



PRODUCED WATER SOCIETY
SEMINAR 2018

Flowback and Produced Water Treatment for Recycle and Discharge to the Environment

Lisa Henthorne, P.E.



Outline

- Project Background
- Pilot Approach and Treatment Options
- Early Pilot Results
- Conclusions

Project Background



Pilot required to permit fixed facility due to state regulatory requirements and stringent discharge water quality coupled with complex feed water quality:

- Treat produced and flowback water to discharge standards for the nearby river
- Treated water to be re-used in their operations
- Validate Monarch Separators proposed technologies' ability to consistently meet discharge requirements
- De-risk and confirm inlet water quality for full-scale fixed facility
- De-risk cost of facility: CAPEX and OPEX

Project Goals and Challenges



WS contracted to design and provide the pilot system capable of treating approximately 1,500 BWPD to treat for oil and dissolved organics removal, iron and metals removal, radionuclides and ammonia removal, and salinity reduction.

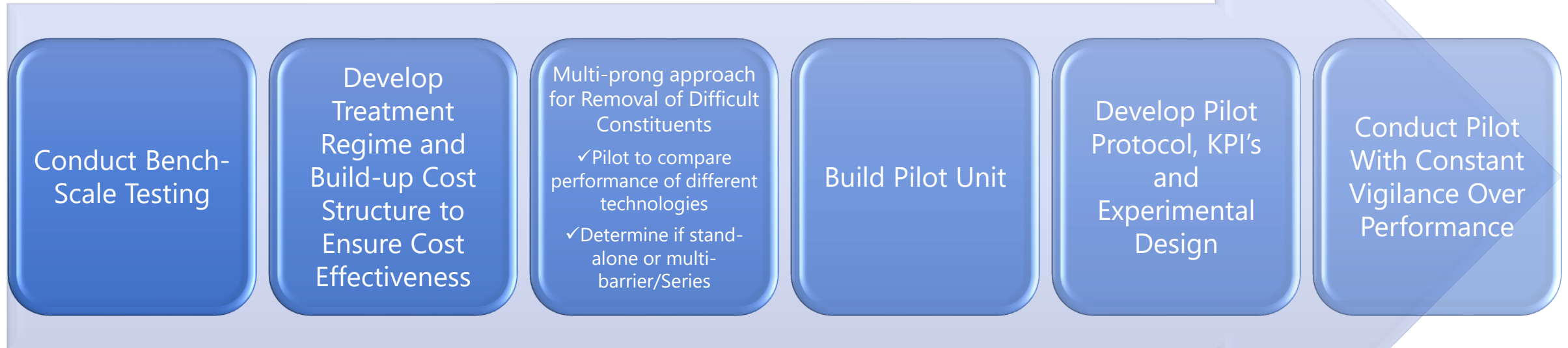
Project and pilot tests challenged by:

- Urban corridor setting
- Stringent regulatory requirements – Whole Effluent Toxicity (WET) tests
- Rigorous HSE requirements
- Piloting during winter conditions
- Greatly varying incoming water quality (fed from small tanks receiving daily truck deliveries)
- Need for cost-effective treatment scheme to provide high quality water

Pilot Approach



How To Develop the Most Cost-effective, Reliable Treatment System



Be Willing to Adapt (Quickly)!

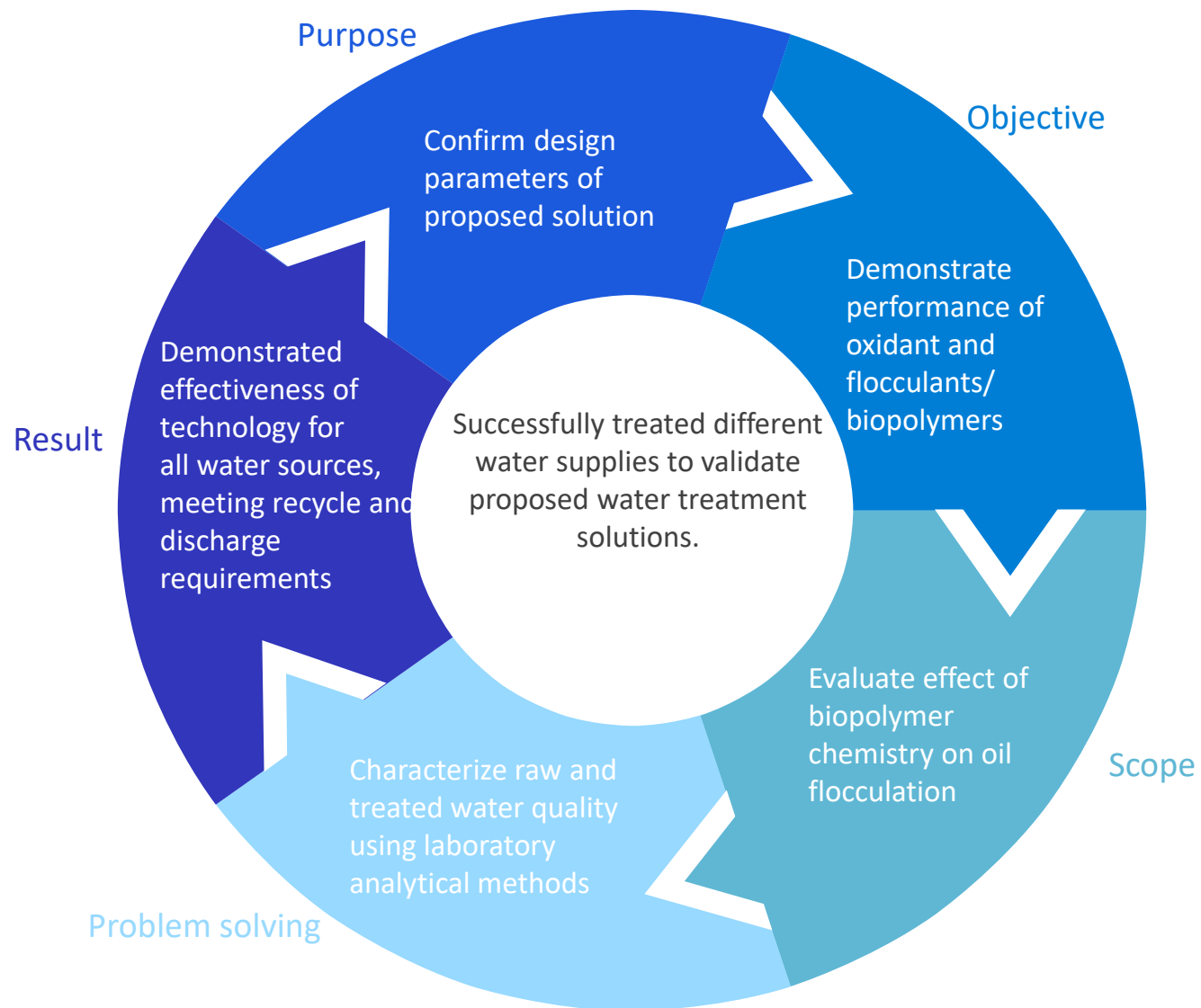
Targeted Treatment Scheme



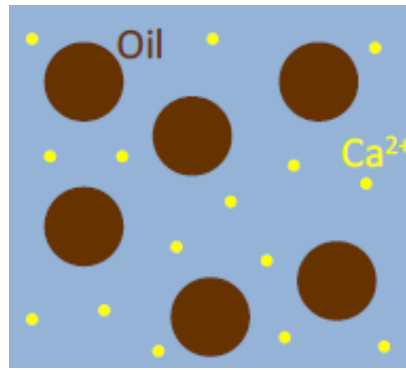
Measuring Performance Versus Cost for Different Treatment Options

Constituent	Technology Options Piloted
Free oil	Flocculant, Dissolved Air Flotation (DAF), Nutshell Filter (NSF)
Iron and metals	Oxidant, Flocculant, DAF, NSF
TSS	Oxidant, Flocculant, DAF, NSF
BTEX	NSF, Granulated Activated Carbon (GAC), Advanced Oxidation Process (AOP), MBR, RO
Bacteria	Oxidant
Ammonia	MBR, RO, AOP
Radionuclides	Flocculant, DAF, RO
Inorganic salts	RO

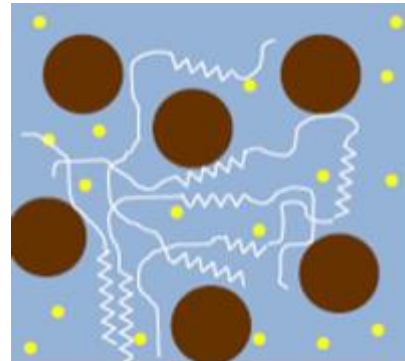
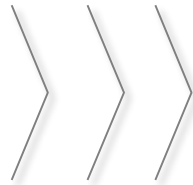
Begin at the Bench



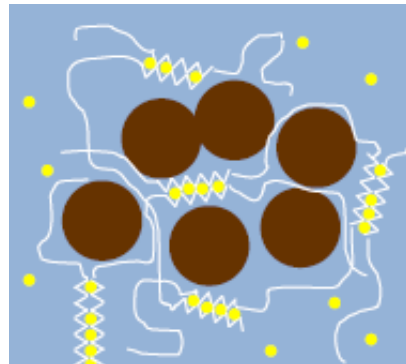
Alginate Flocculation – How it Works



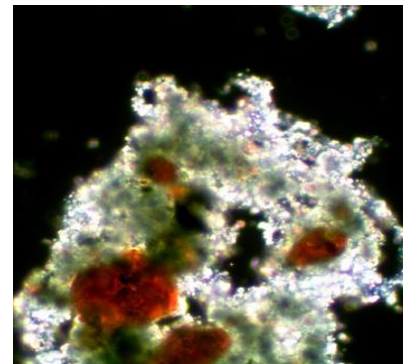
Oil droplets or particles in water



Alginate surrounds any oil droplet or particle



Multi-valent ions cross link Alginate to form large robust flocs



Microscopy: oil droplet captured by Alginate

Biodegradable Oil Separation

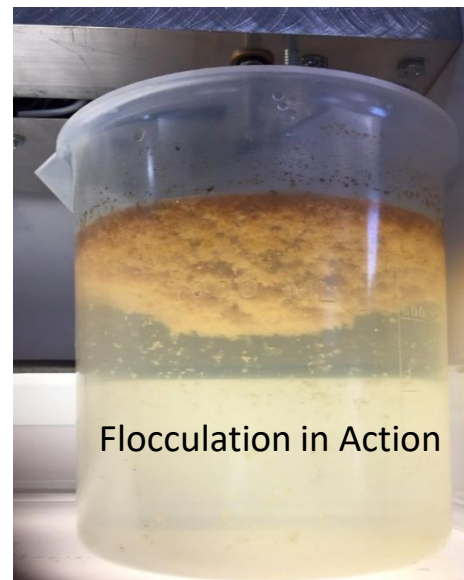
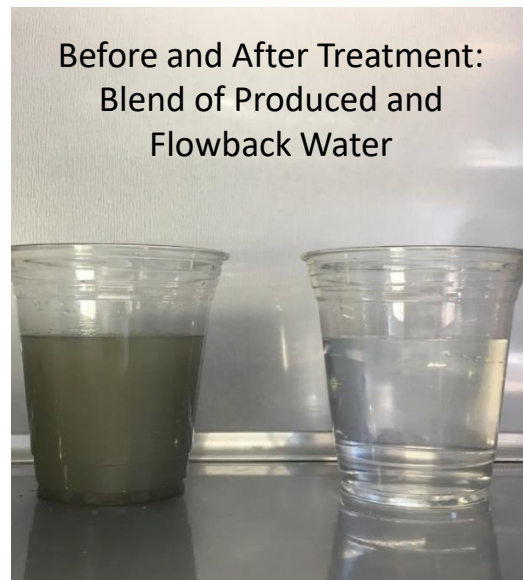
Environmentally-friendly flocculant derived from seaweed, attaches to even the smallest particles or oil droplets in water.

- Alginate draws organic material and particulates together and enables efficient separation from water
- Flocculation occurs via cross-linking rather than charge balance
- Robust floc grows rapidly even in the presence of strong shear forces

Pilot Treatment Results



- Treating 300-650 NTU turbidity to less than 1 NTU
- Treating iron from 35 mg/L to less than 1 mg/L
- Alginate flocculent dosing of 5-7 mg/L for produced water
- Treating Oil in Water to less than 1 mg/L in DAF
- Sorbfloc® plus Sorbstart® cost (dosing of 5 mg/L) less than \$.02/bbl treated water
- Oxidant dosing of 10-25 mg/L, high dosing levels during upset conditions (cross-linked polymer slugs)
- 100% BTEX and TOC removal upstream of RO, 99+% salt removal in RO, 100% ammonia removal in RO
- Pass WET tests!!!



Conclusions



Cutting Costs with Conventional Treatment Combined with Novel Technologies

- The growing volumes of produced water and flowback, combined with restricted SWD usage, are driving operators to more creative disposal options
- Cost-effective treatment schemes are available which provide improved recycle water quality, and that can serve as the backbone for more rigorous treatment, if needed. For cost-effective discharge, target flowback/produced water under 50,000 mg/L salinity
- Keep it simple for recycle treatment but ensure ability to address large swings in flowback/produced water quality
- Minimize operator intervention to keep costs low, i.e. automation where practical
- For discharge option, water quality is not just what you can easily measure/monitor. Think like a fathead minnow and a daphnia.
- Last, but not least, a pilot of this level of optionality requires a multi-disciplined, experienced (and relentless) team!



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Lisa Henthorne, P.E.
lhenthorne@waterstandard.com

Valentina Llano
vllano@waterstandard.com

Corporate Office
4265 San Felipe | Suite 620
Houston, TX 77027
+1.713.400.4777

PRODUCEDWATEREVENTS.COM