Multi-Metals Continuous Water Analyzer Xact 920 to Monitor RO Performance in Potable Reuse
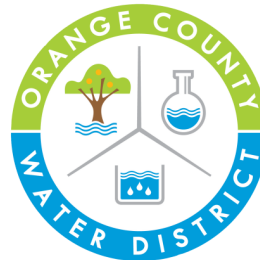
Jana Safarik[1]

Andrew Huang[1], Megan H. Plumlee[1]
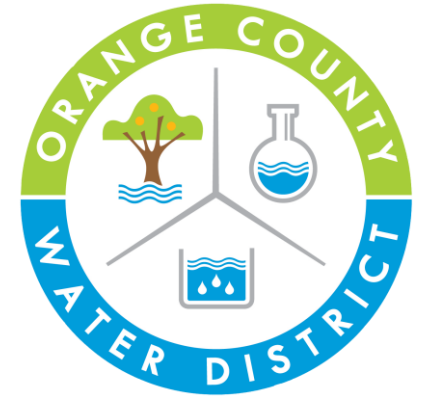
Troy Pittenger[2], Brian Edge[2]

[1]Orange County Water District

[2]SailBri Cooper, Inc.

Project Partners

- Orange County Water District
- SailBri Cooper Environmental – Industrial Partner
- US Bureau of Reclamation

Presentation Outline

- Project objectives
- Test site
- RO surrogates
  - Xact 920 vs Standard Methods
  - Regulatory approval
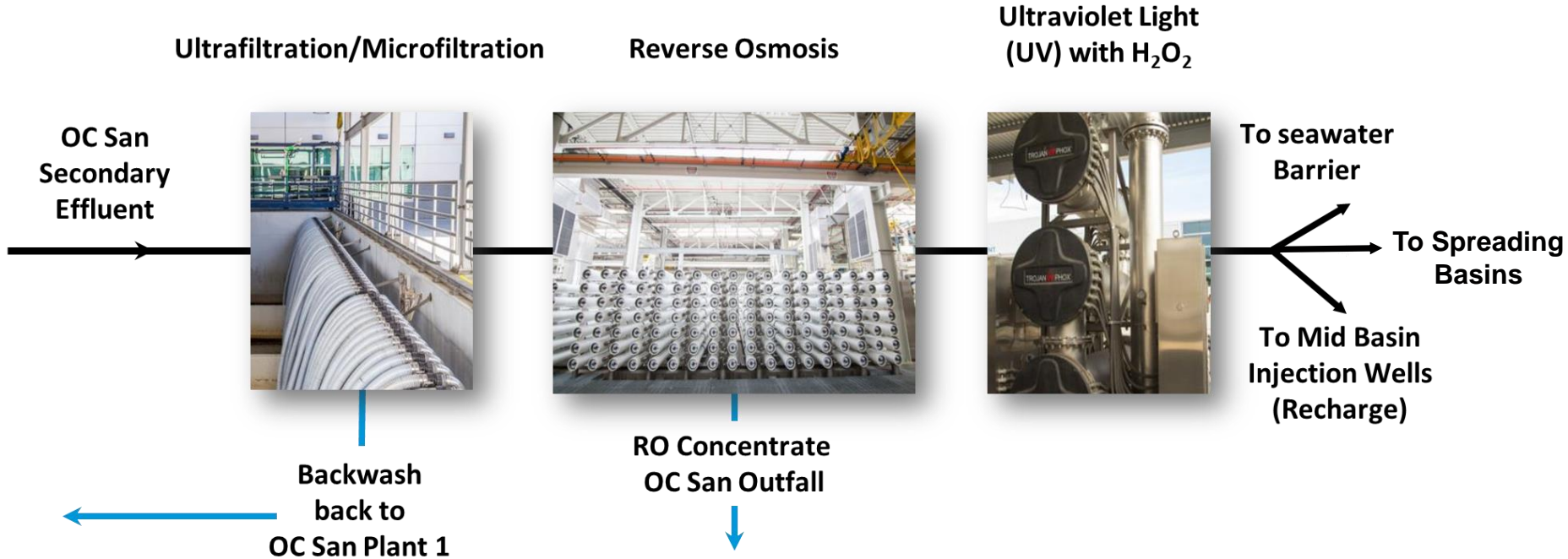- RO scale elements
- Results
- Conclusions

Project Objectives and Results

Through piloting, determine the benefits and limitations of using a novel, online continuous multi-metals water analyzer, Xact 920 to:
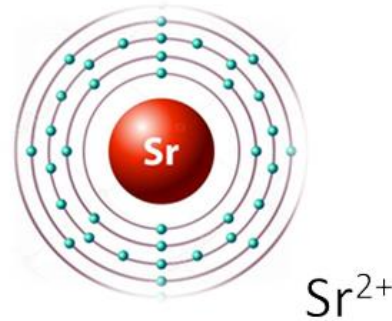
1. Continuously measure **Sr (virus surrogate)** to determine RO integrity
   - ❖ *Xact 920 can replace daily grab samples and continuously measure Sr in RO feed and RO permeate*

2. Continuously measure **mineral-scale forming analytes** in RO feedwater
   - ❖ *Xact 920 can continuously measure mineral scale forming analytes which can potentially be used to inform anti-scalant dosing and predict scale formation*

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OCWD Groundwater Replenishment System (GWRS)

Largest potable reuse facility in the world, producing 130 mgd of high purity water

Ultrafiltration/Microfiltration

Reverse Osmosis

Ultraviolet Light (UV) with H_2O_2

OC San Secondary Effluent

To seawater Barrier

To Spreading Basins

To Mid Basin Injection Wells (Recharge)

Backwash back to OC San Plant 1

RO Concentrate OC San Outfall

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# Objective 1. Continuously measure Sr to determine RO integrity

Sr^{2+}

Pathogen Crediting for Potable Reuse in CA

- Treatment processes must provide water that is free of waterborne pathogens
- Each process receives pathogen removal credit based on its ability to demonstrate such removal
  - IPR = 12 logs (virus)
  - DPR = 20 logs (virus)
- Ability to remove pathogens must be on-going and is process specific

Norovirus
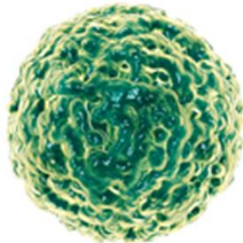
Log Removal Credits Required for Groundwater Replenishment Projects		
Virus	*Giardia*	*Crypto*
12	10	10

Pathogen Reduction at GWRS

Pathogen (LRV Required)	OC SAN ORANGE COUNTY SANITATION DISTRICT	MF/UF + Cl2	RO	UV/AOP	Underground Retention (1-log/Month)	Total
	Pre GWRS	GWRS			Environmental Buffer	
Giardia (10)	0	4+	2+	6	0	**12+**
Crypto (10)	0	4+	2+	6	0	**12+**
Virus (12)	0.18 or 0.7*	0	2+	6	4+	**12.18+**

*Polanco, J. et.al. (2023) *Plos Water* (29).

Reverse Osmosis (RO)

- RO is the core treatment in advanced purification for potable reuse

    - Barrier to pathogens and most dissolved constituents

- Regulators require RO systems have continuous monitoring to demonstrate membrane integrity to ensure public health

- Continuous pathogen (biological) monitoring is not currently available; therefore, non-biological surrogates are used

- Surrogates demonstrate 1 – 2 logs of removal

    - Conductivity - up to 1.5 logs of removal credit
    - Total organic carbon (TOC) - up to 2 logs of removal credit

- Virus spike studies have shown up to 6 logs of virus removal

USBR RO LRV Study (Report No. 243)

- **Objective:** identify easily monitored alternative surrogates with LRV > TOC via grab sampling and online monitoring over multiple months in a full-scale plant RO unit at OCWD

SO_4^{2-}

Sr^{2+}

ATP

Adenine

Ribose

High-energy bond

Fluorescence Peak C
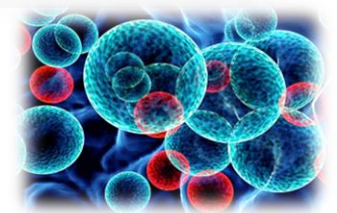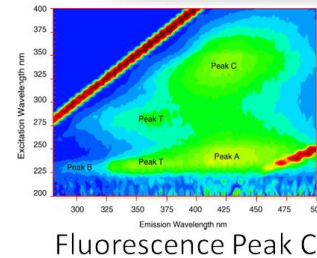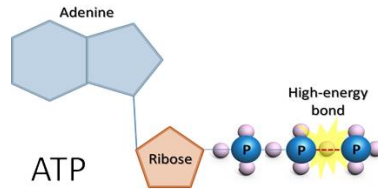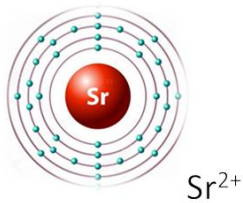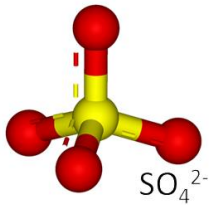
Nanoparticles

Summary of RO LRV Study Results

Surrogate	Study Average LRV	Min LRV	Max LRV
Strontium[1]	**3.28**	**3.01**	**3.38**
Sulfate [1]	2.90	2.79	3.00
Free ATP [2]	3.03	2.60	3.30
Fluorescence Peak C [2]	2.70	2.27	3.00
TOC [2]	2.01	1.77	2.36
EC [2]	1.50	0.72	1.54

Unit B01 (Membranes: Hydranautics ESPA2-LD)

[1]Grab Samples
[2]Continuous (online)

Strontium Log Reduction Value

- Strontium can detect RO integrity issues sooner than TDS
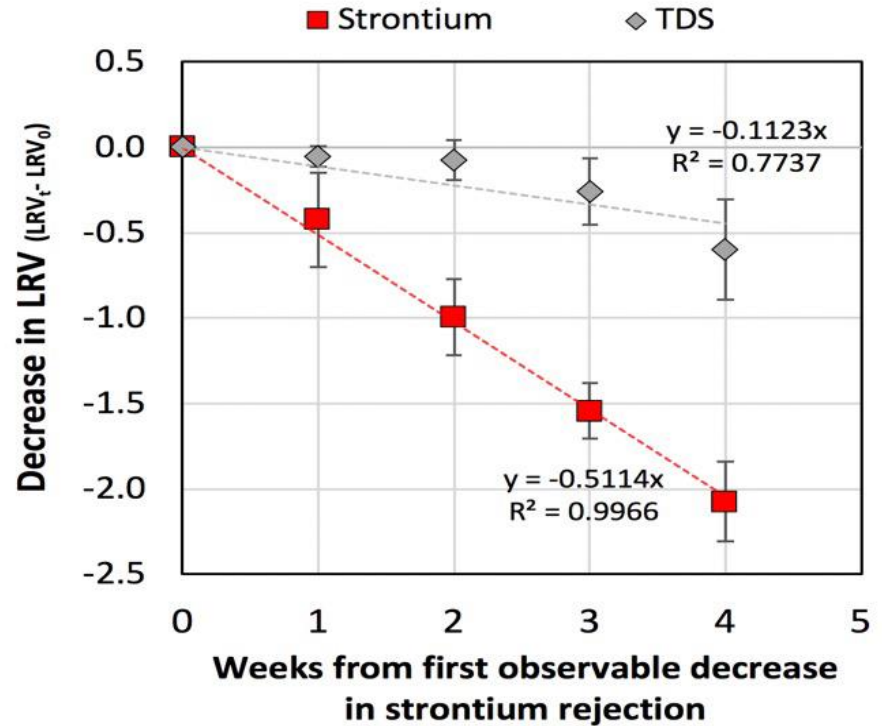
Sen, S. et al., WateReuse CA Annual Conference 2021.

Xact 920 Continuous Water Analyzer

- Uses reel-to-reel filter tape sampling and non-destructive X-ray fluorescence (XRF) for elemental aqueous solutions
- Measure Sr in near real-time at ppb-level detection limits
- Measure up to 65 different elements including:
  - Mineral scale salts such as Fe, Si, Ca, S, K
- Capable of analyzing multiple streams
  - Analysis of sample occurs as the subsequent sample is being collected

Drying Chamber

Master Controller

Heater Controller

User Interface

Air Controller

Liquid Controller

XRF Controller

Exhaust Treatment Controller
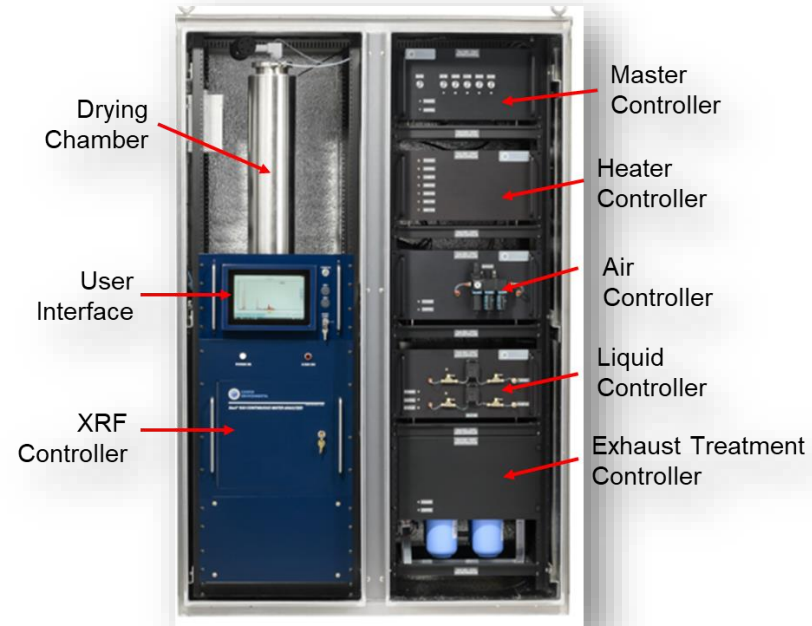
SailBri Copper, Inc.

Xact 920 at OCWD

Xact 920

Feedwater Manifold

RO Permeate

RO Feed
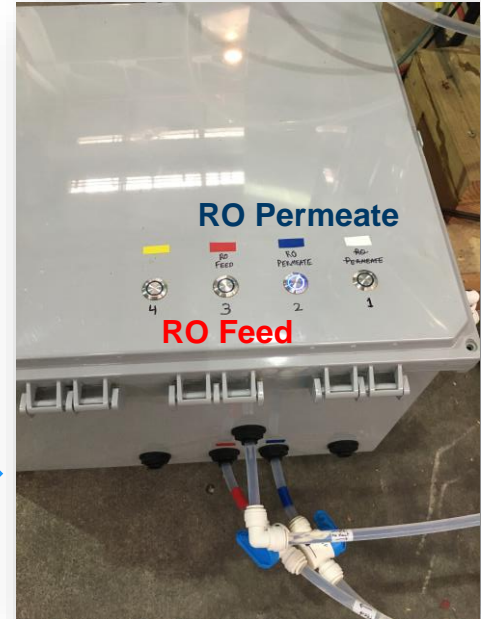
Xact 920 at OCWD

Automated
Feed Manifold
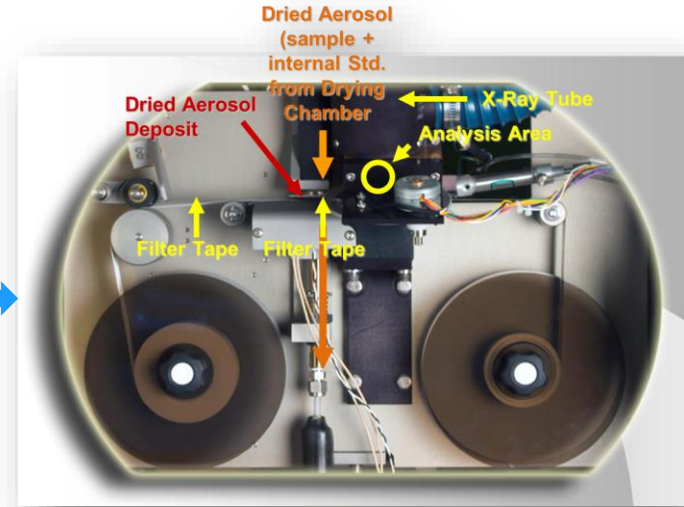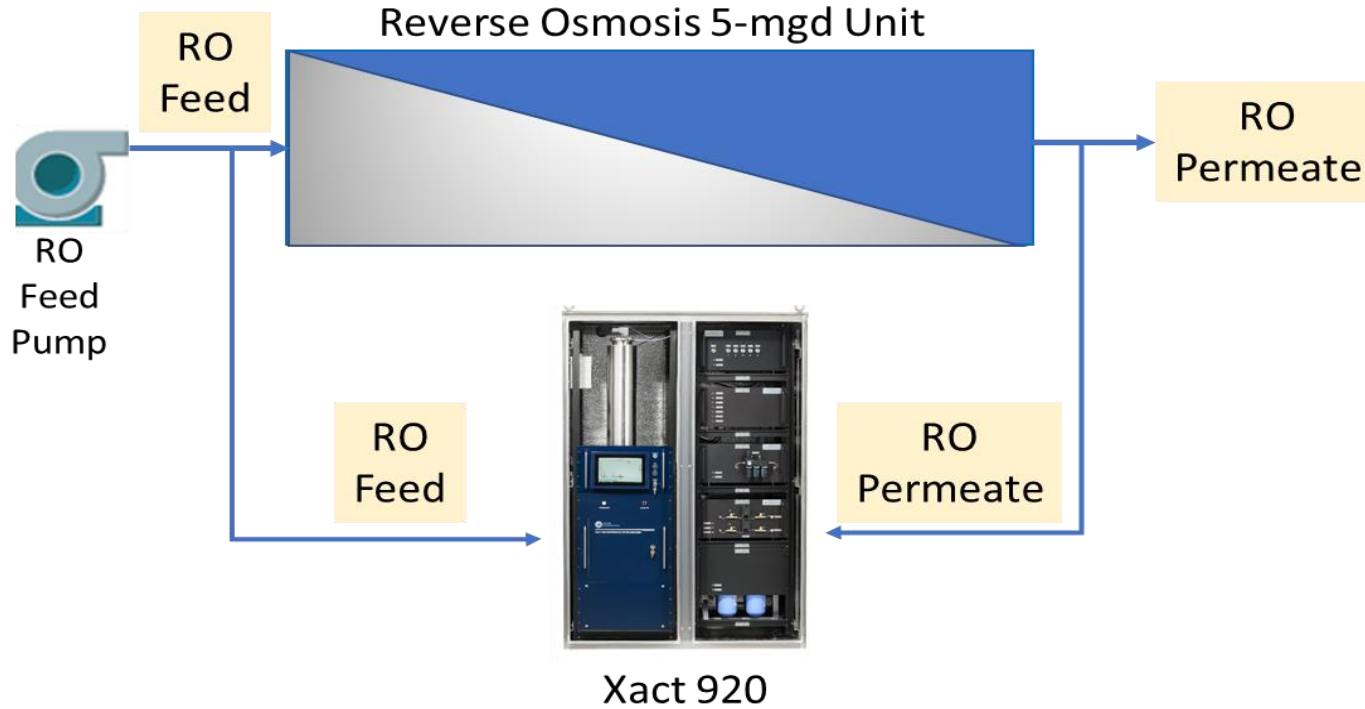

Sample influent
Stream switching

Preconcentration XRF Analysis

Xact 920 at OCWD – 5-MGD RO Unit

Xact 920

Sr LRV: Xact 920 vs Standard Method (Weck Laboratories)

Ave. Weck Labs
2.98 ± 0.12

Ave. Xact 920
3.00 ± 0.13
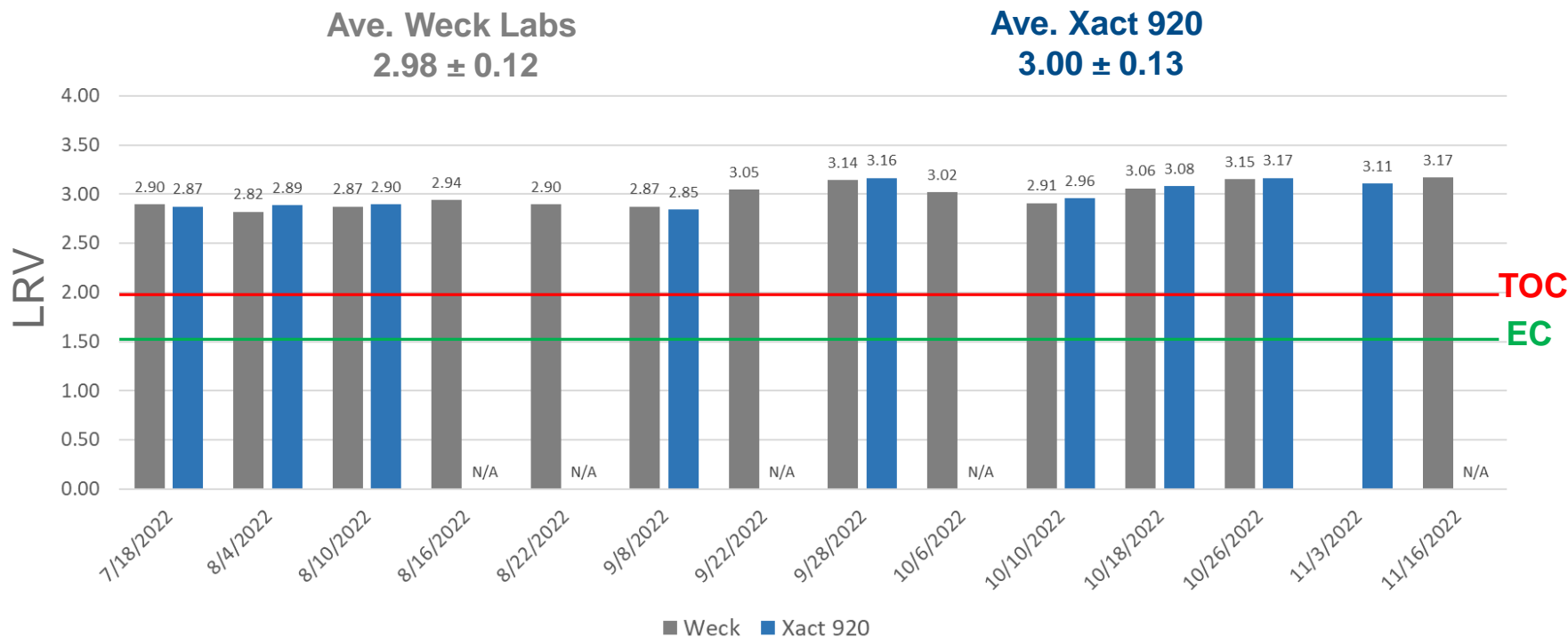
Bulk RO = Combined permeated from 21 5-MGD RO Units
Grab Samples

SR LRV: Xact 920 vs Standard Method (Weck Laboratories)

Legend: ■ Weck ■ Xact 920

RO Unit	Weck	Xact 920
B03	2.75	2.75
F03	2.79	2.74
F01	2.83	2.86
B02	2.87	2.75
C01	2.98	2.95
AVG BULK	2.98	3.00
A03	3.03	3.26
G02	3.06	3.07
G01	3.12	2.96
B01	3.14	3.19
A02	3.17	N/A
F02	3.19	3.27
E01	3.19	3.34
A01	3.34	3.37
E01	3.34	3.41
G03	3.42	3.49

TOC = 2.00
EC = 1.50
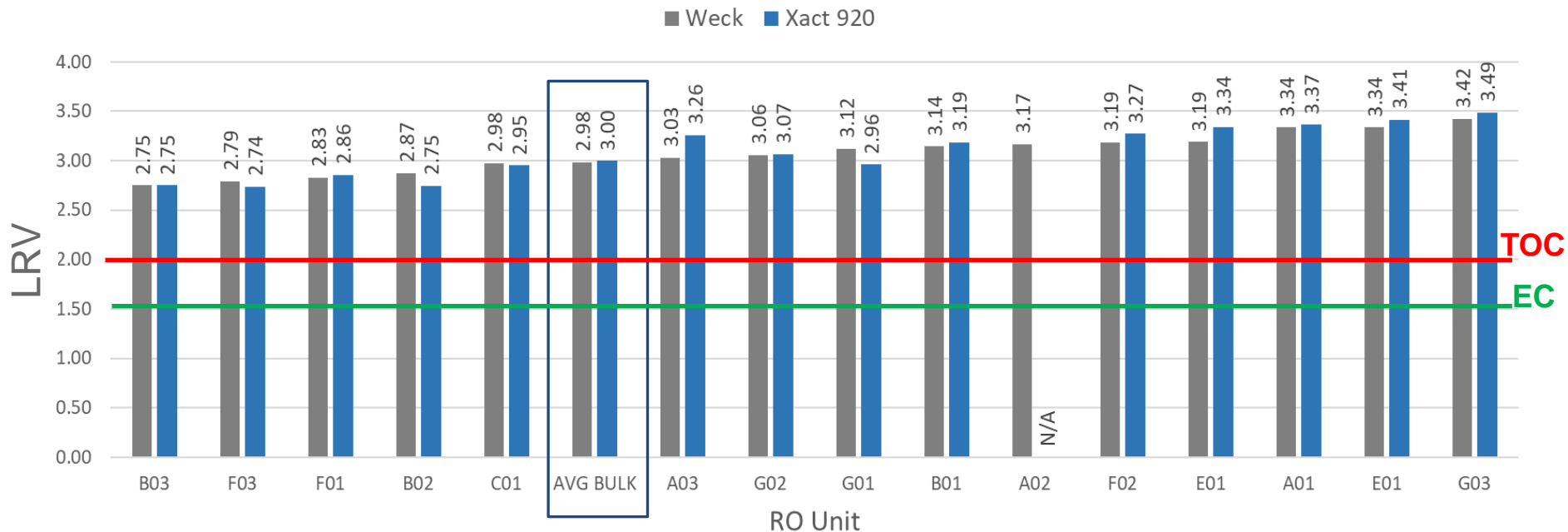
Individual 5-MGD RO Units
Grab Samples

18

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Xact 920 - Sr Continuous Analysis
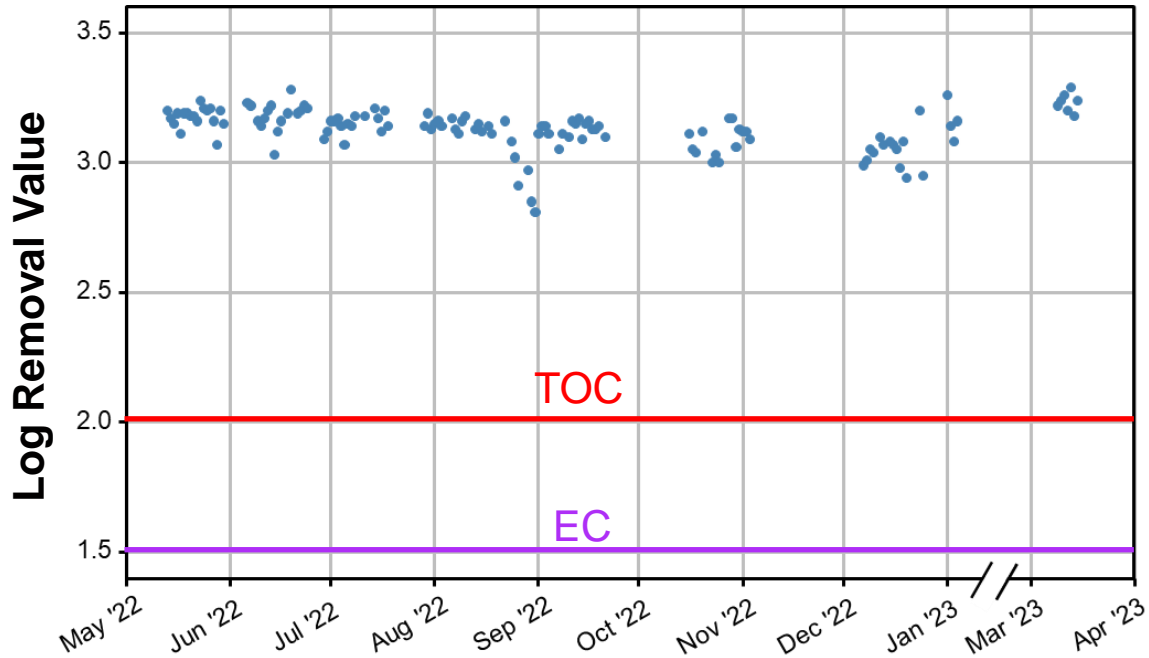
Average LRV = 3.12
Min LRV = 2.81
Max LRV = 3.29

5-MGD RO Unit

Xact 920 Regulatory Approval

- DDW is requiring approval of Xact 920 that is equivalent to the EPA Drinking Water Alternate Test Procedure Program to obtain LRV credit.

- Sailbri Cooper, Inc. has developed a validation study plan, in consultation with Padre Dam MWD, Trussell Technologies, and OCWD, and the team is awaiting DDW approval to begin the study .

  - Proposed plan will follow structure and guidance from EPA's *Protocol for Evaluation of Alternate Test Procedures for Organic and Inorganic Analytes in Drinking Water (ATP)*.

- DDW approval is also required of validation study testing results prior to use of Xact 920 for RO LRV crediting.

WATEREUSE CALIFORNIA CONFERENCE 2023

Reverse Osmosis Pathogen Log Reduction Tiered Monitoring Approach

enhanced (permitted but not implemented)   *current*

RO System Monitoring	Tier 1	Tier 2	Tier 3
Surrogate	Strontium*, ATP, or Sulfate	TOC	EC
Frequency	Continuous online (Each monitoring location at least once daily) <u>or</u> Daily grab**	Continuous online (15-min data)	Continuous online (15-min data)
Monitoring locations	Combined (bulk) ROF & per-train ROP	Bulk ROF & bulk ROP	Bulk ROF & per-train ROP
Awarded LRV	Based on actual removal determined by tiered methodology		

* Online instrument requires DDW approval

**Only likely to be implemented if online analyzer implemented but offline

Objective 2. Continuously measure mineral-scale forming analytes in RO feedwater

RO Membrane Scaling

- Scaling occurs when soluble salts in the RO stream approach a concentration at which they can no longer remain in solution and begin to precipitate on the membrane surface.

- Scale mitigation measures

  - pH correction
  - Antiscalant chemical addition

- Scale results in increased energy costs and chemical cost

- Currently inorganics in RO feedwater are measured via grab sampling
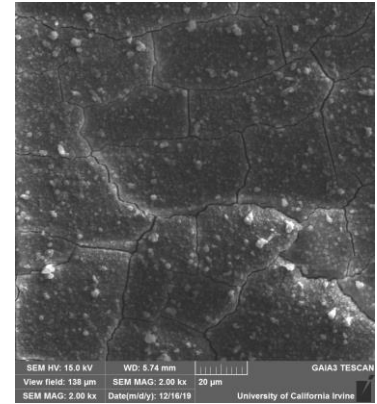

Photo credit: amtaorg.com

Benefits and Needs for Online Monitoring of Mineral Scale Elements

- Improve operations and optimize membrane cleaning based on enhanced knowledge of feedwater quality
  - Narrow down RO clean in place (CIP) chemical formulation
  - Reduce chemical costs
- Determine if antiscalant dose is adequate
  - Measure diurnal variation of scale elements to determine if dosing is adequate
  - Decrease energy use
- Advanced RO systems could be optimized based on real time feedwater quality
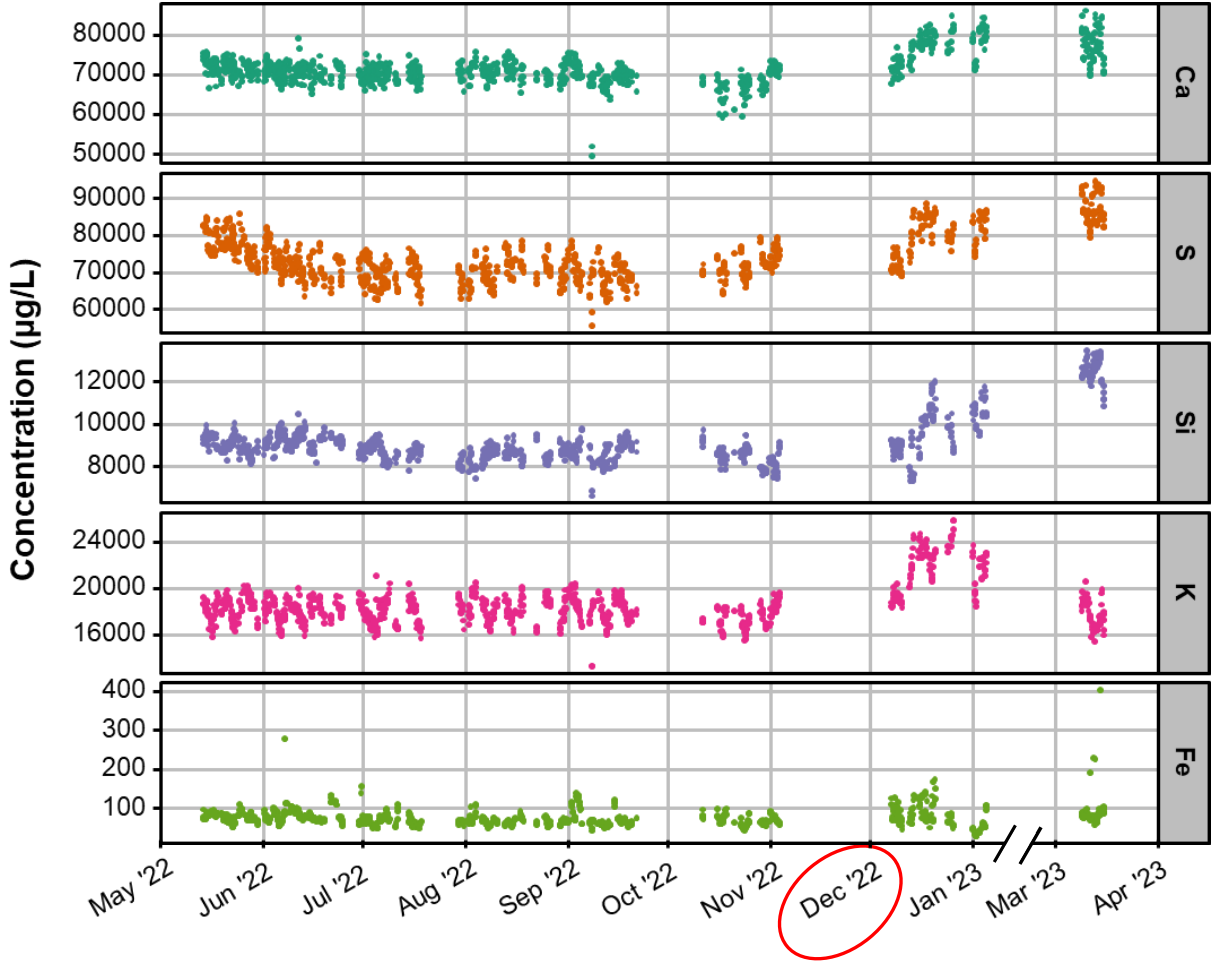 - FR-RO, CCRO, FO-RO

RO Feed Scale Elements
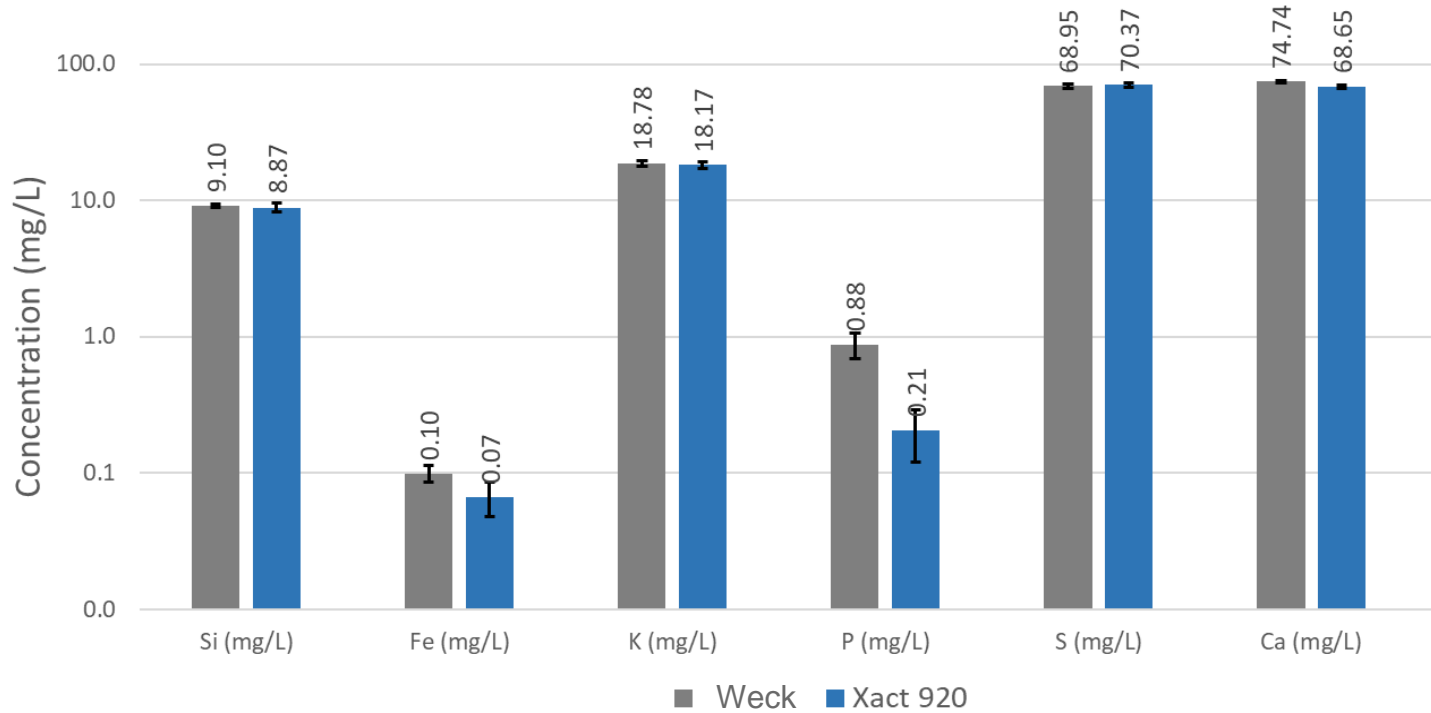
RO Feed Scale Elements Continuous Analysis

- Dec. 2022 - new feedwater
- Increased TDS from ~1500 to ~2300

Scaling Model: Concentration Polarization

- The degree of polarization was different at flux condition.
- The precipitation can be estimated by comparing the concentration on the surface of the membrane (by concentration polarization) and the threshold (by saturation index).
- Potential to predict antiscalant dose.

Si concentration on 1st stage membrane surface

Si concentration on 3rd stage membrane surface
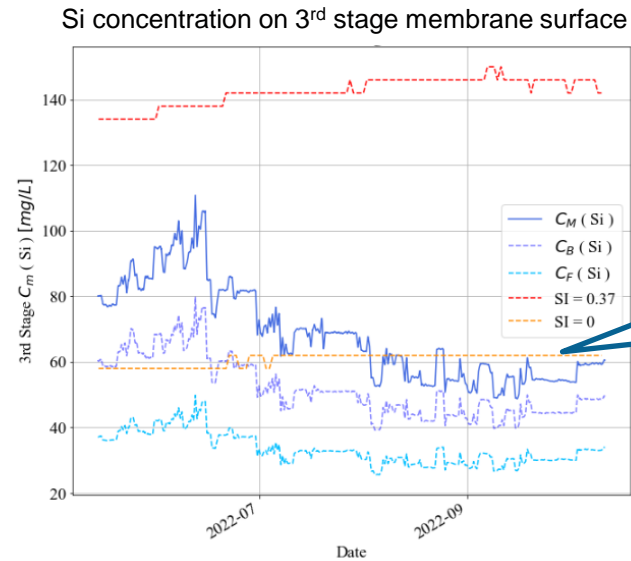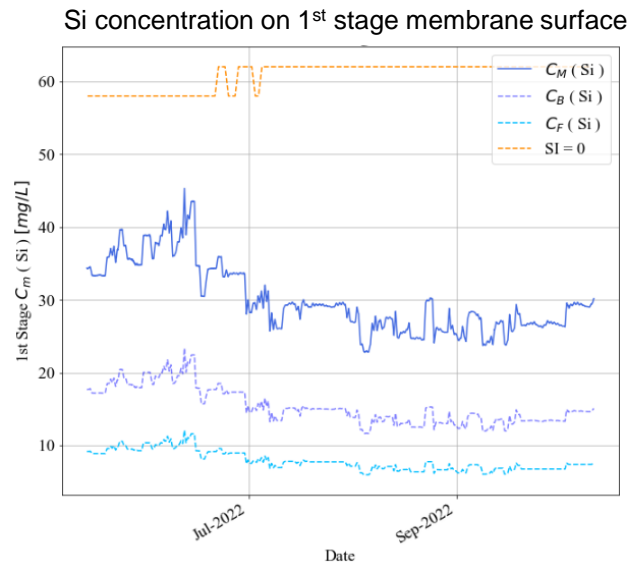
There is a potential to reduce anti-scalant when SI < 0.

Mika Kawate, Ken-ichi Kamada, and Matsui Yasuhiro
NAWI 5.17

Conclusions

- Xact 920 can replace daily grab samples and lab analysis

- Xact 920 results compare well with EPA standard methods for Sr and RO scale elements

- Regulatory approval is pending

  - Case by case basis

Next Steps

- USBR project is complete – final report in progress
- OCWD is participating in DDW permitting process

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