State Water Resources Control Board

Recycled Water Research Needs Workshop

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Thematic Topic 2:

Performance Reliability (Treatment, Operations, and Training)

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Thematic Topic #2

Performance Reliability
(Treatment, Operations, and Training)

- **Fundamental to Indirect or Direct Potable Reuse:**
  - Reliability of treatment performance
  - Goal: Ensure protection of public health from chemical and pathogen risks
- **Reliability:**
  - Treatment effectiveness
  - Appropriate operations
  - Appropriate monitoring schemes
  - Appropriate staff and staff training

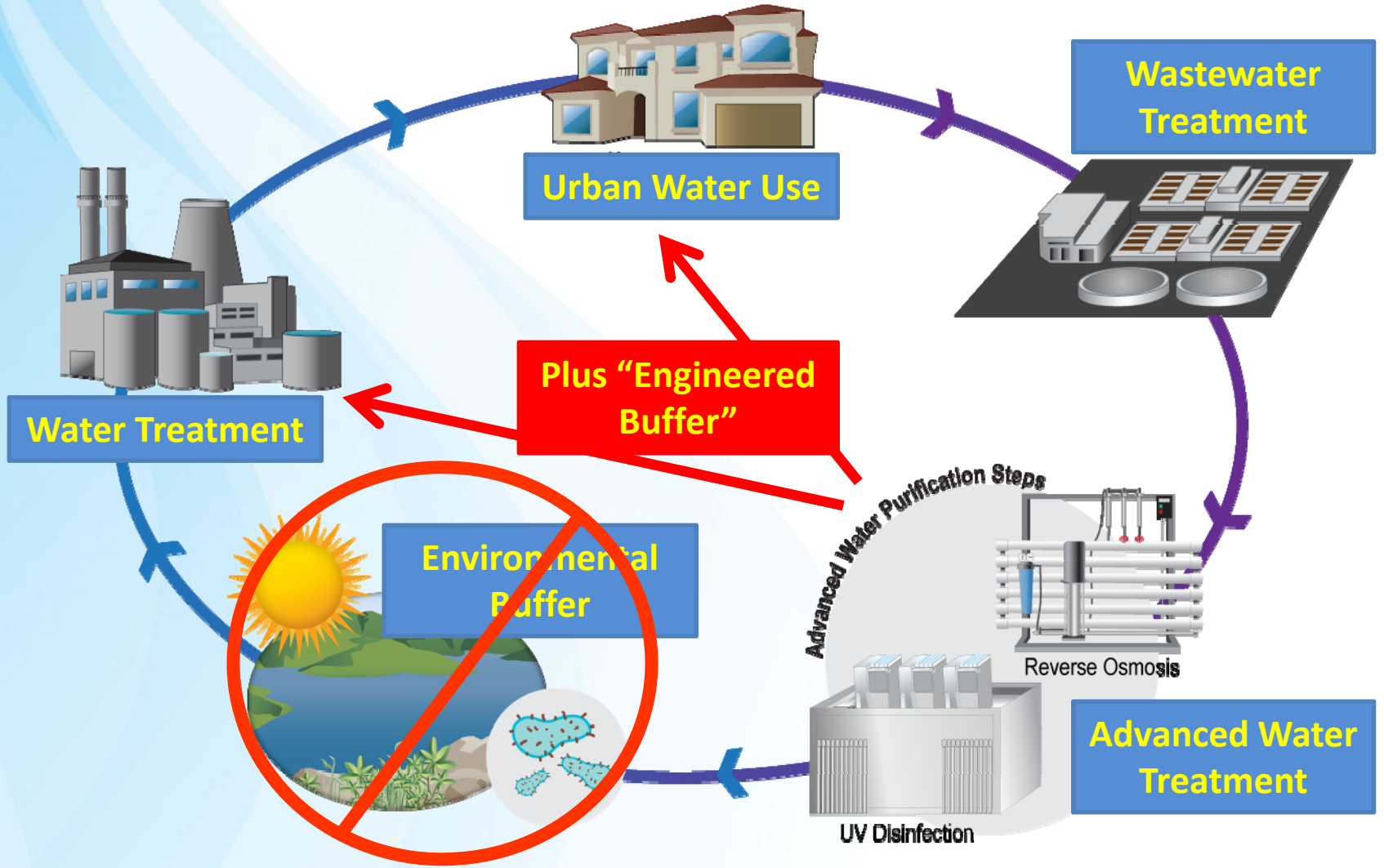
Multiple Barrier Concept

- **Foundation for treatment performance**
  - Drinking water concept
  - Diversity of independent barriers
- **Involves:**
  - Multiple treatment barriers
  - Technical, operational, and managerial barriers
- **Goals:**
  - Prevent contaminants at the source
  - Enhance treatment performance
  - Ensure protection of public health

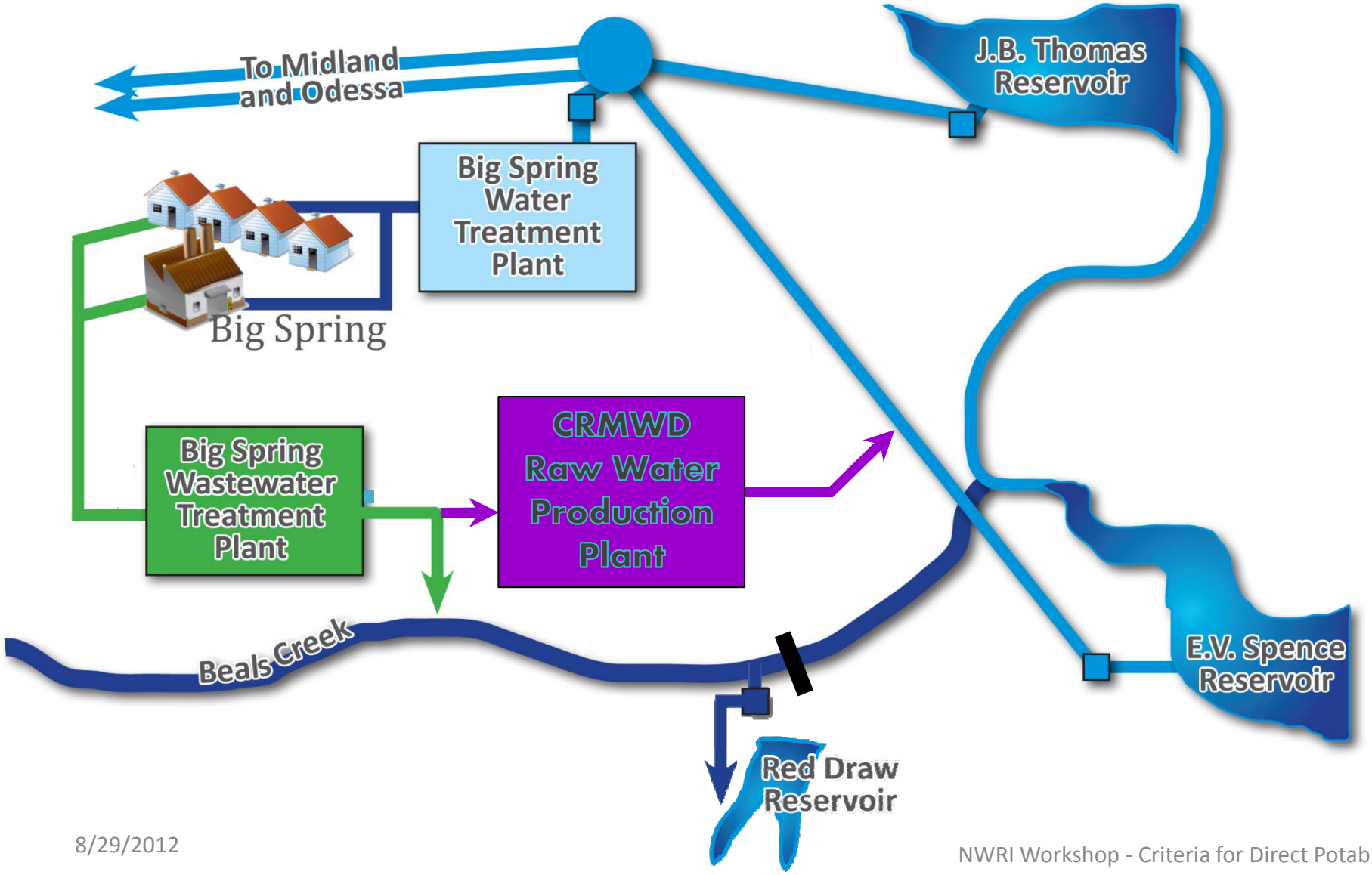
Potable Reuse

- **Indirect Potable Reuse (use of Environmental Barrier)**
  - Groundwater Recharge
    - Spreading of tertiary treated wastewater
    - Spreading or injection of Full Advanced Treatment (FAT) water (MF/RO/AOP)
  - Surface Water Augmentation
    - FAT for Reservoir Augmentation (e.g., City of San Diego)
  - Both must meet stringent chemical and pathogen criteria
  - Plus many other monitoring and operational requirements
- **Direct Potable Reuse**
  - Eliminates the environmental barrier (no aquifer or reservoir)
  - Two options:
    - Advanced treatment (FAT) plus conventional drinking water treatment plant
    - Advanced treatment (FAT) and into a potable distribution system

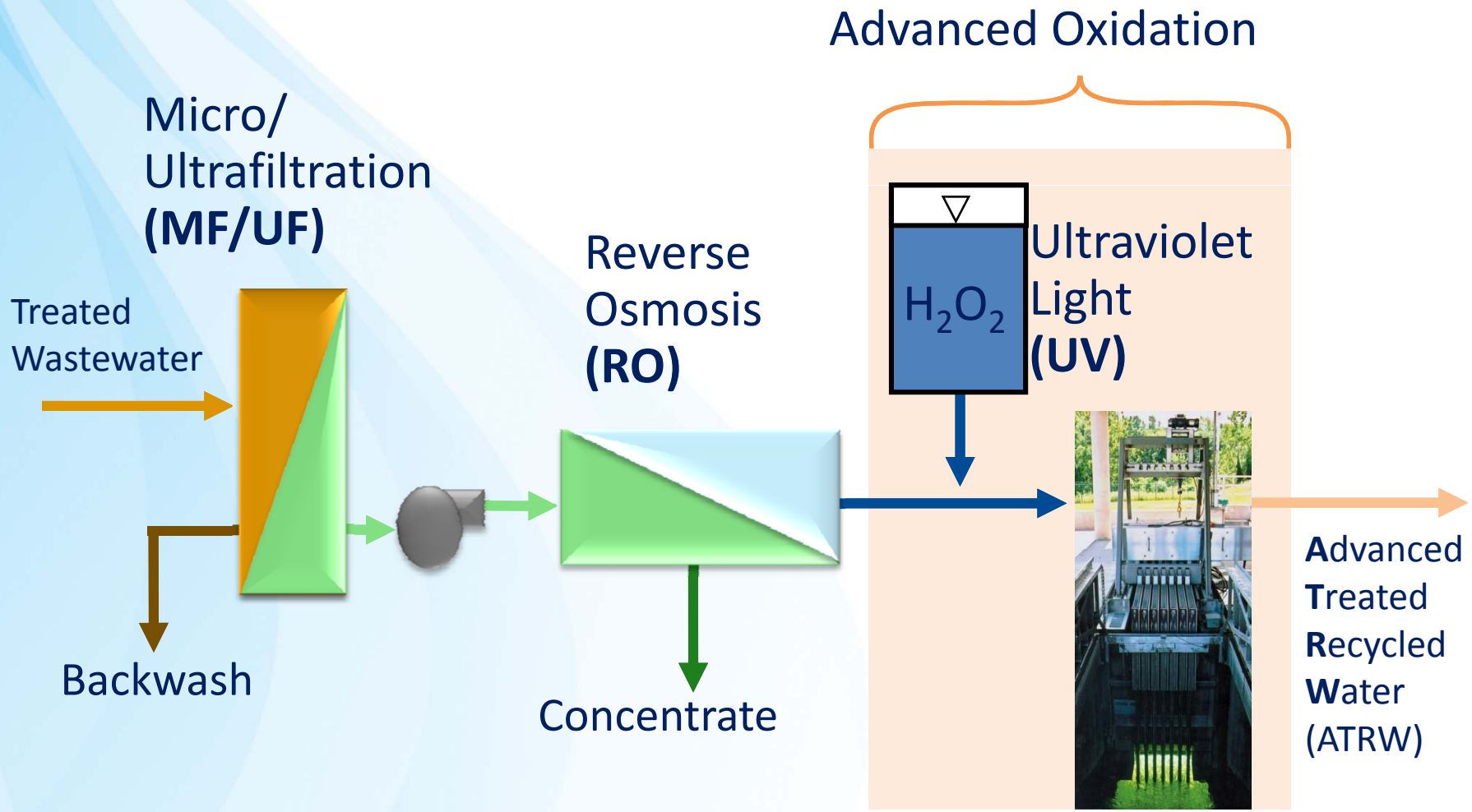
Direct Potable Reuse



Big Spring (TX) Reclamation Project



Potable Reuse: "Full Advanced Treatment"



Direct Potable Reuse

- **Eliminate the environmental buffer:**
  - Is an "engineered storage buffer" needed?
  - What performance monitoring requirements are needed to ensure water quality?
  - What is the role of redundancy and robustness in a treatment train without an environmental buffer?

- **Thinking:**
  - Treatments are proven
  - But measures are needed to provide a "time to react" to address lapses

DPR: Types of Barriers (1)

- **Significant protection provided by:**
  - Management, operational, and technological barriers
- **Examples:**
  - Source control (collection system)
  - Wastewater treatment optimization (equalization, denitrification, monitoring)
  - Use of advanced treatment and monitoring
  - Use of drinking water treatment plant as a barrier
  - Engineered storage and/or additional monitoring

DPR: Types of Barriers (2)

- **Water quality:**
  - Treatment strategies (e.g., FAT)
  - Technical controls (alarms, procedures, etc.)
  - Online and other monitoring
  - Operational controls (“react to upsets”)
  - Monitoring and operational plans (procedures for operators)
- **Monitoring (similar to drinking water):**
  - Bulk parameters (surrogates) and indicators
  - Ensure proper treatment performance
  - Online devices (turbidity, TOC, etc.)
  - Grab or composite samples

DPR Design Topics

- **Source Control Programs**
  - Control of constituents not compatible with DPR
- **Design features**
  - Treatment optimization, performance monitoring
- **Incorporate reliability and resilience**
  - Variability of processes, treatment lapses, other errors
- **Apply "4R" approach to ensure protection of public health**
  - Reliability: resilience, robustness, redundancy
- **New technologies (monitoring and treatment)**
  - Demonstration and validation
- **Surrogates and indicators for performance monitoring**
  - Real-time monitoring
  - Use of "Critical Control Points"
- **Operations, Monitoring, and Maintenance Plans**
  - Address variability, lapses, and errors
- **Operator Training**
  - For advanced treatment technologies; appropriate response times

Definition of 4 R's

Term	Definition as Pertaining to DPR	Notes
Reliability	A measure of the ability of a system to distribute water that meets all requirements protective of public health	Reliability includes design, operation, maintenance, and source control
Redundancy	The use of multiple unit processes to attenuate the same type of contaminant	More unit processes in series, even with reduced individual performance, can result in improved overall performance
Robustness	The combination of technologies that address a broad variety of contaminants	Broad spectrum treatment is required due to the original water source (wastewater)
Resilience	The capacity of a DPR system to adapt successfully in the face of threats or disaster	Resilience can be the ability to simply shut off, or the ability to adjust the level of treatment in response to single or multiple process performance failures

GWRS Microfiltration Operation

Microfiltration Effluent (MFE)	2012	2013
MFE Turbidity	0.07 NTU	0.08 NTU
MFE Turbidity Removal	97.70%	97%
MFE Suspended Solids	<1 mg/L	<1 mg/L

- Continue to operate at 89-90% recovery
- Performed 380 MF cleanings up from 366 MF cleans in 2012 across 26 cells
- Operations continued to optimize cleanings
- Use clean water flux (CWF) to help monitor cleaning effectiveness

GWRS: MF Operations (cont.)

- Overall good MF integrity observed: ~249 million individual fibers
- 1,286 fiber pins in 2013 compared to 499 fiber repairs in 2012
  - 2,828 total fiber repairs since 2008 startup
  - Critical control point (CCP)
- Pin repairs:

The sub module is placed in a Module Test Vessel.

Test vessel pressurized to 7 psi.

Water forced to top of module, integrity leaks identified by bubbles from the faulty fiber.

Faulty fibers blocked off using stainless steel pins tapped into top hole of fiber.

This is repeated until no more bubbles observed.

GWRS: Reverse Osmosis Operation

RO Product	2012	2013
TOC	0.14 mg/L	0.17 mg/L
TOC Removal %	98.30%	97.8%
Electrical Conductivity	57 umhos/cm	58 umhos/cm
Electrical Conductivity Removal %	96.2%	96.2%

- System recovery = 84.5% - 85%
- Pressure range = 130 - 230 psi
- Minimum specific flux = 0.07 gfd/psi
- No O-ring issues during normal operation

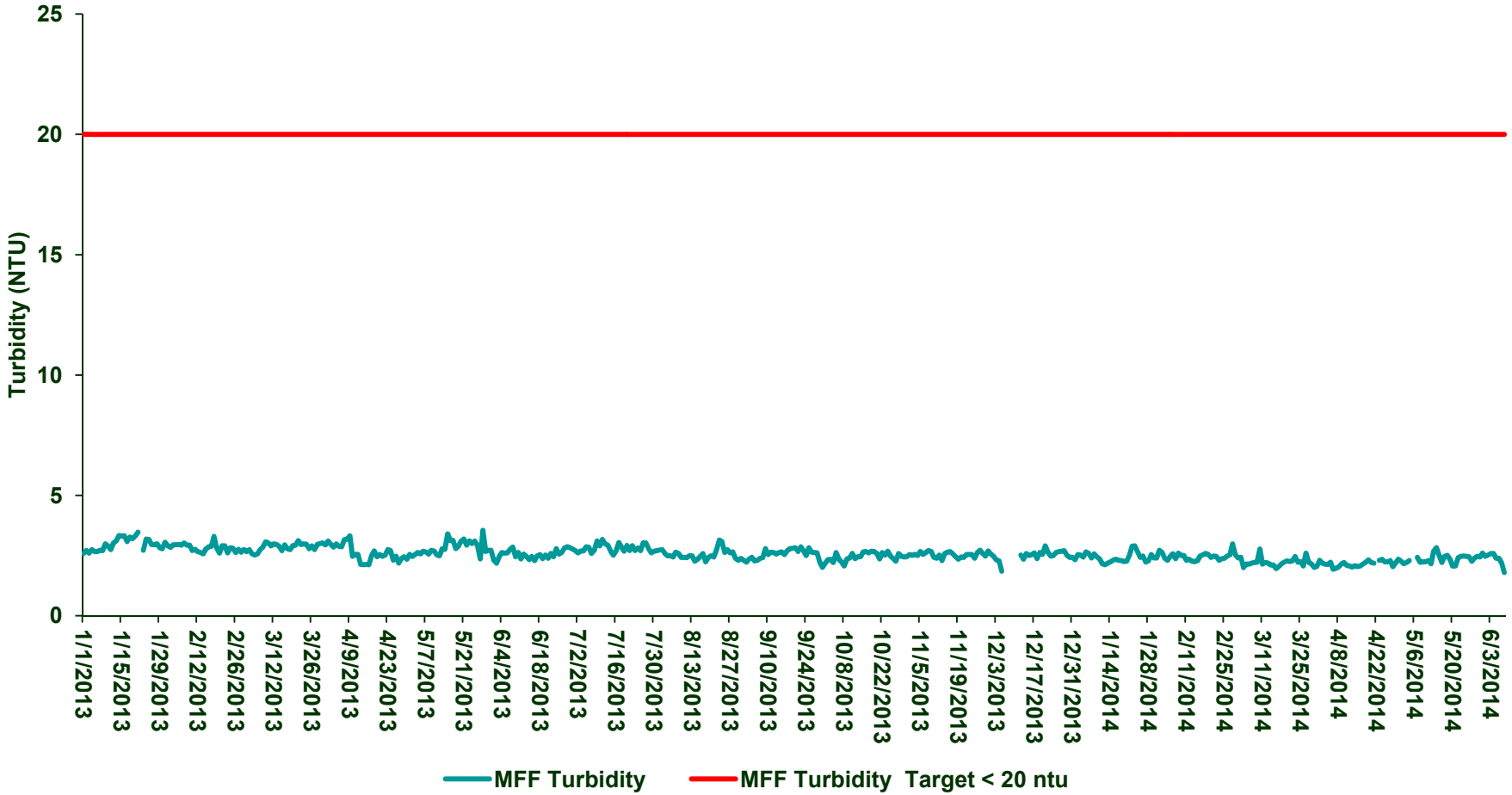
GWRS: UV/Advanced Oxidation Operation

- UV transmittance averaged = 98%
- Operates well above the minimum required disinfection dose of 101 mJ/cm²
- 3,021 UV lamp replacements in 2013
- 2014 lamp failure summary
  - 12% before 9,000 hrs,
  - 51% between 9,000 – 12,000 hrs and
  - 37% reached 12,000 hrs vs. 24% in 2012

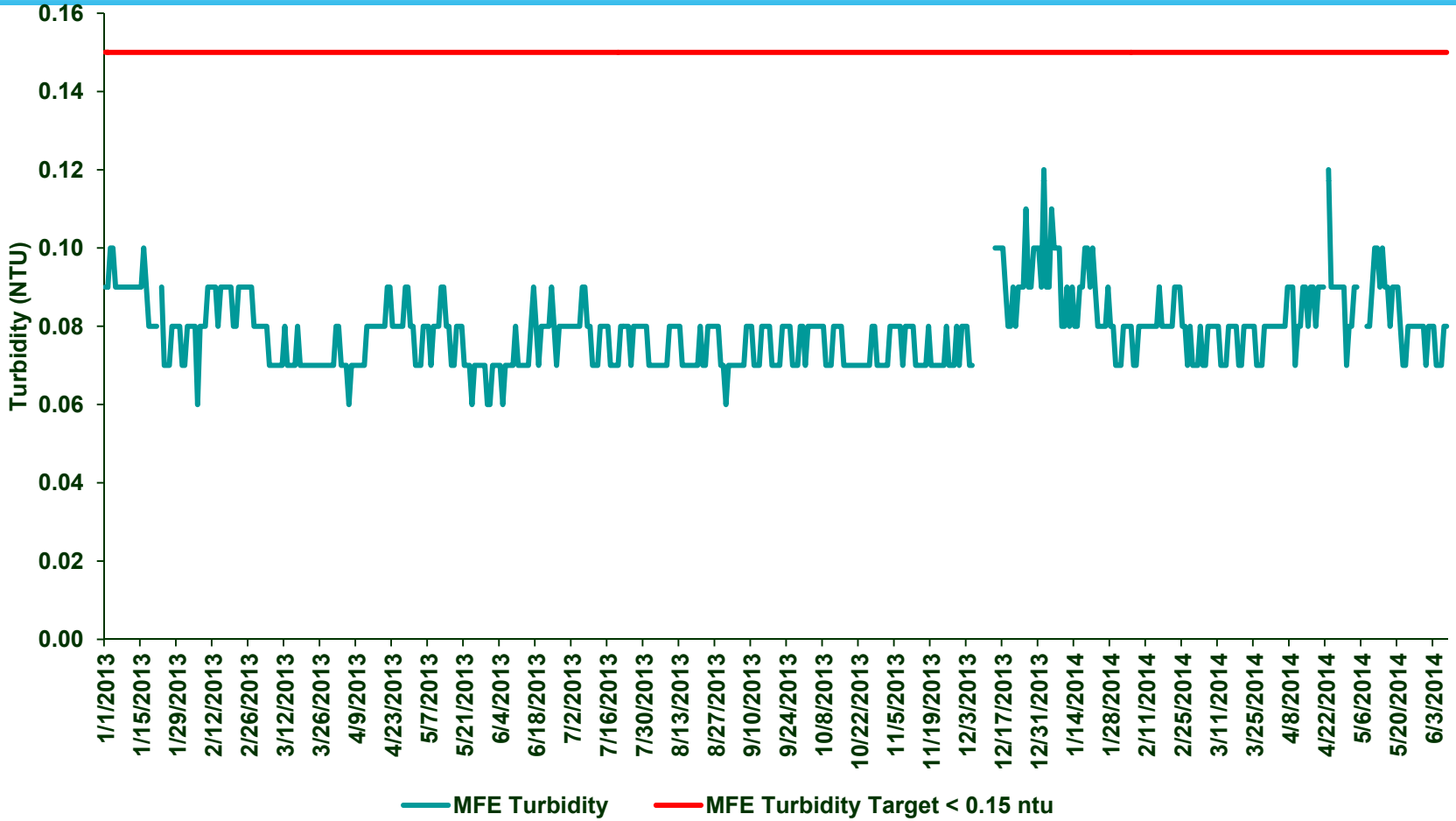
GWRS: "Critical Control Points"

		Flow Stream or Process	Target Operating Range
1.	Chlorine Residual	MF Feed	3 to 5 mg/L
2.	Chlorine Residual	RO Feed	< 5 mg/L
3.	Turbidity	MF Feed	<5 NTU optimum < 20 NTU for membrane warranty > 20 NTU for no more than 4 hours < 50 NTU at all times
4.	Turbidity	MF Effluent	< 0.15 NTU
5.	Turbidity	RO Product	0.1 to 0.15 NTU
6.	Transmembrane Pressure (TMP)	MF	3 to 12.5 psi
7.	Pressure Decay Test (PDT) based on daily testing	MF	< 0.25 psi/minute < 0.5 psi/minute per manufacturer
8.	Electrical Conductivity	RO Product	< 60 µmhos/cm (< 80 for individual units)
9.	Total Organic Carbon	RO Product	0.1 mg/L upper control limit
10.	UV Transmittance	UV/AOP	95% minimum (at 254 nanometers)
11.	Average UV Train Power	UV/AOP	Minimum 74 kW per train
12.	Calculated UV Dose per Train	UV/AOP	101 mJ/cm^2 minimum

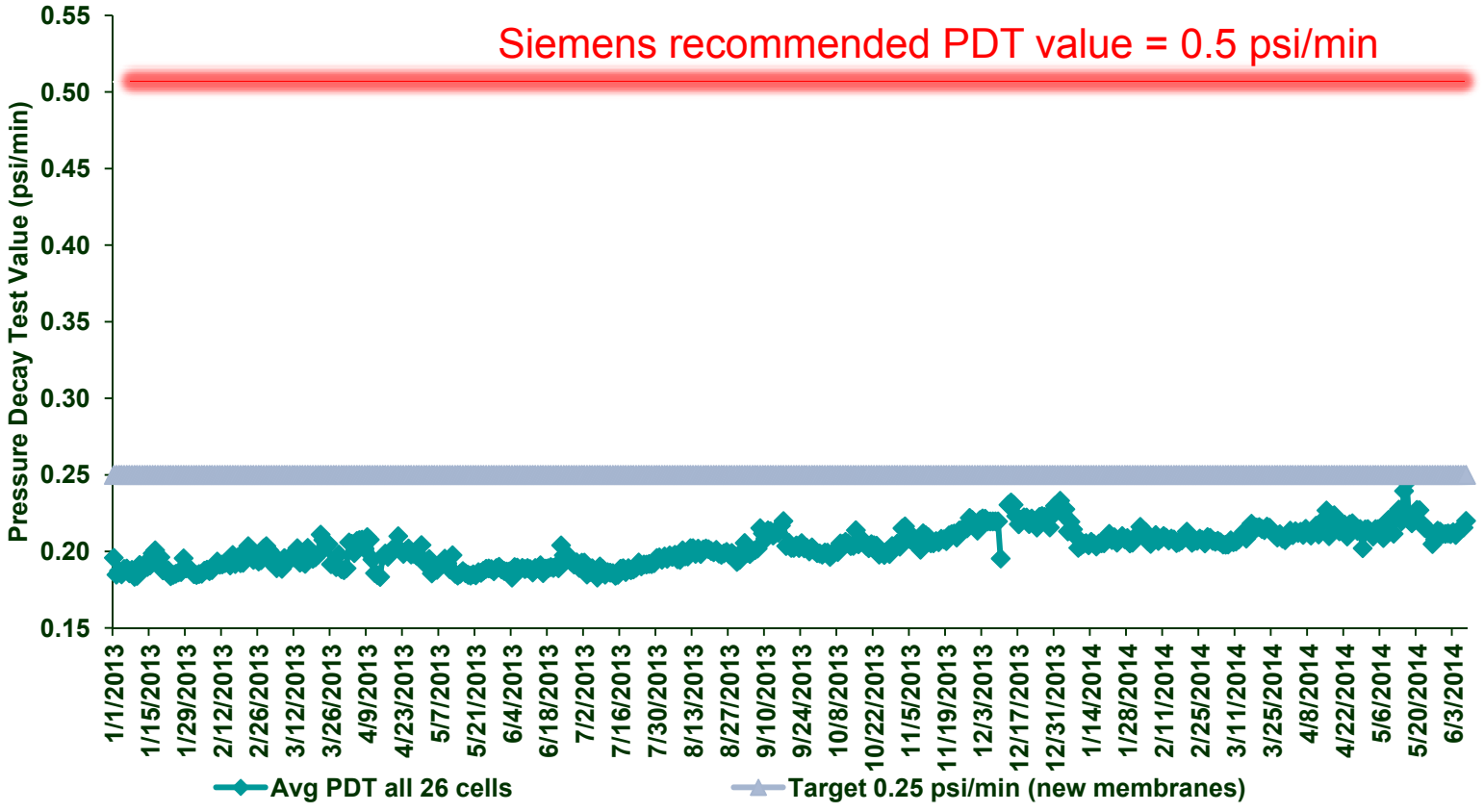
MF Performance – Influent Turbidity (Critical Control Point)



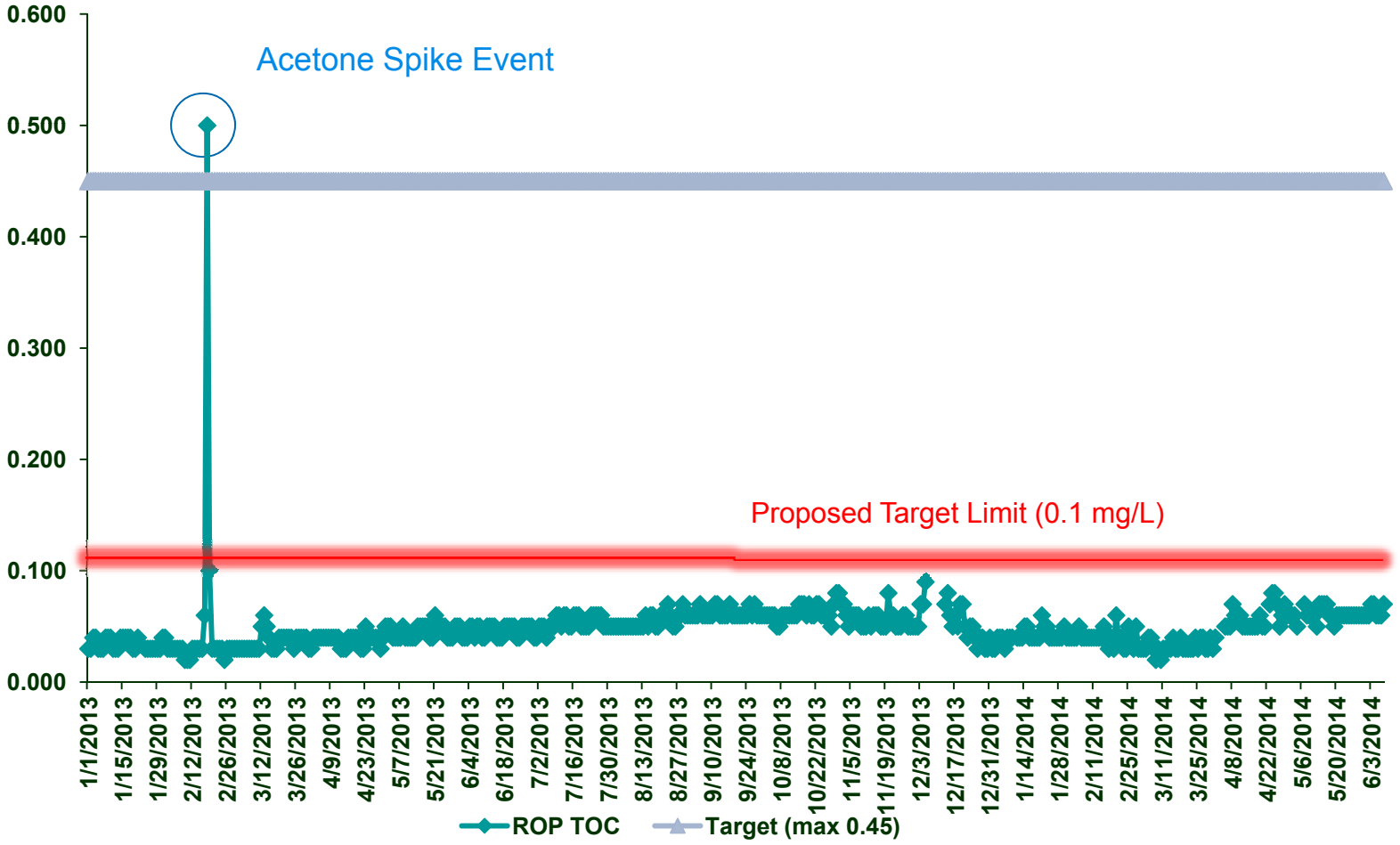
MF Performance – Effluent Turbidity (Critical Control Point)



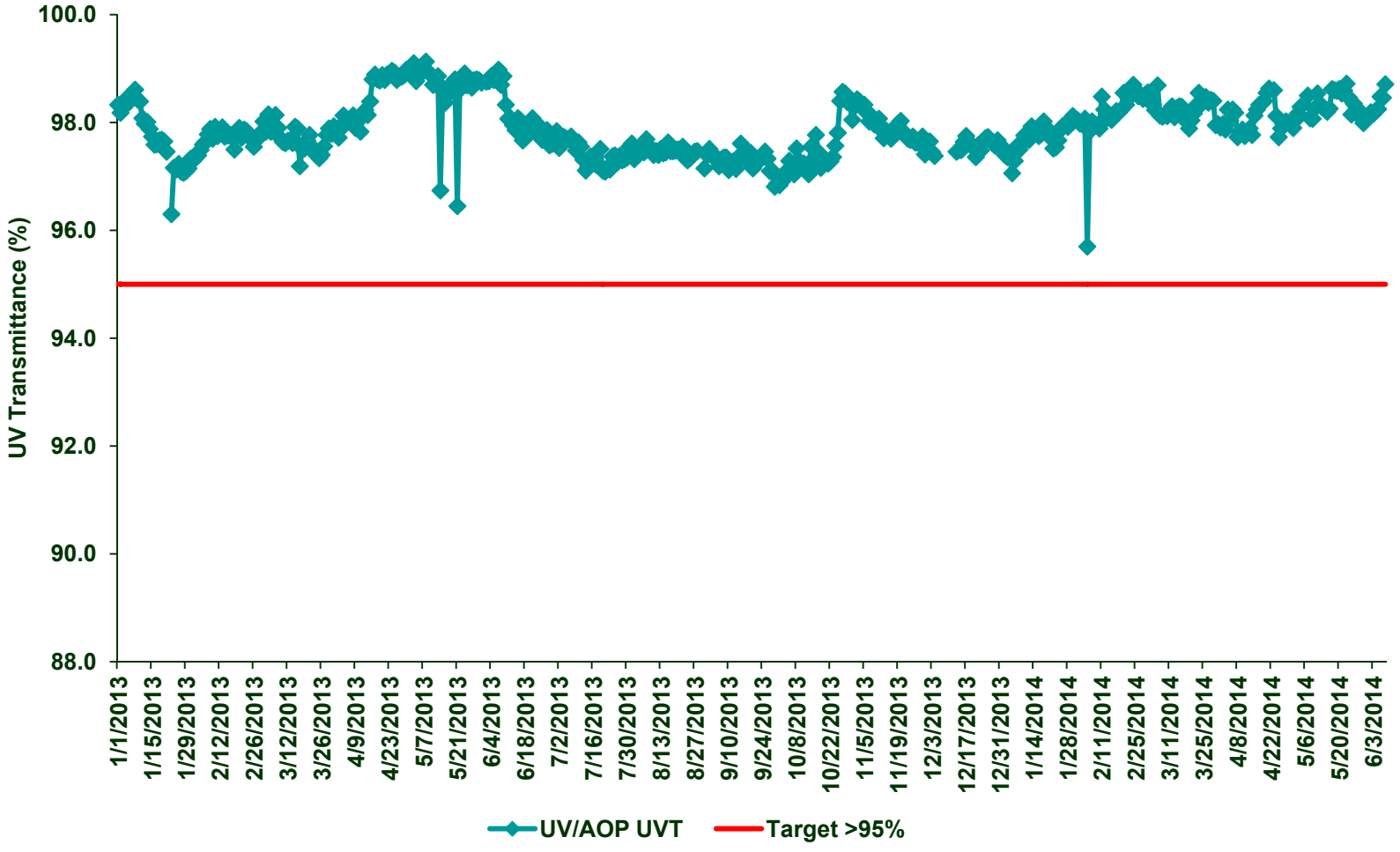
High Level of MF Integrity (Pressure Decay Testing) Ensures Proper Operation



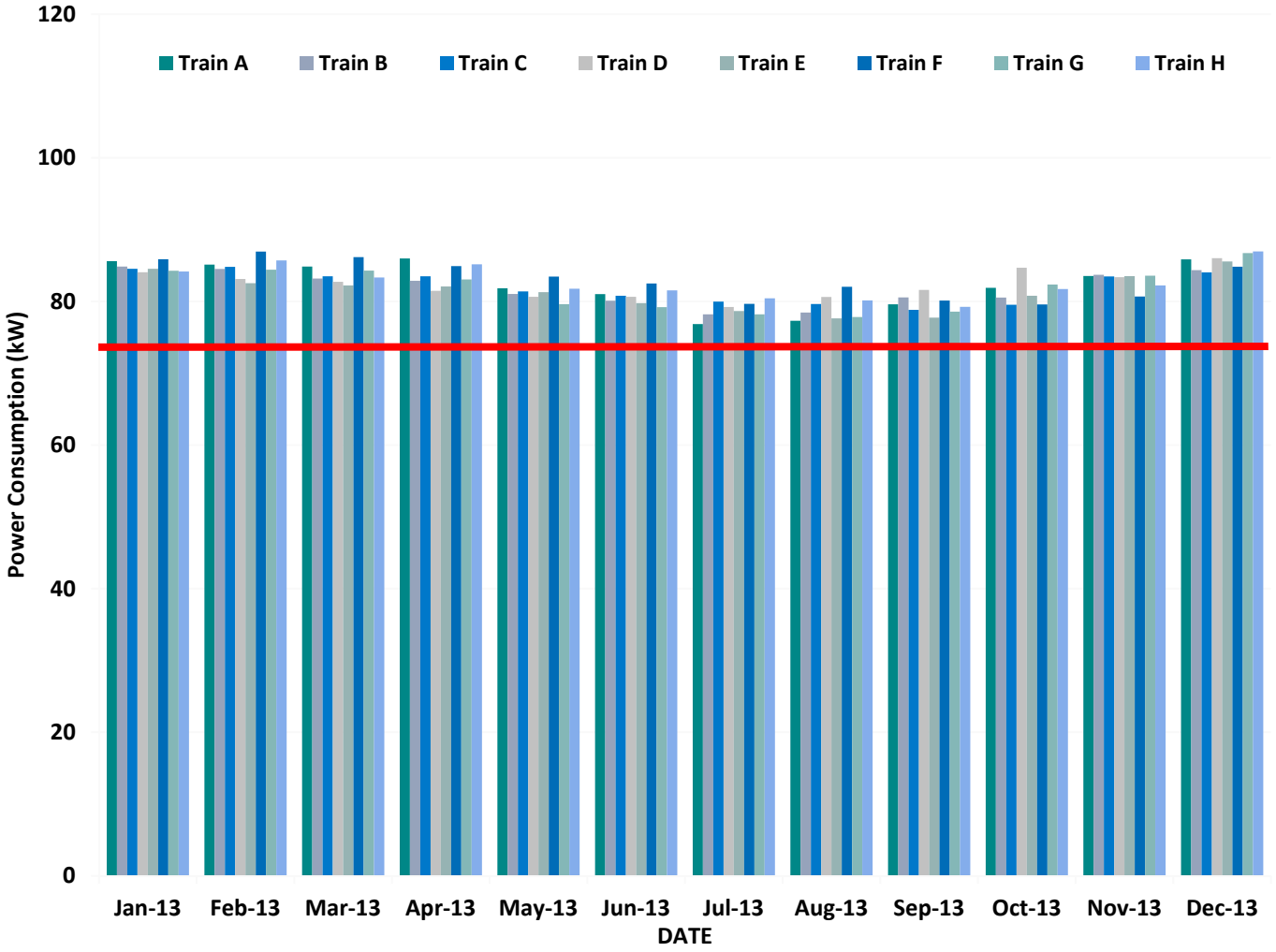
RO Performance – Product TOC (Critical Control Point)



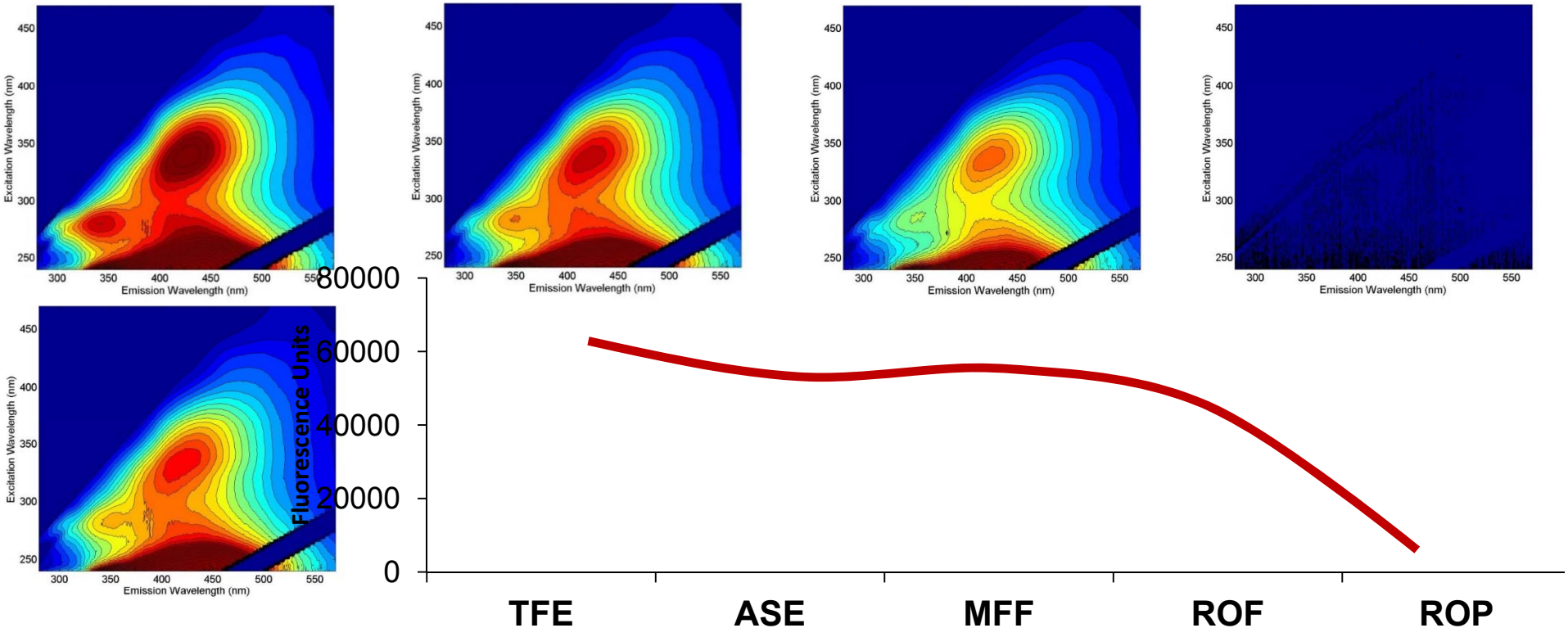
UV/AOP Performance – UV Transmittance (Critical Control Point)



UV/AOP Performance - Power (Critical Control Point)



Dissolved Organic Matter: Excitation/Emission Matrix (EEM) Analysis



DPR Research Needs (1)

- **Assess reliability of overall treatment and resiliency of unit treatment processes**
  - Methods to assess treatment performance
  - Define consistency of treatment
  - Better indicators and surrogates (performance monitoring)
  - Use of Critical Control Points for operations
- **Process to validate new technologies**
  - Treatment trains equivalent to FAT?
- **Characterize pathogen and chemical risks**
  - Removal of precursors of disinfection byproducts
  - Document removal of pathogens and chemicals
  - Better understand microbial communities

DPR Research Needs (2)

- **Preparation for failures (resiliency)**
  - Evaluate out-of-spec behavior
  - Development of plans and protocols
- **Operations**
  - Use of Operation and Monitoring Plans
  - Develop training for operators
  - Certification for “advance treatment plant” operators
- **Transition research to application**
  - Interpretation of results
  - Assist in the implementation of projects