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Nine Plus years of production show value of proper design in oil window of Barnett Shale

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History of Northern Barnett Oil Play

- Primarily in Montague, Cook, and Clay counties in Texas
- Oil rich with high TOC and typically thick (300-700 feet) and high in carbonate.
- Very different both lithologically and consistently lacking open conductive fractures present, compared to typical Barnett shale to the south.
- In our estimation one of the two most difficult shales to fracture successfully.
- Early attempts to complete were with crosslinked gel with high 20/40 sand concentrations.

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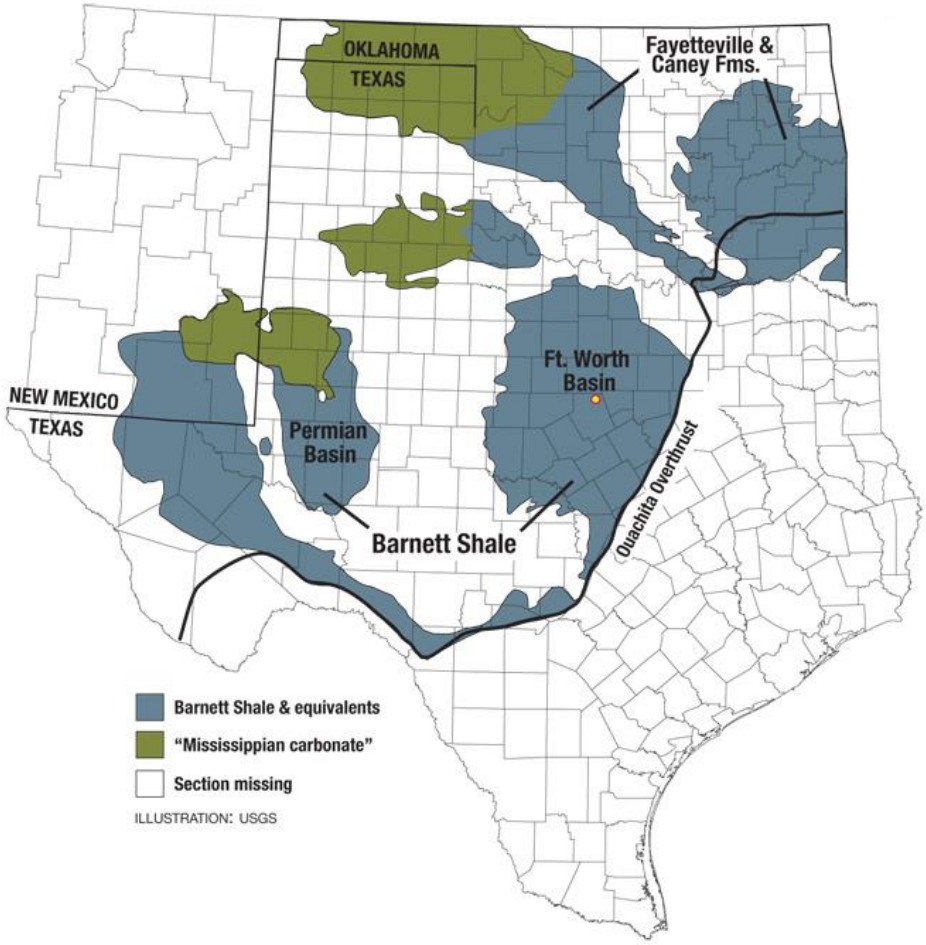
General Barnett Shale



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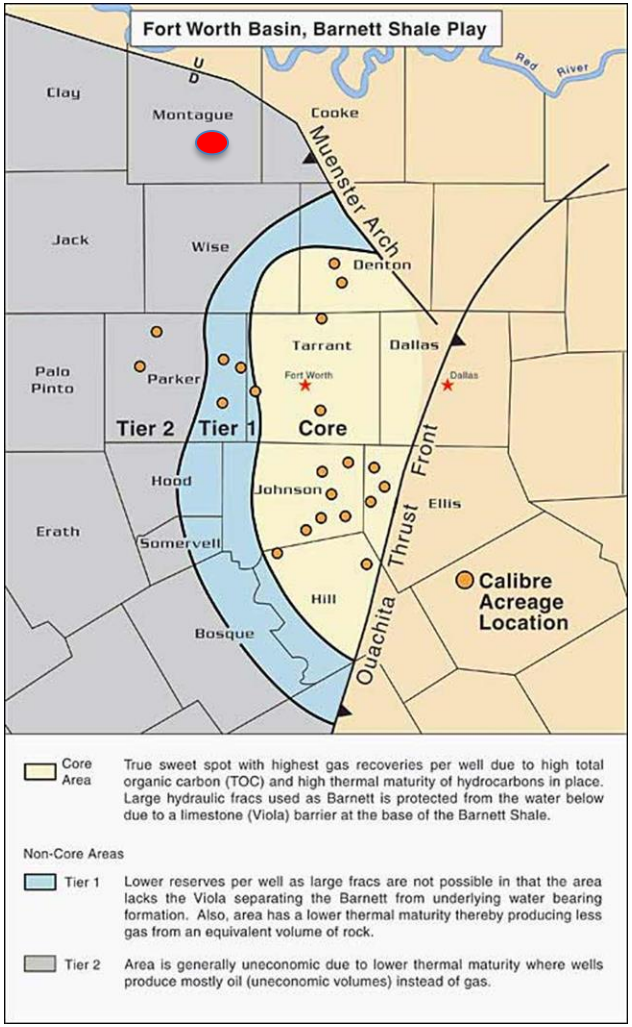
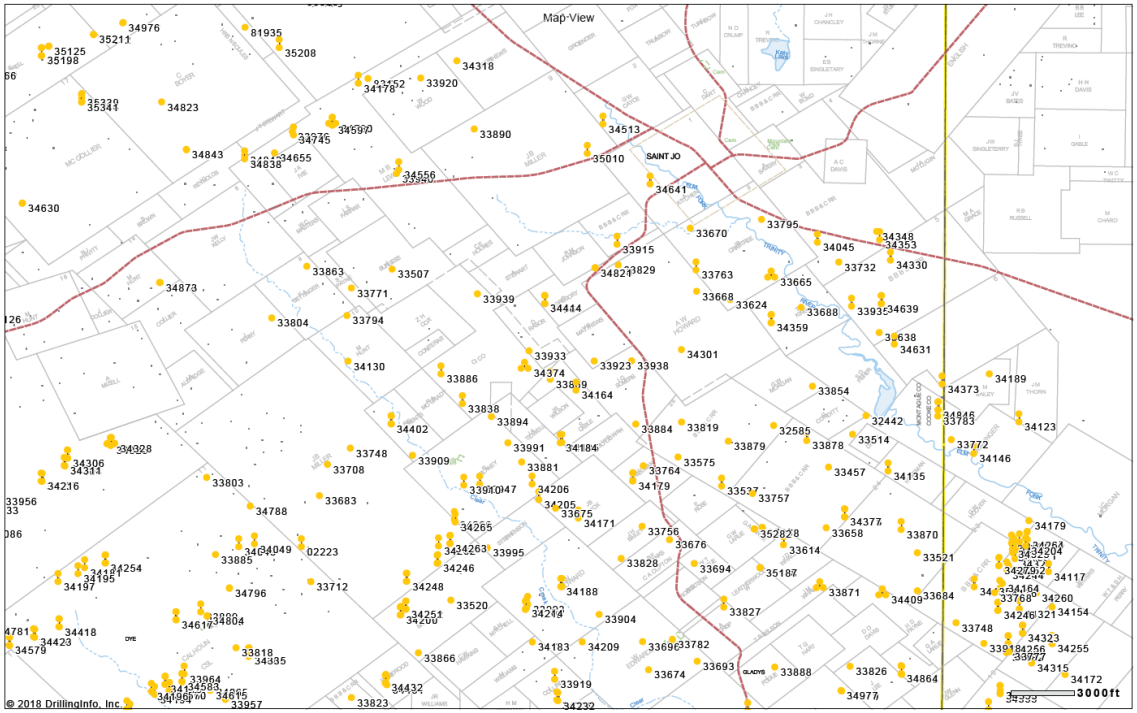
Map of our Play





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History of Northern Barnett Oil Play

- As was the case for a significant number of completions the early wells were all completed vertically. In fact many of the wells with the most successful completions were completed vertically.
- Early completions were plagued with very severe tortuosity during fracturing operations and anything causing a shutdown during a treatment would result in loss of perforations. This also negated any type of pump-in fall off diagnostics.

History of Northern Barnett Oil Play

- Early work started in the 2004 time range and large slick water designs were attempted and a successful slick water refrac of an early crosslinked job led us to believe that economic successful completions could be achieved.
- The success shown in this paper was very much related to utilizing all available technology at the time. The two most significant developments were the use of micro-imaging logs and execution of treatments based on what is termed the waterfrac sweep process. This paper illustrates the success achieved with image log perforating combined with the water frac sweep process.

History of Northern Barnett Oil Play

- As stated earlier no real success was achieved with conventional crosslinked gel and perforating, utilizing conventional techniques such as porosity, resistivity, cleanness of gamma ray etc., All resulted in creation of almost insoluble fracture tortuosity problems. Although some of the areas within our 8 mile radius had some open fractures the majority of logs observed had very few conductive fractures but all indicated significant drilling induced fractures. It was decided to, at the dismay of the logging company, perforate where significant drilling induced fractures existed.

History of Northern Barnett Oil Play

- The use of drilling induced fractures yielded startling results. Where previous treatments required a significant amount of sand slugs to allow for placement of proppant, we were able to achieve rates of in excess of 150 barrels per minute at pressures less than 6,000 psi. It was obvious that we had perforated very brittle rock and thereby negated tortuosity problems. Our mindset was that large volumes were required but the design used did not utilize sand volumes even approaching the volumes presently used.

Example Design - Large Vertical

Stage	Fluid	Stage (bbls)	Proppant	Conc. (ppa)
Pad	Slick Water	8,000		
Slurry	Slick Water	250	40/70	0.10
Spacer	Slick Water	250		
- repeat 0.10 ppa: 3/4 sequences				
Slurry	Slick Water	250	40/70	0.20
Spacer	Slick Water	250		
- repeat 0.20 ppa: 3/4 sequences				
Slurry	Slick Water	250	40/70	0.30
Spacer	Slick Water	250		
- repeat 0.30 ppa: 3/4 sequences				
Slurry	Slick Water	250	40/70	0.40
Spacer	Slick Water	250		
- repeat 0.40 ppa: 3/4 sequences				
Slurry	Slick Water	250	40/70	0.50
Spacer	Slick Water	250		
- repeat 0.50 ppa: 3/4 sequences				
Flush	Slick Water	700		

- **Large Vertical Completions**
- High Rate – 100 to 150 BPM
- 15,000–55,000 Bbls of Water
- 100k – 750k Lbs of Proppant
- Friction Reducer, Biocide, SI

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Example Design - Large Stage Horizontal

Stage	Fluid	Stage (bbls)	Proppant	Conc. (ppa)
Pad	Slick Water	3,000		
Slurry	Slick Water	250	100 Mesh	1.00
Pad	Slick Water	3,000		
Slurry	Slick Water	250	100 Mesh	1.00
Pad	Slick Water	3,000		
Slurry	Slick Water	250	40/70	0.10
Spacer	Slick Water	250		
Slurry	Slick Water	250	40/70	0.50
Spacer	Slick Water	250		
Slurry	Slick Water	250	40/70	0.75
Spacer	Slick Water	250		
Slurry	Slick Water	250	40/70	1.00
Flush	Slick Water	700		

Repeat Sequence/Alternating Sweeps to End of Job

- **Large Horizontal Completions**
- High Rate – 100 to 150 BPM
- 25,000–35,000 Bbls of Water / Stage
- 300k – 350k Lbs of Proppant / Stage
- Max Sand Conc 2.00-2.50 PPA
- Friction Reducer, Biocide, SI

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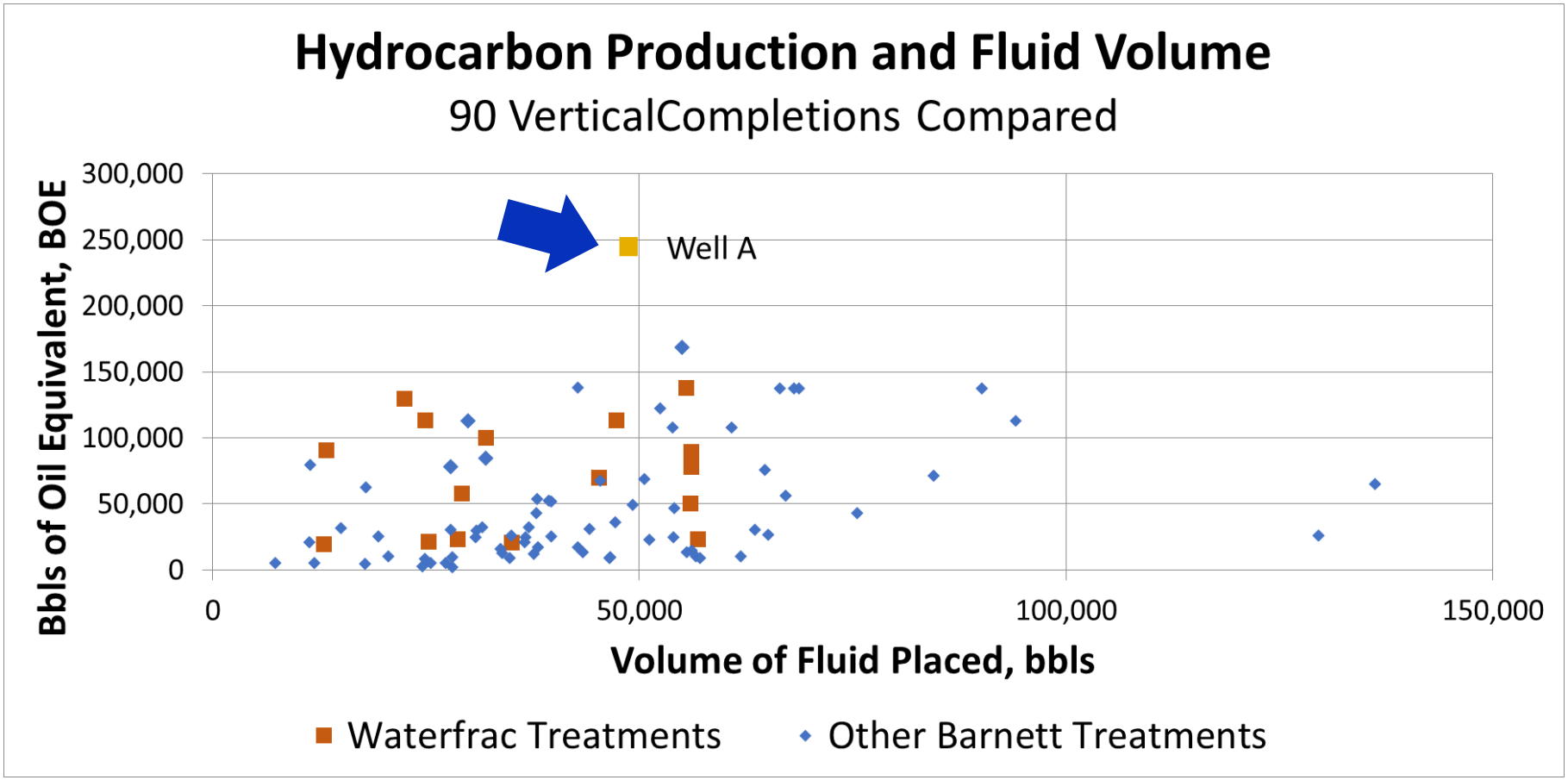
History of Northern Barnett Oil Play

- The rest of the story is that these Micro-imaged/Water Frac Sweep wells were completed more than 9 years ago and the reason for this paper was Paris Oil representatives coming to us and illustrating that these early designs incorporating the micro-imaging perforating and water frac sweep were in the top percent of wells in an 8 mile radius. We have transitioned with time to running diagnostics in shales, where possible, and quantifying pad volumes required. These treatments were run with excess pads and sweeps but have far exceeded offset wells with much more sand, hybrids etc.

Production Data – Northern Barnett Shale



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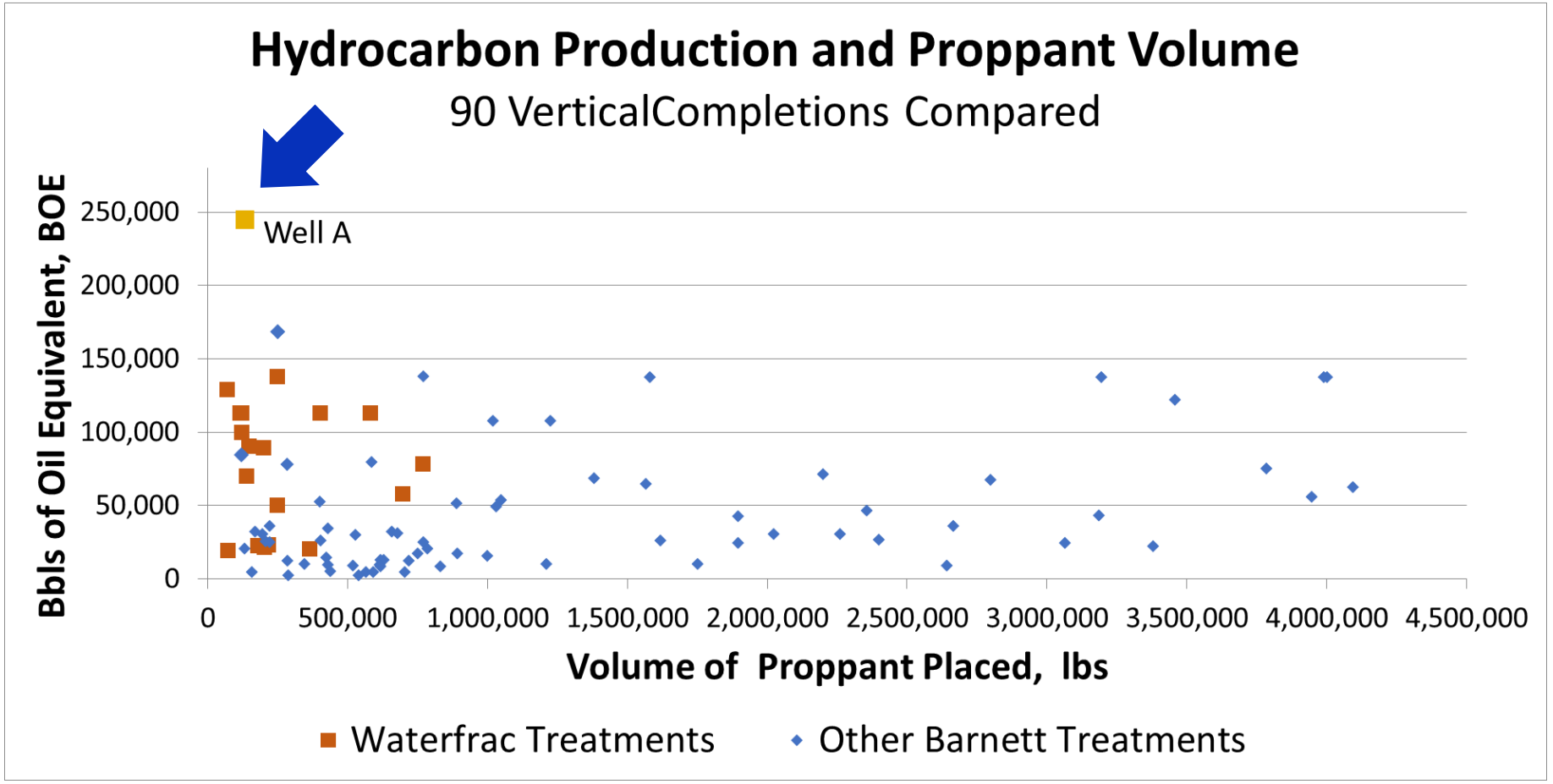

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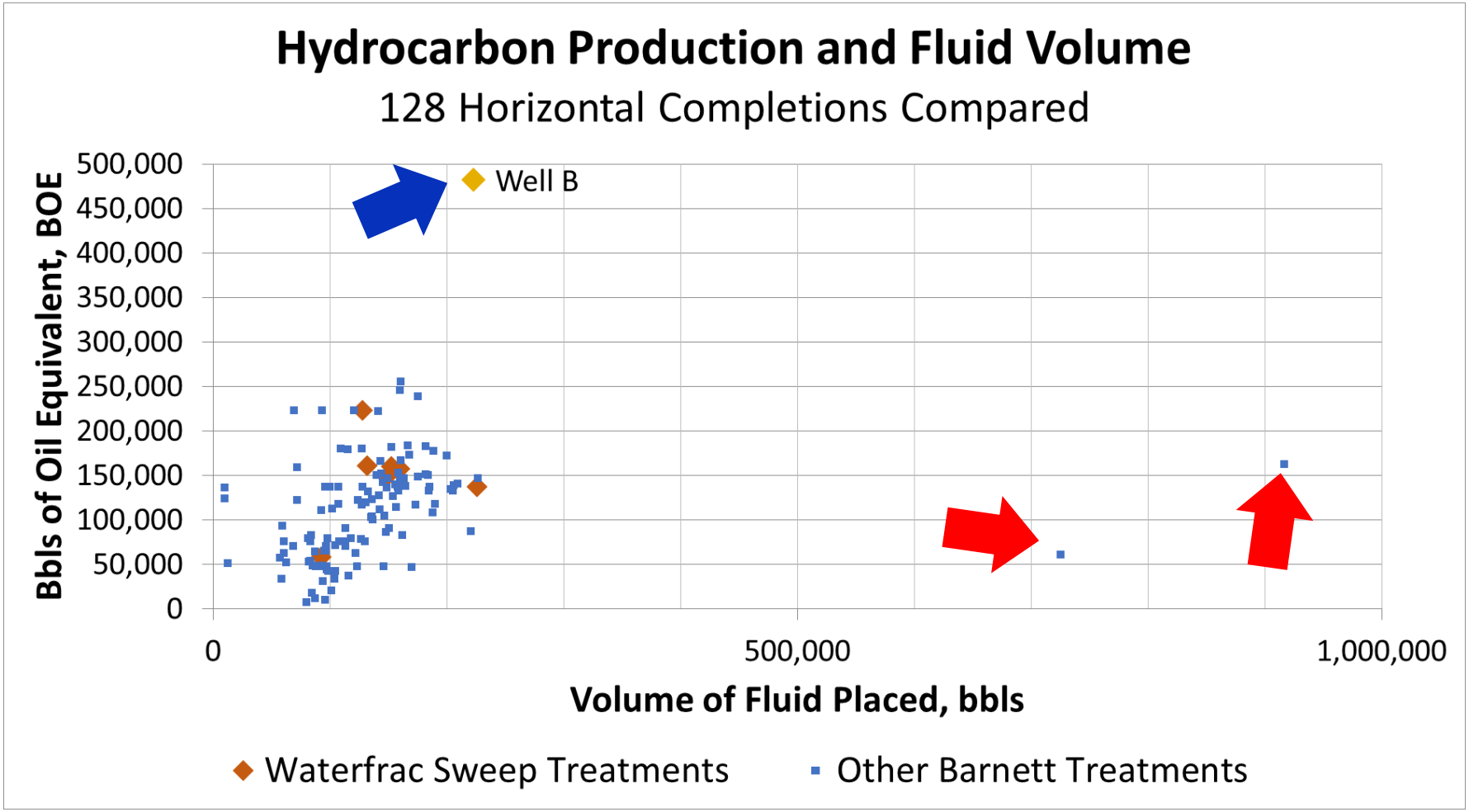

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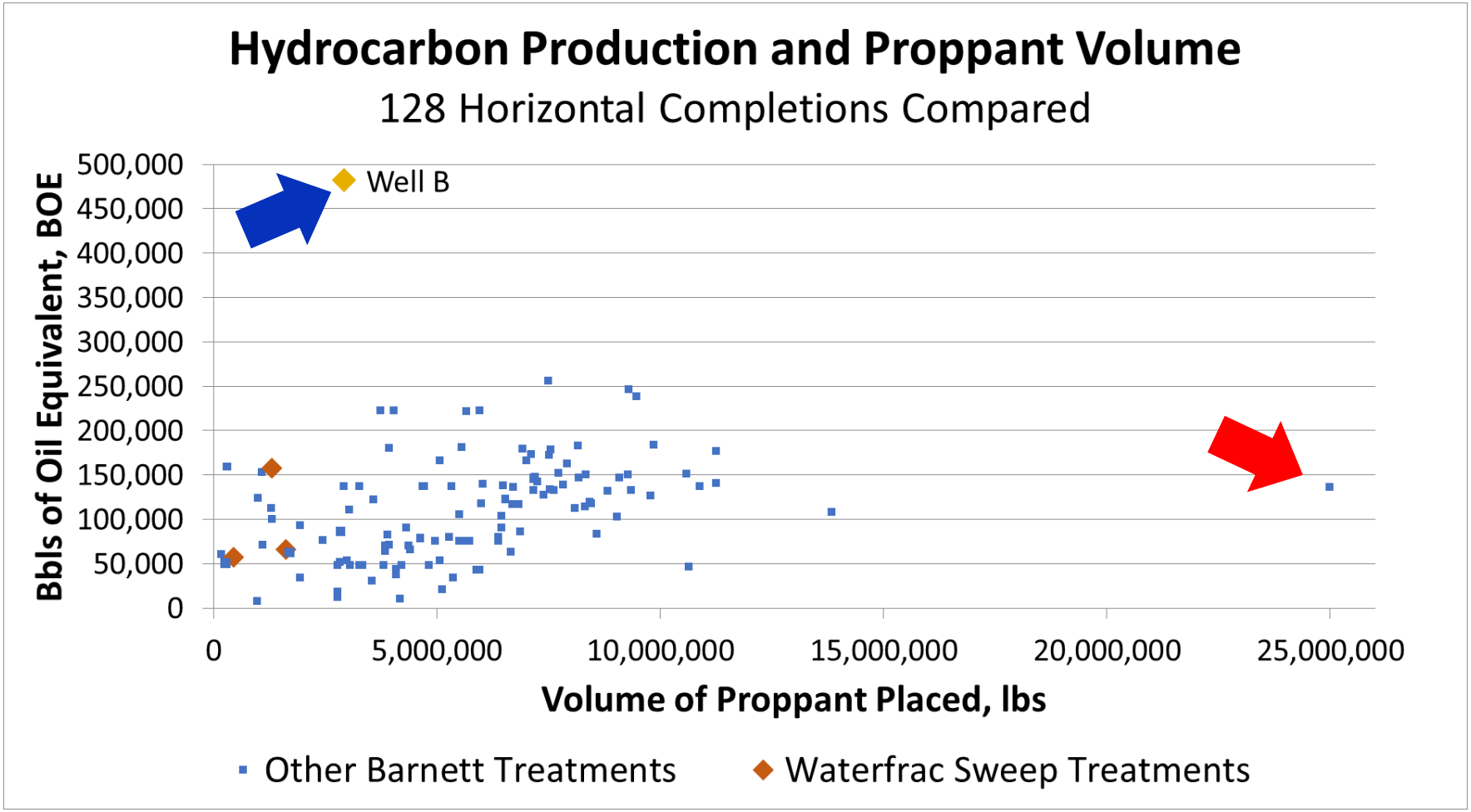

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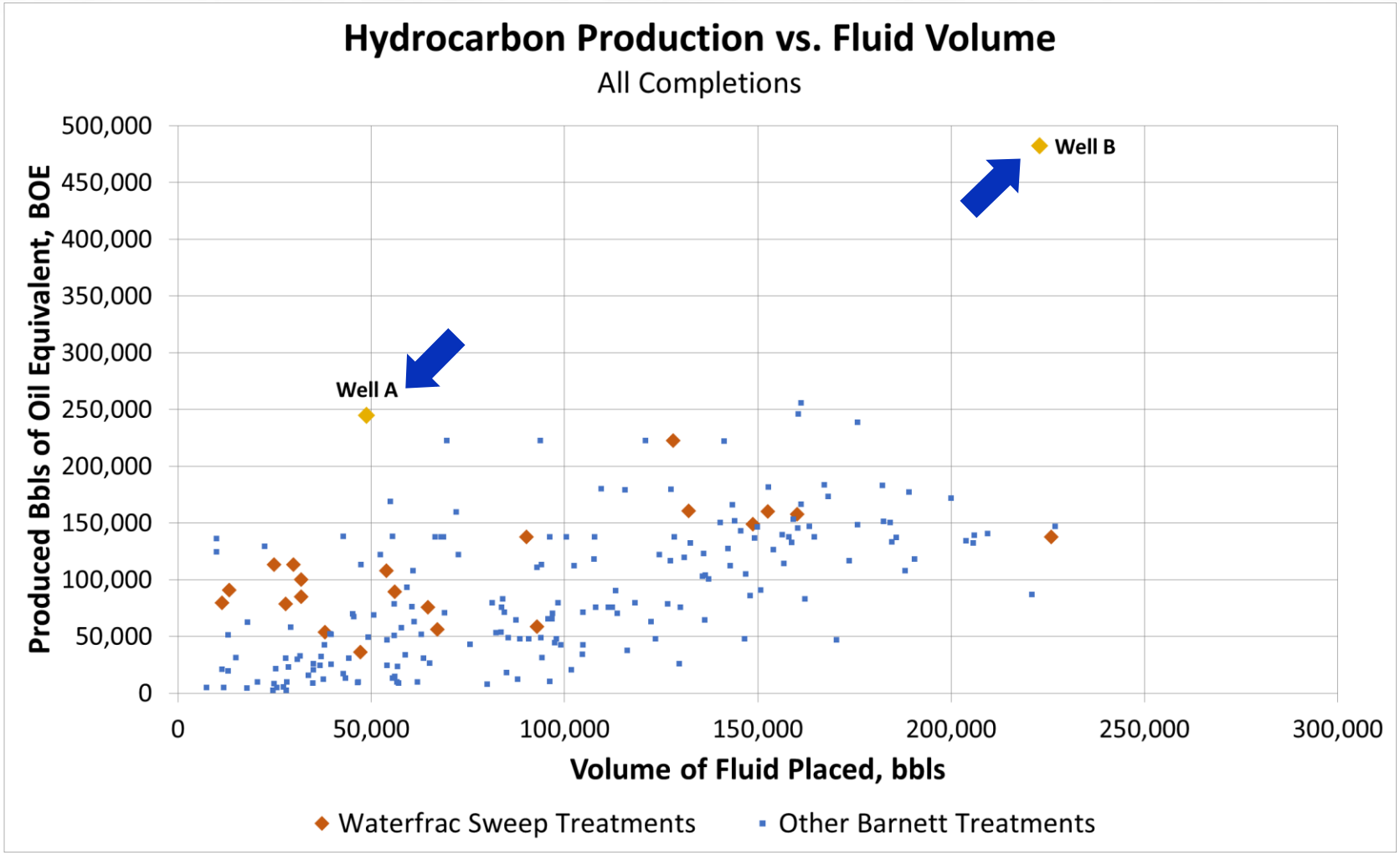

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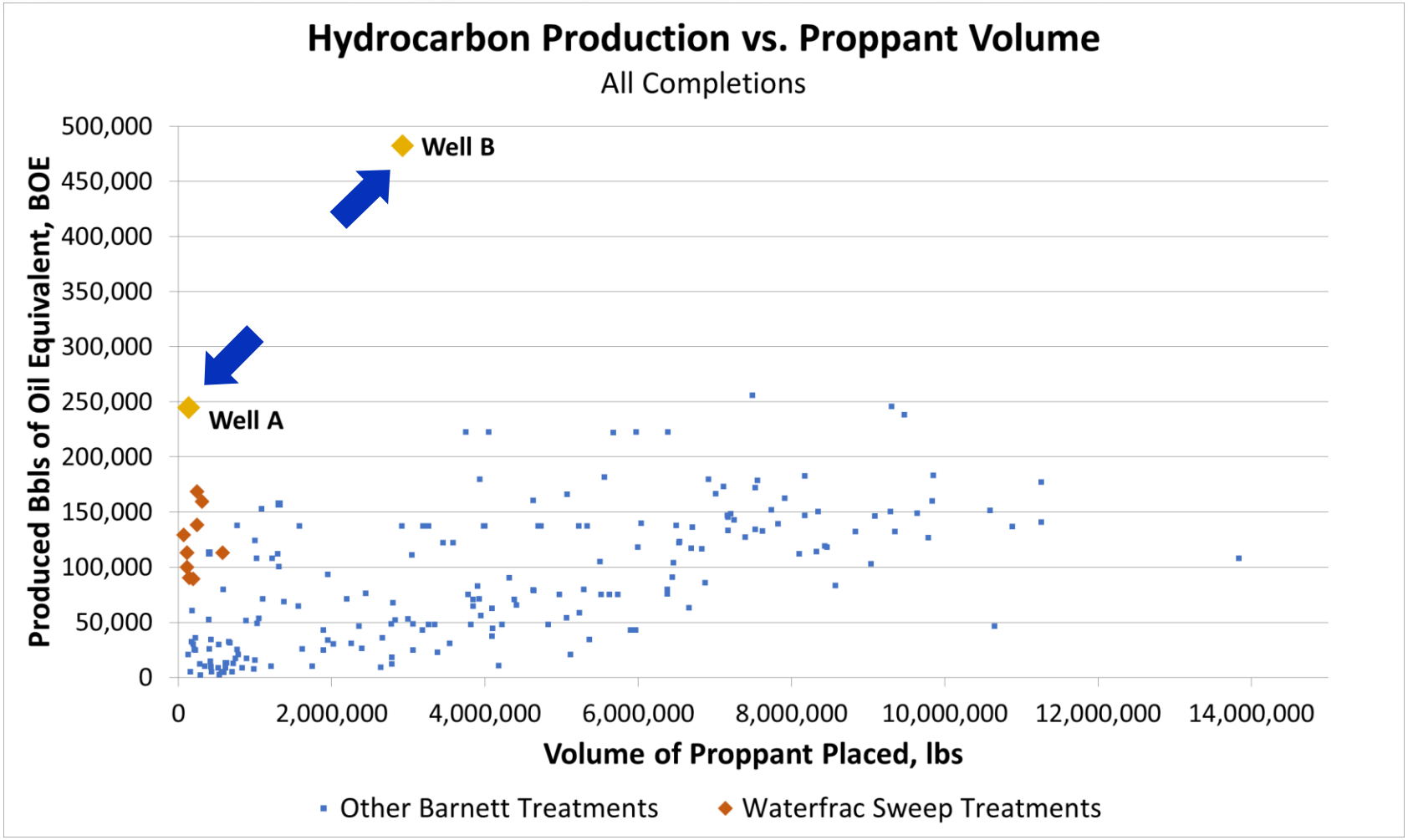

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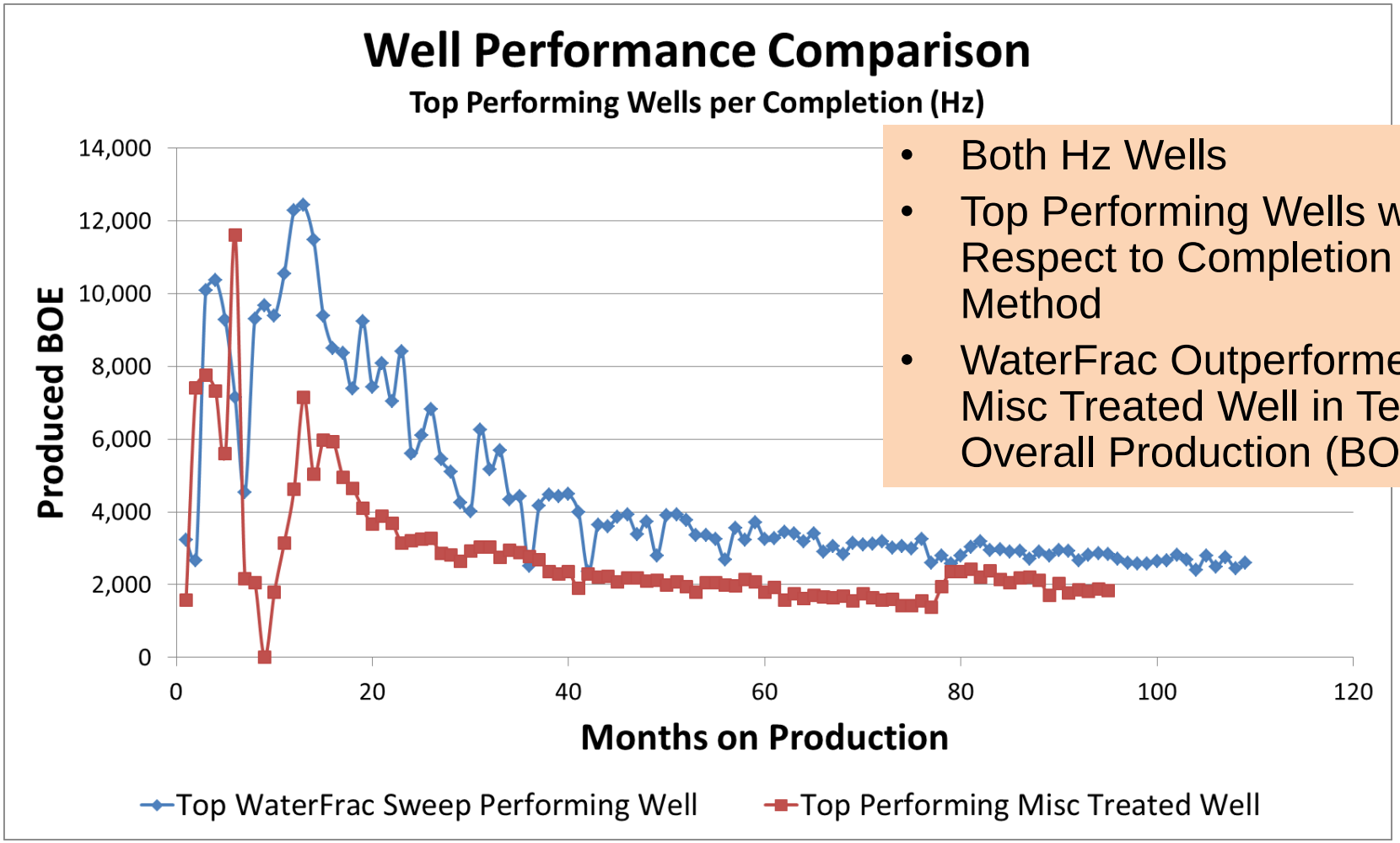
A Quick Comparison



- Both Hz Wells
- Top Performing Wells with Respect to Completion Method
- WaterFrac Outperformed Misc Treated Well in Terms of Overall Production (BOE)

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Production Data – Northern Barnett Shale

	Waterfrac Sweep	Miscellaneous
Average Life of Production, Yrs	11.50	8.00
Avg. Cumulative Oil Produced, bbls	80,000	45,000
Avg. Cumulative Prod Gas, MCF	550,000	600,000

- Enhanced Longevity
- Larger Overall Cumulative Production
- Top Performing Hz Well: 300,000 BO, 1 BCF Gas
- Top Performing Vr Well: 100,000 BO, ½ BCF Gas

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Conclusions and Discussion

- The production results shown indicate very successful stimulation utilizing a combination of perforations using image logs and the use of the WaterFrac Sweep Process,
- The implications of the success are that the presumption that more proppant is the driving force in optimal stimulation of shale is not necessarily the case with slurry volume and pump rate substantial factors.
- The large pads and the designed use of sweeps rather than reacting to pressure problems has been shown not only in Montague county but throughout multiple shale plays.

Conclusions and Discussion

- The long term production of the wells cited using the WaterFrac Sweep process are indicative of significantly larger surface area open to produce and, in the opinion of the authors, indicates some potentially negative results of running high proppant concentrations.
- The high initial IP's of high concentration wells and very steep declines indicate to some that excessive proppant was produced and wells fell off precipitously. Another theory is that the higher sand concentrations yielded proppant packs with dramatically less conductivity than the partial monolayer achieved without the packing from higher sand volumes and concentrations.

Thank You for Your Time!

QUESTIONS, PLEASE…

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