# Speaker Spotlight

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# EMWD Brine Minimization Pilot Study

## USING CCRO TO INCREASE OVERALL WATER RECOVERY IN A WATER REUSE APPLICATION

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# About EMWD

- Sixth largest public water utility in California
- One of 26 member agencies of The Metropolitan Water District of Southern California (MWD)

# EMWD "By the Numbers"

ESTABLISHED IN
**1950**

SERVES:

WATER / WASTEWATER / RECYCLED

WHOLESALE & RETAIL

POPULATION:
**839,000+**

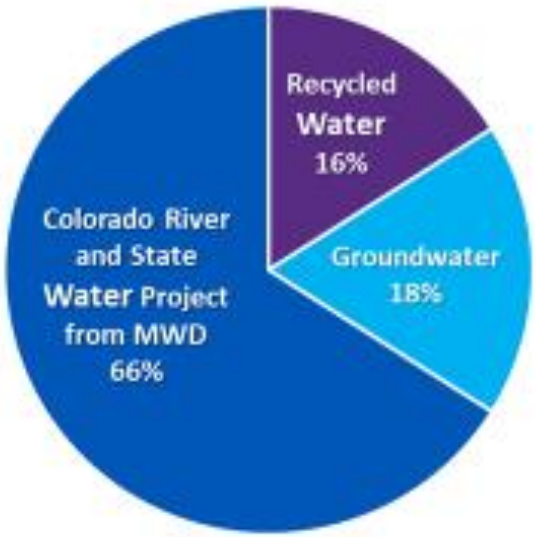
**555**
SQUARE MILE SERVICE AREA

ALMOST
**38%**
CURRENTLY BUILT OUT

# Water Supply Portfolio – 1990 and 2010

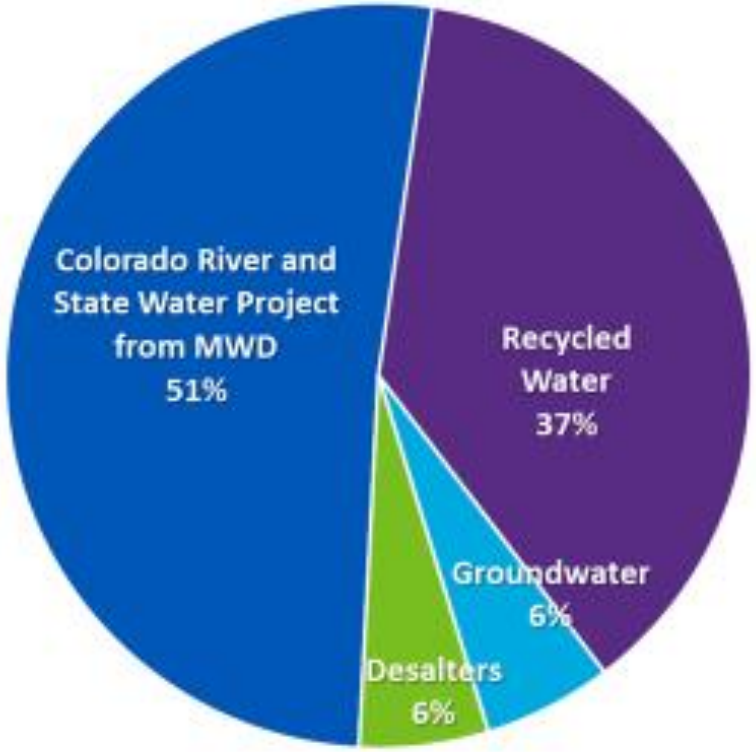
**1990**

Population served: 358,000




**2020***

Population served: 850,000




*Total Water Supply: 135,008 AF per *EMWD Comprehensive Annual Financial Report, FYE 2020*

# Groundwater Reliability Plus Program

# Proposed Purified Water Replenishment

Disinfected Tertiary

2,000 afy Continuous

MF / RO

Imported Water

0 - 2,000 afy Seasonal

Recharge Ponds

Soil

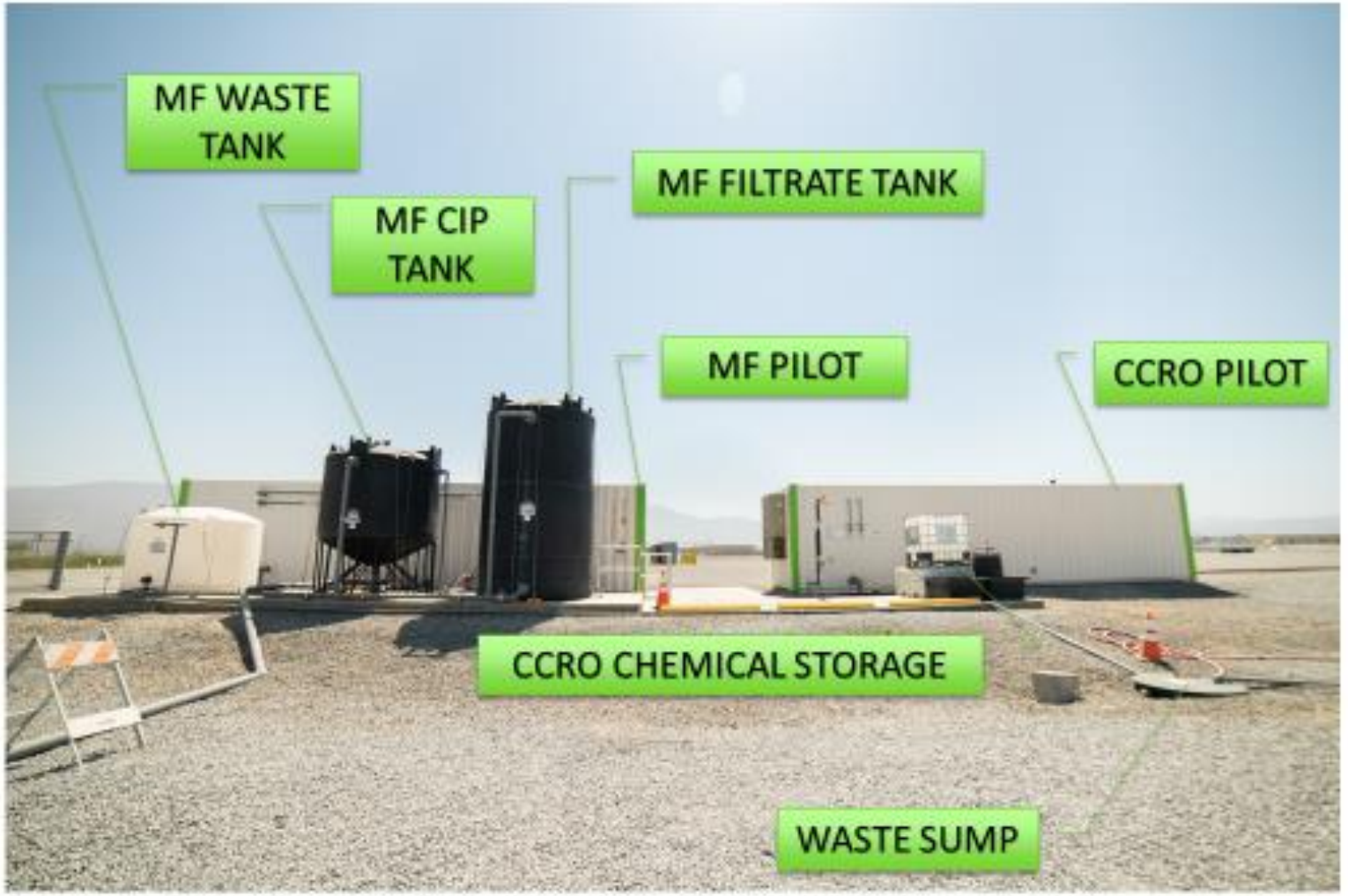
Aquifer

Treatment

~5-year travel time in groundwater aquifer

# Pilot Plant Site

# Pilot Plant Site



# CCRO Schematic

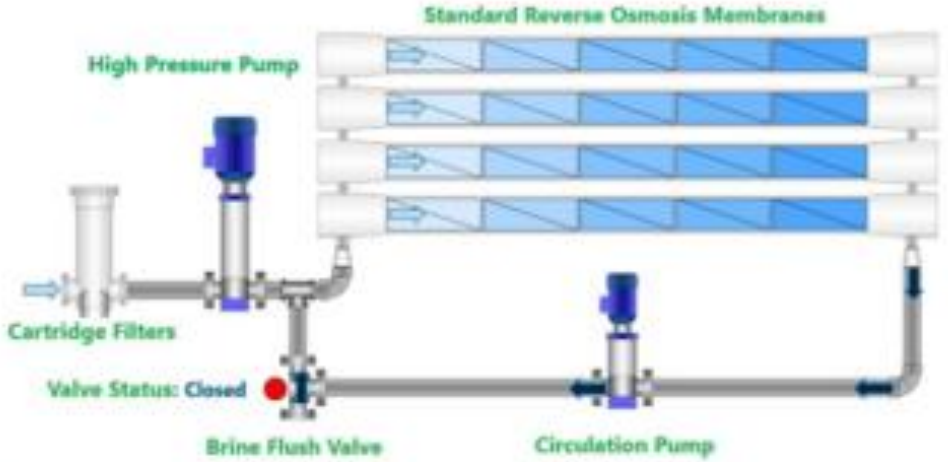



Figure 1A - CC operation cycle

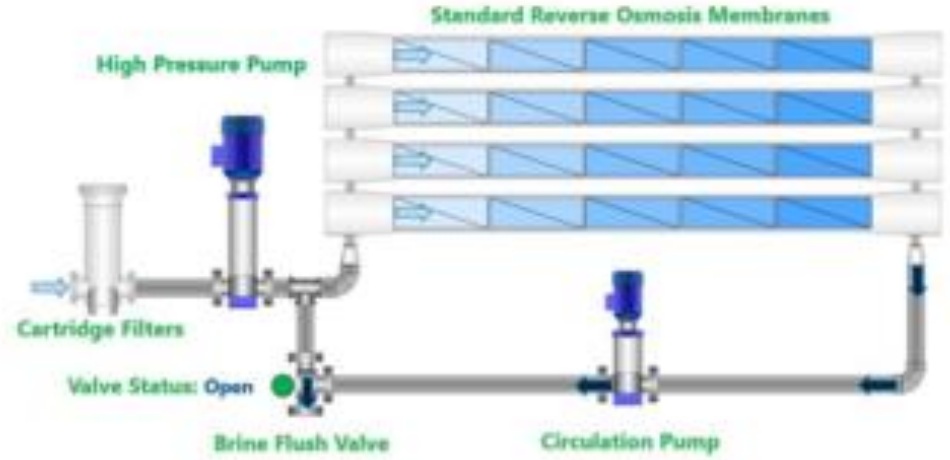



Figure 1B - PF operation cycle

# MF: Key Design Parameters

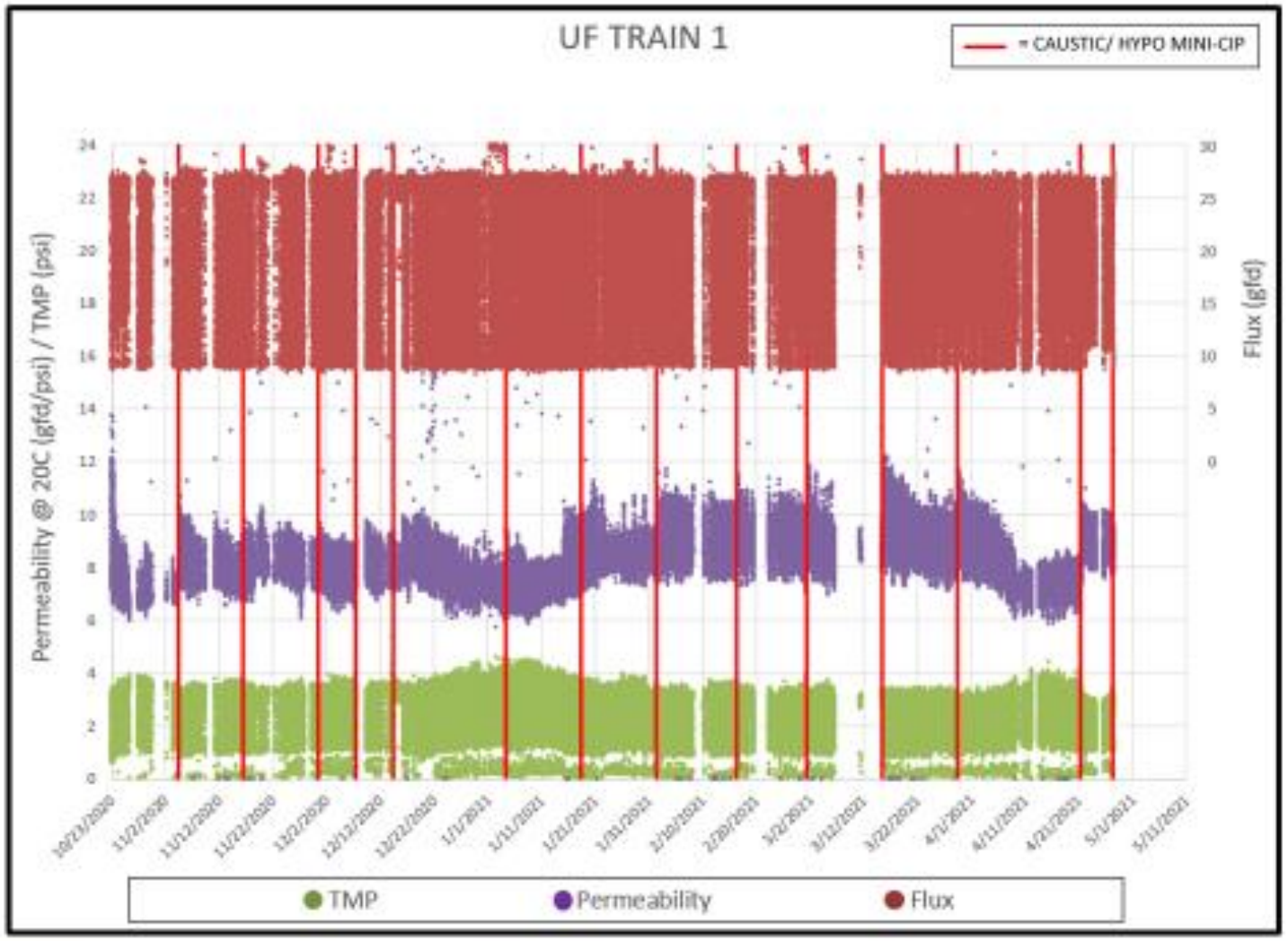
| Parameter | Units | Value |
|---|---|---|
| No. Trains | | 2 |
| Membrane Make/Model | | Toray HFU-2020AN |
| Membrane Material | | PVDF |
| Manufacturing Process | | Thermally Induced Phase Separation (TIPS) |
| Membrane Pore Size | µm | 0.01 |
| Max Instantaneous Flux | gfd | 26 |
| Minimum Design Recovery | % | 90 |
| Backwash Interval | min | 45 |
| Minimum CEB Interval | hr | 24 |
| Autostrainer Rating | micron | 200 |
| Feed Water Chemicals | | Sodium Hypochlorite<br>Liquid Ammonium Sulfate<br>Sodium Bisulfite |

# MF Pilot Container

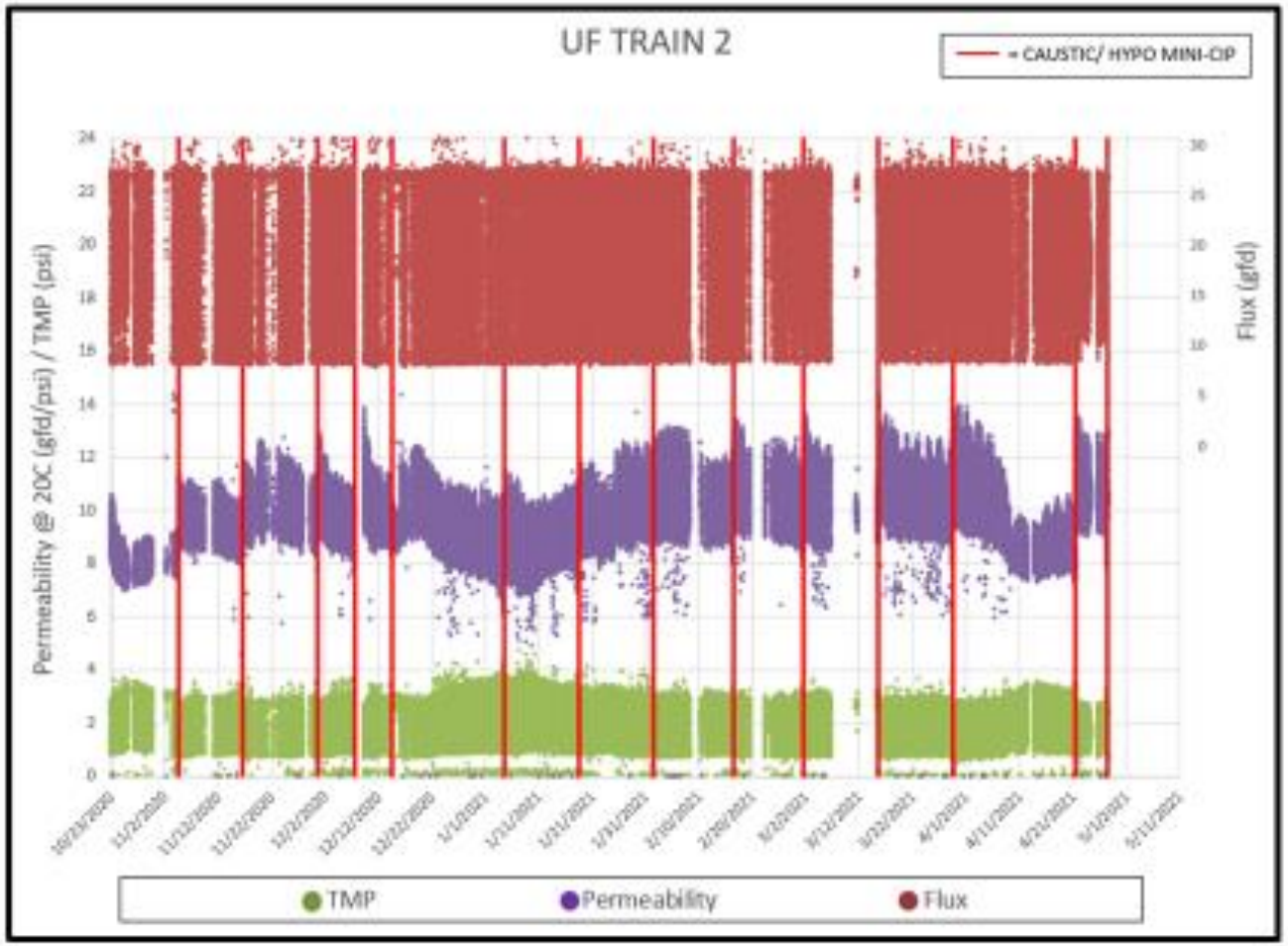
# MF: Key Operating Details

| Parameter | Units | Value |
|---|---|---|
| Operating Philosophy | | Tank Level Control, Variable Flux |
| Operating Flux | gfd | 9 to 26 |
| Flow Rate per Train | gpm | 20 to 57 gpm |
| Backwash Interval | min | 45 |
| Average System Recovery | % | ~98 |
| Typical CEB Interval | days | 14 |

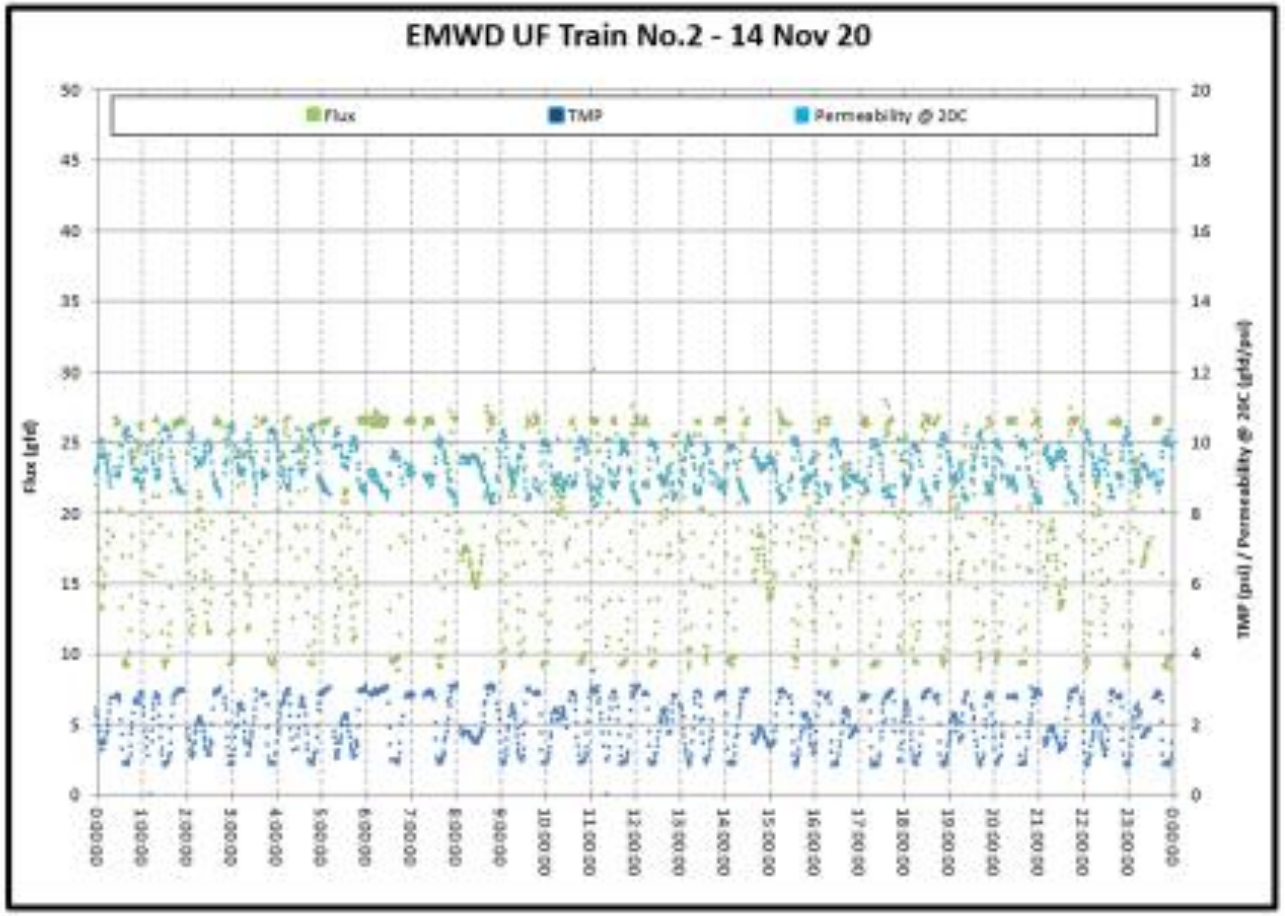
# MF Long-Term Performance Data (Train 1)



# MF Long-Term Performance Data (Train 2)



# Example 24-hr MF Performance Data (Train 2)



# CCRO: KEY DESIGN PARAMETERS

| Parameter | Units | Value |
|---|---|---|
| No. Trains | | 1 |
| Membrane Make/Model | | FilmTec Fortilife CR100 |
| Element Diameter | in | 8 |
| Membrane Material | | Polyamide Thin-Film Composite |
| Minimum Salt Rejection | % | 99.4 |
| Average Flux | gfd | 10 |
| Permeate Flow Rate | gpm | 70 |
| Recovery | % | Variable |
| No. Stages | | 1 |
| Cartridge Filter Rating | micron | 1 |
| Feed Water Chemicals | | Antiscalant<br>Sulfuric Acid |

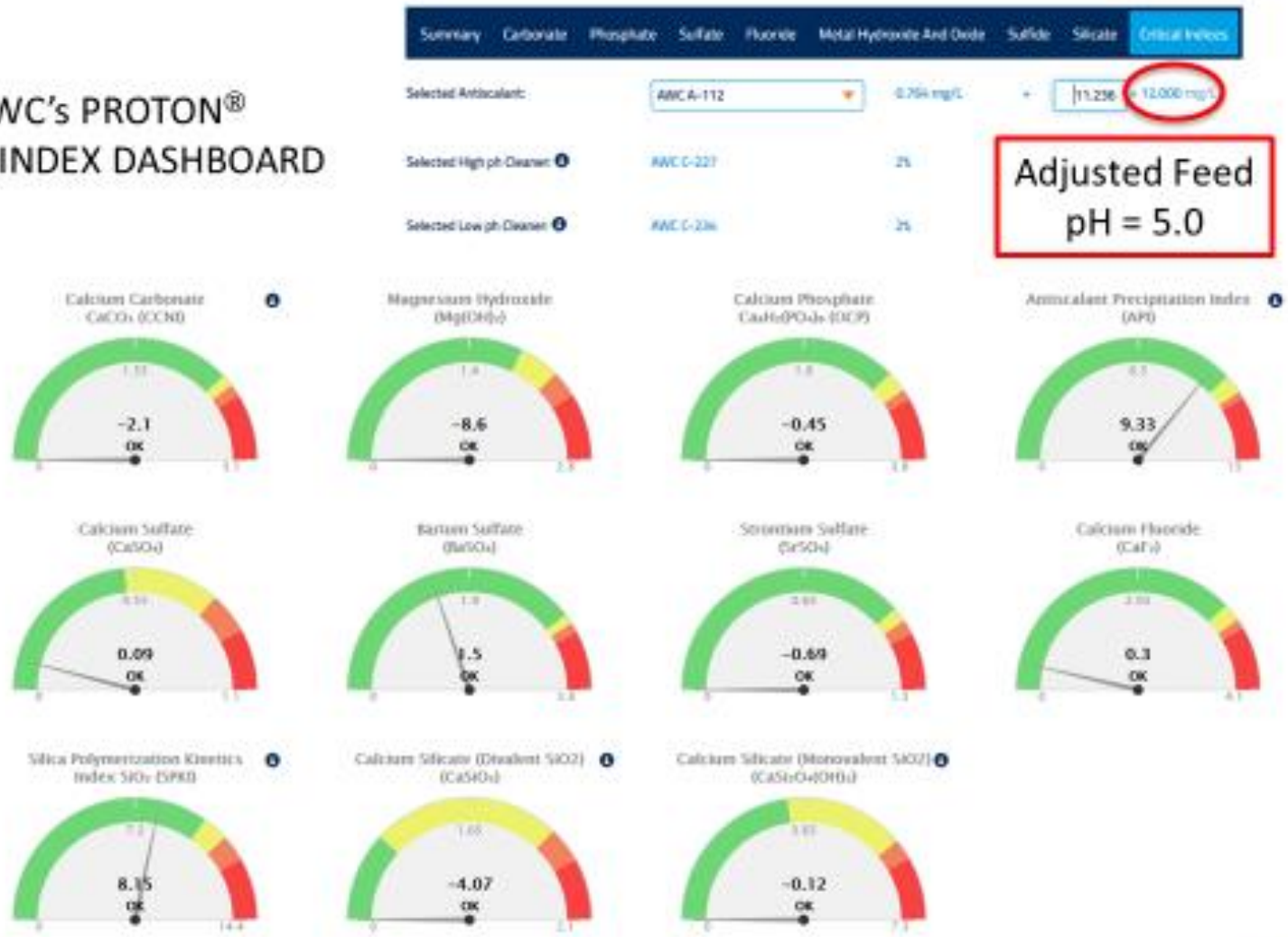
# CCRO Influent WQ (10/28/20 to 03/3/21)

| Parameter | Units | Avg | Max | No. Samples |
|---|---|---|---|---|
| Temperature | °C | 20.1 | 23.4 | 8 |
| Nitrate | mg/L as N | 10.8 | 15.0 | 8 |
| Phosphorus | mg/L as $PO_4$ | 7.5 | 15.0 | 8 |
| Sulfate | mg/L | 171 | 210 | 8 |
| Silica | mg/L | 21 | 23 | 8 |
| Calcium | mg/L | 53.5 | 58.2 | 8 |
| Alkalinity | mg/L as $CaCO_3$ | 41.5 | 77.0 | 8 |
| TDS | mg/L | 611 | 660 | 8 |
| Total Chlorine | mg/L | 1.4 | 2.4 | 8 |

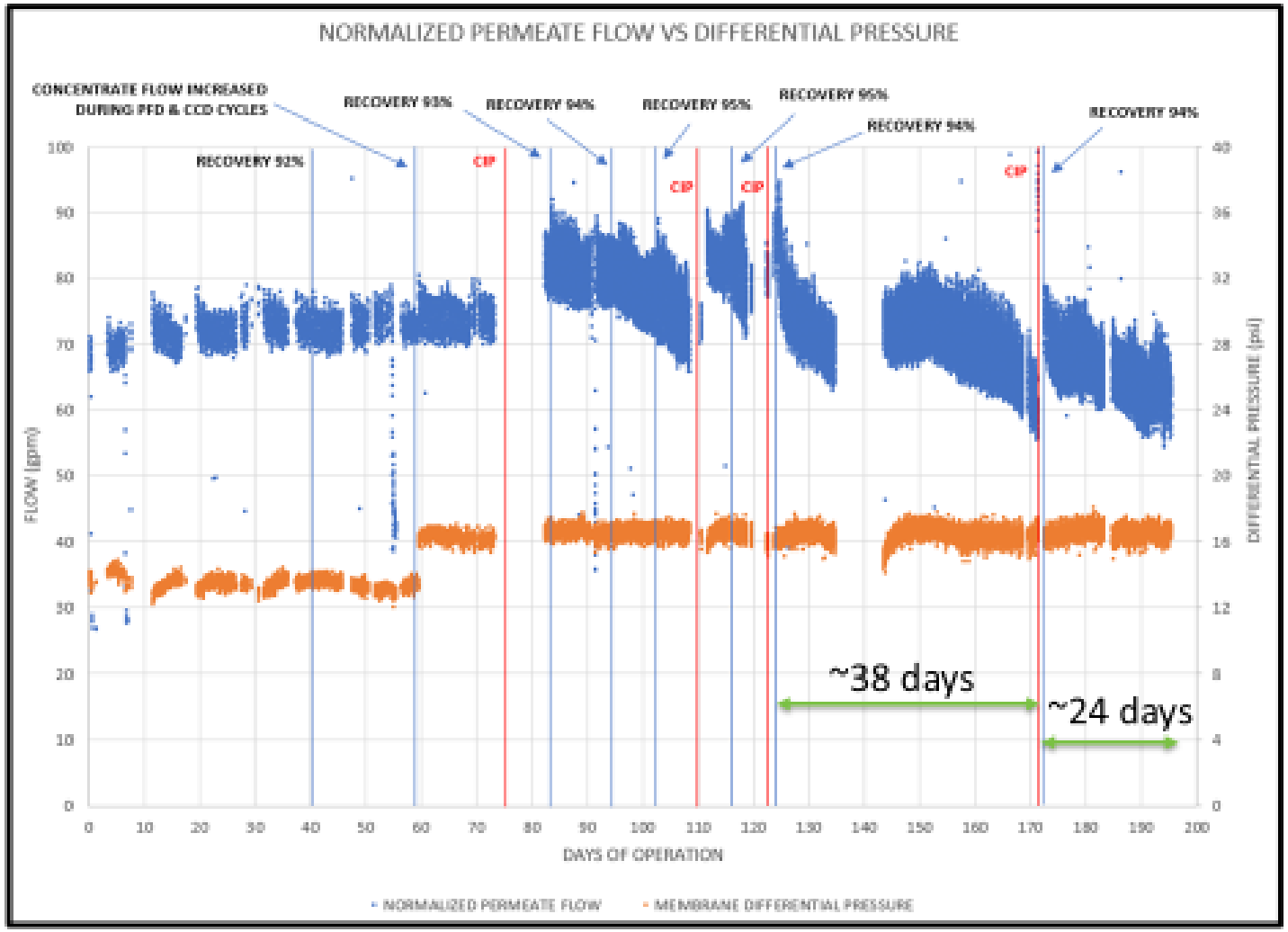
PHOSPHATE LEVELS CONTROLLED ANTISCALANT SELECTION AND TARGET FEED WATER pH

# Feed Water Chemical Conditioning

AWC's PROTON®
SCALE INDEX DASHBOARD



# CCRO – Normalized Permeate Flow vs ΔP



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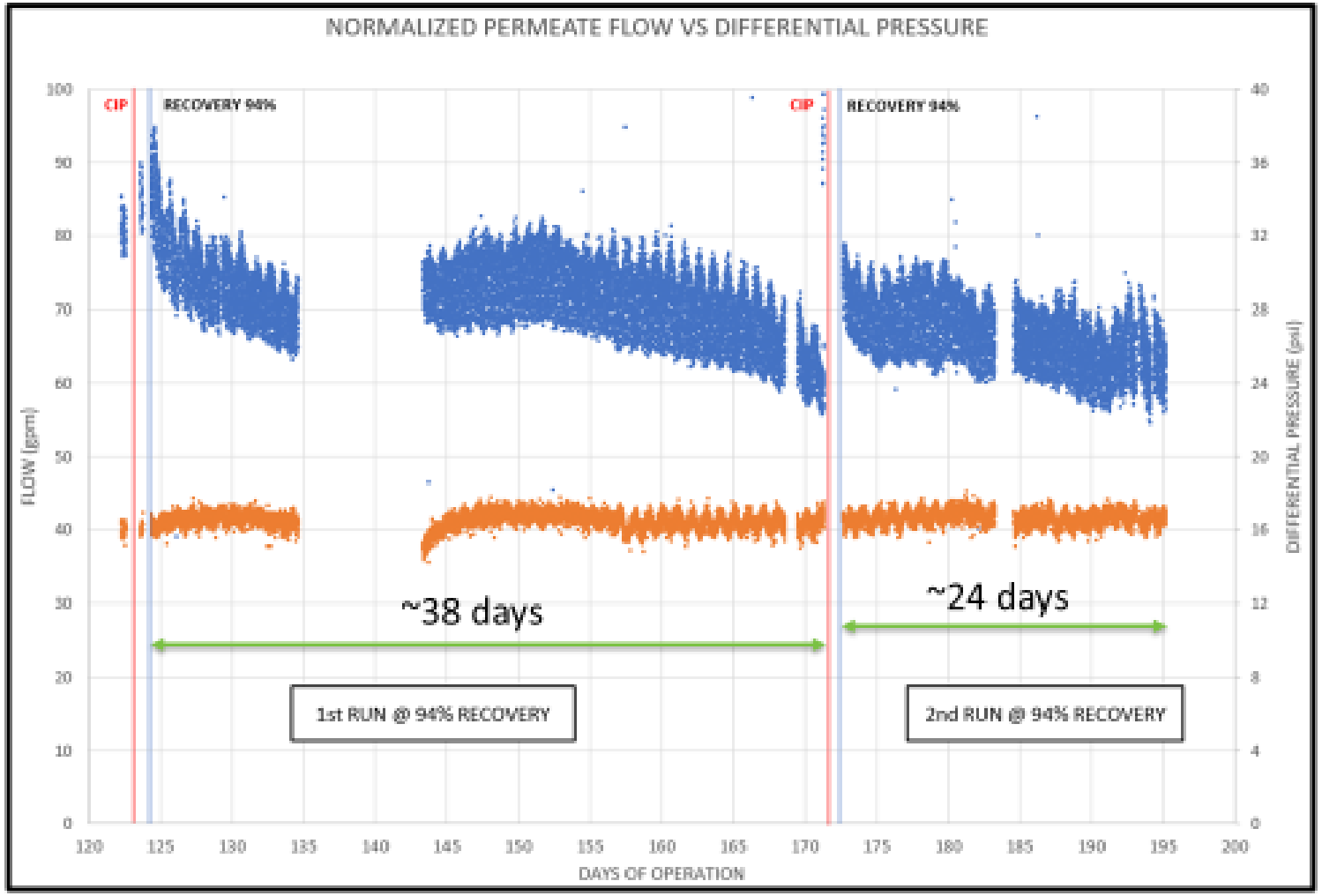
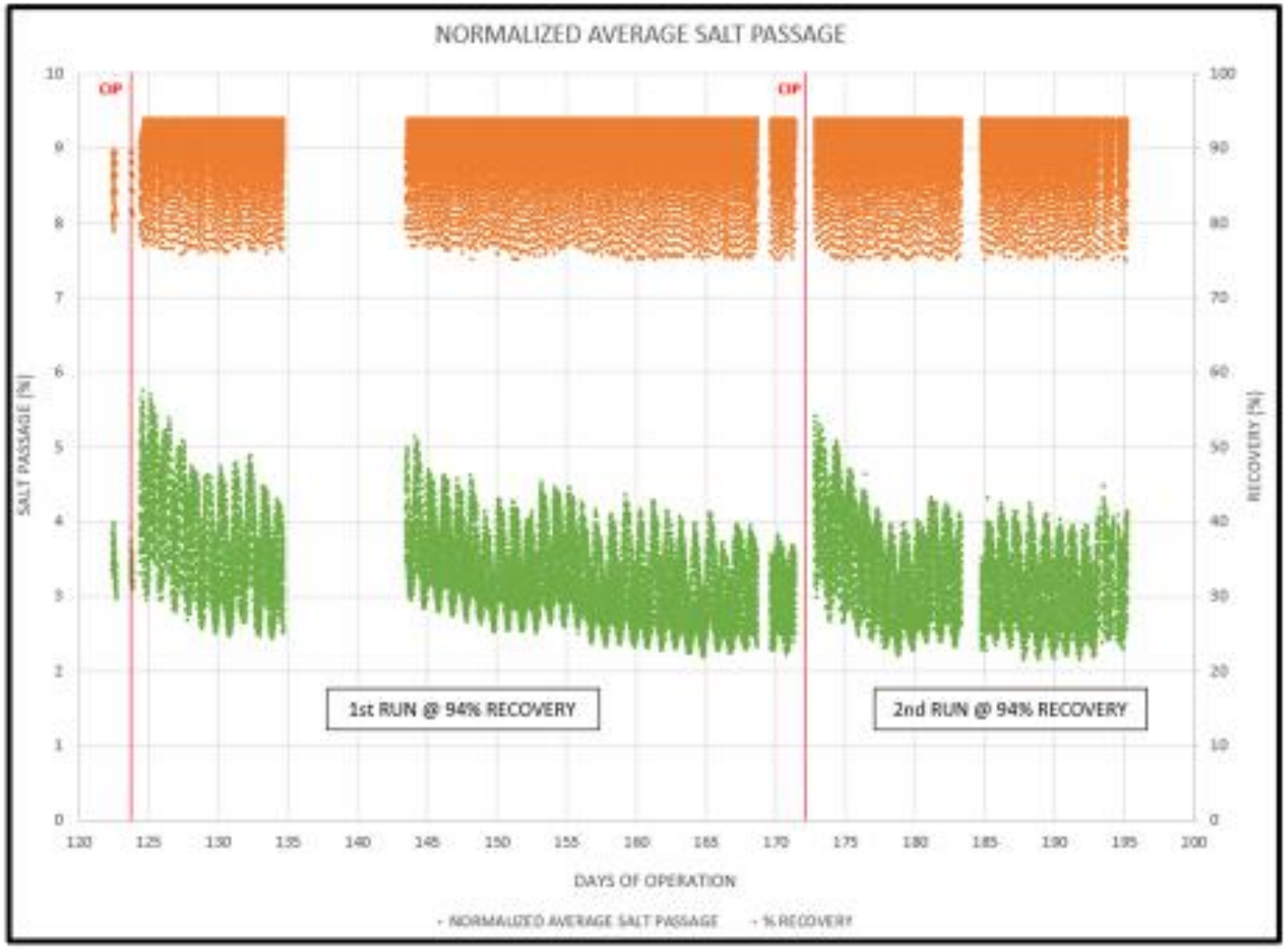


# CCRO – Normalized Salt Passage



# Membrane Autopsy Findings

Tail element pulled at completion of 1st extended run @ 94%

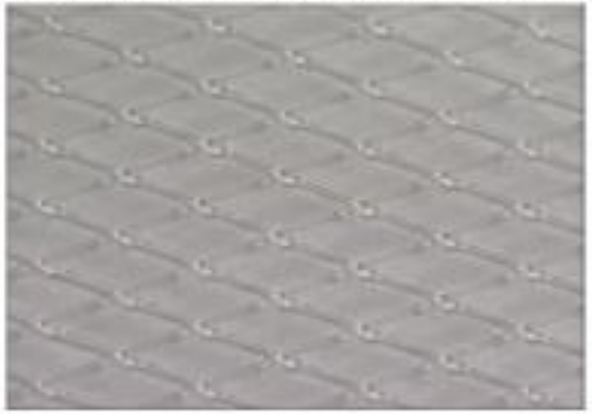
- Membrane was in very good visual condition upon arrival. A very light foulant deposition was observed on the membrane leaves.
- Initial wet testing found that the membrane flux to be ~2.68% below manufacturer's nominal specification
- Flat sheet testing with coupons:
  - After overnight soak in D.I. water, permeability increased by ~20% over the manufacturer's nominal specification. Salt rejection was within spec.
  - After high pH (~11.9) chemical clean, permeability increased significantly
  - After low pH (~1.7) chemical clean, permeability decreased slightly
  - Overall, membrane permeability increased by approximately 45% over the nominal specification. The salt rejection, when normalized for flux, was within specification.

# Membrane Autopsy Findings

FEED END

CONCENTRATE END

FEED SPACER CLEAN AND INTACT



LIGHT FOULANT COLLECTED AFTER ADDITION OF WATER

# Membrane Autopsy Conditions

- Test results suggest foulant was organic. SEM/EDS/SEI/PED analysis found no inorganic deposits on the membrane surface.
- Large increase in permeability not associated with oxidant damage:
  - Fujiwara test negative
  - Salt rejection within specification
- Membrane substantially more permeable than membrane specification.

# Cost Analysis – Basis of Comparison

- Full-Scale Treatment Capacity = 2.0 mgd (2,000 AFY, 90% availability)
- Preliminary design (2018):
  - Conventional 3-stage RO to achieve 92.8% recovery
  - Average Flux = 12 gfd
  - Brine flow = 108 gpm
- Alternative: Full-Scale CCRO
  - Recovery = 94%
  - Average Flux = 10 gfd
  - Brine Flow = 89 gpm (~20% reduction vs conventional 3-stage design)

# Cost Analysis – Key Assumptions

- Cost estimate compares CCRO vs 3-Stage RO equipment, feed water chemical conditioning, and brine ponds.
- All other project components (buildings, ancillary systems, pretreatment, etc.) are assumed to be identical.
- Labor costs assumed to be equal
- Operating costs include:
  - Power
  - Chemicals (sulfuric acid + antiscalant)
  - Replacement (5-yr membrane age assumed)
  - Maintenance (assume 2% of equipment cost)

# Cost Analysis – CAPEX Estimate

- 3-Stage RO
  - Assume 2 x 2.0 mgd trains
  - $2,400,000 ($1,200,000 per train)
- CCRO
  - Assume 3 x 1.0 mgd trains
  - $2,700,000 ($900,000 per train)

## Brine Ponds

- 2018 Preliminary Design Estimate = $9,200,000 → AVG FLOW 108 GPM
- 2021 Cost = $10,580,000 (assuming 5% escalation)

# Cost Analysis – NPV Estimate

| Treatment Option | Category | Value |
|---|---|---|
| Conventional 3-Stage RO | Annual O&M Costs | $369,600 |
| | Capital Costs – 3-Stage RO | $2,400,000 |
| | Capital Costs – Evaporation Ponds | $10,580,000 |
| | 30-yr NPV | $26,508,000 |
| | Total Yield (30 years) | 60,000 AF |
| | NPV | $442/AF |
| CCRO | Annual O&M Costs | $449,900 |
| | Capital Costs – 3-Stage RO | $2,700,000 |
| | Capital Costs – Evaporation Ponds | $8,718,700 |
| | 30-yr NPV | $28,033,000 |
| | Total Yield (30 years) | 60,000 AF |
| | NPV | $467/AF |

89/108 * $10,580,000

~18% Reduction

# CCRO - Potential Enhancement Opportunities

- During the pilot, chemical feed conditioning based on worst-case phosphate levels (15 mg/L)
  - pH = 5.0
  - Antiscalant = 12 mg/L
- By monitoring phosphate levels in the tertiary effluent, pH and antiscalant dose could be optimized
- CCRO technology opens up the possibility for varying the feed water pH in line with recovery (i.e. reduce pH as recovery increases)

# Observations and Conclusions

- Conservative MF operating parameters resulted in very reliable performance
- Stability of CCRO process similar to conventional RO treating this quality of feedwater and operating at 92-93% recovery
- CCRO capable of achieving ~30 days continuous operation between CIPs for recoveries up to 94%
- CIPs initiated based on ~15% loss in normalized permeate flow. Some reuse applications allow losses up to 20-25% prior to initiating CIPs

# Observations and Conclusions

- Reliable pH monitoring/control critical to CCRO operation when phosphate is present. Advance warning systems and redundant instrumentation recommended.

- Membrane autopsy found evidence of organic fouling, but no significant mineral scaling

- 30-yr NPV for conventional 3-stage RO < 30-yr NPV for CCRO even when considering smaller ponds

# THANK YOU

CONTACT US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# Questions & Discussion