First Ever Polymer Flood Field Pilot to Enhance the Recovery of Heavy Oils on Alaska North Slope – Producer Responses and Operational Lessons Learned

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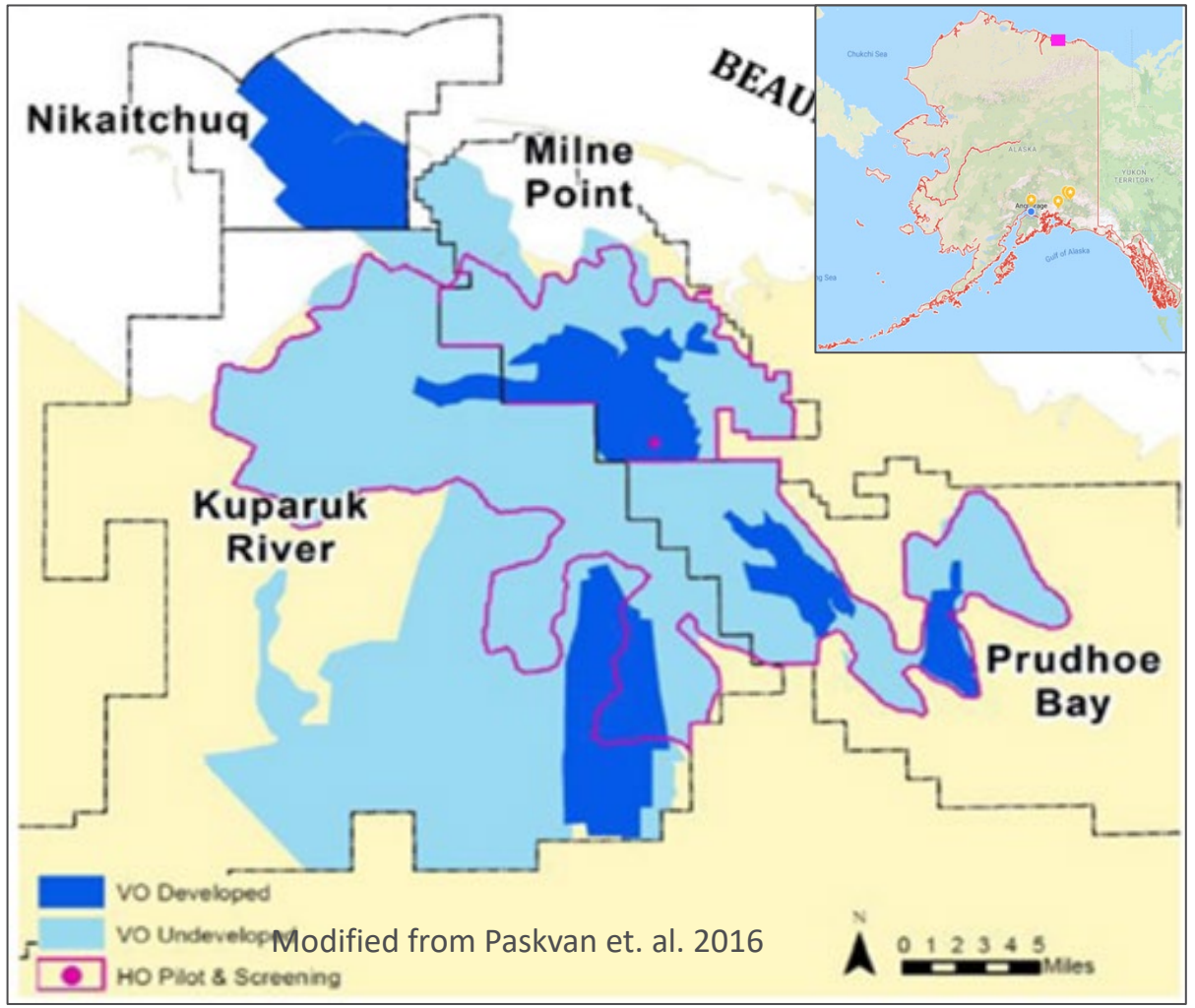
Outline

- ANS Heavy Oil Resources
- Polymer pilot project introduction
- Polymer solution quality control
- Injector performance
- Producer responses
- Preliminary economics
- Conclusions
- Acknowledgement

ANS Heavy Oil Resources

- Resource Area - ~260k acres
- Schrader Bluff/West Sak:
  - Viscosity = 5 – 10,000 cp
  - OOIP = ~12 billion barrels
  - Cum Production = 250 MMBO
- Ugnu:
  - Viscosity = 1,000–1,000,000 cp
  - OOIP = 18-27 billion barrels
  - No significant commercial production to date



Modified from Paskvan et. al. 2016

Project Overview

Participants

- Cosponsors - DOE, Hilcorp Alaska
- Research – UAF, MST, NMT, UND

Objectives

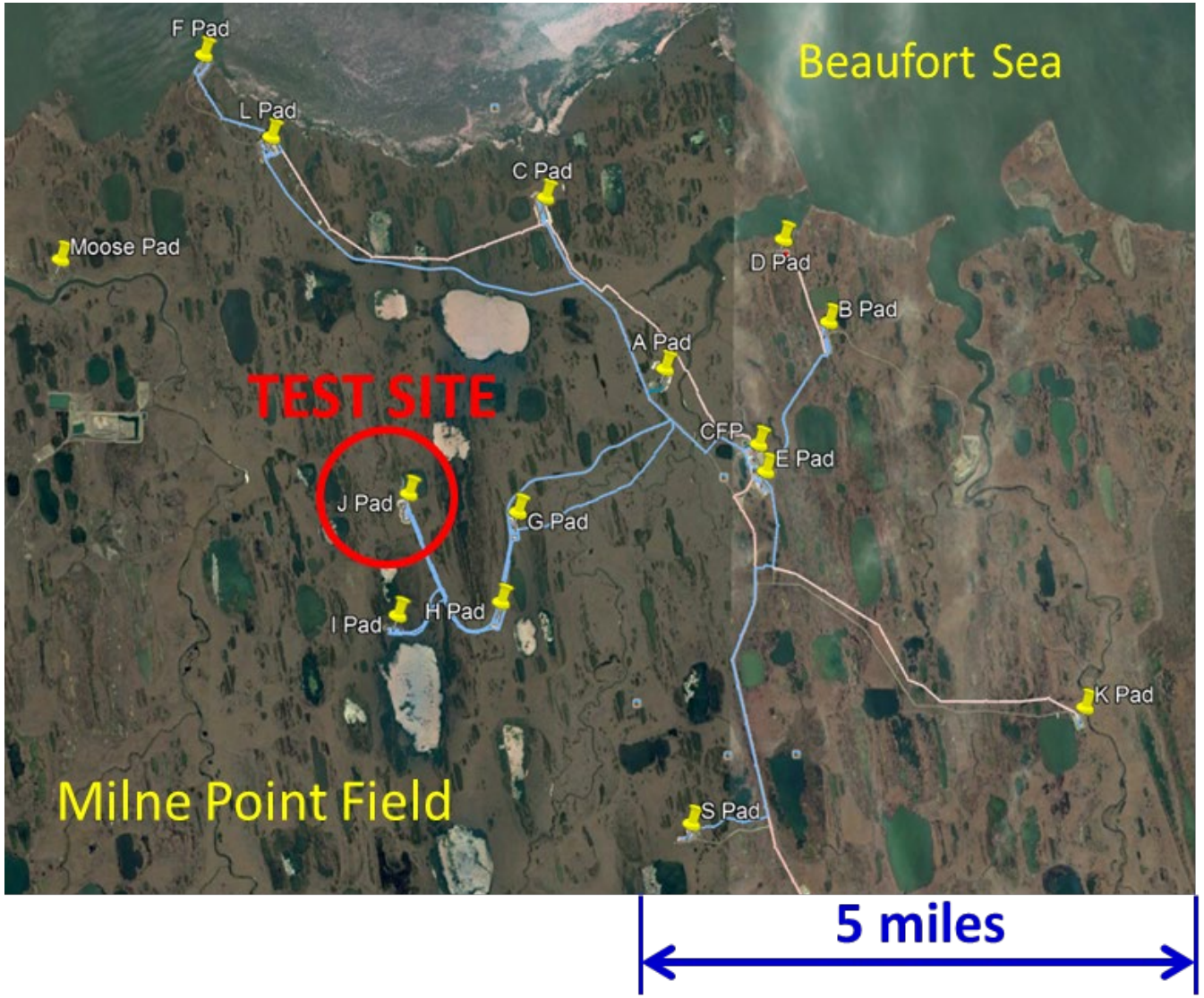
- Develop advanced polymer flooding technology for heavy oil EOR
- Observe field performance to optimize design
- Resolve technical issues regarding heavy oil polymer flooding

Paper Focus

- Producer responses and operational lessons learned

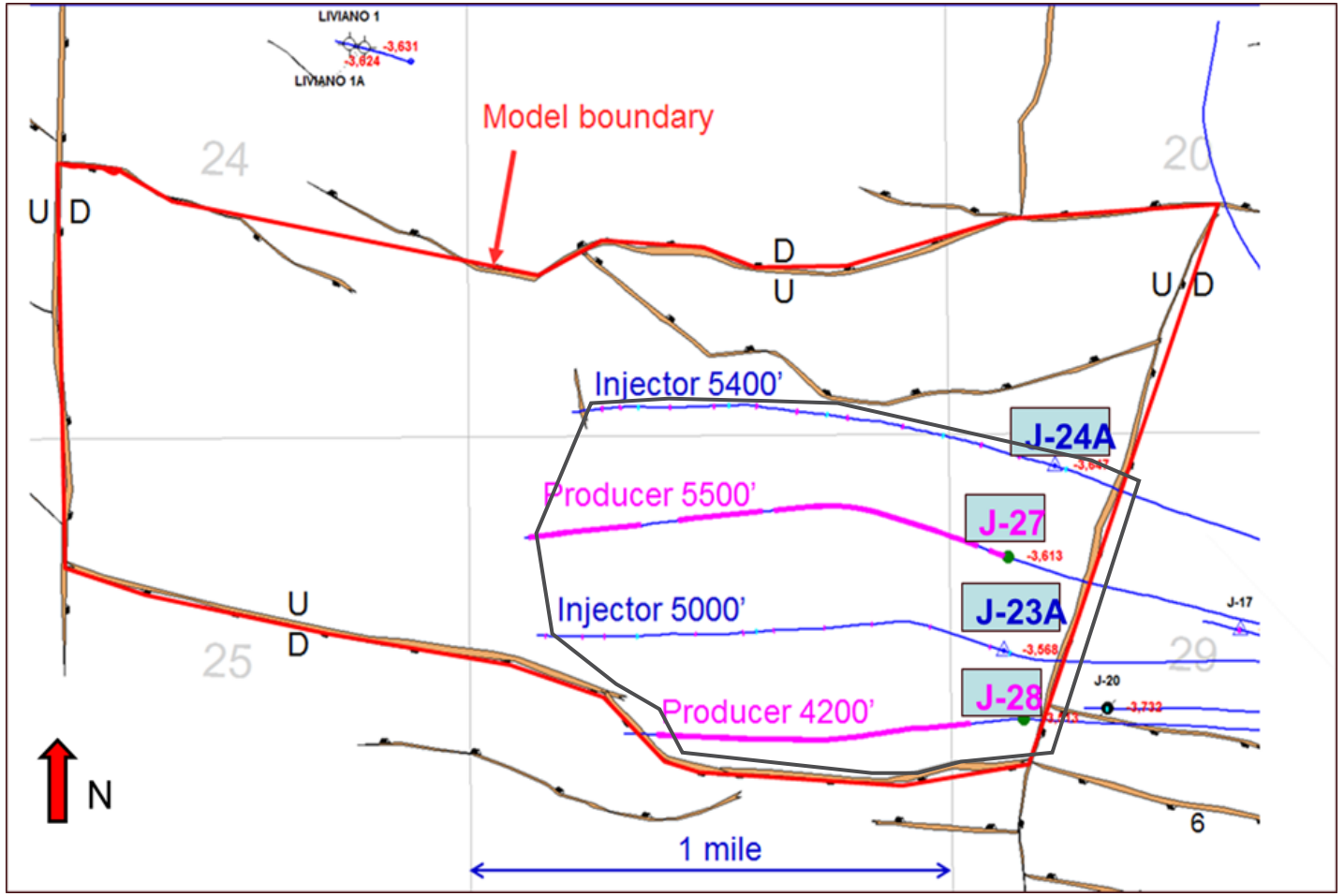
Milne Point field

- ~50,000 acres
- ~490 wells -12 pads – 1 CFP
- Field Development - 1985
- Cumulative Production - 366 MMBO
  - Light oil – 271 MMBO
  - Heavy oil – 95 MMBO
- Current oil rate: ~35 MBD
  - Light oil – 12 MMBO
  - Heavy oil – 23 MMBO
- Polymer Test Site - J Pad



Pilot Well Pattern

- Pattern Area - ~450 acres ▭
- 2 horizontal injectors
  - J-23A : ~5000’ MD
  - J-24A : ~5400’ MD
- 2 horizontal producers
  - J-27 - ~5500’ MD
  - J-28 ~4200’ MD
- Isolated by sealing faults



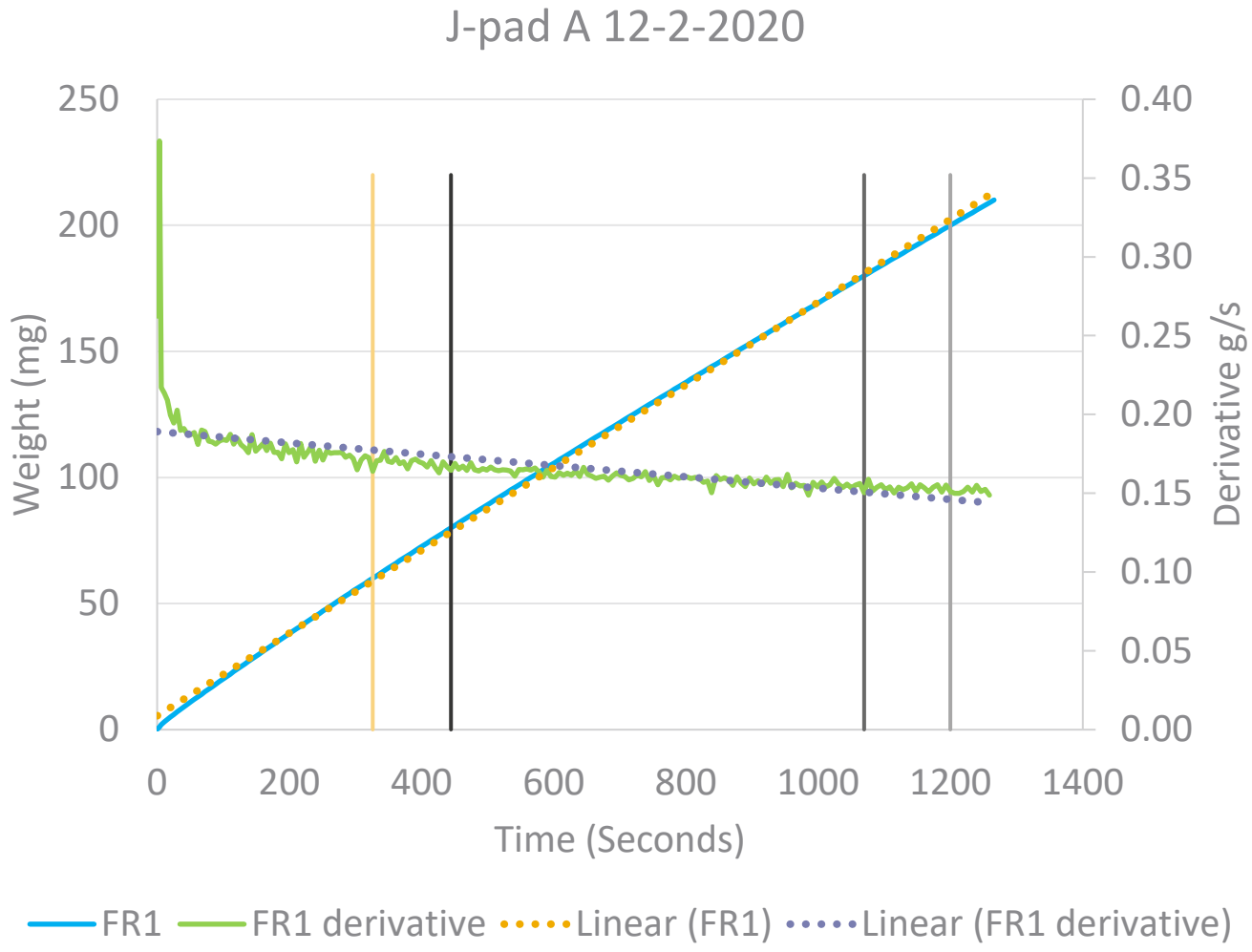
Polymer injection unit

Polymer solution quality control

- Proper QC is the key for a successful polymer flood
- Polymer solution filter ratio:

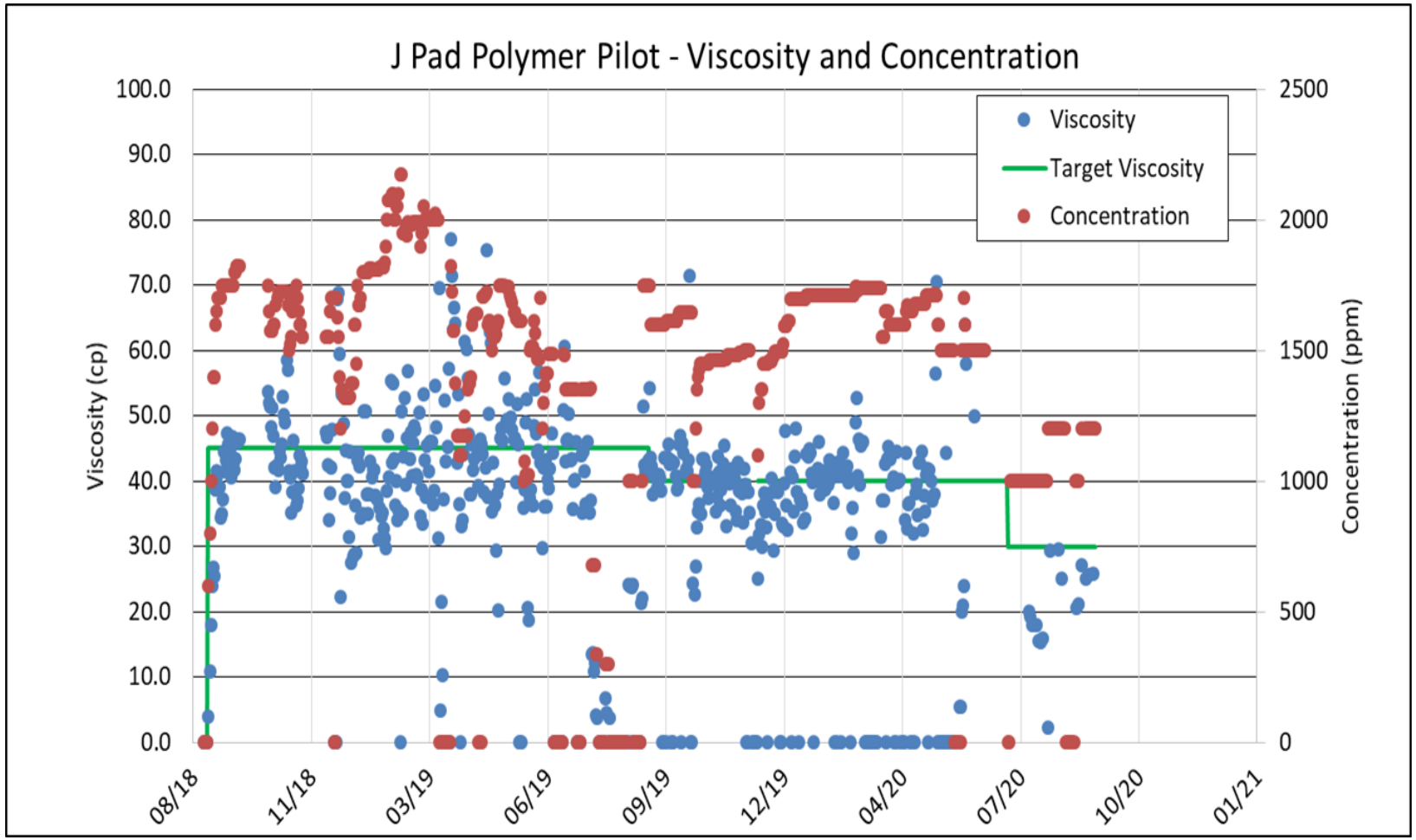
$$\frac{T_{200}-T_{180}}{T_{80}-T_{60}} < 1.2$$

- Automated measurements
- Standardized sampling procedures
- Plot shows filtration volume vs time and the intervals used for the filter ratio calculation

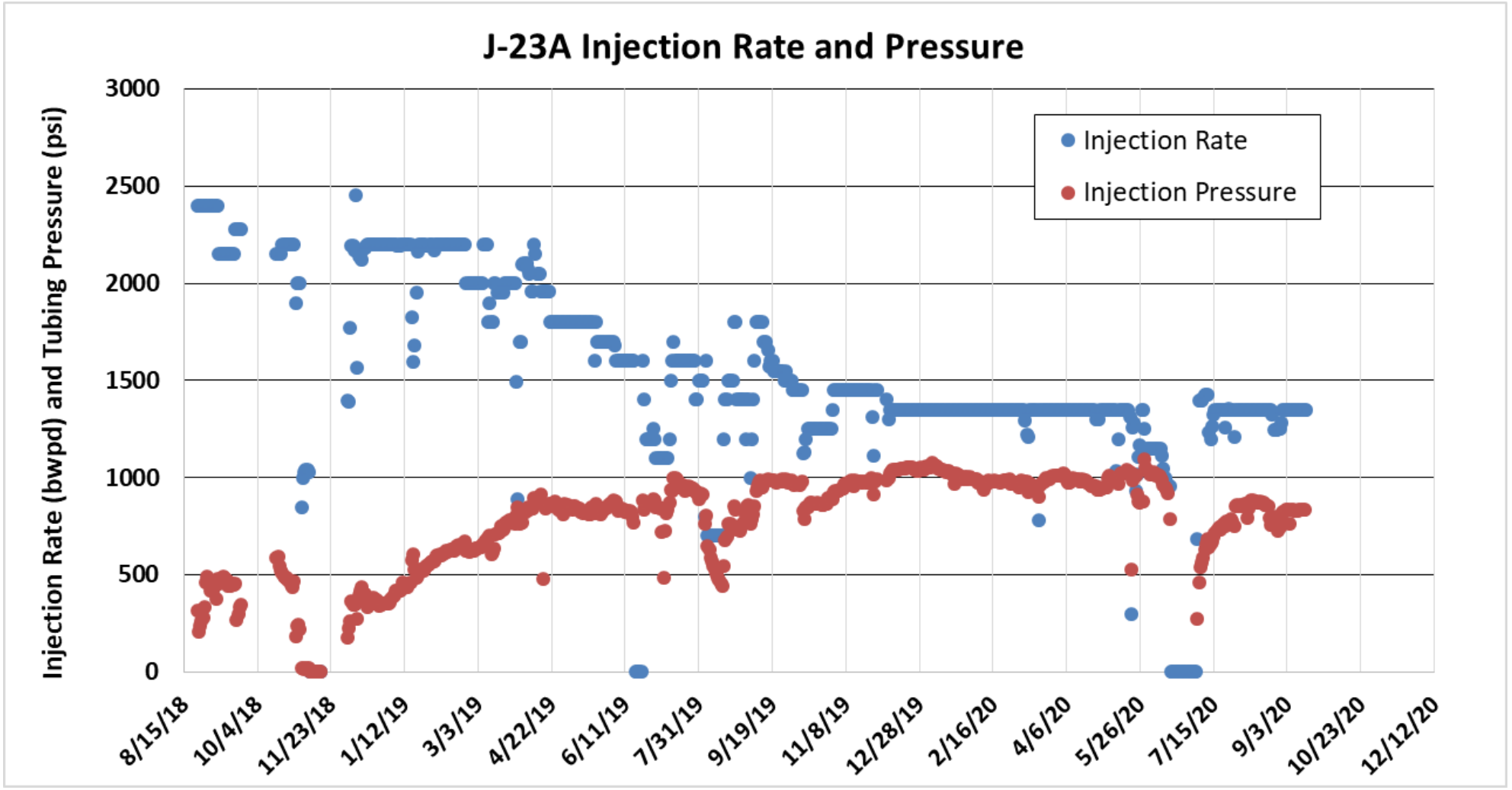


Polymer concentration and viscosity vs. time

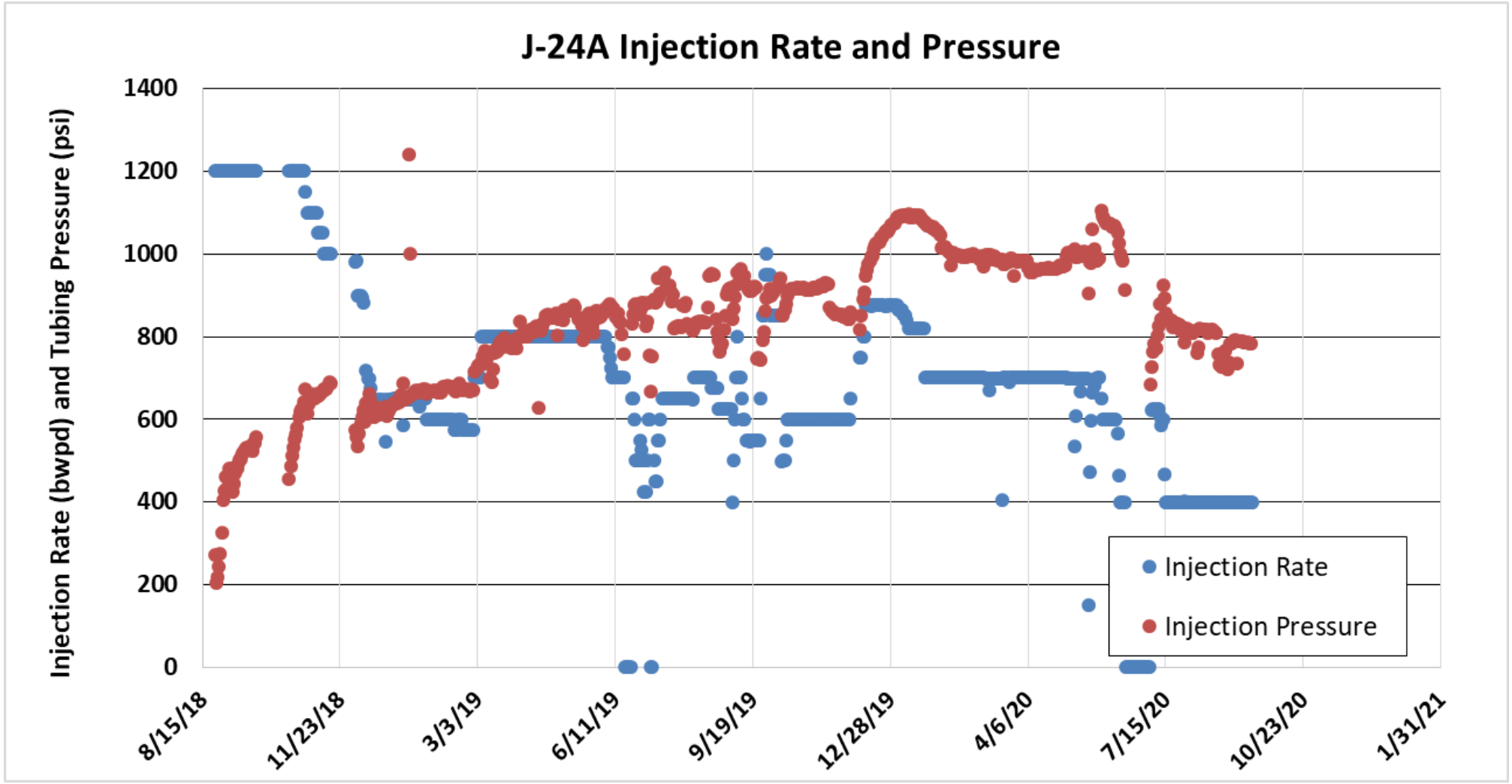
- Target viscosity: reduced from 45 to 30 cP
- Polymer concentration: reduced from 1750 to 1200 ppm
- Cum polymer injected: 769,000 lbs



J-23A Pad Injection Performance

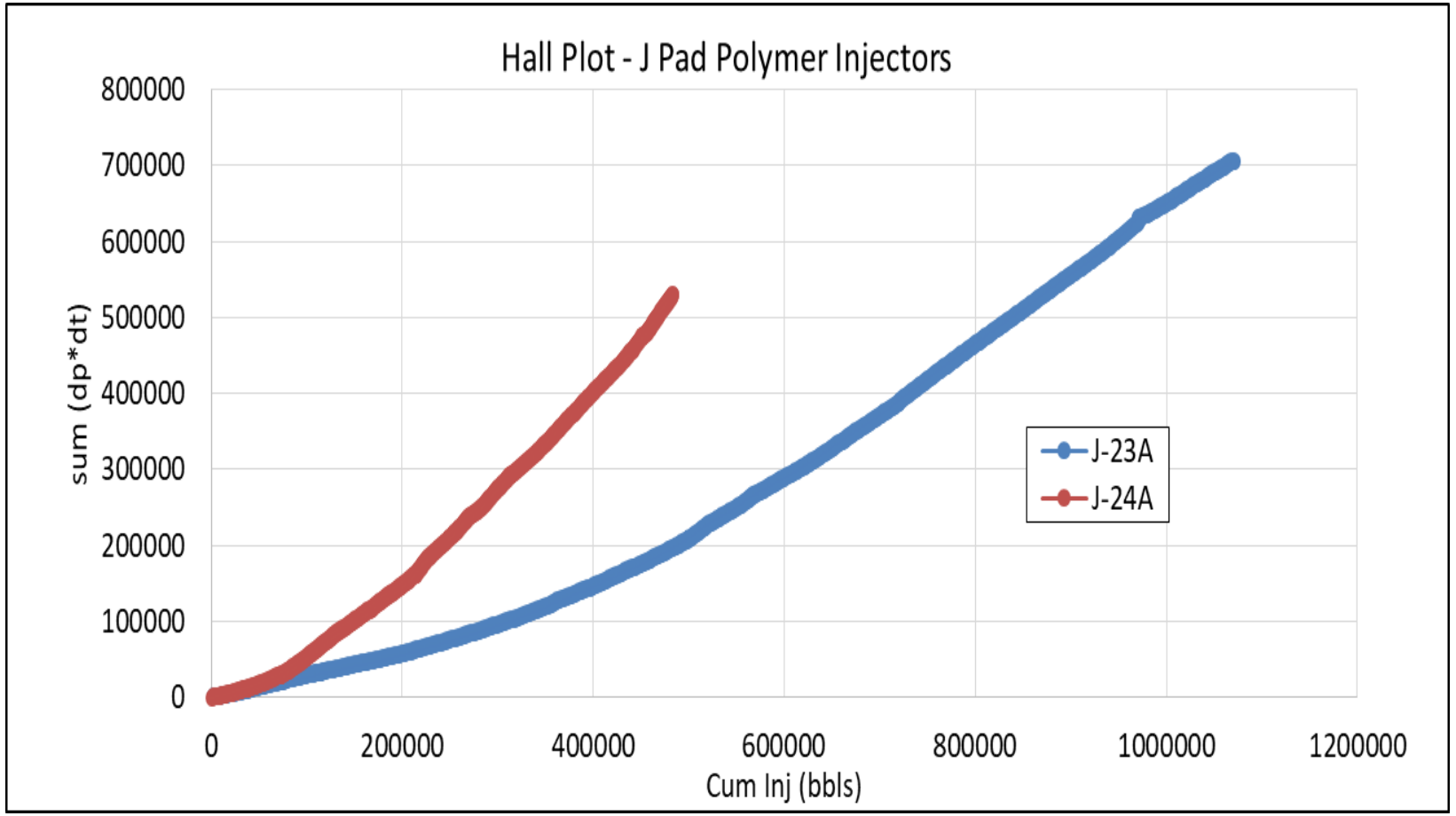


J-24A Pad Injection Performance

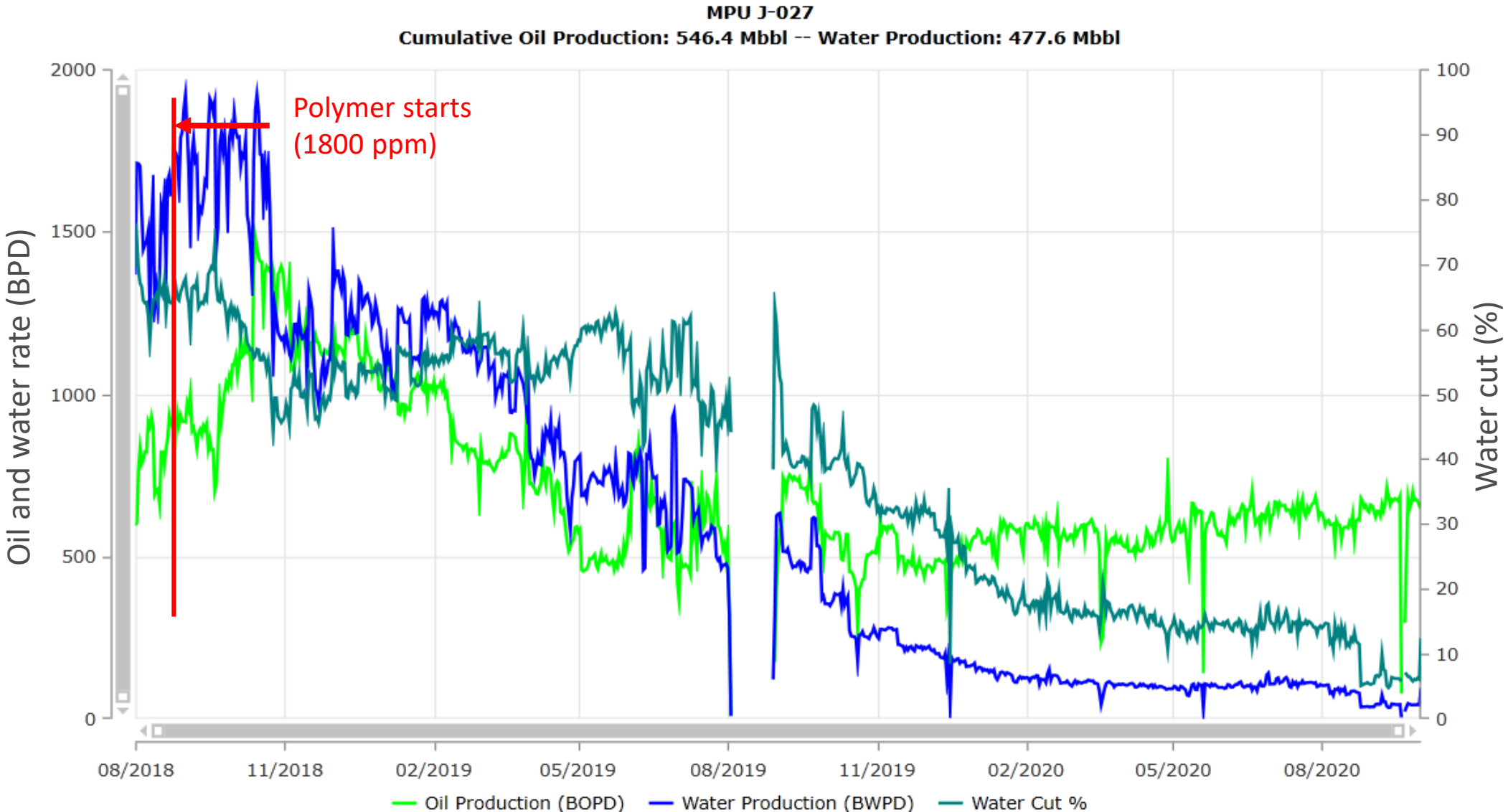


Hall plot

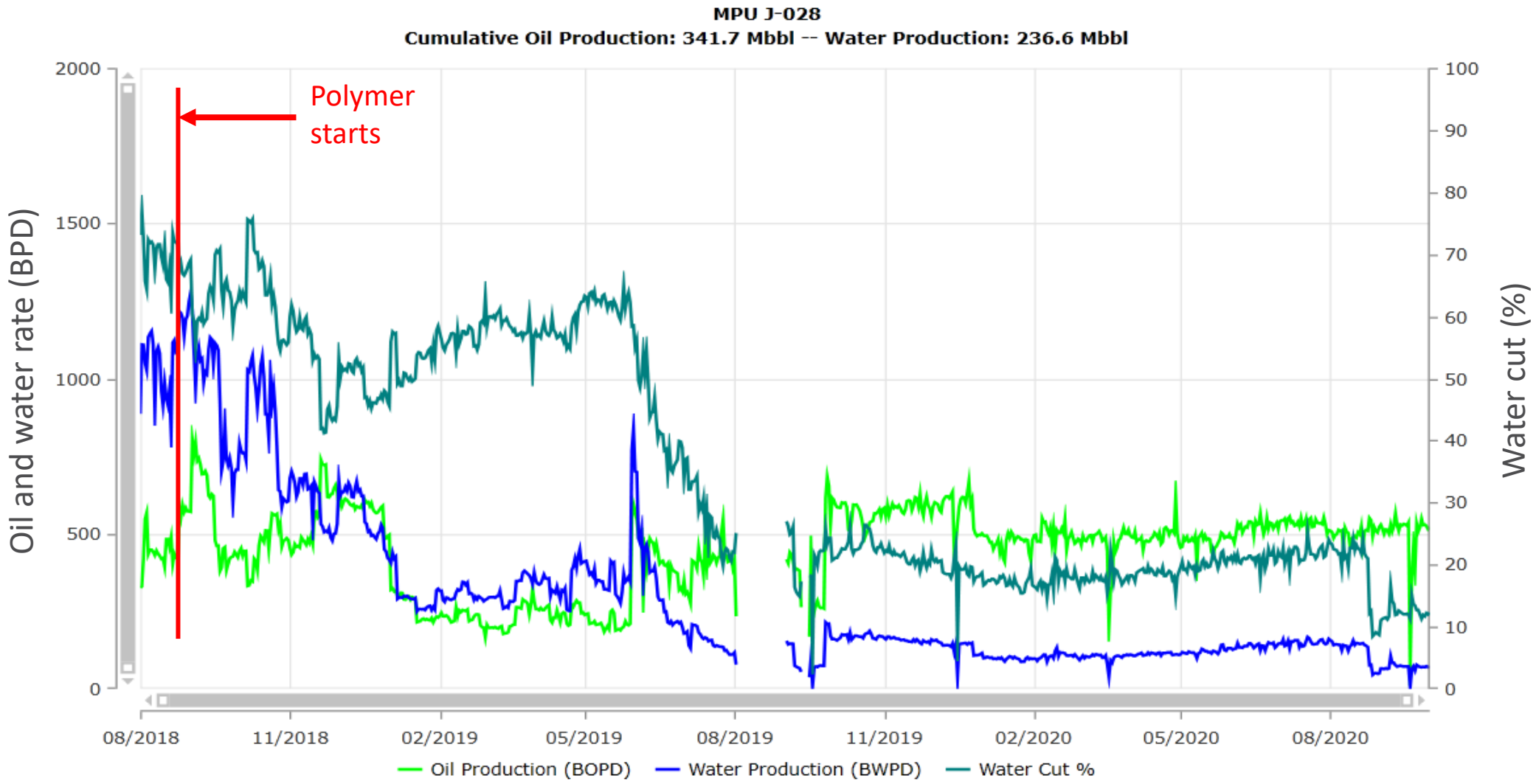
- J-23A injectivity increasing due to lower viscosity
- J-24A injectivity decreasing, pressuring up?



J-27 Pad Production Performance

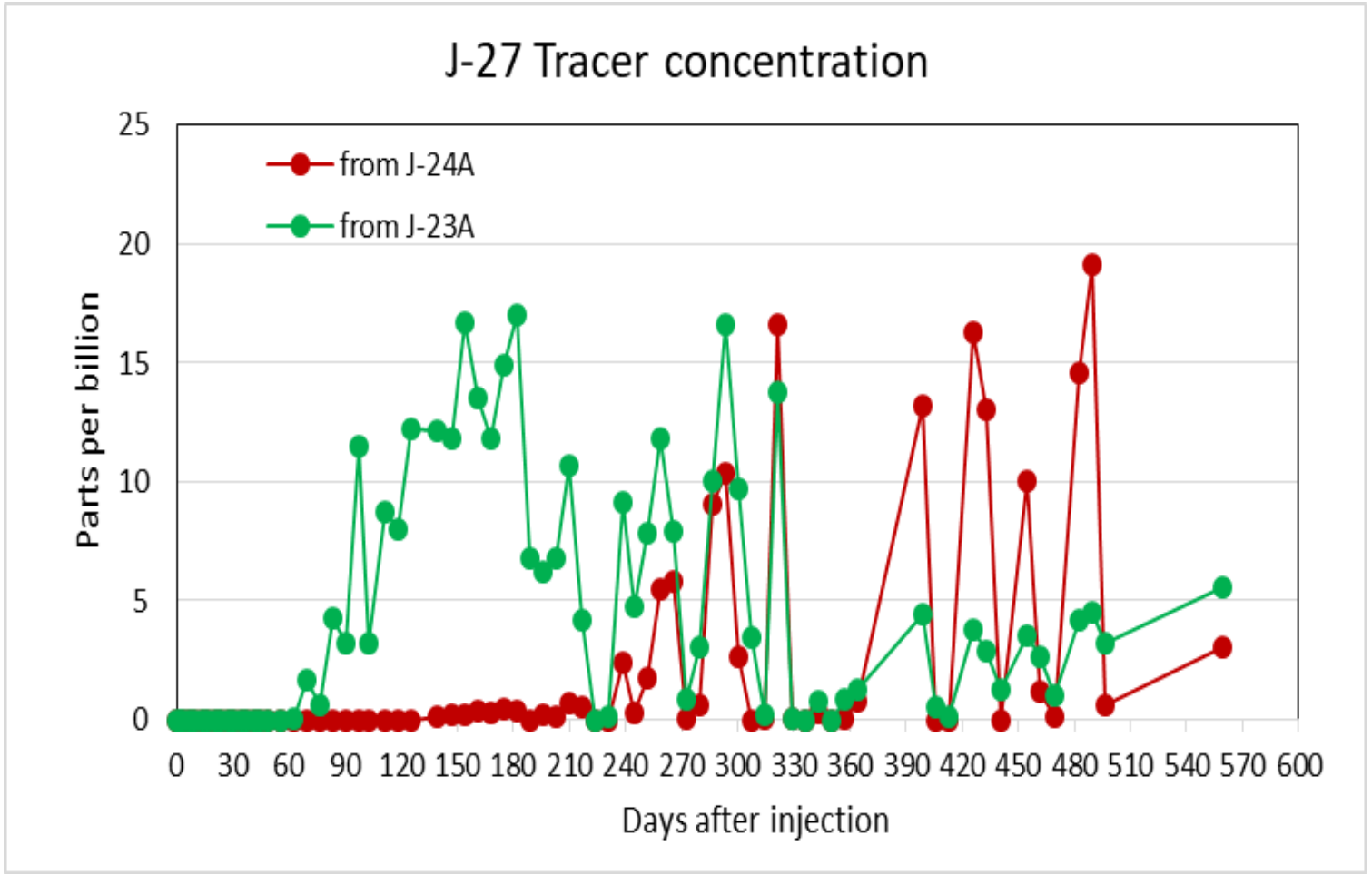


J-28 Pad Production Performance



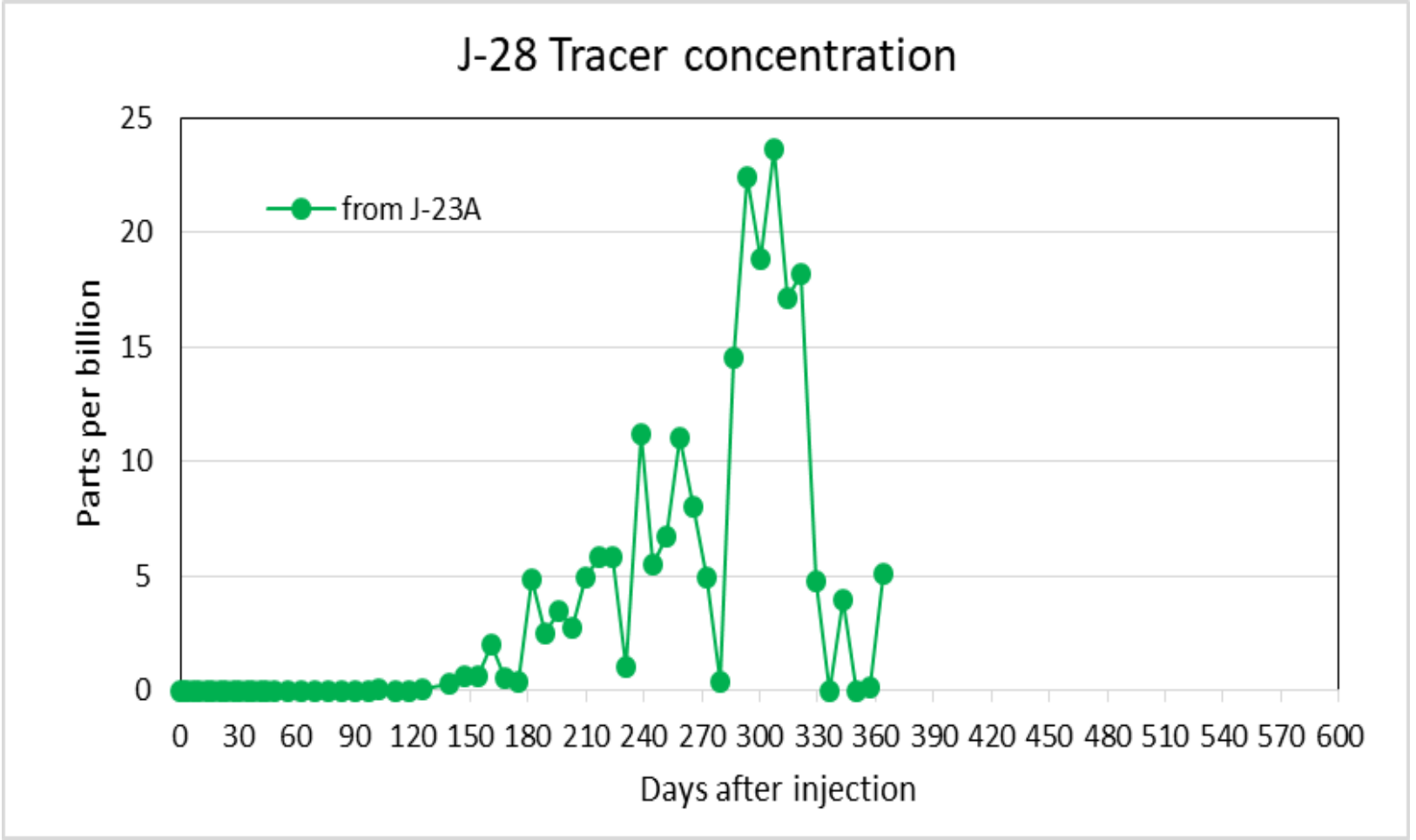
J-27 Pre-polymer tracer concentration

- Tracer from J-23A first appeared in producer J-27 after 70 days of injection
- Tracer from J-24A first appeared in producer J-27 after 240 days of injection
- Volumetric sweep efficiency from waterflood was estimated to be less than 3%



J-28 Pre-polymer tracer concentration

- Tracer from J-23A first appeared in producer J-28 after 140 days of injection
- Volumetric sweep efficiency from waterflood was ~9%
- Low sweep efficiency by waterflood creates a great opportunity for polymer flood.

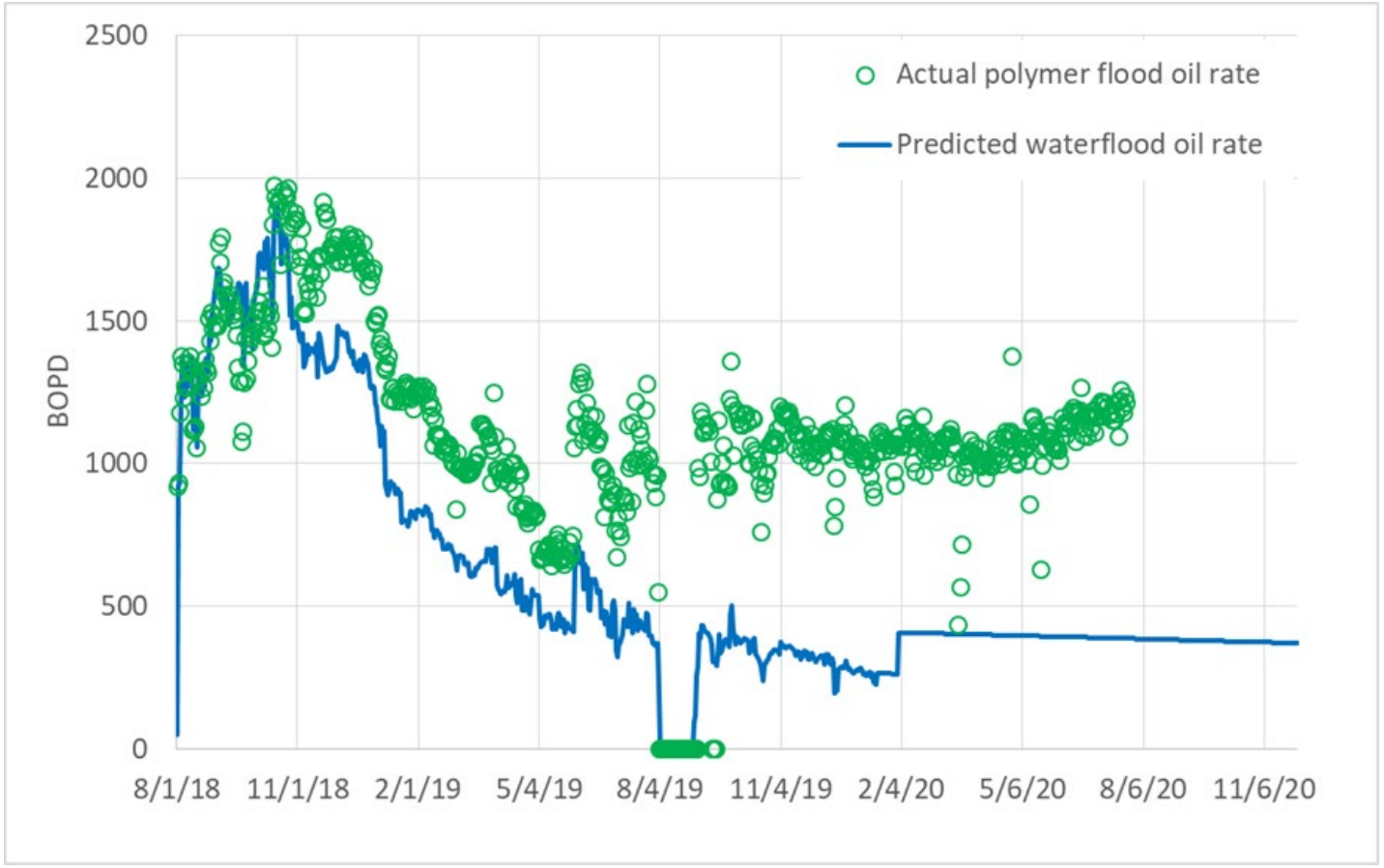


Monitoring Polymer Breakthrough

- Produced water samples have been collected weekly when possible
- Unable to collect water sample afterwards after Feb 2020
- Water samples analyzed
  - onsite using the clay flocculation test
  - in the laboratory via nitrogen-fluorescence water composition analyses
- No polymer has been confirmed in the production stream 26 months after the start of polymer injection

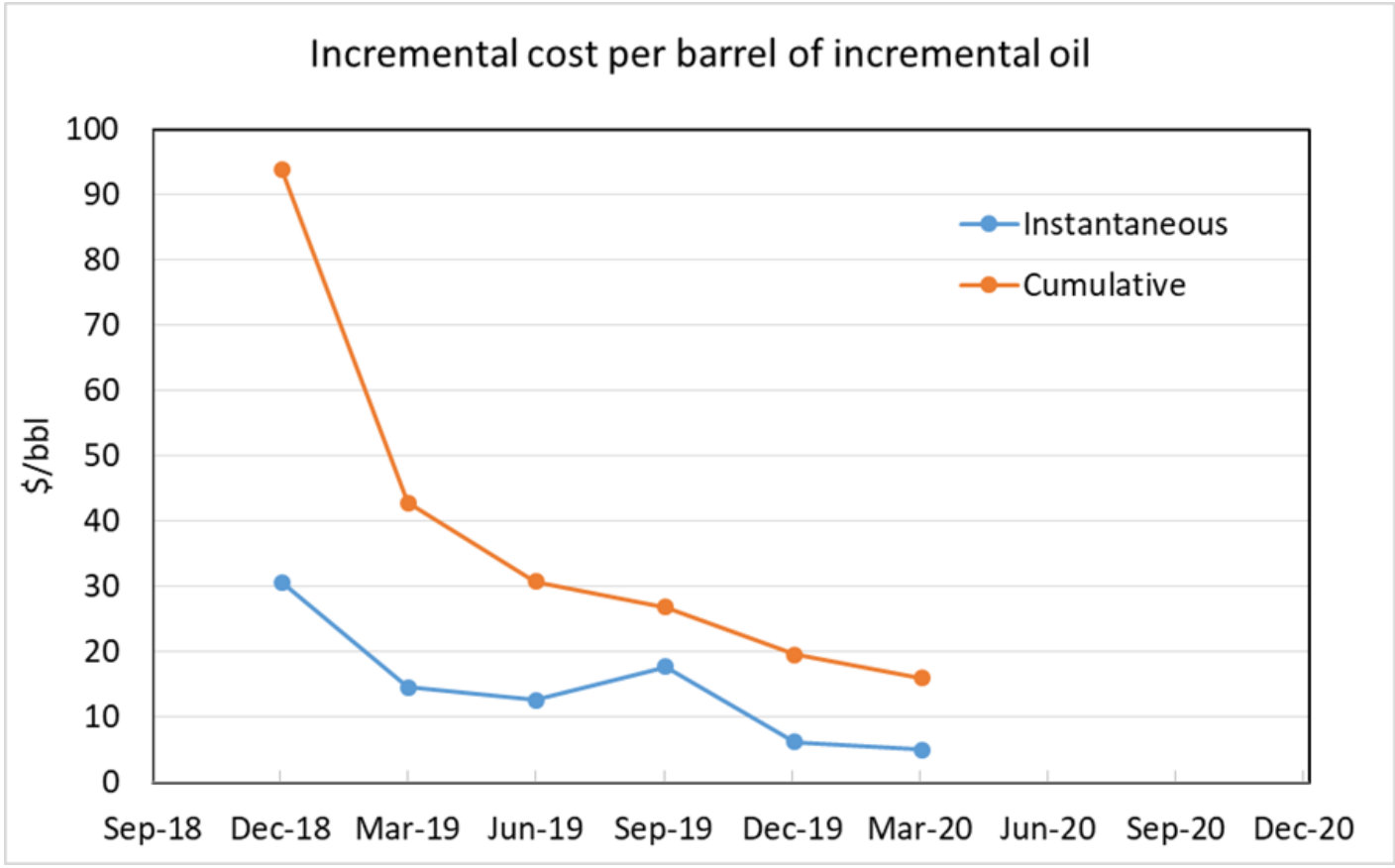
EOR benefit

- Current oil rate is approximately 1200 bopd
- Predicted oil rate without polymer injection is about 400 bopd
- EOR benefit is approximately 800 bopd
- Cumulative Incremental Oil Recovery (IOR) is 300,000 bbls



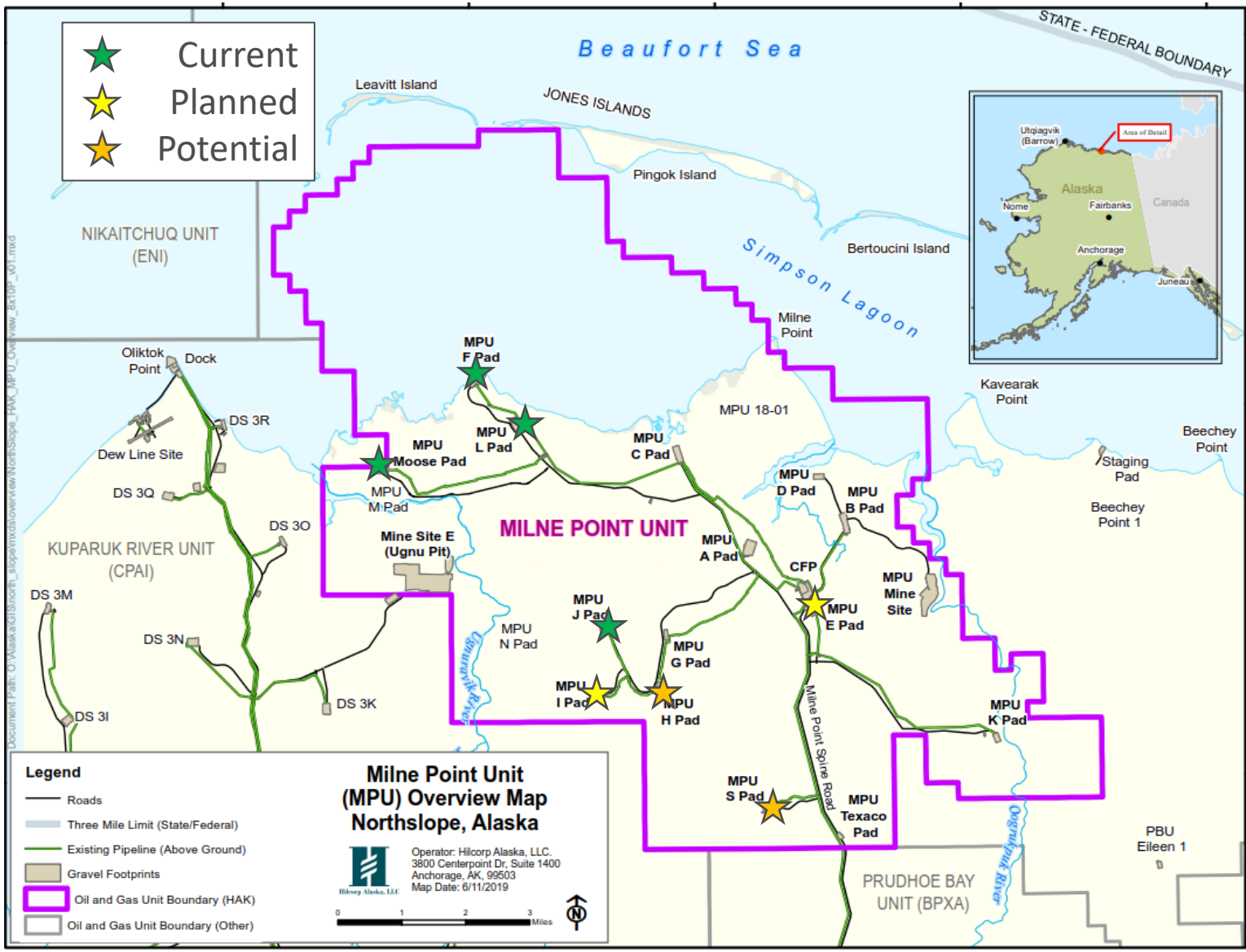
Preliminary economics

- Cumulative Incremental Oil Recovery (IOR) ~ 300,000 bbls
- Cumulative polymer injected: 708,000 lbs
- Polymer utilization: 2.4 pounds per bbl IOR
- Current instantaneous cost: $5 per barrel
- 20 month cumulative cost: $16 per barrel of IOR



Milne Point polymer flooding expansion

- Currently injecting polymer into 19 wells at 4 pads
- Planning to expand to 2-4 more pads
- All new SB development will be based on polymer flood



Conclusions

1. Adequate polymer injectivity can be achieved with horizontal wells in the Schrader Bluff N-sand reservoir. However, polymer solution quality control is critical to ensure polymer propagation through the reservoir.
2. Water-cut has decreased from approximately 70% to less than 15% in the project wells since the start of polymer injection. Estimated EOR benefit is approximately 800 bopd at the present time. Estimated polymer utilization to date is approximately 2.4 pounds per barrel of incremental oil.
3. Twenty six months after the start of polymer injection, no polymer production has been confirmed from the producers yet, compared with waterflood breakthrough timing of 3 months.
4. Encouraged by the promising results of this pilot, Hilcorp Alaska is planning to apply polymer flood technology in the Schrader Bluff reservoir throughout the Milne Point Field.

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