

From Flowback to Fracturing: Water Recycling Grows in the Marcellus Shale

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A hydraulic fracturing job in progress in Pennsylvania.

In Pennsylvania, recycling water from wells in the Marcellus Shale has been transformed from a trend to an essential skill. The tipping point came in mid-April in a notice from the state's Department of Environmental Protection (DEP) telling 15 public water treatment plants to stop handling waste water from wells in the Marcellus.

The order to the only public facilities treating water from fracturing was voluntary, but the intent was clear. In the letter, Michael Krancer, the DEP secretary said: "Now is the time to take action to end this practice."

If there was any doubt, the US Environmental Protection Agency (EPA) followed up with a letter in May

telling the state agency to make that a mandatory order. The federal agency said it would contact large oil and gas companies and the water treatment facilities to ensure they were no longer processing water that had flowed back after fracturing, and then disposing it in the state's waterways.

At that time two-thirds of the water from fracturing was recycled in Pennsylvania, where water use for shale gas companies has become a battleground with environmentalists, politicians, and the people who live on the land holding enormous natural gas reserves. The industry was already moving toward recycling, said Pete Miller, water resources manager of the Marcellus Shale division at Range

Resources, which reuses nearly all the water from its wells there. "When the standard came out, it was another push in that direction."

The state's letter sparked a rush by those who faced higher disposal costs because they could no longer have their waste water treated in state. "People are calling and telling me, 'I've got to figure this out,'" said Dave Grottenthaler, general manager of Kroff Oil Services, a Pittsburgh water treatment specialist that got into fracturing water reuse early on. "I've been telling them for a while, you can reuse all your flowback and you will be safe."

Range Resources is evidence to how fast this transition can happen. It first used a mixture of fracturing flowback

water and fresh water in August 2009. In 2010, it said it reused 96% of its produced water in Pennsylvania.

“We are going to have to see more recycling,” said David Yoxtheimer, a hydrogeologist at Penn State University’s Marcellus Center for Outreach and Research. He said water permits indicated about two-thirds of the flowback water has been recycled.

The Marcellus has become a proving ground for reuse of water flowing back to the surface in the weeks after fracturing, as well as the flow of produced water after that. Operators have demonstrated that fresh water is not a must for fracturing, and have tested a wide range of water treatment options. The constant drilling needed to maintain output from shale formations creates more than enough demand. Typically 10% to 30% of the water used to fracture well returns to the surface.

The economics of water reuse remains an issue in some places in Pennsylvania, and in most places outside it. The problem and the opportunity are both based on the fact that it is costly to haul millions of gallons of water using trucks. Recycling in Pennsylvania is likely the lowest cost alternative where there are ponds built for storage and treatment near the drill sites. Otherwise it is often cheaper to use fresh water plus high-tech onsite water purification to avoid a long haul.

Transportation costs are creating opportunities in places where sources of fresh water, or injection wells for disposal, are far away. Halliburton’s CleanWave water treatment technology is in use in a growing list of unconventional gas plays, where arid conditions or distance is an issue. Its truck-mounted units are working in Colorado, North Dakota, and Louisiana.

There is even talk of increased recycling in Texas where the low cost of injection disposal has capped fracturing water reuse to about 5% of the amount used for shale gas completions, according to a study by Jean-Philippe Nicot, a research scientist at the Bureau of Economic Geology of the University of Texas at Austin. The drilling boom in the Eagle Ford Shale requires a lot of water in a dry region in the midst of a severe drought. “We are getting more and more interest in Texas,” from oil and gas operators, said Larry Ryan,



This portable water treatment system is able to process 10,000 b/d of produced water for reuse in fracturing gas wells in the Marcellus Shale in Pennsylvania. The series of units remove minerals, clarifies the water and reduces the volume of the solids that can reduce a field’s output.

global manager for water treatment at Halliburton. “The centerpiece of this is they are under pressure from municipalities and the public to conserve water. If they can recycle flowback and produced water and save money, that is the best of both worlds.”

Lessons in Doing More with Less

The industry focus on water treatment is overdue, said David Burnett, a professor at Texas A&M University who is an expert in treating water from oil and gas operations. “The thing where technology needs to improve is where we are using water. It is the area where companies are laggards,” said Burnett. He is on the committee advising the EPA on the environmental impact of hydraulic fracturing on water supplies.

A few years ago, the question holding back recycling in the Marcellus was: Will reusing fracturing water damage the well? “Everyone was scared to death of what might happen if treated frac water was used again,” said Matt Blauch, director of product development at Superior Well Services, a Nabors subsidiary. Superior Well and Kroff addressed those doubts in an article describing how they successfully fractured a well using all recycled water.

Now major Marcellus players such as Range Resources, Anadarko, Atlas Energy, and Chesapeake Energy are

moving toward total recycling. Salt water is a common component in fracturing fluids, which employ a growing array of salt-tolerant chemicals. Reuse for fracturing limits the amount of treatment required. “The goal is to reuse waste water, not to use the technology to make potable or drinking water,” said Ryan of Halliburton.

There is no consensus on the minimum standards for fracturing quality water. Some say barium and sulfate levels need to be strictly managed. Others trust in dilution, and keep a close eye on the production. “The practice is all over the place,” said Radisav Vidic, chair of the Department of Civil and Environmental Engineering at the University of Pittsburgh. “Some will frac with any water they can get their hands on. Others will frac only with potable water.”

Recycling’s Fuzzy Economics

Recycling is growing where the cost of reuse is less than the alternatives. When the last public water treatment plants in Pennsylvania stopped accepting water from gas producers, the economics abruptly shifted.

Trucking waste water to an injection well can be a long haul because the state’s geology does not allow disposal wells. The nearest available concentration of injection wells is in Ohio. One observer estimated the injection wells



These pipes connect a treatment pond to well sites where water produced from nearby shale gas wells is reused for fracturing. Netting keeps out birds and two liners plus an alarm system are used to prevent leaks.

charge from USD 1.50 to USD 2/bbl, which another said fails to reflect rising prices. Getting the waste water there requires many trucks, each costing about USD 100/hr. Ryan estimated a six-hour trip, which would be typical in eastern Pennsylvania, with a 150 bbl tank truck adds USD 4 bbl to the cost of disposing of one barrel of waste water.

Shipping costs are also a consideration in recycling. Range recycles water in southwestern Pennsylvania using a system of storage ponds. Eight of its ponds are specially built for water from fracturing, with double liners and leak control alarms. Where possible, it installs water pipes to the wells.

In northeastern Pennsylvania, where Range does not have treatment ponds to store reused water, the lowest cost disposal option for the company is distillation. It is processed by a private water treatment company using the Nomad Water Purification Units produced by a water treatment startup, Fountain Quail Water Management. It is competing with other high-tech newcomers such as Purestream Technology. Its vapor recompression technology, developed by Utah State University, reduces the cost by using waste heat in the process.

Purestream charges from USD 3.50 to USD 7.50/bbl, depending on the water processed, said Andrea Metil, vice president of marketing. "There is no

reason to use technology unless we can save them money. More often than not, we can."

Less Process, Less Disposal

There is a downside to producing drinking water quality from what flows out of the Marcellus Shale. It is far saltier than sea water and laden with elements such as strontium and radium. A 1-million-gallon-a-day plant distilling water from the Marcellus generates about 400 tons of waste, according to an SPE paper by Blauch. That amount of water is often the product of a single fracturing job. "Each level of removal impacts the cost. If you don't have to remove it, you are way ahead of the game," said Blauch in an interview.

Frequent water testing is needed because water quality varies with time. For example, water produced after fracturing is significantly higher-quality water than the flowback two weeks later. Treatment also varies based on the well location. In a SPE paper by Blauch, he noted that the barium present in flowback water ranges from 3,000 mg/L in southwestern Pennsylvania to 17,000 mg/L in northeastern Pennsylvania.

There are wide differences of opinion on what is the minimum treatment needed to ensure a good well. Some experts say it is essential to treat the

water to strictly limit barium, iron, strontium, and sulfates. Those add to the risk of scaling—particles created by a chemical reaction in the well that clog fractures and reduce production.

"Some people are taking frac water and running it through a cartridge filter—it can only reduce the solids by 15% to 20%. Eighty percent is still there and that is not acceptable," said Burnett of Texas A&M.

Researchers at Texas A&M are working on a lab test that simulates conditions in a shale formation to see if the chemicals in fracturing water can cause precipitates that limit hydrocarbon flow within rocks. John Yilin Wang, an assistant professor at Penn State, recently began a similar project.

"I don't think these guys really know whether reusing dirty water" will affect the long-term production, said Robert Lane of Texas A&M. At this stage of shale research, there is still significant work needed on predicting future production, making it difficult to determine if the ultimate output has been affected by the water used for fracturing.

On the other side of the debate, Range Resources is fracturing wells in southwest Pennsylvania with fluids containing flowback water run through a 25 micron filter. It also adds anti-scaling chemicals and biocides, and mixes it with 80% or more fresh water. "We are constantly looking at any impact on wells. To date we have not seen any," Miller said. The company has a database going back more than two years with a mix of wells fractured using a mix of recycled and fresh water and others where only fresh water was used.

With support from the US National Energy Technology Laboratory, Burnett created a portable well-side water treatment to demonstrate how high-tech treatment can clean up water for less than the cost of injection. Burnett's mobile unit shows new filtration designs for chemical-free treatment. "As I get the opportunity to show this data and do longer-term tests, people will accept the fact that it is technically and economically acceptable to do water treatment," he said.

Halliburton's portable units are designed to remove extremely fine particles such as clay, iron, and hydrocarbons using electrocoagulation. The system's anodes release positively charged



Using vapor recompression technology, Purestream's Trilogy unit reduces the cost of recycling fracturing water by using waste heat. The unit produces water vapor and solid residue that is disposed of in a waste facility.

ions that bond with tiny, negatively charged particles in the water, causing them to coagulate. The heavier ones sink to the bottom where they are removed. At the same time, cathodes produce gas bubbles that attach to lighter coagulated material, causing it to float to the surface where it is skimmed off, leaving clear water. Further treatment is needed if heavy metals, such as barium, need to be removed.

Tapping More Water Sources

The realization that fracturing does not require pristine water opens the door to new sources. In Canada, Apache and Encana tapped a saltwater aquifer and built a water treatment plant to provide water to fracture wells in the water-short Horn River Basin.

In Pennsylvania, a project by the University of Pittsburgh and Carnegie-Mellon is exploring whether drillers can benefit from a legacy of coal mining known as acid mine drainage. (AMD) Over time, chemicals have leached into this water in abandoned coal mines. It is blamed for polluting 4,000 miles of streams in Pennsylvania, said Vidic of the University of Pittsburgh. When this sulfate-rich mixture is combined with flowback water containing barium, the result is barium sulfate, which can be easily removed. The process is similar to the method used to remove metals in fracturing water widely believed to reduce long-term gas output.

The future of this idea depends, in large part, on the regulators. Users such as Range are interested in AMD only if it is clear that short-term use of water from a mine does not make a company responsible for the mine long term. **JPT**

For further reading:

SPE 131784-MS • "Developing Effective and Environmentally Suitable Fracturing Fluids Using Hydraulic Fracturing Flowback Waters" by M.E. Blauch, Superior Well Services

SPE 137430-MS • "Balancing Environmental Tradeoffs Associated with Low Impact Drilling Systems to Produce Unconventional Natural Gas Resources" by Richard C. Haut, Houston Advanced Research Center, David Burnett, Global Petroleum Research Institute, Texas A&M University, et al.

SPE 141145-MS • "Evaluation of Scale Inhibitors in Marcellus Waters Containing High Levels of Dissolved Iron" by Dong Shen, Baker Hughes Corporation, et al.

SPE 125740-MS • "Marcellus Shale Post-Frac Flowback Waters—Where is All the Salt Coming from and What are the Implications?" by M.E. Blauch, Superior Well Services, et al.