Use of Real-time Monitoring to Minimize Chemical Incompatibility In Hydraulic Fracturing Fluid

Nancy Zakhour
Callon Petroleum Company
Jinxuan Hu
Mark Patton
Hydrozonix, LLC

Outline

- Problem Statement
- Gel Compatibility and the Realtime Monitoring
- Slickwater compatibility and the Realtime Monitoring

Callon Petroleum Company

Problem Statement

Water-Based Fracturing Fluid

Slickwater	Gel Fluid
• High Retained Conductivity • Lower Requirement on Water Quality • Less Chemical, Lower Cost	• May Affect Conductivity • Higher Water Quality Requirement • More Chemicals, Higher Cost
• Larger Water Volume • Larger Horsepower • Reduced Performance for Larger Proppant	• Lower Water Volume • Smaller Horsepower Requirement • Transport Large Proppants

- High pump pressure
- Gel failure
- Premature crosslinking

Callon Petroleum Company

Cross-linked gel fluids

- Borate or Zirconium Crosslinker
- TSS, TDS, Chlorides, Hardness and Boron all affect gel compatibility.
- Once Gel recipe is developed water quality must remain in a narrow range to maintain gel compatibility
- Control of water quality is paramount

Callon Petroleum Company

H2O 4

Gel Compatibility Testing

Rheology Testing

- Viscosity
- Gel Stability
- Break Time

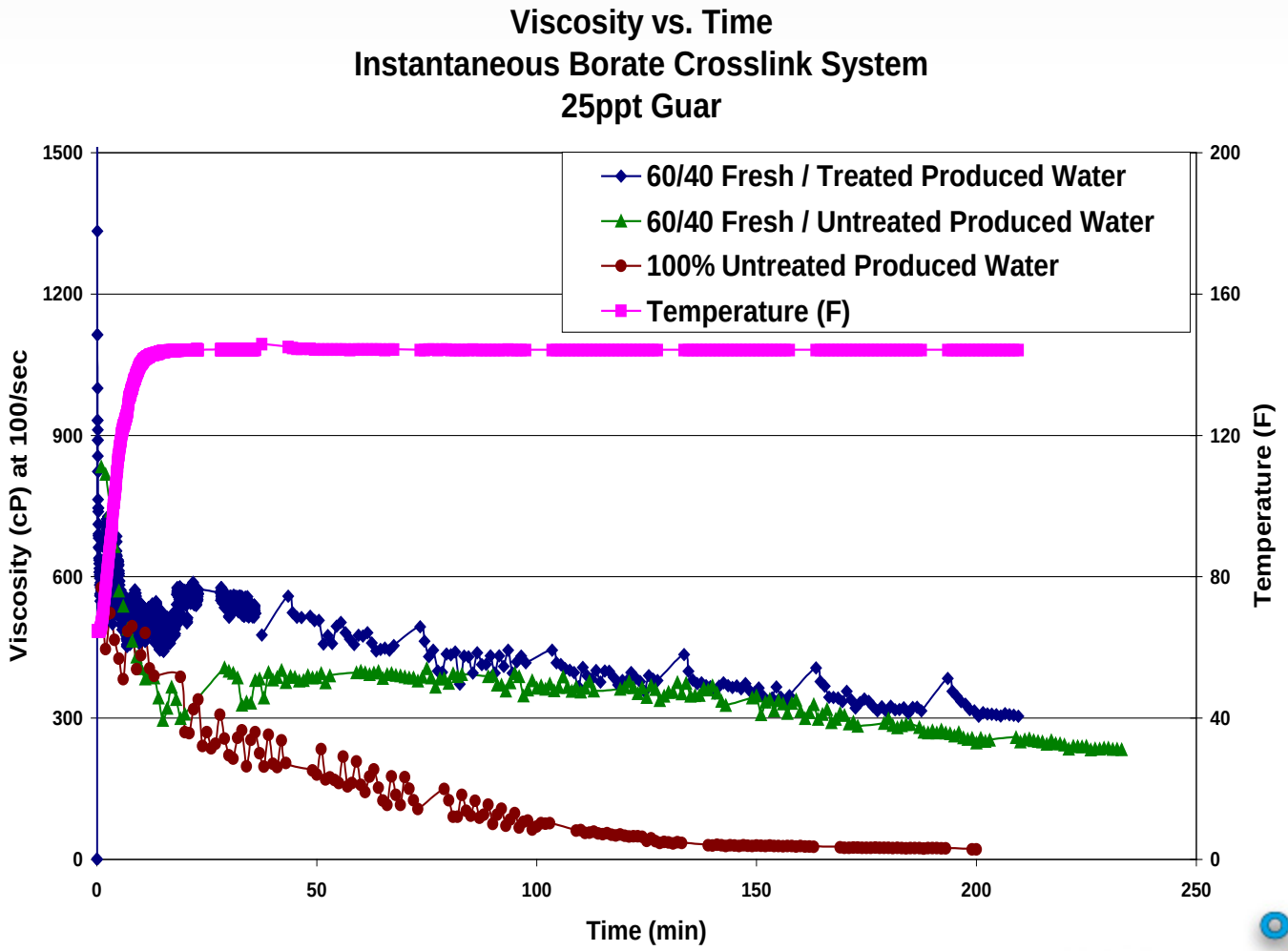
Callon Petroleum Company

H2O

Crosslink Gel Compatibility

Slide 1 of 2

- Gel Test with Borate Crosslinker
- No Adjustments made
- Purely trying to identify compatibility issues



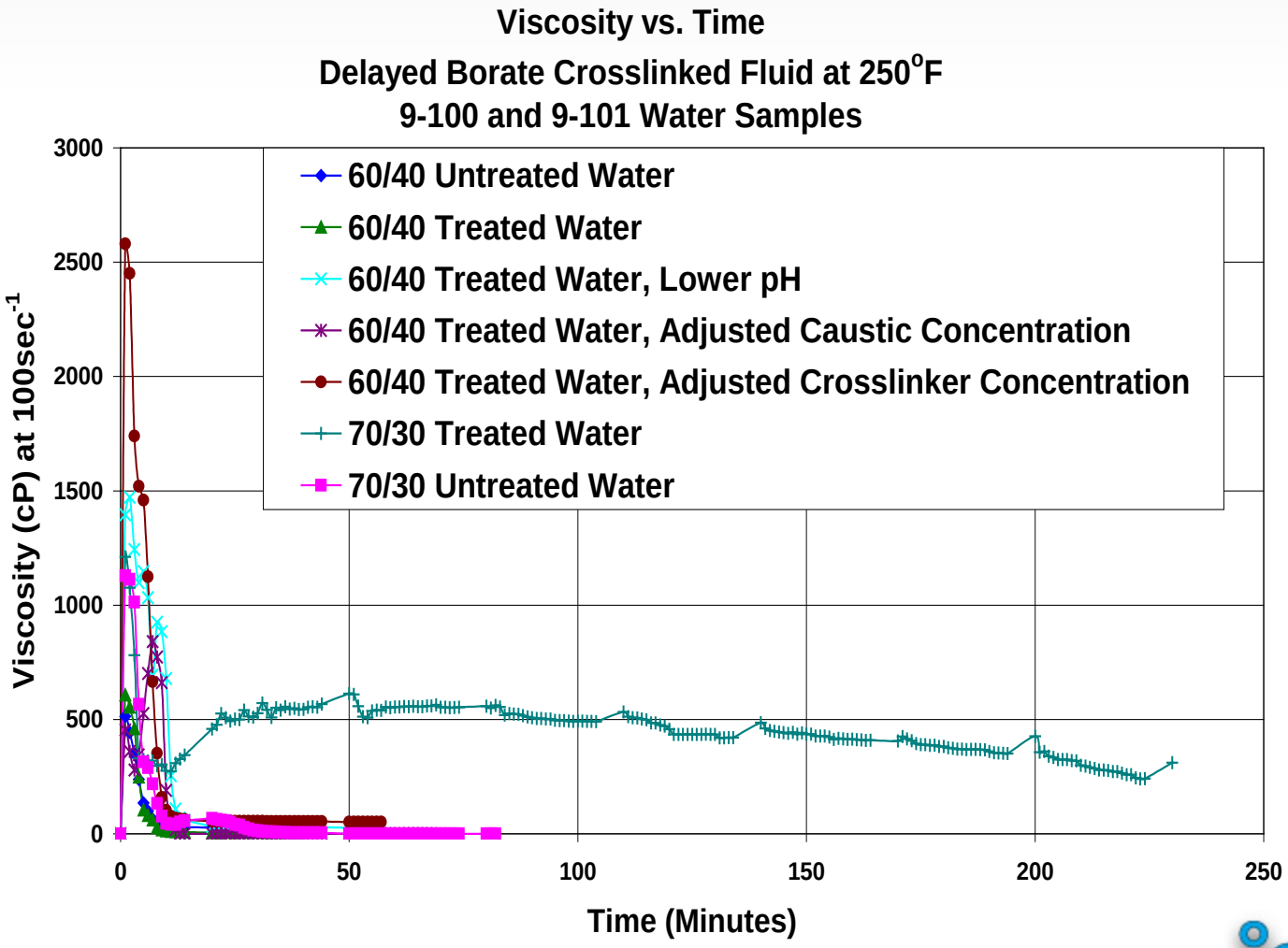
Callon Petroleum Company

H2O

Crosslink Gel Compatibility

Slide 2 of 2

- Temperature effected stability
- 70/30 Blend showed significant improvement with temperature
- No changes in crosslinker concentration for 70/30 blend
- No pH adjustment for 70/30 blend
- No Buffers



Callon Petroleum Company

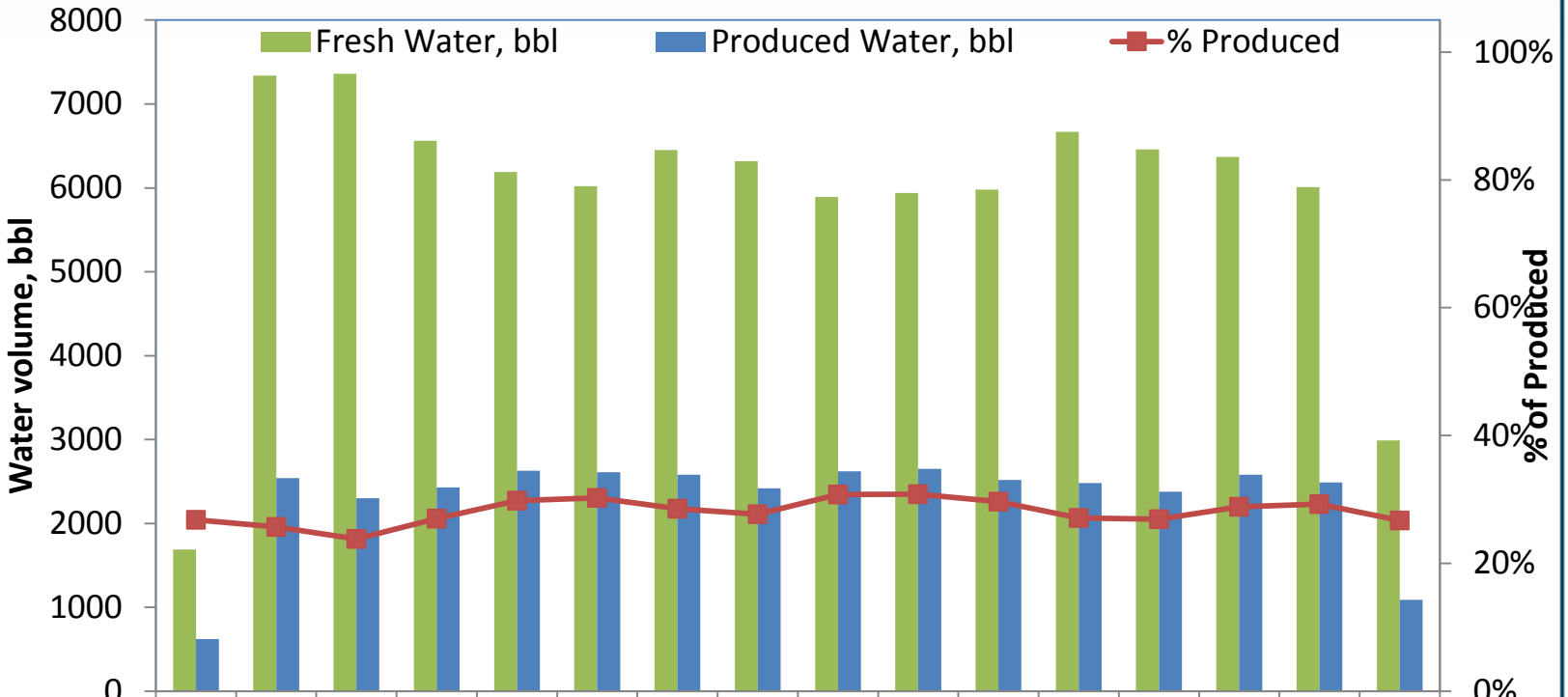
Real Time Water Quality Monitoring for Crosslinked Gel Frac

- Chloride / TDS
  - Good Indicator of Quality
  - Monitor Blend Consistency
  - For KCl Equivalency
- Boron
  - To Identify Inhibitor Dose Rate
- Bacteria Disinfection Monitoring
  - Test Influent/Effluent
  - Test Working Tanks
- Other Parameters
  - pH / TSS / Hardness etc

Callon Petroleum Company

Real Time Water Quality Monitoring

Keep Water Quality Consistent – Adjust Blend Rate Stage by Stage

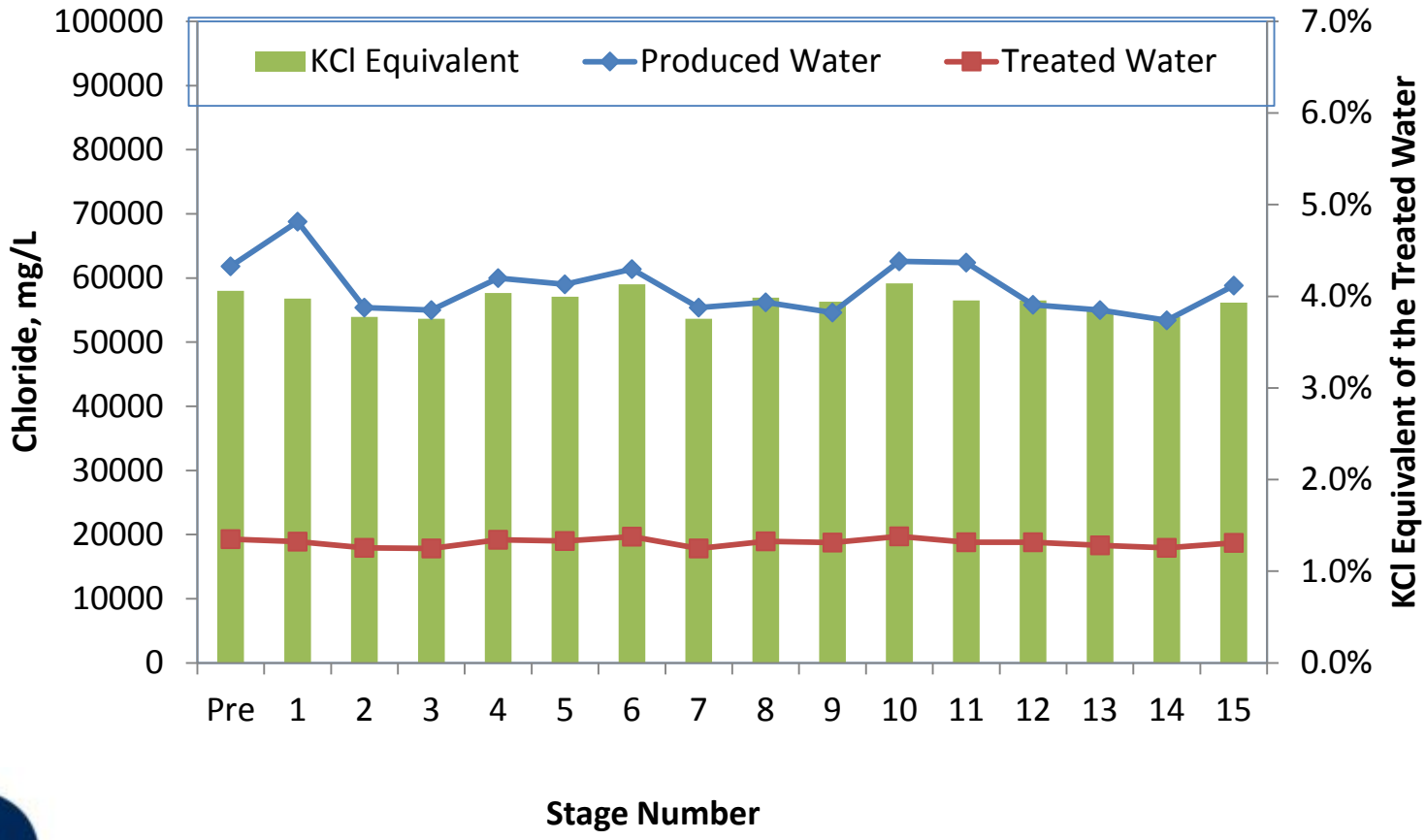


	Pre*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fresh Water, bbl	1690	7340	7360	6560	6190	6020	6450	6320	5890	5940	5980	6670	6460	6370	6010	2990
Produced Water, bbl	620	2540	2300	2430	2630	2610	2580	2420	2620	2650	2520	2480	2380	2580	2490	1090
	26.8%	25.7%	23.8%	27.0%	29.8%	30.2%	28.6%	27.7%	30.8%	30.8%	29.6%	27.1%	26.9%	28.8%	29.3%	26.7%

Callon Petroleum Company

Real Time Water Quality Monitoring

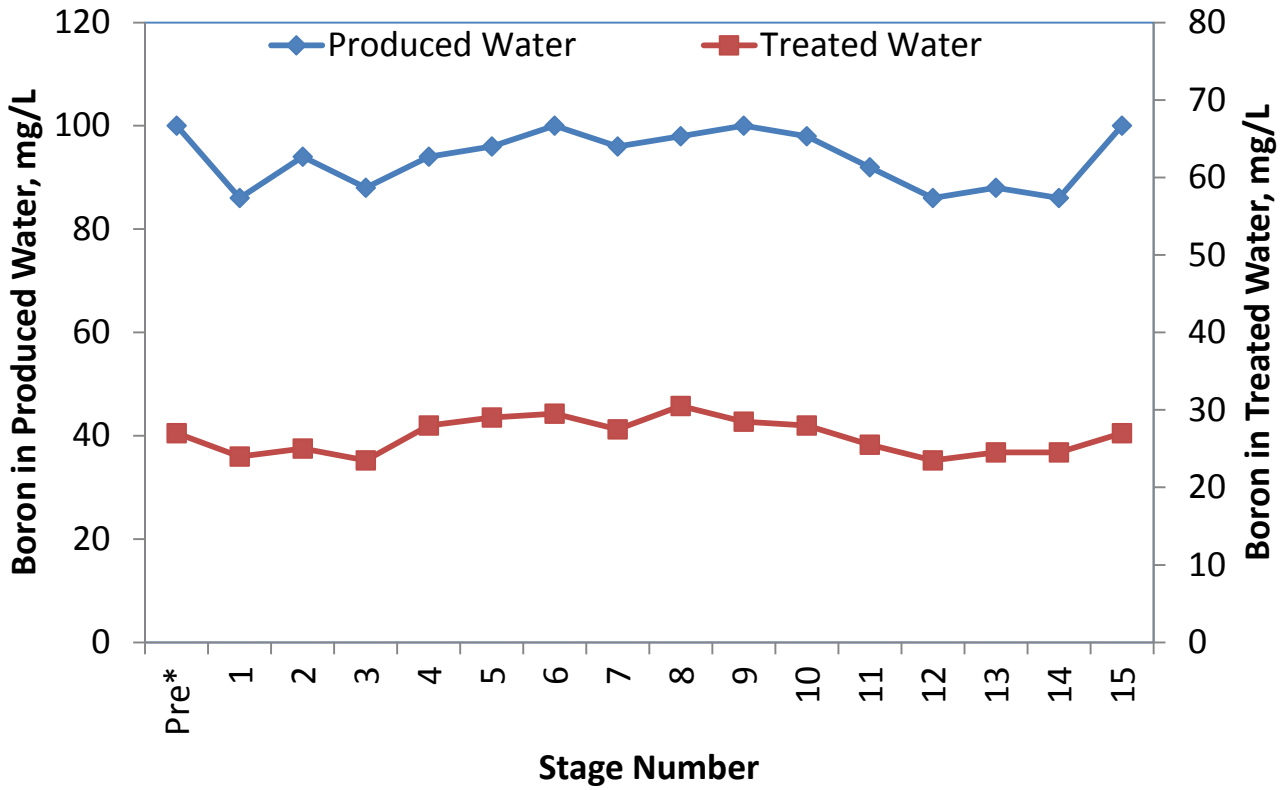
Keep Water Quality Consistent



Callon Petroleum Company

Real Time Water Quality Monitoring

Keep Water Quality Consistent

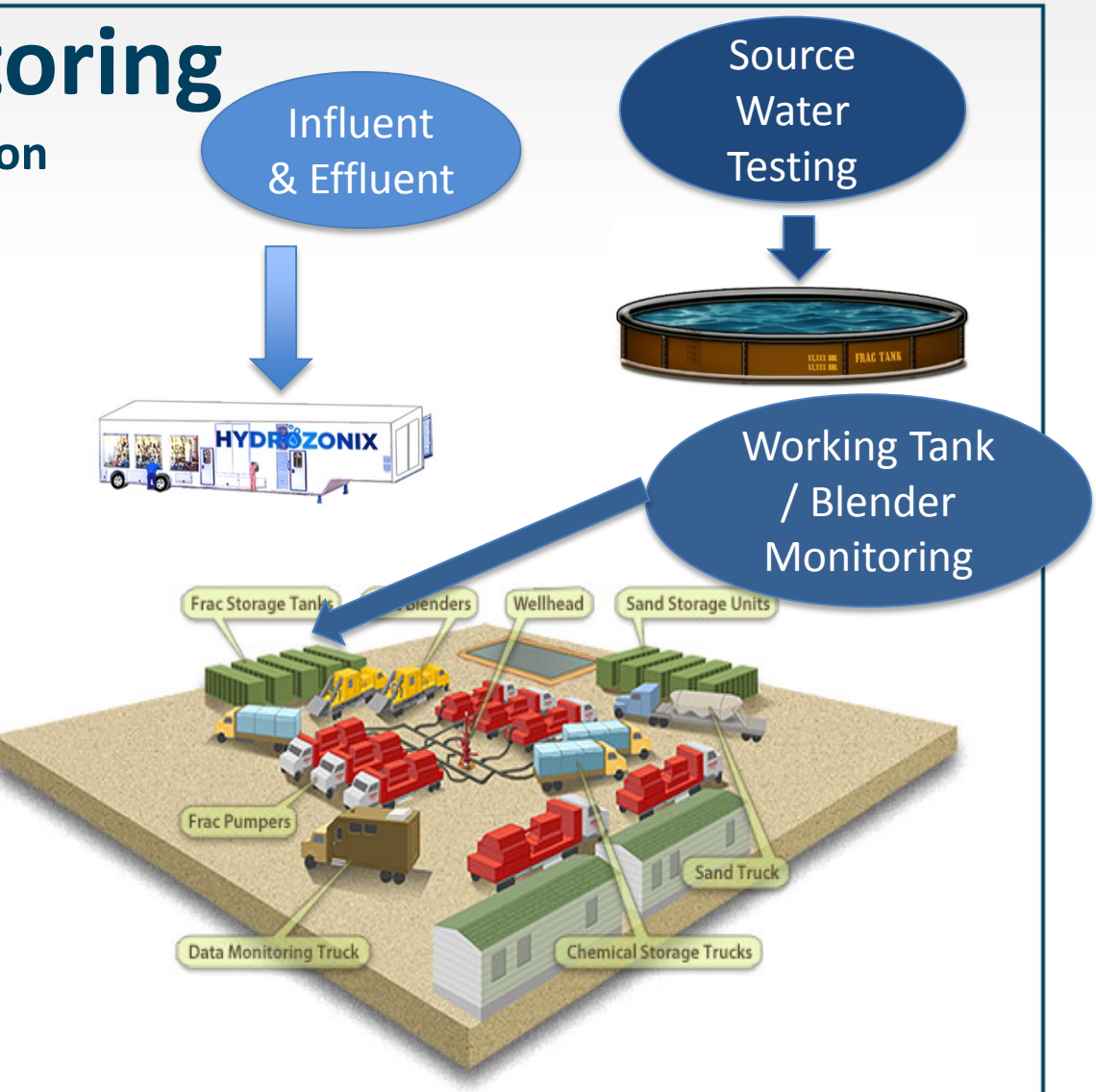


Callon Petroleum Company

Bacteria Monitoring

How do we confirm disinfection

- Source Water
  - Bacteria Testing
  - Baseline Testing
- Influent/Effluent of Treatment System
  - Bacteria Testing
  - Continuous Testing
- Residual Disinfection / Working Tanks / Blenders
  - Bacteria Testing
  - Continuous Testing
- Proppant Testing
- Drillout and Flowback Monitoring

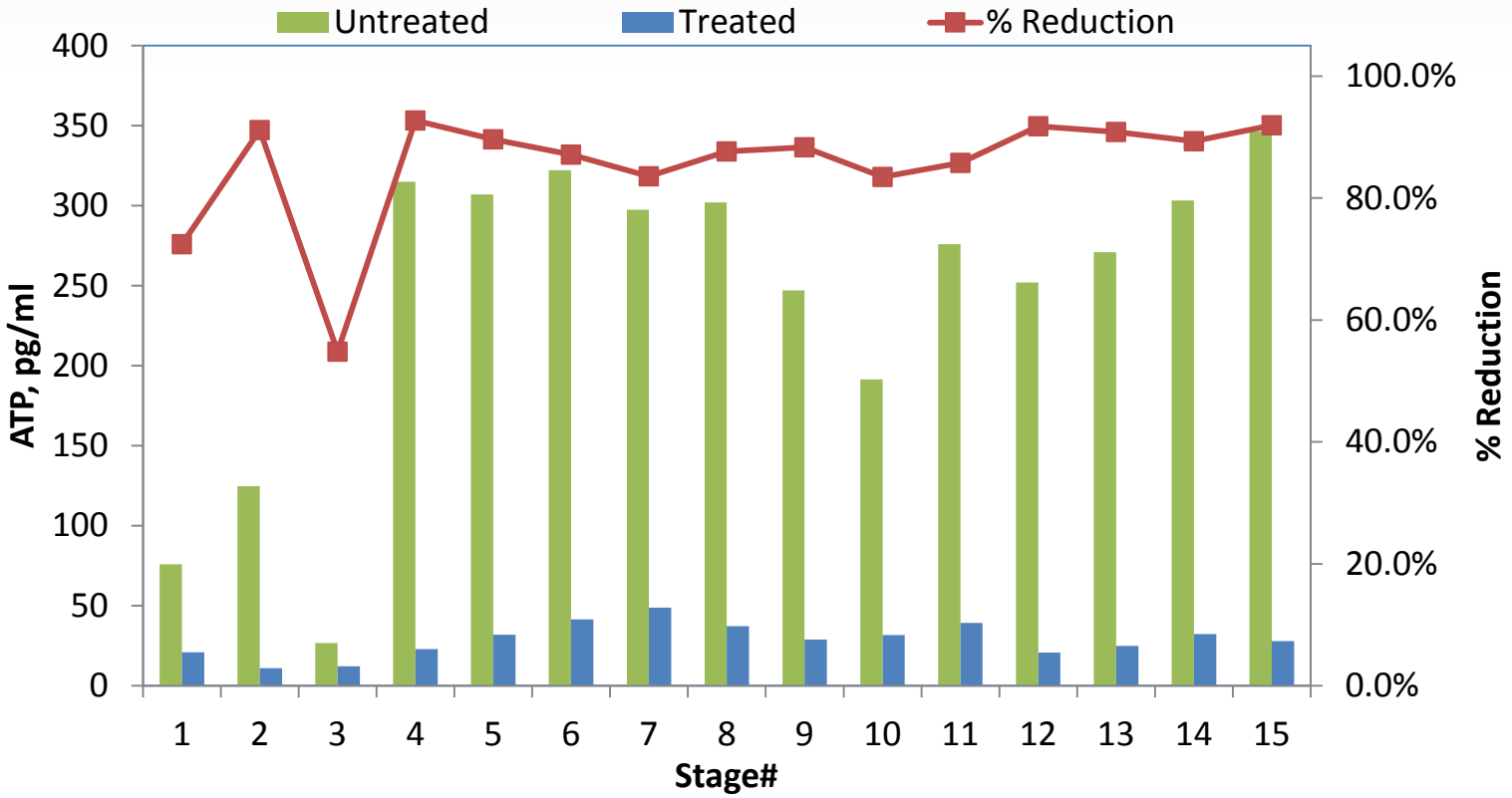


Callon Petroleum Company

What do we use for Bacteria Testing

Callon Petroleum Company

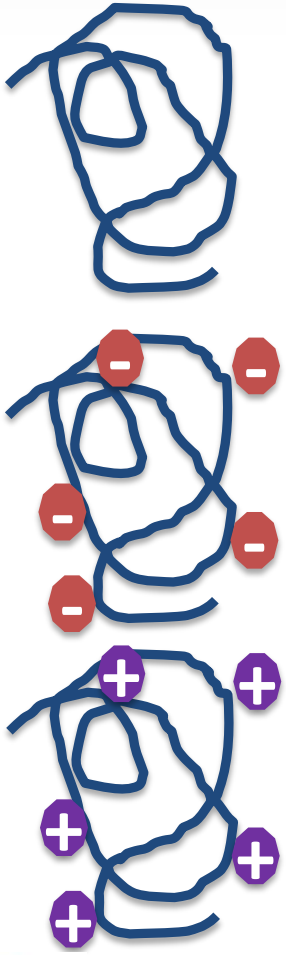
Real-Time Bacteria Treatment Monitoring



- **Testing conducted on location, Real-Time confirmation**
- **Test the influent and effluent at different stages throughout the frac**

Callon Petroleum Company

Slickwater



Non-ionic

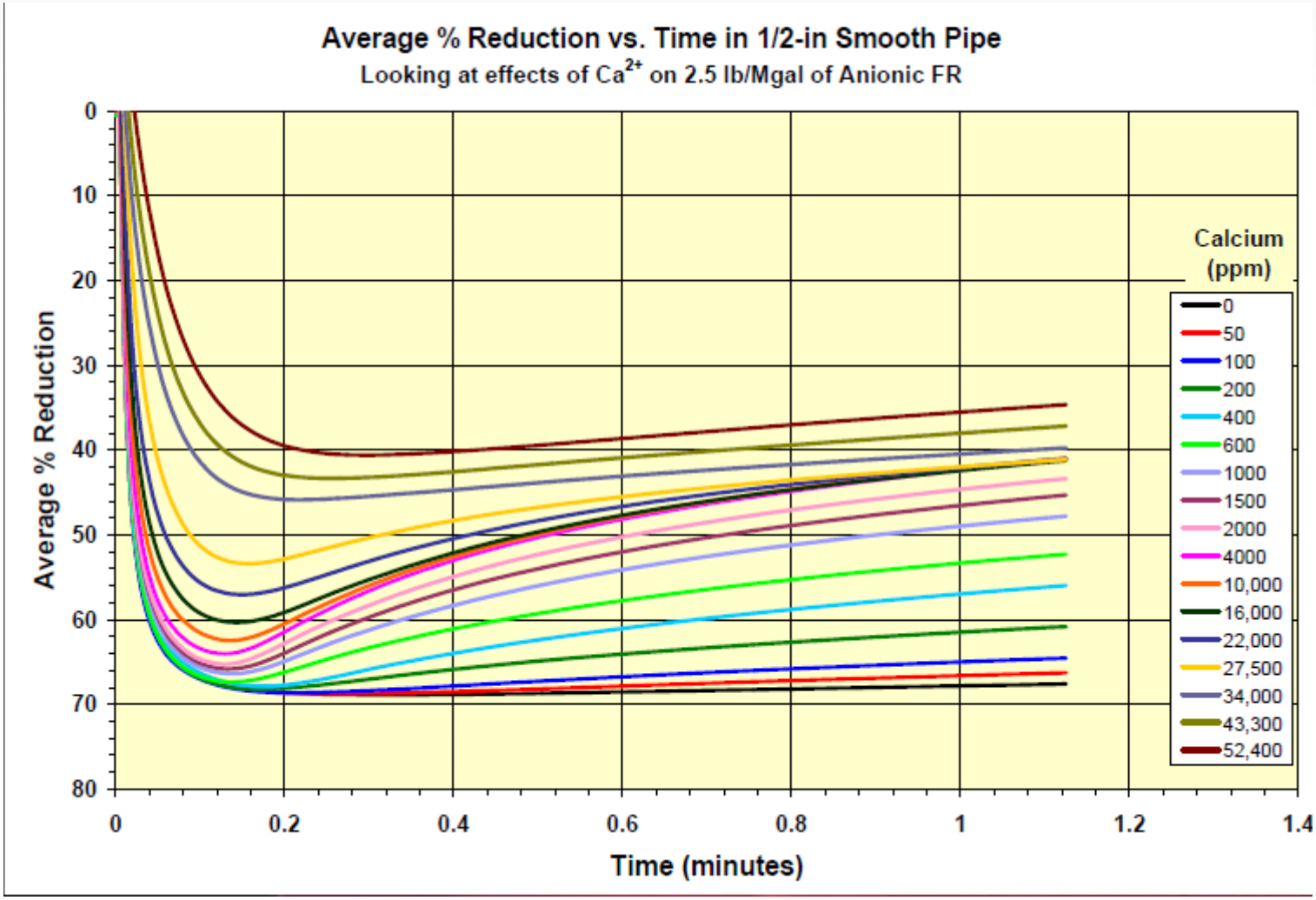
Anionic

Cationic

- Three groups of FR
- Reduction of friction by 50% - 60% is possible
- May degraded by biocides or oxidants
- May affected by other coexisting chemicals

Callon Petroleum Company

Effect of Ca^{2+} on Anionic FR

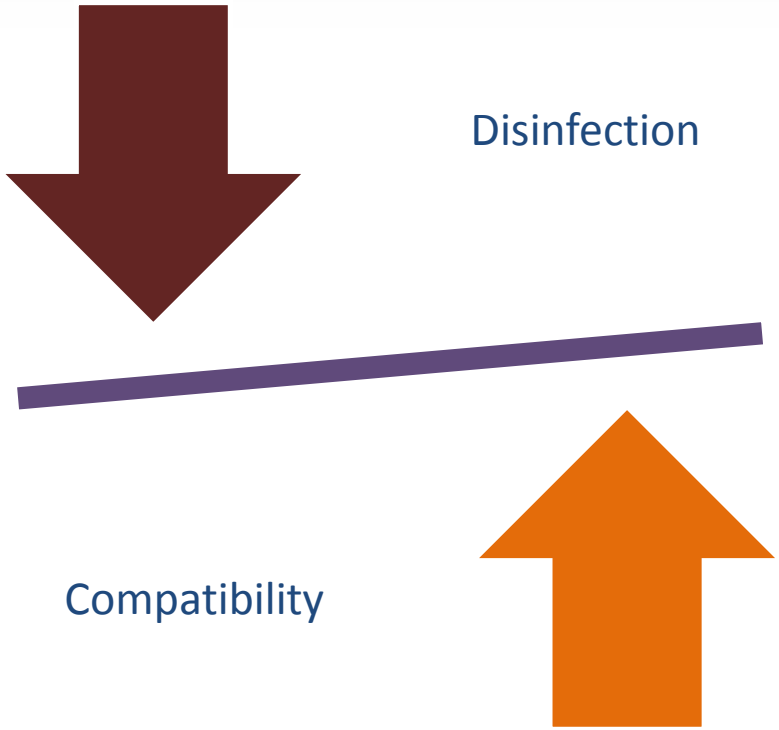


J. Bryant etc, Halliburton

Callon Petroleum Company

Selection of Oxidative Biocides

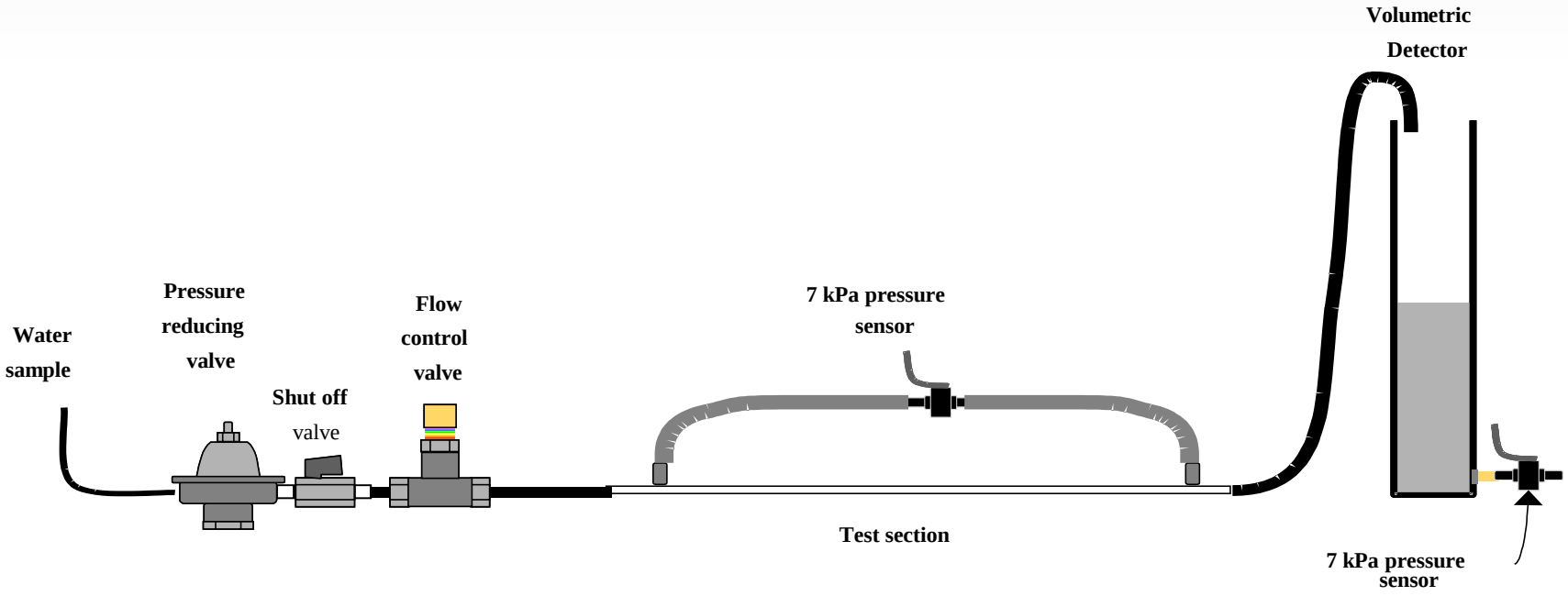
Oxidant	Oxidation Potential, V	Half-Life @ 20^{O}C
Hydroxyl Radicals	2.8	< 1 sec
Ozone	2.3	20 min.
Hydrogen Peroxide	1.8	Hours
Chlorine Dioxide	1.5	93 min.
Chlorine	1.4	140 min.



Callon Petroleum Company

Realtime Monitoring for Slickwater Frac

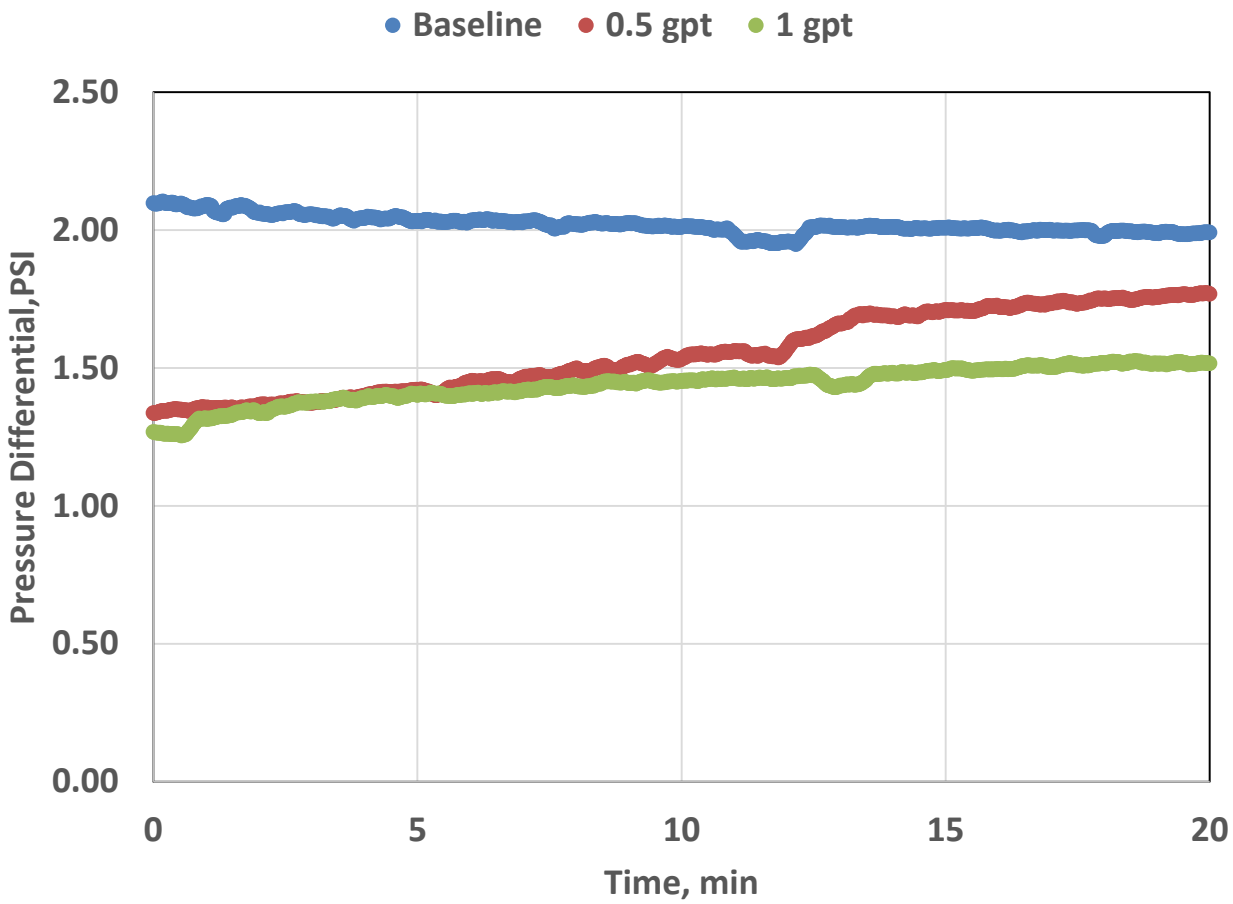
Field Friction Loop Test



Callon Petroleum Company

Friction Reducer Compatibility

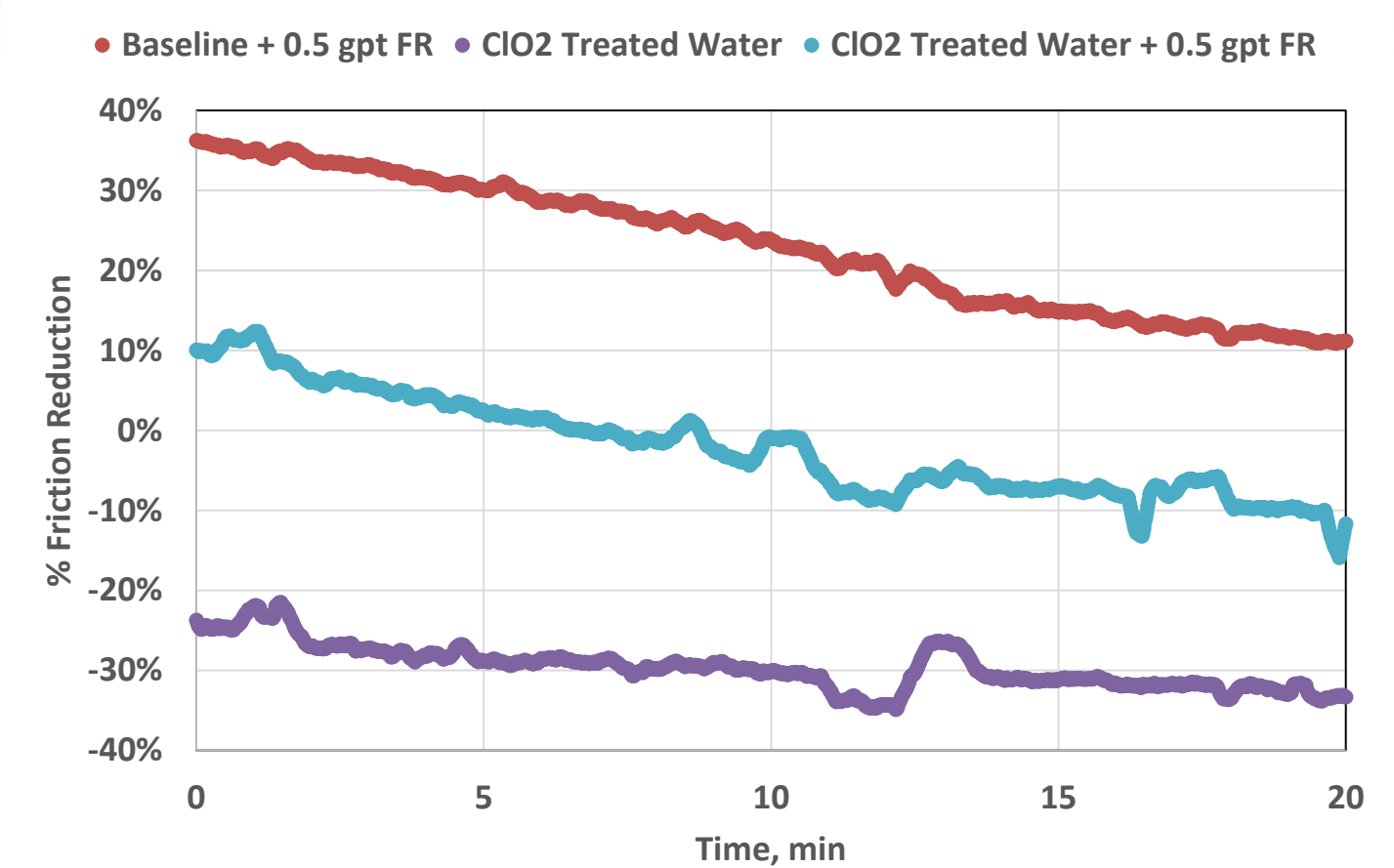
Friction Testing Baseline



Callon Petroleum Company

Friction Reducer Compatibility

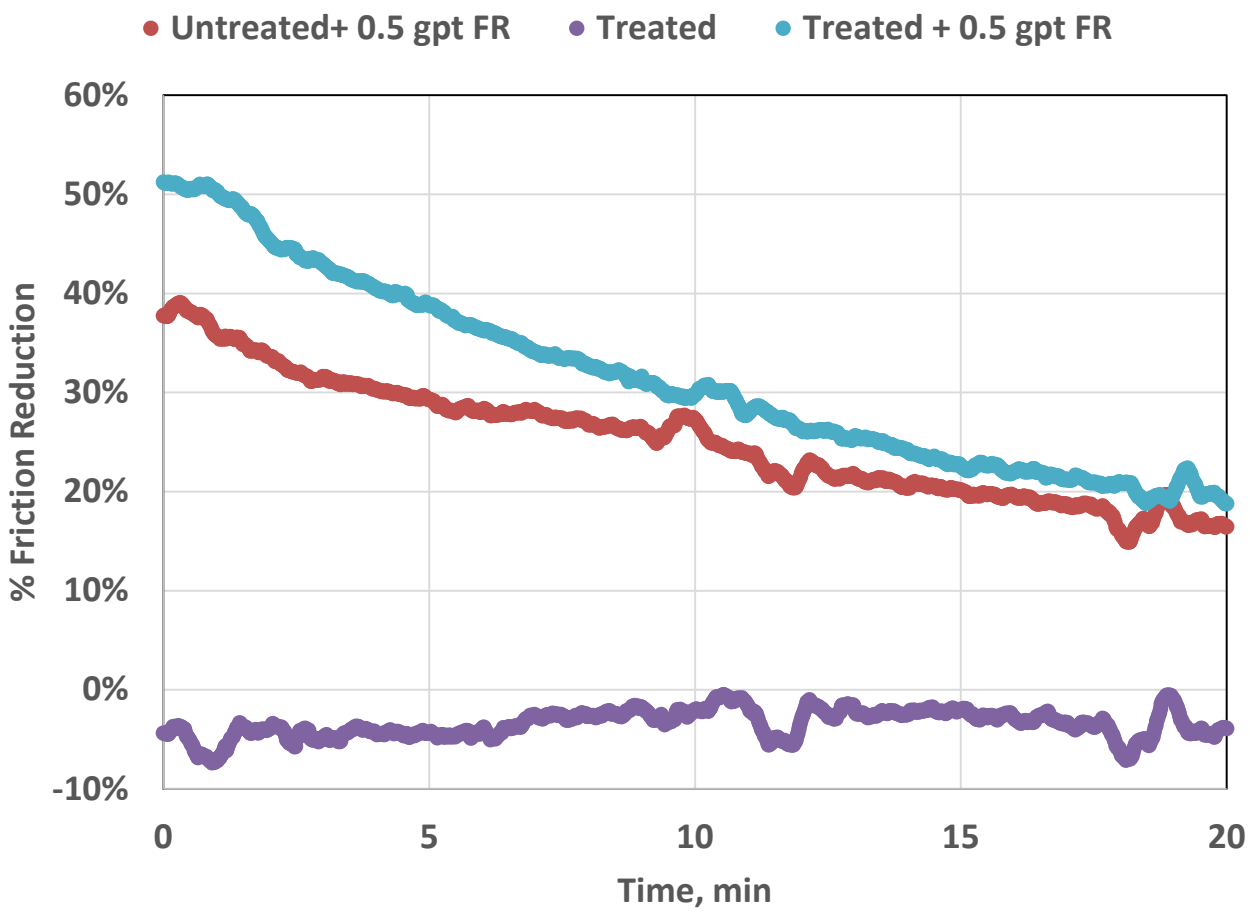
Friction Testing – Chlorine Dioxide



Callon Petroleum Company

Friction Reducer Compatibility

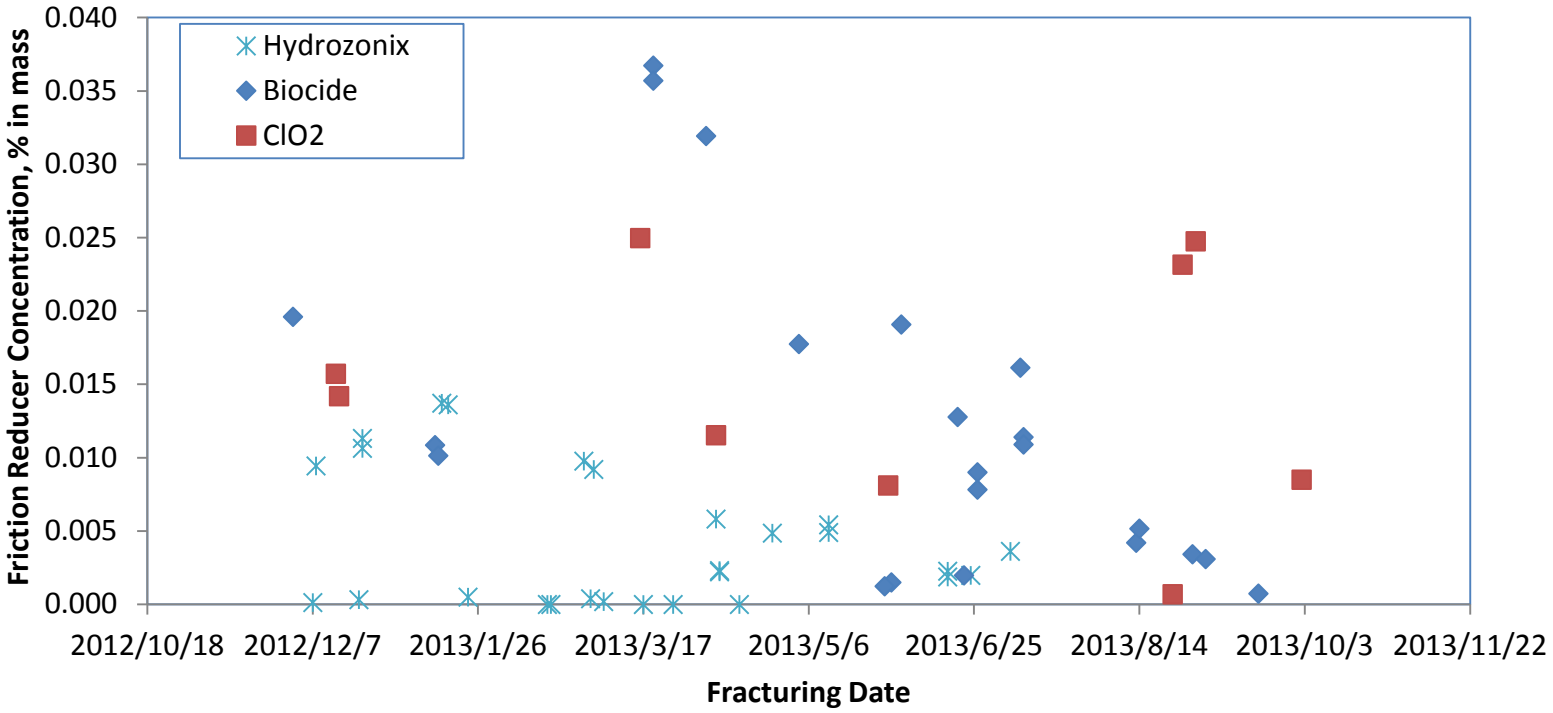
Friction Testing – Ozone



Callon Petroleum Company

Disinfection vs. Compatibility

Slickwater: HZO vs. Biocide vs. Chlorine Dioxide

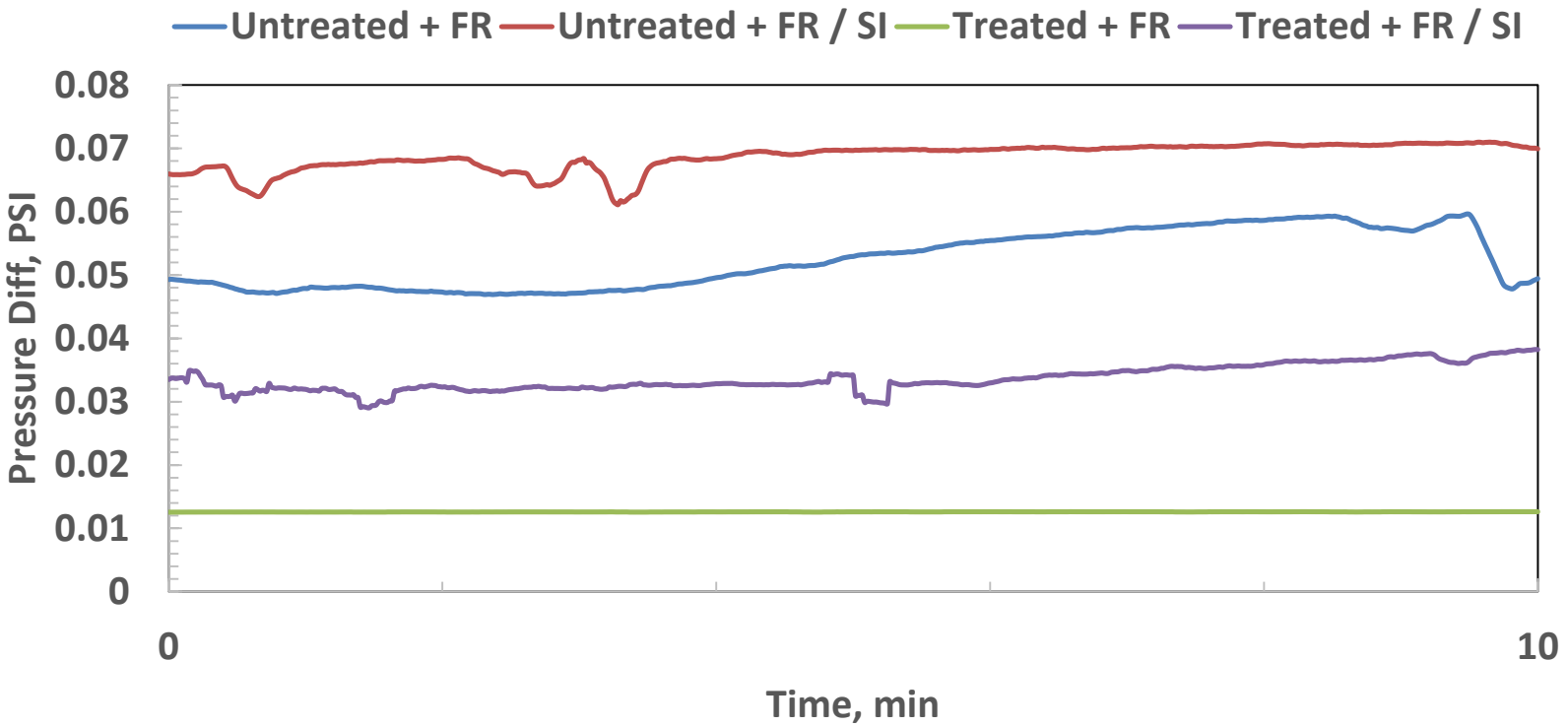


Water Treatment Technology	# of Wells	FR Concentration, % in mass
Biocide	22	0.0123
ClO_2	9	0.0146
Hydrozonix	27	0.0042

Callon Petroleum Company

Friction Reducer Compatibility

Case 1: FR / SI

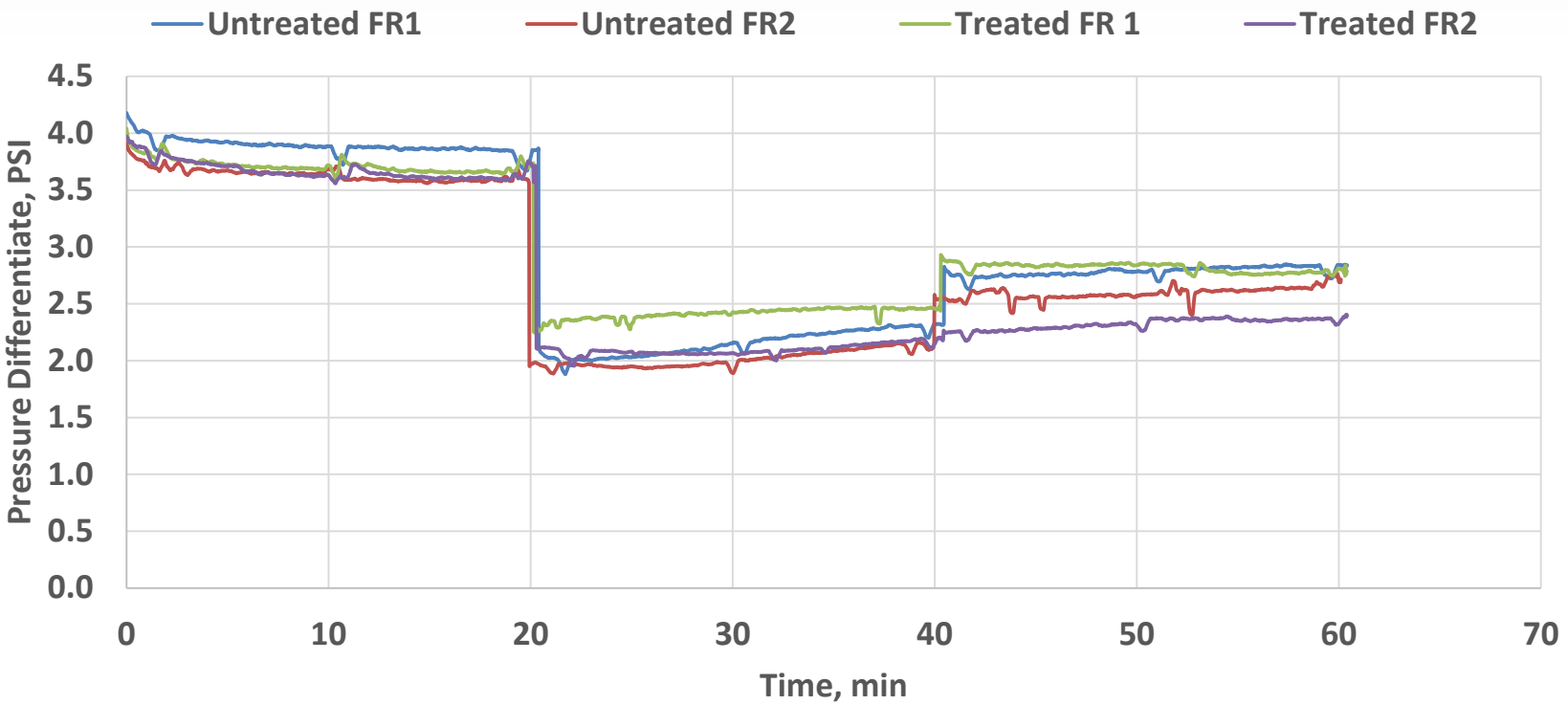


- **FR concentration was at 1.0 gpt, SI concentration was at 0.25 gpt. Both of the chemicals were obtained from ProPetro.**
- **Test was run at 1.5 L/min, room temperature.**
- **Clearly, there is the incompatibility of the FR with the SI.**
- **Ozone treatment reduced the friction factor of the water.**

Callon Petroleum Company

Friction Reducer Compatibility

Case 2: Friction Testing for Two Different FRs



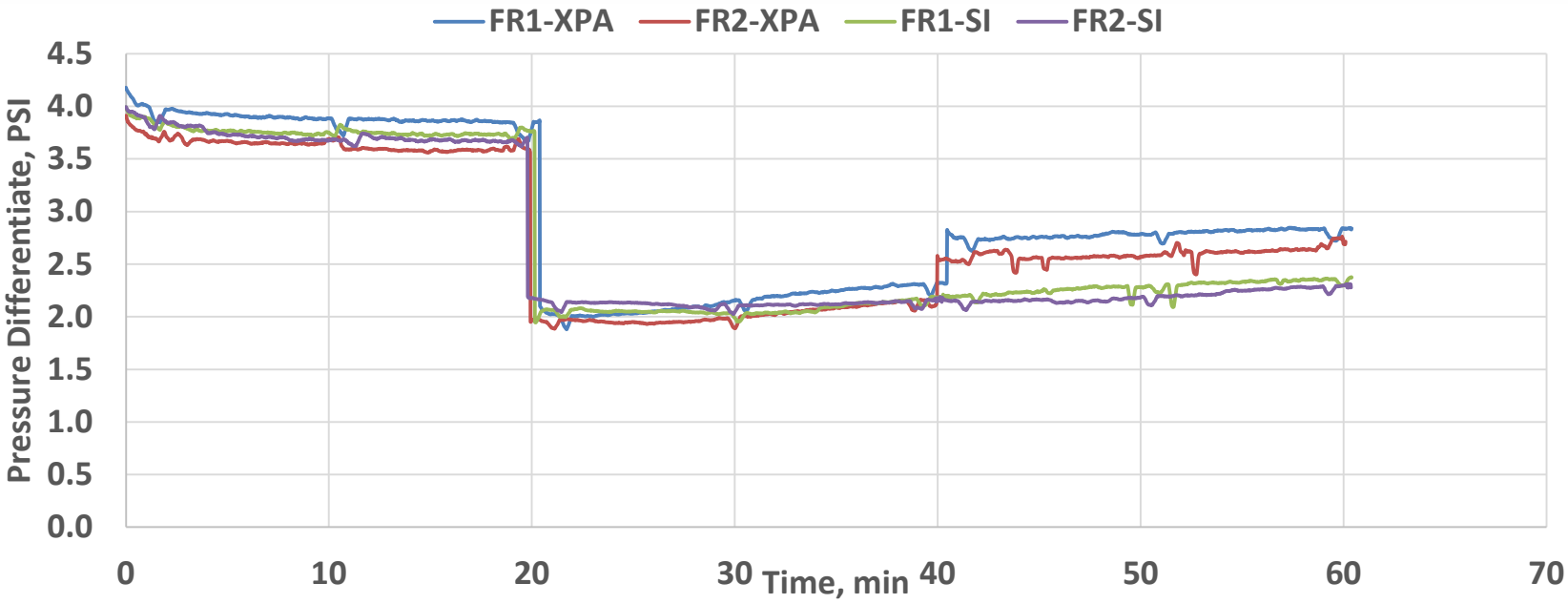
- FR1 vs FR2.
- First 20 minutes was baseline test. FR was added at time 20 min, following by the addition of breaker (XPA) at time 40 min.

- Both FRs were effective.
- No significant difference between untreated and treated water.
- Rapid Increase of pressure after XPA addition

Callon Petroleum Company

Friction Reducer Compatibility

Case 2: Friction Testing for Two Different FR



- FR1 vs FR2 .
- First 20 minutes was baseline test. FR was added at time 20 min, following by the addition of breaker (XPA) or SI at time 40 min.
- SI had little impact on the performance of either FR.
- FR1 might have been interfered by other frac chemicals.

Callon Petroleum Company

Takeaways

- **For Gel Fluid**
  - Maintain the water quality in a narrow range
  - Gel compatibility test needs to be conducted to determine proper recipe
  - Monitoring of blend rate, chloride, TDS and boron level is necessary
  - Bacteria monitoring is important
- **For Slickwater**
  - Different types of FR have different tolerances on water quality change
  - Proper selection of disinfection technology
  - Field friction loop testing to confirm compatibility

Callon Petroleum Company

Thank You

Callon Petroleum Company