Reclaimed Water Disinfection Challenges and Solutions at Brightwater

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American Water Works Association
Pacific Northwest Section

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Key Takeaways

- Reclaimed Water Distribution Challenges
- Chloramination Benefits/Challenges
- How Pathogen Crediting for MBRs Can Impact Disinfection

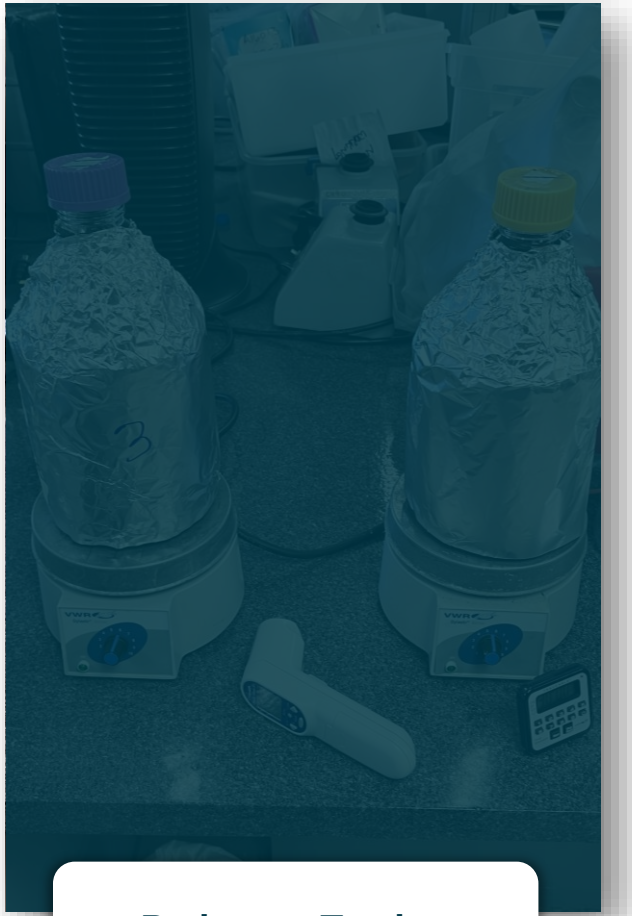
Acknowledgements

King County

Agenda

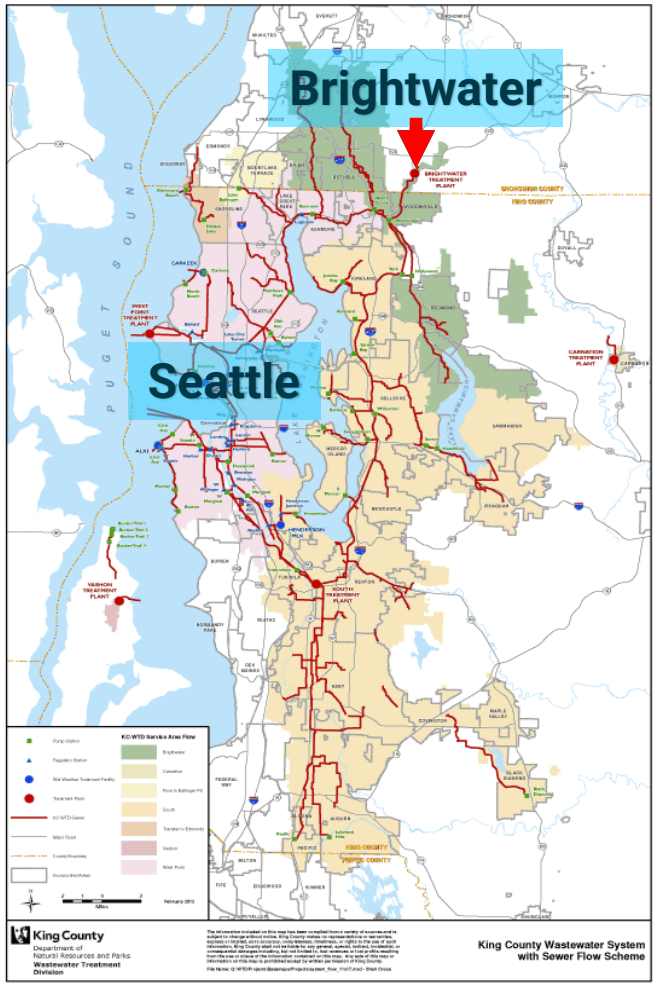
Project Background

Disinfection Solutions



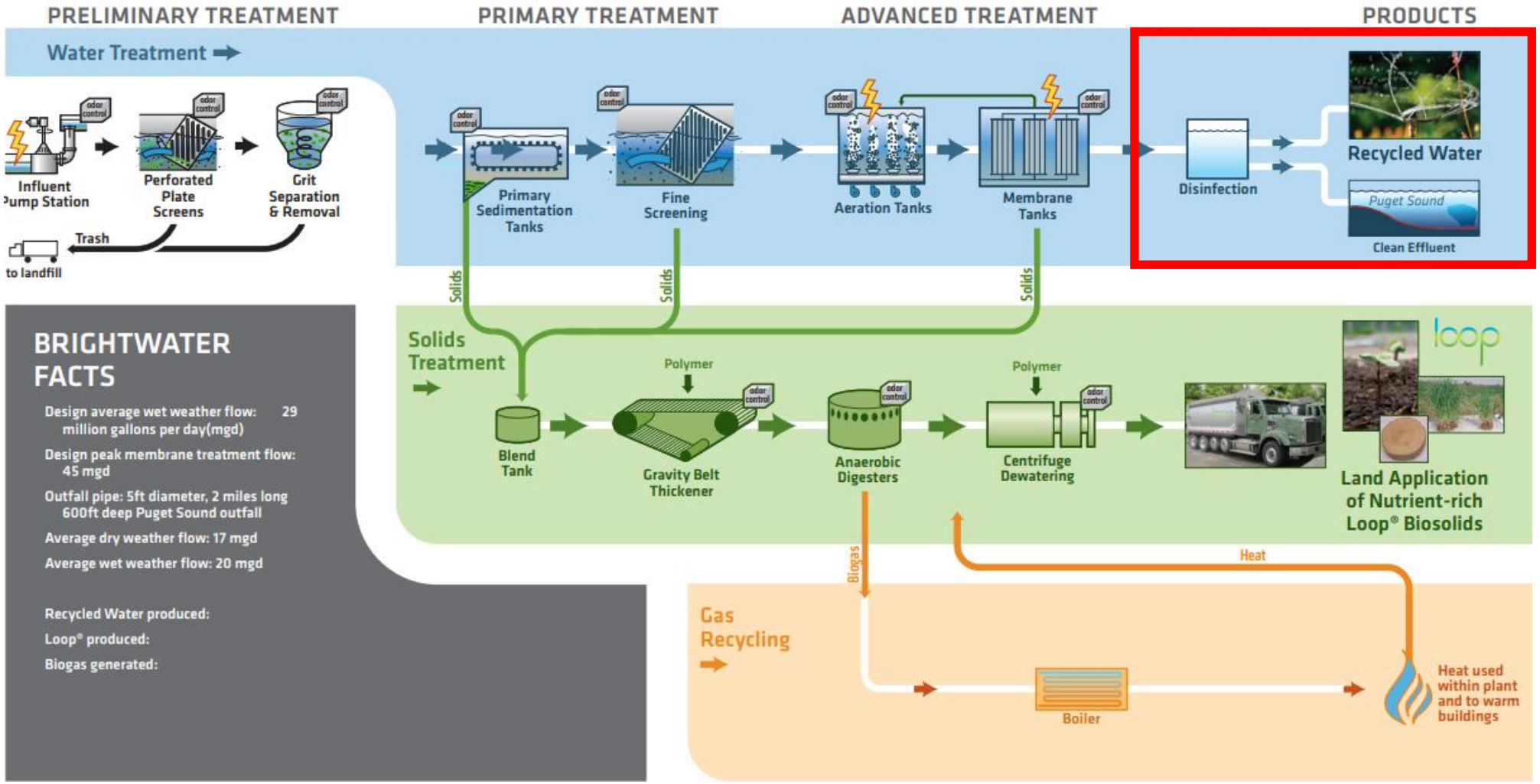
Pathogen Testing

Brightwater Treatment Plant

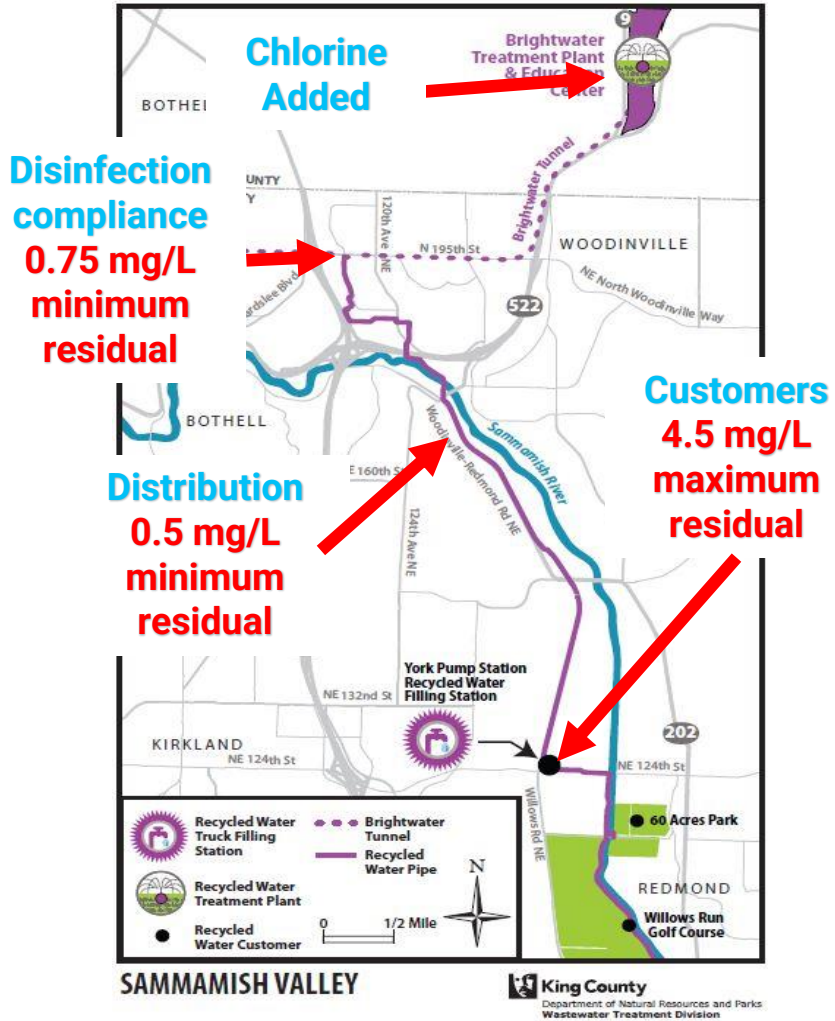


- King County Wastewater Treatment Division
  - Serves ~1.6 million residents
  - 5 regional WWTPs
- Brightwater
  - Woodinville, WA
  - Membrane bioreactor (MBR) process
  - Completed 2011/2012
  - Capacity:
    - Average Monthly Flow - 30 MGD
    - Peak Hourly Flow - 44 MGD

Process Flow Diagram

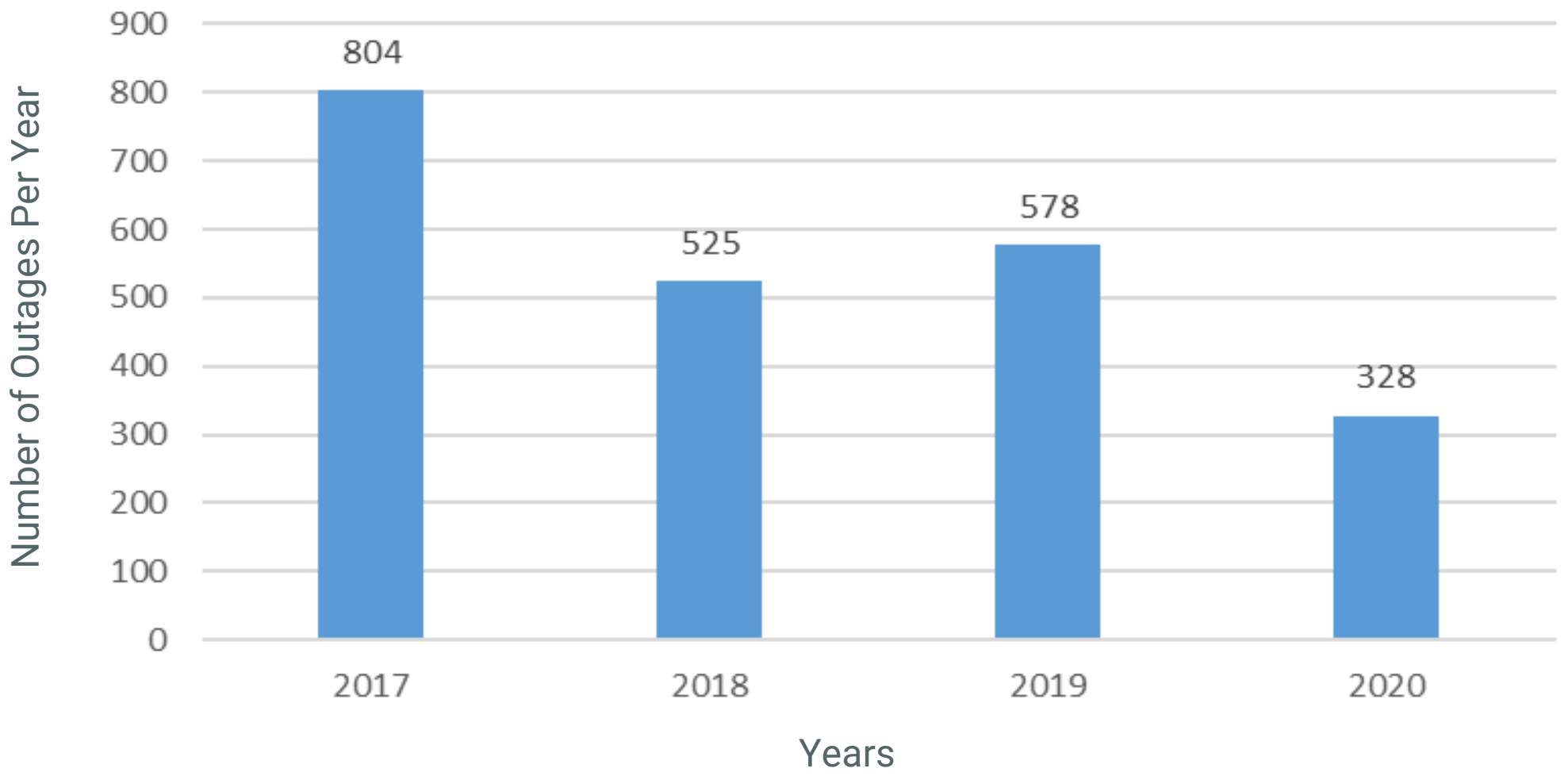


Reclaimed Water Disinfection & Distribution



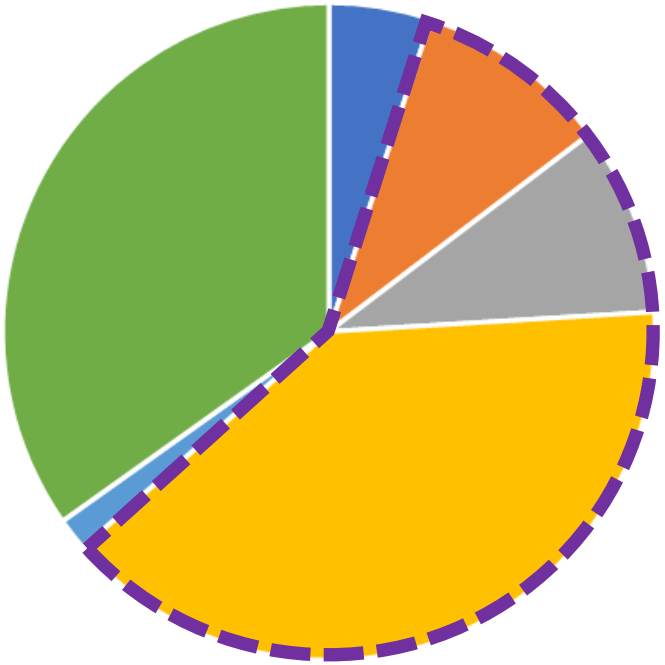
- 3-mile pipeline contactor for disinfection
- 5 miles from compliance point to customers
- Need to maintain chlorine residual within a range of 0.5 to 4.5 mg/L

Number of RW System Outages Per Years

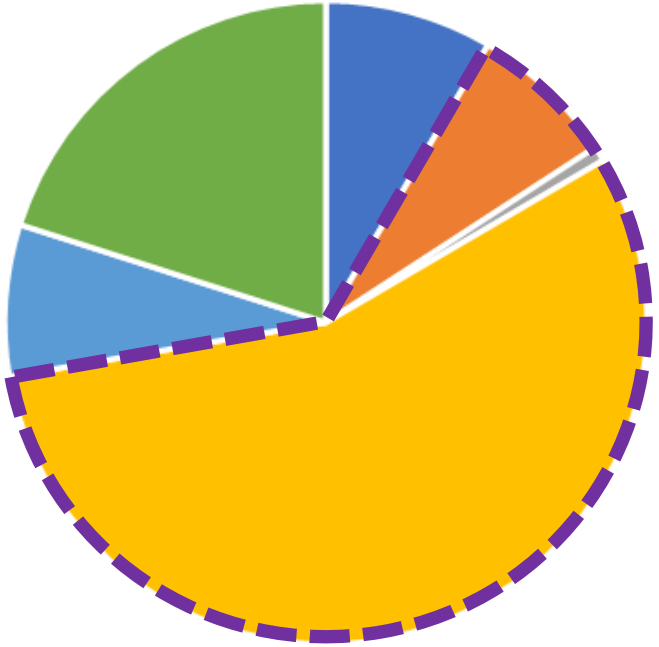


Causes of Outages

2020 Outage Durations

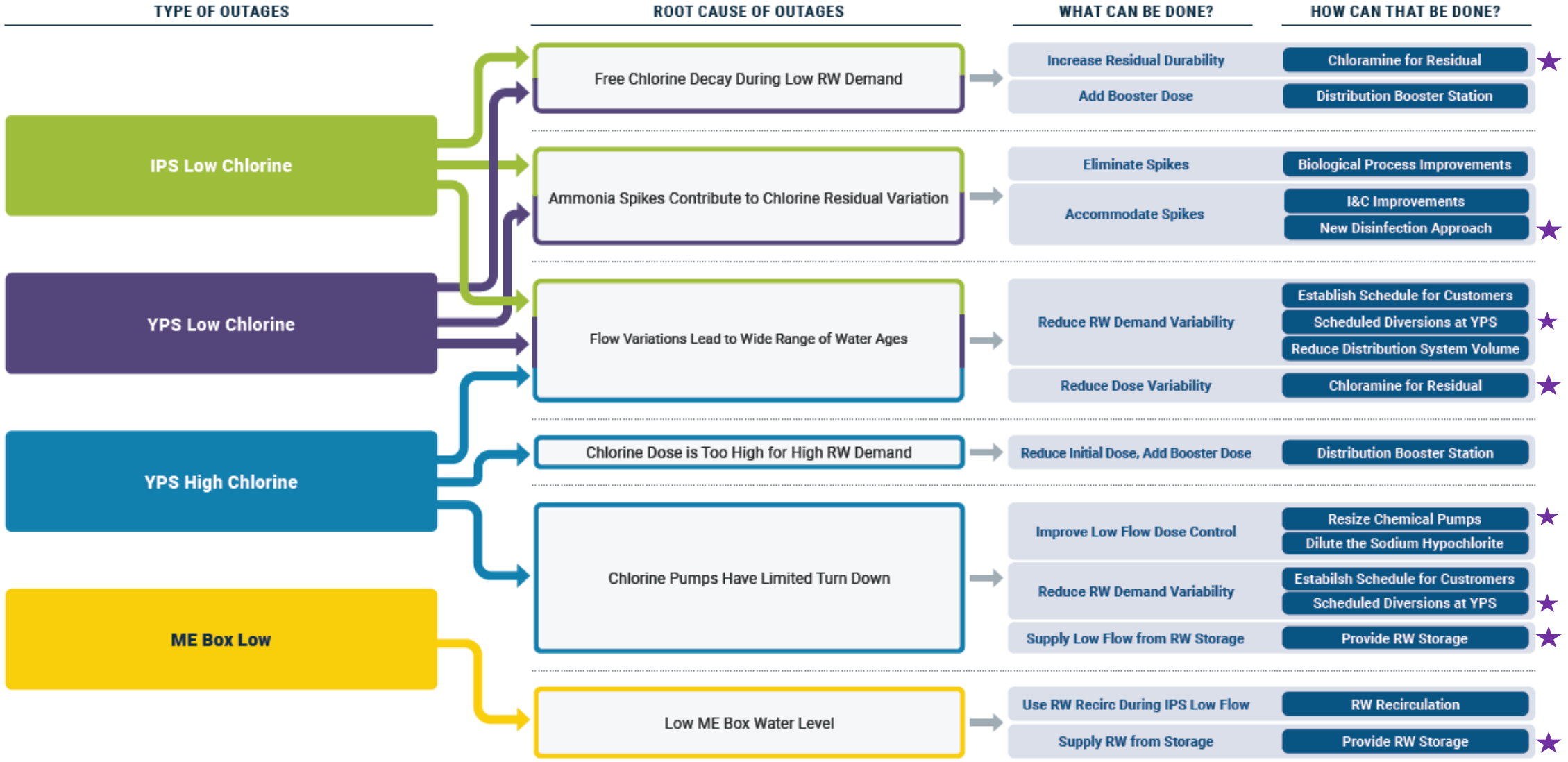


2021 Outage Durations



- Flow not available
- Low residual at compliance point
- Low residual in distribution
- High residual at customer
- Diversion valve opening/closing
- Other (likely diversion valve)

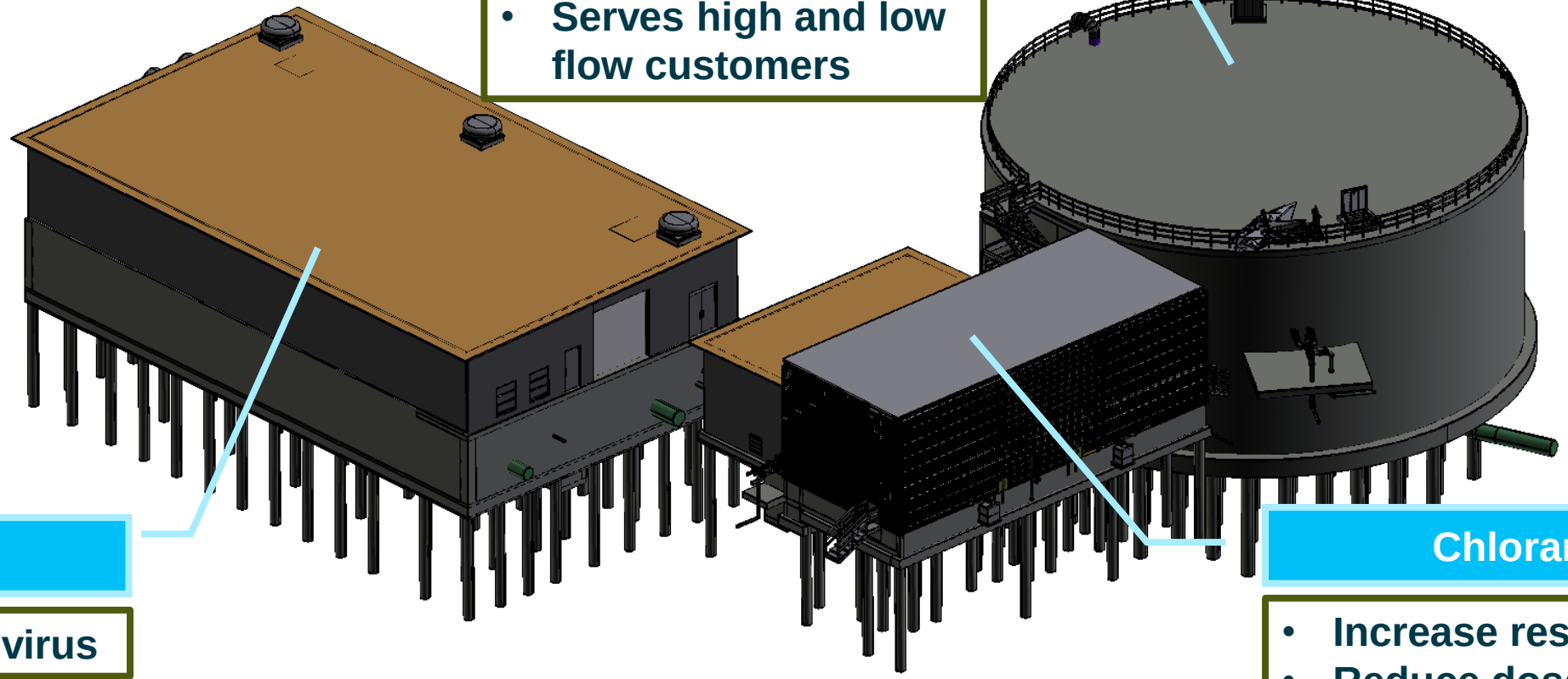
Solutions Mapping



Recommended Solution

Storage

- Provides water during low plant flow
- Serves high and low flow customers



UV

- 4-LRV virus

Chloramination

- Increase residual durability
- Reduce dose variability

Agenda

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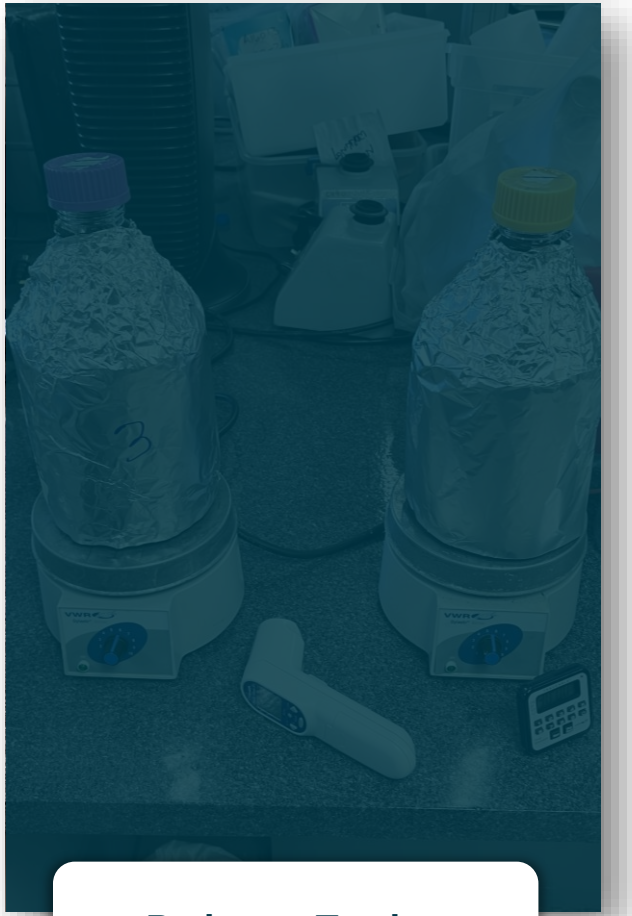
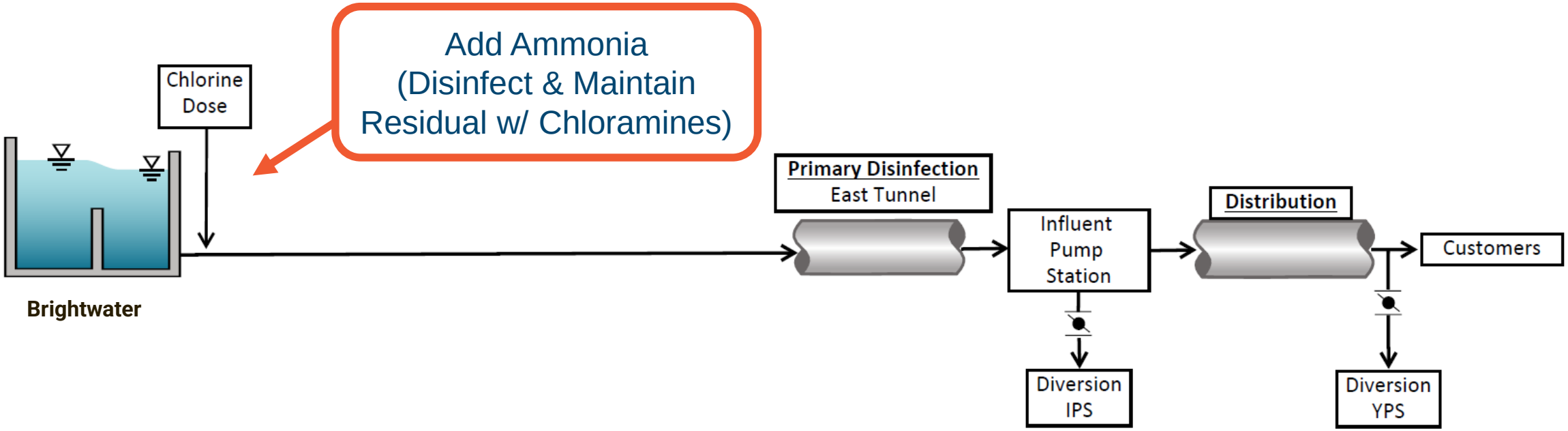
Disinfection Solutions

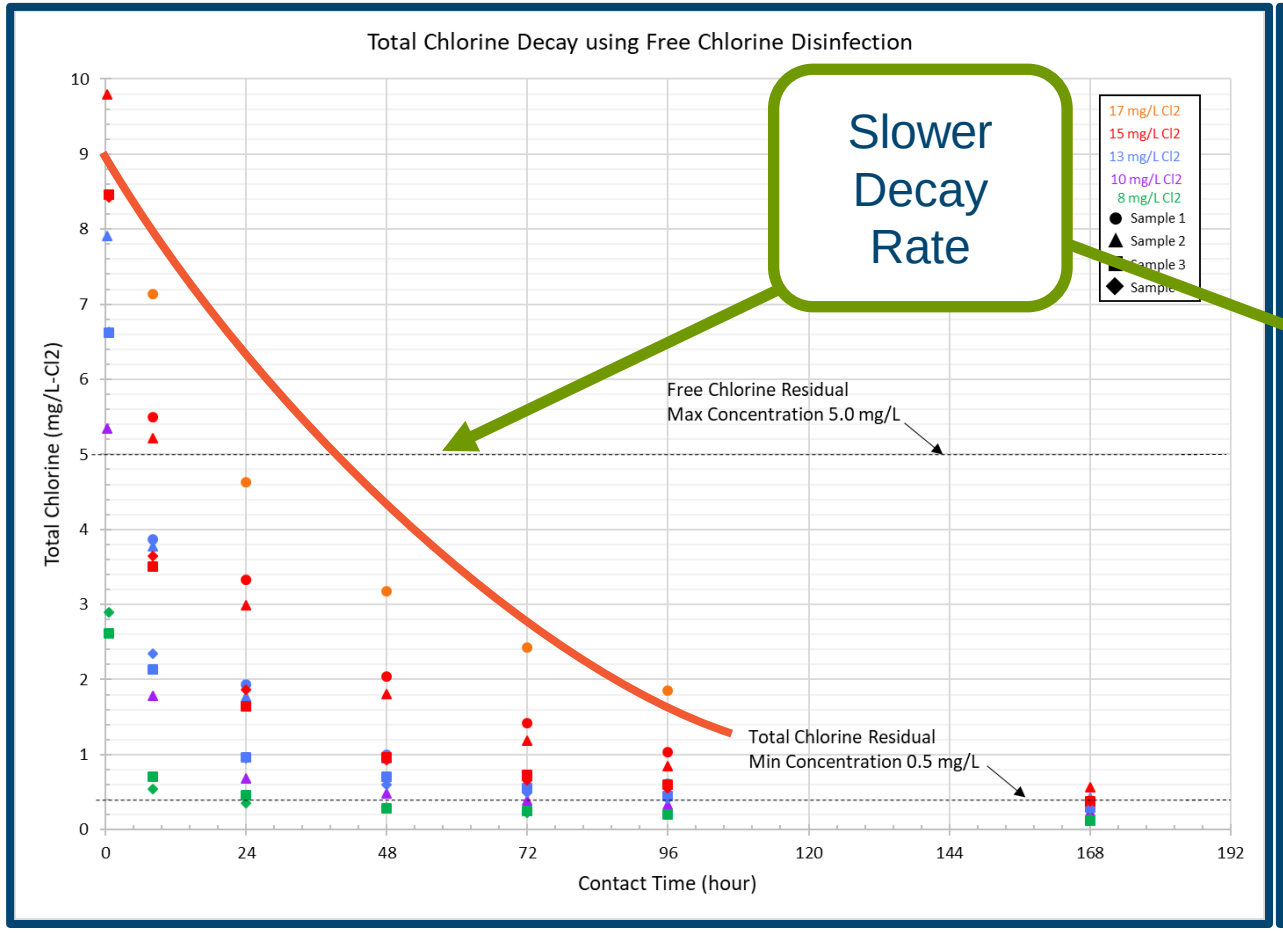


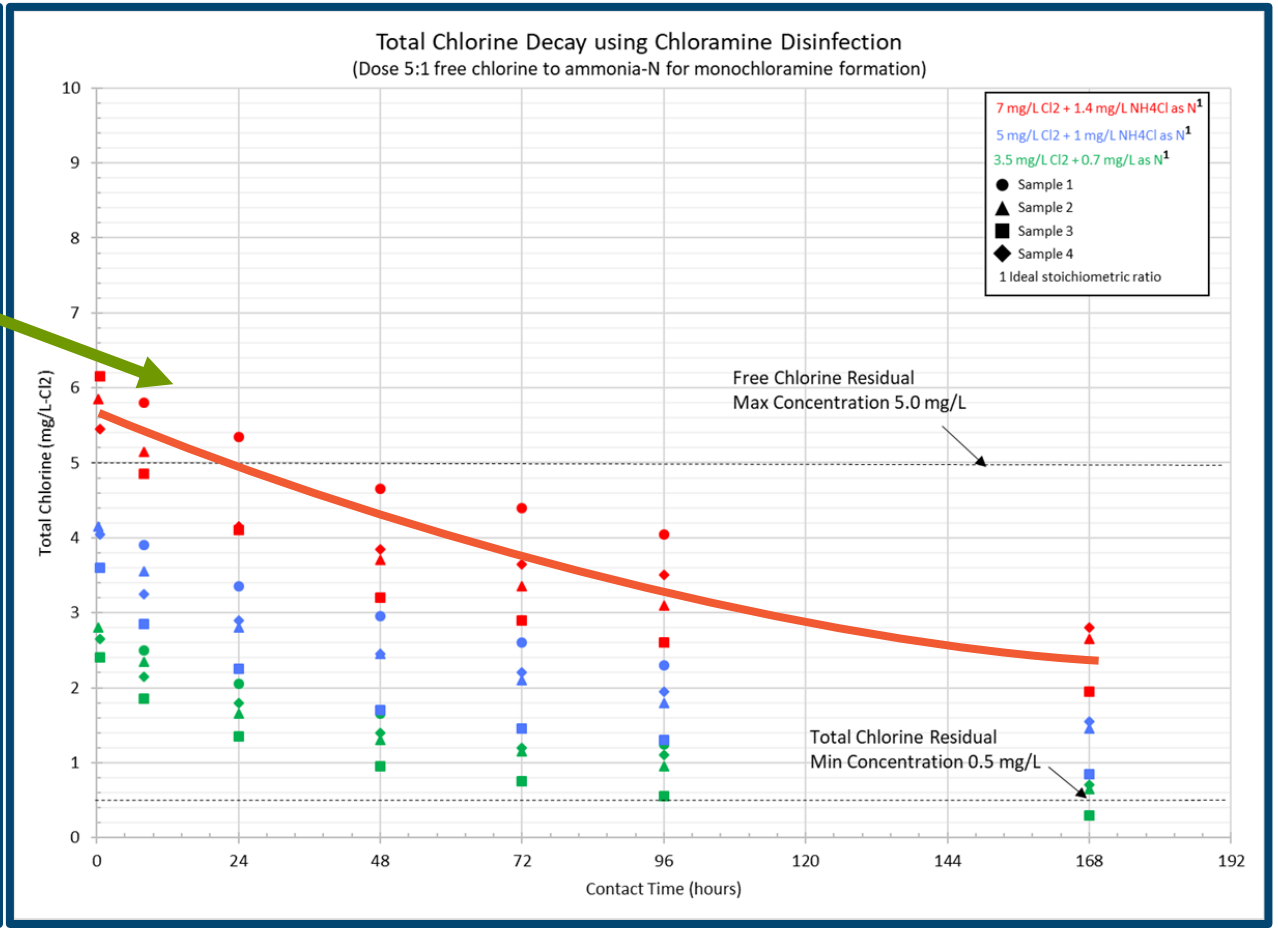
PathogenTesting

Chloramine Disinfection Approach



Monochloramine Benefits – More Durable Residual

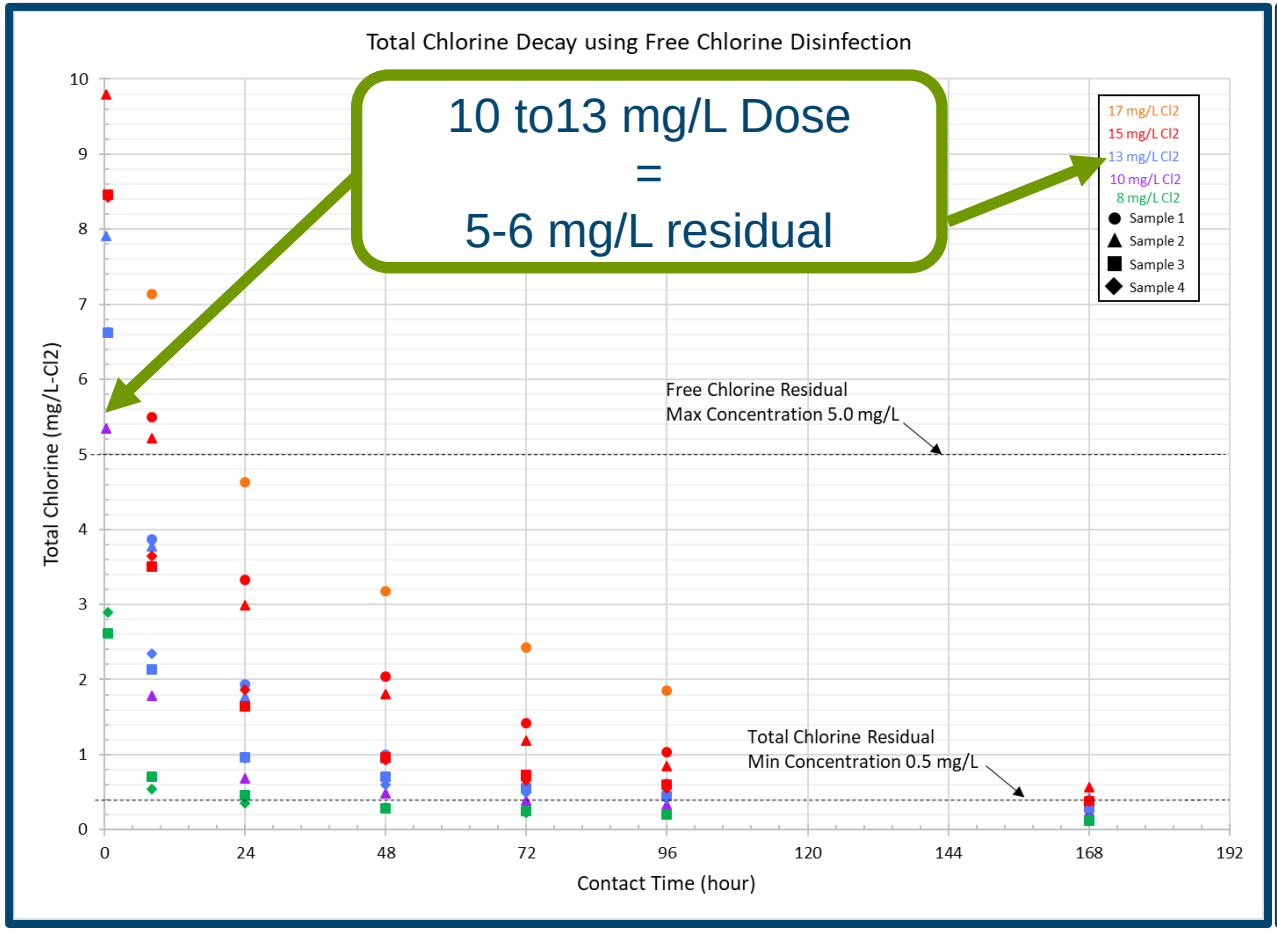


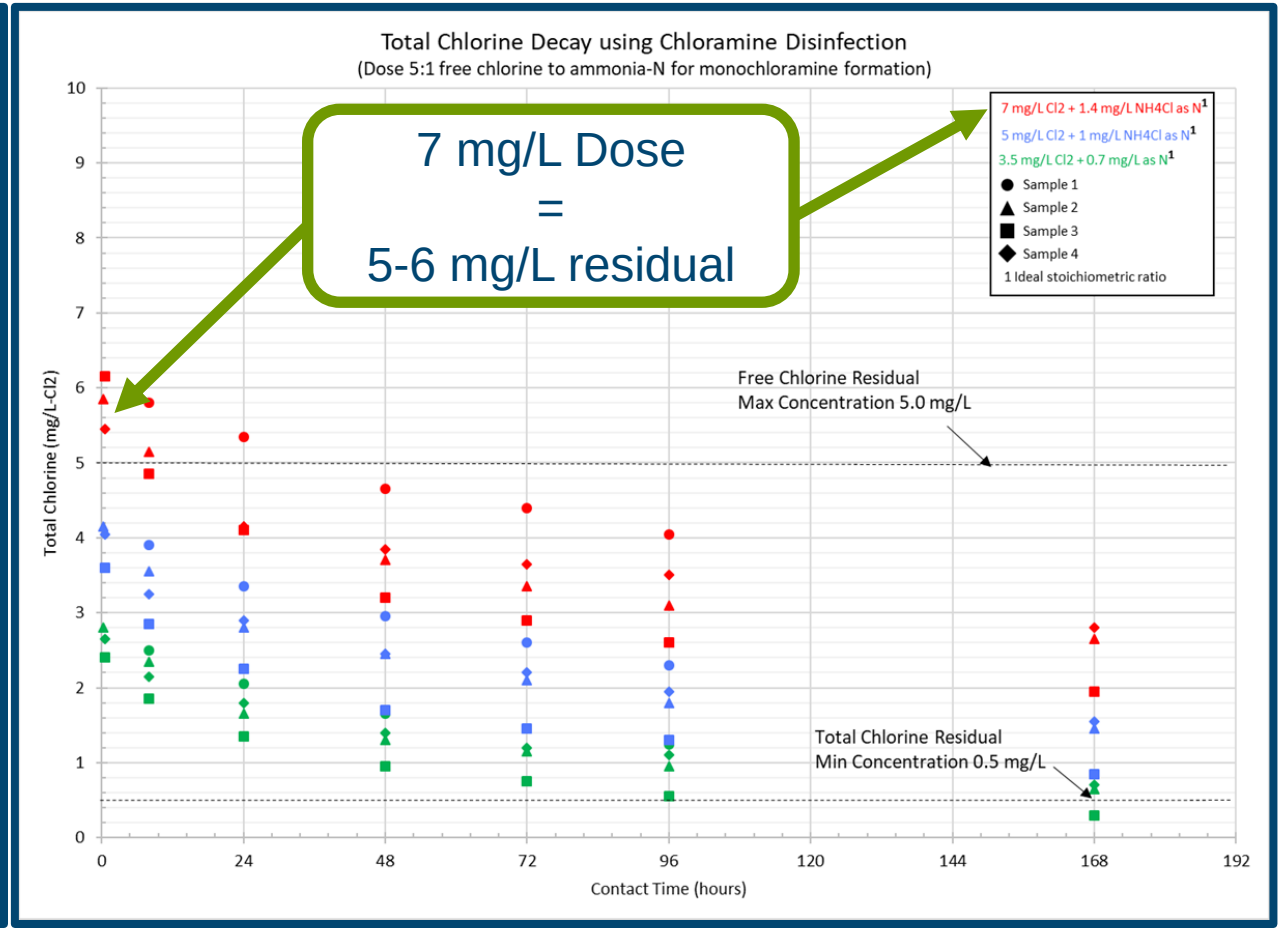


Free Chlorine

Monochloramine

Monochloramine Benefits – Use Less Chlorine





Free Chlorine

Monochloramine

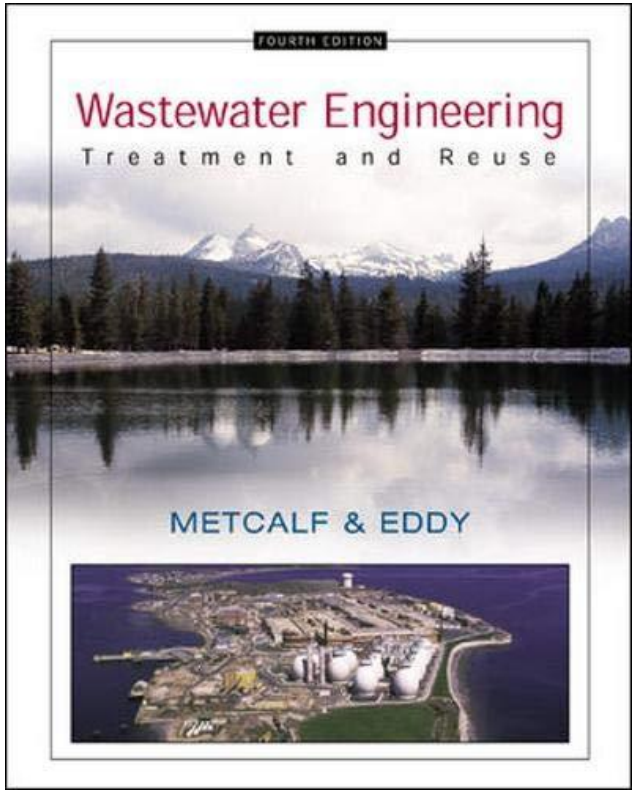
Chloramine Disinfection Challenges

WAC 173-219-340 requires:

All Class A reclaimed water generation disinfection processes must, in combination with treatment processes following biological oxidation, result in a minimum 4-log virus removal or inactivation.

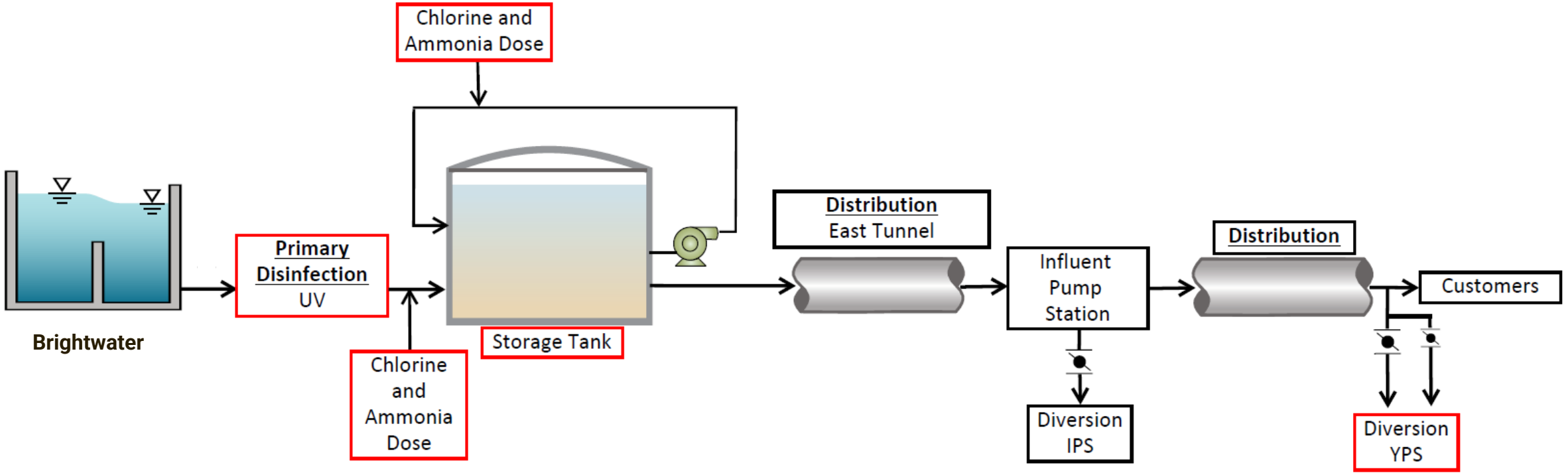
Chloramine Disinfection Challenges

Disinfectant	Unit	1-log Inactivation	2-log Inactivation	3-log Inactivation	4-log Inactivation
Bacteria					
Chlorine (free)	mg*min/L	0.1-0.2	0.4-0.8	1.5-3	10-12
Chloramine	mg*min/L	4-6	12-20	30-75	200-250
UV	mJ/cm^2	-	30-60	60-80	80-100
Virus					
Chlorine (free)	mg*min/L	-	2.5-3.5	4-5	6-7
Chloramine	mg*min/L	-	300-400	500-800	200-1200
UV	mJ/cm^2	-	20-30	50-60	70-90
Protozoan Cysts					
Chlorine (free)	mg*min/L	20-30	35-45	70-80	-
Chloramine	mg*min/L	400-650	700-1000	1100-2000	-
UV	mJ/cm^2	5-10	10-15	15-25	-



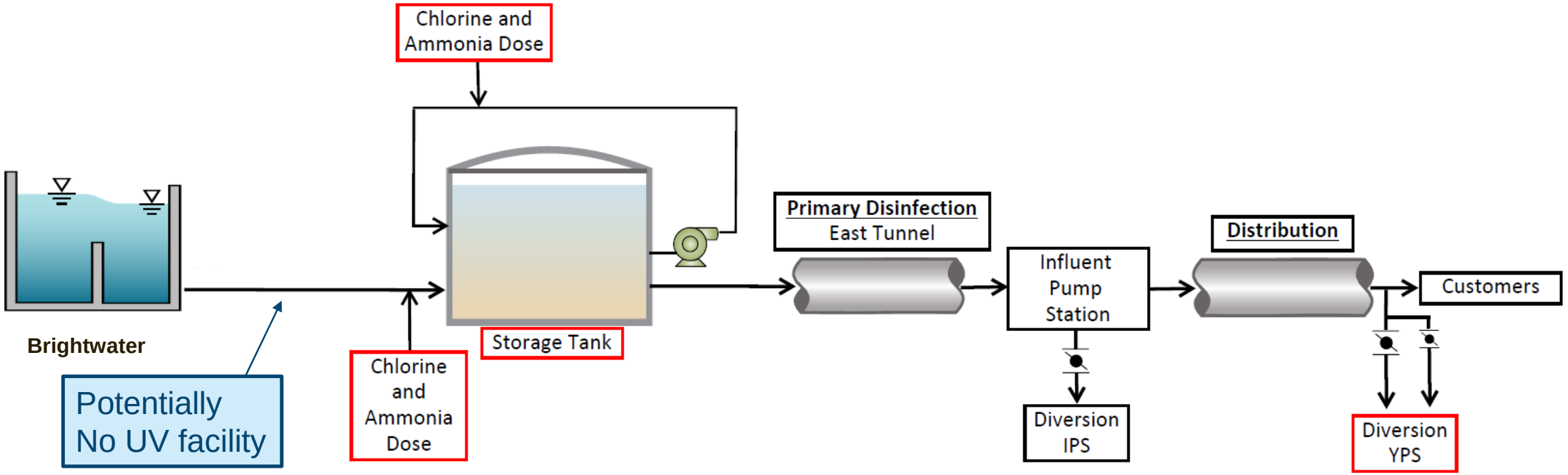
Metcalf & Eddy, *Wastewater Treatment & Reuse*, 4th Ed.

Strategy to Achieve 4-Log with Chloramine – Alternative 1



	CURRENT APPROACH	ALTERNATIVE 1
DISINFECTION	FREE CHLORINE	ULTRAVIOLET (UV)
RESIDUAL	FREE CHLORINE	CHLORAMINES

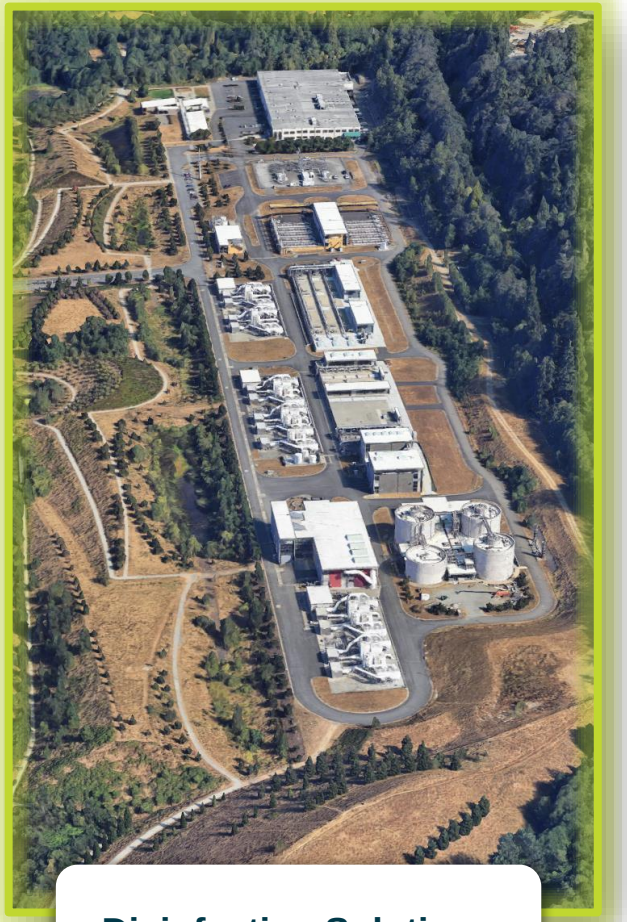
Strategy to Achieve 4-Log with Chloramine – Alternative 2



	CURRENT APPROACH	ALTERNATIVE 1	ALTERNATIVE 2
DISINFECTION	FREE CHLORINE	ULTRAVIOLET (UV)	MBR LRV + CHLORAMINES
RESIDUAL	FREE CHLORINE	CHLORAMINES	CHLORAMINES

Agenda

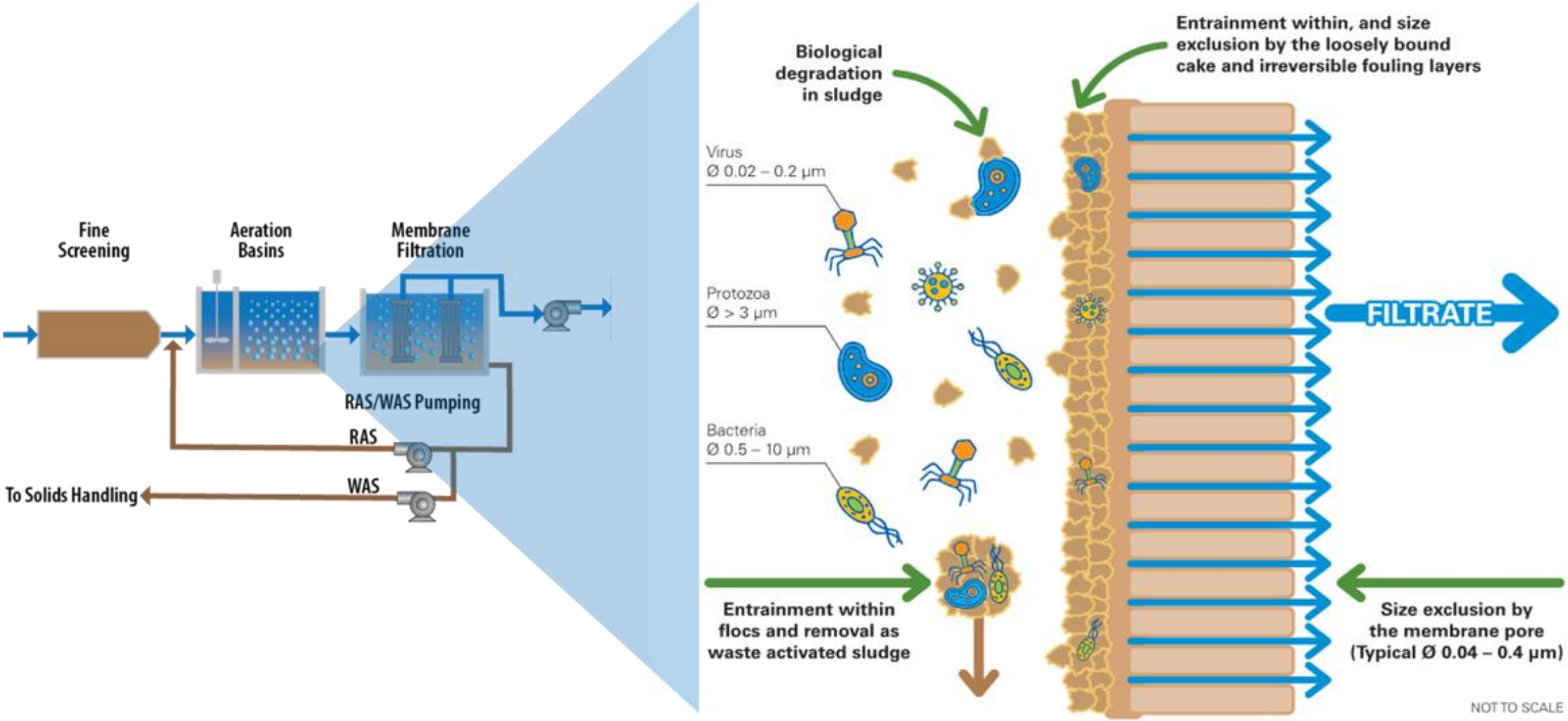
Project Background



Disinfection Solutions

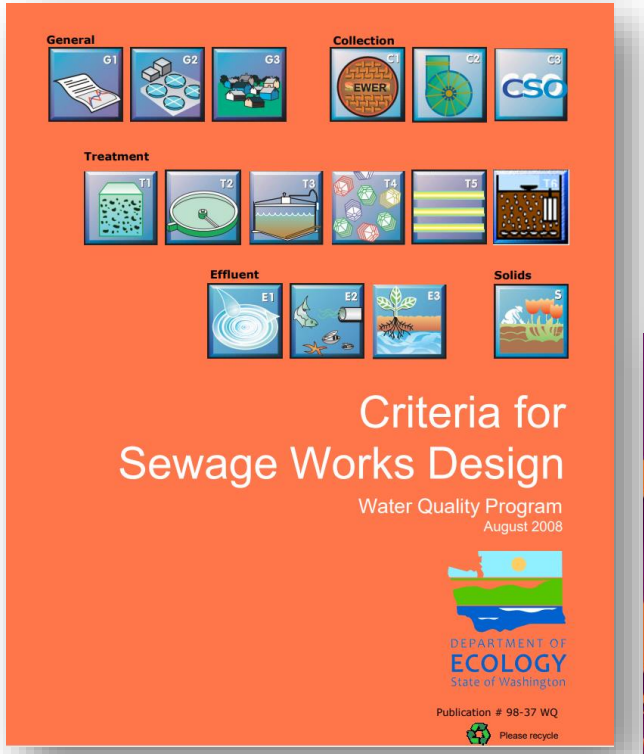
PathogenTesting

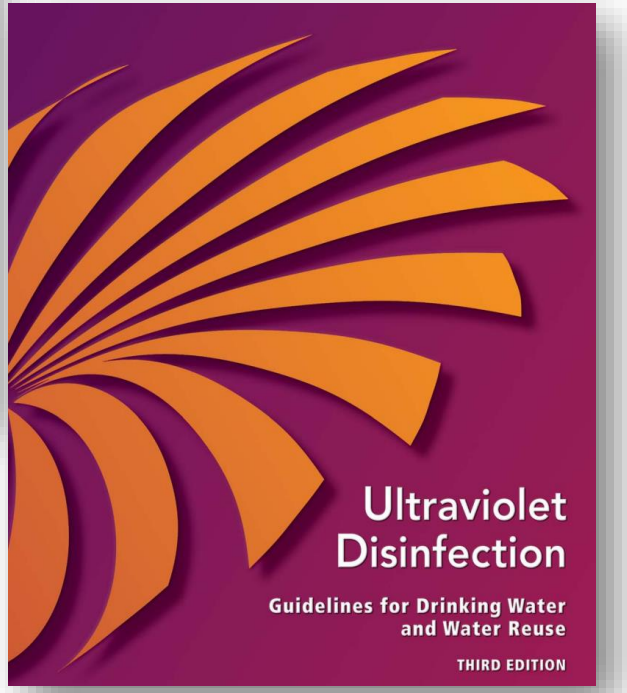
Pathogen Removal with MBR



MBR Virus Removal Credit

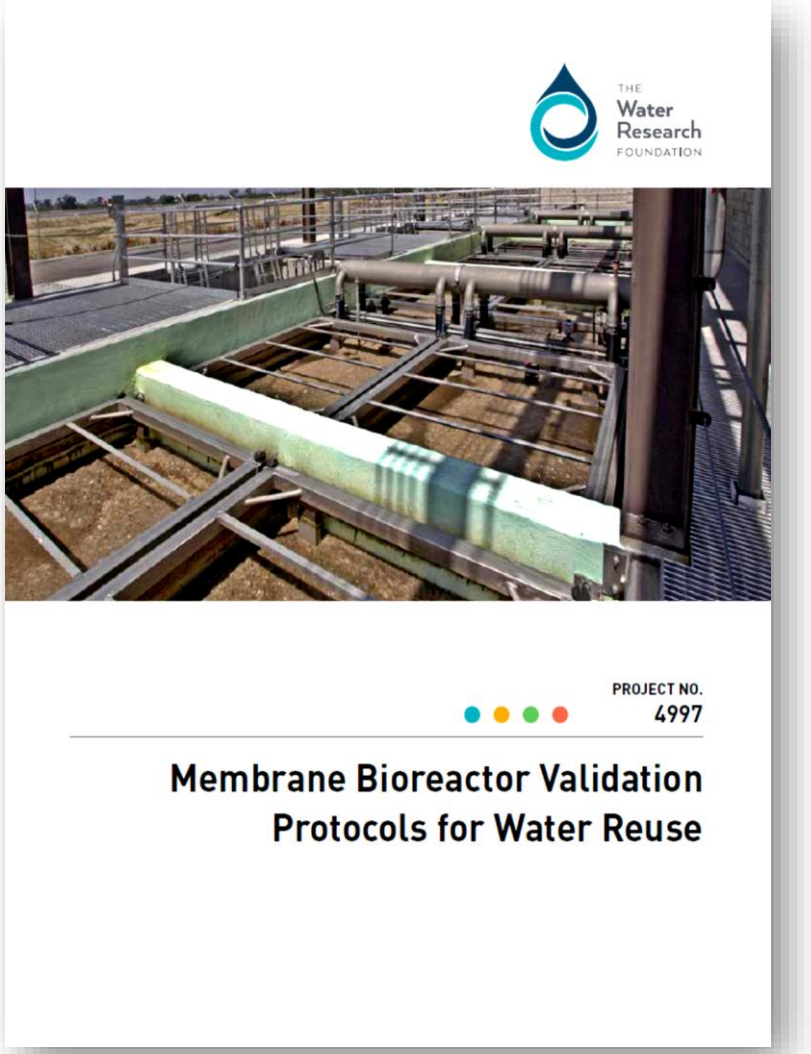
- WA DOE Orange Book allows 1.0 LRV credit for MBRs
- Permittees may petition to review and revise determination
- Per NWRI, lower dose guidelines for UV disinfection systems following MBR





MBR Virus Removal Credit

- Water Research Foundation Project Report
- Tier 1: Conservative 1.0 LRV for virus
  - Turbidity operating limits
- Tier 2: Challenge Testing
  - Demonstrate higher LRVs at specific facilities
  - Ongoing monitoring
  - Turbidity operating limits
  - Secondary integrity monitoring

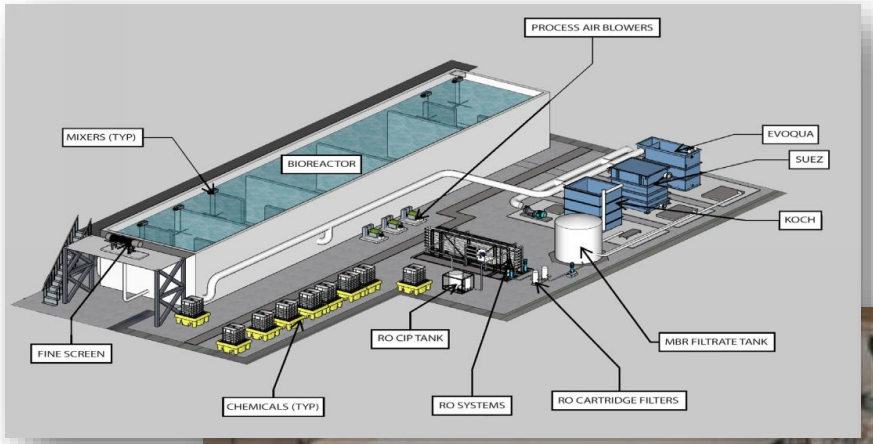


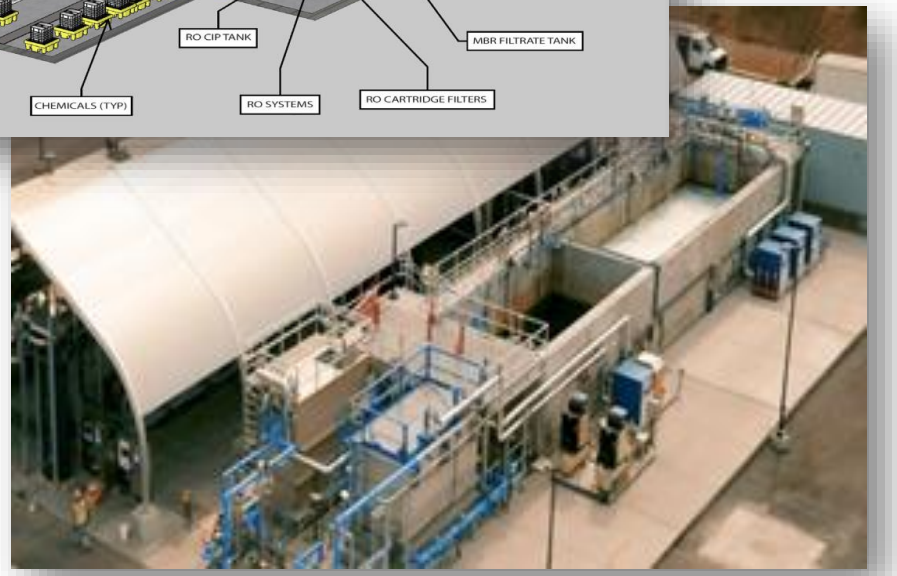
MBR Tier 2 Challenge Testing Scope

- Twenty-four feed/filtrate samples
- Extended sampling period
- Analysis
  - Bacteriophage (indicators)
  - Pathogens
  - Turbidity
  - Secondary surrogate
- Anticipated LRV 3.5 to 4.5

Tier 2 Validations at Locations in California

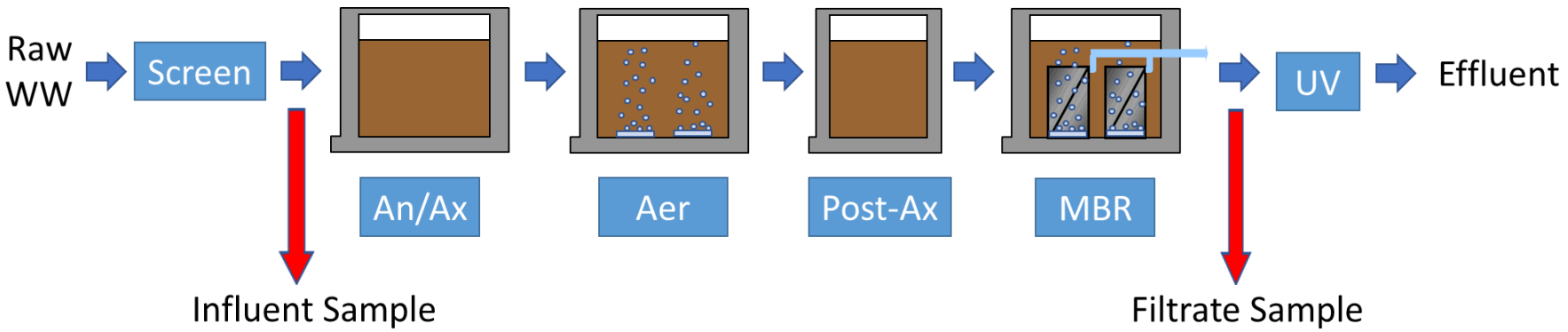
- Los Angeles County Sanitation District w/ Metropolitan Water District
  - Carson JWPCP Advanced Water Purification Center
  - Focused on protozoa reduction, >4 LRV
- City of LA Hyperion Water Reclamation Plant
  - 1 mgd MBR demo facility
  - Focused on both protozoa and virus validation testing



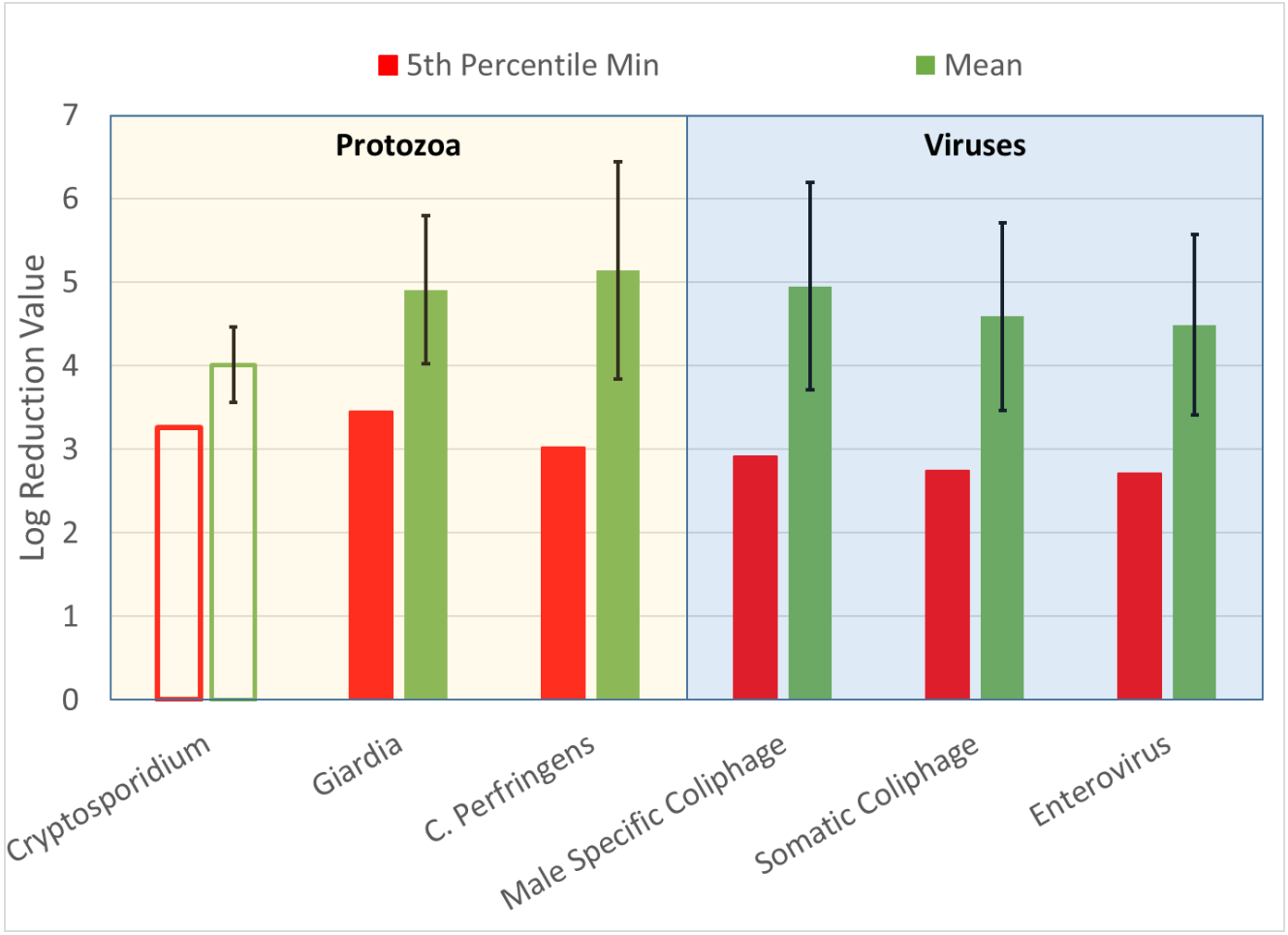


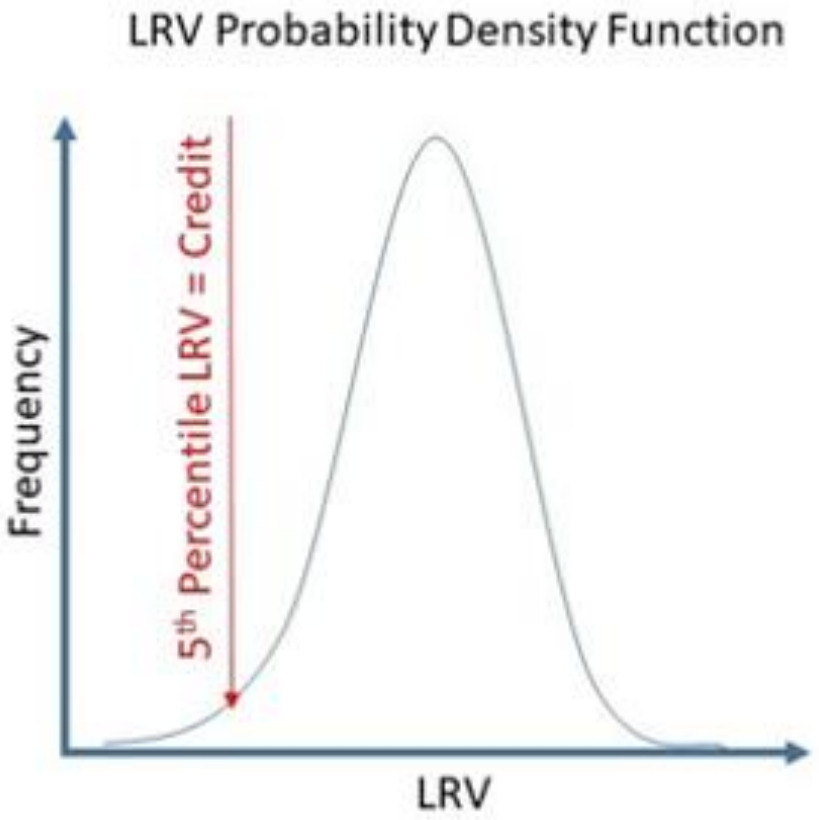
Tier 2 Validation Case Study – Lake of the Pines WWTP

- Auburn, California (Kubota System)
- Using flat sheet, MF membranes for MBR
- 10-year-old membranes
- **NO** membrane replacements!



Tier 2 Validation Case Study – Lake of the Pines WWTP

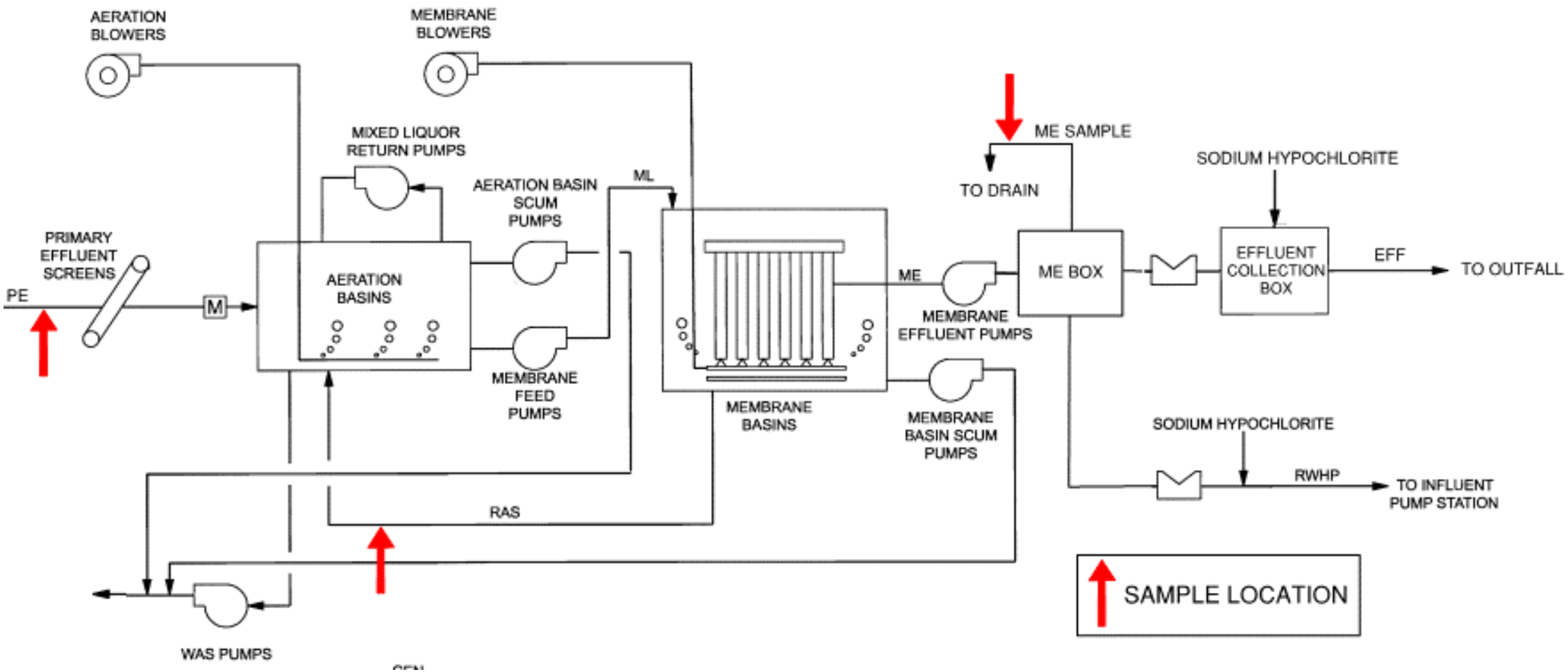




Brightwater MBR Exploratory Testing - Scope & Goals

- Limited sampling effort to inform the potential success
- Not seeking regulatory approval (yet)
- Include chloramination virus removal bench-top study

Brightwater MBR Exploratory Testing – Sampling Locations

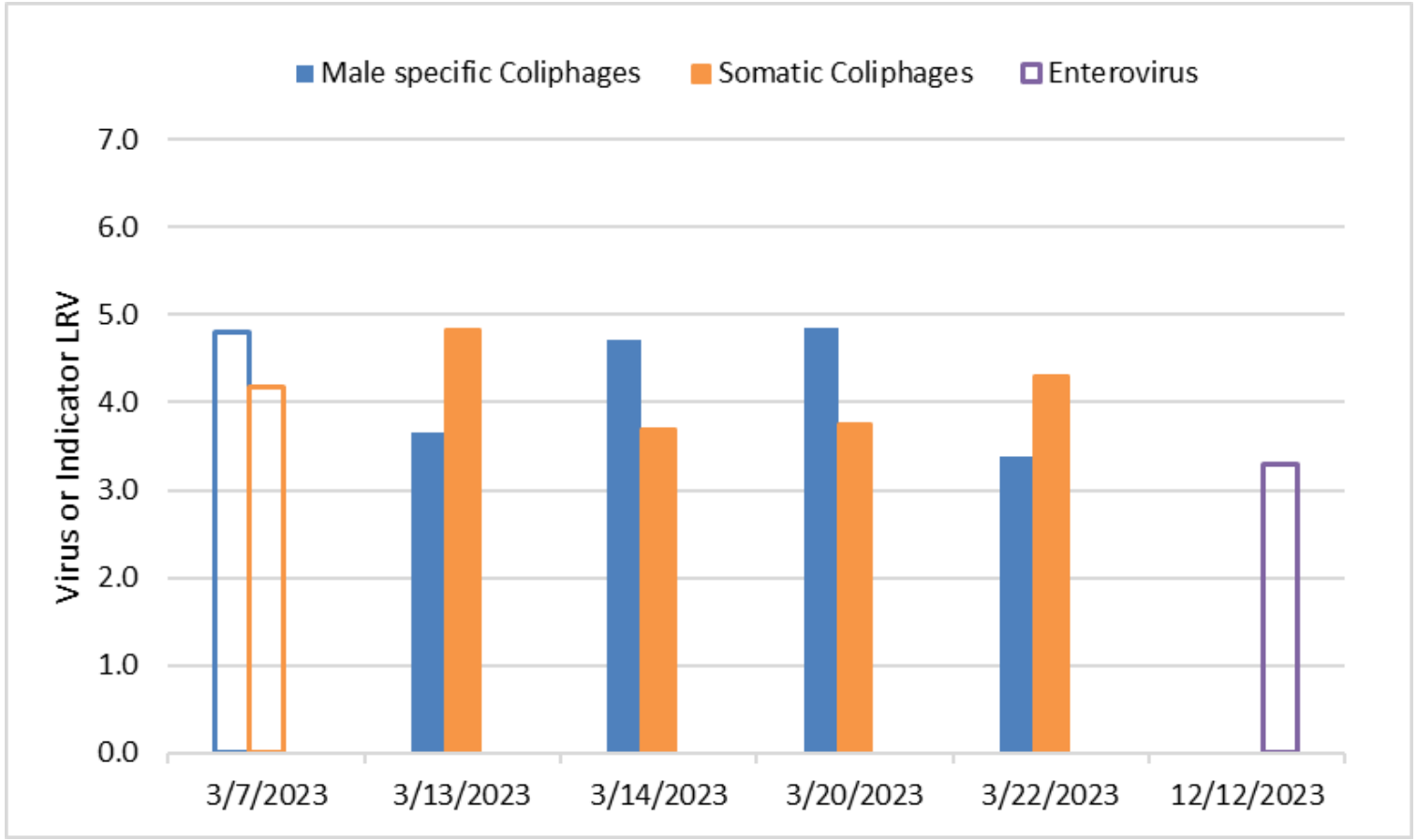


MBR Operational Performance During Sampling

- Compiled MBR performance data for three months preceding sampling and during sampling
- MBR operating normally during sampling period
- Higher TMP and Flux on one sample day (+4 gfd and +0.3 psi)

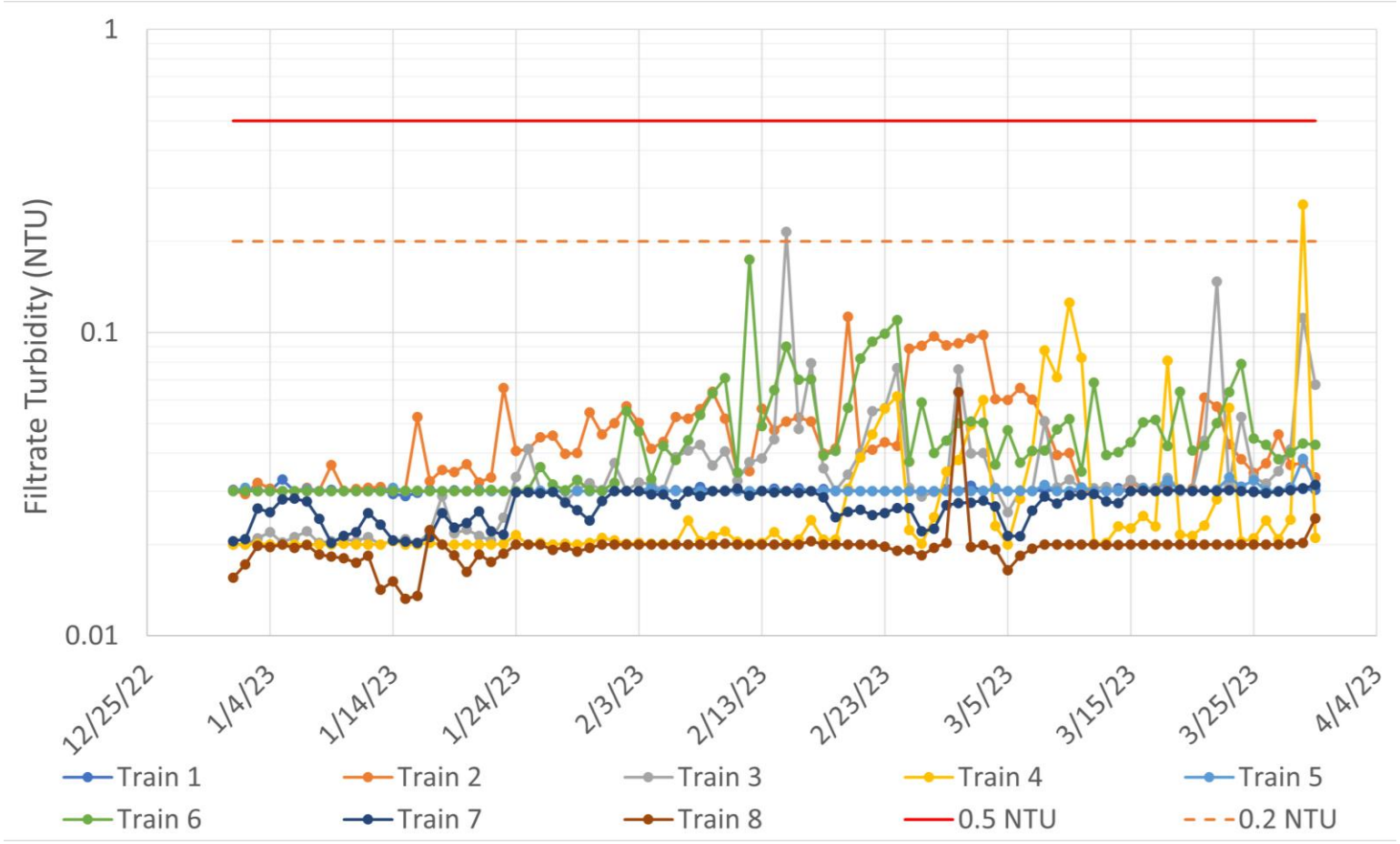
Brightwater MBR Exploratory Testing – Results

- Indicator organisms LRV 3.4 to > 4.0
- Enterovirus LRV 3.3
- Meets and exceeds previous MBR work



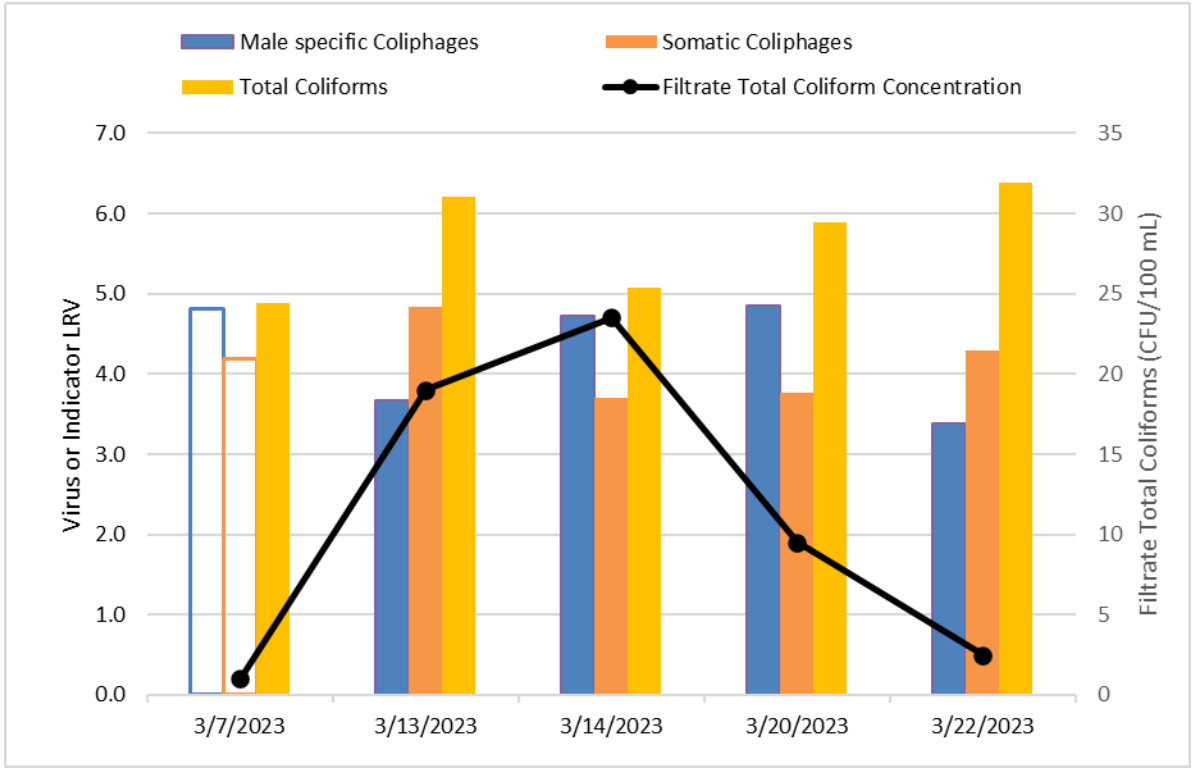
MBR Integrity Monitoring Data

- Rarely exceeded 0.2 NTU
- Typically very low on individual filtrates and always low at the combined filtrate turbidity compliance point.



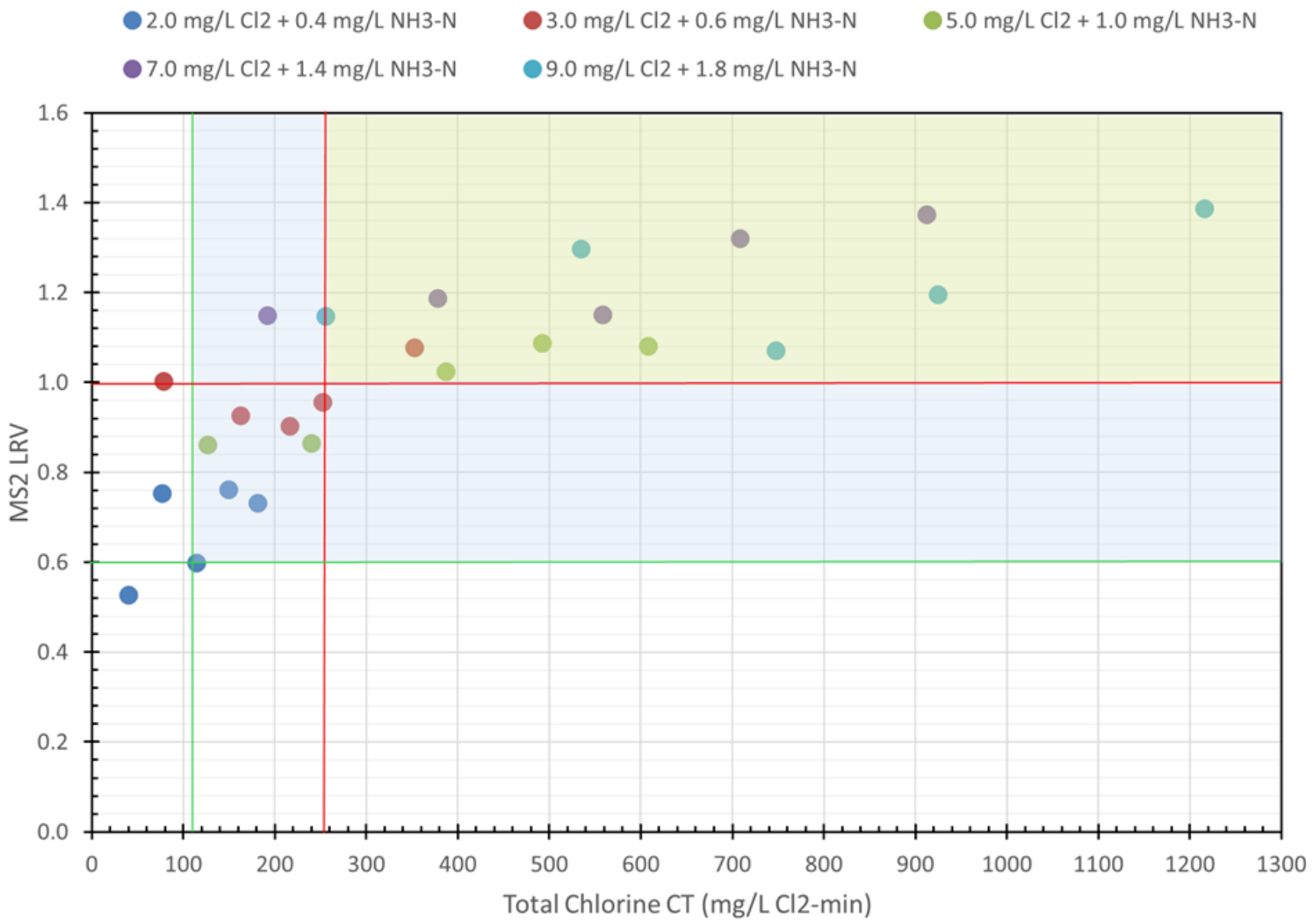
Brightwater MBR Exploratory Testing – Results Secondary Integrity Monitoring

- Filtrate Total Coliform ranged from 1 to 25 CFU/100 mL
- No apparent trend between total coliform and indicator LRV



Chloramination Results CT – MS2 Data

- LRVs of MS2 > 1.0 log units reliably achieved at CTs > 255 mg-min/L.
- LRVs of MS2 > 0.6 log units reliably achieved at CTs >115 mg-min/L.

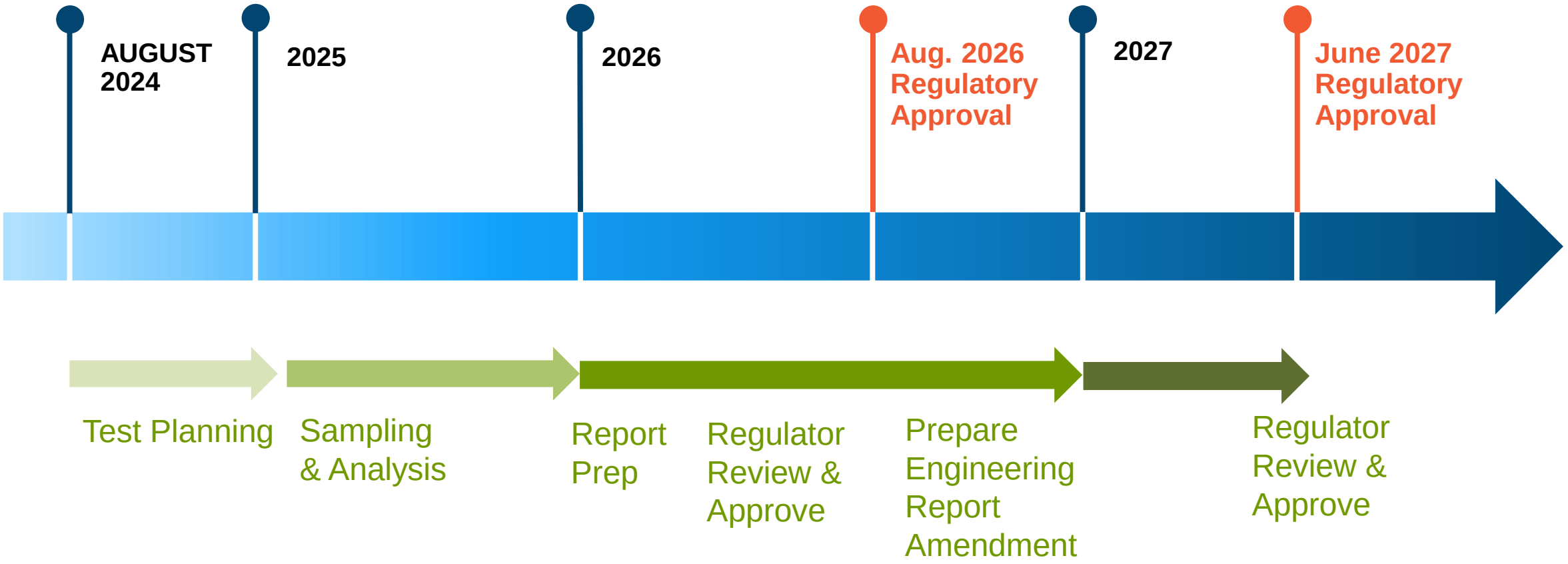


Brightwater MBR Exploratory Testing Results Review

- Indicator organisms LRV >3.4
- Pathogen LRV 3.3
- Chloramination provides 0.6 to 1 LRV of MS2 at 115 - 255 mg-min/L

Brightwater MBR Challenge Testing Next Steps

MBR Tier 2 Challenge Testing Schedule



MBR Virus Removal Credit – Disinfection Process Impact

	NO CREDIT	CREDIT	CREDIT
Disinfection Process	Full Dose UV System + Chloramination	Reduced Dose UV System + Chloramination	Chloramination
New Facilities	$$$$	$$$	$$
Energy	++++	+++	+
Maintenance	+++	+++	+

Key Takeaways

- Distribution residual control
- Residual durability/variability
  Virus LRV
- LRV crediting may reduce downstream disinfection requirements

Q&A

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