Characteristics and Performance of an Environmentally-Friendly Microbial-Based Paraffin Dispersal Treatment

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Locus Bio-Energy Solutions

- Four year old Ohio-based company with patent pending microbe-based solutions for upstream, midstream and downstream applications
- World-class team of R&D scientists – have solved many of the problems plaguing traditional microbial treatments that lead to marginal or ineffective results
- Now commercially treating hundreds of wells in the Appalachia area after year+ of pilot projects
- Launching pilot projects in Texas Q4 2017 with 6 E&P operators
- Upstream Applications – cost competitive, effective, and environmentally safe
  - Paraffin control in wellbores, flowlines and tanks
  - Storage tank de-sludging
  - Production enhancement

Product Technology

- Portfolio of naturally-occurring microbes using patent-pending microbe generation/fermentation processes
- Microbial cocktails are customized for each customer
- **Microbes are non-toxic, biodegradable, and non-GMO with no special handling required**
- Local fermentation ensures maximum potency at point of application: Up to 1000x greater
- Operational in a new region within four months

Upstream Applications

Application	Description

Paraffin Removal	• Disperses paraffin
	  - Wellbore components
	  - Flowlines and tanks
	• Increases well productivity and potentially increases recoverable reserves
	• Proven in over 300 wells in Appalachia

Other Upstream Applications Being Commercialized	
Sludge Removal	• Eliminates paraffinic sludge without heating and with no human intervention - Storage tanks, pipelines, tankers, tanks, rail, trucks • Commercializing for global oil trading company
Production Enhancement	• Increases oil recovery by reducing IFT and selectively plugging thief zones • Successfully validated in stripper wells in Appalachia

Paraffin Wax Deposition – Clogs tubing and pipelines, places strain on well and pipeline pumping systems

Effect of Paraffin Treatment on Tubing and Flowlines

Numerous Mechanisms of Action

Paraffin Dispersal

- Disperses paraffin by effective emulsification and keeping it suspended in solution through bio-solvents and bio-surfactants. Effective down the wellbore, through the flowlines, and with tank sludge.
- Shortens paraffin chains with no adverse impact on hydrocarbon profile (PIONA) or increase in acidity. Certified by three refineries that no byproducts are harmful or unsuitable for refining processes

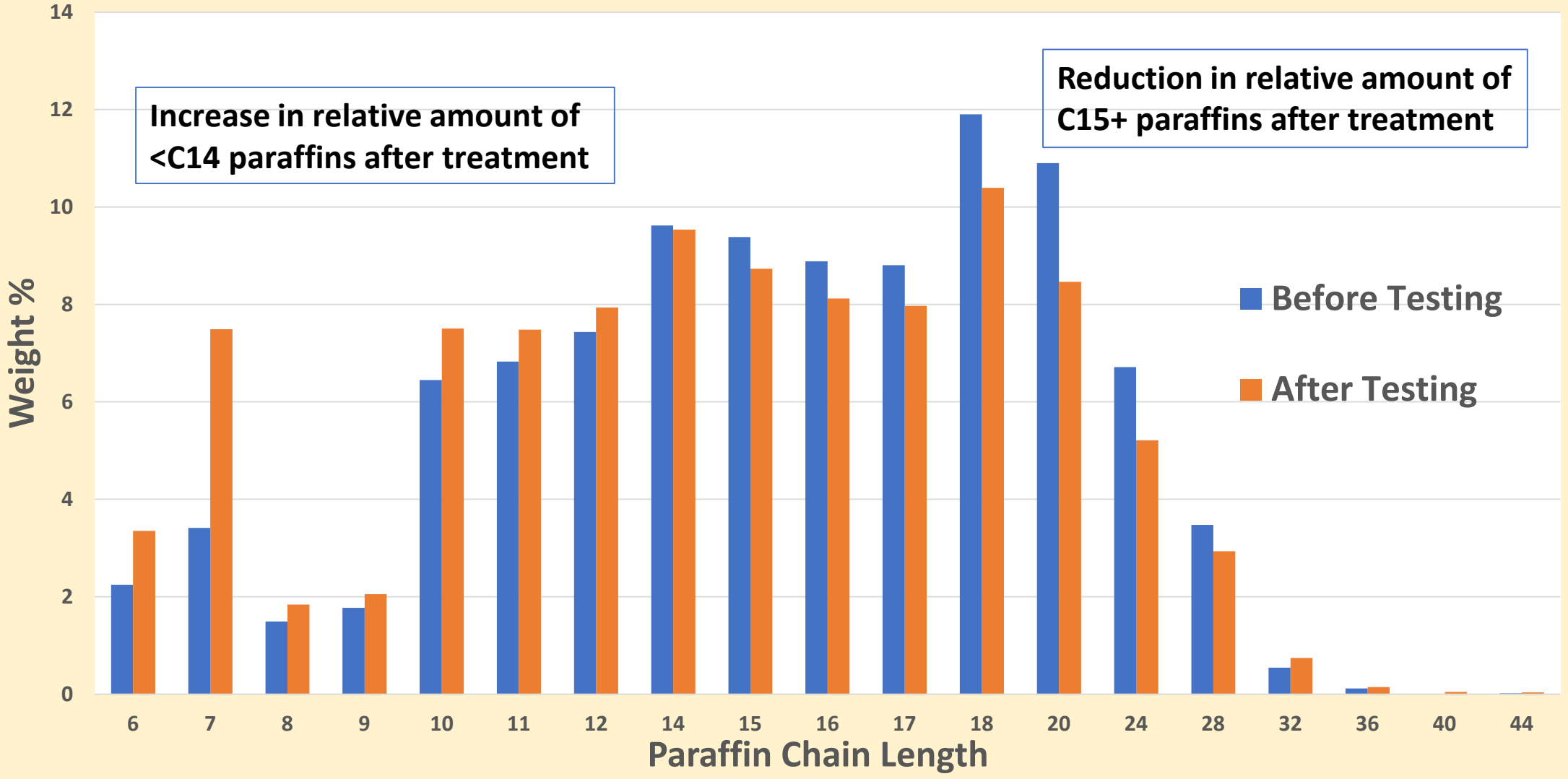
Enhanced Production Effect

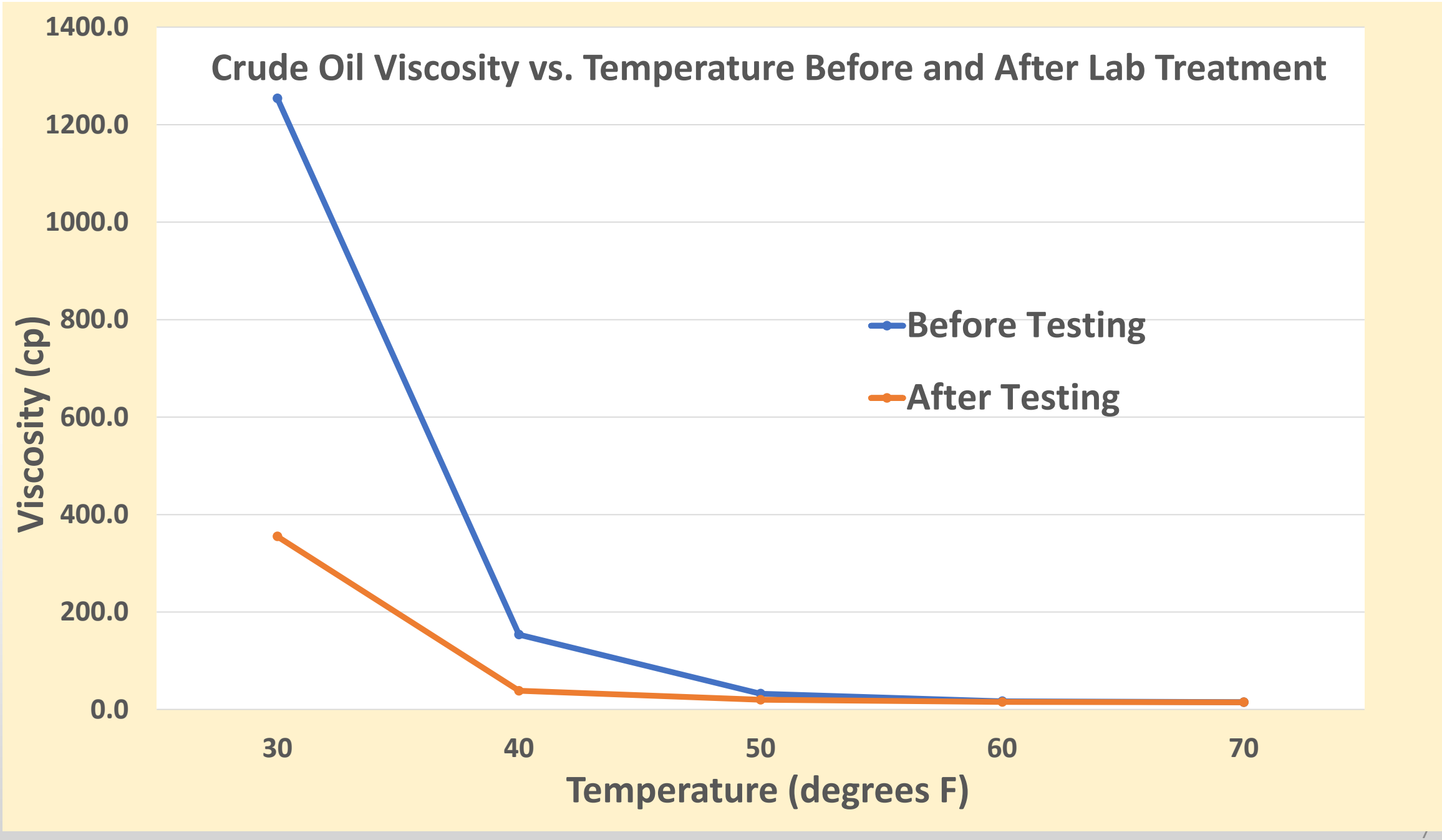
- Disperses excessive paraffin to improve flow.
- Reduces interfacial tension and crude viscosity and alters wettability of rock close to the wellbore to ease oil access and flow from pores.
- Progressively dissolves bio-polymers such as polylactic acid (PLA) and guar from previous fracs that otherwise might be blocking parts of the formation.

Protection from Corrosion

- Microbes and metabolites can reduce concentrations of SRBs, other bacteria, and biofilms.

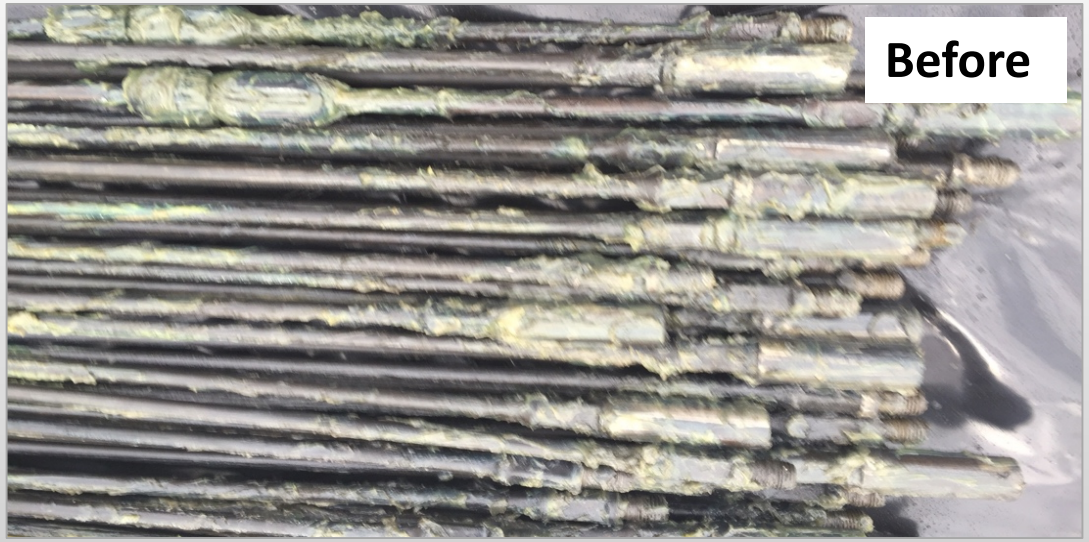
Paraffin Chain Length Distribution in Crude Oil Before and After Lab Treatment




Crude Oil Viscosity vs. Temperature Before and After Lab Treatment
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
Viscosity (cp)
30
40
50
60
70
Temperature (degrees F)
Before Testing
After Testing

Positive Impact of Paraffin Treatment

Effect on Sucker Rods: Appalachian Basin



Paraffin Treatment: Advantages vs. Current Options

- **No toxicity or HSE issues as those resulting from the use of BTEX solvents**
- **But applied the same way as solvents**
  - Product is pumped in through the backside with no shut in required
- **More effective than any contemporary technology**
  - Treated rods and pumps exhibit almost no paraffin when pulled
- **Does not push paraffin further into the formation as with thermal treatments**
  - No heat loss as with thermal treatments

Paraffin Treatment: Reduces Long-term Costs

LOWER COSTS	Microbial	Hot water	Hot oil	Solvent	Chemicals
Reduces corrosive biofilms	☑	☒	☒	☒	☒
Cleans flowlines and storage tank bottoms as part of treatment	☑	☒	☒	☒	☑
Reduced LOE through less frequent treatments & stripping jobs	☑	☒	☒	☒	☒
Progressively dissolve bio-polymers from previous hydraulic fracs	☑	☒	☒	☒	☒

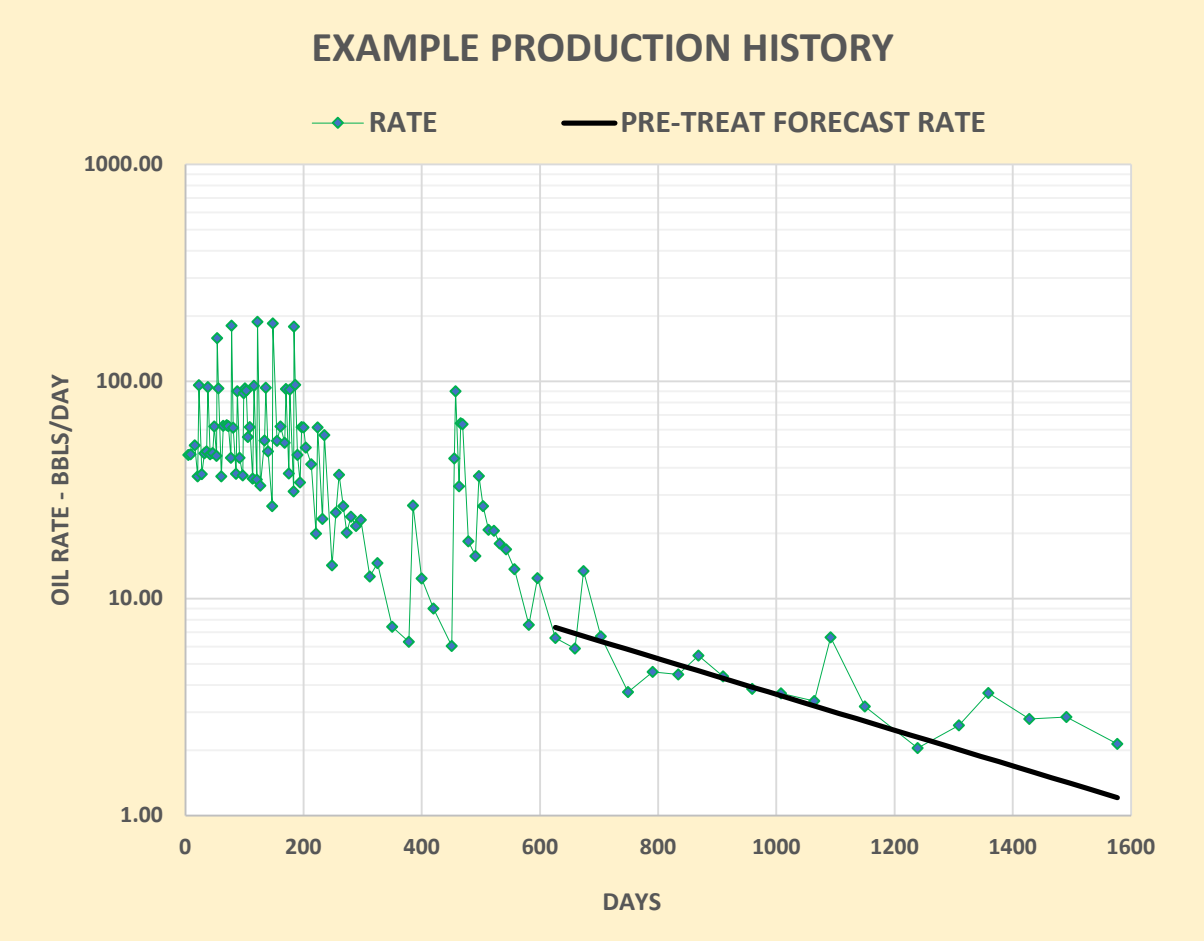
Microbial Treatments

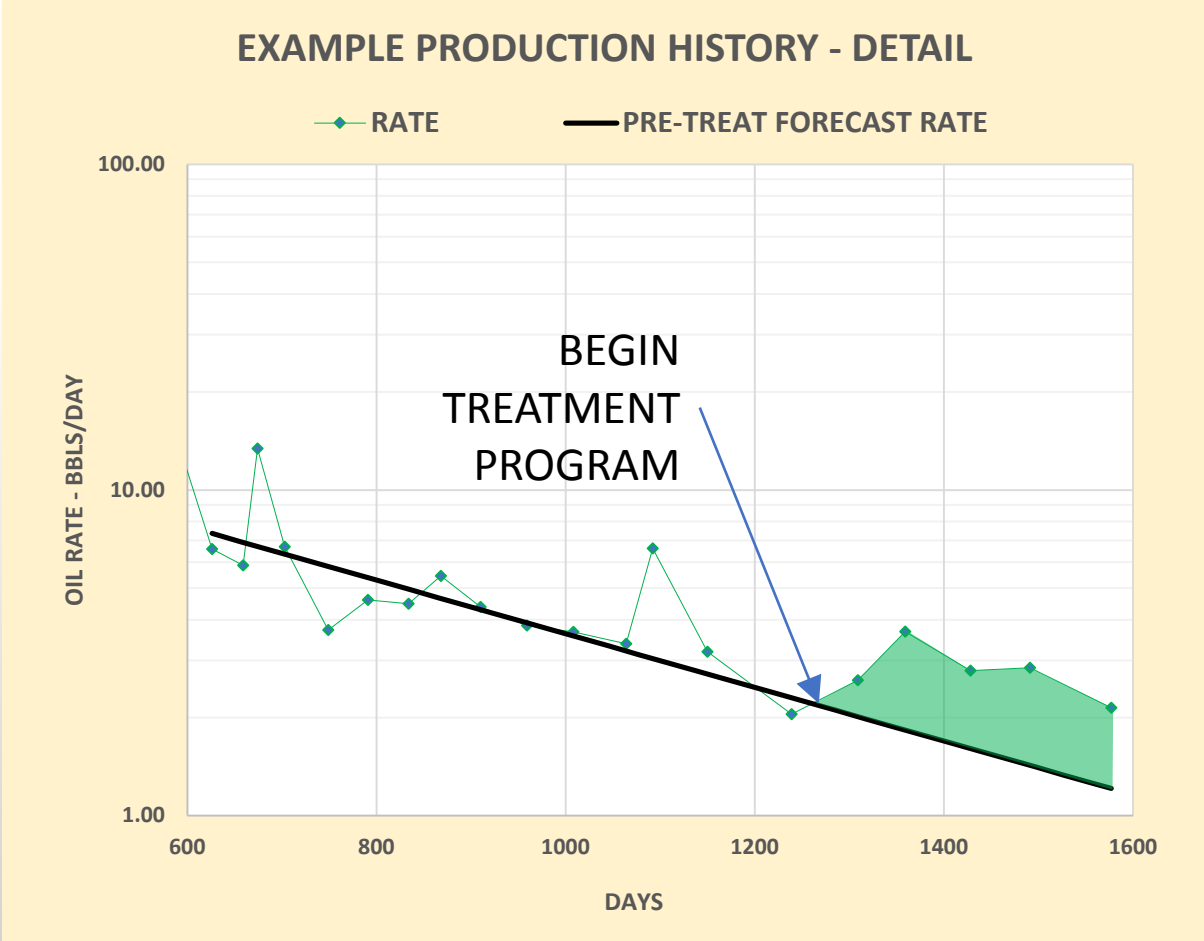
Effective across Geologies, Depths, Porosities, Temperatures and Salinities

- **Formation type:** Sandstones and Carbonates
- **Depth:** 1,500’ – 10,000’
- **Porosity:** 7 - 25+ % Porosity
- **Operating temperature:** Up to 190°F "wellbore temperature"
- **Operating pressure:** No bottom-hole pressure limitations
- **Salinity:** 1,000-100,000 ppm TDS

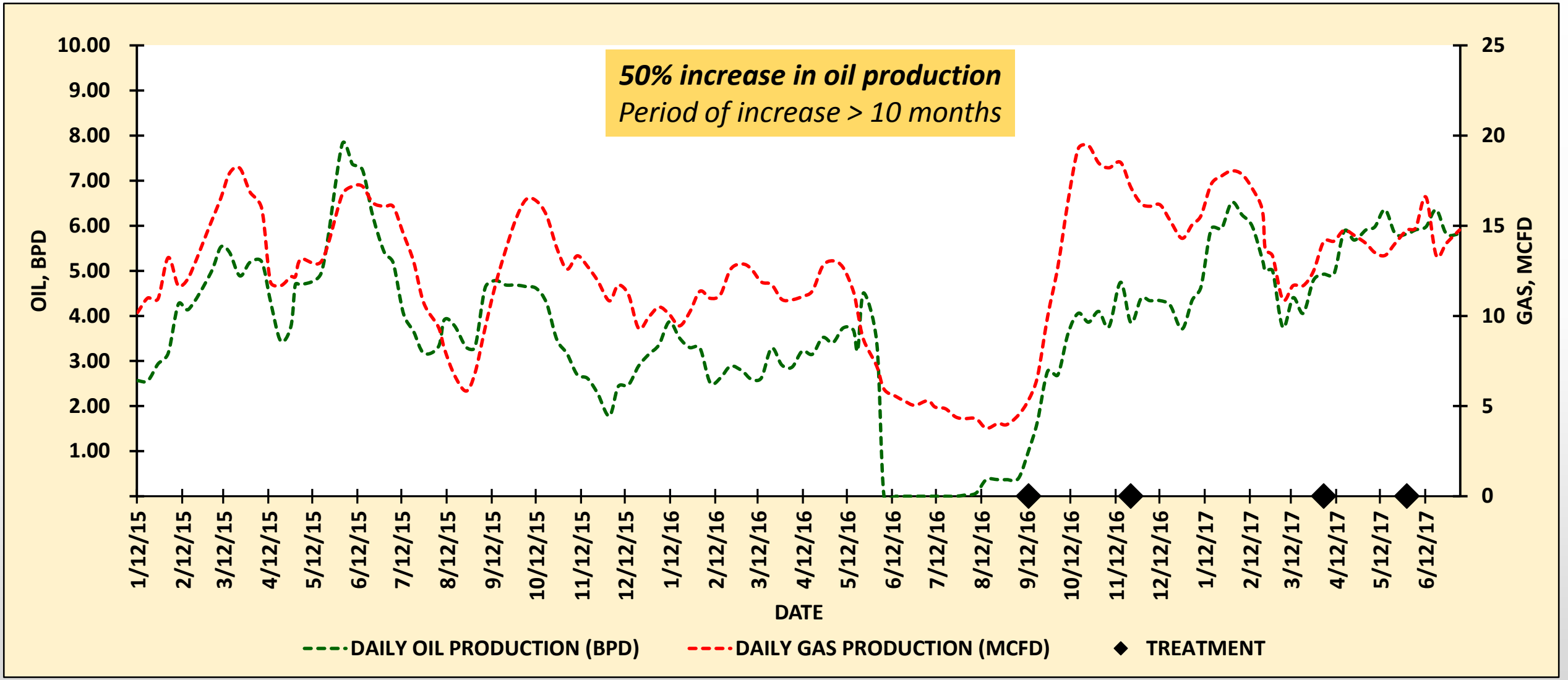
Paraffin Removal – Appalachian Vertical Well
Change in Production Decline

INCREMENTAL POST-TREATMENT OIL = 343 BARRELS
PERCENT INCREASE OVER FORECAST = 87%





Paraffin Removal – Appalachian Vertical Well
Daily Oil and Gas Production Curves



More case studies are available for reference

Paraffin Treatment: Increases Revenue

GREATER INCOME

	Microbial	Hot water	Hot oil	Solvent	Chemicals
Potential increase in oil and gas production income	☑	☒	☒	☒	☒
Potentially qualify for Enhanced Production tax breaks or credits	☑	☒	☒	☒	☒
Preserve deep rights by keeping marginal wells in production	☑	☒	☒	☒	☒

Sludge Dispersal in Storage and Transportation

Rapidly disperse paraffinic sludge and scale without need for mechanical cleaning solutions or toxic solvents

Process

- Inject microbial-based cleaner which can be produced on-site
- Inject air into tank
- Sludge is rapidly softened
- Treatment is complete within a few hours to 1-3 days depending upon size of tank

Advantages

- **No heat, toxic cleaning chemicals, or dangerous manual cleaning required**
- Trapped oil can be recovered
- With almost no remaining hydrocarbon, insurance liabilities will be lower for storage unit or ship/train/truck storage tank owner

Status

- Efficacy was observed as a side effect of well paraffin treatment where microbial product flowing into storage tanks from wellbores rapidly de-sludged the tank bottoms and made the hydrocarbons economically recoverable
- Pilot with major oil trading company cleaning ocean-going barges and storage tanks

Source: NACE, University of Ohio, Oil & Gas Pipeline journal

Summary – Microbial-Based Paraffin Dispersal

- Paraffin deposition is a major issue in the oil industry.
- A new microbial-based dispersal product provides an environmentally-friendly, cost-effective option for both well treatment and tank cleaning.
- Product exhibits low toxicity and functions well without external heating.
- Dispersal effectiveness results from high product potency leading to reduced interfacial tension and crude oil viscosity.
- Enhanced production can be used to offset treatment costs.

Microbial Treatment For Production Enhancement

Mechanism

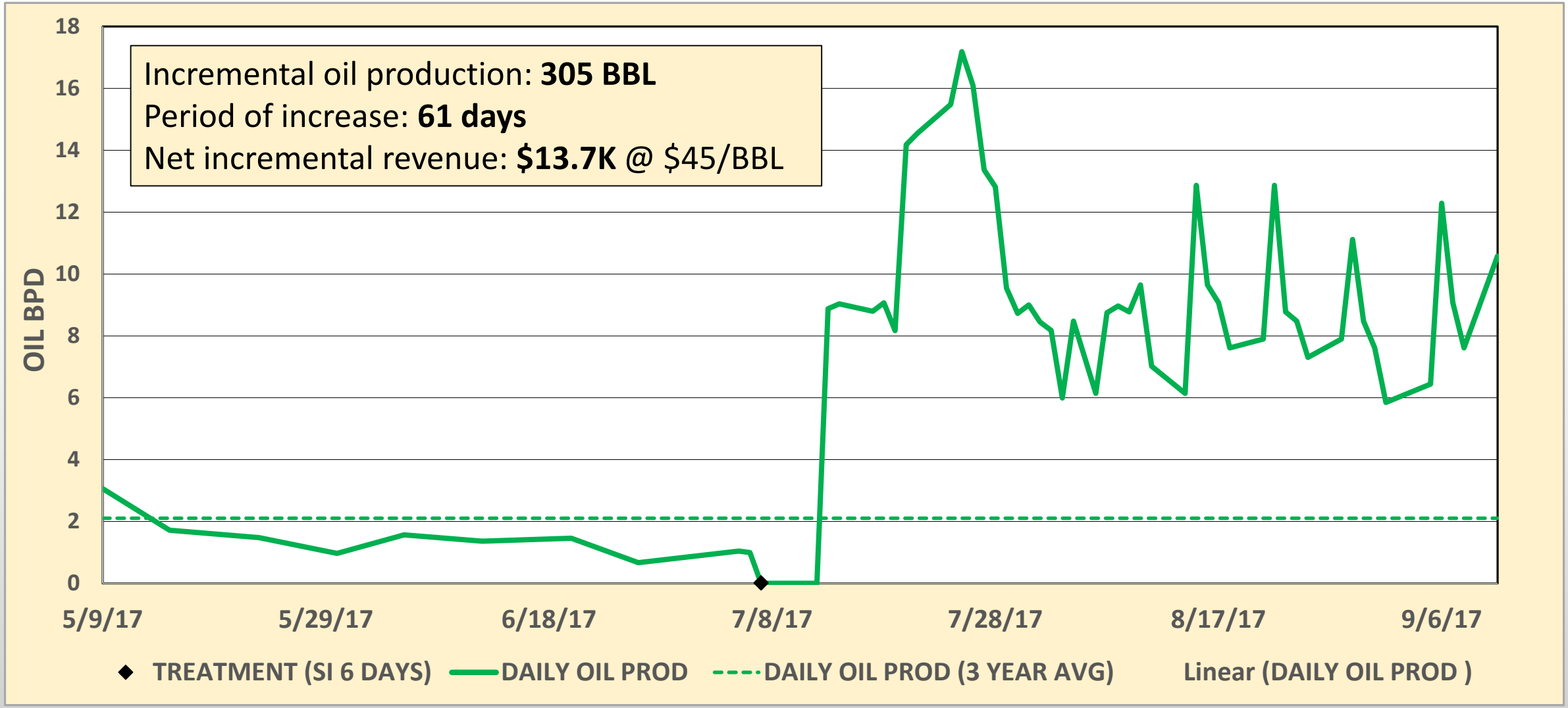
- Decrease interfacial tension, surface tension and viscosity
- Wettability alteration to displace oil out
- Selective plugging to recover excess oil that was otherwise unrecoverable
- Significant decrease in the water cut has also been observed in every pilot
- Wax and scale removal from formation

Advantages

- **Decrease in water cut increases the "green" quotient of the product and reduces disposal costs**
- **HSE friendly**
- Qualify for Texas (and potentially Federal) ER tax credits, which adds to upside
- Increases "recoverable reserves" and thus collateral for loans

Production Enhancement Example: 400% increase

Vertical Well, Speechley Sand, PA



Additional Applications – All HSE Friendly

Application	Description	Applicable markets
Viscosity reduction	Reduces viscosity to decrease the extraction and transportation costs of crude and processed oils	• E&P operators, • Midstream (pipelines)
Asphaltene dispersal	Disperses precipitated asphaltenes and resins to help restore formations, or reduce maintenance and parts replacement costs	• E&P (including offshore) • Midstream (pipelines, tankers, tanks, rail, trucks) • Downstream (refineries)
Remediating bio-polymers	Dissolves PLA frac balls, bio-polymers and dissolvable packers much more quickly - in hours rather than days and at a wide range of temperatures	• E&P (completions)
H_2S & Corrosion Control	Suppresses sulfate reducing bacteria (SRB) that produce H_2S and cause corrosion. Sequester existing H_2S and mercaptans	• E&P

Thank you for your attention!

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