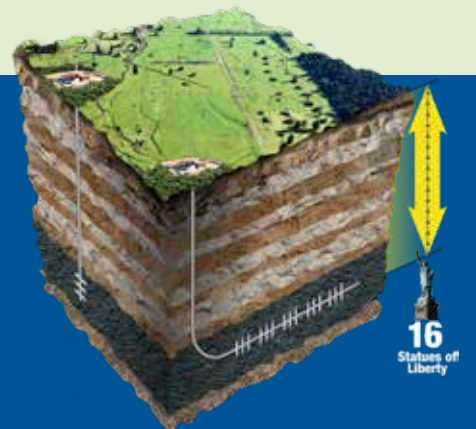




Developing natural gas from the Marcellus and Utica shale formations is a process regulated by both state and federal agencies responsible for the protection of the environment and our water resources. In fact, **up to 40 individual permits, specific to a well's specific location, are required to drill a natural gas well in Pennsylvania.** The industry is committed to planning, drilling and operating its wells in compliance with the regulations that govern natural gas development, and operators typically go beyond what is required by these agencies.



The full length of a Marcellus or Utica shale well is built with thick steel pipe and cement "casing" to isolate the well from the earth and rock. The Marcellus Shale formation is found between 5,000-9,000 feet below ground surface in Pennsylvania, with the Utica Shale in the range of 3,000 feet deeper than the Marcellus in Western Pennsylvania and Ohio. This diagram assumes the formation is 6,000 feet in depth, or 16 Statues of Liberty below the ground. Drinking water aquifers in Pennsylvania, at their deepest, are no more than 500 feet below ground surface, with the well casing and the distance of a mile or more of rock present to protect groundwater supplies.

Site Preparation

Protecting the environment begins with constructing roads and grading the drill pad location, using engineered controls to prevent soil erosion and sedimentation. Roads are often improved prior to starting the drilling process to accommodate additional truck traffic, with culverts placed along road berms to reduce sedimentation. Filter socks and erosion control blankets are installed and maintained at the pad throughout the drilling process to prevent stormwater runoff. Finally, a thick, high-density plastic liner is placed under the entire drill pad, and then covered with gravel to fully contain any inadvertent spills that might occur during drilling and completion.

Shale wells can be drilled both vertically and horizontally, as shown in the diagram on the lower left. The full length of the well is built with thick steel pipe and cement "casing" to isolate the well from the earth and rock. The Marcellus Shale formation is found between 5,000-9,000 feet below ground surface in Pennsylvania, with the Utica Shale even deeper. The diagram assumes the formation is 6,000 feet in depth, or 16 Statues of Liberty below the ground. Drinking water aquifers in Pennsylvania, at their deepest, are no more than 500 feet below ground surface, with the well casing and the distance of a mile or more of rock present to protect groundwater supplies.

Drilling and Casing

The drilling process involves driving several increasingly smaller diameter steel pipes, called casing strings, into the wellbore, with the injection of cement into the pipe and up the sides of the wellbore at the completion of each casing string. This isolates the wellbore from the earth with two durable materials – steel and cement – and protects groundwater aquifers. Each successive steel casing string is cemented into place as the well is drilled, extending to the end of the horizontal portion of the wellbore that will produce natural gas. The casing and cementing process is tested as the well is drilled and devices called centralizers keep the pipe and cement centered in the middle of the wellbore. These steel and cement liners ensure the integrity of the well, and remain in place throughout the well's years of production.

An inert material called drilling mud, which is also used to drill drinking water wells, is used to lubricate the drill bit and to aid in bringing rock cuttings to the surface. The cuttings are then processed through a shaker and allowed to settle, with the rock fragments stored at the drilling location for transportation to a permitted landfill. Drilling mud is processed in an on-site treatment facility and recycled for continued use in the drilling process.

Completion and Production

Environmental protection during hydraulic fracturing turns to the careful use of water and the additives required to fracture the shale formation, along with the proper management and recycling of flowback water that returns to the surface. Water allocation permits are required to withdraw water from streams for hydraulic fracturing; the state Department of Environmental Protection and federal interstate river basin commissions monitor withdrawals to ensure the protection of waterways. Permits must also be obtained to purchase water from municipal water suppliers.

Fresh water is stored in steel tanks or lined impoundments at or near the drilling location, and water pumps and pipelines are often used to convey water and reduce truck traffic at well sites. Approximately 3 to 5 million gallons of water is used to fracture a horizontal well. Of this, about 20-30 percent of the water, called flowback, is returned to the surface shortly after drilling and stored in steel tanks. Recent advances in technology to treat and recycle

FAST FACTS

- Horizontal drilling from a multi-well pad allows for the most efficient extraction of natural gas from an area, reducing estimated total surface impacts by more than 95 percent over vertical drilling techniques.
- Pennsylvania's oil and natural gas regulations consistently achieve the highest ranking among the states by the State Review of Oil and Natural Gas Environmental Regulations (STRONGER), an independent monitor of environmental programs that has conducted three separate reviews of the state DEP's program since 2010.
- Well casing requirements in Pennsylvania are among the strongest in the nation, providing multiple layers of steel and cement between the wellbore and surrounding geology to protect groundwater.

flowback water for multiple fracturing operations are significantly reducing consumptive water use and the need for off-site treatment. Most natural gas producers are successfully recycling 100 percent of flowback water.

Additives used in the fracturing process are transported and managed at the drilling location according to state and federal regulations. There are commonly five additives used in the hydraulic fracturing process, and those materials can be found in products in the home. These include a surfactant (or soap) to reduce the friction of the water, a biocide (similar to an anti-bacterial hand cleaner) to keep the wellbore free of bacteria, a scale inhibitor (comparable to a household product used to keep wastewater pipes free of scale) to prevent the buildup of scale, and a lubricant (similar to vegetable oil) to make the water heavier and further reduce friction.

Hydraulic fracturing has not been identified as the source of groundwater contamination, as the fracture process takes place at depths between 5,000-8,000 feet below ground surface. Most groundwater aquifers are found between 100-200 feet below the surface, a typical distance

of more than a mile above the shale layer being fractured. After the drilling and hydraulic fracturing processes are completed, the drilling pad is restored, as agreed to with the property owner. A completed and secure producing well only requires a relatively small surface footprint, and includes the well head, water storage tanks and a small amount of production equipment. Producing wells are monitored throughout the life of the well by a well tender. Some water slowly returns to the surface over time, which is stored and pumped into trucks for treatment at permitted facilities as needed.

At the completion of the drilling process, the land near the finished well is restored to its original condition, as requested by a landowner. All that remains is a wellhead (called a Christmas Tree), a small amount of production equipment, measuring devices and storage tanks to collect water that returns slowly up the wellbore. Even more energy can be produced by developing multiple wells from a single drilling pad, with a minimum of earth disturbance activity.

Wellpad Restoration and Revegetation

Drilling and completing wells at a typical Marcellus well pad takes place over the course of several months and involves the use of a drilling rig and different types of heavy equipment, with periods of inactivity as equipment is moved into place and assembled. Upon completion, equipment is removed and the wellpad is revegetated. The small remaining footprint on the wellpad commonly includes wellheads, water storage tanks, dehydrators and monitoring equipment.



During Active Drilling Process



Completed and Restored Wellpad