HYDRAULIC FRACTURING FACTS

How Fracturing Works

Engineers design a fracturing operation based on the unique characteristics of the formation and reservoir. Basic components of the fracturing design include the injection pressure, and the types and volumes of materials (e.g., chemicals, fluids, gases, proppants) needed to achieve the desired stimulation of the formation.

The fracturing operation is intended to create fractures that extend from the wellbore into the target oil or gas formations. Injected fluids have been known to travel as far as 3,000 feet from the well.[1] Although attempts are made to design fracturing jobs to create an optimum network of fractures in an oil or gas formation, fracture growth is often extremely complex, unpredictable and uncontrollable.[2] Computer models are used to simulate fracture pathways, but the few experiments in which fractures have been exposed through coring or mining have shown that hydraulic fractures can behave much differently than predicted by models.[3]

Diagnostic techniques are available to assess individual elements of the fracture geometry, but most have limitations on their usefulness[4] One of the better methods, microseismic imaging, provides a way to image the entire hydraulic fracture and its growth history. But it is expensive and is only used on a small percentage of wells. According to the Department of Energy, in coalbed methane wells "where costs must be minimized to maintain profitability, fracture diagnostic techniques are rarely used."[5] And up until 2006 approximately 7,500 in the Barnett shale wells had been drilled, but only 200 had been mapped using microseismic imaging.[6]

What's in fracturing fluids?

A single fracturing operation in a shallow gas well (such as a coalbed methane well) may use several hundreds of thousands of gallons of water. Slickwater fracs, which are commonly used in shale gas forma-

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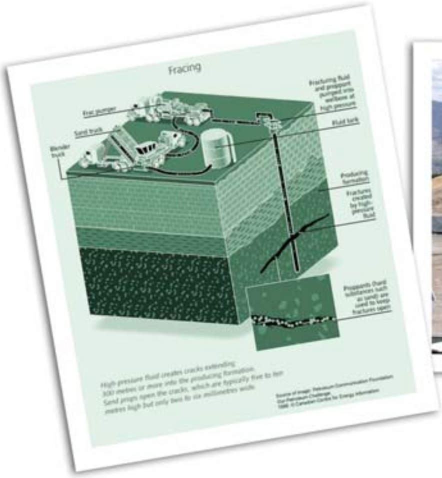

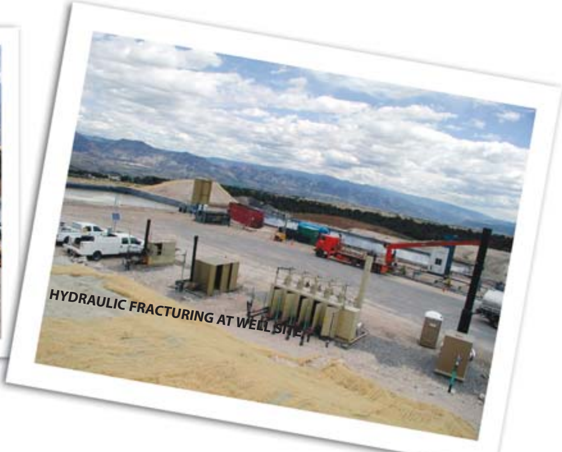

HYDRAULIC FRACTURING AT WELL SITE

tions, have been known to use up to five million gallons of water to fracture on one horizontal well.[7] Many wells have to be fractured several times over the course of their lives, further increasing water use.

A small proportion of wells are fractured using gases, such as nitrogen or compressed air, instead of water-based fluids. In all fracturing jobs, thousands or hundreds of thousands of pounds of proppants (such as sand or ceramic beads) are injected to hold open the fractures.

In most cases, fresh water is used to fracture wells because it is more effective than using wastewater from other wells. If wastewater is used, the water must be heavily treated with chemicals to kill bacteria that cause corrosion, scaling and other problems.[8] Even freshwater fracturing operations, however, contain numerous chemicals such as biocides, acids, scale inhibitors, friction reducers, surfactants and others, but the names and volumes of the chemicals used on a specific fracturing job are almost never fully disclosed. In general, it is known that many fracturing fluid chemicals are toxic to human and wildlife, and some are known to cause cancer or are endocrine disruptors.[9]

It has been roughly estimated that chemicals used to fracture some gas shale wells can make up 0.44% (by weight) the amount of fracturing fluids.[10] In an operation that uses 2 million gallons of water, that means roughly 80,000 pounds of chemicals would be used.[11] These chemicals flow back out of the well along with much of the injected water, and together, these wastes are usually disposed of by injection into underground formations rather than being treated so that they water can be re-used.

Our Drinking Water at Risk

There are number of ways in which hydraulic fracturing threatens our drinking water. Where drilling companies are developing fairly shallow oil or gas resources, such as some coalbed methane formations, drilling may take place directly in the aquifers from which we draw our drinking water. In this case, contamination may result from the fracturing fluids that are stranded underground. The few available studies have shown that 20-30% of fracturing fluids may remain trapped underground, but this number can be much higher for some chemicals, which are preferentially left behind (i.e., do not return to the surface with the bulk of the fracturing fluids).[12]

Where drilling companies are developing deeper oil or gas resources there a number of issues and concerns:

- **Underground Contamination.** Hydraulic fracturing can open up pathways for fluids or gases from other geologic layers to flow where they are not intended. This may impact deeper ground water resources that may be considered for drinking water supplies in the future. If fracturing wastewater disposal is conducted through underground injection wells, there is additional opportunity for groundwater contamination.
- **Surface Contamination.** Fracturing fluid chemicals and wastewater can leak or spill from injection wells, flowlines, trucks, tanks, or pits. And leaks and spills can contaminate soil, air and water resources.
- **Depletion and degradation of shallow drinking water aquifers.** Often companies will use massive quantities of drinking water resources from shallower aquifers in the area to conduct fracturing operations. This industrial draw down can lead to changes in traditional water quality of quantity. If wastewater disposal occurs in streams, the chemical make-up or temperature of the wastewater may affect aquatic organisms, and the sheer volume of water being disposed may damage sensitive aquatic ecosystems.

Protect Our Drinking Water

Join us and support efforts to:

- End the Safe Drinking Water Act exemption for fracturing.
- Require full chemical disclosure and monitoring of fracturing products.
- Require non-toxic fracturing and drilling products.

Visit www.ogap.org to learn more, receive action alerts.

HYDRAULIC FRACTURING FACTS

CITATIONS

[1] IN THE SUPREME COURT OF TEXAS, No. 05-0466, Coastal Oil & Gas Corp. and Coastal Oil & Gas USA, L.P., Petitioners, v. Garza Energy Trust et al., Respondents, On Petition for Review from the Court of Appeals for the Thirteenth District of Texas, Argued September 28, 2006.

[2] Mayerhofer, M.J. and Lolon, E.P., Youngblood, J.E. and Heinze, J.R. 20206. "Integration of Microseismic Fracture Mapping Results with Numerical Fracture Network Production Modeling in the Barnett Shale." Paper prepared for the 2006 SPE Technical Conference and Exhibition, San Antonio, TX. Sept. 24-27, 2006.). SPE 102103. http://www.pe.tamu.edu/wattenbarger/public_html/Selected_papers/--Shale%20Gas/SPE102103%20Mayerhofer.pdf

[3] Warpinski, N., Uhl, J. and Engler, B. (Sandia National Laboratories). 1997.
Review of Hydraulic Fracture Mapping Using Advanced Accelerometer-Based Receiver Systems.
http://www.netl.doe.gov/publications/proceedings/97/97ng/ng97_pdf/NG10-6.PDF

[4] Warpinski, N., Uhl, J. and Engler, B. (Sandia National Laboratories). 1997.
Review of Hydraulic Fracture Mapping Using Advanced Accelerometer-Based Receiver Systems.
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[5] U.S. Department of Energy. "Appendix A Hydraulic Fracturing White Paper." p. A-20. In: Environmental Protection Agency. June 2004. Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs. EPA 816-R-04-003.
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[7] Information for Barnett wells: Burnett, D.B. and Vavra, C.J. August, 2006. Desalination of Oil Field Brine - Texas A&M Produced Water Treatment. p. 25. http://www.pe.tamu.edu/gpri-new/home/BrineDesal/MembraneWkshpAug06/Burnett8-06.pdf and Global Petroleum Research Institute (Texas A&M University) web site: "Conversion of Oil Field Produced Brine to Fresh Water."

http://www.pe.tamu.edu/gpri-new/home/BrineDesal/BasicProdWaterMgmnt.htm; Information for Marcellus wells: Arthur, D. et al. September 23, 2008. "Hydraulic Fracturing Considerations for Natural Gas Wells of the Marcellus Shale." Presented at Ground Water Protection Council 2008 Annual Forum.
http://www.gwpc.org/meetings/forum/2008/proceedings/Ground%20Water%20&%20Energy/ArthurWater Energy.pdf

[8] Fichter, J.K., Johnson, K., French, K. an Oden, R. 2008. "Use of Microbiocides in Barnett Shale Gas Well Fracturing Fluids to Control Bacterially-Related Problems." NACE International Corrosion 2008 Conference and Expo. Paper 08658. I pp. 2, 3. http://content.nace.org/Store/Downloads/7B772A1BA1-6E44-DD11-889D-0017A446694E.pdf

[9] The Endocrine Disruption Exchange web site: http://www.endocrinedisruption.com/

[10] According to Arthur, D. et al. (2008) analysis of a fracturing fluid used at a Fayetteville shale well found that it was composed of 90.6% water (by weight); sand comprised 8.95%; and chemicals comprised 0.44%. Arthur et al. assumed this same make-up for Marcellus shale wells. (Sources: Fayetteville information: Arthur, D., Bohm, B., Coughlin, B.J., and Layne, M. 2008. Evaluating The Environmental Implications Of Hydraulic Fracturing In Shale Gas Reservoirs. p. 16. http://www.all-llc.com/shale/ArthurHydrFracPaperFINAL.pdf; Marcellus shale information: Arthur, D., Bohm, B., Coughlin, B.J., and Layne, M. November, 2008. "Evaluating The Environmental Implications Of Hydraulic Fracturing In Shale Gas Reservoirs." Presentation at the International Petroleum & Biofuels Environmental Conference (Albuquerque, NM,November 11?13, 2008). p. 22.
htpp://ipec.utulsa.edu/Conf2008/Manuscripts%20&%20presentations%20received/Arthur_73_presentation.pdf

[11] At 80°F, water weighs 8.3176 pounds per gallon (http://www.engineeringtoolbox.com/water-density-specific-weight-d_595.html). If 2 million gallons of water are used to fracture a Marcellus well when it's 80°F outside, the water weighs 16,690,808 lbs, i.e., 16.7 million pounds. If this water is 90.6% of the total weight of the fracturing fluid (as estimated by Arthur et al.), then the total fracturing fluid weighs 18,361,148 lbs (18.4 million lbls). If chemicals make up 0.44% of the fluids by weight, then the chemicals weigh 0.44% of 18.4 million lbs, which is 80,789 lbs. If sand makes up 8.95% of the fluids by weight, then 1,648,816 or 1.6 million pounds of sand are used.

[12] See discussion in Sumi, L. (Oil and Gas Accountability Project). 2005. Our Drinking Water At Risk. pp. 12 and 13, and footnote 91. http://www.earthworksaction.org/pubs/DrinkingWaterAtRisk.pdf

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