

March 10, 2020

# Hydraulic Fracture Design, Planning & Execution

## Wapiti Area Synergy Partnership

Dustin Domres – Lead, Fracture Optimization, Calfrac Well Services Ltd.



# AGENDA

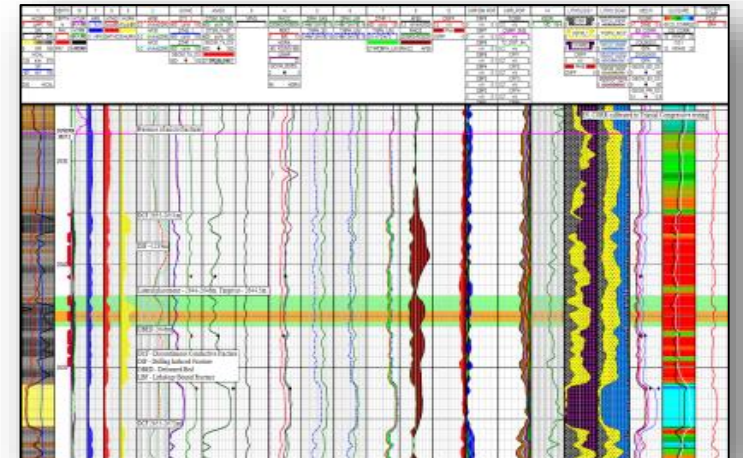
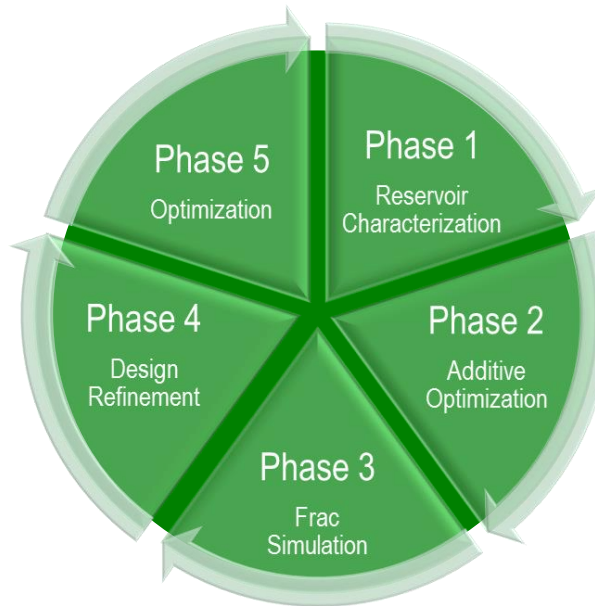
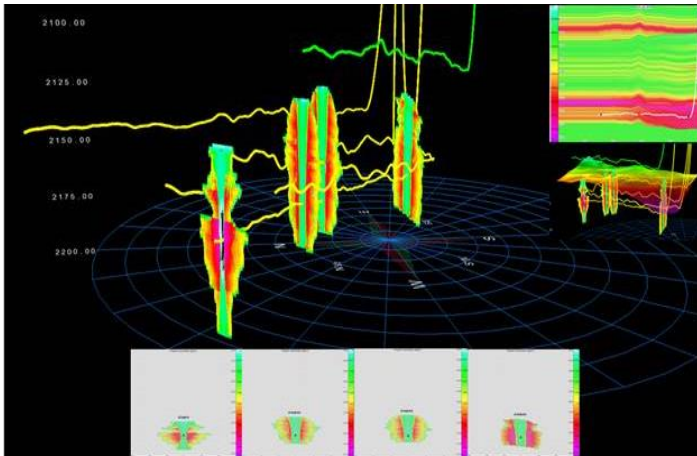
## **Calfrac's Asset Enhancement Group**

### **Hydraulic Fracturing - Equipment, Operations & Logistics**

- Completions System Overview
- Fluid System Overview
- Equipment Layout
- Operational Limitations
- Field Experience and Fracture Placement
- Supply Chain & Logistics

# CWS Asset Enhancement

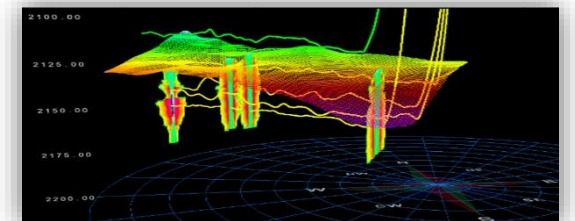
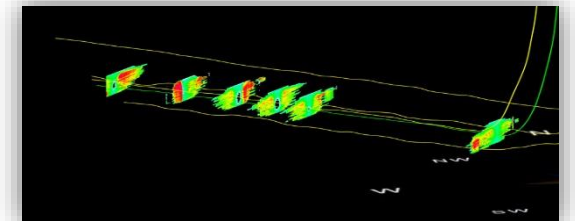
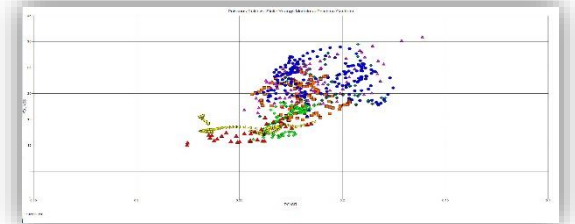
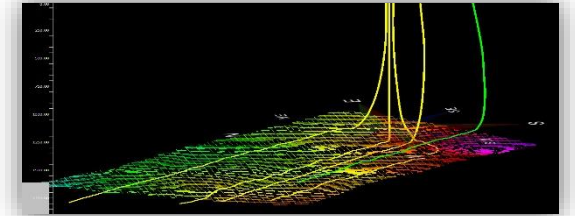
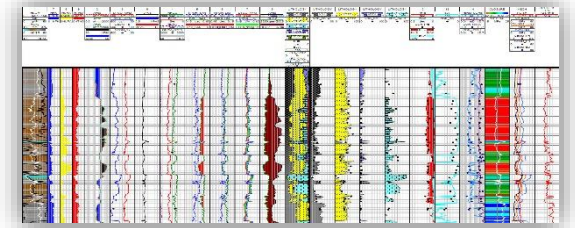
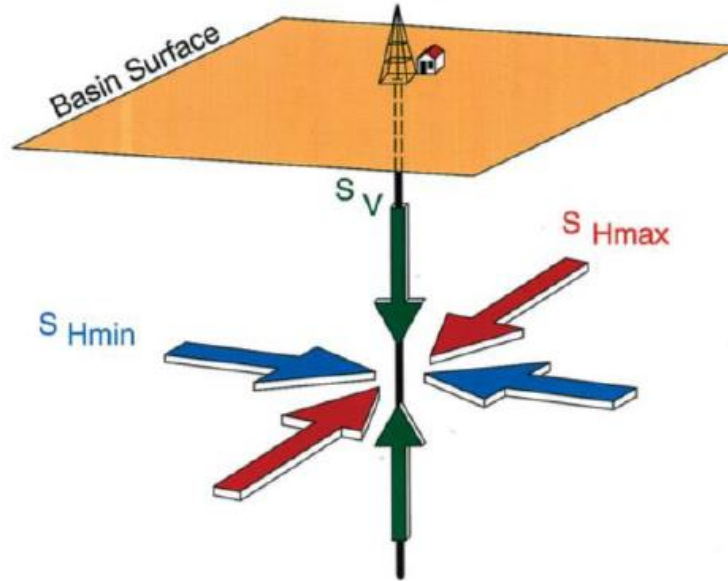
**CWS Asset Enhancement** provides **advanced technical expertise** and in-depth analyses for internal and external clients to **progress reservoir understanding and identify optimal completion methodologies**. Asset Enhancement creates value for stakeholders by applying multi-disciplinary knowledge of hydraulic fracture and reservoir factors which influence the planning phases, fracturing operations and post-frac evaluations. We aim to be on the leading edge of market evaluation and innovative technology implementation to improve our client's efficiencies and assist them in **making technically sound business decisions**.



# Resource Integration & Collaboration

## Asset Enhancement – Multi-Disciplinary Approach

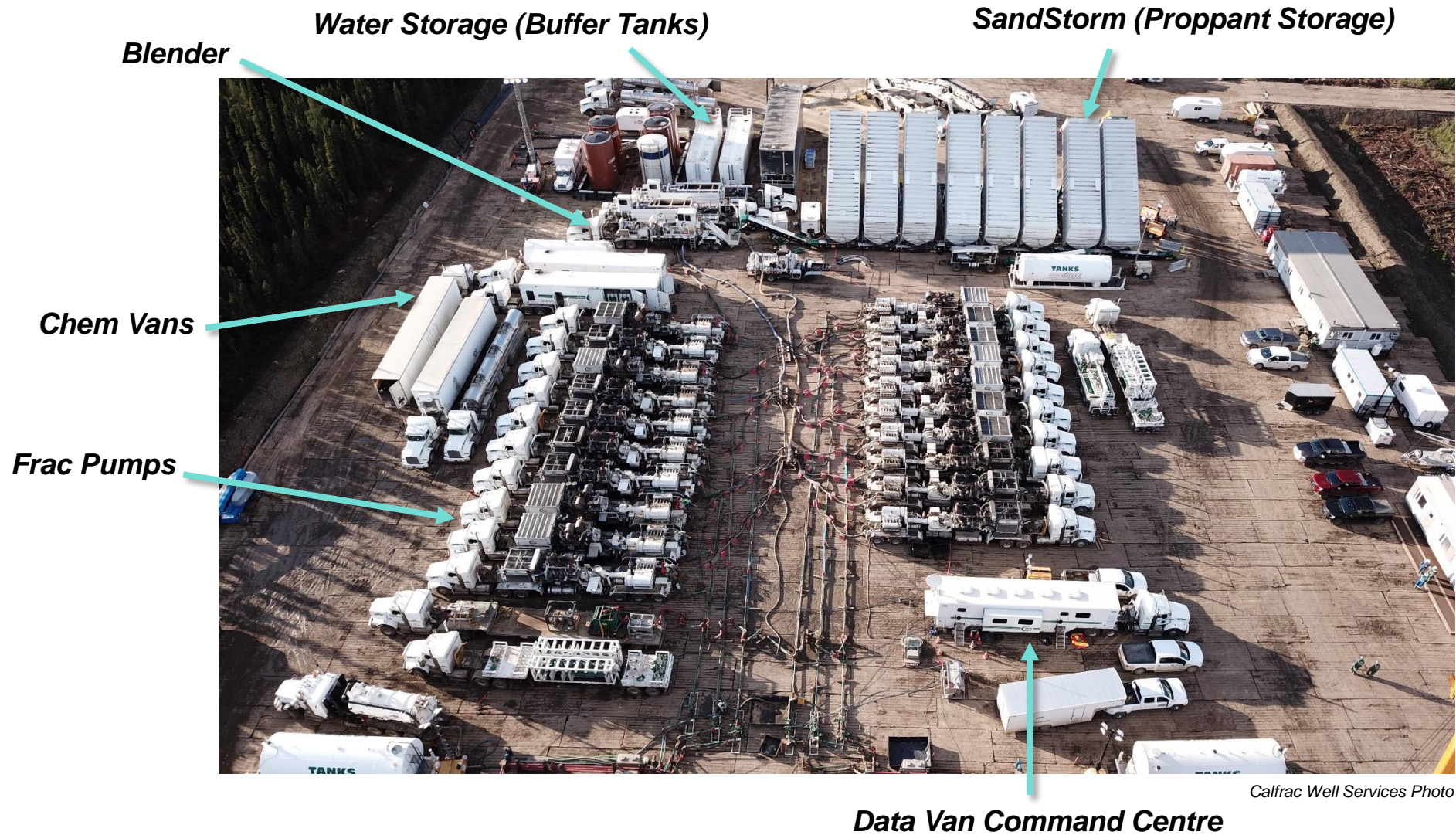
- Reservoir characterization
- Stress environment
- Treatment design optimization
- Lateral placement
- Stage spacing
- Perforation Design
- Fracture conductivity
- DFIT and Step Rate Test analysis





# Introduction to Fracturing

## Hydraulic Fracturing Spread



# Introduction to Fracturing

## Fracturing Program

Well Data									
<b>Well Name:</b> Province: Alberta Field: Elmworth Equipment Mileage (km): 45			<b>Well Type:</b> Gas <b>Treatment Modes:</b> Down Casing <b>Completion Technologies:</b> Plug & Perf <b>Material Mileage (km):</b> 45			<b>Fluid Systems:</b> Acid Spearhead, CalVisc, CWS-600 <b>Proppant Total (tonne):</b> 6,338.00			
Reservoir									
Formation	TVD (m)	BH Temp (°C)	H2S (ppm)						
Montney (C)	2,503.4	84	137,800						
Well Configuration									
<b>Wellbore Orientation:</b> Horizontal					<b>Cross Over (m):</b> 2,524.4				
<b>PBTD (m):</b> 5,038.0									
Tubular Type	OD (mm)	Weight (kg/m)	Wall Thickness (mm)	Grade	Int. Yield (MPa)	Collapse (MPa)	Capacity (m³/m)	Top (m)	Bottom (m)
Casing	139.70	34.23		VA-XP-L80-1	82.70	85.10	0.0111	0.0	2,524.4
Casing	114.30	22.47		VA-XP-L80-1	83.40	84.30	0.0074	2,524.4	5,041.7
Design Criteria									
<b>Max Clean Rate (m³/min):</b> 13.00					<b>Surface Pumping Pressure (kPa):</b> 67,006				
<b>Max Slurry Rate (m³/min):</b> 13.00					<b>Max Req Pump Power (kW):</b> 14,518				

Program specifies all components required to conduct a successful frac:

- Pressure Limitations
- Treatment Design
- Equipment Required
- Proppant / Additives

Proppants / Items					
Proppants	Total (tonne)	Contingency (tonne)	Final (tonne)		
30/50 Import Proppant	6,338.00	0.00	6,338.00		
Fluids					
Base Fluids	Total (m³)	Bottoms (m³)	Contingency (m³)	CT (m³)	Final (m³)
15% HCl Acid	130.0	0.0	0.0	0.0	130.0
Fresh Water	21,078.2	2,144.0	2,107.8	0.0	25,330.0
Chemicals					
Chemicals	Total	Contingency	CT	Final	Unit
CalSurf 9400, Flowback Surfactant	21,078.2	0.0	0.0	21,078.2	L
CalVisc	50,640.0	0.0	0.0	50,640.0	L
DWP-690, Slickwater Breaker	10,539.1	0.0	0.0	10,539.1	L
DWP-913, Clay Control	16,862.5	0.0	0.0	16,862.5	L
SaniFrac 8844, Biocide	2,107.8	0.0	0.0	2,107.8	L
Chemicals	Primary Injection Point	Alternative Injection Point	Pump Type		
CalSurf 9400, Flowback Surfactant	2	1	W		
CalVisc	10A	-	W		
DWP-690, Slickwater Breaker	3	1	W		
DWP-913, Clay Control	6	5	W		
SaniFrac 8844, Biocide	2	1	W		
<b>*Note:</b> 1 L/m3 into 10A. Remaining L/m3 into 7					
Premix & Additional Items					
Premix & Additional Items	Total	Contingency	CT	Final	Unit
CI-9100G, Corrosion Inhibitor	65.0	0.0	0.0	65.0	L
Premixed Chemicals	Fluid System	Concentration	Unit		
CI-9100G, Corrosion Inhibitor	Acid Spearhead / 15% HCl Acid	0.50	L/m³		

### Pump Schedule 4

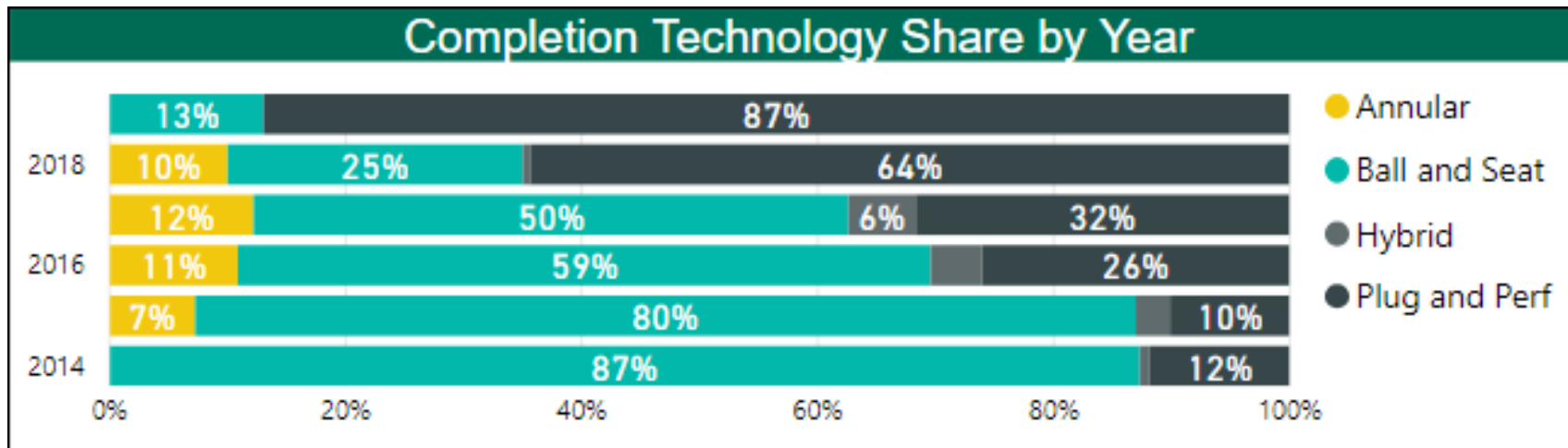
Proppant Total (kg): 285,000

Zone 18-26	Rate		Volume			Proppant			Time	
	Slurry Rate	Clean Rate	Slurry Volume	Clean Volume Cum	Clean Volume	Blender Conc	Proppant Stage	Proppant Cum	Stage Time	Time Cum
	m³/min	m³/min	m³	m³	m³	kg/m³	kg	kg	hh:mm:ss	hh:mm:ss
1 Pre-Pad (CalVisc)	0.50	0.50	2.0	2.0	2.0	0	0	0	00:04:00	00:04:00
2 Acid (Acid Spearhead)	1.00	1.00	5.0	7.0	5.0	0	0	0	00:05:00	00:09:00
3 Pad (CalVisc)	6.00	6.00	70.0	77.0	70.0	0	0	0	00:11:40	00:20:40
4 Proppant (CalVisc) 30/50 Import Proppant	13.00	12.88	40.4	117.0	40.0	25	1,000	1,000	00:03:06	00:23:46
5 Proppant (CalVisc) 30/50 Import Proppant	13.00	12.76	40.8	157.0	40.0	50	2,000	3,000	00:03:08	00:26:54
6 Proppant (CalVisc) 30/50 Import Proppant	13.00	12.53	41.5	197.0	40.0	100	4,000	7,000	00:03:11	00:30:06
7 Proppant (CalVisc) 30/50 Import Proppant	13.00	12.30	42.3	237.0	40.0	150	6,000	13,000	00:03:15	00:33:21
8 Proppant (CalVisc) 30/50 Import Proppant, CalVisc @ 2L/m3	13.00	12.09	43.0	277.0	40.0	200	8,000	21,000	00:03:18	00:36:39
9 Proppant (CalVisc) 30/50 Import Proppant, CalVisc @ 2L/m3	13.00	11.88	43.8	317.0	40.0	250	10,000	31,000	00:03:22	00:40:01
10 Proppant (CalVisc) 30/50 Import Proppant, CalVisc @ 2L/m3	13.00	11.68	44.5	357.0	40.0	300	12,000	43,000	00:03:25	00:43:27
11 Proppant (CalVisc) 30/50 Import Proppant, CalVisc @ 2L/m3	13.00	11.48	45.3	397.0	40.0	350	14,000	57,000	00:03:28	00:46:56
12 Proppant (CalVisc) 30/50 Import Proppant, CalVisc @ 4L/m3	13.00	11.30	46.0	437.0	40.0	400	16,000	73,000	00:03:32	00:50:28
13 Proppant (CalVisc) 30/50 Import Proppant, CalVisc @ 4L/m3	13.00	11.11	46.8	477.0	40.0	450	18,000	91,000	00:03:35	00:54:04
14 Proppant (CalVisc) 30/50 Import Proppant, CalVisc @ 4L/m3	13.00	10.94	47.5	517.0	40.0	500	20,000	111,000	00:03:39	00:57:44
15 Proppant (CalVisc) 30/50 Import Proppant, CalVisc @ 4L/m3	13.00	10.77	48.3	557.0	40.0	550	22,000	133,000	00:03:42	01:01:27
16 Proppant (CalVisc) 30/50 Import Proppant, CalVisc @ 4L/m3	13.00	10.60	49.1	597.0	40.0	600	24,000	157,000	00:03:46	01:05:13
17 Proppant (CalVisc) 30/50 Import Proppant, CalVisc @ 4L/m3	13.00	10.44	49.8	637.0	40.0	650	26,000	183,000	00:03:49	01:09:03
18 Proppant (CalVisc) 30/50 Import Proppant, CalVisc @ 4L/m3	13.00	10.28	50.6	677.0	40.0	700	28,000	211,000	00:03:53	01:12:56
19 Proppant (CalVisc) 30/50 Import Proppant, CalVisc @ 4L/m3	13.00	10.13	51.3	717.0	40.0	750	30,000	241,000	00:03:56	01:16:53
20 Proppant (CalVisc) 30/50 Import Proppant, CalVisc @ 4L/m3	13.00	9.99	51.6	772.0	55.0	800	44,000	<b>285,000</b>	00:05:30	01:22:24
21 Spacer (CalVisc) CalVisc @ 4L/m3	13.00	13.00	5.0	777.0	5.0	0	0	0	00:00:23	01:22:47
22 Flush (CalVisc)	13.00	13.00	41.1	818.1	41.1	0	0	0	00:03:09	01:25:56



# Introduction to Fracturing Completion Systems

Plug & Perf	Ball & Seat	Annular	Frac Through Coil (FTC)
Multi-well/Single well Cemented casing <b>High rate / low friction</b> <b>6 – 20 m<sup>3</sup>/min</b> Must mill out plugs* Full wellbore ID* <b>5/180 min between zones</b>	Single well Cemented or Openhole Liner <b>High rate / port friction</b> <b>8 – 10 m<sup>3</sup>/min</b> Milling optional Restricted ID (unless milled) <b>No downtime between zones</b>	Single well <b>Cemented sleeves</b> <b>Limited rate / Annular Friction</b> <b>6.5 m<sup>3</sup>/min</b> No milling Full wellbore ID <b>10-15 min between zones</b>	Single well Burst Ports <b>Low rate / high friction</b> <b>~3 m<sup>3</sup>/min max rate</b> No milling Full wellbore ID <b>5 min between zones</b> <b>Depth limited by coil</b>

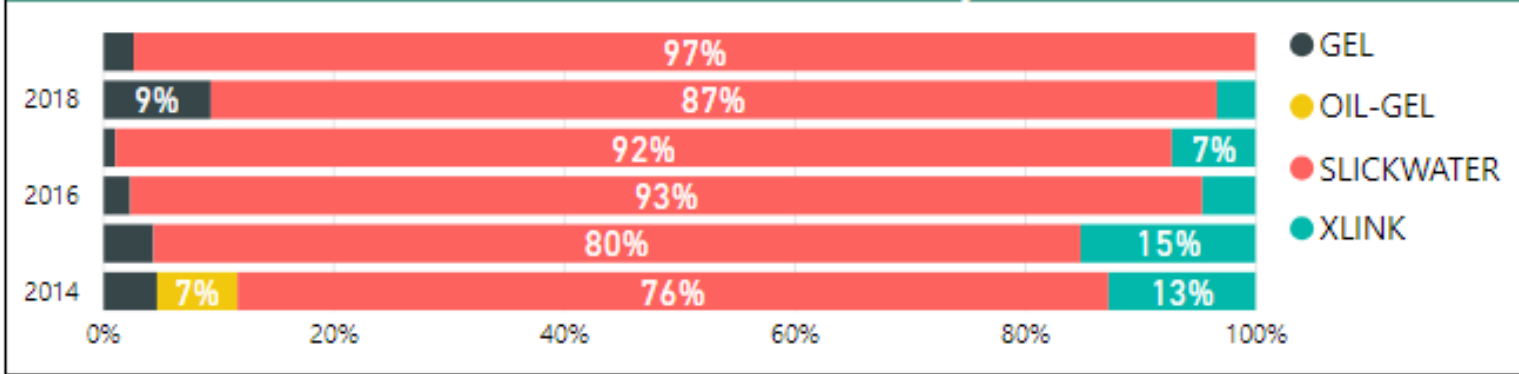


# Introduction to Fracturing

## Fracturing Fluid Systems

Slickwater	High Viscosity FR	Linear Gelled	Crosslinked Gel	Foam
~2-5 cP	~20-600 cP	~20 cP	~1000 cP	~150 cP 75% N <sub>2</sub> / 25% H <sub>2</sub> O

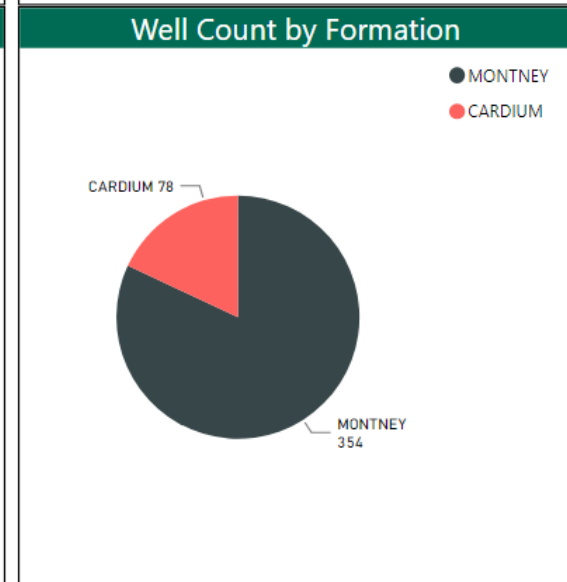
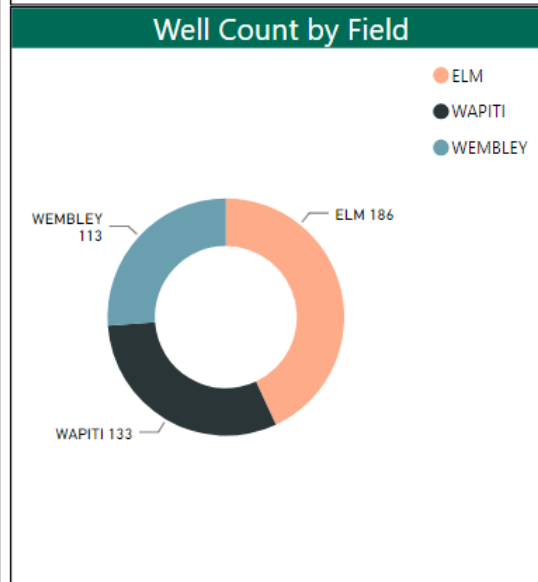
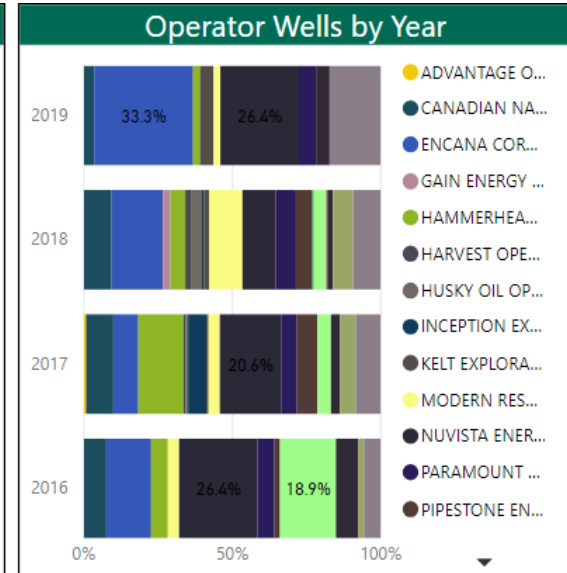
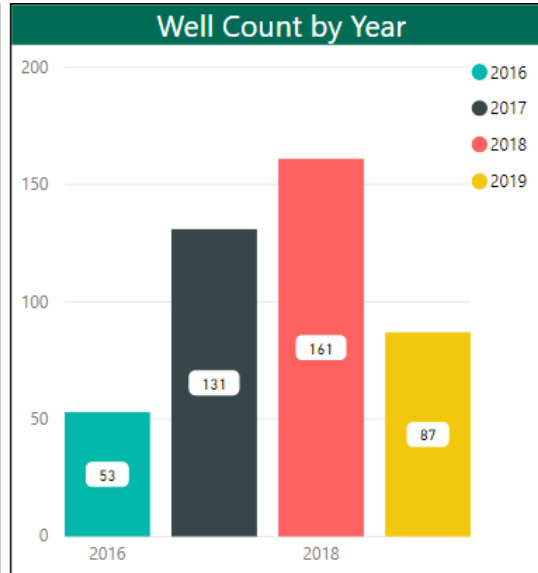
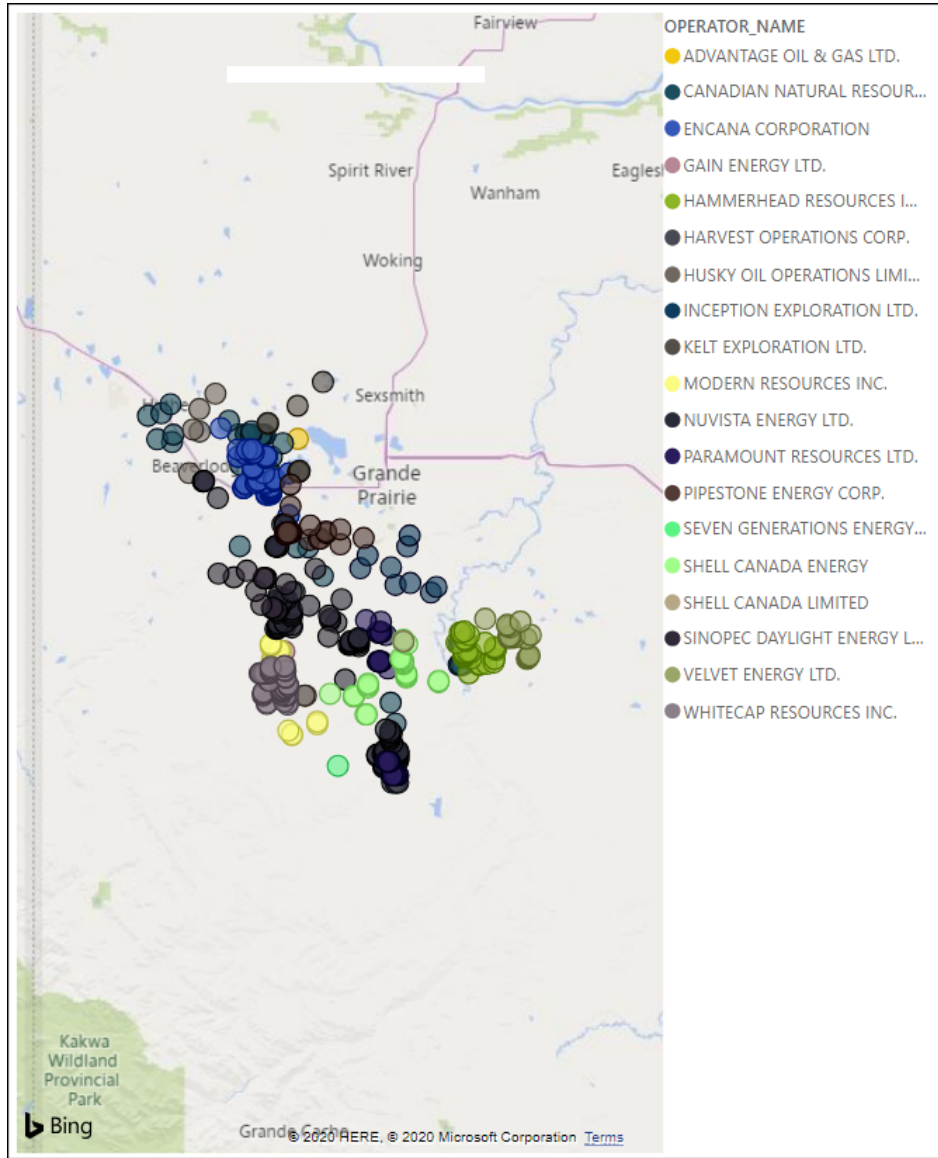
Stimulation Fluid Share by Year





# Regional Intelligence – Public and Internal Completions Databases

## Area of Interest



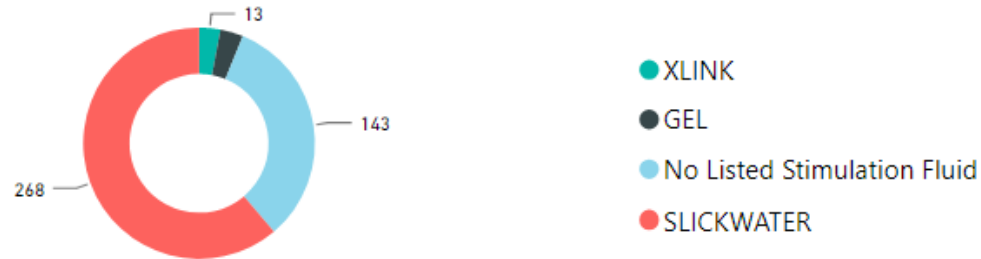
# Regional Intelligence – Public and Internal Completions Databases

## Completion Technology and Fluid System

### Completion Technology



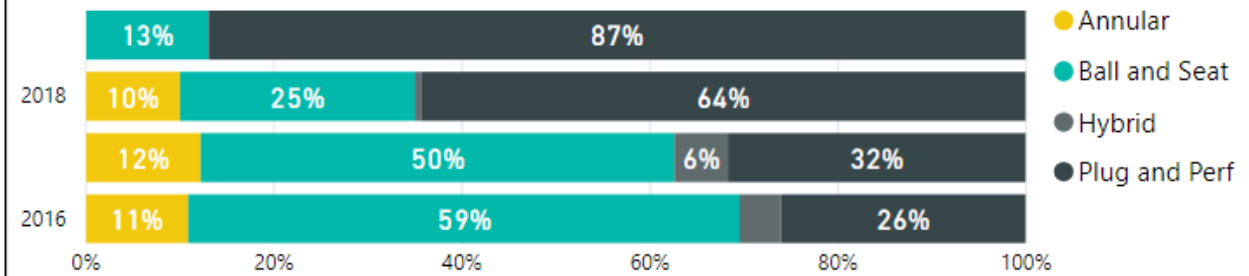
### Well Count by Stimulation Fluid



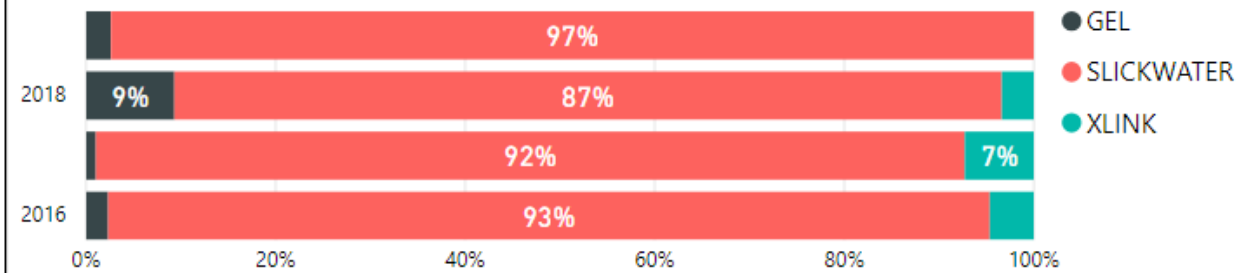
### Well Count by Energizer



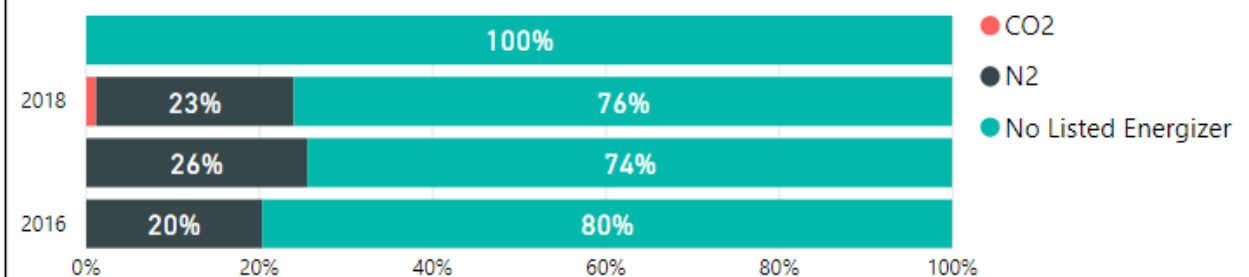
### Completion Tech. Share by Year



### Stimulation Fluid Share by Year

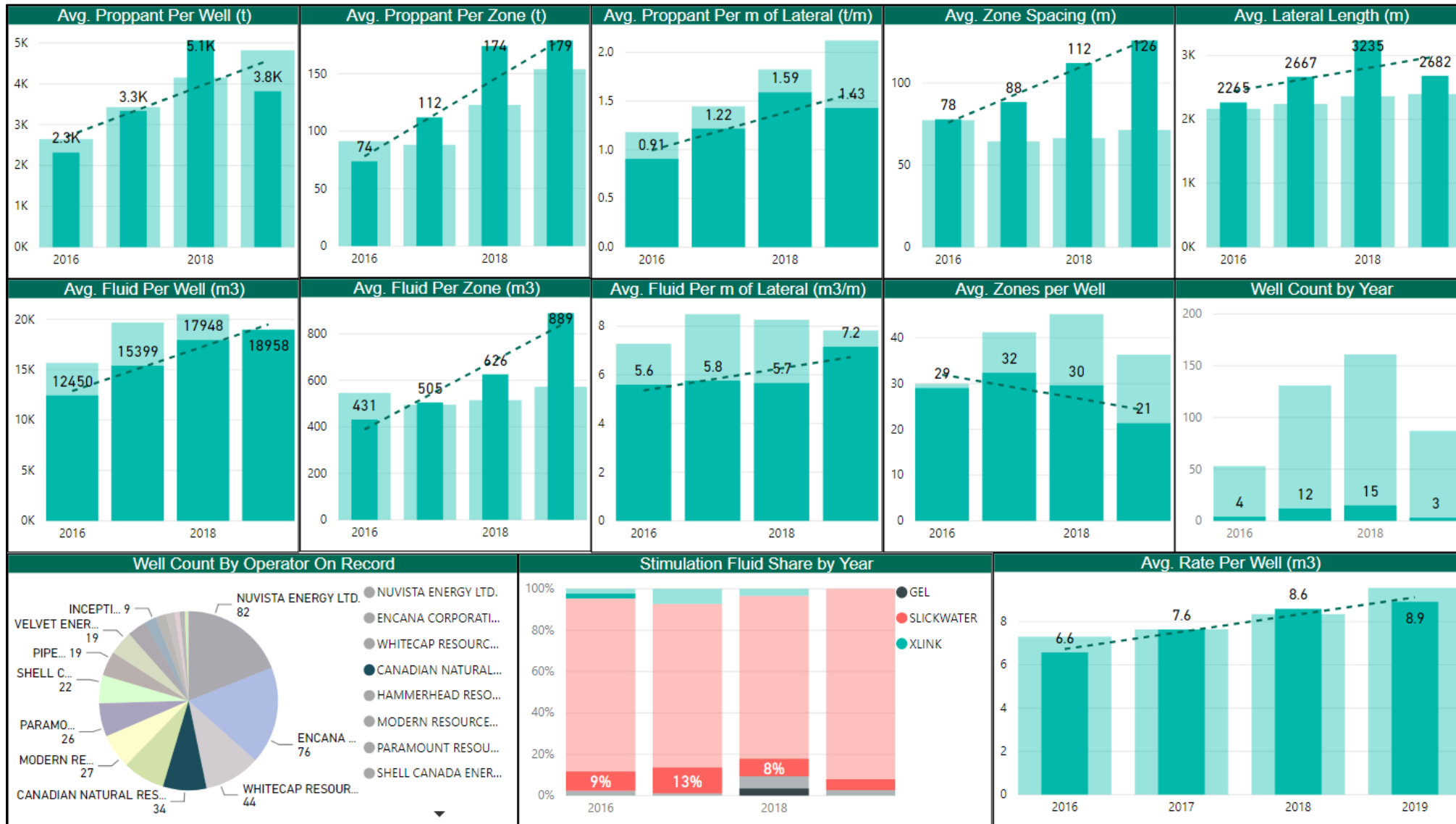


### Energizer Share by Year

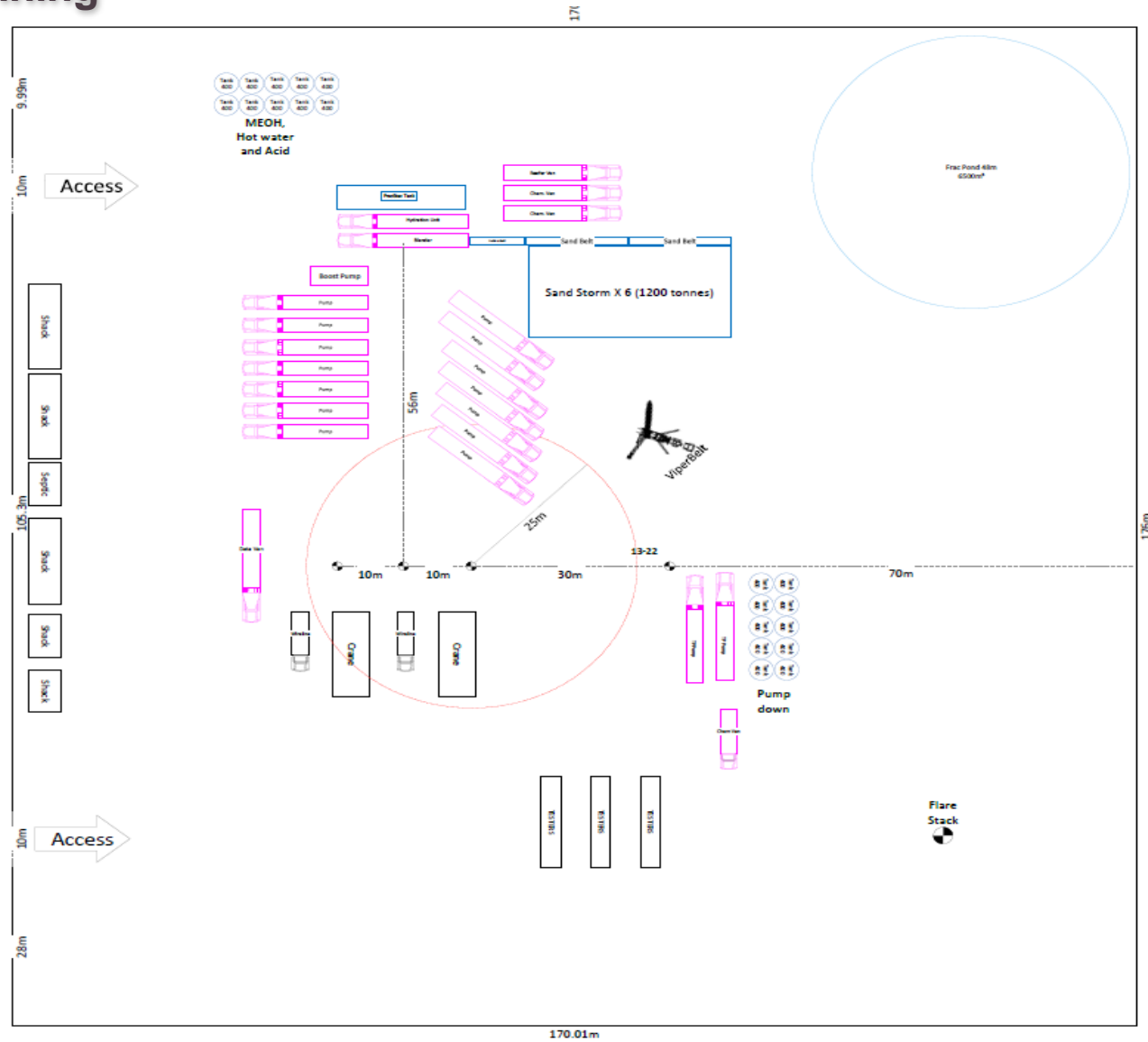


# Regional Intelligence – Public and Internal Completions Databases

## Treatment Design Trends



# Equipment and Operations Lease Layout and Planning





# Equipment and Operations

## Lease Layout and Planning





# Equipment and Operations

## Sandstorm Proppant Delivery System



*The SandStorm proppant delivery system is a mobile, rapid-deployment proppant handling system that delivers unmatched storage capacity, dust control and digital automation. Calfrac Well Services Photo*

### Features & Benefits

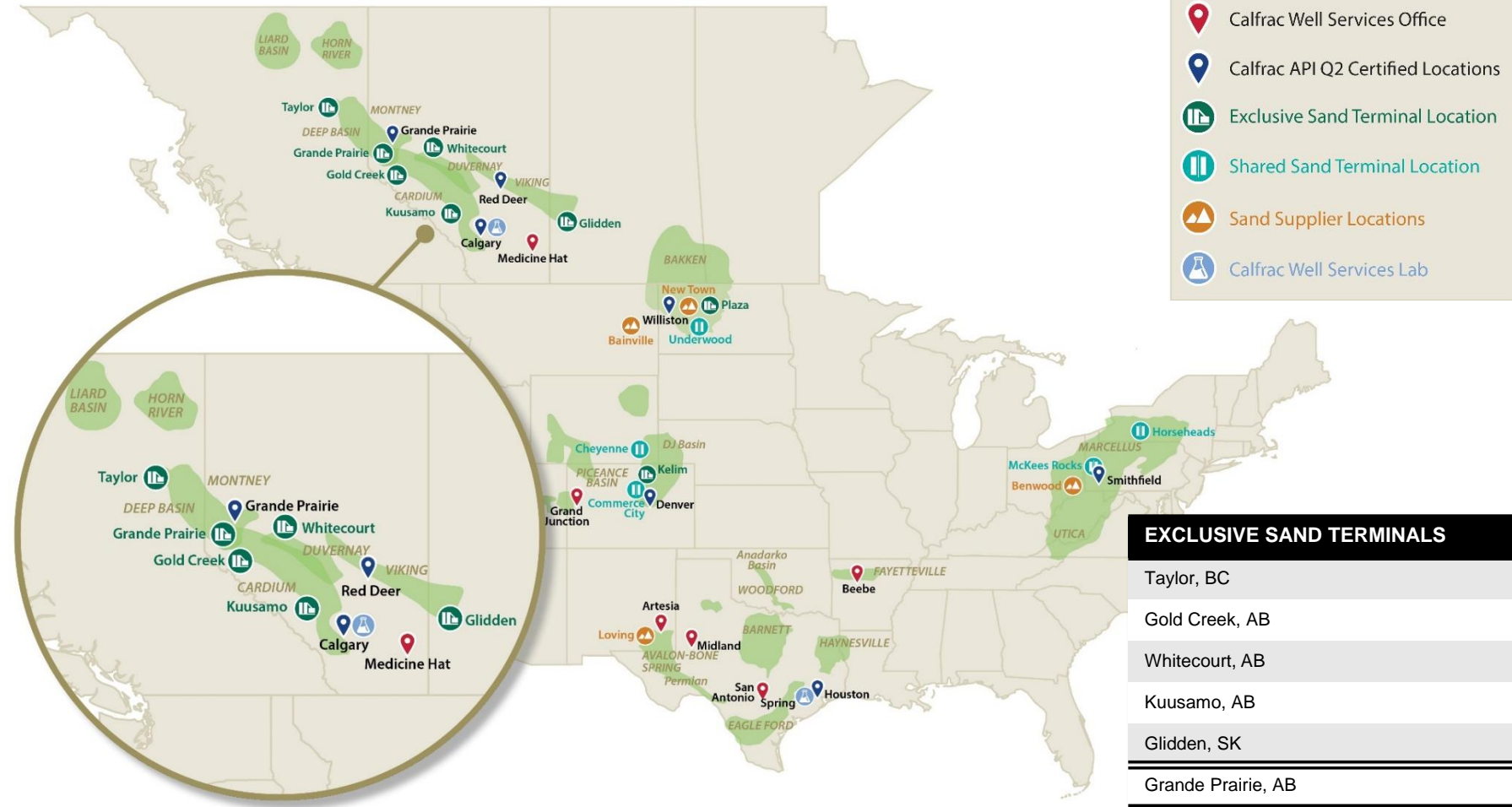
- ✓ Larger sand volumes can be stored on-site to decrease footprint by up to 30 percent
- ✓ Significantly increases the rate of sand delivery while reducing highway transport equipment
- ✓ Innovative gravity-feed system eliminates temperamental belts and conveyors
- ✓ Self-contained scales improve accuracy of weight measurement
- ✓ Enclosed conveyors and transition points ensure a silica dust controlled operation

### Technical Specifications

- ✓ Gravity Boxes can hold up to 1,200 tonnes of sand as a set of six
- ✓ 45 foot enclosed endless belt delivering up to 10 tonnes of sand per minute
- ✓ Incline conveyor capable of up to 20,000 pounds per minute straight to the blender
- ✓ Computer remote control system housed by the Hydrabear
- ✓ Hydrabear has enough hydraulic power to operate entire system and can be used to start the fracturing pumps, eliminating the need for an additional tractor unit

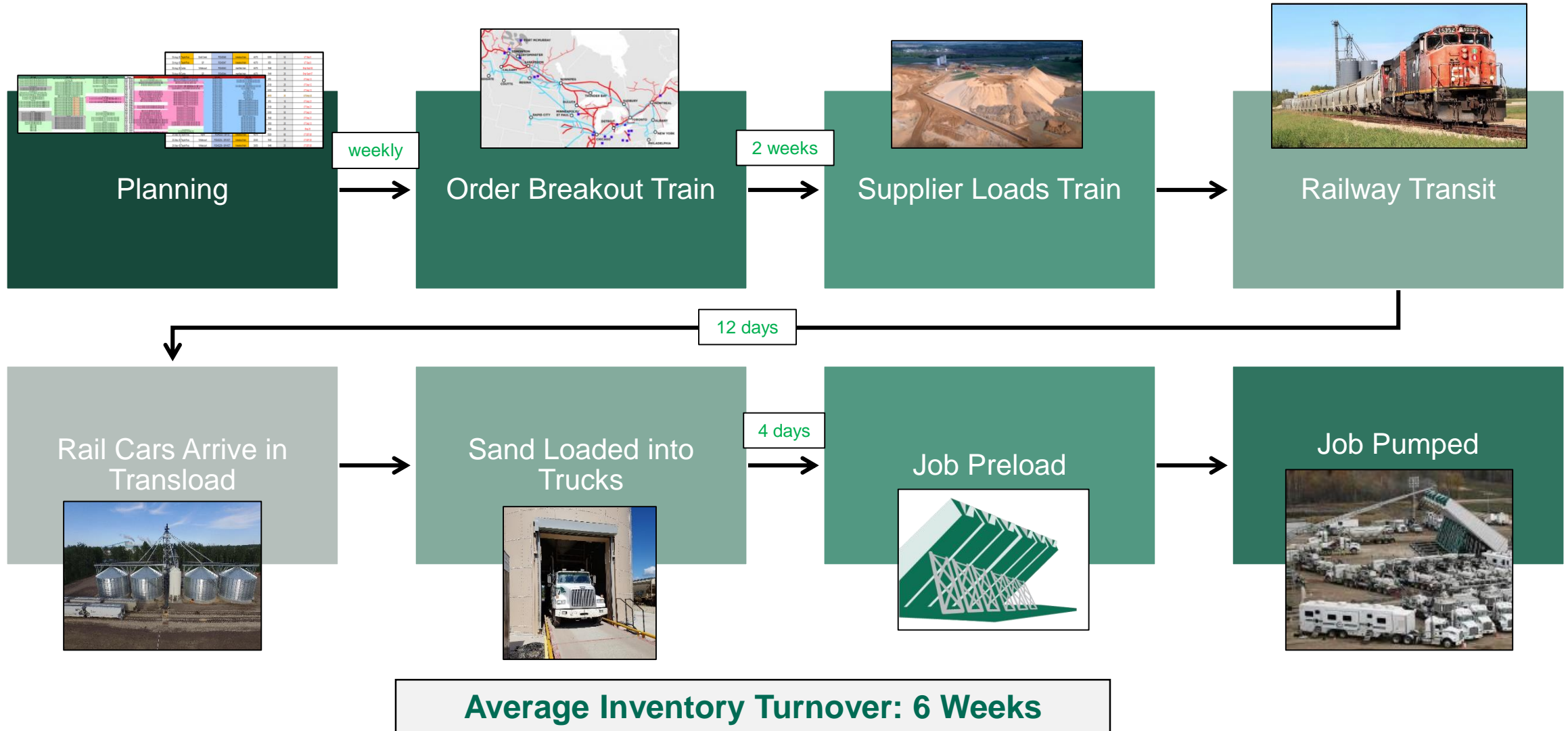
# Calfrac North America Logistics and Storage Network

- 5 CWS-exclusive sand transload facilities in WCSB
- Almost 1MM Litres of bulk chemical storage capacity
- Priority rail contracts for shipping from the United States
- ~960 CWS-owned rail cars
  - 20 for chemical



# Equipment and Operations

## Supply Chain – Proppant





# Equipment and Operations

## Blender



*This blender delivers the high pump rate required for unconventional and tight gas reservoirs. Calfrac Well Services Photo*

### Technical Specifications

- ✓ CAT C18 630 HP hydraulic engine and CAT C18 800 HP discharge pump engine
- ✓ Gorman Rupp 12x12 HD suction pump
- ✓ UE Manufacturing tub
- ✓ Mission Magnum 14x12" XP HC discharge pump
- ✓ Rosemount 10" high signal magnetic flow meters
- ✓ Three 12" sand augers with density control system

### Features & Benefits

- ✓ Delivers 20 m<sup>3</sup>/min
- ✓ Hydraulically driven suction pump
- ✓ Open tub design with auto level control system
- ✓ Driveline coupled to engine with clutch

# Equipment and Operations

## Fracturing Pump



*Quintuplex pump delivers maximum power along with dual fuel capability. Calfrac Well Services Photo*

### Technical Specifications

- ✓ 2,500 HP (1,865 KW)
- ✓ Dual fuel operation
  - Up to 70% natural gas and 30% diesel fuel ratio
  - Controls automatically regulate between diesel-only or a diesel/natural gas mixture based on engine load
- ✓ Piping rated for CO<sub>2</sub> service
- ✓ Maximum rod load of 250,000 pounds
- ✓ Operational in temperatures from -40°F to 122°F

### Features & Benefits

- ✓ Can be optimized with a natural gas or diesel fuel kit
- ✓ Convertible chassis offers versatility
- ✓ Slide-out platform for safe maintenance access to the well servicing pump
- ✓ Remotely controlled and monitored for advanced data acquisition
- ✓ Wide variety of fluid-end sizes available

# Equipment and Operations

## Data Van Multi-Pump Control





# Equipment and Operations

## Data Van Command Center





# Equipment and Operations

## Coiled Tubing – Mast & Conventional Units



*Coiled tubing operations in Canada. Calfrac Well Services Photos*



# Equipment and Operations

## Hydraulic Fracturing Spread

*Blender*

*Water Storage (Buffer Tanks)*

*SandStorm (Proppant Storage)*



*Chem Vans*

*Frac Pumps*

*Calfrac Well Services Photo*

*Data Van Command Centre*

### Sand Logistics:

- 20 pumps (50,000 HP!)
- 8,000 Tonnes/well
- 40,000 Tonnes/pad
  - 400 rail cars
  - 950-1400 trucks
- 1,820 Tonnes/day
  - 45-65 trucks

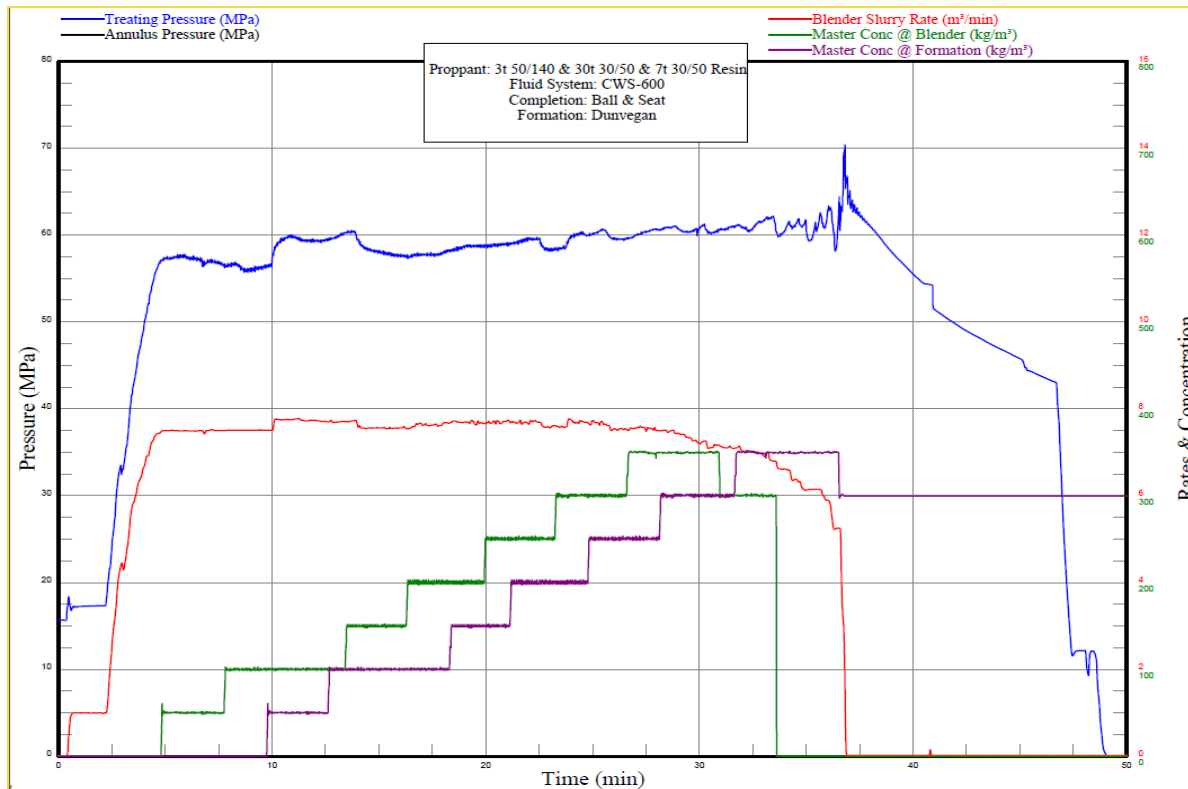
Fluid, Chemical, 3<sup>rd</sup> Party

# Equipment and Operations

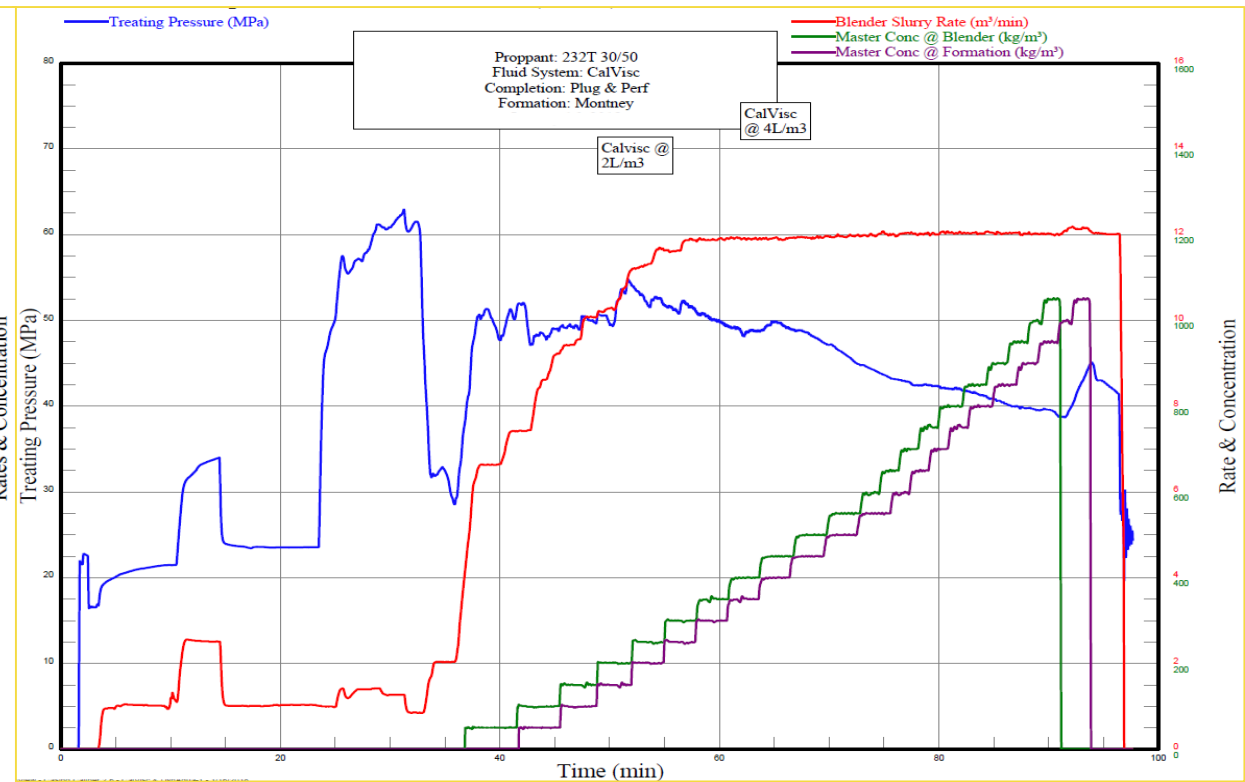
## Execution: Real-Time Frac Management

- 24/7 treatment monitoring by a technical team
- Experience in frac placement in all areas / formations
- On the fly changes and optimization to ensure successful application

### Unsuccessful Placement



### Successful Placement

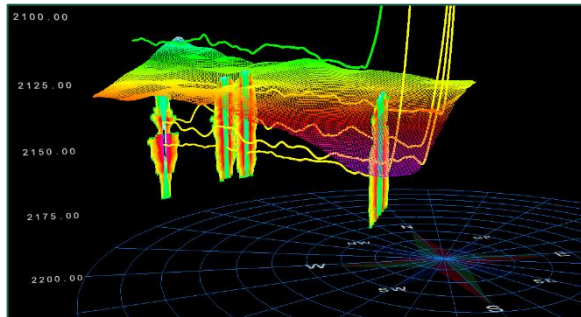
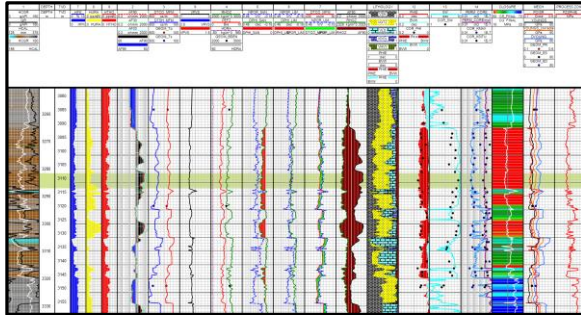




# Questions?

## Hydraulic Fracture Design, Planning & Execution

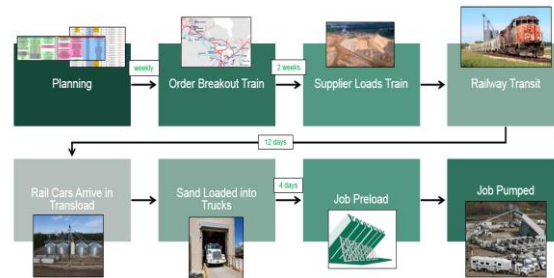
### Fracture Design



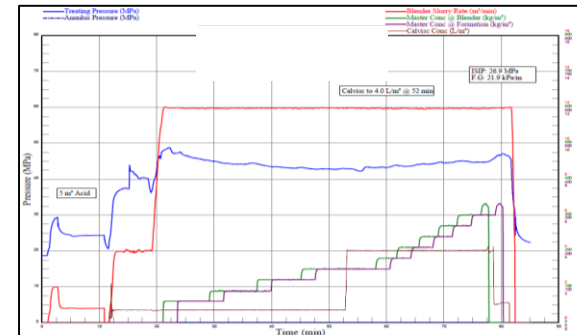
### Planning

**Pump Schedule 4**  
Proppant Total (kg): 285,000

	Rate		Volume		Proppant		Time	
	Slurry Rate m <sup>3</sup> /min	Clean Rate m <sup>3</sup> /min	Slurry Volume m <sup>3</sup>	Clean Volume m <sup>3</sup>	Blender Conc kg/m <sup>3</sup>	Proppant Stage kg	Proppant Cum kg	Stage Time h:m:ss
1 Pre-Pad (Cal/Vec)	0.50	0.50	2.0	2.0	0	0	0	00:04:00
2 Acid (Acid Squeeze)	1.00	1.00	5.0	7.0	5.0	0	0	00:05:00
3 Pad (Cal/Vec)	6.00	6.00	30.0	17.0	70.0	0	0	00:14:00
4 Proppant (Cal/Vec) 30/50 Import Proppant	13.00	12.88	40.4	117.0	40.0	25	1,000	00:23:45
5 Proppant (Cal/Vec) 30/50 Import Proppant	13.00	12.76	40.8	157.0	40.0	50	2,000	00:26:54
6 Proppant (Cal/Vec) 30/50 Import Proppant	13.00	12.53	41.5	197.0	40.0	100	4,000	00:31:11
7 Proppant (Cal/Vec) 30/50 Import Proppant	13.00	12.30	42.3	237.0	40.0	150	6,000	00:35:21
8 Proppant (Cal/Vec) 30/50 Import Proppant, Cal/Vec @ 2.0m3	13.00	12.09	43.0	277.0	40.0	200	8,000	00:39:30
9 Proppant (Cal/Vec) 30/50 Import Proppant, Cal/Vec @ 2.0m3	13.00	11.88	43.8	317.0	40.0	250	10,000	00:43:39
10 Proppant (Cal/Vec) 30/50 Import Proppant, Cal/Vec @ 2.0m3	13.00	11.68	44.5	357.0	40.0	300	12,000	00:47:48
11 Proppant (Cal/Vec) 30/50 Import Proppant, Cal/Vec @ 2.0m3	13.00	11.48	45.3	397.0	40.0	350	14,000	00:51:57
12 Proppant (Cal/Vec) 30/50 Import Proppant, Cal/Vec @ 4.0m3	13.00	11.30	46.0	437.0	40.0	400	16,000	00:56:06
13 Proppant (Cal/Vec) 30/50 Import Proppant, Cal/Vec @ 4.0m3	13.00	11.11	46.8	477.0	40.0	450	18,000	01:00:15
14 Proppant (Cal/Vec) 30/50 Import Proppant, Cal/Vec @ 4.0m3	13.00	10.94	47.5	517.0	40.0	500	20,000	01:04:24
15 Proppant (Cal/Vec) 30/50 Import Proppant, Cal/Vec @ 4.0m3	13.00	10.77	48.3	557.0	40.0	550	22,000	01:08:33
16 Proppant (Cal/Vec) 30/50 Import Proppant, Cal/Vec @ 4.0m3	13.00	10.60	49.1	597.0	40.0	600	24,000	01:12:42
17 Proppant (Cal/Vec) 30/50 Import Proppant, Cal/Vec @ 4.0m3	13.00	10.44	49.8	637.0	40.0	650	26,000	01:16:51
18 Proppant (Cal/Vec) 30/50 Import Proppant, Cal/Vec @ 4.0m3	13.00	10.28	50.6	677.0	40.0	700	28,000	01:21:00
19 Proppant (Cal/Vec) 30/50 Import Proppant, Cal/Vec @ 4.0m3	13.00	10.13	51.3	717.0	40.0	750	30,000	01:25:09
20 Proppant (Cal/Vec) 30/50 Import Proppant, Cal/Vec @ 4.0m3	13.00	9.99	51.6	757.0	55.0	800	44,000	01:29:18
21 Spacer (Cal/Vec) Cal/Vec @ 4.0m3	13.00	13.00	5.0	772.0	5.0	0	0	00:30:27
22 Flush (Cal/Vec)	13.00	13.00	41.1	881.1	41.1	0	0	00:31:36



### Execution



### Ongoing Optimization

