

Evaluation of Disinfection By-Product Formation with Source Water Blending at the City of Brandon

Kasia Piskorz, XCG Consultants Ltd.
Brad McIntosh, City of Brandon



Outline

- Introduction
- Background
- Summary of Previous Work Completed
- Objectives of Source Water Blending Study
- Bench-Scale and Full-Scale Testing
- Conclusions

Introduction

- XCG Consultants and Andrews Hofmann & Associates Inc. have been working with the City of Brandon since 2007 to address issues related to the formation of disinfection by-products (DBPs) within the City's water supply system.



Objectives

- Investigate blending of source water from the Assiniboine River with the Turtle Crossing Well and Canada Games Park Well
- Investigate the use of chloramination on the rate of DBP formation





Background



Background

- DBP's are formed when chlorine reacts with natural organic matter (NOM) and/or bromide ions to form halogenated by-products
 - Trihalomethanes (THMs)
 - Haloacetic acid (HAAs)
- THMs – chloroform, bromodichloromethane (BDCM), dibromochloromethane, bromoform
- HAA - monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, dibromoacetic acid.

Background

- THM formation increases as a function of :
 - chlorine dose
 - contact time
 - NOM concentration
(total organic carbon (TOC)
is used as an indicator of NOM)
 - temperature
 - pH
 - bromide ion
concentration
- THMs and HAAs are formed at the same time; however, ideal conditions differ for each
 - THM formation ↑ as water pH ↑
 - HAA formation ↓ as water pH ↑

Background

- Manitoba Drinking Water Quality Standards Reg. 41/2007
 - THM maximum acceptable concentration (MAC) of 100 µg/L
 - Bromodichloromethane (BDCM) MAC of 0.016 µg/L
- Guidelines for Canadian Drinking Water Quality (GCDWQ)
 - HAA MAC of 80 µg/L
- US EPA Drinking Water Standard, 2006
 - THM 80 µg/L
 - HAA 60 µg/L
- Ontario Drinking Water Standards, Objectives and Guidelines
 - N-Nitrosodimethylamine (NDMA) interim maximum acceptable concentration (IMAC) of 0.009 µg/L

*All guidelines are based on an annual average of quarterly samples except NDMA

Background

- Disinfection Study - 2008
 - Evaluated the existing treatment, testing and disinfection practices at the Brandon Water Treatment Facility (WTF)
 - Chloramination was identified as the preferred alternative for the reduction of DBPs
- Monthly bench scale testing - 2009
 - Evaluated the benefits of chloramination on formation of THMs and HAAs
- Evaluation of Technologies for NOM Removal - 2010
 - Optimization of existing powdered activated carbon (PAC) system
 - Reviewed TOC Removal Technologies



Raw Water Quality



Raw Water Quality

- Assiniboine River is the water source for the Brandon WTF
- Turbidity
 - Average raw water turbidity 41 NTU during 2006 to 2010
 - Spikes of over 400 NTU observed
- Raw water total TOC
 - Average 13 mg/L during 2006 to 2010
 - Max observed and as high as 20 mg/L
- Brandon WTF treatment process consistently achieved a TOC removal of 45 percent



Raw Water Quality

Table 1: Raw Water Quality Data

	Canada Games Park Well	Turtle Crossing Park Well	Assiniboine River Raw Water	Anticipated Blended Water (55% Groundwater to 45 % Surface Water) ⁴	Anticipated Blended Water (75% Groundwater to 25 % Surface Water) ⁵
Ammonia (mg/L) ²	1.85	0.77	0.01 ³	1.02	1.12
Iron (mg/L)	1.70	2.88	1.89	1.79	2.04
Manganese (mg/L)	0.13	0.15	0.19	0.16	0.15
Arsenic (mg/L)	0.027	0.026	0.003	0.016	0.021
TOC	2.9	2.4	11	6.9	5.0
Hardness (mg/L) ²	344	467	82	226	309

Notes:

1. Indicated average concentrations for the period of 2002 to 2007 obtained from City of Brandon Disinfection Study Report, XCG Consultants May 2008.
2. Analysis of well raw water completed on July 16, 2008. All other raw well water analysis completed on August 28, 2009.
3. Analysis completed on June 2, 2008.
4. Groundwater consists of 55% Canada Games Park Well
5. Groundwater consists of 50% Canada Games Park and 25% Turtle Crossing Park



Bench Scale Testing



Bench-Scale Testing

- 55 percent groundwater (Turtle Crossing Well and Canada Games Park Well) to 45 percent Assiniboine River
- Chlorine dosage of 5.26 mg/L was applied to correspond to the chlorine dose used at the Brandon WTF
- Chlorination and chloramination was investigated
- THMs, HAAs, NDMA, inorganics and metal concentrations monitored

Bench Scale Testing

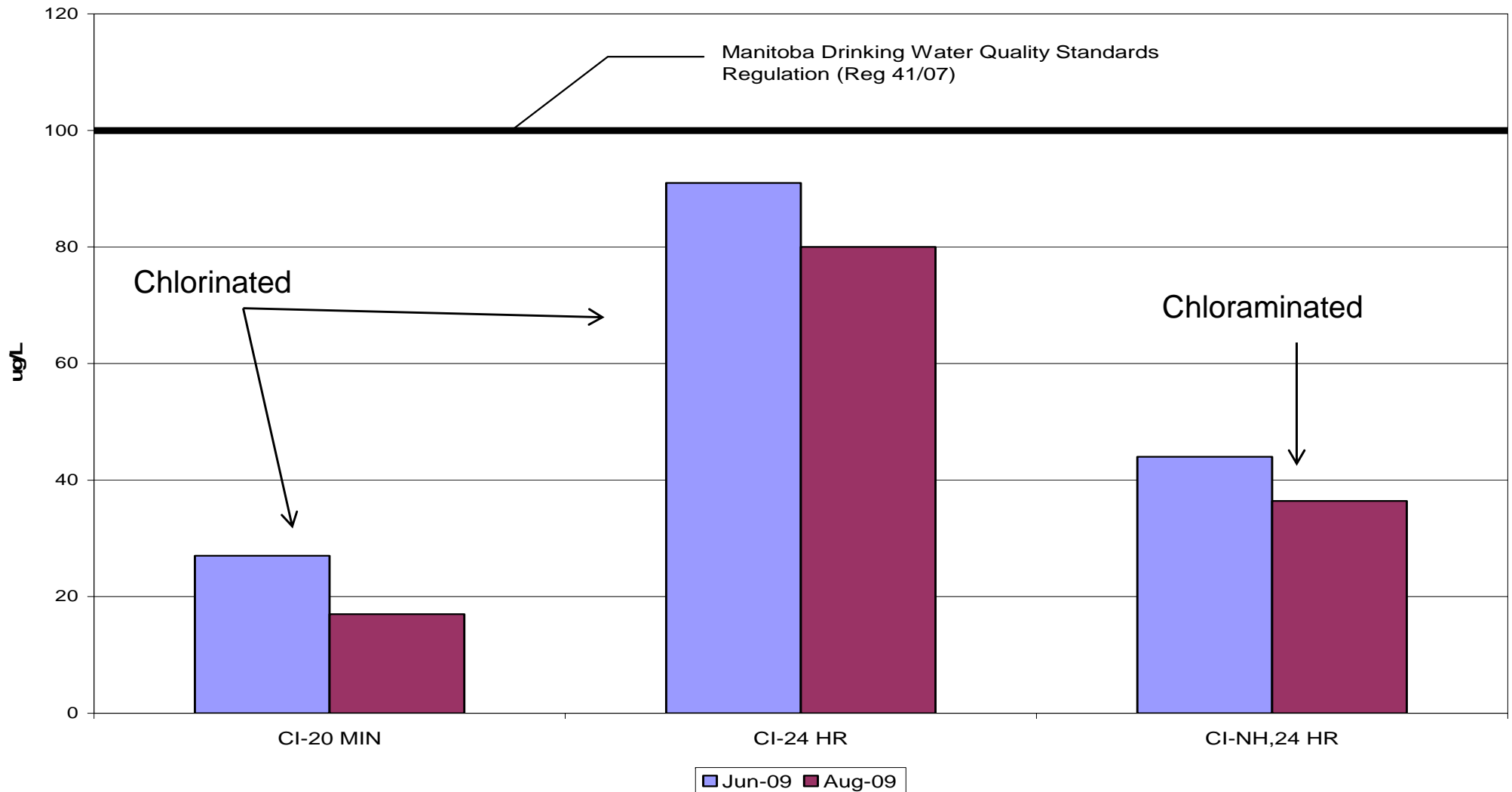


Figure 1: THM Formation – 55 percent groundwater to 45 percent Assiniboine River

Bench Scale Testing

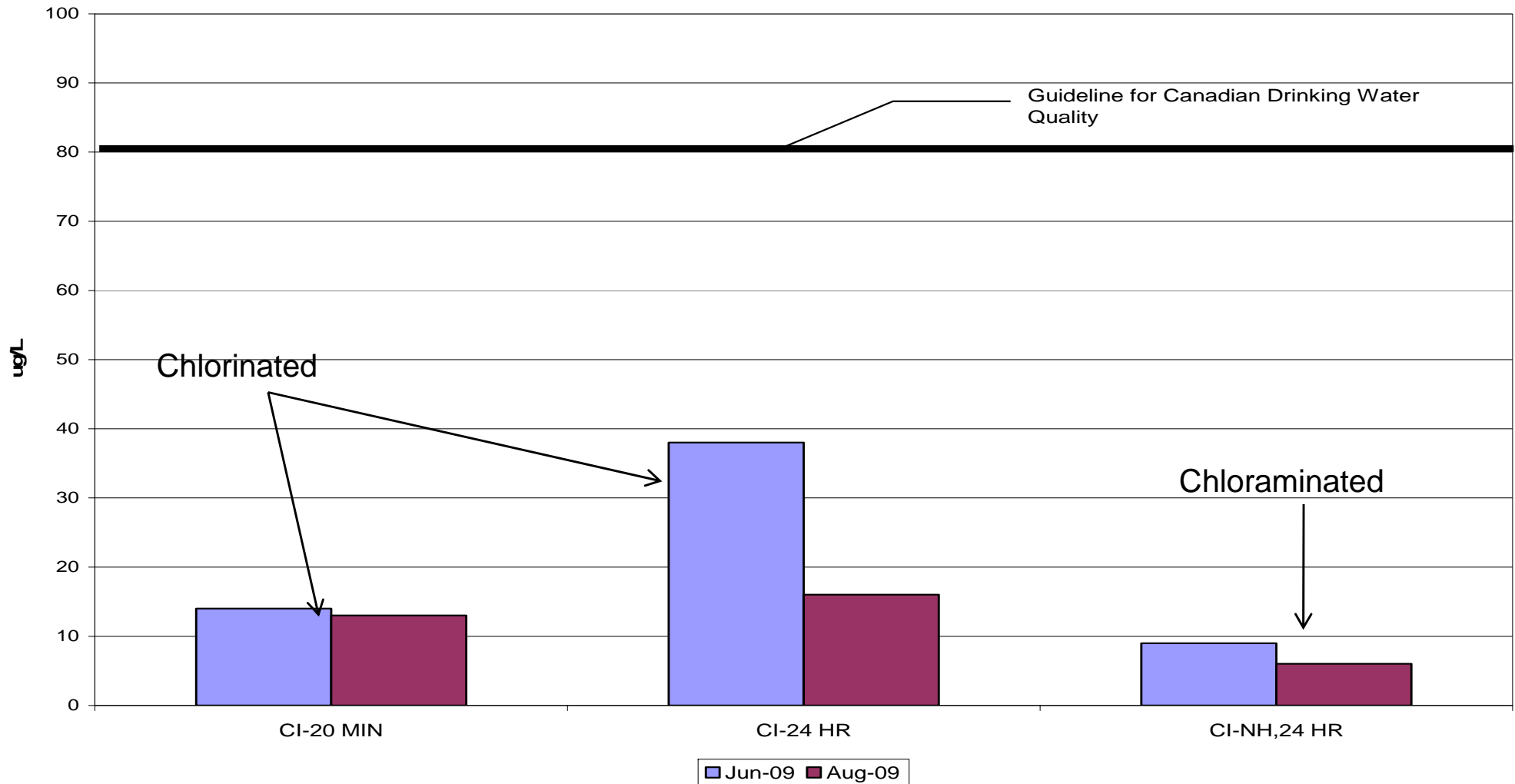


Figure 2: HAA Formation – 55 percent groundwater to 45 percent Assiniboine River

Bench Scale Testing

Table 2: THM, HAA and NDMA Bench-Scale Results

	Chlorinated		Chloramination	Chlorination		Chloramination
	20 min	24 hrs	24 hrs	20 min	24 hrs	24 hrs
THMs (µg/L)	27	91	44	17	80	37
HAA ₅ (µg/L)	14	38	9	13	16	6
NDMA (µg/L)	Not analyzed	Not analyzed	Not analyzed	0.005	0.013	0.013



Full Scale Implementation



Full-Scale Implementation

- Two different blending ratios were evaluated
 - 55 percent groundwater to 45 percent Assiniboine River water
 - 75 percent groundwater to 25 percent Assiniboine River water



Full-Scale Implementation

- THMs, HAAs, inorganics, metals and microbiological parameters monitored at several locations
 - Waverly Park School
 - Chalet (furthest point in distribution system)
 - Civics Works
 - Laboratory Tap (Brandon WTF)
 - River Heights Terrace
- NDMA monitored at Chalet and Brandon WTF
- Monitoring of routine operational parameters

Full-Scale Implementation



Date	Operation
11-Aug-09	Supply groundwater (Canada Games Park Well only) to the Brandon WTF. Commenced 10% groundwater blend and gradually increased to 25%, water provided the remaining supply
12-Aug-09	Increased groundwater blend (Canada Games Park Well) to achieve 55% and 45% Assiniboine River water blend
13-Aug-09	55% groundwater (Canada Games Park Well only) 45% Assiniboine River Water
14-Aug-09	55% groundwater (Canada Games Park Well only) 45% Assiniboine River Water
15-Aug-09	55% groundwater (Canada Games Park Well only) 45% Assiniboine River Water
16-Aug-09	55% groundwater (Canada Games Park Well only) 45% Assiniboine River Water
17-Aug-09	Increased to 75% groundwater supply and 25% Assiniboine River water. Groundwater supply was comprised of 50% Canada Games Park Well and 25% Turtle Crossing Well
18-Aug-09	75% groundwater supply (50% Canada Games Park Well and 25% Turtle Crossing Well) and 25% Assiniboine River water
19-Aug-09	75% groundwater supply (50% Canada Games Park Well and 25% Turtle Crossing Well) and 25% Assiniboine River water
20-Aug-09	75% groundwater supply (50% Canada Games Park Well and 25% Turtle Crossing Well) and 25% Assiniboine River water
21-Aug-09	Gradually shut off the supply of groundwater to the Brandon WTF

Full-Scale Implementation

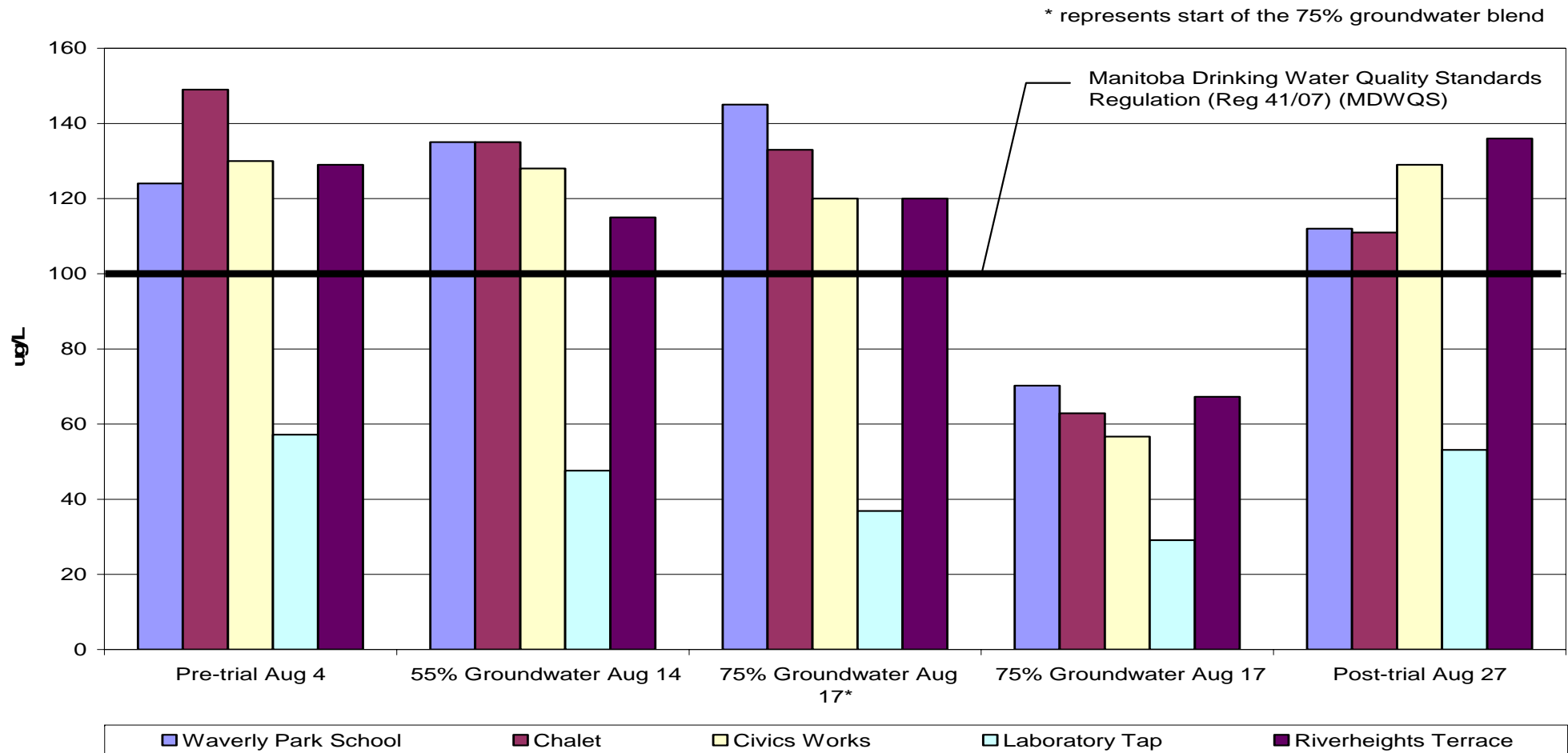


Figure 3: THM Formation

Full-Scale Implementation

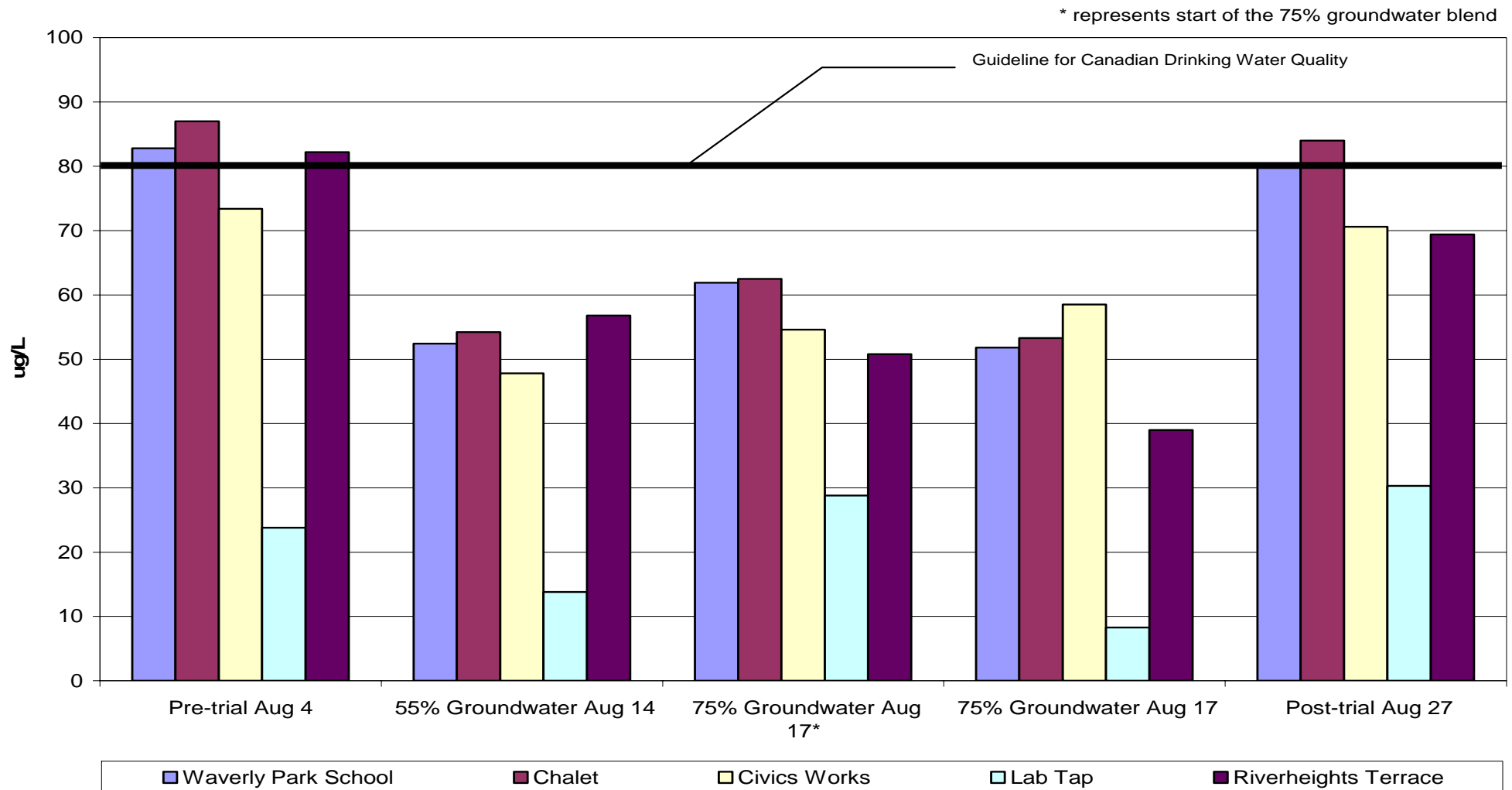


Figure 4: HAA Formation

Bench Scale Testing

Table 3 : THM, HAA, NDMA - Chalet

*Sampled on 21-Sept-09

	Pre- Trial	Trial			Post Trial
	(4- Aug-09)	(14-Aug-09)	(17-Aug-09)	(21- Aug -09)	(27-Aug-09)
THMs (µg/L)	149	135	133	63	111
HAA5 (µg/L)	101	64	74	65	96
NDMA (µg/L)	Not analyzed	Not analyzed	Not analyzed	0.116	0.007/0.181*

Full-Scale Implementation

- Microbiological testing
 - Zero total coliform, E. Coli, Crypto, Giardia
- Metals concentrations met the GCDWQ

Full-Scale Implementation

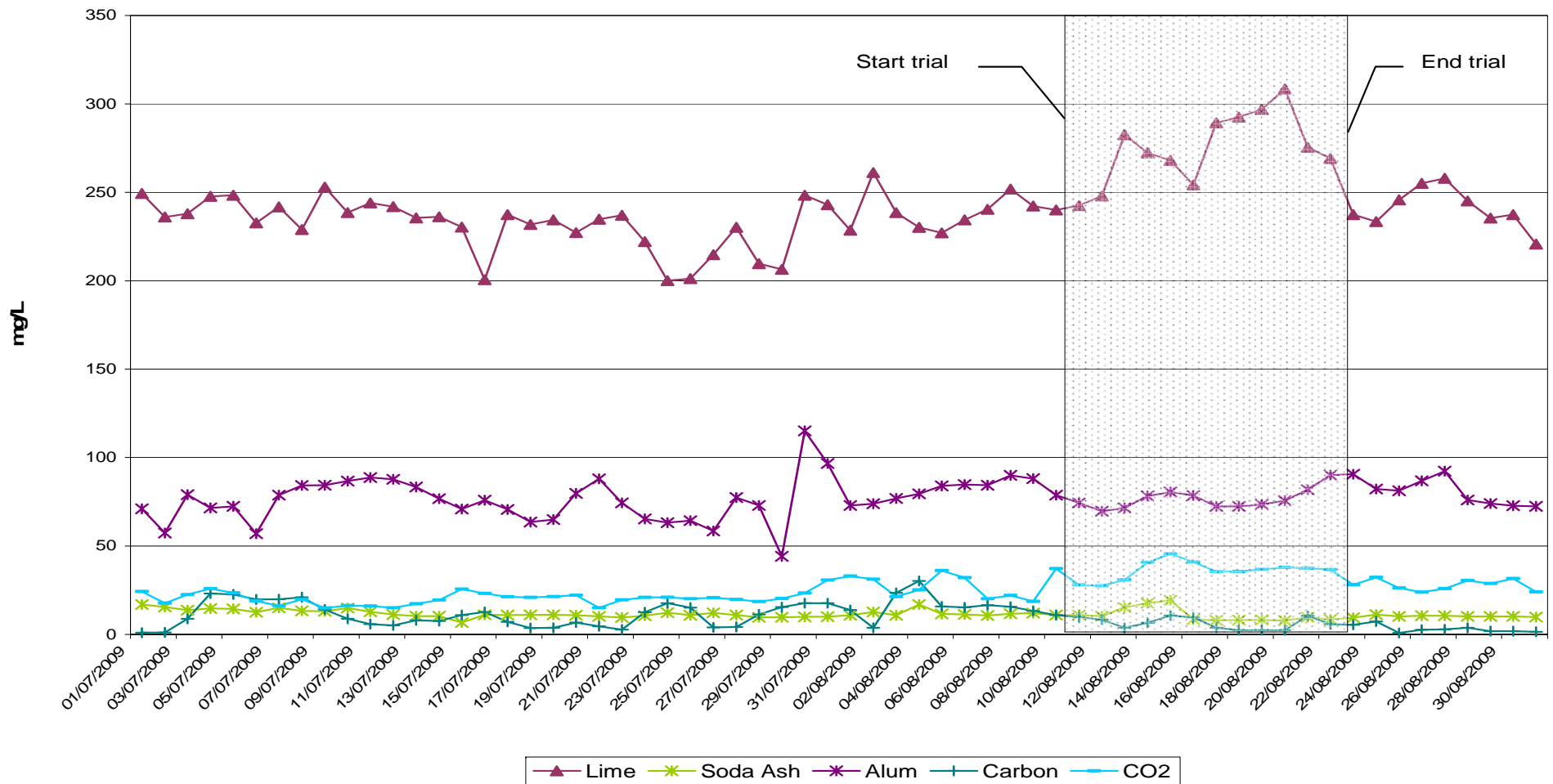


Figure 5: Brandon WTF Chemical Dosages – Lime, Soda Ask, Alum, Carbon, CO₂

Full-Scale Implementation

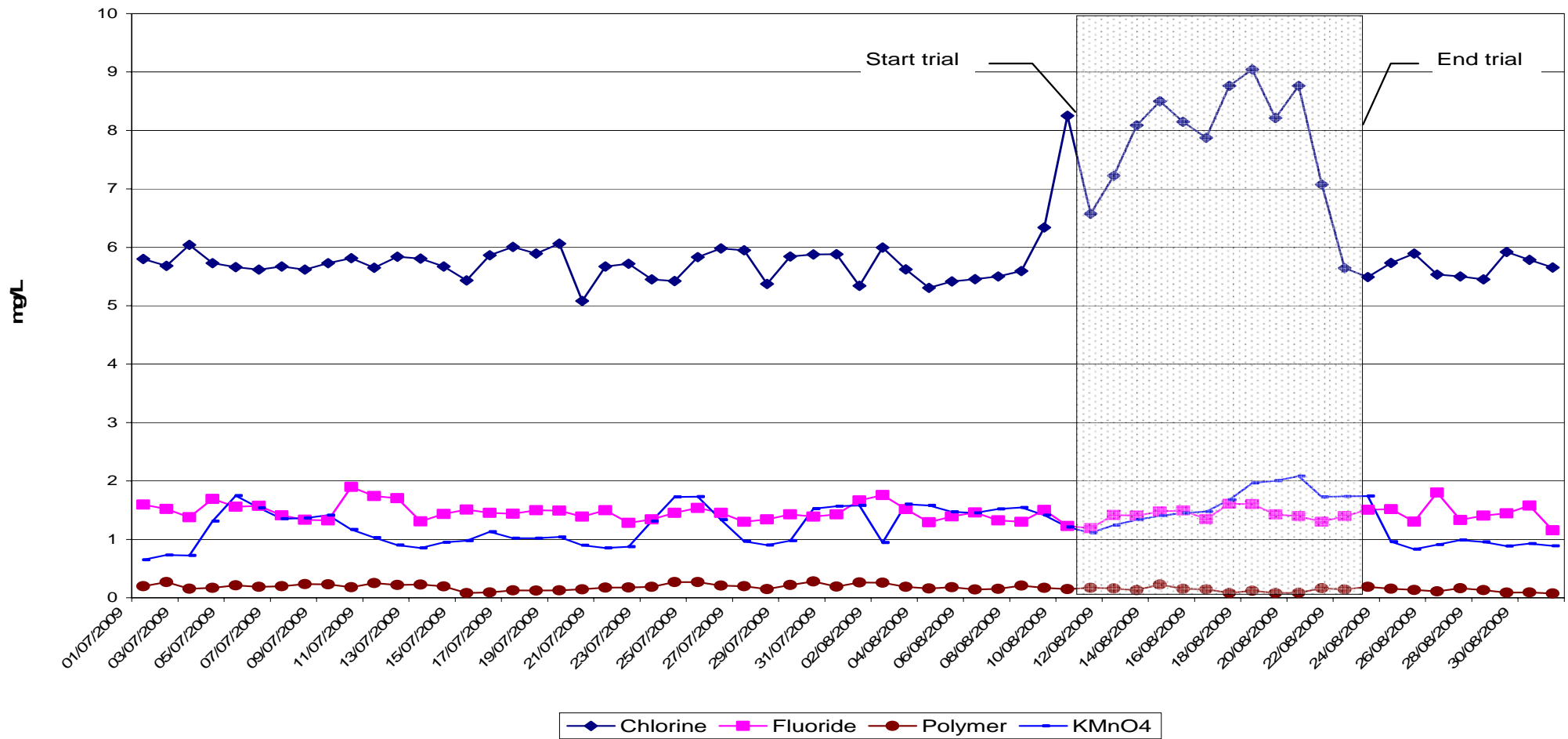


Figure 6: Brandon WTF Chemical Dosages – Chlorine, Fluoride, Poymer, KMnO₄



Conclusions



Conclusion

- DBP formation is a function of NOM in water
- TOC levels of the source water were reduced from the blending of the Assiniboine River with the groundwater
- Source water blending reduced the formation of THMs and HAAs at the City of Brandon



Conclusion

■ Bench-scale testing

- 55 percent groundwater to 45 percent groundwater blend
- THMs reduced below MDWQS of 100 µg/L
- HAAs reduced below GCDWQ of 80 µg/L
- Disinfection using chloramination showed the most significant reduction in THM and HAA formation

Conclusion

- Full-scale Implementation
 - Two blending ratios were investigated
 - 55 percent groundwater to 45 percent Assiniboine River
 - 75 percent groundwater to 25 percent Assiniboine River
 - 75 percent groundwater to 25 percent Assiniboine River blend showed the greatest reduction of THMs to levels below 70 µg/L
 - 55 percent groundwater to 45 percent Assiniboine River blend THM levels were above the MDWQS of 100 µg/L

Conclusion

- Full-scale Implementation (cont'd)
 - HAAs were below the GCDWQ for all blending ratios
 - Blending of the source water increased raw water ammonia levels
 - Process adjustments to ensure proper disinfection were required
 - Chlorine demand increased

Conclusion

- NDMA concentrations
 - Bench-scale
 - 0.013 $\mu\text{g/L}$ during chlorination and chloramination
 - Full-scale (75 percent groundwater to 25 percent River water)
 - Brandon WTF – 0.116 $\mu\text{g/L}$
 - After trial
 - Brandon WTF – 0.007 $\mu\text{g/L}$
 - Chalet - 0.181 $\mu\text{g/L}$

Questions

