Advanced Pretreatment with Ion Exchange for Organic Carbon Removal from Delta Water

A Project Funded by the California Bay-Delta Authority,
Drinking Water Quality Program
for Solano County Water Agency

Presented at the Third Biennial CALFED Science Conference
Sacramento, California
October 5, 2004

MWH

Acknowledgements

Sponsors
Sam Harader, California Bay-Delta Authority
Rick Sakaji, California Department of Health Services

Program Manager
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Study Objectives

- **Determine the effectiveness of ion exchange technology in:**
  - Reducing organic carbon/DBP formation potential under normal operating conditions as well as during storms
  - Mitigating the effects of rapid alkalinity and turbidity changes in NBA during storm events

North Bay Aqueduct

- **Turbidity:** 10 to 200 NTU
- **Alkalinity:** 10 to 150 mg/L as $CaCO_3$
- **TOC:** 3 to 20 mg/L
- **SUVA:** 3 to 5 L/mg-cm^{-1}
- **Bromide:** <0.1 mg/L

The NBR WTP is an ozone plant with deep bed GAC filters

Two Phased Approach

- **Bench-scale study (UNC-Chapel Hill)**
  - Determine the most effective resin for organic carbon removal for the pilot conditions
- **Pilot-scale study (NBR WTP)**
  - Determine the effects of pretreatment with best performing resin on conventional water treatment

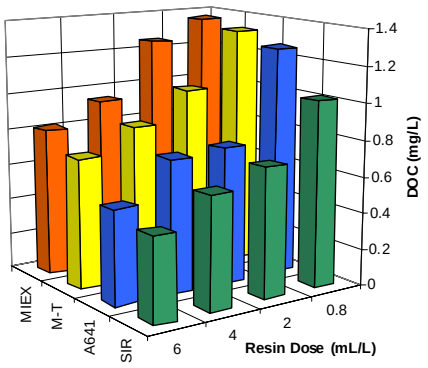
Bench-scale Tests Conducted With Different Resins to Determine Which Is Best Suited for Pilot-scale Evaluation

- **Test Waters (CA)**
  - NBA, SBA, Castaic Lake, Sweetwater Reservoir/Groundwater blend
- **Ion Exchange Resins**
  - MIEX, Resintech, Rohm and Haas (2), Sybron (2)

- **Other resins had higher ultimate organics removal, but MIEX® resin had fastest kinetics in time scales of interest**

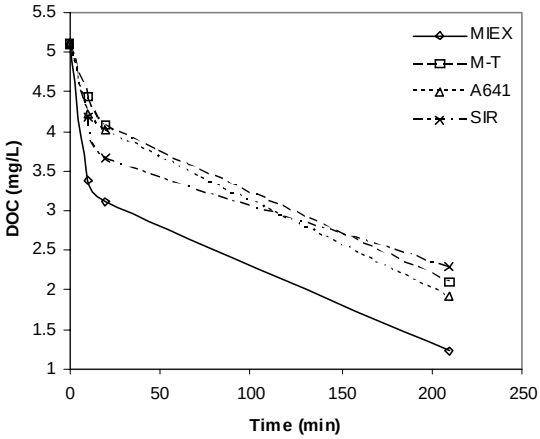
DOC Removal Capacity for 7-day Isotherm Tests on NBA Water (Raw Water DOC 5.1 Mg/l)

- MIEX® had a lower capacity for DOC removal compared to the other resins



Rate of Removal of DOC by Ion Exchange Treatment for NBA Water (2 Ml/l Resin)

- MIEX® removed DOC at a higher rate than other resins during the first 20 minutes of contact

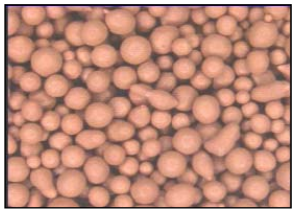


Bromide Removal by MIEX® Was Most Effective in Waters With a Low Alkalinity and a Relatively Low Raw Water Bromide Concentration

Water Source	Treatment	Bromide (µg/L)
NBA	Raw	76
NBA	5 mL/L MIEX® + 16 mg/L Alum	56
CL	Raw	240
CL	2 mL/L MIEX® + 4 mg/L Alum	190
SBA	Raw	83
SBA	2 mL/L MIEX® + 5 mg/L Alum	43
SL	Raw	540
SL	4 mL/L MIEX® + 20 mg/L Alum	470

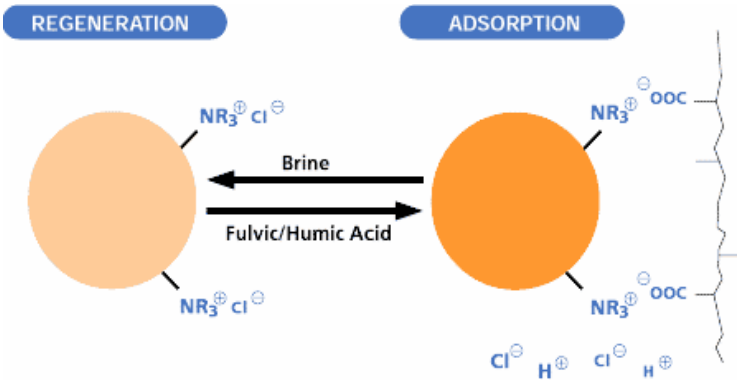
MIEX Resin Characteristics

- Particles contain a magnetized component within their structure
- Particle diameter ~ 150 um
  - Provides a high surface area
  - Allows rapid adsorption kinetics
  - Rapid regeneration



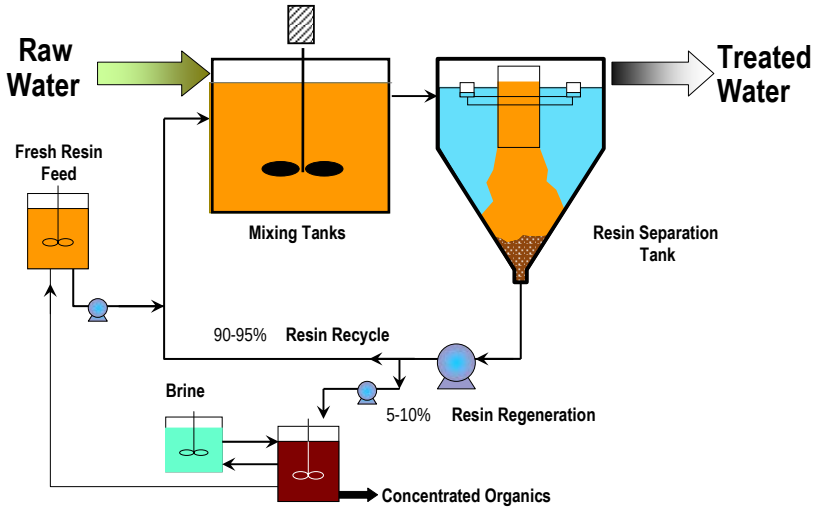
- Magnetic particles agglomerate into large, rapidly settling resin particles

Treatment and Regeneration: Chloride for DOC



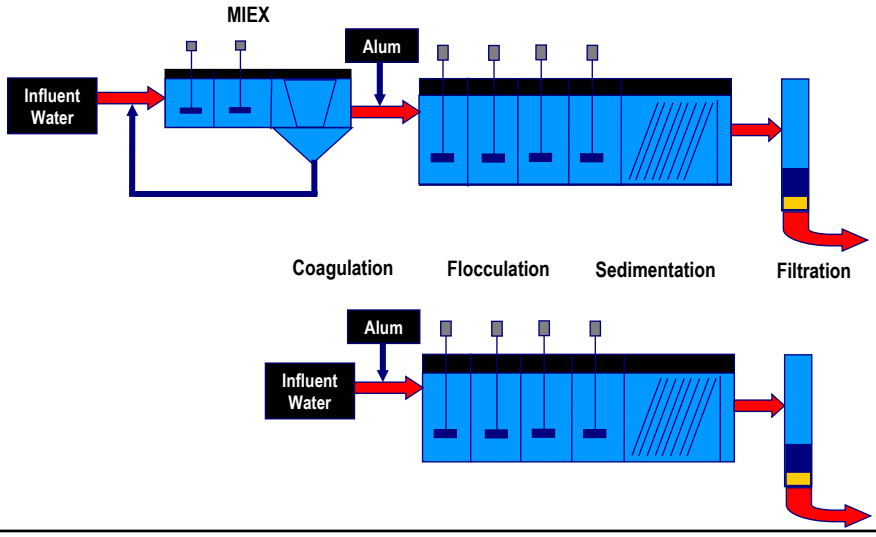
- Regeneration brine is saturated sodium chloride solution (Chloride ~ 40,000 mg/L)

MIEX Process Schematic



MIEX® Pilot Plant at North Bay Aqueduct WTP

Pilot study compares the benefits of MIEX pretreatment on downstream processes



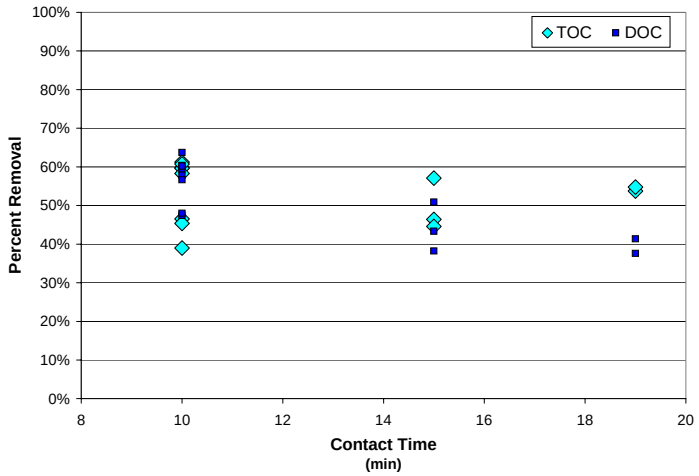
Simulated Conventional Treatment

- **Coagulation**
  - Alum doses comparable to NBR
- **Flocculation**
  - G - 60, 40, 20 ,10
- **Clarification**
  - Actual surface loading rate 0.4 gpm/ft2
  - Goal to maintain settled water turbidity < 2 NTU
- **Filtration**
  - Dual media filters, 6 gpm/ft2, NI polymer

Optimization of MIEX System

- **Pilot Parameters**
  - Resin Concentration (CR) - 10 to 30 mL/L
  - Contact Time (T) - 10 to 19 min
  - Regeneration Rate (R) - 5 to 10%
- **Pretreatment performance is a function of all three parameters (and more?)**
  - Org. Carbon Removal = (CR)a (T)b (R)c (DOC)d (Mix. E)…
- **Difficult to find comparable results because of raw water quality variations**

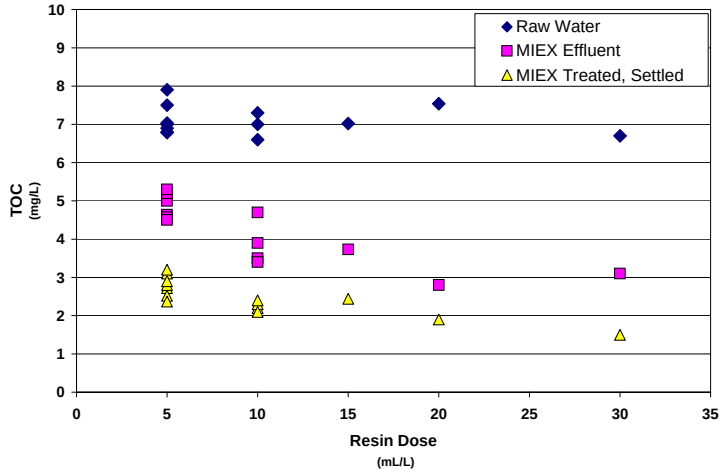
TOC/DOC Removal Not Significantly Affected by Contact Time



Resin Dose 30 mL/L, 10 % Regeneration Rate

Effluent TOC As a Function of MIEX® Resin Concentration .

Contact Time – 30 Minutes, Regeneration Rate – 10%

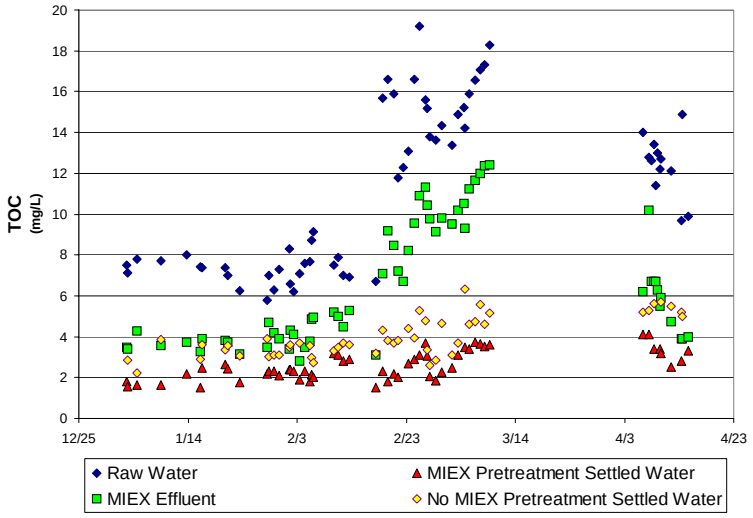


Decrease in Coagulant Demand and Settled TOC When Regeneration Rate Increased

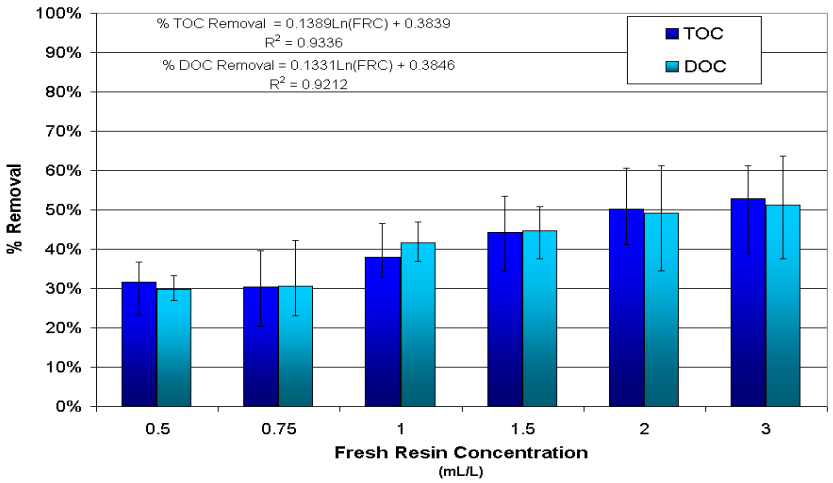
MIEX® Resin Regeneration Rate (% Recycle Flow)	Raw Water TOC/DOC (mg/L)	MIEX® Pretreated TOC/DOC (mg/L)	MIEX® Settled Water TOC/DOC (mg/L)	Alum Dose for Settled Water Turbidity < 2 NTU (mg/L)	Fresh Resin Concentration (mL/L)
5%	16.7/15.3	12.0/10.6	3.7/3.8	100	0.75
7.5%	16.4/15.1	10.7/9.4	2.9/3.1	80	1.1
10%	16.5/15.4	9.0/8.0	2.2/2.5	50	1.5

MIEX: 15 mL/L, 10 minutes of contact time
Raw Water: TOC 6-8 mg/L

Total Organic Carbon Removal Over the Course of the Pilot Tests



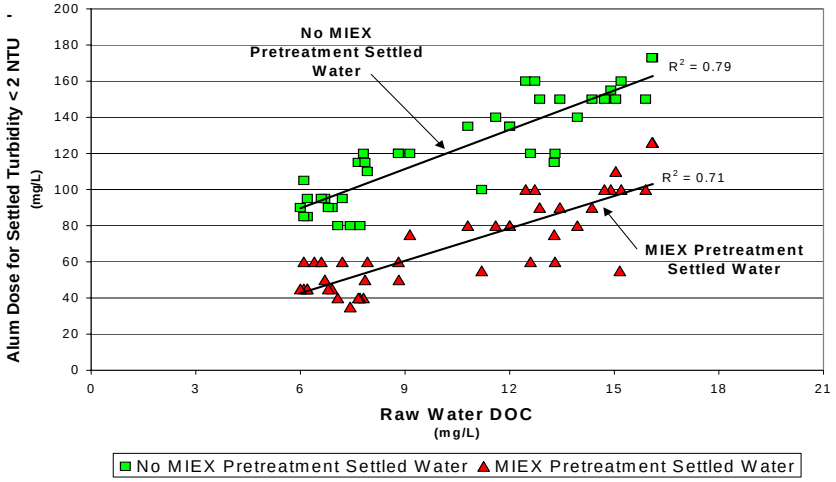
Organic Carbon Removal Through MIEX® Pretreatment As a Function of Freshly Regenerated Resin Concentration



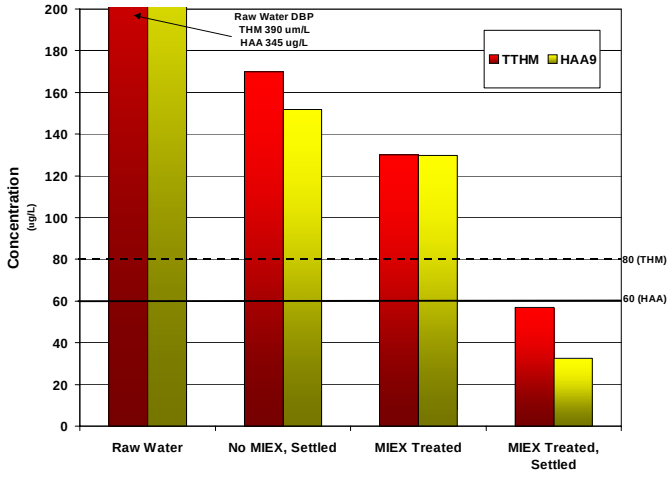
Settled Water Has Lower TOC/DOC Following Pretreatment

	MIEX Effluent	MIEX Pretreated, Settled	No Pretreatment, Settled
TOC Removal	30-60%	70-80%	50-70%
DOC Removal	30-60%	70-80%	50-70%
Chlorine Demand Reduction	~50 %	70-90%	50-80%

Alum Dose Reduced by 40 to 50% After MIEX Pretreatment



MIEX Process Removes DBP Precursors

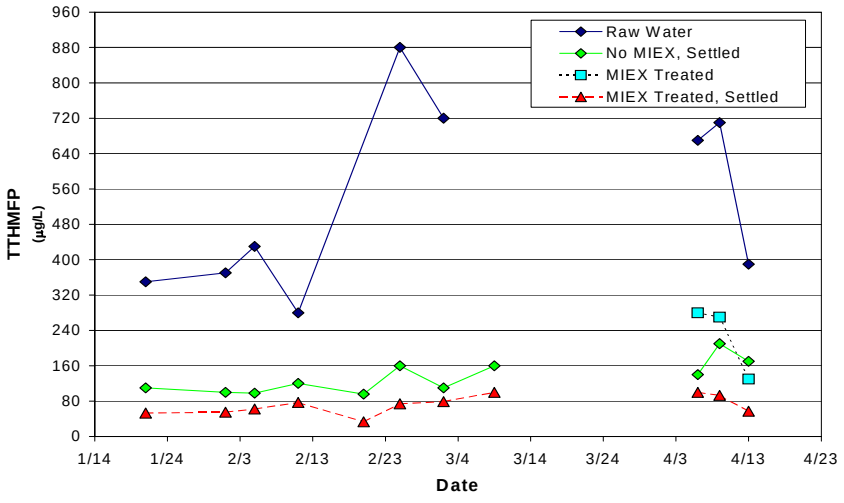


Raw Water: Turbidity 40 NTU, pH 7.2, Alkalinity ~130 mg/L as $CaCO_3$.
MIEX: 30 mL/L, 10 minutes contact time, 10% regeneration rate

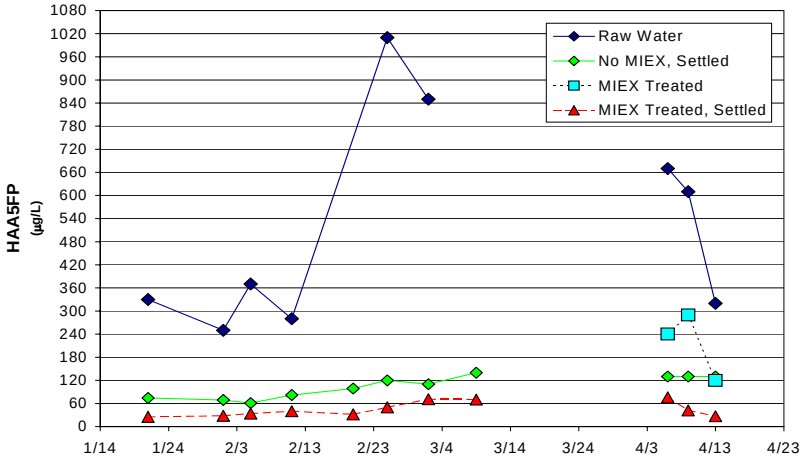
MIEX Pretreatment Reduced DBP Formation

- **MIEX pretreated, settled water**
  - Average TTHM ~ 70 mg/L
  - Average HAA9 ~ 50 mg/L
- **No pretreatment, settled water**
  - Average TTHM ~ 130 mg/L
  - Average HAA9 ~ 110 mg/L

TTHMFP in the MIEX® Pretreated Water Was Approximately 60 to 70% Less Than That Observed in the Raw Water



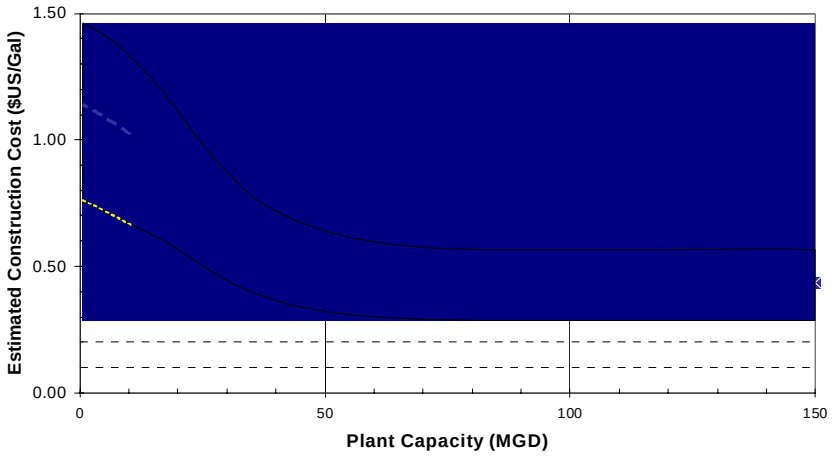
HAA5FP in the MIEX® Pretreated Water Was Approximately 50 to 60% Less Than That Observed in the Raw Water



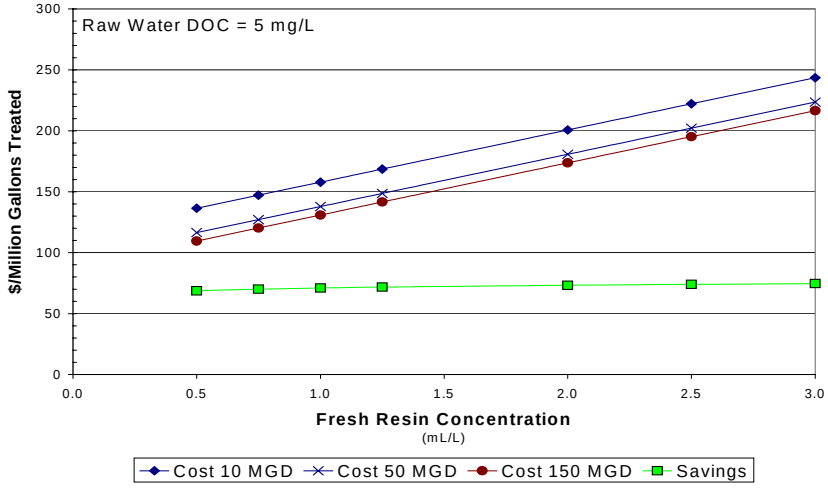
Design Criteria for MIEX® System

Criteria	Value
Contact Time	10 minutes
Resin Concentration (in Contact Tanks)	25 mL/L
Regeneration Rate (Fresh Resin)	8-10% (2 to 2.5 mL/L)
Brine to Rinse Water Ratio	1 Rinse
Maximum Number of Brine Reuses	5

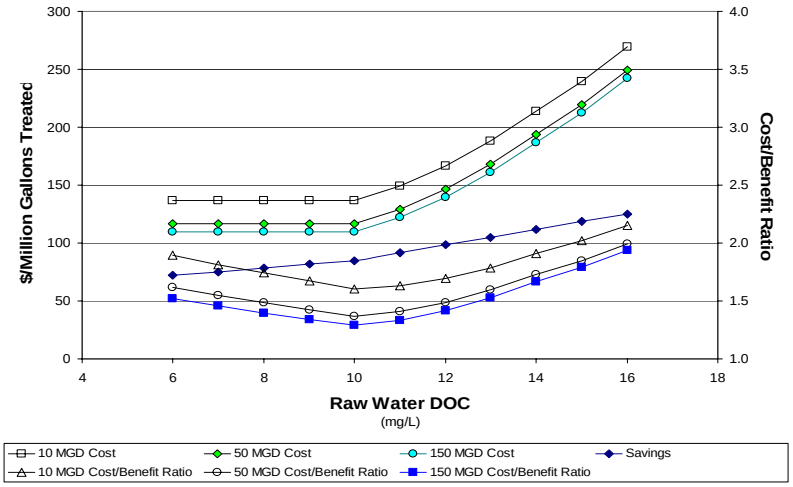
Estimated Construction Cost for MIEX Pretreatment



Variable Cost of MIEX Pretreatment and Savings for Conventional Treatment vs. Fresh Resin Concentration



Variable Cost of MIEX Pretreatment and Savings for Conventional Treatment vs. Raw Water DOC to Limit TTHM ~ 70 µg/L



Conclusions

- The MIEX® process was found to improve the performance of the downstream process of coagulation by reducing the coagulant demand of the raw water by 40 to 50%.
- TOC, DOC, and DBP formation potential were reduced significantly when MIEX® pre-treatment was employed.
- Economic viability will be determined by local water quality conditions and residual handling and disposal costs.