

RAPID SMALL SCALE COLUMN TEST

SUMMARY REPORT FOR THE

CITY OF ABILENE, TEXAS

Conducted from April 6, 1998 to January 28, 1999

Prepared by:
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In July, 1999

For:
City of Abilene, TX 79601
P.O. Box 60
Abilene, TX 79604

Grimes Treatment Plant, ICR # 652

Attachments: 1 diskette containing the *Data Collection Spreadsheets*, *TSSUMRPT1 Spreadsheet* and the *Final RSSCT Report*

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SUMMARY REPORT FOR THE CITY OF ABILENE, TEXAS

I. Introduction

The City of Abilene Water Utilities consists of three (3) water treatment facilities. Primary disinfection for all three plants is chlorine dioxide treatment prior to any chemical addition, with secondary disinfection consisting of chloramine treatment concurrently with chemical addition. Each plant utilizes upflow clarifiers followed by filtration by filter beds consisting of sand and anthracite. There are five booster stations throughout the utility system that provide booster chlorination; three (3) with free chlorination and two (2) with chloramine treatment. The following table indicates the water treatment plants in the City of Abilene:

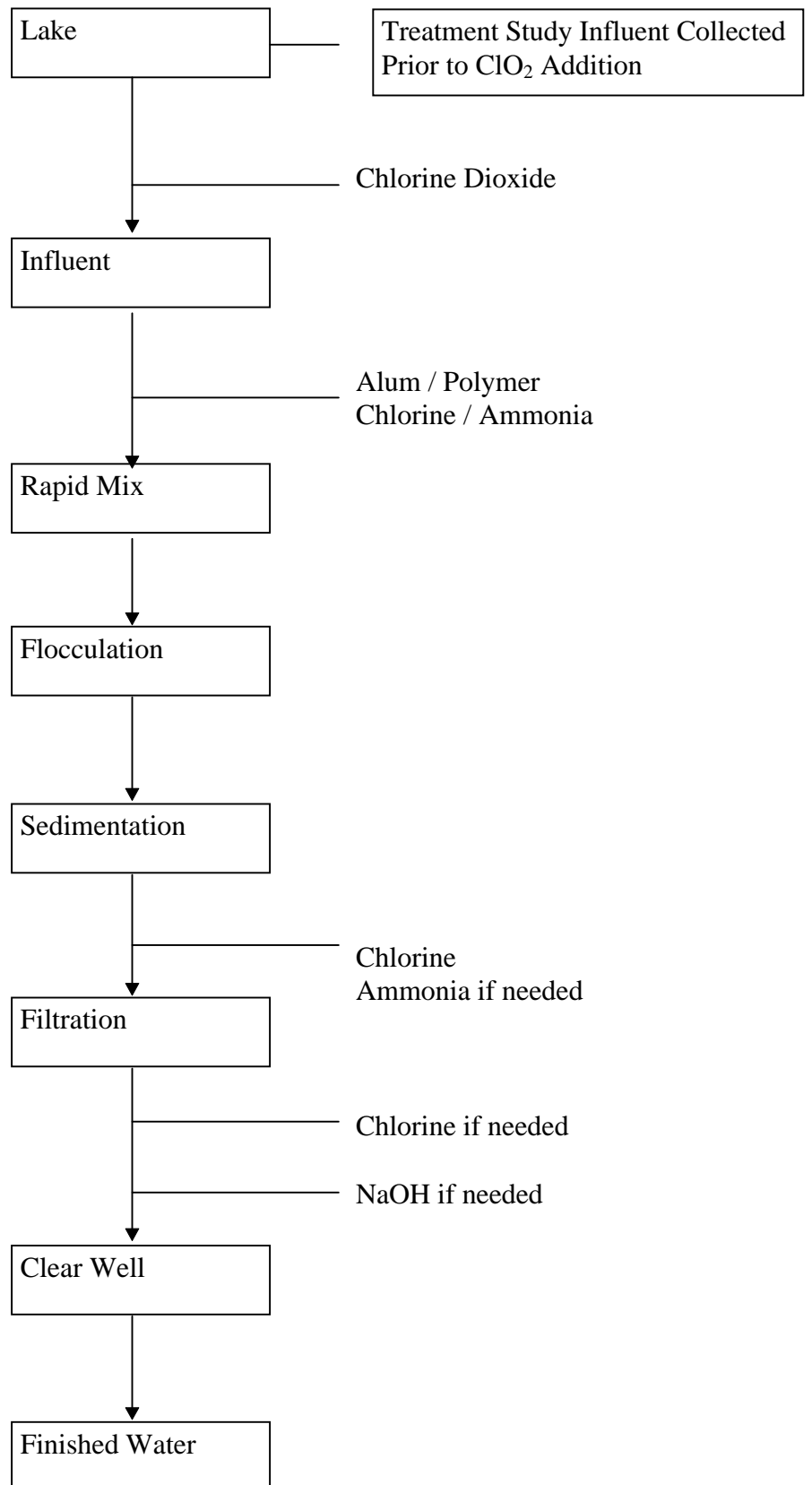
Treatment Plant	State Approved Plant Capacity	Coagulant Chemicals	Surface Water Sources
Abilene WTP	1.5 MGD	Aluminum Sulfate Cationic Polymer	Lake Abilene
Grimes WTP	25 MGD	Aluminum Sulfate Cationic Polymer	Lake Fort Phantom Hubbard Creek Reservoir
Northeast WTP	25 MGD	Calcium Oxide Cationic Polymer Aluminum Sulfate	Lake Fort Phantom Hubbard Creek Reservoir

In a normal, non-drought influenced, year the majority of the City's raw water is supplied by the Lake Fort Phantom surface water reservoir. Therefore, this particular water source was chosen to be studied prior to beginning the Treatment Study Applicability Monitoring. It was determined during the Applicability Monitoring that the Total Organic Concentration for this source was 4.3 mg/L carbon.

Monthly TOC (mg/l) Applicability Monitoring¹

Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12
3.6	4.0	4.4	4.4	4.4	4.6	4.6	4.6	4.5	4.5	4.2	4.1

In response to future regulations from the SDWA (i.e. D/DBP rule and IESWTR rule) it was determined that presedimentation of the raw water would be achieved through the addition of aluminum sulfate with a cationic organic polymer.



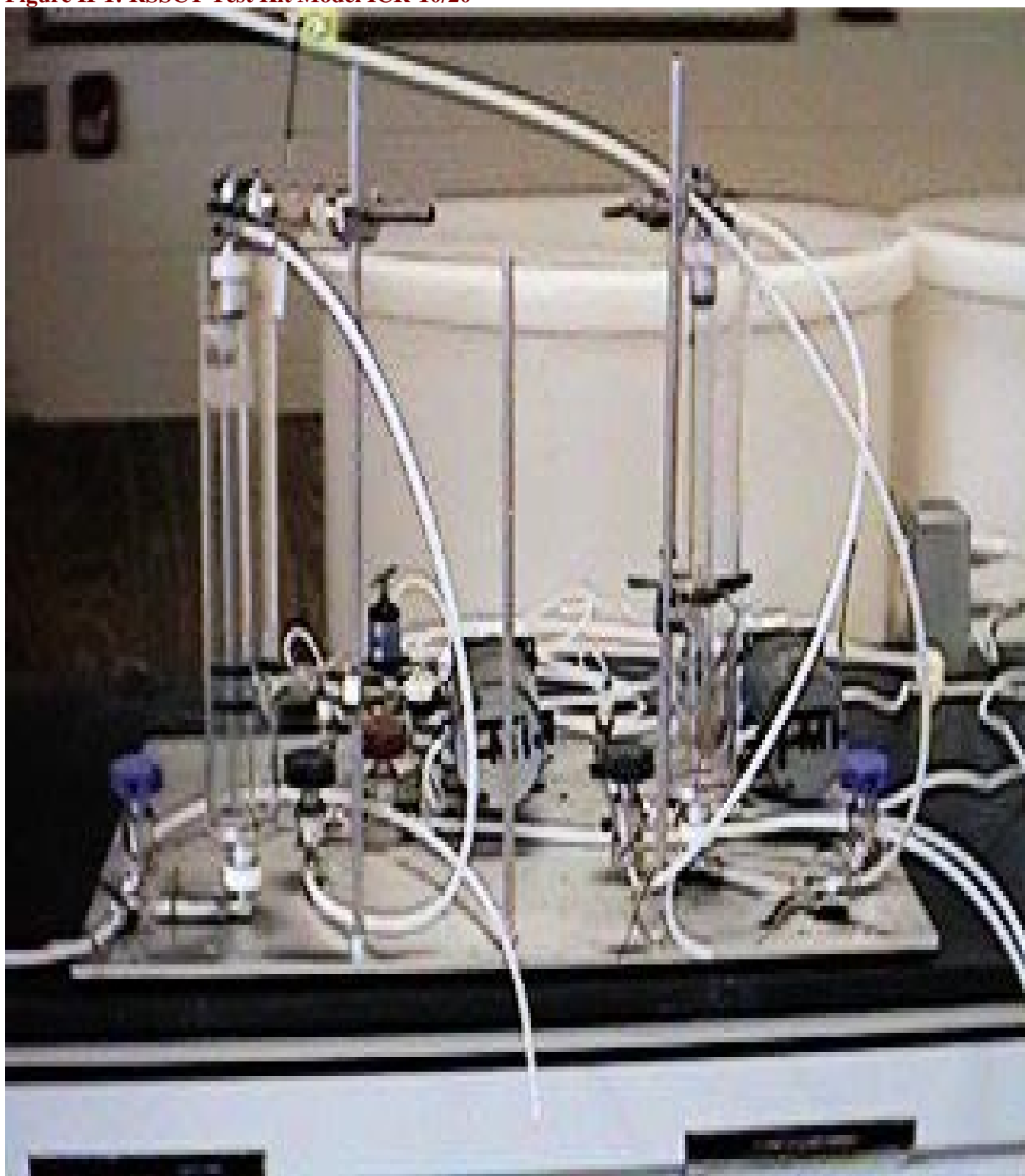
II. Experimental Design

The City of Abilene elected to perform the ICR RSSCT Bench Scale study, due mostly to the fact that for the concentration of the TOC measured in our source water, GAC seems to provide the most efficient means of removal of TOC. After some evaluation, it was decided that a prefabricated Rapid Small Scale Column Test Kit available from Process Optimization Services, Model ICR-10/20 would be utilized. This kit was designed to operate both a 10-minute EBCT column and 20-minute EBCT column. The kit was equipped with two Fluid Metering, Inc. (FMI) QSY-2 metering pumps, each rated to deliver a flow between 0 – 51.0 ml/min. Each kit was also equipped with two FMI Model PD-60-LF Pulse Dampeners. Figure II-1 shows the Process Optimization Service ICR-10/20 RSSCT Test Kit.

Each GAC column was 15 mm in diameter and filled with a Calgon Bituminous Carbon 8X30 mesh that was crushed, sieved and washed to 100X200 mesh by Process Optimization Services. The design parameters of the City of Abilene's RSSCT are contained in the *EPA ICR Treatment Study Data Collection Spreadsheets* and will, therefore, not be in this discussion. Loading of the GAC columns was performed in the manner outlined in the EPA's *ICR Manual for Bench-and Pilot-Scale Studies*.

All raw water samples were collected before any chemical or disinfectant addition. Samples were collected in 2 – 150 gallon containers, filled with approximately 130 gallons of untreated water. Once the laboratory obtained the raw water samples, the temperature was allowed to equilibrate to approximately room temperature to aid in the coagulation and settling process.

Figure II-1: RSSCT Test Kit Model ICR-10/20



III. Experimental and Analytical Methods

Pretreatment of Raw Water and Sample Collection

1. Pretreatment of the raw water consisted of coagulation, flocculation and settling, utilizing aluminum sulfate (Alum) and a cationic organic polymer. Coagulation was accomplished with the addition of 15-ppm alum and 4-ppm cationic polymer during a rapid mixing which lasted for 2 minutes following the chemical addition. This was followed by a slow mix of 30 minutes.
2. The resulting floc was then allowed to settle before being filtered through a 1-micron filter. Following the settling process the treated influent water was filtered through a 5µm membrane filter cartridge to remove any large particulate matter followed by a 1µm membrane filter cartridge. The filtered water was collected in clean tanks for storage during the RSSCT run.
3. Grab samples of the treated influent water were then collected for pH, temperature, alkalinity, calcium and total hardness, ammonia, bromide, TOC, UV₂₅₄ and a SDS sample was collected for THM's, HAA(6), TOX and chlorine demand. Two more influent grab samples were collected during each RSSCT, one at the approximate mid-point of the run, and one at the end of the run.
4. After the initial influent sample was collected, each pump (one for the 10 min EBCT and one for the 20 min EBCT) was started. Treated influent water was allowed to pass through each system for 20 minutes, at which point, the RSSCT test time began.
5. After 1 hour of operation, the first of a minimum of 12 effluent composite samples was collected for each column. Length of the sampling event was determined by volume of sample needed for all analyses.
6. Samples were then collected at intervals of 5% - 8% TOC increase until 70% TOC breakthrough was achieved. A duplicate sample was collected at samples 3 or 4, samples 7 or 8, and samples 10 or 11.
7. Samples were immediately analyzed for pH and temperature. TOC and UV₂₅₄ samples were collected in the proper containers for analysis at a later date and the remaining sample was stored at 4°C in amber glass containers until the SDS chlorine demand was started. TOC was run as soon as practical; UV₂₅₄ was run within 48 hrs; SDS was started within 5 days.

Simulated Distribution System (SDS)

1. Samples collected for SDS were stored at 4°C for no longer than 5 days as specified in the EPA's *ICR Manual for Bench- and Pilot-Scale Treatment Studies*.
2. All containers used for storage of reagents and sample collection bottles were washed and stored following the guidelines established by the EPA's *ICR Manual for Bench- and Pilot-Scale Treatment Studies* so as to ensure that each container was free from any chlorine demand.
3. Dilution studies were performed comparing TOC concentration against chlorine demand, so as to achieve a final SDS chlorine residual of 1.0 ± 0.4 mg/L.

4. Uniform Formation Conditions (UFC), except for the pH, outlined in Section 6.2 of the EPA's *ICR Manual for Bench- and Pilot-Scale Treatment Studies* were followed and are listed below.

- Incubation Time: 24 ± 1 hour
- Incubation Temperature: $20 \pm 1.0^{\circ}\text{C}$
- pH: 8.2 ± 0.2 SU *
- 24 hour chlorine residual: 1.0 ± 0.4 mg/L
- Chlorine dose: Chlorine demand + 1.0 mg/L Cl_2

* This particular pH range chosen due to requirements of corrosion control plan.

Analytical Methodology

Analytical Methodology approved for the EPA Information Collection Rule and guidelines established in the EPA's *DBP/ICR Analytical Methods Manual* were followed for the RSSCT Study.

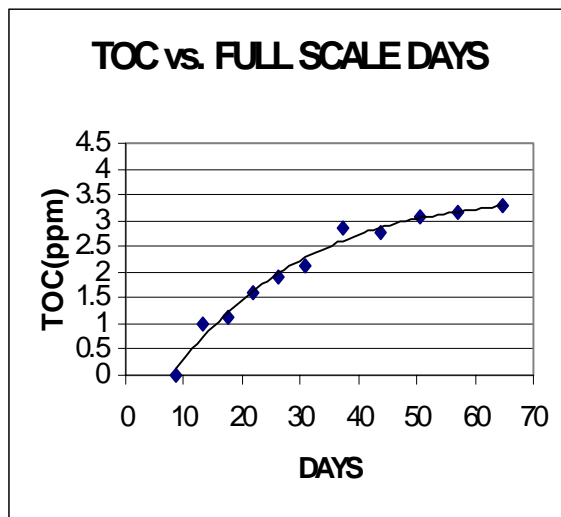
Parameter	Approved ICR Method	% Recovery for Low Level Control	% Recovery for Mid Level Control	% Recovery for High Level Control	% Surrogate Recovery
PH	EPA 150.1	NR	NR	NR	NR
Temperature	SM 2250 B	NR	NR	NR	NR
Alkalinity	SM 2320 B	NR	NR	NR	NR
Calcium and Total Hardness	SM 3120 B	NR	NR	NR	NR
Ammonia	SM 4500-NH3 D	NR	NR	NR	NR
Turbidity	SM 2130 B	NR	NR	NR	NR
TOC	SM 5310 C	50 – 150%	90 – 110%	90 – 110%	NR
UV ₂₅₄	SM 5910	75 – 125%	85 – 115%	85 – 115%	NR
HAA(6)	EPA 552.1	50 – 150%	80 – 120%	80 – 120%	70 – 130%
THM4	EPA 551.1	50 – 150%	80 – 120%	80 – 120%	70 – 130%

IV. Significance of Results

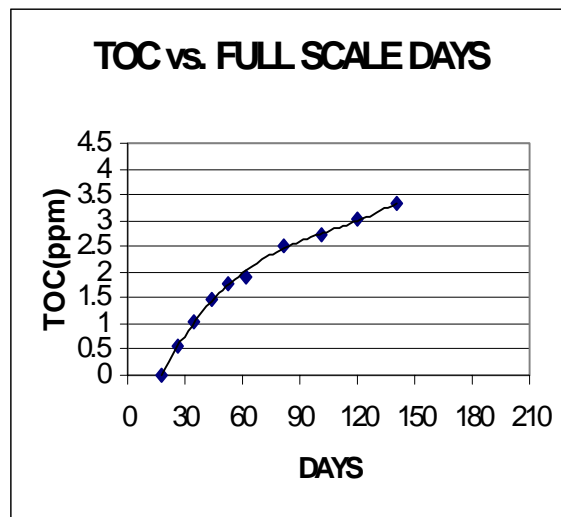
The following pages show some of the relationships found between time (or bed volumes) and the various by-products as well as relationships between TOC and the by-products. Since seasonal variation was determined to be insignificant in relation to TOC an average of the four quarterly runs is also included:

FIRST QUARTER RESULTS

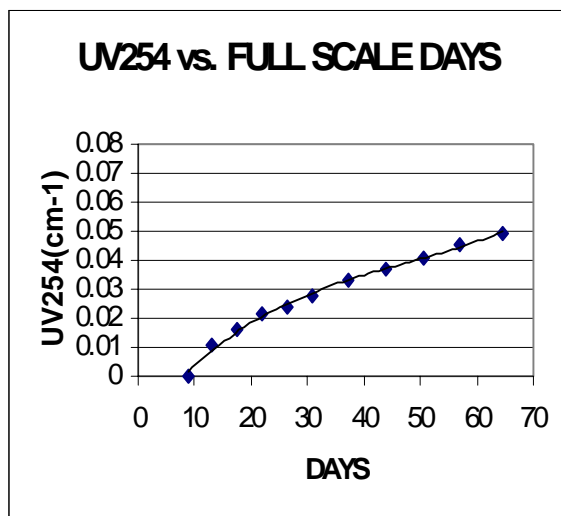
1st Quarter 10 min. EBCT



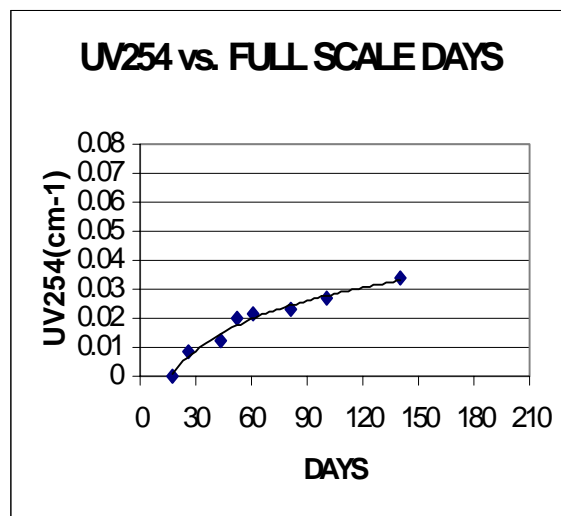
1st Quarter 20 min. EBCT



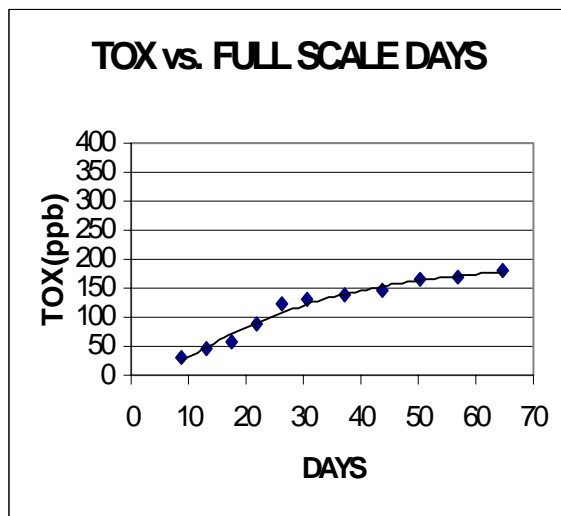
UV254 vs. FULL SCALE DAYS



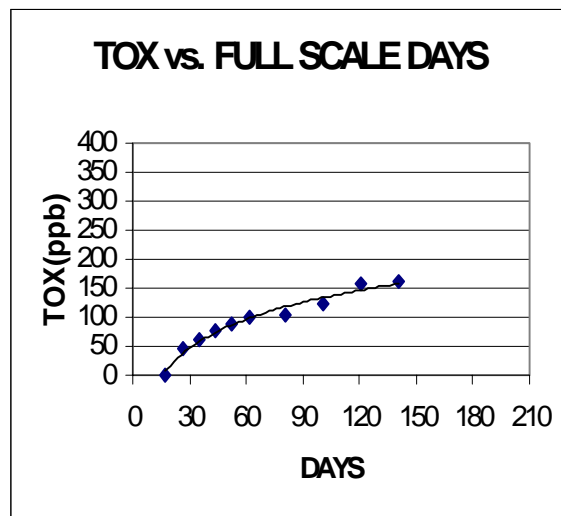
UV254 vs. FULL SCALE DAYS



TOX vs. FULL SCALE DAYS



TOX vs. FULL SCALE DAYS



FIRST QUARTER RESULTS

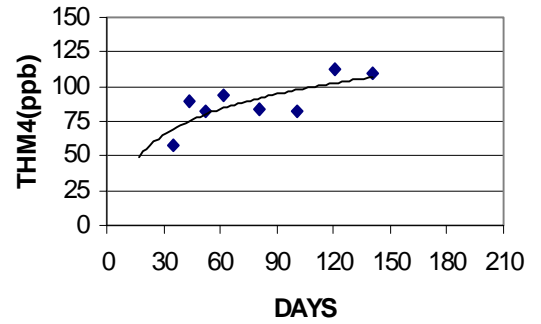
Page 2 of 3

1st Quarter 10 min. EBCT

THM4 vs. FULL SCALE DAYS --
NOT ENOUGH DATA

1st Quarter 20 min. EBCT

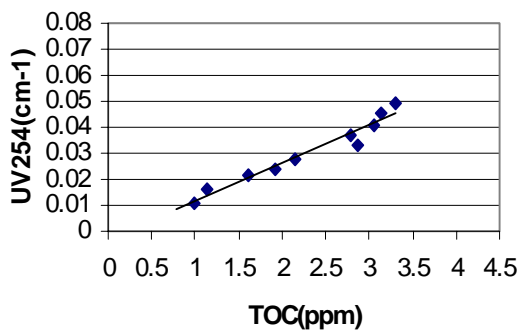
THM4 vs. FULL SCALE DAYS



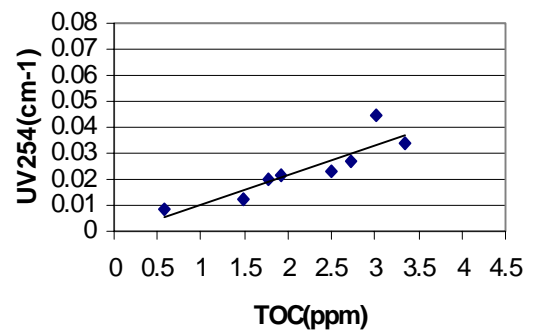
HAA6 vs. FULL SCALE DAYS --
NOT ENOUGH DATA

HAA6 vs. FULL SCALE DAYS --
NOT ENOUGH DATA

UV254 vs. TOC



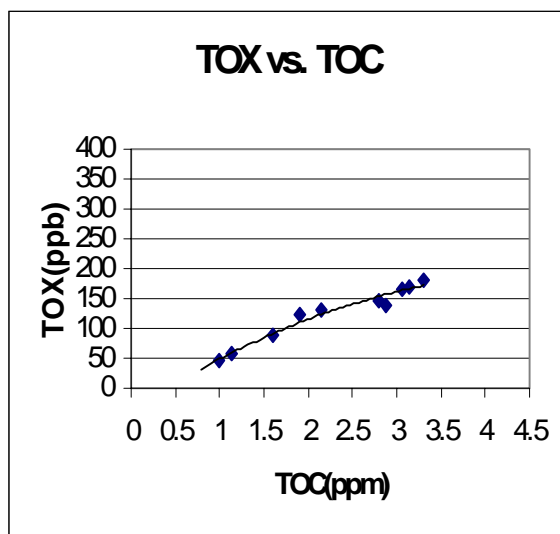
UV254 vs. TOC



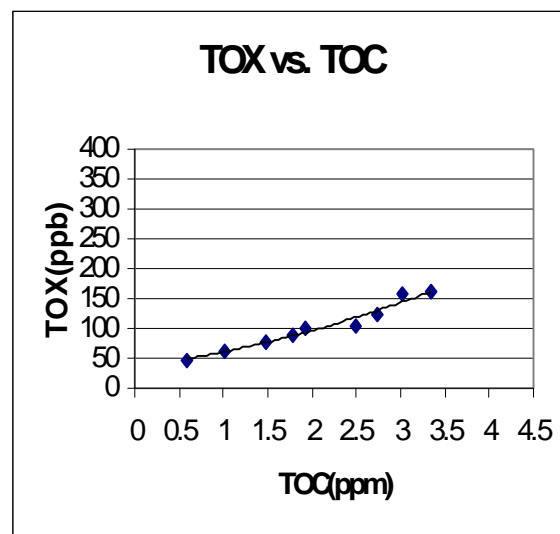
FIRST QUARTER RESULTS

Page 3 of 3

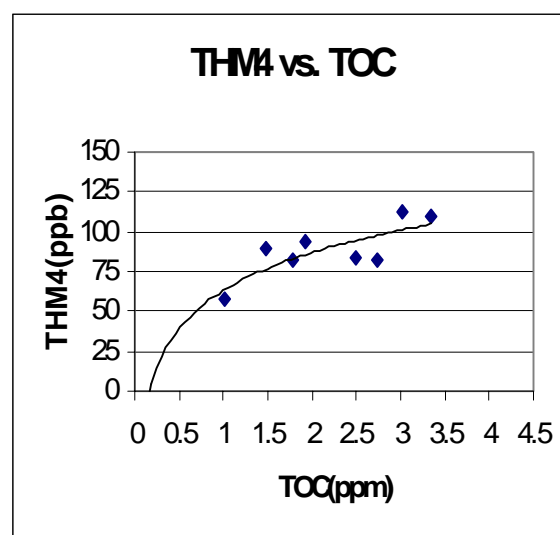
1st Quarter 10 min. EBCT



1st Quarter 20 min. EBCT



THM4 vs. TOC – NOT ENOUGH
DATA

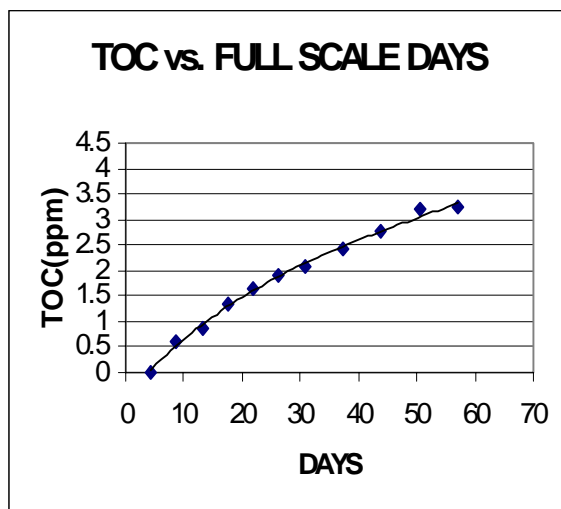


HAA6 vs. TOC – NOT ENOUGH
DATA

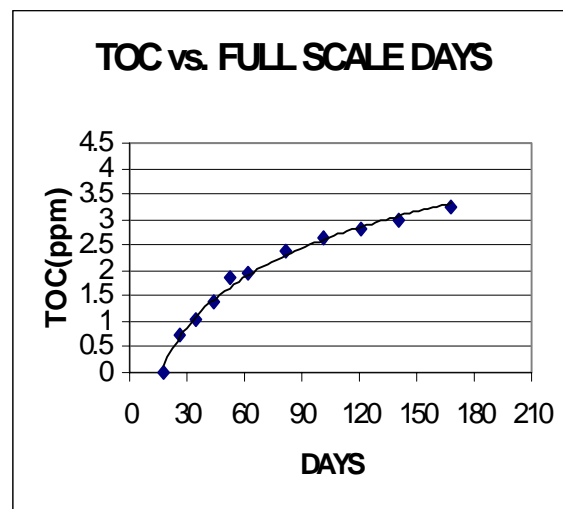
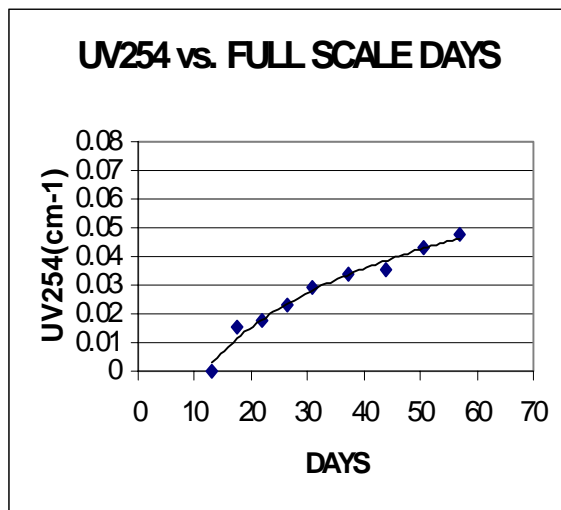
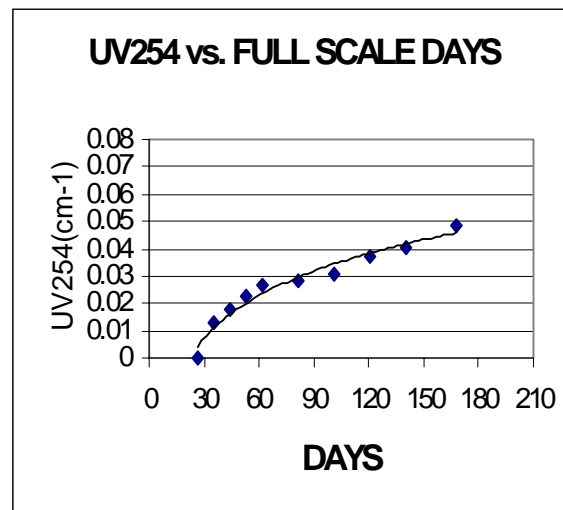
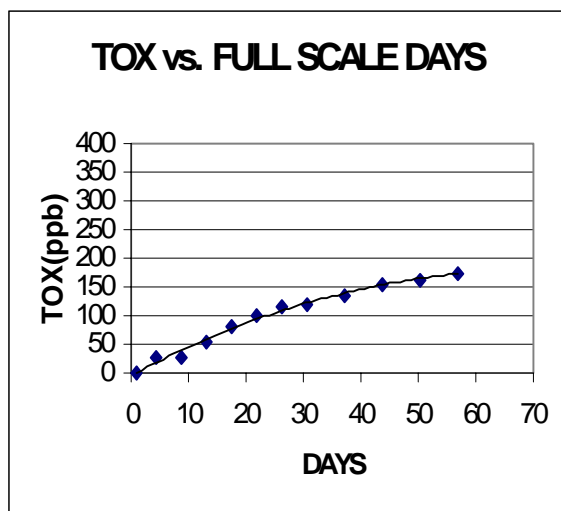
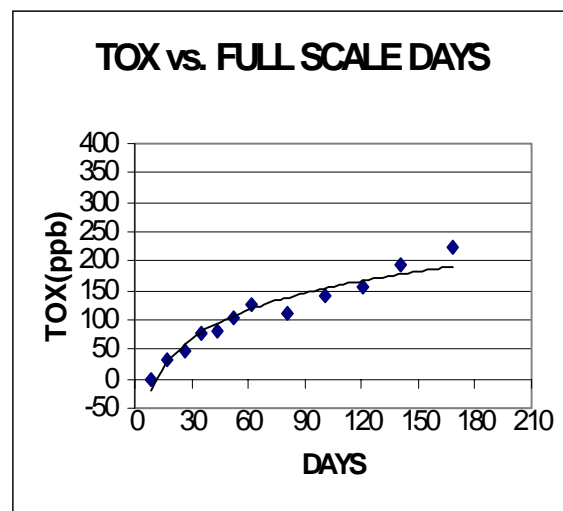
HAA6 vs. TOC – NOT ENOUGH
DATA

SECOND QUARTER RESULTS

2nd Quarter 10 min. EBCT

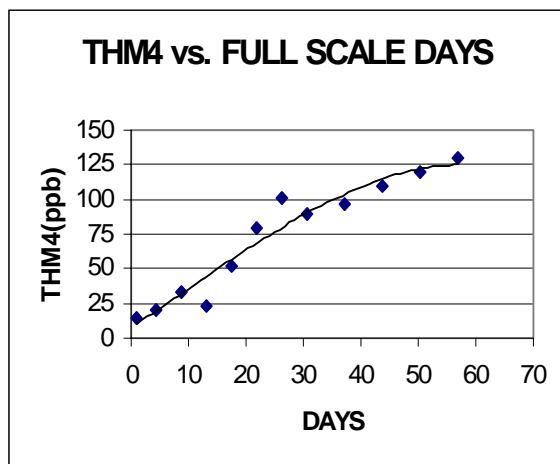


2nd Quarter 20 min. EBCT

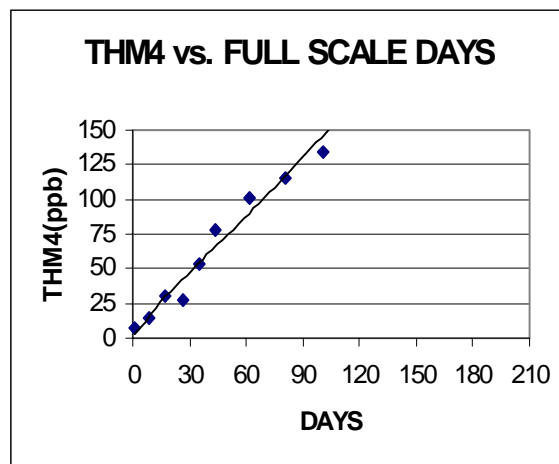
**UV254 vs. FULL SCALE DAYS****UV254 vs. FULL SCALE DAYS****TOX vs. FULL SCALE DAYS****TOX vs. FULL SCALE DAYS**

SECOND QUARTER RESULTS

2nd Quarter 10 min. EBCT



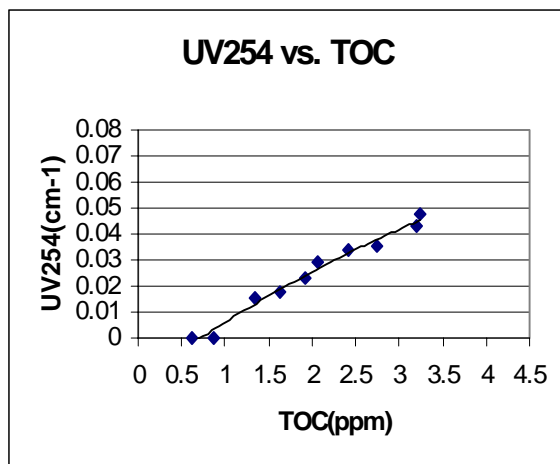
2nd Quarter 20 min. EBCT



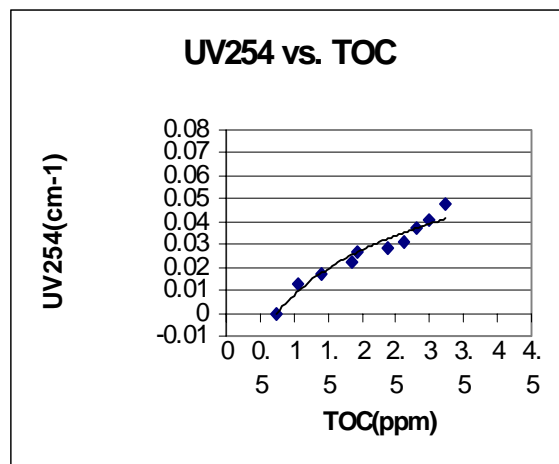
HAA6 vs. FULL SCALE DAYS --
INCONCLUSIVE RESULTS

HAA6 vs. FULL SCALE DAYS --
INCONCLUSIVE RESULTS

UV254 vs. TOC



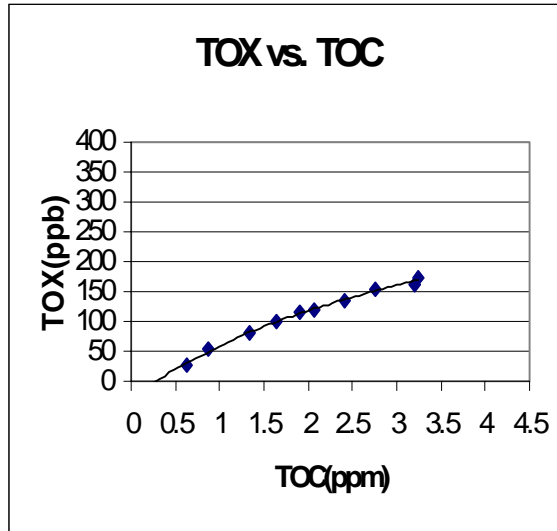
UV254 vs. TOC



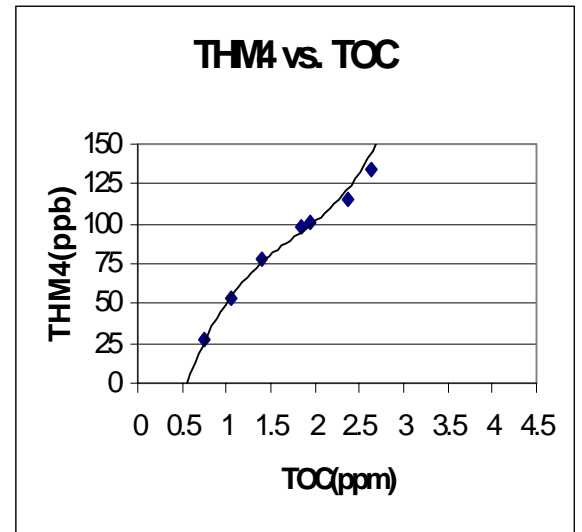
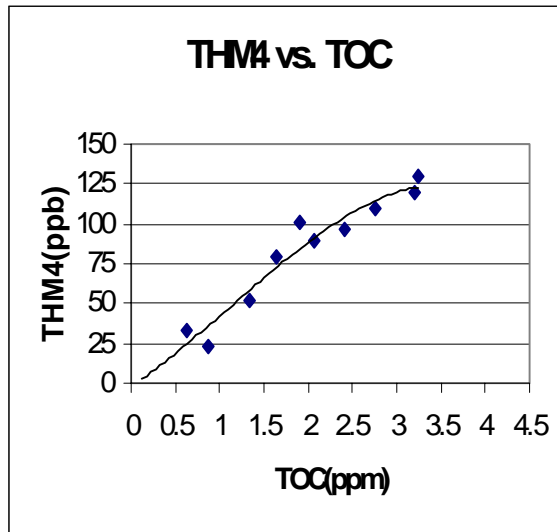
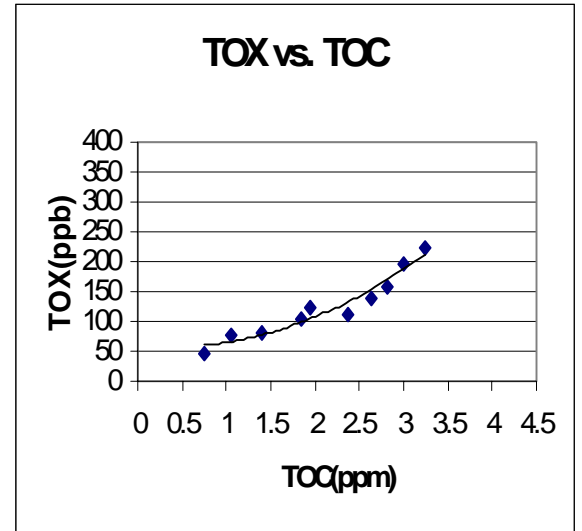
SECOND QUARTER RESULTS

Page 3 of 3

2nd Quarter 10 min. EBCT



2nd Quarter 20 min. EBCT

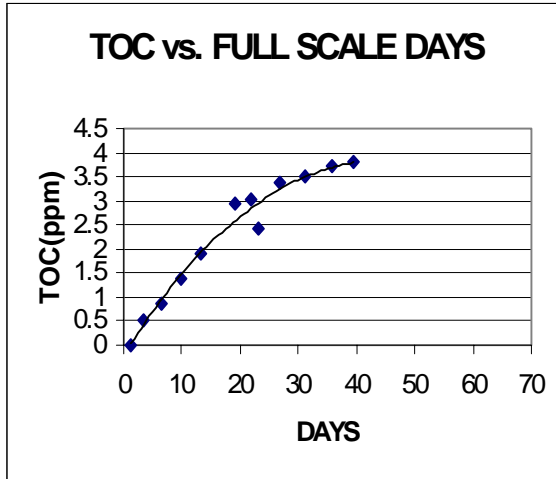


HAA6 vs. TOC --
INCONCLUSIVE RESULTS

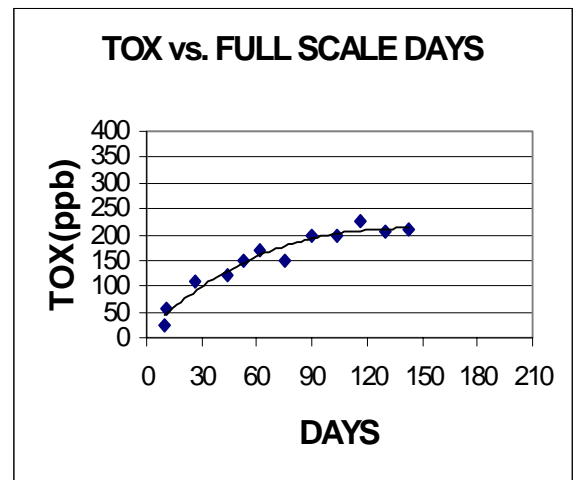
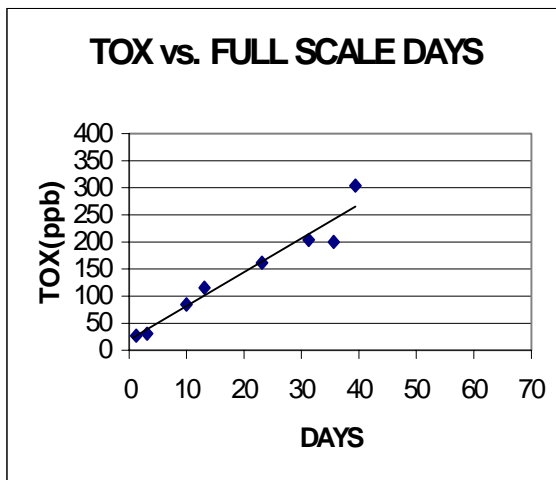
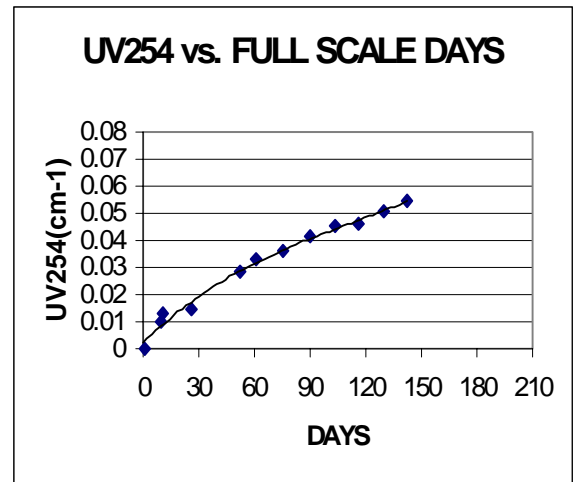
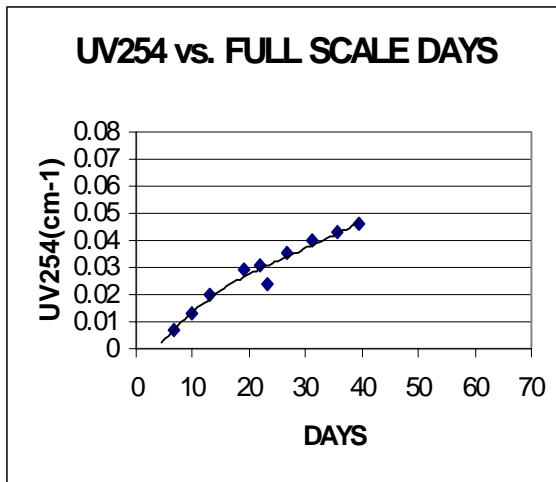
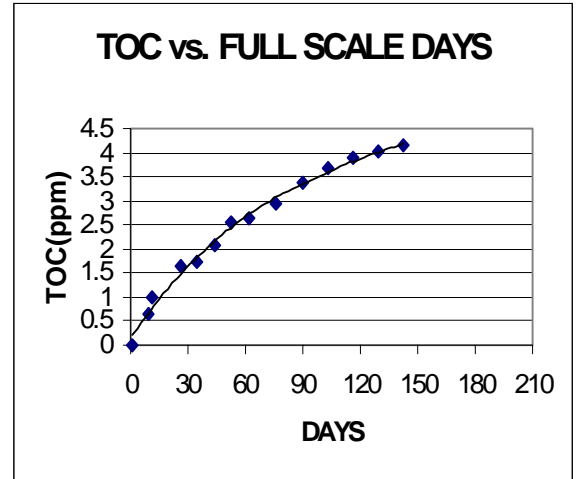
HAA6 vs. TOC --
INCONCLUSIVE RESULTS

THIRD QUARTER RESULTS

3rd Quarter 10 min. EBCT

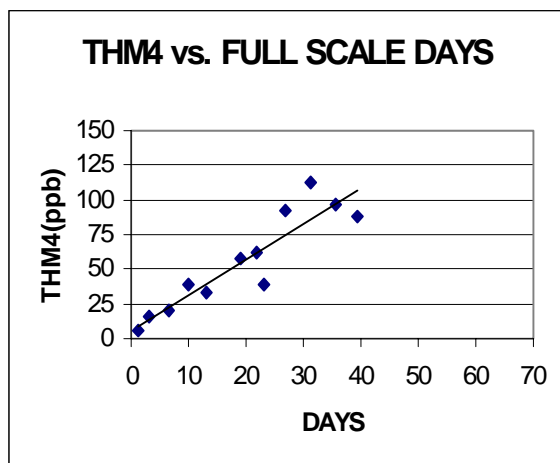


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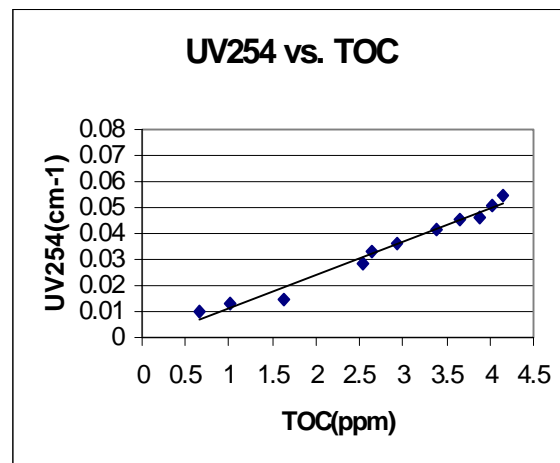
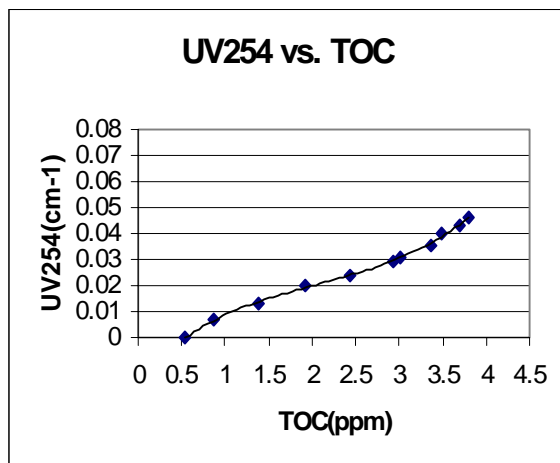
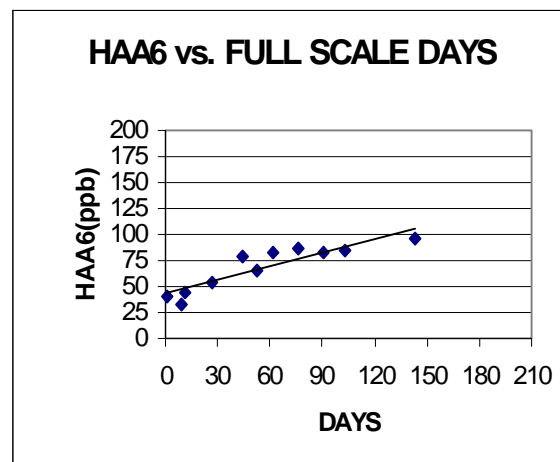
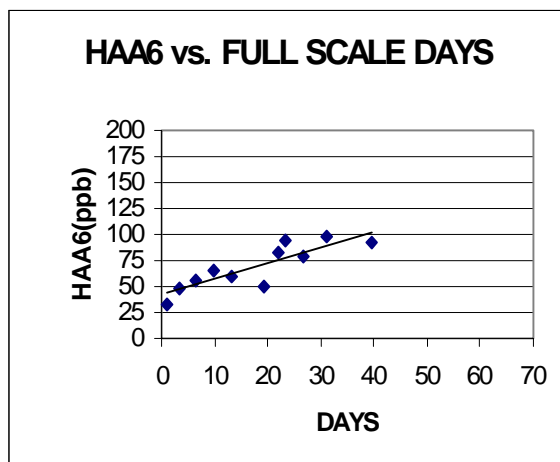
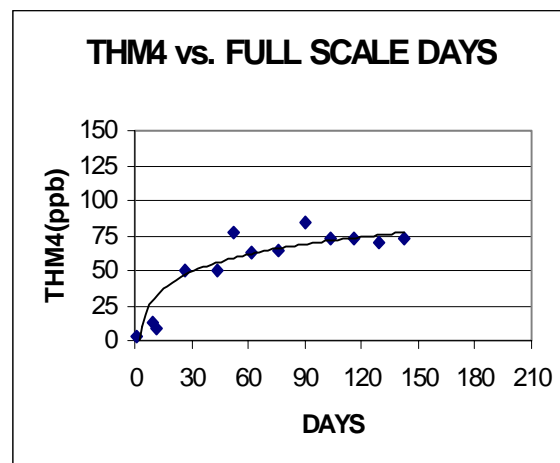


THIRD QUARTER RESULTS

3rd Quarter 10 min. EBCT

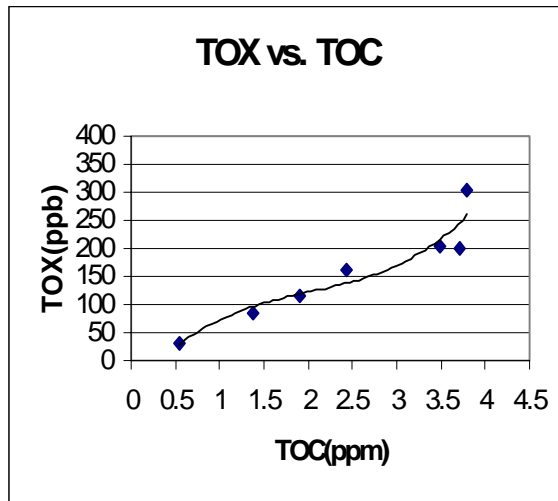


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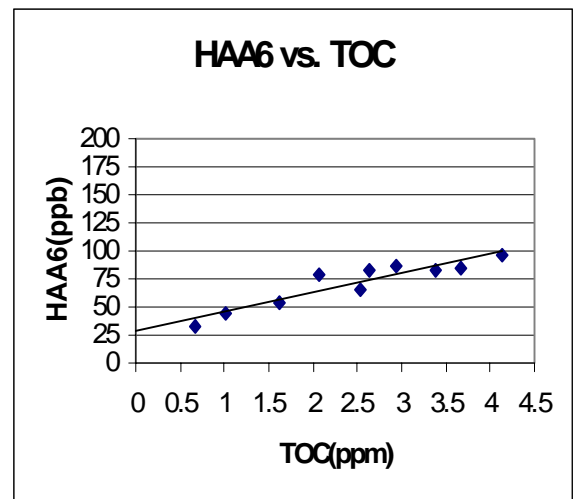
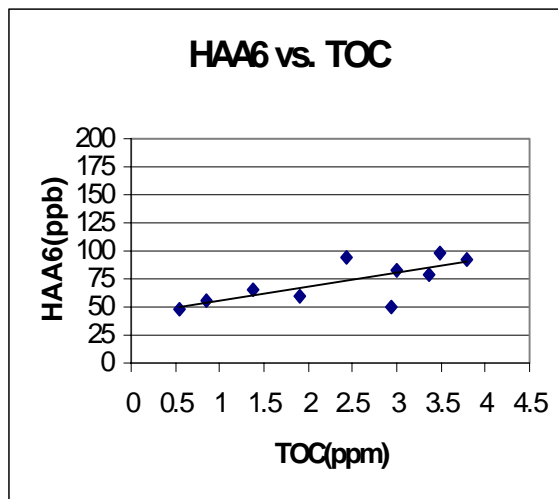
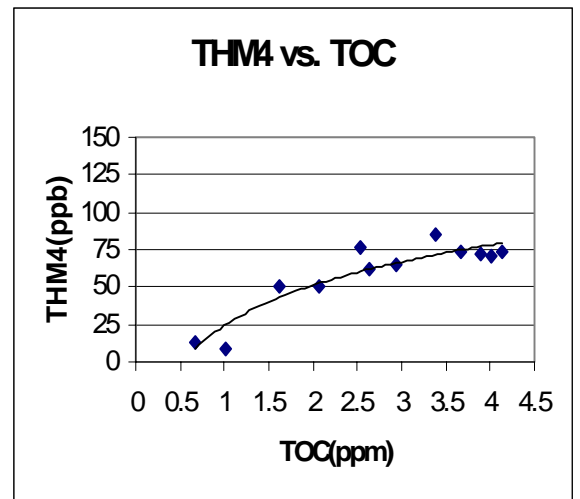
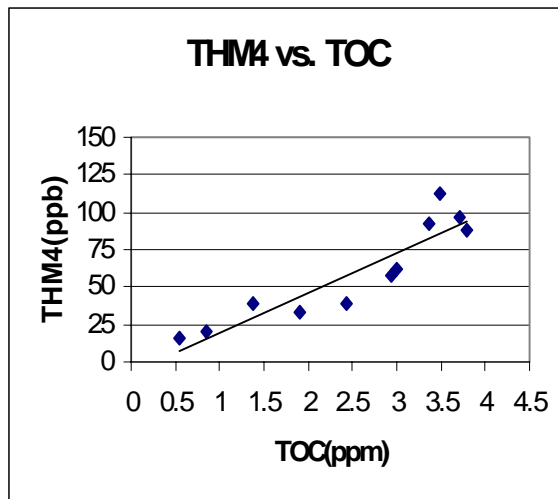
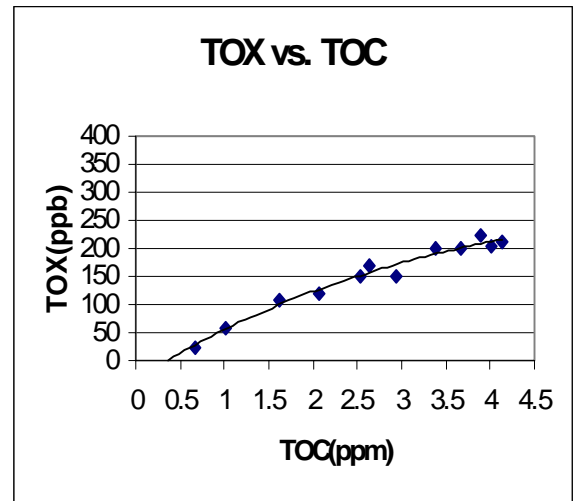


THIRD QUARTER RESULTS

3rd Quarter 10 min. EBCT



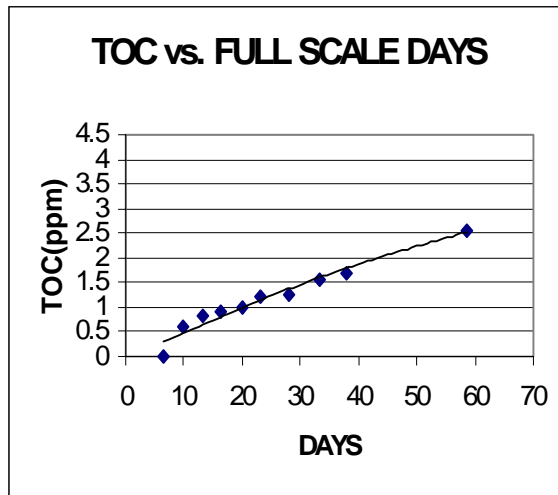
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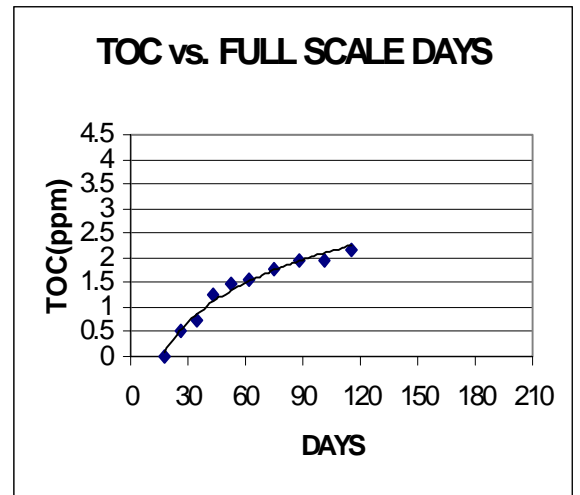
FOURTH QUARTER RESULTS

Page 1 of 3

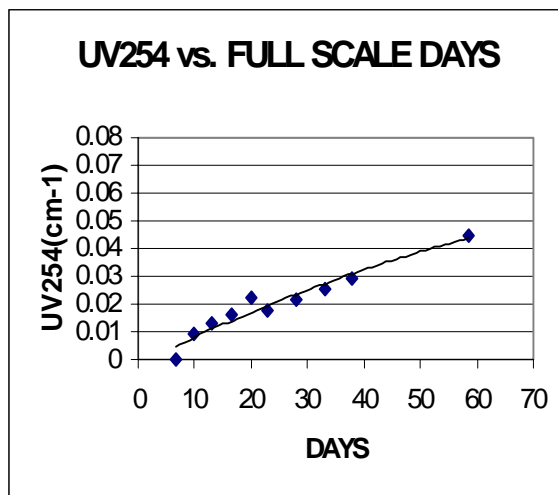
4th Quarter 10 min. EBCT



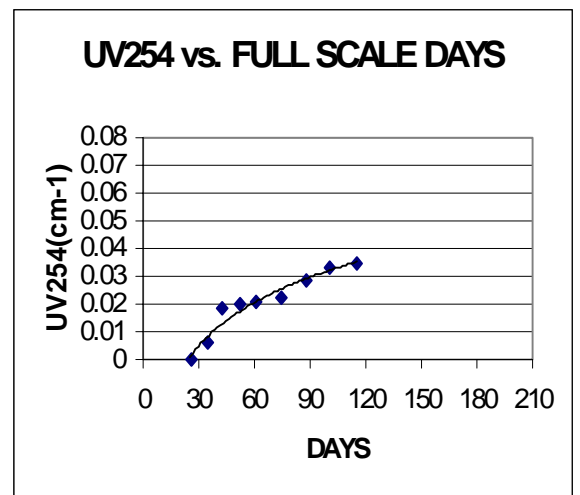
4th Quarter 20 min. EBCT



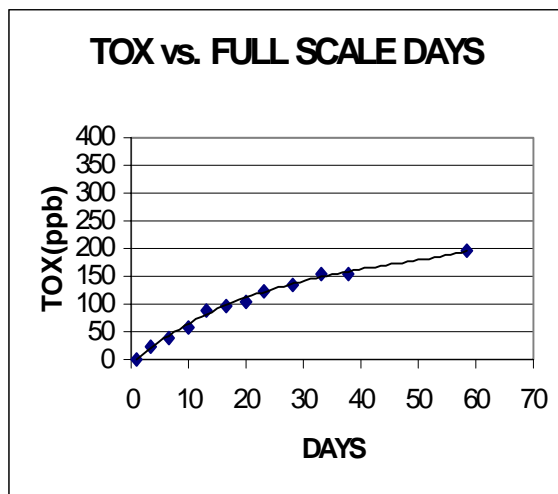
UV254 vs. FULL SCALE DAYS



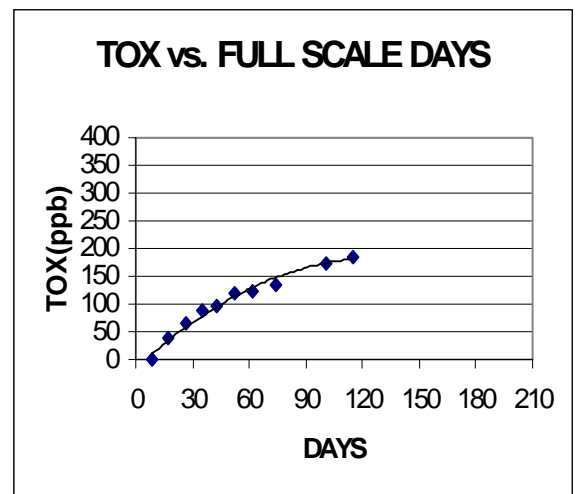
UV254 vs. FULL SCALE DAYS



TOX vs. FULL SCALE DAYS



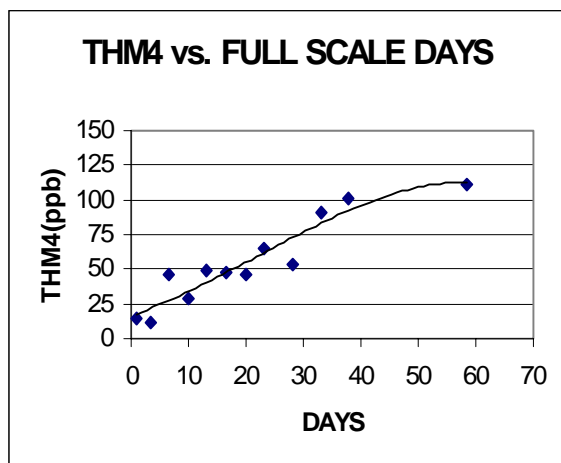
TOX vs. FULL SCALE DAYS



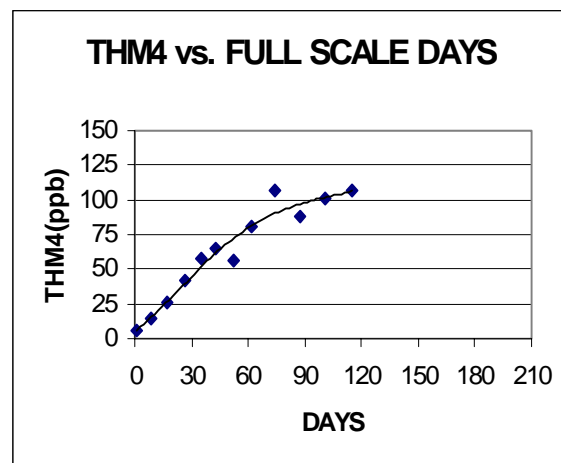
FOURTH QUARTER RESULTS

Page 2 of 3

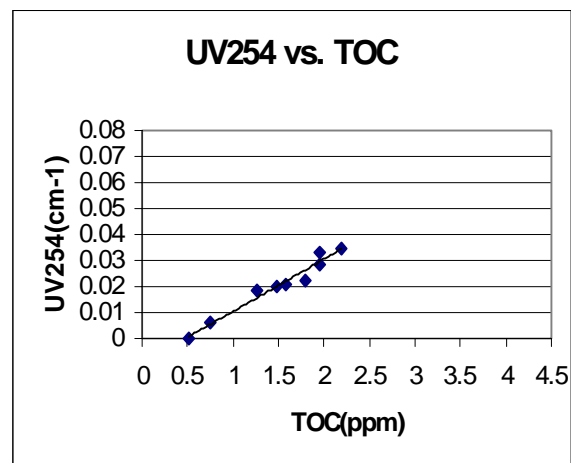
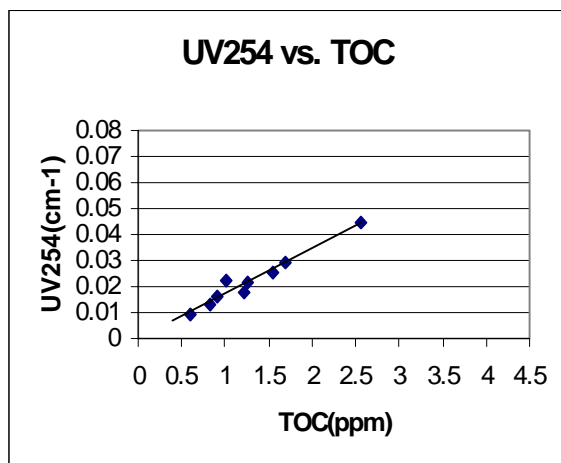
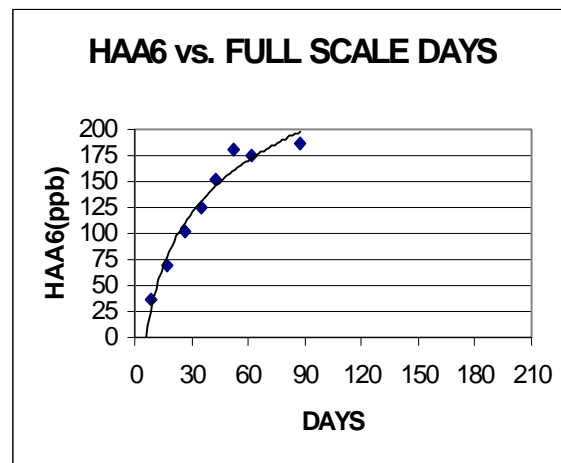
4th Quarter 10 min. EBCT



4th Quarter 20 min. EBCT

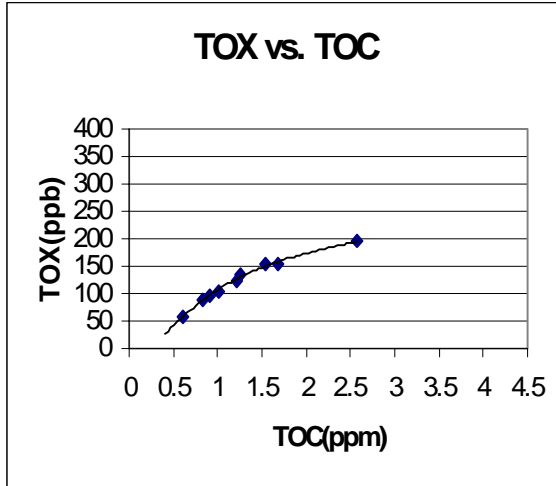


HAA6 vs. FULL SCALE DAYS --
INCONCLUSIVE RESULTS

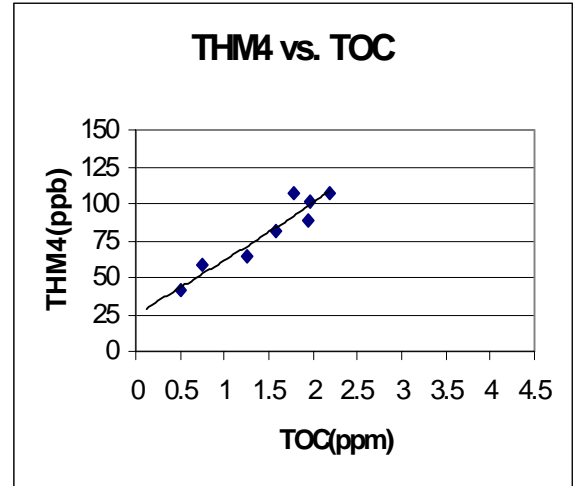
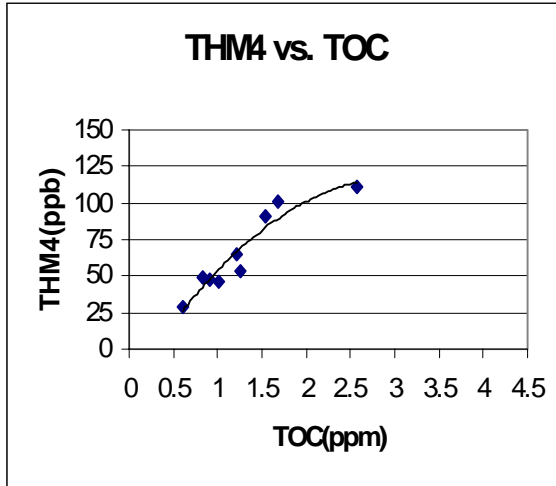
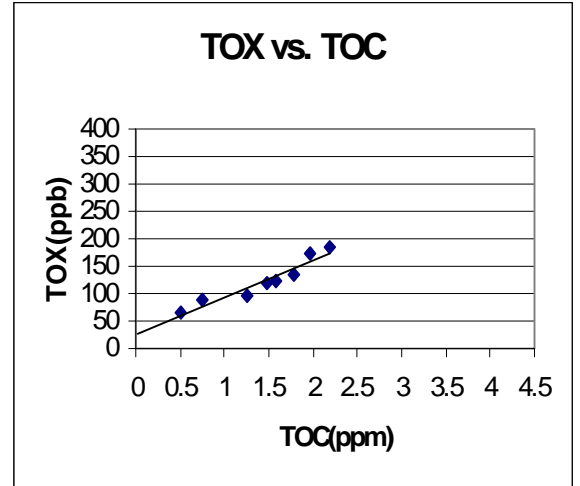


FOURTH QUARTER RESULTS

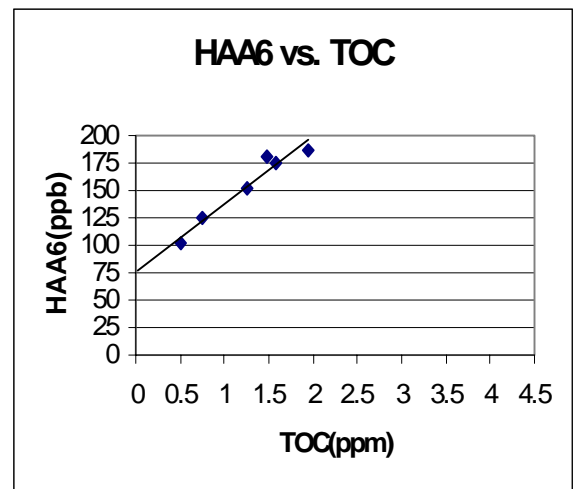
4th Quarter 10 min. EBCT



4th Quarter 20 min. EBCT

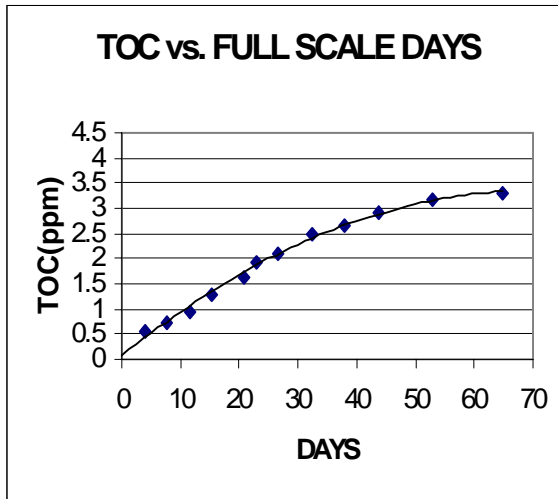


HAA6 vs. TOC --
INCONCLUSIVE RESULTS

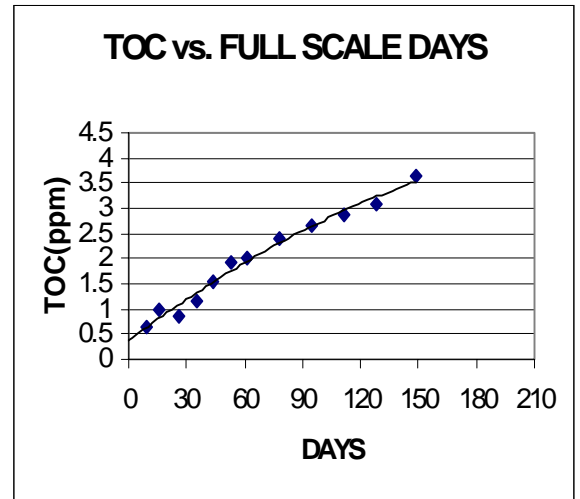


FOUR QUARTER AVERAGE RESULTS

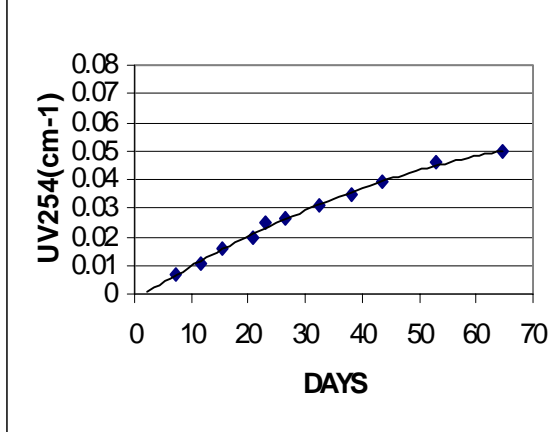
4 Quarter Average 10 min. EBCT



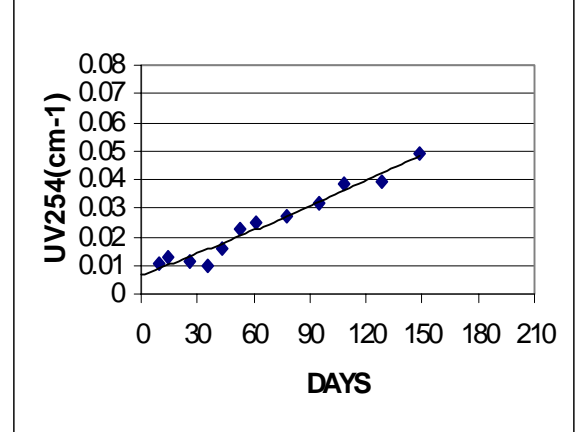
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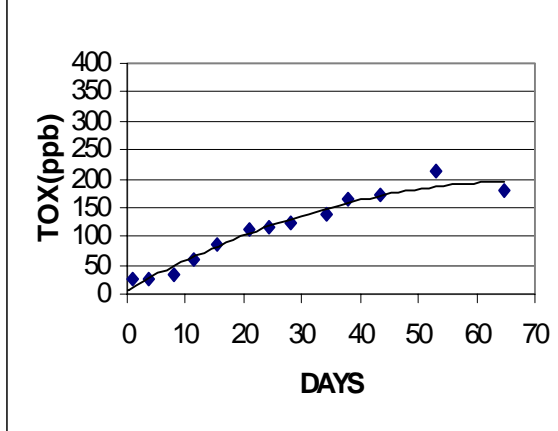
UV254 vs. FULL SCALE DAYS



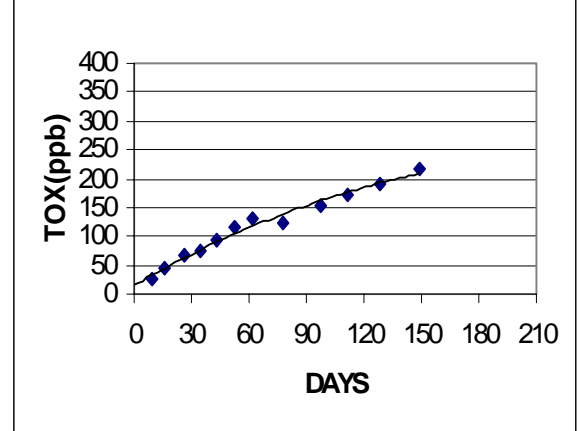
UV254 vs. FULL SCALE DAYS



TOX vs. FULL SCALE DAYS



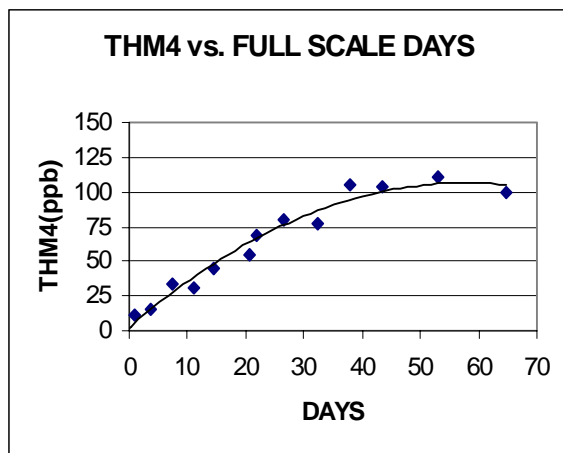
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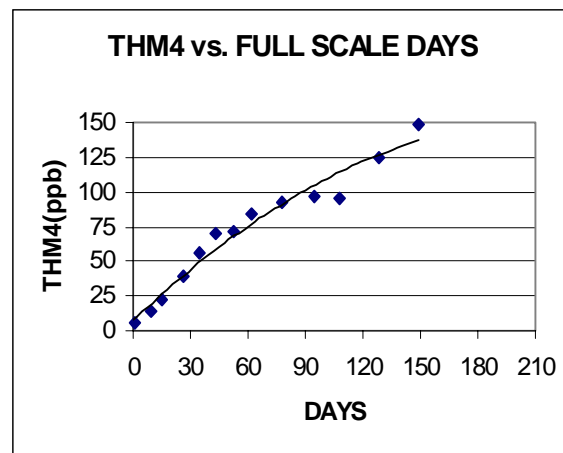
FOUR QUARTER AVERAGE RESULTS

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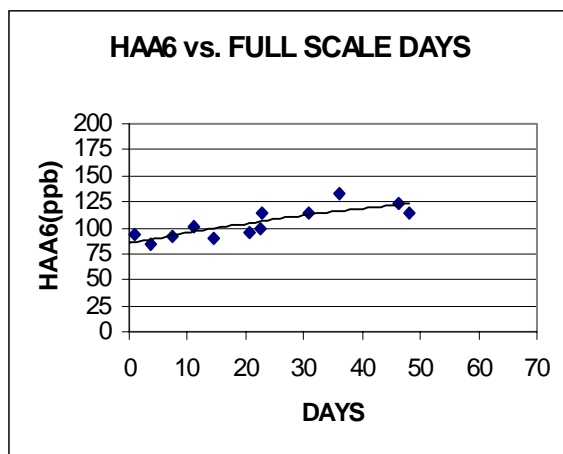
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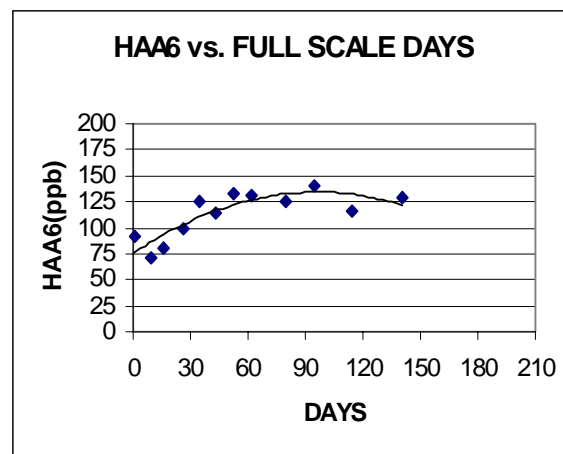
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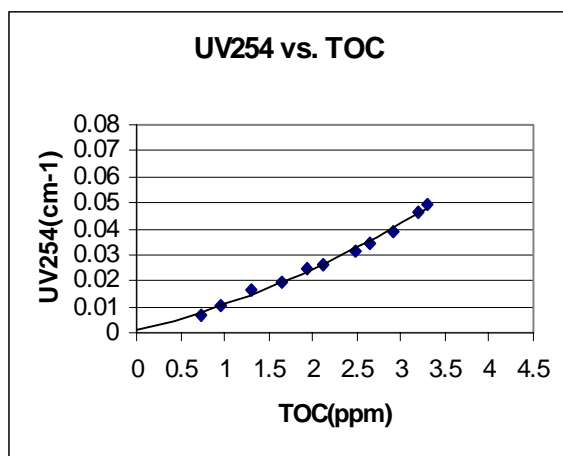
HAA6 vs. FULL SCALE DAYS



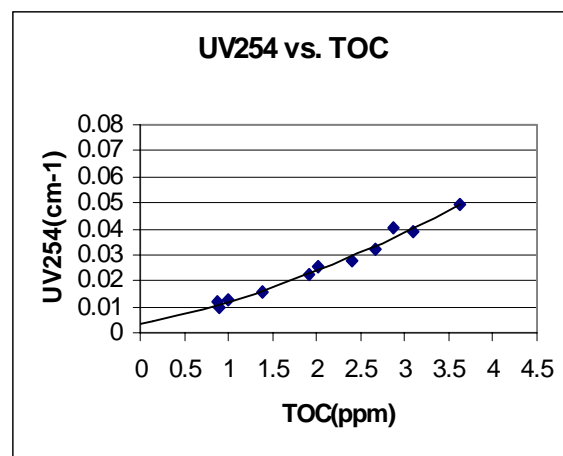
HAA6 vs. FULL SCALE DAYS



UV254 vs. TOC



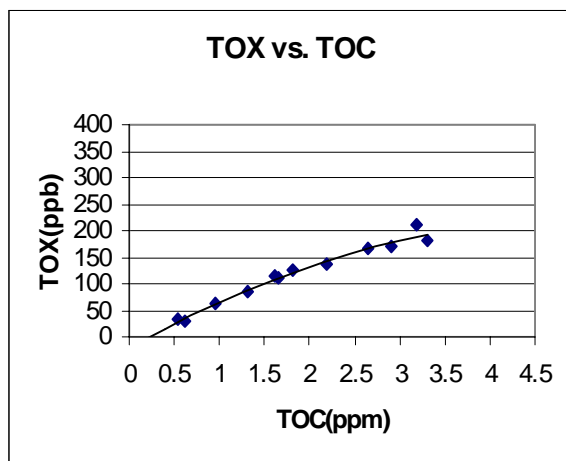
UV254 vs. TOC



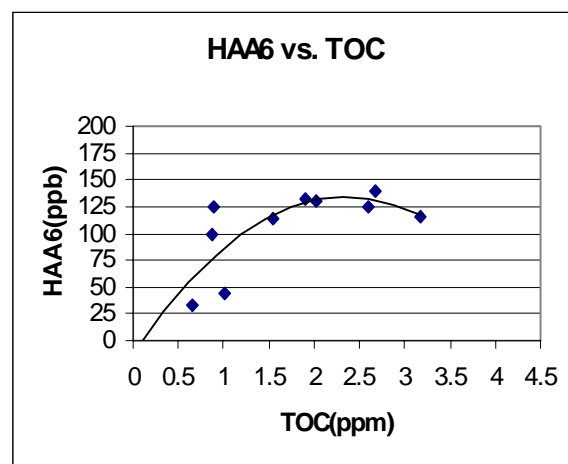
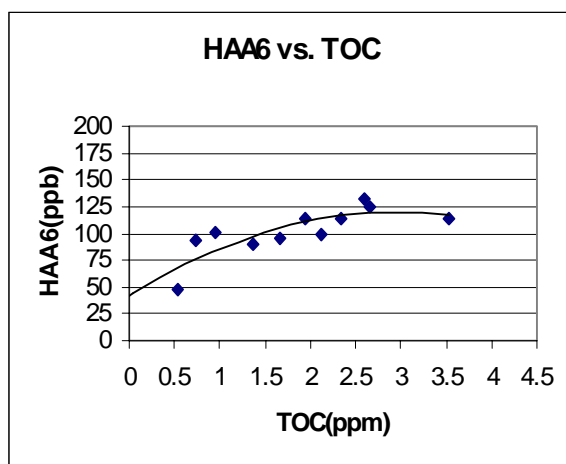
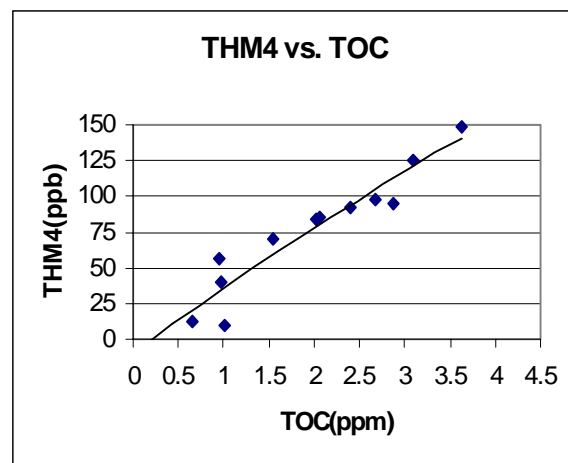
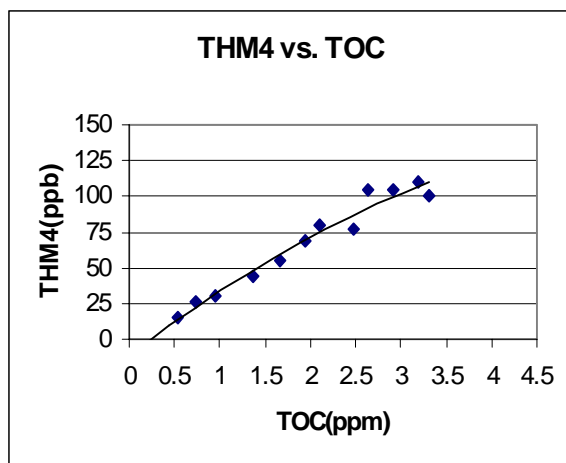
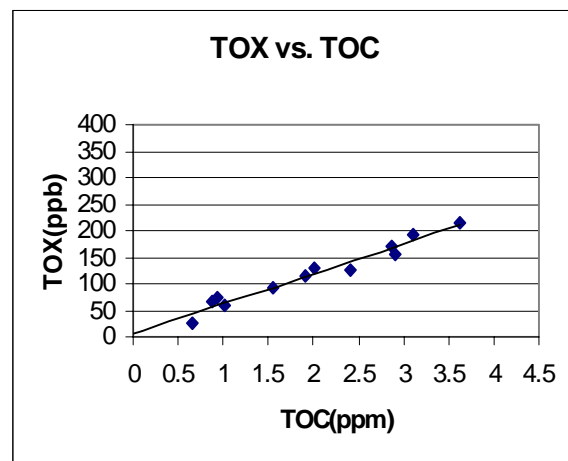
FOUR QUARTER AVERAGE RESULTS

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4 Quarter Average 10 min. EBCT



4 Quarter Average 20 min. EBCT



It can be seen from the data that TOC is effectively decreased by up to 50 percent for 30 to 60 full-scale days via activated carbon using 10 and 20 minute empty bed contact times respectively. There are some disconcerting points as well. The removal of precursors that lead to THM₄ formation at the stage 2 breakthrough level of 40 ppb is only effective for about half of this time or 15 and 30 days respectively. Removal of precursors that form HAA₆ does not appear effective enough to be considered. Values for HAA₅ averaged about 10 to 15 ppb lower than HAA₆.

Where inconclusive results are mentioned, the values for HAA₆ showed no definitive trends and their averages were above the stage 2 breakthrough points. It is not clear as to whether or not there may have been outside interferences present during analysis.

V. QA/QC Summary

THM₄ analysis was conducted in accordance with EPA method 551.1 using MtBE as the extraction solvent. A series of 6 standards (0.100, 1.00, 5.00, 10.0, 20.0, 30.0 µg/L) was used to produce a curve. The curve was verified by the use of standard checks and decafluorobiphenyl surrogate standards.

HAA₆ analysis was conducted in accordance with EPA method 552.1. A series of 6 standards (1.00, 10.0, 20.0, 30.0, 40.0, 50.0 µg/L) was used to produce a curve. 1,2,3-trichloropropane internal and 2-Bromopropanoic Acid surrogate standards were used along with check standards to verify the curve.

TOC analysis was conducted in accordance with SM 5310 C. A series of 5 standards (0.30, 2.0, 5.0, 8.0, 10.0 mg/L) was used to produce a curve. Check standards were used to verify the curve.

Total Organic Halide and Bromide analyses were performed by Montgomery Watson Laboratories under the Information Collection Rule conditions.

VI. Problems Encountered

At the outset, there was some difficulty in determining mixing rates to properly mimic conditions at the treatment facility.

At the end of the first RSSCT run, the water used to prepare some of the chlorine demand studies was not free of organic contamination. Also, the HAA samples were incorrectly spiked with calibration standard instead of surrogate standard.

Estimating TOC values at 5-8% of the previous value proved difficult at the lower concentration levels.