Ceramic Membrane Ultrafiltration Enables Cost Effective Produced Water Reuse

Siemens Water Solutions
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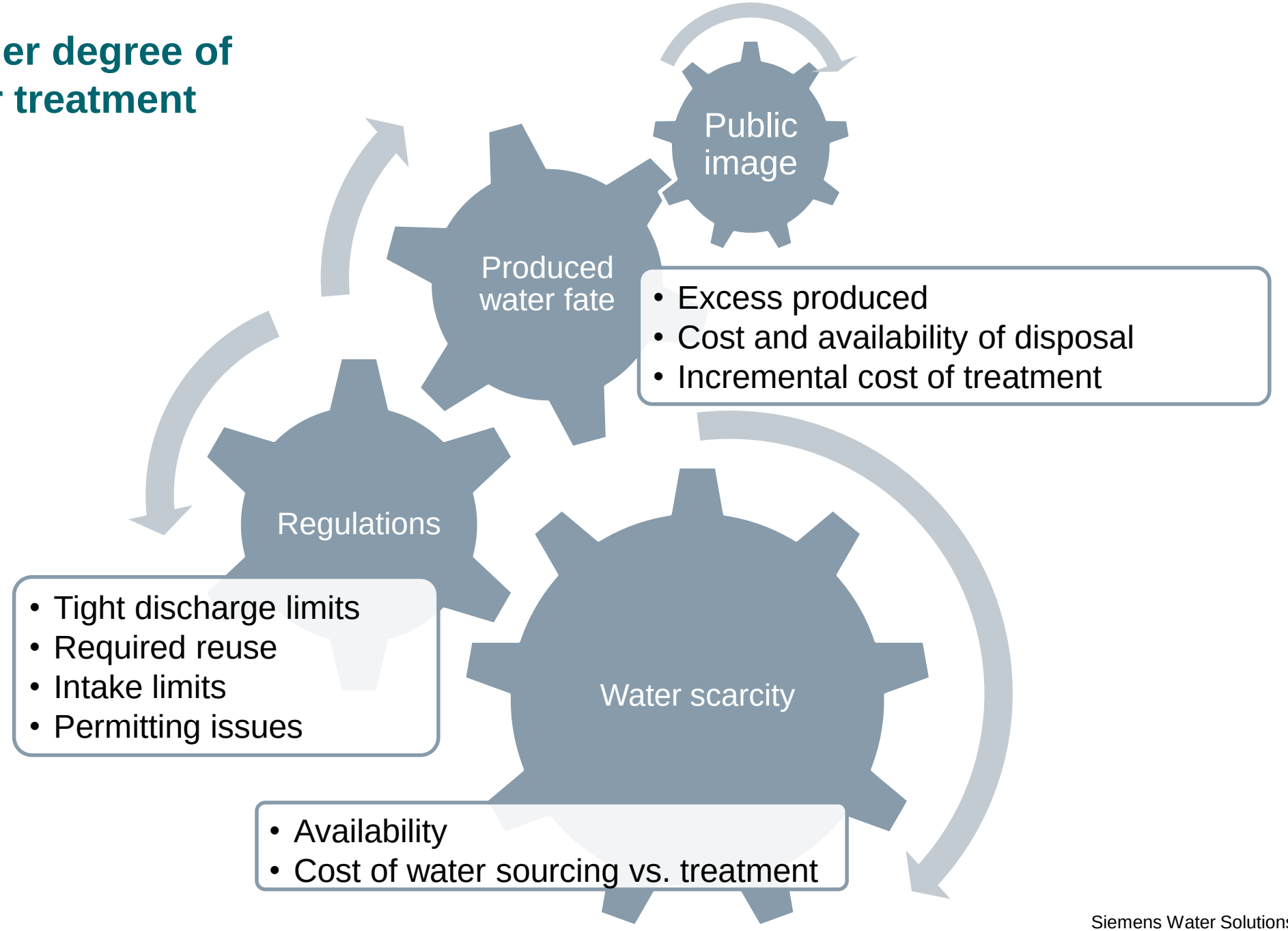
Topics Addressed in this Presentation

- Drivers for ultrafiltration of produced water
- Challenges for membranes for produced water
- Cost comparison
- Test data

Drivers for higher degree of produced water treatment



Why Use Ultrafiltration Membranes

Low TSS / O&G requirements

- Surface discharge
- Reuse
- IX or RO feedwater
- Re-injection

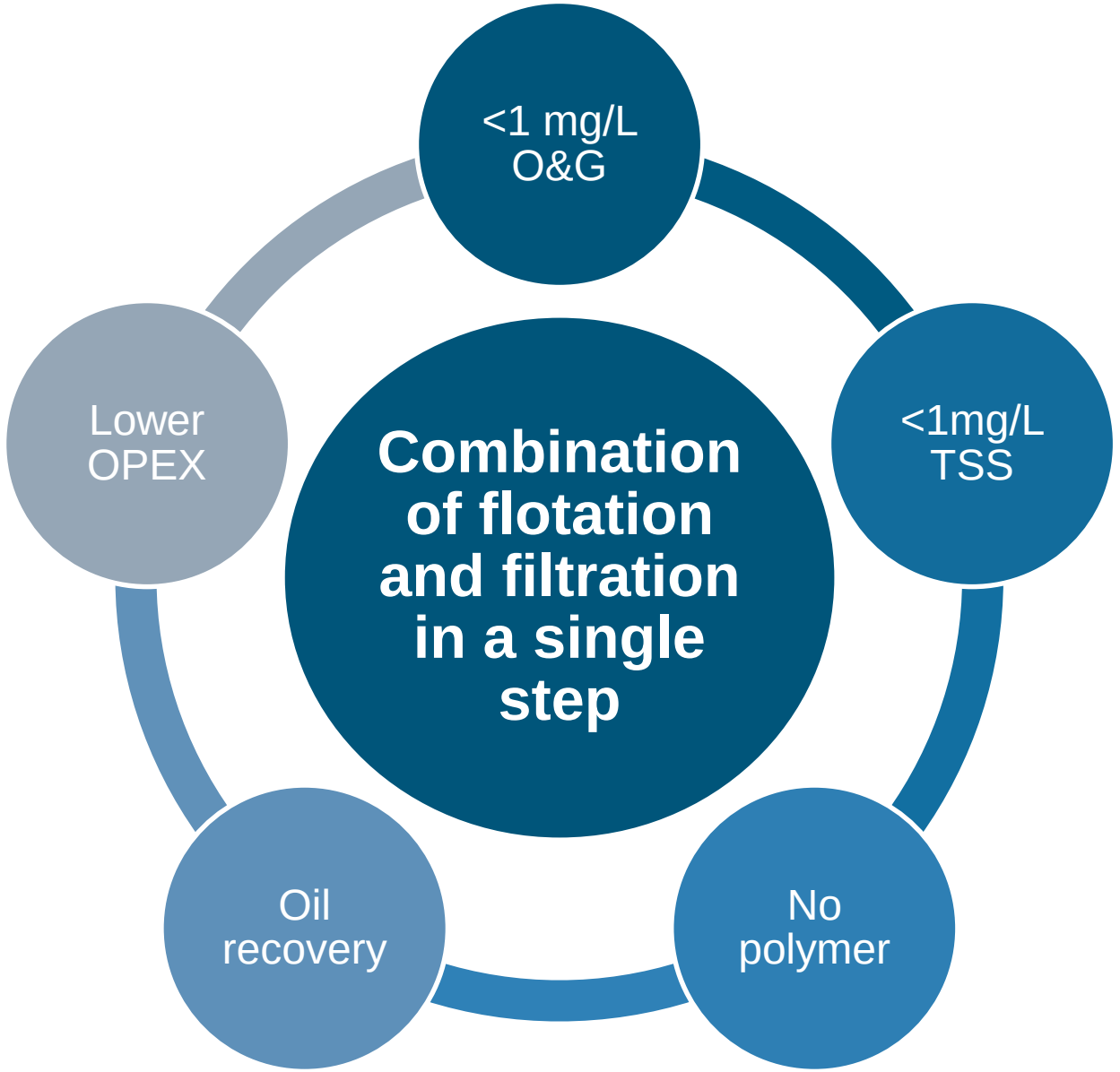
High temperature operation

- Heavy oil
- EOR
- SAGD
- Feed to evaporator / boiler

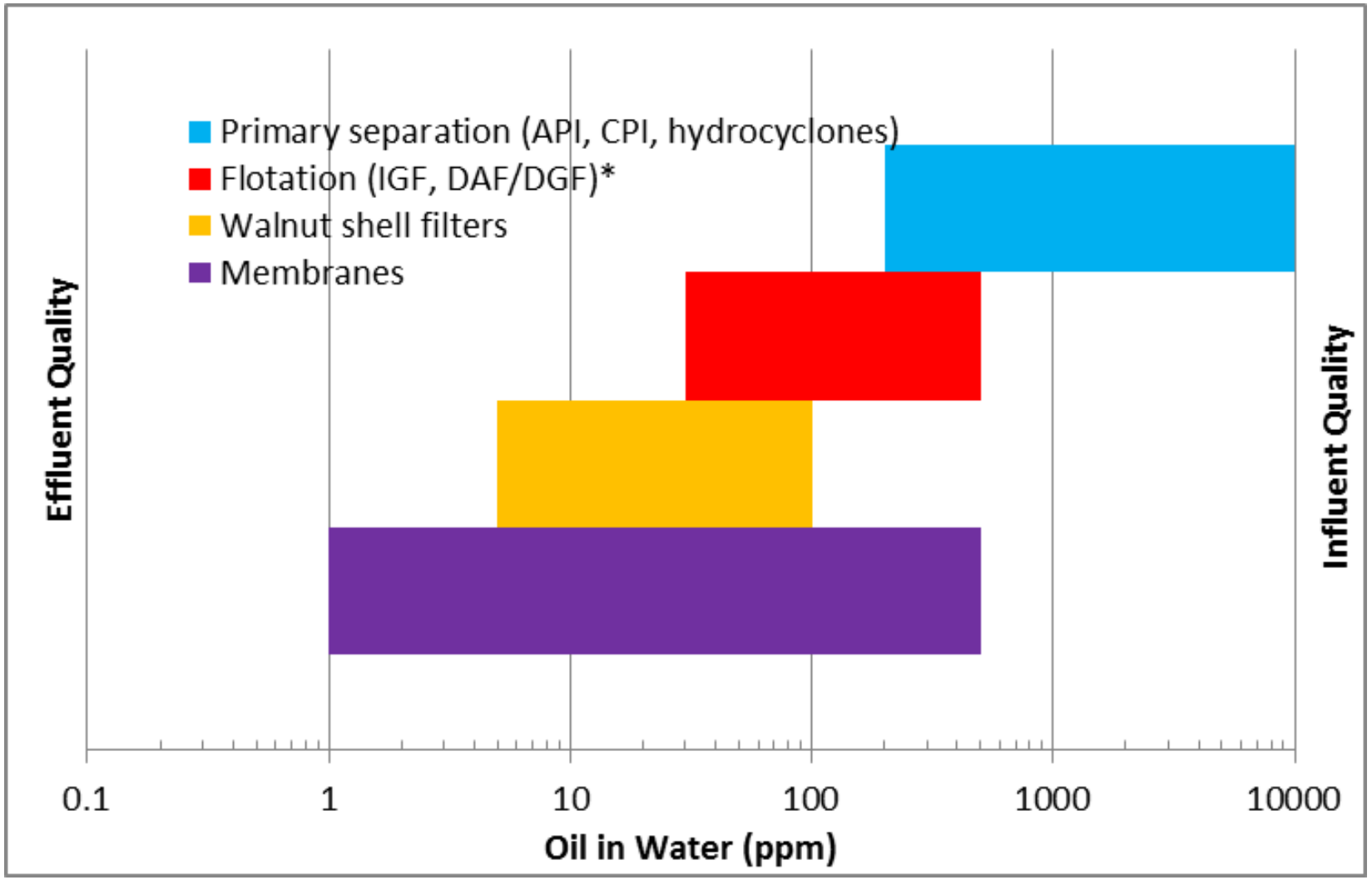
Pretreatment for reuse

- Boiler feed water
- Cooling tower make-up
- Process water
- Irrigation
- Surface discharge

Why Use Ultrafiltration Membranes



Ultrafiltration Membrane Treatment Fit



*requires chemicals

** <1 mg/L non-detectable

Reuse - How to Meet Requirements?

Produced Water after Primary Separation

- TDS >1000 mg/L
- TSS 50-200 mg/L
- O&G >50 mg/L

Reinjection

- 95% removal of suspended solids > 2 microns or depending on reservoir for injection

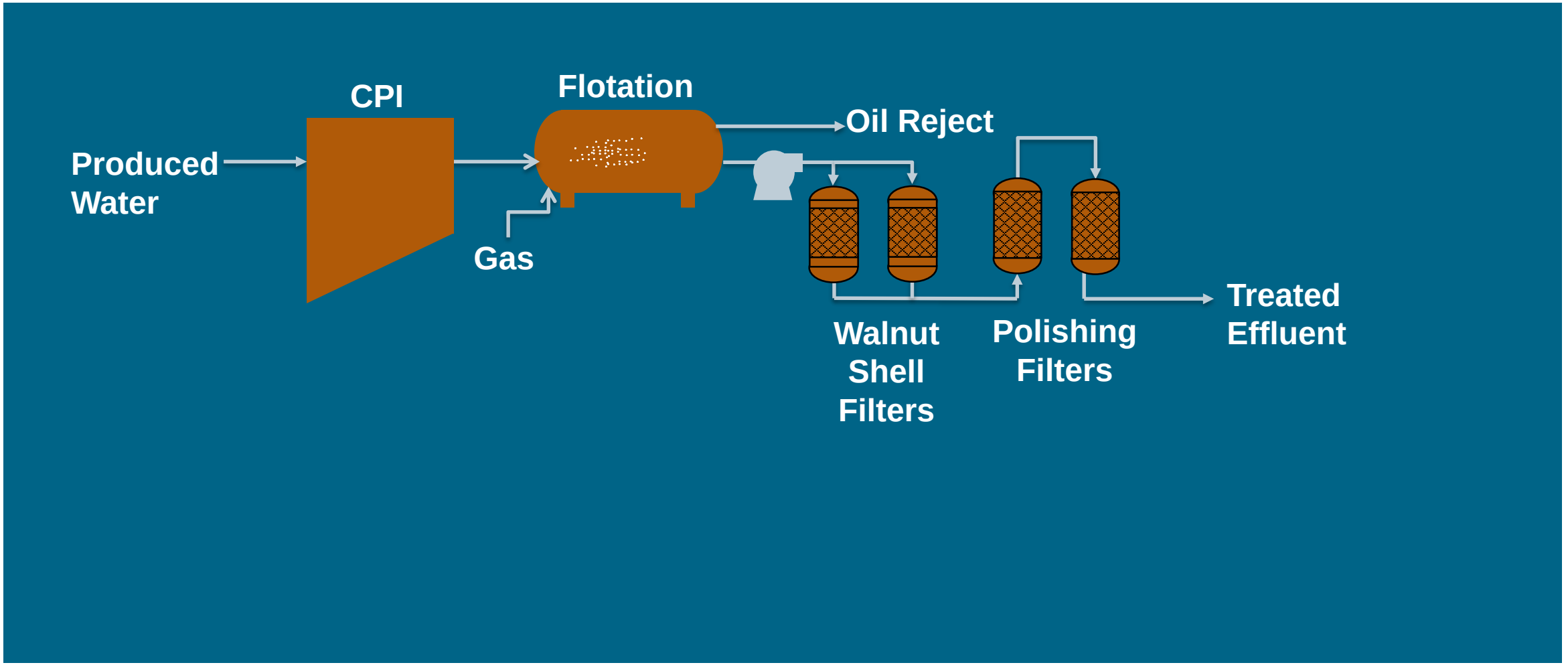
RO Feedwater

- COD < 10 mg/L
- TOC < 3 mg/L
- O&G < 0.1 mg/L
- SDI < 5 – lower the better
- Turbidity < 1 NTU with < 0.5 NTU recommended for long-term, reliable operation

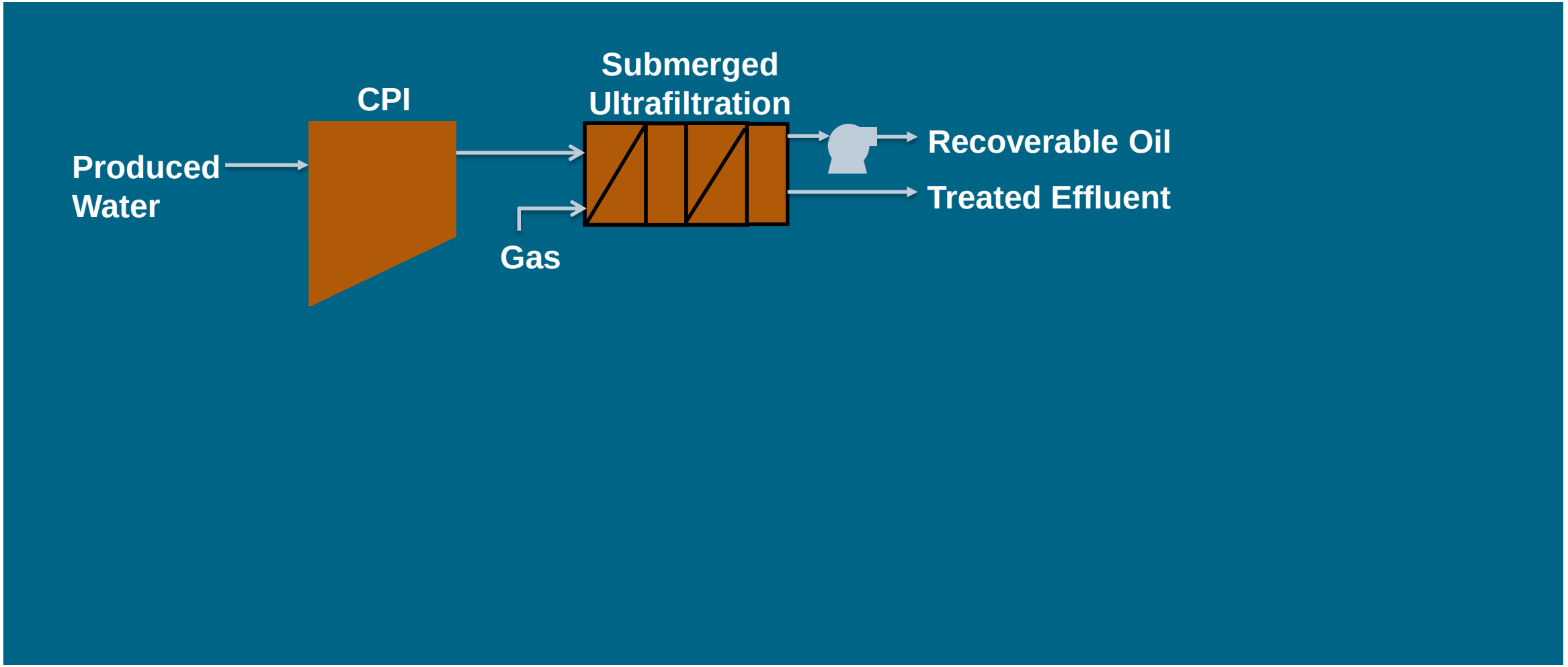
Irrigation

- TDS limit, typically requires RO
- Sometimes a BOD limit as well

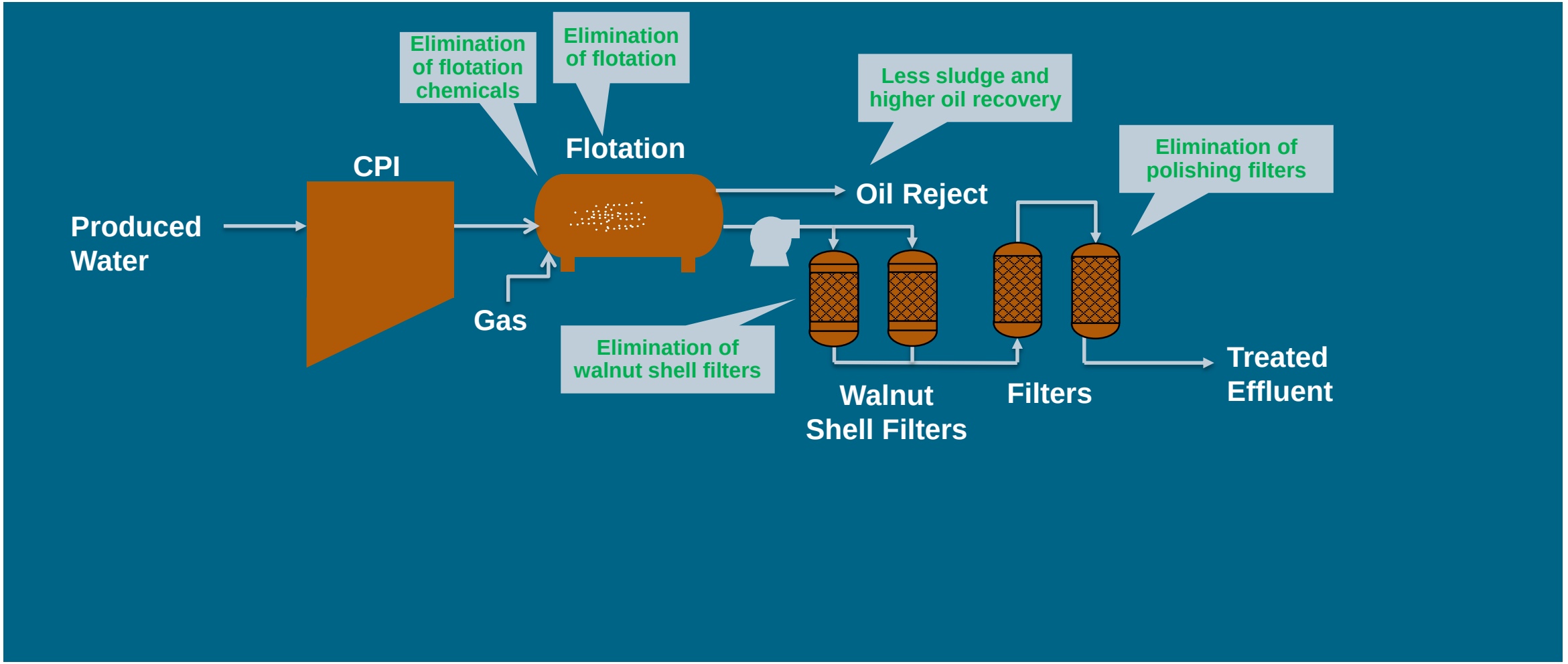
Conventional Approach to Meeting Strict Effluent Requirement



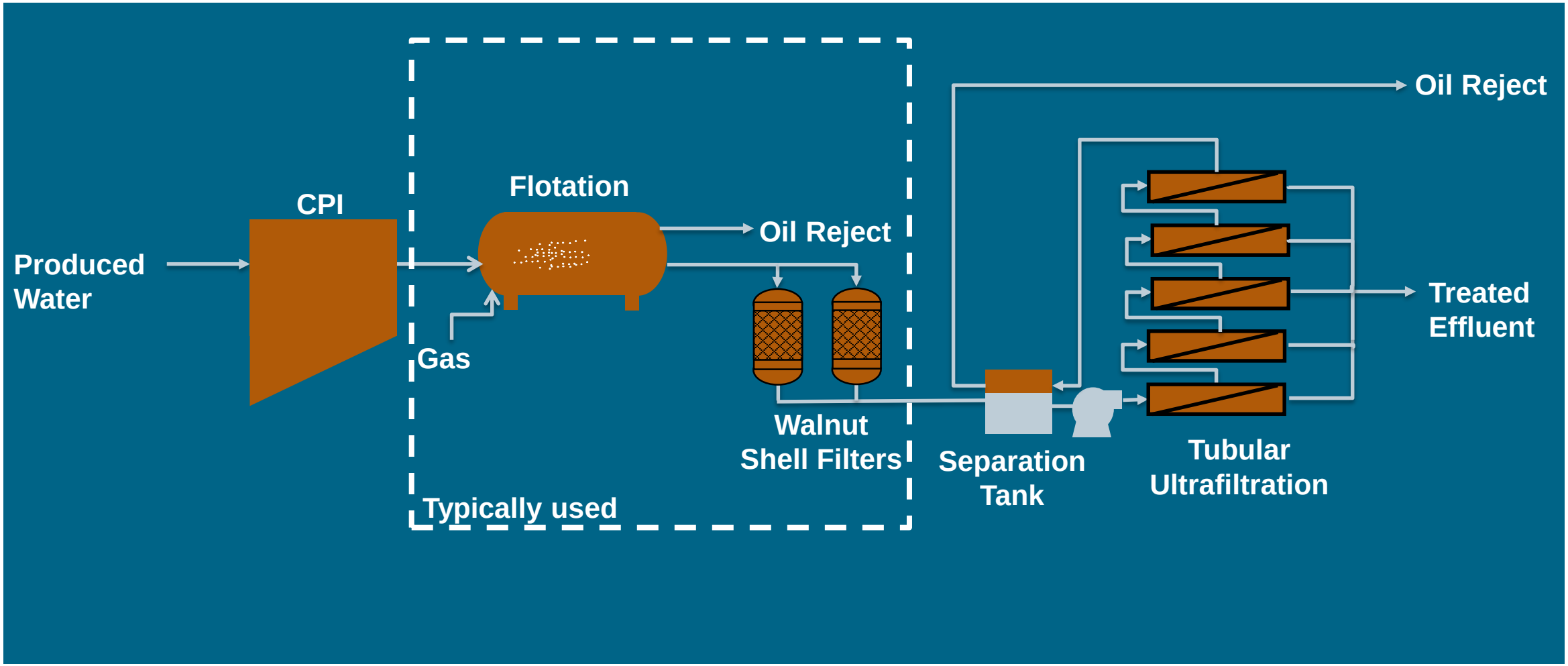
Submerged Ultrafiltration Process



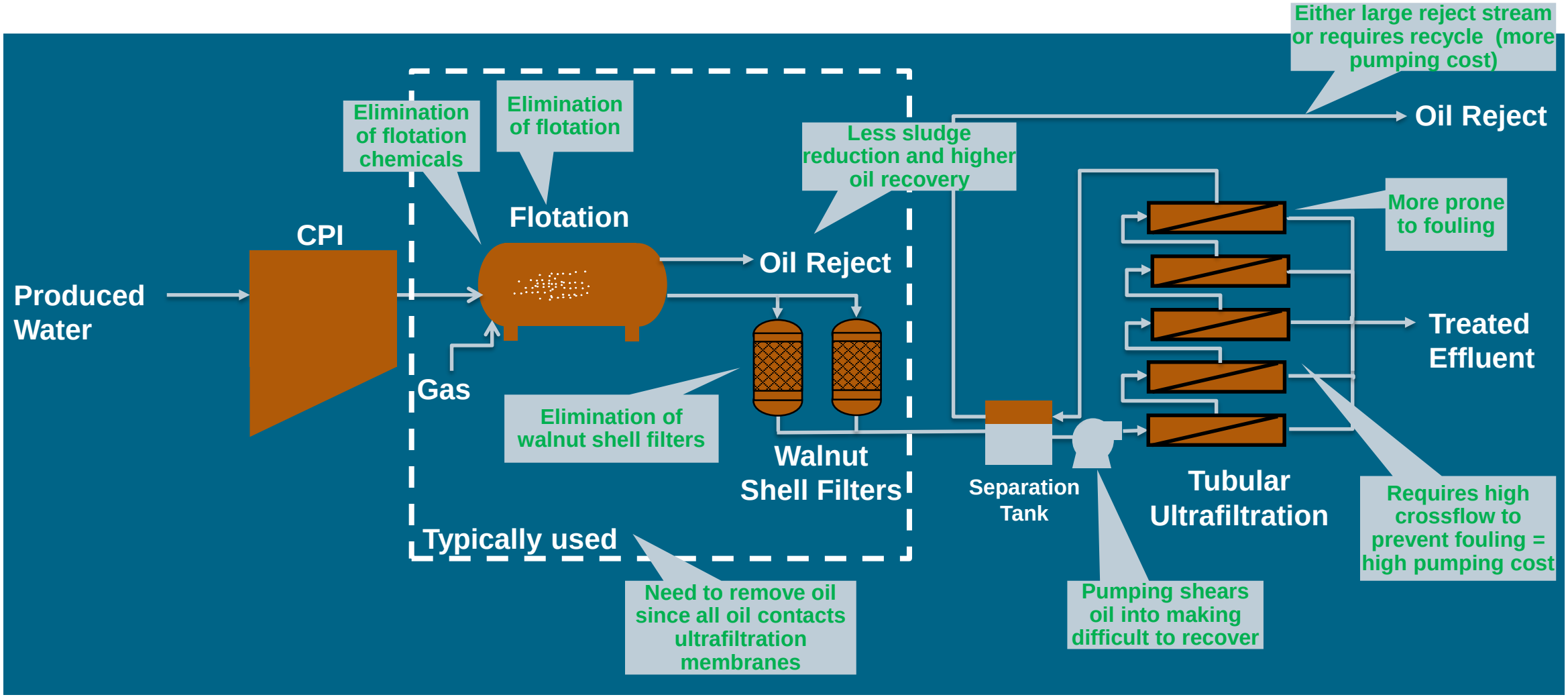
Cost Savings of Ultrafiltration for Produced Water Treatment



Tubular Ultrafiltration Process



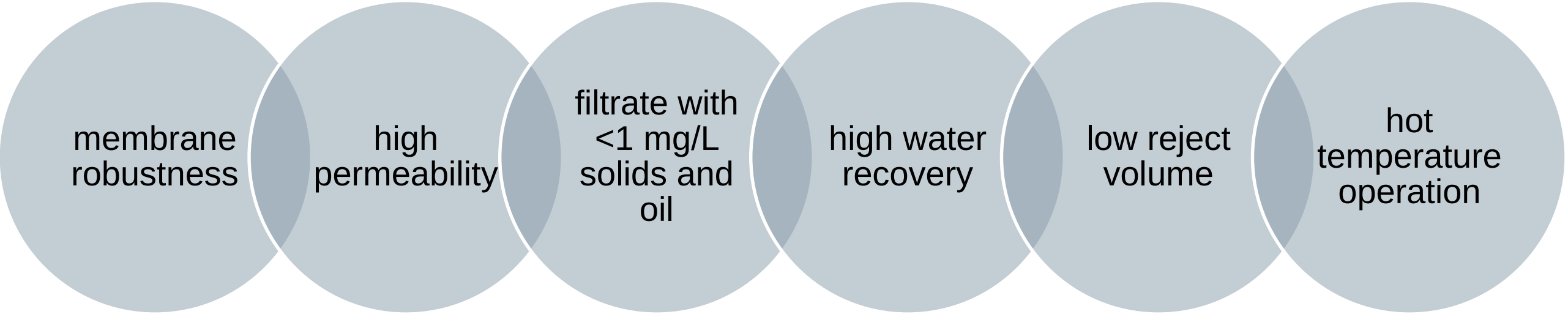
Cost Savings of Submerged Ultrafiltration Over Tubular Ultrafiltration



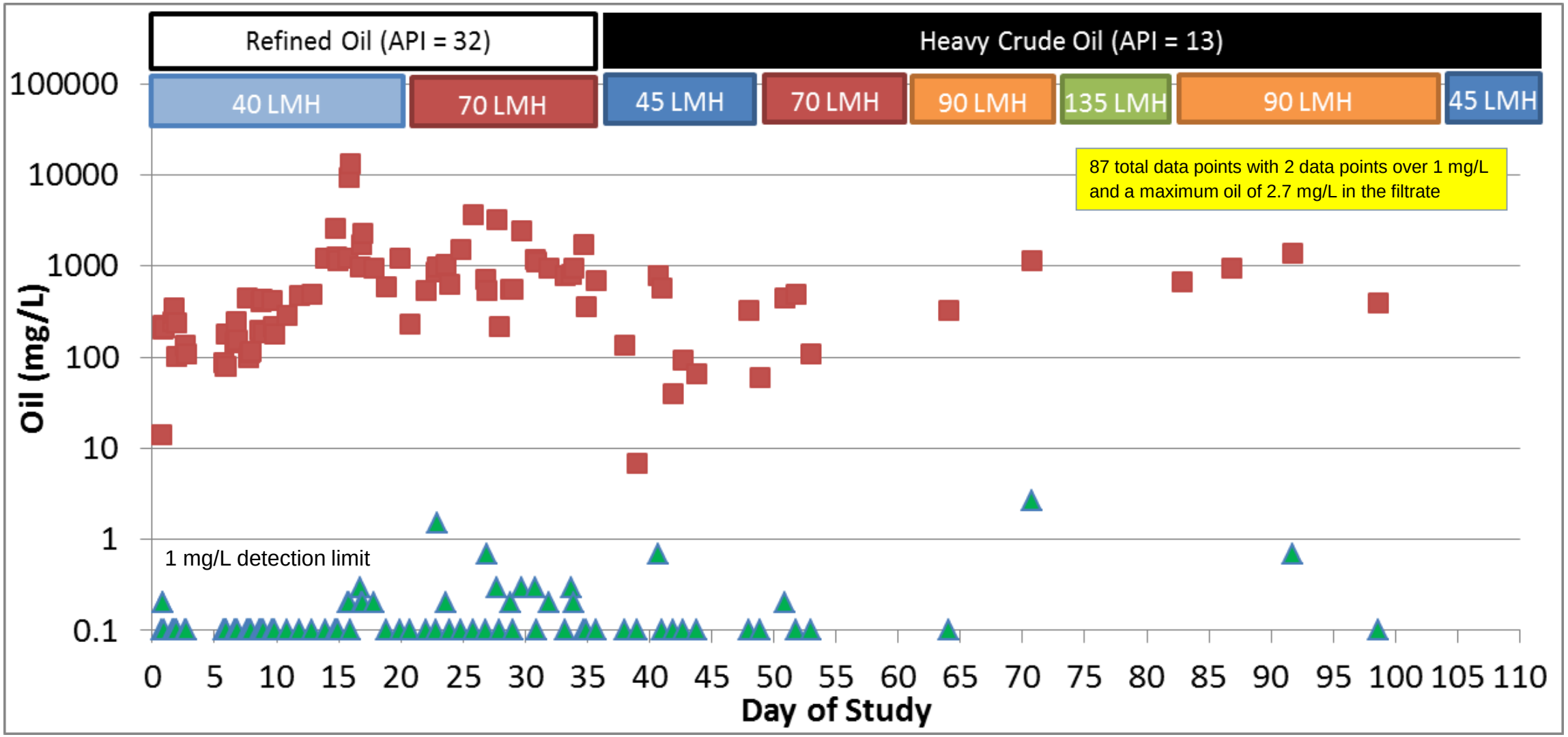
Cost Savings of Submerged Ultrafiltration Over Tubular Ultrafiltration

Pumping comparison between submerged and tubular system (100,000 BPD basis)	**Power Consumption**	**Annual Cost (at $0.10/kWh)**
Tubular system Feed pump: 1,300 m³/h (50% recovery per pass), 7 bar, 600 HP	9,390 kWh/day	$343,000
Submerged system Filtrate pump: 2 x 360 m³/h, 1 bar, 2 x 25 HP	740 kWh/day	$27,000
Savings of submerged vs. tubular system	8,650 kWh/day	$316,000
Total savings with submerged membrane system vs. tubular	**>90%**	**>90%**

Study Objectives



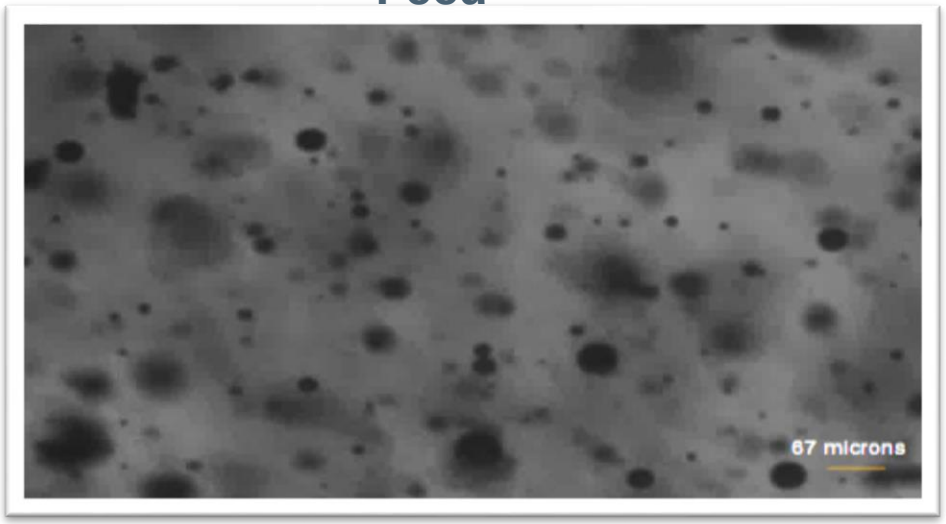
Ceramic Membrane Performance Study #1—Oil Removals



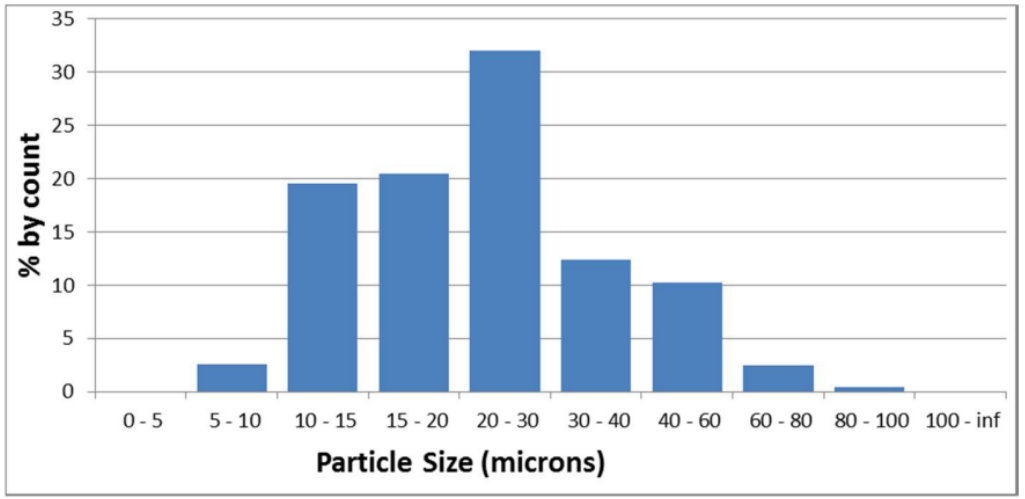
Ceramic Membrane Performance Study #2—Particle Size Distribution

Still image during in-line Canty particle size analysis

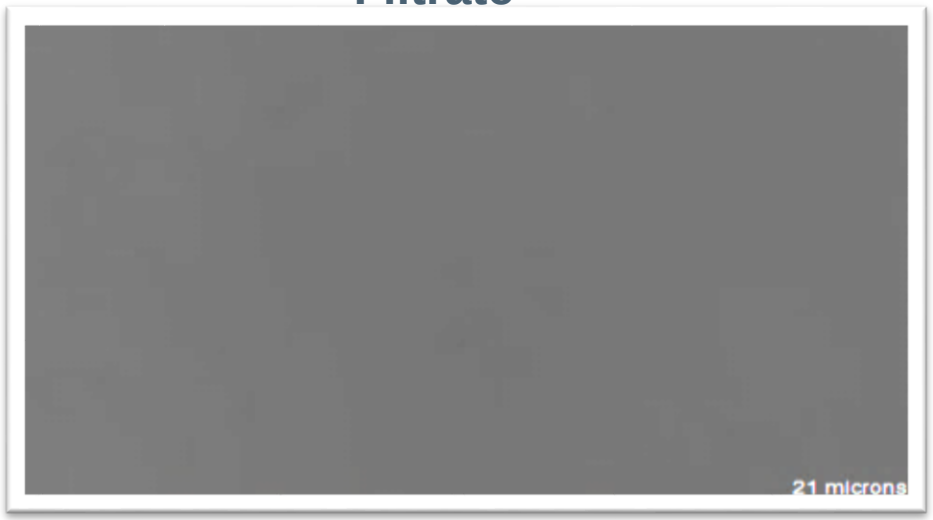
Feed



Feed



Filtrate



Filtrate

No particles in filtrate to analyze

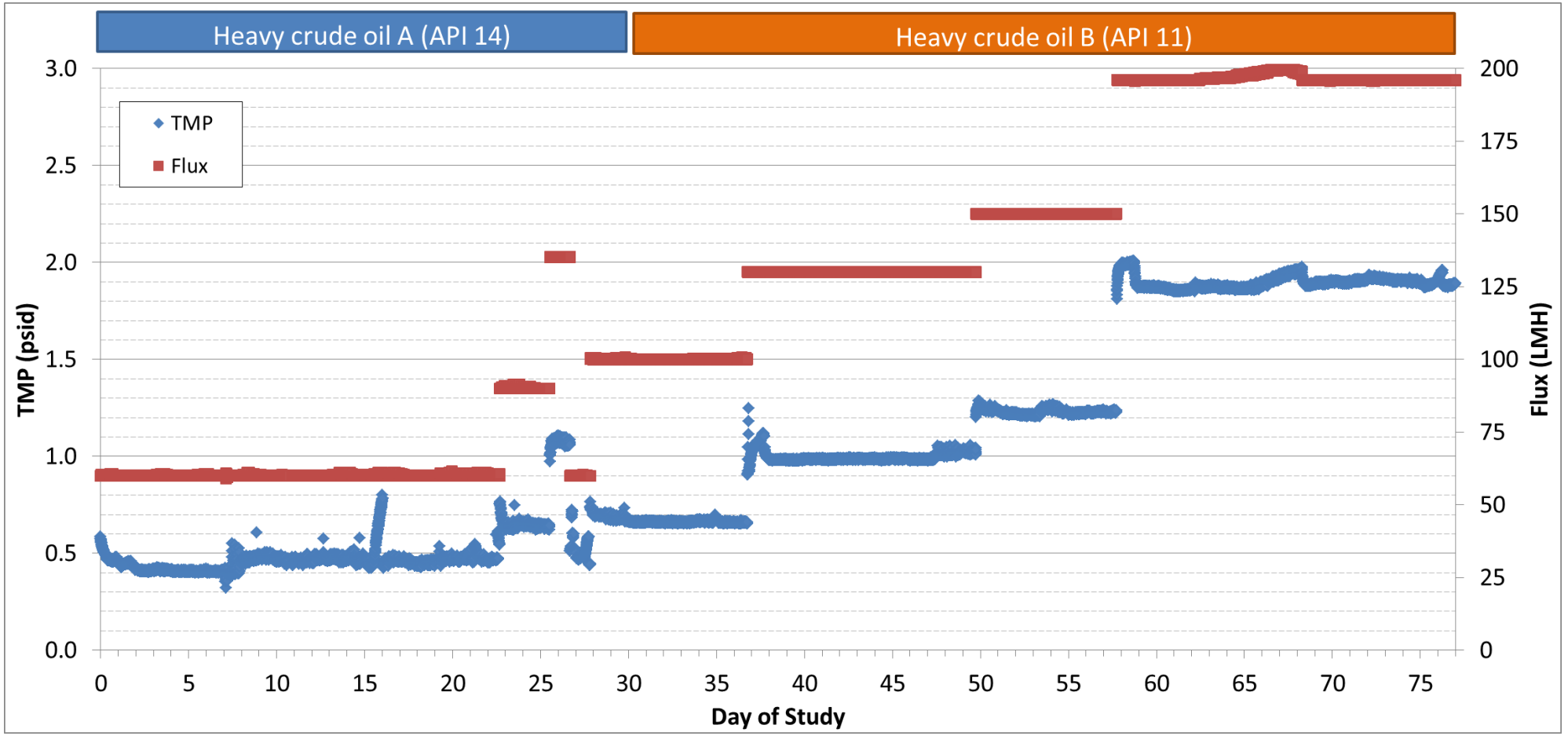
Ceramic Membrane Performance Study #2—TMP

Two different heavy crude oils

No fouling with heavy crude oil

No chemical cleanings

Up to 196 LMH flux



Ceramic Membrane Performance Study #2 – Detailed Analysis

SDI

- Avg <3

TSS

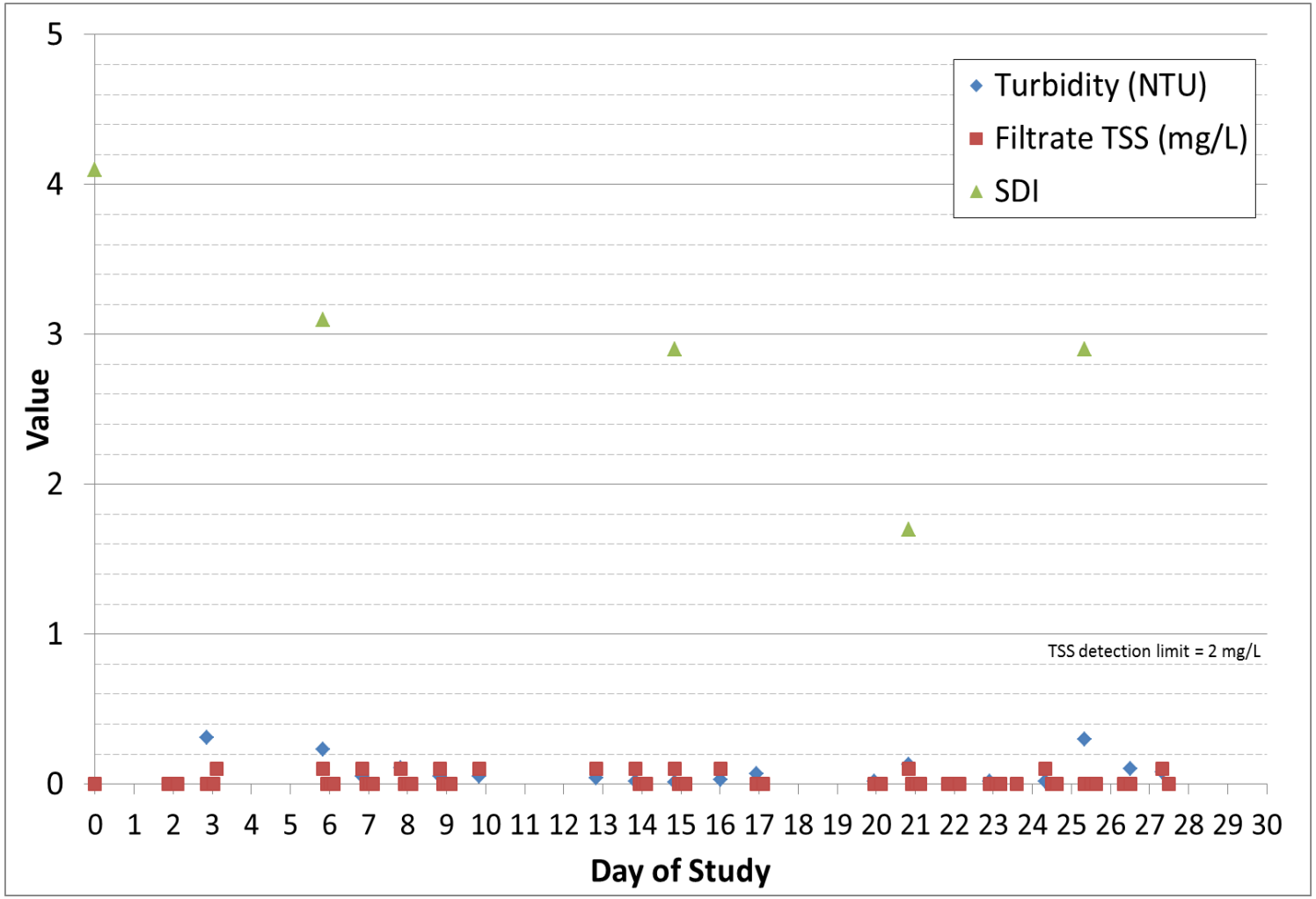
- All < 2 mg/L (detection limit)

O&G

- Avg < 1 mg/L (detection limit)

Turbidity

- Avg <0.1 NTU
- Max 0.3 NTU



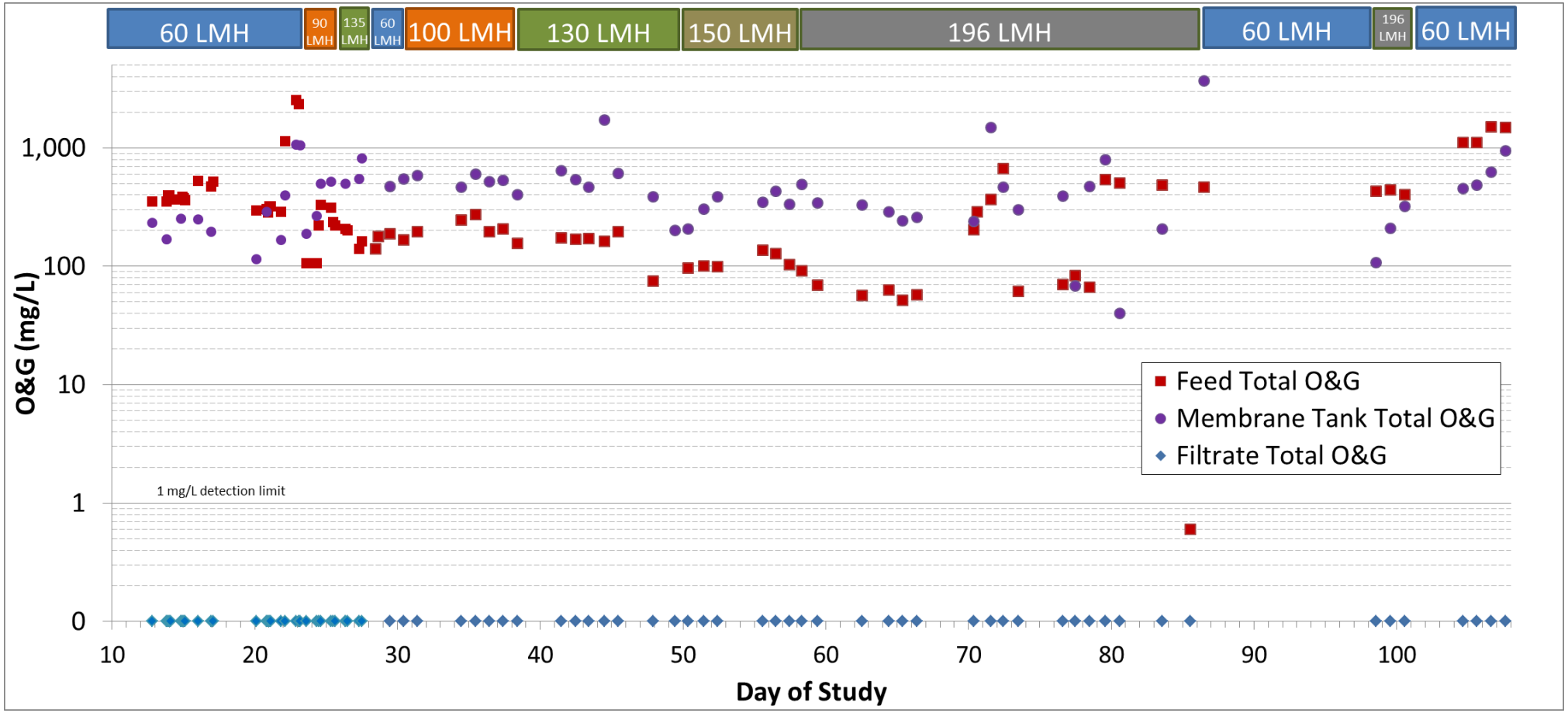
Ceramic Membrane Performance Study #2—Oil Removals

Heavy crude oil (as noted previously)

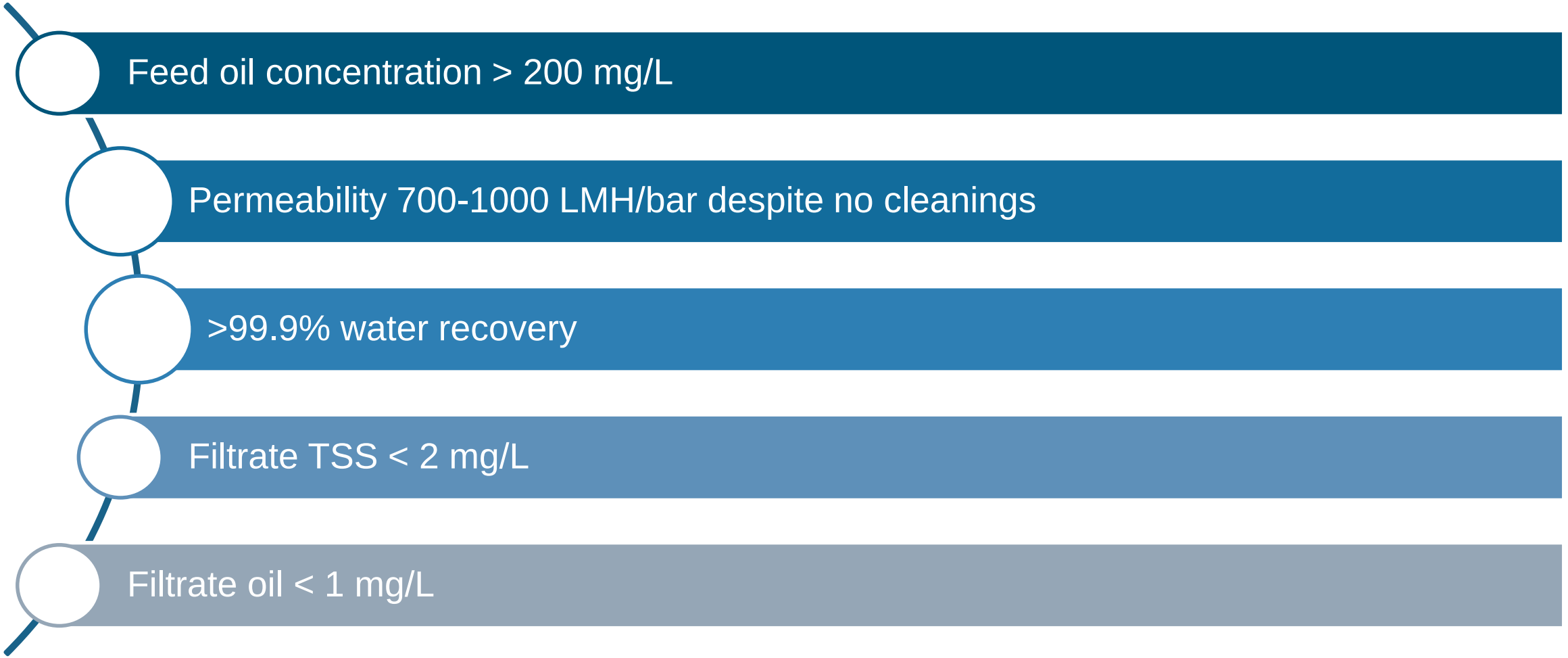
Feed oil variation to simulate after primary separation

99.9% water recovery – scooped oil off top of tank

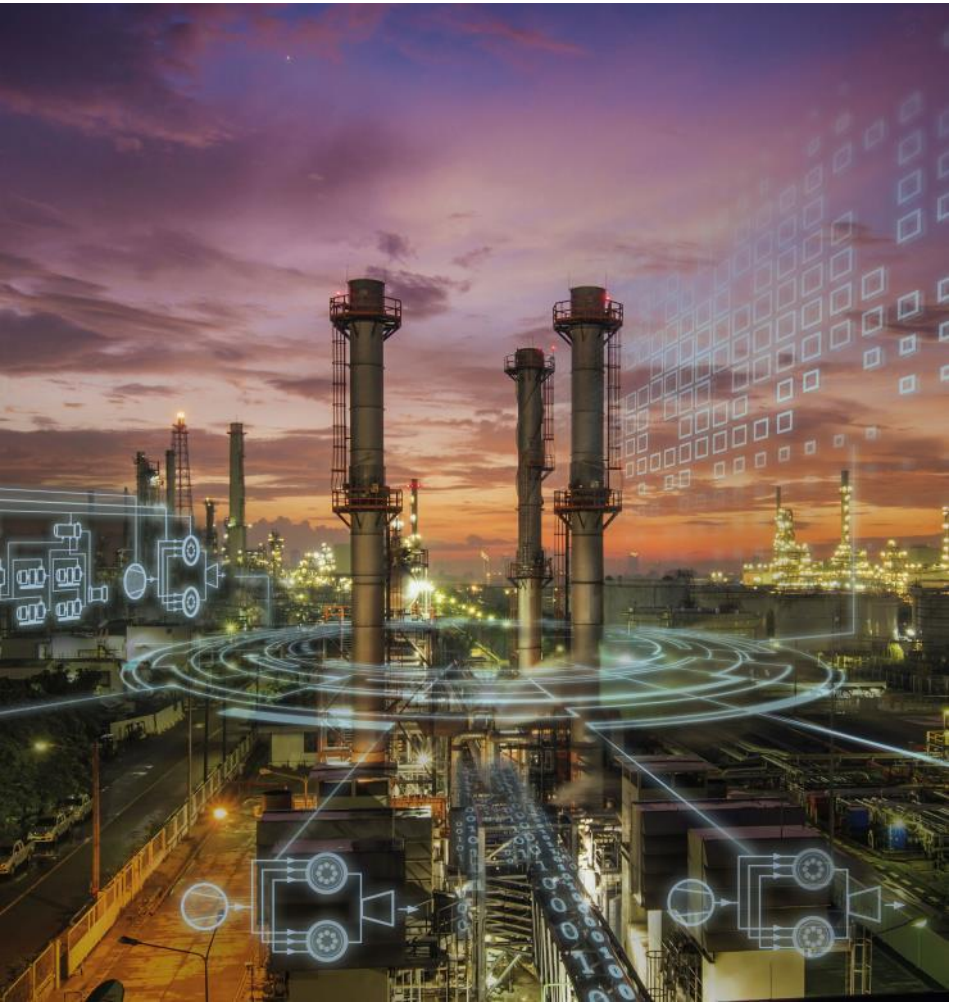
4 month test



Submerged Ultrafiltration Performance



Contact



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