Refracturing: Candidate Selection & Potential Solutions

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Outline

- Benefits and mechanism of refracturing
- Refrac candidate selection process
- Does refracturing work and is it applicable in Canada?
- Candidate selection and economic evaluation examples

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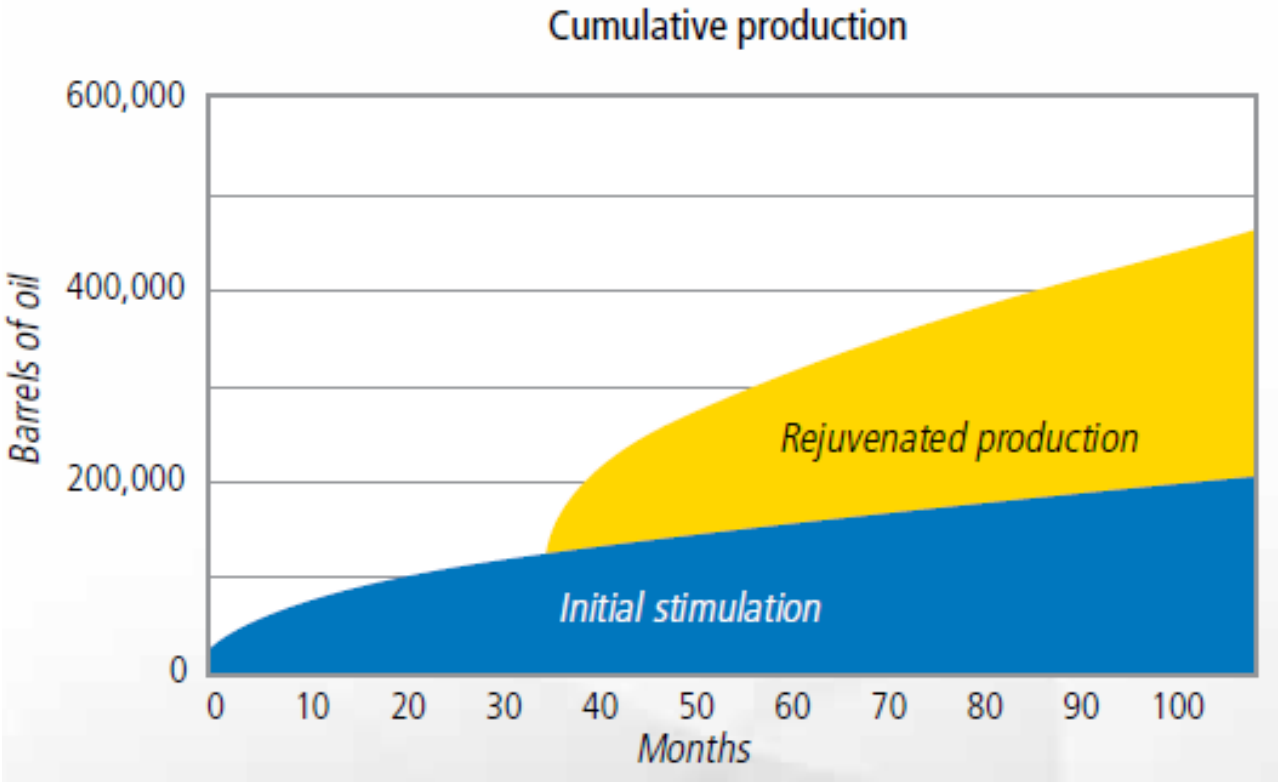
Why Refracture Wells?

- Increase booked reserves
- Improved ROI
- Faster, higher cash flow
- Lower cost per BOE
- Faster payback
- Lower environmental impact



Mechanisms Contributing to Refrac Success

- Stimulating intervals initially bypassed
- Enlarged fracture geometry enhancing reservoir contact
- Increased fracture conductivity compared to initial frac
- Improved frac complexity
- Fracture re-orientation due to stress field alterations leading to contact of "new rock"

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Steps Involved in Selecting a Refrac Candidate Well

- Four steps to the screening & selection process:

1. Merging of Canadian public data sets
   - GeoScout → production data, formation properties, and well information
   - Canadian Discovery Frac Database → Completion details
2. Candidate selection criteria
   - Frac spacing, tonnage, depletion, reservoir quality, etc.
3. Production type curve analysis
   - Compare to offset wells and expected production type curve
   - Estimation of production rates after refracturing
4. Economic potential of rejuvenation
   - Run through economical model

Candidate Selection Criteria

1. Reservoir and production data:
   - High IP and productivity in nearby wells
   - Low cumulative depletion

2. Original completion:
   - Older wells with large frac spacing
   - Intervals not fractured initially
   - Insufficient proppant tonnage (under stimulated)
   - Poor fluid choice

- Candidate Selection Criteria from Vincent et al. (SPE 134330)

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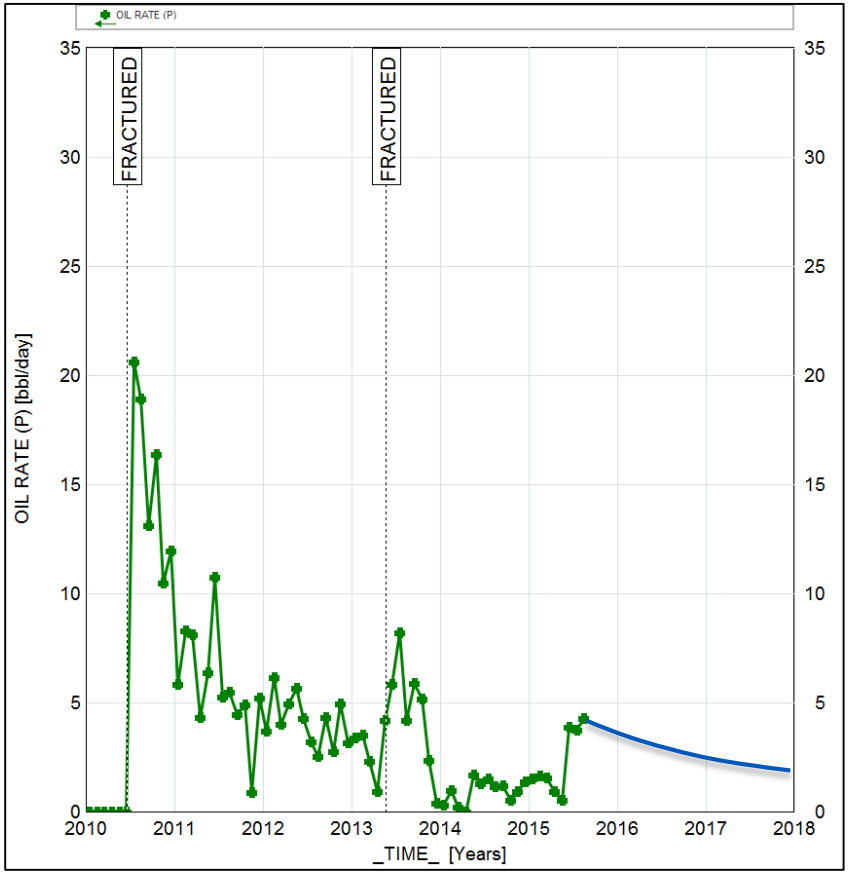
Importance of Selecting the Right Candidate

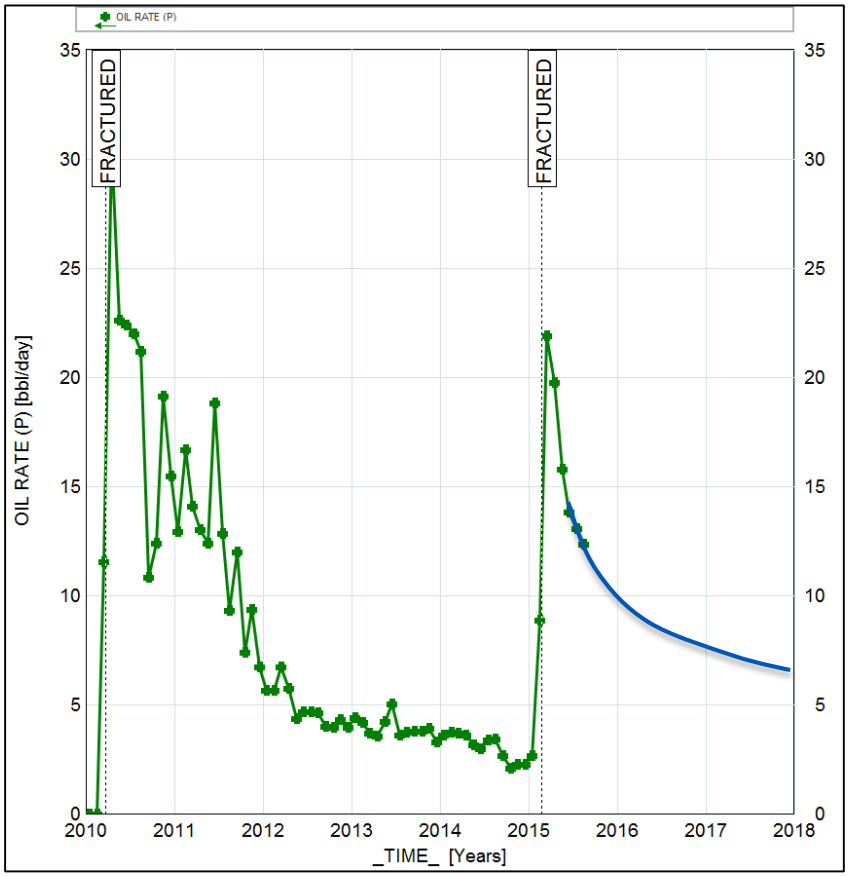
Well A

- Lower reservoir quality
- Higher than average proppant placed



Well B

- Higher reservoir quality
- Lower than average proppant placed



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Refrac Search in Western Canada

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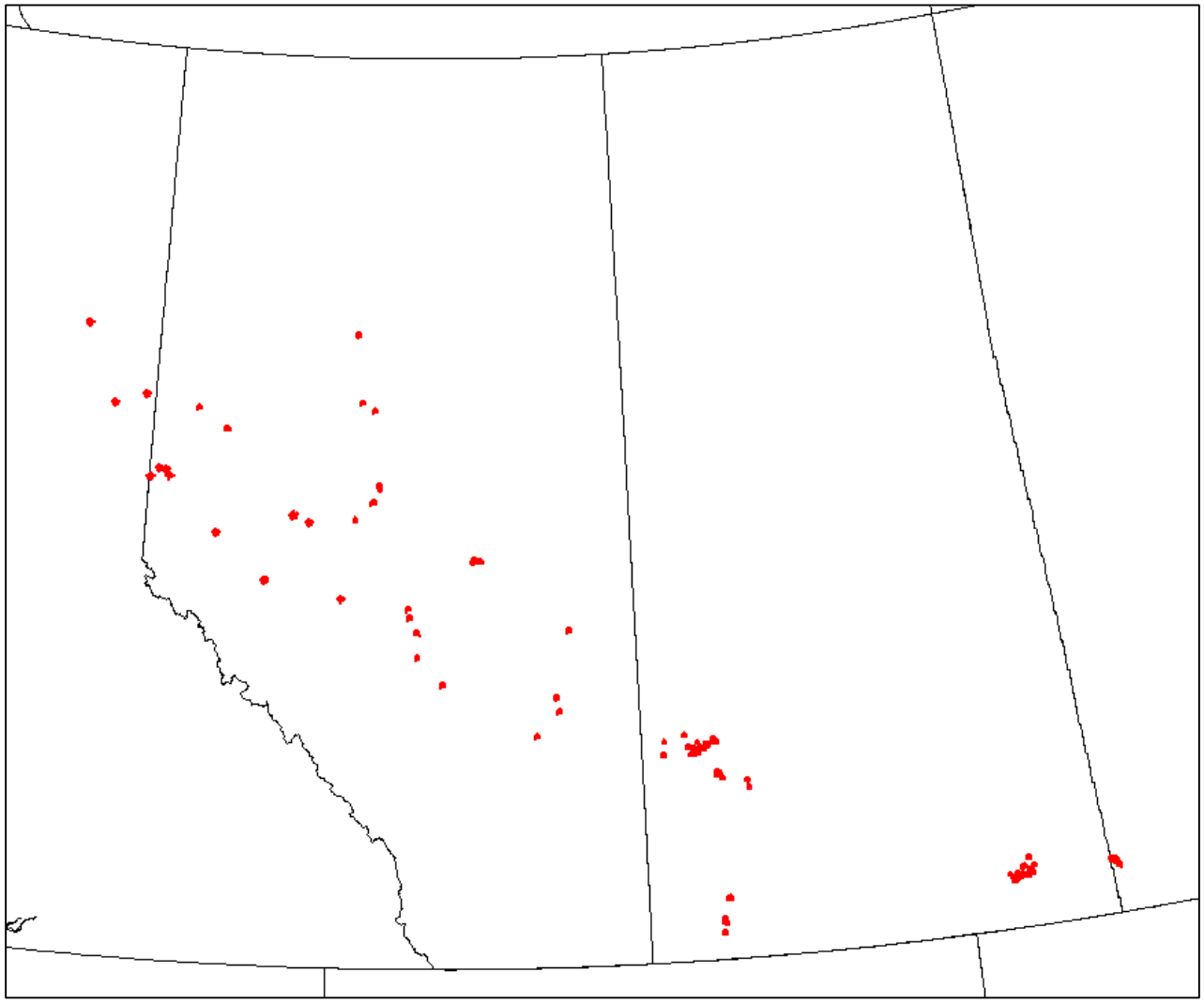
Horizontal Refracs Since 2010



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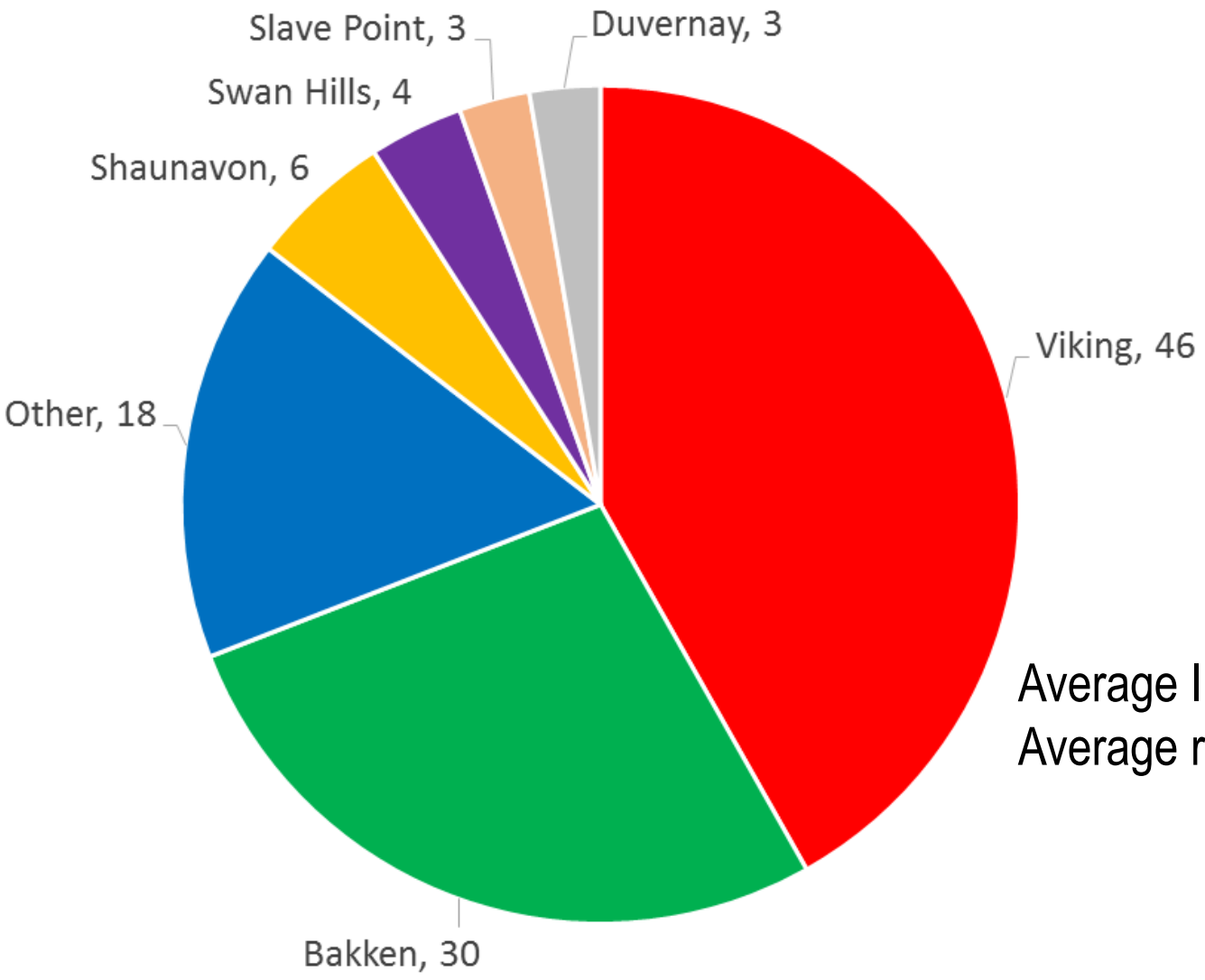
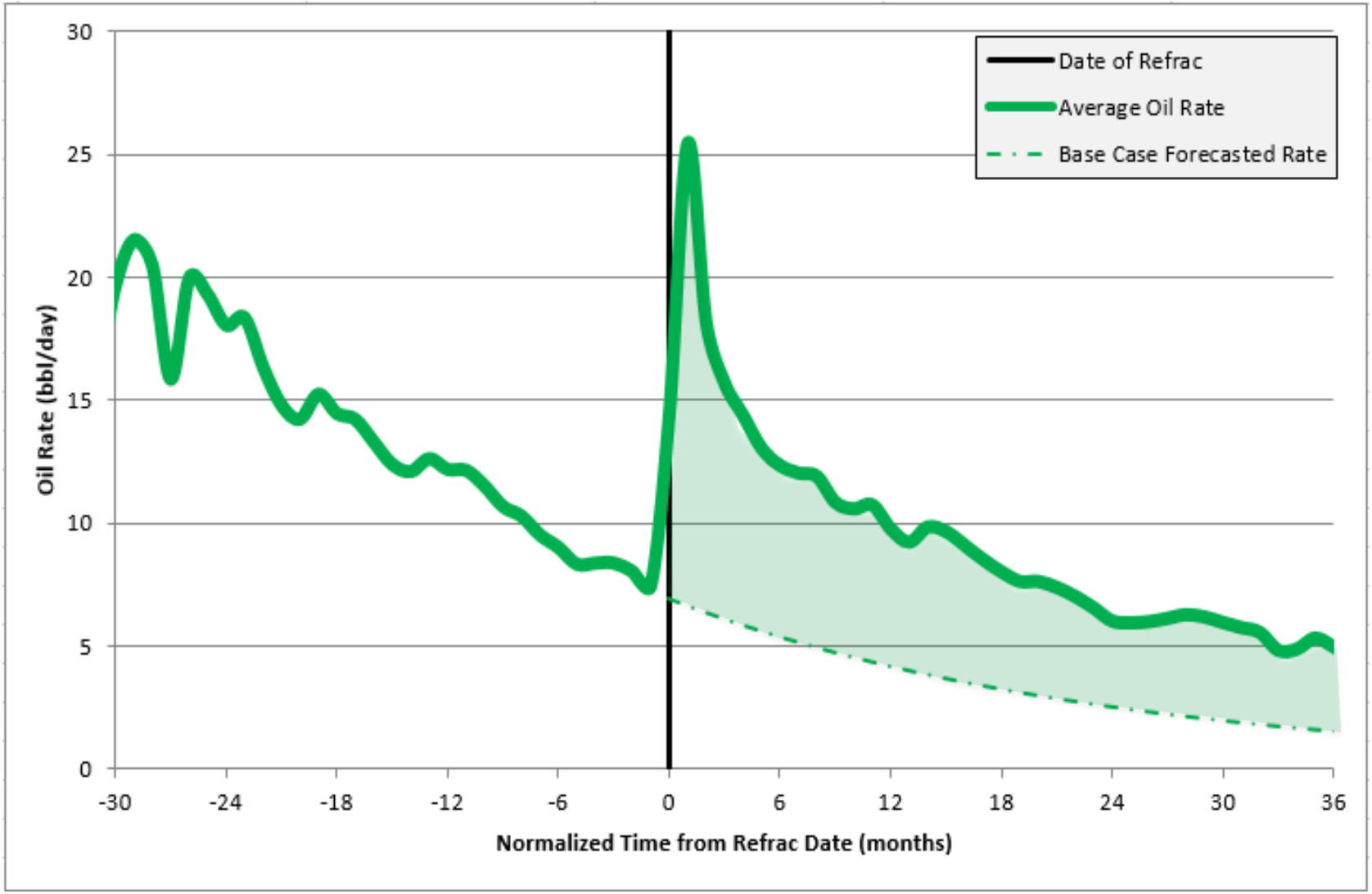
Refracture by Formation



Average IP ratio = 61%
Average rate increase = 40 bbl/d

Average Oil Rate Before and After HZ Viking Refrac



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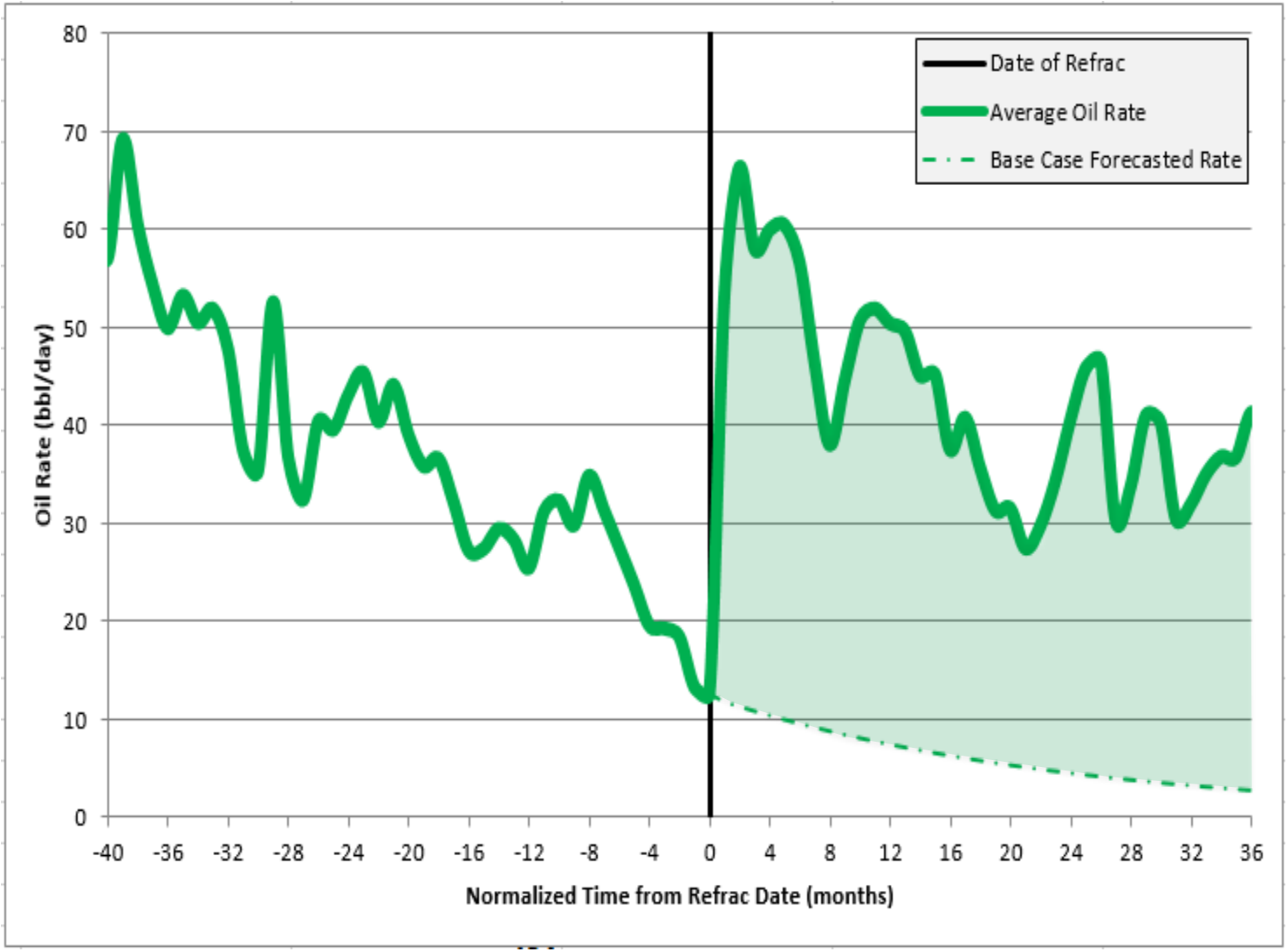
Average Oil Rate Before and After HZ Bakken Refrac



- Incremental production after 3 years ~ 40,000 bbl
- Incremental revenue after 3 years ~ $1.6 mm (@ $40/bbl)

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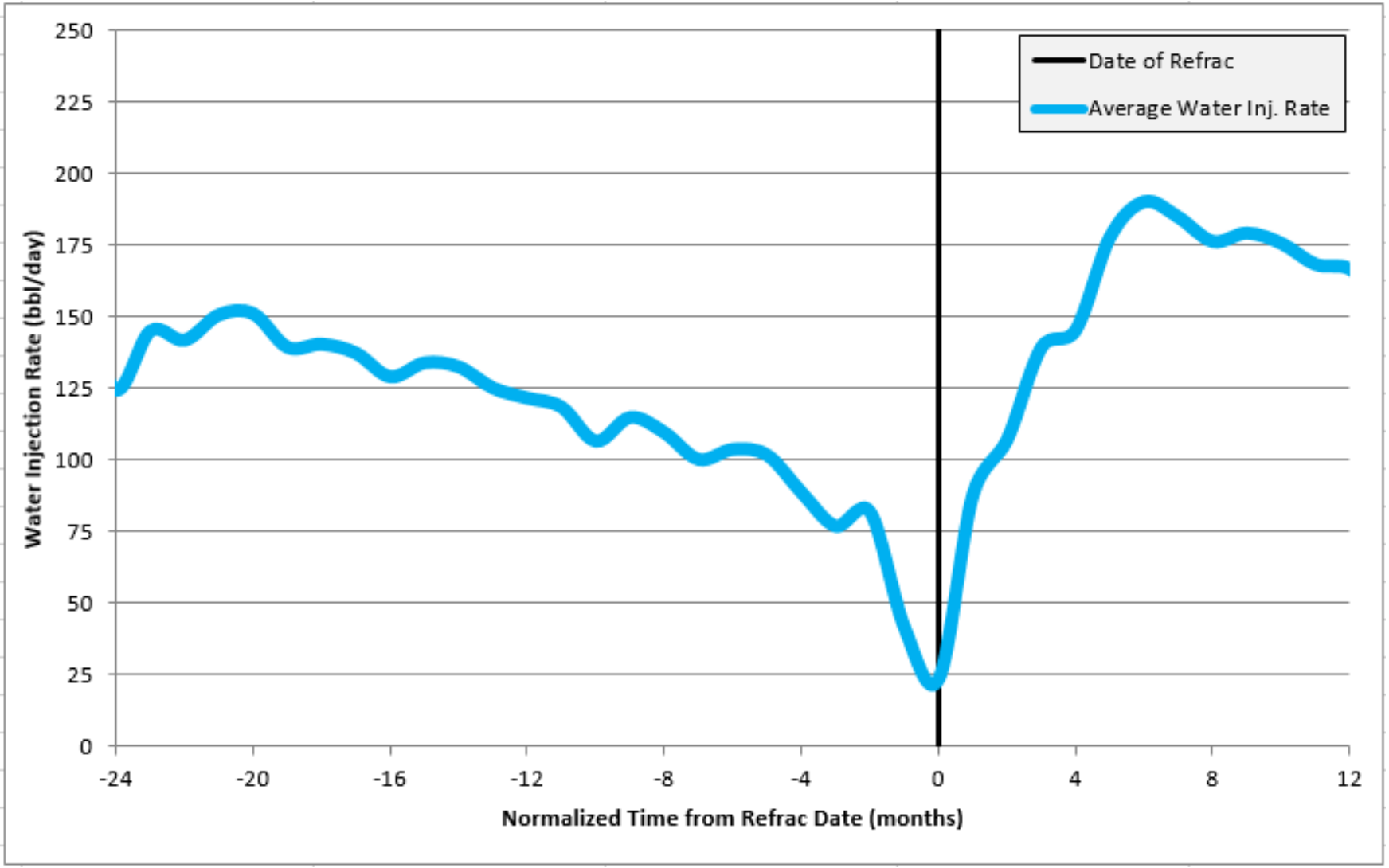
Injection Well Refracs



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Summary of Refracs in Western Canada

- More than 100 horizontal wells refractured since 2010
  - > 15 different formations
  - > 30 different operators

- Positive results in producers and injectors
  - Average IP ratio = 60%
  - Average rate increase = 40 bbl/day

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Using Historical Refrac Data

- Looking at results from historical refracs helps to:
  - Estimate expected production rates from refracturing
  - Helps refine candidate selection
  - Optimize future stimulations

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Montney Candidate Selection Example

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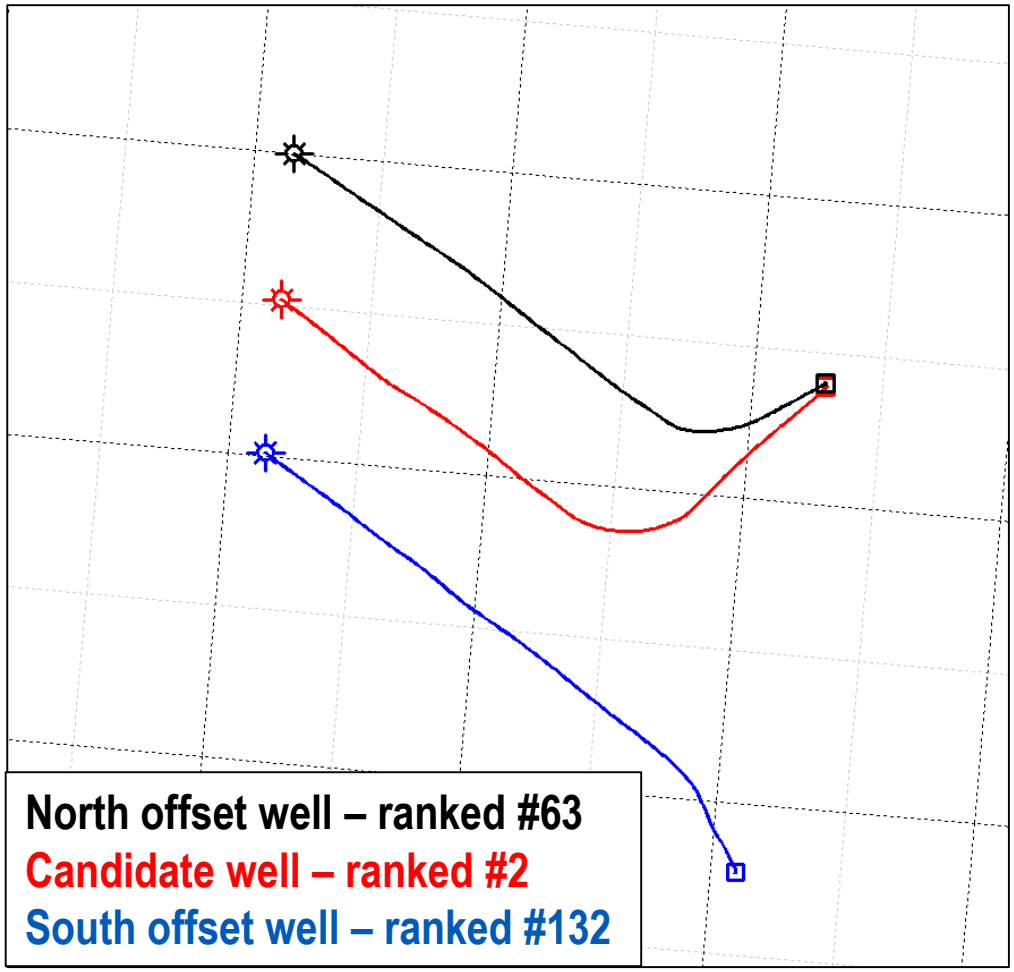
Location of Chosen Candidate Well



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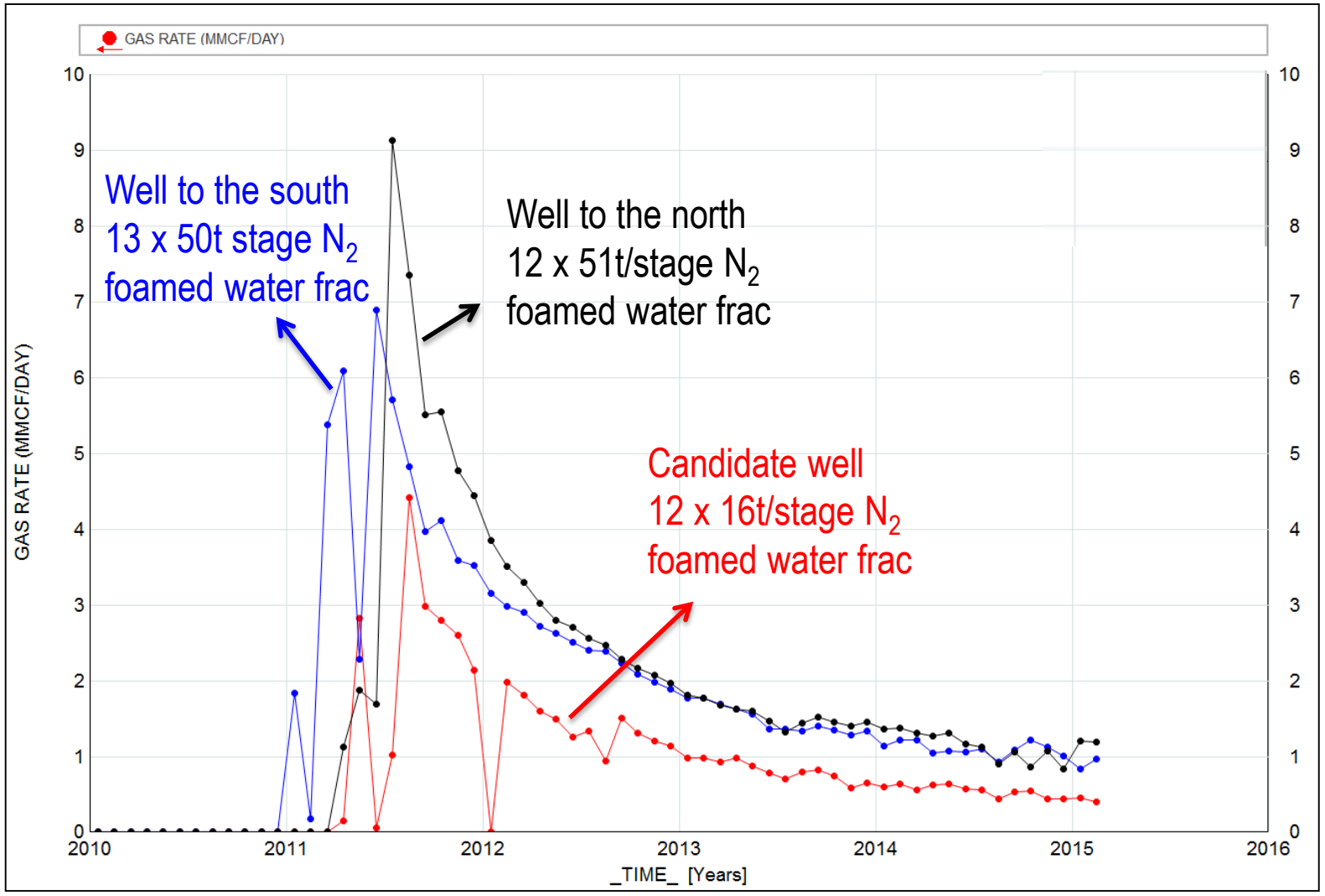
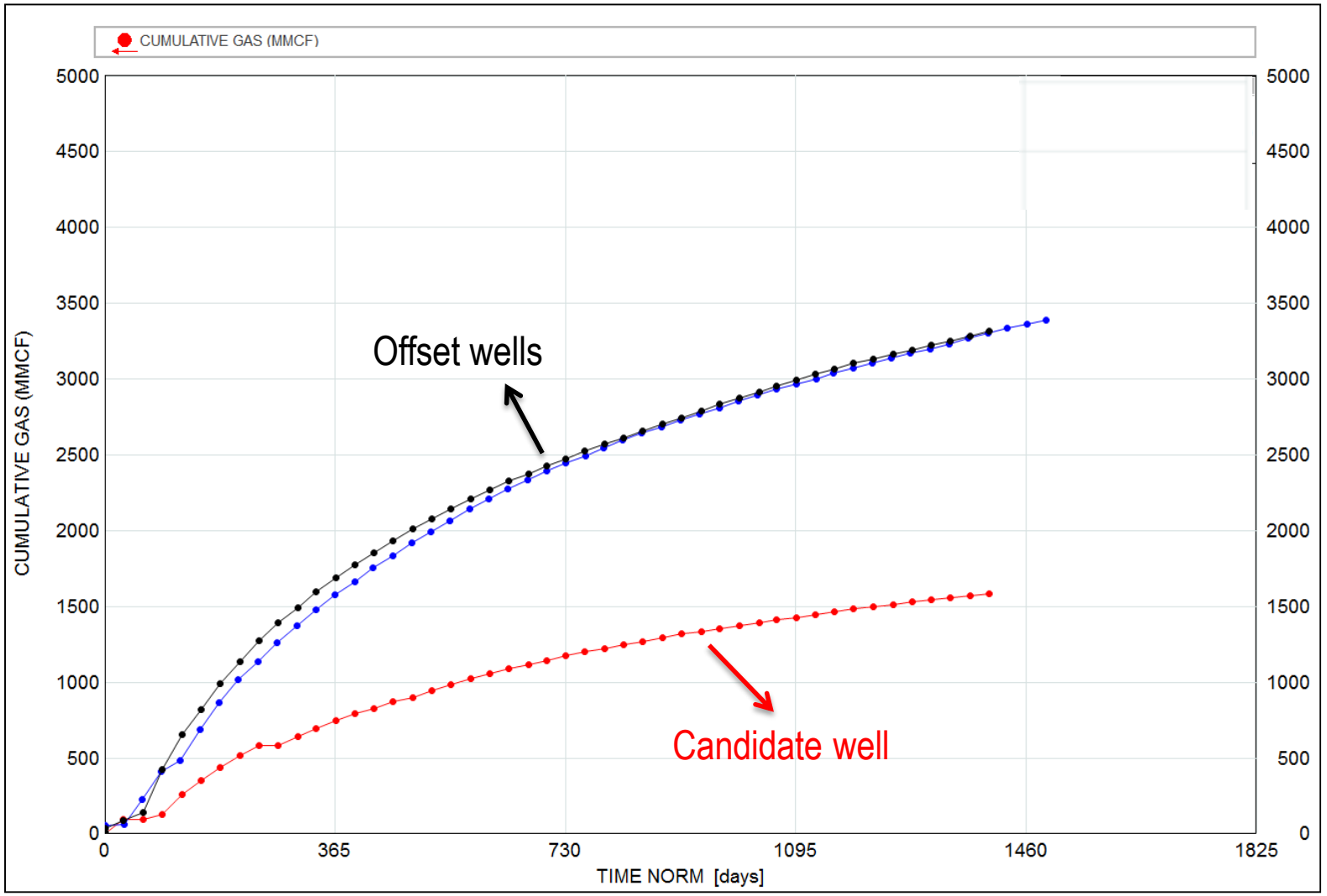
Comparing Production Declines and Completion Details



Comparing Cumulative Production



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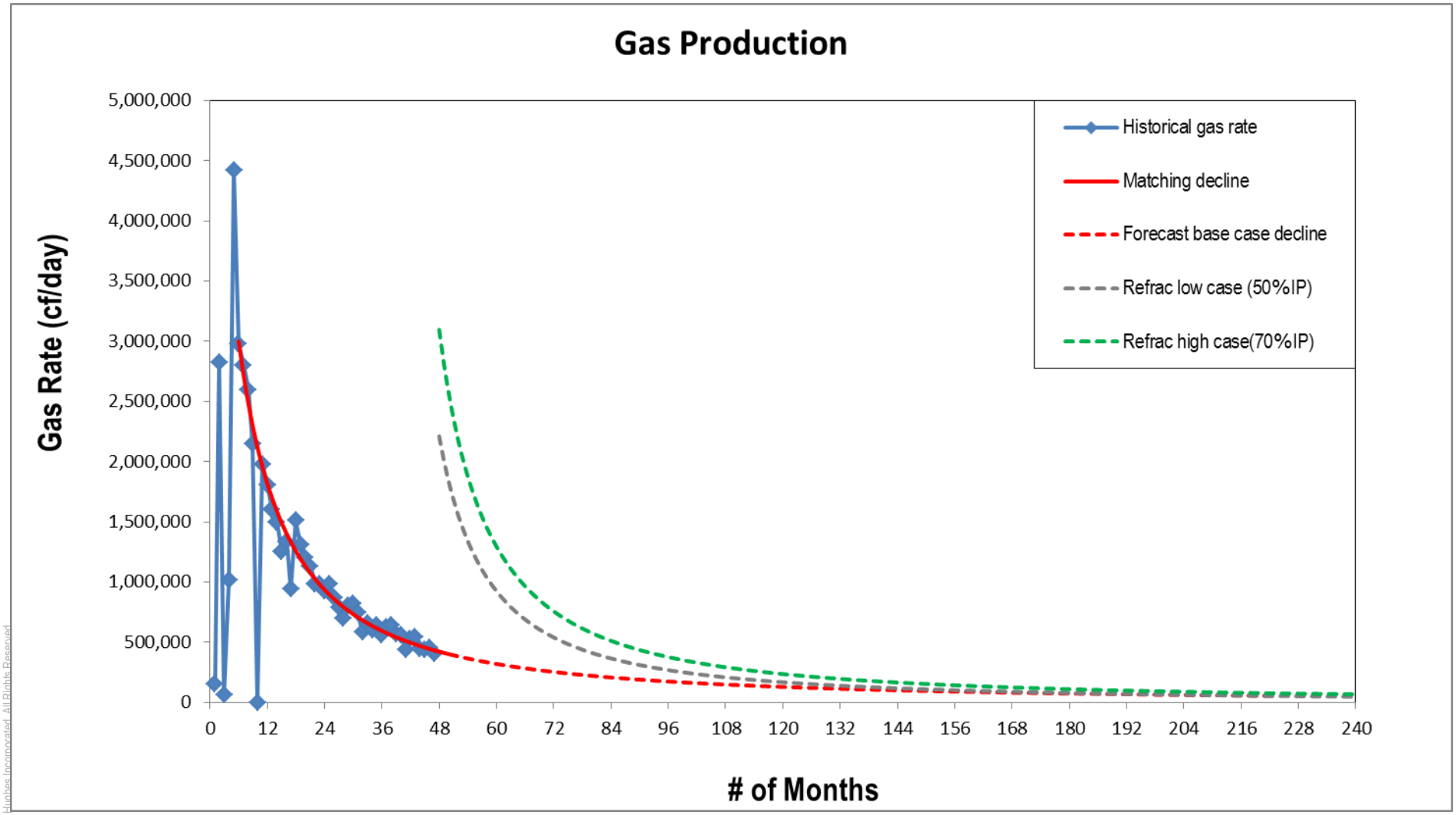
Potential of rejuvenation



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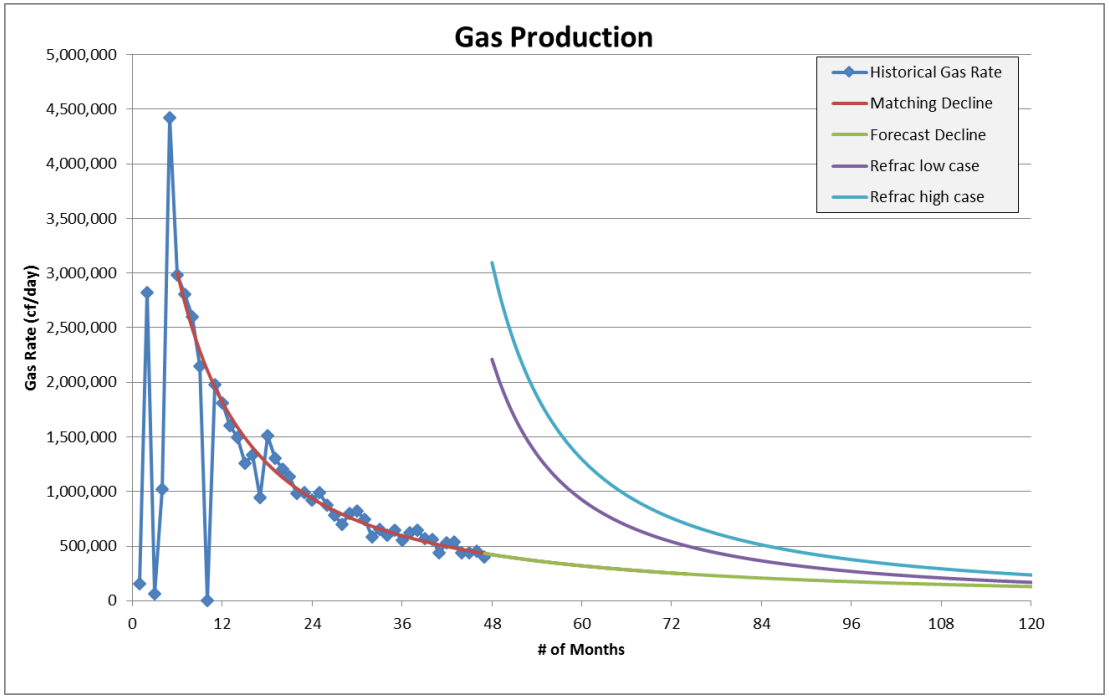
Methodology and Assumptions for Economic Analysis

- Decline analysis used to forecast base case and refrac production
- Peak rate after refrac set to 50% and 70% of IP
- Well Cost: $5MM
- Operating Costs: $3.4/boe
- Refrac Cost: $1MM



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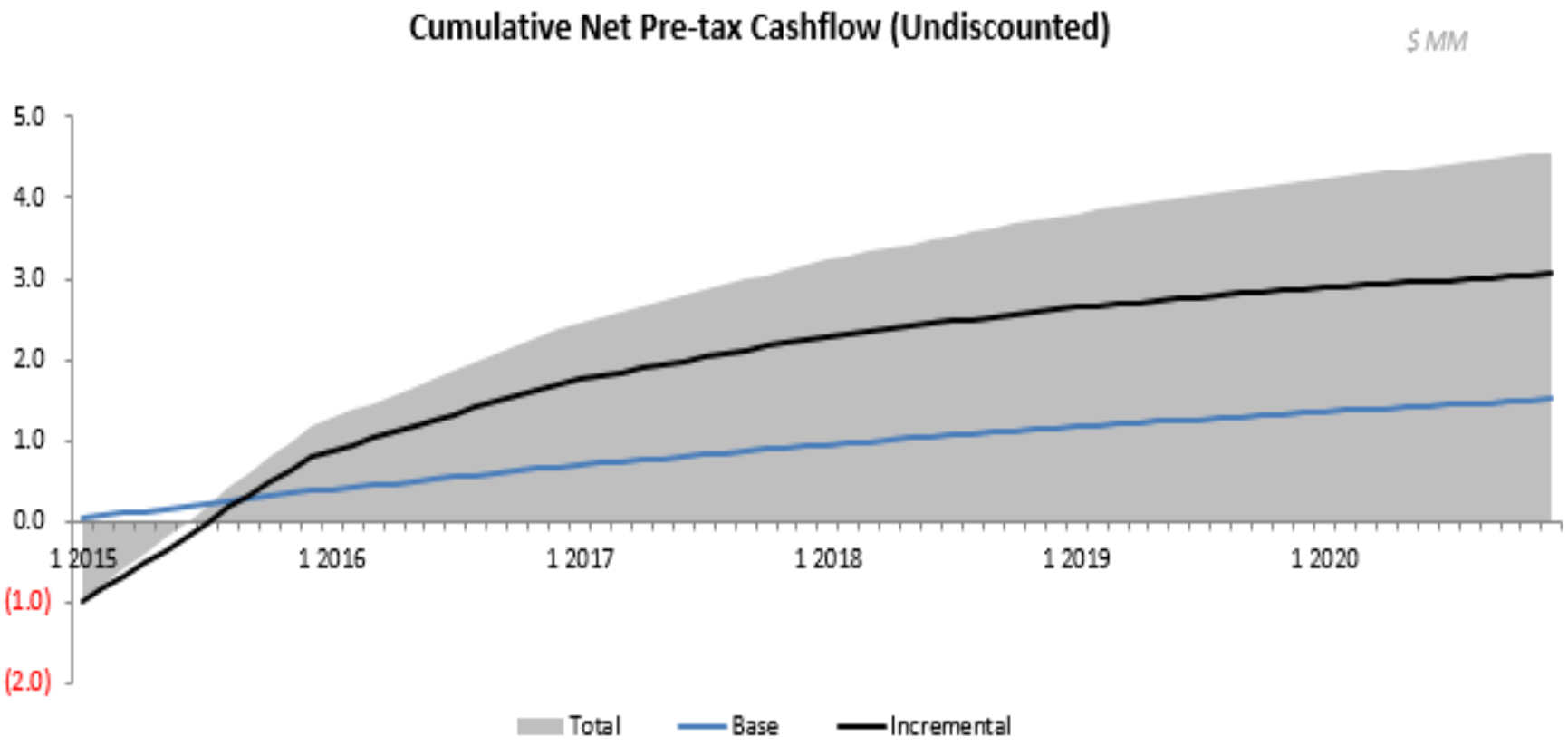
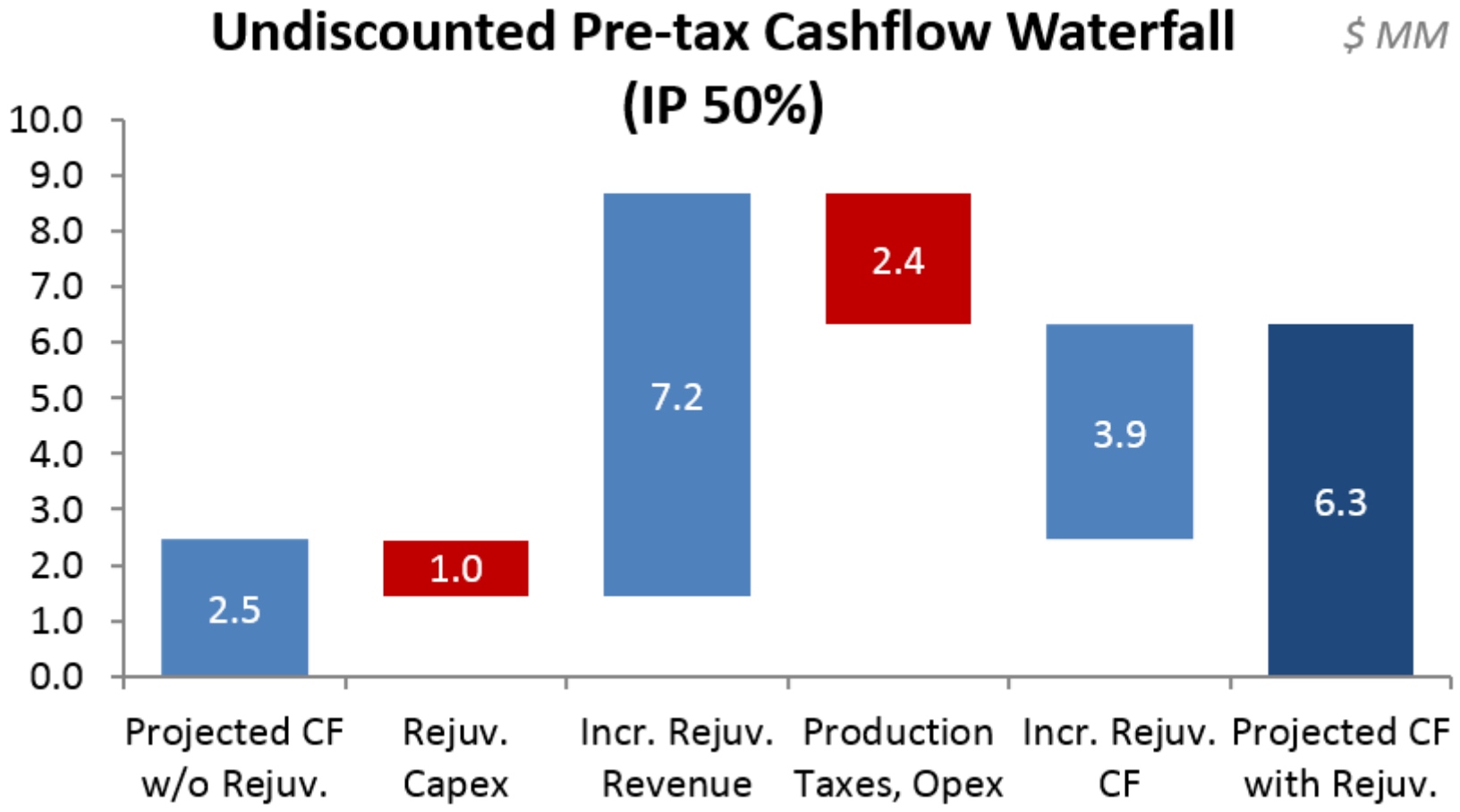
Cashflow Economic Analysis

- Payout period = 7 months



Waterfall Cashflow Economic Analysis



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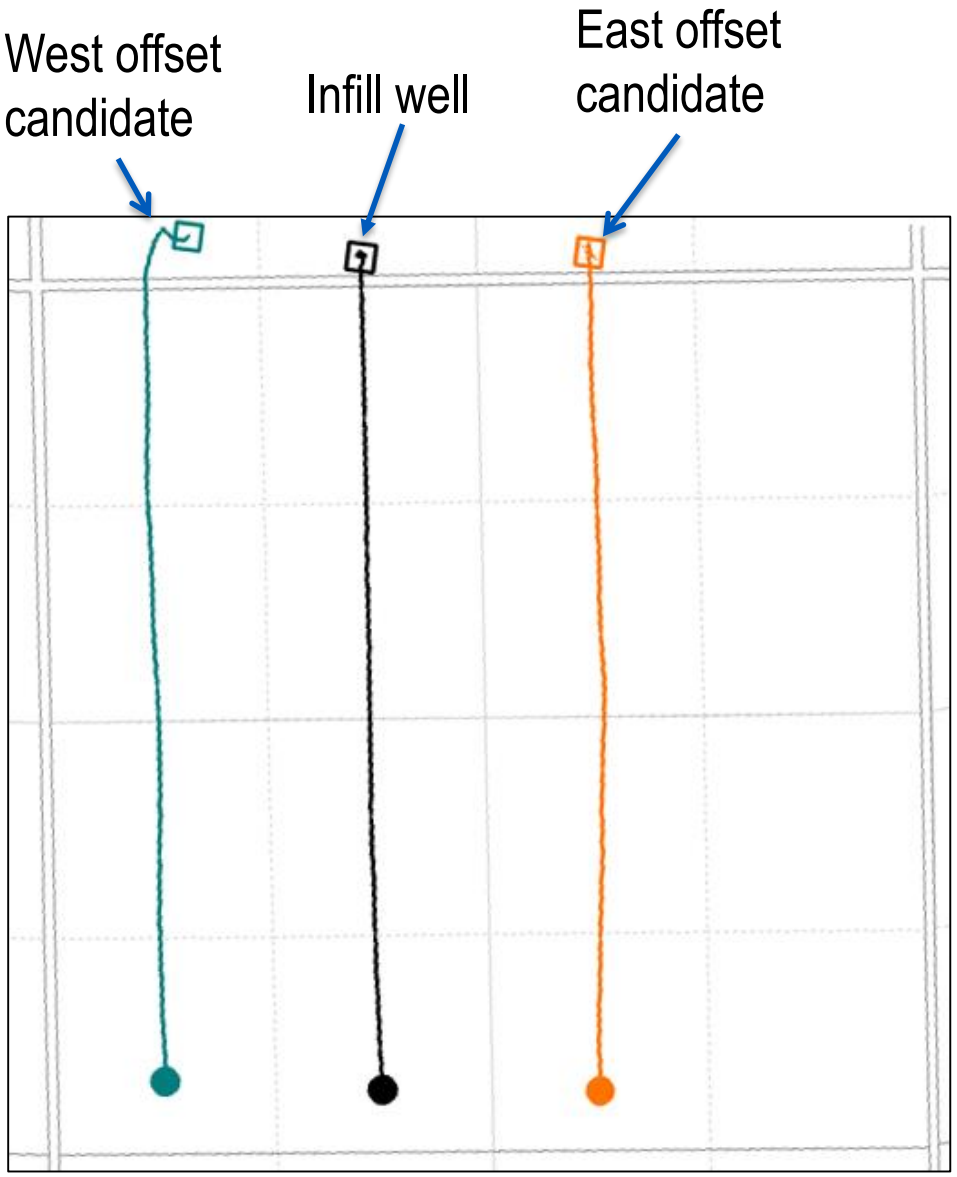
Bakken Candidate Selection Example

Location of Top Candidate Wells



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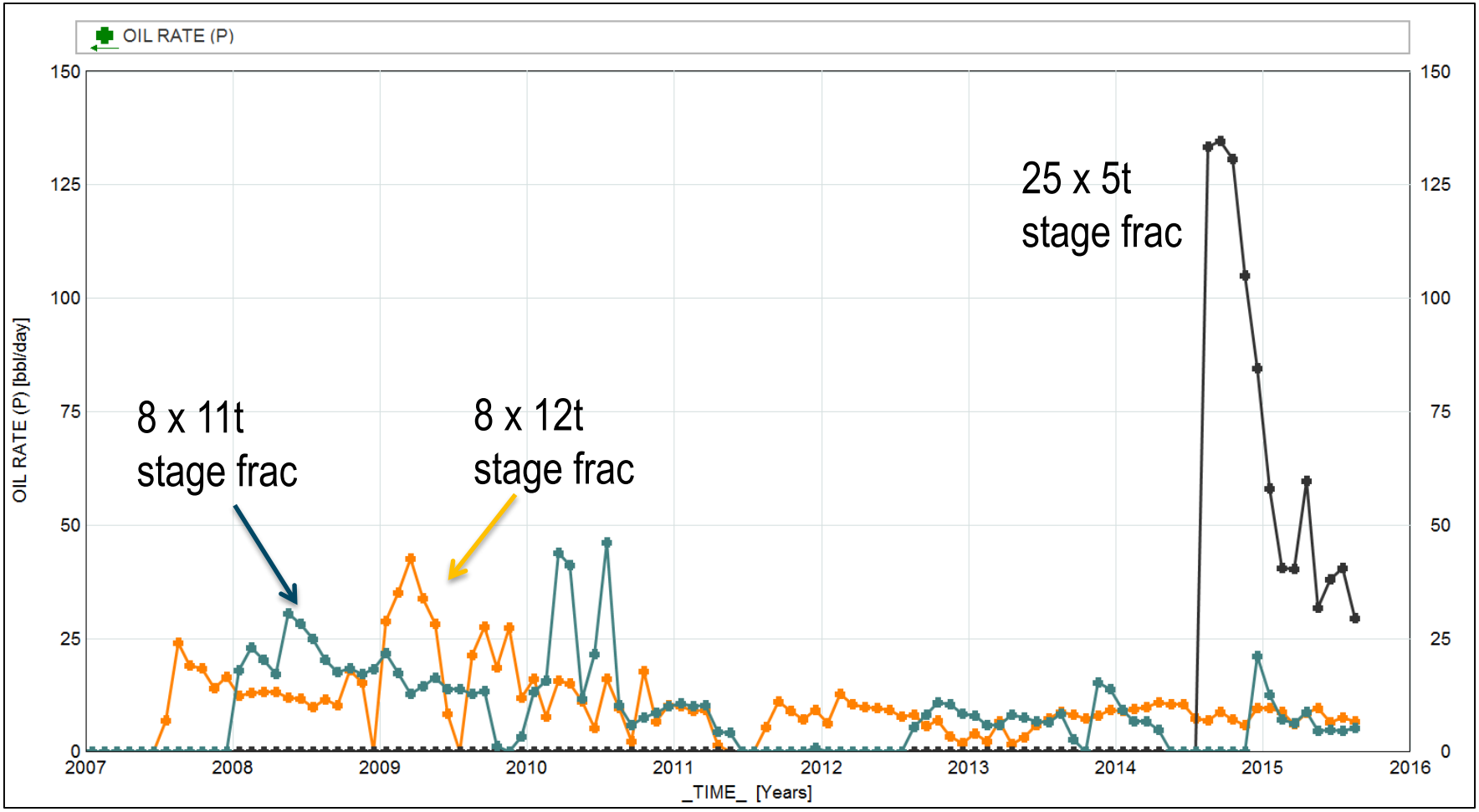
Production of Potential Candidates and Infill Well



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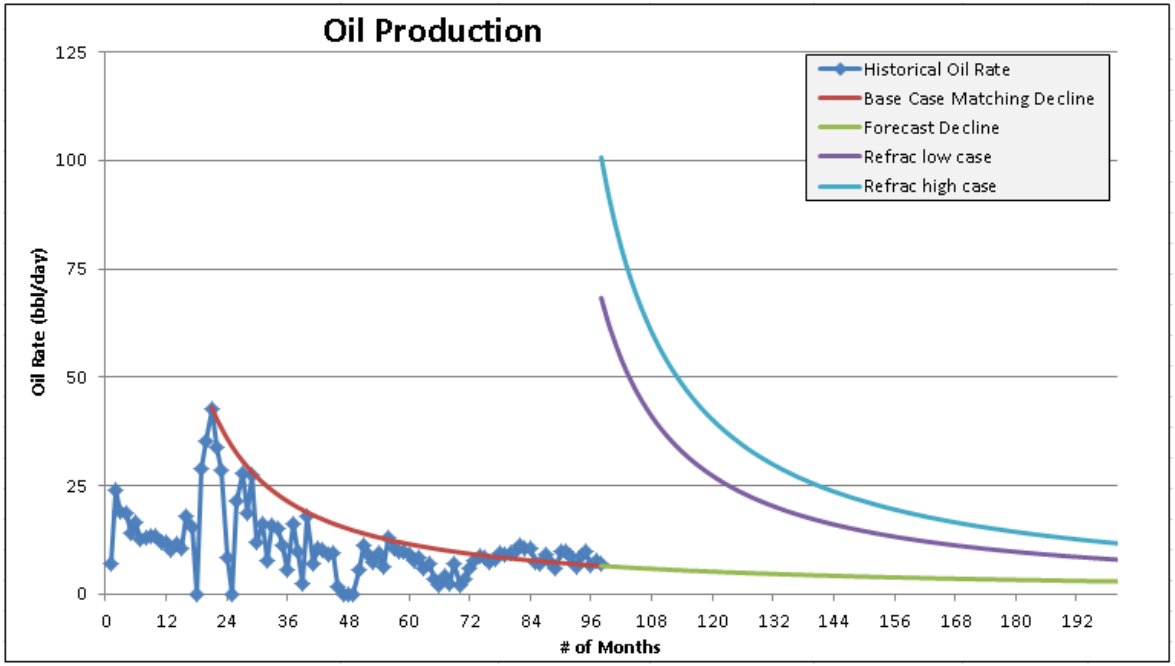
Methodology and Assumptions for Economic Analysis

- Decline analysis used to forecast base case production and production after refrac
- Peak rate after refrac set to 50% and 70% of IP of infill well with 25 stages
- Well Cost: $2MM
- Operating Costs: $9/boe
- Refrac Cost: $0.5MM



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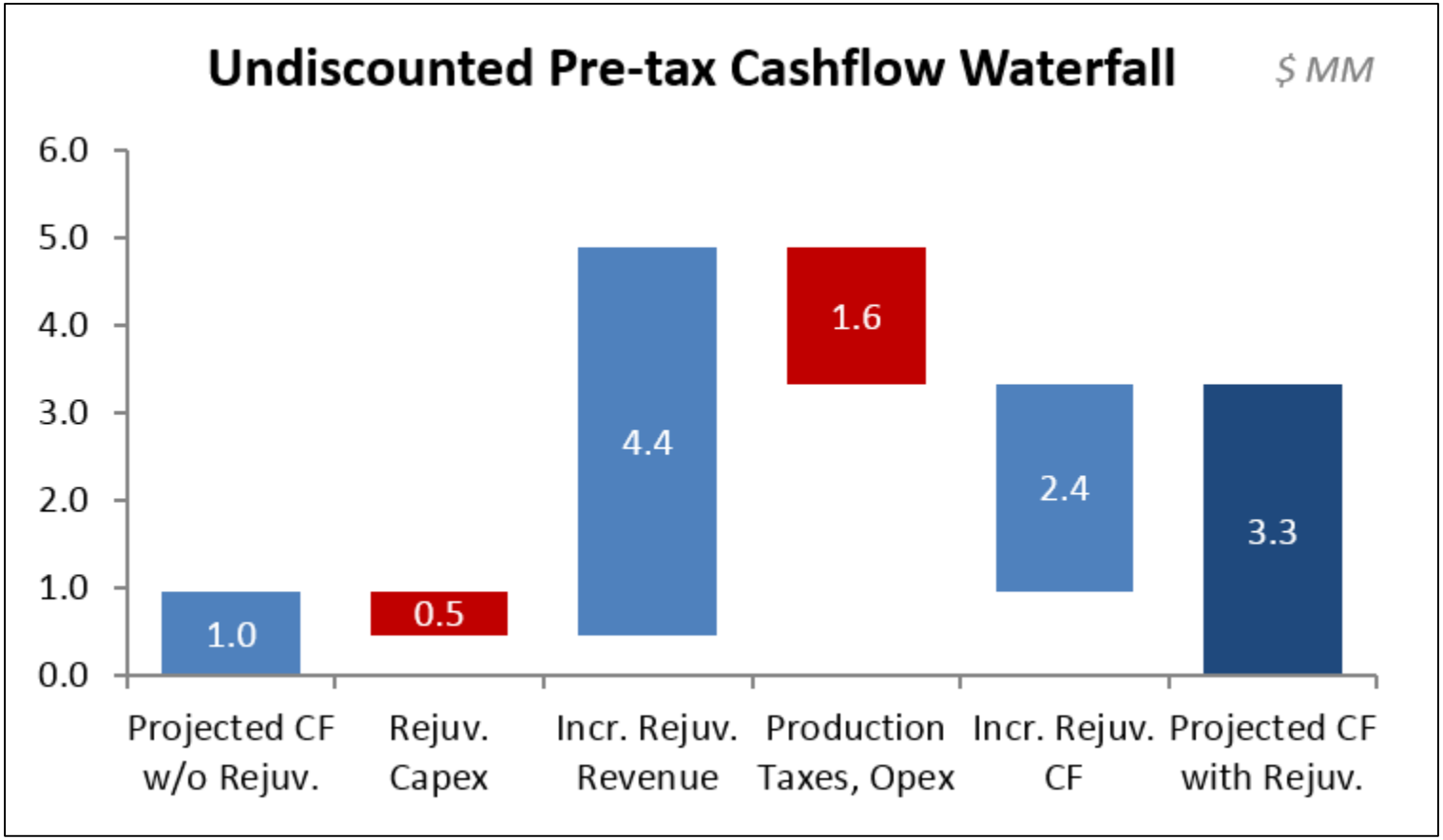
Waterfall Cashflow Economic Analysis

- Payout Period 10 months @ $40/bbl oil



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Final Observations

- Refracing is a data driven approach
- Candidate selection is paramount and most important
- Know your refrac objectives before designing a solution
- More calculated approach to each well
- Stimulate new intervals and reconnect to currently producing zones
- A thorough understanding of your candidate well is necessary for refrac success

- For questions please contact Tim Stephenson (Tim.Stephenson@bakerhughes.com) or Dawn Nagazina (Dawn.Nagazina@bakerhughes.com)

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