2021 Membrane Technology CONFERENCE & EXPOSITION

Presented by

AMTA American Membrane Technology Association

American Water Works Association

Richard L. Stover
info@glorifiedplumber.com

Chloride Reduction in Municipal Wastewater Effluent with Membrane Brine Concentration

THE BRINE CHALLENGE

Brine ≡ greater than 75,000 mg/l TDS

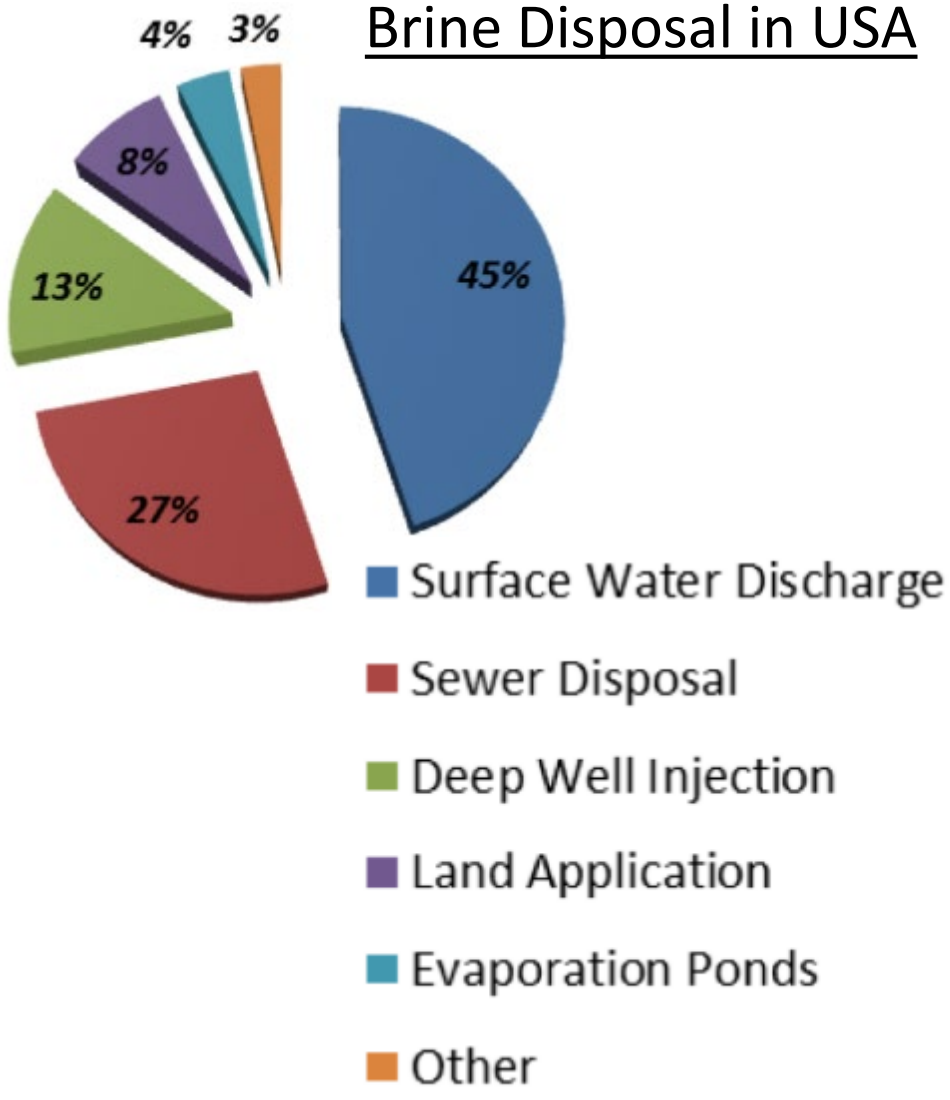
Seawater desalination: 60% brine waste

Inland desalination: 10-25% brine waste

Oil & gas, cooling towers, textile plants, pulp & paper, mining: 100%

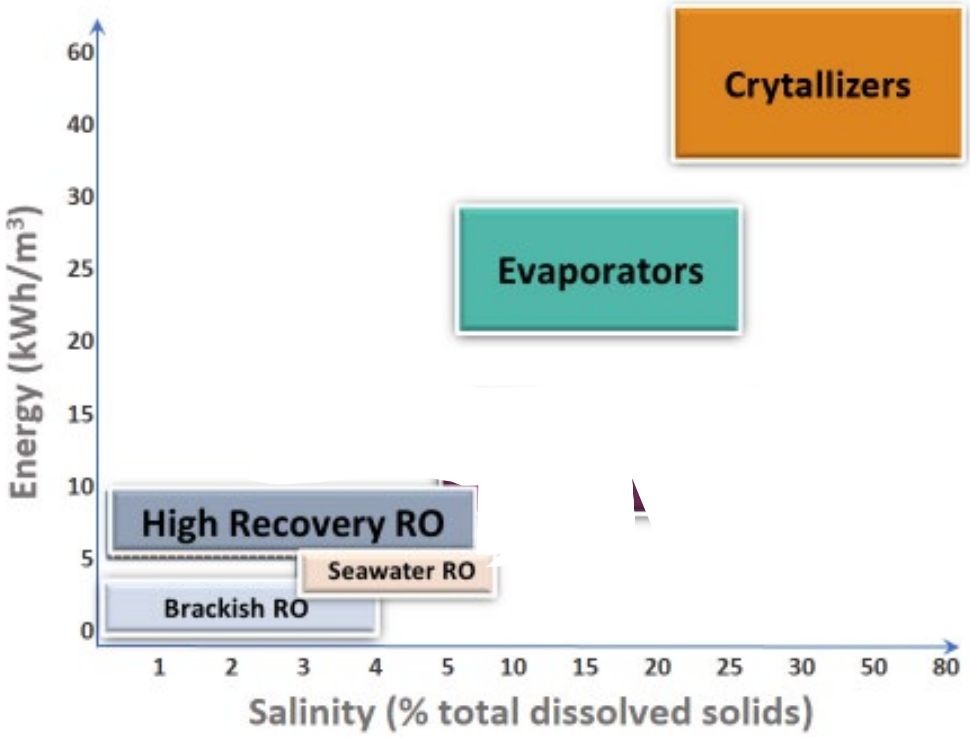
Brine disposal can be expensive and limiting

Conventional brine concentration is very expensive



Existing Technology - Evaporators





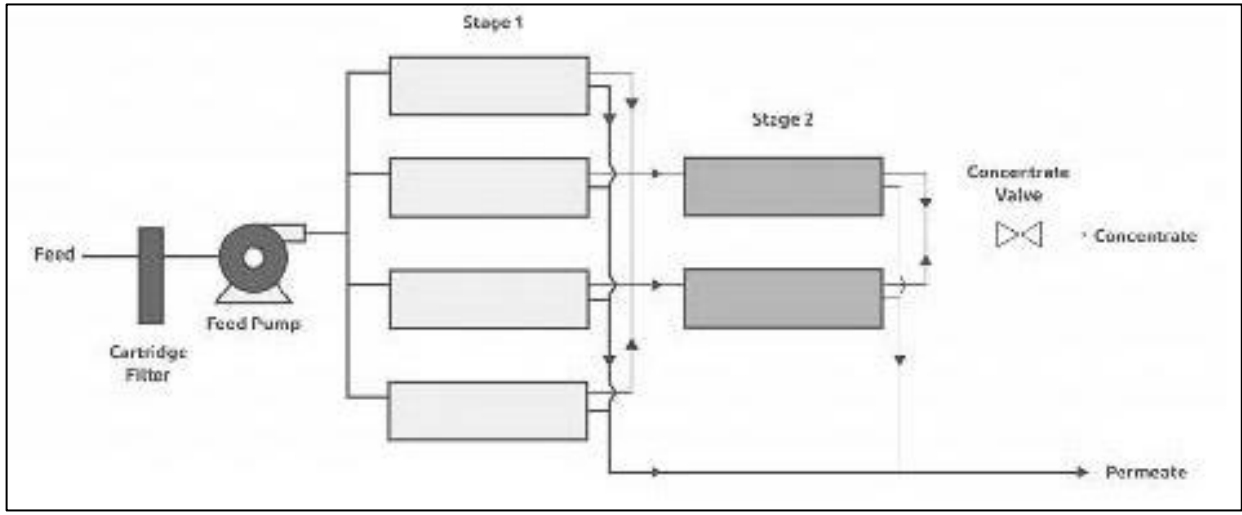
Existing Technology - High Recovery RO

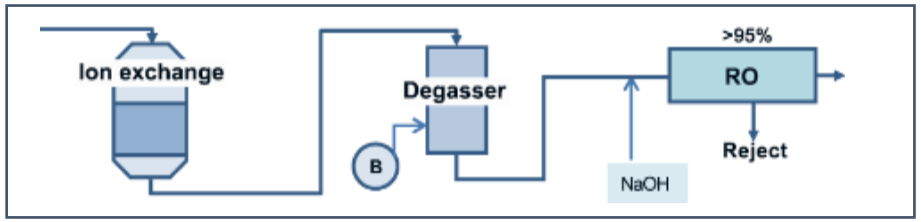
Proprietary process schemes and pretreatments

High recovery with conventional RO components

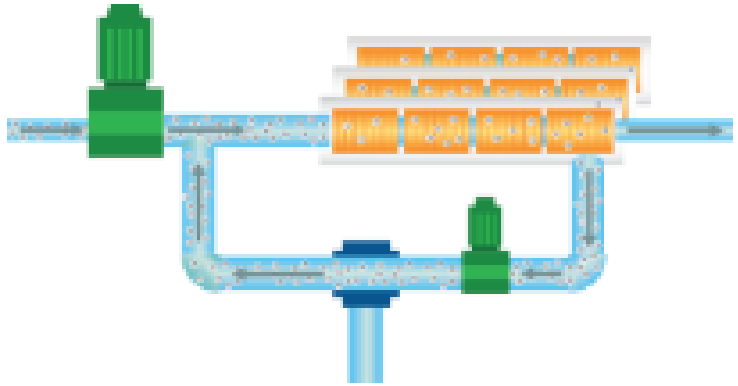
Typical max: 40,000 mg/l Brine (Max 70,000)

Recovery limited by pressure









Existing Technology - High Pressure RO

UHPRO, DTRO, STRO

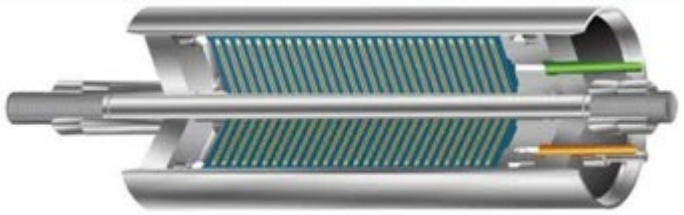
Up to 1,800 psi (120 bar)

Low flux due to compaction

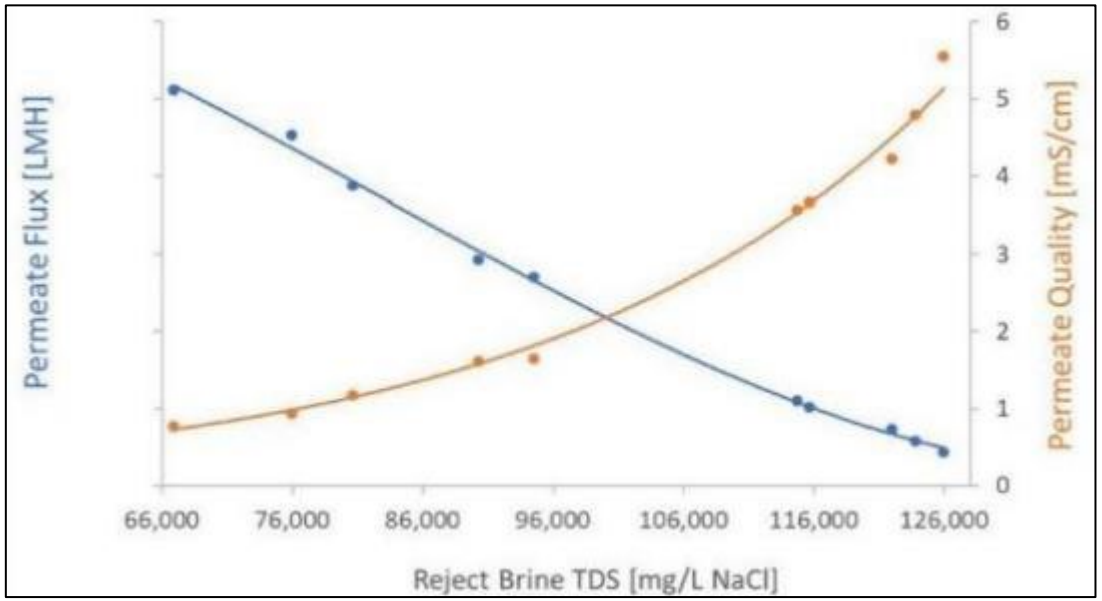
Specialty vessels, pumps, ERDs, couplings

Max 126,000 mg/l TDS brine

Worker Safety





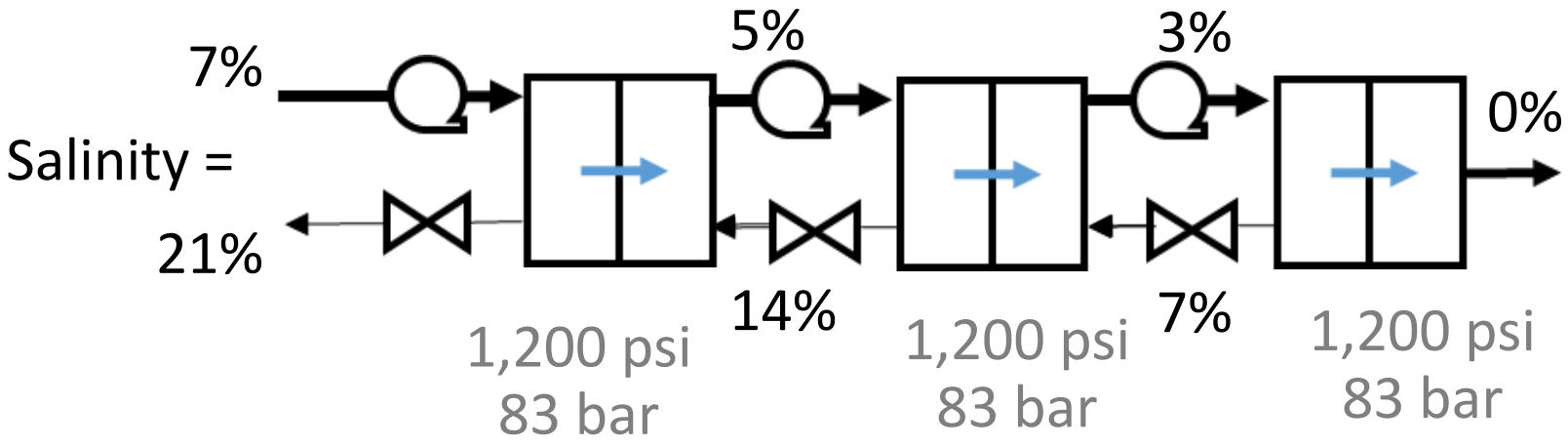


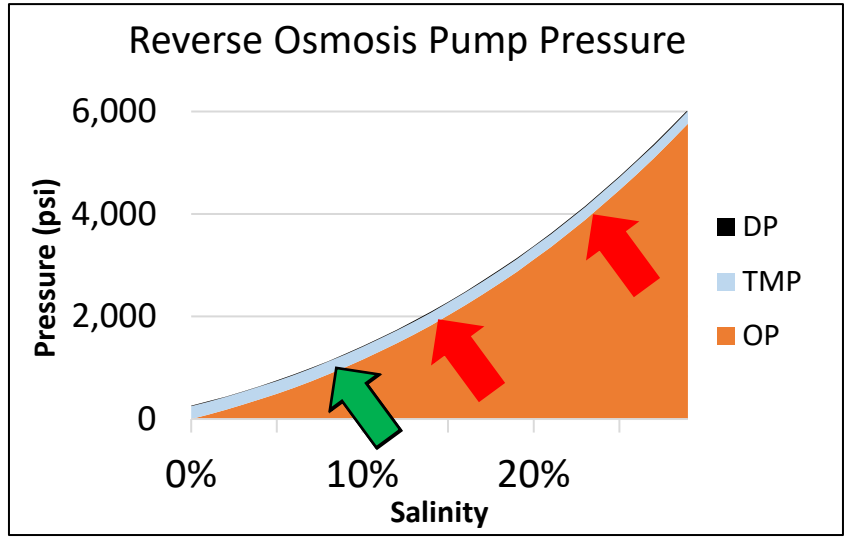
UHPRO compaction & salt passage



We want higher brine TDS, less brine flow, <1,200 psi with RO

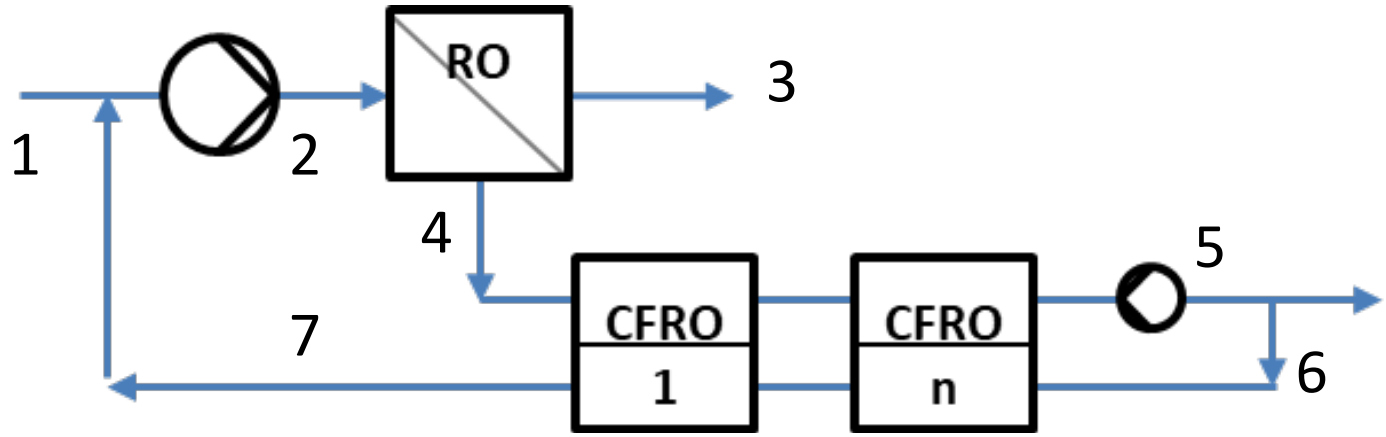
Counter Flow Reverse Osmosis (CFRO)





- Saline solution on permeate side reduces osmotic barrier
- Up to 260,000 mg/l brine concentrate
- Drinking water quality permeate
- Pressure low enough for use of commercially available components

Counter Flow Reverse Osmosis (CFRO)



stream	1	2	3	4	5	6	7
flow	100	271	63	208	38	56	171
pressure, bar	0	75	0	70	0	5	0
salinity, g/l	75	69	0	90	200	200	66

2021 Membrane Technology CONFERENCE & EXPOSITION



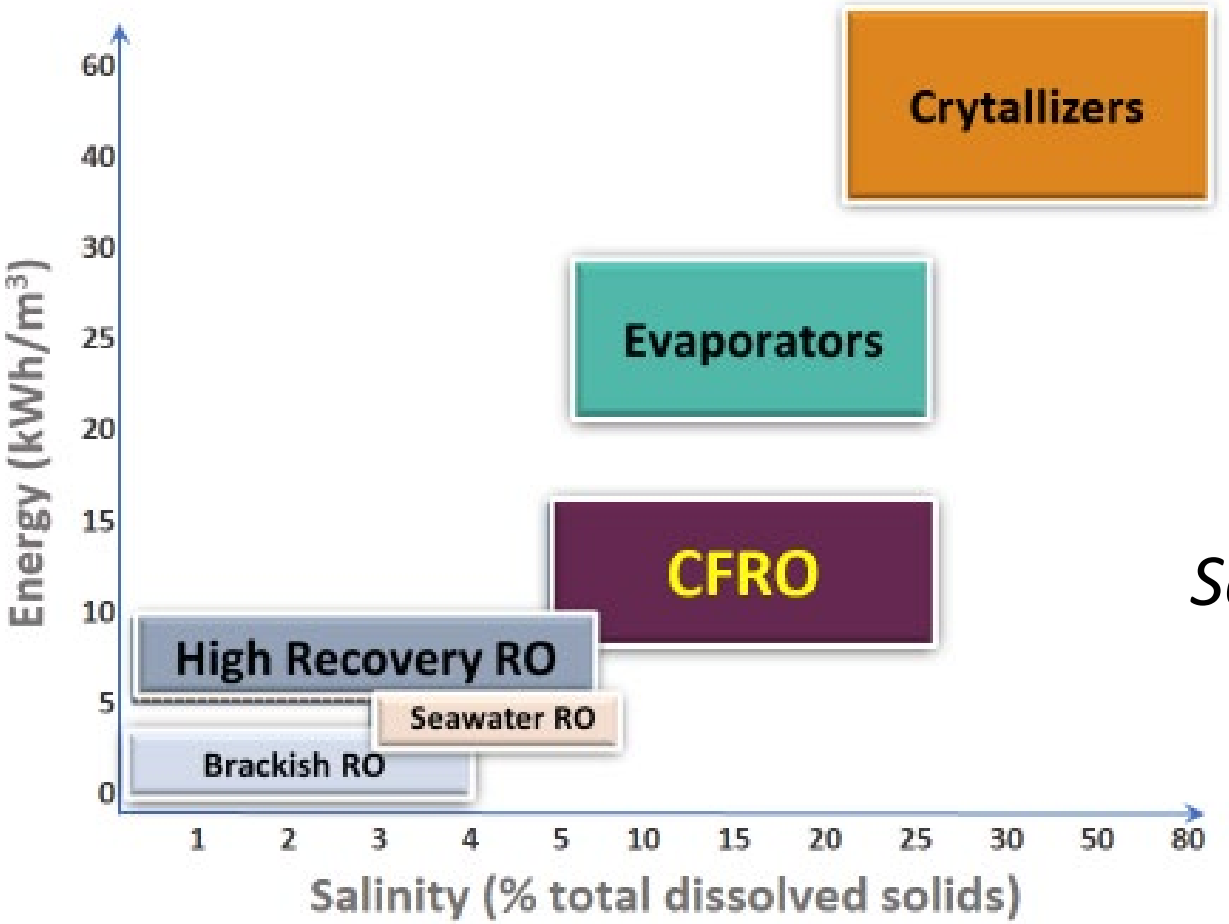






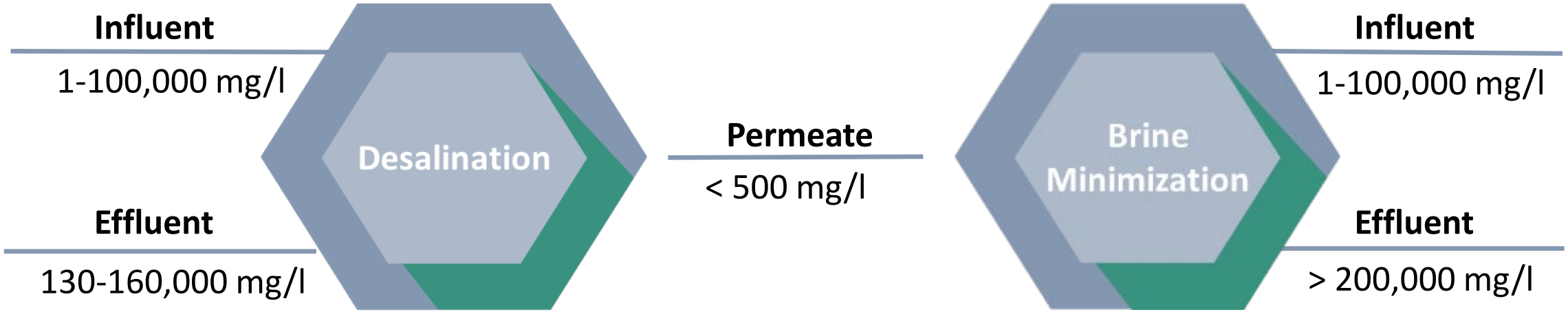






Same efficiency as RO

APPLICATIONS





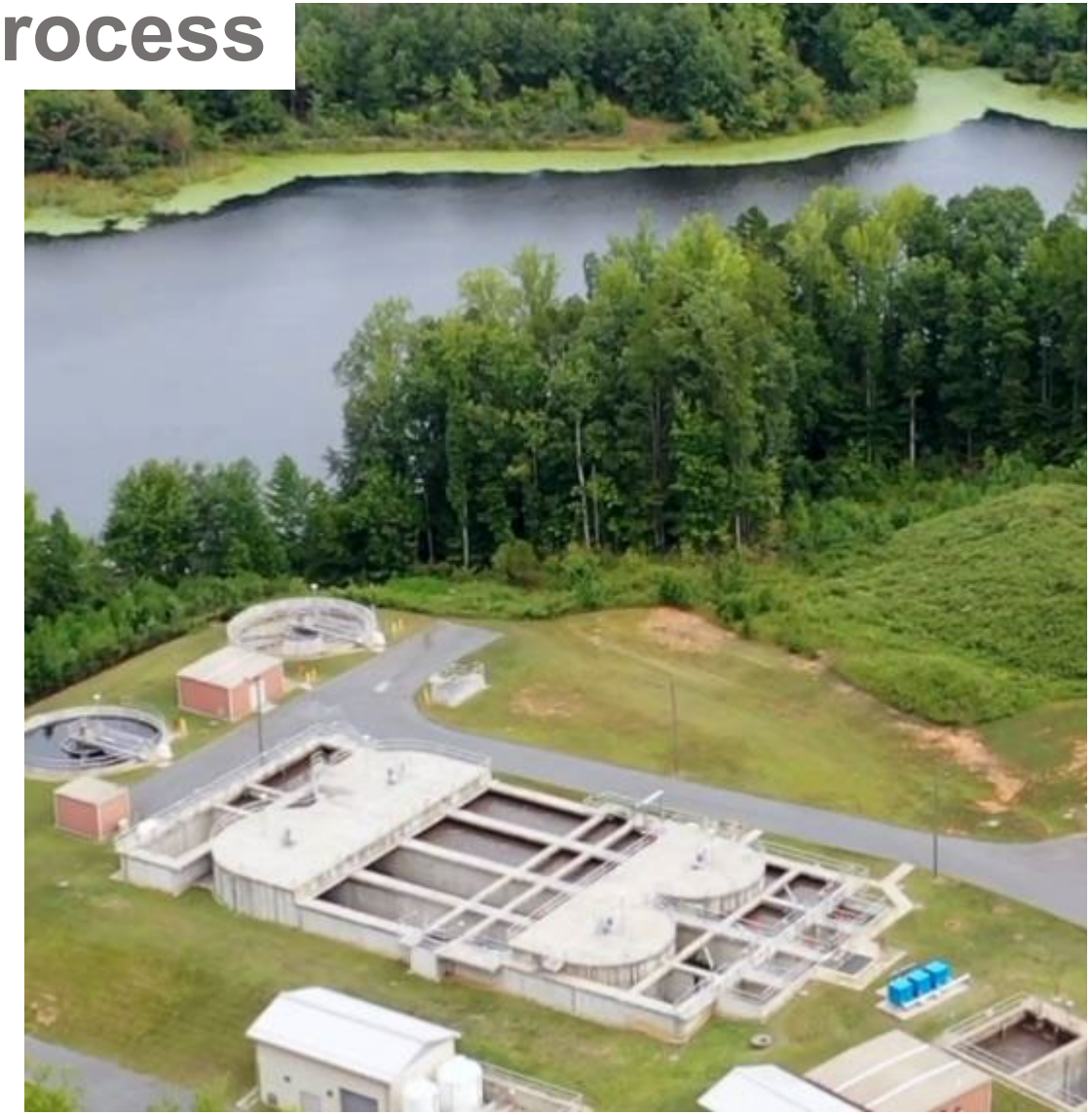
Evolution of the Technology

+ Seawater RO to 75,000 mg/l or higher
+ Energy recovery devices to reduce energy by 50%
+ Membranes with salt water feed to both sides (forward osmosis)
+ Osmotically-assisted RO concept
+ Multiple stages with counterflow arrangement

CounterFlow Reverse Osmosis (CFRO™)

Advanced Chloride Reduction Process

- Confidential location
- Secondary wastewater effluent
- Effluent discharge to river
- Chloride exceeds discharge limits
- Effluent desalination required, but no available brine disposal



Prior Work – Valencia

- Los Angeles County Sanitation Districts
- Cl- 126 mg/l → <100 mg/l
- High silica & hardness
- Maximum recovery
- No sludge allowed

Feedwater Analysis

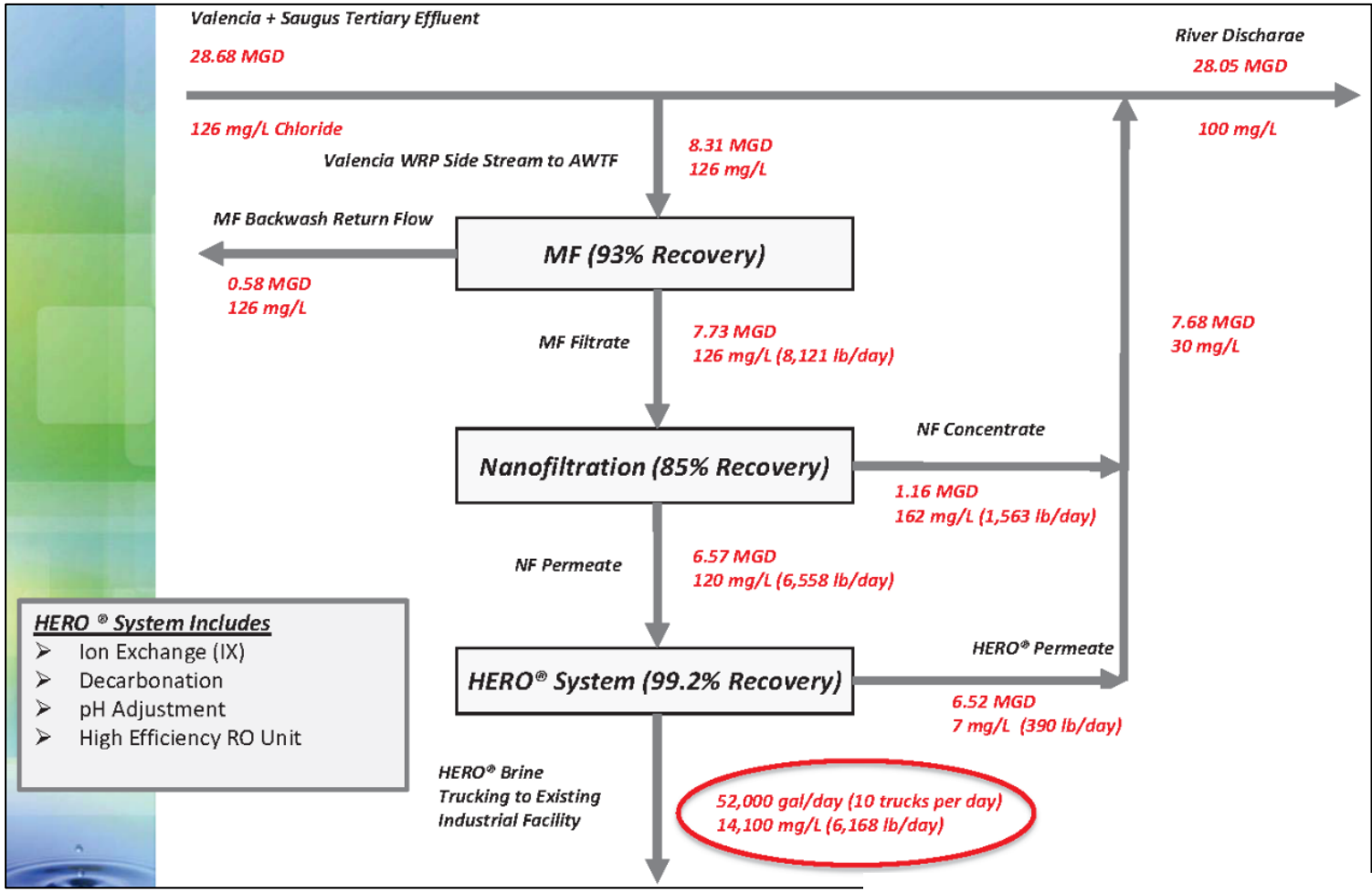
Constituent	MF Filtrate (mg/L)	NF Permeate (mg/L)	Removal (%)
TOC	5.1	0.50	90
TDS	945	483	48
Calcium	84	30	64
Magnesium	25	7	72
Barium	0.01	0.0032	71
Strontium	0.69	0.26	62
Total Hardness	313 (as $CaCO_3$)	105 (as $CaCO_3$)	67
Sulfate	291	15	95
Phosphate	5.4	0.36	93
Alkalinity	262 (as $CaCO_3$)	134 (as $CaCO_3$)	49
Chloride	126	120	5
Silica	23	21	9

Bruce Mansell 2016

Prior Work – Valencia

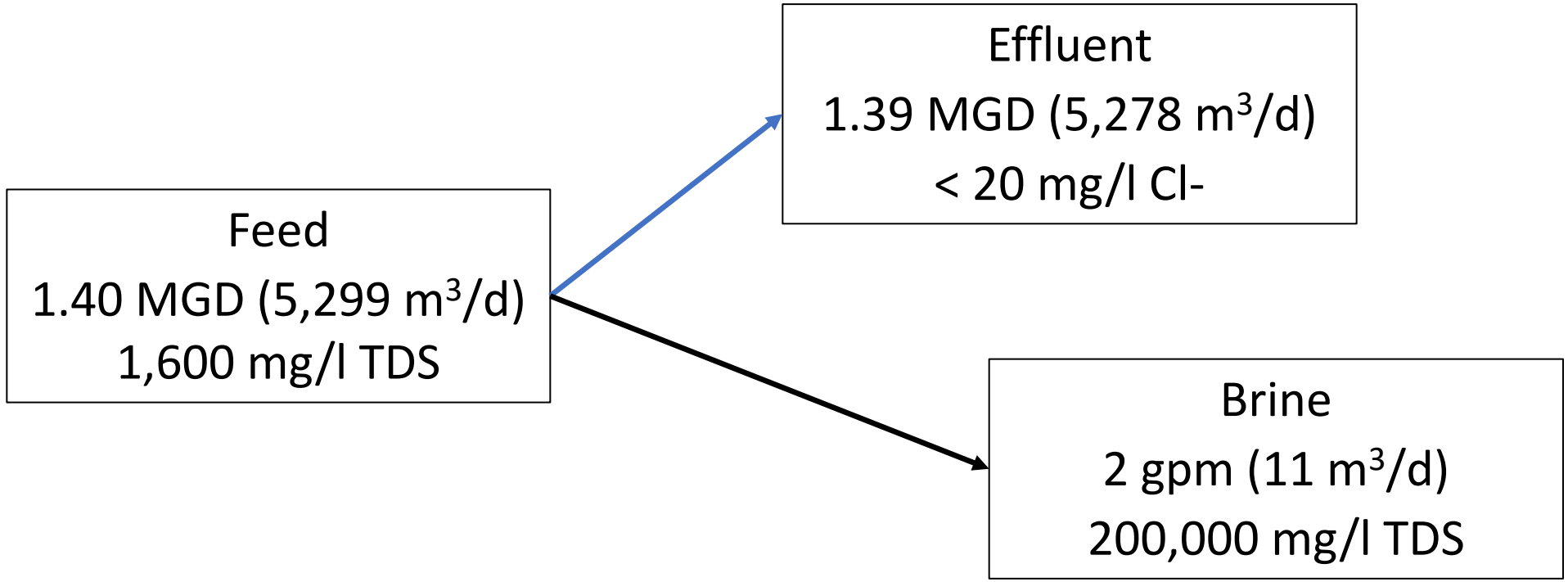
- Partial desalination
- NF rejects organics, hardness to river
- RO permeate dilutes Cl-
- 97.8% recovery
- 2,500 mg/l silica, pH 11
- **10 trucks/day brine**

Treatment Scheme



Bruce Mansell 2016

Advanced Chloride Reduction Process



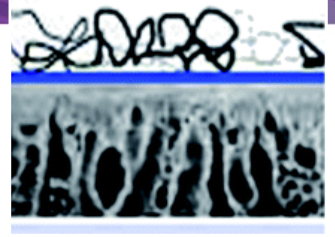
99.6% recovery = 150x concentration factor!

Advanced Chloride Reduction Process

Parameter	Unit	Feed	Effluent	Brine
TSS	mg/L	1.06	0.0	0.0
Turbidity	NTU	0.28	0.0	0.0
Oil & Grease	mg/L	2.15	0.0	0.0
BOD	mg/L	1.69	0.0	0.0
TOC	mg/L	0.6	0.0	0.0
NH_4^+	mg/L	1.4	1.0	235
Na^+	mg/L	170	66.4	74,819
Mg^{+2}	mg/L	54.3	41.8	1.7
Ca^{+2}	mg/L	181	128.4	61.1
CO_3^{-2}	mg/l	2.88	0.1	1.0
HCO_3^-	mg/l	396	99.3	241
NO_3^-	mg/l	3.6	0.5	1,562
F^-	mg/l	0.5	0.0	13.8
Cl^-	mg/l	133	19.1	92,318
SO_4^{-2}	mg/l	448	507.6	30,413
PO_4^{-3}	mg/l	3.7	1.9	197
SiO_2	mg/l	39.2	10.7	135
CO_2	mg/l	7.7	91.9	59.3
TDS	mg/l	1,367	881	200,000

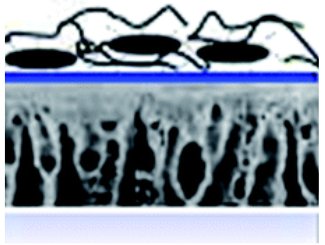
Stream Compositions

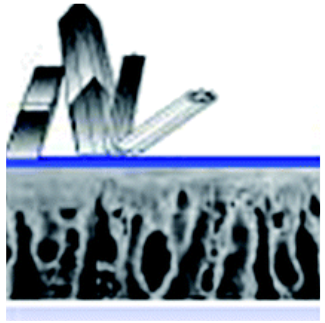
What could possibly go wrong?



Organic fouling

Biofouling

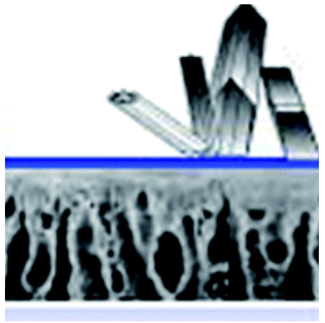




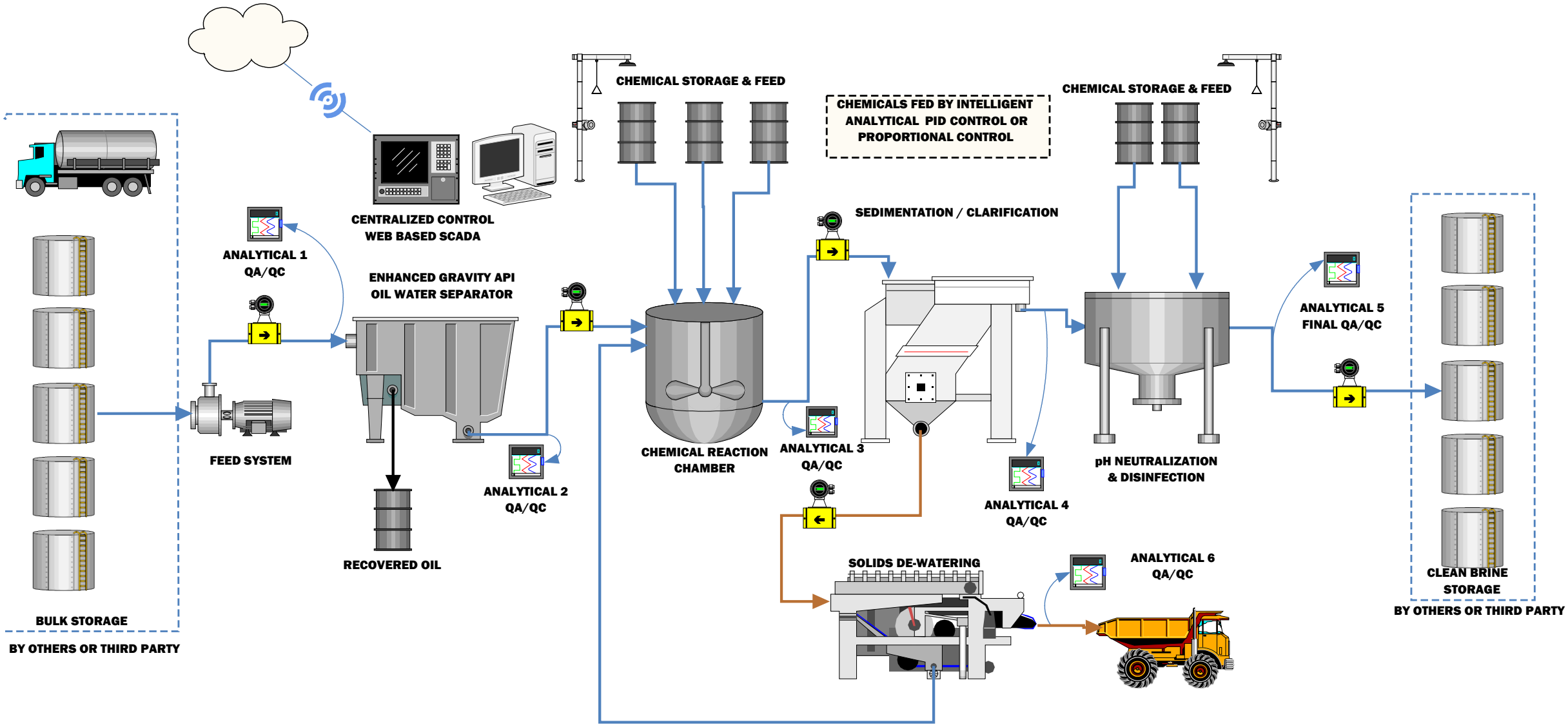
Calcium scaling



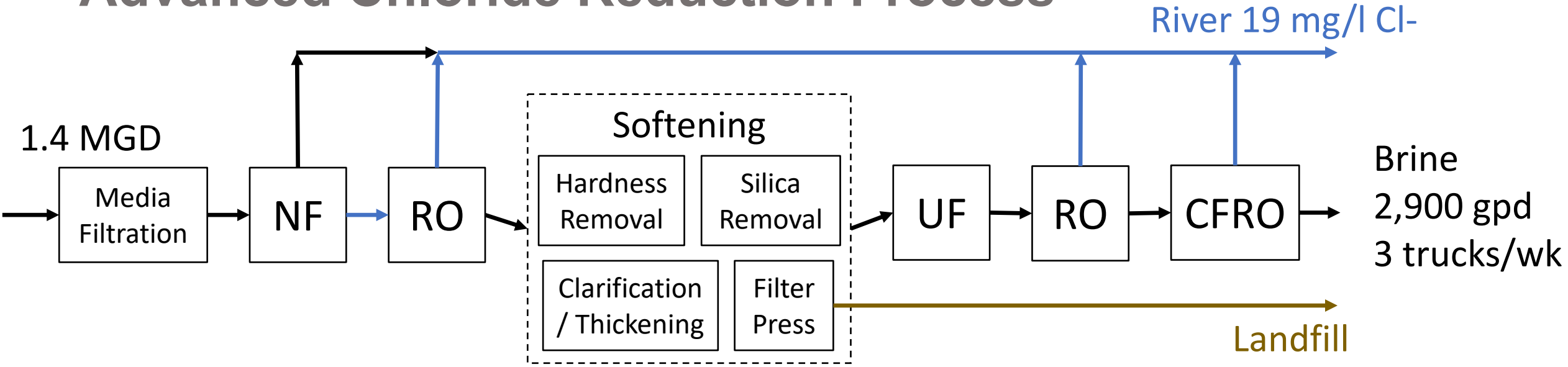
Silica scaling






CENTRALIZED CONTROL
WEB BASED SCADA
CHEMICAL STORAGE & FEED
CHEMICALS FED BY INTELLIGENT
ANALYTICAL PID CONTROL OR
PROPORTIONAL CONTROL
CHEMICAL STORAGE & FEED
ANALYTICAL 1
QA/QC
ENHANCED GRAVITY API
OIL WATER SEPARATOR
SEDIMENTATION / CLARIFICATION
ANALYTICAL 5
FINAL QA/QC
FEED SYSTEM
ANALYTICAL 2
QA/QC
CHEMICAL REACTION
CHAMBER
ANALYTICAL 3
QA/QC
ANALYTICAL 4
QA/QC
pH NEUTRALIZATION
& DISINFECTION
RECOVERED OIL
SOLIDS DE-WATERING
ANALYTICAL 6
QA/QC
BULK STORAGE
BY OTHERS OR THIRD PARTY
CLEAN BRINE
STORAGE
BY OTHERS OR THIRD PARTY

Advanced Chloride Reduction Process



Nanofiltration
85% recovery
$CaCO_3$, $CaSO_4$, SiO_2, Cl_2, organics
3 stages

Reverse Osmosis
90% recovery
15.4 gfd
150 psi
3 stages or semi-batch (LA San)

Softening
2 reaction tanks
Lime, soda ash, mag chloride
Lamella clarifier
Thickener
Filter press

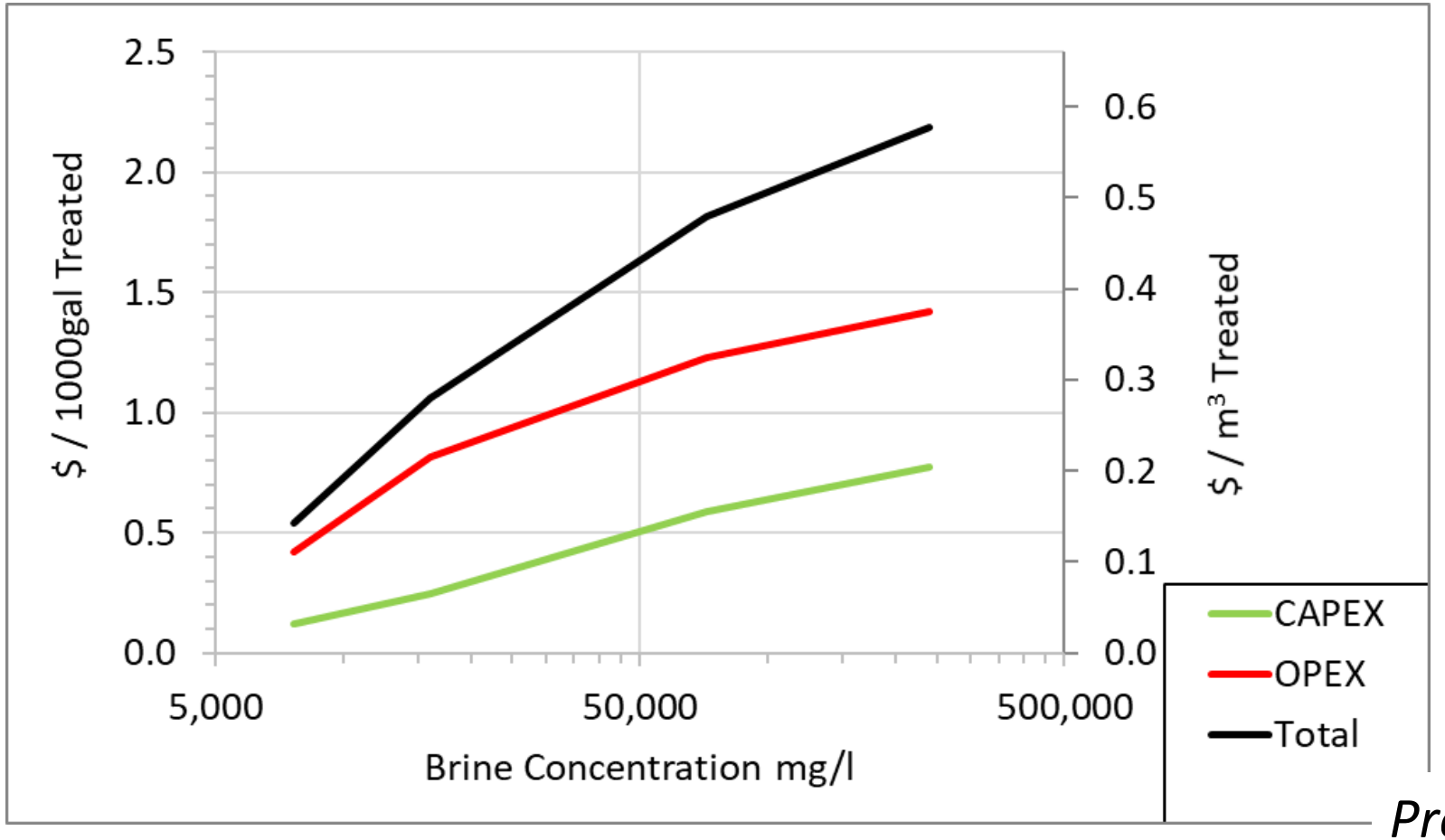
Ultra-Filtration
91% recovery
34 gfd
Backwash to softener

Reverse Osmosis
63% recovery
15 gfd
870 psi
2 stages

CounterFlow Reverse Osmosis
69% recovery
63,000 mg/l feed
200,000 mg/l brine
1,000 psi

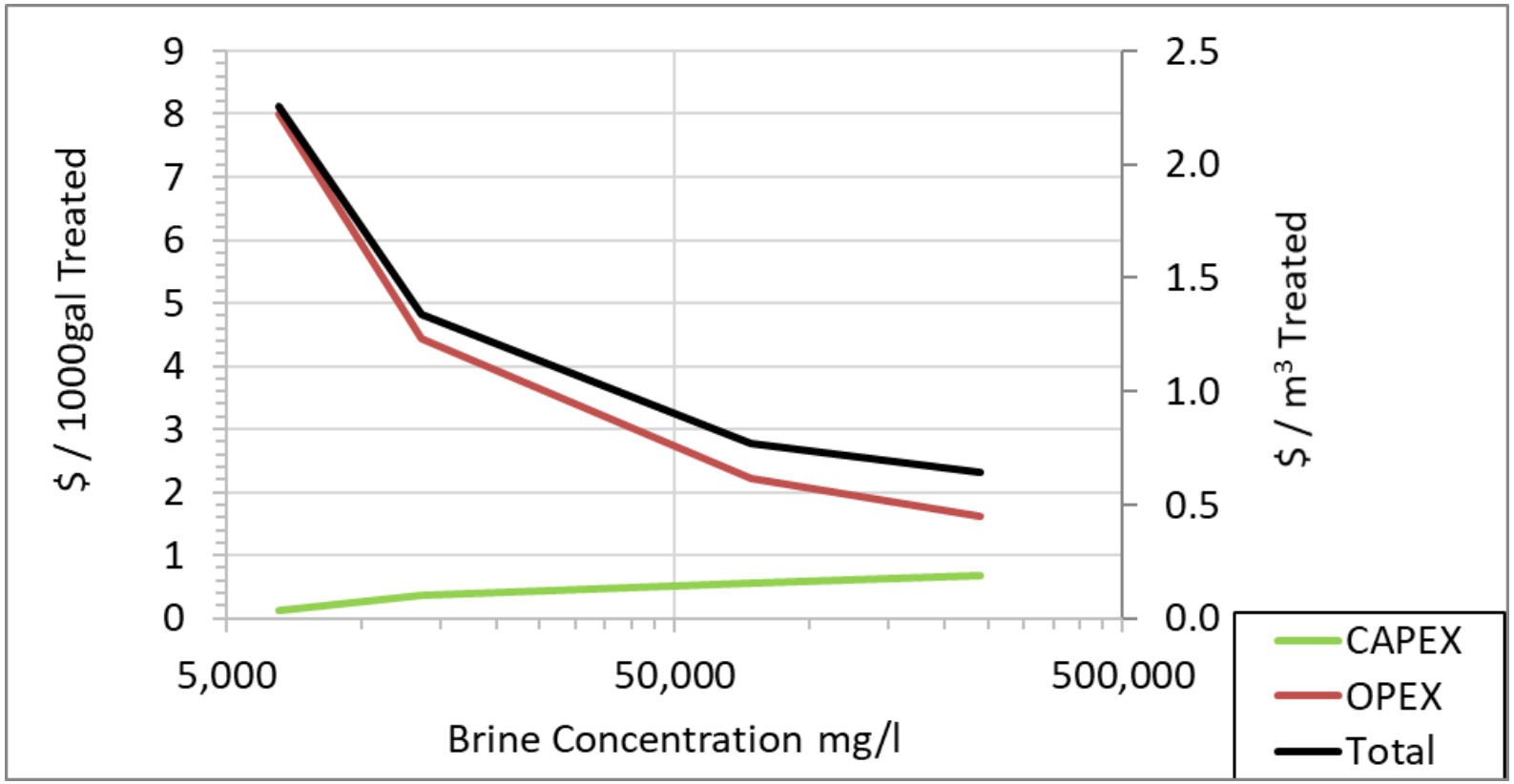
99.6% recovery = 150x concentration factor

Cost of Water Treatment – Industrial & Brackish Desalination



Projected Costs

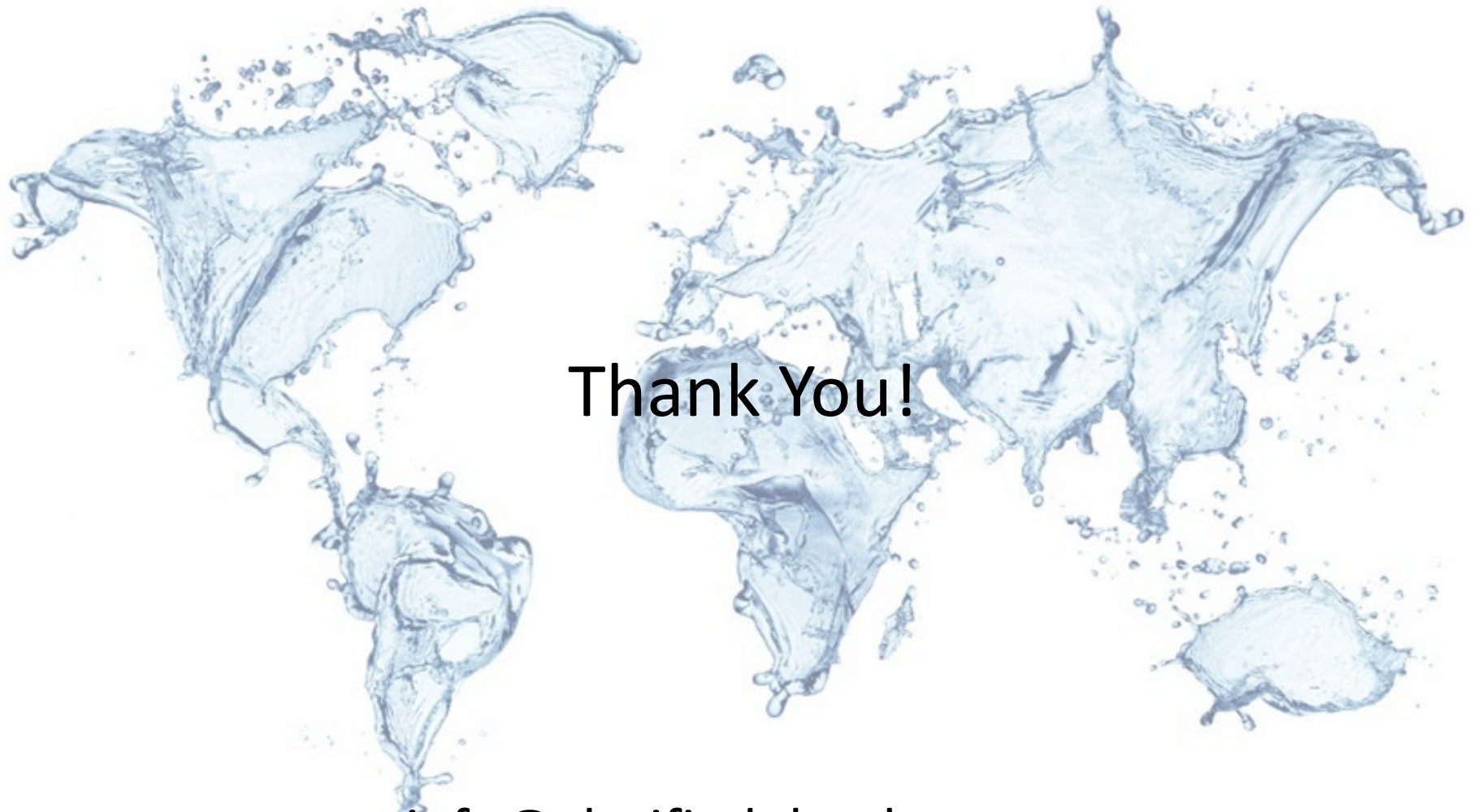
Cost of Water Treatment – Including Brine Disposal



Projected Costs

IMPLICATIONS

- Membrane brine desalination + softening
- Final TDS = up to saturation
- Chloride reduction = water reuse or desalination
- Saline sources that could not previously be used now can be
- Power, mining, textiles, electronics, pharmaceuticals, food & beverage, inland desalination
- Seawater desalination: double plant capacity with no new intake, outfall or pre-treatment costs



Thank You!

info@glorifiedplumber.com