Go with the Flow

Reduce Water Costs Using Continuous Pumping Completions

As completion designs trend towards longer laterals, tighter stage spacing, higher proppant and more fluid, operators have reaped the benefit of more productive wells and increasing ultimate recovery. But increased productivity has come with a cost.

Water management – including collection, transportation, storage, treatment, and disposal – costs have increased along with production and can also be a challenge, particularly in regions where availability is relatively limited. In the Bakken, for example, while production has improved year over year, average completion fluid volumes have increased over 140% from 2013 to 2016 (Figure 1).

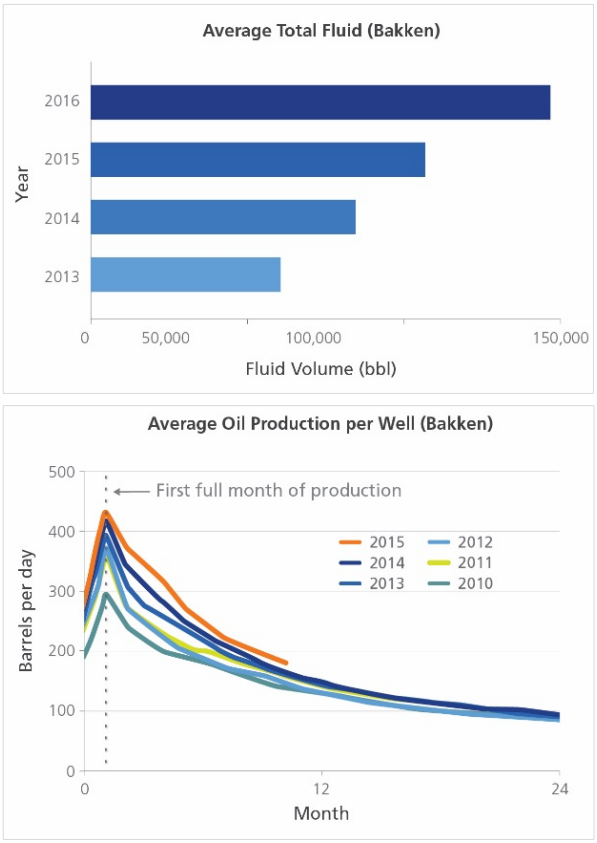

Figure 1: Yearly average total fluid volumes and production curves in the US Bakken. (Sources: NavPort Analytics, U.S. EIA)

One way to lower water management costs is a change in completion technology. Continuous pumping, sliding sleeve completion systems can significantly reduce both water usage and management costs compared to most other systems. Lower water usage improves all stages of water management, including:

1. Water collection
2. Transportation and storage
3. Pre-frac heating
4. Post-frac millout / cleanout
5. Disposal and recycling

Besides cost constraints, regulatory and environmental concerns are challenges that will make water management more important in the future, requiring a closer look today.

Fluid Requirements

While water volumes can fluctuate slightly using the same completion method depending on stimulation design, they vary substantially between continuous and non-continuous pumping methods.

Water requirements are shown below for a continuous pumping sliding sleeve system versus plug-and-perf operations for the first 3 stages of a 4.5-in. completion and frac string in the Permian Basin. For this scenario, the well has a measured depth of 23,000 ft (7,000 m) and lateral length of 7,000 ft (2,134 m)[1].

	Continuous Pumping (bbl)	Plug-and-Perf (bbl)	Fluid Savings
Stage 1 treatment	5,000	5,000	-
Flush 1	50	456	9x
Pump down tools	-	138	∞
Stage 2 treatment	5,000	5,000	-
Flush 2	50	454	9x
Pump down tools	-	131	∞
Stage 3 treatment	5,000	5,000	-
Flush 3	50	450	9x
Total Volume	15,150	16,629	0.1x
Non-treatment Volume	**150**	**1,629**	**11x**

Using continuous pumping technology, the spacer volume flushes the wellbore while moving the next ball to its sleeve.

The main difference is in the non-treatment volumes. For continuous pumping sliding sleeve operations, pumping down tools is not required, and the post-treatment flush is 9 times less. Together, these add up to 11 times less fluid.

In plug-and-perf operations, these volumes can only be minimized slightly because the well must be flushed of proppant before tools can be pumped for the next stage. Continuous pumping sliding sleeve operations efficiently use the spacer volume to flush the wellbore of proppant while moving the next ball to its sleeve.

[1] For simplicity, stage spacing is set at 200 ft intervals with a treatment volume of 5,000 bbl (750 m^3) per stage. These would be the first 3 out of a total 35 stages.

Maximizing water efficiency helps to lower overall costs throughout any completion.

FIVE BENEFITS OF REDUCING FLUID VOLUMES

Water logistics begin before a completion and continues after treatment. Lower volumes impact these and everything in between. Five general categories are discussed here.

1. Water Collection

As a finite resource, sourcing enough water for high-rate or extended lateral treatments can be a challenge.

In the State of North Dakota, where groundwater resources are limited, domestic use is given the highest priority and industrial use the lowest[2]. Furthermore, temporary water sale permits have created a private market where operators can buy water from irrigators. In this environment, water costs may rise steeply depending on supply and demand.

Since water is the largest component of a fracture treatment, a low-volume completion is the first step to lowering all other water management costs.

2. Transportation & Storage

Transportation is by far the costliest part of water management for well completions, accounting up to 60% of total water-related costs (Figure 2).

On-site freshwater storage ponds or tanks require materials, personnel, and significant time for construction and inspection. Lower volumes require smaller or fewer ponds or tanks, which reduce time and cost.

After the completion, the flowback is stored temporarily during testing and early production of the well.

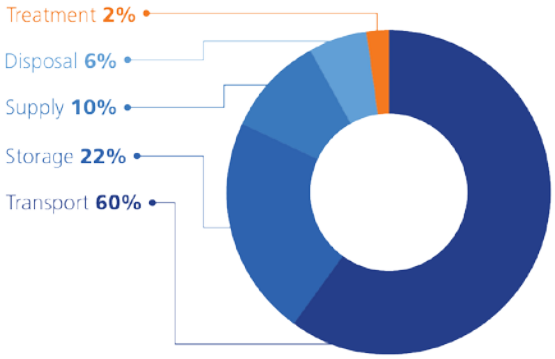

Figure 2: Breakdown of completion water costs. (Adapted from Bluefield Research, 2014)

[2] Hearne, R., Fernando, F.; Strategies for Community and Industry Water Management in the Oil Producing Region of North Dakota; Water 2016, 8(8), 331; doi:10.3390/w8080331

This fluid is considered wastewater and operators are usually required to build a secondary lining or barrier in case of a breach.

In continuous pumping completions where less water is used, associated water transportation and storage requirements can be reduced.

3. Pre-Frac Treatment

In colder climates, water stored in tanks and ponds is usually heated to around 20˚C (70˚F) to prevent tanks and valves from freezing, optimize chemical performance, and minimize stress on downhole tools.

During winter operations in the Williston Basin, heating costs are estimated to be around $0.50 per barrel. This would have translated to over $70,000 per well in the Bakken in 2016, based on the Figure 1 volume of nearly 150,000 bbl.

Heating is only one component of pre-frac operations. Chemicals are also added to kill bacteria, change fluid viscosity, energize the fluid, and so on. Since these additives are a percentage of fluid volume, reducing overall fluid volumes can add up to significant savings.

4. Post-Frac Millout and Cleanout

For most plug-and-perf completions, the plugs that provided zonal isolation during stimulation must be milled out to allow flowback. In general, US operators reserve about 1,000 bbl of fluid for a millout / cleanout of about 20 stages. Constant fluid circulation is needed to flush debris out of the well.

One operator estimates the average cost for millout / cleanout to be around $300,000 per well, across key unconventional formations. This additional fluid and cost can be saved by switching to sliding sleeve completions. Rather than milling out plugs, actuation balls can be retrieved during flowback, or simply left to dissolve if degradable.

Montney Operator Switches to Ball-Activated Sleeves

One operator in the Montney began trialing continuous pumping sliding sleeve completions and adopted the technology over several years.

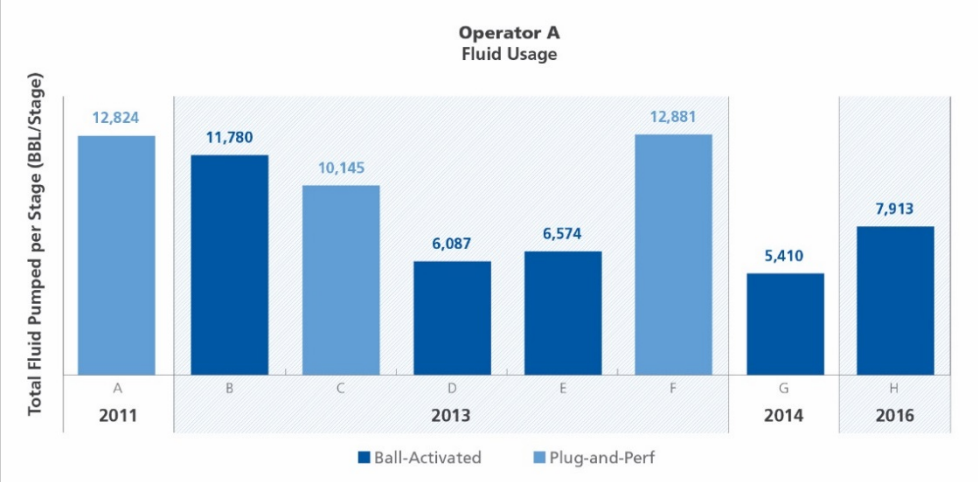

Figure 3: Comparison of fluid usage for ball-activated versus plug-and-perf completions in the Montney. (Source: geoLOGIC Systems)

Water usage was gradually lowered over 4 years for 10-14 stage completions[3]. The plug-and-perf well in 2011 used 1.6 times more fluid than the sliding sleeve well in 2016.

5. Disposal and recycling

Moving wastewater to a disposal well ranges between $3-7 per barrel of fluid[4] — a newly completed well with 15,000 bbl of flowback could cost the operator over $100,000.

[3] Data from geoSCOUT, Nov 2017, Operator A targeting the Montney, slickwater, non-energized
[4] Easton, J.; Centered on Wastewater Treatment, Water & Wastes Digest, Jul 9, 2013

As previously mentioned, produced water is considered wastewater that requires treatment or disposal. During flowback, up to 60% of the water initially injected during hydraulic stimulation can be recovered. The cost of treating produced water is typically prohibitive, so the most economical solution is often disposal at injection wells. Commercial disposal costs typically range between $0.50 and $2.50 per barrel[6].

Macro Comparison

A high level view across major formations[5] in Canada with data spanning 4 years and over 3,700 wells shows that sliding sleeve completions use less water, regardless of operator or formation.

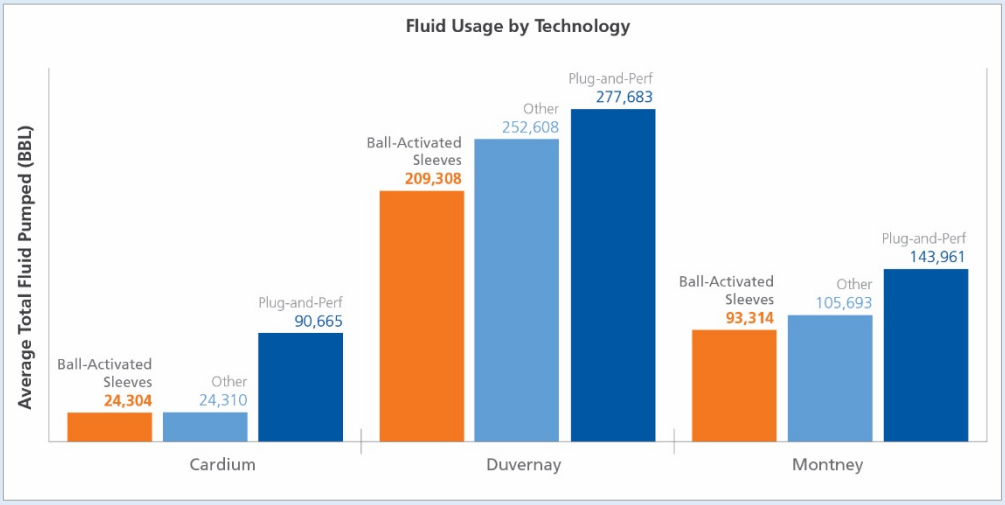

Figure 4: Comparison of average fluid volumes pumped for completions in major formations in Canada. (Source: geoLOGIC Systems)

Many operators are reusing produced water to help offset these costs. However, before reuse, a minimal level of processing is needed, such as filtering or biocide treatment.

As with other water management costs, operators who can efficiently use water ultimately save on disposal as well.

[5] Data from geoSCOUT, Oct 2017; Over 3700 Canadian wells completed from 2014 to 2017; 10- to 30- stages; water or slickwater, non-energized completions
[6] McCurdy, R.; Underground Injection Wells for Produced Water Disposal; Chesapeake Energy Corporation; accessed Oct 10, 2017

CONCLUSION

Water is the largest component of hydraulic fracturing and a critical factor in the operation and economics of unconventional reservoir production. Lower water volumes reduce overall water management costs, including collection, transportation, storage, treatment, and disposal.

A completion system with reduced water requirements can be achieved using completion solutions based on continuous pumping operations. These include:

- Ball-activated sliding sleeve systems
- Full bore latch sleeve systems

Continuous pumping completions offer a triple advantage for major cost reduction:

1. Reduce water management costs
2. Minimize non-productive time
3. Eliminate the need for millout

Packers Plus offers sliding sleeve systems, as well as a variety of completion solutions for both cemented and open hole applications. For more information, see packersplus.com.