CARDIUM, MONTNEY & DUVERNAY

ONE OF THESE FORMATIONS IS NOT LIKE THE OTHERS, ONE OF THEM JUST DOESN'T BELONG. CAN YOU TELL WHICH FORMATION IS UNLIKE THE OTHERS?

ICoTA Canada 2017 Roundtable Program – 25th October

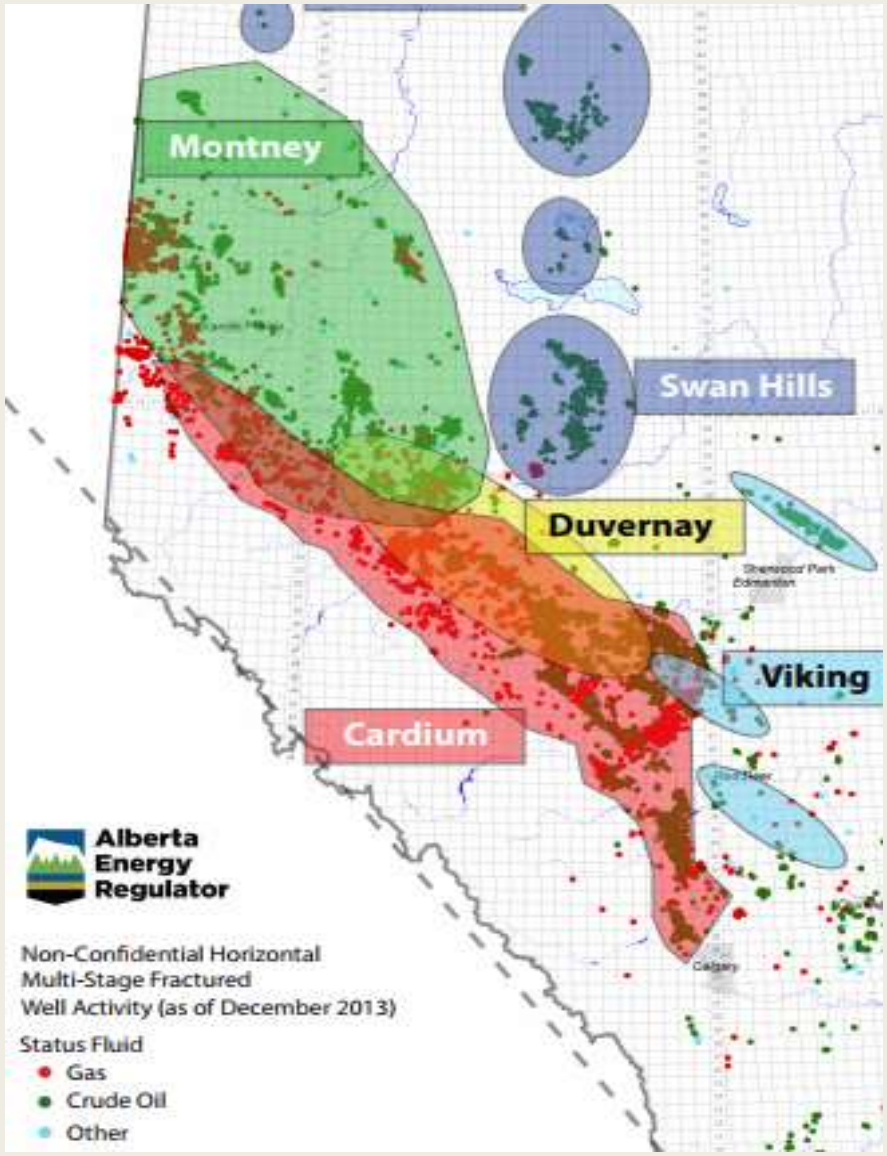
TRICAN

Robert J. Hawkes
QC, JSS Barristers

Distant Cousins: *separated, far away or not immediately connected.*

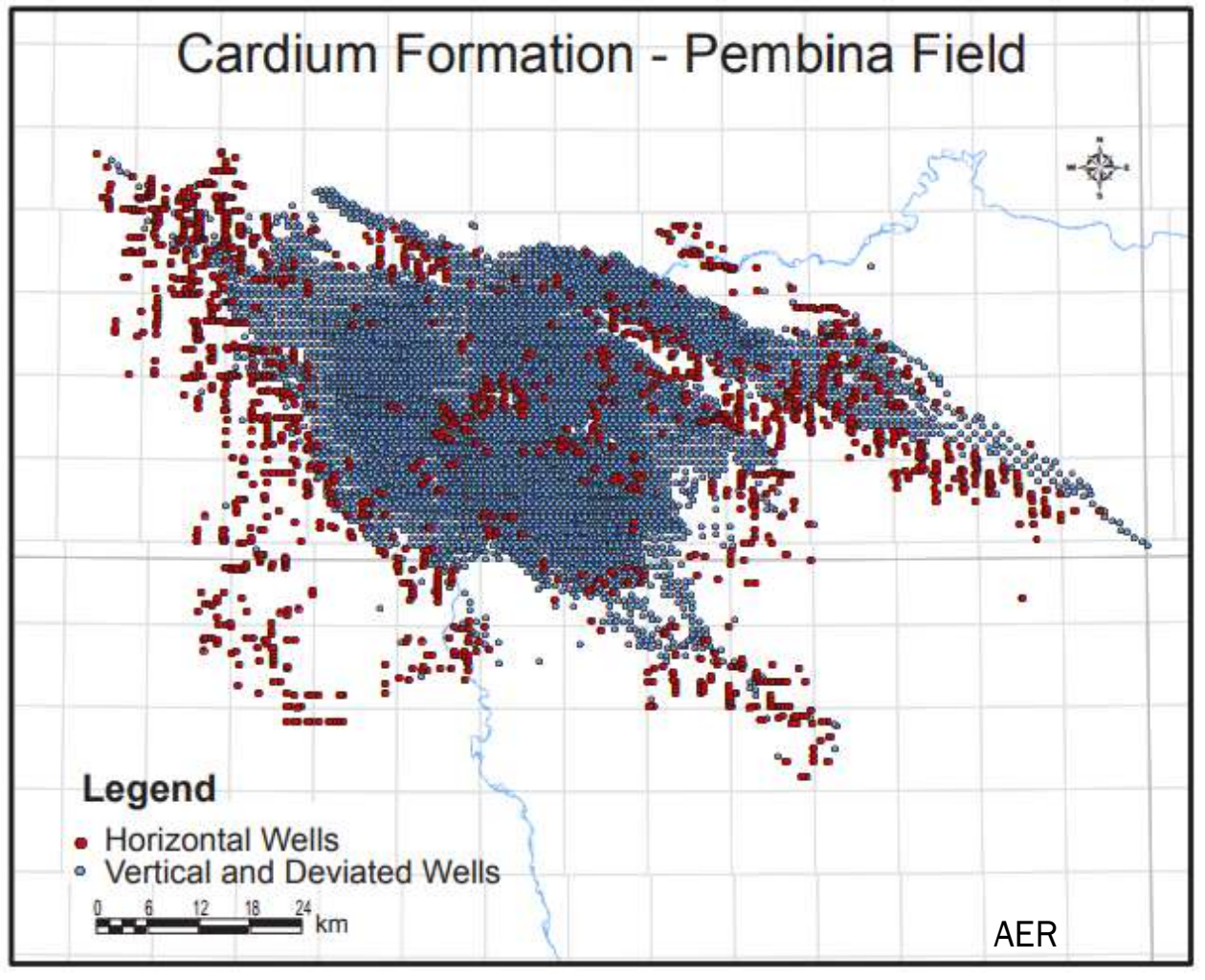
Cardium, Montney & Duvernay

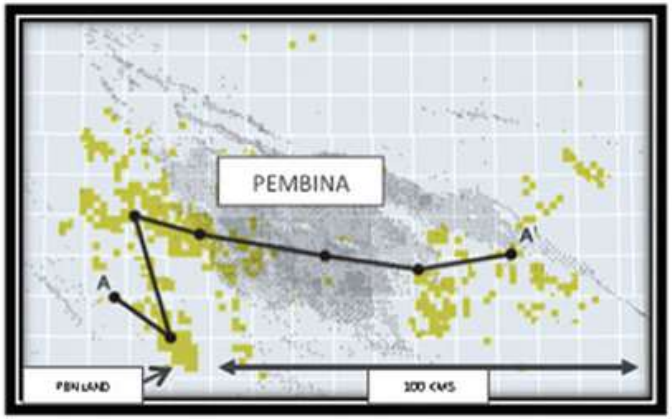
Robert V. Hawkes, Trican Well Service

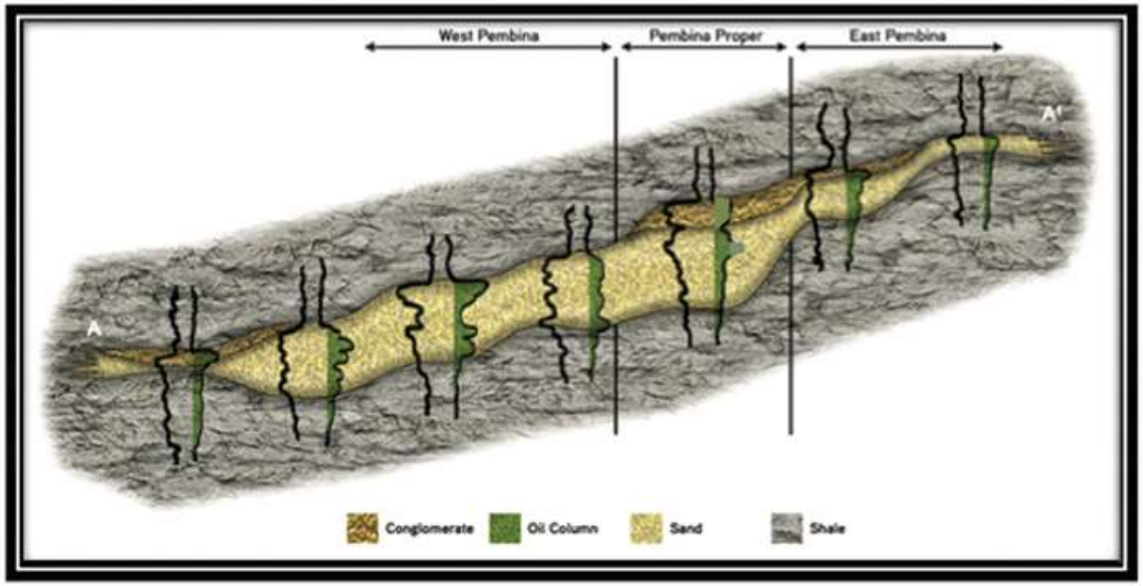


I think it's the one on the left

- ✓ Oil & Gas from coarse to fine to very fine sandstone
- ✓ Between 5 and 15 meters of pay







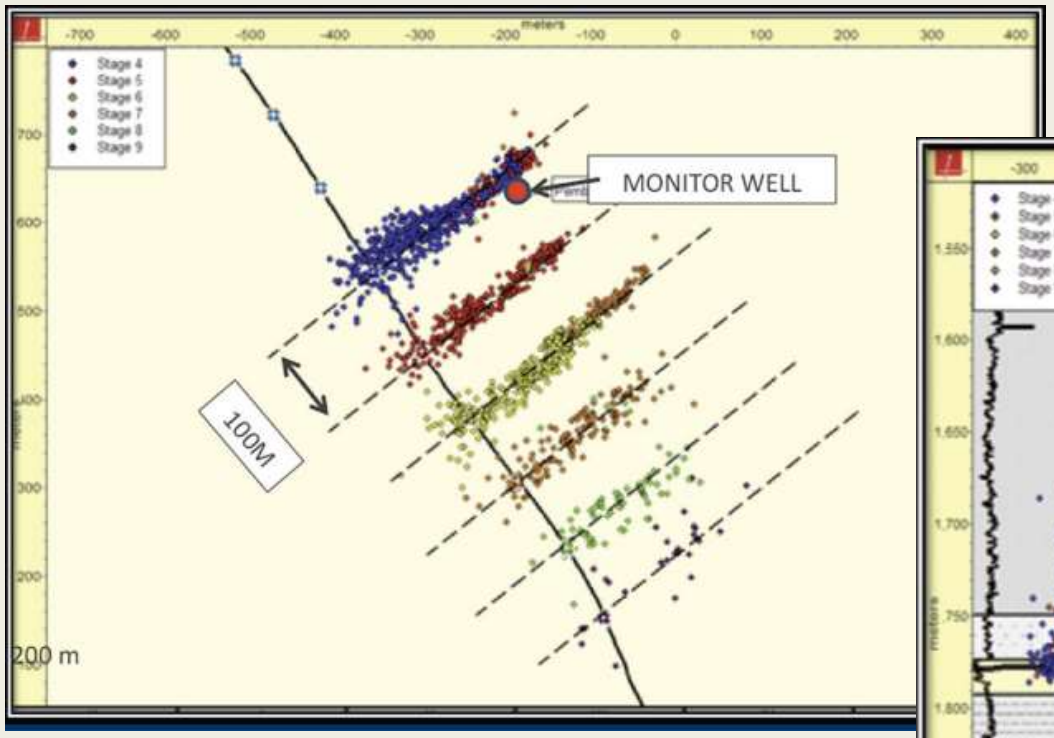
Depth: 1350m TVD

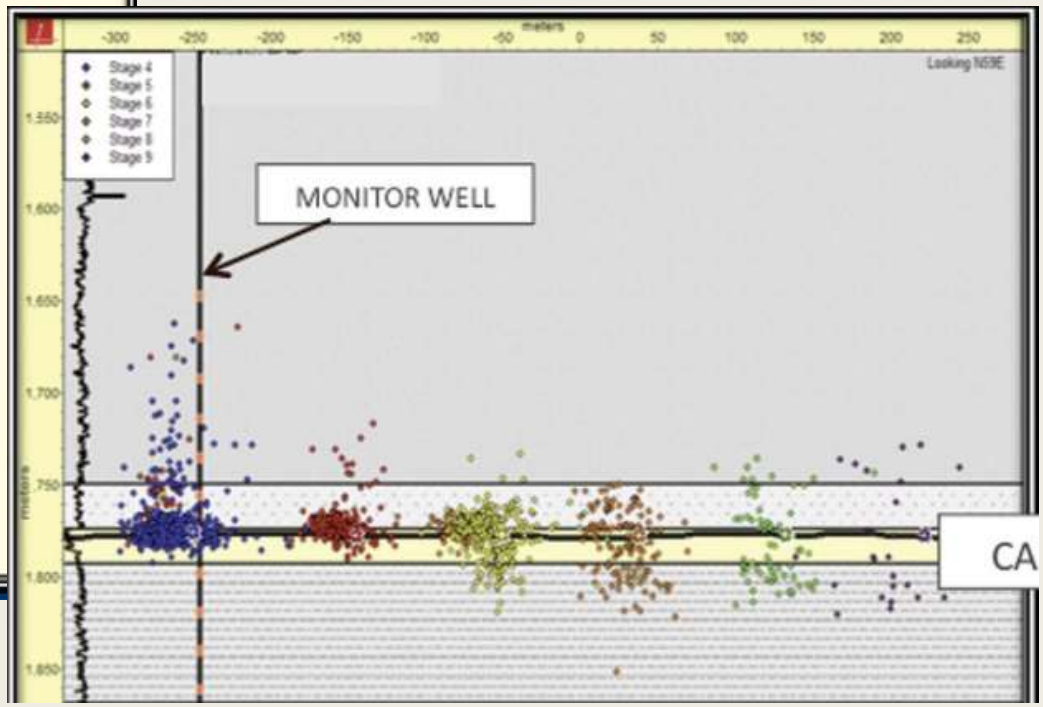
Depth:2200m TVD

Petrobakken

West Pembina

Burst Ports in Cemented Liner,
100m spacing, 30-40 tonne
Gelled Oil Fracs at 3.5 m3/mimn

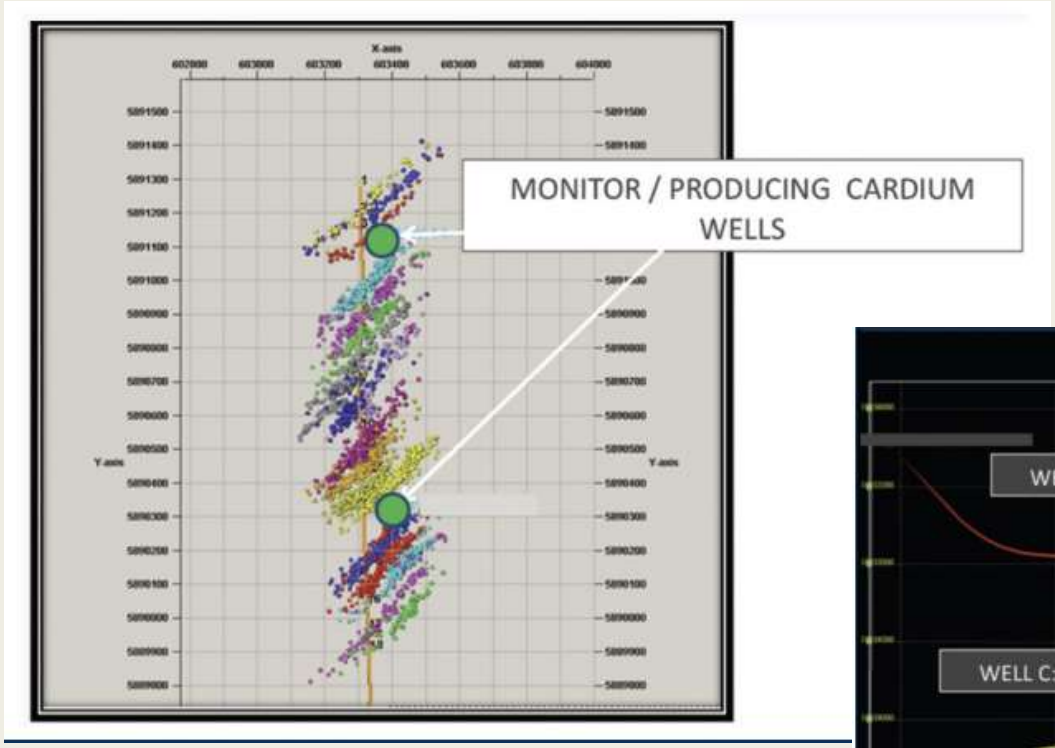




CSEG Recorder, Oct 2012

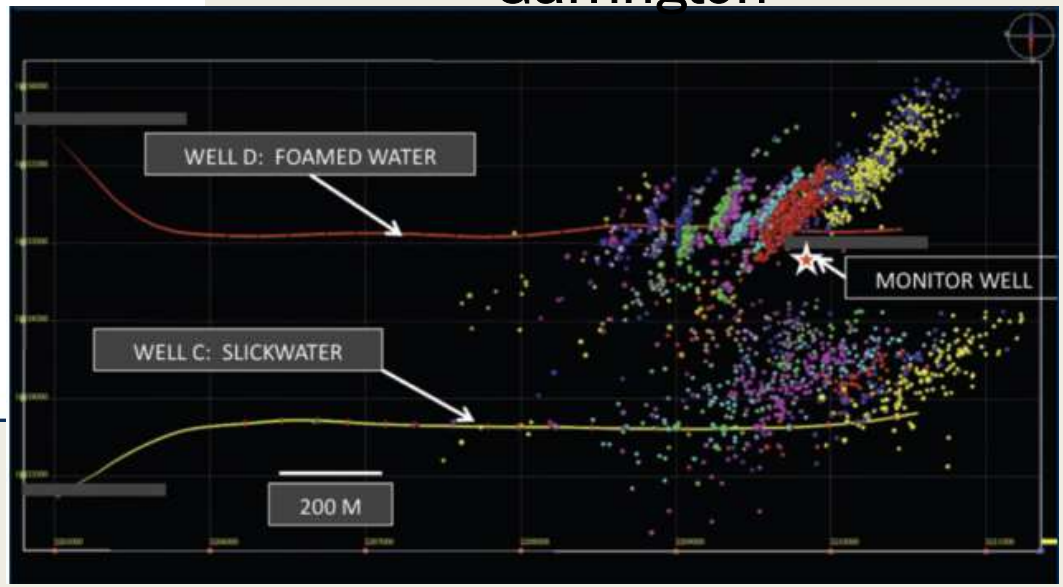
West Pembina

Frac Ports (66 m spacing) in Cemented Liner
22 tonne Slickwater

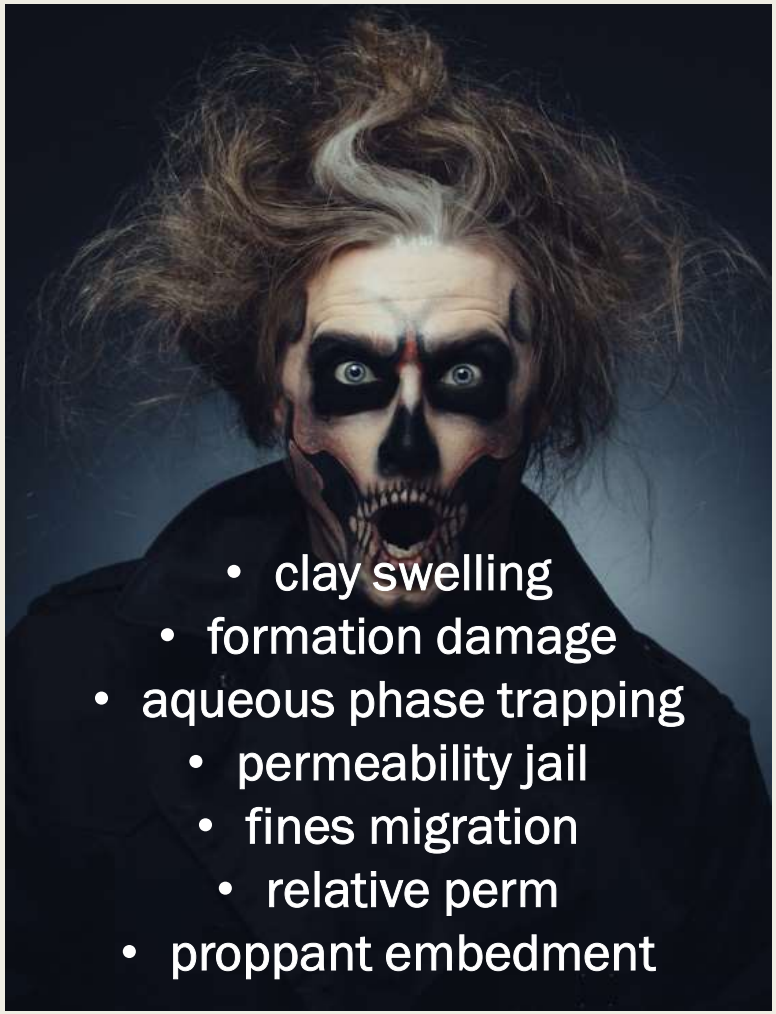


CSEG Recorder, Oct 2012

Lessons learned from Garrington



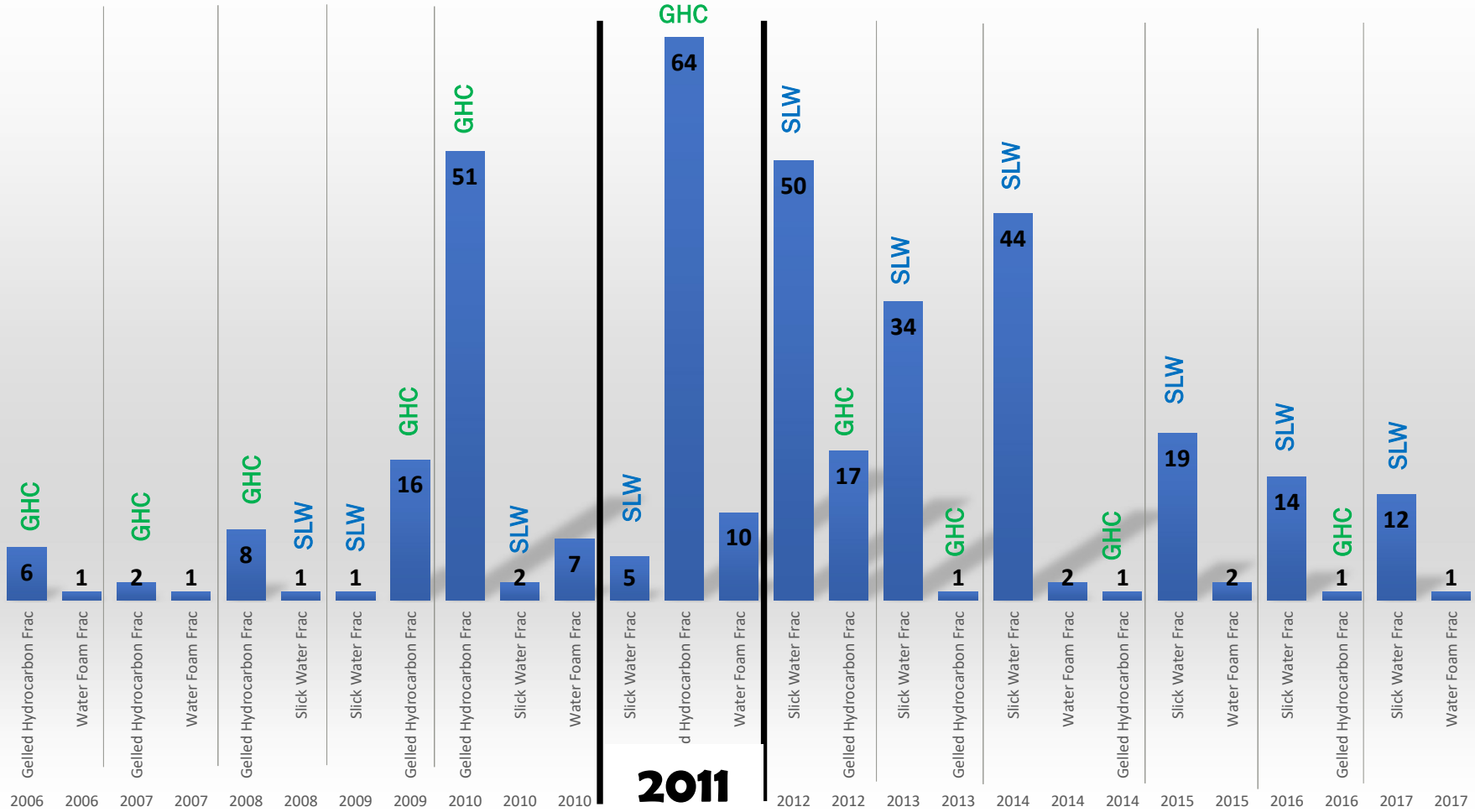
The Boogeyman



Many of use were raised on Hydrocarbon Gelled Oil Treatments, Energized Fluids and Predict-k, mostly driven by <u>Lab</u> Test Results.

Now, our clients are pushing us to tier 2 proppant and smaller mesh size proppant.....driven by <u>Field</u> test results.

CRDM Fluid Treatments



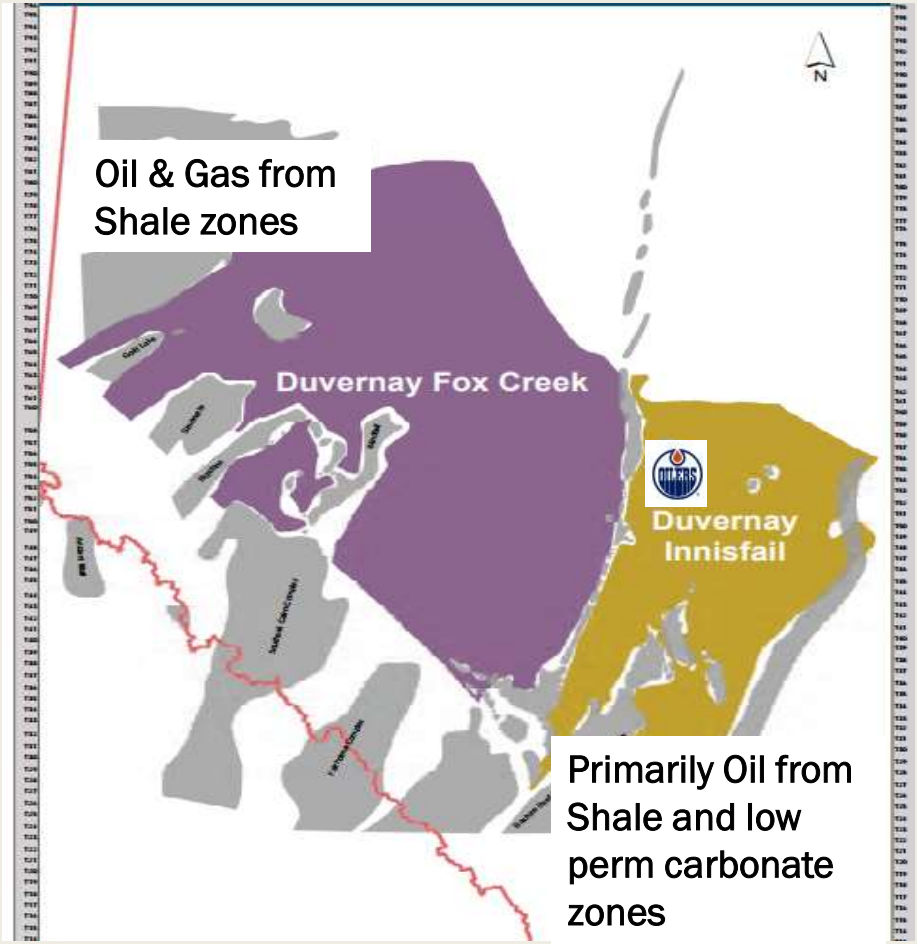
Yangarra Resources and NCS Multistage Announce Record-Breaking Well in the Cardium Formation

October 23, 2017 3:17 PM Globe Newswire

CALGARY, Alberta, Oct. 23, 2017 (GLOBE NEWSWIRE) — Yangarra Resources Ltd. ("Yangarra") and NCS Multistage Holdings, Inc. (Nasdaq:NCSM) ("NCS Multistage") have completed a 135-stage well in the Cardium Formation in 116 operating hours. The well was completed in a single coiled-tubing run with 7.4 million lb (3,374 tonnes) of proppant placed and an average frac rate of 34.59 bbl/min (5.5 m3/min). The completion alternated between single- and double-casing joint spacing between fracture sleeves, enabling Yangarra to optimize the lateral section of the wellbore and better understand the impact of increased fracture intensity on stage isolation effectiveness.

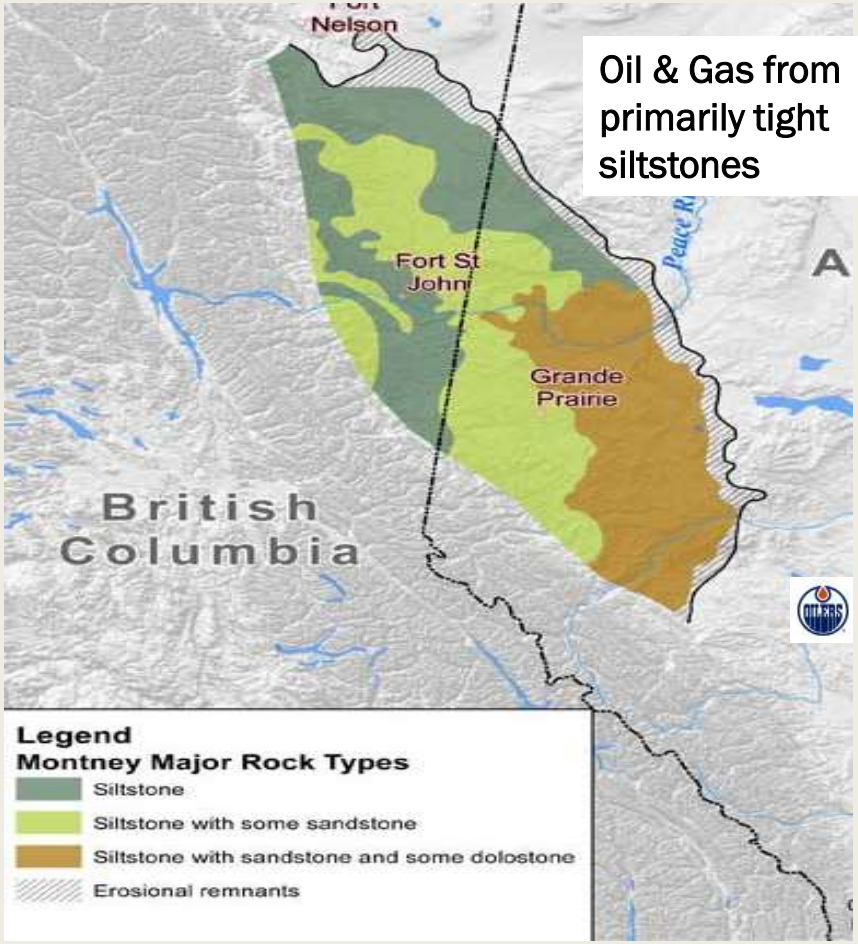
Groulx et al (SPE 185077), using multivariant analysis shows frac spacing and pump rate had major effects on production performance in a CRDM Oil study.

Duvernay Area Play

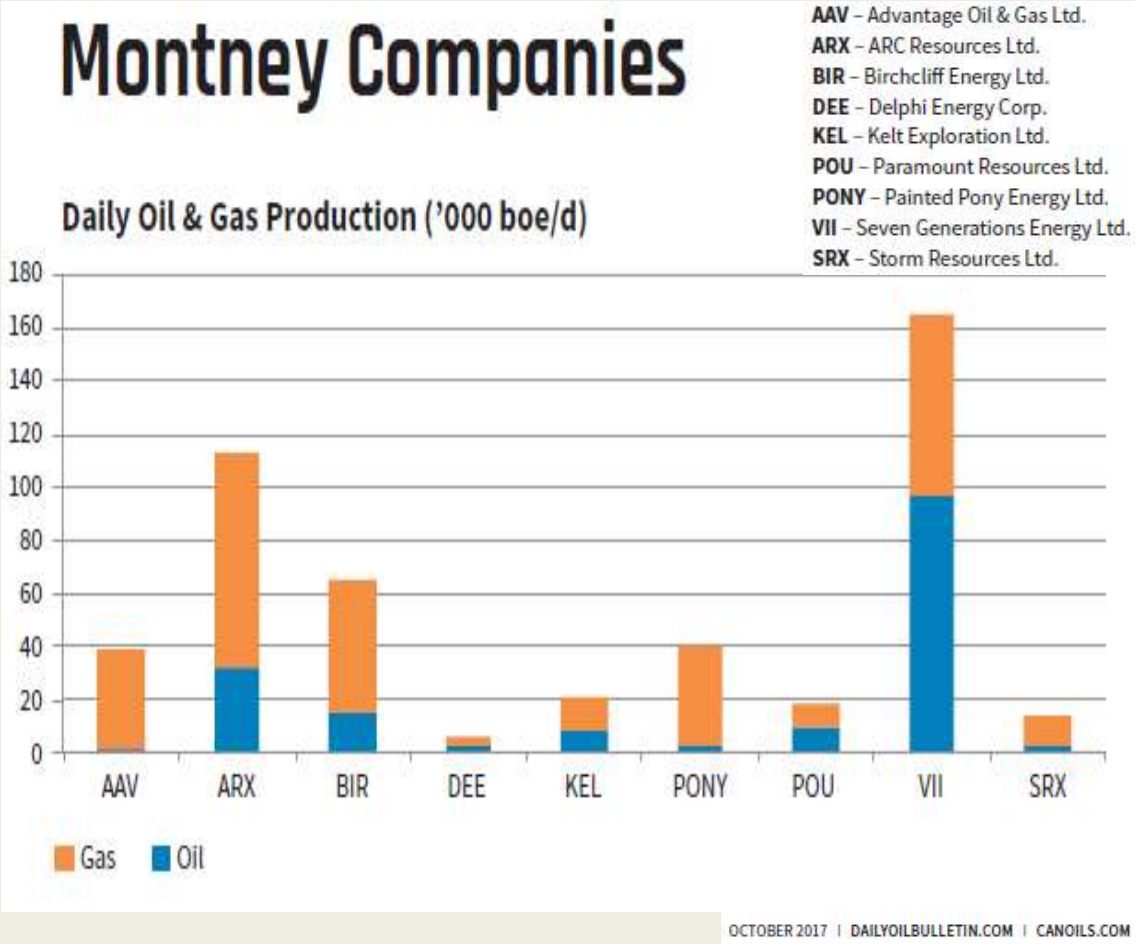


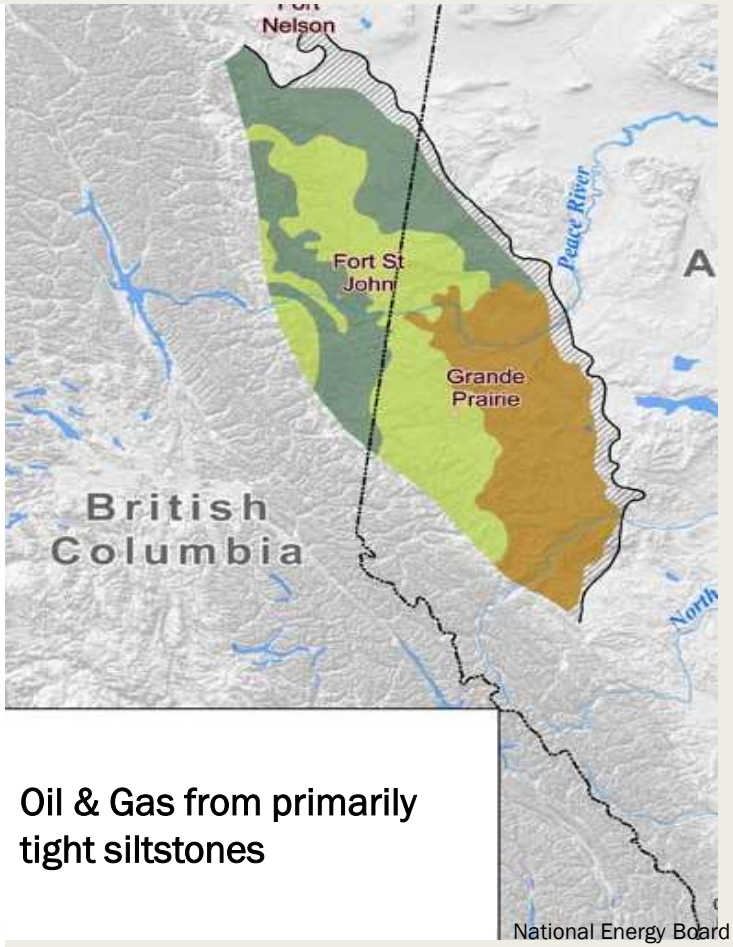
AER

Montney Area Play



National Energy Board



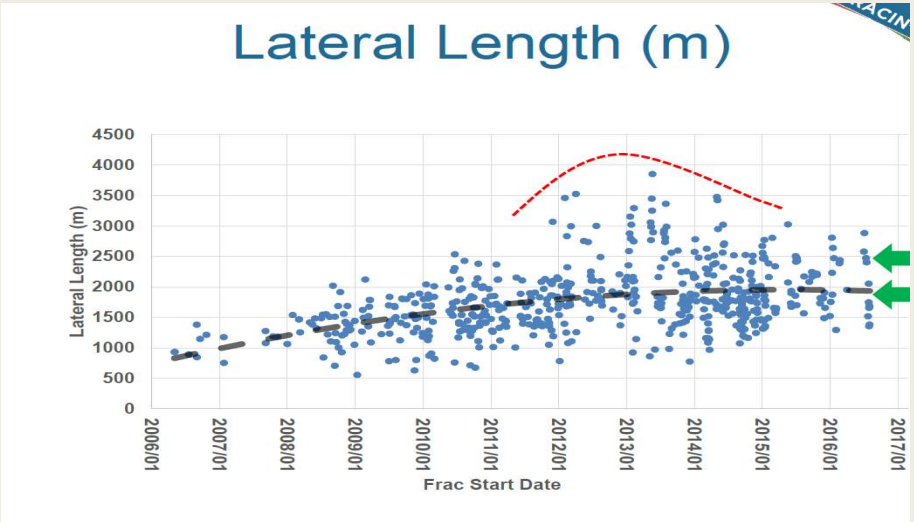


Oil & Gas from primarily tight siltstones

National Energy Board

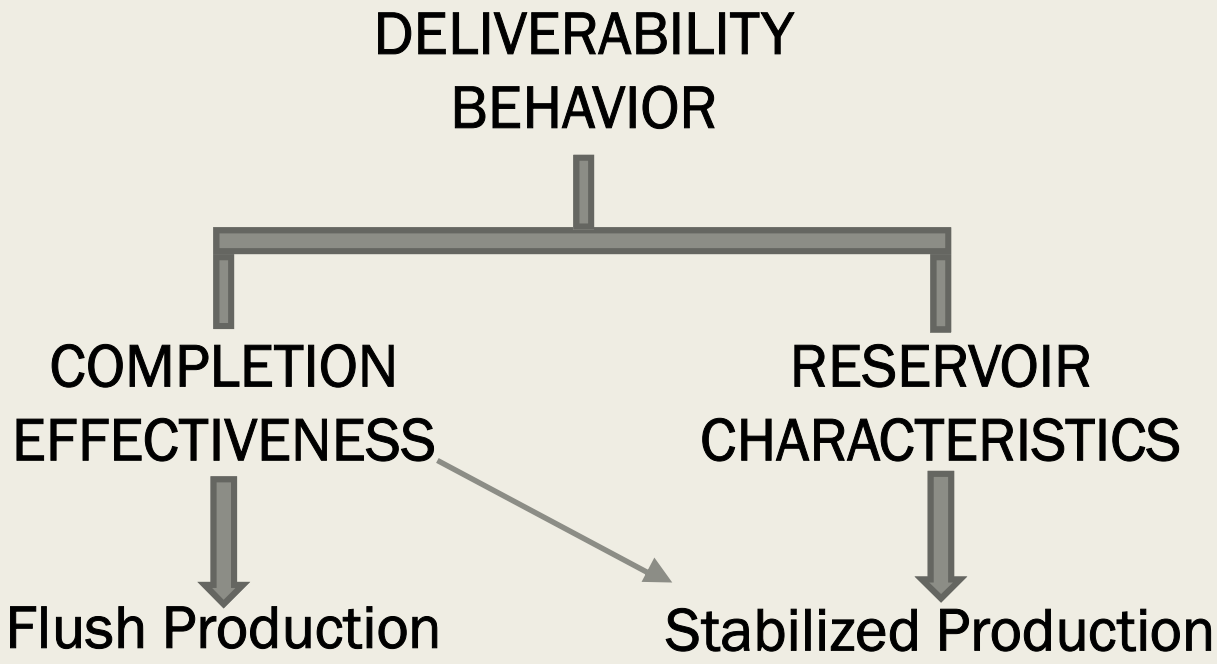
MNTN Design Evolution Over Time

- Total Proppant / Well
- Total Proppant / Stage
- Proppant Intensity (T / m)
- Lateral Length
- Stages / Well
- Total Fluid / Well
- Stage Spacing



FracKnowledge, 2016

In Vertical Wells……



The Completion Controls flush production, where as the Reservoir controls *Stabilized* production

Why is it so difficult to efficiently optimize Hz well design?

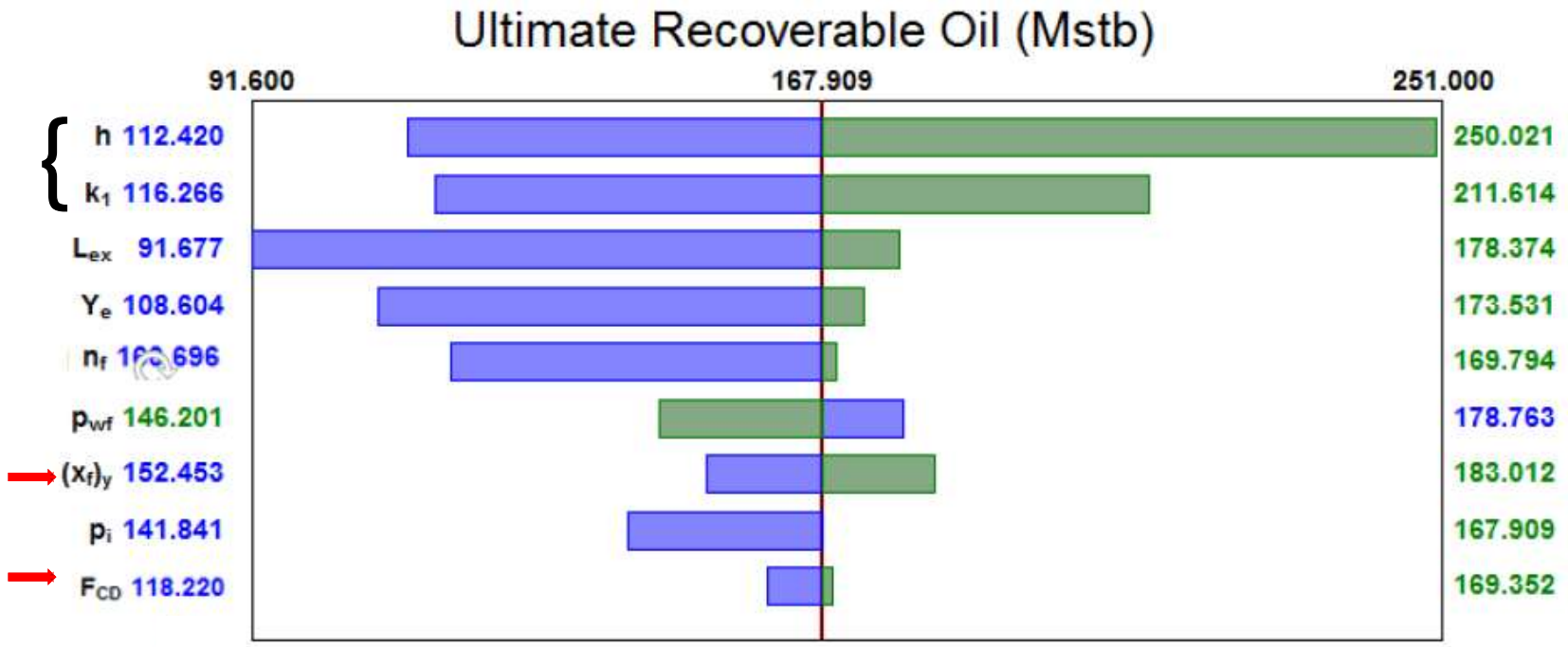
Well Design
- Proppant type
- Lateral length
- Landing depth
- Tubing/casing size/depth
- Number of entry points
- Missed entry points
- Proppant volume
- Cluster effectiveness
- Proppant type
- Fluid volume
- Fluid type
- Treatment schedule
- Well spacing
- Azimuth
- Toe up/down

Reservoir/Fluid
- Reservoir pressure
- Net pay
- Porosity
- Sw
- Young's modulus
- Poisson's ratio
- Natural fractures
- Stress profile
- Permeability
- Fluid compressibility
- Pore compressibility
- Fluid viscosity
- Gas solubility
- Gas gravity
- Oil API gravity

Operations
- Open versus choked flow
- Shut-ins
- Flowing pressure profile
- Artificial lift
- Separator pressure/temp

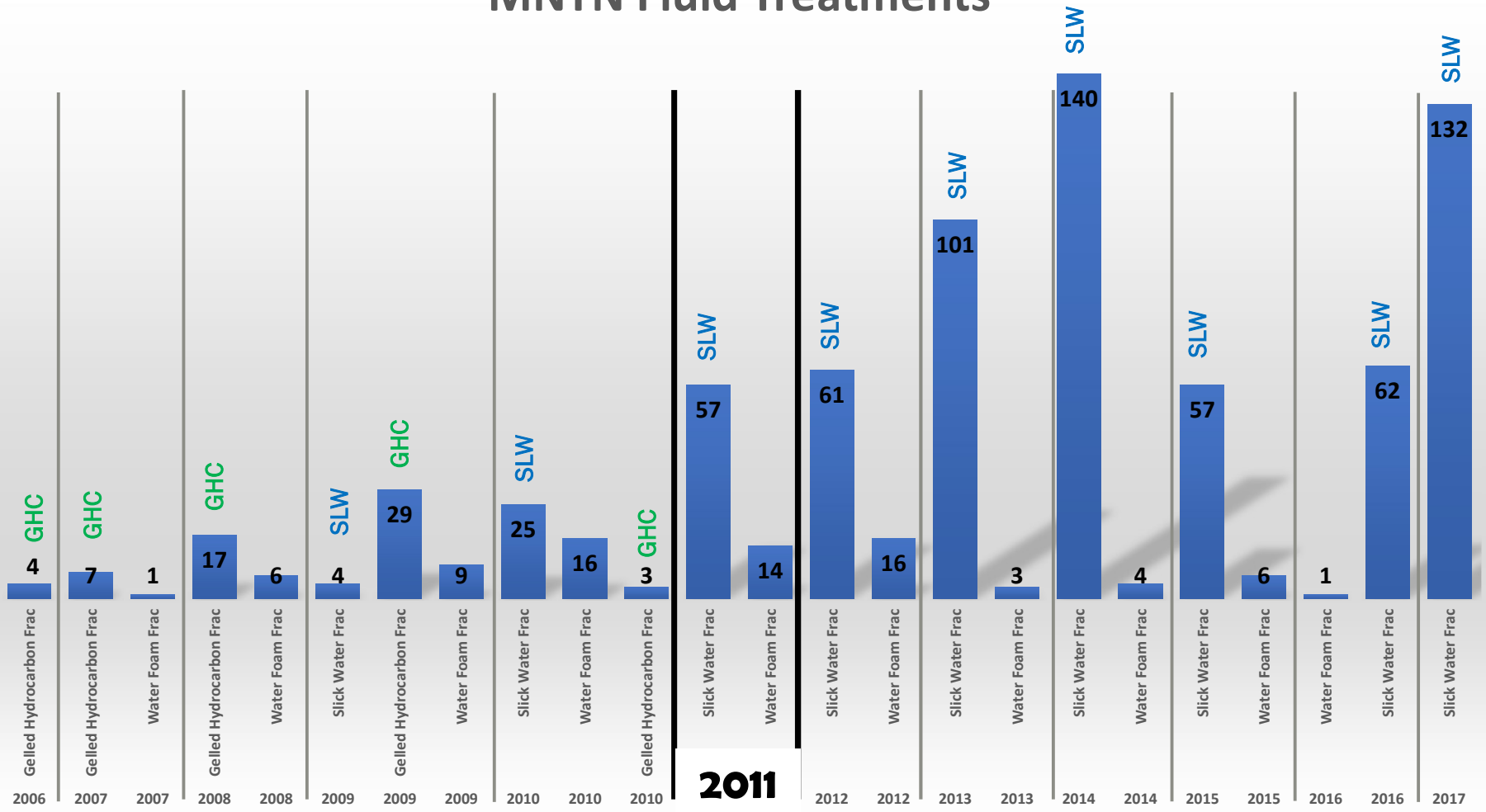
Modified from AndersonThompson

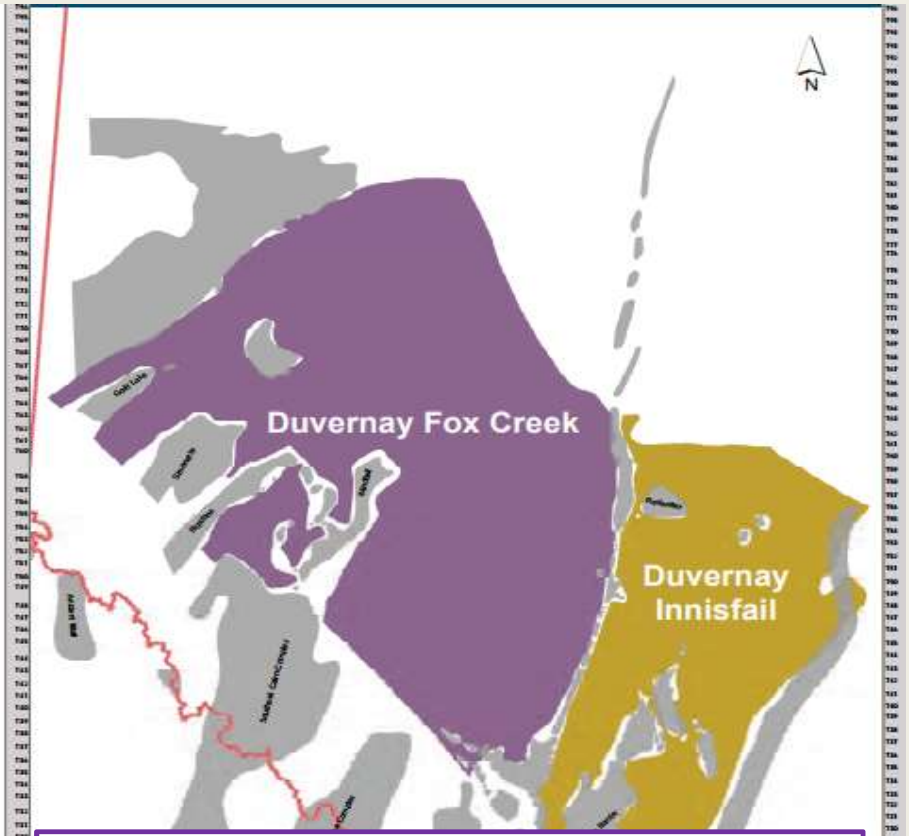
Impact of Hz Well Completion Technology Still has an Impact on Flush Production (IP), but it can be masked by more dominant reservoir variables for Ultimate Recovery.



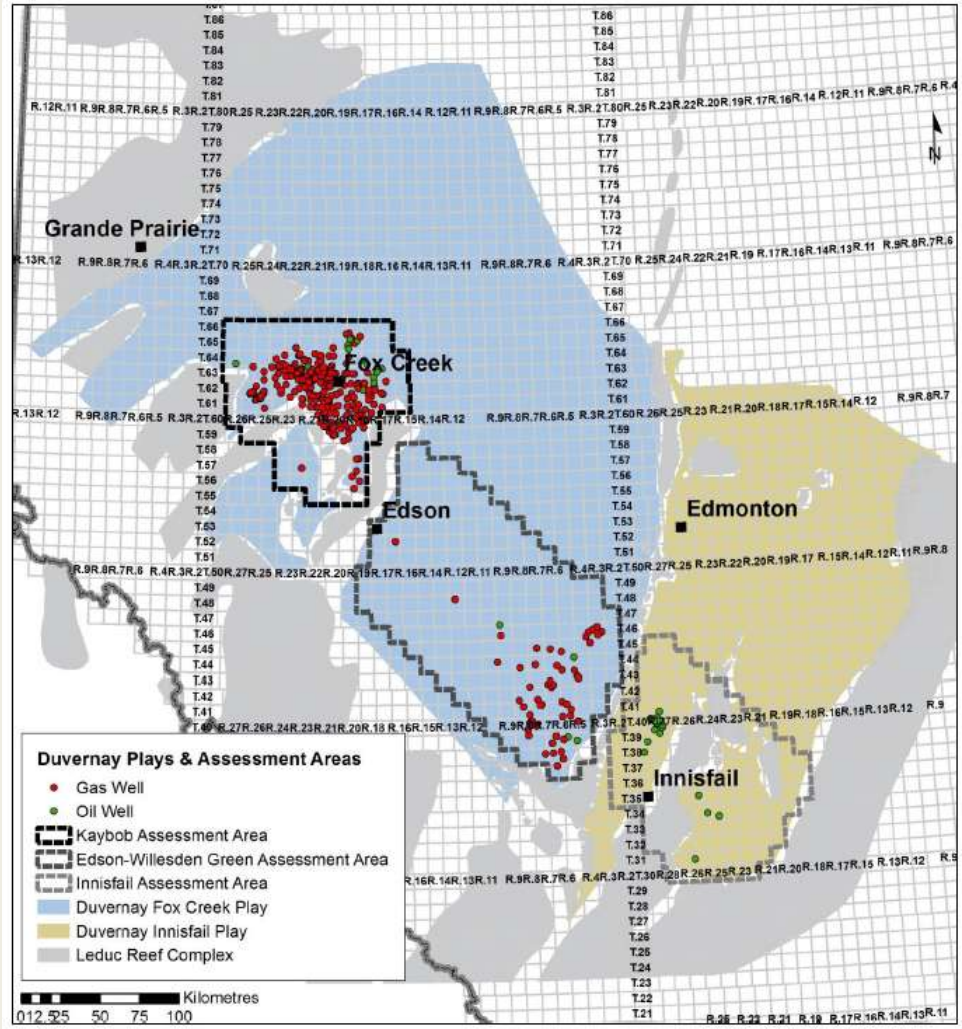
Modified from AndersonThompson

MNTN Fluid Treatments



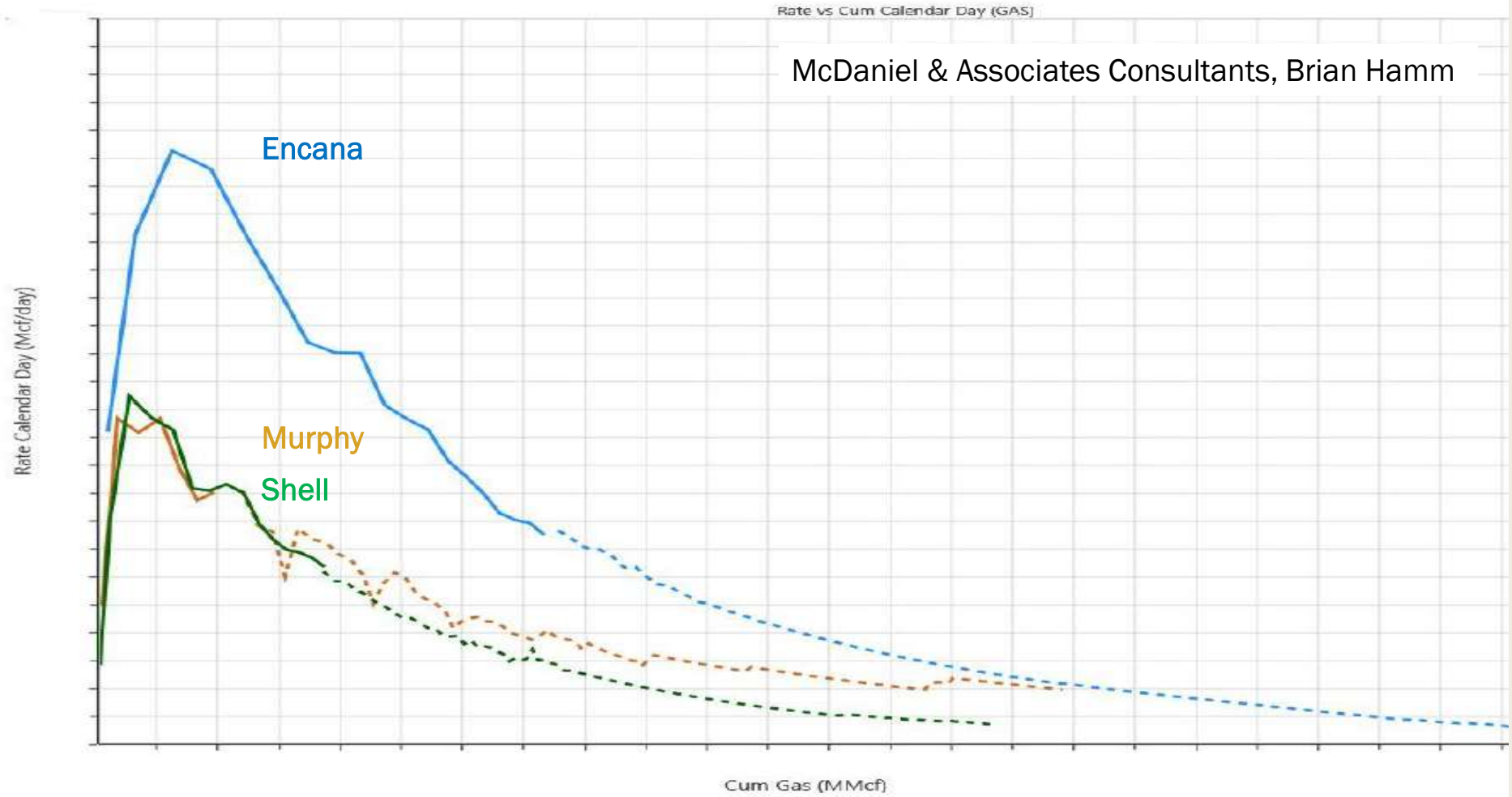


Distant Cousins: *separated, far away or not immediately connected.*

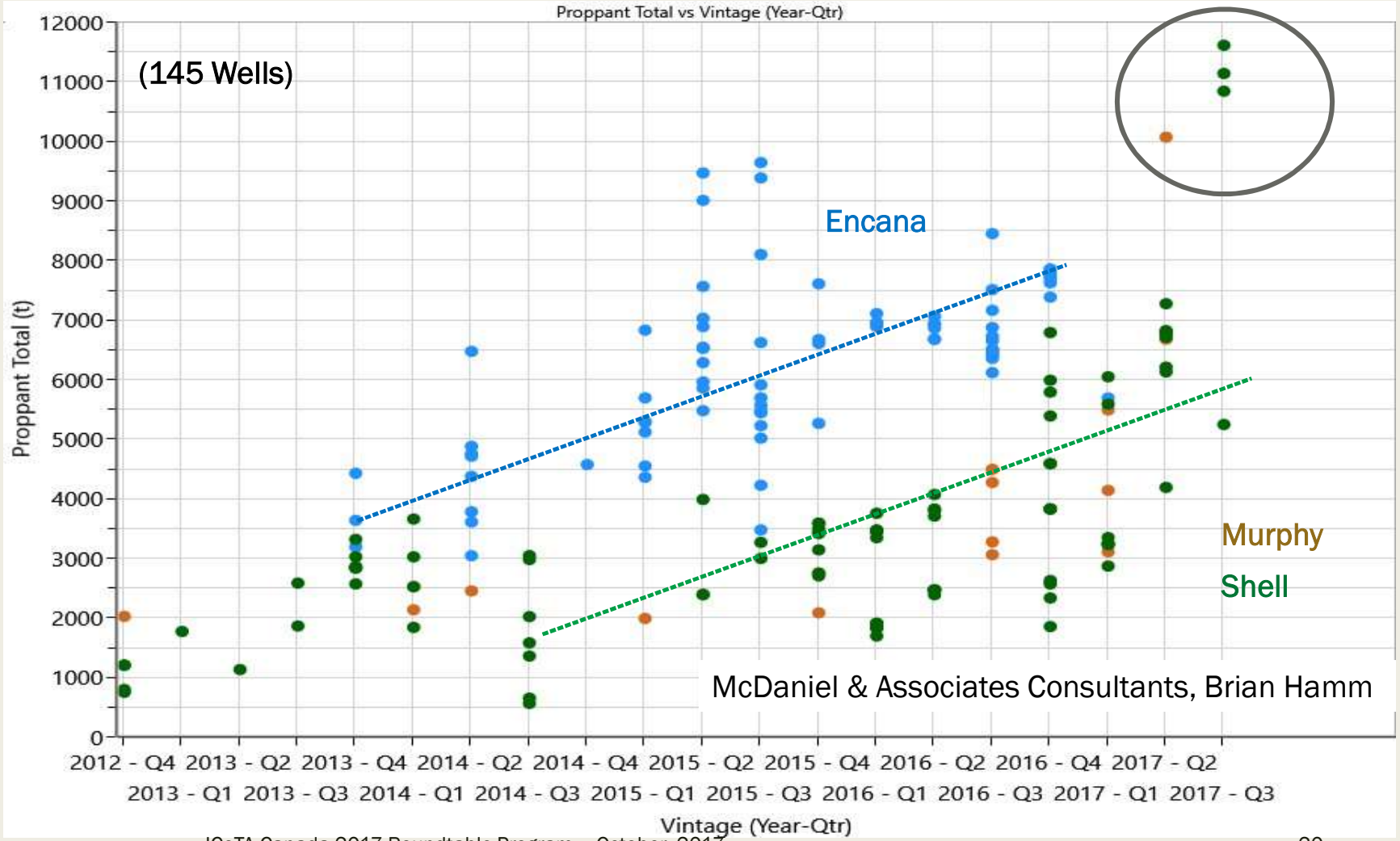


AER, Mark Taylor

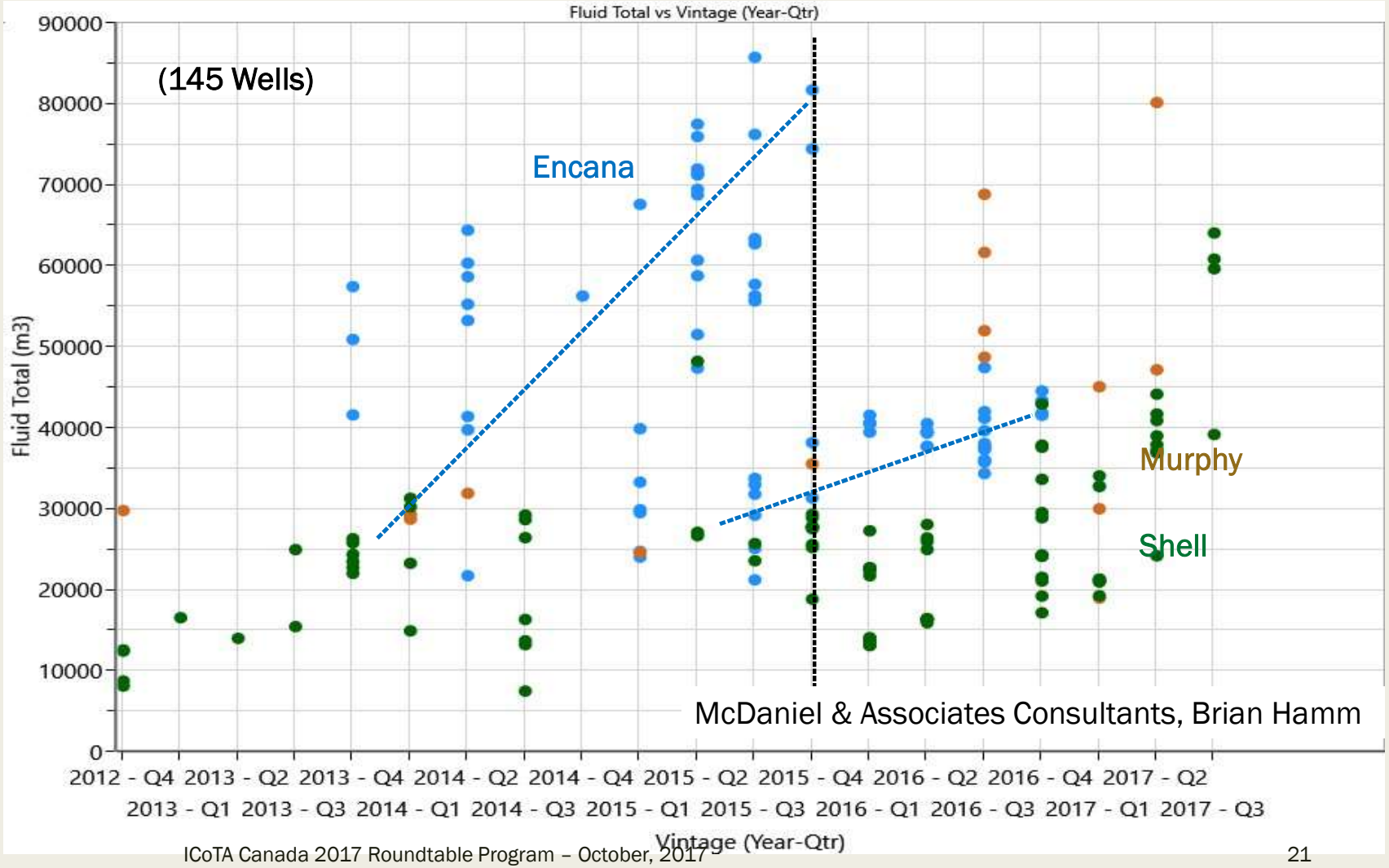
Type Curves (145 Wells)



Proppant Total Pumped vs Vintage (Year-Qtr)



Fluid Total Pumped vs Vintage (Year-Qtr)



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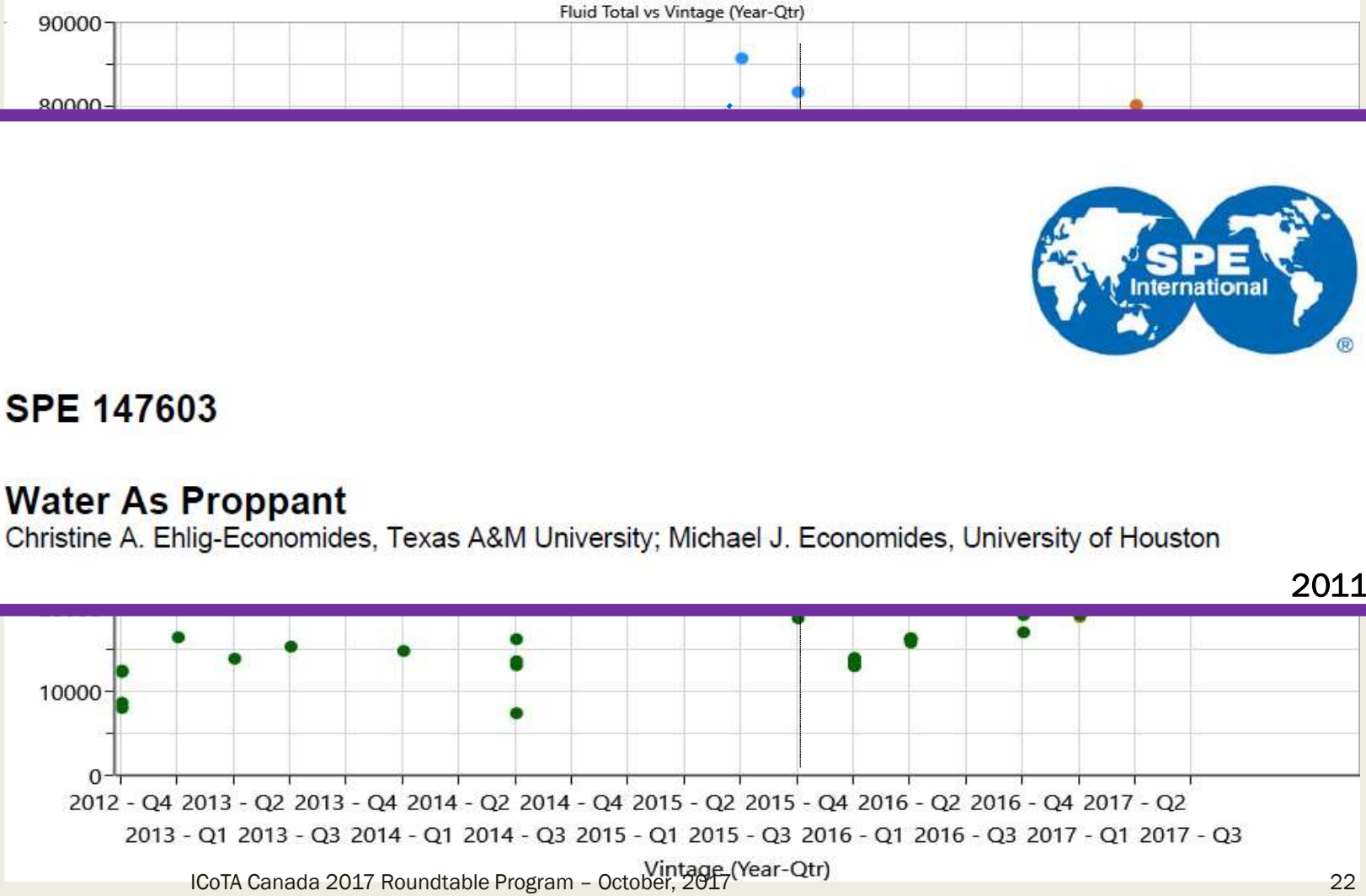


SPE 147603

Water As Proppant

Christine A. Ehlig-Economides, Texas A&M University; Michael J. Economides, University of Houston

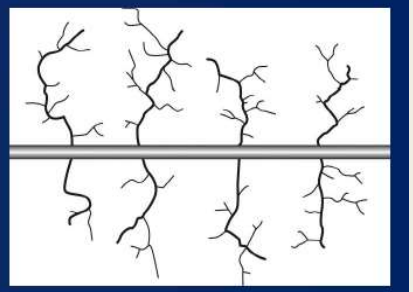
2011

How much fracture surface area do we create?

SPE DISTINGUISHED LECTURER

Mass balance

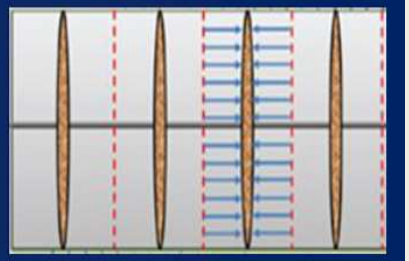
- Frac fluid: Frac surface area ~ 100 MMsqft
- Proppant: Propped frac surface area ~ 2-3 MMsqft



Example

15 transverse hydraulic fractures each 200 ft high and 500 ft across

Frac surface area = 2*15*200*500 sqft
= 3 MMsqft



Ian Walton, UofUtah

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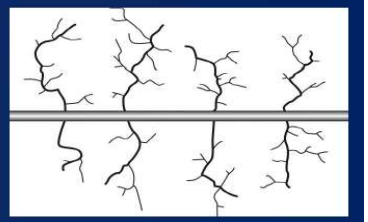

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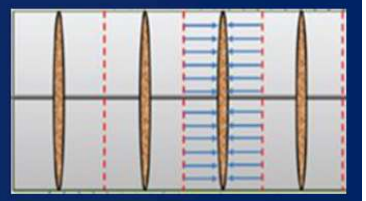


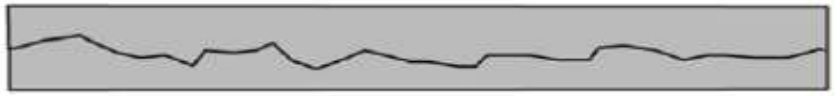
Ian Walton, UofUtah

SPE 147603

Water As Proppant

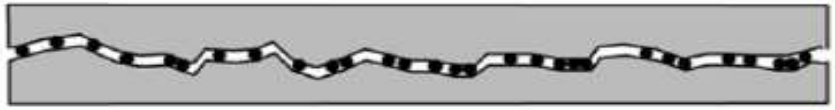
Christine A. Ehlig-Economides, Texas A&M University; Michael J. Economides, University of Houston

Case 1: Aligned fracture faces, no proppant



Case 2: Displaced fracture faces, no proppant

Case 3: Aligned fracture faces, 0.1 lbm/ft² proppant



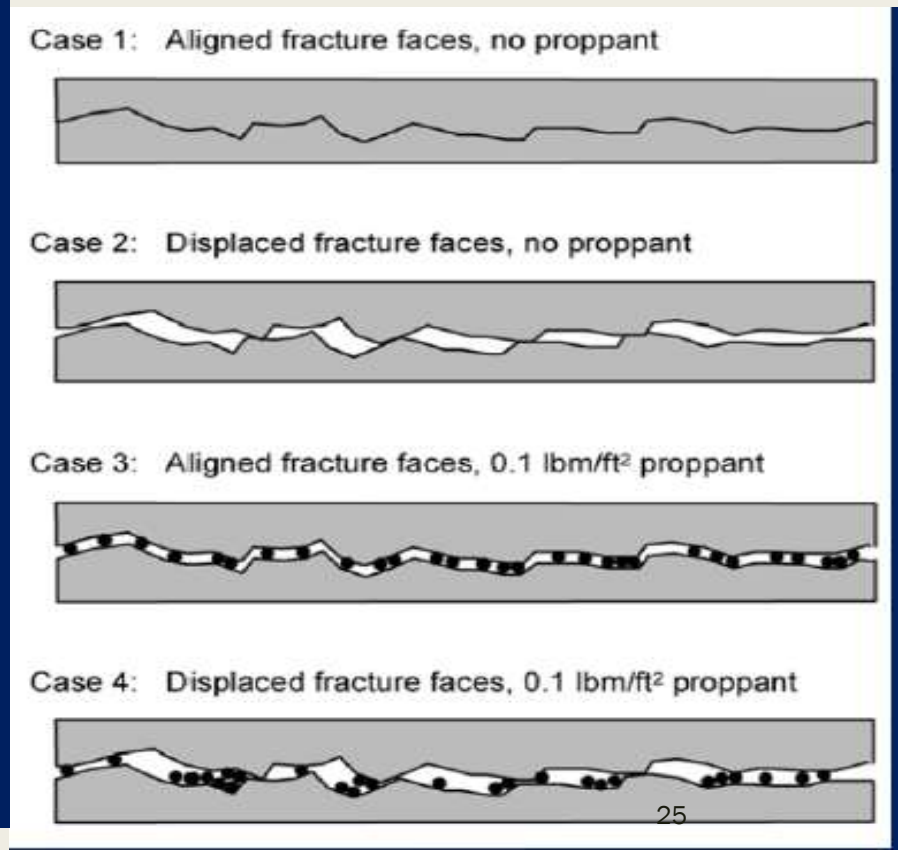
Case 4: Displaced fracture faces, 0.1 lbm/ft² proppant

SPE 147603

Water As Proppant

Christine A. Ehlig-Economides, Texas A&M University; Michael J. Economides, University of Houston

As the hydraulic fracture closes, 60 – 80% of the SLW is imbibed into the formation with only 20 – 40% returning back to surface. When is this a detriment and when is it a benefit?



SPE 147603

Water As Proppant

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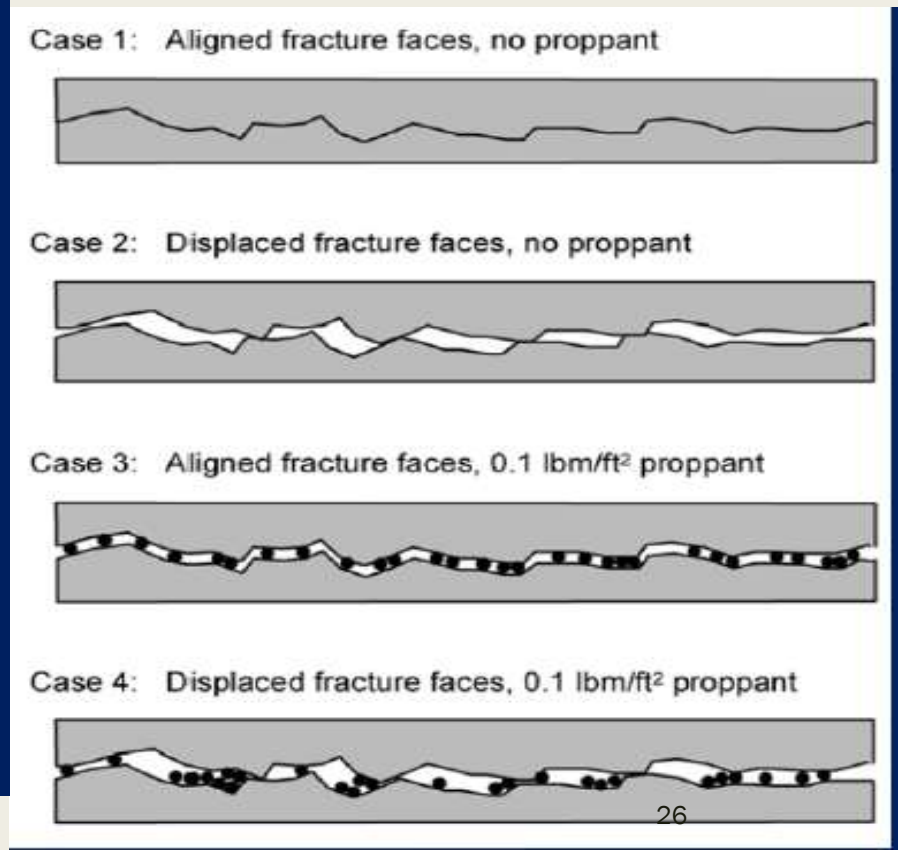
As the hydraulic fracture closes, 60 – 80% of the SLW is imbibed into the formation with only 20 – 40% returning back to surface. When is this a detriment and when is it a benefit?.....**It Depends**



Most geology is like a duck, walks like a duck, sounds like a duck and **NOT** being a duck……more like a Coot.

One of these formations is not like the others, one of them just doesn't belong. Can you tell which formation is unlike the others?

Trick Question, none of the formations are the same

The Montney is a prime example of the geology not really being what we had thought. In order for us to optimize the completion, we really need to understand the geology.

Over the last year we have seen a number of Montney cases where there are production issues, plant fouling and other issues. It all likely ties back to the geology and more specifically the geochemistry and interactions with completion fluids, production strings etc.

"Never theorize before you have data. Invariably, you end up twisting facts to suit theories instead of theories to suit facts."

—Sherlock Holmes