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URTeC 554

Maximizing Asset Value with Full Field Development

Case Studies in the Permian Basin

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UNIVERSITY LANDS

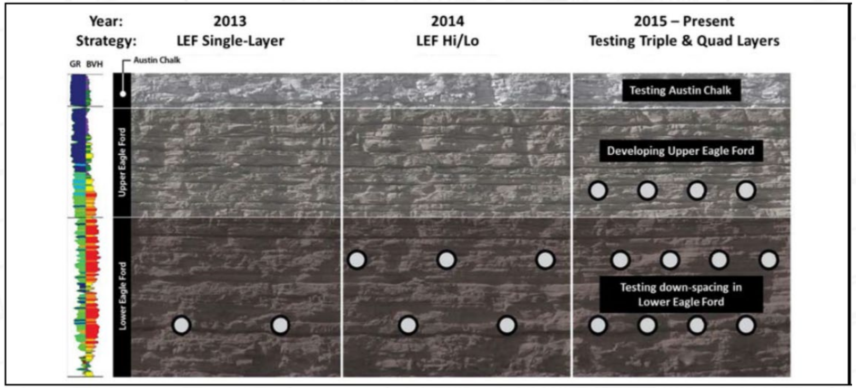
The integrated event for unconventional resource teams

Overview

- Introduction
- Drivers for Well Performance in Unconventional Reservoirs
- Comparing Different Field Developments (FDPs) – Case Study 1
- Workflow for Systematic FDP Optimization
- Case Study 2 – FDP Optimization Results
- Conclusions

Well Spacing Decision Progress and Difference

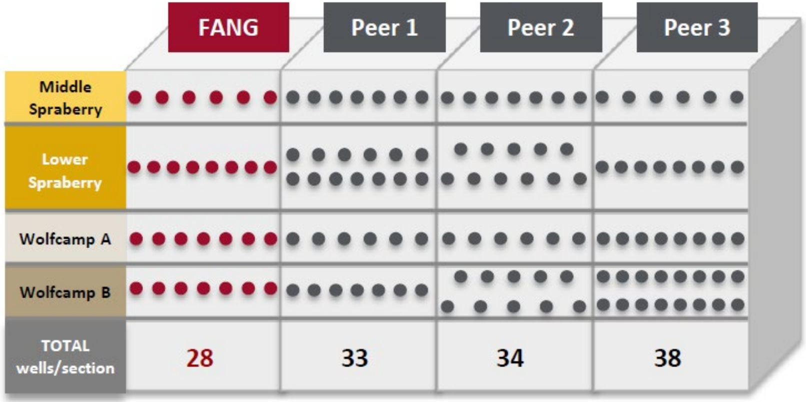
Eagle Ford



More wells with time

URTeC 2671245 (COP IR)

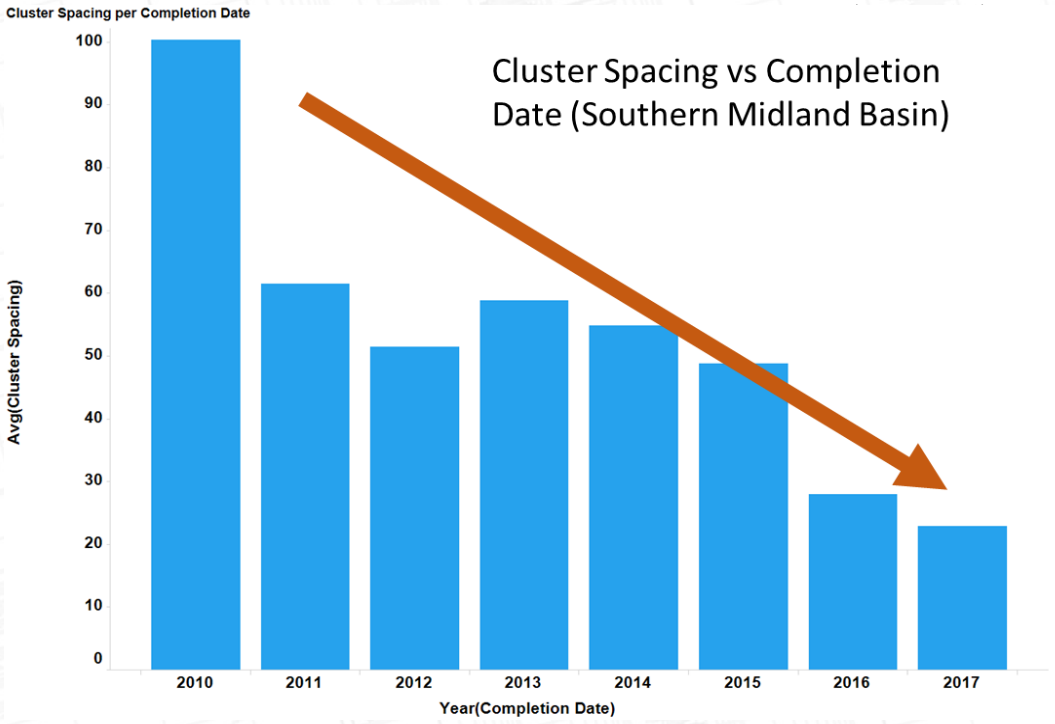
North Midland Basin



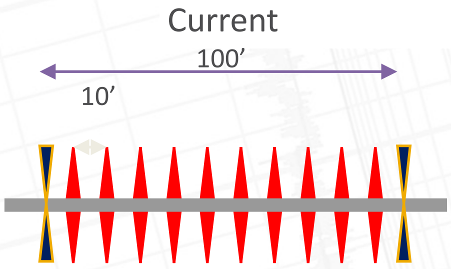
Different operators make different decisions

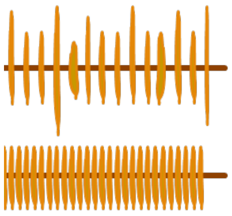
FANG 2019 Q1 IR

Testing Different Completion Designs



Permian Basin





It is **hard** to create **uniform long** fractures for all perforation clusters

it is a **better strategy** to target more effective fractures with shorter cluster spacing – HD Completion

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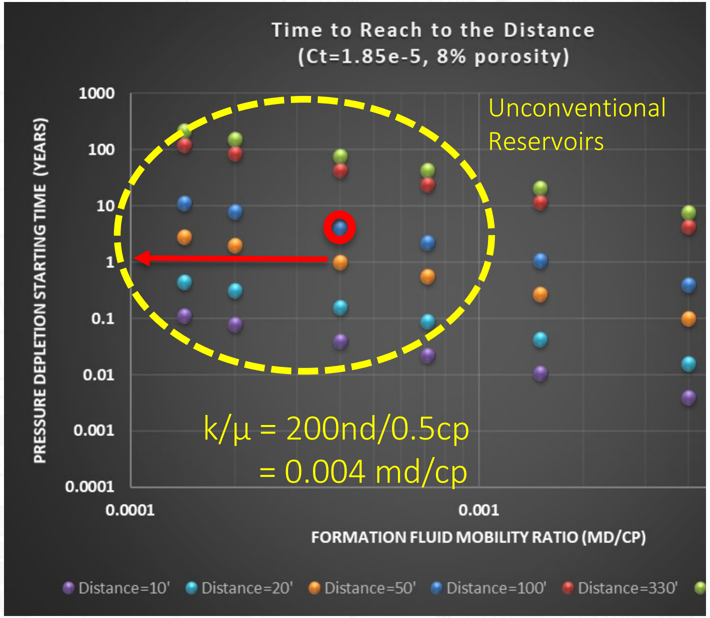
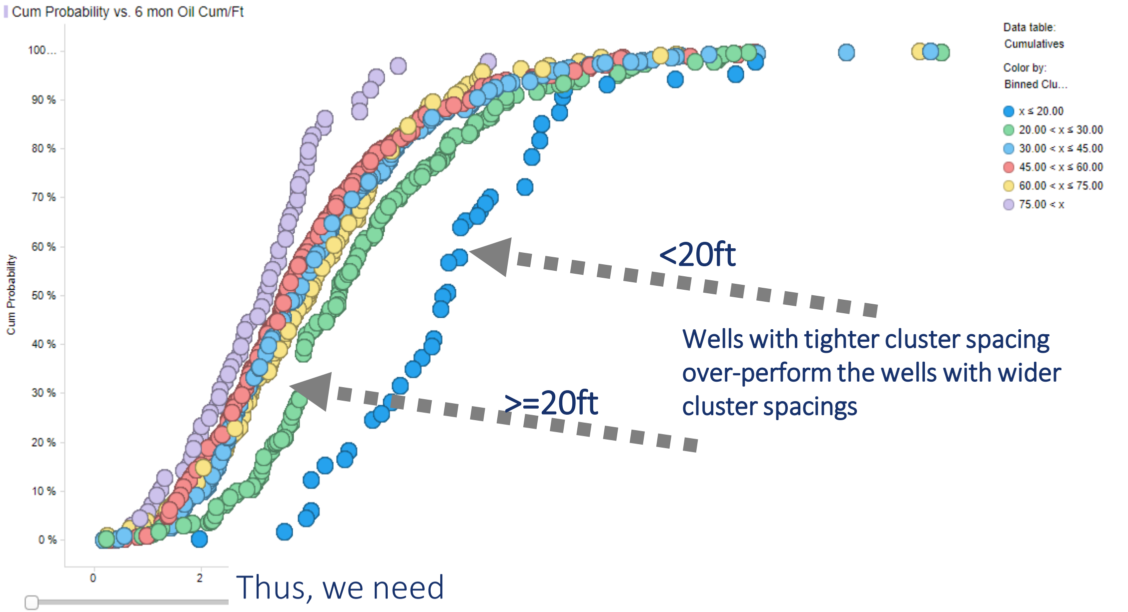
Pressure depletion propagation is very **slow** in the unconventional reservoirs!



Pressure depletion time depending on reservoir mobility ratio - k/μ

Field Data Set - Tighter Cluster Spacing Wells Over-Perform



Wells with tighter cluster spacing over-perform the wells with wider cluster spacings

Thus, we need
(1) **larger fracture surface area** for higher rate; and
(2) **tighter fracture spacing** for faster depletion

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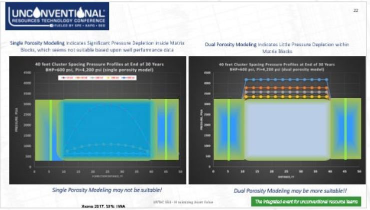
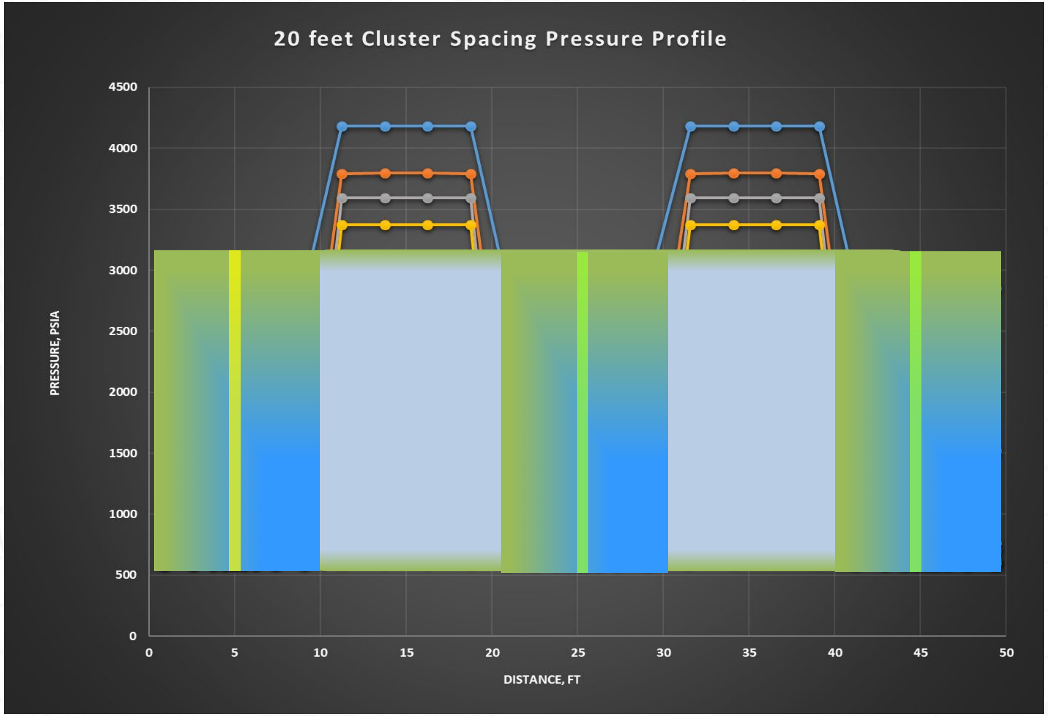
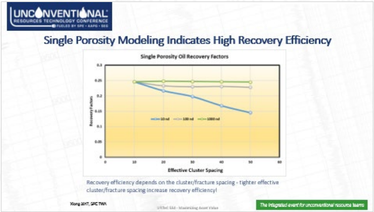
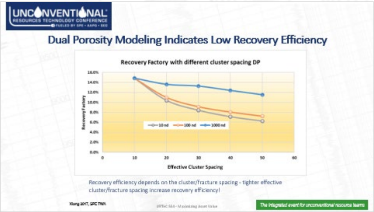
Ultra Tight Reservoirs Need Tight Cluster Spacing

Dual porosity modeling









Given cluster/fracture spacing of 20ft, there is more depletion area comparing to the 40ft cluster spacing. **EUR =** $\int f(Rqi, A, k)\Delta pdt$

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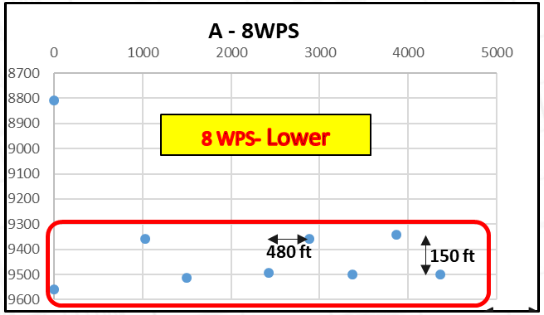
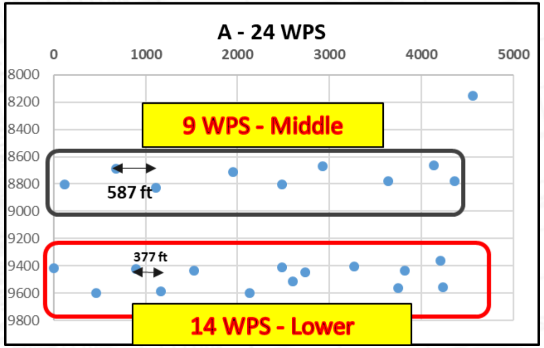
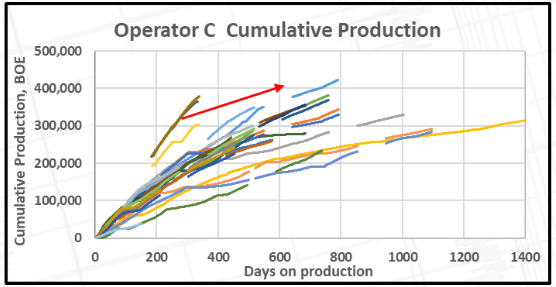
Case Study 1 - Northern Midland Basin

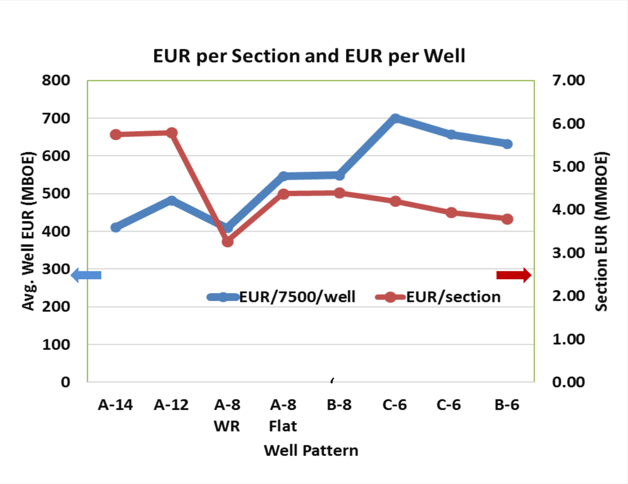


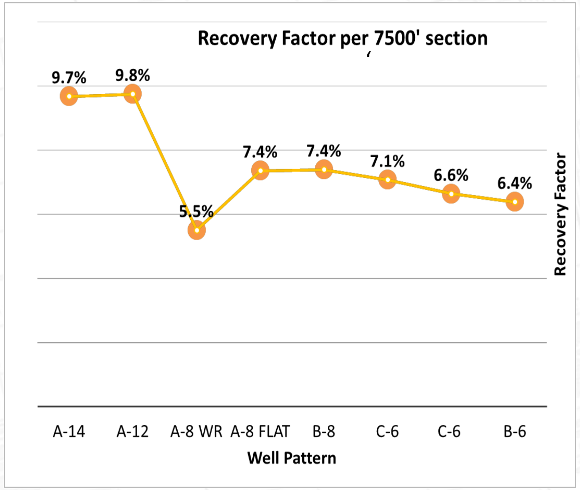


New Completion Design	Operator A	Operator B	Operator C (version 3.0 +)
Average Effective LL, ft	7,400	13,000	9,100
Fluid Type	Slickwater	Slickwater	Slickwater
Fluid Amount, bbl/ft	42	45	55
Proppant Type	100 Mesh 30/50	100 mesh 30/50	100 Mesh, 30/50, 40/70, 20/40
Proppant Amount, lb/ft	1,400	1,600	3,000
Cluster Spacing,ft	30	25	40
Cluster/Stage	5	8	6
Stage Length, ft	150	198	240
Pump Rate, bpm	65-70	95-100	100
Well Spacing, WPS	12-14	8	6



The Case Study 1 - EUR Estimation of Different Well Patterns





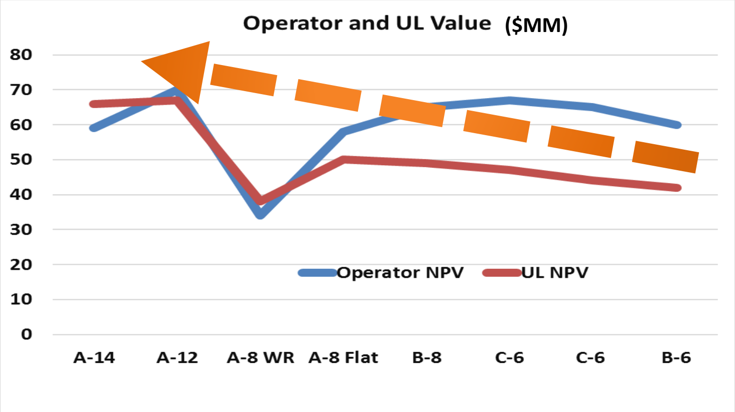
- EUR per 7500’ section is calculated by sum of all EUR/well in that section divided by total lateral length and then multiply by 7,500 and number of wells/section.
- EUR per well trend decreases as number of well per section increases.
- A-8 WR pattern yields abnormal results, probably due to sub-optimal completion effectiveness.

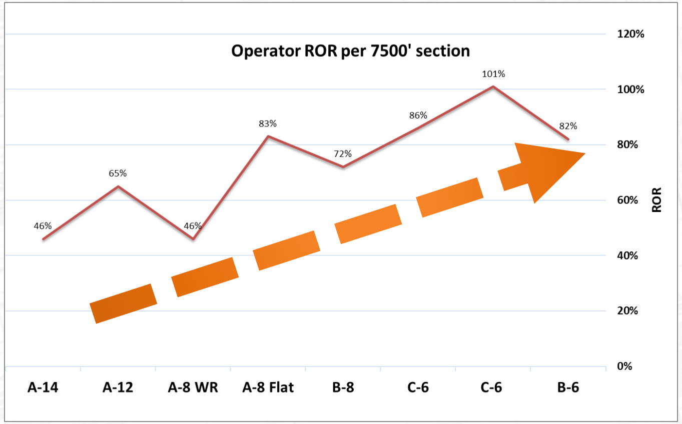
OOIP Estimation:

Sw = 50%, porosity = 5.5%, Bo =1.56 bbl/stb, net pay = 200 ft

→ OOIP = 25 MBO per 7500 section

The Case Study 1 – Economics Depends on Well Pattern and Completion





- More wells, as expected, bring in more resource recovery and more value to both the operator and UL. However, the Return of Return may show a different trend.
- Depending on the well spacing/placement and corresponding completion design, the value of developing the reservoir is different

Well Cost ($MM)	Operator A	Operator B	Operator C (Version 2)	Operator C (Version 3.0+)
Spraberry Intervals (D&C)	5.2 (per 7,500') 6.4 (per 10,000')	5-5.5 (for 7,500')	6.5 (per 9,700')	7.5 (per 9,500')
Wolfcamp B (D&C)	6.4 (per 7,500')		8.0 (per 9,500')	8.9 (per 10,000')
Facilities+ AL	0.8	0.8	0.5	0.5-1.0

➢ Source: Investor relation presentation

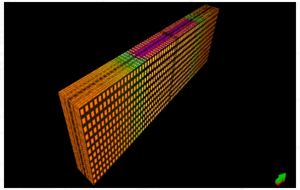
Net wellhead price (flat) assumptions:
- Oil price =$60/bbl
- Gas Price = $2.6/mmcf
- NGL price = $24/bbl

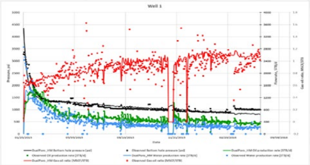
OPEX:
Gas LOE = $0.1/mmcf
Water LOE = $0.3/bbl
Oil LOE = $1.0/bbl

Resource:
NGL yield = 151 bbl/mmcf
Gas shrinkage factor = 40%
Cumulative GOR = 1 mcf/stb

Workflow for FDP Optimization

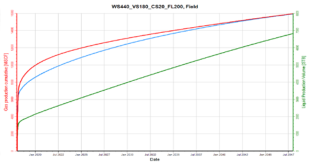
1. Built and calibrated the reservoir simulation model





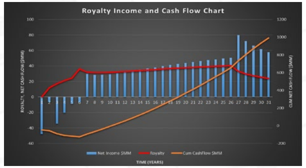
Build and calibrate model

2. Predicted well performance based upon well spacing and completion design for multiple cases



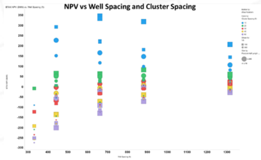
Prod Forecasting w/ different well spacing and completion designs

3. Evaluated economics



Economic analysis

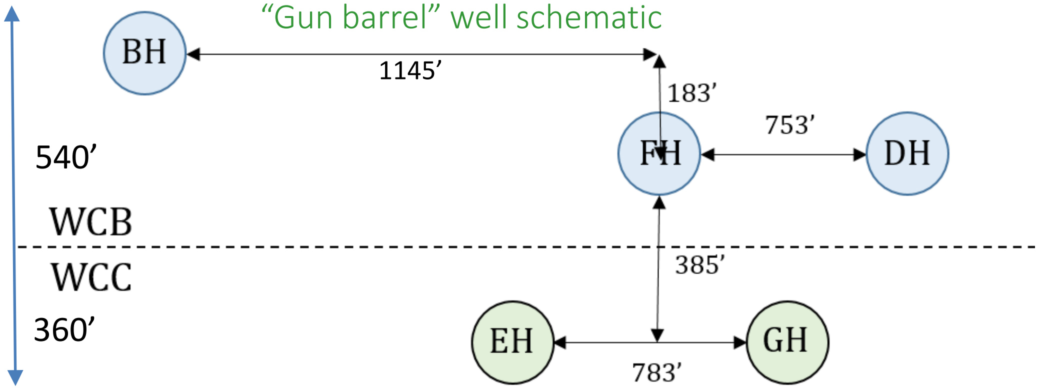
4. Identified the "optimal" field development scenarios with the optimal completion designs

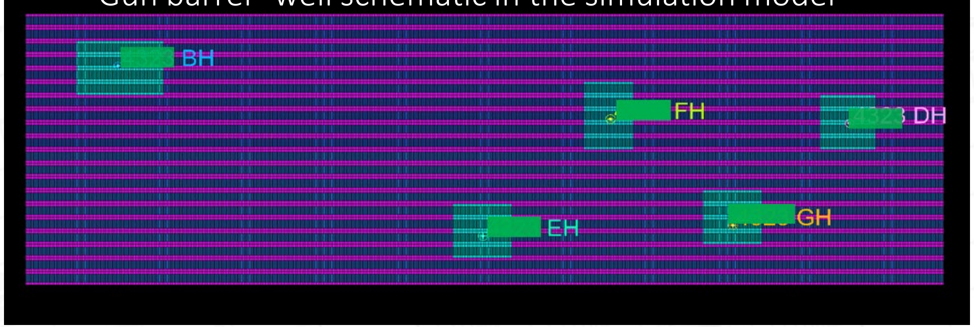


Identify optimal FDP

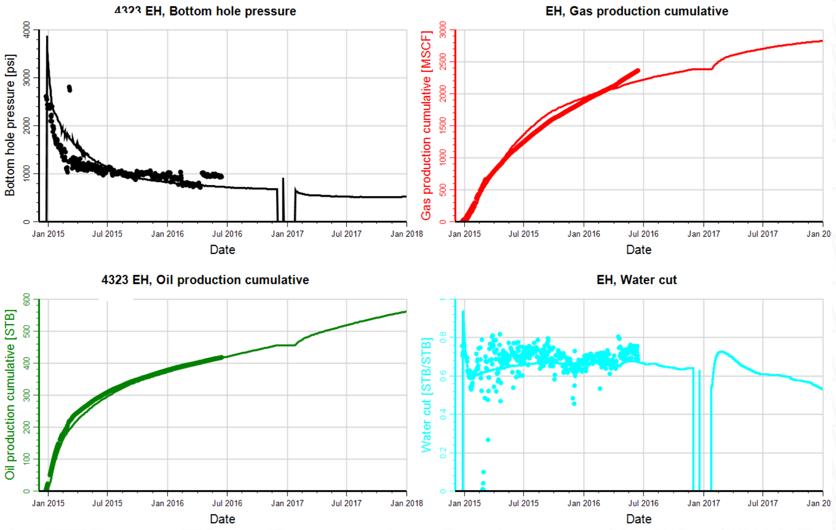
Case Study 2 – Model Calibration (Southern Midland Basin)

"Gun barrel" well schematic

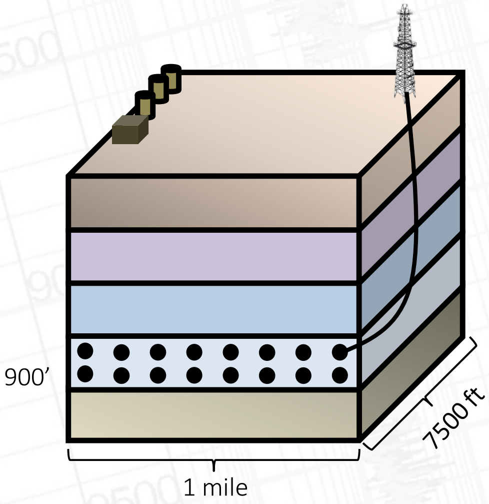




Model calibration with production data

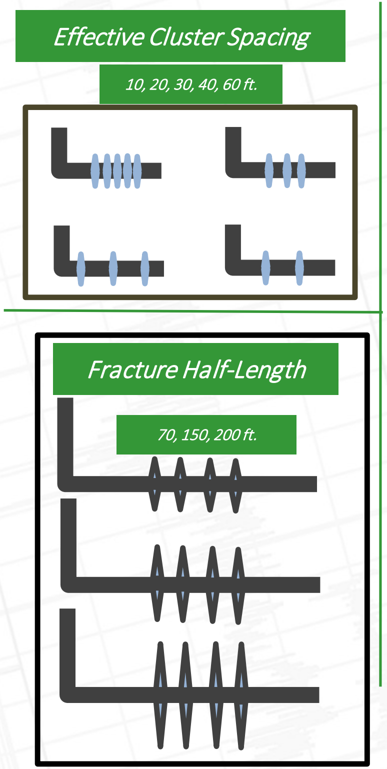


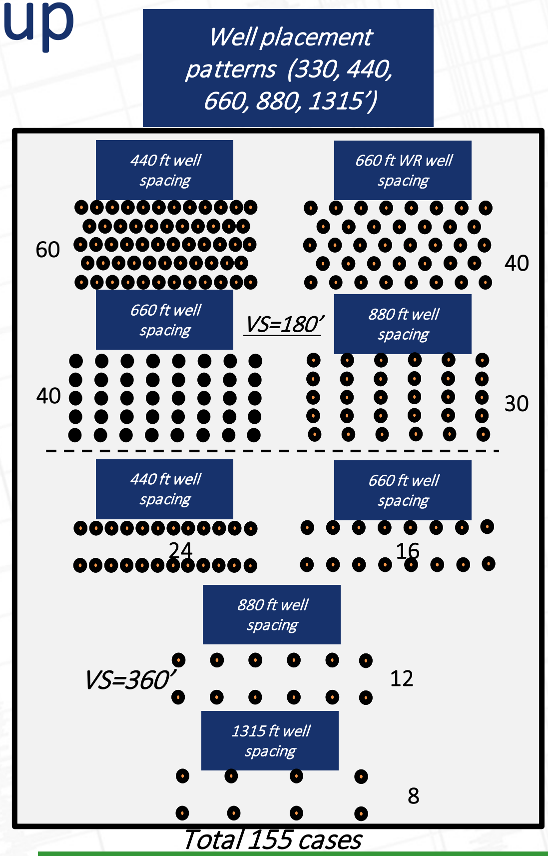
Case 2 FDP Scenario Setup



Fixed reservoir properties based upon history match, and general geological and petrophysical interpretations, including

- Matrix Perm is around 200-300nd
- Porosity ranges from 7 to 9%; Avg Sw=48%
- 40-41o API Black oil model with Initial GOR of 700-800 scf/stb





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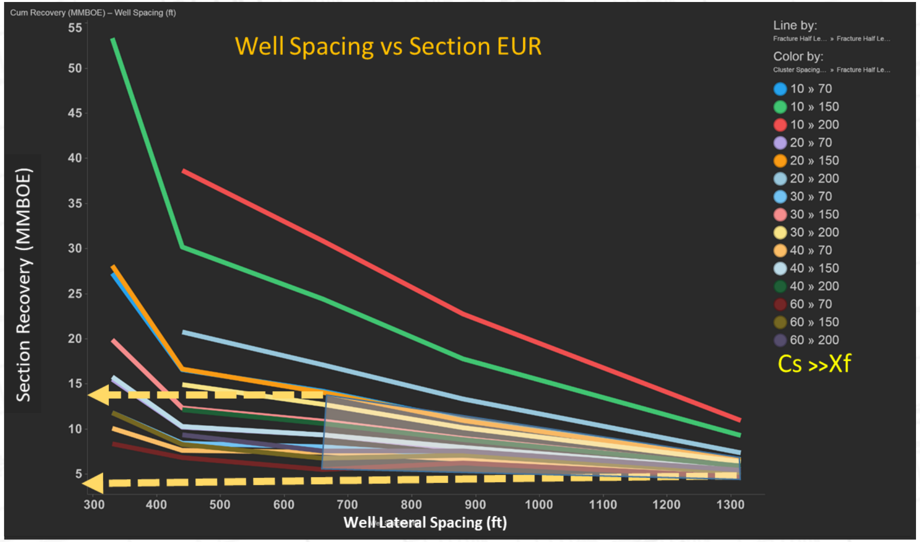
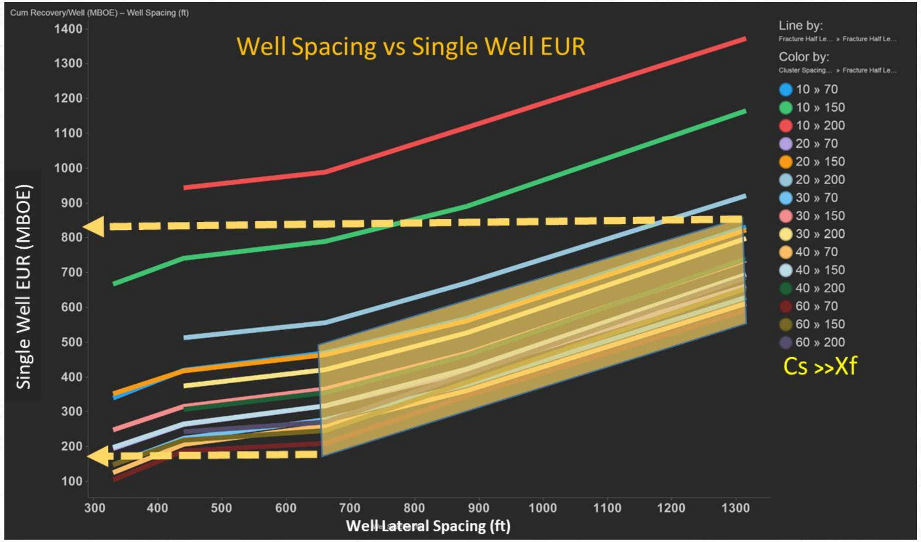
Well EUR vs Section EUR

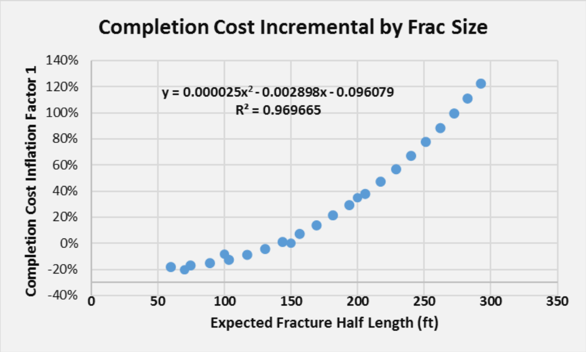


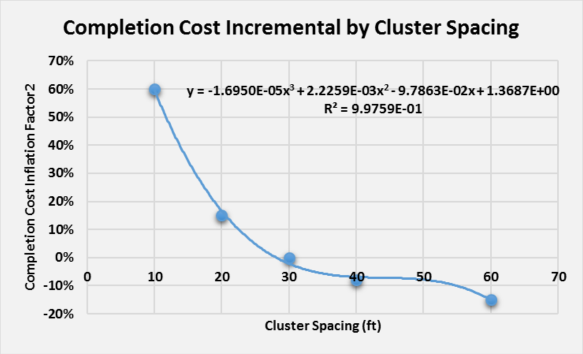
Signal Well EUR depends on the drainage area and completion effectiveness!



Signal Well EUR depends on the drainage area and completion effectiveness!

Cost for HD (Well Cost, Price, and OPEX Assumptions)





Wellhead Price (Flat)		
Oil	60	$/STB
Gas	2.75	$/MSCF
NGL	20	$/STB

- 25% Royalty Rate
- 10% discount rate for operator
- 6% discount rate for landowner
- 30 year economics
- Wells start at the same time

Scenario Note	Exp Frac Half Length Xf (ft)	Cluster Spacing Cs (ft)	Xf Incr Factor	Cs Incr Factor	D&C Cost adjusted	Compl Cost ($MM)	D&C Cost ($MM)	Total Well Cost ($MM)
1 - HD Compl	70	10	-19%	60%	41%	5.0	7.0	7.5
2 - Less HD Compl	100	20	-15%	17%	1%	3.6	5.5	6.0
3 - Best Compl	150	10	2%	60%	62%	5.8	7.7	8.2
4 - Med Better Compl	150	20	2%	17%	19%	4.2	6.2	6.7
5 - Base Case (Mediocre)	*150*	*30*	*2%*	*-2%*	*0%*	*3.6*	*5.5*	*6.0*
6 - Most Intensive Compl	200	10	34%	60%	93%	6.9	8.8	9.3
7 - Large Compl	200	40	34%	-7%	27%	4.5	6.5	7.0
8 - Super Long	200	60	34%	-15%	19%	4.2	6.2	6.7

OPEX		
Water	0.5	$/BW
Oil	1	$/BO
Gas	0.1	$/MSCF
Fixed Well OPEX	60	$M/Well/Yr

Base case D&C well cost - $5.5MM (as in Scenario 5): 2/3 for completion, 1/3 for drilling; plus 0.55 for wellhead facility

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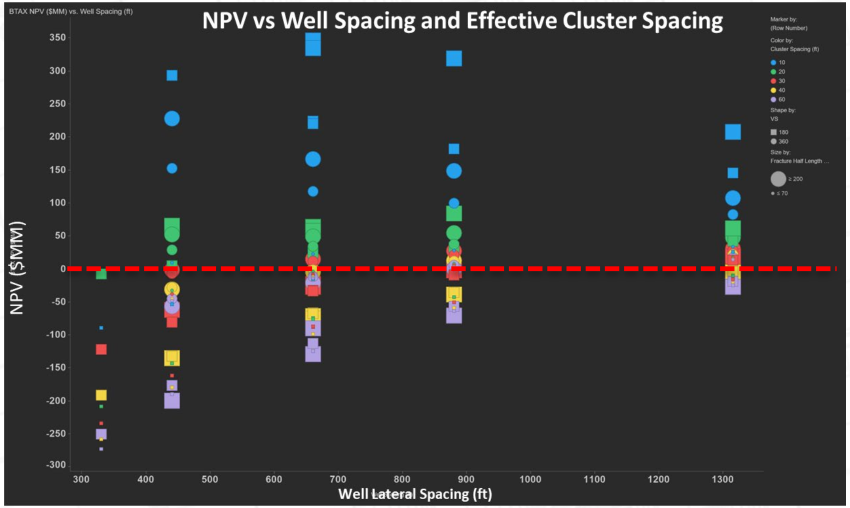
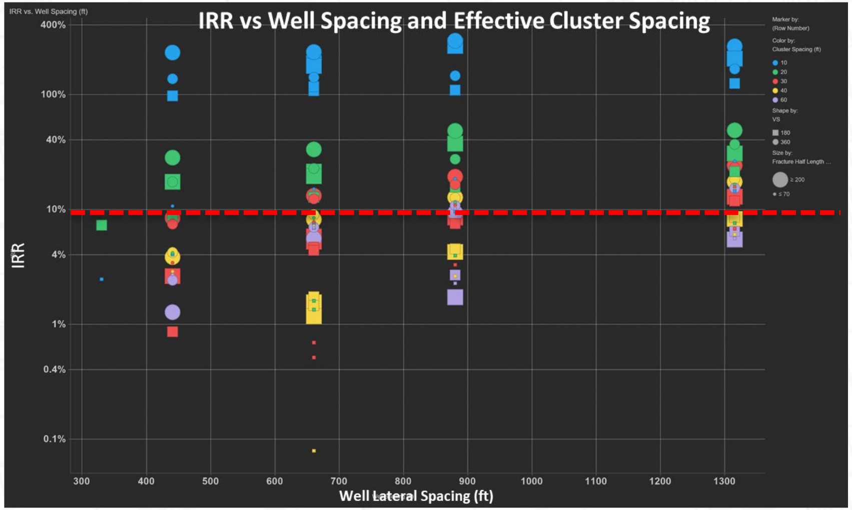
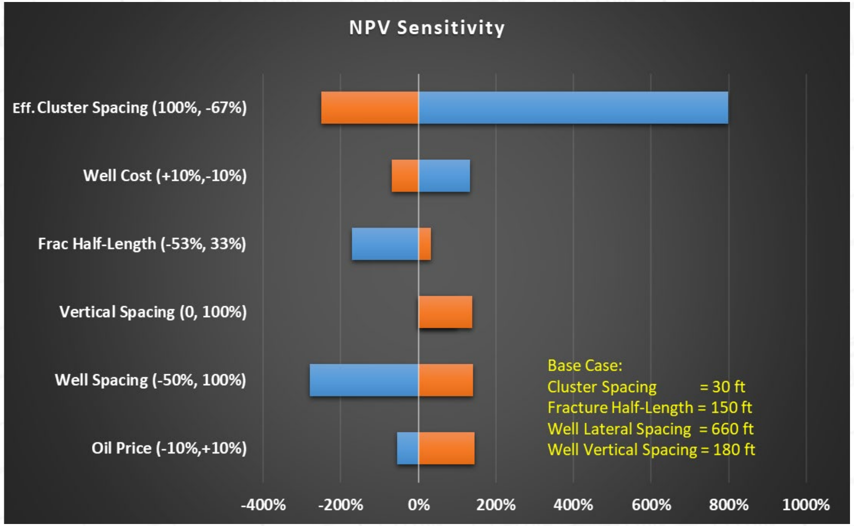
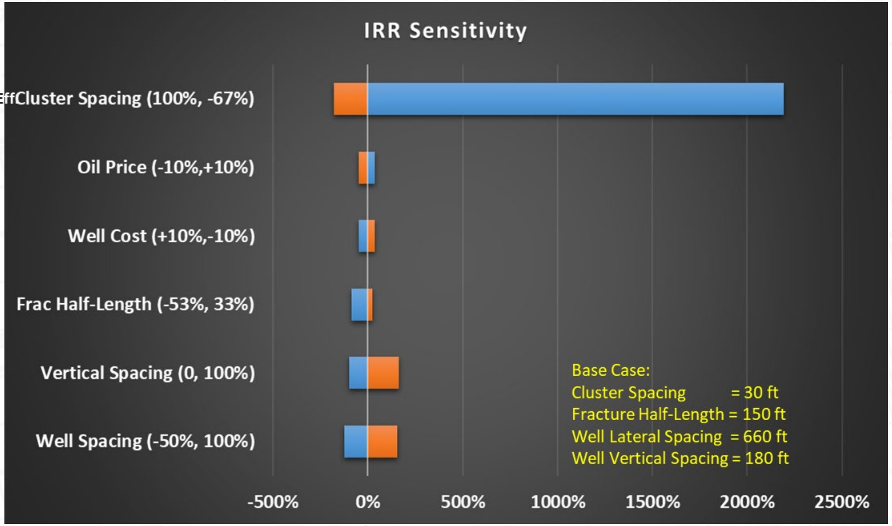
Field Development Plan Optimization Results





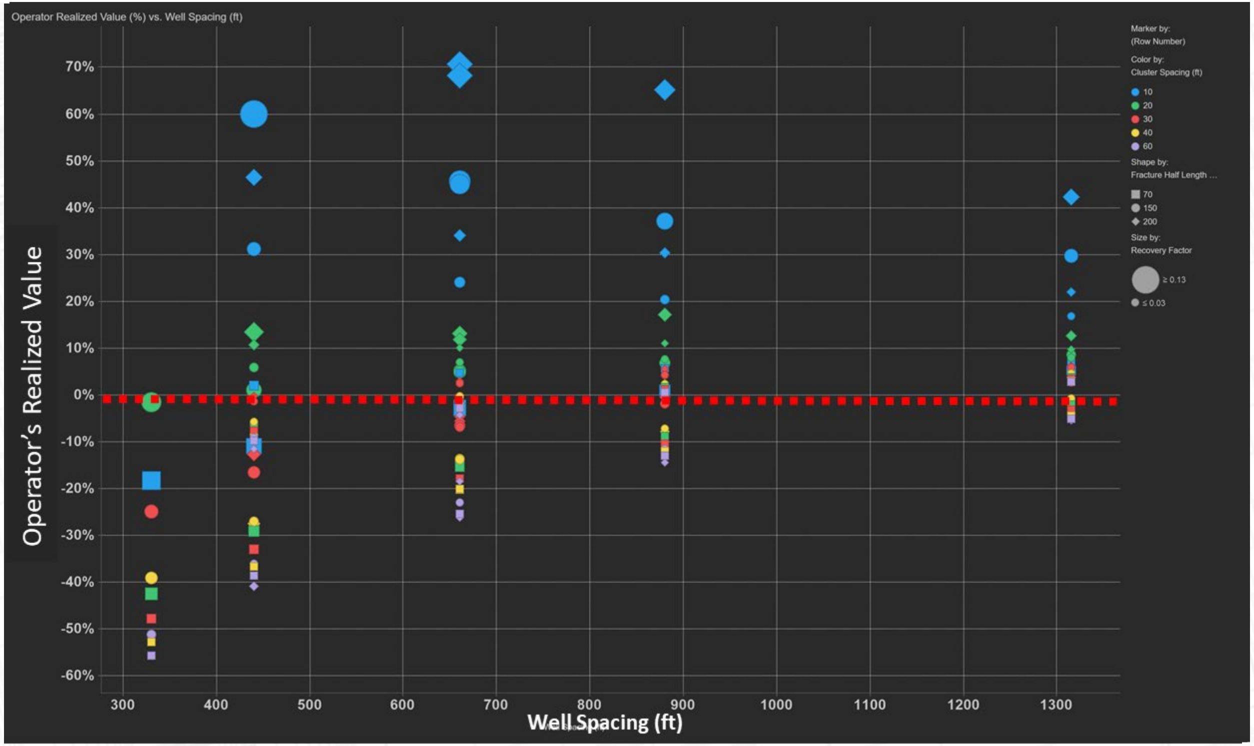
Simple Sensitivity Analysis





Identify Potential Value Zone

$$Operator\ Realized\ Value = \frac{NPV}{Max(NPVs\ of\ all\ Cases)}$$



Conclusions

- We can realize the maximum potential values by high density (HD) development of targeting very tight cluster spacing and tighter well spacing.
  - Larger fracture surface area for higher production rate
  - Tighter fracture spacing speeds up depletion
  - Tighter fracture spacing may reduce the investment risk brought by the tighter well spacing
- The drilling and completion cost structure and operation efficiency are very critical to realize potential value. The key economical motivator, such as Rate of Return Vs Net Present Value, will drive very different full field development decisions.
- With the max NPV, for the given reservoir in the case study, the optimal lateral well spacing could range from 440 ft to 880 ft depending on the cost and oil price, and the operator’s operation efficiency. The 660’ well spacing is recommended. The tighter effective cluster spacing 20 ft or less will significantly enhance the value, which is highly recommended as the completion design for the reservoir.

More Slides

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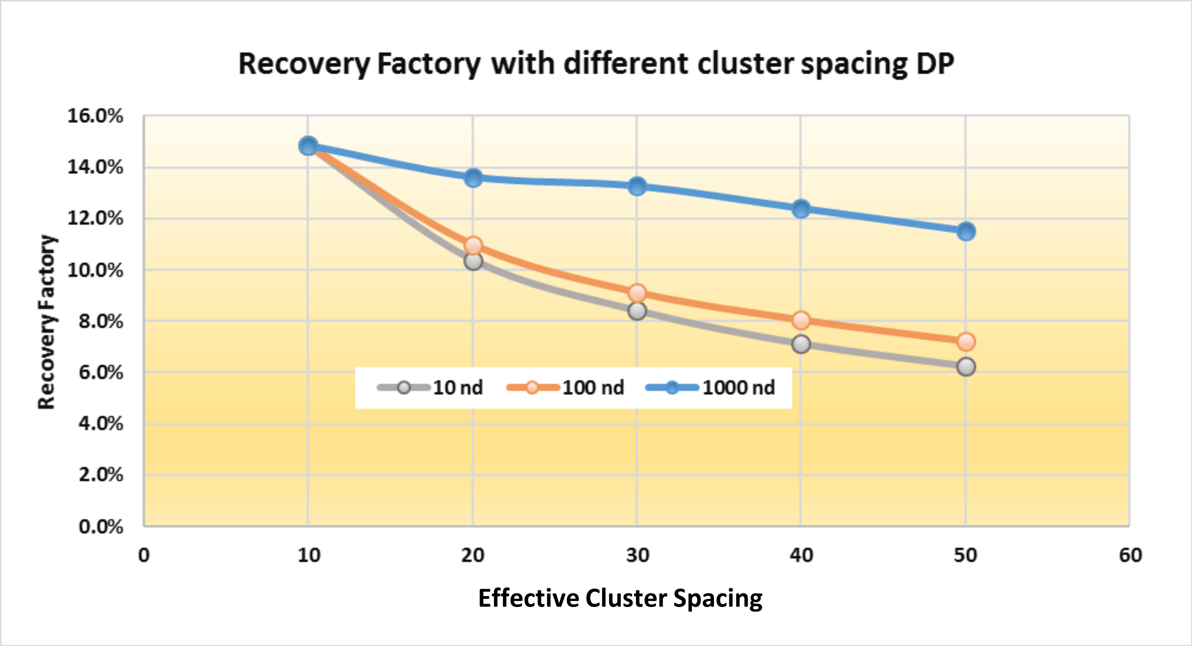
Dual Porosity Modeling Indicates Low Recovery Efficiency



Recovery efficiency depends on the cluster/fracture spacing - tighter effective cluster/fracture spacing increase recovery efficiency!

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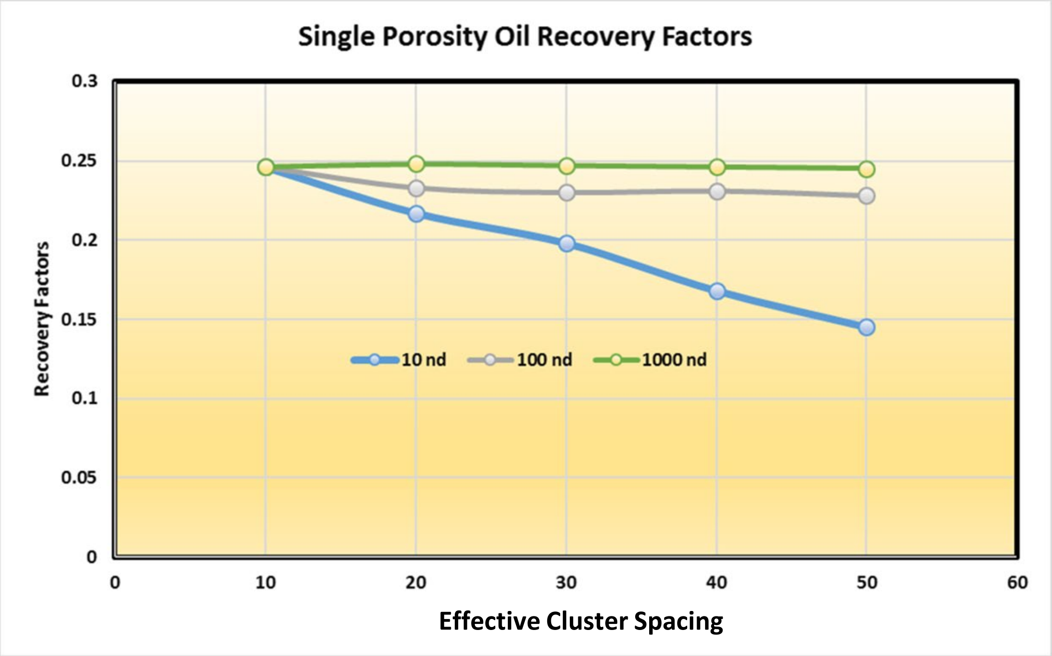
Single Porosity Modeling Indicates High Recovery Efficiency



Recovery efficiency depends on the cluster/fracture spacing - tighter effective cluster/fracture spacing increase recovery efficiency!

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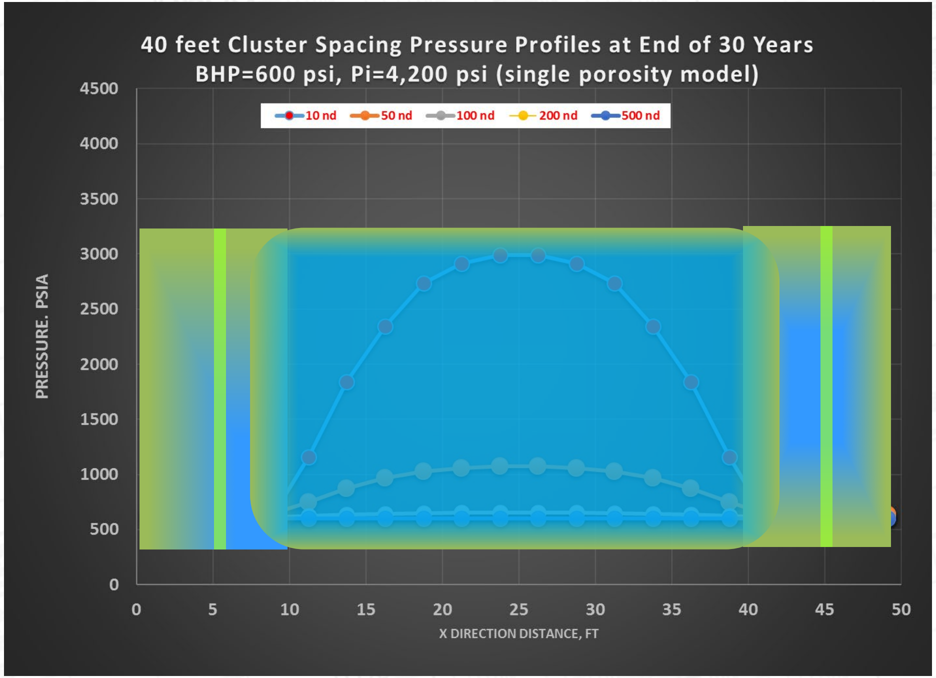
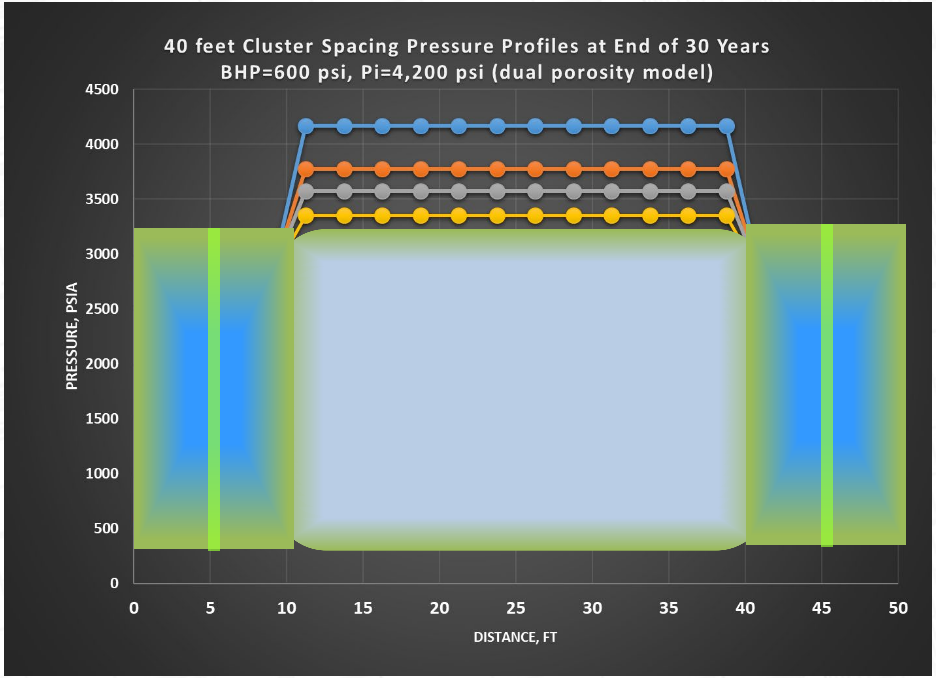
Single Porosity Modeling Indicates Significant Pressure Depletion inside Matrix Blocks, which seems not suitable based upon well performance data



Single Porosity Modeling may not be suitable!

Dual Porosity Modeling Indicates Little Pressure Depletion within Matrix Blocks



Dual Porosity Modeling may be more suitable!!

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Identify Potential Value Zone

$$Operator\ Realized\ Value = \frac{NPV}{Max(NPVs\ of\ all\ Cases)}$$