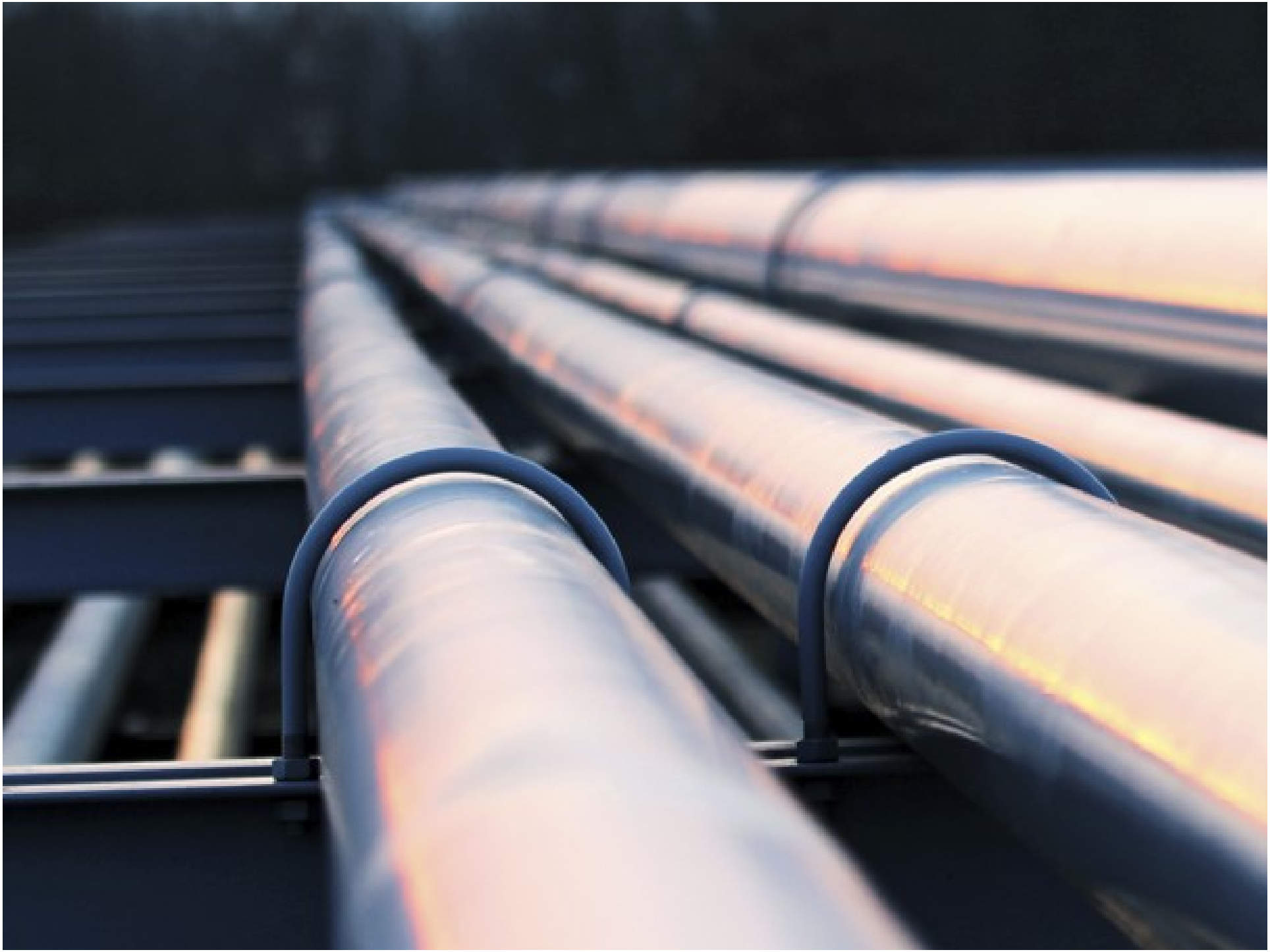

Some of the most flooded formations are pushing back—almost literally—in the form of earthquakes of increasing magnitude and frequency, creating significant consequences to surface dwellers in the region—and possibly creating issues for future fracturing and production. July tremors reaching as high as 5.1 on the Richter Scale on the Scurry/Fisher County line triggered a disaster declaration by Scurry County Judge Dan Hick, bringing new focus to these issues.

Katie Smye

In the coverage that follows, B3 Insight's CEO and Cofounder Kelly Bennett sheds some light on the growing disposal costs faced by producers and water midstream companies; UT Bureau of Economic Geology's Dr. Katie Smye explains what's causing the quakes and how the Texas Railroad Commission is working to reduce seismic activity; and Select Water's EVP, Chief Strategy and Technology Officer Mike Lyons explains the development of some new alternatives to SWD.

There are only so many possible destinations for this produced water, as most oil and gas wells produce many times more of it than they produce of oil or gas. To keep the oil flowing, the water must go somewhere,

yet without creating problems.

One option is to treat and recycle as much of that produced water as possible for use in (yet more) hydraulic fracturing, a reuse that happens in the same region as the production, so transportation is fast and relatively inexpensive. Water treatment costs have dropped greatly over the past 10 years, and most producers now are fracturing with recycled produced water almost 100 percent.

The two issues with using produced water in fracs are, first, that this doesn't require nearly all the produced water—only about 10-15 percent by some estimates. Most of it still has to go elsewhere. Second, using it to complete new wells only creates *more* produced water to be disposed of.

The Wrong Kind of Waterflood?

With Permian oil and gas production at record levels, it's not surprising that water output is also rising, said B3 Insight's Bennett.

Because most companies are using high percentages of produced water in completions,

Kelly Bennett

groundwater use is dropping. But for operators, balancing the need to produce more means that today's disposal issues "seem to be growing and compounding" for the future, he said. "In our best-case scenario we're disposing almost three-and-a-half million barrels more water (per day) in 10 years than we are today." That's a 21 percent increase over the current level of 15.6 barrels per day.

However, "We can't recycle our way out of this," Bennett declared. "The industry's ability to ramp up recycling has surprised us. Each of the last three years we've been wrong in our forecast—we've been too low." But for the future, "We produce more water than we could ever use," and new non-frac recycling technologies are 5-10—more likely 10—years away, he said, especially on the scale needed to put a dent in the rising SWD rates. Tens of millions of dollars are being spent on technologies to mine trace minerals like lithium, and other dollars to desalinate water for ag or

even domestic use—but current technology offers neither the scale nor the affordability to make it useful.

Send it Packing?

For disposal, the shortest distance between production and disposal is a straight pipeline—and the closer the better. Understandably, the biggest seismic issues are happening in the heart of the most productive areas in West Texas. So shipping at least some of that produced water farther away—out of the Basin—is an idea that's growing, Bennett noted. But that's not without its own issues, most of which, as with recycling, involve cost.

Several of the larger produced water midstream companies are now sending some water south, to Irion and Reagan counties—but so far not enough to show up on charts, Bennett said. Midstream companies looking to extend pipelines beyond the Basin face issues of costs and of landowners highly resistant to having water pipelines cross their property.

Regarding cost, he said, "We're talking 50-100 miles" of pipelines, he said. "On the high end, you're talking about gathering fees [charged to producers] that are going to have to be well over a dollar a barrel, *well over a dollar a barrel* [repeated for emphasis], if you're going to have real

capital recovery associated with this well.”

Pushing the costs even higher are the same inflationary pressures faced by consumers at the grocery store. Prices for steel, pumps, and every component are rising almost daily.

Landowner challenges comes first because water pipelines are not considered common carriers under current regulations, meaning pipeline companies don’t have power of adverse possession or eminent domain to require landowners to grant access. But there’s also an economic concern for farmers and ranchers.

“There’s a dynamic in place where a lot of landowners had benefitted previously from selling groundwater, fresh or brackish, to these companies,” Bennett explained. Now, because producers are replacing groundwater with recycled produced water for fracturing, landowners face losing that sizable water revenue.

But that old revenue is replaced by the water midstream companies sending water across that same land, right?

Not exactly, at least not in the eyes of many landowners.

“Even if those dollars are replaced by throughput fees on pipes for reuse, there is uniform resistance to allowing those kinds of pipelines to be built,” Bennett said. What’s actually happening is that some landowners are requiring E&Ps who signed take-or-pay contracts years ago to continue to pay, even though the E&P will never again need that water. Bennett says this thinking is especially true for landowners who don’t own mineral rights, so selling water is their only oil industry income.

“Some people have made large portions on that,” he said, so they want both the payment for the new produced water pipelines and the money for the fresh water that they were already getting. All this creates construction delays and raises costs, while exacerbating the disposal dilemma.

Here’s what’s happening below the surface, along with preventive measures that are showing promise.

The Water Underground

The Texas Railroad Commission had already identified three Seismic Response Areas (SRAs) in which they and a coalition of industry leaders were reducing and otherwise managing SWD amounts, pressures, and zones to mitigate anthropogenic temblors. The Scurry/Fisher area is outside that region but, says BEG's Smye, it was not without its own record of smaller quakes.

"…it is likely that changes in operational practices could lead to a reduction in earthquake rates and magnitudes," Smye said in an email interview. "This has been observed in other areas such as North Culberson-Reeves and Gardendale SRAs, where curtailments of deep injection rates have resulted in earthquake rate reductions."

However, as with solutions outlined by Bennett, this one also contains a "but." She noted that curtailing deep injection in the Scurry/Fisher area "poses other challenges in managing the millions of barrels of water produced daily in the Permian Basin region, as those volumes either must be diverted to other areas, ideally with fewer critically stressed faults, or to other stratigraphy such as shallow formations."

And again—while shallower formations are considered less of a quake threat because they're

closer to the surface, operators must drill through them to get to the oil, which creates “additional operational considerations.” Many orphaned wells are also in shallower formations, being legacy drills from pre-shale days, and pressure increases there “could lead to surface flows or other challenges, highlighting the importance of timely and effective plugging of these wells.”

In short, shallower SWDs could create issues for new wells, and for those abandoned but unplugged.

A Place Far, Far Away

While changing locations of SWDs is important, Smye says there may yet be conducive formations near home. BEG’s analysis “shows that there are likely areas and strata with fewer injection constraints than others.” It’s also true that not every formation with large injection volumes has seen earthquakes, so those might well continue taking water at least for the near future.

An area’s sensitivity to injection involves the presence of sensitive faults, the geology controlling pore pressure, and more, “requiring a holistic analysis to understand injection capacity” Smye explained. The best option while waiting for beneficial reuse technology to develop may be “‘kicking the can down the road’ by effective reservoir management, and optimization of the

injection source may be the only short-term solution."

Relatively Cost-Effective Desalination May Be Closer Than Expected—For Surprising Reasons

For Select's Mike Lyons, making desalination the most cost-effective treatment option involves a lot of moving parts—and one thing that's moving upward is the cost of SWDs, as alluded to by B3's Bennett. If all things fall into place, cost-effective desalination for industrial or municipal use could be onsite, at scale, in one-to-two years. Some of that depends on advancing technology, but the comparison will be against marginal out-of-basin delivery costs and the 'all in' economics may be improved with incremental salable byproducts such as usable water and even retrievable minerals such as lithium, iodine, and others.

Lyons's per-barrel numbers for out-of-Basin delivery match Bennett's, reaching as high as $3 per barrel, but Lyons feels Select's procedures for beneficial re-use would be competitive even at $1 or $1.50.

For the process itself to be cost effective, it would require affordable heat input, from sources such as waste heat from compressors or other large machinery; cheap gas from oversupply such as

flares; proximity to both intake from producing wells and offtake facilities such as water transfer pipelines; and finally, it still needs to be close to an SWD because 40 percent of the water, carrying concentrated byproducts, still requires disposal.

For those reasons, Lyons said Select is selective about where it will be placing these systems.

To reach the ideal scale for efficiency, Lyons sees a unit's capacity being around 10,000 barrels per day of input. For sites needing more capacity, several units could be delivered, assuming all the above-listed contingent conditions are met.

Selling the Offtake

A key ingredient in affordability also comes from turning the liability of produced water into an asset. Lyons said the cleaned and desalinated water itself could be sold for about $0.20 per barrel for industrial use, or similar prices for agricultural use. Mineral extraction becomes more cost-effective because the waste stream containing the minerals can be 3-6 times more concentrated than in the untreated water. Basically, desalination performs a first step in the process.

Lyons has a dream for how this system will work on multiple fronts. “The Select of the future will be a super-site that enables water recycling, scaled desalination, mineral extraction, and connectivity to disposal. And we will do that in large water networks where we have interconnected supersites, and all of them will be working together.”

“They will be a source of value for oil and gas customers, a source of water for communities and businesses around that site. It could be an individual customer for water, it could be agricultural. It will be an area where we will extract lithium and iodine and perhaps other minerals of value,” he said.

Recouping costs from those byproducts, assuming good market prices for them, could turn produced water from a liability to a significant asset. And while it does not eliminate SWD, desalinating the water reduces the need by 60 percent, hopefully extending the life of formations to a significant extent.

The future of oil and gas production in the Permian depends on there being a safe—and hopefully beneficial—option for handling the third leg of the production stool, the produced water that amounts to many times more volume than the oil and gas combined. However many years out it is, watering the desert in addition to providing energy would check a lot of positive boxes.

Paul Wiseman is a longtime writer in the energy industry.

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NOVEMBER 2024