ICR TREATMENT STUDY SUMMARY REPORT

EVALUATION OF GRANULAR ACTIVATED CARBON FILTRATION USING THE RAPID SMALL SCALE COLUMN TEST FOR COMPLIANCE WITH THE INFORMATION COLLECTION RULE

PROJECT NUMBER 80105901

Conducted during the period of April 20, 1998 through June 8, 1999

CITY OF JACKSON, OWNER

HARVEY JOHNSON, JR., MAYOR

Ben Allen, Ward 1
Leslie B. McLemore, PhD, Ward 2
Kenneth Stokes, Ward 3
William R. Brown, Ward 4
Robert L. Williams, Ward 5
Allen G. Reno, Ward 6
Margaret C. Barrett, Ward 7

City of Jackson, Mississippi
Department of Public Works
Water / Sewer Utilities Division

Dedicated to Safe Drinking Water
American Water Works
Association MEMBER

PWSID NO. MS0250008
200 SOUTH PRESIDENT STREET
JACKSON, MISSISSIPPI 39201
(601)960-2090
FAX (601)960-2351

O.B. CURTIS WATER TREATMENT PLANT, ICR NO. 731

JULY, 1999

Attachments: 2 diskettes containing the *Data Collection Spreadsheets* and softcopy of this summary report
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1 Conclusions and Recommendations.

1.1 Conclusions. The following conclusions have been derived from this Information Collection Rule (ICR) Bench Study of Granular Activated Carbon (GAC) filtration to remove chlorine disinfection by-product precursors:

0.0.1 The GAC filters appear to be effective in the absorption of disinfection by-product pre-cursors as measured in the form of Total Organic Carbon (TOC), generally exceeding the theoretical time required for TOC breakthrough.

1.1.1 There exists a strong correlation between chlorine demand and the concentrations of disinfection by-products generated in the form of Trihalomethanes (THMs) and Haloacetic Acids (HAAs).

0.0.2 Air binding appeared to be a major problem with operation of the bench scale filters.

1.1.2 Generation of THMs and HAAs appear to spike when the GAC filter runs are started.

1.2 Recommendations. The following recommendations are made following this ICR Bench Study of GAC filtration to remove chlorine disinfection by-product precursors:

1.2.1 Prior to full scale installation of GAC filtration, pilot or plant scale studies should be conducted to fully determine the suitability of GAC filters for plant use.

0.0.3 Because other studies have shown that GAC filtration is not cost effective downstream of chlorine-based disinfection and because operation of the full scale plant requires chloramine disinfection upstream of the filters to meet disinfectant contact time requirements and for algae control, the costs of alternative schemes for disinfection and algae control should be considered when considering the costs of the addition of GAC filtration.

1.2.2 Filter-to-waste capability should be considered to reduce the effects of disinfection by-product generation spikes when the filters are brought into service following backwashing or other cleaning.

2 Background Information.

2.1 Treatment Plant Description.

2.1.1 Figure 1 shows a schematic of the O.B. Curtis Water Treatment Plant.

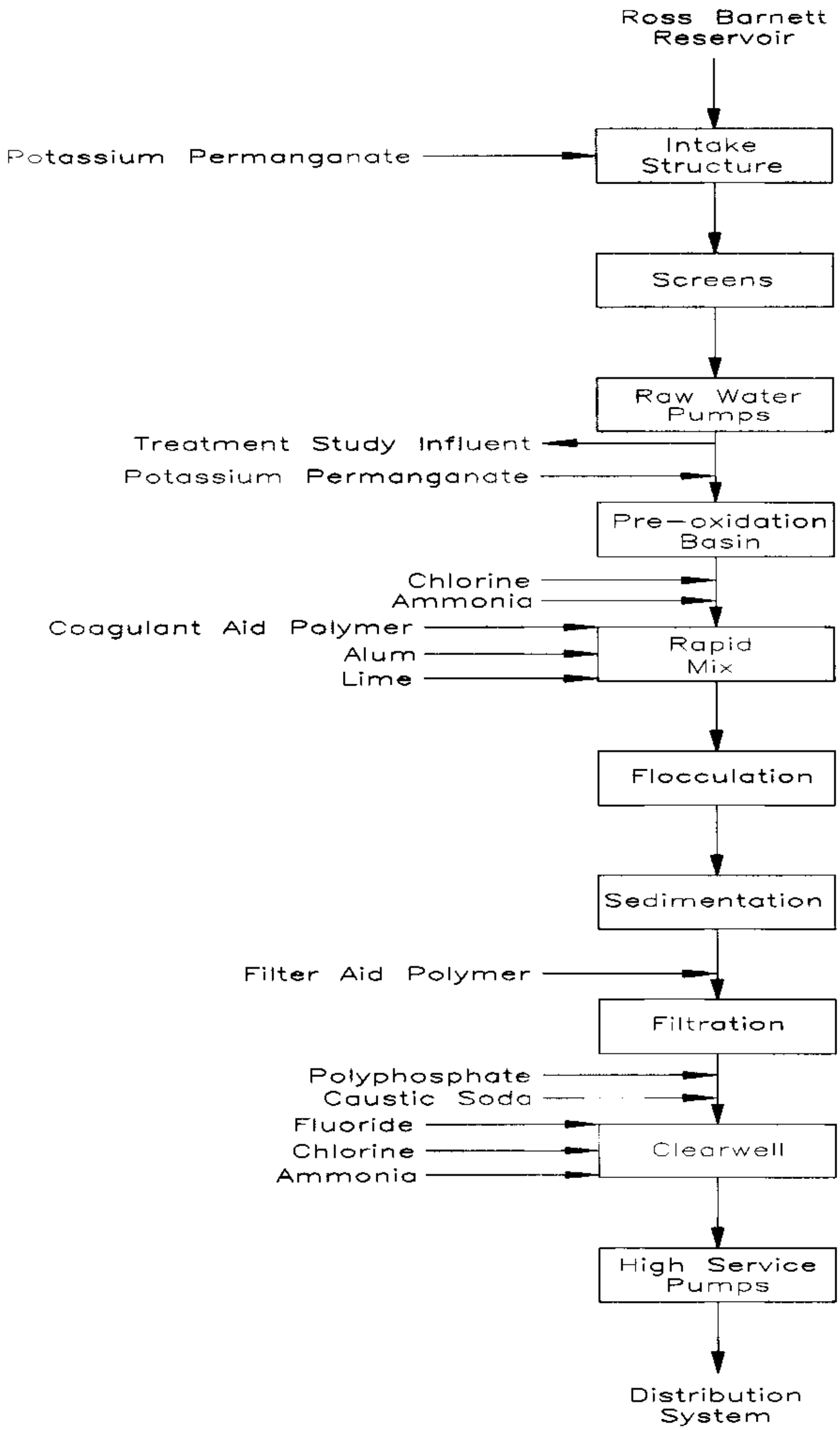

Figure 1.
O.B. Curtis Water Treatment Plant
Schematic Process Flow Diagram

0.0.4 The attached Report G.1, Final Design Plant Parameters and Report G.2, Final Design Plant Chemical parameters from the *ICR Water Utility Database System* show the treatment plant design information.

2.2 Tabular Summary of Source / Finished Water Quality. The "tssumrp5.xls" spreadsheet included in the enclosed diskettes shows a tabular summary of source / finished water quality.

3 Materials and Methods.

3.1 Pretreatment Processes to the Advanced Treatment Process. Figure 2 shows a schematic for the pretreatment processes. Design data for full scale pretreatment processes are shown in the attached Report G.1, Final Design Plant Parameters and Report G.2, Final Design Plant Chemical parameters from the *ICR Water Utility Database System.* Design data for bench scale pretreatment processes are shown in the "gacrssct.xls" spreadsheet

3.2 Advanced Treatment Process Information. Figure 3 shows a schematic and design data for the GAC filtration advanced treatment process. Materials which would not adsorb organic carbons were used in construction of the bench test apparatus. Tubing used was Tygon SE-200, lined with FEP. Stop cock valves had glass bases and Teflon coated cocks. The columns were glass. The screens within the columns were cut from stainless steel sieves. The flow meters featured stainless steel balls within glass tubing.

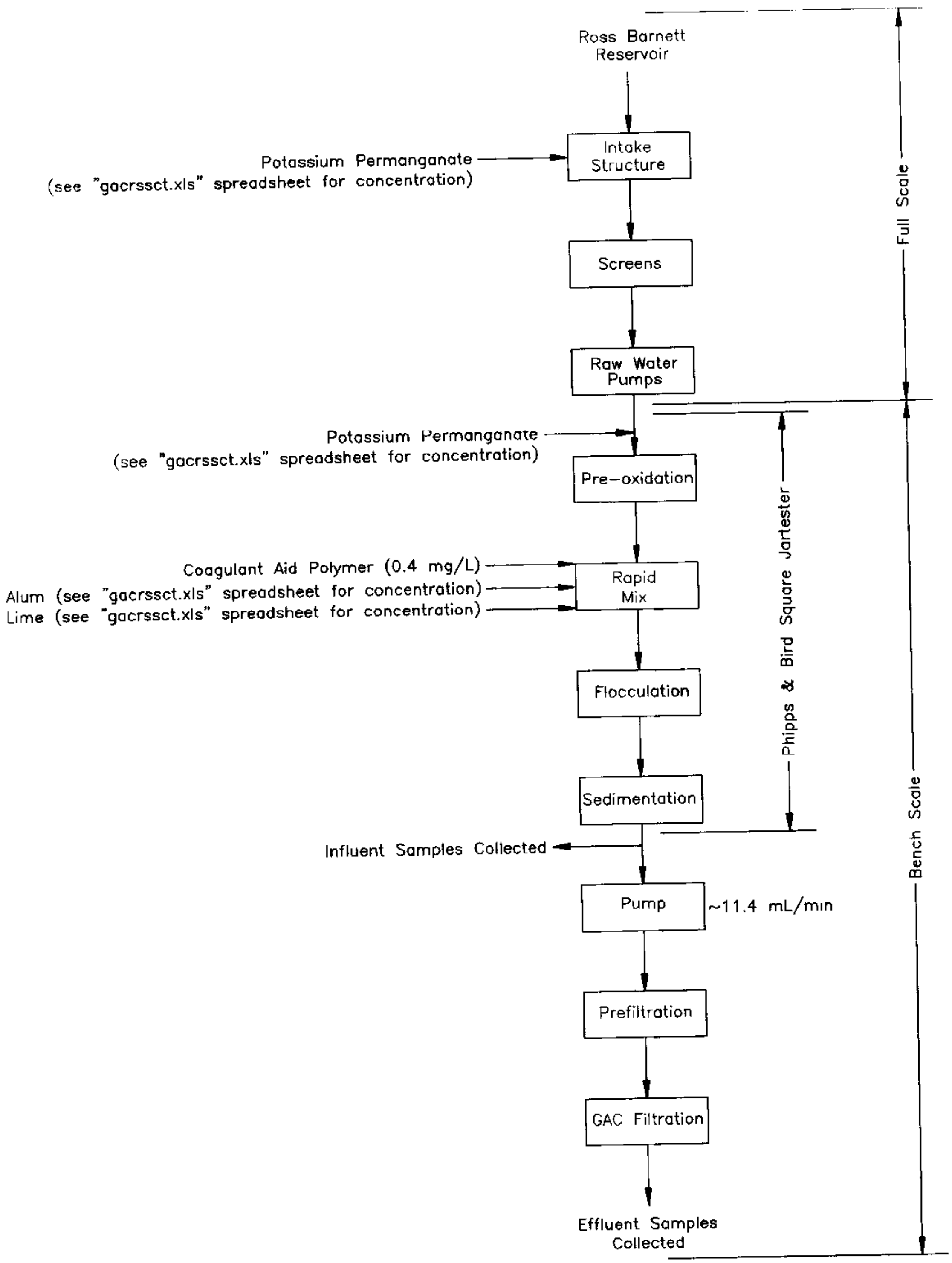

Figure 2.
O.B. Curtis Water Treatment Plant
Bench Study Schematic

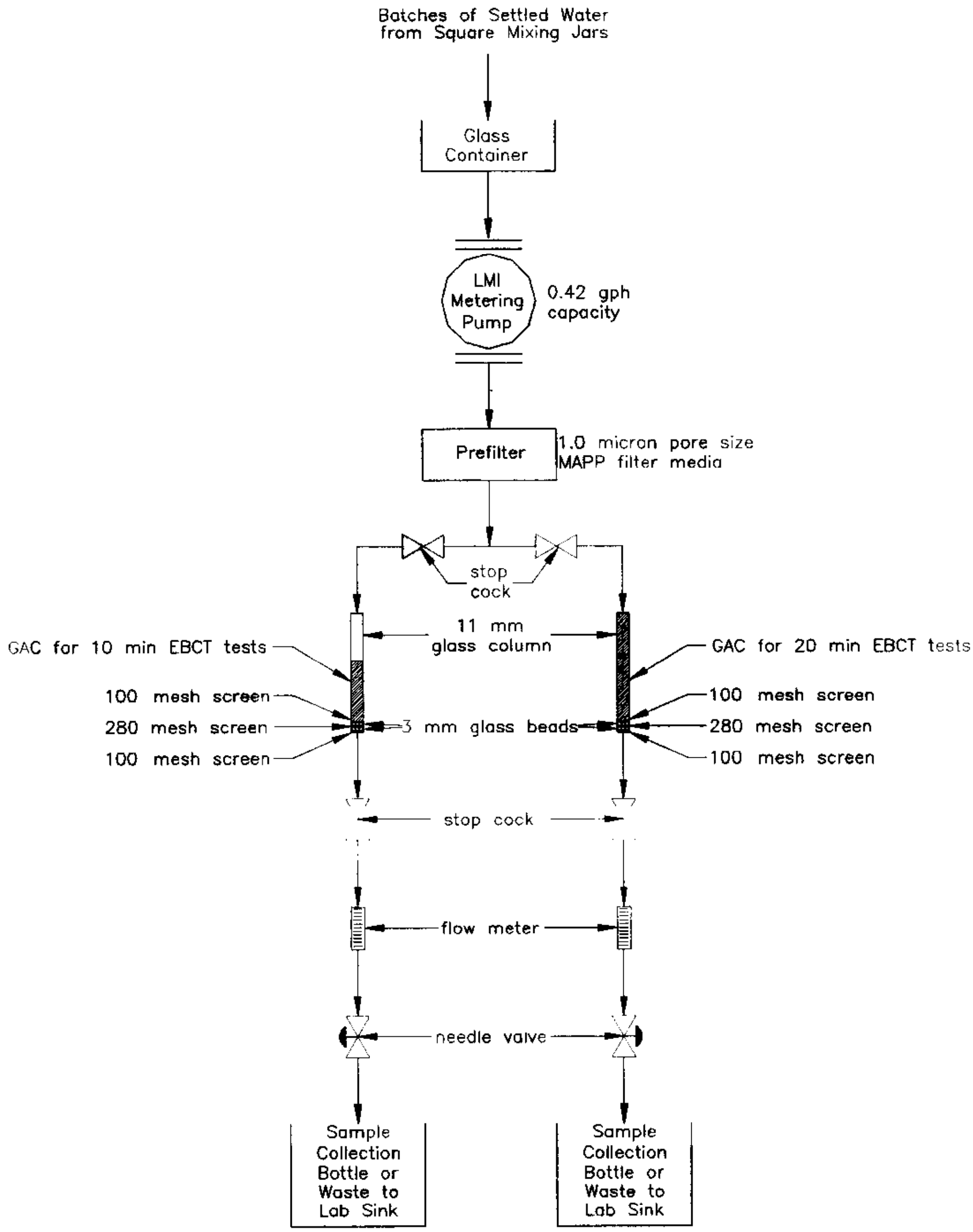

Figure 3.
O.B. Curtis Water Treatment Plant
Rapid Small Scale Column Test Schematic

3.3 Experimental Design. Based upon theoretical times to Total Organic Carbon (TOC) breakthrough, samples were scheduled to be collected at runtimes to satisfy the requirements listed in the _ICR Manual for Bench- and Pilot-Scale Treatment Studies_. Theoretical runtime calculations and sample collection times are listed in the "gacrssct.xls" spreadsheet. Two full scale Empty Bed Contact Time (EBCT) tests were conducted during each of four quarters to investigate seasonal variation. Ten and twenty minute full scale EBCT tests were conducted each quarter. Each day during the test, water from the plant's raw water pump station was mixed with potassium permanganate, alum, lime and coagulant aid polymer. This water was then flocculated, settled and poured into a storage reservoir to be pumped through the GAC filtration system. The dosages of alum and lime were adjusted to match the dosages used in the full-scale plant on each day of operation. At the scheduled times, samples were collected prior to the bench-scale pre-filter (influent samples) and from the GAC filter effluent. Depending on the schedule, some influent samples were analyzed for alkalinity, total hardness, calcium hardness, ammonia and bromide concentrations. All influent and effluent samples were analyzed for pH, temperature and TOC, UV-254 and turbidity concentrations. To provide Simulated Distribution System (SDS) samples, influent and effluent samples were dosed with enough chlorine to provide a residual at the end of the incubation period and enough lime to raise the pH to approximately 8.5, a minimum pH for the distribution system. The samples were incubated for 24 hours (average residence time within the Jackson distribution system) at a temperature of 22.7 degrees Celsius (average temperature within the distribution system). Following incubation, the samples were analyzed for pH, temperature and free chlorine, Total Organic Halide (TOX), Trihalomethane (THM) and Haloacetic Acid (HAA) concentrations.

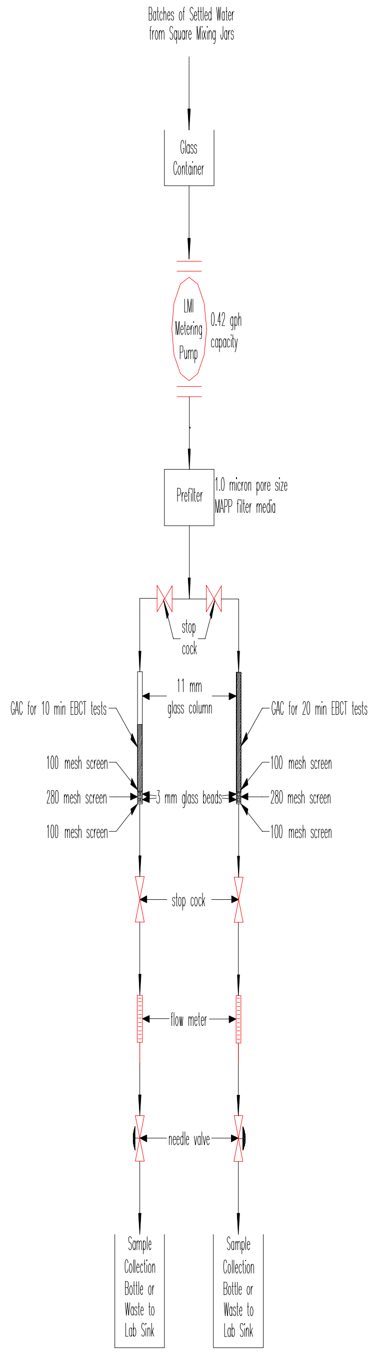

Figure 3.
O.B. Curtis Water Treatment Plant
Rapid Small Scale Column Test Schematic

3.4 Analytical Methods. Analytical methods used are listed in the "tssumrp5.xls" spreadsheet. Quality Assurance / Quality Control (QA / QC) procedures listed in the _DBP / ICR Analytical Methods Manual_ were used during sample analysis.

4 Results and Discussion.

4.1 Problems Encountered. The following problems were encountered:

0.0.1 Lack of on-site ability to analyze for TOC concentrations and slow reporting of TOC results from the contract laboratory led to complete dependance on the theoretical schedule for TOC breakthrough. Equipment problems prevented local analysis of UV254 concentrations from being useful in predicting TOC breakthrough in order to extend run times.

4.1.1 The original sample schedule was based on raw water

TOC concentration, instead on settled water TOC concentration, which was approximately half of the raw water concentration. This reduced influent TOC concentration resulted in run times to TOC breakthrough to be approximately twice as long as originally anticipated.

4.1.2 Air binding appeared to be a problem with the GAC filter columns. Due to air binding, the flow rate of the 3rd quarter 10 minute test was limited to 4 mL/min from the runtime of 365.568 hours until the end of the test. The number of bed volumes column in the "gacrssct.xls" spreadsheet was adjusted to compensate for this low flow. Due to air binding, the GAC filter columns were emptied and re-packed at the following times:

2nd quarter, 10 minute test at runtime of 169.583 hours.
4th quarter, 20 minute rest at runtime of 147.85 hours.

4.1.3 Some GAC media was lost through the screens at the bottom of the test columns.

4.1.4 Some data analysis results collected by local laboratory personnel were lost.

4.1.5 Some samples were not properly preserved prior to shipment to contract laboratory.

4.1.6 Some sample bottles were broken en route to contract laboratory.

4.1.7 Problems with laboratory equipment prevented proper analysis of some of the samples.

4.1.8 Problems were encountered in maintaining a constant flow rate, especially when the two different EBCT tests were conducted in parallel. Toward the end of the study, the LMI metering pump began losing prime.

4.2 Water Quality Data.

0.0.1 Water Quality of Pretreated Influent. The water quality of the pretreated influent appeared to correspond well with the water quality of the full scale settled water.

4.2.1 DBP Data and Data Analysis. The GAC filters appeared to be effective in adsorbing disinfection by-product pre-cursors. However, there appears to be a spike of THM and HAA generation when the GAC filters runs are first started. There appears to be a strong correlation between chlorine demand and the concentrations of disinfection by-products generated in the form of THMs and HAAs.

4.3 Impact of Seasonal Variability. Although influent TOC did not appear to vary significantly during the year, effluent chlorine demand and THM and HAA formation was significantly less during the second quarter (late Fall) and noticeably less during the third quarter (Winter).

4.4 Cost Information and Analysis. Utility-specific cost information is summarized in the "gacrssct.xls" spreadsheet. Within the City of Jackson's 1997 Water and Wastewater System Master Plan, a cost of $2,950,000 to add GAC to the existing filters and bring filtration capacity to 75 MGD. Studies at other plants have indicated that GAC filtration is not cost effective if used following chlorine-based disinfection. Operation of the O.B. Curtis Water Treatment Plant requires pre-chloramination to control the growth of algae and to provide adaquate disinfectant contact time. One solution to the algae control and disinfection contact time problems presented by the use of GAC filters may be to use pre-ozonation. The Master Plan provided an estimate of $9,100,000 for pre-ozonation having a capacity of 50 MGD.

4.5 Summary of Significant Results. It appears that the GAC filters as tested were effective in adsorbing adverse disinfection by-product pre-cursors, appearing to have a longer-than-theoretical breakthrough curve.

5 QA / QC Summary. QA / QC information is summarized in the "tssumrp5.xls" spreadsheet.

APPENDIX A

TREATMENT PLANT DESIGN INFORMATION

Treatment Plant Name: OB Curtis Water Treatment Plant
ICR Treatment Plant ID: 731
Treatment Plant PWS ID:
Treatment Plant Type: CONV

State Approved Plant Capacity (MGD): 25
Historical Min. Water Temperature (deg C): 2.2
Installed Sludge Handling Capacity (GPD): 2,800,000.00
Blending Indicator: N

Water Resource Name: Ross Barnett Reservoir
Water Resource Type: Reservoir/lake
Average Residence Time (Days): 35
Intake Name: Raw Water Intake Structure
Watershed Control: N

Hydrologic Unit Code:
River Reach:
Latitude (degrees, minutes, seconds): +32°24'13"
Longitude (degrees, minutes, seconds): -90°4'25"
River Reach Miles:

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
	Influent	INF	1	

Process Train Name: OBC1
Process Train Category: CONV

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
1	Intake Pipe	Other Treatment Process		Surface Area (ft2): Liquid Volume (gal): 587,478 Short Circuiting Factor:
2	Chlorine gas	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: CL2 Dose Rate (mg/L): 0.00
3	Preoxidation	Other Treatment Process		Surface Area (ft2): 1,540 Liquid Volume (gal): 172,788

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Short Circuiting Factor:
4	Anhydrous ammon	Disinfectant Addition		Chemical Code: NH3A Measurement Formula: NH3 Dose Rate (mg/L): 0.40
5	Chlorine gas	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: CL2 Dose Rate (mg/L): 2.00
6	Rapid Mix	Rapid Mix	4	Type of Mixer: ME Baffling Type: AV Liquid Volume (gal): 172,788 Short Circuiting Factor: Mean Velocity Gradient (sec-1): 340.0
7	Flocculation	Flocculation Basin	5	Type of Mixer: ME Liquid Volume (gal): 716,958 Short Circuiting Factor: Baffling Type: AV Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec-1): 40 Stage Liquid Volume (gal): 238,986 Stage Sequence Number: 2

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Stage Mean Velocity Gradient (sec-1): 20 Stage Liquid Volume (gal): 238,986
				Stage Sequence Number: 3 Stage Mean Velocity Gradient (sec-1): 7 Stage Liquid Volume (gal): 238,986
8	Sedimentation	Sedimentation	6	Surface Area (ft2): 45,369 Liquid Volume (gal): 4,751,042 Baffling Type: PR Short Circuiting Factor: Plate Settler Surface Area (ft2): Plate Settler Brand Name: Tube Settler Surface Area (ft2): Tube Settler Brand Name:
9	Add Filter Aid	Other Treatment Process		Surface Area (ft2): Liquid Volume (gal): Short Circuiting Factor:
10	Filtration	Filtration	7	Surface Area (ft2): 5,520 Liquid Volume (gal): 247,738 Total Media Depth (in): 39 Depth of GAC (in): Media Type: DUAL Type of Activated Carbon:

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Minimum Water Depth To Top of Media (ft): 7.0 Depth From Top of Media to Top of Backwash Trough (ft): 3.1
11	Chlorine gas	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: CL2 Dose Rate (mg/L): 3.50
12	Anhydrous ammon	Disinfectant Addition		Chemical Code: NH3A Measurement Formula: NH3 Dose Rate (mg/L): 0.94
13	Clearwell	Clearwell		Surface Area (ft2): 45,900 Liquid Volume (gal): 5,000,000 Minimum Liquid Volume (gal): 2,300,000 Baffling Type: PF Short Circuiting Factor: Covered Indicator Code: Y
	Finished Water	FIN	9	

End of Report G.1 – Final Design Plant Parameters

Seq. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)

Treatment Plant Name: OB Curtis Water Treatment Plant
ICR Treatment Plant ID No: 731
Treatment Plant Category: CONV

Process Train Name: OBC1
Process Train Category: CONV

Seq. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)
1	Intake Pipe	Other Treatment Process		Potassium permanganate	KMnO4	1.50
2	Chlorine gas	Disinfectant Addition		Chlorine gas	CL2	0.00
3	Preoxidation	Other Treatment Process		Potassium permanganate	KMnO4	1.50
4	Anhydrous ammon	Disinfectant Addition		Anhydrous ammonia	NH3	0.40
5	Chlorine gas	Disinfectant Addition		Chlorine gas	CL2	2.00
6	Rapid Mix	Rapid Mix	4	Aluminum sulfate (Alum)	AlSO4	34.00
				Calcium hydroxide	Ca(OH)2	17.00
				Organic polymer - coagulant aid	Chemfoc 615	0.20
7	Flocculation	Flocculation Basin	5			
8	Sedimentation	Sedimentation	6			
9	Add Filter Aid	Other Treatment Process		Organic polymer - filter aid	Chemfloc 615	0.20

Seq. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)
10	Filtration	Filtration	7			
11	Chlorine gas	Disinfectant Addition				
				Chlorine gas	CL2	3.50
12	Anhydrous ammon	Disinfectant Addition				
				Anhydrous ammonia	NH3	0.94
13	Clearwell	Clearwell				
				Sodium hydroxide	NaOH	24.00
				Hydrofluorosilic acid	F	0.80
				Other chemical	SEAQUEST Liquid	0.40

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