Hazen

Brine/Concentrate Management Technologies and Trends

Troy Walker – Hazen and Sawyer

Acknowledgements

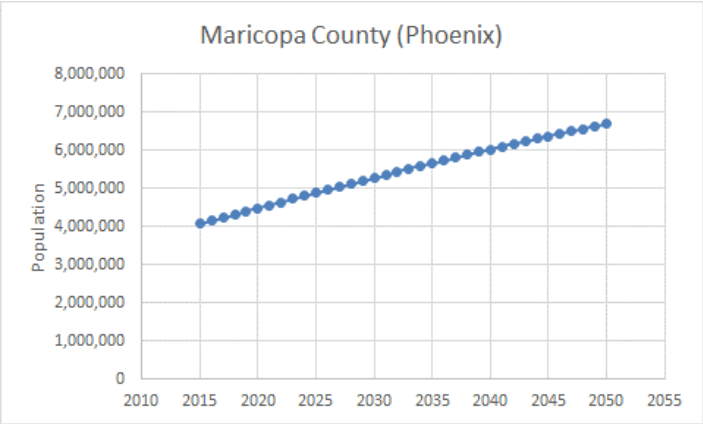
Kevin Alexander
Hazen and Sawyer

Rick Stover
Gradiant

Buddy Boysen
Hazen and Sawyer

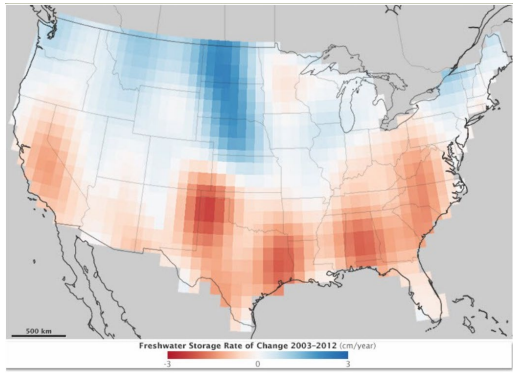
Agenda


Introduction
Current State of Market
Concentrate Minimization
Concentrate Disposal
Salt Recovery
Questions



Population Growth

Earth Imaging Journal 2013

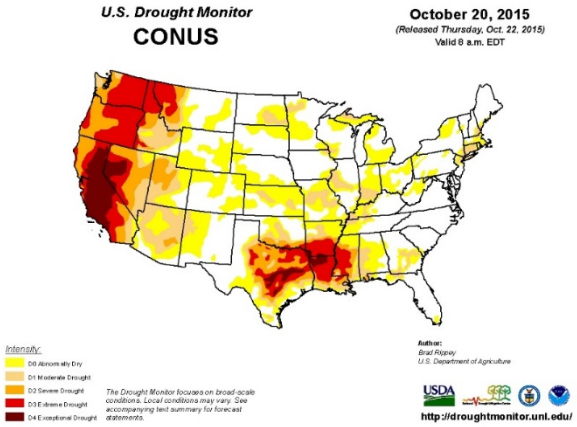


This map shows how water supplies have changed between 2003 and 2012. GRACE measures subtle shifts in gravity from month to month. Variations in land topography or ocean tides change the distribution of Earth's mass; the addition or subtraction of water also changes the gravity field.

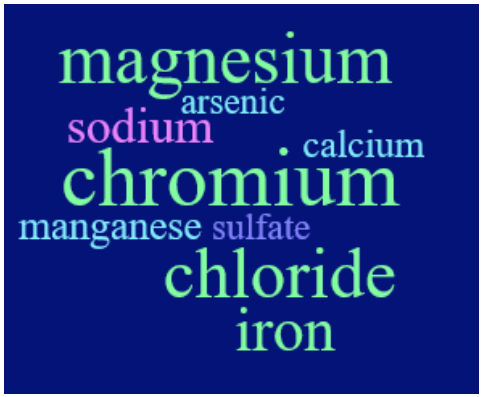
Fresh Water Reduction

Alternative Supplies Required

Drought

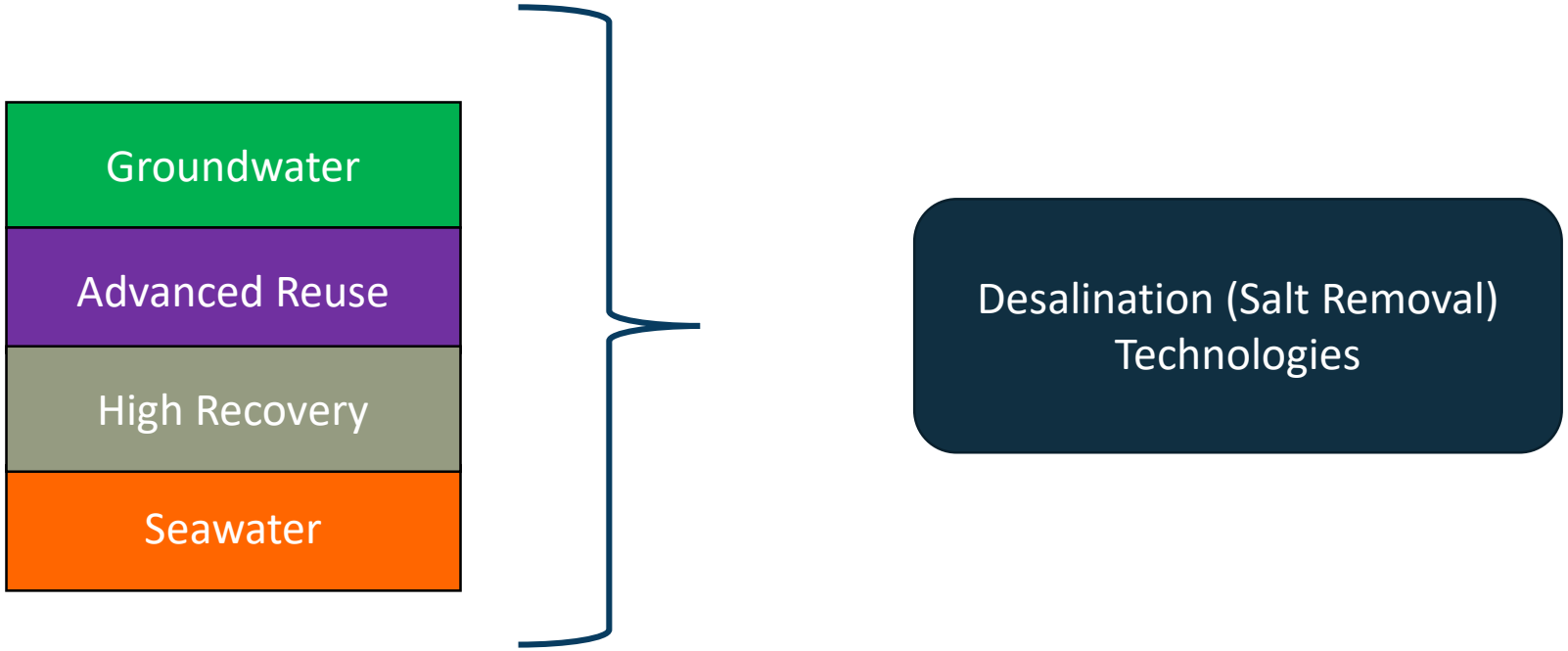


Challenging water quality

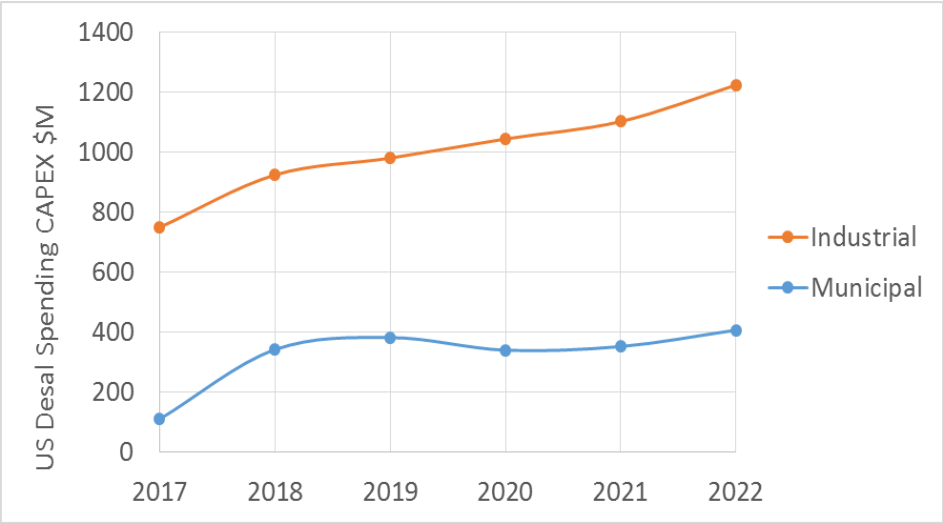


Considerations for Sustainable Water

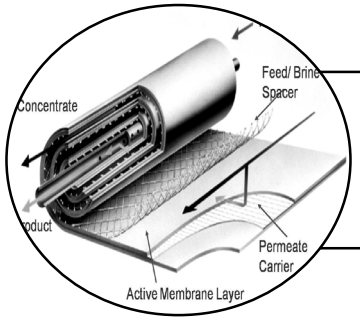
Simple Costs	Sustainable
Traditional Recycled	Conservation
Imported	Traditional Recycled
Conservation	Groundwater
Groundwater	Urban Runoff
Advanced Reuse	Advanced Reuse
High Recovery	High Recovery
Seawater	Seawater
Urban Runoff	Imported


Groundwater
Advanced Reuse
High Recovery
Seawater
Desalination (Salt Removal) Technologies

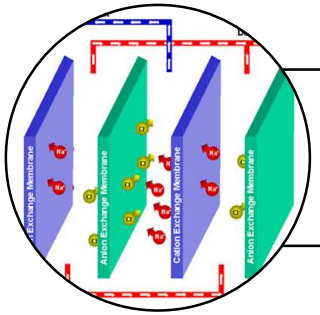
Solid Growth in Desalination Application



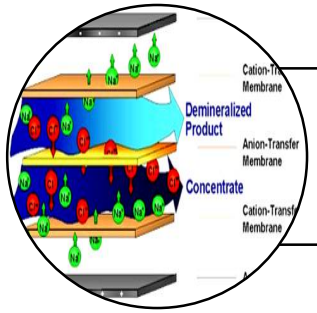
Salt Removal Technologies



Reverse Osmosis

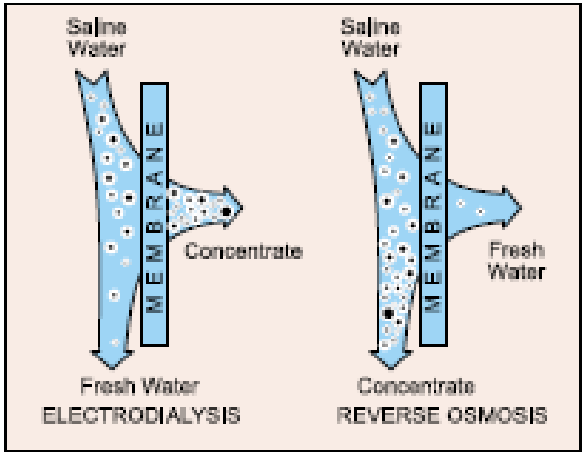


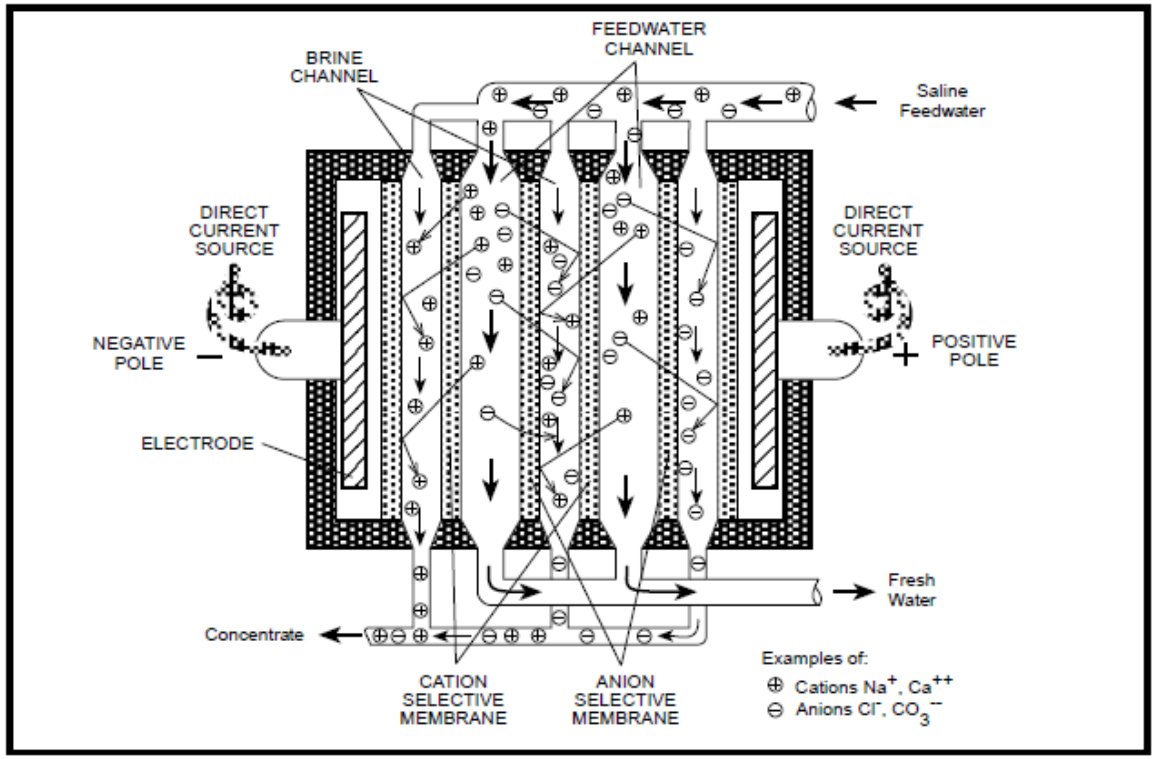
Electrodialysis



Electrodialysis Reversal

Electrodialysis

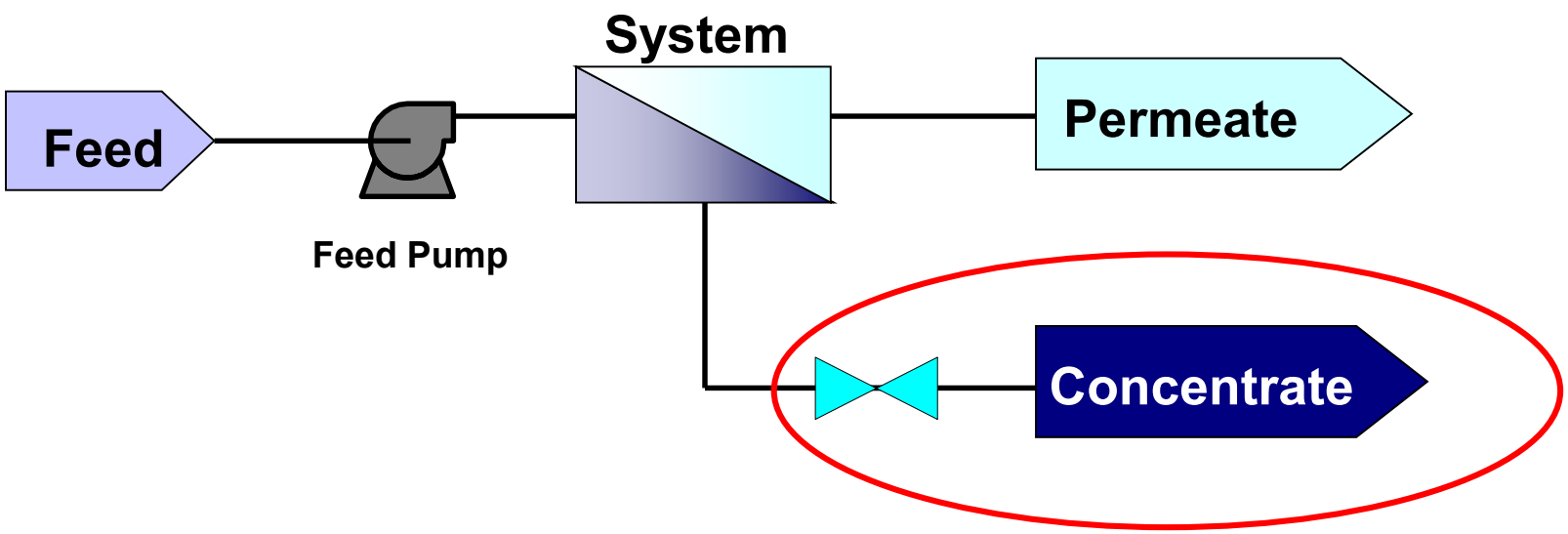




Movement of ions in the electrodialysis process *USAID*

What Do Technologies Have in Common?

- Low TDS (total dissolved solids) Product Water
- 75-85% of Flow
- Concentrated Saline Waste Stream
- 15-25% of Flow is concentrate waste



Why so much concentrate ?

Scaling

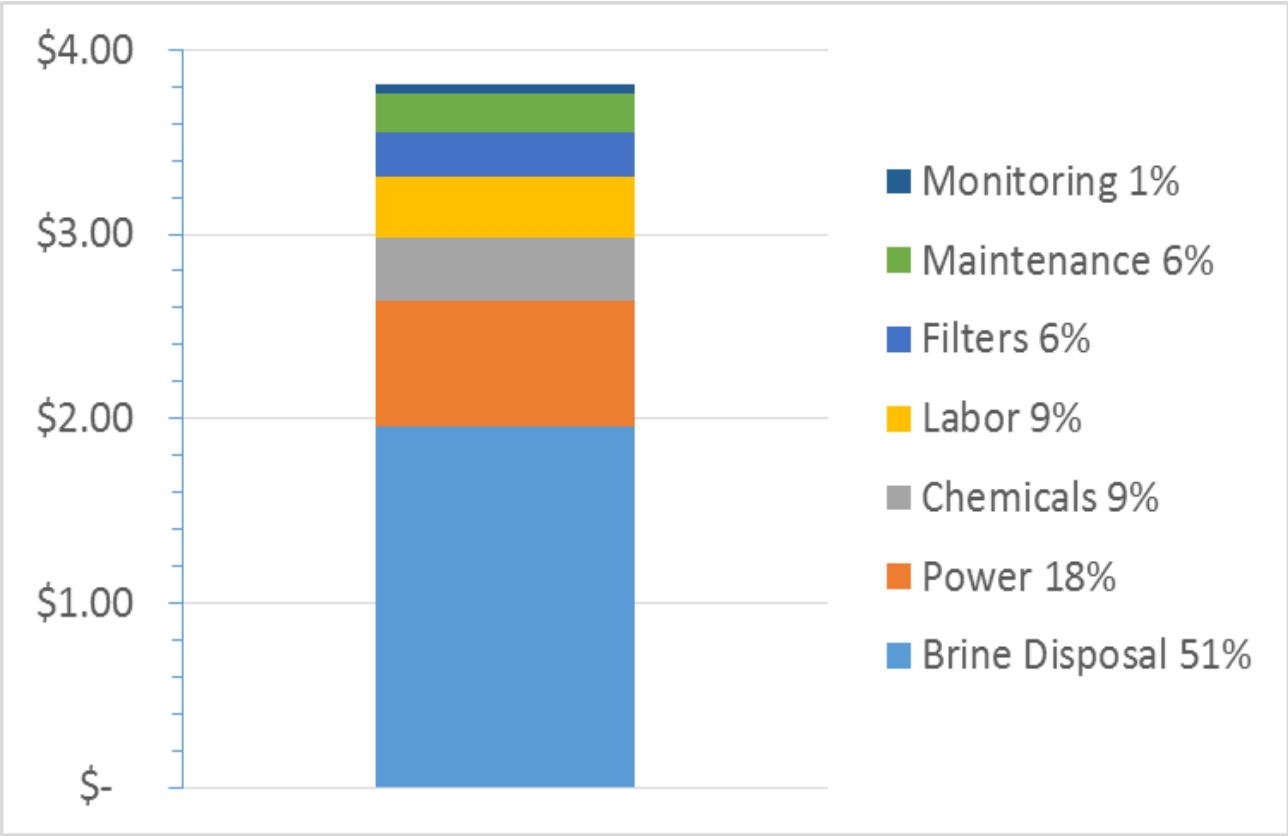
Main culprits:

- Alkaline scales: $CaCO_3$ / $Mg(OH)_2$
- Non-alkaline: $CaSO_4$
- Sparingly soluble: $BaSO_4$/$SrSO_4$/CaF_2
- Silica (gel & colloidal)
- $Ca_3(PO_4)_2$ – (Water Reuse)

Control techniques:

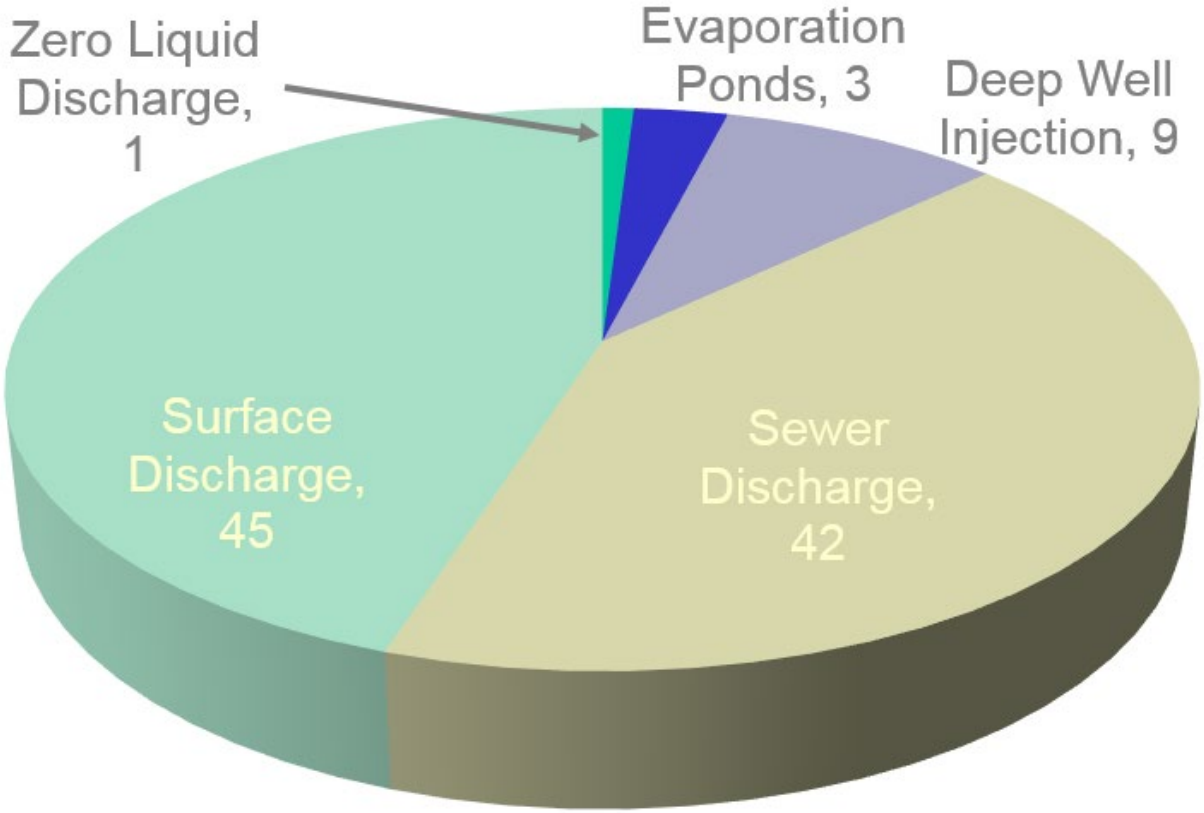
- Antiscalant (threshold inhibitor)
- pH Control (usually acid dosing)
- Limit maximum recovery

For Inland Systems Disposal Can be Highest Cost



Inland desalination operating cost per 1000 gallons of RO permeate - RO with brine disposal to sewer at average US commercial sewage tariffs.

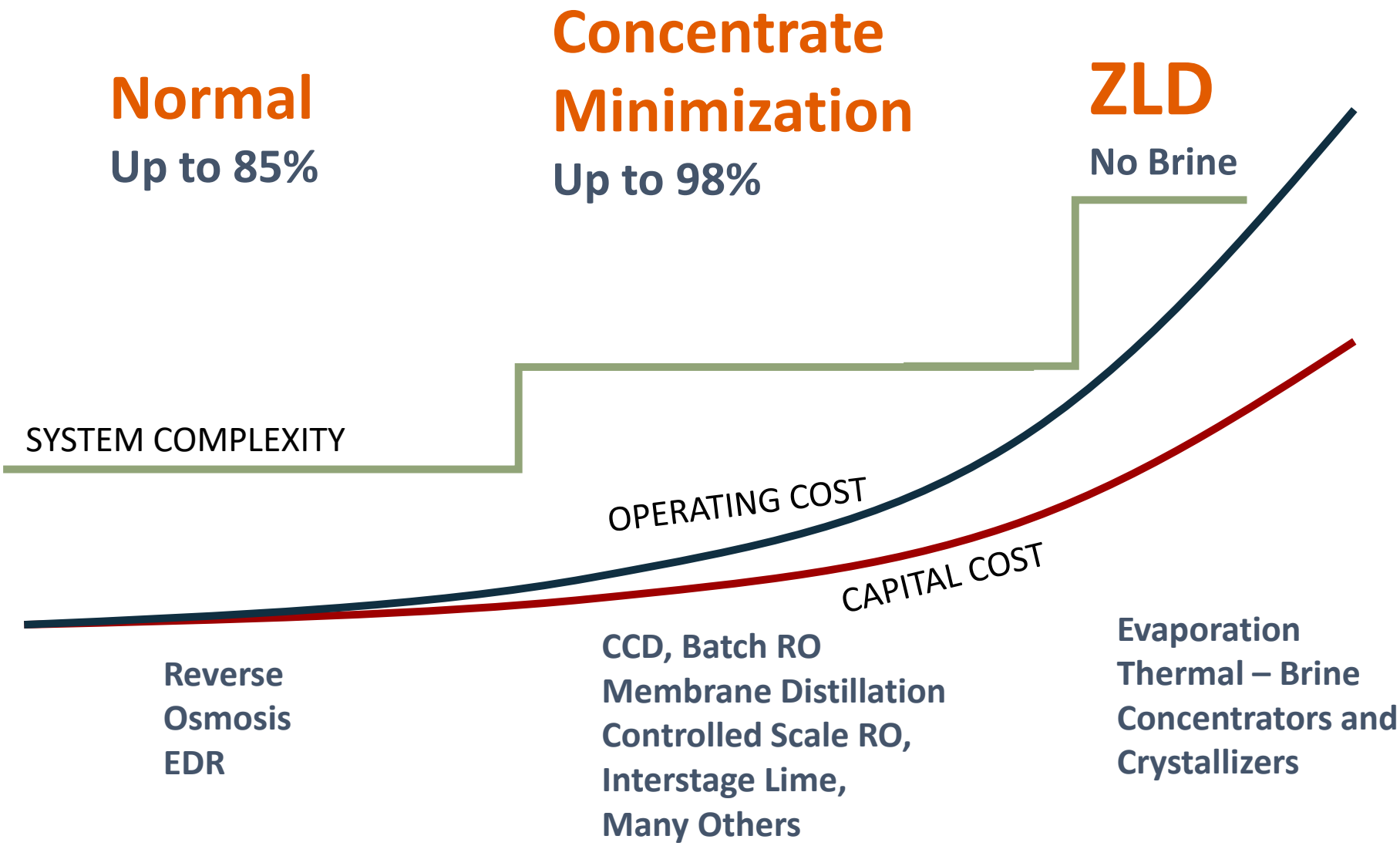
What do we do with Concentrate (Brine) in the USA?



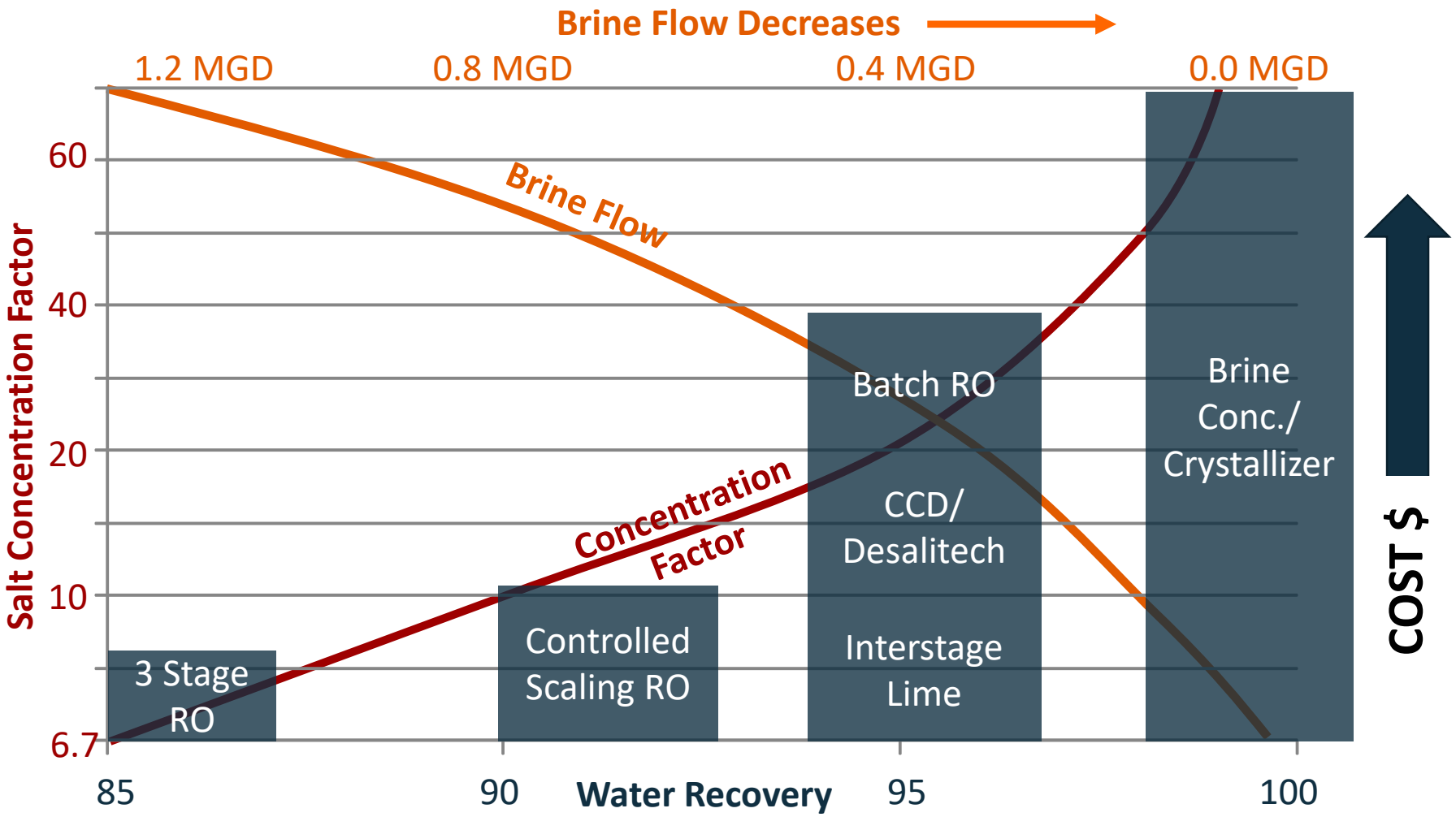
US Concentrate Disposal

Mickley, 2003

Costs of Increasing Recovery



What Does Increasing Recovery Cost ?

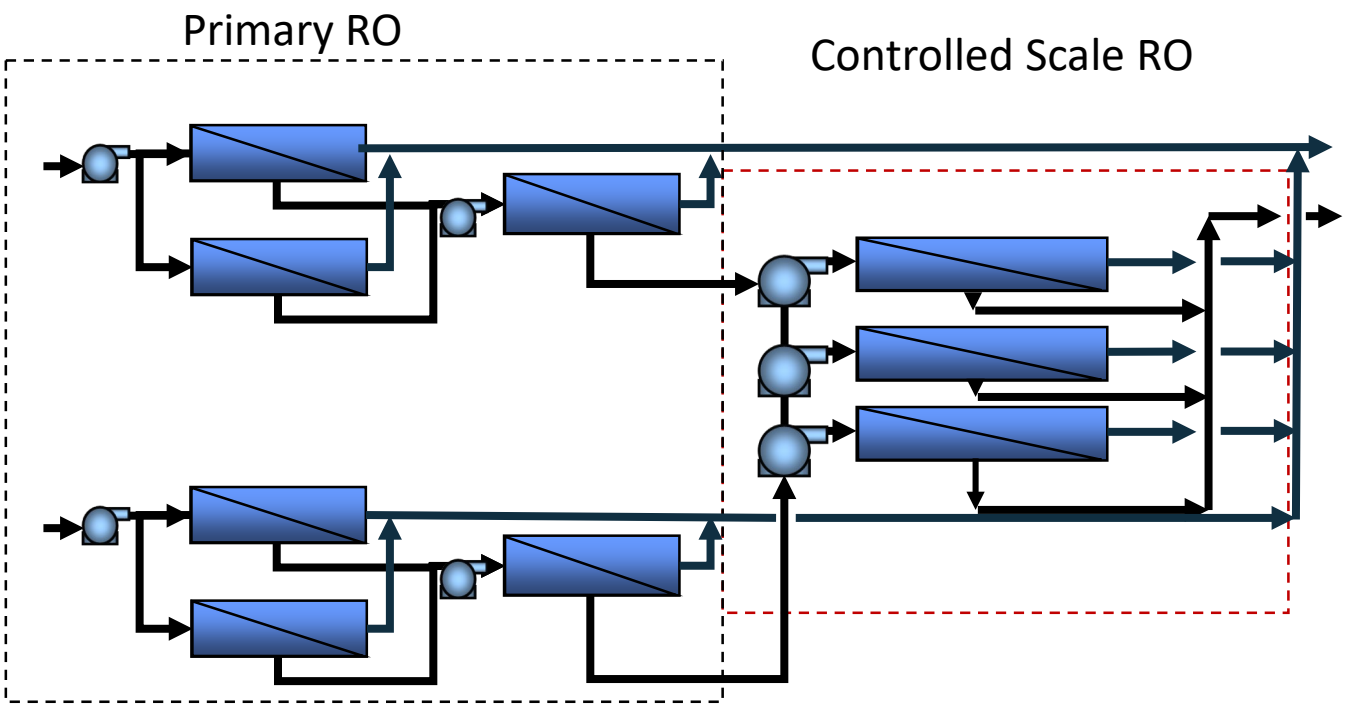


Minimizing the Concentrate

Strategies to Increase Recovery

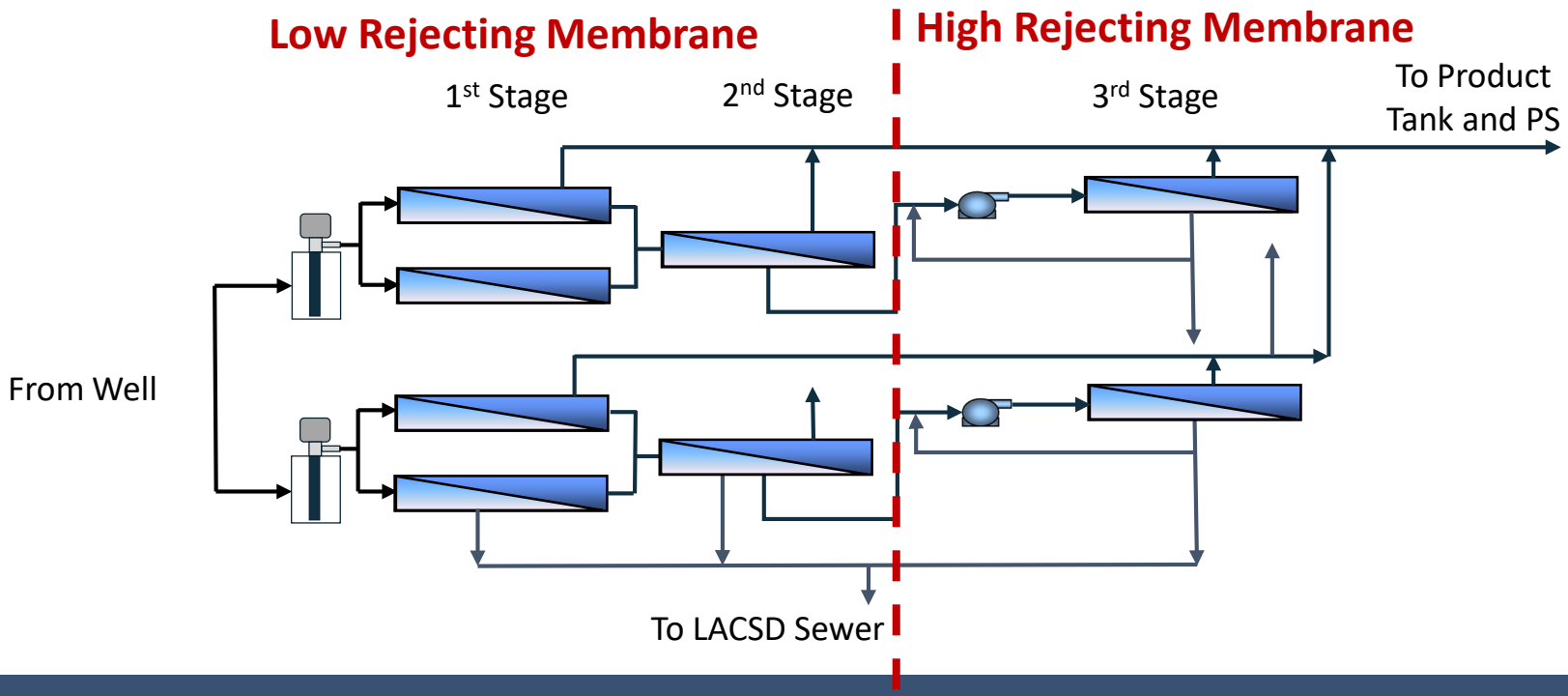
Controlled Scaling RO

- Achieves 93% water Recovery – WRD Vander Lans, CA
- Scale is controlled by permeate flushing
- Dispose of membranes every 2 years



Hybrid Membrane NF

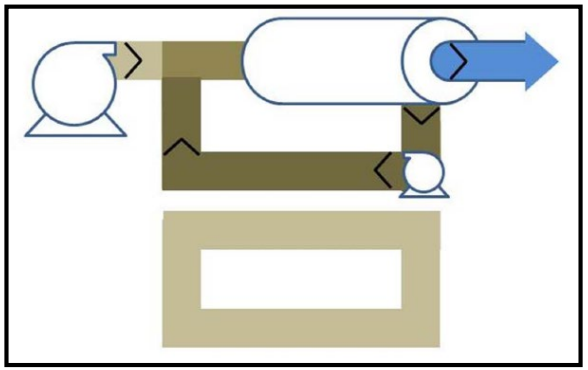
- Achieved 98% Recovery – Signal Hill, CA
- Scale is controlled by passing salts in stage 1,2
- Stage 3 concentrates silica and CaCO3



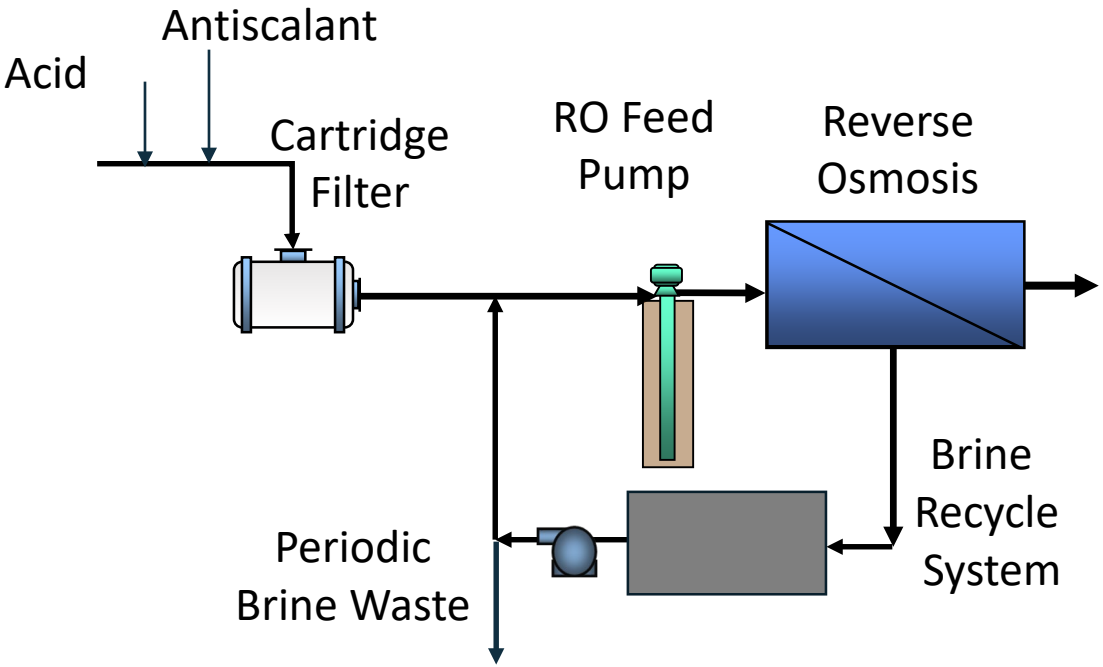
Signal Hill – Hybrid Membrane Approach

Closed Circuit Desalination(CCD)

- Achieving 96-97% Recovery on WW Effluent Conc.
- Pilots at Gila Bend, AZ, Padre Dam MWD

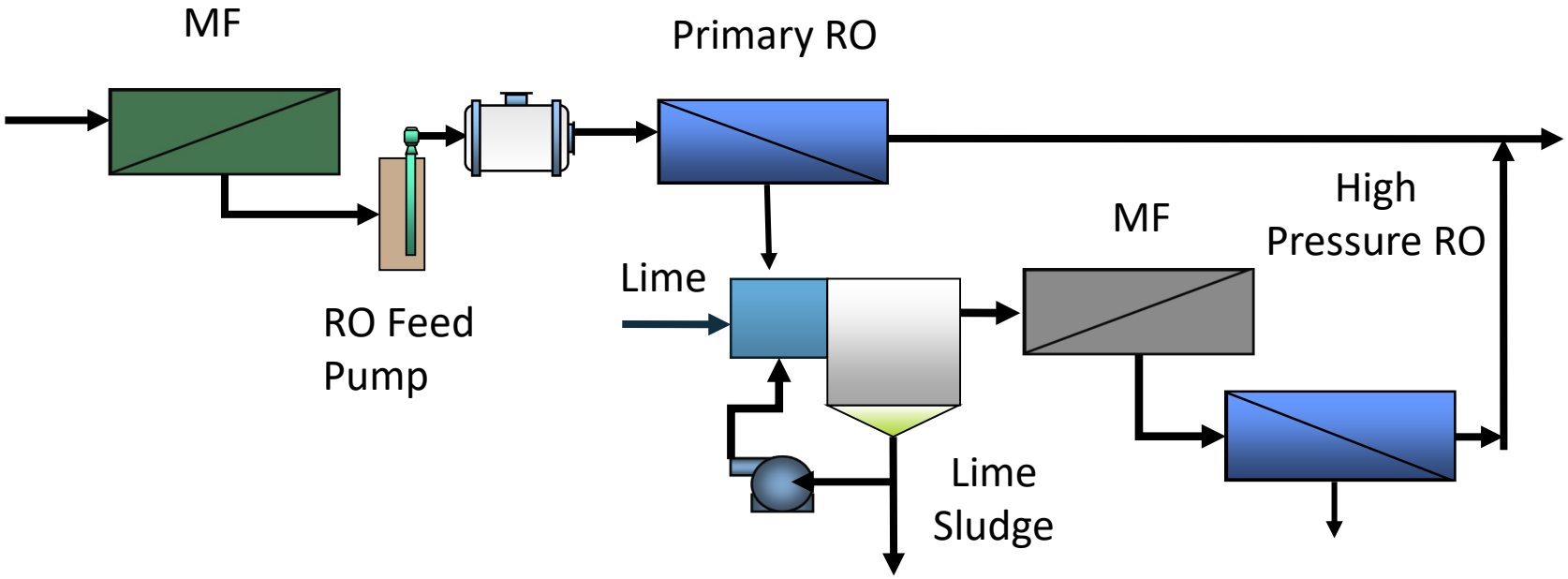


Desalitech
Advanced Desalination Technologies



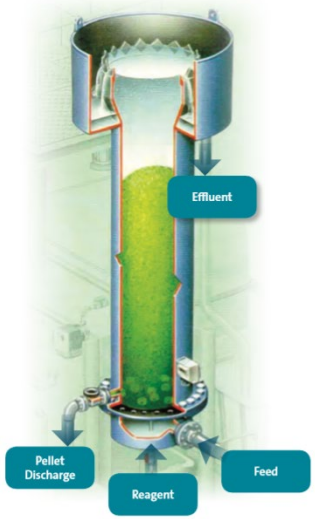
Interstage Lime

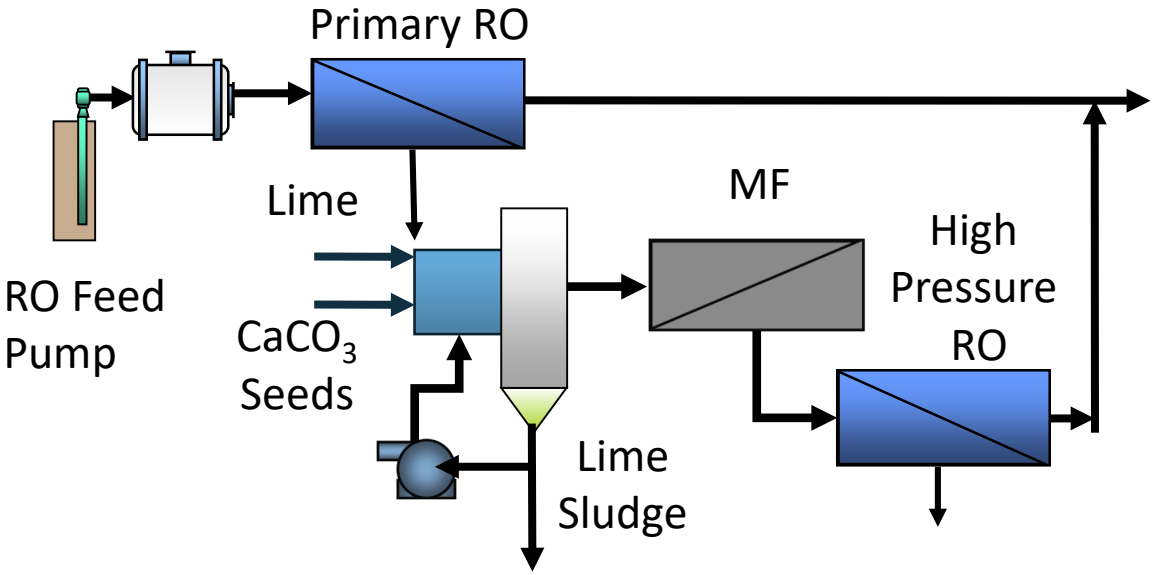
- Achieved 95% water Recovery – Phoenix Pilot
- Solids Contact Clarifier
- Silica Removal was better than predicted



Interstage Pellet Lime

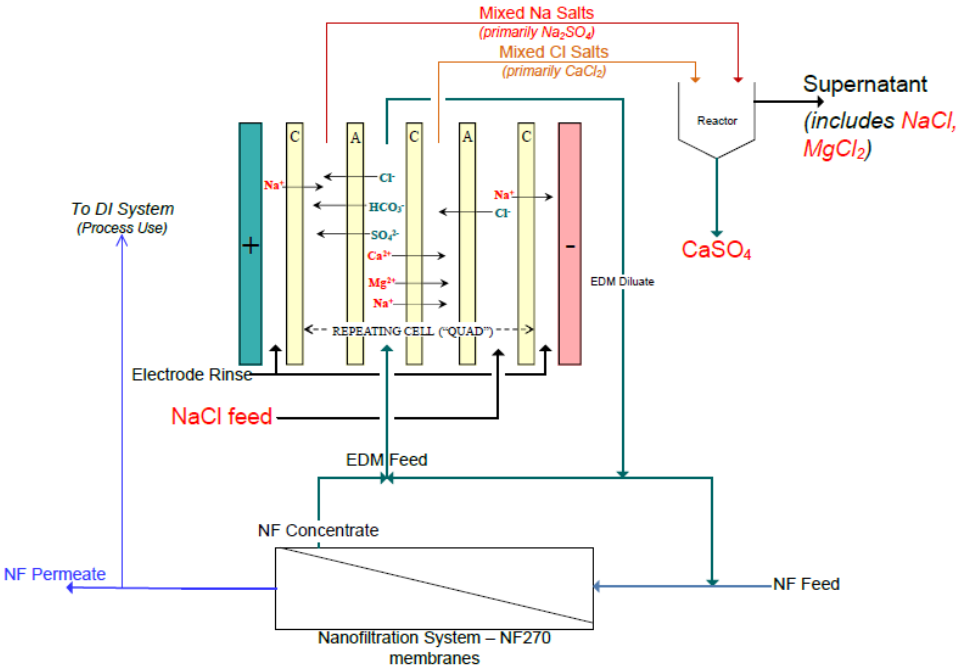
- Crystalactor – Interstage Lime Pellet
- Installed at Chino Desalter Authority – Chino, CA
- $50M for 1.7 MGD of Treatment





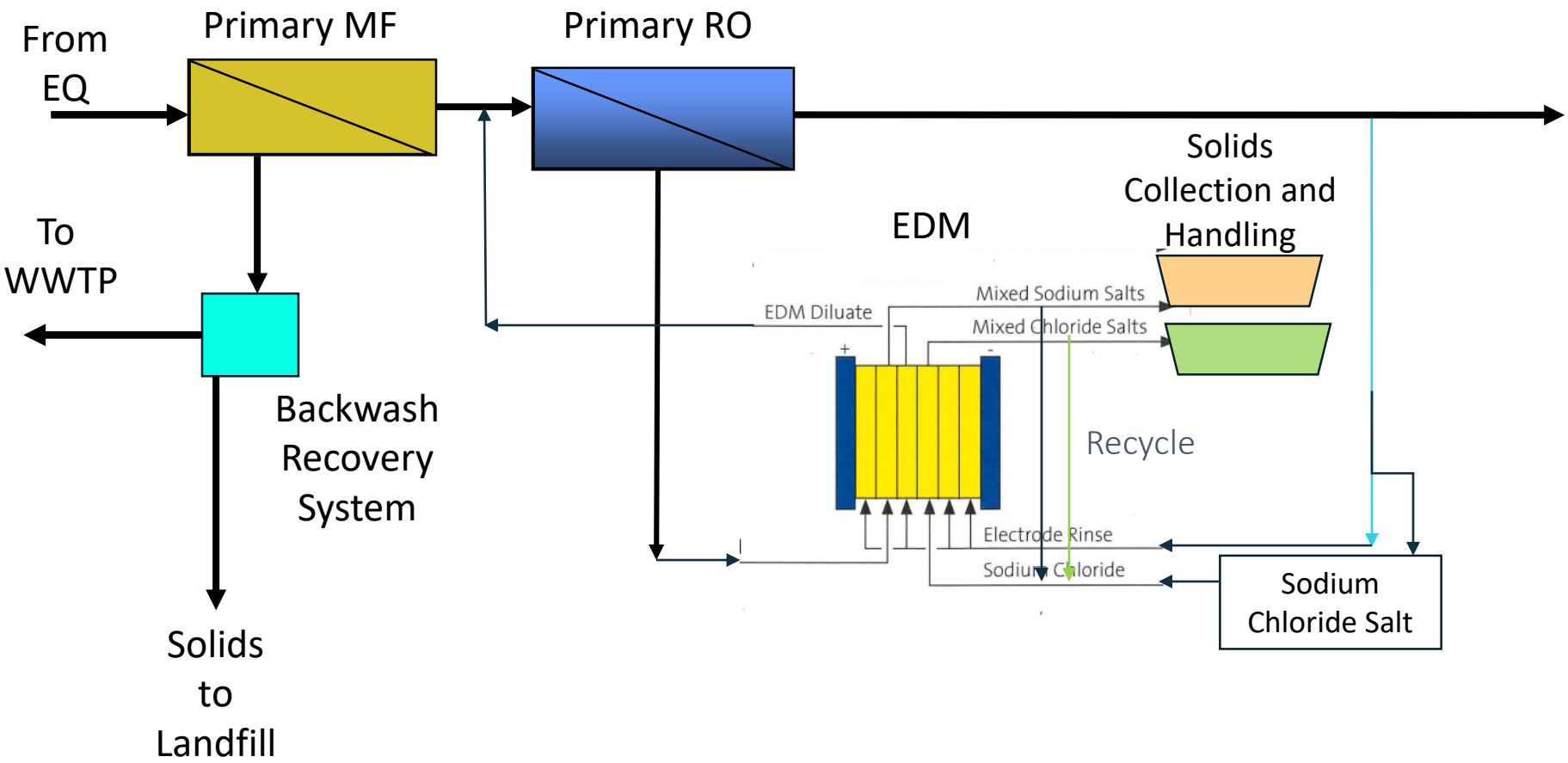
Zero Discharge Desalination (ZDD)

- Veolia/Kruger
- Dr. Tom Davis UTEP



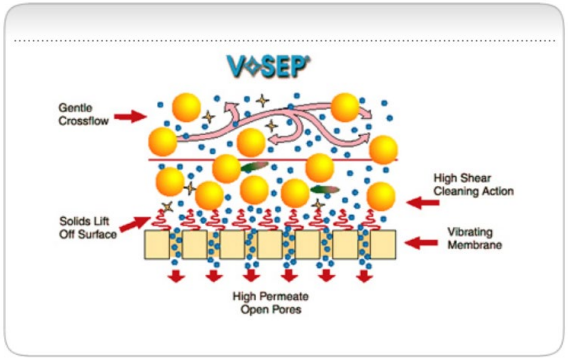
Capelle et al, AMTA 2013

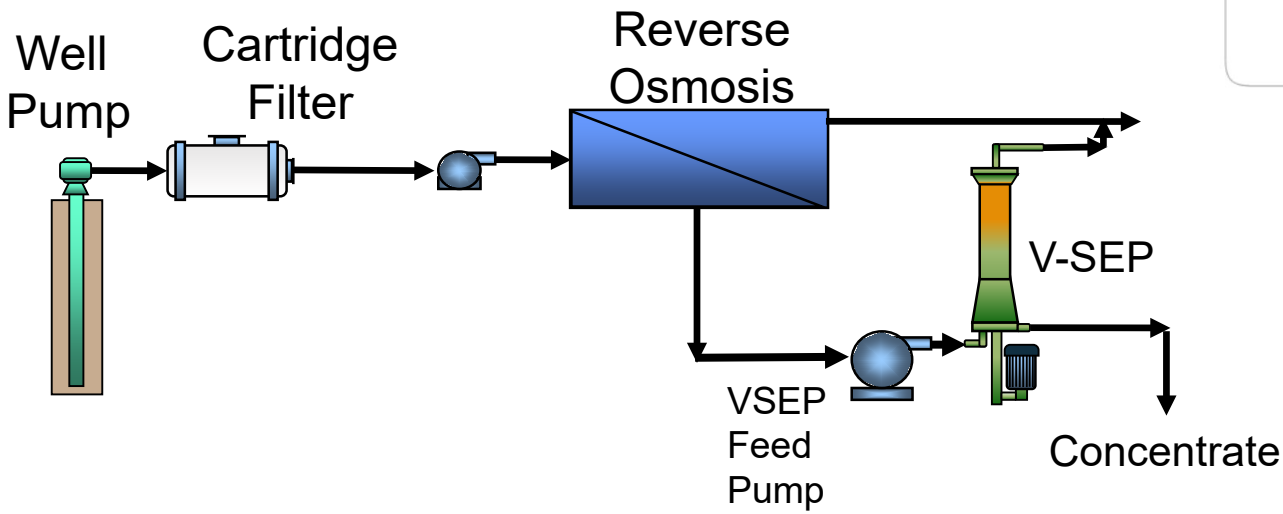
ZDD


From EQ
Primary MF
Primary RO
To WWTP
Backwash Recovery System
Solids to Landfill
EDM
Solids Collection and Handling
EDM Diluate
Mixed Sodium Salts
Mixed Chloride Salts
Recycle
Electrode Rinse
Sodium Chloride
Sodium Chloride Salt

Vibratory Shear Enhanced Process (V-SEP)

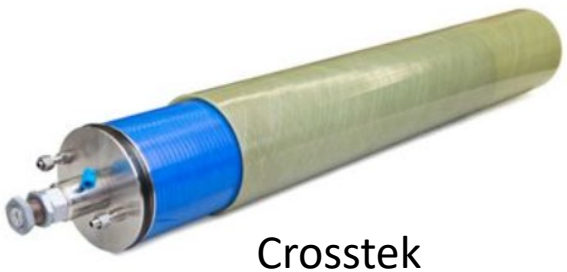
- Use proprietary vibration to reduce boundary layer
- Tested by USBOR in Tucson



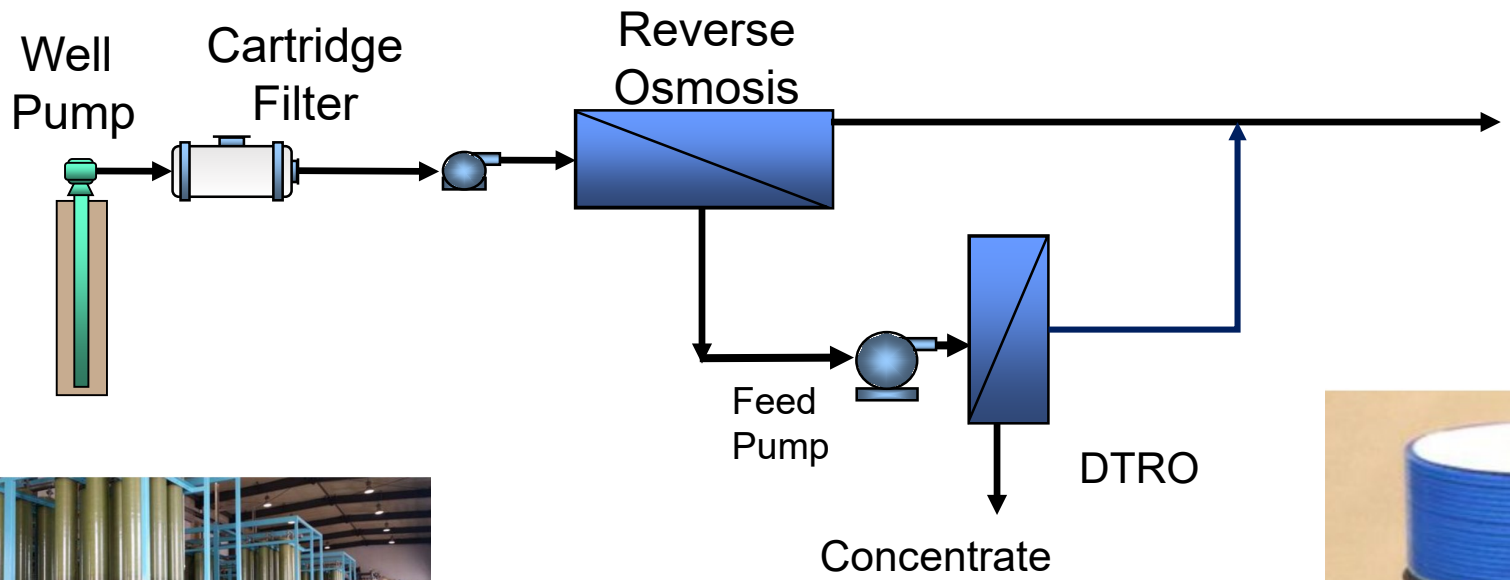


Disc Tube Reverse Osmosis

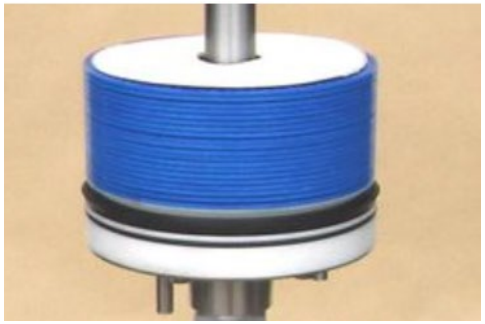
Used currently in landfill leachate



Crosstek

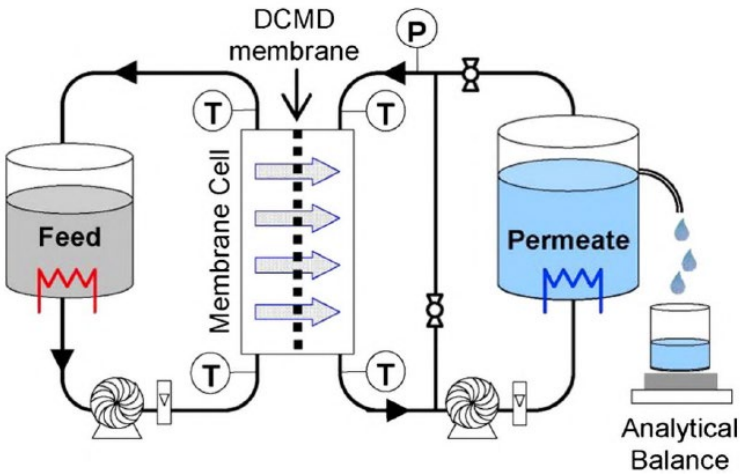


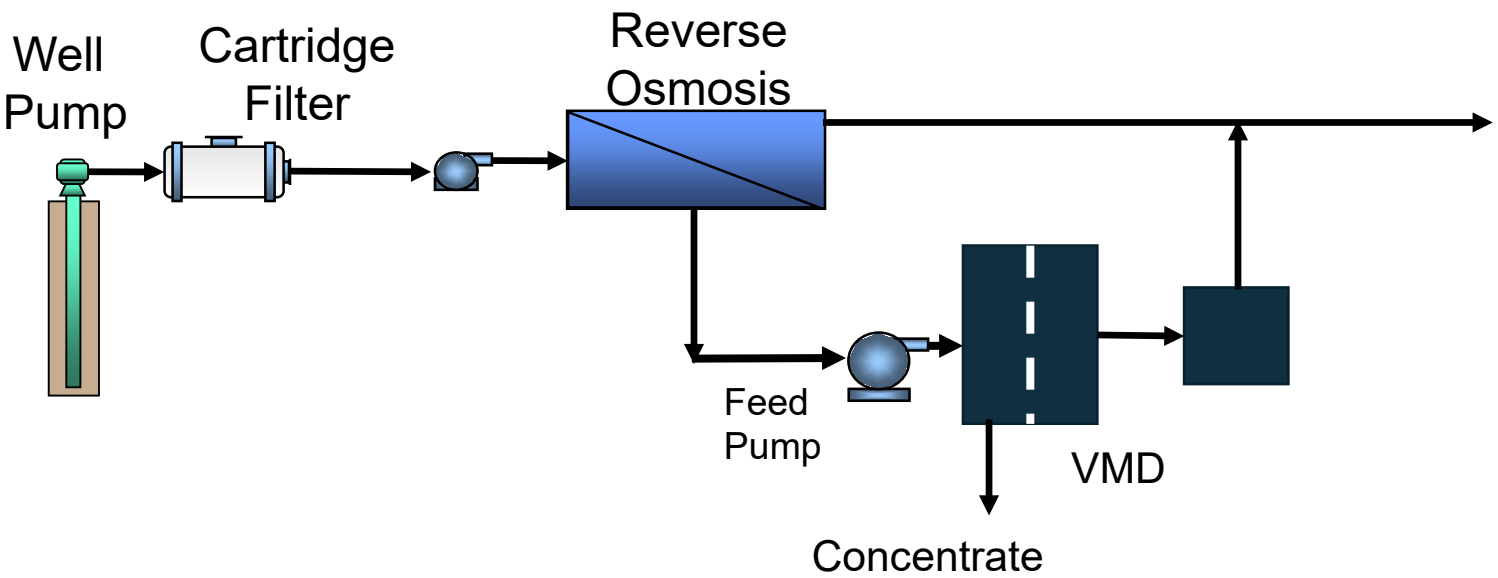
Crosstek



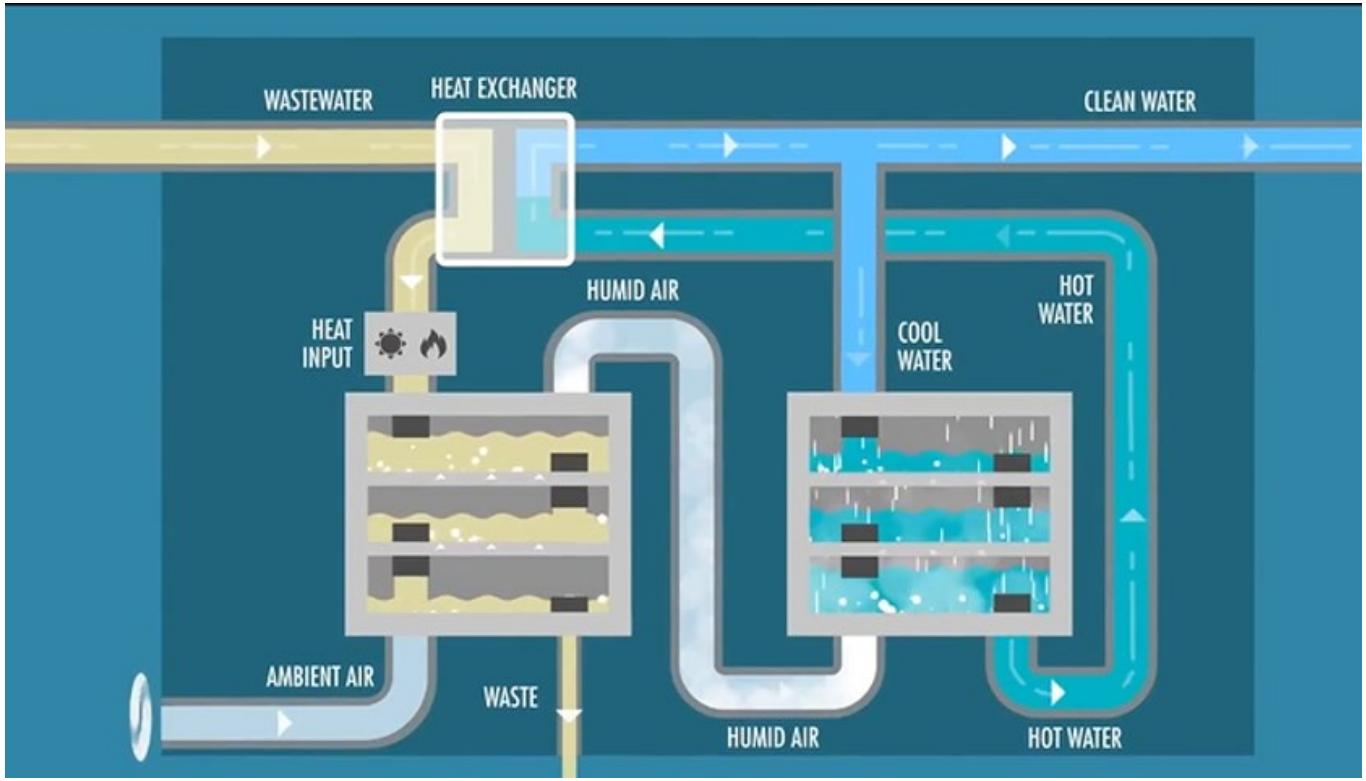
Membrane Distillation

- Use Temperature Differential





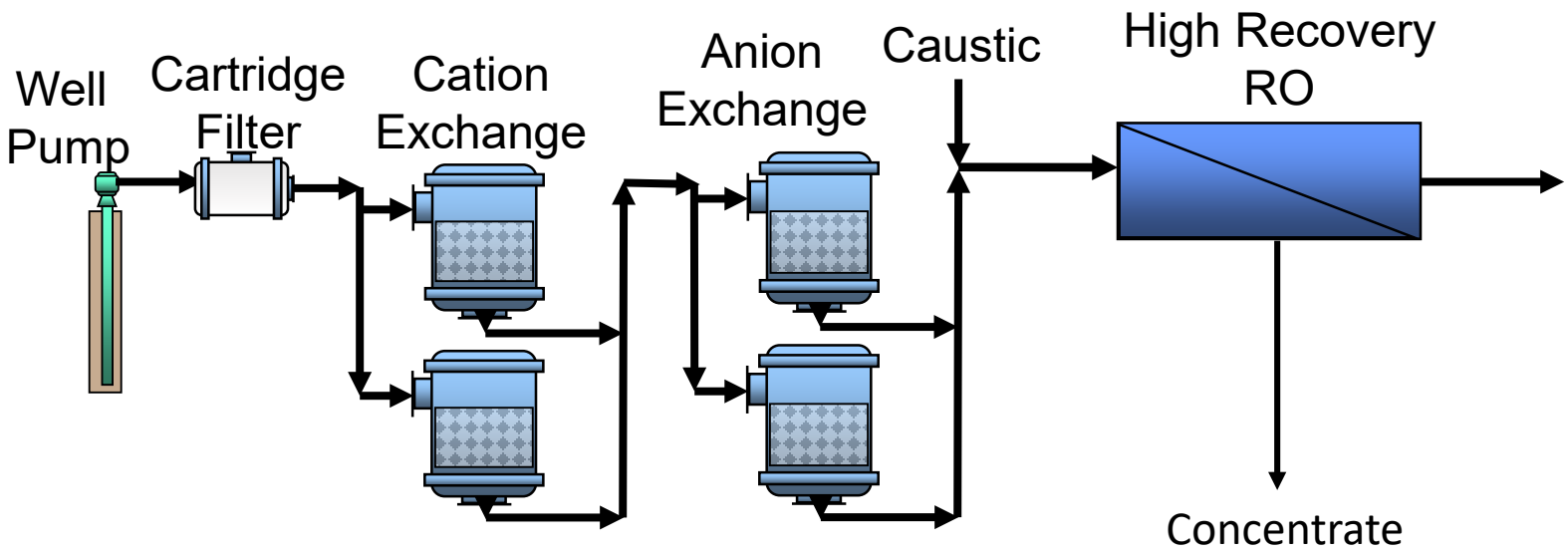
Humidification - Dehumidification



Gradiant – Carrier Gas Extraction

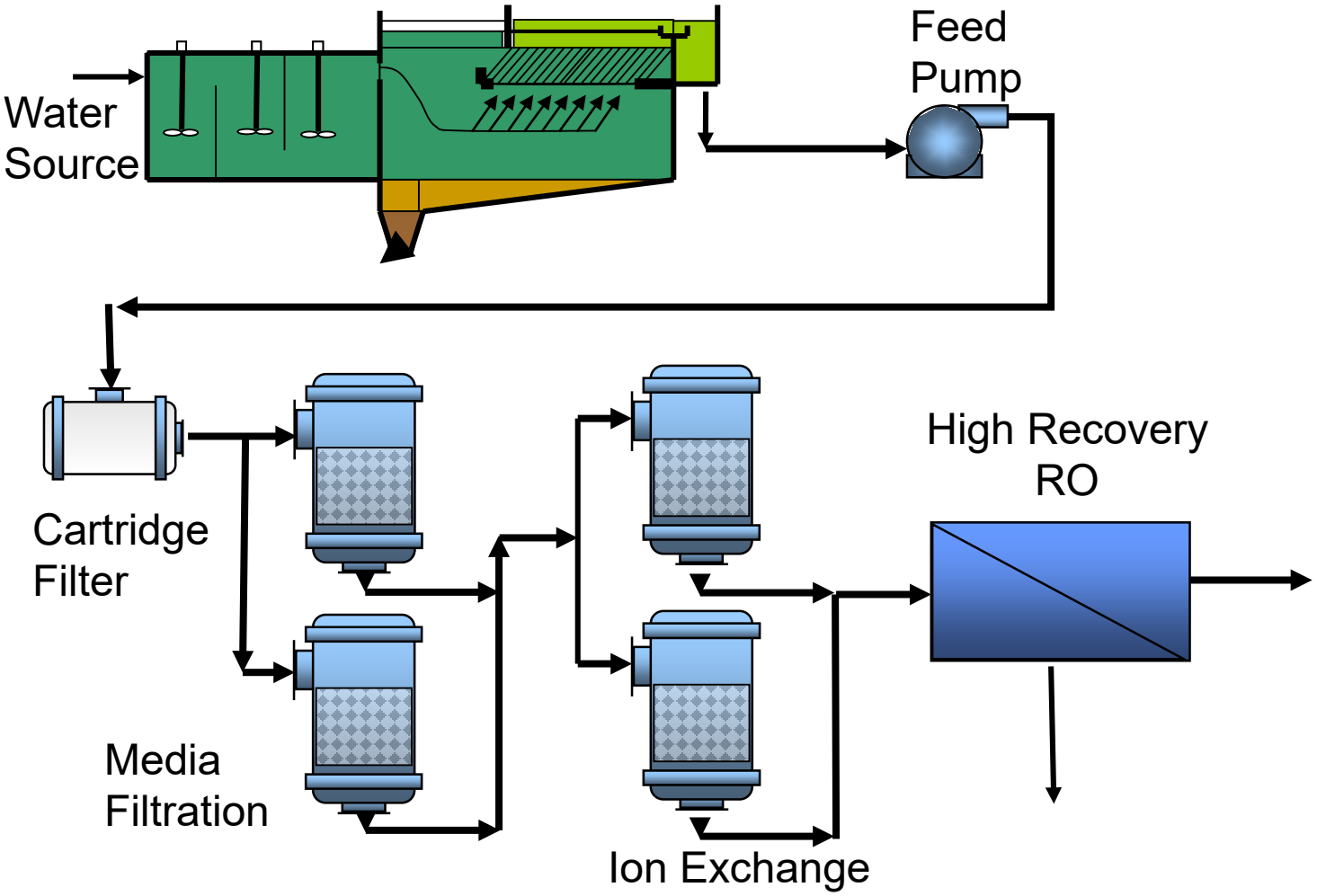
High Efficiency RO HERO™ by Aquatech

- Remove Cations first, then Anions
- Caustic to keep silica in solution
- 98% or greater

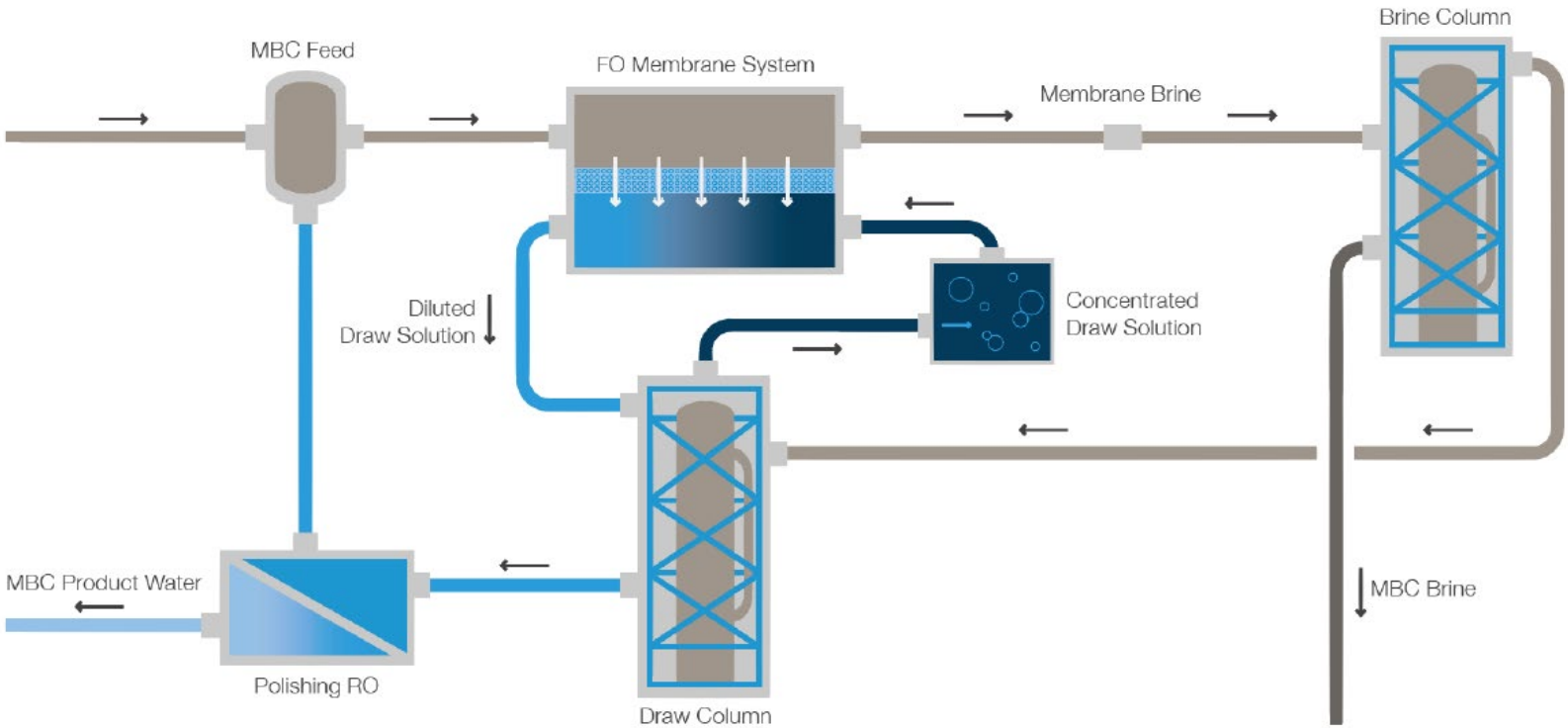


HERO is a registered trademark of Debasish Mukhopadhyay

OPUS ™ - Kruger Process



Forward Osmosis



Pendergast, 2018 (Oasys)

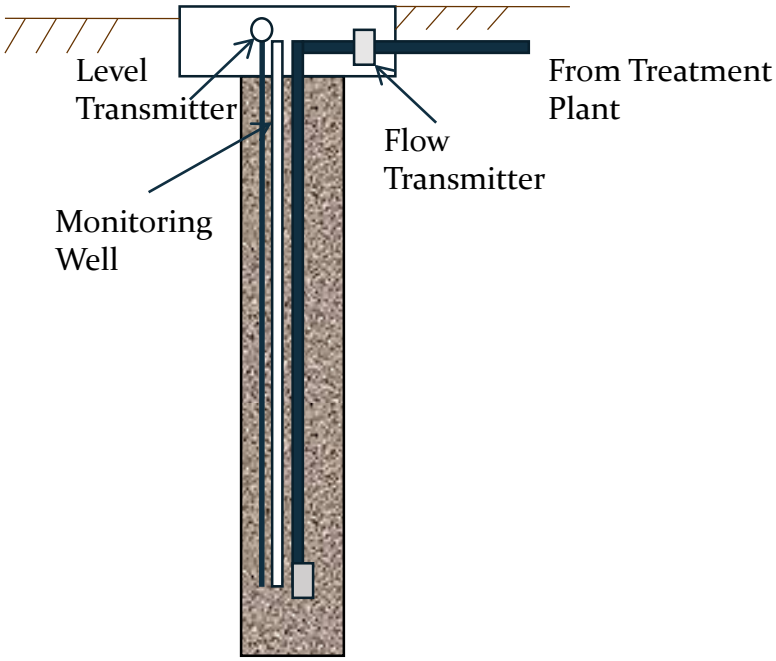
Mostly Oil and Gas

Concentrate Disposal

Concentrate Pipelines

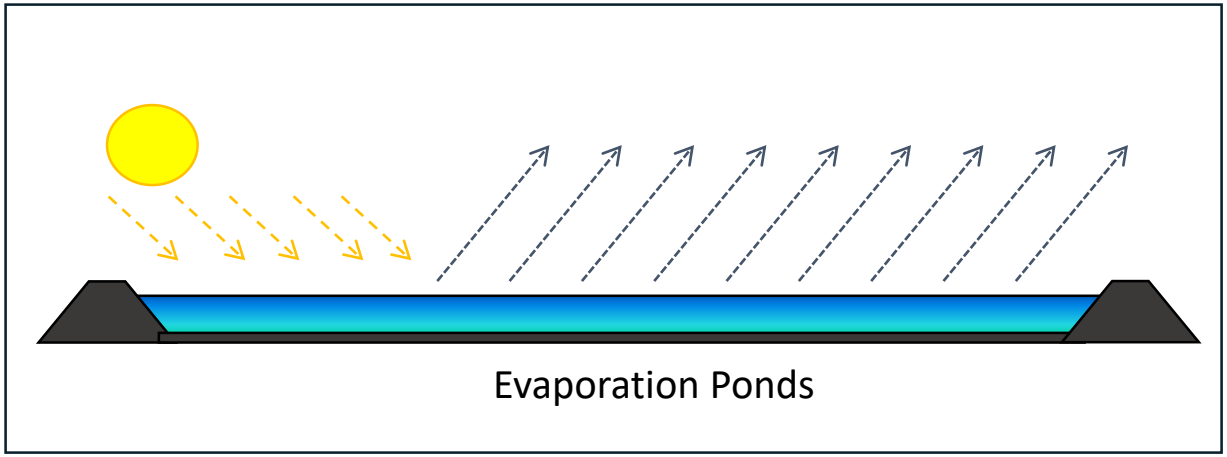
Deep Well Injection

- El Paso has injection for K. Bailey Hutchison RO Plant
- 22 miles from plant
- 3 mgd
- 3,800 ft deep
- $19 M construction (20%)



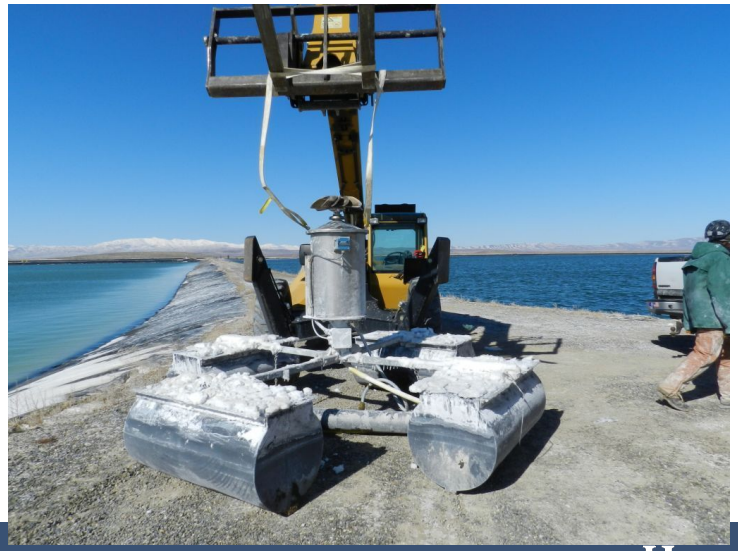
Pond Evaporation

- 1-2 inches per day in Arizona
- Intel – Chandler since 1996



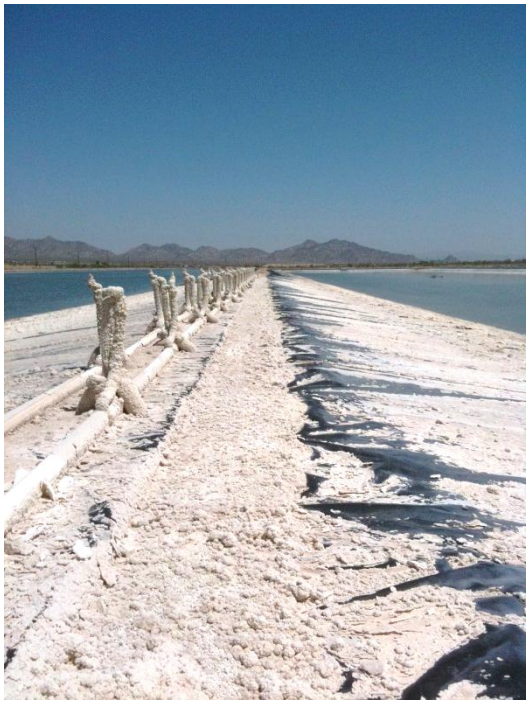
Semi Enhanced Evaporation

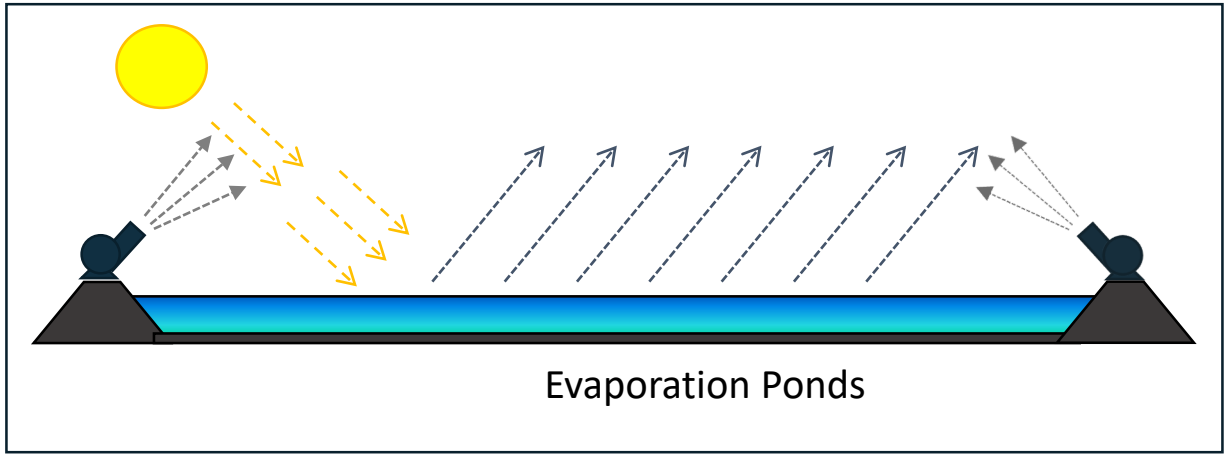
- 6 inches per day in Arizona
- Maintained by Equipment Vendors



Fully Enhanced Evaporation

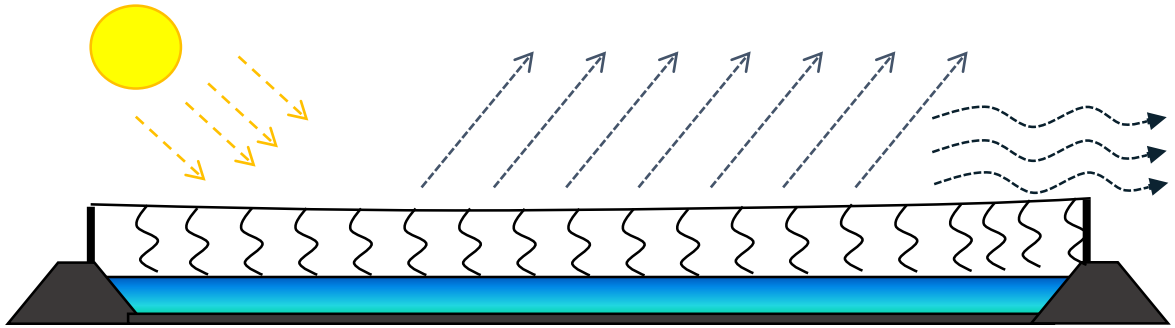
- Up to 30 times evapotranspiration





Wind Aided Evaporation

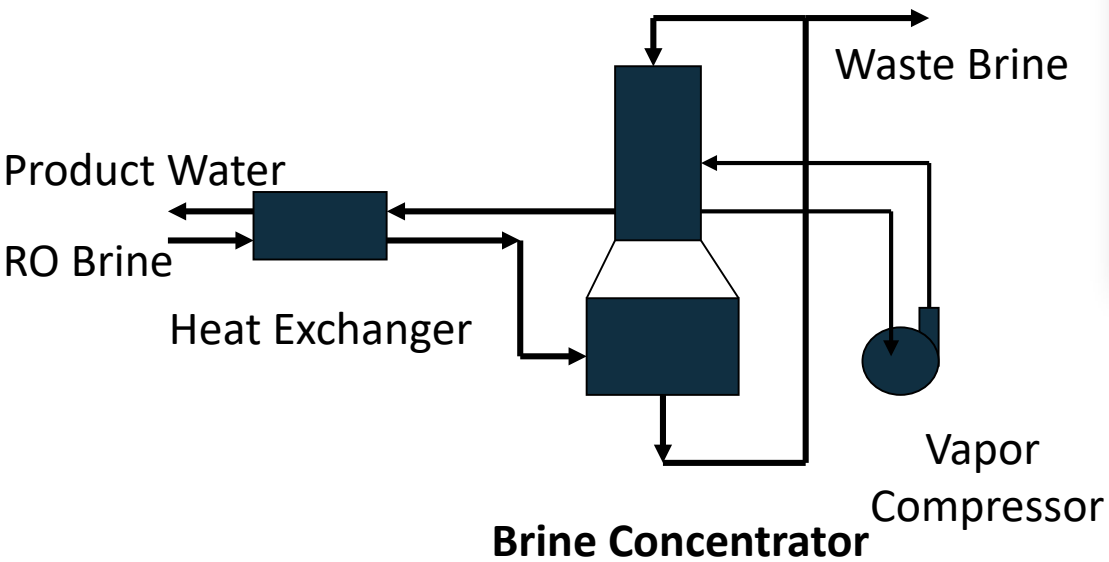
- Up to 20 time Eto
- Considering at Intel in Arizona



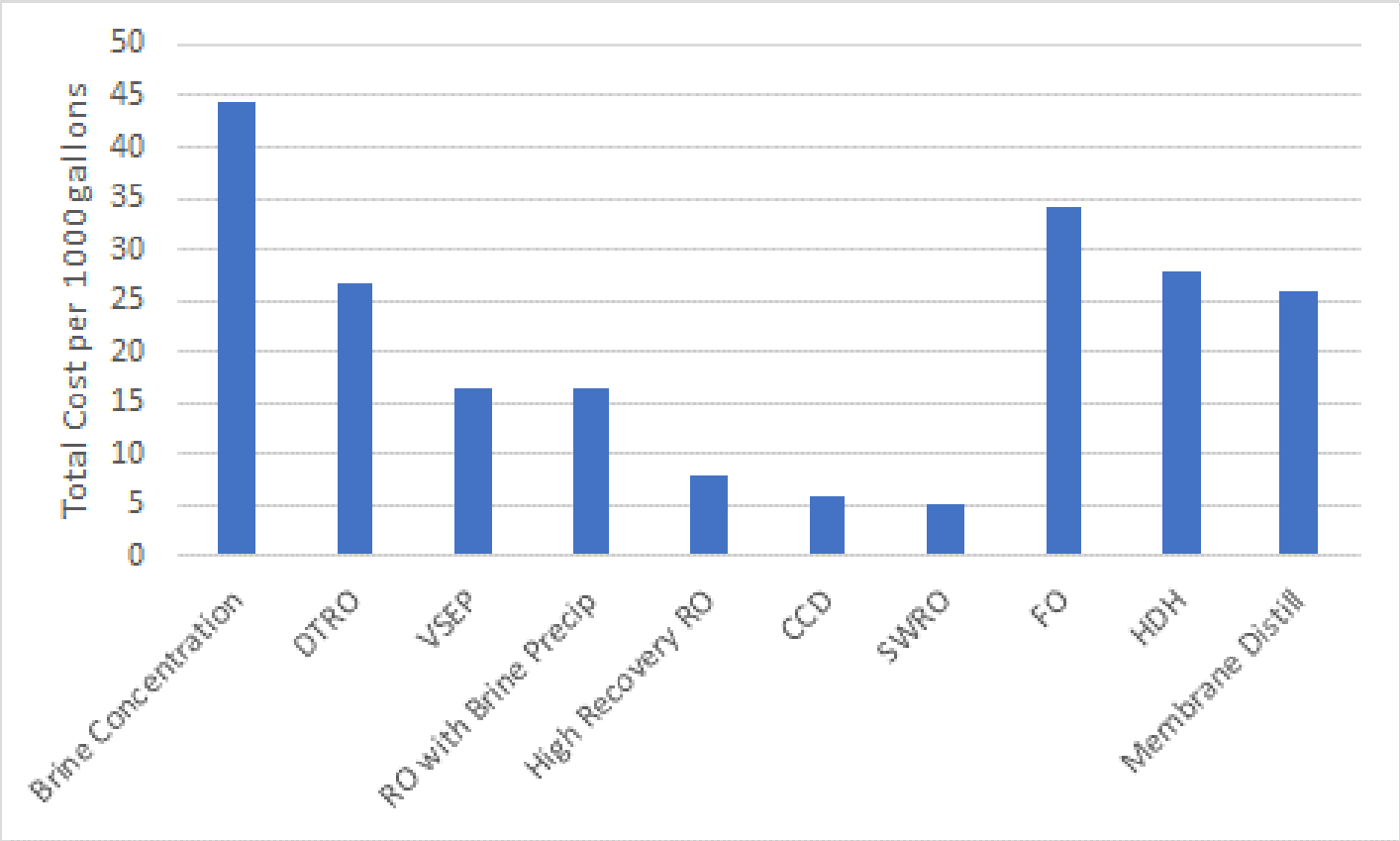
Evaporation Ponds

Concentrator Technologies

- Single Effect Evaporators/Multi-Effect Evaporators
- Thermal Vapor Recompression
- Mechanical Vapor Recompression



Typical Costs



Recovery of Products

Potentially Recoverable Salts

Salt	Price	Basis (Year)	Source
Calcium Carbonate (precipitated)	70-248	$/metric ton (2012)	Alibaba.com, 2012
Calcium Sulfate (gypsum)			
Crude	7	$/metric ton (2011)	Crangle, 2012
Calcined	30	$/metric ton (2011)	Crangle, 2012
Magnesium Hydroxide	603	$/metric ton (2011)	Kramer, 2011
Sodium Sulfate	180	$/ton (2011)	Kostick, 2012
Sodium Carbonate	260-285	$/ton (2011)	Kostick, 2012b
Sodium Chloride			
Solar Salt	60	$/ton (2011)	Kostick, 2012c
Rock Salt	32	$/ton (2011)	Kostick, 2012c
Brine	8	$/ton (2011)	Kostick, 2012c
Calcium Chloride			
Dry	250	$/ton (2005)	Fowlie, et al. 2011
Liquid	160	$/ton (2005)	Fowlie, et al. 2011

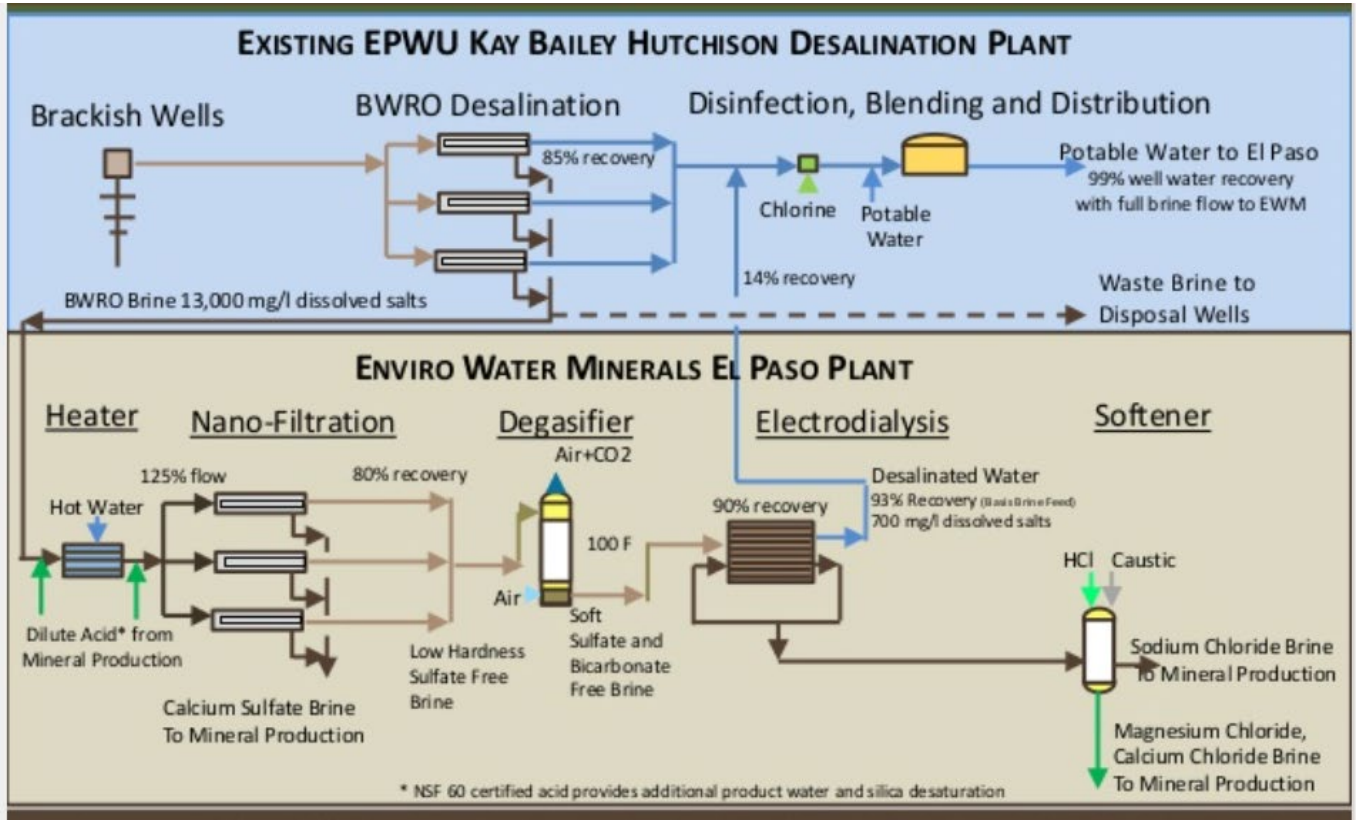
Capelle (UTEP) et al 2013.

Purity Requirements for Sale

Salt	Purity Requirements
Calcium Carbonate	• 96% as $CaCO_3$ • Less than 0.5% by weight of SO_4, Cl, and other constituents
Calcium Sulfate (gypsum)	• 75-85% as $CaSO_4$ for use in cement • $\leq$ 0.3% by weight of Na_2O, K_2O, and Mg_2O for use in wallboard • $\leq$ 100 ppm Cl
Sodium Sulfate	99% by weight as Na_2SO_4 for use in detergent
Sodium Carbonate	• 99% pure for use in glass industry • No Cl or Fe
Sodium Chloride	• 96% pure for use in rock salt • No SO_4, Ca, or Mg for use in chlor-alkali process
Calcium Chloride	• ASTM Standard D98 • Other limits are specific to the user

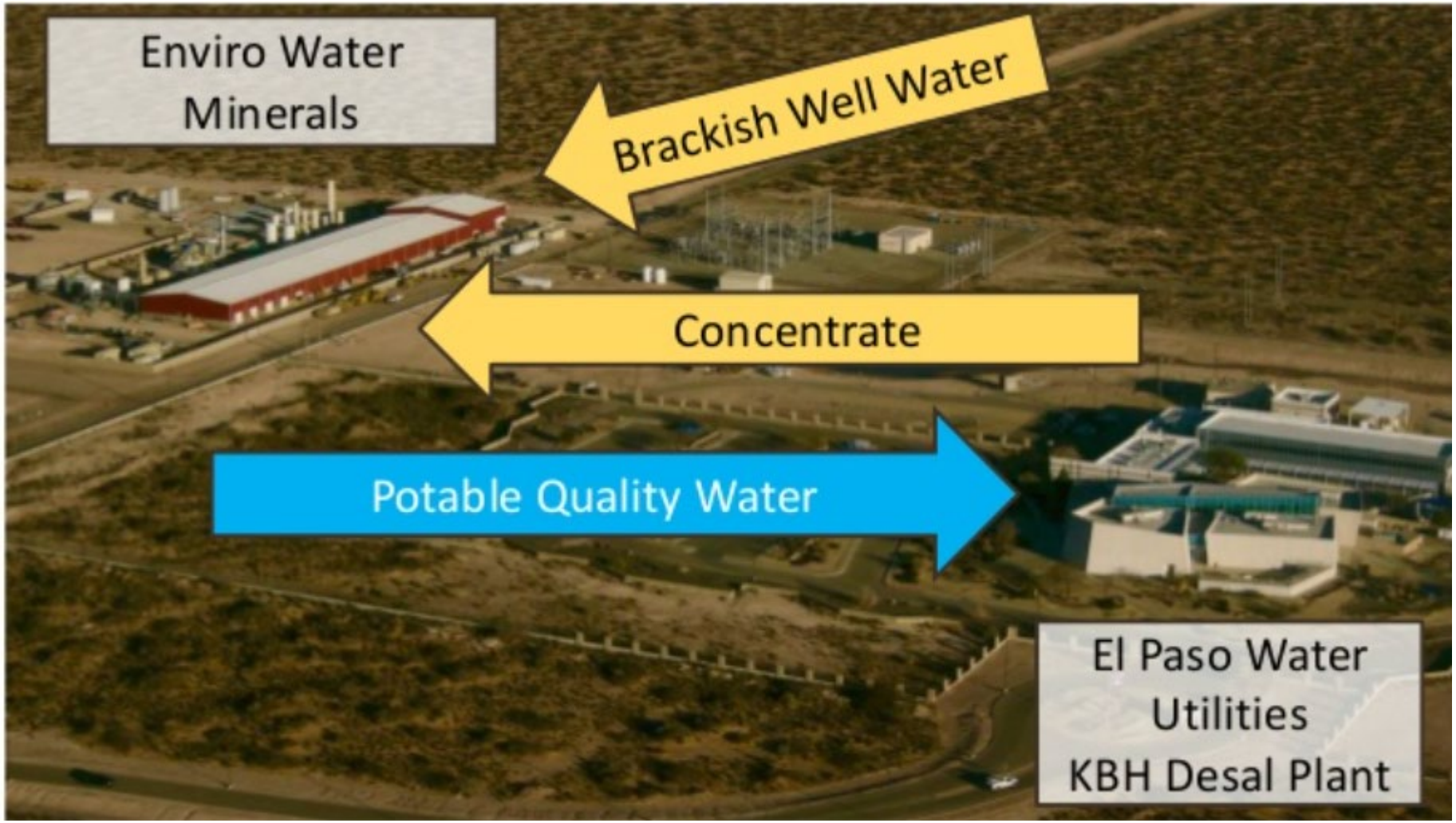
Enviro Water Minerals – El Paso

- Add in three more from memo.



Courtesy Enviro Water Minerals

Significant Facility



Courtesy Enviro Water Minerals

Questions?

Troy Walker

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twalker@hazenandsawyer.com