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OriginClear™ Water Treatment with Innovative Desalination Techniques

High TDS Water Treatment for Oil & Gas Markets in Oman

Breakthrough water cleanup technology.

A Technology & A Process

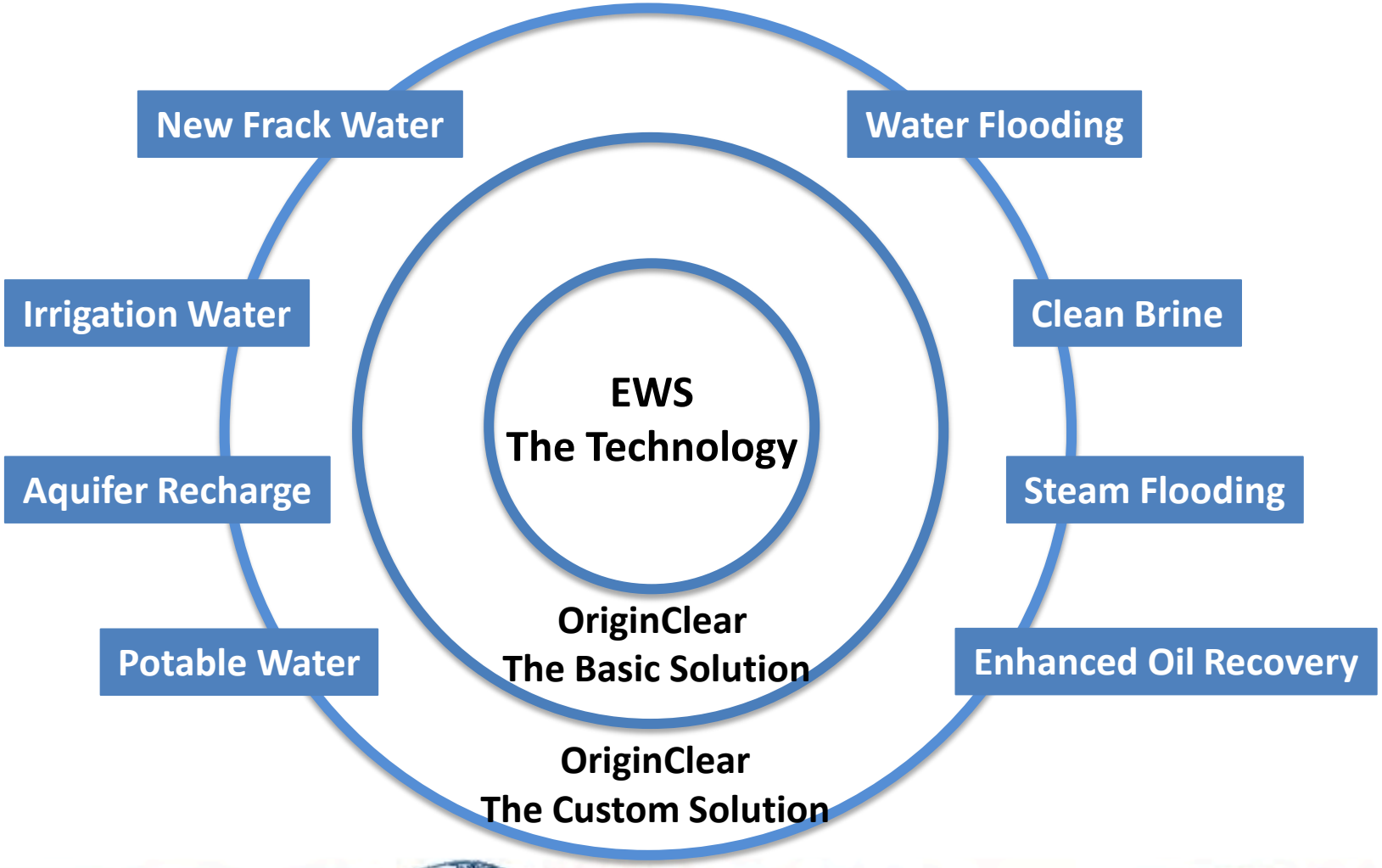
Electro Water Separation™ (EWS)

- A first stage technology for all O&G water
- Removes essentially all TPH, TSS, and bacteria
- EWS is a patented licensable technology
- Currently licensed to Gulf Energy in MENA

OriginClear™

- A commercial process incorporating EWS
- Suitable for most water treatment applications
- Precursor to downstream desalination processes.

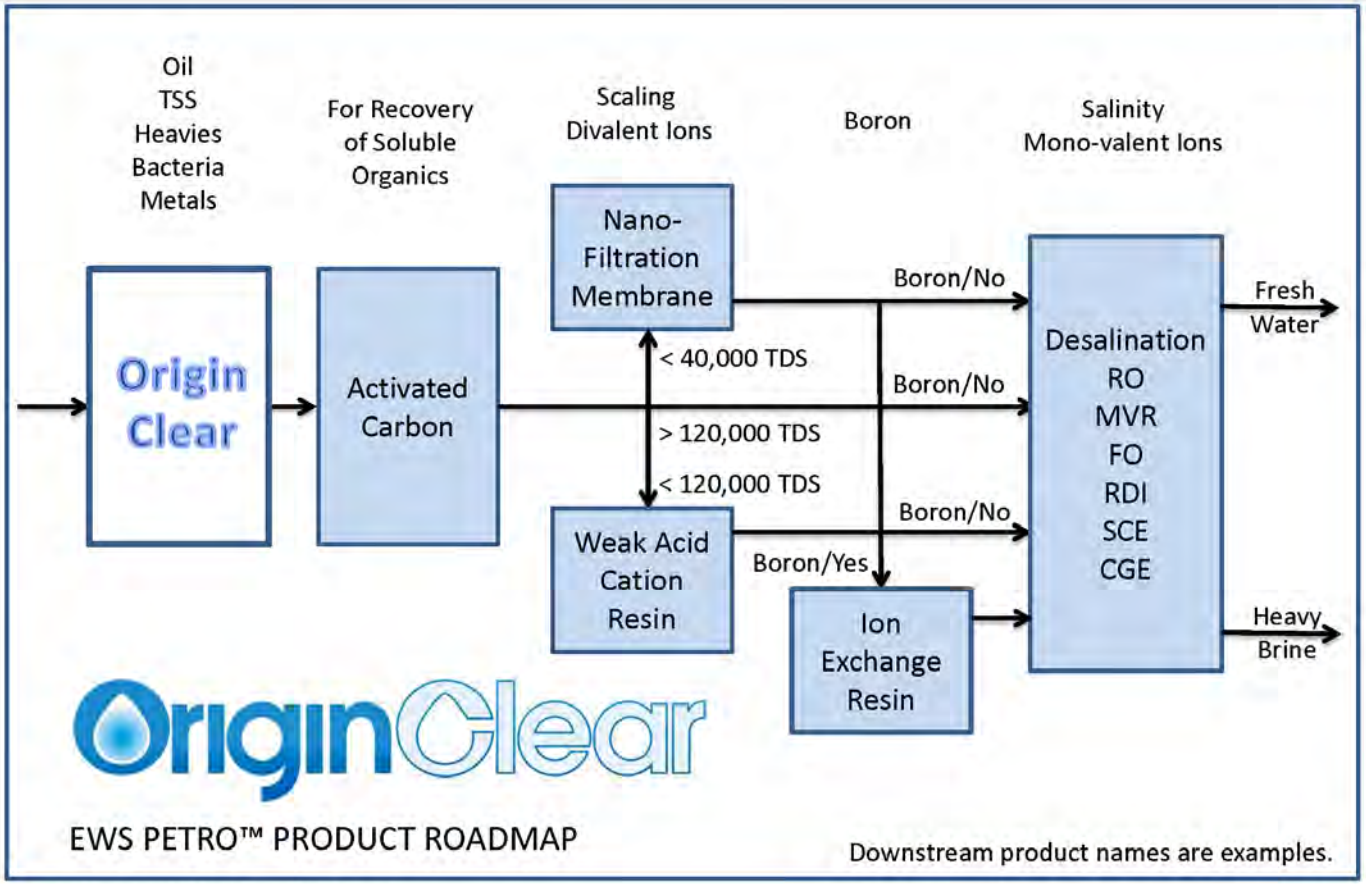
A Technology & A Solutions



The Oman Challenge

- Produced water with TDS > 170,000 ppm
  - Chlorides to be reduced to less < 30,000
  - TDS too high for RO or WAC resin
- Produced water hardness in > 15,000 ppm
  - Hardness to reduced < 50 ppm
- Evaporative distillation is too expensive
- New technologies limited field experience
- All desalination techniques require total removal of free and dispersed oil and suspended solids

Downstream Road Map



Electro Water Separation

Process Flow Diagram

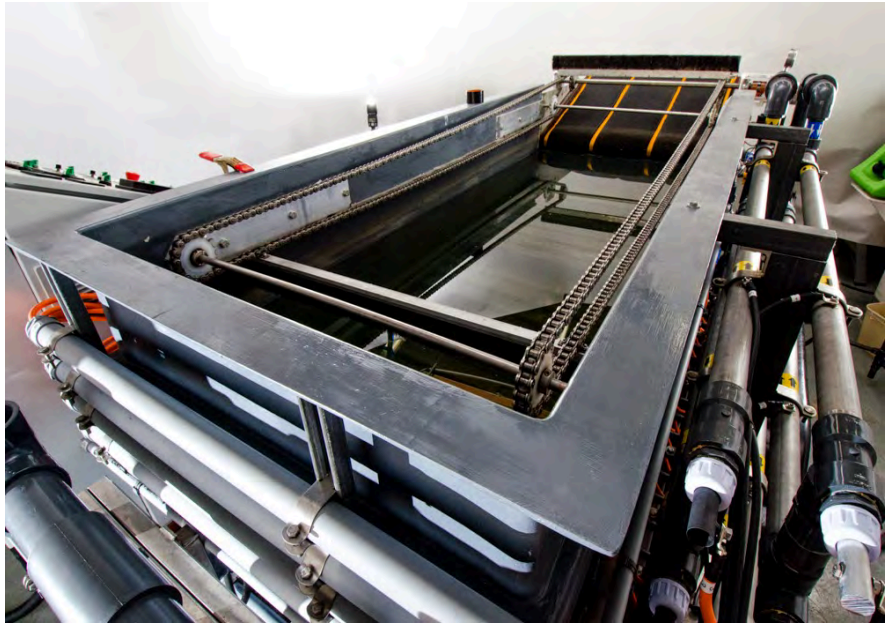
- Post upfront oil-water separator
- Integrated single equipment

The Essentials

- Continuous & very low energy
- No chemical addition
- Mobile or centralized facility

Function

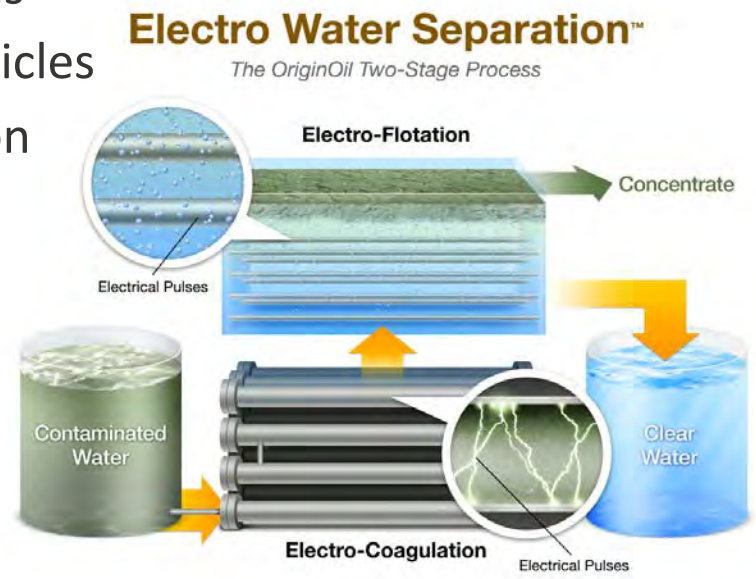
- Targets dispersed 1 to 25 micron size oil droplets and suspended solids
- Coalesces to 25 micron plus
- Disinfects bacteria
- Oxidizes and co-precipitates specific dissolved ions



OriginClear P1000
With Electro Coagulation
Reactors on Right

Basic EWS Technologies

- Proprietary electro-coagulation
  - Breaks the oil-water emulsion
  - Neutralizes charge on droplets & particles
  - Coalesces 1 to 25 micron droplets & particles
  - Coalesces to 25 plus for gravity separation
- Proprietary electro-oxidation
  - Creates oxidizing agents
  - Disinfects bacteria
  - Oxidizes heavy metals
  - Breaks up dissolved organics
- Proprietary electro-flotation
  - Creates cloud of micron-sized gas bubbles
  - Lifts oil & solids into a surface mat

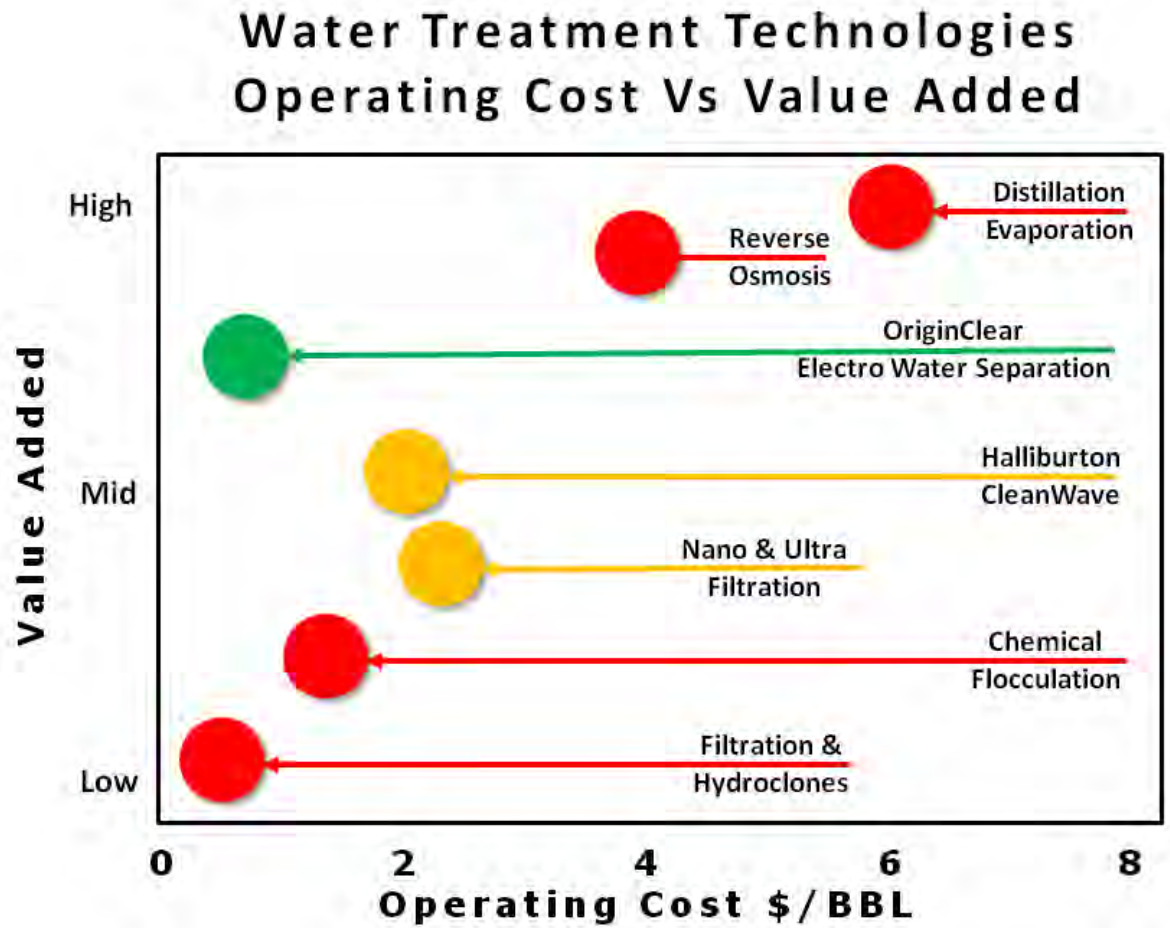


Technology Differentiation

- Proprietary Electro-Coagulation
  - Unique electrode configuration for minimum power and ease of maintenance
  - Unique choice of anode & cathode materials
  - High mass transfer & pressurized reactor to keep gas in solution
- Integrated EC to EF
  - Pressure releasedin flotation chamber for immediatate dispersion of gas
  - In-line flocculation of oil & suspended solids
- Proprietary Electro-Flotation
  - 100% of water exposed to micron gas bubbles
  - Unique non-sacrificial anode/ cathode configuration for low power
  - Four chambered flotation chamber
- Proprietary SCADA process control with touch screen control
  - PLC algorithms for real time control and off site monitoring and control

Differentiated removal of the hard to treat influent fraction

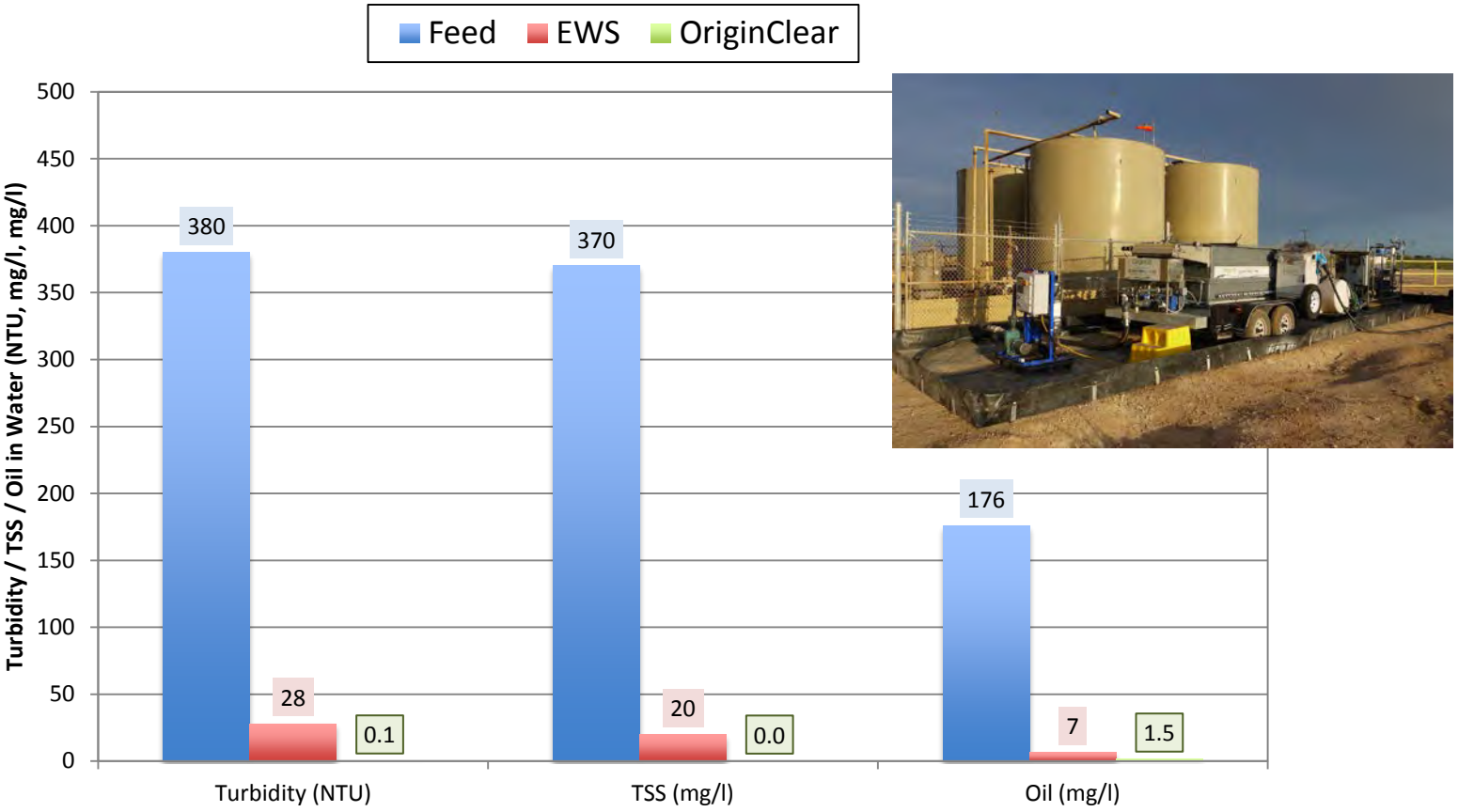
Best Value Added Process



Field Case Studies

- Three Unique Produced & Flowback Water Trials
  - Gas wells from western slope of Colorado – Niobrara
  - West Texas Intermediate oil wells of west Texas – Permian
  - Heavy oil CSG wells of Bakersfield – Monterey basin
- One process train used for all three trials
  - System throughput 1000 barrels per day
  - Spiral Water self cleaning filter for BS&W
  - EWS for 90+% removal of all non-soluble contaminants
  - Ultra-filtration polishing to achieve non-detectable levels

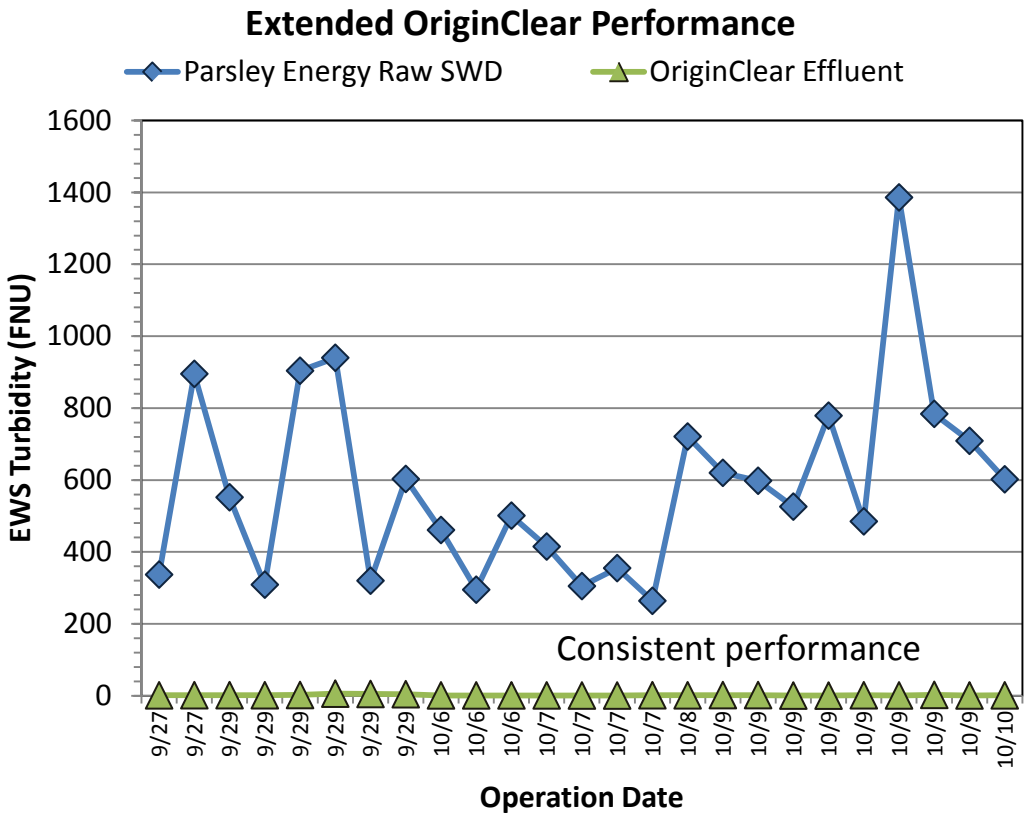
Niobrara Performance



Feed water for testing: Produced & frac flowback from Colorado Western Slope disposal well facility

Better than 99% removal of Turbidity, TSS and Oil observed

Permian Robustness



Recovered Oil

Water Samples

Wide variations in feed from many different truckloads and tank mixing over two weeks of operation in the Permian

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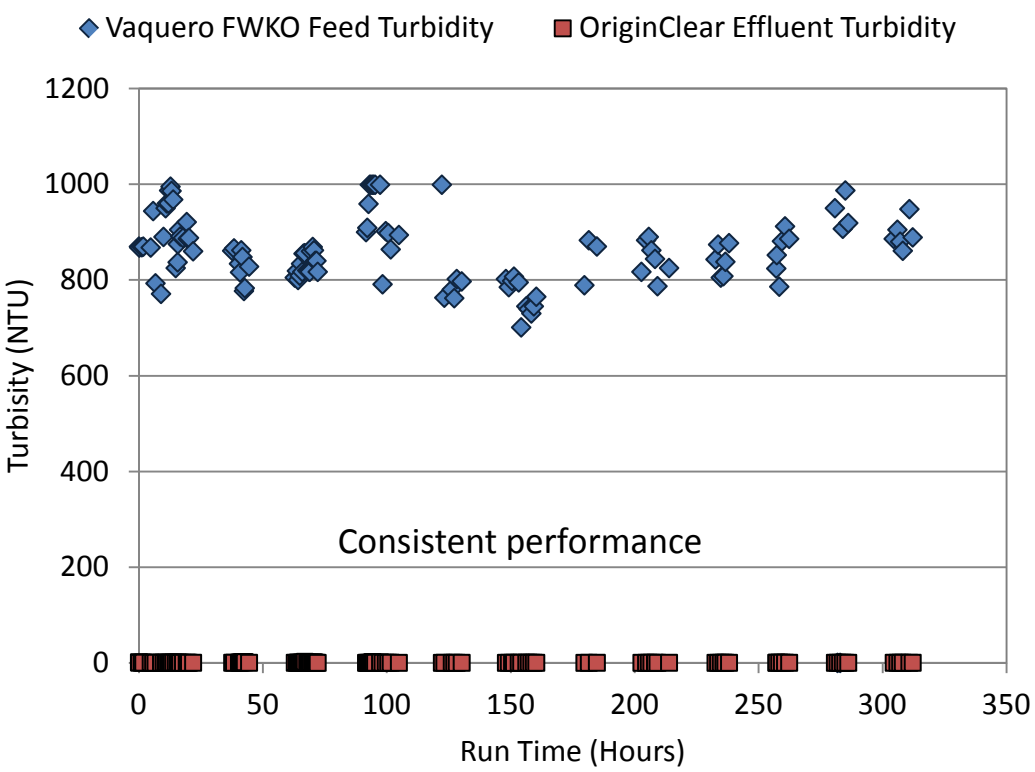
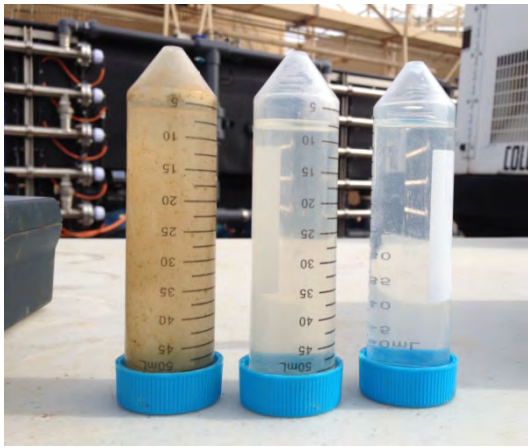
Monterey Clarity



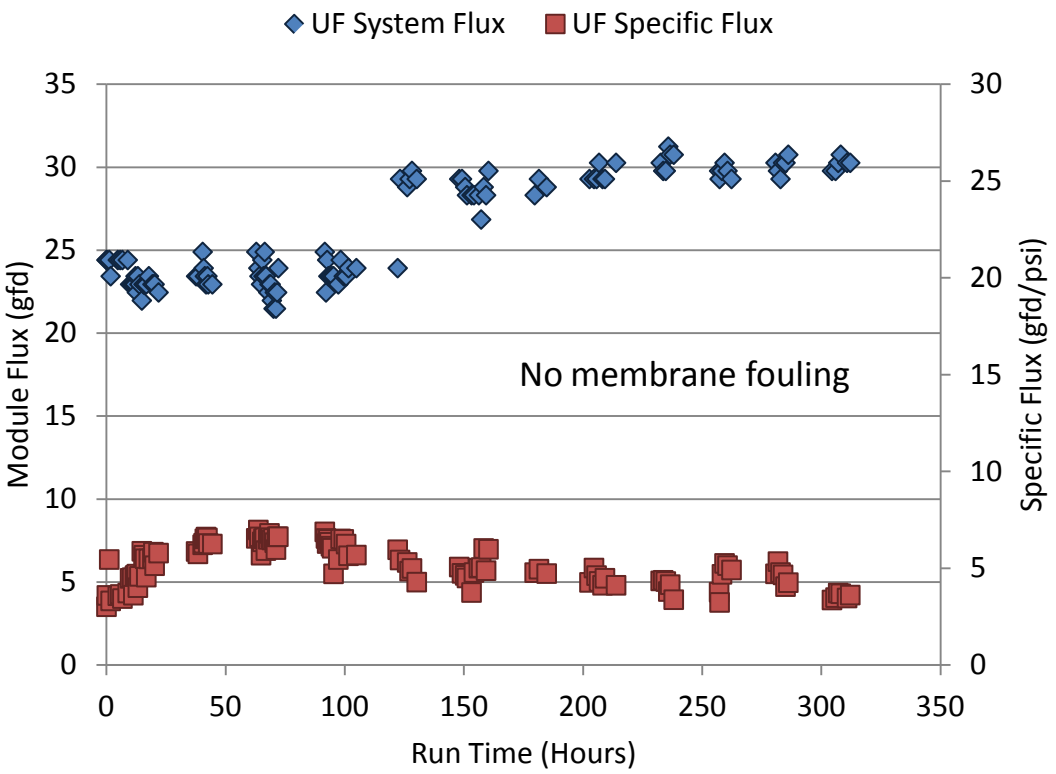
Field operations to treat CSS produced water to steam boiler make-up and irrigation quality

Beneficial Re-use



Water Samples

High Energy Efficiency



No observable membrane fouling even at high production capacity due to complete produced water pre-treatment

Beneficial Re-use

Independent Lab Data

Parameter (ppm)	Vaquero Feed	EWS Effluent	OriginClear Effluent
BOD	20	7.2	5.9
COD	530	110	41
TSS	100	64	3 (Detection Limit)
TRPH (HEM)*	142	9	<5.0 (Detection Limit)
Diesel Range Organics	108	6.4	0.7
Gasoline Range Organics	0.46	.19	.063
Motor Oil Range Organics	196	8.8	1.03

All data generated by Zalco Laboratories

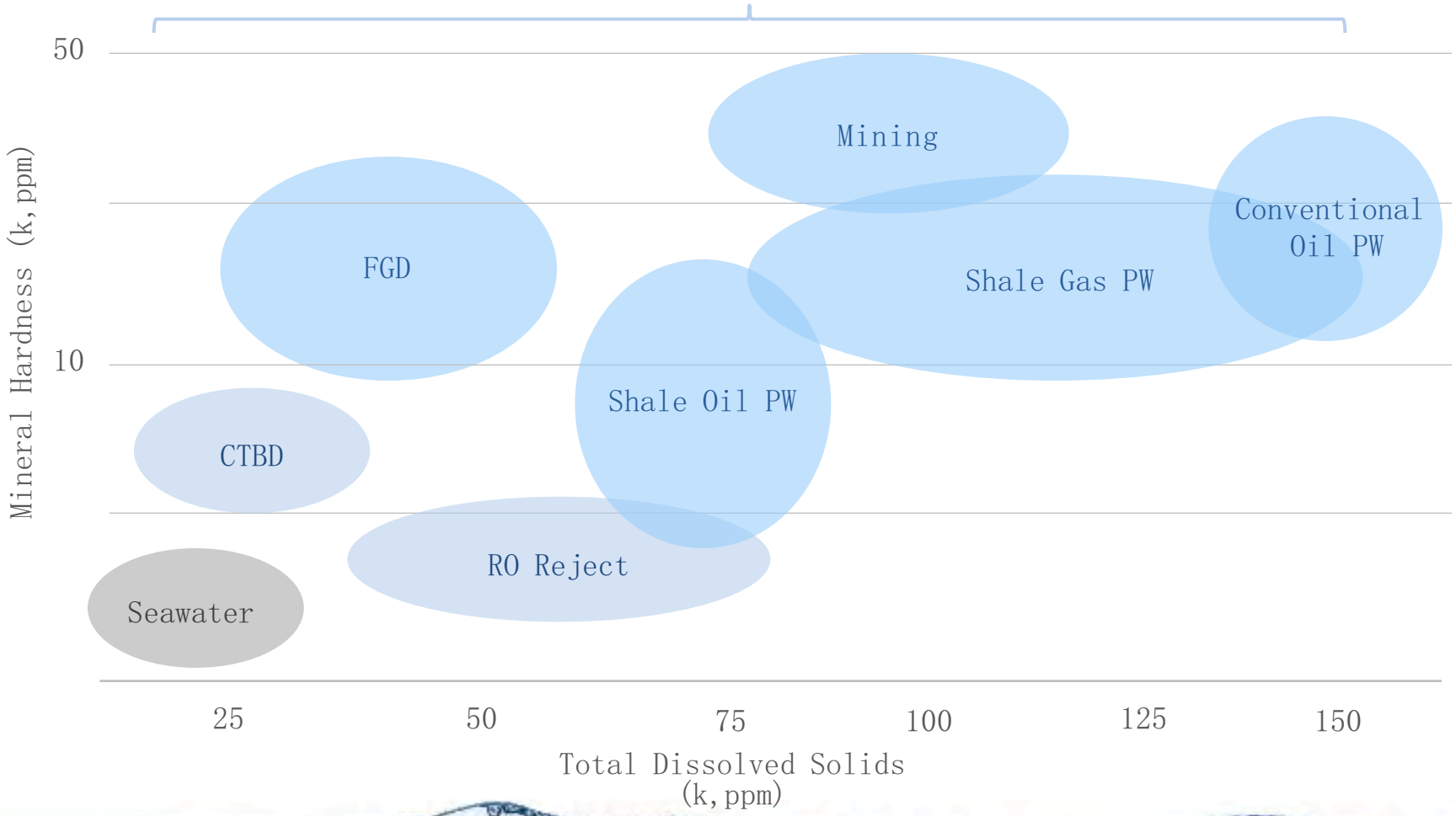
Sampled 18 Feb 2015 at Hershey Tank Battery, Vaquero Energy (Bakersfield CA)

TRPH: Total Recoverable Petroleum Hydrocarbons
HEM: Hexane Extractable Material

Bottom Line Performance

- OriginClear performed in wide range of environments
  - Gas wells to WTI to Heavy Oil
  - Truck load to truck load (black to yellow)
  - Salinities from 900 to 160,000 ppm
- Contaminants removed by OriginClear
  - TPH is below detection limits of 5 ppm
  - TSS to below detection limits of 3 ppm
  - Gasoline, Diesel, Motor Oil Range to less than 1 ppm
  - Bacteria removal expected to be higher than 99.5%
- Eliminates plugging of downstream desalination
- Desalination requires total removal of oil and TSS
- OriginClear is most effective solution

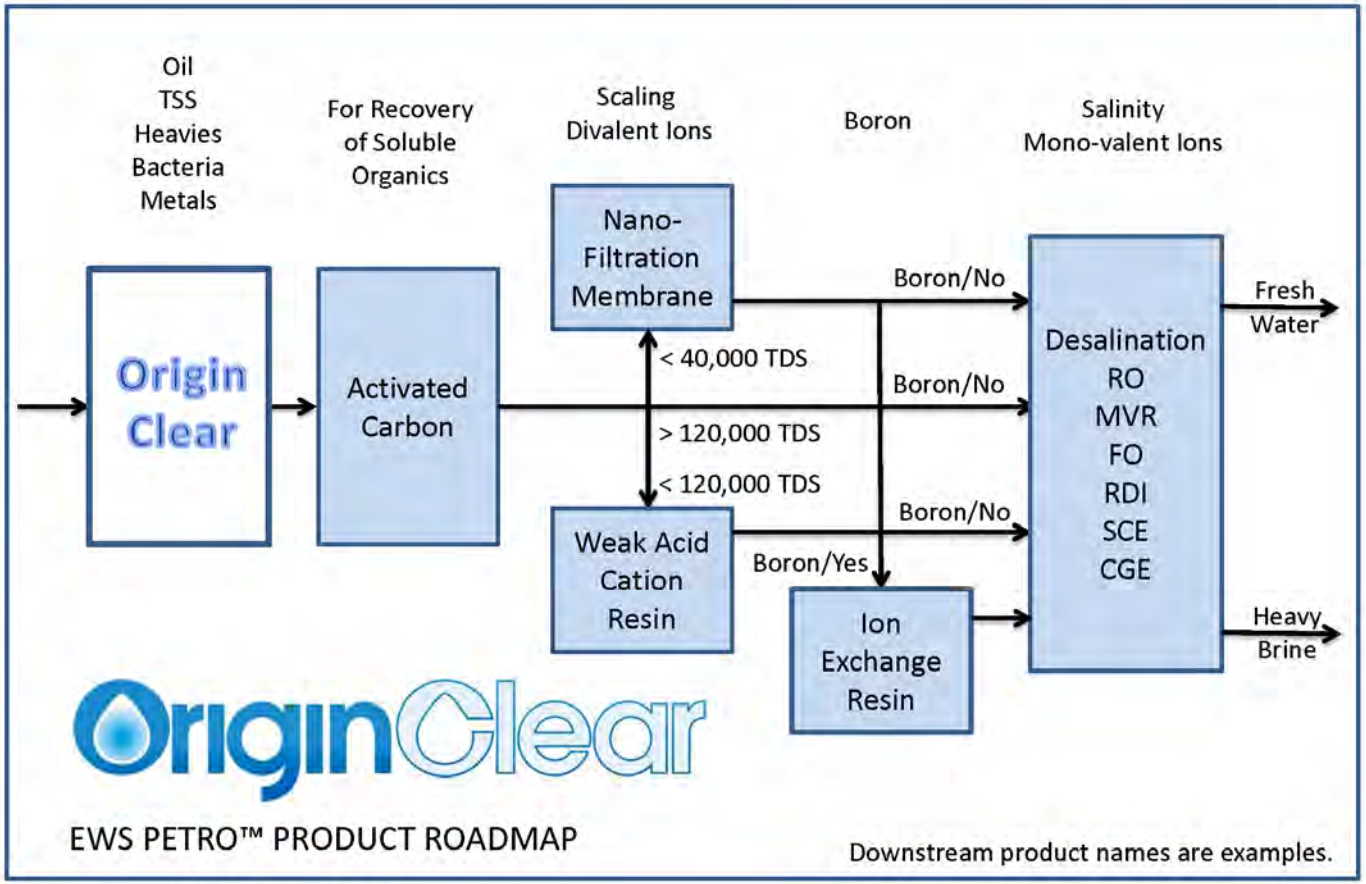
The Typical Challenge



The Oman Challenge

- TDS as high as 170,000 ppm
- Hardness in excess of 15,000 ppm
- RO membranes limited to ~ 50,000 ppm
- Traditional evaporative distillation is too expensive
  - Falling film/flat plate/tubular evaporators
  - Mechanical vapor recompression
- New technologies have limited field experience
  - Capacitive deionization/radial deionization
  - Forward osmosis
  - Humidifier/dehumidifier
  - To name a few

The Oman Challenge



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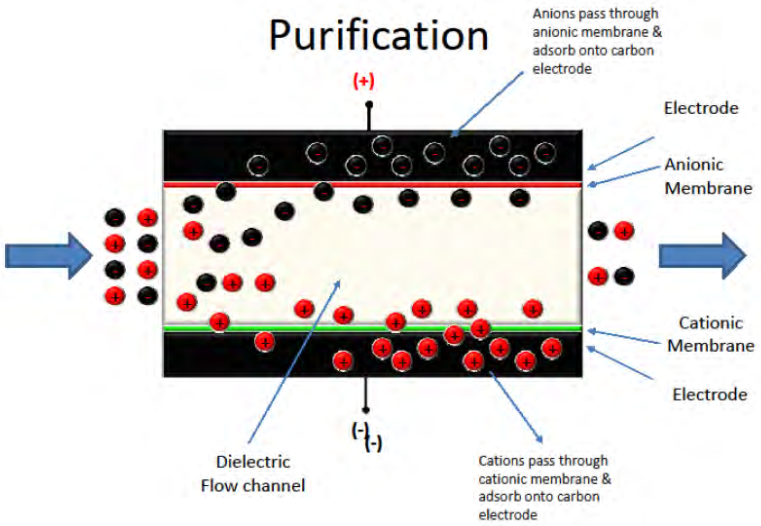
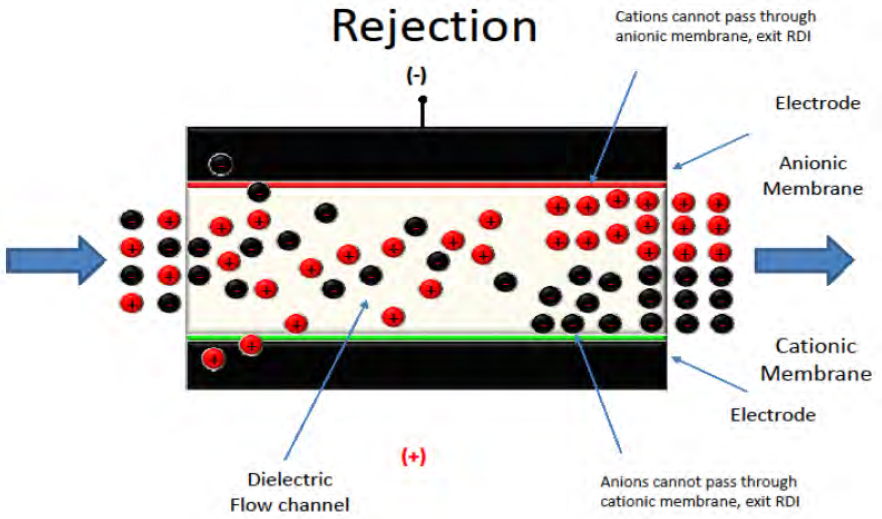
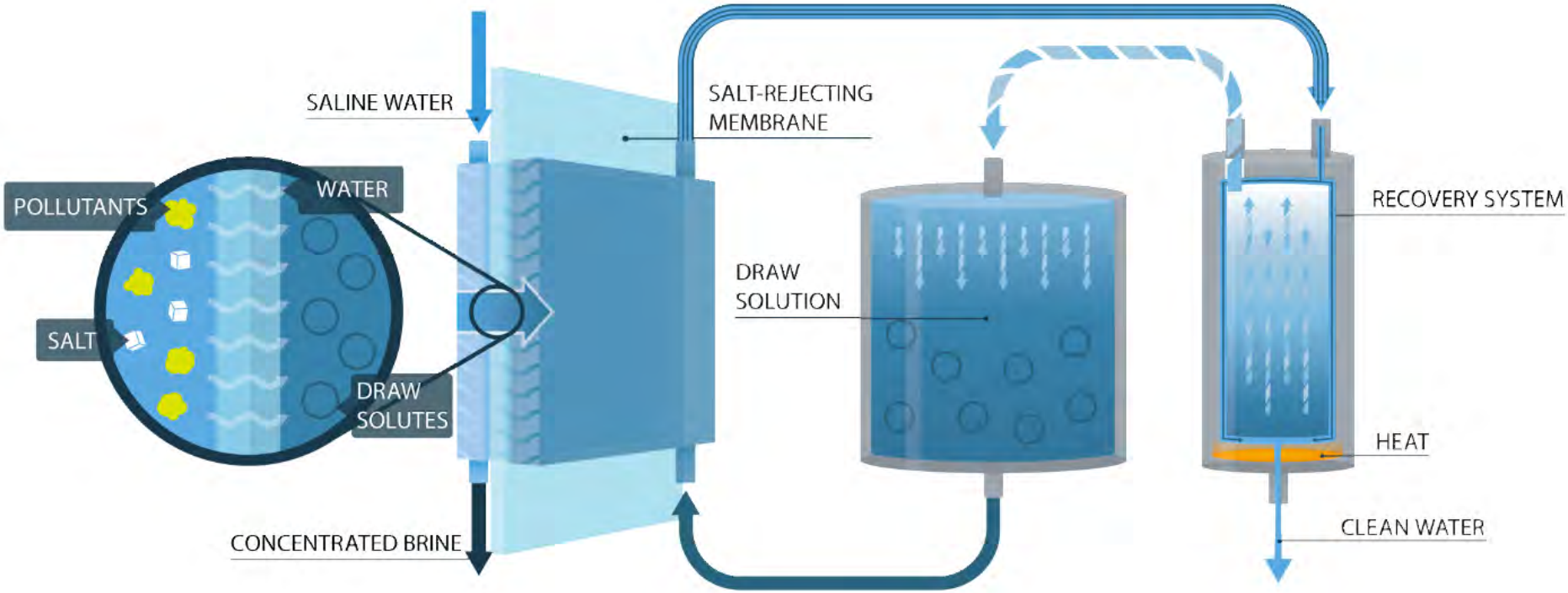
CDI/RDI Principle



- Does not require pre-softening
- Removes all ions proportionally
- Less expensive than most
- Least commercial field testing



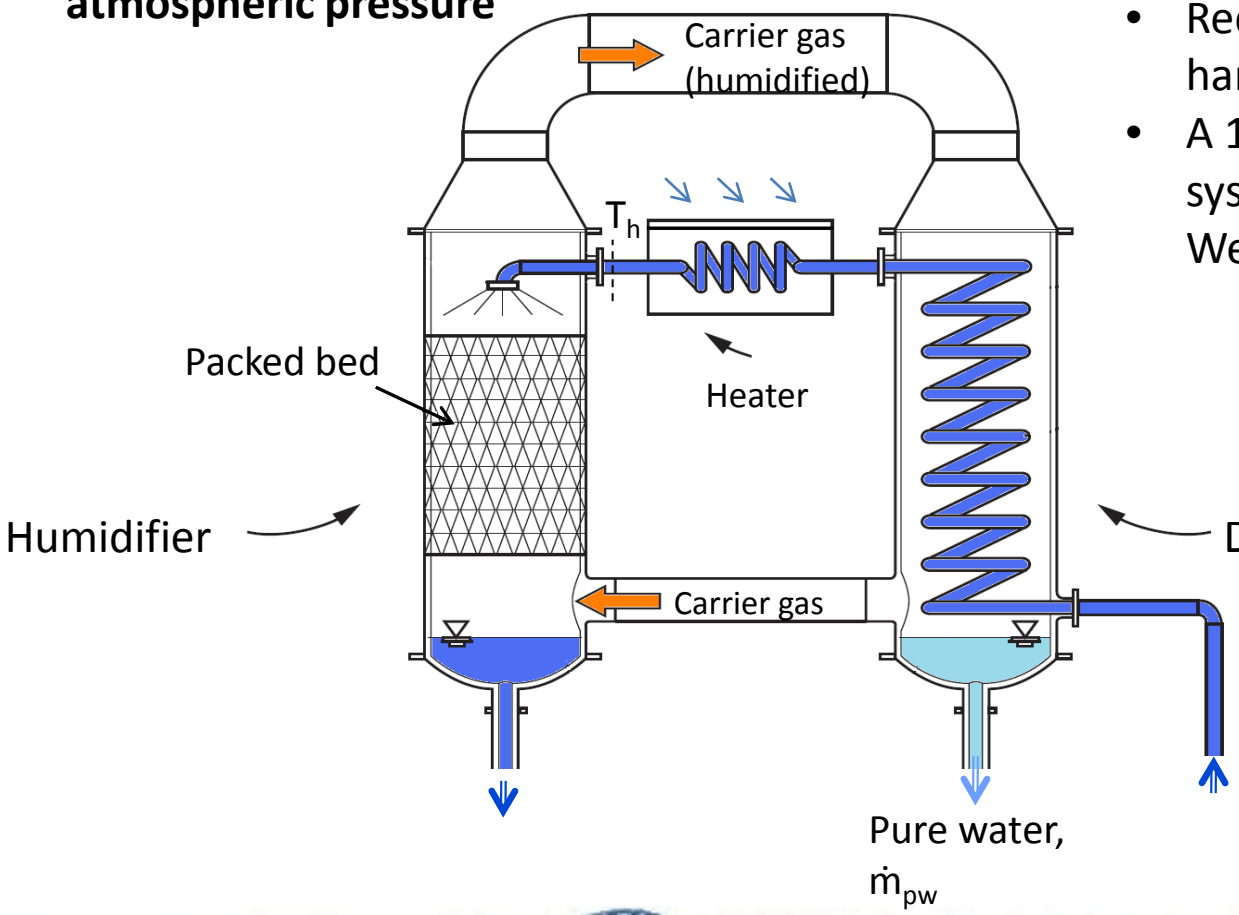
Forward Osmosis Principle



- Draw solution of thermolytic salts
- Draw solution pulls the fresh water through the salt rejecting membrane
- Draw solution has a low heat of vaporization
- Separation of fresh water from the draw solution with low grade heat
- Pilot studies in Marcellus and Permian basins

Humifier/Dehumifier Principle

Desalination at low temperature and atmospheric pressure



- Requires pre-softening for hardness removal
- A 12,000 and a 10,000 bpd system in operation in West Texas

OriginClear/Gulf Energy Solution

- Gulf Energy has the best solution for pre-treatment prior to desalination in OriginClear's technology
- Gulf Energy and OriginClear are jointly working to identify the best solution for desalination challenge
- That solution provider will then become the third partner to offer the most cost effective solution
- Gulf Energy/Tasneea will build OriginClear systems in Oman and integrate it with the desalination technology

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