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CASE STUDIES OF FIT-FOR-PURPOSE WELL AND RESERVOIR SURVEILLANCE TO SUPPORT DEVELOPMENT PLAN DECISIONS

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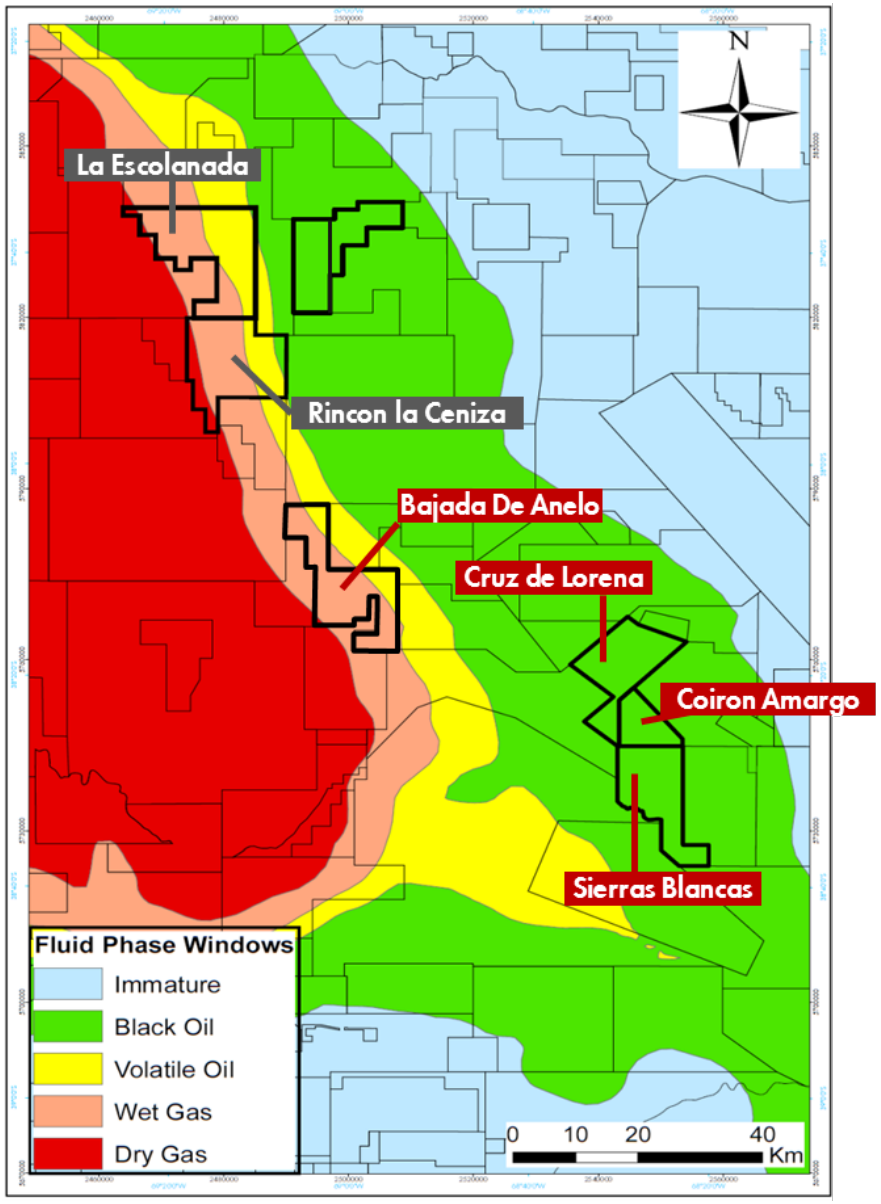
Agenda

- Introduction
- Case Study 1
  - Confined Well EUR, Type Curve Forecasting and Impact of Production History on the Forecasts
- Case Study 2
  - Limited Scale Trial to Determine Lateral Length and Completion Scaling Factors
- Summary and Future Work

Introduction



- Shell's position in Vaca Muerta
  - 6 blocks (4 operated)
- 3 black oil blocks matured to development phase by utilizing
  - learnings from North American analogs,
  - geomechanics coupled dynamic models,
  - **fit-for-purpose field trials**

  for the initial optimization of
  - well spacing in Lower Vaca Muerta (LVM)
  - timing of Upper Vaca Muerta development (UVM)
  - completion designs
  - well lateral lengths

CASE1 – Confined Well EUR and Type Curve Forecasting

Objective

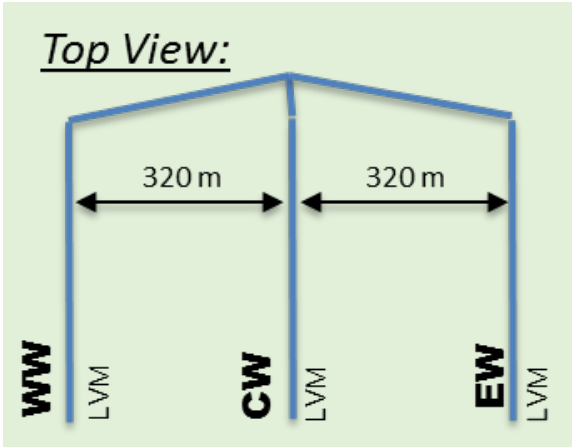
- Well calibrated dynamic models to determine
  - Confined well Type Curves (P90-P50-P10)
  - Well spacing and interference factors

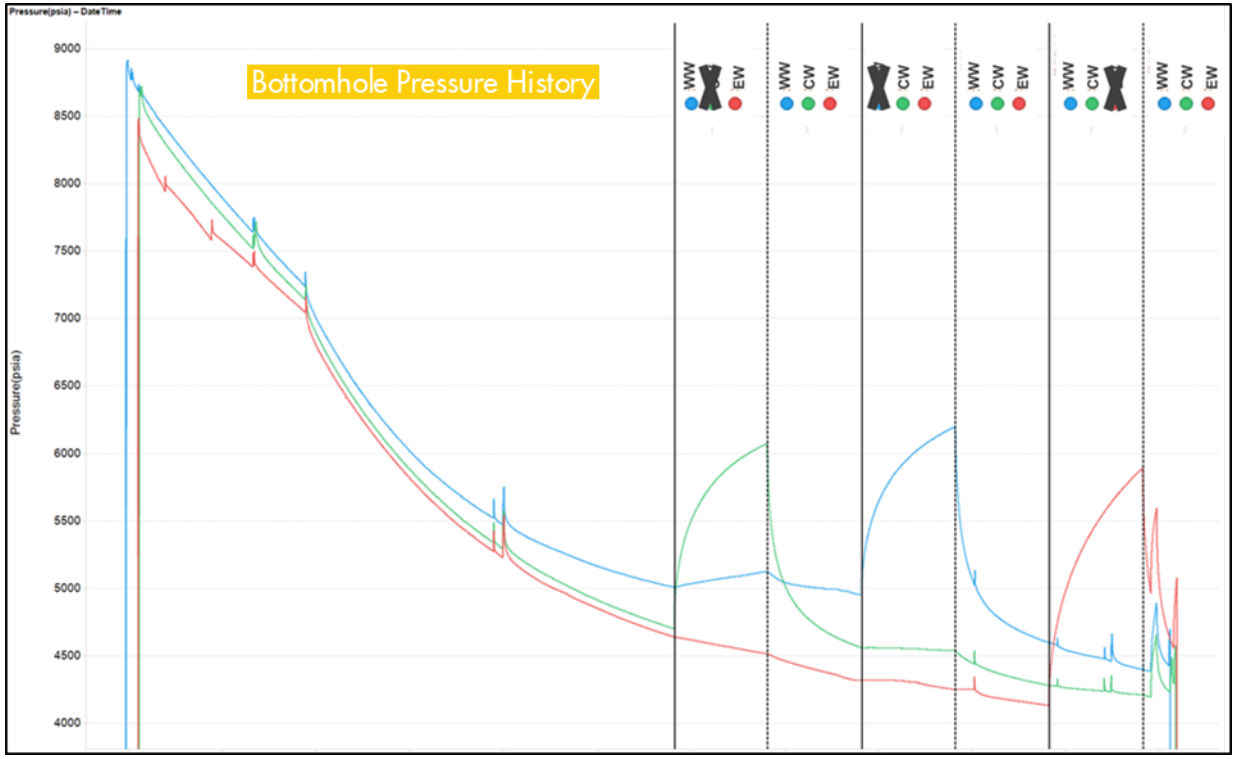
Pad Setup

- 3 LVM wells with 320 m well spacing

Data acquisition

- Bottom-hole pressures via memory gauges (first 6 months)
- Geochemical sampling for fracture height (H_f) estimation
- Interference test for well-to-well communication

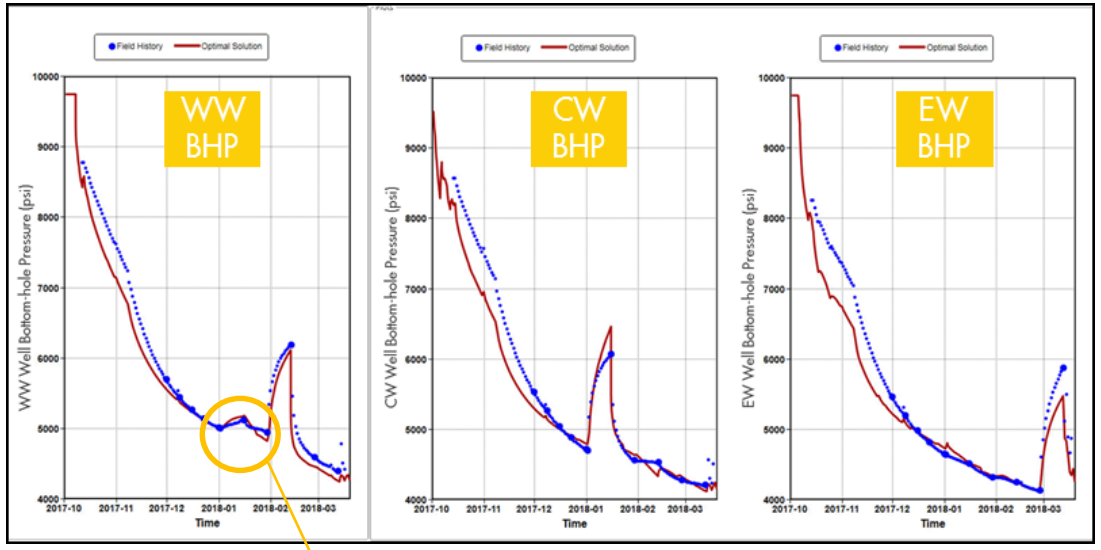


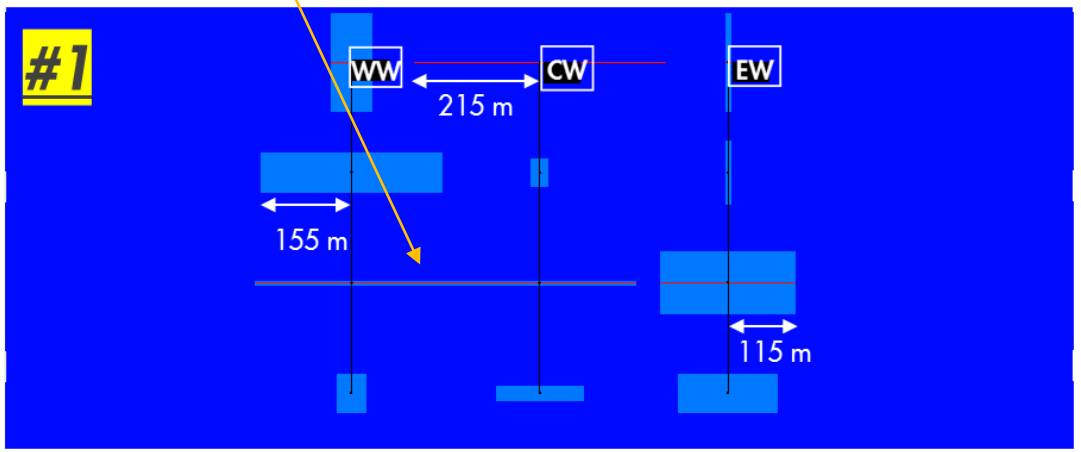


CASE1 – IP180 Conclusions

Cakici et al. “Dynamic Modeling Workflows for Vaca Muera Well Spacing Optimization”, 10th ConExplo, Nov 2018

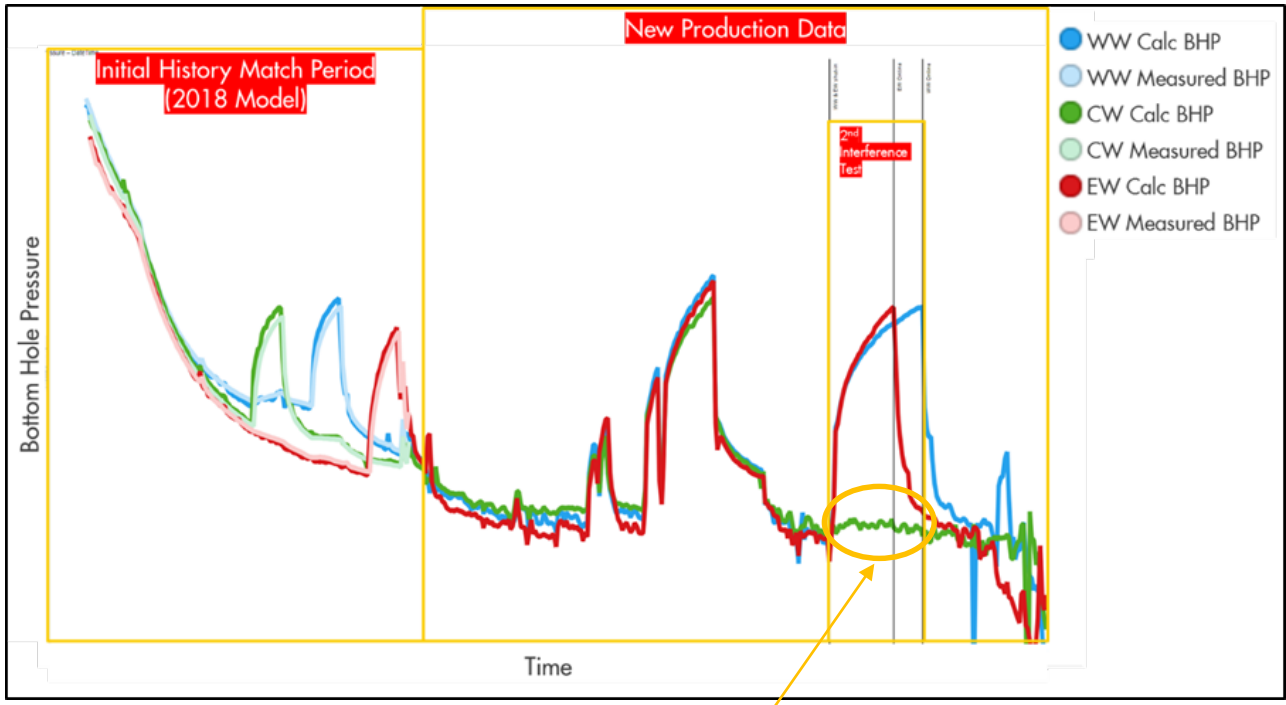
- Interference test showed communication between wells
- Simplified model consisted of 3 wells with one stage per well
- At least one “skinny” frac with a very high permeability required to match the interference response
- The calibrated models were used to determine
  - confined well EURs
  - confined well Type Curves
  - interference factors as a function of well spacing





CASE1 – Beyond IP180

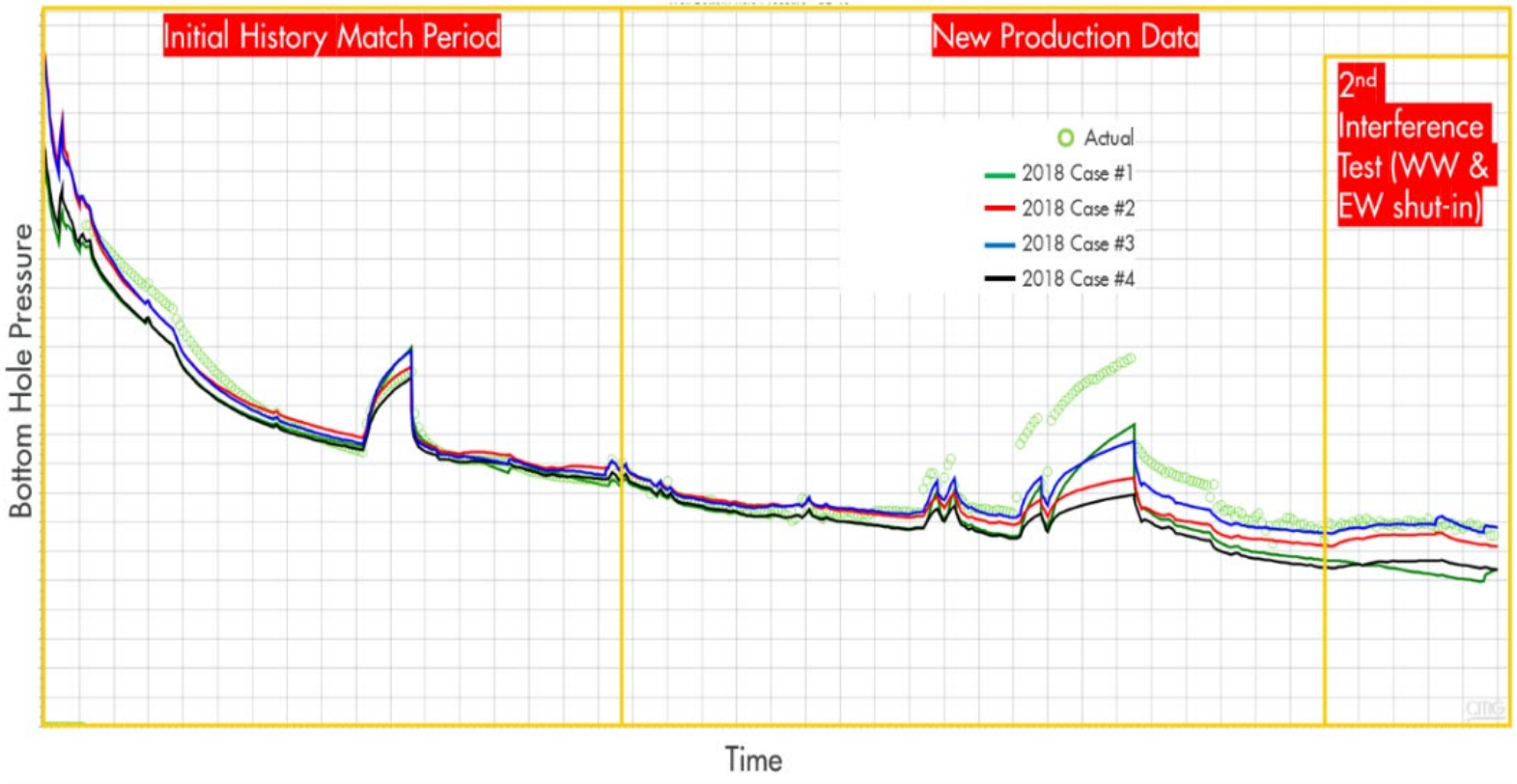
- +1 year of production data, including
  - Several build-up periods
  - 2nd interference test
- 2nd interference test
  - EW and WW shut in for 1 month
  - EW back on production at the end of 1st month
  - WW on production two weeks after



- Well-to-well connections existed after 18 months of production

CASE1 – IP180 Model vs New Production Data

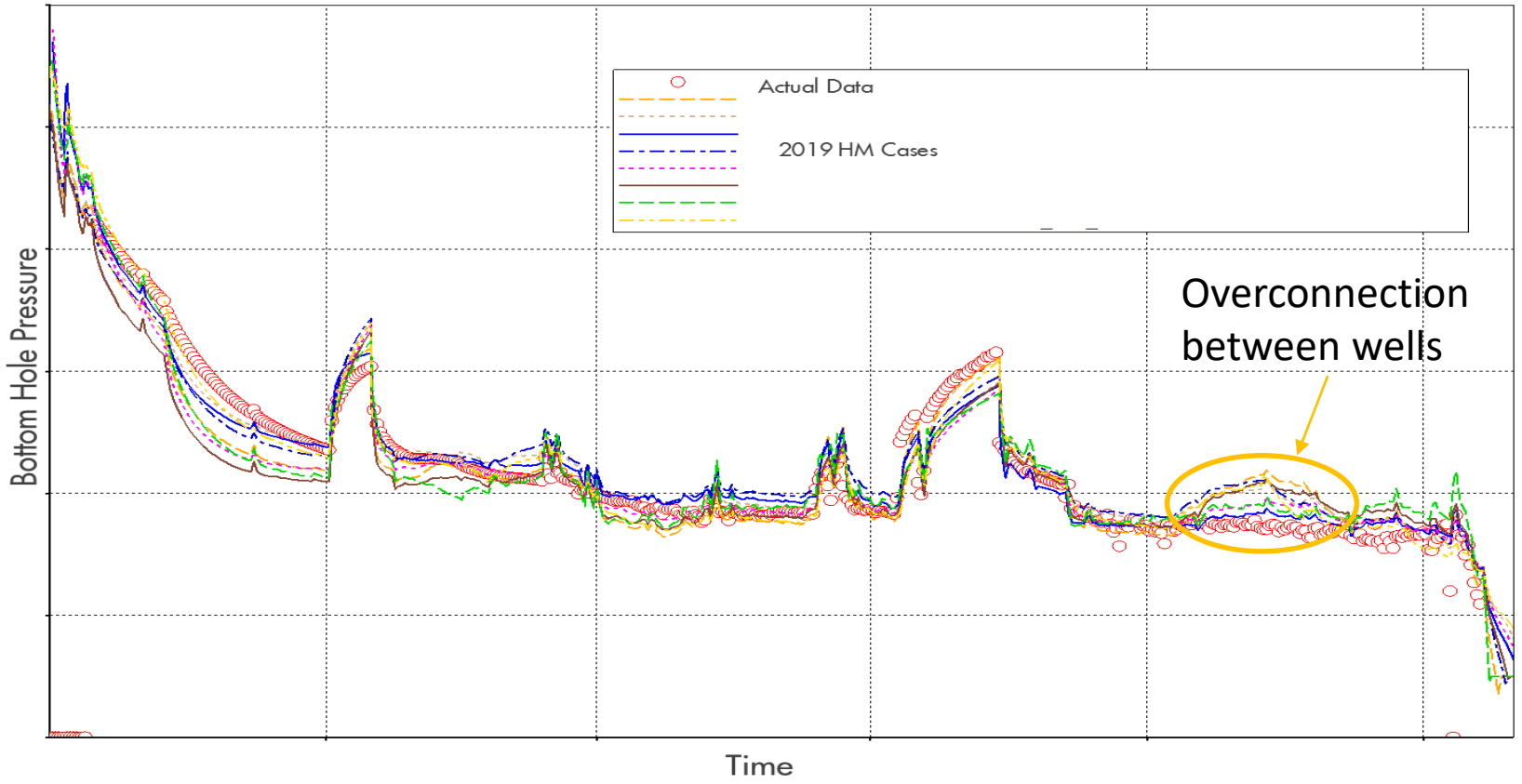
CW BHP Match by IP180 Models



- Models decline faster than actual BHP data
- The underestimation is more severe during buildup periods

CASE1 – 2019 Model Update and EUR Impact

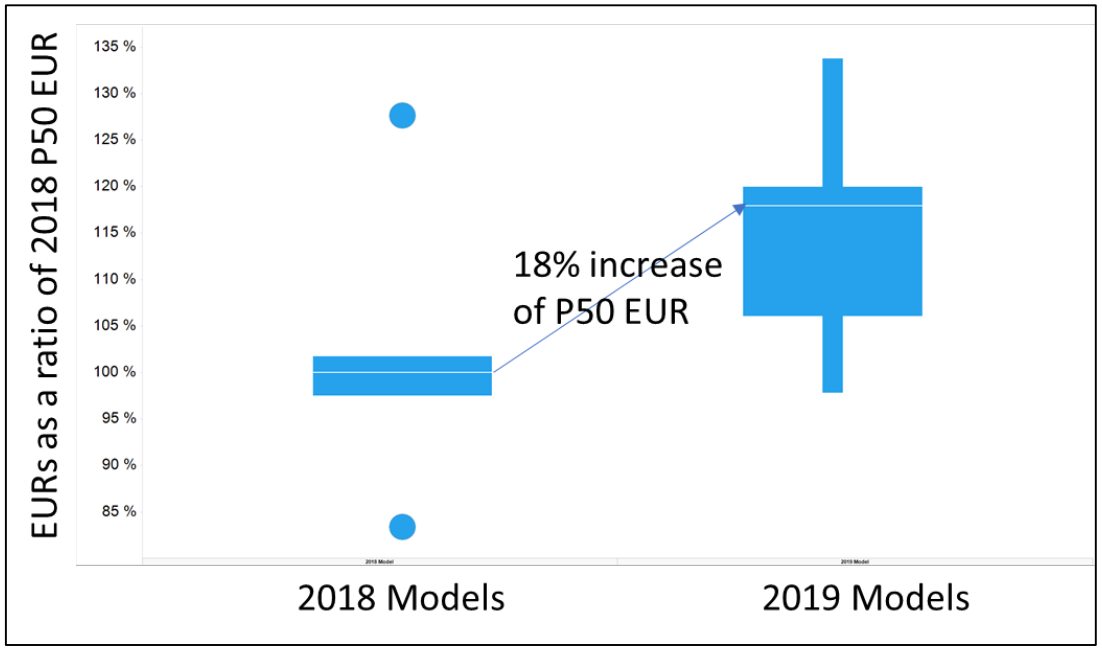
CW BHP Match by 2019 Models



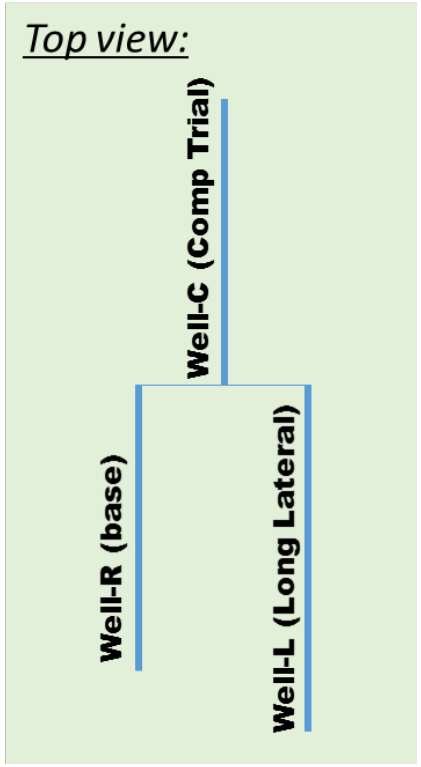
- Improved late time match of BHP history
- Models were not able to match the 2nd interference test response.

CASE-1 Summary

- The model pressures match the late time historical pressure levels
  → led to EUR update
- Correcting the model underestimation by latest data, increases the EURs
- Over estimation of interference response due to overconnection of wells in the model
  → The interference factors were unchanged



CASE2 – Performance Analysis for Lateral Length and Completion Scaling Parameters



Objective

- To determine incremental EUR due to increases in
  - lateral length
  - completion intensity

Pad Setup

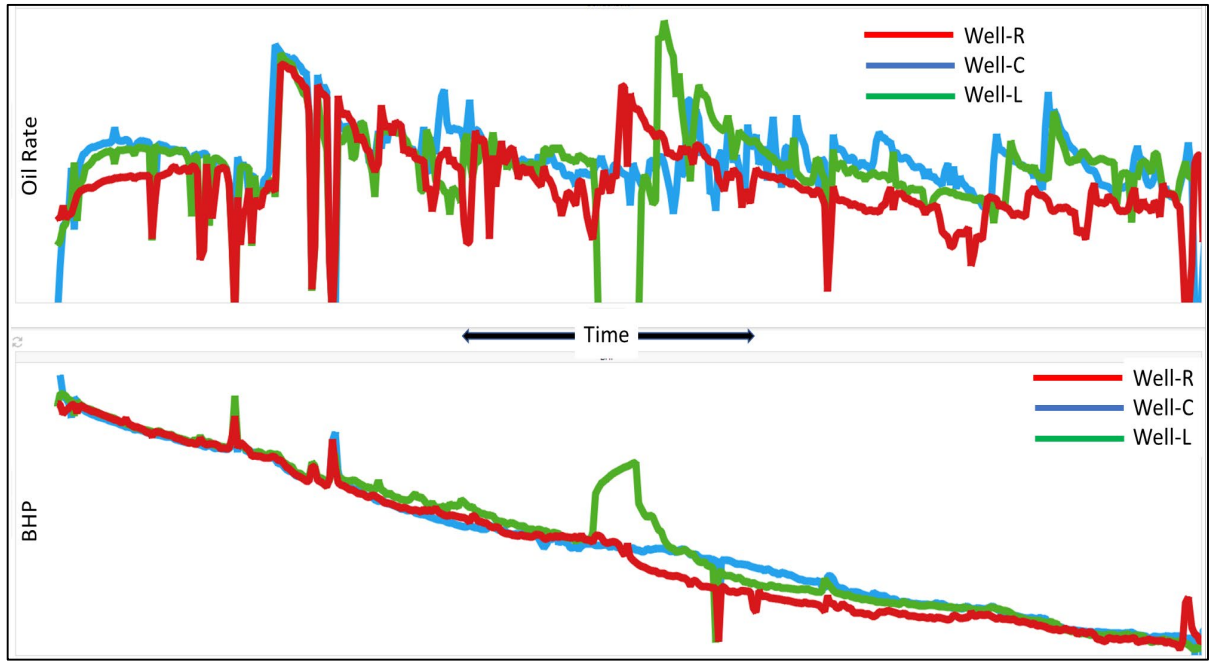
- 3 wells placed in the same landing zone

Data Acquired

- Chemical tracers (Well-L)
  - Contribution along longer lateral
  - Communication with Well-R
- Geochemical sampling
  - Fracture heights comparable to other wells in the development blocks

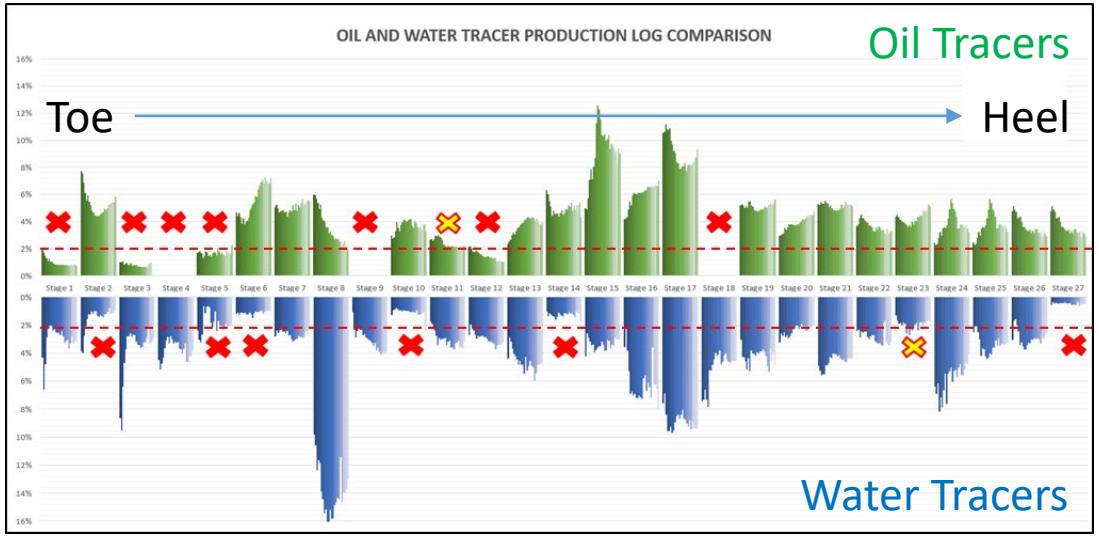
Well		Lateral Length	Stage Length	Proppant Intensity
Well-R	Base Case	LL_R	SL_R	PPI_R
Well-C	Comp Trial	LL_R	$0.8*SL_R$	$1.15*PPI_R$
Well-L	LL Trial	$1.21*LL_R$	SL_R	PPI_R

CASE2 – Well Performance

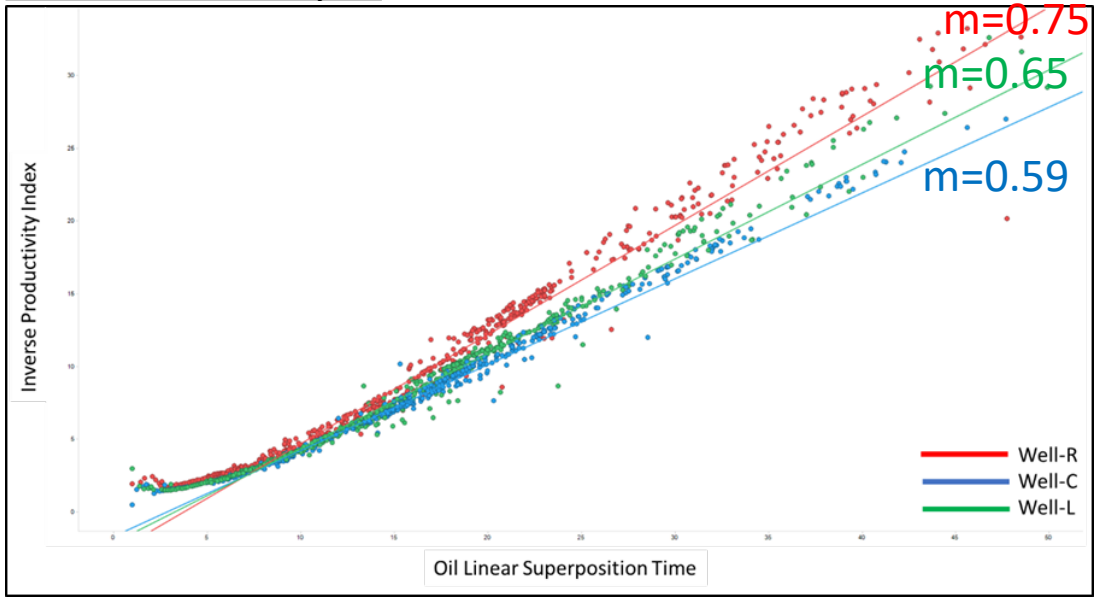


- ~20% increase in initial oil rate (IP30)
  - Comparable BHP declines
- 70-80% of stages contributing at Well-R
  - less contribution from toe stages 1-6
- 15-27% increase in productivity based on linear plot analysis

Stage Contribution at Well-L based on Chemical Tracers



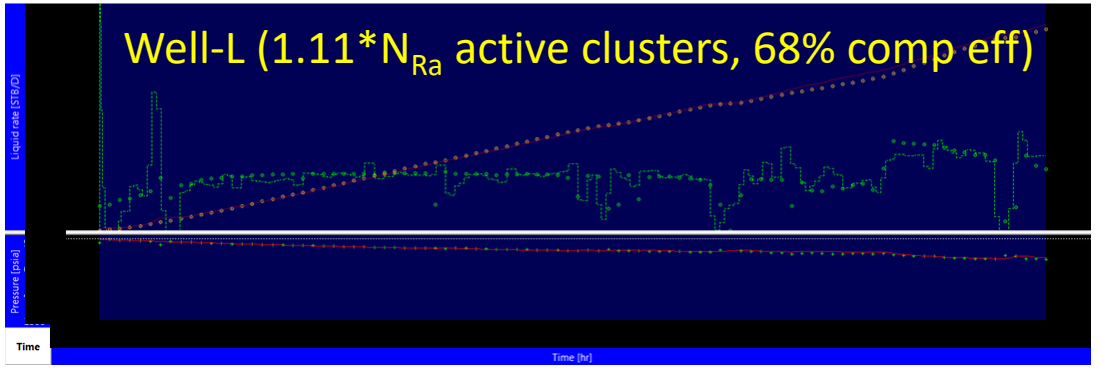
Linear Plot Analysis



CASE2 – Using RTA for Performance Comparison

Workflow

- Perform RTA on base case (Well-R)
  - Determine # active clusters, H_f, X_f, k_{SRV}, α
- Perform RTA on trial wells by only modifying fracture efficiency
  - History match by only changing # active clusters
  - Keep the values of all other parameters' as in Well-R model



Well	# Clusters	Comp Efficiency	# Active Clusters	EUR
Well-R	N_R	75%	$0.75*N_R$	EUR_R
Well-C	$1.27*N_R$	70%	$0.89*N_R$	$1.09*EUR_R$
Well-L	$1.23*N_R$	68%	$0.83*N_R$	$1.16*EUR_R$

CASE2 – Summary

- Lateral length incremental EUR is consistent for all methods
- More uncertainty on EUR impact of completion intensity
  - Larger incremental EURs based on early time performance indicators (Qi & m) vs. RTA
  - Indicating accelerated type curve
    - i.e. 9% EUR uplift with >20% early time performance increase

Method	Well-R	Well-C	Well-L	Comp Uplift (R-2-C)	LL Uplift (for 21% LL increase)
Qi Comp	Q_i	$1.22*Q_i$	$1.17*Q_i$	22%	17%
LP m	m_R	$0.79*m_R$	$0.87*m_R$	27%	15%
RTA	EUR_R	$1.09*EUR_R$	$1.16*EUR_R$	9%	16%

Reality check

- Geomech+Dynamic model estimate
  - 9% completion uplift
- North American analogs
  - 8% completion uplift
  - 16% LL uplift

Summary and Future Work

- Case studies discussed were used to support decision making in the early development phase
- Ongoing optimization by
  - Fit-for-purpose trials
  - Data analytics by increased number of producers
  - Geomechanics coupled dynamic models
  - North American analogs
- Integrated diagnostics pad, to understand fracture growth in LVM and UVM, is in plan
  - Fiberoptics, microseismic, geochemistry, chemical tracers and bottomhole gauges

Q&A