



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

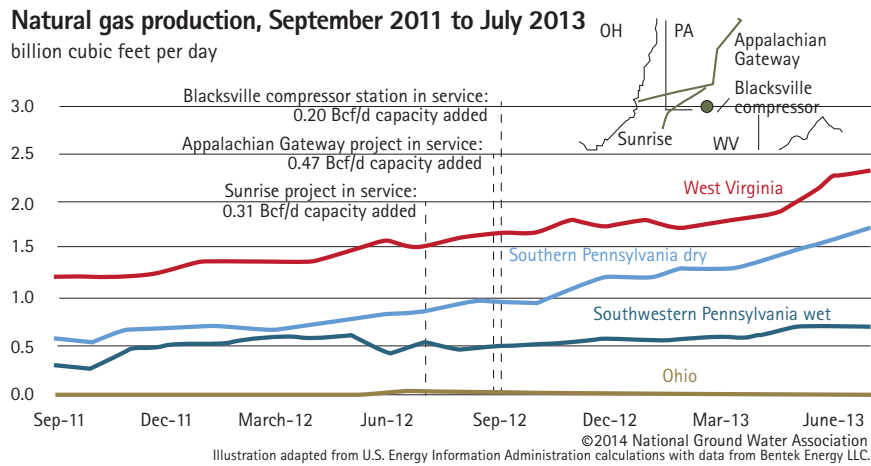
Issue

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 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.

For the first time in nearly two decades, the United States in October 2013 produced more crude oil than it imported.³ Since 2008, U.S. petroleum production has increased 7 quadrillion Btu. Natural gas production has increased by 3 quadrillion Btu over the same period, with much of this growth coming from the eastern United



States. Russia and Saudi Arabia each increased their combined hydrocarbon output by about 1 quadrillion Btu over the past five years (2008-2013).⁴ The greater use of horizontal wells and hydraulic fracturing technology has expanded natural gas and oil supplies;⁵ however, concomitant with this enhanced production is concern about 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. Possible pathways to potential groundwater and drinking water contamination or impacts that have been raised include:

- Improper well construction, both water well and oil or gas well
- Accidents during the transport or storage and use of oil and gas well development chemicals
- Improper wastewater management and disposal
- Abandoned water, oil 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
- Upward migration along geologic features such as faults^{6,7}
- Increased use of freshwater, including ground-water, in oil and gas operations, especially in areas with water constraints.

Concurrent with the need for increasing the nation's energy supplies is 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.^{8,9} Groundwater is a critical component of the nation's water resources. Because groundwater is hidden from view, its value as a resource is often forgotten or misunderstood. Groundwater is, in fact, vital to public health, the environment, and the economy of the United States. Approximately 77% of community water systems are groundwater supplied.¹⁰ 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.¹¹ Groundwater feeds streams and rivers, especially during periods of drought or low flow. The percentage of total irrigation withdrawals from ground-water increased from 23% in 1950 to 42% in 2005.¹²

At the direction of Congress, U.S. EPA is currently studying the potential for hydraulic fracturing to adversely impact groundwater and drinking water resources. The study will focus largely on natural gas development using hydraulic fracturing in shale formations, but other oil and gas-producing formations, including tight sands and coalbeds, are included. The scope of the research includes the full lifespan of the hydraulic fracturing process, from water acquisition, through chemical mixing and actual fracturing, to the post-fracturing stage, including the management of flowback and produced water. U.S. EPA issued a progress report on the study in December 2012. The report described the 18 research projects underway but no conclusions were presented.¹³ The agency anticipates releasing a draft report on research results in 2014.¹⁴

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. No widespread water quality or quantity issues have been definitively documented that are attributable to the hydraulic fracturing process itself. However, there have been several cases related to oil and gas activities such as faulty casing installations (including poor cement bonds), unsealed abandoned wells, or poor management of materials/chemicals at the surface that are suspected to have or have negatively impacted groundwater, surface water, or water wells.^{15,16,17,18,19,20} NGWA believes that additional studies, field-based research, and ground-water monitoring to characterize the potential for groundwater contamination from the installation, hydraulic fracturing, production from 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 gas development.^{21,22} In addition, some states and federal agencies have or are reviewing their current requirements and enforcement capabilities to ensure continued public health and environmental protection.^{23,24,25} Industry has also developed best suggested practices.^{26,27} As we await the completion of the U.S. EPA study and other research reports, NGWA offers the following principles as a foundation for policymaking 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.²⁸
- 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.²⁹ Water well construction regulations developed and enforced by state and local governments can address differences in the geology and hydrogeology of the area. Currently, forty-seven³⁰ states have statewide water well construction regulations, with additional local water well ordinances in some areas. Relevant NGWA 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 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 cemented oil or gas well). Oil and gas well construction requirements such as casing depth, the number of casing strings, and cementing requirements should be implemented, among other factors, to protect shallower, useable groundwater.

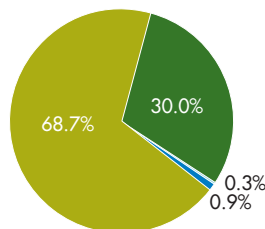
Of all freshwater on Earth:

68.7% is icecaps and glaciers

30.0% is groundwater

0.3% is surface water

0.9% is other



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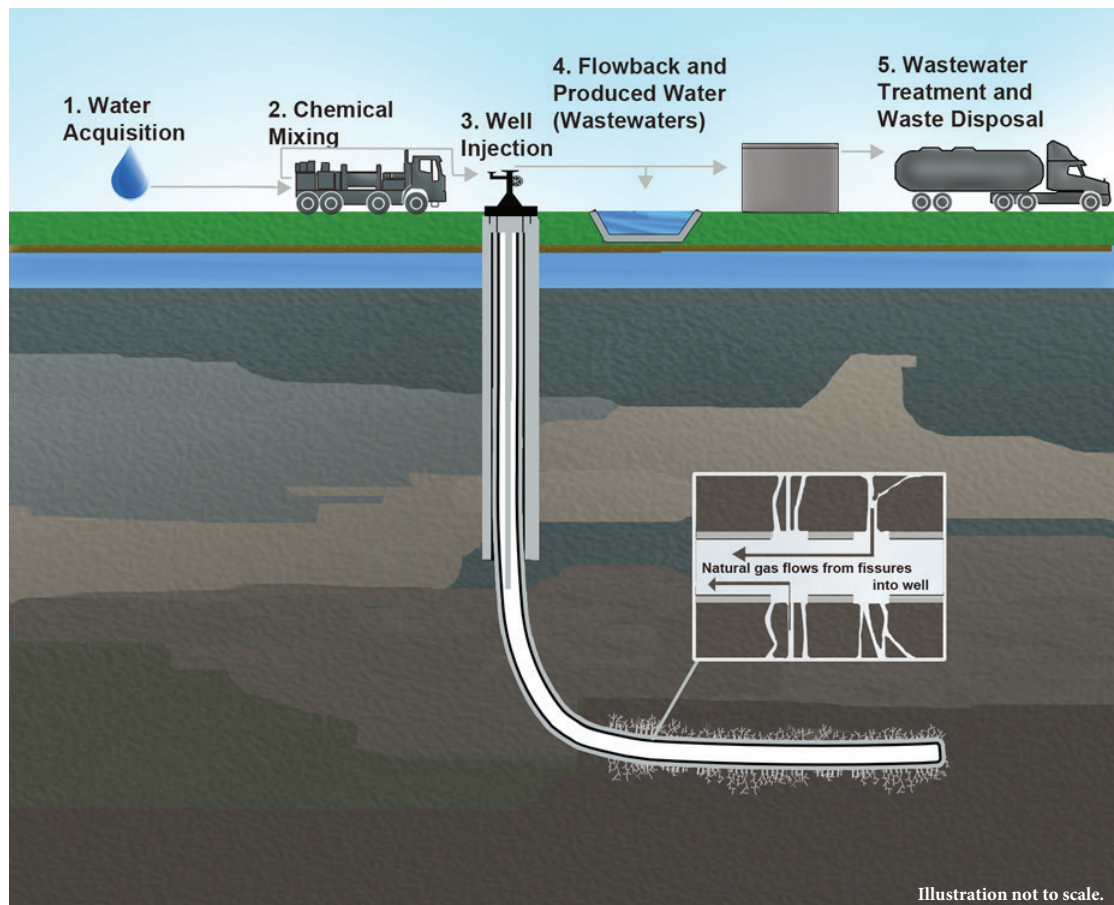


Illustration courtesy of United States Environmental Protection Agency

- 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.³¹ 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 management plans should be developed and implemented using best management practices. Where feasible use of 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 or through state-mandated reporting protocols. 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 and may have varying concentrations over time, based on temperature or other conditions, or can be liberated from other manmade sources or operations.³² 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 and recommended sampling protocols. The NGWA Information Brief *Water Wells in Proximity to Natural Gas or Oil Development* provides a list of constituents for consideration.³³ 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 studies using dedicated wells at multiple levels 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 representative active oil and gas producing areas.³⁴ Unlike contaminant hydrogeology, monitoring designs will be needed to assess upward contaminant migration as well as surface or near surface sources.³⁵ *Groundwater*, an NGWA scientific journal, has carried articles discussing potential monitoring approaches, tools or constituents.^{36,37,38,39,40} A review of past and evolving scientific literature should be undertaken to inform and optimize monitoring plans.
- 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.

Proper construction and regular maintenance of water are important to reducing risks to groundwater and protecting public health.

Summary

NGWA recognizes that hydraulic fracturing of oil and gas wells is a mature technology and has been employed for many decades. No widespread water quality or quantity issues have been definitively documented that are attributable to the hydraulic fracturing process itself. However, there have been cases related to oil and gas activities, such as faulty casing installations (including poor cement bonds) or poor management of materials/chemicals at the surface, that are suspected to have or have negatively impacted groundwater, surface water, or water wells. NGWA believes that additional studies, field-based research, and groundwater monitoring to characterize the potential for groundwater contamination from the installation, hydraulic fracturing, production from and maintenance of oil and gas wells are needed, given the widespread 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 administered 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 management planning so as to minimize 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; integrated groundwater studies at representative active oil and gas producing areas; as well as recognition of the timeframe of groundwater movement.

Thesaurus

As used in this document, 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.

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Dates

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References

- ¹ U.S. Energy Information Administration. *A number of western states increased oil production since 2010*. Retrieved October 7, 2013 at <http://www.eia.gov/todayinenergy/detail.cfm?id=11351>
- ² U.S. Energy Information Administration. *New infrastructure boosts West Virginia, southern Pennsylvania natural gas production*. Retrieved October 7, 2013 at <http://www.eia.gov/todayinenergy/detail.cfm?id=12311>
- ³ Mufson, Steven. Improving U.S. oil production reaches milestone in October, agency says. *Washington Post*. November 13, 2013.
- ⁴ U.S. Energy Information Administration. *U.S. expected to be largest producer of petroleum and natural gas hydrocarbons in 2013*. Retrieved October 7, 2013 at <http://www.eia.gov/todayinenergy/detail.cfm?id=13251#>
- ⁵ U.S. Energy Information Administration. *A number of western states increased oil production since 2010*. Retrieved October 7, 2013 at <http://www.eia.gov/todayinenergy/detail.cfm?id=11351>
- ⁶ Myers, T. 2012. *Potential Contaminant Pathways from Hydraulically Fractured Shale to Aquifers*. *Groundwater* Vol. 50, No. 6, pp 872-882 (Also see discussion of paper in *Groundwater* Vol. 50, No. 6, pp 826-830 and Vol. 51, No. 3, pp 317-321.
- ⁷ Flewelling, S.A. and M. Sharma. *Constraints on Upward Migration of Hydraulic Fracturing Fluid and Brine*. *Groundwater*. DOI:10.1111/gwat.12095.
- ⁸ 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 <http://www.gao.gov/new.items/d03514.pdf>
- ⁹ Konikow, Leonard. *Groundwater Depletion in the United States (1900–2008)*. Scientific Investigations Report 2013–5079. Retrieved January 7, 2014 at <http://pubs.usgs.gov/sir/2013/5079/SIR2013-5079.pdf>
- ¹⁰ U.S. EPA. *Fiscal Year 2011 Drinking Water and Ground Water Statistics*. Retrieved October 10, 2013 at <http://water.epa.gov/scitech/datait/databases/drink/sdwisfed/upload/epa816r13003.pdf>
- ¹¹ National Ground Water Association. *Groundwater's Role in America's Economic Vitality*. Retrieved October 10, 2013 at <http://www.ngwa.org/Documents/usfactsheet.pdf>
- ¹² Kenny, J.F. et al. *Estimated Water Use in the United States in 2005*. USGS Circular 1344. 2009. Retrieved July 25, 2011 at <http://pubs.usgs.gov/circ/1344/pdf/c1344.pdf>
- ¹³ U.S. EPA. *Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources: Progress Report*, December 2012. Retrieved October 10, 2013 at <http://www2.epa.gov/sites/production/files/documents/hf-progress-report-exec-summary20121214.pdf>

- ¹⁴ U.S. EPA. *EPA's Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources*. Retrieved October 8, 2013 at <http://www2.epa.gov/hfstudy>
- ¹⁵ Osborn, S.G. et al. 2011. *Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing*. Proceedings National Academy of Sciences. Vol. 108, No. 20, pp 8172-8176.
- ¹⁶ Jackson, R.B. et al. 2013. *Increased Stray Gas Abundance in a Subset of Drinking Water Wells near Marcellus Shale Gas Extraction*. Proceedings National Academy of Sciences. Vol. 110, No. 28, pp. 11250-11255.
- ¹⁷ Jackson, R.E. et al. *Groundwater Protection and Unconventional Gas Extraction: The Critical Need for Field-Based Hydrogeological Research*. *Groundwater* Vol. 51, No. 4, pp 488-510.
- ¹⁸ Secretary of Energy Advisory Board. *Shale Gas Production Subcommittee Ninety Day Report*. Retrieved October 8, 2013, at http://energy.gov/sites/prod/files/Final_90_day_Report.pdf
- ¹⁹ Harrison, S.S. 1985. *Contamination of Aquifers by Overpressuring the Annulus of Oil and Gas Wells*. *Groundwater* Vol. 23, No. 3. pp. 317-324.
- ²⁰ Harrison, Samuel S. *Evaluating System for Ground-Water Contamination Hazards Due to Gas-Well Drilling on the Glaciated Appalachian Plateau*. *Groundwater* Vol. 21, No. 6, pp 689-700
- ²¹ Groundwater Protection Council and ALL Consulting under U.S. Department of Energy award. *Modern Shale Gas Development in the United States: A Primer*. April 2009, p ES-2. Retrieved October 8, 2013 at http://fracfocus.org/sites/default/files/publications/shale_gas_primer_2009.pdf
- ²² Resources for the Future. *A Review of Shale Gas Regulations by State (2013)*. Retrieved October 8, 2013 at http://www.rff.org/centers/energy_economics_and_policy/Pages/Shale_Maps.aspx
- ²³ Bureau of Land Management. Hydraulic Fracturing Rule. Unified Agenda of Regulatory and Deregulatory Actions. Retrieved January 7, 2014 at <http://www.reginfo.gov/public/do/eAgendaViewRule?pubId=201310&RIN=1004-AE26>
- ²⁴ State Review of Oil & Natural Gas Environmental Regulations. Retrieved January 8, 2014 at <http://www.strongerinc.org/>
- ²⁵ *New York Times*. Strong Rules on Fracking in Wyoming Seen as Model. Retrieved January 8, 2014 at http://www.nytimes.com/2013/11/23/business/energy-environment/wyomings-strong-fracking-rules-may-be-a-model.html?_r=0
- ²⁶ American Petroleum Institute. Overview of Industry Guidance/Best Practices Supporting Hydraulic Fracturing. Retrieved January 8, 2014 at <http://www.api.org/policy-and-issues/policy-items/hf/hydraulic-fracturing-best-practices>
- ²⁷ Getches-Wilkinson Center for Natural Resources, Energy, and the Environment. Intermountain Oil and Gas BMP Project. Retrieved January 8, 2014 at <http://www.oilandgasbmps.org/index.php>
- ²⁸ National Ground Water Association. *Ground Water Protection*. May 1990. Retrieved July 25, 2011 at http://www.ngwa.org/Documents/PositionPapers/GW_Protection_09.pdf
- ²⁹ National Ground Water Association. *Grouting of Water Wells*. 1989. Retrieved July 25, 2011 at http://www.ngwa.org/Documents/PositionPapers/Grouting_of_Wells_09.pdf
- ³⁰ Alaska, Massachusetts, and Pennsylvania are the three states without statewide water well construction standards.
- ³¹ National Ground Water Association. *Decommissioning of Wells and Boreholes*. 1992. Retrieved July 25, 2011 at http://www.ngwa.org/Documents/PositionPapers/Decommissioning_of_Wells_and_Boreholes_09.pdf
- ³² Molofsky, Lisa J., John A. Connor, Albert S. Wylie, Tom Wagner, and Shahla K. Farhat. *Evaluation of Methane Sources in Groundwater in Northeastern Pennsylvania*. *Groundwater* Vol. 51, No. 3, pp 333-349.
- ³³ National Ground Water Association. *Water Wells in Proximity to Natural Gas or Oil Development Information Brief*. Retrieved October 10, 2013 at http://www.ngwa.org/Documents/Water_Wells_in_proximity_info_brief_2012.pdf
- ³⁴ U.S. EPA. *EPA's Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources*. Retrieved January 8, 2014 at <http://www2.epa.gov/hfstudy>
- ³⁵ Jackson, R.E., A.W. Gorody et al. *Groundwater Protection and Unconventional Gas Extraction: The Critical Need for Field-Based Hydrogeological Research*. *Groundwater* Vol. 51, No. 4, pp 488-510 – see page 505.
- ³⁶ Roy, J.W. and M.C. Ryan. *Effects of Unconventional Gas Development on Groundwater: A Call for Total Dissolved Gas Pressure Field Measurements*. *Groundwater* Vol. 51, No. 4, pp 480-482.
- ³⁷ Sharma, Shikha, Michon L. Mulder, Andrea Sack, Karl Schroeder, and Richard Hammack. *Isotope Approach to Assess Hydrologic Connections during Marcellus Shale Drilling*. *Groundwater*. DOI:10.1111/gwat.12083.
- ³⁸ Heilweil, Victor M., Bert J. Stolp, Briant A. Kimball, David D. Susong, Thomas M. Marston, Philip M. Gardner, and Ryan C. Rowland. *A Stream-Based Methane Monitoring Approach for Evaluating Groundwater Impacts Associated with Unconventional Gas Development*. *Groundwater* Vol. 51, No. 4. pp 511-512.
- ³⁹ Novak, Stephanie A. and Yoram Eckstein. *Hydrochemical Characterization of Brines and Identification of Brine Contamination in Aquifers*. *Groundwater* Vol. 26, No 3. pp 317-324
- ⁴⁰ Roy, J.W. and M.C. Ryan. *In-Well Degassing Issues for Measurements of Dissolved Gases in Groundwater*. *Groundwater* Vol. 48. No. 6, pp 869-877.

The National Ground Water Association is a not-for-profit professional society and trade association for the global groundwater industry. Our members around the world include leading public and private sector groundwater scientists, engineers, water well system professionals, manufacturers, and suppliers of groundwater-related products and services. The Association's vision is to be the leading groundwater association advocating for responsible development, management, and use of water.



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