Kennedy Jenks

Managing Ammonia from Source to Tap

Strategies for Water Treatment, Disinfection, and Distribution

Andrew Dow, PE

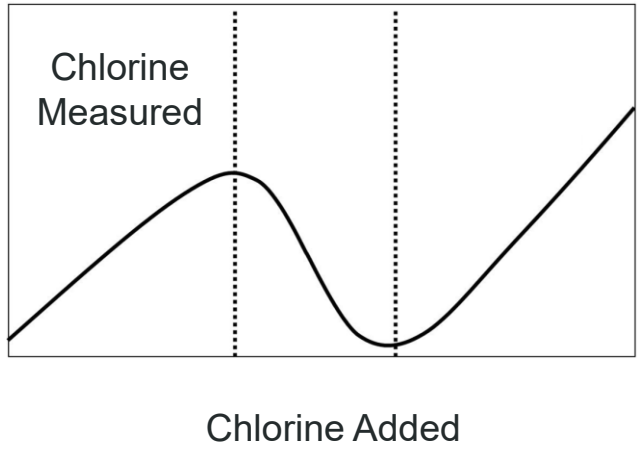
Pacific Northwest Section – American Water Works Association

Section Conference: May 8th, 2026



Impacts on Treatment and Water Quality

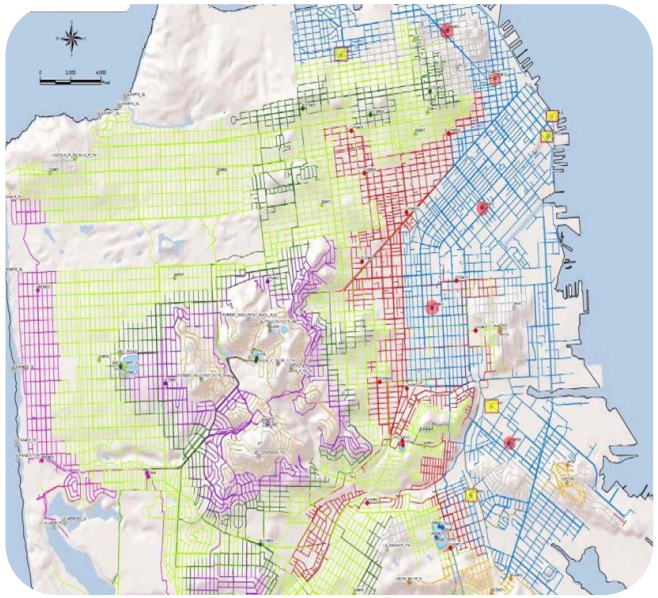
Chlorine Demand



Taste & Odor

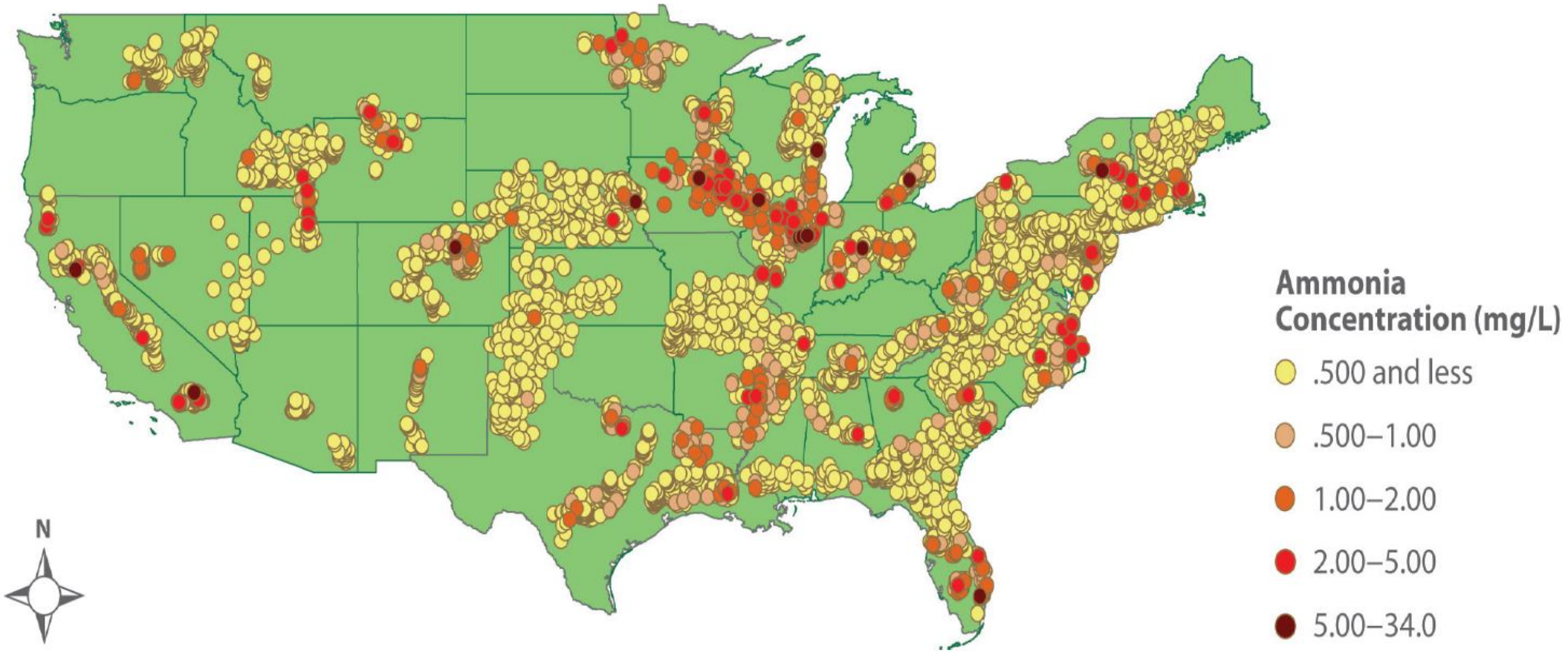


Distribution System Water Quality



Managing Ammonia In Source Water

Ammonia in Source Water

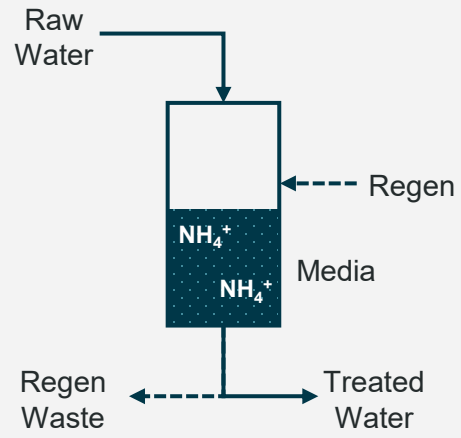


EPA United States Environmental Protection Agency

Lytle, Darren A. *Managing Naturally Occurring Ammonia in Groundwater Systems*. U.S. EPA's Office of Research and Development and Region 6 2019 Small Drinking Water Systems Meeting May 21-22, 2019

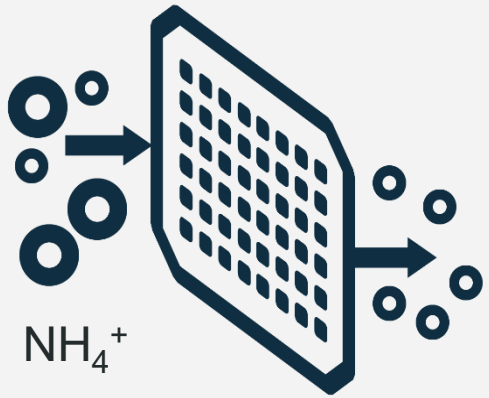
Methods for Treating Ammonia in Source Water

Ion Exchange



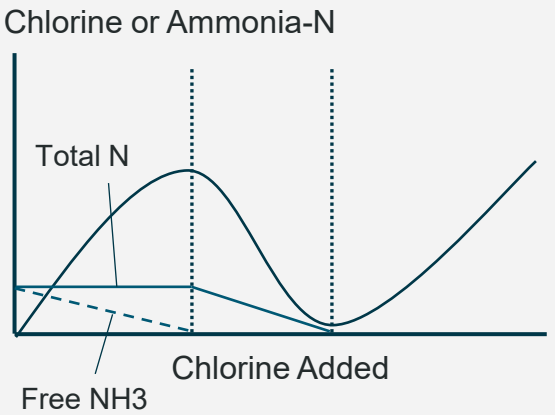
- Variable Output
- Incomplete Removal
- Brine Waste

Reverse Osmosis



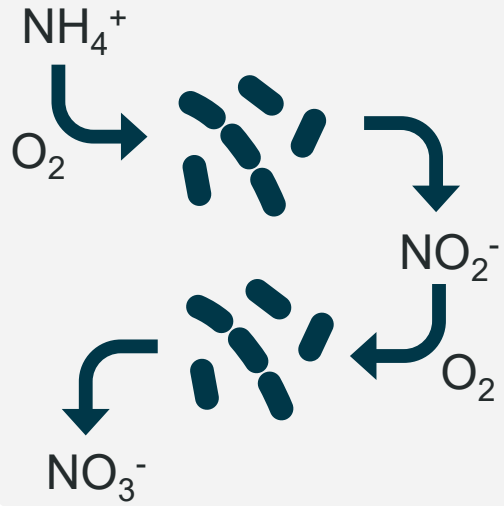
- Water Quality Impacts
- Brine Waste

Chlorination



- Common Method
- High Chemical Use
- Dosing Limitations with Hypochlorite

Biological Treatment



- Practiced in Europe
- Also Practiced in US (Often Unintentionally)

Breakpoint Chlorination

Chlorine + Free Ammonia

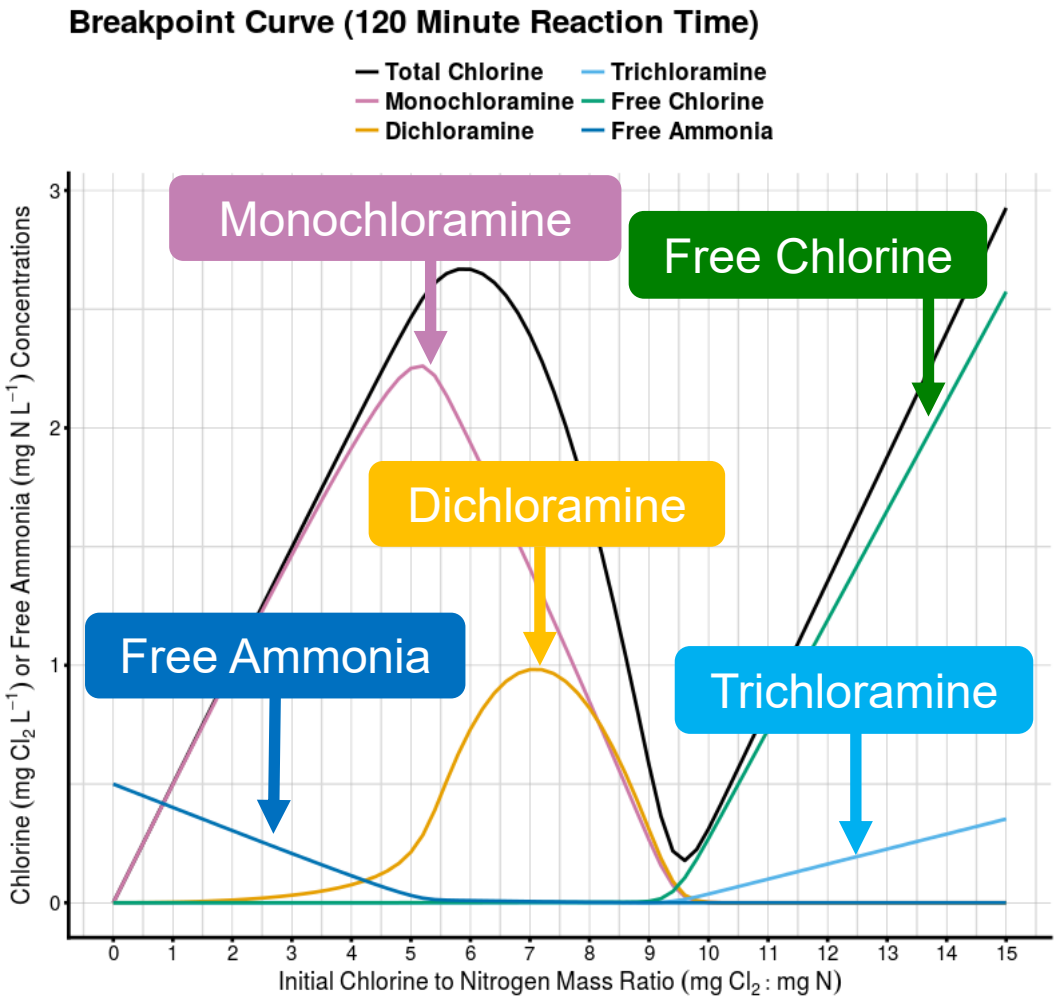
Chlorine + Monochloramine

Chlorine + Dichloramine

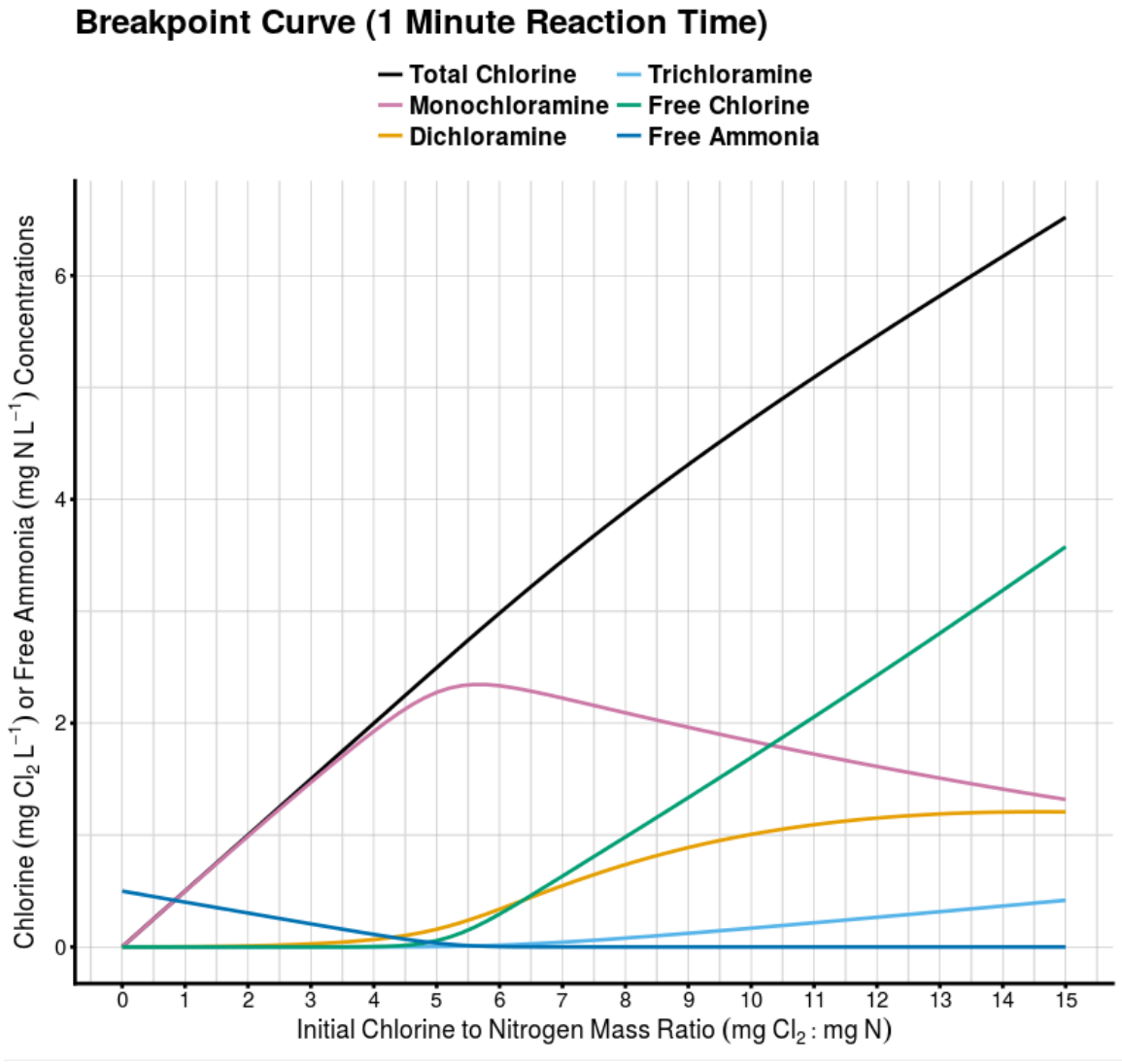
Trichloramine

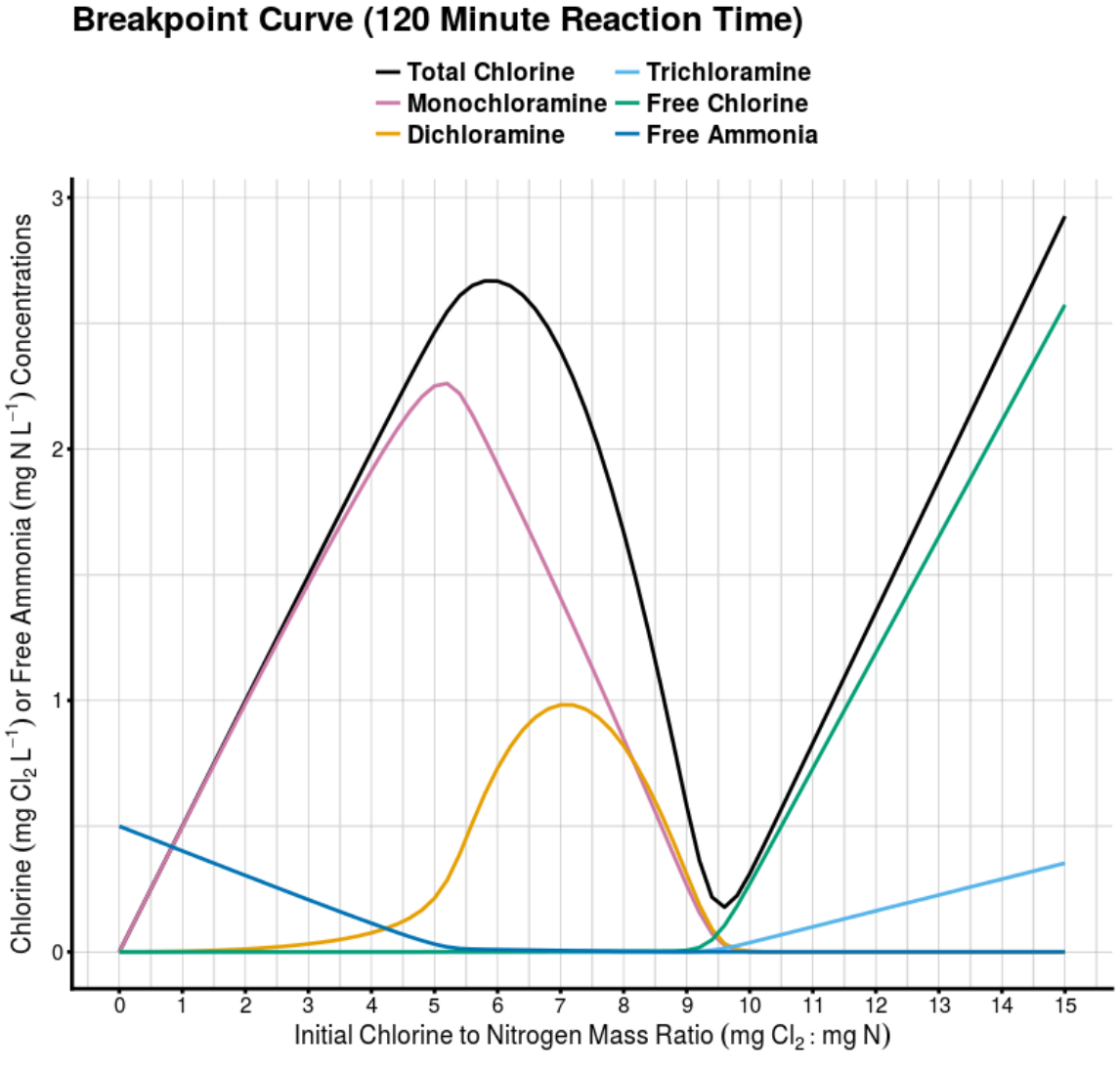
Nitrogen Gas
(& Nitrate)
+
Free Chlorine

Generated using USEPA Web-Based Application:
Chlorine Breakpoint Curve Simulator
https://usepaord.shinyapps.io/Breakpoint-Curve/
Developed by Dr. David Wahman, USEPA

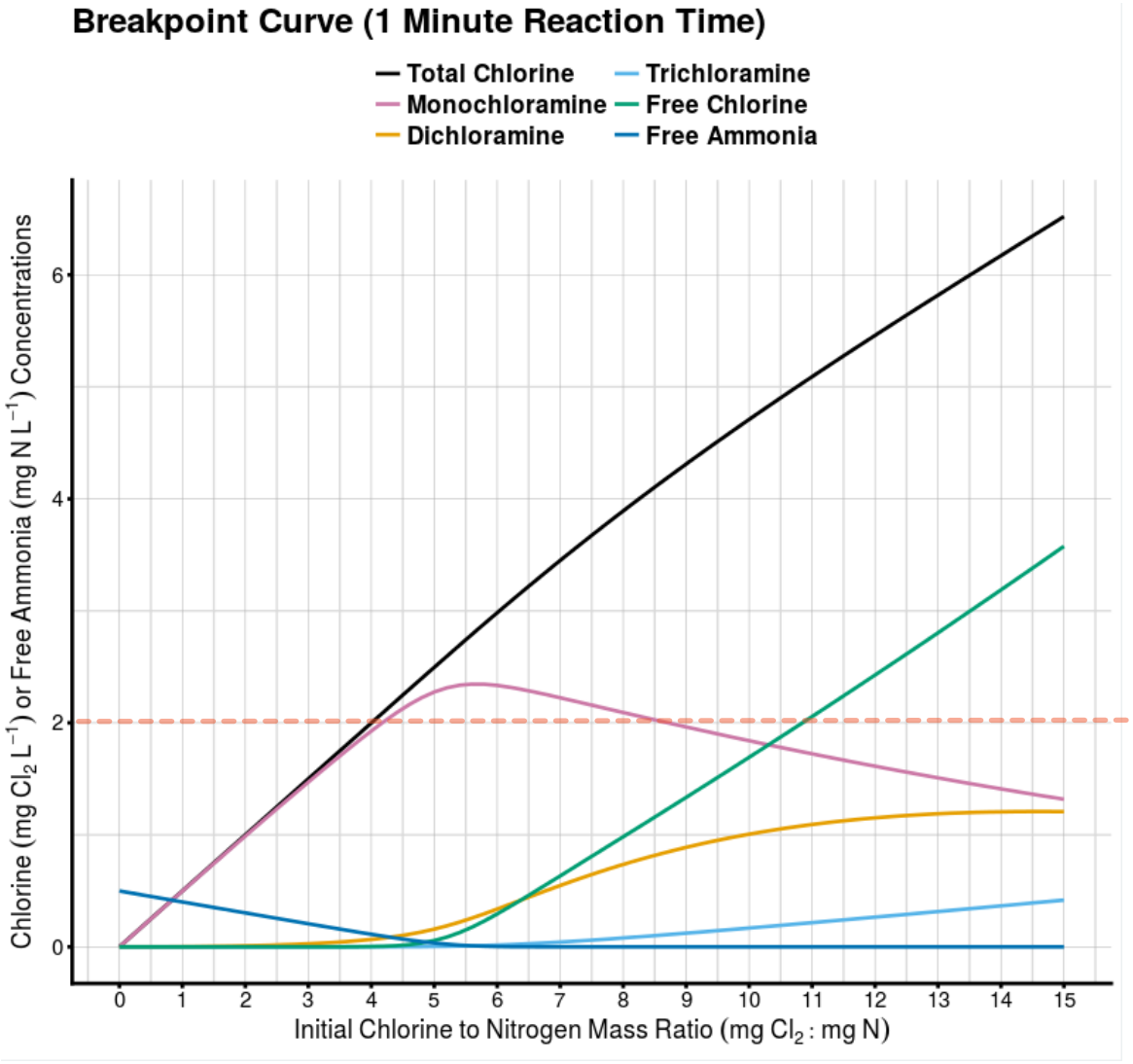


Breakpoint Chlorination

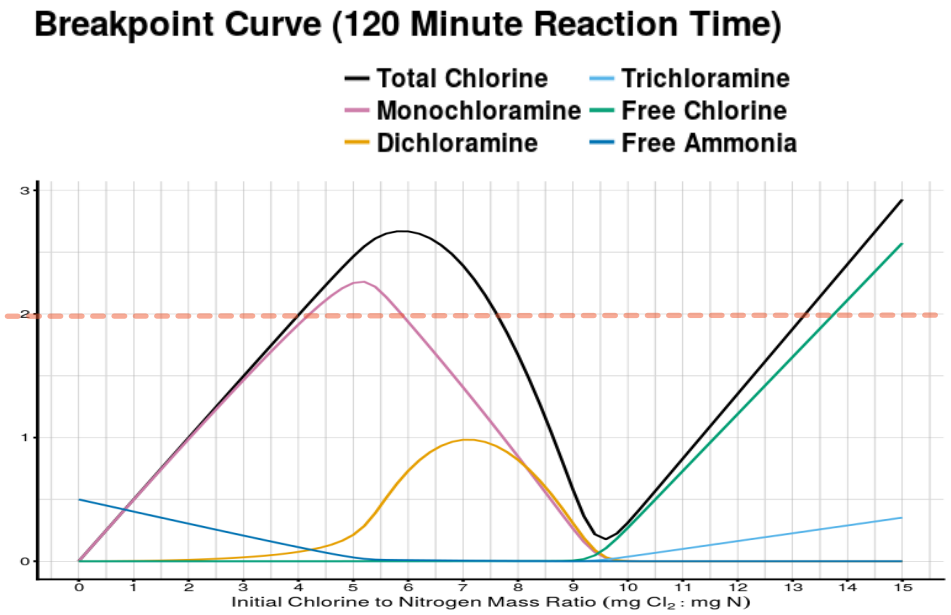




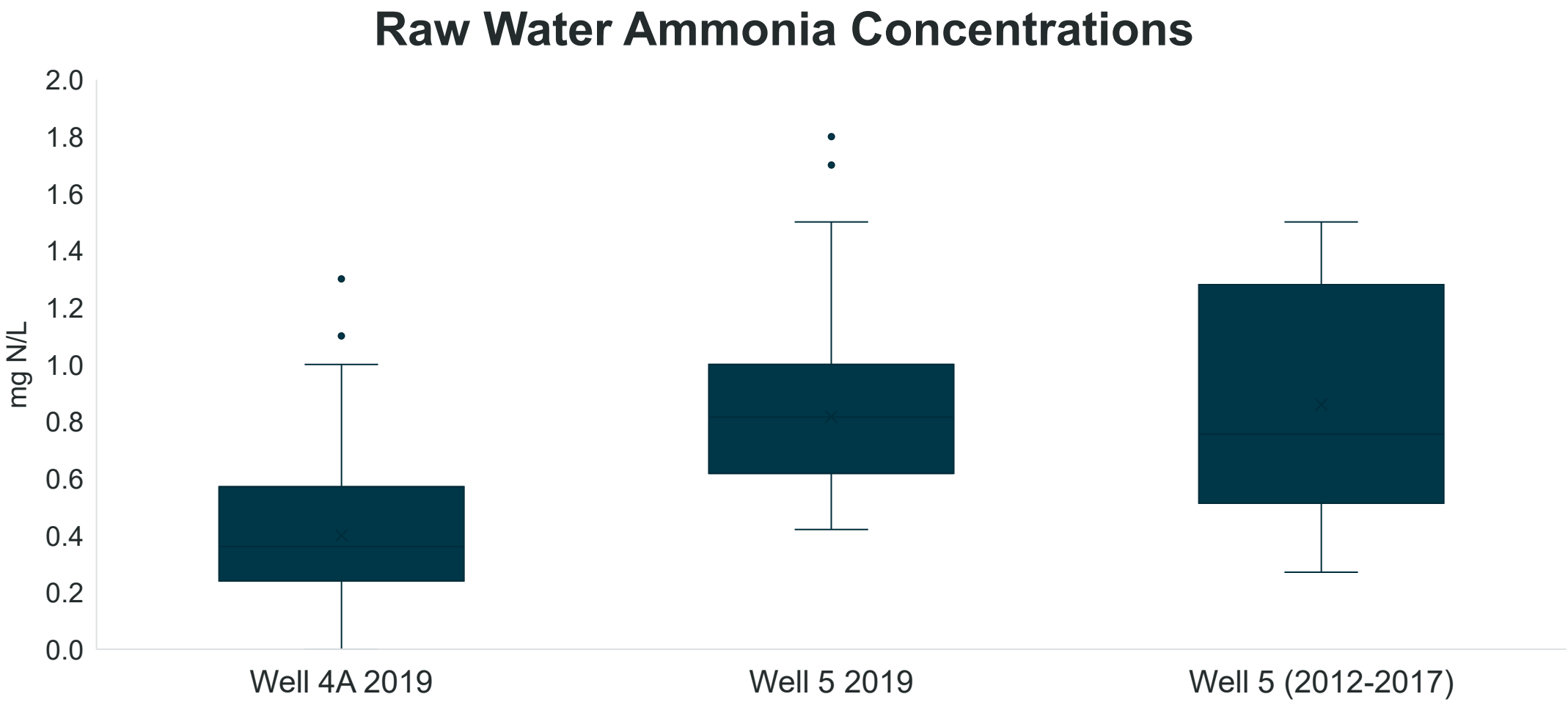
Breakpoint Chlorination



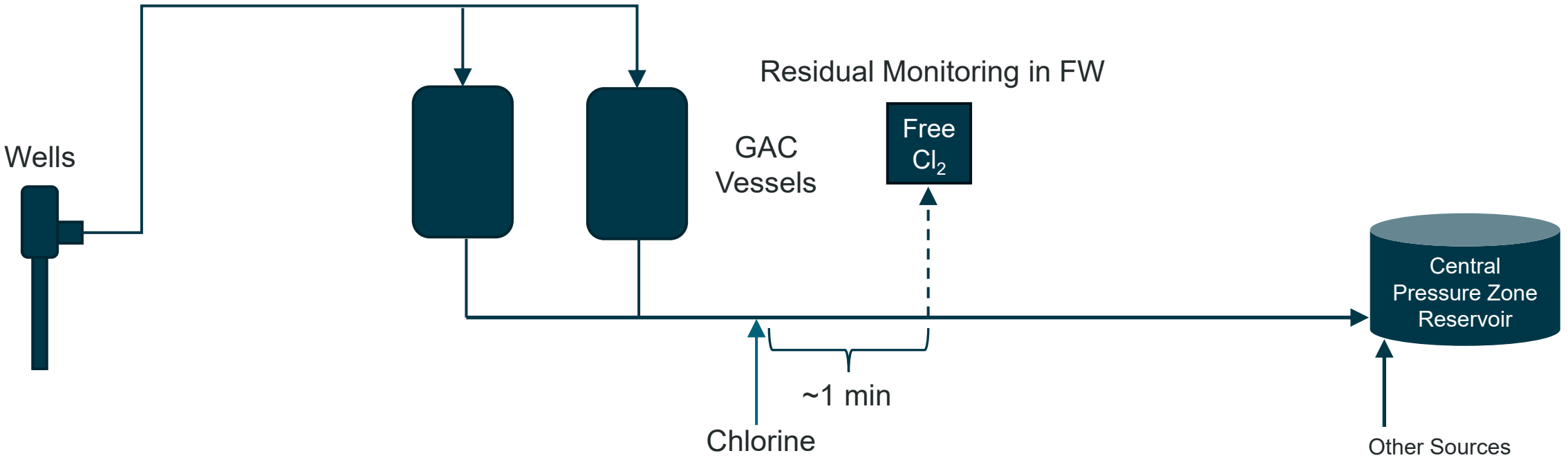
Getting true breakpoint residual measurement takes time



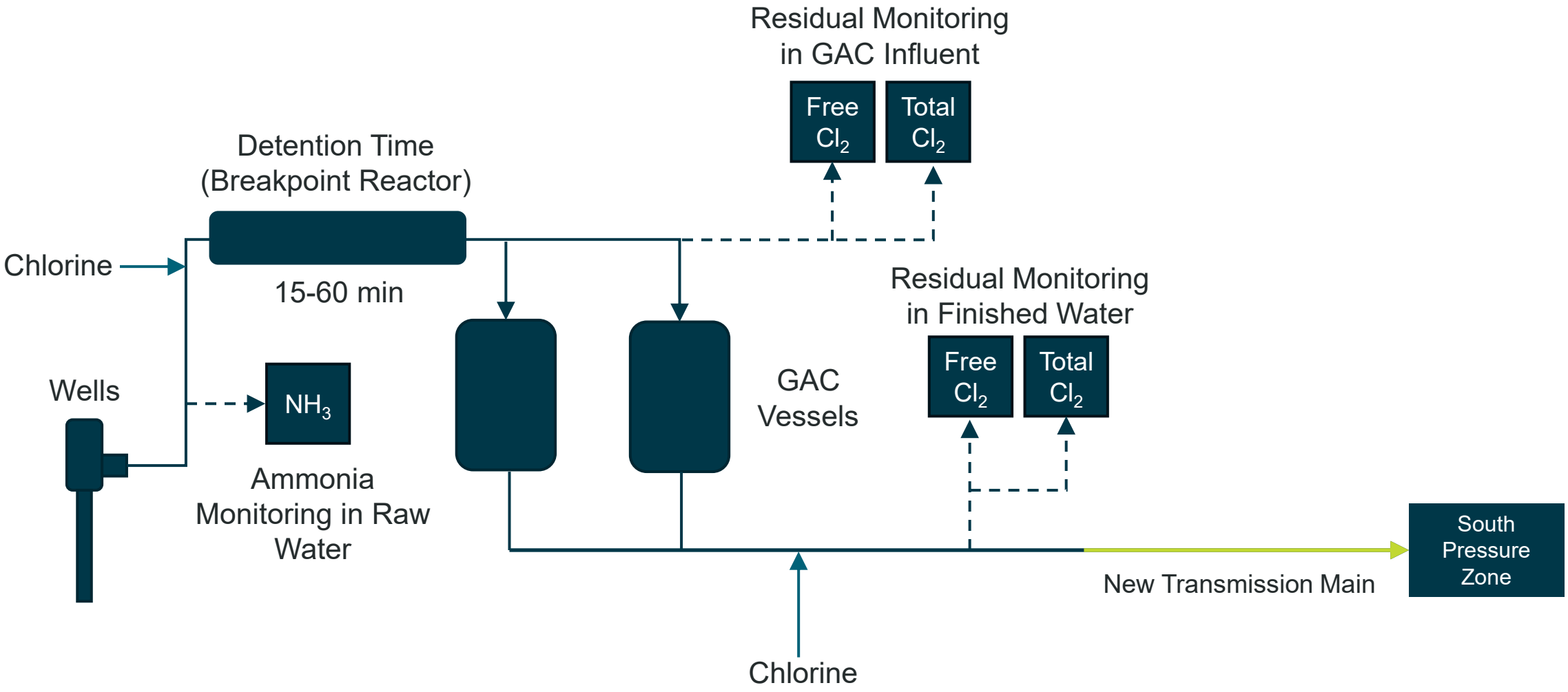
Case Study: Groundwater with Variable Ammonia



Case Study: Existing Conditions

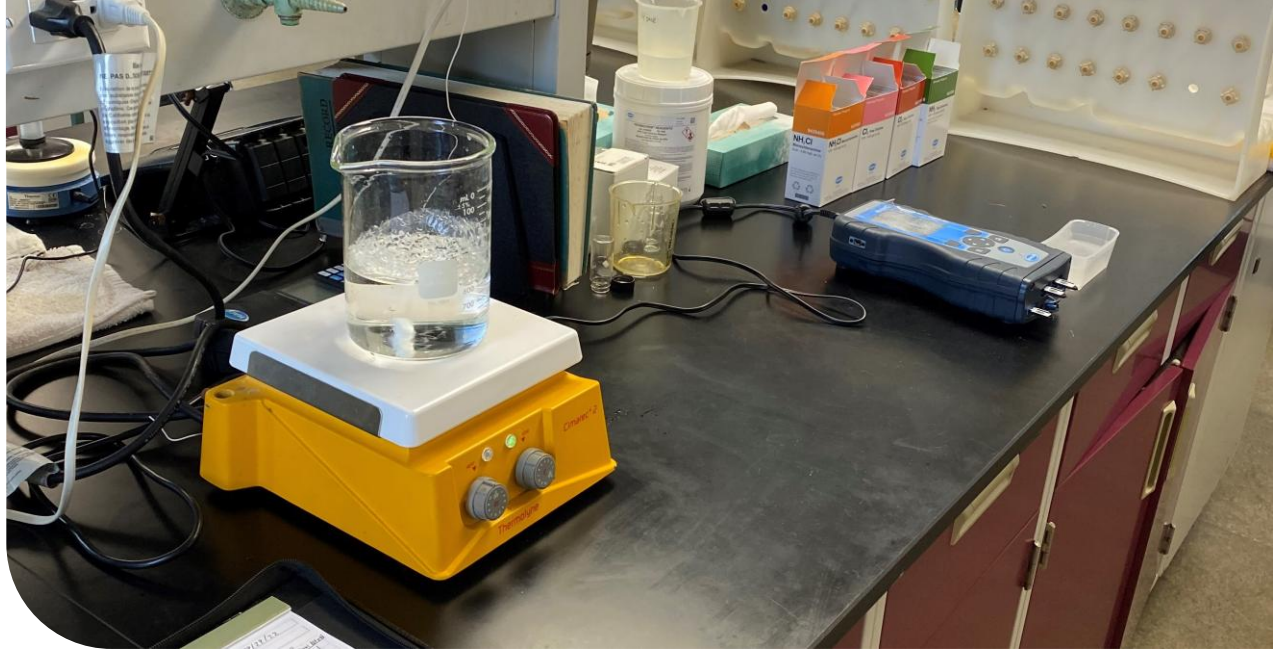


Case Study: Proposed Conditions



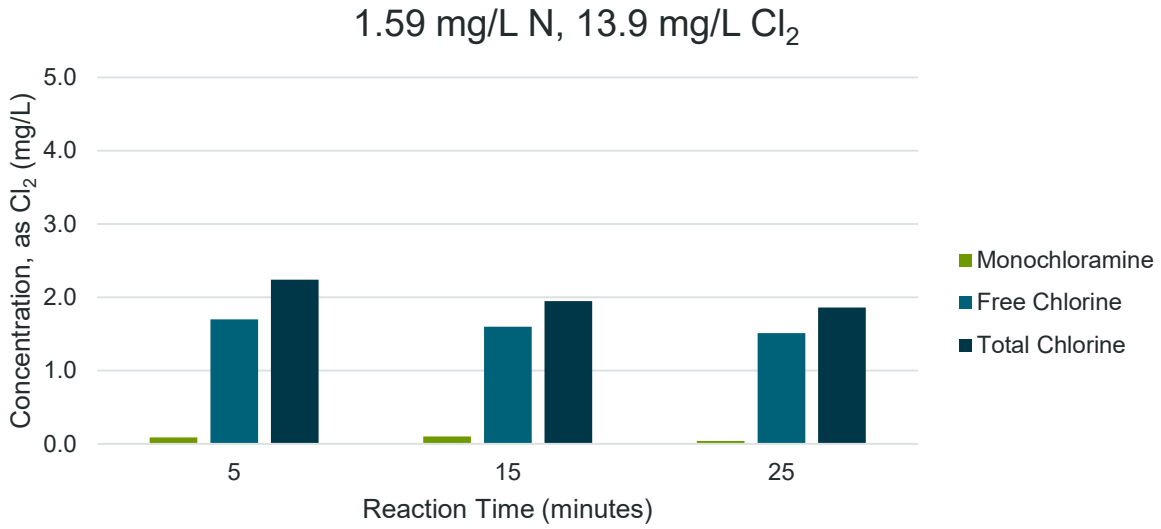
Breakpoint Chlorination Bench Testing

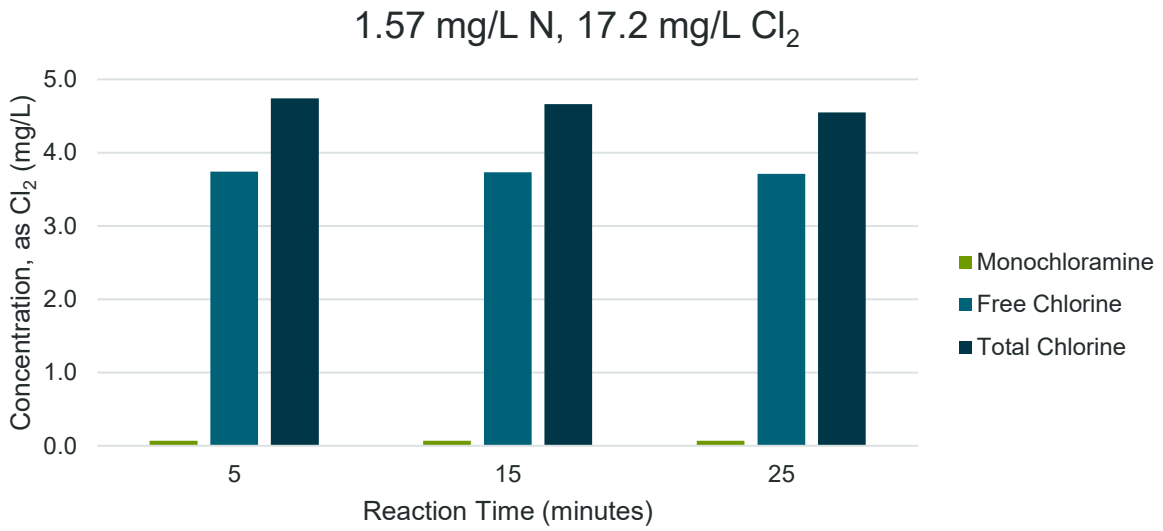
- Ammonia: 0.3 – 1.6 mg/L
- Multiple Cl:N mass ratios
- Simultaneous measurement:
  - Monochloramine
  - Free chlorine
  - Total chlorine
- 5-, 15-, 25-minute intervals

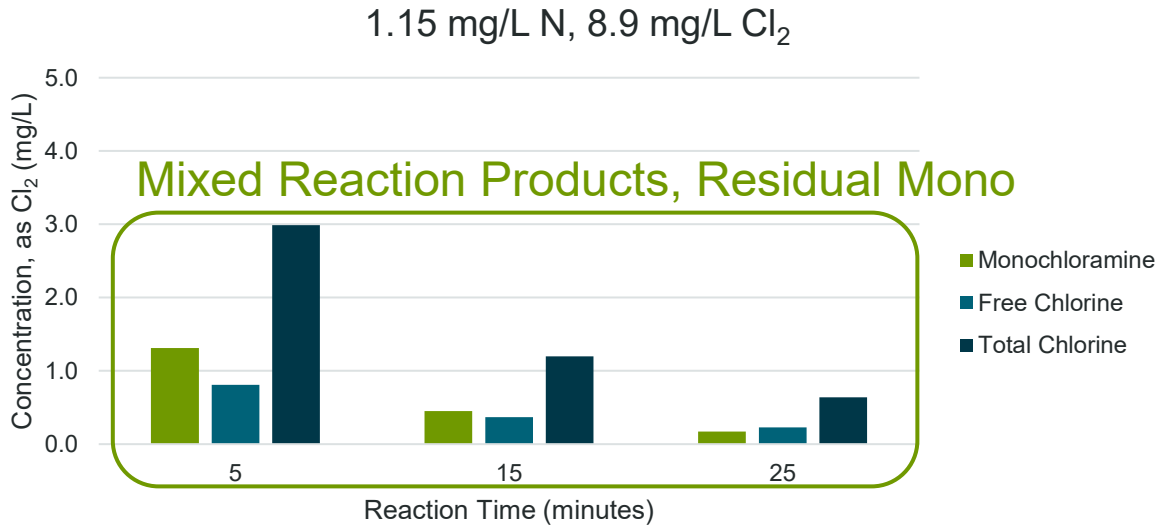


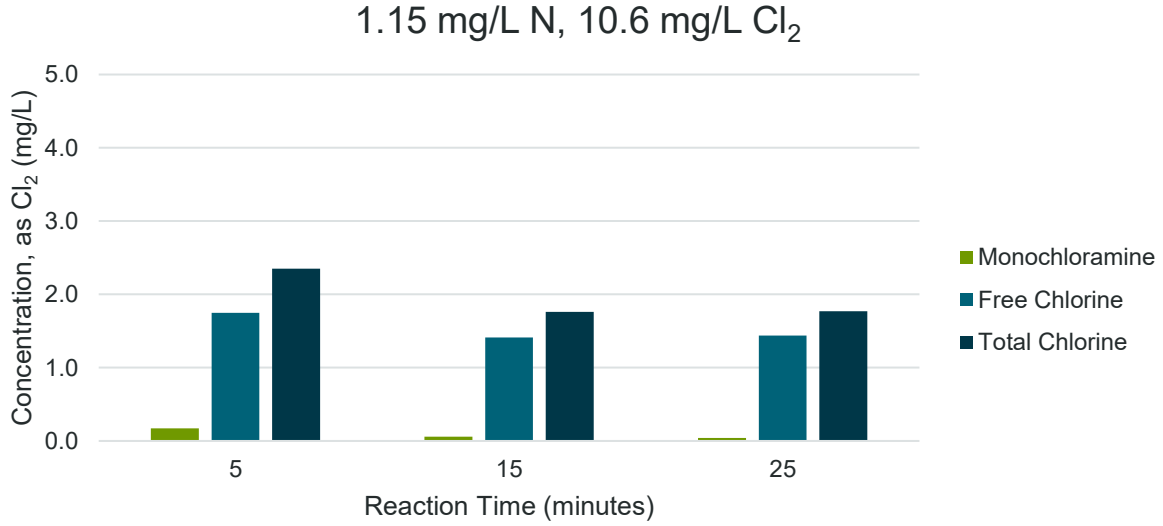


Bench Test Results

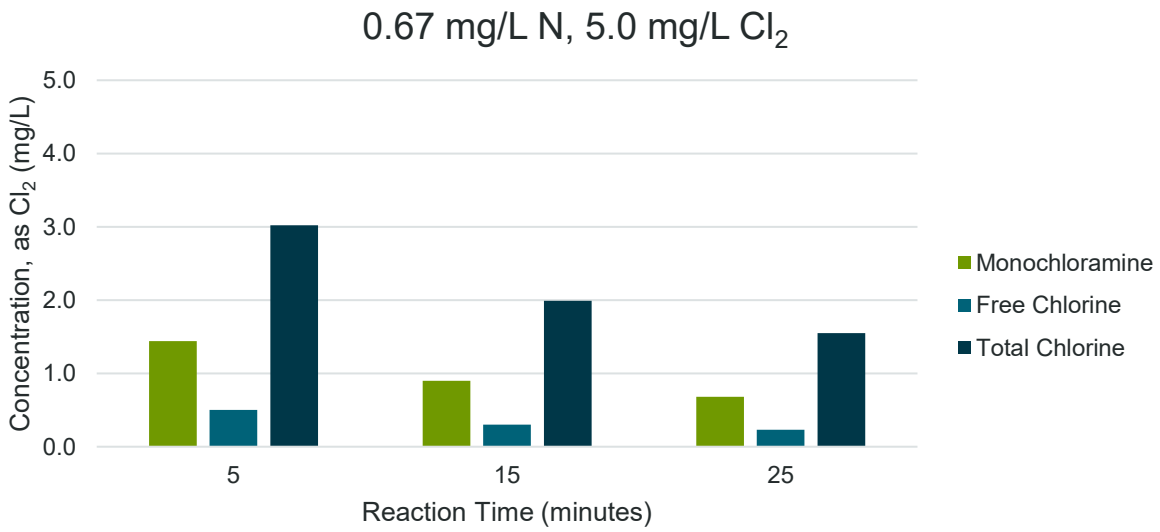


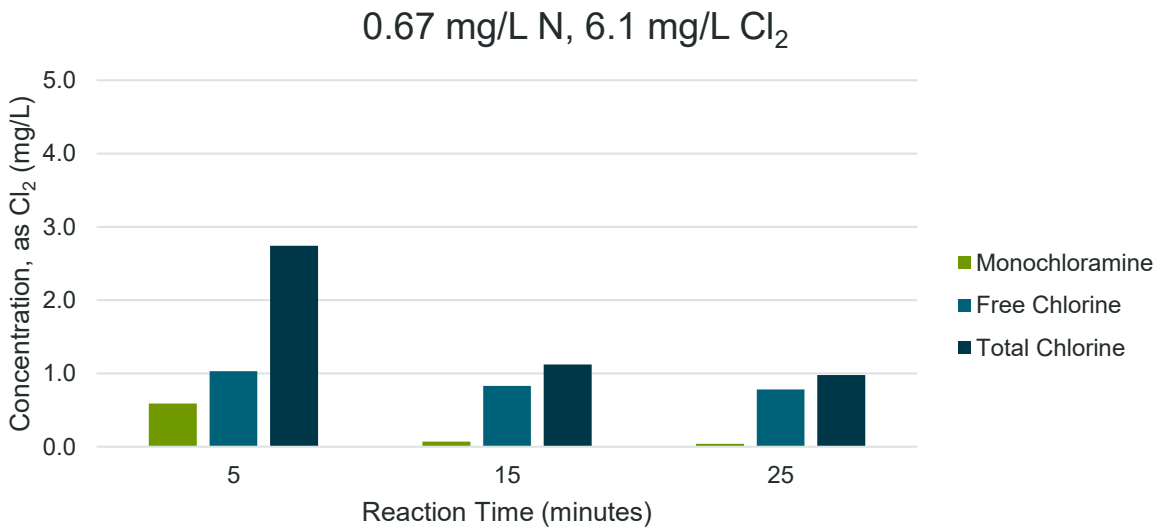




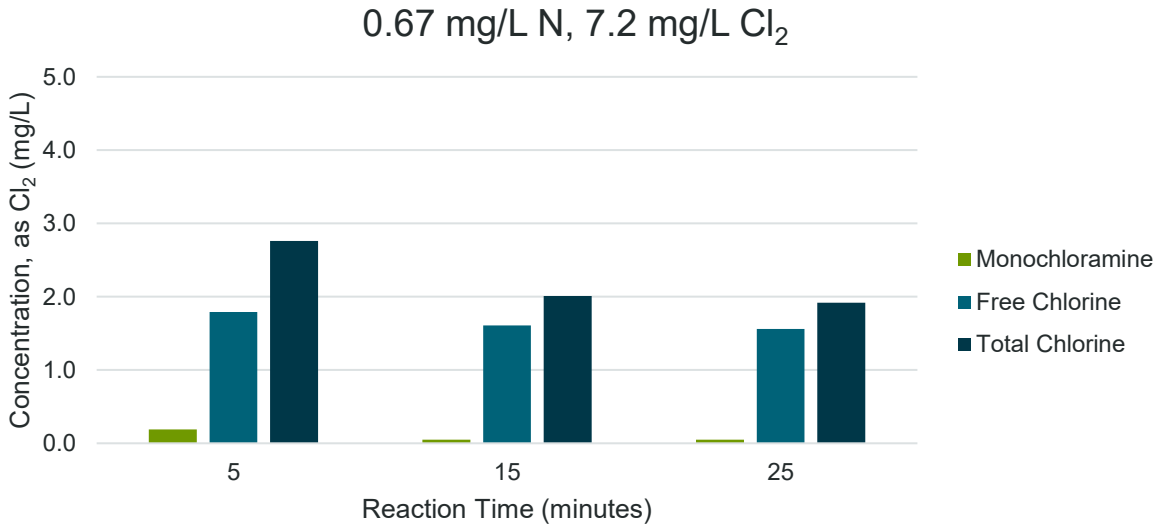


Bench Test Results

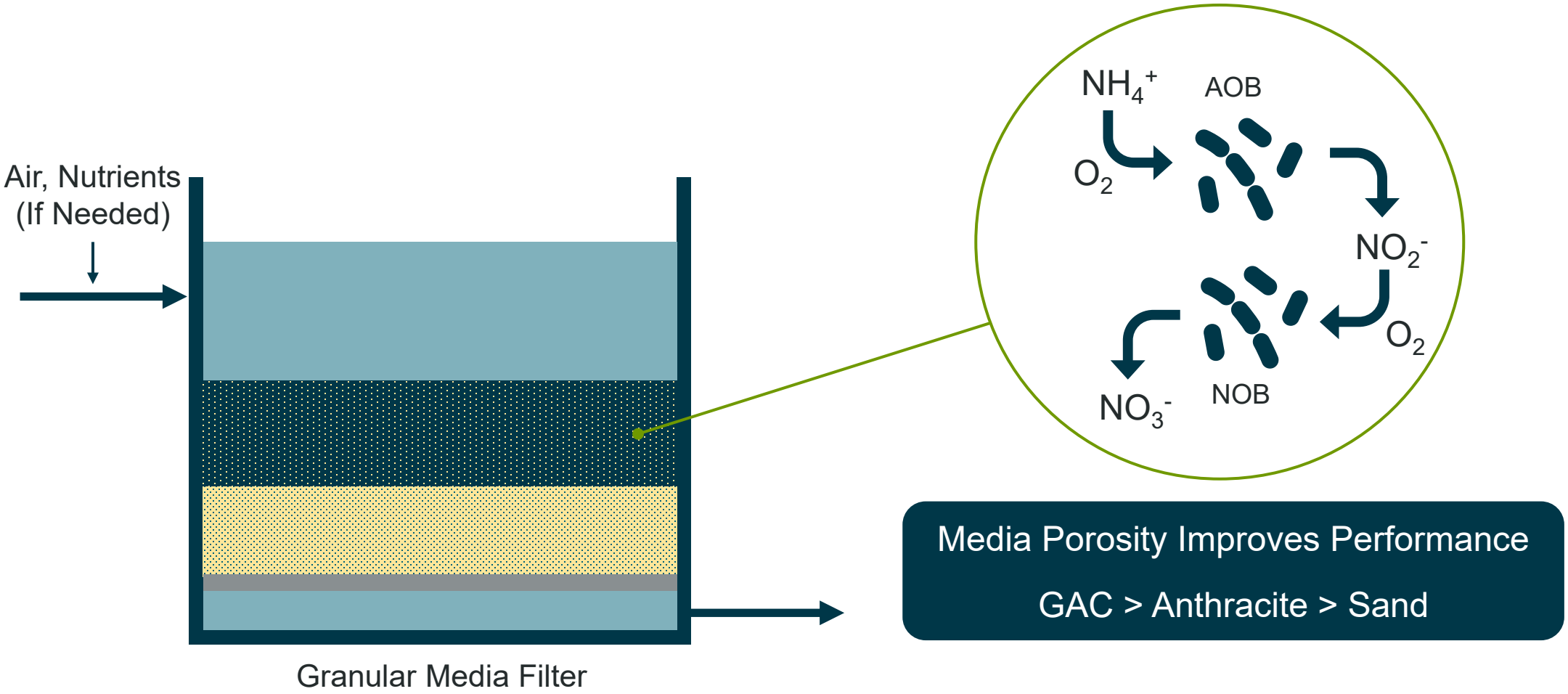




Design for > 15 min reaction time



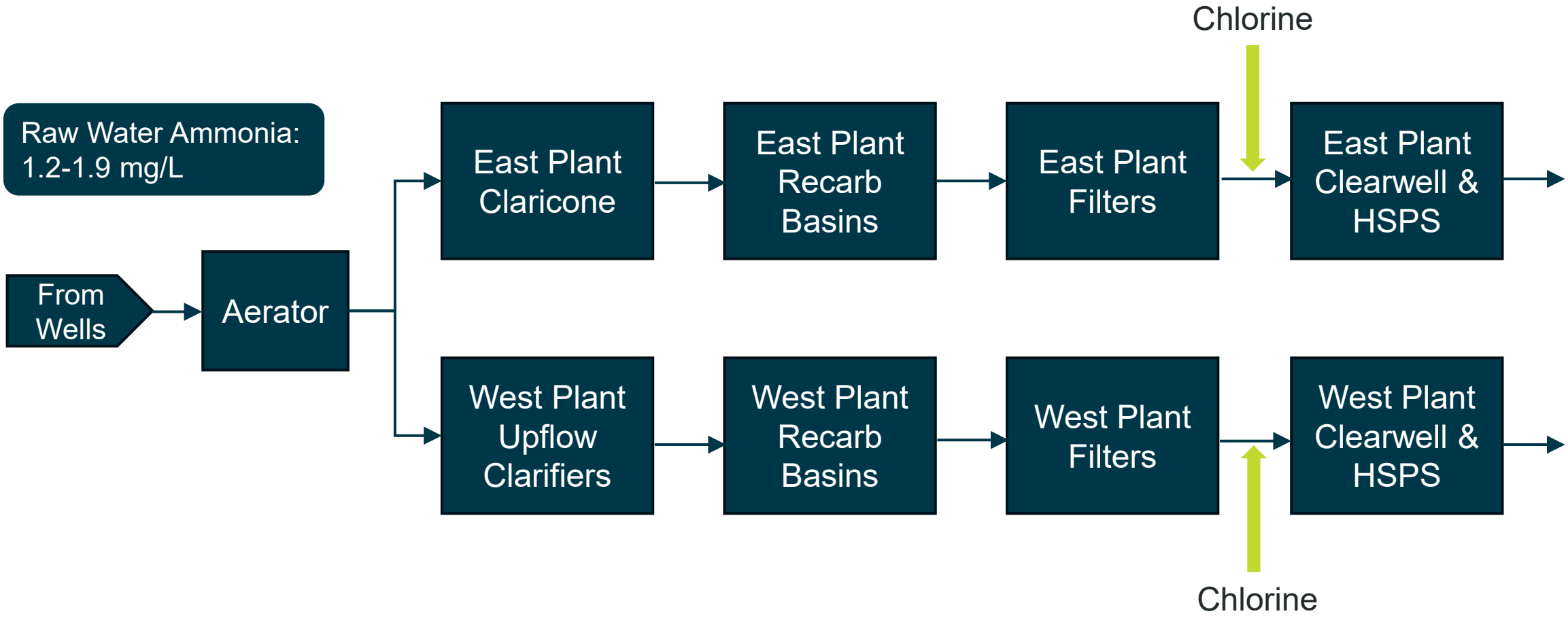
Biological Treatment of Ammonia



Media Porosity Improves Performance

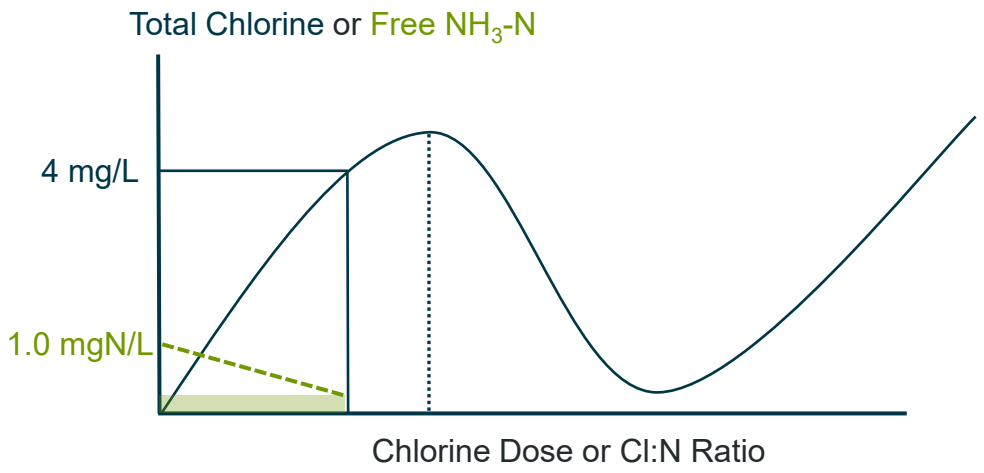
GAC > Anthracite > Sand

Case Study: Biological Filtration



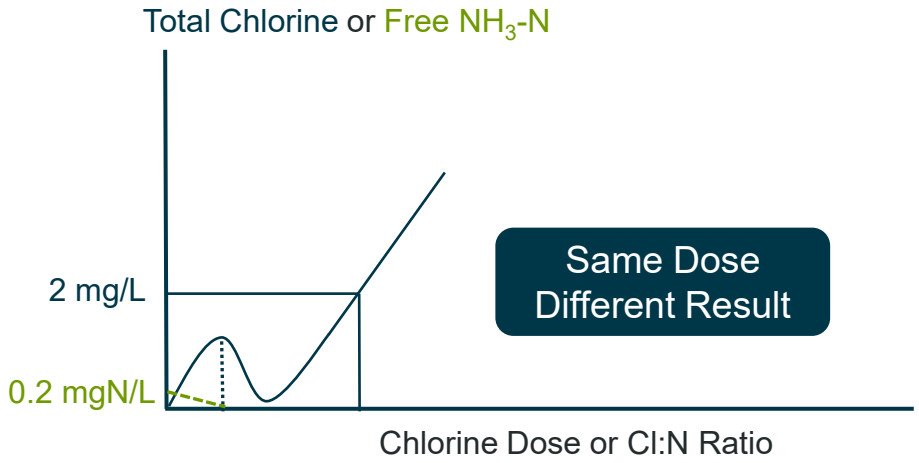
Disinfection Options for Case Study

Scenario 1: Monochloramine Formation



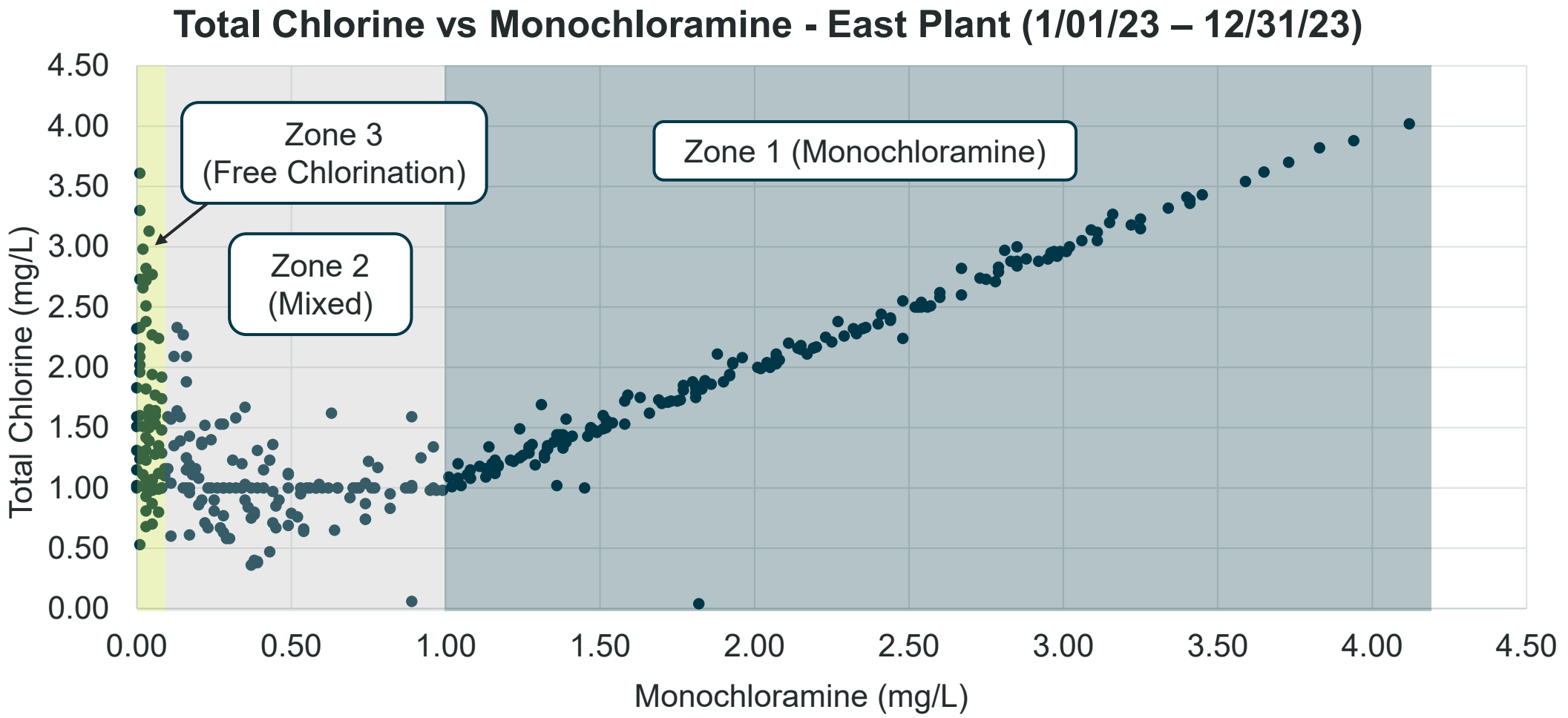
- Add chlorine feed upstream of filters (or downstream if nitrification is limited)
- Cl:N ratio < 5
- Operate with monochloramine residual
- Remaining free ammonia (varies)

Scenario 2: Nitrification and Free Chlorine

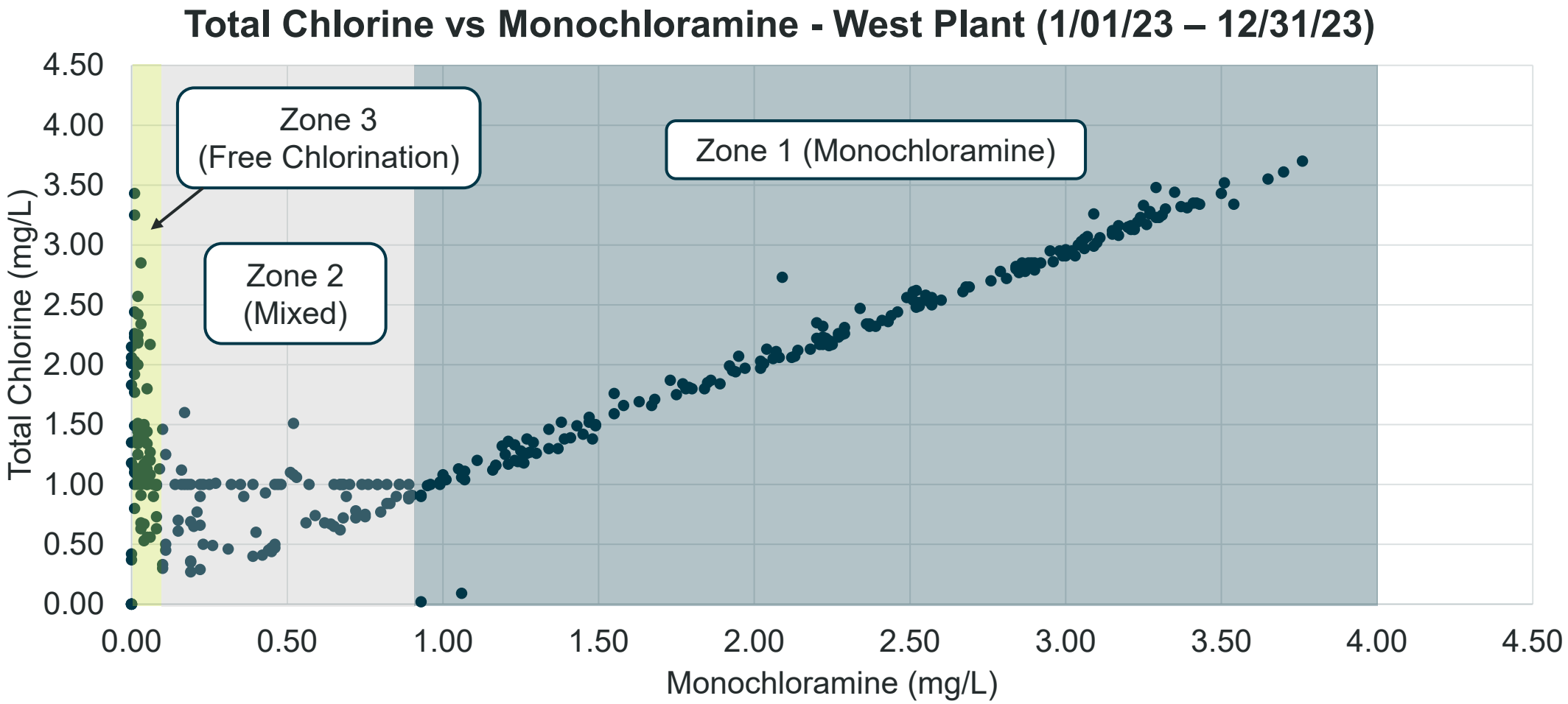


- Operate filters biologically
- Monitor filter effluent ammonia
- Breakpoint chlorinate remaining ammonia
- Produce free chlorine residual

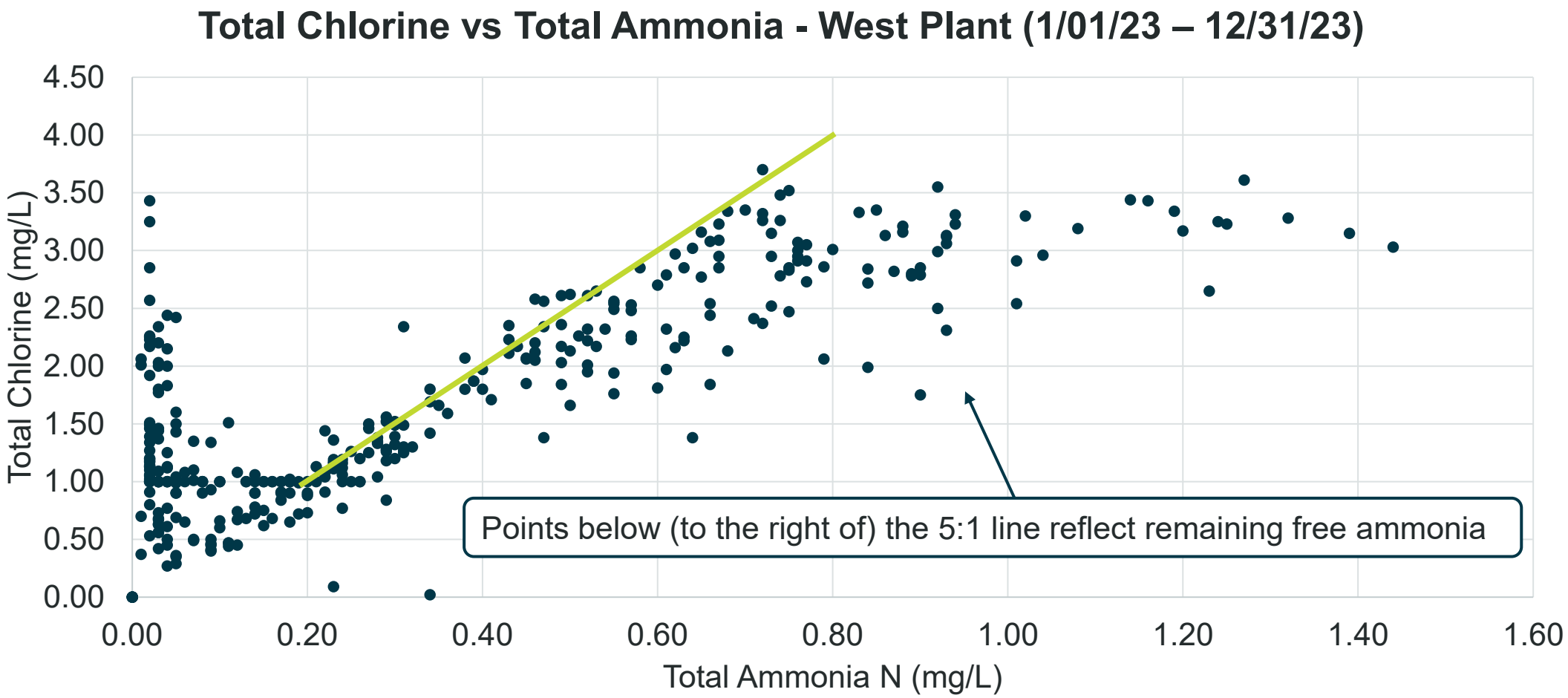
Finished Water Chlorine Residual Data



Finished Water Chlorine Residual Data

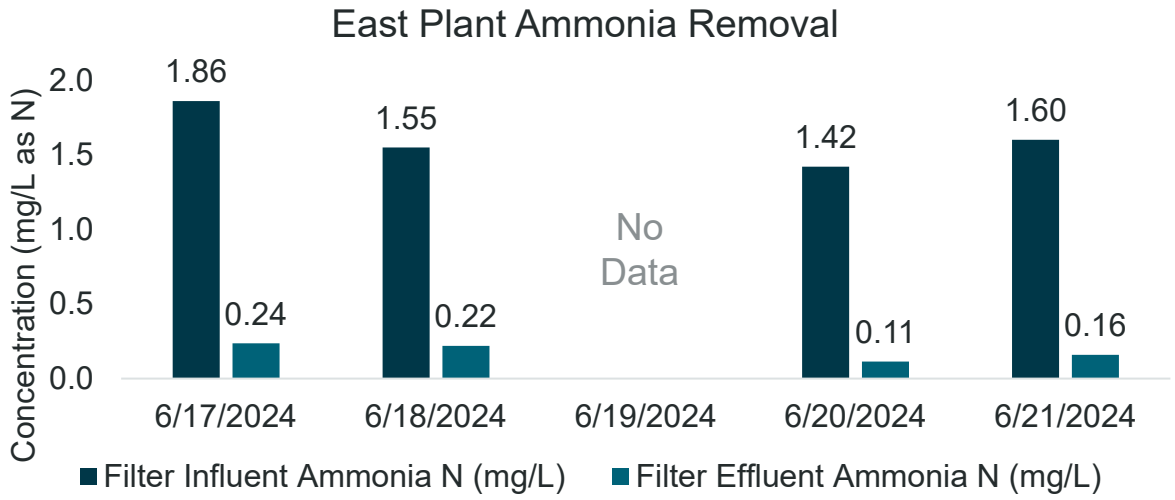


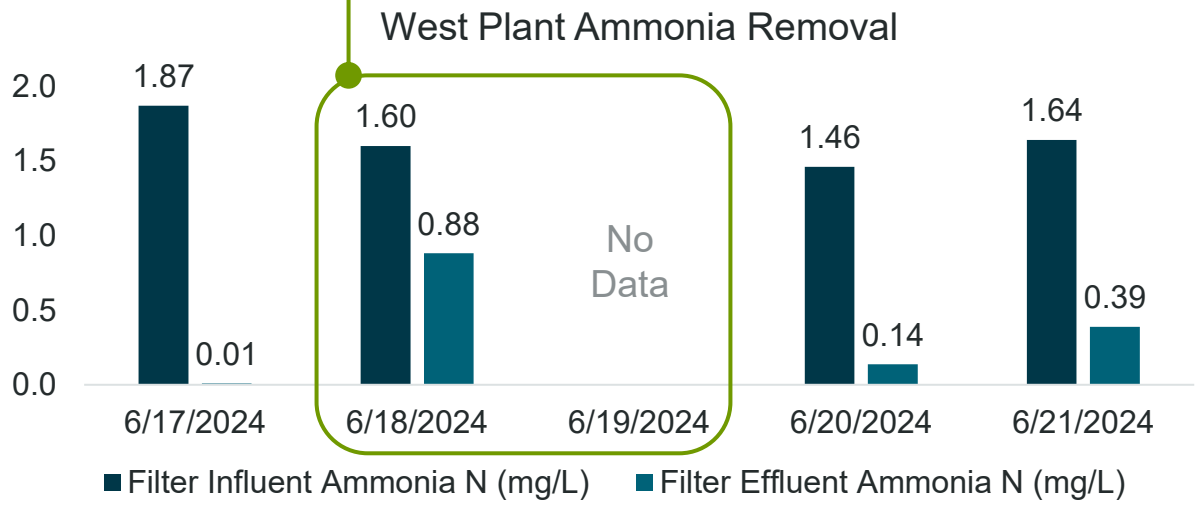
Finished Water Total Chlorine vs Total Ammonia N

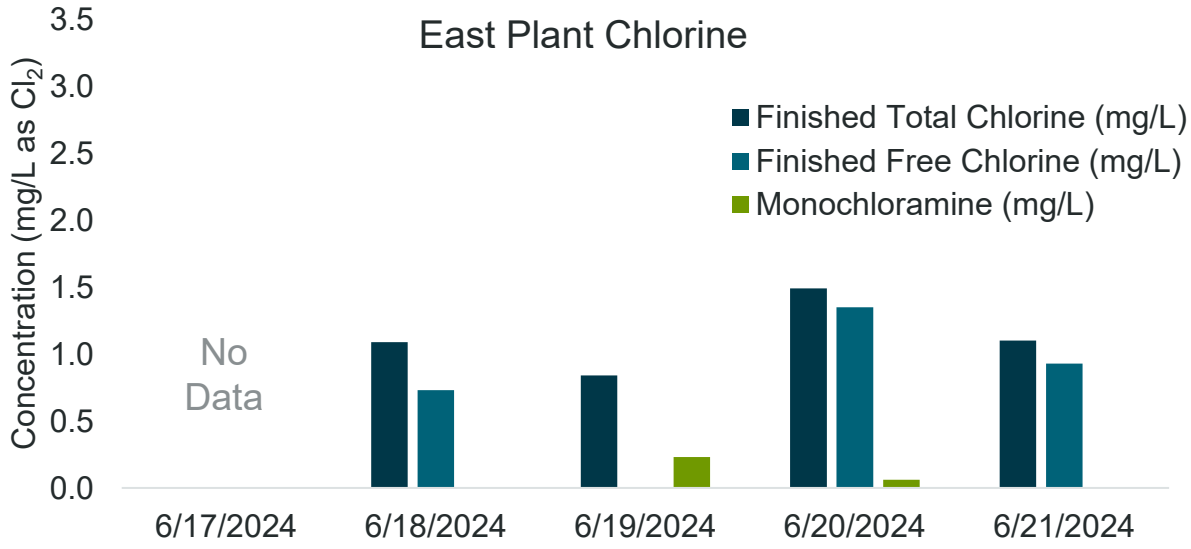


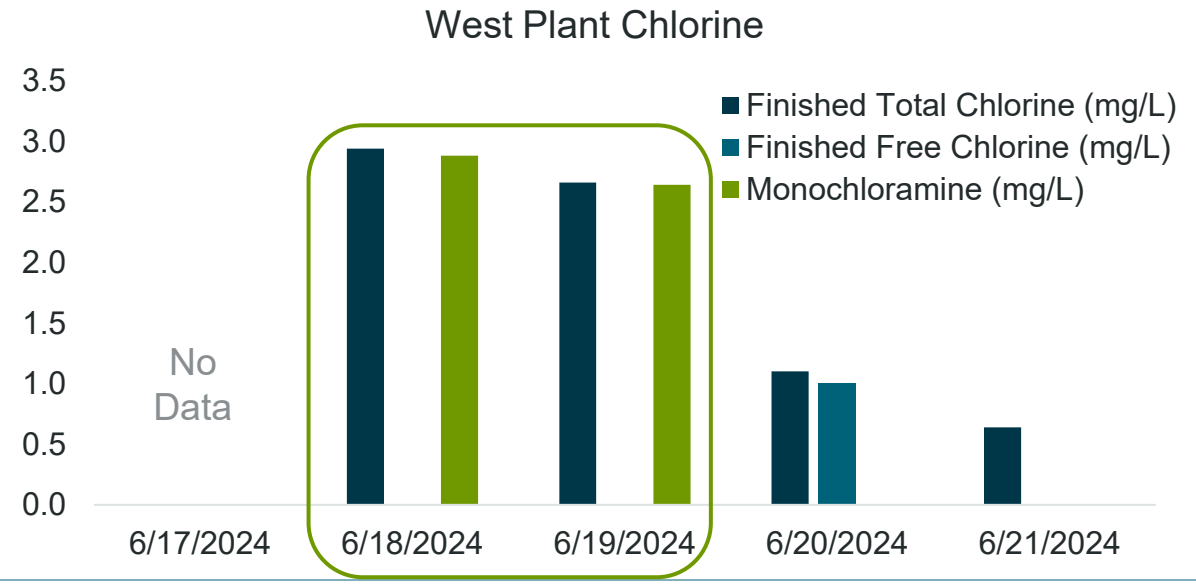
Week 1 of Ammonia Monitoring

Limited nitrification, Monochloramine formation

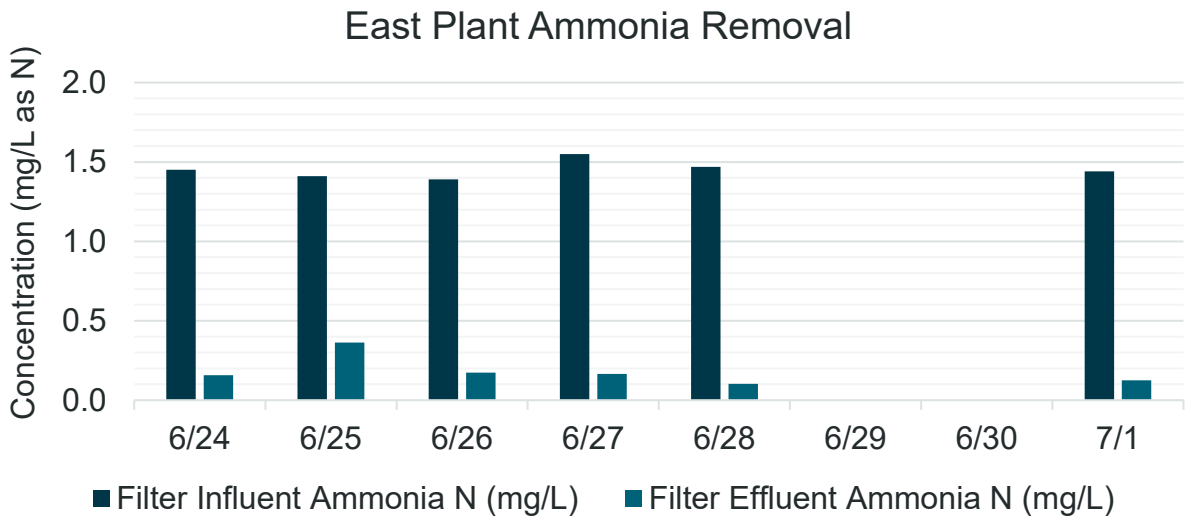


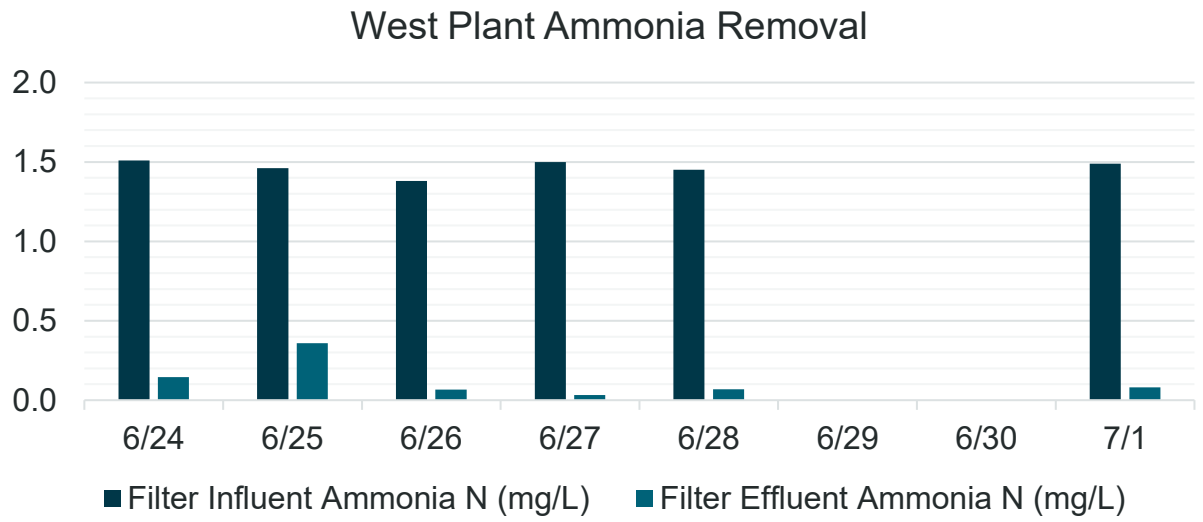


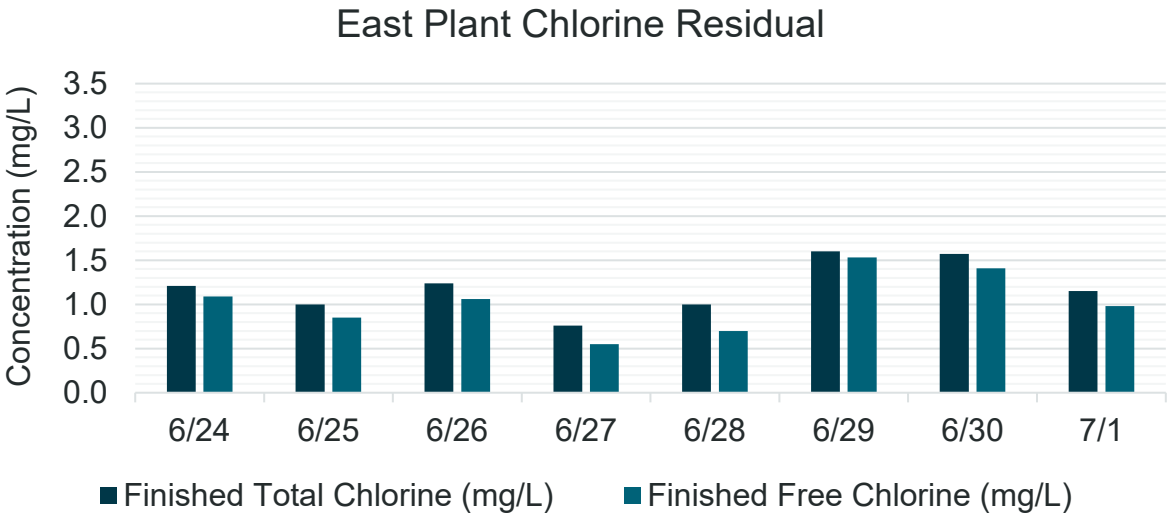


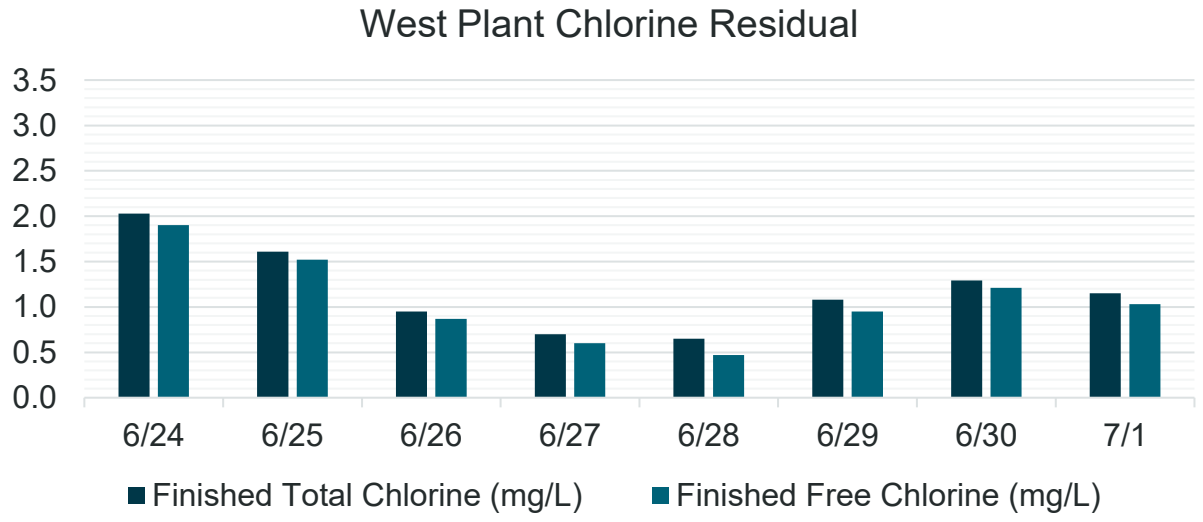


Week 2 of Ammonia Monitoring









Managing Ammonia for Disinfection and in Distribution Systems

Optimizing Chloramination at the Plant for Distribution System Success

Success Factors



Good Mixing
Prevents localized Cl:N ratio variation

Good Dispersion
Minimizes scaling in hard waters

pH > 8.3
Minimizes taste & odor
Improves residual stability

Target Operational Ranges

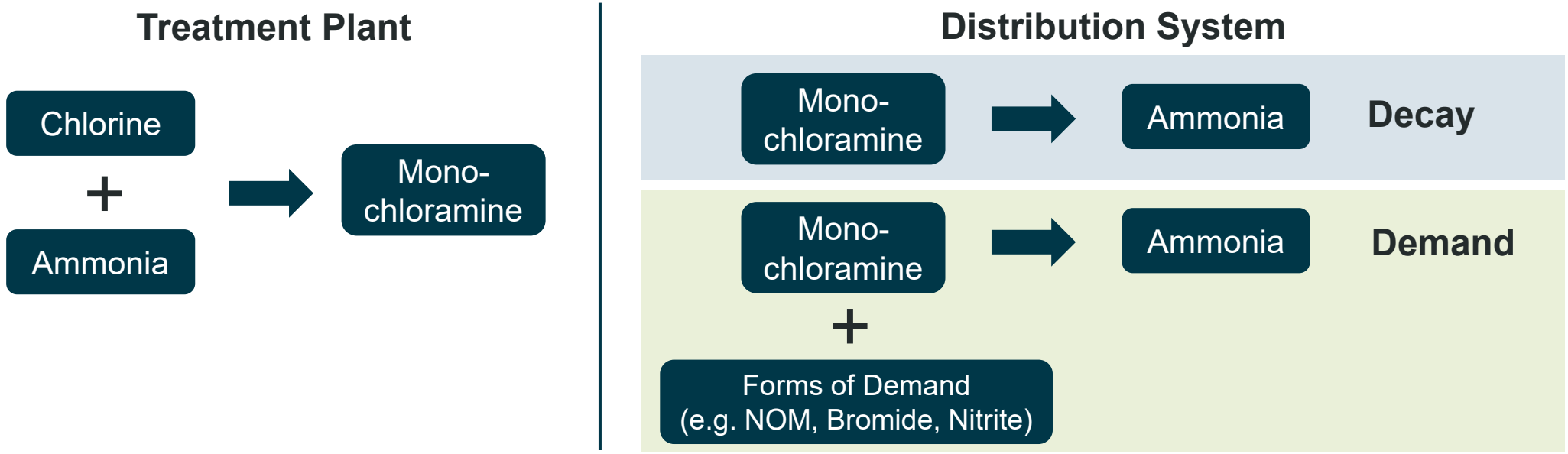


Cl:N Ratio:
4.5-5.0

Free Ammonia:
0.01-0.05 mg/L

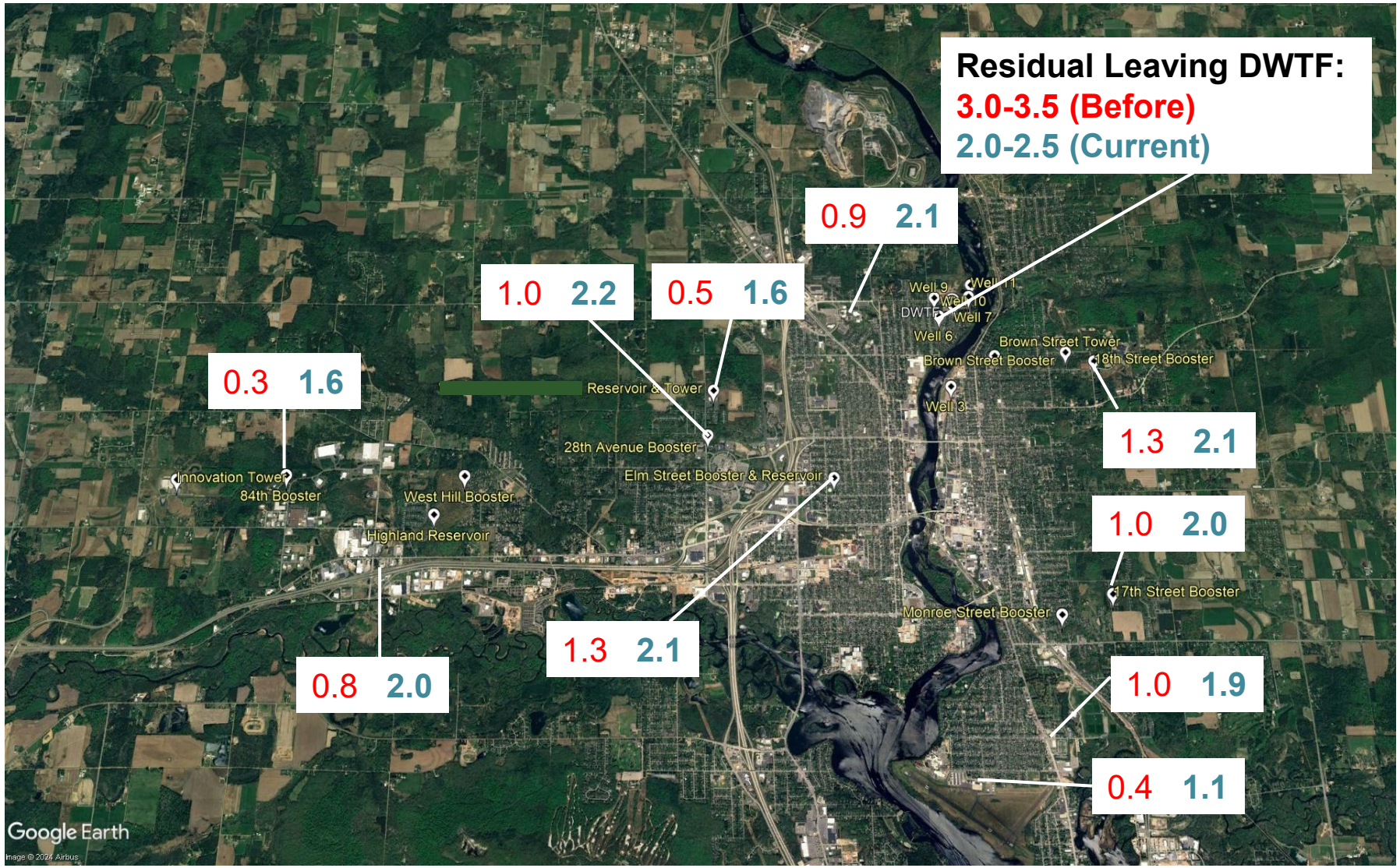
- Minimizes free ammonia
- Maximizes monochloramine formation

Factors Affecting Chloramine Stability



Parameter	Ability to Impact	Strategy Considerations
Temperature	Limited	Minimize water age, source blending (e.g., groundwater)
pH	High	Optimize chemical feed and pH monitoring
Total Organic Carbon	Moderate	Source selection/blending, enhanced coagulation, other treatment
Bromide	Limited	Source selection/blending, free chlorine contact, optimized pH

Case Study: Impact of TOC Reduction



Red = Avg Total Cl_2 (mg/L) before New DWTF (2022) Higher TOC

Blue = Avg Total Cl_2 (mg/L) after New DWTF (2023-2024) Lower TOC

Monitoring for Nitrification

Parameter	Usefulness	Indicator of Risk	Indicator of Occurrence	Example Alert or Indication Level (Varies by System)
Total Chlorine	High	☑	☑	< 2.0 mg/L
Free Ammonia-N	High	☑		> 0.2 mg/L
Nitrite-N	High		☑	> 0.01 mg/L
Nitrate-N	Moderate		☑	Background Concentration Dependent
Temperature	High	☑		> 20°C
pH	Moderate	☑	☑	< 8.0
HPC-R2A	Moderate		☑	Varies

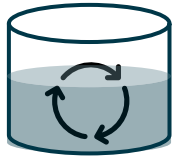
Sampling Location Considerations:

- Storage Facilities
- Low Flow Areas
- Source Blended Zones
- Range of Water Age
- Pipe Materials

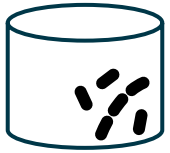
Nitrification Action Plan:

Goal | Alert Level | Alarm Level

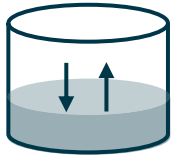
Nitrification Mitigation Strategies: Non-Chemical



Tank Mixing



Tank Cleaning



Tank Cycling



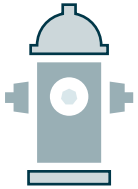
Tank Inlet/Outlet Modifications



Taking Tanks Out of Service

#

Distribution System Improvements

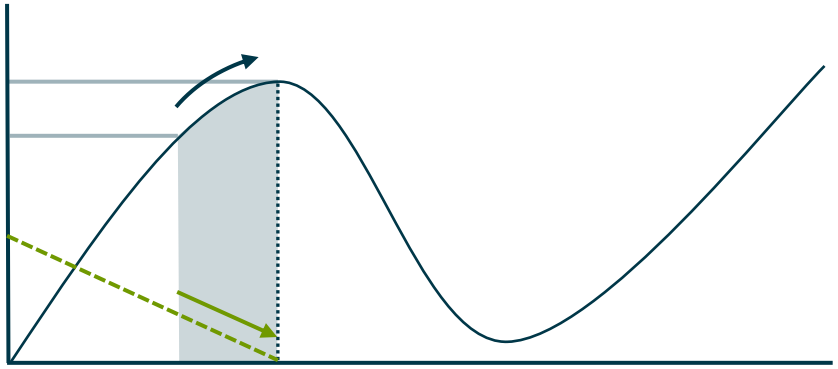


Flushing

Nitrification Mitigation Strategies: Chemical

1. Increase Total Chlorine and/or Cl:N Ratio at Entry Point (Incremental Adjustments)

2. Booster Chlorination



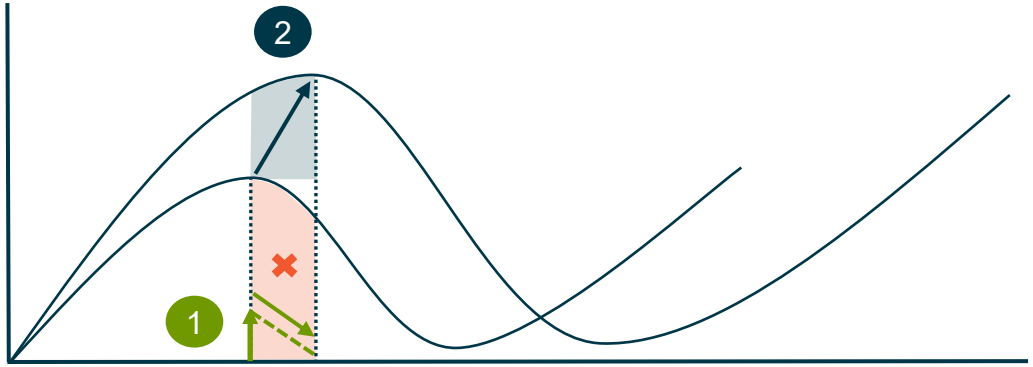
Chlorine/Nitrogen Ratio

Requires chlorine feed system

Counteracts chlorine demand/decay

Increases total chlorine concentration

3. Booster Chloramination



Chlorine/Nitrogen Ratio

Requires chlorine and ammonia feed systems

Greater flexibility to increase residual

For in-line boosting: add ammonia first, then chlorine

4. Breakpoint Chlorination / Temporary Free Chlorine → Once Nitrification is Occurring

Q & A

AndrewDow@KennedyJenks.com

Kennedy Jenks