

Hydraulic Fracturing: Meeting the Nation's Energy Needs While Protecting Groundwater Resources

Issue

What steps should be taken that will protect the country's valuable groundwater and drinking water supplies as a result of addressing the nation's energy needs through increased oil and shale gas development using hydraulic fracturing?

Background

As the need for energy security becomes an increasingly critical issue, focus has been placed on development of unconventional oil and gas resources through the use of hydraulic fracturing techniques. Hydraulic fracturing of oil and gas wells was first used in the United States in 1947. Hydraulic fracturing is a method where fluids are injected under very high pressures to create fractures that extend from a borehole hundreds of feet into surrounding rock formations. The fractures are typically maintained by a proppant, which is a rigid material such as grains of sand or other inert substance that keeps the fractures open. Fractures held open by proppants are more permeable than the surrounding rock and allow oil, gas, and formation fluids to flow more readily into the well for extraction. More recently, technological advances that combine hydraulic fracturing and horizontal drilling capable of creating extensive (e.g., thousands of feet) lateral collection wells have been used in unconventional (i.e., low-permeability) reservoirs where oil and gas resources were previously uneconomic to develop.

The number of producing onshore gas wells in the United States increased from approximately 260,000 wells in 1989 to 493,100 wells in 2009.¹ According to the Independent Petroleum Association of America, more than 90% of new natural gas wells in the United States rely on hydraulic fracturing, and together they have accounted for the production of more than 600 trillion cubic feet of gas. Similarly, hydraulic fracturing is increasingly applied to U.S. oil production, and more than 7 billion barrels of oil have been produced using this process.²

The U.S. Energy Information Administration (EIA) projected various scenarios for shale gas³ production against a reference case. In the No Shale Gas Drilling and No Low-Permeability Gas Drilling cases, total domestic natural gas production in 2035

would be lower by 18% and 25%, respectively. EIA also projected that prices would be higher under these scenarios, approximately 17% and 23%, respectively, than the reference case price of \$8.88 per million Btu.⁴

The greater use of horizontal wells and hydraulic fracturing technology has the potential to significantly expand natural gas and oil supplies and hold down prices; however, concomitant with this enhanced production is the increased possibility for groundwater contamination, and other impacts to drinking water supplies if best practices and proper procedures are not used, and if appropriate regulations are not in place. Among possible avenues for impacts to groundwater and drinking water are:^{5,6,7}

- Improper well construction, both water well and oil or gas well
- Abandoned wells, either water or oil and/or gas wells, which have not been properly filled and sealed that could provide a preferential pathway for contaminants to enter shallower formations, or migrate from surface spills
- Increased use of freshwater, including groundwater, in oil and gas operations, especially in areas with water constraints
- Accidents during the transport or storage and use of oil and gas well development chemicals
- Improper wastewater management and disposal.

At the direction of Congress, U.S. EPA is currently studying the potential for adverse impacts on groundwater and drinking water from oil and gas shale petroleum product extraction using horizontal wells and hydraulic fracturing. The scope of the proposed research includes the full lifespan of water in hydraulic fracturing, from acquisition of the water, through the mixing of chemicals and actual fracturing, to the post-fracturing stage, including the management of flowback and produced water. Initial research results are expected by the end of 2012, with a final report in 2014.⁸

The need for increasing the nation's energy supplies exists concurrently with the need to ensure adequate freshwater for drinking; utility, industrial, and manufacturing activity; food production; and ecosystem support. Thirty-six state water managers have reported that they expect statewide, regional or

localized water supply shortages even under normal precipitation conditions.⁹ Groundwater is a critical component of the nation's water resources. Globally, groundwater resources dwarf surface water supplies. Approximately 25% of the earth's total freshwater supply is stored as groundwater, while less than 1% is stored in surface water resources such as rivers, lakes, and near surface soil moisture. The rest of the freshwater supply is locked away in polar ice and glaciers.¹⁰ Because groundwater is hidden from view, as a resource it is often forgotten or misunderstood. Groundwater is, in fact, vital to public health, the environment, and the economy of the United States. Approximately 78% of community water systems are groundwater supplied.¹¹ Nearly all of rural America's self-supplied systems use groundwater. In total, nearly 44% of the U.S. population relies on groundwater for their drinking water supply.¹² Groundwater feeds streams and rivers, especially during periods of drought or low flow. The agricultural industry uses groundwater for irrigation. The percentage of total irrigation withdrawals from groundwater increased from 23% in 1950 to 42% in 2005.¹³

Position

The National Ground Water Association (NGWA) is the largest association of groundwater professionals in the world. Our members include leading public and private sector groundwater scientists, engineers, water well contractors, manufacturers, and suppliers of groundwater-related products and services. NGWA provides guidance to members, government representatives, and the public regarding sound scientific, economic, and beneficial development, protection, and management of the world's groundwater resources.

NGWA recognizes that hydraulic fracturing of oil and gas wells is a mature technology and has been a widespread practice for many decades. While no widespread water quality or quantity issues have been definitively documented that are attributable to hydraulic fracturing and related activities at oil and gas well sites, there have been isolated cases where faulty casing installations (including poor cement bonds) or poor management of materials/chemicals at the surface are suspected as having negatively impacted groundwater, surface water, or water wells.^{14,15,16} NGWA believes that additional studies, research, and monitoring related to the potential for groundwater contamination from the installation, hydraulic fracturing, operation, and maintenance of oil and gas wells are needed, given the growing use of horizontal wells and hydraulic fracturing. Therefore, NGWA supports U.S. EPA's hydraulic fracturing study, and thinks if adequately funded, implemented, and peer reviewed, this study will result in valuable data upon which to build.

Existing federal, state, and local laws currently address various aspects of shale gas development.¹⁷ As production increases, horizontal well and hydraulic fracturing techniques are employed more

widely, and public concern grows, some states and federal agencies are reviewing their current requirements and enforcement capabilities to ensure continued public health and environmental protection. As we await the completion of the U.S. EPA study and other research reports,^{18,19} NGWA offers the following principles as a foundation for policy-making focused on groundwater and drinking water protection:

- Control of potential and active sources of contamination should be a national objective, thereby reducing the need for remediation of groundwater. The goal of groundwater quality protection programs should be protection of the resource for existing or potential beneficial uses.²⁰
- Proper construction and regular maintenance of water wells, including in areas of oil and gas well installation, are important to reducing risks to groundwater and protecting public health and should be followed.²¹ Water well construction regulations developed and enforced by state and local governments can address differences in the geology and hydrogeology of the area. Currently, 47 states²² have statewide water well construction regulations, with additional local water well ordinances in some areas. The *NGWA Manual of Water Well Construction Practices* and relevant Best Suggested Practices documents offer technical guidance to industry members and regulators on water well construction and maintenance.
- Proper construction and regular maintenance of oil or gas production wells also are critical to ensuring the well's integrity and preventing the migration of both natural and injected fluids that could endanger current or future drinking water sources (for instance, through a damaged oil or gas well casing or an improperly grouted oil or gas well). Oil and gas well construction requirements—such as casing depth, the number of casing strings, and cementing requirements—should be designed, among other factors, to protect shallower, useable groundwater.²³
- All unused or abandoned wells and boreholes, including water wells, oil and gas wells, which penetrate aquifers or breach a zone that provides a significant barrier to contaminant migration, should be properly sealed.²⁴ Prior to the installation of oil and gas wells, abandoned wells of all types within the area of operation should be identified and properly filled and sealed.
- Overall water withdrawals for oil and gas operations may be a small percentage of total water withdrawals. In areas where water is scarce or the potential for water use conflicts exists, water supply plans should be prepared to show available sources of water. Generally, the feasibility of using brackish water, water reuse, or other alternatives that minimize freshwater supply withdrawals should be encouraged.

- Surface spills and waste management practices may potentially impact surface water or infiltrate into the subsurface. Accidents or mishandling of chemicals or waste at the surface may allow contaminants to reach groundwater through natural infiltration, fractures, or preferential pathways, such as improperly sealed or abandoned wells. Best management practices or appropriate regulations should be in place and aggressively implemented to address surface spills and waste management.
- All chemicals used in the oil or gas well hydraulic fracturing process should be disclosed to the appropriate governmental entity. This information is needed to ensure proper monitoring as well as to assess and respond to potential problems that may arise.
- Some constituents related to oil and gas production also occur naturally in the groundwater or can be liberated from other manmade sources or operations. Testing of water wells in proximity to oil or gas development prior to and after drilling and/or hydraulic fracturing would assist in determining the source of and liability for future contamination complaints. Site-specific geology and hydrogeology will dictate which water wells in proximity to oil and gas operations should be tested and monitored. Testing should be performed by qualified water well system professionals using certified laboratories. To assist household and public water system owners who are in proximity to oil and gas operations, state agencies should develop a recommended list of testing parameters. The NGWA Information Brief *Water Wells in Proximity to Natural Gas or Oil Development* provides a list of constituents for consideration.²⁵ State agencies should also compile, maintain, and use the data from baseline testing of water wells in proximity to oil and gas operations to inform applicable policymaking or address specific contamination incidents.
- Integrated groundwater monitoring programs using dedicated wells at both the regional and local scale should be developed to establish baseline conditions, and to determine long-term trends in both water quality and quantity in active oil and gas producing areas.
- Dependent on groundwater conditions and the nature of the release, contaminant occurrence in drinking water supplies may lag, by months or years, oil and gas well installation and hydraulic fracturing. Monitoring, financial responsibility, and liability provisions related to oil and gas development should be cognizant of the actual travel times observed in natural hydrologic systems.

Summary

NGWA recognizes that hydraulic fracturing of oil and gas wells is a mature technology and has

been employed for many decades. While no widespread water quality or quantity issues have been definitively documented that are attributable to hydraulic fracturing and related activities at oil and gas well sites, there have been isolated cases where faulty casing installations (including poor cement bonds) or poor management of materials/chemicals at the surface are suspected as having negatively impacted groundwater, surface water, or water wells. Therefore, NGWA believes that additional studies, research, and monitoring related to the potential for groundwater contamination from the installation, hydraulic fracturing, operation, and maintenance of oil and gas wells are needed, given the growing use of horizontal wells and hydraulic fracturing. U.S. EPA's hydraulic fracturing study, if adequately funded, implemented, and peer reviewed, will result in valuable data upon which to build. In the interim, the nation's groundwater resource can best be protected by ensuring that policies are in place and enforced at the appropriate level of government that promote proper well construction and maintenance, both water well and oil and gas; the filling and sealing of abandoned wells; water supply planning and minimization of freshwater use in oil and gas operations; careful chemical handling and waste disposal by the oil and gas industry; disclosure of chemicals used in oil and gas hydraulic fracturing; baseline testing of drinking water wells in proximity to future oil and gas operations; an integrated groundwater quality and level monitoring program tailored to these operations; as well as recognition of the timeframe of groundwater movement.

Contact

J.C. Sandberg
 National Ground Water Association
 Washington Representative
 Baker Donelson Bearman Caldwell &
 Berkowitz, PC
 920 Massachusetts Avenue, NW, Suite 900
 Washington, D.C. 20001
 202 508.3470
 fax 202 220.2270
 jcsandberg@bakerdonelson.com

Christine Reimer
 National Ground Water Association
 601 Dempsey Rd.
 Westerville, OH 43081-8978
 614 898.7791, ext. 560
 fax 641 898.7786
 creimer@ngwa.org

Date

Approved by National Ground Water Association Board of Directors on November 1, 2011. NGWA position papers are updated, as needed, to reflect changes in information. Footnote 16 added January 13, 2012.

NGWA wishes to acknowledge the following contributors to this position paper:

Lynn Bartholomew, Northwest Hydro-Fracturing
Fred Baros, Water Works Plus
Jeffrey Davis, Cardno ENTRIX
David Haupt, Haupt Well and Pump Co.
Sean Kyle, Northeast Water Production
Ken Nichols, CH2M Hill
J.P. Nicot, University of Texas
Timothy K. Parker, Parker Groundwater
Jill Van Dyke, Environmental & Compliance Solutions LLC

References

- ¹ U.S. Energy Information Administration. *Number of Producing Gas Wells*. Retrieved August 18, 2011 at www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm.
- ² Tiemann, Mary, and Adam Vann. Congressional Research Service, *Hydraulic Fracturing and Safe Drinking Water Act Issues*. May 18, 2011.
- ³ Government of Alberta, Canada. Retrieved September 23, 2011 at www.energy.alberta.ca/NaturalGas/944.asp. Shale is one of the most common sedimentary rocks in the world and it is primarily composed of clay and fragments of other minerals such as quartz and calcite. Shale can be the source, reservoir, and the seal for natural gas. Shale formations normally have low permeability (limited ability for gas or fluids to flow easily through the shale formation) and normally require stimulation techniques (such as fracturing) to economically produce shale gas. Shale gas is natural gas that is attached to, or “adsorbed” onto, organic matter or is contained in thin, porous silt or sand beds interbedded in the shale.
- ⁴ U.S. Energy Information Administration. *Importance of low permeability natural gas reservoirs*. Annual Energy Outlook 2010 with Projections to 2035. Retrieved July 22, 2011 at www.eia.gov/oiaf/aeo/otheranalysis/aoe_2010analysispapers/lpnat_gas.html.
- ⁵ Soeder, Daniel J., and William M. Kappel. U.S. Geological Survey. *Water Resources and Natural Gas Production from the Marcellus Shale. Fact Sheet 2009-3032*. May 2009.
- ⁶ Osborn, Stephen G., Avner Vengosh, Nathaniel Warner, and Robert B. Jackson. *Methane Contamination of Drinking Water Accompanying Gas-well Drilling and Hydraulic Fracturing*. Retrieved October 4, 2011 at www.pnas.org/content/early/2011/05/02/1100682108.
- ⁷ Snow, Nick. *Oklahoma frac case actually involves above-ground handling*. OGJ Washington Editor. Retrieved July 26, 2011 at www.pennenergy.com/index/articles/pe-article-tools-template/_printArticle/articles/oil-gas-journal/general-interest-2/hse/201007/july-2011/oklahoma-frac_case.html.
- ⁸ U.S. EPA. *Hydraulic Fracturing*. Retrieved July 25, 2011 at water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/index.cfm.
- ⁹ U.S. Government Accountability Office. *Freshwater Supply: States' Views of How Federal Agencies Could Help Them Meet the Challenges of Expected Shortages (GAO-03-514)*. July 2003. Retrieved July 26, 2011 at www.gao.gov/new.items/d03514.pdf.
- ¹⁰ Alley, William M., Thomas E. Reilly, and O. Lehn Frank. 1999a. *Sustainability of ground-water resources*. U.S. Geological Survey Circular 1186.
- ¹¹ U.S. EPA. *Factoids: Drinking Water and Ground Water Statistics for 2009*. Retrieved July 26, 2011 at water.epa.gov/scitech/datait/databases/drink/upload/data_factoids_2009.pdf.
- ¹² National Ground Water Association. *Groundwater's Role in America's Economic Vitality*. Retrieved August 18, 2011 at www.ngwa.org/Fundamentals/use/Documents/usfactsheet.pdf.
- ¹³ Kenny, Joan F., Nancy L. Barber, Susan S. Hutson, Kristin S. Linsey, John K. Lovelace, and Molly A. Maupin. *Estimated Use of Water in the United States in 2005*. USGS Circular 1344. 2009. Retrieved July 25, 2011 at pubs.usgs.gov/circ/1344/pdf/c1344.pdf.
- ¹⁴ Harrison, Samuel S. *Contamination of Aquifers by Overpressuring the Annulus of Oil and Gas Wells*. *Ground Water*, May-June 1985, p. 317.
- ¹⁵ Osborn, S.G., A. Vengosh, N.R. Warner, and R.B. Jackson. 2011. *Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing*. Retrieved October 4, 2011 at www.pnas.org/content/early/2011/05/02/1100682108.
- ¹⁶ U.S. EPA. *Investigation of Ground Water Contamination near Pavillion, Wyoming*. EPA 600/R-00-000, December 2011. Retrieved at www.epa.gov/region8/superfund/wy/pavillion/EPA_ReportOnPavillion-Dec-8-2011.pdf.
- ¹⁷ U.S. Department of Energy. *Modern Shale Gas Development in the United States: A Primer*. April 2009, p. ES-2.
- ¹⁸ Temple Researchers Will Investigate Methane Gas from Marcellus Shale Drilling. Temple University. July 20, 2011. Retrieved October 4, 2011 at www.temple.edu/newsroom/2011_2012/07/stories/Marcellus_Shale_drilling.htm.
- ¹⁹ University of Texas at Austin Researchers to Conduct Comprehensive Study of Hydraulic Fracturing of Shale Gas. May 9, 2011. Retrieved October 4, 2011 at www.utexas.edu/news/2011/05/09/energy_shale_gas/.
- ²⁰ National Ground Water Association. *Ground Water Protection*. May 1990. Retrieved July 25, 2011 at www.ngwa.org/Documents/PositionPapers/GW_Protection_09.pdf.
- ²¹ National Ground Water Association. *Grouting of Water Wells*. 1989. Retrieved July 25, 2011 at www.ngwa.org/Documents/PositionPapers/Grouting_of_Wells_09.pdf.
- ²² Alaska, Massachusetts, and Pennsylvania are the three states without statewide water well construction standards.
- ²³ Harrison, Samuel S. *Contamination of Aquifers by Overpressuring the Annulus of Oil and Gas Wells*. *Ground Water*, May 1985, p. 317.
- ²⁴ National Ground Water Association. *Decommissioning of Wells and Boreholes*. 1992. Retrieved July 25, 2011 at www.ngwa.org/Documents/PositionPapers/Decommissioning_of_Wells_and_Boreholes_09.pdf.
- ²⁵ National Ground Water Association. *Water Wells in Proximity to Natural Gas or Oil Development Information Brief*. 2011. Retrieved August 20, 2011 at www.ngwa.org/Documents/Water_Wells_in_proximity_info_brief_2011.FINAL.pdf.