ICR Treatment Study Summary Report

Evaluation of GAC Using the Rapid Small-Scale Column Test for Compliance with the Information Collection Rule

Conducted during the period of March 8, 1996 through December 9, 1996

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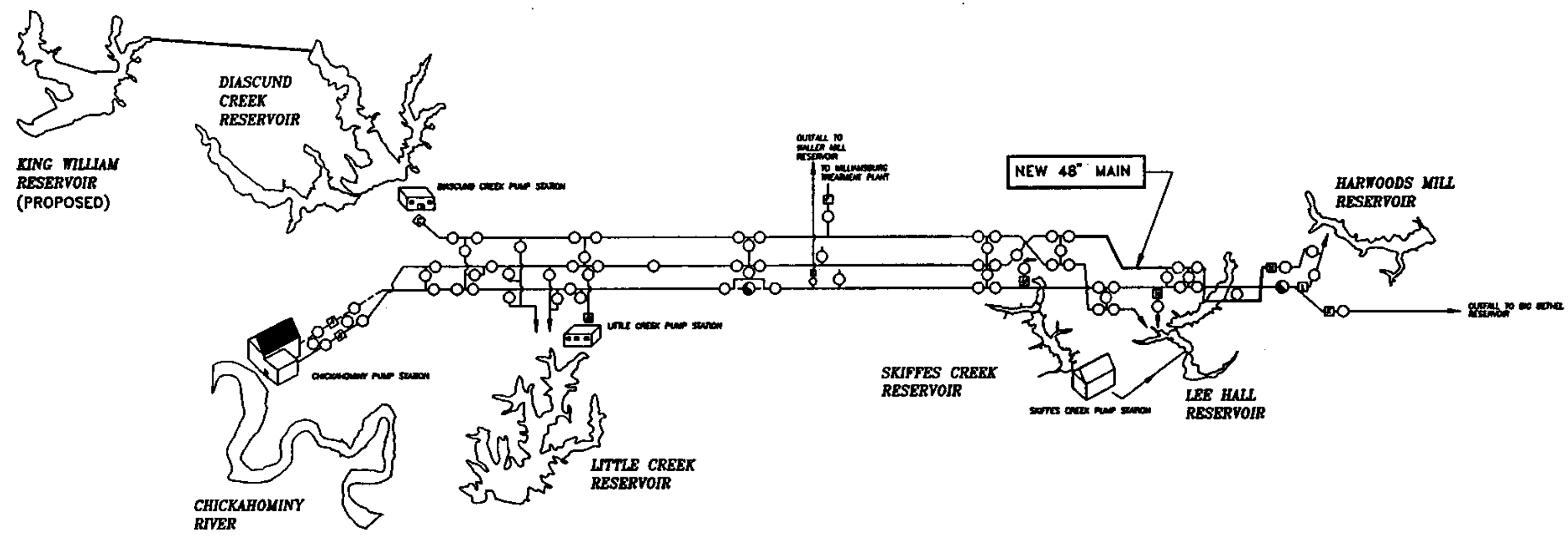
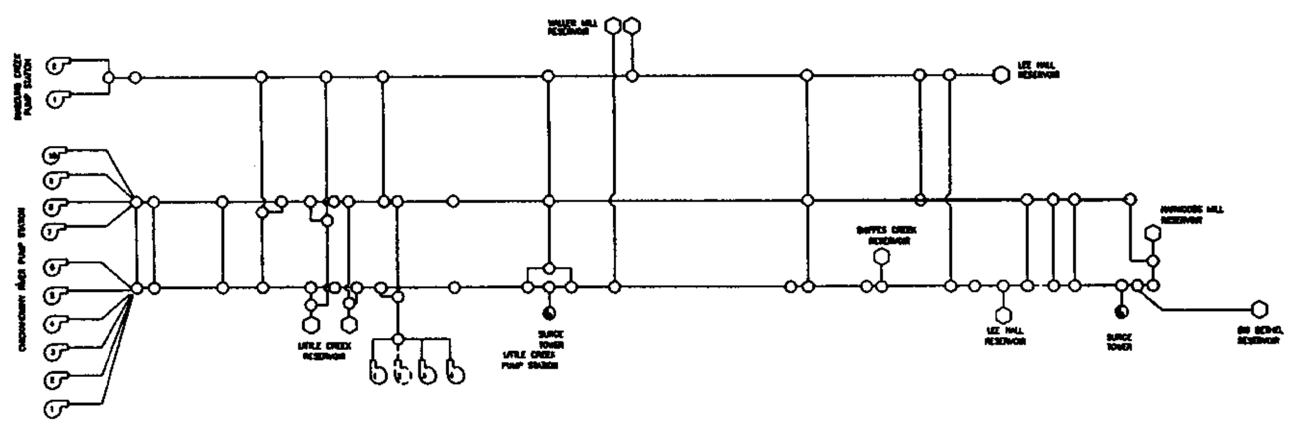
MALCOLM PIRNIE

November 1997





List of Improvements

1. Complete Contract 44, Phase 3.

Year 1997
Complete Contract 44, Phase 3.
Figure 6-1

MONTGOMERY WATSON

Table 5-1 General Public Water System And Plant Information (page 1 of 2)

Public Water System Information

Utility name	City of Newport News Waterworks
PWSID#	VA0050032
WIDB# (optional)	
PWS combined population served	360,000
PWS ground water population served	0

Official Contact Person

Name	Brian L. Ramaley, P.E.
Mailing address	Director 2600 Washington Ave., sixth floor Newport News, VA 23607
Phone #	(757) 247-8545
FAX #	(757) 867-9271
E-mail address	bramaley@ci.Newport_News.VA.US

ICR Contact Person

Name	Michael L. Hotaling, P.E.
Mailing address	Water Production Manager 3629 George Washington Memorial Highway
Phone #	(757) 867-6990
FAX #	(757) 867-9271
E-mail address	mhotaling@ci.Newport_News.VA.Us

Treatment Plant Information

Plant name	Lee Hall Water Treatment Plant
Plant ICR #	673
Plant combined population served	200,000
Plant ground water population served	0
Plant surface water population served	200,000

Plant Contact Person

Name	Michael L. Hotaling, P.E.
Mailing address	(same as above)
Phone #	
FAX #	
E-mail address	

Table 5-1 General Public Water System And Plant Information (page 1 of 2)

Public Water System Information

Utility name	City of Newport News Waterworks
PWSID#	VA3700500
WIDB# (optional)	1555
PWS combined population served	360,000
PWS ground water population served	0

Official Contact Person

Name	Brian L. Ramaley, P.E.
Mailing address	Director 2600 Washington Ave., sixth floor Newport News, VA 23607
Phone #	(757) 247-8545
FAX #	(757) 247-2424
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ICR Contact Person

Name	Michael L. Hotaling, P.E.
Mailing address	Water Production Manager 3629 George Washington Memorial Highway Yorktown, VA 23693
Phone #	(757) 867-6990
FAX #	(757) 867-9271
E-mail address	mhotaling@ci.newport news.Va.Us

Treatment Plant Information

Plant name	Harwood's Mill Treatment Plant
Plant ICR #	675
Plant combined population served	160,000
Plant ground water population served	0
Plant surface water population served	160,000

Plant Contact Person

Name	Michael L. Hotaling, P.E.
Mailing address	(same as above)
Phone #	
FAX #	
E-mail address	

Table 5-2 Treatment Study Applicability Data Reporting Form (page 1 of 2)

Utility name	Newport News Waterworks	PWSID #	VA0050032
Plant name	Lee Hall	Plant ICR #	673
Plant surface water population served	200,000	Plant ground water population served	---

Monthly TOC (mg/L) Applicability Monitoring [1]

Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12	Average
9.73	7.70	8.78	7.76	7.03	6.11	4.70	4.92	6.81	7.45	6.78	6.75	7.07

1 TOC monitoring is to be conducted on the treatment plant influent for surface waters and on the finished water for ground waters.

Monthly UFCTOX (μg/L) Applicability Monitoring [2,3]

Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12	Average

2 UFCTOX monitoring may be required if a treatment plant is trying to qualify for a common source designation.

3 UFCTOX monitoring is to be conducted on the treatment plant influent for surface waters and on the finished water for ground waters.

Quarterly DBP (μg/L) Applicability Monitoring [4]

	Date of sample collection	Max[5] DSS THM4	1st Avg[6] DSS THM4	2nd Avg[6] DSS THM4	3rd Avg[6] DSS THM4	Max[5] DSS HAA5	1st Avg[6] DSS HAA5	2nd Avg[6] DSS HAA5	3rd Avg[6] DSS HAA5	Quarterly average THM4	Quarterly average HAA5
1st quarter											
2nd quarter											
3rd quarter											
4th quarter											
yearly avg.											

4 Treatment plants that use only chlorine as the primary and residual disinfectant may monitor THM4 and HAA5 to determine applicability.

5 The Max DSS (distribution system sample) point must be representative of the maximum residence time for the treatment plant.

6 The three Avg DSS sample locations must be representative of the average residence time for the treatment plant.

Table 5-2 Treatment Study Applicability Data Reporting Form (page 1 of 2)

Utility name: Newport News Waterworks

Plant name: Harwood's Mill

Plant surface water population served: 160,000

PWSID #: VA 0005975

Plant ICR #: 675

Plant ground water population served:

Monthly TOC (mg/L) Applicability Monitoring [1]

Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12	Average
6.67	7.93	7.13	6.44	6.98	5.75	4.43	5.04	6.85	7.29	6.67	8.13	6.47

1 TOC monitoring is to be conducted on the treatment plant influent for surface waters and on the finished water for ground waters.

Monthly UFCTOX (μg/L) Applicability Monitoring [2,3]

Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12	Average

2 UFCTOX monitoring may be required if a treatment plant is trying to qualify for a common source designation.

3 UFCTOX monitoring is to be conducted on the treatment plant influent for surface waters and on the finished water for ground waters.

Quarterly DBP (μg/L) Applicability Monitoring [4]

	Date of sample collection	Max[5] DSS THM4	1st Avg[6] DSS THM4	2nd Avg[6] DSS THM4	3rd Avg[6] DSS THM4	Max[5] DSS HAA5	1st Avg[6] DSS HAA5	2nd Avg[6] DSS HAA5	3rd Avg[6] DSS HAA5	Quarterly average THM4	Quarterly average HAA5
1st quarter											
2nd quarter											
3rd quarter											
4th quarter											
yearly avg.											

4 Treatment plants that use only chlorine as the primary and residual disinfectant may monitor THM4 and HAA5 to determine applicability.

5 The Max DSS (distribution system sample) point must be representative of the maximum residence time for the treatment plant.

6 The three Avg DSS sample locations must be representative of the average residence time for the treatment plant.

Table 5-6 Application For Multiple Plants Owned By A Single PWS And Operating On A Common Source To Conduct A Single Treatment Study[1]

Plants Applying to Conduct a Single Common Source Study[2]

Plant name	Plant ICR #	PWSID #	Plant population served
Harwood's, Mill Water Treatment	675	VA0005975	160,000
~~Lee Hall Water Treatment Plant~~	673	VA0050032	200,000

Proposed Studies to be Conducted[3,4]

Technology to be investigated (GAC or membranes)	Scale of study (pilot or bench)
GAC	Bench

1 Only one application accompanied by one common source application, Table 5-10, should be submitted.

2 Each cooperating plant must submit Table 5-1 with this application.

3 A study concept form, Table 5-11, must be submitted for each proposed study to be conducted during the common source study.

4 Only one treatment study is required for multiple plants owned by a single PWS and operating on a common source. If the largest plant serves at least 500,000 persons, then the single study for multiple plants must be a pilot-scale study.

Table 5-10 Common Source Designation Application

Source water name: Chickahominy River/Diascund Reservoir/Little Creek Reservoir

Source water type: River/Reservoir/Reservoir

List of Plants Applying for a Common Source Designation[1]

Plant name	Plant ICR #	PWSID #	Average TOC[2] (mg/L)	Average UFCTOX[3] (ug/L)	River miles to the intake of the most distant plant[4]
Lee Hall	673	VA0050032	7.07	----	n/a
Harwood's Mill	675	VA0005975	6.47	-----	n/a

Mean of all average plant TOC values (mg/L)	6.83
90% of the mean TOC (mg/L)	6.15
110% of the mean TOC (mg/L)	7.51

Mean of all average plant UFCTOX values (ug/L)	
90% of the mean UFCTOX (ug/L)	
110% of the mean UFCTOX (ug/L)	

1 All plants applying for a common source designation must also submit Table 5-1.

2 The TOC requirement is for plants using (1) river sources with intakes less than 20 river miles apart, (2) lakes and reservoirs, and (3) ground water resources.

3 The UFCTOX requirement is for plants using river sources with intakes between 20 and 200 river miles apart.

4 Plants operating on a common river source must report the distance, in river miles, from the intake of each cooperating plant to the most distant intake of a cooperating plant.

Table 5-11 Study Concept Form[1]

General Study Information

Is this an individual or a joint study?	single study for multiple plants
Will GAC or membranes be investigated?	GAC
Is this a pilot- or a bench-scale study?	Bench
At what point in the full-scale plant will water be collected for the study?	settled water
Where is the first point that chlorine is added in the full-scale plant?	prior to filtration
Will the treatment study influent be collected prior to the addition of chlorine based oxidants?	yes
What is the average TOC concentration of the treatment study influent?	6.5
How many tests will be required to evaluate seasonal variability?	12 monthly tests

GAC Study Information

Carbon type and manufacturer to be investigated	calgon F816
Carbon particle diameter	0.11 mm
Carbon column diameter	11 cm

Membrane Study Information

Procedure to be used (RBSMT, SEBST, pilot)	
Element size to be investigated	
Model number and manufacturer of membrane #1	
Molecular weight cutoff of membrane #1	
Model number and manufacturer of membrane #2	
Molecular weight cutoff of membrane #2	

Study Plan

Attach a brief study plan (usually not more than two pages of text and two pages of figures) which should include the equipment to be used, pretreatment to be used prior to GAC or membranes, design parameters, operating parameters, whether or not seasonal variability need to be evaluated and if seasonal variability can be evaluated in fewer than four quarters, the parameters that will be investigated in lieu of seasonal variability.

1 One study concept form must be submitted for each study to be conducted.

I. CONCLUSIONS AND RECOMMENDATIONS

RSSCT testing was performed using procedures presented in the *Draft ICR Guidance Manual - 5.0 Bench-Scale GAC Test Protocol*. No extraordinary results were observed, and the results of the study exhibited the following generally expected trends:

- ➢ RSSCT column influent TOC ranged from 3.0 to 4.2 mg/L, and the non-adsorbable fraction of TOC was approximately 15 percent of the influent concentration or 0.5 to 0.6 mg/L. The TTHM and HAA6 formation potentials of the column influent ranged from 160 to 179 µg/L and from 68 µg/L to 107 µg/L, respectively, and the non-adsorbable fraction of THM and HAA6 precursors ranged from 1 to 18 µg/L and 1 to 13 µg/L, respectively. These results indicate that the relative amount of THM and HAA precursor material is lower in the non-adsorbable fraction of TOC.

- ➢ UV breakthrough occurred later than TOC breakthrough, and THM and HAA breakthrough appear to correlate better with UV breakthrough than TOC breakthrough.

- ➢ THM precursor material exhibited more rapid breakthrough than HAA precursor material, and based on proposed Stage II MCLs, THM levels controlled bed life.

- ➢ Although increasing the EBCT from 10 to 20 minutes increased the run time, the number of bed volumes processed was similar, except in the second quarter when the bed volumes to breakthrough were 108 percent and 60 percent higher for THMs and HAAs, respectively.

The RSSCT results from this study indicate that GAC is an effective technology for THM and HAA control. Enhanced microbial protection is also, however, a primary goal for Newport News Waterworks, and an additional technology would be required to address this issue. A recently completed study compared the feasibility of several alternatives for meeting future regulatory requirements and improving the overall quality of water produced. Treatment strategies considered included:

- ▸ Conventional treatment with ozone and biological filtration with chloramine secondary disinfection

- ▸ Membrane filtration (with and without pretreatment) with chloramine secondary disinfection

- ▸ Membrane filtration (with and without pretreatment) followed by nanofiltration with free chlorine secondary disinfection

Based on reliability, flexibility, consistency and economics, conventional treatment with ozone and biological filtration with chloramine for secondary disinfection was selected as the treatment strategy for the existing Harwood's Mill WTP and a new facility (currently in final design) planned to replace the existing Lee Hall WTP. The selected treatment strategy will provide 2-log *Cryptosporidium* inactivation and meet the proposed Stage II TTHM and HAA5 MCLs of 40 µg/L and 30 µg/L, respectively.

II. BACKGROUND INFORMATION

Newport News Waterworks (VA3700500) operates two water treatment plants: Lee Hall Filtration Plant (ICR No. 673/VA0050032) and Harwood's Mill Water Treatment Plant (ICR No. 675/VA0005975). The estimated population serviced by each facility is greater than 100,000. The Information Collection Rule requires that both plants monitor for disinfection by-products (DBP) and microbiological water quality parameters and conduct treatability testing for the removal of DBP precursors. Because the raw water for both plants comes from a common source[1] and historical data suggests that the raw water TOC concentrations for the two plants are within 10 percent, a joint precursor removal study was conducted for the two plants[2].

Treatment Plant Description Facilities at Harwood's Mill Treatment Plant include raw water intake and pumps, preoxidation basins, in-line flash mixers, upflow solids contact clarifiers (*Super-pulsators*), multi-media filters, finished water storage, and high service pumping facilities. Chemical feed facilities in order of application include: potassium permanganate, alum, coagulant-aid, powdered activated carbon, filter-aid polymer, chlorine (gaseous), lime, zinc orthophosphate, and fluosilicic acid. Ammonia feed facilities for conversion of secondary disinfection from free chlorine to chloramines are currently under construction. A schematic of the Harwood's Mill Treatment Plant indicating the points of chemical addition and sample collection for the treatability testing is shown on Figure 1. Lee Hall Filtration Plant is also a conventional filtration facility with similar chemical additions as indicated in Figure 2. Tables 1 and 2 list plant design parameters for Harwood's Mill and Lee Hall, respectively, and Tables 3 and 4 provide plant chemical parameters.

DBP control has been a key challenge for Waterworks. A planned conversion to chloramines for secondary disinfection is anticipated to bring TTHM and HAA5 levels below the proposed Stage I D/DBP Rule MCLs and future installation of ozone and biological filtration will bring DBP levels below Stage II MCLs. Increased microbial

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[1]Table 5-6 *Application for Multiple Plants Owned by a Single PWS and Operated on a Common Source to Conduct a Single Treatment Study* and Table 5-10 *Common Source Designation Application* will be submitted with all other required applications and documentation at a later date.

[2]Table 5-9 *Grandfathered Treatment Study Application* and a treatability testing study description was submitted to EPA and accepted (February 1997).

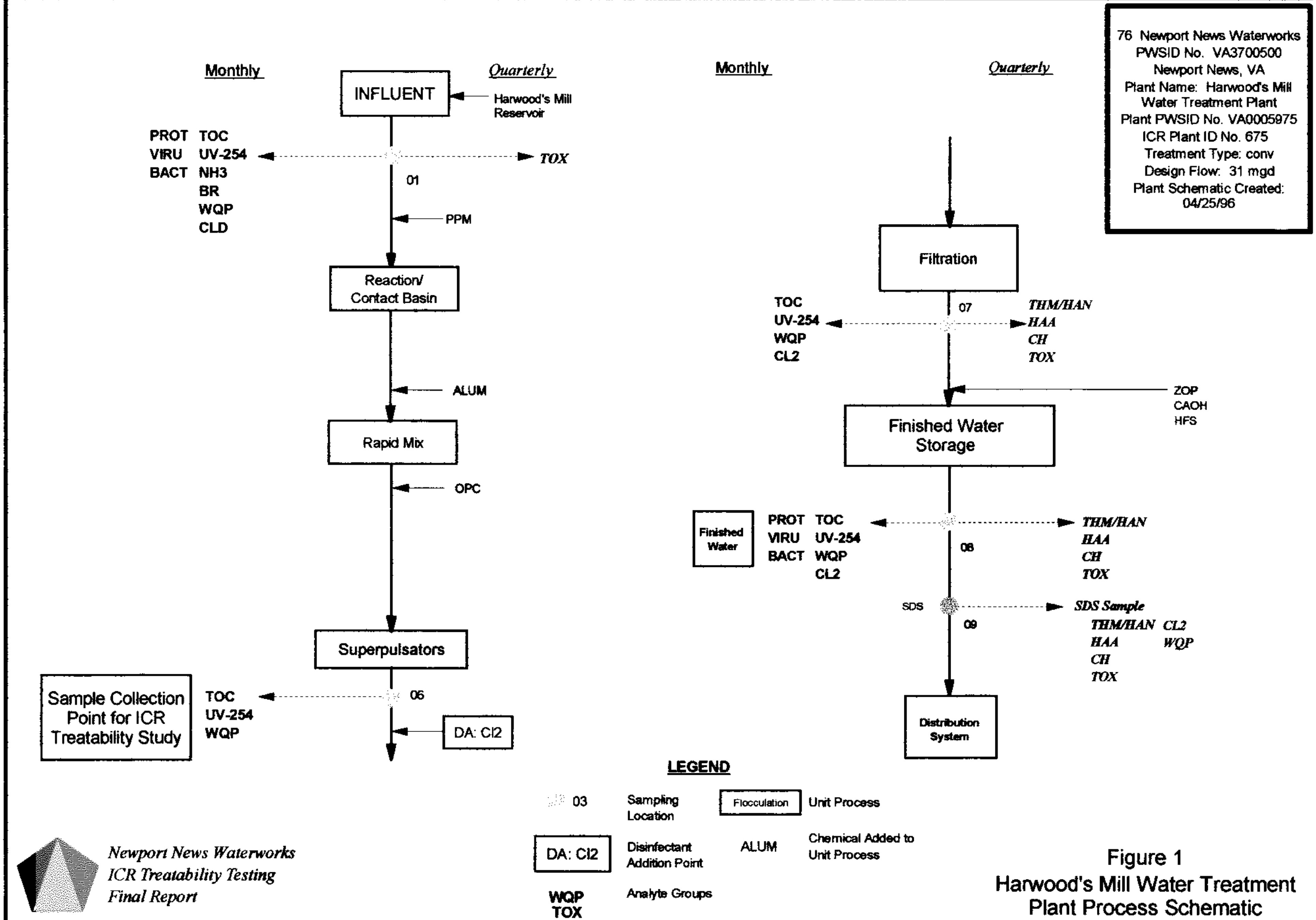


Figure 1
Harwood's Mill Water Treatment Plant Process Schematic

TABLE 1
HARWOOD'S MILL DESIGN PLANT PARAMETERS

Treatment Plant Name: Harwood's Mill **ICR Treatment Plant ID:** 675 **Treatment Plant PWS ID:** VA005975 **Treatment Plant Category:** CONV		**State Approved Plant Capacity (MGD):** 31.0 **Historical Min. Water Temperature (deg C):** 3.3 **Installed Sludge Handling Capacity (DPD):** 17,500.00 **Blending Indicator:** N	
Water Resource Name: Harwood's Mill Reservoir **Water Resource Type:** Reservoir/lake **Average Residence Time (Days):** 27 **Intake Name:** Raw Water Pumping Station **Watershed Control:** Y		**Hydrologic Unit Code:** 02080206 **River Reach:** **Latitude (degrees, minutes, seconds):** +37°8'56" **Longitude (degrees, minutes, seconds):** -76°28'41" **River Reach Miles:**	
Seq. No.	**Sample Location Name**	**Sample Location Type**	**Sample Loc. No.**
	Influent	INF	1
Process Train Name: Harwood's Mill **Process Train Category:** CONV			
1	Contact Basin	Disinfection Contact Basin	Surface Area (ft^2): 9,000 Liquid Volume (gal): 1,077,200 Baffling Type: SP Short Circuiting Factor: 0.7
2	Rapid Mix	Rapid Mix	Type of Mixer: ME Baffling Type: PF Liquid Volume (gal): 633 Short Circuiting Factor: 1.0 Mean Velocity Gradient (sec^{-1}): 3,170.0

TABLE 1
HARWOOD'S MILL DESIGN PLANT PARAMETERS

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.
3	Superpulsator	Solids Contact Clarifier	16 Clarifier Type: Not specified Brand Name: Infilco Degremont Surface Area (ft^2): 9,494 Liquid Volume (gal): 1,278,320 Short Circuiting Factor: 0.5 Baffling Type: AV Plate Settler Surface Area (ft^2): Tube Settler Surface Area (ft^2): Plate Settler Brand Name: Infilco Degremont Tube Settler Brand Name:
4	Chlorine gas	Disinfectant Addition	Chemical Code: CL_2 Measurement Formula: CL_2 Dose Rate (mg/L): 7.00
5	Filtration	Filtration	7 Surface Area (ft^2): 5,389 Liquid Volume (gal): 634,878 Total Media Depth (in): 27 Depth of GAC (in): Media Type: TRIM Type of Activated Carbon: Minimum Water Depth To Top of Media (ft): 12.0 Depth From Top of Media to Top of Backwash Trough (ft): 3.5
6	Clearwell	Clearwell	Surface Area (ft^2): 40,000 Liquid Volume (gal): 6,000,000 Minimum Liquid Volume (gal): 1,000,000 Baffling Type: SP Short Circuiting Factor: 0.7 Covered Indicator Code: Y
	Finished Water	FIN	8

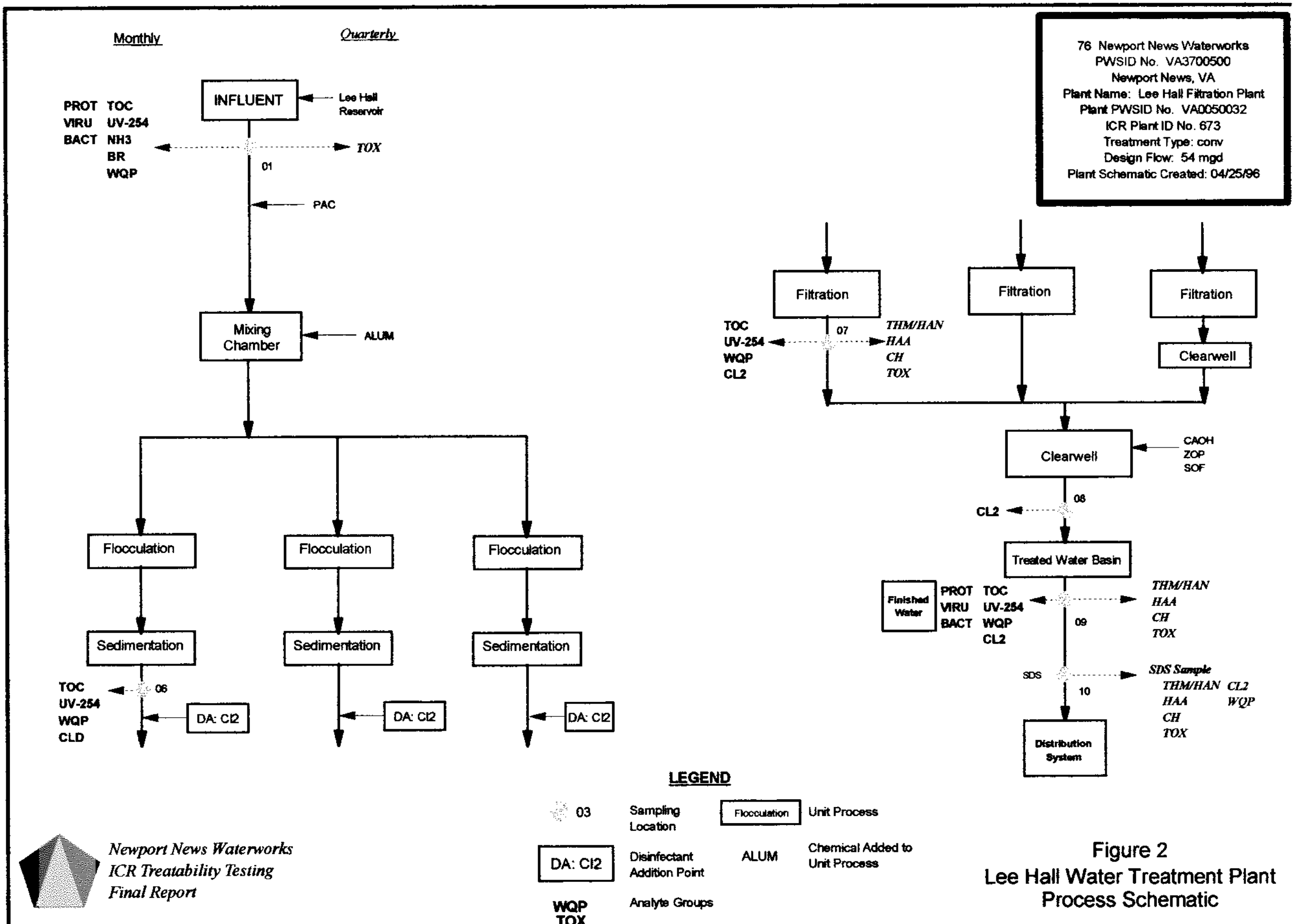


Figure 2
Lee Hall Water Treatment Plant
Process Schematic

TABLE 2
LEE HALL DESIGN PLANT PARAMETERS

Treatment Plant Name: Lee Hall **ICR Treatment Plant ID:** 673 **Treatment Plant PWS ID:** VA0050032 **Treatment Plant Category:** CONV		**State Approved Plant Capacity (MGD):** 54.0 **Historical Min. Water Temperature (C):** 3.3 **Installed Sludge Handling Capacity (DPD):** 34,000.00 **Blending Indicator:** N	
Water Resource Name: Lee Hall Reservoir **Water Resource Type:** Reservoir/lake **Average Residence Time (Days):** 24 **Intake Name:** Raw Water Pump Station **Watershed Control:** Y		**Hydrologic Unit Code:** 54.0 **River Reach:** **Latitude (degrees, minutes, seconds):** +37°10'12" **Longitude degrees, minutes, seconds):** -76°33'25" **River Reach Miles:**	
Seq. No.	**Sample Location Name**	**Sample Location Type**	**Sample Loc. No.**
	Influent	INF	1
Process Train Name: Lee Hall			
Process Train Category: CONV			
1	Rapid Mix	Rapid Mix	Type of Mixer: ME Baffling Type: AV Liquid Volume (gal): 30,518 Short Circuiting Factor: 0.5 Mean Velocity Gradient (sec^{-1}): 100.0
2	Flocculation	Flocculation Basin	Type of Mixer: ME Liquid Volume (gal); 1,101,564 Short Circuiting Factor: 0.5 Baffling Type: AV Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec^{-1}): 30 Stage Liquid Volume (gal): 1,101,564

TABLE 2
LEE HALL PLANT PARAMETERS

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
3	Sedimentation	Sedimentation	6	Surface Area (ft^2): 70,600 Liquid Volume (gal): 7,577,276 Baffling Type: PR Short Circuiting Factor: 0.3 Plate Settler Surface Area (ft^2): Plate Settler Brand Name: Tube Settler Surface Area (ft^2): Tube Settler Brand Name:
4	Chlorine Gas	Disinfectant Addition		Chemical Code: CL_2 Measurement Formula: CL_2 Dose Rate (mg/L): 7.00
5	Filtration	Filtration	7	Surface Area (ft^2): 11,952 Liquid Volume (gal): 560,452 Total Media Depth(in): 30 Depth of GAC (in): Media Type: TRIM Type of Activated Carbon: Minimum Water Depth To Top of Media (ft): 6.2 Depth From Top of Media to Top of Backwash Trough (ft): 2.9
6	Clearwell	Clearwell		Surface Area (ft^2): 8,021 Liquid Volume (gal): 600,00 Baffling Type: PR Short Circuiting Factor: 0.3 Covered Indicator Code: Y
	Finished Water	FIN	9	

TABLE 3
LEE HALL DESIGN PLANT CHEMICAL PARAMETERS

Sep. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)
Treatment Plant Name: Lee Hall **ICR Treatment Plant ID No:** 673 **Treatment Plant Category:** CONV **Process Train Name:** Lee Hall **Process Train Category:** CONV						
1	Rapid Mix	Rapid Mix		Aluminum sulfate (Alum)	AL2(SO4)3*14H20	45.00
2	Flocculation	Flocculation Basin				
3	Sedimentation	Sedimentation	6			
4	Chlorine gas	Disinfectant Addition		Chlorine gas	CL_2	7.00
5	Filtration	Filtration	7			
6	Clearwell	Clearwell				
				Zinc orthophosphate Sodium fluoride Calcium hydroxide	ZOP as F CaOH	2.00 0.90 27.30

TABLE 4
HARWOOD'S MILL DESIGN PLANT CHEMICAL PARAMETERS

Sep. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)
Treatment Plant Name: Harwood's Mill **ICR Treatment Plant ID No:** 675 **Treatment Plant Category:** CONV **Process Train Name:** Harwood's Mill **Process Train Category:** CONV						
1	Contact Basin	Disinfection Contact Basin				
2	Rapid Mix	Rapid Mix				
3	Superpulsator	Solids Contact Clarifier	16	Aluminum sulfate (Alum)	AL2(SO4)3*14H2O	45.00
4	Chlorine gas	Disinfectant Addition		Organic polymer-coagulant aid	as Product	0.10
5	Filtration	Filtration	7	Chlorine gas	CL_2	7.00
6	Clearwell	Clearwell				
				Zinc orthophosphate Hyfrofluorosilic acid Calcium hydroxide	ZOP as F CaOH	2.00 0.90 10.00

protection is also a goal for Waterworks, and the planned addition of ozone will increase the level of disinfection.

Source and Finished Water Quality The source water for these plants is a surface water broadly characterized as having moderate TOC, low to moderate alkalinity, and low turbidity. Tables 5 and 6 summarize typical water quality parameters for raw and finished water for the Harwood's Mill WTP.

TABLE 5
HARWOOD'S MILL RAW WATER QUALITY SUMMARY - 1996

Water Quality Parameter	Average Yearly Concentration	Standard Deviation	Maximum Yearly Value	Minimum Yearly Value
Temperature (°C)	17.4	6.2	28.3	4.0
pH	7.2	0.3	7.9	6.8
Turbidity (NTU)	4.0	2.3	9.6	1.1
Alkalinity (mg/L as $CaCO_3$)	39	5.6	45	32
Calcium Hardness (mg/L as $CaCO_3$)	38	2.1	44	34
Total Hardness (mg/L as $CaCO_3$)	61	11.6	76	49
TOC (mg/L)	7.1	0.9	9.4	6.0
UV254 (cm^{-1})	0.24	0.08	0.43	0.15
Bromide (µg/L)	NA	NA	NA	NA

TABLE 6
HARWOOD'S MILL FINISHED WATER QUALITY SUMMARY - 1996

Water Quality Parameter	Average	Standard Deviation	Maximum	Minimum
Temperature (C)	17.4	6.2	28.3	4
pH	6.8	0.5	7.5	6.0
Turbidity (NTU)	0.09	0.02	0.25	0.05
TOC (mg/L)	3.4	0.3	3.9	3.0
Distribution System THM4 (µg/L)	105	40	214	46

III. Materials and Methods

<u>Pretreatment and Advanced Process Information</u> RSSCTs were performed using procedures presented in the *Draft ICR Guidance Manual - 5.0 Bench-Scale GAC Test Protocol*. The tests were performed quarterly for one year at the Harwood's Mill Treatment Plant using water collected from the full-scale facility after clarification and prior to chlorine addition and filtration. The RSSCT apparatus included a 1 μm cartridge prefilter to simulate filtration and prevent excessive pressure build-up in the RSSCT columns. RSSCT testing was run in parallel mode, with glass beads (control) and 10- and 20-minute GAC columns run concurrently on the same batch of water. Figure 3 is a schematic of the preatreatment and advanced processes.

The RSSCT apparatus was constructed using three 11 mm diameter glass chromatography columns outfitted with Teflon fittings and tubing. The columns were attached to a vertical board, and water to be tested was pumped via gear pump from 55-gallon drums through a 1 μm cartridge filter and into the columns. The columns were connected in parallel, with flow rate and distribution controlled by needle valves on the effluent of each column.

Glass beads were added to one of the three columns to produce a control sample. GAC was added to the other two columns to allow RSSCT evaluation of GAC treatment at 10- and 20-minute EBCTs. Using the data provided in Table 5-2[3] of the *Draft ICR Guidance Manual*, carbon was pulverized, sieved, and added to columns. A summary of the RSSCT design and operating parameters is included in Table 7.

TABLE 7
STUDY DESIGN AND OPERATING PARAMETERS

Parameter	Value
Sieve Size	100x200
Carbon Diameter (d_{SC}, mm)	0.11
Flow Rate[4] (Q_{SC}, mL/min)	11.5
$EBCT_{LC}$ = 10 min.	
$EBCT_{SC}$ (min)	0.7

[3]Table 5-2. RSSCT design for full-scale 8x30 mesh GAC (d_{LC} = 1.6 mm)

[4]Per 11 mm diameter column

76 Newport News Waterworks
PWSID No. VA3700500
Newport News, VA
Plant Name: Harwood's Mill Water Treatment Plant
Plant PWSID No. VA0005975
ICR Plant ID No. 675
Treatment Type: conv
Design Flow: 31 mgd
Plant Schematic Created: 04/25/96

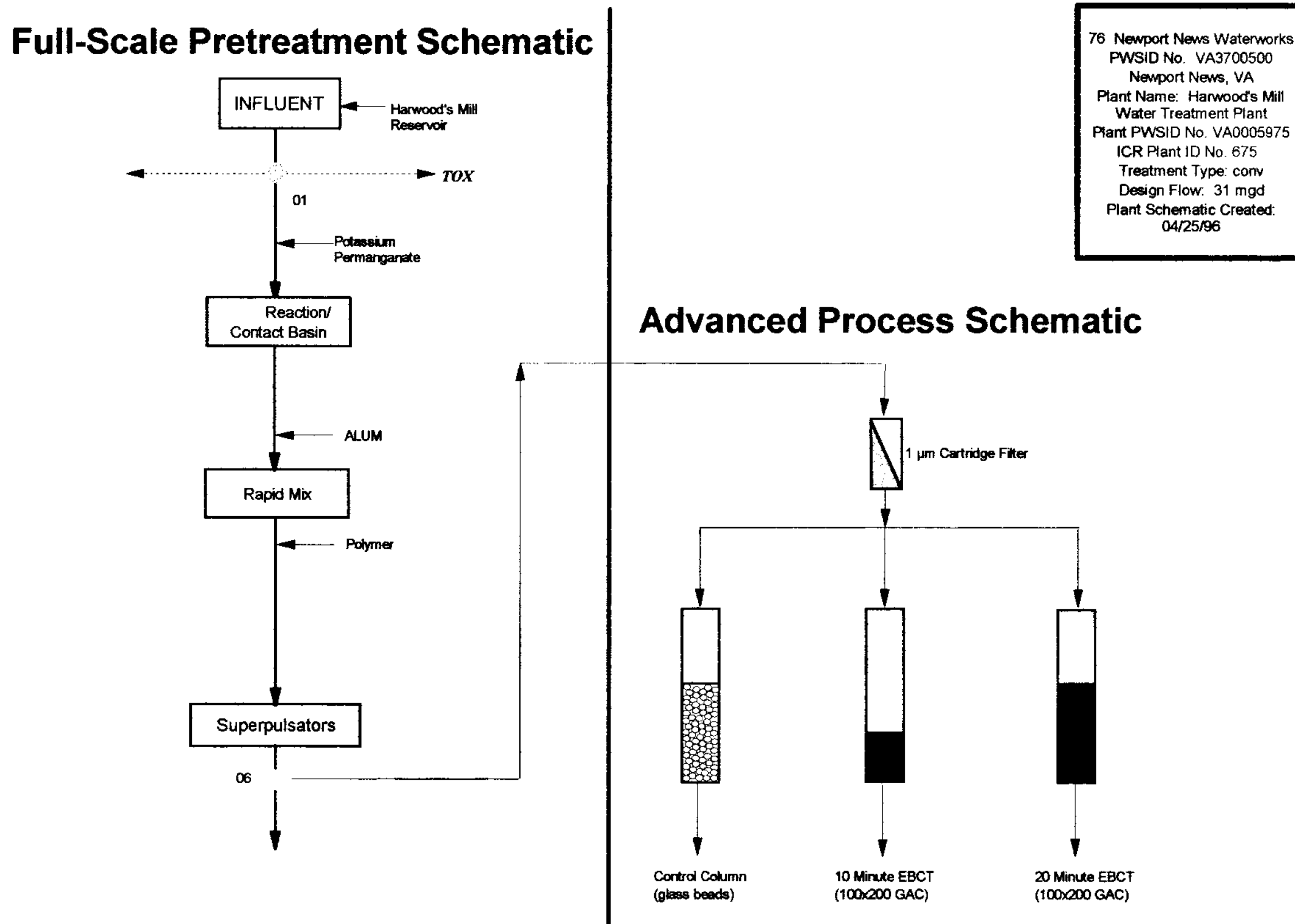


Figure 3
Full-Scale Pretreatment and Advanced Treatment Process Schematic

Carbon depth (l_{SC}, mm)	84
$EBCT_{LC}$ = 20 min.	
$EBCT_{SC}$ (min)	1.4
Carbon depth (l_{SC}, mm)	169

Experimental Design Water for the treatability studies was collected from a tap providing clarifier effluent prior to chlorine or filter-aid addition. For each quarterly test, water was collected in 55-gallon polyethylene drums immediately prior to test initiation. Water was pumped from the drums through a 1 μm cartridge filter and into the RSSCT columns. A summary of plant operating conditions and water quality information for the dates of sample collection is shown in Table 8.

TABLE 8
SUMMARY OF OPERATING CONDITIONS AND WATER QUALITY

		1st Quarter 3/8/96 - 3/23/96	2nd Quarter 5/23/96 - 6/11/96	3rd Quarter 8/2396 - 9/15/96	4th Quarter 11/21/96- 12/9/96
Plant Flow	(mgd)	24.8	25.8	25.8	20.8
Chemicals Added Prior to RSSCT	Alum (mg/L)	41	44	65	45
	Polymer (mg/L)	0.08	0.11	0.10	0.08
	KMnO4 (mg/L)	0	1.2	0	0
Raw Water	Turbidity (NTU)	9.1	1.8	10.2	5.8
	TOC (mg/L)	6.5	6.6	6.9	6.8
Clarifier (Superpulsator)	Turbidity (NTU)	0.68	0.78	0.92	0.40
	TOC (mg/L)	3.7	4.2	3.0	3.5
	Loading rate (gpm/sf)	1.8	1.9	1.9	1.5
	Detention time (min.)	74	71	71	88

Column influent and effluent samples were collected and analyzed as specified in Table

5.0 of the *Draft ICR Guidance Manual* which is reproduced below as Table 9. A minimum of 12 samples were collected and analyzed from the effluent of the 10- and 20-minute EBCT columns. In addition, duplicate samples were collected from the batch influent and effluent of each column three times during each quarterly study. In general, samples were collected from the effluent of each column at intervals corresponding to increases in the effluent TOC concentration of approximately 5 to 8 percent.

TABLE 9
ICR SAMPLING REQUIREMENTS

Sampling Point	Analyses	Sample Frequency
GAC Influent	Alkalinity, total & calcium hardness, ammonia and bromide	Two samples per batch of influent evenly spaced over the RSSCT run
GAC Influent	pH, turbidity, temperature, TOC and UV_{254}. SDS for THM, HAA6, TOX and chlorine demand	Three samples per batch of influent evenly spaced over the RSSCT run
GAC Effluent @ EBCT=10 min.(scaled)	pH, temperature, TOC and UV_{254}. SDS for THM, HAA6, TOX and chlorine demand	A minimum of 12 samples. One after one hour, and thereafter at 5% to 8% increments of the average influent TOC
GAC Effluent @ EBCT=20 min.(scaled)	pH, temperature, TOC and UV_{254}. SDS for THM, HAA6, TOX and chlorine demand	A minimum of 12 samples. One after one hour, and thereafter at 5% to 8% increments of the average influent TOC

The SDS test conditions used for the RSSCT treatability testing were as follows:

- ➢ Incubation time of 72 hours, which was based on a distribution system model estimate of the maximum residence time in the system.
- ➢ Samples were chlorinated at dosages which would provide a free chlorine residual between 0.5 and 1.5 mg/L after 72 hours. This required that a couple of samples be collected and dosed at different chlorine dosages. The sample which had a free residual within the specified range after 72 hours was analyzed for the various parameters.
- ➢ After dosing with chlorine, the sample pH was adjusted to 8.0.

- Samples were incubated at 30°C.

The chlorine dosages and incubation time were consistent with the average distribution system conditions of the full-scale plant. The pH of 8.0 used for the studies was higher than the average pH of 7.0 leaving the plant, but was used because it would provide a slightly conservative estimate of the THM formation potential. An incubation temperature of 30°C was selected so that test conditions would be consistent with other pilot testing that Waterworks was conducting concurrently with the RSSCT study. Although the annual average temperature in the distribution system is less than 30°C, using this high temperature for all of the pilot and RSSCT work provided consistent (and conservative) test conditions for comparing DBP formation potentials of samples collected at different times of the year.

Analytical Methods During Quarters 1 and 2 of the study, standard EPA methods were used for analysis of the required parameters, while during Quarters 3 and 4, ICR-specific guidelines were followed for sampling and analysis. Data collected during Quarters 1 and 2 are consistent with data from Quarters 3 and 4, indicating that the data collected during the first two quarters are valid.

Table 10 lists analytes, analytical method and MRL for each parameter measured during the testing. All analyses were performed by Newport News Waterworks Laboratory.

TABLE 10
ANALYTICAL METHODS AND MRLs

Analyte	Method	Minimum Reporting Level
Coliform	Membrane Filtration	1
Bromide	EPA 300.0	0.010 mg/L
Alkalinity	SM 2320 B	2 mg/L
Ammonia	SM 4500-NH3 G	0.02 mg/L
Bromide	EPA 300.0	20 µg/L
Calcium Hardness	SM 3500-Ca D	2 mg/L
Chlorine Residual	SM 4500-Cl G & D	0.2 mg/L
HAA6	EPA 552.1	1 µg/L
THM4	EPA 502.2	1 µg/L
pH	SM 4500 H+	Not applicable
Temperature	SM 2550 B	Not applicable
Total Hardness	SM 2340 C	2 mg/L

TABLE 10 ANALYTICAL METHODS AND MRLs		
Analyte	**Method**	**Minimum Reporting Level**
TOC	SM 5310 B	0.5 mg/L
HAN/CH	SM 552.1	0.5 µg/L
TOX	SM 5320 B	25 µg/L
Turbidity	SM 2130 B	0.1 NTU
UV254	SM 5910	0.009 cm^{-1}

IV. RESULTS AND DISCUSSION

Problems Encountered During Testing Although in general the testing went well, there were some operational problems encountered during the course of the study. Most of the problems associated with maintaining steady flow rates through the GAC columns were encountered during the first quarter of testing and were associated with the initial start-up of the test equipment. Most of the problems were resolved and did not re-occur in the subsequent quarters of testing.

First Quarter

➢ Experienced difficulties in maintaining steady flowrates through both GAC columns. Unsteady flow was associated with the development of air pockets in the top of the columns and excessive headloss through the GAC bed. Flow problems were resolved by purging the air from the column. Temporary delays up to 1 hour were necessary to purge the air and restore flow rates to specified values. In subsequent quarters, carbon was rinsed more thoroughly to remove fines that cause excessive headloss.

Second Quarter

➢ Experienced problems with UV Spectrophotometer. Samples were stored in refrigerator until instrument was repaired.

Third Quarter

➢ Experienced problems with colorimeter used to measure free and total chlorine residuals. Some of the data suspect to inaccuracy.

Fourth Quarter

➢ No problems.

Summary of Significant Results The results of the quarterly RSSCT tests are presented in tables at the end of this report and on Figures 4 through 17.

Key results include:

➢ The TOC concentration in the influent water ranged between 3.0 and 4.2 mg/L for the four quarters of testing, with the highest level occurring during the second quarter. The THM and HAA6 formation potentials ranged from 160 to 179 µg/L and 68 to 107 µg/L, respectively. The highest level for both of these parameters occurred during the fourth quarter.

➢ Each quarter of testing indicated that there was a non-adsorbable fraction of TOC in the column influent water that corresponded to approximately 15 percent of the influent concentration or 0.5 mg/L. The non-adsorbable fraction of THM and HAA6 precursors ranged from 1 to 18 µg/L and 1 to 13 µg/L, respectively.

➢ Table 11 shows the time to breakthrough for the proposed Stage II MCLs for both THMs and HAAs. The data indicate that the proposed MCL for THMs was exceeded before HAAs in each quarter of testing.

TABLE 11
RUN TIME TO PROPOSED STAGE II BREAKTHROUGH*
(HOURS)

		First Quarter	Second Quarter	Third Quarter	Fourth Quarter
10 minute EBCT	THM	60	30	80	70
	HAA	100	50	110	85
20 minute EBCT	THM	140	125	175	140
	HAA	200	160	180	165

* Proposed Stage II MCLs: THM = 40 µg/L; HAA5 = 30 µg/L

➢ Increasing the empty bed contact time from 10 to 20 minutes did not significantly increase the number of bed volumes of water processed before breakthrough, except in the second quarter when the bed volumes to breakthrough were 108 percent and 60 percent higher for THMs and HAAs, respectively (See Table 12).

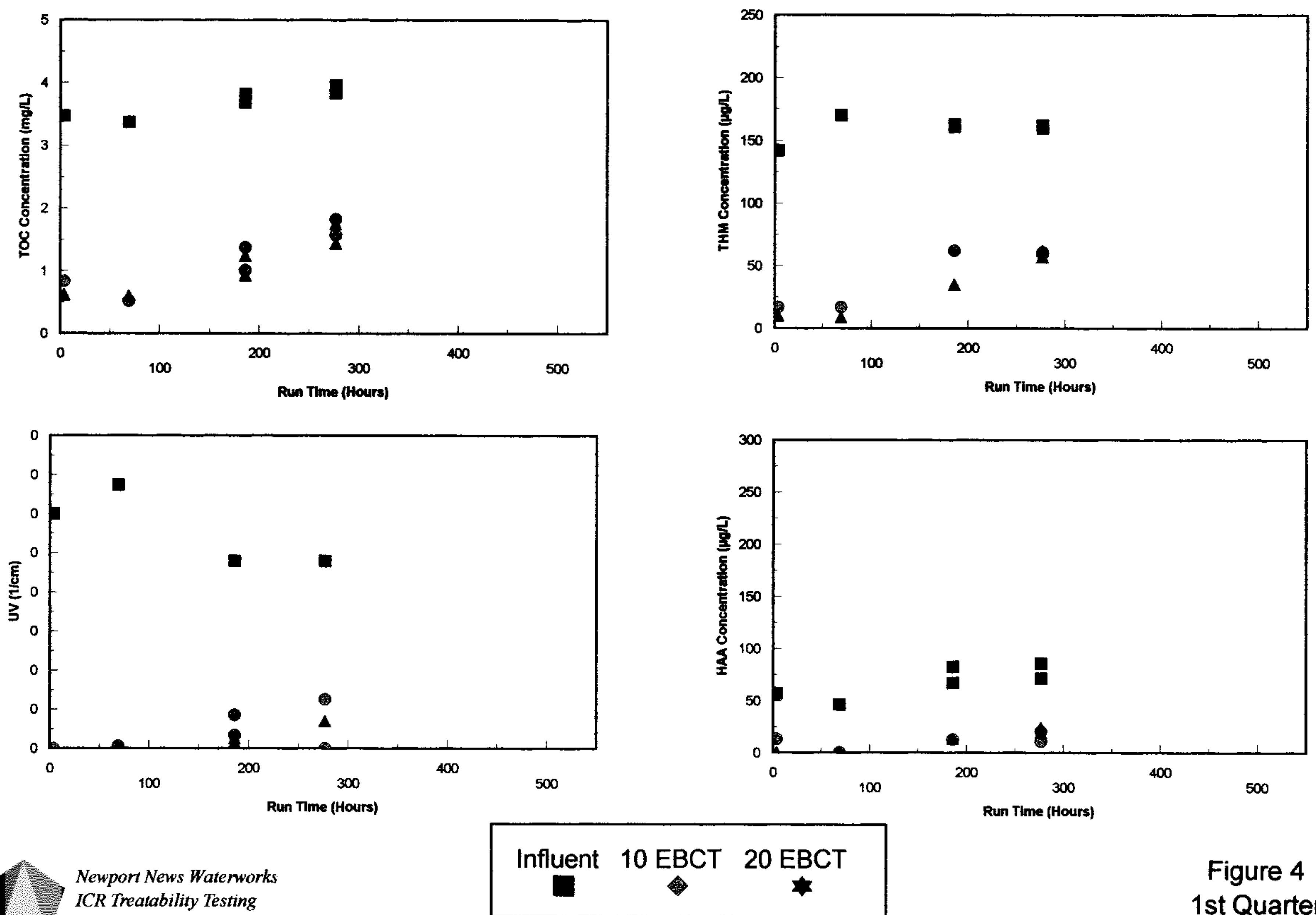
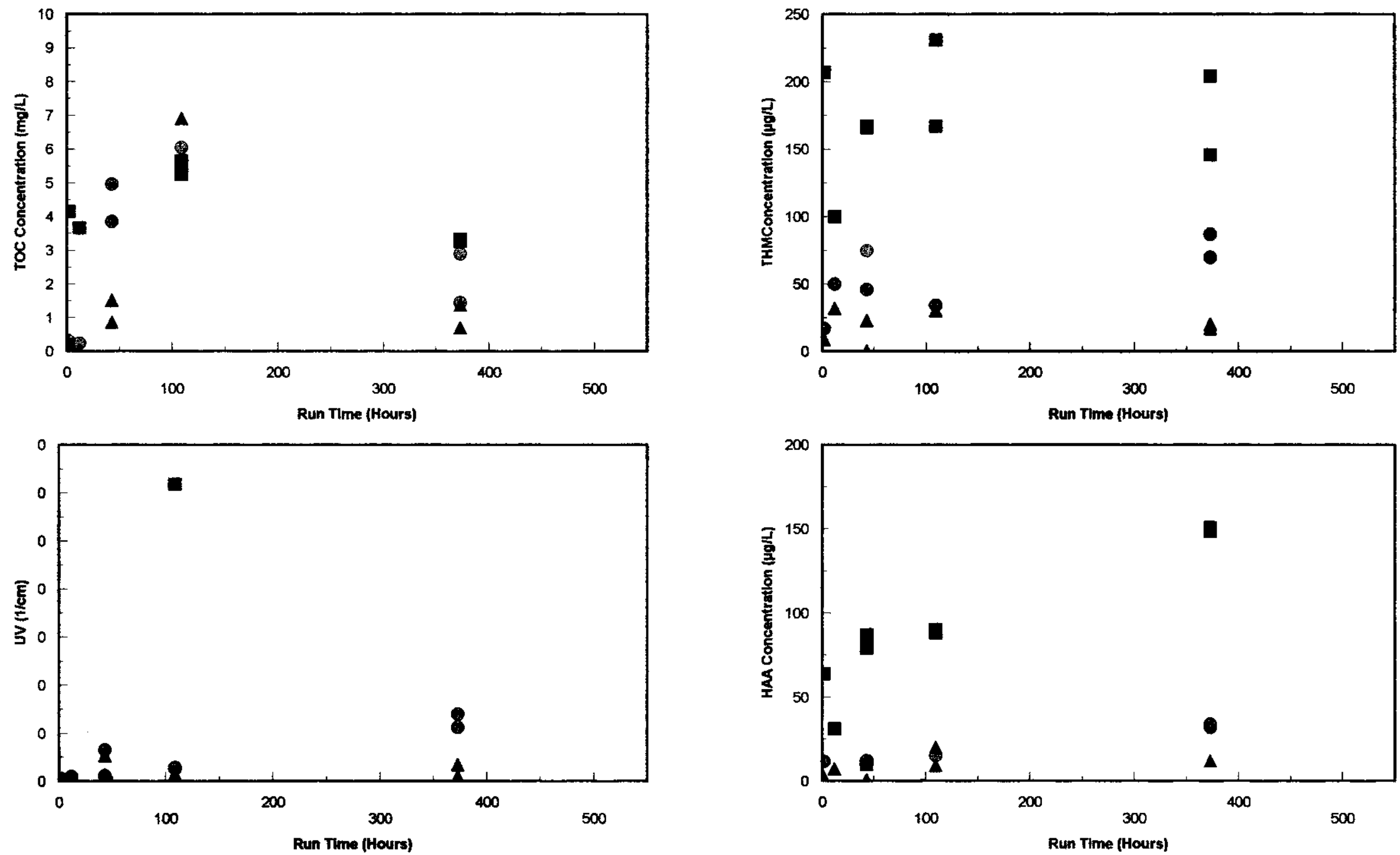


Figure 4
1st Quarter



Influent 10 EBCT 20 EBCT

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Figure 5
2nd Quarter

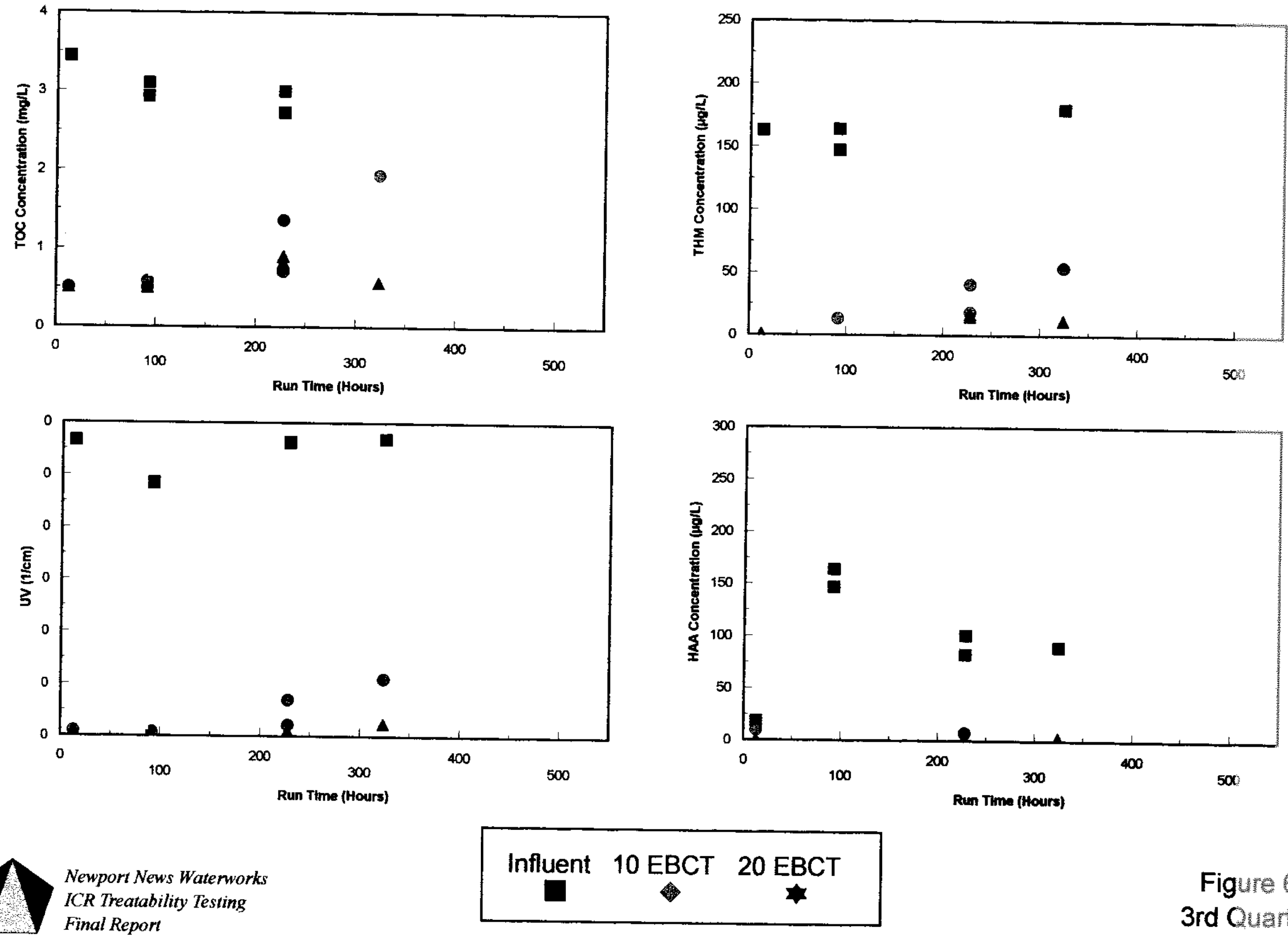

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Figure 6
3rd Quarter

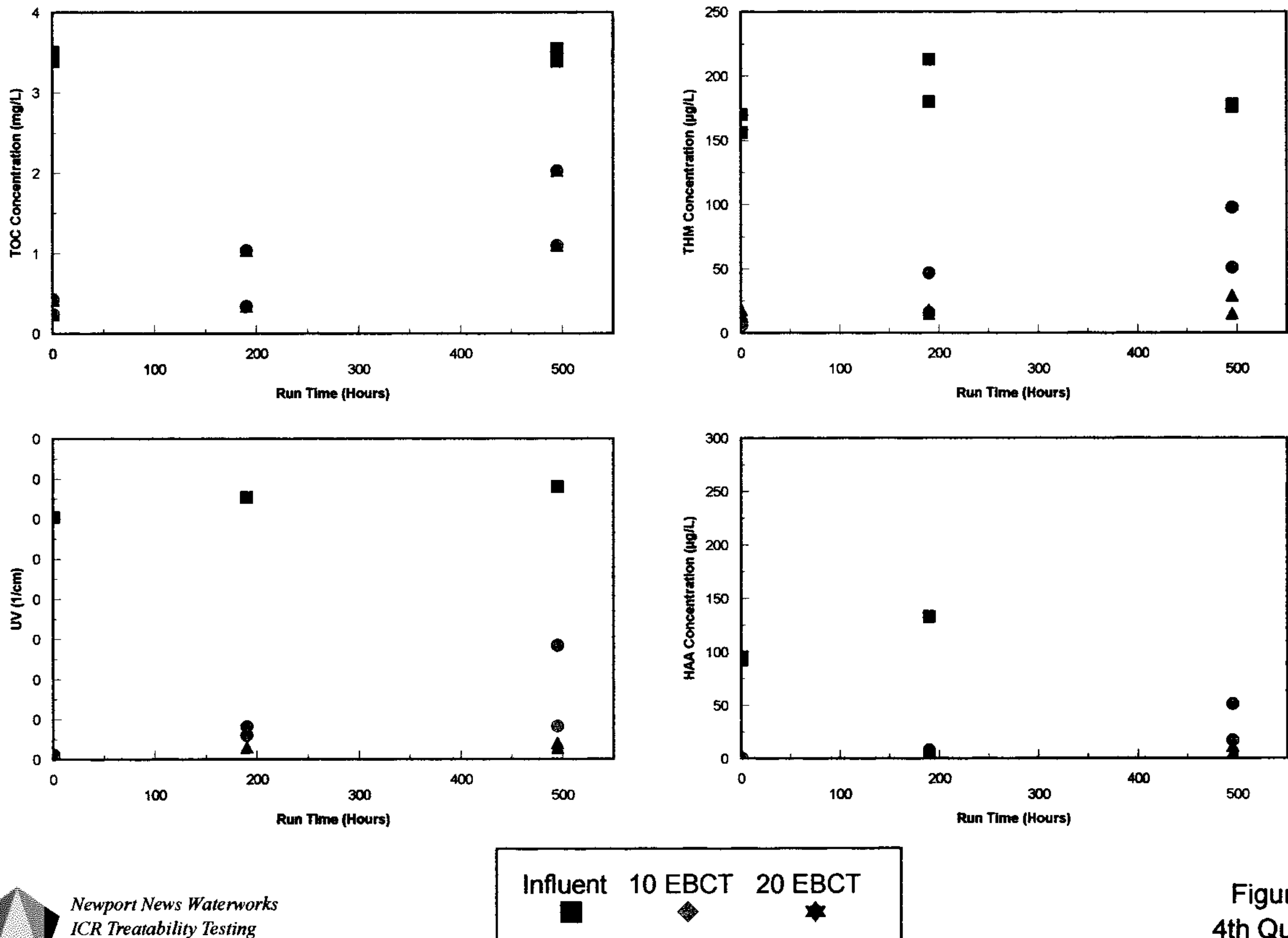

Figure 7
4th Quarter

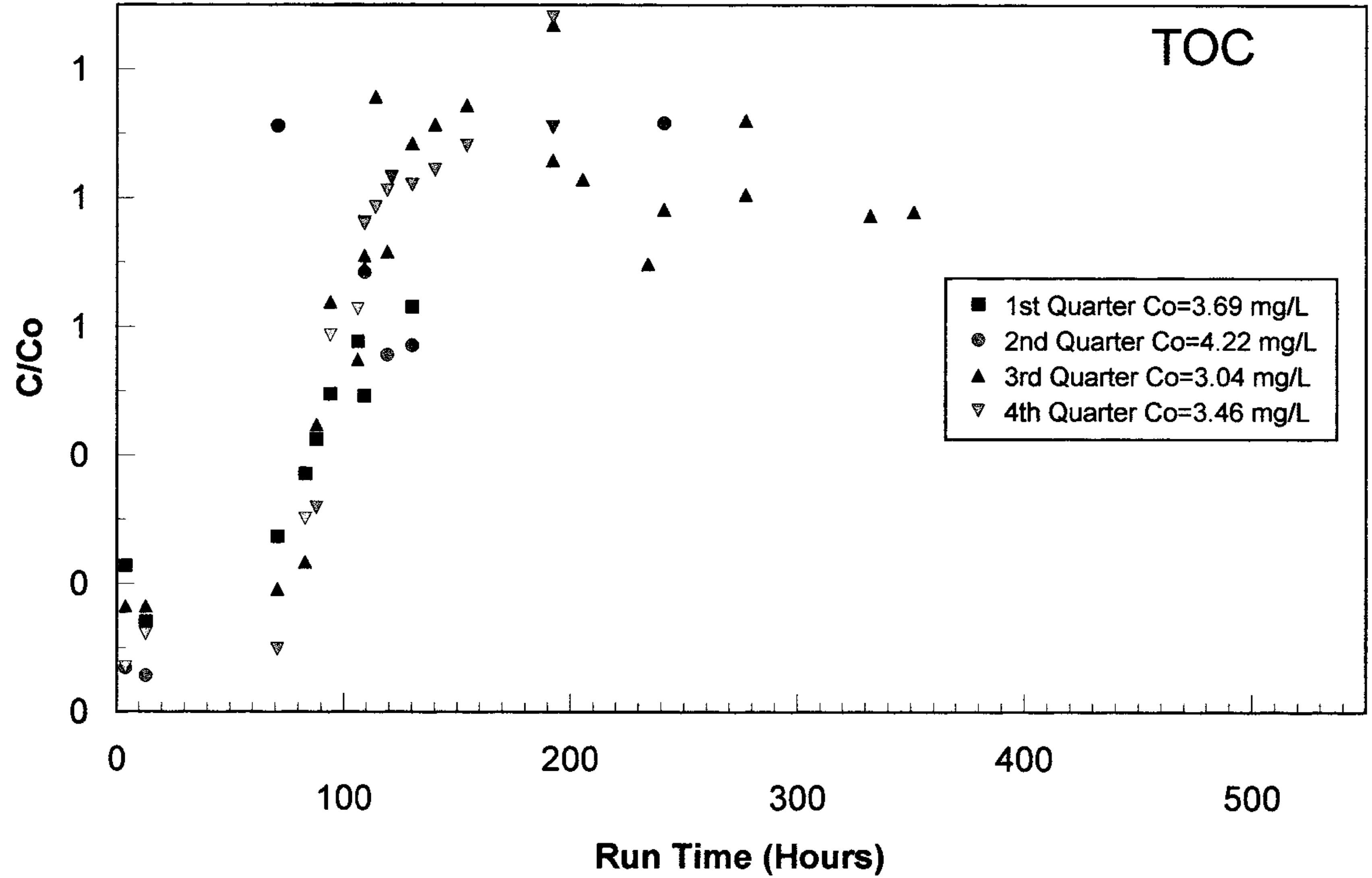

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Figure 8
EBCT = 10 minutes

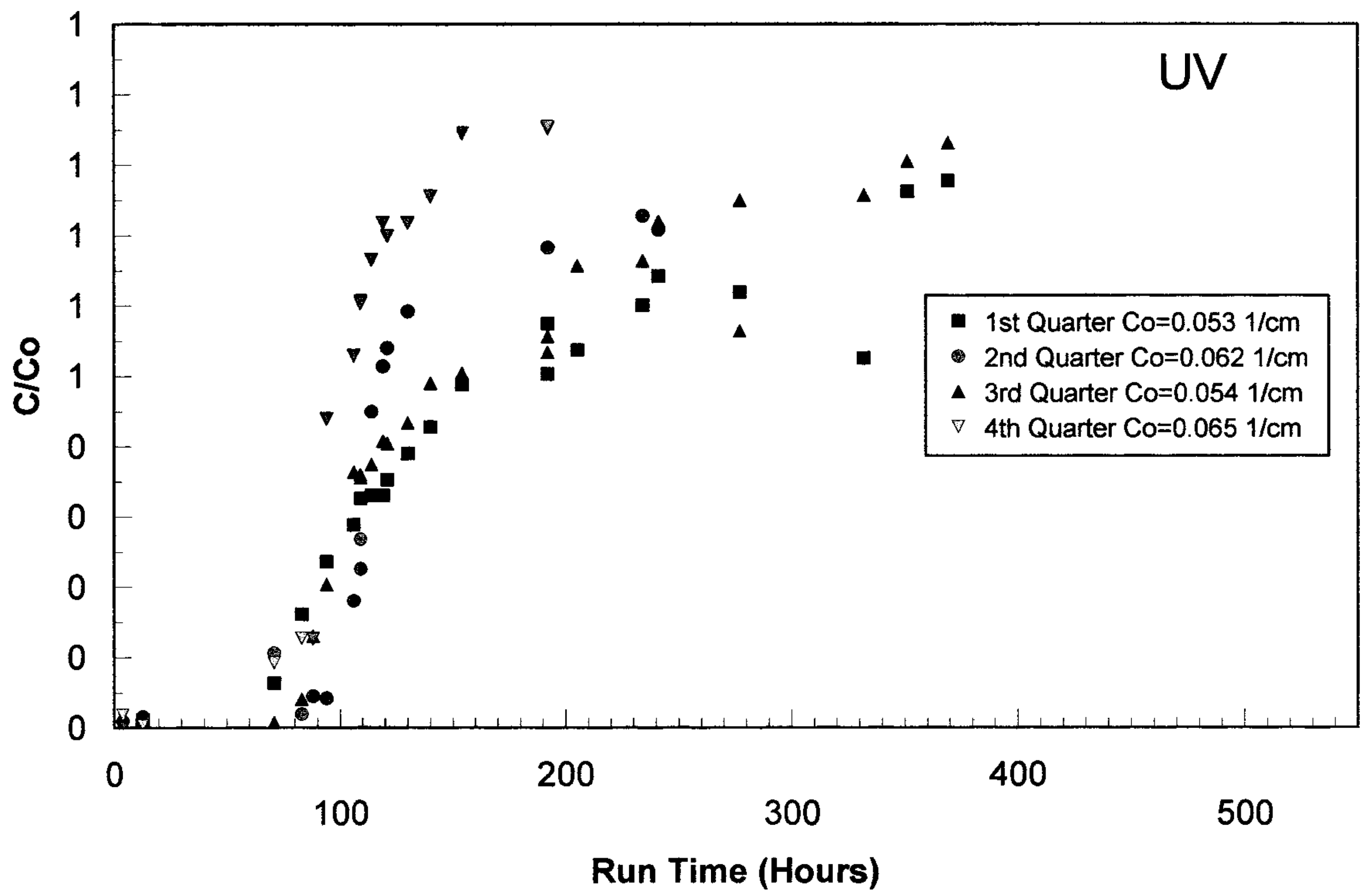

Figure 9
EBCT = 10 minutes

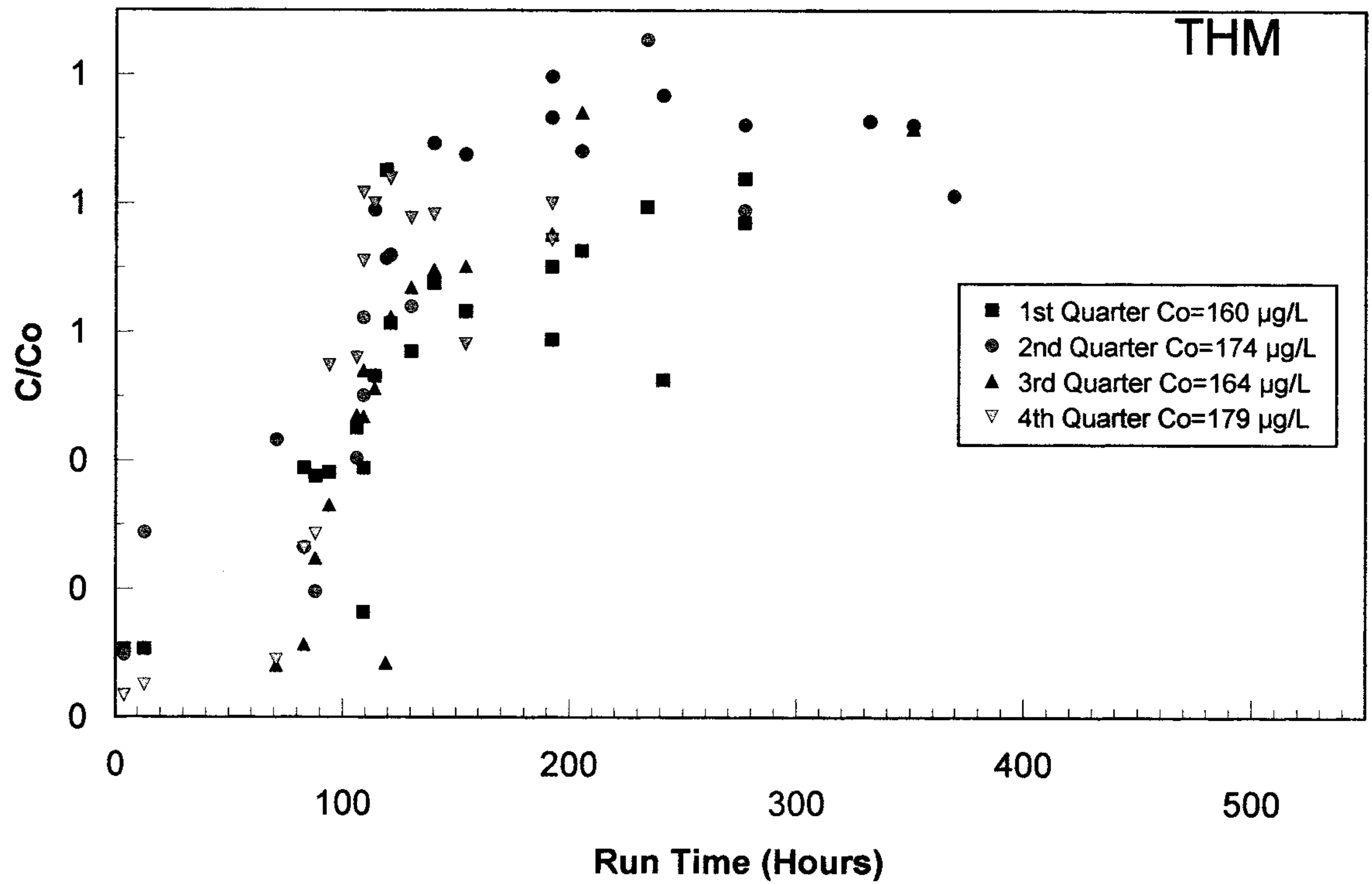

Figure 10
EBCT = 10 minutes

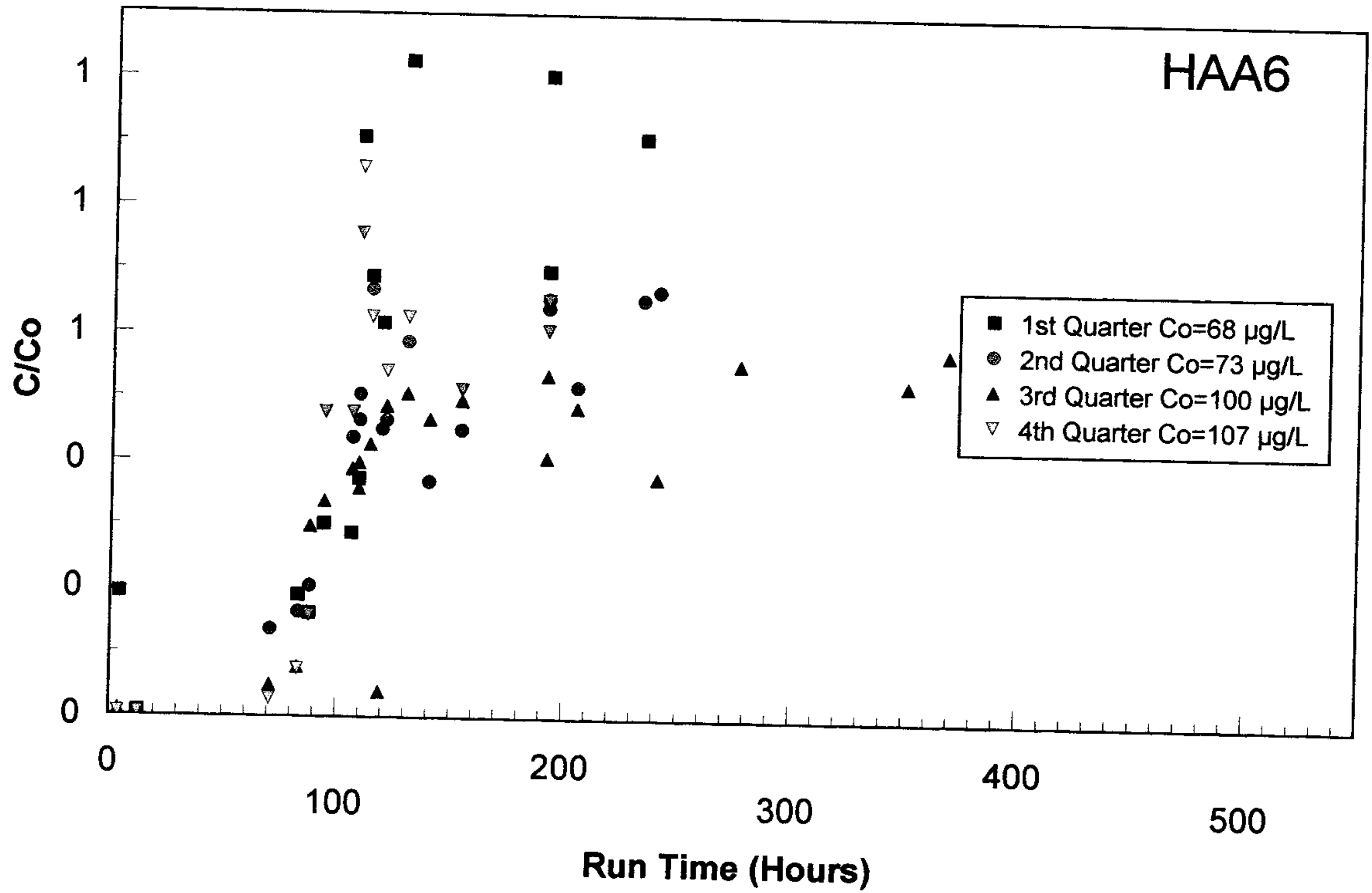

Figure 11
EBCT = 10 minutes

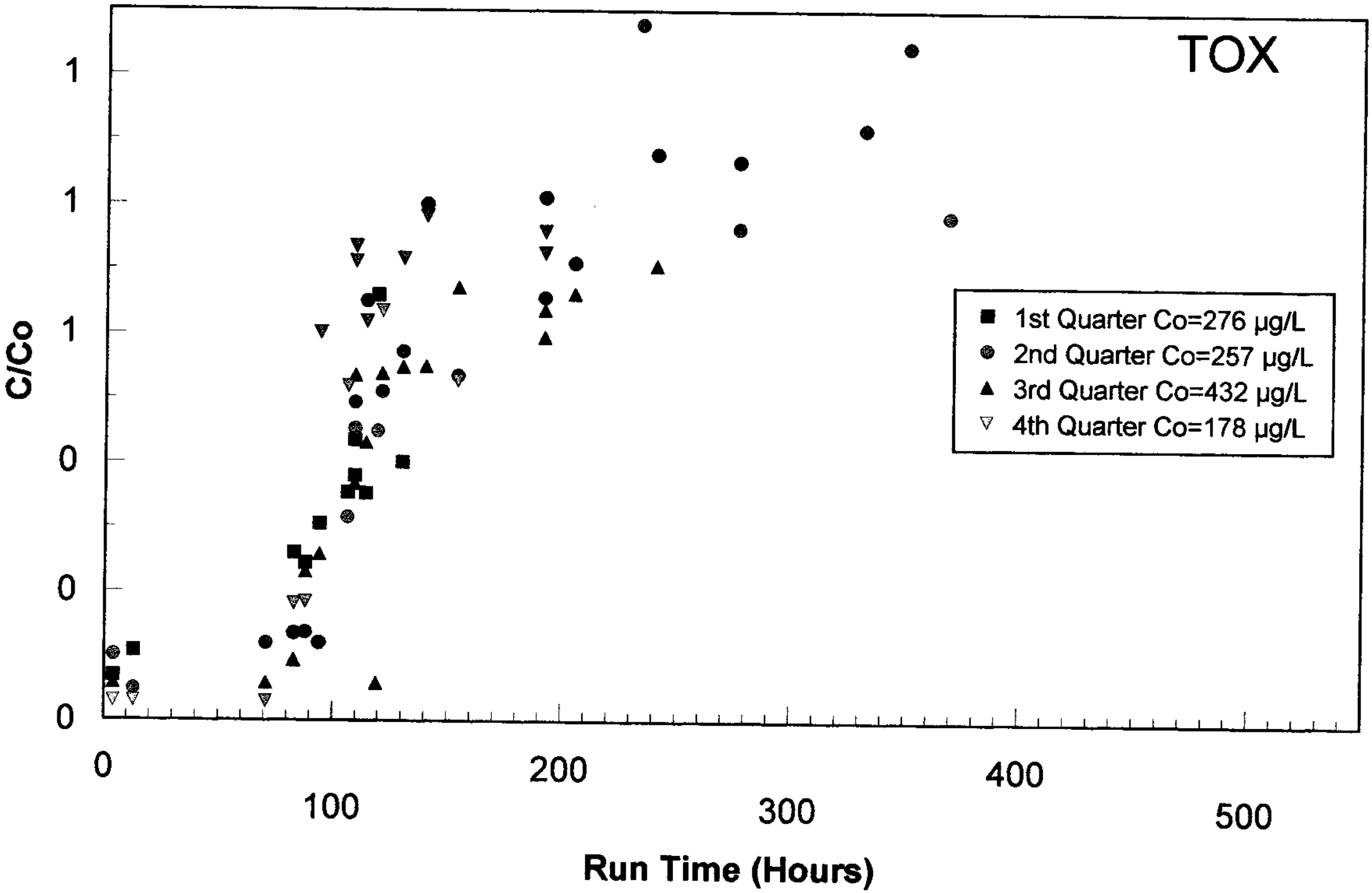

Figure 12
EBCT = 10 minutes

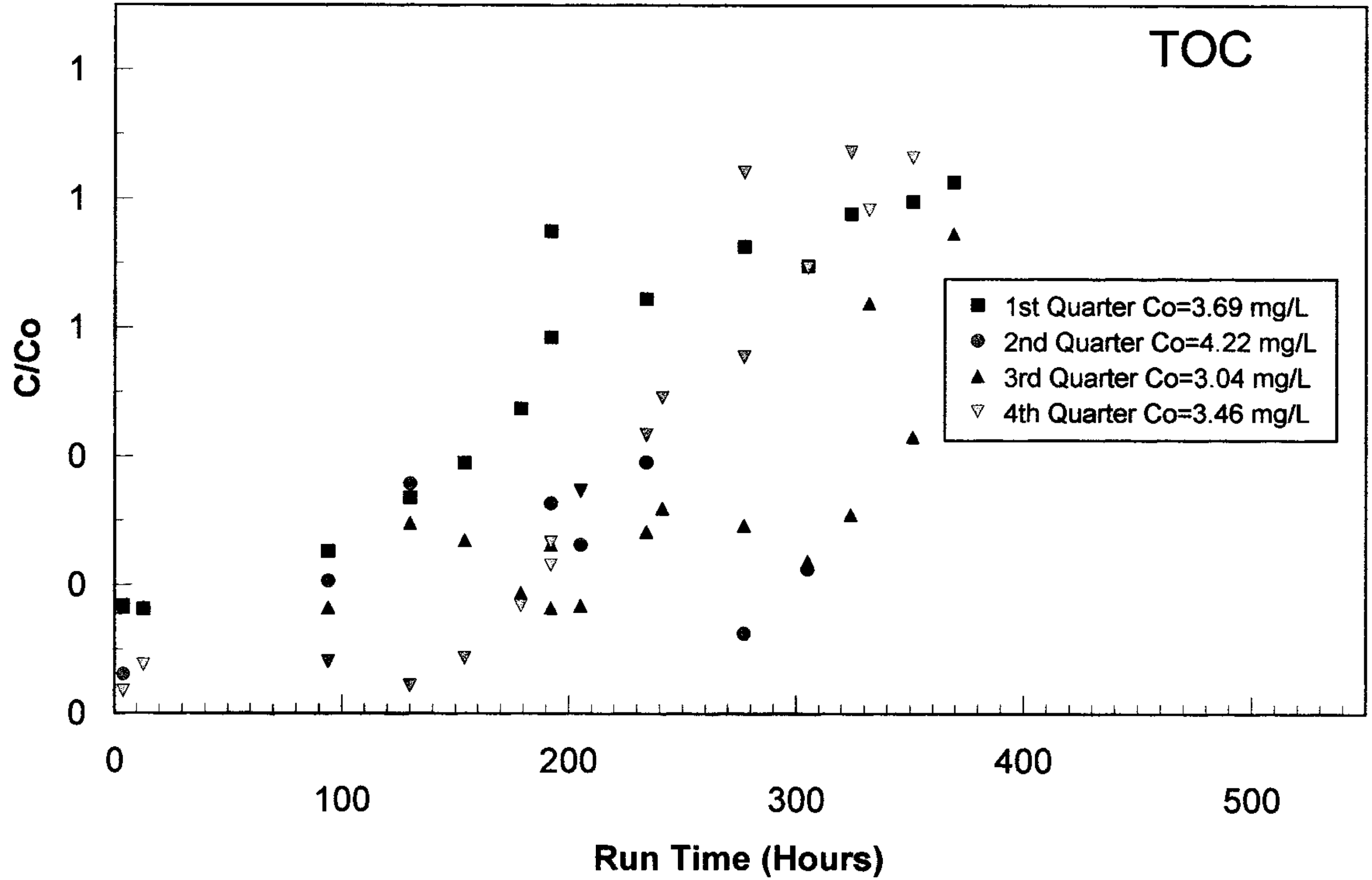

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Figure 13
EBCT = 20 minutes

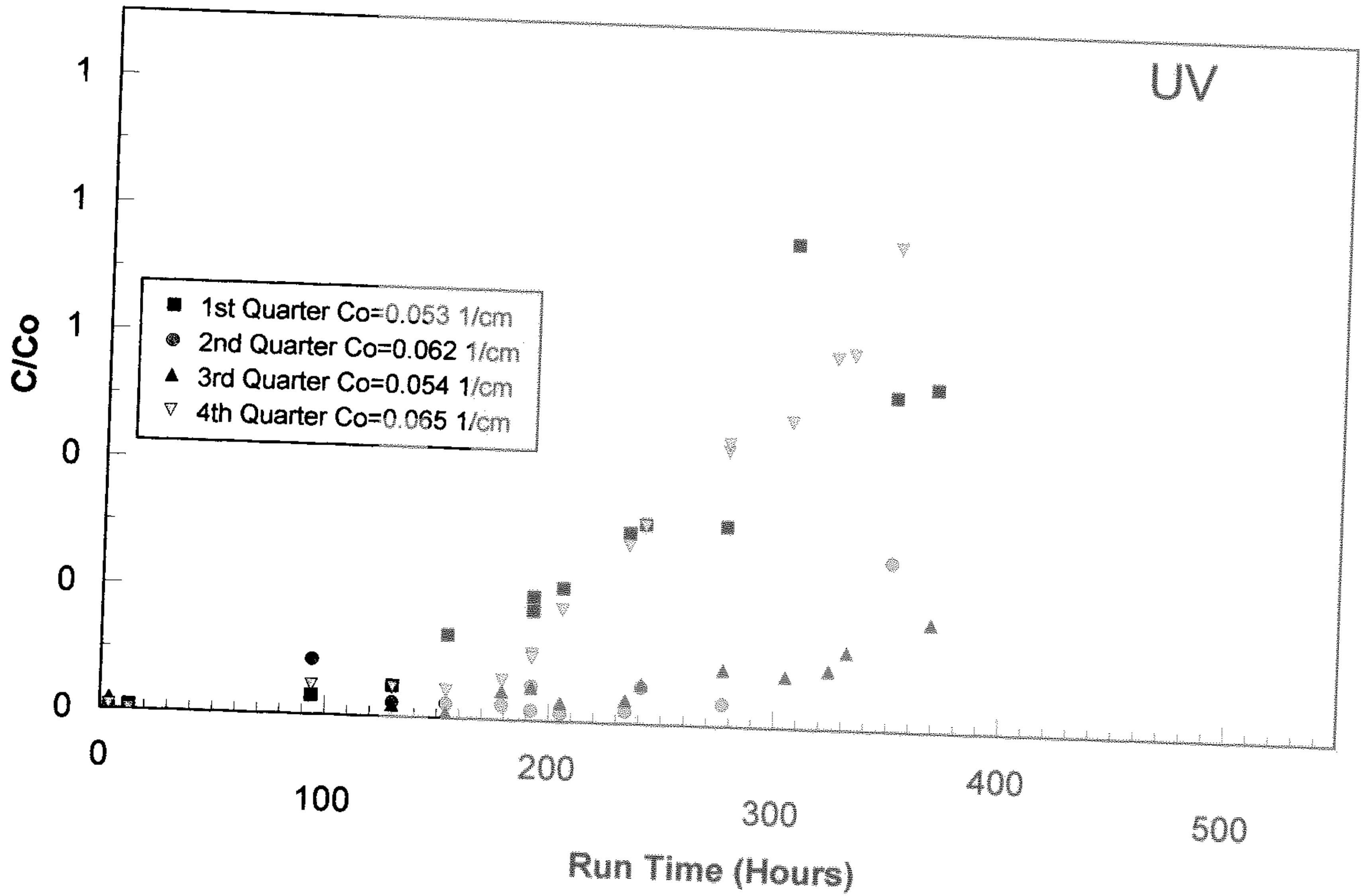

Figure 14
EBCT = 20 minutes

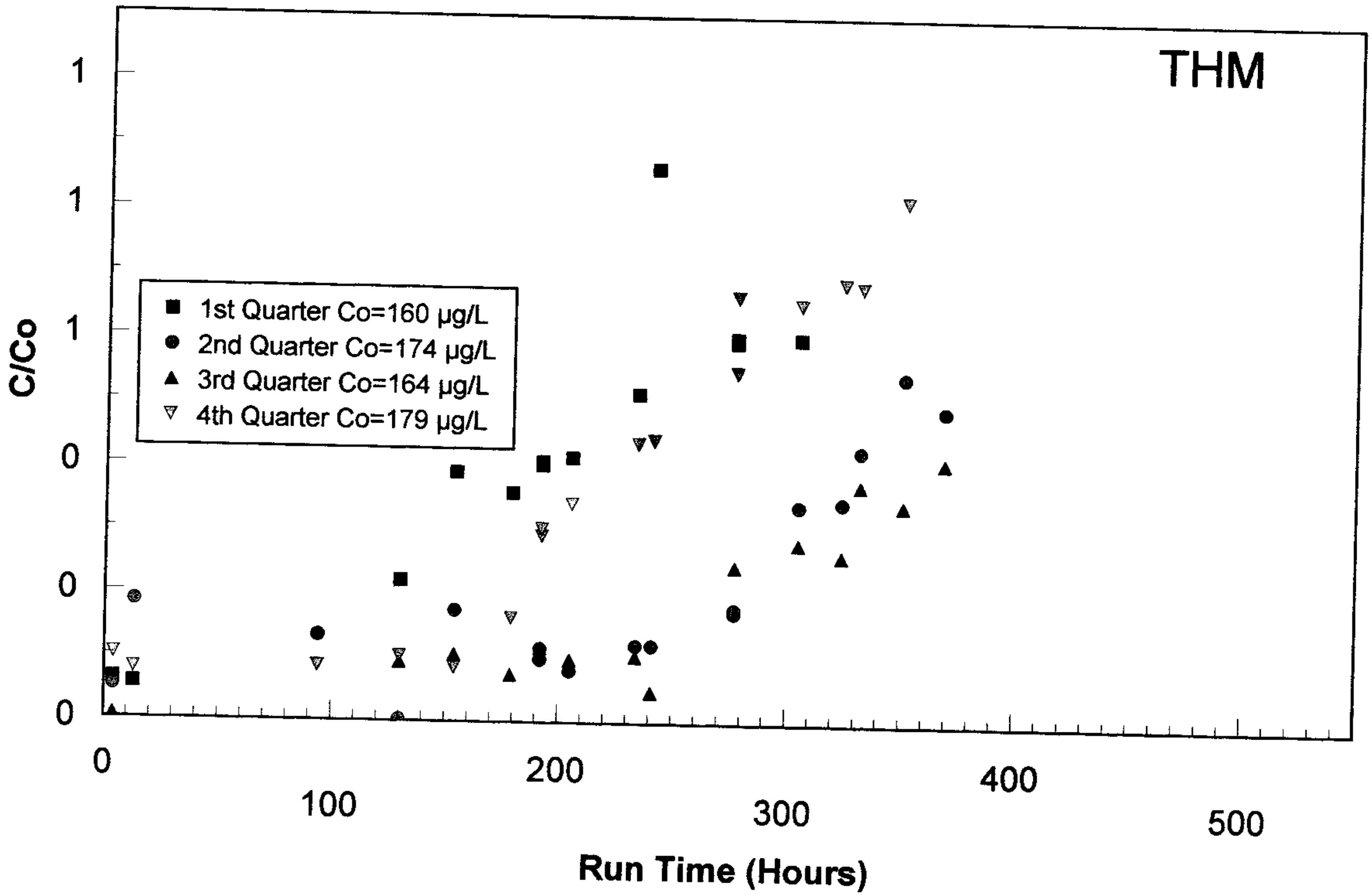

Figure 15
EBCT = 20 minutes

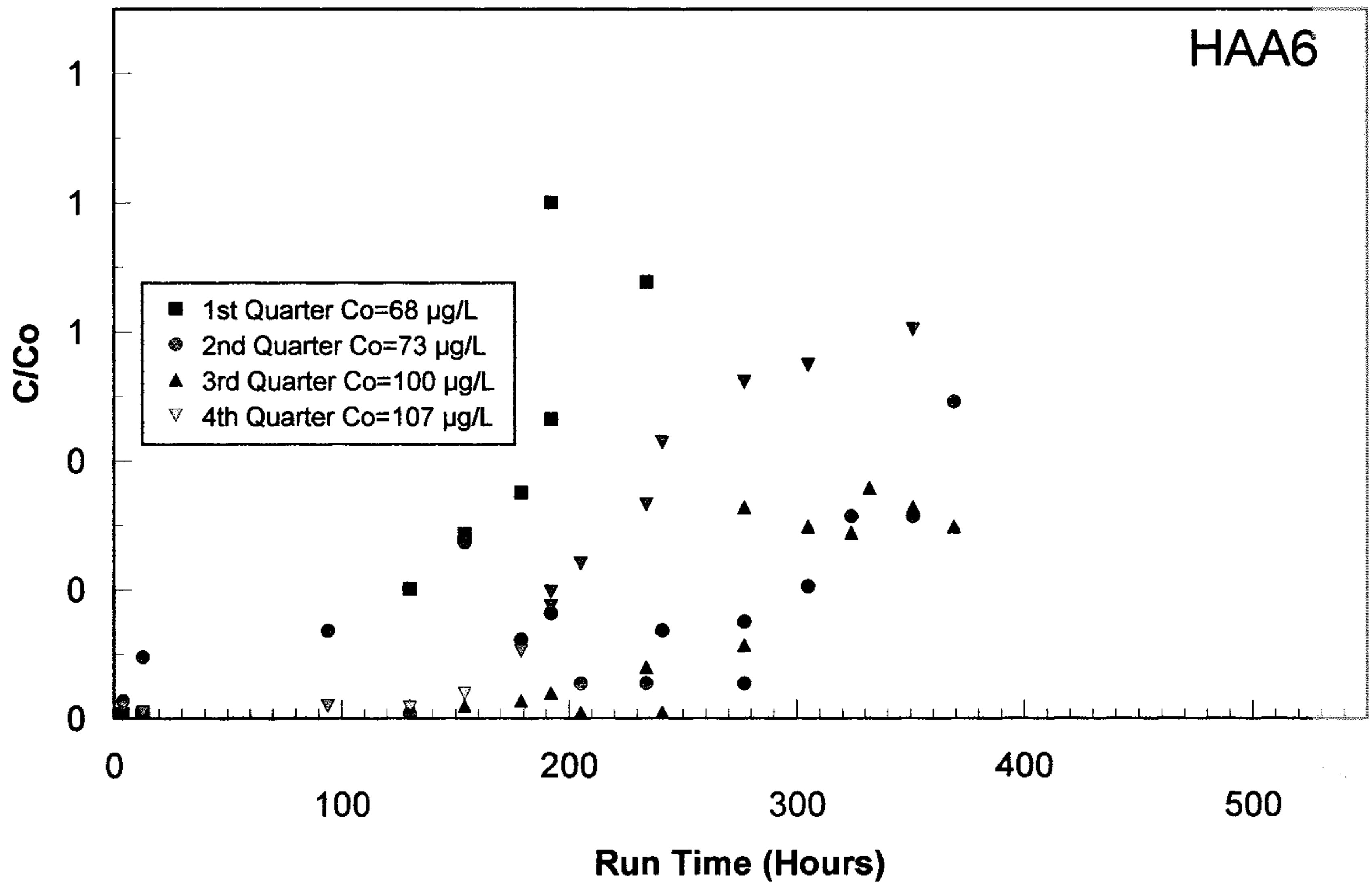

Figure 16
EBCT = 20 minutes

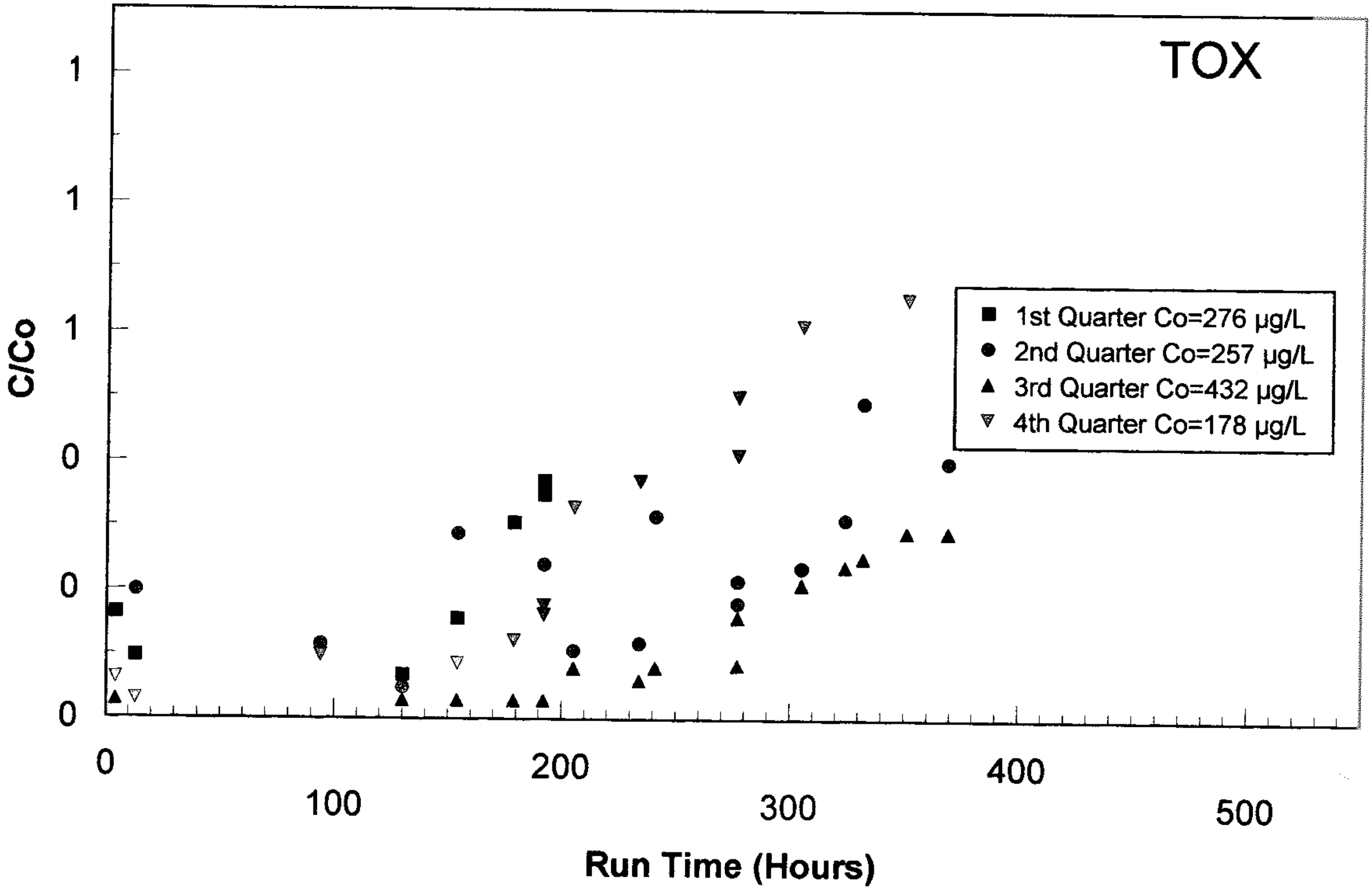

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Figure 17
EBCT = 20 minutes

TABLE 12 BED VOLUMES OF WATER PROCESSED TO PROPOSED STAGE II BREAKTHROUGH (HOURS)					
		First Quarter	**Second Quarter**	**Third Quarter**	**Fourth Quarter**
10 minute EBCT	THM	5,100	2,600	6,900	6,000
	HAA	8,600	4,300	9,400	7,300
20 minute EBCT	THM	6,000	5,400	7,500	6,000
	HAA	8,600	6,900	7,700	7,100

V. QA/QC SUMMARY

During Quarters 1 and 2, QA/QC procedures consisted of standard protocols, and during Quarters 3 and 4, ICR QA/QC procedures were followed. Results indicate that the data quality was similar for all quarters. Attached are spreadsheets listing all laboratory duplicates and fortified matrix samples as well as PE sample results.

Calibration procedures for THM, HAA, TOX, TOC, UV254, and bromide are as follows:

THM: During the first two quarters the calibration consisted of a daily initial analysis of a method blank and a mid range calibration standard. If the results were not within acceptance limits, the GC was recalibrated. In addition, at the beginning of each week, a new calibration curve was established. Random calibration standards were analyzed throughout the each analytical batch. During the final two quarters, the ICR protocol was observed. Before each analytical batch, a method blank and a low standard (1.00 ug/L THM) was analyzed. If the results were within the accepted limits, the analytical batch commenced with a mid-level standard (20 ug/L THM) after the tenth sample and a high level standard (40 ug/L THM) at the end of the batch. If the results of the mid and high level calibration was not within 20% of the true value, the sample results were voided and the duplicate samples were analyzed after a new calibration curve had been established and verified.

HAA(6): For the first two quarters, a calibration curve consisting of 5-7 calibration points was determined Monday of each week. The range of each HAA species varied depending on the initial concentration of the commercial HAA stock calibration solution. Fresh solvents and solutions were prepared prior to extraction of the calibration standards and these solutions were used for all samples, QC samples, and calibration standards for the remainder of the week. For the rest of the week, a method blank and a mid-range calibration standards were analyzed prior to an analytical batch. For the final two quarters, the preparation of solutions and solvents and the weekly re-establishment of the calibration curve was continued but the ICR protocol was also initiated. Daily, a method blank and low level calibration standard (1 ug/L HAA) were analyzed prior to an analytical batch. A mid range (5 ug/L HAA) or high range (40 ug/L HAA) standard was analyzed at the end of each analytical batch which consisted of 6-8 samples. If the final calibration sample was not within 20% of the expected value, the previous sample results were voided and a new calibration standard was prepared. If the new calibration standard was within 20% of the expected value, the sample extract were reanalyzed. Samples were also reanalyzed if the internal standard or surrogate were not within the specific acceptance range of 30% of the expected concentration.

TOX: For the first two quarters, the daily calibration of the TOX instrument consisted of several cell test with a 100 mg/L Cl^-, followed by several nitrate wash blanks. A low level commercial QC standard was used daily to verify the calibration of the TOX unit. For the last two quarters, the ICR protocol was followed. This included the analysis of several cell test, nitrate wash blanks, distilled water blank and a low level TOX calibration standard (25 ug/L TOX). Since only 5-6 samples could be analyzed daily, at the end of each analytical batch a mid-level (200 ug/L TOX) or a high level (500 ug/L TOX) calibration standard was analyzed. If the final calibration sample results were not within 15% of the expected value, the previous sample results were voided and reanalyzed after the analysis of a calibration standard which satisfied the acceptance criteria.

TOC: During the first 2 quarters, daily verification of TOC calibration consisted of analyzing a distilled water blank and a mid-range calibration standard (4-5 mg/L). The calibration curve covered the range of 0.5-10.0 mg/L TOC. At the end of the daily analytical batch, another distilled water blank and mid-range calibration standard were analyzed. The results of all of the calibration standards had to be within 10% of the true value or else the calibration curve had to be reestablished or the previous samples were voided and reanalyzed. For the remaining quarters, ICR protocol was observed. Prior to any sample being analyzed, a distilled water blank and a 0.5 mg/L TOC calibration standard was analyzed. After every tenth sample and at the end of an analytical batch, a mid-range TOC standard (4.0 mg/L TOC) or a high level TOC standard (10.0 mg/L TOC) was analyzed and the results had to be within 10% of the true value. If this criteria was not satisfied, the previous sample results were voided and the samples reanalyzed after recalibration. Triplicate injections were used for all reported sample results. The third and forth quarter reported sample results were the average of two laboratory duplicates, with each duplicate injected at least three times into the TOC analyzer.

UV254: For the first two quarters, the daily calibration verification consisted analyzing a method blank and quarterly UV/VIS spectrophotometer calibration. For the remaining quarters, the ICR protocol was followed which included initially analyzing a method blank and a low range standard (0.009 cm^{-1}). A mid range standard (0.088 cm^{-1}) or a high range standard (0.87 cm^{-1}) were analyzed after every tenth sample and at the end of the analytical batch. The consultant's personnel performed this analysis.

BROMIDE: For all four quarters, a complete calibration curve was established before any samples were analyzed. The calibration curve ranged from 0.05-2.00 mg/L Bromide. The minimum reporting limit for this study was the lowest calibration standard.