ICR Treatment Study Summary Report

Evaluation of Membrane Technology Using the Rapid Bench-Scale Test for Compliance with the Information Collection Rule

Conducted during the period of April 1998 through Jan 1999

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Water Plant # 381

Attachments: 2 diskettes containing the *Data Collection Spreadsheets*
1 diskette containing the *Treatment Summary Report Spreadsheets*
1 diskette containing the *ICR Treatment Summary Report*

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I. Conclusions and Recommendations-

A. Conclusions

1. As expected, both of the membranes tested were successful in removing DBP-precursors. For example, even at the highest recovery tested (90 percent) TTHM and $HAA_{(5)}$ precursor rejection exceeded 74 percent and was frequently greater than 90 percent.
2. Even the membrane with the lower rejection rate for Total Dissolved Solids (the NF20B membrane) successfully removed DBP-precursors, with rejection rates on average about 15 percent lower than the more successful BW30-LXE membrane.

B. Recommendations

1. If future regulations require the Water District to produce lower concentrations of DBPs, these membranes should be one of the treatment options considered.

II. Background Information

A. Treatment Plant Description

Treatment Plant Schematic: See Figure 1.

Treatment Plant Design Information: Table 1a contains the full-scale plant unit process design information; Table 1 b contains the Bench-scale unit process information.

Treatment challenges facing plant: Include reduction of DBP concentrations if this is required by future regulations and the use of a disinfectant for inactivation of Cryptosporidium if this is required by future regulations.

B. Tabular summary of source and finished water quality: Tables 2a and 2b contain summaries of source and finished water quality provided by the Water District.

III. Materials and Methods

A. Pretreatment Processes to the Advanced Treatment Process

Schematics of pretreatment processes: Figure 1 outlines the full-scale process used in the plant prior to the sampling point.

Figure 2 describes water pretreatment at the bench-scale level. For this study, the water could not be collected downstream of the filters near the end of the treatment train due to the inability to turn off chlorinators upstream. The water was collected just after the presedimentation basins.

This raw water had to undergo simulated treatment at the bench-scale level. A lime softening process followed by carbonation was performed in the laboratory. The procedure for the simulation was as follows:

1. For each quarter, the $Ca(OH)_2$ dose used to lime soften the water was estimated based upon the total alkalinity and magnesium hardness. Alum was obtained from the plant and was added at 15 mg/L throughout the study.
2. The lime and alum were added to each drum of sample and mixed. The drums were allowed to stand overnight to simulate the settling process.
3. Supernatant was combined into one large sample. Carbon dioxide was added to bring the pH between 9.3-9.6.
4. The sample was pumped back into clean drums through a cartridge filter.
5. The sample was taken to the RBSMT.

B. Advanced Treatment Process Information

A schematic for the process equipment used for the RBSMT is shown in Figure 3. This schematic shows only one unit, but two identical units were used during the study. This allowed for the simultaneous evaluation of two membranes using the same influent water. The ICR Manual for Bench and Pilot-scale Studies was used as a guide in the set-up of the apparatus.

In general, the guidelines for evaluating the membranes in the RBSMT came directly from the ICR Manual for Bench and Pilot-scale Studies. The membranes were cleaned as described in the manual using manufacturer recommended cleaning solutions. For both membranes, the following procedure was used:

1. Rinse with reagent water for 1-2 min at high cross- flow velocity (using recycle pump setting near “8”).
2. Clean with 0.5% phosphoric acid for 20 min at high cross-flow velocity.
3. Rinse with reagent water, 1-2 min.
4. Clean with 0.1% sodium hydroxide for 20 min at high cross-flow velocity.
5. Rinse with reagent water, 1-2 min.

After the final rinse, the membrane cell was re-attached to the system. The MTCw was then evaluated at 30% recovery using the test water. Note: At no time was the membrane cell opened during cleaning. After cleaning, the system was run until a stable MTCw was obtained, and permeate and concentrate samples were taken to compare feed rejection prior to cleaning. The system was then shut down for total cleaning.

C. Experimental Design

Table 3 describes the experimental design used in the study. Seasonal variability was examined as the primary variable using two nanofiltration membranes. Flux during each season was essentially held constant, and the four recoveries of 30, 50, 70, and 90 % were investigated. During the 4^{th} quarter, the flux was decreased in an effort to slow membrane fouling. The two membranes chosen for the study were the NF200 and the BW30-XLE. The XLE is considered the "tighter" membrane since it rejects a higher percentage of inorganic ions than the NF-200. Each membrane meets the ICR MWCO criteria set forth in the ICR Treatment Studies Manual.

D. Analytical Methods

Table 4 lists the analytical methods and MRLs used for the study. There were no deviations from the QA/QC procedures outlined in the DBP/ICR Analytical Methods Manual.

All analytical services were performed at Environmental Health Laboratories.

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IV. Results and Discussion

A. Problems Encountered

During the first quarter, the sample was stored approximately five days after bench-scale pretreatment at 4 C. For all other quarters, the membranes were set and ready to receive the pretreated water within 12-15 hours after pretreatment. It was best to run the test water as soon as possible after pretreatment so that potential pH changes would be kept to a minimum.

The pH of the sample was not adjusted with acid because it was desirable to check the performance of the membranes under actual plant conditions. The pH during the run changed as the sample absorbed CO_2 from the atmosphere. To minimize this, aliquots were kept as sealed as possible and allowed to be out in use for 48 hrs or less.

Membrane fouling occurred in the XLE membrane. This membrane is considered the “tighter” membrane, and fouling was likely due to some scale build-up on the membrane during the run.

B. Water Quality Data

1. The water quality of the pretreated influent is summarized in Table 5.
2. Table 6 contains the specific simulated distribution system (SDS) conditions for each quarter in the study. Table 5 includes a summary of the DBP data obtained at these SDS conditions in the influent water.

C. Impact of Seasonal Variability and

D. Impact of Specific Variables on Performance

Included in this final report are several Tables and Graphs that illustrate the performance of the membranes throughout the course of the study. They are as follows:

1. Flux and water mass transfer coefficient relationships- NF200 Membrane
   - Figures 4–7: Flux as a function of operation time
   - Figures 8-12: MTCw as a function of operation time
   - Figures 13-16: Rate of MTCw Decline Linear Regression Plots
   - Table 7: Summary of Membrane Productivity for each season

2. Pressure, temperature, pH, and TDS grab samples-NF200 Membrane
   - Figures 17-20: Influent, osmotic, and NDP as a function of operation time
   - Figures 21-24: Influent and ave feed temperature as a function of operation time
   - Figures 25-28: pH of permeate, concentrate, and feed as a function of operation time
   - Figures 29-32: TDS of feed and permeate as a function of operation time

3. Analyte concentration and DBP formation as a function of recovery- NF200 Membrane
   - Figure 33: Recovery plot for all 4 quarters as a function of operation time
   - Figures 34-39: Permeate water quality parameters as a function of recovery
   - Figures 40-44: Permeate SDS THMs as a function of recovery
   - Figures 45-49: Permeate SDS HAA6 as a function of recovery

4. Feed and bulk rejection plots- NF200 Membrane
   Tables 8a-d: Effect of recovery on feed rejection on the composite samples for the RBSMT
   Figures 50-57: TDS and UV254 rejection as a function of operation time

5. Flux and water mass transfer coefficient relationships- XLE Membrane
   Figures 58-61: Flux as a function of operation time
   Figures 62-66: MTCw as a function of operation time
   Figures 67-70: Rate of MTCw Decline Linear Regression Plots
   Table 13: Summary of Membrane Productivity for each season

6. Pressure, temperature, pH, and TDS grab samples-XLE Membrane
   Figures 71-74: Influent, osmotic, and NDP as a function of operation time
   Figures 75-78: Influent and ave feed temperature as a function of operation time
   Figures 79-82: pH of permeate, concentrate, and feed as a function of operation time
   Figures 83-86: TDS of feed and permeate as a function of operation time

7. Analyte concentration and DBP formation as a function of recovery- XLE Membrane
   Figure 87: Recovery plot for all 4 quarters as a function of operation time
   Figures 88-93: Permeate water quality parameters as a function of recovery
   Figures 94-98: Permeate SDS THMs as a function of recovery
   Figures 99-103: Permeate SDS HAA6 as a function of recovery

8. Feed and bulk rejection plots- XLE Membrane
   Table 14a-d: Effect of recovery on feed rejection on the composite samples for the RBSMT
   Figures 104-111: TDS and UV254 rejection as a function of operation time

9. Atrazine Rejection
   Atrazine rejection was examined during the treatment study. Each quarter, atrazine was tested on the pretreated feed water and the permeate water taken from the XLE membrane at 50 % recovery. The results are as follows:

Quarter	Influent Conc (ug/L)	Permeate Conc	% Rejection
1	0.21	BMRL	100
2	0.76	BMRL	100
3	0.34	BMRL	100
4	0.11	BMRL	100

E. Cost Information and Analysis

This section is optional and is omitted from this report.

F. Summary of Significant Results

In addition to the tables and graphs listed above in Sections C and D, the following tables illustrate the blend ratios to achieve various finished water qualities for each membrane:

Tables 9-12: Blend Ratio Tables –NF200 Membrane
Tables 15-18: Blend Ratio Tables- XLE Membrane

In general, both membranes reject significant amounts of precursor material at all recoveries (UV 254 and TOC at > 90%). Membrane fouling was a problem with the XLE membrane.

V. QA/QC Summary

All QA/QC procedures and requirements were followed as described in the DBP/ICR Analytical Methods Manual. Note that Table 4 lists the MRLs, some of which are lower than those listed in the manual.

All results for lab duplicates and lab fortified matrices are summarized in the ICR Treatment Study Summary Report Spreadsheets, along with some miscellaneous data about the public water supply.

PE results: Environmental Health Laboratories is a certified ICR lab that participated in all ICR PE studies. The results for these studies during the ICR Treatment Studies are listed in Tables 19-22.

Calibration Procedures: The calibration procedures used during the study are consistent with the DBP/ICR Analytical Methods Manual. Tables 9.1 to 9.4 in this manual were used as guidelines for the frequency and percent recovery requirements.

Noted QC failures: The following samples failed QC criteria and were reported as “NR” in the spreadsheets:

During the 2nd quarter, a run of permeate samples for HAA analysis had a low-level CCC internal standard low out-of-range. The samples could not be repeated due to holding time. All of the analytes in the CCC calculated in range according to ICR criteria. The data from this run was entered in the Data Collection Spreadsheets, ie., “NR” was not used.

<u>SDS Testing: Incubation temperature and time measurements</u>- During the bench-scale runs, a high-precision incubator was used. All of the samples in a given batch were taken out of the incubator at the same time and measurements for residual chlorine were taken immediately and quenched using the proper dechlorinating agent. The temperature of the incubator was recorded for the batch. Therefore the same temperature reading was recorded in the Data Collection Spreadsheets for the entire group of samples. This is why some of the observed standard deviations (SDs) are 0.0. Also, the time recorded for all SDS samples in a given batch was the same, as this was monitored very closely during the study. This will also result in times having SDs of 0.0.

Figure 1: Water District No. 1 of Johnson County, Kansas

FACILITY 1 TREATMENT PLANT SCHEMATIC

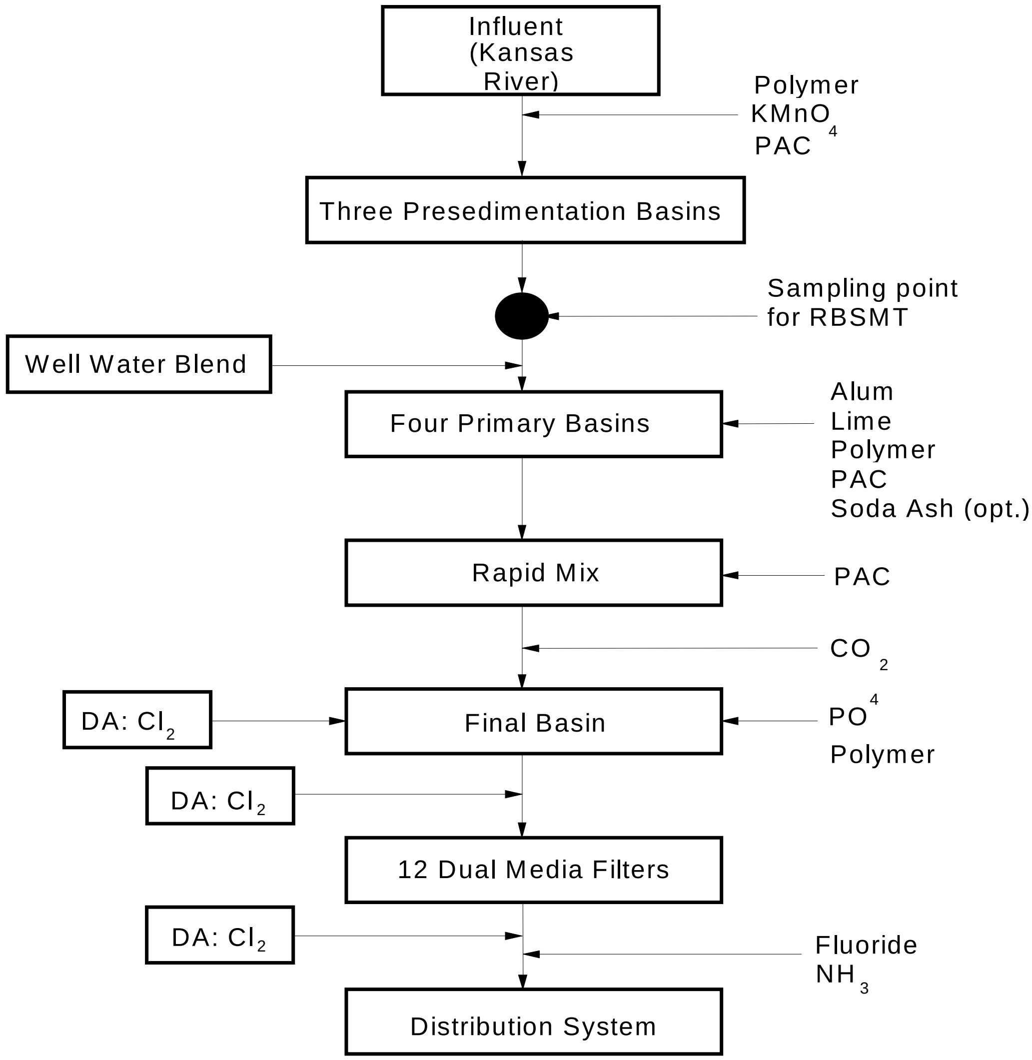
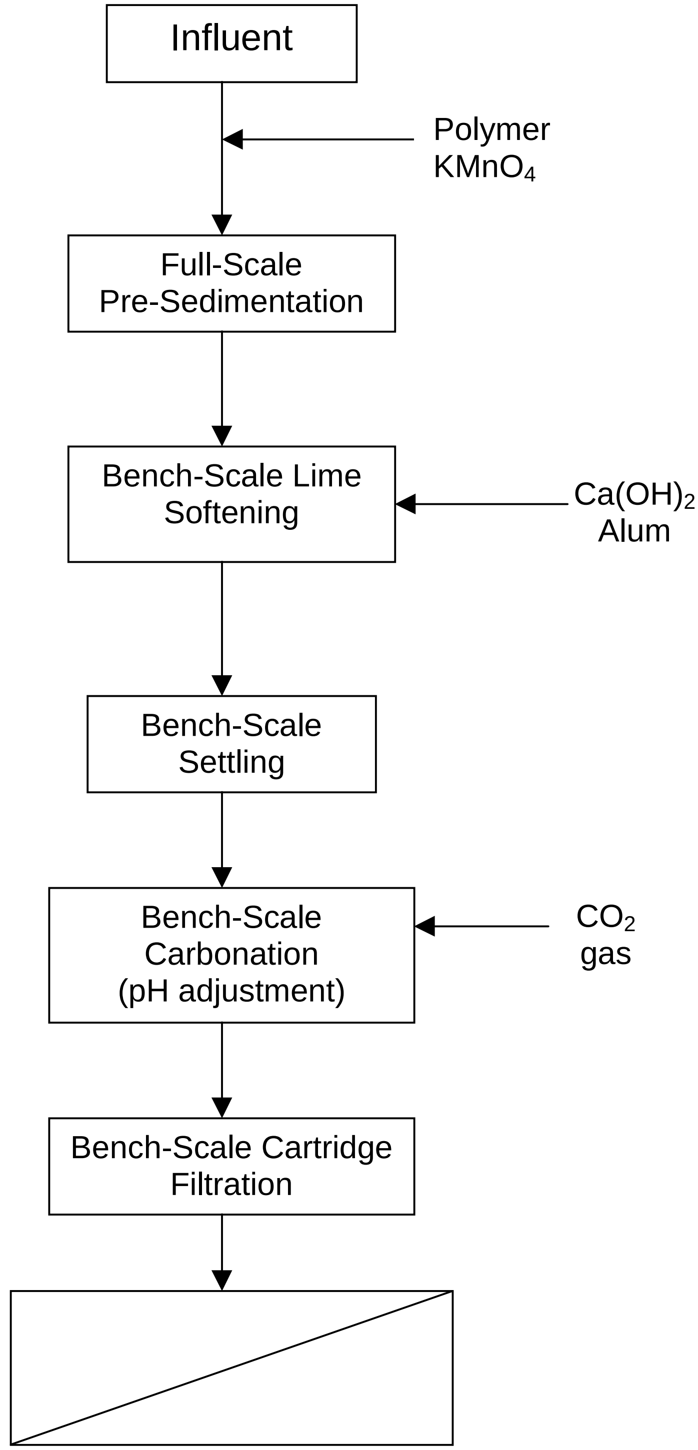


Figure 2: Pretreatment System Prior to Bench-Scale Nanofiltration



Bench-Scale Nanofiltration

Figure 3:

RBSMT Test Apparatus Diagram

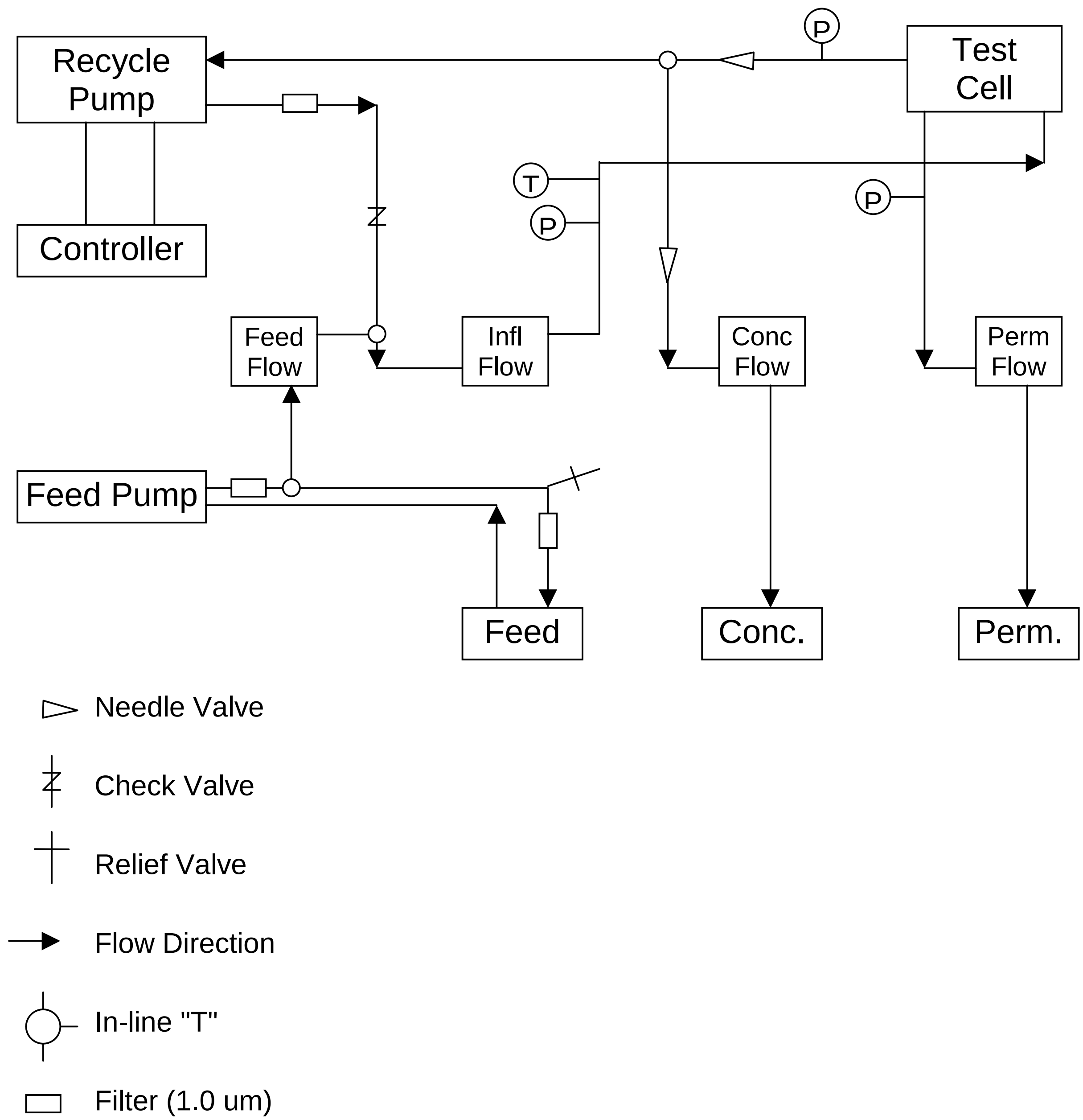


Table 1a: Kansas River Supply and Facility 1 – Process Design Information

Item	Process Design Data
Rated Capacity, mgd	55
Presedimentation Basins	
Number	3
Capacity each, mgd	18.3
Diameter, ft	105
Loading Rate, gpm/ft^2	1.47
Primary Basins	
Infilco Solids Contact Units	
Number	2
Capacity each, mgd	12
Loading Rate, gpm/ft^2	1.88
Walker Process Solids Contact Units	
Number	2
Capacity each, mgd	20
Loading Rate, gpm/ft^2	2.13
Final Basin	
Number	1
Capacity, mgd	55
Detention Time, min.	19
Filters	
Number	12
Capacity each, mgd	4.6
Surface Area, ft^2	700
Loading Rate, gpm/ft^2	4.6
Media Type	dual

Table 1b: Bench-Scale Pretreatment Data

Unit Process	Process Description
Lime Softening (Bench-Scale)	Chemical Type: *Calcium hydroxide, Alum – 15.0 mg/L
Settling (Bench-Scale)	Overnight (12 hours)
Carbonation (Bench-Scale)	CO_2 added to pH 9.3 – 9.6
Scale Control (Bench-Scale)	Chemical Type: Hypersperse AF200 UL
	Dose Rate (mg/L): 4.0 mg/L
Cartridge Filtration (Bench-Scale)	Surface Area (ft2): 4.5
	Nominal Pore Size (μm): 1.0
	Filter Material: Polypropylene
	Filter Life (gallons of processed water): NA

*Quarter 1 = 23.2g / 30 gal
Quarter 2 = 20.0g / 30 gal
Quarter 3 = 22.1g / 30 gal
Quarter 4 = 30.1g / 30 gal

Table 2a: Tabular Summary of Source Water Quality

Water Quality Parameter	Average Yearly Concentration	Standard Deviation	Maximum Yearly Value	Minimum Yearly Value
Temperature, °C	15.4	10.1	30	1
pH	8	0.3	8.5	7.36
Turbidity, NTU	169.6	154.9	545	43
Alkalinity mg/L as $CaCO_3$	165.7	29.4	208	119
Calcium Hardness mg/L as $CaCO_3$	182.8	41.8	248	119
TOC, mg/L	5.8	1.3	8.8	4.1
UV254, cm^{-1}	0.1	0	0.19	0.09
Bromide, µg/L	100	0	190	50

Table 2b: Tabular Summary of Finished Water Quality

Water Quality Parameter	Average Yearly Concentration	Standard Deviation	Maximum Yearly Value	Minimum Yearly Value
Temperature, °C	16.9	8.6	28.7	3
pH	9.4	0.3	9.91	8.62
Turbidity, NTU	0.2	0.1	0.4	0.07
TOC, mg/L	2.5	0.5	3.5	1.9
Distribution System THM4 µg/L	22	13	88	8.6

able 3: Experimental Design Summary for a RBSMT Study

Season	Membrane	Pretreatment	Water Flux, gfd	Recovery, %
Spring	Membrane A	Conventional filtration & antiscalant addition	15.0	29, 50, 71, & 89
Spring	Membrane B	Conventional filtration & antiscalant addition	15.0	31, 50, 69, & 87
Summer	Membrane A	Conventional filtration & antiscalant addition	15.0	30, 51, 70, & 89
Summer	Membrane B	Conventional filtration & antiscalant addition	15.0	30, 50, 69, & 89
Fall	Membrane A	Conventional filtration & antiscalant addition	15.0	30, 50, 71, & 89
Fall	Membrane B	Conventional filtration & antiscalant addition	15.0	29, 51, 71, & 89
Winter	Membrane A	Conventional filtration & antiscalant addition	12.0	30, 50, 71, & 88
Winter	Membrane B	Conventional filtration & antiscalant addition	12.0	29, 50, 71, & 87

tes:
embrane A: NF200
embrane B: XLE

Table 4: Summary of Analytical Methods and MRLs Used During a Study

Analyte	Method	Minimum Reporting Level
Alkalinity	SM 2320 B	1 mg/L $CaCO_3$
Ammonia	SM 4500-NH_3 D	0.30 mg/L NH_3-N
Bromide	EPA 300.0	20 μg/L
Calcium Hardness	SM 2340 B	0.25 mg/L $CaCO_3$
Chlorine Residual	SM 4500-Cl G	0.1 mg/L
BCAA, DBAA, DCAA, MBAA, MCAA, TCAA,	EPA 552.2	2.0 μg/L for MCAA 1.0 μg/L for all others
pH	SM 4500-H^+	Not Applicable
TDS	SM 2510 B (TDS meter)	5.0 mg/L
Temperature	SM 2550 B	Not Applicable
CHCl3, BDCM, DBCM, CHBr3	EPA 524.2	1.0 μg/L for each analyte
Total Hardness	SM 2340 B	0.33 mg/L $CaCO_3$
TOC	SM 5310 C	0.50 mg/L
TOX	SM 5320 B	25.0 μg/L
Turbidity	EPA 180.1	0.05 ntu
UV_{254}	SM 5910	0.001 cm^{-1}

ble 5: Average Pretreated Feed Water Quality During 4 Seasons of a RBSMT Study

Water Quality Parameter	Units	Spring Average	Spring S.D.	Summer Average	Summer S.D.	Fall Average	Fall S.D.	Winter Average	Winter S.D.
pH	---	8.62	0.07	9.13	0.22	8.82	1.12	9.36	0.00
Temperature	°C	22.3	1.06	24.9	2.69	23.6	2.69	22.9	0.14
Alkalinity	mg/L as $CaCO_3$	54.8	1.06	49.3	13.08	54.7	9.69	44.1	2.90
Total dissolved solids	mg/L	322.0	0.00	220.1	30.97	190.3	16.55	556.0	0.00
Total hardness	mg/L as $CaCO_3$	117.3	1.63	98.0	7.14	87.7	4.03	156.8	7.78
alcium hardness	mg/L as $CaCO_3$	97.4	2.47	81.7	6.01	74.2	3.89	103.4	8.49
Turbidity	ntu	0.16	0.01	0.13	0.01	0.10	0.03	0.09	0.01
Ammonia	mg NH_3-N / L	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL
tal organic carbon	mg/L	3.15	0.07	2.60	0.00	2.45	0.07	2.28	0.18
UV_{254}	cm^{-1}	0.053	0.00	0.045	0.00	0.041	0.00	0.030	0.00
SUVA	L/(mg*m)	1.67	0.06	1.73	0.06	1.65	0.10	1.32	0.11
Bromide	μg/L	113.5	16.50	110.0	14.14	77.5	3.54	150.0	0.00
SDS-Cl_2 dose	mg/L	4.40	0.57	3.65	0.00	3.64	0.00	4.30	0.00
SDS-Free Cl_2 residual	mg/L	1.18	0.25	0.67	0.06	0.93	0.13	0.78	0.12
DS-Cl_2 demand	mg/L	3.22	0.31	2.98	0.07	2.72	0.13	3.52	0.12
DS-Chlorination temp.	°C	13.0	0.00	26.0	0.00	20.0	0.00	6.0	0.00
S-Chlorination pH	---	9.49	0.01	9.42	0.01	9.50	0.00	9.52	0.03
S-Incubation time	hours	42.0	0.00	24.0	0.00	31.0	0.00	40.0	0.00
SDS-TOX	μg Cl^- /L	180.00	42.43	177.50	3.54	165.00	7.07	95.00	0.00
SDS-CHCl3	μg/L	50.60	12.45	60.41	7.26	46.43	1.29	14.92	2.24
SDS-BDCM	μg/L	28.50	4.10	26.14	1.97	21.92	0.11	17.50	0.13
SDS-DBCM	μg/L	17.35	1.06	13.82	1.92	10.67	0.25	17.52	1.01
SDS-CHBr3	μg/L	3.55	0.08	2.65	0.44	1.85	0.14	10.02	0.84
SDS-THM4	μg/L	100.00	17.68	103.03	2.93	80.86	1.02	59.95	0.52
SDS-MCAA*	μg/L	1.16	NA	3.37	NA	BMRL	BMRL	BMRL	BMRL
SDS-DCAA*	μg/L	17.63	2.36	18.34	0.54	19.83	0.66	13.40	1.48
SDS-TCAA*	μg/L	3.25	0.35	3.46	0.76	3.31	0.08	2.68	0.04
SDS-MBAA*	μg/L	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL
SDS-DBAA*	μg/L	4.18	0.44	3.20	0.76	3.50	0.14	7.35	0.50
SDS-BCAA*	μg/L	8.68	0.35	7.75	0.94	9.66	1.05	8.11	0.95
SDS-TBAA	μg/L	NA	NA	NA	NA	NA	NA	NA	NA
SDS-CDBAA	μg/L	NA	NA	NA	NA	NA	NA	NA	NA
SDS-DCBAA	μg/L	NA	NA	NA	NA	NA	NA	NA	NA
SDS-HAA5	μg/L	25.64	2.39	26.69	3.37	26.64	0.88	23.43	1.02
SDS-HAA6	μg/L	34.32	2.74	34.45	4.31	36.30	1.93	31.53	1.97

Table 6: SDS (Simulated Distribution System) Conditions

Parameters	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
pH	-	9.5	9.4	9.5	9.5
Temperature	°C	13.0	26.0	20.0	6.0
Target residual	mg/L	0.5 - 1.0	0.5 - 1.0	0.5 - 1.0	0.5 - 1.0
Retention Time	hours	40.00	24.00	31.00	40.00

Table 7: Average NF200 Membrane Productivity Observed Under Different Operating Conditions During a Membrane Treatment Study

Operating Conditions	Average Rate of MTCw Decline (gfd/psi/day)	*Initial MTCw (gfd/psi)	Final MTCw (gfd/psi)	MTCw After Cleaning (gfd/psi)
Spring	-0.0041	0.237	0.192	0.254
Summer	-0.0030	0.253	0.202	0.349
Fall	-0.0006	0.280	0.230	0.285
Winter	-0.0037	0.255	0.223	0.277

*MTCw at setting

Effect of Recovery on Feed Rejection for a RBSMT Study on Composite Samples Using the NF200 Membrane

Table 8a: Quarter 1

Water Quality Parameter	Feed Rejection at Listed Recovery (%)			
	Recovery=29%	Recovery=50%	Recovery=71%	Recovery=89%
TDS	61.15	56.06	53.50	48.40
Ca Hardness	73.09	70.01	65.70	58.70
Total Hardness	73.22	70.75	66.60	60.20
Bromide	19.82	11.89	17.20	16.30
TOC	100.00	100.00	100.00	100.00
UV254	88.57	92.38	92.40	92.40
SDS-THM4	94.42	94.34	91.80	88.20
SDS-HAA5	100.00	100.00	98.70	96.80
SDS-HAA6	100.00	100.00	99.10	97.60
SDS-TOX	100.00	100.00	100.00	100.00

Table 8b: Quarter 2

Water Quality Parameter	Feed Rejection at Listed Recovery (%)			
	Recovery=30%	Recovery=51%	Recovery=70%	Recovery=89%
TDS	50.75	41.21	36.50	29.90
Ca Hardness	73.91	64.24	60.90	53.30
Total Hardness	74.17	65.19	62.10	54.70
Bromide	0.00	0.00	1.40	0.00
TOC	100.00	100.00	100.00	100.00
UV254	88.89	93.33	90.00	82.20
SDS-THM4	89.23	87.44	81.60	69.00
SDS-HAA5	95.11	94.79	92.00	74.90
SDS-HAA6	96.21	95.96	89.90	72.50
SDS-TOX	100.00	100.00	79.60	82.30

Table 8c: Quarter 3

Water Quality Parameter	Feed Rejection at Listed Recovery (%)			
	Recovery=30%	Recovery=50%	Recovery=71%	Recovery=89%
TDS	59.75	50.34	40.10	37.80
Ca Hardness	71.41	65.61	55.90	60.90
Total Hardness	70.56	64.63	55.00	59.30
Bromide	10.97	4.52	0.00	1.90
TOC	100.00	100.00	100.00	100.00
UV254	92.59	92.59	88.90	85.20
SDS-THM4	85.51	92.12	88.60	82.00
SDS-HAA5	91.33	95.46	91.80	85.40
SDS-HAA6	89.67	96.67	90.80	84.70
SDS-TOX	100.00	100.00	100.00	100.00

Table 8d: Quarter 4

Water Quality Parameter	Feed Rejection at Listed Recovery (%)			
	Recovery=30%	Recovery=50%	Recovery=71%	Recovery=88%
TDS	49.10	41.19	35.10	30.00
Ca Hardness	63.73	61.61	59.10	54.20
Total Hardness	65.37	61.42	58.00	52.40
Bromide	0.00	0.00	0.00	0.00
TOC	100.00	100.00	100.00	100.00
UV254	90.00	86.67	85.00	76.70
SDS-THM4	92.73	94.19	87.90	80.20
SDS-HAA5	82.13	87.18	73.30	74.50
SDS-HAA6	86.72	90.47	76.90	76.40
SDS-TOX	100.00	72.32	100.00	100.00

ble 9: *Quarter 1 - Blend Ratios to Achieve Various Finished Water Qualities for a NF200 Nanofiltration Membrane*

tage	Controlling Treatment Objective	Value of Listed Parameter at Blend Ratio to Achieve Controlling Treatment Objective				
		Permeate:Total Flow Blend Ratio	*TOC (mg/L)*	*SDS-THM4 (µg/L)*	*SDS-HAA5 (µg/L)*	*SDS-HAA6 (µg/L)*
1	SDS-THM4 = 72 (µg/L) (Recovery = 29%)	0.297	NA	72.00	18.04	24.13
2	SDS-THM4 = 36 (µg/L) (Recovery = 29%)	0.678	NA	36.00	8.26	11.05
1	SDS-THM4 = 72 (µg/L) (Recovery = 50%)	0.297	NA	72.00	18.03	24.13
2	SDS-THM4 = 36 (µg/L) (Recovery = 50%)	0.678	NA	36.00	8.25	11.05
1	SDS-THM4 = 72 (µg/L) (Recovery = 71%)	0.305	NA	72.00	17.92	23.85
2	SDS-THM4 = 36 (µg/L) (Recovery = 71%)	0.697	NA	36.00	8.00	10.40
1	SDS-THM4 = 72 (µg/L) (Recovery = 89%)	0.318	NA	72.00	17.76	23.67
2	SDS-THM4 = 36 (µg/L) (Recovery = 89%)	0.726	NA	36.00	7.63	10.01

ote:
age 1: SDS-THM4 = 72 mg/L
age 2: SDS-THM4 = 36 mg/L
e value of SDS-HAA6 at the appropriate blend ratio (Q_P/Q_T) was calculated using the following formula:
$(Q_P/Q_T)/100 * (SDS\text{-}HAA6_P - SDS\text{-}HAA6_F) + SDS\text{-}HAA6_F$

able 10: *Quarter 2 - Blend Ratios to Achieve Various Finished Water Qualities for a NF200 Nanofiltration Membrane*

Stage	Controlling Treatment Objective	Value of Listed Parameter at Blend Ratio to Achieve Controlling Treatment Objective				
		Permeate:Total Flow Blend Ratio	*TOC (mg/L)*	*SDS-THM4 (µg/L)*	*SDS-HAA5 (µg/L)*	*SDS-HAA6 (µg/L)*
1	SDS-THM4 = 72 (µg/L) (Recovery = 30%)	0.337	NA	72.00	18.12	23.28
2	SDS-THM4 = 36 (µg/L) (Recovery = 30%)	0.729	NA	36.00	8.18	10.28
1	SDS-THM4 = 72 (µg/L) (Recovery = 51%)	0.344	NA	72.00	17.98	23.08
2	SDS-THM4 = 36 (µg/L) (Recovery = 51%)	0.744	NA	36.00	7.87	9.84
1	SDS-THM4 = 72 (µg/L) (Recovery = 70%)	0.369	NA	72.00	17.63	23.09
2	SDS-THM4 = 36 (µg/L) (Recovery = 70%)	0.797	NA	36.00	7.12	9.91
1	SDS-THM4 = 72 (µg/L) (Recovery = 89%)	0.436	NA	72.00	17.97	23.55
2	SDS-THM4 = 36 (µg/L) (Recovery = 89%)	0.943	NA	36.00	7.84	10.88

ote:
age 1: SDS-THM4 = 72 mg/L
age 2: SDS-THM4 = 36 mg/L
e value of SDS-HAA6 at the appropriate blend ratio (Q_P/Q_T) was calculated using the following formula:
$(Q_P/Q_T)/100 * (SDS\text{-}HAA6_P - SDS\text{-}HAA6_F) + SDS\text{-}HAA6_F$

ble 11: ***Quarter 3 - Blend Ratios to Achieve Various Finished Water Qualities for a NF200 Nanofiltration Membrane***

tage	Controlling Treatment Objective	Value of Listed Parameter at Blend Ratio to Achieve Controlling Treatment Objective				
		Permeate:Total Flow Blend Ratio	*TOC (mg/L)*	*SDS-THM4 (μg/L)*	*SDS-HAA5 (μg/L)*	*SDS-HAA6 (μg/L)*
1	SDS-THM4 = 72 (μg/L) (Recovery = 30%)	0.128	NA	72.00	23.52	32.13
2	SDS-THM4 = 36 (μg/L) (Recovery = 30%)	0.649	NA	36.00	10.85	15.18
1	SDS-THM4 = 72 (μg/L) (Recovery = 50%)	0.119	NA	72.00	23.61	32.12
2	SDS-THM4 = 36 (μg/L) (Recovery = 50%)	0.602	NA	36.00	11.32	15.18
1	SDS-THM4 = 72 (μg/L) (Recovery = 71%)	0.124	NA	72.00	23.61	32.29
2	SDS-THM4 = 36 (μg/L) (Recovery = 71%)	0.626	NA	36.00	11.32	16.05
1	SDS-THM4 = 72 (μg/L) (Recovery = 89%)	0.134	NA	72.00	23.60	32.18
2	SDS-THM4 = 36 (μg/L) (Recovery = 89%)	0.676	NA	36.00	11.26	15.51

te:
ge 1: SDS-THM4 = 80 mg/L, SDS-HAA5 = 60 μg/L
ge 2: SDS-THM4 = 40 mg/L, SDS-HAA5 = 30 μg/L
e value of SDS-HAA6 at the appropriate blend ratio (Q_P/Q_T) was calculated using the following formula:

$(Q_P/Q_T)/100 * (SDS\text{-}HAA6_P - SDS\text{-}HAA6_F) + SDS\text{-}HAA6_F$

ble 12: ***Quarter 4 - Blend Ratios to Achieve Various Finished Water Qualities for a NF200 Nanofiltration Membrane***

tage	Controlling Treatment Objective	Value of Listed Parameter at Blend Ratio to Achieve Controlling Treatment Objective				
		Permeate:Total Flow Blend Ratio	*TOC (mg/L)*	*SDS-THM4 (μg/L)*	*SDS-HAA5 (μg/L)*	*SDS-HAA6 (μg/L)*
1	SDS-THM4 = 72 (μg/L) (Recovery = 30%)	NA	NA	NA	NA	NA
2	SDS-THM4 = 36 (μg/L) (Recovery = 30%)	0.431	NA	36.00	15.14	19.75
1	SDS-THM4 = 72 (μg/L) (Recovery = 50%)	NA	NA	NA	NA	NA
2	SDS-THM4 = 36 (μg/L) (Recovery = 50%)	0.424	NA	36.00	14.77	19.43
1	SDS-THM4 = 72 (μg/L) (Recovery = 71%)	NA	NA	NA	NA	NA
2	SDS-THM4 = 36 (μg/L) (Recovery = 71%)	0.455	NA	36.00	15.62	20.75
1	SDS-THM4 = 72 (μg/L) (Recovery = 88%)	NA	NA	NA	NA	NA
2	SDS-THM4 = 36 (μg/L) (Recovery = 88%)	0.498	NA	36.00	14.73	19.53

te:
ge 1: SDS-THM4 = 72 mg/L
ge 2: SDS-THM4 = 36 mg/L
e value of SDS-HAA6 at the appropriate blend ratio (Q_P/Q_T) was calculated using the following formula:

$(Q_P/Q_T)/100 * (SDS\text{-}HAA6_P - SDS\text{-}HAA6_F) + SDS\text{-}HAA6_F$

Table 13: Average XLE Membrane Productivity Observed Under Different Operating Conditions During a Membrane Treatment Study

Operating Conditions	Average Rate of MTCw Decline (gfd/psi/day)	*Initial MTCw (gfd/psi)	Final MTCw (gfd/psi)	MTCw After Cleaning (gfd/psi)
Spring	-0.0164	0.216	0.140	0.204
Summer	-0.0266	0.286	0.121	0.197
Fall	-0.0065	0.290	0.213	0.241
Winter	-0.0059	0.309	0.244	0.238

*MTCw at setting

Effect of Recovery on Feed Rejection for a RBSMT Study on Composite Samples Using the XLE Membrane

Table 14a: Quarter 1

Water Quality Parameter	Feed Rejection at Listed Recovery (%)			
	Recovery=31%	Recovery=50%	Recovery=69%	Recovery=87%
TDS	96.34	94.63	91.50	83.70
Ca Hardness	99.38	99.18	96.00	91.60
Total Hardness	99.40	99.32	96.70	92.60
Bromide	100.00	100.00	100.00	70.90
TOC	100.00	100.00	100.00	100.00
UV254	92.38	96.19	96.20	94.30
SDS-THM4	98.54	100.00	98.00	94.70
SDS-HAA5	100.00	100.00	100.00	100.00
SDS-HAA6	100.00	100.00	100.00	100.00
SDS-TOX	100.00	100.00	100.00	100.00

Table 14b: Quarter 2

Water Quality Parameter	Feed Rejection at Listed Recovery (%)			
	Recovery=30%	Recovery=50%	Recovery=69%	Recovery=89%
TDS	93.09	91.69	89.80	78.60
Ca Hardness	98.90	98.90	98.70	98.00
Total Hardness	98.88	98.88	98.70	98.10
Bromide	100.00	100.00	100.00	57.30
TOC	100.00	100.00	100.00	100.00
UV254	93.48	97.83	97.80	100.00
SDS-THM4	96.78	97.73	94.70	92.30
SDS-HAA5	100.00	100.00	100.00	100.00
SDS-HAA6	100.00	100.00	100.00	100.00
SDS-TOX	100.00	100.00	100.00	100.00

Table 14c: Quarter 3

Water Quality Parameter	Feed Rejection at Listed Recovery (%)			
	Recovery=29%	Recovery=51%	Recovery=71%	Recovery=89%
TDS	94.43	92.85	87.30	79.80
Ca Hardness	98.65	98.52	96.90	91.60
Total Hardness	98.63	98.40	96.80	92.10
Bromide	100.00	100.00	100.00	58.70
TOC	100.00	100.00	100.00	100.00
UV254	97.53	97.53	90.10	95.10
SDS-THM4	96.69	96.77	93.30	92.40
SDS-HAA5	100.00	100.00	100.00	95.90
SDS-HAA6	100.00	100.00	100.00	94.10
SDS-TOX	100.00	100.00	77.90	100.00

Table 14d: Quarter 4

Water Quality Parameter	Feed Rejection at Listed Recovery (%)			
	Recovery=29-%	Recovery=50%	Recovery=71%	Recovery=87%
TDS	92.99	90.25	83.40	68.70
Ca Hardness	98.94	98.55	97.20	93.60
Total Hardness	98.98	98.60	97.00	93.60
Bromide	85.33	81.33	68.30	42.70
TOC	100.00	100.00	100.00	100.00
UV254	93.33	90.00	91.70	83.30
SDS-THM4	100.00	100.00	100.00	92.40
SDS-HAA5	93.94	94.83	94.10	88.00
SDS-HAA6	95.49	96.16	95.60	91.10
SDS-TOX	100.00	100.00	100.00	100.00

able 15: *Quarter 1 - Blend Ratios to Achieve Various Finished Water Qualities for a XLE Nanofiltration Membrane*

tage	Controlling Treatment Objective	Value of Listed Parameter at Blend Ratio to Achieve Controlling Treatment Objective				
		Permeate:Total Flow Blend Ratio	*TOC (mg/L)*	*SDS-THM4 (μg/L)*	*SDS-HAA5 (μg/L)*	*SDS-HAA6 (μg/L)*
1	SDS-THM4 = 72 (μg/L) (Recovery = 31%)	0.284	NA	72.00	18.36	24.57
2	SDS-THM4 = 36 (μg/L) (Recovery = 31%)	0.360	NA	36.00	8.99	21.96
1	SDS-THM4 = 72 (μg/L) (Recovery = 50%)	0.280	NA	72.00	18.46	24.71
2	SDS-THM4 = 36 (μg/L) (Recovery = 50%)	0.360	NA	36.00	9.23	21.96
1	SDS-THM4 = 72 (μg/L) (Recovery = 69%)	0.286	NA	72.00	18.31	24.50
2	SDS-THM4 = 36 (μg/L) (Recovery = 69%)	0.360	NA	36.00	8.89	21.96
1	SDS-THM4 = 72 (μg/L) (Recovery = 87%)	0.296	NA	72.00	18.06	24.16
2	SDS-THM4 = 36 (μg/L) (Recovery = 87%)	0.360	NA	36.00	8.31	21.96

ote:
age 1: SDS-THM4 = 72 mg/L
age 2: SDS-THM4 = 36 mg/L
e value of SDS-HAA6 at the appropriate blend ratio (Q_P/Q_T) was calculated using the following formula:

$$(Q_P/Q_T)/100 * (\text{SDS-HAA6}_P - \text{SDS-HAA6}_F) + \text{SDS-HAA6}_F$$

able 16: *Quarter 2 - Blend Ratios to Achieve Various Finished Water Qualities for a XLE Nanofiltration Membrane*

age	Controlling Treatment Objective	Value of Listed Parameter at Blend Ratio to Achieve Controlling Treatment Objective				
		Permeate:Total Flow Blend Ratio	*TOC (mg/L)*	*SDS-THM4 (μg/L)*	*SDS-HAA5 (μg/L)*	*SDS-HAA6 (μg/L)*
1	SDS-THM4 = 72 (μg/L) (Recovery = 30%)	0.311	NA	72.00	18.38	23.74
2	SDS-THM4 = 36 (μg/L) (Recovery = 30%)	0.672	NA	36.00	8.75	11.30
1	SDS-THM4 = 72 (μg/L) (Recovery = 50%)	0.308	NA	72.00	18.47	23.84
2	SDS-THM4 = 36 (μg/L) (Recovery = 50%)	0.666	NA	36.00	8.92	11.51
1	SDS-THM4 = 72 (μg/L) (Recovery = 69%)	0.318	NA	72.00	18.20	23.49
2	SDS-THM4 = 36 (μg/L) (Recovery = 69%)	0.687	NA	36.00	8.35	10.78
1	SDS-THM4 = 72 (μg/L) (Recovery = 89%)	0.326	NA	72.00	17.98	23.22
2	SDS-THM4 = 36 (μg/L) (Recovery = 89%)	0.705	NA	36.00	7.87	10.16

te:
ge 1: SDS-THM4 = 72 mg/L
ge 2: SDS-THM4 = 36 mg/L
e value of SDS-HAA6 at the appropriate blend ratio (Q_P/Q_T) was calculated using the following formula:

$$(Q_P/Q_T)/100 * (\text{SDS-HAA6}_P - \text{SDS-HAA6}_F) + \text{SDS-HAA6}_F$$

able 17: Quarter 3 - Blend Ratios to Achieve Various Finished Water Qualities for a XLE Nanofiltration Membrane

tage	Controlling Treatment Objective	Value of Listed Parameter at Blend Ratio to Achieve Controlling Treatment Objective				
		Permeate:Total Flow Blend Ratio	*TOC (mg/L)*	*SDS-THM4 (µg/L)*	*SDS-HAA5 (µg/L)*	*SDS-HAA6 (µg/L)*
1	SDS-THM4 = 72 (µg/L) (Recovery = 29%)	0.113	NA	72.00	23.62	32.20
2	SDS-THM4 = 36 (µg/L) (Recovery = 29%)	0.574	NA	36.00	11.35	15.46
1	SDS-THM4 = 72 (µg/L) (Recovery = 51%)	0.113	NA	72.00	23.62	32.20
2	SDS-THM4 = 36 (µg/L) (Recovery = 51%)	0.573	NA	36.00	11.37	15.50
1	SDS-THM4 = 72 (µg/L) (Recovery = 71%)	0.117	NA	72.00	23.51	32.05
2	SDS-THM4 = 36 (µg/L) (Recovery = 71%)	0.595	NA	36.00	10.80	14.70
1	SDS-THM4 = 72 (µg/L) (Recovery = 89%)	0.119	NA	72.00	23.61	32.23
2	SDS-THM4 = 36 (µg/L) (Recovery = 89%)	0.600	NA	36.00	11.30	15.80

ote:
age 1: SDS-THM4 = 72 mg/L
age 2: SDS-THM4 = 36 mg/L
e value of SDS-HAA6 at the appropriate blend ratio (Q_P/Q_T) was calculated using the following formula:
$(Q_P/Q_T)/100 * (SDS\text{-}HAA6_P - SDS\text{-}HAA6_F) + SDS\text{-}HAA6_F$

able 18: Quarter 4 - Blend Ratios to Achieve Various Finished Water Qualities for a XLE Nanofiltration Membrane

tage	Controlling Treatment Objective	Value of Listed Parameter at Blend Ratio to Achieve Controlling Treatment Objective				
		Permeate:Total Flow Blend Ratio	*TOC (mg/L)*	*SDS-THM4 (µg/L)*	*SDS-HAA5 (µg/L)*	*SDS-HAA6 (µg/L)*
1	SDS-THM4 = 72 (µg/L) (Recovery = 29%)	NA	NA	NA	NA	NA
2	SDS-THM4 = 36 (µg/L) (Recovery = 29%)	0.400	NA	36.00	14.64	19.49
1	SDS-THM4 = 72 (µg/L) (Recovery = 50%)	NA	NA	NA	NA	NA
2	SDS-THM4 = 36 (µg/L) (Recovery = 50%)	0.400	NA	36.00	14.55	19.40
1	SDS-THM4 = 72 (µg/L) (Recovery = 71%)	NA	NA	NA	NA	NA
2	SDS-THM4 = 36 (µg/L) (Recovery = 71%)	0.400	NA	36.00	14.62	19.47
1	SDS-THM4 = 72 (µg/L) (Recovery = 87%)	NA	NA	NA	NA	NA
2	SDS-THM4 = 36 (µg/L) (Recovery = 87%)	0.432	NA	36.00	14.52	19.12

te:
ige 1: SDS-THM4 = 72 mg/L
ige 2: SDS-THM4 = 36 mg/L
e value of SDS-HAA6 at the appropriate blend ratio (Q_P/Q_T) was calculated using the following formula:
$(Q_P/Q_T)/100 * (SDS\text{-}HAA6_P - SDS\text{-}HAA6_F) + SDS\text{-}HAA6_F$

Table 19: PE Study for 1st Quarter (PE Study #6)

Parameter	Units	True Value	Measured Value	RPD
UV_{254}	cm^{-1}	0.101	0.090	10.89
TOC	mg/L	2.69	3.01	11.90
TOX	µg Cl^-/L	135	102.0	24.44
Bromide	mg/L	0.059	0.056	5.08
Inorganic DBPs:				
ClO_2^-	µg/L	73.6	63.0	14.40
BrO_3^-	µg/L	16.2	17.10	5.56
ClO_3^-	µg/L	141	140.0	0.71
HAAs:				
MCAA	µg/L	9.04	7.86	13.05
MBAA	µg/L	8.10	6.84	15.56
DCAA	µg/L	18.1	16.60	8.29
TCAA	µg/L	26.2	26.80	2.29
BCAA	µg/L	11.1	8.50	23.42
DBAA	µg/L	4.97	4.36	12.27
THMs:				
$CHCl_3$	µg/L	16.2	15.10	6.79
BDCM	µg/L	22.8	23.20	1.75
DBCM	µg/L	28.6	29.70	3.85
$CHBr_3$	µg/L	20.2	20.20	0.00
HANs:				
TCAN	µg/L	-	5.97	-
DCAN	µg/L	10.9	9.02	17.25
DCP	µg/L	9.00	8.30	7.78
BCAN	µg/L	13.0	12.00	7.69
TCP	µg/L	8.01	6.90	13.86
DBAN	µg/L	15.9	15.20	4.40
CH	µg/L	12.2	13.80	13.11

Table 20a: PE Study for 2nd Quarter (PE Study #7)

Parameter	Units	True Value	Measured Value	RPD
UV_{254}	cm^{-1}	0.361	0.339	6.09
TOC	mg/L	1.22	1.29	5.74
TOX	µg Cl^-/L	188	149.0	20.74
Inorganic DBPs:				
ClO_2^-	µg/L	483	449.0	7.04
BrO_3^-	µg/L	26.1	24.50	6.13
ClO_3^-	µg/L	375	352.0	6.13
HAAs:				
MCAA	µg/L	5.94	5.07	14.65
MBAA	µg/L	11.1	7.50	32.43
DCAA	µg/L	24.0	17.10	28.75
TCAA	µg/L	15.0	12.90	14.00
BCAA	µg/L	12.1	7.37	39.09
DBAA	µg/L	14.0	9.03	35.50
THMs:				
$CHCl_3$	µg/L	17.0	16.00	5.88
BDCM	µg/L	11.0	11.30	2.73
DBCM	µg/L	28.1	28.00	0.36
$CHBr_3$	µg/L	18.2	18.20	0.00
HANs:				
TCAN	µg/L	12.1	12.00	0.83
DCAN	µg/L	19.0	18.60	2.11
DCP	µg/L	5.06	5.22	3.16
BCAN	µg/L	9.10	8.69	4.51
TCP	µg/L	11.1	11.80	6.31
DBAN	µg/L	14.0	14.30	2.14
CH	µg/L	22.1	20.10	9.05

Table 20b: Makeup PE Study for 2nd Quarter

Parameter	Units	True Value	Measured Value	RPD
Bromide	mg/L	0.091	0.090	1.10

Table 21a: PE Study for 3rd Quarter (PE Study #8)

Parameter	Units	True Value	Measured Value	RPD
UV_{254}	cm^{-1}	0.072	0.066	8.33
TOC	mg/L	2.62	3.14	19.85
TOX	µg Cl^-/L	80.3	62.8	21.79
Bromide	mg/L	0.325	0.296	8.92
Inorganic DBPs:				
ClO_2^-	µg/L	687	635.0	7.57
BrO_3^-	µg/L	13.1	12.30	6.11
ClO_3^-	µg/L	768	700.0	8.85
HAAs:				
MCAA	µg/L	13.0	12.60	3.08
MBAA	µg/L	16.0	14.30	10.63
DCAA	µg/L	14.2	12.60	11.27
TCAA	µg/L	8.03	6.76	15.82
BCAA	µg/L	5.07	4.77	5.92
DBAA	µg/L	18.0	17.90	0.56
HANs:				
TCAN	µg/L	6.92	5.52	20.23
DCAN	µg/L	6.16	4.51	26.79
DCP	µg/L	4.09	4.38	7.09
BCAN	µg/L	10.0	7.44	25.60
TCP	µg/L	2.99	3.61	20.74
DBAN	µg/L	5.07	4.52	10.85
CH	µg/L	9.08	10.60	16.74

Table 21b: Makeup PE Study for 3rd Quarter

Parameter	Units	True Value	Measured Value	RPD
THMs:				
$CHCl_3$	µg/L	17.1	17.10	0.00
BDCM	µg/L	11.0	11.00	0.00
DBCM	µg/L	28.1	26.70	4.98
$CHBr_3$	µg/L	18.2	18.10	0.55

Table 22: PE Study for 4th Quarter (PE Study #9)

Parameter	Units	True Value	Measured Value	RPD
UV_{254}	cm^{-1}	0.223	0.206	7.62
TOC	mg/L	4.19	4.25	1.43
TOX	$\mu g\ Cl^-/L$	92.9	62.5	32.72
Bromide	mg/L	0.091	0.092	1.10
Inorganic DBPs:				
ClO_2^-	µg/L	167	170.0	1.80
BrO_3^-	µg/L	9.17	9.68	5.56
ClO_3^-	µg/L	211	209.0	0.95
HAAs:				
MCAA	µg/L	11.1	12.10	9.01
MBAA	µg/L	9.11	8.54	6.26
DCAA	µg/L	8.01	7.39	7.74
TCAA	µg/L	12.0	9.47	21.08
BCAA	µg/L	7.05	5.60	20.57
DBAA	µg/L	5.00	3.85	23.00
THMs:				
$CHCl_3$	µg/L	32.2	32.10	0.31
BDCM	µg/L	15.0	14.90	0.67
DBCM	µg/L	9.10	8.73	4.07
$CHBr_3$	µg/L	2.98	2.91	2.35
HANs:				
TCAN	µg/L	17.0	18.30	7.65
DCAN	µg/L	16.2	16.20	0.00
DCP	µg/L	8.13	9.73	19.68
BCAN	µg/L	14.1	11.50	18.44
TCP	µg/L	14.1	14.50	2.84
DBAN	µg/L	12.1	9.64	20.33
CH	µg/L	19.1	15.30	19.90

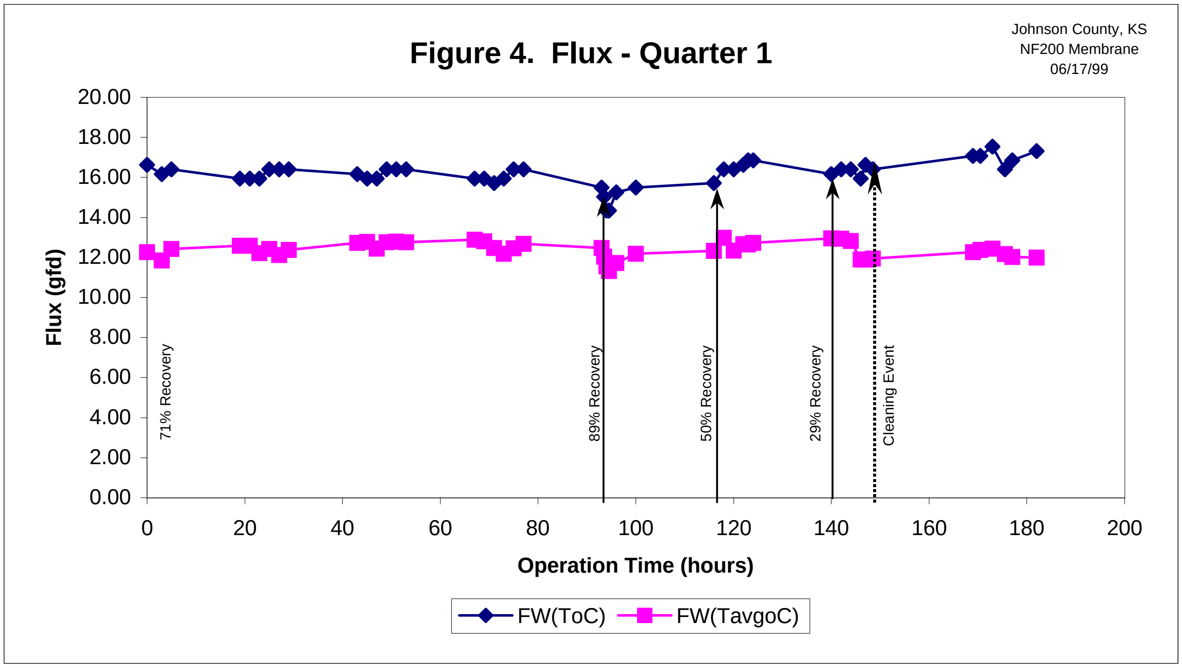


Figure 4. Flux - Quarter 1
Johnson County, KS
NF200 Membrane
06/17/99
Flux (gfd)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
20
40
60
80
100
120
140
160
180
200
Operation Time (hours)
71% Recovery
89% Recovery
50% Recovery
29% Recovery
Cleaning Event
FW(ToC)
FW(TavgoC)

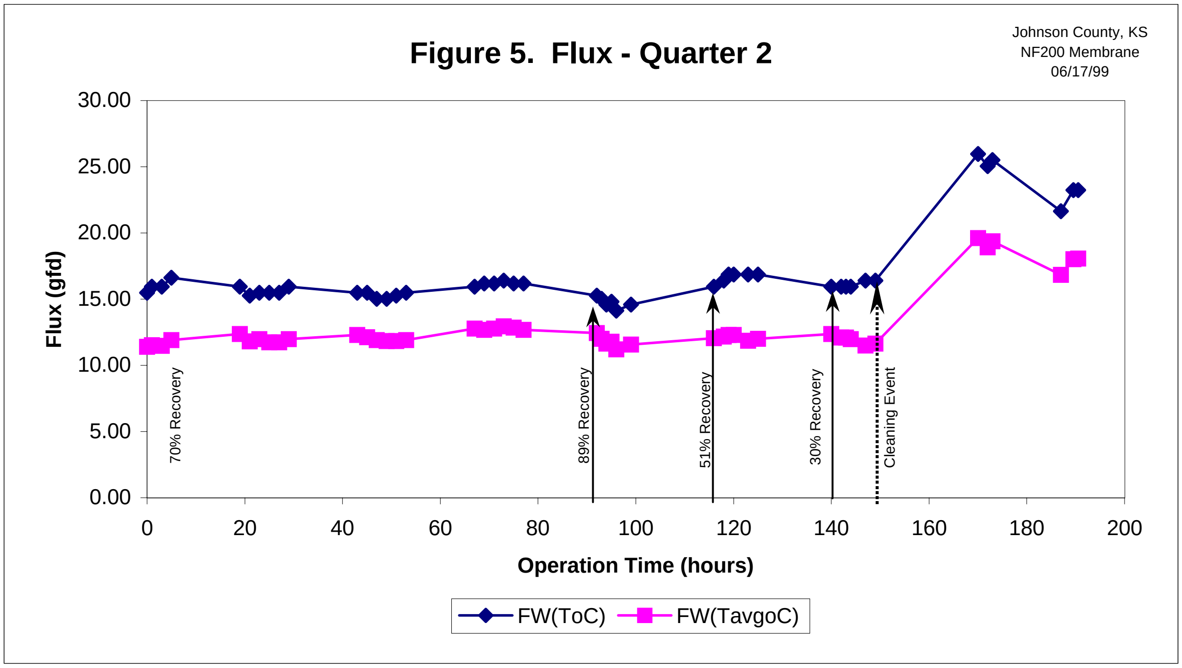


Figure 5. Flux - Quarter 2
Johnson County, KS
NF200 Membrane
06/17/99
Flux (gfd)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
20
40
60
80
100
120
140
160
180
200
Operation Time (hours)
70% Recovery
89% Recovery
51% Recovery
30% Recovery
Cleaning Event
FW(ToC)
FW(TavgoC)

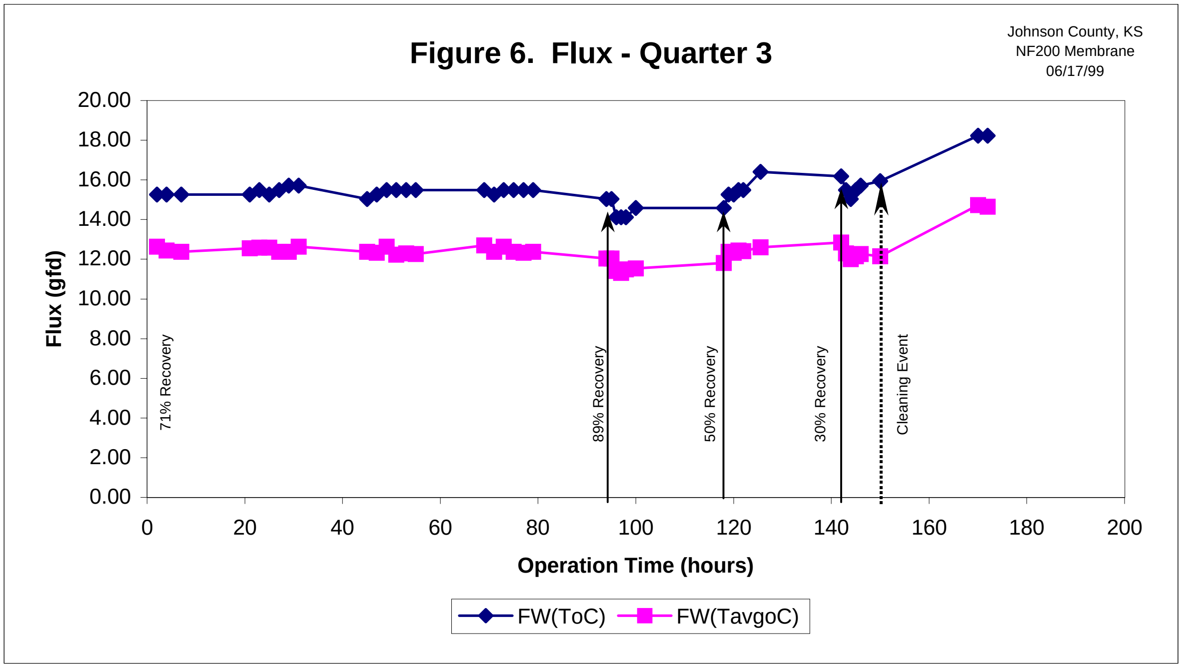


Figure 6. Flux - Quarter 3
Johnson County, KS
NF200 Membrane
06/17/99
Flux (gfd)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
20
40
60
80
100
120
140
160
180
200
Operation Time (hours)
71% Recovery
89% Recovery
50% Recovery
30% Recovery
Cleaning Event
FW(ToC)
FW(TavgoC)

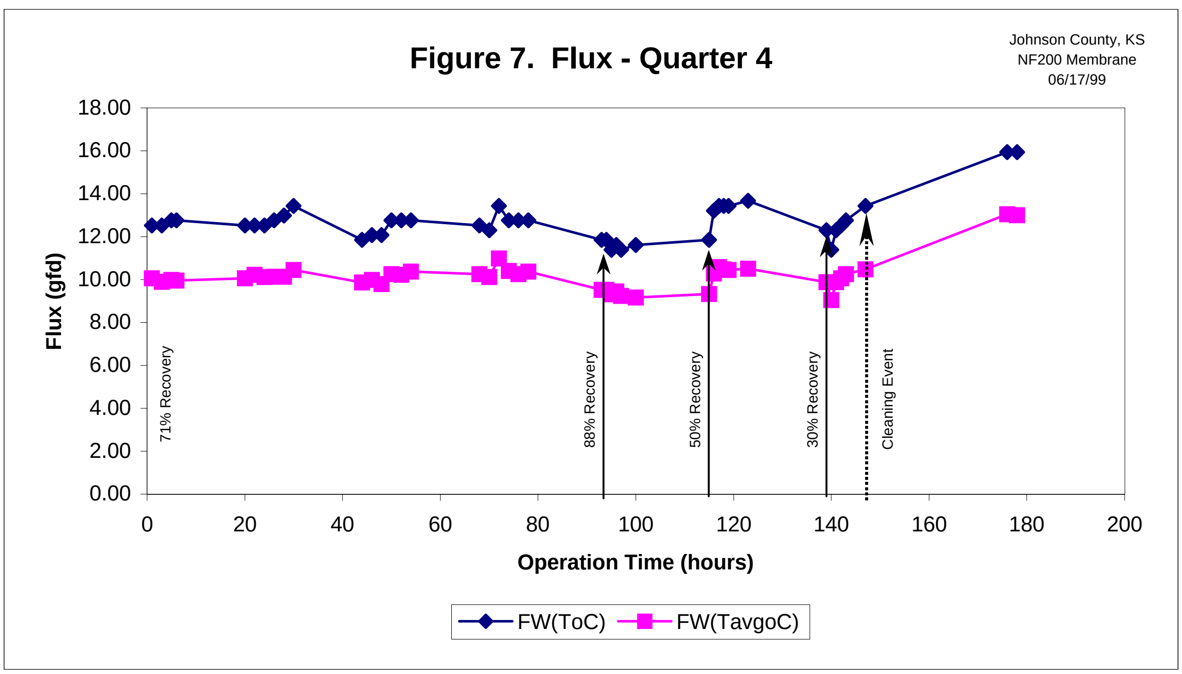


Figure 7. Flux - Quarter 4
Johnson County, KS
NF200 Membrane
06/17/99
Flux (gfd)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
20
40
60
80
100
120
140
160
180
200
Operation Time (hours)
71% Recovery
88% Recovery
50% Recovery
30% Recovery
Cleaning Event
FW(ToC)
FW(TavgoC)

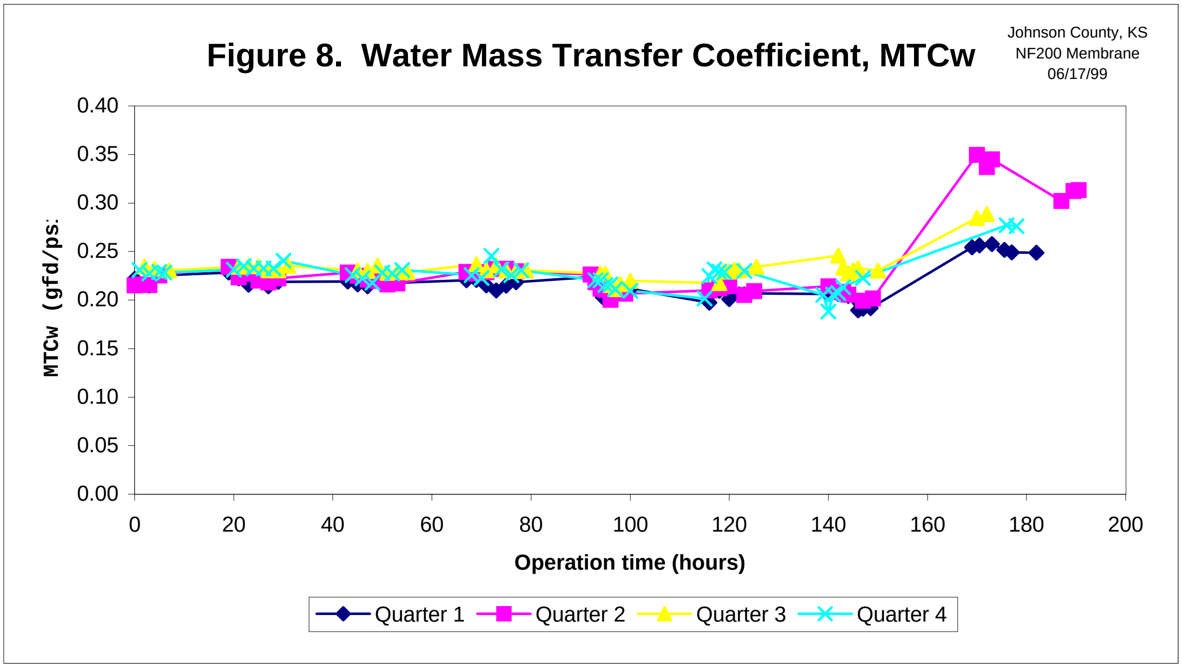


Figure 8. Water Mass Transfer Coefficient, MTCw
Johnson County, KS
NF200 Membrane
06/17/99
MTCw (gfd/psi)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
20
40
60
80
100
120
140
160
180
200
Operation time (hours)
Quarter 1
Quarter 2
Quarter 3
Quarter 4

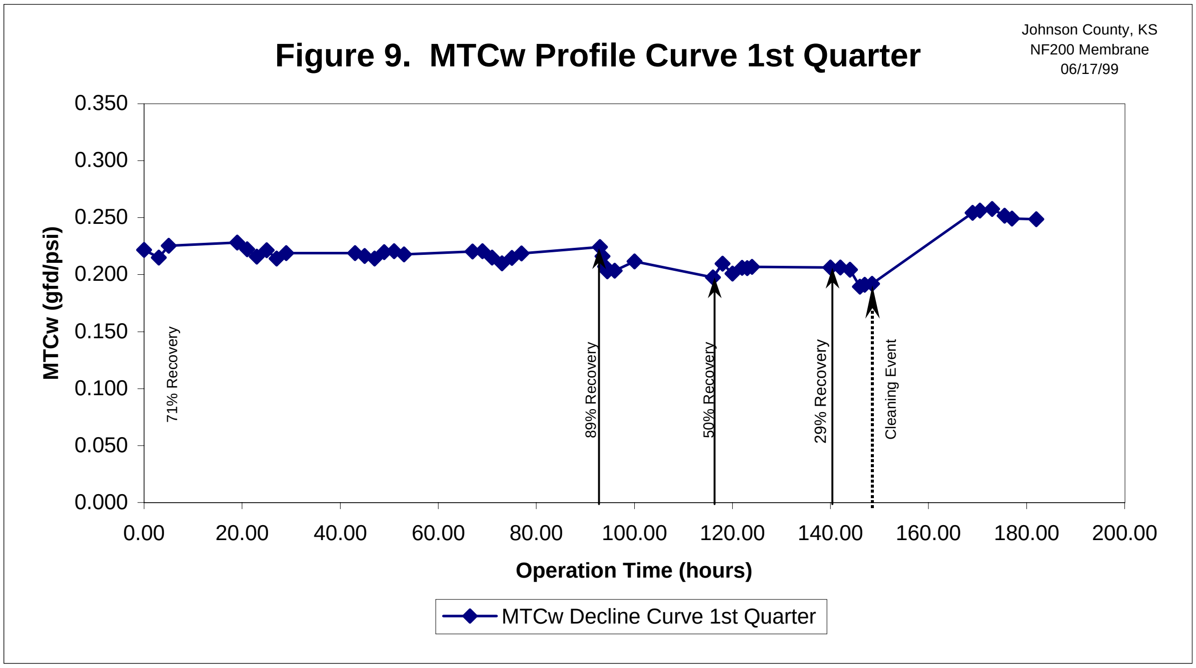


Figure 9. MTCw Profile Curve 1st Quarter
Johnson County, KS
NF200 Membrane
06/17/99
MTCw (gfd/psi)
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
71% Recovery
89% Recovery
50% Recovery
29% Recovery
Cleaning Event
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
MTCw Decline Curve 1st Quarter

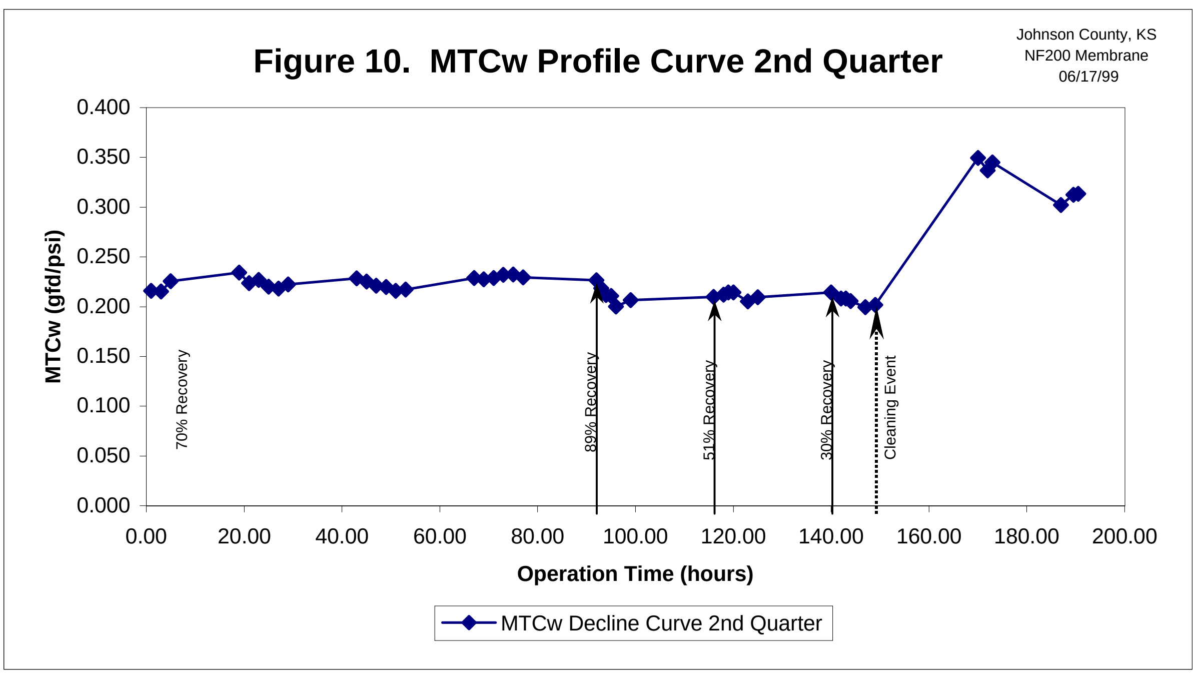


Figure 10. MTCw Profile Curve 2nd Quarter
Johnson County, KS
NF200 Membrane
06/17/99
MTCw (gfd/psi)
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
70% Recovery
89% Recovery
51% Recovery
30% Recovery
Cleaning Event
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
MTCw Decline Curve 2nd Quarter

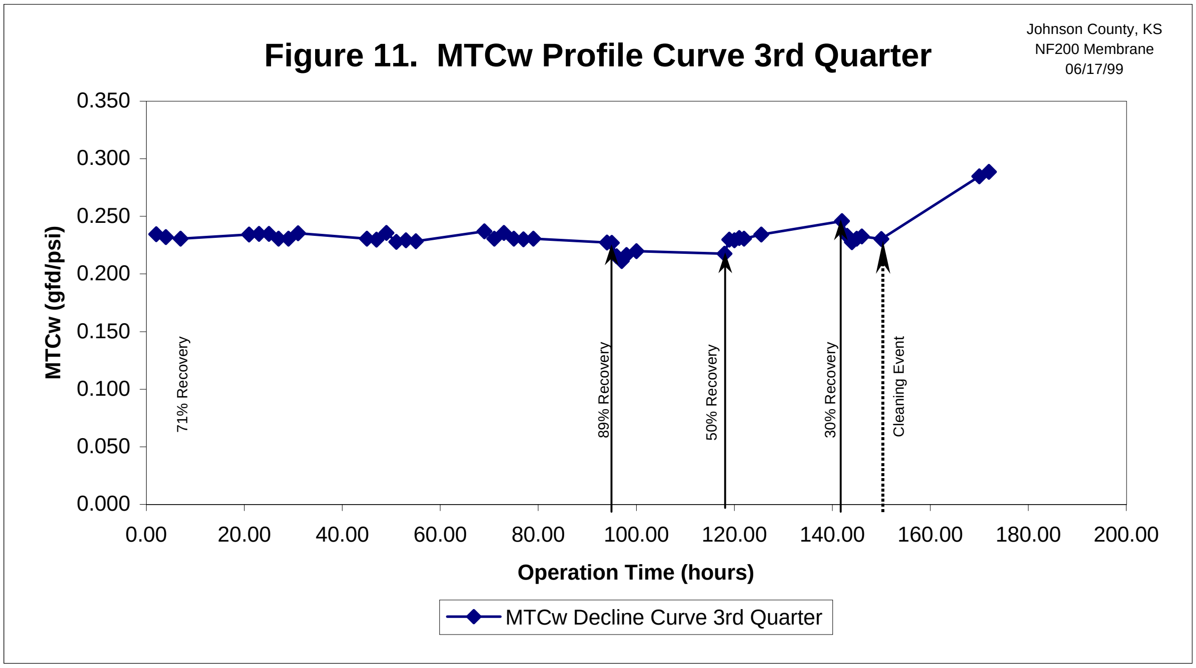


Figure 11. MTCw Profile Curve 3rd Quarter
Johnson County, KS
NF200 Membrane
06/17/99
MTCw (gfd/psi)
Operation Time (hours)
71% Recovery
89% Recovery
50% Recovery
30% Recovery
Cleaning Event
MTCw Decline Curve 3rd Quarter

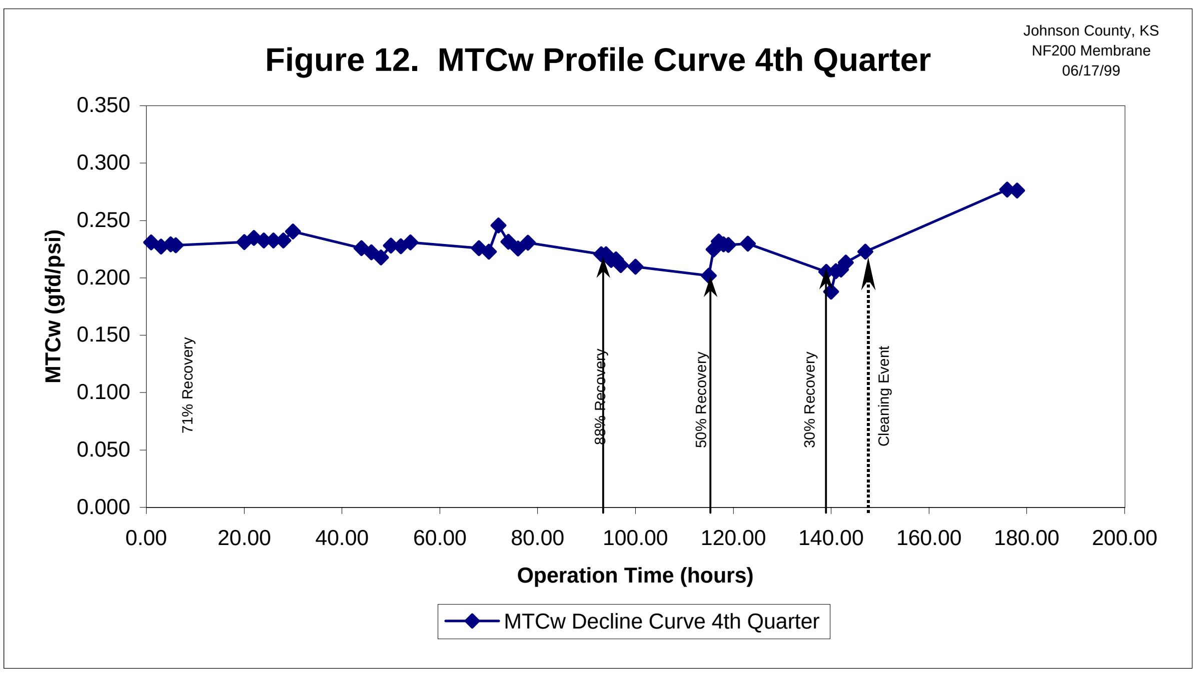
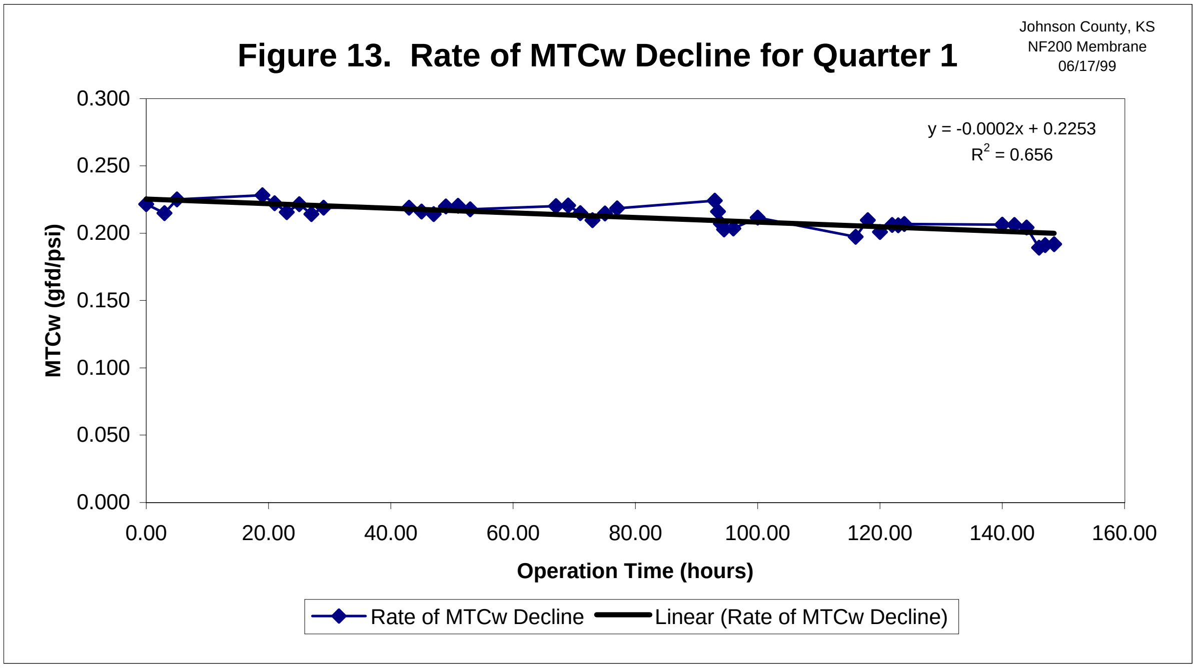
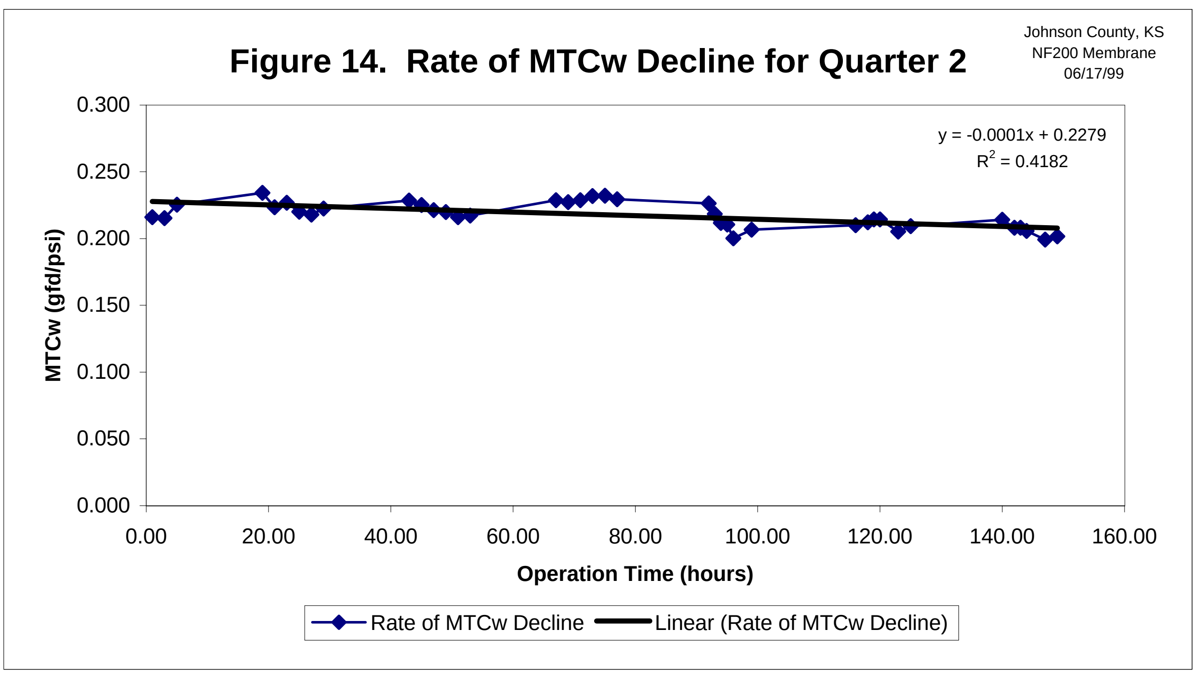


Figure 12. MTCw Profile Curve 4th Quarter
Johnson County, KS
NF200 Membrane
06/17/99
MTCw (gfd/psi)
Operation Time (hours)
71% Recovery
88% Recovery
50% Recovery
30% Recovery
Cleaning Event
MTCw Decline Curve 4th Quarter


Johnson County, KS
NF200 Membrane
06/17/99
Figure 13. Rate of MTCw Decline for Quarter 1
y = -0.0002x + 0.2253
R2 = 0.656
MTCw (gfd/psi)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
Rate of MTCw Decline
Linear (Rate of MTCw Decline)


Johnson County, KS
NF200 Membrane
06/17/99
Figure 14. Rate of MTCw Decline for Quarter 2
y = -0.0001x + 0.2279
R2 = 0.4182
MTCw (gfd/psi)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
Rate of MTCw Decline
Linear (Rate of MTCw Decline)

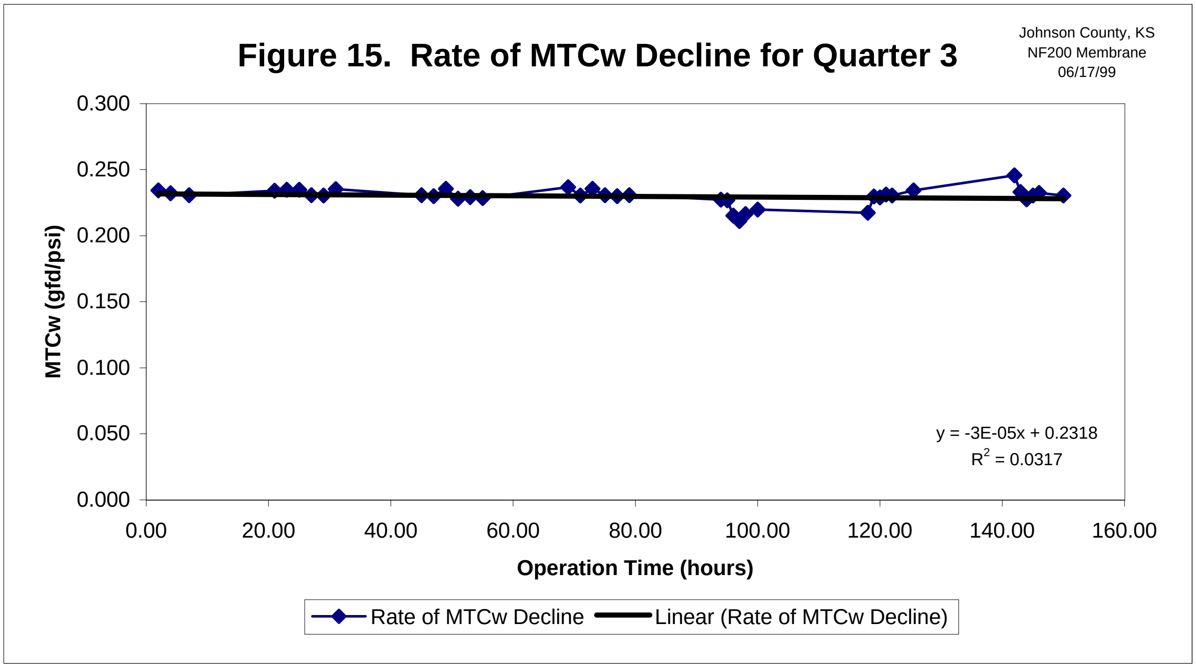


Figure 15. Rate of MTCw Decline for Quarter 3
Johnson County, KS
NF200 Membrane
06/17/99
MTCw (gfd/psi)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
y = -3E-05x + 0.2318
R2 = 0.0317
Rate of MTCw Decline
Linear (Rate of MTCw Decline)

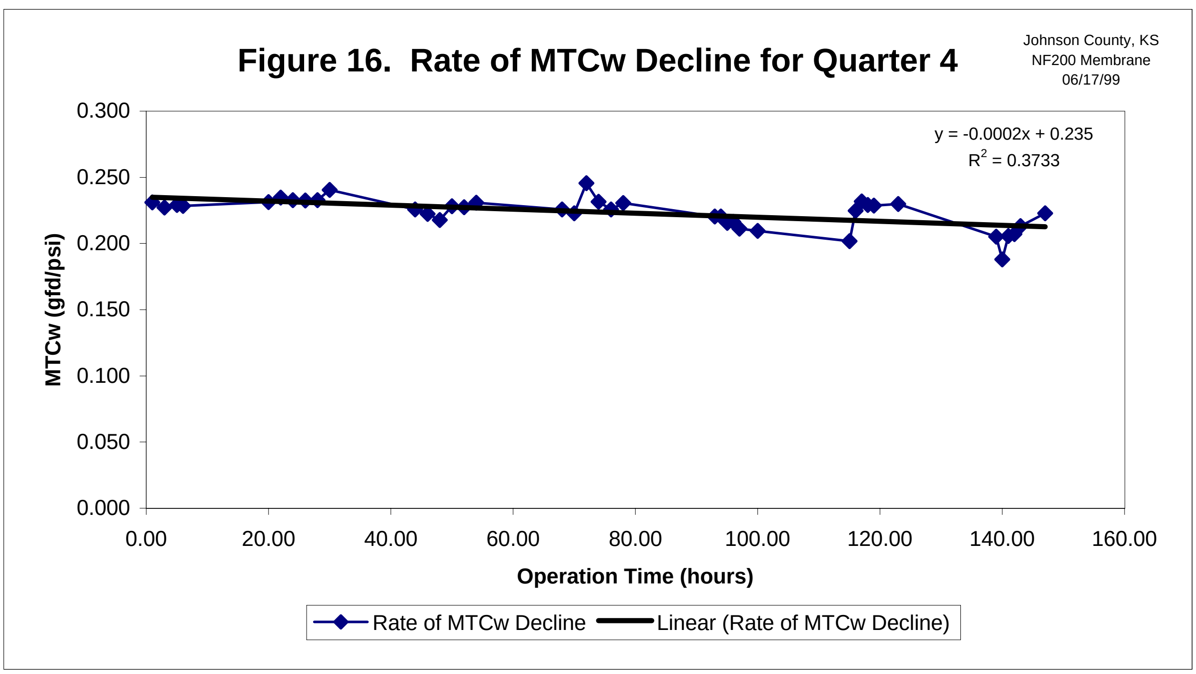


Figure 16. Rate of MTCw Decline for Quarter 4
Johnson County, KS
NF200 Membrane
06/17/99
MTCw (gfd/psi)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
y = -0.0002x + 0.235
R2 = 0.3733
Rate of MTCw Decline
Linear (Rate of MTCw Decline)

Figure 17. Pressure - Quarter 1

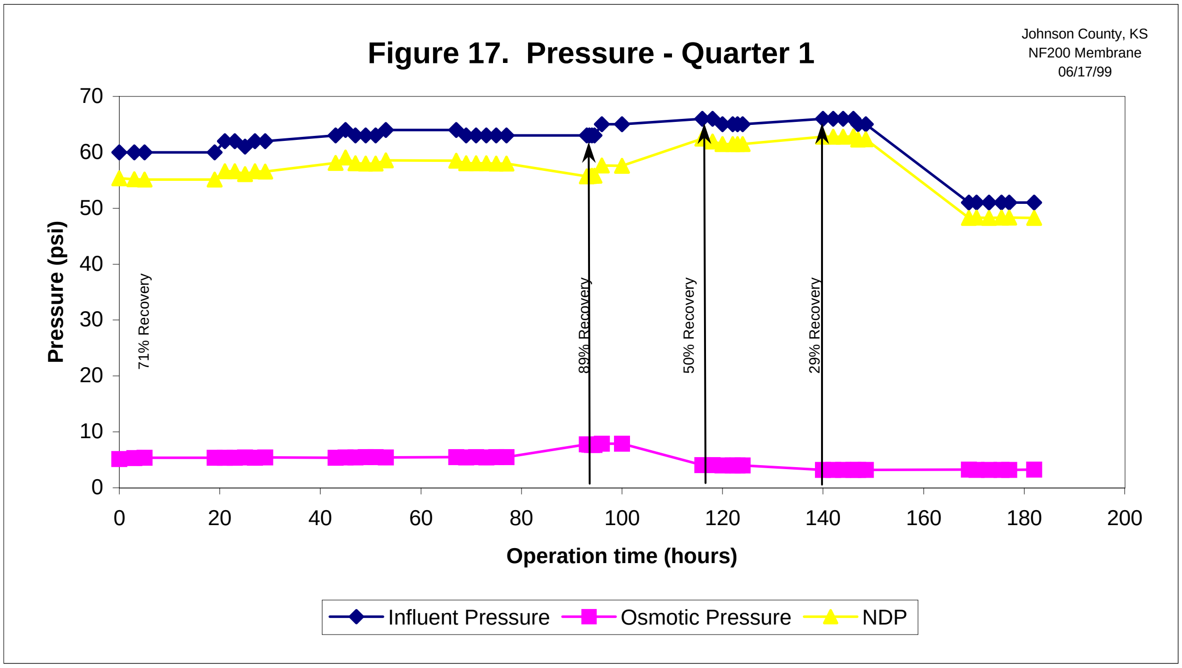
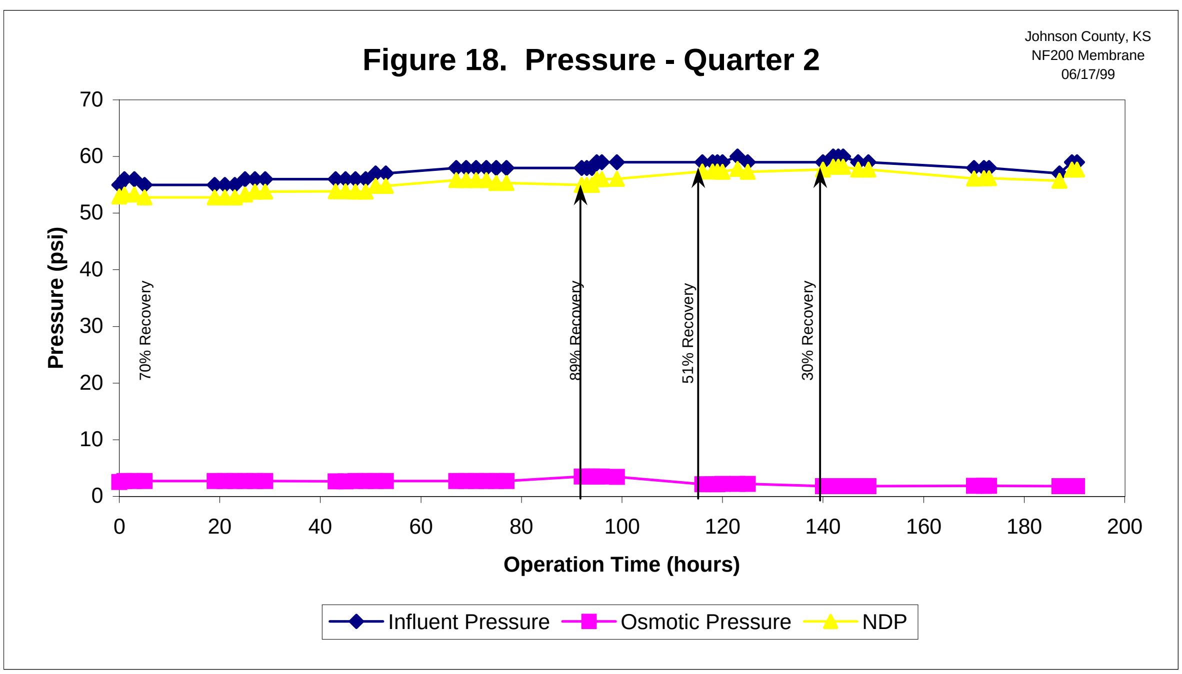


Figure 18. Pressure - Quarter 2



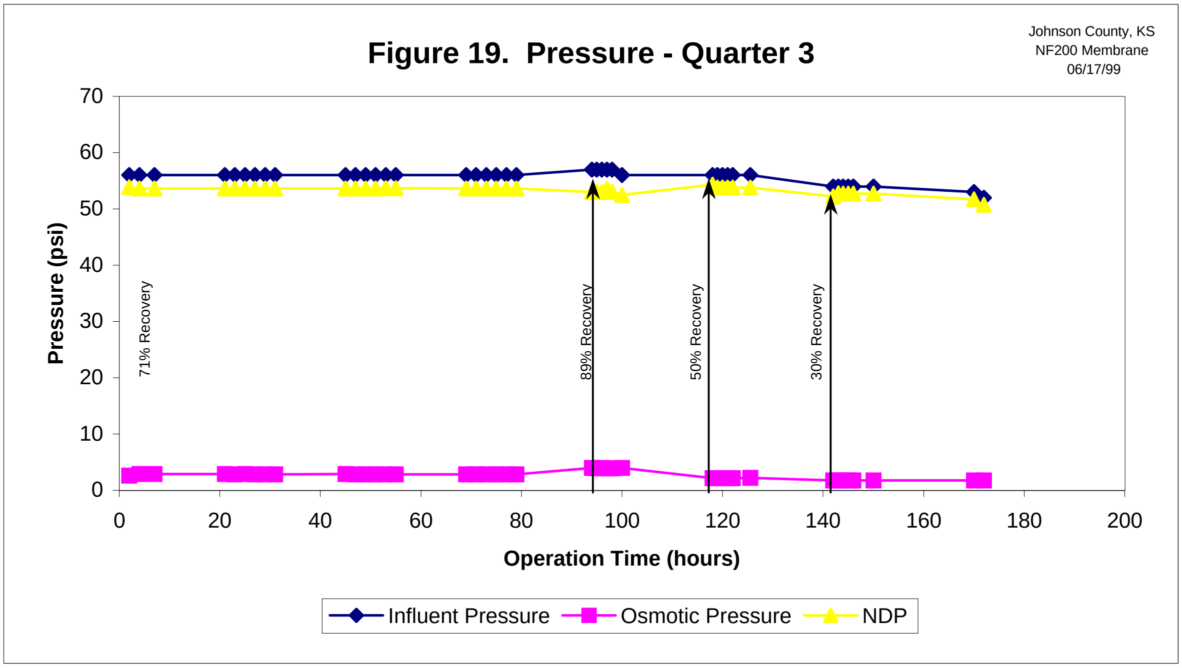


Figure 19. Pressure - Quarter 3
Johnson County, KS
NF200 Membrane
06/17/99
Pressure (psi)
Operation Time (hours)
71% Recovery
89% Recovery
50% Recovery
30% Recovery
Influent Pressure
Osmotic Pressure
NDP

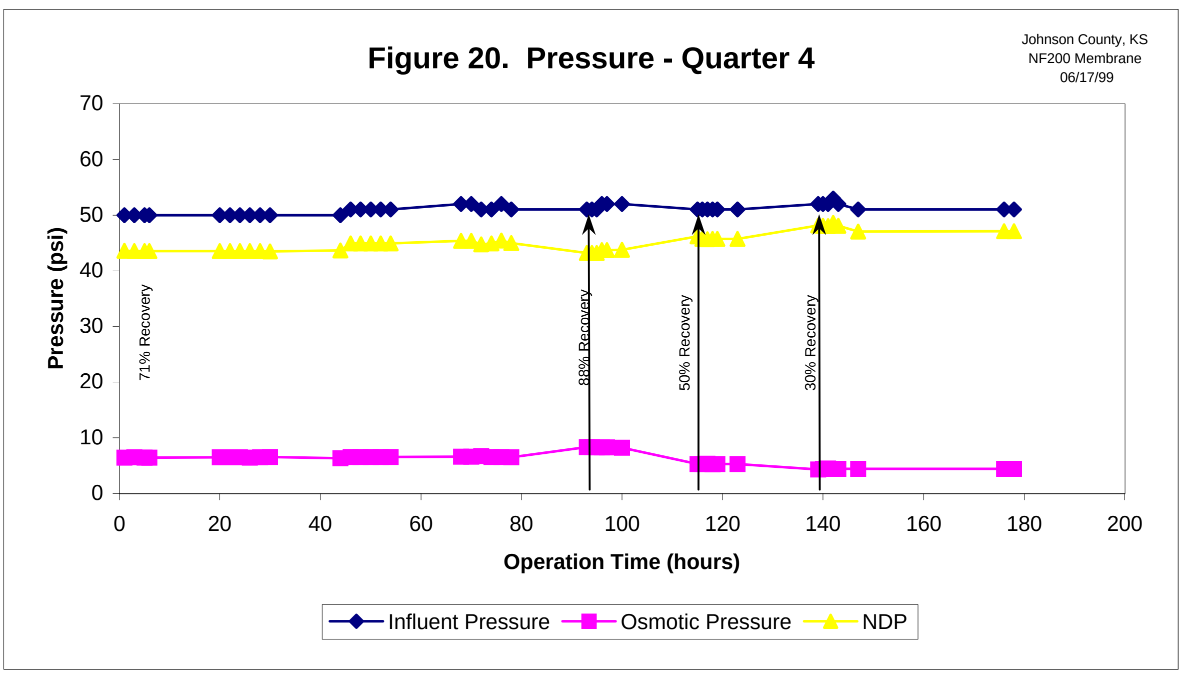


Figure 20. Pressure - Quarter 4
Johnson County, KS
NF200 Membrane
06/17/99
Pressure (psi)
Operation Time (hours)
71% Recovery
88% Recovery
50% Recovery
30% Recovery
Influent Pressure
Osmotic Pressure
NDP

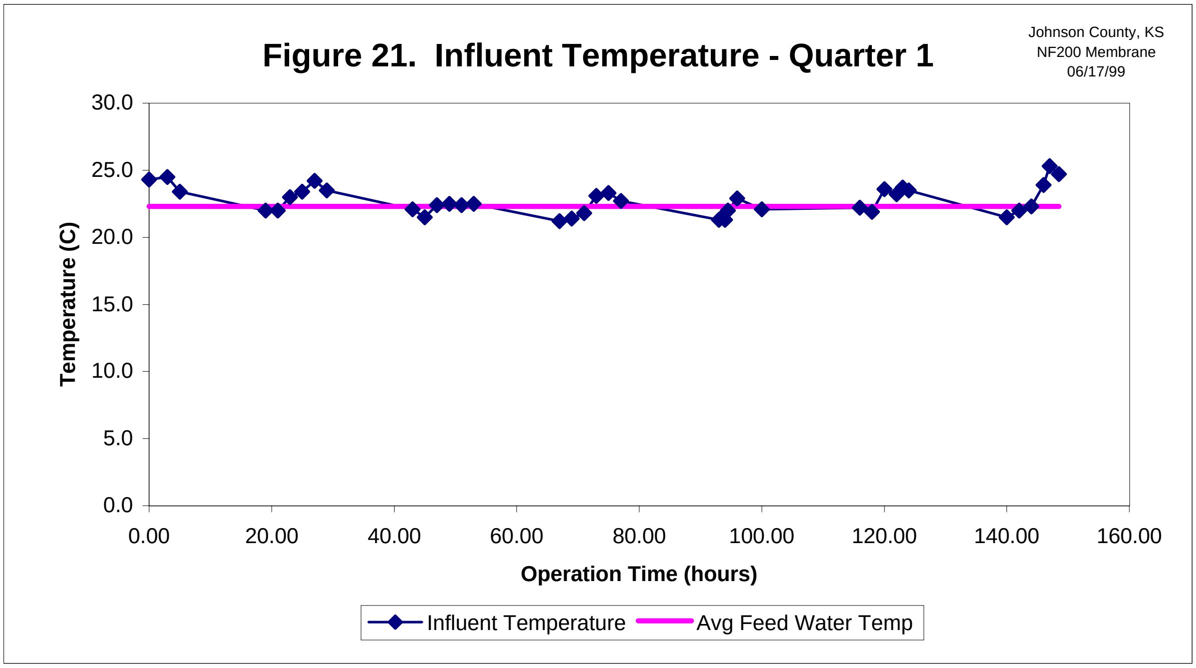


Figure 21. Influent Temperature - Quarter 1
Johnson County, KS
NF200 Membrane
06/17/99
Temperature (C)
Operation Time (hours)
Influent Temperature
Avg Feed Water Temp

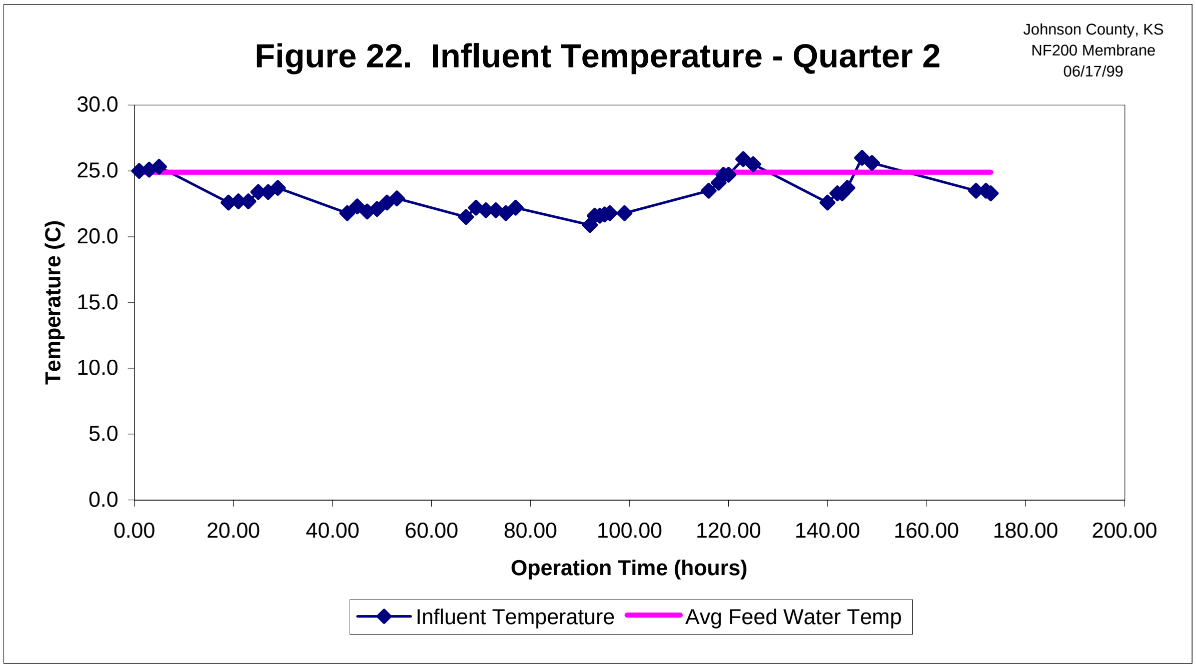


Figure 22. Influent Temperature - Quarter 2
Johnson County, KS
NF200 Membrane
06/17/99
Temperature (C)
Operation Time (hours)
Influent Temperature
Avg Feed Water Temp

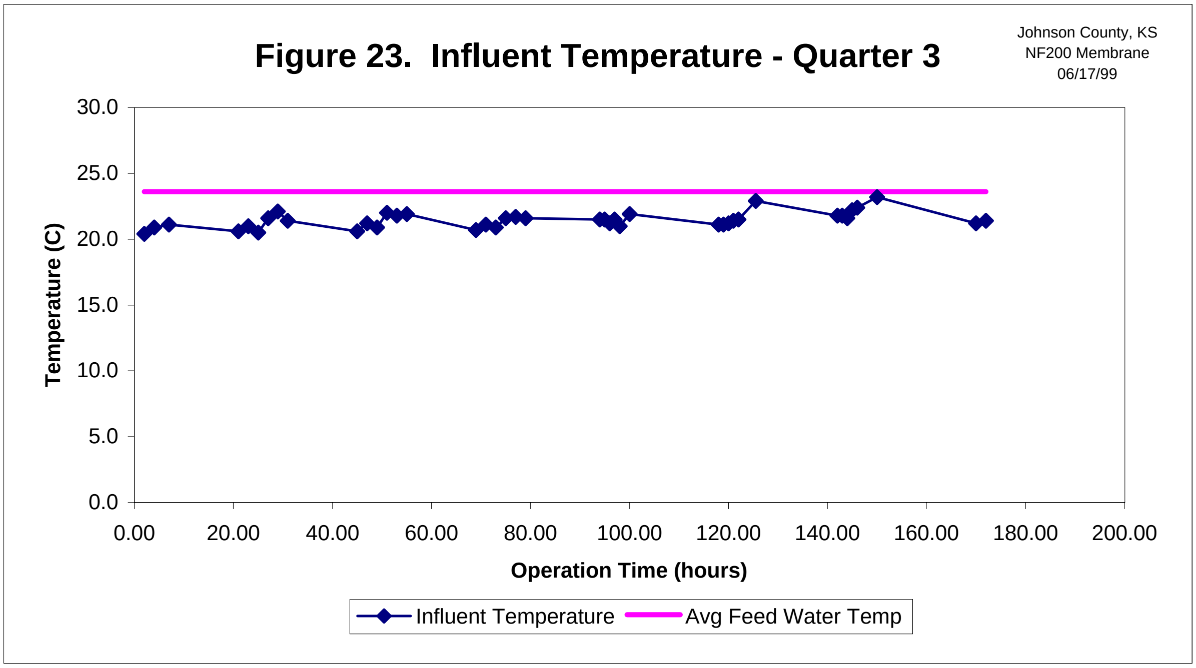


Figure 23. Influent Temperature - Quarter 3
Johnson County, KS
NF200 Membrane
06/17/99
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (C)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
Influent Temperature
Avg Feed Water Temp

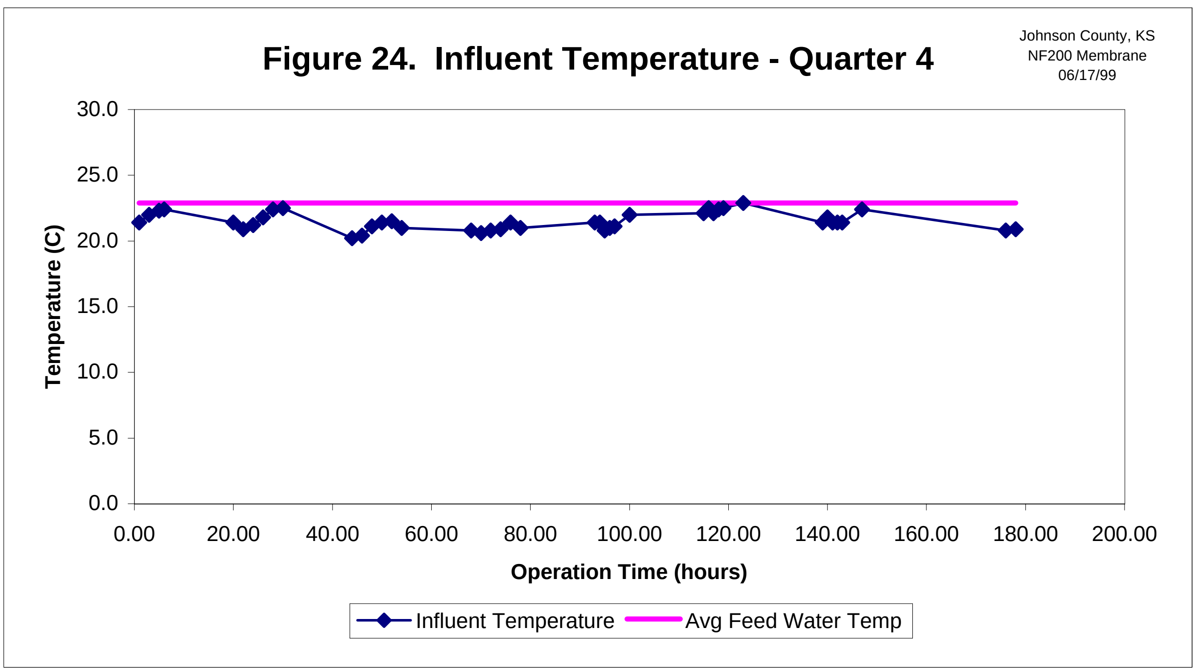


Figure 24. Influent Temperature - Quarter 4
Johnson County, KS
NF200 Membrane
06/17/99
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (C)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
Influent Temperature
Avg Feed Water Temp

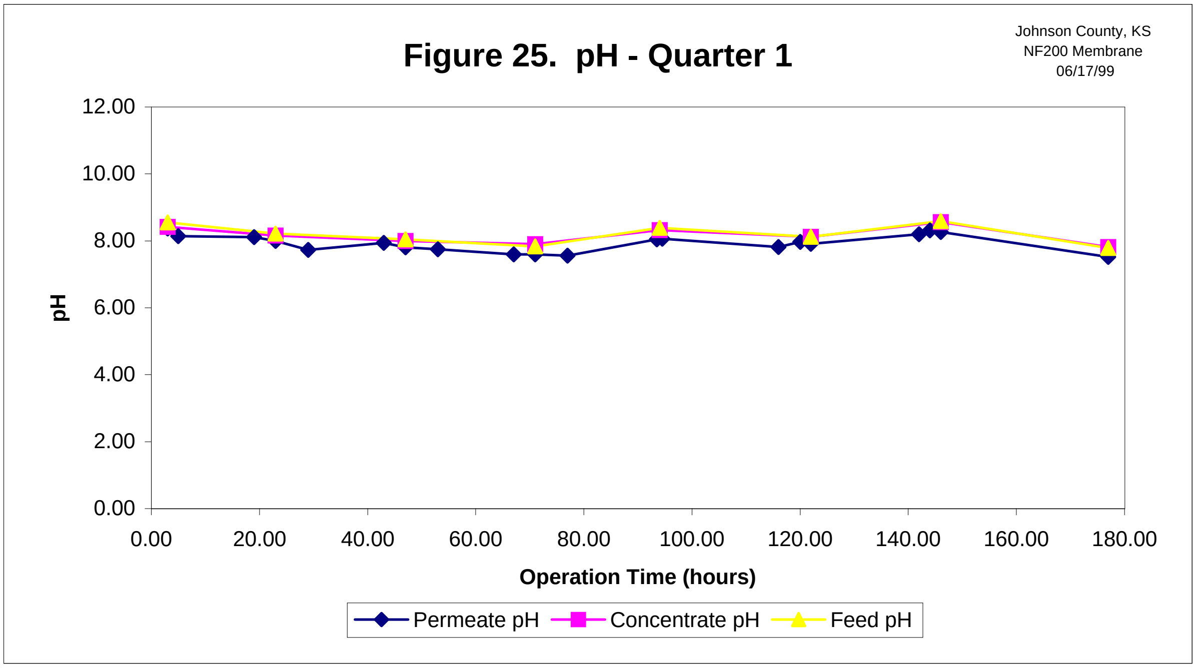


Figure 25. pH - Quarter 1
Johnson County, KS
NF200 Membrane
06/17/99
12.00
10.00
8.00
6.00
4.00
2.00
0.00
pH
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
Operation Time (hours)
Permeate pH
Concentrate pH
Feed pH

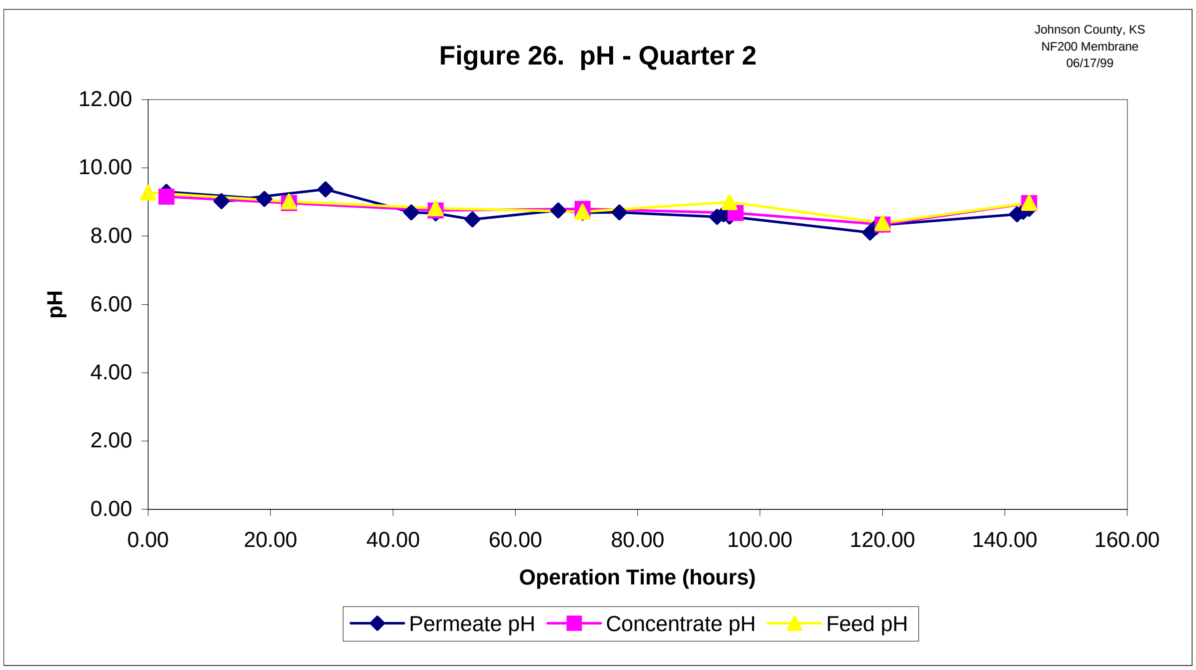


Figure 26. pH - Quarter 2
Johnson County, KS
NF200 Membrane
06/17/99
12.00
10.00
8.00
6.00
4.00
2.00
0.00
pH
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
Permeate pH
Concentrate pH
Feed pH

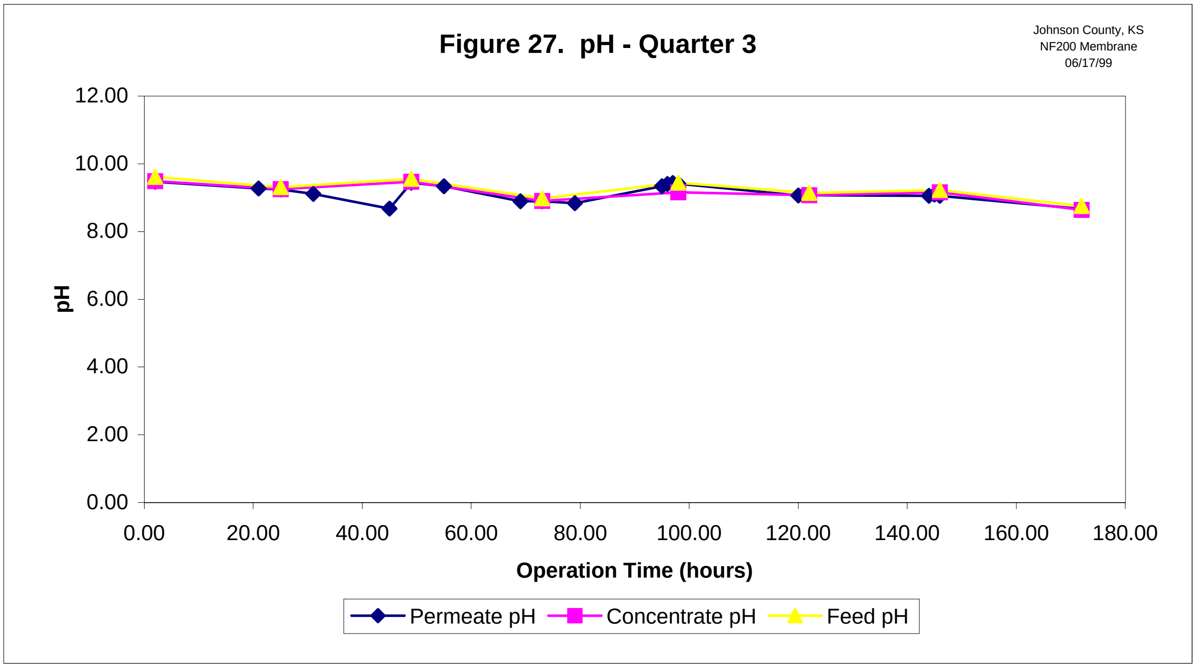


Figure 27. pH - Quarter 3
Johnson County, KS
NF200 Membrane
06/17/99
pH
Operation Time (hours)
Permeate pH
Concentrate pH
Feed pH

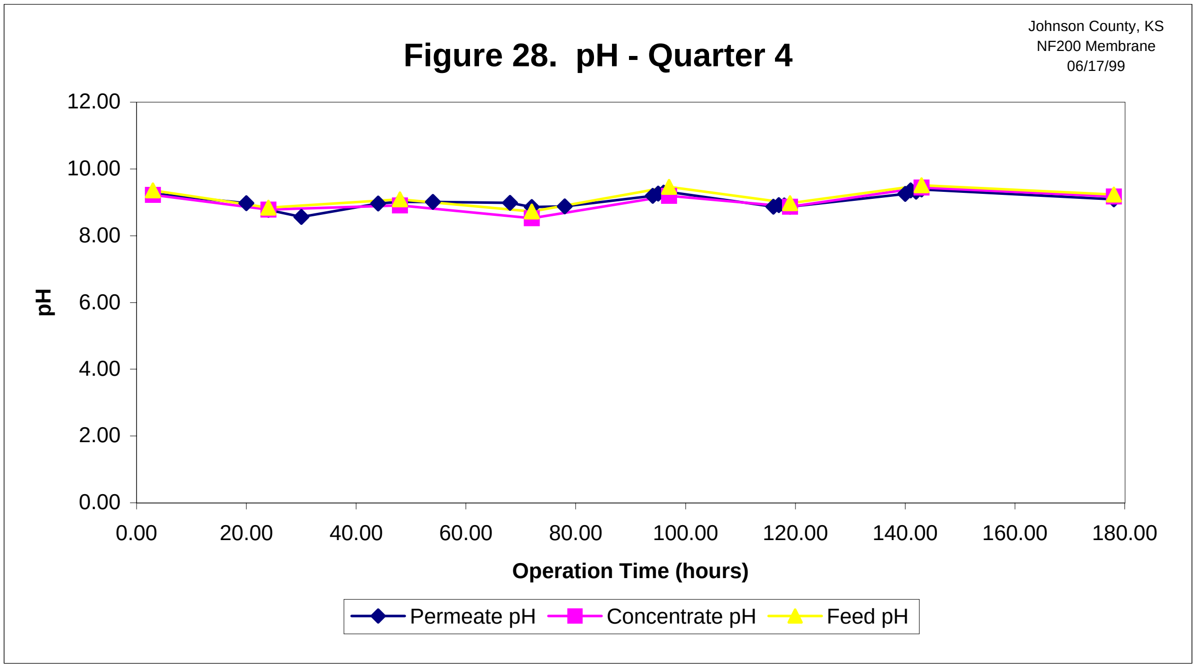


Figure 28. pH - Quarter 4
Johnson County, KS
NF200 Membrane
06/17/99
pH
Operation Time (hours)
Permeate pH
Concentrate pH
Feed pH

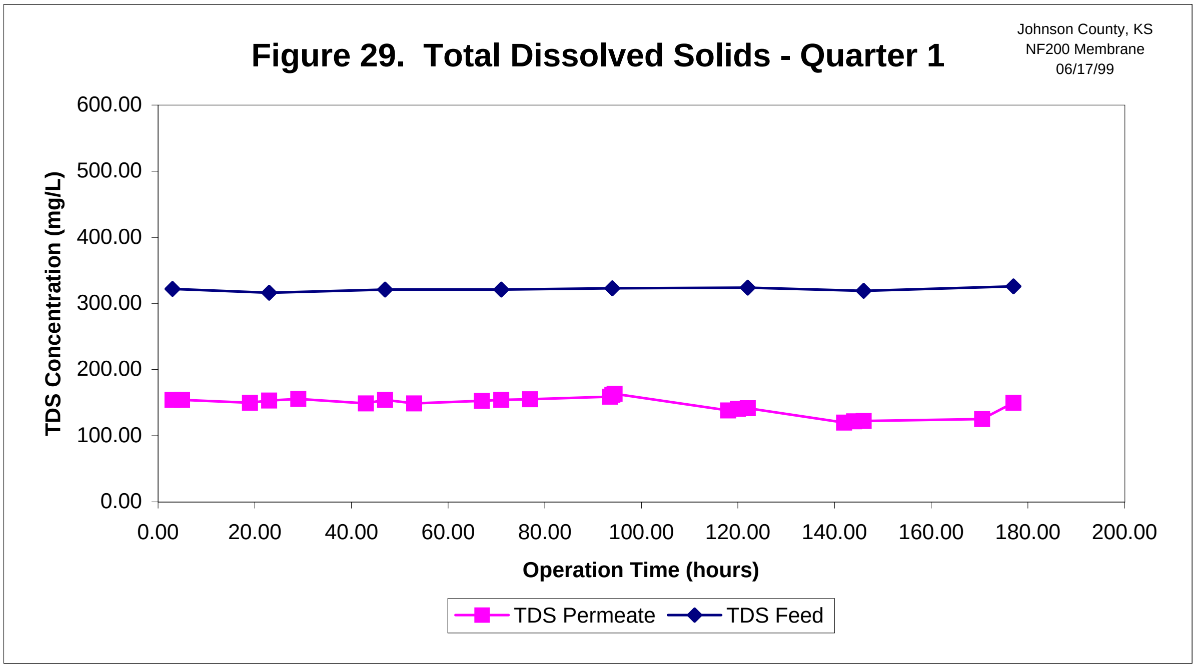


Figure 29. Total Dissolved Solids - Quarter 1
Johnson County, KS
NF200 Membrane
06/17/99
TDS Concentration (mg/L)
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
TDS Permeate
TDS Feed

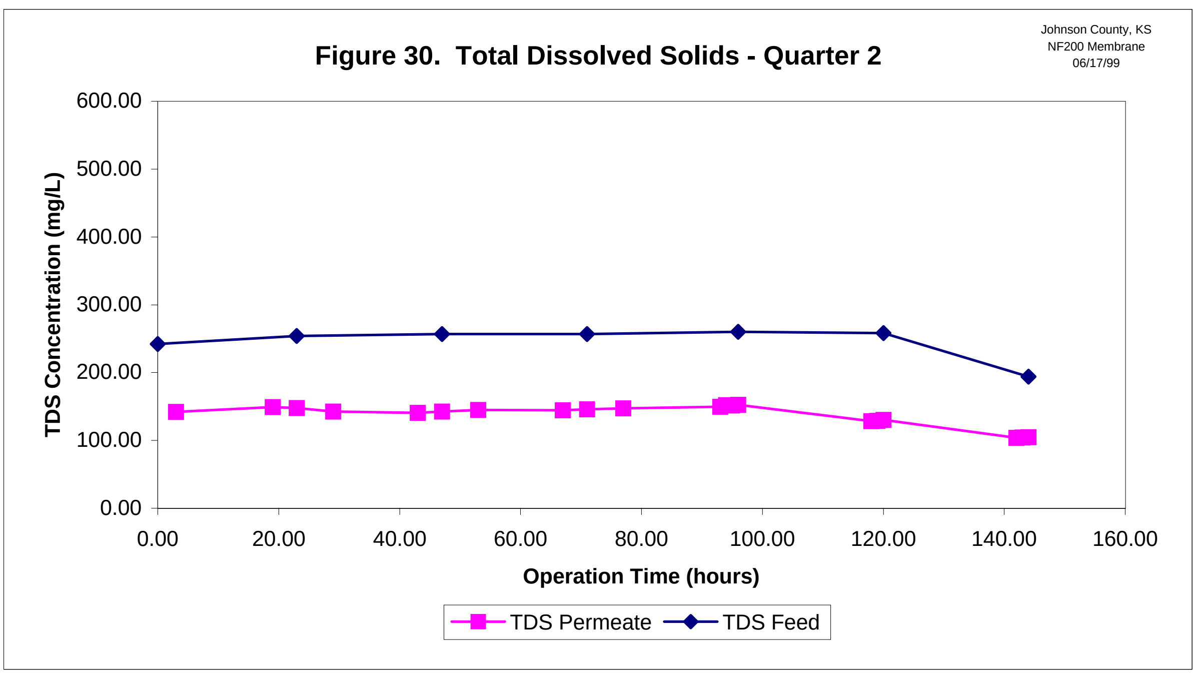


Figure 30. Total Dissolved Solids - Quarter 2
Johnson County, KS
NF200 Membrane
06/17/99
TDS Concentration (mg/L)
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
TDS Permeate
TDS Feed

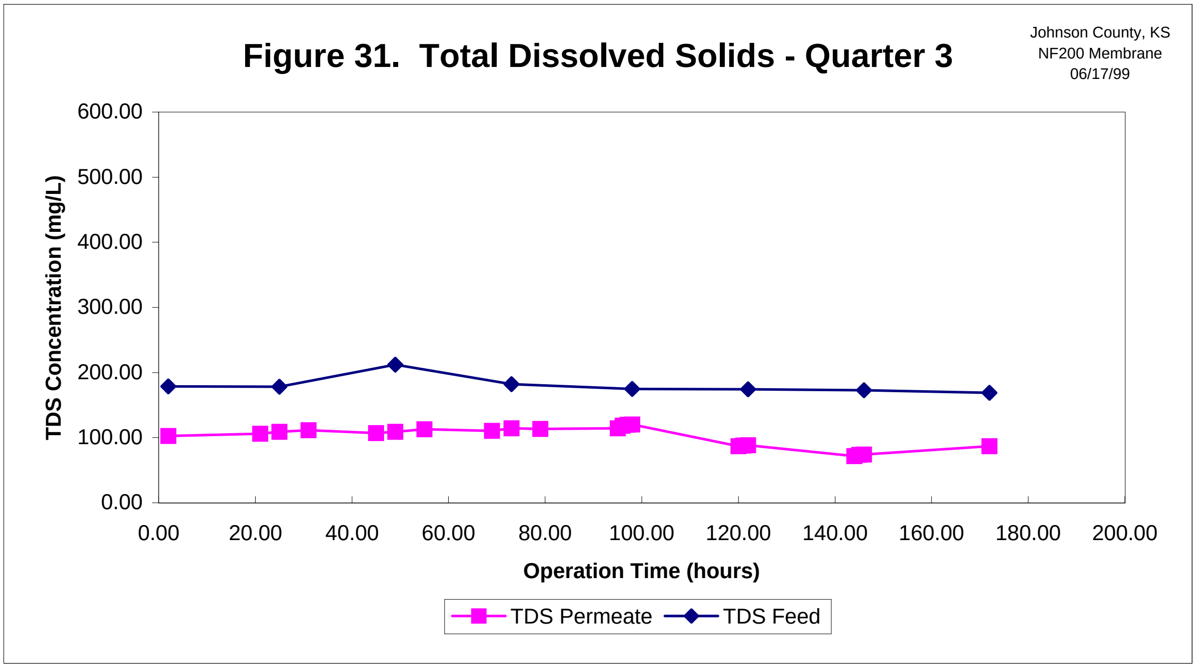


Figure 31. Total Dissolved Solids - Quarter 3
Johnson County, KS
NF200 Membrane
06/17/99
TDS Concentration (mg/L)
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
TDS Permeate
TDS Feed

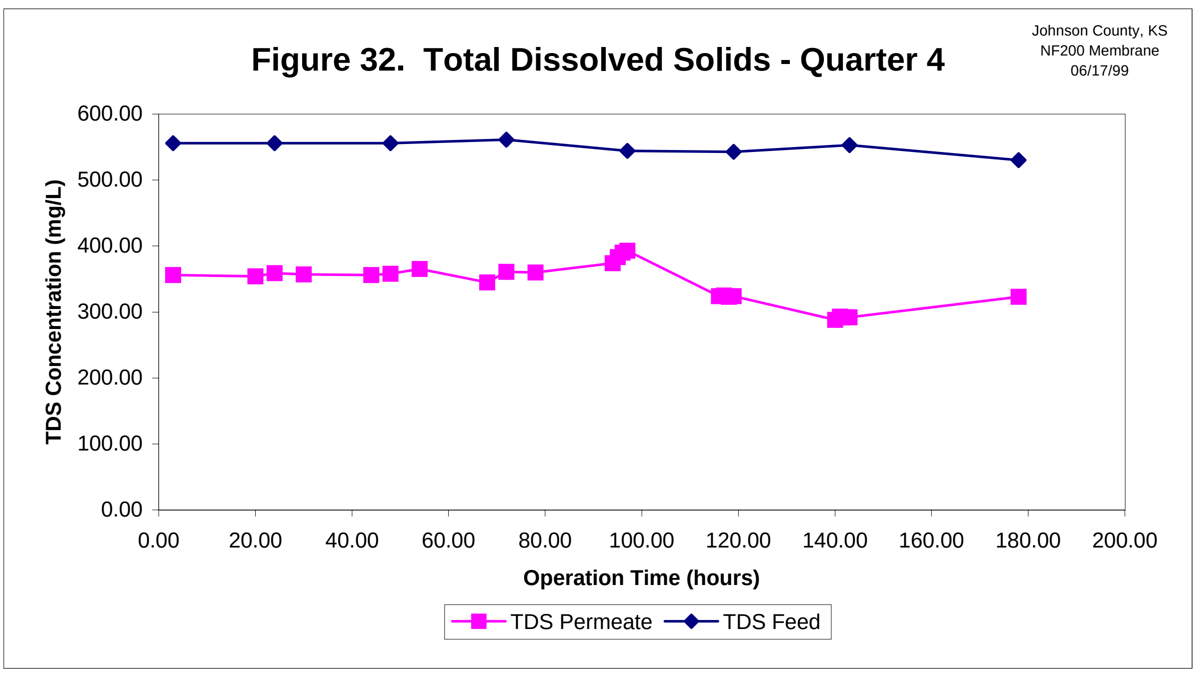


Figure 32. Total Dissolved Solids - Quarter 4
Johnson County, KS
NF200 Membrane
06/17/99
TDS Concentration (mg/L)
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
TDS Permeate
TDS Feed

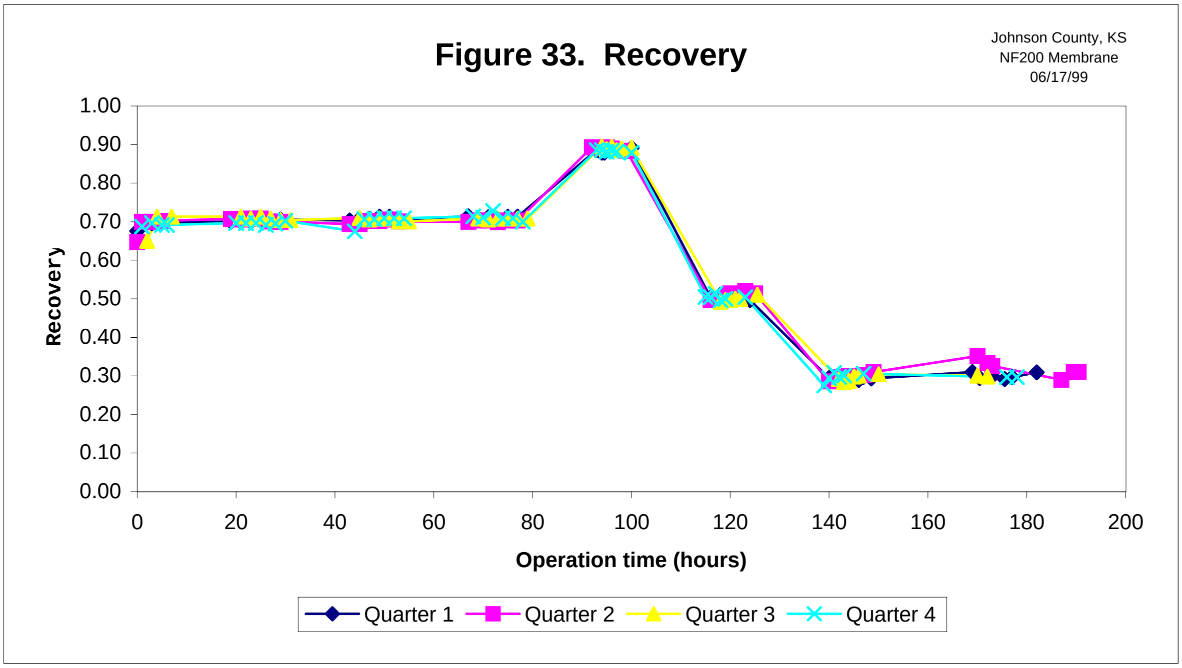
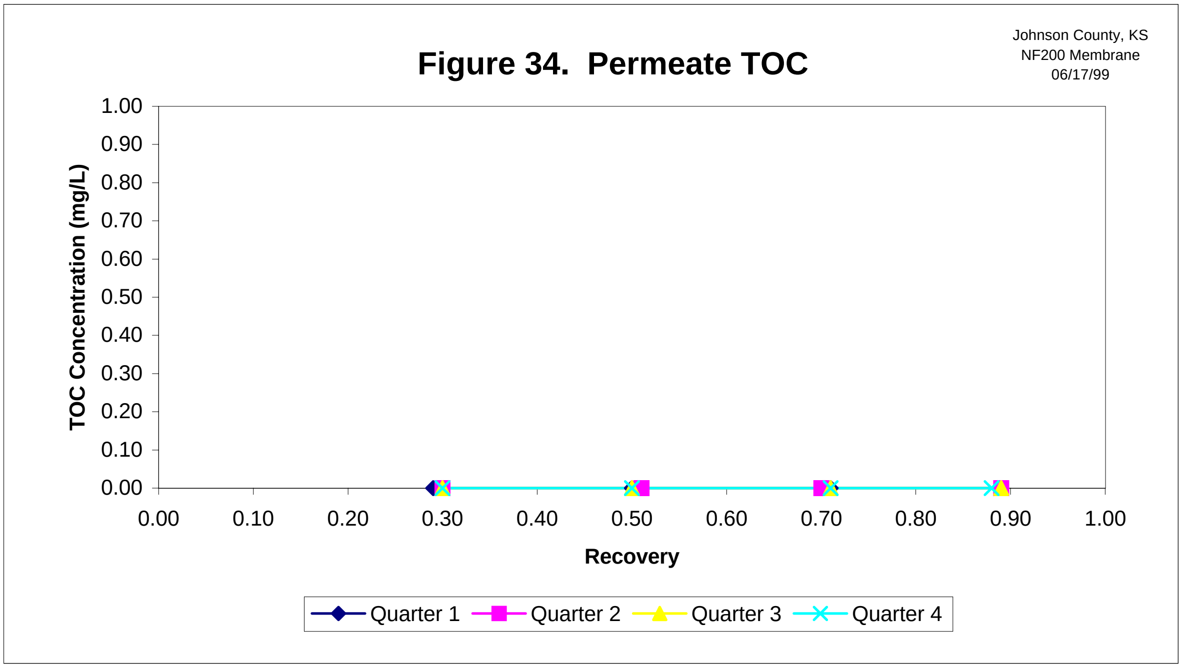
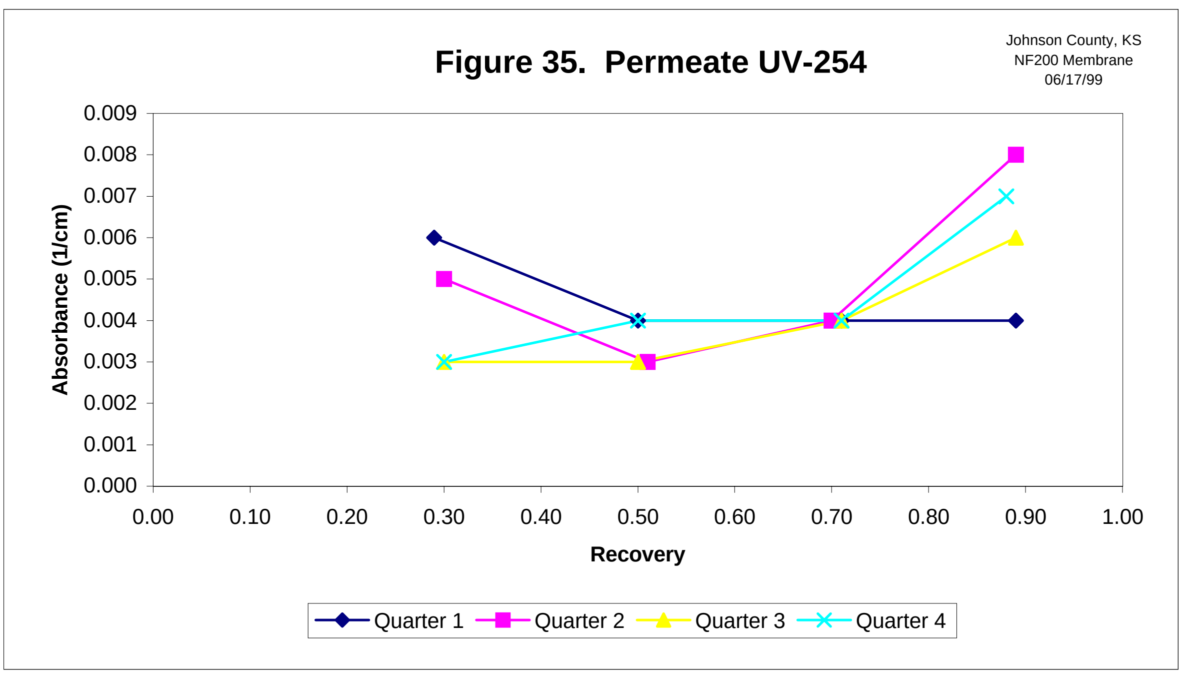


Figure 33. Recovery
Johnson County, KS
NF200 Membrane
06/17/99
Recovery
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
20
40
60
80
100
120
140
160
180
200
Operation time (hours)
Quarter 1
Quarter 2
Quarter 3
Quarter 4


Johnson County, KS
NF200 Membrane
06/17/99
Figure 34. Permeate TOC
TOC Concentration (mg/L)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
Quarter 1
Quarter 2
Quarter 3
Quarter 4


Johnson County, KS
NF200 Membrane
06/17/99
Figure 35. Permeate UV-254
Absorbance (1/cm)
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
Quarter 1
Quarter 2
Quarter 3
Quarter 4

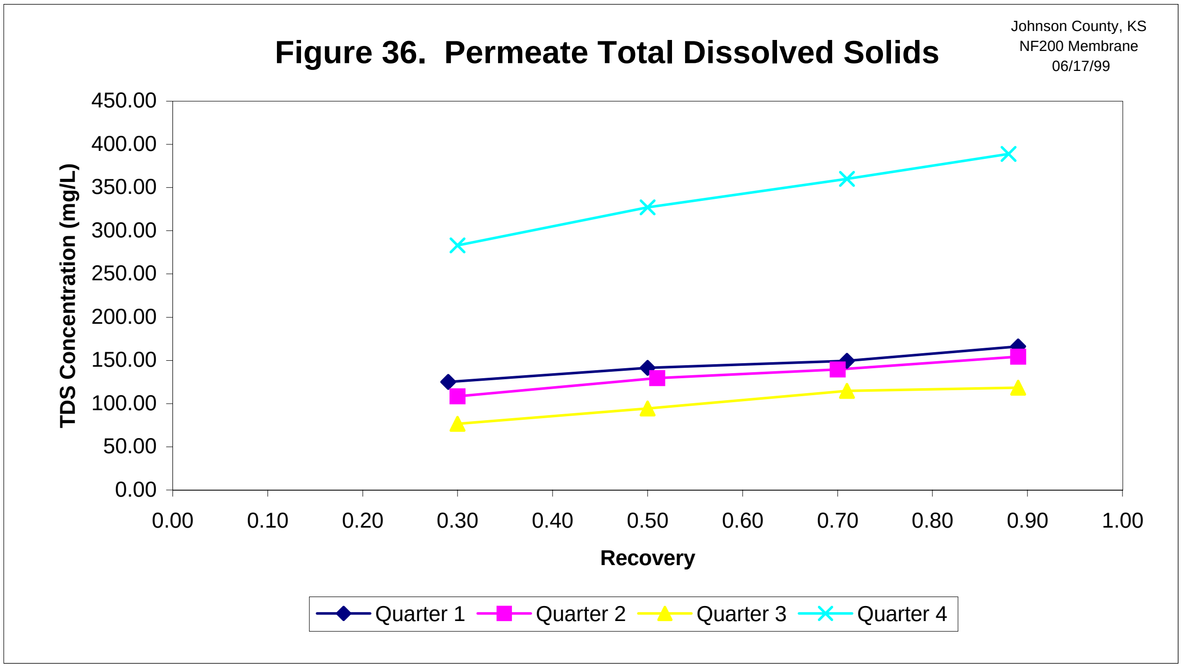


Figure 36. Permeate Total Dissolved Solids
Johnson County, KS
NF200 Membrane
06/17/99
TDS Concentration (mg/L)
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
Quarter 1
Quarter 2
Quarter 3
Quarter 4

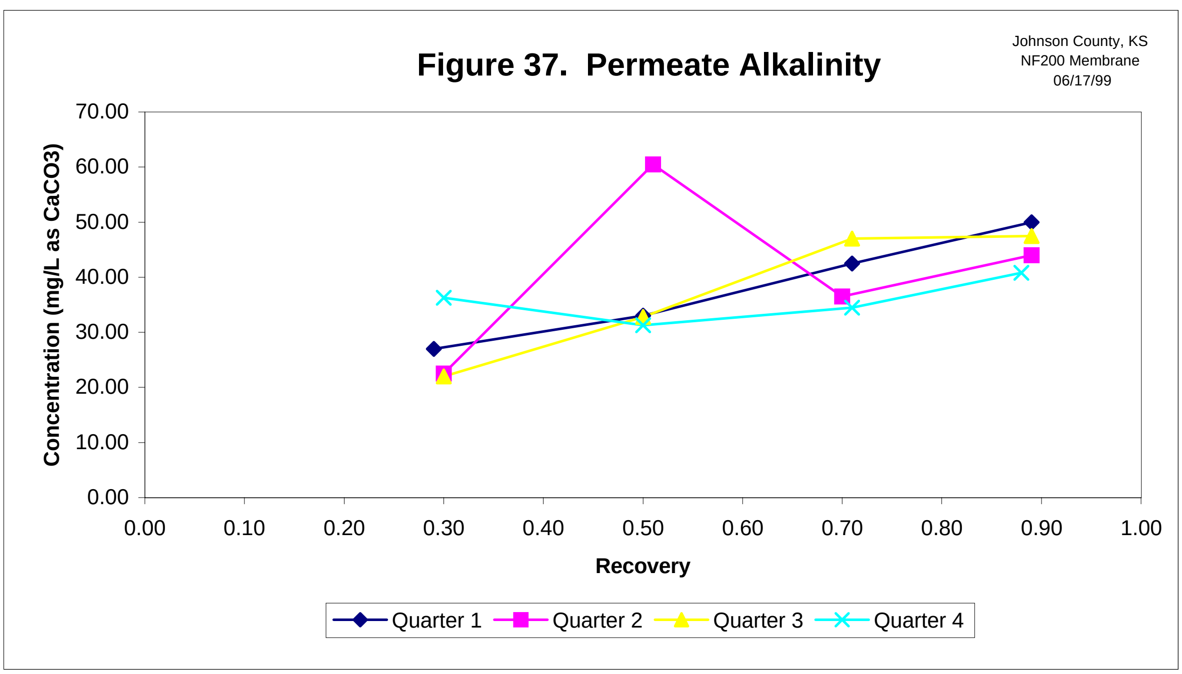


Figure 37. Permeate Alkalinity
Johnson County, KS
NF200 Membrane
06/17/99
Concentration (mg/L as CaCO3)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
Quarter 1
Quarter 2
Quarter 3
Quarter 4

Figure 38. Permeate Total Hardness

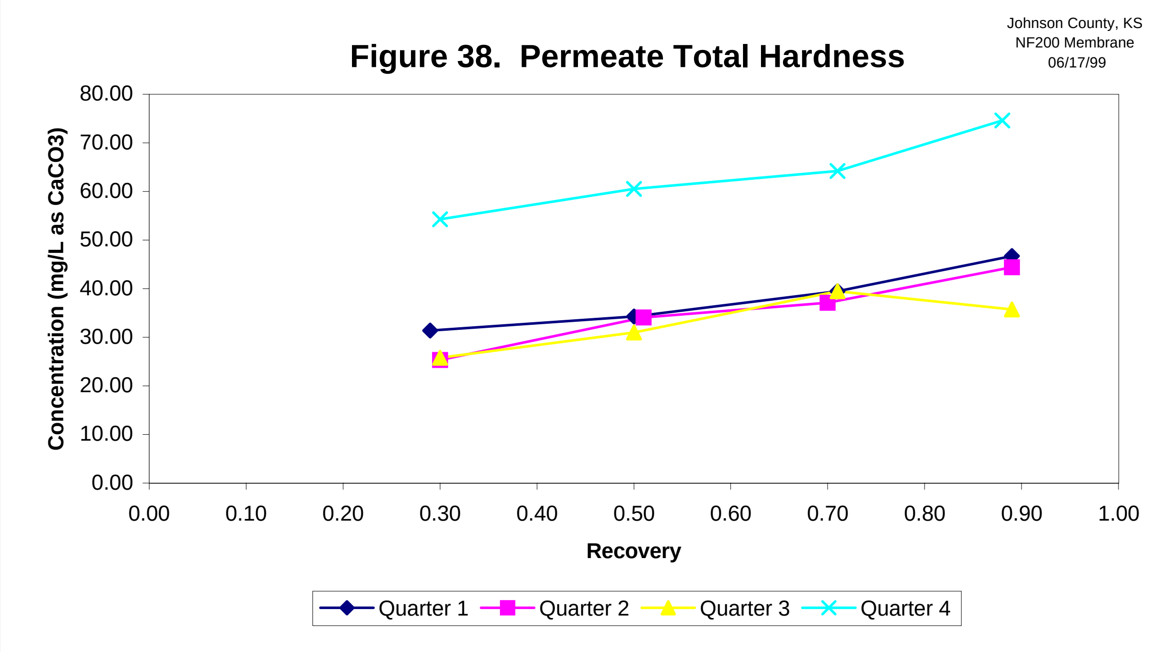
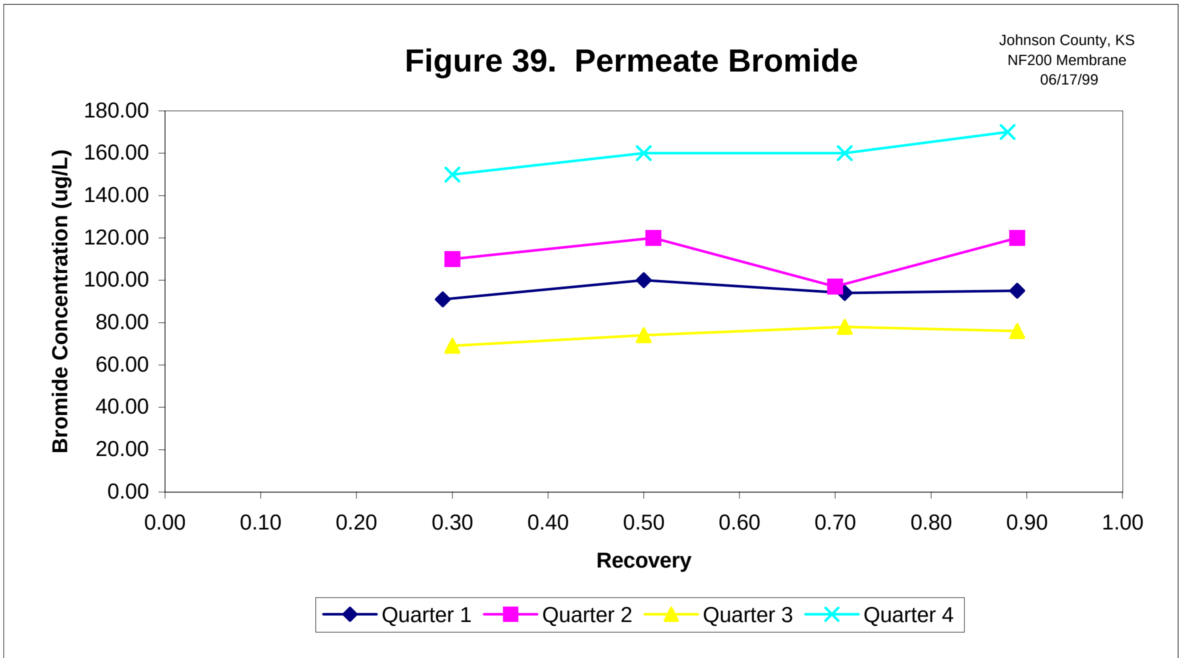


Figure 39. Permeate Bromide



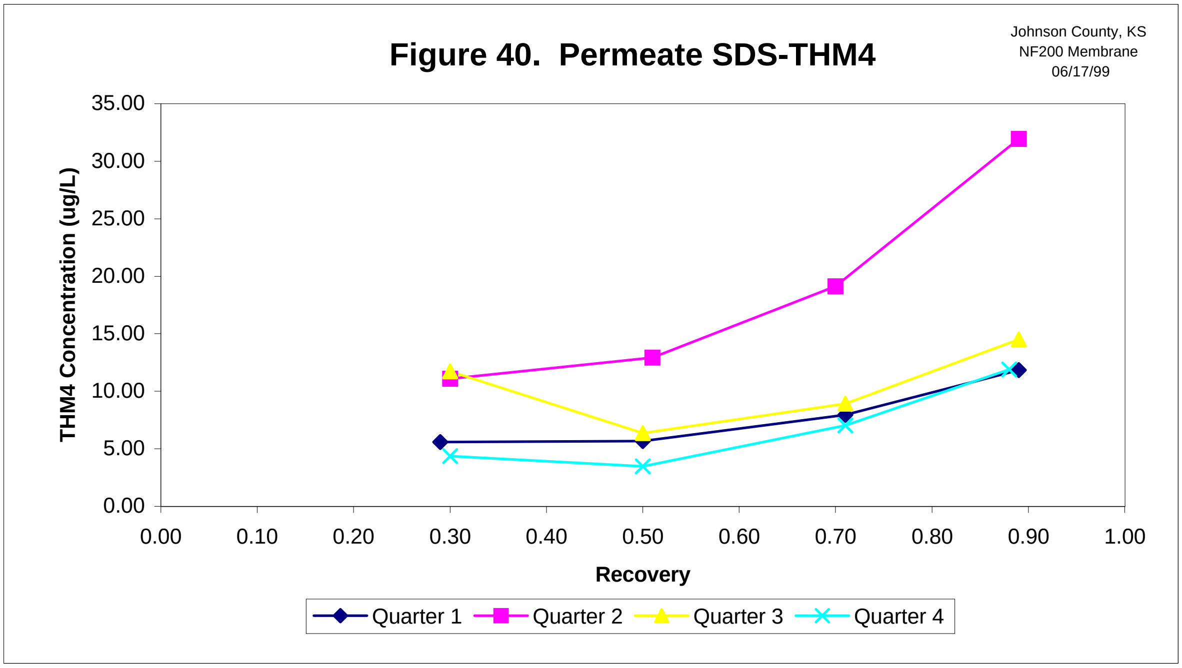


Figure 40. Permeate SDS-THM4
Johnson County, KS
NF200 Membrane
06/17/99
THM4 Concentration (ug/L)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
Quarter 1
Quarter 2
Quarter 3
Quarter 4

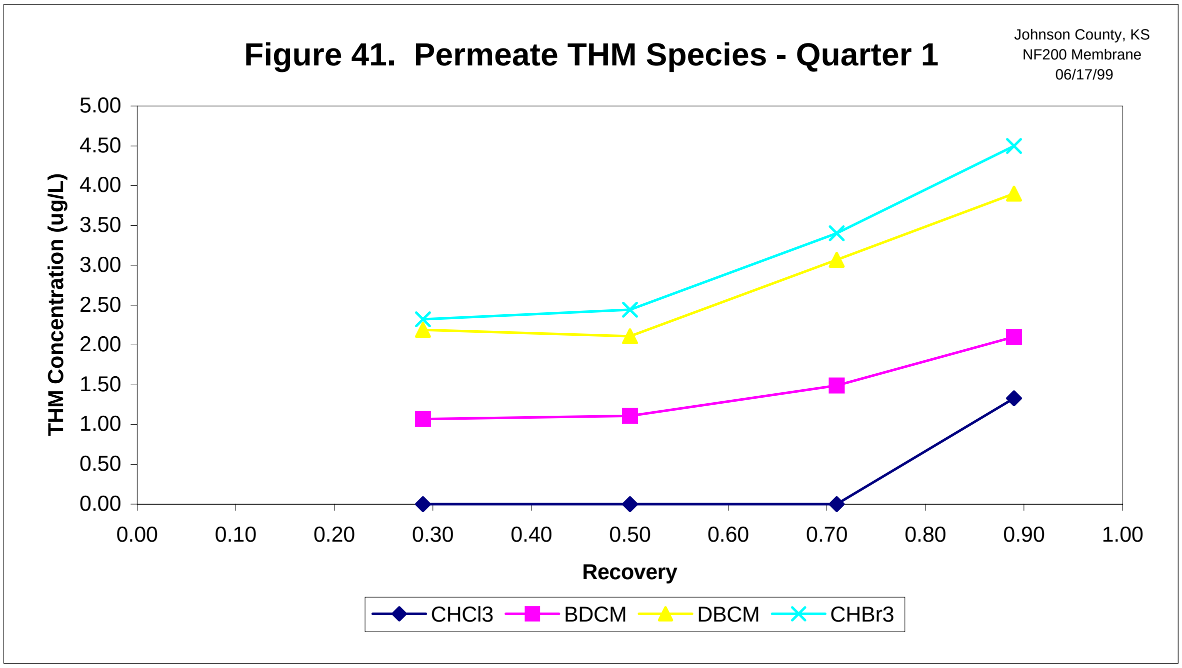


Figure 41. Permeate THM Species - Quarter 1
Johnson County, KS
NF200 Membrane
06/17/99
THM Concentration (ug/L)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
CHCl3
BDCM
DBCM
CHBr3

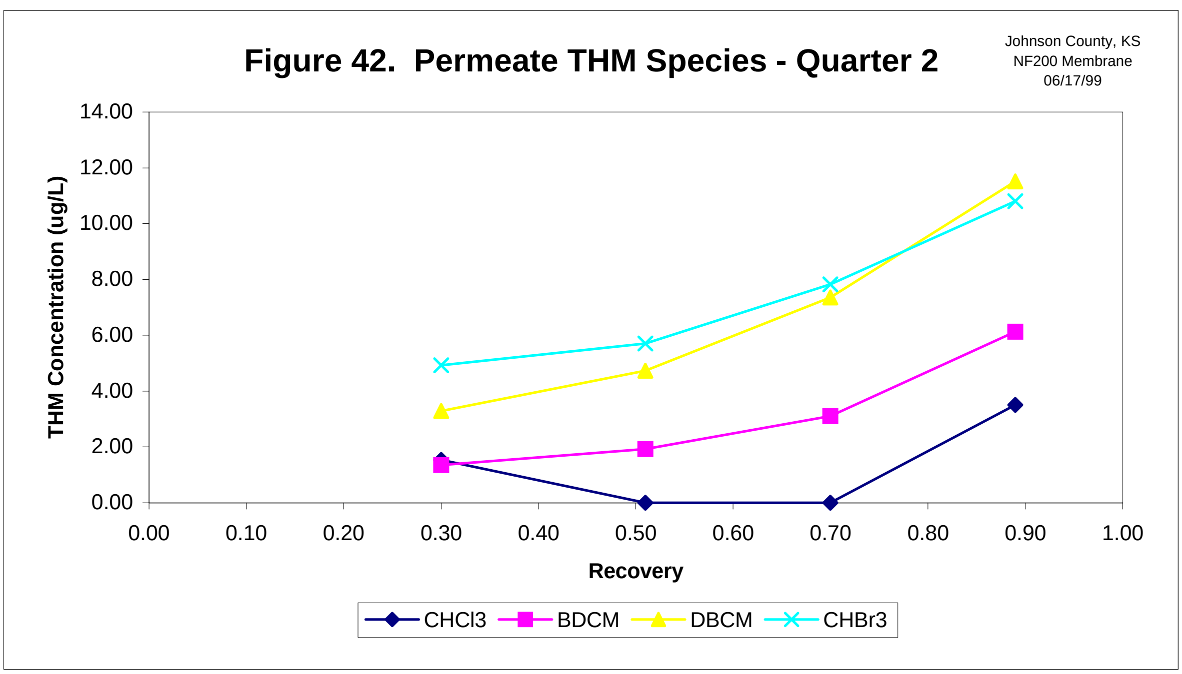
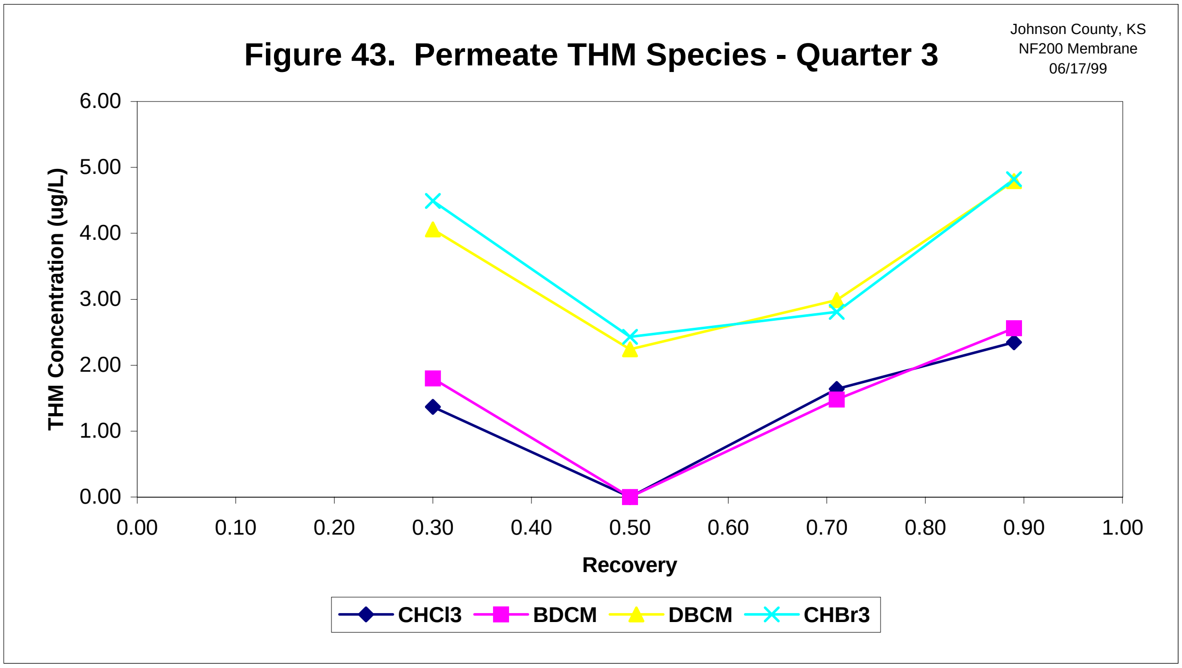
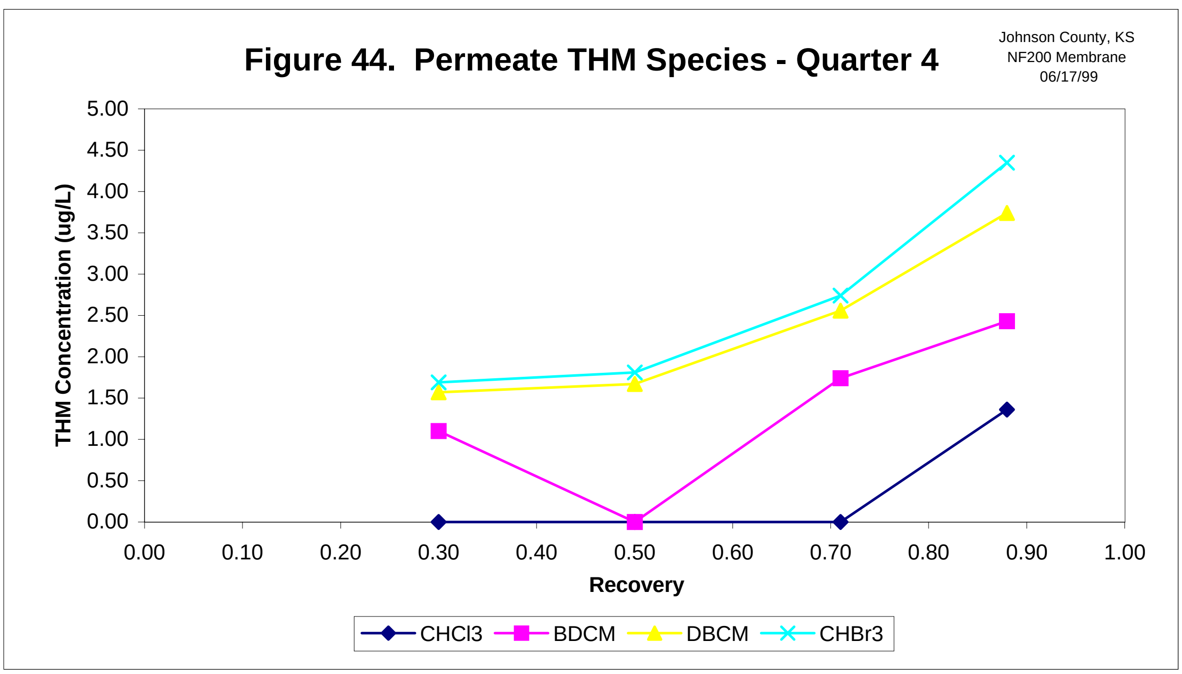
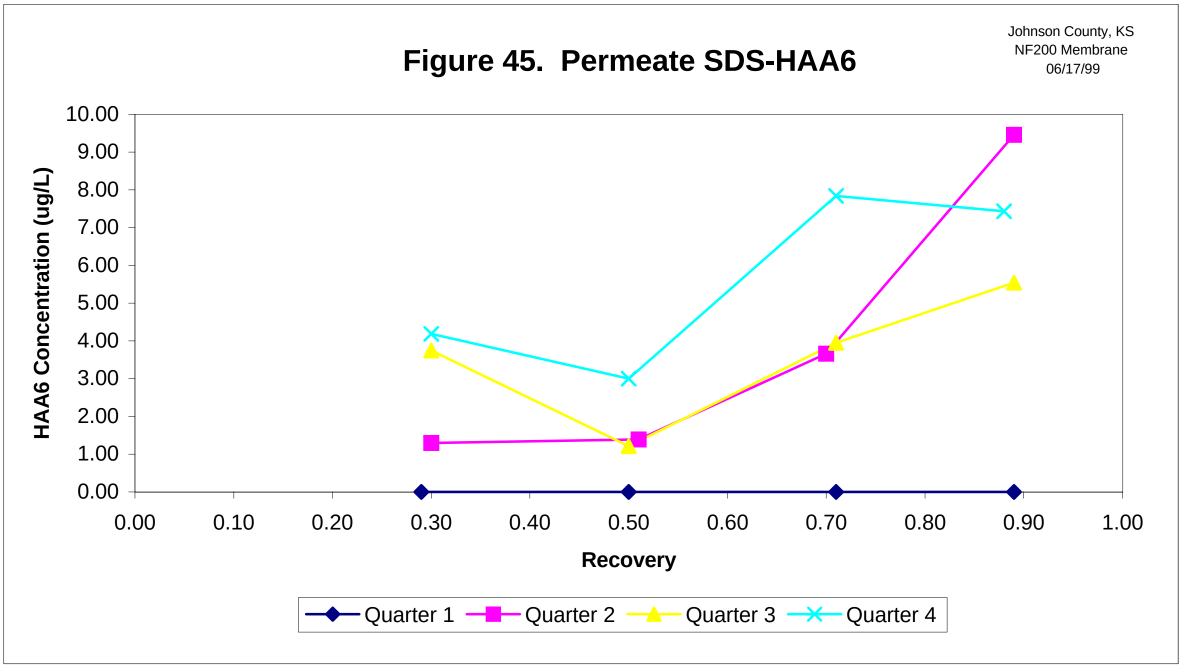


Figure 42. Permeate THM Species - Quarter 2
Johnson County, KS
NF200 Membrane
06/17/99
THM Concentration (ug/L)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
CHCl3
BDCM
DBCM
CHBr3


Johnson County, KS
NF200 Membrane
06/17/99
Figure 43. Permeate THM Species - Quarter 3
THM Concentration (ug/L)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
CHCl3
BDCM
DBCM
CHBr3


Johnson County, KS
NF200 Membrane
06/17/99
Figure 44. Permeate THM Species - Quarter 4
THM Concentration (ug/L)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
CHCl3
BDCM
DBCM
CHBr3


Johnson County, KS
NF200 Membrane
06/17/99
Figure 45. Permeate SDS-HAA6
HAA6 Concentration (ug/L)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
Quarter 1
Quarter 2
Quarter 3
Quarter 4

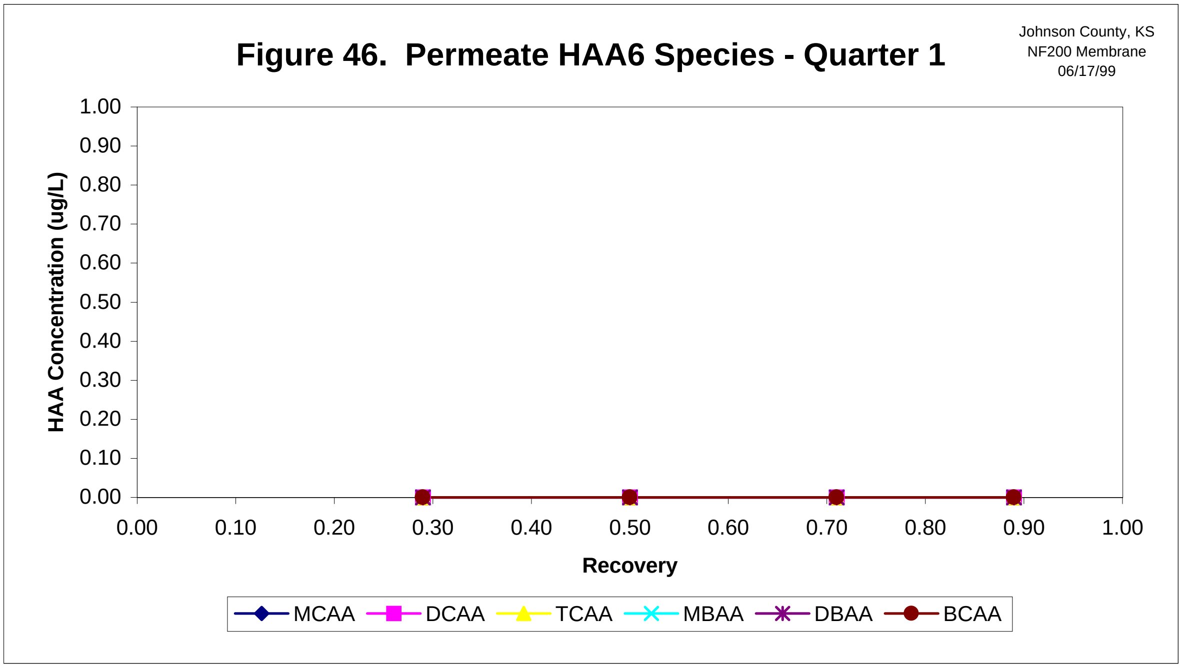
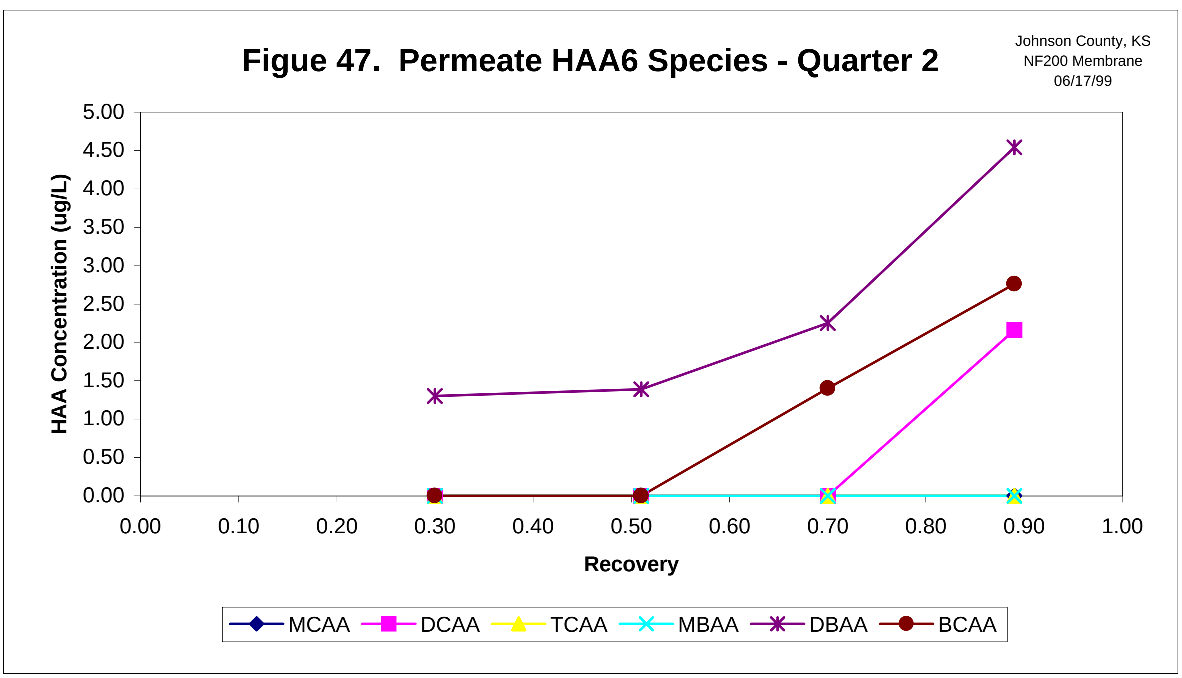


Figure 46. Permeate HAA6 Species - Quarter 1
Johnson County, KS
NF200 Membrane
06/17/99
HAA Concentration (ug/L)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA


Figue 47. Permeate HAA6 Species - Quarter 2
Johnson County, KS
NF200 Membrane
06/17/99
HAA Concentration (ug/L)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

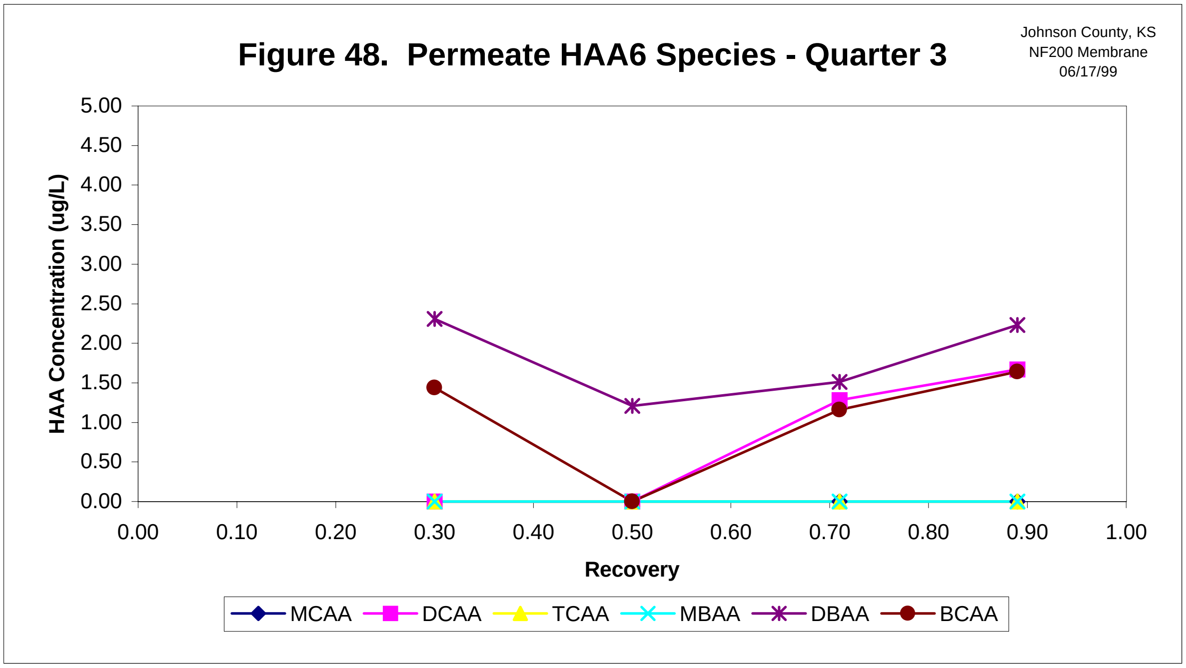


Figure 48. Permeate HAA6 Species - Quarter 3
Johnson County, KS
NF200 Membrane
06/17/99
HAA Concentration (ug/L)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

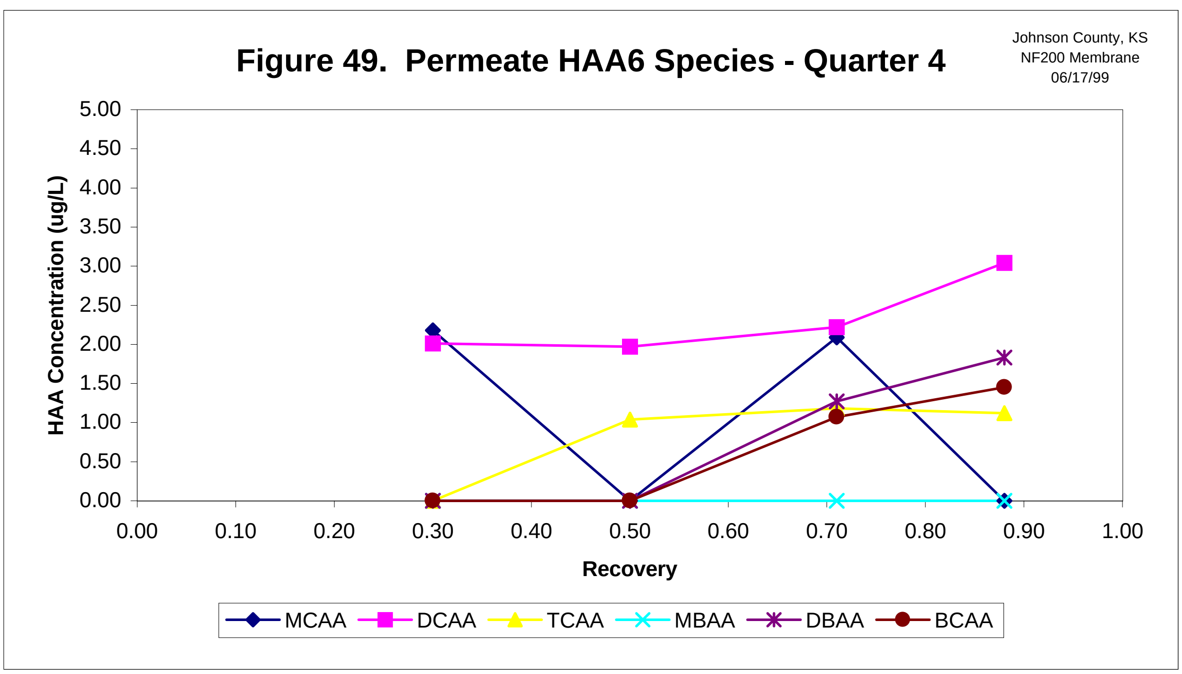


Figure 49. Permeate HAA6 Species - Quarter 4
Johnson County, KS
NF200 Membrane
06/17/99
HAA Concentration (ug/L)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

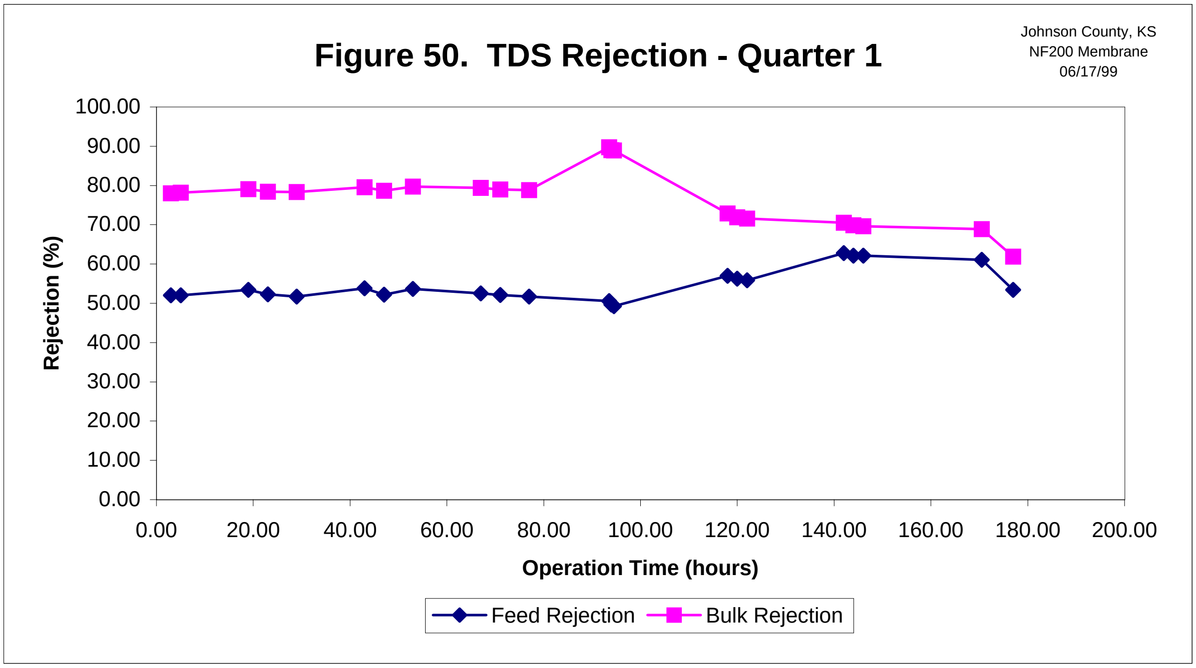


Figure 50. TDS Rejection - Quarter 1
Johnson County, KS
NF200 Membrane
06/17/99
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Rejection (%)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
Feed Rejection
Bulk Rejection

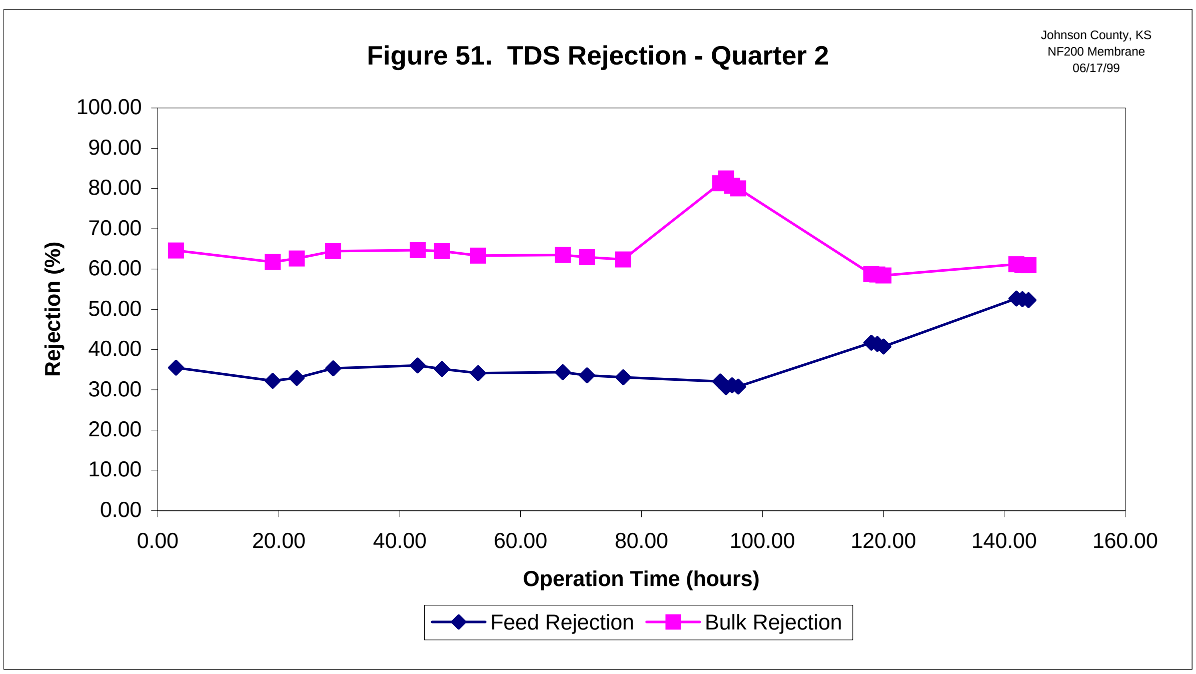


Figure 51. TDS Rejection - Quarter 2
Johnson County, KS
NF200 Membrane
06/17/99
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Rejection (%)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
Feed Rejection
Bulk Rejection

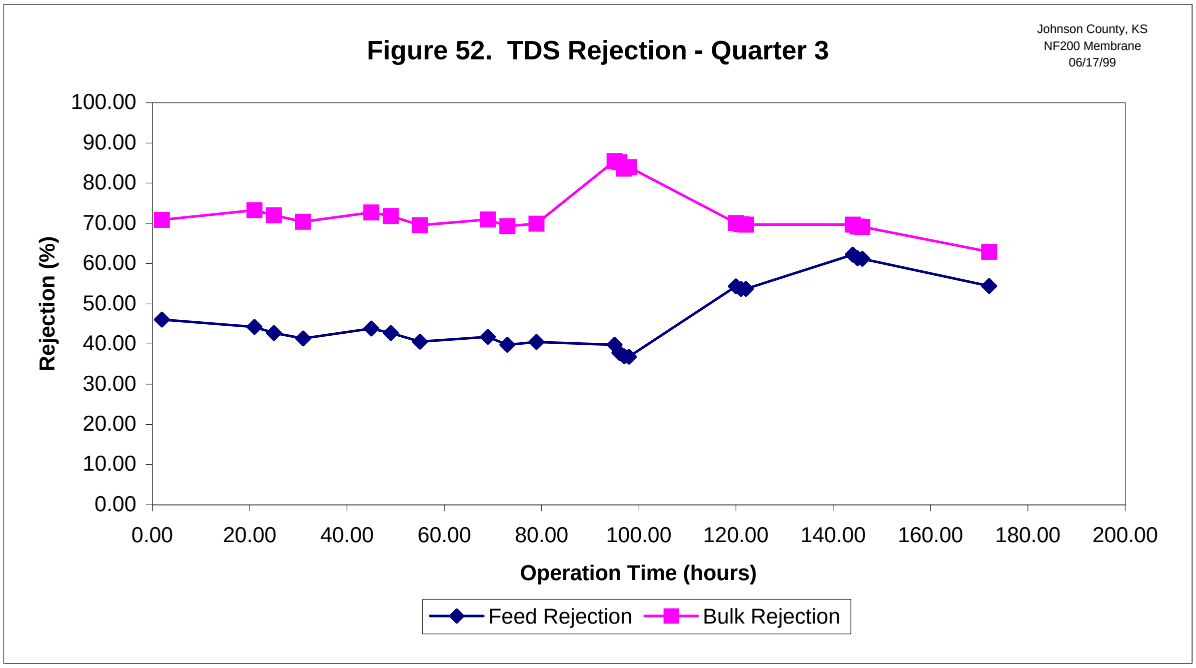


Figure 52. TDS Rejection - Quarter 3

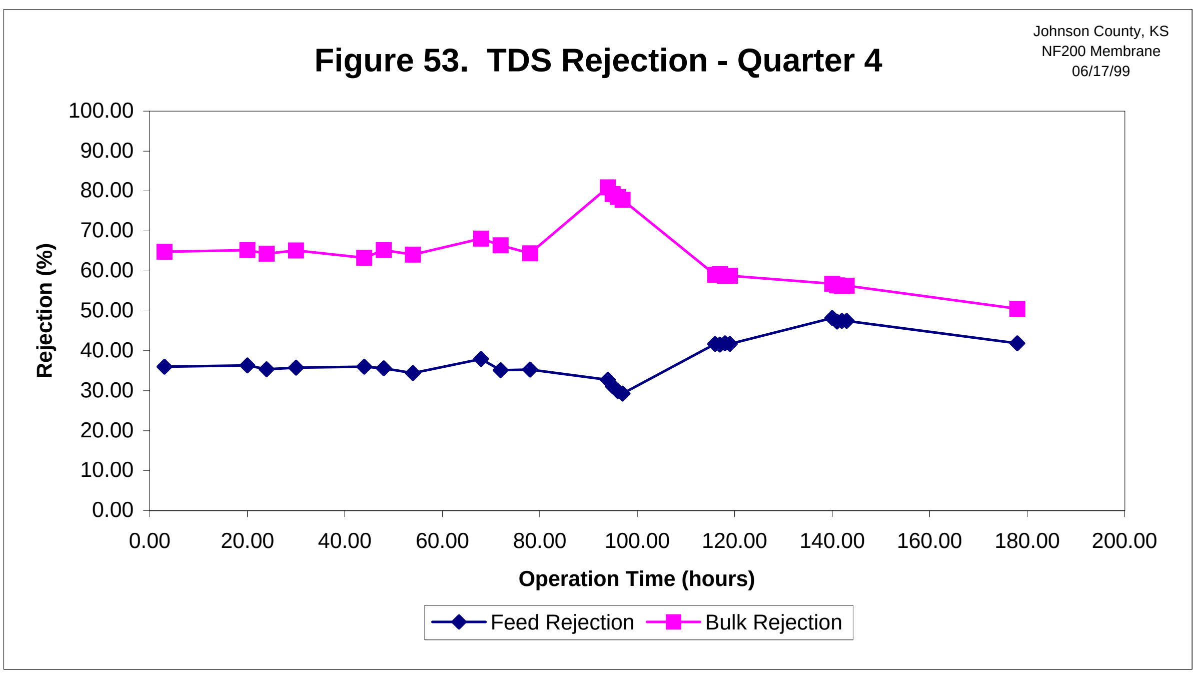


Figure 53. TDS Rejection - Quarter 4

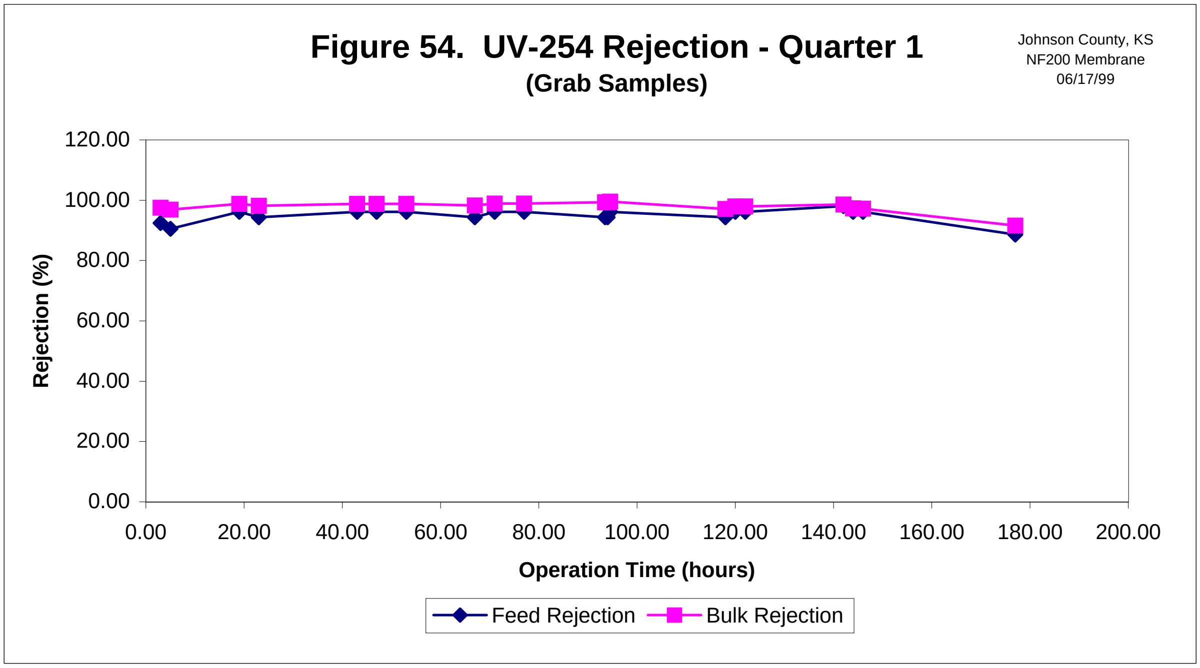


Figure 54. UV-254 Rejection - Quarter 1
(Grab Samples)
Johnson County, KS
NF200 Membrane
06/17/99
Rejection (%)
Operation Time (hours)
Feed Rejection
Bulk Rejection

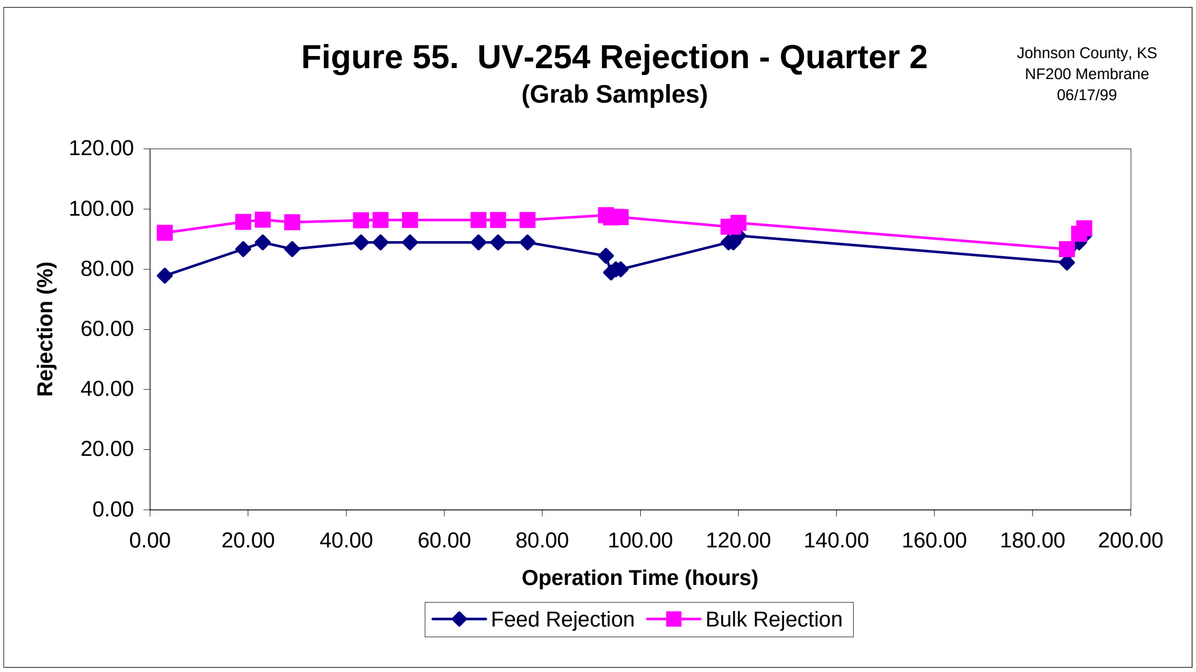


Figure 55. UV-254 Rejection - Quarter 2
(Grab Samples)
Johnson County, KS
NF200 Membrane
06/17/99
Rejection (%)
Operation Time (hours)
Feed Rejection
Bulk Rejection

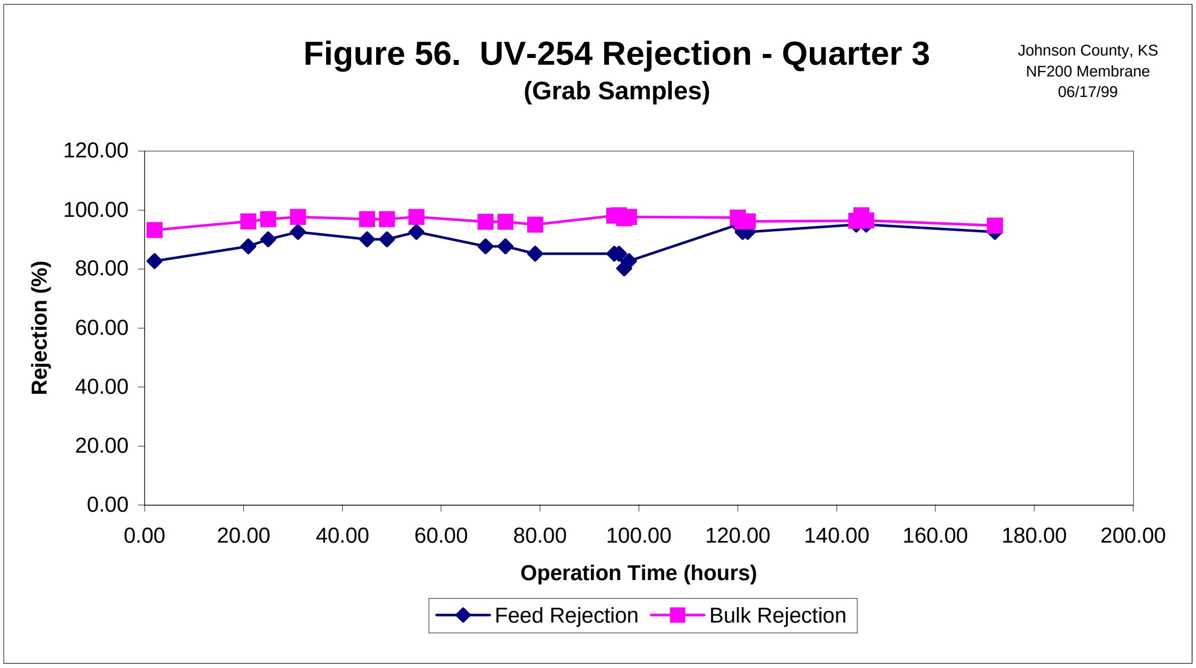


Figure 56. UV-254 Rejection - Quarter 3
(Grab Samples)
Johnson County, KS
NF200 Membrane
06/17/99
Rejection (%)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
Feed Rejection
Bulk Rejection

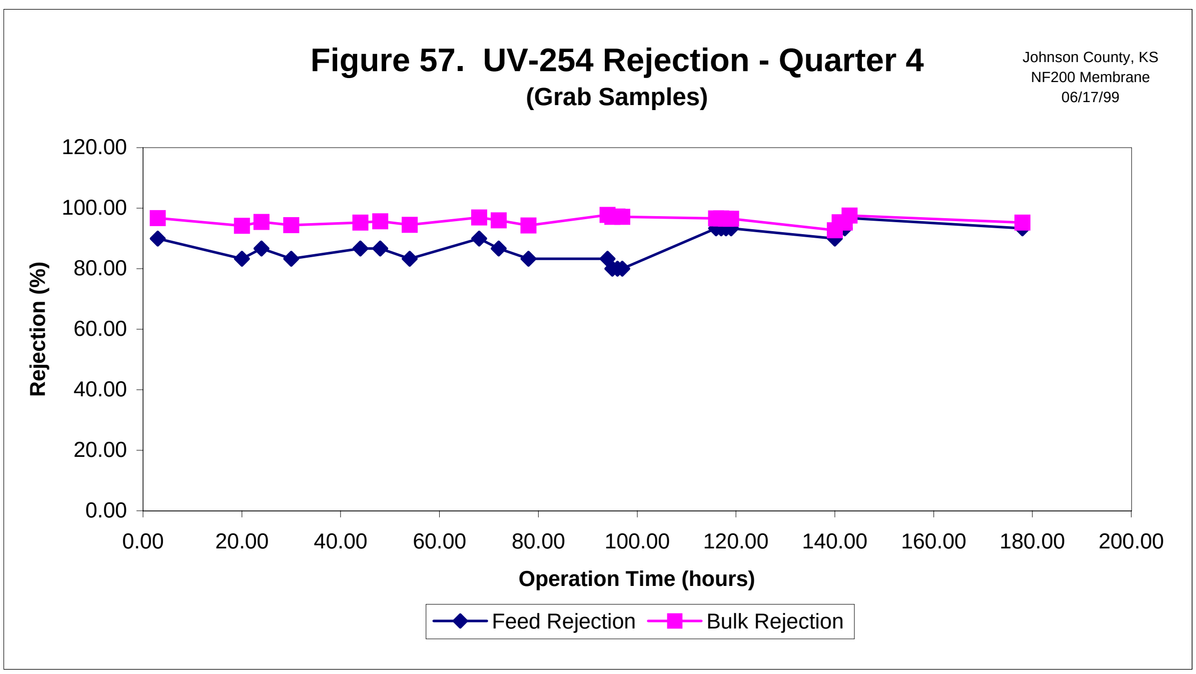
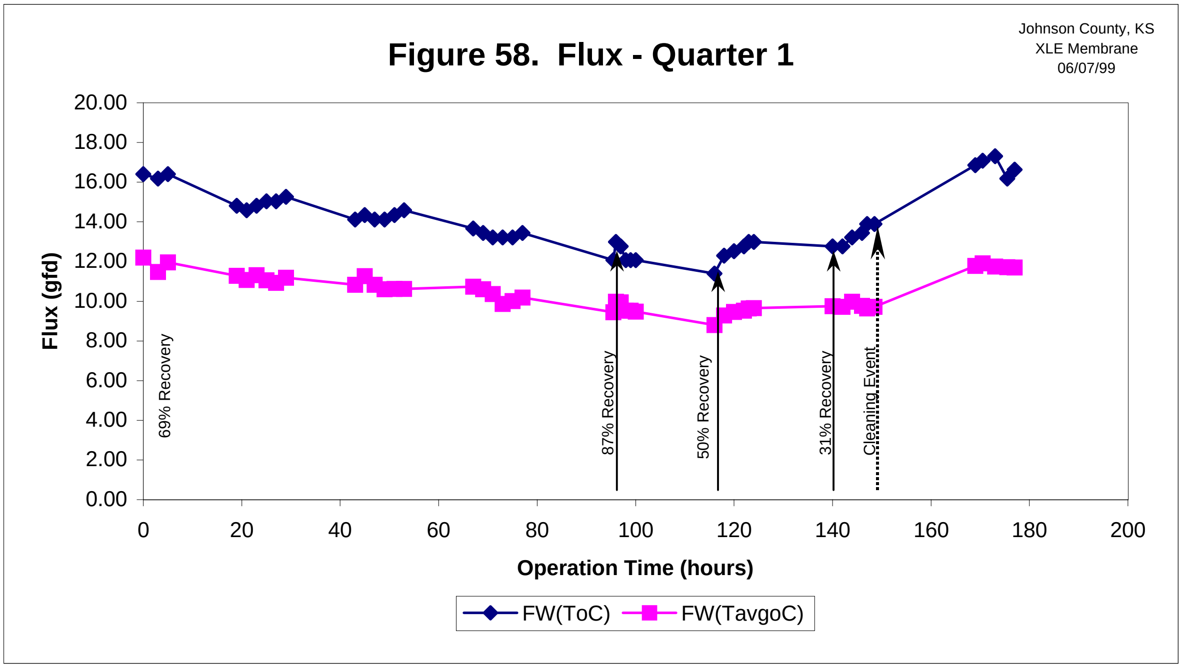
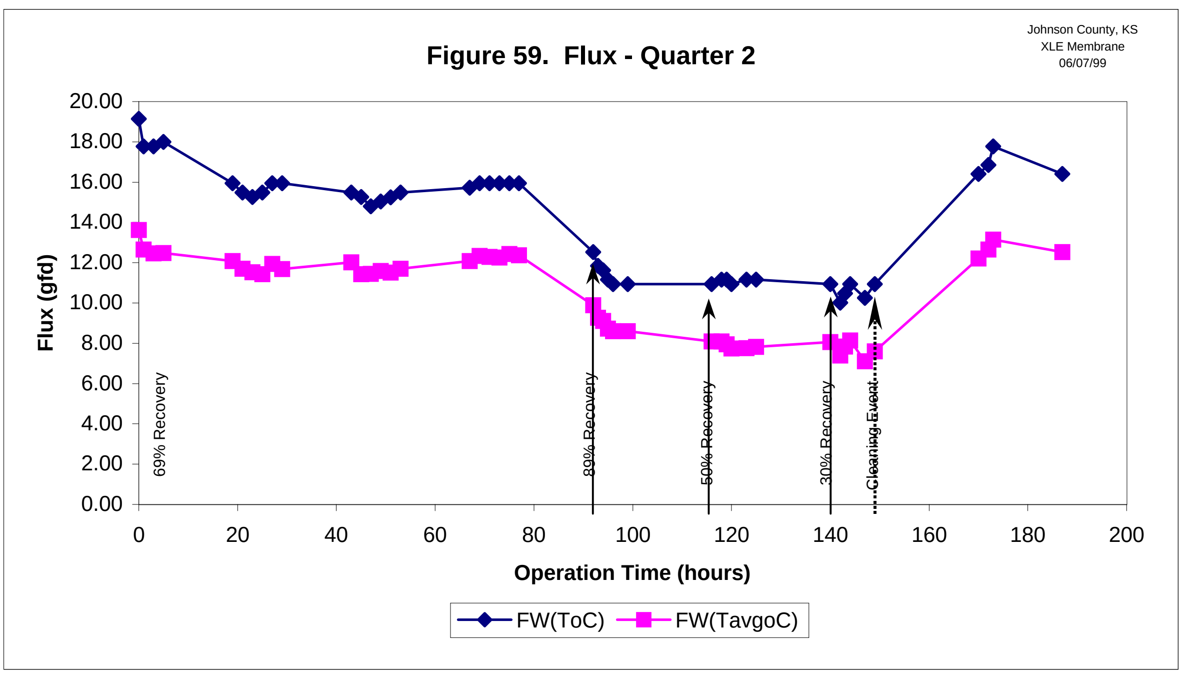


Figure 57. UV-254 Rejection - Quarter 4
(Grab Samples)
Johnson County, KS
NF200 Membrane
06/17/99
Rejection (%)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
Feed Rejection
Bulk Rejection


Johnson County, KS
XLE Membrane
06/07/99
Figure 58. Flux - Quarter 1
Flux (gfd)
Operation Time (hours)
69% Recovery
87% Recovery
50% Recovery
31% Recovery
Cleaning Event
FW(ToC)
FW(TavgoC)


Johnson County, KS
XLE Membrane
06/07/99
Figure 59. Flux - Quarter 2
Flux (gfd)
Operation Time (hours)
69% Recovery
89% Recovery
50% Recovery
30% Recovery
Cleaning Event
FW(ToC)
FW(TavgoC)

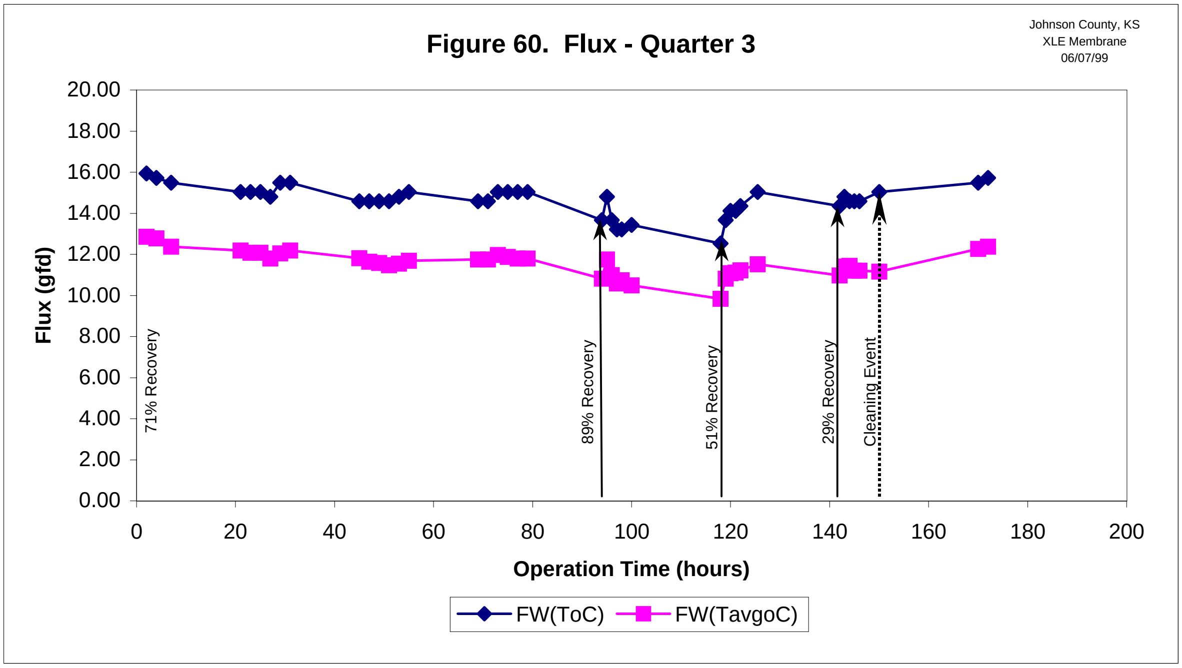


Figure 60. Flux - Quarter 3
Johnson County, KS
XLE Membrane
06/07/99
Flux (gfd)
Operation Time (hours)
71% Recovery
89% Recovery
51% Recovery
29% Recovery
Cleaning Event
FW(ToC)
FW(TavgoC)

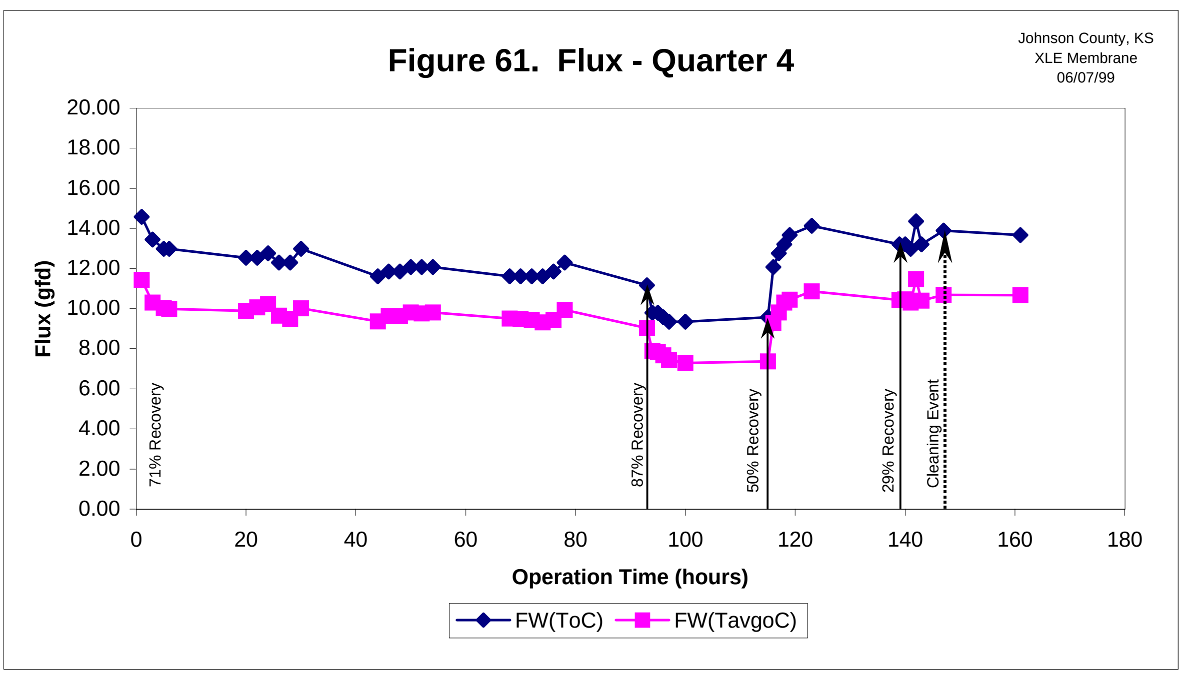


Figure 61. Flux - Quarter 4
Johnson County, KS
XLE Membrane
06/07/99
Flux (gfd)
Operation Time (hours)
71% Recovery
87% Recovery
50% Recovery
29% Recovery
Cleaning Event
FW(ToC)
FW(TavgoC)

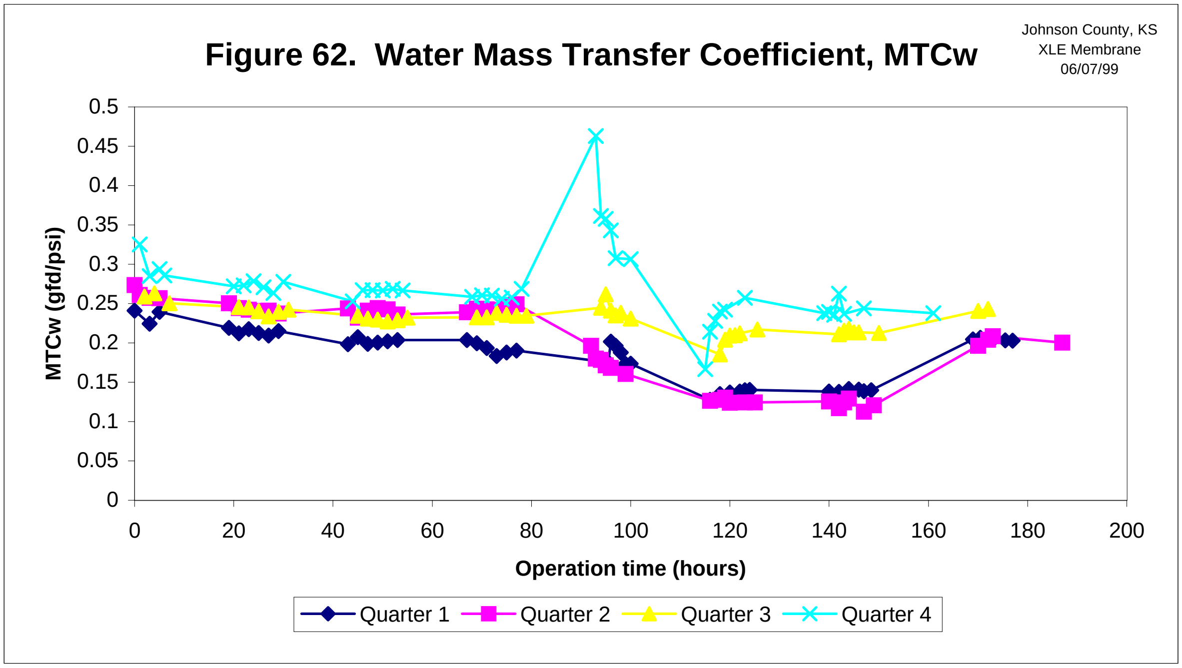
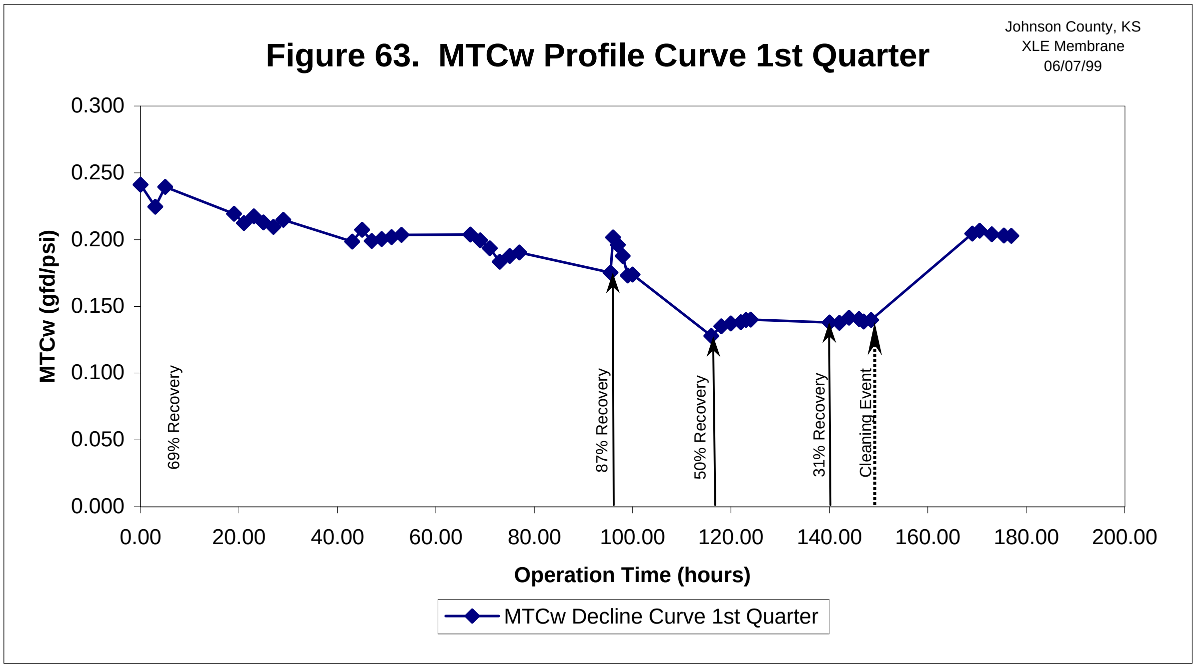
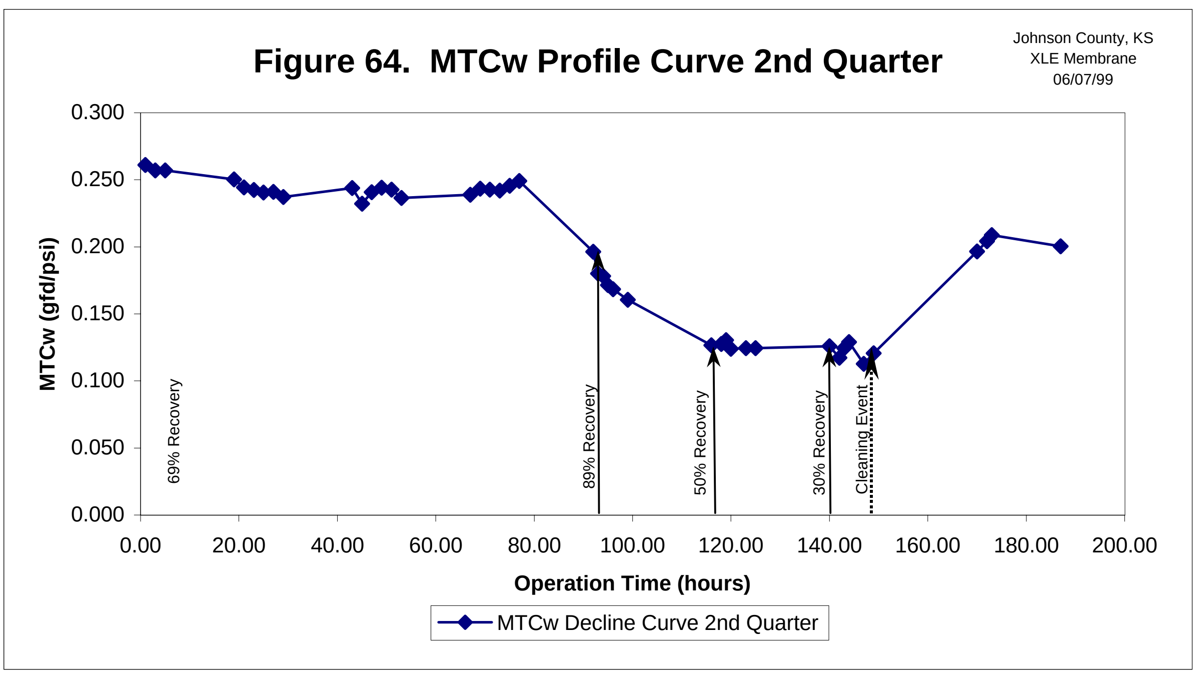
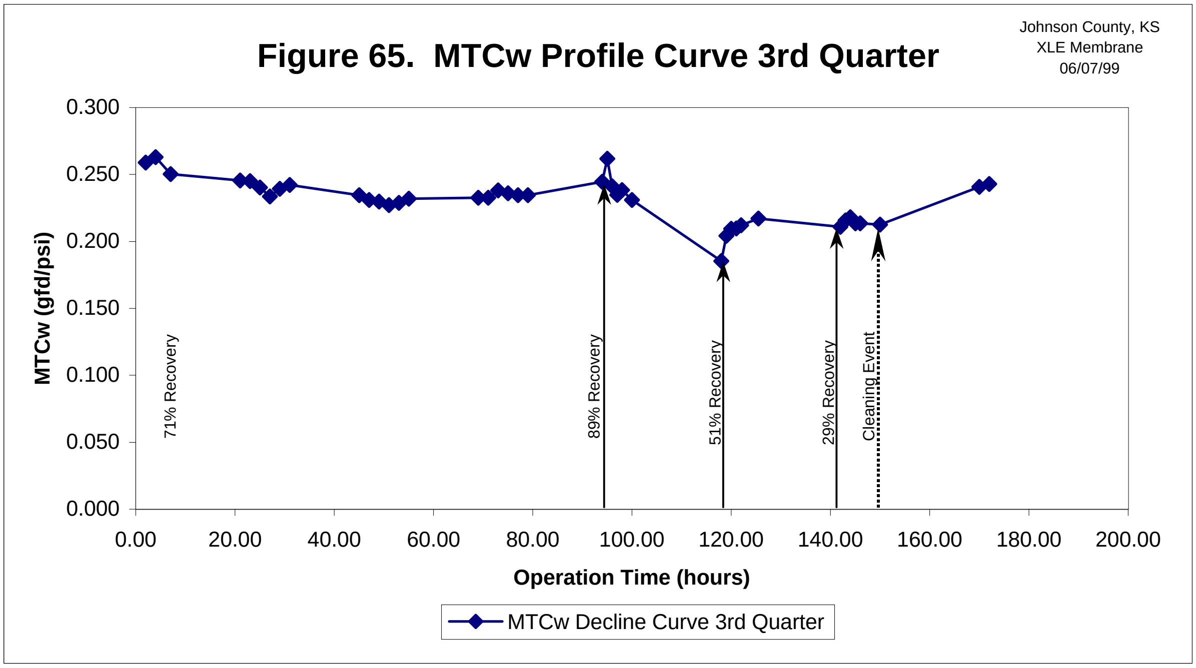


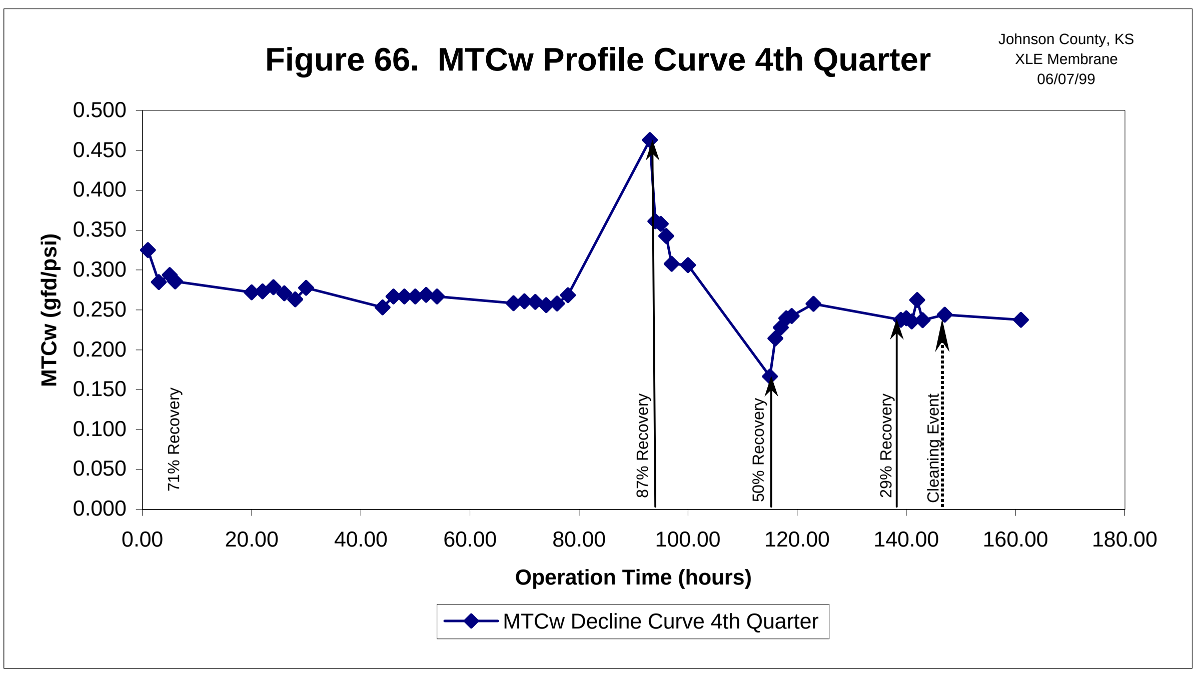
Figure 62. Water Mass Transfer Coefficient, MTCw
Johnson County, KS
XLE Membrane
06/07/99
MTCw (gfd/psi)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100
120
140
160
180
200
Operation time (hours)
Quarter 1
Quarter 2
Quarter 3
Quarter 4


Johnson County, KS
XLE Membrane
06/07/99
Figure 63. MTCw Profile Curve 1st Quarter
MTCw (gfd/psi)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
69% Recovery
87% Recovery
50% Recovery
31% Recovery
Cleaning Event
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
MTCw Decline Curve 1st Quarter


Johnson County, KS
XLE Membrane
06/07/99
Figure 64. MTCw Profile Curve 2nd Quarter
MTCw (gfd/psi)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
69% Recovery
89% Recovery
50% Recovery
30% Recovery
Cleaning Event
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
MTCw Decline Curve 2nd Quarter



Johnson County, KS
XLE Membrane
06/07/99
Figure 65. MTCw Profile Curve 3rd Quarter
MTCw (gfd/psi)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
71% Recovery
89% Recovery
51% Recovery
29% Recovery
Cleaning Event
MTCw Decline Curve 3rd Quarter



Johnson County, KS
XLE Membrane
06/07/99
Figure 66. MTCw Profile Curve 4th Quarter
MTCw (gfd/psi)
0.500
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
Operation Time (hours)
71% Recovery
87% Recovery
50% Recovery
29% Recovery
Cleaning Event
MTCw Decline Curve 4th Quarter

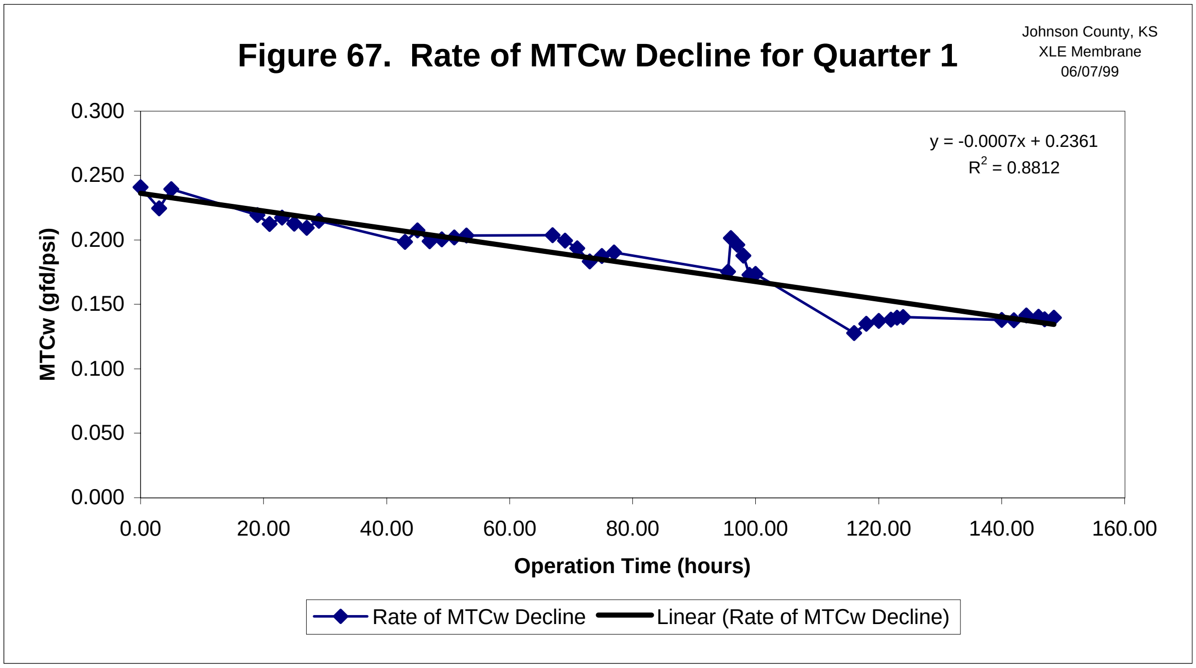


Figure 67. Rate of MTCw Decline for Quarter 1
Johnson County, KS
XLE Membrane
06/07/99
y = -0.0007x + 0.2361
R2 = 0.8812
MTCw (gfd/psi)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
Rate of MTCw Decline
Linear (Rate of MTCw Decline)

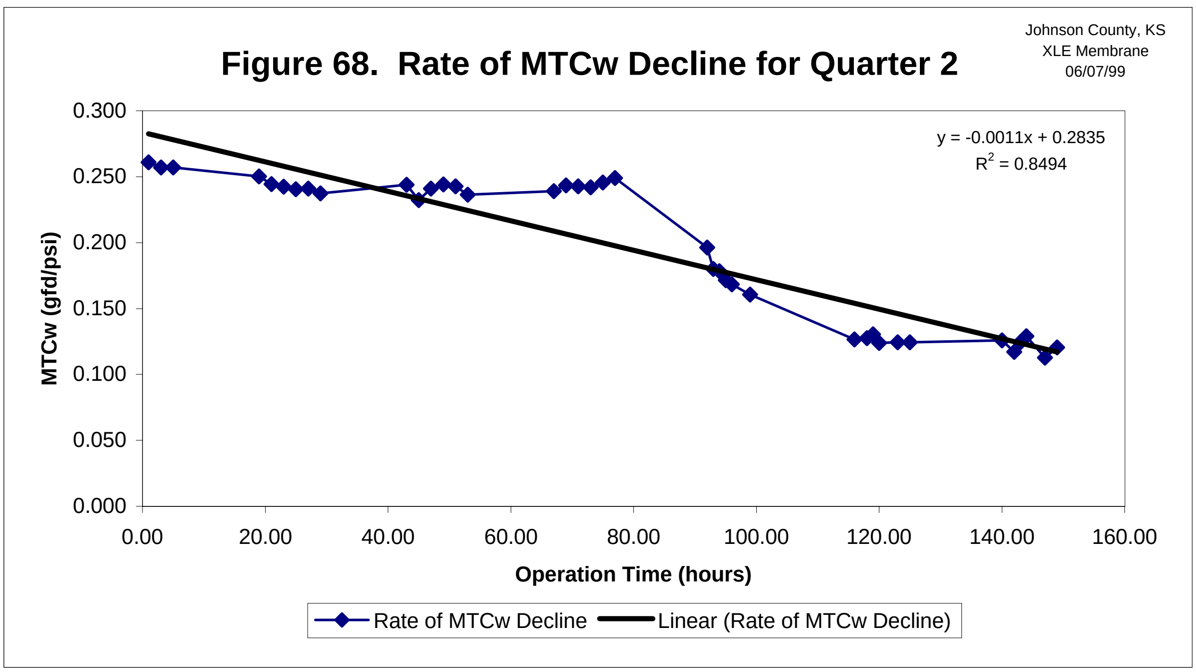


Figure 68. Rate of MTCw Decline for Quarter 2
Johnson County, KS
XLE Membrane
06/07/99
y = -0.0011x + 0.2835
R2 = 0.8494
MTCw (gfd/psi)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
Rate of MTCw Decline
Linear (Rate of MTCw Decline)

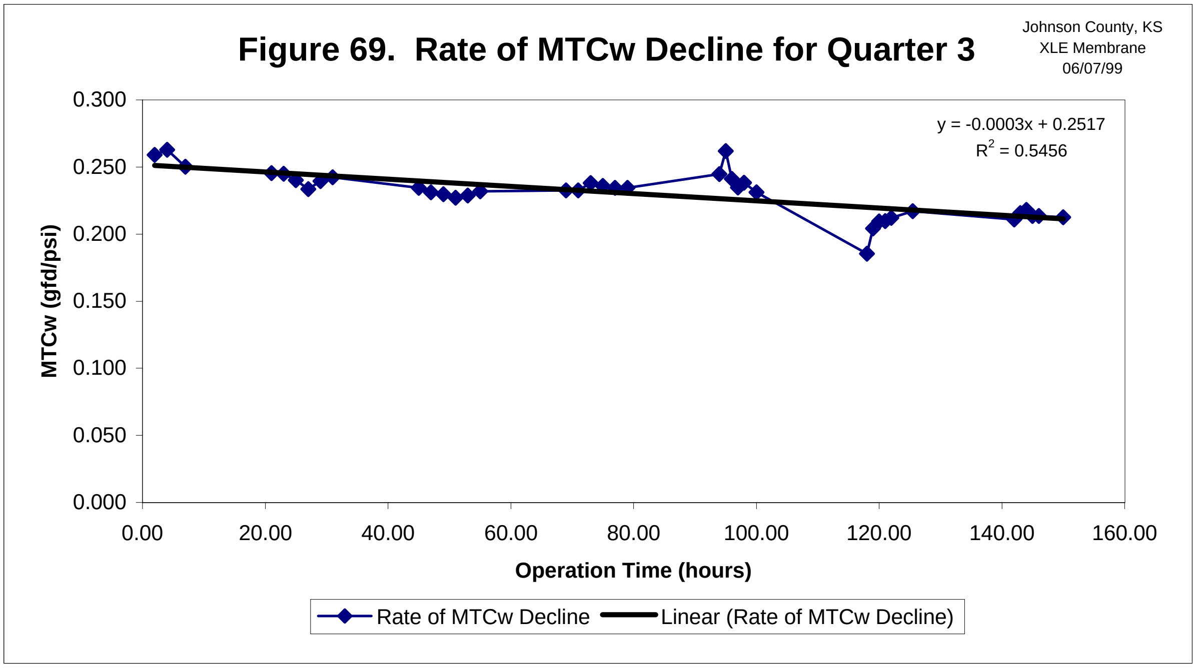


Figure 69. Rate of MTCw Decline for Quarter 3
Johnson County, KS
XLE Membrane
06/07/99
y = -0.0003x + 0.2517
R2 = 0.5456
MTCw (gfd/psi)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
Rate of MTCw Decline
Linear (Rate of MTCw Decline)

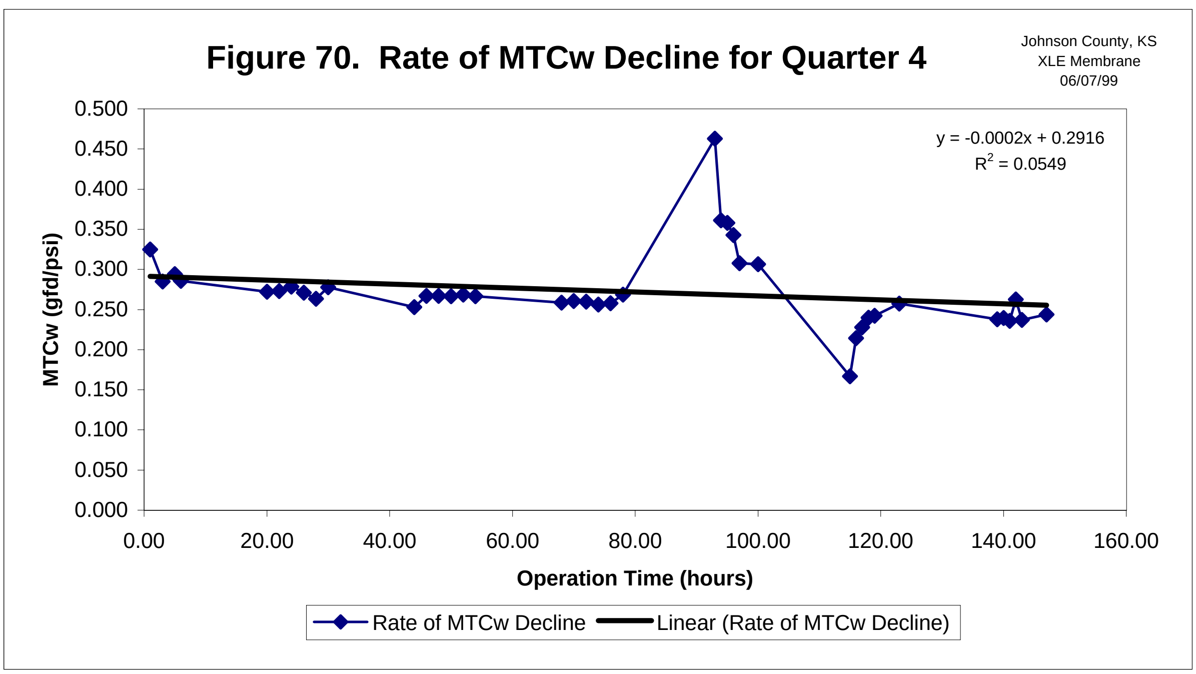


Figure 70. Rate of MTCw Decline for Quarter 4
Johnson County, KS
XLE Membrane
06/07/99
y = -0.0002x + 0.2916
R2 = 0.0549
MTCw (gfd/psi)
0.500
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
Rate of MTCw Decline
Linear (Rate of MTCw Decline)

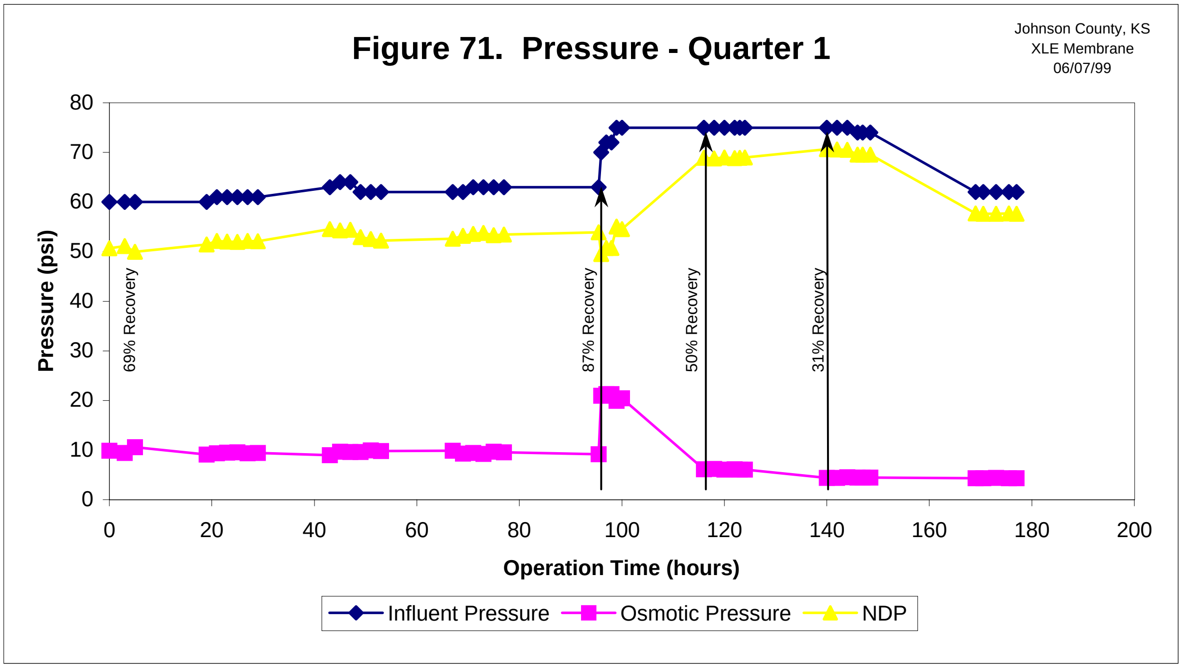


Figure 71. Pressure - Quarter 1
Johnson County, KS
XLE Membrane
06/07/99
Pressure (psi)
Operation Time (hours)
69% Recovery
87% Recovery
50% Recovery
31% Recovery
Influent Pressure
Osmotic Pressure
NDP

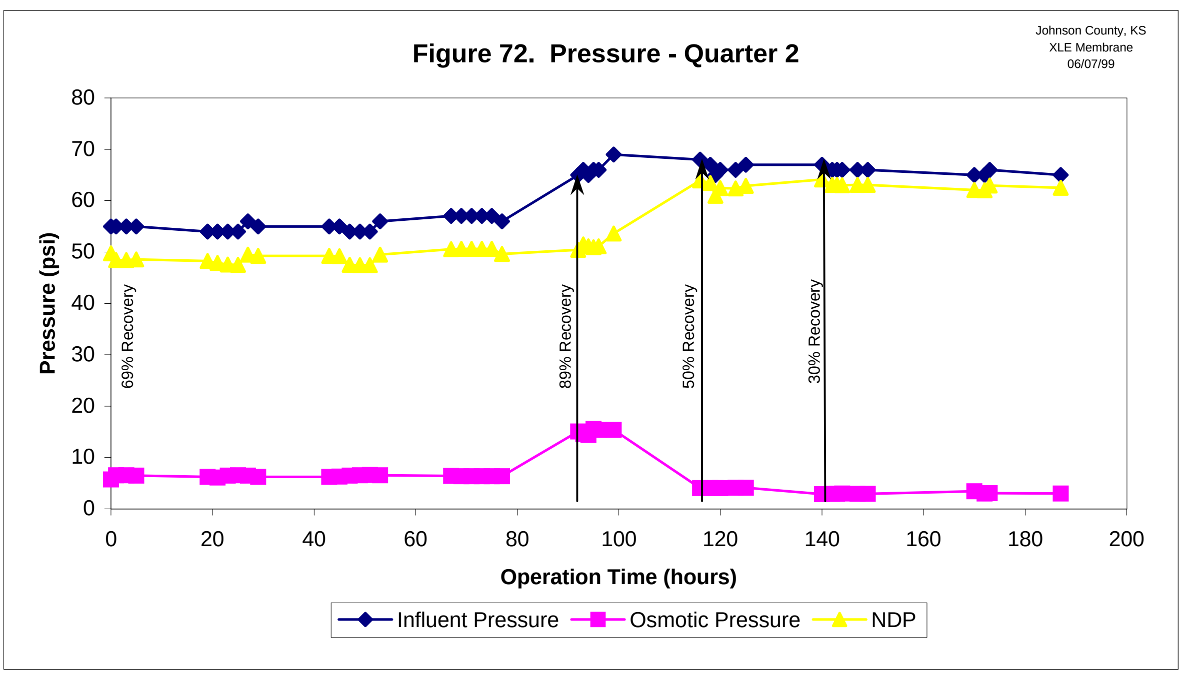


Figure 72. Pressure - Quarter 2
Johnson County, KS
XLE Membrane
06/07/99
Pressure (psi)
Operation Time (hours)
69% Recovery
89% Recovery
50% Recovery
30% Recovery
Influent Pressure
Osmotic Pressure
NDP

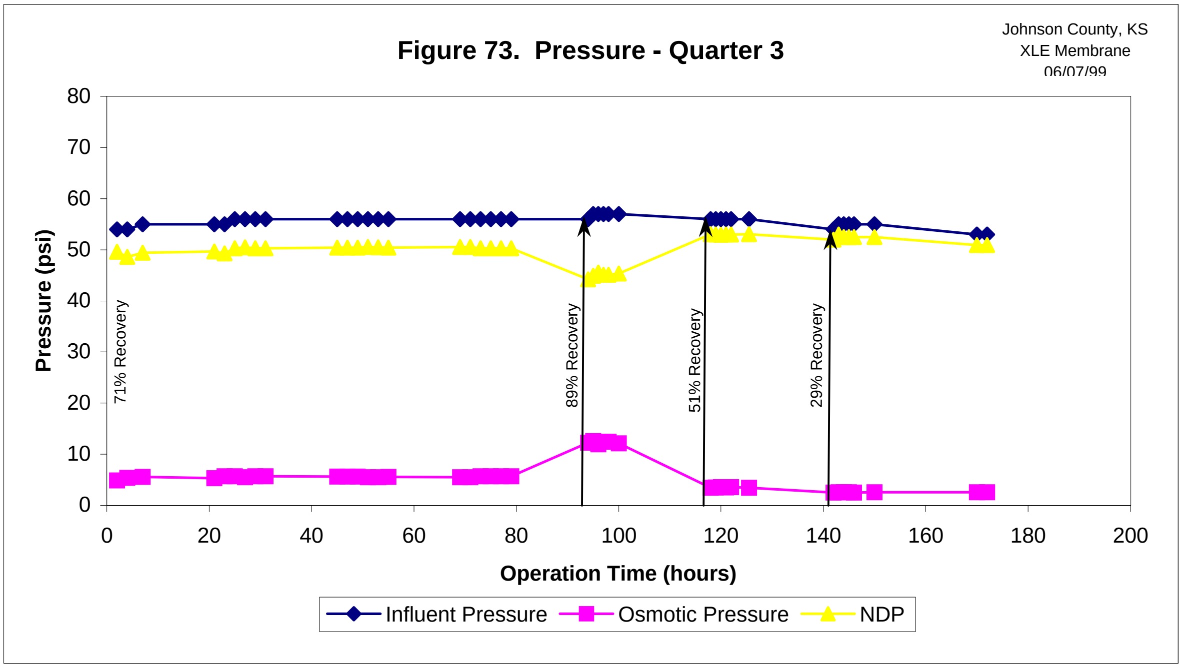


Figure 73. Pressure - Quarter 3
Johnson County, KS
XLE Membrane
Pressure (psi)
Operation Time (hours)
71% Recovery
89% Recovery
51% Recovery
29% Recovery
Influent Pressure
Osmotic Pressure
NDP

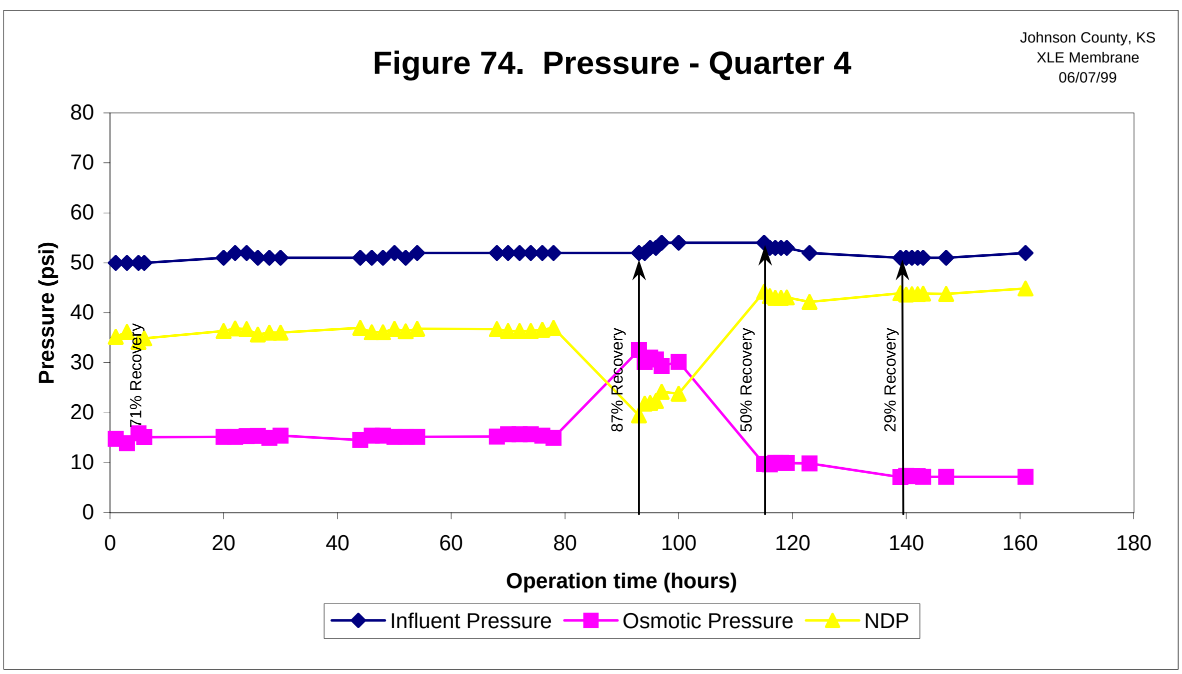


Figure 74. Pressure - Quarter 4
Johnson County, KS
XLE Membrane
06/07/99
Pressure (psi)
Operation time (hours)
71% Recovery
87% Recovery
50% Recovery
29% Recovery
Influent Pressure
Osmotic Pressure
NDP

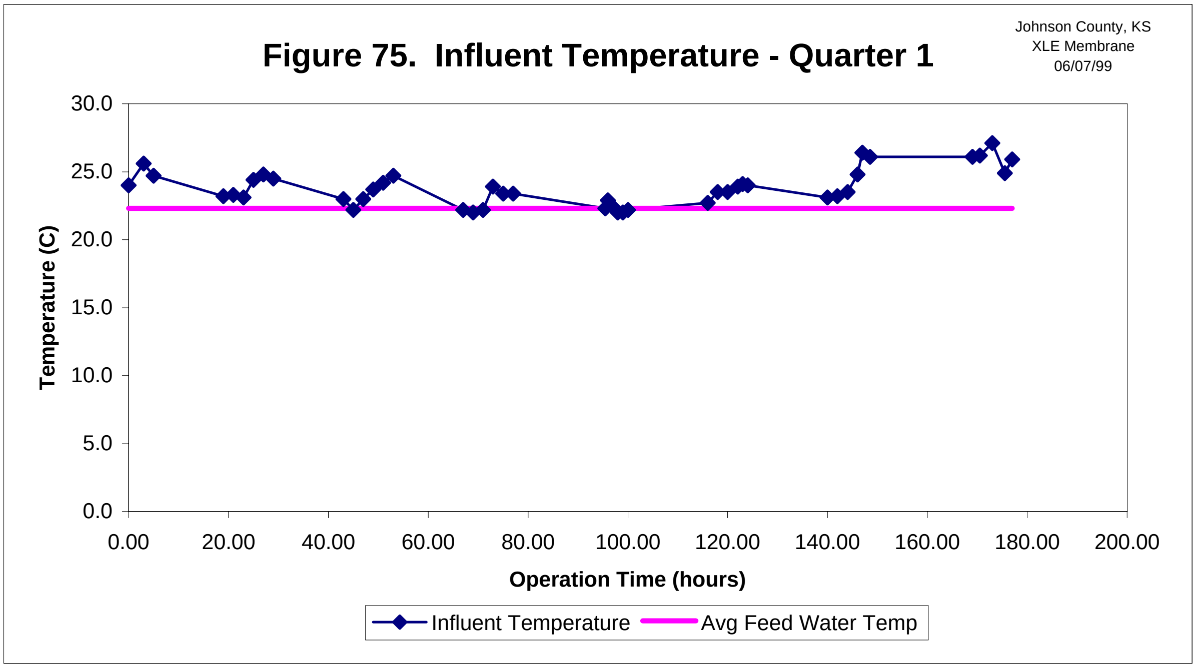


Figure 75. Influent Temperature - Quarter 1
Johnson County, KS
XLE Membrane
06/07/99
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (C)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
Influent Temperature
Avg Feed Water Temp

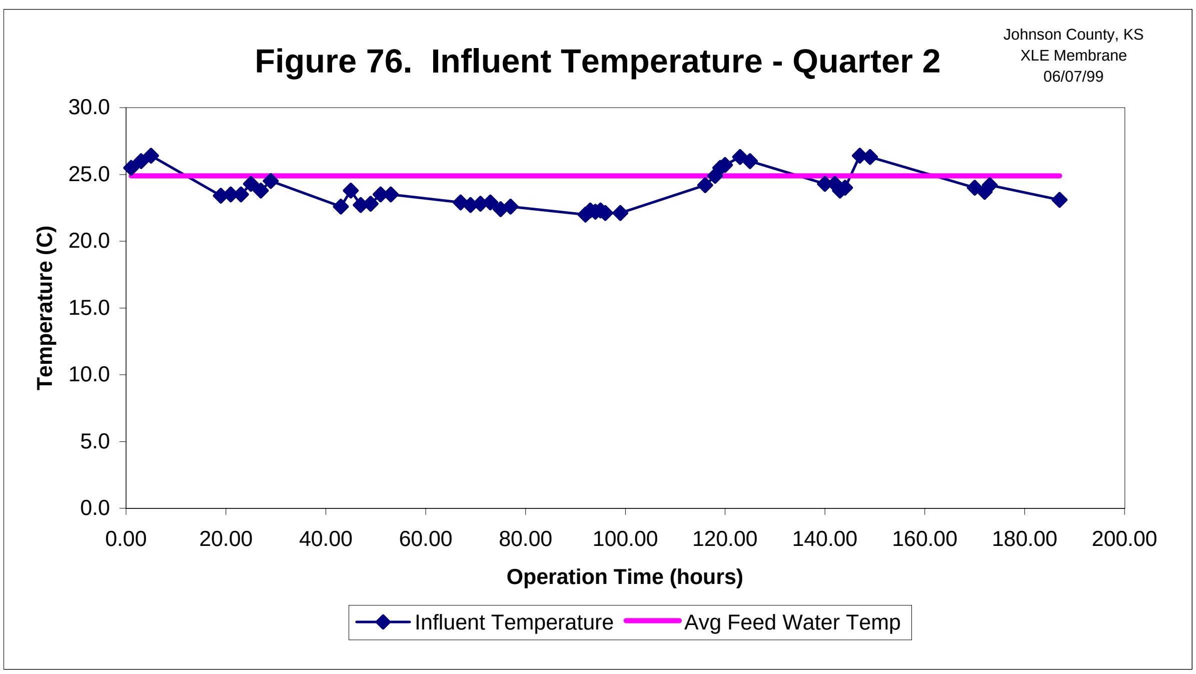
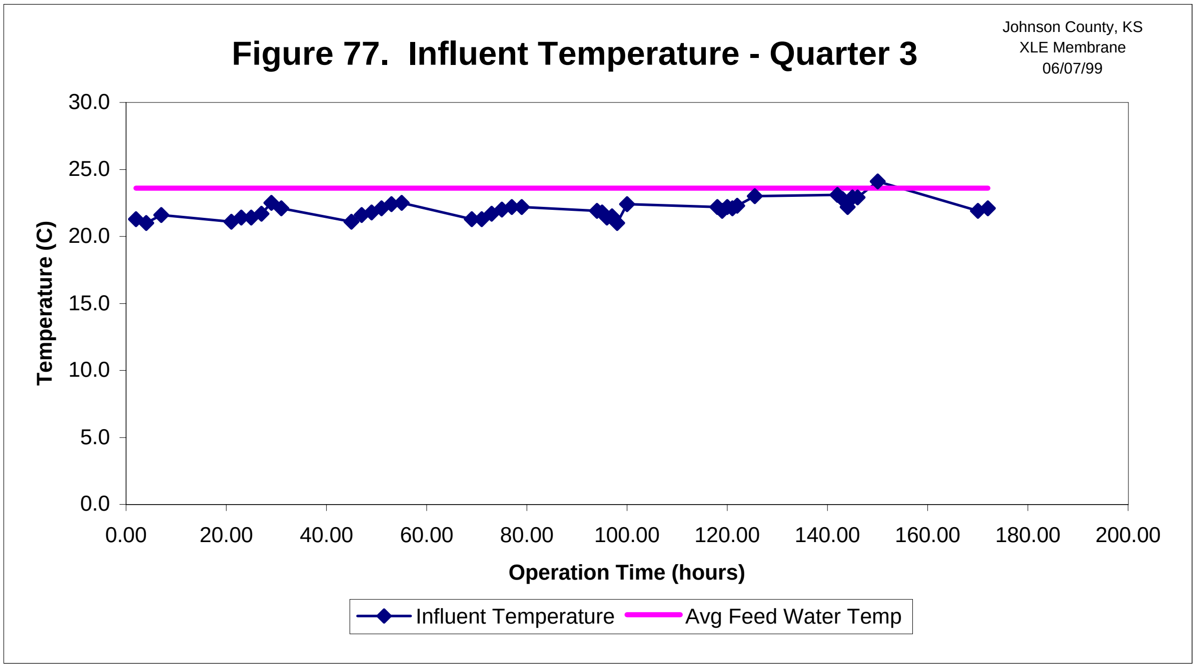
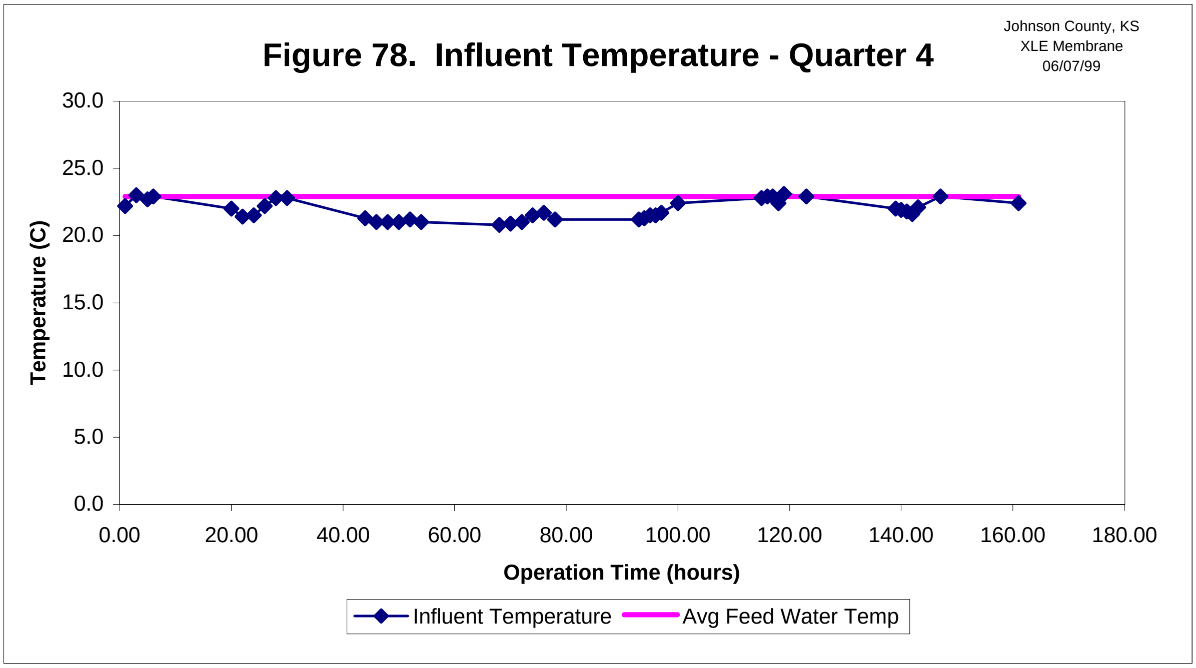


Figure 76. Influent Temperature - Quarter 2
Johnson County, KS
XLE Membrane
06/07/99
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (C)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
Influent Temperature
Avg Feed Water Temp


Johnson County, KS
XLE Membrane
06/07/99
Figure 77. Influent Temperature - Quarter 3
Temperature (C)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
Influent Temperature
Avg Feed Water Temp


Johnson County, KS
XLE Membrane
06/07/99
Figure 78. Influent Temperature - Quarter 4
Temperature (C)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
Operation Time (hours)
Influent Temperature
Avg Feed Water Temp

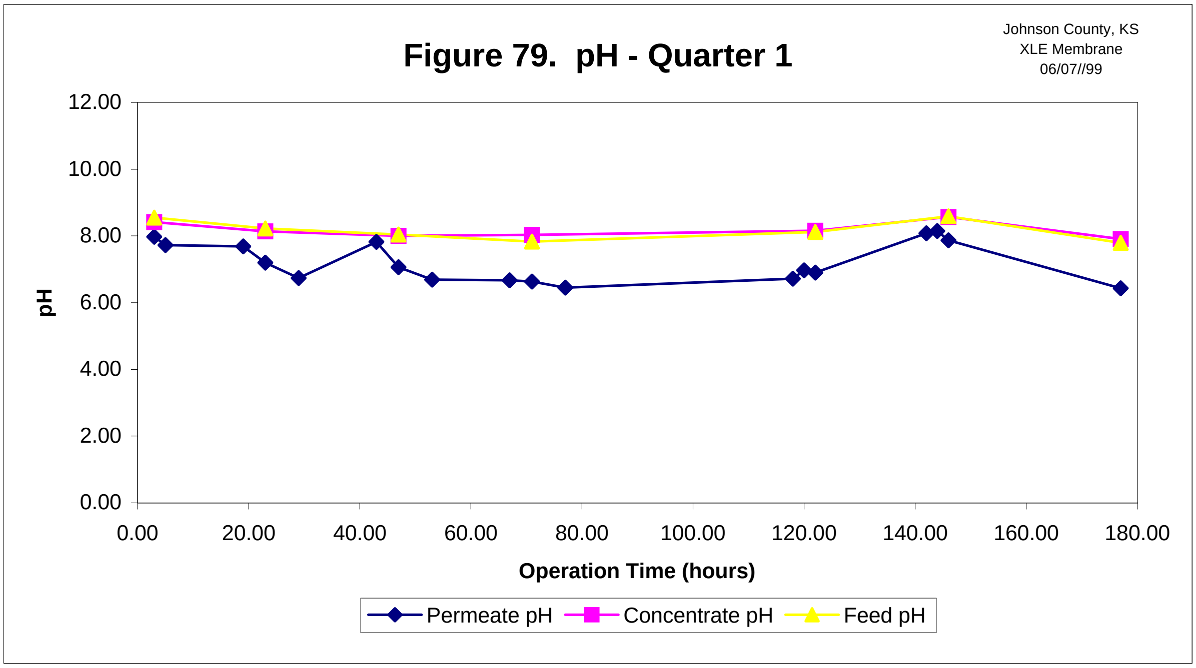


Figure 79. pH - Quarter 1
Johnson County, KS
XLE Membrane
06/07//99
12.00
10.00
8.00
6.00
4.00
2.00
0.00
pH
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
Operation Time (hours)
Permeate pH
Concentrate pH
Feed pH

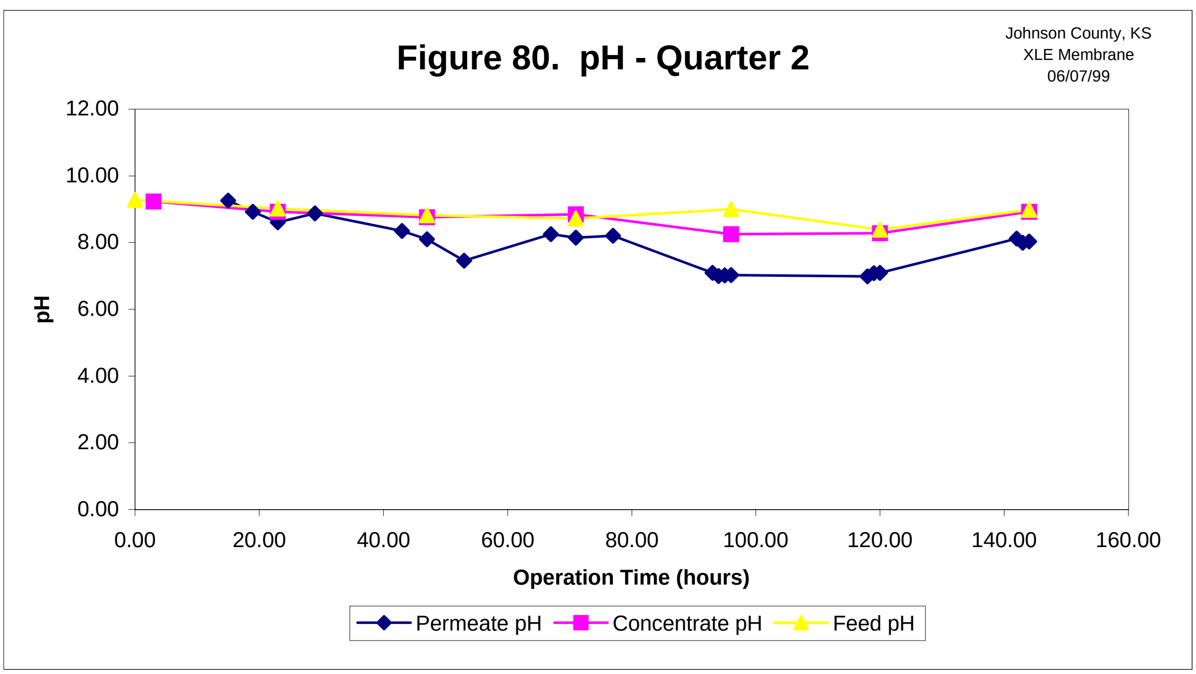
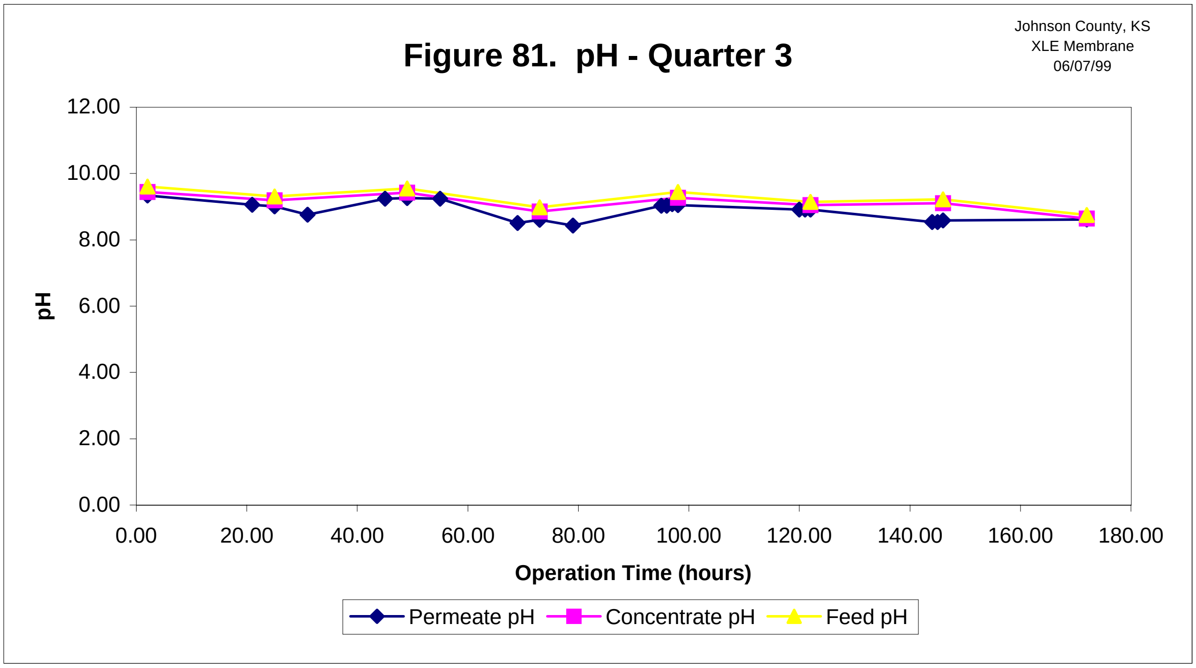
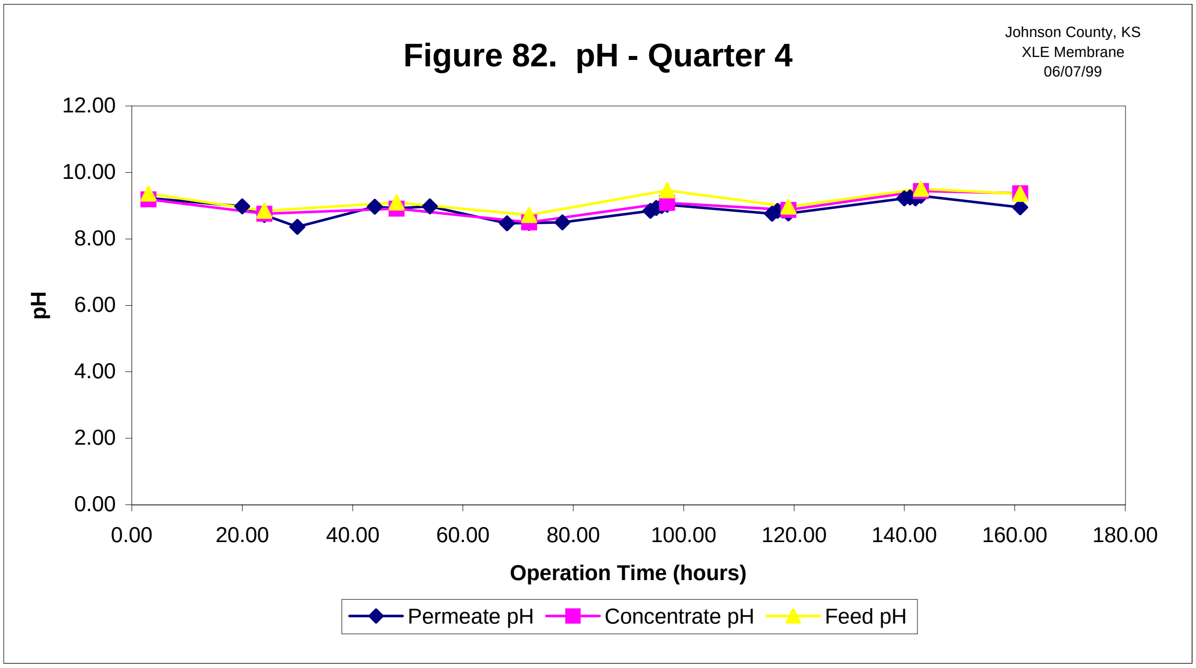
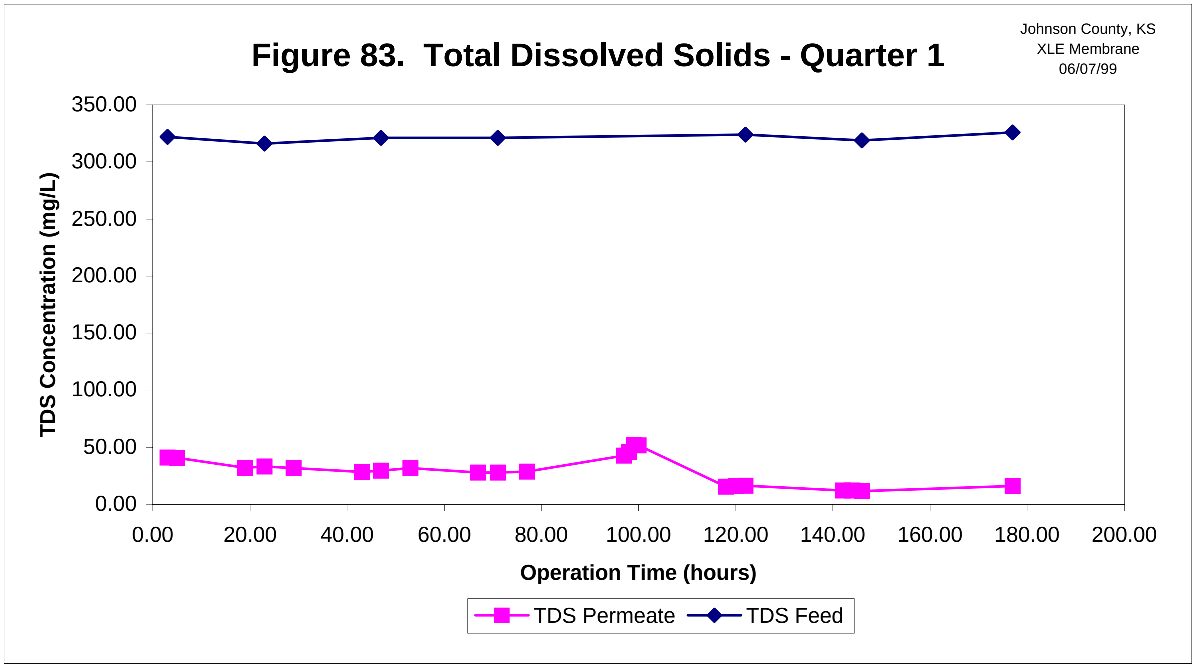
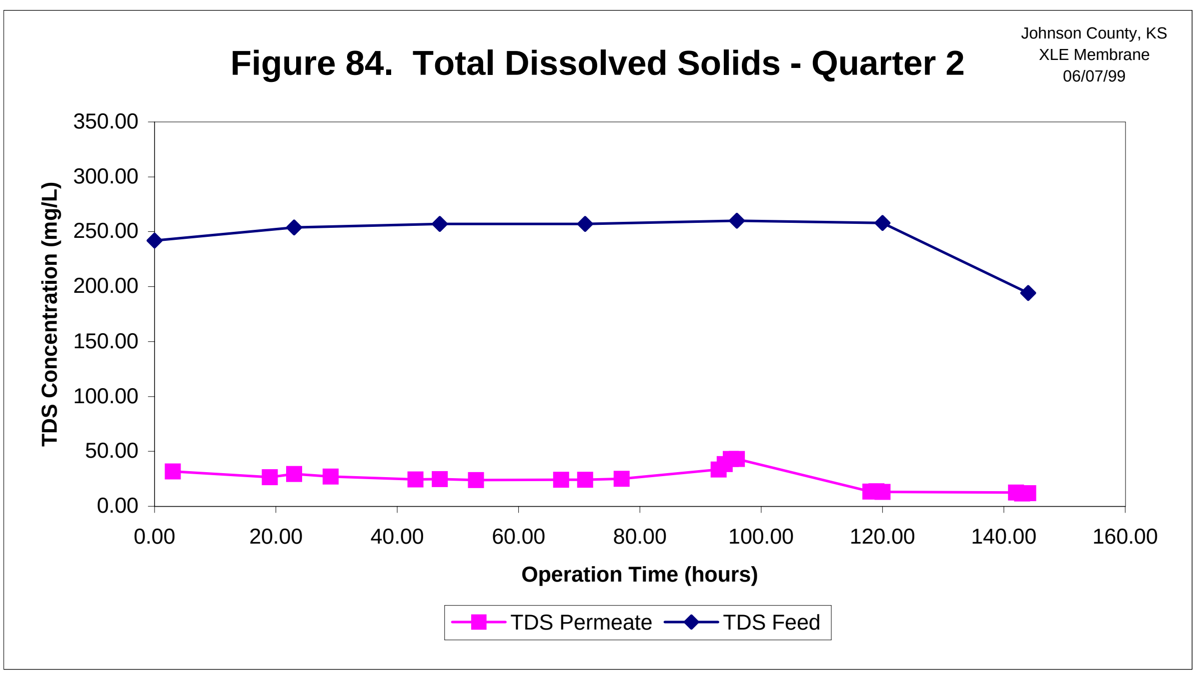


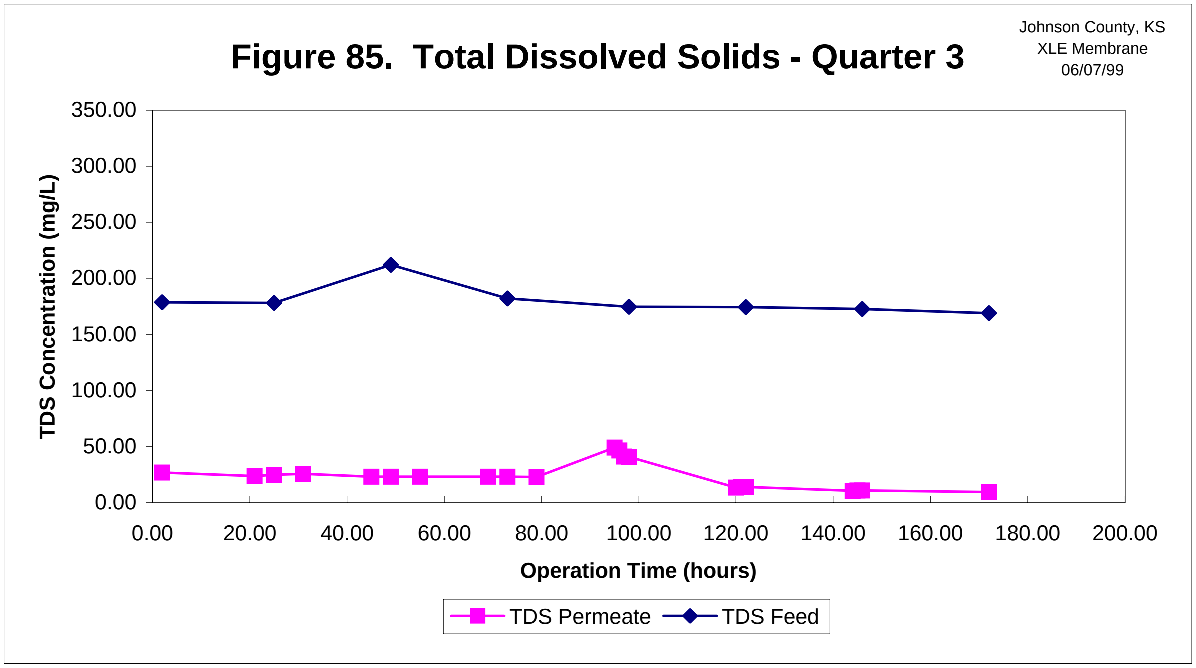
Figure 80. pH - Quarter 2
Johnson County, KS
XLE Membrane
06/07/99
12.00
10.00
8.00
6.00
4.00
2.00
0.00
pH
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
Permeate pH
Concentrate pH
Feed pH


Johnson County, KS
XLE Membrane
06/07/99
Figure 81. pH - Quarter 3
12.00
10.00
8.00
6.00
4.00
2.00
0.00
pH
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
Operation Time (hours)
Permeate pH
Concentrate pH
Feed pH

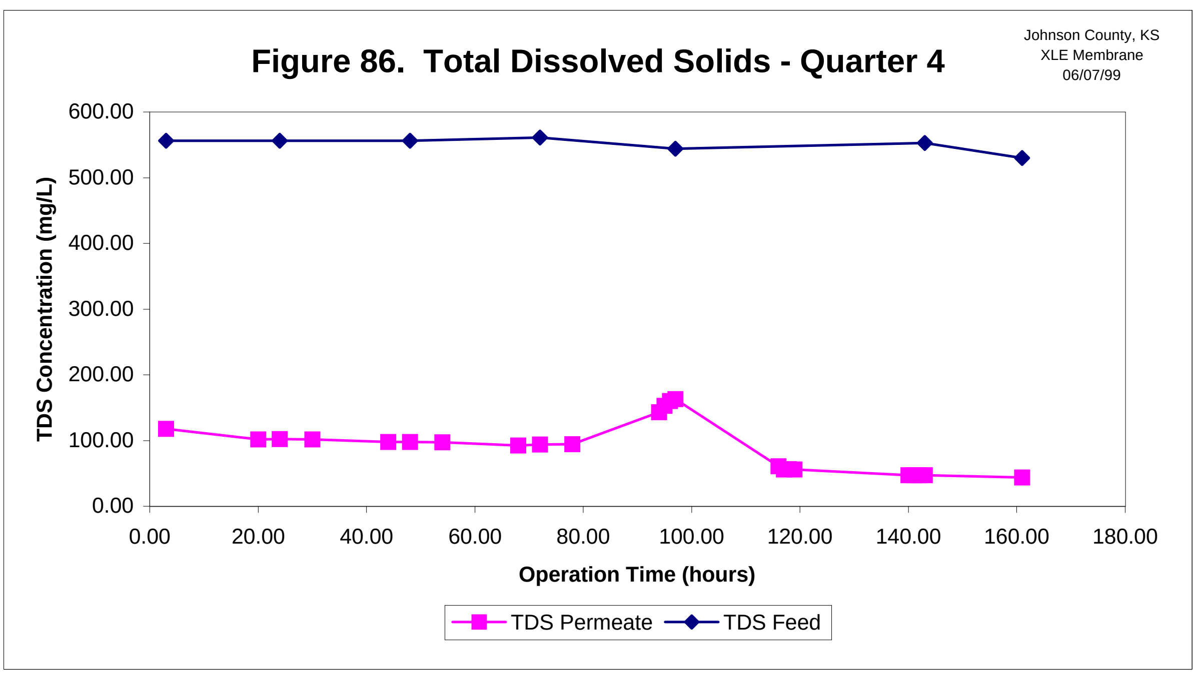

Johnson County, KS
XLE Membrane
06/07/99
Figure 82. pH - Quarter 4
12.00
10.00
8.00
6.00
4.00
2.00
0.00
pH
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
Operation Time (hours)
Permeate pH
Concentrate pH
Feed pH


Johnson County, KS
XLE Membrane
06/07/99
Figure 83. Total Dissolved Solids - Quarter 1
TDS Concentration (mg/L)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
TDS Permeate
TDS Feed


Johnson County, KS
XLE Membrane
06/07/99
Figure 84. Total Dissolved Solids - Quarter 2
TDS Concentration (mg/L)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
TDS Permeate
TDS Feed



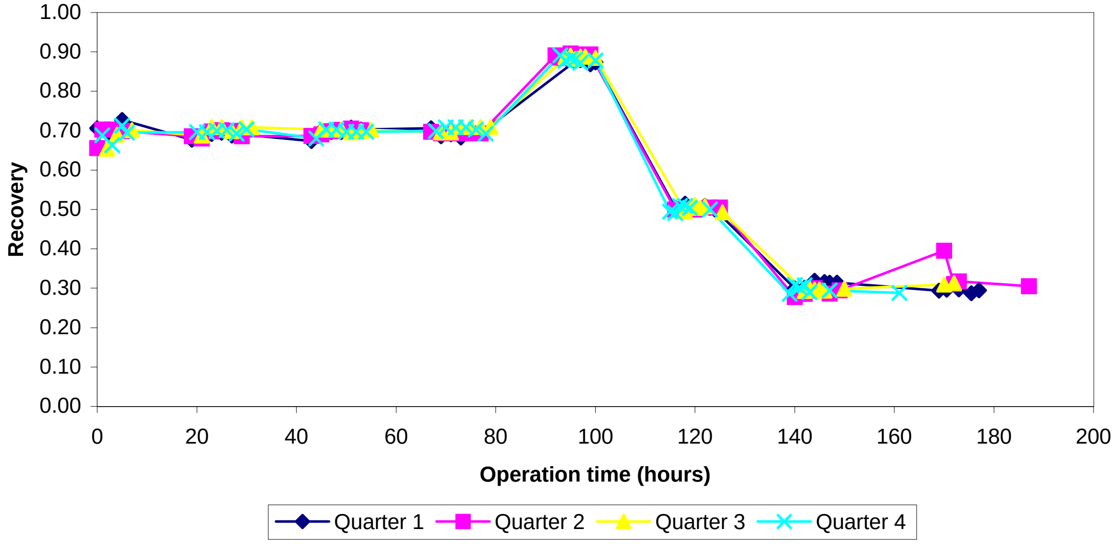
Johnson County, KS
XLE Membrane
06/07/99
Figure 85. Total Dissolved Solids - Quarter 3
TDS Concentration (mg/L)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
TDS Permeate
TDS Feed



Johnson County, KS
XLE Membrane
06/07/99
Figure 86. Total Dissolved Solids - Quarter 4
TDS Concentration (mg/L)
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
Operation Time (hours)
TDS Permeate
TDS Feed

Figure 87. Recovery

Johnson County, KS
XLE Membrane
06/07/99



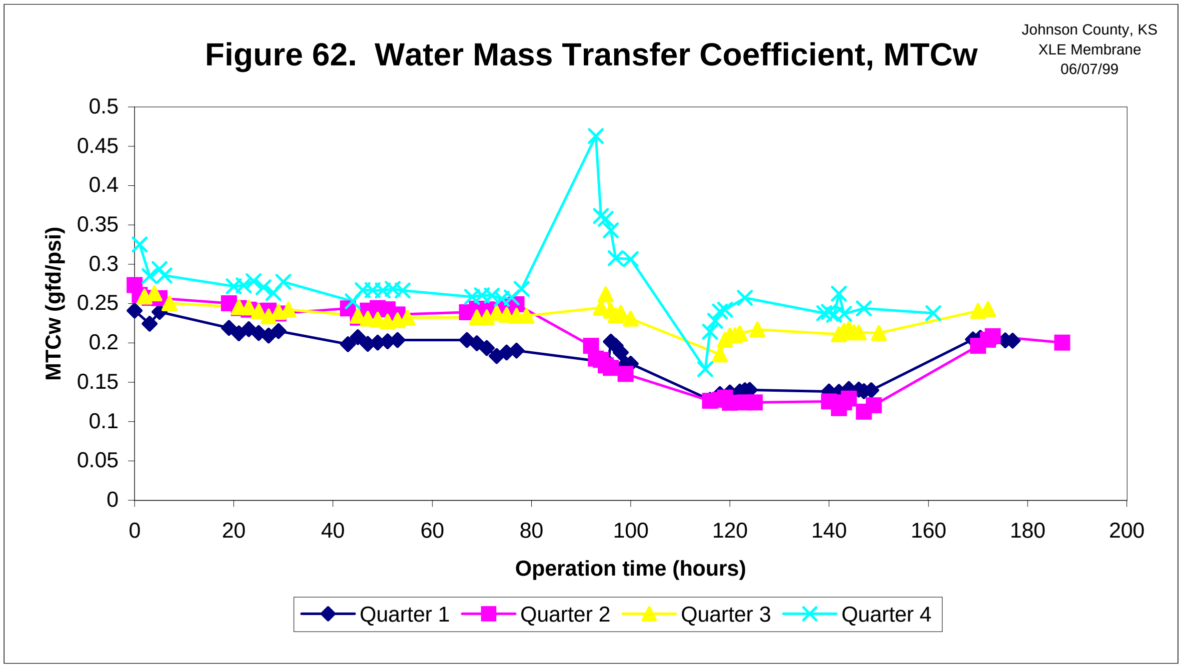
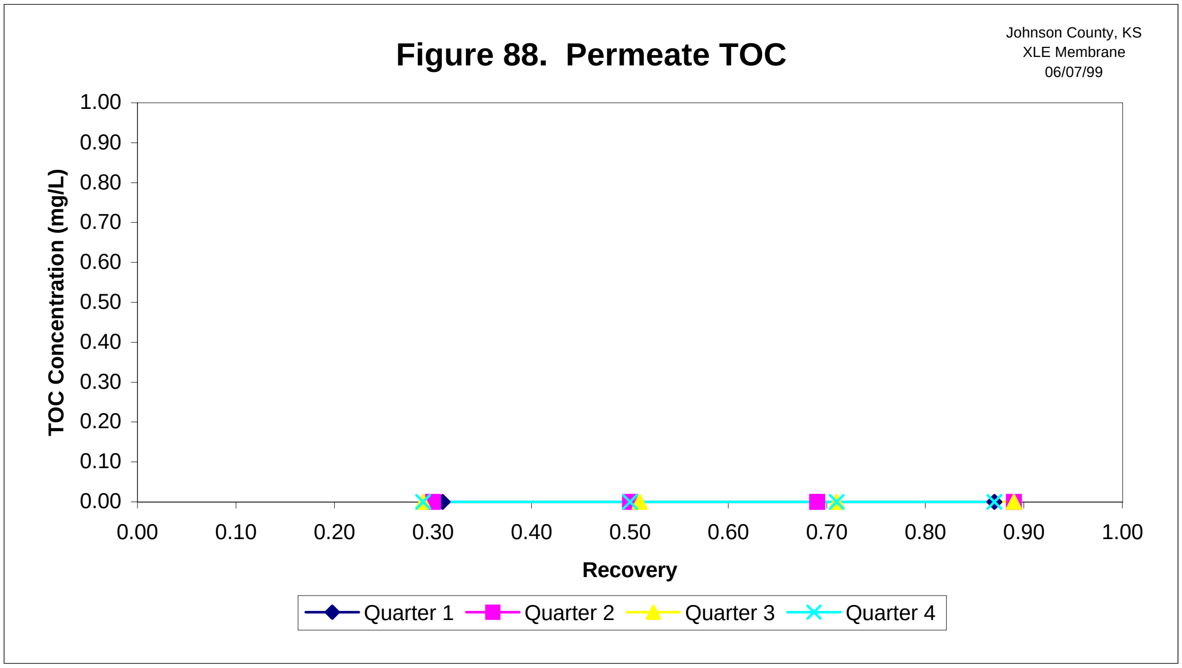
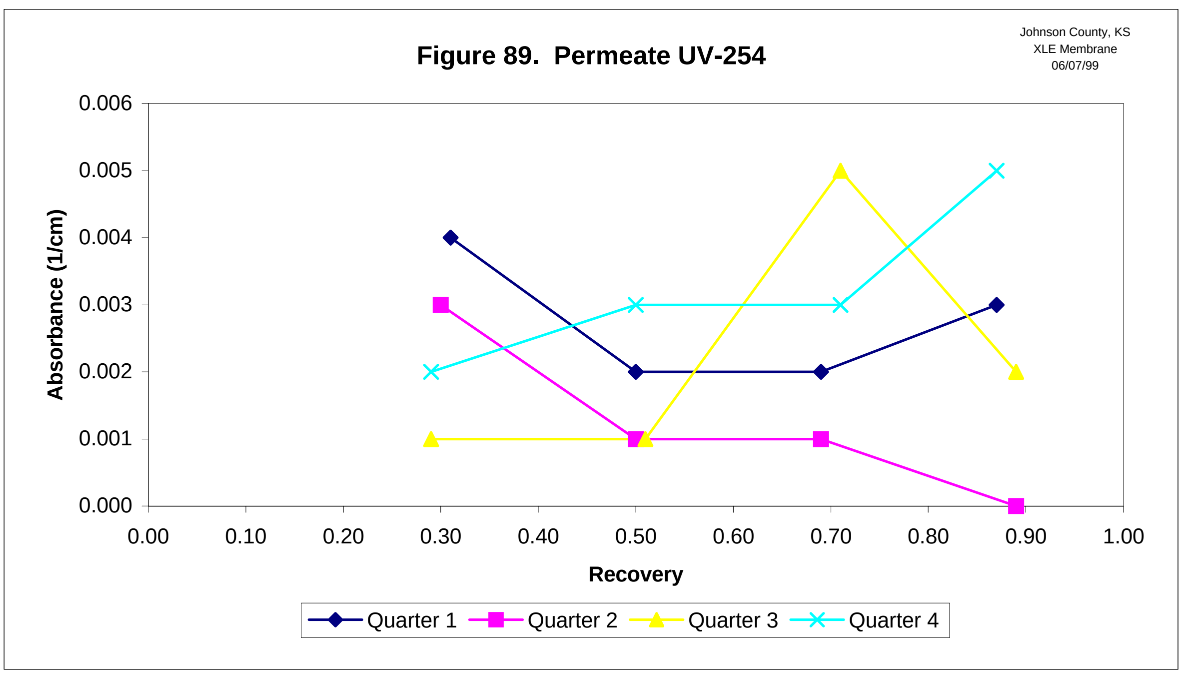


Figure 62. Water Mass Transfer Coefficient, MTCw
Johnson County, KS
XLE Membrane
06/07/99
MTCw (gfd/psi)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100
120
140
160
180
200
Operation time (hours)
Quarter 1
Quarter 2
Quarter 3
Quarter 4


Johnson County, KS
XLE Membrane
06/07/99
Figure 88. Permeate TOC
TOC Concentration (mg/L)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Recovery
Quarter 1
Quarter 2
Quarter 3
Quarter 4


Johnson County, KS
XLE Membrane
06/07/99
Figure 89. Permeate UV-254
Absorbance (1/cm)
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Recovery
Quarter 1
Quarter 2
Quarter 3
Quarter 4

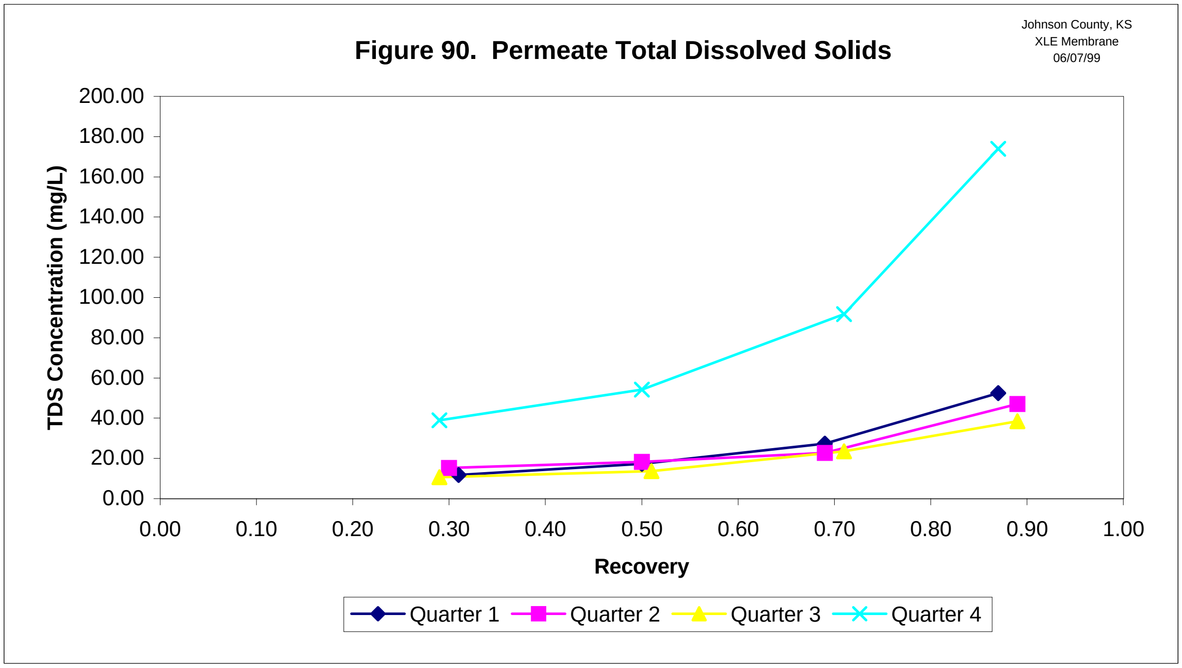


Figure 90. Permeate Total Dissolved Solids
Johnson County, KS
XLE Membrane
06/07/99
TDS Concentration (mg/L)
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
Quarter 1
Quarter 2
Quarter 3
Quarter 4

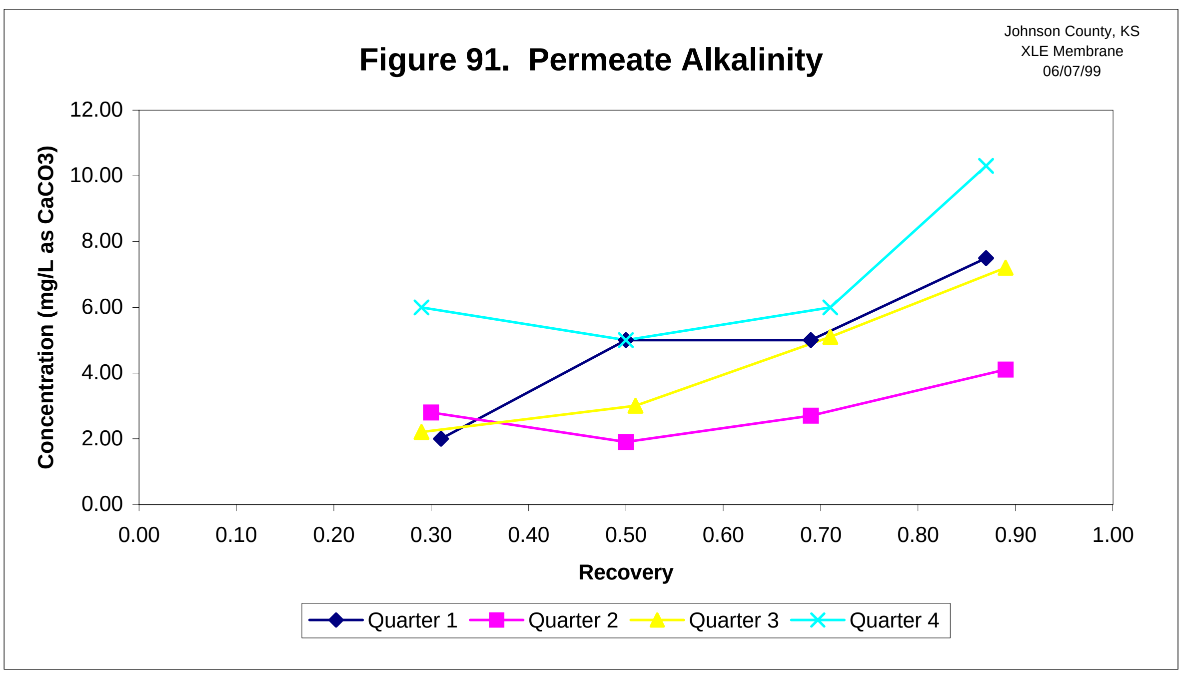


Figure 91. Permeate Alkalinity
Johnson County, KS
XLE Membrane
06/07/99
Concentration (mg/L as CaCO3)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
Quarter 1
Quarter 2
Quarter 3
Quarter 4

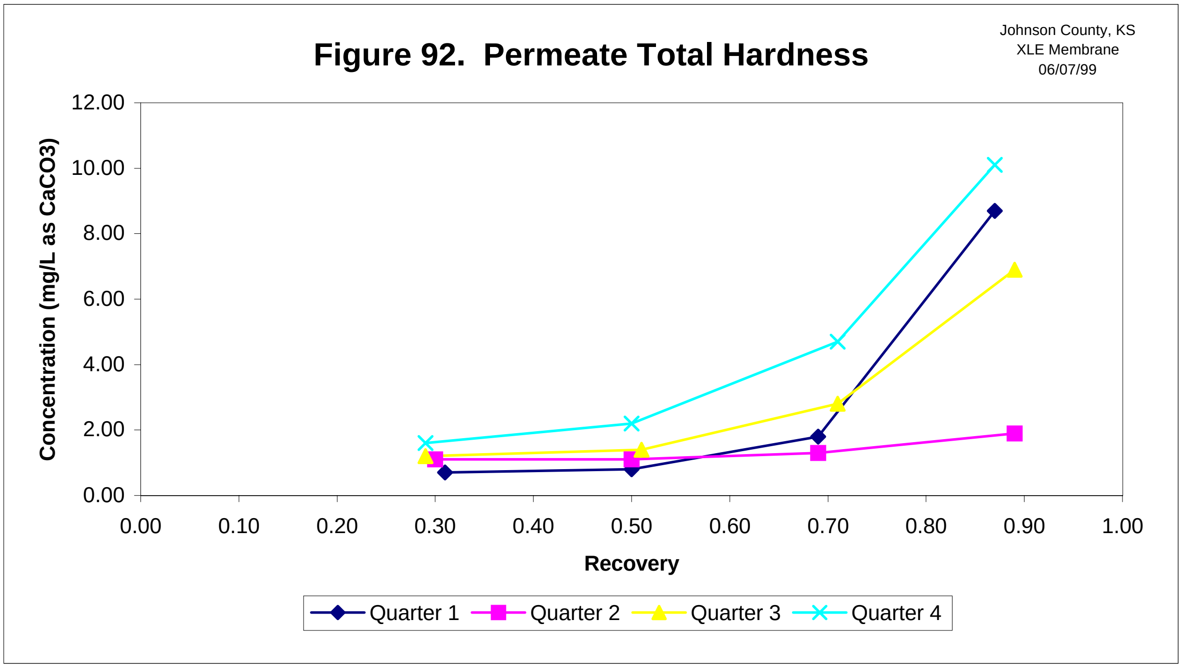


Figure 92. Permeate Total Hardness
Johnson County, KS
XLE Membrane
06/07/99
Concentration (mg/L as CaCO3)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
Quarter 1
Quarter 2
Quarter 3
Quarter 4

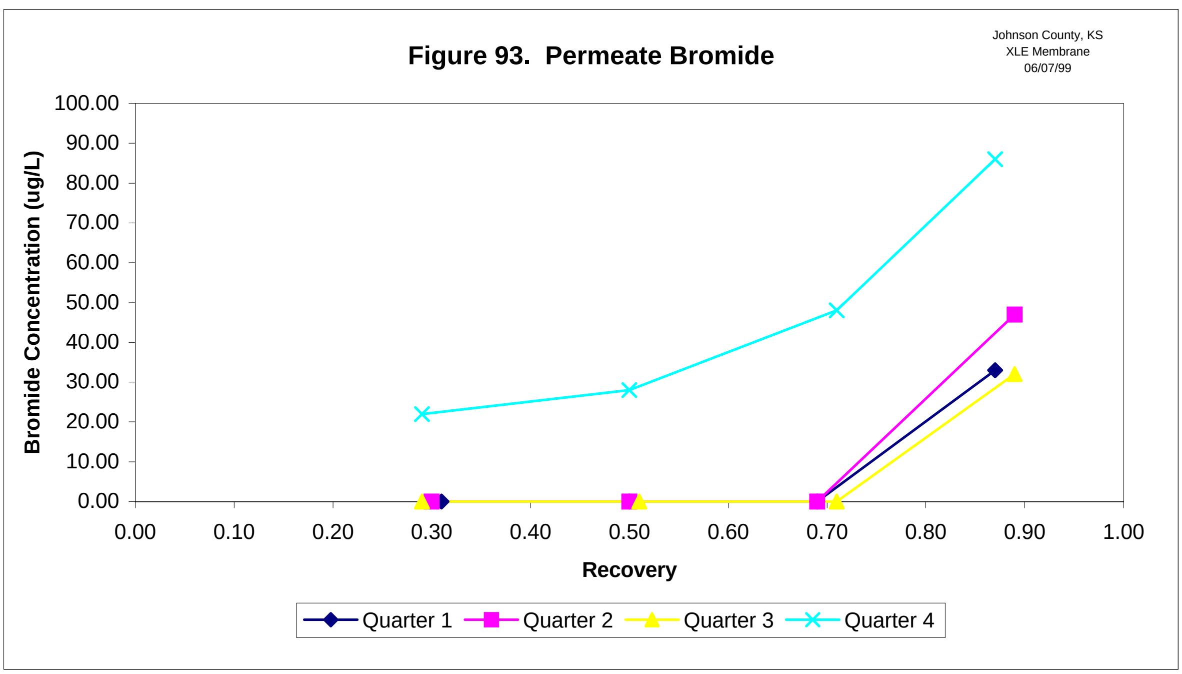


Figure 93. Permeate Bromide
Johnson County, KS
XLE Membrane
06/07/99
Bromide Concentration (ug/L)
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
Quarter 1
Quarter 2
Quarter 3
Quarter 4

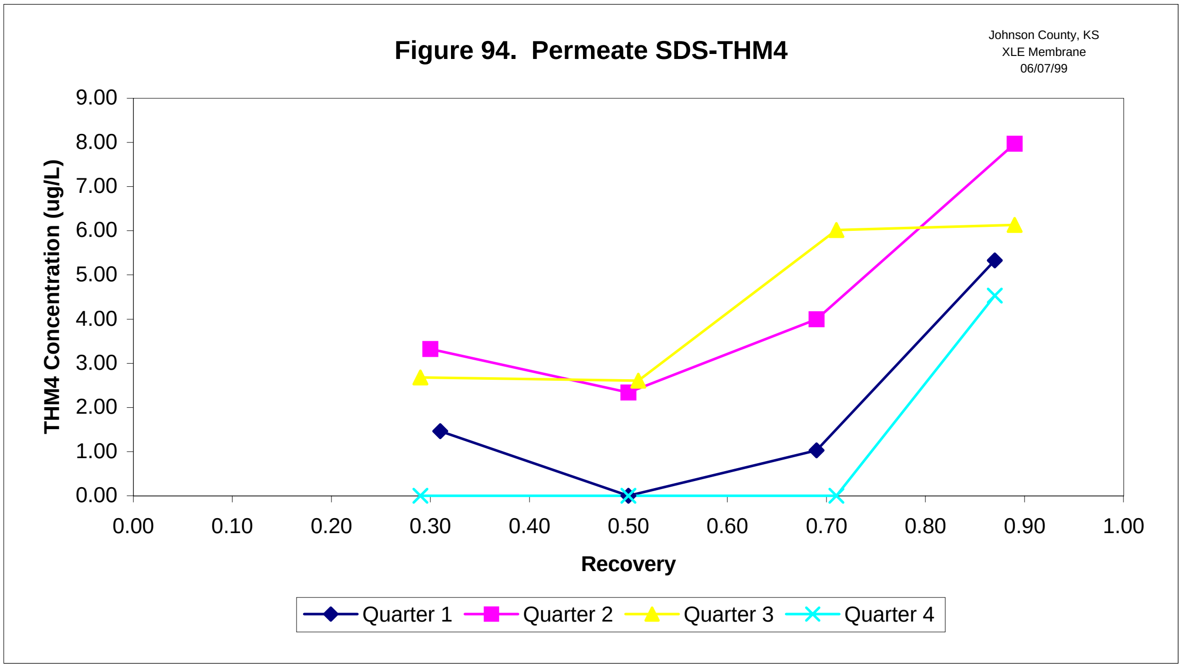


Figure 94. Permeate SDS-THM4
Johnson County, KS
XLE Membrane
06/07/99
THM4 Concentration (ug/L)
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
Quarter 1
Quarter 2
Quarter 3
Quarter 4

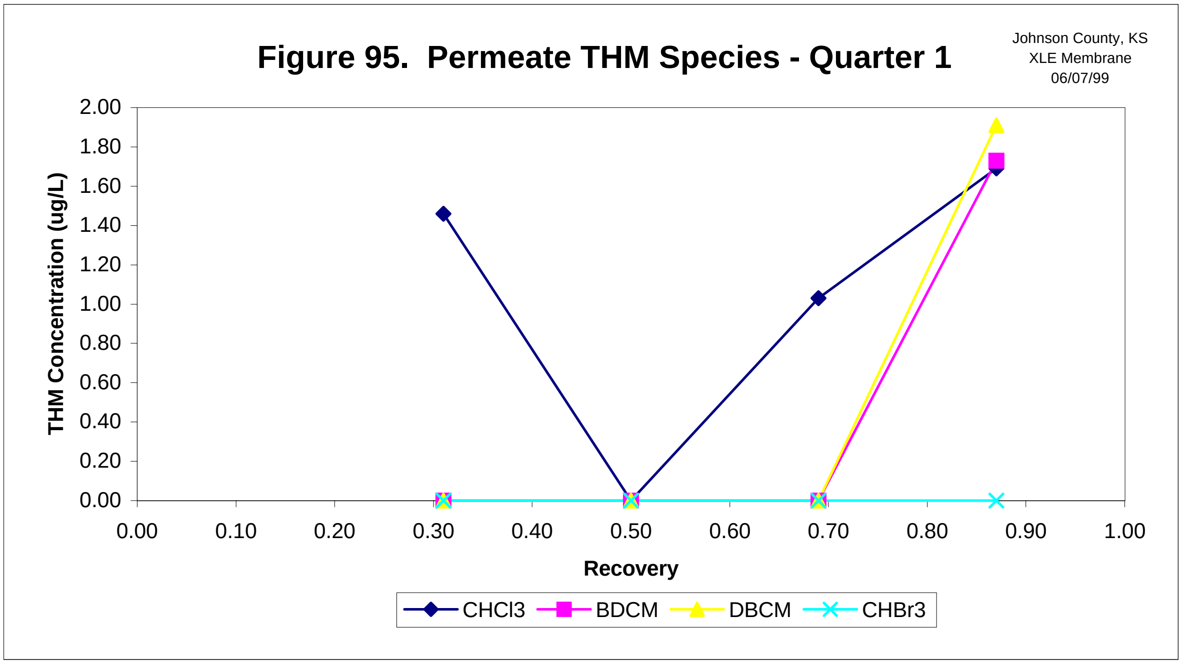


Figure 95. Permeate THM Species - Quarter 1
Johnson County, KS
XLE Membrane
06/07/99
THM Concentration (ug/L)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
CHCl3
BDCM
DBCM
CHBr3

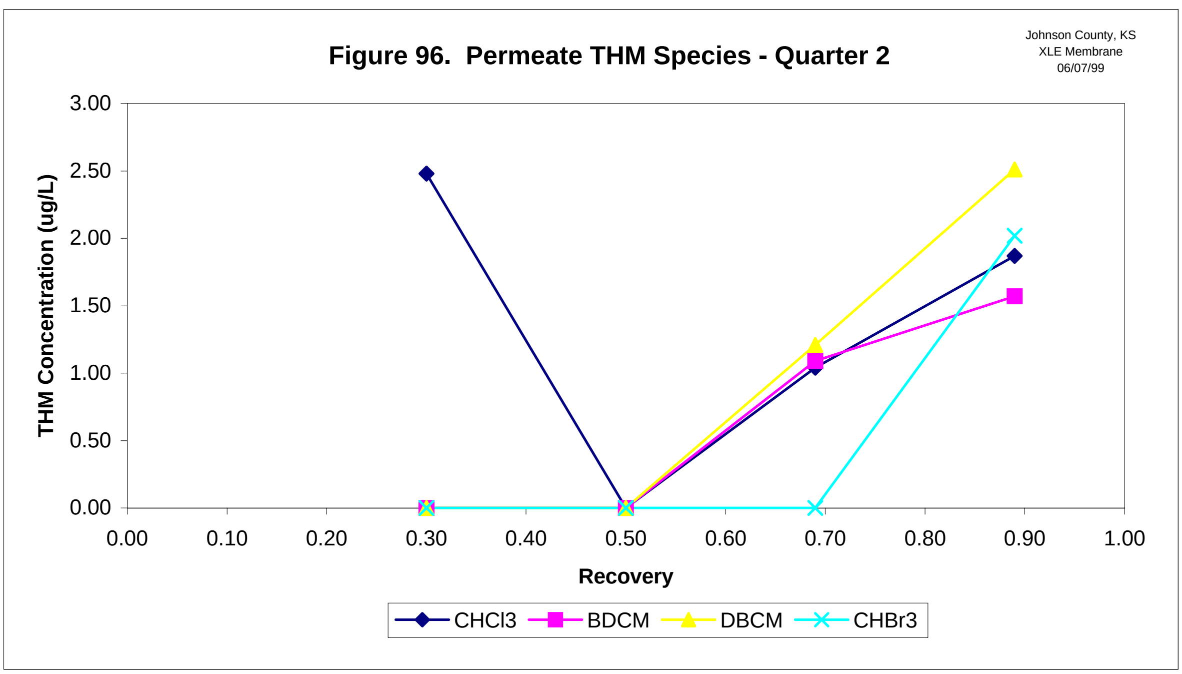


Figure 96. Permeate THM Species - Quarter 2
Johnson County, KS
XLE Membrane
06/07/99
THM Concentration (ug/L)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
CHCl3
BDCM
DBCM
CHBr3

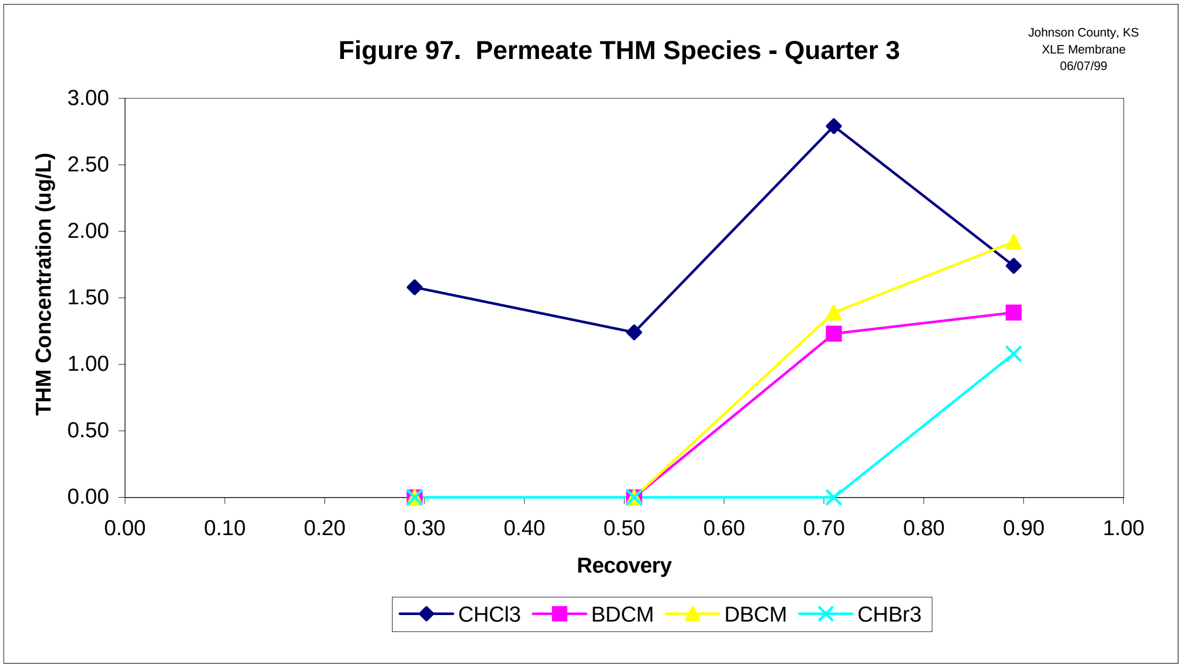


Figure 97. Permeate THM Species - Quarter 3
Johnson County, KS
XLE Membrane
06/07/99
THM Concentration (ug/L)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
CHCl3
BDCM
DBCM
CHBr3

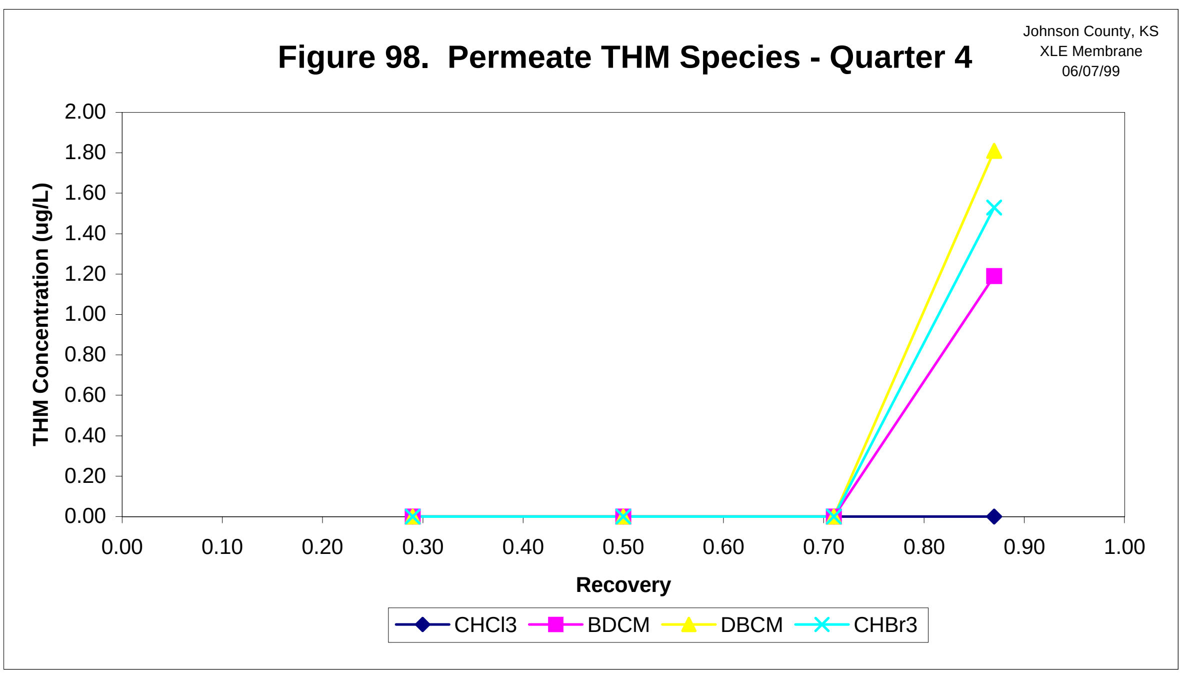


Figure 98. Permeate THM Species - Quarter 4
Johnson County, KS
XLE Membrane
06/07/99
THM Concentration (ug/L)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
CHCl3
BDCM
DBCM
CHBr3

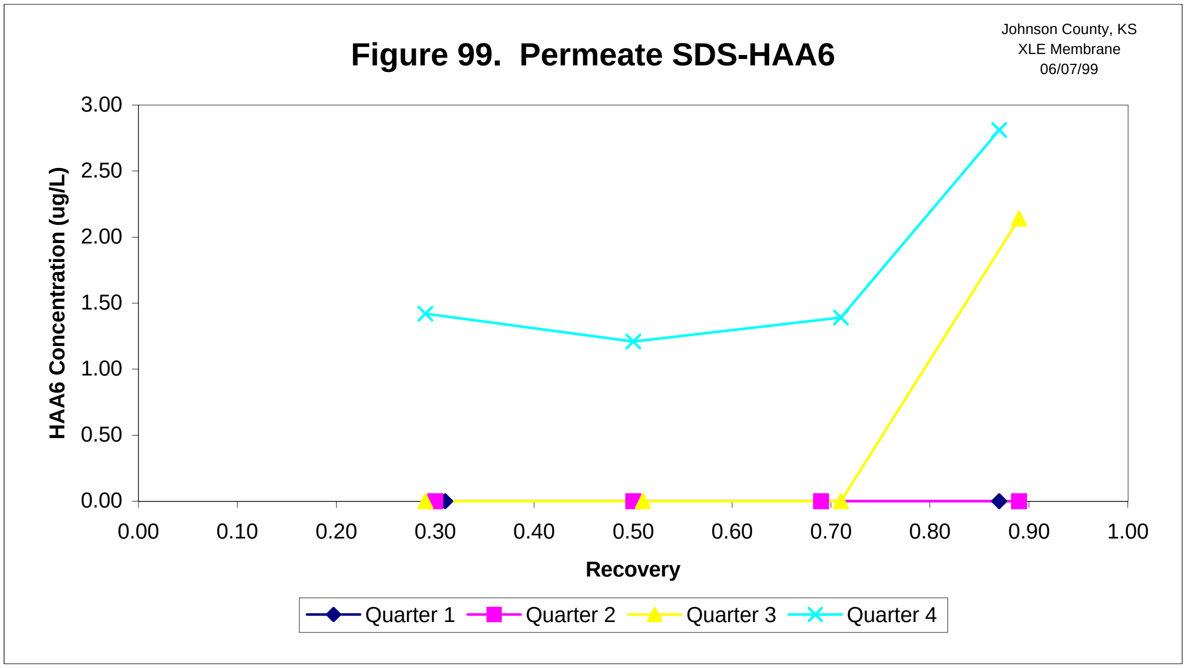


Figure 99. Permeate SDS-HAA6
Johnson County, KS
XLE Membrane
06/07/99
HAA6 Concentration (ug/L)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
Quarter 1
Quarter 2
Quarter 3
Quarter 4

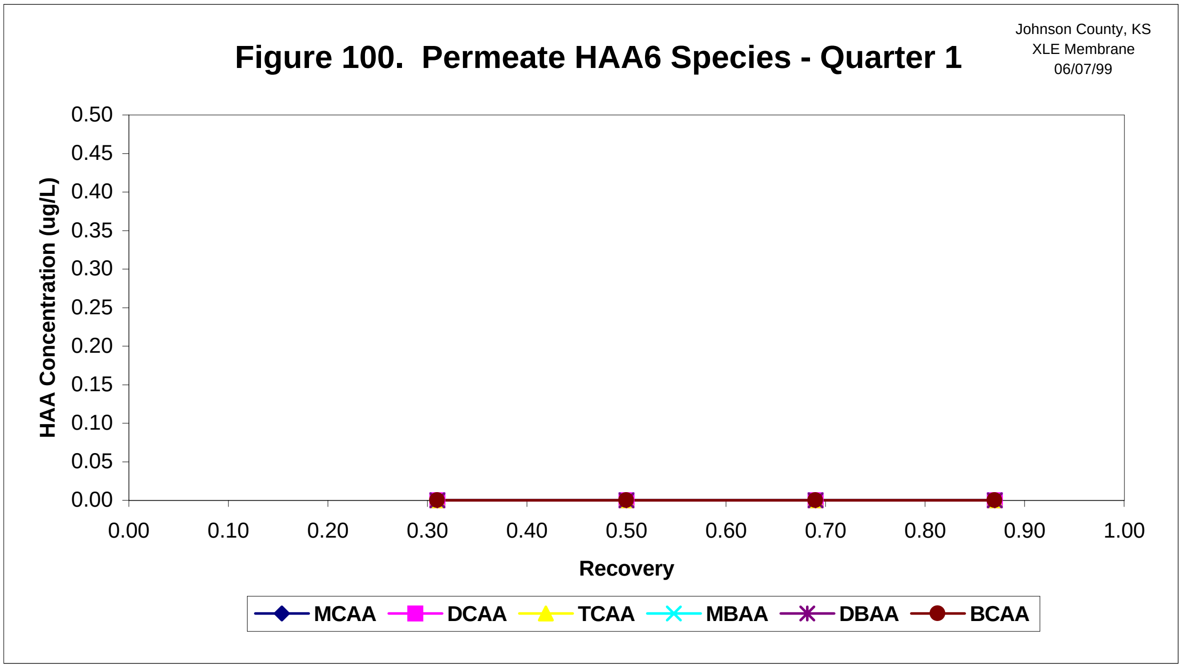


Figure 100. Permeate HAA6 Species - Quarter 1
Johnson County, KS
XLE Membrane
06/07/99
HAA Concentration (ug/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

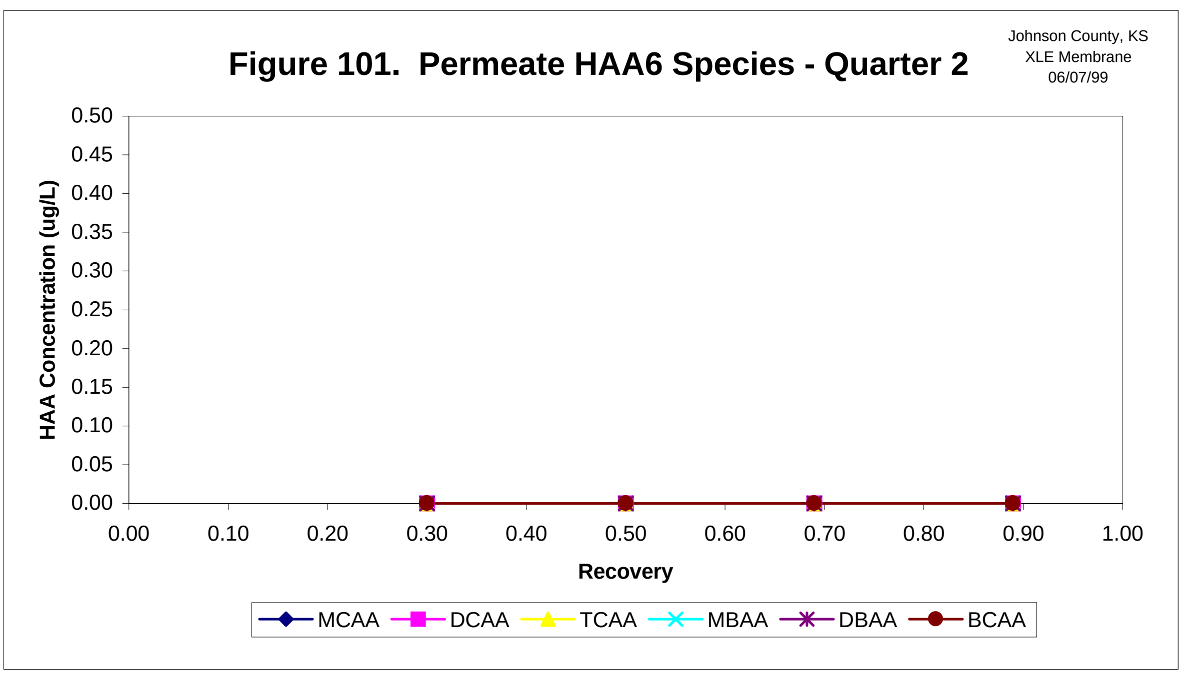
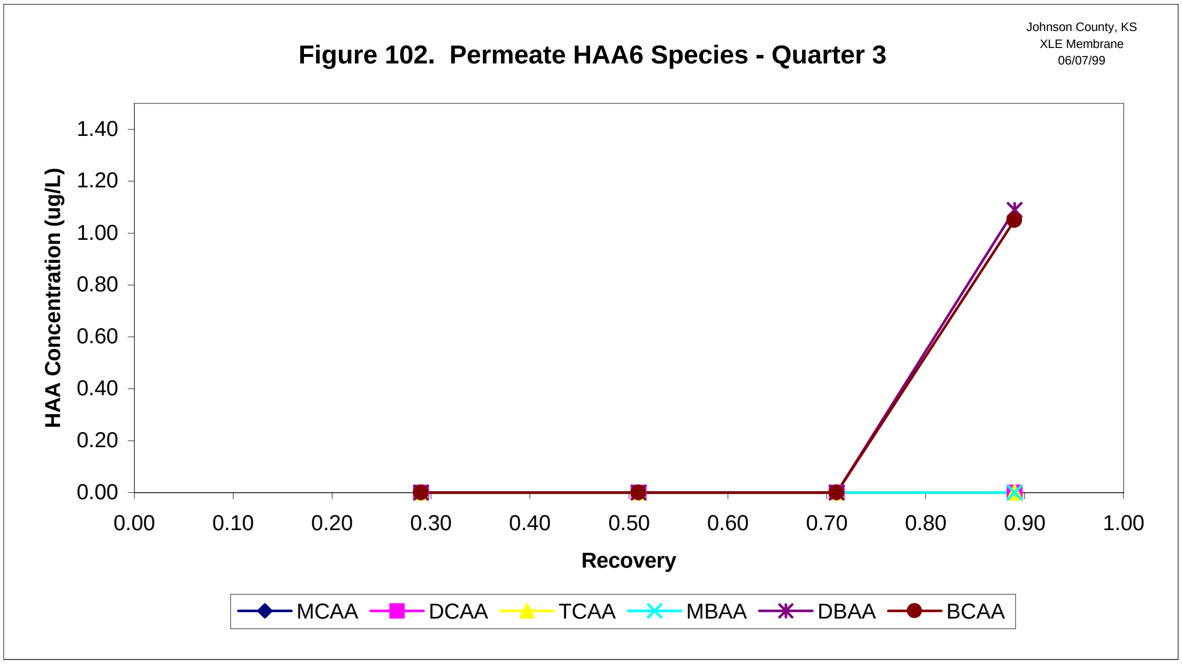
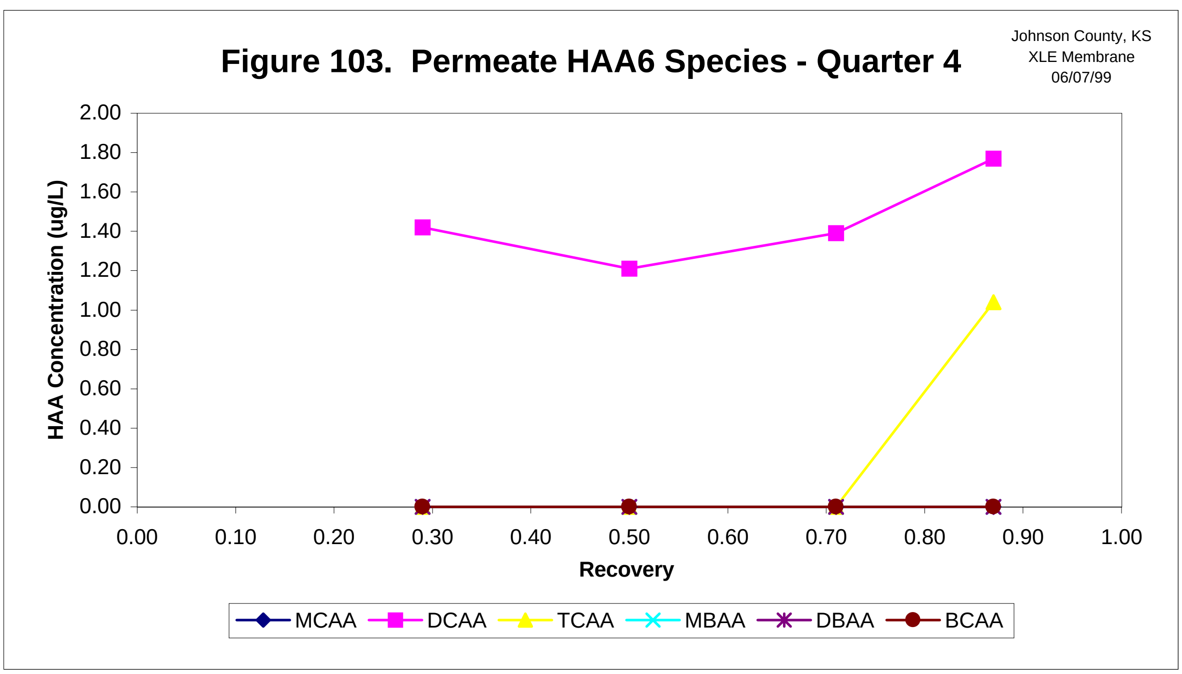


Figure 101. Permeate HAA6 Species - Quarter 2
Johnson County, KS
XLE Membrane
06/07/99
HAA Concentration (ug/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA


Johnson County, KS
XLE Membrane
06/07/99
Figure 102. Permeate HAA6 Species - Quarter 3
HAA Concentration (ug/L)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA


Johnson County, KS
XLE Membrane
06/07/99
Figure 103. Permeate HAA6 Species - Quarter 4
HAA Concentration (ug/L)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Recovery
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

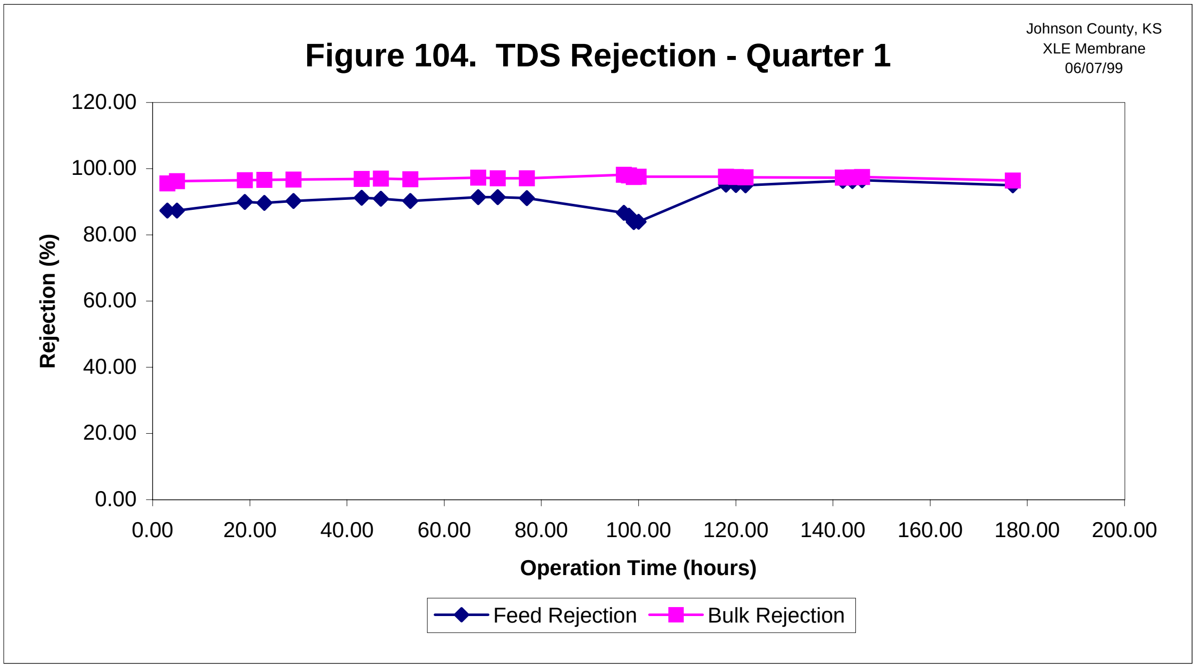


Figure 104. TDS Rejection - Quarter 1
Johnson County, KS
XLE Membrane
06/07/99
Rejection (%)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
Feed Rejection
Bulk Rejection

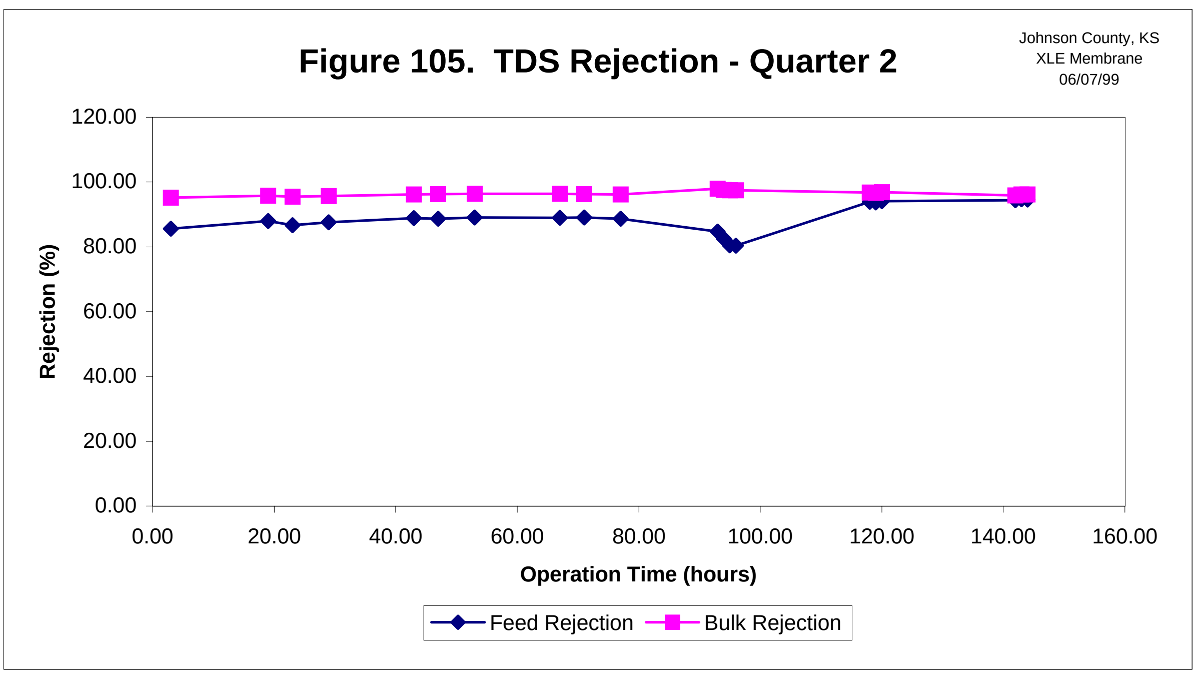


Figure 105. TDS Rejection - Quarter 2
Johnson County, KS
XLE Membrane
06/07/99
Rejection (%)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
Feed Rejection
Bulk Rejection

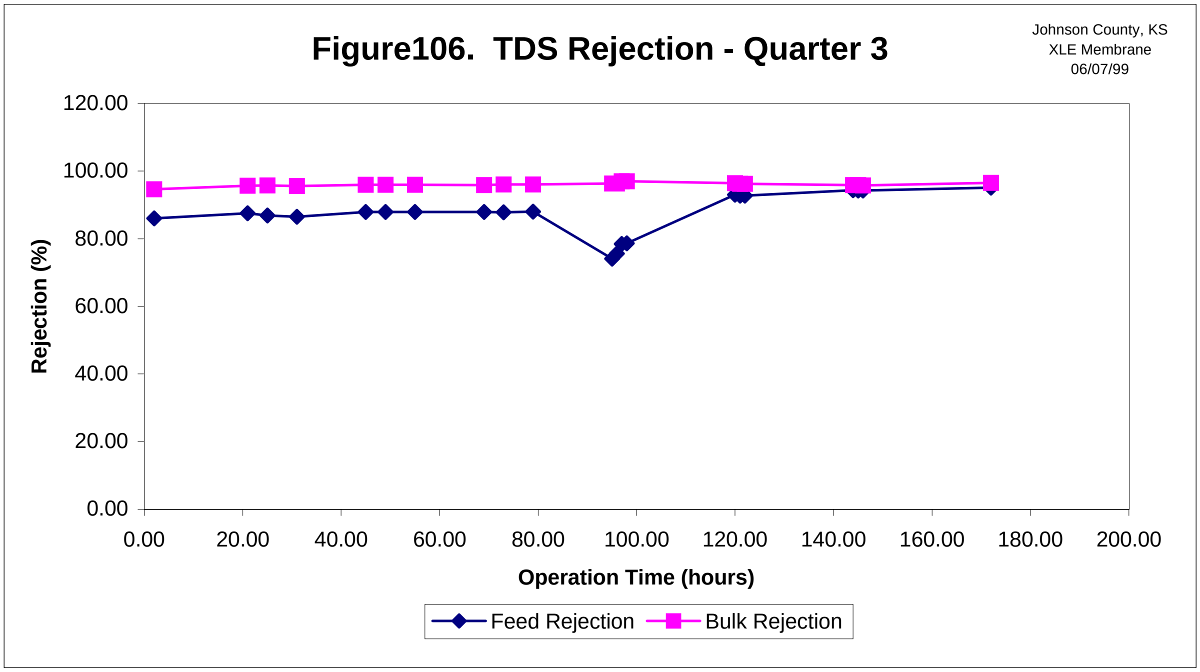


Figure106. TDS Rejection - Quarter 3
Johnson County, KS
XLE Membrane
06/07/99
Rejection (%)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
Feed Rejection
Bulk Rejection

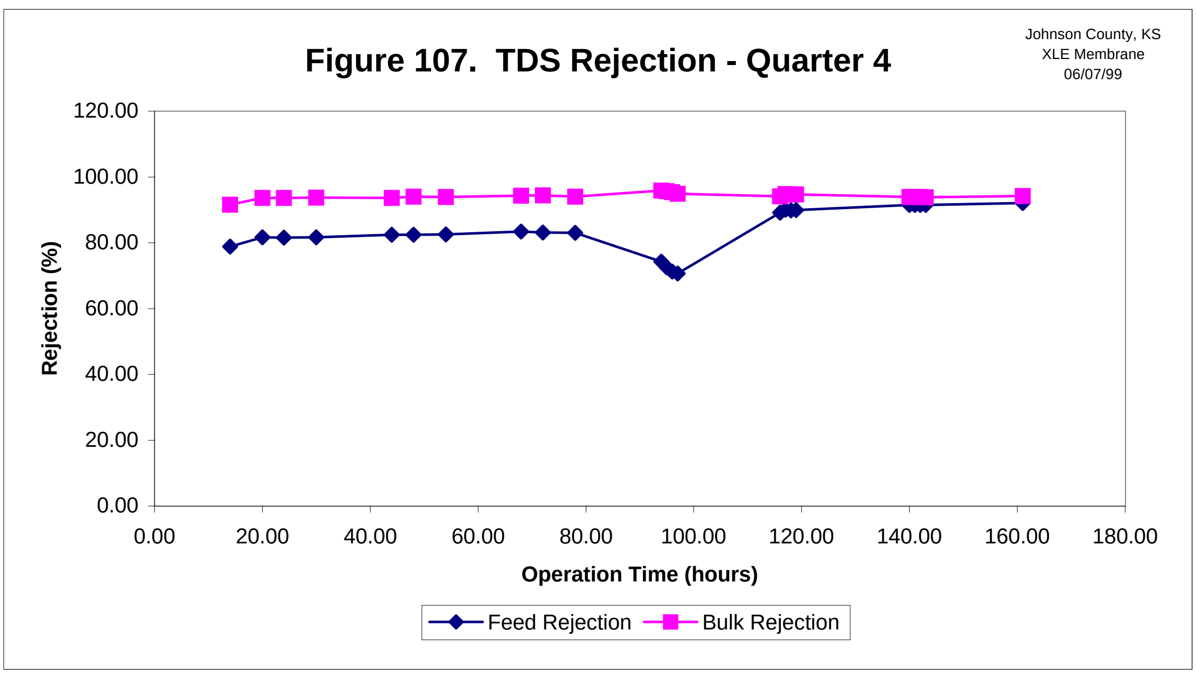
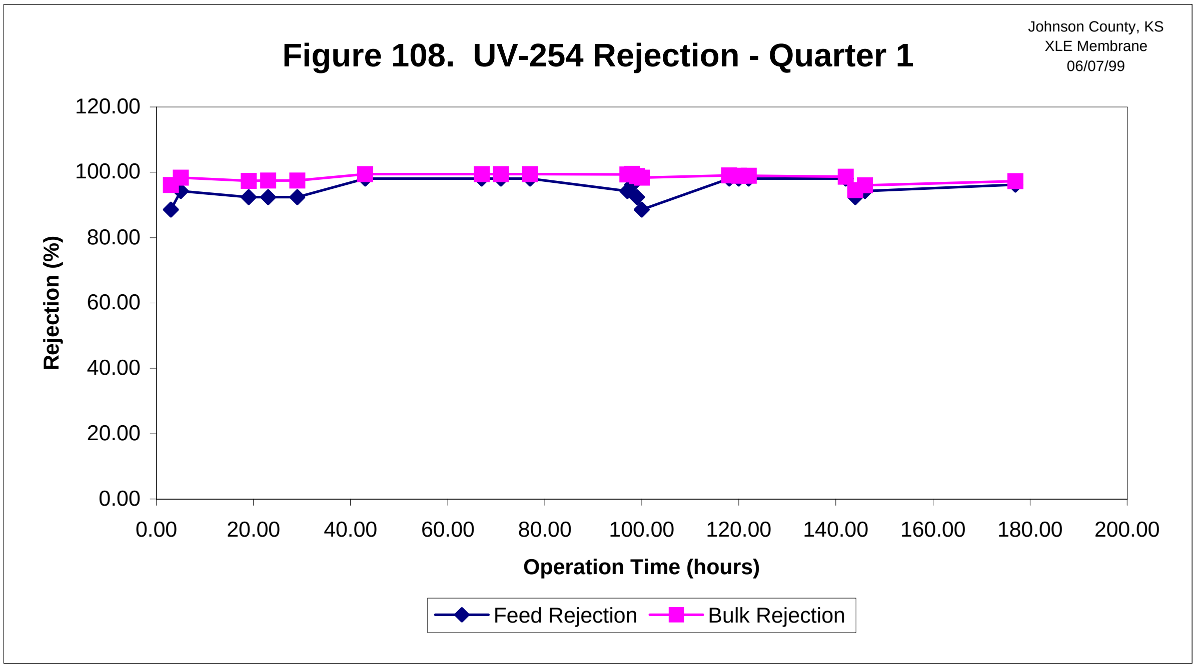
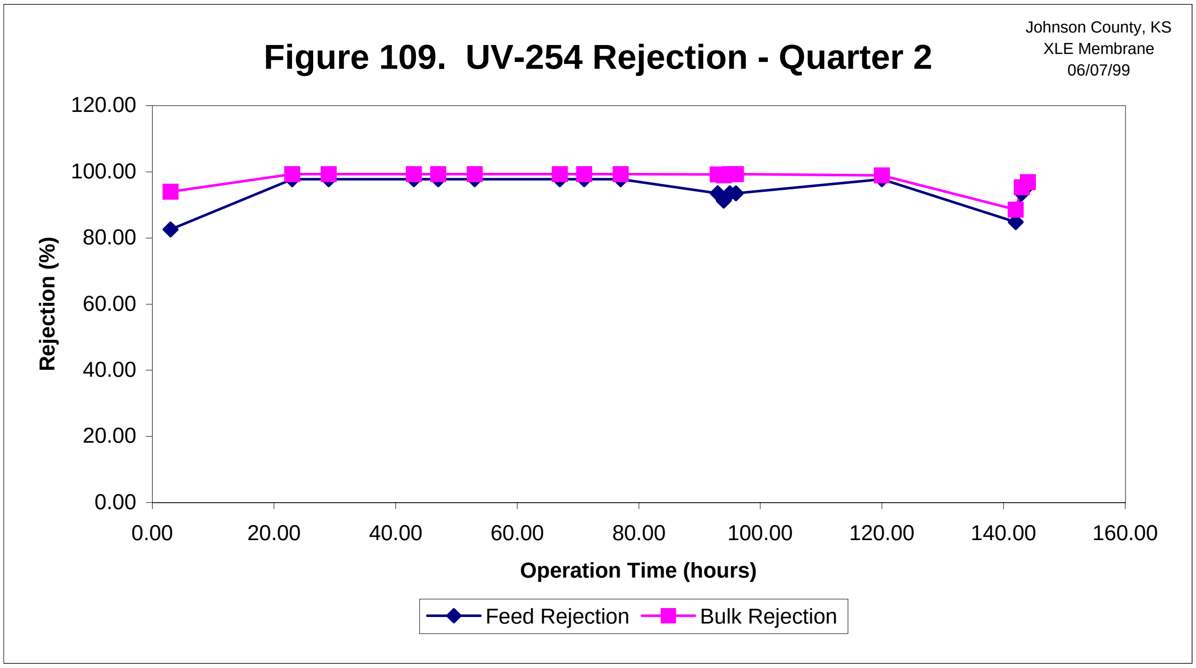
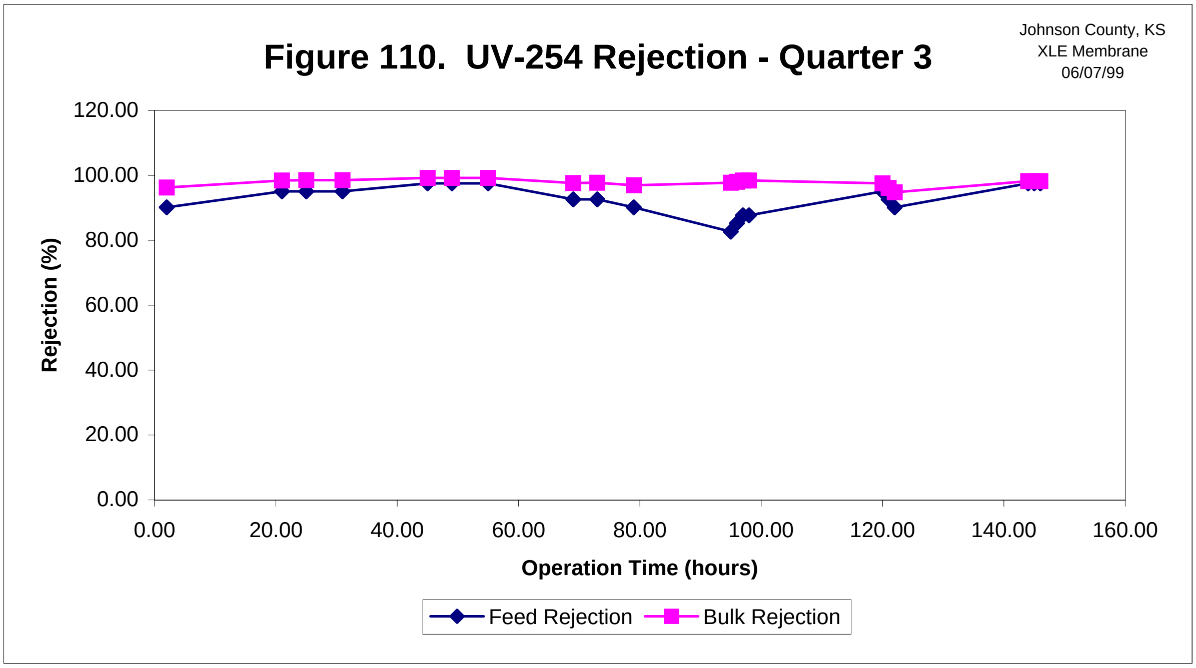
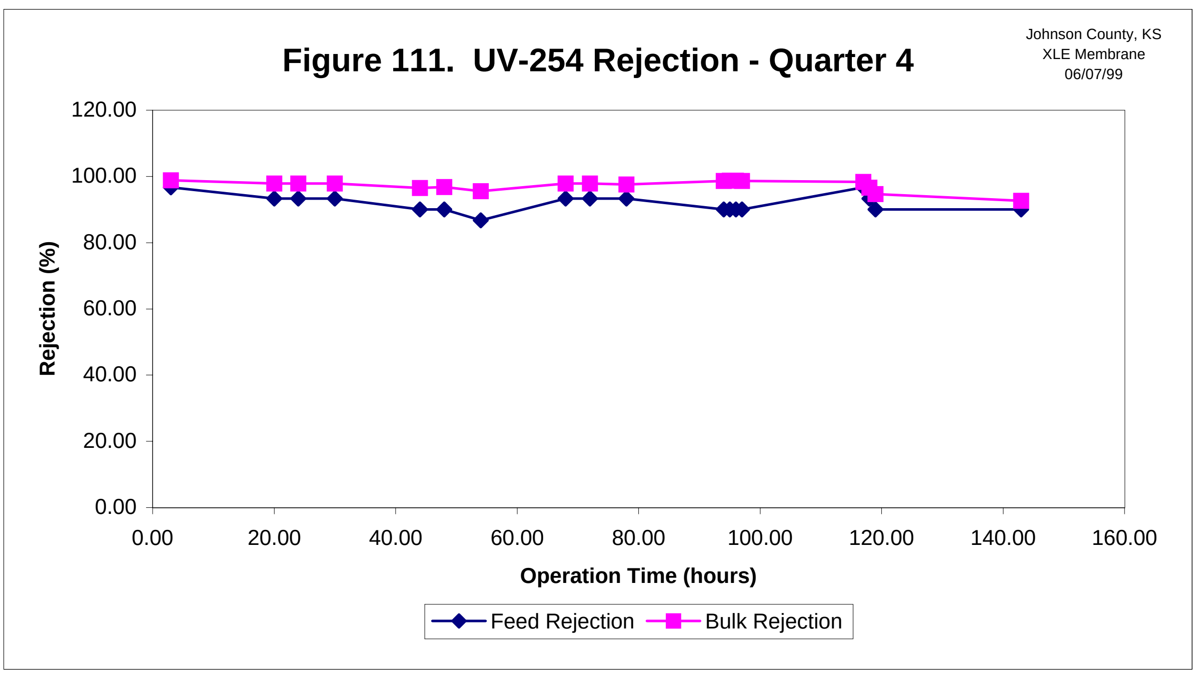


Figure 107. TDS Rejection - Quarter 4
Johnson County, KS
XLE Membrane
06/07/99
Rejection (%)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
Operation Time (hours)
Feed Rejection
Bulk Rejection


Johnson County, KS
XLE Membrane
06/07/99
Figure 108. UV-254 Rejection - Quarter 1
Rejection (%)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Operation Time (hours)
Feed Rejection
Bulk Rejection


Johnson County, KS
XLE Membrane
06/07/99
Figure 109. UV-254 Rejection - Quarter 2
Rejection (%)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
Feed Rejection
Bulk Rejection


Johnson County, KS
XLE Membrane
06/07/99
Figure 110. UV-254 Rejection - Quarter 3
Rejection (%)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
Feed Rejection
Bulk Rejection


Johnson County, KS
XLE Membrane
06/07/99
Figure 111. UV-254 Rejection - Quarter 4
Rejection (%)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Operation Time (hours)
Feed Rejection
Bulk Rejection