from any water source. If a previously docketed withdrawer wishes to supply water for hydrofracturing of wells, the withdrawer will require DRBC approval for a modification of the service area established by his or her docket.

Susquehanna River Basin Commission

The Susquehanna River Basin Commission was established in late 1970 via legislation enacted by the states of New York, Pennsylvania, and Maryland and the federal government. The commission's 100-year compact seeks to protect and manage the water resources of the basin.

The Susquehanna River starts in Cooperstown, New York, and flows 444 miles to Havre de Grace, Maryland, where the water empties into the Chesapeake Bay. Almost three-quarters of the entire Susquehanna River watershed, comprising 27,510 square miles in three states, is underlain by Marcellus and other organic-rich shales. In 2008 SRBC approved fifty-one surface water withdrawals for gas drilling in the Susquehanna basin.

As of August 14, 2008, the Susquehanna River Basin Commission began requiring gas companies to seek prior approval before withdrawing or consumptively using any amount of water to develop wells in the Marcellus or Utica shale formations in the Susquehanna watershed. Companies may not begin gas well construction, drilling, or hydrofracturing without commission approval. This requirement applies even if the anticipated water withdrawal or consumptive use would not have triggered commission review under its standard regulatory thresholds.

This requirement allows the commission to regulate the gas industry's individual and cumulative impacts on water resources. The SRBC can require this level of review on an industry basis when they determine that water-use activities could have an "adverse, cumulative adverse, or interstate effect on the water resources of the basin." SRBC is concerned about the quantity and rate of water used, the source for withdrawals and consumptive uses, the potential to alter the physical, biological, chemical, or hydrological characteristics of the basin's water resources, and the potential to affect interstate water quality.

This decision increased the number of projects SRBC has to review and also increased the natural gas industry's administrative requirements. As a result, the commission streamlined the administrative procedure for reviewing these water uses. This latest rulemaking expanded SRBC's "Approval by Rule procedures," which previously applied only to consumptively used water taken from public water supply systems. Gas companies can use the new procedure to seek approval for consumptive water use, no matter where the water comes from. SRBC is currently developing incentives to encourage the reuse of municipal wastewater, mine pool water, and other lesser quality sources instead of freshwater.

This SRBC rule took effect on January 15, 2009. In addition to the above, it also:

- Regulates projects on a drilling-pad basis.
- Accounts separately for fracturing fluids that are reused on new hydrofracture operations. These waters are not included in the calculation of consumptive use amounts.
- Grants approvals for five years.
- Speeds the approval process because requests for Approval by Rule are issued administratively rather than at quarterly commission meetings.

- Requires daily water-use monitoring and quarterly reporting.
- Requires mitigation of consumptive water uses.

Check the commission's Web site (www.srb.net) for updates.

In 2008 SRBC also issued twenty area-wide consumptive use approvals (Figure 5) to a number of drilling companies. This allows a company to consumptively use a certain amount of water (usually 5 million gallons) per day from sources other than public water supplies at any one of their drilling operations within a certain area (generally a county). New approvals by rule will be issued for existing area-wide consumptive use approvals for all drilling pads constructed on or before December 31, 2009. On that date the existing consumptive use approval will end and companies will need to follow the standard Approval by Rule process for any new drilling pads.

SRBC has stated that they intend to meet economic needs of the state and the industry while ensuring that adequate water resources are available for all users. The Approval by Rule process will allow SRBC to efficiently handle a large jump in regulatory review activity should the gas industry in Pennsylvania move from the current exploratory phase to the development phase.

The regulations governing water withdrawals for natural gas drilling may very well evolve further as the industry expands and moves from exploration into development. See the Resources section at the end of this publication for links to the latest regulations.

Other Pennsylvania Watersheds

Great Lakes' waters in Pennsylvania fall under the jurisdiction of the Great Lakes–St. Lawrence River Basin Water Resources Compact enacted into law in 2008. Pennsylvania DEP is applying SRBC's passby flow guidelines to water management plans associated with applications for new gas well drilling permits targeting Marcellus shale in this basin.

Pennsylvania DEP is applying SRBC's passby flow guidelines to water management plans associated with applications for new gas well drilling permits targeting Marcellus shale across the state.

Similarly, water management plans associated with Marcellus shale gas well development in the Ohio River basin are subject to review by DEP using SRBC's guidelines even though no river basin commission oversees water quantity issues in this basin. However, some citizens and organizations in the basin remain concerned about whether their water resources will be adequately protected given (1) DEP's admitted staffing shortage for processing permit applications and doing routine inspections of drilling operations, and (2) the difficulty of proving adverse effects on water supplies from gas drilling activities (see sidebar).

A River Basin Commission Focused on Water Quantity for the Ohio River?

The Ohio River Basin Sanitary Commission (ORSANCO) regulates water quality in that basin, but not water withdrawals. Some citizens and organizations in western Pennsylvania and other parts of the Ohio River basin have asked what it would take to establish a water-quantity-focused river basin commission for the Ohio with powers similar to SRBC's and DRBC's. A river basin commission is formed by an interstate compact adopted into law by each of the participating states and consented to by the U.S. Congress. It is a form of collaborative government. The new Great Lakes–St. Lawrence River Basin Water Resources Council is the most recently created interstate compact body. SRBC was created in 1970. DRBC was established in 1961, and the Interstate Commission on the Potomac River Basin in 1940. Creation of each commission required (1) adoption of concurrent state-level legislation in which each of the partners adopted the interstate compact, and (2) consent of Congress. It seems now as though the Delaware and Susquehanna river basin commissions were ahead of their time in acknowledging the importance of managing a river system without regard to political boundaries. However, it seems unlikely that all parties could now agree on the many provisions necessary to start a similar commission for the Ohio River to address water quantity, even though a commission may offer water management benefits.

Pennsylvania Department of Environmental Protection and Other Relevant State Government Agencies

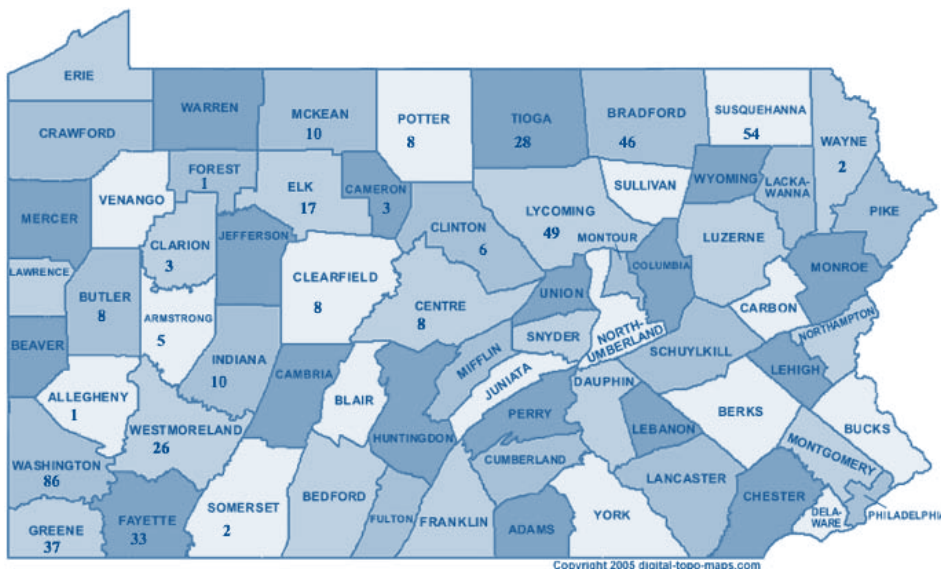
More than 350,000 oil and gas wells have been drilled in Pennsylvania since Drake's well in 1859. Most of these are very shallow in comparison to the wells now being drilled into the Marcellus shale. Pennsylvania regulates water management related to oil and gas exploration and drilling under the state's oil and gas laws, the Clean Streams Law, the Dam Safety and Encroachments Act, and the Water Resources Planning Act. DEP reviews and issues drilling permits (Figure 6), inspects drilling operations, and responds to complaints about water quality problems.

Regardless of the basin in which water sources are located, DEP requires an approved water management plan in connection with the gas well permit to cover the water sources used for fracturing each Marcellus shale gas well in the Commonwealth. A water management plan includes information about the sources of water to be used in the fracturing process, expected impacts of withdrawals on water resources, and proof of approval by the appropriate river basin commission, among other items. (See the Resources section at the end of this publication for a link to the latest information from DEP.) This should help protect water resources in areas not covered by a river basin commission.

DEP and the river basin commissions are concerned about large-scale water use for gas drilling largely from small, remote, forested streams, often home to wild trout and other sensitive species, that are very susceptible to damage from withdrawals. However, the location of water use is critical. Marcellus shale wells tend to be in upland areas with streams and smaller tributaries, not near major rivers, as power plants are. Withdrawals from small forested streams must be closely regulated to minimize the potential ecological consequences.

Water-use plans can be structured to allow operators to continuously withdraw water from a stream

Figure 6. DEP-permitted Marcellus shale wells by county in 2008. *Source:* Pennsylvania Department of Environmental Protection.



in a small quantity that has minimal impact on stream flows, such as a quantity that individually or cumulatively does not exceed about 10 percent of very low, drought flows (called an uninterrupted withdrawal). Alternatively, operators can withdraw larger amounts during times of high flow, usually in the spring, and store that water for use throughout the year. The SRBC has granted some “passby flow determinations with interrupted withdrawal” that allow water withdrawal from smaller streams with the condition that withdrawal stop or decrease to a previously designated level when flows reach a preset minimum.

Gas companies can also seek to withdraw groundwater, but the rules for figuring the allowable withdrawal amount are complex. The companies point out that having the water source at the drilling pad decreases the amount of truck traffic to the site, thereby lowering their costs and the future costs of road repairs and lessening the impact on neighbors’ quality of life.

The Pennsylvania Department of Conservation and Natural Resources (DCNR) says that companies are very unlikely to be given access to small forested streams in any state parks, and that they should not assume that DCNR will give them access on state forestland. DCNR is expected to give preference for water access to companies with which they are leasing. The Pennsylvania Game Commission is expected to take a similar stance regarding access to water on state game lands.

Most water uses permitted for gas operations in Pennsylvania to date have been for municipal drinking water sources or small withdrawals from large rivers, such as the Allegheny River, because those withdrawals are simple and quick to approve. DEP and SRBC reported in October 2008 that they were just starting to see project applications asking to withdraw groundwater.

As for future trends in water use for gas drilling in the state, DEP and SRBC hope to see more water recycling and use of other waters, such as treated wastewater and acidic

mine drainage, in the hydrofracturing process. They expect that future water withdrawals will focus on removing water from streams during springtime high flows and storing that water in centralized impoundments for use in many gas wells in an area. Companies must comply with the provisions of the Dam Safety and Encroachments Act for impoundments.

Municipalities and counties must be notified of water management plans for gas wells in their area. State and river basin commission regulations consider impacts to existing water users at the time of review of proposed new uses.

Pennsylvania’s Clean Streams Law limits the amount of water that can be withdrawn from streams to maintain sufficient stream flows for aquatic life. Failure to obtain necessary approvals or follow regulations on water withdrawals for drilling can shut down gas well drilling operations.

DEP stated in September 2008 that they needed at least sixty more staff members to process incoming gas well permit applications. Although application filings have certainly slowed with the downturn in the economy, many citizens and the industry remain concerned about the pace of permit approvals, especially in the western third of the state where no river basin commission exists. As of early 2009, although Pennsylvania was generally under a hiring freeze, DEP was in the process of hiring thirty-seven new oil and gas inspectors.

New Marcellus shale gas well permit fees were published as a final rulemaking in the *Pennsylvania Bulletin* on April 18, 2009. DEP also published a proposed rulemaking in the *Pennsylvania Bulletin* on February 14, 2009, to increase all other oil and gas well permit fees to hire additional staff. Permit fees have been \$100 per well since the early 1980s. The proposed rulemaking would establish a sliding scale based on well depth and type. For a Marcellus shale well or other nonvertical (horizontal) well, the proposed new permit fee would be \$900 for the first 1,500 feet plus \$100 per

500 feet of wellbore thereafter. The proposed new fees for a vertical well would be \$250 for wells up to 2,000 feet deep, plus \$50 for every 500 feet of depth from 2,000 to 5,000 feet deep, then an additional fee of \$100 for every 500 feet of vertical well drilled beyond 5,000 feet. DEP cites the extra oversight necessary on these wells—for water use, hydrofracturing, and wastewater treatment and disposal—as the reason for the increase.

The regulations governing water withdrawals for gas drilling may continue to change rapidly should the industry expand and move from exploration into full production. Check the Internet for the latest regulations (see the Resources section at the end of this publication).

The Sale of Water for Use in Gas Drilling

Within the Susquehanna River basin interested parties can purchase water, up to the total permitted amount, from other users who have surplus water under their approvals. These sources may be used as long as they are registered under the applicable Approval by Rule for each drilling pad at which such sources would be used. In the Delaware basin, the sale of water by a permitted facility requires a “docket modification” to include the new use in the docket holder’s approved service area.

Consequently, a number of gas companies have purchased water from municipal water systems and other permitted users. Permit holders should consider future drinking water needs and other water-related economic development opportunities before agreeing to a sale. Transportation of water from the source to the drilling location can put tremendous stress on rural roads, so some local governments require gas companies to post a bond for road repair and maintenance.

Water can be withdrawn from private ponds and lakes if companies have permission to access the water body, for which some landowners are charging an access fee. Withdrawals of water from ponds or lakes more than one acre in size

may require additional approvals, such as a drawdown permit from the Pennsylvania Fish and Boat Commission. Water withdrawals from ponds or lakes that do not receive stream water would generally be much easier to approve than withdrawals from stream-fed ponds and lakes. SRBC approval is likewise required for all surface-water withdrawals used in conjunction with Marcellus shale development.

In Pennsylvania water can be sold in certain situations. Water that is on or under the land, such as accumulated snowmelt, stormwater runoff, or water from a spring-fed pond, can be sold as long as it has no impact on water on or under another property. Landowners do not have the right to sell water from a watercourse that passes through their land parcel. Landowners can, however, charge an access fee. Some landowners have addressed access to water on the property in the addendum to a gas well drilling lease, and some landowners have sought compensation for access to water resources on their property. Although landowners may be considered to have certain ownership rights in subsurface waters on their property, they can incur liability if their sale of water adversely affects a well or spring on another property. Generally, it will be difficult for landowners to sell water.

The legality of selling water in Pennsylvania has been decided by case law rather than regulations. The sale of water of use in gas drilling and payments to private landowners for access to water are evolving issues surrounded by a good deal of confusion. Check the Resources section at the end of this publication for updates.

Water Quality Issues Related to Gas Drilling

Sand, gas, and chemicals are added to water used for hydrofracturing to facilitate gas extraction. Water removed from the well after hydrofracturing, called fracing fluid, may also contain brine and other contaminants, such as radioactive radon released from the underground rock formation. The chemicals used in hydrofracturing may include oils, gels, acids, alcohols, and various human-made organic chemicals. Therefore, this fracing fluid is a water quality concern, and separate regulations and issues surround it.

In 2005 the U.S. Congress exempted fracing from coverage under the Safe Drinking Water Act. Therefore, the regulation of fracing and fracing fluids falls to the states. There is an ongoing discussion among some federal policy makers and stakeholders about the appropriate roles of the federal and state governments in regulating the environmental impacts of fracing and related issues. Several changes to federal laws were proposed in spring 2009.

Drilling wastewater must be treated appropriately before disposal. SRBC requires well operators to certify that all disposal methods meet DEP standards. SRBC, DRBC, and DEP require disclosure of the chemicals used in well development, although the exact ratios are proprietary. Some water experts are quite concerned about the storage, treatment, and return of these waste fluids to the environment. This set of issues is a major challenge to development of gas from the Marcellus shale in Pennsylvania. If not thoroughly addressed, ecological, social, and economic costs will be incurred as a result of gas extraction from the Marcellus shale.

It is important to remember that there is a connection between water quantity and water quality. Taking water from a small stream concentrates any contaminants in the stream water. If small streams are used for release of fracing fluid, the lower dilution rate can damage fragile ecosystems and harm aquatic life.

Owners of private drinking water supplies in areas with active Marcellus shale drilling should be alert for a sudden change in water quantity and/or quality. Under certain circumstances, the oil and gas company is presumed responsible for degradation of water quality in water wells or springs for six months following gas well drilling. Concerned private water supply owners should contact the local DEP office if they suspect that a water quality problem was induced by a new oil or gas well. Refer to the Penn State Extension publication *Gas Well Drilling and Your Private Water Supply* for more information related to Marcellus shale well drilling and water quality issues (see the Resources section at the end of this publication).

However, compliance with the regulations governing gas well drilling and private water supplies is variable, especially when water supply owners are unaware of their rights. Keeping good records of well water quality will help establish a baseline in case of a problem. The public policies described here with respect to interactions between oil and gas and private water supply quality may be reevaluated as drilling continues. DEP staffing levels have not kept up with the demand for enforcement because of the rapid rate of expansion of Marcellus shale exploration. DEP is in the process of hiring more inspectors, but until the staffing shortfall is addressed, enforcement may be inadequate. Given the uncharted, fast-paced nature of developments, citizens may be wise to be alert for possible environmental impacts from drilling operations in their area.

“An ounce of prevention is worth a pound of cure.”

—Ben Franklin

Conclusion

Water is a critical ingredient to extracting gas from the Marcellus shale. Without adequate water, the shale around the well cannot be hydrofractured, allowing the gas to flow into the well. This is another of water's invaluable and innumerable uses.

Regulators estimate that the total annual water withdrawal by drillers into the Marcellus shale (roughly ten billion gallons per year) will equal about the same amount of water as thermoelectric power plants in the Susquehanna basin use in three days (Figure 7). In this light, the amounts seem manageable. But given that these gas wells often occur in remote areas where the closest water source may be an ecologically sensitive, small forested stream, Pennsylvania's overall environmental and economic health demands that these withdrawals receive the kind of scrutiny they are. The unknown extent to which well refracing may be needed could increase water demands for extracting gas from the Marcellus shale, thereby increasing the potential for water-use conflicts.

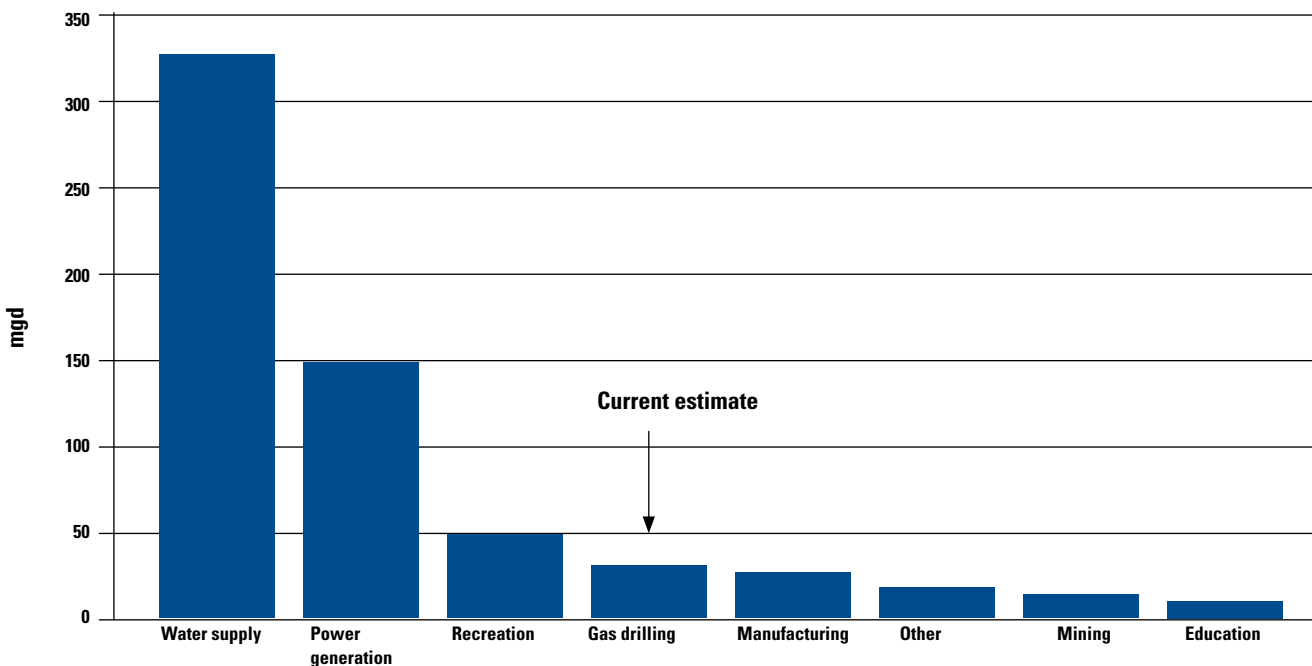
It is important to realize that water quantity and water quality are intimately linked. If the amount of water in a stream is reduced, any pollutants in the remaining water become more concentrated. Currently, the treatment and disposal of drilling wastewater is an obstacle to the full-fledged development of gas from the Marcellus shale in Pennsylvania. This is an area of intense research.

Development of the Marcellus shale for gas extraction may present a major economic expansion opportunity for Pennsylvania, but we need to learn from the legacy of coal mining in the state and ensure that environmental protections are in place up front, before drilling happens. "An ounce of prevention is worth a pound of cure," as famous Pennsylvania resident Ben Franklin once said. The state's water supplies are critical inputs to the activities of households, municipalities, and industries, and support water-based tourism and recreation. They are vital to Pennsylvania's economy and residents' quality of life, and they need up-to-date protections.

The dynamic, cutting-edge nature of exploration and drilling in the Marcellus shale, plus the effects of the economic downturn on the industry, leave uncertainty regarding how extensive this industry may become in Pennsylvania. State and regional agencies were forced in late 2008 to play catch-up with the fast-moving industry. Existing permit requirements may be further modified. Stay tuned for updates (see the Resources section at the end of this publication) to state regulations regarding water quantity and quality issues surrounding Marcellus shale natural gas development. Some water experts and interest groups have called for updates, including

- designation of required water quality testing parameters for fracing fluid;
- an increase in the water protection bond required from drilling companies; and
- an increase in the minimum distance of wells from streams or ponds.

Figure 7. Maximum approved daily consumptive water use by various industries. *Source:* Susquehanna River Basin Commission.



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Resources

Delaware River Basin Commission
www.state.nj.us/drbc

Interstate Council on Water Policy
www.icwp.org/cms

Penn State Cooperative Extension
Natural Gas Impacts
naturalgas.psu.edu

Penn State Dickinson School of Law, Agricultural Law Resources and Reference Center, Natural Gas Exploration
www.dsl.psu.edu/centers/aglaw/gas.cfm

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www.eesi.psu.edu/news_events/EarthTalks/2009Spring/EarthtalksSpring09.shtml

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