



FRACTURED

Experts examine the contentious issue of hydraulic fracturing water use

In a state where oil and gas are king, and water is—in words commonly attributed to Mark Twain—“for fighting over,” an unconventional method that uses water to extract oil and gas from Texas’ underground fields is causing passionate debate.

This method—hydraulic fracturing—uses water and other fluids under pressure to fracture or crack shale rock, releasing oil and gas from the rock. Combined with the use of horizontal drilling, fracturing has unlocked large deposits of oil and gas and opened up new oil and gas fields in areas around the country. The majority of hydraulic fracturing in Texas occurs in the Barnett Shale near the Dallas–Fort Worth Metroplex, Eagle Ford Shale in South Texas and Wolfe Camp Shale in West Texas’ oil-rich Permian Basin.

One slice of the debate centers on the amount of water fracturing uses and the impact on and value of the water used to nearby communities.

Although the current conversations about hydraulic fracturing can be intense, the method has been around for years.

“We’ve been doing hydraulic fracturing for 50 years, and we’ve been horizontal drilling for 20 or 30 years,” said Dr. Stephen Holditch, professor in Texas A&M University’s Harold Vance Department of Petroleum Engineering. Holditch is also director of Texas A&M Energy Institute for Petroleum Research, and the Global Petroleum Research Institute.

He said that in the 1990s and 2000s, hundreds of rigs were running in South and Central Texas, developing the Austin Chalk formation. These wells were drilled horizontally and were stimulated using hydraulic fracturing. “So the technology being used today in the shale reservoirs was actually developed over the last 20 years in the Austin Chalk and other areas,” Holditch said.

“We can always improve some of our operating principles and practices, but it’s not brand new technology that we’re trying to understand.”

The current attention, according to Texas A&M experts, is caused by the dramatic increase over the past few years in unconventional natural gas and oil production using hydraulic fracturing and horizontal drilling and the fact that this drilling is in areas unaccustomed to oil and gas activity.

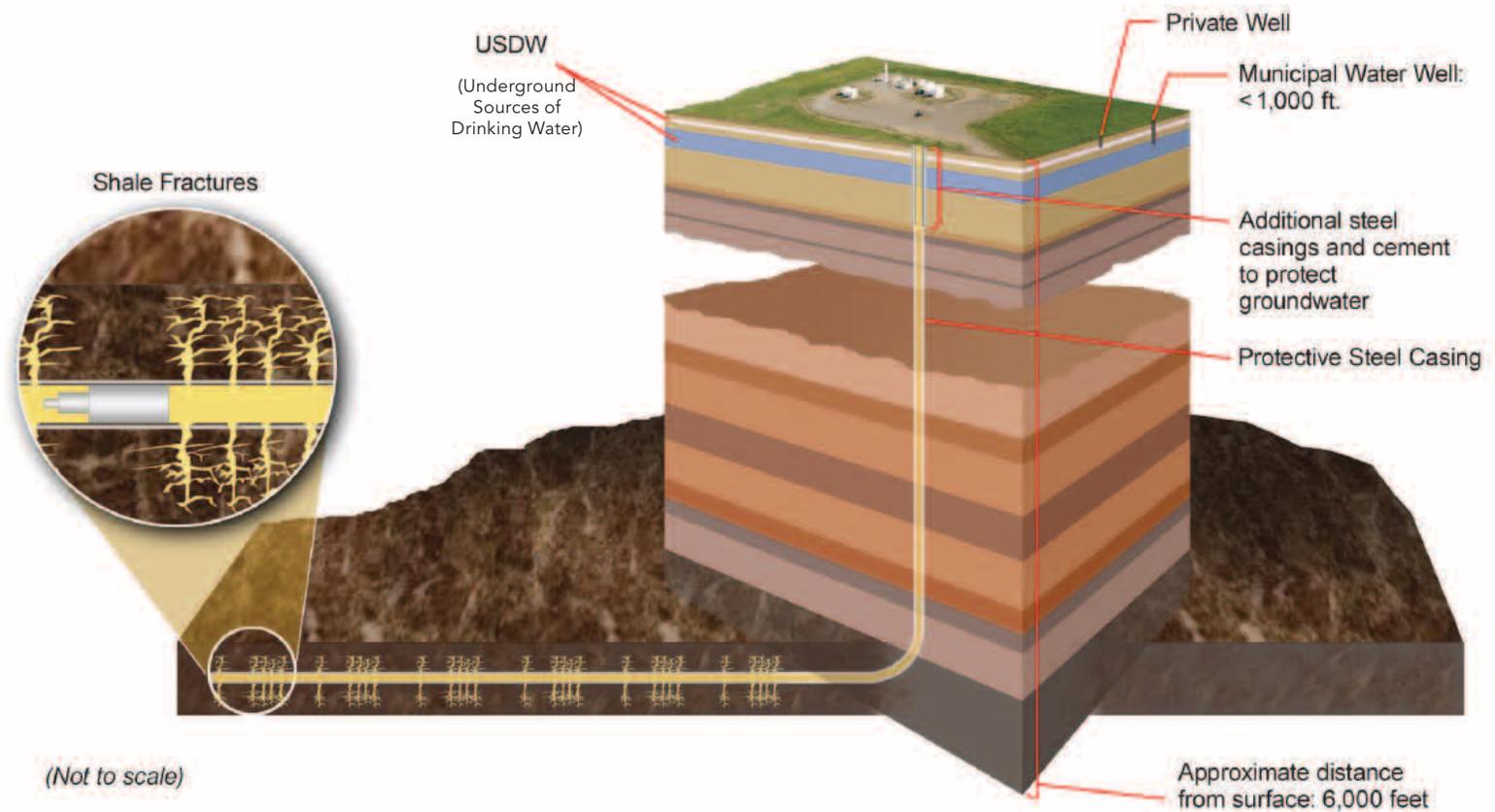
Holditch said the industry has been producing oil and gas from conventional reservoirs for a hundred years. “Now what we have found in the last five or 10 years is that source rocks are still loaded with oil and gas,” he said. Source rocks are usually organic-rich shales in which petroleum forms.

“The energy industry has never had this much advancement in technology since the invention of the rotary drilling rig,” said Dave Burnett, director of technology for the Global Petroleum Research Institute and research coordinator for Texas A&M’s Harold Vance Department of Petroleum Engineering. “Hydraulic fracturing practices designed for shale plays are causing that growth. As we learn more, it becomes more economical and each well becomes more productive. Wells are two to three times more productive than they were 10 years ago.”

Much of the increased activity is occurring near communities, such as west of Dallas–Fort Worth, that have had little oil and gas exploration activity until recently. These communities are witnessing a huge buildup of oil and gas wells as well as the associated effects on infrastructure and increase in traffic, experts said.

Extracting new sources of oil and gas

Hydraulic fracturing is not a drilling process but a method of extracting oil and gas after wells are drilled. Oil and gas companies use a fracturing liquid that is a mixture of approximately 90 percent water, 9 percent sand or other granular propping agents, and less than 1 percent chemicals used primarily to viscosify the fluid so it can transport the sand, Holditch said. The fracture fluid is then pumped into the drilled well with enough pressure to fracture the low-porosity shale rock, which is usually one to three miles below the surface.



These cracks or fractures increase the permeability of the reservoir allowing the natural gas or oil to more easily flow to the wellbore.

Holditch said hydraulic fracturing pushes the earth apart with hydraulic force. “After the fluid opens the cracks, the propping agent is pumped in to prop open the fracture,” he said. “It creates pathways for the oil and gas to flow from the reservoir back to the surface.”

Water use in hydraulic fracturing

The amount of water used in hydraulic fracturing is a major concern, especially in drought-prone Texas. Water-use volumes vary widely, from 1 million to 6 million gallons per well, depending, in part, on where the wells are drilled and what fracturing techniques are used.

Estimates of current and future water use in each basin also vary. Some of the variation is because of unknowns such as development of new fracturing technologies that consume less water and the discovery of new formations for drilling.

According to a study conducted by Drs. Jean-Philippe Nicot and Bridget Scanlon of The

University of Texas at Austin’s Bureau of Economic Geology and published in *Environmental Science & Technology*, the cumulative water use for shale gas production fracturing in the Barnett Shale totaled 117,000 acre-feet, or just over 38 billion gallons to stimulate about 15,000 wells from 2000 to June 2011.

A June 2011 Bureau of Economic Geology report, *Current and Projected Water Use in the Texas Mining and Oil and Gas Industry*, estimated that in 2008, the latest year with complete information, 35,800 acre-feet of water were used in Texas for fracturing wells, mostly in the Barnett Shale area. The report was funded by the Texas Water Development Board to help with its water planning.

The report authors also projected that the overall water use for fracturing will increase to a peak of approximately 120,000 acre-feet by 2020–2030.

Comparing water uses

The amount of water used in hydraulic fracturing may seem substantial, but is small when compared to water use by agriculture, manufacturing and municipalities, according to the Texas Water Development Board’s 2012 state water plan. Mining, ⇨

Steel casing lines the well and is cemented in place to prevent any communication up the wellbore as the fracturing job is pumped or the well is produced. Shallow formations holding freshwater that may be useful for farming or public consumption are separated from the fracture shale by thousands of feet of rock. Image from *Shale Gas: Applying Technology to Solve America’s Energy Challenges*, National Energy Technology Laboratory, 2011.



which includes oil and gas drilling, comprised an estimated 168,273 acre-feet out of a total of 16,321,364 acre-feet per year in 2009. By 2060, the demand for mining is projected to increase to 292,294 acre-feet per year or 1.3 percent of the total water demand.

Referring to 2010 data about the Barnett Shale's water use for fracturing, Holditch said: "By far, the amount of water being used for other sources has been more than what is used in drilling. That's not to say that it's not an issue, but the oil and gas industry is not using, in the grand scheme of things, a lot of water when compared to other uses."

Local impacts cause concern

Though water use for shale gas is only about 1 percent of statewide water withdrawals, local impacts of using the water vary, the experts said.

"It is a lot of water, and if it's in your backyard you're going to be concerned with it," Holditch said. "I don't downplay this as a non-issue; it is a real issue."

Dr. Susan Stuver, research scientist with the Texas Water Resources Institute and Texas A&M Institute of Renewable Natural Resources, said though a great deal of water is needed for hydraulic fracturing, it is not needed for a sustained amount of time.

"A lot of water is needed during the completion phase of energy production, which is when the fracturing occurs, but then not much is needed after that," she said. "Therefore, a problem may arise with timing. If the oil and gas industry needs water in a peak water-use season and during a drought, will we be prepared to balance the municipal, agricultural and other industrial demands to account for this?"

"Just like there are institutions that manage electrical demand during peak months, we are going to need an institution that can properly predict and manage water needs and demands to ensure there is enough supply to meet everyone's needs."

According to the Nicot and Scanlon paper, at the county level, the projected net water use for fracturing is sometimes larger than projected pumping for all other uses. The authors gave the example of Karnes County in the Eagle Ford Shale, where most of the water used for fracturing is groundwater.

The authors wrote that in 2010-2060 Karnes County is projected to use a maximum of 2,000 acre-feet of water a year for fracturing and average 1,100 acre-feet per year. The projected average annual water use for all uses except fracturing for local water government entities is projected to be 1,900 acre-feet.

Citing Cotulla—a town in South Texas between San Antonio, Corpus Christi and Laredo with a

population of 3,603—as an example, Burnett said: "Each one of the wells in South Texas uses more water in the 3 months that it is drilling than Cotulla uses in the same 3 months."

The difference, he said, is the use of water for fracturing is a temporary, one-time use.

"Once the well is drilled, it is not such an impact on the environment," Burnett said.

Competing interests

When comparing water use for fracturing to other uses, Dr. Darrell Brownlow, a cattle rancher and landowner in South Texas, who has a doctorate in geology and geochemistry, said a broad perspective needs to be taken, looking at not only the amount of water used but also the economic value for the communities where fracturing is taking place.

He said research suggests there is enough water to support agriculture and hydraulic fracturing in the Eagle Ford Shale and that the economic opportunities for local landowners defend the use of the area's groundwater for hydraulic fracturing.

Brownlow is a board member for the San Antonio River Authority and for more than a decade was a member of the South Central Texas Regional Planning Group (Region L). He said in Region L, where 80 percent of the Eagle Ford Shale activity occurs, the regional planning group predicts about 42 percent of available water will be used for municipal purposes in 2020, 30 percent for irrigation and 5 percent for mining, of which about 2.5 percent would be for fracturing.

"In South Central Texas, we use more water for washing clay out of rock (to make roads, bridges, concrete and cement) than we do for hydraulic fracture," he said.

Everything associated with oil activity is taxable, Brownlow said. Mineral taxes; severance taxes paid to the state; federal income taxes paid on royalties and profits; property taxes; school district taxes—everything in that economic arena is taxed. Those taxes, he said, bring money to the communities.

"Every acre-foot of water from the Carrizo (Aquifer) used in hydraulic fracturing has a gross revenue potential of about \$2,080,000," he said.

Some interest groups have examined whether fracturing can negatively affect the value of homes near the oil and gas operations.

In the Barnett Shale area, some property values may be negatively affected, according to a study conducted by Integra Realty Resources—DFW for the city of Flower Mound. The study said residential property in the Flower Mound market valued at more than \$250,000 and within 1,000 feet of a well site can experience a 3 to 14 percent decrease in value.

DOES HYDRAULIC FRACTURING CAUSE CONTAMINATION?

However, the report also stated that “data from most well sites studied in this report outside Flower Mound suggests that there is little or no impact on residential property from proximity to well sites. Sales comparison research indicated that a diminution in value due to proximity to natural gas sites occurs only for properties immediately adjacent to the site.”

The report pointed out that several sales where view of the well site was obstructed by buffers such as trees indicated value is not measurably impacted, even when the property is in close proximity.

Ways to save water

Almost everyone involved agrees that the amount of water used in hydraulic fracturing needs to be reduced. The answer is better technology—both in the fracturing process and in recycling more of the flowback, or water left over from the fracturing process—and identifying other substances besides freshwater that could be used for fracturing, the experts said.

According to Holditch, in most cases, the well will return between 10 and 30 percent of the water injected over the first few days and weeks back to the surface. The rest of the water stays in the formation and cannot be reused.

“The water that flows back will have minerals, oil, salt and other impurities that must be filtered or removed before the flowback water can be reused,” he said.

Burnett and his partners from the Houston Advanced Research Center, Matagorda Redfish Society and CMGC Foundation are focusing on research and demonstrations to remove contaminants in flowback water through advanced water treatment technologies.

Burnett said they are beginning a three-year project in South Texas to bring new membrane filtration technologies to the field and demonstrate to the industry, the public and regulators the technologies that work.

By using different filtration processes and reverse osmosis, the group is able to remove the different contaminants such as bacteria, corrosion products, suspended solids, heavy metals, hydrocarbons and other chemicals from the flowback water, making it more suitable for reuse.

With these advanced treatments removing contaminants from the flowback and with fracturing technology becoming more efficient, Burnett believes the percent of flowback water will increase and the amount of that water that can then be recycled will increase. ➡

Another, more contentious, issue for hydraulic fracturing than the amount of water used is the possible contamination of groundwater and surface water with byproducts of the fracturing process or the other activities associated with unconventional oil and gas exploration.

Reports exist supporting the fact that hydraulic fracturing does not cause contamination; others conclude it does.

Dr. Stephen Holditch, professor in Texas A&M’s Harold Vance Department of Petroleum Engineering, said he does not believe water contamination specifically from the fracturing process is occurring. What may happen, he said at the Growing Texas conference in October 2012, is that shallow wells are not plugged properly or are cracked, causing the fracturing water to seep into the water supply.

Because of all the controversy, at the request of Congress, the U.S. Environmental Protection Agency is conducting a study to better understand any potential impacts of hydraulic fracturing on drinking water resources: epa.gov/hfstudy/index.html.

To address the concerns about hydraulic fracturing, the Texas Senate passed a bill in May 2011 requiring oil and gas operators to disclose the chemicals they use in fracturing on the website FracFocus (fracfocus.org) as well as with the Railroad Commission of Texas. FracFocus is maintained by the Groundwater Protection Council and the Interstate Oil and Gas Compact Commission.



Burnett also believes that the industry will turn from using fresh groundwater sources to make up the fluid and begin tapping brackish groundwater resources not used for either agriculture or public consumption.

“By the end of four years we should be able to see brackish water being used; we should see freshwater use by oil and gas drop by 90 percent,” he said.

Holditch said the key to saving water with hydraulic fracturing is not using freshwater at the start, noting that the oil and gas industry does not pump freshwater during hydraulic fracturing operations.

“They start with freshwater, but then add 2 percent to 6 percent potassium chloride solution to the fluid to minimize clay swelling in the formation,” he said. “As such, the industry could easily convert to using low salinity brine for mixing fracturing fluids, thus eliminating the need to use any freshwater. Some companies are already using low salinity brines.

“There is no reason that we couldn’t start with saltwater,” he said. “There’s no reason we can’t drill down into some brackish aquifers and produce

water ... and use that for fracturing. That’s what I predict is going to be the future.”

According to Stuver, the main reason why the industry doesn’t currently start with brackish water is that the amount of salt in brackish water varies depending on water well location. “The industry would need to either desalinate down to proper salt levels or measure and add more to get the proper saline concentration,” she said.

Holditch said research is ongoing to develop the “recipe” for using saltwater as fracture fluid, a recipe that will vary with each well site. Petroleum engineering researchers at Texas A&M, as well as oil and gas service companies, are investigating using saltwater for fracturing, he said. (See sidebar on Texas A&M research projects.)

“Since the source of the saltwater will be totally different depending on where the water comes from, then the recipes will be site-specific,” he said. “As such, you will need a chemist in the field to make sure the recipe is tweaked for each well because the base fluid will be different.”

According to the Railroad Commission of Texas, the state agency that oversees the oil and

TEXAS A&M RESEARCH ONGOING IN HYDRAULIC FRACTURING

Texas A&M University Harold Vance Department of Petroleum Engineering and its partners have numerous projects dealing with hydraulic fracturing. A few include:

Reducing the Environmental Impact of Gas Shale Development: Advanced Analytical Methods for Air and Stray Gas Emissions and Produced Brine Characterization (GSI Environmental, Texas A&M Global Petroleum Research Institute [GPRI] and Research Partnership to Secure Energy for America [RPSEA])

Laboratory Measurement of Propped Fracture Conductivity in the Barnett Shale (Crisman Institute: Hill)

Field Testing of Environmentally Friendly Drilling Systems (GPRI, U.S. Department of Energy National Energy Technology Laboratory, and M-I SWACO)

Environmentally Friendly Drilling: Technology Integration Program (Houston Advanced Research Center, GPRI)

Diagnosis of Multiple Fracture Stimulation in Horizontal Wells by Downhole Temperature Measurement for Unconventional Oil and Gas Wells (Crisman Institute: Zhul)

gas industry, it has approved several companies' requests for recycling projects in the Barnett Shale that will reduce the amount of freshwater used.

Other possible sources of water for fracturing include reuse of municipal wastewater.

"What we need to do is to get away from using freshwater ... and that'll solve a lot of problems," Holditch said.

Waterless fracturing?

According to David Blackmon, managing director for public policy and strategic communications for FTI Consulting, oil and gas companies are working to develop technologies to reduce the amount of water used in fracturing jobs. Blackmon spoke in October 2012 at the Growing Texas conference, organized by the Texas A&M Energy Institute.

One new development, Blackmon said, is a gel that keeps brine water from contacting the drill pipe, preventing corrosion of the pipe. "We have been able to use 33 percent brine content rather than freshwater in frac jobs using this gelling agent," he said, adding that it has helped reduce the overall volume of water used.

In a joint House Committee on Natural Resources and House Committee on Energy Resources meeting in June 2012, Lance Robertson, vice president for Marathon Oil Company, testified that the company is trying waterless fracturing by using a gel.

Robertson said Marathon's move to waterless fracturing has reduced water consumption by 40 percent in the first 90 days of operations. In the company's Eagle Ford fracturing operations, 97 percent of the water is nonpotable brine.

Some companies are using propane as the fracturing fluid instead of water, Blackmon said. "The great thing about that is it doesn't use any water," he said, "and the companies are able to resell the propane when it comes up back from the hole."

Blackmon said one company executive has told him that in two to three years, the industry won't have to use any freshwater in hydraulic fracturing.

"That is a huge game changer."

For more information, visit [txH2O](http://txH2O.twri.tamu.edu/publications/txH2O) online at twri.tamu.edu/publications/txH2O. 

Image from
CGTextures.com

Integrated Fracture Placement and Design Optimization in Unconventional Gas Reservoirs (Crisman Institute: Gildin and Jafarpour)

Modeling Hydraulic Fracturing of Shales (Crisman Institute: Ghassemi)

Shale Permeability Estimation from Fracture Calibration Test (Crisman Institute: Economides)

Extent of Propped Fractures in the Stimulated Reservoir Volume (Crisman Institute: Economides)

Evidence of Stress Dependent Permeability in Long Term Production Data (Crisman Institute: Economides)

Simulation of Multistage Fracturing of Horizontal Wells for Shale Oil Production (Crisman Institute: Economides and Moridis)

Investigation of Fracture Fluid Performance in Oil Shale with Surfactant Additives by X-Ray Tomography Methods (Crisman Institute: Schechter)

Re-Use of Produced Waters as Hydraulic Fracturing Fluids (Crisman Institute: Nasr-El-Din)