



Use of a Magnetic Ion Exchange Resin for Total Organic Carbon (TOC) Removal to Enable Compliance with the EPA Disinfection By-Product Rule

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NEWWA Spring Regional Joint Conference
April 1, 2009

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TOC Characteristics

Allochthonous NOM (degradation and leaching of organic detritus)

- High molecular weight (> 1,0000 Daltons)
- Hydrophobic
- Higher SUVA values



TOC Characteristics

Autochthonous NOM (Derived mostly from algae that utilize CO_2 as a source of carbon)

- ECPs are mostly polysaccharides, proteins, amino sugars and other biochemical compounds
- Rich in carboxylic acid functional groups
- Low in molecular weight (<1000 Daltons)
- Hydrophilic - contributes to their higher level of bioreactivity
- Lower SUVA values



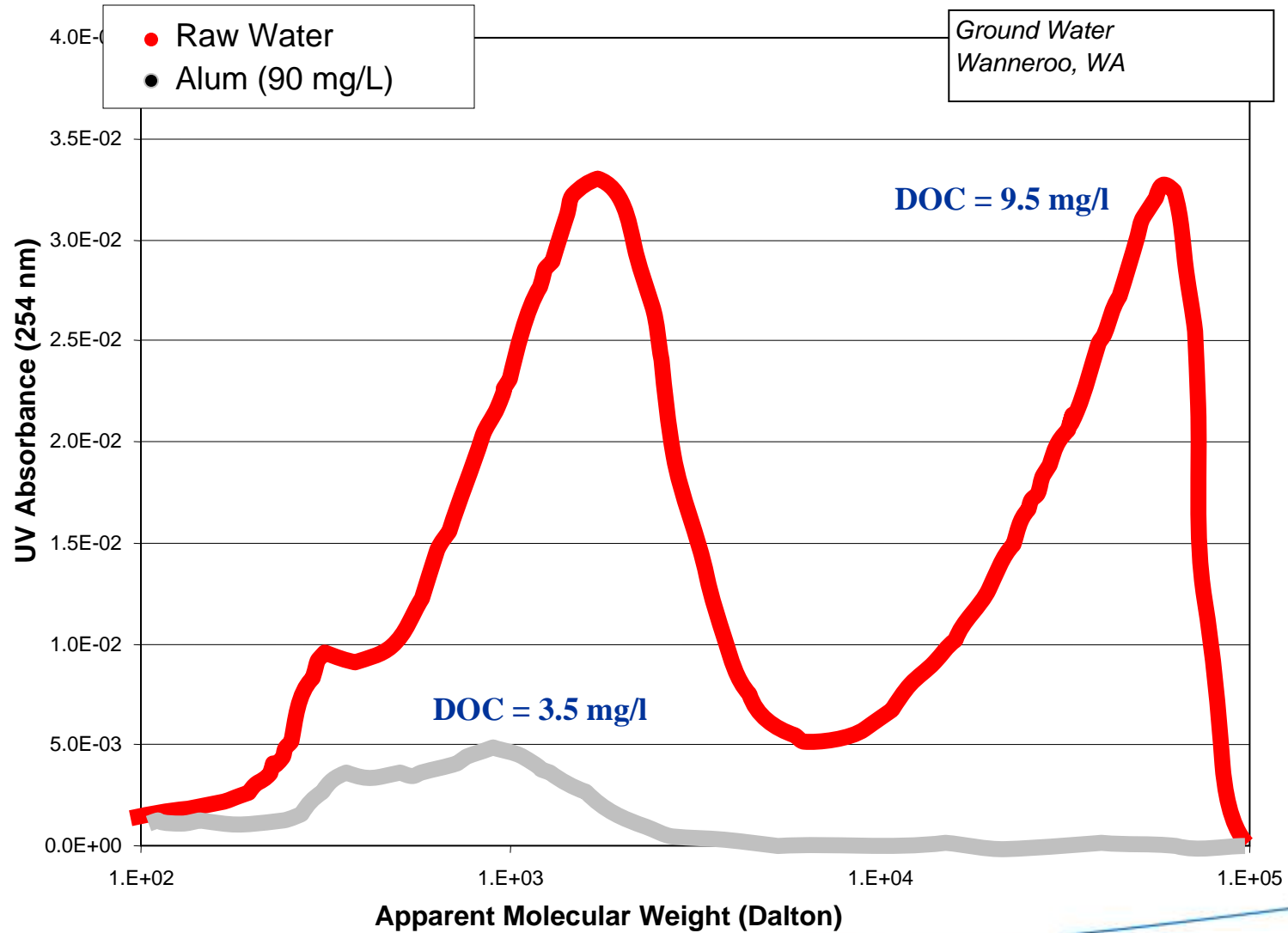
TOC Characteristics

EfOM (Municipal Waste Effluent and Industrial Waste Effluent)

- Presence of nitrogenous compounds, i.e. proteins
- Hydrophilic - similar to bioreactive NOM
- Polysaccharide and protein contents (higher than NOM)
- Low SUVA values



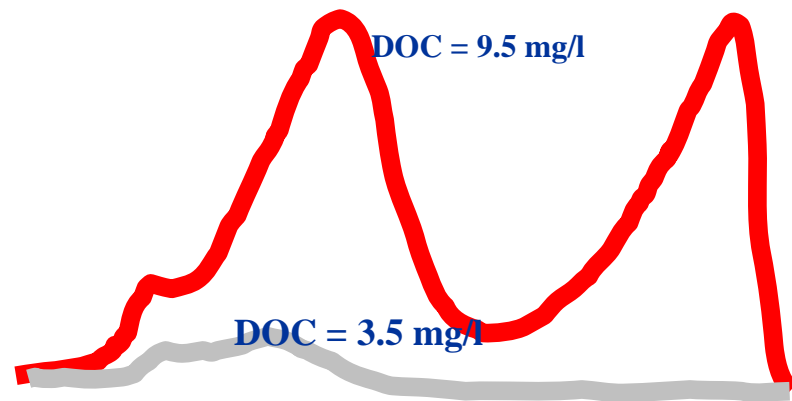
Fraction Removed with Coagulation



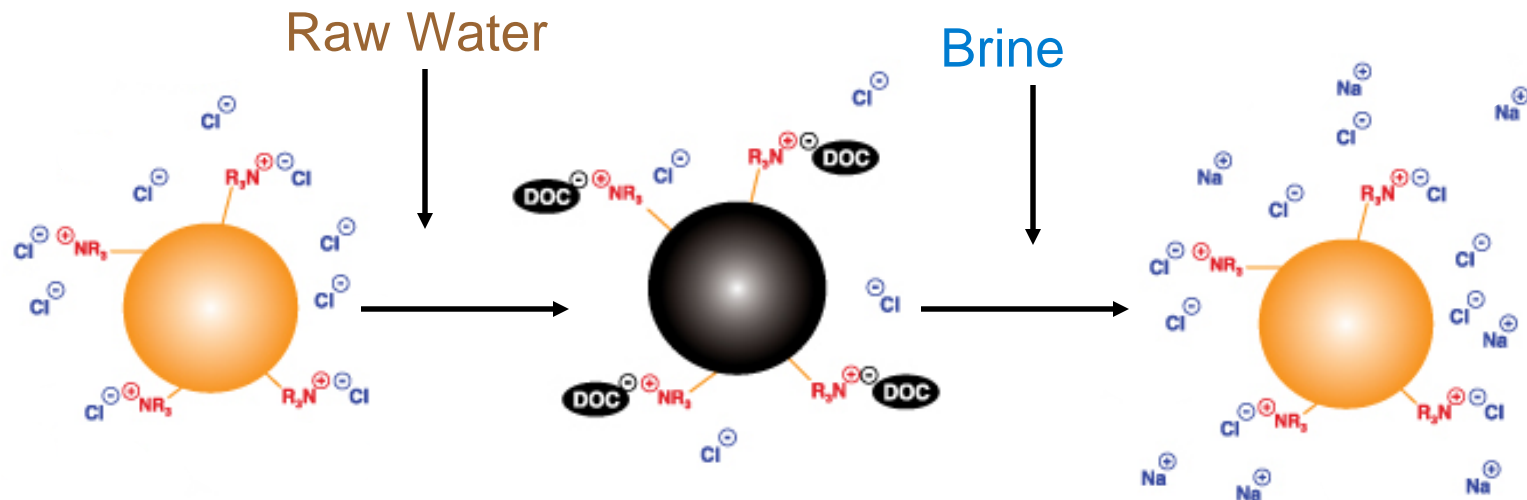
TOC Left Behind after Coagulation

After Coagulation the remaining TOC is likely:

- Low molecular weight OM
- Low SUVA
- Hydrophilic
- Autochthonous NOM
- Large portions of EfOM



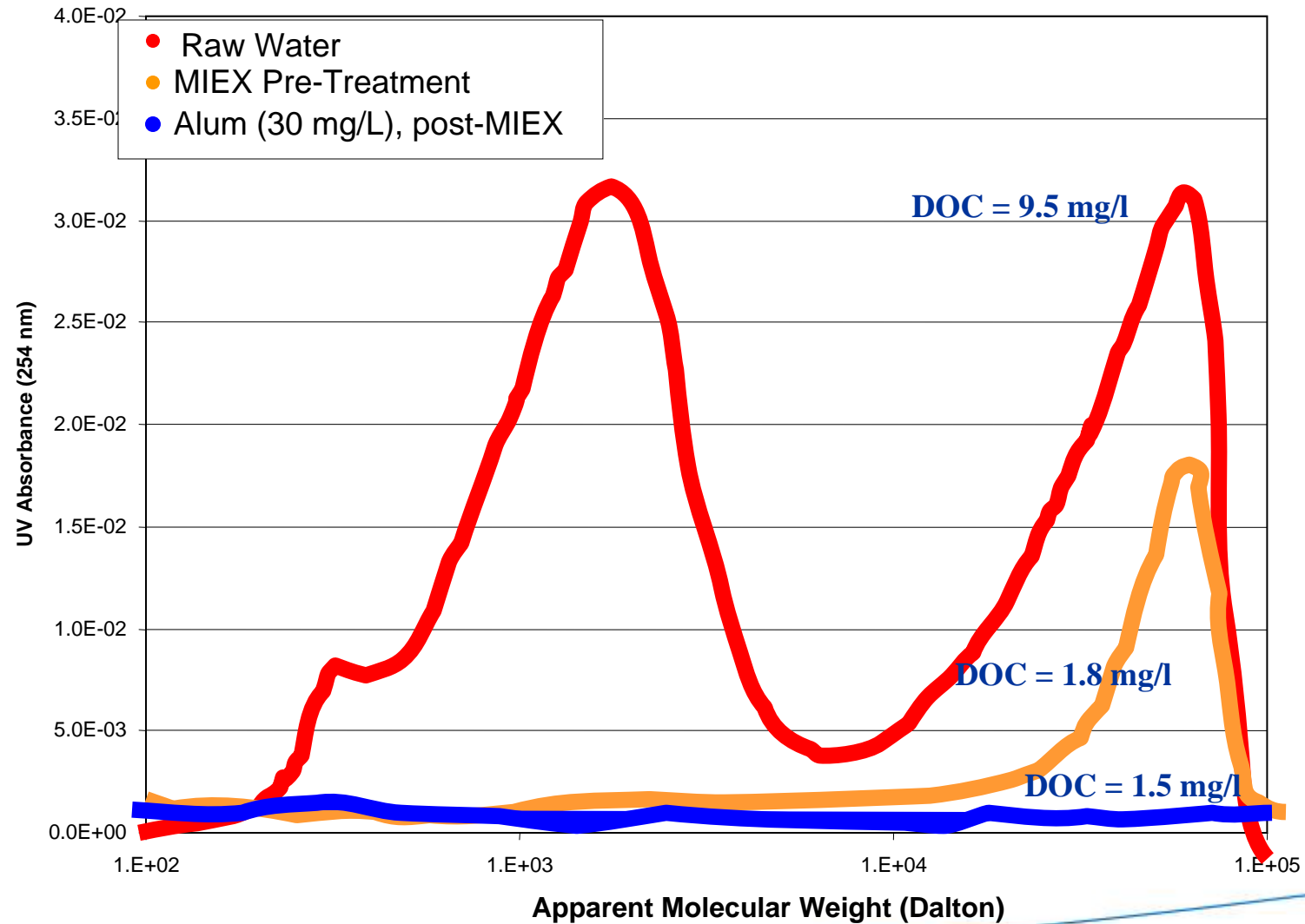
Ion Exchange Chemistry



In *raw water* chloride ions on the resin surface are exchanged for negatively charged humic and fulvic acids (hydrophilic and hydrophobic, low and mid-MW)

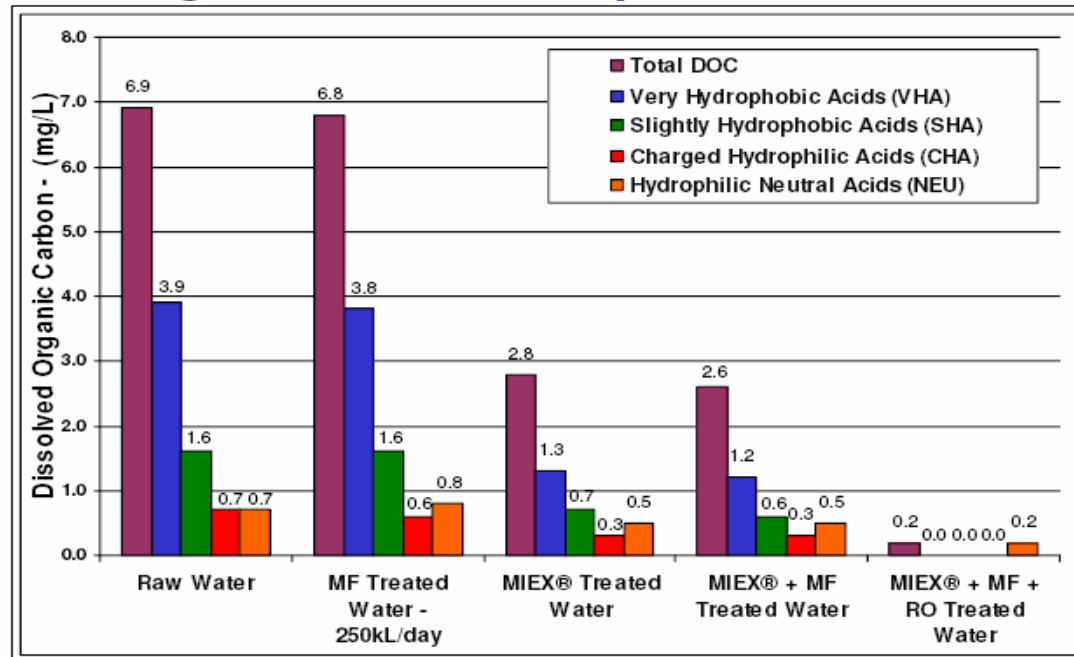
In a *salt solution*, ion exchange is reversed and DOC is replaced by chloride ions.

TOC Removal with IX



Lexton WTP Pilot Plant Trial – Results

Dissolved Organics Profile - Rapid Fractionation



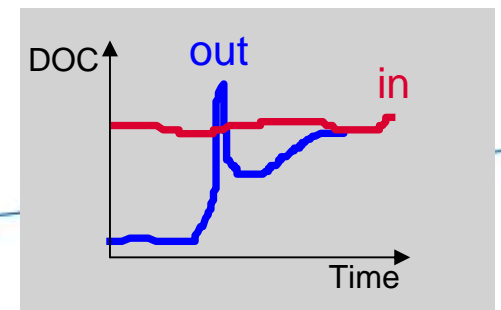
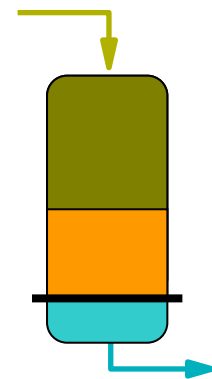
- Key Results:**
- Significant reduction in VHA (63%), SHA (57%) & CHA (75%) after MIEX® pre-treatment.
 - Minimal reduction in hydrophilic neutral acids – as expected.

Conventional IX

Traditional IX, applied post filtration, has many disadvantages

- Large Waste Volumes
- Column Peaking and Bleed Off
- NDMA, N-nitrisodimethylamine, formation
- Turbidity and Head Loss
- Bacteriological Activity and Slime
- Exhausted Resin Replacement
- Tank Cycling

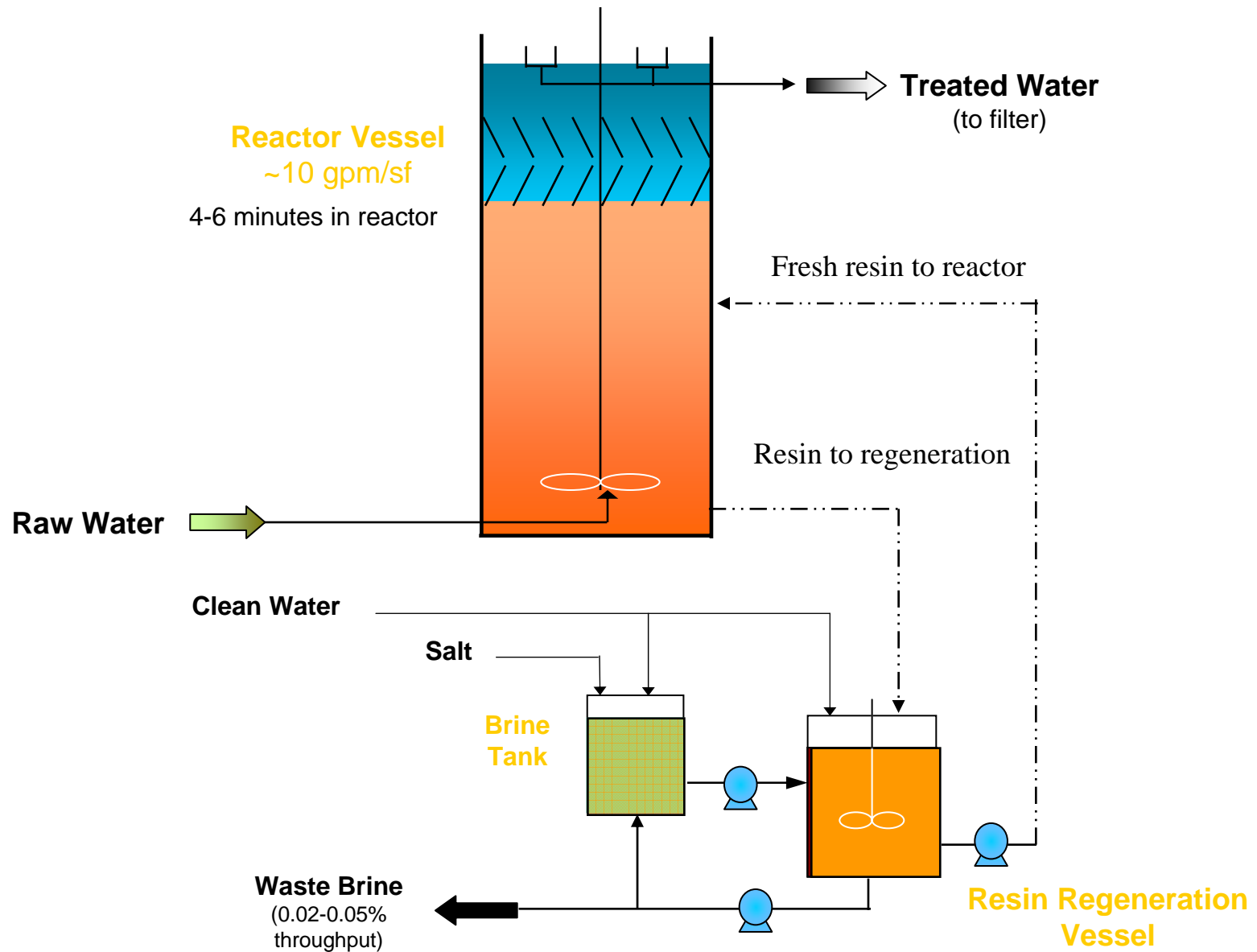
Trad. IEX



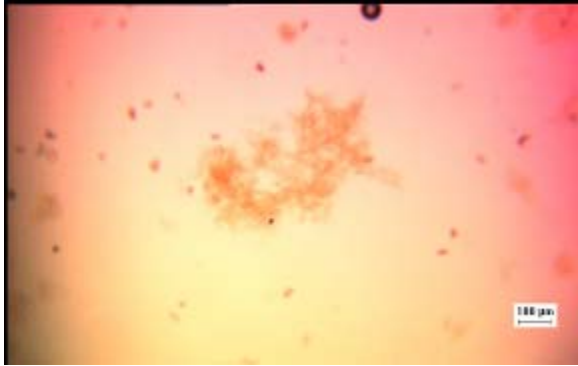



The MIEX[®] Process

- MIEX[®] stands for Magnetic Ion Exchange
 - Uses a fluidized bed approach rather than a column
 - Resin is ~10 times smaller than conventional resins – improves kinetic IX reaction
 - Continuous process with a consistent effluent
 - Used as pretreatment
 - Minimal head loss
 - Minimal resin loss due to magnetic property
-

Process Overview High Rate System



Floc pictures

	Fe 15 mg/L	MIEX [®] + Fe 7.5 mg/L
Albert Raw water	 <p>Micrograph showing flocs in Albert Raw water with Fe 15 mg/L. The flocs are small and dispersed. A 100 µm scale bar is visible in the bottom right corner.</p>	 <p>Micrograph showing flocs in Albert Raw water with MIEX[®] + Fe 7.5 mg/L. The flocs are larger and more aggregated. A 100 µm scale bar is visible in the bottom right corner.</p>
Humic acid solution	 <p>Micrograph showing flocs in Humic acid solution with Fe 15 mg/L. The flocs are very large and dense. A 100 µm scale bar is visible in the bottom right corner.</p>	 <p>Micrograph showing flocs in Humic acid solution with MIEX[®] + Fe 7.5 mg/L. The flocs are smaller and less dense. A 100 µm scale bar is visible in the bottom right corner.</p>

Advantages of IX as Pretreatment

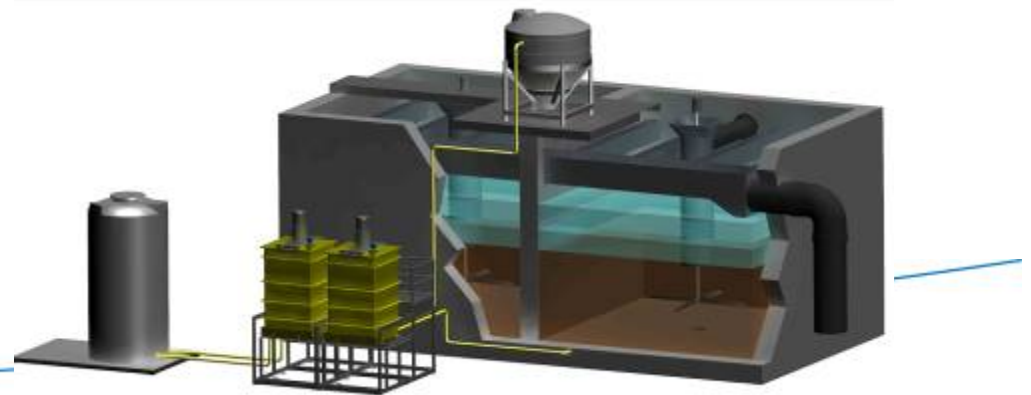
Reduces

- DOC 40-80%
- Color 80-100%
- DBPs 40-80%
- Coagulation chemicals 50-80%
- thus a reduction in sludge too
- Disinfection chemicals 50-60%
- pH adjusting chemicals

Requires no additional manpower (PLC driven)

Improves

- Floc settling ability
- Filter runs
- Membrane Flux and Life
- Sludge dewatering
- Distribution system maintenance



Vallejo CA – Green Valley WTP

Variable surface water sources

- Local lakes
 - Higher TOC (6-9mg/L)
 - SUVA 3-4
- Solano Irrigation District
 - Lower TOC (2-3 mg/L) but must be purchased
 - SUVA 2-2.5
- Blended water



“After an exhaustive review of the best available technologies to meet current and future D/ DBP regulations, we believe the IX pretreatment process is the best fit for the Green Valley WTP.” Franz Nestlerode, Deputy Water Superintendent

Vallejo CA – Green Valley WTP

Alum coagulation process alone
removed 20-30% of the raw water TOC

Significant retention time in distribution
system

LRAA TTHM >120 ppb

San Francisco Chronicle

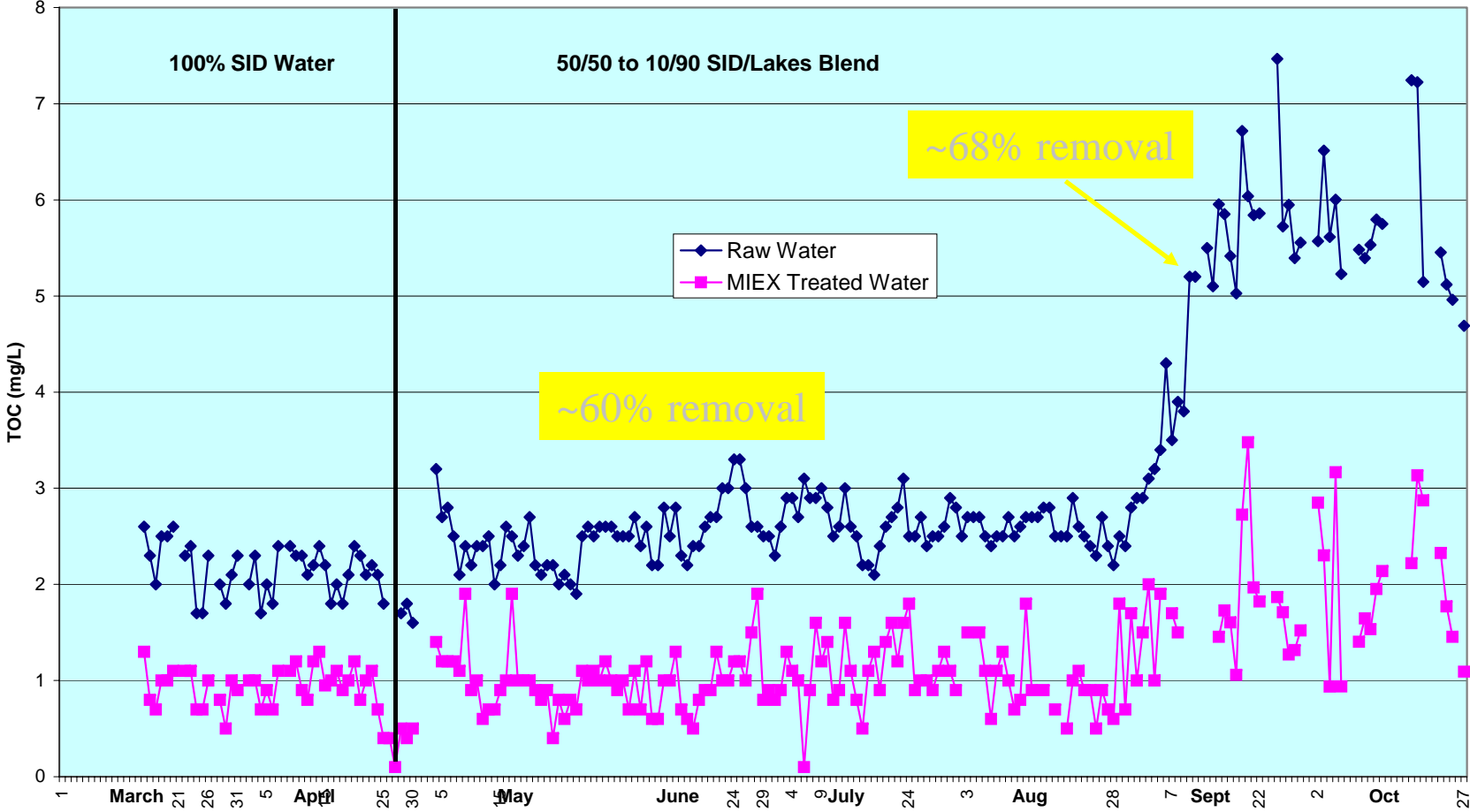
SOLANO COUNTY Water violates standards But officials assure Green Valley that health risks are low

Demian Bulwa, Chronicle Staff Writer

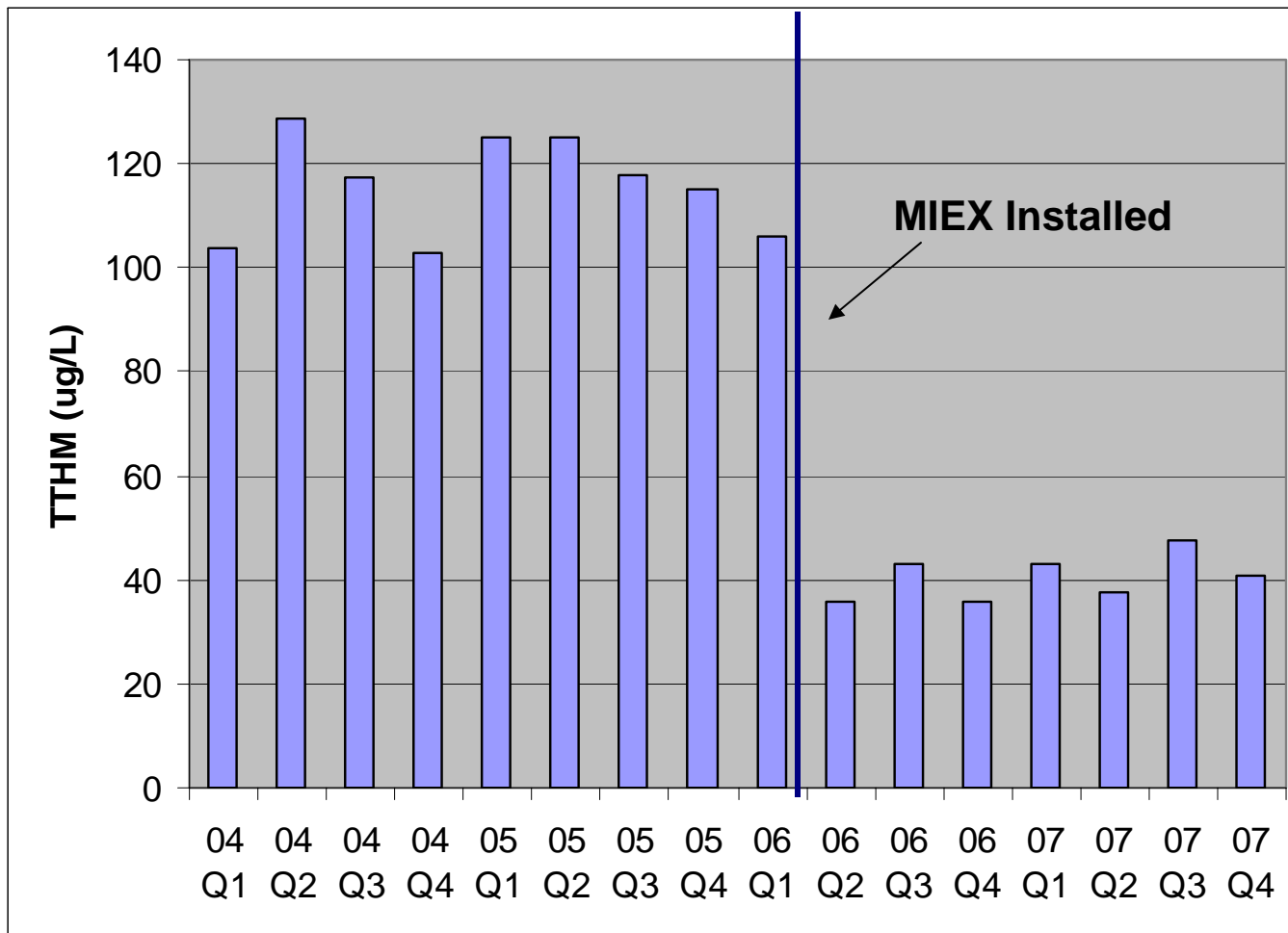
Friday, January 28, 2005

Lennen said Thursday that water samples taken from four different households last February, May, August and November found trihalomethanes at an average of 113 parts per billion – exceeding the federal standard of 80 parts per billion.

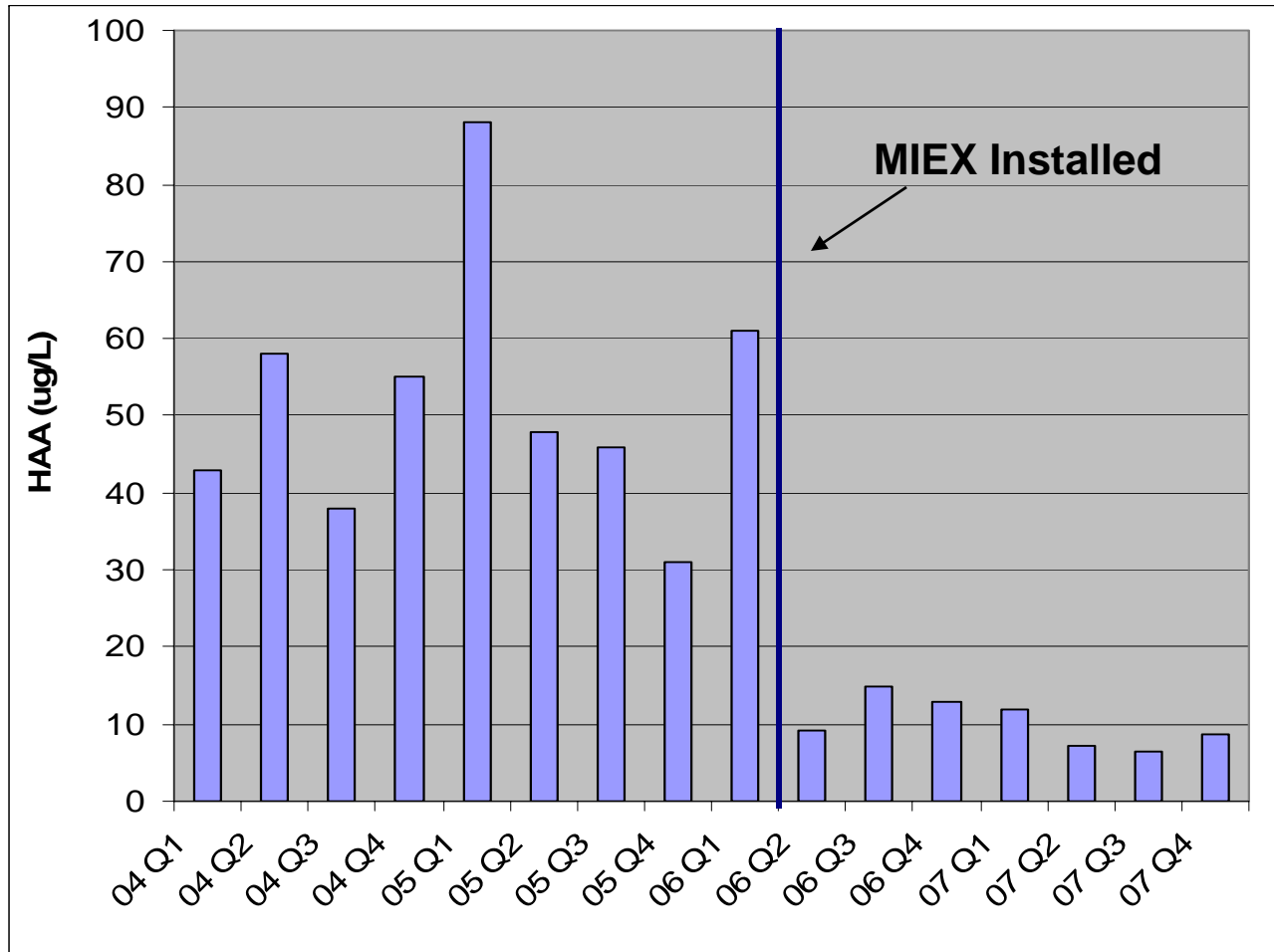
Green Valley WTP - TOC Removal



Green Valley WTP - Distribution TTHM



Green Valley WTP – Quarterly HAA5s



Green Valley WTP – Downstream Benefits

Reduction in coagulant dose and pH adjustment chemicals

- Alum replaced by lower dose of PACl
- Eliminated soda ash

Reduced solids handling

50% reduction in hypochlorite use

Improved settled water turbidity



"We are relieved to be back in compliance with Stage 1 so quickly and the comfort margin achieved will allow us to easily meet Stage 2."

Franz Nestlerode, Deputy Water Superintendent, City of Vallejo, CA

Green Valley WTP, 1 MGD

Pretreatment to MicroFloc System



Waters in New England Area

Water	Raw DOC (mg/L)	Raw Color (PCU)	Raw UVA (cm¹)	MIEX[®] DOC (mg/L)	Finished¹ DOC (mg/L)	Finished Color (PCU)	Finished UVA (cm¹)	COAG Reduction
Water A Summer	10.5	208	0.552	4.67	1.99	1	0.034	81%
Water A Winter	5.84	62	0.297	2.33	1.11	0	0.013	67%
Water B Spring	6.96	8	0.271	2.11	2.11	0	0.059	NA
Water C Fall	4.5	27	0.135	1.30	1.80	8	0.026	NA

1. Finished is MIEX treated followed by downstream coagulation or slow sand filtration
2. Sample A from Massachusetts, B from Rhode Island and C from Maine
3. Samples B and C are from Slow Sand Filtration Plants

DBP Production from New England Samples

Sample	Plant Control DOC (mg/L)	Plant Control TTHM FP (µg/L)	Plant Control HAA FP (µg/L)	Finished DOC (mg/L)	MIEX® Treated TTHM FP (µg/L)	MIEX® Treated HAA FP (µg/L)
Water A Summer	3.17	99.8	66.7	1.99	56.4	18.9
Water A Winter	1.90	65.2	32.8	1.11	28.5	7.9
Water B Spring	6.96	212	65	2.11	53.6	30.0
Water C Fall	4.50	128	55	1.80	34.9	25.5

Water A Summer, 31 µg of TTHM formed per mg of DOC as 28 µg of TTHM formed per mg of DOC for the MIEX® Treated.
Water A Winter, 34 µg of TTHM formed per mg of DOC as 25 µg of TTHM formed per mg of DOC for the MIEX® Treated.
Water B Spring, 30 µg of TTHM formed per mg of DOC as 25 µg of TTHM formed per mg of DOC for the MIEX® Treated.
Water C Fall, 28 µg of TTHM formed per mg of DOC as 19 µg of TTHM formed per mg of DOC for the MIEX® Treated.

Summary: Improved Public Health

- MIEX is a non-chemical treatment process that substantially reduces the downstream chemical doses
 - IX preferential removes low to medium molecular weight DOC compounds and the fractions that tend to be most reactive with chlorine to form DBPs
 - IX can reduce DOC by as much as 90% leading to a large reduction in DBPs
 - When used as pretreatment,
 - IX is a complimentary process to coagulation or direct filtration
 - IX pretreatment demonstrates many downstream benefits
 - Many New England Waters will be able to comply with the EPA DBP Stage 2 Rule through the application of IX
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Questions ?

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