ICR Treatment Study Summary Report

Evaluation of Granular Activated Carbon Technology Using the Bench-Scale Test for Compliance with The Information Collection Rule

Conducted during the period of May 4, 1998 through February 11, 1999

May, 1999

City of Austin, Texas, PWSID# TX2270001
625 E. 10th Street
Austin, Texas 78701
512-322-2819
512-322-2795

Joint Study for:

Davis Water Treatment Plant, ICR # 654

Ullrich Water Treatment Plant, ICR # 655

Green Water Treatment Plant, ICR # 656

Attachments: 1 diskette containing the Data Collection Spreadsheets

Section I: Conclusions and Recommendations

The granular activated carbon (GAC) worked very well in reducing the total organic carbon (TOC) in the water and thereby reducing the disinfection by-products that were formed. Two columns were tested, a 10-minute empty bed contact time and a 20-minute empty bed contact time. The 10-minute column had an average breakthrough time of 239 hours over the four runs, and the 20-minute column had an average breakthrough time of 436 hours over the four runs. The breakthrough was based upon reaching a TOC level of 70% or greater of the influent TOC. With the scaling factor applied, this scales to 131 days and 239 days.

The source water quality for the City of Austin is typically good, with higher TOC in the spring and sometimes the fall. The water plants are all lime softening plants, and for corrosion control, the pH of the tap water is kept between 9.4 and 10.0. Through a series of studies it has been found that a pH of less than 9.4 causes corrosion in the distribution system. Part 2 of the *Granular Activated Carbon Precursor Removal Studies* report by Summer, Hooper and Hong, states that lower pH values enhance the removal of TOC by GAC. It is assumed that the higher pH values used by the City of Austin inhibit the removal of TOC and lead to a quicker breakthrough of TOC.

The cost to install and replace GAC filters as needed would be higher than would be feasible for this water type. It would be better for Austin to look at alternative disinfectants to lower the DBPs before going to a GAC filtration system.

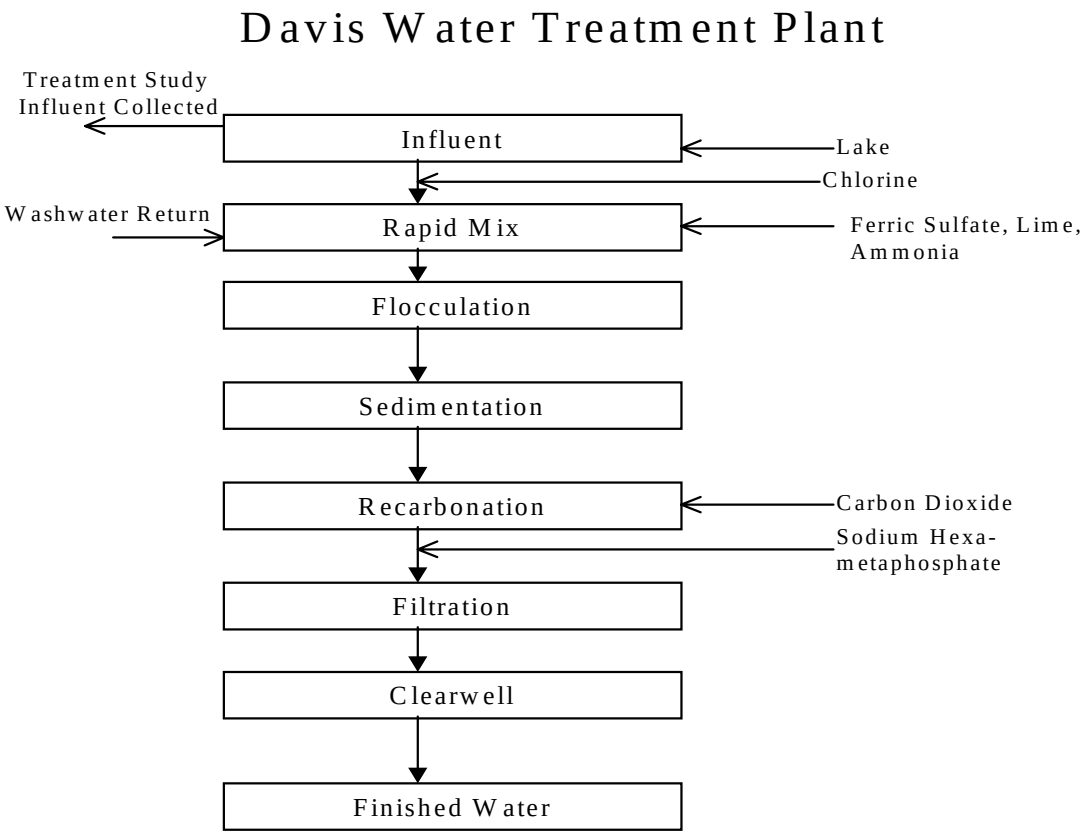
Section II: Background Information

The City of Austin Water and Wastewater Utility operates three water treatment plants. All three of the plants are located on a tributary of the Colorado River as it flows through a series of lakes formed by dams. The three water plants are the Davis Water Treatment Plant, the Ullrich Water Treatment Plant, and the Green Water Treatment Plant. The Davis and Ullrich plants are located on Lake Austin, and the Green plant is just downstream on Town Lake.

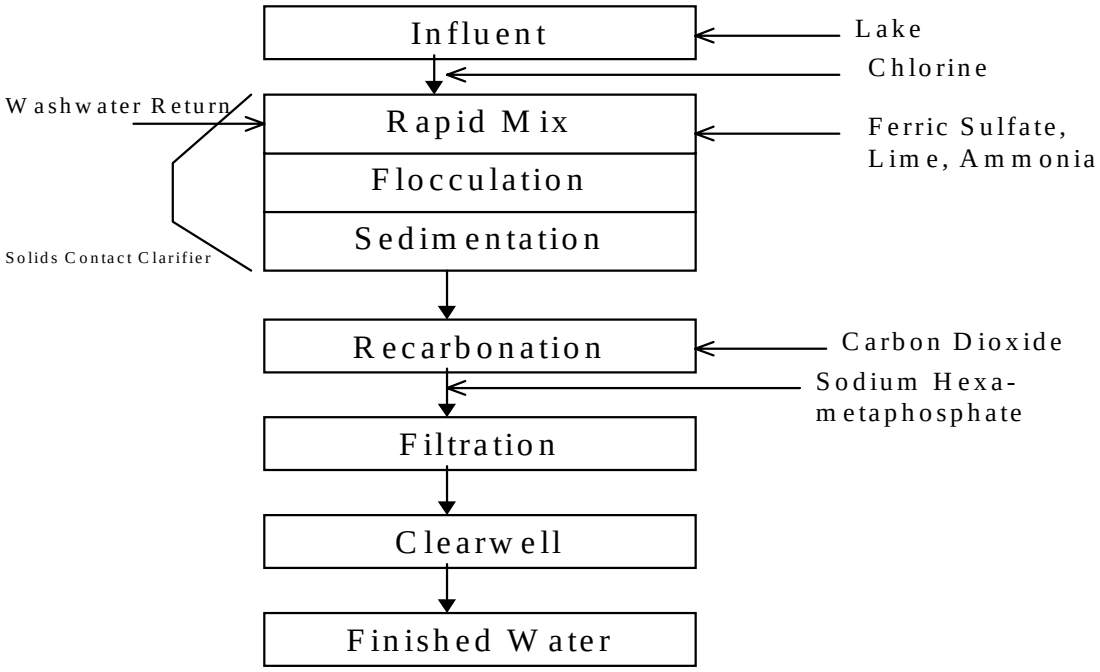
Treatment Plant Description

The influent water quality for the three plants is relatively the same. The capacities are as follows: Davis – 120 MGD, Ullrich – 60 MGD, Green – 45 MGD. For a summary of the basic engineering data for each unit process for each of the plants, see Appendix "A".

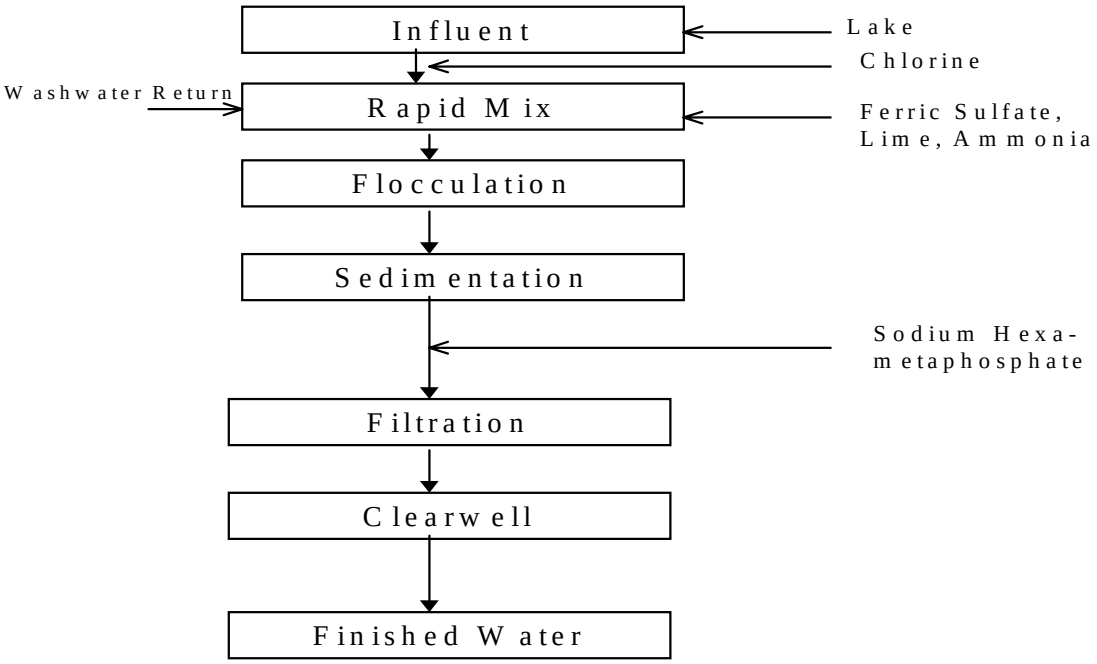
The schematics of each are as follows:



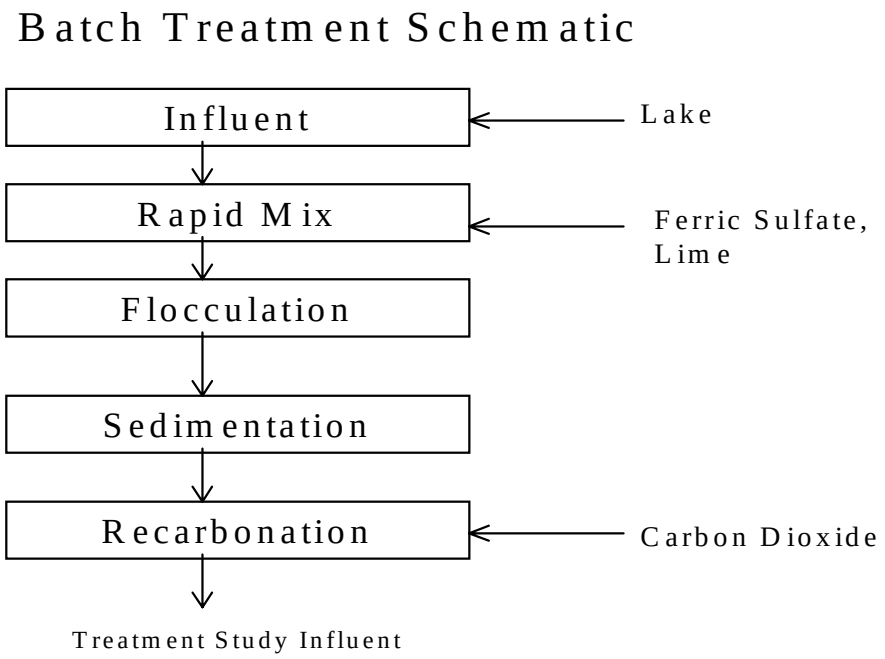
Ullrich Water Treatment Plant



Green Water Treatment Plant



The water could not be pulled for the GAC bench study prior to chlorination, so the water was batch treated. The batch treatment schematic is as follows:



The influent water quality averaged over the previous twelve months is summarized in the following table:

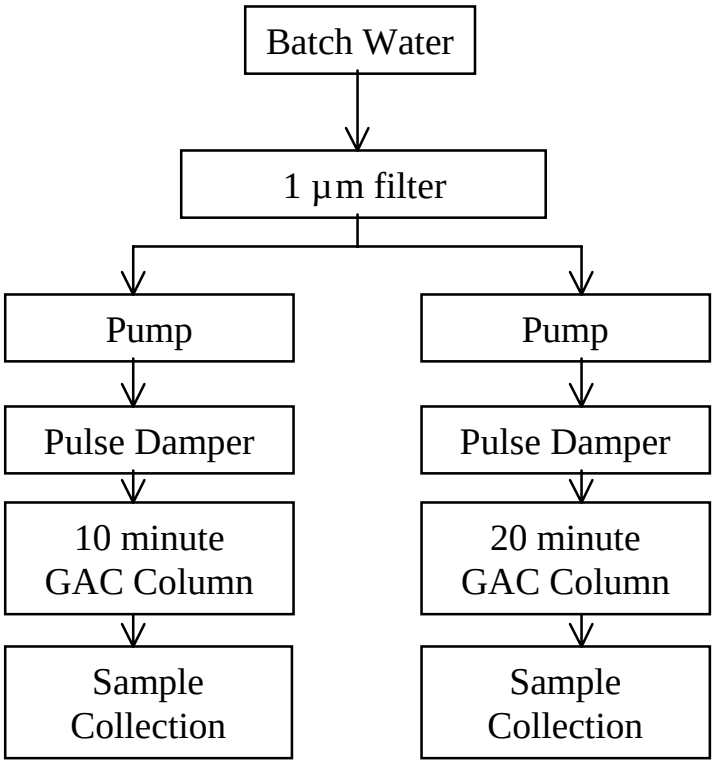
Influent Water Quality Parameter	Average Yearly Concentration	Standard Deviation	Minimum Yearly Value	Maximum Yearly Value
Temperature (°C)	20.1	4.1	11.0	27.0
pH	8.1	0.3	7.6	8.3
Turbidity (ntu)	4.1	3.7	1.2	34
Alkalinity (mg/L as $CaCO_3$)	176	17	151	247
Calcium Hardness (mg/L $CaCO_3$)	136	22	114	222
Total Hardness (mg/L $CaCO_3$)	216	21	182	300
TOC (mg/L)	3.54	0.69	2.27	8.56
UV_{254} (cm^{-1})	0.081	0.017	0.066	0.176
Bromide (µg/L)	0.198	0.027	0.126	0.249

The finished water quality parameters averaged over that same time period are shown in the following table:

Finished Water Quality Parameter	Average Yearly Concentration	Standard Deviation	Minimum Yearly Value	Maximum Yearly Value
Temperature (°C)	20.1	4.1	11.0	27.0
pH	9.6	0.1	9.3	9.8
Turbidity (ntu)	0.07	0.03	0.02	0.19
TOC (mg/L)	2.24	0.25	1.91	3.57
Distribution System TTHM4 (µg/L)	40.3	10.81	20.5	69.5

Section III: Materials and Methods

The testing apparatus was set up as shown in the schematic below:



The water was made in a batch the day prior to the start of the experiment and placed in five-gallon carboys. The carboys were stored in a large cool room at four degrees centigrade, and pulled out 24 hours prior to use.

The procedures outlined in the *ICR Manual for Bench and Pilot-Scale Treatment Studies* were followed. The water was filtered with a 1-µm glass fiber filter. Even with the filtering, there was still some headloss build-up in the 10-minute EBCT column after approximately one day of running. Stirring the GAC media with a stainless steel wire relieved the head loss. That was done once for each run and was not needed again.

The first run, the spring run in May 1998, had one interruption in operation. The 10-minute EBCT column was turned off for three days, and the 20-minute EBCT column was turned off for two days. The run times in the spreadsheets were adjusted accordingly.

During all four runs the flow rate of each column was checked, and adjusted if necessary, every 12 hours. The flow rate stayed very constant and had to be adjusted only rarely.

The experimental design was to use conventional softening for each of the four seasons studied for both the 10 and 20-minute columns. Enhanced softening doesn't work well at

the Austin water plants, there is too much magnesium floc carried over to the filters, so enhanced softening was not looked at as an experiment option.

The target SDS conditions were as follows:

SPRING

Incubation Time	24 Hours
Temperature	20 – 23
End pH	9.0 – 9.4
End Free Chlorine Residual	0.5-1.0 mg/l

SUMMER

Incubation Time	24 Hours
Temperature	24 - 26
End pH	9.7 – 10.0
End Free Chlorine Residual	0.5-1.0 mg/l

FALL

Incubation Time	24 Hours
Temperature	20 – 23
End pH	9.6 – 9.9
End Free Chlorine Residual	0.5-1.0 mg/l

WINTER

Incubation Time	24 Hours
Temperature	18 - 21
End pH	9.4 – 9.8
End Free Chlorine Residual	0.5-1.0 mg/l

The following table is a list of all the analytical methods used and the minimum reporting levels of each (MRL's)

Analyte	Method	Minimum Reporting Level
pH	4500-H+B	Not Applicable
Temperature	2550 B	Not Applicable
Alkalinity	2320 B	5 mg/L $CaCO_3$
Ammonia	4500-NH_3	0.10 mg/L NH_3-N
Calcium Hardness	3500-Ca D	5 mg/L $CaCO_3$
Chlorine Residual	4500-ClG	0.2 mg/L
Total Hardness	2340 C	5 mg/L $CaCO_3$
Turbidity	2130 B	0.05 ntu
Bromide	300	20 µg/L
UV_{254}	5910	0.009 cm^{-1}

TOC	5310 C	0.50 mg/L
TOX	5320 B	25 µg/L
$CHCl_3$, BDCM, DBCM, $CHBr_3$	502.2	1 µg/L for each analyte
MCAA, CDBAA	6251 B	2 µg/L for each analyte
DCAA, TCAA, MBAA, DBAA, BCAA, DCBAA	6251 B	1 µg/L for each analyte
TBAA	6251 B	4 µg/L

The following two tables outline the laboratory information on the laboratories used during the study.

Laboratory	Dates of Service	Analyses Performed
City of Austin Water Quality Services Division	5/4/98 – 2/11/99	pH, Temperature, Alkalinity, Ammonia, Calcium Hardness, Chlorine Residual, Total Hardness, Turbidity, Bromide, UV_{254}, TOC
Montgomery Labs	5/4/98 – 2/11/99	THM, HAA, TOX, Bromide

Laboratory	ICR No.	Address/Contact/Phone & FAX
City of Austin Water Quality Services Division	ICRTX004	3500 W. 35th Street, Austin, Texas 78703 Rosie Barrios, 512-421-3774, FAX: 512-421-3770
Montgomery Labs	ICRCA013	5555 East Walnut Street, Pasadena, California 91101, James Hein, 626-568-6400, FAX: 626-568-6324

Section IV: Results and Discussion

There was some seasonal variability in the results. The temperature was not affected greatly by the change of seasons, but the TOC of the raw water is much higher in the spring than in the other months.

The average pretreated feed water quality during the four seasons of the RSSCT study are shown in the table below. "SD" is standard deviation.

Water Quality Parameter	Spring Average (SD)	Summer Average (SD)	Autumn Average (SD)	Winter Average (SD)
Temperature (°C)	21.9 (.62)	25 (0)	21.3 (2.67)	19.8 (.58)
pH	9.37 (.62)	9.95 (.51)	9.83 (1.17)	9.6 (0)
Turbidity	.23 (4.35)	.05 (108.25)	.11 (60.27)	.23 (25.11)
Alkalinity (mg/L $CaCO_3$)	69 (0)	56 (0)	53.5 (1.87)	54.5 (5.5)
Calcium Hardness (mg/L $CaCO_3$)	41.5 (2.41)	36.5 (2.74)	31.5 (3.17)	35 (5.71)
Total Hardness (mg/L $CaCO_3$)	122 (1.64)	97.5 (1.03)	94 (0)	95.5 (5.24)
Bromide (µg/L)	200 (NA)	199.5 (1.5)	206.5 (2.42)	197.5 (10.63)
TOC (mg/L)	3.23 (7.97)	1.96 (2.38)	2.25 (2.86)	2.10 (1.93)
UV_{254} (cm^{-1})	.060 (1.67)	.036 (10.42)	.045 (5.56)	.036 (2.78)
SDS THM4 (µg/L)	120.67 (7.15)	100.57 (18.99)	92.07 (36.17)	99 (7.07)
SDS HAA5 (µg/L)	68.5 (5.86)	19.7 (11.94)	21.03 (17.95)	20.9 (7.22)
SDS HAA6 (µg/L)	80.5 (4.17)	28.77 (11.65)	29.47 (17.15)	28.07 (5.88)
SDS TOX (µg Cl^- /L)	391.67 (37.05)	546.67 (67.69)	886.67 (97.58)	291.67 (45.69)
SDS Chlorine Demand (mg/L)	1.68 (3.06)	1.63 (1.27)	1.59 (21.93)	1.6 (2.19)

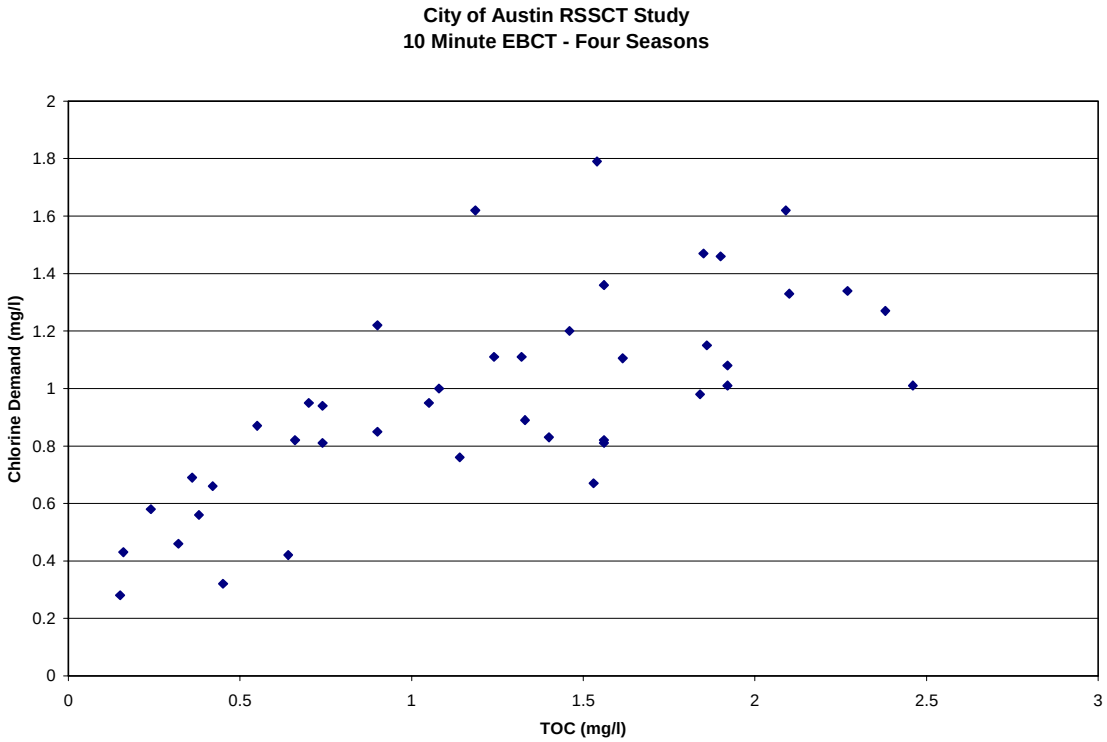
The graphs produced as a result of this study are in Appendix B of this report.

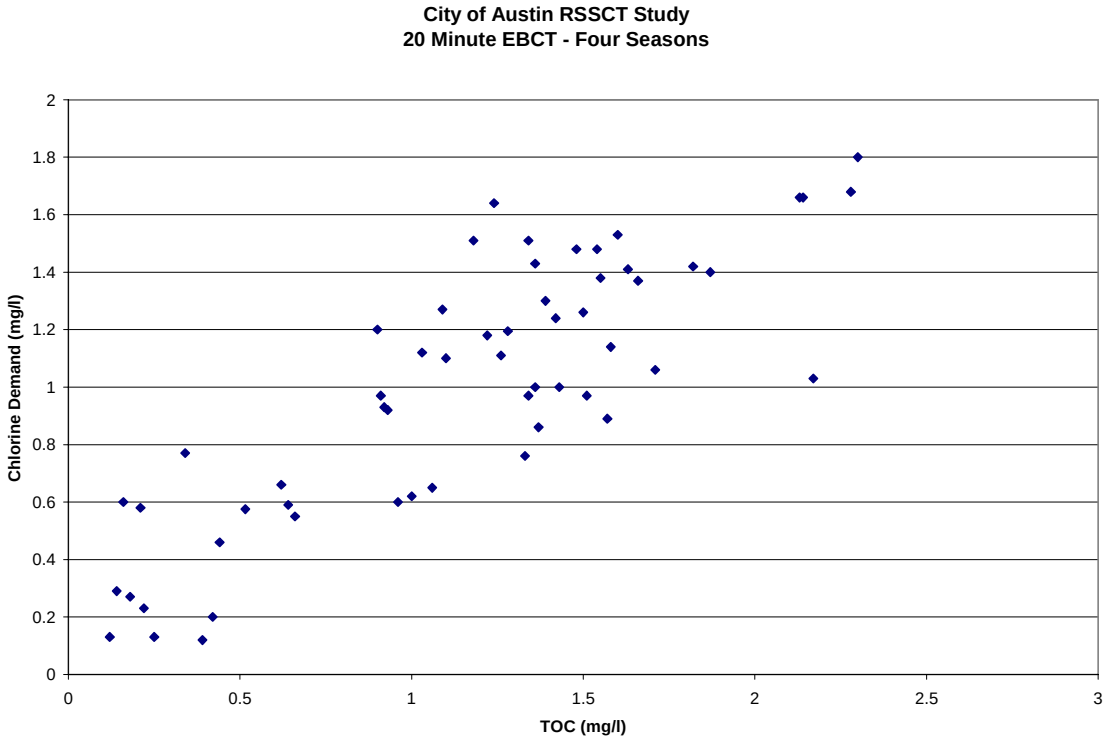
Section V: QA/QC Summary

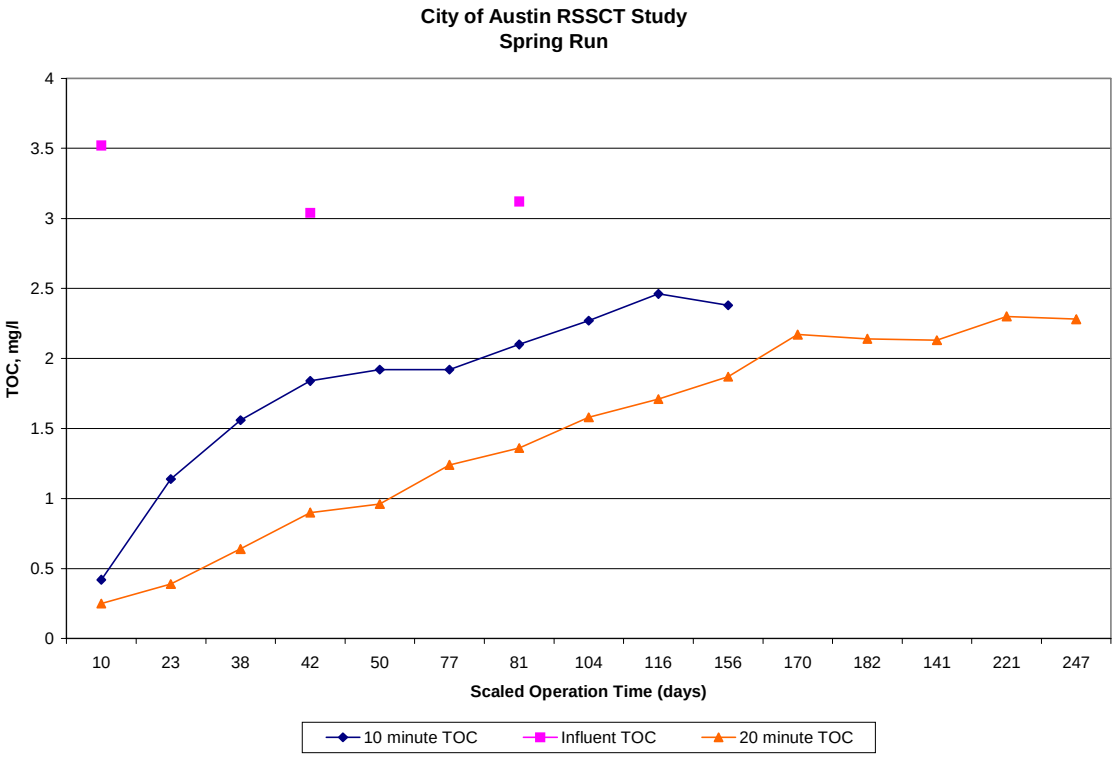
The QA/QC information submitted by the laboratories is included in Appendix C of this report.

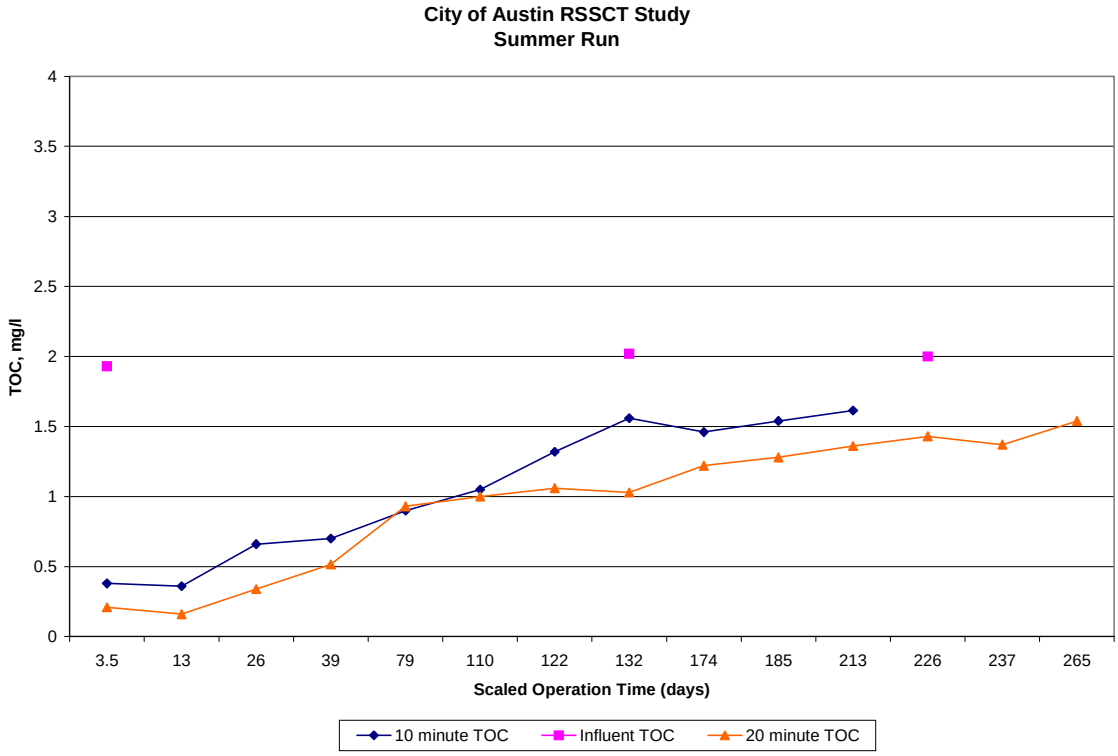
Appendix B

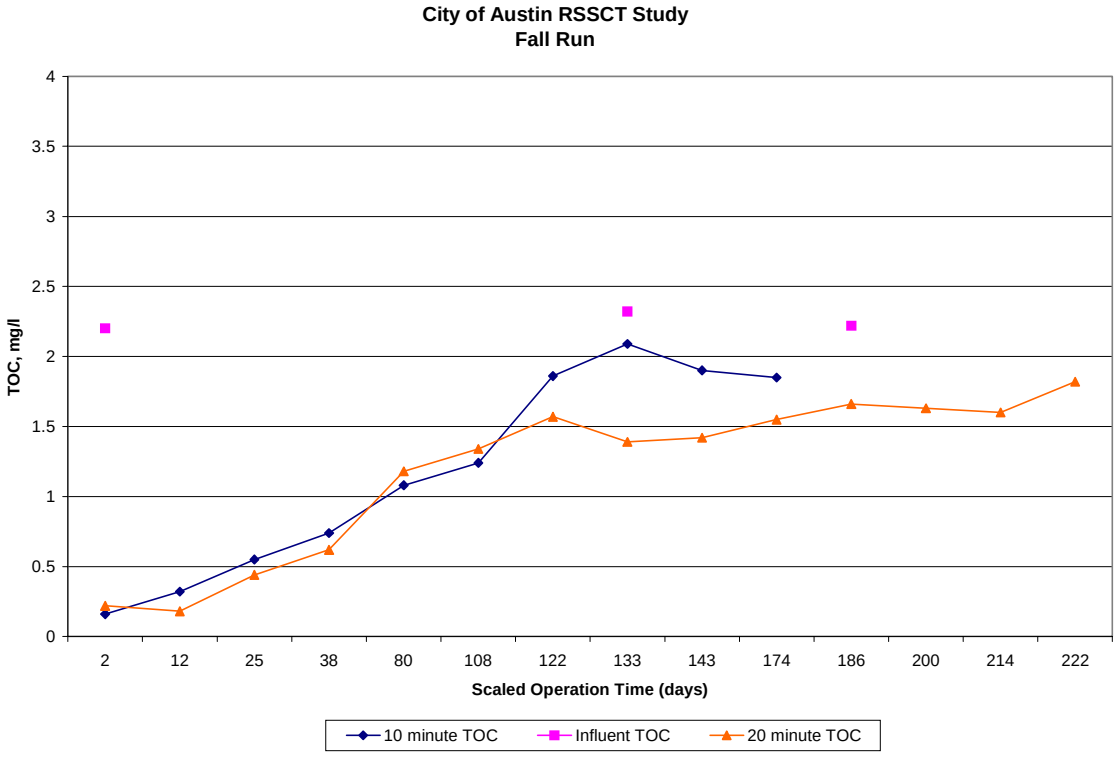
The following are all the graphs constructed with the data from the ICR bench study.

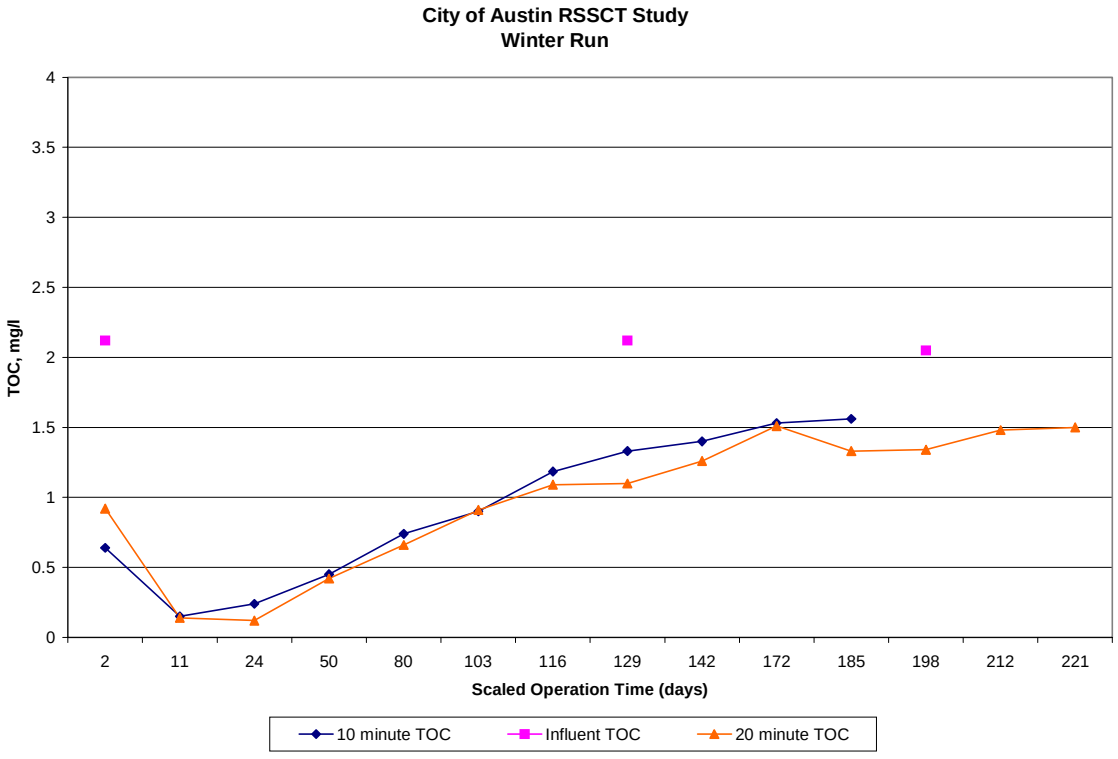


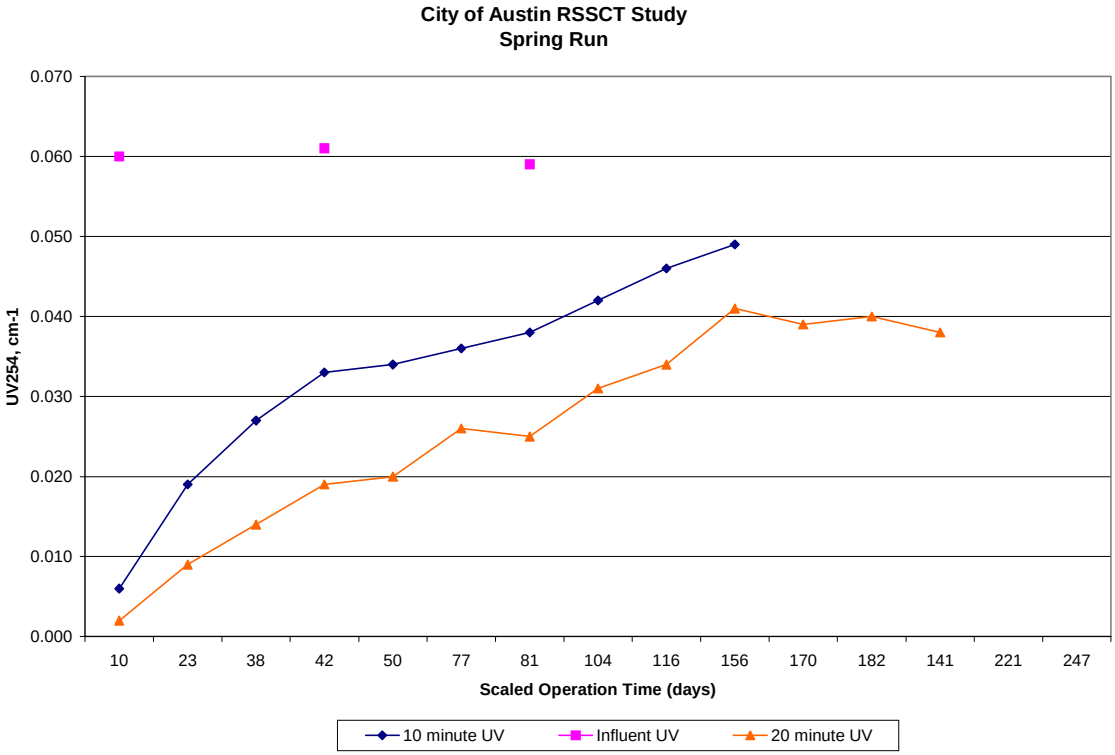


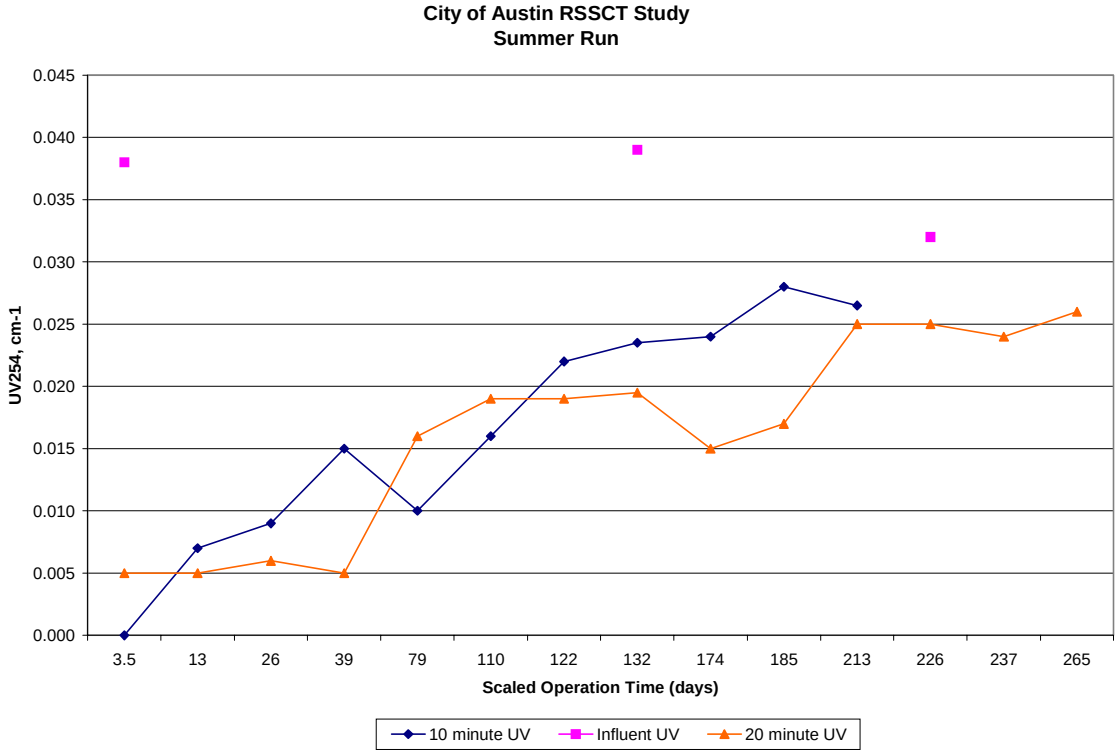

City of Austin RSSCT Study
Spring Run
TOC, mg/l
4
3.5
3
2.5
2
1.5
1
0.5
0
10
23
38
42
50
77
81
104
116
156
170
182
141
221
247
Scaled Operation Time (days)
10 minute TOC
Influent TOC
20 minute TOC

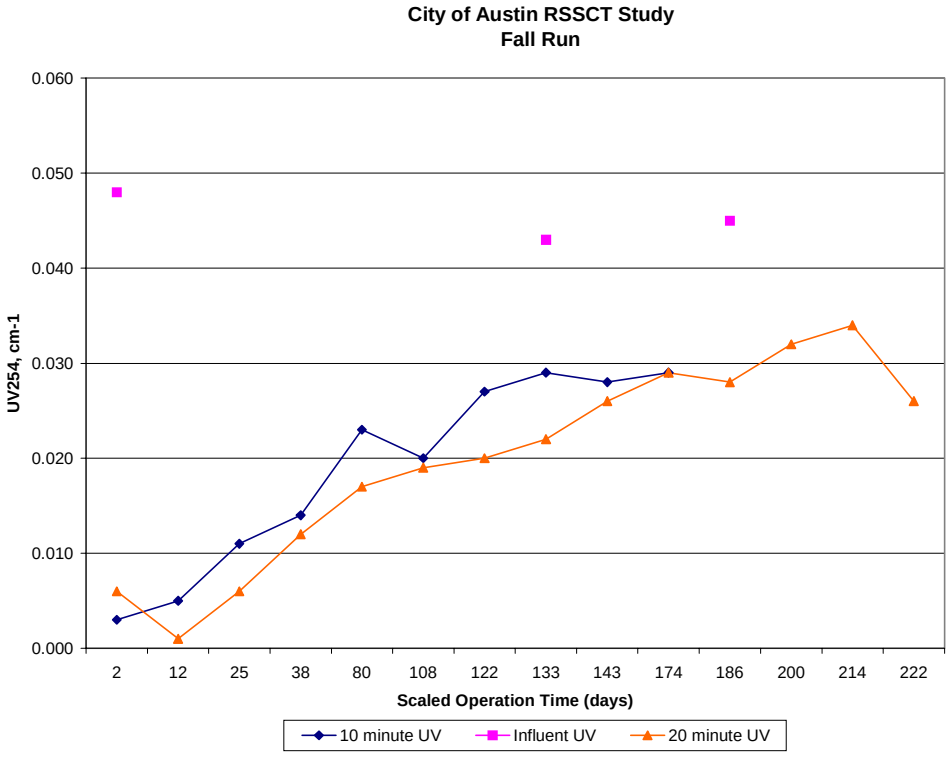

City of Austin RSSCT Study
Summer Run
TOC, mg/l
4
3.5
3
2.5
2
1.5
1
0.5
0
3.5
13
26
39
79
110
122
132
174
185
213
226
237
265
Scaled Operation Time (days)
10 minute TOC
Influent TOC
20 minute TOC

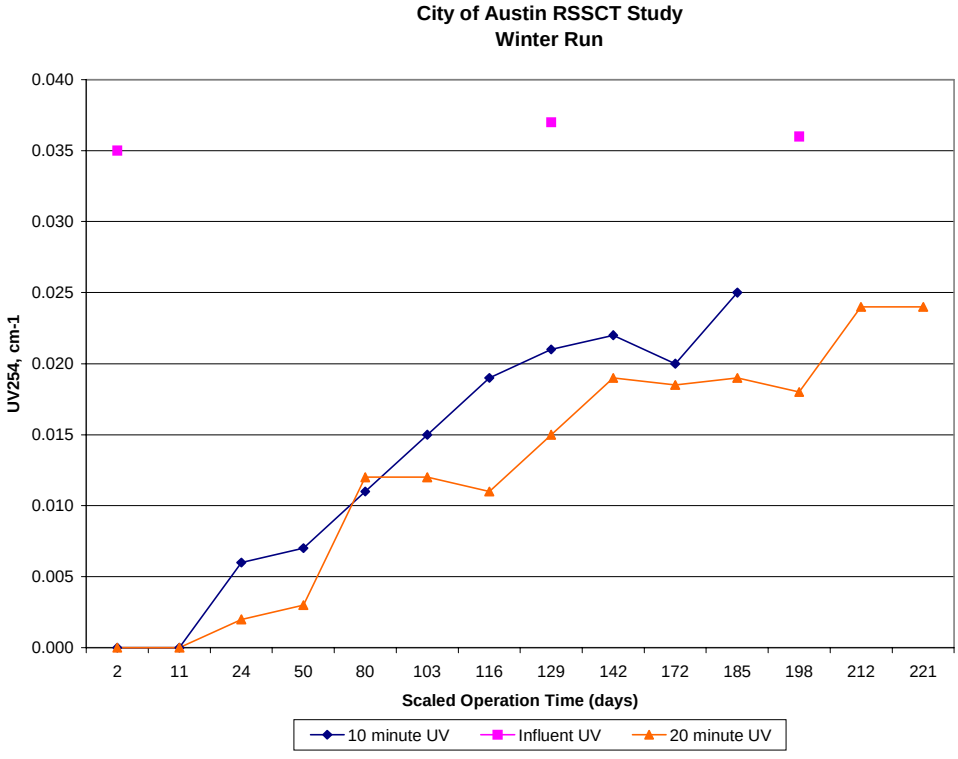

City of Austin RSSCT Study
Fall Run
TOC, mg/l
4
3.5
3
2.5
2
1.5
1
0.5
0
2
12
25
38
80
108
122
133
143
174
186
200
214
222
Scaled Operation Time (days)
10 minute TOC
Influent TOC
20 minute TOC

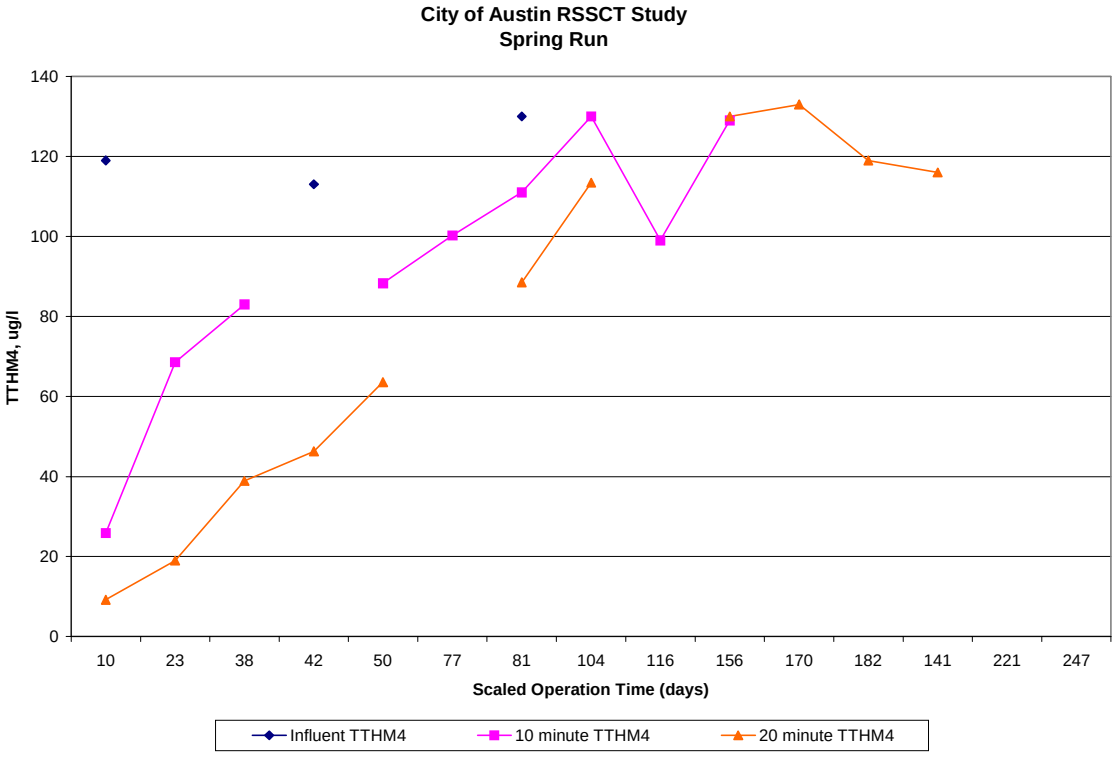

City of Austin RSSCT Study
Winter Run
TOC, mg/l
4
3.5
3
2.5
2
1.5
1
0.5
0
2
11
24
50
80
103
116
129
142
172
185
198
212
221
Scaled Operation Time (days)
10 minute TOC
Influent TOC
20 minute TOC

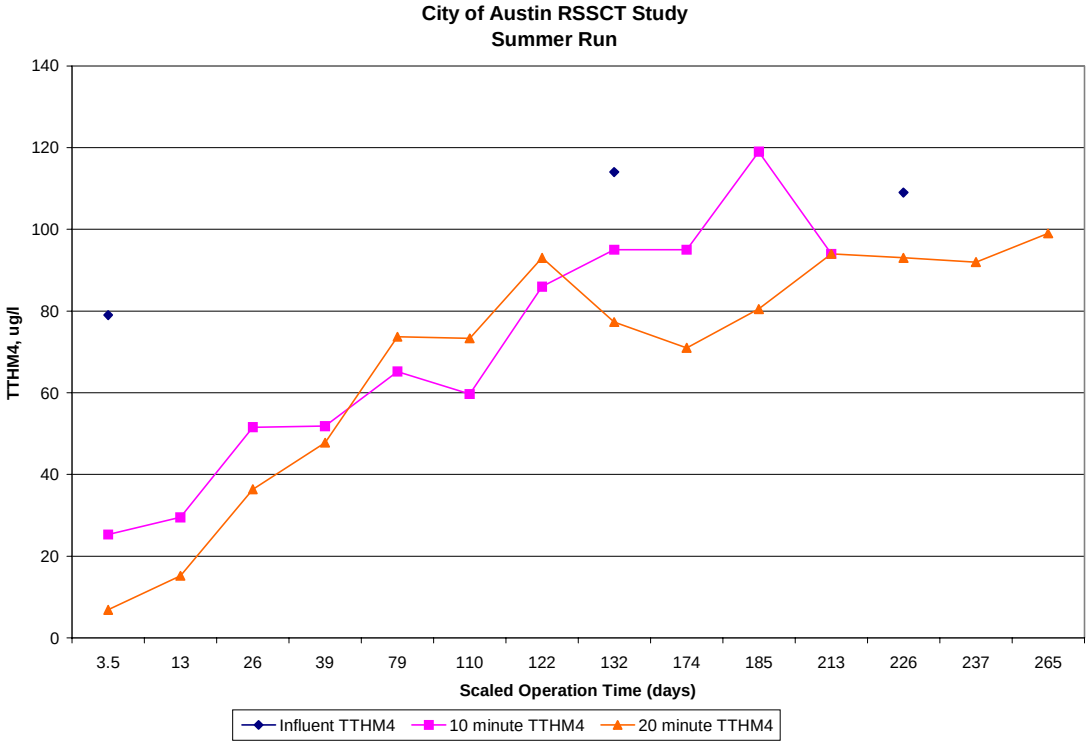

City of Austin RSSCT Study
Spring Run
UV254, cm-1
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
10
23
38
42
50
77
81
104
116
156
170
182
141
221
247
Scaled Operation Time (days)
10 minute UV
Influent UV
20 minute UV

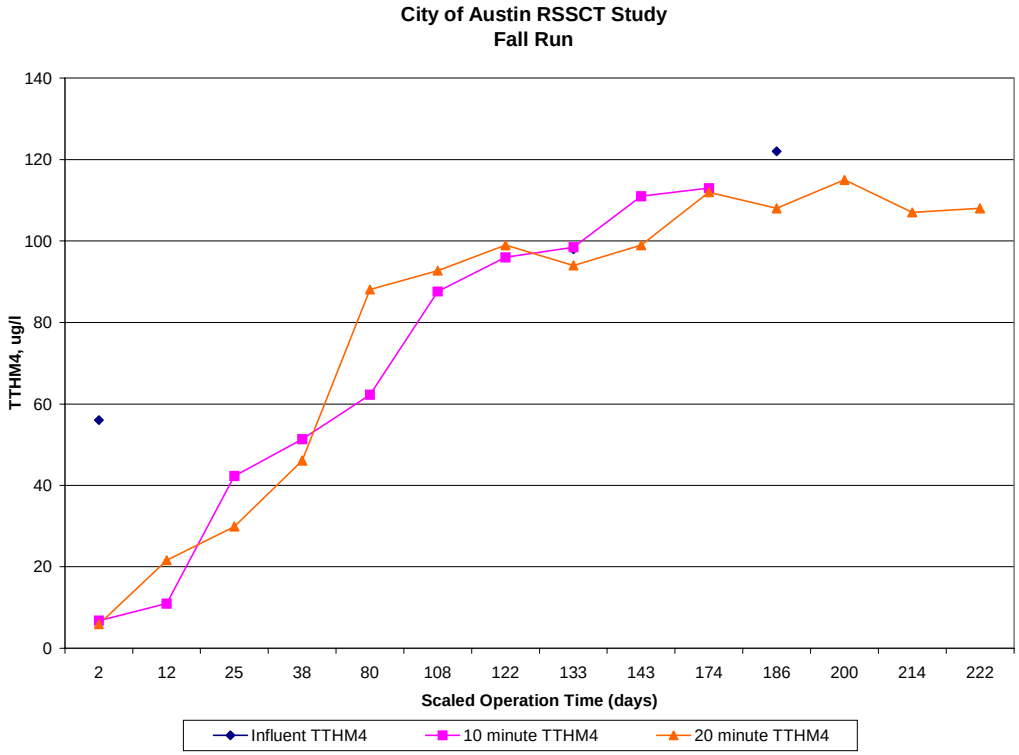

City of Austin RSSCT Study
Summer Run
UV254, cm-1
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
3.5
13
26
39
79
110
122
132
174
185
213
226
237
265
Scaled Operation Time (days)
10 minute UV
Influent UV
20 minute UV

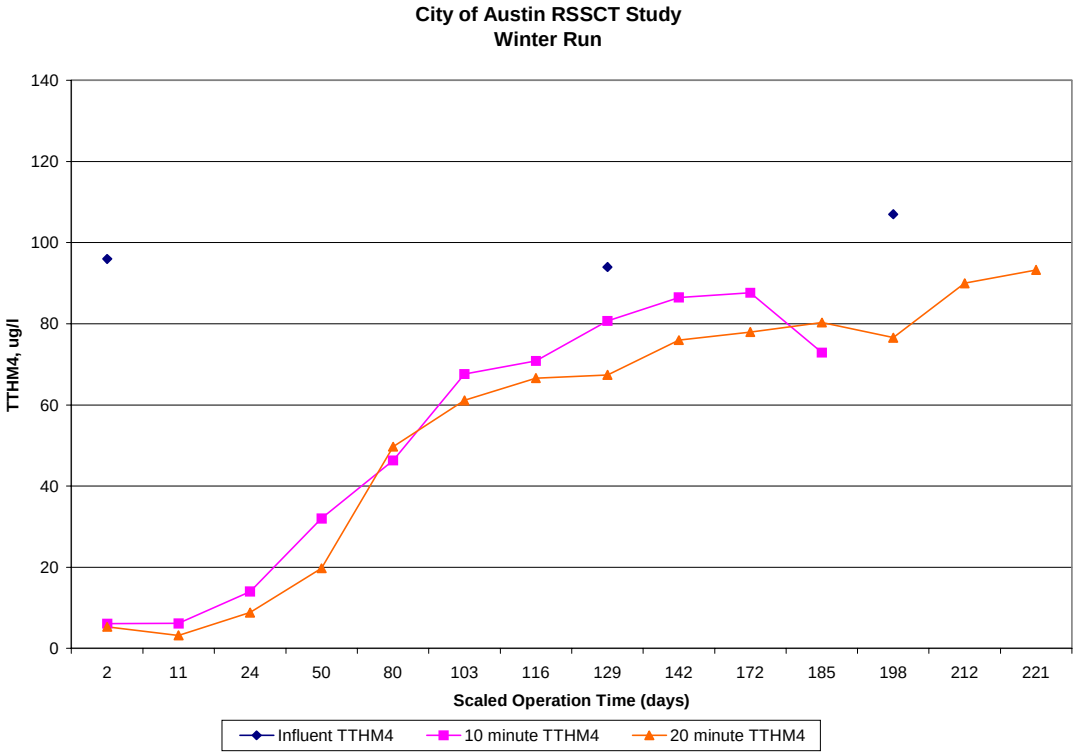

City of Austin RSSCT Study
Fall Run
UV254, cm-1
0.060
0.050
0.040
0.030
0.020
0.010
0.000
2
12
25
38
80
108
122
133
143
174
186
200
214
222
Scaled Operation Time (days)
10 minute UV
Influent UV
20 minute UV

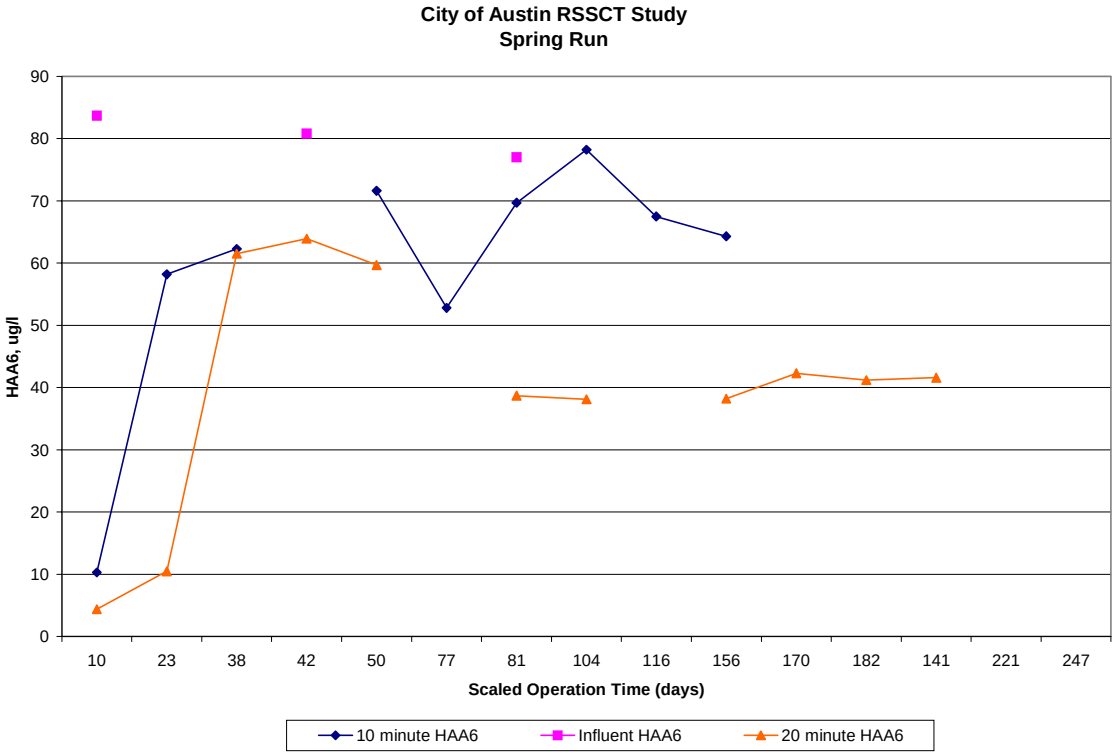

City of Austin RSSCT Study
Winter Run
UV254, cm-1
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
2
11
24
50
80
103
116
129
142
172
185
198
212
221
Scaled Operation Time (days)
10 minute UV
Influent UV
20 minute UV

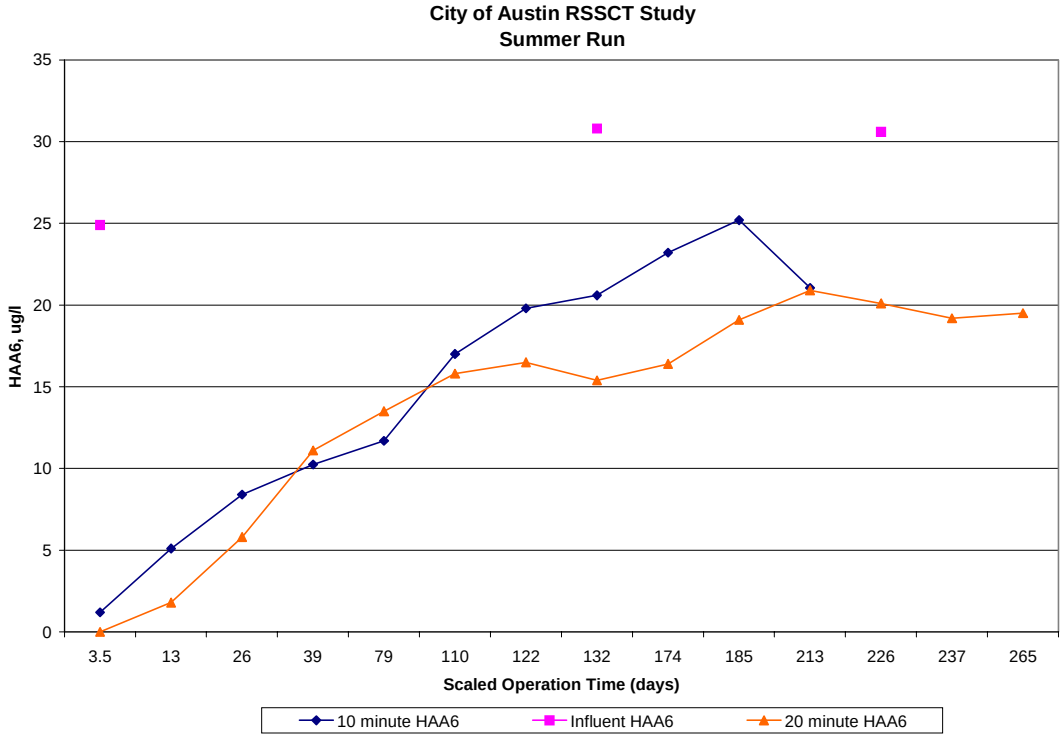

City of Austin RSSCT Study
Spring Run
TTHM4, ug/l
0
20
40
60
80
100
120
140
10
23
38
42
50
77
81
104
116
156
170
182
141
221
247
Scaled Operation Time (days)
Influent TTHM4
10 minute TTHM4
20 minute TTHM4

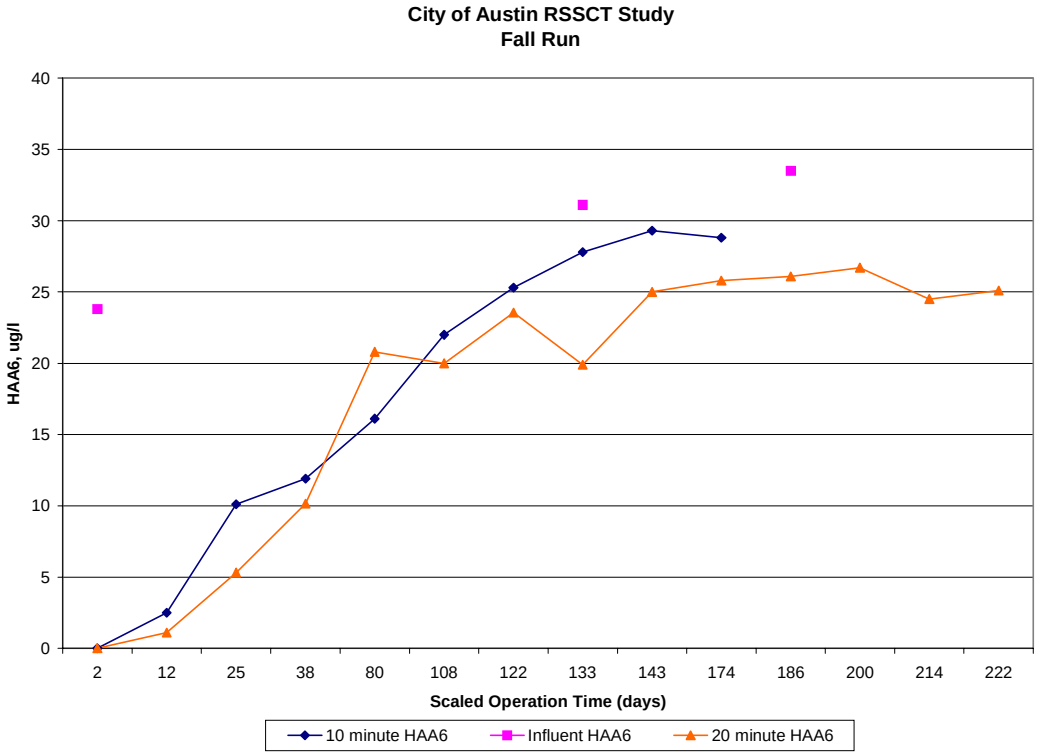

City of Austin RSSCT Study
Summer Run
TTHM4, ug/l
0
20
40
60
80
100
120
140
3.5
13
26
39
79
110
122
132
174
185
213
226
237
265
Scaled Operation Time (days)
Influent TTHM4
10 minute TTHM4
20 minute TTHM4

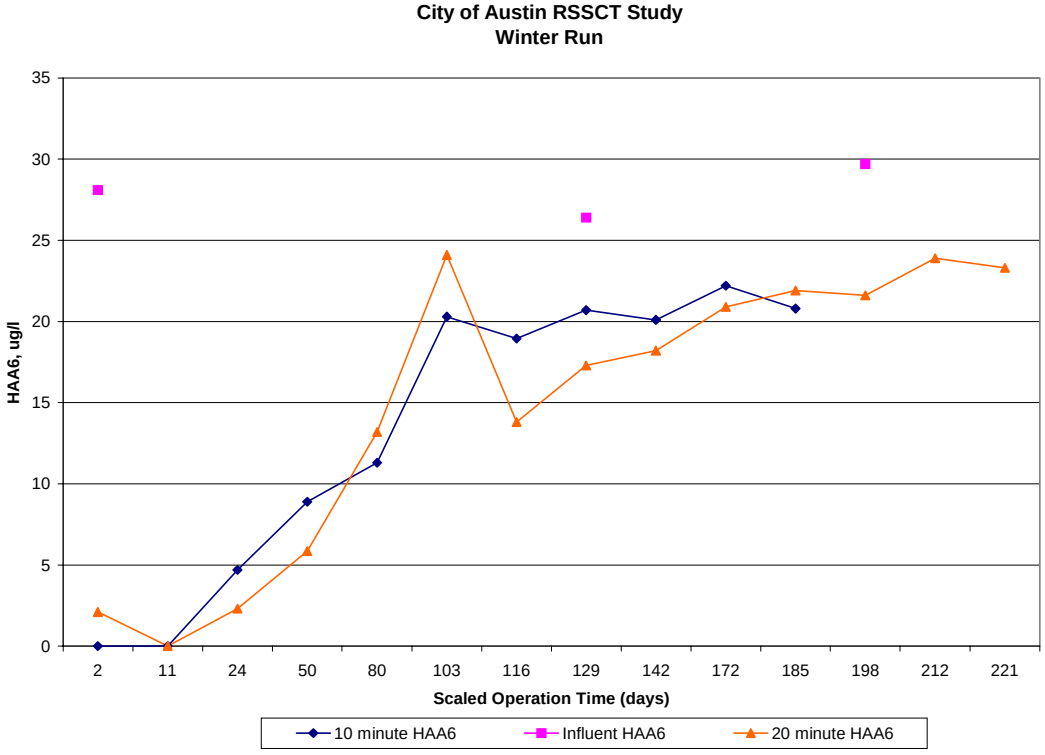

City of Austin RSSCT Study
Fall Run
TTHM4, ug/l
140
120
100
80
60
40
20
0
2
12
25
38
80
108
122
133
143
174
186
200
214
222
Scaled Operation Time (days)
Influent TTHM4
10 minute TTHM4
20 minute TTHM4


City of Austin RSSCT Study
Winter Run
TTHM4, ug/l
140
120
100
80
60
40
20
0
2
11
24
50
80
103
116
129
142
172
185
198
212
221
Scaled Operation Time (days)
Influent TTHM4
10 minute TTHM4
20 minute TTHM4


City of Austin RSSCT Study
Spring Run
HAA6, ug/l
90
80
70
60
50
40
30
20
10
0
10
23
38
42
50
77
81
104
116
156
170
182
141
221
247
Scaled Operation Time (days)
10 minute HAA6
Influent HAA6
20 minute HAA6


City of Austin RSSCT Study
Summer Run
HAA6, ug/l
35
30
25
20
15
10
5
0
3.5
13
26
39
79
110
122
132
174
185
213
226
237
265
Scaled Operation Time (days)
10 minute HAA6
Influent HAA6
20 minute HAA6


City of Austin RSSCT Study
Fall Run
HAA6, ug/l
40
35
30
25
20
15
10
5
0
2
12
25
38
80
108
122
133
143
174
186
200
214
222
Scaled Operation Time (days)
10 minute HAA6
Influent HAA6
20 minute HAA6


City of Austin RSSCT Study
Winter Run
HAA6, ug/l
35
30
25
20
15
10
5
0
2
11
24
50
80
103
116
129
142
172
185
198
212
221
Scaled Operation Time (days)
10 minute HAA6
Influent HAA6
20 minute HAA6

Appendix C

The QA/QC information for the analyses done in the bench study are as follows:

CALIBRATION VERIFICATION AND QUALITY CONTROL PROCEDURES - METHOD SPECIFIC -
City of Austin Water Quality Laboratory Services Divison

Performance Criteria ↓	Method → / Analytes	*TOC* SM 5310 C *TOC*	*UV 254* SM 5910 B *UV 254*	*Br* EPA 300.0 *Br*
	Target Analytes	**Total Organic Carbon (TOC)**	**UV Absorbance at 254 nm (UV254)**	**Bromide (Br^-)**
1.0 IDC (Initial Demonstration of Capability)				
1.1 IDLSB (Initial Demonstration of Low System Background)	**Method Blank**	< 1/2 MRL	< 1/2 MRL	<1/2 MRL (0.010 mg/l)
1.2 IDA (Initial Demonstration of Accuracy)	**QC check sample (external source)**	+/- 20% of true value	+/- 20% of true value	+/- 20% of true value
1.3 IDP (Initial Demonstration of Precision)	**No. of replicates**	5	5	5
	Spike conc.	TOC 4.00 mg/l	6.5 mg/L ± 0.5 mg/L DOC (Dissolved Organic Carbon)	Br 0.10 mg/l
	% RSD	< 20%	< 20%	<20%
	% Recovery	80-120	80-120	80-120%
	No. of replicates	7	7	7
	Spike conc.	0.50 mg/l	0.5 mg/L DOC (Dissolved Organic Carbon) = 0.009 cm^{-1}	0.020 mg/l
	% Recovery	50-100	50-150	50-150
2.0 MRL		0.50 mg/L	0.009 cm^{-1}	0.020 mg/l
3.0 Calibration Verification/ Frequency		Lowest level standard analyzed at the beginning, before first sample run. Mid level and high level analyzed alternately after 10th sample and after the last sample. Each level standard analyzed in duplicate.	All level standards analyzed at the beginning of each sample run. Each level standard analyzed in duplicate.	The low level calibration check standard is used to verify the calibration prior to the analysis of the first sample. Calibration verification is performed after every tenth sample and after the analysis of the last sample by alternating between the mid and high level calibration check standards.
Calibration Verification Concentrations and Acceptance Criteria		***TOC*** *(mg/L)* *(% rec.)* *(%RPD)*	***UV254*** *(cm^{-1})* *(% rec.)* *(%RPD)*	***Br*** *(mg/l)* *(%rec.)*
	Low	0.50 50-150 </= 20	0.009 75-125 </= 20	0.020 50-150
	MIdlevel	4.00 90-110 </= 10	0.088 85-115 </= 10	0.10 90-110
	High	10.00 90-110 </= 10	0.870 85-115 </= 10	0.30 90-110
4.0 Reagent (Method) Blank Frequency		one per analysis batch, in duplicate.	Initial zero; Check after each 10 samples.	1 per analysis batch
QC Criteria		< 1/2 of MRL (<0.25 mg/l)	< 1/2 of MRL (<0.0045 cm^{-1})	< 1/2 of MRL (< 0.010 mg/l)

5.0	**Shipping Blank**	**Travel Blank/ Field Reagent Blank**	NA	NA	NA
	QC Criteria		NA	NA	NA
6.0	**LFM**	**Fortified Sample**			
	Frequency		10 % per analysis batch	NA	5% of ICR samples
	Matrix spike Level		same concentration as mid level standard, (4.00 mg/l).	NA	Low Level: 0.020 mg/l Mid Level: 0.100 mg/l High Level: 0.300 mg/l
	QC criteria		NA	NA	NA
7.0	**Field/Lab Duplicate**		Lab duplicate	Lab duplicate	Lab duplicate
	Frequency		all samples analyzed in duplicate	all samples analyzed in duplicate	At least 5% of the samples in each analysis batch.
	% RPD		</= 20 % (TOC </=2.00 mg/l)	</= 20 % (UV_{254} </=0.045)	NA
	QC criteria		</= 10 % (TOC >2.00 mg/l)	</= 10 % (UV_{254} >0.045)	NA
8.0	**Internal Std.**		NA	NA	NA
	QC criteria		NA	NA	NA
9.0	**Surrogate Standards**		NA	NA	NA
	QC Criteria		NA	NA	NA
10.0	**Method Calibration Procedures**		TOC Concentration (mg/L)	NA	BR Concentration:mg/l Calibration is performed using 0.020, 0.100, 0.200 & 0.300 mg/l standards. A method BLK is analyzed, then an ICV (0.020 mg/l) is analyzed to verify the calibration.
			According to manufacturer's instructions. Primary calibration is performed with a 10.00 mg/l standard. A method blank is analyzed first, followed by a duplicate of the method blank. Then the low level standard, 0.50 mg/l and its duplicate. All must meet QC criteria to proceed.		
		Initial Calibration Curve	NA	NA	
		Standard 1			0.020 mg/l
		Standard 2			0.100 mg/l
		Standard 3			0.200 mg/l
		Standard 4			0.300 mg/l
		Standard 5			
		Standard 6			

CALIBRATION VERIFICATION AND QUALITY CONTROL PROCEDURES - METHOD SPECIFIC - Montgomery Watson Labs.

Performance Criteria		Method → / Analytes	EPA300.0 A, B *Br*	SM 6251B Haloacetic Acids *(HAA)*
		Target Analytes	Bromide (Br^-)	Monochloroacetic (MCAA) Dichloroacetic acid (DCAA) Dibromoacetic acid(TCAA) Trichloroacetic acid (TCAA) Monobromoacetic acid (MBAA) Bromochloroacetic acid (BCAA)
1.0	**IDC**			
1.1	**IDLSB**	**Method Blank**	< 1/2 MRL	< 1/2 MRL
1.2	**IDA**	**QC check sample (external source)**	+/- 20% of true value	+/- 20% of true value
1.3	**IDP**			
		No. of replicates	5	5
		Spike conc.	Br^- 0 .10 mg/L	20
		% RSD	< 20	< 20
		% Recovery	80-120	80-120
		No. of replicates	7	7
		Spike conc.	1/2 MRL	1/2 MRL
		% Recovery	50-150	50-150
2.0	**MRL**		Br: 0.020 mg/L	MCAA: 2.0 ug/L Others:1.0 ug/L
3.0	**Calibration Verification/ Frequency**		Lowest level std. analyzed at the beginning of each 24 hour- before first sample run Mid level and high level analyzed alternately after 10th sample and after the last sample.	Lowest level std. analyzed at the beginning of each 24 hour- before first sample run Mid level and high level analyzed alternately after 10th sample and after the last sample.
	Calibration Verification Concentrations and Acceptance Criteria		***Br-***	***MCAA***
			(mg/L) (% rec.)	***(ug/L) (% rec.)***
		Low	0.02 50-150	2.0 50-150
		MIdlevel	0.10 90-110	20 80-120
		High	0.30 90-110	32 80-120
				All others
				(ug/L) (% rec.)
		Low		1 50-150
		MIdlevel		20 80-120
		High		32 80-120
4.0	**Reagent (Method) Blank Frequency**		one per analysis batch	one per analysis batch (one per extraction batch)
	QC Criteria		< 1/2 of MRL	< 1/2 of MRL
5.0	**Shipping Blank**	**Travel Blank/ Field Reagent Blank**	NA	NA
	QC Criteria		NA	NA
6.0	**LFM**	**Fortified Sample**		
	Frequency		5 % per analysis batch	one sample per extraction batch
	Matrix spike Level		same concentration as cal verification. If no historical data for sample level, rotate low, mid, high as spike conc.	same concentration as cal verification. If no historical data for sample level, rotate low, mid, high as spike conc.
	QC criteria		NA	NA
7.0	**Field/Lab Duplicate**			

7.0	**Field/Lab Duplicate Frequency**		5% of the samples per analysis batch	one lab duplicate per extraction batch
	% RPD QC criteria		NA	NA
8.0	**Internal Std.**		NA	1,2-dibromopropane or 1,2,3-trichloropropane in each extract
	QC criteria		NA	+/- 30% of calibration curve AVG IS response
9.0	**Surrogate Standards**		NA	70-130 % 2,3-dibromopropionic acid
9.0	**Surrogate Standards QC Criteria**		NA	or 2,3,5,6-tetrafluorobenzoic acid in each sample 70-130 %
10.0	**Method Calibration Procedures**	**Initial Calibration Curve**	Bromide Concentration (mg/L)	MCAA Concentration (ug/L)
		Standard 1	0	2
		Standard 2	0.02	5
		Standard 3	0.05	10
		Standard 4	0.1	20
		Standard 5	0.3	40
		Standard 6	0.5	-
				All others Concentration (ug/L)
		Standard 1		1
		Standard 2		2
		Standard 3		5
		Standard 4		10
		Standard 5		20
		Standard 6		40

CALIBRATION VERIFICATION AND QUALITY CONTROL PROCEDURES - METHOD SPECIFIC
Montgomery Watson Laboratories

	Performance Criteria	Method	THMs EPA 551.1	TOX SM 5320B
		Analytes	***THM***	***TOX***
		Target Analytes	**Trihalomethanes (THMs)** Chloroform (CHCl3) Bromodichloromethane (BDCM) Dibromochloromethane(DBCM) Bromoform (CHBR3)	**Total Organic Halide (Dissolved Organic Halogen) (DOX)**
1.0	**IDC**			
1.1	**IDLSB**	**Method Blank**	< 1/2 MRL	< 1/2 MRL
1.2	**IDA**	**QC check sample**	+/- 20% of true value	+/- 20% of true value
1.3	**IDP**	**No. of replicates**	5	5
		Spike conc.	THM 20 ug/L	TOX 250 ug/L
		% RSD	< 20	< 20
		% Recovery	80-120	80-120
1.4	**MDL**			
		No. of replicates	7	7
		Spike conc.	1/2 MRL	1/2 MRL
		% Recovery	50-150	50-150
2.0	**MRL**		THM 1.0 ug/L Others: 0.5 ug/L	50 ug Cl^-/L 25 ug Cl^-/L (during treatment studies)
3.0	**Calibration Verification**	**Verification Frequency**	Lowest level std. analyzed at the beginning of each 24 hr before the first sample	3 microcoulometer titration cell checks with NaCl std at start of 8-10 hr. work shift. Lowest level std. analyzed before the first sample.
			Mid level and high level analyzed alternately after every 10th sample and last sample	Mid level and high level analyzed alternately after every 7th sample and last sample
		Conc. and QC criteria (%rec)	***THM***	***TOX***
			(ug/L) (% rec)	(ug Cl-/L) (% rec)
		Low	1.0 50-150	50 (25) 75-125
		Mid-level	20 80-120	200 85-115
		High	40 80-120	500 85-115
4.0	**Reagent (Method) Blank**	***Frequency***	One per analysis batch (one per extraction batch)	2 nitrate-washed activated carbon at the start of ea analysis batch, then 1 after every 7 samples (run in duplicate)- minimum of 3 per day; Analyze 1 system blank per analysis batch.
		QC criteria	< 1/2 MRL	<0.80 ug/Cl-/40 mg of activated carbon; < 1/2 of MRL, <25 or < 12.5
5.0	**Shipping Blank Criteria**	**Travel Blank**	NA	NA
6.0	**LFM Frequency**	***Fortified Sample***	one sample in each extraction batch	at least 5% of all ICR samples analyzed each quarter (fortified sample analyzed in duplicate

6.0	**LFM**	***Fortified Sample***		
	Frequency		one sample in each extraction batch	at least 5% of all ICR samples analyzed each quarter (fortified sample analyzed in duplicate
	Matrix spike level		same concentration as cal verification. If no historical data for sample level, rotate low, mid, high as spike conc.	same concentration as cal verification. If no historical data for sample level, rotate low, mid, high as spike conc.
	QC criteria	**% Recovery**	NA	NA
7.0	**Lab (Field) Duplicate**		field duplicate	lab duplicate
	QC Criteria	**% RPD**	NA	NA
8.0	**Internal Std.**		BFB if pentane solvent is used; Optional if MTBE is the extracting solvent	NA
	QC Criteria	**IS Recoveries**	+/- 30% of calibration curve AVG IS response	NA
			70-130 % Rec.	
9.0	**Surrogate QC Standards**		decafluorobiphenyl in ea sample	NA
		Surrogate Recoveries	70-130 % Rec.	NA
10.0	**Method Calibration Procedures Trihalomethane**	**Initial Calibration Curve**	THMs: CHCL3, BDCM Concentration (ug/L)	
		Standard 1	0.5	
		Standard 2	1	
		Standard 3	2	
		Standard 4	5	
		Standard 5	10	
		Standard 6	20	
		Standard 7	30	
		Standard 8	40	
		Standard 9	50	
			THMs: DBCM, CHBR3 Concentration (ug/L)	
		Standard 1	0.25	
		Standard 2	0.5	
		Standard 3	1	
		Standard 4	2.5	
		Standard 5	5	
		Standard 6	10	
		Standard 7	15	
		Standard 8	20	
		Standard 9	25	