Infill Well Potential In Tight Gas Reservoirs

Shu Luo, Baurzhan Kassenov

And Mohan Kelkar

The University of Tulsa

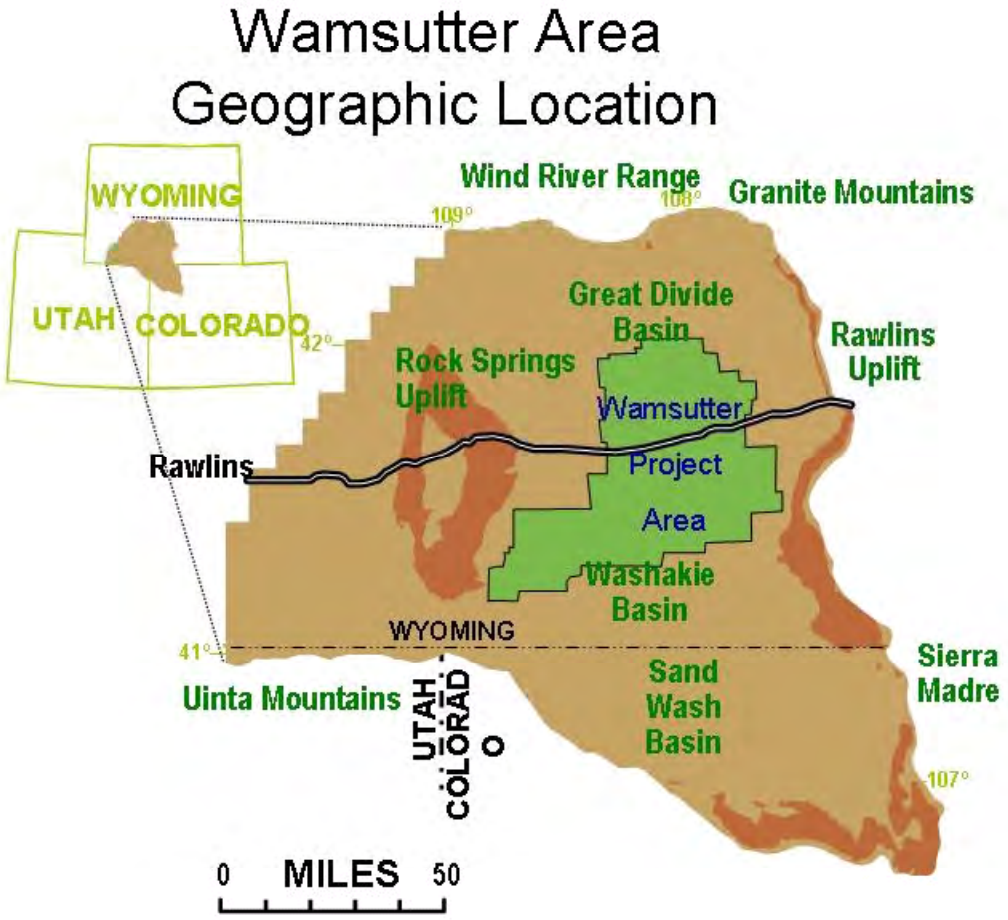
Outline

- Background
- Introduction
- Objectives
- Approaches
- Examples of the Procedure
- Results and Recommendation
- Conclusions

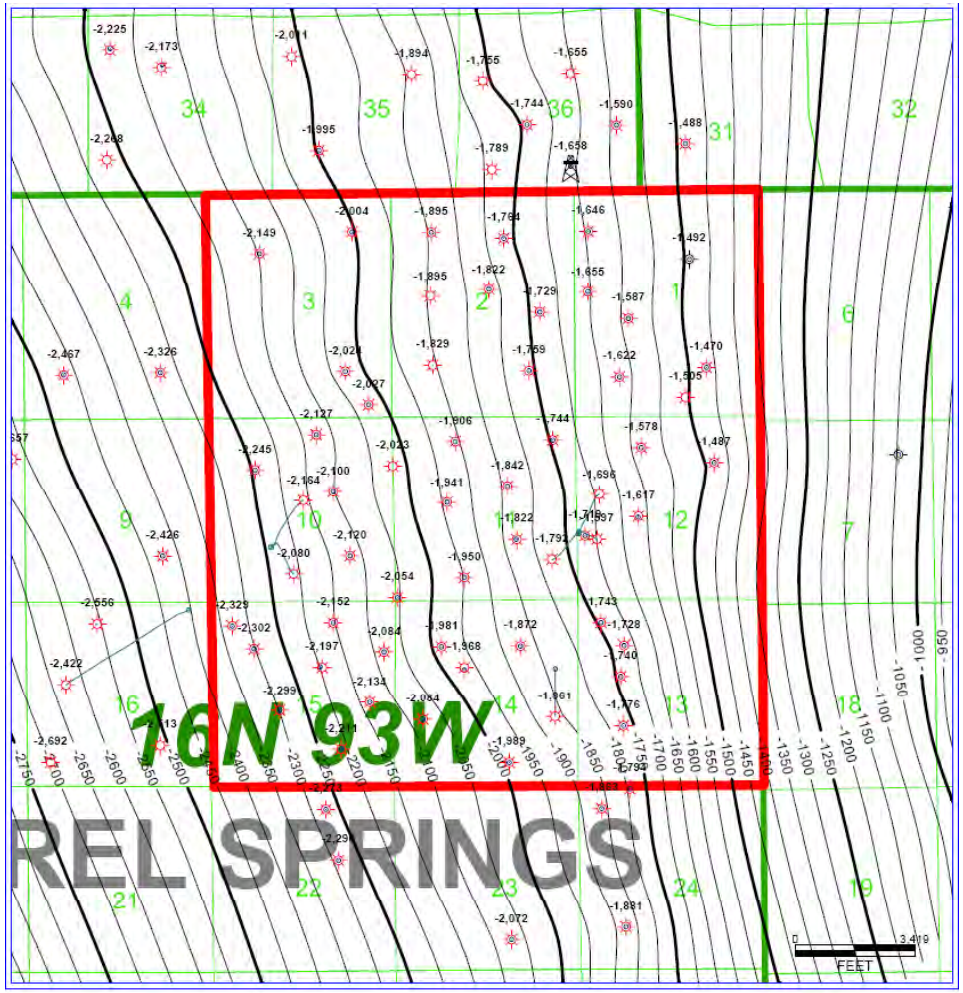
Background

- For unconventional reservoirs, one of the key understandings needed is the in fill well potential for wells drilled at closer spacing
- Understanding the difference between “acceleration” and “incremental” production can help operator make better economic decisions

Wamsutter Field



Study Area



Field Data

Field Data	Number of Wells
Study Area	81
Almond Producers	80
Vertical Wells	75
Directional Wells	6
Directional Survey	4
Reservoir Flag Log	77
Pay Flag Log	78
Porosity Log	77
Permeability Log	77
Water Saturation Log	77
Well Tops	75
Wellhead Pressure	47
Production Data	75

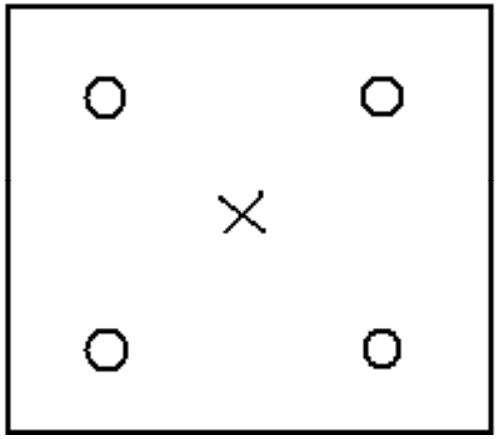
Introduction

- Determine EUR of in fill well in tight gas reservoirs
- Predict incremental and acceleration components for in fill well using analytical method
- Predict performance of the wells through traditional history matching and prediction methods

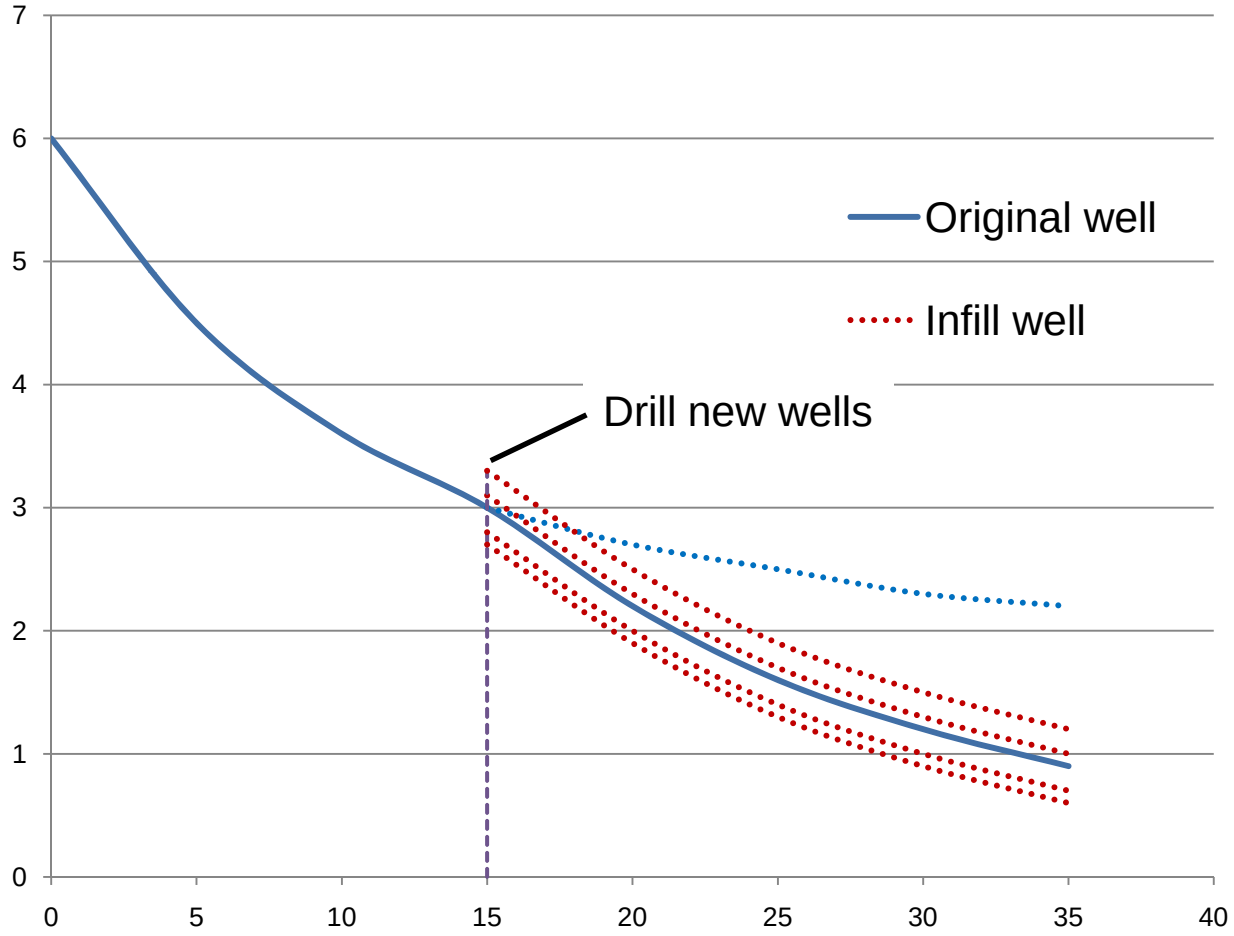
Introduction

- Homogeneous and heterogeneous reservoirs will exhibit different behavior when in fill wells are drilled:
  - Initial production rates will indicate access to new reserves
  - Difference in decline rates from the surrounding wells will indicate communication

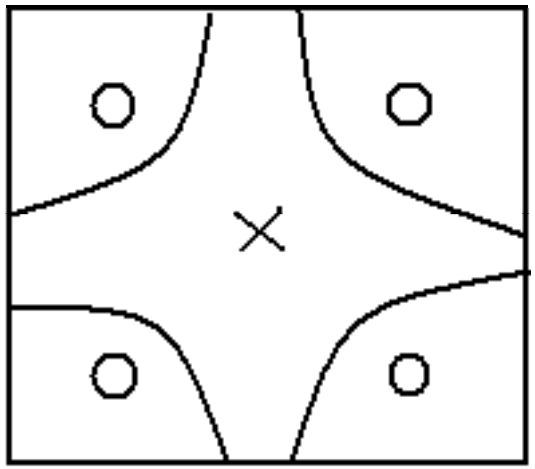
Homogeneous Reservoir



×: Original well
○: Infill wells



Heterogeneous Reservoir



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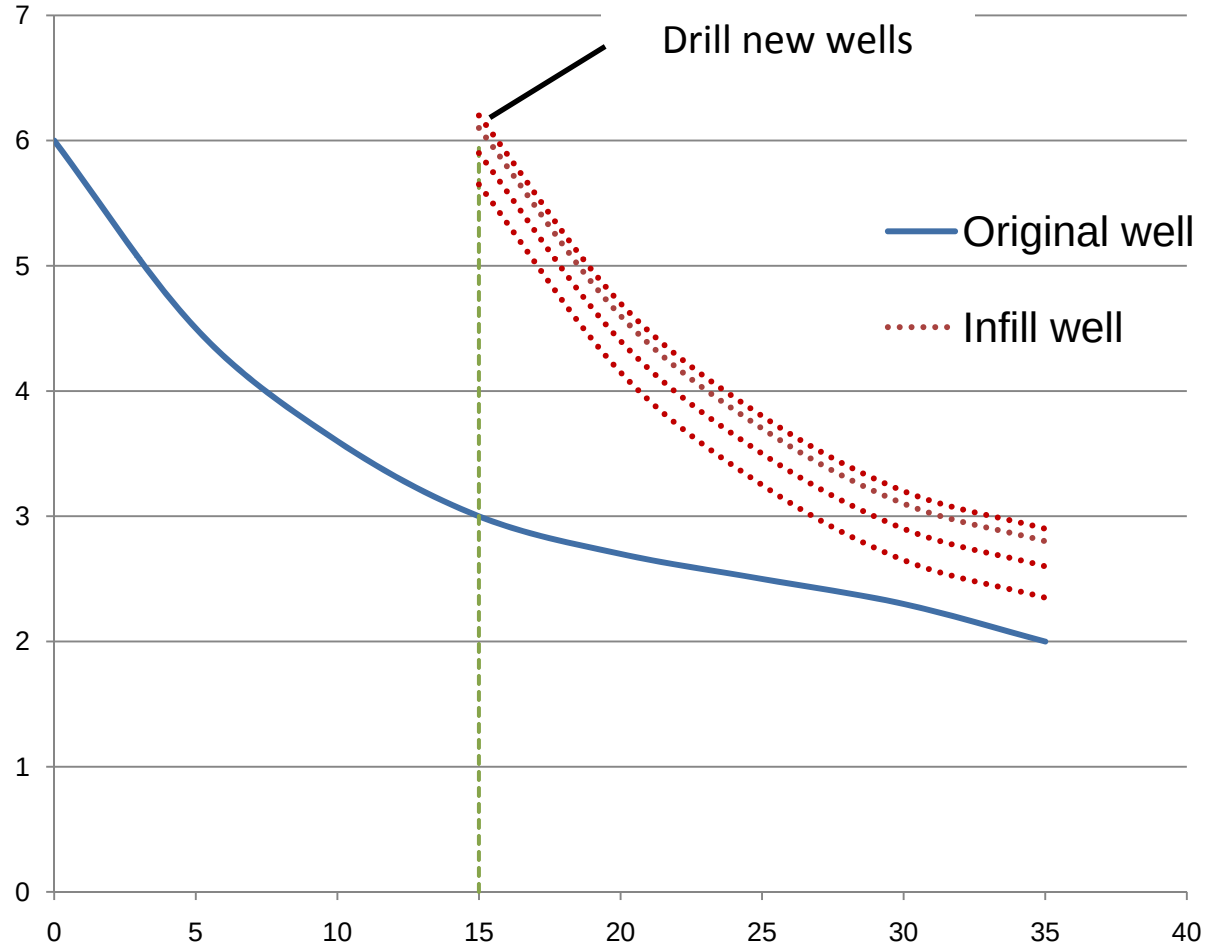


Objectives

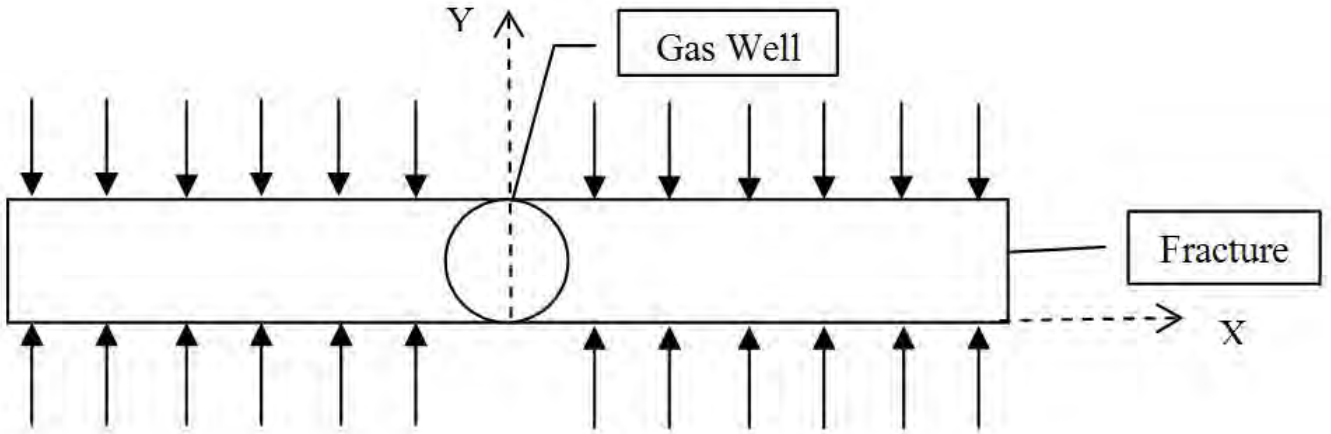
- Develop a methodology to predict the gas which is “stolen” by new wells.
- Using the existing production data, determine the in fill well EUR
- Determine the contribution of acceleration and incremental potential.

Analytical Method

Approach

- Determine an appropriate time function such that cumulative production is linearly related.
- Divide the data into chronological groups so that average behavior can be predicted.
- Plot cum production vs. time function and examine inflection in the graph as successive groups of wells are drilled.
- Compare EUR calculated from this method with the EUR reported by companies.

Linear Flow



$$q_{sc,l} = \frac{m(p_i) - m(p_{wf})}{64.345} \frac{h}{T} x_f \sqrt{k_f b_f (k\varphi(\mu c_t)_i)^{0.5} t^{-0.5}}$$

$$Gp_{l,pseudo} = K_3 t^{0.5}$$

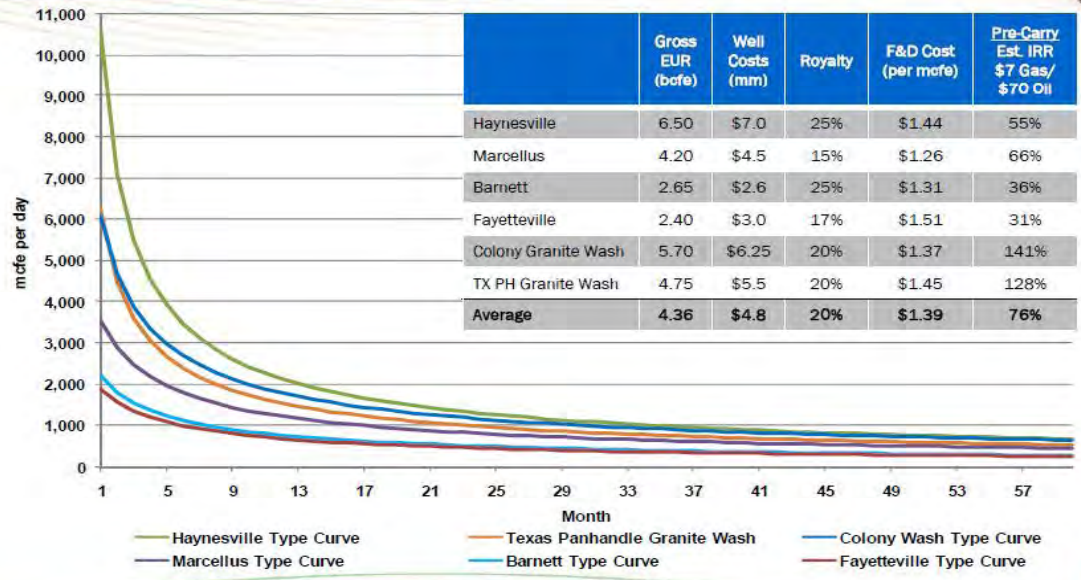
Where: $$K_3 = \frac{h x_f \sqrt{k_f b_f} (k\varphi(\mu c_t)_i)^{0.5} (m(P_i) - m(p_{wf,last}))}{64.345T}$$

Chesapeake Energy

January 2010 Investor Presentation

CHK Play Comparison

	Gross EUR (bcfe)	Well Costs (mm)	Royalty	F&D Cost (per mcfe)	Pre-Carry Est. IRR $7 Gas/ $70 Oil
Haynesville	6.50	$7.0	25%	$1.44	55%
Marcellus	4.20	$4.5	15%	$1.26	66%
Barnett	2.65	$2.6	25%	$1.31	36%
Fayetteville	2.40	$3.0	17%	$1.51	31%
Colony Granite Wash	5.70	$6.25	20%	$1.37	141%
TX PH Granite Wash	4.75	$5.5	20%	$1.45	128%
Average	**4.36**	**$4.8**	**20%**	**$1.39**	**76%**

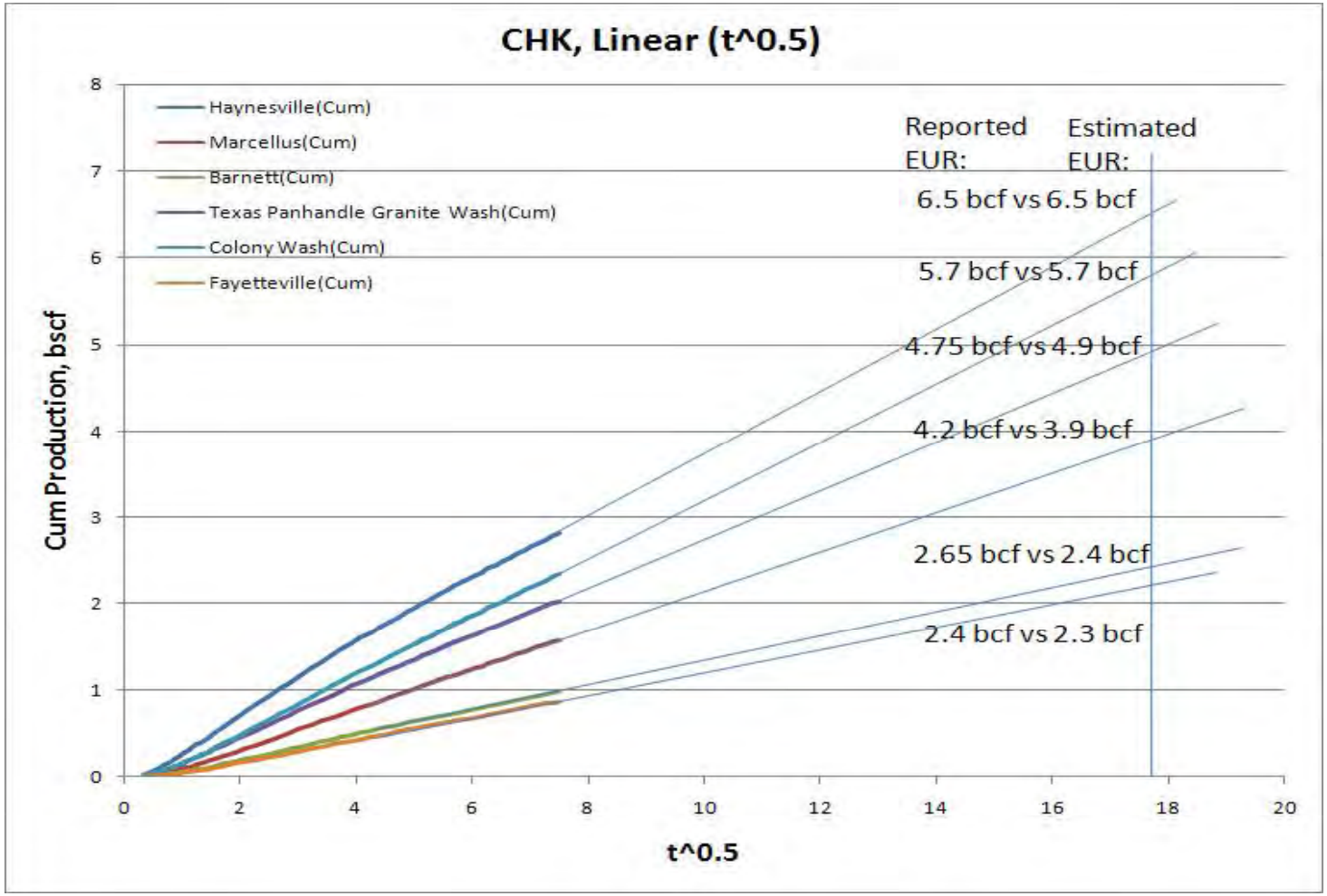


Chesapeake ENERGY

• Risk disclosure regarding unproved reserve estimates appears on page 33

9

Type Curve Extrapolation Chesapeake Energy



Approach

- Determine a function of time such that cumulative production is directly related.
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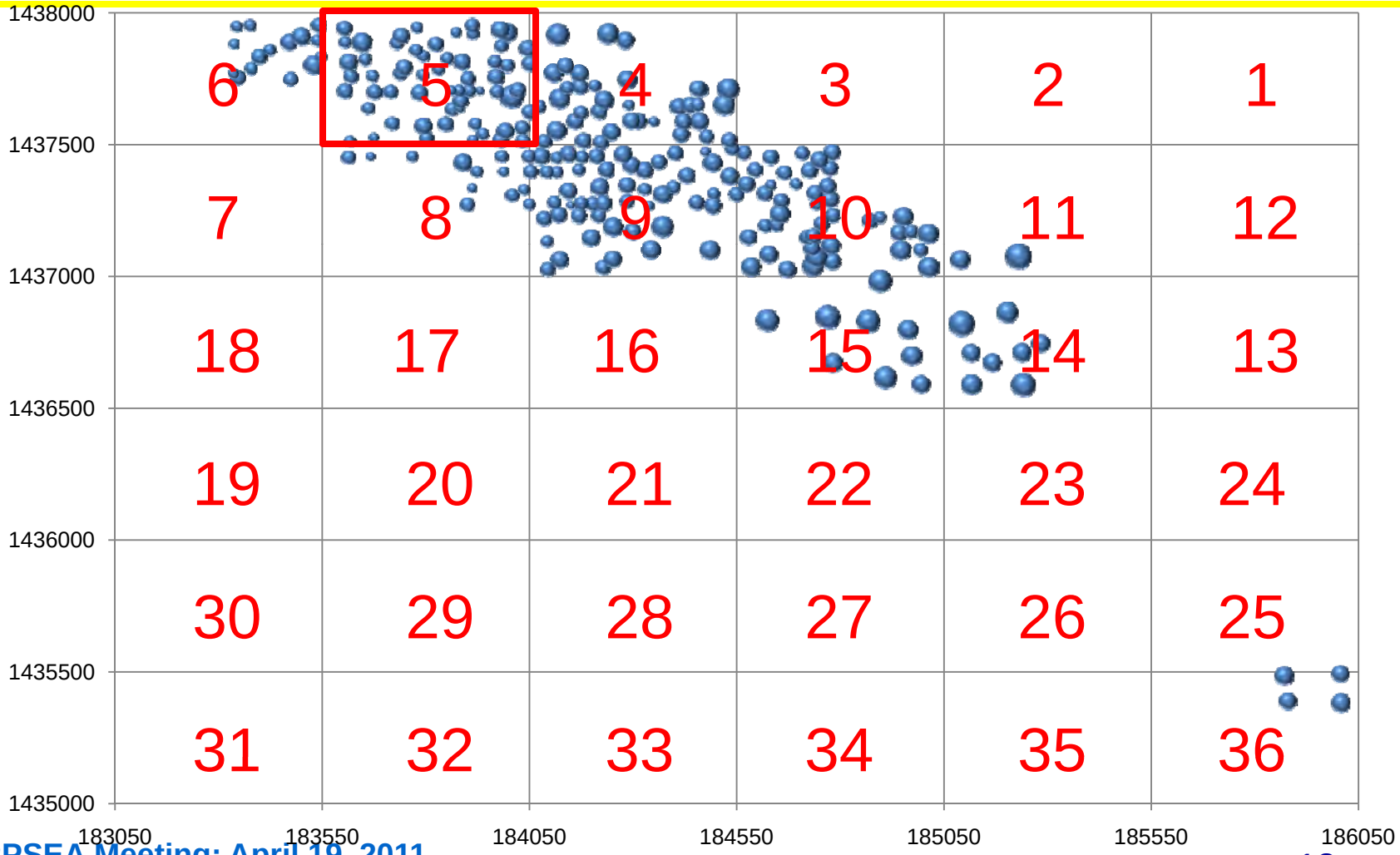
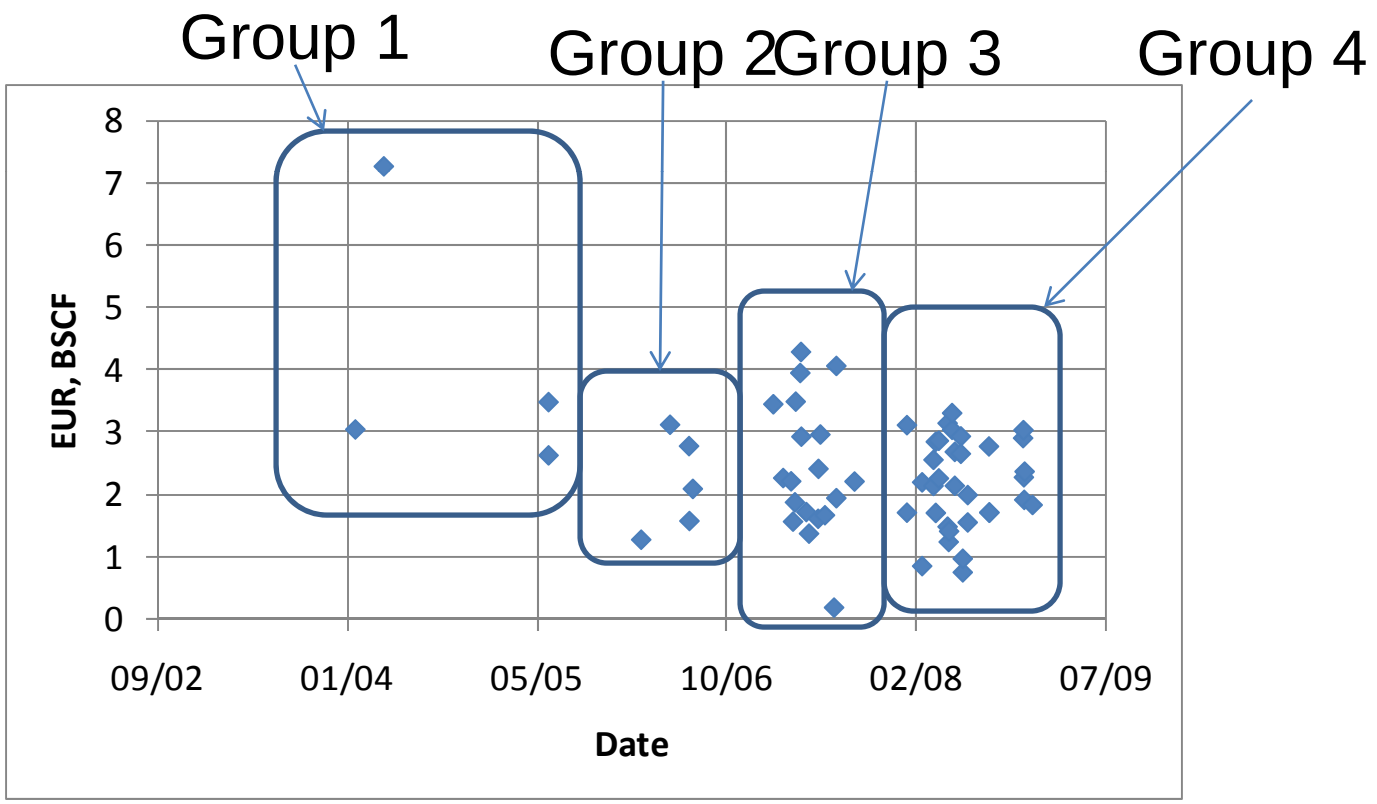
Pinedale Field



Well Grouping



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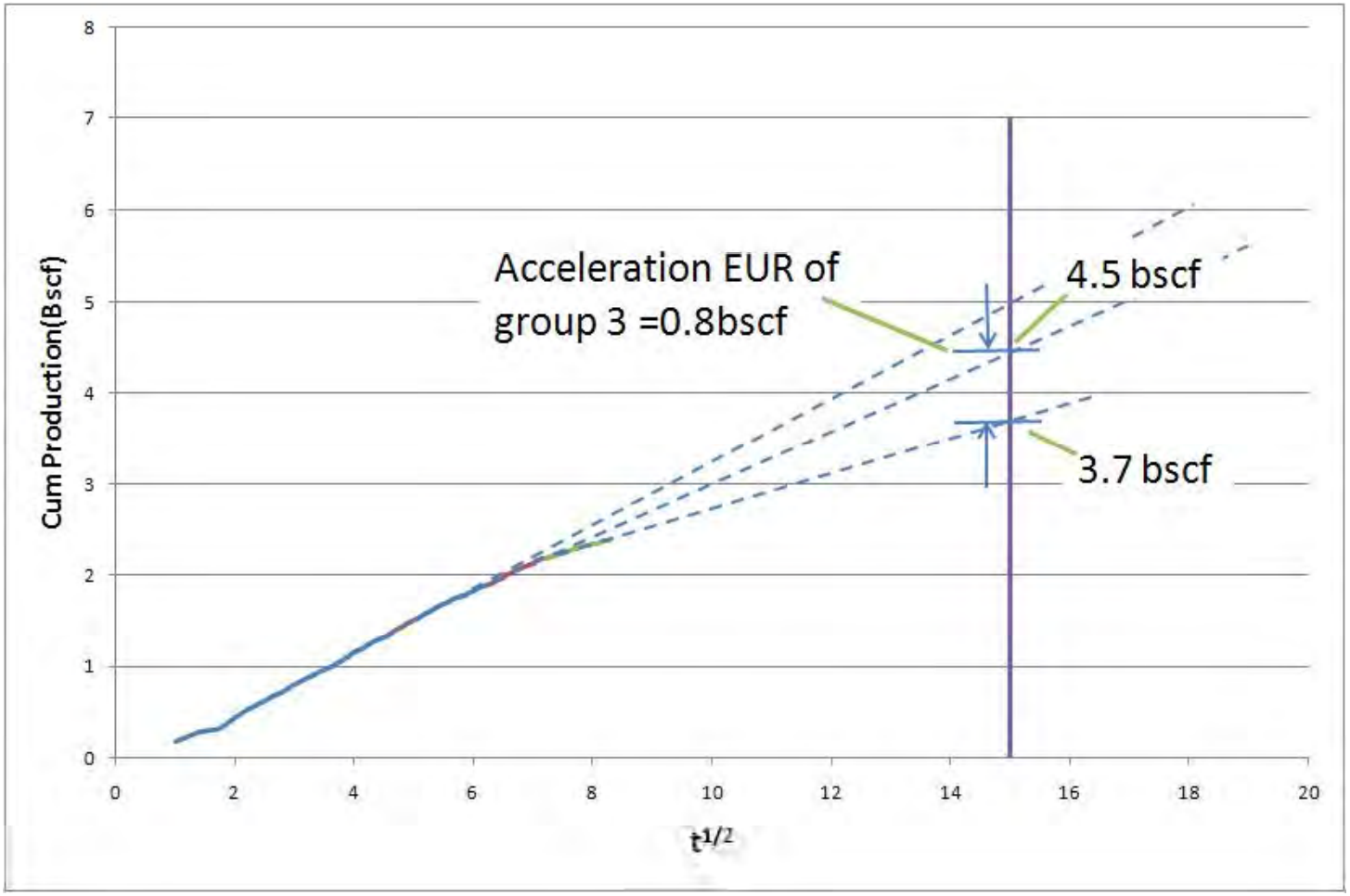
Example in Pinedale Field



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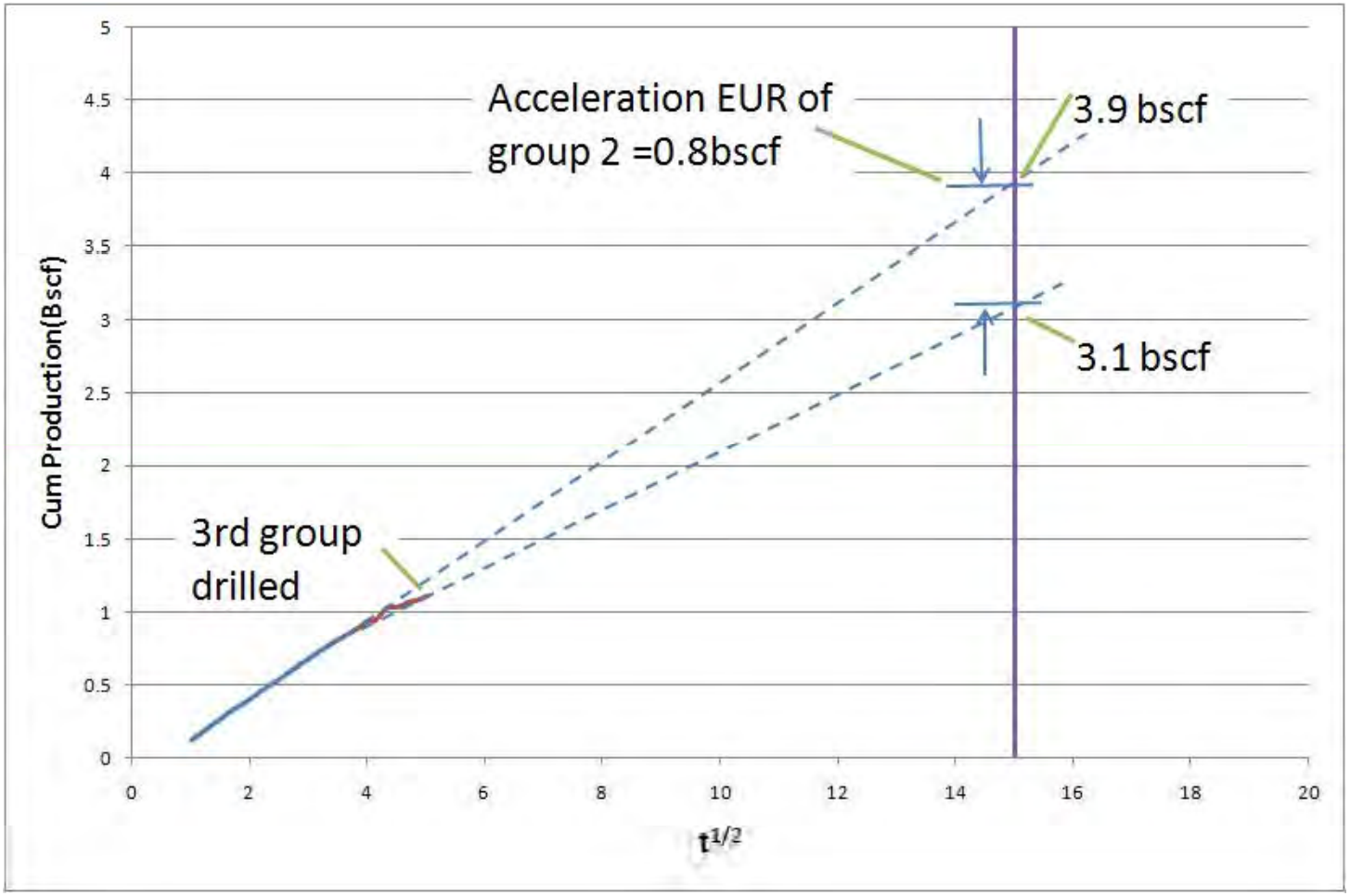

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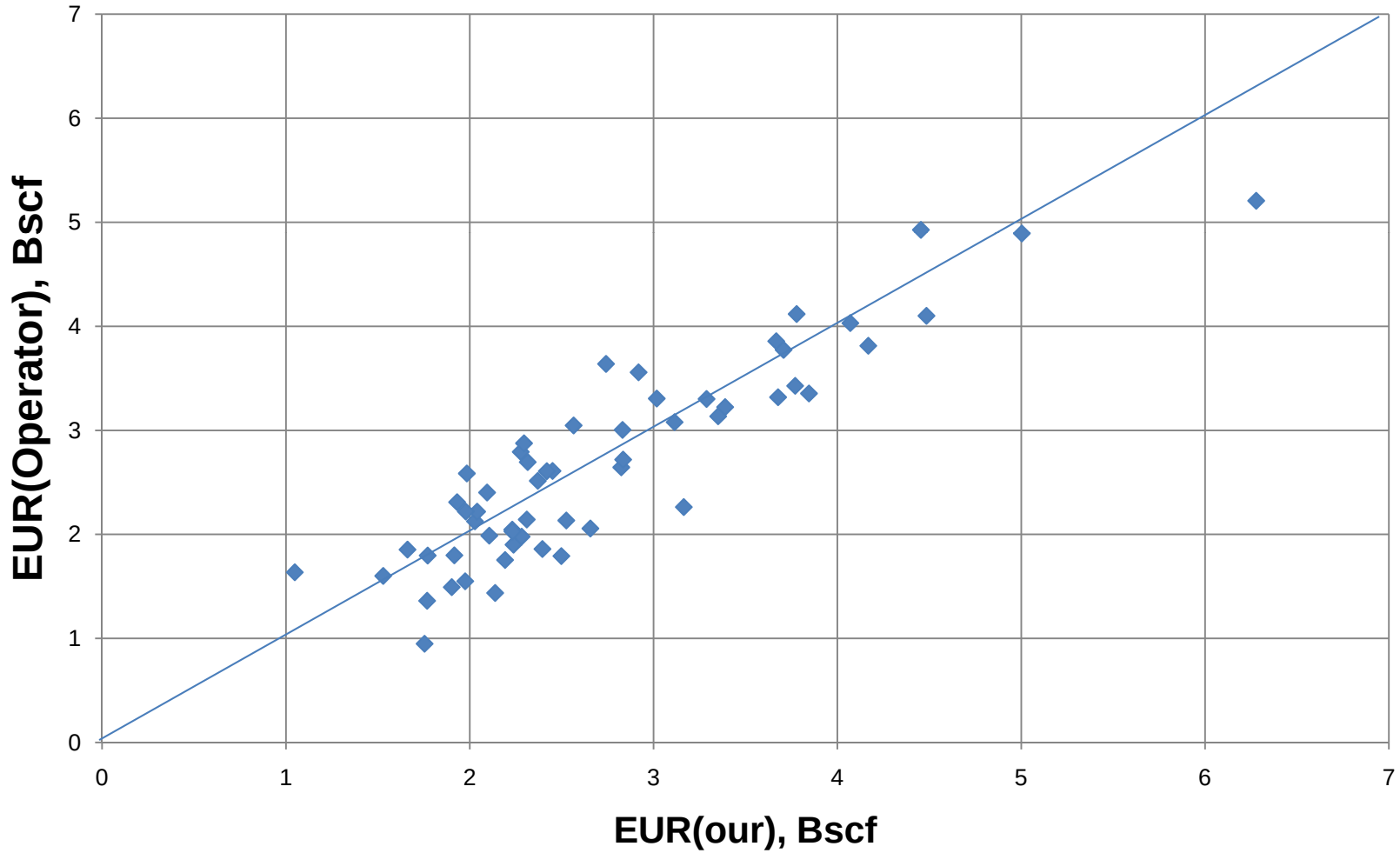
EUR Comparison
Pinedale Field



Approach

- For every “child” well, calculate average Incremental and Acceleration components.
- Plot Acceleration percentage, Incremental percentage and total EUR as a function of spacing.
- Recommend potential sections where in fill well potential is the greatest.

Calculation

- Acceleration vs. Incremental
  - Total EUR for 2nd group per well = 3.57 BCF
  - Acceleration EUR for 2nd group per well
    = Decreased EUR = 0.24 BCF
  - Incremental EUR for 2nd group per well
    = Total EUR - Acceleration EUR
    = 3.57 - 0.24 = 3.33 BCF

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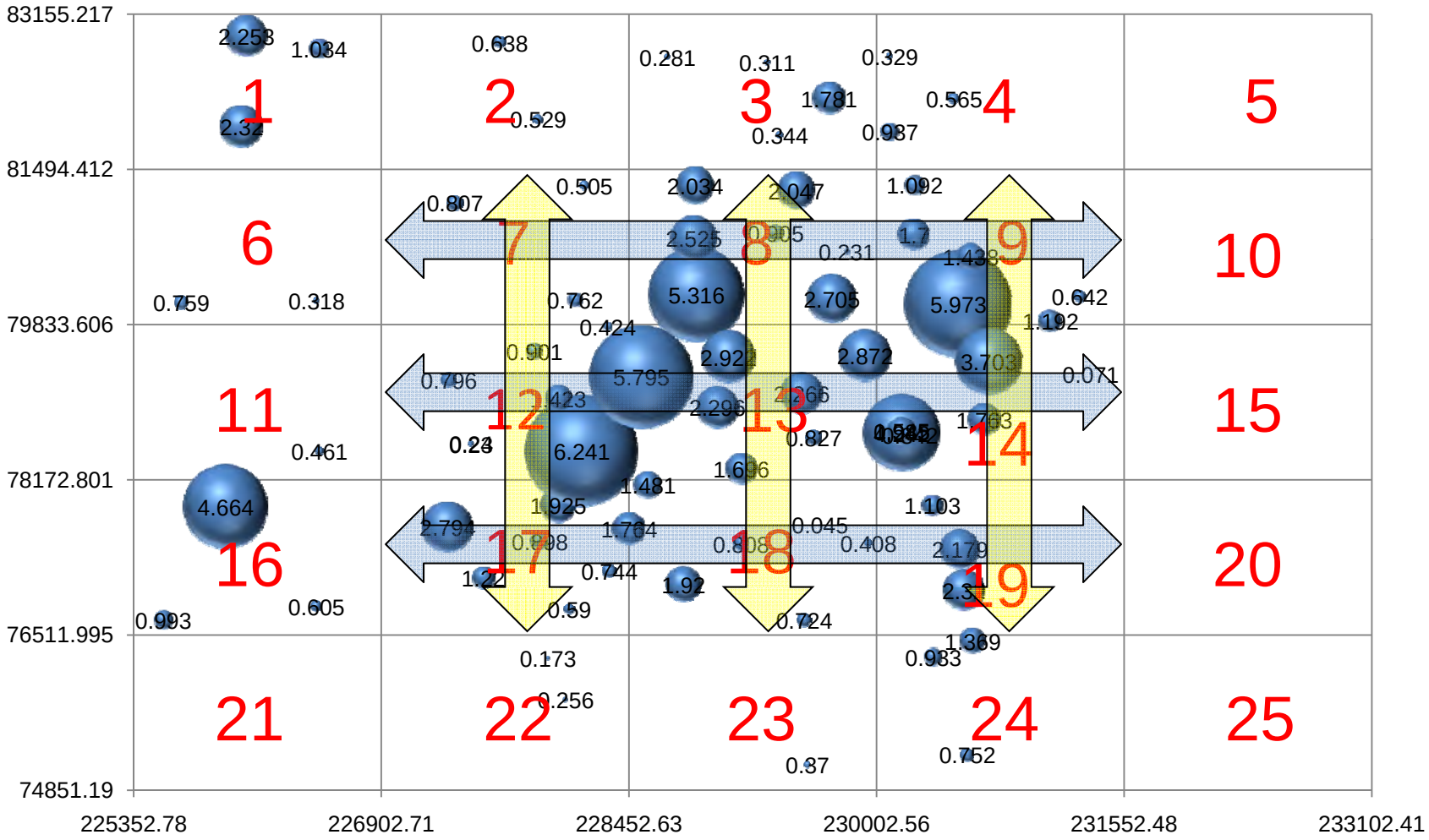
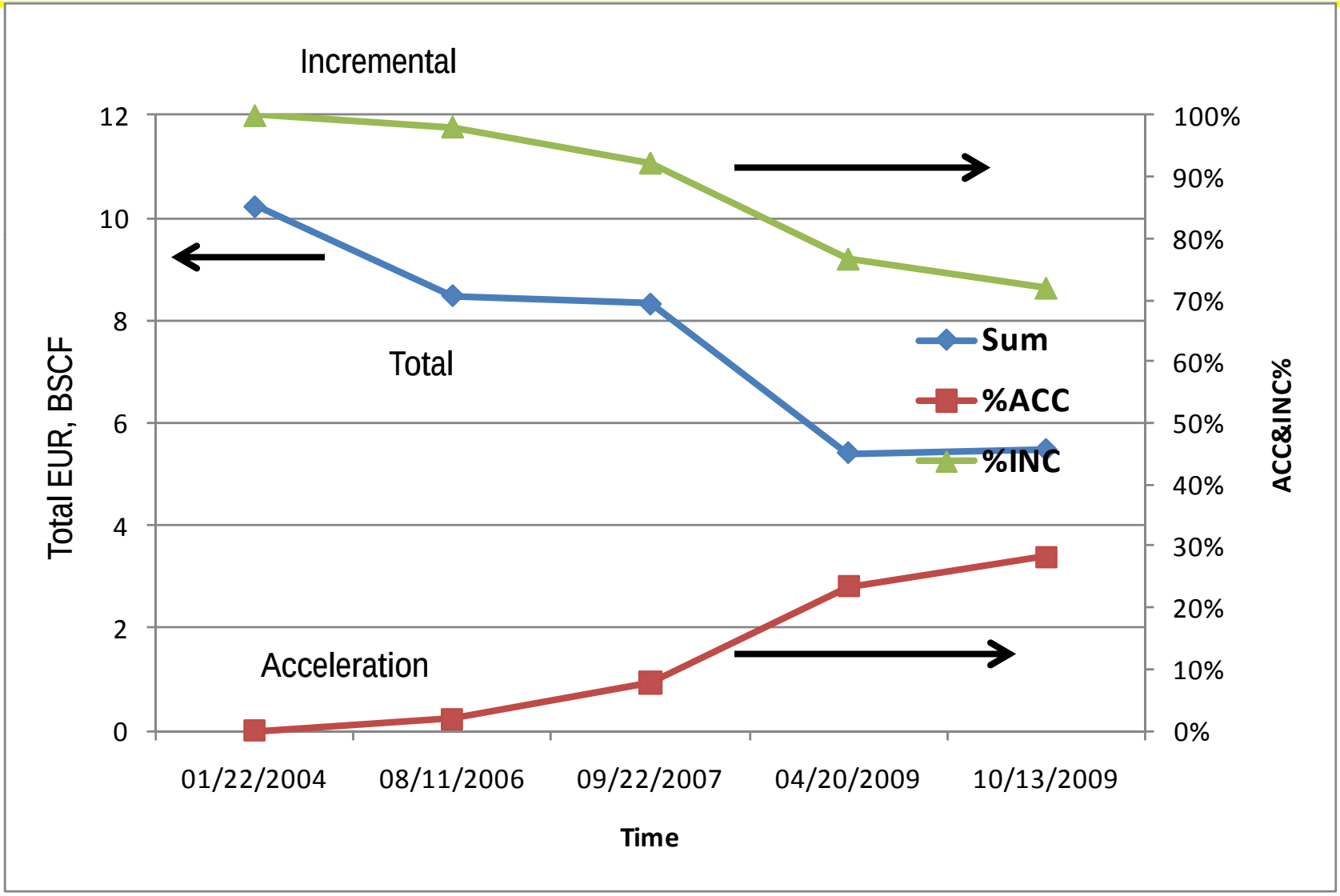
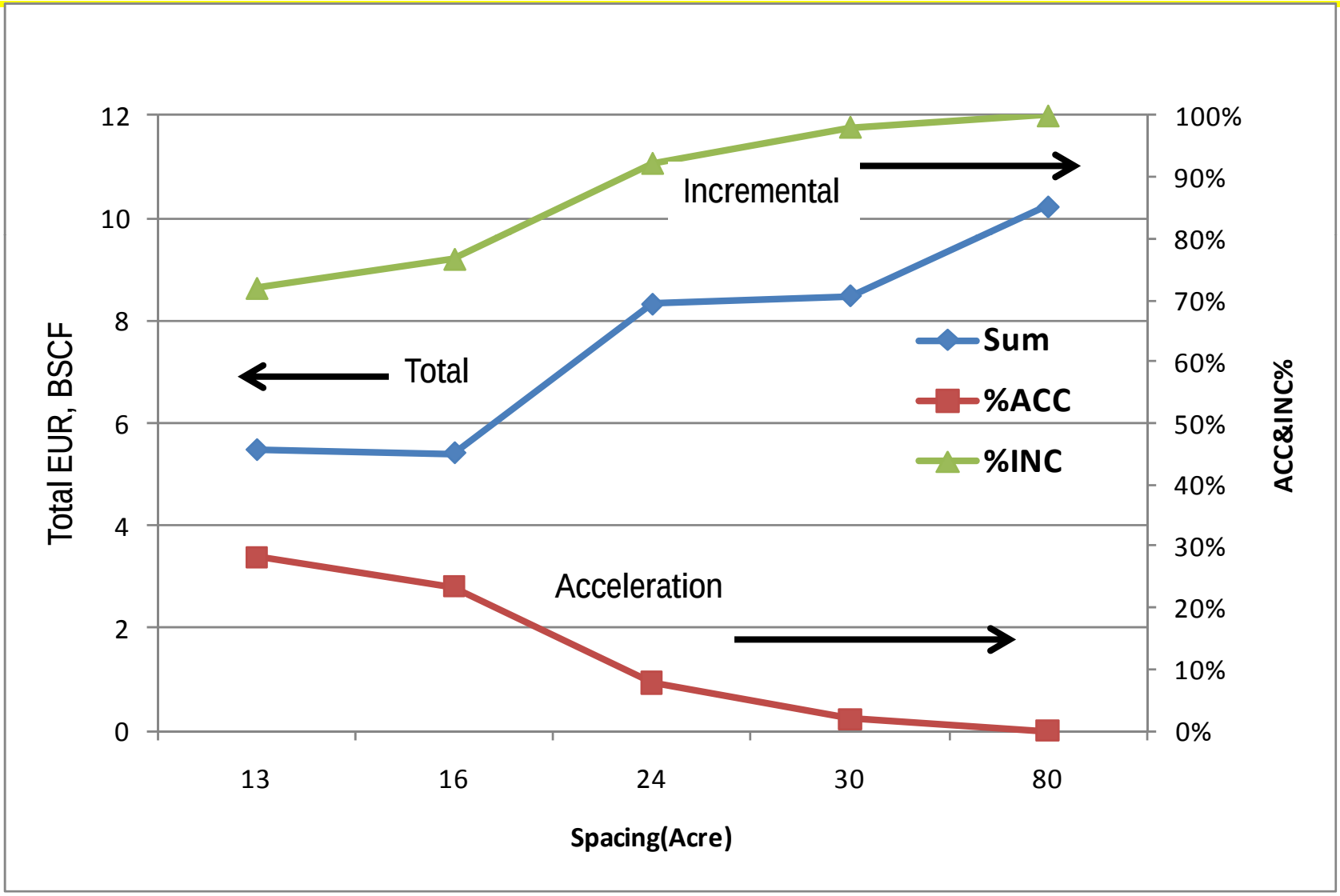
Wamsutter Field
Multiple Section Analysis



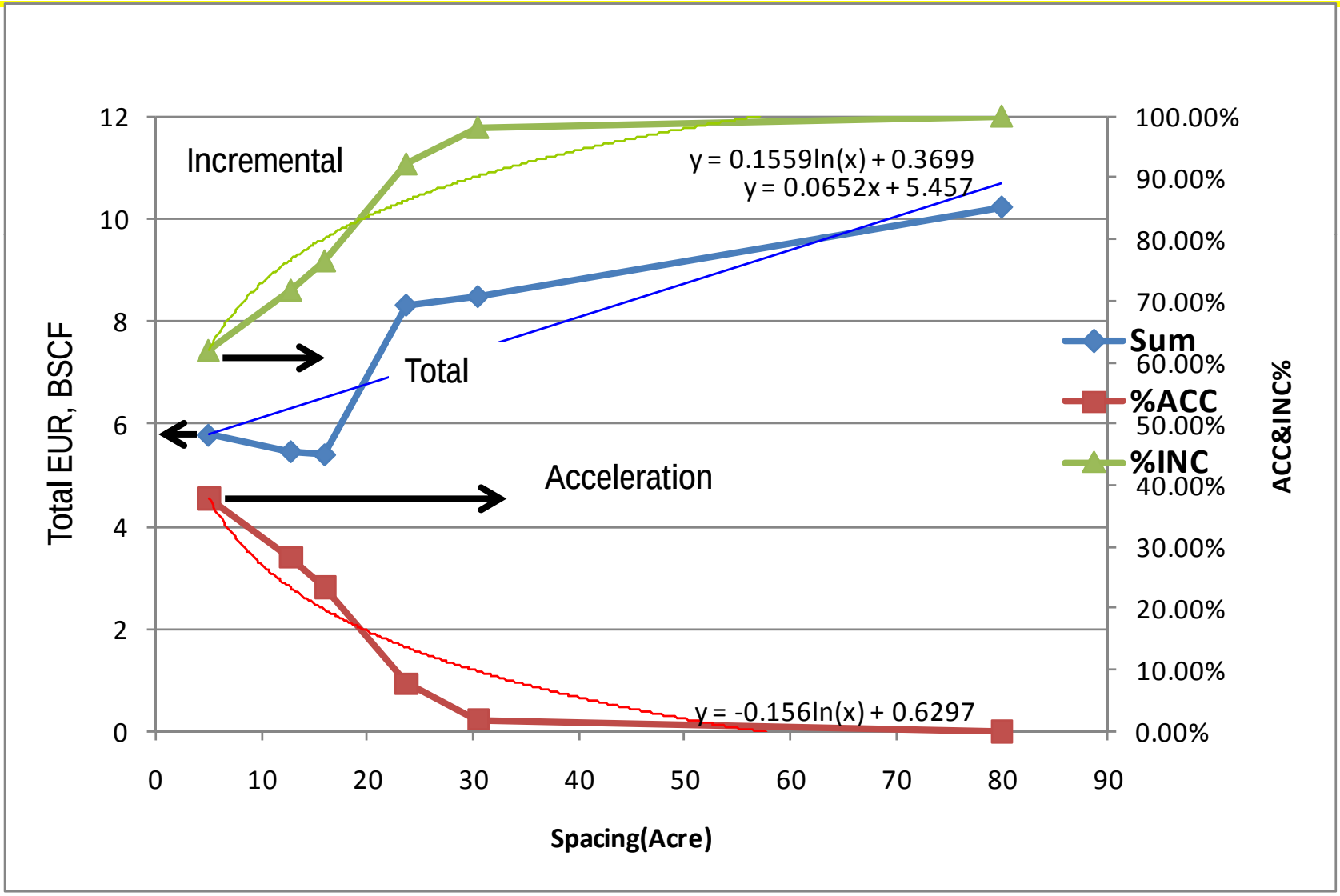
Acceleration, Incremental, and Total EUR vs. Time



Acceleration, Incremental, and Total EUR vs. Spacing



Extrapolation for Smaller Well Spacing



Approach

- For every “child” well, calculate average Incremental and Acceleration component.
- Plot Acceleration percentage, Incremental percentage and total EUR as a function of spacing.
- Recommend potential sections where in fill well potential is the greatest.

Extrapolation Results

	Total (bscf)	%(ACC)	%(INC)
EW-7,8,9	1.350	88%	12%
EW-12,13,14	2.300	43%	57%
EW-17,18,19	2.140	84%	16%
NS-7,12,17	0.900	70%	30%
NS-8,13,18	1.750	91%	9%
NS-9,14,19	2.150	64%	36%

Recommended Sections

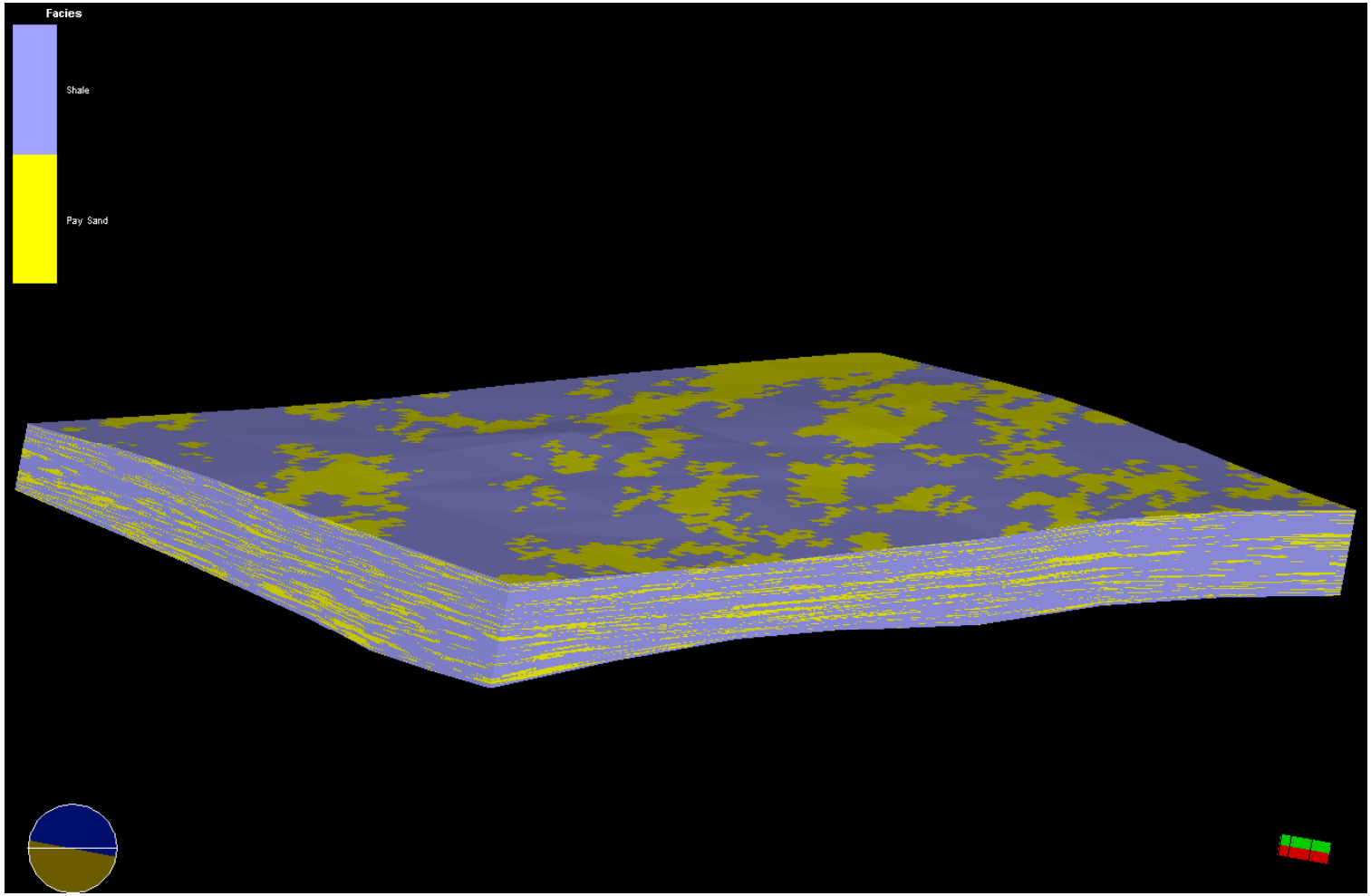
	Total (bscf)	%(ACC)	%(INC)
EW-12,13,14	2.300	43%	57%
NS-9,14,19	2.150	64%	36%

Simulation Method

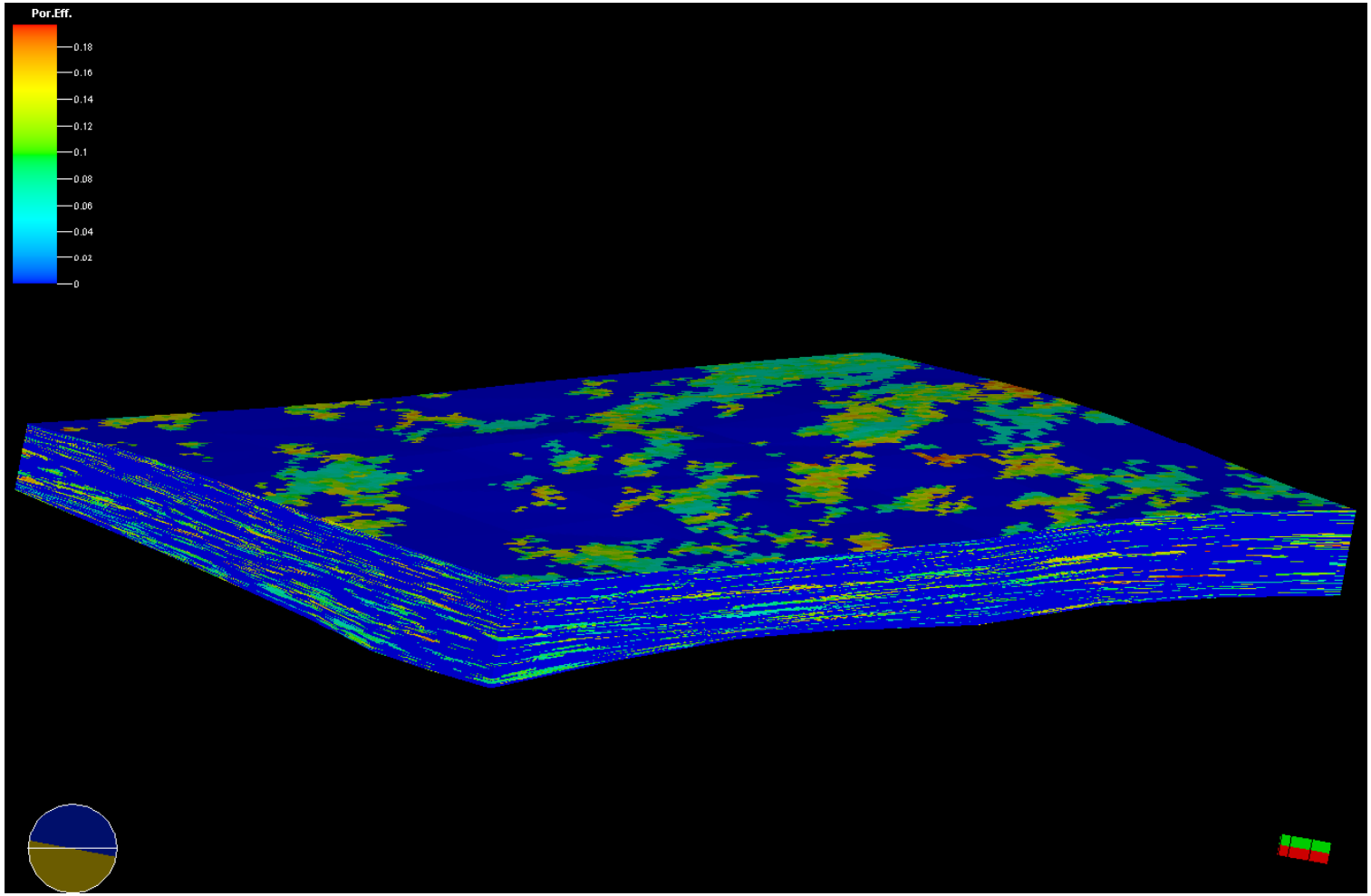
History Matching and Prediction

- Build the geological model
- Adjust the fracture conductivity and fracture length to match the historical performance
- Predict the future performance of the wells

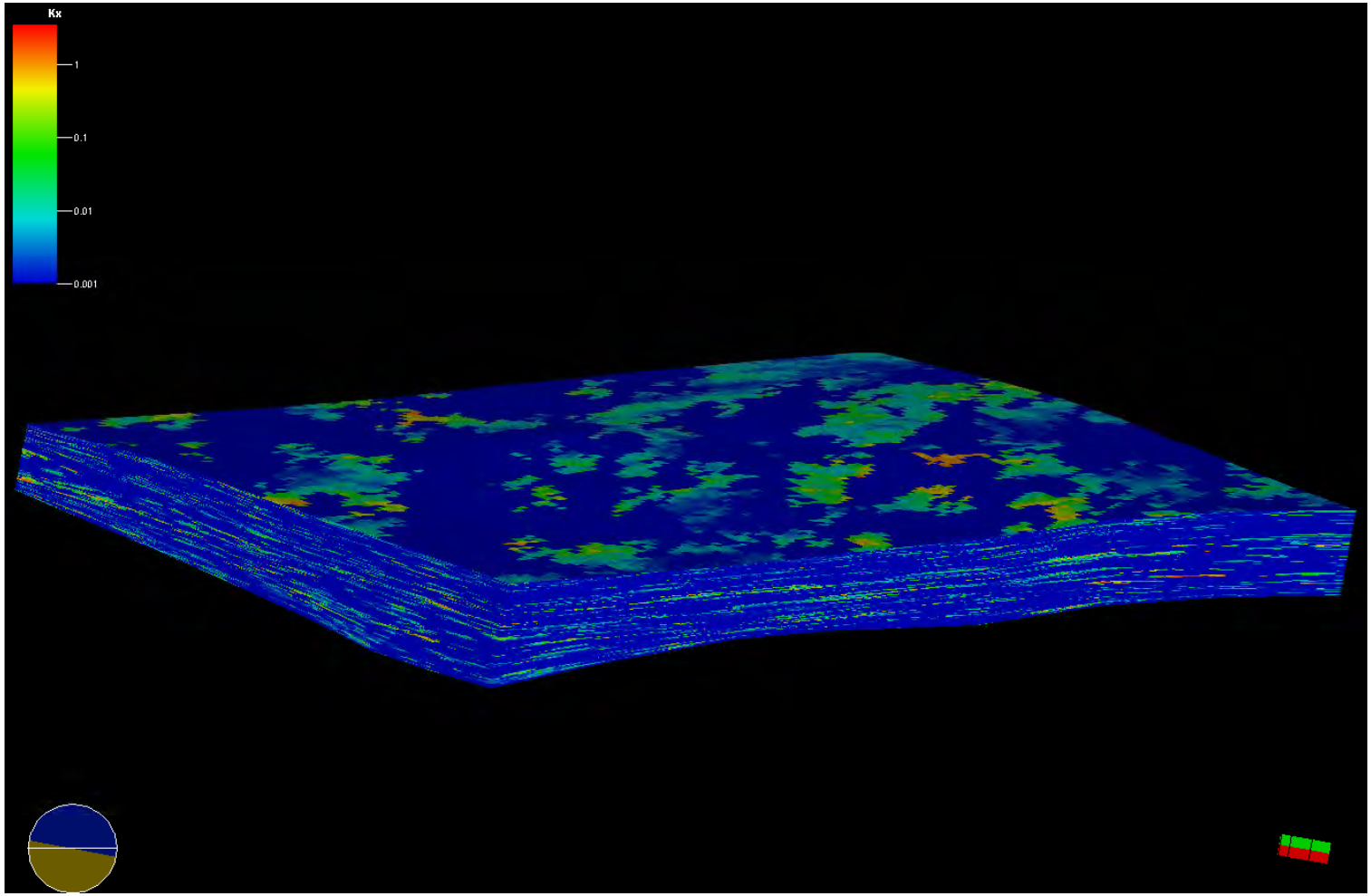
Facies Property Distribution



Porosity Property Distribution



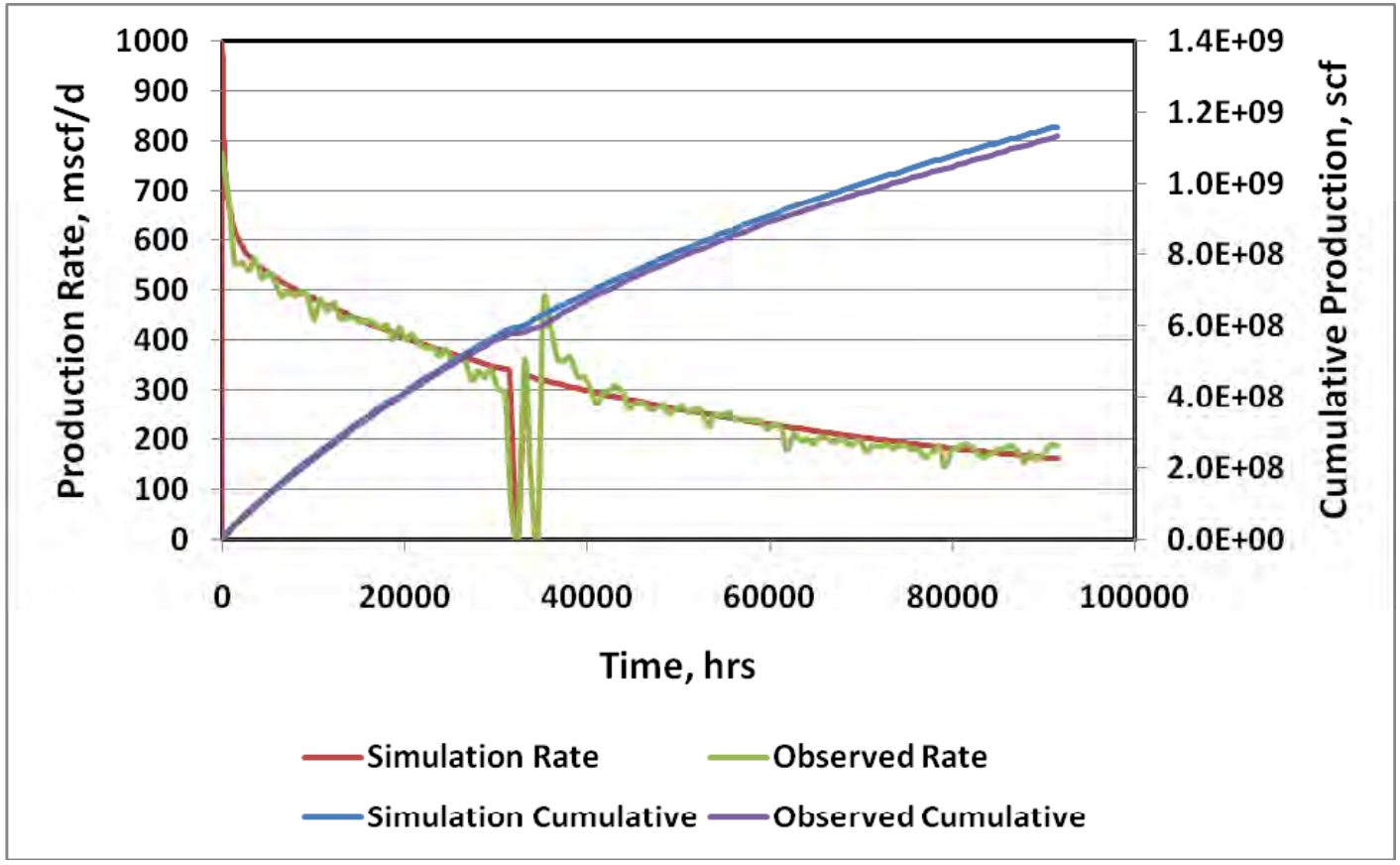
Permeability Property Distribution



History Matching and Prediction

- Build the geological model
- Adjust the fracture conductivity and fracture length to match the historical performance
- Predict the future performance of the wells

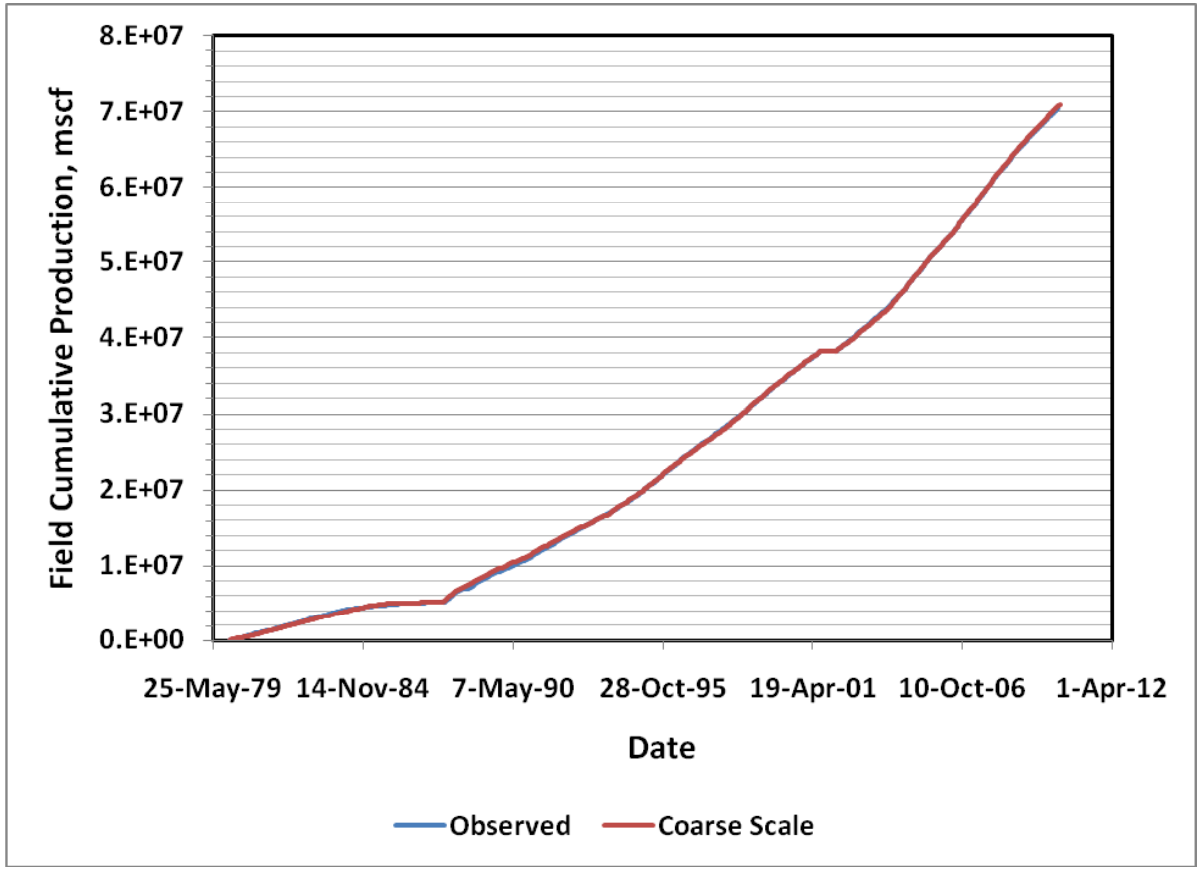
Well 21435 Production Data Analysis



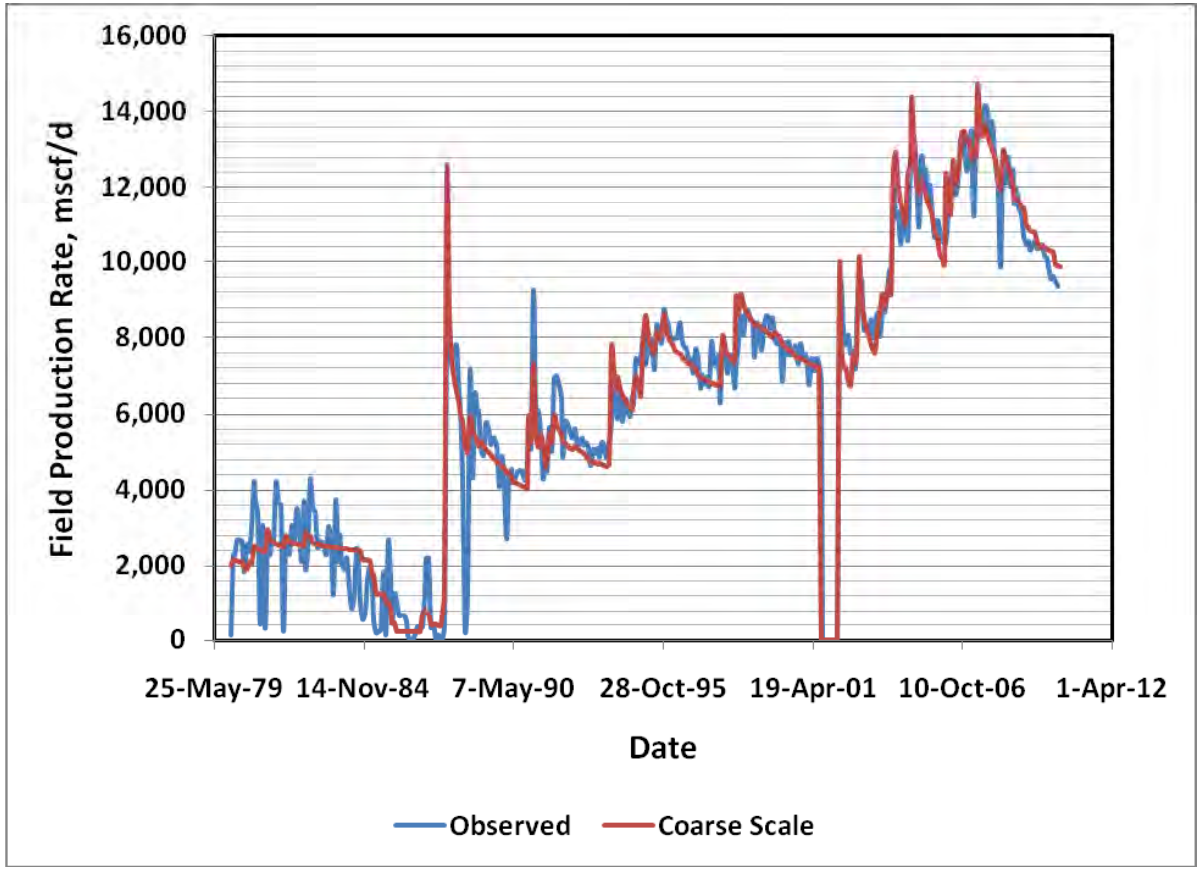
Fracture Properties

Well	Kh, md-ft	X_f, ft	F_{cd}, md-ft	R_e, ft	STGIP, bcf
20894	0.679	450	50	718	5.38
20946	0.561	450	18	676	6.6
20947	4.8	500	1	951	6
21162	0.55	573	40	973	4
21284	1.8	200	1	296	11.8
21338	1.5	300	4.5	986	8
21391	1.66	300	0.7	735	3.5
21435	2	360	0.5	675	2.6
21688	1.4	500	10	1010	3.5
22224	0.28	125	2	387	0.85
22447	4	125	0.7	737	1.7
21366	0.18	380	1	414	1.6

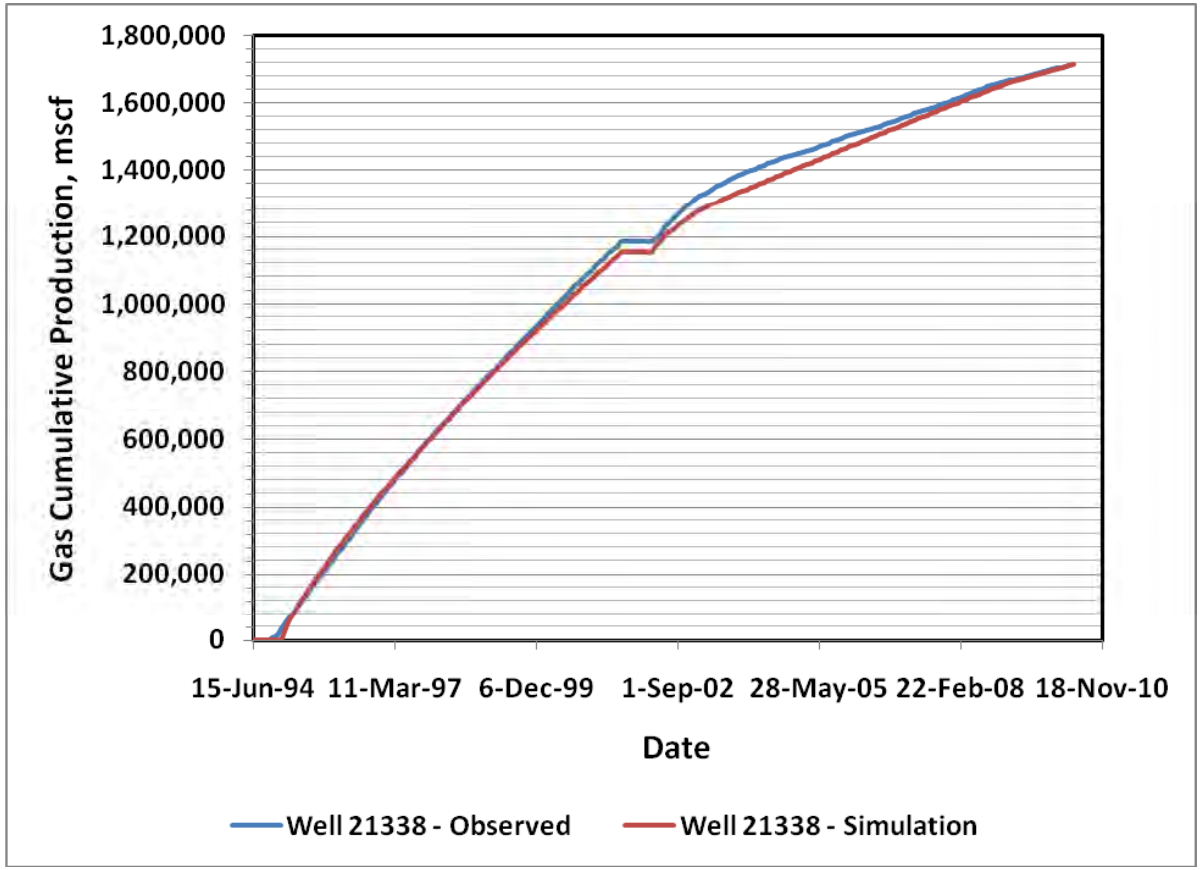
Field Cumulative Production Match



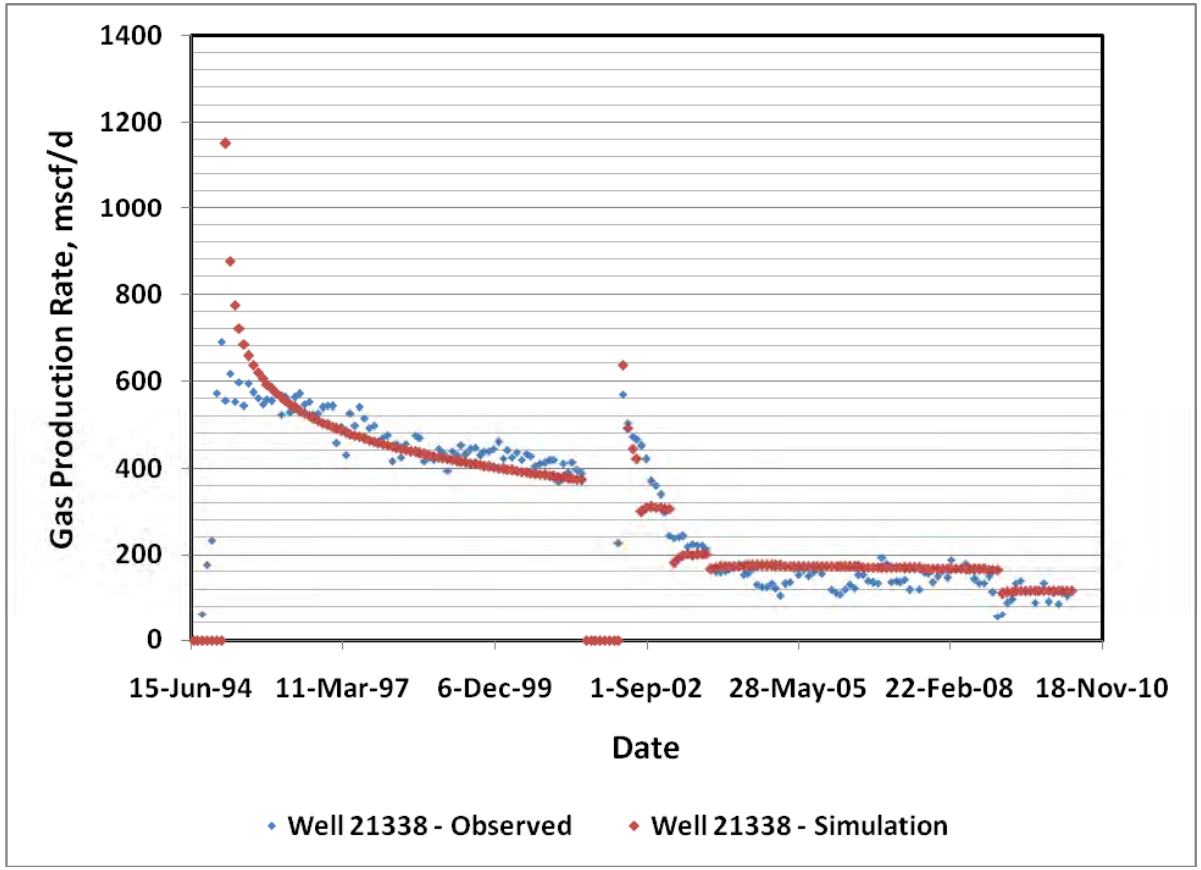
Field Production Rate Match



Well 21338 – Cumulative Production Match



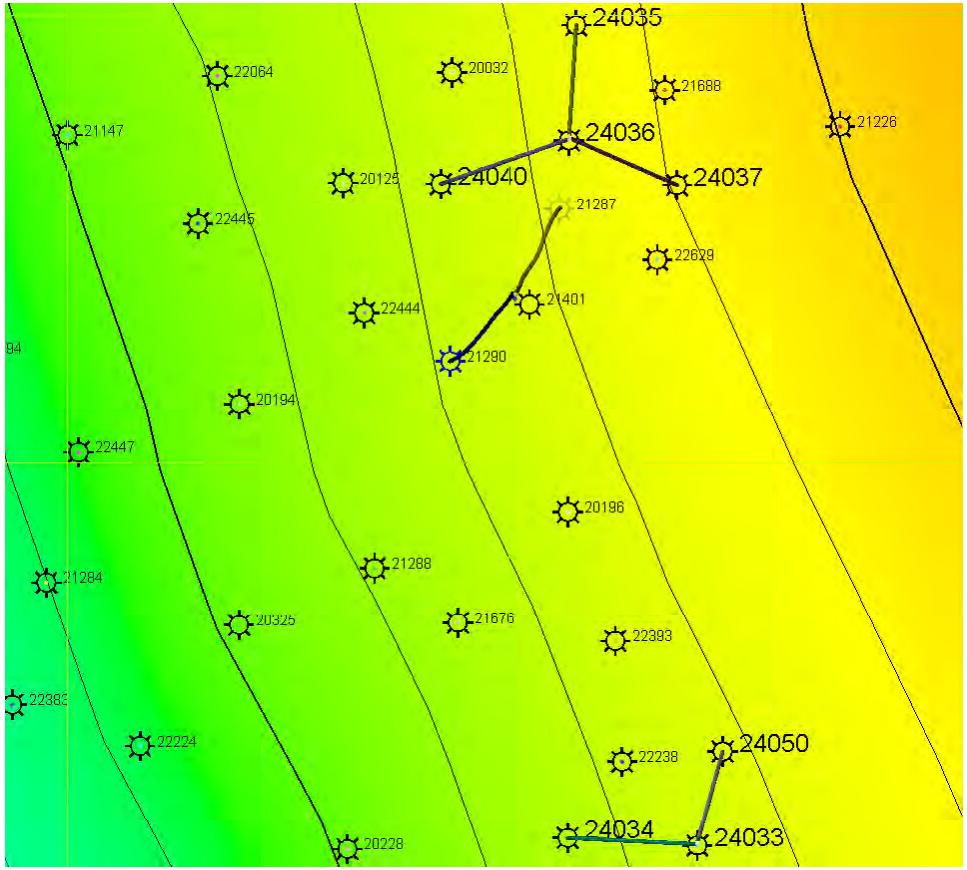
Well 21338 – Production Rate Match



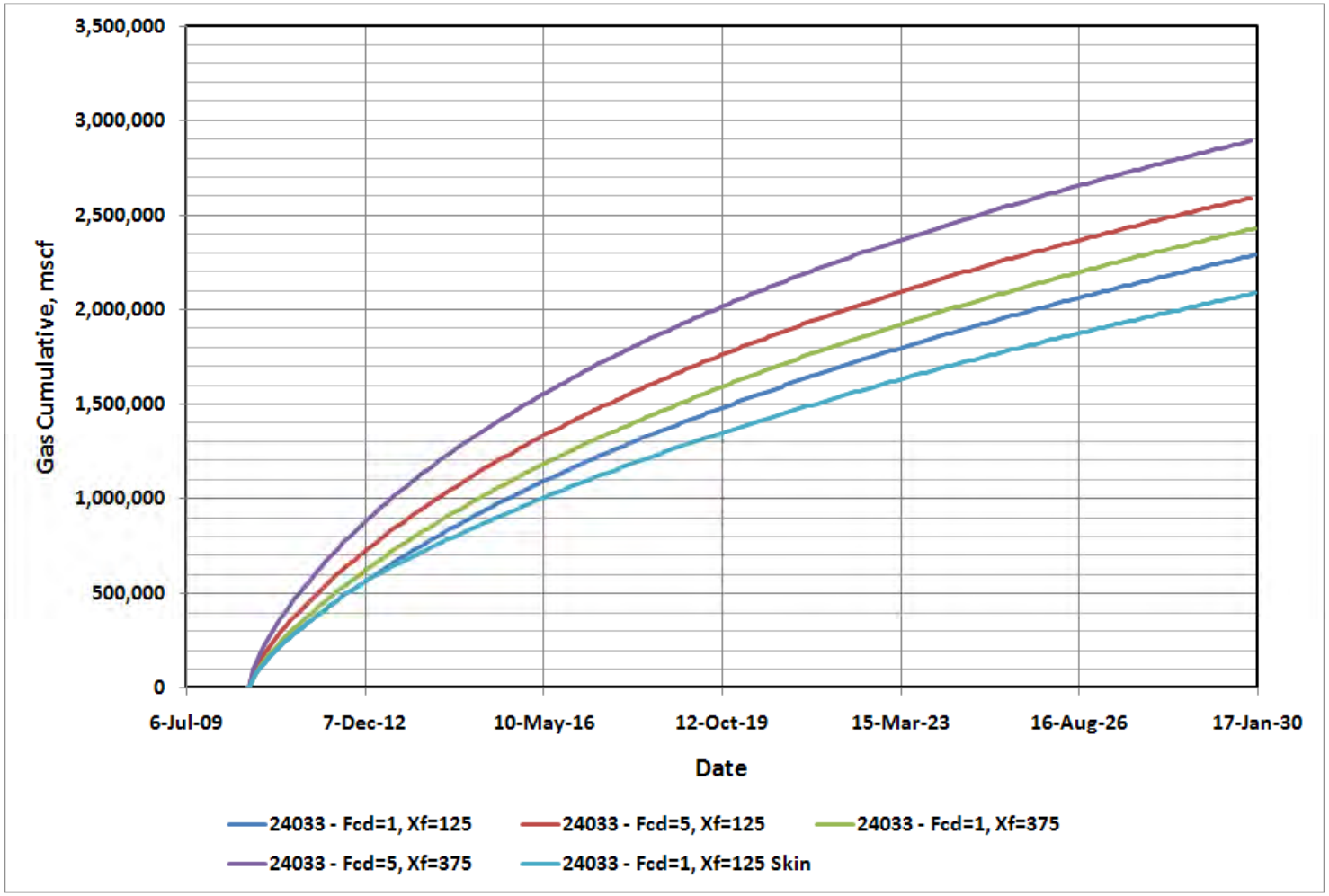
History Matching and Prediction

- Build the geological model
- Adjust the fracture conductivity and fracture length to match the historical performance
- Predict the future performance of the wells

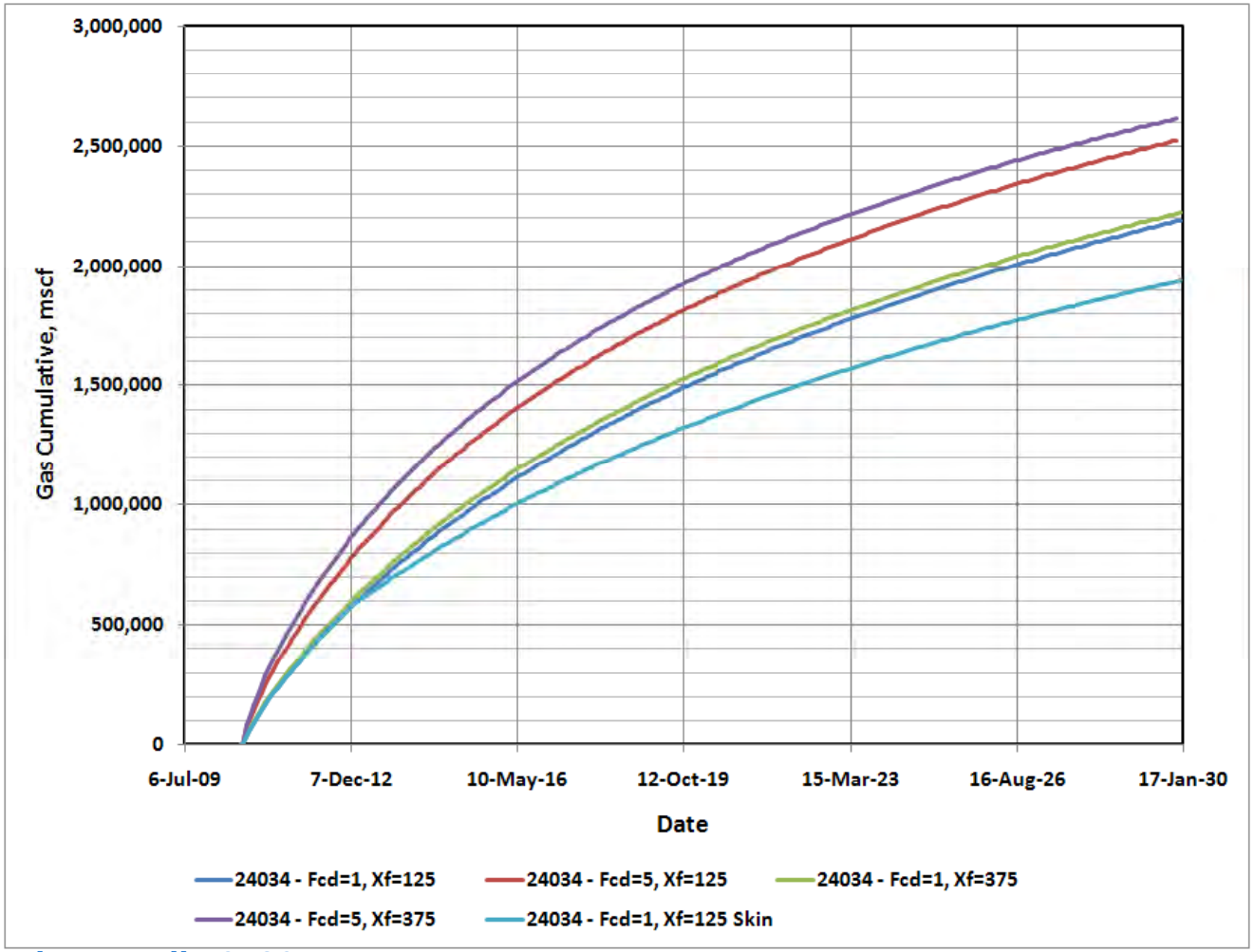
Future Seven Wells' Locations



Well 24033 Cumulative Production



Well 24034 Cumulative Production



Conclusions

- Using a newly developed methodology, we determined the acceleration and incremental contributions for in fill wells
- We validated our method in Wamsutter and Pinedale gas fields.
- We matched the production data using 3-D simulation model and made predictions
- Based on our recommendation,
  - Devon has drilled seven wells in Wamsutter field

Thank You!