2023 Membrane Technology CONFERENCE & EXPOSITION

February 20-23, 2023
Knoxville, TN

We could use more water: Potable reuse pilot study to increase water production with Flow-Reversal RO targeting 95% recovery rate

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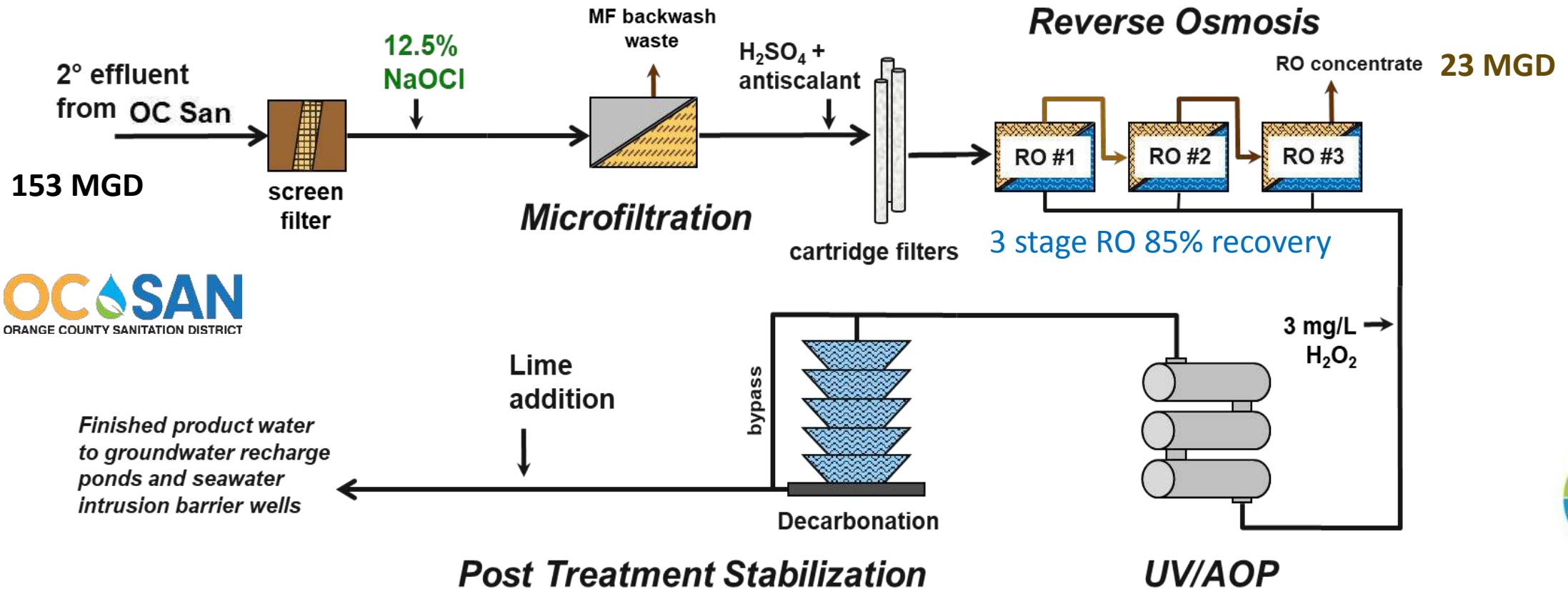
AMTA American Membrane Technology Association

American Water Works Association

Advanced Water Purification Facility (AWPF) at OCWD Groundwater Replenishment System (GWRS)

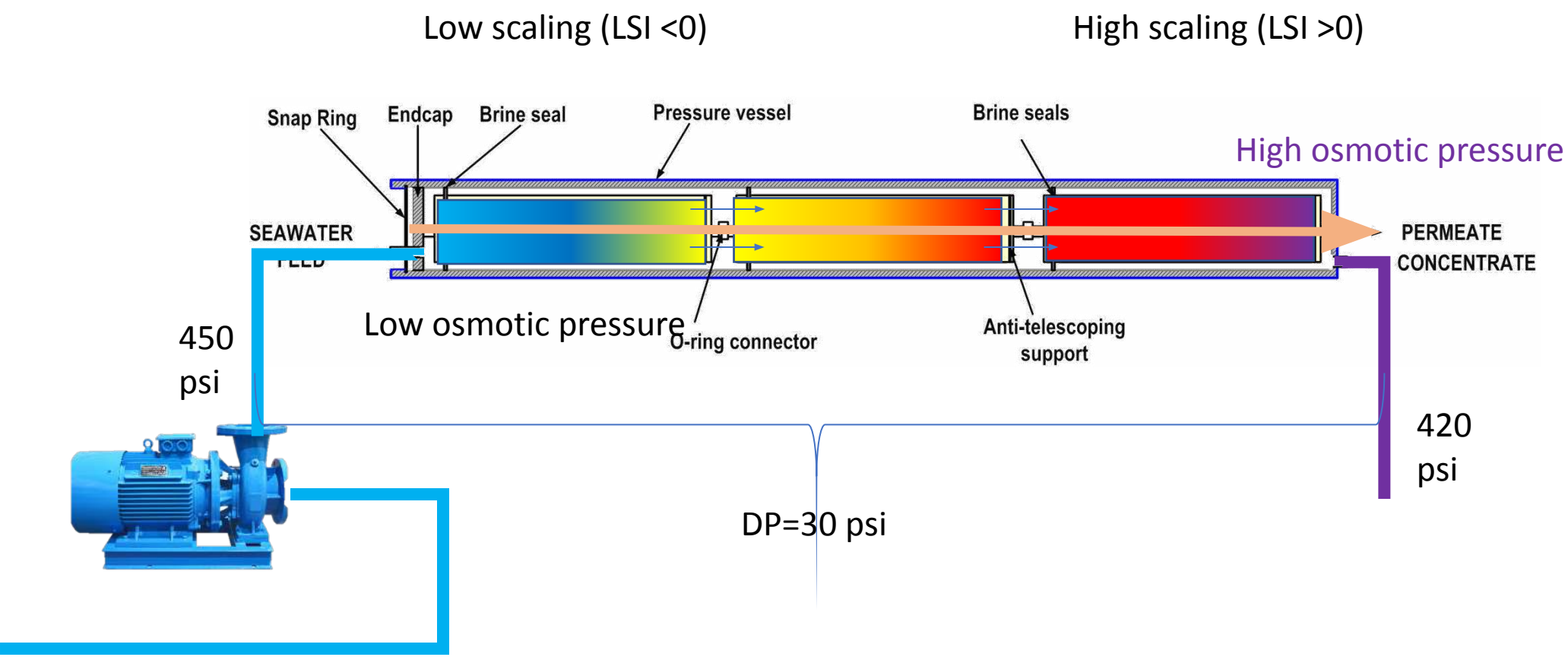
GWRS is the largest potable reuse facility in the world, producing 100 MGD of high purity water.
(130 MGD after final expansion in 2023)



Utilization of RO for Potable Reuse

- **Conventional RO** effectively removes dissolved solids, macro-molecules, and pathogens, but **is a lower-recovery process**
- RO generates large volumes of **concentrated waste stream**, making concentrate management (CM) a challenge
- Economically feasible **high-recovery desalination** technologies, such as Flow-Reversal RO (FRRO), may make potable reuse a more viable option for more utilities

What is Flow-Reversal RO?



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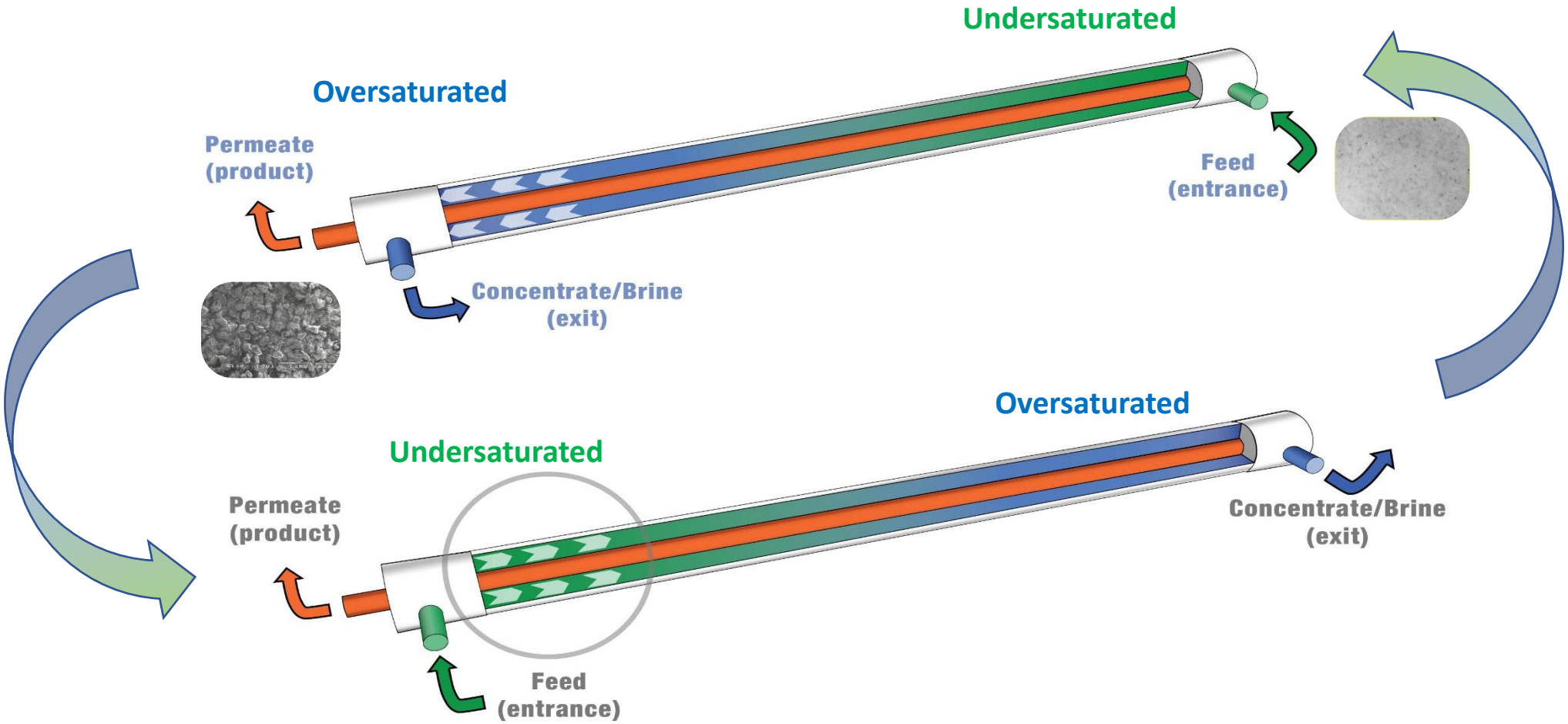
Reversing the Flow in the Pressure Vessel

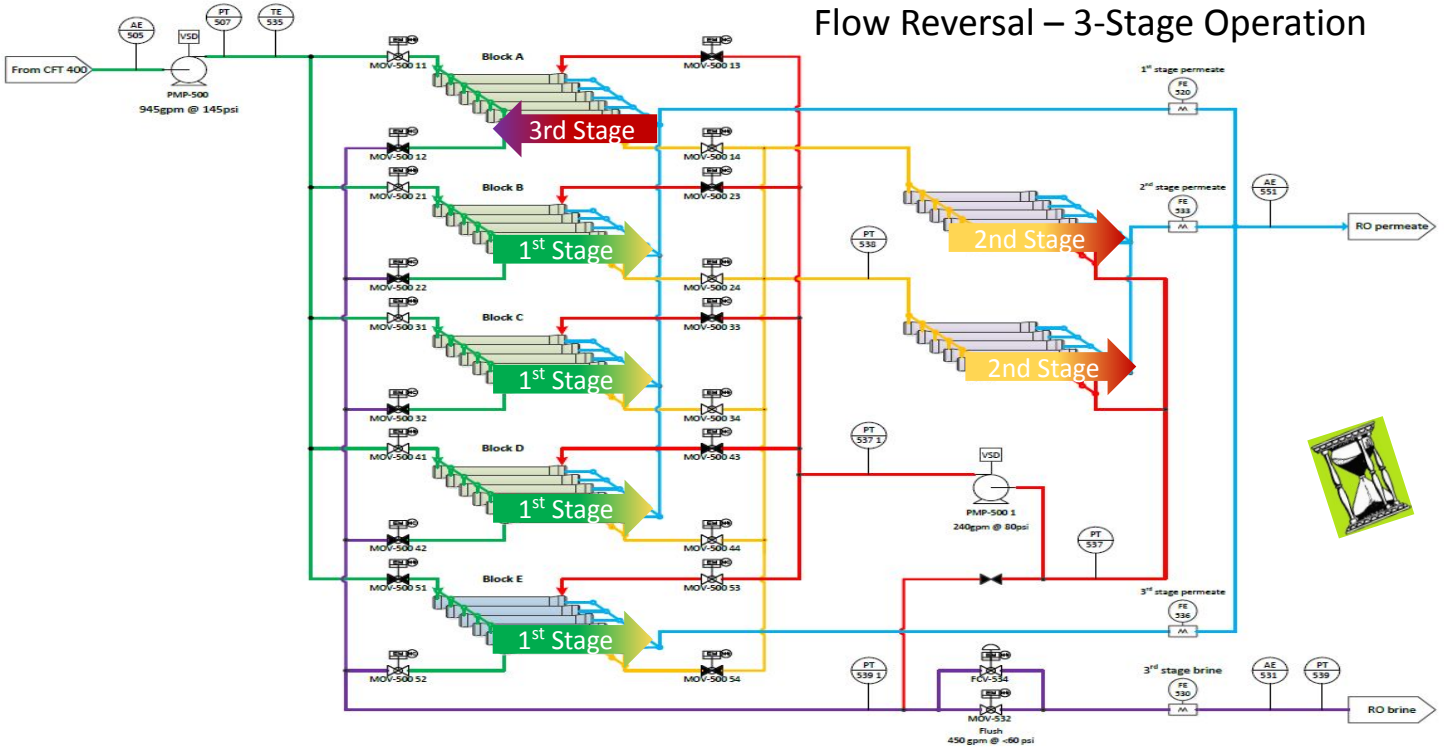


Flow Reversal – Basic principle

Flow Reversal - basic principles & ROTEC Technology- Block Rotation

3-Stage FR-RO

How is Flow Reversal applied to a 3-stage RO?



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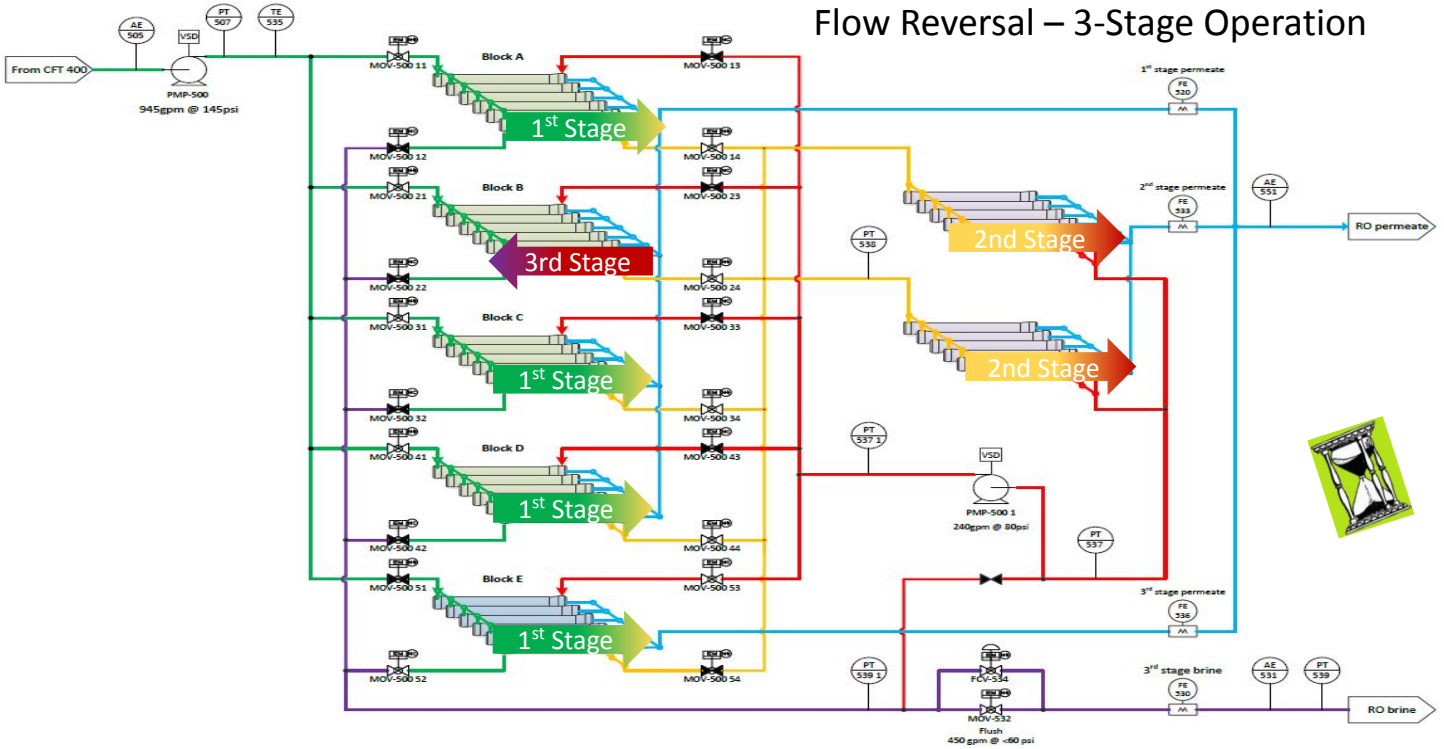

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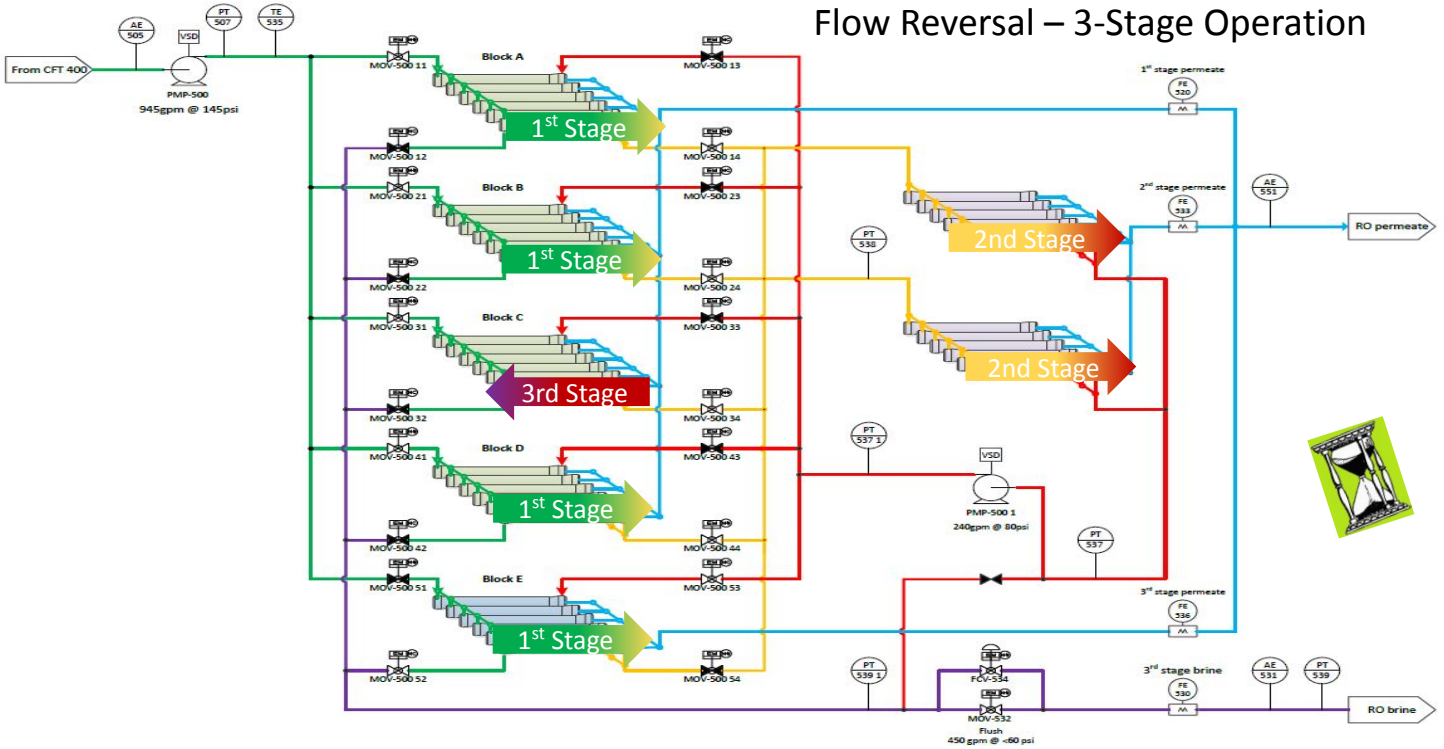

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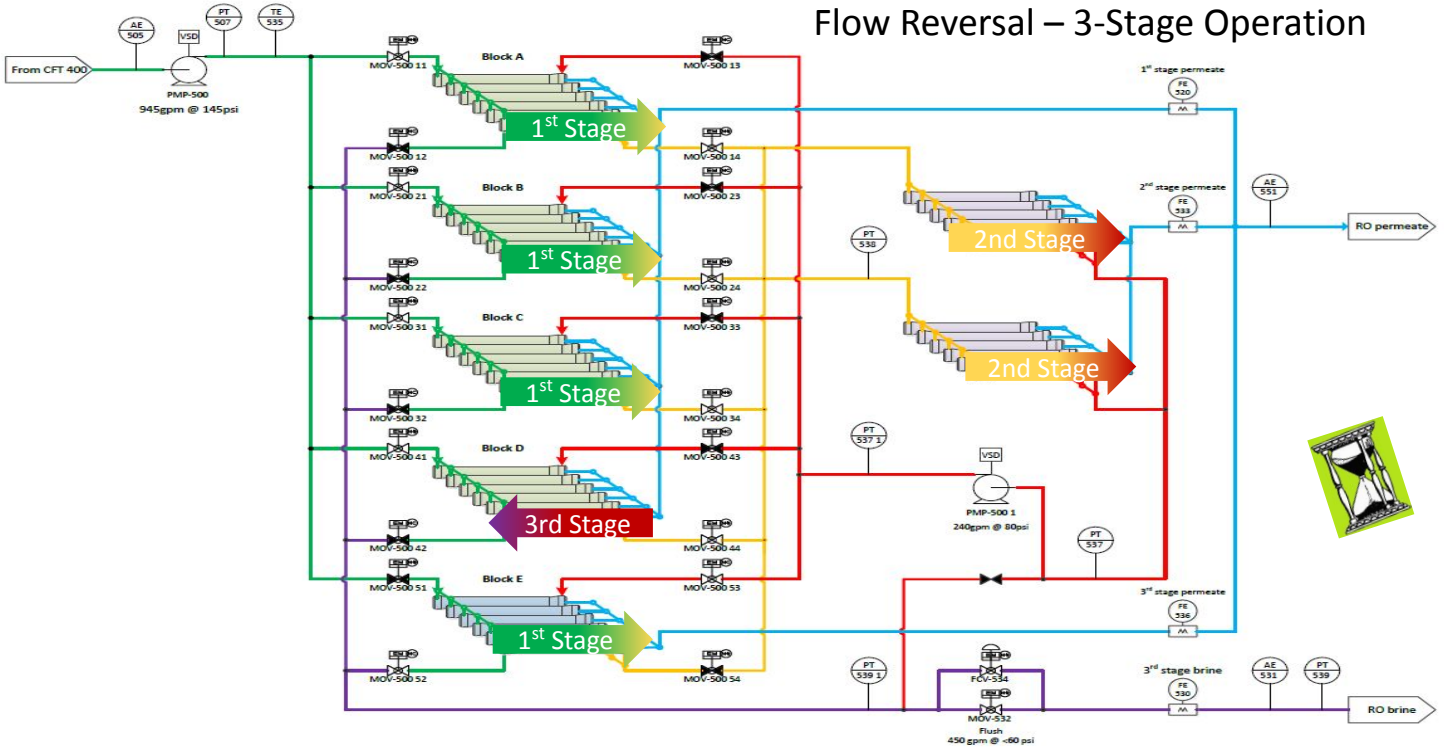

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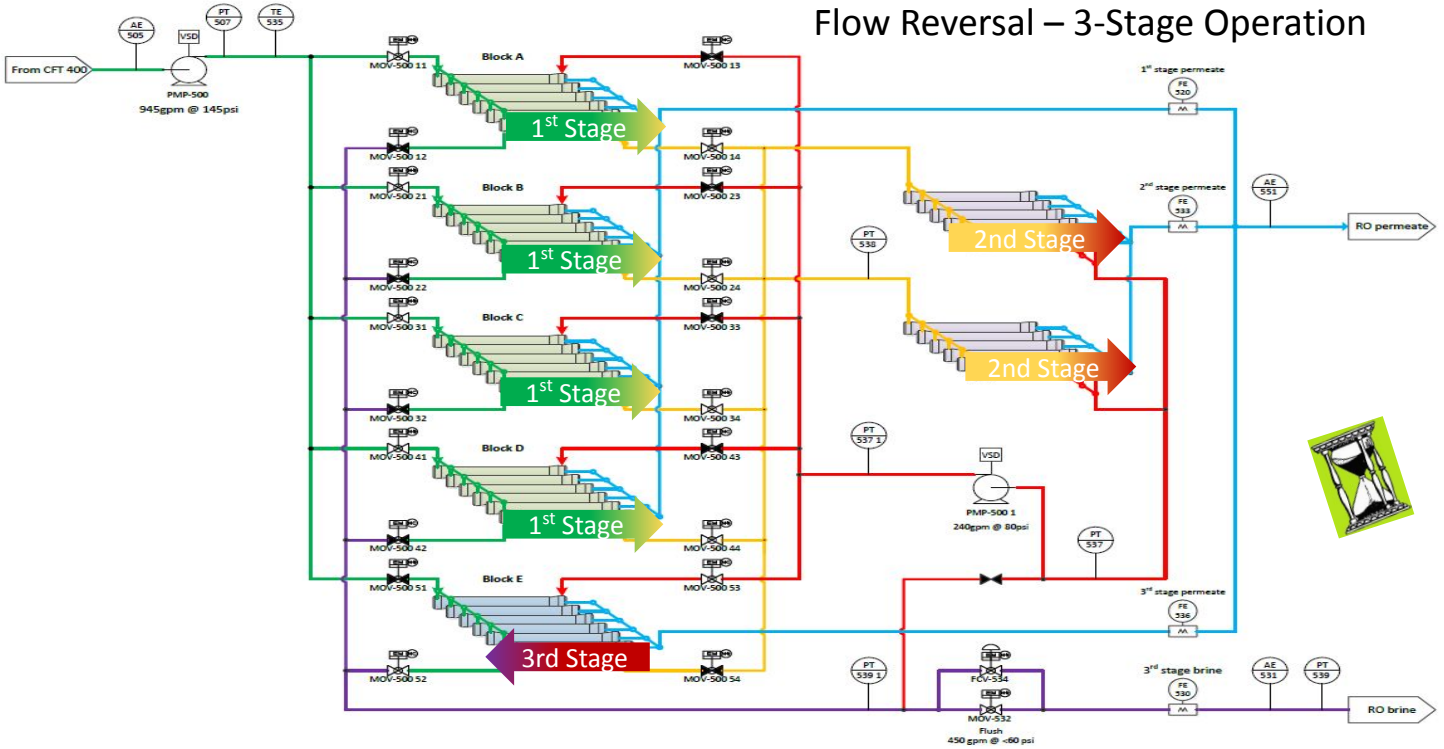
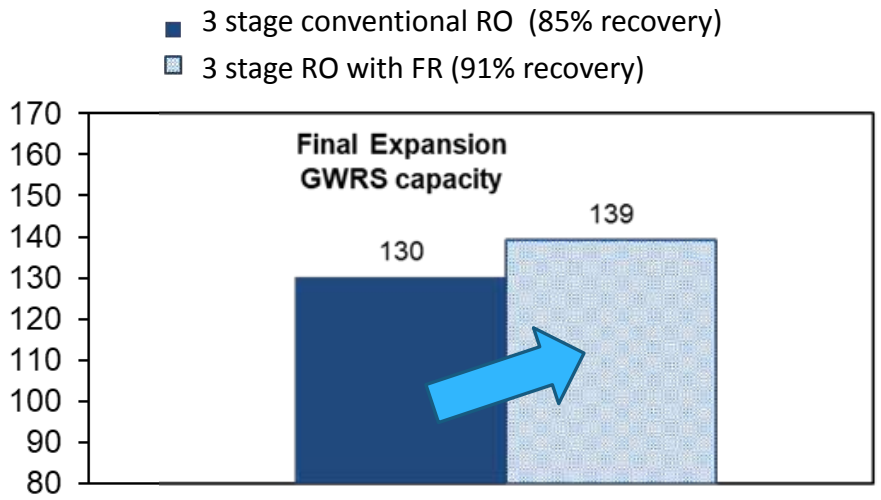


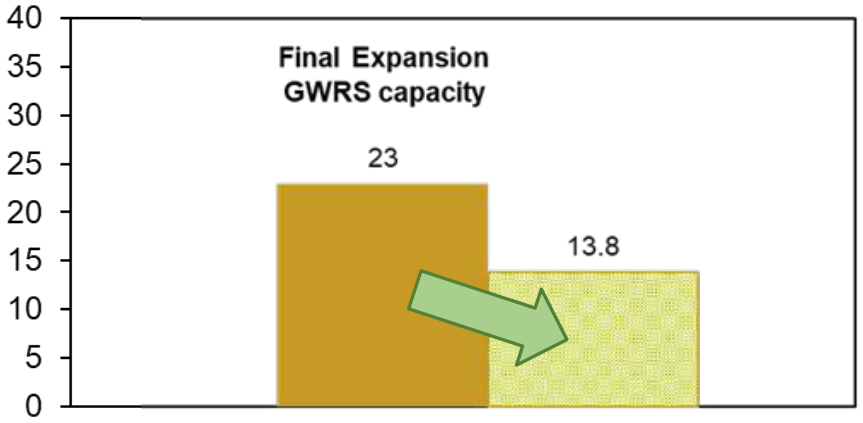
Benefit of Increasing the RO Recovery for GWRS

Increasing RO recovery would increase the overall GWRS production and lower the volume of reject water (currently discharged to ocean outfall)

RO permeate (MGD)

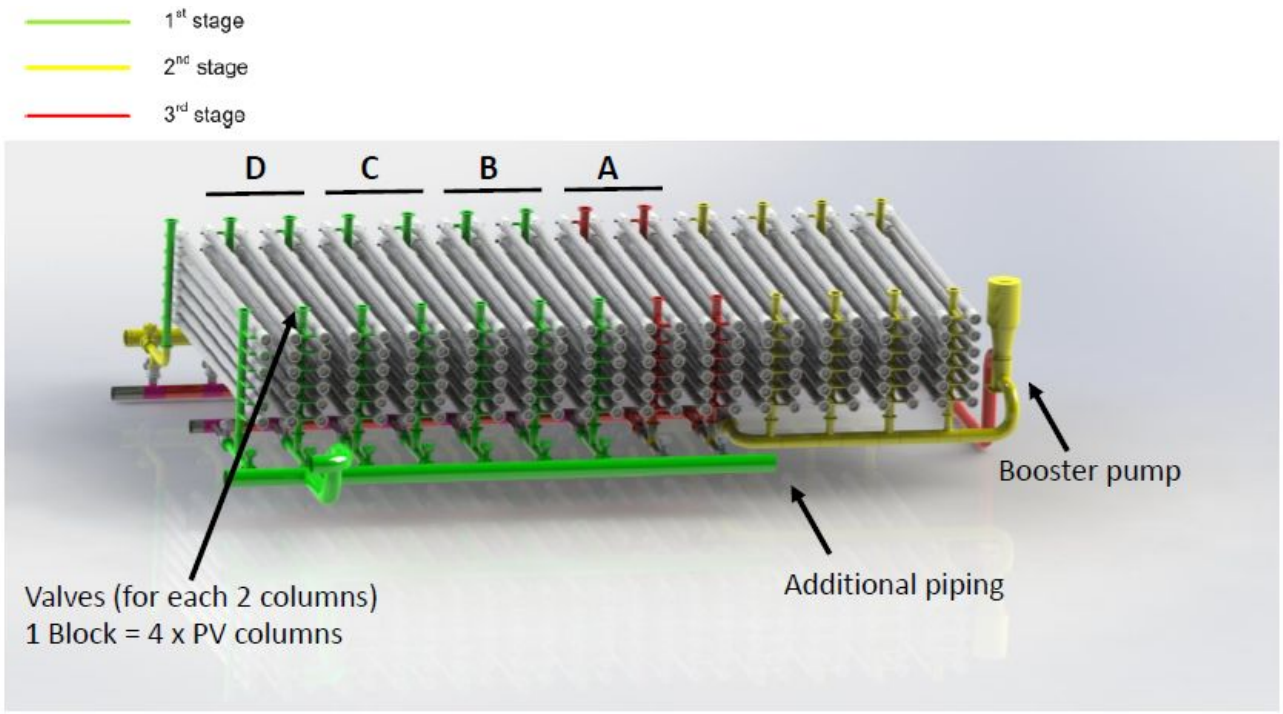


RO concentrate (MGD)



Full Scale FR Retrofit Considerations for OCWD

- FR-RO full-scale options:
  - Retrofit existing RO units to allow FR; or,
  - Construct a "4th stage" concentrate treatment unit using FR-RO



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OCWD FRRO Pilot Study – Overview

- Pilot located in the OCWD RO building and commissioned in September 2021 in collaboration with AdEdge/ChartWater, and ROTEC
- Phase 2 (treating GWRS MF effluent)
  - **Phase 2A:** Control phase (no flow reversal); successfully completed in Nov. 2021
  - **Phase 2B:** Flow reversal/block rotation enabled; ongoing
- Phase 3A (treating GWRS RO Concentrate); recently started

FRRO Pilot at OCWD

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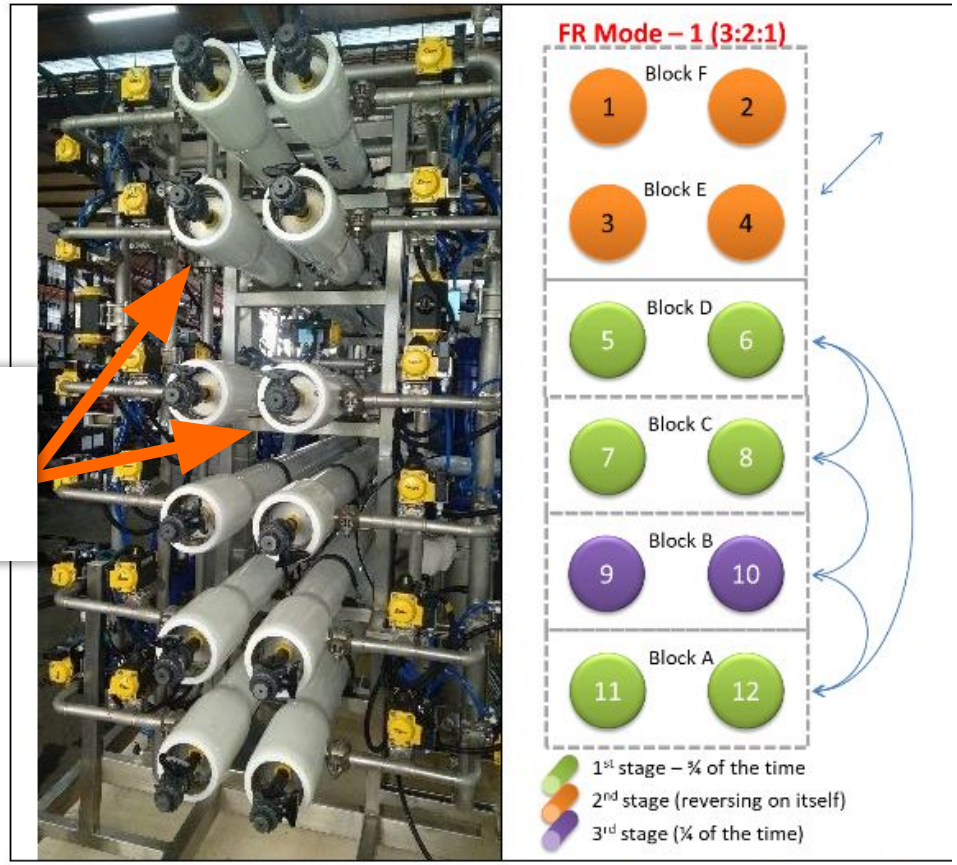
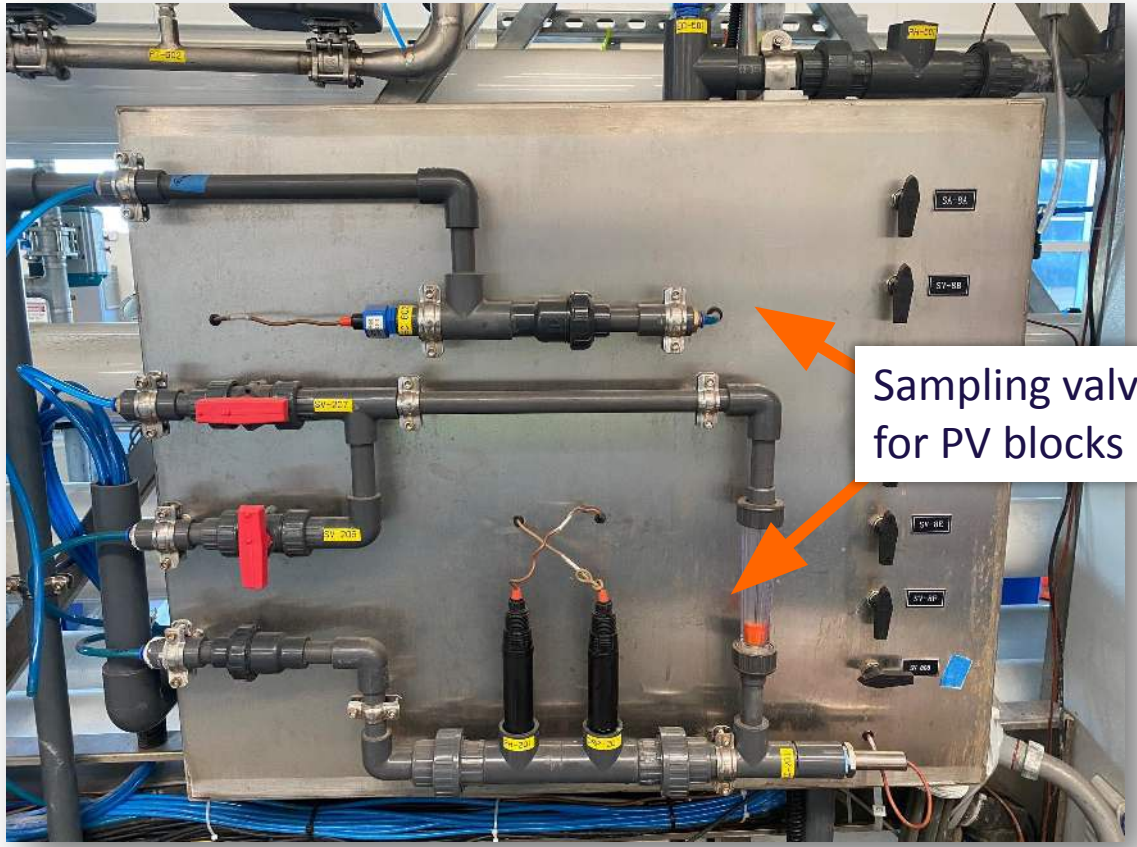
Conductivity Profiling for FR-RO Pilot

Permeate sampling:

- PV block permeate under different stage rotation

Sampling valves for individual PVs





Sampling valves for PV blocks

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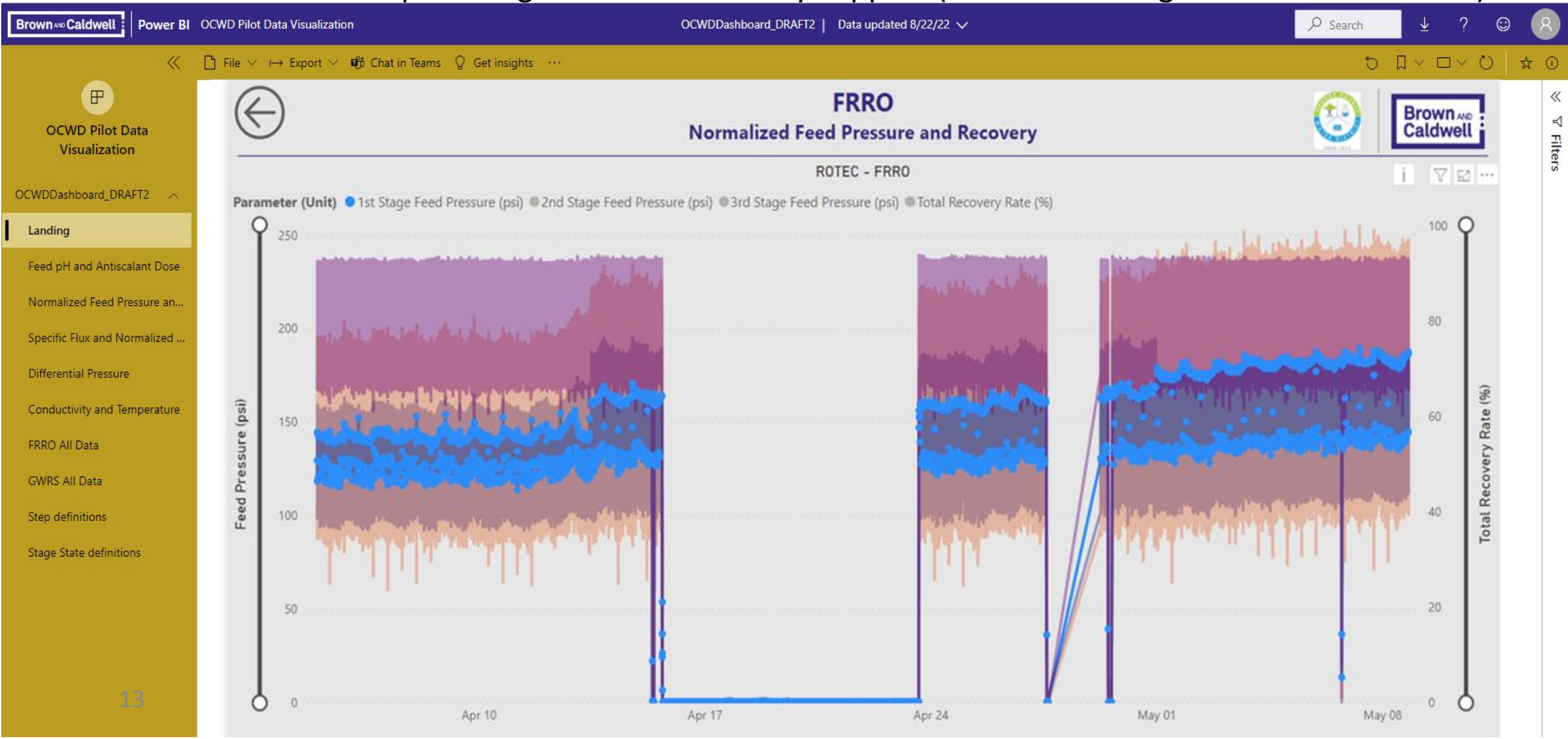
Real-Time Dashboard for Performance Tracking

Brown & Caldwell providing additional advisory support (data monitoring- Power BI dashboard)



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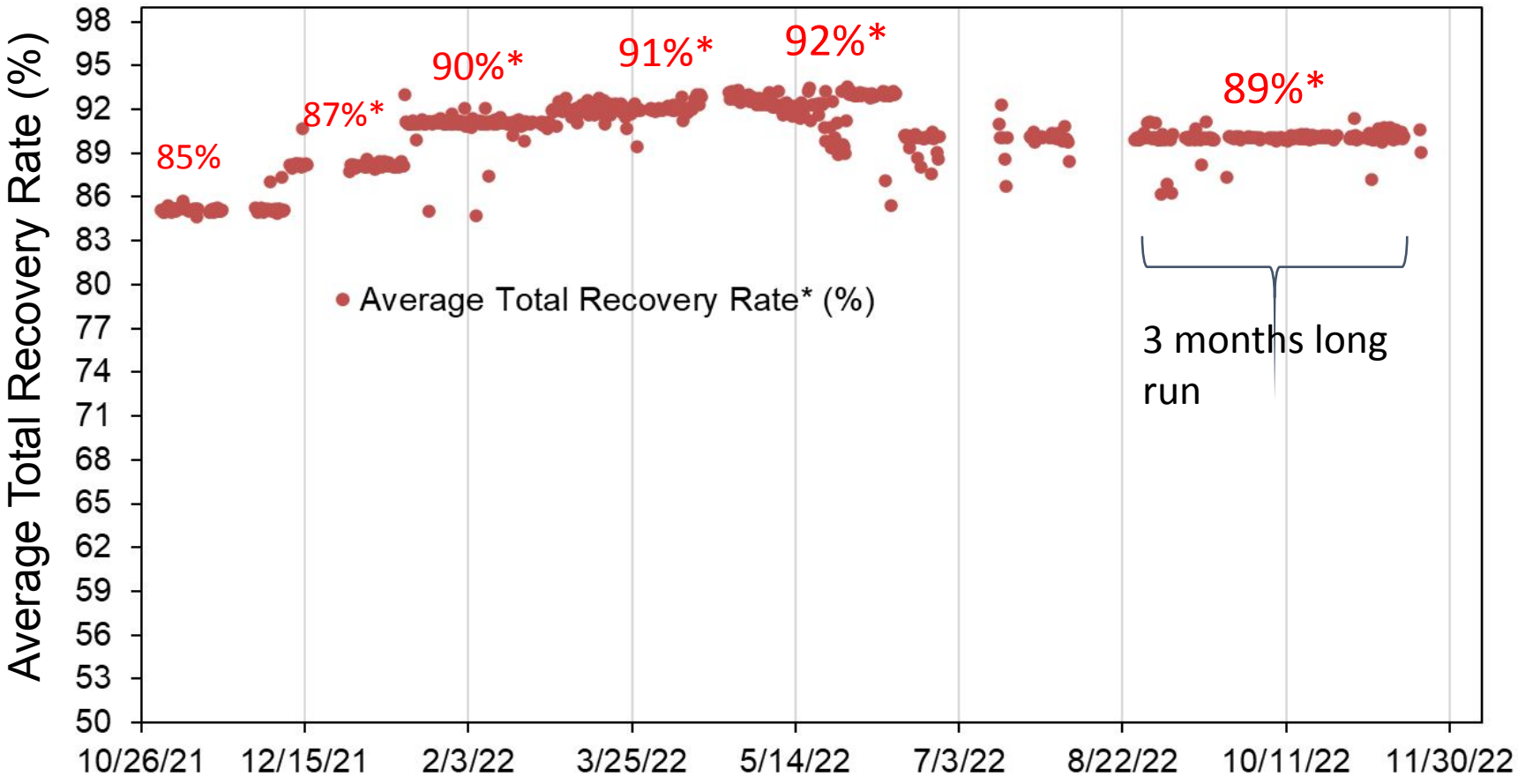
Pilot Recovery During Flow Reversal Test (Phase 2B)



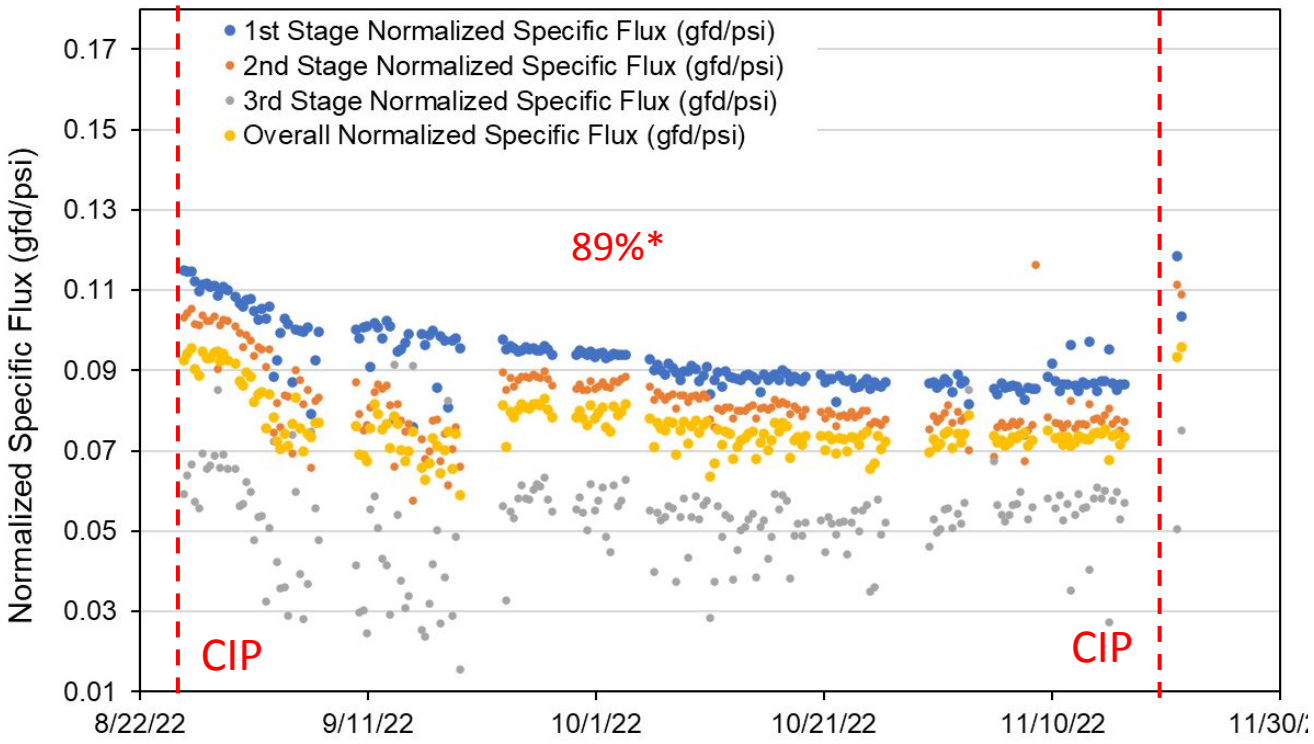
RO feed conditions:

pH adjusted to 6.9, TDS: ~1,000 mg/L, TOC: ~10 mg/L, SiO2: ~21 mg/L Antiscalant: AWC A-108 at 3.0 mg/L

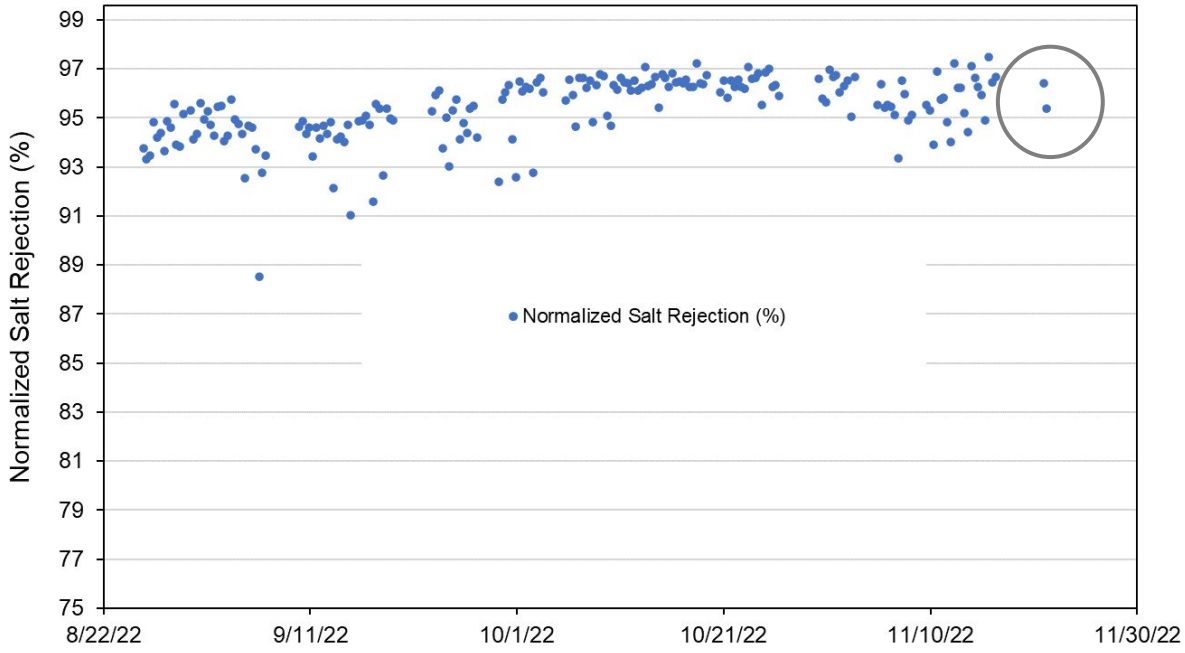
- 3-stage RO pilot with interstage booster pumps
- Block rotation and flow reversal enabled
- Push recovery up (1-3% increase per change) to determine maximum recovery
- Completed 3 months long term trial

*True recovery rate accounts for transitional periods during block rotation (instantaneous recovery is ~1% higher)

Pilot Performance in Flow Reversal Test (**Phase 2B**)



- 9/23/2022. ROTEC inspected the pilot for mechanical problems.
- 11/4/22 AdEdge engineers on site. Replaced all elements interconnectors to double o-ring, added shims to end cap adapter when needed. Moved all “blank” elements to the 4th element position.



- Total online time is ~3 months
- Block rotation and flow reversal for the 1st and 3rd stage occurs every 40 min (decreased from 1 hr since 3/3/22)
- Flow reversal for the 2nd stage is every 10 hours

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Various Piloting Challenges Encountered *and Addressed* in Phase 2B

- Total Permeate flux set too high [13.4 gfd] (4/13-5/18 RR:92%)
  - Causing improper stage flux balance, lowered to 12 gfd
- Recovery set point not stable (84-93%) (5/22-5/30)
  - Concentrate control valve issue
- Observed feed water pH between 7.0 - 7.2 (4/24-6/9)
  - Replaced faulty pH sensor
  - Higher pH may cause scaling
  - Added local pH adjustment to 6.8
- 7/24-8/5 observed rapid fouling
  - Likely due to citric acid (a highly assimilable carbon source) that will result in severe biological fouling (switched to sulfuric acid)
- Poor post-CIP performance (6/27 and 7/14)
  - Incomplete CIP or ineffective CIP cleaner

Extended CIP with specialty organic cleaner provided the best result

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Specific Energy Consumption (SEC) Projection for Retrofitted GWRS RO unit

		Projected GWRSFE Water Quality
Full scale design	Recovery Rate (%)	Specific Energy (Kwh/m^3)
Current GWRS RO design (no FR)	85	0.34
3-stage FR-RO with 2 interstage booster pumps	85	0.34
	87	0.34
	90	0.34
	92	0.35
	93	0.36

Summary

- Control phase (no FR) trial completed in Nov. 2021 treating GWRS MF effluent
- Phase I flow reversal/block rotation test is ongoing (treating GWRS MF effluent) to determine the maximum recovery set point (currently at 92%)
- Pilot encountered various mechanical and fouling challenges that delayed progress
- CIPs using specialty high pH organic cleaner provided optimal results
- SEC projections for full scale FRRO (retrofitted RO) is comparable with existing GWRS RO unit's SEC between 85-90% recovery

20

Future Plans

Phase 2B

Steady state operation at the maximum feasible recovery (3 mo.)

Composite sampling of feed and permeate quality. Unexpected change to feed water quality, therefore we will conduct a short repeat of Phase 2B

Phase 3A

Using OCWD GWRS RO concentrate (“ROC”) as the feed water to FR-RO

Flow Reversal (FR-RO) Concentrator mode

- Start at an overall recovery (RO plant + FR-RO) lower than the feasible recovery from Phase IB and push it up step-wise to determine highest feasible recovery 1-2% increase per week
- At the highest feasible recovery, hold for 3-6 months
- Consider chemical dosing optimization, washing cycles

21

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Acknowledgements

- OCWD team, on-site monitoring of pilots, sampling
- OCWD oversight – Mehul Patel, Jason Dadakis, and Sandy Scott-Roberts
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- ROTEC – Yair Shnurmacher
- Brown and Caldwell - Adam Zacheis, Jishnu Mehta and Jocelyn Lu
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- Funding Agencies:

—BUREAU OF—
RECLAMATION
Awarded to
AdEdge / ChartWater

SCSC
Southern California Salinity Coalition
Awarded to OCWD

OCWD R&D Team:


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Andrew Huang


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Thank you! Questions?

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