2015 International Petroleum Environmental Conference (IPEC)
Denver, CO

Hydraulic Fracturing with Cryogenic Fluids: Boosting Hydrocarbon Production While Conserving Fresh Water Resources

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November 18, 2015

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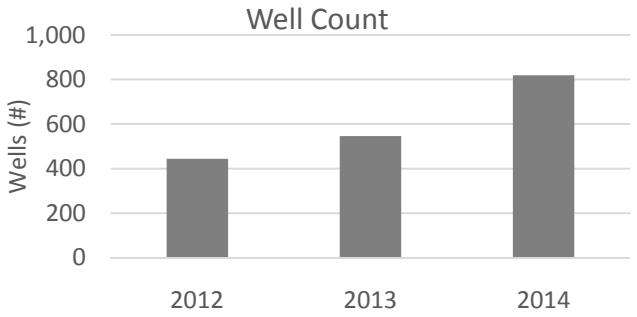
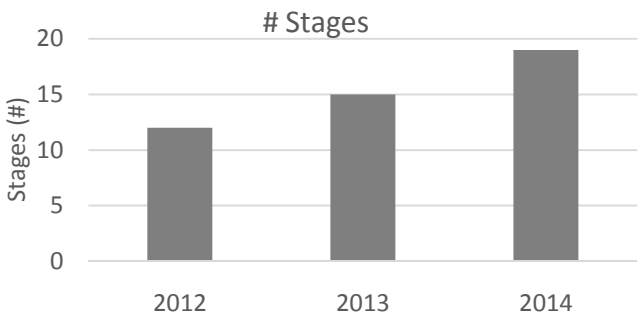
CURRENT CHALLENGES IN UNCONVENTIONAL FIELD DEVELOPMENT

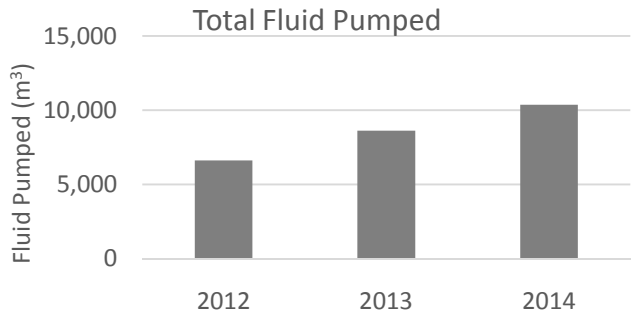
- Demand growth
- Volumes
- Number of wells
- Water management
- Logistics
- Well performance
- Environmental footprint
- Emissions and GHG's
- Truck traffic on county roads
- COST!!

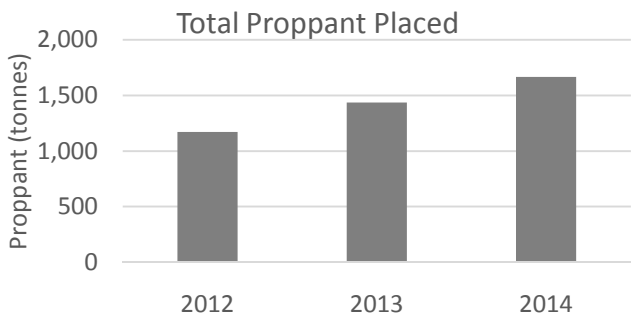
DEMAND GROWTH

Montney gas/ average per well YoY



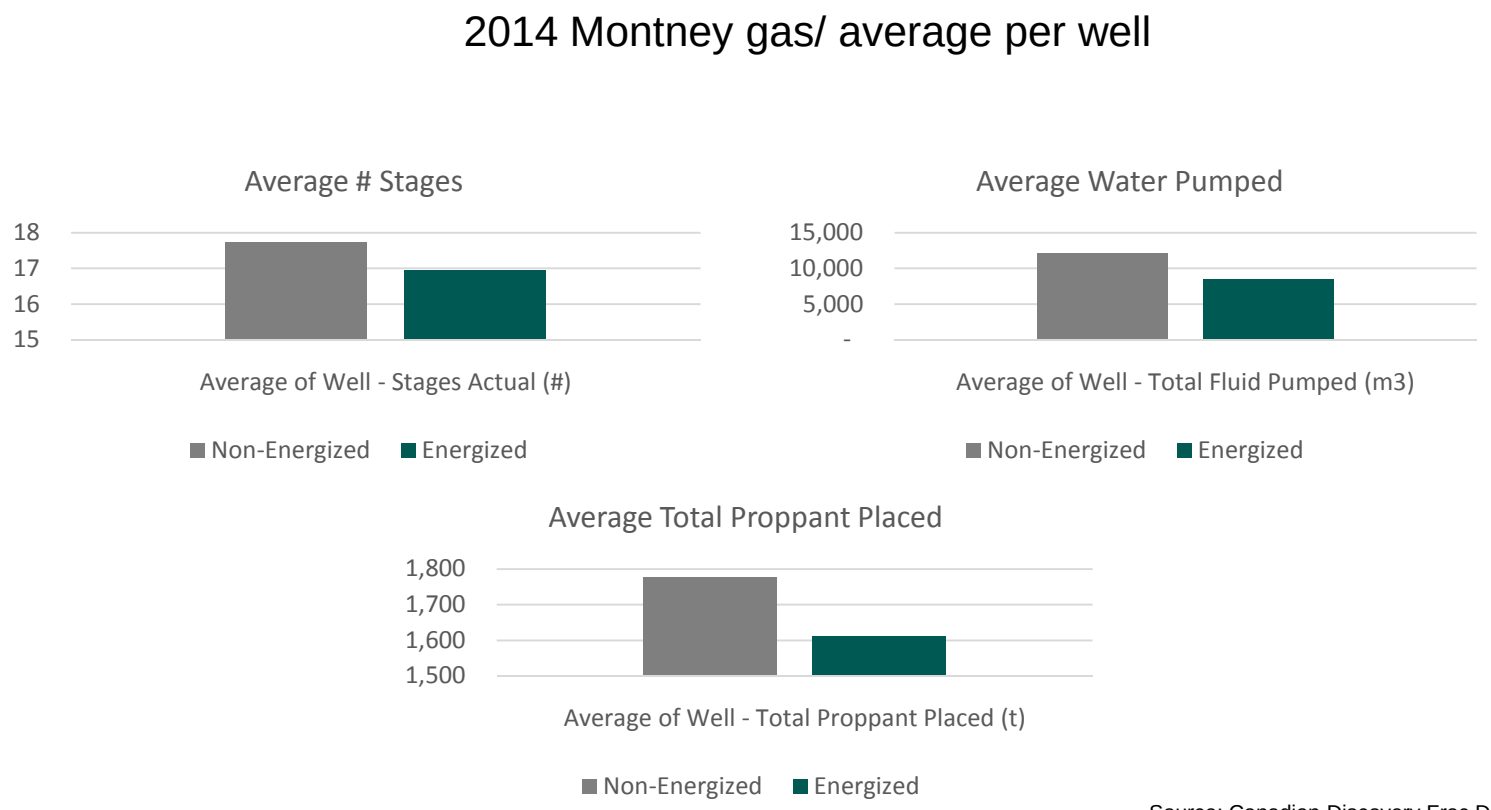






Source: Canadian Discovery Frac DataBase

OPTIMIZE JOB SIZE



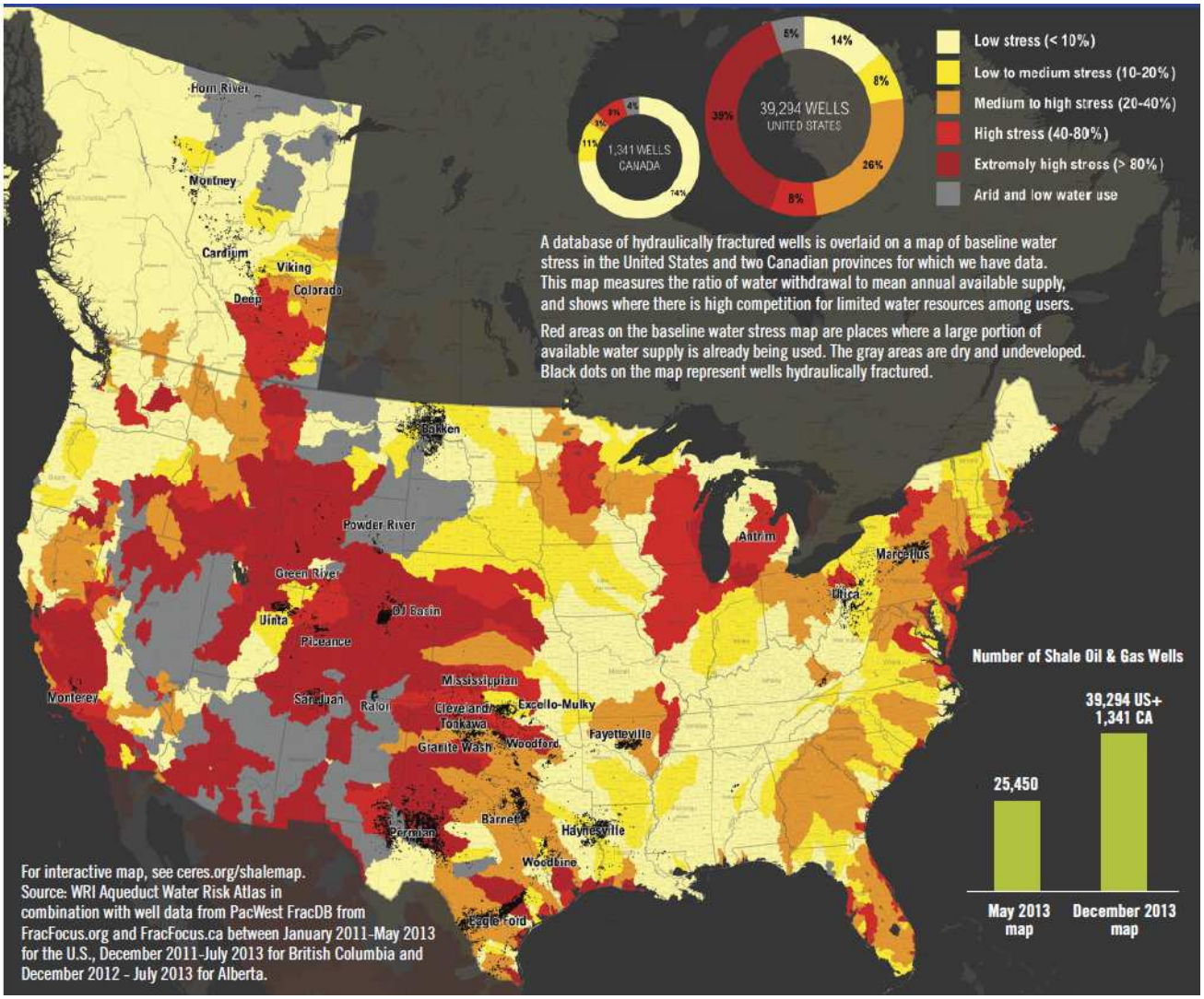
Source: Canadian Discovery Frac DataBase

WATER MANAGEMENT

- Water sourcing and sourcing restrictions
- Water transportation
- Water storage
- Water infrastructure investment
- Disposal and recycling challenges
- Pad sizing
- Hidden costs


Fox Creek Water Pit

NA Water Stress Map

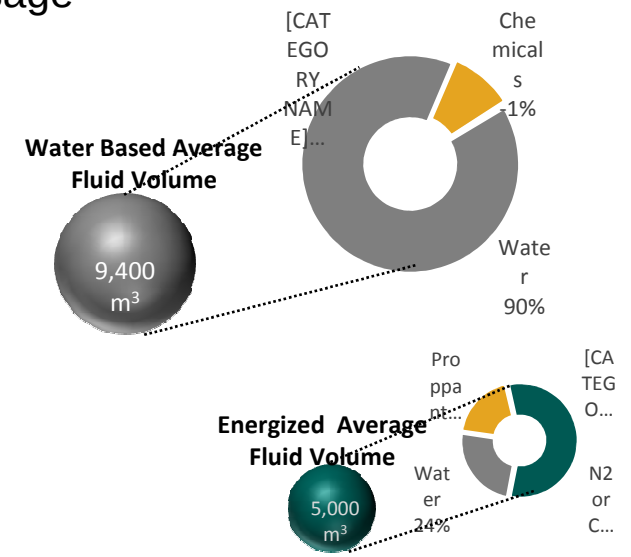


ALTERNATIVES TO MANAGE CHALLENGES

- Optimize job size
- Energize your wells

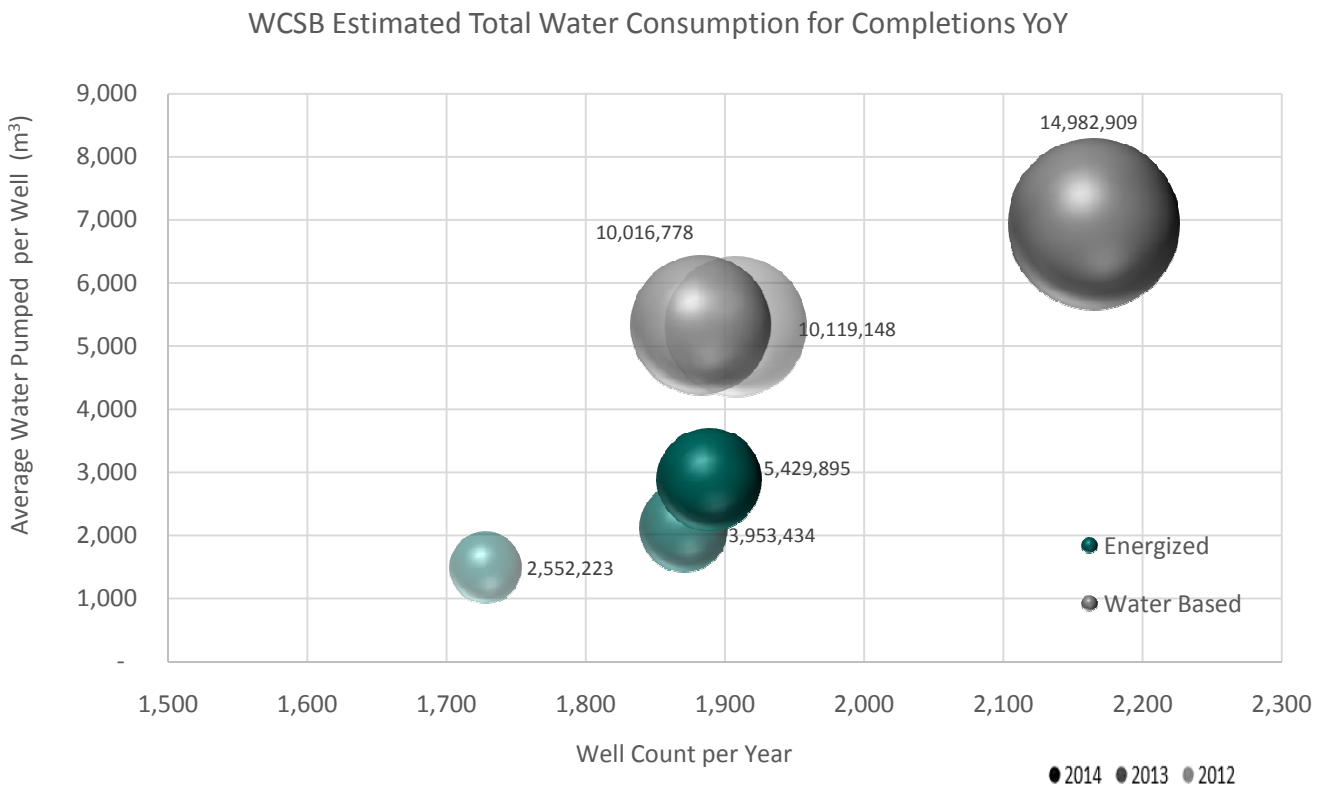
Optimize number of stages
Optimize sand tonnage
Reduce water usage

In 2014 on average, energized fracturing fluids volume were ~**50% smaller** than water based fracturing fluids volume



Source: Canadian Discovery Frac DataBase

REDUCE WATER USAGE

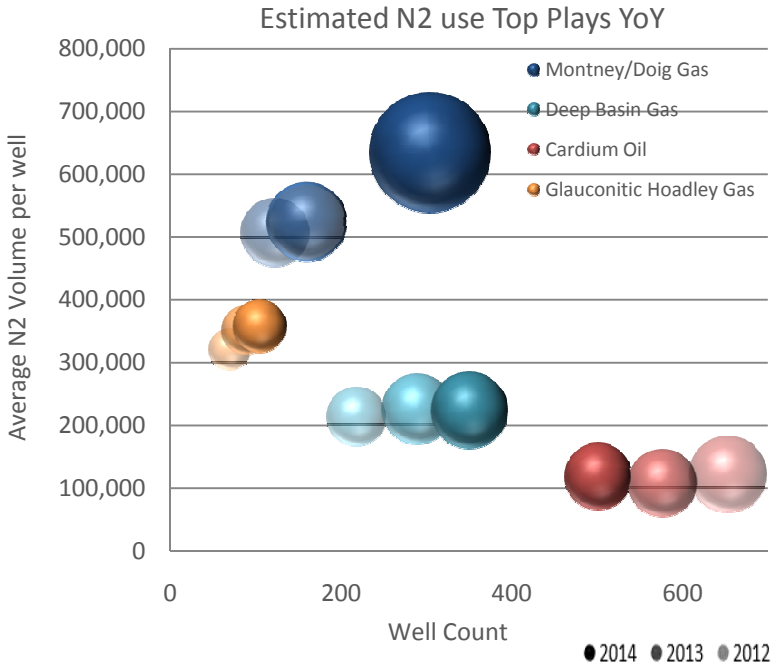


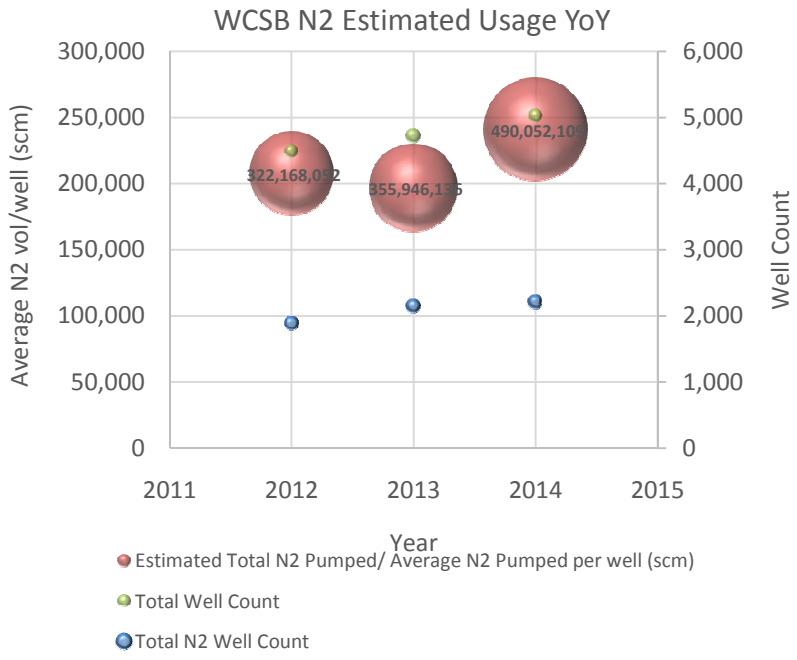
Bubble size is the estimated total water used YoY (in Million m3)

Source: Canadian Discovery Frac DataBase

FOLLOW PRODUCTIVE INITIATIVES

Nitrogen Usage Growth in WCSB

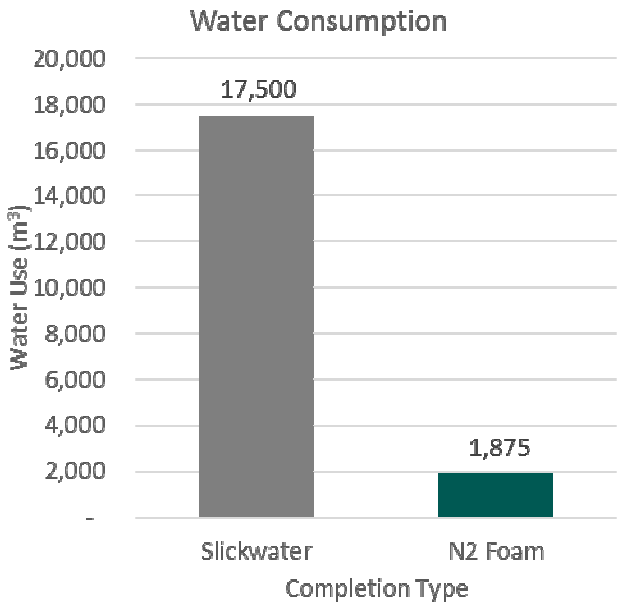


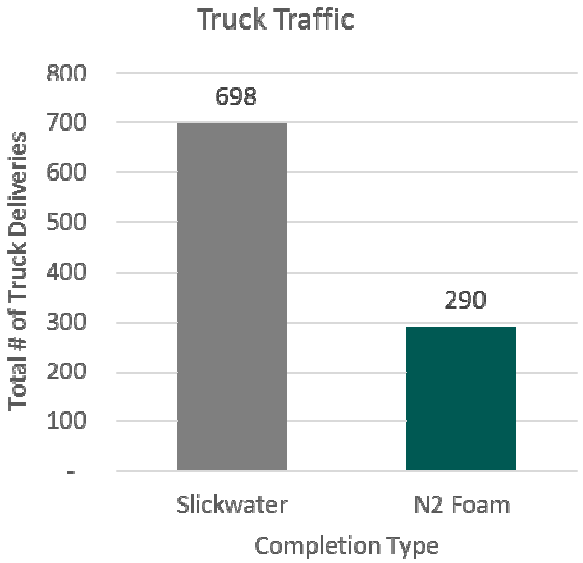


Source: Canadian Discovery Frac DataBase

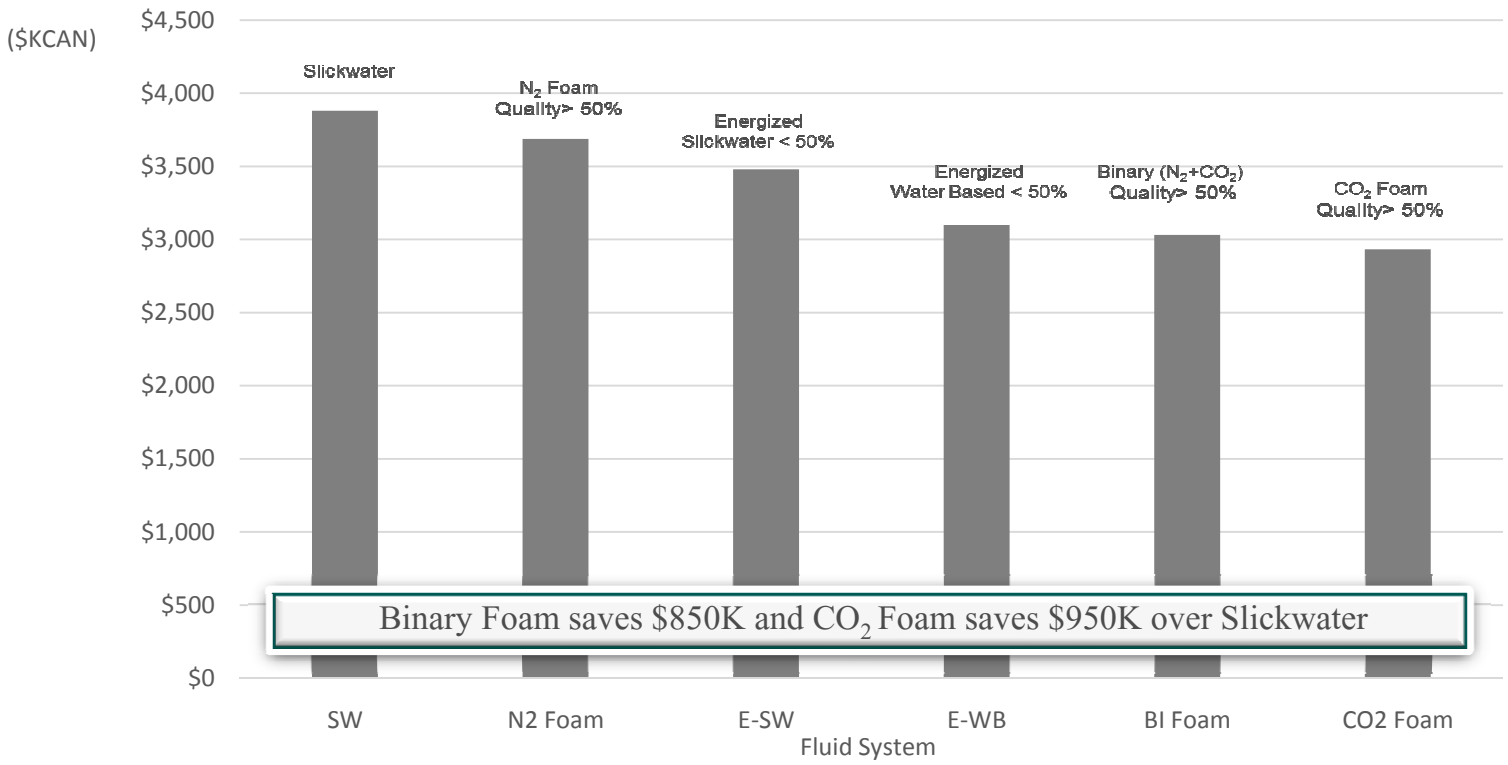
REDUCE TRUCK TRAFFIC

Kakwa river water usage





REDUCE COST



Source: SPE 175948

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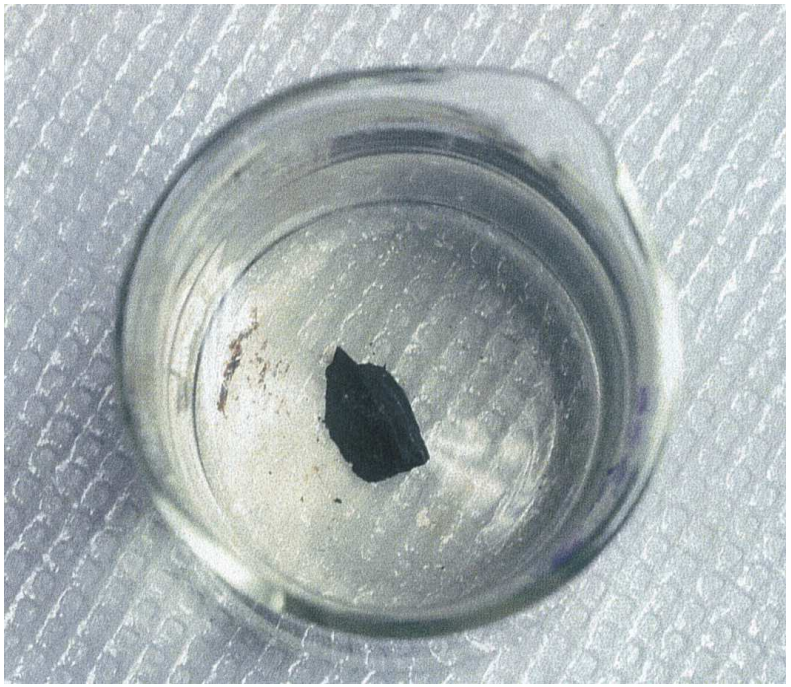
ENHANCE WELL PERFORMANCE

- Water damage mechanisms:
  - Clay swelling / softening / movement
  - Aqueous phase trapping (high capillary pressure)
  - Proppant embedment
  - Fracture face damage (fluid imbibition)
  - Poor cleanup and water recoveries during flowback
  - Poor proppant transport / conductivity
  - Lower hydrocarbon rates and EUR's

ADVERSE ROCK – WATER INTERACTION (VIKING ZONE)

Core Immersed in Mcbride dugout water

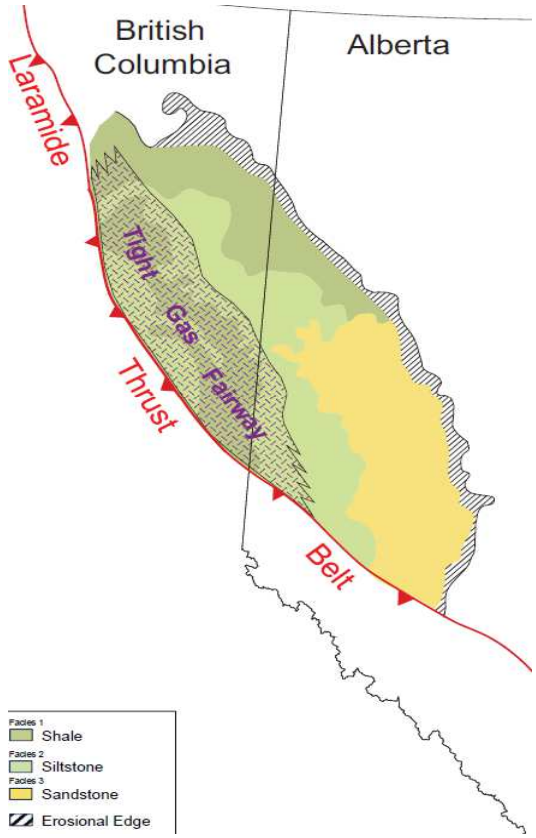
Core Immersed in Bridge Creek 3% KCl Water



SOURCE: Baker Hughes

CASE STUDY SHOWING ENHANCED
PRODUCTION / REDUCED COST – SPE 175948

- Cryogenic N_2 and CO_2 used in energized fluid systems provide proven, effective technology to stimulate tight sands and shales
- Non-damaging fluid which greatly reduces water volumes, chemicals and proppants
- Reduces real and environmental costs while maximizing NPV



Source: BMO A&D Drill Bits – October 2011

STUDY SCOPE

- >3,500 Hz Montney wells completed to date
- Study criteria:
  - Montney/Doig Gas
  - OGR < 75 stb/mmscf
  - 12 months of production data
  - On Production Date >2010
  - 1,627 wells met the criteria

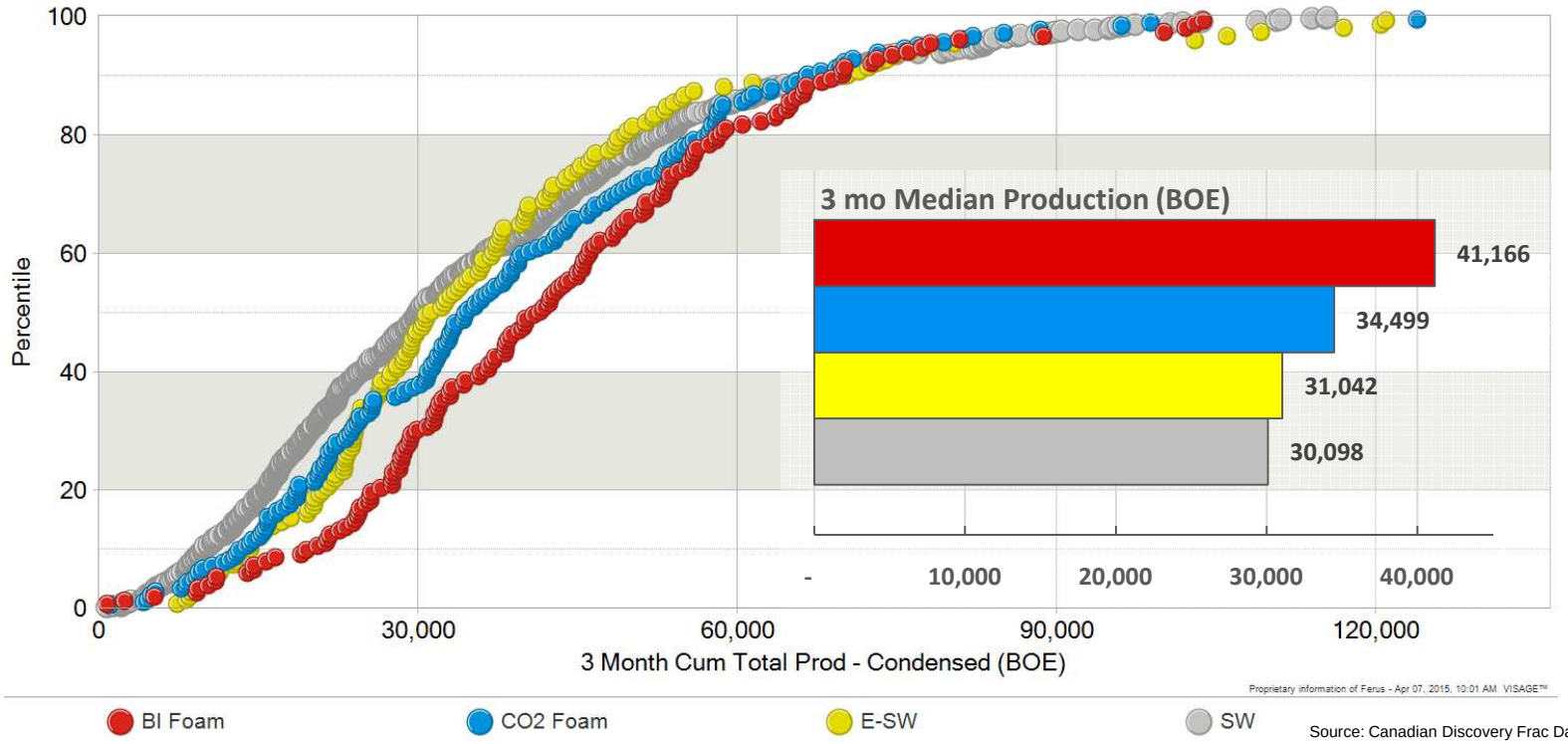
- Fluid systems analyzed

Fluid	Acronym
Slickwater	SW
Energized Slickwater	E-SW
Other Water Based Fluids	WB
Energized Water Based	E-WB
Oil Based	Oil
Energized Oil Based	E-Oil
N_2 Foam	N_2 Foam
CO_2 Foam	CO_2 Foam
Binary (N_2+CO_2) Foam	BI Foam

Energized Fluids < 50% CO_2 or N_2
Foams CO_2 / N_2 / Both > 50%

The most comprehensive statistical analysis of the Montney

PRODUCTION RECOVERY - 3 MONTH CUMULATIVE PRODUCTION



Source: Canadian Discovery Frac Database & Accumap integrated through Visage

Binary Foams outperform any other fluid on a 90 day basis!

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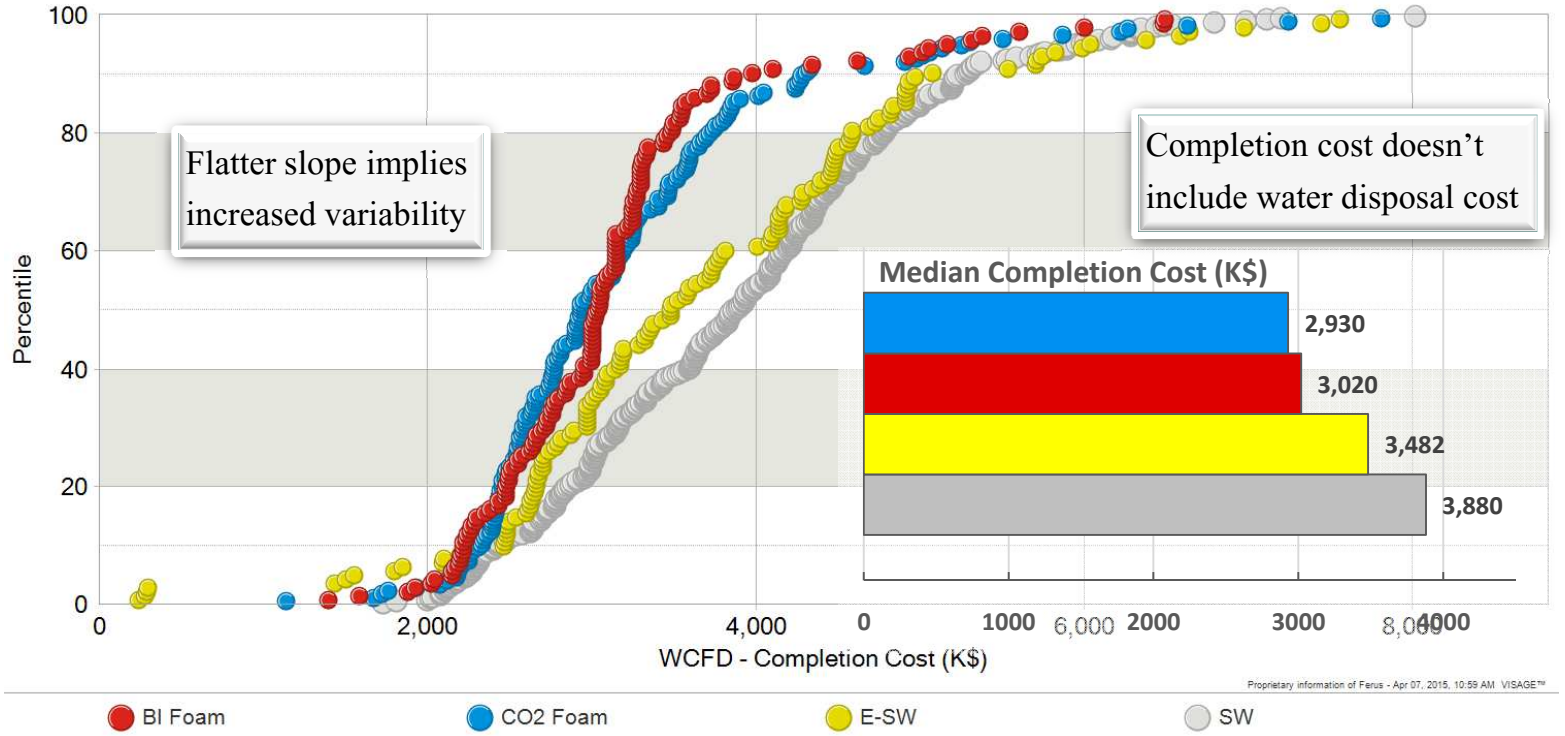
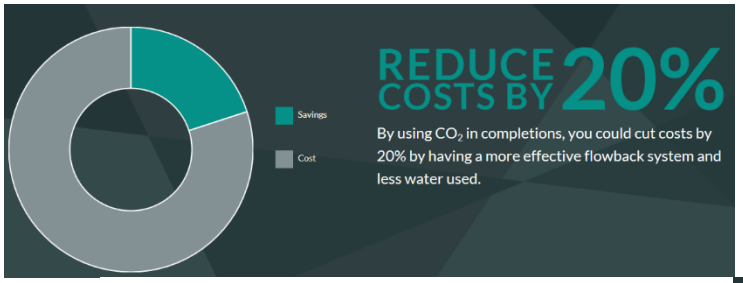
MONTNEY GAS COMPLETION COST

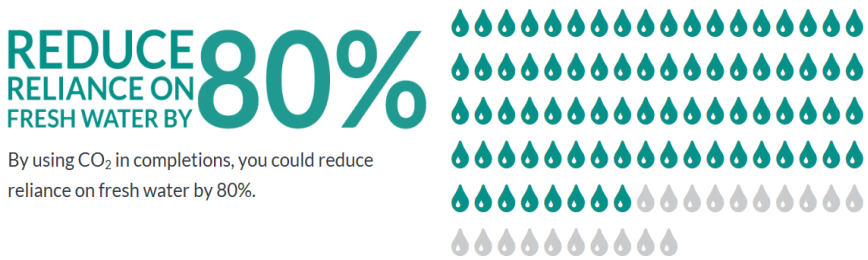


Source: Canadian Discovery Frac Database & Accumap integrated through Visage

Slickwater is consistently the MOST expensive fluid used in the Montney!

WHAT WE LEARNED





INCREASE PRODUCTION BY 15%

By using CO_2 in completions, you could increase production by 15%. The duration of the well life is extended using Co_2.

useCO2.com by ferus

RECENT US SUCCESSFUL APPLICATION

- 2015 - first application of CO_2 based fracture fluid in the Bakken fm (North Dakota)
- Over 6,000 tons used in a multi-stage fractured HZ completion
- Stay tuned for results

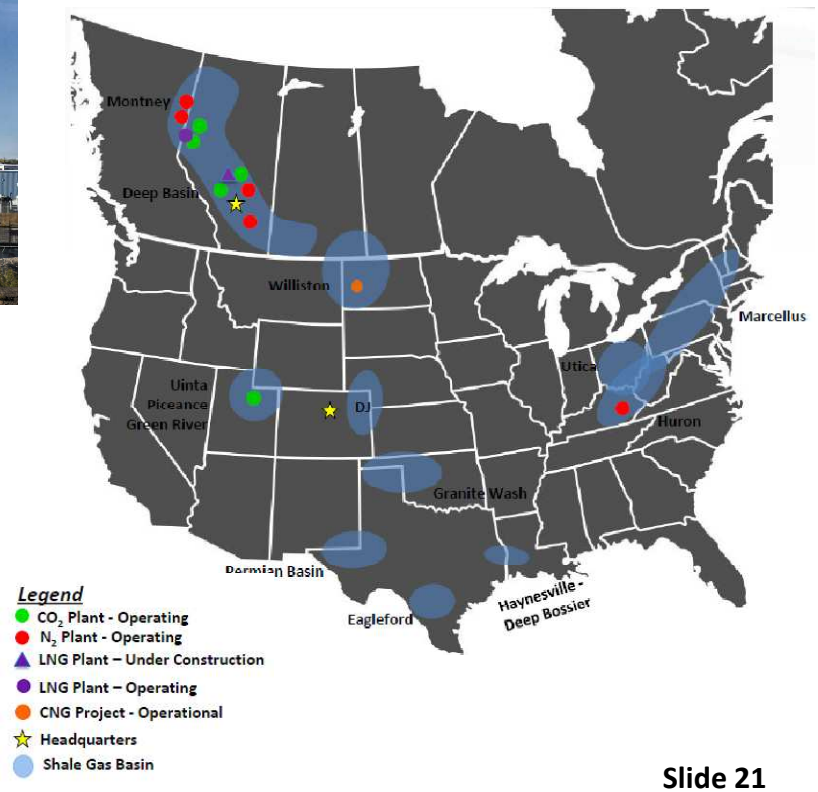
LOGISTICAL CHALLENGES

- Large volume hydraulic fracturing jobs
  - Supply constraints
  - Truck traffic
  - Site layout challenges
  - Sub-optimal product delivery
  - Over-sizing of fracture treatments
  - Cost

OPTIMIZE LOGISTICS

- Proximal Supply
  - Substantially reduced plant gate price
  - Significantly reduced transportation
  - Scheduling flexibility; reduced standby
  - Reduced exposure to weather & road bans

Ferus North American Operations



OPTIMIZE LOGISTICS

- Demand Planning
  - 24/7 Real-Time Dispatch Services
  - Coordinate storage, trucks and product deliveries
  - Optimize delivery times through real-time interaction
- Reliable Transportation
  - Triple drive axle tractors allowing for larger capacity
  - Typically use tandem tractors requiring two trailers
- On-Location Storage
- On-Site Service - Field supervisors

INTEGRATED SOLUTIONS

- Holistic approach to solve the problem
- Technical services
  - Optimize job size
  - Improve fracturing fluid design
- Partner with experts
  - Supply
  - Logistics
  - Transportation
- Reduced costs
- Reduce environmental Impact
- Enhanced well productivity and economics

Questions?

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