

December 5-6, 2018

Norris Conference Centers -
City Centre, Houston, Texas
ShaleTechConference.com

SHALETECH™



Stacked Pay Development in the Delaware Basin

Raj Malpani

Production Engineering Lead

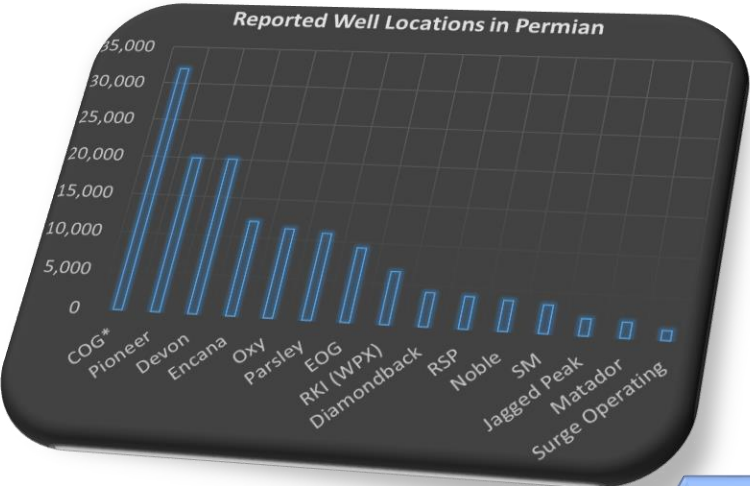
Schlumberger

SHALETECH™

Outline

- Delaware Basin Introduction & Trends
- Reservoir Characterization
- Well Stacking & Interference
- Completion Sequencing
- Well Staggering
- Conclusions

Permian Basin: Delaware Basin



Delaware Basin
Offset Operators are Targeting Multiple Horizons

	Apache	CENTENNIAL	CONOCO	DEVON	ENERGEN	OKM	Jagged Peak	NOBLE ENERGY	OCY	PDC ENERGY
Brushy Canyon					☆		☆		☆	
Avalon Shale	☆		☆	●						
1st Bone Spring Sand	☆		☆	●			☆	☆	☆	☆
2nd Bone Spring Shale							●		☆	
2nd Bone Spring Sand	☆	●	☆	●					●	☆
3rd Bone Spring Carb					☆					
3rd Bone Spring Sand	☆	●	☆	●	●		●	●	●	☆
Upper Wolfcamp A (XY)	☆		●	●	●		●		●	●
Middle Wolfcamp A	●		●	●	●		●	●	●	●
Lower Wolfcamp A	●		●	☆	●		●		☆	●
Upper Wolfcamp B			●	●	●		●	●	●	●
Lower Wolfcamp B	●		●	●	●		●	●	●	●
Wolfcamp C	☆		●		●		☆	●	●	●
Wolfcamp D / Cine	☆				●				☆	●
Development Zones	3	3	5	6	3	4	4	4	4	3
Total Potential Zones	10	9	26+	30+	25+	7	6	9	6	6
Potential Wells/DSU	24+									

● Current Development Zone ☆ Potential Zone
Source: Company investor presentations, press releases, and public filings.
DSU = Drill Spacing Unit



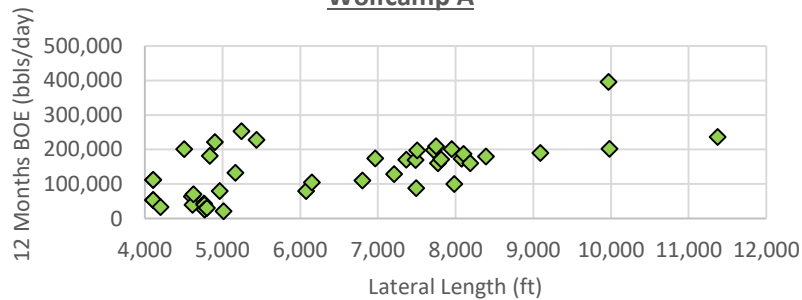
Source: Investor reports of multiple operators

Delaware Basin: Study Area

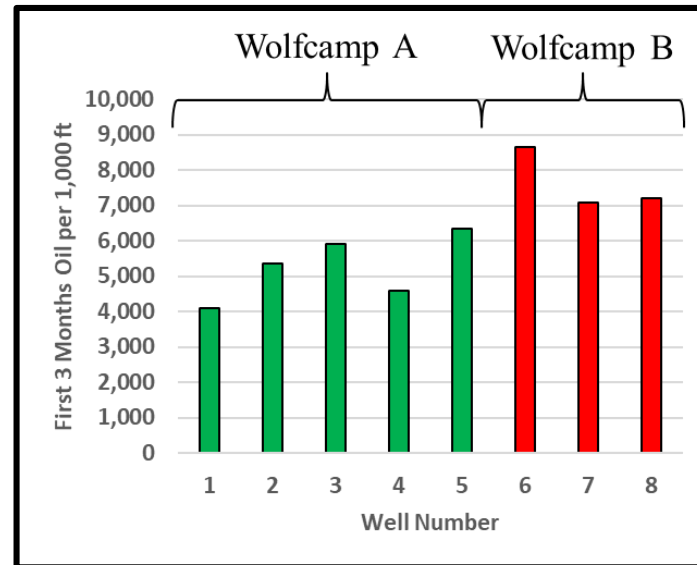
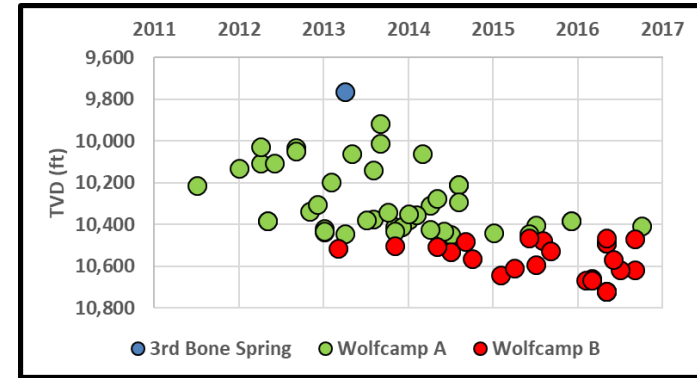
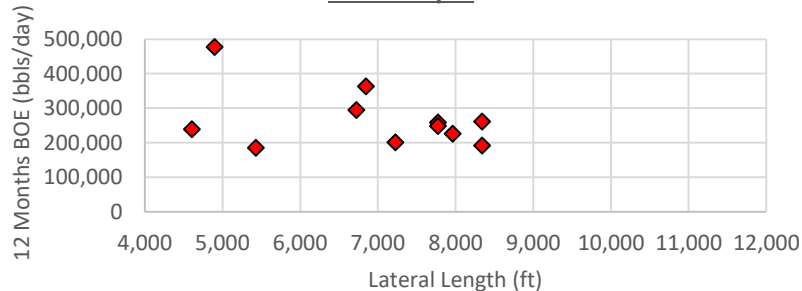
Permian Basin of West Texas and New Mexico during late Permian



Wolfcamp A



Wolfcamp B



Reservoir Characterization

Pilot Well

Advanced Logs

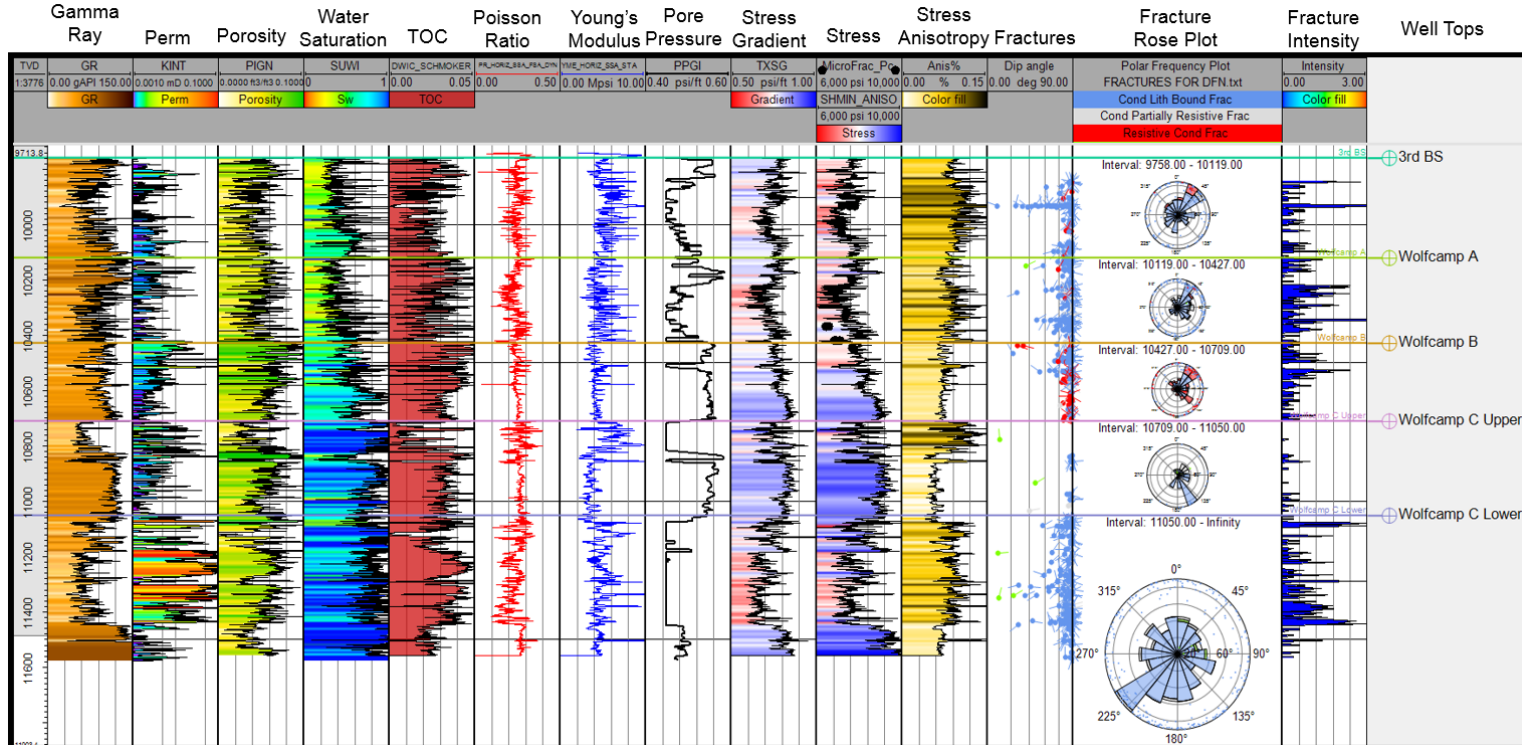
Cores

MDT

Horizontal Well

Dipole Sonic

Image Logs

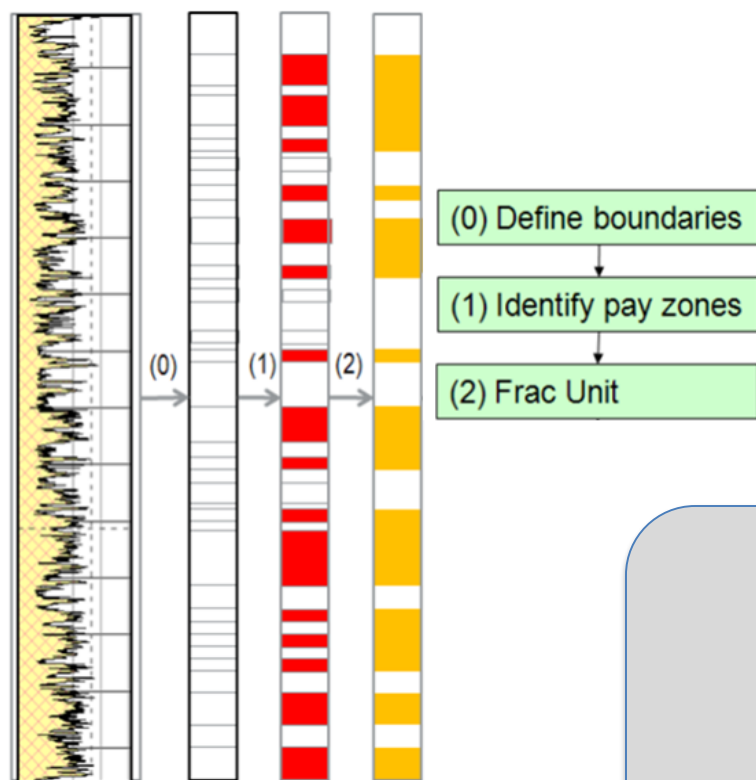


Reservoir Characterization

Zone Name	Avg. Porosity	Phi*H	Avg. Perm	K*H	Avg. Sw	HCPV
	fraction	ft	md	md-ft	fraction	ft
3rd Bone Spring	0.043	6.28	0.0041	0.597	0.58	2.65
Wolfcamp A	0.052	15.94	0.0036	1.116	0.45	8.73
Wolfcamp B	0.065	18.26	0.0075	2.119	0.64	6.51
Wolfcamp C_Upper	0.054	18.34	0.0068	2.278	0.83	3.11
Wolfcamp C_Lower	0.057	22.45	0.0374	14.810	0.84	3.52

Wolfcamp A has the highest hydrocarbon pore volume

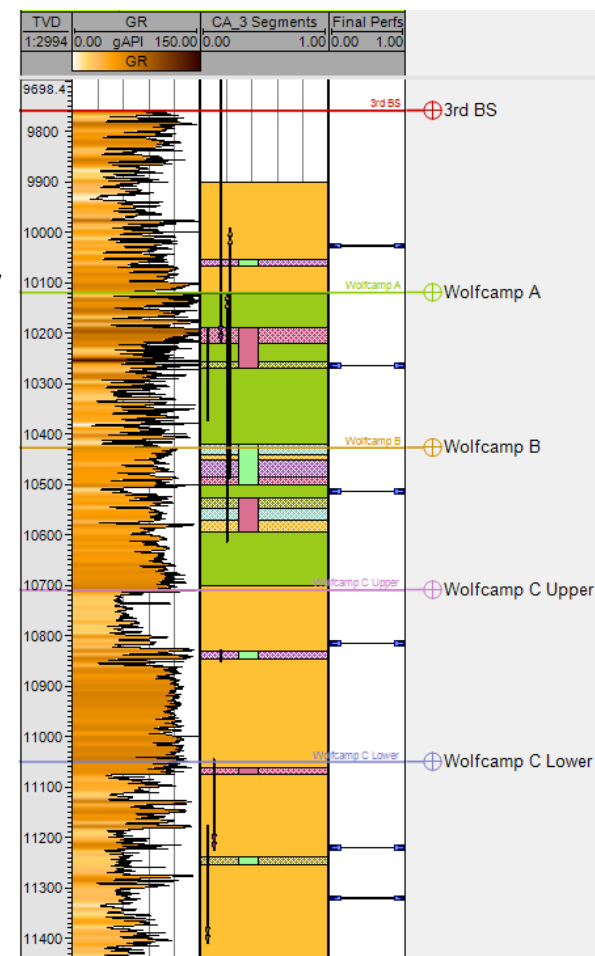
Well Stacking



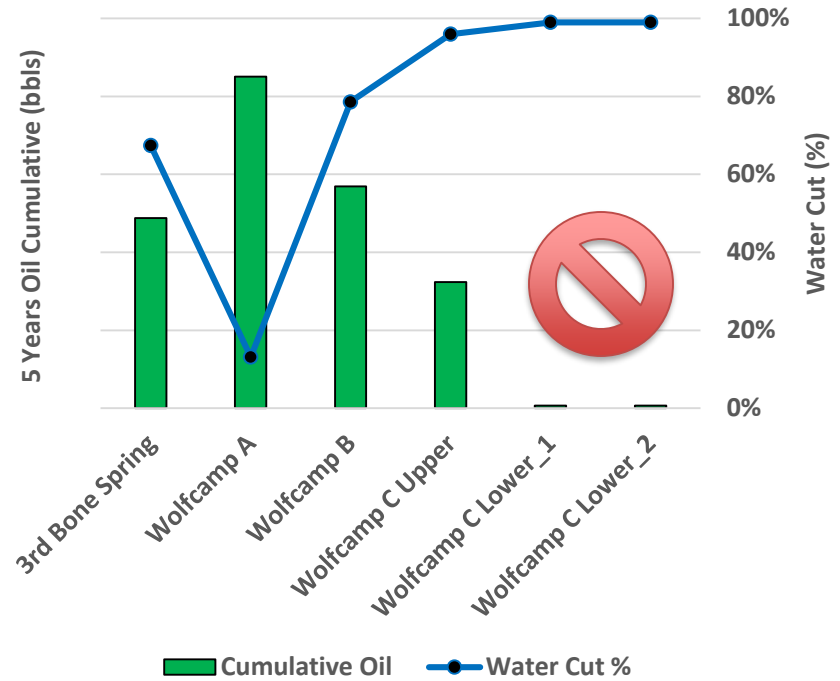
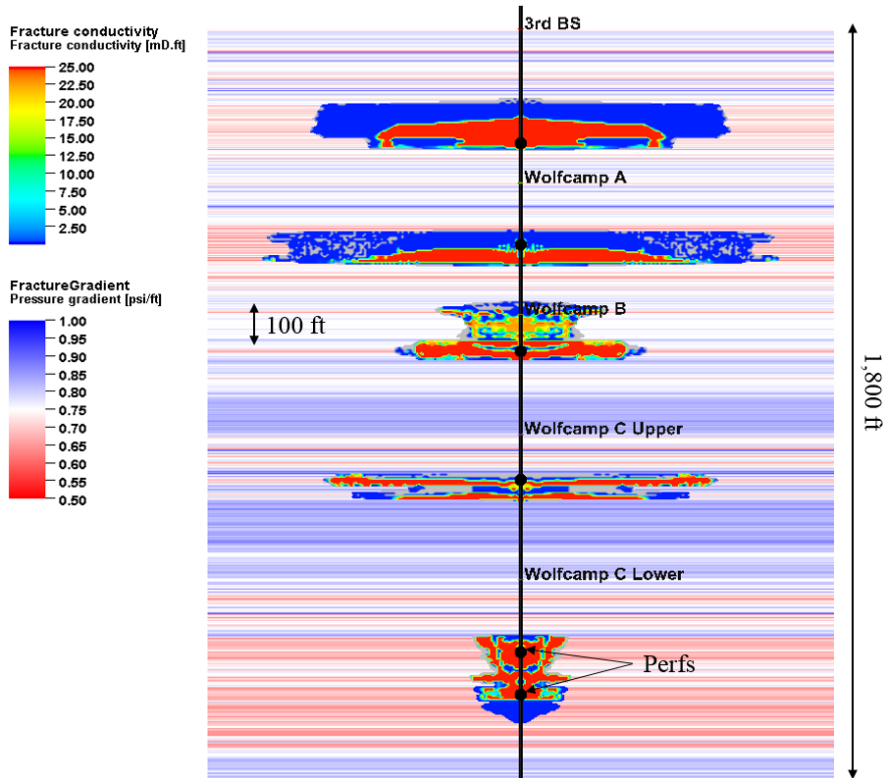
- Equilibrium height growth model
- Staging algorithm
 - Group pay & non-pay

Landing Targets (6)

- 3rd Bone Spring (1)
- Wolfcamp A (1)
- Wolfcamp B (1)
- Wolfcamp C Upper (1)
- Wolfcamp C Lower (2)



Well Stacking

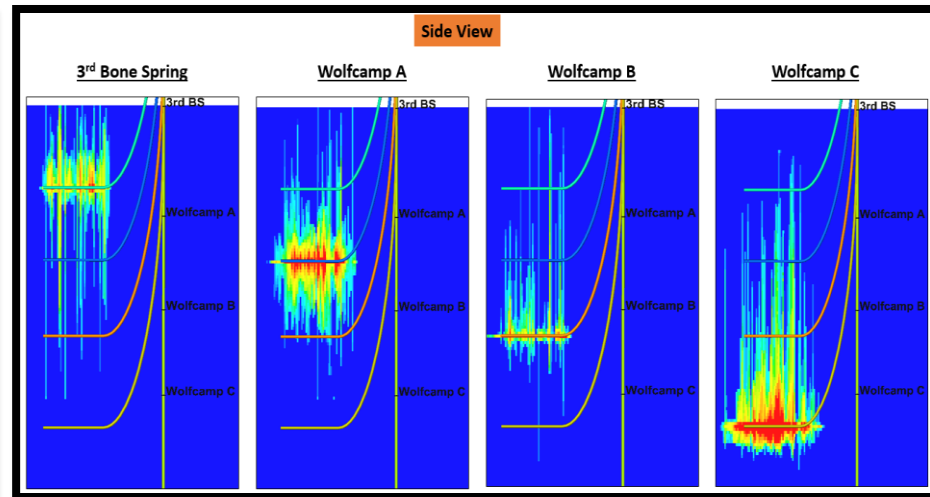
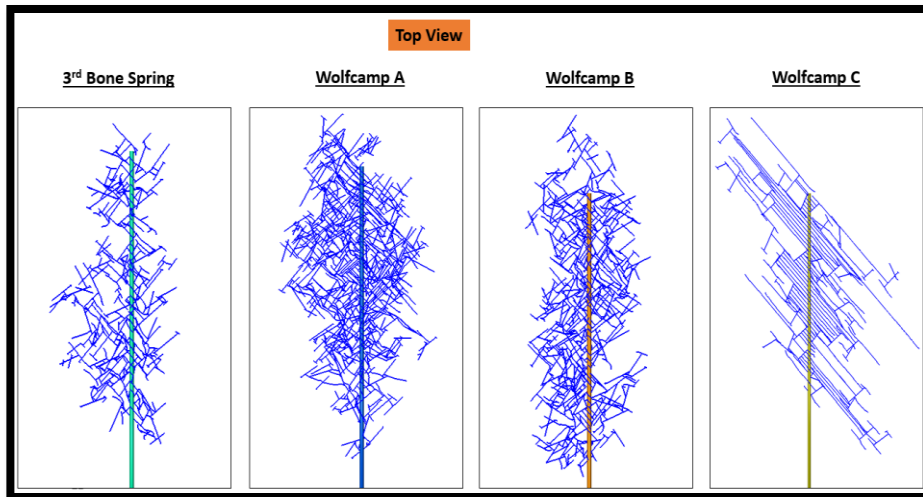


Completion Design

Completion Parameters	3 rd Bone Spring	All Wolfcamp
Cluster Spacing, feet	33	25
Number of Clusters per Stage	6	8
Proppant/Lateral Foot (lbs/foot)	1,800	2,250
Fluid/Lateral Foot (bbls/foot)	35	63
Pump Rate (bbls/min)	80	90
Proppant Types	100 Mesh, 40/70, 30/50	100 Mesh, 40/70
Fluid Types	Slick water, 10# & 15# Linear Gel	Slick water
Maximum Proppant Concentration (PPA)	3	2

Single Well

Completing & Producing Each Zone Individually



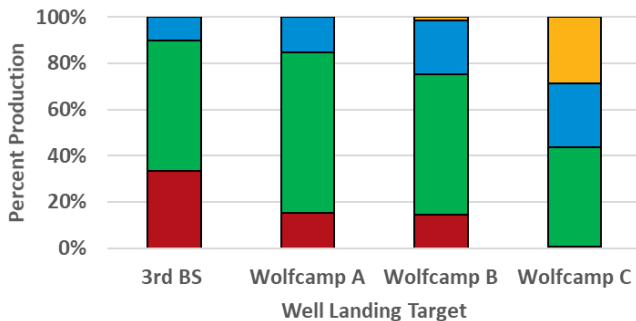
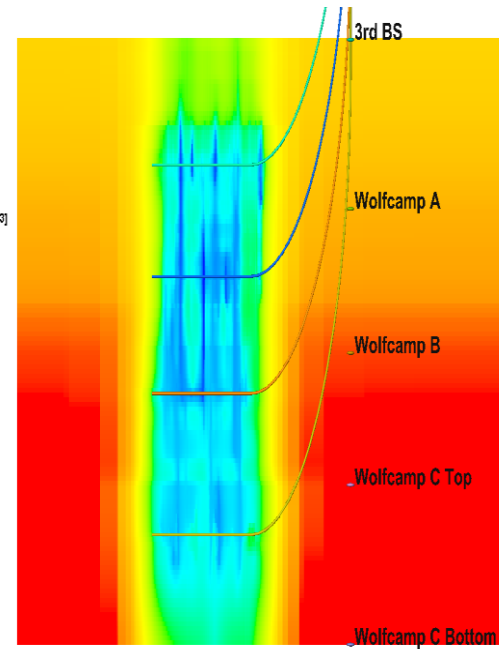
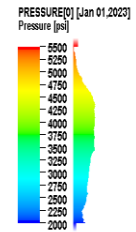
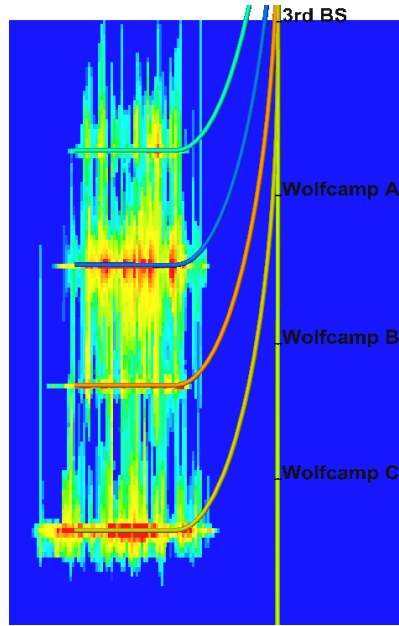
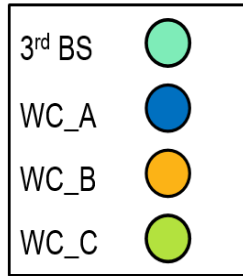
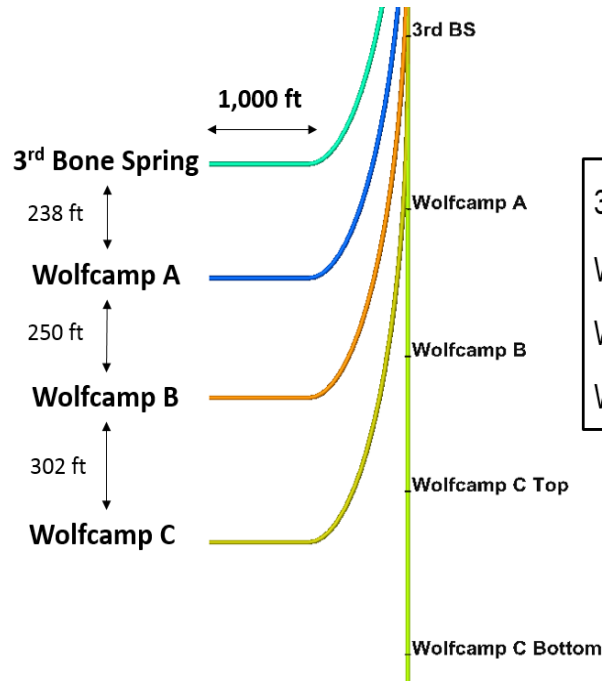
2 3rd Bone Spring
45,871 bbls/1,000 ft

1 Wolfcamp A
49,515 bbls/1,000 ft

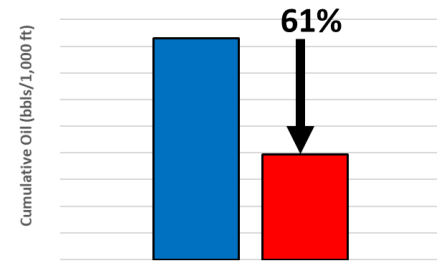
3 Wolfcamp B
42,015 bbls/1,000 ft

4 Wolfcamp C Upper
28,476 bbls/1,000 ft

Vertical Interference (Direct Stack)



■ 3rd BS ■ Wolfcamp A ■ Wolfcamp B ■ Wolfcamp C

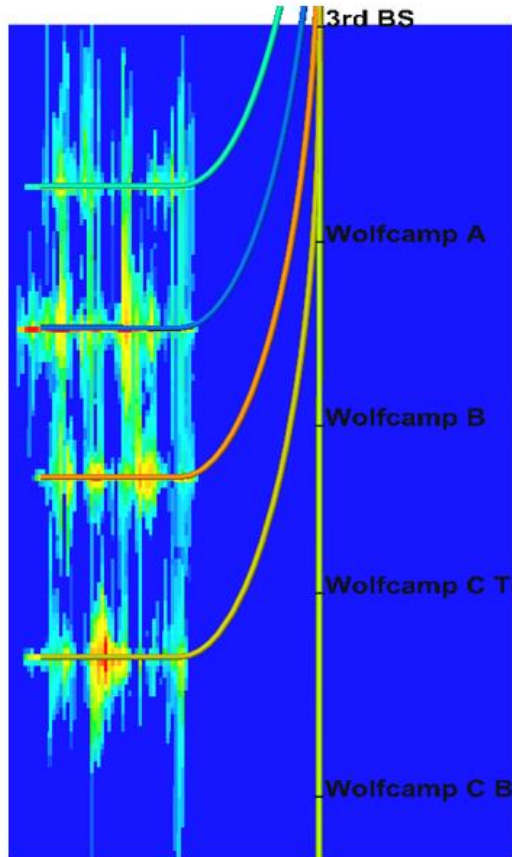


■ All Wells Producing Individually ■ All Zones Producing Together

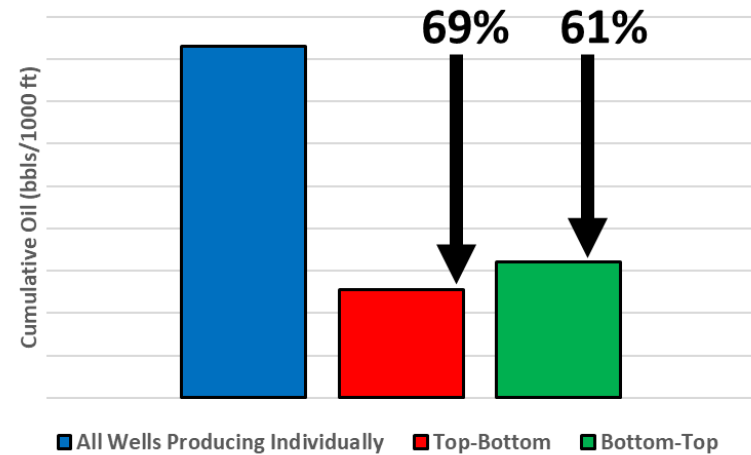
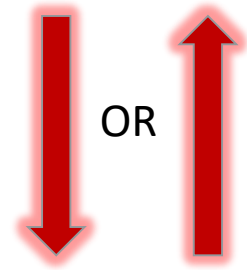
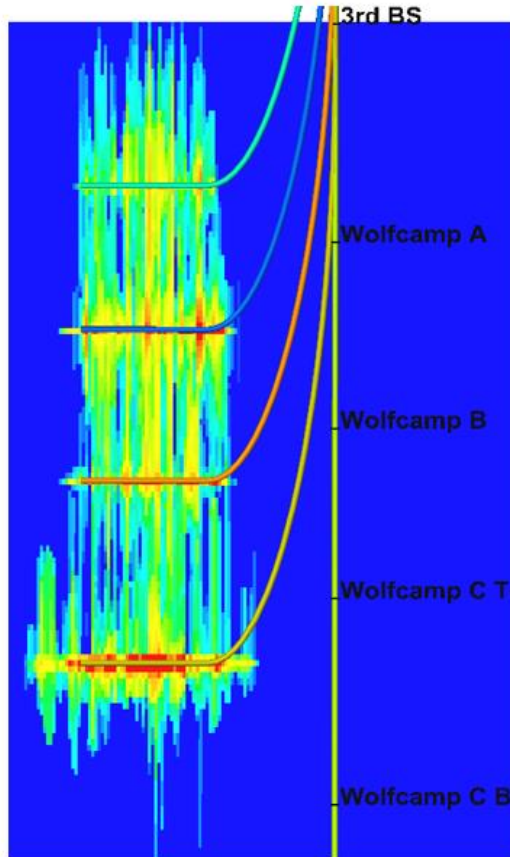
Vertical Completion Sequencing

Gun Barrel

View Top-Bottom



Bottom-Top

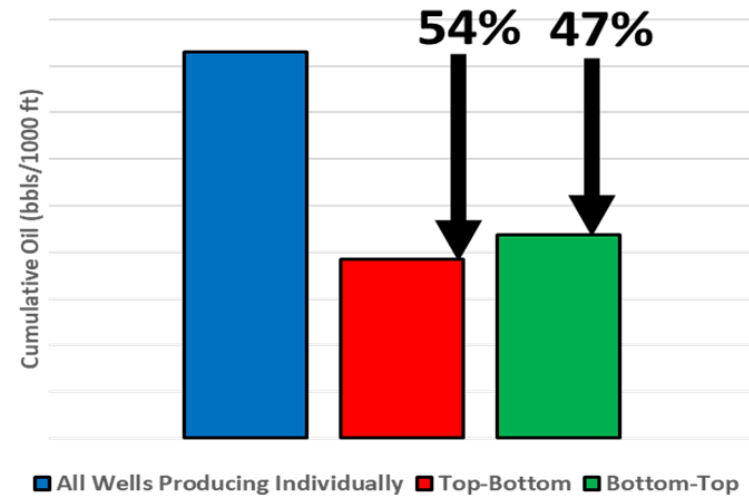
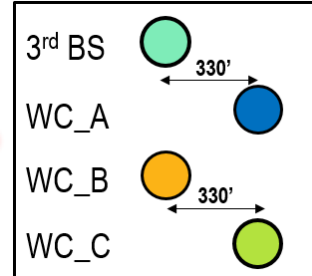
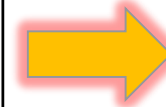
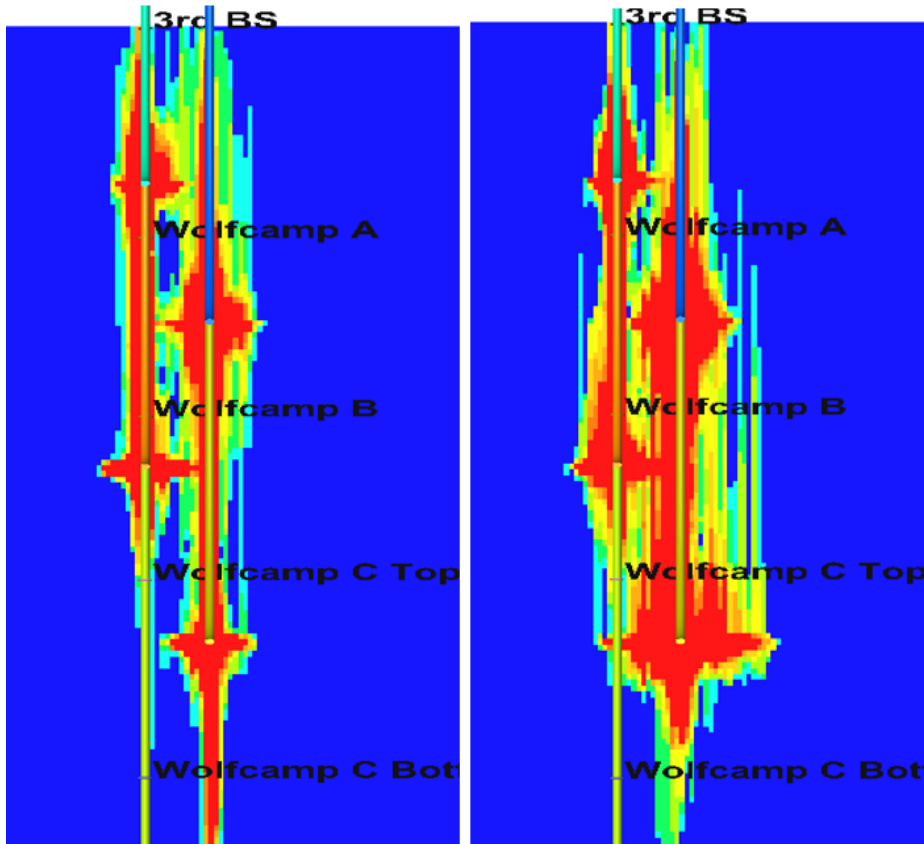


Well Staggering 330ft

Gun Barrel View

Top-Bottom

Bottom-Top

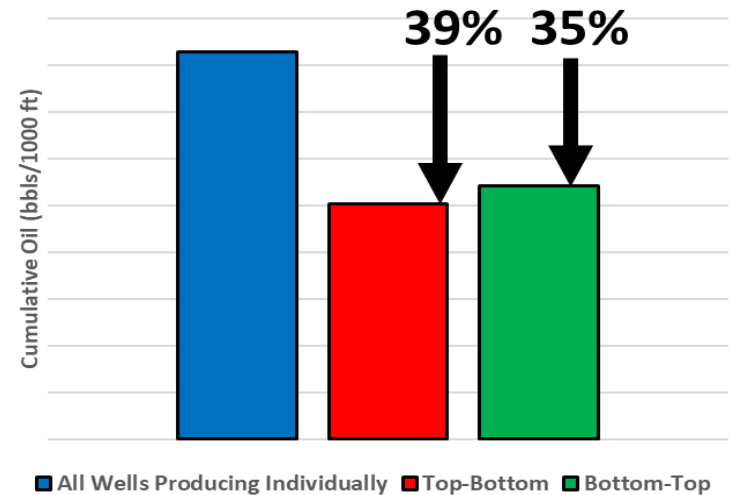
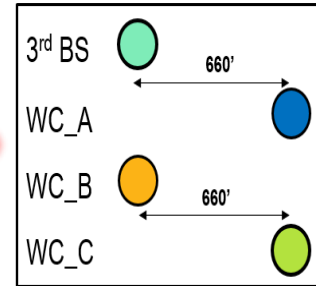
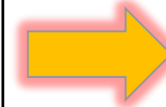
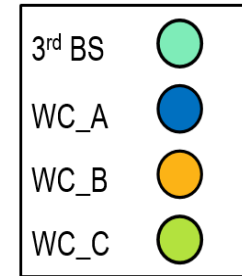
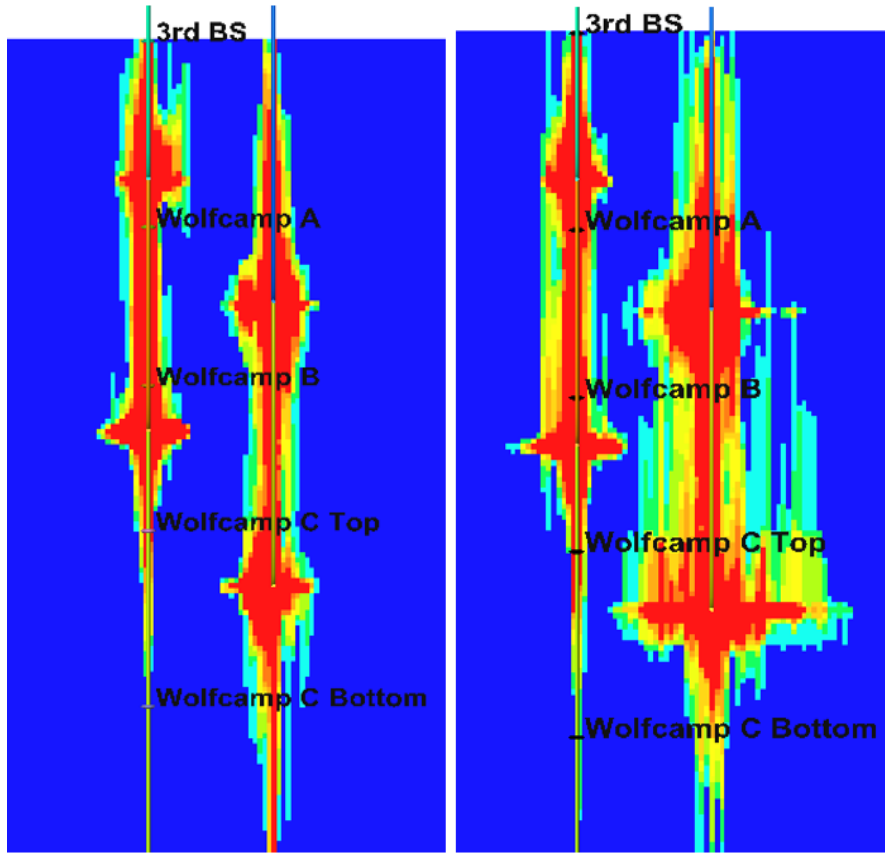


Well Staggering 660ft

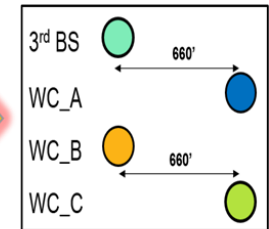
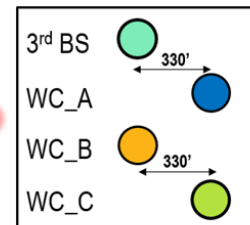
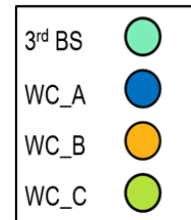
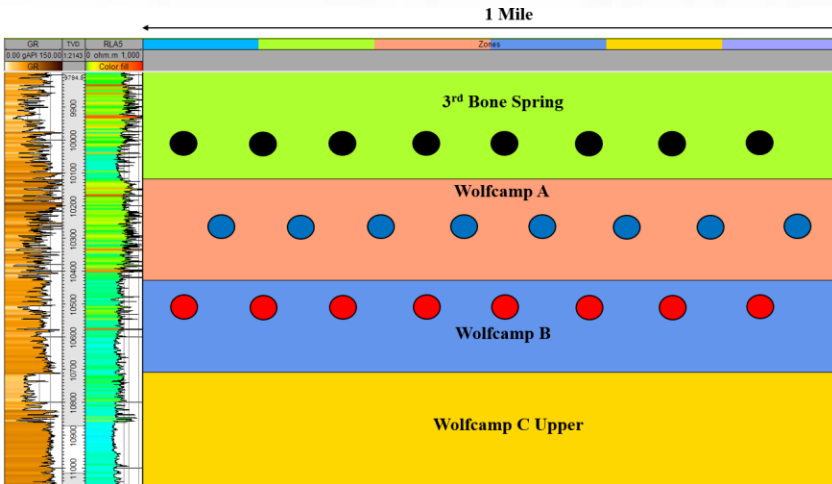
Gun Barrel View

Top-Bottom

Bottom-Top



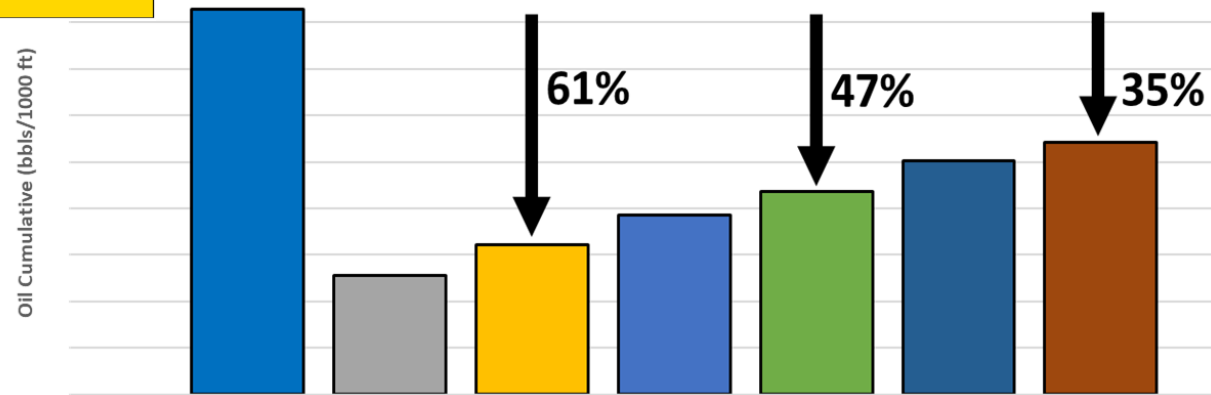
Staggering Summary



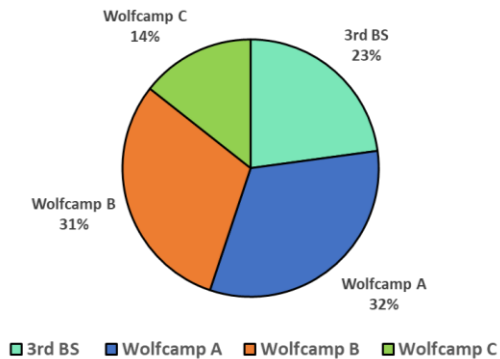
Wells Stacked Over Each Other

Wells Staggered 330 ft

Wells Staggered 660 ft

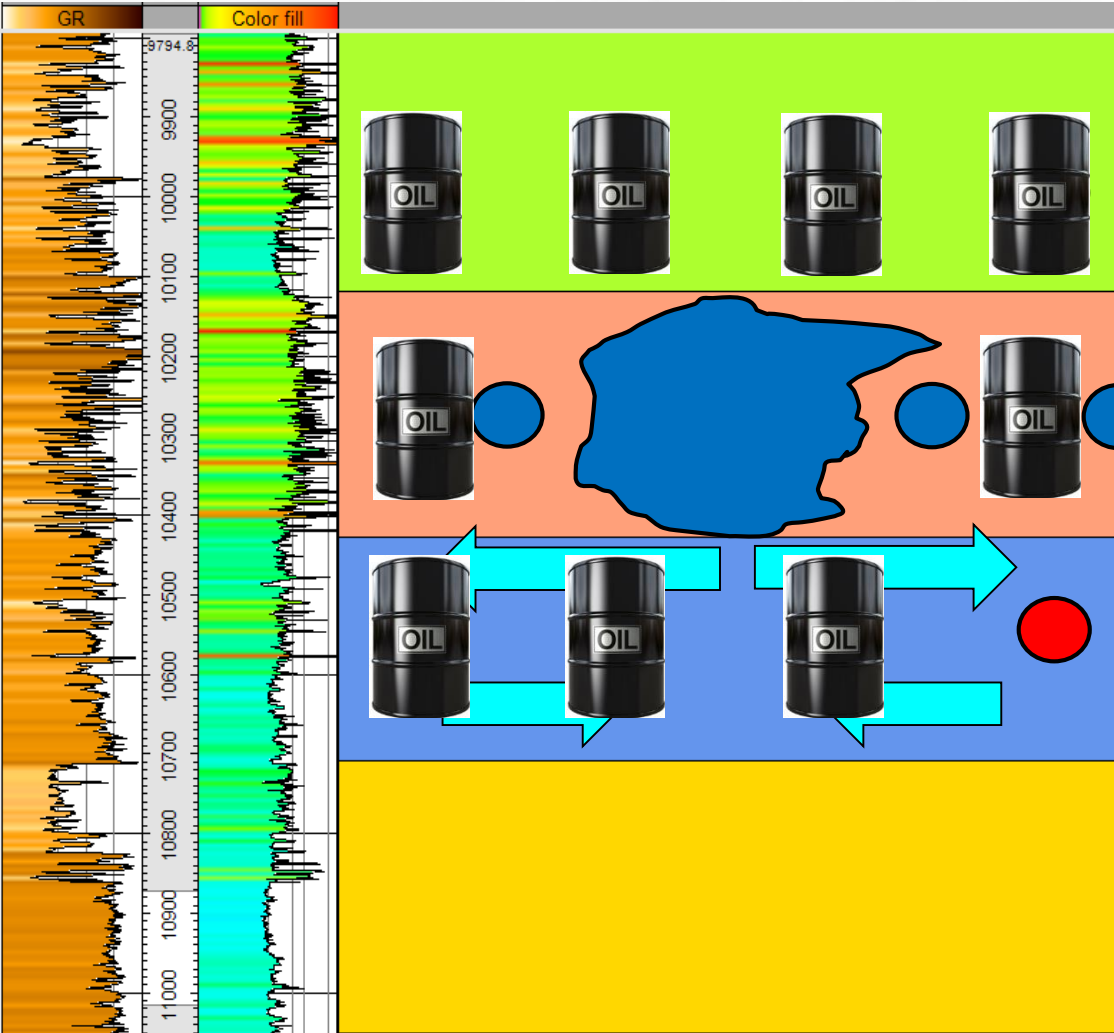


Cases Investigated



- All Wells Producing Individually
- Top-Bottom_3D
- Bottom-Top_3D
- 330_Top-Bottom_3D
- 330_Bottom-Top_3D
- 660_Top to Bottom_3D
- 660_Bottom to Top_3D

4D Planning/Scheduling/Sequencing



Conclusions

- Six potential landing targets were identified in four zones
- Wolfcamp C showed high water saturation
- Wolfcamp A exhibited the best potential
- Completing wells bottom to top produced more oil
- Optimum staggering spacing is between 330 ft and 660 ft
- Incorporating reservoir state in planning is key
- Economic analysis is needed for optimum winerack configuration

Stacked Pay Development in the Delaware Basin



Delaware Basin Workflow

