Efficient Resource Development – Think Deep!

CSUR Technical Luncheon Series

December 5, 2012

CALFRAC WELL SERVICES

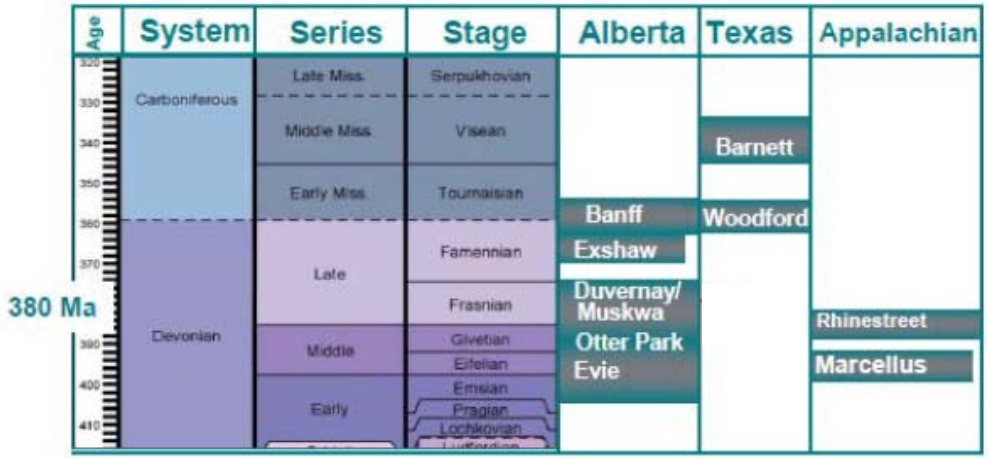
Presentation Outline

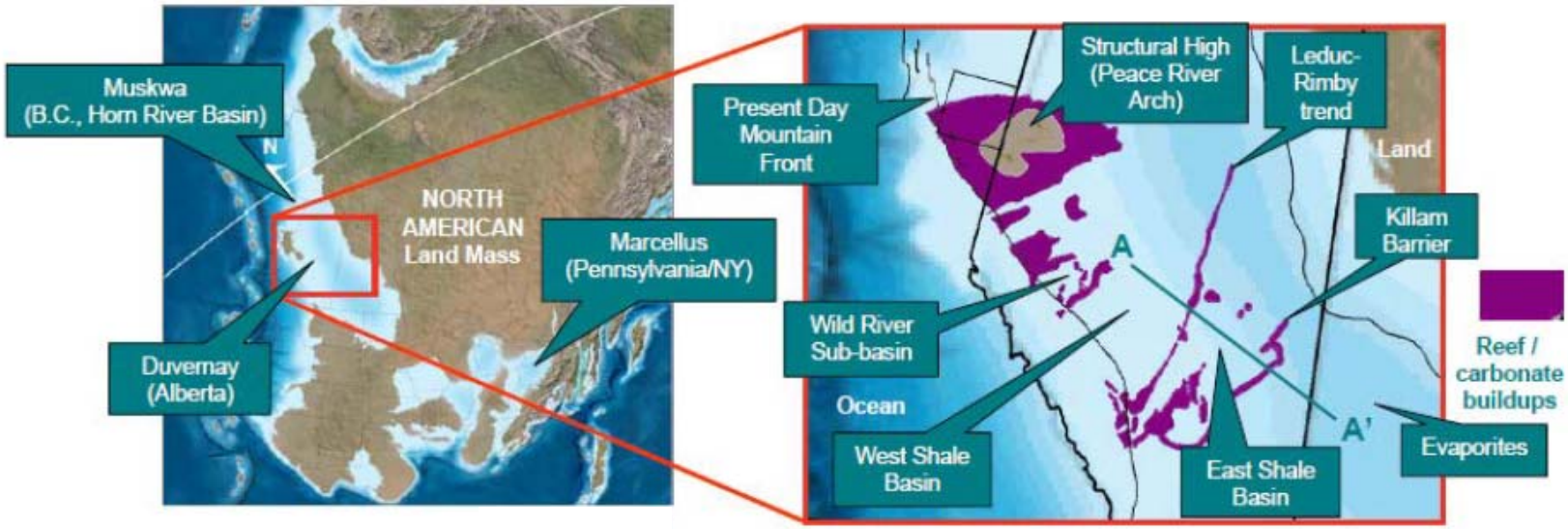
- The Duvernay
  - Introduction
  - Duvernay Overview
  - Activity Summary 2011/2012
  - Greater Kaybob Area Focus
- Wellbore Design Considerations
- Optimizing Treatment Design
- Operational Efficiencies
- Concluding Remarks
- Questions

Efficient Resource Development

- One of Canada's most prolific resource plays
- Over $4.5B spent on land sales in the last three years
- Associated high drilling and completion costs
- Economic viability of the play is front and center
- Drilling and completion efficiencies are proving to be instrumental at this stage
- Preliminary learnings will be critical to the long term development of the play

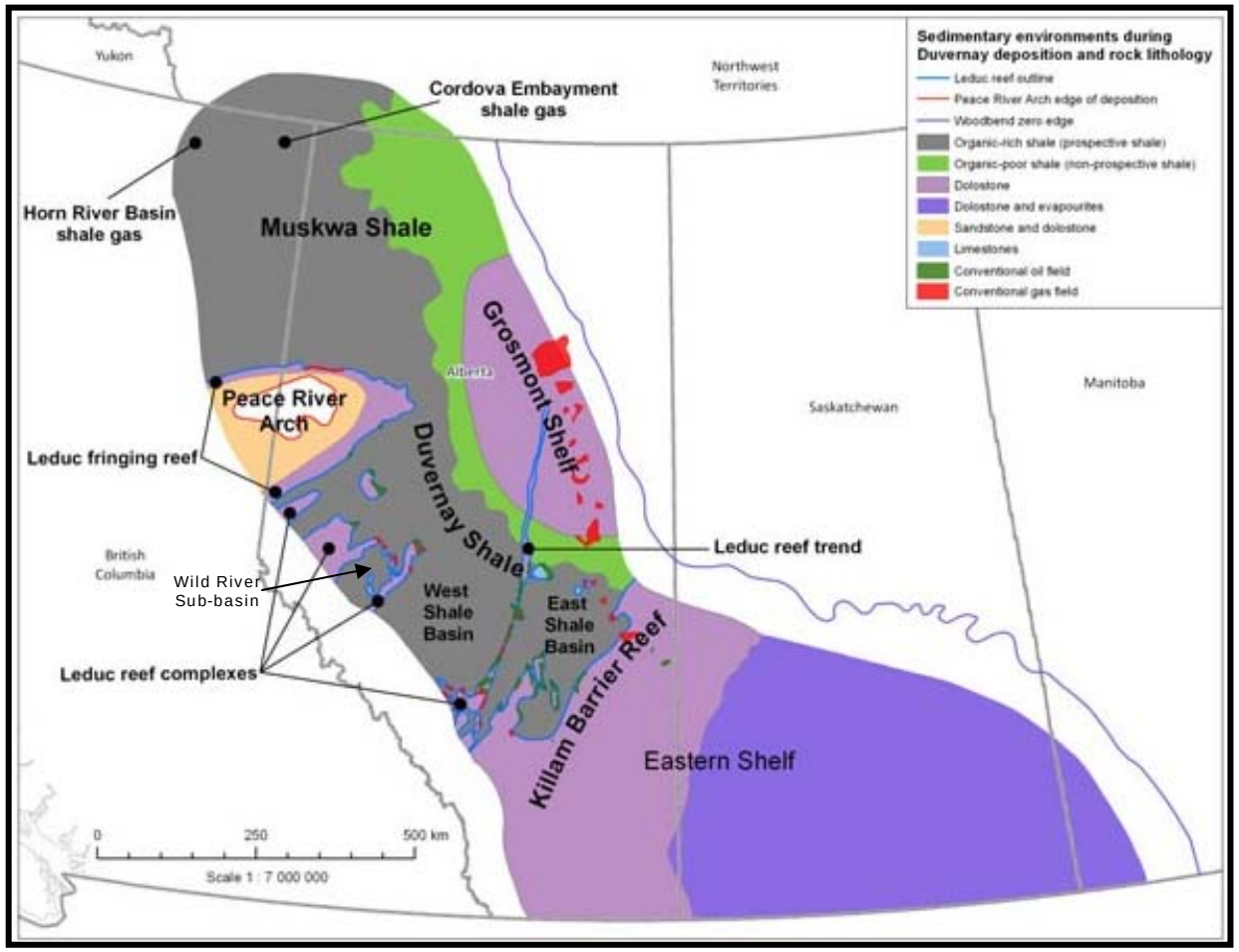
Duvernay Overview





Blakey http://jan.ucc.nau.edu/~rcb7/namD385, Dunn, L., Schmidt, G., Hammermaster, K., Brown, M., Bernard, R., Wen, E., Befus, R., and Gardiner, S.

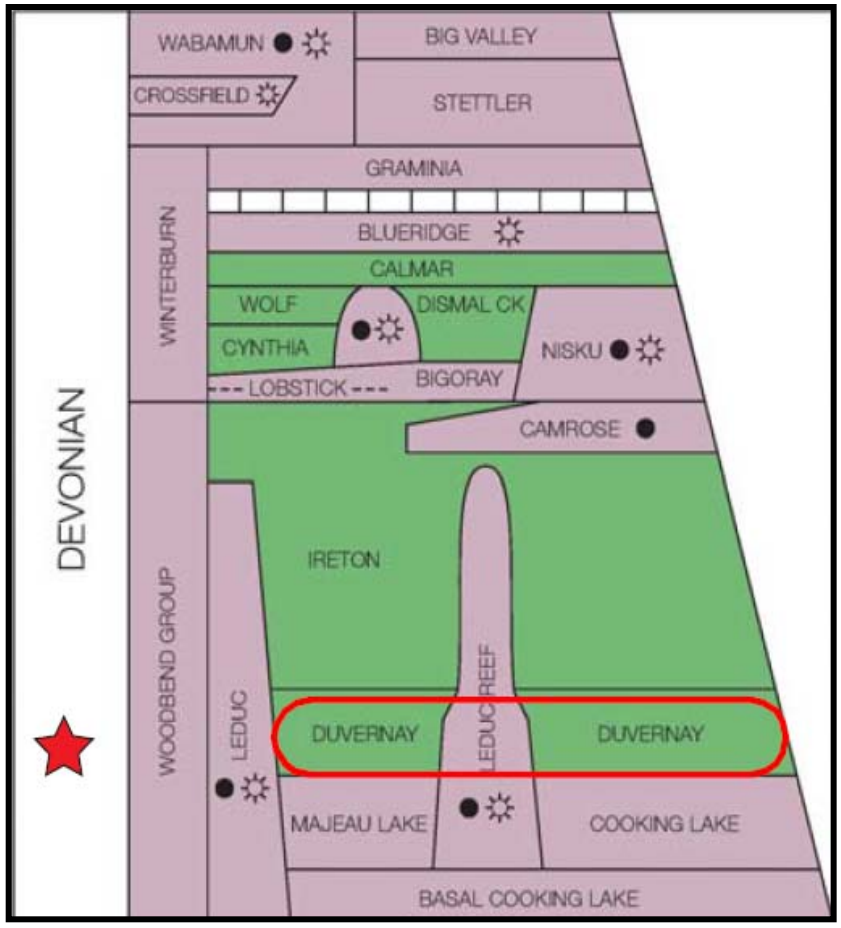
Depositional Play Extent



Source: modified from *Atlas of the Western Canada Sedimentary Basin*

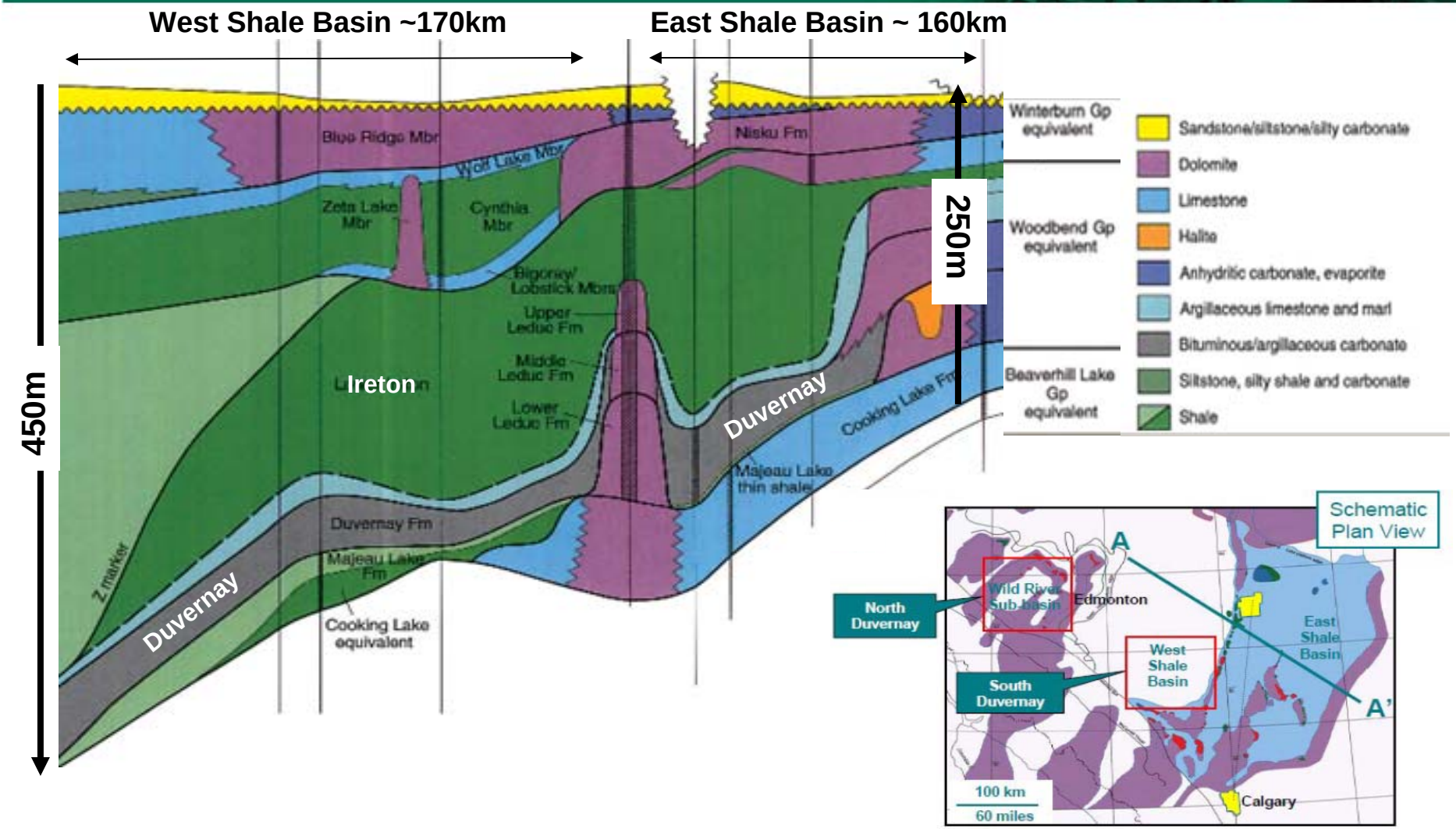
- Extent >100,000 km^2
- VR_o% Equivalent Maturity ~ 24,000 km^2
- Liquids-rich resource est. 2-5B bbls of liquid
- Liquids-rich window est. 7,500 km^2
- ~750 Tcf of gas

Duvernay Key Attributes



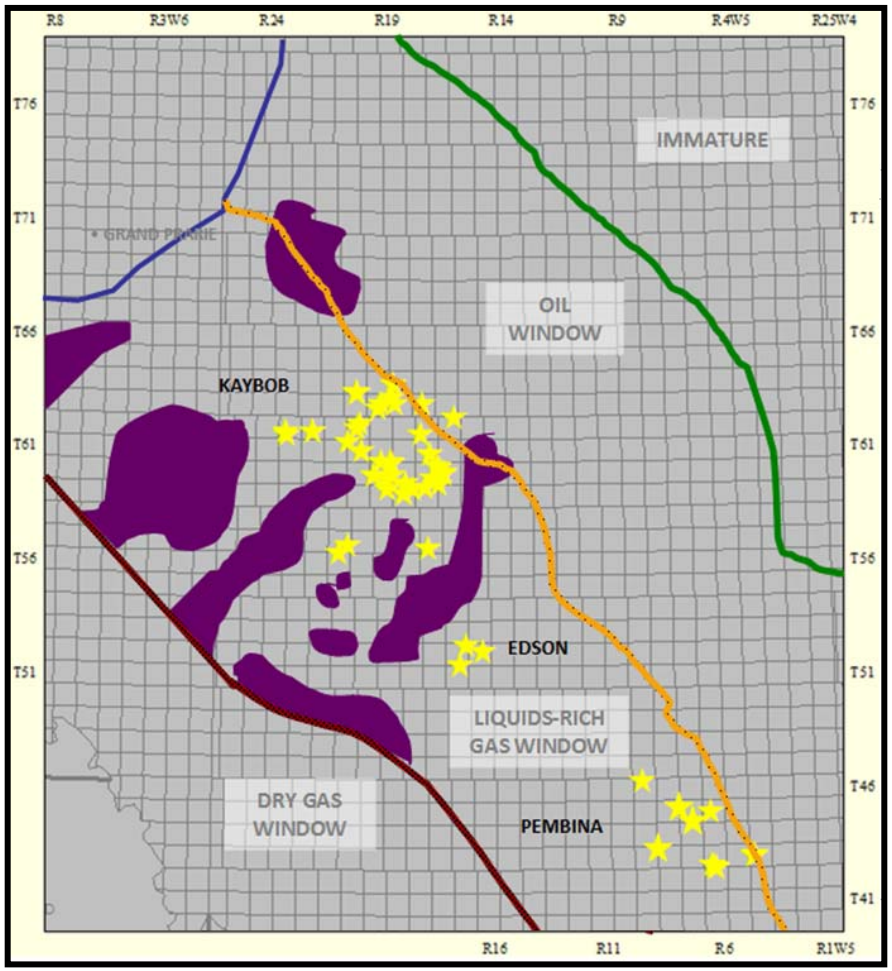
- Depth: 2400-4000m
- Thickness: 10-70m
- TOC: 1-20%
- Porosity: 3-15%
- Permeability: nD to µD
- Complex Mineralogy
- Pressure: Normal to Overpressured

Duvernay Overview



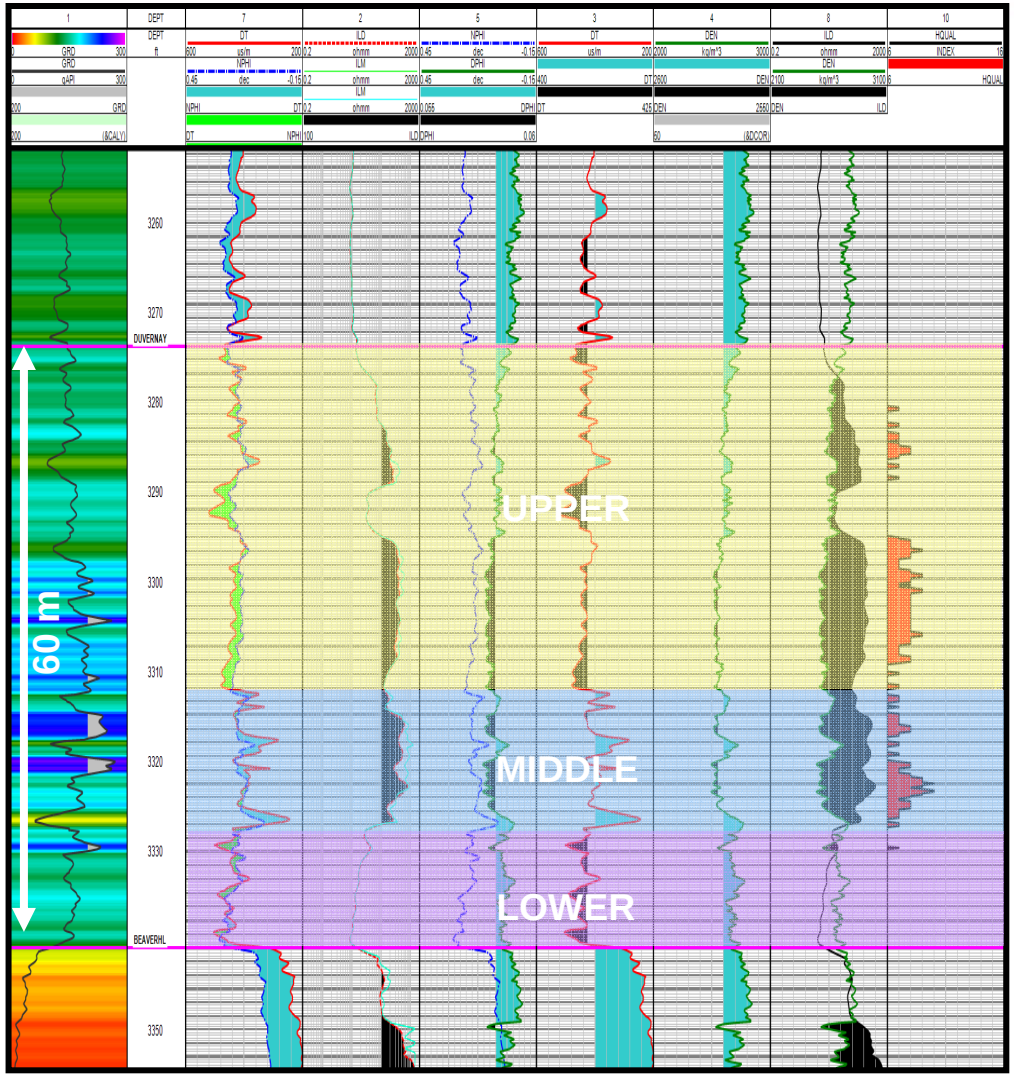
Switzer et al., Dunn, L., Schmidt, G., Hammermaster, K., Brown, M., Bernard, R., Wen, E., Befus, R., and Gardiner, S.

Duvernay Activity – 2011/12



- >50 Wells drilled to date
- ~ 17 Vertical Wells
- ~ 10 HZ Drilled and Completed 2011
- ~ 23 HZ Drilled and Completed in 2012

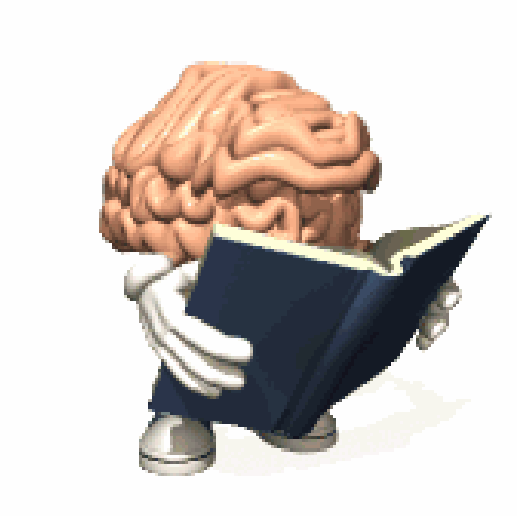
Kaybob Area – Key Attributes



- Depth 3200-3800m
- Thickness 35-60m
- Maturity 1.2-1.8%
- TOC - ~4.5%
- Mineralogy
  - Quartz content 1-47%
  - Carbonate content 10-90%
  - Clay content 3-37%
- Average Porosity ~6.5%
- Average Permeability ~400nD
- Pressure Gradient 15-20 kPa/m

Reservoir Impact….Think Deep!

- Heterogeneity
- Stress Environment
- Lateral Placement / Orientation
- Fracture Initiation
- Fracture Complexity
- Fracture Width
- Fracture Conductivity
- Deliverability



Applying What We Know…..

Activity Overview

Duvernay - Per-Well Estimated Characteristics by Operator

	Drilling Costs [C$mm]	Liquids Cut [Bbls/MMcf]	Gross EUR [Raw Bcf/Bcfe]	Wells/ Section
Celtic	$10.5	100 to 125	6.6 to 7.2 Bcfe	4 to 8
Trilogy	$12.0	80 to 100	5 Bcf	6 to 8
Yoho	$10.0	100 to 150	4.3 Bfc	6 to 8
Enerplus	$12.0	75 to 100	3.5 Bcf	4
Mako	$12.0	100	5.8 Bcfe	-
Angle	$12.0	50 to 200	2.5 to 6.8 Bcf	-
Encana	$15.0	100+	3 to 6 Bcf	-

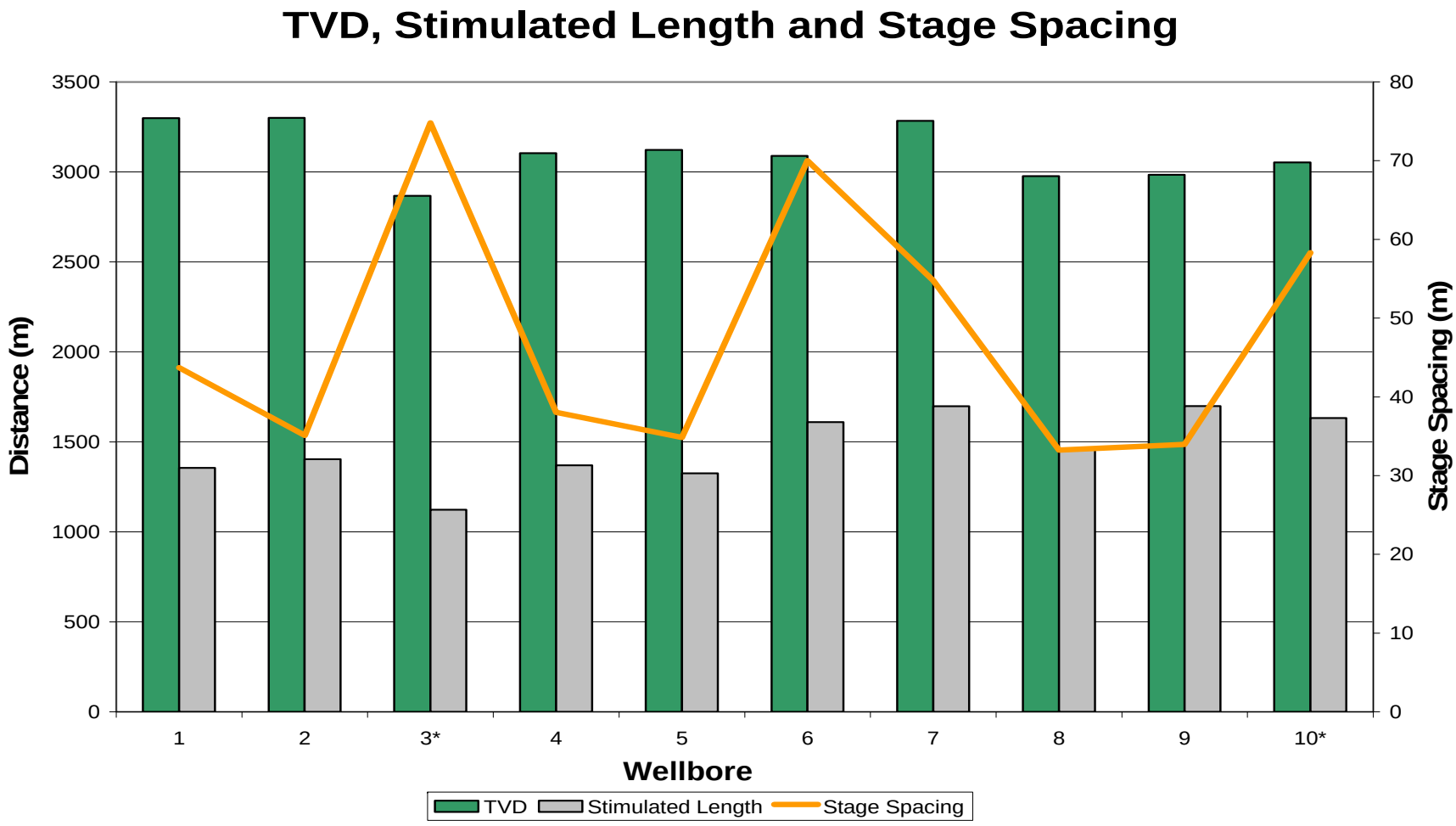
Notes:Approximations based on company disclosure and public data.

Source: Scotiabank GBM; Company reports

Activity Overview

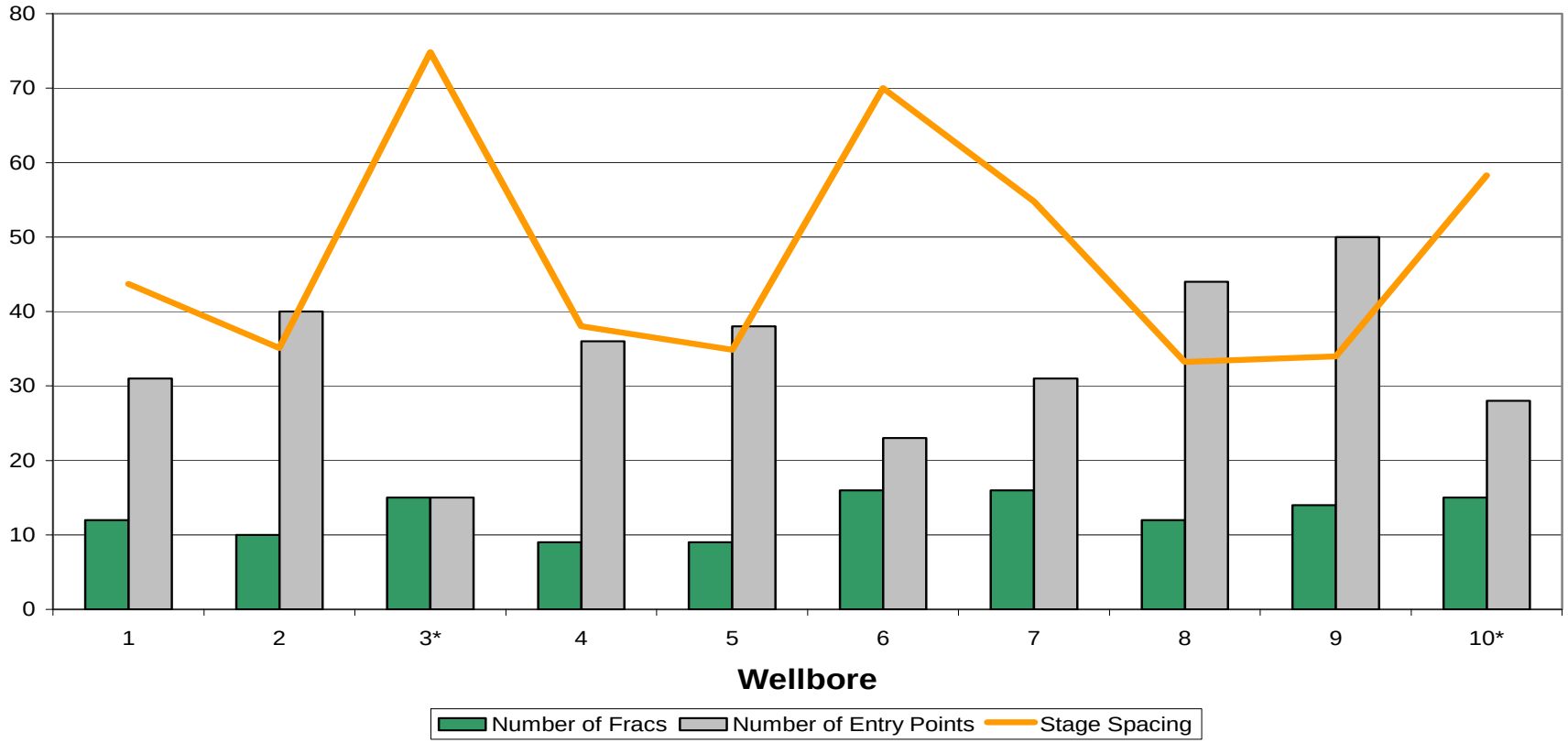
- 10 wells in study area
  - 2 completions ongoing
- 6 Plug and Perf, 4 open Hole
- Single and Limited entry perforation strategies
- Various fluid systems
  - Slickwater, X-Linked and Hybrid
- Various Proppants
  - 50/140, 40/70 and 30/50
  - Mostly naturally occurring although some resin or ceramic tail-ins
- 2-20 m^3 acid/stage

Activity Overview



Activity Overview

Number of Fracs, Number of Entry Points and Average Stage Spacing



Activity Overview

Wellbore Treatment Volumes

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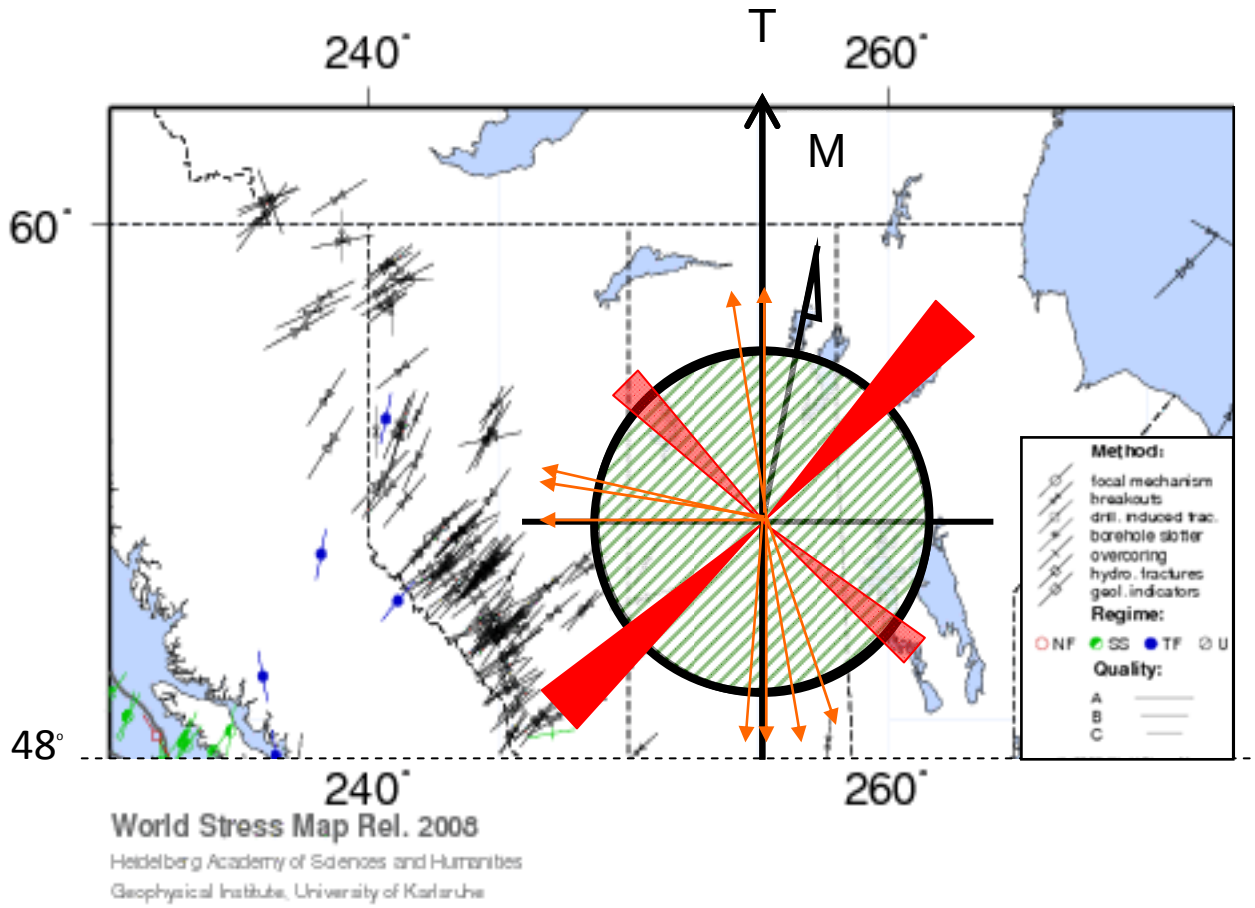
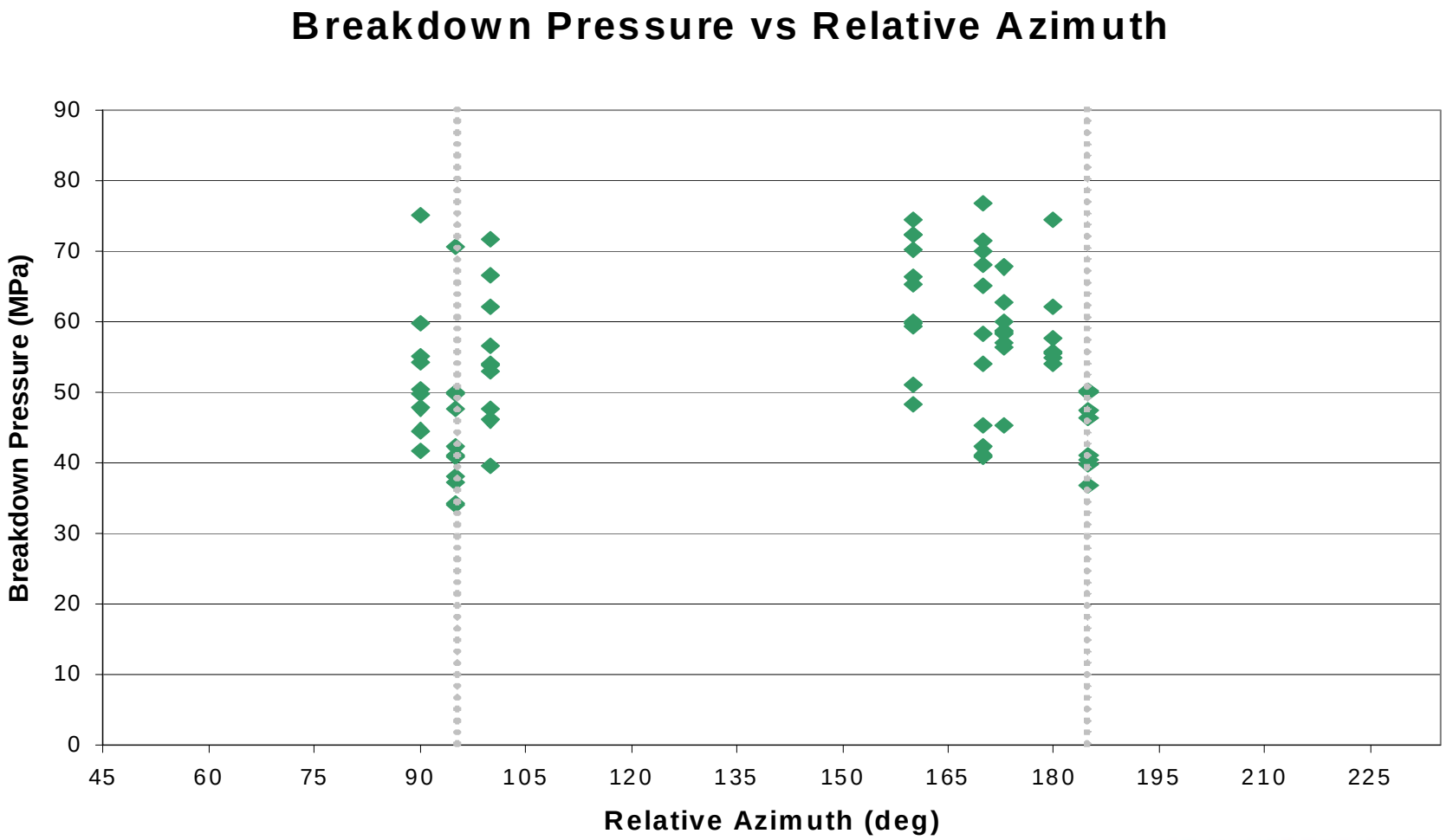
Wellbore Design Considerations

- Lateral Positioning
  - Azimuth
  - Lithofacies
- Wellbore Configuration
  - Cased vs. Open Hole
  - Perf Strategy
  - Tubular Specs

Lateral Orientation



Lateral Orientation



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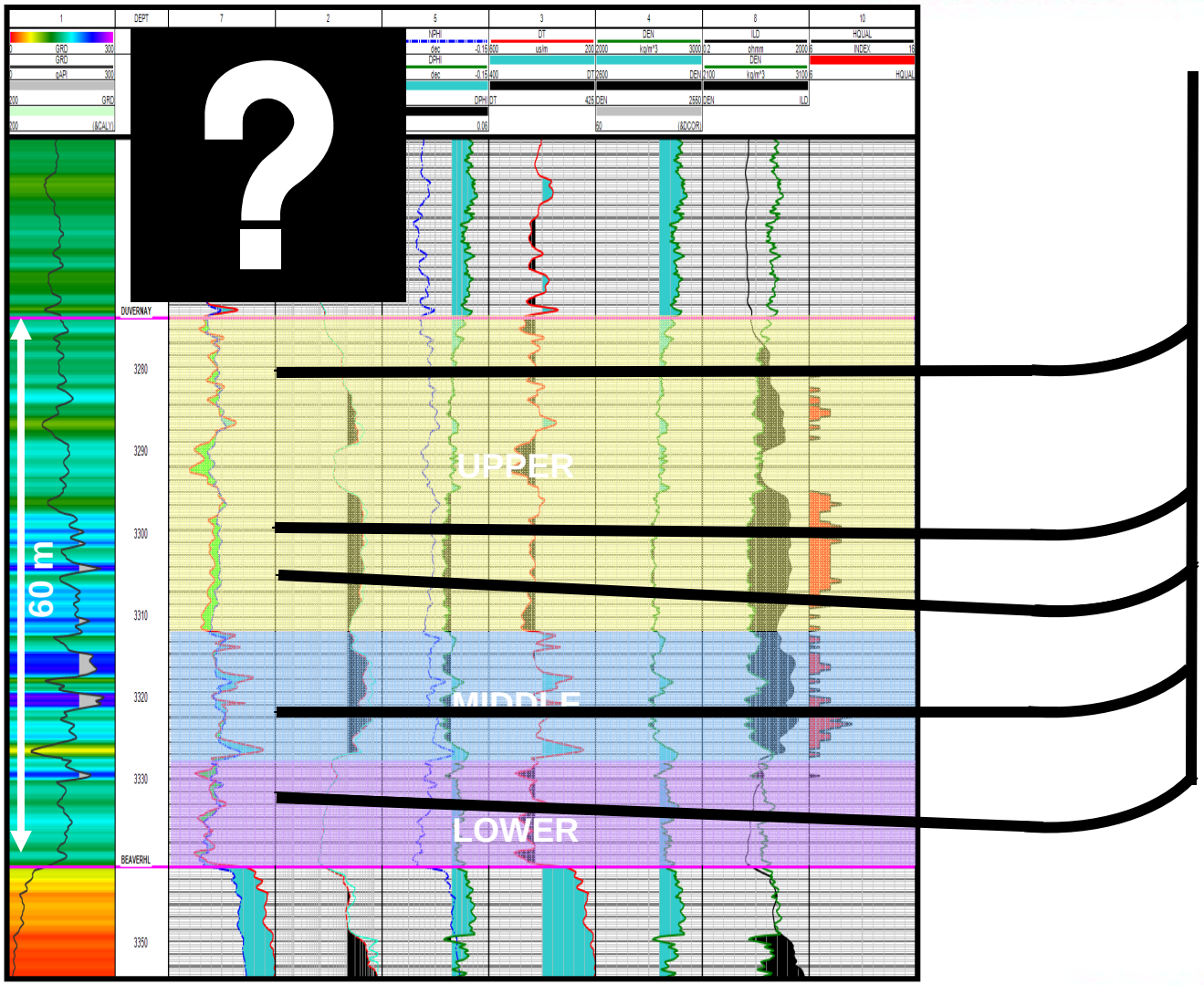
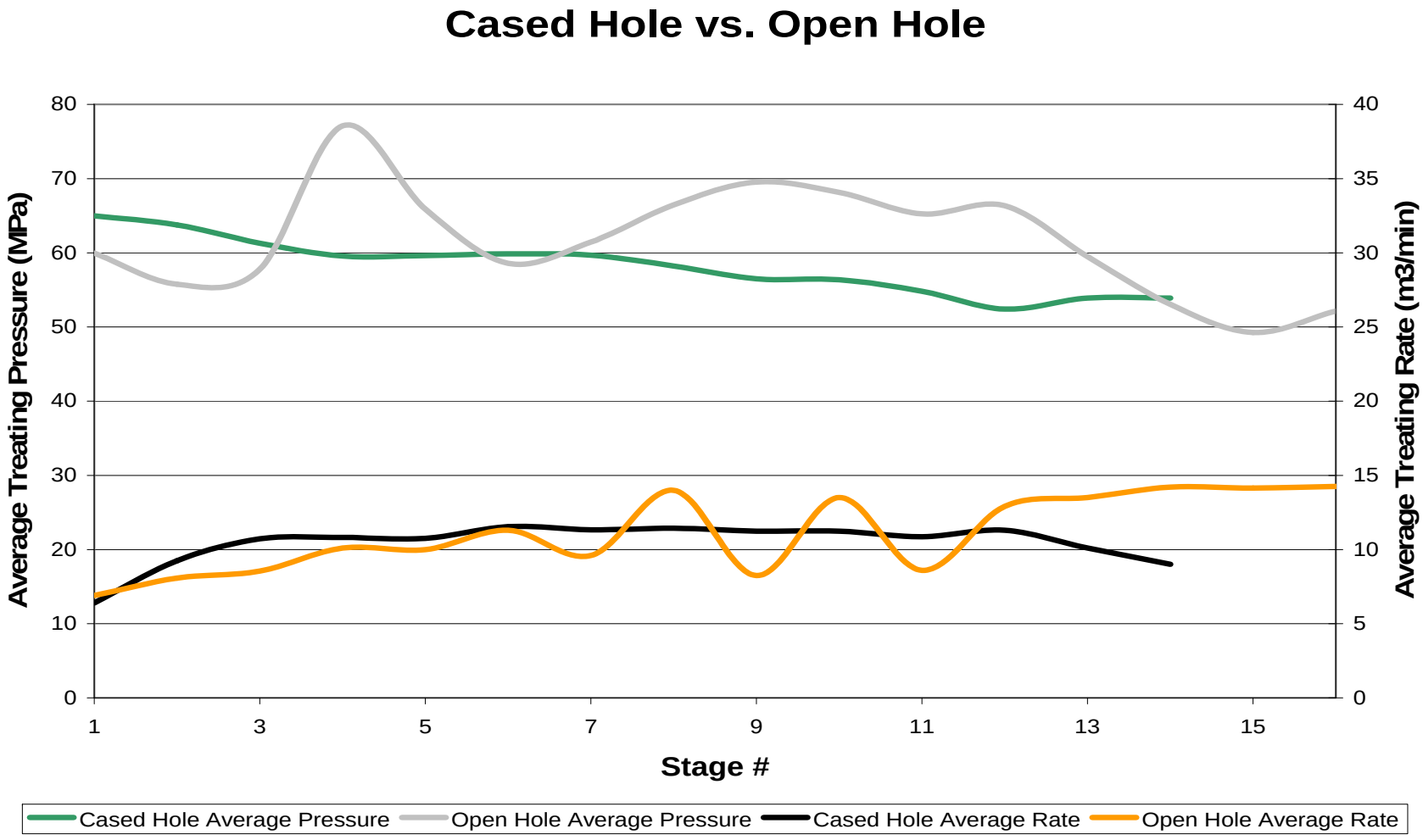
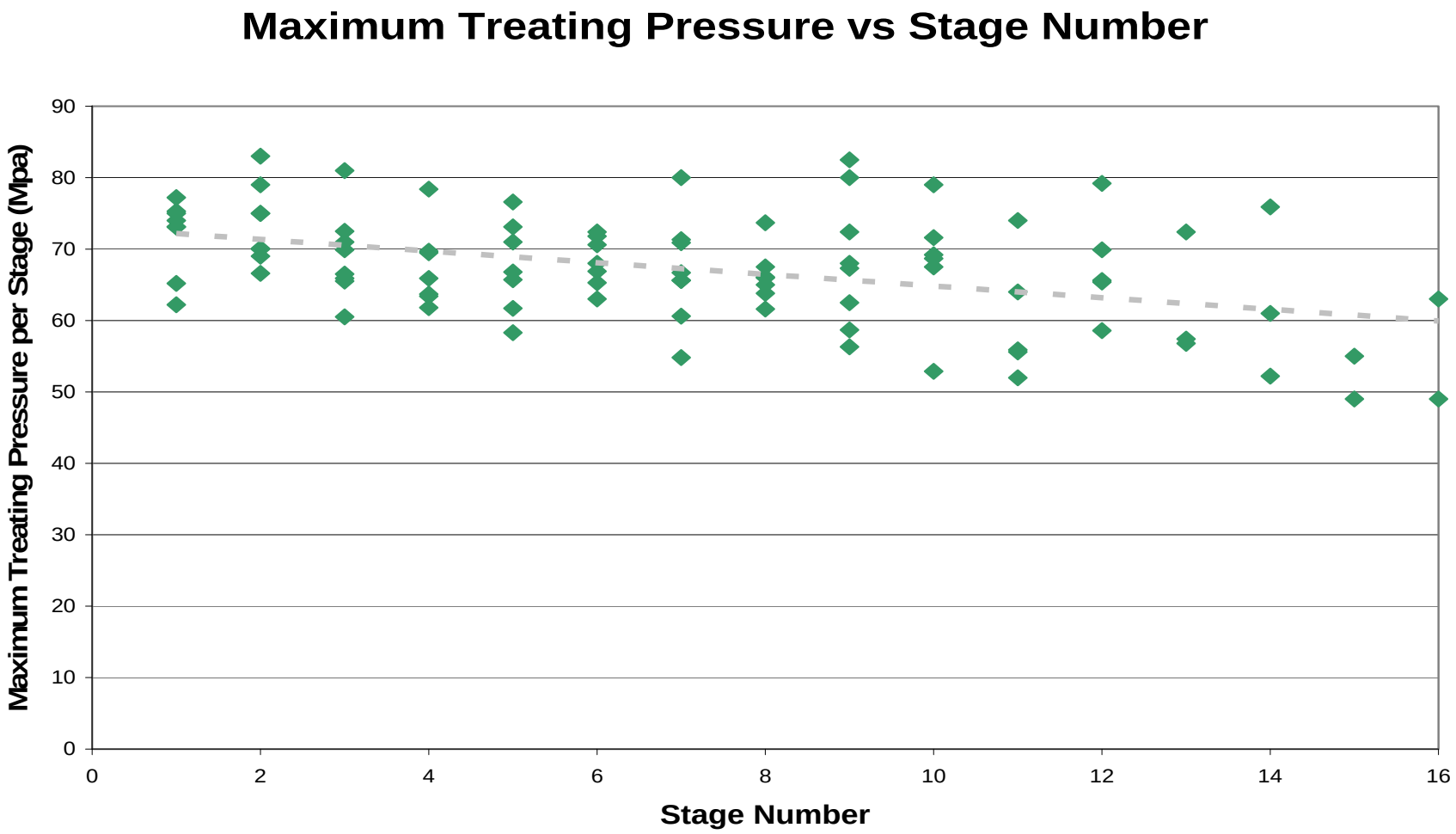
Lateral Placement



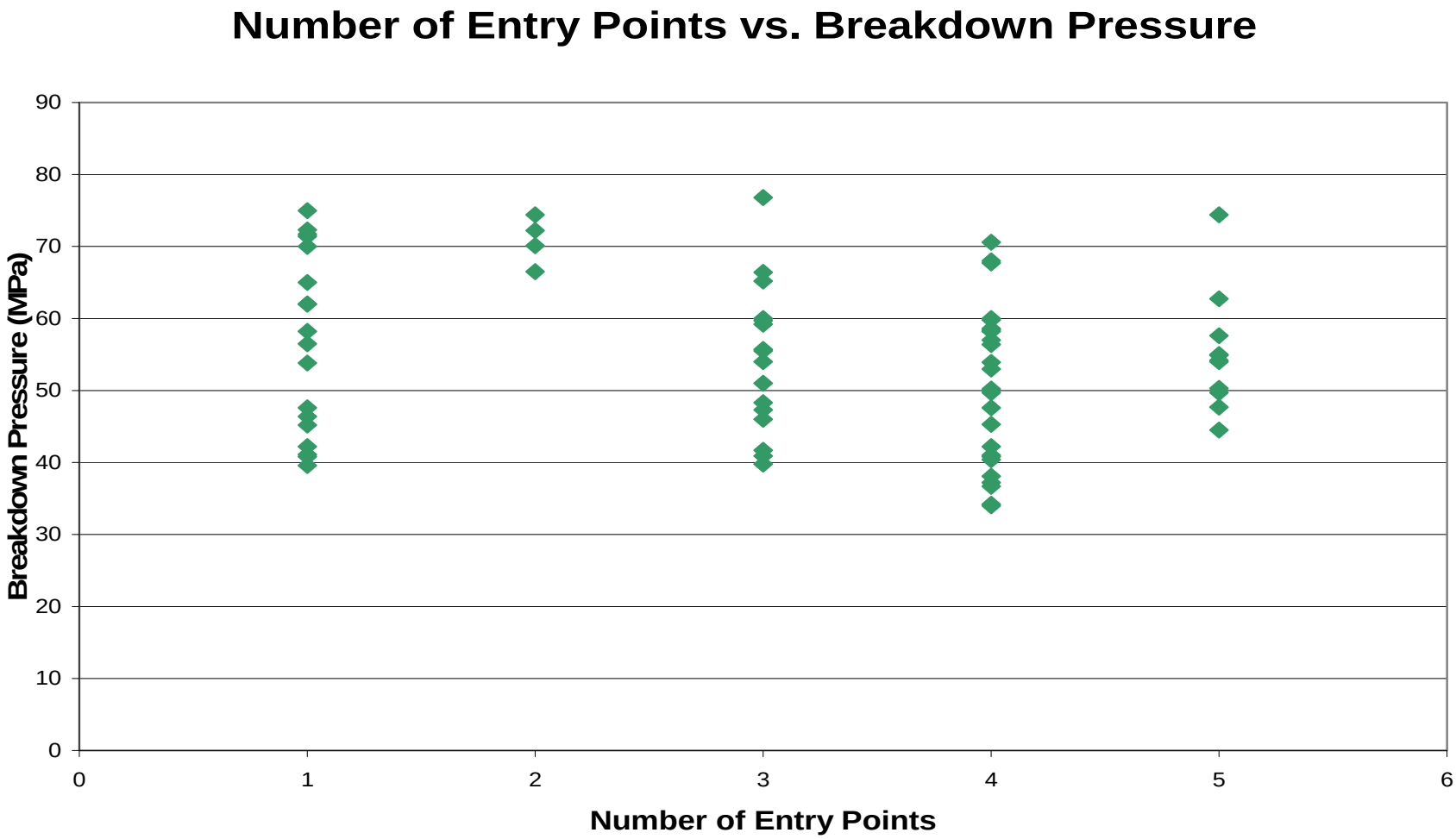
Wellbore Design Considerations



Wellbore Design Considerations



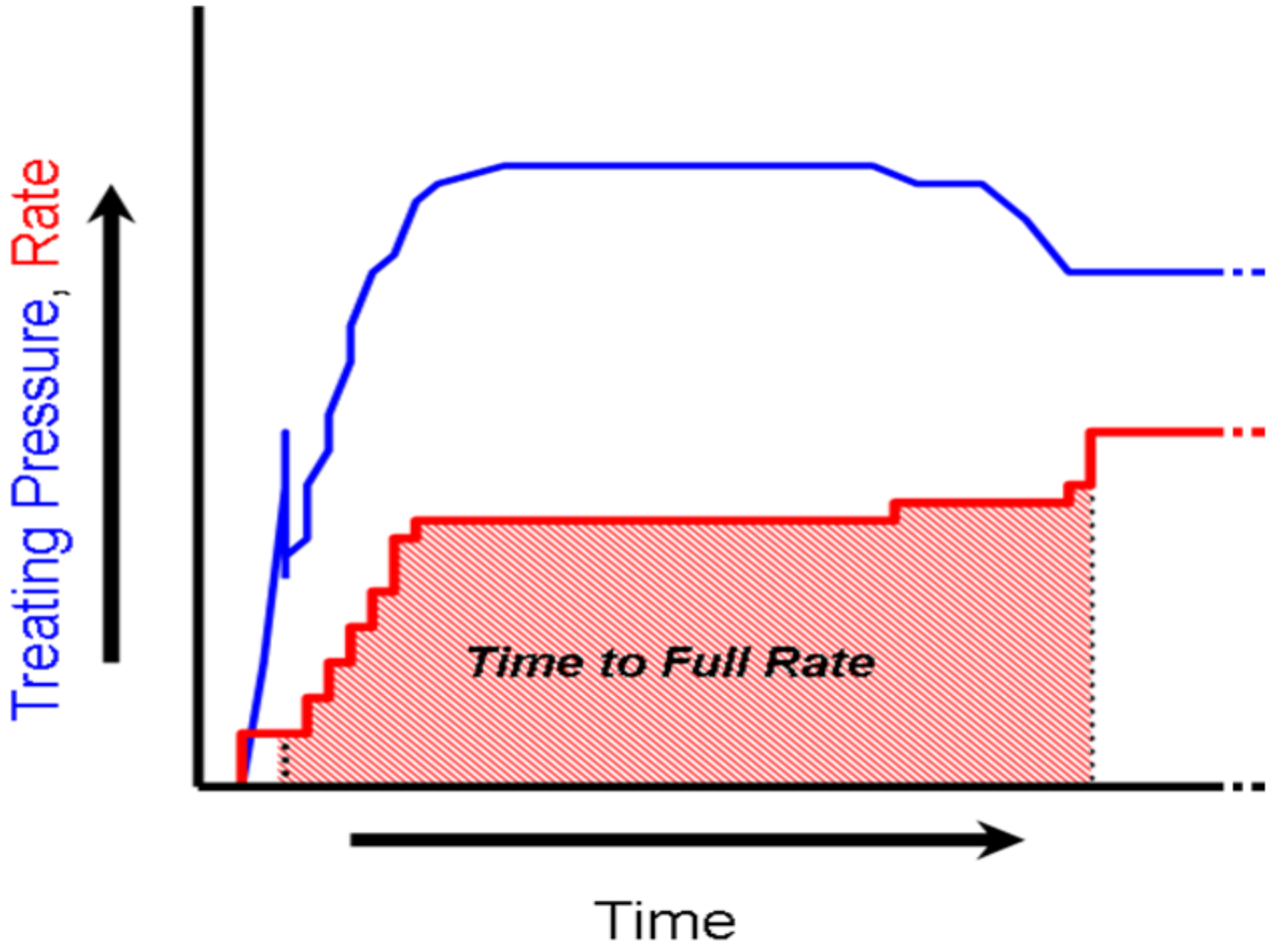
Wellbore Design Considerations



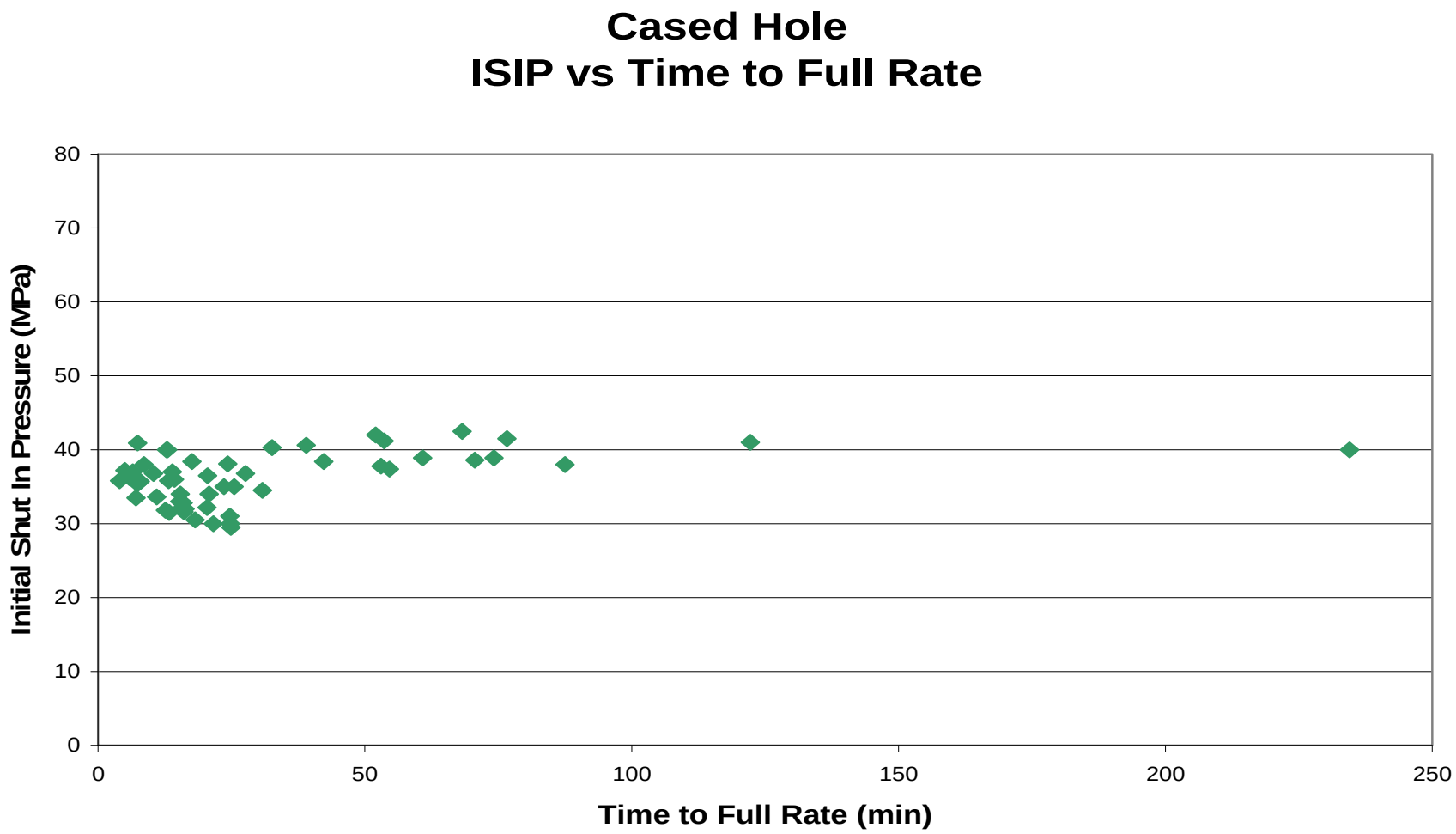
Optimizing Treatment Design

- Time to Rate
  - Initiation Variables
  - Acid Spearheads
- Proppant Selection
- Revisiting Toe Frac Design
- Operational Considerations

Time to Rate

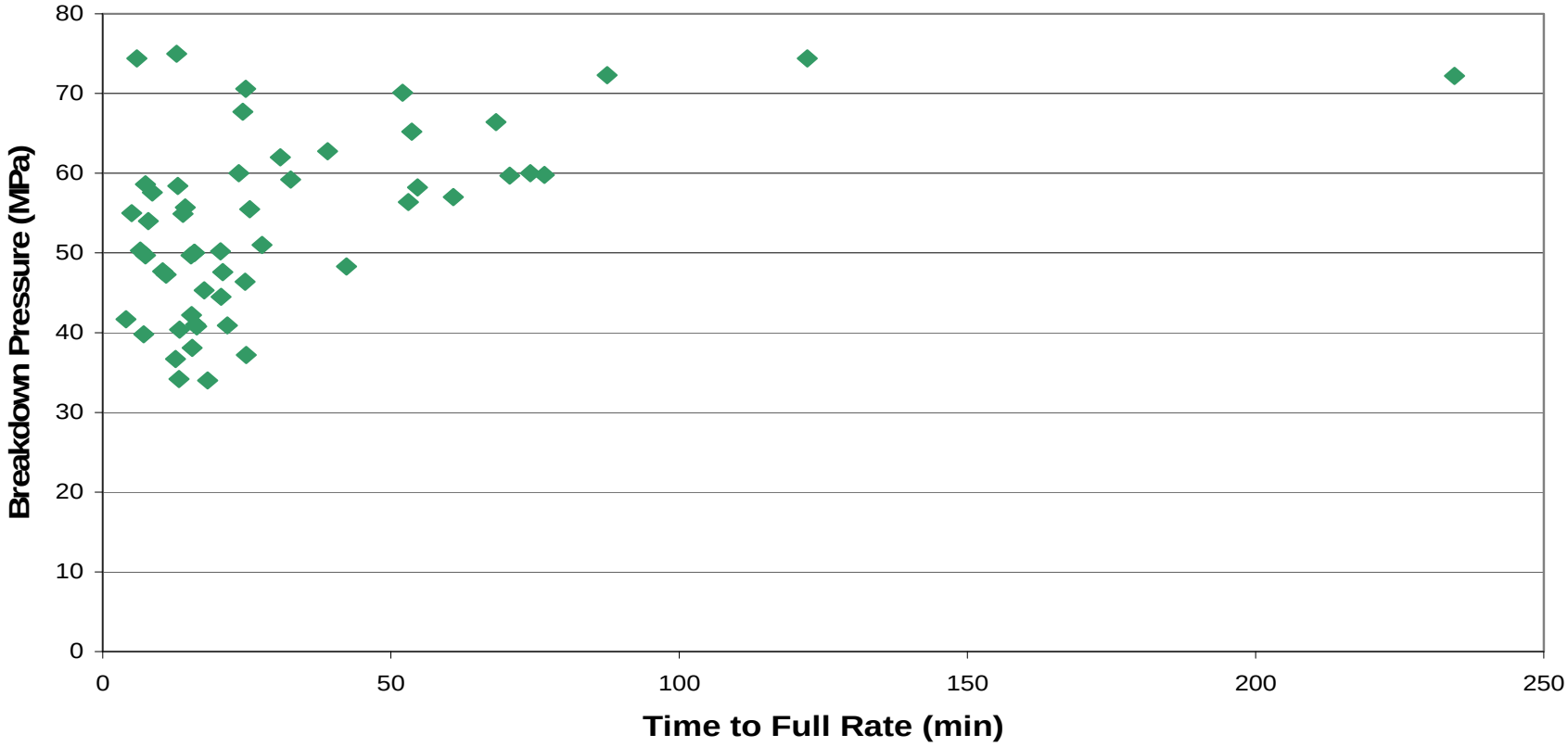


Initiation Variables



Initiation Variables

Cased Hole
Breakdown Pressure vs Time to Full Rate



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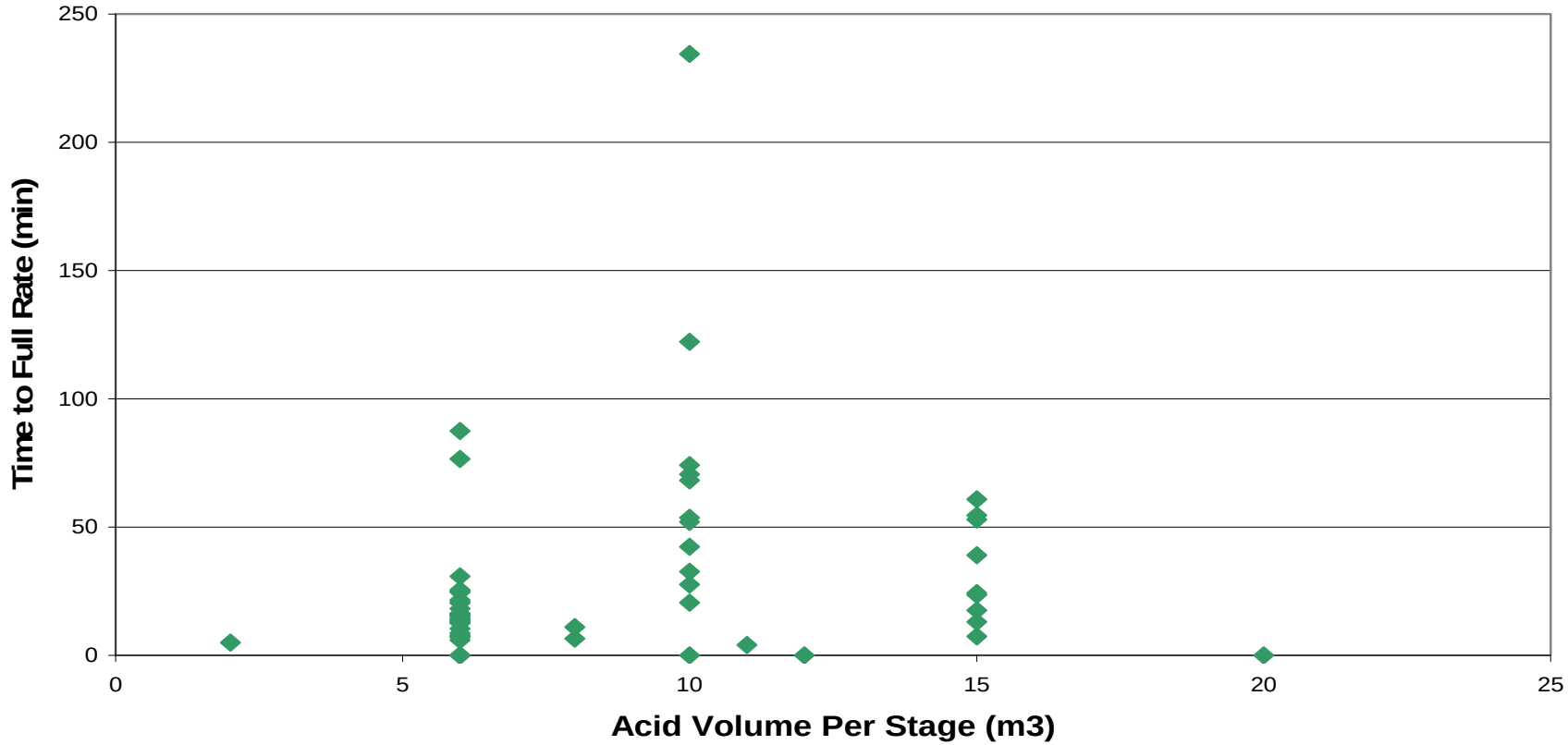
Acid Spearhead Design

Cased Hole
Time to Full Rate vs Acid Volume



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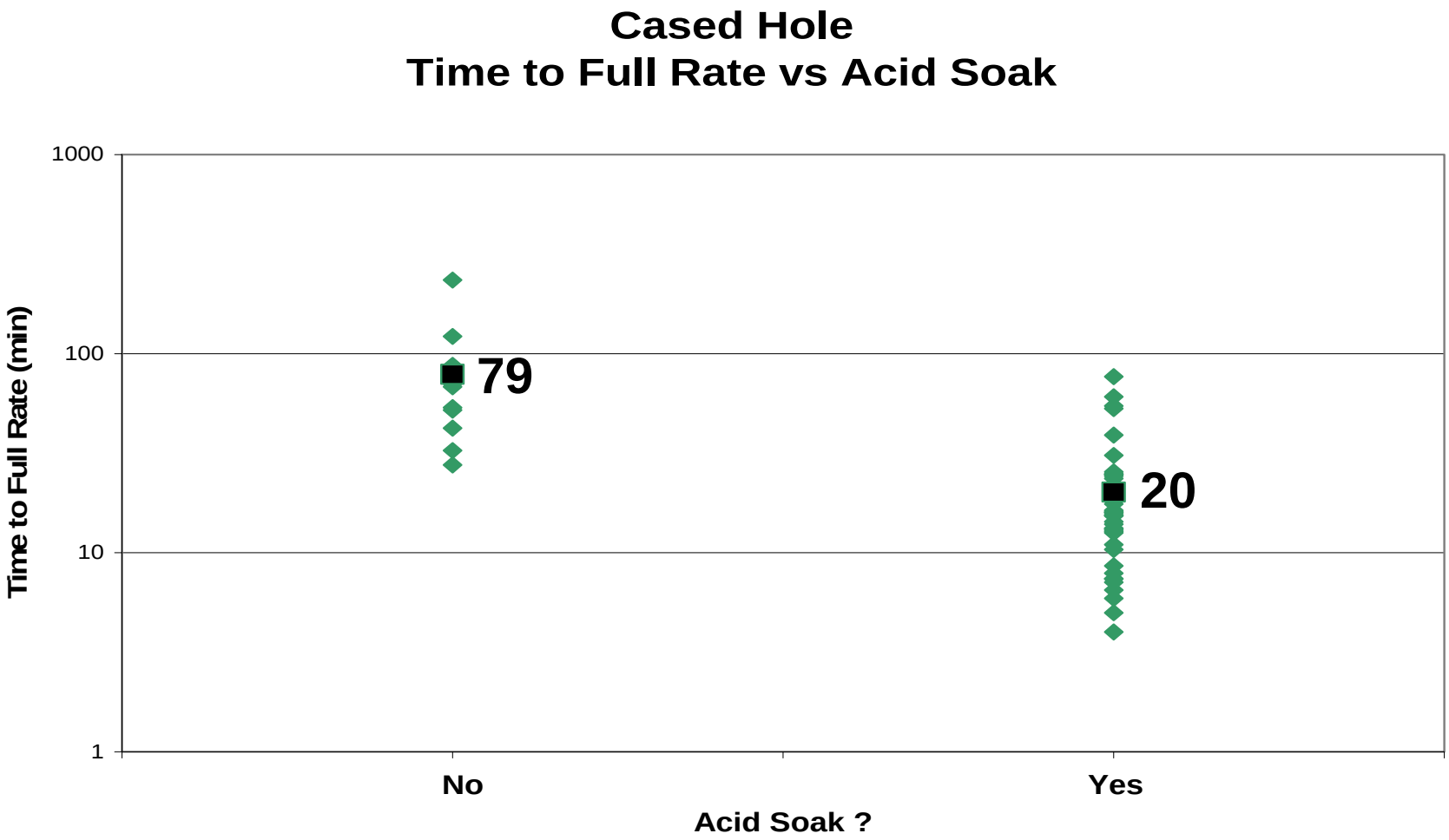
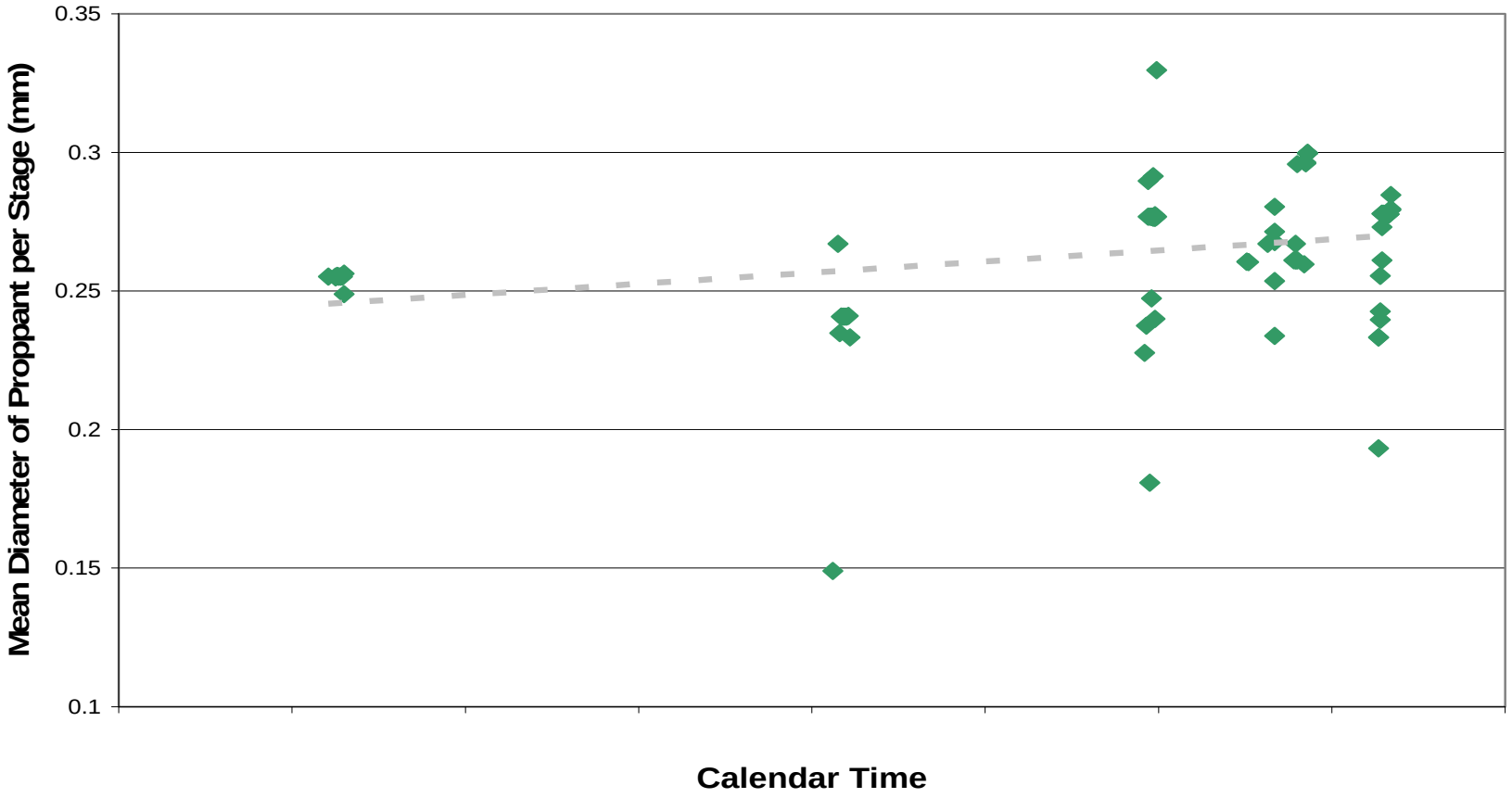
Acid Spearhead Design

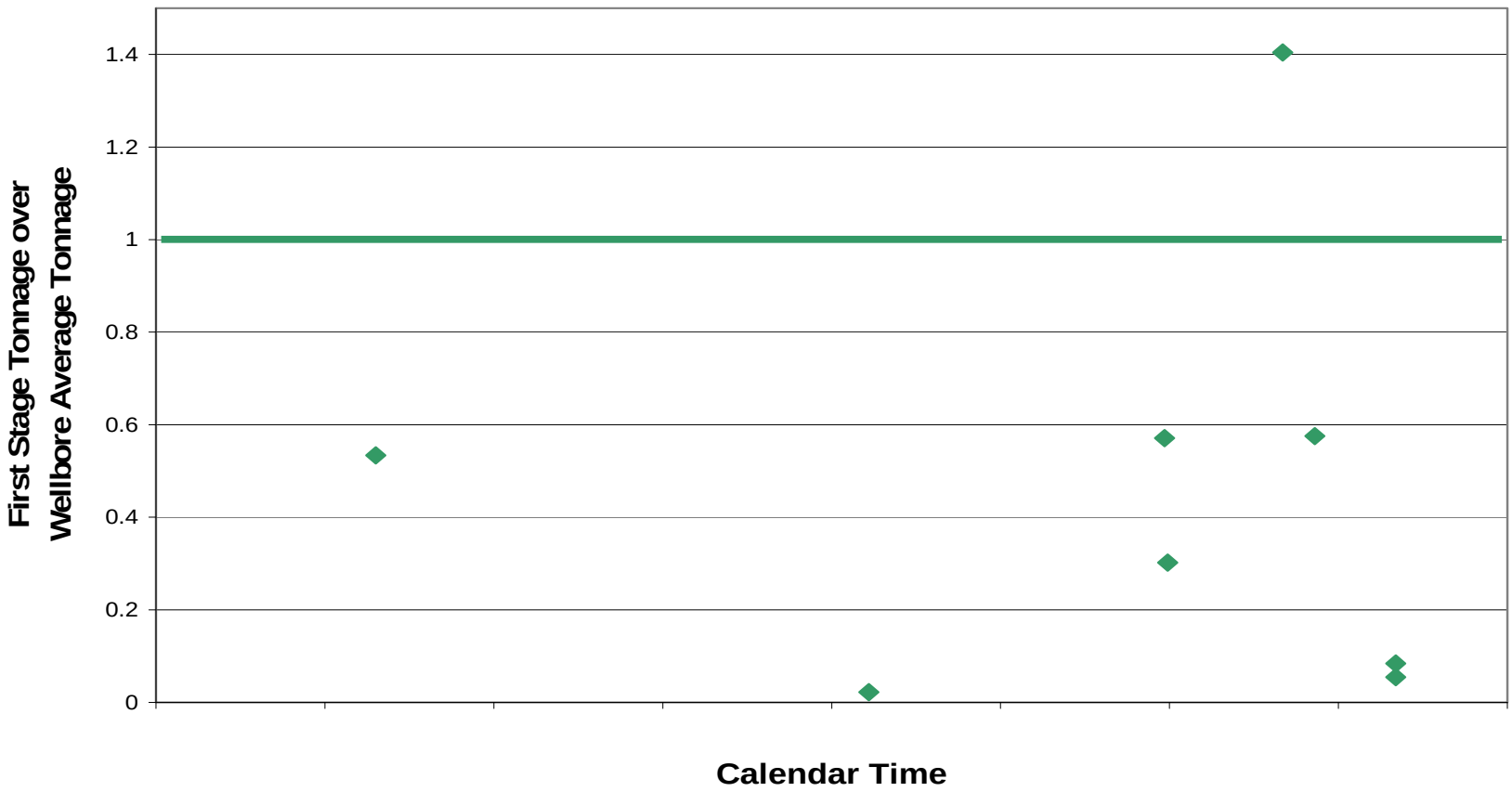


Proppant Selection

Proppant Mean Diameter Chronologically



Revisiting Toe Frac Design



Operational / Logistical Considerations

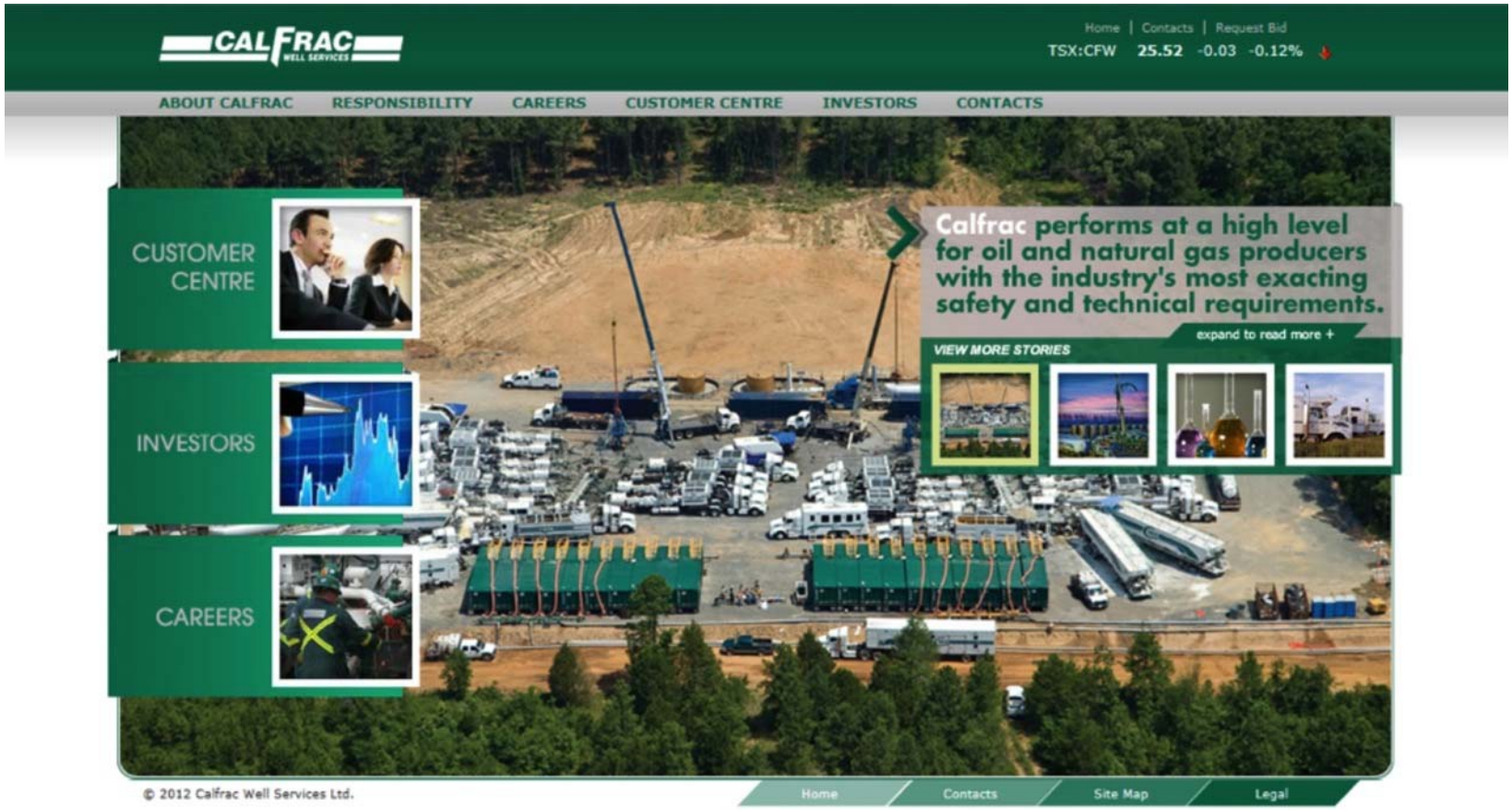
- Collaborative pre-planning is key
  - On site capacity for products
    - Lease sizing
    - Requirements for water, proppant, etc…
  - 24 hour operations
  - Concurrent operations
    - Pad drilling in the future

Efficiencies are lost when the job isn't designed properly.

Concluding Remarks

- Importance of reservoir characterization
- Tubular design for suspected treatment conditions
  - High rates and pressures
- Treatment design to consider:
  - Minimizing time to rate
  - Acid spearhead design
  - Maximizing production potential with proppant selection
  - Maximized toe frac design
- Efficient operations
  - Logistically challenging….be prepared!

Thank You….Questions?



For more information on Calfrac Well Services visit:

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