Optimization of Completions in Unconventional Reservoirs for Ultimate Recovery*

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Abstract

Over the last decade, an industry wide shift to unconventional plays has occurred due to advances in technology allowing for the recovery of previously uneconomic reserves. The primary objective of completions in these unconventional reservoirs is to increase the effective surface area of the well to maximize reservoir contact. Horizontal drilling and multi-stage fracturing are two technologies which have accomplished this. The two main methods of horizontal, multi-stage completions currently used in unconventional reservoirs are cemented liner "plug and perf" and open hole, multi-stage fracturing systems.

Operators working in a number of unconventional reservoirs, such as shales and other tight rock formations are experiencing faster than expected production decline rates, resulting in reduced long-term, ultimate recovery. This may be in part due to the abandonment of good fracturing practices, developed over the past 50 years, with the advent of horizontal, multi-stage fracturing. Issues such as near wellbore conductivity, flowback, and fracture tortuosity that can have a significant effect on the long-term production of wells need to be considered when choosing a completion method, particularly for unconventional reservoirs.

This presentation will introduce unconventional reservoirs, describe the main methods of horizontal, multi-stage completions, discuss how the choice of method can affect good fracturing practices and provide case study examples from a variety of unconventional reservoirs including tight sandstone, limestone and shale.

References

Masters, J., 1979, Deep Basin Gas Trap, Western Canada: AAPG Bulletin, v. 63/2, p. 151-181.

Miskimins, J.L., 2008, Design and Life Cycle Considerations for Unconventional Reservoir Wells: SPE Unconventional Reservoirs Conference, 10-12 February 2008, Keystone, Colorado, SPE 114170-MS. Web accessed 2 March 2010, http://www.onepetro.org/mslib/app/Preview.do?paperNumber=SPE-114170-MS&societyCode=SPE.

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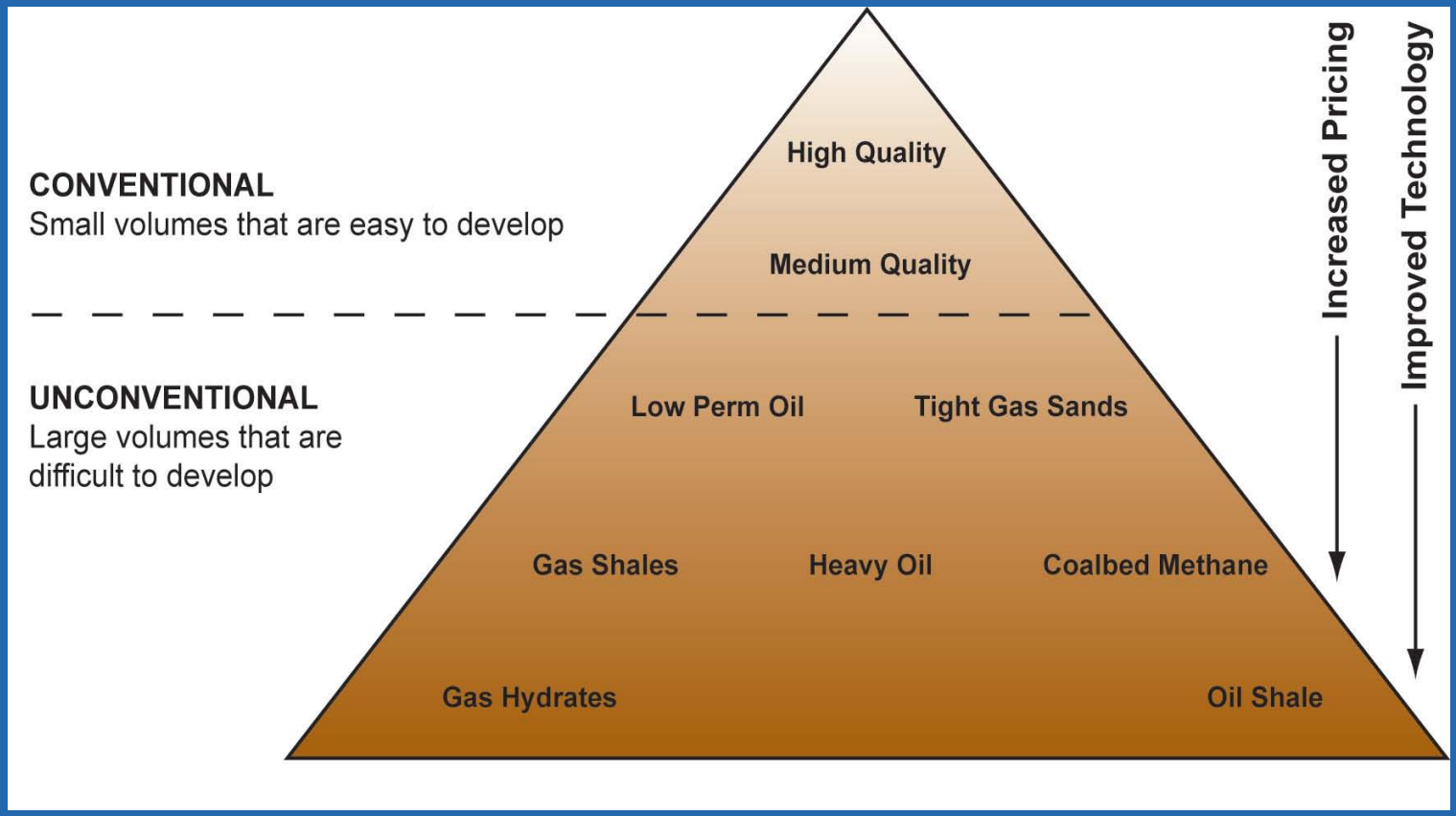
Outline

- Unconventional reservoirs
- Completions history
- Study areas
- Conclusions
- Summary

Resource Triangle



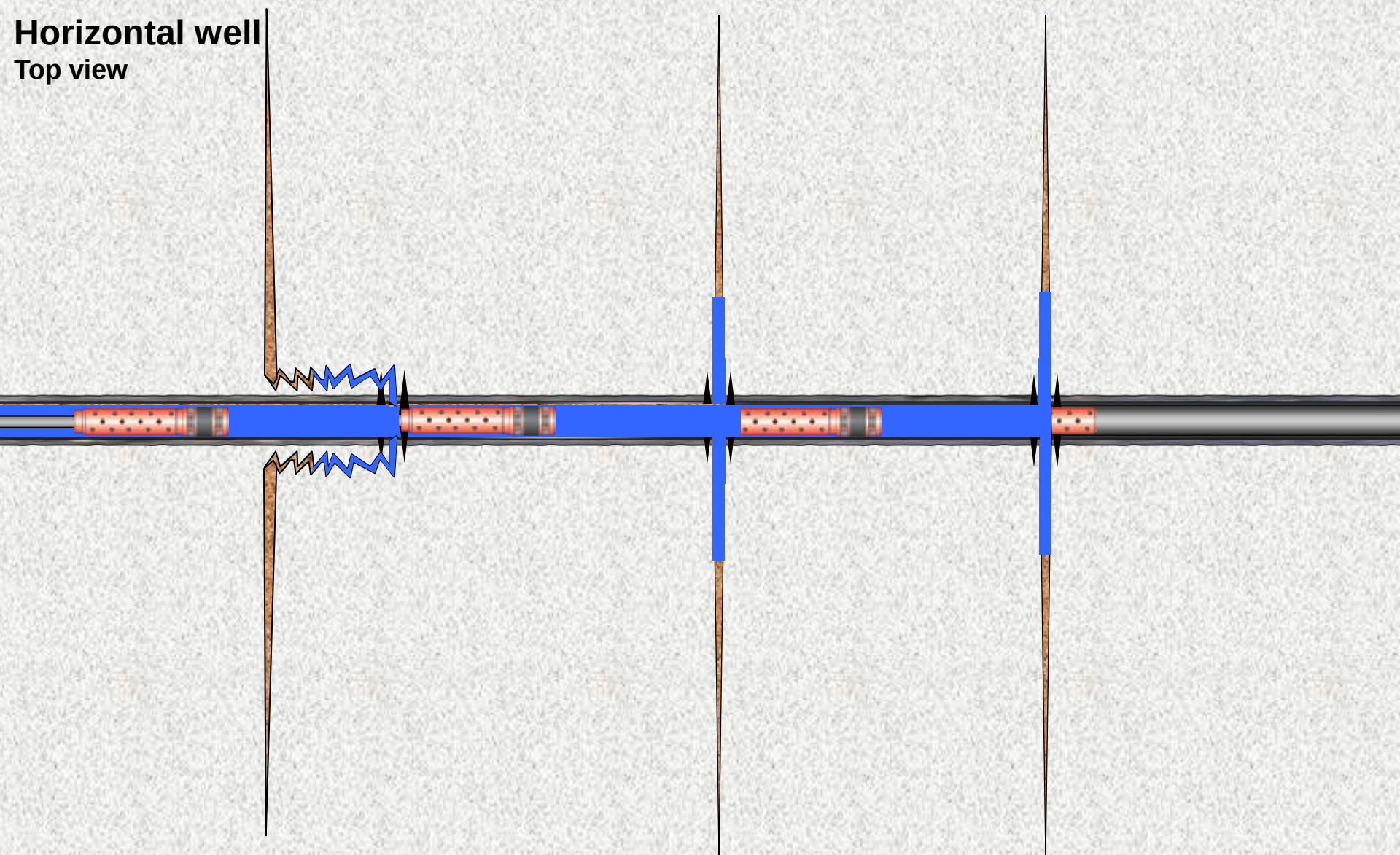
Modified from Masters, 1979 and Miskimins, 2008

Unconventional Reservoirs

Completions History

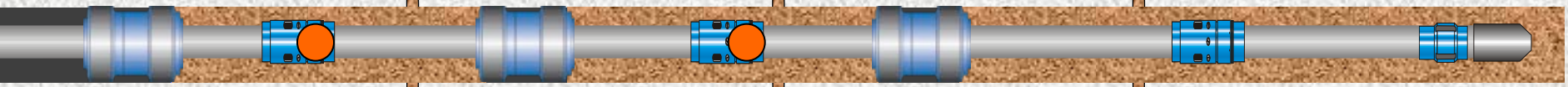
- Open Hole - “Hail Mary”
- Cemented Liner, Limited Entry
  - Ball Sealers
- Cemented Liner – “Plug and Perf”
- Open Hole Multi-Stage System (OHMS)

Cemented Liner “Plug and Perf”



Open Hole System

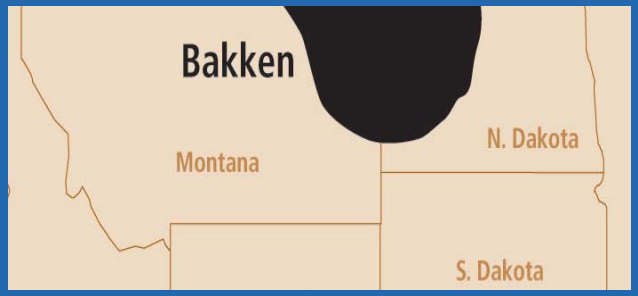
Horizontal well
Top view



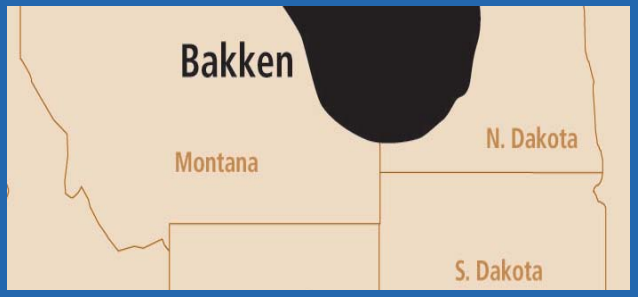
Carbonates

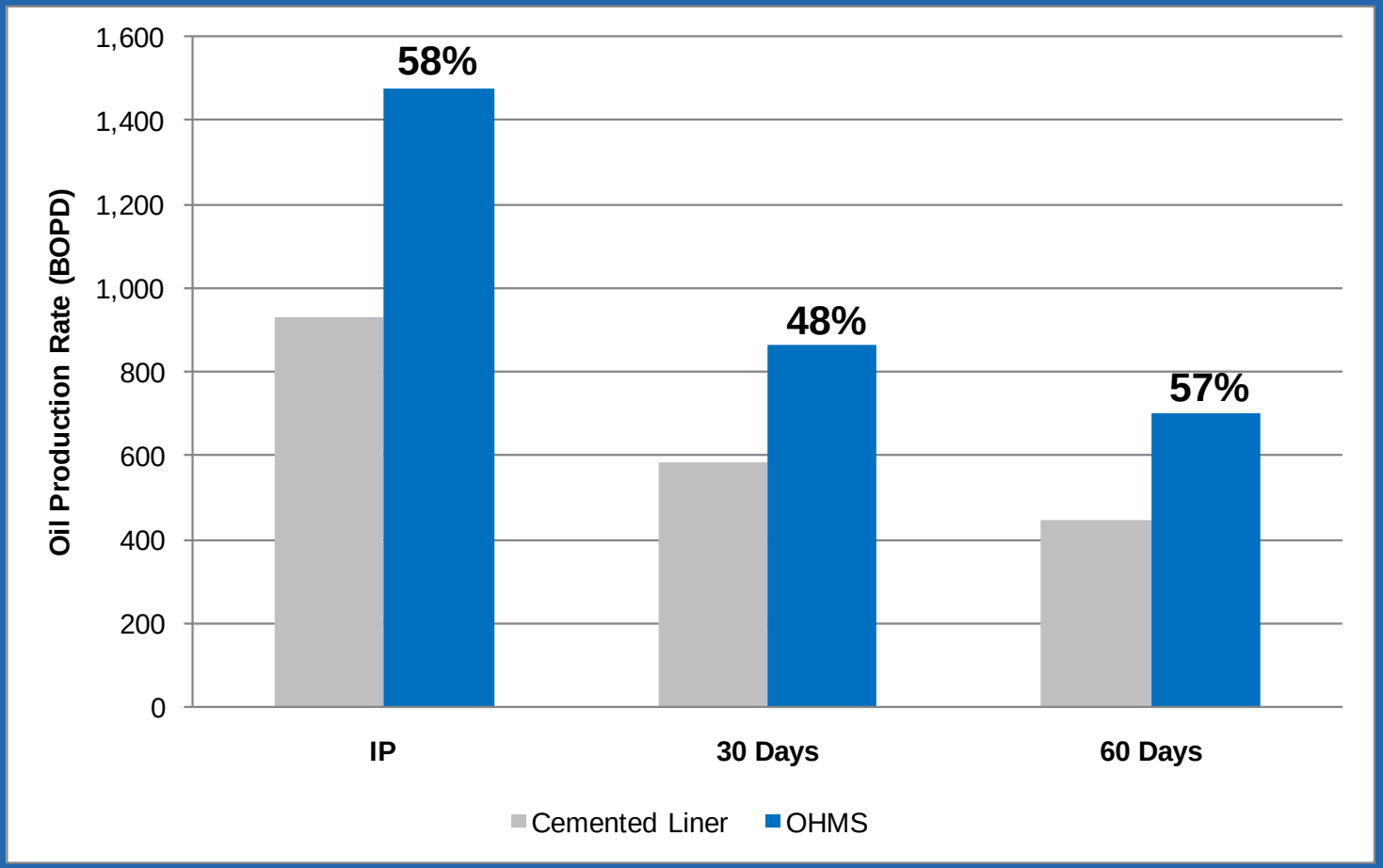
	2004	2010
Average Stages	3.0	17.2
Lateral length	3726	5864
Average Stage Length	1242	293

- Bakken Dolomite (oil)
  - 10,000 – 11,000 ft TVD
  - +250°F
  - 5% porosity
  - 0.04 mD



Bakken Dolomite



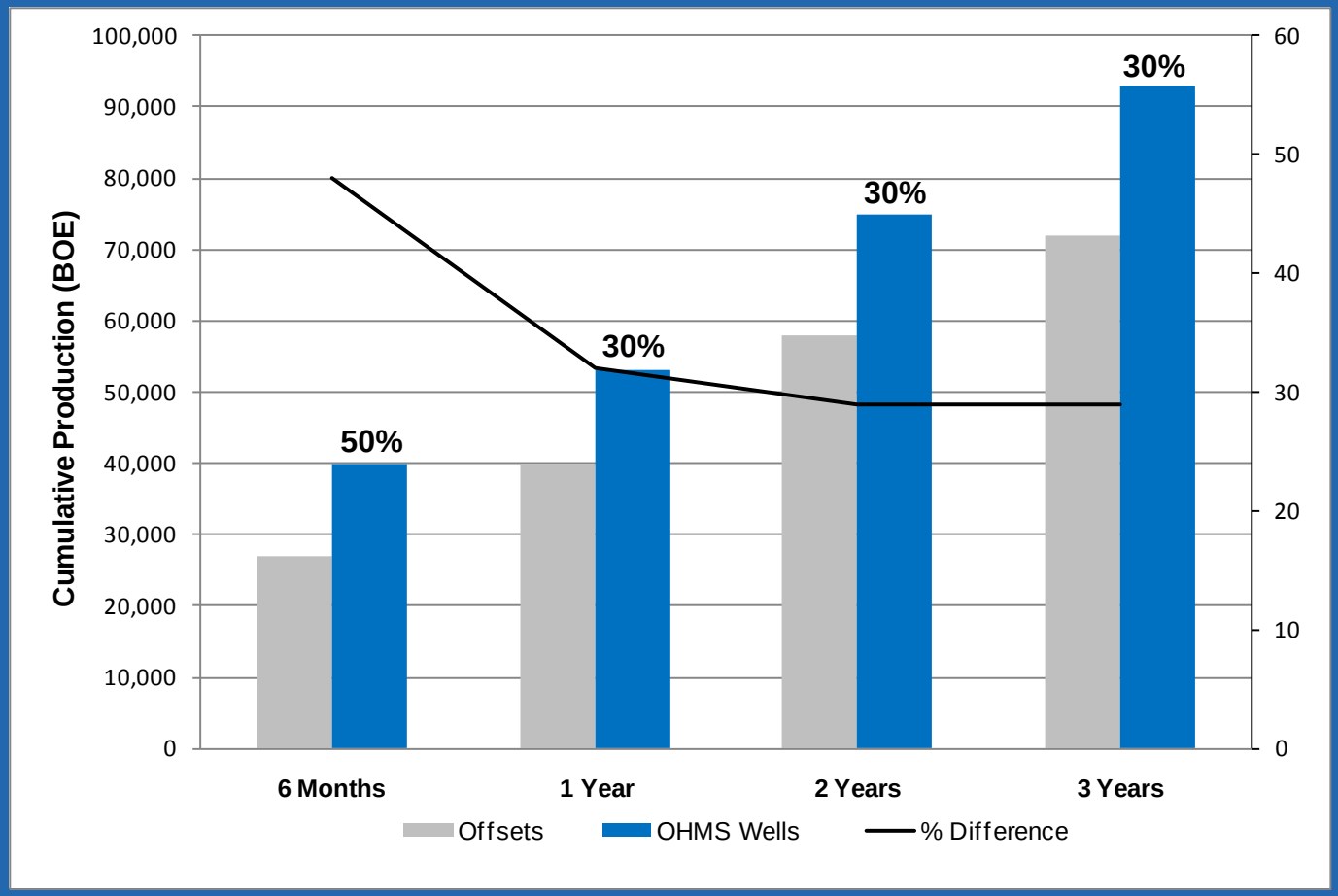


Tight Sandstones

	2005	2010
Average Stages	4.1	14.1
Lateral length	1650	3847
Average Stage Length	443	252

- Cleveland Sand (oil & gas)
  - 7,500 ft TVD
  - +150°F
  - 4 to 14% porosity
  - 0.03 to 1.1 mD

Cleveland Sand



Shales

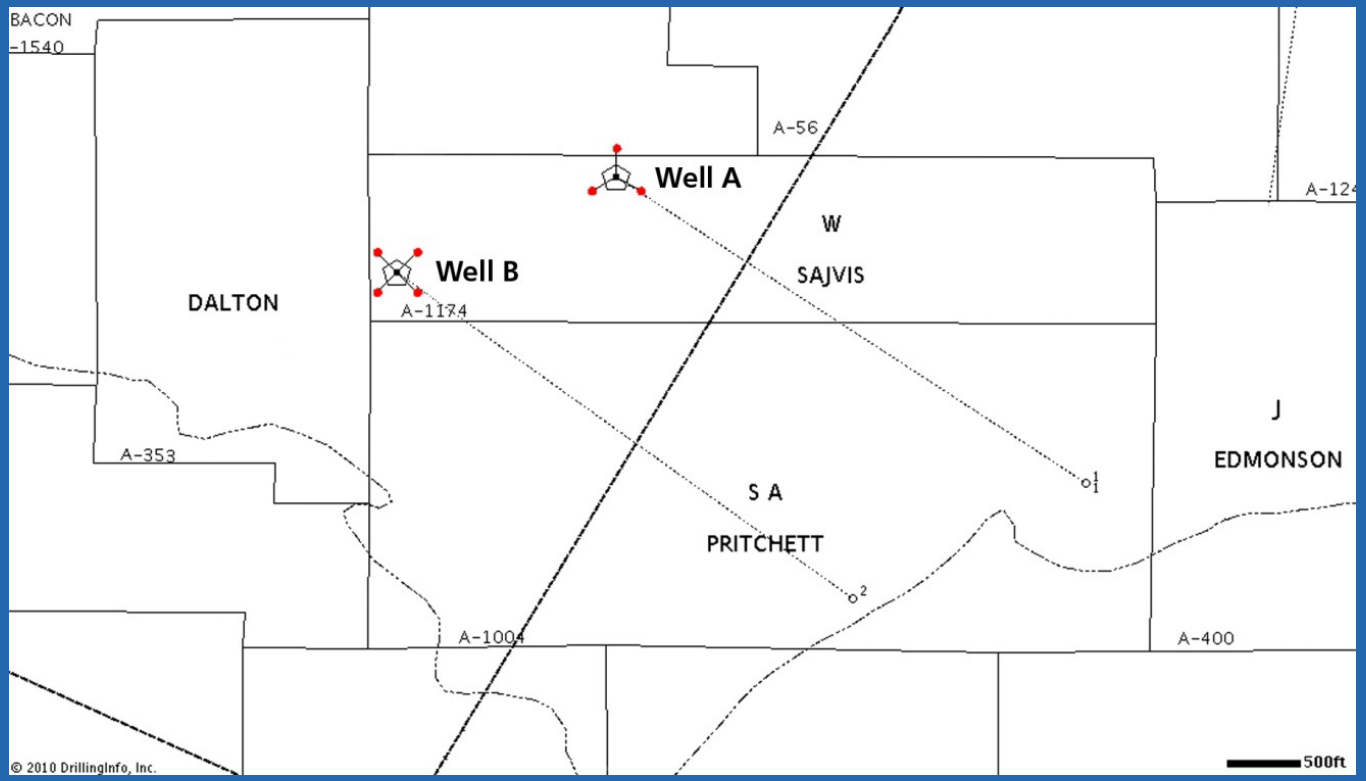
	2004	2010
Average Stages	4.6	12.3
Lateral length	1,863	3256
Average Stage Length	342	278

- Barnett Shale (gas)
  - 7,500 ft TVD
  - +180 °F
  - 3 to 5% porosity
  - 0.00007 to 0.0005 mD

Barnett Shale

Well A
7-stage open hole

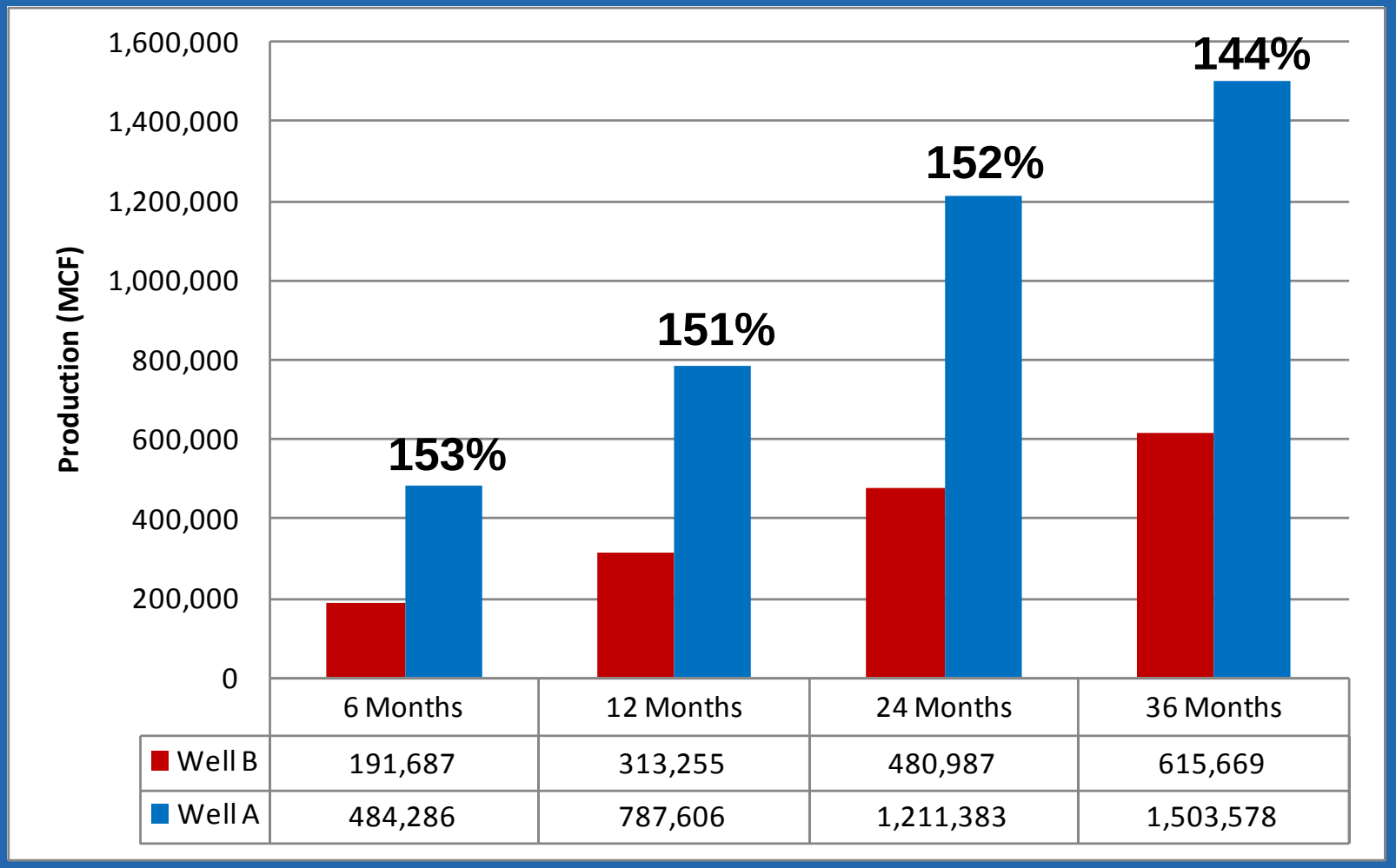
Well B
8-stage cemented liner



Barnett Shale

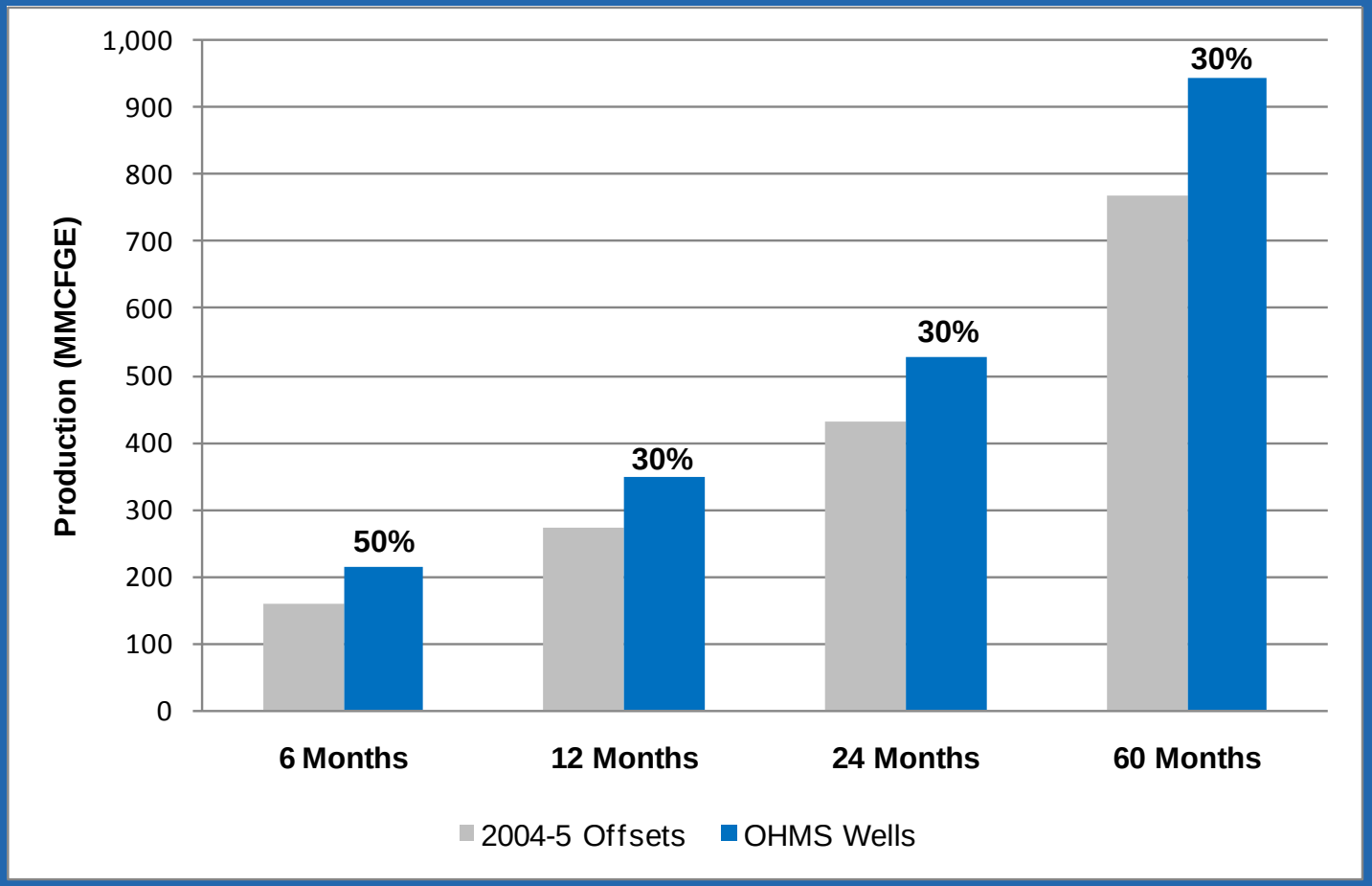
- Well A
  - 1,276,503 lb proppant
  - 4,500 psi – 8,000 psi
  - 60 BPM – 140 BPM
  - 21 hours
- Well B
  - 1,273,745 lb proppant
  - 7,400 psi – 9,000 psi
  - 29 BPM – 93 BPM
  - 3+ days

Barnett Shale



	6 Months	12 Months	24 Months	36 Months
Well B	191,687	313,255	480,987	615,669
Well A	484,286	787,606	1,211,383	1,503,578

Barnett Shale

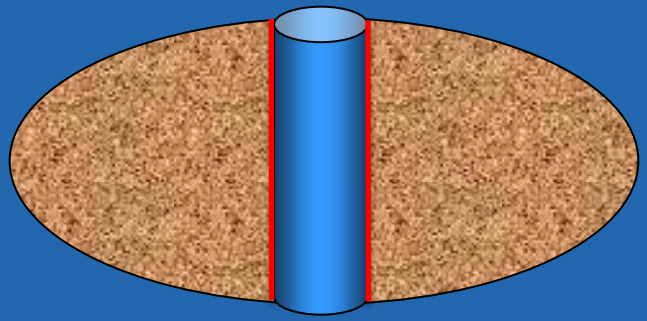


Good Fracture Practices

- Don’t overdisplace proppant
- Ensure near wellbore conductivity
- Keep breakdown pressures low
- Minimize fracture tortuosity
- Promote immediate flowback
  - Minimize fluid loading
  - Optimize load recovery

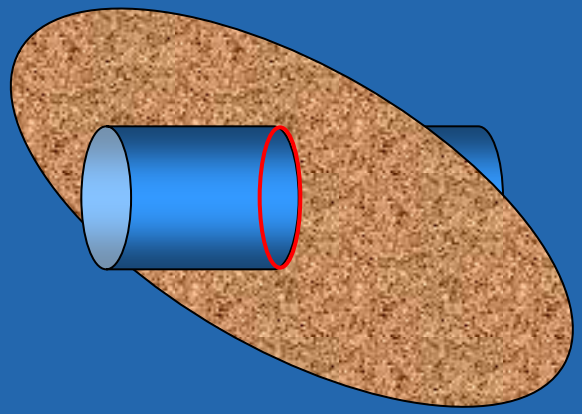
Maximum Effective Reservoir Contact

Vertical wellbore
6 ⅛-in. x 100 ft



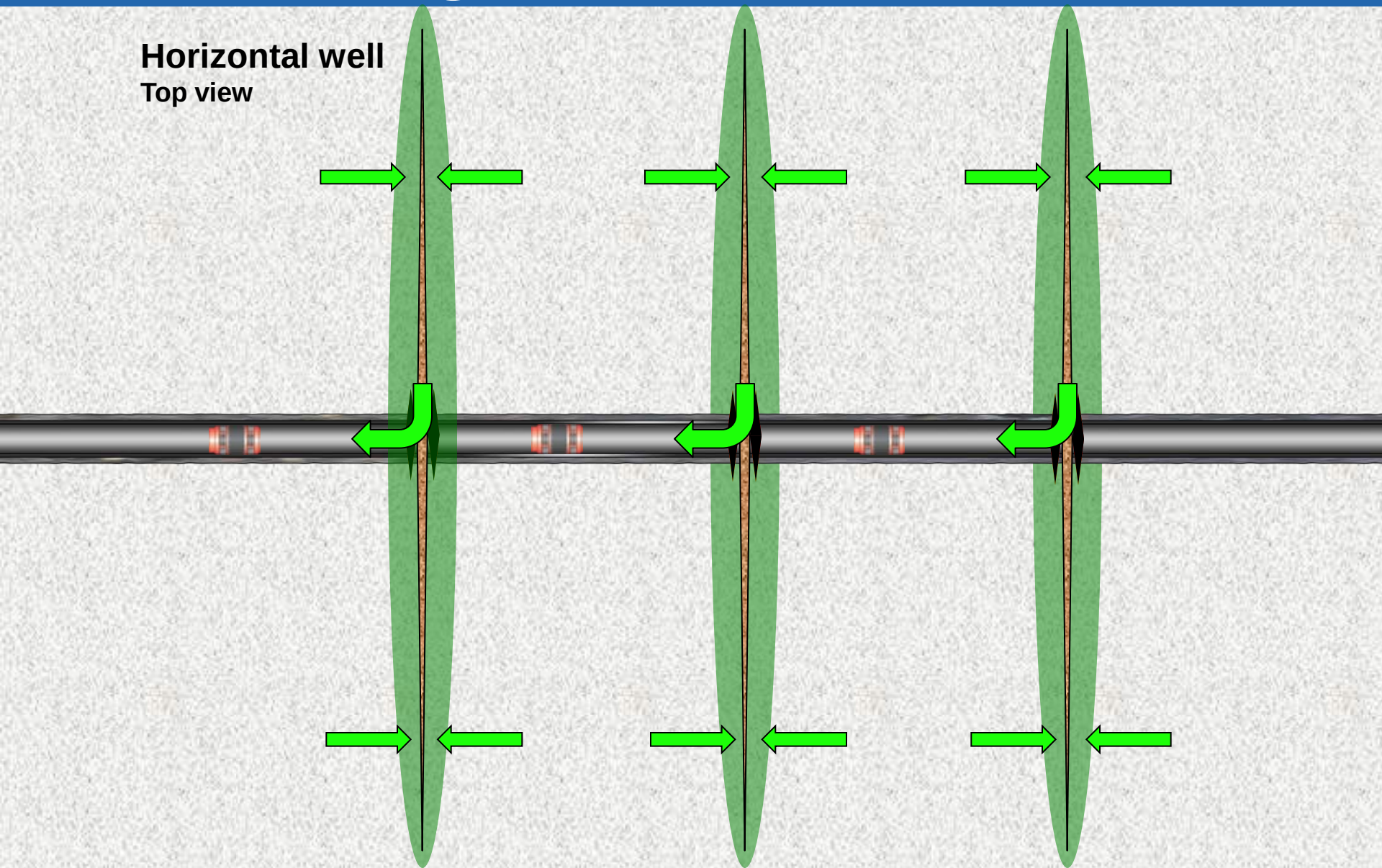
One vertical fracture
(100 ft x 150 ft x ⅛ in.)
23,562 ft^2
Feeding into 2.1 ft^2

Horizontal wellbore
6 ⅛-in.

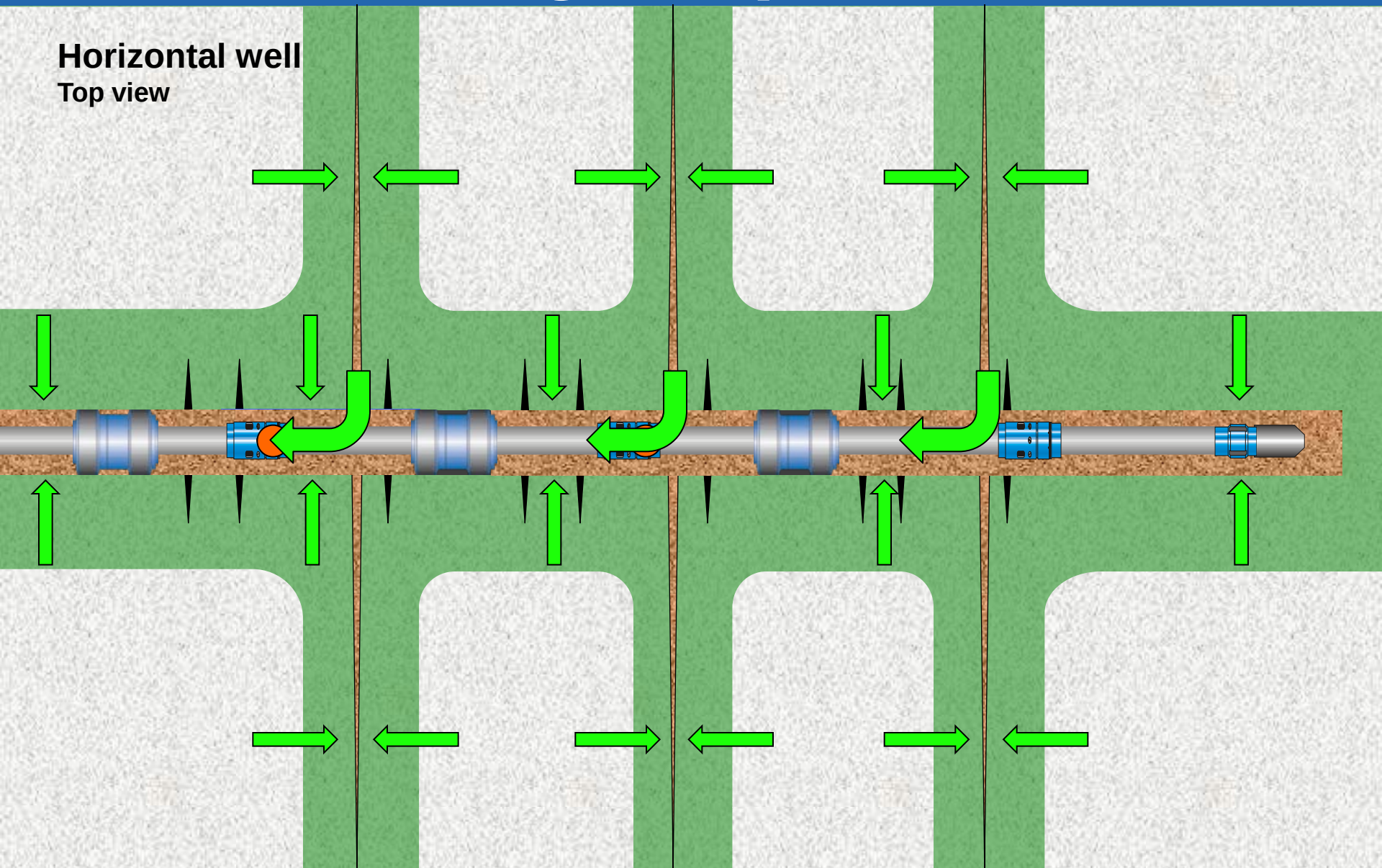


One transverse fracture
(100 ft x 150 ft x ⅛ in.)
23,562 ft^2
Feeding into 0.017 ft^2

Drainage: Cemented Liner



Drainage: Open Hole



Conclusions

CEMENTED

- More complicated, takes longer, less productive

UNCEMENTED

- Simpler, quicker, higher production

Summary

- Good Frac Practices
  - Have not changed
- OHMS better results
  - More stages

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