



# OPTIMIZING WELL COMPLETIONS AND DELIVERING DRAMATIC PRODUCTION IMPROVEMENTS ON THE BAKKEN



This report is based on the paper: Optimization of Bakken Well Completions in a Multivariate World, published by Society of Petroleum Engineers 2018.

# Drillinginfo's **optimized completion design** achieves dramatic results.

The emergence of large hydraulic fracturing jobs on the Bakken/Three Forks play in the Williston Basin – incorporating an increased density of proppant per foot, enlarged fluid volumes, tighter cluster spacing, and shorter stages – have increased initial production rates (IPs) by over 20% over the past two years.

Yet, despite this increase, concerns still exist as to whether completion design and treatments are fully optimized. To this end, a multidisciplinary geoscience and engineering team led by Drillinginfo developed an optimized completion design on two wells in the Middle Bakken and Three Forks formations. Challenges in the Williston Basin included low pressures due to depletion drainage from offset wells and less-than-ideal stress and fracture orientation.

The results of the new optimized designs, however, were dramatic – providing a four-month production improvement of 49% on the Middle Bakken well (known as well A) and a 101% increase on the Three Forks well. Figure 1 compares three Middle Bakken wells including well A with different completion designs over a four-month production period. Yet, how was this achieved?

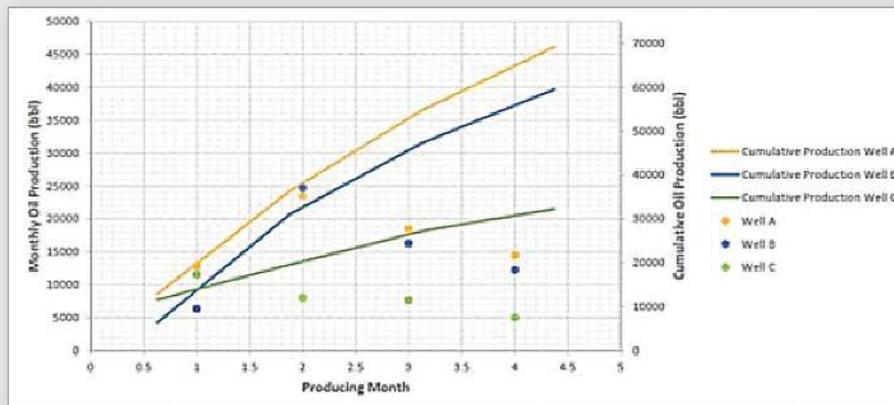
**Continue reading for the five key stages in Drillinginfo's optimized completion design process.**

**Learn more at [drillinginfo.com](http://drillinginfo.com)**

# 1.

## Reviewing Historic Completion Trends

In order to answer some of the key questions (highlighted in **Figure 1**), the team used public domain data to provide an overview of changes in completion techniques and results within the AOI over time. Multiple variables and parameters were monitored covering completion comparators (peak BOE, well spacing, production curves over time, etc.), engineering insights and trends (creaming curves of historic completion, basin target depth variation, etc.), and proppant trends versus production trends (treatment types versus six-month BOE, proppant type versus normalized three-month BOE etc.). Operator production was also analyzed against offset wells in the immediate area, taking into account completion parameters, such as vintage, fluid, proppant volume per lateral foot, perforating technique, and others.



**Figure 1** – Comparison of Four-Month Production on Three Middle Bakken Wells, With the Newly Designed Wells Coming Out On Top

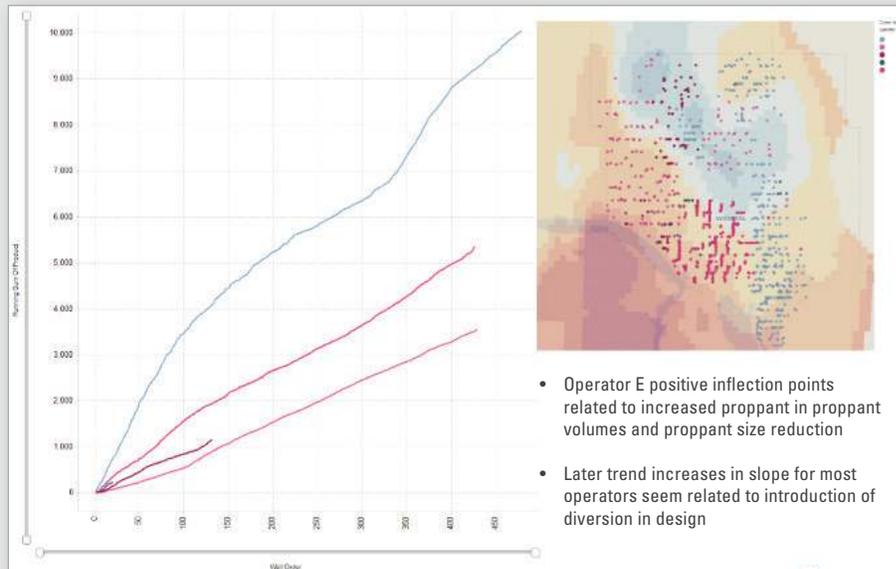
### Answering the Key Questions

- How does the reservoir of this well compare to those near by?
- Is there significant geologic or lithologic heterogeneity along the wellbore path?
- What is the optimized perforation scenario to maximize cluster efficiency?
- Was the wellbore steered properly within the target reservoir?
- How variable are the geomechanical properties along the path of the well?
- What are the overlying reservoir parameters that would affect the growth and propagation of the hydraulic fracture and resultant stimulated reservoir volume (SRV)?
- Are there offset operator learnings that can improve the E&P curve?

# 2.

## Customizing the Completion Design

A completion design comparison was then conducted on five major offset operators to determine how learnings were being adapted and implemented in the AOI, with cross-plots and creaming curves used to analyze the results. **Figure 2** illustrates the creaming curves of operators within the AOI's graded acreage, showing cumulative production versus well count by operator.



**Figure 2** – Creaming Curves of Operators

Key findings included:

- Increased proppant volume has a strong positive impact with wells in poorer reservoir quality but less so in higher-quality reservoirs.
- Positive inflections on the creaming curves could be related to new technologies, such as diverting agencies, that increase cluster efficiencies.
- The introduction of intra-stage diversion tied to the well count was considered positive to production.
- Other positive production impacts included the move from viscosified fluid systems to new slickwater designs, smaller sieve proppants, and the outperformance of silica completions compared to costly ceramic completions.

## 3. Conducting Reservoir Analysis and Enhancing Stimulated Reservoir Volume (SRV)

Additional insight into the reservoir included detailed layered and geomechanical models – taken from the petrophysical attributes within the 3-D geologic model – to produce optimized perforation cluster design and groupings in precise fracturing stages.

The data and models also confirmed the target accuracy of the wellbore trajectory within the geo-model, calculated variations along the wellbore path as it lands within the formation, and identified potential heterogeneity issues along the wellbore path. The team also analyzed near wellbore stress to optimize perforation cluster placement.

Taking localized reservoir information into account also allowed the team to identify optimum proppant loading (500-850 pound/normalized foot (lb./n ft.) of lateral) – nearly twice the amount previously placed in offset wells. In addition, when looking to stimulate SRV, it was determined that diverting agents could add value to the completion.

## 4. Developing the Hydraulic Fracturing Stage

The next stage was a 3-D hydraulic fracturing model designed to simulate fracture geometry characteristics including height growth, half-length, and aperture. Near-offset vertical wells incorporated within the model provided the team with the basis for lithologic layers within the fracture model and empirical formation pressures, and stress field assumptions were incorporated into the model to improve stimulated reservoir volume.

The reservoir pressure toward the middle of the well is not depleted when compared to the toe of the well. Findings from this and other models suggested that the operator might consider lowering the well spacing as the drainage distance away from the wellbore is limited, with the half-length of the fracture laying closer to the axis of the wellbore.

# 5.

## Perforation Design and Proppant Tracing

Finally, perforation design comparisons and a radioactive tracer – used as a reliable method for identifying fluid and proppant transport within a near wellbore environment and for the post-completion monitoring of cluster efficiency – were deployed to validate the approach. Used as a diagnostics tool, the tracer also proved invaluable in supporting the team hypothesis on near-longitudinal fracture stimulation growth and the pressure profiles.

### The Results

The combination of historic completion analysis and reservoir analysis – alongside modeling carried out on the fracture stimulation design – enabled the team to perform an optimized completion design.

As **Figure 1** illustrates, production from the two near-offset wells is substantially higher than historic well C, with well A – the target well for this well completion optimization process – at over 69,208 bbl. at four months, versus 32,237 bbl. for well C in the same time frame. The optimized design has provided a four-month production improvement of 49% on the Middle Bakken well A and a 101% improvement on four-month production numbers on the Three Forks well.

Other key findings included:

- Completion designs favoring less-expensive and smaller-sieve proppants, volumes, and fluid designs can still increase production.
- In well completion design within a pressure completed area, it is possible to design stimulations that both mitigate the risk of potential well interference and screen-outs, while aggressively addressing optimization issues.
- Cemented liners (well A had a cemented liner completion) have significant advantages over open hole completions in terms of improved production, well modeling, diagnostics, and remediation. Such liners also allow a more specific placement of proppant around the wellbore.
- Through cemented liners and deploying intra-stage diversion (as was the case with well A), the observed pressure profiles were reversed from the expected increased pressure trend found in a geometric completion and also led to better near wellbore conductivity supplied by the hybrid diverting agent (a reason for the difference in production between well A and well B in **Figure 1**).
- The tracer – as a diagnostic tool – proved invaluable in supporting the hypothesis on near-longitudinal fracture stimulation growth and pressure profiles, especially near the toe of the well.

**With the right multidisciplinary geoscience and engineering teams and through the consideration of offset wells, reservoir quality data analytics, and detailed geomechanical and fracturing models, customized completion programs that have a significant impact on production can be designed.**

**For further information or to read the full SPE paper (SPE-189868-MS), contact Drillinginfo today.**

By monitoring the market, Drillinginfo continuously delivers innovative energy solutions that enable our customers to sustain a competitive advantage in any environment. Drillinginfo customers constantly perform above their competitors because they are more efficient and more proactive than the competition.

**Learn more at [drillinginfo.com](http://drillinginfo.com)**

Updated Q2 2018

