ICR TREATMENT STUDY SUMMARY REPORT

PILOT PLANT GAC ICR TREATABILITY STUDY

Conducted during period of April 14, 1998 through April 15, 1999

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NTMWD PILOT PLANT GAC ICR TREATABILITY STUDY

CONCLUSIONS AND RECOMMENDATIONS

A pilot scale granular activated carbon (GAC) plant was operated by the North Texas Municipal Water District (NTMWD) as part of the Information Collection Rule (ICR). The GAC pilot plant resulted in data that will be useful for the purpose of determining whether or not GAC filtration is a viable method of removing total organic carbon (TOC) from treated water prior to disinfection with chlorine.

The pilot plant consisted of full-scale chemical addition (coagulant and lime), full-scale rapid mix, full-scale flocculation and settling, and a pilot scale filter and GAC columns. Normal water treatment plant pre-chlorination procedures were halted during the course of the pilot plant study in order to conform with the requirements of the treatability study requirements.

While the pilot plant data will be useful, data were collected under conditions that are not representative of normal plant operations. Normal plant operations involve the addition of chlorine (disinfectant) to the raw water prior to the addition of lime or coagulants. The addition of chlorine at the head of the plant would reduce the expected life or usefulness of the carbon and require frequent regeneration of the GAC. Disinfection of the raw water (pre-chlorination) and chlorination ahead of the filters is needed to provide sufficient CT values and to control biological growth in the treatment plant and filters.

Effluent TOC levels from the GAC columns was an unsteady state process resulting, generally, in higher effluent TOC concentrations during periods of high

influent TOC concentrations. The unsteady state nature of the TOC removal by GAC could result in large variations in treated water TOC concentrations if utilized in a full-scale operation.

The NTMWD water plant uses chloramines for disinfectant residual. While simulated distribution samples (SDS) of influent to the GAC columns indicate that trihalomethanes (THM) are formed in excess of both stage 1 and stage 2 levels, the chlorination of the SDS samples was performed with free chlorine. The use of free chlorine does not adequately represent the disinfection by product (DBP) formation that is observed in a system that uses chloramines to maintain a chlorine residual.

The data that was collected during the pilot plant study will be useful as a benchmark to compare other techniques of DBP and DBP precursor removal. The reduction in TOC (precursors) and the resultant decrease in DBP's in SDS samples collected from the GAC columns indicates that filtration of water through GAC columns is one method of reducing THMs and haloacetic acids (HAAs) to stage 2 levels. However, other less costly methods of precursor removal need to be considered. Utilization of GAC to remove DBP precursors would result in other problems such as biological growth in the water treatment plant due to the inability to use chlorine based disinfectants ahead of the GAC, loss of "CT", costs of regeneration of the GAC, and extensive costly construction of new filter facilities, pumps, and pipelines.

BACKGROUND INFORMATION

The source of water for the NTMWD Wylie Water Treatment Plant is Lake Lavon, located in Collin County, Texas. Water is pumped to the plant from one of three

pump stations. The raw water is conveyed to the plant via pipeline. The average detention time in the lake is 1033 days. All three pump stations are located on the south end of the lake close to the dam.

The NTMWD water plant has two process trains. Train one is the original train and receives water primarily through pump station one. Process train one is a 70 MGD train. Water is pumped to a chemical building where lime and ferric sulfate are added. The water goes through a single rapid mix and then is split to four clariflocculators. From there it flows to dual media filters, and into a clearwell for distribution.

Train two has a rated capacity of 350 MGD. It is split into two separate but identical trains (2A and 2B). Train 2A has a rated capacity of 280 MGD while 2B is rated 70 MGD. Train 2A has a chemical building, eight rapid mix basins, eight three-stage flocculation basins, eight flow through settling basins, and 40 filter basins. Water supply for train 2A is pumped primarily from pump station two. Water is pumped from pump station two to a chemical building where slaked lime is added. The water then gravity flows to a rapid mix basin located at the head of the settling basin. Ferric sulfate is added at the rapid mix basin. The water then flows through a three stage flocculation basin, through a settling basin, and then through a dual media filter. After filtering, the water flows to a clearwell where it is blended with water from train 2B. From there it is pumped into the distribution system. Train 2B has its own chemical building, two rapid mix basins, two flocculators, two settling basins, and 10 filters. Water is supplied to train 2B is from pump station 3. Powdered activated carbon, potassium permanganate, and chlorine can be added to the raw water between each of the pump stations and the chemical buildings.

Chlorine is added to the raw water prior to the chemical building. The water is chlorinated again ahead of the filters. Chlorine and ammonia are added at the clearwells to form chloramines for residual disenfectant.

Train 2B was used for the pilot plant treatability study. It was used since the rule required that no prechlorination of raw water occur prior to passing through the GAC. Since train 2B has it's own chemical feed facilities, the NTMWD was able to perform full scale treatment of the raw water for the pilot plant without the addition of chlorine ahead of the pilot plant. This allowed the NTMWD to provide actual production water to the pilot plant for testing without sacrificing the quality of the water being pumped to the distribution system. Schematics of the treatment plants are presented in the Appendix.

Included in the Appendix are reports G.1 (Final Design Plant Parameters), G.2 (Final Design Plant Chemical Parameters) and G.3 (Final Design Water System Information) taken from the ICR software used by NTMWD. Final design reports were included rather than initial design reports because plant 2B was placed in service after the ICR data collection began so it was not part of the initial design. The reports (G.1, G.2, and G.3) show the final water and chemical design data for all of the process trains at the NTMWD Wylie Water Treatment Plant. Actual chemical feed rates varied as needed to operate the plant during the study period. Typically, the raw water is treated using approximately 5.4 mg/L of ferric iron and approximately 50 mg/L of lime (CaO). Table 1 shows select source water quality parameters. Data for Table 1 was collected during the last (final) twelve months of ICR sampling. Table 2 provides statistical data for finished water quality and THM formation in the NTMWD distribution system. This data was also compiled from the final twelve months of ICR data.

Table 1. Source Water Quality for 1998 Period

Water Quality Parameter	Average Concentration	Standard Deviation	Maximum Value	Minimum Value
Temperature (^{O}C)	19.38	6.71	28.8	9.8
pH	8.20	0.11	8.4	8.04
Alkalinity (mg/L as $CaCO_3$)	100.83	21.98	135	60
Calcium Hardness (mg/L as $CaCO_3$)	112.7	18.71	143.00	78.00
Total Hardness (mg/L as $CaCO_3$)	120.25	16.37	146	92
TOC (mg/L)	4.4	0.57	5.6	3.6
UV254 (cm^{-1})	0.08	0.01	0.11	0.07
Bromide (µg/L)	56	13	77	40
Turbidity (ntu)	17.78	6.08	32.4	11.3

Table 2. Finished Water WQP and Distribution System THM4 for 1998

Water Quality Parameter	Average Concentration	Standard Deviation	Maximum Value	Minimum Value
Temperature (^{O}C)	20.7	4.59	26.8	13.1
pH	8.12	0.19	8.5	7.9
Turbidity (ntu)	0.38	0.18	0.77	0.23
TOC (mg/L)	3.78	0.41	4.4	3.3
Distribution System THM4 (µg/L)	64.24	5.84	74.1	55

MATERIALS AND METHODS

The pilot plant was set up and operated in accordance with the guidelines as set forth in the "ICR Manual for Bench and Pilot Scale Treatment Studies". Water from the

Table 3. Design Data for Process Train 2B (South Settling Basin) and the GAC Pilot Plant

UNIT PROCESS	PROCESS DESCRIPTION
Chemical Addition	Chemical: Slaked Lime as $Ca(OH)_2$ Dose Rate: 98.0 (design)
Rapid Mix (Full Scale)	Mixer Type: Mechanical Baffling Type: Average Liquid Volume: 5835 gal. Mean Velocity Gradient: 850 sec^{-1} Chemical Addition: Ferric Sulfate as $Fe_2(SO_4)_3$ Dose Rate: 14.4 mg/L (design)
Flocculation (Full Scale)	Mixer Type: Mechanical Liquid Volume: 520400 gal Baffling Type: Average Stage Sequence No: 1 Stage Mean Velocity Gradient: 36 sec^{-1} Stage Liquid Volume: 520400 gal Design Flow Rate: 35 MGD
Sedimentation (Full Scale)	Surface Area: 36720 ft^2 Liquid Volume: 4669627 gal Baffling Type: Poor Design Flow Rate: 35 MGD
Filtration (Pilot Scale)	Construction Material: 6.125 inch ID Clear Plastic Pipe Surface Area: 0.205 ft^2 Flow Rate: 0.61 gpm Media: Anthracite and Sand Media Depth: 36 inches
GAC Column (Pilot Scale)	Construction Material: 6.125 inch ID Clear Plastic Pipe Surface Area: 0.205 ft^2 Flow Rate: 0.61 gpm Empty Bed Contact Time: 10 minutes Media: Granular Activated Carbon Media Depth: 48 inches
GAC Column (Pilot Scale)	Construction Material: 6.125 inch ID Clear Plastic Pipe Surface Area: 0.205 ft^2 Flow Rate: 0.61 gpm Empty Bed Contact Time: 10 minutes Media: Granular Activated Carbon Media Depth: 48 inches

pilot plant was supplied from the south sedimentation basin in process train 2B. Train 2B was selected because it allowed the NTMWD to provide actual produced water to the

pilot plant without pre-chlorination. Water was pumped from Lake Lavon through a pipeline to the chemical building. Slaked lime was added at the chemical building. The water then flowed to a rapid mix basin where ferric sulfate was added as a coagulant. The water then passed through a three-stage flocculation basin and through a sedimentation basin. Design information for the unit processes and the pilot plant are presented in Table 3. A schematic of the process train and pilot plant is presented in the Appendix. Water for the pilot plant was pumped from the effluent launders using a submersible pump. The water was conveyed to the pilot plant through a one inch PVC pipeline. The pilot plant was constructed so that water flowed under pressure through three columns in series. The first column was a dual media filter consisting of sand and anthracite coal. The second and third columns contained GAC. Each GAC column had a ten minute empty bed contact time (EBCT) at a flow rate of 0.61 gallons per minute (gpm). Columns were constructed out of 6.125 inch (ID) clear plastic pipe. All other piping was constructed with one inch PVC pipe. Settled water was pumped from the settling basin effluent launders to the pilot plant where it passed through a flow meter. The water then entered the top of the dual media filter and flowed down through the filter column. The water then flowed to the top of the first GAC column and down through it. The water then flowed to the top of the second GAC column and downward through it. The effluent was collected in a one hundred gallon washwater collection basin. The washwater basin provided a supply of non-chlorinated filter backwash water. The excess overflowed to a drain. Each column had a separate sample port and pressure guage. The dual media filter was backwashed every twenty four hours using the pilot plant effluent. Backwash water was allowed to flow to a drain. With the exception of the flow meter

and pressure gauges, all pipes and valves were made of PVC. A schematic of the pilot plant columns is presented in the Appendix.

The GAC used in the pilot plant was a 12 x 40 mesh carbon provided by Calgon, Inc. The GAC was placed in the columns as specified in the "ICR Manual for Bench and Pilot Scale Treatment Studies". The required depth of GAC for a 10 minute EBCT was calculated to be 48 inches. GAC column one was loaded with 33.25 pounds of carbon to a depth of 52.5 inches. Column 2 was loaded with 33.5 pounds of GAC to a depth of 52.25 inches. The actual total weight of GAC put in the columns (sum of columns 1 and 2) was 67.15 pounds. The theoretical weight needed including 5% excess as recommended in the manual was 67.03 pounds. The columns were backwashed to remove some of the fines. After backwashing, water was allowed to flow through the system for one hour to settle the columns to the required bed depth and to purge air from the system. The GAC was then allowed to soak in the water for 24 hours prior to beginning operation of the pilot plant. The following day, April 14, 1998, the pilot plant was placed into operation. The first sample for analysis was collected after the first day of operation (April 15, 1998).

A chlorine demand study was performed by the NTMWD laboratory on samples of influent to the GAC column and effluent from the 20 minute EBCT column in order to determine the dose needed to leave a free chlorine residual of 1.0 mg/L.

Prior to utilizing the pilot plant filters, tests were run to show that the pipe and plant materials were not adsorbing or otherwise removing TOC from the water that was being pumped through them. Prior to loading the pilot plant columns with GAC, seven samples of water were collected before passing through the pilot plant and seven samples

were collected after passing through the plant. Each of these samples were analyzed for UV-254. Each sample had an analytical duplicate, for a total of 28 measurements. UV-254 measurements showed that there was no difference between the water before and after passing through the pilot plant and pipes.

Laboratory work for the analyses of pilot plant samples was performed by the NTMWD and Gannet Fleming Environmental Laboratories. Water quality parameters and UV-254 were determined in the NTMWD laboratory. Concentrations of bromides, TOX, TOC, THMs, and HAAs were determined by Gannet Fleming. The Gannet

Table 4. Table of Analytes, Methods, and MRLs

Analyte	Method	Minimum Reporting Level
Alkalinity	SM2320 B	Not Applicable
Ammonia	SM4500-NH3 D	0.1 mg/L
Bromide	EPA 300.0	20 µg/L
Calcium Hardness	SM3111B	Not Applicable
Chlorine Residual	SM4500-Cl D	0.2 mg/L
BCAA, DBAA, DCAA, MBAA, TCAA	SM 19th 6251B	1 µg/L for all analytes
pH	SM 4500-H+	Not Applicable
Temperature	SM 2550 B	Not Applicable
$CHCL_3$, BDCM, DBCM, $CHBr_3$	EPA 551.1	1 µg/L for all analytes
Total Hardness	SM 2340 C	Not Applicable
TOC	SM 18th 5310C	0.5 mg/L
TOX	SM 18th 5320B	25 µg/L
Turbidity	EPA 180.1	Not Applicable
UV_{254}	SM 5910	0.009 cm^{-1}
MCAA	SM 19th 6251B	2 µg/L

Fleming Environmental Laboratory underwent a name change during the testing. Their new name is Microbac Laboratories. Both labs were used to run analytical measurements during the ICR sampling. Both labs received certification for the ICR and maintained that certification during the entire ICR sampling period. Pilot plant samples were tested by each laboratory in accordance with the ICR approved methods and using ICR quality assurance/ quality checks. Table 4 shows the methods used and the minimum reporting level for each analyte tested. The laboratories used for the pilot plant testing, the dates of service for each laboratory, and the analyses performed are presented in Table 5. The laboratory ICR ID numbers, addresses, and contact information are listed in Table 6.

Table 5. Table of Laboratories and Analyses Performed

Laboratory	Dates of Service	Analyses Performed
North Texas Municipal Water District	4/14/98 - 4/15/99	pH, Turbidity, Alkalinity, Temperature, Total Hardness, Calcium Hardness, Ammonia, UV254, SDS Cl2 residual
Gannett Fleming Environmental Laboratories	4/14/98 - 4/15/99	TOC, Bromide, TOX, HAAs, THMs

Table 6. Table of Laboratories Addresses and IDs

Laboratory	ICR Lab ID	Address, Phone, Fax, Contact
North Texas Municipal Water District	ICRTX037	P.O. Box 2405 Wylie, Texas 75098 Phone: 972-442-5405 Fax: 972-442-5405 Contact: Mr. Mike Gooch
Gannett Fleming Environmental Laboratories	ICRPA006	209 Senate Avenue, Suite 105 Camp Hill, PA 17011 Phone: 717-763-0582 Fax: 717-763-8150 Contact: Cheri Casari

Simulated distribution sample (SDS) chlorine dosing and incubation was accomplished using the "Uniform Formation Conditions (UFC) For DBP Formation" procedure that was provided in the "ICR Manual for Bench and Pilot Scale Treatment Studies". This procedure was chosen for simplicity and because the method came very close to matching normal conditions in the NTMWD distribution system. The average detention time for water in the NTMWD system is about twenty four hours. Using the UFC method provided a more consistent approach to dosing and incubating SDS samples. The validity of using the UFC approach was verified by a call to the USEPA Safe Drinking Water Hotline.

The pilot plant was shut down for one month during the winter for routine maintenance of process train 2B. Process train 2B and the pilot plant were shut down on January 4, 1999. Operation of both resumed on February 5, 1999. During the shut down, routine cleaning and repairs were performed. Routine maintenance is performed during low flow periods.

RESULTS AND DISCUSSION

Chart 1 shows the running average of the normalized influent TOC along with the 10 minute and 20 minute EBCT column's TOC. The 10 minute EBCT column had 70% breakthrough at 1489 hours of operation time. The 20 minute column did not reach 70% breakthrough until 7603 hours of operation time. It is obvious that the effluent TOC from the GAC columns is an unsteady state process that is dependent upon the influent TOC concentration. Influent TOC concentration has a large effect on the effluent TOC concentration. Seventy percent breakthrough in the 20 minute EBCT column would have

occurred much sooner had the influent TOC remained steady. There was a sharp decrease in influent TOC beginning at 3529 hours (September 8, 1998). The reason for the decrease in TOC concentration is unknown, however, the Wylie area experienced fairly heavy rainfall at that time due to tropical storm Francis. The effluent TOC concentration in the 20 minute column mirrored the influent and also declined. Two consecutive samples collected from the 20 minute column showed a decrease in TOC concentration. After decreasing for two sample collection periods, the TOC concentration in the 20 minute EBCT column began to steadily increase.

During the course of the study, it was noted that there were fairly large changes in TOC concentration from one sample to the next on both the 20 minute and 10 minute columns. No apparent reason for the fluctuations was noted except that influent TOC

Chart 1. Normalized Influent and Effluent GAC

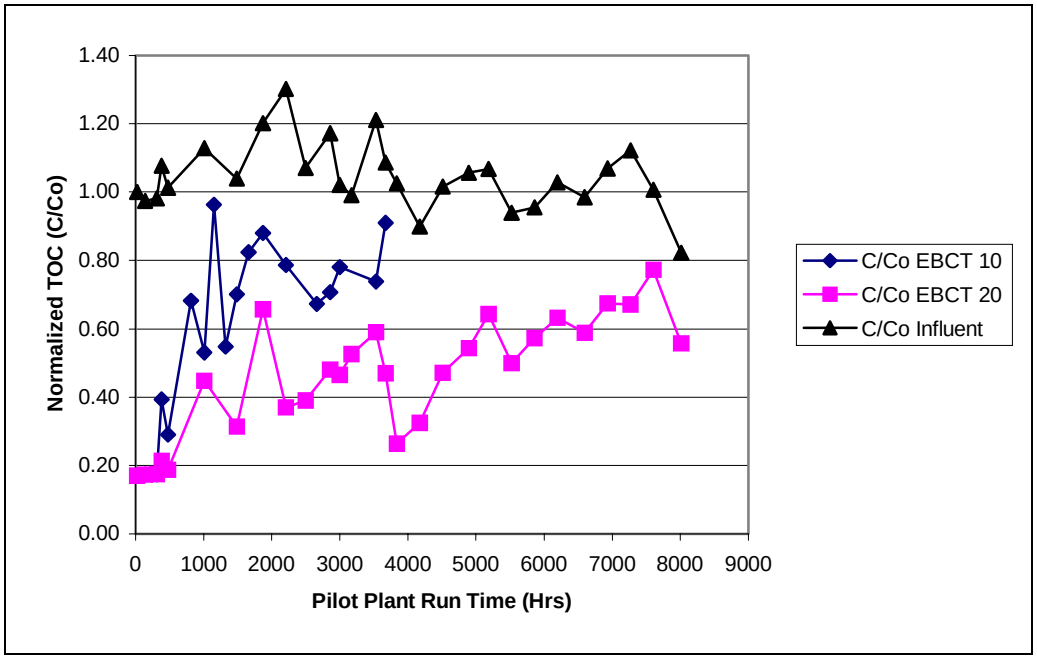


Chart 2. GAC Influent and Effluent TOC

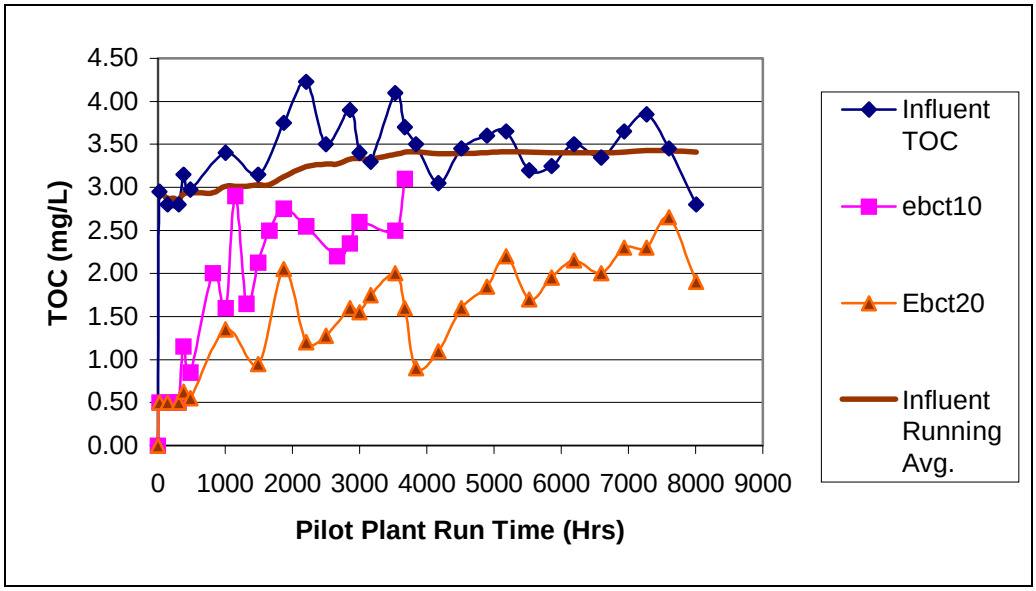


Table 7. Select Water Quality Parameters of the Influent to GAC Columns

Statistic	**Analyte**						
	pH	**Turbidity**	**Alkalinity**	**Temp.**	**Total Hardness**	**TOC**	**UV-254**
	(Std. Units)	**(NTU)**	**(mg/L as $CaCO_3$)**	**(^{O}C)**	**(mg/L as $CaCO_3$)**	**(mg/L)**	**(cm^{-1})**
Average	8.15	0.39	92.02	22.00	125.48	3.41	0.060
Standard Deviation	0.25	0.09	22.61	4.92	25.10	0.37	0.007
Maximum	8.63	0.59	126.50	29.00	158.00	4.23	0.071
Minimum	7.70	0.25	56.00	9.80	81.00	2.80	0.046

concentrations had also undergone a relatively large change and there appears to be a relatively large variance in the laboratory measurements at low concentrations of TOC.

Some of the data points appear to be outliers but when taken as a whole, provide a well defined breakthrough curve. There is no known reason to label any of the data as outliers.

Total organic carbon in the influent to the GAC columns exceeded 4.0 mg/L only twice during the sampling period. Average TOC entering the GAC columns was 3.41 mg/L. Statistics for select water quality constituents of the influent to the GAC columns is presented in Table 7.

The THM4 and HAA6 concentrations in the 20 minute EBCT SDS samples were well below 80 and 60 µg/L. THM4 exceeded 60 µg/L only one time during the study. THM4 exceeded 40 µg/L (stage 2 requirements) consistently after approximately 4900 hours of operation. HAA levels in the 20 minute EBCT column never exceeded stage 2 levels. The SDS THM4 and HAA6 concentrations from the 20 minute EBCT GAC column are presented graphically in Chart 3. Table 8 shows

Chart 3. 20 Minute EBCT SDS THM4 and HAA6

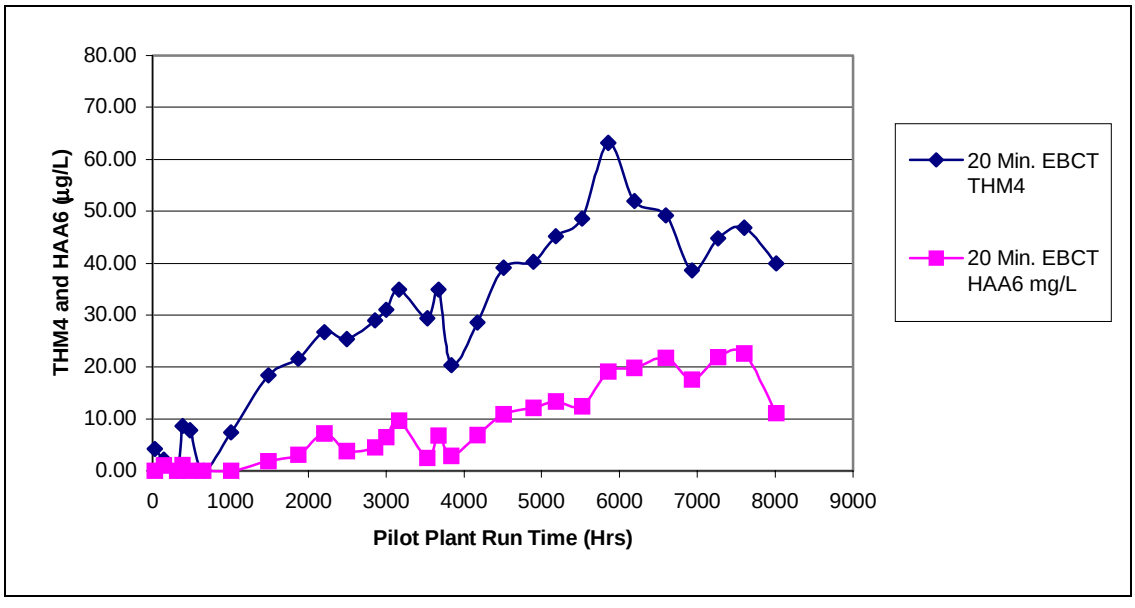


Table 8. Table of Breakthrough Criteria

Break Through Criteria	Value of Listed Parameter When Breakthrough Criterion is Met						
	Run Time (days)	Throughput (Bed Volume)	TOC (mg/L)	SDS-THM4 (µg/L)	SDS-HAA5 (µg/L)	SDS-HAA6 (µg/L)	SDS-TOX (µg/L)
SDS-THM4 = 90 µg/L	NA	NA	NA	NA	NA	NA	NA
SDS-THM4 = 72 µg/L	NA	NA	NA	NA	NA	NA	NA
SDS-THM4 = 54 µg/L	244	17570	1.95	63.2	13.00	19.10	86.00
SDS-THM4 = 36 µg/L	188	13538	1.60	39.10	8.80	10.90	58.00
SDS-HAA5 = 54 µg/L	NA	NA	NA	NA	NA	NA	NA
SDS-HAA5 = 27 µg/L	NA	NA	NA	NA	NA	NA	NA
SDS-HAA6 = 54 µg/L	NA	NA	NA	NA	NA	NA	NA
SDS-HAA5 = 27 µg/L	NA	NA	NA	NA	NA	NA	NA

breakthrough criteria for stage 1 and 2 THM and HAA formation. Meeting HAA criteria was accomplished easily while THM criteria were ultimately exceeded.

No serious problems were encountered during the treatability study. There was biological growth in the pilot plant columns due to the lack of disinfectant but no problems developed as a result. The only shutdown of the plant occurred for routine maintenance of the process train 2B. Maintenance is normally scheduled during low flow periods. Rainfall events at Wylie occur primarily during the winter months. Consequently, low flow for the NTMWD Wylie Water Treatment Plant occurs during the winter months. The GAC columns were backwashed twice during the study period. Backwashing was performed as a preventative measure rather than a response to a

problem. Pressure drop through the columns increased over the study period but not significantly.

QA/QC

All analyses were run with ICR approved laboratories and ICR approved methods. The laboratories that were used for the pilot plant treatability study were the same laboratories that were used for the ICR.

Calibration and quality control procedures were performed in accordance with procedures as outlined in the "DBP/ICR Analytical Methods Manual". Treatability study samples were treated in the same manner as ICR samples. Quality control and assurance was accomplished by the use of analytical duplicates, spiked samples (laboratory fortified matrix), internal standards, and surrogate standards as required for the particular analyte being tested. Samples were also checked for proper temperature, pH, and holding time as per ICR requirements. Strict quality control and quality assurance protocol was practiced at all times.

APPENDIX

G.1 -- Final Design Plant Parameters

Date: 6/2/99

PWS Name: North Texas Municipal Water District
PWS ID: TX0430044
WIDB:
ICR Contact Person: Mr. Steve Long

Sampling Period: Final
Design Sampling Start Date: 7/8/97
Design Sampling End Date: 12/31/98

Treatment Plant Name: NTMWD Wylie Water Treatment Plant
ICR Treatment Plant ID: 617
Treatment Plant PWS ID: TX0430044
Treatment Plant Type: CONV

State Approved Plant Capacity (MGD): 420
Historical Min. Water Temperature (deg C): 5.0
Installed Sludge Handling Capacity (GPD): 5,218,400.00
Blending Indicator: N

Water Resource Name: Lake Lavon
Water Resource Type: Reservoir/lake
Average Residence Time (Days): 1033
Intake Name: Raw Water 1
Watershed Control: N

Hydrologic Unit Code: 12030106
River Reach:
Latitude (degrees, minutes, seconds): +33°2'4"
Longitude (degrees, minutes, seconds): -96°28'59"
River Reach Miles:

Water Resource Name: Lake Lavon
Water Resource Type: Reservoir/lake
Average Residence Time (Days): 1033
Intake Name: Raw Water 2
Watershed Control: N

Hydrologic Unit Code: 12030106
River Reach:
Latitude (degrees, minutes, seconds): +33°2'21"
Longitude (degrees, minutes, seconds): -96°30'16"
River Reach Miles:

Water Resource Name: Lake Lavon
Water Resource Type: Reservoir/lake
Average Residence Time (Days): 1033
Intake Name: Raw Water 3

Hydrologic Unit Code: 12030106
River Reach:
Latitude (degrees, minutes, seconds): +33°2'11"
Longitude (degrees, minutes, seconds): -96°31'24"

Intake Name: Raw Water 3 Longitude (degrees, minutes, seconds): -96 51 24

Watershed Control: N **River Reach Miles:**

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
	Influent	INF	1	
Process Train Name: Train 1				
Process Train Category: CONV				
1	Chlorine gas 1a	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: Cl2 Dose Rate (mg/L): 2.57
2	Wash Return 1	Washwater Return		Washwater Treated: N Coagulation/Sedimentation: N Filtration: N Disinfectant Addition: N Plain Sedimentation: Y Other Treatment: 24 hr average Water flow Returned (MGD): 7.0
3	Rapid Mix 1	Rapid Mix		Type of Mixer: ME Baffling Type: AV Liquid Volume (gal): 17,280 Short Circuiting Factor: Mean Velocity Gradient (sec-1): 850.0
4	Flocculation 1	Flocculation Basin		Type of Mixer: ME

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Liquid Volume (gal): 1,834,680 Short Circuiting Factor: Baffling Type: AV Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec-1): 36 Stage Liquid Volume (gal): 1,834,680
5	Sedimentation 1	Sedimentation		Surface Area (ft2): 65,083 Liquid Volume (gal): 8,430,000 Baffling Type: PR Short Circuiting Factor: 0.3 Plate Settler Surface Area (ft2): Plate Settler Brand Name: Tube Settler Surface Area (ft2): Tube Settler Brand Name:
6	Chlorine gas 1b	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: Cl2 Dose Rate (mg/L): 3.43
7	Filtration 1	Filtration		Surface Area (ft2): 13,872 Liquid Volume (gal): 856,152 Total Media Depth (in): 34 Depth of GAC (in): Media Type: DUAL

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Type of Activated Carbon: Minimum Water Depth To Top of Media (ft): 8.2 Depth From Top of Media to Top of Backwash Trough (ft): 3.5
8	Clearwell 1	Clearwell		Surface Area (ft2): 67,092 Liquid Volume (gal): 8,000,000 Minimum Liquid Volume (gal): 4,000,000 Baffling Type: AV Short Circuiting Factor: Covered Indicator Code: Y
9	Chlorine gas 1c	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: Cl2 Dose Rate (mg/L): 1.71
10	Anhydrous NH3 1	Disinfectant Addition		Chemical Code: NH3A Measurement Formula: NH3 Dose Rate (mg/L): 1.00
Process Train Name:	Train 2			
1	Chlorine gas 2A	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: Cl2 Dose Rate (mg/L): 1.97
2	Wash Return 2	Washwater Return	5	Washwater Treated: N Coagulation/Sedimentation: N

Seq. No.	Sample Location Name	Sample Location Type	nple Loc. No.	
				Filtration: N Disinfectant Addition: N Plain Sedimentation: Y Other Treatment: none 24 hr average Water flow Returned (MGD): 20.0
4	Rapid Mix 2	Rapid Mix	4	Type of Mixer: ME Baffling Type: AV Liquid Volume (gal): 58,350 Short Circuiting Factor: Mean Velocity Gradient (sec-1): 850.0
5	Flocculation 2	Flocculation Basin	6	Type of Mixer: ME Liquid Volume (gal): 5,204,000 Short Circuiting Factor: Baffling Type: AV Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec-1): 36 Stage Liquid Volume (gal): 5,204,000
6	Sedimentation 2	Sedimentation	7	Surface Area (ft2): 367,200 Liquid Volume (gal): 46,696,273 Baffling Type: PR Short Circuiting Factor: Plate Settler Surface Area (ft2):

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Plate Settler Brand Name: Tube Settler Surface Area (ft2): Tube Settler Brand Name:
7	Chlorine gas 2b	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: Cl2 Dose Rate (mg/L): 3.77
8	Filtration 2	Filtration	8	Surface Area (ft2): 48,400 Liquid Volume (gal): 3,620,800 Total Media Depth (in): 34 Depth of GAC (in): Media Type: DUAL Type of Activated Carbon: Minimum Water Depth To Top of Media (ft): 10.0 Depth From Top of Media to Top of Backwash Trough (ft): 4.0
9	Clearwell 2	Clearwell	9	Surface Area (ft2): 135,717 Liquid Volume (gal): 14,000,000 Minimum Liquid Volume (gal): 9,000,000 Baffling Type: AV Short Circuiting Factor: Covered Indicator Code: Y
10	Chlorine gas 2c	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: Cl2

Seq. No.	Sample Location Name	Sample Location Type	mple Loc. No.	
				Dose Rate (mg/L): 0.94
11	Anhydrous ammon	Disinfectant Addition		Chemical Code: NH3A Measurement Formula: NH3 Dose Rate (mg/L): 0.80
	Finished Water	FIN	12	

End of Report G.1 -- Final Design Plant Parameters

G.2 -- Final Design Plant Chemical Parameters

Date: 6/2/99

PWS Name: North Texas Municipal Water District
PWS ID: TX0430044
WIDB:
ICR Contact Person: Mr. Steve Long

Sampling Period: Final
Sampling Start Date: 7/8/97
Sampling End Date: 12/31/98

Seq. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)
Treatment Plant Name: NTMWD Wylie Water Treatment Plant						
ICR Treatment Plant ID No: 617						
Treatment Plant Category: CONV						
Process Train Name: Train 1						
Process Train Category: CONV						
1	Chlorine gas 1a	Disinfectant Addition		Chlorine gas	Cl2	2.57
2	Wash Return 1	Washwater Return		Calcium hydroxide	Ca(OH)2	50.00
				Potassium permanganate	KMno4	0.50
				Powdered activated carbon	C	10.00
3	Rapid Mix 1	Rapid Mix		Ferric sulfate	Fe2(SO4)3	18.50
4	Flocculation 1	Flocculation Basin				
5	Sedimentation 1	Sedimentation				

Seq. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)
6	Chlorine gas 1b	Disinfectant Addition				
				Chlorine gas	Cl2	3.43
7	Filtration 1	Filtration				
				Hydrofluorosilic acid	F	1.30
8	Clearwell 1	Clearwell				
9	Chlorine gas 1c	Disinfectant Addition				
				Chlorine gas	Cl2	1.71
10	Anhydrous NH3 1	Disinfectant Addition				
				Anhydrous ammonia	NH3	1.00
Process Train Name: Train 2						
Process Train Category: CONV						
1	Chlorine gas 2A	Disinfectant Addition				
				Chlorine gas	Cl2	1.97
2	Wash Return 2	Washwater Return	5			
				Powdered activated carbon	C	10.00
				Calcium hydroxide	Ca(OH)2	98.00
				Potassium permanganate	KMno4	0.50
4	Rapid Mix 2	Rapid Mix	4			
				Ferric sulfate	Fe2(SO4)3	14.37
5	Flocculation 2	Flocculation Basin	6			
6	Sedimentation 2	Sedimentation	7			
7	Chlorine gas 2b	Disinfectant Addition				

Seq. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)
				Chlorine gas	Cl2	3.77
8	Filtration 2	Filtration	8			
				Hydrofluorosilic acid	F	1.30
9	Clearwell 2	Clearwell	9			
10	Chlorine gas 2c	Disinfectant Addition				
				Chlorine gas	Cl2	0.94
11	Anhydrous ammon	Disinfectant Addition				
				Anhydrous ammonia	NH3	0.80

End of Report G.2 -- Final Design Plant Chemical Parameters

G.3 -- Final Design Water System Information

Date: 6/2/99

PWS Name: North Texas Municipal Water District
PWS ID: TX0430044
WIDB:

Official Contact Person: Mr. Jim Parks
Job Title: Executive Director
Address: 505 East Brown Street, P.O. Box 2408
City: Wylie **State:** TX
Zip Code: 75098-2408
Mail Stop:
Phone Number: (972) 442-5405
Phone Number Extension:
Fax Number: (972) 442-5405
E-mail Address:

Sampling Period: Final
Design Sampling Start Date: 7/8/97
Design Sampling End Date: 12/31/98

ICR Contact Person: Mr. Steve Long
Job Title: Water System Manager
Address: 505 East Brown Street, P.O. Box 2408
City: Wylie **State:** TX
Zip Code: 75098-2408
Mail Stop:
Phone Number: (972) 442-5405
Phone Number Extension:
Fax Number: (972) 442-5405
E-mail Address:

Treatment Plant Name: NTMWD Wylie Water Treatment Plant
ICR Treatment Plant ID No: 617
Treatment Plant PWS ID: TX0430044
Treatment Plant Category: CONV

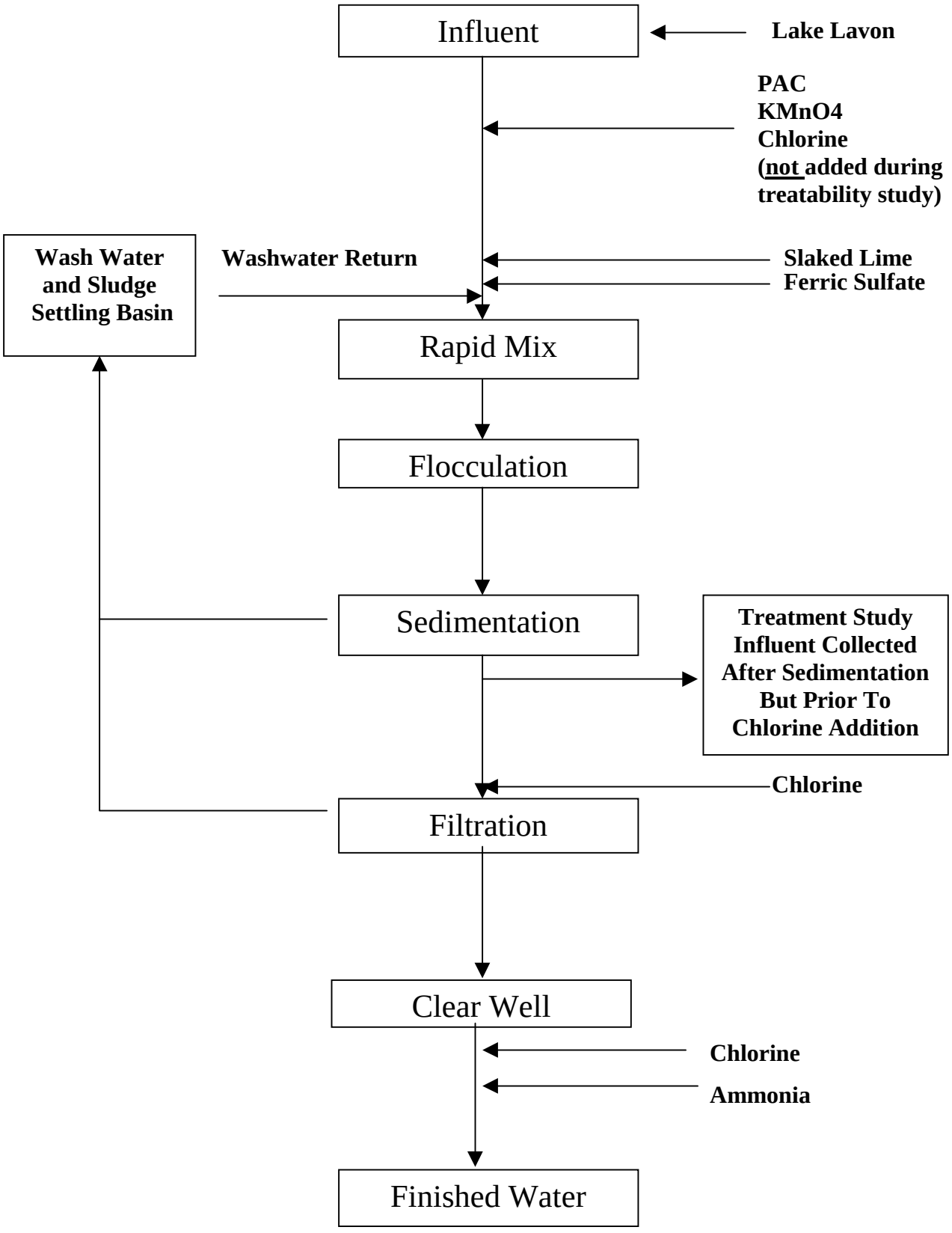
Process Train Name: Train 2
Process Train Name: Train 1

State Approved Plant Capacity (MGD): 420.0
Historical Min. Water Temperature (deg C): 5
Installed Sludge Handling Capacity (GPD): 5,218,400.00

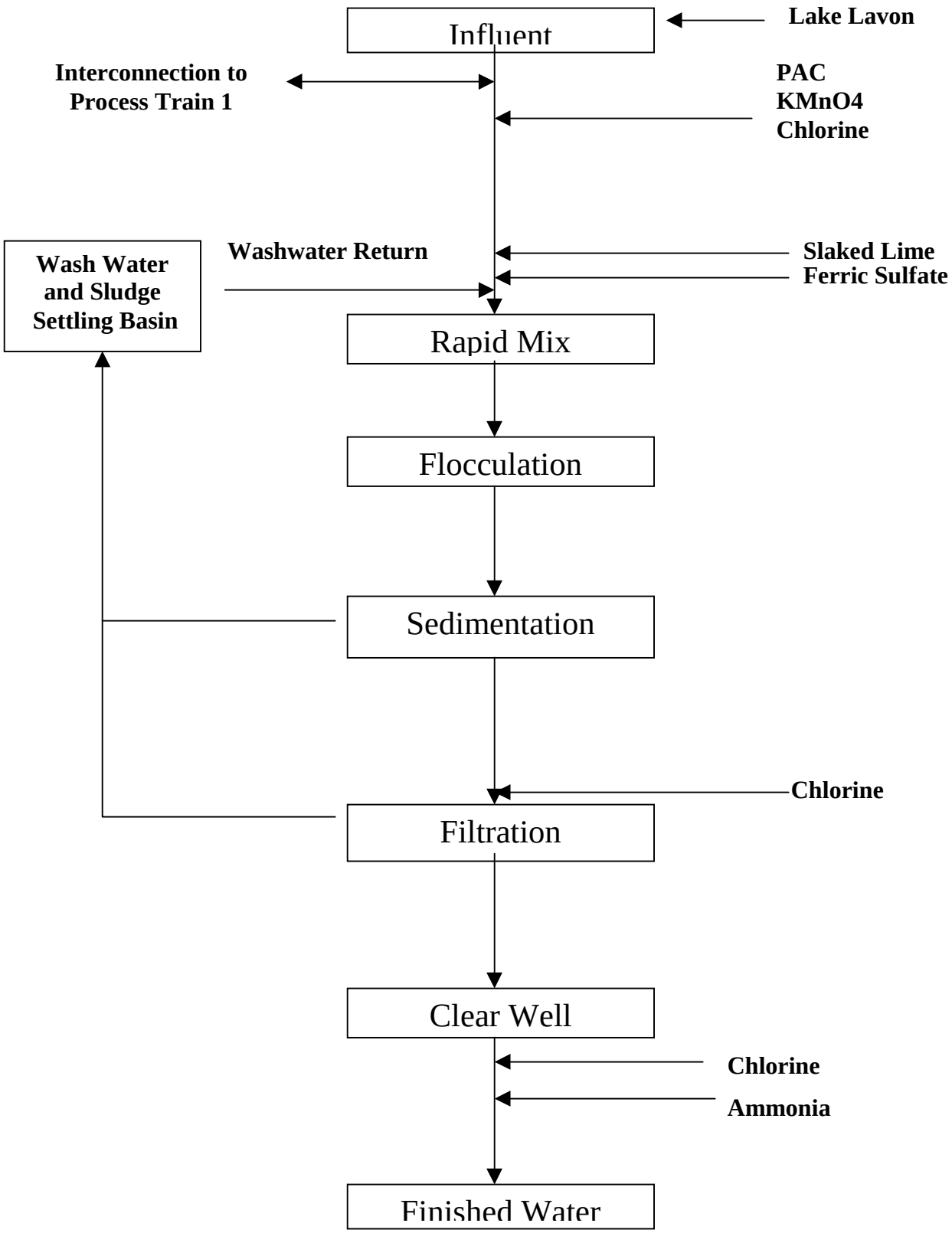
Process Train Category: CONV
Process Train Category: CONV

End of Report G.3 -- Final Design Water System Information

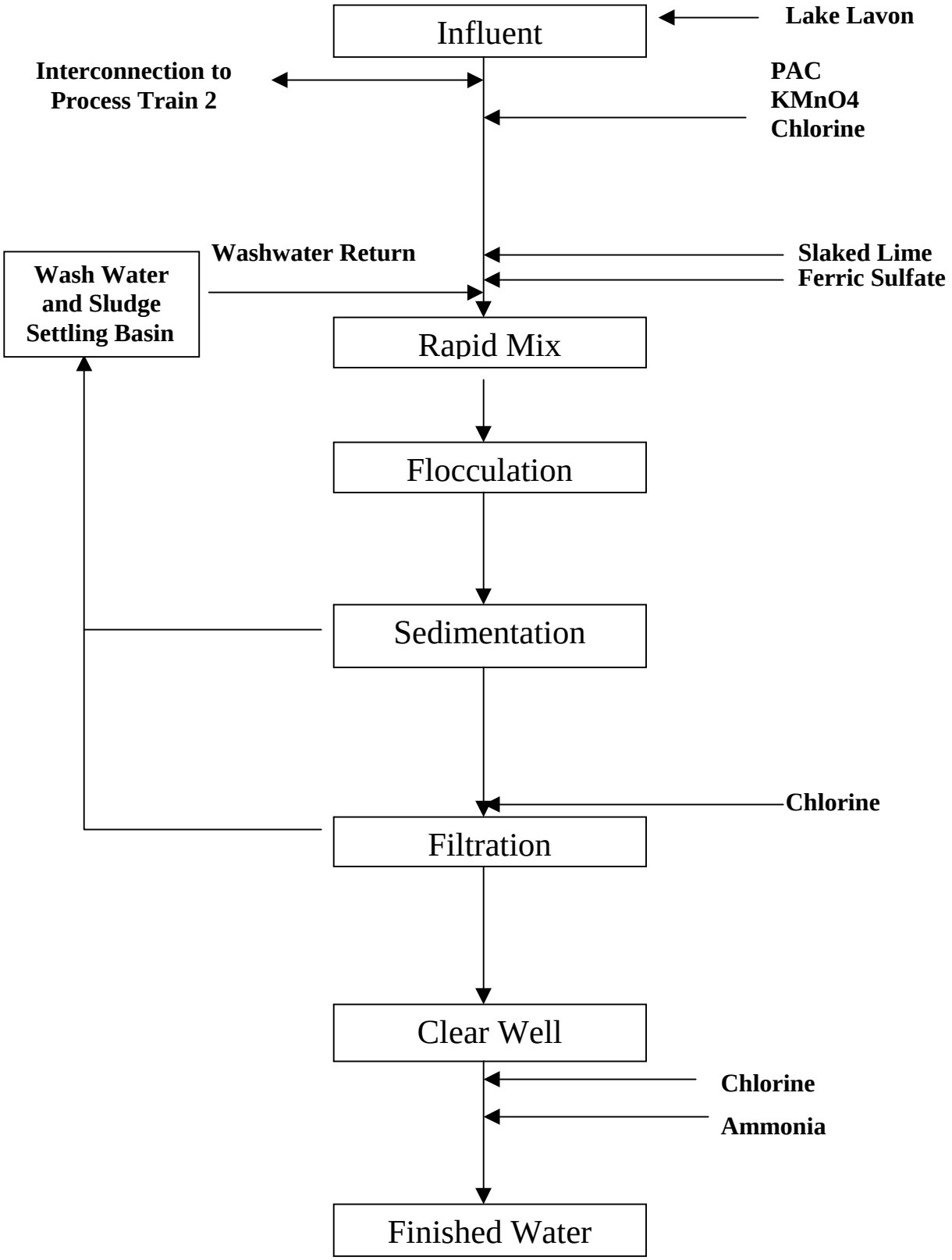
NTMWD Wylie WTP Process Train 2B Schematic (70 MGD)



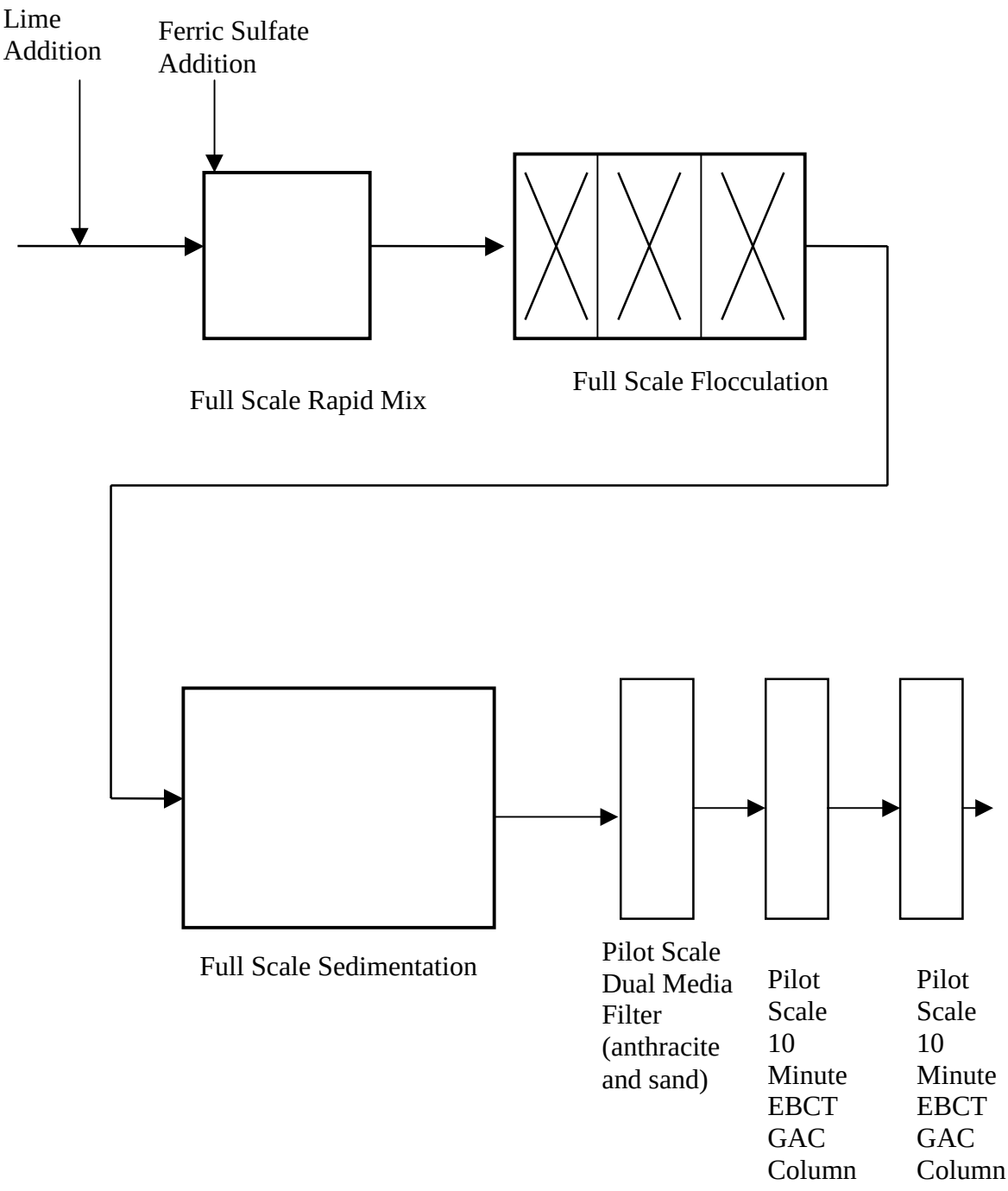
NTMWD Wylie WTP Process Train 2A Schematic (280 MGD)



NTMWD Wylie WTP Process Train 1 Schematic (70 MGD)



Pretreatment System Prior to GAC Columns



Pilot Scale Filter and GAC Columns