



Willmar Municipal Utilities - Water System

Supt. of Water Bart Murphy - (612) 235-4422

Water Sources Southwest Wells, Northeast Wells Treat. Plants Southwest Plant, Northeast Plant

Treatment Packed Tower Aeration,

Permanganate Oxidation of Mn,

Pressure Greensand Filtration,

Chloramination, Fluoridation

Population 22,000 (1995)

Production 3.4 mgd (avg.) 6.9 mgd (peak)







Willmar's Tower Aerators

Aerated Water pH ≥ 8.0

Willmar staff have
developed a freezing
technique for cleaning
plastic media
in the tower aerator



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Willmar, MN

pH = 7.5; Temperature: 5 - 15 °C

Alk.= 400 - 441 mg CaCO3 equiv. / I

Ca = 150 - 260 mg CaCO3 equiv. / I

Ammonium Ion

3.2 mg N / I (NE); 2.5 mg N / I (SW)

Iron Removal

1.67

0.00 mg Fe / I
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Mn Removal

0.109

0.00 mg le / l

Lead (1992) < 5 to 43 µg Pb / I Copper (1992) < 0.50 to 7.0 mg Cu / I

Corrosion Control Treatment:

Aeration to increase pH from 7.5 to 8.1





Uniform, Smooth, Colored Deposits in Copper Pipe

Optimum Copper Corrosion Control Treatment (OCCT)

pH / alkalinity to decrease solubility of

metal carbonates, oxides

calcium to increase calcium carbonate

supersaturation, deposition

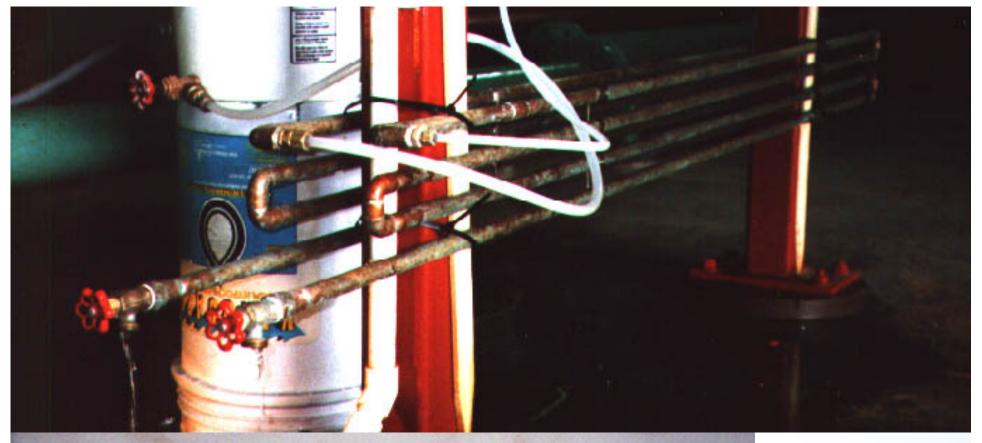
polyphosphate to cause formation of phosphate

films on mains and plumbing

silicate to promote formation of

protective silicate films







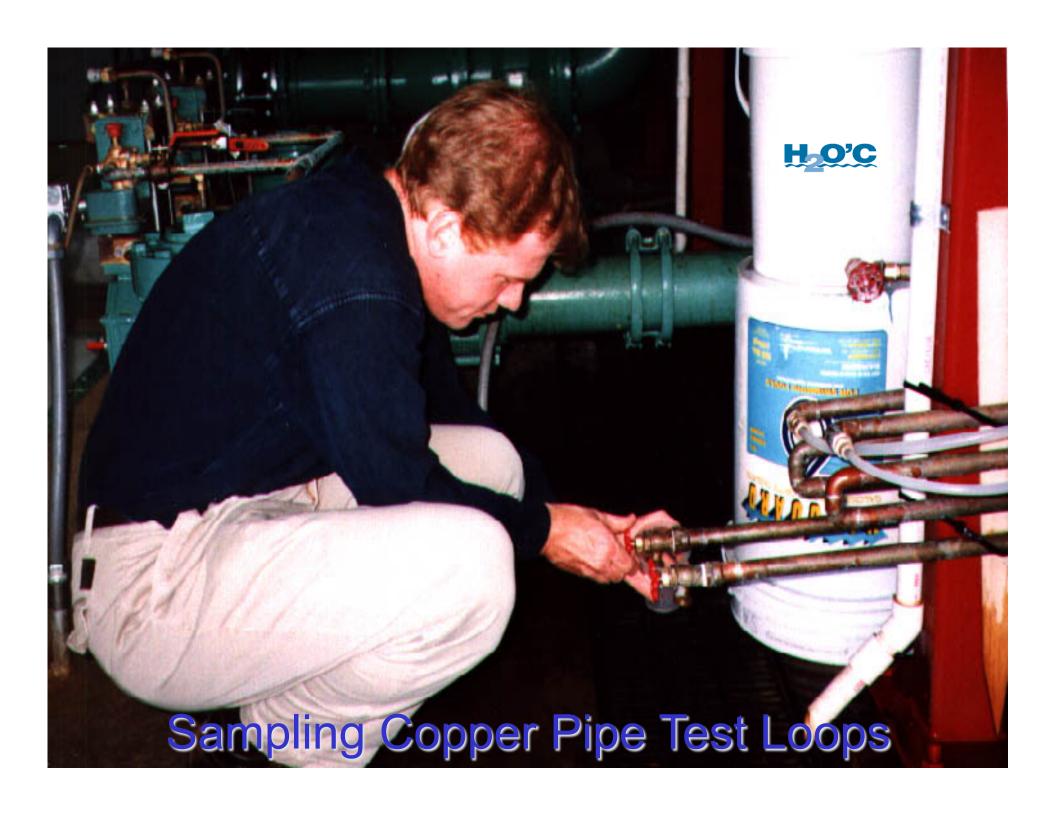
Copper Pipe Test

and

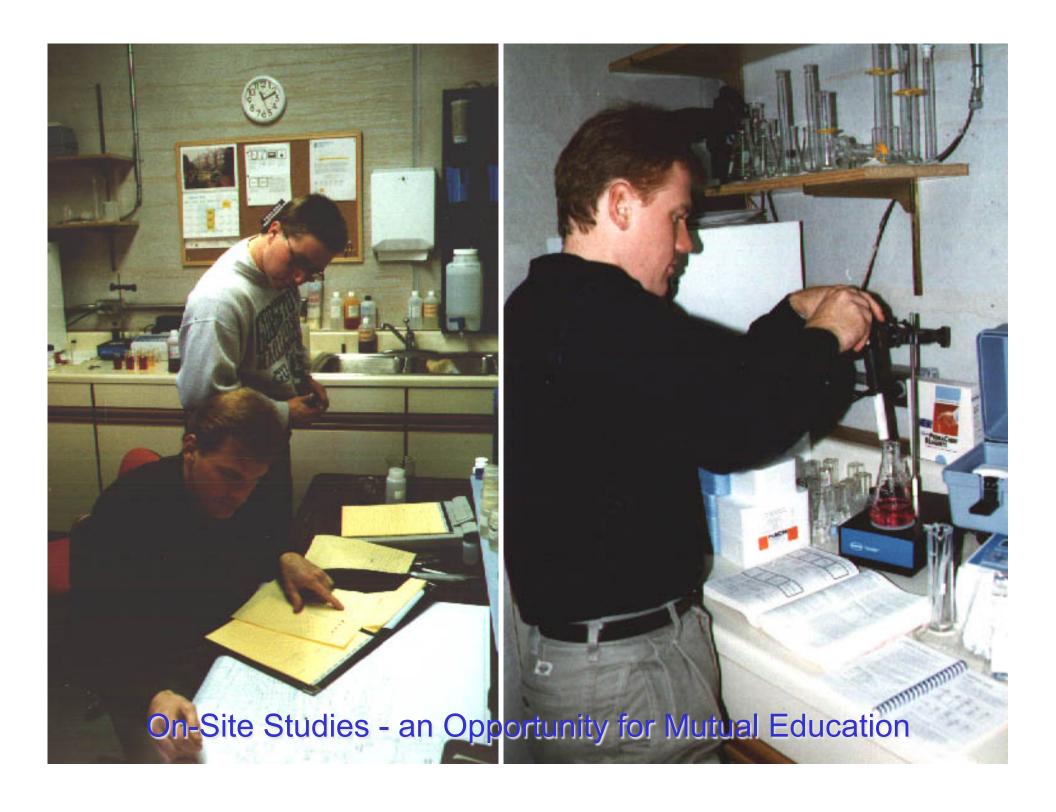
Copper Pipe Test

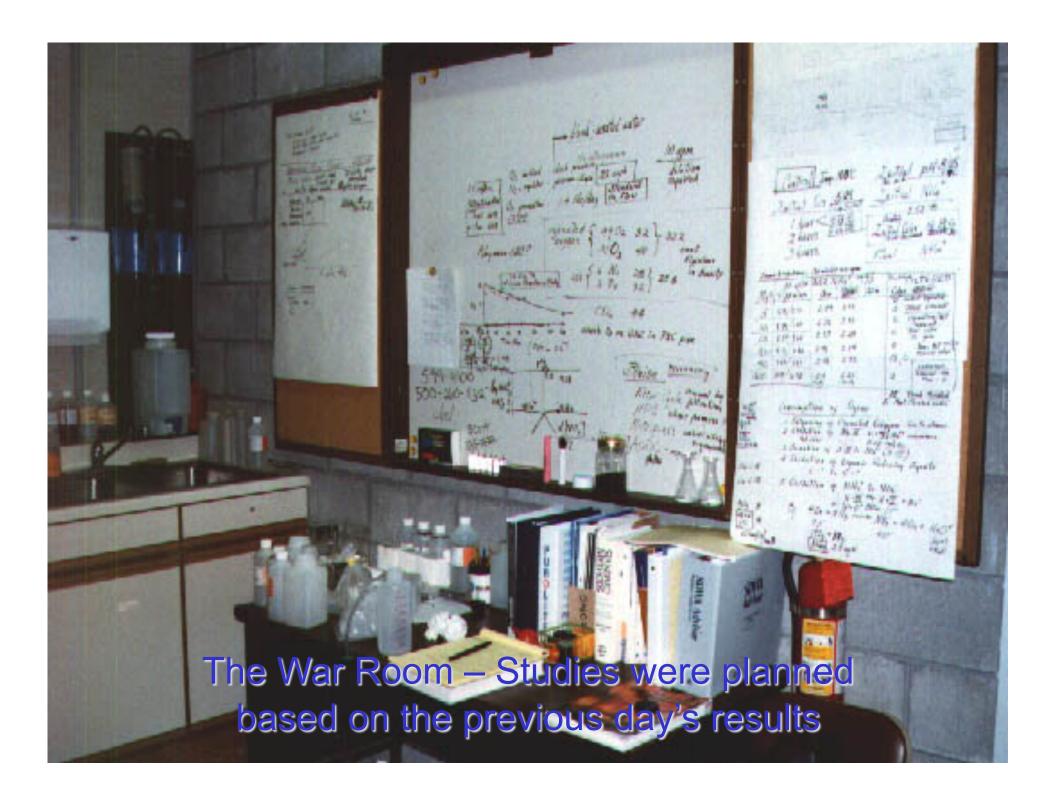
Copper Pipe Test Sections





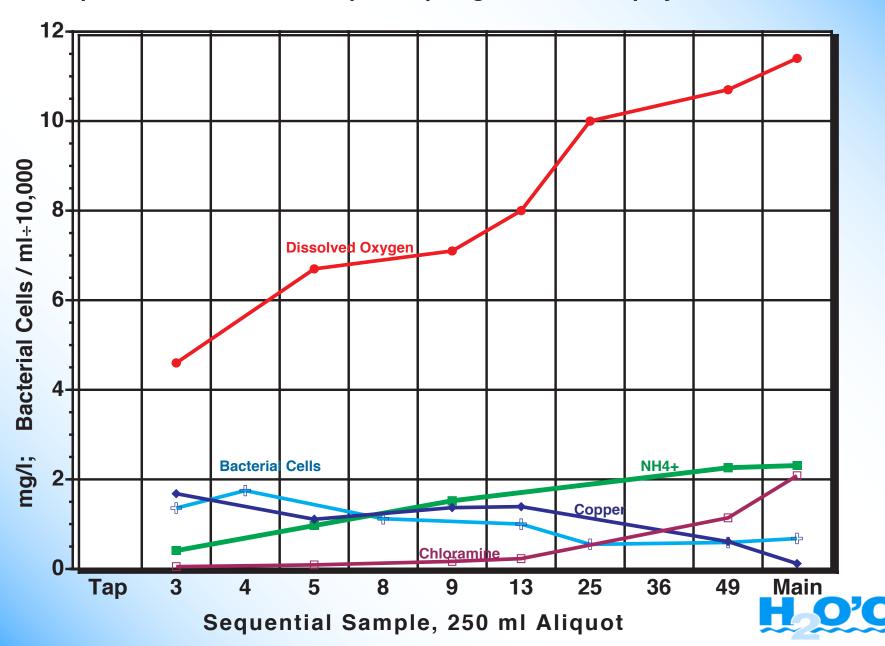


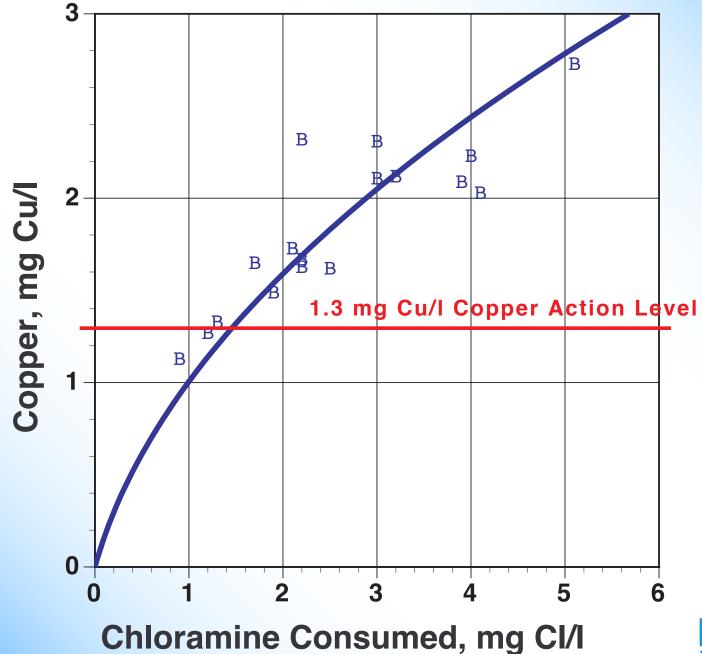




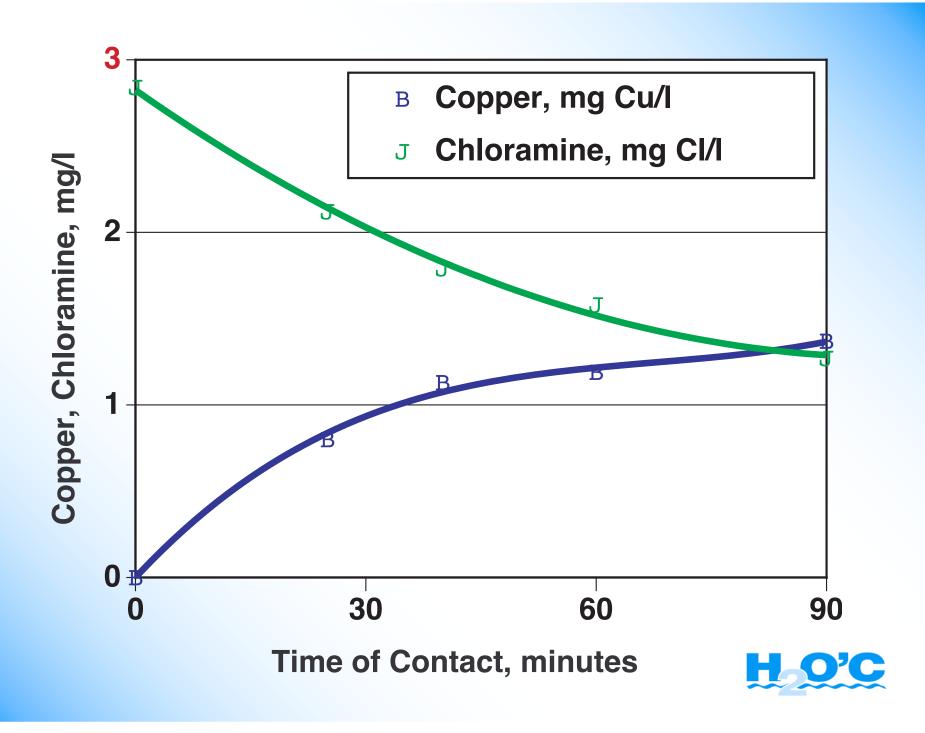


Sequential Household Tap Sampling at Bart Murphy Residence









Control Strategy

- Control nitrifying bacteria in the distribution system.
- Control formation of nitrite during distribution.
- Control the loss of chloramine in distribution system.
- Reduce concentration of chloramine applied as a distribution system residual.





Ozone Generator and Ozonation Pilot Plant

Oxygen Cylinder; Ozone generator; Pump, Injector and Contactor Degassing Separator; Ozone Destruct Column (wall-mounted, black) Two Greensand Filter Columns (black) in Series;



Clear Well (white)

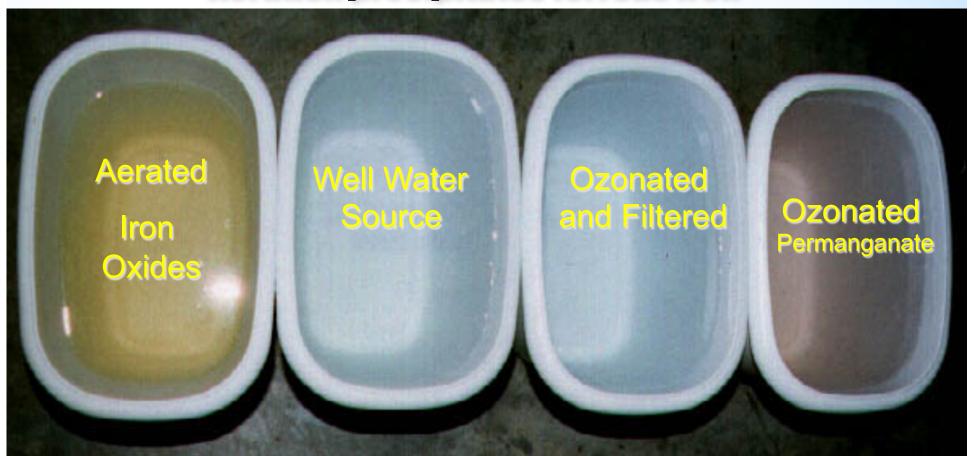




Well water has a slight yellow color, not evident unless compared with ozonated and greensand-filtered water

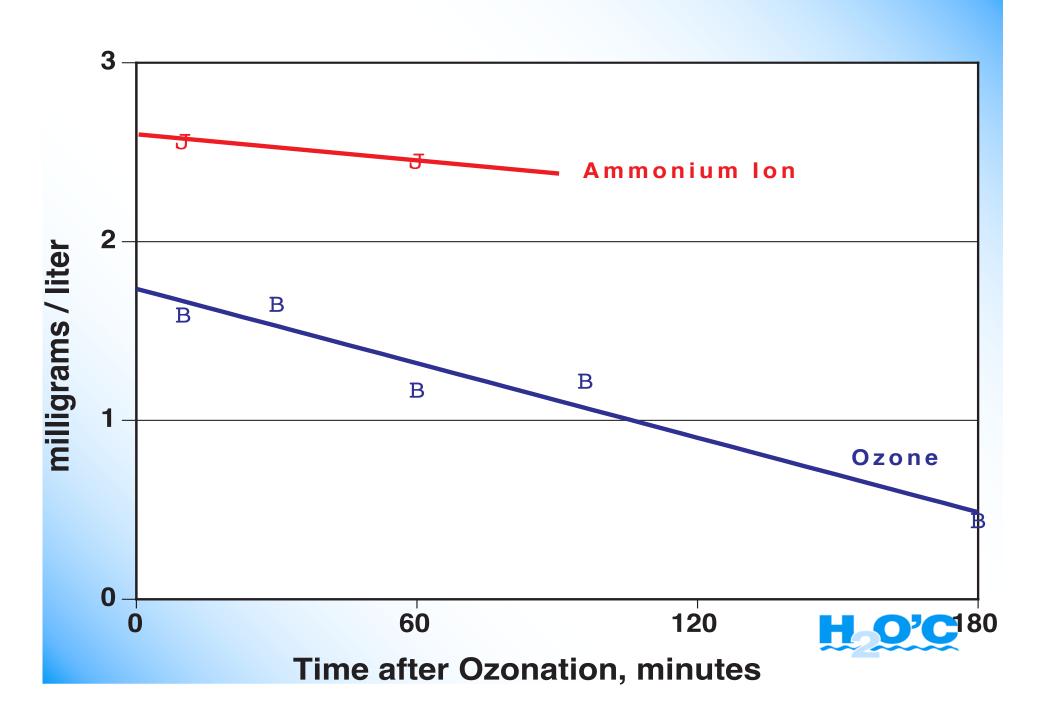
Ozonation converts manganous ion to permanganate

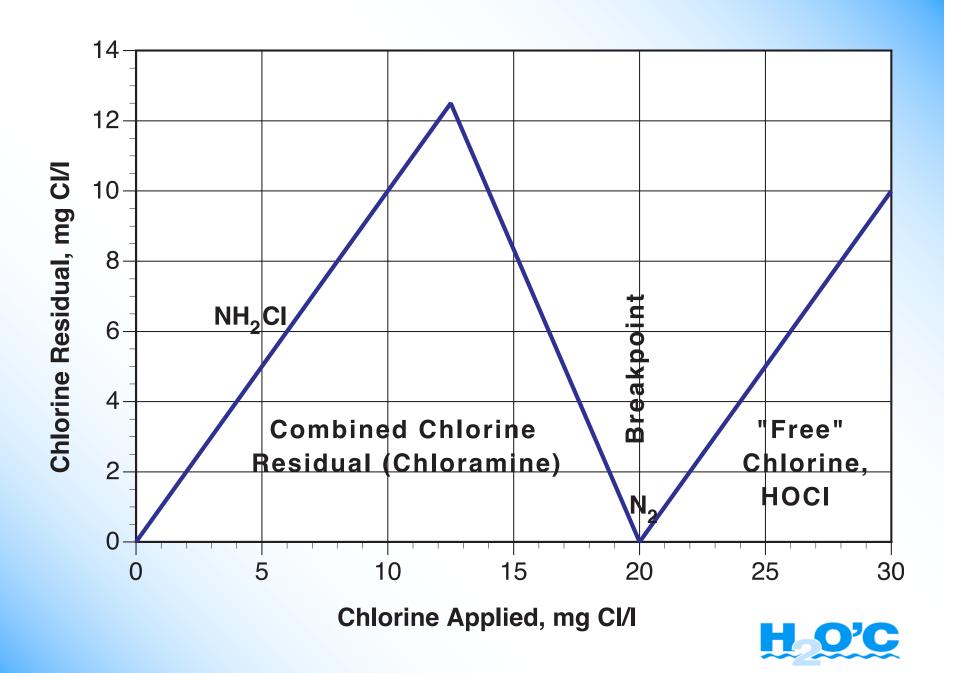
Aeration precipitates ferrous iron

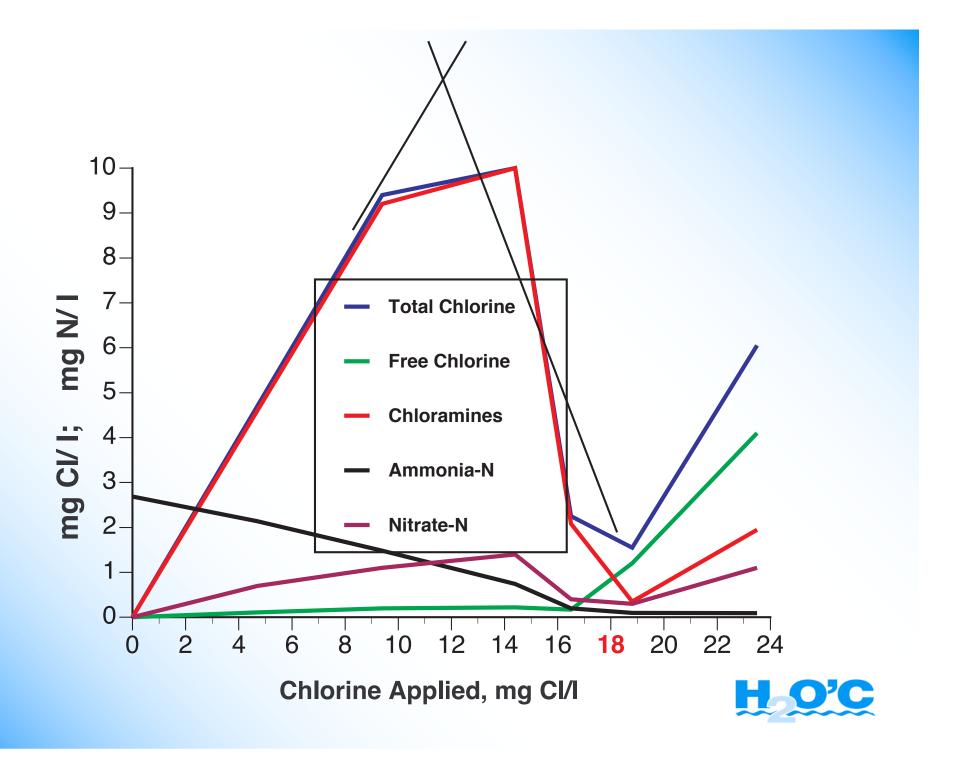


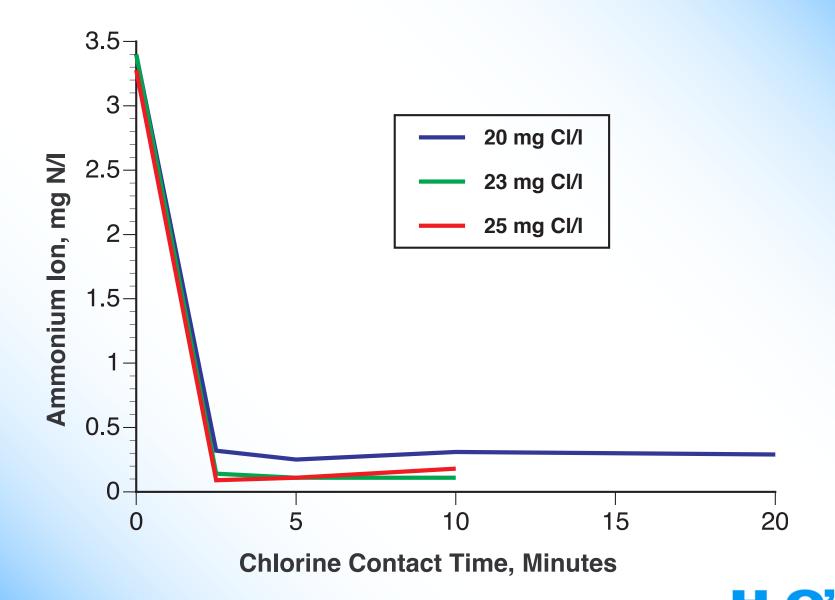


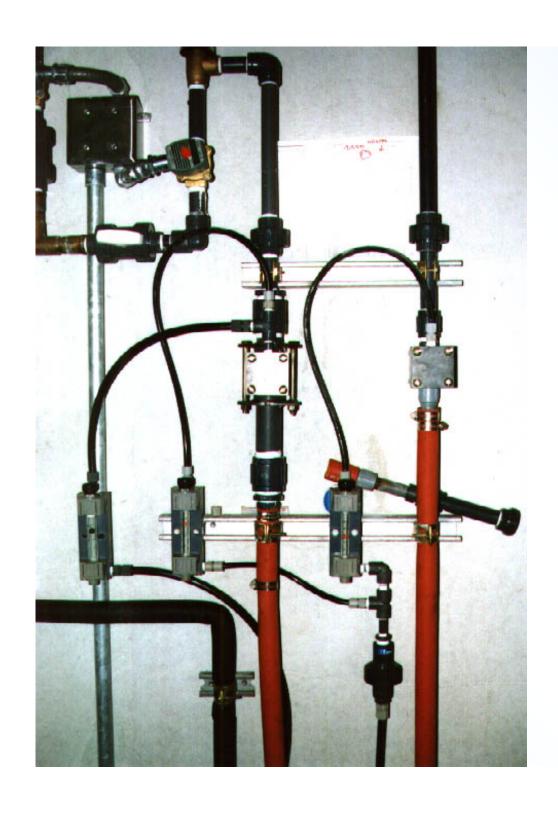
Ozone and Ammonium Ion Persistence











Breakpoint Ammonium Reduction Treatment (BART)

Chlorine Injectors
for Increased
Application of
Chlorine Gas



Southwest Plant	Aerator Effluent	#1: BART Influent	#1: BART Effluent	#2: Chloramine Influent	#2: Chloramine Effluent	Combined Plant Effluent	Clearwell
NH4+	2.4	0	0	1.92	1.96	0.93	
Free Chlorine	0.02	1.16	0.76	0.14	0.13	0.17	0.14
Total Chlorine		1.56	1.01	3.12	3.18	2.48	2.44
рН	8	7.6	7.6	8.0	8.1	8.1	-



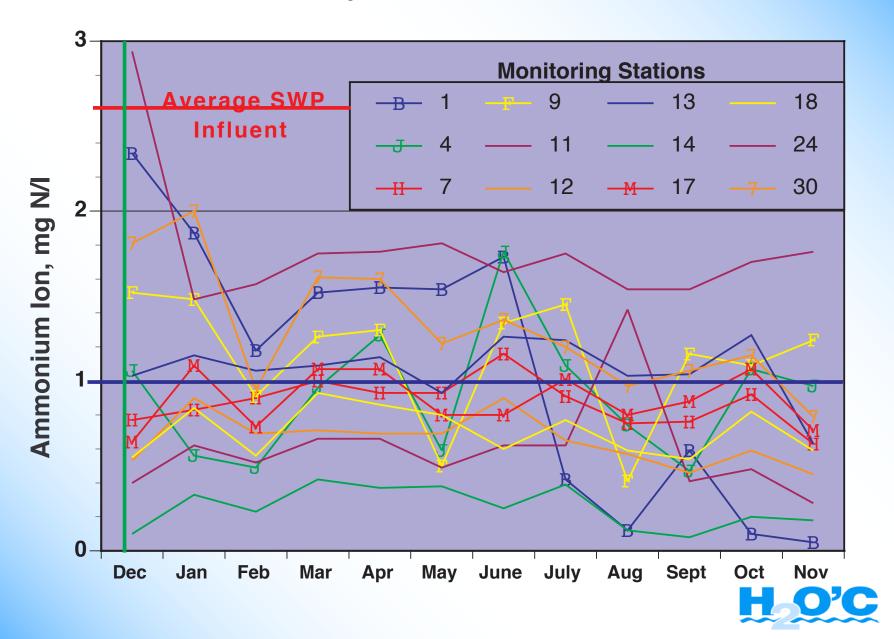
Southwest Plant after BART	Influent	Aerated	#1: BART	#2: Chloramine + KMnO4	#1 + #2: Finished
Fe, mg/l	2.11	2.11	0.006	0.005	-
Mn++, mg/l	0.13	0.14	0.03	0.08	-
H2S, mg/l	0.001	0.001	0.001	0.001	-
Color, Pt-Co	14	14	4	3	-
Temp. °C	9	10	10	10	-
рН	7.46	-	7.57	8.03	-
NH4+ , mg N/I	-	-	0.0	2.0	1.0
Total CI, mg CI/I	-	-	1.50	-	2.12
Free CI, mg CI/I	-	-	0.80	-	0.11



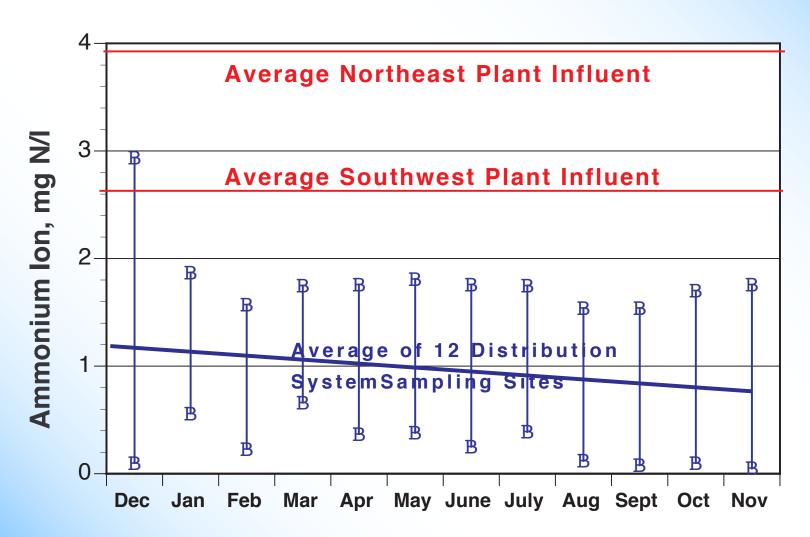
Southwest Plant	Total THM, μg/l
BART-12/7/96	18
BART-12/8/96	26
BART-12/9/96	25
Chloramine-12/7	3
Chloramine-12/8	3
Chloramine-12/9	3
Combined-12/7	10
Combined-12/8	10
Combined-12/9	10
Clearwell-12/7	11
Clearwell-12/8	10
Clearwell-12/9	10
College SysNear	27
College SysFar	31



Willmar Distribution System Ammonium Ion after BART

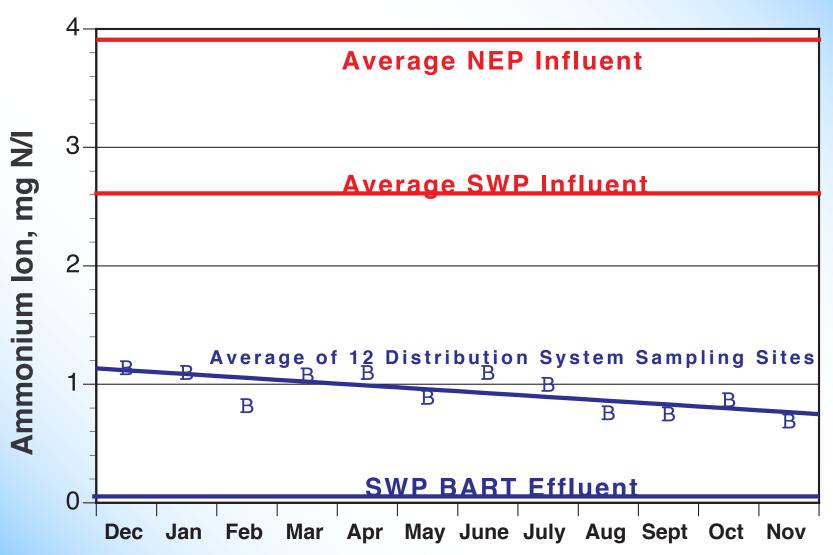


Range of Ammonium Ion Concentrations after BART



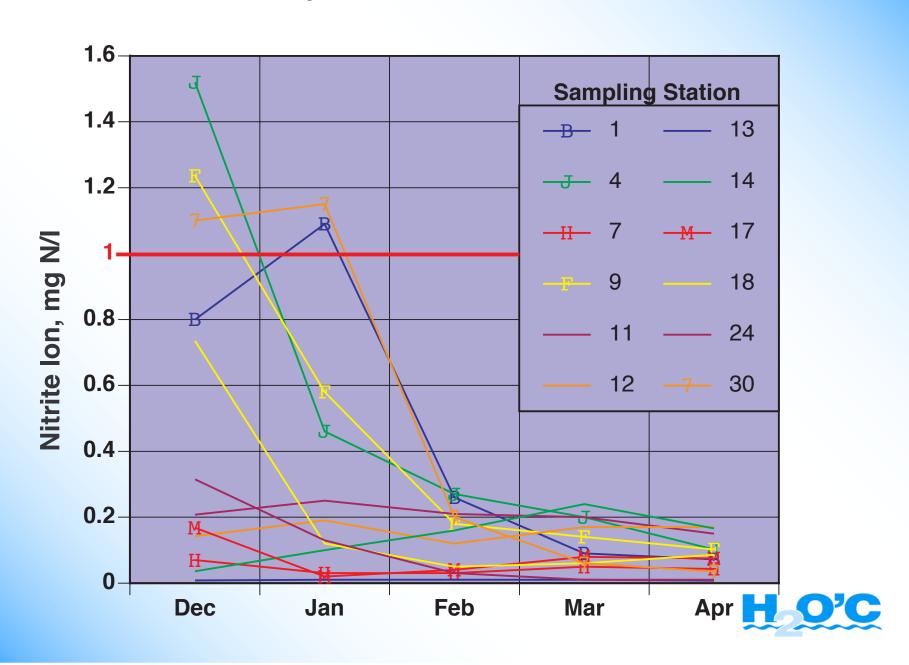


Average Ammonium Ion Concentration after BART

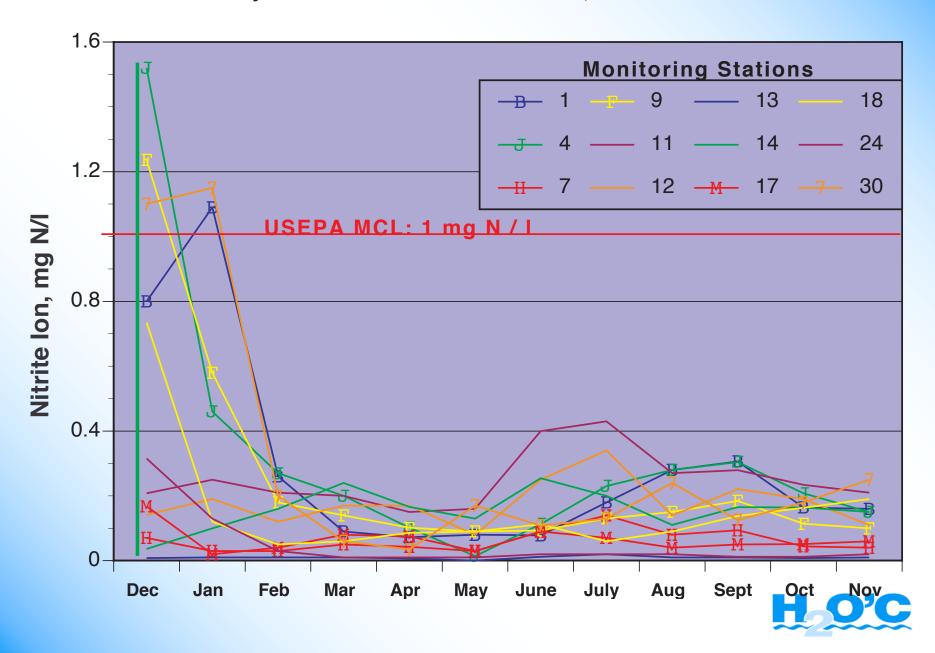




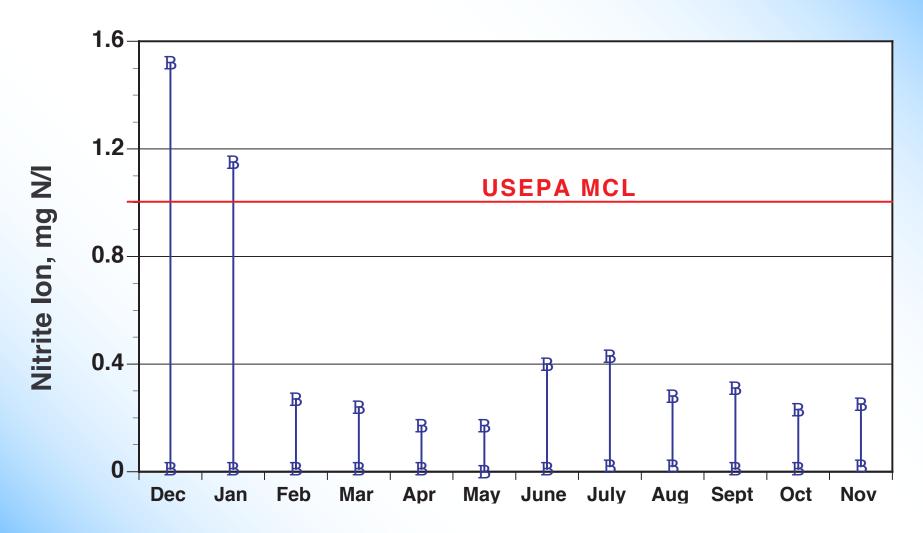
Distribution System Nitrite Ion - Willmar, MN



Distribution System Nitrite Ion after BART, Dec. '96 - Nov. '97

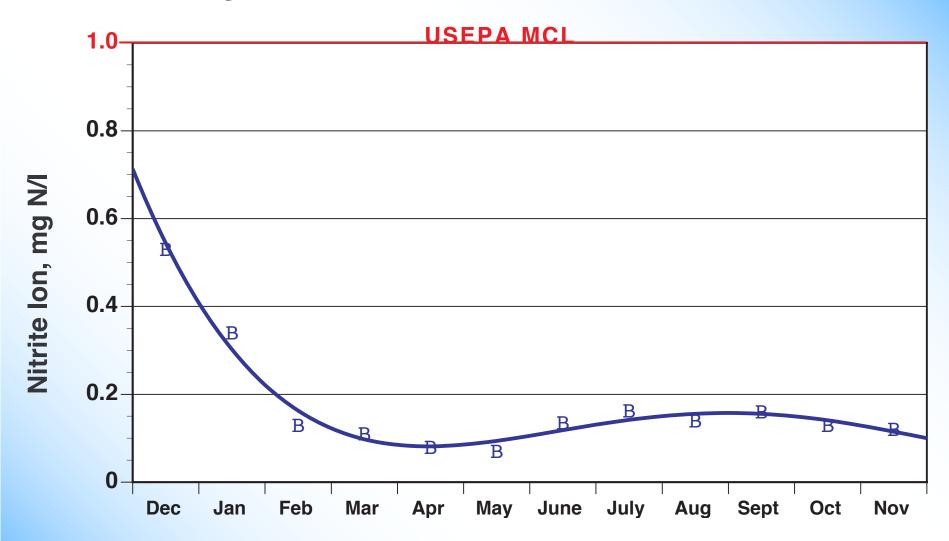


Range of Nitrite Ion Concentrations after BART - Willmar, MN



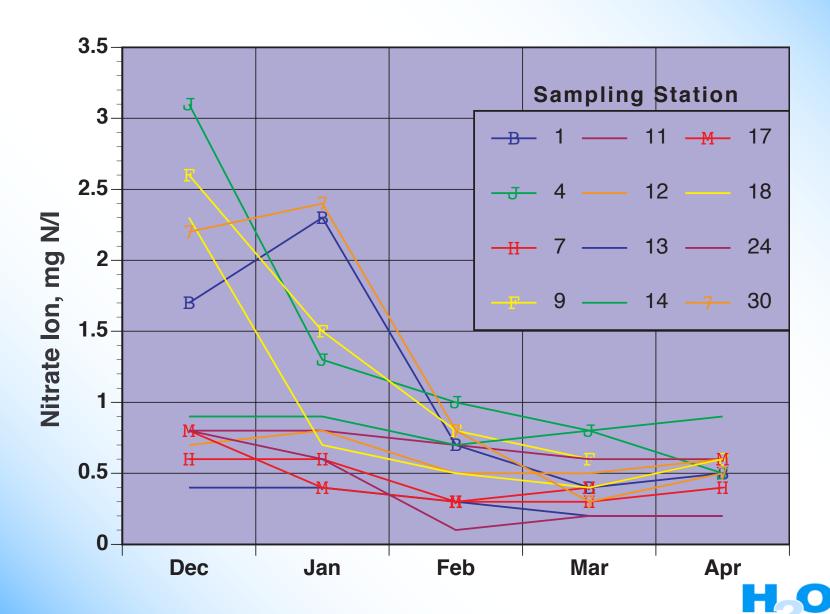


Average of Nitrite Ion Concentrations after BART

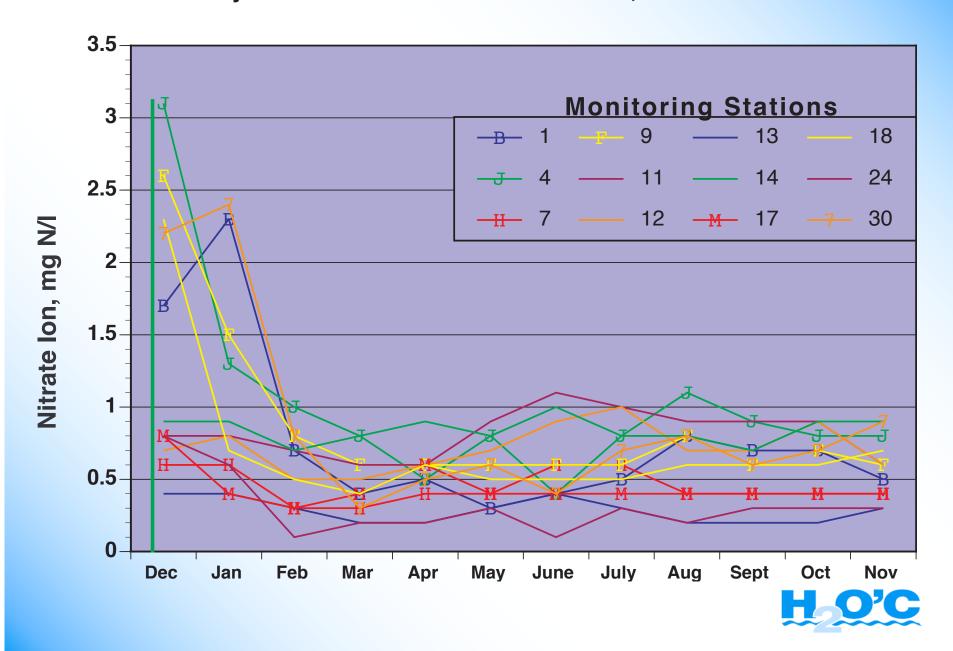




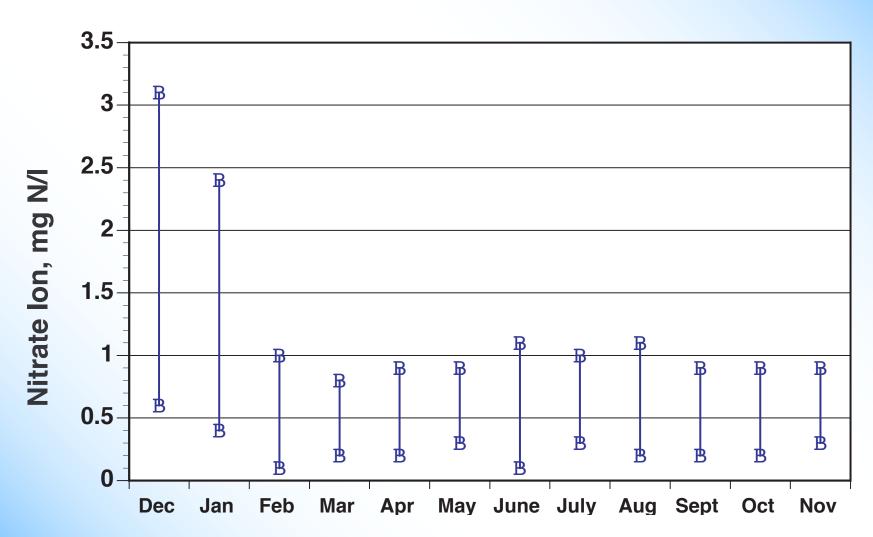
Distribution System Nitrate Ion - Willmar, MN



Distribution System Nitrate Ion after BART, Dec. '96 - Nov. '97

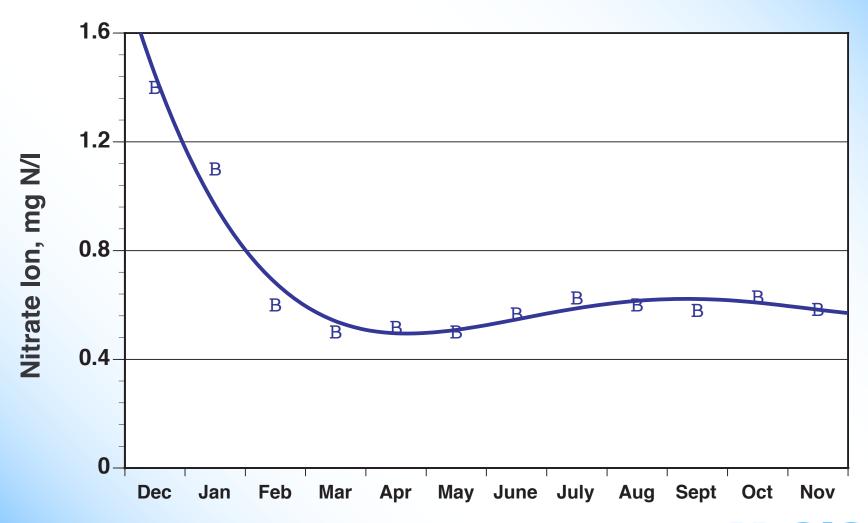


Range of Nitrate Ion Concentration after BART - Willmar, MN



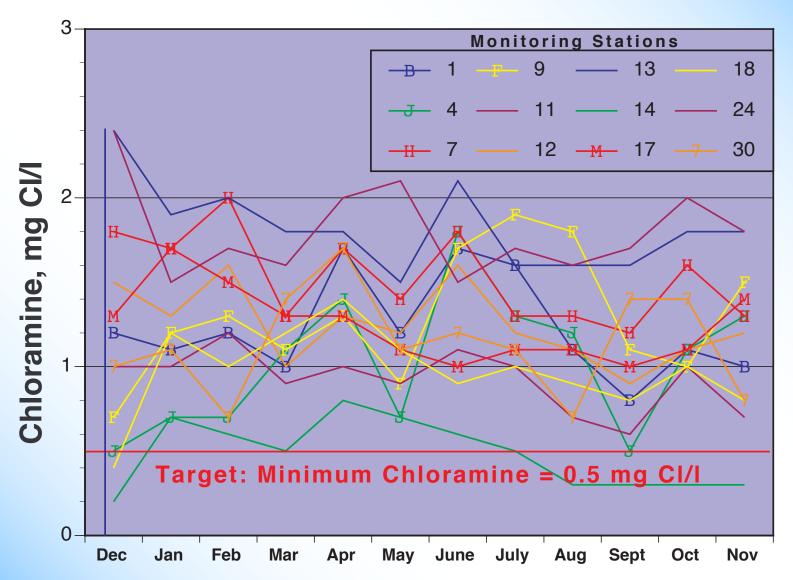


Average Nitrate Ion Concentration after BART



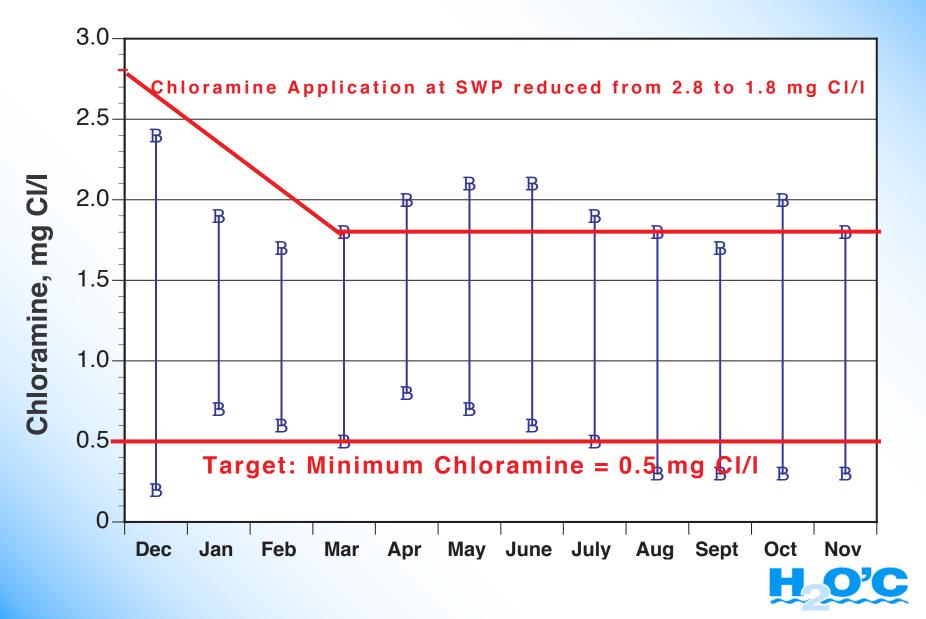


Distribution System Chloramine after BART

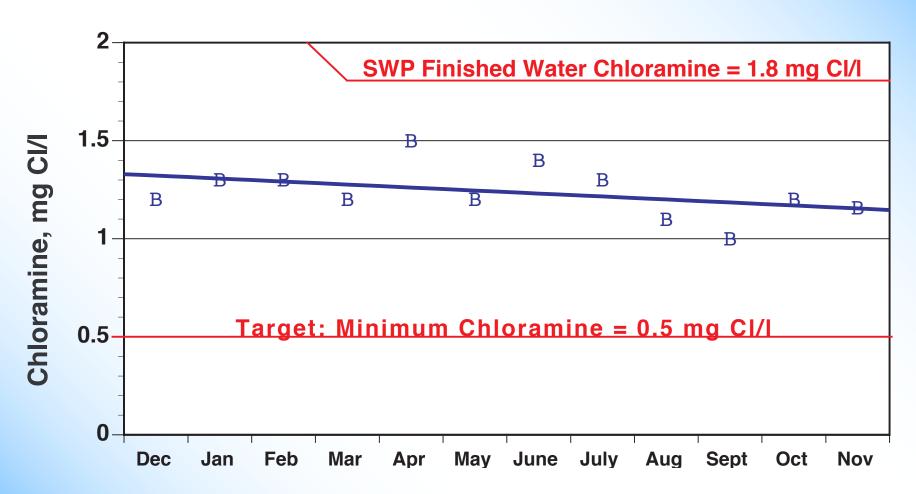




Range of Chloramine Concentrations after BART



Average Chloramine Concentrations after BART





BART

Breakpoint Ammonia Reduction Treatment

- Persistent disinfectant residuals
- Suppression of nitrite ion formation
- Avoidance of excessive trihalomethanes
- Enhanced manganese removal
- Reduction of true natural color = ozone







Back Road to Willmar's East Plant



Specializing in Municipal Drinking Water Treatment

John T. O'Connor, PE, EngD (877) 22-WATER

john@h2oc.com