Marco Island Water System Conceptual Treatment Alternative and SWTR Planning Study

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Prepared For

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1.0 Introduction

1. **Meet Regulations** - Regulatory considerations should be focused on achieving standard water quality goals throughout the water system. Pathogens and disinfection by-products are the two primary constituents of concern; however, turbidity, and corrosion have been identified as important water quality parameters that may warrant further scrutiny. Although it is difficult to predict possible ramifications of future water regulations, the alternative should be as flexible as possible to accommodate new regulations. Appendix A present a review of water quality regulations.
2. **Maintain Water Quality and Stability** - The treatment alternative should produce water that is chemically and biologically stable to minimize chemical impacts and biological re-growth potential in the distribution system. Chemical treatment would need to address inorganic; organic; radionuclide; and microbial parameters. The alternative should have flexibility in regard to changes in water quality and yet maintain water quality control.
3. **Provide Aesthetically Pleasing Water** - Total water quality management would include those parameters that have secondary and/or perceptive impacts, the most common of which are clarity, and taste and odor. Aesthetics are becoming a more critical factor that public water systems must now address on a daily basis.
4. **Ease of Operation, Proven Technology and Durability** - The alternatives should be easy to operate and reliable. Other considerations, such as noise, aesthetics, risk and safety, limited residuals production and disposal, proven technology, durability, and permitting are additional factors to consider.

The goals along with enhancements investigated for the MIWS are presented in Table 1.2. The goals at the MIWS are based on the evaluation of existing conditions on the system and recent trends in the water industry. Again, the system consists of a LS and an RO facility each located on opposite ends of the island. It is desired to increase the capacity and water quality of the overall system while reducing operational cost.

Many of the proposed and anticipated regulations currently being considered by the USEPA will have a significant impact on contaminant monitoring throughout the MIWS. Since the final outcome of the proposed and anticipated SDWA rules remain uncertain, the treatment alternatives selected for the MIWS should be those processes that allow the most flexibility in design, modification, and implementation. For example, two revised rules, the ESWTR and the D/DBP can be considered to be in conflict with one another. The objective of the D/DBP is to reduce residual amounts of disinfectants in the water whereas the objective of the ESWTR is to reduce pathogens in the water. These two rules are in opposition because to comply with the ESWTR, the level of disinfection must be increased which may produce additional DBPs, but the D/DBP necessitates the reduction of disinfectant residuals. Consequently, the ESWTR would be a constraint relative to the D/DBP rule. Therefore processes that allow flexibility should be investigated.

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List of Abbreviations

$/kW-hr	dollars per kilowatt-hour
°C	degrees Celsius
µg/L, ppb	micrograms per liter
µm	micrometer
ANOVA	analysis of variance
AOC	assimable organic carbon
ASR	Aquifer Storage/Recovery
AWWA	American Water Works Association
BCAA	bromochloroacetic acid
Boyle	Boyle Engineering Corporation
BW	brackish water
C	carbon
CaCH	calcium carbonate hardness
$CaCO_3$	calcium carbonate
CaNCH	calcium non-carbonate hardness
CaO	calcium oxide (slaked lime)
CFR	Code of Federal Regulations
$CHBr_3$	bromoform
$CHCl_2Br$	dichlorobromoform
$CHCl_3$	chloroform
$CHClBr_2$	dibromochloroform
Cl_2	chlorine
cm	centimeter
cm^{-1}	1/centimeter
CO_2	carbon dioxide
CT	disinfection concentration at the end of contact time
D/DBP	Disinfectant - Disinfect By-Products
DBAA	dibromacetic acid
DBP	Disinfection By-Products
DBPFP	Disinfection By-Product Formation Potential
DCAA	dichloroacetic acid
DEP, FDEP	Florida Department of Environmental Protection
DI	deionized water
DO	dissolved oxygen
DOC	dissolved organic carbon
DWPL	Drinking Water Priority List
DWRD	Drinking Water Research Division

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EPA, USEPA	United States Environmental Protection Agency
eq	equivalents
ESEI	Environmental Systems Engineering Institute
ESWTR	Enhanced Surface Water Treatment Rule
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
$Fe_2(SO_4)_3$, FS	ferric sulfate
$FeCl_3$, FC	ferric chloride
Florida Water	Florida Water Services Corporation
FR	Federal Register
ft	feet
ft^2	square feet
ft^3/day	cubic feet per day
F_w	water flux
GAC	granular activated carbon
gpd	gallons per day
gpd/ft^2, gsfd	gallons per square foot day
gpm	gallons per minute
gpm/ft^2, gsfm	gallons per square foot minute
GWDR	Ground Water Disinfection Rule
H_2SO_4	sulfuric acid
HAA	haloacetic acid
HAAFP	haloacetic acid formation potential
HCO_3^-	alkalinity
HPC	hetrotrophic plate count
IOC	inorganic compounds
kgal	1000 gallons
L	liter
lb	pound
LCR	Lead and Copper Rule
LS	Marco Island Lime Softening Plant
MBAA	monobromoacetic acid
MCAA	monochloroacetic acid
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDRL	Maximum Disinfectant Residual Level
meq/L	milliequivalent per liter
MF	microfiltration
mg/L	milligrams per liter

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mg/L, ppm	milligram per liter
MGD	million gallons per day
MgH	magnesium hardness
MIWS	Marco Island Water System
mL	milliliter
MOR	monthly operating reports
mrem	effective radiation dosage to organs
N	nitrogen
N/A	not applicable
NaOH	sodium hydroxide (caustic)
NF	nanofiltration
NH_3	ammonia
NIPDWR	National Interim Primary Drinking Water Regulations
nm	nanometer
NOM	natural organic matter
NPDOC	non-purgeable dissolved organic carbon
NPDWR	National Primary Drinking Water Regulations
NTU	Nephelometric turbidity units
O & M	operations and maintenance
O_2	oxygen
O_3	ozone
P	phosphorous
PAC	powdered activated carbon
pC	log speciation concentration
pCi/L	picocuries per liter
psi	pounds per square inch
PtCo, CPU	platinum cobalt units
PWS	public water system
QA/QC	quality assurance/ quality control
R^2	correlation coefficient
RCRA	Resource Conservation Recovery Act
reg-neg	negotiated rule - making process
RO	Marco Island Reverse Osmosis Plant
ROWTP	reverse osmosis water treatment plant
rpm	revolutions per minute
RSD	relative standard deviation
s^{-1}	1/second
SCU	solids contact unit
SDI	silt density index

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SDS	Simulated Distribution System
SDWA	Safe Drinking Water Act
S_g	specific gravity
SiO_2	silica oxide
SLR	surface loading rate
SM*	Standard Methods
SMCL	Secondary Maximum Contaminant Levels
SO_4^{-3}	sulfate
SOC	synthetic organic compounds
SS	suspended solids
SSU	Southern States Utilities, Inc.
SV	settling velocity
SW	salt water
SWTR	Surface Water Treatment Rule
T_{10}	time at 10% concentration
TCAA	trichloroacetic acid
TCE	trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TCR	Total Coliform Rule
TDS	total dissolved solids
TFC	thin-film composite
TH	total hardness
THAA	total haloacetic acid
THAAFP	total haloacetic acid formation potential
THM	trihalomethane
THMFP	trihalomethane formation potential
TOC	total organic carbon
TSS	total suspended solids
TT	treatment technique
TT	treatment technique
TTHM	total trihalomethane
TTHMFP	total trihalomethane formation potential
UCF	University of Central Florida
UF	ultrafiltration
USF	University of South Florida
UV-254	ultra-violet @ 254 wavelength
VFD	variable frequency drive
VOC	volatile organic compounds
WTP	water treatment plant

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Executive Summary

The Marco Island Water System (MIWS) Conceptual Treatment Alternatives and Surface Water Treatment Rule (SWTR) Planning Study was prepared by Boyle Engineering Corporation. This water quality plan was developed as part of an evaluation of the existing conditions and current performance of the lime softening (LS) and reverse osmosis (RO) facilities relative to compliance with existing and future regulations. This study was conducted to evaluate long-range treatment alternatives for expanding capacity and enhancing water quality within the MIWS.

Findings

LS WTP

1. Evaluation of historical data confirmed that:
   - The LS plant has difficulty in complying with natural organic matter removals.
   - The LS plant has dissolved aluminum passing through the filters.
   - The LS plant has difficulty with settling of the chemical precipitant.
   - The LS plant chemical dosing amounts need adjustment for enhanced treatment.
2. Laboratory enhanced lime-softening jar testing indicated that:
   - Ferric sulfate and ferric chloride settled two times faster than alum.
   - During softening magnesium hydroxide precipitation enhanced organic removal.
   - Increasing the total suspended solids (TSS) concentration of the settled sludge can reduce sludge volume, but the sludge blow-down rate would have to be adjusted for a higher TSS concentration.
3. Plant operations investigations indicated that
   - Turbidity carry-over from the clarifier is limiting filter performance at the LS plant.
   - *Cryptosporidium* and *Giardia* was found to be absent in the MIWS

RO WTP

1. Evaluation of historical data confirmed that:
   - The RO plant is producing a finished water that meets current and proposed future drinking water regulations.
   - Train No. 5 at the RO plant is consistently producing more finished water at a higher

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quality than Trains 1 through 4.

2. Plant operations investigations indicated that:
   - Interstage turbine booster pumps on Train No. 5 demonstrated energy recovery.
3. Membrane modeling performance projections indicated that:
   - Computer modeling indicates that blending of surface water or surficial well water with brackish RO WTP feedwater is a viable alternative that warrants further investigation.
   - Elimination of sulfuric acid addition to RO WTP trains 1 through 4 is possible, but expect to see a slightly higher degree of salt passage to the permeate.

General

1. Bench-scale treatability evaluations demonstrated that membrane processes produced a superior finished water quality versus enhanced lime softening and ion-exchange processes.
2. Membranes were short listed for long-range planning of a new facility.

Recommendations

Immediate Modifications

LS WTP

1. Adjust chemical dosing concentrations to more efficient feed rates.
2. Increase pH to 10.3 for enhanced organic removal using caustic and stabilize pH with recarbonation units or H_2SO_4 addition to pH 8.3 prior to filtration.
3. Continue to monitor turbidity, aluminum, pH, temperature, chemical dose and flow throughout the LS plant.
4. Replace the use of alum with ferric salts for turbidity and pH adjustment to increase organic removal.
5. Measure sludge discharge rates and percent TSS in discharged sludge.

RO WTP

1. Retrofit the original four RO trains with interstage turbine booster pumps.
2. Expand the RO plant by 1 MGD via installation of Train No. 6.

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3. The membrane replacement program should be initiated after retrofit of the original four skids with interstage boosters.

General

1. Initiate pilot testing of membrane softening using Marco Lakes as a raw water supply to prepare for future regulations and expansions.
2. Initiate pilot testing of brackish water membranes for blending of source waters and reduce TDS in feedwater of the RO WTP.
3. Eliminate the use of sulfuric acid as a pretreatment to the RO WTP.

Long-Range Treatment Alternatives

1. Move forward with the development of long-range treatment alternatives for construction of a new softening facility while implementing immediate modifications to the LS and RO WTPs.
2. Perform a site identification and location alternatives planning study in order to evaluate the advantages and disadvantages related to the placement of a new membrane softening WTP either on the mainland or at some location on Marco Island.
3. Florida Water should work towards retiring the Marco Island and Marco Shores LS plants.
4. Use the Marco Island LS site to allow additional land area for alternative uses.

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Report Summary

The Marco Island Water System (MIWS) Conceptual Treatment Alternatives and Surface Water Treatment Rule (SWTR) Planning Study was prepared by Boyle Engineering Corporation. This water quality plan was developed as part of an evaluation of the existing conditions and current performance of the lime softening (LS) and reverse osmosis (RO) facilities relative to compliance with existing and future regulations. This study was conducted to evaluate long-range treatment alternatives for expanding capacity and enhancing water quality within the MIWS.

Objectives

The objective of this report is to develop guidance for Florida Water in making decisions for immediate, short-term and long range treatment alternatives for meeting current and future water quality regulations. The modifications identified within this report are:

- Immediate Modifications - Improvements to current operational processes at the MIWS. Also, WTP facilities that will increase capacity and comply with current water quality regulations.
- Long-Range - Modifications that will comply with future regulations and meet projected water quantity demand.

Findings

LS Water Quality and Existing Facilities

Analysis of historical water quality data for raw and treated water confirmed the following:

- The surface loading rates on the solids contact unit (SCU) is 1.5 gsfd.
- The LS plant provides water quality that complies with inorganic parameters.
- The LS plant has difficulty with removing organic contaminants.
- Dissolved aluminum passes through the filters at the LS plant.
- The plant has difficulty with settling in the SCU.
- Plant alum and lime dosing concentrations calculations should be reviewed and adjusted to account for flow rates and chemical impurities.

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RO Water Quality and Existing Facilities

Analysis of historical water quality data for raw and treated water confirmed the following:

- The RO plant is producing a finished water that meets current and proposed drinking water regulations.
- Train No. 5 at the RO plant is consistently producing more finished water at a higher quality.

Membrane Probing Evaluation

Vessels whose average conductivity were greater than 200 umhos/cm were selected for probing. The change in average feed/brine concentration between stages was not taken into account. The probing of each selected vessel was accomplished by utilizing a length of tubing as long as a pressure vessel. This enabled sampling for conductivity measurements as the tube was pulled past each membrane in the vessel. The probing would allow the reviewer to determine if the poor performance may be caused by a defective end-cap, leaking o-ring, or possibly a failure within an element. After evaluating the performance of the probing within the vessels, the membrane elements were identified for further investigation during membrane replacement.

Membrane Interstage Retrofit Evaluation

Train No. 5 consistently showed enhanced performance with an average recovery of 74.6 %, a normalized flux of 14.8 gsfd, and a salt passage of 1.8 %. Whereas Trains No. 1 - 4 showed an average recovery of 69.9 %, a normalized flux of 13.3 gsfd, and a salt passage of 2.7 %, the recovery and flux for train No. 5 had very little variation. This shows the advantage of the interstage turbine booster.

Energy Savings Evaluation

Energy savings for each train was determined by measuring the amperage of the high-pressure feed pump used for each train and the amount of permeate water produced. This enabled the power consumption for each train to be compared to the amount of permeate water produced. Variations in raw water quality and system variations over time can be seen with the power consumption from each train. The amperage recordings of Train No. 5 exhibited the less noise at a lower amperage consumption. In addition more permeate water was produced under control from Train No. 5. Train No. 5 required 14 percent less power consumption and produced 6 percent more permeate water when compared to Train No 1 - 4.

Membrane Modeling Evaluation

Vendor-supplied computer modeling software was used to perform an evaluation using FilmTec, Fluid System and Hydranautic membranes for blending lake or surficial well water with brackish well water. The purpose of the modeling was to determine if fresh water could be used to dilute the salinity of the brackish wellfield that is used as RO WTP feedwater. In addition, the use of sulfuric acid for pretreatment was modeled for the brackish feedwater water to determine if it's use was warranted.

Blending Evaluation

Comparison of the pressures required for the surficial well and Lake Marco source waters showed very similar pressure reductions by percent blend. Therefore, these projections suggest overall feed pressure reductions by blending could equally be met by both alternative source waters. However, careful attention would need to be made for the associated pretreatment requirements necessary for sustained production using either the surface water or surficial well source. It is realized that this information could only be gathered by bench- or pilot-scale evaluation. The available water quality information on the alternative source waters reinforces the need for such evaluations prior to full-scale implementation.

Sulfuric Acid Elimination Evaluation

Sulfuric acid and antiscalant pretreatment are currently used to control the scaling potential of these two sparingly soluble salts. Given the relatively low LSI projection in the final concentrate without sulfuric acid pretreatment, it is possible that sufficient scaling control could be provided by antiscalant alone for both calcium carbonate and barium sulfate. Elimination of sulfuric acid addition would also reduce barium sulfate saturation but would be expected to allow a slightly higher degree of salt passage to the permeate.

Treatability Evaluation

Laboratory treatability evaluations were conducted using enhanced lime softening, ion-exchange and membrane processes. Membrane processes provided the highest quality water and did not require additional treatment to comply with water quality regulations when compared to ion-exchange and enhanced lime softening which produce a lower quality water and require additional treatment. The following results were observed:

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Lime Softening Treatability

- MgH removal via increased pH should be used to enhance dissolved natural organic matter removal. Caustic can be used to increase the pH to 10.3 in the SCU and recarbonation or H_2SO_4 would have to be applied to stabilize the pH to 8.3 prior to filtration. Recarbonation or sulfuric acid chemical feed facilities would have to be constructed and installed at the LS WTP to accomplish enhanced lime softening treatment.
- Turbidity, temperature, pH, flow, as well as lime, alum, chlorine and ammonia dose should be monitored from the clarifier weir and through the filters.
- Ferric salts as a settling aid should be used in place of alum, keeping in mind that pH values will not decrease as much and sludge volumes will increase. Alum addition should be terminated at the LS WTP.
- Sludge discharge rates and % TSS should be measured and evaluated to determine optimum sludge blow down rates for ferric salt additions because of the expected increase in sludge volume.

Ion-Exchange Treatability

- Ion exchange can remove organics down to 2 mg/L as non-purgeable dissolved organic carbon (NPDOC), but require frequent regeneration which will drive up operational cost and additional treatment would be required to remove hardness.
- Ion-exchange can not disinfect and the threat of microbiological contamination exists therefore additional treatment to remove or disinfect will be required.
- Maintaining anionic resin for organic removal and cationic resin hardness removal would be complex and at times could be labor intensive.

Membrane Treatability

- Membrane softening can successfully remove inorganic and organic contaminants.
- Bench-scale treatability evaluations demonstrated that membrane processes produced a superior finished water quality versus enhanced lime softening and ion-exchange processes.

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Recommendations

Recommendations for Immediate Process Modifications

Currently, the LS and RO plants each produce 5 MGD. The RO plant is expandable to 6 MGD giving an immediate total of 11 MGD for the MIWS. Immediate modifications to the RO WTP should be implemented to reduce operational costs via the installation of interstage turbines. These modifications do not account for future needed capacity, but are imperative to address problems for the near term until the future plan can be implemented.

The improvements to the LS plant should be recognized as temporary to increase capacity and improve water quality. However the improvements to the RO plant should increase capacity and lower operational costs. These immediate system improvement for MIWS have been identified in the LS enhanced lime precipitation jar test and in the RO energy recovery evaluation.

LS Immediate Modifications:

- Chemical dosing concentrations calculations should be evaluated and adjusted to better control chemical additions.
- Enhanced softening (via increased pH using caustic) should be used to remove NPDOC.
- Turbidity and flow rates should be measured at the clarifier, at the filters, after the filter and on the finished water at the point-of-entry.
- Ferric salts should be considered to help increase settleability thus increasing capacity. Also with ferric the issues with dissolved aluminum would no longer be of concern. However, color and increased sludge volumes would have to be monitored and adjusted accordingly. Sludge volumes can be theoretically calculated and a sludge blow-down rate can be derived and adjusted to compensate for the additional sludge produced.
- Sludge discharge rates and percent TSS should be measured and evaluated to determine optimum sludge blow down rates for current operations.
- Samples of raw, settled (pre- and post- chlorine addition), filtered and finished water should be collected and measured for aluminum, pH, temperature, and turbidity.
- Additional chlorine demand data, THM and HAA data for the filtration system should be collected.

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RO Immediate Modifications:

- Florida Water should proceed with a program that enhances the original membrane trains (No. 1 - 4), primarily by retrofitting each train with an interstage turbine in a similar fashion to that provided in the recent expansion (membrane train No. 5).
- Based on probe data provided by Harn R/O Systems, Inc. (203 South Jackson Road, Venice, FL 34292), the low performance membranes identified in the original four trains should be removed from service. In order to accomplish membrane replacement, an entire train should be removed from service, and the unacceptable membranes in the remaining three trains then be replaced using the best membranes taken from that train removed from service. The train that was removed from service would then be completely reloaded with new membrane elements. Any FilmTec® membranes that provided acceptable performance that were removed from the train taken out of service and was not used for replacing poor elements in the three remaining trains could be stored for future replacement needs.
- Additional enhancements that should be considered for the original four membrane trains (currently using FilmTec® elements) include:
    - replacement of the feed header pipe with a larger diameter pipe to reduce excessive velocity within the feed stream;
    - replacement of the feed control valve to each of the original trains;
    - modification of existing interstage feed, permeate and concentrate piping to allow inclusion of interstage turbines;
    - replacement of membrane interconnectors, stub tubes, o-rings and brine seals;
    - replacement of the sample panels so that interstage sampling can be accomplished;
    - modification of the instrumentation and control methods related to water quality and flow in support of the addition of interstage turbines to each of the original four trains;
    - replacement of existing VFDs with an enhanced unit that includes addition of line arrestors and isolation transformers.
- Since current and future available funds are limited, a phased program for the retrofit enhancements of the Marco Island RO WTP is required.

Recommendations for Short-Term Treatment Alternatives

Estimated population projections by Florida Water indicate the need for a total of 15 MGD from

the Marco Shores and Marco Island facilities by the year 2018. Because of space constraints at the existing LS WTP, any treatment beyond 5 years would have to be at another location. It should be recognized that after short-term alternatives are utilized then a new facility needs to be evaluated.

In the short-term after implementing immediate modifications, the answer remains to stick with the existing process to meet immediate capacity. Immediate modifications are designed to carry Florida Water through short-term, so short-term on site expansion alternatives do not appear to be a benefit. Expansion of the RO WTP from 5 to 6 MGD, implementation of 1 MGD of reuse capacity on the island, and operation enhancements to the Marco Island LS WTP should assist Florida Water in the short-term.

Recommendations for Long-Range Treatment Alternatives

Long-range treatment alternatives would require a new 9 MGD water treatment facility at a new site should both the Marco Island and Marco Shores LS plants being retired. The additional space at the LS plant on Marco Island could then be used for alternative uses.

A new ion-exchange facility was removed as a potential long-range alternative because it would have limited organic removal, and no microbial removal. Enhanced LS was also removed as a long-range treatment alternative because as a stand-alone treatment option, it would not meet future water quality requirements. Consequently additional treatment such as GAC, ozone, or ion-exchange softening would have to be added to the process to meet current and future regulations. Therefore, membrane processes have been selected as the treatment alternative candidate for the new facility.

For the long-range, a site evaluation study should be conducted that would assist in determining the most feasible location for a new membrane treatment facility. It is recognized that Florida Water is actively pursuing reclaimed water to reduce demand, and has a 1 MGD reduction planned for next year.

A pilot-scale evaluation of membrane softening using Marco Lakes as a raw water supply should be conducted in order to determine the effects of fouling and membrane productivity, as well as issues related to surface water.

Temperature effects on the membrane softening process should further be investigated because the source water is surface water and experiences seasonal temperature variations.

1.0 Introduction

This document has been prepared by Boyle Engineering Corporation (Boyle) in support of the "Marco Island Water System (MIWS) Conceptual Treatment Alternatives and Surface Water Treatment Rule (SWTR) Planning Study Evaluation" for Florida Water Services Corporation (Florida Water). Boyle evaluated the MIWS which is comprised of a lime-softening (LS) and reverse osmosis (RO) water treatment plant (WTP). The water quality plan was developed as part of the evaluation of the existing conditions and current performance of the lime softening (LS) and reverse osmosis (RO) facilities relative to compliance with existing and future regulations..

The purpose of this report was to review current water quality and unit operations practiced within the MIWS. This study was conducted to evaluate treatment alternatives for expanding capacity and improving water treatment within the MIWS in a cost-effective manner. The exercise will help identify conditions that will assist in developing a water quality master plan for the following:

- Immediate process modifications of current operations for the MIWS.
- Short-term treatment alternatives that will increase capacity and comply with current water quality regulations.
- Long-range modifications that will comply with future regulations and meet projected water quantity demand.

1.1 Background

Marco Island is a popular tourist resort and is located off the southwest coast of Florida near Naples just west of the Everglades. The island measures approximately 6 miles long by 4 miles wide and has experienced rapid population growth over the past several years.

Florida Water Services Corporation (Florida Water) owns and operates the LS and RO plants on the island. Florida Water has historically been treating and distributing water from a 5 MGD lime softening facility located at the north end of the island. In response to growth and increasing water demands, Florida Water expanded its water services. A 4.0 MGD RO plant expandable to 6 MGD was designed and constructed to treat groundwater having a varying total dissolved solids (TDS) concentration between 6,800 and 10,000 mg/L, and was placed into operation in April 1992. In July 1996, the RO plant capacity was further increased by adding an additional 1.0 MGD of permeate capacity. Currently the two plants can provide 10 MGD average daily flow. Table 1.1 presents projected maximum daily flow data for the MIWS and the Marco Shores LS plant as compiled by Florida Water. Therefore there exists a need to provide an additional 4.0 MGD in the year 2018 to meet these future demands. A location map showing the proximity of the LS plant, RO plant and wellfield is given in Figure 1.1. The finished water from the LS and RO WTPs are blended to a desired finished water goal. However, since it is less expensive to operate the LS plant, the RO plant is used to supplement the demand on the LS plant. Therefore the finished water quality in the distribution system varies.

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Table 1.1
Project Water Demands *
(to the nearest 1000 gallons)

Year	Marco Island Projected Max. Day Flow (gal)	Marco Shores Projected Max. Day Flow	Total Water Demand Max Day Flow (gal)
1996	9,629,000	370,000	9,999,000
1997	10,115,000	419,000	10,534,000
1998	10,324,000	443,000	10,767,000
1999	10,533,000	455,000	10,988,000
2000	10,743,000	496,000	11,239,000
2001	10,952,000	557,000	11,509,000
2002	11,162,000	638,000	11,800,000
2003	11,371,000	720,000	12,091,000
2004	11,580,000	801,000	12,381,000
2005	11,790,000	882,000	12,672,000
2006	11,983,000	964,000	12,947,000
2007	12,176,000	1,045,000	13,221,000
2008	12,370,000	1,127,000	13,497,000
2009	12,563,000	1,208,000	13,771,000
2010	12,756,000	1,260,000	14,016,000
2011	12,885,000	1,260,000	14,145,000
2012	13,014,000	1,260,000	14,274,000
2013	13,143,000	1,260,000	14,403,000
2014	13,272,000	1,260,000	14,532,000
2015	13,401,000	1,260,000	14,661,000
2016	13,529,000	1,260,000	14,789,000
2017	13,658,000	1,260,000	14,918,000
2018	13,760,000	1,260,000	15,020,000
2019	13,823,000	1,260,000	15,083,000

* Source: Florida Water

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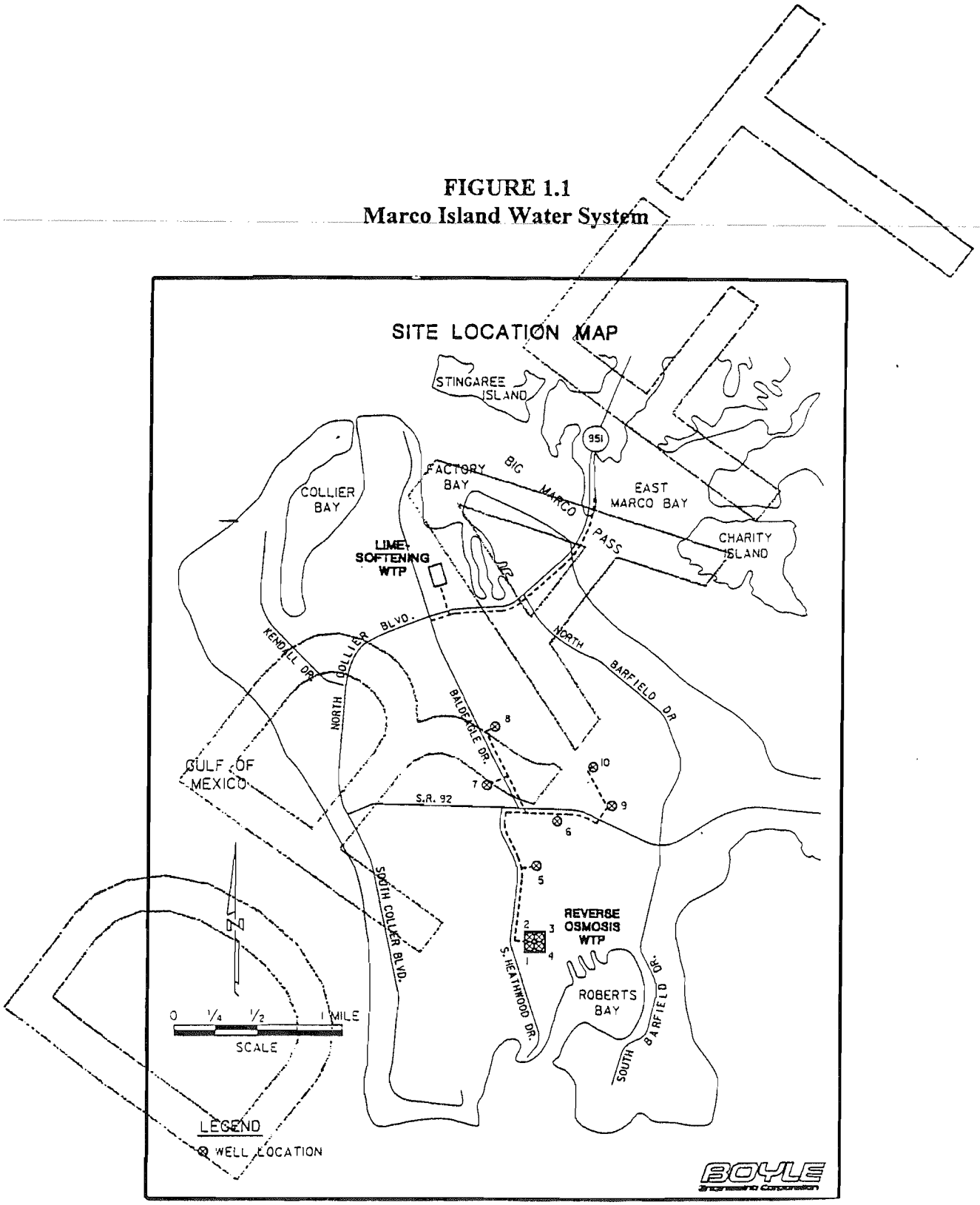
1.0 Introduction

FIGURE 1.1
Marco Island Water System



1.0 Introduction

Raw source water to the LS plant is supplied by Marco Lakes, an off-site surface water source located 9 miles away from the plant on the mainland. The surface water has a relatively high hardness and color content. Periods of high demand and low water levels in the lakes result in increased hardness. Treatment processes at the LS plant include lime softening for calcium removal, filtration, chloramination for disinfection, inhibitor addition for corrosion control and storage. From the high-service pumps finished water is sent to the distribution system with a portion going to blending with finished RO water at the RO plant.

Raw source water to the RO plant is provided by four on-site and several off-site wells. The Marco Island RO plant utilizes the lower portion of the Hawthorne aquifer between 400 and 550 feet deep. Raw water enters the plant through a common header where the combined wellfield flow is metered. Pretreatment consists of sulfuric acid addition for pH adjustment, antiscalant addition (Flocon 100) to protect the membranes from fouling, and microfiltration using cartridge filters to remove suspended matter. The original 4.0 MGD RO process was constructed as a four train, two-stage 24:12 pressure vessel array to allow operation in the 65 to 75 percent water recovery range, having operating pressures of 325 to 375 psi and using brackish and seawater elements. The 1.0 MGD expansion was designed as a one train, two-stage 22:12 pressure vessel array to allow 65 to 75 percent water recovery with a design feed water quality of 7,500 to 10,500 mg/L TDS, respectively. After the water is treated it is blended with LS water. The RO treated ground water was intended to increase capacity as well as water quality throughout the MIWS. However because of the cost of operating the RO plant, the LS plant is typically operated at increased capacity to reduce RO usage.

1.2 Objectives

Florida Water has continued its drinking water treatment improvement program with this study of the MIWS. As part of this program, Florida Water authorized Boyle to conduct a treatment alternatives evaluation for the MIWS. Specific tasks to be accomplished during this evaluation include the following:

- Plant performance information and water quality from Florida Water was utilized to evaluate the MIWS.
- Water quality criteria along with an overview of potential operating schemes were conceptually identified for short-term improvements and /or enhancements to the existing LS process. Treatments proposed and reported by others were identified. Enhancements and/or modified precipitation using iron salts were considered conceptually, and advantages and disadvantages were identified. In addition an evaluation of alternative coagulant aids was performed to investigate methods to enhance settleability.
- Review the Marco Lakes water supply water quality. The opportunity for blending surface water with highly brackish well water at the RO WTP was investigated conceptually. Review water

quality impacts associated with use of shallow surficial wells as a water supply option. Reports related to the site prepared by others were reviewed for informational purposes. In addition, a review of the utilization of lake, brackish and surficial well water supplies was reviewed conceptually for incorporation into identified master planning action items.

- The RO WTP membrane train engineering enhancements and alternative design concepts were evaluated. RO element membrane profile and probe scenarios were explored, with emphasis related to conceptual engineering of the original 4 skids. The evaluation conceptually evaluated the merits of inter-stage booster pumps and feed water header pipe retrofit enhancements and include feed water hydraulic considerations. The evaluation investigated the opportunity of retrofitting the 4 FilmTec RO process trains with an inter-stage turbine for energy recovery and second-stage pressure boost. The feed water hydraulics of the FilmTec RO trains were reviewed. Replacement of existing header pipe with larger diameter stainless steel pipe was considered. Also, energy savings activities to maintain consistency with project objectives and activities related to the RO WTP conceptual skid engineering activities were evaluated.
- Short-term and long-range treatment alternatives were developed and evaluated and a numerical matrix evaluation was developed to a short-list the highest ranked short-term and long-range treatment alternatives. The highest ranked short-term and long-range treatment alternatives were then short-listed using treatment performance and non-cost considerations. Then a conceptual capital cost estimate was prepared for the short-listed short-term and long-range treatment alternatives.

1.3 Criteria and Water Treatment Goals

The options evaluated as part of the *Conceptual Treatment Alternatives Study,* include immediate modifications, and short-term and long-range alternatives.

- Immediate Modifications - Improvements to current operational processes at the MIWS.
- Short-Term - Identify alternative treatment improvements at the existing LS and RO WTP facilities that will increase capacity (if possible) and comply with current water quality regulations.
- Long-Range - Modifications that will comply with future regulations and meet projected water quantity demand.

A set of screening criteria and treatment goals were used to compare and evaluate the options for treatment alternatives of the LS and RO plants in order to eliminate unsuitable approaches for enhancing and expanding the MIWS. Consequently, the following criteria were used to screen the various alternatives considered:

The RO plant meets the water quality criteria. Methods to increase capacity with reduced operating costs were investigated. Conceptual enhancement operating schemes for the RO plant were identified as blending water sources, retrofitting existing RO trains and expanding the RO plant. These enhancements should provide for increased capacity with reduced operational costs.

The MIWS needs to increase capacity, increase organic removal, reduce hardness and improve settleability. Enhanced lime softening, coagulation, ion exchange, chemical oxidation (ozone and hydrogen peroxide), hybrid (integrated) membrane process and/or activated carbon were considered as conceptual enhancements to the LS plant.

TABLE 1.2
MIWS Treatment Goals with Possible Enhancements

TREATMENT	RO	LS
GOALS	• Increase Capacity • Reduce Operational Cost	• Remove Organic Compounds • Improve Settleability • Reduce Hardness
ENHANCEMENT		
Immediate Modifications	• Retrofit 4 Original RO Trains with Turbine Boosters • Add 1 MGD to RO Plant • Blend Lake Water Supplies with Brackish Well Water	• Enhance Lime Softening • Enhance Coagulation
Short-Term		• Expand LS plant on Site with RO or Ion Exchange Process
Long-Range		• Add Oxidation Process to LS • Add Activated Carbon Process to LS • Build new plant at Marco Lakes or at a new or existing site and retire Marco Island and Marco Shores LS plants

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2.0 LS Plant SWTR Evaluation

Utilizing the LS plant information and data received from the Florida Water, existing water quality data for the source and finished water quality was reviewed and evaluated. The water quality data was then compared to current operational practices and drinking water regulations. This section presents LS plant performance and its relation to the MIWS treatment process. The plant layout flow diagram for the LS plant is described and then plant performance for LS is evaluated.

This chapter presents the SWTR evaluation for the LS plant which included:

- Historical water quality and operational evaluation of the LS facility relating to the SWTR.
- Lime-Softening and Ion-Exchange treatability evaluations of LS plant.

2.1 Historical Water Quality

The LS plant collects samples for water quality analysis raw and finished lime softened water. The water sources are representative of the current overall process. The current process at the LS plant is depicted in Figure 2.1. At the LS plant, raw water is withdrawn from the Marco Lakes located nine miles away. The quick lime (CaO) is added as a slurry in the solids contact unit (SCU). Alum is also added here to aid in settling. After the SCU, chlorine is added and roughly 10 to 20 seconds later ammonia is added to the settled water to provide disinfection. Then the water passes through one four-cell filter that shows signs of post-precipitation on the filters. A phosphate inhibitor is added after filtration to control corrosion in the distribution system. The finished water then proceeds to storage and is pumped to the distribution system where it blends with RO finished water. Table 2.1 presents typical LS plant operational data and the remainder of this section will describe the inorganic, organic, and microbial water quality at the LS plant.

The LS plant SCU operates at a surface loading rate (SLR) of 1.5 gpm/ft^2. This is based on a flow rate of 5 MGD through a 54 ft diameter SCU. Typical lime softening plant SCUs are now designed to operate a SLR of 1.0 gpm/ft^2 (Ten States Standards). Addition of a settling aid can increase the SLR up to 1.5 gpm/ft^2. Alum is currently the settling aid used at the LS plant. However, carry-over turbidity and dissolved aluminum continues to be a problem at the LS plant using alum as a settling aid. A cationic polymer was tested at the plant to assist the alum, but the sludge blow-down schedule was not adjusted to compensate for the additional sludge so this practice was discontinued. Alum typically precipitates effectively at pH 5.5 to 6.5. The LS plant SCU pH is approximately 9.0, so a portion of the alum remains dissolved and this can pass through the filters and this can possibly lead to the LS plant exceeding the aluminum maximum contaminant level (MCL) of 0.2 mg/L.

Upon review of electronically compiled historical data it was found that the chemical dosage rates need adjustments. The chemical dosage rates are based on pounds of chemicals used and the flow rate through the plant. Also, these calculated doses need to account for impurities that may be in the dry chemicals.

2.0 LS Plant SWTR Evaluation

FIGURE 2.1
MIWS LS Process Flow Diagram

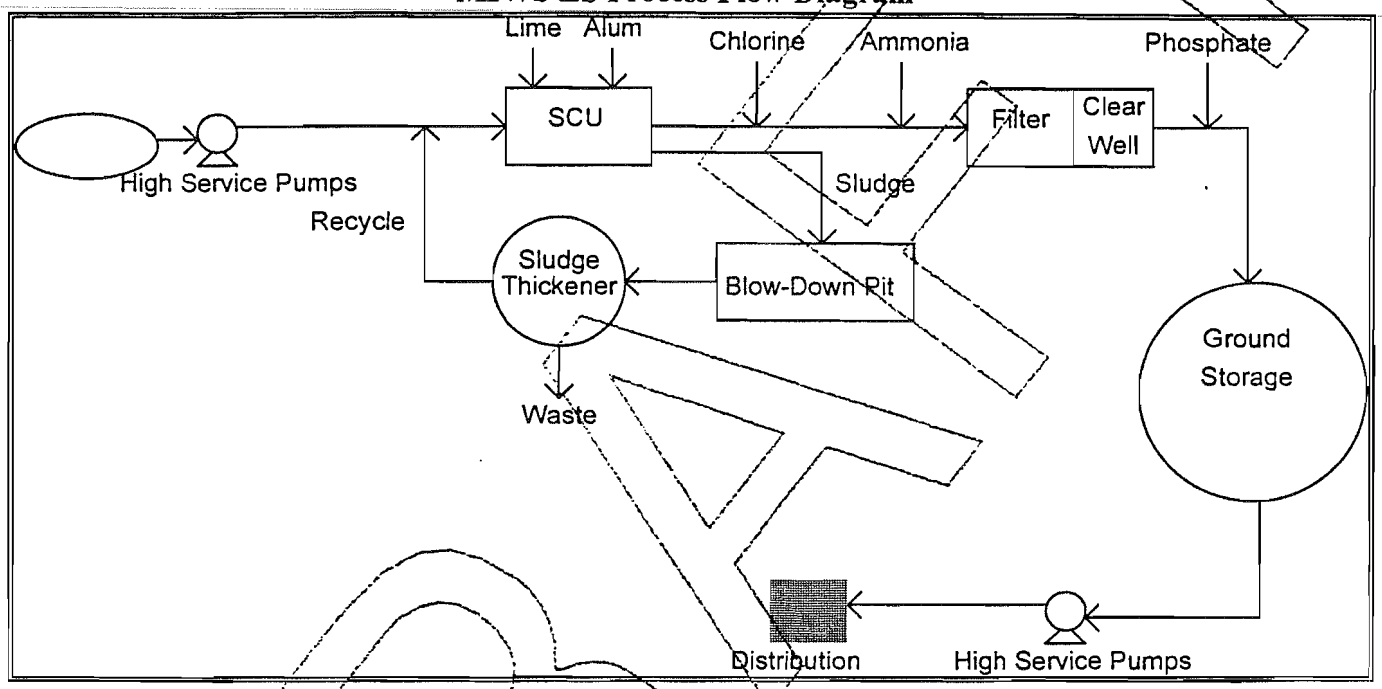

TABLE 2.1
Typical LS Plant Historical Operating Parameters

Parameter	Units
Flow	5 MGD
SCU Surface Loading Rate	1.5 gpm/ft^2
Filter Surface Loading Rate	2.43 gpm/ft^2
Lime Dose	152 mg/L as CaO
Alum Dose	10 mg/L
Chlorine Dose	8.6 mg/L
Ammonia Dose	1.7 mg/L
Phosphate Dose	1.9 mg/L

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2.1.1 Inorganic Water Quality

Samples of raw and finished water were collected and analyzed for inorganic and physical water quality. The MIWS raw and finished water were evaluated for fluoride, nitrite, nitrate, phosphate, strontium, sulfate, magnesium, chloride, iron, sodium, barium, potassium, total phosphorous, conductivity, total dissolved solids (TDS), calcium hardness, total hardness, alkalinity, pH, temperature and ammonia. Results of the inorganic water quality analysis are presented in Table 2.2. None of the inorganic finished water qualities for the LS plant exceeded their respected MCLs.

2.1.2 Organic Water Quality

DBPs are formed by reactions between chlorine or other disinfectants such as chloramines, chlorine dioxide, and ozone with natural organic matter (NOM) (Bull, and Kopfler, 1991). Of these disinfectants, chloramines generally produce by-products, but at a lower concentrations compared to free chlorine (Amy et. al. 1990). Currently USEPA and the State of Florida allow the maximum total THM annual average concentration based on four quarterly samples collected in the distribution system to be 100 µg/L. Proposed future DBP regulations will be implemented in two phases for reduction in THM levels (59 FR 38668, and USEPA 811-R-42-005, August 1992). Phase I is expected to lower the THM MCL to 80 µg/L, and a new class of DBPs, the HAAs are expected to be regulated at 60 µg/L. In addition, total organic carbon (TOC) is expected to be regulated based upon source water TOC and alkalinity values. The proposed TOC reduction requirements are presented in Table 2.3.

Raising the pH of the finished water increases TTHMs and decreases HAAs. This option could be evaluated for control of HAAs if the TTHM and HAA MCLs are eventually reduced to 40 and 30 µg/L respectively.

The chlorine dose currently varies from 7.8 to 13 mg/L and depends upon raw water quality and maintenance of a residual of 4.0 mg/L as total Cl_2 in the distribution system. Chlorine is injected at weir on the SCU. Ammonia is then added as 1.7 mg/L to form chloramines.

Samples of the raw and finished LS plant water were collected and analyzed for organic water quality at the University of Central Florida (4000 Central Florida Blvd., Orlando, Florida 32826) (Table 2.4). The samples were analyzed for non-purgeable dissolved organic carbon (NPDOC), UV-254, and color. NPDOC, UV-254, and color are all indicators of organic matter present in the water. UV-254 is not currently regulated, but it has shown to possess correlation to NPDOC and color (See Appendix B).

Based on Table 2.3, since the MIWS alkalinity is > 120 mg/L and raw surface water TOC is > 8.0 mg/L, MIWS would be required to reduce raw water TOC by 30 percent for a limit of 9.8 mg/L. The MIWS currently exceeds the MCL for NPDOC and color with 10.7 mg/L and 20 CPU respectively.

TABLE 2.2
LS Plant Physical and Inorganic Water Quality

DESCRIPTION	Raw	Finished	MCL
FIELD DATA			
pH	7.35	8.27	6.5-8.5
Temperature (C)	24	23.7	N/A
Conductivity (umhos/cm @ 25 °C)	1311	714	N/A
INORGANIC (mg/L)*			
Fluoride	< 0.02	< 0.02	4.0
Chloride	138	147	250
Total Nitrite + Nitrate (as N)	0.258	0.269	10
Strontium	0.578	0.295	
Sulfate	65.7	64.9	250
Iron (Total)	< 0.2	< 0.2	0.3
Magnesium (Total)	12	11.2	N/A
Sodium (Total)	73.7	69	160
Calcium (Total) (as $CaCO_3$)	315	103	N/A
Hardness (Total) (as $CaCO_3$)	344	158	N/A
Alkalinity (Total) (as $CaCO_3$)	259	44	N/A
Ammonia Nitrogen (NH_3 as N)	0.1	1.45	
TDS	948	299	500
Barium (Total) (ug/L)	36	15	
Potassium (Total)	2.53	2.36	
Total Phosphorous (as P)	0.03	0.36	

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TABLE 2.3
Proposed TOC Reduction Requirements@

TOC (mg/L as C)	Raw Water Alkalinity (mg/L as $CaCO_3$) 0-60	60-120	>120
2-4	40%	30%	20%
4-8	45%	35%	25%
>8	50%	40%	**30%**

@ = According to D-DBP Rule

TABLE 2.4
LS Plant Organic Water Quality

Description	Raw	Finished	MCL
NPDOC (mg/L as C)	13.5	10.7	TT*
UV-254 (cm^{-1})	0.335	0.181	N/A
Color (CPU)	40	20	15
Chlorine Residual (mg/L)	---	3.7	4
TTHM (µg/L)			100
$CHCl_3$ (µg/L)			---
$CHCl_2Br$ (µg/L)			---
$CHClBr_2$ (µg/L)			---
$CHBr_3$ (µg/L)			---
THAA (µg/L)			N/A
MCAA (µg/L)			---
MBAA (µg/L)			---
DCAA (µg/L)			---
TCAA (µg/L)			---
BCAA (µg/L)			---
DBAA (µg/L)			---

* TT = Treatment Technique. Based on Table 2.3 "Proposed TOC Reduction Requirements"

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2.1.4 Microbial Water Quality

Samples of raw LS water were collected and analyzed for microbial water quality at the University of South Florida. The surface water was evaluated for turbidity, heterotrophic plate count (HPC), total coliform, and the presence of *Giardia* and *Cryptosporidium*.

Giardia cysts and *Cryptosporidium* oocysts (parasitic "eggs") are accepted organisms for waterborne disease. *Giardia* and *Cryptosporidium* require a host body for viability so they remain dormant until they infiltrate a host body. Viability is the ability to live, develop, and prosper under favorable conditions. Ingested *Cryptosporidium* causes gastrointestinal illness that can become life threatening to persons with compromised immune systems. Ingestion of only one viable *Cryptosporidium* oocyst may lead to infection (Watanabe, 1996). Symptoms of cryptosporidiosis linger for 2 to 4 weeks and include nausea, diarrhea, and cramps. *Cryptosporidium* is similar to the *Giardia* organism, but it is more resistant to disinfection than *Giardia* and half the size. *Cryptosporidium* is approximately 4 - 6 microns in diameter (Rose, 1988). Therefore *Cryptosporidium* is more difficult to inactivate and physically remove from water supplies than *Giardia*. *Cryptosporidium* have a tough outer shell that makes them resistant to environmental conditions. *Giardia* cysts and *Cryptosporidium* oocysts are commonly found in the feces of most mammals. Surface water treatment plants located down stream of agricultural (grazing) areas waste water discharge, and sewage hazards are susceptible to a greater risk of contamination. Rainfall events increase the risk because the rain may rinse the feces in to nearby surface waters.

Results in monitoring *Giardia* and *Cryptosporidium* can vary significantly among laboratories. Commercial laboratories have shown a lack of proficiency in analyzing for *Giardia* and *Cryptosporidium* (Clancy et. al., 1994, Watanabe, 1996). A complicating factor in the current analysis is the discrimination between viable and non-viable oocysts. Performance of water treatment plants can be evaluated by HPC. HPC and turbidity measurements can be effective tools in determining expected removals of *Giardia*, and *Cryptosporidium*, but a correlation was not demonstrated between the removal of these organisms and heterotrophic bacteria (Nieminski, 1994).

Sub-optimal water treatment operations have been identified during outbreaks of *Giardia* and *Cryptosporidium* in other water systems across the nation (Rose, 1996), and include:

1. start-up of unwashed filters;
2. start-up of just-washed filters; and
3. recycling of backwash waters.

Recycled water can contain high levels of oocysts greater than 150 / L even after sedimentation (Rose et al., 1991, Colbourne, 1989). Since recycling is a common practice in an effort to conserve water, Cornwell and Lee (1994) recommend the following recycling practices:

1. recycle streams should be equalized and blended over a 24 hour time period;
2. recycle should be less than 10 percent of the flow;
3. recycle streams should be regularly monitored for contaminants of concern;
4. recycle sedimentation basins should be regularly cleaned; and
5. recycled turbidities should be less than 5 NTU or have a suspended solids concentration of less than 10 mg/L.

With respect to these recycling practices, the MIWS recycles blow down water after dewatering. In addition to the above recycling practices, regulatory rules are being developed that may:

1. Limit the rate of recycled backwash water to a 2 to 5 percent rate of plant inflow. So return rates up to 10 percent may no longer be considered.
2. Require the recycled water quality to have a turbidity standard with possible periodic monitoring requirements for *Cryptosporidium* and *Giardia*.
3. Require filtration treatment down to 3 to 4 micron particle size of the recycled filter backwash water. So microfiltration may be considered.

Chlorine and chloramines as disinfectants used in water treatment are relatively ineffective at killing or inactivating *Cryptosporidium* oocysts. Deactivation is primarily related to the concentration of the disinfectant and contact time. For example, Korich et al. (1991) reported that 80 mg/L of free chlorine or monochloramine required 90 minutes to produce 90 percent oocyst inactivation. The best disinfection approach for effectively killing *Cryptosporidium* oocysts has been shown to be ozone (Korich et al., 1991, Peeters et al., 1991, and Finch et al. 1993). Ozone required 4.5 minutes at 1 mg/L to produce 99 percent oocyst inactivation on average. The use of disinfectants to inactivate *Cryptosporidium* could create high levels of DBPs. Therefore physical removal (filtration) is a better process approach over disinfection alone (Rose, 1988, Jacangelo et. al., 1995).

For the microbial water quality collection of *Giardia*, and *Cryptosporidium* samples, 1 gallon per minute (gpm) of sample water passed through a polypropylene yarn-wound filter cartridge and flow meter at about 30 psi. The filter was 1 micrometer (μm) nominal porosity. Organisms can potentially blow through the yarn filter therefore the test flow rate threshold is 2 gpm. The filters were used to collect and concentrate cysts and oocysts from the water. After collection of sample, the filters were then put on ice and transported back to the University of South Florida (USF) where they were analyzed utilizing immunofluorescence microscopy with monoclonal antibodies (MAb) for detection of *Giardia* cysts and *Cryptosporidium* oocysts (Section 9711 Standard Methods 19th Edition, 1995).

Table 2.5 presents the *Giardia* and *Cryptosporidium* microbial water quality at MIWS for one sampling period. The volume collected represents the amount of water that passed through the yarn filters. No

Cryptosporidium or *Giardia* organisms were detected at the detection limit in the volumes sampled. Not finding *Cryptosporidium* or *Giardia* present at the time of sampling should not be interpreted that the source water is safe in this regard.

TABLE 2.5
***Giardia* and *Cryptosporidium* Microbial Water Quality at MIWS**

Parameter	4/2/97	MCL
Volume Collected(liters)	383	N/A
Giardia (organisms)	Absent	TT
Cryptosporidium (organisms)	Absent	TT

TT = Treatment Technique required.

For the microbial water sampling of HPC and total coliform grab samples were collected and analyzed by Florida Water Laboratories. Table 2.6 presents the turbidity, HPC and total coliform microbial water quality for the LS plant. The percent removal of HPC from raw surface water was 91.3 percent, and 0 percent. HPCs were maintained below 500 organisms/mL. Total coliforms concentrations for the LS plant were absent from the finished water.

TABLE 2.6
LS Plant HPC and Total Coliform Microbial Water Quality

DESCRIPTION	Raw	Finished	MCL
Turbidity	1.18	0.39	TT
HPC (organisms/mL)	0.12	< 0.01	TT
Total Coliform(organisms/mL)	Present	Absent	< 5% *

* less than 5% of the number of samples collected should show the presence of Total Coliform Bacteria.

2.1.5 Disinfection Effectiveness

The Surface Water Treatment Rule (SWTR) requires that all water treatment systems which utilize a surface water source must achieve an overall minimum 3-log removal/inactivation (99.9 percent) of *Giardia* cysts and an overall minimum of 4-log removal/inactivation (99.99 percent) of viruses. The SWTR prescribes CT (C, residual disinfectant concentration (mg/L), * T, contact time (minutes)) levels for specific treatment and disinfection conditions to achieve different levels of inactivation under various conditions.

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The required minimum primary disinfection is the disinfection needed for the entire treatment process to meet the overall treatment requirement of 3-log *Giardia* and 4-log virus removal/inactivation. According to the *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*, October 1990, the expected minimum level of treatment performance in a well operated, conventional filter system is 2.5-log removal of *Giardia* and 2-log removal of viruses. To achieve the overall removal/inactivation goal for *Giardia* and viruses, the recommended disinfection for *Giardia* is 0.5-log removal and 2.0-log removal for viruses. The MIWS utilizes chloramines as a disinfectant at the LS plant and free chlorine at the RO plant. The recommended minimum level of disinfection and assumed log removals by filtration are summarized in Table 2.7.

TABLE 2.7
Recommended Minimum Level of Disinfection

Treatment	*Giardia*	Virus
Required Removal	3.0 log	4.0 log
Assumed Log Removal by Filtration	2.5 log	2.0 log
Recommended Minimum Level of Disinfection	0.5 log	2.0 log

2.1.5.1 CT Calculation

The value of CT is specific for each treatment system. For the purpose of calculating the value of CT, T is the time, in minutes, it takes for the water during peak flow conditions to reach a point downstream where C, the residual disinfectant concentration, is measured. The residual is measured at a point before or at the first customer. The value of T_{10} can be determined using a tracer study. The value of T_{10} corresponds to the concentration of the tracer once 90 percent has been retained in the system. The value of T_{10} is found graphically using the information obtained from the tracer study. The value of C/C_0 vs. time in minutes is graphed, where C is the concentration of the tracer and C_0 is the tracer dosage. The value of T_{10} is the time corresponding to the value of 0.1 on the C/C_0 axis. The value of CT_{calc} is calculated used the value of T_{10} obtained from the tracer study, multiplied by the residual disinfectant concentration at some predetermined point downstream in the system.

Marco Island performed a tracer study in April 1994. The results of the study are presented in the Appendix D. The tracer study was used to determined the value of T_{10} to be 100 minutes. This value is assumed to remain valid as long as no physical changes are made to the process basins or storage tanks.

2.1.5.2 Inactivation Ratios

Compliance with the Surface Water Treatment Rule requirements is determined by calculating inactivation ratios for *Giardia* and viruses. The inactivation ratios for *Giardia* and viruses must be 1.0 or greater. These ratios are determined by dividing the CT_{calc}, calculated as described above, by the $CT_{99.9}$ for *Giardia* and $CT_{99.99}$ for viruses for specific temperatures. *The Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources* (the Guidance Manual) publish values for $CT_{99.9}$ and $CT_{99.99}$ for *Giardia* and viruses, respectively. These values vary with pH and temperature.

The inactivation ratios for *Giardia* and viruses are determined using the following steps:

1. Determine the required log inactivation of *Giardia* and viruses, accounting for inactivation credits for the treatment process utilized.
2. Determine the value of T_{10} using a tracer study.
3. Calculate the value of CT by multiplying T_{10} by the residual chlorine concentration.
4. Determine the values of $CT_{99.9}$ for *Giardia* and $CT_{99.99}$ for viruses for chloramines using the Guidance Manual.
5. Calculate the inactivation ratios of *Giardia* ($CT_{calc}/CT_{99.9}$).
6. Calculate the inactivation ratio of viruses ($CT_{calc}/CT_{99.99}$).

If the inactivation ratio is greater than 1.0 for *Giardia*, the system provides greater that 99.9 percent inactivation of *Giardia* cysts. If the inactivation ratio is greater than 1.0 for viruses, the system provides 99.99 percent inactivation of viruses. The data collected for the Marco Island WTP is located in Appendix D.

Disinfection requires a minimum level of disinfection to be 0.5 and 2.0 log removal for *Giardia* and virus, respectively. These values were used to calculate the inactivation ratios which should be greater than 1.0. A CT study conducted from September 1994 to February 1995 was conducted to determine the inactivation ratios over time. On average the inactivation ratios for *Giardia* and virus were 2.6 and 1.6, respectively. Table 2.8 presents the results of the tracer study. The results of the tracer study indicated that the CT values are in compliance with the SWTR at the MIWS since the inactivation ratios are greater than 1.0.

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TABLE 2.8
Comparison of CT Values for Compliance using Chloramines

Parameter	Temp (C)	Cl_2 Residual Min (mg/L)	CT Calc. (mg/L-min)	$CT_{Required}$ @ 20 C 0.5-log Giardia Inactivation	$CT_{Required}$ @ 20 C 2.0-log Virus Inactivation	Inactivation Ratio $CT/CT_{Required}$ *Giardia*	Inactivation Ratio $CT/CT_{Required}$ Virus
Average	24.9	3.8	379	160	246	2.60	1.61
Std. Dev.	1.8	0.5	47	55	49	0.77	0.35
Max	26.8	4.7	470	250	321	3.76	2.20
Min	20.8	2.2	220	125	214	1.00	0.78

2.1.6 Compliance and MCL Performance

The LS plant treats surface water. The surface water treatment consists of lime softening, coagulation, sedimentation, chloramination, filtration, inhibitor addition, stabilization, ground storage, and finally distribution. Currently, the LS plant relies on phosphate inhibitors and stabilization of the treated surface water in order to comply with the requirements of the Lead and Copper Rule (LCR).

As required by permit, Florida Water submits monthly operating permits (MORs) for the WTP to the FDEP. Based on regulatory monitoring data, operational logs, and other water quality records provided by Florida Water, the MIWS currently has difficulty complying with ESWTR and D-DBP regulations. Additionally, dissolved aluminum is passing through the filters and at times exceeds the secondary standard of 0.2 mg/L as aluminum.

The newer regulatory provisions of the SDWA are more restrictive and are more difficult for water purveyors to comply with than in the past. Today, more emphasis has to be placed on compliance with water quality regulations at the consumer tap (especially as it relates to lead and copper corrosion control). Moreover, public water purveyors are under increased demands to maintain consumer confidence and manage water quality in expanding distribution systems as a result of economic and population growth. As regulations continue to be developed, water utilities are preparing by implementing total quality management programs to increase productivity and enhance consumer attitudes.

Many of the proposed and anticipated regulations currently being considered by the USEPA will have a significant impact on contaminant monitoring throughout the MIWS and the ability of the LS facility to meet future regulations. Since the final outcome of the proposed and anticipated SDWA rules remain uncertain, it is possible that the future additional treatment processes that will be required for the LS plant will be very extensive and could represent a significant cost burden to Florida Water. Furthermore, it is possible that the enhancement will result in only limited treatment process options to address future

regulations. The treatment schemes selected for the MIWS should be those processes that allow the most flexibility in design, modification, and implementation.

Consequently, a set of alternative treatments that allow for the consideration of additional pretreatment, post-treatment, or easy modifications of the planned treatment would provide the most flexible response to potential future regulations.

2.2 Plant Performance Evaluation

Plant performances at the LS plant was evaluated according to finished water turbidity. According to the SWTR:

1. the filtered water turbidity must not exceed 5 NTUs, and
2. 95 percent of the measurements taken for turbidity must not exceed 0.5 NTU.

Historical finished water turbidity data from January 1996 to December 1996 was compiled and evaluated for compliance with the SWTR. For the LS plant finished water turbidities were correlated to operating conditions such as lime dose, color, hardness, alkalinity, and flow.

Frequency distribution curves were generated for the historical finished water turbidity. The frequency distribution curve is presented as a histogram with cumulative distributions. A histogram is a probability distribution frequency for a given data set of classes (ranges) of data. Whereas a cumulative distribution represents the cumulative percent of the data set "less than" a given class.

The LS historical finished water turbidity frequency distribution curve is presented in Figure 2.2. Figure 2.2 shows 0.6 NTUs as the limit for 95 percent of the measurements taken for finished water turbidity. Therefore the LS plant is not in compliance with the finished water turbidities according to the SWTR.

The LS plant exceeded the 0.5 NTU finished water turbidity on 39 events. The finished water turbidity is over 0.2 NTU 57 percent of the time. USEPA has publicly stated a desire to see finished water turbidity below 0.2 NTU. Such a regulation would have major impact on the LS plant and is a strong reason why the LS plant should endeavor to determine the lowest turbidity the plant can achieve by optimization of operation.

The operating parameters of the LS plant were statistically analyzed to determine if any relationship existed with finished water turbidity. The results of this analysis are shown in Table 2.9. The finished water turbidities were divided into a high and low turbidity group in order to evaluate the LS plant operating relationships to finished water turbidities. The operating conditions for all turbidities greater than 0.4 NTU were compared to the same operating conditions when the finished water turbidities were less than 0.4 NTU. Turbidities greater than 0.4 NTUs occurred on 47 separate events. The second group

FIGURE 2.2
LS Finished Water Turbidity Frequency Distribution

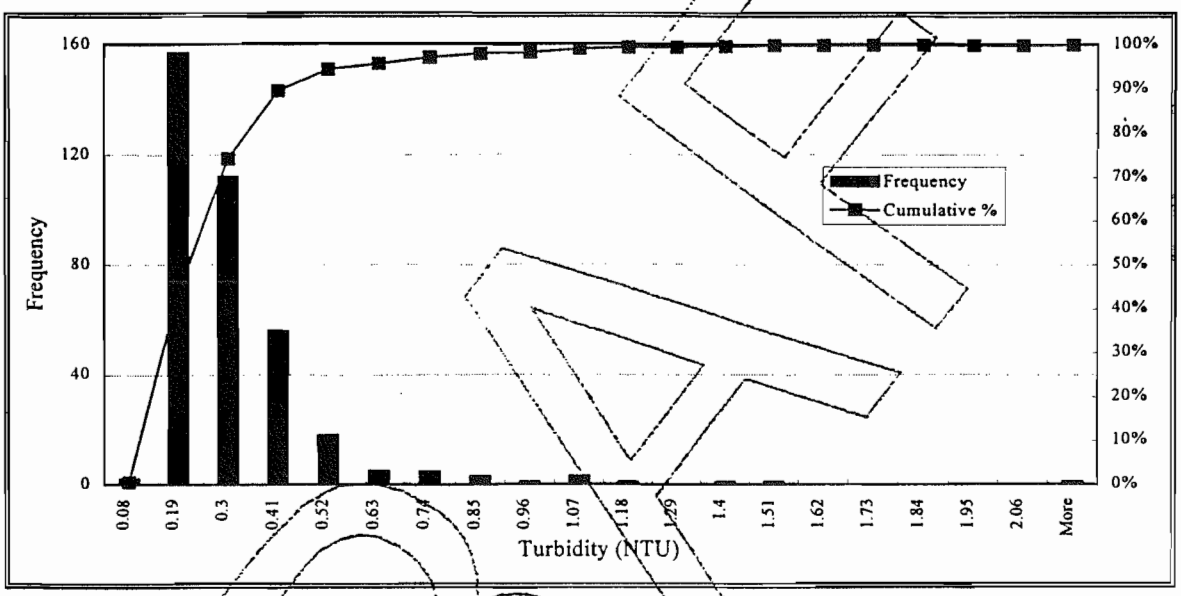

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TABLE 2.9
Statistical Analysis of LS Operating Parameter Relative to Finished Water Turbidity

Operating Parameter	Finished Water Turbidity		Significance
	<0.12 NTU	>0.4 NTU	
Finished Turbidity (NTU)	0.10	0.64	Yes
Raw Water to Plant (MGD)	5.5	5.3	No
Lime (mg/L)	171	171	No
Chlorine (mg/L	9.28	7.99	Yes
Ammonia (mg/L)	1.7	1.6	Yes
Soda Ash (mg/L)	2.0	1.9	Yes
Phosphate (mg/L)	1.5	2.1	Yes
Alum (mg/L)	14.5	9.0	Yes
Raw pH	7.7	7.8	Yes
Raw Alkalinity (mg/L as $CaCO_3$)	249	263	Yes
Raw Hardness (mg/L as $CaCO_3$)	198	296	Yes
Finished pH	8.4	8.5	No
Finished Alkalinity (mg/L as $CaCO_3$)	37	66	Yes
Finished Hardness (mg/L as $CaCO_3$)	146	169	Yes

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was 47 events less than 0.12 NTUs picked at random. Average, standard deviation, maximum and minimum conditions for the two turbidity ranges were then evaluated (see Appendix C). An analysis of variance (ANOVA) was used to determine if there was any difference between the operating parameters associated with the high and low turbidity data set. For example, the average finished water turbidity for the low turbidity data set was 0.10 NTU and the average for the high turbidity data set was 0.64 NTU. Obviously these groups are different and the statistical ANOVA test was confirmed.

The data represented in Table 2.9 is separated by high and low turbidity groups. Consequently, if there is a significant difference between the data in the high and low turbidity groups, that difference indicates that parameter is associated with the occurrence of high and low finished water turbidity.

Increased raw water flow to the plant did not appear to be associated with either turbidity group. This indicates that flow rate through the plant is not necessarily causing the higher turbidities.
Increased raw and finished water alkalinity and hardness correlated to increased finished water turbidities. This indicates the plant is reacting to changes in these parameters in an adverse fashion.

Lime doses were similar for the 0.4 NTU range compared to the 0.1 NTU range. This indicates that lime is not being changed as water quality changes. As chlorine, ammonia, soda ash and alum increase, finished water turbidities decreased. Whereas increased phosphate doses correlated to increased finished water turbidities. This indicates the plant is reacting to changes in phosphate in an adverse fashion.

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3.0 RO Treatment Evaluation

In July, 1996, Florida Water completed the expansion of its existing 4.0 MGD brackish water reverse osmosis water treatment plant (ROWTP) by adding an additional 1.0 MGD of permeate capacity. Issues related to a variable and potentially deteriorating water supply required innovative approaches for the retrofit expansion. The expansion was completed within a 7-month period, using a negotiated fast-track design effort and a negotiated construction contract.

The facility expansion was designed to provide treatment for a highly variable brackish feed water, approximating between 7,500 mg/L and 10,500 mg/L total dissolved solids (TDS). Preliminary and final design took into consideration hybrid membrane arrays (two different types of brackish water membranes) and provided for a system water recovery of 65 to 75 percent, depending on feed water quality. Most important was the decision to include an interstage turbine boost pumping system to increase second stage permeate productivity while maintaining permeate quality.

The original four 1-MGD membrane trains did not utilize an interstage turbine in the process. Although Florida Water did investigate energy recovery in the original design, as a cost-savings method the use of energy recovery was deferred to a later date. The expansion did however, take into account interstage boost pumping because there was sufficient energy in the concentrate to make energy recovery economically worthwhile at Marco Island. Consequently, it is possible to compare applications of an interstage to that without interstage.

This chapter presents an evaluation of the RO plant. The evaluation included:

- RO plant description
- Water quality evaluation for the RO plant.
- Operational evaluation of the RO facility.
- An examination of the efficiency of the interstage turbine as compared to a process without an energy recovery device for an equivalent feedwater, and include presentation of operation, cost and performance data.
- RO element membrane profile and probe scenarios were explored, with emphasis related to an engineering evaluation of the original four trains.
- Evaluate the raw water characteristics of blending surface water or well water with highly brackish well water at the RO plant.

3.1 Membrane Train Overview

Membrane train engineering enhancements and alternative design concepts were incorporated in the expansion of the ROWTP (Train No. 5). Interstage booster pumps were installed in Train No. 5 making

3.0 RO Treatment Evaluation

it possible to compare applications with (Train No. 5) and without (Train No. 1 - 4) an interstage booster.

3.1.1 Membrane Process Description

The membrane process array in membrane Train No. 5 was designed as a 22:12 (first pass:second pass) system, with each pressure vessel containing six 8-inch diameter, 40-inch long membrane elements. The 1.0 MGD permeate capacity membrane train contained 132 Fluid Systems® thin-film composite (TFC) 8822XR very high-rejection brackish membrane elements in 22 pressure vessels in the first stage, and 72 Fluid Systems® TFC 8822HR high rejection brackish membrane elements in 12 pressure vessels in the second stage. Fluid Systems® modeled projections indicated a year three permeate water quality of 125 parts per million (ppm) total dissolved solids (TDS) at 25 °C, based on a design feed water quality of 10,500 ppm TDS.

The original process arrays in Train No. 1 - 4 were designed as a 24:12 (first pass:second pass) system, with each pressure vessel containing six 8-inch diameter, 40-inch long membrane elements. Each of the original trains initially provided approximately 1.0 MGD permeate capacity for a total of 4 MGD. The first stage of each train contains 48 FilmTec® SW30-8040 sea water membrane elements and 96 FilmTec® BW30-8040 brackish water membrane elements in 24 pressure vessels. The first two elements in each vessel are SW30-8040's and the remaining four elements are BW30-8040's. The second stage of each train contains 72 FilmTec® BW30-8040 brackish water membrane elements in 12 pressure vessels. Table 3.1 identifies the membranes and surface areas of each train.

Train No. 5 provides 67,320 ft^2 of membrane surface area and trains No. 1 - 4 each provide 72,000 ft^2 of membrane surface area. These surface areas were designed to produce water fluxes (F_w) of 14.9 and 13.9 gsfd for train No. 5 and trains No. 1 - 4, respectively at 1 MGD of permeate production.

For the Train No. 5 retrofit a feed header analysis was performed with larger diameter piping for two different recoveries (Duranceau, 1996). Table 3.2 provides the flow and velocity values associated with the larger diameter piping used in the retrofit.

3.1.2 Interstage Boost and Energy Recovery

The RO process, by its nature, produces a concentrate stream that is under relatively high residual pressure. Because of the characteristics of the Marco Island facility there is sufficient energy in the concentrate to make energy recovery worthwhile under certain scenarios. During the design phase, a plan for utilization of an energy recovery device was formulated for the project.

As a general concept, the recoverable energy is proportional to the concentrate flow rate, the pressure of the concentrate stream, and the efficiency of the energy recovery device. This energy is normally

3.0 RO Treatment Evaluation

TABLE 3.1
Marco Island RO Membrane Identification for Each Train

Train (#)	Stage	Type of Element Manufacture	Type of Element Model	Vessels per Stage (#)	Elements per Vessel (#)	Surface Area per Element (ft^2)	Surface Area per Stage (ft^2)
1	1st*	FilmTec®	SW30-8040	24	2	345	16,560
	1st	FilmTec®	BW30-8040	24	4	330	31,680
	2nd	FilmTec®	BW30-8040	12	6	330	23,760
2	1st*	FilmTec®	SW30-8040	24	2	345	16,560
	1st	FilmTec®	BW30-8040	24	4	330	31,680
	2nd	FilmTec®	BW30-8040	12	6	330	23,760
3	1st*	FilmTec®	SW30-8040	24	2	345	16,560
	1st	FilmTec®	BW30-8040	24	4	330	31,680
	2nd	FilmTec®	BW30-8040	12	6	330	23,760
4	1st*	FilmTec®	SW30-8040	24	2	345	16,560
	1st	FilmTec®	BW30-8040	24	4	330	31,680
	2nd	FilmTec®	BW30-8040	12	6	330	23,760
5	1st	Fluid Systems®	TFC 8822XR	22	6	330	43,560
	2nd	Fluid Systems®	TFC 8822HR	12	6	330	23,760

* First two elements in 1st stage pressure vessels are salt water membranes.

TABLE 3.2
Marco Island ROWTP Feed Header Pipe Flow and Velocity Capacity Calculations

DESCRIPTION	65 % Recovery Total Flow (GPM)	65 % Recovery Velocity (ft/sec)	75% Recovery Total Flow (GPM)	75% Recovery Velocity (ft/sec)
6" Pump Discharge (existing)	1068	12	925	10
8" Pump Discharge (proposed)	1068	7.0	925	5.7
4" 1st Pass Feed (existing)	534	13.2	462.5	11.6
6" 1st Pass Feed (proposed)	534	5.8	462.5	5.2

recovered in the form of a turbine attached to either a booster pump in the membrane feed line or in the form of concentrate pressure from the first-stage concentrate line. For the Marco Island expansion, providing an interstage pressure boost via the use of a turbine between the first and second stage appeared to optimize the performance of both the first and second stage elements.

The hydraulic TurboCharger™, manufactured by Pump Engineering Incorporated (Monroe, MI), was specified for this application. The TurboCharger™ is an energy recovery device specifically designed for RO processes (Oklejas, 1992). This patented device can be used to transfer hydraulic energy from RO concentrate streams to any other stream in a RO process. The hydraulic pressure boost has been used to reduce feed pump energy requirements, increase permeate production, and reduce permeate TDS (Oklejas, 1994).

In the case of Marco Island, during the preliminary design phase of the Train No. 5 expansion the concentrate flow was calculated to be approximately 230 gallons per minute (gpm) per 926 gpm feed flow (at 75 percent water recovery operation). The TurboCharger™ was specified to provide a wide range of boost pressures in order to accommodate variations in raw water quality and system variations over time. It was anticipated that the TurboCharger™ would be required to produce 90 psi of boost at year zero conditions and 30 psi of boost at year three conditions, based on a feedwater of 10,500 ppm TDS. Start-up data indicated that the TurboCharger™ produced 70 psi second-stage feedwater boost using a slightly lower TDS than that used for design. Operating conditions and projections for interstage energy recovery by the manufacturer for year 0 and year 3 are provided in Figures 3.1 and 3.2, respectively.

3.2 RO Plant Water Quality

Physical, inorganic, organic, and microbial water quality for the RO plant are presented in Table 3.3. The RO plant complies with current regulations

3.3 RO Plant Performance Evaluation

Plant performance at the MIWS RO plant was evaluated according to finished water turbidity. Historical finished water turbidity data from January 1996 to December 1996 was compiled and evaluated. For the RO plant finished water turbidities were correlated to operating conditions such as antiscalant dose, acid dose, color, hardness, alkalinity, TDS, flow and pressure.

The RO historical finished water turbidity frequency distribution curve is presented in Figure 3.3. Figure 3.3 shows 0.4 NTUs as the limit for 95 percent of the measurements taken for finished water turbidity. The RO plant exceeded the 0.5 NTU finished water turbidity on 5 events. The finished water turbidity is over 0.2 NTU 48 percent of the time.

FIGURE 3.1: Design TurboCharger™ Operating Conditions (Year 0, 75%)

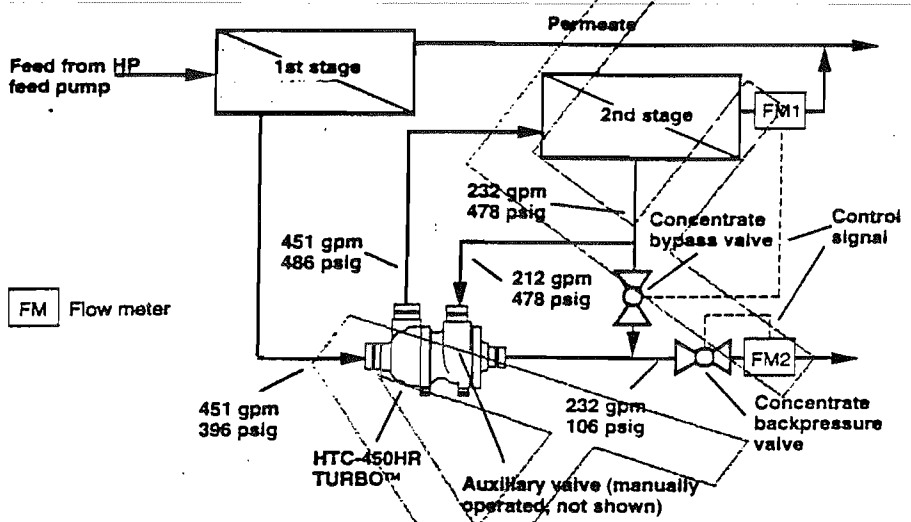

FIGURE 3.2: Design TurboCharger™ Operating Conditions (Year 3, 75%)

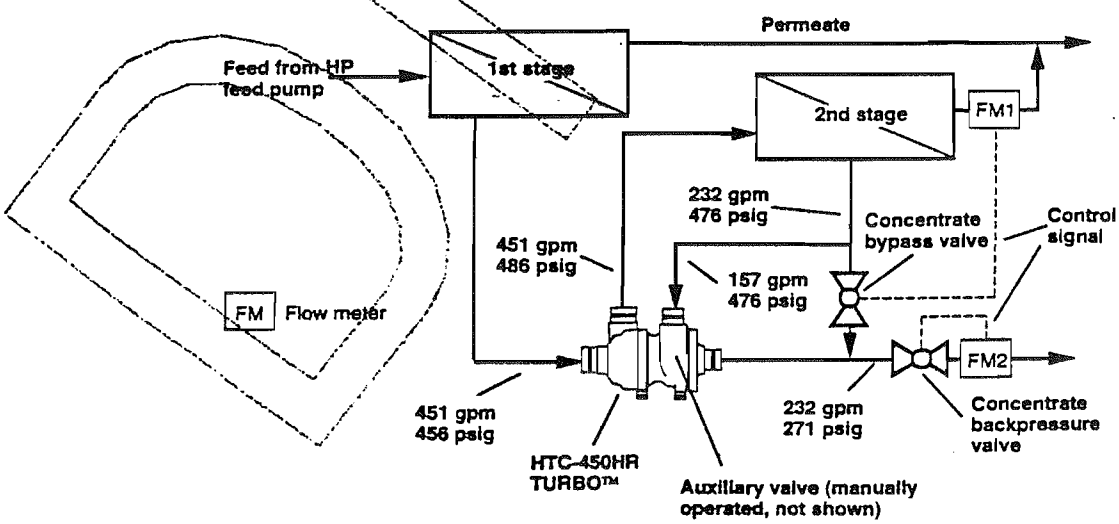

TABLE 3.3
RO Plant Water Quality

Description	Raw	Permeate
FIELD DATA		
pH	6.97	7.76
Temperature (C)	25.7	26.3
Conductivity (umhos/cm @ 25 C)	9130	255
INORGANIC (mg/L)*		
Fluoride	< 0.02	< 0.02
Chloride	2230	60.4
Nitrite	< 0.02	< 0.02
Nitrate	< 0.02	< 0.02
Strontium	7.23	0.05
Sulfate	442	3.88
Iron (Total)	< 0.2	< 0.2
Magnesium (Total)	192	1.27
Sodium (Total)	1580	40
Calcium (Total) (as $CaCO_3$)	368	5
Hardness (Total) (as $CaCO_3$)	1280	6.27
Alkalinity (Total) (as $CaCO_3$)	172	8
Ammonia Nitrogen (NH_3 as N)	0.57	0.72
TDS	5183	114
Barium (Total) (ug/L)	27	< 5
Potassium (Total)	53	1.56
Total Phosphorous (as P)	0.02	< 0.02
ORGANIC		
TOC (mg/L as C)	2.08	0.62
Color (CPU)	<5	< 5
UV-254 (cm^{-1})	0.03	0.011
MICROBIAL		
Total Coliforms (cfu/100mL)	Absent	Absent
HPC (cfu/100mL)	1.5	< 1
Turbidity (NTU)	0.14	0.45

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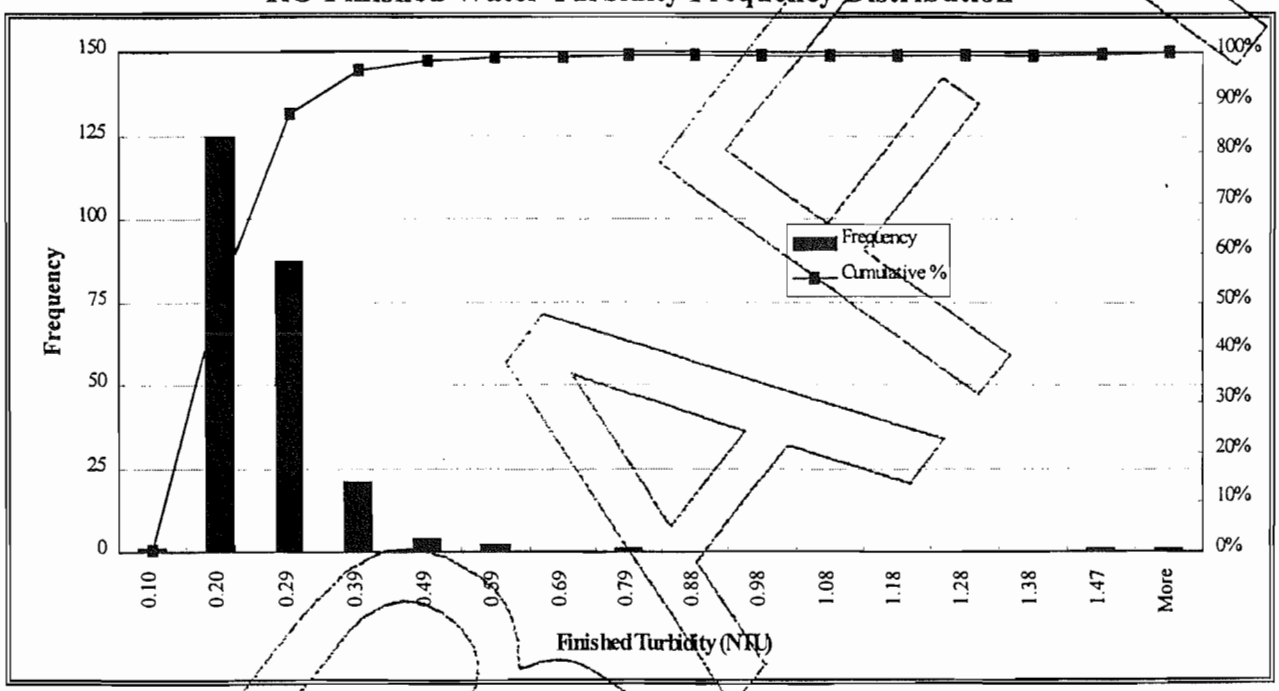
FIGURE 3.3
RO Finished Water Turbidity Frequency Distribution



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The operating parameters of the RO plant were statistically analyzed to determine if any relationship existed with finished water turbidity. The results of this analysis are shown in Table 3.4. The finished water turbidities were divided into a high and low turbidity group in order to evaluate the RO plant operating relationships to finished water turbidities. The operating conditions for all turbidities greater than 0.3 NTU were compared to the same operating conditions when the finished water turbidities were less than 0.3 NTU. Turbidities greater than 0.4 NTUs occurred on 27 separate events. The second group was 27 events less than 0.15 NTUs picked at random. Average, standard deviation, maximum and minimum conditions for the two turbidity ranges were then evaluated (Appendix C). An analysis of variance (ANOVA) was used to determine if there was any difference between the operating parameters associated with the high and low turbidity data set.

The data represented in Table 3.4 is separated by high and low turbidity groups. Consequently, if there is a significant difference between the data in the high and low turbidity groups, that difference indicates that parameter is associated with the occurrence of high and low finished water turbidity.

Increased raw water flow to the plant did not appear to be associated with either turbidity group. This indicates that flow rate through the plant is not necessarily causing the higher turbidities.

Increased raw water conductivity, TDS, and SDI correlated to increased finished water turbidities. Likewise, an increase in finished water pH and permeate TDS, and a decrease in finished water temperature was associated with increased finished water turbidities. An increase in feed pressure also correlated to increased turbidities. This indicates the plant is reacting to changes in these parameters in an adverse fashion.

Increases in Flocon, acid, caustic and chlorine dosages did not correlate to increased finished water turbidities. This indicates the plant is reacting to changes in these parameters in a satisfactory fashion.

3.4 Membrane Probe Profile Evaluation

RO element membrane profile and probe scenarios were explored by Harn R/O Systems, Inc. from November 12 - 21, 1996 on the four original RO trains (No. 1 - 4).

The profiling of each train consisted of setting the train back to start-up conditions. The conditions were based on historical records of the start-up feed pressure and concentrate flow. After each train stabilized at these conditions, each pressure vessel was volumetrically tested using a bucket test on the permeate flow from each vessel. During the bucket test a sample of permeate from each individual vessel was collected and the conductivity was measured and recorded.

Vessels whose average conductivity were greater than 200 umhos/cm were selected for probing. The change in average feed/brine concentration between stages was not taken into account. The probing of

TABLE 3.4
Statistical Analysis of RO Operating Parameter Relative to Finished Water Turbidity

Operating Parameter	Finished Water Turbidity <0.12 NTU	Finished Water Turbidity >0.3 NTU	Significance
Finished Turbidity (NTU)	0.13	0.48	Yes
Raw Water Flow (MGD)	2.26	2.45	No
Permeate Flow (MGD)	1.41	1.52	No
By-Pass Flow (MGD)	0.16	0.16	No
Finished Flow (MGD)	3.39	3.64	No
Raw pH	7.3	7.3	No
Raw Conductivity (uhmos/cm)	10,860	13,752	Yes
Raw TDS (mg/L)	7,176	9,088	Yes
Raw Chlorides (mg/L)	3,534	4,133	No
Raw Turbidity (NTU)	0.42	0.62	No
Feed pH	6.1	6.0	No
SDI	0.8	1.2	Yes
Flocon (mg/L)	78	85	No
Sulfuric Acid (mg/L)	121	136	No
Caustic Soda (mg/L)	25	40	No
Chlorine (mg/L)	44	50	No
Finished pH	8.1	8.3	Yes
Finished Temperature (°C)	27	24	Yes
Finished Alkalinity (mg/L as $CaCO_3$)	28	40	Yes
Finished Calcium Hardness (mg/L $CaCO_3$)	88	95	No
Finished Total Hardness (mg/L $CaCO_3$)	101	107	No
Finished Conductivity (uhmos/cm)	562	605	No
Finished TDS (mg/L)	376	405	No
Permeate TDS (mg/L)	142	295	Yes
Finished Chloride (mg/L)	137	139	No
Feed Pressure (psi)	285	381	Yes

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each selected vessel was accomplished by utilizing a length of tubing as long as a pressure vessel. This enabled sampling for conductivity measurements as the tube was pulled past each membrane in the vessel. The probing would allow the reviewer to determine if the poor performance may be caused by a defective end-cap, leaking o-ring, or possibly a failure within an element. After evaluating the performance of the probing within the vessels, the membrane elements were identified for investigation during membrane replacement.

3.5 Membrane Interstage Retrofit Evaluation

Train performance data collected by Florida Water was evaluated for the five operating trains from October 1996 until March 1997 by Boyle (See Appendix F). Gross average membrane productivity was investigated, however, membrane age and type were not taken into account. Average recovery, normalized flux to 25 °C and salt passage were calculated from the performance data. Average, standard deviation, maximum and minimum values trends were compiled for each train for each performance criteria. Train No. 1 - 4 were compared to Train No. 5 that had interstage booster pumps and feed water header pipe retrofit enhancements.

Train No. 5 consistently showed enhanced performance with an average recovery of 74.6 %, a normalized flux of 14.8 gsfd, and a salt passage of 1.8 %. Whereas Trains No. 1 - 4 showed an average recovery of 69.9 %, a normalized flux of 13.3 gsfd, and a salt passage of 2.7 %, the recovery and flux for train No. 5 had very little variation. This shows the advantage of the interstage turbine booster. Figures 3.4, 3.5, and 3.6 show the Marco Island ROWTP average performances for percent recovery, normalized flux, and percent salt passage, respectively. Tables 3.5, 3.6, and 3.7 show the Marco Island plant trend performances for percent recovery, normalized flux, and percent salt passage, respectively.

3.5.1 Membrane Interstage Performance Evaluation

Figure 3.7, 3.8 and 3.9 show the average recovery, flux and salt passage by stage per train. The recoveries and fluxes in stage one for the trains are similar, however the recovery and flux in stage two for train 5 performs better than the original 4 trains. This can also be seen for the overall recovery and flux. Train 5 rejects more salt than any of the original 4 trains. It is important to remember that Train No. 5 utilized new membrane elements in a different configuration. Consequently, the significantly improved performance would be in part due to the design, which included an interstage turbine, and also because Train No. 5 incorporated new elements.

Average permeate produced and water quality, represented by conductivity are presented in Figure 3.10. Figure 3.10 shows that train 5 continuously produces more water at a higher quality.

FIGURE 3.4
Marco Island RO Plant Average Recovery per Train
From October 1996 to March 1997

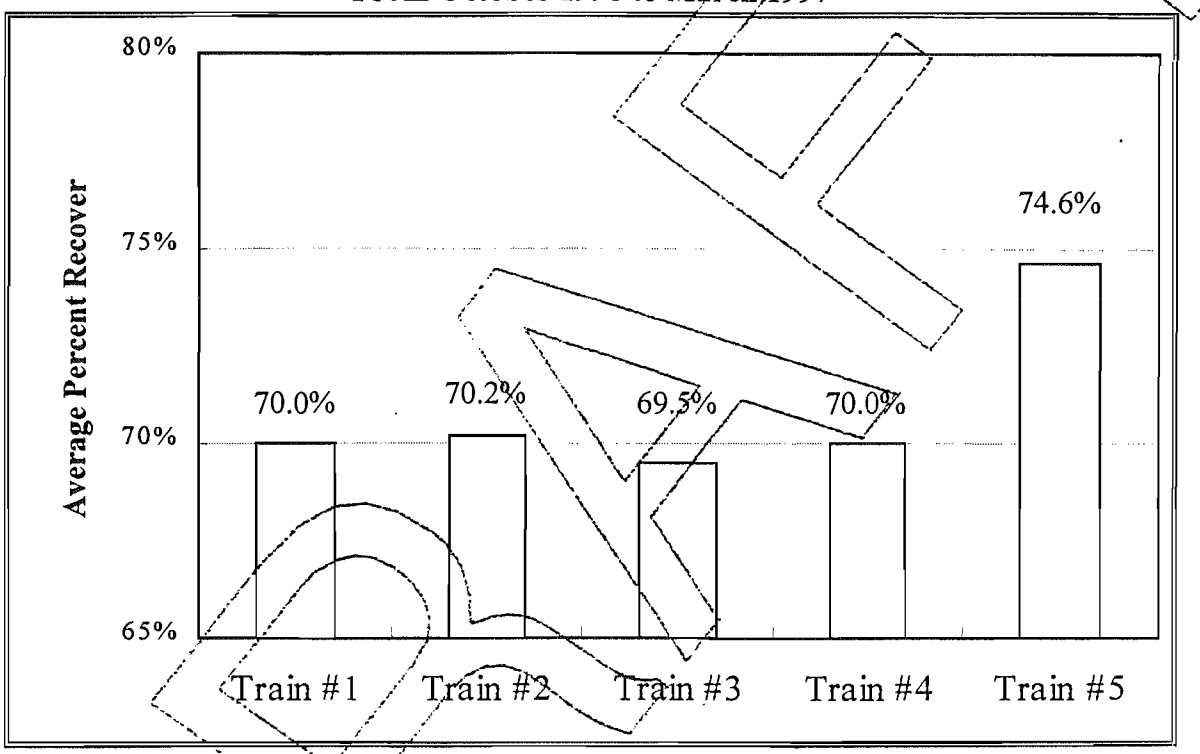

TABLE 3.5
RO Membrane Percent Recovery Trend per Train

	Average	Std Dev.	Max	Min
Train #1	70.0%	1.78%	74.2%	63.3%
Train #2	70.2%	1.90%	80.9%	56.0%
Train #3	69.5%	1.59%	71.2%	66.0%
Train #4	70.0%	1.38%	71.4%	65.6%
Train #5	74.6%	0.63%	76.2%	70.4%

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FIGURE 3.5
Marco Island RO Plant Average Normalized Flux (25 °C) per Train From October 1996 to March 1997

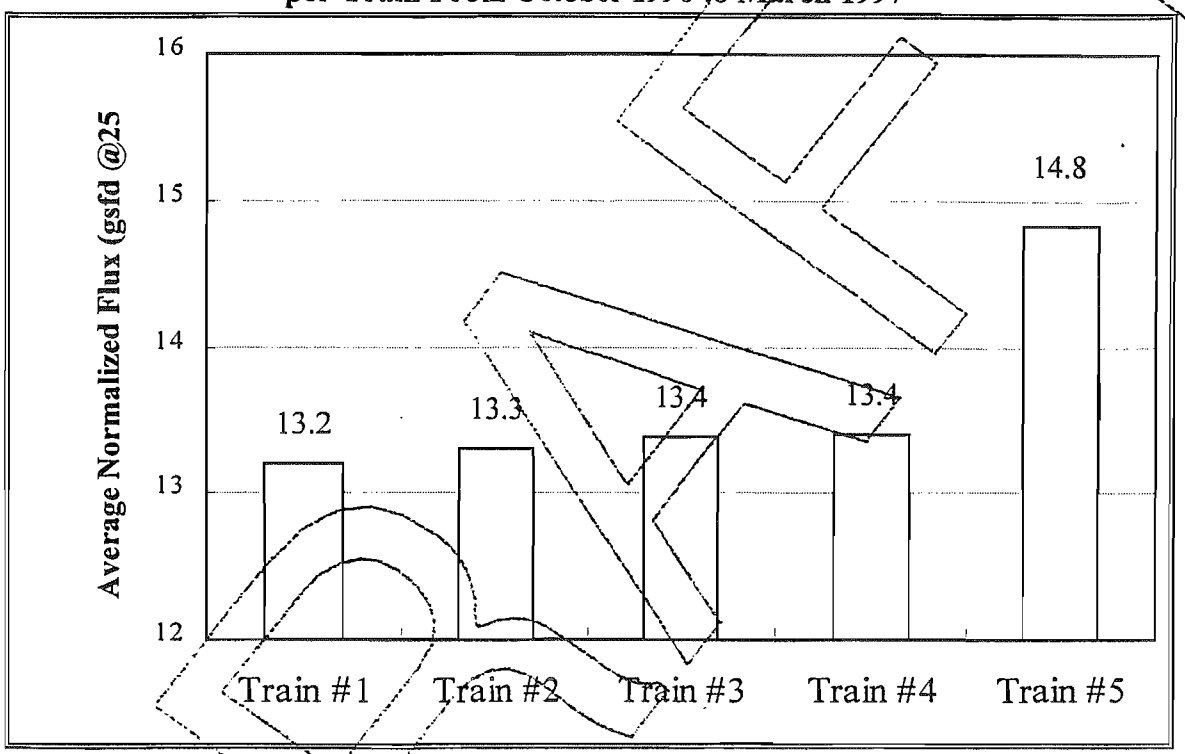

TABLE 3.6
RO Membrane Normalized Flux Trend per Train (gsfd @ 25 °C)

	Average	Std Dev.	Max	Min
Train #1	13.2	0.93	15.7	9.3
Train #2	13.3	0.91	15.6	7.3
Train #3	13.4	0.62	14.5	11.8
Train #4	13.4	0.63	14.3	11.5
Train #5	14.8	0.42	16.6	13.8

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FIGURE 3.6
Marco Island RO Plant Average Salt Passage per Train
From October 1996 to March 1997

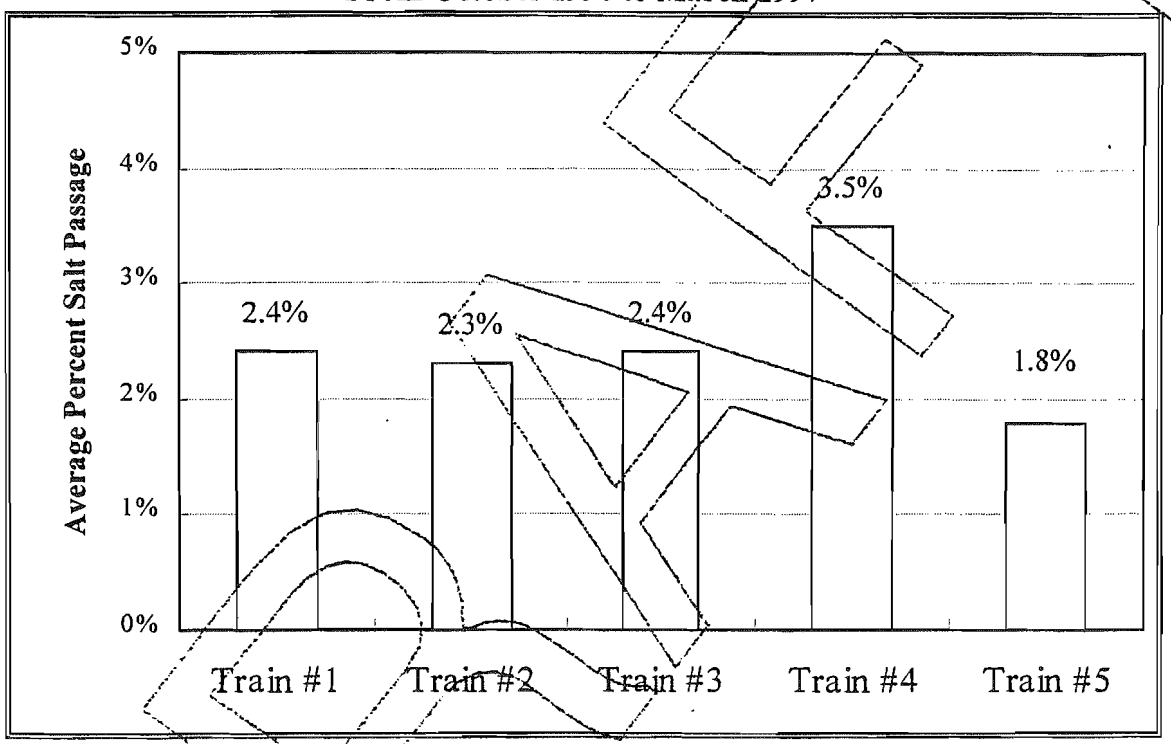

TABLE 3.7
RO Membrane Percent Salt Passage Trend per Train

	Average	Std Dev.	Max	Min
Train #1	2.4%	0.24%	3.8%	1.3%
Train #2	2.3%	0.35%	6.2%	1.6%
Train #3	2.4%	0.42%	3.4%	1.4%
Train #4	3.5%	0.24%	4.6%	2.9%
Train #5	1.8%	0.54%	3.6%	1.1%

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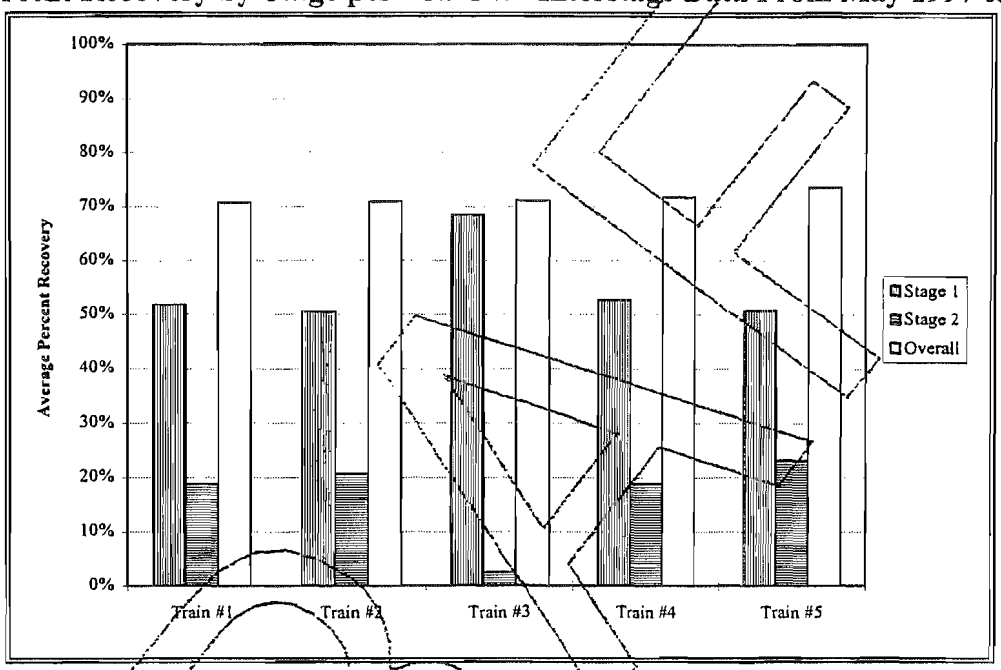
FIGURE 3.7
Average Percent Recovery by Stage per Train for Interstage Data From May 1997 to June 1997



Overall Percent Recovery Trend per Train

	Average	Std Dev.	Max.	Min.
Train #1	70.7%	2.5%	74.2%	63.4%
Train #2	70.9%	2.1%	73.6%	63.2%
Train #3	71.1%	1.0%	72.2%	69.5%
Train #4	71.7%	1.0%	74.2%	70.3%
Train #5	73.5%	1.4%	75.0%	65.5%

Stage 1 Percent Recovery Trend per Train

	Average	Std Dev.	Max.	Min.
Train #1	51.8%	2.3%	56.5%	45.2%
Train #2	50.5%	1.4%	53.5%	48.0%
Train #3	68.5%	1.0%	70.1%	67.1%
Train #4	52.7%	1.0%	54.1%	51.3%
Train #5	50.8%	0.6%	51.9%	49.4%

Stage 2 Percent Recovery Trend per Train

	Average	Std Dev.	Max.	Min.
Train #1	18.9%	1.7%	21.1%	14.0%
Train #2	20.7%	0.8%	22.3%	19.4%
Train #3	2.5%	1.2%	4.4%	1.1%
Train #4	18.9%	1.3%	20.6%	16.4%
Train #5	23.1%	1.2%	28.6%	21.7%

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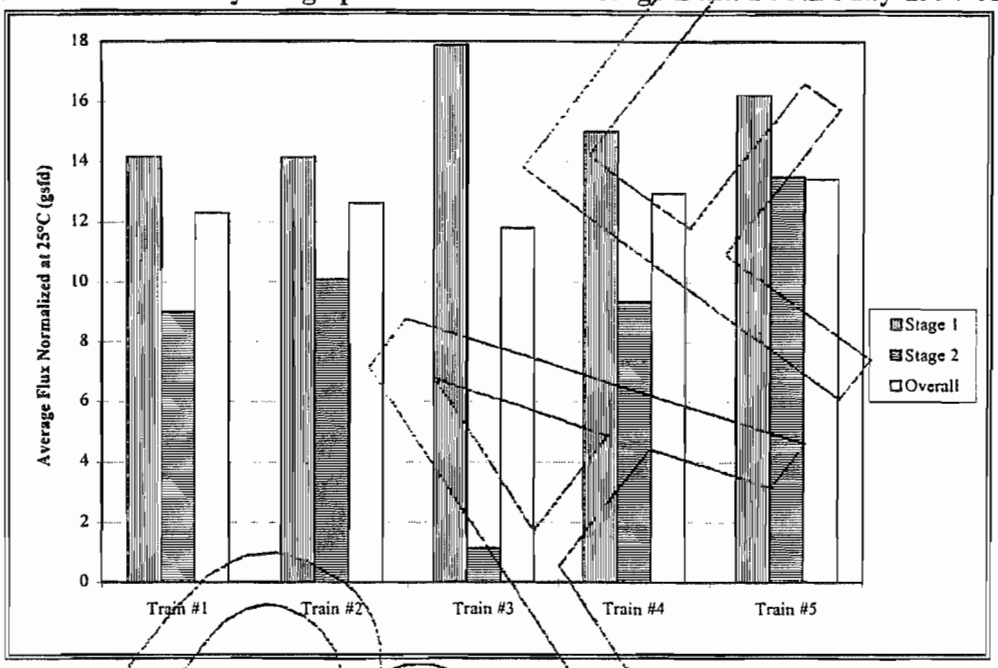
FIGURE 3.8

Average Normalized Flux by Stage per Train for Interstage Data From May 1997 to June 1997



Overall Flux Trend Normalized at 25°C per Train (gsfd)

	Average	Std Dev.	Max.	Min.
Train #1	12.3	0.5	13.5	11.5
Train #2	12.6	0.5	13.4	11.0
Train #3	11.8	0.3	12.2	11.3
Train #4	13.0	0.5	13.7	12.4
Train #5	13.4	0.2	13.6	12.1

Stage 1 Flux Trend Normalized at 25°C per Train (gsfd)

	Average	Std Dev.	Max.	Min.
Train #1	14.2	0.6	15.3	13.0
Train #2	14.2	0.5	15.4	13.3
Train #3	17.9	0.2	18.1	17.5
Train #4	15.0	0.4	15.7	14.4
Train #5	16.2	0.1	16.5	15.6

Stage 2 Flux Trend Normalized at 25°C per Train (gsfd)

	Average	Std Dev.	Max.	Min.
Train #1	9.0	0.8	10.5	6.9
Train #2	10.1	0.5	11.1	9.2
Train #3	1.1	0.6	2.0	0.5
Train #4	9.3	0.8	10.4	7.9
Train #5	13.5	0.7	16.6	12.9

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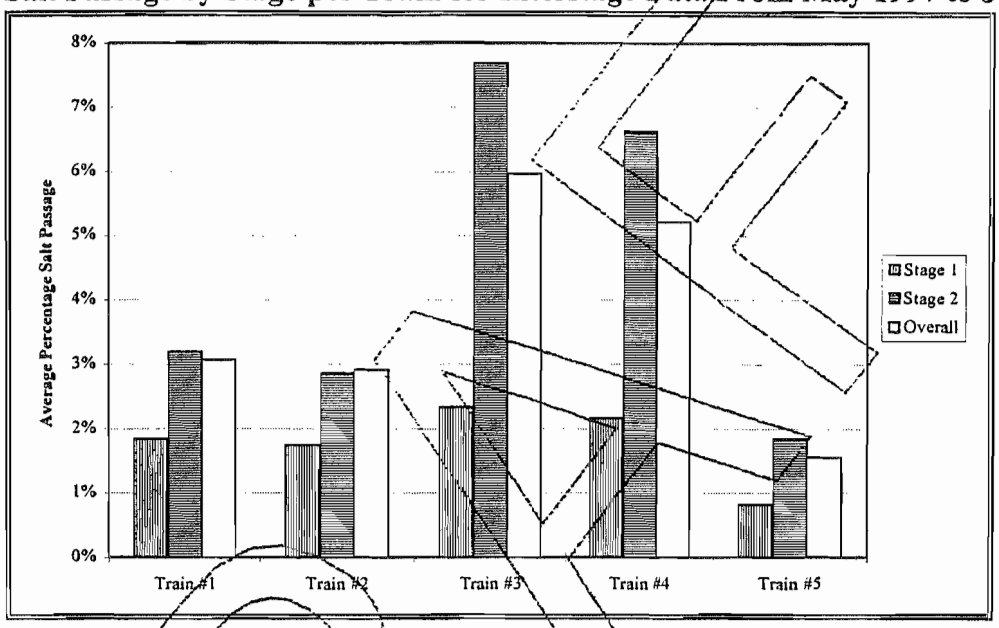
FIGURE 3.9

Average Salt Passage by Stage per Train for Interstage Data From May 1997 to June 1997



Overall Percent Salt Passage Trend per Train

	Average	Std Dev.	Max.	Min.
Train #1	3.07%	0.30%	3.50%	2.36%
Train #2	2.91%	0.46%	3.99%	1.72%
Train #3	5.96%	0.17%	6.23%	5.77%
Train #4	5.21%	1.09%	8.65%	4.01%
Train #5	1.56%	0.56%	4.93%	0.91%

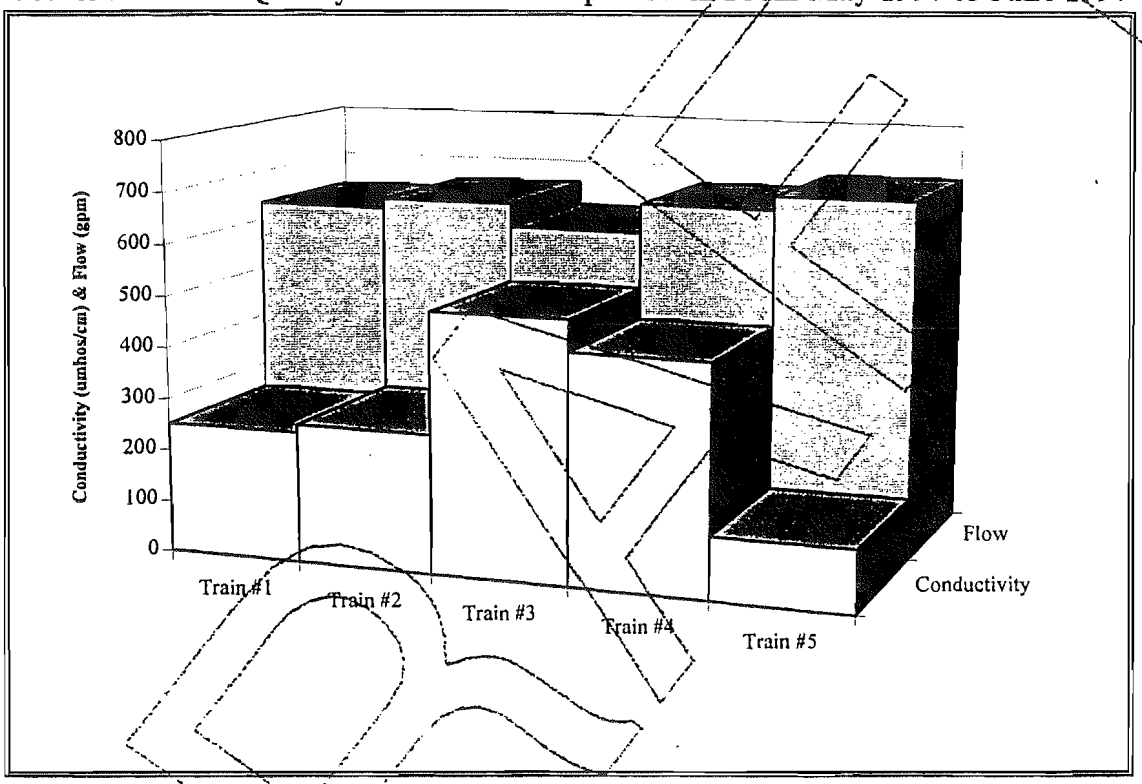
Stage 1 Percent Salt Passage Trend per Train

	Average	Std Dev.	Max.	Min.
Train #1	1.85%	0.15%	2.09%	1.43%
Train #2	1.75%	0.26%	2.39%	0.96%
Train #3	2.33%	0.14%	2.51%	2.18%
Train #4	2.16%	0.71%	4.56%	1.78%
Train #5	0.81%	0.29%	2.58%	0.38%

Stage 2 Percent Salt Passage Trend per Train

	Average	Std Dev.	Max.	Min.
Train #1	3.19%	0.21%	3.45%	2.67%
Train #2	2.86%	0.43%	3.74%	1.66%
Train #3	7.68%	0.26%	8.16%	7.26%
Train #4	6.62%	0.59%	7.51%	5.42%
Train #5	1.84%	0.57%	3.30%	1.00%

FIGURE 3.10
Permeate Water Quality and Production per Train From May 1997 to June 1997



Overall Conductivity per Train

	Average	Std Dev.	Max.	Min.
Train 1	251	46	323	156
Train 2	266	46	344	180
Train 3	499	120	567	255
Train 4	438	74	596	329
Train 5	121	19	165	97

Overall Flow per Train

	Average	Std Dev.	Max.	Min.
Train 1	634	24	673	589
Train 2	653	22	690	615
Train 3	607	18	627	580
Train 4	665	23	702	640
Train 5	692	8	696	659

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3.6 Amperage Evaluation (Energy Savings)

Train pump performance amperage data was collected from the five trains from February 1997 until March 1997 (See Appendix G). Energy savings for each train was determined by measuring the amperage of the high-pressure feed pump used for each train and the amount of permeate water produced. This enabled the power consumption for each train to be compared to the amount of permeate water produced. Variations in raw water quality and system variations over time can be seen with the power consumption from each train. As seen in Table 3.8, the amperage recordings of Train No. 5 exhibited the less noise at a lower amperage consumption. Table 3.9 shows more permeate water was produced under control from Train No. 5. Train No. 5 required 14 percent less power consumption and produced 6 percent more permeate water when compared to Train No 1 - 4.

Figures 3.11 and 3.12 show an amperage test recorded on February 26, 1997, over a 24 hour on feed pumps for Train No. 2 and 5, respectively. Train No. 5 (Figure 3.12) shows less noise in it's amperage recordings. Also as seen in Table 3.8, the amperage recordings of Train No. 5 exhibited less noise at a lower amperage consumption. Table 3.9 shows more permeate water was produced under control from Train No. 5. Train No. 5 required 14 percent less power consumption and produced 6 percent more permeate water when compared to Train No 1 - 4.

3.7 RO Membrane Modeling Evaluation

This section first discusses the impacts of blending surface water with ground water with respect to physical, chemical and microbial characteristics. An evaluation using FilmTec, Fluid System and Hydranautic membranes are modeled for blending lake or surficial well water with brackish well water. In addition, the use of sulfuric acid for pretreatment was modeled for the brackish feedwater water to determine if it's use was warranted. Printouts for these model projections are presented in Appendix J.

3.7.1 Surface Water Quality Impacts

The various natural characteristics of a surface water supply and surrounding watershed can have a significant effect on water quality. The watershed can impact the water supply physically, chemically and microbiologically. The stratification of a surface water impoundment and reservoir can also have significant impacts on water quality, particularly dissolved oxygen and temperature.

Membrane processes are sensitive to water quality changes (Duranceau, 1993). Knowledge of the long-term changes in water quality (seasonal variation) and the potential for short-term events (algae bloom) is essential for determining additional pretreatment requirements necessary to reduce fouling potential and maintain water production (permeate flux) at the RO plant should a surface water supply be available.

TABLE 3.8
Amperage Trend per Train (amps)

	Average	Std. Dev.	Max.	Min.
Train #1	334	13.51	358	309
Train #2	300	12.70	323	277
Train #3	281	13.00	302	252
Train #4	291	14.03	316	263
Train #5	259	11.47	286	241

TABLE 3.9
Permeate Water Produced Trend per Train (gpm)

	Average	Std. Dev.	Max.	Min.
Train #1	652	18.51	693	620
Train #2	650	26.59	696	570
Train #3	655	31.23	684	595
Train #4	667	21.27	692	604
Train #5	694	0.49	695	693

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FIGURE 3.11: Train No. 2 Feed Pump Amperage Readings

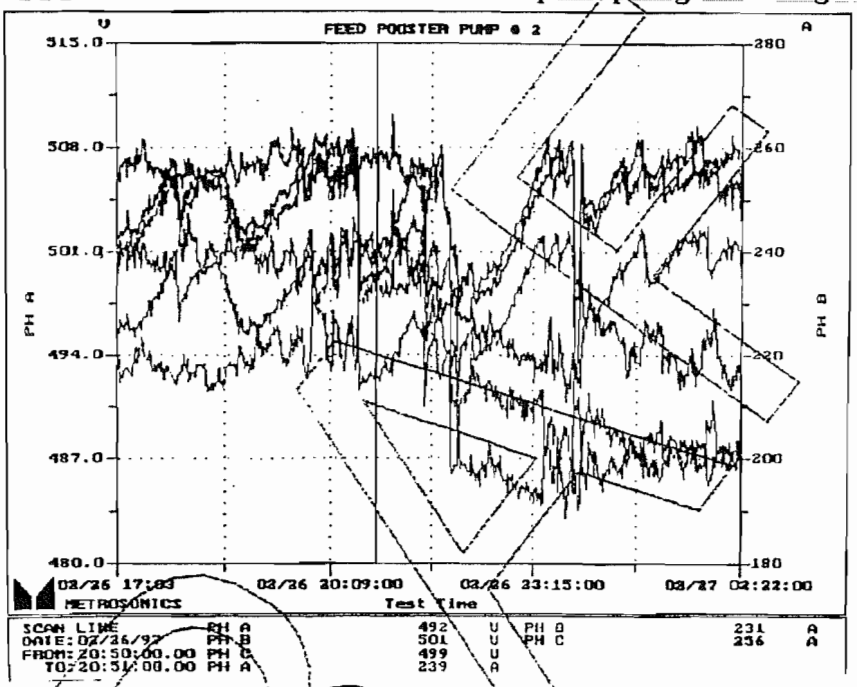
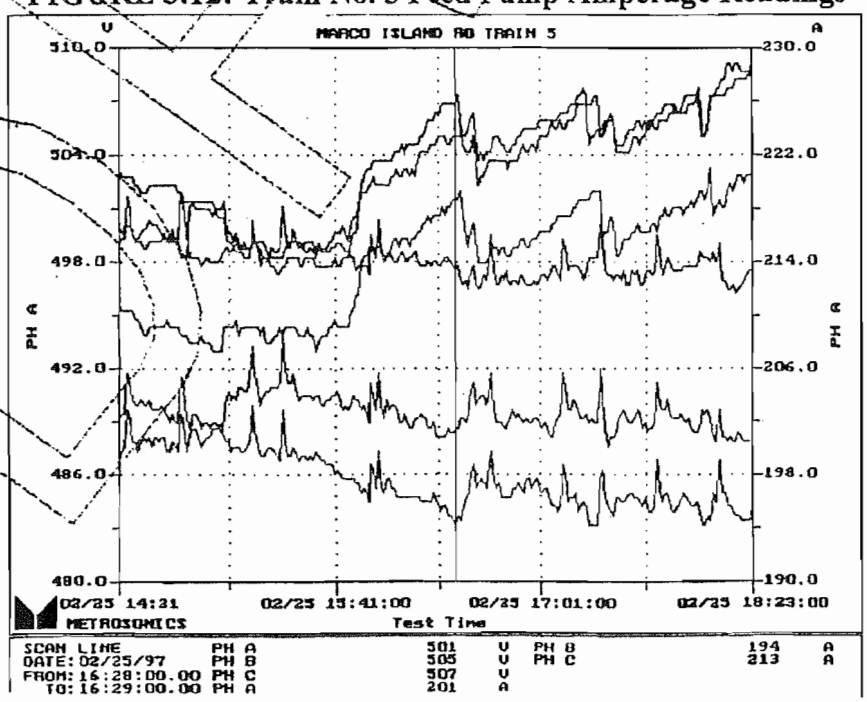


FIGURE 3.12: Train No. 5 Feed Pump Amperage Readings



Additional pretreatment of the Marco Island surface water source would be necessary to protect the RO membrane elements if a surface source or blended surface/groundwater were used as the RO feed water. This could potentially include the use of ultrafiltration for pretreatment.

3.7.1.1 Temperature

The influence of viscosity on flux is apparent in Poiseuille's law, where water flux increases as viscosity decreases. Viscosity decreases as temperature increases. Consequently, accurate comparisons of water flux requires that viscosity be adjusted to a common temperature (typically 77 degrees Fahrenheit), or that the tests be conducted at the same temperature. The diffusivity of water increases as temperature increases, but to a lesser degree, whereas viscosity decreases. The flux can most easily be adjusted for temperature using factors that are provided by the manufacturer of the membrane.

Impacts of loss of water production at the RO plant due to decreases in temperature as a result of blended cooler surface waters with steady-state (ambient room temperature) groundwater supplies may reduce water production. A flux production decline as much as *1 percent per degree Fahrenheit* is typical, and will result in either loss of production or increase in net operating pressure (Belfort, 1984). The surface water supply seasonal variations and effects on blends of the brackish water source remains unknown at the present time.

3.7.1.2 Biological Fouling

In general, microorganisms will proliferate where there is an adequate source of nutrients and favorable environmental conditions. The membrane surface will often serve as an ideal location for organism attachment growth because the attached microorganisms feed on the nutrients carried past them across the membrane surface. Once a plant is infested, maintaining water production becomes more difficult.

An example of the impact of biological fouling and the importance of salinity shock treatment to control biofouling has been realized at the City of Dunedin RO plant. The City's membrane process relies on ground water under the influence of a surface water source and has often experienced biological fouling (i.e. *psuedonomas* bacteria) since start-up in 1992. The biofouling is reduced when cleaning is performed with salt solutions and other chemicals. The plant's feed water has elevated dissolved oxygen levels, contains iron and manganese, and has significant heterotrophic plate count (HPC) levels in the ground water source. Operation at low pH (approximately 4.5) can prevent *psuedonomas* bacteria growth, however, yeast and mold infestation occurred when operating at the lower pH (Knippel and Bolin, 1995). Yeast and mold are partially controlled during cleaning using salt solutions.

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These results would indicate that a surface water supply could be mixed with brackish water to produce a salinity which would inhibit biological growth experienced in membrane plants using aerated feed waters (i.e. fresh surface water sources of supply). However, additional investigations would be required prior to implementing such a major process feed water change to the existing RO WTP.

3.7.1.3 Colloidal Silica

Silica may be present either as a colloid or in a soluble form. The maximum concentration of silica depends on the crystalline form of silica present. Quartz has a maximum concentration of 10 mg/L, whereas amorphous silica has a solubility of about 120 mg/L as SiO_2, and typically controls the formation of silica oxide in membrane processes. Colloidal silica can be effectively removed during pretreatment by using a coagulant such as sodium aluminate or ferric chloride (Potts et al., 1981).

Silica solubility is difficult to increase, relative to the solubility of inorganic salts, because silica is not in an ionic form and is unaffected by ionic strength and most anti-scalants. The potential colloidal silica loading of the surface water supply to the RO plant is at present unknown because of limited silica data.

3.7.1.4 Assimilable Organic Carbon

Organisms utilize carbon, nitrogen and phosphorous for the synthesis of cell material and the generation of energy for sustained growth. Easily assimilable organic carbon (AOC) is that portion of the total organic carbon (TOC) which can be readily digested by aquatic organisms and used for cellular growth. Typically, the AOC comprises just a fraction (typically less than 10 percent) of the total dissolved organic carbon (Van der Kooij, 1982). The AOC content of the existing brackish well-field at present and potential surface supply are unknown because of limited data, and hence impacts on microbial growth specific to the Marco Island RO plant cannot be predicted at the present time.

3.7.1.5 Bacteria

Growth is defined as the increase in bacterial numbers in the membrane system as a result of cell reproduction. Significant growth will occur at the expense of an organic and/or inorganic substrate. The combination of low nutrient concentration in waters with large flow rates can transport tremendous quantities of nutrients to fixed microorganisms on the membrane surface.

Since most bacteria in aquatic environments exist at solid-liquid interfaces, the membrane structure provides an excellent opportunity for continual bacterial growth. Many bacteria often produce

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secondary metabolites (antibiotics, bacteriocins, poly saccharides and colcins) which can inhibit competing organisms but further foul the membrane element. The seasonal bacteriological cycle of the surface water supply is at present unknown because of limited data.

3.7.2 Surface Water Supply Intake Design

The design yield of the surface water supply will in part determine the type and location of an intake structure at the surface water impoundment. The intake structure may require the inclusion of additional pretreatment facilities prior to pumping, transmission and blending with brackish water at the RO plant. Conventional intakes will not provide significant filtering of the surface water supply. It may be more desirable to use an alternative design concept that would provide additional pretreatment and produce a higher quality feed water prior to brackish water blending.

3.7.3 RO Membrane Modeling Performance Projections

Computer software packages provided by membrane manufacturers were applied to various treatment scenarios for the Marco Island WTP. These scenarios included both existing and proposed operations with an emphasis on determining the effect of membrane type, blended water sources upon feed pressure requirements and elimination of sulfuric acid treatment.

3.7.3.1 Membrane Screening and Selection

Before modeling various blended water sources, screening exercises were conducted which identified specific membranes suitable for application under the existing and proposed operating conditions. Nominal membrane performance was gauged for membranes manufactured by Hydranautics, Film-Tec and Fluid Systems. The screening procedures were conducted under simplified conditions. Firstly, all screening projections were carried-out with an intermediate 50:50 blend of the surficial well and the brackish water. This is warranted by similarity in TDS among the two alternative sources and the anticipated greater fouling potential associated with the Lake Marco surface water source.

Furthermore, the existing 24x12 treatment arrays with 6 8"x40" (8040) single membrane element per pressure vessel were simulated. The resulting information is presented in graphical form and includes the variables system recovery, system flux, feed pressure, final permeate TDS, and required permeate Stage I back-pressure (Figure 3.13).

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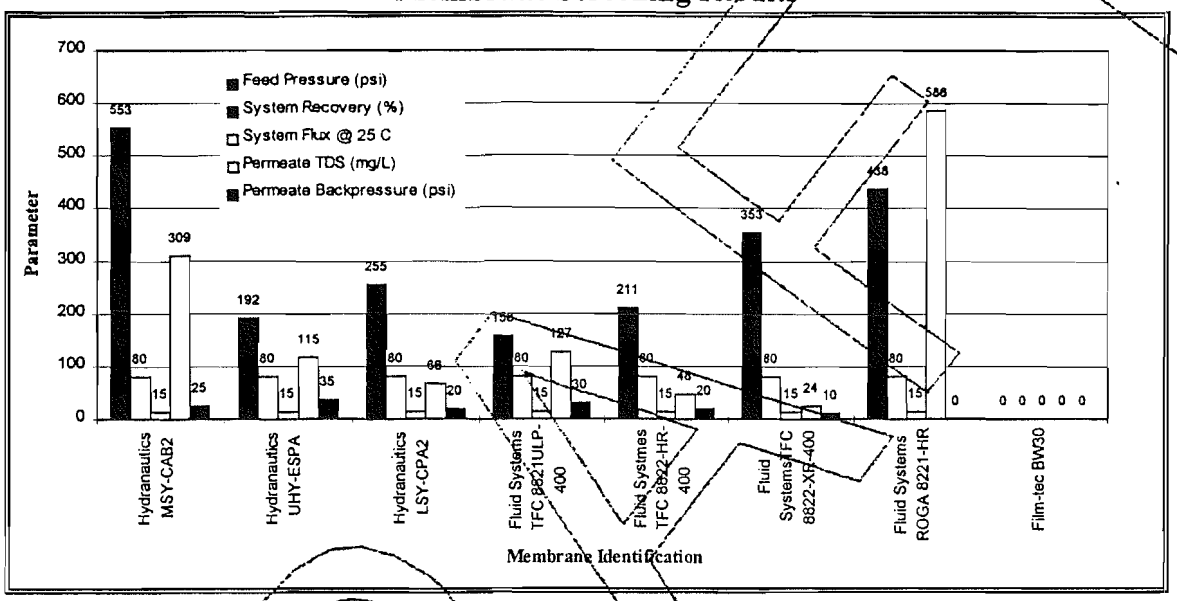
FIGURE 3.13
Membrane Screening Results



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From the screening results a membrane from each manufacturer offering the most optimal treatment option was selected. The membranes selected for further consideration are Hydranautics' UHY-ESPA, Fluid Systems' TFC 8821ULP-400 and Film-Tec's BW30 membrane. This field of membranes was applied to the blended source waters and evaluated for respective operating pressure requirements.

3.7.3.2 Source Water Blend Evaluation

As a means of increasing raw water capacity and quality blending was considered for a combination of blends, membranes and recoveries at the RO plant. Blending of surface water used at the LS plant or surficial well water with brackish well water were considered as potential sources to serve as a water supply for the RO plant. The blending is intended to increase the water quality before treatment to reduce operating cost and increase capacity.

Blending of surface water supply source (local quarry water in proximity to the Marco Island RO plant) with brackish ground water sources for potential use as a feed water for the RO plant presents several issues that should be considered. The potential use of surface water as a feed source is a viable alternative for Florida Water and would have an impact on future process considerations. There still exists items needing further study and consideration to characterize the necessary baseline of information required for use of a fresh water and brackish water blend prior to RO treatment.

Reverse osmosis treatment of surface water has in the past been historically limited to conversion of open sea water to potable water in areas where freshwater was not available. In more recent times, use of microfiltration, ultrafiltration and nanofiltration membrane processes has advanced the use of surface water treatment with membrane technology. However, there are a number of technical concerns associated with the use of a surface water as RO feed supply water by itself or as a blend with brackish ground water.

A major problem would occur if there was irreversible fouling of the membrane elements. Irreversible physio-chemical and microbial fouling of the membranes elements at the RO plant would result in a reduction of the membrane efficiency. Fouling is defined as the build-up of materials on the surface of the membrane which restrict and reduce flow through the membrane. Because equilibrium chemistry will differ widely from one supply source to another, the changes inherent to variability of surface supply water quality may impact the operation of the existing RO plant. In coastal areas, sodium and chloride is typically more predominant and hence would have more importance on the water chemistry than calcium and carbonate (Watson and Missimer, 1994). However the use of surface water and groundwater as sources of supply will change the equilibrium chemistry of the feed water and impact chemical additions during process operation.

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The source waters evaluated consisted of a surface water source (Lake Marco) or a ground water source blended with the currently used brackish water source. Blending of these water sources would be expected to reduce the TDS of the brackish water, reducing the osmotic pressure to be overcome during RO treatment. The respective water qualities are presented in Table 3.10.

Each of the manufacturer membrane modeling packages provided for automatic water quality blending. The two alternative source waters were blended with the brackish water source in the amounts of 25, 50 and 75 percent. Each of these projections were performed at 70 percent recovery, which is similar to the existing system and a membrane age of time zero. Recovery is equally important in reducing feed pump hp as is reduced average osmotic pressure. The general trends gleaned from these projections support, as expected, that with increasing percent blend of surficial well and Lake Marco water that less feed water pressure is required (Figures 3.14 and 3.15). This attributable to the reduced osmotic pressure that needs to be overcome as the brackish water is progressively diluted.

Comparison of the pressures required for the surficial well and Lake Marco source waters showed very similar pressure reductions by percent blend. Therefore, these projections suggest overall feed pressure reductions by blending could equally be met by both alternative source waters. However, careful attention would need to be made for the associated pretreatment requirements necessary for sustained production using either the surface water or surficial well source. It is realized that this information could only be gathered by bench- or pilot-scale evaluation. The available water quality information on the alternative source waters reinforces the need for such evaluations prior to full-scale implementation.

Naturally, Lake Marco would be expected to possess a substantial amount of foulants due to colloidal particles, biological activity and the seasonal variation. The surficial well water source would be expected to offer a more suitable raw water source, however, the feed water turbidity was roughly five times greater than the Lake Marco water. The source of this turbidity may have been from the precipitation of iron that occurred upon sampling and subsequent analysis. If the surficial well water was anaerobic upon collection, a portion of the 1.75 mg/L total iron may have been driven from solution as the sample became aerated. Although, it is recognized that under anaerobic conditions this would not be expected to occur and membrane treatment could still possibly be used without its removal.

3.7.3 Projected Results for Sulfuric Acid Pretreatment Elimination

To reduce operational cost an additional scenario was modeled which evaluated the possible impact of the elimination of acid addition in trains 1 through 4. These trains are configured identically in terms of membrane type, quantity and array configuration (Table 3.1). The source water for this projection was

TABLE 3.10
Source Water Quality

Location	Marco Lake	Simulated Well Field	RO Plant
Description	**Surface**	**Surficial Well**	**Brackish Well**
FIELD DATA			
pH	7.35	6.73	6.97
Temperature (C)	24	25.1	25.7
Conductivity (umhos/cm @ 25 C)	1311	606	9130
Turbidity (NTU)	1.18	6.18	0.14
INORGANIC (mg/L)*			
Fluoride	< 0.02	0.103	< 0.02
Chloride	138	35.1	2230
Nitrite	<0.02	< 0.02	< 0.02
Nitrate	0.258	< 0.02	< 0.02
Strontium	0.578	---	7.23
Sulfate	65.7	22.2	442
Iron (Total)	< 0.2	1.75	< 0.2
Magnesium (Total)	12	3.58	192
Sodium (Total)	73.7	12.6	1580
Calcium (Total) (as $CaCO_3$)	126	125	147
Hardness (Total) (as $CaCO_3$)	344	326	1280
Alkalinity (Total) (as $CaCO_3$)	259	286	172
Ammonia Nitrogen (NH_3 as N)	0.1	0.146	0.57
TDS	948	591	5183
Barium (Total) (ug/L)	36	44	27
Potassium (Total)	2.53	0.22	53
Total Phosphorous (as P)	0.03	0.02	0.02
ORGANIC			
TOC (mg/L as C)	13.5	7.94	6.09
Color (CPU)	40	50	10
UV-254 (cm^{-1})	0.335	0.362	0.102

* unless indicated

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FIGURE 3.14
Projected Feed Pressures for Surficial Well and Brackish Water Blends

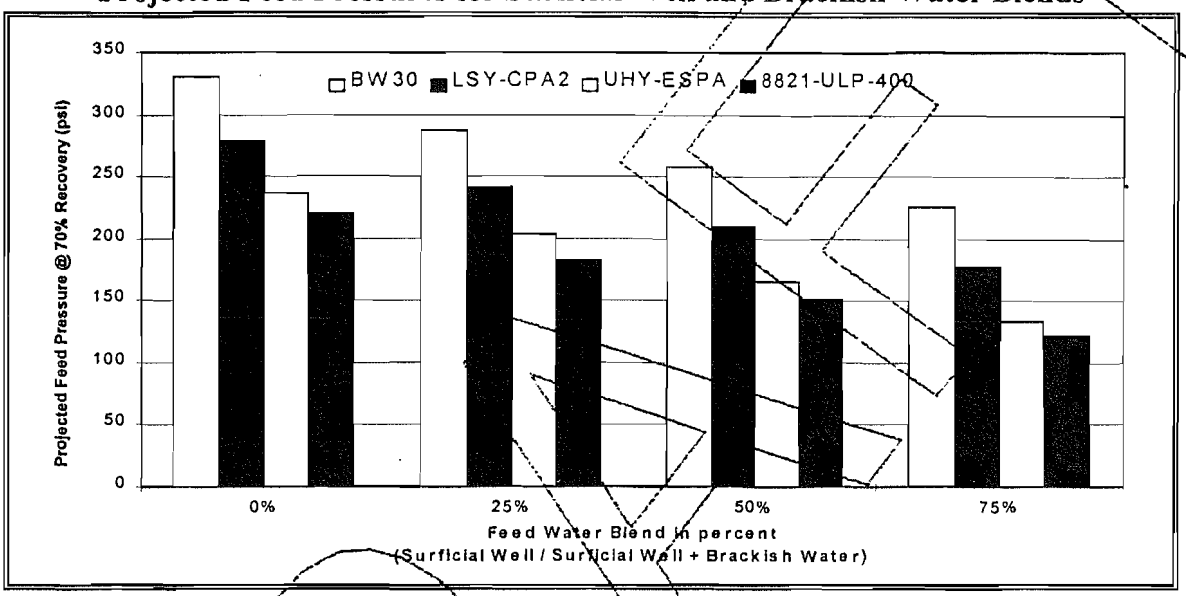
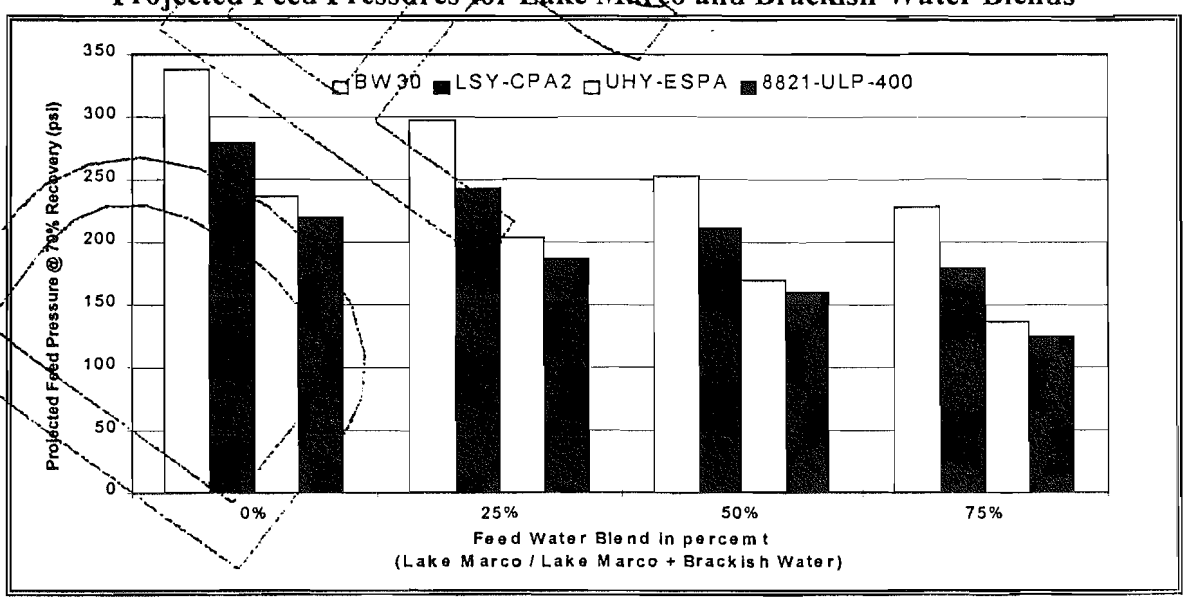


FIGURE 3.15
Projected Feed Pressures for Lake Marco and Brackish Water Blends



taken as the water quality analysis provided in Table 3.10 for the currently used brackish water wells. A worst case scenario was considered by modeling performance at the highest allowable recovery. At 72 percent recovery and 14.4 gsfd solvent flux, both calcium carbonate and barium sulfate were projected to be supersaturated. Calcium carbonate saturation was measured by the Langelier Saturation Index (LSI = pH - pH_s) and was shown to be 0.63. Since pH_s represents the pH at which calcium carbonate is 100 percent saturated, positive LSIs indicate supersaturation since the pH is in excess of the pH at which calcium carbonate becomes 100 saturated (pH_s). Barium sulfate saturation was projected as percent saturation and was shown to be 5400 times greater than its theoretical saturation limit. Sulfuric acid and antiscalant pretreatment are currently used to control the scaling potential of these two sparingly soluble salts. Given the relatively low LSI projection in the final concentrate without sulfuric acid pretreatment, it is possible that sufficient scaling control could be provided by antiscalant alone for both calcium carbonate and barium sulfate. Elimination of sulfuric acid addition would also reduce barium sulfate saturation but would be expected to allow a slightly higher degree of salt passage to the permeate.

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4.0 Bench-Scale Treatability Evaluation

Laboratory treatability evaluations were conducted using enhanced lime softening, ion-exchange and membrane processes on Marco Lakes water.

4.1 Lime-Softening Bench-Scale Jar Test Treatability Evaluation

The bench-scale lime softening jar testing demonstrated the application of precipitation processes for the removal of hardness, color, total organic carbon, and sedimentation for flocculant material for the removal to total suspended solids and turbidity. A literature review and hardness theory are present in Appendix E.

Water quality analyses were used to evaluate the effectiveness of the individual Jar Test conditions. Hardness, alkalinity and turbidity were used to further characterize the raw and treated waters. Additionally, organic removal was quantified by the measurement of non-purgeable dissolved organic carbon (NPDOC) and color. Ultraviolet absorbance (UV-254) was also measured which could be in turn correlated to NPDOC. Table 4.1 summarizes these analyses in terms of the equipment used and the methodology applied.

4.1.1 Jar Test Methods and Materials

"The Jar Test is universally recognized as the most valuable and most commonly used tool for coagulation control" (Pontius, 1990). The following items are a listing of the typical uses of information generated from Jar Test evaluations.

1. Lime and dosage selection
2. Settling aid and dosage selection
3. Optimum pH determination

Standardized jar testing procedures have been established which mimic as closely as possible plant operating conditions while optimizing conditions for organic removal. This section is a general overview of the established jar testing procedures. When administrating an evaluation, the general jar test procedures were adjusted to accommodate for the parameter being evaluated. Descriptions of the methods are described in more detail within each evaluation section. There were three items being investigated using jar tests.

1. Organic and Hardness Removal
2. Floc Settling Distribution Curves
3. Sludge Curves

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TABLE 4.1
Water Quality Analysis Summary Table

Parameter	Standard Method	Equipment Used	Comments
Total Hardness	Potentiometric SM*-19th Ed. -2340	Standard Laboratory Equipment	All samples titrated to pH inflection point. Unit equipped with rapid response reference and glass electrode.
Calcium Hardness	Potentiometric SM*-19th Ed. -3500-Ca	Standard Laboratory Equipment	All samples titrated to pH inflection point. Unit equipped with rapid response reference and glass electrode.
Alkalinity	Potentiometric SM*-19th Ed. -2320	Standard Laboratory Equipment	All samples titrated to pH inflection point. Unit equipped with rapid response reference and glass electrode.
Color	Spectrophotometric SM-19th Ed.-2120	Hach DR 13 Spectrophotometer	Samples filtered with 0.45 micron filter paper, pH adjusted to 7.6, absorbance read at 454 nm.
NPDOC	Persulfate-UV Oxidation SM*-19th Ed. -5310	Dohrman DC-180 Carbon Analyzer	Samples filtered with 0.45 micron filter paper.
UV-254	Spectrophotometric SM*-19th Ed. -5910	Hach DR 4000 Spectrophotometer Model 48000	Samples filtered with 0.45 micron filter paper, pH adjusted to 7.6, absorbance read at 254 nm.
Turbidity	Nephelometric SM*-19th Ed. -2130	Hach Ratio Turbidimeter Model 18900	Equipment calibrated with Formazin standard.

SM = Standard Methods

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4.0 Bench-Scale Treatability Evaluation

In order to produce meaningful data for practical application, consideration was given to all pertinent control variables. These variables are as follows:

1. Jar test temperature
2. Lime solution strength
3. Lime dose
4. Jar test pH
5. Mixing energy
6. Method for lime addition
7. Sludge addition
8. Settling aid dose
9. Sample collection technique
10. Laboratory analyses to be performed

Lime softening was investigated for hardness and organic removal using jar tests. These jar tests were used to determine total hardness, calcium hardness, alkalinity, color, TOC and UV-254 removal as a function of coagulant dose and pH. The hardness data was used to evaluate actual and theoretical reductions in calcium and magnesium hardness. The organic data was used to construct isopleths showing percent color, TOC and UV-254 removal as a function of dose and pH.

The lime under investigation was diluted so as to enhance chemical dispersion upon addition during rapid mix. In order to better understand softening, the lime was expressed as meq/L.

All jar tests were performed at approximately 22°C. Lime was added to the water surface of the jars during rapid mix. This was done as an effort to mimic plant operation given their addition of lime to the feed water surface at the solids up-flow clarifier. Generated calcium carbonate sludge was added. This was done so as to enhance the precipitation process by providing a nucleation site for rapid floc formation and settling.

Rapid mix was performed for 1 minute at 100 rpm, whereas slow mix conditions for floc formation were carried out for 15 minutes at 35 rpm. Lime sludge and settling aids were added during rapid mix in order to achieve a uniform dispersion of the reagents. Following rapid mix, acid or base was added during the flocculation step for pH control. (Note: Adding excessive acid or base as the additional TDS will make the jar test results less viable).

The pH was not adjusted on several different dosages so that pH and alkalinity could be measured on these jars as well as the raw water. This determined the exact acid strength of the lime.

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Samples for analysis were collected from each jar following a 5 minute settling period. These samples were collected at roughly 10 cm below the water surface within the jar. This corresponds to about a 0.5 gpm/ft^2 overflow rate. Upon collection, the samples were filtered with 0.45 micron glass fiber organic free filter paper and stored in a refrigerator at 4°C until chemically analyzed for color, TOC and uv-254.

Floc settling distribution curves were produced by measuring the turbidity from the 10 cm sampling port after flocculation was completed as a function of time. Zero time was identified as when mixing ceased. The data was plotted using a normal scale to assess jar test conditions relative to other jar test conditions for settling efficiency. The settling velocity and percent turbidity removal of the plant could also be determined to correlate the jar test results to plant performance.

After completion of the organic removal investigation, an "optimum" dose and pH was selected for the lime. The jar testing procedures were repeated, but settling aids were added during rapid mix. Floc settling distribution curves were produced for settling aid doses of 0.1 and 0.2 meq/L for alum, ferric sulfate and ferric chloride.

Sludge volume was estimated using a sludge volume equation. The sludge estimate should include the water quality before and after chemical addition including pH and TDS, the chemical used per MGD, and the volume of sludge produced from the clarifier.

All water quality samples generated and received were handled according to the University of Central Florida's (UCF's) Environmental Systems Engineering Institute (ESEI) laboratory protocol. Analysis usually began the day of collection; however, those samples requiring storage were stored per Standard Methods recommendations (Standard Methods 19th Edition, 1995). Refrigerated samples were stored at 4°C. Most analyses were completed within three days.

4.1.2 Jar Test Results and Discussion

Results of the jar test for hardness removal, organic removal, settling velocity, and sludge volumes are presented in this section.

4.1.2.1 Organic and Hardness Removal

Based on water quality characteristics a theoretical dose of 6.1 meq/L (170 mg/L as CaO) was predicted to be the "optimum" dose for CaH removal. This dose provided a hardness of 145 mg/L as $CaCO_3$ in the jar tests. The plant doses lime 170 mg/L to provide a hardness of 160 mg/L as $CaCO_3$. This discrepancy can be attributed to the plant dosing not accounting for the purity of the lime. The actual plant lime dosed based on 90 percent purity is 153 mg/L.

Theoretically MgH is not expected to occur until pH 10.3. The softening jar test indicted that 6.1 meq/L was required to for CaH removal (Figure 4.1). MgH removal gradually began as the dose increased. Therefore to remove MgH a high dose and pH are required. During softening magnesium hydroxide precipitation has been shown to enhance removal of NOM and SOCs (Randtke, 1988). When magnesium is present in raw water and pH is increased magnesium will precipitate. Magnesium hydroxide has a high surface area as well as a positive charge which makes it similar to aluminum and iron hydroxides. On the other hand, calcium carbonate solids (calcite) have low surface area with a negative charge making it repulsive to the majority of NOM and SOCs. This can be seen in Figure 4.1 as the magnesium hardness is removed with increased lime dose the NPDOC is removed in a similar fashion. However the calcium hardness increases after "optimum" hardness removal using lime. Therefore, pH adjustment using caustic should be used to increase pH to approximately 10.3 to enhance organic removal. Then CO2 or H_2SO_4 should be used to lower filtered pH to 8.8. Figure 4.2 show as lime dose increases so does pH and consequently NPDOC decreases.

The enhanced conditions for hardness removal was 180 mg/L CaO (6.1 meq/L) at a pH of 9.4. These conditions required no pH adjustment, therefore additional chemicals are not required. This condition provided NPDOC, color, and UV-254 removals of 27, 40 and 31 percent, respectively.

4.1.2.2 Floc Settling Distribution Curves

Figure 4.3 shows the floc settling distribution curves for lime softening with a settling aid. These curves are generated by measuring the settling water turbidity over time. For lime softening, surface loading rates (SLRs) of 1.0 gpm/ft^2 are recommended for design. However the LS plant operates at a SLR of 1.5. The lime dose that removed the most organics and hardness was selected for the floc settling distribution curves. Alum, ferric sulfate, and ferric chloride were used as settling aids to enhance settleability of the $CaCO_3$ precipitation. Settling aid doses of 0, 0.1 and 0.2 meq/L were used to evaluate the settling velocity. The settling aid doses of 0.1 and 0.2 meq/L were chosen because they represent 10 and 20 mg/L as alum which are typically doses used at the Marco Island LS plant. The ferric salts were twice as effective as alum.

4.1.2.3 Sludge Curves

Previously at the LS plant the use of a polymer increased the volume of sludge. This increased sludge volume was not accounted for during operations of the sludge blow-down. Sludge curves using actual plant data, and water and sludge quality can be used to help predict the blow-down rate at the LS plant.

The volume of sludge produced by softening was theoretically calculated for sludge that contained 1, 5, 10 and 30 % TSS at a lime dose of 6.1 meq/L. It can be seen that by increasing the total suspended solids (TSS) concentrations from 1 to 5 percent, 78 percent less sludge was produced (Figure 4.4).

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FIGURE 4.1
NPDOC and Hardness Removal Jar Test Results

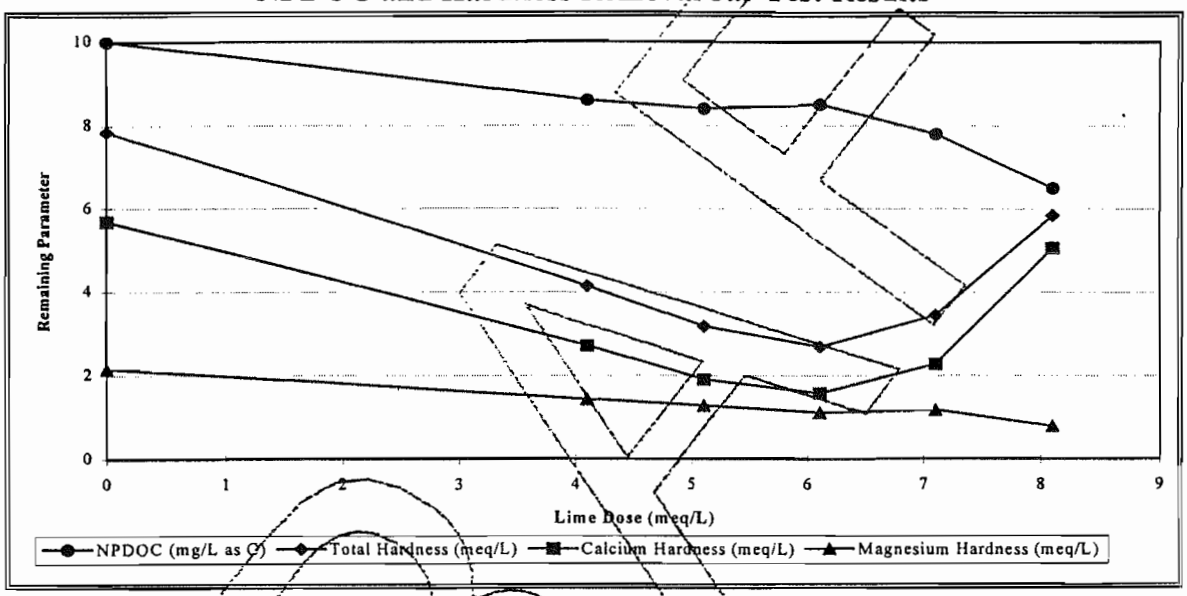


FIGURE 4.2
Organic Removal Jar Test Results

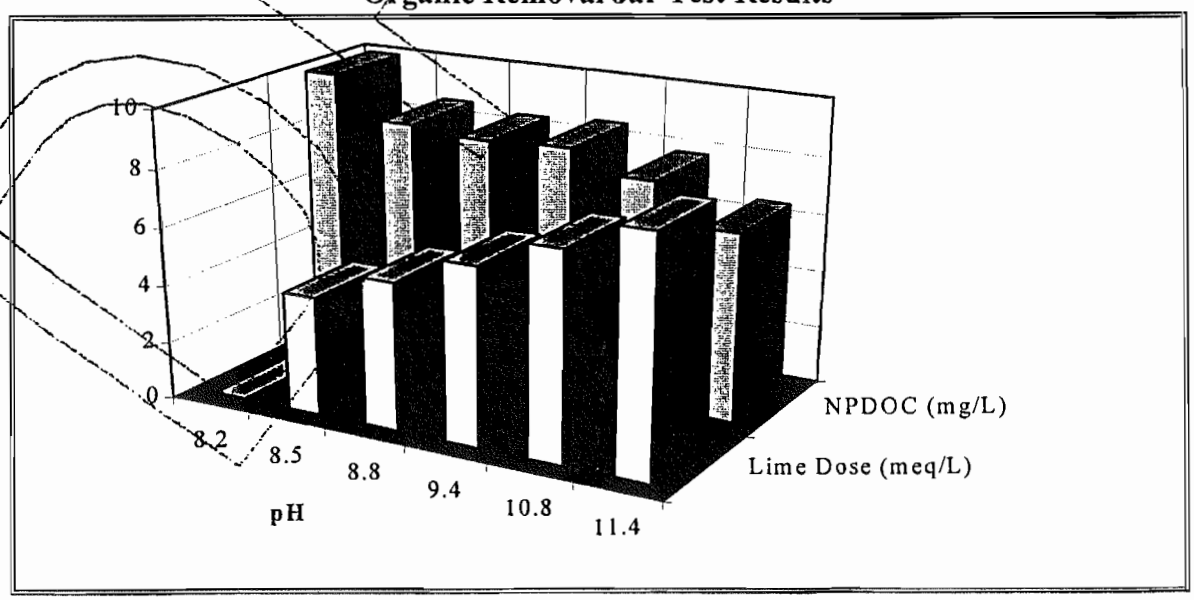


FIGURE 4.3
Lime Softening Floc Settling Distribution Curves

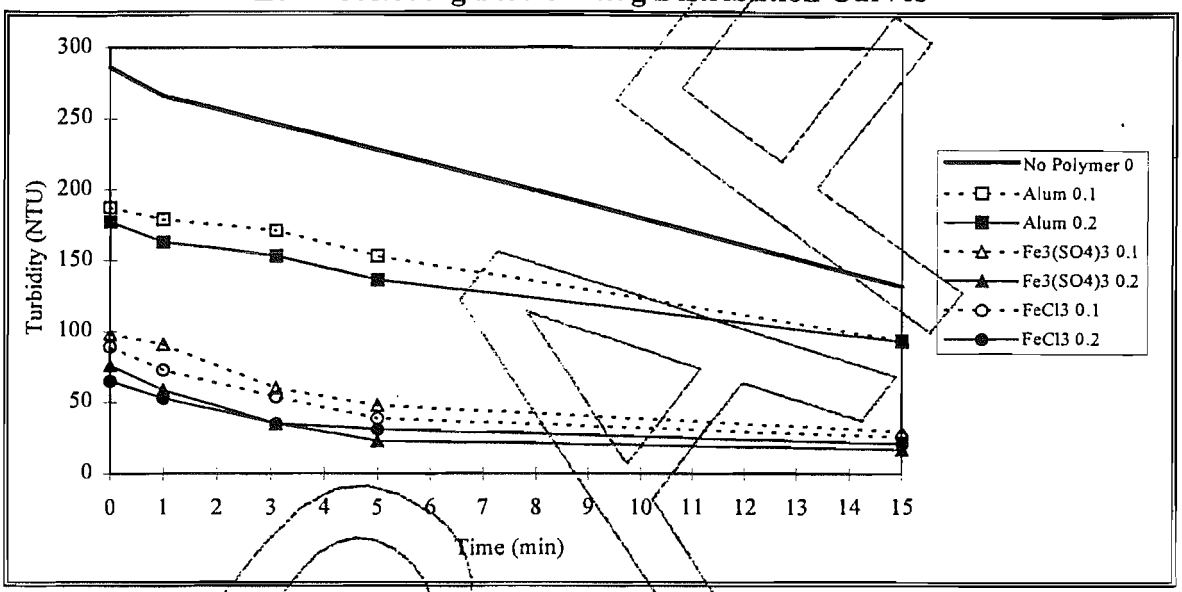
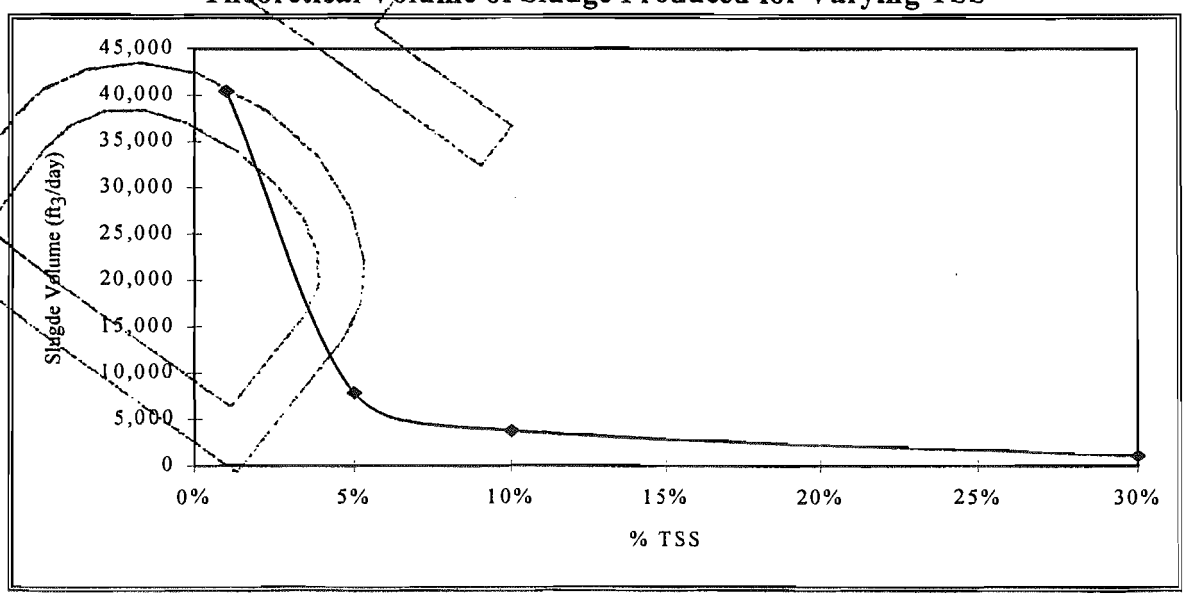


Figure 4.4
Theoretical Volume of Sludge Produced for Varying TSS



4.1.3 Jar Test Conclusions

- The theoretical lime dose of 6.1 meq/L required to remove hardness was also demonstrated to soften the best in the jar tests.
- Magnesium hardness was gradually removed.
- Ferric sulfate addition as a settling aid significantly provided twice the settleability in the jar tests.
- Increasing the percent TSS theoretically reduces the volume of sludge produced.

4.1.4 Jar Test Recommendations

- Plant alum and lime dosing concentrations calculations should be reviewed and adjusted to account for flow rates and chemical impurities.
- MgH removal via increased pH should be used to enhance NPDOC removal. Caustic can be used to increase the pH to 10.3 in the SCU and recarbonation or H_2SO_4 can be applied to stabilize the pH to 8.3 prior to filtration.
- Turbidity, temperature, pH, flow, as well as lime, alum, chlorine and ammonia dose should be monitored from the clarifier weir and through the filters.
- Ferric salts as a settling aid should be used in place of alum. Keeping in mind that pH values will not decrease as much and sludge volumes will increase.
- Sludge discharge rates and % TSS should be measured and evaluated to determine optimum sludge blow down rates for ferric salt additions because of the expected increase in sludge volume.

4.2 Ion-Exchange Bench-Scale Column Test Treatability Evaluation

The ion exchange column test demonstrated the application of adsorption processes for the removal of color and total organic carbon. Both column tests and isotherms were developed for this evaluation.

This evaluation used Tannex Resin to remove organic solutes from settled lime coagulated surface water. The settled water was pre-filtered through a fiber wound filter to remove particulates. This simulated a filtered non-chlorinated water.

4.2.1 Ion Exchange Methods and Materials

Two methods for organic removal were evaluated for comparison of design for capacity. The methods were:

- Small-Scale Column Study

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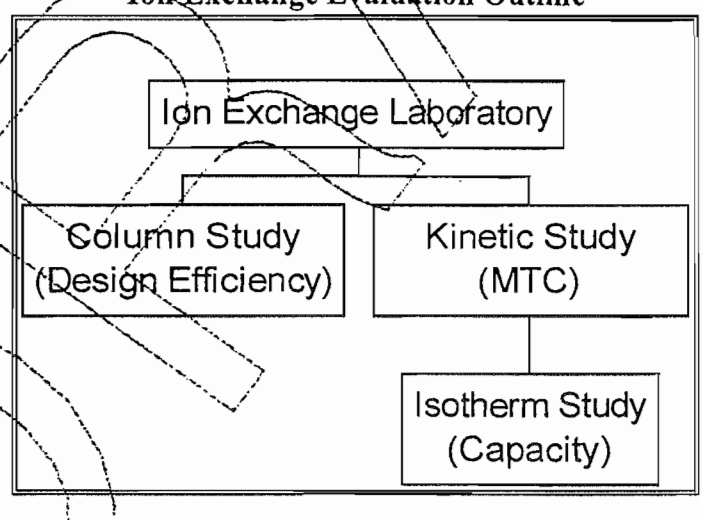
- Kinetic Rate and Equilibrium Isotherm Study

The column test was used to determine removal efficiencies.

The kinetic adsorption rate was used to determine the mass transfer coefficient (MTC) for column design. The MTC was then used to determine the length of the transfer zone which is used to determine column efficiency.

Isotherms provided the ability to determine the equilibrium surface concentration of contaminant on to the resin as a function of the raw concentration of contaminant in solution. Adsorption isotherms can be used to estimate resin capacity for achieving required ion removal. Isotherms are used to describe adsorption equilibrium that may require long contact times to reach equilibrium. Insufficient contact items may result in non-equilibrium conditions. Factors that affect equilibrium are the background matrix, surface loading rates, resin surface area and surface chemistry. The methods used in this evaluation are outlined in Figure 4.5.

Figure 4.5
Ion Exchange Evaluation Outline



4.2.1.1 Kinetic Studies

Kinetic studies were conducted on the resin to determine how long the resin requires to reach equilibrium. Six 500 mL Erlenmeyer flasks were filled with 500 mL of sample and 0.1 grams of resin giving a resin concentration of 0.2 g/L in each flask. The same resin was used in the column studies and in the isotherm studies. NPDOC, UV-254 and color were measured in these samples at zero, 1, 2, 8, 24, 48, and 96 hours. UV-254 was plotted verses time and equilibrium conditions were selected from this analysis.

4.2.1.2 Isotherm Studies

Six 500 mL Erlenmeyer flasks were filled with 500 mL of settled water and varying masses of resin. The doses of resin were 0, 0.1, 0.2, 0.5, 1.0 and 2.5 g/L of resin. Two additional flasks were used for a total of eight. The two additional flasks consisted of a settled water blank and a duplicate. These flasks were shaken for a time period determined from the kinetic rate experiment. Each flask was analyzed for UV-254, color and NPDOC. This data was fitted to a isotherm and used to determine hypothetical resin demand on the LS settled water.

4.2.1.3 Small-Scale Resin Preparation and Apparatus Set-Up

The RSSCT is a mini-column that uses dimensional analysis to simulate a full-scale column. Similitude was applied to the particle diameter, empty bed contact time (EBCT), hydraulic loading and operation time factors. Dimensional analysis was then used to establish the relationships between these factors for appropriate scale-up of the resulting capacity and breakthrough information. Various cases with varied conditions and treated source waters are presented within the ICR manual which warrant the application of this technique.

The test column used consists of a glass column 14 inches in length and 10 mm in diameter. Influent flow is achieved via a diaphragm chemical feed pump. The feed side of the column was equipped with a pressure gauge to monitor pressure. There is a stop cock at the column base.

An anionic resin (Tannex) was used for evaluation. The resin was dried, weighed, volume measured, wetted again, and put into the column. Following these procedures, the column was packed and readied for operation. The necessary steps are outlined as followed.

The methods and equipment required for this laboratory are:

1. RSSCT procedure described in the ICR
2. pH meter
3. Turbidimeter
4. UV Spectrophotometer
5. TOC Analyzer
6. Titration equipment for measuring alkalinity and hardness
7. RCSST Materials Required
    a. Glass column
    b. Chemical feed-pump with stroke and frequency adjustment

c. Pressure gauge
d. Rubber plug
e. Tygon tubing and bared nylon slip connections
f. Glass beads and glass wool
g. Sampling bottles

Guidelines for effective RSSCT evaluations are outlined in the ICR manual. These procedures are concerned with, but not limited to, materials and configuration, column design, water quality sampling and data interpretation. These items are discussed in the proceeding sections.

4.2.1.3.1 Resin Preparation

a. Resin was dried to a constant weight at a temperature not exceeding 100°C.
b. The dried resin was stored in a dessiccator until use.

4.2.1.3.2 Packing the Column

a. The resin was pre-wet with organic free DI water before column application and transferred into the column as a slurry.
b. The column was tapped while filling with resin in order to pack the resin particles.
c. The column was connected to the remainder of the RSSCT equipment.
d. The column was tested for leaks, air pockets or immediate head loss buildup by running the unit for about 10 minutes.

2.4.1.3.3 Pre-treatment of Influent Water

a. The influent water used in the study was settled unchlorinated water that was filtered through a 1.0 μm pore size membrane or cartridge filters.
b. The filter was flushed with the settled water and TOC of the effluent was checked prior to actual filtration of the influent.

4.2.1.3.4 Sampling

a. The first 20 minutes of flow was discarded before sampling began.
b. Twelve samples were collected.

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1. one sample after 1 hour
2. 3 samples at regular intervals through 50% breakthrough
3. 1 sample following 50% breakthrough
4. One sample at the end of the run

4.2.1.4 Ion-Exchange Column Design

The design of the ion exchange column is identical to the design of a normal column. The RSSCT column was designed using carbon that was ground and sieved so that the time to breakthrough would be reduced. If normal sized carbon was used the column would operate for 1 to 3 months before breakthrough was achieved. Ion exchange resin has a larger particle diameter, a smaller surface area and will exhaust more rapidly than activated carbon. Consequently, there is no need to reduce the size of resin in order to enhance the time to breakthrough and no direct scale up can be provided for estimation of system design.

The ion-exchange column was designed for the laboratory using a 1 cm column and a 12.70 cm (5") bed depth. The flow into the column was estimated at 4.7 mL/min, which provided a EBCT of 5 minutes. These operating conditions and frequent water quality samples should provide an estimate of the transfer zone length and resin capacity in the column study.

4.2.1.5 Water Quality Monitoring

Water quality monitoring were performed on both the pretreated influent and RSSCT treated effluent. The parameters of interest include true color, NPDOC, UV-254, alkalinity, pH and temperature. A breakdown of the analyses to be performed and their respective frequency over the run period for both the pretreated raw water and the resin filtered effluent is summarized in Table 4.2. It is estimated that at least 250 mL of water is required to satisfy volume requirements for analysis.

Table 4.2
RSSCT Experimental Water Quality Monitoring Summary

Sampling Point	Analysis	Sampling Frequency
Influent	Alkalinity, true color, UV-254, NPDOC and pH	One sample just before operation begins
Effluent	Alkalinity, true color, UV-254, NPDOC and pH	Five times during column run

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4.2.2 Ion Exchange Results and Discussion

Results of the column study, kinetic rate study and isotherm study are presented in this section with more detailed data in Appendix I.

4.2.2.1 Selectivity

To present the selectivity fractional passage was used to determine breakthrough. A fractional passage of 1 indicates that the component has broken through the column.

The fractional passage of chloride, sulfate, alkalinity and NPDOC over run-time are presented in Figure 4.6. High chlorides were attributed to the chloride based resin which swapped out a chloride for a more selective ion or compound. Figure 4.6 shows that the resin selects NPDOC over sulfates since the sulfate have already broken through.

The fractional passage of color, UV-254, NPDOC and sulfate over run-time are presented in Figure 4.7. UV-254 and NPDOC follow similar paths, however the resin is more selective of UV-254. Color and sulfates both show a "dump" with color being more selective to the resin. A "dump" indicates that a more selective compound on to the resin has broken through the column.

4.2.2.2 Transfer Zone

The transfer zone length was calculated assuming breakthrough occurs at 2.0 mg/L NPDOC and exhaustion occurs at 4.2 mg/L NPDOC. Using the following equation and the breakthrough curve (Figure 4.8) the transfer zone length was found to be 1.4 ft.

$$d = \frac{L(V_x - V_b)}{V_b + f(V_x - V_b)} = \frac{12.7\text{cm}(2870 - 100)}{100 + 0.26(2870 - 100)} = 42\text{cm} \cong 1.4\text{ft}$$

d = transfer zone length

L = length of column = 12.7cm

V_x = volumn to exhaustion = 2870 BV

V_b = volumn to breakthrough = 100 BV

$$f = \frac{\text{mass adsorbed in transfer zone}}{\text{capacity of transfer zone}} = \frac{0.5(4.2 - 2)}{(4.2 - 0)} = 0.26$$

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FIGURE 4.6:
Inorganic Selectivity

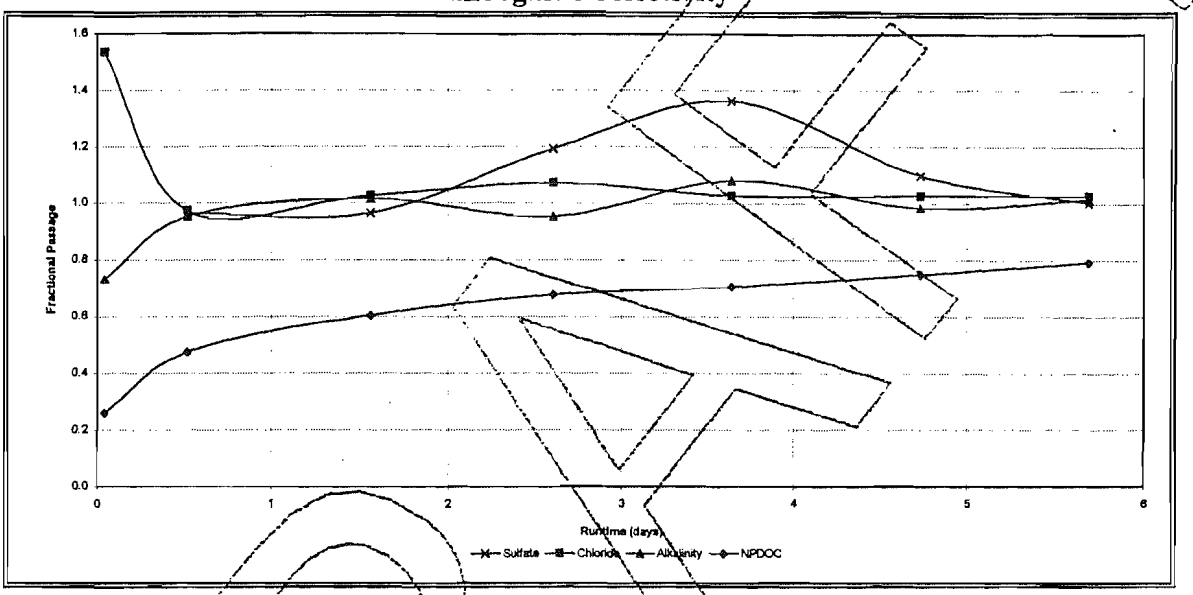
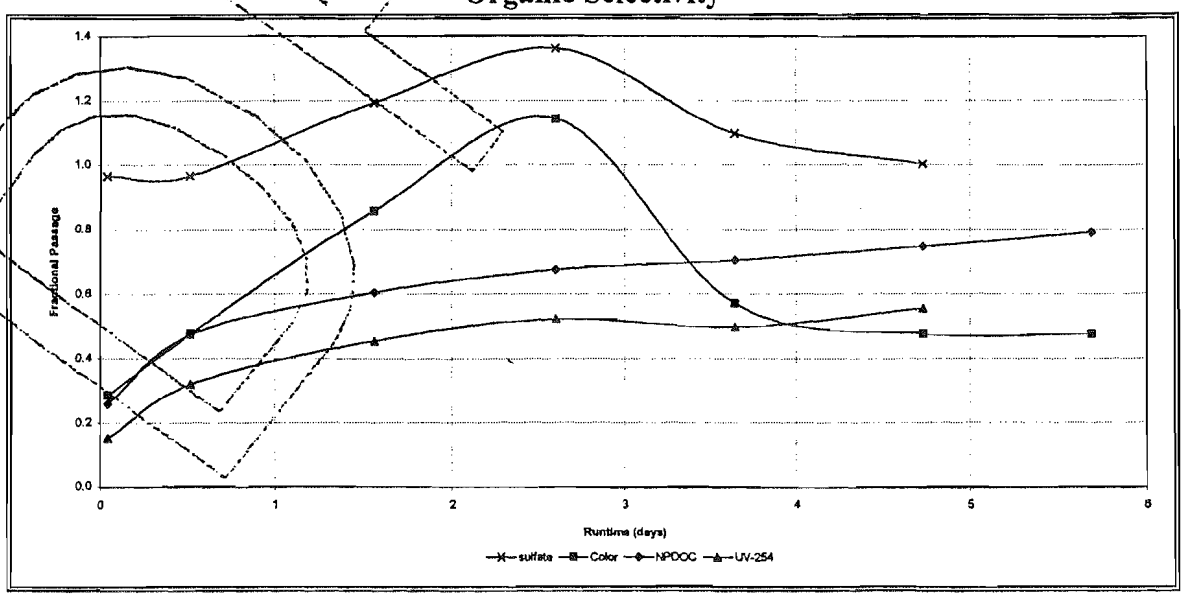


FIGURE 4.7:
Organic Selectivity



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4.2.2.3 Langmuir Isotherm

The Langmuir Isotherm was constructed from the isotherm data. The low dose resin, which is represented by high capacity (X/M = 30 and 18), appear not to follow the typical concave down isotherm (Figure 4.9). The resin was not homogeneous. The resin had two types of beads present therefore one type may have been more selective of certain organic compounds than the other. This would have been more noticeable at low doses because the ratio of between the resin beads is more variable. Nonetheless the actual data was linearized (Figure 4.10) giving the following equation with a = 0.5468 and b = 3.2787:

$$\left(\frac{X}{M}\right)^{-1} = \frac{1}{b} + \frac{1}{ab}(C_e)^{-1} = 0.305 + 0.5578(C_e)^{-1}$$

where:

$$\frac{1}{ab} = 0.5578 \Rightarrow ab = 1.7928$$

$$\frac{1}{b} = 0.305 \Rightarrow b = 3.2787$$

$$a(3.2787) = 1.7928 \Rightarrow a = 0.5468$$

With the isotherm constants a and b calculated a theoretical isotherm was developed from the following equation and plotted in Figure 4.11.

$$\frac{X}{M} = \frac{abC_e}{aC_e + 1} = \frac{1.7928C_e}{0.5468C_e + 1}$$

4.2.2.4 Mass Transfer Coefficient

The mass transfer coefficient (MTC) term is necessary if a column is being designed and the efficiency of the transfer zone is desired.

The slope of a plot of $\ln\left|\frac{C_t - C_{et}}{C_o - C_e}\right|$ versus time is ka. The mass transfer coefficient (ka) can be defined by using the initial concentration, C_o, final concentration, C_e, the concentration at time t, C_t, and the equilibrium concentration at time et, C_{et}. The values of C_t and C_o would be taken from the actual kinetic study. The values of C_{et} would be taken from the equilibrium value determined from an operating line drawn on an equilibrium plot of X/M vs. C_e (Figure 4.12). Using these assumption and plotting the slope ka = 0.0209 per hour (Figure 4.13). This means that a mass of 0.02 mg/L NPDOC was exchanged on to the resin per hour.

FIGURE 4.8:
NPDOC Breakthrough Curve

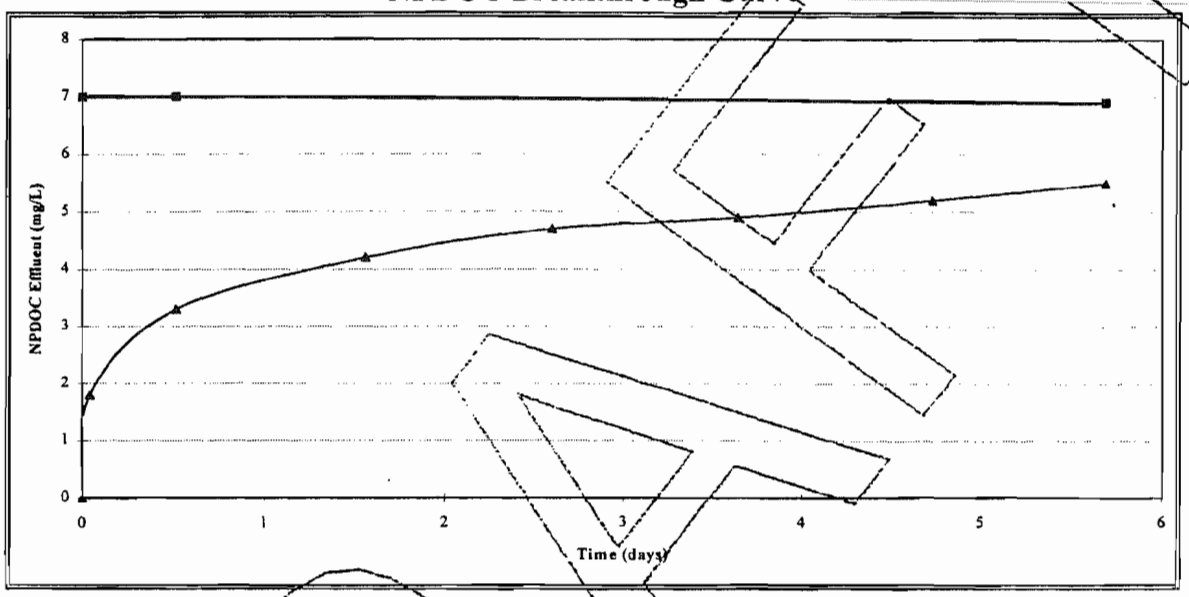

FIGURE 4.9:
Actual Isotherm

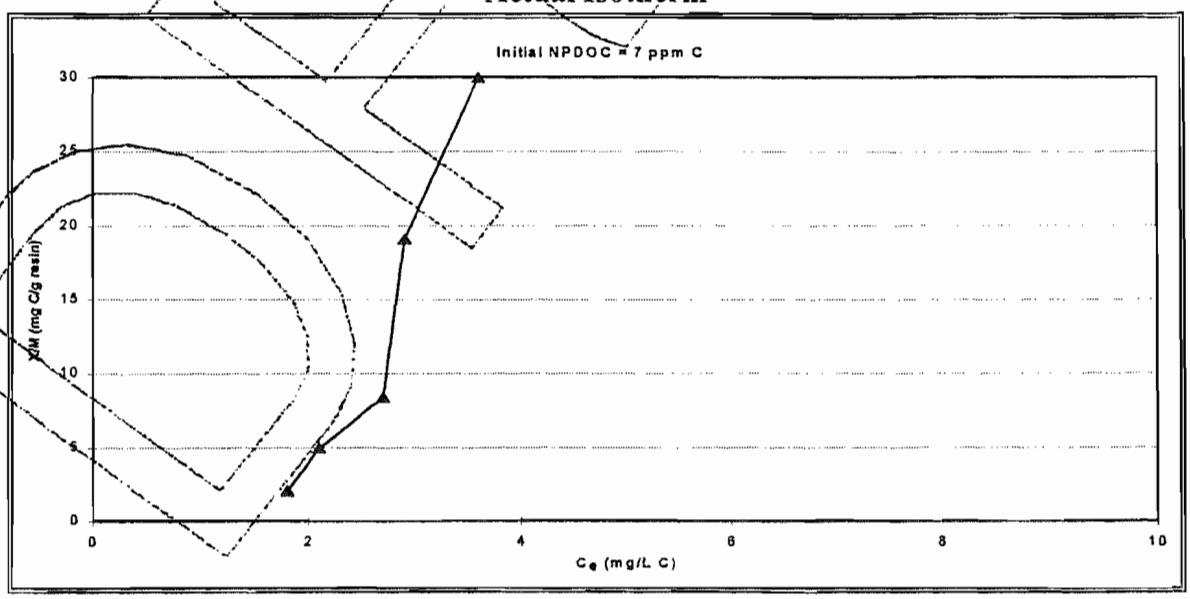

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FIGURE 4.10:
Linearized Langmuir Isotherm

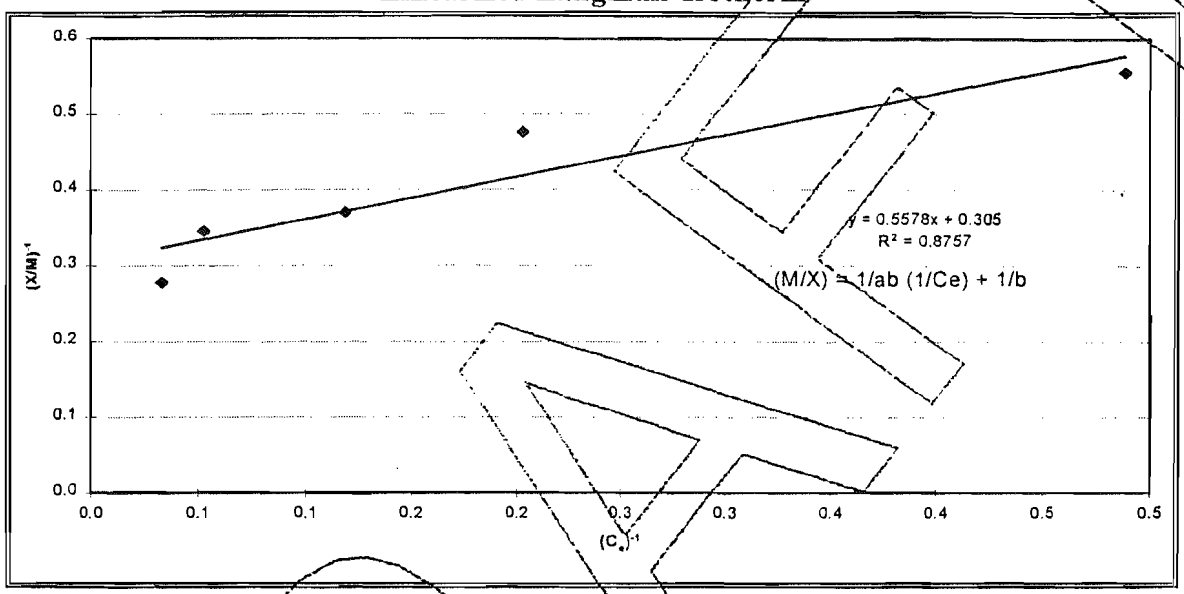

FIGURE 4.11:
Theoretical Langmuir Isotherm

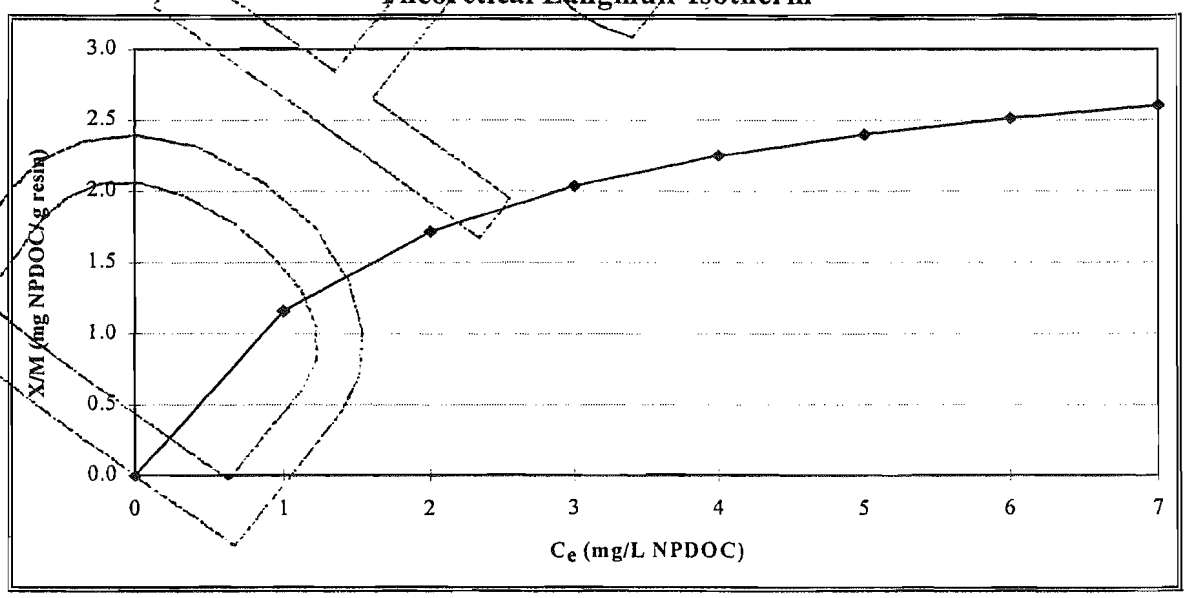

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FIGURE 4.12:
Equilibrium and Operating Line Isotherm

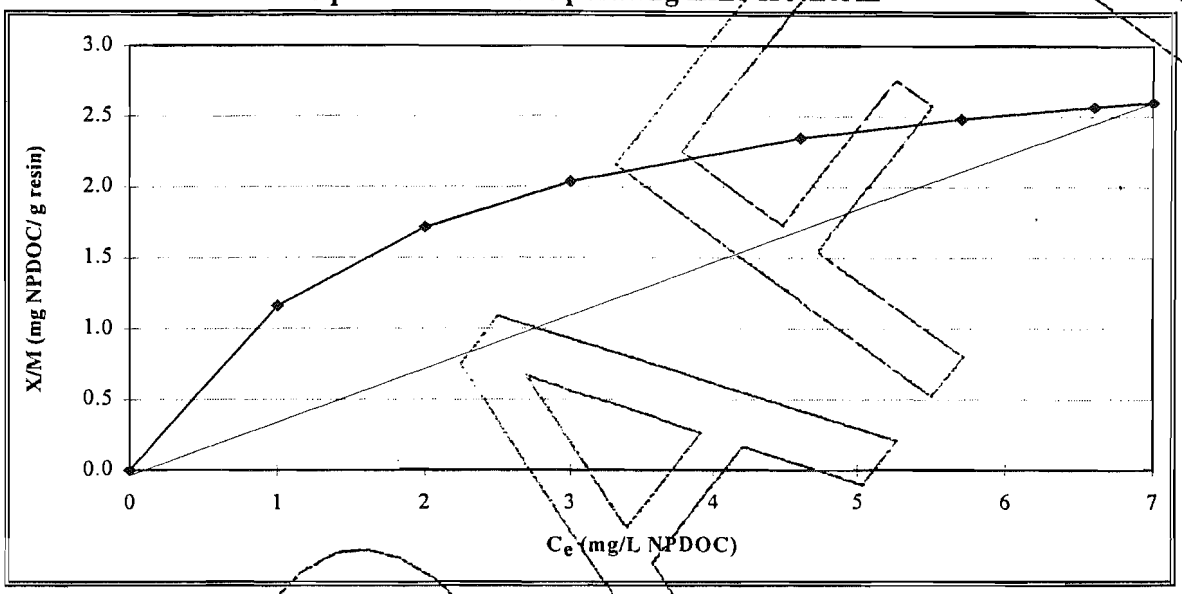
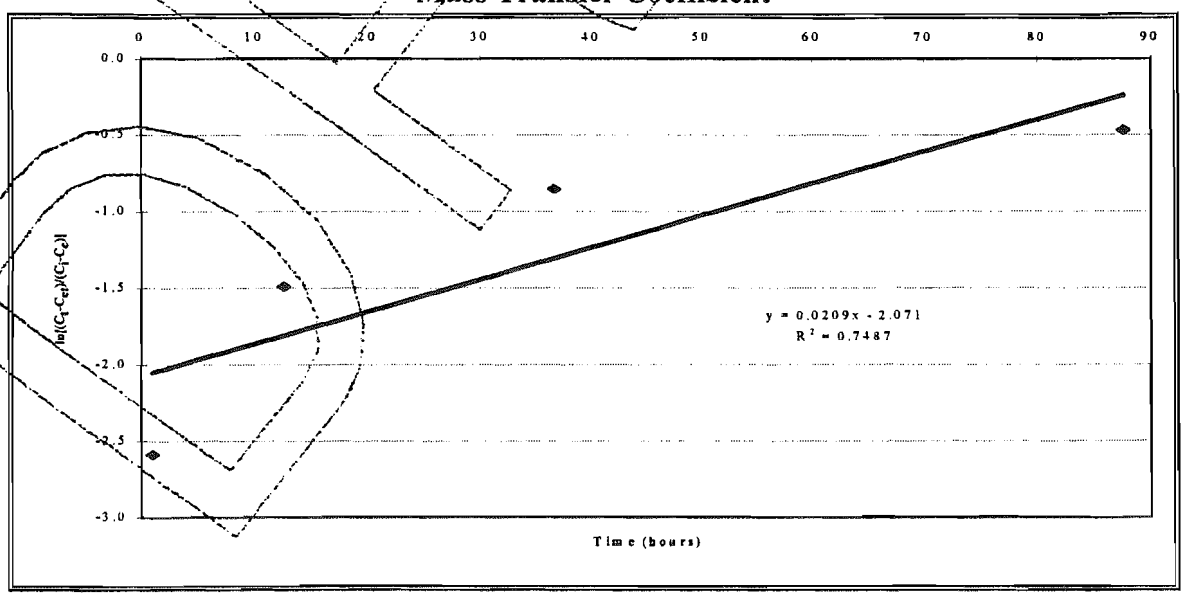


FIGURE 4.13:
Mass Transfer Coefficient



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4.2.2.5 Counter Current Column Design

A design for reducing NPDOC from 7 to 2 mg/L using a column at a flow rate of 5 MGD was calculated using the flow rate and the resin capacity. The resin capacity (X/M) for counter-current were calculated using the Langmuir Isotherm to be 1.7 and 2.6, respectively.

$$\frac{X}{M} = \frac{abC_e}{aC_e + 1} = \frac{1.7928C_e}{0.5468C_e + 1}$$

Counter – Current (C_e = 7 mg / L NPDOC):

$$\frac{X}{M} = \frac{1.7928(7)}{0.5468(7) + 1} = 2.60 \text{ mg NPDOC / g resin}$$

Then assuming the density of the resin to be 76.5 lb/ft^3, the volume required to treat using a column to 2 mg/L as NPDOC per day was 1,048 ft^3/day.

4.2.2.6 Column Design

Column design can be effected by the following factors:

- Surface Loading Rate (SLR)

  Efficiency of the transfer zone is determined by the SLR.

  ↑ SLR ⇒ ↑ Flow ⇒ ↑ Transfer Zone ⇒ ↓ Efficiency

  ↓ SLR ⇒ ↓ Flow ⇒ ↓ Transfer Zone ⇒ ↑ Efficiency

  A small transfer zone is desired, so by increasing the cross-sectional surface area or decreasing the flow the efficiency of the transfer zone can be increased.

- Feed Concentrations

  Feed concentrations, driving force, will affect the capacity of the resin.

  ↑ Driving Force ⇒ ↑ Capacity

  This can be accomplished with a counter-current design.

- Temperature

  Temperature will affect the capacity of the resin.

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↓ Temp ⇒ ↑ Capacity

But kinetically it may take more time to reach equilibrium at low temperature.

4.2.3 Ion Exchange Conclusions

- The organics are reduced from by 50 percent (from 7 to about 3.5 mg/L). The resin can remove organics to 2 mg/L but this breakthrough occurs within 200 bed volumes.
- According to the selectivity study, organic go to exhaustion slower than inorganic.
- The length of the transfer zone is 1.4 ft.
- The resin capacity can be represented by: $\frac{X}{M} = \frac{abC_e}{aC_e + 1} = \frac{1.7928C_e}{0.5468C_e + 1}$
- The mass transfer coefficient based on kinetic studies was 0.02 per hour.
- The volume of resin required to treat from 7 to 2 mg/L as NPDOC per day was 1,048 ft^3/day assuming the density of the resin was 76.5 lb/ft^3.
- ↑ SLR ⇒ ↑ Flow ⇒ ↑ Transfer Zone ⇒ ↓ Efficiency
- ↓ SLR ⇒ ↓ Flow ⇒ ↓ Transfer Zone ⇒ ↑ Efficiency
- ↑ Driving Force ⇒ ↑ Capacity
- ↓ Temp ⇒ ↑ Capacity

4.2.4 Ion Exchange Recommendations

- Ion exchange can remove organics but require frequent regeneration which will drive up cost.
- Additional treatment would be required to remove hardness via the use of a second resin/process.
- Ion-exchange can not disinfect and the treat of microbiological contamination exists therefore additional treatment to remove or disinfect will be required.
- Complexity exists for maintaining anionic resin for organic removal and cationic resin hardness removal.

4.3 Membrane Process Bench-Scale Test Treatability Evaluation

This evaluation involves nanofiltration (NF) testing protocol. The intent of this evaluation was to provide an understanding of the membrane process and a method of measuring membrane productivity.

Existing literature has shown that membranes can reduce finished water TOC to < 2.0 mg/L, can reduce DBP precursors to the new phase I MCLs and that TOC removal is sieving controlled.

Literature has shown that the rate of fouling in surface water application is one or two orders of magnitude higher than the rate of fouling in groundwater applications even with advanced pretreatment. Consequently, the existing literature has shown that membrane utilization on surface water sources will require much pretreatment, making it more costly to produce the same high water quality as membrane utilization on ground waters (Taylor et al., 1992). However limited surface water NF or RO membrane investigations have been done and much more surface water testing is justified especially on surface waters with TOCs ranging from > 4 to < 12 mg/L.

4.3.1 Membrane Process Methods and Materials

A single element Dow-FilmTec 2540N 70 nanofilter was set up at the Civil and Environmental Engineering Field Laboratory (CEEFL) at UCF. This unit was operated in seven different modes to evaluate the effect of varying flux, recovery and temperature on permeate water quality. The seven different modes are shown in Table 4.3.

The membrane system was operated a minimum of 10 minutes under conditions of run # prior to sample collection. Sampling procedures are described in the following text.

1. Feed samples were taken at beginning and end of each experiment (2 samples, one liter each).

Table 4.3:
Membrane Unit Operational Parameters

Run	Recovery (%)	Flux (gsfd)	Temperature (°C)
1	25	10	Ambient
2	75	10	Ambient
3	25	15	Ambient
4	75	15	Ambient
5	25	10	Cold
6	75	10	Cold
7	25	15	Cold

2. Feed samples were used for all QA/QC analysis.

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3. Permeate and concentrate samples were taken for each run (14 samples, 500 mL each). Analyses shown in roman numerals were conducted on both the feed stream samples and each of the seven permeate and concentrate stream samples.

   I. Field TDS by meter
   II. Field pH
   III. Alkalinity
   IV. Calcium hardness
   V. Chloride
   VI. Sulfate
   VII. Color
   VIII. NPDOC

The membrane specifications for the 2540 NF 70 FilmTec element are described in the attached manufactures literature in Appendix I. Summary specifications are shown below:

- FilmTec NF 70 - 2540 (2.5 inch diameter by 40-inch long element)
- 23.8 ft^2 surface area
- K_w 0.33 gsfd/psi
- 95% rejection of magnesium sulfate

4.3.2 Membrane Process Results and Discussion

Results of the bench-scale membrane process productivity are summarized in this section with more detailed data in Appendix I.

4.3.2.1 Experimental Results

The results of water flow, recovery, flux, pressure, mass transfer coefficient (MTC) and normalized MTC for each experiment are presented in Tables 4.4 and 4.5. Recoveries ranged from 25 to 75 percent with normalized fluxes from 10 to 18 gsfd for temperature ranges of 16 to 25 °C.

4.3.2.2 Flux vs. Recovery

Table 4.6 presents the percent removal for each solute based on raw water quality. The percent removal of each water quality characteristic relative to flux and recovery can determine whether the membrane is

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diffusion or size exclusion (sieving) controlled. For diffusion control, percent removal increases as flux increases and percent removal decreases as recovery increases. For size exclusion control, the percent removal remains constant for varying flux and recovery. By inspection of the percent removal for varying flux and recovery, it can be seen that the organics are sieving controlled and the inorganics are diffusion controlled.

4.3.2.3 Mass Balance

Mass balances for each experiment were compiled to evaluated quality control of each chemical analysis. Percent errors of ± 15 percent are strived for. Errors for the measured water quality are presented in Table 4.7. There was some slight discrepancy in some mass balances but overall they were sufficient.

4.3.3 Membrane Process Conclusions

- The inorganic parameters were diffusion controlled whereas the organic parameter was size exclusion.
- The NF membrane removed hardness from 304 to 30 mg/L as $CaCO_3$ on average.
- The NF membrane removed NPDOC from 11 to < 0.5 mg/L.
- As flux increased percent removal increased.
- As recovery increased percent removal decreased.
- As temperature increased flux increased.
- Mass balances were adequate, but recycle may have an effect on some parameters.

4.3.4 Membrane Process Recommendations

- The NF membrane can successfully remove inorganics and organics.
- The NF membrane should be run continuously over time in a pilot study to determine the effects of fouling and membrane productivity, as well as issues related to surface water.
- Temperature effects should further be investigated because the source water is surface water.

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Table 4.4:
Operating Conditions and Corresponding Recovery and Flux

Run	T_f (°C)	Q_f (gph)	Q_p (gph)	Q_c (gph)	Q_r (gpm)	Recovery (%)	F_w (gsfd)	Normalized F_w (gsfd @ 25 C))
1	25.0	39	10	29	1.25	26%	10.1	10.1
2	24.8	13	10	3	1.60	77%	10.1	10.1
3	23.0	60	15	45	0.90	25%	15.1	15.9
4	25.0	20	15	5	1.55	75%	15.1	15.1
5	16.0	39	10	29	1.25	26%	10.1	12.7
6	18.0	13	10	3	1.60	77%	10.1	12.1
7	16.0	60	15	45	0.95	24%	14.6	18.4

Table 4.5:
Operating Conditions and Corresponding MTC

Run	P_f (psi)	P_p (psi)	P_c (psi)	C_f (mg/L	C_p (mg/L)	C_c (mg/L)	K_w (gsfd/psi)	Normalized K_w (gsfd/psi @ 25 C))
1	78	45	54	480	90	600	0.611	0.611
2	105	75	90	500	220	1190	0.621	0.624
3	60	0	50	460	50	620	0.302	0.318
4	92	35	77	470	150	1450	0.365	0.365
5	80	40	65	450	50	580	0.362	0.456
6	105	75	90	470	190	1080	0.606	0.725
7	63	0	50	450	40	540	0.281	0.355

Table 4.6
Percent Removal for Varying Flux and Recovery on Water Quality Characteristics

Run	Recovery (%)	F_w (gsfd)	% Removal TDS	Alkalinity	Chloride	Sulfate	CaH	NPDOC
1	26%	10.1	81%	91%	74%	99%	93%	97%
2	77%	10.1	56%	70%	31%	99%	75%	97%
3	25%	15.9	89%	93%	82%	99%	95%	98%
4	75%	15.1	68%	81%	53%	99%	87%	97%
5	26%	12.7	89%	93%	81%	99%	95%	97%
6	77%	12.1	60%	75%	40%	99%	85%	96%
7	24%	18.4	91%	96%	88%	99%	97%	97%
Control			diffusion	diffusion	diffusion	sieving	diffusion	sieving

Table 4.7
Percent Error of Mass Balance

Run	Percent Error in mass Balances TDS	Alkalinity	Chloride	Sulfate	CaH	NPDOC
1	2.2%	5.7%	5.2%	7.8%	4.6%	2.6%
2	11.2%	5.5%	-5.3%	32.2%	5.3%	19.3%
3	-3.8%	-2.6%	5.3%	18.3%	-2.5%	-1.3%
4	-1.6%	-13.5%	-5.2%	12.5%	-10.9%	-12.1%
5	1.3%	5.6%	5.5%	10.2%	10.1%	1.9%
6	15.9%	5.6%	-2.9%	31.7%	9.4%	10.5%
7	7.1%	2.8%	9.5%	5.4%	5.1%	-1.0%

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5.0 Treatment Modifications and Alternatives

Conceptual treatment modifications and alternatives for the MIWS LS and RO plants have been identified as immediate modifications, short-term alternatives and long-range alternatives. These treatments should provide for increased capacity with reduced operational costs and improved water quality. The following explains these phases of treatment and implication

Immediate modifications to the MIWS includes improvements to current operational processes. These modifications are based on water quality and operational data which has been previously been presented in this report. The modifications are as follows:

- Practice enhanced lime precipitation at existing LS plant.
- Implement the use of ferric salts as a settling aid at the existing LS plant.
- Retrofit the four original RO trains with interstage turbine boosters and VFDs.
- Expand the existing RO plant by an additional 1 MGD.
- Replace membranes from the four original RO trains with more efficient membranes.
- Consider blending surficial or Lake Marco water with brackish well water.

The improvements to the LS plant should be recognized as temporary to increase capacity and improve water quality. However the improvements to the RO plant should increase capacity and lower operational costs.

Short-term treatment alternatives for the MIWS consider expansions to the existing facilities that will increase capacity and comply with current water quality regulations. However, because of space constraints these expansions would be limited and any additional capacity at the LS WTP would require additional space. Therefore short-term alternatives are not an option and long-range alternatives options should begin during immediate modifications.

Long-range treatment alternatives for the MIWS look at the construction of new facilities that will comply with future regulations and meet projected water quantity demand.

Conceptual treatment alternatives for the MIWS have been identified using a numerical matrix evaluation of the identified treatment alternatives in order to develop a short-list of the highest ranked treatment alternatives.

Based upon discussions with Florida Water, recent trends in the water industry, and Boyle's evaluation of existing conditions within the Marco Island Water System, the following potable water treatment technologies were considered for expanding existing or designing new water treatment facilities:

1. Lime Softening
2. Chemical Sequestering
3. Chlorine Oxidation

4. Hydrogen Peroxide Oxidation
5. Ozone Oxidation
6. Greensand Filtration
7. Membrane Processes
8. Activated Carbon Processes
9. Biological Processes
10. Ion Exchange Processes

Alternatives that did not conform with the criteria and water quality goals established previously were eliminated from further consideration. Those alternatives included chemical sequestering, chlorine oxidation, hydrogen peroxide oxidation, greensand filtration, activated carbon and biological processes.

5.1 Identification of Treatment Alternatives

The following four alternatives have been identified as the best candidates for further consideration for the MIWS:

1. Lime Softening
2. Membrane Processes
3. Ozone Oxidation
4. Ion Exchange Processes

5.2 Treatment Alternative Evaluation Matrix

To further narrow the field of potential treatment alternatives, a numerical matrix evaluation was conducted to help develop a treatment alternatives "short-list" (Table 5.1). This matrix evaluation was developed based upon non-cost considerations. The four alternatives were evaluated in this manner to aid in identifying the process or combination of processes that meet regulatory requirements and aesthetic water quality goals outlined by Florida Water. Construction and operating costs become a factor when evaluating the feasibility of the short-listed treatment alternatives. The non-cost considerations used in the matrix evaluation are presented below:

1. Operation Complexity: The superintendent of the treatment processes discussed should be a Class A licensed operator. The shift supervisor should be a licensed Class A, B or C operator. Many of the processes will require a staff that has training in electronics, instrumentation and computers for the advanced automated processes. All of the supervisors, and at least some of the staff, should have specific training in the process selected.

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2. Chemical Handling: Each of the processes requires the use of potentially hazardous chemicals. The chemicals could include sulfuric acid, sodium hydroxide, carbon dioxide, polymer, sulfur dioxide, hydrogen peroxide, anti-scalant, ozone, lime, and chlorine.
3. Process Reliability: All of the processes produce a water of reliable quality. Each process is a continuous flow process and each can be designed to produce water continuously unless they are shut down for repair, maintenance or cleaning. Each of the processes have the ability to recover from some upsets or contaminants, but to varying degrees. Generally, those processes that have more unit processes are less reliable and more problematic.
4. Solids and Residuals Handling: Each alternative will require some type of residuals handling and disposal facilities. The type and quantity of residual will vary between alternatives.
5. Potential for Meeting Future Water Quality Regulations: Each of the alternatives discussed herein have the ability to meet several existing regulatory goals, and all have the ability to produce water quality that may meet future regulatory requirements.
6. Varying Raw Water Quality: All of the alternatives can handle a degradation in raw water quality to some extent without major modifications to the system.
7. Appearance, Noise and Odor: Due to the proximity of residential neighborhoods, the appearance, noise and odor of each alternative is an important non-cost consideration. Processes housed inside closed structures are beneficial since the noise and appearance problems are minimized.
8. Risk and Safety: Protection of employees and visitors to Marco Island facilities, especially water treatment plants, is a concern, and is recognized as an important consideration.
9. Permitting: The permitting process will be more extensive for the alternatives involving concentrate or sludge disposal.
10. Durability: The ability of a process to withstand abnormal operating conditions is another important non-cost consideration. Those alternatives that require more mechanical equipment will require maintenance of a regular nature. Those alternatives protected from hostile environmental conditions will be expected to last longer than those alternatives having equipment exposed to the elements.

Table 5.1 presents the summary matrix of non-cost considerations for each of the water treatment processes evaluated. Within this matrix, alternatives were scored on a scale of 1 to 3 (with 1 being best, 3 being worst) for each consideration. These considerations were also weighted based on a system impact factor between 1 and 3 (with 1 being least, 3 being most). Based on the consideration and impact factors used for the non-cost evaluation of treatment alternatives membrane and ion exchange processes have better ratings than lime softening or ozone oxidation.

TABLE 5.1
Non-Cost Considerations Summary Matrix

		Alternative Score (1)							
		Lime Softening		Membrane Processes		Ozone Oxidation		Ion Exchange Processes	
Non-Cost Consideration	Impact Factor	Point Score	Weighted Score	Point Score	Weighted Score	Point Score	Weighted Score	Point Score	Weighted Score
Operation Complexity	2	2	4	3	6	3	6	2	4
Chemical Handling	2	3	6	3	6	3	6	1	2
Process Reliability	2	2	4	1	2	3	6	1	2
Residuals Handling	3	3	9	3	9	2	6	3	9
Meeting Future Regulations	2	2	4	1	2	1	2	3	6
Varying Raw Water Quality	2	2	4	2	4	3	6	2	4
Aesthetics	1	2	2	1	1	1	1	1	1
Risk & Safety	2	2	4	2	4	3	6	2	4
Permitting	3	2	6	2	6	2	6	3	9
Durability	1	2	2	1	1	1	1	1	1
Total Score (3)			45		41		46		42

1. Processes are ranked with a point score from 1 to 3 with 1 being the best.
2. System impact factors are ranked 1 to 3 with 1 being the least impact.
3. The first number designation in each process evaluation refers to point score, with the second number relating to an overall weighted score based on the corresponding system impact factor.

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5.3 Treatment Alternative Advantages and Disadvantages

The relative advantages and disadvantages of the four individual treatment alternatives can be evaluated in relation to the quality of the treated water. This evaluation takes into account contaminants that are currently regulated, including those contaminants anticipated to be regulated, or contaminants that have secondary impacts and hence would be worthwhile to remove from the water supply.

Table 5.2 lists several groups of water quality parameters in relation to the four treatment process alternatives. This format evaluates each of the alternatives and includes water quality groups that are continually under regulatory scrutiny in terms of effective treatment. Each process listed in Table 5.2 was evaluated with respect to its ability to treat specific water quality parameters. It is important to note that combinations of two or more individual treatment processes may be required to remove all listed contaminants.

Following the review of specific water quality parameters, the treatment alternatives were conceptually evaluated with respect to regulations, operations, water quality, aesthetics and overall system compatibility. The four alternatives were evaluated in this manner to aid in identifying the process or combination of processes that meet regulatory requirements and aesthetic water quality goals. Table 5.3 presents a summary of the advantages and disadvantages associated with the four water treatment process alternatives that were evaluated for their potential implementation as part of the MIWS.

5.3.1 Lime Softening

Currently, the major treatment processes used at the LS plant include lime softening and filtration. The current treatment system does not comply with existing organic removal regulations. However the need for increased capacity and improved water quality exists.

Lime softening is a coagulation process that removes hardness from water in order to minimize scale-forming tendencies. During precipitative softening, calcium is removed from water in the form of calcium carbonate. Treatment at the LS plant consists of lime addition, rapid mixing, flocculation, sedimentation, chloramination, multi-media filtration, phosphate corrosion inhibitor addition, and storage prior to high-service pumping to the distribution system.

The current capacity of the upflow softener at the Marco Island LS plant is 5.0 MGD, which provides an surface loading rate (SLR) of 1.5 gpm/ft^2. Ten States Standards and Reynolds (1982) recommends an SLR of 1.0 gpm/ft^2 for designing a surface water lime softening process. Operation at a SLR of 1.0 gpm/ft^2 would require a flow rate of 3.3 MGD.

Both slaked quicklime (CaO) and alum are added at the softener unit's influent rapid mix basin. Addition of a polymer could enhance settleable thereby increasing capacity. However the use of a

TABLE 5.2
Treatment Performance Conceptual Evaluation

Water Quality Parameter	Treatment Alternative: Lime Softening	Membrane Processes	Ozone Oxidation	Ion Exchange
INORGANICS:				
-Hardness	E	E	N	E*
-Hydrogen sulfide	P	N	E	P*
-TDS	N	E	N	N
ORGANICS:				
-Color	N	E	E	E*
-TOC	N	E	P	E*
-Pesticides	N	E	E	N
-SOCs	N	E	E	N
-VOCs	N	P	P	N
-THMs	N	E	E	N
-DBPs	N	E	E	N
RADIONUCLIDES:				
-Radium 226/228	E	E	N	E**
-Radon	N	N	N	N
MICROBIALS:				
-Bacteria	P	E	E	N
-Viruses	P	E	E	N
-Turbidity	P	E	E	P
OVERALL	**P**	**E**	**E**	**P**

N = Not very effective treatment; P = Partially effective; E = Effective
* anion exchange; ** cation exchange

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TABLE 5.3
Conceptual Level Advantages and Disadvantages of Treatment Alternatives

Alternative	Advantage	Disadvantage
1. Lime Softening	◆ taste and odor control ◆ biological growth control ◆ conditions and softens water ◆ removes inorganics, radionuclides ◆ removes hardness, scale	◆ not effective at sulfide removal ◆ produces sludge waste stream ◆ requires sludge handling facility ◆ reduced finished water alkalinity ◆ jar testing recommended
2. Membrane Processes	◆ reduces chlorine demand ◆ conditions and softens water ◆ removes bacteria and viruses ◆ reduces TDS and chlorides ◆ removes inorganics, radionuclides ◆ mainly enclosed operations ◆ removes DBP precursors	◆ aeration process still required ◆ concentrate disposal required ◆ post-treatment required ◆ pilot testing required ◆ membranes subject to fouling ◆ reduced finished water alkalinity ◆ no sulfide removal
3. Ozone Oxidation	◆ reduces chlorine demand ◆ strongest oxidant & disinfectant ◆ effective taste and odor control ◆ effective for decolorization ◆ reduces potential for turbidity ◆ no waste by-product stream ◆ mainly enclosed operations ◆ may reduce DBP formation	◆ no additional capacity provided ◆ off-gas destruction required ◆ unstable at elevated pH levels ◆ may produce ozone by-products ◆ increased costs for high sulfide ◆ increases DO content ◆ can induce air binding in filters ◆ sophisticated process operations ◆ post-filtration may be needed
4. Ion Exchange Processes	◆ high treated water recovery (97%) ◆ selective contaminant removal ◆ less area required than lime softening ◆ no solid sludge is produced ◆ low power consumption ◆ no hazardous chemicals are used ◆ simple, automatic operation	◆ substantial waste brine to dispose ◆ does not reduce TDS ◆ increases sodium concentration ◆ cannot remove microbes ◆ cannot remove THM precursors ◆ cannot remove DBP

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polymer must be closely regulated. If the sludge blow-down of the clarifier is not closely regulated the sludge bed could become dense and possibly burn-out the sludge rakes or "gum up" the sludge blow-down pipe. A non-moving rake will allow the bed to thicken. The dense sludge in turn clogs up the blow-down pipe allowing the sludge bed to possibly overflow the weir. In order to prevent this clogging or rake engine burn-out, regular routine withdrawal of sludge should be practiced.

Enhanced lime softening with modified precipitation using iron salt coagulants is an immediate modification that could help increase capacity. But there still exists a need for capacity to meet short-term and long-range demands that should take into account a SCU design with a SLR of 1.0 gpm/ft^2.

The main advantage of lime softening is the reduction of dissolved minerals, particularly calcium and magnesium, in order to minimize scale-forming tendencies. In addition, because lime softening is the historical method of treatment for the LS plant, operators have familiarity with this process. Lime softening can provide the following additional benefits:

- effective bacterial control and other biological growth control;
- removes trace inorganics, radionuclides and metals;
- can condition different or mixed sources of water; and
- provides taste and odor control.

In recent years, the advantages offered by lime softening have been partially offset by the increased costs required to manufacture lime. In addition, continual environmental concerns have required many water plants to dispose of large amounts of lime sludge through more expensive, energy-intensive methods such as dewatering or wet sludge hauling. WTP sludges are considered industrial sludges and have limited disposal alternatives. To use the sludge at the landfill, the sludge would require some dewatering or thickening. Lime sludges tend to be "slippery" when wet, and can be difficult to use as landfill cover. For sludge lagoons to be considered as an option to sludge thickening and dewatering processes, adequate space would be necessary and be located in an isolated place. Disposal of supernatant would also have to be addressed.

Other disadvantages associated with lime softening include:

- reduced finished water alkalinity which can affect corrosion control;
- inhibitors or pH adjustment may be required for corrosion control; and
- ineffective for removing disinfection by-product precursors.

In the interim the plant should use enhanced lime precipitation. To accommodate the short-term plant expansion, additional lime softening, filtration and chemical feed systems will need to be added. The total treatment capacity of the existing LS plant is approximately 5.0 MGD. However, preliminary site

evaluations indicate that a plant expansion can only accommodate short-term capacity needs. Although expanding the plant could meet capacity demands it would have difficulty complying with water quality goals. For this reason, the potential of expanding the current plant is limited. Since it is desired to improve organics removal, the lime softening process was eliminated from further consideration.

5.3.2 Membrane Processes

Membrane softening is a pressure-driven process that separates dissolved solutes from water by passing the water through a semi-permeable membrane. The pressure applied exceeds the osmotic pressure of the groundwater against the semi-permeable membrane, forcing water to permeate the membrane and leave dissolved components behind. Raw well or surface water is pretreated using cartridge filters to remove suspended solids. Sulfuric acid and anti-scalant are added to the flow stream prior to membrane filtration to prevent membrane scaling.

In the case of well water use, pretreated feedwater passes through the membrane array, the resulting permeate (treated water) is degassified to remove hydrogen sulfide and carbon dioxide. Several types of degassification systems can be used to treat the permeate flow. For the purpose of this investigation, it will be assumed that packed tower air stripping and odor control treatment will be used for the permeate flow of treated well water.

The permeate flow is then chlorinated for disinfection prior to sodium hydroxide treatment or alkalinity recovery for final stabilization and corrosion control. The concentrate stream that results from the membrane treatment process is treated and either re-used or discharged as a waste stream.

Water softening using low-pressure membranes has been successfully accomplished in many public and private water supplies in Florida. Membrane softening is a pressure driven process that is also referred to as nanofiltration or low-pressure reverse osmosis. The primary advantage to using nanofiltration is that softening and organic removal are accomplished on low TDS water by using these membranes.

Membrane softening is generally a more advantageous membrane process to install than reverse osmosis systems because less power is consumed due to lower operating pressures and less wastewater is generated per unit volume of water produced. These operating conditions have lowered the overall cost such that membrane softening becomes cost-effective when compared to the traditional lime softening treatment. Membrane softening offers the following principle advantages:

- provides superior finished water quality;
- removes microbes, THM/DBP precursors, lowers TDS, and removes calcium and magnesium hardness;
- provides for flexibility relative to permeate water quality and the need to provide a non-corrosive finished water;

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- removes color and taste and odor compounds;
- provides smaller chlorine demand and water more easily disinfected;
- produces less substances for re-growth in distribution system;
- reduces chlorides, sulfates, arsenic, radium and other IOCs;
- removes high levels of *Giardia* cyst and enteric virus constituents; and
- enclosed modular system allows for greater design flexibility.

The membrane treated water should require a lower dose of chlorine to achieve the required CT value, and a lower dose to maintain a measurable chlorine residual throughout the distribution system. Also, chlorine residual maintenance within the distribution system is improved since membranes remove chlorine demanding substances.

However, membrane softening has some disadvantages which can include:

- need for pilot-testing for design parameters for a full-scale facility;
- need for pretreatment to prevent fouling of membrane;
- required additional monitoring related to water quality;
- if well water is used, post-treatment would be required to remove sulfide;
- concentrated waste stream requires disposal;
- increased operator training requirements; and
- inhibitors or pH adjustment will be required for corrosion control.

Of these disadvantages, concentrate disposal can be the most challenging to overcome. Safe concentrate disposal alternatives could include discharge to the sewer system, deep well injection, surface water discharge or reuse as an irrigation supply. Utilizing the concentrate as an irrigation supply poses several concerns, including the salinity levels of the concentrate and the tolerance of the plants or crops to those levels.

Membrane softening (MS) or low pressure reverse osmosis is very effective in removing organic material (i.e., color and TOC) and hardness and there is a growing trend in Florida to combine low pressure reverse osmosis with existing lime softening processes. Preliminary site evaluations indicate that a plant expansion can only accommodate short-term capacity needs and provisions should be made to address long-range demands. These provisions should include either procurement of additional adjacent property or consideration of retiring the LS WTP and constructing a new MS WTP at Marco Lakes or at an existing or new location on the island.

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5.3.3 Ozone Oxidation

Ozone has been used since 1906 for potable water treatment. Ozone is often used when several water quality constituents need to be oxidized. Ozone is a highly reactive gas that is typically formed by electrical discharge in the presence of air or pure oxygen. In typical situations, ozone is contacted with the raw water in a contactor or reaction vessel before entering the ground storage tank. Water leaving the ground storage tank is chlorinated for residual disinfection before entering the distribution system, and ozone off-gases are eliminated by a scrubbing process. Corrosion control using pH adjustment or inhibitor addition would have to be performed.

Ozone is the strongest oxidant and disinfectant and represents the most effective strategy in meeting contact time (CT) such that it provides the lowest CT value. The major advantage associated with ozone oxidation is the complete oxidation of sulfide to sulfate with minimal to no elemental sulfur turbidity formation. In addition, although ozone can destroy up to 15 percent of THM precursors, it still allows free chlorine to be used later in the treatment train. Ozonation in drinking water treatment has been used for the following benefits:

- inactivates both *Giardia* and *Cryptosporidium*;
- reduction of dissolved color organics;
- disinfection, algae control and minimizes turbidity formation;
- oxidation of inorganic contaminants (iron and sulfide);
- oxidation of organics (phenols, pesticides, taste and odor);
- no significant liquid-waste stream produced;
- improved coagulation/flocculation of colloidal matter; and
- operated in an enclosed and protected area.

The main disadvantage of using ozonation is that organic-laden waters may produce formaldehyde and other biodegradable organic material that can lead to nuisance biological growths in distribution systems. As a result, biological stabilization using GAC filtration or alternative secondary disinfection (i.e. chloramines) may be necessary to reduce excessive biological growth in distribution systems. Also, ozonation may produce organics that are themselves DBP precursors.

Additionally, ozonation of waters with high sulfide concentrations may require forced-draft air stripping pre-treatment. Other disadvantages include:

- ozone is unstable at elevated pH values and in high TOC waters;
- ozone is used as a primary disinfectant and requires use of a secondary disinfectant because ozone does not carry a residual;

- air binding in filters can be a problem;
- formation of by-products and assimilable organic carbon;
- potentially enhances microbial activity in the distribution system;
- increases dissolved oxygen content in water, and could affect corrosion rates of distribution materials;
- off-gas generated at site must be properly destroyed;
- increased operation and maintenance requirements;
- requires use of chloramines if post-chlorine produces THMs; and,
- pilot-testing would be required.

Although adding ozone oxidation could improve organics removal, this additional treatment process would not increase the plant's overall capacity. For this reason, the potential for using ozone at the current plant is limited. Since it is desired to increase capacity, ozone oxidation as an addition was eliminated from further consideration

5.3.4 Ion Exchange Processes

Ion exchange treatment processes can be used to reduce hardness and organics. Deep well injection of the brine is included in this option. The process would require a cationic resin for hardness removal and a anionic resin for organics removal. If the process was to be run in parallel with the LS plant and blended to increase capacity, both resins would be required. If the process was added to the end of the process, either one or both of the resins could be used depending on the desired water quality. The ion exchange process requires that the resin be regenerated from time to time as it becomes exhausted. Regeneration is accomplished by passing a concentrated sodium chloride brine through the bed. During regeneration, concentrated sodium ions in the regenerate brine drive that calcium and magnesium ions off of the resin and into solution.

During the ion exchange process ions are transferred from a liquid to a solid or vice versa. As a result, selective removal of a contaminant (ion) is possible and this represents a major advantage associated with using ion exchange for water treatment. Other advantages of this treatment process include:

- over 97 percent treated water recovery is possible;
- no solid sludge is produced;
- low power consumption;
- no hazardous chemicals are used (plain salt is used to regenerate the exchange media); and
- system operation is simple and automatic.

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However, this treatment process is not without disadvantages. Most notably, this process is not capable of removing microbes or THM/DBP precursors. As a result, if microbial removal or DBPs become a concern, ion exchange will need to be used in conjunction with a second advanced treatment process. Other disadvantages include:

- substantial waste brine production (creates significant disposal need); and
- process does not reduce TDS in treated water and increases sodium concentration in the treated water.

High quality ion exchange processed water can be blended with lime softened water to produce a blended finished water. Under this operating scenario, ion exchange effluent (combined with raw water) can be blended with current lime softening effluent. Or, the ion exchange process can be added after lime softening and filtration. This option could provide a higher water quality than blending, but capacity is not increased.

Ion exchange processes are effective in removing organic material (i.e., color and TOC) and hardness. Preliminary site evaluations indicate that a plant expansion can only accommodate short-term capacity needs and provisions should be made to address long-range demands.

5.4 Short-Listing of Treatment Alternatives

When looking to the future and toward the development of a water quality master plan, the treatment alternatives selected for evaluation must have the built-in flexibility to satisfy dynamic regulatory conditions and water treatment capacity based on space constraints. Of the four treatment alternatives, ozone is not a stand alone treatment processes that could solely be applied at Marco Island. Since ozone is not a stand alone treatment process, ozone was removed from consideration as a viable treatment alternative.

Based upon a conceptual review of treatment alternatives advantages and disadvantages and based upon the non-cost evaluation and ranking of the potential alternatives, the following processes were identified as having the best potential for implementation within the MIWS:

1. Membrane Processes
2. Ion Exchange Processes
3. Combination of Lime Softening with either Membranes or Ion Exchange

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6.0 Conceptual Cost Considerations

Conceptual cost estimates are important in utility deliberations and planning activities. To develop conceptual costs that take into account SDWA compliance considerations, several interrelated process-related components must be evaluated. The objective in determining conceptual treatment alternative costs is to develop estimates of costs that Florida Water would be expected to encounter when complying with forthcoming drinking water regulations under the SDWA. USEPA cost curves, equipment cost data from manufacturer's representatives, other literature and previously conducted studies of the Marco Island Water System was used to develop conceptual opinions of probable costs (USEPA 1979, Taylor 1992, Bergman 1995). The costs presented in this section are intended to be used for planning purposes only, as they do not represent design-based engineering evaluations.

For purposes of this report, alternative treatment conceptual costs refer to the capital costs and annual operations and maintenance costs presented as cost per volume water treated (i.e. dollars per 1,000 gallons) for an array of treatment technologies and given system capacity.

Conceptual capital cost estimates are based on an overview of major equipment selection, energy and material balances, and conceptual flow diagrams. Conceptual capital costs include both direct and indirect construction costs. Indirect costs include engineering, legal, financial and interest costs accrued during construction and are typically estimated as a percentage of the total direct construction cost. The costs presented in this document are preliminary in nature and are considered conceptual because equipment selection, layout and engineering design activities have not been performed.

Estimates of probable conceptual annual operating costs include costs for operating the treatment facility and maintaining the treatment facilities in operational order. Direct operation and maintenance (O&M) costs include costs for labor, energy, materials, chemicals, residuals handling, waste disposal, and contingencies for unforeseen events. Indirect costs include costs for administration and overhead, insurance and regulatory fees.

6.1 Treatment Modifications and Alternatives for Cost Considerations

Currently, the LS and RO plants each produce 5 MGD. The RO plant is expandable to 6 MGD giving an immediate total of 11 MGD for the MIWS. Estimated population projections by Florida Water indicate the need for a total of 15 MGD from the Marco Shores and Marco Island facilities. Therefore, a 4.0 MGD expansion for short-term treatment alternatives was assumed should the Marco Shores plant be retired. Long-range treatment alternatives would require 9 MGD of either additional water treatment facilities or demand reduction through the use of reclaimed water (such as the Collier Boulevard Reclaimed Water Line) should both the Marco Island and Marco Shores LS plants be retired. Additional treatment facilities could be constructed either on adjacent purchased properties on the island or at Marco Lakes in which case the additional space at the LS plant on Marco Island could then be used for other needs or uses. Estimated construction and operating costs for the a long-range new treatment plant

were based upon development of a new site and was developed for a population projected in 20 years. The short-term and long-range cost considerations do not account for the use of reuse or aquifer storage/recovery (ASR) water.

Conceptual treatments have been selected in the previous section based on water quality, operations and maintenance, and capacity. This divided conceptual costs into three phases: immediate modifications; short-term alternatives; and long-range alternatives.

6.2 Immediate Modification Cost Considerations

Immediate modifications should be implemented to efficiently produce higher quality water, and reduce operational costs. These modifications do not account for future needed capacity, but are imperative to address problems for the near term until a future plan can be established. Immediate modifications include:

- enhance the lime softening process ;
- add the final 1 MGD expansion to the RO plant;
- retrofit the four original trains to reduce operational and maintenance costs; and
- initiate membrane replacement upon retrofit completion.

6.2.1 RO Plant 1 MGD Expansion

The Marco Island RO plant was originally designed to be expanded to operate at 75 percent recovery and produce 6 MGD in the future. Currently the plant can be operated at 5 MGD. There is space set aside for addition of 1 MGD to the existing facilities before an additional facility must be considered However, the current permitted wellfield capacity is 8.2 MGD with an installed capacity of 8.2 MGD. Therefore additional wellfield capacity should be considered. To accomplish this expansion a new train and well field expansion are needed. The cost of installing a new train and well field expansion are itemized in Table 6.1.

6.2.2 RO Plant Retrofit and Pay-Back

Energy savings attributed retrofitting membranes with interstage turbine boosters and VFD pumps indicates that Train No. 5 (with a turbine booster) has more control of varying water quality and flow conditions compared to an original train (e.g. Train No. 2 without a turbine booster). This was also seen in the trend performance data for recovery and flux associated with operating with an interstage booster. Using an assumed electrical cost of $0.075/kW-hr for the energy cost calculations, the equations used to calculate the energy cost per train along with an example are provided in Table 6.2.

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6.0 Conceptual Cost Considerations

TABLE 6.1
Membrane Train Conceptual Cost Estimate for 1 MGD Expansion

ITEM	$ /UNIT	# UNITS	$1000
Mobilization	---	---	$70
Cartridge Filter	$69,700	1	$70
Post-Treatment Systems	$40,200	1	$40
Cleaning and Chemical Systems	$32,200	1	$32
Membrane Process	$616,400	1	$616
Electrical and Instrument	$310,900	1	$311
VFD, Line Arrestor, Transformer	$125,000	1	$125
New High Pressure 350 hp Pump	$117,900	1	$118
Well and Transmission	$1,286,400	1	$1,286
Contingencies (15%)	---	---	$400
TOTAL			**$3,069**

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TABLE 6.2
RO Membrane Energy Cost Equations and Example

$$\text{Energy Cost}\left(\frac{\$}{\text{kgal}}\right) = \frac{\text{Power (kW)} * \text{Power Cost}\left(\frac{\$}{\text{kW - hr}}\right)}{\text{Perameate Flow (gpm)}} * \left|\frac{1000\text{ gal}}{1\text{ kgal}}\right|\left|\frac{1\text{ hr}}{60\text{ min}}\right|$$

$$\text{Power (kW)} = \text{Amperes} * \text{Volts} * \left|\frac{1\text{ kW}}{1000\text{ W}}\right|$$

Example:

Train #5

$$\text{Power (kW)} = 259\text{Amperes} * 500\text{ Volts} * \left|\frac{1\text{ kW}}{1000\text{ W}}\right| = 130\text{ kW}$$

$$\text{Energy Cost}\left(\frac{\$}{\text{kgal}}\right) = \frac{130\text{ kW} * \left(\frac{\$0.075}{\text{kW - hr}}\right)}{694\text{ (gpm)}} * \left|\frac{1000\text{ gal}}{1\text{ kgal}}\right|\left|\frac{1\text{ hr}}{60\text{ min}}\right| = \$0.23 / \text{kgal}$$

Train #1 – 4 Average:

$$\text{Power (kW)} = 301.5\text{ Amperes} * 500\text{ Volts} * \left|\frac{1\text{ kW}}{1000\text{ W}}\right| = 151\text{ kW}$$

$$\text{Energy Cost}\left(\frac{\$}{\text{kgal}}\right) = \frac{151\text{ kW} * \left(\frac{\$0.075}{\text{kW - hr}}\right)}{656\text{ (gpm)}} * \left|\frac{1000\text{ gal}}{1\text{ kgal}}\right|\left|\frac{1\text{ hr}}{60\text{ min}}\right| = \$0.29 / \text{kgal}$$

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6.0 Conceptual Cost Considerations

Not only did train No. 5 operate at a higher recovery, flux and lower salt passage, the cost of energy consumption was consistently lower when compared to the four original trains (Table 6.3). Figure 6.1 showed that the average cost of energy for producing 1000 gallons of permeate from Train No. 5 was $0.23. Whereas the average cost of train Nos. 1 - 4 was $0.29. Therefore Train No. 5 provided a 20 percent reduction in energy cost while producing more permeate water.

Comparison of operational performance and energy savings have dictated the need for evaluating the cost of retrofitting of the original four FilmTec® RO process trains with an interstage turbine for energy recovery and second-stage pressure boost. The interstage turbine has been shown to increase the capacity while lowing the energy cost. The energy recovered from these turbine boosters should payback the initial capital cost by increasing capacity of each train as well as reduce the energy cost by recovering and reusing the energy.

In addition installation of an enhanced VFD with line arrestors and isolation transformers should be considered as part of the retrofit. The enhancements are additional items needed to help maintain increased capacity while preventing fluctuations in train performance.

Conceptual cost considerations for retrofitting the four original trains with interstage turbine booster pumps and replacement of existing header pipe with larger diameter stainless steel pipe are itemized in Table 6.4. Enhancement cost for VFD, line arrestors and isolation transformers are included separately.

An average cost savings of $0.07/kgal was provided by using an interstage turbine booster, which is an annual savings of $25,550 per train per year. A pay-back time accounting for inflation rates can be calculated using

$$P = A\left(\frac{(1+i)^n - 1}{i(1+i)^n}\right)$$

where: P = present worth capital cost

A = annual pay-back savings

i = annual interest rate

n = annual time.

The amount of time required to pay-back the initial capital cost can be calculated by inputting all variables and solving for n. Table 6.5 presents the pay-back periods in years for 0, 1, 3 and 5 percent inflation rates for retrofitting each train with an interstage turbine as well as additional installed items.

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6.0 Conceptual Cost Considerations

FIGURE 6.1
Marco Island RO Plant Average Energy Cost Using Amperage Data per Train From February 1997 to March 1997

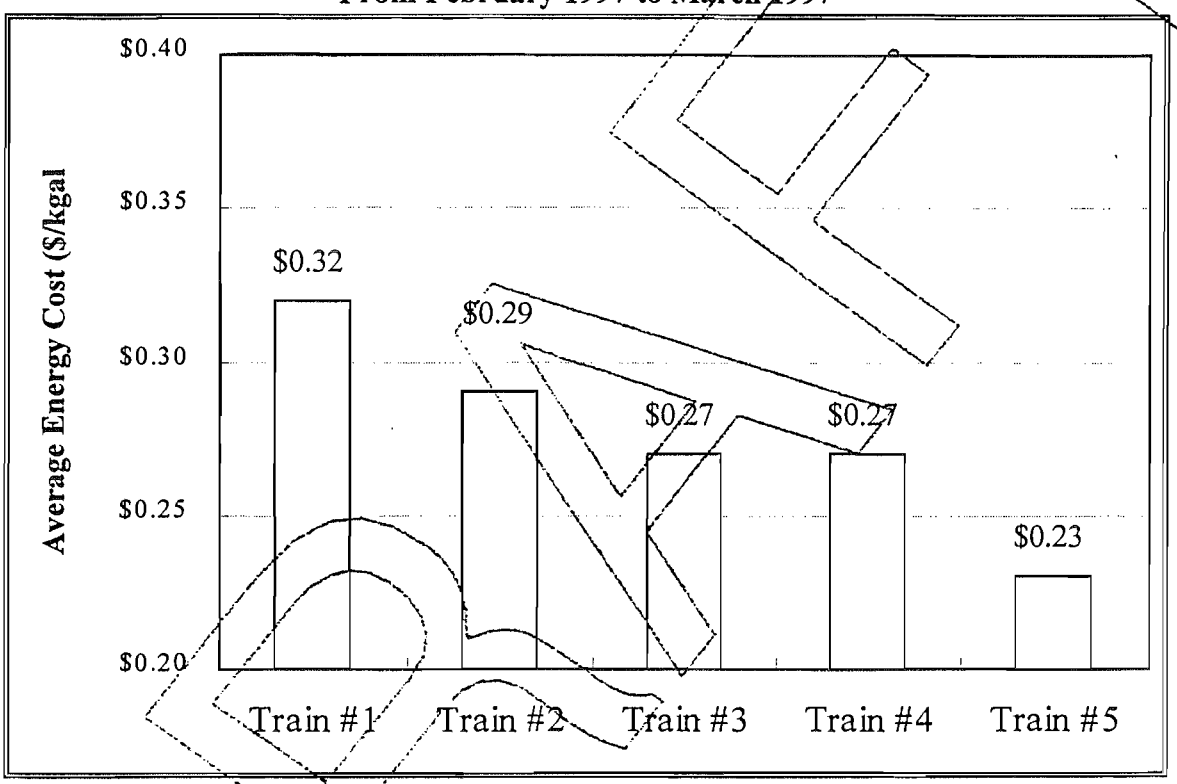

TABLE 6.3
RO Membrane Energy Cost Trend per Train ($/kgal)

	Average	Std. Dev.	Max.	Min.
Train 1	$0.32	$0.011	$0.34	$0.30
Train 2	$0.29	$0.013	$0.35	$0.26
Train 3	$0.27	$0.012	$0.29	$0.25
Train 4	$0.27	$0.012	$0.29	$0.25
Train 5	$0.23	$0.010	$0.26	$0.22

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TABLE 6.4
Membrane Train Conceptual Cost Estimate for Interstage Turbine Retrofit and Other Enhancements

ITEM	$ /UNIT	# UNITS	$ 1000
Feed Header Piping and Valve Modifications	$60,000	4	$240
Pump Suction Header Replacement	$15,000	4	$60
Electrical and Instrumentation	$48,000	4	$192
Sample Panel Board	$12,000	4	$48
VFD/ Line Arrestor/ Isolation Transformer	$125,000	4	$500
Interstage Turbine	$40,000	4	$160
Interstage Piping and Control	$35,000	4	$140
Membrane Replacement	$200,000	4	$800
Contingencies (15%)	---	---	$321
TOTAL			**$2,461**

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TABLE 6.5
Pay-Back Years for Capital Cost at Various Inflation Rates

Description	Interstage Turbine, Piping, Controls and Other Enhancements**	Interstage Turbine & Piping and Controls	Interstage Turbine
Capital Cost	$210,000	$75,000	$40,000
i = 0 % *	8.2 yrs	2.9 yrs	1.6 yrs
i = 1 %	8.6	3.0	1.6
i = 3 %	9.6	3.1	1.7
i = 5 %	10.8	3.3	1.7

* i = 0.0001 % to prevent division by zero
** does not include membrane replacement or VFD/line arrestors/isolation transformer

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6.3 Short-Term Costs Considerations

Short-term treatment alternatives are limited by space constraints and are expandable to an additional 4 MGD on the existing LS site plan over the next 5 years. It should be recognized that after short-term alternatives are utilized then a new facility needs to be evaluated. Therefore a short-term expansion of the existing LS plant would be impractical and is hence no longer considered in this evaluation.

6.4 Long-Range Cost Considerations

Treatment alternatives for new treatment facilities within the MIWS were examined for the purpose of conceptual design and cost estimating,. Long-range treatment alternatives involve the construction of a new 9 MGD facility at a new site. The potential treatment alternative candidates for this new site has been selected as:

- membrane processes; or
- ion exchange process.

A combination of lime softening with either membranes or ion exchange has been ruled out as an alternative because the increase in labor cost plus the complexity of operating a two different processes within one plant.

Table 6.6 presents capital planning costs of new facilities at a new site, assuming that the LS plant at Marco Island and Marco Shores are retired from service. The cost this new site includes cost for construction of unit processes, and operation and maintenance, but it does not account land purchase. These costs are not based on engineering design and are for comparison only. Cost of deep well injection (estimated to be approximately $3.5 Mil) is not included. Administration, laboratory, and maintenance facilities should be considered at the new facility.

Although Table 6.6 represents that ion-exchange is somewhat less expensive than membrane softening, the values represented in Table 6.6 are approximately of the same order of magnitude. Also, when one considers that ion-exchange has not been utilized to any significant degree for water treatment in Florida, it could be rationalized that ion-exchange would involve additional uncertainties not taken into account in this evaluation. Because membrane softening has been demonstrated to produce a superior finished water quality versus ion-exchange in the bench-scale evaluations performed in this study, membrane softening appears to be a more favorable treatment option. Furthermore, when one considers the fact that membrane softening continues to be demonstrated as the treatment option for expansion of many local South Florida utilities (Ft. Myers, Collier County, North Miami Beach, Hollywood, Plantation, etc.), membrane softening is hence recommended for the MIWS as the most favored treatment alternative.

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Table 6.6
Opinion of Conceptual Capital and O&M Costs (Process) for Long-Range (20 year) New Plant Treatment Alternatives [a, b] at New Site

	New Membrane Process (9.0 MGD) ($1,000)	New Ion Exchange Process (9.0 MGD) ($1,000)
Estimated Capital Costs		
Construction Cost	9,523	6,041
Legal, Engineering, Contingencies (35%)	3,333	2,114
Total Estimated Capital	12,855	8,155
$/ gpd	*$1.07*	*$0.91*
$/1000 gallons Capital (installed)	*$0.41*	*$0.26*
Estimated Operating Costs		
Operating Labor Wages & Fringes	155	180
Energy & Power	155	40
Maintenance Material	164	141
Contingencies (25%)	118	90
Total Estimated Annual Operating Costs	592	451
$/1000 gallons O&M	*$0.63*	*$0.64*
TOTAL ANNUAL COST ($/ kgal)	**$1.04**	**$0.90**

a) These costs are not based on engineering design and are for relative comparison only.
b) Waste stream to deep-well injection $3.5 million not included in cost.

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7.0 Summary and Recommendations

This Conceptual Treatment Alternatives and SWTR Planning Study has been prepared for improving the current operational processes, increasing the capacity and improving the water quality within the MIWS. The document has been developed to assist Florida Water in planning and designing immediate modifications, short-term alternatives and long-rang alternatives to the Marco Island water treatment processes. Based upon a review of historical water quality and existing operational processes, a conceptual treatment alternatives assessment related to the MIWS compliance with proposed SDWA regulations has been developed.

Holistic action plans that consider water quality requirements are necessary to resolve a number of potential concerns in the potable water treatment and distribution system. Immediate modifications to the MIWS includes improvements to current operational processes. These modifications are based on water quality and operational data. Short-term treatment alternatives for the MIWS consider expansions to the existing facilities that will increase capacity and comply with current water quality regulations. However, because of space constraints these expansions would be limited and any treatment beyond 5 years would have to be at another location. Long-range treatment alternatives for the MIWS look at the construction of new facilities that will comply with future regulations and meet projected water quantity demand. Anticipation of potential future concerns and development of alternative solutions that can be implemented before problems occur requires a proactive, long-range planning process that considers multiple water quality goals and objectives to maintain compliance with regulations that are often in conflict with one another.

7.1 Findings

7.1.1 LS Water Quality and Existing Facilities

Based on site visits, information reviews, water quality evaluations, historical data reviews and using professional engineering judgment, the following conclusions from the evaluations of the existing LS treatment facilities are presented in this section:

1. Based on regulatory monitoring data, operational logs, and other water quality records provided by Florida Water, the LS plant currently does not comply with the forthcoming organic removal provisions of the Safe Drinking Water Act.
2. The LS plant SCU operates at a surface loading rate (SLR) of 1.5 gpm/ft^2. Typical lime softening plant SCUs are designed to operate a SLR of 1.0 gpm/ft^2. Addition of a settling aid can increase the SLR up to 1.5 gpm/ft^2. Alum is currently the settling aid used at the LS plant. However, carry-over turbidity and dissolved aluminum continues to be a problem at the LS plant using alum as a settling aid. Alum typically precipitates effectively at pH 5.5 to 6.5. The LS plant SCU pH is approximately 9.0, so a portion of the alum remains dissolved and this can pass

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through the filters and this can possibly lead to the LS plant exceeding the aluminum maximum contaminant level (MCL) of 0.2 mg/L.

3. A cationic polymer was tested at the plant to assist the alum, but the sludge blow-down schedule was not adjusted to compensate for the additional sludge so this practice was discontinued.
4. Upon review of the historical data it was found that the chemical dosage rates were in need of adjustment. The chemical dosage rates are based on pounds of chemicals used and the feed flow rate through the plant. Also, these calculated doses could be skewed because they do not account for impurities that may be in the dry chemicals.
5. Increased raw and finished water alkalinity and hardness correlated to increased finished water turbidities. Increased phosphate doses correlated to increased finished water turbidities. This indicates the plant is reacting to changes in these parameters in an adverse fashion.

7.1.2 RO Water Quality and Existing Facilities

Based on site visits, information reviews, water quality evaluations, historical data reviews and using professional engineering judgment, the following conclusions from the evaluations of the existing RO treatment facilities are presented in this section:

1. Based on regulatory monitoring data, operational logs, and other water quality records provided by Florida Water, the RO plant provides a safe drinking water and has not violated any drinking water standard.
2. Increased raw water conductivity, TDS, and SDI correlated to increased finished water turbidities. Likewise, an increase in finished water pH and permeate TDS, and a decrease in finished water temperature was associated with increased finished water turbidities. An increase in feed pressure also correlated to increased turbidities. This indicates the plant is reacting to changes in these parameters in an adverse fashion.
3. Vessels whose average conductivity were greater than 200 umhos/cm were selected for probing. The probing determined if the poor performance may be caused by a defective end-cap, leaking o-ring, or possibly a failure within an element. After evaluating the performance of the probing within the vessels, the inefficient membrane elements were identified.
4. Based upon an engineering evaluation of the performance of the membrane process trains at the Marco Island RO WTP, it has been demonstrated that the membrane train (No. 5) that utilizes an interstage turbine for boosting the feed pressure to the second stage is more efficient than those membrane trains (No. 1 - 4) which do not have the interstage device. Moreover, operating data collected by Florida Water that was analyzed by Boyle indicates that the original membrane trains (No. 1 - 4) are producing lower water quality (increased salt permeation) in the second

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stage, and are not as productive. Arbitrarily increasing the flux across the second stage by reducing the permeate valve is detrimental to the membrane process, and is to be avoided.

5. According to computer modeling, elimination of sulfuric acid addition in trains 1 through 4 to reduce operational cost is possible. Given the relatively low LSI projection in the final concentrate without sulfuric acid pretreatment, it is possible that sufficient scaling control could be provided by antiscalant alone for both calcium carbonate and barium sulfate. Elimination of sulfuric acid addition would also reduce barium sulfate saturation but would be expected to allow a slightly higher degree of salt passage to the permeate.

7.1.3 Bench-Scale Treatability Evaluation

7.1.3.1 LS Bench-Scale Treatability Evaluation

The following conclusions were derived from the bench-scale jar test treatability evaluation:

1. The theoretical lime dose of 180 mg/L (6.1 meq/L) required to remove hardness was also demonstrated to in the jar tests to approximate plant performance.

2. During softening magnesium hydroxide precipitation was shown to enhanced organic removal.

3. Ferric salt addition as a settling aid provided twice the settleability in the jar tests compared to alum.

4. Theoretically, increasing the percent TSS reduces the volume of sludge produced. To increase the TSS the clarifier SLR needs to be increased, a settling aid can be administered or the sludge blow down rate can be adjusted.

7.1.3.2 Ion-Exchange Treatability Evaluation

The following conclusions were derived from the bench-scale ion exchange treatability evaluation:

1. The Tannex resin can remove NPDOC to 2 mg/L, but it will breakthrough the column within 200 bed volumes requiring frequent regeneration.

2. Additional treatment would be required to remove hardness and microbiological contaminants.

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7.1.3.3 Membrane Treatability Evaluation

The following conclusions were derived from the bench-scale membrane treatability evaluation:

1. The NF 2540 FilmTec membrane reduced NPDOC from 11 to < 0.5 mg/L and hardness from 300 to 30 mg/L as $CaCO_3$.

2. Membrane treatment of Marco Lake water provided a superior finished water quality as compared to either enhanced lime softening or ion-exchange processes.

7.1.4 Conceptual Treatment Alternatives

When looking to the future and toward the development of a water quality master plan, the treatment alternatives selected for evaluation must have the built-in flexibility to satisfy dynamic regulatory conditions, water treatment capacity based on space constraints, cost considerations, operational complexity and reliability. Membrane processes, ion exchange processes or a combination of lime softening with either membranes or ion exchange were identified as possible water treatment alternatives that may be necessary to meet current and proposed regulations and increase capacity.

1. Combination of lime softening with either membranes or ion exchange has been ruled out as an alternative because the increase in labor cost plus the complexity of operating a two different processes within one plant.

2. Ion-Exchange processes will not address all water quality issues and will need to consist of hardness and organic removal which could make the process more labor intensive.

3. Membrane processes provide quality water reliably that would meet future water quality regulations and the staff is familiar with the process.

7.2 Recommendations

7.2.1 Recommendations for Immediate Modifications

Currently, the LS and RO plants each produce 5 MGD. The RO plant is expandable to 6 MGD giving an immediate total of 11 MGD for the MIWS. Immediate modifications should be implemented to efficiently produce higher quality water, and reduce operational costs. These modifications do not account for future needed capacity, but are imperative to address problems for the near term until a future plan can be established.

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7.0 Summary and Recommendations

The improvements to the LS plant should be recognized as temporary to increase capacity and improve water quality. However the improvements to the RO plant should increase capacity and lower operational costs. These immediate system improvement for MIWS have been identified in the LS enhanced lime precipitation jar test and in the RO energy recovery evaluation.

The following recommendations are offered relative to the lime softening process at the Marco Island LS WTP:

1. Chemical dosing concentrations calculations should be adjusted to control chemical additions.
2. Enhanced softening (via increased pH using caustic) should be used to remove NPDOC.
3. Turbidity and flow rates should be measured at the clarifier, at the filters, after the filter and on the finished water.
4. Ferric salts should be considered to help increase settleability thus increasing capacity. Also with ferric the issues with dissolved aluminum would no longer be of concern. However, color and increased sludge volumes would have to be monitored and adjusted accordingly. Sludge volumes can be theoretically calculated and a sludge blow-down rate can be derived and adjusted to compensate for the additional sludge produced.
5. Sludge discharge rates and percent TSS should be measured and evaluated to determine optimum sludge blow down rates for current operations.
6. Samples of raw, settled (pre- and post- chlorine addition), filtered and finished water should be collected and measured for aluminum, pH, temperature, and turbidity.
7. Additional chlorine demand data and HAA data for the filtration system should be collected.

The following recommendations are offered relative to the membrane process at the Marco Island RO WTP:

1. Florida Water should proceed with a program that enhances the original membrane trains (No. 1 - 4), primarily by retrofitting each train with an interstage turbine in a similar fashion to that provided in the recent expansion (membrane train No. 5).
2. Based on probe data provided by Harn R/O Systems, Inc. (203 South Jackson Road, Venice, FL 34292), the low performance membranes identified in the original four trains should be removed from service. In order to accomplish membrane replacement, an entire train should be removed from service, and the unacceptable membranes in the remaining three trains then be replaced using the best membranes taken from that train removed from service. The train that was removed from service would then be completely reloaded with new membrane elements. Any FilmTec® membranes that provided acceptable performance that were removed from the train taken out of service and was not used for replacing poor elements in the three remaining trains could be stored for future replacement needs.

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7.0 Summary and Recommendations

3. Additional enhancements that should be considered for the original four membrane trains (currently using FilmTec® elements) include:
   - replacement of the feed header pipe with a larger diameter pipe to reduce excessive velocity within the feed stream;
   - replacement of the feed control valve to each of the original trains;
   - modification of existing interstage feed, permeate and concentrate piping to allow inclusion of interstage turbines;
   - replacement of membrane interconnectors, stub tubes, o-rings and brine seals;
   - replacement of the sample panels so that interstage sampling can be accomplished;
   - modification of the instrumentation and control methods related to water quality and flow in support of the addition of interstage turbines to each of the original four trains;
   - replacement of existing VFDs with an enhanced unit that includes addition of line arrestors and isolation transformers.
4. Since current and future available funds are limited, a phased program for the retrofit enhancements of the Marco Island RO WTP is required. Table 7.1 shows a five phased five year RO retrofit and improvements program.

The following recommendations are offered relative to blending surface or surficial well water to brackish well water for RO treatment:

1. The surface water supply replenishment rate and safe yield of supply for production capacity should be determined.
2. The surface water supply must be further evaluated to come to a more complete understanding of the chemical, biological and physical constraints prior to proceeding with surface water blend operations to serve as a supplemental water supply source for the RO plant. This would include an evaluation of the AOC levels in the surface water supply source and brackish wells to determine relative impact on AOC mass loading to the membrane elements.
3. A comprehensive conceptual treatment alternative evaluation and feasibility study should be performed on the surface water supply source to determine the feasibility for use as a feed water source for the Marco Island RO plant. If the new well field water quality is good, then blending does not need to be practiced. So, Train No. 6 should be installed and the water quality and well field capacity reevaluated before proceeding with blending. The evaluation would include development of an experimental protocol which would include pilot and bench testing. If Train No. 6 is added the new wellfield may allow this procedure to be eliminated or delayed. Ultrafiltration pretreatment should be included as one of several alternative tests in the evaluation of the surface supply.

TABLE 7.1
Phased Program for RO Interstage Turbine Retrofit and Other Enhancements

YEAR	ITEM	$/Train	# Trains	$
1997	Interstage Retrofit/Train Modifications	$210,000	2	$420,000
	Contingencies (15%)	---	---	$63,000
	Sub Total			***$483,000***
1998	Interstage Retrofit/Train Modifications	$210,000	2	$420,000
	Membrane Replacement	$200,000	1	$200,000
	VFD/ Line Arrestor/ Isolation Transformer	$125,000	1	$125,000
	Contingencies (15%)	---	---	$111,750
	Sub Total			***$856,750***
1999	Membrane Replacement	$200,000	1	$200,000
	VFD/ Line Arrestor/ Isolation Transformer	$125,000	1	$125,000
	Contingencies (15%)	---	---	$48,750
	Sub Total			***$373,750***
2000	Membrane Replacement	$200,000	1	$200,000
	VFD/ Line Arrestor/ Isolation Transformer	$125,000	1	$125,000
	Contingencies (15%)	---	---	$48,750
	Sub Total			***$373,750***
2001	Membrane Replacement	$200,000	1	$200,000
	VFD/ Line Arrestor/ Isolation Transformer	$125,000	1	$125,000
	Contingencies (15%)	---	---	$48,750
	Sub Total			***$373,750***
	TOTAL			**$2,461,000**

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4. Several alternative types of spiral wound membrane elements currently available in the market that have different polymer material film compositions should be evaluated for use with a feed water consisting of a blended brackish ground water and surface water supply. The ideal membrane characteristics required would include that the membrane be manufactured of a material that is resistive to a number of solvents, a wide range in pH, can withstand rigorous cleanings, and uphold to elevated temperatures for short periods of time.

7.2.2 Recommendations for Long-Range Planning

Estimated population projections by Florida Water indicate the need for a total of 15 MGD from the Marco Shores and Marco Island facilities by the year 2018. Long-range treatment alternatives would require a new 9 MGD water treatment facility at a new site should both the Marco Island and Marco Shores LS plants being retired. The additional space at the LS plant on Marco Island could then be used for other uses.

A new ion-exchange facility was removed as a potential long-range alternative because it would have limited organic removal, no microbial removal and has limited historical use in the area. Consequently additional treatment such as GAC, ozone, ion-exchange softening or lime softening would have to be added to the process to meet current and future regulations. Therefore, membrane processes have been selected as the treatment alternative candidate for the new facility.

For the long-range a site evaluation study should be conducted that would assist in determining the most feasible location for a new membrane treatment facility. It is recognized that Florida Water is actively pursuing reclaimed water to reduce demand, and has a 1 MGD reduction planned for next year.

To develop more detailed treatment performance evaluations for the long-range treatment alternatives, bench-scale and/or pilot-scale testing programs are recommended for the MIWS. The primary benefit of pilot investment is that pilot studies can help lower construction and life-cycle costs. The basic purpose of membrane softening pilot-testing is to identify secondary impacts of treatment for a specific water supply.

Membrane processes should be investigated further in terms of the following perspective:

1. Develop detailed water quality trend information, color evaluations, chlorine demand curves, disinfection by-product formation potentials, and chlorine residual curves, and other miscellaneous chemical analysis using the *Water Quality Parameter Identification List*;
2. Evaluate via bench-scale testing the applicability of membrane alternatives to develop chemical loading criteria and preliminary design and operation parameter information;
3. Implement master planning activities that include conceptual treatment plant site layouts;
4. Perform detailed cost evaluation;

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5. Review findings with FDEP;
6. Perform preliminary design of selected treatment option;
7. Define capital, operating, maintenance and replacement costs;
8. Establish a schedule for final design, bidding and construction of MIWS improvements.

Keeping in mind, a new facility must be designed such that additional enhancement processes can be easily added to the process train in order to satisfy the upcoming SDWA regulatory requirements that were identified as part of this study. Similarly, a new membrane facility should be designed with the flexibility to add other treatment processes or additional membrane trains in order to satisfy future treatment requirements.

It is also recommended that Florida Water move forward with the development of long-range treatment alternatives for construction of a new plant while implementing immediate modifications. Although the development of a new plant will likely be more costly than the expansion of the existing LS plant, a new processes will provide afford Florida Water with greater flexibility in satisfying existing and future, more stringent water quality standards.

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APPENDIX A
Drinking Water Regulations

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APPENDIX A
Drinking Water Regulations

A.1 Constraints

This section presents water quality constraints. A regulatory constraint is governed by action levels or maximum contaminant levels (MCLs) which identify the acceptable concentration level in the drinking water. A functional constraint is governed by chemical composition, kinetic reaction, and process limitations.

The regulatory constraints for pH, alkalinity, or calcium adjustment of the MIWS include the Lead and Copper Rule (LCR), the Disinfectant/Disinfection By-Product (DBP) Rule, the Surface Water Treatment Rule (SWTR), turbidity standard, and disinfection requirements. The total coliform rule and radionuclides rule also have regulatory constraints on the MIWS

In response to the challenges of the Safe Drinking Water Act regulated by the United States Environmental Protection Agency (USEPA), the Authority has initiated a water quality enhancements and drinking water treatment improvements program for the MIWS. The 1996 Amendments (Public Law 104-182) to the Safe Drinking Water Act (SDWA) required the United States Environmental Protection Agency (USEPA) to make significant changes to a number of standard setting processes. The SDWA regulatory process is now required to rely on sound science, and consider items as costs, benefits, and competing risks in order to establish new drinking water quality and treatment regulations. The USEPA is still in the process of creating, proposing, reviewing and promulgating new drinking water quality regulations which will continue to significantly impact water treatment practices and water utility operations throughout the United States.

USEPA has informally stated at technical conferences that the 0.5 NTU turbidity regulation will be decreased to at least 0.2 NTU and perhaps less than 0.1 NTU (Clarke 1997). Although the literature has shown that particle counts are not related to turbidity below 0.1 NTUs, there is some impetus to regulate particle counts and many plants are installing particle counters. There are however, problems with particle counters. Particle counts on the same water vary greatly by instrument manufacturer and there is currently no standardization.

There is much debate in the water community on the issue of particle counters. Plants that have spent significant sums to install particle counters may find themselves using a non-standard technology in a few years and having to spend much more to conform to future regulation. Although particle counting is fundamentally more accurate than turbidity measurements for measuring particles in drinking water, we recommend that water plants should concentrate on optimizing turbidity removal and wait to install particle counters until a standard technology for the industry is adopted.

A functional constraint can be the lack of alkalinity in the raw water to aid in coagulation. Existing measures to deal with the lack of alkalinity for the alum to react with include use of caustic to provide

additional alkalinity. The settling velocity process limitation functional is enhanced by polymer addition to aid in settling.

Some turbidity is expected to be produced from significant pH, alkalinity or calcium adjustments of the treated water to slightly more than saturation. Several water suppliers in Florida adjust finished water pH with NaOH to slightly more than saturation without producing any turbidity in the finished water. Consequently, moderate additions of NaOH are not expected to produce significant turbidity. There are many functional constraints for pH, alkalinity, or calcium adjustments.

For corrosion control, increased pH values above $pH_{stabilization}$ can cause calcium carbonate ($CaCO_3$) precipitation in the distribution system. This creates a $CaCO_3$ "protective" coating within the distribution system which reduces corrosion, therefore the water is considered "passive". In essence, the coating acts as a short-circuit between the water and the metal ions. Whereas pH values below $pH_{stabilization}$ will not provide the $CaCO_3$ coating, therefore the water is considered "aggressive". This can increase the rate of corrosion for lead, copper, and other transition metals.

In the case of DBPs, raising the pH of the finished water can increase total trihalomethanes (TTHMs) yet decrease haloacetic acids (HAAs). This option could be evaluated for control of HAAs if the TTHM and HAA MCLs are eventually reduced to 40 and 30 µg/L respectively, as could be proposed for Stage 2 of the Disinfectants-Disinfection byproducts (D-DBP) rule (ICR EPA 814-B-96-003).

A.2 The Safe Drinking Water Act

The original SDWA, signed into law in December 1974 (PL 93-523), represented the first drinking water regulations that applied to all public water systems in the United States. The 1974 SDWA authorized the USEPA to set numerous national drinking water standards, conduct special studies and research, and oversee implementation of the SDWA.

Under the provisions of the SDWA, the USEPA was required to establish National Primary Drinking Water Regulations (NPDWR). Enforceable maximum contaminant levels (MCLs) were promulgated in 1975 as a part of the National Interim Primary Drinking Water Regulations (NIPDWR). The NIPDWR were amended in 1977 and 1979 to include MCLs for additional contaminants.

In addition to the health-related primary drinking water regulations, the SDWA also authorized the USEPA to develop secondary regulations for contaminants which may adversely affect the aesthetic quality of drinking water. Non-enforceable secondary maximum contaminant levels (SMCLs) were promulgated in 1979, and could allow individual states to enforce the standards. The SMCLs are enforced by the Florida Department of Environmental Protection (FDEP).

APPENDIX A
Drinking Water Regulations

In 1986, Congress passed legislation which amended most of the original 1974 Safe Drinking Water Act. The 1986 Amendments to the Safe Drinking Water Act (SDWA) required the United States Environmental Protection Agency (USEPA) to establish new drinking water quality and treatment regulations. The USEPA is still in the process of creating, proposing, reviewing and promulgating new drinking water quality regulations which will continue to significantly impact water treatment practices and water utility operations throughout the United States. The 1986 amendments were signed into law (PL 99-339) to strengthen the regulations, and added six new sections to the original Act. Six key provisions of these major water quality-related regulations resulting from the 1986 amendments are listed below:

1. **MCLGs and MCL -** Maximum Contaminant Level Goals (MCLGs) and MCLs were to be established for eighty-three contaminants previously identified by Congress. MCLGs are non-enforceable health based goals while MCLs are enforceable water quality regulations.
2. **Monitoring -** Monitoring programs for unregulated contaminants were to be established to develop data for evaluating the health risks of these unregulated contaminants.
3. **Filtration -** Criteria were to be established which require filtration for water treatment systems utilizing surface water as the raw water supply.
4. **Disinfection -** Disinfection was to be required of all public water supplies throughout the United States. A public water supply as defined by the USEPA is any system that provides distributed water to the public for human consumption, if it has at least 15 service connections, or regularly serves at least 25 persons daily at least 60 days out of the year.
5. **Use of Lead Materials -** The use of solder or flux containing more than 0.2 percent lead, or pipes and pipe fittings containing more than 8 percent lead, was prohibited in public water supply systems.
6. **Wellhead Protection -** All states were required to develop Wellhead Protection Programs, designed to protect potable supplies from sources of contamination.

In addition, the USEPA was required to develop the Drinking Water Priority List (DWPL), which identified contaminants that are known or anticipated to occur in public water systems. Pesticides in particular were to be addressed by the USEPA in the DWPL. The initial DWPL, finalized in 1988, listed 83 contaminants (either individually or in contaminant groups) that either occur in PWSs or are suspected to occur in public water systems at high levels. Although the 1986 Amendments indicated that the DWPL is required to be updated at three year intervals with at least 25 contaminants being addressed every three years, the 1996 SDWA Amendments (Public Law 104-182) has altered these requirements.

The SDWA of 1996 has made significant changes to a number of standard-setting-processes, which includes establishing new requirements for selecting contaminants to be regulated, mandating the use of sound science, allowing analyses of health risk reductions, costs, and benefits, establishing an

occurrence database, and permitting competing risks to be weighed. Current regulations for fluoride, volatile organic compounds, total coliforms, Phase II and Phase V synthetic organic and inorganic contaminants, SWTR, and the lead and cooper rule (LCR) remain basically unchanged. New deadlines are established for the regulation of arsenic, sulfate, radon, DBP Rule, Enhanced SWTR, and groundwater disinfection.

Under the 1996 SDWA, the USEPA is required to list and subsequently regulate 25 contaminants known or anticipated to occur in public water systems and which may require regulation. Within five years, and every five years thereafter, USEPA must decide whether or not to regulate at least five contaminants on the list. The 1996 SDWA Amendments require USEPA to publish a maximum contaminant level goal (MCLG) and promulgate a National Primary Drinking Water Regulation (NPDWR) for a contaminant that: (i) has an adverse effect on human health; (ii) is known to occur or there is substantial likelihood that the contaminant will occur in public water systems with a frequency and level of public health concern; and (iii) in the sole judgment of USEPA, regulation presents a meaningful opportunity for public health risk reduction.

The 1996 SDWA Amendments now require USEPA to identify contaminants that would be candidates for regulatory consideration, and from this list, determine whether regulatory action is appropriate or inappropriate for at least five contaminants within five year increments. The first regulatory determinations must occur within 5-years of the SDWA Amendments, and every five years thereafter.

With the passage of the 1996 Safe Drinking Water Act amendments, the EPA will require each community water system to provide customers with a "consumer confidence report" at least once a year. A regulation addressing consumer confidence reports is due by August 1998, and water systems will likely begin publishing these reports in 1999.

At a minimum, consumer confidence reports are to include the following in brief, plainly worded language: include the following in brief, plainly worded language:

- information on the source water of the water system
- an explanation of the contaminants that may reasonably be expected to be present in drinking water and reasonably be expected to be present in drinking water and that the presence of contaminants in drinking water does not necessarily indicate a health risk
- the number for the USEPA toll-free hot line - (800) 426-4791 - that consumers can call for more information about contaminants and potential health effects
- definitions of the terms "MCL," "MCLG," "variances," and "exemptions"
- whether any regulated contaminants is detected in the water by the PWS, and if so, the MCLG, MCL, and the level of the contaminant in the water system

- in the case of a violation of the MCL for any regulated contaminant during the year concerned, an statement of the health concerns that resulted in the regulation of the contaminant
- information on compliance with National Primary Drinking Water Regulations
- a statement of whether the system is operating under a variance or exemption, and the basis on which the variance or exemption was granted
- information on the levels of unregulated contaminants for which monitoring is required, including levels of *Cryptosporidium* and radon where states determine they maybe found.

The FDEP has primary enforcement responsibility for the SDWA in Florida, which included implementation and enforcement of all regulations promulgated by the USEPA. Accordingly, the SDWA requires water purveyors to assess operation, engineering designs and management methods in order to effectively balance multiple water quality goals. Promulgation of drinking water regulations has increased significantly since the SDWA Amendments were enacted in 1986. Public perception has strongly influenced more recent regulations and will continue to affect future legislation.

In summary, under the provisions of the SDWA, water purveyors are finding it more difficult to comply with regulations. Today, more emphasis has to be placed on compliance with water quality regulations at the consumer tap. Moreover, public water purveyors are under increased demands to maintain consumer confidence and manage water quality in expanding distribution systems as a result of economic and population growth. As regulations continue to be developed, water utilities are preparing to implement total quality management programs to increase productivity and enhance consumer attitudes.

A.3 SDWA Promulgated Regulations

The USEPA has promulgated National Primary Drinking Water Standards for the following contaminants: volatile organic compounds (VOCs); synthetic organic compounds (SOCs); inorganic compounds (IOCs) including fluoride, lead and copper; radionuclides; and, coliform and other microbial contaminants. Table A.1 provides a summary of the promulgated drinking water regulations.

Under the SDWA, systems must demonstrate compliance with regulations through monitoring requirements. Compliance monitoring requirements are generally promulgated along with MCLs, MCLGs, and treatment techniques. A summary of the contaminants regulated under the SDWA is provided in Appendix A.2, which is intended to serve as an overview of the contaminant MCLs and requirements of the SDWA; however, many of the details of each specific rule or contaminant are not included for brevity.

A.3.1 Inorganic, Synthetic Organic and Volatile Organic Compounds

The majority of the existing drinking water contaminants regulated under the SDWA amendments fall into the following three categories:

1. Inorganic Compounds (IOCs);
2. Synthetic Organic Compounds (SOCs); and;
3. Volatile Organic Compounds (VOCs).

The rule making process for contaminants in drinking water is complex, and is divided into several categories referred to as phases by the USEPA:

- Phase I - VOCs;
- Phase II - SOCs and IOCs;
- Phase IIA - Fluoride;
- Phase III - Proposed Phase, no reference by USEPA to date;
- Phase IV - Proposed Phase, no reference by USEPA to date;
- Phase V - Additional SOCs and IOCs.

The Phase I VOC final rule established MCLs for eight VOCs (benzene, carbon tetrachloride, *Para*-dichlorobenzene, 1,2-Dichloroethane, 1,1-Dichloroethylene, 1,1,1-Trichloroethane, Trichloroethylene, and vinyl chloride). The MCL for each regulated VOC can be found in Table A.2. Phase I monitoring requirements included sampling at each WTP point-of-entry (POE) to the distribution system and each groundwater source, or a combination of groundwater sources for one entry point. If no VOCs are detected during the initial monitoring, repeat monitoring is required every three years. However, if Phase I VOCs are detected during the initial monitoring period, quarterly samples must be analyzed, with compliance based on the annual average of the quarterly samples. In addition to the 8 regulated VOCs, the Phase I rule included monitoring requirements for 51 additional VOCs.

The Phase II Rule for SOCs and IOCs set MCLs and treatment techniques for 10 VOCs, 20 SOCs, and 8 IOCs. Included with the Phase II Rule contaminants were compounds that are unregulated yet required monitoring. Compliance with the Phase II Rule is determined by the annual average of quarterly samples. The MCLs for these contaminants is provided in Table A.2.

The Phase IIA Rule for fluoride established an MCL of 4.0 mg/L in drinking water to protect against skeletal fluorosis and a SMCL of 2.0 mg/L to protect against dental fluorosis. Under this rule, the fluoride concentration is to be monitored yearly for surface water sources and every three years for groundwater sources. For those PWSs using fluoridation in the treatment process as a public health benefit, daily monitoring of fluoride in treated water at the POE is recommended by the USEPA.

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The Phase V Rule set MCLGs and MCLs for 23 additional SOCs and IOCs. Some of the 23 contaminants included in the Phase V Rule were also included for monitoring as unregulated contaminants under previous rules. To eliminate any duplicated monitoring effort, monitoring as unregulated contaminants under previous rules was withdrawn.

The MCL for sulfate was deferred in the Phase V Rule, so that the USEPA will establish a separate deadline for responding to a sulfate MCL.

A.3.2 Radionuclides

Radionuclides are demonstrated human carcinogens, and can enter a water supply naturally from geologic formations in contact with the source aquifer, or from the leaching of man-made radioactive wastes. The current regulated radionuclides include radium-226, radium-228, and alpha and beta emitters. The existing MCL for radium-226 plus radium-228 is 5 picocuries per liter (pCi/L) (Table A.2).

The MCL for alpha emitters is 15 pCi/L, and the MCL for beta-particle and photon emitters is 4 mrem, where mrem is a measurement of effective radiation dosage to organs. Currently there are no regulations for radon and uranium.

A.3.3 Lead and Copper Rule

The Lead and Copper Rule (LCR) was promulgated in 1991 by the USEPA, and became effective on January 1, 1993 by the FDEP and established compliance dates for implementation of corrosion control in drinking water systems. The LCR requires all PWSs to meet "action levels" for lead and copper measured at consumer taps. The LCR consists of MCLGs and a treatment technique triggered by lead and copper action levels of 0.015 mg/L and 1.3 mg/L, respectively, as measured in the 90th percentile tap sample.

The LCR has required many water systems in the United States to have a corrosion control program for compliance. However, there are many causal factors that impact corrosion of plumbing fixtures and piping (i.e. flow velocity, galvanic corrosion, flux corrosion, chemical factors, temperature, microbial induced corrosion, stray current, etc.) which can impact corrosion control strategies.

Treatment options for control of lead and copper corrosion include pH, alkalinity, calcium adjustment and inhibitor addition. Many Central Florida communities have found that inhibitor treatment of tray-aerated, chlorinated, non-stabilized water containing sulfur turbidity and moderate hardness often does not reduce copper corrosion rates below action levels (Boyle 1995).

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Many Florida groundwater utilities using tray aeration and chlorine disinfection have triggered the copper action limit of 1.3 mg/l (Wu 1996, Lyn 1992). Additionally, coastal communities in Florida utilizing lime-softening of colored Upper Floridan and Coastal shallow groundwaters have intermittently exceeded the 0.015 mg/l limit for lead. Consequently, since promulgation of the LCR these groundwater communities have implemented corrosion control treatment which often includes pH adjustment, alkalinity adjustment, or addition of inhibitor. Lime-softening facilities must optimize the treatment processes to produce a water that does not aggravate lead corrosion. Lime softening often produces a finished water with pH greater than 8.4. This increases the potential for lead dissolution and THM formation. Changes in plant operation or recarbonation can control the pH. However, membrane softening and reverse osmosis treated groundwater systems have had favorable results with compliance with the LCR (Wu 1996).

A.3.4 Total Coliform Rule

The total coliform rule (TCR) became effective in 1990 and established microbiological standards and monitoring requirements that apply to public water systems. Enforceable standards have been set for total and fecal coliforms; in addition, the MCL is based on the presence or absence of total coliforms (including fecal coliforms and *E. coli*). The TCR has been modified several times to allow for variances and exemptions and to improve analytical methods for *E. coli* (Table A.2).

The total number of samples to be collected from a water distribution system is dependent upon the population served by the system, and is defined by the USEPA. The routine sampling for coliforms must be according to a written sampling plan that has been approved by the overseeing regulatory agency. If a PWS detects a positive coliform in any of the routine samples collected each month, then repeat sampling is required within 24 hours and until no positive samples are detected. Repeat samples are required to be collected from the original location and two additional locations within five service connections of the original sample detecting coliform.

TCR compliance is based simply on having all positive samples in both routine and repeat samples. Moreover, if a repeat sample produces a positive result for fecal coliforms or *E coli.* the system violates the MCL.

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TABLE A.1
Promulgated Regulations

Promulgated Rules	Final Rule	Federal Register Citation
Trihalomethanes	November 29, 1979	44 FR 68624
Fluoride	April 1, 1986	51 FR 11396
Public Notification	October 28, 1987	52 FR 41534
Volatile Organic Contaminants (VOCs) (Phase I)	July 1, 1988	53 FR 25108
Surface Water Treatment Rule (SWTR)	June 29, 1989	54 FR 27488
Total Coliform Rule (TCR)	June 29, 1989	54 FR 27547
Analytical Methods of *E. Coli*	January 8, 1991	56 FR 636
Stay of TCR Variance Provisions	January 15, 1991	56 FR 1556
1991 Drinking Water Priority List (DWPL)	January 17, 1991	56 FR 1470
SOCs and IOCs (Phase II)	January 30, 1991	56 FR 3526
Reconsideration of Primary Withdrawal Language	June 3, 1991	56 FR 25046
Lead and Copper	June 7, 1991	56 FR 26460
Postponement of effective date for Aldicarb, Aldicarb Sulfoxide, aldicarbsulfone MCLs	May 19, 1992	57 FR 22178
Approval of MMO-MUG Test for *E. Coli*	June 10, 1992	57 FR 24744
SOCs and IOCs (Phase V)	July 17, 1992	57 FR 31776
Analytical Methods Final Rule	December 5, 1994	59 FR 62466
ICR	May 1996	59 FR 6332

TABLE A.2
USEPA Drinking Water Standards for Regulated Contaminants

Contaminant	Regulation	MCLG (mg/L)	MCL (mg/L)
Synthetic Organic & Volatile Organic Compounds			
Acrylamide	Phase II	zero	treatment technique
Alachlor	Phase II	zero	0.002
Benzene	Phase I	zero	0.005
Benzo(a)pyrene	Phase V	zero	0.0002
Benz(a)anthacene	---	---	0.0001 (proposed)
Benz(b)fluoranthene	---	---	0.0002 (proposed)
Butylbenzyl-phthalate	---	---	0.1 (proposed)
Carbofuran	Phase II	0.04	0.04
Carbon tetrachloride	Phase I	zero	0.005
Chlordane	Phase II	zero	0.002
2,4-D	Phase II	0.07	0.07
Dalapon	Phase V	0.2	0.2
Di(2-ethylhexyl) adipate	Phase V	0.5	0.5
Di(2-ethylhexyl) phthalate	Phase V	zero	0.006
Dibromochloropropane (DBCP)	Phase II	zero	0.0002
p-Dichlorobenzene	Phase I	0.075	0.075
o-Dichlorobenzene	Phase II	0.6	0.6
1,2-Dichloroethane	Phase I	zero	0.005
1,1-Dichloroethylene	Phase I	0.007	0.007
cis-1,2-Dichloroethylene	Phase II	0.07	0.07
trans-1,2-Dichloroethylene	Phase II	0.1	0.1
Dichloromethane	Phase V	zero	0.005
1,2-Dichloropropane	Phase II	zero	0.005

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TABLE A.2 (continued)
USEPA Drinking Water Standards for Regulated Contaminants

Contaminant	Regulation	MCLG (mg/L)	MCL (mg/L)
SOCs & VOCs (continued)			
Dinoseb	Phase V	0.007	0.007
Diquat	Phase V	0.02	0.02
Endothall	Phase V	0.1	0.1
Endrin	Phase V	0.002	0.002
Epichlorohydrin	Phase II	zero	treatment technique
Ethylbenzene	Phase II	0.7	0.7
Ethylenedibromide (EDB)	Phase II	zero	0.00005
Glyphosate	Phase V	0.7	0.7
Heptachlor	Phase II	zero	0.0004
Heptachlor epoxide	Phase II	zero	0.0002
Heptachlorobenzene	Phase V	zero	0.001
Hexachlorocyclopentadiene	Phase V	0.05	0.05
Lindane	Phase II	0.0002	0.0002
Methoxychlor	Phase II	0.04	0.04
Monochlorobenzene	Phase II	0.1	0.1
Oxamyl (vydate)	Phase V	0.2	0.2
Pentachlorophenol	Phase II	zero	0.001
Picloram	Phase V	0.5	0.5
Polychlorinated biphenyls (PCBs)	Phase II	zero	0.0005
Simazine	Phase V	0.004	0.004
Styrene	Phase II	0.1	0.1
2,3,7,8-TCDD (dioxin)	Phase V	zero	5×10^{-8}
Tetrachloroethylene	Phase II	zero	0.005

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TABLE A.2 (continued)
USEPA Drinking Water Standards for Regulated Contaminants

Contaminant	Regulation	MCLG (mg/L)	MCL (mg/L)
SOCs & VOCs (continued)			
Toluene	Phase II	1	1
Toxaphene	Phase II	zero	0.005
2,4,5-TP (silvex)	Phase II	0.05	0.05
1,2,4-Trichlorobenzene	Phase V	0.07	0.07
1,1,1-Trichloroethane	Phase I	0.2	0.2
1,1,2-Trichloroethane	Phase V	0.003	0.005
Trichloroethylene	Phase I	zero	0.005
Trihalomethanes (total)	Interim	NA	0.10
Vinyl chloride	Phase I	zero	0.002
Xylenes (total)	Phase II	10	10
Inorganic Compounds (IOCs)			
Antimony	Phase V	0.005	0.005
Arsenic	Interim	NA	0.05
Asbestos (fibers/L > 10 μm long)	Phase II	7 million fibers/L	7 million fibers/L
Barium	Phase II	2	2
Beryllium	Phase V	zero	0.001
Cadmium	Phase II	0.005	0.005
Chromium (total)	Phase II	0.1	0.1
Copper	LCR	1.3 (90th percentile)	treatment technique
Cyanide	Phase V	0.2	0.2
Fluoride		4	4

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TABLE A.2 (continued)
USEPA Drinking Water Standards for Regulated Contaminants

Contaminant	Regulation	MCLG (mg/L)	MCL (mg/L)
IOCs (continued)			
Lead	LCR	zero	treatment technique
Mercury	Phase II	0.002	0.002
Nickel	Phase V	0.1	0.1
Nitrate (as N)	Phase II	10	10
Nitrite (as N)	Phase II	NA	1
Nitrate + Nitrite (as N)	Phase II	10	10
Selenium	Phase II	0.05	0.05
Thallium	Phase IV	0.0005	0.002
Radionuclides			
Gross beta activity	Interim	NA	4 mrem/year
Alpha emitters	Interim	NA	15 pCi/L
Radium-226 + Radium-228	Interim	NA	5 pCi/L
Radon	Phase III	---	300 pCi/L (proposed)
Uranium	Phase III	---	0.02 (proposed)
Microbials			
E. Coli	TCR	zero	see text
Fecal coliforms	TCR	zero	see text
Giardia lamblia	SWTR	zero	treatment technique
Heterotrophic plate count (HPC)	SWTR	NA	treatment technique
Legionella	SWTR	zero	treatment technique
Total coliforms	TCR	zero	see text
Turbidity	SWTR	NA	performance standard
Viruses	SWTR	zero	treatment technique

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A.3.5 Surface Water Treatment Rule

One of the basic assumptions that the USEPA used in developing the Surface Water Treatment Rule (SWTR) was that surface waters and groundwaters under the direct influence of surface waters are at risk of contamination by *Giardia lamblia* and other protozoa, viruses, and pathogenic organisms. Table A.2 lists the microbials that the USEPA regulates. The SWTR requires that surface waters, as well as groundwaters under the direct influence of a surface water, be treated to achieve a minimum of a 3-log (99.9 percent) inactivation and/or removal of *Giardia lamblia* cysts and a 4-log (99.99 percent) inactivation and/or removal of enteric viruses, while monitoring for turbidity routinely.

The USEPA estimates that well-operated conventional filtration water treatment systems are capable of achieving a 2.5 log (99.7 percent) removal of *Giardia lamblia* cysts and 2.0 log (99 percent) removal of enteric viruses. Additional inactivation by primary disinfection is required to achieve a 3-log *Giardia lamblia* inactivation/removal standard. The inactivation requirements of the SWTR are based on "CT" criteria, where 'C' is the disinfectant concentration (mg/L) at the end of the contact time, and 'T' is the contact time (min) for disinfection. The USEPA has published required CT criteria in the Code of Federal Regulations and supporting Guidance Manuals (available through the American Water Works Association) for a number of disinfectants (chlorine, chloramines, ozone and chlorine dioxide).

The SWTR requires that for those systems that provide conventional filtration, the filtered water turbidity must not at any time exceed 5 nephelometric turbidity units (NTUs), and that 95 percent of the measurements taken for turbidity (at least one every 4 hours) must not exceed 0.5 NTU. In addition, under the SWTR the treated water entering the distribution system must maintain a residual disinfectant concentration of at least 0.2 mg/L, a residual disinfectant in the distribution must be detectable, and the heterotrophic plate count (HPC) must remain below 500 colonies/mL for 95 percent of the samples evaluated for HPC.

The SWTR requires the primacy agency to evaluate each groundwater source within a public water system and determine if it is under the direct influence of surface water. The intent of the evaluation is to identify the groundwater source(s) which may be a risk to *Giardia lamblia* or larger protozoans through microscopic particulate analysis of filtered groundwater residues. If a system is determined to be under the influence of a surface water, then the system must comply with the filtration and disinfection requirements of the SWTR.

As part of the 1996 Amendments of the SDWA, the USEPA must promulgate a regulation to govern the recycling of filter backwash water within the treatment process of a public water system. The regulation is due by August 6, 2000, unless backwash recycling is addressed by the Enhanced SWTR before that date. This could potentially impact the MIWS relative to compliance with the SWTR and Enhanced SWTR, if recycling of backwash water is practice at the facility.

A.3.6 Information Collection Rule

Unlike previous regulations, a negotiated rule-making processes will determine many future MCL values and compliance schedules. In November 1992, the negotiated rule-making process was initiated, referred to as "reg-neg." The reg-neg process was completed in 1994, which resulted in three new rule-making proposals that included: and Information Collection Rule (ICR); and Enhanced SWTR; and a two-stage rule for DBPs.

The ICR was proposed in February, 1994 (59 FR 6332). It will be the first rule implemented because its purpose is to collect data critical to the development of the other two rules. The ICR was developed during the regulatory negotiations for the DBP Rule because an improved database is needed to support development of the DBP and other Rules. Consequently, the ICR will develop a national database of microbial and DBP occurrences for input into the Stage II of the D/DBP Rule. Microbials include *Giardia lamblia*, *Cryptosporidium*, *E. Coli*, total coliforms, and viruses (59 FR 6332). All sampling was anticipated to be completed by March 31, 1997; however, final dates have not been established. In addition:

- Surface water systems serving under 100,000 and groundwater systems serving under 50,000 are not affected by the ICR;
- Groundwater systems serving more than 50,000 will be required to perform total organic carbon (TOC) sampling at the point-of-entry monthly for one year.
- Groundwater systems serving more than 100,000 will be required to monthly water quality parameter sampling and quarterly DBP sampling for 18 months;
- Surface water systems serving more than 10,000 will be required to perform microbial sampling (no viruses) every 2 months for one year;
- Surface water systems serving more than 100,000 population will be required to sample every month for 18 months. Depending on the TOC levels in raw water, all large systems may be required to conduct GAC/membrane pilot studies to assess DBP precursor removal.

A.4 Secondary Standards

In addition to the health-related primary drinking water regulations, the SDWA also authorized the USEPA to develop secondary regulations for contaminants which may adversely affect the aesthetic quality of drinking water. Non-enforceable federal secondary maximum contaminant levels (SMCLs) were promulgated in 1979, and would allow for the individual states to enforce the standards. The SMCLs are enforced by the Florida Department of Environmental Protection (FDEP). A list of the secondary standards is provided in Table A.3. These aesthetic contaminants are regulated because they

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have the ability to reduce customer confidence in the PWS. Consequently, the FDEP considers this a public health threat, because the customer may drink water from some other unapproved source of water.

TABLE A.3
USEPA Drinking Water Secondary Standards*

Contaminant	MCL (mg/L unless shown)
Aluminum	0.2
Chloride	250
Color	15 color units
Copper	1.0
Corrosivity	noncorrosive
Fluoride	2 (proposed)
Foaming Agents (MBAS)	0.5
Iron	0.3
Manganese	0.05
Odor	3 T.O.N.
pH	6.5-8.5
Silver	0.10
Sulfate	250
Total Dissolved Solids (TDS)	500
Zinc	5

* Secondary Drinking Water Standards (SDWSs) are non-enforceable Federal guidelines that refer to the taste, odor, color and certain other aesthetic effects of drinking water. USEPA recommends them to States as reasonable goals, but Federal law does not require PWSs to comply with secondary standards. The State of Florida enforces SDWSs.

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A.5 SDWA Proposed Regulations

The proposed SDWA regulations are provided for review are based on current available information, but which may be subject to change:

A.5.1 Radionuclides

USEPA's proposed rule for radionuclides was published on July 18, 1991 (Federal Register Citation 56 GR 33050), and will be referred to as the Phase III Rule. The USEPA has evaluating more than 600 public comments submitted on the proposed rule. Although a court deadline of April 1993 existed for issuance of the finalized rule, the USEPA has further delayed this deadline due to resource constraints.

Under the proposed rule, a minimum of one sample would be required from each point-of-entry (POE) and the distribution system. If a system does not comply with the MCLs, more frequent monitoring would be required. The frequency of sampling would depend on which radionuclide MCL was exceeded.

Uranium and radon are proposed to be included in the Phase III Rule, having MCLs proposed at 30 pCi/L and 300 pCi/L, respectively. Although the USEPA Radon report to Congress supports a radon MCL of 300 pCi/L, a May 1994 USEPA memorandum indicated that the Office of Water supports an MCL of 200 pCi/L and that the Science Advisory Board suggests a radon MCL of 1,000 pCi/L. In addition, under the proposed rule Radium-226 and Radium-228 MCLs would be relaxed to 20 pCi/L, respectively. It is unclear whether or not the State of Florida would also relax this regulation.

A.5.2 Sulfate

Regulation of sulfate was planned for Phase V, but was deferred by USEPA in order to evaluate alternative regulatory approaches to deal with contaminants that primarily affect transient, new resident, and infant populations. Sulfate is considered an acute contaminant; however, sulfate's health effect (diarrhea) is short-term and most people can acclimate to sulfate within a few weeks.

The USEPA reproposed the Sulfate Rule to include an MCL of 500 mg/L but allowed for an alternative compliance options. The options include providing centralized treatment, public education and information programs, and provision of alternative supplies (such as bottled water or point-of-use treatment devices).

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A.5.3 Disinfectants/Disinfection By-Products Rule

Safe drinking water is the foundation of public health protection. Through the Safe Drinking Water Act, Congress has required the USEPA to set regulations for specific chemical and microbiological contaminants in drinking water. The trade-offs between disinfection for microbial protection and disinfection by-product chronic toxicity potential will force utilities to make key decisions about the operation of its existing facilities.

These trade-offs become more complex when balancing organic molecule management, microbial protection and optimum corrosion control. Consequently, a systematic approach to treatment, operation and distribution practices that produce favorable finished water quality is required for regulatory compliance.

Often these trade-offs translate into the use of advanced treatment technologies, optimization of existing facilities, master planning for future treatment, and using alternative disinfectants. The major approaches to controlling disinfection by-products include: precursor removal; alternative disinfection; and by-product removal. The USEPA tends to favor precursor removal over all other DBP strategies. Changing type or increasing amount of coagulation or precipitation efficiency with higher chemical dosages can improve precursor removal. However, the resultant greater sludge volume can pose economic, environmental and residuals management problems. Membrane processes effectively remove precursors and is now widely used throughout the coastal areas of Florida.

The Disinfectants/Disinfection By-Products (D/DBP) Rule was proposed in July, 1994, would be referred to as Phase VI and apply to all PWSs using disinfection and serving non-transient populations, unlike the current MCL for total trihalomethanes (TTHM) which pertains to systems serving more than 10,000 people (59 FR 38668).

In a previous USEPA publication on this issue, *Framework for Decision Making: An USEPA Perspective* (USEPA 811-R-42-005, August 1992), twelve chemical compounds have been identified as candidate compounds for potential regulation, and are shown in Table A.4 with MCLG and health effects information. Currently, total THMs are the only regulated DBP with an MCL of 0.1 mg/L determined by averaging the most recent four quarterly samples collected in the distribution system. USEPA uses the average of four quarterly samples because total THM formation has been shown to vary with seasonal water temperature changes.

The factors affecting DBP formation, particularly THMs, include pH, natural organic matter (NOM), time, temperature and chlorine dosage. Consideration to selection of treatment alternatives should take into account the fact that process changes that include pH, time of contact and chlorine dose will most certainly effect THM formation.

The USEPA intends to set MCLs for DPBs; however, three regulatory options are being considered for THMs and HAAs. For THMs, USEPA is evaluating:

1. MCLs for each of the four THMs;
2. an MCL for TTHMs; and
3. an MCL for each of the THMs and a separate MCL for TTHMs.

For HAAs USEPA is considering:

1. MCLs for trichloroacetic acid (TCA) and dichloroacetic acid (DCA);
2. an MCL for THAAs; and
3. a combination of HAA options (1) and (2).

Reg-neg discussions indicate that in the first D/DBP stage an MCL of 80 ug/l for a total THMs and 60 ug/l for total haloacetic acids will be adopted. Preliminary information indicates that the second stage of implementation may require that the MCL be dropped to 40 ug/L for THMs and 30 ug/L for HAAs.

In addition, the best available technology (BAT) for this rule could be enhanced coagulation. Enhanced coagulation will be defined in a future USEPA guidance manual and will consider low pH alum addition, iron salts, electrolytes, precipitative softening, and other enhancement strategies.

For variance purposes other alternatives considered may include adjustment in point of chlorination, switch residual disinfectant to chloramines, or utilize advanced processes such as ozone with biologically active filtration or membrane processes. It is USEPA's long-term intent to reduce organic material in the water prior to addition of disinfectant.

For utilities that filter, but do not soften, enhanced coagulation will consist of lowering the pH and increasing the coagulant dose until a specified percentage of total organic carbon (TOC) removal is achieved. Actual percentages for removal will be outlined in the proposed rule. Enhanced coagulation for lime softening and direct filtration is yet to be defined.

A.6 SDWA Anticipated Regulations

The anticipated SDWA regulations are provided for review are based on current available information but may be subject to change.

A.6.1 Enhanced SWTR

The proposed interim enhanced SWTR included options to be refined based on ICR microbiological data. Generally, these include:

1. Requirements that surface water systems with poorer quality source waters remove microbiological contaminants above levels currently required by the SWTR (99.9 percent for *Giardia* and 99.9 percent of viruses); and
2. Making no changes if the current SWTR is determined adequate.

In addition, systems would be subject to sanitary surveys and may be required to treat for *Cryptosporidium*. USEPA plans to publish a *Notice of Availability* containing ICR microbial occurrence data and EPA's preferred enhanced SWTR option for public comment in mid-to-late 1998. A long-term enhanced SWTR will be developed for systems <10,000 and may include revisions to the interim enhanced SWTR for systems ≥10,000.

A.6.2 Aldicarb Contaminants

A notice of postponement of certain provisions of the final rule related to the MCLs for aldicarb, aldicarb sulfoxide, and aldicarb sulfone was issued in May 1992 (57 FR 22178). The MCLs that were set aside would have limited aldicarb, aldicarb sulfoxide, and aldicarb sulfone concentrations to 0.003 mg/L, 0.003 mg/L, and 0.004 mg/L, respectively. The USEPA has discussed proposing revised MCLs of 0.007 mg/L for each compound, along with a 0.009 mg/L not-to-exceed total for all three compounds.

A.6.3 Arsenic

The USEPA was under a court-ordered deadline to identify anticipated rules and submit revised regulations related to arsenic, however the rule has continually been delayed due to USEPA resource constraints. The final rule is due November 30, 1997. The current MCL for arsenic is 0.05 mg/L, which was established as a part of the NIPDWR.

A.6.4 Phase VIb SOCs and IOCs

USEPA is required to regulate a total of 25 additional contaminants as part of the DWPL, the D/DBP Rule and the Phase VIb rule. Since the total number of contaminants to be regulated by the D/DBP Rule is not finalized, the total number of contaminants that would then remain to be incorporated into Phase VIb has not yet to be determined. However, a preliminary list of the anticipated contaminant has been provided by the USEPA and is summarized in Table A.5.

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TABLE A.4
Candidate Compounds For D/DBP Regulation

Candidate Compound	Possible MCL	Health Effect and Cancer Status[a]
Total Trihalomethanes (TTHMs)	80 ug/L (Stage 1) 40 ug/L (Stage 2)	Cancer, B2
- chloroform	---	Cancer, B2
- bromodichloromethane	---	Cancer, B2
- dibromochloromethane	---	Liver, C
- bromoform	---	Cancer, B2
Total Haloacetic Acids (THAAs)[b]	60 ug/L (Stage 1) 30 ug/L (Stage 2)	Cancer, B2
- trichloroacetic acid	---	Liver, C
- dichloroacetic acid	---	Cancer, B2
- bromochloroacetic acid	---	---
- dibromoacetic acid	---	---
- monobromoacetic acid	---	---
- monochloroacetic acid	---	---
Other[c]		
- chloral hydrate	5 ug/L	Liver, C
- bromate	0.01 mg/L	Cancer, B2
- chlorine	4 mg/L (as Cl_2)	Blood, D
- chloramines[d]	3 mg/L	Blood, D
- chlorine dioxide	0.8 mg/L (as ClO_2)	Blood, D
- chlorite	0.3 mg/L (as Cl_2)	Blood, D

Source: Framework for Decision Making: An USEPA Perspective (August, 1992).

a. Tentative: B2 compounds include probable human carcinogens, C compounds include possible human carcinogens, and D compounds include those with inadequate or no human and animal evidences of carcinogenicity.
b. Includes mono-, di-, and tri-chloroacetic acid; mono- and dibromoacetic acid.
c. Additional aldehyde and organic peroxide compounds may be regulated at a future date after more health effects data become available.
d. mg/l if measured as total chlorine.

A.6.5 Groundwater Disinfection Rule

The USEPA intended to provide the anticipated GWDR in June 1993, but this rule has been delayed because of the focus the USEPA is giving to the D/DBP rule. The GWDR will establish minimal disinfection requirements for all water systems using a groundwater source unless they are able to demonstrate their supplies are not vulnerable to fecal viral and bacterial contamination.

Under this rule, public water systems using groundwater would have to disinfect the source water from the wellfield unless

1. the system meets "natural disinfection" criteria (in which case the system is not required to source water disinfect); or
2. the systems qualifies for a variance.

The rule also establishes distribution system disinfection requirements, calls for qualified operators and establishes treatment technique requirements in lieu of MCLs for viruses, heterotrophic plate count (HPC) and *Legionella.* The issue of whether or not to include coverage for *Legionella* in this anticipated rule has yet to be resolved, as data concerning the presence of *Legionella* in groundwater is limited. The draft rule has proposed criteria and conditions, which may be subject to change, and include:

a. Pre-qualifying Conditions - In order for a well to avoid source water disinfection, the wellfield must not have been identified as a source of a water borne disease outbreak, the well (wellfield) must meet State-approved well construction codes, and the system must not have violated the TCR unless the cause of the violation had been identified and corrected.

b. The vulnerability of supply wells for each system to "Natural Disinfection" conditions will be determined, based upon the location of fecal contamination sources (sewage lines, force mains, septic tanks, etc.) with respect to each well, and hydrogeological features.

In the proposed rule, it is anticipated that the USEPA will include some method(s) for PWSs to show that disinfection is meeting treatment technique performance standards. The most likely method USEPA is planning to propose is the CT method used previously in the SWTR, and CT values will be key parameters in determining adequacy of the treatment technique for viruses, in lieu of an MCL. Viruses have been chosen for CT determinations since disinfection for viruses is more difficult than bacteria because of size. Even though the order of CTs are Cysts > bacteria > viruses, viruses are smaller than bacteria and cysts. Therefore the CTs of viruses are utilized for determination of disinfection effectiveness.

TABLE A.5
Anticipated Phase VIb SOC and IOC Contaminant List

Contaminant	Expected MCL (mg/L unless shown)	Expected BAT*
Inorganic Compounds		
Boron	0.6	LS, IE, RO, NF
Manganese	0.2	IE, LS, OF
Molybdenum	0.04	IE, RO, NF
Zinc	2	LS, RO, NF
Synthetic Organic Compounds**		
Acifluorfen	0.002	GAC
Bromomethane	0.01	PTA
Cyanazine	0.001	GAC
Dicamba	0.2	GAC
1,3-Dichloropropene	0.0006	GAC, PTA
Ethylene thiourea	0.025	GAC
Methomy	0.2	GAC
Metolachlor	0.1	GAC
Metribuzin	0.02	GAC
Trifluralin	0.005	GAC
Acrylonitrile-dinitrotoluenes (total)	0.003	GAC
Hexachlorobutadiene	0.001	GAC, PTA
1,1,1,2-Tetrachloroethane	0.07	PTA
1,2,3-Trichloropropane	0.0008	GAC, PTA

* Best Available Technology (BAT): GAC-granular activated carbon; LS-lime softening; IE-ion exchange; RO-reverse osmosis; NF-nanofiltration; PTA-packed tower aeration; OF-oxidation and filtration.

** Phase VIb Rule includes monitoring for Bromoacil, Prometon, and methyl-*t*-butyl-ether.

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APPENDIX B
UV-254 TOC Correlation

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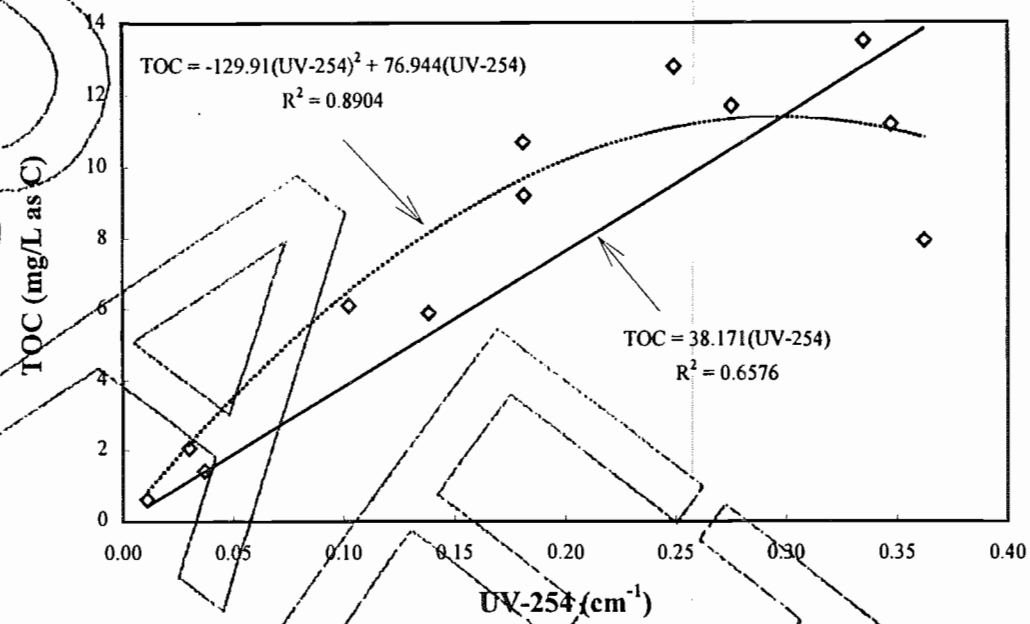
Appendix B
UV-254 TOC Correlation

UV-254 (cm-1)	TOC (mg/L as C)	Color (CPU)
0.011	0.62	< 5
0.030	2.08	< 5
0.037	1.43	< 5
0.102	6.09	10
0.138	5.89	10
0.181	10.70	20
0.181	9.23	20
0.249	12.80	25
0.275	11.70	25
0.335	13.50	40
0.347	11.20	45
0.362	7.94	50



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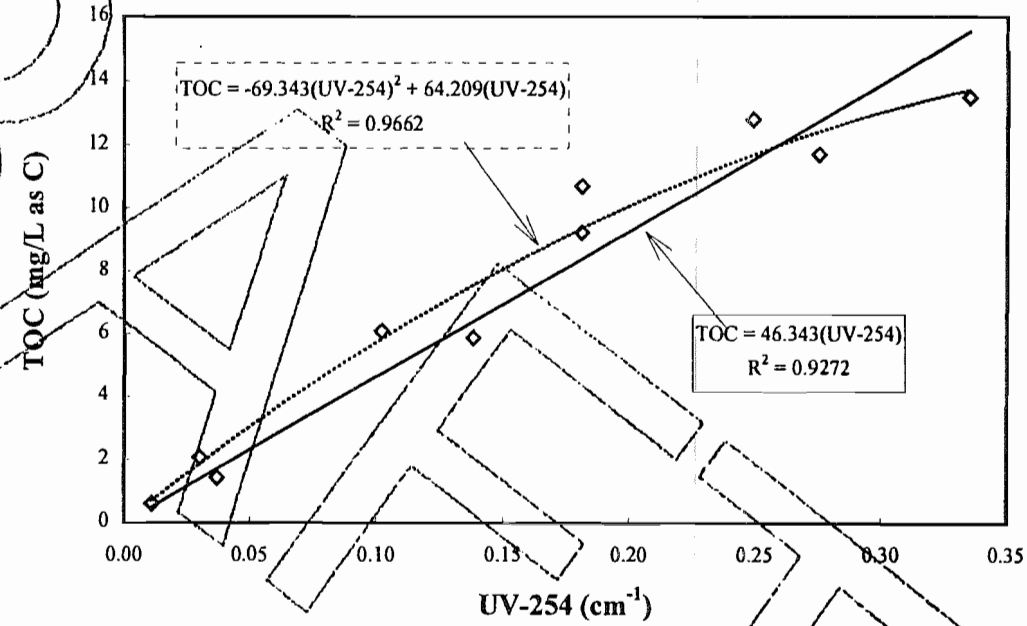
0.138	5.89	10
0.181	10.70	20
0.181	9.23	20
0.249	12.80	25
0.275	11.70	25
0.335	13.50	40



APPENDIX C
Statistical Analysis

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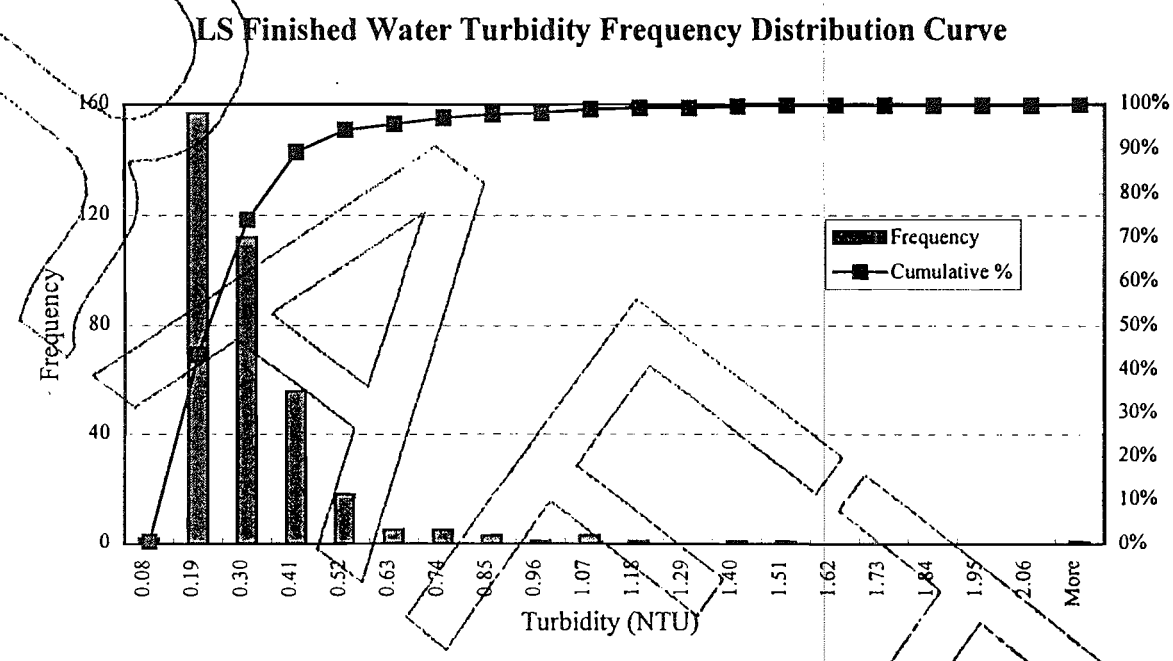
Appndix C.1
Lime Softening Turbidity Frequency Distribution

Final Turbidity	Frequency	Cumulative %
0.08	2	0.55%
0.19	157	43.44%
0.30	112	74.04%
0.41	56	89.34%
0.52	18	94.26%
0.63	5	95.63%
0.74	5	96.99%
0.85	3	97.81%
0.96	1	98.09%
1.07	3	98.91%
1.18	1	99.18%
1.29	0	99.18%
1.40	1	99.45%
1.51	1	99.73%
1.62	0	99.73%
1.73	0	99.73%
1.84	0	99.73%
1.95	0	99.73%
2.06	0	99.73%
More	1	100.00%



Appendix C.2
Lime Softening Turbidity Statistics

Date		Turbidity (NTU)		Raw (GPD)		Lime Sludge (GPD)		CL2 WATER USE (GPD)		RAW WATER RESULTS pH		Methly Orange Alkalinity		Total Hardness		FINISHED WATER RESULTS pH		Methly Orange Alkalinity		Total Hardness		CHEMICAL DOSAGES (mg/L) Lime		Ammonia		Phosphate		Soda Ash		Alum		Cl^2	
< 0.12	>0.4	< 0.12	>0.4	< 0.12	>0.4	< 0.12	>0.4	< 0.12	>0.4	< 0.12	>0.4	< 0.12	>0.4	< 0.12	>0.4	< 0.12	>0.4	< 0.12	>0.4	< 0.12	>0.4	< 0.12	>0.4	< 0.12	>0.4	< 0.12	>0.4	< 0.12	>0.4	< 0.12	>0.4	< 0.12	>0.4
05/30/96	03/18/96	0.08	0.40	5,415,000	6,736,000	11,000	91,000	40,000	40,000	7.7	7.8	254	280	250	376	8.2	8.6	40	62	140	166	176	167	1.7	1.7	1.5	1.5	2.0	2.0	15.0	15.0		8.0
08/06/96	08/08/96	0.08	0.40	6,249,000	6,055,000	30,000	45,000	43,000	25,000	7.8	7.7	238	250	168	236	8.2	8.5	36	42	154	142	175	175	1.1	1.1	1.5	1.5	2.0		15.0	2.0		
05/20/96	02/04/96	0.09	0.41	2,481,000	4,915,000	25,000	7,000	41,000	25,000	7.6	7.9	278	292	204	392	8.2	8.2	58	62	152	174	176	171	1.7	1.5	1.5	4.1	2.0	2.0	15.0	13.0		
05/26/96	02/11/96	0.09	0.41	4,599,000	6,453,000	2,000	13,000	39,000	25,000	7.8	7.9	242	280	234	380	8.8	8.7	36	38	132	164	176	171	1.7	1.5	1.5	4.1	2.0	2.0	15.0	13.0		
05/29/96	03/14/96	0.09	0.41	4,578,000	6,571,000	17,000	16,000	40,000	40,000	7.8	7.8	244	282	180	388	8.4	8.6	30	76	118	150	176	167	1.7	1.7	1.5	1.5	2.0	2.0	15.0	15.0		8.0
06/02/96	03/17/96	0.09	0.41	6,263,000	6,635,000	15,000	4,000	40,000	40,000	7.7	7.8	260	272	294	380	8.5	8.6	38	58	148	164	169	167	1.7	1.7	1.5	1.5	2.0	2.0	15.0	15.0	7.8	8.0
07/02/96	11/14/96	0.09	0.41	6,636,000	5,223,000	24,000	68,000	38,000	30,000	7.7	7.7	242	250	168	300	9.0	8.4	36	48	146	170	165		1.9	1.8	1.5	1.5	2.0		15.0	2.3	7.8	
07/22/96	12/04/96	0.09	0.41	6,247,000	4,313,000	37,000	78,000	56,000	20,000	7.8	7.9	242	264	152	364	8.3	8.4	32	66	148	194	165	170		1.8	1.5	1.5	2.0		15.0	2.3	13.0	8.0
07/29/96	01/07/96	0.09	0.42	6,706,000	3,938,000	36,000	40,000	36,000	24,000	7.8	7.8	242	260	152	358	8.5	8.5	34	56	144	168	165				1.5		2.0		15.0		13.0	
05/14/96	03/15/96	0.10	0.42	6,615,000	6,558,000	16,000	13,000	42,000	40,000	7.8	7.8	260	286	274	390	8.2	8.2	44	92	168	166	176	167	1.7	1.7	1.5	1.5	2.0	2.0	15.0	15.0		8.0
05/13/96	09/05/96	0.10	0.42	4,763,000	4,907,000	19,000	31,000	40,000	26,000	7.7	7.7	256	246	182	256	8.3	8.6	46	40	160	140	176	175	1.7	1.7	1.5	3.3	2.0	1.5	15.0			
05/15/96	12/07/96	0.10	0.42	5,204,000	6,746,000	26,000	98,000	41,000	20,000	7.6	7.9	260	274	244	290	8.4	8.5	46	80	174	186	176	170	1.7	1.8	1.5	1.5	2.0		15.0	2.3		8.0
05/18/96	12/13/96	0.10	0.42	6,329,000	6,617,000	3,000	64,000	43,000	21,000	7.6	7.8	258	240	186	180	8.4	8.4	32	68	148	174	176	170	1.7	1.8	1.5	1.5	2.0		15.0	2.3		8.0
05/21/96	03/11/96	0.10	0.43	4,767,000	5,528,000	6,000	20,000	41,000	39,000	7.5	7.9	280	278	246	386	8.4	8.2	32	100	144	212	176	167	1.7	1.7	1.5	1.5	2.0	2.0	15.0	15.0		8.0
05/23/96	01/22/96	0.10	0.44	4,765,000	6,540,000	16,000	28,000	41,000	26,000	7.7	7.8	258	264	240	348	8.5	8.6	24	54	132	162	176		1.7		1.5		2.0		15.0			
05/24/96	12/11/96	0.10	0.44	4,705,000	6,489,000	28,000	76,000	41,000	20,000	7.7	7.8	250	260	184	196	8.5	8.4	30	60	138	174	176	170	1.7	1.8	1.5	1.5	2.0		15.0	2.3		8.0
05/27/96	01/20/96	0.10	0.45	4,896,000	4,759,000	9,000	6,000	42,000	24,000	7.7	7.9	264	280	192	364	8.3	8.6	30	56	148	164	176		1.7		1.5		2.0		15.0			
05/28/96	02/07/96	0.10	0.45	4,378,000	5,286,000	24,000	20,000	39,000	24,000	7.7	7.9	254	288	252	394	8.3	8.8	36	52	144	152	176	171	1.7	1.5	1.5	4.2	2.0	2.0	15.0	13.0		
06/08/96	02/10/96	0.10	0.45	6,242,000	6,532,000	4,000	16,000	39,000	25,000	7.8	7.9	252	278	160	364	8.4	8.3	46	58	150	158	169	170	1.7	1.5	1.5	4.1	2.0	2.0	15.0	13.0	7.8	
06/09/96	02/27/96	0.10	0.45	5,811,000	6,123,000	21,000	21,000	41,000	38,000	7.8		230		200		8.3		34		120		169	171	1.7	1.5	1.5	4.1	2.0	2.0	15.0	13.0	7.8	
06/18/96	08/27/96	0.10	0.45	4,834,000	2,458,000	16,000	24,000	40,000	8,000	7.8	7.7	140	248	242	176	8.4	8.8	38	42	136	160	169	175	1.7	1.1	1.5	1.5	2.0		15.0		7.8	
06/24/96	03/05/96	0.10	0.46	5,134,000	6,540,000	37,000	15,000	40,000	38,000	7.9	7.8	244	264	190	358	8.5	7.8	40	220	162	226	169	167	1.7	1.7	1.5	1.5	2.0	2.0	15.0	15.0	7.8	8.0
06/30/96	03/01/96	0.10	0.48	4,995,000	6,636,000	1,000	4,000	39,000	40,000	7.6	7.8	248	258	188	384	8.3	8.1	38	82	158	168	169	167	1.7	1.7	1.5	1.5	2.0	2.0	15.0	15.0	7.8	8.0
07/20/96	08/28/96	0.10	0.48	5,771,000	1,022,000	5,000	19,000	56,000	48,000	7.7		238		164		8.2	8.3	26	36	154	160	165	175		1.1	1.5	1.5	2.0		15.0		13.0	
07/27/96	06/21/96	0.10	0.50	6,794,000	4,117,000	5,000	15,000	46,000	43,000	7.6	7.7	234	240	148	140	8.4	8.3	38	50	150	156	165	169		1.7	1.5	1.5	2.0	2.0	15.0	15.0	13.0	7.8
08/07/96	12/27/96	0.10	0.52	6,161,000	6,438,000	37,000	91,000	26,000	20,000	7.7		242		174		8.5	8.6	34		136		175	170	1.1	1.8	1.5	1.5			2.0	2.3		8.0
05/05/96	12/29/96	0.11	0.53	5,834,000	5,490,000	5,000	106,000	40,000	10,000	7.8	7.8	264	290	264	380	8.3	8.4	36	80	158	186	186	170	1.7	1.8	1.5	1.5	2.0		15.0	2.3		8.0
05/19/96	12/06/96	0.11	0.55	3,827,000	4,556,000	2,000	87,000	39,000	14,000	7.7	7.9	268	260	248	368	8.6	8.2	30	88	146	168	176	170	1.7	1.8	1.5	1.5	1.1		15.0	2.3		8.0
05/22/96	08/14/96	0.11	0.57	4,636,000	7,001,000	6,000	16,000	41,000	27,000	7.7	7.7	250	248	194	198	8.2	8.6	38	38	142	178	176	175	1.7	1.1	1.5	1.5	2.0		15.0			
05/31/96	02/18/96	0.11	0.61	5,175,000	5,236,000	7,000	16,000	41,000	25,000	7.7	7.7	248	242	184	368	8.4	8.5	26	60	122	164	176	170	1.7	1.5	1.5	4.1	2.0	2.0	15.0	13.0		
06/03/96	12/12/96	0.11	0.63	5,093,000	6,506,000	4,000	73,000	42,000	19,000	7.8		250		142		8.4		30		132		169	170	1.7	1.8	1.5	1.5	2.0		15.0	2.3	7.8	8.0
06/12/96	03/30/96	0.11	0.64	5,373,000	5,623,000	33,000	4,000	43,000	39,000	7.8	7.7	254	260	244	364	8.3	8.2	44	68	158	190	169	167	1.7	1.7	1.5	1.5	2.0	2.0	15.0	15.0	7.8	8.0
06/29/96	08/18/96	0.11	0.66	5,144,000	4,428,000	4,000	25,000	40,000	26,000	7.6	7.6	252		192		8.3		38		144		169	175	1.7	1.1	1.5	1.5	2.0		15.0		7.8	
07/01/96	08/30/96	0.11	0.68	5,638,000	1,487,000	25,000	61,000	40,000	4,000	7.7	7.7	240	244	178	172	8.4	8.1	42	70	156	50	165	175	1.9	1.1	1.5	1.5	2.0		15.0		7.8	
07/08/96	12/26/96	0.11	0.69	5,943,000	6,694,000	52,000	90,000	41,000	20,000	7.7	7.9	248	300	154	200	8.5	8.8	40	78	152	184	165	170	1.9	1.8	1.5	1.5	2.0		15.0	2.3	7.8	8.0
07/13/96	05/03/96	0.11	0.71	5,160,000	5,110,000	4,000	17,000	68,000	32,000	7.7	7.8	250	260	158	200	8.3	8.2	36	50	142	174	165	176	1.9	1.7	1.5	1.5	2.0	2.0	15.0	15.0	7.8	
07/14/96	03/31/96	0.11	0.76	5,053,000	6,513,000	29,000	18,000	11,000	39,000	7.6	7.9	252	270	142	394	8.3	8.3	36	62	150	192	165	167	1.9	1.7	1.5	1.5	2.0	2.0	15.0	15.0	7.8	8.0
07/30/96	12/28/96	0.11	0.81	6,395,000	6,576,000	43,000	102,000	37,000	19,000	7.7	7.8	248	280	156	390	8.2	8.6	40	78	138	180	165	170		1.8	1.5	1.5	2.0		15.0	2.3	13.0	8.0
10/10/96	08/29/96	0.11	0.81	4,721,000	1,091,000	65,000	13,000	551,000	42,000	7.7		248		238		8.8	8.3	42	32	150	166	180	175	1.9	1.1	1.5	1.5			2.0			
04/07/96	09/02/96	0.12	0.88	6,790,000	5,192,000	4,000	5,000	39,000	25,000	7.7	7.7	270	244	284	176	8.4	8.2	38	62	170	168		175		1.7		3.3		1.5				
05/07/96	08/12/96	0.12	1.00	6,824,000	6,132,000	18,000	5,000	41,000	25,000	7.7	7.6	258	242	272	178	8.3	8.7	38	50	160	198	176	175	1.7	1.1	1.5	1.5	2.0		15.0	2.0		
05/12/96	09/03/96	0.12	1.06	5,251,000	5,236,000	14,000	35,000	40,000	25,000	7.6	7.7	262	242	246	185	8.1	9.0	58	46	150	152	176	175	1.7	1.7	1.5	3.3	2.0	1.5	15.0			
06/05/96	08/11/96	0.12	1.07	6,325,000	6,155,000	47,000	22,000	41,000	26,000	7.6	7.6	242	250	142	182	8.4	8.6	30	34	134	170	169	175	1.7	1.1	1.5	1.5	2.0		15.0	2.0	7.8	
07/04/96	05/02/96	0.12	1.09	7,114,000	5,396,000	39,000	29,000	41,000	41,000	7.7	7.7	244	254	142	272	8.3	8.8	38	34	140	148	165	176	1.9	1.7	1.5	1.5	2.0	2.0	15.0	15.0	7.8	
07/10/96	08/31/96	0.12	1.33	6,270,000	1,768,000	10,000	62,000	40,000	8,000	7.7	7.6	246	236	148	224	8.6	7.9		172	-	214	165	175	1.9	1.1	1.5	1.5	2.0		15.0		7.8	
07/18/96	09/01/96	0.12	1.50	5,837,000	5,267,000	31,000	8,000	58,000	25,000	7.7		250		158		8.2		36		150		165	175		1.7	1.5	3.3	2.0	1.5	15.0		13.0	
07/21/96	09/04/96	0.12	2.17	5,930,000	4,360,000	26,000	42,000	59,000	26,000	7.7	7.7	238	250	156	176	8.3	8.4	26	58	142	168	165	175		1.7	1.5	3.3	2.0	1.5	15.0		13.0	
Average		**0.10**	**0.64**	**5,524,915**	**5,318,128**	**19,894**	**37,426**	**52,191**	**27,362**	**7.7**	**7.8**	**249**	**263**	**198**	**296**	**8.4**	**8.4**	**37**	**66**	**146**	**169**	**171**	**171**	**1.7**	**1.6**	**1.5**	**2.1**	**2.0**	**1.9**	**14.5**	**9.0**	**9.3**	**8.0**
Standard Deviation		**0.01**	**0.35**	**913,965**	**1,558,454**	**15,255**	**31,776**	**74,792**	**10,269**	**0.1**	**0.1**	**19**	**17**	**45**	**91**	**0.2**	**0.2**	**7**	**34**	**12**	**26**	**5**	**5**	**0.2**	**0.3**	**0.0**	**1.0**	**0.1**	**0.2**	**2.6**	**6.2**	**2.4**	**0.1**
Maximum		**0.12**	**2.17**	**7,114,000**	**7,001,000**	**65,000**	**106,000**	**551,000**	**48,000**	**7.9**	**7.9**	**280**	**300**	**294**	**394**	**9.0**	**9.0**	**58**	**220**	**174**	**226**	**180**	**176**	**1.9**	**1.8**	**1.5**	**4.2**	**2.0**	**2.0**	**15.0**	**15.0**	**13.0**	**8.0**
Minimum		**0.08**	**0.40**	**2,481,000**	**1,022,000**	**1,000**	**4,000**	**11,000**	**4,000**	**7.5**	**7.6**	**140**	**236**	**142**	**140**	**8.1**	**7.8**	**24**	**32**	**118**	**50**	**165**	**167**	**1.1**	**1.1**	**1.5**	**1.5**	**1.1**	**1.5**	**2.0**	**2.0**	**7.8**	**7.8**

Appendix C.3
Lime Softening ANOVA (alpha = 0.05) Continued

Anova: Single Factor **Finished Turbidity (NTU)**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	47	4.88	0.10	0.00
>0.4	47	30.11	0.64	0.12

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6.77	1	6.77	112.93	1.11E-17	3.94
Within Groups	5.52	92	0.06			
Total	12.29	93				

Anova: Single Factor **Raw (MGD)**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	47	259671000	5524915	835331992599
>0.4	47	249952000	5318128	24287804181 31

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1E+12	1	1E+12	0.62	0.43	3.94
Within Groups	1.5E+14	92	1.63E+12			
Total	1.51E+14	93				

Anova: Single Factor **Lime Sludge (MGD)**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	47	935000	19893.62	232705827.94
>0.4	47	1759000	37425.53	1009684551.34

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7.22E+09	1	7.22E+09	11.63	0.0010	3.94
Within Groups	5.71E+10	92	6.21E+08			
Total	6.44E+10	93				

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Appendix C.3
Lime Softening ANOVA (alpha = 0.05) Continued

Anova: Single Factor **CL2 WATER USE**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	47	2453000	52191.49	559381036 0.78
>0.4	47	1286000	27361.70	105453284.00

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.45E+10	1	1.45E+10	5.08	0.03	3.94
Within Groups	2.62E+11	92	2.85E+09			
Total	2.77E+11	93				

Anova: Single Factor **Raw pH**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	47	362.28	7.71	0.01
>0.4	41	318.70	7.77	0.01

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.0928	1	0.0928	12.1126	0.0008	3.9519
Within Groups	0.6586	86	0.0077			
Total	0.7514	87				

Anova: Single Factor **Raw MO Alk**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	47	11692	249	376
>0.4	40	10504	263	302

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4135.58	1	4135.58	12.10	7.97E-04	3.95
Within Groups	29046.03	85	341.72			
Total	33181.61	86				

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Appendix C.3
Lime Softening ANOVA (alpha = 0.05) Continued

Anova: Single Factor **Raw Total Hardness**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	47	9310	198.09	2021.73
>0.4	40	11827	295.68	8253.35

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	205801.38	1	205801.38	42.16	5.38E-09	3.95
Within Groups	414880.43	85	4880.95			
Total	620681.82	86				

Anova: Single Factor **Raw pH**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	47	393.93	8.38	0.03
>0.4	43	363.20	8.45	0.06

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.09	1	0.09	2.13	0.15	3.95
Within Groups	3.92	88	0.04			
Total	4.02	89				

Anova: Single Factor **Finished P Alk**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	46	34	0.74	1.84
>0.4	42	55	1.31	3.63

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7.14	1	7.14	2.65	0.11	3.95
Within Groups	231.85	86	2.70			
Total	238.99	87				

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Appendix C.3
Lime Softening ANOVA (alpha = 0.05) Continued

Anova: Single Factor **Finished MO Alk**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	46	1696	37	50
>0.4	42	2758	66	1175

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	18206.31	1	18206.31	31.04	2.84E-07	3.95
Within Groups	50436.55	86	586.47			
Total	68642.86	87				

Anova: Single Factor **Finished Total Hardness**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	46	6720	146	148
>0.4	42	7100	169	693

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	11574.26	1	11574.26	28.39	7.84E-07	3.95
Within Groups	35057.56	86	407.65			
Total	46631.82	87				

Anova: Single Factor **Lime**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	46	7873.93	171.17	25.11
>0.4	43	7372.00	171.44	10.50

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.61	1	1.61	0.09	0.77	3.95
Within Groups	1570.98	87	18.06			
Total	1572.59	88				

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Appendix C.3
Lime Softening ANOVA (alpha = 0.05) Continued

Anova: Single Factor **Ammonia**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	39	66.81	1.71	0.02
>0.4	44	69.14	1.57	0.06

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.41	1	0.41	9.17	3.30E-03	3.96
Within Groups	3.66	81	0.05			
Total	4.08	82				

Anova: Single Factor **Phosphate**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	46	69.00	1.50	7.55556E-05
>0.4	44	90.60	2.06	1.01

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7.03	1	7.03	14.22	2.94E-04	3.95
Within Groups	43.52	88	0.49			
Total	50.55	89				

Anova: Single Factor **Soda Ash**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	44	87.02	1.98	0.02
>0.4	23	43.50	1.89	0.04

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.11	1	0.11	4.03	0.05	3.99
Within Groups	1.82	65	0.03			
Total	1.94	66				

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Appendix C.3
Lime Softening ANOVA (alpha = 0.05) Continued

Anova: Single Factor **Alum**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	46	664.73	14.45	6.78
>0.4	32	288.75	9.02	37.94

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	555.85	1	555.85	28.52	9.33E-07	3.97
Within Groups	1481.33	76	19.49			
Total	2037.17	77				

Anova: Single Factor **Chlorine**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
< 0.12	24	222.75	9.28	5.94
>0.4	20	159.75	7.99	3.14E-03

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	18.26	1	18.26	5.61	0.02	4.07
Within Groups	136.72	42	3.26			
Total	154.99	43				

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Appendix C.4
RO Turbidity Statistics

	Finished Turbidity		Flow											
			Finished Flow		Permeate		By-Pass		Brine		Raw		pH	
	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30
	0.10	0.30	4,129,000	2,340,000	1,357	20	156	2	540	7	2,053	29	7.46	7.30
	0.11	0.30	3,534,000	2,318,000	1,061	90	153	63	523	48	1,738	200	7.00	
	0.12	0.30	4,368,000	3,894,000	1,361	955	103	101	612	430	2,076	1,485	7.45	7.30
	0.12	0.30	4,086,000	4,644,000	1,315	1,206	86	67	590	642	1,991	1,915	7.30	
	0.12	0.31	2,157,000	3,886,000	635	1,102	31	18	212	555	878	1,675	7.30	7.30
	0.12	0.31	4,435,000	3,952,000	1,311	1,134	238	67	589	560	2,158	1,762	7.37	7.30
	0.12	0.31	2,501,000	3,179,000	389	1,057	50	13	116	760	553	1,645	7.30	7.30
	0.13	0.33	4,306,000	3,246,000	1,127	979	78	110	581	571	1,786	1,660	7.32	7.40
	0.13	0.34	3,169,000	3,664,000	1,259	1,077	277		565	538	2,101	1,745	7.30	7.30
	0.13	0.34	3,575,000	3,738,000	913	653	67	141	470	319	1,450	1,113	7.30	
	0.13	0.34	4,522,000	3,193,000	1,399	642	181		628	331	2,208	1,018	7.42	
	0.13	0.36	2,412,000	1,480,000	1,331	1,121	206	51	598	560	2,135	1,732	7.30	7.30
	0.14	0.36	2,710,000	3,302,000	621	692	39	35	266	356	926	1,089	7.40	
	0.14	0.37	3,271,000	3,528,000	190	695	21	53	89	374	299	1,123	7.30	7.40
	0.14	0.37	3,012,000	2,705,000	1,263	847	151	328	567	423	1,981	1,597	7.30	7.30
	0.14	0.38	1,775,000	4,188,000	149	1,338	42	244	74	601	265	2,182	7.30	
	0.14	0.40	2,467,000	4,294,000	153	629	18	63	72	339	244	1,031	7.30	7.50
	0.14	0.43	2,386,000	4,486,000	463	2,697	24	60	463	1,564	1,398	4,321	7.40	7.40
	0.14	0.44	3,912,000	3,576,000	938	1,097	137	31	474	590	1,549	1,717	7.33	7.30
	0.15	0.48	2,312,000	2,799,000	1,333	632	219	111	599	311	2,149	1,054	7.30	
	0.15	0.54	3,654,000	4,841,000	1,099	1,401	106	194	566	537	1,772	2,131	7.30	
	0.15	0.58	4,132,000	3,783,000	1,388	694	130	101	624	347	2,141	1,142	7.24	7.30
	0.15	0.76	4,382,000	5,086,000	1,131	591	90	139	588	255	1,810	985	7.30	
	0.15	1.47	4,048,000	3,818,000	1,175	2,133	94	140	561	1,220	1,830	3,493	7.23	
	0.15	1.57	3,464,000	5,116,000	1,032	2,938	70	449	588	1,263	1,690	4,650	7.30	
Average	**0.13**	**0.48**	**3,388,760**	**3,642,240**	**976**	**1,057**	**112**	**112**	**462**	**540**	**1,567**	**1,700**	**7.31**	**7.34**
Std Dev	**0.01**	**0.33**	**844,969**	**885,801**	**420**	**677**	**74**	**106**	**194**	**355**	**650**	**1,072**	**0.09**	**0.06**
Maximum	**0.15**	**1.57**	**4,522,000**	**5,116,000**	**1,399**	**2,938**	**277**	**449**	**628**	**1,564**	**2,208**	**4,650**	**7.46**	**7.50**
Minimum	**0.10**	**0.30**	**1,775,000**	**1,480,000**	**149**	**20**	**18**	**2**	**72**	**7**	**244**	**29**	**7.00**	**7.30**

Appendix C.4
RO Turbidity Statistics

	Finished		Feed												Concentrate			
	Turbidity		Conductivity		TDS		Chlorides		Turbidity		Feed pH		SDI		Brine Conductivity		Brine pH	
	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30
	0.10	0.30	9,750	12,210	5,350	8,240	2,870	4,000	0.28	0.43	6.10	6.00	0.36	0.83	32,800	40,500	6.57	
	0.11	0.30	9,580		6,380		3,850		0.36		6.10		1.75	0.89	29,430		6.60	
	0.12	0.30	7,190	13,960	4,810	9,340	2,250	4,100	0.50	0.20	6.10	6.00	0.48	1.01	25,000		6.43	6.41
	0.12	0.30	10,350		5,710		3,190		0.30		6.10	6.10	0.34	1.04	35,500		6.57	
	0.12	0.31	13,450	14,740	8,990	9,850	3,200	3,640	0.55	1.28	6.10	6.10		1.56		42,300		
	0.12	0.31	7,390	13,920	4,940	9,300	2,340	3,500	0.16	0.16	6.00	6.00	0.95	0.79	24,800		6.42	
	0.12	0.31	13,300	14,530	8,860	9,700	3,220	3,678	0.48	1.20	6.10	6.00		1.81				
	0.13	0.33	12,760	11,250	8,530	7,546	4,700	3,452	0.10	0.40	6.10	6.10	0.84	1.25	36,900		6.34	6.54
	0.13	0.34	10,200	14,030	6,900	9,300	3,269	4,980	0.18	1.40	6.10	6.00	0.63	2.79				
	0.13	0.34	15,100		10,200		4,262		0.68		6.00	6.00	0.80	0.69		33,300		
	0.13	0.34	7,060		4,710		2,200		1.32		6.10	6.10	0.60	0.65	25,400		6.53	6.37
	0.13	0.36	9,170	13,620	6,300	9,100	2,820	3,902	0.30	0.20	6.00	6.00	0.78	0.92				
	0.14	0.36	11,620		7,550		3,520		0.14			6.00		2.56		40,800		
	0.14	0.37	11,300	15,750	7,580	10,520	3,600	5,830	0.14	0.22	6.10	6.10		0.87				6.49
	0.14	0.37	10,040	13,640	6,700	9,100	3,157	4,460	0.11	0.28	6.00	6.00	0.69	1.00				
	0.14	0.38	9,260		6,180		2,850		0.14		6.00	6.00	1.10	1.12		42,700		
	0.14	0.40	12,800	13,900	8,590	9,290	4,960	5,350	0.12	0.81		6.00		1.13				6.04
	0.14	0.43	7,900	12,580	5,300	6,980	2,589	3,630	0.84	0.40	6.10	6.10	1.15	0.84	29,100		6.58	6.70
	0.14	0.44	14,400	14,420	9,630	9,620	5,100	3,610	2.20	1.38	6.10	6.00	0.62	1.29	43,300	40,600	6.41	
	0.15	0.48	8,580		5,930		5,620		0.39		6.00	6.00	1.28	0.73	25,900	55,400	6.33	6.39
	0.15	0.54	11,450		7,660		3,368		0.41		6.00	6.10	0.68	2.10	43,400		6.35	
	0.15	0.58	10,020	13,980	6,700	9,350	3,150	3,728	0.17	0.28	6.10	6.00	0.39	1.49	34,500	41,100	6.59	
	0.15	0.76	11,780		7,900		3,455		0.18		6.10	6.10	1.22	0.62	32,700		6.29	
	0.15	1.47	11,780		7,800		3,265		0.18		6.00	6.10	0.98	0.78				
	0.15	1.57	15,280		10,210		5,550		0.17		6.10	6.00	0.81	1.70			6.27	
Average	**0.13**	**0.48**	**10,860**	**13,752**	**7,176**	**9,088**	**3,534**	**4,133**	**0.42**	**0.62**	**6.07**	**6.04**	**0.82**	**1.22**	**32,210**	**42,088**	**6.45**	**6.42**
Std Dev	**0.01**	**0.33**	**2,391**	**1,119**	**1,658**	**924**	**976**	**747**	**0.47**	**0.49**	**0.05**	**0.05**	**0.35**	**0.58**	**6,438**	**6,121**	**0.12**	**0.20**
Maximum	**0.15**	**1.57**	**15,280**	**15,750**	**10,210**	**10,520**	**5,620**	**5,830**	**2.20**	**1.40**	**6.10**	**6.10**	**1.75**	**2.79**	**43,400**	**55,400**	**6.60**	**6.70**
Minimum	**0.10**	**0.30**	**7,060**	**11,250**	**4,710**	**6,980**	**2,200**	**3,452**	**0.10**	**0.16**	**6.00**	**6.00**	**0.34**	**0.62**	**24,800**	**33,300**	**6.27**	**6.04**

Appendix C.4
RO Turbidity Statistics

	Finished		Finished																			
	Turbidity		Total Alkalinity		Calcium Hardness		Total Hardness		Chloride		Conductivity		TDS		pH		Temperature		Plant Residual		Distribution Residual	
	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30
	0.10	0.30	24	36	78	68	96	72	119	112	489	555	328	372	8.00	8.20	30	27	3.4	2.8		
	0.11	0.30	24	24	68	111	72	117	133	129	360	594	241	398	8.40	8.40	28	28	3.1	3.3		
	0.12	0.30	27	34	86	110	101	121	136	165	506	692	339	464	8.00	8.50	28	22	3.1	3.3	4.1	4.2
	0.12	0.30	24	28	68	66	83	66	119	117	480	481	322	322	7.90	8.20	30		3.0	2.5		3.6
	0.12	0.31	34	35	100	97	108	110	130	155	638	619	427	415	8.40	8.20		22	3.5	3.2	4.4	4.0
	0.12	0.31	31	38	83	95	99	111	133	153	561	625	376	419	8.10	7.90	27	21	2.7	2.9	3.8	1.0
	0.12	0.31	30	41	103	100	128	110	135	147	618	620	414	415	8.20	8.00		22	3.3	3.0	4.2	3.3
	0.13	0.33	30	56	96	114	108	116	165	124	669	584	448	391	8.10	8.40	27	27	3.0	3.1	3.5	
	0.13	0.34	25	50	83	112	90	129	114	156	491	671	329	450	8.00	8.20	28	23	3.0	3.4	3.2	3.5
	0.13	0.34	26	38	100	109	109	116	166	158	653	677	438	454	8.40	8.40	27	24	3.6	2.7	4.3	4.1
	0.13	0.34	26	37	79	110	85	130	116	154	470	652	315	437	8.30	8.20	27	25	3.0	3.3	4.1	3.1
	0.13	0.36	25	30	81	88	87	99	107	151	483	621	324	416	8.30	8.40	27	24	2.5	3.4		3.6
	0.14	0.36	42	37	96	88	112	106	131	156	650	592	436	397	7.80	8.50		21	2.0	3.5	3.3	3.5
	0.14	0.37	22	36	100	100	118	114	139	156	574	610	385	409	7.80	8.40		22	3.0	2.9	4.0	3.5
	0.14	0.37	29	33	87	89	101	110	129	152	462	638	310	427	8.00	8.10	27	25	3.3	3.2	3.7	3.9
	0.14	0.38	23	28	56	82	72	96	104	115	413	500	277	335	8.20	8.00	27	27	1.7	3.4		4.1
	0.14	0.40	38	32	96	100	120	113	135	149	650	616	436	413	8.00	8.20		21	2.0	2.9	0.8	3.5
	0.14	0.43	25	46	66	67	76	71	106	112	446	491	299	329	8.00	8.50	27	27	2.9	2.3		
	0.14	0.44	27	35	98	90	110	109	170	146	678	600	454	402	8.30	8.10	26	22	3.2	2.4	3.5	3.5
	0.15	0.48	28	39	92	110	114	136	168	156	606	685	406	459	8.20	8.30	28	25	3.0	3.2	3.9	4.4
	0.15	0.54	30	58	100	96	118	98	165	110	668	535	448	358	8.10	8.40	25		3.3	3.0	3.5	2.0
	0.15	0.58	21	62	76	125	87	151	115	156	511	732	342	490	8.10	8.30	29	23	3.0	3.4		3.5
	0.15	0.76	32	54	98	94	110	94	163	106	655	554	439	371	8.00	8.40	27		3.1	3.0	3.8	2.1
	0.15	1.47	32	44	106	62	108	62	164	116	637	484	427	324	8.10	8.40	27		3.0	2.5	4.5	3.8
	0.15	1.57	26	44	95	104	110	112	170	127	680	703	456	471	8.30	8.40	25		3.5	3.0	3.1	1.6
Average	**0.13**	**0.48**	**28**	**40**	**88**	**95**	**101**	**107**	**137**	**139**	**562**	**605**	**376**	**406**	**8.12**	**8.28**	**27**	**24**	**3.0**	**3.0**	**3.6**	**3**
Std Dev	**0.01**	**0.33**	**5**	**10**	**13**	**17**	**16**	**21**	**23**	**20**	**96**	**70**	**65**	**47**	**0.18**	**0.17**	**1**	**2**	**0.5**	**0.3**	**0.8**	**1**
Maximum	**0.15**	**1.57**	**42**	**62**	**106**	**125**	**128**	**151**	**170**	**165**	**680**	**732**	**456**	**490**	**8.40**	**8.50**	**30**	**28**	**3.6**	**3.5**	**4.5**	**4**
Minimum	**0.10**	**0.30**	**21**	**24**	**56**	**62**	**72**	**62**	**104**	**106**	**360**	**481**	**241**	**322**	**7.80**	**7.90**	**25**	**21**	**1.7**	**2.3**	**0.8**	**1**

Appendix C.4
RO Turbidity Statistics

	Finished		Chemicals										Pressure	
	Turbidity		FLOCON		Sulfuric		Caustic Soda		Chlorine		TDS		Feed Pressure	
	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30
	0.10	0.30				4		6						
	0.11	0.30	78	20	155	11	24	4		10	108		188	
	0.12	0.30	100	80	177	129	33	24	60	60		450		410
	0.12	0.30	120	98	169	155	30	45	80	30		191		365
	0.12	0.31	40	60	70	132	17	32	20	40	273	395	413	409
	0.12	0.31	100	70	199	140	20	34	60	40		360		405
	0.12	0.31	40	70	42	147	12	27	20	80		395		416
	0.13	0.33	100	78	125	118	32	55	40	80		152		300
	0.13	0.34	120	100	162	155	32	25	40	50		320		415
	0.13	0.34	60	60	110	103	22	22	20	20		315		
	0.13	0.34	120	60	177	74	34	15	60	20				390
	0.13	0.36	100	80	169	151	41	31	60	60		360		392
	0.14	0.36	60	40	73	81	27	17	40	20		375		388
	0.14	0.37	20	70	22	88	8	17	60	80		370		420
	0.14	0.37	100	60	147	140	37	32	40	50		280		392
	0.14	0.38	20	120	18	199	8	40	20	40				
	0.14	0.40	10	40	22	74	8	22	10	60		380		417
	0.14	0.43	78	195	103	313	24	88	100	190	45	160	146	300
	0.14	0.44	60	70	96	118	20	22	20	40		380		416
	0.15	0.48	100	60	199	81	29	12	40	20		303		390
	0.15	0.54	80	117	140	171	42	95	40	40		140		332
	0.15	0.58	100	60	155	103	34	17	60	40		345		410
	0.15	0.76	80	39	140	316	29	37	40	60		140		314
	0.15	1.47	80	156	132	74	22	130	40	60		180		349
	0.15	1.57	100	234	110	320	22	145	40	20		198	392	370
Average	**0.13**	**0.48**	**78**	**85**	**121**	**136**	**25**	**40**	**44**	**50**	**142**	**295**	**285**	**381**
Std Dev	**0.01**	**0.33**	**33**	**50**	**56**	**82**	**10**	**37**	**21**	**36**	**118**	**101**	**137**	**40**
Maximum	**0.15**	**1.57**	**120**	**234**	**199**	**320**	**42**	**145**	**100**	**190**	**273**	**450**	**413**	**420**
Minimum	**0.10**	**0.30**	**10**	**20**	**18**	**4**	**8**	**4**	**10**	**10**	**45**	**140**	**146**	**300**

Appendix C.4
RO Turbidity Statistics Continued

	Finished		Feed												Concentrate			
	Turbidity		Conductivity		TDS		Chlorides		Turbidity		Feed pH		SDI		Brine Conductivity		Brine pH	
	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30
	0.10	0.30	9,750	12,210	5,350	8,240	2,870	4,000	0.28	0.43	6.10	6.00	0.36	0.83	32,800	40,500	6.57	
	0.11	0.30	9,580		6,380		3,850		0.36		6.10		1.75	0.89	29,430		6.60	
	0.12	0.30	7,190	13,960	4,810	9,340	2,250	4,100	0.50	0.20	6.10	6.00	0.48	1.01	25,000		6.43	6.41
	0.12	0.30	10,350		5,710		3,190		0.30		6.10	6.10	0.34	1.04	35,500		6.57	
	0.12	0.31	13,450	14,740	8,990	9,850	3,200	3,640	0.55	1.28	6.10	6.10		1.56		42,300		
	0.12	0.31	7,390	13,920	4,940	9,300	2,340	3,500	0.16	0.16	6.00	6.00	0.95	0.79	24,800		6.42	
	0.12	0.31	13,300	14,530	8,860	9,700	3,220	3,678	0.48	1.20	6.10	6.00		1.81				
	0.13	0.33	12,760	11,250	8,530	7,546	4,700	3,452	0.10	0.40	6.10	6.10	0.84	1.25	36,900		6.34	6.54
	0.13	0.34	10,200	14,030	6,900	9,300	3,269	4,980	0.18	1.40	6.10	6.00	0.63	2.79				
	0.13	0.34	15,100		10,200		4,262		0.68		6.00	6.00	0.80	0.69		33,300		
	0.13	0.34	7,060		4,710		2,200		1.32		6.10	6.10	0.60	0.65	25,400		6.53	6.37
	0.13	0.36	9,170	13,620	6,300	9,100	2,820	3,902	0.30	0.20	6.00	6.00	0.78	0.92				
	0.14	0.36	11,620		7,550		3,520		0.14			6.00		2.56		40,800		
	0.14	0.37	11,300	15,750	7,580	10,520	3,600	5,830	0.14	0.22	6.10	6.10		0.87				6.49
	0.14	0.37	10,040	13,640	6,700	9,100	3,157	4,460	0.11	0.28	6.00	6.00	0.69	1.00				
	0.14	0.38	9,260		6,180		2,850		0.14		6.00	6.00	1.10	1.12		42,700		
	0.14	0.40	12,800	13,900	8,590	9,290	4,960	5,350	0.12	0.81		6.00		1.13				6.04
	0.14	0.43	7,900	12,580	5,300	6,980	2,589	3,630	0.84	0.40	6.10	6.10	1.15	0.84	29,100		6.58	6.70
	0.14	0.44	14,400	14,420	9,630	9,620	5,100	3,610	2.20	1.38	6.10	6.00	0.62	1.29	43,300	40,600	6.41	
	0.15	0.48	8,580		5,930		5,620		0.39		6.00	6.00	1.28	0.73	25,900	55,400	6.33	6.39
	0.15	0.54	11,450		7,660		3,368		0.41		6.00	6.10	0.68	2.10	43,400		6.35	
	0.15	0.58	10,020	13,980	6,700	9,350	3,150	3,728	0.17	0.28	6.10	6.00	0.39	1.49	34,500	41,100	6.59	
	0.15	0.76	11,780		7,900		3,455		0.18		6.10	6.10	1.22	0.62	32,700		6.29	
	0.15	1.47	11,780		7,800		3,265		0.18		6.00	6.10	0.98	0.78				
	0.15	1.57	15,280		10,210		5,550		0.17		6.10	6.00	0.81	1.70			6.27	
Average	**0.13**	**0.48**	**10,860**	**13,752**	**7,176**	**9,088**	**3,534**	**4,133**	**0.42**	**0.62**	**6.07**	**6.04**	**0.82**	**1.22**	**32,210**	**42,088**	**6.45**	**6.42**
Std Dev	**0.01**	**0.33**	**2,391**	**1,119**	**1,658**	**924**	**976**	**747**	**0.47**	**0.49**	**0.05**	**0.05**	**0.35**	**0.58**	**6,438**	**6,121**	**0.12**	**0.20**
Maximum	**0.15**	**1.57**	**15,280**	**15,750**	**10,210**	**10,520**	**5,620**	**5,830**	**2.20**	**1.40**	**6.10**	**6.10**	**1.75**	**2.79**	**43,400**	**55,400**	**6.60**	**6.70**
Minimum	**0.10**	**0.30**	**7,060**	**11,250**	**4,710**	**6,980**	**2,200**	**3,452**	**0.10**	**0.16**	**6.00**	**6.00**	**0.34**	**0.62**	**24,800**	**33,300**	**6.27**	**6.04**

Appendix C.4
RO Turbidity Statistics Continued

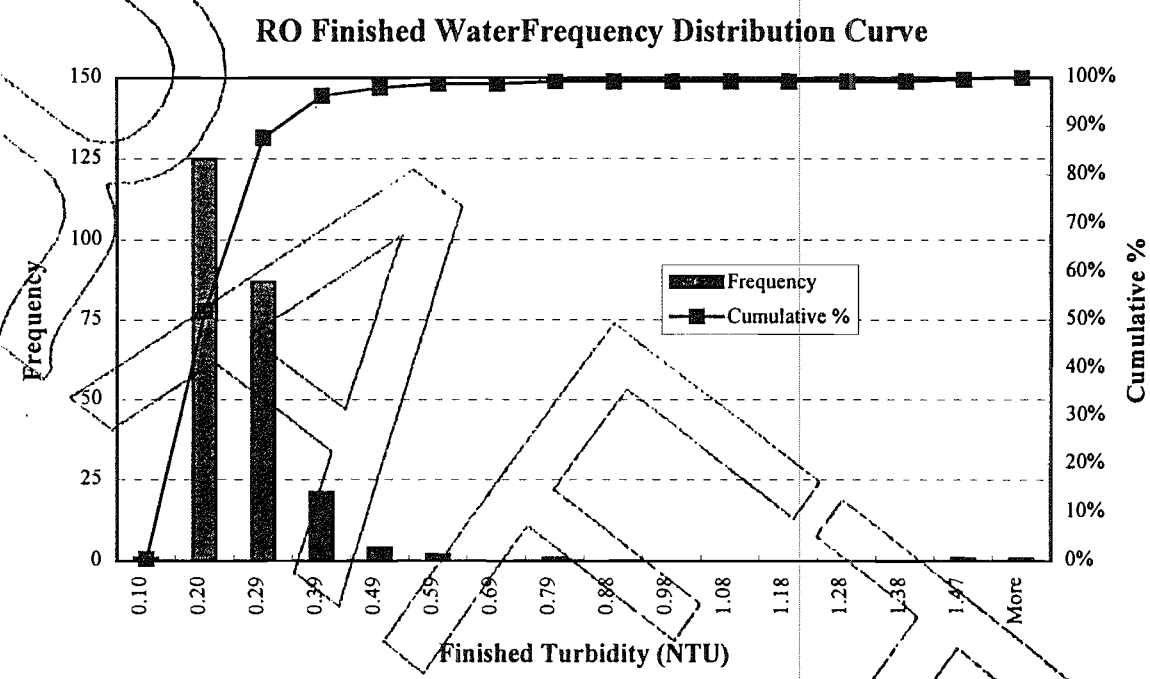
	Finished		Finished																			
	Turbidity		Total Alkalinity		Calcium Hardness		Total Hardness		Chloride		Conductivity		TDS		pH		Temperature		Plant Residual		Distribution Residual	
	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30
	0.10	0.30	24	36	78	68	96	72	119	112	489	555	328	372	8.00	8.20	30	27	3.4	2.8		
	0.11	0.30	24	24	68	111	72	117	133	129	360	594	241	398	8.40	8.40	28	28	3.1	3.3		
	0.12	0.30	27	34	86	110	101	121	136	165	506	692	339	464	8.00	8.50	28	22	3.1	3.3	4.1	4.2
	0.12	0.30	24	28	68	66	83	66	119	117	480	481	322	322	7.90	8.20	30		3.0	2.5		3.6
	0.12	0.31	34	35	100	97	108	110	130	155	638	619	427	415	8.40	8.20		22	3.5	3.2	4.4	4.0
	0.12	0.31	31	38	83	95	99	111	133	153	561	625	376	419	8.10	7.90	27	21	2.7	2.9	3.8	1.0
	0.12	0.31	30	41	103	100	128	110	135	147	618	620	414	415	8.20	8.00		22	3.3	3.0	4.2	3.3
	0.13	0.33	30	56	96	114	108	116	165	124	669	584	448	391	8.10	8.40	27	27	3.0	3.1	3.5	
	0.13	0.34	25	50	83	112	90	129	114	156	491	671	329	450	8.00	8.20	28	23	3.0	3.4	3.2	3.5
	0.13	0.34	26	38	100	109	109	116	166	158	653	677	438	454	8.40	8.40	27	24	3.6	2.7	4.3	4.1
	0.13	0.34	26	37	79	110	85	130	116	154	470	652	315	437	8.30	8.20	27	25	3.0	3.3	4.1	3.1
	0.13	0.36	25	30	81	88	87	99	107	151	483	621	324	416	8.30	8.40	27	24	2.5	3.4		3.6
	0.14	0.36	42	37	96	88	112	106	131	156	650	592	436	397	7.80	8.50		21	2.0	3.5	3.3	3.5
	0.14	0.37	22	36	100	100	118	114	139	156	574	610	385	409	7.80	8.40		22	3.0	2.9	4.0	3.5
	0.14	0.37	29	33	87	89	101	110	129	152	462	638	310	427	8.00	8.10	27	25	3.3	3.2	3.7	3.9
	0.14	0.38	23	28	56	82	72	96	104	115	413	500	277	335	8.20	8.00	27	27	1.7	3.4		4.1
	0.14	0.40	38	32	96	100	120	113	135	149	650	616	436	413	8.00	8.20		21	2.0	2.9	0.8	3.5
	0.14	0.43	25	46	66	67	76	71	106	112	446	491	299	329	8.00	8.50	27	27	2.9	2.3		
	0.14	0.44	27	35	98	90	110	109	170	146	678	600	454	402	8.30	8.10	26	22	3.2	2.4	3.5	3.5
	0.15	0.48	28	39	92	110	114	136	168	156	606	685	406	459	8.20	8.30	28	25	3.0	3.2	3.9	4.4
	0.15	0.54	30	58	100	96	118	98	165	110	668	535	448	358	8.10	8.40	25		3.3	3.0	3.5	2.0
	0.15	0.58	21	62	76	125	87	151	115	156	511	732	342	490	8.10	8.30	29	23	3.0	3.4		3.5
	0.15	0.76	32	54	98	94	110	94	163	106	655	554	439	371	8.00	8.40	27		3.1	3.0	3.8	2.1
	0.15	1.47	32	44	106	62	108	62	164	116	637	484	427	324	8.10	8.40	27		3.0	2.5	4.5	3.8
	0.15	1.57	26	44	95	104	110	112	170	127	680	703	456	471	8.30	8.40	25		3.5	3.0	3.1	1.6
Average	**0.13**	**0.48**	**28**	**40**	**88**	**95**	**101**	**107**	**137**	**139**	**562**	**605**	**376**	**406**	**8.12**	**8.28**	**27**	**24**	**3.0**	**3.0**	**3.6**	**3**
Std Dev	**0.01**	**0.33**	**5**	**10**	**13**	**17**	**16**	**21**	**23**	**20**	**96**	**70**	**65**	**47**	**0.18**	**0.17**	**1**	**2**	**0.5**	**0.3**	**0.8**	**1**
Maximum	**0.15**	**1.57**	**42**	**62**	**106**	**125**	**128**	**151**	**170**	**165**	**680**	**732**	**456**	**490**	**8.40**	**8.50**	**30**	**28**	**3.6**	**3.5**	**4.5**	**4**
Minimum	**0.10**	**0.30**	**21**	**24**	**56**	**62**	**72**	**62**	**104**	**106**	**360**	**481**	**241**	**322**	**7.80**	**7.90**	**25**	**21**	**1.7**	**2.3**	**0.8**	**1**

Appendix C.4
RO Turbidity Statistics Continued

	Finished		Chemicals										Pressure	
	Turbidity		FLOCON		Sulfuric		Caustic Soda		Chlorine		TDS		Feed Pressure	
	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30	<0.12	> 0.30
	0.10	0.30				4		6						
	0.11	0.30	78	20	155	11	24	4		10	108		188	
	0.12	0.30	100	80	177	129	33	24	60	60		450		410
	0.12	0.30	120	98	169	155	30	45	80	30		191		365
	0.12	0.31	40	60	70	132	17	32	20	40	273	395	413	409
	0.12	0.31	100	70	199	140	20	34	60	40		360		405
	0.12	0.31	40	70	42	147	12	27	20	80		395		416
	0.13	0.33	100	78	125	118	32	55	40	80		152		300
	0.13	0.34	120	100	162	155	32	25	40	50		320		415
	0.13	0.34	60	60	110	103	22	22	20	20		315		
	0.13	0.34	120	60	177	74	34	15	60	20				390
	0.13	0.36	100	80	169	151	41	31	60	60		360		392
	0.14	0.36	60	40	73	81	27	17	40	20		375		388
	0.14	0.37	20	70	22	88	8	17	60	80		370		420
	0.14	0.37	100	60	147	140	37	32	40	50		280		392
	0.14	0.38	20	120	18	199	8	40	20	40				
	0.14	0.40	10	40	22	74	8	22	10	60		380		417
	0.14	0.43	78	195	103	313	24	88	100	190	45	160	146	300
	0.14	0.44	60	70	96	118	20	22	20	40		380		416
	0.15	0.48	100	60	199	81	29	12	40	20		303		390
	0.15	0.54	80	117	140	171	42	95	40	40		140		332
	0.15	0.58	100	60	155	103	34	17	60	40		345		410
	0.15	0.76	80	39	140	316	29	37	40	60		140		314
	0.15	1.47	80	156	132	74	22	130	40	60		180		349
	0.15	1.57	100	234	110	320	22	145	40	20		198	392	370
Average	**0.13**	**0.48**	**78**	**85**	**121**	**136**	**25**	**40**	**44**	**50**	**142**	**295**	**285**	**381**
Std Dev	**0.01**	**0.33**	**33**	**50**	**56**	**82**	**10**	**37**	**21**	**36**	**118**	**101**	**137**	**40**
Maximum	**0.15**	**1.57**	**120**	**234**	**199**	**320**	**42**	**145**	**100**	**190**	**273**	**450**	**413**	**420**
Minimum	**0.10**	**0.30**	**10**	**20**	**18**	**4**	**8**	**4**	**10**	**10**	**45**	**140**	**146**	**300**

Appendix C.5
RO Turbidity Frequency Distribition

Finished Turbidity	Frequency	Cumulative %
0.10	1	0.41%
0.20	125	51.85%
0.29	87	87.65%
0.39	21	96.30%
0.49	4	97.94%
0.59	2	98.77%
0.69	0	98.77%
0.79	1	99.18%
0.88	0	99.18%
0.98	0	99.18%
1.08	0	99.18%
1.18	0	99.18%
1.28	0	99.18%
1.38	0	99.18%
1.47	1	99.59%
More	1	100.00%



Appendix C.6
RO ANOVA (alpha=0.05)

Anova: Single Factor — Finished Turbidity

SUMMARY

Groups	Count	Sum	Average	Variance
<0.12	25	3.32	0.13	1.87E-04
> 0.30	25	11.98	0.48	0.11

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.50	1	1.50	27.23	3.82E-06	4.04
Within Groups	2.64	48	0.06			
Total	4.15	49				

Anova: Single Factor — Finished Flow

SUMMARY

Groups	Count	Sum	Average	Variance
<0.12	25	84719000	3388760	7.14E+11
> 0.30	25	91056000	3642240	7.85E+11

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	8.03E+11	1	8.03E+11	1.07	0.31	4.04
Within Groups	3.60E+13	48	7.49E+11			
Total	3.68E+13	49				

Anova: Single Factor — PERMEATE Flow

SUMMARY

Groups	Count	Sum	Average	Variance
<0.12	25	24391.06	975.64	176317.04
> 0.30	25	26418.75	1056.75	458431.69

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	82230.90	1	82230.90	0.26	0.61	4.04
Within Groups	15233969.60	48	317374.37			
Total	15316200.50	49				

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Appendix C.6
RO ANOVA (alpha=0.05) Continued

Anova: Single Factor BY-PASS Flow

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	25	2788.00	111.52	5486.42
> 0.30	23	2577.78	112.08	11325.75

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3.72	1	3.72	4.49E-04	0.98	4.05
Within Groups	380840.53	46	8279.14			
Total	380844.26	47				

Anova: Single Factor BRINE Flow

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	25	11555.78	462.23	37761.23
> 0.30	25	13501.39	540.06	125711.43

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	75708.05	1	75708.05	0.93	0.34	4.04
Within Groups	3923343.79	48	81736.33			
Total	3999051.85	49				

Anova: Single Factor RAW Flow

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	25	39179.86	1567.19	423073.14
> 0.30	25	42494.44	1699.78	1148588.39

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	219729.25	1	219729.25	0.28	0.60	4.04
Within Groups	37719876.83	48	785830.77			
Total	37939606.09	49				

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Appendix C.6
RO ANOVA (alpha=0.05) Continued

Anova: Single Factor — Raw pH

SUMMARY

Groups	Count	Sum	Average	Variance
<0.12	25	182.82	7.31	7.63E-03
> 0.30	14	102.70	7.34	4.01E-03

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.71E-03	1	4.71E-03	0.74	0.39	4.11
Within Groups	0.24	37	6.36E-03			
Total	0.24	38				

Anova: Single Factor — Raw COND

SUMMARY

Groups	Count	Sum	Average	Variance
<0.12	25	271510.00	10860.40	5715129.00
> 0.30	14	192530.00	13752.14	1252587.36

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	75045175.98	1	75045175.98	18.10	1.37E-04	4.11
Within Groups	153446731.71	37	4147208.97			
Total	228491907.69	38				

Anova: Single Factor — Raw TDS

SUMMARY

Groups	Count	Sum	Average	Variance
<0.12	25	179410.00	7176.40	2747432.33
> 0.30	14	127236.00	9088.29	853268.84

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	32804037.04	1	32804037.04	15.76	3.19E-04	4.11
Within Groups	77030870.86	37	2081915.43			
Total	109834907.90	38				

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Appendix C.6
RO ANOVA (alpha=0.05) Continued

Anova: Single Factor — Raw CHLORIDES

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	25	88355	3534.20	952304.50
> 0.30	14	57860	4132.86	558650.90

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3216323.88	1	3216323.88	3.95	0.05	4.11
Within Groups	30117769.71	37	813993.78			
Total	33334093.59	38				

Anova: Single Factor — Raw TURB

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	25	10.40	0.42	0.22
> 0.30	14	8.64	0.62	0.24

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.36	1	0.36	1.62	0.21	4.11
Within Groups	8.27	37	0.22			
Total	8.64	38				

Anova: Single Factor — FEED pH

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	23	139.50	6.07	2.37E-03
> 0.30	24	144.90	6.04	2.45E-03

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	9.02E-03	1	9.02E-03	3.74	0.06	4.06
Within Groups	0.11	45	2.41E-03			
Total	0.12	46				

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Appendix C.6
RO ANOVA (alpha=0.05) Continued

Anova: Single Factor SDI

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	20	16.45	0.82	0.12
> 0.30	25	30.46	1.22	0.34

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.74	1	1.74	7.11	0.01	4.07
Within Groups	10.53	43	0.24			
Total	12.27	44				

Anova: Single Factor BRINE Cond

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	13	418730	32210.00	41445133.33
> 0.30	8	336700	42087.50	37461250.00

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	483179079	1	483179079	12.09	2.53E-03	4.38
Within Groups	759570350	19	39977387			
Total	1242749429	20				

Anova: Single Factor Brine pH

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	14	90.28	6.45	0.01
> 0.30	7	44.94	6.42	0.04

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3.81E-03	1	3.81E-03	0.17	0.69	4.38
Within Groups	0.44	19	0.02			
Total	0.44	20				

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Appendix C.6
RO ANOVA (alpha=0.05) Continued

Anova: Single Factor — Finished Alkalinity

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	25	701	28.04	24.37
> 0.30	25	995	39.80	97.08

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1728.72	1	1728.72	28.47	2.55E-06	4.04
Within Groups	2914.96	48	60.73			
Total	4643.68	49				

Anova: Single Factor — Finished Calcium Hardness

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	25	2191	87.64	179.82
> 0.30	25	2387	95.48	275.18

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	768.32	1	768.32	3.38	0.07	4.04
Within Groups	10920.00	48	227.50			
Total	11688.32	49				

Anova: Single Factor — Finished Total Hardness

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	25	2522	100.88	243.36
> 0.30	25	2669	106.76	461.11

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	432.18	1	432.18	1.23	0.27	4.04
Within Groups	16907.20	48	352.23			
Total	17339.38	49				

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Appendix C.6
RO ANOVA (alpha=0.05) Continued

Anova: Single Factor — Finished Chloride

SUMMARY

Groups	Count	Sum	Average	Variance
<0.12	25	3432	137.28	508.21
> 0.30	25	3478	139.12	380.44

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	42.32	1	42.32	0.10	0.76	4.04
Within Groups	21327.68	48	444.33			
Total	21370.00	49				

Anova: Single Factor — Finished Conductivity

SUMMARY

Groups	Count	Sum	Average	Variance
<0.12	25	14048	561.92	9295.74
> 0.30	25	15131	605.24	4939.86

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	23457.78	1	23457.78	3.30	0.08	4.04
Within Groups	341654.40	48	7117.80			
Total	365112.18	49				

Anova: Single Factor — Finished TDS

SUMMARY

Groups	Count	Sum	Average	Variance
<0.12	25	9412.16	376.49	4172.86
> 0.30	25	10137.77	405.51	2217.50

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	10530.20	1	10530.20	3.30	0.08	4.04
Within Groups	153368.66	48	3195.18			
Total	163898.86	49				

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Appendix C.6
RO ANOVA (alpha=0.05) Continued

Anova: Single Factor — Finished pH

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	25	203	8.12	0.03
> 0.30	25	207	8.28	0.03

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.32	1	0.32	10.82	1.89E-03	4.04
Within Groups	1.42	48	0.03			
Total	1.74	49				

Anova: Single Factor — Finished Temperature

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	20	547	27.35	1.71
> 0.30	20	478	23.90	5.46

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	119.03	1	119.03	33.17	1.22E-06	4.10
Within Groups	136.35	38	3.59			
Total	255.38	39				

Anova: Single Factor — Chlorine Residual Plant

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	25	74.23	2.97	0.22
> 0.30	25	75.60	3.02	0.12

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.04	1	0.04	0.22	0.64	4.04
Within Groups	8.16	48	0.17			
Total	8.19	49				

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Appendix C.6
RO ANOVA (alpha=0.05) Continued

Anova: Single Factor — Chlorine Residual Distribution

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	18	65.65	3.65	0.69
> 0.30	21	69.80	3.32	0.81

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.01	1	1.01	1.34	0.25	4.11
Within Groups	27.91	37	0.75			
Total	28.92	38				

Anova: Single Factor — Flocon

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	24	1866	77.75	1060.28
> 0.30	24	2037	84.88	2483.68

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	609.19	1	609.19	0.34	0.56	4.05
Within Groups	81511.13	46	1771.98			
Total	82120.31	47				

Anova: Single Factor — Sulfuric

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	24	2912	121.33	3092.23
> 0.30	25	3397	135.88	6654.36

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2591.09	1	2591.09	0.53	0.47	4.05
Within Groups	230825.97	47	4911.19			
Total	233417.06	48				

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Appendix C.6
RO ANOVA (alpha=0.05) Continued

Anova: Single Factor — Caustic

SUMMARY

Groups	Count	Sum	Average	Variance
<0.12	24	607	25.29	97.87
> 0.30	25	994	39.76	1334.44

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2563.26	1	2563.26	3.51	0.07	4.05
Within Groups	34277.52	47	729.31			
Total	36840.78	48				

Anova: Single Factor — Chlorine

SUMMARY

Groups	Count	Sum	Average	Variance
<0.12	23	1010	43.91	461.26
> 0.30	24	1210	50.42	1299.82

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	496.77	1	496.77	0.56	0.46	4.06
Within Groups	40043.66	45	889.86			
Total	40540.43	46				

Anova: Single Factor — AVG Finished TDS

SUMMARY

Groups	Count	Sum	Average	Variance
<0.12	3	426.33	142.11	13830.70
> 0.30	21	6187.83	294.66	10153.60

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	61085.79	1	61085.79	5.82	0.02	4.30
Within Groups	230733.49	22	10487.89			
Total	291819.28	23				

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Appendix C.6
RO ANOVA (alpha=0.05) Continued

Anova: Single Factor AVG Feed Pressure

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
<0.12	4	1139.17	284.79	18834.21
> 0.30	21	7996.98	380.81	1561.50

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	30976.77	1	30976.77	8.12	0.01	4.28
Within Groups	87732.65	23	3814.46			
Total	118709.42	24				

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APPENDIX D
CT Calculations

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Appendix D
Lime Softening CT Calculations Continued

Date	Temperature (°C)	Cl2 Residual Minimum	CT Calculation	CT 99.99 Giardia	CT 99.99 Virus	Giardia Inactivation Ratio	Virus Inactivation Ratio
09/06/94	26.6	3.6	360	125	214	2.88	1.68
09/07/94	26.5	3.9	390	125	214	3.12	1.82
09/08/94	26.2	4.0	400	125	214	3.20	1.87
09/09/94	26.2	3.8	380	125	214	3.04	1.78
09/10/94	26.2	3.6	360	125	214	2.88	1.68
09/11/94	26.1	3.7	370	125	214	2.96	1.73
09/12/94	26.3	4.5	450	125	214	3.60	2.10
09/13/94	25.9	4.1	410	125	214	3.28	1.92
09/14/94	26.6	3.4	340	125	214	2.72	1.59
09/15/94	25.8	3.7	370	125	214	2.96	1.73
09/16/94	25.2	3.7	370	125	214	2.96	1.73
09/17/94	25.3	3.5	350	125	214	2.80	1.64
09/18/94	25.7	3.8	380	125	214	3.04	1.78
09/19/94	25.9	4.0	400	125	214	3.20	1.87
09/20/94	25.1	4.2	420	125	214	3.36	1.96
09/21/94	25.9	4.0	400	125	214	3.20	1.87
09/22/94	26.5	3.8	380	125	214	3.04	1.78
09/23/94	25.8	4.3	430	125	214	3.44	2.01

Appendix D
Lime Softening CT Calculations Continued

Date	Temperature (°C)	Cl2 Residual Minimum	CT Calculation	CT 99.99 Giardia	CT 99.99 Virus	Giardia Inactivation Ratio	Virus Inactivation Ratio
09/24/94	26.4	3.9	390	125	214	3.12	1.82
09/25/94	26.3	3.8	380	125	214	3.04	1.78
09/26/94	26.2	4.0	400	125	214	3.20	1.87
09/27/94	26.5	4.2	420	125	214	3.36	1.96
09/28/94	26.4	4.1	410	125	214	3.28	1.92
09/29/94	26.3	4.0	400	125	214	3.20	1.87
09/30/94	26.4	4.1	410	125	214	3.28	1.92
10/01/94	25.8	4.3	430	125	214	3.44	2.01
10/02/94	25.9	4.0	400	125	214	3.20	1.87
10/03/94	26.2	4.0	400	125	214	3.20	1.87
10/04/94	26.0	2.7	270	125	214	2.16	1.26
10/05/94	25.8	2.6	260	125	214	2.08	1.21
10/06/94	26.3	4.5	450	125	214	3.60	2.10
10/07/94	26.3	4.3	430	125	214	3.44	2.01
10/08/94	25.9	4.2	420	125	214	3.36	1.96
10/09/94	26.8	3.8	380	125	214	3.04	1.78
10/10/94	26.1	4.0	400	125	214	3.20	1.87
10/11/94	26.0	4.0	400	125	214	3.20	1.87

Appendix D
Lime Softening CT Calculations Continued

Date	Temperature (°C)	Cl2 Residual Minimum	CT Calculation	CT 99.99 Giardia	CT 99.99 Virus	Giardia Inactivation Ratio	Virus Inactivation Ratio
10/12/94	26.2	2.9	290	125	214	2.32	1.36
10/13/94	26.4	3.0	300	125	214	2.40	1.40
10/14/94	26.1	4.1	410	125	214	3.28	1.92
10/15/94	26.2	4.0	400	125	214	3.20	1.87
10/16/94	26.0	4.1	410	125	214	3.28	1.92
10/17/94	35.8	4.0	400	125	214	3.20	1.87
10/18/94	25.8	4.2	420	125	214	3.36	1.96
10/19/94	25.9	4.7	470	125	214	3.76	2.20
10/20/94	25.2	4.2	420	125	214	3.36	1.96
10/21/94	26.0	2.9	290	125	214	2.32	1.36
10/22/94	26.1	4.6	460	125	214	3.68	2.15
10/23/94	26.1	3.6	360	125	214	2.88	1.68
10/24/94	26.2	4.0	400	125	214	3.20	1.87
10/25/94	25.9	2.8	280	125	214	2.24	1.31
10/26/94	26.3	3.7	370	125	214	2.96	1.73
10/27/94	26.2	3.5	350	125	214	2.80	1.64
10/28/94	26.3	4.0	400	125	214	3.20	1.87
10/29/94	26.2	3.5	350	125	214	2.80	1.64

Appendix D
Lime Softening CT Calculations Continued

Date	Temperature (°C)	Cl2 Residual Minimum	CT Calculation	CT 99.99 Giardia	CT 99.99 Virus	Giardia Inactivation Ratio	Virus Inactivation Ratio
10/30/94	26.1	3.0	300	125	214	2.40	1.40
10/31/94	26.1	2.7	270	125	214	2.16	1.26
11/01/94	26.5	3.1	310	125	214	2.50	1.40
11/02/94	26.0	4.1	410	125	214	3.30	1.90
11/03/94	26.3	4.0	400	125	214	3.20	1.90
11/04/94	26.8	4.2	420	125	214	3.40	2.00
11/05/94	25.6	4.2	420	125	214	3.40	2.00
11/06/94	25.8	3.9	390	125	214	3.10	1.80
11/07/94	26.1	4.4	440	125	214	3.50	2.10
11/08/94	25.3	3.1	310	125	214	2.50	1.40
11/09/94	25.4	3.9	390	125	214	3.10	1.80
11/10/94	25.8	3.8	380	125	214	3.00	1.80
11/11/94	26.1	3.8	380	125	214	3.00	1.80
11/12/94	26.4	4.1	410	125	214	3.30	1.90
11/13/94	26.4	4.0	400	125	214	3.20	1.90
11/14/94	24.9	3.6	360	185	321	1.90	1.10
11/15/94	26.1	3.9	390	125	214	3.10	1.80
11/16/94	25.5	3.5	350	125	214	2.80	1.60

Appendix D
Lime Softening CT Calculations Continued

Date	Temperature (°C)	Cl2 Residual Minimum	CT Calculation	CT 99.99 Giardia	CT 99.99 Virus	Giardia Inactivation Ratio	Virus Inactivation Ratio
11/17/94	26.4	3.8	380	125	214	3.00	1.80
11/18/94	24.8	3.8	380	125	214	3.00	1.80
11/19/94	24.9	3.9	390	185	321	2.10	1.20
11/20/94	25.2	3.7	370	125	214	3.00	1.70
11/21/94	25.1	4.0	400	125	214	3.20	1.90
11/22/94	24.8	3.8	380	185	321	2.10	1.20
11/23/94	25.3	3.8	380	125	214	3.00	1.80
11/24/94	26.1	4.0	400	125	214	3.20	1.90
11/25/94	25.8	4.3	430	125	214	3.40	2.00
11/26/94	24.8	4.3	430	185	321	2.30	1.30
11/27/94	25.3	4.0	400	125	214	3.20	1.90
11/28/94	24.6	3.7	370	185	321	2.00	1.20
11/29/94	25.3	3.5	350	125	214	2.80	1.60
11/30/94	25.8	3.8	380	125	214	3.00	1.80
12/01/94	25.2	3.0	300	125	214	2.40	1.40
12/02/94	25.0	3.2	320	125	214	2.56	1.50
12/03/94	26.3	3.2	320	125	214	2.56	1.50
12/04/94	26.0	3.8	380	125	214	3.04	1.78

Appendix D
Lime Softening CT Calculations Continued

Date	Temperature (°C)	Cl2 Residual Minimum	CT Calculation	CT 99.99 Giardia	CT 99.99 Virus	Giardia Inactivation Ratio	Virus Inactivation Ratio
12/05/94	25.7	3.8	380	125	214	3.04	1.78
12/06/94	25.2	4.1	410	125	214	3.28	1.92
12/07/94	25.3	4.1	410	125	214	3.28	1.92
12/08/94	25.1	4.4	440	125	214	3.52	2.06
12/09/94	24.9	3.3	330	250	321	1.32	1.03
12/10/94	25.0	2.2	220	125	214	1.76	1.03
12/11/94	25.3	2.7	270	125	214	2.16	1.26
12/12/94	24.8	3.2	320	250	321	1.28	1.00
12/13/94	25.0	4.6	460	125	214	3.68	2.15
12/14/94	24.8	4.1	410	250	321	1.64	1.28
12/15/94	25.5	4.2	420	125	214	3.36	1.96
12/16/94	24.9	4.3	430	250	321	1.72	1.34
12/17/94	25.1	3.8	380	125	214	3.04	1.78
12/18/94	25.6	4.0	400	125	214	3.20	1.87
12/19/94	24.9	3.9	390	250	321	1.56	1.21
12/20/94	25.2	4.1	410	125	214	3.28	1.92
12/21/94	25.2	4.3	430	125	214	3.44	2.01
12/22/94	24.9	3.8	380	250	321	1.52	1.18

Appendix D
Lime Softening CT Calculations Continued

Date	Temperature	Cl2 Residual	CT Calculation	CT 99.99	CT 99.99	Giardia Inactivation	Virus Inactivation
	(°C)	Minimum		Giardia	Virus	Ratio	Ratio
12/23/94	25.3	3.4	340	125	214	2.72	1.59
12/24/94	25.6	3.4	340	125	214	2.72	1.59
12/25/94	24.9	4.1	410	250	321	1.64	1.28
12/26/94	25.1	4.0	400	125	214	3.20	1.87
12/27/94	25.7	4.5	450	125	214	3.60	2.10
12/28/94	25.0	4.3	430	125	214	3.44	2.01
12/29/94	25.1	3.5	350	125	214	2.80	1.64
12/30/94	24.8	2.5	250	250	321	1.00	0.78
12/31/94	25.1	3.0	300	125	214	2.40	1.40
01/01/95	22.6	3.5	350	250	321	1.40	1.90
01/02/95	22.5	3.3	330	250	321	1.32	1.03
01/03/95	23.0	3.5	350	250	321	1.40	1.90
01/04/95	22.3	3.4	340	250	321	1.36	1.06
01/05/95	22.4	3.6	360	250	321	1.44	1.12
01/06/95	22.6	3.5	350	250	321	1.40	1.09
01/07/95	21.3	3.4	340	250	321	1.36	1.06
01/08/95	21.2	3.3	330	250	321	1.32	1.03
01/09/95	21.5	3.7	370	250	321	1.48	1.15

Appendix D
Lime Softening CT Calculations Continued

Date	Temperature (°C)	Cl2 Residual Minimum	CT Calculation	CT 99.99 Giardia	CT 99.99 Virus	Giardia Inactivation Ratio	Virus Inactivation Ratio
01/10/95	21.5	4.0	400	250	321	1.60	1.25
01/11/95	21.7	3.9	390	250	321	1.56	1.21
01/12/95	21.6	4.3	430	250	321	1.72	1.34
01/13/95	21.6	4.2	420	250	321	1.68	1.31
01/14/95	20.8	3.2	320	250	321	1.28	1.00
01/15/95	20.9	3.6	360	250	321	1.44	1.12
01/16/95	21.3	3.6	360	250	321	1.44	1.12
01/17/95	21.3	4.0	400	250	321	1.60	1.25
01/18/95	21.1	4.4	440	250	321	1.76	1.37
01/19/95	21.5	3.4	340	250	321	1.36	1.06
01/20/95	21.8	3.9	390	250	321	1.56	1.21
01/21/95	21.9	3.8	380	250	321	1.52	1.18
01/22/95	21.5	3.3	330	250	321	1.32	1.03
01/23/95	21.4	3.3	330	250	321	1.32	1.03
01/24/95	21.8	4.1	410	250	321	1.64	1.28
01/25/95	21.2	4.2	420	250	321	1.68	1.31
01/26/95	21.0	4.2	420	250	321	1.68	1.31
01/27/95	21.3	4.2	420	250	321	1.68	1.31

Appendix D
Lime Softening CT Calculations Continued

Date	Temperature	Cl2 Residual	CT Calculation	CT 99.99	CT 99.99	Giardia Inactivation	Virus Inactivation
	(°C)	Minimum		Giardia	Virus	Ratio	Ratio
01/28/95	21.5	4.3	430	250	321	1.72	1.34
01/29/95	21.4	3.3	330	250	321	1.32	1.03
01/30/95	21.2	3.4	340	250	321	1.36	1.06
01/31/95	21.4	4.3	430	250	321	1.72	1.34
AVG	**24.9**	**3.8**	**379**	**160**	**246**	**2.60**	**1.61**
STD. DEV.	**1.8**	**0.5**	**47**	**55**	**49**	**0.77**	**0.35**
Max.	**26.8**	**4.7**	**470**	**250**	**321**	**3.76**	**2.20**
Min.	**20.8**	**2.2**	**220**	**125**	**214**	**1.00**	**0.78**

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APPENDIX E
Treatability

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E.1 Softening Definitions

In developing the softening theory specific terms must be defined:

Coagulation consists of adding a floc-forming chemical reagent (coagulant) to a water to form a solid precipitate nuclei. Examples of this precipitate would be calcium carbonate ($CaCO_3$) or magnesium hydroxide ($Mg(OH)_2$). The coagulation step consists of rapid mixing which is intended to uniformly distribute the coagulant within the matrix being treated. The formation of nuclei occur ideally in the rapid mixing process and would be more desirable in conditions of instantaneous or complete mixing. Velocity gradient (G) values of more than 300 sec^{-1} for less than 1 minute during rapid mixing are desirable.

Flocculation is the building of floc particles from an already formed solid precipitate. The floc particles enmesh or combine with non-settleable colloidal solids and slow-settling suspended solids. These particles agglomerate to produce a rapid-settling floc. Flocculation involves the slow mixing of the coagulated water so as to allow for the destabilized particles to collide, agglomerate, and form a settleable floc material. Velocity gradient (G) values of 35 to 50 sec^{-1} during slow mixing should be limited to less than 15 minutes.

Sludge Addition is the addition of previously formed $CaCO_{3(s)}$ or $Mg(OH)_{2(s)}$ solids to the rapid mix or slow mix process in order to provide previously formed solids nucleation sites. Effective in both coagulation and softening processes for enhancing turbidity removal and treatment.

Settling Velocity is the surface loading rate (SLR) of the clarified water as determined by the surface area for clarification divided by the flow of the settled water out of the clarification basin.

Chemical Reaction is the basis chemical reaction for Ca^{+2} or Mg^{+2} hydrolysis. This reaction will generate 2 H^+ for every mole of Ca^{+2} or Mg^{+2} reacted. The protons will react with and destroy HCO_3^- alkalinity. Consequently Ca^{+2} or Mg^{+2} reacts as a Lewis acid and will lower pH.

Base Dose and pH are the dose of caustic, lime or soda ash in meq/L added to the rapid mix process and the pH of the settled water following coagulation and flocculation as measured in the overflow weirs of the settling basin.

Polymers are the inorganic or organic chemicals added to the rapid mix or slow mix processes to enhance settling of the floc. Typically organic polymers are used as settling aids for aluminum and iron during coagulation, but aluminum or iron coagulants can be used as settling aids during softening processes.

pC-pH Solubility Diagrams are thermodynamic models of the solid and ionic phases of any metal precipitate such as $Al(OH)_{3(s)}$, $Fe(OH)_{3(s)}$. and $CaCO_3$. The model can be constructed by plotting the

negative log of the solubility products and anionic form of the metal hydroxide such $Al(OH)_4^-$ or $Fe(OH)_4^-$. This defines the optimum or acceptable pH range of the coagulation process for aluminum or iron salts. Softening usually does not begin until pH 8.5 and continues until pH 10.3. After pH 10.3 more calcium or sodium from the base hydroxide would come into solution than would precipitate from solution because most of the bicarbonate alkalinity would have been previously precipitated.

Sludge is the total volume of solids including water and total suspended solids (TSS) produced during the coagulation reaction. Typically aluminum or iron sludge will contain 0.1 to 0.5 percent TSS following sedimentation. Softening sludge contains 2 to 5 % TSS.

E.2 Lime Softening Literature Review

Total Hardness (TH) is the sum of the concentrations of the polyvalent cations, all expressed as equivalent concentrations of $CaCO_3$. Since the majority of polyvalent ions in potable water are calcium and magnesium, the sum off these two is generally taken as TH. The AWWA Water Quality Goals (AWWA, 1968) recommend a TH range of 80 to 100 mg/L as $CaCO_3$. This is desirable because of aesthetics and corrosion control. Removal of hardness by softening can be accomplished by precipitation, ion exchange, or low-pressure reverse osmosis.

E.3 Lime Softening Theory

The common inorganic bases used in softening water treatment are lime (CaO, $Ca(OH)_2$), soda (Na_2CO_3) and caustic (NaQH). When added to water, the Ca^{+2} and Mg^{+2} ions in these bases react with water to from an insoluble metal hydroxide precipitate floc and generates protons which destroy alkalinity. The precipitate formation is pH dependent and will not be complete if there is not enough alkalinity to buffer the reaction so that an acceptable reaction pH is maintained.

The lime softening equations are shown in Table E.1. This table can be easily constructed if the following key points are noted:

I. There are the following forms of lime demand.

   A. Carbon Dioxide (CO_2): This is carbon dioxide and removes no hardness or alkalinity but does represent a demand for a base and must be considered to determine base dose.

   B. Calcium Carbonate Hardness (CaCH): This is calcium that is neutralized by carbonate alkalinity.

   C. Calcium Non-Carbonate Hardness (CaNCH): This is calcium that is neutralized by any other species (anionic) than carbonate species.

D. Magnesium Carbonate Hardness (MgCH): This is magnesium that is neutralized by carbonate alkalinity.

E. Magnesium Non-Carbonate Hardness (MgNCH): This is magnesium that is neutralized by any other species (anionic) than carbonate species.

F. Negative Hardness (NegH): This is any other cation that is neutralized by carbonate alkalinity other than calcium or Magnesium.

II. Only lime ($CaOH_2$ or CaO), soda ash (Na_2CO_3) or caustic (NaOH) is added as the base to cause the precipitation reactions.

III. The only precipitation products are $CaCO_3$ or $MgOH_2$.

To remove the various forms of hardness the following chemicals are used.

- Lime removes CaCH.
- Soda ash removes CaCH and NCH.
- Excess lime removes CaCH, MgCH and NCH.
- Caustic economically removes MgNCH.

Typical goals for softening are:

TH ≤ 100 mg/L $CaCO_3$

MgH ≤ 40 mg/L $CaCO_3$

Alk ≥ 35 mg/L $CaCO_3$

pH ≥ pH_s

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TABLE E.1
Softening Equations

Lime Softening

Demand@	Reactions	CaO*	Na_2CO_3 *	NaOH *	$CaCO_3$ *	$Mg(OH)_2$*
CO_2	$CO_2 + CaO + H_2O \rightarrow CaCO_3 + H_2O$	1	0	0	1	0
CaCH	$Ca(HCO_3)_2 + CaO + H_2O \rightarrow 2CaCO_3 + 2H_2O$	1	0	0	2	0
MgCH	$Mg(HCO_3)_2 + 2CaO + 2H_2O \rightarrow 2CaCO_3 + Mg(OH)_2 + 2H_2O$	2	0	0	2	1
CaNCH	$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 + NaSO_4$	0	1	0	1	0
MgNCH	$MgSO_4 + CaO + H_2O + Na_2CO_3 \rightarrow Mg(OH)_2 + CaCO_3 + H_2O$	1	1	0	1	1
	$MgSO_4 + 2NaOH \rightarrow Mg(OH)_2 + Na_2SO_4$	0	0	1?	0	1
Neg H	$Na(HCO_3) + CaO \rightarrow CaCO_3 + NaOH$	1	0	0?	1	0
	$Ca(HCO_3)_2 + NaOH \rightarrow CaCO_3 + Na(HCO_3) + H_2O$	0	0	1	1	0
	$CO_2 + NaOH \rightarrow NaHCO_3$	0	0	0?	0	0

@: CH = Carbonate Hardness
NCH = Non-Carbonate Hardness
* = units of meq dose / sludge.

Carbonate System Equilibrium Constants

1) $CO_{2(g)} + H_2O \Leftrightarrow CO_{2(aq)}$; $pK_{H,\,25°C} = 1.47$

2) $H_2CO_3^* \Leftrightarrow HCO_3^- + H^+$; $pK_{a,\,1,\,25°C} = 6.35$

3) $HCO_3^- \Leftrightarrow CO_3^{2-} + H^+$; $pK_{a,\,2,\,25°C} = 10.33$

4) $CaCO_{3(s)} \Leftrightarrow Ca^{2+} + CO_3^{2-}$; $pK_{SO,\,25°C} = 8.34$

5) $CaCO_{3(s)} + H^+ \Leftrightarrow Ca^{2+} + HCO_3^-$; $p(K_{so}/K_{a,\,2})_{25°C} = -1.99$

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Always leave the softened water in the most costly form of hardness that is allowable within the goals. This will produce an economically softened water. The cost for hardness removal varies depending on the type of hardness to be removed (i.e. $ MgNCH > $ MgCH and $ CaNCH > $ CaCH).

Each of the above equations show that alkalinity is destroyed as a result of the metal-hydroxide precipitation. The basic chemical reaction Ca^{+2} or Mg^{+2} hydrolysis will generate 2 protons for every mole of Ca^{+2} or Mg^{+2} reacted. The protons will react with and destroy alkalinity. Consequently Ca^{+2} or Mg^{+2} reacts as a Lewis acid and will lower pH. The following are the stoichiometric hydrolysis reactions of Ca^{+2} or Mg^{+2} ions with water. These equations indicate that 1 mole of divalent metal ions should produce 1 mole of metal hydroxide and 2 mole of hydrogen ions (protons), provided the reactions go to completion.

E.3.1 pC-pH Diagrams

The above reactions are, however, oversimplifications of the actual reactions which occur during softening processes. These reactions do not account for the unknown reactions between the individual coagulants and natural organic matter. Moreover, the form of the metal available for reaction is a strong function of concentration and pH. pC-pH solubility diagrams are thermodynamic models of the solid and ionic phases of any metal precipitate such as $CaCO_{3(s)}$ and $Mg(OH)_{2(s)}$. The model can be constructed by plotting the negative log of the solubility products and cationic form of the metal hydroxide such Ca^{+2} or Mg^{+2}. This defines the optimum or acceptable pH range of the softening process for lime. Figures E.1 illustrate the various hydrolysis products associated with the lime coagulant. Figure E.1 is based upon equilibrium calculations for the known hydroxo-metal complexes known to occur and relate speciation to concentration (pC) and pH. As a result of these considerations, the stoichiometry from the simplified reactions used to describe the coagulation process cannot be used to accurately predict resultant pH values for a given coagulant dosage. Therefore, titration curves are necessary for defining the functional relationship between alkalinity destruction (pH) and coagulant dosage.

The thermodynamic equilibrium diagram for $CaCO_3$ and $Mg(OH)_2$ is shown in Figure E.1. Note the change of slope for $CaCO_3$ at pK_1 and pK_2. These slopes can be determined by taking the derivative of the $CaCO_3$ solubility product with respect to pH. Here the CO^{-2} species has to be written as $\alpha_2 C_{T(CO_3)}$. Also note the intersection of the $CaCO_3$ and $Mg(OH)_2$ equilibrium lines. The horizontal section of the $CaCO_3$ equilibrium lime immediately to the left of this intersection is denoted as excess lime and represents the additional OH^- that must be added to precipitate $Mg(OH)_2$.

Figures 3.4 can also be used to establish regions for minimal solubility. The regions above these lines correspond to supersaturation conditions (i.e. metal hydroxide precipitation). Optimum softening conditions exist where the metal hydroxides are least soluble which leads to maximum precipitation. Following this technique, Figure E.1 suggests optimal coagulation for lime in the pH range 10.3.

The addition of ions with opposite charge (counter ions) to a suspended colloid reduces the repulsive forces among similar colloidal particles. These oppositely charged ions "compress the diffuse layer surrounding the particles" which reduces the repulsive forces between the colloids (Pontius, 1990). These similar colloids can then agglomerate to form larger particles which then settle by gravity. This method for destabilization is applicable to the interaction of the hydrolyzed species of lime coagulant with colloidal materials. Additional coagulant dosages results in restabilization of the colloidal material and thus significant agglomeration ceases.

Given solubility limitations, metal hydroxide precipitation will occur for calcium (Ca^{+2}) provided sufficient dosage and alkalinity. Upon formation of these precipitates, colloidal materials can become enmeshed in the metal hydroxide as the salt settles from solution. This method for destabilization is commonly referred to as "sweep flocculation." Since "sweep" flocculation requires large coagulant dosages in comparison to charge neutralization destabilization, large amounts of metal hydroxide floc are generated which "sweep" the colloidal contaminants from solution.

Interparticulate bridging is achieved by synthetic organic polymer addition. These polymers serve to link colloids together by attaching to more than one colloidal particle. The degree of interparticulate bridging is sensitive to polymer and coagulant dose. Thus, colloidal particles can become restabilized if overdosed (Pontius, 1990).

Drinking water treatment facilities using coagulation have been primarily used for color removal in a sweep coagulation process which requires large coagulant doses to produce a "sweep floc" of aluminum or iron hydroxide precipitate to remove color. Fortunately this sweep floc is very effective for removal of pathogens common in surface waters and is essential to the effective control of pathogens in a CSF process. Figure E.2 presents a schematic of turbidity removal by the charge neutralization and "sweep floc" mechanisms for destabilization where a generalization for the differing mechanisms for turbidity removal with increasing coagulant dosage are indicated. Charge neutralization destabilization represents destabilization of colloidal materials by way of charge interaction with the aluminum(III) or iron(III) hydrolysis products. Notice that additional dosages may lead to restabilization of the particles. Once the solubility limit is exceeded for the aluminum(III) or iron(III) hydroxide salts, "sweep flocculation" occurs and the colloidal materials become enmeshed in the precipitate as the precipitate coalesces and settles from solution.

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The addition of ions with opposite charge (counter ions) to a suspended colloid reduces the repulsive forces among similar colloidal particles. These oppositely charged ions "compress the diffuse layer surrounding the particles" which reduces the repulsive forces between the colloids (Pontius, 1990). These similar colloids can then agglomerate to form larger particles which then settle by gravity. This method for destabilization is applicable to the interaction of the hydrolyzed species of lime coagulant with colloidal materials. Additional coagulant dosages results in restabilization of the colloidal material and thus significant agglomeration ceases.

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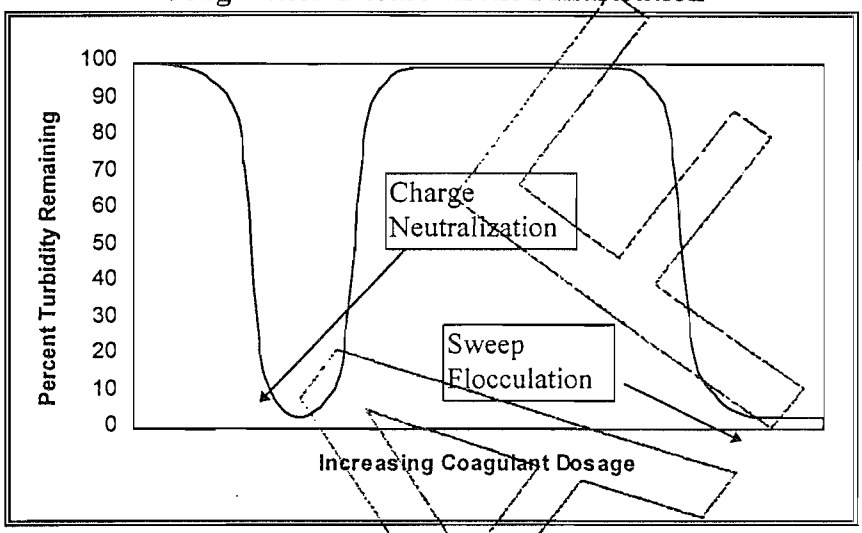
FIGURE E.2
Coagulation Destabilization Illustration



According to the classical residual turbidity versus alum dose curve: at low alum doses there is no reduction in turbidity; the further addition of alum causes a destabilized particle region where a reduction in turbidity to a minimum value is achieved; a further increase in alum dose will restabilize the particle and will increase the turbidity; eventually a bulky precipitate enmeshes particles in it and settles rapidly forming a "sweep floc" (Snoeyink and Jenkins, 1980). In other words, a precipitate at high coagulant doses causes a rapid precipitation that enmeshes many particles, enhances collisions with other particles, and increases the available surface area for adsorption of organic contaminants.

In this evaluation sweep coagulation was performed. This was done in response to a variable high organic content surface water. Pristine water such as the Great Lakes have been able to operate in the charge neutralization zone because of a low variability and organic content surface water.

E.3.3 Mixing Conditions and Settling Velocity

To be effective in a coagulation/flocculation/sedimentation process, consideration must be given to mixing conditions and settling velocity.

Mixing conditions should not be excessive in that it results in "shearing the floc". Shearing of the floc reduces the settleability. For coagulation the formation of nuclei occur ideally in the rapid mixing process and would be more desirable in conditions of instantaneous or complete mixing. Velocity gradient (G) values of more than 300 sec^{-1} for less than 1 minute during rapid mixing are desirable. Flocculation involves the slow mixing of the coagulated water so as to allow for the destabilized

particles to collide, agglomerate, and form a settleable floc material. Velocity gradient (G) values of 35 to 50 sec^{-1} during slow mixing should be limited to less than 15 minutes.

Surface loading rates (SRL) should not be greater than the settling velocity (V_s). The V_s is the distance the floc or particle travels over time (Equation E.1), whereas the SLR is the rate at which water or sludge flows over a given area (Equation E.2). Therefore the SLR over the weir should not exceed the V_s (SLR < V_s).

$$V_s = \frac{\text{DistanceTraveled}}{\text{TimeTraveled}}\left(\text{gpm}/\text{ft}^2\right) \qquad \textbf{(EQUATION E.1)}$$

$$\text{SLR} = \frac{\text{Flow}}{\text{Surface Area}}\left(\text{gpm}/\text{ft}^2\right) \qquad \textbf{(EQUATION E.2)}$$

Knowing the V_s, design criteria based on SLR can be established. Typical design criteria for coagulation/flocculation, and lime softening are 0.5 and 1.0 gpm/ft^2, respectively.

The use of polymers or sludge addition are processes that can help improve V_s. Polymers are the inorganic or organic chemicals added to the rapid mix or slow mix processes to enhance settling of the floc. Typically organic polymers are used as settling aids for aluminum and iron during coagulation, but aluminum or iron coagulants can be used as settling aids during softening processes.

Sludge addition is the addition of previously formed $CaCO_3$ solids to the rapid mix or slow mix process in order to provide previously formed solids nucleation sites. Effective in both coagulation and softening processes for enhancing turbidity removal and treatment.

E.3.4 Sludge Volume

Sludge is the total volume of solids including water and total suspended solids (TSS) produced during the coagulation reaction. Typically softening sludge will contain 2 to 5 percent TSS following sedimentation. The volume of sludge produced can be estimated by adding the suspended solids (turbidity) removed to the amount of precipitate formed by the coagulant (Equation E.3).

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$$V = \frac{8.33}{\rho_w} QC\left(\frac{1}{S_G} + \frac{1-x}{x}\right) \qquad \text{(EQUATION E.3)}$$

V = Sludge Volume (ft^3 / day)

Q = Flow (MGD)

C = TSS Formed (mg / L)

r_w = Density of Water (lb / ft^3) = 62.43 lb / ft^3

S_G = Specific Gravity (2.8 = $CaCO_3$, 2.4 = $MgOH_2$)

x = Decimal Fraction TSS

The impact of sludge volume on waste disposal for a water treatment plant is based on economic and operational factors. The objective of waste disposal is to reduce the volume of material while minimizing environmental impacts and meeting regulatory issues. As seen in Equation E.3 the challenge arises from the ability to increase the TSS by removing the water. This can be costly so methods for dewatering sludge from water treatment plants should be evaluated. The following are processes used for dewatering:

- Drying beds
- Vacuum filtration
- Pressure filter press
- Belt filter press Centrifugation
- Sludge recovery

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APPENDIX F
Marco Island RO WTP Train Performance Data

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Appendix F.1
ROWTP Train Performance Data - Train #1 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data												Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
10/07/96	7:00	779	0.1	0.20	78.0	7,669	6.09	51	80.5%	100%	302	592	240	160	299	260	44.0	22.6	11	66%	11.8	11.6	3.1%
10/08/96	5:00	1,768	0.1	0.39	75.5	7,188	6.00	51	81.0%	100%	303	601	175	117	302	250	45.1	23.8	11	67%	12.0	12.3	2.4%
10/08/96	7:00	1,772	0.0	0.39	75.5	7,169	6.00	50	80.0%	100%	300	594	171	114	298	255	44.9	23.9	11	67%	11.8	12.1	2.4%
10/08/96	9:00	1,774	0.1	0.39	75.0	7,290	6.09	48	80.5%	100%	299	586	169	114	301	255			11	66%	11.7	12.1	2.3%
10/11/96	11:00	1,098	0.1	0.20	78.0	9,450	6.09	59	80.6%	100%	300	596	235	158	299	255	43.1	22.8	11	67%	11.9	11.7	3.2%
10/17/96	10:00	4,780	1.0	1.10	78.0	11,100	6.09	60	88.5%	100%	391	651	299	210	303	340	45.6	22.6	15	68%	13.0	12.7	2.7%
10/18/96	3:00	4,734	0.1	1.10	78.0	10,764	6.00	52	90.5%	100%	393	649	282	188	300	340	45.1	22.3	14.5	68%	12.9	12.7	2.6%
10/18/96	5:00	4,784	0.1	1.10	78.0	10,650	6.00	52	91.0%	100%	392	656	284	189	302	335	45.3	22.5	14.5	68%	13.1	12.8	2.7%
10/18/96	7:00	4,764	0.1	0.94	78.0	10,588	6.00	48	89.5%	100%	390	647	276	184	293	340	44.6	21.8	14.5	69%	12.9	12.7	2.6%
10/18/96	9:00	4,788	0.1	0.95	78.0	10,588	6.09	45	91.5%	100%	389	648	274	183	295	335	44.9	22.1	14.5	69%	12.9	12.7	2.6%
10/18/96	11:00	758	0.1	0.94	78.0	10,963	6.09	45	91.5%	100%	393	655	275	183	303	340	45.4	22.2	14.5	68%	13.0	12.8	2.5%
10/18/96	13:00	4,778	0.1	0.94	78.0	10,594	6.09	43	91.5%	100%	391	653	268	177	303	340	44.9	22.6	14.5	68%	13.0	12.8	2.5%
10/18/96	15:00	4,778	0.1	0.94	78.0	10,856	6.09	42	90.5%	100%	392	652	266	177	303	340	45.3	22.3	14.5	68%	13.0	12.8	2.5%
10/18/96	17:00	4,769	0.1	0.94	78.0	10,594	6.09	42	90.0%	100%	389	653	262	175	303	340	45.3	22.6	14.5	68%	13.0	12.8	2.5%
10/18/96	19:00	4,756	0.1	0.94	78.0	10,556	6.09	40	91.5%	100%	387	647	259	173	296	340	45.0	22.0	14.5	69%	12.9	12.7	2.5%
10/18/96	21:00	4,410	0.7	0.85	78.0	10,725	6.12	63	87.8%	100%	383	644	254	169	302	330	47.3	22.7	13	68%	12.8	12.6	2.4%
10/18/96	23:00	4,780	0.0	0.95	78.0	10,594		60	89.5%	100%	386	652	254	169	295	340	45.0	22.2	15	69%	13.0	12.8	2.4%
10/19/96	3:00	4,670	0.0	0.95	78.0	10,625	6.00	50	87.5%	100%	379	630	259	173	303	330	43.2	27.7	14.5	68%	12.5	12.3	2.4%
10/19/96	5:00	4,659	0.0	0.94	78.0	10,588	6.10	51	87.5%	100%	375	614	259	173	304	325	43.7	21.5	14.5	67%	12.2	12.0	2.4%
10/19/96	7:00	4,677	0.0	0.95	78.0	10,625	6.00	50	88.0%	100%	371	616	261	174	305	330	43.4	22.2	14.5	67%	12.3	12.1	2.5%
10/19/96	9:00	4,673		0.71	78.0	10,622	6.07	50	88.5%	100%	380	628	260	173	305	330	43.5	22.1	14.5	67%	12.5	12.3	2.4%
10/19/96	11:00	4,635	0.0	0.95	78.0	10,656	6.09	50	88.5%	100%	381	622	262	175	300	330	43.7	22.0	14	67%	12.4	12.2	2.5%
10/19/96	13:00	4,681		0.93	78.0	10,500	6.06	48	88.5%	100%	383	641	263	175	303	330	44.2	22.5	14.5	68%	12.8	12.5	2.5%
10/19/96	15:00	4,666		0.94	78.0	10,644	6.09	46	88.0%	100%	372	622	266	177	299	330	44.9	22.5	14.5	68%	12.4	12.2	2.5%
10/19/96	17:00	3,682		0.74	78.0	10,711	6.08	60	85.0%	100%	371	606	278	185	294	320	42.9	22.2	13	67%	12.1	11.9	2.6%
10/19/96	19:00	3,677		0.73	78.0	10,984	6.09	59	85.5%	100%	367	604	364	203	291	320	42.6	22.0	13	67%	12.0	11.8	3.3%
10/19/96	21:00	3,778		0.76	78.0	11,081	6.06	46	90.0%	100%	407	653	318	212	280	355	43.6	20.0	14	70%	13.0	12.8	2.9%
10/19/96	23:00	3,732	0.1	0.72	78.0	10,712	6.69	50	89.0%	100%	385	630	301	201	365	350	42.4	21.9	13.5	63%	12.5	12.3	2.8%
10/21/96	17:00	4,788	0.1	0.87	78.0	10,400	6.06	62	87.5%	100%	381	636	274	183	295	340	44.8	21.8	14.5	68%	12.7	12.5	2.6%
10/21/96	19:00	4,395	0.1	0.92	78.0	10,262	6.00	59	89.0%	100%	379	648	262	175	304	325	45.2	22.6	13	68%	12.9	12.7	2.6%
10/21/96	21:00	4,697	0.1	0.93	78.0	10,562	6.12	52	89.0%	100%	377	642	262	175	296	330	44.4	23.2	14.5	68%	12.8	12.6	2.5%
10/22/96	3:00	1,934	0.1	0.39	78.0	8,012	6.00	58	83.5%	100%	328	626	194	129	300	275	45.1	24.0	11	68%	12.5	12.3	2.4%
10/22/96	5:00	1,918	0.1	0.40	78.0	8,120	6.00	58	83.0%	100%	325	618	190	127	302	280	45.8	23.5	11	67%	12.3	12.1	2.3%
10/24/96	15:00	3,100	0.1	0.68	78.0	7,131	6.09	60	81.0%	100%	318	652	154	103	274	270	43.9	22.8	11	70%	13.0	12.8	2.2%
10/24/96	19:00	2,824	0.1	0.61	78.0	7,081	6.09	54	82.5%	100%	319	649	148	120	281	270	46.7	22.5	12	70%	12.9	12.7	2.1%
10/24/96	21:00	2,818	0.0	0.60	78.0	6,969	6.09	43	84.0%	100%	318	652	148	110	282	270	45.8	22.4	12	70%	13.0	12.8	2.1%
10/25/96	3:00	2,826	0.0	0.61	78.0	7,050	6.00	49	84.0%	100%	320	654	148	99	277	275	44.2	22.1	12	70%	13.0	12.8	2.1%
10/25/96	5:00	2,748	0.0	0.62	78.0	7,038	6.00	59	79.5%	100%	294	601	144	96	301	250	44.4	23.8	12	67%	12.0	11.8	2.0%
10/25/96	7:00	2,763	0.0	0.60	78.0	7,062	6.00	59	80.0%	100%	298	605	143	95	300	250	44.2	23.5	12	67%	12.0	11.8	2.0%

Appendix F.1
ROWTP Train Performance Data - Train #1 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gfd)	(gfd @ 25C)	(%)
10/25/96	9:00	2,730	0.1	0.60	78.0	7,225	6.09	45	81.0%	100%	302	600	150	100	301	250	43.7	23.4	12	67%	11.9	11.7	2.1%
10/25/96	11:00	2,697	0.1	0.61	78.0	7,156	6.07	44	82.0%	100%	300	604	149	99	299	250	43.6	24.0	11.5	67%	12.0	11.8	2.1%
10/25/96	13:00	2,748	0.0	0.61	78.0	7,181	6.12	44	81.5%	100%	298	596	148	99	299	250	44.8	23.5	12	67%	11.9	11.7	2.1%
10/28/96	11:00	3,106	0.1	0.61	71.0	7,556	6.06	60	83.5%	100%	330	655	163	109	302	170	46.8	24.2	12	68%	13.0	14.4	2.2%
10/29/96	3:00	3,119	0.1	0.60	72.0	7,331	6.00	61	83.5%	100%	325	651	154	103	304	270	46.6	24.5	12.5	68%	13.0	14.1	2.1%
10/29/96	5:00	3,045	0.0	0.66	72.0	7,350	6.00	60	83.5%	100%	326	646	158	105	300	270	46.1	24.2	12.5	68%	12.9	14.0	2.1%
10/29/96	7:00	2,822	0.0	0.67	72.5	7,244	6.00	56	84.5%	100%	325	653	154	103	301	270	45.8	24.0	12.5	68%	13.0	14.0	2.1%
10/29/96	9:00	2,798	0.1	0.66	72.0	7,250	6.00	48	85.0%	100%	327	661	151	101	300	270	45.4	24.1	12.5	69%	13.2	14.3	2.1%
10/29/96	11:00	2,748	0.0	0.65	72.0	7,350	5.96	55	82.0%	100%	318	635	154	103	297	265	45.1	24.5	12	68%	12.6	13.7	2.1%
10/29/96	13:00	2,702	0.1	0.67	72.0	6,894	5.96	52	80.0%	100%	290	594	143	95	300	250	43.4	24.2	12	66%	11.8	12.8	2.1%
10/29/96	15:00	2,723	0.0	0.60	72.5	6,738	6.00	49	80.0%	100%	291	598	139	93	299	240	43.8	23.4	12	67%	11.9	12.8	2.1%
10/30/96	9:00	2,949	0.0	0.64	75.0	9,719	6.09	58	88.0%	100%	378	661	255	190	293	330	46.6	22.1	12	69%	13.2	13.6	2.6%
10/30/96	11:00	2,953	0.0	0.64	74.0	8,831	6.12	59	89.5%	100%	375	673	222	160	289	320	45.3	22.5	11.5	70%	13.4	14.1	2.5%
10/30/96	13:00	2,927	0.0	0.64	74.0	8,769	6.09	58	89.5%	100%	368	668	221	160	290	320	47.0	23.2	12	70%	13.3	14.0	2.5%
11/01/96	3:00	2,859	0.1	0.59	75.0	8,319	6.09	49	88.0%	100%	360	688	192	150	270	300	45.7	21.9	12	72%	13.7	14.1	2.3%
11/01/96	5:00	2,896	0.1	0.60	75.0	8,269	6.09	49	88.0%	100%	357	675	194	150	274	310	47.0	21.6	12	71%	13.4	13.9	2.3%
11/01/96	7:00	2,848	0.0	0.59	74.5	8,550	6.06	42	88.0%	100%	369	685	208	150	276	305	45.9	22.0	12	71%	13.6	14.2	2.4%
11/01/96	9:00	2,870	0.1	0.59	74.5	8,506	6.06	41	88.0%	100%	366	685	212	160	273	310	46.8	21.9	12	72%	13.6	14.2	2.5%
11/01/96	11:00	2,877	0.1	0.59	74.5	8,606	6.09	35	89.0%	100%	362	681	211	160	278	320	46.9	22.2	12	71%	13.6	14.1	2.5%
11/01/96	13:00	2,857	0.1	0.60	74.5	8,981	6.06	49	89.0%	100%	373	675	226	160	278	320	45.8	21.6	12	71%	13.4	14.0	2.5%
11/01/96	15:00	2,881	0.1	0.59	74.5	8,981	6.06	48	89.5%	100%	372	682	227	155	278	320	45.5	21.3	12	71%	13.6	14.1	2.5%
11/01/96	17:00	2,868	0.1	0.60	74.5	8,975	6.06	48	89.0%	100%	370	681	221	160	278	320	45.2	21.5	12	71%	13.6	14.1	2.5%
11/01/96	19:00	2,863	0.1	0.59	74.5	8,994	6.06	48	89.0%	100%	384	703	219	160	279	320	45.7	21.5	12	72%	14.0	14.6	2.4%
11/02/96	3:00	2,804	0.1	0.58	74.5	8,894	6.00	59	85.5%	100%	356	650	219	146	267	310	43.1	21.3	12	71%	12.9	13.5	2.5%
11/02/96	5:00	2,787	0.0	0.61	75.5	8,712	6.00	60	86.0%	100%	356	649	219	146	282	310	43.6	21.7	11.5	70%	12.8	13.1	2.5%
11/02/96	7:00	2,894	0.0	0.60	75.5	8,825	6.00	45	89.5%	100%	324	681	228	152	277	320	45.7	21.7	12	71%	13.6	13.9	2.6%
11/02/96	9:00	2,850	0.1	0.60	75.5	8,781	6.06	44	88.0%	100%	360	656	216	144	276	320	45.1	21.5	12	70%	13.1	13.4	2.5%
11/02/96	11:00	2,877	0.1	0.61	75.5	8,800	6.09	44	88.5%	100%	374	683	216	144	271	320	44.7	21.1	12	72%	13.6	13.9	2.5%
11/02/96	13:00	2,874	0.1	0.60	75.5	8,669	6.09	44	88.5%	100%	382	690	221	147	270	320	44.3	21.8	12	72%	13.7	14.1	2.5%
11/03/96	9:00	801	0.2	0.19	75.5	7,825	6.12	46	85.0%	100%	327	651	181	121	293	280	46.1	23.6	12	69%	13.0	13.3	2.3%
11/03/96	11:00	2,763	0.1	0.55	75.5	7,738	6.12	45	81.5%	100%	303	601	179	119	296	260	42.8	23.2	12	67%	12.0	12.3	2.3%
11/03/96	13:00	2,721	0.1	0.55	75.5	7,738	6.09	45	82.0%	100%	307	596	180	120	300	260	43.3	23.6	12	67%	11.9	12.2	2.3%
11/03/96	15:00	2,745	0.1	0.56	75.5	7,850	6.06	41	82.0%	100%	310	596	181	121	302	260	43.7	23.9	12	66%	11.9	12.2	2.3%
11/04/96	11:00	1,997	0.1	0.40	75.5	7,844	6.09	57	87.0%	100%	355	690	198	132	271	310	46.7	21.8	11	72%	13.7	14.1	2.5%
11/04/96	13:00	1,982	0.1	0.39	75.5	7,825	6.09	57	87.0%	100%	360	695	199	133	275	305	45.1	22.0	11	72%	13.8	14.2	2.5%
11/05/96	3:00	1,833	0.1	0.40	75.5	8,056	6.00	47	84.0%	100%	326	621	203	135	303	275	44.7	23.9	11.5	67%	12.4	12.7	2.5%
11/05/96	5:00	1,820	0.1	0.40	75.5	8,101	6.00	46	84.5%	100%	327	629	201	134	304	270	45.5	24.2	12	67%	12.5	12.8	2.5%
11/05/96	7:00	1,813	0.1	0.39	75.5	8,038	6.10	47	84.0%	100%	329	631	201	174	295	275	44.9	23.6	12	68%	12.6	12.9	2.5%
11/05/96	11:00	3,096	0.1	0.59	75.5	8,787	6.06	66	86.5%	100%	351	653	219	160	301	300	45.3	23.7	12	68%	13.0	13.3	2.5%

Appendix F.1
ROWTP Train Performance Data - Train #1 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
11/05/96	13:00	3,190	0.1	0.52	75.5	8,780	6.05	60	86.5%	100%	350	650	220	170	300	300	45.4	22.6	12	68%	12.9	13.3	2.5%
11/06/96	3:00	2,846	0.1	0.55	75.5	7,844	6.06	43	88.0%	100%	359	700	198	132	249	310	45.7	19.7	13	74%	13.9	14.3	2.5%
11/06/96	5:00	2,798	0.1	0.55	75.5	7,775	6.06	43	88.0%	100%	354	693	196	131	246	310	44.3	20.0	13	74%	13.8	14.1	2.5%
11/06/96	7:00	2,763	0.1	0.55	75.5	7,806	6.09	48	85.5%	100%	343	661	199	132	250	305	43.6	19.6	13	73%	13.2	13.5	2.5%
11/06/96	9:00	2,864	0.1	0.56	75.5	7,808	6.06	47	85.5%	100%	348	665	212	141	256	321	43.7	28.9	13	72%	13.2	13.6	2.7%
11/06/96	11:00	2,836	0.1	0.55	75.5	7,852	6.06	46	85.5%	100%	346	671	210	140	237	320	44.8	29.6	13	74%	13.4	13.7	2.7%
11/10/96	9:00	1,882	0.1	0.40	75.5	7,050	6.05	38	78.2%		302	602	170	150	270	250	42.3	21.6	12	69%	12.0	12.3	2.4%
11/10/96	11:00	1,890	0.1	0.40	75.5	6,962	6.05	38	78.2%		278	605	165	140	272	244	42.1	20.7	12	69%	12.0	12.3	2.4%
11/10/96	13:00	1,835	0.1	0.40	75.5	6,881	6.00	45	79.0%		269	645	128	120	281	255	43.5	22.2	12	70%	12.8	13.2	1.9%
11/11/96	3:00	1,916	0.1	0.39	75.0	8,106	6.00	56	85.0%	100%	341	656	183	122	279	280	47.0	24.3	12	70%	13.1	13.5	2.3%
11/11/96	5:00	1,932	0.1	0.39	75.0	8,087	6.00	55	85.0%	100%	342	653	184	123	300	285	46.8	24.4	12	69%	13.0	13.4	2.3%
11/11/96	7:00	1,941	0.1	0.38	75.0	8,094	6.10	56	85.0%	100%	333	641	182	121	302	285	46.2	24.1	12	68%	12.8	13.2	2.2%
11/11/96	9:00	2,857	0.1	0.58	75.0	8,000	6.08	38	85.0%		332	647	182	120	282	285	43.5	22.5	12	70%	12.9	13.3	2.3%
11/11/09	11:00	2,872	0.1	0.57	75.0	8,062	6.08	36	85.0%		330	652	180	120	280	285	42.6	22.4	12	70%	13.0	13.4	2.2%
11/11/96	13:00	2,879	0.1	0.57	74.5	8,006	6.09	34	85.0%		331	649	179	120	281	285	43.2	22.7	12	70%	12.9	13.5	2.2%
11/12/96	5:00	1,964	0.1	0.40	75.5	8,031	6.00	58	83.5%	100%	324	621	179	119	296	220	44.7	23.3	11.5	68%	12.4	12.7	2.2%
11/12/96	7:00	1,949	0.1	0.40	75.5	8,084	6.00	58	83.0%	100%	328	630	181	121	300	280	43.5	23.3	11.5	68%	12.5	12.8	2.2%
11/12/96	9:00	1,969	0.1	0.40	75.5			57	83.5%		326	628			300	260	43.2	24.0	11	68%	12.5	12.8	
11/12/96	13:00	1,936	0.1	0.39	75.0	8,019	6.06	59	72.0%		283	505	189	120	231	255	33.9	16.8	11	69%	10.0	10.4	2.4%
11/12/96	15:00	1,942	0.1	0.39	75.0	8,019	6.12	59	72.0%		282	448	258	150	235	250	33.9	17.2	11	66%	8.9	9.2	3.2%
11/12/96	17:00	1,921	0.1	0.39	75.5	8,031	6.06	59	72.0%	100%	282	506	247	150	232	260	34.1	16.7	11	69%	10.1	10.3	3.1%
11/12/96	19:00	1,934	0.1	0.40	75.5	8,050	6.09	57	84.0%	100%	335	648	192	160	272	290	44.7	21.8	11.5	70%	12.9	13.2	2.4%
11/12/96	21:00	1,932	0.1	0.40	75.0	8,062	6.06	57	84.5%	100%	339	652	189	160	282	290	45.5	22.4	11.5	70%	13.0	13.4	2.3%
11/15/96	3:00	2,780	0.1	0.57	75.5	7,938	6.10	43	85.5%	100%	343	651	186	124	269	290	43.2	21.6	12.5	71%	13.0	13.3	2.3%
11/15/96	5:00	2,813	0.1	0.57	75.0	7,894	6.00	44	85.0%	100%	339	656	192	128	278	285	42.3	21.4	12.5	70%	13.1	13.5	2.4%
11/15/96	7:00	2,800	0.1	0.59	75.5	7,919	6.00	42	86.0%	100%	341	654	187	125	279	290	42.6	22.0	12.5	70%	13.0	13.3	2.4%
11/15/96	11:00	2,723	0.1	0.57	75.5	7,850	6.10	52	85.0%	100%	354	663	155	103	231	310	41.0	18.1	12.5	74%	13.2	13.5	2.0%
11/15/96	13:00	2,719	0.1	0.58	76.0	7,781	6.09	53	85.0%	100%	352	660	206	130	231	310	40.9	17.8	12	74%	13.1	13.4	2.6%
11/15/96	19:00	2,715	0.1	0.58	76.0	7,881	6.09	52	85.0%	100%	349	650	202	160	228	310	41.4	17.5	12.5	74%	12.9	13.1	2.6%
11/15/96	23:00	2,809	0.1	0.57	76.0	7,962	6.09	39	86.5%	100%	336	650	183	140	278	290	44.2	22.3	12	70%	12.9	13.1	2.3%
11/16/96	3:00	2,811	0.1	0.58	76.0	7,944	6.00	40	85.5%	100%	342	658	178	119	279	290	42.9	21.9	12.5	70%	13.1	13.3	2.2%
11/16/96	5:00	2,789	0.1	0.57	76.0	7,969	6.00	40	85.0%	100%	336	645	182	122	271	300	43.7	21.6	12.5	70%	12.8	13.0	2.3%
11/16/96	21:00	2,778	0.1	0.57	76.0	7,875	6.09	48	87.5%	100%	350	680	180	150	275	300	46.5	22.7	12	71%	13.5	13.8	2.3%
11/17/96	3:00	2,793	0.1	0.58	76.0	8,038	6.00	41	88.0%	100%	354	685	183	122	273	300	45.2	22.2	12.5	72%	13.6	13.9	2.3%
11/17/96	5:00	2,820	0.1	0.58	76.0	8,069	6.00	42	87.5%	100%	352	669	187	125	275	310	46.4	22.1	12.5	71%	13.3	13.5	2.3%
11/17/96	7:00	2,802	0.1	0.57	76.0	8,038	6.00	41	88.0%	100%	353	686	185	123	273	305	45.5	22.1	12.5	72%	13.7	13.9	2.3%
11/17/96	9:00	2,804	0.1	0.57	76.0	8,026	6.06	42	88.0%	100%	352	682	186	124	272	305	45.4	22.1	12.5	71%	13.6	13.8	2.3%
11/17/96	11:00	2,804	0.1	0.57	76.0	7,975	6.06	42	88.0%	100%	352	686	184	123	272	305	44.3	21.1	12.5	72%	13.7	13.9	2.3%
11/17/96	13:00	2,796	0.1	0.58	76.0	8,094	6.12	42	87.5%	100%	347	677	180	120	272	305	44.9	26.9	12	71%	13.5	13.7	2.2%

Appendix F.1
ROWTP Train Performance Data - Train #1 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data												Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press.	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gfd)	(gfd @ 25C)	(%)
11/18/96	11:00	2,682	0.1	0.56	76.0	7,918	6.10	59	86.8%		355	689	189	120	273	292	44.5	21.5	11.5	72%	13.7	13.9	2.4%
11/18/96	13:00	2,684	0.1	0.55	76.0	7,922	6.09	58	87.1%		357	690	189	140	275	292	44.4	21.1	11.5	72%	13.7	14.0	2.4%
11/18/96	15:00	2,682	0.1	0.54	76.0	8,024	6.09	59	87.1%		352	684	192	160	276	294	44.5	21.1	11.5	71%	13.6	13.8	2.4%
11/18/96	19:00	2,850	0.1	0.55	76.0	8,100	6.06	34	88.5%		360	688	199	160	267	310	45.5	21.9	11.5	72%	13.7	13.9	2.5%
11/18/96	21:00	2,883	0.1	0.55	76.0	8,069	6.09	32	88.5%	100%	360	681	192	150	275	310	44.1	21.4	12	71%	13.6	13.8	2.4%
11/19/96	3:00	2,772	0.1	0.55	76.0	8,138	6.09	41	85.0%	100%	338	637	192	150	271	300	44.1	20.9	12	70%	12.7	12.9	2.4%
11/19/96	5:00	2,765	0.1	0.56	76.0	8,125	6.12	41	86.5%	100%	348	655	191	150	269	295	42.9	21.2	12.5	71%	13.0	13.3	2.4%
11/19/96	13:00	2,656	0.1	0.54	76.0	7,894	6.09	59	84.5%	100%	348	645	185	160	272	295	43.7	20.5	12	70%	12.8	13.0	2.3%
11/19/96	19:00	2,726	0.1	0.55	76.0	8,069	6.09	47	85.0%	100%	341	646	268	160	272	295	45.1	21.7	12	70%	12.9	13.1	3.3%
11/21/96	7:00	2,710	0.1	0.55	76.0	8,038	6.06	54	87.0%	100%	358	682	105	160	267	310	47.0	21.5	12.5	72%	13.6	13.8	1.3%
11/22/96	13:00	1,826	0.1	0.40	76.0	8,293	6.10		89.0%	100%	368	688	193	160	267	310	47.2	21.6	12	72%	13.7	13.9	2.3%
11/22/96	17:00	2,785	0.1	0.57	73.0	8,025	6.09	46	88.5%	100%	359	678	187	150	274	310	46.4	21.6	12	71%	13.5	14.4	2.3%
11/22/96	19:00	2,772	0.1	0.57	73.0	8,069	6.06	44	88.5%	100%	362	687	189	140	269	310	46.4	21.0	12	72%	13.7	14.6	2.3%
11/22/96	21:00	2,761	0.1	0.56	73.5	8,125	6.09	40	89.0%	100%	358	681	184	150	270	310	47.1	21.9	12.5	72%	13.6	14.4	2.3%
11/23/96	3:00	2,754	0.1	0.57	74.5	8,235	6.00	41	88.5%	100%	356	676	181	121	268	310	46.3	21.0	13	72%	13.5	14.0	2.2%
11/23/96	5:00	2,774	0.1	0.57	74.5	8,198	6.00	42	88.0%	100%	363	682	184	123	270	315	47.4	21.0	13	72%	13.6	14.1	2.2%
11/25/96	9:00	2,763	0.1	0.55	75.0	7,879	6.09	47	85.0%	100%	336	643	179	160	268	290	44.3	21.6	12	71%	13.0	13.4	2.3%
11/25/96	11:00	2,762	0.1	0.55	75.0	7,870	6.06	46	85.0%	100%	337	652	192	160	272	290	44.4	21.5	12	71%	13.0	13.4	2.3%
11/25/96	13:00	2,769	0.1	0.55	75.0	7,956	6.06	47	85.0%	100%	338	659	182	140	273	290	44.4	22.1	12	71%	13.1	13.6	2.3%
11/26/96	3:00	2,802	0.1	0.55	75.0	7,894	6.00	53	85.0%	100%	336	651	166	110	302	280	47.1	24.6	12	68%	13.0	13.4	2.1%
11/26/96	5:00	2,772	0.1	0.55	75.5	7,931	6.00	48	85.0%	100%	332	640	172	115	298	280	47.5	24.1	12	68%	12.7	13.1	2.2%
11/26/96	7:00	2,780	0.1	0.56	75.0	7,944	6.10	47	86.5%	100%	340	660	171	114	300	280	46.9	24.6	12	69%	13.1	13.6	2.2%
11/29/96	5:00	1,964	0.1	0.19	76.0	7,950	6.00	59	85.0%	100%	338	654	179	119	299	280	46.7	24.5	12	69%	13.0	13.2	2.3%
11/29/96	7:00	1,972	0.1	0.20	76.0	7,938	6.10	58	85.0%	100%	335	649	181	121	300	285	47.4	24.6	12	68%	12.9	13.1	2.3%
12/01/96	7:00	1,953	0.1	0.42	76.0	8,044	6.00	58	85.0%	100%	332	638	189	126	301	280	47.3	24.8	11.5	68%	12.7	12.9	2.3%
12/02/96	3:00	1,982	0.1	0.40	76.0	7,956	6.20	59	81.0%	100%	314	601	174	116	300	265	44.1	24.7	11.5	67%	12.0	12.2	2.2%
12/02/96	5:00	1,999	0.1	0.40	76.0	7,988	6.20	59	81.5%	100%	308	599	166	110	296	260	45.4	24.4	11.5	67%	11.9	12.1	2.1%
12/02/96	7:00	1,975	0.1	0.40	76.0	7,962	6.20	59	81.5%	100%	316	602	182	121	303	265	43.8	23.7	11.5	67%	12.0	12.2	2.3%
12/02/96	8:30	1,962	0.1	0.40	76.0	8,056	6.25	59	85.2%	100%	337	643	180	126	269	295	45.2	21.8	11.5	71%	12.8	13.0	2.2%
12/04/96	11:00	2,824	0.1	0.62	76.0	7,875	6.10	53	88.2%	100%	356	692	166	120	271	295	46.5	21.6	11.5	72%	13.8	14.0	2.1%
12/04/96	13:00	2,833	0.1	0.60	76.0	7,875	6.06	49	87.0%	100%	355	685	164	140	269	305	46.6	21.4	11.5	72%	13.6	13.9	2.1%
12/04/96	15:00	4,648	0.1	0.90	76.0	9,562	6.09	49	88.5%	100%	384	674	269	160	267	325	42.8	20.8	15	72%	13.4	13.6	2.8%
12/04/96	17:00	4,642	0.1	0.91	76.0	10,925	6.09	47	91.5%	100%	408	657	279	190	270	365	43.3	20.8	14	71%	13.1	13.3	2.6%
12/04/96	19:00	4,662	0.1	0.92	76.0	9,788	6.06	50	88.5%	100%	377	646	224	170	273	330	41.9	28.6	14.5	70%	12.9	13.1	2.3%
12/04/96	21:00	4,646	0.1	0.92	76.0	9,319	6.06	50	87.0%	100%	377	661	211	150	268	320	43.2	20.7	14.5	71%	13.2	13.4	2.3%
12/04/96	23:00	4,657	0.1	0.92	76.0	9,206	6.12	48	88.0%	100%	374	657	206	160	270	320	43.7	21.2	15	71%	13.1	13.3	2.2%
12/05/96	3:00	4,640	0.1	0.92	76.0	9,162	6.09	46	88.0%	100%	366	656	198	150	267	320	44.3	21.6	15	71%	13.1	13.3	2.2%
12/05/96	5:00	4,642	0.1	0.92	76.0	9,156	6.09	46	88.0%	100%	362	650	198	150	269	320	43.7	20.7	15	71%	12.9	13.1	2.2%
12/05/96	7:00	4,672	0.1	0.92	76.0	9,262	6.09	45	87.0%	100%	348	650	201	150	272	320	43.4	20.6	15	70%	12.9	13.1	2.2%

Appendix F.1
ROWTP Train Performance Data - Train #1 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
12/05/96	9:00	4,646	0.1	0.92	76.0	9,231	6.06	45	86.5%	100%	356	642	195	150	272	320	43.3	21.4	15	70%	12.8	13.0	2.1%
12/05/96	11:00	4,682	0.1	0.92	76.0	9,237	6.04	46	86.6%	100%	358	648	198	150	270	320	45.4	21.3	15	71%	12.9	13.1	2.1%
12/05/96	13:00	4,684	0.2	0.92	76.0	9,219	6.06	45	88.5%	100%	360	643	195	150	274	320	45.6	21.4	15	70%	12.8	13.0	2.1%
12/05/96	15:00	4,659	0.2	0.93	76.0	9,222	6.06	44	88.5%	100%	359	650	195	150	272	320	44.3	20.8	15	70%	12.9	13.1	2.1%
12/05/96	17:00	4,662	0.2	0.92	76.0	9,225	6.09	45	88.5%	100%	362	698	195	160	276	320	44.5	20.6	15	72%	13.9	14.1	2.1%
12/05/96	19:00	4,629	0.2	0.92	76.0	9,225	6.09	44	88.5%	100%	365	654	192	160	275	320	44.3	21.7	15	70%	13.0	13.2	2.1%
12/05/96	21:00	4,640	0.3	0.92	76.0	9,112	6.12	45	87.5%	100%	364	652	192	130	272	320	44.3	20.8	14.5	71%	13.0	13.2	2.1%
12/05/96	23:00	4,640	0.2	0.92	76.0	9,175	6.06	45	88.5%	100%	369	652	194	150	275	320	44.2	21.6	14.5	70%	13.0	13.2	2.1%
12/06/96	3:00	4,622	0.3	0.92	76.0	9,144	6.09	45	87.0%	100%	364	640	193	140	269	320	45.4	21.6	14.5	70%	12.7	12.9	2.1%
12/06/96	5:00	4,631	0.3	0.92	76.0	9,122	6.09	45	87.5%	100%	370	652	194	140	274	320	45.7	21.2	14.5	70%	13.0	13.2	2.1%
12/06/96	7:00	4,653	0.2	0.92	76.0	9,244	6.09	43	87.0%	100%	368	655	188	140	272	320	45.9	21.0	15	71%	13.0	13.3	2.0%
12/06/96	9:00	4,645	0.2	0.92	76.0	9,246	6.06	44	87.5%	100%	367	652	190	140	272	320	45.8	21.1	15	71%	13.0	13.2	2.1%
12/06/96	11:00	4,585	0.3	0.92	76.0	9,131	6.06	47	84.0%	100%	342	595	180	140	268	300	41.2	20.7	14	69%	11.8	12.0	2.0%
12/10/96	11:00	2,010	0.1	0.42	76.0	7,950	6.06	57	84.9%	100%	337	658	174	120	303	280	45.2	24.4	13	68%	13.1	13.3	2.2%
12/13/96	5:00	1,754	0.1	0.39	76.5	7,500	6.00	31	82.5%	100%	305	603	174	116	301	250	43.8	24.3	12	67%	12.0	12.1	2.3%
12/13/96	7:00	1,741	0.1	0.40	76.5	7,600	6.00	28	82.5%	100%	306	595	174	116	303	260	42.4	24.2	12	66%	11.8	11.9	2.3%
12/15/96	17:00	1,726	0.1	0.34	77.0	7,750	6.06	41	84.0%	100%	324	627	181	150	268	280	42.0	21.1	11.5	70%	12.5	12.5	2.3%
12/15/96	19:00	1,732	0.1	0.34	77.0	7,781	6.12	37	84.0%	100%	320	620	191	150	268	280	42.3	21.5	11.5	70%	12.3	12.3	2.5%
12/15/96	21:00	1,735	0.1	0.34	77.0	7,819	6.09	36	84.0%	100%	325	624	192	150	269	280	42.1	21.4	11.5	70%	12.4	12.4	2.5%
12/16/96	3:00	1,726	0.1	0.35	77.0	7,825	6.00	36	83.5%	100%	325	630	192	128	268	280	41.5	21.3	12	70%	12.5	12.5	2.5%
12/16/96	5:00	1,731	0.1	0.35	77.0	7,838	6.00	34	83.5%	100%	323	627	188	125	273	280	41.0	21.4	12	70%	12.5	12.5	2.4%
12/16/96	7:00	1,744	0.1	0.34	77.0	7,856	6.00	33	84.0%	100%	326	631	188	125	267	285	41.6	21.4	12	70%	12.6	12.6	2.4%
12/17/96	5:00	1,748	0.1	0.35	77.0	7,903	6.00	56	83.5%	100%	326	629	189	124	269	280	41.4	21.4	12	70%	12.5	12.5	2.4%
12/27/96	3:00	2,717	0.2	0.39	76.5	7,794	6.00	30	83.5%	100%	314	598	175		296	260	43.8	24.4	12	67%	11.9	12.0	2.2%
12/27/96	5:00	2,739	0.2	0.40	76.0	7,788	5.90	31	83.5%	100%	309	592	177		302	255	44.3	24.6	12	66%	11.8	12.0	2.3%
12/27/96	7:00	2,544	0.1	0.39	77.5	7,700	5.90	52	75.0%	100%	280	550	193		275	240	38.1	21.7	11.5	67%	10.9	10.9	2.5%
12/28/96	3:00	2,782	0.1	0.60	77.5	7,906	6.00	45	82.5%	100%	309	605	186		298	260	43.3	24.6	12	67%	12.0	11.9	2.4%
12/28/96	5:00	2,765	0.1	0.60	77.5	7,938	6.00	45	82.0%	100%	312	609	184		299	265	44.5	24.4	12	67%	12.1	12.0	2.3%
12/28/96	7:00	2,752	0.1	0.66	78.0	8,006	6.00	37	83.0%	100%	311	604	191		298	265	43.3	23.8	12	67%	12.0	11.8	2.4%
12/28/96	9:00	2,769	0.1	0.60	78.0	8,025	6.09	35	86.0%	100%	343	653	190	120	270	275	44.1	21.1	12	71%	13.0	12.8	2.4%
12/30/96	3:00	1,754	0.1	0.38	76.5	7,088	5.90	49	80.5%	100%	300	595			303	250	45.3	24.6	11	66%	11.8	11.9	
12/30/96	5:00	1,761	0.1	0.39	77.5	7,475	6.00	34	82.0%	100%	305	601	175		296	255	43.6	24.7	11	67%	12.0	11.9	2.3%
12/30/96	7:00	1,748	0.1	0.39	74.5	7,481	5.90	34	82.5%	100%	304	604	176		298	260	44.5	24.8	11	67%	12.0	12.5	2.4%
01/02/97	3:00	1,873	0.2	0.38	71.5	7,256	6.06	61	85.0%	100%	342	690	162	120	285	285	46.9	23.4	11	71%	13.7	15.0	2.2%
01/02/97	5:00	1,886	0.2	0.39	71.5	7,250	6.09	61	85.0%	100%	343	692	161	130	283	285	46.8	23.8	11	71%	13.8	15.1	2.2%
01/02/97	7:00	1,880	0.2	0.38	71.5	7,262	6.06	60	85.0%	100%	342	690	160	130	282	285	46.7	23.6	11	71%	13.7	15.0	2.2%
01/02/97	9:00	1,859	0.2	0.38	70.0	7,269	6.06	60	86.0%	100%	343	692	156	120	281	285	47.2	23.4	11	71%	13.8	15.4	2.1%
01/02/97	11:00	1,806	0.2	0.37	70.5	7,261	6.06	60	86.0%	100%	347	694	158	130	280	285	47.1	23.6	11	71%	13.8	15.4	2.2%
01/02/97	19:00	3,863	0.2	0.90	70.5	10,706	6.09	39	94.5%	100%	418	685	276	190	277	380	49.1	21.9	13.5	71%	13.6	15.2	2.6%

Appendix F.1
ROWTP Train Performance Data - Train #1 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data												Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
01/02/97	21:00	3,839	0.2	0.89	70.5	10,525	6.06	40	94.5%	100%	422	694	275	200	286	365	47.7	22.0	13.5	71%	13.8	15.4	2.6%
01/02/97	23:00	3,852	0.2	0.90	71.0	10,569	6.09	40	94.5%	100%	418	690	270	190	276	365	47.6	21.7	13.5	71%	13.7	15.2	2.6%
01/03/97	3:00	3,819	0.3	0.89	71.5	10,412	6.00	39	93.5%	100%	412	687	258		282	360	47.6	21.8	13	71%	13.7	15.0	2.5%
01/03/97	5:00	3,809	0.3	0.90	71.5	10,350	6.00	40	94.0%	100%	417	691	259		277	360	47.9	21.5	13.5	71%	13.8	15.1	2.5%
01/03/97	7:00	3,857	0.3	0.88	71.5	10,431	6.00	35	94.5%	100%	413	692	253		282	360	48.5	22.3	13	71%	13.8	15.1	2.4%
01/03/97	11:00	3,846	0.3	0.91	70.0	10,344	6.09	36	94.0%	100%	417	699	252	200	279	365	47.1	21.7	13	71%	13.9	15.6	2.4%
01/03/97	15:00	4,775	0.2	0.96	70.0	9,775	6.12	55	91.5%	100%	401	692	217	160	278				15	71%	13.8	15.4	2.2%
01/03/97	17:00	4,784	0.2	0.98	70.5	9,831	6.09	56	91.0%	100%	399	688	222	150	283	350	46.6	22.2	15	71%	13.7	15.2	2.3%
01/03/97	19:00	4,773	0.2	0.92	71.0	9,794	6.06	56	91.5%	100%	401	689	224	170	283	350	46.5	22.4	15	71%	13.7	15.1	2.3%
01/03/97	21:00	4,793	0.2	0.96	71.0	9,875	6.09	54	92.0%	100%	404	694	225	160	278	350	45.5	21.6	15	71%	13.8	15.2	2.3%
01/03/97	23:00	4,756	0.2	0.93	71.0	9,888	6.06	55	91.0%	100%	399	686	224	160	280	350	46.8	22.2	15	71%	13.7	15.1	2.3%
01/04/97	3:00	4,781	0.2	0.94	70.5	9,900	6.00	53	91.5%	100%	402	691	225		283	350	46.5	22.0	15	71%	13.8	15.3	2.3%
01/04/97	5:00	4,782	0.2	0.92	70.5	9,850	6.10	54	92.0%	100%	404	690	224		273	350	45.7	21.8	15	72%	13.7	15.3	2.3%
01/04/97	7:00	4,797	0.2	0.94	71.0	9,831	6.00	53	92.0%	100%	403	694	221		280	350	46.0	21.9	15	71%	13.8	15.2	2.2%
01/04/97	9:00	4,784	0.2	0.94	71.0	9,950	6.00	52	92.5%	100%	405	692	223		278	350	46.0	21.8	15	71%	13.8	15.2	2.2%
01/04/97	11:00	4,788	0.2	0.92	70.5	9,950	6.09	53	92.0%	100%	403	691	225	160	282	345	45.9	22.3	15	71%	13.8	15.3	2.3%
01/04/97	13:00	4,810	0.2	0.97	71.0	9,950	6.06	53	91.5%	100%	403	691	223	160	278	350	46.4	22.1	15	71%	13.8	15.2	2.2%
01/06/97	5:00	1,708	0.2	0.36	75.0	8,425	5.90	29	80.0%	100%	301	549			303	280	42.1	23.7	11	64%	10.9	11.3	
01/06/97	7:00	1,822	0.2	0.42	75.0	7,969	6.00	49	85.0%	100%	333	646	174		305	285	47.4	25.4	11.5	68%	12.9	13.3	2.2%
01/06/97	9:00	1,785	0.2	0.37	75.5	8,025	6.06	55	84.5%	100%	344	655	189	140	268	295	44.8	26.2	11.5	71%	13.0	13.4	2.4%
01/06/97	11:00	1,770	0.2	0.37	75.5	8,219	6.09	52	86.0%	100%	348	666	192	140	273	300	48.3	26.7	11	71%	13.3	13.6	2.3%
01/06/97	13:00	1,772	0.2	0.37	75.0	8,238	6.09	52	85.0%	100%	352	655	190	130	267	300	48.6	26.3	11	71%	13.0	13.5	2.3%
01/06/97	19:00	2,796	0.2	0.61	78.6	11,631	6.12	54	92.4%	100%	434	652	358	240	270	380	43.4	28.2	12.5	71%	13.0	12.6	3.1%
01/07/97	3:00	4,728	0.1	0.80	75.5	10,525	6.00	56	89.0%	100%	394	649	278		267	355	44.5	19.7	14.5	71%	12.9	13.2	2.6%
01/07/97	5:00	4,841	0.2	0.82	76.0	10,138	6.10	55	88.5%	100%	388	665	242		273	340	43.6	21.1	15	71%	13.2	13.5	2.4%
01/07/97	7:00	4,732	0.1	0.80	77.0	10,056	6.10	61	88.5%	100%	386	663	240		267	335	43.2	20.5	14.5	71%	13.2	13.2	2.4%
01/07/97	13:00	4,742	0.2	0.91	76.0	9,906	6.09	58	91.0%	100%	401	679	238	170	272	325	44.8	21.1	15	71%	13.5	13.7	2.4%
01/07/97	17:00	4,751	0.2	0.92	76.5	10,056	6.06	58	90.0%	100%	397	675	237	140	274	350	44.7	21.1	15	71%	13.4	13.5	2.4%
01/07/97	19:00	4,767	0.2	0.89	76.5	10,050	6.09	58	88.5%	100%	399	672	236	170	265	355	43.8	21.2	15	72%	13.4	13.5	2.3%
01/07/97	23:00	4,760	0.2	0.92	76.0	9,956	6.09	57	89.0%	100%	400	680	236	170	267	350	44.1	20.7	15	72%	13.5	13.8	2.4%
01/08/97	3:00	4,764	0.2	0.93	76.5	10,038	6.06	55	91.0%	100%	400	680	236	170	268	355	44.2	20.6	15	72%	13.5	13.6	2.4%
01/08/97	5:00	4,740	0.2	0.91	76.5	9,981	6.12	56	90.5%	100%	401	679	237	170	267	350	44.1	20.6	15	72%	13.5	13.6	2.4%
01/08/97	9:00	4,432	0.2	0.90	76.5	9,880	6.09	54	91.0%	100%	402	680	238	170	278	355	44.0	20.7	15	71%	13.5	13.6	2.4%
01/08/97	11:00	4,729	0.2	0.89	76.5	9,838	6.06	53	91.0%	100%	401	682	236	180	274	254	44.8	21.2	15	71%	13.6	13.7	2.4%
02/18/97	15:00	3,467	0.1	0.75	78.0	8,106	6.40	35	82.0%	100%	313	596	192	128	267	270	41.8	21.4	12.5	69%	11.9	11.7	2.4%
02/18/97	19:00	3,798	0.1	0.75	78.0	9,769	6.09	46	88.0%	100%	381	678	270	200	268	335	43.9	22.0	13	72%	13.5	13.3	2.8%
02/18/97	21:00	3,806	0.1	0.75	78.5	9,431	6.12	43	88.0%	100%	368	663	268	200	271	325	46.1	21.3	13	71%	13.2	12.9	2.8%
02/18/97	23:00	3,815	0.3	0.74	78.5	9,306	6.09	44	88.5%	100%	382	685	240	200	270	320	43.8	21.2	13	72%	13.6	13.3	2.6%
02/19/97	3:00	3,791	0.3	0.75	78.5	9,256	6.09	42	87.5%	100%	376	666	234	160	270	325	45.1	21.1	13	71%	13.3	12.9	2.5%

Appendix F.1
ROWTP Train Performance Data - Train #1 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data												Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
02/19/97	5:00	3,813	0.3	0.75	78.5	9,256	6.06	38	88.5%	100%	377	678	226	160	272	330	43.4	20.9	13	71%	13.5	13.2	2.4%
02/19/97	7:00	3,808	0.3	0.75	78.5	9,244	6.09	38	89.5%	100%	378	679	229	160	268	320	43.0	21.0	13	72%	13.5	13.2	2.5%
02/19/97	9:00	3,723	0.3	0.75	78.5	9,288	6.09	25	89.5%	100%	382	693	227	170	273	320	45.5	20.6	13	72%	13.8	13.5	2.4%
02/19/97	11:00	3,618	0.2	0.75	78.5	8,994	6.06	54	84.0%	100%	339	622	211	141	270	295	42.1	21.0	12.5	70%	12.4	12.1	2.3%
02/19/97	13:00	2,734	0.1	0.53	78.0	7,150	6.06	55	81.5%	100%	315	626	157	105	270	270	42.1	21.6	12	70%	12.5	12.3	2.1%
02/19/97	15:00	2,723	0.1	0.53	77.5	7,094	6.09	56	81.0%	100%	310	632	269	179	265	265	43.4	21.6	11.5	70%	12.6	12.5	3.8%
02/19/97	17:00	2,728	0.1	0.53	77.5	7,086	6.09	56	80.0%	100%	310	634	152	120	268	265	43.1	21.6	11.5	70%	12.6	12.5	2.1%
02/19/97	19:00	2,721	0.1	0.53	78.0	7,081	6.09	57	80.0%	100%	311	631	149	120	271	265	43.5	21.6	11.5	70%	12.6	12.4	2.1%
02/19/97	21:00	2,748	0.1	0.53	78.0	7,156	6.09	44	83.5%	100%	319	640	147	120	274	265	43.6	21.3	11.5	70%	12.7	12.5	2.1%
02/21/97	3:00	4,666	0.1	0.95	78.5	10,212	6.00	49	89.0%	100%	389	650	258	170	272	350	42.7	20.2	14	70%	12.9	12.6	2.5%
02/21/97	5:00	4,646	0.1	0.96	78.5	10,150	6.00	48	88.0%	100%	398	645	252	170	271	340	42.8	20.7	14	70%	12.8	12.5	2.5%
02/21/97	7:00	4,677	0.1	0.96	78.0	10,194	6.00	54	88.5%	100%	387	646	251	170	274	340	42.0	20.6	14	70%	12.9	12.6	2.5%
02/21/97	9:00	4,679	0.1	0.94	78.0	10,069	6.09	54	87.5%	100%	381	641	248	175	267	335	43.8	21.2	14.5	71%	12.8	12.5	2.5%
02/21/97	11:00	4,699	0.1	0.95	78.0	10,150	6.06	53	88.5%	100%	388	659	251	170	269	350	43.8	19.0	15	71%	13.1	12.9	2.5%
02/21/97	13:00	4,679	0.1	0.96	78.0	10,031	6.09	54	88.0%	100%	390	660	249	165	268	340	43.1	20.9	15	71%	13.1	12.9	2.5%
02/21/97	15:00	4,670	0.1	0.95	78.0	10,019	6.06	55	89.5%	100%	384	646	248	165	268	345	44.6	20.0	15	71%	12.9	12.6	2.5%
02/21/97	17:00	4,668	0.1	0.94	78.0	10,100	6.12	55	89.0%	100%	379	642	249	170	269	340	43.0	20.9	14	70%	12.8	12.6	2.4%
02/21/97	19:00	4,672	0.1	0.97	78.5	10,019	6.06	55	88.5%	100%	387	658	249	170	271	340	42.9	20.5	14	71%	13.1	12.8	2.5%
02/22/97	3:00	4,686	0.1	0.96	78.5	9,975	6.00	53	88.5%	100%	389	653	249	165	269	340	42.1	21.2	14	71%	13.0	12.7	2.5%
02/22/97	5:00	4,659	0.1	0.96	77.5	10,069	6.00	54	86.5%	100%	370	621	244	165	282	325	42.8	21.2	14	69%	12.4	12.3	2.4%
02/22/97	7:00	4,633	0.1	0.94	77.5	10,081	6.00	54	86.5%	100%	374	630	244	165	278	325	42.3	21.3	14	69%	12.5	12.4	2.4%
02/22/97	9:00	4,659	0.1	0.96	77.5	10,031	6.00	54	86.0%	100%	372	626	248	165	280	330	41.3	21.4	14	69%	12.5	12.4	2.5%
02/22/97	11:00	4,653	0.1	0.96	77.5	10,069	6.06	53	87.0%	100%	377	635	246	165	278	330	41.3	21.6	14	70%	12.6	12.5	2.4%
02/22/97	13:00	4,640	0.1	0.97	77.0	10,069	6.06	48	87.0%	100%	375	630	244	170	278	325	42.2	21.3	14	69%	12.5	12.5	2.4%
02/22/97	15:00	3,972	0.1	0.78	77.0	9,569	6.06	55	88.0%	100%	393	683	220	150	262	340	45.0	20.3	12.5	72%	13.6	13.6	2.3%
02/22/97	19:00	2,920	0.1	0.78	77.0	10,525	6.09	53	91.5%	100%	416	685	267	190	258	370	43.2	19.4	11.5	73%	13.6	13.6	2.5%
02/22/97	21:00	2,929	0.1	0.58	77.0	10,212	6.09	53	92.0%	100%	419	686	272	180	261	370	43.0	19.3	12	72%	13.7	13.7	2.7%
02/23/97	3:00	2,940	0.1	0.58	77.0	10,287	6.00	54	89.0%	100%	403	658	275	180	258	355	42.3	19.3	12	72%	13.1	13.1	2.7%
02/23/97	5:00	2,916	0.1	0.57	77.0	10,362	6.00	54	88.5%	100%	402	655	276	180	263	350	43.2	20.1	12	71%	13.0	13.0	2.7%
02/23/97	7:00	2,968	0.1	0.58	77.0	10,519	6.00	54	87.5%	100%	403	663	276	180	259	350	40.9	19.5	12	72%	13.2	13.2	2.6%
02/23/97	11:00	2,772	0.1	0.57	77.5	10,081	6.06	38	90.0%	100%	390	646	271	170	270	345	43.7	20.4	11.5	71%	12.9	12.8	2.7%
02/23/97	13:00	2,762	0.1	0.56	77.5	10,052	6.09	40	88.0%	100%	382	652	256	160	271	345	44.1	20.5	11.5	71%	13.0	12.9	2.5%
02/23/97	15:00	2,785	0.1	0.57	77.5	9,969	6.09	42	88.0%	100%	379	647	252	160	272	345	44.1	20.5	11.5	70%	12.9	12.8	2.5%
02/23/97	17:00	4,014	0.1	0.80	77.5	9,744	6.06	55	88.0%	100%	388	665	228	160	273	350	44.4	20.3	13	71%	13.2	13.1	2.3%
02/23/97	23:00	3,749	0.1	0.75	77.0	9,569	6.09	52	87.5%	100%	381	660	224	160	270	340	43.7	20.9	13	71%	13.1	13.1	2.3%
02/24/97	3:00	3,780	0.1	0.77	77.5	9694	6.00	51	88.5%	100%	390	669	229	150	272	340	45.1	20.6	13	71%	13.3	13.2	2.4%
02/24/97	5:00	3,778	0.1	0.71	77.5	9850	6.00	45	89.5%	100%	388	665	226	150	270	345	44.0	20.6	13	71%	13.2	13.1	2.3%
02/24/97	7:00	3,800	0.1	0.78	77.5	9681	6.00	49	88.0%	100%	381	655	226	150	271	345	44.9	20.9	13	71%	13.0	12.9	2.3%
02/24/97	9:00	3,776	0.1	0.75	77.5	9788	6.09	58	88.5%	100%	396	678	231	155	272	340	43.5	20.3	13	71%	13.5	13.4	2.4%

Appendix F.1
ROWTP Train Performance Data - Train #1 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data												Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gfd)	(gfd @ 25C)	(%)
02/24/97	13:00	4,010	0.1	0.76	77.5	9138	6.09	58	89.5%	100%	374	669	184	125	289	320	45.7	23.1	13	70%	13.3	13.2	2.0%
02/24/97	15:00	3,927	0.1	0.73	77.5	9056	6.09	62	87.0%	100%	372	672	185	125	286	320	47.2	24.0	13	70%	13.4	13.3	2.0%
02/24/97	19:00	3,741	0.1	0.76	77.5	9025	6.09	40	88.5%	100%	361	652	195	140	269	320	43.9	22.0	13	71%	13.0	12.9	2.2%
02/24/97	21:00	3,744	0.1	0.77	77.5	9012	6.09	40	88.0%	100%	362	654	194	140	268	320	43.6	21.6	13	71%	13.0	12.9	2.2%
02/24/97	23:00	3,745	0.2	0.76	78.0	8981	6.06	39	88.0%	100%	361	648	193	140	267	320	43.6	21.2	13	71%	12.9	12.7	2.1%
02/25/97	3:00	3,771	0.2	0.76	78.0	8,969	6.00	40	88.0%	100%	363	648	190	125	268	320	43.9	21.1	13	71%	12.9	12.7	2.1%
02/25/97	5:00	3,758	0.2	0.76	78.0	8,981	6.00	39	87.5%	100%	364	656	194	130	269	315	44.2	20.8	13	71%	13.1	12.8	2.2%
02/25/97	7:00	2,765	0.2	0.55	77.5	7,881	6.00	54	84.5%	100%	341	650	151	100	270	295	44.2	21.5	12	71%	12.9	12.8	1.9%
02/25/97	9:00	2,796	0.1	0.53	77.5	8,200	6.09	46	86.0%	100%	337	647	166	125	269	300	44.5	21.4	12	71%	12.9	12.8	2.0%
02/25/97	11:00	2,021	0.1	0.55	77.5	8,331	6.09	60	87.0%	100%	370	682	172	115	282	315	47.4	22.7	11	71%	13.6	13.5	2.1%
02/25/97	13:00	3,697	0.1	0.74	78.0	8,675	6.09	43	86.0%	100%	356	654	208	140	258	310	43.6	20.3	13	72%	13.0	12.8	2.4%
02/25/97	15:00	3,679	0.1	0.73	78.0	8,806	6.06	42	87.0%	100%	361	653	212	140	259	315	43.2	19.3	13	72%	13.0	12.8	2.4%
02/25/97	17:00	3,674	0.1	0.73	78.0	8,862	6.08	41	87.0%	100%	360	642	218	160	259	315	43.1	20.1	13	71%	12.8	12.6	2.5%
02/25/97	19:00	3,673	0.1	0.73	78.0	8,875	6.12	40	87.0%	100%	358	648	214	150	258	315	43.1	20.1	13	72%	12.9	12.7	2.4%
02/25/97	21:00	3,652	0.1	0.73	78.0	8,878	6.06	36	87.0%	100%	360	652	215	160	260	310	43.1	19.9	13	71%	13.0	12.8	2.4%
02/25/97	9:00	3,653	0.1	0.73	78.0	8,731	6.06	44	87.0%	100%	362	653	212	160	263	310	43.1	19.8	13	71%	13.0	12.8	2.4%
02/26/97	3:00	2,778	0.1	0.53	78.0	7,200	6.09	37	84.5%	100%	321	641	142	110	269	280	44.2	21.9	11.5	70%	12.8	12.5	2.0%
02/26/97	5:00	2,774	0.1	0.53	78.0	7,194	6.09	37	85.0%	100%	328	649	145	110	269	275	44.6	21.7	12	71%	12.9	12.7	2.0%
02/26/97	7:00	2,767	0.1	0.54	78.0	7,206	6.06	37	85.0%	100%	324	656	142	110	272	280	44.2	21.7	12	71%	13.1	12.8	2.0%
02/26/97	11:00	2,767	0.1	0.54	78.0	7,162	6.06	37	84.0%	100%	325	648	142	110	270	280	44.0	22.0	11.5	71%	12.9	12.7	2.0%
02/26/97	13:00	2,752	0.1	0.53	78.0	7,131	6.09	43	84.0%	100%	330	654	142	95	271	280	44.7	21.9	12	71%	13.0	12.8	2.0%
02/26/97	15:00	2,769	0.1	0.54	78.0	7,119	6.09	43	83.5%	100%	323	648	141	94	268	280	44.1	21.2	12	71%	12.9	12.7	2.0%
02/26/97	19:00	2,748	0.1	0.54	78.5	10,182	6.09	50	89.0%	100%	400	650	186	190	270	350	43.1	21.3	12	71%	12.9	12.6	2.8%
02/26/97	21:00	2,759	0.1	0.53	78.5	10,281	6.06	49	89.0%	100%	401	658	281	190	272	355	43.9	21.1	12	71%	13.0	12.7	2.7%
02/27/97	3:00	3,644	0.1	0.75	78.0	8,931	6.09	41	86.0%	100%	356	637	213	160	262	315	43.4	19.9	12.5	71%	12.7	12.5	2.4%
02/27/97	5:00	3,662	0.1	0.74	78.0	8,919	6.09	42	86.5%	100%	361	648	218	160	259	315	43.6	19.6	13	71%	12.9	12.7	2.4%
02/27/97	7:00	3,647	0.1	0.73	78.5	9,031	6.09	40	87.5%	100%	357	647	213	140	261	315	43.2	19.5	13	71%	12.9	12.6	2.4%
02/27/97	9:00	3,655	0.1	0.73	78.5	9,019	6.06	41	87.0%	100%	359	645	216	145	264	315	43.5	20.2	13	71%	12.8	12.5	2.4%
02/27/97	11:00	3,636	0.1	0.72	78.0	9,131	6.09	37	87.0%	100%	361	642	211	140	258	320	42.7	19.9	13	71%	12.8	12.6	2.3%
02/27/97	15:00	3,721	0.1	0.73	78.5	9,125	6.12	61	85.0%	100%	364	653	216	145	262	320	43.5	19.9	13	71%	13.0	12.7	2.4%
02/27/97	19:00	3,632	0.1	0.73	78.5	9,836	6.06	41	87.0%	100%	366	650	214	160	261	320	44.3	19.9	13	71%	12.9	12.6	2.2%
02/27/97	21:00	3,683	0.1	0.73	78.0	9,838	6.08	40	87.0%	100%	362	645	216	160	260	320	44.2	20.0	13	71%	12.8	12.6	2.2%
02/28/97	3:00	3,647	0.1	0.75	78.0	10444	6.00	48	84.5%	100%	355	604	263	175	272	320	41.8	20.2	12	69%	12.0	11.8	2.5%
02/28/97	5:00	3,625	0.1	0.75	78.0	10875	6.00	47	85.0%	100%	363	599	275	180	268	310	41.0	19.8	12	69%	11.9	11.7	2.5%
02/28/97	7:00	3,657	0.2	0.76	78.5	9500	6.00	45	84.0%	100%	345	594	249	165	271	310	41.8	20.1	12	69%	11.8	11.5	2.6%
02/28/97	9:00	3,673	0.2	0.76	78.5	9488	6.09	42	84.5%	100%	350	601	242	170	271	310	41.9	20.2	12	69%	12.0	11.7	2.6%
02/28/97	15:00	4,150	0.2	0.76	78.0	9175	6.12	60	85.0%	100%	358	641	206	140	269	315	43.4	20.6	13	70%	12.8	12.5	2.2%
02/28/97	17:00	3,688	0.1	0.75	78.5	9644	6.06	40	87.0%	100%	370	643	239	160	269	340	43.3	20.4	12.5	71%	12.8	12.5	2.5%
02/28/97	21:00	3,677	0.2	0.75	78.0	8862	6.09	31	87.5%	100%	355	652	198	140	267	310	43.8	20.4	13	71%	13.0	12.8	2.2%

Appendix F.1
ROWTP Train Performance Data - Train #1 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data												Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
02/28/97	23:00	3,666	0.1	0.75	78.0	8,950	6.06	39	87.5%	100%	360	652	209	150	270	315	43.0	20.6	12.5	71%	13.0	12.8	2.3%
Average		3,259	0.1	0.66	76.1	8,799	6.06	48	86.5%	100%	356	649	209	147	278	307	44.4	22.0	12.8	70%	12.9	13.1	2.4%
Standard Deviation		1,037	0.1	0.20	2.1	1,155	6.96	8	3.5%	0%	32	33	41	26	16	33	2.0	1.8	1.3	2%	0.7	0.9	0.2%
Maximum		4,841	1.0	1.10	78.6	11,631	5.90	66	94.5%	100%	434	703	364	240	365	380	49.1	29.6	15.0	74%	14.0	15.6	3.8%
Minimum		758	0.0	0.19	76.0	6,738	6.69	25	72.0%	100%	269	448	105	93	228	170	33.9	16.7	11.0	63%	8.9	9.2	1.3%

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Appendix F.2
ROWTP Train Performance Date - Train #2 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
10/07/96	10:00	833	0.1	0.2	77.5	7,744	6.09	58	77.26%	100%	294	588	235	157	291	260	22.4	14.5	10.0	67%	11.7	11.6	3.0%
10/08/96	5:00	1,763	0.1	0.4	75.5	7,156	6	51	77.76%	100%	293	598	173	115	296	255	22.7	16.6	10.5	67%	11.9	12.2	2.4%
10/08/96	7:00	1,796	0.1	0.4	75.5	7,175	6	50	78.26%	100%	295	607	174	117	288	260	22.1	16.5	10.5	68%	12.1	12.4	2.4%
10/11/96	13:00	1,087	0.1	0.2	77	7,644	6.09	60	77.26%	100%	300	591	230	155	260	260	22.4	16.2	11.0	69%	11.8	11.8	3.0%
10/17/96	10:00	4,791	0.1	1.1	77	11,288	6.09	50	88.26%	100%	395	673	288	210	289	350	23.0	14.2	14.5	70%	13.4	13.4	2.6%
10/18/96	3:00	4,753	0.1	1.1	77	10,712	6.09	52	89.26%	100%	397	673	284	189	278	360	22.4	12.9	14.5	71%	13.4	13.4	2.7%
10/18/96	5:00	4,762	0.1	1.1	77	10,650	6	52	89.76%	100%	400	679	284	189	279	365	24.2	13.5	15.0	71%	13.5	13.5	2.7%
10/18/96	7:00	4,760	0.1	0.9	77	10,588	6	49	88.76%	100%	402	680	279	186	282	355	22.5	13.4	14.5	71%	13.5	13.5	2.6%
10/18/96	9:00	4,762	0.1	0.9	77	10,538	6.06	47	88.26%	100%	395	675	275	183	280	360	23.2	12.8	14.5	71%	13.4	13.4	2.6%
10/18/96	11:00	4,791	0.1	0.9	77	11,025	6.09	45	89.76%	100%	401	677	278	185	277	350	23.8	13.0	14.0	71%	13.5	13.5	2.5%
10/18/96	13:00	4,771	0.1	0.9	77	10,644	6.09	43	89.26%	100%	394	666	269	179	285	360	23.4	14.2	14.5	70%	13.3	13.3	2.5%
10/18/96	15:00	4,786	0.1	0.9	77	10,844	6.12	42	89.76%	100%	393	667	269	179	278	350	24.0	13.7	14.0	71%	13.3	13.3	2.5%
10/18/96	17:00	4,775	0.1	0.9	77	10,975	6.09	40	89.76%	100%	403	690	272	181	281	360	22.4	13.0	14.0	71%	13.7	13.7	2.5%
10/18/96	19:00	4,780	0.1	0.9	77	10,575	6.09	41	89.76%	100%	398	681	269	179	280	360	23.2	13.6	14.0	71%	13.6	13.6	2.5%
10/18/96	21:00	4,456	0.8	0.9	77	10,844	6.09	63	88.26%	100%	388	673	263	175	266	350	24.3	13.1	13.0	72%	13.4	13.4	2.4%
10/18/96	23:00	4,769	0	0.9	77	10,538	6.09	59	88.76%	100%	397	685	261	174	280	350	22.2	12.7	14.5	71%	13.6	13.6	2.5%
10/19/96	3:00	4,664	0	1.0	77	10,581	6	50	87.76%	100%	383	653	266	177	278	350	23.0	13.7	14.0	70%	13.0	13.0	2.5%
10/19/96	5:00	4,683	0	0.9	77	10,612	6	51	87.86%	100%	382	649	264	176	280	345	21.7	13.3	14.5	70%	12.9	12.9	2.5%
10/19/96	7:00	4,664	0	1.0	77	10,556	6	50	87.76%	100%	380	651	266	177	282	350	21.9	13.3	14.5	70%	13.0	13.0	2.5%
10/19/96	9:00	4,660		1.0	77	10,591	6.09	50	87.26%	100%	380	650	265	177	286	350	21.7	13.3	14.5	69%	12.9	12.9	2.5%
10/19/96	11:00	4,659	0	0.9	77	10,600	6.06	50	87.76%	100%	382	648	266	177	288	350	22.1	13.3	14.5	69%	12.9	12.9	2.5%
10/19/96	13:00	4,659	0	1.0	77	10,475	6.09	48	87.76%	100%	381	655	264	176	279	350	22.4	13.5	14.0	70%	13.0	13.0	2.5%
10/19/96	15:00	4,642		1.0	77	10,712	6.06	47	87.26%	100%	383	654	267	178	281	345	22.8	13.4	14.0	70%	13.0	13.0	2.5%
10/19/96	17:00	3,672		0.8	77	10,822	6.08	59	83.41%	100%	364	596	271	181	292	320	21.4	14.2	13.0	67%	11.9	11.9	2.5%
10/19/96	19:00	3,886		0.7	77	10,963	6.06	60	82.76%	100%	360	591	278	185	301	320	21.2	15.0	13.0	66%	11.8	11.8	2.5%
10/19/96	21:00	3,754		0.8	77	10,969	6.09	46	87.75%	100%	392	647	286	191	269	360	21.7	13.7	13.0	71%	12.9	12.9	2.6%
10/19/96	23:00	3,734		0.7	77	10,188	6.09	50	86.26%	100%	379	640	281	187	290	330	22.0	14.5	13.0	69%	12.7	12.7	2.8%
10/21/96	17:00	4,963	0.1	0.9	77	10,400	6.09	62	88.26%	100%	392	677	279	186	272	350	23.3	13.3	14.5	71%	13.5	13.5	2.7%
10/21/96	21:00	4,694	0.1	0.9	77	10,575	6.06	52	82.26%	100%	344	587	279	186	308	320	22.1	14.5	14.0	66%	11.7	11.7	2.6%
10/22/96	3:00	1,938	0	0.4	77	8,087	6	58	81.76%	100%	328	653	177	118	305	290	24.7	15.2	11.0	68%	13.0	13.0	2.2%
10/22/96	5:00	1,921	0.1	0.4	77	8,112	6	58	80.76%	100%	320	638	185	123	310	280	24.0	16.7	11.0	67%	12.7	12.7	2.3%
10/24/96	15:00	3,091	0.1	0.7	77	7,119	6.06	60	76.26%	100%	285	597	138	92	311	250	22.2	16.5	11.0	66%	11.9	11.9	1.9%
10/24/96	19:00	2,848	0.1	0.6	77	7,106	6.06	54	82.26%	100%	317	676	141	120	271	275	25.6	15.8	11.5	71%	13.5	13.5	2.0%
10/24/96	21:00	2,833	0	0.6	77	6,981	6.09	44	82.76%	100%	315	671	141	110	279	280	24.7	16.1	12.0	71%	13.4	13.4	2.0%
10/25/96	3:00	2,782	0	0.6	77	7,038	6	50	81.76%	100%	319	673	141	94	292	280	25.5	14.3	12.0	70%	13.4	13.4	2.0%
10/25/96	5:00	2,778	0	0.6	77	7,044	6	59	79.76%	100%	309	648	143	95	268	275	23.9	15.3	12.0	71%	12.9	12.9	2.0%

Appendix F.2
ROWTP Train Performance Date - Train #2 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
10/25/96	7:00	2,767	0	0.6	77	7,031	6	59	79.76%	100%	302	631	141	94	288	275	24.2	15.8	12.0	69%	12.6	12.6	2.0%
10/25/96	9:00	2,728	0.1	0.6	77	7,219	6.06	44	78.26%	100%	288	591	146	97	304	255	23.2	17.2	12.0	66%	11.8	11.8	2.0%
10/25/96	11:00	2,719	0.1	0.6	77	7,162	6.06	44	78.26%	100%	286	591	144	96	295	250	22.9	15.1	11.5	67%	11.8	11.8	2.0%
10/25/96	13:00	2,743	0.1	0.6	77	7,181	6.09	43	79.26%	100%	287	591	143	95	311	260	22.7	16.9	11.5	66%	11.8	11.8	2.0%
10/28/96	11:00	3,069	0.1	0.6	74	7,538	6.12	68	81.26%	100%	318	661	163	109	299	280	24.7	16.9	12.0	69%	13.2	14.5	2.2%
10/28/96	14:00	2,754	0.1	0.6	71.5	7,250	6.06	59	80.26%	100%	301	647	132	104	309	260	25.7	16.0	11.0	68%	12.9	14.1	1.8%
10/29/96	3:00	3,106	0.1	0.6	72	7,344	6	60	80.26%	100%	310	645	156	104	293	270	24.7	17.6	12.0	69%	12.8	13.9	2.1%
10/29/96	5:00	3,058	0	0.7	72.5	7,338	5.9	60	80.76%	100%	312	658	160	107	284	270	24.6	17.5	12.0	70%	13.1	14.1	2.2%
10/29/96	7:00	2,804	0	0.7	72.5	7,269	6	55	80.76%	100%	317	664	152	101	293	275	24.9	17.4	12.0	69%	13.2	14.2	2.1%
10/29/96	9:00	2,804	0	0.7	72.5	7,256	6.03	48	81.76%	100%	310	645	151	101	310	275	25.1	16.7	12.0	68%	12.8	13.8	2.1%
10/29/96	11:00	2,798	0	0.7	72	7,344	5.96	55	70.26%	100%	308	634	153	102	289	265	23.8	15.6	12.0	69%	12.6	13.7	2.1%
10/29/96	13:00	2,708	0	0.7	72	6,881	6	52	77.26%	100%	283	594	141	94	313	250	23.2	17.1	11.0	65%	11.8	12.8	2.0%
10/29/96	15:00	2,717	0	0.6	72.5	6,712	6.03	49	77.76%	100%	285	603	136	91	308	250	23.1	16.9	11.0	66%	12.0	12.9	2.0%
10/30/96	15:00	2,824	0.1	0.6	74.5	12,300	6.09	54	90.76%	100%	423	647	238	159	302	380	22.8	14.1	11.5	68%	12.9	13.4	1.9%
10/30/96	17:00	2,787	0.4	0.6	74	11,394	6.09	53	90.26%	100%	413	652	344	240	279	390	22.0	12.8	11.5	70%	13.0	13.6	3.0%
10/30/96	19:00	2,888	0	0.6	74	10,488	6.09	59	87.26%	100%	387	643	296	281	281	360	22.6	13.3	11.5	70%	12.8	13.4	2.8%
10/30/96	21:00	2,892	0	0.6	74	10,850	6.06	60	88.26%	100%	393	647	304	289	289	360	22.3	13.7	11.5	69%	12.9	13.5	2.8%
10/30/96	23:00	2,874	0	0.6	74	10,756	6.06	59	88.26%	100%	395	659	301	277	277	360	22.7	13.5	11.5	70%	13.1	13.8	2.8%
10/31/96	3:00	2,863	0	0.6	74	10,956	6.09	60	87.76%	100%	392	649	284	210	280	360	22.6	13.4	11.5	70%	12.9	13.6	2.7%
10/31/96	5:00	2,846	0.1	0.6	74.5	10,969	6.09	60	88.26%	100%	394	651	291	210	273	355	22.1	13.9	12.0	70%	13.0	13.5	2.7%
10/31/96	7:00	2,839	0	0.6	74.5	10,969	6.09	59	89.26%	100%	396	660	296	210	280	350	22.6	13.4	12.0	70%	13.1	13.7	2.7%
10/31/96	9:00	2,953	0	0.6	75	9,719	6.09	58	88.76%	100%	379	685	228	170	306	340	25.2	16.3	12.0	69%	13.6	14.1	2.3%
11/01/96	3:00	2,872	0.1	0.6	75	8,338	6.09	49	84.76%	100%	340	676	179	140	302	300	26.2	15.9	12.0	69%	13.5	13.9	2.1%
11/01/96	5:00	2,881	0.1	0.6	75	8,338	6.12	44	84.76%	100%	338	669	178	130	299	300	25.3	15.3	12.0	69%	13.3	13.8	2.1%
11/01/96	7:00	2,852	0	0.6	74.5	8,581	6.18	42	87.26%	100%	350	684	190	140	293	310	25.3	15.8	12.0	70%	13.6	14.2	2.2%
11/01/96	9:00	2,883	0.1	0.6	74	8,525	6.09	41	85.76%	100%	344	675	191	150	293	310	25.4	15.7	12.0	70%	13.4	14.1	2.2%
11/01/96	11:00	2,866	0.1	0.6	74.5	8,569	6.12	35	86.76%	100%	351	693	196	140	289	310	25.8	15.6	12.0	71%	13.8	14.4	2.3%
11/01/96	13:00	2,859	0.1	0.6	74.5	8,994	6.09	49	87.26%	100%	356	684	206	150	297	320	24.7	15.3	11.5	70%	13.6	14.2	2.3%
11/01/96	15:00	2,863	0.1	0.6	74.5	9,006	6.09	48	87.76%	100%	355	684	204	140	288	320	25.0	16.4	11.5	70%	13.6	14.2	2.3%
11/01/96	17:00	2,868	0.1	0.6	74.5	8,988	6.09	49	87.76%	100%	362	700	209	150	284	320	25.2	15.3	12.0	71%	13.9	14.5	2.3%
11/01/96	19:00	2,879	0.1	0.6	74.5	9,031	6.09	48	87.26%	100%	358	684	204	150	301	320	25.5	15.3	11.5	69%	13.6	14.2	2.3%
11/02/96	3:00	2,811	0	0.6	74.5	8,888	6.1	59	83.26%	100%	342	654	202	135	287	305	24.3	14.2	11.5	70%	13.0	13.6	2.3%
11/02/96	5:00	2,780	0.1	0.6	74.5	8,674	5.9	59	83.76%	100%	347	656	203	135	293	310	23.3	14.9	11.0	69%	13.1	13.6	2.3%
11/02/96	7:00	2,879	0.1	0.6	74.5	8,812	5.9	45	85.76%	100%	350	660	204	136	301	310	24.2	14.6	12.0	69%	13.1	13.7	2.3%
11/02/96	9:00	2,894	0.1	0.6	74.5	8,750	6.09	44	87.26%	100%	360	679	201	134	294	310	25.0	15.4	12.0	70%	13.5	14.1	2.3%
11/02/96	11:00	2,896	0.1	0.6	74.5	8,806	6.06	44	86.26%	100%	353	663	201	134	297	310	24.4	16.1	12.0	69%	13.2	13.7	2.3%

Appendix F.2
ROWTP Train Performance Date - Train #2 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data												Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
11/02/96	13:00	2,868	0.1	0.6	74.5	8,694	6.09	46	86.76%	100%	353	667	201	134	303	320	24.8	15.4	11.5	69%	13.3	13.8	2.3%
11/03/96	11:00	2,745	0.1	0.6	74.5	7,750	6.09	46	79.26%	100%	293	583	161	107	318	265	22.5	16.9	12.0	65%	11.6	12.1	2.1%
11/03/96	13:00	2,754	0.1	0.6	74.5	7,719	6.06	44	79.26%	100%	295	590	181	121	289	260	23.1	14.3	11.5	67%	11.7	12.2	2.3%
11/03/96	15:00	2,763	0.1	0.6	74.5	7,838	6.09	41	79.26%	100%	295	600	181	121	307	260	22.4	16.7	11.0	66%	11.9	12.4	2.3%
11/04/96	11:00	1,986	0.1	0.4	74.5	7,875	6.15	58	84.76%	100%	345	682	196	131	282	305	24.0	13.9	11.0	71%	13.6	14.1	2.5%
11/04/09	13:00	1,960	0.1	0.4	74.5	7,944	6	57	83.75%	100%	340	683	190	127	282	310	24.0	14.7	11.0	71%	13.6	14.2	2.4%
11/05/96	3:00	1,822	0.1	0.4	74.5	8,052	6	46	80.26%	100%	302	591	206	137	309	265	21.7	14.8	11.0	66%	11.8	12.3	2.6%
11/05/96	5:00	1,840	0.1	0.4	74.5	8,031	6	46	79.26%	100%	300	588	209	139	293	275	22.7	15.2	11.0	67%	11.7	12.2	2.6%
11/05/96	7:00	1,811	0.1	0.4	74.5	8,025	6	44	79.26%	100%	300	601	207	138	297	270	21.8	15.3	11.0	67%	12.0	12.5	2.6%
11/05/96	11:00	3,092	0.1	0.5	74.5	8,038	6.15	60	82.76%	100%	342	641	214	160	304	300	24.3	15.7	12.0	68%	12.8	13.3	2.4%
11/05/96	13:00	3,084	0.1	0.5	74.5	8,062	6.06	60	82.86%	100%	344	653	218	160	302	300	24.3	15.6	12.0	68%	13.0	13.5	2.7%
11/08/96	17:00	1,864	0.1	0.4	74.5	6,825	6.09	58	81.26%	100%	311	685	138	120	279	270	25.9	15.0	11.0	71%	13.6	14.2	2.0%
11/08/96	21:00	1,837	0.1	0.4	74.5	6,681	6.09	58	81.26%	100%	311	685	127	100	290	275	25.7	15.1	11.0	70%	13.6	14.2	1.9%
11/09/96	3:00	1,833	0.1	0.4	74.5	6,675	6	58	82.26%	100%	319	694	176	84	274	265	26.1	15.3	11.0	72%	13.8	14.4	1.9%
11/09/96	5:00	1,822	0.1	0.4	74.5	6,694	6	58	81.76%	100%	313	690	125	83	281	250	25.6	15.1	11.0	71%	13.7	14.3	1.9%
11/10/96	9:00	1,882	0.1	0.4	74.5	7,050	6.06	38	79.92%		306	652	136	120	302	256	29.1	14.9	12.0	68%	13.0	13.5	1.9%
11/10/96	11:00	1,890	0.1	0.4	74.5	6,960	6.06	38	79.92%		308	657	134	120	306	256	29.7	15.6	12.0	68%	13.1	13.6	1.9%
11/10/96	13:00	1,835	0.1	0.4	74.5	6,881	6.06	38	81.31%		303	548	136	120	273	253	22.9	14.6	12.0	56%	6.9	7.2	2.0%
11/11/96	3:00	1,929	0.1	0.4	75	8,112	6	55	83.26%	100%	337	674	179	119	310	300	25.8	15.7	11.5	68%	13.4	13.9	2.2%
11/11/96	5:00	1,912	0.1	0.4	74.5	8,131	6	56	83.76%	100%	334	671	181	121	305	290	25.5	15.4	11.0	69%	13.4	13.9	2.2%
11/11/96	7:00	1,936	0.1	0.4	75	8,061	6	56	83.26%	100%	338	679	183	122	302	300	25.0	15.8	12.0	69%	13.5	14.0	2.3%
11/11/96	9:00	2,880	0.1	0.6	75	8,006	6.06	38	84.76%		334	668	174	120	282	300	24.7	14.2	12.0	70%	13.3	13.7	2.2%
11/11/96	11:00	2,836	0.1	0.6	75	8,067	6.05	36	84.76%		333	676	176	130	279	300	24.2	14.3	12.0	71%	13.3	13.8	2.2%
11/11/96	13:00	2,843	0.1	0.6	74.5	7,996	6.06	35	85.26%		332	670	171	130	269	299	23.9	13.4	12.0	71%	13.3	13.9	2.1%
11/12/96	5:00	1,927	0.1	0.4	75.5	8,056	6	58	81.26%	100%	325	650	178	119	299	280	25.7	15.8	11.5	68%	12.9	13.3	2.2%
11/12/96	7:00	1,953	0.1	0.4	75.5	8,087	6	58	81.76%	100%	320	634	176	117	307	290	24.2	15.3	11.5	67%	12.6	12.9	2.2%
11/12/96	9:00	1,958	0.1	0.4	75.5	8,086	6.06	57	81.76%		325	631	183	120	300	290	22.2	15.4	10.5	68%	12.6	12.9	2.3%
11/12/96	13:00	1,916	0.1	0.4	75	8,025	6.12	59	84.76%		348	690	178	140	278	305	25.0	15.4	12.0	71%	13.7	14.2	2.2%
11/12/96	15:00	1,921	0.1	0.4	75	8,025	6.06	58	84.76%		344	690	179	130	276	308	24.8	14.3	11.5	71%	13.7	14.2	2.2%
11/12/96	17:00	1,929	0.3	0.4	75.5	8,019	6.06	59	84.76%	100%	348	687	176	140	280	305	24.9	14.3	11.0	71%	13.7	14.0	2.2%
11/12/96	19:00	1,929	0.1	0.4	75.5	8061	6.09	58	84.26%	100%	344	682	178	140	287	305	24.6	15.2	11.5	70%	13.6	13.9	2.2%
11/12/96	21:00	1,938	0.1	0.4	75	8,081	6.06	57	84.76%	100%	343	674	176	150	283	310	25.2	14.9	11.5	70%	13.4	13.9	2.2%
11/13/96	11:00	1,940	0.1	0.4	75.5	8,062		59	73.50%		291	470	221	140	238	256	17.1	10.2	12.0	66%	9.4	9.6	2.7%
11/13/96	13:00	1,932		0.4	75.5	8,163		60	73.26%		290	539	241	160	237	255	17.3	10.8	12.0	69%	10.7	11.0	3.0%
11/13/96	19:00	1,818	0.1	0.4	75.5	8,025	6.12	59	84.76%	100%	348	690	192	150	277	305	24.7	14.1	11.0	71%	13.7	14.1	2.4%
11/14/96	15:00	2,719	0.1	0.6	75.5	8,106	6.09	58	73.76%		290	557	208		234				11.5	70%	11.1	11.4	2.6%

Appendix F.2
ROWTP Train Performance Date - Train #2 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gfd)	(gfd @ 25C)	(%)
11/14/96	19:00	2,804	0.1	0.6	75.5	7,862	6.09	45	81.76%	100%	329	647	178	150	290				12.0	69%	12.9	13.2	2.3%
11/15/96	3:00	2,797	0.1	0.6	75.5	7,858	6	43	83.26%	100%	332	652	178	119	229	290	23.21	14.18	12.0	74%	13.0	13.3	2.3%
11/15/96	5:00	2,820	0.1	0.6	75	7,904	6	43	81.76%	100%	325	639	174	116	277	300	23.88	13.47	12.0	70%	12.7	13.1	2.2%
11/15/96	7:00	2,791	0.1	0.6	75.5	7,919	6	42	83.76%	100%	334	655	174	116	279	290	23.64	13.42	12.0	70%	13.0	13.4	2.2%
11/15/96	11:00	2,726	0.1	0.6	75.5	7,825	6.1	52	82.76%	100%	343	663	145		246	310	22.09	12.9	12.0	73%	13.2	13.5	1.9%
11/15/96	13:00	2,712	0.1	0.6	76	7,781	6.09	53	82.76%	100%	340	654	185	140	254	310	21.53	11.48	12.0	72%	13.0	13.2	2.4%
11/15/96	19:00	2,710	0.1	0.6	76	7,869	6.09	52	82.76%	100%	341	658	184	140	239	305	21.75	11.75	12.0	73%	13.1	13.3	2.3%
11/15/96	23:00	2,802	0.1	0.6	76	7,969	6.12	38	84.26%	100%	333	651	172	130	277	290	23.71	14.66	12.0	70%	13.0	13.2	2.2%
11/16/96	3:00	2,804	0.1	0.6	76	7,981	6	41	82.76%	100%	336	651	176	117	273	295	23.28	14.58	12.0	70%	13.0	13.2	2.2%
11/16/96	5:00	2,785	0.1	0.6	76	7,944	6	40	83.76%	100%	339	664	174	116	266	305	22.49	14.51	12.0	71%	13.2	13.4	2.2%
11/18/96	5:00	1,908	0.1	0.4	76	8,369	6.12	58	85.26%	100%	352	683	192	160	281	310	24.54	14.91	11.5	71%	13.6	13.8	2.3%
11/18/96	7:00	1,914	0.1	0.4	76	8,350	6.09	58	84.76%	100%	346	677	189	150	281	310	24.27	13.4	11.5	71%	13.5	13.7	2.3%
11/18/96	19:00	2,859	0.1	0.6	76	8,081	6.06	33	85.76%	100%	347	678	159	140	273	305	23.87	13.36	12.0	71%	13.5	13.7	2.0%
11/18/96	21:00	2,872	0.1	0.6	76	8,087	6.09	32	86.26%	100%	344	671	189	140	269	310	24.01	14.01	12.0	71%	13.4	13.6	2.3%
11/19/96	3:00	2,780	0.1	0.6	76	8,131	6.12	41	82.76%	100%	333	650	186	140	260	300	22.35	13.67	12.0	71%	12.9	13.1	2.3%
11/19/96	5:00	2,782	0.1	0.6	76	8,163	6.06	41	83.26%	100%	335	656	184	140	259	295	22.58	13.05	12.0	72%	13.1	13.3	2.3%
11/25/96	9:00	2,768	0.1	0.6	75.5	7,980	6.05	46	81.76%	100%	326	650	181	140	274	295	23.82	14.12	12.0	70%	12.9	13.3	2.3%
11/25/96	11:00	2,770	0.1	0.6	75.5	7,992	6.06	47	81.76%	100%	325	652	186	140	270	295	23.62	14.1	12.0	71%	13.0	13.3	2.3%
11/25/96	13:00	2,772	0.1	0.6	75.5	7,994	6.09	46	81.76%	100%	327	648	182	140	272	295	23.85	14.14	12.0	70%	12.9	13.2	2.3%
11/26/96	17:00	2,807	0.1	0.6	75.5	8,056	6.06	47	85.76%	100%	343	691	173	140	278	300	24.33	14.85	12.0	71%	13.8	14.1	2.1%
11/26/96	21:00	2,793	0.1	0.6	75.5	8,194	6.09	43	84.76%	100%	341	674	174	140	278	310	23.69	14.65	12.0	71%	13.4	13.7	2.1%
11/29/96	17:00	1,776	0.1	0.4	75.5	8,250	6.1	35	85.26%	100%	335	679	180	130	275	290	23.86	14.91	11.5	71%	13.5	13.8	2.2%
11/29/96	19:00	1,784	0.1	0.4	75.5	8,310	6.06	35	85.26%	100%	336	678	182	130	274	300	23.72	14.62	11.5	71%	13.5	13.8	2.2%
11/29/96	21:00	1,792	0.1	0.4	75.5	8,075	6.09	31	85.76%	100%	335	672	177	120	270	290	23.5	14.47	11.5	71%	13.4	13.7	2.2%
11/30/96	19:00	2,002	0.1	0.4	76	7,944	6	58	82.26%	100%	326	650	178	119	292	290	25.29	15.43	11.0	69%	12.9	13.1	2.2%
11/30/96	21:00	1,973	0.1	0.4	76.5	7,988	5.96	58	81.76%	100%	328	659	180	120	291	280	23.46	15.3	11.0	69%	13.1	13.2	2.3%
11/30/96	23:00	1,967	0.1	0.4	76.5	8,000	6	58	81.76%	100%	330	654	181	121	291	285	23.86	15.48	11.0	69%	13.0	13.1	2.3%
12/01/96	3:00	1,994	0.1	0.4	76.5	8,194	5.9	58	81.76%	100%	326	648	179	119	293	290	24.46	15.43	11.0	69%	12.9	13.0	2.2%
12/01/96	5:00	1,964	0.1	0.4	76.5	8,156	5.9	58	81.76%	100%	324	639	181	120	291	300	23.83	15.62	12.0	69%	12.7	12.8	2.2%
12/04/96	15:00	4,657	0.1	0.9	76.5	10,131	6.12	49	87.76%	100%	384	663	310	170	276	345	22.3	14.99	15.0	71%	13.2	13.3	3.1%
12/04/96	17:00	4,627	0.1	0.9	76.5	10,919	6.09	47	89.26%	100%	395	651	309	210	277	360	22.59	13.11	14.0	70%	13.0	13.1	2.8%
12/04/96	19:00	4,662	0.1	0.9	76.5	9,794	6.09	50	86.26%	100%	367	649	251	180	270	330	22.13	12.91	14.5	71%	12.9	13.0	2.6%
12/04/96	21:00	4,618	0.1	0.9	76.5	9,231	5.93	48	84.76%	100%	358	654	238	170	270	320	22.45	13.17	14.5	71%	13.0	13.1	2.6%
12/04/96	23:00	4,640	0.1	0.9	76.5	9,200	6.12	49	84.76%	100%	355	655	222	170	274	320	22.7	13.7	14.5	71%	13.0	13.1	2.4%
12/05/96	3:00	4,657	0.1	0.9	76.5	9,144	6.06	45	85.76%	100%	351	642	206	160	279	325	22.33	13.05	15.0	70%	12.8	12.9	2.3%
12/05/96	5:00	4,666	0.1	0.9	76.5	9,162	6.09	45	85.26%	100%	353	645	204	160	276	320	22.48	13.93	14.5	70%	12.8	12.9	2.2%

Appendix F.2
ROWTP Train Performance Date - Train #2 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gfd)	(gfd @ 25C)	(%)
12/05/96	7:00	4,631	0.1	0.9	76.5	9,252	6.09	46	84.26%	100%	356	649	202	160	265	315	22.64	13.55	14.5	71%	12.9	13.0	2.2%
12/05/96	9:00	4,646	0.2	0.9	76.5	9,250	6.09	43	85.26%	100%	353	647	200	160	270	320	22.75	12.24	15.0	71%	12.9	13.0	2.2%
12/05/96	11:00	4,648	0.2	0.9	76.5	9,258	6.06	43	85.26%	100%	358	648	204	160	270	320	22.82	13.28	15.0	71%	12.9	13.0	2.2%
12/05/96	13:00	4,670	0.2	0.9	76.5	9,231	6.06	43	85.26%	100%	355	651	198	160	270	320	22.56	13.29	14.5	71%	13.0	13.1	2.1%
12/05/96	15:00	4,648	0.2	0.9	76.5	9,206	6.06	44	85.26%	100%	353	646	194	160	268	320	22.66	13.36	14.5	71%	12.9	13.0	2.1%
12/05/96	17:00	4,650	0.2	0.9	76.5	9,262	6.06	45	85.26%	100%	353	652	196	160	270	320	21.96	13.12	14.5	71%	13.0	13.1	2.1%
12/05/96	19:00	4,698	0.2	0.9	76.5	9,200	6.09	45	85.26%	100%	355	653	196	160	269	320	22.06	13.22	14.5	71%	13.0	13.1	2.1%
12/05/96	21:00	4,640	0.2	0.9	76.5	9,144	6.12	45	85.26%	100%	356	649	194	140	270	320	22.6	13.26	14.5	71%	12.9	13.0	2.1%
12/05/96	23:00	4,642	0.2	0.9	76.5	9,094	6.09	45	85.26%	100%	353	646	191	150	278	325	22.08	12.63	14.0	70%	12.9	13.0	2.1%
12/06/96	3:00	4,609	0.3	0.9	76.5	9,212	6.06	45	85.26%	100%	358	650	189	150	278	320	22.67	13.76	14.5	70%	12.9	13.0	2.1%
12/06/96	5:00	4,642	0.3	0.9	76.5	9,234	6.09	45	84.26%	100%	347	643	189	140	272	320	23.03	13.92	14.5	70%	12.8	12.9	2.0%
12/06/96	7:00	4,635	0.3	0.9	76.5	9,275	6.09	44	85.76%	100%	361	654	191	150	271	320	22.84	13.38	15.0	71%	13.0	13.1	2.1%
12/06/96	9:00	4,636	0.2	0.9	76.5	9,100	6.12	45	85.76%	100%	357	657	188	150	270	320	22.91	13.64	15.0	71%	13.1	13.2	2.1%
12/06/96	11:00	4,574	0.3	0.9	76.5	9,138	6.06	47	85.26%	100%	354	645	184	150	270	320	22.45	13.42	15.0	70%	12.8	12.9	2.0%
12/06/96	17:00	3,665	0.2	0.7	76.5	9,136	6.06	55	86.76%	100%	356	668	190	160	268	320	22.62	12.46	13.5	71%	13.3	13.4	2.1%
12/06/96	19:00	3,673	0.2	0.7	76.5	9,125	6.06	56	86.76%	100%	357	667	186	160	266	320	22.51	12.59	13.0	71%	13.3	13.4	2.0%
12/06/96	21:00	3,688	0.1	0.7	76.5	9,069	6.09	56	86.26%	100%	368	674	185	140	275	340	22.88	13.31	13.0	71%	13.4	13.5	2.0%
12/07/96	3:00	3,695	0.1	0.7	76.5	9,194	6.09	55	86.76%	100%	366	672	184	140	275	340	22.86	13.54	13.0	71%	13.4	13.5	2.0%
12/07/96	5:00	3,668	0.1	0.7	76.5	9,256	6.09	56	85.76%	100%	361	658	181	140	277	330	22.63	13.05	13.0	70%	13.1	13.2	2.0%
12/07/96	7:00	3,677	0.1	0.7	76.5	9,250	6.06	55	85.76%	100%	370	680	185	140	266	330	23.93	13.6	13.0	72%	13.5	13.6	2.0%
12/07/96	9:00	3,688	0.1	0.7	76.5	9,119	6.06	55	86.76%	100%	369	680	185	140	270	330	23.81	13.39	13.0	72%	13.5	13.6	2.0%
12/22/96	23:00	1,759	0.1	0.4	77.5	7,994	6.09	38	83.26%	100%	321	646	203	160	277	285	23.69	14.52	11.0	70%	12.9	12.8	2.5%
12/23/96	3:00	1,765	0.1	0.4	78	8,015	6	34	83.76%	100%	328	657	204		281	285	23.19	13.18	11.0	70%	13.1	12.9	2.5%
12/23/96	5:00	1,772	0.1	0.4	78	8,031	6	34	83.76%	100%	322	652	203		270	290	24.84	13.52	11.0	71%	13.0	12.8	2.5%
12/23/96	7:00	1,746	0.1	0.4	78	8,050	6	30	83.76%	100%	325	650	201		281	290	23.18	13.14	11.0	70%	12.9	12.7	2.5%
12/23/96	9:00	1,975	0.1	0.4	78	8,138	6.06	52	84.76%	100%	346	699	268	200	278	305	24.77	14.73	11.5	72%	13.9	13.7	3.3%
12/23/96	11:00	1,772	0.1	0.4	78	8,092	6.09	55	83.76%	100%	343	690	267	220	276	305	24.72	14.62	11.5	71%	13.7	13.5	3.3%
12/23/96	13:00	1,986	0.1	0.4	78.5	8,120	6.09	56	83.76%	100%	344	688	266	220	272	305	24.97	13.73	11.0	72%	13.7	13.4	3.3%
12/26/96	15:00	1,970	0.1	0.4	78.5	8,025	6.08	65	85.20%	100%	344	684	200	180	261	296	24.73	12.78	11.5	72%	13.6	13.3	2.5%
12/26/96	19:00	1,890	0.1	0.4	77	8,119	6.06	59	83.76%	100%	342	685	193	150	280	310	24.11	13.96	11.0	71%	13.6	13.6	2.4%
12/26/96	21:00	1,894	0.1	0.4	77.5	8,150	6.09	56	85.26%	100%	352	696	195	150	262	305	24.69	13.17	11.0	73%	13.9	13.7	2.4%
12/27/96	3:00	2,721	0.2	0.4	76	7,819	6	29	80.76%	100%	308	611	188		293	265	23.45	16.314	12.0	68%	12.2	12.4	2.4%
12/27/96	5:00	2,697	0.2	0.4	76	7,812	5.9	29	81.26%	100%	305	607	192		298	260	22.74	16.48	12.0	67%	12.1	12.3	2.5%
12/27/96	7:00	2,555	0.1	0.4	77.5	7,731	6	52	74.26%	100%	278	544	196		287	245	19.98	13.12	11.5	65%	10.8	10.7	2.5%
12/27/96	11:00	2,774	0.1	0.5	78	8,175	6.12	37	83.26%	100%	330	657	190	130	270	295	23.5	13.14	12.0	71%	13.1	12.9	2.3%
12/27/96	13:00	2,772	0.1	0.6	78	8,162	6.1	36	83.76%	100%	324	652	192	120	268	270	23.64	13.12	12.0	71%	13.0	12.8	2.4%

Appendix F.2
ROWTP Train Performance Date - Train #2 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data												Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
12/27/96	15:00	2,763	0.1	0.5	78	8,191	6.09	36	83.76%	100%	321	654	186	120	267	285	23.64	13.03	12.0	71%	13.0	12.8	2.3%
12/28/96	3:00	2,776	0.1	0.6	77.5	7,925	6	45	83.26%	100%	321	646	193		295	280	24.97	16.23	12.0	69%	12.9	12.8	2.4%
12/28/96	5:00	2,767	0.1	0.6	77.5	7,919	5.9	44	82.26%	100%	322	651	192		291	285	25.73	16.7	12.0	69%	13.0	12.8	2.4%
12/28/96	7:00	2,776	0.1	0.6	78	8,000	6	36	83.76%	100%	328	649	192		305	285	24.9	15.5	12.0	68%	12.9	12.7	2.4%
12/28/96	9:00	2,778	0.1	0.6	78	8,031	6.09	35	83.76%	100%	334	651	200	140	278	300	23.44	13.43	12.0	70%	13.0	12.7	2.5%
12/30/96	11:00	2,745	0.1	0.6	76.5	8,168	6.09	40	85.96%	100%	342	687	200	120	269	290	25.31	13.34	13.0	72%	13.7	13.8	2.4%
12/30/96	13:00	2,815	0.1	0.6	76.5	8,144	6.09	33	86.76%	100%	344	689	197	140	273	305	24.98	13.87	12.0	72%	13.7	13.8	2.4%
12/31/96	3:00	1,726	0.2	0.4	76.5	8,700	6	46	80.34%	100%	314	603	230		300	275	22.13	14.78	12.0	67%	12.0	12.1	2.6%
12/31/96	5:00	1,734	0.2	0.4	76.5	8,631	6	45	80.26%	100%	313	594	227		292	280	22.84	15.04	12.0	67%	11.8	11.9	2.6%
12/31/96	7:00	17	0.2	0.4	77	8,831	5.9	45	80.76%	100%	316	600	239		310	275	22.4	15.48	12.0	66%	11.9	11.9	2.7%
12/31/96	13:00	2,802	0.26	0.5	77	8,235	6.06	37	83.76%	100%	345	682	198	140	270	305	24.48	13.48	12.0	72%	13.6	13.6	2.4%
12/31/96	15:00	2,745	0.2	0.5	76.5	7,586	6.12	40	82.76%	100%	318	655	159	120	269	280	23.78	13.57	12.0	71%	13.0	13.1	2.1%
12/31/96	19:00	2,737	0.1	0.5	76.5	7,506	6.09	38	82.76%	100%	322	661	161	120	271	280	23.21	13.5	11.5	71%	13.2	13.3	2.1%
12/31/96	21:00	2,739	0.2	0.5	76.5	7,500	6.06	35	82.76%	100%	316	648	158	120	275	280	23.2	13.28	12.0	70%	12.9	13.0	2.1%
12/31/96	23:00	2,719	0.2	0.5	77	7,538	6.09	38	82.26%	100%	320	652	155	120	154	280	23.7	13.41	12.0	81%	13.0	13.0	2.1%
01/01/97	3:00	2,723	0.2	0.5	77	7,525	6.03	35	83.26%	100%	317	650	156	120	268	285	23.52	14.08	12.0	71%	12.9	12.9	2.1%
01/01/97	5:00	2,718	0.2	0.5	77	7,525	6.06	33	83.26%	100%	317	651	158	120	270	280	23.47	13.97	12.0	71%	13.0	13.0	2.1%
01/01/97	7:00	2,724	0.2	0.5	77	7,562	6.06	32	83.26%	100%	318	698	162	120	272	280	23.22	13.62	12.0	72%	13.9	13.9	2.1%
01/01/97	9:00	2,728	0.2	0.5	77	2,575	6.06	31	83.26%	100%	320	643	160	130	270	280	22.94	13.3	12.0	70%	12.8	12.8	6.2%
01/02/97	19:00	3,852	0.2	0.9	70.5	10,681	6.12	40	93.26%	100%	420	702	296	200	272	375	23.51	12.1	13.5	72%	14.0	15.5	2.8%
01/02/97	21:00	3,848	0.2	0.9	70.5	10,638	6.09	40	92.26%	100%	415	696	284	200	273	370	23.22	11.91	13.5	72%	13.9	15.4	2.7%
01/02/97	23:00	3,841	0.2	0.9	71	10,525	6.12	40	91.76%	100%	410	686	278	200	268	370	23.56	12.89	13.5	72%	13.7	15.1	2.6%
01/03/97	3:00	3,821	0.3	0.9	71.5	10,469	6	40	91.26%	100%	405	688	267		273	360	23.34	12.74	13.0	72%	13.7	15.0	2.6%
01/03/97	5:00	3,808	0.3	0.9	71.5	10,294	6	39	90.76%	100%	404	685	270		271	370	23.66	12.06	13.5	72%	13.6	14.9	2.6%
01/03/97	7:00	3,839	0.3	0.9	71.5	10,425	6	36	92.26%	100%	412	697	268		260	360	23.76	11.97	13.5	73%	13.9	15.2	2.6%
01/03/97	11:00	3,830	0.3	0.9	71	10,300	6.09	37	91.76%	100%	408	693	256	220	272	365	23.32	13.05	13.5	72%	13.8	15.2	2.5%
01/03/97	15:00	4,839	0.2	1.0	70	9,775	6.12	56	87.26%	100%	386	688	221	160	268	340	25.11	12.23	15.0	72%	13.7	15.4	2.3%
01/03/97	17:00	4,784	0.2	1.0	70.5	9,825	6.09	55	88.26%	100%	392	692	227	160	264	350	23.85	13.41	15.0	72%	13.8	15.3	2.3%
01/03/97	19:00	4,788	0.2	1.0	71	9,881	6.09	55	89.26%	100%	396	694	229	160	273	360	24.16	12.69	15.0	72%	13.8	15.2	2.3%
01/03/97	21:00	4,802	0.2	1.0	71	9,825	6.09	55	88.76%	100%	397	694	231	160	270	360	23.39	12.64	15.0	72%	13.8	15.2	2.4%
01/03/97	23:00	4,788	0.2	0.9	71	9,844	6.09	55	88.26%	100%	391	682	226	170	268	350	24.09	13.46	15.0	72%	13.6	15.0	2.3%
01/04/97	3:00	4,788	0.2	0.9	70.5	9,881	6	54	88.76%	100%	393	684	228		278	355	24.28	12.1	15.0	71%	13.6	15.1	2.3%
01/04/97	5:00	4,753	0.2	0.9	70.5	9,869	6	54	88.76%	100%	392	682	230		281	350	23.67	11.89	15.0	71%	13.6	15.1	2.3%
01/04/97	7:00	4,771	0.2	1.0	71	9,888	6	53	88.26%	100%	392	684	228		267	350	25.28	12.81	15.0	72%	13.6	15.0	2.3%
01/04/97	9:00	4,775	0.2	0.9	71	9,938	6	52	89.26%	100%	398	690	234		273	360	24.39	13.02	15.0	72%	13.7	15.2	2.4%
01/04/97	11:00	4,795	0.2	0.9	71	9,900	6.09	53	89.26%	100%	402	707	234	160	267	355	23.95	13.08	15.0	73%	14.1	15.5	2.4%

Appendix F.2
ROWTP Train Performance Date - Train #2 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data												Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
01/04/97	13:00	4,806	0.2	1.0	71	9,925	6.12	52	89.26%	100%	386	674	232	160	259	360	24.46	13.54	15.0	72%	13.4	14.8	2.3%
01/05/97	11:00	2,758	0.1	0.6	73	7,356	6.08	52	81.25%		313	652	148	120	262	269	23.52	14.3	13.0	71%	13.0	13.9	2.0%
01/05/97	13:00	2,758	0.2	0.6	73	7,431	6.09	50	80.84%		312	646	155	110	279	270	24.05	13.43	13.0	70%	12.9	13.7	2.1%
01/06/97	19:00	2,773	0.2	0.6	75	12,056	6.09	53	91.96%	100%	432		396	240	267	360	22.11	11.81	13.0				3.3%
01/07/97	3:00	3,708	0.1	0.8	75.5	10,562	6	57	87.76%	100%	388	649	291		258	350	22.16	13.4	13.0	72%	12.9	13.2	2.8%
01/07/97	5:00	4,622	0.2	0.8	76	10,206	6	64	80.76%	100%	337	587	240		309	300	22.85	14.13	15.0	66%	11.7	11.9	2.4%
01/07/97	7:00	4,686	0.2	0.8	77	9,962	6	61	81.26%	100%	342	592	244		301	305	22.09	14.48	15.0	66%	11.8	11.8	2.4%
01/07/97	13:00	4,749	0.2	0.9	76	9,931	6.12	57	87.26%	100%	393	670	246	170	274	350	24.39	12.7	15.0	71%	13.3	13.6	2.5%
01/07/97	17:00	4,742	0.2	0.9	76.5	9,956	6.09	58	87.76%	100%	382	666	233	170	277	360	23.82	13.19	15.0	71%	13.3	13.4	2.3%
01/07/97	19:00	4,745	0.2	0.9	76.5	10,069	6.09	57	87.76%	100%	387	676	237	170	282	355	23.57	12.9	15.0	71%	13.5	13.6	2.4%
01/07/97	23:00	4,721	0.2	0.9	76	9,944	6.12	58	88.76%	100%	389	683	236	170	271	350	23.63	12.66	15.0	72%	13.6	13.8	2.4%
01/08/97	3:00	4,736	0.2	0.9	76.5	9,975	6.09	55	88.76%	100%	399	694	236	170	271	350	23.55	12.9		72%	13.8	13.9	2.4%
01/08/97	5:00	4,747	0.2	0.9	76.5	9,988	6.09	55	87.76%	100%	393	684	233	170	267	350	23.55	12.92		72%	13.6	13.7	2.3%
01/08/97	9:00	4,742	0.2	0.9	76.5	9,920	6.09	54	88.76%	100%	392	678	234	180	270	355	22.92	12.67	15.0	72%	13.5	13.6	2.4%
01/08/97	11:00	4,720	0.2	0.9	76.6	10,191	6.06	55	88.76%	100%	387	675	237	180	268	355	22.67	12.46	15.0	72%	13.4	13.5	2.3%
01/08/97	13:00	3,725	0.2	0.7	76.5	9,144	6.09	61	87.76%	100%	375	692	191	160	272	335	24.62	13.62	13.0	72%	13.8	13.9	2.1%
01/08/97	15:00	3,732	0.2	0.7	76.5	9,131	6.09	60	87.76%	100%	376	696	190	160	272	335	24.58	13.65	13.0	72%	13.9	14.0	2.1%
01/08/97	19:00	3,743	0.2	0.7	76.5	8,838	6.06	59	86.76%	100%	369	689	182	160	268	320	24.4	13.3	13.0	72%	13.7	13.8	2.1%
01/09/97	3:00	3,732	0.2	0.8	76.5	8,894	6	60	86.76%	100%	370	692	181		268	330	24.8	13.51	13.0	72%	13.8	13.9	2.0%
01/09/97	5:00	3,719	0.2	0.7	77	8,964	6.1	56	87.26%	100%	368	690	184		266	330	24.54	14.02	13.0	72%	13.7	13.7	2.1%
01/09/97	11:00	3,778	0.2	0.7	77	8,944	6.1	60	86.76%	100%	367	684	184	120	272	330	25.24	18.64	13.0	72%	13.6	13.6	2.1%
01/09/97	13:00	3,714	0.2	0.7	77	9,000	6.09	59	86.76%	100%	367	686	183	130	273	330	25.36	13.23	13.0	72%	13.7	13.7	2.0%
01/09/97	15:00	2,903	0.2	0.6	76.5	8,250	6.06	62	85.26%	100%	354	694	153	130	267	310	24.54	14.39	12.0	72%	13.8	13.9	1.9%
02/18/97	15:00	3,472	0	0.8	78	8,181	6.4	37	80.26%	100%	312	613	198	160	266	265	21.67	13.76	12.5	70%	12.2	12.0	2.4%
02/18/97	19:00	3,817	0.1	0.8	78	9,788	6.09	46	88.26%	100%	378	669	269	200	283	320	24.47	11.86	13.0	70%	13.3	13.1	2.7%
02/18/97	21:00	3,804	0.1	0.7	78.5	9,444	6.06	45	87.26%	100%	367	672	249	180	270	325	23.98	12.83	13.0	71%	13.4	13.0	2.6%
02/18/97	23:00	3,802	0.3	0.7	78.5	9,312	6.09	43	86.76%	100%	365	673	272	200	272	320	24.68	12.81	13.5	71%	13.4	13.1	2.9%
02/19/97	3:00	3,806	0.3	0.8	78.5	9,244	6.06	42	87.26%	100%	367	675	226	160	278	320	23.81	12.27	13.5	71%	13.4	13.1	2.4%
02/19/97	5:00	3,798	0.3	0.7	78.5	9,231	6.06	38	88.26%	100%	368	679	222	160	266	320	24.47	12.77	13.5	72%	13.5	13.2	2.4%
02/19/97	7:00	3,826	0.3	0.8	78.5	9,250	6.09	34	87.76%	100%	364	671	221	160	269	320	24.93	12.83	13.5	71%	13.4	13.0	2.4%
02/19/97	9:00	3,811	0.3	0.7	78.5	9,256	6.09	38	86.76%	100%	360	662	216	160	269	315	24.64	12.83	13.5	71%	13.2	12.9	2.3%
02/19/97	11:00	3,631	0.2	0.7	78.5	8,925	6.09	54	81.26%	100%	331	617	202	135	284	285	22.56	13.45	13.0	68%	12.3	12.0	2.3%
02/19/97	13:00	2,732	0.1	0.5	77.5	7,438	6.06	55	79.26%	100%	307	626	148	100	275	270	23.01	13.13	12.0	69%	12.5	12.4	2.0%
02/19/97	15:00	2,721	0.1	0.5	77.5	7,088	6.06	55	78.76%	100%	305	632	138	90	262	255	23.55	14.5	11.5	71%	12.6	12.5	1.9%
02/19/97	17:00	2,728	0.1	0.5	77.5	7,062	6.06	56	78.76%	100%	306	634	140	100	263	255	23.19	13.97	12.0	71%	12.6	12.5	2.0%
02/19/97	19:00	2,730	0.1	0.5	78	7,069	6.06	56	79.26%	100%	301	627	139	100	264	255	23.3	13.68	12.0	70%	12.5	12.3	2.0%

Appendix F.2
ROWTP Train Performance Date - Train #2 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data												Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
02/19/97	23:00	2,761	0.1	0.5	78	7,162	6.09	43	80.76%	100%	312	634	135	100	273	265	24.6	14.04	12.0	70%	12.6	12.4	1.9%
02/20/97	3:00	2,763	0.1	0.5	78	7,200	6.12	37	82.26%	100%	318	646	133	110	267	275	24.23	13.42	12.0	71%	12.9	12.6	1.8%
02/20/97	5:00	2,785	0.1	0.5	78	7,200	6.09	37	82.26%	100%	315	644	129	110	278	270	24.63	13.27	12.0	70%	12.8	12.6	1.8%
02/20/97	7:00	2,778	0.1	0.5	78	7,194	6.06	36	83.26%	100%	319	658	132	100	264	270	24.57	13.91	12.0	71%	13.1	12.9	1.8%
02/20/97	11:00	2,769	0.1	0.5	78	7,150	6.06	38	81.76%	100%	316	646	130	110	270	275	23.98	13.49	12.0	71%	12.9	12.6	1.8%
02/20/97	13:00	2,739	0.1	0.5	78	7,144	6.09	43	81.26%	100%	315	656	132	90	270	270	23.76	13.17	12.0	71%	13.1	12.8	1.8%
02/20/97	15:00	2,754	0.1	0.5	78	7,125	6.09	44	81.76%	100%	317	646	134	90	281	270	24.14	13.42	12.0	70%	12.9	12.6	1.9%
02/20/97	19:00	2,762	0.1	0.6	78.5	10,320	6.09	49	88.16%	100%	390	652	268	180	270	340	23.22	12.48	12.0	71%	13.0	12.7	2.6%
02/20/97	21:00	2,769	0.1	0.5	78.5	10,287	6.09	50	88.26%	100%	391	649	269	180	272	345	23.17	12.35	12.0	70%	12.9	12.6	2.6%
02/21/97	3:00	4,653	0.1	0.9	78.5	10,244	6	49	87.76%	100%	384	648	242	160	279	340	22.65	11.96	14.5	70%	12.9	12.6	2.4%
02/21/97	5:00	4,677	0.1	1.0	78.5	10,156	6	48	87.26%	100%	382	651	244	160	277	345	22.96	12.24	15.0	70%	13.0	12.6	2.4%
02/21/97	7:00	4,694	0.1	1.0	78	10,188	6.1	54	86.26%	100%	382	646	238	160	283	335	22.77	13.48	15.0	70%	12.9	12.6	2.3%
02/21/97	9:00	4,681	0.1	1.0	78	10,000	6.06	54	86.26%	100%	386	656	241	175	274	335	23.9	12.39	15.0	71%	13.1	12.8	2.4%
02/21/97	11:00	4,683	0.1	0.9	78	10,094	6.09	54	87.26%	100%	383	646	241	160	270	335	23.74	12.5	15.0	71%	12.9	12.6	2.4%
02/21/97	13:00	4,688	0.1	1.0	78	10,081	6.06	54	86.76%	100%	385	653	234	155	284	340	22.18	13.6	15.0	70%	13.0	12.8	2.3%
02/21/97	15:00	4,679	0.1	1.0	78	9,988	6.06	55	86.26%	100%	383	645	241	160	259	335	23.65	13.34	15.0	72%	13.0	12.8	2.4%
02/21/97	17:00	4,666	0.1	1.0	78.5	10,088	6.06	55	86.76%	100%	379	649	233	170	277	340	23.35	11.97	14.5	70%	12.9	12.6	2.3%
02/21/97	19:00	4,657	0.1	1.0	78.5	10,056	6.09	55	86.76%	100%	381	655	238	165	260	335	23.57	13	14.5	72%	13.0	12.7	2.4%
02/22/97	3:00	4,677	0.1	1.0	78.5	10,000	6.1	53	86.76%	100%	376	638	234	160	264	335	22.84	13.39	15.0	71%	12.7	12.4	2.4%
02/22/97	5:00	4,657	0.1	1.0	77.5	10,025	6	54	86.26%	100%	379	650	237	160	252	340	23.75	11.64	14.5	72%	12.9	12.8	2.4%
02/22/97	7:00	4,670	0.1	1.0	77.5	10,031	6	54	85.76%	100%	378	642	230	150	283	330	23.44	11.62	14.5	69%	12.8	12.7	2.3%
02/22/97	9:00	4,638	0.1	1.0	77.5	10,000	6	54	86.76%	100%	381	649	234	155	271	335	23.48	12.59	15.0	71%	12.9	12.8	2.3%
02/22/97	11:00	4,659	0.1	1.0	77.5	10,006	6.09	53	86.76%	100%	381	649	231	155	267	335	23.57	12.81	15.0	71%	12.9	12.8	2.3%
02/22/97	13:00	4,668	0.1	1.0	77	10,044	6.12	48	87.26%	100%	381	651	230	160	268	340	23.37	12.54	14.0	71%	13.0	13.0	2.3%
02/22/97	15:00	4,003	0.1	0.8	77	9,488	6.09	54	87.76%	100%	380	673	196	150	276	340	23.85	11.88	13.0	71%	13.4	13.4	2.1%
02/22/97	19:00	2,918	0.1	0.8	77	10,388	6.09	53	88.26%	100%	396	656	244	180	258	365	23.96	12.08	12.0	72%	13.1	13.1	2.3%
02/22/97	21:00	2,920	0.1	0.6	77	10,294	6.12	48	89.76%	100%	411	686	253	180	257	365	23.99	12.12	12.5	73%	13.7	13.7	2.5%
02/23/97	3:00	2,944	0.1	0.6	77	10,406	6	53	88.26%	100%	406	677	248	165	272	360	23.03	12.39	12.0	71%	13.5	13.5	2.4%
02/23/97	5:00	2,909	0.1	0.6	77	10,506	6	54	88.76%	100%	410	683	251	165	253	365	23.5	11.96	12.0	73%	13.6	13.6	2.4%
02/23/97	7:00	2,855	0.1	0.6	77	10,394	6.1	54	88.76%	100%	409	681	246	165	252	350	24.36	12.53	12.0	73%	13.6	13.6	2.4%
02/23/97	11:00	2,779	0.1	0.6	77	10,206	6.05	31	88.76%	100%	382	634	249	170	272	350	22.41	11.25	12.0	70%	12.6	12.6	2.4%
02/23/97	15:00	2,768	0.1	0.6	77	9,942	6.09	40	87.76%	100%	380	648	260	160	262	345	22.46	11.98	12.0	71%	12.9	12.9	2.6%
02/23/97	17:00	2,774	0.1	0.6	77	9,935	6.09	42	87.76%	100%	383	639	258	160	260	345	22.98	12.08	12.0	71%	12.7	12.7	2.6%
02/23/97	19:00	3,992	0.1	0.8	77.5	9725	6.09	55	87.26%	100%	384	661	212	160	273	345	23.69	11.82	13.0	71%	13.2	13.0	2.2%
02/23/97	23:00	3,787	0.1	0.7	77.5	9,569	6.09	48	88.26%	100%	387	674	211	160	253	350	23.78	12.34	13.5	73%	13.4	13.3	2.2%
02/24/97	3:00	3,789	0.1	0.8	77.5	9,731	6	47	88.26%	100%	389	683	217	145	258	340	24.08	12.16	14.0	73%	13.6	13.5	2.2%

Appendix F.2
ROWTP Train Performance Date - Train #2 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
02/24/97	5:00	3,808	0.1	0.8	77.5	9,719	6	48	86.76%	100%	381	671	219	145	256	345	24.34	12.64	13.5	72%	13.4	13.2	2.3%
02/24/97	7:00	3,795	0.1	0.8	77.5	9,662	6	48	88.26%	100%	384	666	214	145	264	340	23.5	12.17	14.0	72%	13.3	13.1	2.2%
02/24/97	9:00	3,813	0.1	0.8	77.5	9,762	6.09	58	87.26%	100%	390	675	218	145	254	340	24.87	11.76	14.0	73%	13.4	13.3	2.2%
02/24/97	13:00	4,008	0.1	0.8	77.5	9,062	6.09	58	86.76%	100%	369	681	170	110	284	320	26.64	14.61	14.0	71%	13.6	13.4	1.9%
02/24/97	15:00	3,964	0.1	0.8	77.5	9,091	6.09	61	86.76%	100%	369	681	166	110	296	320	26.59	14.78	14.0	70%	13.6	13.4	1.8%
02/24/97	19:00	3,741	0.1	0.8	77.5	9,038	6.09	39	85.76%	100%	354	645	179	130	268	315	24.2	13.56	13.5	71%	12.8	12.7	2.0%
02/24/97	21:00	3,738	0.1	0.8	77.5	9,042	6.09	40	85.76%	100%	352	648	173	140	266	315	24.22	13.64	14.0	71%	12.9	12.8	1.9%
02/24/97	23:00	3,760	0.2	0.8	77.5	9,032	6.09	40	85.76%	100%	358	642	172	140	266	315	24.24	13.62	13.8	71%	12.8	12.7	1.9%
02/25/97	3:00	3,736	0.2	0.8	78	9,031	6	37	86.76%	100%	358	651	174	110	259	310	23.67	13.56	13.0	72%	13.0	12.7	1.9%
02/25/97	5:00	3,771	0.2	0.8	78	9,025	6	38	85.76%	100%	363	659	176	110	263	320	24.12	12.49	13.0	71%	13.1	12.9	2.0%
02/25/97	13:00	2,043	0.1	0.4	77.5	8,844	6.09	60	80.76%	100%	330	606			307	280	23.22	14.99	11.0	66%	12.1	12.0	
02/25/97	15:00	1,842	0.1	0.4	78	9,438	6.03	60	86.76%	100%	373	677	206	135	296	320	26.07	14.34	11.0	70%	13.5	13.3	2.2%
02/25/97	19:00	1,846	0.1	0.4	78	9,388	6.06	60	86.26%	100%	370	665	204	130	306	315	26.4	14.74	11.0	68%	13.2	13.0	2.2%
02/26/97	9:00	2,837	0.1	0.6	78	8,662	6.09	49	86.76%	100%	365	680	136	150	281	320	25.06	13.64	12.0	71%	13.5	13.3	1.6%
02/26/97	13:00	3,708	0.1	0.7	78	8,712	6.06	44	84.76%	100%	347	653	186	125	264	300	23.91	12.78	13.0	71%	13.0	12.8	2.1%
02/26/97	15:00	3,682	0.1	0.7	78	8,819	6.06	42	83.76%	100%	347	641	186	125	272	310	22.48	13.01	13.0	70%	12.8	12.5	2.1%
02/26/97	17:00	3,678	0.1	0.7	78	8,864	6.06	41	84.26%	100%	348	648	186	180	268	315	22.38	13.12	13.0	71%	12.9	12.7	2.1%
02/26/97	19:00	3,668	0.1	0.7	78	8,869	6.06	40	84.26%	100%	349	646	189	180	267	315	22.47	13.13	13.0	71%	12.9	12.6	2.1%
02/26/97	21:00	3,664	0.1	0.7	78	8,872	6.06	36	84.26%	100%	348	648	191	180	268	315	22.42	13.23	13.0	71%	12.9	12.7	2.1%
02/26/97	23:00	3,699	0.1	0.7	78	8,730	6.06	45	80.26%	100%	333	607	189	180	258	290	21.41	11.9	13.0	70%	12.1	11.9	2.3%
02/27/97	3:00	3,636	0.1	0.8	78	8,931	6.09	42	81.26%	100%	333	604	200	150	260	290	21.26	11.91	13.0	70%	12.0	11.8	2.2%
02/27/97	5:00	3,655	0.1	0.7	78	8,925	6.12	42	80.76%	100%	330	595	200	160	259	290	21.38	12.33	13.0	70%	11.8	11.6	2.2%
02/27/97	7:00	3,636	0.1	0.7	78.5	9,000	6.09	41	81.26%	100%	332	601	201	135	258	290	21.89	11.96	13.0	70%	12.0	11.7	2.2%
02/27/97	9:00	3,653	0.1	0.7	78.5	9,000	6.06	40	81.76%	100%	333	607	200	135	261	290	21.21	12.01	13.0	70%	12.1	11.8	2.2%
02/27/97	11:00	3,647	0.1	0.7	78	9,069	6.06	41	81.26%	100%	330	598	199	135	257	295	21.15	12.06	13.0	70%	11.9	11.7	2.2%
02/27/97	15:00	3,715	0	0.7	78.5	9,112	6.09	61	80.26%	100%	328	592	198	130	272	300	20.85	12.4	13.0	69%	11.8	11.5	2.2%
02/27/97	19:00	3,682	1	0.7	78	9,012	6.09	41	81.26%	100%	332	596	202	160	262	300	20.44	12.36	13.0	69%	11.9	11.7	2.2%
02/27/97	21:00	3,660	0.1	0.7	78	9,019	6.02	40	81.26%	100%	335	603	201	160	259	295	20.56	11.88	13.0	70%	12.0	11.8	2.2%
02/28/97	3:00	3,612	0.1	0.8	78	9,762	6	47	81.76%	100%	344	600	224	150	274	300	21.73	12.04	13.0	69%	11.9	11.7	2.3%
02/28/97	5:00	3,642	0.1	0.8	78	10,250	6	48	82.26%	100%	352	612	231	155	264	305	22.13	12.98	13.0	70%	12.2	12.0	2.3%
02/28/97	7:00	3,649	0.2	0.8	78.5	9,532	6	46	80.76%	100%	345	603	215	140	278	310	21.01	12.58	13.0	68%	12.0	11.7	2.3%
02/28/97	9:00	3,668	0.2	0.7	78.5	9,731	6.09	40	81.76%	100%	341	598	211	160	269	305	22.37	12.29	13.0	69%	11.9	11.6	2.2%
02/28/97	15:00	3,526	0.1	0.7	78.5	9,425	6.09	56	84.76%	100%	369	658	187	125	264	320	23.55	12.85	13.0	71%	13.1	12.8	2.0%
02/28/97	17:00	3,699	0.1	0.8	78.5	9,581	6.06	42	86.76%	100%	369	655	212	150	267	325	23.13	12.98	13.0	71%	13.0	12.7	2.2%
02/28/97	21:00	3,699	0.2	0.8	78	8,725	6.06	38	85.26%	100%	346	649	171	130	268	305	23.61	12.98	13.0	71%	12.9	12.7	2.0%
02/28/97	23:00	3,651	0.1	0.8	78	8,794	6.06	35	86.26%	100%	356	652	188	140	277	310	23.54	12.45	13.0	70%	13.0	12.8	2.1%

Appendix F.2
ROWTP Train Performance Date - Train #2 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data												Calculations			
		Raw Plant Water Flow	Raw Water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
Average		3,291	0.1	0.7	76.2	8,885	6.06	49	85%	100%	351	653	206	148	277	312	23.54	13.82	12.7	70%	13.0	13.2	2.3%
Standard Deviation		1,010	0.1	0.2	1.9	1,225	6.97	8	4%	0%	33	36	44	32	16	32	1.36	1.38	1.3	2%	0.7	0.9	0.3%
Maximum		4,963	1.0	1.1	78.5	12,300	5.90	65	93%	100%	432	707	396	289	318	380	29.66	18.64	15.0	81%	14.1	15.5	6.2%
Minimum		17	0.0	0.2	70.0	2,575	6.40	29	70%	100%	278	348	125	83	154	245	17.12	10.24	10.0	56%	6.9	7.2	1.6%

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Appendix F.3
ROWTP Train Performance Data - Train #3 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
10/07/96	11:00	825	0.1	0.19	77.0	7,569	6.00	58	76.0%	100%	281	602	240	160	300	235	30.5	19.6	10.5	67%	12.0	12.0	3.2%
10/11/96	15:00	1,715	0.1	0.36	76.5	7,175	6.10	58	72.5%	100%	270	583	220	150	301	220	28.9	19.5	11.0	66%	11.6	11.7	3.1%
10/17/96	11:00	4,808	0	1.08	76.5	11,425	6.00	60	81.5%	100%	353	669	236	250	281	310	29.0	17.0	15.0	70%	13.3	13.4	2.1%
10/18/96	3:00	4,771	0.1	1.08	76.5	10,706	6.00	52	83.0%	100%	351	675	261	174	282	310	25.9	16.6	15.0	71%	13.4	13.5	2.4%
10/18/96	5:00	4,791	0	1.11	76.5	10,681	6.00	52	82.5%	100%	347	658	262	175	283	305	28.8	16.5	14.5	70%	13.1	13.2	2.5%
10/18/96	7:00	4,769	0.1	0.94	76.5	10,619	6.00	48	83.0%	100%	346	678	255	170	280	305	28.7	16.6	14.5	71%	13.5	13.6	2.4%
10/18/96	9:00	4,791	0.1	0.94	76.5	10,594	6.00	46	83.0%	100%	345	677	251	167	279	310	29.4	16.8	14.5	71%	13.5	13.6	2.4%
10/18/96	11:00	4,760	0.1	0.94	76.5	10,988	6.00	42	83.5%	100%	354	652	251	167	282	310	28.7	16.6	14.5	70%	13.0	13.1	2.3%
10/18/96	13:00	4,795	0.1	0.94	76.5	10,612	6.00	42	83.5%	100%	348	677	245	163	276	310	29.3	16.4	14.5	71%	13.5	13.6	2.3%
10/18/96	15:00	4,786	0.1	0.95	76.5	10,562	6.00	42	84.5%	100%	348	665			280	310	28.7	17.1	14.5	70%	13.2	13.3	
10/18/96	17:00	4,778	0.1	0.95	76.5	10,625	6.10	40	84.0%	100%	353	675	252	168	281	310	29.0	16.8	14.5	71%	13.4	13.5	2.4%
10/18/96	19:00	4,775	0.1	0.93	76.5	10,569	6.00	40	84.0%	100%	349	676	259	173	282	310	28.9	16.7	14.5	71%	13.5	13.6	2.5%
10/18/96	21:00	4,714	0.9	0.98	76.5	10,694	6.00			100%													
10/18/96	23:00	4,767	0	0.95	76.5	10,512	6.00	60	82.0%	100%	345	661	0		281	300	29.6	16.9	14.5	70%	13.2	13.3	
10/19/96	3:00	4,659	0	0.95	76.5	10,575	6.00	50	81.5%	100%	338	625	254	169	281	300	27.0	16.7	14.5	69%	12.4	12.5	2.4%
10/19/96	5:00	4,686	0	0.94	76.5	10,506	6.00	50	82.5%	100%	339	652	258	172	285	290	27.3	17.0	14.5	70%	13.0	13.1	2.5%
10/19/96	7:00	4,662	0	0.94	76.5	10,575	6.00	49	81.5%	100%	338	661	255	170	278	290	28.4	16.3	14.0	70%	13.2	13.3	2.4%
10/19/96	9:00	4,650		0.94	76.5	10,656	6.00	49	81.4%	100%	340	660	257	171	280	290	28.2	16.4	14.0	70%	13.1	13.2	2.4%
10/19/96	11:00	4,659		0.95	76.5	10,662	6.00	49	80.5%	100%	334	650	257	171	278	290	27.9	16.7	14.0	70%	12.9	13.0	2.4%
10/19/96	13:00	4,629	0.1	0.95	76.5	10,506	6.00	47	81.5%	100%	337	647	252	168	281	300	28.5	16.7	14.0	70%	12.9	13.0	2.4%
10/19/96	15:00	4,664		0.95	76.5	10,700	6.00	47	80.0%	100%	341	645	251	167	281	300	27.8	16.4	14.0	70%	12.8	12.9	2.3%
10/19/96	23:00	3,736		0.73	76.5	10,838	6.00	50	80.0%	100%	331	615			300	290	27.8	18.9	13.0	67%	12.2	12.3	
10/21/96	17:00	4,898	0.1	0.97	76.5	10,381	6.00	61	81.0%	100%	345	670	257	171	278	300	29.3	16.7	14.5	71%	13.3	13.4	2.5%
10/21/96	19:00	4,688	0.1	0.97	76.5	10,131	6.00	60	81.5%	100%	342	678	248	165	284	300	28.2	17.4	13.0	70%	13.5	13.6	2.4%
10/21/96	21:00	4,699	0.1	0.94	76.5	10,519	6.10	52	81.5%	100%	340	686	244	163	279	300	28.3	17.5	14.0	71%	13.7	13.8	2.3%
10/28/96	14:00	2,693	0.1	0.6	71.0	7,406	6.10	59	75.0%	100%	278	640	254	169	280	230	30.7	18.1	11.0	70%	12.7	14.1	3.4%
10/29/96	3:00	3,139	0.1	0.61	72.0	7,344	6.10	57	77.0%	100%	290	659	0		301	240	32.1	20.2	12.0	69%	13.1	14.2	
10/29/96	5:00	3,056	0	0.66	72.5	7,362	6.00	60	74.0%	100%	276	602	0		299	225	29.7	19.9	12.5	67%	12.0	12.9	
10/29/96	7:00	2,813	0	0.66	72.5	7,275	6.00	55	74.0%	100%	275	600	119	79	303	225	30.5	20.2	12.0	66%	11.9	12.9	1.6%
10/29/96	9:00	2,813	0	0.67	72.5	7,244	5.90	48	75.0%	100%	273	595	121	81	298	230	30.0	20.1	12.5	67%	11.8	12.7	1.7%
10/29/96	11:00	2,778	0	0.67	72.0	7,325	6.00	54	73.5%	100%	271	595	117	78	299	220	30.0	19.5	12.5	67%	11.8	12.9	1.6%
10/29/96	13:00	2,682	0	0.66	72.0	6,881	6.00	48	74.0%	100%	266	595	101	67	300	220	29.6	20.2	12.0	66%	11.8	12.9	1.5%
10/29/96	15:00	2,702	0.1	0.59	72.5	6,712	6.00	49	74.5%	100%	262	605	96	64	302	220	30.2	20.2	12.0	67%	12.0	13.0	1.4%
10/30/96	15:00	2,780	0.1	0.63	75.0		6.00	54	88.0%	100%	401	679	274	183	282	360	29.7	16.8	13.0	71%	13.5	14.0	
10/30/96	17:00	2,793	0	0.59	74.5	11,487	6.00	53	85.5%	100%	374	674	306	260	281	340	29.8	16.9	11.5	71%	13.4	14.0	2.7%

Appendix F.3
ROWTP Train Performance Data - Train #3 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
10/30/96	19:00	2,879	0	0.58	74.0	10,494	6.00	60	84.5%	100%	368	683	269	230	282	320	30.2	16.9	11.5	71%	13.6	14.3	2.6%
10/30/96	21:00	2,868	0	0.59	74.0	10,944	6.00	60	84.0%	100%	365	675	262	230	278	320	29.6	17.2	11.5	71%	13.4	14.1	2.4%
10/30/96	23:00	2,870	0	0.58	74.0	10,688	6.10	59	83.5%	100%	364	667	260	230	279	320	30.8	17.7	12.0	71%	13.3	13.9	2.4%
10/31/96	3:00	2,863	0	0.59	74.0	10,976	6.00	60	80.3%	100%	364	656	255	220	280	320	29.4	17.4	11.5	70%	13.1	13.7	2.3%
10/31/96	5:00	2,866	0	0.57	74.0	11,031	6.00	59	83.0%	100%	363	690	254	230	279	320	30.0	17.2	12.0	71%	13.7	14.4	2.3%
10/31/96	7:00	2,866	0.1	0.57	74.5	10,938	6.00	59	84.0%	100%	363	665	252	220	277	320	29.6	17.3	12.0	71%	13.2	13.8	2.3%
10/31/96	9:00	2,977	0	0.67	75.0	9,731	6.00	59	83.5%	100%	377	666		200	287	300	32.2	18.8	12.0	70%	13.3	13.7	
10/31/96	11:00	2,944	0.1	0.64	74.0	8,819	6.00	59	80.5%	100%	321	680		170	292	280	30.6	19.0	12.0	70%	13.5	14.2	
10/31/96	13:00	2,931	0	0.64	74.0	8,775	6.00	59	80.5%	100%	324	679	233	160	291	280	29.8	18.9	12.0	70%	13.5	14.2	2.7%
Average		3,745	0.1	0.78	75.2	9,791	6.01	53	80.7%	100%	332	652	216	170	286	288	29.3	17.9	13.1	70%	13.0	13.4	2.4%
Standard Deviation		1,073	0.1	0.21	1.8	1,513	7.08	6	3.8%	0%	36	31	81	47	9	37	1.2	1.8	1.3	2%	0.6	0.6	0.4%
Maximum		4,898	0.9	1.11	77.0	11,487	5.90	61	88.0%	100%	401	690	306	260	303	360	32.2	26.2	15.0	71%	13.7	14.4	3.4%
Minimum		825	0.0	0.19	71.0	6,712	6.10	40	72.5%	100%	262	583	0	64	276	220	25.9	16.3	10.5	66%	11.6	11.7	1.4%

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Appendix F.4
ROWTP Train Performance Data - Train #4 Continued

		F-1 Pretreatment						F-3 Train Data													Calculations			
Date	Time	Raw Plant Water Flow	Raw Water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
10/07/96	12:00	794	0.1	0.2	75.5	7,631	6.06	58	74.0%	100%	302	595	280	180	297	230	25.2	17.4	10.0	67%	11.8	12.1	3.7%
10/10/96	15:00	1,698	0.1	0.3	77.0	7,469	6.03	57	74.0%	100%	290	574	290	190	301	225	25.4	16.9	11.0	66%	11.4	11.4	3.9%
10/17/96	10:00	4,948	0.0	1.1	77.0	11,294	6.09	56	86.0%	100%	394	677	397	280	277	330	25.3	14.7	14.5	71%	13.5	13.5	3.5%
10/18/96	3:00	4,784	0.0	1.1	77.0	10,700	6.00	52	86.0%	100%	397	676	379	253	280	320	25.5	14.8	14.5	71%	13.5	13.5	3.5%
10/18/96	5:00	4,791	0.0	1.1	77.0	10,612	6.00	52	85.5%	100%	395	667	376	251	278	325	24.8	15.3	14.5	71%	13.3	13.3	3.5%
10/18/96	7:00	4,782	0.0	1.0	77.0	10,581	6.10	48	86.0%	100%	394	659	370	247	279	320	25.7	14.9	14.5	70%	13.1	13.1	3.5%
10/18/96	9:00	4,762	0.1	1.0	77.0	10,562	6.12	47	86.0%	100%	400	670	372	248	279	325	25.8	14.6	15.0	71%	13.3	13.3	3.5%
10/18/96	11:00	4,788	0.1	1.0	77.0	10,956	6.03	46	84.5%	100%	389	671	379	253	282	325	25.3	14.9	15.0	70%	13.4	13.4	3.5%
10/18/96	13:00	4,793	0.1	0.9	77.0	10,638	6.06	43	85.5%	100%	392	697	364	243	279	320	24.8	15.1	15.0	71%	13.9	13.9	3.4%
10/18/96	15:00	4,784	0.1	1.0	77.0	10,831	6.12	42	85.0%	100%	395	678	361	241	280	320	25.5	15.6	15.0	71%	13.5	13.5	3.3%
10/18/96	17:00	4,786	0.1	1.0	77.0	10,588	6.06	40	85.5%	100%	394	683	374	249	284	320	25.6	14.8	15.0	71%	13.6	13.6	3.5%
10/18/96	19:00	4,769	0.1	0.9	77.0	10,594	6.09	40	85.5%	100%	392	685	369	246	284	320	24.6	14.6	15.0	71%	13.6	13.6	3.5%
10/18/96	21:00	4,452	0.8	0.9	77.0	10,888	6.09	57	85.0%	100%	390	663	357	238	279	320	25.6	15.1	13.0	70%	13.2	13.2	3.3%
10/18/96	23:00	4,802	0.0	1.0	77.0	10,600	6.06	60	84.0%	100%	387	670	354	236	281	310	25.3	14.6	15.0	70%	13.3	13.3	3.3%
10/19/96	3:00	4,681	0.0	1.0	77.0	10,638	6.00	50	83.5%	100%	384	649	365	243	279	310	23.7	14.7	14.0	70%	12.9	12.9	3.4%
10/19/96	5:00	4,646	0.0	0.9	77.0	10,550	6.00	49	83.5%	100%	378	661	362	241	280	310	24.0	14.8	14.5	70%	13.2	13.2	3.4%
10/19/96	7:00	4,655	0.0	1.0	77.0	10,631	6.00	50	84.5%	100%	380	653	364	243	283	302	23.9	14.9	14.5	70%	13.0	13.0	3.4%
10/19/96	9:00	4,665		0.9	77.0	10,626	6.08	49	84.2%	100%	380	645	363	242	284	310	23.5	15.9	14.5	70%	12.8	12.8	3.4%
10/19/96	11:00	4,672		0.9	77.0	10,612	6.06	49	84.0%	100%	377	639	363	242	280	310	23.6	14.5	15.0	70%	12.7	12.7	3.4%
10/19/96	13:00	4,664		1.0	77.0	10,431	6.09	48	83.5%	100%	378	656	365	243	279	310	23.8	14.6	14.0	70%	13.1	13.1	3.5%
10/19/96	15:00	4,664		1.0	77.0	10,731	6.06	46	84.5%	100%	385	659	360	240	279	302	24.0	14.4	14.0	70%	13.1	13.1	3.4%
10/19/96	17:00	3,660		0.8	77.0	10,941	6.07	59	79.4%	100%	366	618	391	261	311	290	23.2	15.4	12.5	67%	12.3	12.3	3.6%
10/19/96	19:00	3,667		0.7	77.0	10,969	6.06	60	78.5%	100%	361	604	395	263	301	290	22.9	15.9	12.0	67%	12.0	12.0	3.6%
10/19/96	21:00	3,752		0.8	77.0	11,044	6.09	47	83.5%	100%	390	649	409	273	277	320	25.7	14.6	13.0	70%	12.9	12.9	3.7%
10/19/96	23:00	3,756	0.1	0.7	77.0	10,712	6.20	50	86.0%	100%	393	662	392	261	280	320	24.5	14.5	12.0	70%	13.2	13.2	3.7%
10/21/96	17:00	5,038	0.1	0.9	77.0	10,381	6.09	56	84.5%	100%	388	676	394	263	280	320	25.1	15.1	15.0	71%	13.5	13.5	3.8%
10/21/96	19:00	4,729		0.9	77.0	10,231	6.09	62	83.5%	100%	385	679	375	250	280	310	25.1	15.3	13.0	71%	13.5	13.5	3.7%
10/21/96	21:00	4,714	0.1	0.9	77.0	10,538	6.09	52	84.5%	100%	388	685	369	246	277	310	24.5	14.9	15.0	71%	13.6	13.6	3.5%
10/28/96	11:00	3,041	0.1	0.6	71.0	7,531	6.09	60	77.5%	100%	312	647	217	145	302	235	28.4	18.3	11.0	68%	12.9	14.2	2.9%
10/30/96	15:00	2,835	0.1	0.6	74.5	12,394	6.06	54	91.0%	100%	447	681	566	377	280	380	25.4	14.1	11.5	71%	13.6	14.1	4.6%
10/30/96	17:00	2,791	0.1	0.6	74.5	11,400	6.09	53	88.5%	100%	428	671	436	310	281	350	25.6	15.0	11.5	70%	13.4	13.9	3.8%
10/30/96	19:00	2,868	0.0	0.6	74.0	10,888	6.06	59	86.0%	100%	409	653	393	270	279	340	26.2	15.2	11.5	70%	13.0	13.7	3.6%
10/30/96	21:00	2,894	0.1	0.9	74.0	10,931	6.09	59	85.5%	100%	403	670	387	270	281	340	26.7	15.5	11.5	70%	13.3	14.0	3.5%
10/30/96	23:00	2,863	0.0	0.6	74.0	10,756	6.12	59	86.5%	100%	405	661	383	270	281	330	26.3	15.5	11.0	70%	13.2	13.8	3.6%
10/31/96	3:00	2,859	0.0	0.6	74.0	10,906	6.06	60	86.0%	100%	404	675	382	270	278	340	26.4	15.0	11.0	71%	13.4	14.1	3.5%

Appendix F.4
ROWTP Train Performance Data - Train #4 Continued

		F-1 Pretreatment						F-3 Train Data													Calculations			
Date	Time	Raw Plant Water Flow	Raw Water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	Conc. Press.	1st Stage Delta P	2nd Stage Delta P	Prod. Press	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(GPM)	(umhos)	(mg/L)	(GPM)	(psi)	(psi)	(psi)	(psi)	(%)	(gsfd)	(gsfd @ 25C)	(%)
10/31/96	5:00	2,866	0.0	0.6	74.5	10,925	6.09	59	86.0%	100%	405	667	382	260	276	330	26.1	15.3	11.5	71%	13.3	13.8	3.5%
10/31/96	13:00	2,929	0.0	0.6	74.0	8,756	6.09	59	83.0%	100%	363	682	314	220	281	290	26.8	16.2	11.5	71%	13.6	14.3	3.6%
Average		3,990	0.1	0.8	76.2	10,472	6.07	53	84.1%	100%	384	660	372	250	283	312	25.1	15.2	13.3	70%	13.1	13.3	3.5%
Standard Deviation		1,049	0.1	0.2	1.5	1,008	7.10	6	3.4%	0%	30	26	50	35	8	30	1.1	0.9	1.6	1%	0.5	0.6	0.2%
Maximum		5,038	0.8	1.1	77.0	12,394	6.00	62	91.0%	100%	439	697	566	377	311	380	28.4	18.3	15.0	71%	13.9	14.3	4.6%
Minimum		794	0.0	0.2	71.0	7,469	6.20	40	74.0%	100%	290	574	217	145	276	225	22.9	13.9	10.0	66%	11.4	11.4	2.9%

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Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
10/17/96	10:00	4,771	0.1	1.1	75.1	11,375	6.10	61	74%	100%	329	364	26%	696	314	150	232	493	202	53%	75%	14.9	15.4	2.8%
10/18/96	3:00	4,791	0.1	1.1	75.1	10,706	6.10	51	75%	100%	330	364	25%	693	332	220	230	488	206	54%	75%	14.8	15.3	3.1%
10/18/96	5:00	4,773	0.1	1.1	75.1	10,694	6.00	52	75%	100%	329	364	24%	694	331	221	234	487	204	54%	75%	14.8	15.3	3.1%
10/18/96	7:00	4,762	0.1	1.0	75.1	10,600	6.10	48	75%	100%	328	362	24%	694	324	216	230	488	208	54%	75%	14.8	15.3	3.1%
10/18/96	9:00	4,786	0.1	1.0	75.1	10,588	6.10	47	76%	100%	329	362	24%	692	325	217	232	488	203	54%	75%	14.8	15.3	3.1%
10/18/96	11:00	4,782	0.1	1.0	75.1	10,975	6.04	47	76%	100%	329	364	28%	694	307	205	232	492	202	53%	75%	14.8	15.3	2.8%
10/18/96	13:00	4,775	0.1	0.9	75.1	10,631	6.07	43	76%	100%	328	365	29%	693	316	211	232	487	207	53%	75%	14.8	15.3	3.0%
10/18/96	15:00	4,764	0.1	1.0	75.1	10,906	6.10	43	76%	100%	28	364	31%	695	297	198	231	488	206	53%	75%	14.9	15.3	2.7%
10/18/96	17:00	4,760	0.1	0.9	75.1	10,562	6.07	41	76%	100%	329	364	25%	693	315	210	232	490	203	53%	75%	14.8	15.3	3.0%
10/18/96	19:00	4,760	0.1	1.0	75.1	10,600	6.13	39	77%	100%	329	364	23%	695	315	210	232	490	207	55%	75%	14.9	15.3	3.0%
10/18/96	21:00	4,430	0.7	1.0	75.1	10,725	6.13	59	74%	100%	323	358	31%	691	289	193	231	487	205	53%	75%	14.8	15.2	2.7%
10/18/96	23:00	4,762	0.04	0.9	75.1	10,569	6.10	60	74%	100%	326	356	30%	693	281	187	232	491	201	56%	75%	14.8	15.3	2.7%
10/19/96	3:00	4,690	0	0.9	75.1	10,612	6.00	50	75%	100%	328	362	26%	693	312	208	231	490	204	54%	75%	14.8	15.3	2.9%
10/19/96	5:00	4,664	0	0.9	75.1	10,519	6.10	49	75%	100%	327	364	26%	692	322	215	236	489	208	55%	75%	14.8	15.3	3.1%
10/19/96	7:00	4,690	0	0.9	75.1	10,681	6.00	49	75%	100%	328	362	23%	694	311	207	232	489	205	55%	75%	14.8	15.3	2.9%
10/19/96	9:00	4,655		1.0	75.1	10,667	6.04	50	75%	100%	327	363	24%	692	316	211	233	488	204	54%	75%	14.8	15.3	3.0%
10/19/96	11:00	4,629		1.0	75.1	10,681	6.07	50	75%	100%	327	362	22%	694	320	213	234	487	206	54%	75%	14.8	15.3	3.0%
10/19/96	13:00	4,657		1.0	75.1	10,481	6.10	47	75%	100%	326	363	27%	693	199	133	231	484	211	50%	75%	14.8	15.3	1.9%
10/19/96	15:00	4,638		1.0	75.1	10,744	6.10	47	75%	100%	324	360	25%	693	182	121	232	485	209	51%	75%	14.8	15.3	1.7%
10/19/96	17:00	3,662		0.8	75.1	10,943	6.09	59	74%	100%	328	368	30%	694	212	141	232	485	207	48%	75%	14.8	15.3	1.9%
10/19/96	19:00	3,649		0.8	75.1	10,956	6.10	60	74%	100%	330	372	31%	693	216	144	231	485	208	48%	75%	14.8	15.3	2.0%
10/19/96	21:00	3,789		0.8	75.1	10,963	6.07	46	76%	100%	330	373	32%	692	202	135	234	485	209	46%	75%	14.8	15.3	1.8%
10/21/96	17:00	4,788	0.1	0.9	75.1	10,381	6.10	63	73%	100%	322	359	29%	696	211	141	233	485	212	53%	75%	14.9	15.4	2.0%
10/21/96	19:00	4,705	0.1	0.9	75.1	10,194	6.10	61	73%	100%	322	350	29%	696	195	130	227	491	205	53%	75%	14.9	15.4	1.9%
10/21/96	21:00	4,708	0.1	1.0	75.1	10,538	6.07	52	74%	100%	318	351	27%	693	184	123	232	484	209	55%	75%	14.8	15.3	1.7%
10/24/96	15:00	3,102	0.1	0.7	75.1	7,138	6.10	61	67%	100%	276	266	29%	693	115	77	231	484	208	92%	75%	14.8	15.3	1.6%
10/24/96	19:00	2,798	0.1	0.6	75.1	7,100	6.13	54	68%	100%	274	268	32%	694	104	85	232	480	212	79%	75%	14.8	15.3	1.5%
10/24/96	21:00	2,776	0	0.6	75.1	6,944	6.10	44	69%	100%	276	270	26%	693	118	70	233	479	213	77%	75%	14.8	15.3	1.7%
10/25/96	3:00	2,785	0	0.6	75.1	7,031	6.00	50	68%	100%	278	271	29%	696	118	79	227	480	214	77%	75%	14.9	15.4	1.7%
10/25/96	5:00	2,743	0	0.6	75.1	7,038	6.10	59	69%	100%	277	272	27%	695	114	76	233	478	215	78%	75%	14.9	15.3	1.6%
10/25/96	7:00	2,761	0.1	0.6	75.1	7,043	6.10	59	67%	100%	277	272	25%	692	113	75	232	480	212	78%	75%	14.8	15.3	1.6%
10/25/96	9:00	2,728	0.1	0.6	75.1	7,219	6.10	45	69%	100%	279	276	24%	694	121	81	231	480	215	77%	75%	14.8	15.3	1.7%
10/25/96	11:00	2,675	0.1	0.6	75.1	7,162	6.07	44	69%	100%	280	276	27%	694	127	85	231	480	214	75%	75%	14.8	15.3	1.8%
10/25/96	13:00	2,721	0.1	0.6	75.1	7,175	6.07	43	69%	100%	278	274	24%	695	119	79	231	478	214	77%	75%	14.9	15.3	1.7%
10/28/96	14:00	2,723	0.1	0.6	75.1	7,412	6.13	59	67%	100%	274	268	25%	694	111	74	233	481	211	78%	75%	14.8	15.3	1.5%
11/01/96	3:00	2,877	0	0.6	75.1	8,294	6.13	50	70%	100%	287	298	32%	694	149	100	277	480	214	63%	71%	14.8	15.3	1.8%

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Data	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
11/01/96	5:00	2,866	0	0.6	75.1	8,362	6.13	44	71%	100%	288	300	25%	694	152	90	231	480	216	66%	75%	14.8	15.3	1.8%
11/01/96	7:00	2,868	0.1	0.6	74.1	8,594	6.16	41	72%	100%	293	308	27%	694	163	100	231	481	213	64%	75%	14.8	15.6	1.9%
11/01/96	9:00	2,850	0.1	0.6	74.6	8,544	6.07	41	72%	100%	292	306	24%	692	157	100	233	482	211	64%	75%	14.8	15.4	1.8%
11/01/96	11:00	2,885	0.1	0.6	74.6	8,544	6.10	35	73%	100%	291	306	27%	692	145	100	234	479	216	62%	75%	14.8	15.4	1.7%
11/01/96	13:00	2,879	0.1	0.6	74.1	8,994	6.10	49	71%	100%	297	324	27%	695	167	100	233	478	216	59%	75%	14.9	15.6	1.9%
11/01/96	15:00	2,866	0.1	0.6	74.6	8,950	6.10	48	72%	100%	298	324	30%	692	164	100	232	480	214	57%	75%	14.8	15.4	1.8%
11/01/96	17:00	2,839	0.1	0.6	74.6	9,006	6.07	48	72%	100%	298	322	38%	694	152	100	233	478	215	57%	75%	14.8	15.4	1.7%
11/01/96	19:00	2,870	0.1	0.6	74.6	9,075	6.10	48	72%	100%	299	325	28%	691	171	110	228	482	209	58%	75%	14.8	15.4	1.9%
11/02/96	3:00	2,793	0	0.6	74.6	8,900	6.10	59	70%	100%	297	322	31%	695	161	107	234	476	217	58%	75%	14.9	15.5	1.8%
11/06/96	3:00	2,802	0.1	0.5	74.6	7,794	6.10	47	69%	100%	281	288	27%	694	144	96	232	478	215	71%	75%	14.8	15.4	1.8%
11/06/96	5:00	2,800	0.1	0.5	74.6	7,756	6.07	42	70%	100%	282	289	29%	695	142	95	231	479	214	69%	75%	14.9	15.5	1.8%
11/06/96	7:00	2,765	0.1	0.6	74.6	7,788	6.07	47	69%	100%	283	290	32%	694	151	101	231	481	213	68%	75%	14.8	15.4	1.9%
11/06/96	9:00	2,761	0.1	0.6	74.6	7,682	6.04	41	70%	100%	282	290	27%	696	134	89	231	478	215	69%	75%	14.9	15.5	1.7%
11/06/96	11:00	2,758	0.1	0.6	74.6	7,686	6.06	41	70%	100%	280	290	27%	694	136	91	230	479	216	69%	75%	14.8	15.4	1.8%
11/08/96	17:00	1,870	0.1	0.4	74.6	6,762	6.10	58	66%	100%	265	258	32%	694	102	70	232	480	215	87%	75%	14.8	15.4	1.5%
11/08/96	21:00	1,833	0.1	0.4	74.6	6,688	6.10	58	66%	100%	267	258	27%	695	101	70	232	477	217	93%	75%	14.9	15.5	1.5%
11/09/96	3:00	1,807	0.1	0.4	74.6	6,675	6.10	53	67%	100%	269	259	27%	696	105	70	231	480	216	93%	75%	14.9	15.5	1.6%
11/09/96	5:00	1,787	0.1	0.3	74.6	6,694	6.07	56	66%	100%	268	259	27%	694	108	72	233	481	218	93%	75%	14.8	15.4	1.6%
11/13/96	19:00	1,921	0.1	0.4	75.6	8,319	6.10	58	68%	97%	286	297	25%	694	142	100	232	481	215	68%	75%	14.8	15.2	1.7%
11/14/96	11:00	1,940	0.1	0.4	75.5	8,100	6.06	58	68%		286	270		695	118	79	233	477	214		75%	14.9	15.2	1.5%
11/14/96	15:00	2,719	0.1	0.6	76.6	8,100	6.07	60	68%		284	271		694	115	77	232	479	214		75%	14.8	14.9	1.4%
11/16/96	21:00	2,793	0.1	0.6	76.6	7,862	6.10	48	69%	97%	284	291	29%	693	126	90	232	479	214	69%	75%	14.8	14.9	1.6%
11/17/96	3:00	2,796	0.1	0.6	76.6	8,012	6.07	41	71%	95%	288	297	26%	695	132	88	231	480	214	68%	75%	14.9	15.0	1.6%
11/17/96	5:00	2,804	0.1	0.6	76.6	8,050	6.10	42	71%	94%	287	297	27%	693	128	85	232	478	212	68%	75%	14.8	14.9	1.6%
11/17/96	7:00	2,800	0.1	0.6	76.6	8,044	6.07	41	71%	96%	288	296	28%	693	126	84	231	480	214	68%	75%	14.8	14.9	1.6%
11/17/96	9:00	2,798	0.1	0.6	76.6	8,032	6.06	42	71%	95%	289	297	28%	692	128	85	230	482	212	68%	75%	14.8	14.9	1.6%
11/17/96	11:00	2,792	0.1	0.6	76.6	7,994	6.17	40	71%	96%	288	298	22%	694	126	84	232	478	216	65%	75%	14.8	14.9	1.6%
11/17/96	13:00	2,798	0.1	0.6	76.6	8,009	6.07	41	71%	97%	288	300	25%	694	126	84	230	478	215	67%	75%	14.8	14.9	1.6%
11/20/96	15:00	1,960	0.1	0.4	76.6	7,550	6.10	60	69%	95%	283	292	28%	694	116	100	233	480	216	69%	75%	14.8	14.9	1.5%
11/20/96	19:00	2,723	0.1		76.6	8,010	6.10	55	69%	95%	284	294	28%	694	118	100	232		219	70%	75%	14.8	14.9	1.5%
11/20/96	21:00	2,730	0.1	0.6	76.6	8,069	6.10	55	69%	96%	286	299	27%	693	120	90	234	478	218	66%	75%	14.8	14.9	1.5%
11/21/96	5:00	2,728	0.1	0.6	70.6	8,125	6.10	51	70%	96%	290	302	26%	694	137	90	233	479	214	66%	75%	14.8	16.5	1.7%
11/21/96	7:00	2,708	0.1	0.6	71.1	8,044	6.10	54	69%	97%	289	302	25%	696	126	90	232	480	213	65%	75%	14.9	16.4	1.6%
11/21/96	13:00	2,745	0.1	0.6	71.1	8,144	6.07	51	70%	97%	289	310	26%	694	121	60	232	470	217	67%	75%	14.8	16.4	1.5%
11/22/96	13:00	1,842	0.1	0.4	72.6	8,314	6.10	48	72%	100%	292	322	33%	690	142	120	232	477	217		75%	14.8	15.9	1.7%
11/22/96	17:00	2,772	0.1	0.6	73.1	8,000	6.10	47	72%	100%	289	311	28%	694	134	90	230	481	213	66%	75%	14.8	15.8	1.7%

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
11/22/96	19:00	2,763	0.1	0.6	73.1	8,094	6.07	45	72%	100%	290	312	25%	694	135	90	230	481	213	68%	75%	14.8	15.8	1.7%
11/22/96	21:00	2,776	0.1	0.6	73.6	8,156	6.10	45	72%	100%	289	309	28%	693	139	100	232	476	217	65%	75%	14.8	15.7	1.7%
11/23/96	3:00	2,763	0.1	0.6	74.6	8,244	6.10	41	72%	100%	292	310	27%	693	133	89	232	481	212	68%	75%	14.8	15.4	1.6%
11/23/96	5:00	2,752	0.1	0.6	74.6	8,256	6.10	42	72%	100%	291	311	29%	696	139	93	233	478	216	68%	75%	14.9	15.5	1.7%
11/25/96	13:00	2,721	0.1	0.6	74.6	7,912	6.07	57	69%	96%	285	304	25%	696	191	140	231	479	214	69%	75%	14.9	15.5	2.4%
11/25/96	15:00	2,723	0.1	0.6	74.6	7,860	6.08	58	69%	96%	285	305	26%	696	194	140	231	478	214	69%	75%	14.9	15.5	2.5%
11/26/96	3:00	2,798	1.4	0.6	75.1	7,750	6.00	53	69%	96%	285	303	32%	695	187	125	231	478	215	68%	75%	14.9	15.3	2.4%
11/26/96	5:00	2,761	0.1	0.6	75.6	7,919	6.10	48	70%	95%	286	306	27%	692	191	127	232	478	214	69%	75%	14.8	15.1	2.4%
11/26/96	7:00	2,774	0.1	0.6	75.6	7,950	6.10	48	70%	96%	287	307	27%	694	188	125	231	480	215	68%	75%	14.8	15.2	2.4%
11/26/96	19:00	2,807	0.1	0.6	75.6	8,050	6.10	47	70%	96%	286	304	33%	694	194	90	232	478	215	67%	75%	14.8	15.2	2.4%
11/26/96	21:00	2,800	0.1	0.6	75.6	8,156	6.10	44	70%	94%	288	302	26%	694	189	90	232	479	215	69%	75%	14.8	15.2	2.3%
11/27/96	9:00	1,752	0.1	0.4	76	7,645	6.09	44	69%	94%	280	285	26%	692	194	140	231	479	212	75%	75%	14.8	15.0	2.5%
11/27/96	11:00	1,741	0.1	0.4	76.1	7,638	6.10	43	69%	94%	278	286	26%	691				476	214			14.8	15.0	
11/27/96	13:00	1,735	0.1	0.4	76.1	7,838	6.10	41	70%	95%	285	296		693	194	140	233	480	217	69%	75%	14.8	15.0	2.5%
11/27/96	15:00	2,053	0.1	0.4	76.1	7,862	6.13		67%	95%	290	300	37%	693	189	140	231	472	222	66%	75%	14.8	15.0	2.4%
11/27/96	19:00	1,741	0.1	0.4	76.1	7,806	6.07	39	71%	95%	286	299	26%	694	190	90	232	480	212	68%	75%	14.8	15.1	2.4%
11/27/96	21:00	1,741	0.1	0.4	76.1	7,856	6.10	38	71%	95%	286	299	24%	693	195	90	232	477	216	69%	75%	14.8	15.0	2.5%
11/28/96	3:00	1,728	0.1	0.4	76.1	7,856	6.13	38	71%	94%	286	299	31%	694	190	90	231	478	216	69%	75%	14.8	15.1	2.4%
11/28/96	5:00	1,735	0.1	0.4	76.1	7,881	6.13	36	71%	94%	284	288	26%	693	202	90	234	478	216	70%	75%	14.8	15.0	2.6%
11/29/96	17:00	1,776	0.1	0.4	76.6	8,231	6.10	35	71%	85%	282	294	27%	696	189	120	233	478	215	70%	75%	14.9	15.0	2.3%
11/29/96	19:00	1,772	0.1	0.4	76.6	8,246	6.06	35	71%	87%	284	296	27%	694	190	140	233	478	215	69%	75%	14.8	14.9	2.3%
11/29/96	21:00	1,772	0.1	0.4	76.6	8,099	6.10	37	72%	96%	285	298	27%	693	192	140	232	480	216	69%	75%	14.8	14.9	2.4%
11/30/96	3:00	1,964	0.1	0.2	76.1	7,931	6.00	59	69%	95%	288	301	28%	696	193	129	233	479	215	69%	75%	14.9	15.1	2.4%
11/30/96	5:00	1,975	0.1	0.2	76.1	7,950	6.10	59	69%	95%	287	302	28%	694	192	128	232	480	214	69%	75%	14.8	15.1	2.4%
12/01/96	11:00	1,743	0.1	0.4	76.1	7,844	6.09	34	71%	97%	284	299	31%	692	199	140	238	477	220	70%	74%	14.8	15.0	2.5%
12/01/96	13:00	1,748	0.1	0.4	76.1	7,888	6.13	34	71%	95%	284	295	30%	694	196	130	233	479	215	69%	75%	14.8	15.1	2.5%
12/01/96	15:00	1,745	0.1	0.4	76.1	7,882	6.10	35	71%	96%	286	296	30%	695	198	130	237	480	218	69%	75%	14.9	15.1	2.5%
12/02/96	3:00	2,008	0.1	0.4	76.1	7,988	6.20	59	69%	96%	288	300	32%	694	191		233	478	217	68%	75%	14.8	15.1	2.4%
12/02/96	5:00	1,988	0.1	0.4	76.1	7,962	6.20	59	68%	96%	287	299	32%	692	192		233	480	214	68%	75%	14.8	15.0	2.4%
12/02/96	7:00	1,969	0.1	0.4	76.1	7,950	6.20	59	69%	96%	288	302	28%	695	192		232	479	216	67%	75%	14.9	15.1	2.4%
12/02/96	8:30	1,960	0.1	0.4	76.1	8,079	6.29	59	69%	96%	289	307	30%	691	188		233	477	218	68%	75%	14.8	15.0	2.3%
12/02/96	13:00	1,719	0.1	0.4	76.1	7,638	6.10	41	70%	95%	279	286	27%	694	187	140	231	475	218	73%	75%	14.8	15.1	2.4%
12/02/96	15:00	1,715	0.1	0.4	76.1	7,906	6.07	41	71%	95%	285	293	33%	694	187	150	230	479	215	69%	75%	14.8	15.1	2.4%
12/03/96	11:00	798	0.1	0.2	76.1	8,031	6.10	57	69%	95%	290	307	23%	693	186	130	230	478	213	66%	75%	14.8	15.0	2.3%
12/03/96	15:00	794	0.1	0.2	76.1	8,168	6.10	57	66%	95%	292	307	26%	692	191		231	476	214	67%	75%	14.8	15.0	2.3%
12/03/96	19:00	785	0.1	0.2	76.1	8,169	6.09	57	69%	96%	292	307	26%	694	192	90	231	478	215	68%	75%	14.8	15.1	2.4%

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
12/03/96	21:00	785	0.1	0.2	76.1	8,175	6.07	57	69%	95%	290	308	28%	693	193	90	232	477	216	68%	75%	14.8	15.0	2.4%
12/04/96	11:00	2,826	0.1	0.6	76.1	7,869	6.10	50	70%	95%	288	298	26%	694	198	100	232	481	216	69%	75%	14.8	15.1	2.5%
12/04/96	13:00	2,832	0.1	0.6	76.1	7,862	6.10	51	70%	95%	286	299	26%	692	199	100	231	482	217	69%	75%	14.8	15.0	2.5%
12/04/96	15:00	4,642	0.1	0.9	76.1	9,494	6.10	49	74%	96%	310	364	39%	697	194	100	228	477	220	46%	75%	14.9	15.1	2.0%
12/04/96	17:00	4,642	0.1	0.9	76.1	10,888	6.13	47	76%	96%	328	375	27%	689	193	140	232	478	215	48%	75%	14.7	15.0	1.8%
12/04/96	19:00	4,655	0.1	0.9	76.1	9,619	6.10	48	74%	96%	318	346	25%	695	190	110	229	485	211	53%	75%	14.9	15.1	2.0%
12/04/96	21:00	4,640	0.1	0.9	76.1	9,300	5.97	50	73%	95%	310	331	26%	692	194	100	232	480	215	60%	75%	14.8	15.0	2.1%
12/04/96	23:00	4,644	0.1	0.9	76.1	9,219	6.13	48	73%	95%	310	328	25%	694	189	100	232	481	210	61%	75%	14.8	15.1	2.1%
12/05/96	3:00	4,638	0.1	0.9	76.1	9,175	6.13	46	73%	95%	310	325	28%	695	196	100	228	484	207	62%	75%	14.9	15.1	2.1%
12/05/96	5:00	4,638	0.1	0.9	76.1	9,194	6.07	46	73%	95%	310	327	29%	693	192	100	232	484	210	65%	75%	14.8	15.0	2.1%
12/05/96	7:00	4,648	0.1	0.9	76.1	9,200	6.15	45	74%	94%	309	322	23%	693	189	100	238	485	209	70%	74%	14.8	15.0	2.1%
12/05/96	9:00	4,662	0.2	0.9	76.1	9,238	6.10	44	74%	94%	309	322	23%	694	192	120	239	483	209	69%	74%	14.8	15.1	2.1%
12/05/96	11:00	4,848	0.2	0.9	76.1	9,236	6.12	45	74%	96%	308	324	23%	696	194	100	239	482	210	69%	74%	14.9	15.1	2.1%
12/05/96	13:00	4,644	0.2	0.9	76.1	9,244	6.13	45	74%	96%	309	323	23%	694	191	120	241	481	212	70%	74%	14.8	15.1	2.1%
12/05/96	15:00	4,648	0.2	0.9	76.1	9,242	6.10	45	74%	96%	309	324	23%	696	190	120	238	482	210	70%	75%	14.9	15.1	2.1%
12/05/96	17:00	4,664	0.2	0.9	76.1	9,219	6.10	44	74%	96%	310	324	23%	694	190	130	239	484	210	69%	74%	14.8	15.1	2.1%
12/05/96	19:00	4,654	0.2	0.9	76.1	9,212	6.10	39	74%	96%	310	326	23%	694	191	120	241	484	211	69%	74%	14.8	15.1	2.1%
12/05/96	21:00	4,651	0.2	0.9	76.1	9,125	6.07	46	74%	95%	309	325	23%	694	191	90	237	481	211	69%	75%	14.8	15.1	2.1%
12/05/96	23:00	4,618	0.2	0.9	76.1	9,169	6.10	46	74%	96%	312	330	23%	693	192	90	227	487	207	65%	75%	14.8	15.0	2.1%
12/06/96	3:00	4,629	0.3	0.9	76.1	9,212	6.10	45	71%	96%	311	330	23%	696	192	90	231	482	211	66%	75%	14.9	15.1	2.1%
12/06/96	5:00	4,631	0.3	0.9	76.1	9,188	6.10	44	74%	96%	311	330	23%	693	193	90	230	484	211	68%	75%	14.8	15.0	2.1%
12/06/96	7:00	4,627	0.3	0.9	76.1	9,219	6.07	44	74%	92%	311	328	23%	694	197	90	240	484	210	70%	74%	14.8	15.1	2.1%
12/06/96	9:00	4,622	0.3	0.9	76.1	9,138	6.09	48	74%	96%	311	326	22%	693	193	90	240	486	205	69%	74%	14.8	15.0	2.1%
12/06/96	11:00	4,592	0.3	0.9	76.1	9,150	6.07	47	74%	95%	312	326	23%	693	192	90	238	484	211	69%	74%	14.8	15.0	2.1%
12/06/96	17:00	3,706	0.3	0.7	76.1	9,125	6.10	55	72%	92%	310	327	23%	699	194	100	235	485	209	68%	75%	15.0	15.2	2.1%
12/06/96	19:00	3,712	0.3	0.7	76.1	9,136	6.10	54	72%	91%	311	328	23%	695	195	100	236	486	209	68%	75%	14.9	15.1	2.1%
12/06/96	21:00	3,675	0.1	0.7	76.1	9,062	6.13	55	72%	96%	311	330	24%	692	193	90	231	485	210	62%	75%	14.8	15.0	2.1%
12/07/96	3:00	3,688	0.1	0.7	76.1	9,175	6.07	55	72%	96%	310	330	26%	695	194	90	232	484	209	62%	75%	14.9	15.1	2.1%
12/07/96	5:00	3,677	0.1	0.7	76.1	9,212	6.10	55	72%	96%	312	330	25%	695	196	90	232	484	210	61%	75%	14.9	15.1	2.1%
12/07/96	7:00	3,692	0.1	0.7	76.1	9,219	6.07	56	73%	95%	311	333	25%	695	196	90	231	486	209	61%	75%	14.9	15.1	2.1%
12/07/96	9:00	3,675	0.1	0.7	76.1	9,150	6.07	55	72%	96%	311	330	26%	694	201	90	231	483	212	61%	75%	14.8	15.1	2.2%
12/08/96	7:00	1,820	0.1	0.4	76.1	7,681	6.10	58	68%	97%	285	288	29%	693	190	80	232	479	214	72%	75%	14.8	15.0	2.5%
12/08/96	9:00	1,805	0.1	0.4	76.1	7,781	6.10	58	68%	95%	287	291	28%	694	193	100	230	478	214	72%	75%	14.8	15.1	2.5%
12/11/96	11:00	2,822	0.1	0.6	76.1	9,362	6.10	59	71%	90%	306	331	28%	696	146	120	234	477	216	57%	75%	14.9	15.1	1.6%
12/11/96	13:00	2,874	0.1	0.6	76.1	9,382	6.20	60	71%	92%	284	300	26%	694	150	100	233	477	220	66%	75%	14.8	15.1	1.6%
12/12/96	5:00	1,741	0.1	0.4	76.1	7,550	6.10	37	71%	92%	284	283	24%	696	103	80	231	480	211	72%	75%	14.9	15.1	1.4%

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Data	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
12/12/96	7:00	1,739	0.1	0.3	76.6	7,594	6.10	35	71%	94%	284	284	24%	693	107	80	231	480	214	75%	75%	14.8	14.9	1.4%
12/12/96	9:00	1,742	0.1	0.4	76.6	7,514	6.10	36	71%	93%	283	288	23%	692	108	80	232	482	212	75%	75%	14.8	14.9	1.4%
12/12/96	11:00	1,743	0.1	0.3	76.6	8,000	6.13	38	71%	92%	288	299	23%	696	116	100	231	484	215	67%	75%	14.9	15.0	1.5%
12/12/96	13:00	1,739	0.1	0.4	77.1	7,917	6.07	38	71%	96%	288	294	26%	694	109	100	217	480	218	69%	76%	14.8	14.8	1.4%
12/13/96	5:00	1,750	0.1	0.4	76.6	7,506	6.01	31	72%	94%	283	282	24%	694	108		233	480	217	74%	75%	14.8	14.9	1.4%
12/13/96	7:00	1,746	0.1	0.4	76.6	7,600	5.90	28	72%	92%	284	284	28%	694	106		232	479	215	73%	75%	14.8	14.9	1.4%
12/13/96	9:00	1,094	0.1	0.4	76.6	7,925	6.10	59	68%	92%	289	294	27%	694	116		231	480	215	67%	75%	14.8	14.9	1.5%
12/13/96	11:00	1,096	0.1	0.4	76.6	7,950	5.90	58	69%	92%	290	298	27%	695	110		232	478	217	67%	75%	14.9	15.0	1.4%
12/13/96	21:00	1,752	0.1	0.4	75.6	7,888	6.10	34	71%	94%	284	282	27%	694	95	80	233	480	215	73%	75%	14.8	15.2	1.2%
12/13/96	23:00	1,761	0.1	0.4	76.6	8,100	6.10	33	72%	94%	288	294	27%	696	121	90	232	480	213	69%	75%	14.9	15.0	1.5%
12/14/96	3:00	1,975	0.1	0.6	76.6	8,412	6.00	59	69%	95%	294	302	26%	693	121		233	480	214	67%	75%	14.8	14.9	1.4%
12/14/96	5:00	1,969	0.1	0.6	76.6	8,406	6.00	59	69%	95%	294	303	26%	694	124		232	481	216	67%	75%	14.8	14.9	1.5%
12/14/96	7:00	1,972	0.1	0.6	76.6	8,325	6.00	59	70%	95%	295	304	30%	693	117		231	480	212	67%	75%	14.8	14.9	1.4%
12/14/96	21:00	1,730	0.1	0.3	76.6	7,594	6.10	43	70%	95%	284	283	31%	694	101	80	232	479	216	72%	75%	14.8	14.9	1.3%
12/14/96	23:00	1,730	0.1	0.4	76.6	7,712	6.10	38	71%	92%	285	287	28%	694	111	80	233	479	218	71%	75%	14.8	14.9	1.4%
12/15/96	3:00	1,741	0.1	0.3	76.6	7,812	6.10	36	71%	94%	286	290	26%	696	111		224	479	217	70%	76%	14.9	15.0	1.4%
12/15/96	5:00	1,726	0.1	0.4	77.1	7,856	6.10	33	72%	90%	288	292	27%	694	113		232	478	216	70%	75%	14.8	14.8	1.4%
12/15/96	7:00	1,730	0.1	0.3	77.1	7,981	6.00	31	72%	93%	290	295	30%	698	118		233	480	214	68%	75%	14.8	14.8	1.5%
12/15/96	17:00	1,732	0.1	0.4	77.1	7,800	6.10	42	71%	92%	288	291	29%	696	118	90	226	480	213	68%	75%	14.9	14.9	1.5%
12/15/96	19:00	1,754	0.1	0.3	77.1	7,781	6.07	37	71%	89%	288	293	30%	694	118	80	232	479	216	69%	75%	14.8	14.8	1.5%
12/15/96	21:00	1,726	0.1	0.4	77.1	7,819	6.10	36	71%	90%	288	292	30%	694	121	90	233	482	215	69%	75%	14.8	14.8	1.5%
12/16/96	3:00	1,730	0.1	0.4	77.1	7,825	6.10	36	72%	93%	288	294	30%	696	121		232	476	213	69%	75%	14.9	14.9	1.5%
12/16/96	5:00	1,724	0.1	0.3	77.1	7,862	6.10	34	72%	89%	288	293	25%	693	120		233	479	214	69%	75%	14.8	14.8	1.5%
12/16/96	7:00	1,732	0.1	0.3	77.1	7,850	6.10	34	72%	90%	288	294	25%	692	116		231	479	214	69%	75%	14.8	14.8	1.5%
12/17/96	5:00	1,758	0.1	0.4	77.1	7,981	6.10	37	71%	89%	288	291	30%	694	118		233	479	214	69%	75%	14.8	14.8	1.5%
12/17/96	23:00	1,776	0.1	0.3	77.1	7,650	6.10	32	71%	100%	283	282	26%	694	108	80	231	477	215	72%	75%	14.8	14.8	1.4%
12/22/96	23:00	1,757	0.1	0.4	77.6	8,019	6.10	40	71%	100%	288	294	28%	696	120	90	230	478	215	69%	75%	14.9	14.7	1.5%
12/23/96	3:00	1,741	0.1	0.3	78.1	8,025	6.00	34	72%	100%	286	291	31%	693	117		232	430	213	69%	75%	14.8	14.6	1.5%
12/23/96	5:00	1,765	0.1	0.4	78.1	8,031	6.10	33	72%	98%	287	292	30%	693	118		233	479	214	69%	75%	14.8	14.6	1.5%
12/23/96	7:00	1,750	0.1	0.3	78.1	8,019	6.00	30	72%	98%	288	292	25%	693	116		232	478	216	69%	75%	14.8	14.6	1.4%
12/23/96	9:00	1,982	0.1	0.4	78.1	8,144	6.04	52	69%	100%	290	293	29%	694	107	80	231	481	219	71%	75%	14.8	14.6	1.3%
12/23/96	11:00	1,925	0.1	0.4	78.6	8,132	6.08	55	69%	100%	291	292	29%	692	106	80	230	480	220	70%	75%	14.8	14.4	1.3%
12/23/96	13:00	1,978	0.1	0.4	78.6	8,125	6.13	56	69%	100%	289	293	25%	691	103	80	231	478	214	69%	75%	14.8	14.4	1.3%
12/25/96	11:00	1,771	0.1	0.4	78.6	7,450	6.09	58	67%	100%	282	229	31%	692		80	231	477	216	74%	75%	14.8	14.4	
12/25/96	13:00	1,768	0.1	0.4	77.6	7,487	6.07	60	68%	100%	281	279	31%	694		80	232	478	214	74%	75%	14.8	14.7	
12/25/96	15:00	1,765	0.1	0.4	77.6	7,500	6.07	59	68%	96%	282	280	29%	653		80	231	480	214	74%	74%	14.0	13.8	

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Data	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
12/25/96	17:00	1,763	0.1	0.4	77.6	7,531	6.07	58	68%	100%	282	281	30%	697		70	233	479	215	72%	75%	14.9	14.8	
12/25/96	19:00	1,781	0.1	0.4	77.6	7,588	6.10	56	68%	100%	283	282	24%	694		80	231	480	212	72%	75%	14.8	14.7	
12/27/96	3:00	2,710	0.2	0.4	76.1	7,819	6.00	29	73%	100%	291	293	30%	695			233	480	214	72%	75%	14.9	15.1	
12/27/96	5:00	2,738	0.2	0.4	76.1	2,827	5.90	28	73%	100%	292	293	29%	694			233	478	214	72%	75%	14.8	15.1	
12/27/96	7:00	2,544	0.1	0.4	77.6	7,712	5.90	52	69%	99%	286	288	26%	694			231	480	213	69%	75%	14.8	14.7	
12/27/96	11:00	2,767	0.1	0.5	78.1	8,119	6.13	37	72%	100%	289	234	25%	692		80	233	478	215	69%	75%	14.8	14.5	
12/27/96	13:00	2,761	0.1	0.5	78	8,120	6.13	36	72%	100%	290	233	27%	690		80	234	486	214	68%	75%	14.8	14.5	
12/27/96	15:00	2,758	0.1	0.6	78	8,144	6.13	36	72%	100%	290	300	32%	693		90	231	490	214	67%	75%	14.8	14.6	
12/28/96	3:00	2,772	0.1	0.6	77.6	7,931	6.00	44	71%	99%	289	296	33%	693			231	478	217	67%	75%	14.8	14.7	
12/28/96	5:00	2,764	0.1	0.6	77.6	7,925	6.00	45	71%	99%	289	297	34%	696			229	477	215	67%	75%	14.9	14.7	
12/28/96	7:00	2,809	0.1	0.6	77.6	7,994	6.00	35	72%	100%	291	300	26%	693			231	478	216	68%	75%	14.8	14.7	
12/28/96	9:00	2,943	0.1	0.6	78.1	7,998	6.10	35	72%	98%	292	303	26%	694		90	231	480	214	65%	75%	14.8	14.6	
12/30/96	3:00	1,774	0.1	0.4	76.6	7,288	5.90	51	69%	100%	280	279	30%	695			233	481	214	76%	75%	14.8	14.9	
12/30/96	5:00	1,759	0.1	0.4	77.6	7,475	6.00	35	71%	100%	283	288	25%	694			232	478	214	72%	75%	14.8	14.7	
12/30/96	7:00	1,741	0.1	0.4	74.6	7,481	6.00	33	71%	100%	283	288	28%	694			232	479	219	71%	75%	14.8	15.4	
12/30/96	11:00	2,809	0.2	0.6	76.6	8,181	6.07	37	72%	100%	290	308	25%	693		90	233	481	213	67%	75%	14.8	14.9	
12/30/96	13:00	2,793	0.2	0.6	76.6	8,200	6.13	34	72%	100%	291	302	27%	694		90	230	460	214	65%	75%	14.8	14.9	
12/31/96	3:00	1,728	0.1	0.4	76.6	8,712	5.90	46	71%	100%	298	329	30%	695			233	482	212	59%	75%	14.9	15.0	
12/31/96	5:00	1,732	0.2	0.4	76.6	8,700	6.00	46	72%	100%	298	329	31%	693			231	480	213	58%	75%	14.8	14.9	
12/31/96	7:00	1,726	0.2	0.4	77.1	8,849	6.00	45	72%	99%	298	330	28%	695			231	480	214	59%	75%	14.9	14.8	
12/31/96	13:00	2,798	0.2	0.5	77.1	8,225	6.07	37	72%	100%	290	306	23%	694		100	232	476	215	67%	75%	14.8	14.8	
12/31/96	15:00	2,769	0.2	0.5	76.6	7,475	6.13	39	71%	100%	283	287	23%	697		70	236	480	217	75%	75%	14.9	15.0	
12/31/96	19:00	2,743	0.2	0.5	76.6	7,519	6.07	38	71%	100%	286	282	29%	696		70	228	479	214	75%	75%	14.9	15.0	
12/31/96	21:00	2,741	0.2	0.5	76.6	7,506	6.10	34	72%	99%	283	281	23%	694		70	234	478	215	77%	75%	14.8	14.9	
12/31/96	23:00	2,719	0.2	0.5	77.1	7,550	6.07	39	71%	97%	284	283	26%	695		70	231	481	216	74%	75%	14.9	14.8	
01/01/97	3:00	2,719	0.2	0.5	77.1	7,538	6.10	35	71%	100%	283	282	26%	694		70	234	478	216	75%	75%	14.8	14.8	
01/01/97	5:00	2,717	0.2	0.5	77.1	7,562	6.10	35	71%	100%	284	284	29%	694		70	233	478	214	74%	75%	14.8	14.8	
01/01/97	7:00	2,722	0.2	0.5	77.1	7,568	6.10	33	71%	100%	283	284	27%	694		70	231	482	217	74%	75%	14.8	14.8	
01/01/97	9:00	2,726	0.2	0.5	77.1	7,600	6.10	30	72%	100%	284	283	23%	694	140	70	232	477	216	75%	75%	14.8	14.8	1.8%
01/01/97	11:00	1,789	0.2	0.4	77.6	7,384	6.08	58	72%	100%	283	281	27%	693	140	70	232	473	218	75%	75%	14.8	14.7	1.9%
01/01/97	13:00	1,772	0.2	0.4	76.6	7,364	6.07	57	70%	100%	282	282	27%	690	140	70	231	472	216	76%	75%	14.8	14.9	1.9%
01/01/97	15:00	1,778	0.2	0.4	76.6	7,362	6.07	58	68%	100%	284	282	29%	693	140	80	231	478	214	77%	75%	14.8	14.9	1.9%
01/02/97	3:00	1,870	0.2	0.4	71.6	7,231	6.07	61	67%	100%	283	283	31%	693	195	70	233	478	214	77%	75%	14.8	16.2	2.7%
01/02/97	5:00	1,873	0.2	0.4	71.6	7,256	6.10	61	68%	100%	283	283	27%	696	191	70	234	480	215	77%	75%	14.9	16.3	2.6%
01/02/97	7:00	1,820	0.2	0.3	71.1	7,258	6.10	60	68%	100%	282	284	26%	694	190	90	232	481	216	77%	75%	14.8	16.4	2.6%
01/02/97	9:00	1,857	0.2	0.4	70.1	7,256	6.04	61	68%	98%	282	282	23%	693	196	90	234	480	215	77%	75%	14.8	16.6	2.7%

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
01/02/97	11:00	1,878	0.2	0.4	70.1	7,258	6.06	60	68%	98%	283	281	23%	694	195	90	231	480	214	77%	75%	14.8	16.6	2.7%
01/02/97	19:00	3,865	0.2	0.9	70.6	10,625	6.10	39	78%	98%	335	364	23%	693	188	120	251	489	205	63%	73%	14.8	16.5	1.8%
01/02/97	21:00	3,859	0.2	0.9	70.6	10,650	6.10	39	78%	98%	335	362	23%	696	191	120	251	490	203	61%	73%	14.9	16.5	1.8%
01/02/97	23:00	3,837	0.2	0.9	71.1	10,544	6.10	40	77%	98%	336	375	23%	695	191	130	229	490	203	52%	75%	14.9	16.4	1.8%
01/03/97	3:00	3,824	0.3	0.9	71.6	10,425	6.00	39	77%	100%	334	370	23%	694	197		228	488	203	52%	75%	14.8	16.2	1.9%
01/03/97	5:00	3,814	0.3	0.9	71.6	10,381	6.00	40	77%	100%	335	371	23%	694	191		228	490	203	52%	75%	14.8	16.2	1.8%
01/03/97	11:00	3,828	0.3	0.9	71.1	10,519	6.07	36	78%	98%	332	364	23%	694	189	120	249	489	205	63%	74%	14.8	16.4	1.8%
01/03/97	15:00	4,808	0.2	1.0	70.1	9,781	6.07	56	75%	98%	328	360	23%	693	192	120	230	490	205	60%	75%	14.8	16.6	2.0%
01/03/97	17:00	4,804	0.2	1.0	70.6	9,881	6.15	54	73%	90%	313	363	85%	691	194	100	246	468	225	55%	74%	14.8	16.4	2.0%
01/03/97	19:00	4,780	0.2	1.0	71.1	9,825	6.10	56	74%	98%	320	366	28%	693	192	100	233	480	213	52%	75%	14.8	16.3	2.0%
01/03/97	21:00	4,799	0.2	1.0	71.1	9,831	6.10	55	74%	96%	321	367	28%	693	192	100	232	480	215	53%	75%	14.8	16.3	2.0%
01/03/97	23:00	4,786	0.2	1.0	71.1	9,869	6.10	55	74%	100%	322	364	27%	694	194	100	233	482	211	57%	75%	14.8	16.4	2.0%
01/04/97	3:00	4,788	0.2	0.9	70.6	9,906	6.00	53	74%	98%	323	365	32%	693	191		232	483	210	55%	75%	14.8	16.5	1.9%
01/04/97	5:00	4,815	0.2	1.0	70.6	9,944	6.10	54	74%	98%	324	365	31%	693	194		232	484	213	55%	75%	14.8	16.5	2.0%
01/04/97	7:00	4,786	..2	0.9	71.1	9,869	6.10	52	75%	97%	325	366	28%	695	194		231	484	210	56%	75%	14.9	16.4	2.0%
01/04/97	9:00	4,771	0.2	0.9	71.1	9,988	6.00	53	75%	98%	324	366	23%	695	196		234	484	209	57%	75%	14.9	16.4	2.0%
01/04/97	11:00	4,780	0.2	1.0	71.1	9,906	6.07	54	75%	96%	324	360	23%	696	193	110	233	482	212	56%	75%	14.9	16.4	1.9%
01/04/97	13:00	4,784	0.2	1.0	71.1	9,912	6.10	53	75%	98%	325	361	24%	693	194	100	232	485	208	54%	75%	14.8	16.3	2.0%
01/05/97	5:00	672	0.2	0.2	72.1	7,900	6.00	41	72%	100%	293	306	23%	696	191		233	486	210	73%	75%	14.9	16.1	2.4%
01/05/97	7:00	661	0.2	0.1	73.1	8,531	6.10	39	73%	94%	305	329	23%	693	193		234	484	208	69%	75%	14.8	15.8	2.3%
01/05/97	9:00	664	0.2	0.2	73.1	8,422	6.10	40	72%	94%	306	330	23%	690	192	110	233	486	209	68%	75%	14.8	15.7	2.3%
01/05/97	11:00	2,765	0.2	0.2	73.1	7,400	6.10	48	70%	94%	281	286	23%	694	197	100	238	485	209	99%	74%	14.8	15.8	2.5%
01/05/97	13:00	2,750	0.2	0.5	73.1	7,360	6.16	38	71%	100%	288	291	23%	633	194	100	231	485	211	86%	73%	13.5	14.4	2.6%
01/06/97	5:00	1,702	0.9	0.4	75.1	8,444	6.00	29	74%	100%	296	315	25%	692	187		239	480	216	68%	75%	14.8	15.3	2.2%
01/06/97	7:00	1,813	0.2	0.4	74.6	7,981	6.00	50	71%	100%	296	302	23%	694	192		249	486	209	85%	74%	14.8	15.4	2.4%
01/06/97	9:00	1,787	0.2	0.4	75.6	8,025	6.10	55	70%	99%	296	305	23%	693	187	90	244	485	208	79%	74%	14.8	15.2	2.3%
01/06/97	11:00	1,782	0.2	0.4	75	8,120	6.09	50	70%	93%	296	306	23%	693	188	90	292	484	206	79%	70%	14.8	15.3	2.3%
01/06/97	13:00	1,778	0.2	0.4	75.1	8,219	6.07	52	71%	94%	298	315	21%	694	194	100	235	484	211	74%	75%	14.8	15.3	2.4%
01/06/97	19:00	2,758	0.2	0.6	75.6	11,638	613.00	55	77%	94%	356	426	34%	697	194	90	231	481	214	35%	75%	14.9	15.3	1.7%
01/07/97	3:00	4,736	0.2	0.8	75.6	10,525	6.00	65	75%	94%	330	354	26%	694	194		232	486	209	55%	75%	14.8	15.2	1.8%
01/07/97	5:00	4,633	0.2	0.8	76.1	10,200	6.00	64	73%	94%	323	355	26%	692	186		233	485	207	55%	75%	14.8	15.0	1.8%
01/07/97	7:00	4,802	0.2	0.8	77.1	10,119	6.00	58	74%	94%	322	356	26%	699	186		232	486	215	57%	75%	15.0	14.9	1.8%
01/07/97	13:00	4,749	0.2	0.9	76.1	9,925	6.10	58	74%	94%	325	369	23%	693	196	100	236	485	209	57%	75%	14.8	15.0	2.0%
01/07/97	17:00	4,751	0.2	0.9	76.6	9,994	6.07	57	74%	94%	325	361	28%	694	196	110	234	484	211	56%	75%	14.8	14.9	2.0%
01/07/97	19:00	4,736	0.2	0.9	76.6	10,062	6.10	58	74%	94%	325	372	32%	694	194	100	232	484	209	55%	75%	14.8	14.9	1.9%
01/07/97	23:00	4,747	0.2	0.9	76.1	10,000	6.13	58	74%	94%	326	368	23%	695	194	100	235	486	210	55%	75%	14.9	15.1	1.9%

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Data	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
01/08/97	3:00	4,749	0.2	0.9	76.6	9,994	6.10	56	74%	94%	325	368	24%	693	194	100	232	484	208	54%	75%	14.8	14.9	1.9%
01/08/97	5:00	4,758	0.2	0.9	76.6	10,006	6.13	56	74%	94%	326	368	24%	694	195	100	233	486	211	54%	75%	14.8	14.9	1.9%
01/08/97	9:00	4,740	0.2	0.9	76.6	9,962	6.09	54	74%	94%	326	361	23%	693	196	100	235	485	209	54%	75%	14.8	14.9	2.0%
01/08/97	13:00	3,722	0.2	0.8	76.6	8,912	6.09	60	74%	94%	307	342	23%	692	198	100	231	480	210	66%	75%	14.8	14.9	2.2%
01/08/97	15:00	3,710	0.2	0.8	76.6	8,906	6.10	61	71%	94%	308	344	23%	699	193	100	233	482	211	67%	75%	15.0	15.1	2.2%
01/08/97	19:00	3,717	0.2	0.7	76.6	8,944	6.10	60	72%	94%	310	332	28%	694	190	100	233	466	211	65%	75%	14.8	14.9	2.1%
01/09/97	3:00	3,738	0.2	0.7	76.6	8,912	6.10	60	72%	98%	308	330	23%	694	194		235	482	212	68%	75%	14.8	14.9	2.2%
01/09/97	5:00	3,736	0.2	0.8	77.1	8,938	6.10	58	72%	96%	308	330	23%	696	196		235	481	214	66%	75%	14.9	14.9	2.2%
01/09/97	11:00	3,725	0.2	0.7	76.6	9,000	6.10	58	72%	94%	308	330	23%	695	192	80	235	481	212	68%	75%	14.9	15.0	2.1%
01/09/97	13:00	4,075	0.2	0.7	77.1	9,444	6.07	62	73%	94%	317	343	23%	690	189	80	232	485	203	63%	75%	14.8	14.7	2.0%
01/09/97	15:00	2,877	0.2	0.6	76.6	8,219	6.10	63	70%	94%	300	310	23%	694	194	80	232	484	210	73%	75%	14.8	14.9	2.4%
01/11/97	7:00	2,653	0.1	0.6	77.6	8,019	6.00	47	71%	97%	293	310	24%	694	192		240	483	212	85%	74%	14.8	14.7	2.4%
01/11/97	9:00	2,664	0.2	0.6	77.6	8,100	6.10	38	72%	96%	292	310	23%	694	189		244	484	209	85%	74%	14.8	14.7	2.3%
01/11/97	11:00	2,662	0.1	0.6	77.6	8,087	6.10	37	73%	94%	293	305	23%	694	194		248	483	213	94%	74%	14.8	14.7	2.4%
01/11/97	13:00	2,649	0.1	0.6	77.6	8,125	6.10	38	72%	100%	295	317	23%	693	194	100	232	483	204	76%	75%	14.8	14.7	2.4%
01/11/97	15:00	2,621	0.1	0.6	77.6	8,138	6.10	41	72%	100%	296	316	23%	696	193	100	232	486	208	74%	75%	14.9	14.7	2.4%
01/11/97	19:00	3,632	0.1	0.6	77.6	8,219	6.10	38	72%	100%	293	313	27%	694	192	90	231	480	212	69%	75%	14.8	14.7	2.3%
01/11/97	21:00	2,680	0.1	0.6	77.6	7,513	6.07	49	69%	100%	284	292	28%	695	188	70	231	476	217	77%	75%	14.9	14.7	2.5%
01/11/97	23:00	2,680	0.1	0.6	77.6	7,438	6.07	48	70%	98%	284	291	29%	694	194	70	231	480	213	77%	75%	14.8	14.7	2.6%
01/12/97	3:00	2,590	0.1	0.5	78.1	8,000	6.00	43	71%	99%	290	305	30%	695	190		233	480	214	69%	75%	14.9	14.6	2.4%
01/12/97	5:00	2,570	0.1	0.5	78.1	8,138	6.00	43	71%	97%	293	312	29%	694	194		233	479	214	68%	75%	14.8	14.6	2.4%
01/12/97	23:00	1,835	0.1	0.4	77.6	6,875	6.10	54	68%	93%	276	278	23%	694	191	70	237	481	212	90%	75%	14.8	14.7	2.8%
01/13/97	3:00	1,818	0.1	0.4	77.6	6,800	6.00	54	67%	97%	274	275	27%	693	195		232	480	214	94%	75%	14.8	14.7	2.9%
01/13/97	5:00	1,827	0.1	0.4	77.6	6,788	6.10	53	67%	98%	274	274	27%	696	194		238	479	214	94%	75%	14.9	14.7	2.9%
01/13/97	7:00	1,807	0.1	0.4	77.6	6,850	6.00	54	67%	100%	274	273	23%	694	183		235	478	217	100%	75%	14.8	14.7	2.7%
01/13/97	9:00	1,778	0.1	0.4	77.6	6,875	6.10	49	68%	93%	274	276	23%	696	194	70	240	478	215	100%	74%	14.9	14.7	2.8%
01/13/97	13:00	1,782	0.1	0.4	77.6	6,878		35	68%	93%	273	280	23%	692	198	80	236	480	216	94%	75%	14.8	14.7	2.9%
01/13/97	15:00	1,798	0.1	0.4	77.6	6,825	6.13	35	70%	98%	275	270	24%	694	194	80	233	498	215	94%	75%	14.8	14.7	2.8%
01/13/97	17:00	1,780	0.1	0.4	77.6	6,832	6.10	36	70%	98%	276	272	24%	694	194	80	233	482	214	95%	75%	14.8	14.7	2.8%
01/13/97	19:00	1,781	0.1	0.4	77.6	6,842	6.10	36	69%	98%	274	276	22%	692	194	80	232	476	216	94%	75%	14.8	14.7	2.8%
01/13/97	23:00	1,886	0.1	0.4	77.6	6,962	6.07	54	68%	98%	278	277	27%	694	195	90	231	478	214	90%	75%	14.8	14.7	2.8%
01/14/97	3:00	2,664	0.2	0.3	78.1	7,994	6.10	45	71%	100%	290	305	24%	694	194		232	478	215	71%	75%	14.8	14.6	2.4%
01/14/97	5:00	2,672	0.2	0.4	78.1	8,002	6.10	44	71%	100%	290	304	24%	693	190		232	478	216	72%	75%	14.8	14.6	2.4%
01/14/97	7:00	2,669	0.2	0.4	78.1	7,997	6.00	45	71%	100%	291	305	24%	694	191		231	479	218	72%	75%	14.8	14.6	2.4%
01/14/97	9:00	2,678	0.2	0.4	78.1	7,988	6.10	44	71%	96%	290	312	24%	694	191	80	231	479	215	70%	75%	14.8	14.6	2.4%
01/14/97	11:00	2,667	0.1	0.4	78.1	8,031	6.10	44	71%	97%	290	316	29%	694	191	80	231	479	216	70%	75%	14.8	14.6	2.4%

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
01/14/97	13:00	2,664	0.1	0.4	78.1	8,056	6.10	42	71%	97%	292	315	29%	693	191	80	231	476	217	69%	75%	14.8	14.6	2.4%
01/14/97	17:00	2,682	0.1	0.4	78.1	8,064	6.10	44	71%	100%	292	316	30%	693	194	80	233	476	217	69%	75%	14.8	14.6	2.4%
01/14/97	19:00	2,673	0.1	0.5	78.1	8,150	6.07	44	71%	100%	294	317	29%	695	194	90	231	479	217	68%	75%	14.9	14.6	2.4%
01/14/97	21:00	2,888	0.1	0.5	78.1	8,175	6.09	42	72%	100%	295	314	28%	694	193	90	228	476	214	66%	75%	14.8	14.6	2.4%
01/14/97	23:00	2,692	0.1	0.5	78.1	8,169	6.13	40	72%	100%	294	318	28%	695	196	100	224	478	215	69%	76%	14.9	14.6	2.4%
01/15/97	3:00	2,675	0.1	0.5	78.1	8,206	6.10	40	72%	100%	295	310	24%	694	194	80	232	479	213	68%	75%	14.8	14.6	2.4%
01/15/97	5:00	2,680	0.1	0.5	78.1	8,231	6.10	40	72%	97%	296	312	26%	692	197	90	232	481	212	67%	75%	14.8	14.5	2.4%
01/15/97	9:00	2,706	0.1	0.5	78.1	8,288	6.07	40	72%	99%	295	312	29%	693	194	90	233	478	215	67%	75%	14.8	14.6	2.3%
01/15/97	11:00	2,686	0.1	0.5	78.1	8,319	6.10	39	72%	99%	296	312	29%	694	194	90	233	478	216	68%	75%	14.8	14.6	2.3%
01/15/97	13:00	2,688	0.1	0.5	77.6	8,256	6.10	39	72%	100%	296	330	26%	694	192	85	232	480	214	68%	75%	14.8	14.7	2.3%
01/15/97	17:00	2,676	0.1	0.5	77.5	8,264	6.10	39	72%	100%	298	314	28%	692	194	90	231	482	215	68%	75%	14.8	14.7	2.3%
01/15/97	19:00	2,691	0.1	0.5	78.1	8,356	6.10	39	73%	97%	297	310	28%	687	193	90	233	477	216	68%	75%	14.7	14.4	2.3%
01/15/97	21:00	2,688	0.1	0.5	77.6	8,336	6.10	39	73%	98%	298	310	28%	691	196	90	231	478	218	68%	75%	14.8	14.6	2.4%
01/15/97	23:00	2,691	0.1	0.5	77.6	8,331	6.10	39	72%	97%	298	310	28%	693	196	90	232	480	216	66%	75%	14.8	14.7	2.4%
01/16/97	3:00	2,688	0.1	0.5	77.6	8,344	6.13	38	73%	100%	298	312	28%	693	197	80	233	480	214	65%	75%	14.8	14.7	2.4%
01/16/97	5:00	2,684	0.1	0.5	77.6	8,350	6.10	38	72%	100%	297	311	31%	694	199	80	232	478	218	64%	75%	14.8	14.7	2.4%
01/16/97	11:00	2,682	0.1	0.5	77.6	8,350	6.10	38	73%	99%	298	312	29%	695	199	80	232	477	215	64%	75%	14.9	14.7	2.4%
01/16/97	15:00	2,691	0.1	0.6	77.6	8,369	6.07	37	73%	100%	298	325	30%	696	195	90	232	478	217	64%	75%	14.9	14.7	2.3%
01/16/97	21:00	2,675	0.1	0.5	77.6	7,388	6.00	50	70%	98%	286	294	25%	695	191	80	232	480	215	79%	75%	14.9	14.7	2.6%
01/16/97	23:00	2,680	0.1	0.5	77.6	7,381	6.10	51	69%	96%	286	292	29%	692	195	90	242	476	218	77%	74%	14.8	14.7	2.6%
01/17/97	3:00	2,675	0.1	0.5	77.6	7,425	6.10	43	71%	96%	287	297	24%	695	189		234	478	215	75%	75%	14.9	14.7	2.5%
01/17/97	5:00	2,693	0.1	0.6	77.6	7,462	6.00	38	71%	99%	286	296	24%	694	194		233	477	215	77%	75%	14.8	14.7	2.6%
01/17/97	7:00	2,675	0.2	0.5	77.6	7,525	6.00	31	72%	98%	288	298	27%	694	193		230	480	214	77%	75%	14.8	14.7	2.6%
01/18/97	3:00	2,684	0.1	0.4	78.1	7,325	6.00	55	68%	99%	282	283	27%	692	189		232	480	213	88%	75%	14.8	14.5	2.5%
01/18/97	5:00	2,653	0.1	0.4	78.1	7,494	6.10	54	69%	97%	283	300	28%	694	189		232	478	216	78%	75%	14.8	14.6	2.5%
01/18/97	7:00	2,632	0.1	0.4	78.1	7,519	6.00	54	69%	96%	285	294	25%	694	190		229	480	216	78%	75%	14.8	14.6	2.5%
01/18/97	11:00	2,654	0.1	0.5	78.1	7,584	6.06	38	70%	96%	285	294	26%	692	188	80	230	480	216	76%	75%	14.8	14.5	2.5%
01/18/97	13:00	2,675	0.1	0.5	78.1	7,562	6.07	39	71%	96%	286	296	27%	693	186	90	230	481	214	75%	75%	14.8	14.6	2.5%
01/18/97	15:00	2,662	0.1	0.5	78.1	7,556	6.07	38	71%	96%	287	294	27%	692	190	90	232	482	216	77%	75%	14.8	14.5	2.5%
01/18/97	17:00	2,675	0.1	0.5	78	7,544	6.09	36	71%	100%	286	296	26%	694	192	90	233	477	215	76%	75%	14.8	14.6	2.5%
01/18/97	19:00	2,680	0.1	0.5	78.1	7,536	6.07	35	72%	99%	286	296	26%	693	194	90	232	478	215	76%	75%	14.8	14.6	2.6%
01/19/97	3:00	2,649	0.1	0.5	78.6	7,556	6.10	38	71%	98%	286	293	24%	694	187		226	482	212	78%	75%	14.8	14.5	2.5%
01/19/97	5:00	2,660	0.1	0.5	78.6	7,538	6.10	39	71%	99%	286	294	24%	693	182		228	482	211	78%	75%	14.8	14.4	2.4%
01/19/97	7:00	2,669	0.1	0.5	78.6	7,563	6.00	39	71%	96%	285	294	24%	694	188		229	480	213	77%	75%	14.8	14.5	2.5%
01/19/97	9:00	2,634	0.1	0.5	78.1	7,550	6.10	44	71%	99%	288	295	24%	694	192	80	231	479	216	78%	75%	14.8	14.6	2.5%
01/19/97	11:00	2,948	0.1	0.5	78.1	7,545	6.10	45	69%	96%	286	294	23%	691	196	80	230	481	216	78%	75%	14.8	14.5	2.6%

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
01/19/97	13:00	2,614	0.1	0.5	78.1	7,562	6.08	48	69%	98%	284	295	24%	693	194	80	232	480	214	77%	75%	14.8	14.6	2.6%
01/19/97	15:00	2,612	0.1	0.5	78.1	7,456	6.07	51	69%	98%	286	294	23%	694	192	80	232	480	216	77%	75%	14.8	14.6	2.6%
01/19/97	17:00	2,632	0.1	0.5	78.1	7,579	6.10	48	70%	100%	286	292	24%	690	196	80	231	481	215	76%	75%	14.8	14.5	2.6%
01/19/97	19:00	2,680	0.1	0.5	78.6	7,572	6.07	34	72%	100%	287	295	28%	694	187	80	234	478	216	76%	75%	14.8	14.5	2.5%
01/20/97	3:00	2,651	0.1	0.5	78.6	7,506	6.00	43	70%	100%	285	293	26%	693	189		233	477	215	78%	75%	14.8	14.4	2.5%
01/20/97	5:00	2,636	0.1	0.5	78.6	7,487	6.10	43	71%	100%	286	293	25%	694	188		232	478	216	79%	75%	14.8	14.5	2.5%
01/20/97	7:00	2,629	0.1	0.5	78.1	7,525	6.00	42	71%	100%	287	295	25%	694	192		233	480	216	77%	75%	14.8	14.6	2.6%
01/20/97	19:00	2,693	0.1	0.5	78.1	7,481	6.08	49	70%	97%	285	296	24%	692	193	90	238	479	216	80%	74%	14.8	14.5	2.6%
01/20/97	21:00	2,704	0.1	0.5	78.1	7,496	6.07	49	70%	98%	286	295	24%	694	194	90	239	478	214	80%	74%	14.8	14.6	2.6%
01/20/97	23:00	2,664	0.1	0.5	78.1	7,400	6.09	51	69%	99%	286	305	24%	694	192		230	480	214	77%	75%	14.8	14.6	2.6%
01/21/97	3:00	2,673	0.1	0.5	78.6	7,444	6.00	47	70%	97%	286	297	24%	695	192		231	480	214	78%	75%	14.9	14.5	2.6%
01/21/97	5:00	2,664	0.1	0.5	78.6	7,469	6.10	45	70%	97%	286	297	25%	693	191		232	477	218	77%	75%	14.8	14.4	2.6%
01/21/97	7:00	2,658	0.1	0.5	78.6	7,462	6.00	42	71%	97%	287	301	24%	696	191		231	480	215	78%	75%	14.9	14.5	2.6%
01/21/97	9:00	2,671	0.1	0.5	78.6	7,519	6.10	36	72%	96%	285	304	24%	692	197	70	245	480	215	93%	74%	14.8	14.4	2.6%
01/21/97	11:00	2,833	0.1	0.5	78.1	7,306	6.07	56	68%	98%	282	294	24%	696	189	70	233	480	215	88%	75%	14.9	14.6	2.6%
01/21/97	15:00	2,874	0.1	0.5	77.1	8,150	6.10	56	71%	99%	302	311	28%	694	190	80	231	480	214	68%	75%	14.8	14.8	2.3%
01/21/97	17:00	2,884	0.1	0.5	77.1	8,125	6.10	55	71%	98%	301	310	28%	692	192	80	230	480	215	69%	75%	14.8	14.8	2.4%
01/21/97	19:00	2,844	0.1	0.5	78.1	8,200	6.07	55	71%	99%	298	311	31%	695	190	80	232	480	214	69%	75%	14.9	14.6	2.3%
01/21/97	21:00	2,835	0.1	0.5	78.1	8,225	6.08	55	72%	100%	299	312	28%	696		80	230	482	214	69%	75%	14.9	14.6	
01/21/97	23:00	2,835	0.1	0.5	78.1	8,256	6.13	56	71%	100%	300	312	23%	694		80	228	481	213	69%	75%	14.8	14.6	
01/22/97	3:00	2,839	0.1	0.5	78.1	8,300	6.10	55	70%	78%	298	309	26%	693		80	231	479	215	68%	75%	14.8	14.6	
01/22/97	5:00	2,833	0.1	0.5	78.1	8,400	6.10	55	71%	97%	298	301	24%	696	120	80	240	480	215	73%	74%	14.9	14.6	1.4%
01/22/97	7:00	2,833	0.1	0.5	78.1	8,388	6.13	55	71%	97%	297	301	24%	694	120	80	238	481	215	73%	74%	14.8	14.6	1.4%
01/22/97	9:00	2,822	0.1	0.5	78.1	8,325	6.10	55	71%	97%	298	304	24%	696		80	245	479	217	75%	74%	14.9	14.6	
01/22/97	11:00	2,831	0.1	0.6	78.1	8,400	6.07	56	71%	100%	298	304	23%	694		80	238	480	218	71%	74%	14.8	14.6	
01/22/97	13:00	2,846	0.1	0.5	78.1	8,225	6.10	56	71%	97%	298	308	23%	694		80	243	480	216	74%	74%	14.8	14.6	
01/22/97	15:00	2,831	0.1	0.5	78.1	8,200	6.10	56	71%	97%	298	304	23%	694		80	241	478	216	73%	74%	14.8	14.6	
01/22/97	19:00	2,836	0.1	0.5	78.1	8,286	6.10	55	70%	97%	297	308	23%	692		80	232	484	215	70%	75%	14.8	14.5	
01/22/97	21:00	2,822	0.1	0.5	78.1	8,288	6.07	56	70%	100%	298	306	25%	694		80	233	480	215	70%	75%	14.8	14.6	
01/22/97	23:00	2,830	0.1	0.5	78.1	8,256	6.07	56	71%	100%	298	305	24%	693	220	80	236	471	217	71%	75%	14.8	14.6	2.7%
01/23/97	3:00	2,830	0.1	0.5	78.1	8,231	6.09	55	70%	97%	299	305	30%	694	120	80	232	478	220	69%	75%	14.8	14.6	1.5%
01/23/97	5:00	2,824	0.1	0.5	78.1	8,219	6.10	56	71%	99%	300	306	27%	693	120	80	230	481	213	68%	75%	14.8	14.6	1.5%
01/23/97	7:00	2,820	0.1	0.5	78.1	8,212	6.07	56	71%	97%	298	304	24%	693	110	70	238	478	215	72%	74%	14.8	14.6	1.3%
01/23/97	9:00	2,831	0.1	0.5	78.1	8,225	6.07	55	71%	100%	298	306	23%	694		80	247	478	216	73%	74%	14.8	14.6	
01/23/97	11:00	2,831	0.1	0.5	78.1	8,188	6.07	55	71%	100%	298	305	23%	693		80	242	478	218	75%	74%	14.8	14.6	
01/23/97	13:00	2,824	0.1	0.5	78.1	8,194	6.10	55	71%	100%	298	322	23%	693		80	242	478	216	74%	74%	14.8	14.6	

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
01/23/97	15:00	2,837	0.1	0.5	78.1	8,181	6.07	55	71%	100%	298	321	23%	693		80	234	480	212	69%	75%	14.8	14.6	
01/23/97	19:00	2,836	0.1	0.5	78.1	8,212	6.08	55	71%	100%	298	318	23%	692		80	232	478	214	72%	75%	14.8	14.5	
01/23/97	21:00	2,833	0.2	0.6	78.1	8,206	6.13	55	71%	98%	298	317	23%	694		80	244	479	219	75%	74%	14.8	14.6	
01/23/97	23:00	2,822	0.1	0.5	78.1	8,188	6.10	56	71%	99%	300	321	23%	695	210	80	228	482	211	66%	75%	14.9	14.6	2.6%
01/24/97	3:00	2,933	0.2	0.5	78.1	8,175	6.10	56	71%	98%	298	320	24%	693			233	478	214	69%	75%	14.8	14.6	
01/24/97	5:00	2,818	0.2	0.5	78.1	8,194	6.10	56	71%	97%	301	320	24%	694			226	480	212	69%	75%	14.8	14.6	
01/24/97	7:00	2,811	0.2	0.5	78.1	8,206	6.10	55	71%	95%	299	324	24%	693			229	482	214	70%	75%	14.8	14.6	
01/24/97	9:00	2,877	0.2	0.6	76.6	6,894	5.97	57	68%	97%	286	286	23%	693		60	241	478	216	100%	74%	14.8	14.9	
01/24/97	11:00	2,833	0.2	0.6	77.6	8,262	5.97	57	68%	97%	282	290	23%	693		60	238	472	216	100%	74%	14.8	14.7	
01/24/97	13:00	2,852	0.2	0.6	77.6	8,294	5.97	56	71%	97%	298	320	24%	694		70	231	477	215	70%	75%	14.8	14.7	
01/24/97	15:00	2,870	0.2	0.5	77.6	8,075	5.97	55	70%	98%	299	322	28%	692		70	233	478	214	70%	75%	14.8	14.7	
01/24/97	17:00	2,863	0.2	0.6	77.6	8,169	5.97	56	71%	94%	299	327	28%	694	110	70	232	478	214	68%	75%	14.8	14.7	1.3%
01/24/97	19:00	2,846	0.2	0.6	77.6	8,344	6.07	55	71%	94%	298	324	30%	694	110	75	231	478	215	67%	75%	14.8	14.7	1.3%
01/24/97	21:00	2,848	0.2	0.6	77.6	8,181	6.04	55	71%	100%	298	312	24%	694	100	70	245	480	214	76%	74%	14.8	14.7	1.2%
01/25/97	3:00	2,846	0.2	0.6	77.6	8,212	6.10	56	71%	100%	300	314	28%	683			231	479	217	69%	75%	14.6	14.5	
01/25/97	5:00	2,857	0.2	0.6	77.6	8,188	6.00	55	71%	99%	299	313	28%	696			230	478	213	69%	75%	14.9	14.7	
01/25/97	7:00	2,850	0.2	0.6	78.1	8,206	6.00	56	71%	99%	300	312	30%	692			230	479	214	69%	75%	14.8	14.5	
01/25/97	9:00	1,781	0.2	0.4	78.1	9,244	6.10	48	73%	99%	308	341	34%	696		90	233	474	220	57%	75%	14.9	14.6	
01/25/97	11:00	1,148	0.2	0.2	78.1	9,962	6.07	55	74%	98%	325	356	24%	693		100	235	482	210	57%	75%	14.8	14.6	
01/25/97	13:00	998	0.2	0.2	78.1	10,481	6.10	54	75%	98%	336	371	24%	694	170	110	241	489	204	58%	74%	14.8	14.6	1.6%
01/25/97	19:00	774	0.2	0.2	78.1	7,800	6.07	53	70%	100%	295	305	24%	693	100	70	230	480	214	70%	75%	14.8	14.6	1.3%
01/25/97	21:00	757	0.1	0.2	78.1	7,794	6.07	53	70%	100%	295	304	24%	693	100	70	234	480	213	73%	75%	14.8	14.6	1.3%
01/25/97	23:00	759	0.1	0.2	78.1	7,838	6.10	53	70%	99%	294	310	24%	694	100	70	234	418	215	70%	75%	14.8	14.6	1.3%
01/26/97	3:00	759	0.2	0.2	78.1	7,881	6.10	53	70%	97%	295	308	24%	693			233	478	216	71%	75%	14.8	14.6	
01/26/97	5:00	761	0.1	0.2	78.1	7,869	6.10	53	70%	96%	296	306	24%	694			232	477	215	71%	75%	14.8	14.6	
01/26/97	7:00	756	0.1	0.2	78.1	7,925	6.00	53	70%	100%	296	310	24%	694			234	479	217	69%	75%	14.8	14.6	
01/26/97	9:00	744	0.1	0.2	78.1	7,962	6.10	53	70%	100%	298	303	24%	699	210	90	232	479	213	71%	75%	15.0	14.7	2.6%
01/26/97	15:00	2,632	0.1	0.5	78.1	7,382	6.07	40	71%	100%	298	302	27%	696	210	90	231	476	218	74%	75%	14.9	14.6	2.8%
01/26/97	17:00	2,627	0.1	0.5	78.1	7,375	6.07	39	71%	98%	288	304	28%	695	200	90	232	478	217	76%	75%	14.9	14.6	2.7%
01/26/97	19:00	2,704	0.2	0.5	78.1	7,431	6.10	38	72%	98%	288	295	23%	694	90	65	245	479	212	85%	74%	14.8	14.6	1.2%
01/26/97	21:00	2,726	0.2	0.5	78.1	7,475	6.13	33	73%	98%	288	286	23%	694	100	70	245	480	213	93%	74%	14.8	14.6	1.3%
01/27/97	3:00	2,680	0.1	0.5	78.1	7,419	6.10	33	72%	93%	289	296	24%	694			231	479	214	77%	75%	14.8	14.6	
01/27/97	5:00	2,719	0.2	0.5	78.1	7,469	6.00	33	73%	93%	288	298	23%	695			246	480	215	93%	74%	14.9	14.6	
01/27/97	7:00	2,621	0.2	0.5	78.1	7,394	6.10	54	70%	93%	287	293	23%	693			245	479	216	100%	74%	14.8	14.6	
01/27/97	9:00	2,645	0.2	0.5	78.1	7,362	6.10	50	70%	93%	289	294	23%	693		70	246	479	215	97%	74%	14.8	14.6	
01/27/97	11:00	2,627	0.2	0.5	78.1	7,344	6.13	51	70%	100%	288	304	23%	693		60	240	480	214	88%	74%	14.8	14.6	

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Data	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
01/27/97	13:00	2,629	0.2	0.5	78.1	7,300	6.10	54	69%	96%	288	304	28%	694		65	234	479	217	77%	75%	14.8	14.6	
01/27/97	15:00	2,618	0.2	0.5	78.1	7,288	6.10	54	69%	95%	288	304	25%	693		65	232	479	214	77%	75%	14.8	14.6	
01/27/97	17:00	2,622	0.2	0.5	78.1	7,306	6.10	45	70%	94%	287	298	26%	693	198	70	231	481	215	78%	75%	14.8	14.6	2.7%
01/27/97	19:00	2,625	0.2	0.5	78.1	7,331	6.10	49	70%	93%	288	296	26%	693	196	70	232	480	216	78%	75%	14.8	14.6	2.7%
01/27/97	21:00	2,638	0.2	0.5	78.1	7,342	6.10	48	70%	93%	289	295	26%	692	200	80	231	482	215	80%	75%	14.8	14.5	2.7%
01/27/97	23:00	2,638	0.2	0.5	78.1	7,362	6.10	47	71%	93%	290	303	23%	694	198	70	233	482	213	85%	75%	14.8	14.6	2.7%
01/28/97	3:00	2,636	0.2	0.5	78.1	7,419	6.00	46	70%	100%	289	307	28%	695			232	479	214	77%	75%	14.9	14.6	
01/28/97	5:00	2,625	0.2	0.5	78.1	7,400	6.10	46	70%	96%	289	303	27%	694			233	477	215	77%	75%	14.8	14.6	
01/28/97	7:00	2,636	0.2	0.5	78.1	7,388	6.10	46	70%	97%	288	298	24%	694			235	479	218	80%	75%	14.8	14.6	
01/28/97	9:00	2,649	0.2	0.5	78.1	7,412	6.07	43	71%	97%	288	296	23%	695		60	244	478	214	89%	74%	14.9	14.6	
01/28/97	11:00	2,642	0.2	0.5	78.1	7,350	6.10	45	71%	97%	288	294	23%	693		60	245	478	215	94%	74%	14.8	14.6	
01/28/97	13:00	2,645	0.2	0.5	78.1	7,381	6.13	44	71%	96%	288	289	23%	695		60	244	479	216	93%	74%	14.9	14.6	
01/28/97	15:00	2,667	0.2	0.5	78.1	7,338	6.10	47	71%	96%	289	300	23%	695		60	243	479	215	93%	74%	14.9	14.6	
01/28/97	17:00	2,642	0.2	0.5	78.1	7,342	6.10	48	70%	97%	290	301	26%	693			236	479	216	80%	75%	14.8	14.6	
01/28/97	19:00	2,640	0.2	0.5	78.1	7,332	6.10	47	70%	98%	288	303	29%	692			232	480	214	77%	75%	14.8	14.5	
01/29/97	3:00	1,883	0.2	0.4	77.6	9,312	6.10	54	73%	98%	314	349	30%	694	130	85	232	481	216	55%	75%	14.8	14.7	1.4%
01/29/97	5:00	1,881	0.26	0.4	77.1	10,669	6.10	54	75%	98%	334	385	24%	693	150	110	233	479	217	49%	75%	14.8	14.8	1.4%
01/29/97	7:00	1,888	0.2	0.4	78.1	10,212	6.10	54	74%	98%	323	362	24%	694	150	100	236	478	216	55%	75%	14.8	14.6	1.5%
01/29/97	9:00	1,868	0.1	0.4	78.1	9,581	6.10	54	74%	98%	318	346	23%	691		90	262	484	210	78%	73%	14.8	14.5	
01/29/97	11:00	1,883	0.1	0.4	78.1	9,200	6.13	54	74%	96%	312	328	23%	693		90	264	484	210	83%	72%	14.8	14.6	
01/29/97	13:00	1,870	0.2	0.4	78.1	8,994	6.10	54	73%	96%	312	322	23%	696		80	258	485	209	77%	73%	14.9	14.6	
01/29/97	15:00	1,873	0.1	0.4	78.1	8,888	6.10	54	73%	96%	311	325	23%	694		80	239	487	207	68%	74%	14.8	14.6	
01/29/97	19:00	2,947	0.1	0.5	78.1	7,886		57	71%	98%	298	302	23%	692		70	239	482	213	78%	74%	14.8	14.5	
01/29/97	21:00	2,932	0.1	0.5	78.1	7,888		56	71%	98%	294	303	23%	694	210	70	238	484	209	77%	74%	14.8	14.6	2.7%
01/29/97	23:00	2,949	0.1	0.5	78.1	7,806		57	71%	93%	300	303	23%	695	220	80	234	485	209	82%	75%	14.9	14.6	2.8%
01/30/97	3:00	2,920	0.2	0.5	78.1	7,906	6.10	56	70%	95%	296	306	30%	693	90	70	231	480	213	69%	75%	14.8	14.6	1.1%
01/30/97	5:00	2,909	0.2	0.6	78.1	7,806	6.10	56	70%	93%	297	314	28%	694	100	70	232	481	214	72%	75%	14.8	14.6	1.3%
01/30/97	7:00	2,905	0.2	0.6	78.1	7,819	6.10	57	70%	93%	297	314	28%	693	100	65	232	480	213	72%	75%	14.8	14.6	1.3%
01/30/97	9:00	2,903	0.2	0.6	78.1	7,906	6.10	56	70%	93%	297	311	29%	694	100	70	234	479	215	72%	75%	14.8	14.6	1.3%
01/30/97	13:00	2,914	0.2	0.6	77.6	7,950	6.13	56	70%	98%	295	302	30%	695	97	70	232	479	216	71%	75%	14.9	14.7	1.2%
01/30/97	15:00	2,645	0.2	0.6	78.1	7,362	6.07	48	71%	100%	292	290	25%	703	99	70	233	486	217	80%	75%	15.0	14.8	1.3%
01/30/97	19:00	2,664	0.2	0.6	78.1	7,444	6.10	35	72%	96%	288	293	24%	692	190		235	476	218	80%	75%	14.8	14.5	2.6%
01/30/97	21:00	2,644	0.2	0.6	78.1	7,462	6.10	38	72%	96%	287	292	25%	694	200	150	234	473	218	80%	75%	14.8	14.6	2.7%
01/31/97	3:00	2,767	0.2	0.6	77.6	7,556	6.10	55	70%	98%	291	291	29%	675	87	58	232	480	213	78%	74%	14.4	14.3	1.2%
01/31/97	5:00	2,774	0.2	0.6	77.6	7,569	6.10	55	70%	100%	292	291	29%	693	91	61	231	479	215	78%	75%	14.8	14.7	1.2%
01/31/97	7:00	2,769	0.2	0.6	78.1	7,513	6.10	55	70%	93%	292	289	24%	695	94	63	233	479	216	78%	75%	14.9	14.6	1.3%

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
01/31/97	9:00	2,778	0.2	0.6	78.1	7,450	6.07	55	70%	93%	292	290	23%	693	95	70	230	482	214	77%	75%	14.8	14.6	1.3%
01/31/97	11:00	2,776	0.2	0.6	78.1	7,525	6.10	56	70%	93%	292	287	25%	694	99	70	231	478	216	78%	75%	14.8	14.6	1.3%
01/31/97	13:00	2,758	0.2	0.5	78.1	7,600	6.10	55	70%	98%	291	285	29%	696	88	70	233	479	215	79%	75%	14.9	14.6	1.2%
01/31/97	15:00	2,765	0.2	0.6	78.1	7,481	6.13	56	70%	100%	291	286	29%	694	98	65	231	479	215	78%	75%	14.8	14.6	1.3%
01/31/97	17:00	2,756	0.2	0.6	78.1	7,469	6.07	56	70%	96%	291	286	26%	693	84	60	232	480	215	79%	75%	14.8	14.6	1.1%
01/31/97	21:00	2,776	0.1	0.6	78.1	7,487	6.10	55	70%	96%	291	283	23%	694	94	60	245	478	215	100%	74%	14.8	14.6	1.3%
02/01/97	3:00	2,758	0.1	0.6	78.1	7,456	6.10	56	70%	93%	292	286	23%	694	94	63	238	478	217	82%	74%	14.8	14.6	1.3%
02/01/97	5:00	2,678	0.1	0.5	78.1	7,481	6.10	56	70%	93%	292	288	23%	692	92	61	231	480	214	82%	75%	14.8	14.5	1.2%
02/01/97	7:00	2,763	0.1	0.6	78.1	7,487	6.10	56	70%	100%	292	293	23%	694	95	63	228	482	213	77%	75%	14.8	14.6	1.3%
02/01/97	9:00	2,743	0.1	1.0	78.1	7,481	6.10	55	70%	100%	291	292	23%	694	92	60	241	478	215	86%	74%	14.8	14.6	1.2%
02/01/97	11:00	2,741	0.1	0.6	78.1	7,456	6.10	55	70%	100%	291	298	23%	694	89	70	244	479	215	100%	74%	14.8	14.6	1.2%
02/01/97	13:00	2,737	0.2	0.6	78.1	7,450	6.10	55	70%	100%	292	293	23%	692	87	70	233	482	212	80%	75%	14.8	14.5	1.2%
02/01/97	15:00	2,706	0.2	0.6	78.1	7,412	6.07	55	70%	100%	292	288	23%	690	93	80	231	490	212	90%	75%	14.8	14.5	1.3%
02/02/97	3:00	2,675	0.2	0.6	78.1	7,462	6.00	55	70%	100%	292	288	23%	694	91	61	232	480	212	80%	75%	14.8	14.6	1.2%
02/02/97	5:00	2,688	0.2	0.6	78.1	7,475	6.10	55	70%	100%	291	289	23%	693	94	63	224	481	214	80%	76%	14.8	14.6	1.3%
02/02/97	7:00	2,693	0.2	0.6	78.1	7,462	6.10	55	70%	100%	292	288	23%	692	96	64	229	480	214	79%	75%	14.8	14.5	1.3%
02/02/97	9:00	2,682	0.2	0.6	78.1	7,456	6.07	55	70%	98%	292	287	23%	697	96	70	235	481	215	84%	75%	14.9	14.6	1.3%
02/02/97	11:00	2,692	0.2	0.6	78.1	7,446	6.07	56	70%	98%	290	298	23%	695	94	70	238	482	216	84%	74%	14.9	14.6	1.3%
02/02/97	13:00	2,695	0.2	0.6	78.1	7,444	6.07	55	70%	98%	291	266	23%	695	93	60	242	487	216	86%	74%	14.9	14.6	1.2%
02/02/97	15:00	2,692	0.2	0.6	78.1	7,456	6.07	56	70%	98%	290	282	23%	692	96	70	232	481	215	80%	75%	14.8	14.5	1.3%
02/02/97	17:00	2,693	0.2	0.6	78.1	7,381	6.10	55	70%	98%	292	282	23%	694	84	60	241	480	214	98%	74%	14.8	14.6	1.1%
02/02/97	19:00	2,680	0.2	0.6	78.1	7,444	6.07	55	70%	99%	292	282	23%	693	91	60	245	479	214	100%	74%	14.8	14.6	1.2%
02/02/97	21:00	2,688	0.2	0.6	78.1	7,487	6.10	53	70%	99%	291	281	23%	695	93	60	247	479	216	100%	74%	14.9	14.6	1.2%
02/03/97	3:00	2,693	0.2	0.6	78.1	7,519	6.00	55	70%	97%	292	292	23%	694	93	62	231	479	217	81%	75%	14.8	14.6	1.2%
02/03/97	5:00	2,667	0.2	0.6	78.1	7,475	6.10	55	70%	96%	293	291	23%	693	94	63	232	480	215	82%	75%	14.8	14.6	1.3%
02/03/97	7:00	2,684	0.2	0.6	78.1	7,469	6.10	54	70%	97%	293	290	23%	695	94	63	226	482	212	82%	75%	14.9	14.6	1.3%
02/03/97	9:00	2,691	0.2	0.6	78.1	7,475	6.10	41	72%	97%	291	286	23%	696	97	65	247	477	218	100%	74%	14.9	14.6	1.3%
02/03/97	11:00	2,691	0.2	0.6	78.1	7,487	6.10	45	71%	97%	290	286	23%	690	92	70	248	477	214	100%	74%	14.8	14.5	1.2%
02/03/97	13:00	2,686	0.2	0.6	78.1	7,444	6.10	55	70%	97%	291	288	23%	695	90	65	247	480	215	100%	74%	14.9	14.6	1.2%
02/03/97	15:00	2,712	0.2	0.6	78.1	7,444	6.13	55	70%	98%	291	286	23%	693	91	70	237	478	216	81%	75%	14.8	14.6	1.2%
02/03/97	19:00	2,678	0.2	0.6	78.1	7,475	6.10	55	70%	98%	292	289	23%	694	100	80	230	481	213	93%	75%	14.8	14.6	1.3%
02/03/97	21:00	2,672	0.2	0.5	78.1	7,472	6.10	54	70%	98%	290	287	23%	692	96	80	238	479	212	92%	74%	14.8	14.5	1.3%
02/03/97	23:00	2,673	0.2	0.6	78.1	7,469	6.10	55	70%	100%	291	281	23%	694	91	70	245	478	213	100%	74%	14.8	14.6	1.2%
02/04/97	3:00	2,675	0.2	0.6	78.1	7,456	6.10	55	70%	99%	292	287	23%	693	96	64	232	479	216	81%	75%	14.8	14.6	1.3%
02/04/97	5:00	2,664	0.2	0.6	78.1	7,469	6.00	55	70%	97%	292	288	23%	696	93	62	232	477	214	81%	75%	14.9	14.6	1.2%
02/04/97	7:00	2,688	0.2	0.6	78.1	7,487	6.10	48	71%	100%	290	282	23%	696	88	59	246	478	217	97%	74%	14.9	14.6	1.2%

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Data	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
02/04/97	9:00	2,691	0.2	0.6	78.1	7,481	6.07	39	72%	96%	291	280	23%	694	90	60	249	476	219	100%	74%	14.8	14.6	1.2%
02/04/97	11:00	2,678	0.1	0.6	78.1	7,419	6.07	55	70%	94%	291	281	23%	693	91	60	247	477	218	100%	74%	14.8	14.6	1.2%
02/04/97	13:00	2,684	0.2	0.6	78.1	7,425	6.07	55	70%	100%	294	285	23%	694	95	65	233	481	214	87%	75%	14.8	14.6	1.3%
02/04/97	15:00	3,695	0.2	0.6	78.1	7,400	6.07	55	70%	100%	291	286	27%	695	91	60	234	478	216	79%	75%	14.9	14.6	1.2%
02/04/97	19:00	2,673	0.1	0.6	77.6	7,431	6.07	46	71%	97%	290	280	23%	694	93	60	247	478	216	100%	74%	14.8	14.7	1.3%
02/04/97	21:00	2,668	0.2	0.6	77.1	7,432	6.07	48	70%	94%	292	284	27%	693	96	60	246	486	218	100%	74%	14.8	14.8	1.3%
02/04/97	23:00	2,676	0.2	0.6	77.1	7,436	6.07	49	70%	96%	291	285	26%	692	96	60	247	480	217	100%	74%	14.8	14.8	1.3%
02/05/97	3:00	2,684	0.1	0.5	78.1	7,425	6.10	50	70%	96%	292	287	23%	694	94	60	230	480	216	78%	75%	14.8	14.6	1.3%
02/05/97	5:00	2,686	0.1	0.6	78.1	7,462	6.10	44	71%	97%	291	285	23%	694	93	60	237	477	217	81%	75%	14.8	14.6	1.2%
02/05/97	7:00	2,684	0.1	0.6	78.1	7,513	6.10	53	70%	94%	291	284	23%	694	83	60	234	480	214	81%	75%	14.8	14.6	1.1%
02/05/97	9:00	2,695	0.1	0.6	78.1	7,469	6.10	55	70%	100%	293	285	23%	694	96	65	235	479	216	83%	75%	14.8	14.6	1.3%
02/05/97	11:00	2,691	0.1	0.6	78.1	7,419	6.10	42	72%	100%	292	286	23%	692	95	65	231	480	216	80%	75%	14.8	14.5	1.3%
02/05/97	15:00	2,697	0.1	0.6	78.1	7,356	6.10	55	70%	94%	292	287	25%	694	93	62	232	479	218	79%	75%	14.8	14.6	1.3%
02/05/97	19:00	2,682	0.1	1.0	78.1	7,392	6.10	55	70%	96%	291	288	24%	694	93	62	231	480	219	79%	75%	14.8	14.6	1.3%
02/05/97	21:00	2,689	0.1	0.6	78.1	7,406	6.10	51	70%	94%	292	289	23%	696	94	70	231	479	215	79%	75%	14.9	14.6	1.3%
02/06/97	3:00	2,680	0.1	0.6	78.1	7,400	6.10	55	70%	100%	291	288	28%	694	93	60	233	479	213	79%	75%	14.8	14.6	1.3%
02/06/97	5:00	2,686	0.1	0.6	78.1	7,438	6.10	55	70%	100%	292	288	23%	696	90	60	238	478	215	82%	75%	14.9	14.6	1.2%
02/06/97	9:00	2,684	0.1	0.6	78.1	7,412	6.10	51	71%	93%	291	282	23%	693	91	60	248	477	217	100%	74%	14.8	14.6	1.2%
02/06/97	11:00	2,704	0.1	0.6	78.1	7,462	6.10	55	70%	94%	293	282	23%	695	88	59	246	479	216	100%	74%	14.9	14.6	1.2%
02/06/97	13:00	2,732	0.1	0.6	78.1	7,438	6.10	55	70%	93%	292	283	23%	692	90	60	248	479	215	100%	74%	14.8	14.5	1.2%
02/06/97	17:00	2,719	0.1	0.6	78.1	7,444	6.13	55	70%	93%	293	290	28%	695	94	70	228	478	215	78%	75%	14.9	14.6	1.3%
02/06/97	19:00	2,719	0.1	0.6	78.1	7,456	6.10	54	70%	93%	290	292	23%	699	92	70	228	478	214	78%	75%	15.0	14.7	1.2%
02/06/97	21:00	2,700	0.1	0.6	78.1	7,402	6.10	56	70%	93%	292	288	26%	697	86	70	246	482	216	100%	74%	14.9	14.6	1.2%
02/06/97	23:00	2,682	0.1	0.6	78.1	7,400	6.10	42	73%	99%	291	283	23%	695	87	70	240	480	213	100%	74%	14.9	14.6	1.2%
02/07/97	3:00	2,688	0.1	0.6	78.1	7,375	6.10	45	71%	93%	292	288	23%	694	91	61	232	481	213	80%	75%	14.9	14.6	1.2%
02/07/97	5:00	2,704	0.1	0.6	78.1	7,400	6.00	44	71%	93%	292	287	23%	695	101	67	231	480	213	80%	75%	14.9	14.6	1.4%
02/07/97	7:00	2,680	0.1	0.6	78.1	7,394	6.10	45	70%	93%	291	292	23%	692	94	63	232	480	214	80%	75%	14.8	14.5	1.3%
02/07/97	9:00	2,699	0.1	0.6	78.1	7,462	6.10	50	71%	93%	293	286	23%	694	96	60	234	479	215	83%	75%	14.8	14.6	1.3%
02/07/97	13:00	2,695	0.1	0.6	78.1	7,412	6.10	45	72%	93%	291	283	23%	694	91	61	246	478	217	97%	74%	14.8	14.6	1.2%
02/07/97	15:00	2,702	0.1	0.6	78.1	7,406	6.10	48	71%	93%	292	284	23%	694	93	62	247	478	217	100%	74%	14.8	14.6	1.3%
02/07/97	17:00	2,693	0.1	0.6	78.1	7,431	6.07	50	70%	97%	292	289	27%	693	91	60	231	478	216	79%	75%	14.8	14.6	1.2%
02/07/97	19:00	2,695	0.1	0.6	78.1	7,475	6.07	48	71%	98%	292	289	24%	692	93	60	233	481	213	78%	75%	14.8	14.5	1.2%
02/08/97	3:00	2,704	0.1	0.6	78.1	7,462	6.10	51	70%	98%	292	288	25%	693	89	59	233	481	215	79%	75%	14.8	14.6	1.2%
02/08/97	5:00	2,680	0.1	0.6	78.1	7,444	6.10	50	71%	98%	293	288	27%	694	90	60	232	478	215	79%	75%	14.8	14.6	1.2%
02/08/97	7:00	2,697	0.1	0.6	78.1	7,481	6.00	49	71%	97%	292	286	23%	693	91	61	239	479	219	81%	74%	14.8	14.6	1.2%
02/08/97	9:00	2,658	0.1	0.6	78.1	7,375	6.10	54	70%	99%	291	282	23%	694	89	59	248	478	217	99%	74%	14.8	14.6	1.2%

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Data	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
02/08/97	21:00	2,748	0.1	0.6	77.6	7,500	6.13	55	70%	98%	290	287	23%	693	96	60	236	477	218	82%	75%	14.8	14.7	1.3%
02/08/97	23:00	2,741	0.1	0.6	77.6	7,612	6.10	55	70%	96%	291	291	29%	693	96	65	232	478	216	78%	75%	14.8	14.7	1.3%
02/09/97	3:00	2,708	0.1	0.6	78.1	7,550	6.10	55	70%	97%	291	289	24%	694	89	59	231	478	214	79%	75%	14.8	14.6	1.2%
02/09/97	5:00	2,725	0.1	0.6	77.6	7,562	6.10	55	70%	97%	292	288	25%	693	98	65	230	480	216	79%	75%	14.8	14.7	1.3%
02/09/97	7:00	2,715	0.1	0.6	78.1	7,500	6.10	55	70%	98%	291	289	24%	696	99	66	234	477	219	79%	75%	14.9	14.6	1.3%
02/09/97	9:00	2,694	0.1	0.6	78.1	7,552	6.10	55	70%	97%	290	288	24%	694	98	61	232	470	220	79%	75%	14.8	14.6	1.3%
02/09/97	13:00	2,689	0.2	0.6	78.1	7,502	6.10	55	70%	97%	292	290	27%	694	98	60	231	480	218	78%	75%	14.8	14.6	1.3%
02/09/97	15:00	2,680	0.3	0.6	78.1	7,573	6.07	55	70%	97%	291	289	29%	693	96	60	232	480	216	78%	75%	14.8	14.6	1.3%
02/09/97	17:00	2,673	0.4	0.6	78.1	7,600	6.07	56	70%	97%	292	288	23%	694	94	60	234	478	215	82%	75%	14.8	14.6	1.2%
02/09/97	19:00	2,678	0.3	0.6	78.1	7,606	6.07	55	70%	95%	292	288	29%	696	91	60	232	478	216	78%	75%	14.9	14.6	1.2%
02/09/97	23:00	2,675	0.3	0.6	78.1	7,619	6.10	55	70%	97%	292	290	23%	693	93	60	235	480	214	82%	75%	14.8	14.6	1.2%
02/10/97	3:00	2,671	0.3	0.6	78.1	7,575	6.10	54	70%	95%	292	287	23%	694	90	60	243	480	216	93%	74%	14.8	14.6	1.2%
02/10/97	5:00	2,669	0.3	0.6	78.1	7,556	6.10	55	70%	95%	291	287	23%	695	94	63	245	478	217	93%	74%	14.9	14.6	1.2%
02/10/97	7:00	2,673	0.4	0.6	78.1	7,594	6.10	54	70%	95%	292	288	23%	698	93	62	246	480	216	94%	74%	14.9	14.7	1.2%
02/10/97	9:00	2,669	0.4	0.6	78.1	7,612	6.07	52	71%	95%	293	285	23%	694	89	60	246	480	213	100%	74%	14.8	14.6	1.2%
02/10/97	11:00	2,684	0.4	0.6	78.1	7,638	6.04	37	73%	95%	292	286	23%	693	84	56	250	480	213	100%	73%	14.8	14.6	1.1%
02/10/97	13:00	2,660	0.4	0.6	78.1	7,569	6.07	52	71%	95%	291	285	23%	694	86	57	248	480	215	100%	74%	14.8	14.6	1.1%
02/10/97	15:00	2,656	0.2	0.6	78.1	7,544	6.10	56	70%	95%	292	292	23%	693	91	61	238	477	215	81%	74%	14.8	14.6	1.2%
02/10/97	17:00	2,735	0.3	0.5	78.1	2,688	6.10	55	70%	94%	291	290	23%	694	96	70	239	479	213	96%	74%	14.8	14.6	3.6%
02/10/97	19:00	2,743	0.4	0.6	78.1	7,688	6.10	56	70%	94%	293	290	23%	695	96	70	250	476	217	96%	74%	14.9	14.6	1.2%
02/10/97	21:00	2,728	0.1	0.6	78.1	8,290	6.10	55	71%	94%	300	306	23%	692	101	80	234	478	215	79%	75%	14.8	14.5	1.3%
02/10/97	23:00	2,773	0.1	0.6	78.1	8,300	6.10	55	71%	94%	303	314	23%	694	108	88	232	480	214	68%	75%	14.8	14.6	1.3%
02/11/97	3:00	2,734	0.1	0.6	78.1	8,288	6.10	56	71%	94%	302	312	23%	693	106	71	234	479	215	72%	75%	14.8	14.6	1.3%
02/11/97	5:00	2,778	0.1	0.6	78.5	8,325	6.10	55	71%	94%	302	311	23%	694	111	74	234	480	215	72%	75%	14.8	14.5	1.3%
02/11/97	7:00	2,748	0.1	0.6	78.1	8,269	6.10	56	71%	94%	303	313	23%	692	109	73	236	478	216	71%	75%	14.8	14.5	1.3%
02/11/97	9:00	2,726	0.1	0.6	78.1	8,375	6.10	56	71%	94%	302	310	23%	695	110	70	237	479	214	75%	75%	14.9	14.6	1.3%
02/11/97	11:00	2,734	0.1	0.6	78.1	8,319	6.10	56	71%	94%	302	312	23%	694	103	69	230	481	213	70%	75%	14.8	14.6	1.2%
02/11/97	15:00	2,741	0.1	0.6	78.1	8,300	6.07	55	71%	94%	301	312	24%	693	101	67	231	480	211	69%	75%	14.8	14.6	1.2%
02/11/97	19:00	2,730	0.1	0.6	78.1	8,306	6.10	56	71%	97%	302	312	24%	693	105	70	232	480	215	70%	75%	14.8	14.6	1.3%
02/11/97	21:00	2,732	0.1	0.6	78.1	8,308	6.10	55	71%	96%	301	312	24%	692	108	70	231	479	214	70%	75%	14.8	14.5	1.3%
02/11/97	23:00	2,734	0.1	0.5	78.1	8,275	6.04	55	71%	94%	301	312	29%	694	109	70	234	480	213	69%	75%	14.8	14.6	1.3%
02/12/97	3:00	2,737	0.1	0.6	78.1	8,381	6.10	55	71%	96%	300	311	28%	694	97	70	231	479	215	71%	75%	14.8	14.6	1.2%
02/12/97	5:00	2,723	0.1	0.6	78.1	8,319	6.10	55	72%	94%	301	306	23%	694	106	70	248	478	215	79%	74%	14.8	14.6	1.3%
02/12/97	7:00	2,717	0.1	0.6	78.1	8,350	6.07	55	72%	94%	302	306	23%	695	102	70	250	478	218	79%	74%	14.9	14.6	1.2%
02/12/97	9:00	2,728	0.1	0.6	78.1	8,394	6.10	55	72%	94%	301	304	23%	696	109	75	251	479	218	82%	73%	14.9	14.6	1.3%
02/12/97	11:00	2,743	0.1	0.6	78.1	8,350	6.07	55	71%	94%	300	305	23%	694	110	73	247	480	214	79%	74%	14.8	14.6	1.3%

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Data	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
02/12/97	13:00	2,728	0.1	0.6	78.1	8,256	6.10	55	71%	94%	301	312	26%	693	107	71	233	479	215	69%	75%	14.8	14.6	1.3%
02/12/97	15:00	2,748	0.1	0.6	78.1	8,225	6.07	55	71%	94%	301	308	25%	695	104	69	231	479	215	70%	75%	14.9	14.6	1.3%
02/12/97	23:00	2,729	0.1	0.6	78.1	8,312	6.07	56	71%	94%	303	305	23%	694	114	80	235	480	213	74%	75%	14.8	14.6	1.4%
02/13/97	3:00	2,752	0.1	0.6	78.1	8,244	6.07	55	71%	94%	300	307	24%	694	111	70	235	476	216	71%	75%	14.8	14.6	1.3%
02/13/97	5:00	2,730	0.1	0.6	78.1	8,231	6.07	55	71%	94%	302	306	24%	695	121	70	232	480	215	71%	75%	14.9	14.6	1.5%
02/13/97	9:00	2,732	0.1	0.6	78.1	8,325	6.10	55	71%	94%	300	308	23%	694	116	75	229	480	214	69%	75%	14.8	14.6	1.4%
02/13/97	11:00	2,732	0.1	0.6	78.6	8,284	6.07	55	71%	94%	300	307	26%	693	111	74	233	478	215	70%	75%	14.8	14.4	1.3%
02/13/97	13:00	2,743	0.1	0.6	78.6	8,338	6.07	55	71%	94%	300	311	27%	694	113	75	231	480	214	70%	75%	14.8	14.5	1.4%
02/13/97	15:00	2,737	0.1	0.6	78.1	8,300	6.07	55	71%	94%	301	310	24%	694	114	76	231	480	217	70%	75%	14.8	14.6	1.4%
02/13/97	19:00	2,736	0.1	0.6	78.1	8,330		56	71%	94%	303	312	23%	693	116	70	232	481	216	70%	75%	14.8	14.6	1.4%
02/13/97	21:00	2,791	0.1	0.6	78.1	8,312	6.10	55	71%	94%	304	309	23%	693	114	70	231	482	216	69%	75%	14.8	14.6	1.4%
02/13/97	23:00	2,734	0.1	0.6	78.1	8,281	6.07	55	71%	94%	301	310	28%	699	119	70	234	477	219	70%	75%	15.0	14.7	1.4%
02/14/97	3:00	2,730	0.1	0.6	78.1	8,225	6.00	55	72%	94%	301	304	23%	692	107	70	244	480	213	77%	74%	14.8	14.5	1.3%
02/14/97	5:00	2,726	0.1	0.6	78.1	8,219	6.00	55	71%	94%	302	305	23%	694	110	0.7	252	478	214	77%	73%	14.8	14.6	1.3%
02/14/97	7:00	2,717	0.1	0.6	77.1	8,275	6.10	55	71%	94%	300	302	23%	693	111	75	246	479	214	78%	74%	14.8	14.8	1.3%
02/14/97	9:00	2,728	0.1	0.6	78.1	8,219	6.10	55	71%	94%	301	304	23%	694	113	70	242	479	215	77%	74%	14.8	14.6	1.4%
02/14/97	13:00	2,730	0.1	0.6	77.1	8,163	6.07	55	71%	94%	301	310	25%	692	114	75	232	479	215	70%	75%	14.8	14.8	1.4%
02/14/97	15:00	2,730	0.1	0.6	77.1	8,269	6.10	55	72%	94%	303	303	24%	695	97	69	236	484	210	79%	75%	14.9	14.8	1.2%
02/14/97	19:00	2,748	0.1	0.6	77.1	8,344	6.10	55	71%	94%	302	310	26%	694	117	70	232	480	215	70%	75%	14.8	14.8	1.4%
02/14/97	21:00	2,732	0.1	0.6	77.1	8,256	6.10	55	71%	94%	302	310	26%	693	118	70	232	480	215	69%	75%	14.8	14.8	1.4%
02/15/97	3:00	2,734	0.1	0.6	77.1	8,219	6.10	55	71%	94%	302	310	26%	695	114	75	228	479	217	69%	75%	14.9	14.8	1.4%
02/15/97	5:00	2,730	0.1	0.6	77.1	8,225	6.00	56	71%	94%	302	308	24%	693	115	75	232	478	215	70%	75%	14.8	14.8	1.4%
02/15/97	7:00	2,726	0.1	0.6	77.1	8,238	6.10	55	71%	94%	301	309	30%	693	116	80	239	478	216	69%	75%	14.8	14.8	1.4%
02/15/97	11:00	2,723	0.1	0.6	77.1	8,250	6.10	55	71%	94%	302	310	28%	692	115	70	232	478	215	68%	75%	14.8	14.8	1.4%
02/15/97	15:00	2,734	0.1	0.5	77.1	8,194	6.10	55	71%	94%	301	310	28%	694	112	70	233	479	216	70%	75%	14.8	14.8	1.4%
02/16/97	3:00	2,721	0.1	0.6	77.6	8,269	6.10	57	71%	97%	302	308	23%	695	119	80	227	480	213	69%	75%	14.9	14.7	1.4%
02/16/97	5:00	2,712	0.1	0.6	77.6	8,281	6.10	56	71%	97%	303	308	23%	694	115	80	228	479	214	69%	75%	14.9	14.7	1.4%
02/16/97	7:00	2,723	0.1	0.6	77.6	8,299	6.00	56	71%	97%	302	309	24%	696	120	80	226	480	214	69%	75%	14.9	14.7	1.4%
02/16/97	11:00	2,718	0.1	0.6	77.6	8,280	6.10	56	71%	97%	303	304		692	115	70	226	482	213	69%	75%	14.8	14.7	1.4%
02/16/97	13:00	2,722	0.1	0.6	77.6	8,242	6.10	55	71%	96%	302	308		694	116	70	228	480	216	71%	75%	14.8	14.7	1.4%
02/16/97	15:00	2,717	0.1	0.6	77.6	8,225	6.10	57	71%	99%	302	307	25%	695	116	70	231	480	214	71%	75%	14.9	14.7	1.4%
02/17/97	3:00	1,717	0.1	0.3	78.1	9,144	6.10	55	73%	94%	314	328	24%	696	136	90	230	481	214	63%	75%	14.9	14.6	1.5%
02/17/97	5:00	1,715	0.1	0.3	78.1	9,156	6.10	54	73%	94%	312	324	23%	694	133	90	247	480	215	71%	74%	14.8	14.6	1.5%
02/17/97	7:00	1,722	0.1	0.3	78.1	9,181	6.10	55	73%	94%	312	324	23%	692	130	85	246	478	215	69%	74%	14.8	14.5	1.4%
02/17/97	13:00	772	0.1	0.2	78.1	7,981	6.32	47	72%	94%	294	296	23%	692	104	70	244	476	217	76%	74%	14.8	14.5	1.3%
02/17/97	15:00	770	0.1	0.2	78.1	7,981	6.29	47	72%	97%	298	296	23%	694	110	75	253	480	215	82%	73%	14.8	14.6	1.4%

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
02/17/97	19:00	2,662	0.1	0.6	78.1	7,588	6.04	38	72%	100%	290	288	30%	691	102	70	232	478	215	78%	75%	14.8	14.5	1.3%
02/17/97	23:00	2,612	0.1	0.5	78.1	7,475	6.10	41	72%	98%	291	289	23%	696	99	60	235	480	214	88%	75%	14.9	14.6	1.3%
02/18/97	3:00	2,597	0.1	0.5	78.1	7,525	6.10	33	72%	97%	290	287	25%	693	108	70	232	479	218	78%	75%	14.8	14.6	1.4%
02/18/97	5:00	2,616	0.1	0.5	78.1	7,545	6.10	34	72%	97%	291	287	26%	694	106	70	231	480	213	79%	75%	14.8	14.6	1.4%
02/18/97	7:00	2,568	0.1	0.5	78.1	7,462	6.10	44	71%	98%	290	282	23%	694	103	70	241	478	215	87%	74%	14.8	14.6	1.4%
02/18/97	9:00	2,581	0.1	0.5	78.1	7,550	6.07	37	72%	94%	290	280	23%	693	99	65	246	477	215	100%	74%	14.8	14.6	1.3%
02/18/97	13:00	3,478	0.1	0.8	78.1	8,262	6.41	38	74%	98%	302	307	26%	694	111	75	230	480	212	71%	75%	14.8	14.6	1.3%
02/18/97	19:00	3,815	0.1	0.8	78.1	9,806	6.10	45	75%	97%	325	353	27%	695	164	100	232	477	217	55%	75%	14.9	14.6	1.7%
02/18/97	21:00	3,835	0.1	0.8	78.6	9,400	6.07	44	75%	100%	317	340	23%	694	145	80	235	479	213	59%	75%	14.8	14.5	1.5%
02/18/97	23:00	3,782	0.3	0.8	78.6	9,281	6.07	43	75%	100%	318	336	23%	694	147	80	233	482	213	59%	75%	14.8	14.5	1.6%
02/19/97	3:00	3,782	0.3	0.7	78.6	9,294	6.07	41	75%	98%	318	328	23%	696	141	90	241	485	209	71%	74%	14.9	14.5	1.5%
02/19/97	5:00	3,802	0.3	0.7	78.6	9,250	6.10	37	76%	94%	316	322	23%	695	140	80	258	484	210	79%	73%	14.9	14.5	1.5%
02/19/97	7:00	3,798	0.3	0.8	78.6	9,238	6.07	37	76%	94%	317	322	23%	694	140	80	258	484	211	79%	73%	14.8	14.5	1.5%
02/19/97	9:00	3,815	0.3	0.8	78.6	9,175	6.10	38	76%	94%	317	320	23%	694	142	85	258	484	211	80%	73%	14.8	14.5	1.5%
02/19/97	11:00	3,629	0.2	0.8	78.6	8,962	6.10	54	74%	94%	309	307	23%	694	114	75	257	485	209	93%	73%	14.8	14.5	1.3%
02/19/97	13:00	2,741	0.1	0.5	78.1	7,362	6.10	55	70%	94%	294	289	23%	696	99	70	236	481	212	87%	75%	14.9	14.6	1.3%
02/19/97	15:00	2,730	0.1	0.5	77.6	7,088	6.13	56	69%	96%	288	285	23%	694	91	60	235	482	211	100%	75%	14.8	14.7	1.3%
02/19/97	17:00	2,736	0.1	0.6	78.1	7,086	6.13	57	70%	95%	290	292	23%	693	92	60	236	484	213	100%	75%	14.8	14.6	1.3%
02/19/97	19:00	2,743	0.1	0.5	78.1	7,089	6.13	56	70%	94%	289	290	23%	694	97	60	237	481	215	100%	75%	14.8	14.6	1.4%
02/19/97	23:00	2,758	0.1	0.5	78.1	7,162	6.10	43	72%	94%	291	288	23%	699	89	60	240	480	214	100%	74%	15.0	14.7	1.2%
02/20/97	3:00	2,785	0.1	0.5	78.1	7,206	6.07	36	73%	94%	293	288	23%	694	91	50	247	476	215	100%	74%	14.8	14.6	1.3%
02/20/97	5:00	2,776	0.1	0.5	78.1	7,200	6.10	37	73%	94%	293	288	23%	694	90	50	248	477	219	100%	74%	14.8	14.6	1.3%
02/20/97	7:00	2,782	0.1	0.5	78.1	7,194	6.10	37	73%	94%	293	288	23%	695	84	50	247	476	218	100%	74%	14.9	14.6	1.2%
02/20/97	11:00	2,761	0.1	0.5	78.1	7,150	6.10	38	73%	94%	294	284	23%	694	88	60	250	476	217	100%	74%	14.8	14.6	1.2%
02/20/97	13:00	2,754	0.1	0.5	78.1	7,131	6.10	44	72%	94%	296	287	23%	694	92		238	479	213	100%	74%	14.8	14.6	1.3%
02/20/97	15:00	2,767	0.1	0.5	78.1	7,112	6.10	44	72%	94%	295	289	23%	694	90		238	479	215	100%	74%	14.8	14.6	1.3%
02/20/97	19:00	2,762	0.1	0.6	78.1	10,128	6.08	50	77%	100%	338	370	23%	692	152	90	243	478	214	57%	74%	14.8	14.5	1.5%
02/20/97	21:00	2,767	0.1	0.5	78.6	10,219	6.07	50	77%	100%	340	374	23%	694	158	90	246	478	216	57%	74%	14.8	14.5	1.5%
02/21/97	3:00	4,627	0.1	0.9	78.6	10,136	6.10	49	76%	94%	336	370	29%	693	141	95	233	477	215	53%	75%	14.8	14.4	1.4%
02/21/97	5:00	4,651	0.1	1.0	78.6	10,189	6.10	48	76%	94%	335	370	30%	692	139	95	231	479	217	53%	75%	14.8	14.4	1.4%
02/21/97	7:00	4,708	0.1	1.0	78.1	10,206	6.10	54	75%	100%	334	366	25%	694	132	90	232	479	214	54%	75%	14.8	14.6	1.3%
02/21/97	9:00	4,690	0.1	0.9	77.6	10,019	6.07	53	76%	94%	334	365	23%	695	144	90	239	478	215	56%	74%	14.9	14.7	1.4%
02/21/97	11:00	4,666	0.1	0.9	78.1	10,169	6.10	54	76%	94%	334	364	23%	693	132	90	239	481	213	58%	74%	14.8	14.6	1.3%
02/21/97	13:00	4,677	0.1	1.0	78.1	10,019	6.10	55	75%	94%	334	369	29%	694	147	100	232	478	219	53%	75%	14.8	14.6	1.5%
02/21/97	15:00	4,683	0.1	1.0	78.1	9,975	6.10	54	75%	94%	334	379	27%	695	146	100	233	477	216	53%	75%	14.9	14.6	1.5%
02/21/97	17:00	4,675	0.1	1.0	78.1	10,081	6.07	54	76%	94%	337	381	25%	694	144	85	234	484	212	56%	75%	14.8	14.6	1.4%

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
02/21/97	19:00	4,679	0.1	1.0	78.6	10,012	6.10	55	76%	94%	338	384	28%	693	148	90	232	484	209	54%	75%	14.8	14.4	1.5%
02/22/97	3:00	4,662	0.1	1.0	78.6	9,998	6.00	54	76%	94%	338	377	24%	693	149	100	231	484	207	56%	75%	14.8	14.4	1.5%
02/22/97	5:00	4,653	0.1	1.0	77.6	10,019	6.10	54	76%	94%	338	374	23%	694	151	100	234	486	207	58%	75%	14.8	14.7	1.5%
02/22/97	7:00	4,668	0.1	1.0	78.1	10,050	6.00	54	76%	94%	339	372	23%	692	147	100	236	487	210	58%	75%	14.8	14.5	1.5%
02/22/97	9:00	4,672	0.1	1.0	77.6	10,038	6.10	54	76%	94%	334	364	23%	696	143	95	255	480	214	71%	73%	14.9	14.7	1.4%
02/22/97	11:00	4,638	0.1	1.0	77.6	10,050	6.10	53	76%	94%	336	360	23%	694	140	95	250	485	207	74%	74%	14.8	14.7	1.4%
02/22/97	13:00	4,648	0.1	1.0	77.1	9,975	6.07	48	77%	94%	336	367	23%	695	141	80	259	486	209	71%	73%	14.9	14.8	1.4%
02/22/97	15:00	3,972	0.1	0.8	77.1	9,481	6.07	53	75%	94%	328	356	23%	695	123	80	235	484	210	65%	75%	14.9	14.8	1.3%
02/22/97	19:00	2,885	0.1	0.8	77.1	10,431	6.10	53	77%	94%	343	365	23%	694	131	90	256	489	204	75%	73%	14.8	14.8	1.3%
02/22/97	21:00	2,949	0.1	0.6	77.1	10,188	6.07	53	78%	94%	343	365	23%	695	139	90	275	486	208	86%	72%	14.9	14.8	1.4%
02/23/97	3:00	2,940	0.1	0.6	77.1	10,431	6.10	53	77%	94%	342	366	23%	695	131	90	254	490	204	74%	73%	14.9	14.8	1.3%
02/23/97	5:00	2,927	0.1	0.6	77.1	10,381	6.00	54	77%	94%	341	365	23%	693	134	90	255	488	206	75%	73%	14.8	14.8	1.3%
02/23/97	7:00	2,951	0	0.6	77	10,444	6.10	53	78%	94%	342	365	23%	694	129	85	256	489	203	75%	73%	14.8	14.8	1.2%
02/23/97	15:00	2,762	0.1	0.6	77.6	9,982	6.10	50	78%	94%	342	318	23%	692	140	80	254	488	206	74%	73%	14.8	14.7	1.4%
02/23/97	17:00	2,767	0.1	0.6	77.6	9,988	6.10	42	78%	95%	346	369	23%	694	136	80	257	486	207	74%	73%	14.8	14.7	1.4%
02/23/97	19:00	4,001	0.1	0.8	77.6	9,769	6.10	55	75%	94%	332	365	23%	696	130	85	243	484	209	67%	74%	14.9	14.7	1.3%
02/23/97	21:00	3,778	0.1	0.8	77.6	9,594	6.10	53	75%	97%	332	360	23%	694	137	85	235	484	211	61%	75%	14.8	14.7	1.4%
02/24/97	3:00	3,791	0.1	0.8	77.6	9,712	6.10	50	76%	100%	330	358	23%	693	132	90	249	480	212	71%	74%	14.8	14.7	1.4%
02/24/97	5:00	3,800	0.1	0.8	77.6	9,700	6.00	50	76%	99%	329	357	23%	694	135	90	252	481	211	71%	73%	14.8	14.7	1.4%
02/24/97	7:00	3,771	0.1	0.8	77.6	9,712	6.10	35	77%	98%	330	356	23%	692	135	90	253	479	213	74%	73%	14.8	14.7	1.4%
02/24/97	9:00	3,778	0.1	0.8	77.6	9,831	6.07	57	76%	99%	332	352	23%	696	133	90	270	486	208	84%	72%	14.9	14.7	1.4%
02/24/97	13:00	3,959	0.1	0.8	77.6	9,125	6.10	61	74%	94%	322	344	23%	693	111	75	260	486	210	85%	73%	14.8	14.7	1.2%
02/24/97	15:00	3,927	0.1	0.7	77.6	9,156	6.07	60	74%	98%	323	339	23%	698	115	75	264	485	210	95%	73%	14.9	14.8	1.3%
02/24/97	19:00	3,743	0.1	0.8	77.6	9,006	6.10	40	76%	97%	322	341	23%	699	123	70	243	483	211	74%	74%	15.0	14.8	1.4%
02/24/97	21:00	3,745	0.1	0.8	77.6	8,984	6.07	40	76%	97%	324	340	23%	692	124	80	241	482	212	74%	74%	14.8	14.7	1.4%
02/24/97	23:00	3,741	0.2	0.8	77.6	8,962	6.07	39	76%	97%	322	342	23%	693	121	80	234	484	211	73%	75%	14.8	14.7	1.4%
02/25/97	3:00	3,771	0.2	0.8	77.6	8,969	6.00	40	76%	96%	322	341	23%	695	123	80	241	483	210	73%	74%	14.9	14.7	1.4%
02/25/97	5:00	3,734	0.2	0.8	78.6	8,994	6.00	39	76%	96%	323	340	23%	694	124	80	239	482	212	73%	74%	14.8	14.5	1.4%
02/25/97	7:00	2,791	0.1	0.5	77.6	7,919	6.00	44	73%	93%	304	305	23%	696	94	60	257	476	221	100%	73%	14.9	14.7	1.2%
02/25/97	9:00	2,798	0.1	0.6	77.6	8,163	6.10	52	73%	94%	308	311	23%	694	99	70	258	478	217	100%	73%	14.8	14.7	1.2%
02/25/97	11:00	2,028	0.1	0.6	77.6	8,325	6.10	60	73%	93%	312	316	23%	693	98	65	262	482	212	100%	73%	14.8	14.7	1.2%
02/25/97	13:00	2,047	0.1	0.4	77.6	8,862	6.10	60	72%	94%	317	345	23%	693	111	75	235	485	213	66%	75%	14.8	14.7	1.3%
02/25/97	15:00	1,829	0.1	0.4	78.1	9,388	6.10	60	73%	93%	323	367	26%	694	126	85	231	478	215	57%	75%	14.8	14.6	1.3%
02/25/97	19:00	1,837	0.1	0.4	78.1	9,388	6.13	60	73%	93%	327	366	28%	696	142	80	230	480	215	52%	75%	14.9	14.6	1.5%
02/25/97	21:00	1,713	0.1	0.4	78.1	9,062	6.07	34	76%	94%	319	343	23%	694	126	80	256	480	216	72%	73%	14.8	14.6	1.4%
02/25/97	23:00	1,842	0.1	0.4	78.1	9,425	6.07	60	74%	100%	325	355	23%	695	136	80	242	481	212	65%	74%	14.9	14.6	1.4%

Appendix F.5
ROWTP Train Performance Data - Train #5 Continued

Date	Time	F-1 Pretreatment						F-3 Train Data													Calculations			
		Raw Plant Water Flow	Raw water Turbidity	Anti-Scalant Flow	Feed Water Temp	Feed Water Conduct.	Acidified Feed pH	HP Pump Suction Press.	HP Pump Speed	Feed CV Position	Feed Press.	2nd Stage Feed Pressure	Conc. CV Position	Permeate Flow	Permeate Conduct.	Permeate TDS	Conc. Flow	1st Stage Prod. Flow	2nd Stage Prod. Flow	Booster Valve Position	Recovery	Flux	Normalized Flux	Salt Passage
		(GPM)	(NTU)	(GPH)	(F)	(umhos)		(psi)	(%)	(%)	(psi)	(psi)	(%)	(GPM)	(umhos)	(mg/L)	(GPM)	(GPM)	(GPM)	(%)	(%)	(gsfd)	gsfd @ 25C	(%)
02/26/97	3:00	1,846	0.1	0.4	78.1	9,388	6.07	60	73%	94%	325	370	24%	695	145	80	240	480	214	61%	74%	14.9	14.6	1.5%
02/26/97	5:00	1,842	0.1	0.4	78.1	9,431	6.13	60	73%	94%	325	364	24%	696	148	80	239	480	216	61%	74%	14.9	14.6	1.6%
02/26/97	7:00	1,840	0.1	0.4	78.1	9,425	6.10	60	74%	94%	324	347	23%	693	234	80	259	478	216	74%	73%	14.8	14.6	2.5%
02/26/97	9:00	2,820	0.1	0.6	78.1	9,281	6.07	50	73%	99%	312	332	23%	694	205	70	253	478	215	76%	73%	14.8	14.6	2.2%
02/26/97	13:00	3,673	0.1	0.8	78.1	8,894	6.10	35	75%	93%	312	319	23%	694	184	120	248	479	217	78%	74%	14.8	14.6	2.1%
02/26/97	15:00	3,679	0.1	0.7	78.1	8,838	6.10	43	74%	93%	315	339	23%	694	215	145	228	481	210	63%	75%	14.8	14.6	2.4%
02/26/97	17:00	3,884	0.1	0.8	78.1	8,894		41	74%	93%	314	314	24%	694	215	145	231	480	214	65%	75%	14.8	14.6	2.4%
02/26/97	19:00	3,682	0.1	0.8	78.1	8,888	6.10	40	74%	93%	314	347	24%	695	214	90	232	479	214	66%	75%	14.9	14.6	2.4%
02/26/97	21:00	3,622	0.1	0.7	78.1	8,750	6.10	44	75%	93%	314	335	23%	694	213	90	252	479	216	77%	73%	14.8	14.6	2.4%
02/26/97	23:00	3,642	0.1	0.7	78.1	8,752	6.10	44	75%	93%	315	336	23%	692	214	90	252	480	215	77%	73%	14.8	14.5	2.4%
02/27/97	3:00	3,642	0.1	0.7	78.1	8,925	6.10	42	75%	94%	315	334	23%	694	118	70	254	480	214	77%	73%	14.8	14.6	1.3%
02/27/97	5:00	3,647	0.1	0.7	78.1	8,906	6.10	42	75%	93%	315	334	23%	695	114	70	253	478	216	77%	73%	14.9	14.6	1.3%
02/27/97	7:00	3,640	0.1	0.7	78.6	9,019	6.10	41	75%	93%	315	334	23%	693	121	80	253	479	214	76%	73%	14.8	14.4	1.3%
02/27/97	9:00	3,616	0.1	0.8	78.6	8,869	6.10	34	76%	93%	316	334	23%	695	118	80	253	479	219	76%	73%	14.9	14.5	1.3%
02/27/97	11:00	3,638	0.1	0.8	78.1	9,062	6.10	42	75%	93%	316	334	23%	694	114	75	250	480	214	75%	74%	14.8	14.6	1.3%
02/27/97	15:00	3,708	0	0.8	78.1	9,181	6.10	55	72%	93%	316	342	23%	687	126	85	233	478	211	66%	75%	14.7	14.4	1.4%
02/27/97	19:00	3,648	0.1	0.7	78.1	9,102	6.10	42	75%	93%	315	338	23%	691	122	80	232	476	212	76%	75%	14.8	14.5	1.3%
02/27/97	21:00	3,660	0.1	0.7	78.1	9,012	6.10	40	75%	93%	316	332	23%	694	121	80	231	479	214	76%	73%	14.8	14.6	1.3%
02/28/97	3:00	3,638	0.1	0.8	78.6	9,725	6.10	47	75%	93%	324	355	26%	693	187	125	232	477	217	59%	75%	14.9	14.5	1.9%
02/28/97	5:00	3,627	0.1	0.8	78.6	9,688	6.10	48	75%	93%	324	354	26%	693	186	125	233	478	214	59%	75%	14.8	14.4	1.9%
02/28/97	7:00	3,625	0.2	0.8	78.6	9,481	6.00	46	75%	93%	327	350	23%	693	193	130	243	484	209	69%	74%	14.8	14.4	2.0%
02/28/97	9:00	3,679	0.2	0.8	78.6	9,475	6.07	42	76%	100%	327	340	23%	695	194	130	264	484	209	84%	72%	14.9	14.5	2.0%
02/28/97	15:00	3,618	0.1	0.8	78.6	9,400	6.10	49	75%	100%	322	340	24%	692	187	125	239	484	208	93%	74%	14.8	14.4	2.0%
02/28/97	17:00	3,679	0.1	0.8	78.6	9,544	6.07	42	76%	97%	323	360	29%	694	197	85	230	481	213	55%	75%	14.8	14.5	2.1%
02/28/97	21:00	3,697	0.2	0.8	78.1	8,725	6.10	39	75%	96%	312	329	23%	694	193	70	251	478	215	77%	73%	14.8	14.6	2.2%
02/28/97	23:00	3,662	0.1	0.7	78.1	8,938	6.10	40	74%	93%	316	347	23%	696	194	80	227	478	215	61%	75%	14.9	14.6	2.2%
Average		2,852	0.1	0.6	77.0	8,288	6.08	49	72%	97%	299	311	26%	694	150	87	236	480	214	73%	75%	14.8	14.8	1.8%
Standard Deviation		901	0.1	0.2	1.7	1,033	7.06	8	2%	3%	19	28	4%	3	51	29	8	5	3	14%	1%	0.1	0.4	0.5%
Maximum		4,848	1.4	1.1	78.6	11,638	5.90	65	78%	100%	356	426	85%	703	332	221	292	498	225	100%	76%	15.0	16.6	3.6%
Minimum		661	0.0	0.1	70.1	2,688	6.41	28	66%	78%	28	229	21%	633	83	1	217	416	201	35%	70%	13.5	13.8	1.1%

APPENDIX G
Marco Island RO WTP Pump Amperage Performance Data

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Appendix G
ROWTP Pump Amperage Performance Data

Date	Train 1				Train 2				Train 3				Train 4				Train 5			
	Amps[a]	Power[b] (kW)	Flow[c] (gpm)	Energy Cost ($/kgal)	Amps	Power (kW)	Flow (gpm)	Energy Cost ($/kgal)	Amps	Power (kW)	Flow (gpm)	Energy Cost ($/kgal)	Amps	Power (kW)	Flow (gpm)	Energy Cost ($/kgal)	Amps	Power (kW)	Flow (gpm)	Energy Cost ($/kgal)
2/1/97									277	138.5	681	$0.25	277	138.5	681	$0.25	245	122.5	693	$0.22
2/2/97									277	138.5	684	$0.25	288	144	679	$0.27	245	122.5	694	$0.22
2/3/97									277	138.5	678	$0.26	288	144	681	$0.26	244	122	694	$0.22
2/4/97									277	138.5	674	$0.26	281	140.5	678	$0.26	243	121.5	694	$0.22
2/5/97									277	138.5	680	$0.25	277	138.5	678	$0.26	241	120.5	694	$0.22
2/6/97									281	140.5	680	$0.26	281	140.5	679	$0.26	244	122	695	$0.22
2/7/97									295	147.5	659	$0.28	288	144	679	$0.27	255	127.5	694	$0.23
2/8/97									281	140.5	652	$0.27	288	144	684	$0.26	246	123	693	$0.22
2/9/97									274	137	683	$0.25	277	138.5	686	$0.25	241	120.5	694	$0.22
2/10/97									281	140.5	678	$0.26	294	147	676	$0.27	248	124	694	$0.22
2/11/97									281	140.5	676	$0.26	288	144	679	$0.27	247	123.5	693	$0.22
2/12/97									302	151	679	$0.28	298	149	675	$0.28	251	125.5	694	$0.23
2/13/97									298	149	677	$0.28	298	149	675	$0.28	248	124	694	$0.22
2/14/97									281	140.5	678	$0.26	288	144	683	$0.26	250	125	694	$0.23
2/15/97									289	144.5	678	$0.27	291	145.5	674	$0.27	247	123.5	693	$0.22
2/16/97									270	135	653	$0.26	281	140.5	649	$0.27	246	123	694	$0.22
2/17/97									274	137	646	$0.27	277	138.5	628	$0.28	247	123.5	694	$0.22
2/18/97									256	128	607	$0.26	263	131.5	664	$0.25	250	125	694	$0.23
2/19/97	351	176	650	$0.34	319	160	646	$0.31					309	154.5	660	$0.29	266	133	695	$0.24
2/20/97																				
2/21/97	344	172	650	$0.33	312	156	651	$0.30	295	147.5	682	$0.27	316	158	679	$0.29	270	135	694	$0.24
2/22/97	333	167	650	$0.32	312	156	655	$0.30	302	151	676	$0.28	298	149	656	$0.28	267	133.5	694	$0.24
2/23/97	358	179	656	$0.34	309	155	662	$0.29					312	156			264	132	694	$0.24
2/24/97	354	177	662	$0.33	316	158	666	$0.30					312	156	681	$0.29	270	135	694	$0.24
2/25/97	333	167	653	$0.32	309	155	652	$0.30					309	154.5	679	$0.28	275	137.5	694	$0.25
2/26/97	330	165	650	$0.32	298	149	646	$0.29					309	154.5	669	$0.29	260	130	694	$0.23
2/27/97	340	170	646	$0.33	281	141	600	$0.29					288	144	652	$0.28	269	134.5	693	$0.24
2/28/97	316	158	623	$0.32	288	144	628	$0.29	302	151			316	158	679	$0.29	273	136.5	694	$0.25
3/1/97	333	167	646	$0.32	298	149	647	$0.29	277	138.5	657	$0.26					273	136.5	693	$0.25
3/2/97	319	160	630	$0.32	282	141	636	$0.28					282	141	633	$0.28	282	141	693	$0.25
3/3/97	319	160	636	$0.31	288	144	633	$0.28					281	140.5	635	$0.28	264	132	693	$0.24
3/4/97	332	166	636	$0.33	292	146	634	$0.29	291	145.5	634	$0.29					272	136	694	$0.24
3/5/97	333	167	634	$0.33	291	146	636	$0.29	291	145.5	622	$0.29					272	136	694	$0.24
3/6/97	335	168	637	$0.33	292	146	633	$0.29					282	141	637	$0.28	272	136	694	$0.24
3/7/97	309	155	636	$0.30	277	139	635	$0.27									251	125.5	694	$0.23

Appendix G
ROWTP Pump Amperage Performance Data

Date	Train 1				Train 2				Train 3				Train 4				Train 5			
	Amps[a]	Power[b]	Flow[c]	Energy Cost	Amps	Power	Flow	Energy Cost	Amps	Power	Flow	Energy Cost	Amps	Power	Flow	Energy Cost	Amps	Power	Flow	Energy Cost
		(kW)	(gpm)	($/kgal)		(kW)	(gpm)	($/kgal)		(kW)	(gpm)	($/kgal)		(kW)	(gpm)	($/kgal)		(kW)	(gpm)	($/kgal)
3/8/97	309	155	638	$0.30	277	139	644	$0.27	252	126							268	134	694	$0.24
3/9/97	323	162	647	$0.31	291	146	643	$0.28	259	129.5	599	$0.27					264	132	694	$0.24
3/10/97	330	165	649	$0.32	295	148	648	$0.28	274	137	605	$0.28					264	132	694	$0.24
3/11/97	344	172	650	$0.33	298	149	645	$0.29	274	137	606	$0.28					264	132	694	$0.24
3/12/97	333	167			297	149							267	133.5	604	$0.28	262	131	694	$0.24
3/13/97	351	176	650	$0.34	312	156	651	$0.30	267	133.5	595	$0.28	277	138.5	628	$0.28	286	143	694	$0.26
3/14/97	358	179	669	$0.33	323	162	671	$0.30					302	151	642	$0.29	274	137	694	$0.25
3/15/97	319	160	626	$0.32	288	144	653	$0.28									270	135	695	$0.24
3/16/97	320	160			289	145	601	$0.30									271	135.5	693	$0.24
3/17/97	319	160	620	$0.32	288	144	637	$0.28									270	135	694	$0.24
3/18/97	330	165	659	$0.31	298	149	648	$0.29	274	137	603	$0.28					262	131	694	$0.24
3/19/97	340	170	686	$0.31	309	155	687	$0.28									252	126	694	$0.23
3/20/97	340	170	670	$0.32	309	155	625	$0.29									262	131	694	$0.24
3/21/97	340	170	670	$0.32	312	156	672	$0.29	295	147.5	673	$0.27					265	132.5	694	$0.24
3/22/97	319	160	674	$0.30	295	148	696	$0.26									246	123	695	$0.22
3/23/97					316	158	696	$0.28					302	151	688	$0.27	260	130	694	$0.23
3/24/97					316	158	570	$0.35					302	151	667	$0.28	257	128.5	694	$0.23
3/25/97																				
3/26/97													291	145.5	685	$0.27	246	123	694	$0.22
3/27/97	358	179	683	$0.33									302	151	692	$0.27	262	131	694	$0.24
3/28/97	344	172	682	$0.32	319	160	693	$0.29									256	128	694	$0.23
3/29/97	340	170	648	$0.33	302	151	651	$0.29					267	133.5			268	134	694	$0.24
3/30/97	340	170			302	151	669	$0.28									253	126.5	693	$0.23
3/31/97	344	172	693	$0.31	309	155	689	$0.28									254	127	694	$0.23
Average	334	167	652	$0.32	300	150	650	$0.29	281	140	655	$0.27	291	145	667	$0.27	259	130	694	$0.23
Standard Deviation	13.5	6.8	18.5	$0.01	12.7	6.4	26.6	$0.01	13.0	6.5	31.2	$0.01	14.0	7.0	21.3	$0.01	11.5	5.7	0.5	$0.01
Maximum	358	179	693	$0.34	323	162	696	$0.35	302	151	684	$0.29	316	158	692	$0.29	286	143	695	$0.26
Minimum	309	155	620	$0.30	277	139	570	$0.26	252	126	595	$0.25	263	132	604	$0.25	241	121	693	$0.22

a) Shaded areas indicate No amperage data was collected on that day.

b) Power is based on a supply of 500 Volts.

c) Permeate Flows are the Daily Average for that day.

APPENDIX H
Conceptual Cost Estimates

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Appendix H
Conceptual Cost Estimates

Table H.1: 4 MGD Ion Exchange

Treatment Alternative Conceptual Capital and O&M Costs in 1997 Dollars *

		ion exchange
Estimated Capital Costs (4 MGD)		
Construction Cost[a]		$1,973,364
Legal, Engineering, Contingencies	35%	$690,677
Total Estimated Capital		$2,664,041
$/ gpd		*$0.67*
$/ kgal Capital (installed) **		*$0.19*
Estimated Operating Costs (3 MGD)		
Operating Labor Wages & Fringes ($/yr)[b]		$138,000
Energy & Power ($/yr)[c]		$20,000
Maintenance Material ($/yr)		$56,350
Contingencies, etc.	25%	$53,587
Total Estimated Annual Operating Costs[d]		$267,937
$/ kgal O&M **		*$0.86*

a) Construction Cost for Two 4 MGD Pressure Ion Exchange Units Include: Excavation and Sitework, Manufactured Equipment, Resin, Concrete, Steel Labor, Pipes and Valves, Electrical and Instrumentation, Housing, and Miscellaneous and Contingency.
b) Labor Wages = $30 hr
c) Electricity Cost = $0.075/kW-hr
d) Assumes: Concentrate Discharged to Wastewater Plant.
* USEPA Cost Curves, 1979
** A given P over 20 years @ 8% interest = 0.10185

Table H.2: 9 MGD Ion Exchange

Treatment Alternative Conceptual Capital and O&M Costs in 1997 Dollars *

		ion exchange
Estimated Capital Costs (9 MGD)		
Construction Cost[a]		$6,040,990
Legal, Engineering, Contingencies	35%	$2,114,318
Total Estimated Capital		$8,155,308
$/gpd		*$0.91*
$/ kgal Capital (installed) **		*$0.26*
Estimated Operating Costs (6.75 MGD)		
Operating Labor Wages & Fringes ($/yr)[b]		$180,000
Energy & Power ($/yr)[c]		$40,000
Maintenance Material ($/yr)		$140,874
Contingencies, etc.	25%	$90,219
Total Estimated Annual Operating Costs[d]		$451,093
$/gpd O&M **		*$0.64*

a) Construction Cost for Two 9 MGD Pressure Ion Exchange Units Include: Excavation and Sitework, Manufactured Equipment, Resin, Concrete, Steel Labor, Pipes and Valves, Electrical and Instrumentation, , Housing, and Miscellaneous and Contingency.
b) Labor Wages = $30 hr
c) Electricity Cost = $0.075/kW-hr
d) Assumes: Concentrate Discharged to Wastewater Plant.
* USEPA Cost Curves, 1979
** A given P over 20 years @ 8% interest = 0.10185

Appendix H
Conceptual Cost Estimates

Table H.3: 9 MGD Ion Exchange Combo

Treatment Alternative Conceptual Capital and O&M Costs in 1997 Dollars *

		ion exchange	LS	Total
Estimated Capital Costs (9 MGD)				
Construction Cost[a]		$2,416,364	$1,763,945	$4,180,309
Legal, Engineering, Contingencies	35%	$0	$617,381	$617,381
Total Estimated Capital		$2,416,364	$2,381,326	$4,797,690
$/gpd		*$0.48*	*$0.48*	*$0.53*
$/ kgal Capital (installed) **		*$0.14*	*$0.14*	*$0.15*
Estimated Operating Costs (6.75 MGD)				
Operating Labor Wages & Fringes ($/yr)[b]		$144,000	$144,900	$288,900
Energy & Power ($/yr)[c]		$22,000	$25,000	$47,000
Maintenance Material ($/yr)		$64,400	$18,112	$82,512
Contingencies, etc.	25%	$57,600	$47,372	$104,972
Total Estimated Annual Operating Costs[d]		$287,999	$236,859	$524,859
$/ kgal O&M **		*$0.74*	*$0.61*	*$0.75*

a) Construction Cost for Two 9 MGD Pressure Ion Exchange Units Include: Excavation and Sitework, Manufactured Equipment, Resin, Concrete, Steel Labor, Pipes and Valves, Electrical and Instrumentation, , Housing, and Miscellaneous and Contingency.
b) Labor Wages = $30 hr
c) Electricity Cost = $0.075/kW-hr
d) Assumes: Concentrate Discharged to Wastewater Plant.
* USEPA Cost Curves, 1979
** A given P over 20 years @ 8% interest = 0.10185

Table H.4: 4 MGD Membrane

Treatment Alternative Conceptual Capital and O&M Costs in 1997 Dollars *

		Membrane
Estimated Capital Costs (4 MGD)		
Construction Cost[a,b]		$6,179,048
Legal, Engineering, Contingencies	35%	$0
Total Estimated Capital		$6,179,048
$/gpd		*$1.16*
$/ kgal Capital (installed) **		*$0.44*
Estimated Operating Costs (3 MGD)		
Operating Labor Wages & Fringes ($/yr)[c]		$105,000
Process Energy ($/yr)[d]		$105,000
Maintenance Material ($/yr)		$111,096
Contingencies, etc.	25%	$80,274
Total Estimated Annual Operating Costs		$401,370
$/ kgal O&M **		*$0.96*

a) Construction Cost for a 4 MGD RO System @ 75% Includes: Manufactured Equipment, Labor, Electrical and Instrumentation, Housing, and Miscellaneous and Contingency.
b) Not included are: Cost of Pretreatment Chemicals, Odor Control
c) Labor Wages = $30 hr
d) Electricity Cost = $0.075/kW-hr
e) Assumes: Concentrate Discharged to Wastewater Plant.
* Bergman "Cost of Membrane Softening WTP in Florida" 1995
** A given P over 20 years @ 8% interest = 0.10185

Appendix H
Conceptual Cost Estimates

Table H.5: 9 MGD Membrane

Treatment Alternative Conceptual Capital and O&M Costs in 1997 Dollars *

		Membrane
Estimated Capital Costs (9 MGD)		
Construction Cost[a,b]		$9,522,506
Legal, Engineering, Contingencies	35%	$0
Total Estimated Capital		$9,522,506
$/gpd		*$0.79*
$/ kgal Capital (installed) **		*$0.30*
Estimated Operating Costs (6.75 MGD)		
Operating Labor Wages & Fringes ($/yr)[c]		$154,968
Process Energy ($/yr)[d]		$154,968
Maintenance Material ($/yr)		$163,984
Contingencies, etc.	25%	$118,480
Total Estimated Annual Operating Costs		$592,400
$/ kgal O&M **		*$0.63*

a) Construction Cost for a 9 MGD RO System @ 75% Includes: Manufactured Equipment, Labor, Electrical and Instrumentation, Housing, and Miscellaneous and Contingency.
b) Not included are: Cost of Pretreatment Chemicals, Odor Control
c) Labor Wages = $30 hr
d) Electricity Cost = $0.075/kW-hr
e) Assumes: Concentrate Discharged to Wastewater Plant.
* Bergman "Cost of Membrane Softening WTP in Florida" 1995
** A given P over 20 years @ 8% interest = 0.10185

Table H.6: 9 MGD Membrane Combo

Treatment Alternative Conceptual Capital and O&M Costs in 1997 Dollars *

		Membrane	LS	Total
Estimated Capital Costs (9 MGD)				
Construction Cost[a,b]		$6,179,048	$1,763,945	$7,942,994
Legal, Engineering, Contingencies	35%	$0	$617,381	$617,381
Total Estimated Capital		$6,179,048	$2,381,326	$8,560,375
$/gpd		*$1.16*	*$0.48*	*$0.71*
$/ kgal Capital (installed) **		*$0.44*	*$0.14*	*$0.27*
Estimated Operating Costs (6.75 MGD)				
Operating Labor Wages & Fringes ($/yr)[c]		$105,000	$144,900	$249,900
Process Energy ($/yr)[d]		$105,000	$25,000	$130,000
Maintenance Material ($/yr)		$192,909	$18,112	$211,022
Contingencies, etc.	25%	$100,727	$47,372	$148,099
Total Estimated Annual Operating Costs		$503,637	$236,859	$740,496
$/ kgal O&M **		*$1.21*	*$0.61*	*$1.05*

a) Construction Cost for a 5 MGD RO System @ 75% plus a 4 MGD Lime Softening Unit Includes: Manufactured Equipment, Labor, Electrical and Instrumentation, Housing, and Miscellaneous and Contingency.
b) Not included are: Cost of Pretreatment Chemicals, Odor Control
c) Labor Wages = $30 hr
d) Electricity Cost = $0.075/kW-hr
e) Assumes: Concentrate Discharged to Wastewater Plant.
* Bergman "Cost of Membrane Softening WTP in Florida" 1995
** A given P over 20 years @ 8% interest = 0.10185

APPENDIX I
Ion Exchange and Membrane Treatability Evaluation

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Table I.1

Ion Exchange Kinetic and Isotherm Data for Marco Island Softened and Settled Laboratory Filtered Water

Kinetic Data for 0.2 mg resin/L

Sample Type	Start Time	Stop Time	Time (hr)	UV-254 (cm-1)	% UV-254 Removed	pH	Color (cpu)	% Color Removed	NPDOC (mg/L)	% NPDOC Removed
Raw	7/7/97 9:25 PM	7/7/97 9:25 PM	0	0.1863	0.0%	8	12.5	0.0%	7	0.0%
1	7/7/97 9:25 PM	7/7/97 10:25 PM	1	0.1871	-0.4%	7.6	7	44.0%	6.6	5.7%
2	7/7/97 9:25 PM	7/8/97 10:00 AM	13	0.1518	18.5%	7.9	5	60.0%	5.7	18.6%
3	7/7/97 9:25 PM	7/9/97 10:00 AM	37	0.1139	38.9%	7.7	1	92.0%	4.6	34.3%
4	7/7/97 9:25 PM	7/11/97 1:00 PM	88			7.6	0	100.0%	3	57.1%
5	7/7/97 9:25 PM	7/14/97 3:00 PM	162			7.6	0	100.0%	3	57.1%

Isotherm Data

Sample	pH	Resin-Dose (g/L)	Equilibrium Concentration		
			UV-254 (cm-1)	Color (CPU)	NPDOC (ppm C)
Initial	8	0.000	NA	12.5	7
1	7.6	0.113	NA	3	3.6
2	7.8	0.215	NA	1	2.9
3	7.6	0.511	NA	1	2.7
4	7.9	0.994	NA	1	2.1
5	7.6	2.540	NA	0	1.8

Manipulated Isotherm Data

Sample	GAC-Dose (g/L)	NPDOC (ppm C)	X/M (mg NPDOC/g resin)	Freundlich Linearization		Langmuir Linearization	
				Log (Ce)	Log (X/M)	(X/M)-1	(Ce)-1
Initial	0.000	7	---	---	---		
1	0.113	3.6	29.98	0.556302501	1.476865862	0.033352941	0.277777778
2	0.215	2.9	19.09	0.462397998	1.28074958	0.052390244	0.344827586
3	0.511	2.7	8.41	0.431363764	0.924707732	0.118930233	0.37037037
4	0.994	2.1	4.93	0.322219295	0.692634964	0.202938776	0.476190476
5	2.540	1.8	2.05	0.255272505	0.311169627	0.488461588	0.555555556

Resulting Isotherm Data Fits

Langmuir Isotherm Model		Fruendlich Isotherm Model	
Ce	Predicted X/M	Ce	Predicted X/M
1.5	1.6957	1.5	1.1431
2	3.0478	2	3.4392
2.5	5.8440	2.5	8.0822
3	15.0472	3	16.2447
3.2	29.6279	3.5	29.3124
		4	48.8768
		4.5	76.7302

Table I.2
Ion-Exchange Column Study Operating and Water Quality Data for Marco Island Softened and Settled Laboratory Filtered Water

Recording			Influent			8.7 Minute EBCT Column									
Date	Time	Cum. Runtime (days)	Temp. (C)	Dissolved Oxygen (ppm)	Effluent pH	Flow Rate (ml/min)	Bed Volumes Treated #	Back-pressure (psi)	Down-time (hours)	Pump Frequency	Pump Stroke	Sample Collection (y/n)	Effluent D.O. (ppm)	Effluent pH	Initials
7/7/97	22:30	0.04	23.7	7.4		15.2	91	0	0	33	32	Y	7.5	7.7	WAL
7/8/97	10:00	0.52	22.5	7.9	8.9	15	968	0	0	33	32	Y	7.7	8.7	WAL
7/9/97	11:00	1.56	22.5	8.2	8.3	15.1	2870	0	0	33	32	Y	6.9	8.1	WAL
7/10/97	12:00	2.60	22	7.9	8.1	14.8	4759	0	0	31	32	Y	7.1	8.3	WAL
7/11/97	13:00	3.64	23	7.8	8.5	14.9	6635	0	0	31	32	Y	7	8.1	WAL
7/12/97	15:00	4.73	22	7.8	8.6	14.6	8589	0	0	31	32	Y	7.2	8.4	WAL
7/13/97	14:00	5.69	22	8.1	8.5	14.7	10297	0	0	31	32	Y	7.6	8.2	WAL

Water Quality Data															
Date	Time	Cum. Runtime (days)	Bed Volumes Treated #	Influent NPDOC (ppm C)	Effluent NPDOC (ppm C)	Influent UV-254 (cm-1)	Effluent UV-254 (cm-1)	Influent Color (CPU)	Effluent Color (CPU)	Influent Chloride (ppm Cl)	Effluent Chloride (ppm Cl)	Influent Sulfate (ppm SO4)	Effluent Sulfate (ppm SO4)	Influent Alkalinity (ppm CaCO3)	Effluent Alkalinity (ppm CaCO3)
7/7/97	22:30	0.04	91		1.8		0.0283		3		172				23
7/8/97	10:00	0.52	968	7	3.3	0.1904	0.0593	11	5	109	109	80	74	31	30
7/9/97	11:00	1.56	2870		4.2		0.0843		9		115		74		32
7/10/97	12:00	2.60	4759		4.7	0.1938	0.0969		12		120		93		30
7/11/97	13:00	3.64	6635		4.9	0.1789	0.0922		6		115		107		34
7/12/97	15:00	4.73	8589		5.2	0.1783	0.1029		5		115		85		31
7/13/97	14:00	5.69	10297	6.9	5.5			10	5	115	115	74	77	32	32

Recording			Fractional Passage												
Date	Time	Cum. Runtime (days)	Bed Volumes Treated #		NPDOC		UV-254		Color		Chloride		Sulfate		Alkalinity
7/7/97	22:30	0.04	91		0.26		0.15		0.29		1.54				0.73
7/8/97	10:00	0.52	968		0.47		0.32		0.48		0.97		0.96		0.95
7/9/97	11:00	1.56	2870		0.60		0.45		0.86		1.03		0.96		1.02
7/10/97	12:00	2.60	4759		0.68		0.52		1.14		1.07		1.21		0.95
7/11/97	13:00	3.64	6635		0.71		0.50		0.57		1.03		1.39		1.08
7/12/97	15:00	4.73	8589		0.75		0.56		0.48		1.03		1.10		0.98
7/13/97	14:00	5.69	10297		0.79				0.48		1.03		1.00		1.02

Effluent TTHMFP								
Date	Time	Cum. Runtime (days)	Bed Volumes Treated #	Effluent CHCl3 (ppb)	Effluent CHCl2Br (ppb)	Effluent CHClBr2 (ppb)	Effluent CHBr3 (ppb)	Total TTHMFP (ppb)
7/9/97	11:00	1.56	2870	69	80	71	23	244

Figure I.1 Ion Exchange Column Study Water Quality versus Runtime for Marco Island Softened and Settled Laboratory Filtered Water

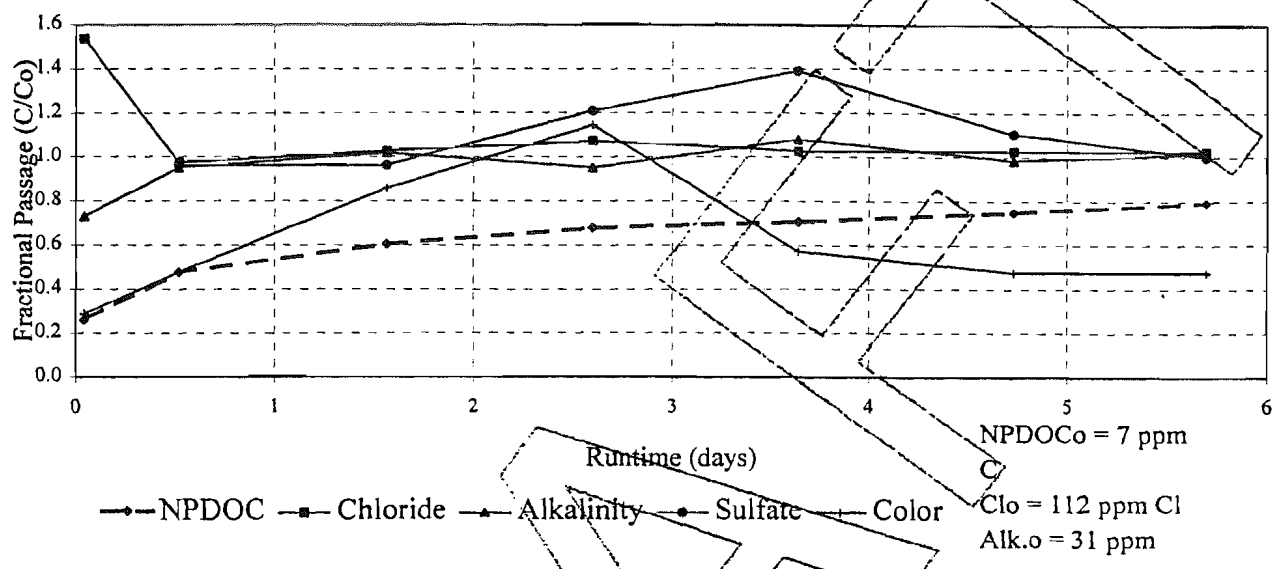

Figure I.2 Cummulative Bed Volumes versus Runtime for Ion- Exchange Column Study Marco Island Softened and Settled Laboratory Filtered Water

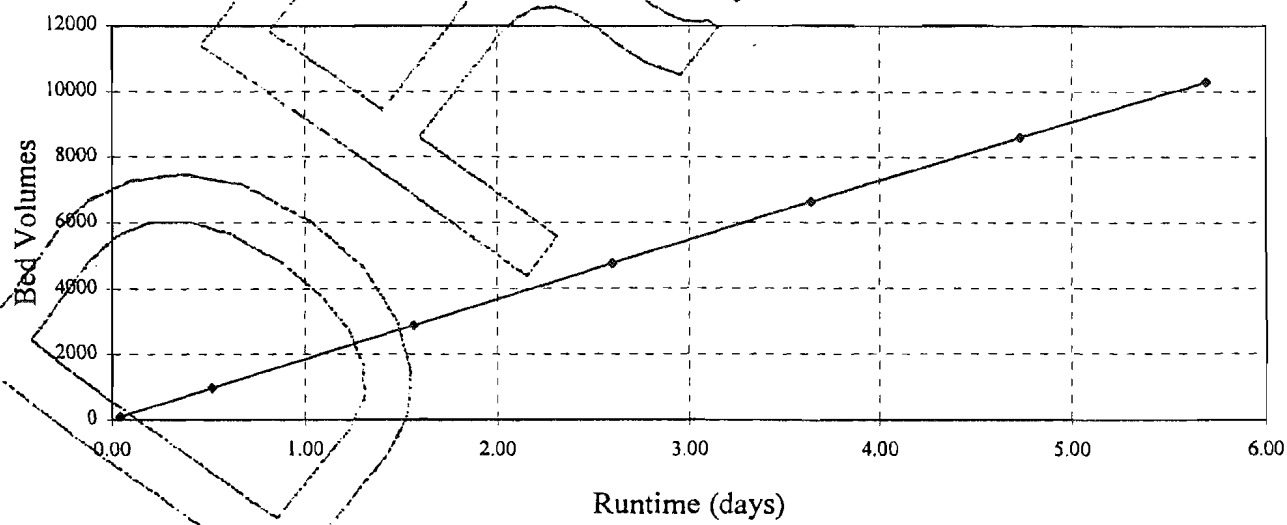

Table I.3 Marco Island Nanofiltration Batch Test Operation Conditions and Water Quality Data

Time				Flow				Pressure			TDS		
Run	On	Off	Data Rec.	Permeate (gph)	Concentrate (gph)	Feed (gph)	Recycle (gpm)	Feed (psi)	Permeate (psi)	Concentrate (psi)	Feed	Concentrate	Permeate
1	20:25	20:33	20:33	10	29	39	1.25	78	45	54	460	620	50
2	19:40	19:55	19:55	10	3	13	1.60	105	75	90	500	1190	220
3	19:20	19:30	19:25	15	45	60	0.90	60	0	50	470	1450	150
4	20:12	20:23	20:25	15	5	20	1.55	92	35	77	480	600	90
5	20:55	21:03	21:03	10	29	39	1.25	80	40	65	470	1080	190
6	20:37	20:51	20:51	10	3	13	1.60	105	75	90	450	580	50
7	21:04	21:15	21:14	15	45	60	0.95	63	0	50	450	540	40

Run	Runtime (min)	Q_r	Feed Temperature (°C)	Recover	$Flux_T$ (gsfd)	$Flux_{25C}$ (gsfd)	Osmotic Pressure (psi)	TMP (psi)	MTC_W (gsfd/psi)	MTC_{25C} (gsfd/psi)
3	10	0.9	23.0	0.25	15.1	16.04723	8.1	55.0	0.323	0.342
2	40	11.1	24.8	0.77	10.1	10.14382	6.3	22.5	0.621	0.624
4	68	4.65	25.0	0.75	15.0	15.02521	4.5	49.5	0.334	0.334
1	78	1.92	25.0	0.26	10.1	10.08403	4.9	21.0	0.626	0.626
6	96	7.4	18.0	0.77	10.1	12.40209	4.7	22.5	0.565	0.695
5	108	1.92	16.0	0.26	10.1	13.15738	5.9	32.5	0.378	0.494
7	119	0.95	16.0	0.24	14.6	19.0782	4.6	56.5	0.281	0.367

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Figure I.3
Solute Rejection versus Recovery and Flux for Marco Island
FilmTec NF-70 Evaluation

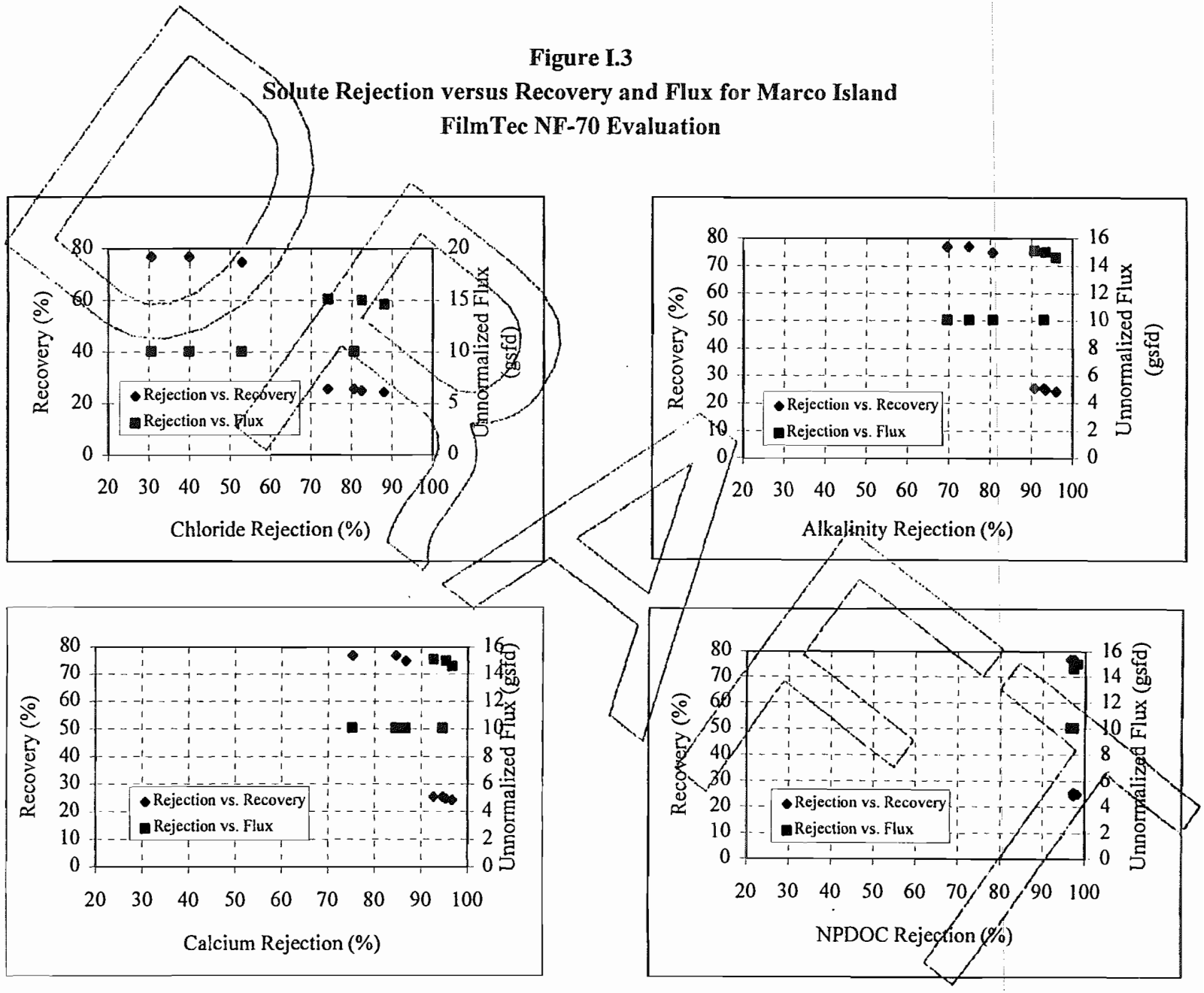

Table I.4 Water Quality Mass Balances
Marco Island NF Treatment Bench-Scale Evaluation

Experiment	Alkalinity (mg/L CaCO3)			Percent Recovery	Analytical Mass % Recovery
	Permeate	Concentrate	Feed		
1	21	280	227	25.6	94.3
2	69	698	227	76.9	94.6
3	15	305	227	25	102.6
4	44	891	227	74.9	113.3
5	16	282	227	25.6	94.4
6	57	737	227	76.9	94.3
7	9	288	227	24.4	97.1

Experiment	Chloride (mg/L)			Percent Recovery	Analytical Mass % Recovery
	Permeate	Concentrate	Feed		
1	28	128	108	25.6	94.8
2	75	243	108	76.9	105.4
3	19	130	108	25	94.7
4	51	299	108	74.9	104.9
5	21	130	108	25.6	94.5
6	65	265	108	76.9	103.0
7	13	125	108	24.4	90.4

Experiment	Calcium (mg/L CaCO3)			Percent Recovery	Analytical Mass % Recovery
	Permeate	Concentrate	Feed		
1	22	376	299	25.6	95.4
2	74	980	299	76.9	94.7
3	14	404	299	25	102.5
4	40	1200	299	74.9	110.8
5	16	356	299	25.6	90.0
6	46	1020	299	76.9	90.6
7	10	372	299	24.4	94.9

Experiment	Sulfate (mg/L)			Percent Recovery	Analytical Mass % Recovery
	Permeate	Concentrate	Feed		
1	0	115	93	25.6	92.0
2	0	270	93	76.9	67.1
3	0	101	93	25	81.5
4	0	321	93	74.9	86.6
5	0	112	93	25.6	89.6
6	0	272	93	76.9	67.6
7	0	116	93	24.4	94.3

Experiment	NPDOC (mg/L)			Percent Recovery	Analytical Mass % Recovery
	Permeate	Concentrate	Feed		
1	0.3	14.7	11.3	25.6	97.5
2	0.3	38.5	11.3	76.9	80.7
3	0.2	15.2	11.3	25	101.3
4	0.3	49.5	11.3	74.9	111.9
5	0.3	14.8	11.3	25.6	98.1
6	0.4	42.5	11.3	76.9	89.6
7	0.3	15	11.3	24.4	101.0

* Values of zero indicate measurements that were below the analytical detection level. Zeros were included to accommodate the mass balance calculations for each analysis.

Table I.5 Marco Island Temperature and Flux Data for Film Tec NF-70

Feed Temperature (°C)	MTCW (gsfd/psi)	(T-25) (°C)	log(Kw)
23.0	0.323	-2.0	-0.491
24.8	0.621	-0.2	-0.207
25.0	0.334	0.0	-0.476
25.0	0.626	0.0	-0.203
18.0	0.565	-7.0	-0.248
16.0	0.378	-9.0	-0.423
16.0	0.281	-9.0	-0.551

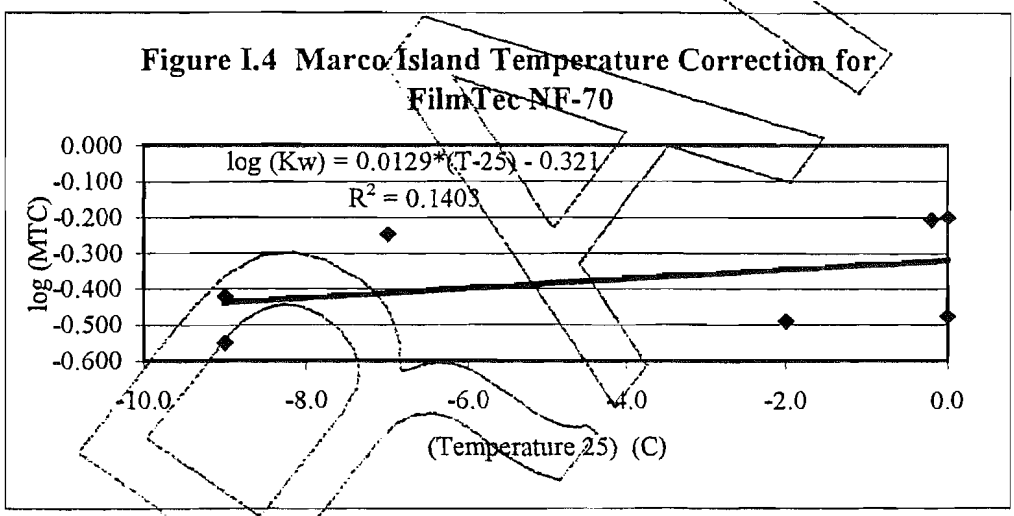

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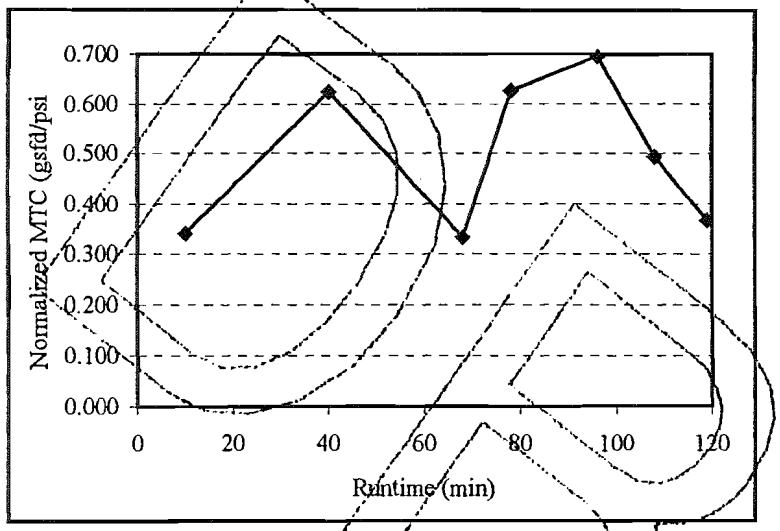
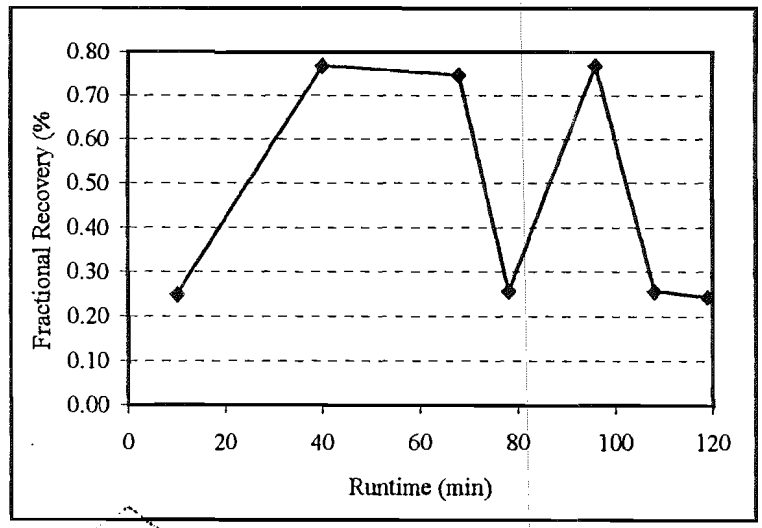
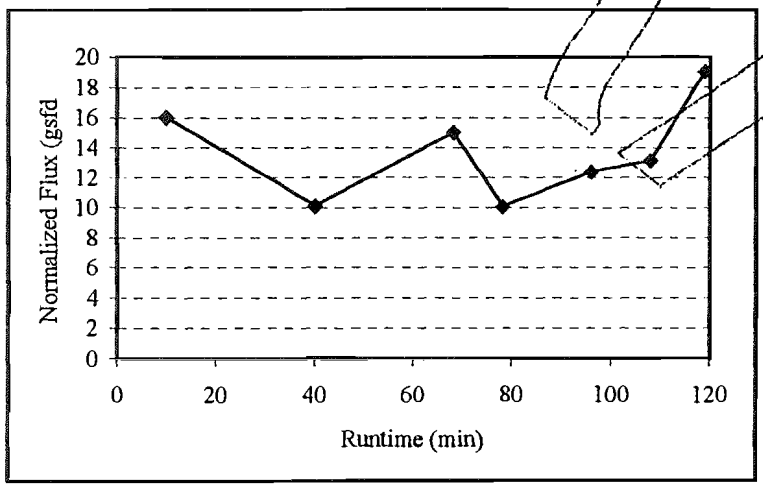
Figure I.5 Batch Test Film Tec NF-70 Operational Trend Data for Marco Island NF Evaluation







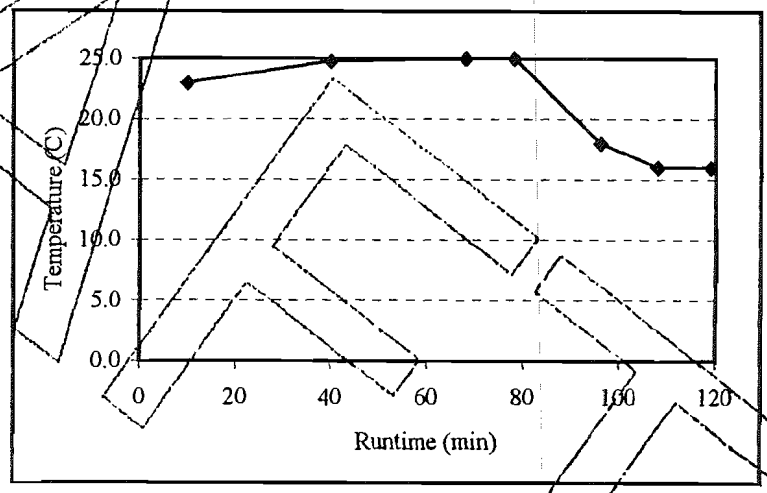


Table I.5

Linear Homogeneous Solution Diffusion Model and Film-Theory Modeling Results for Marco Island Film Tec NF-70 Nanofiltration Evaluation

Hydraulic Condition			Alkalinity		HSD Modeling Results	
r	Flux25 C (gsfd)	Recovery	Cp	Cf	Cp Predicted	Residual
1.9	16.0	0.25	21	227	14	7
7.4	10.1	0.77	69	227	58	11
0.9	15.0	0.75	15	227	34	-19
4.7	10.1	0.26	44	227	22	22
1.9	12.4	0.77	16	227	46	-30
7.4	13.2	0.26	57	227	17	40
1.0	19.1	0.24	9.3	227	12	-2

Hydraulic Condition			Alkalinity		F-T Modeling Results	
r	Flux25 C (gsfd)	Recovery	Cp	Cf	Cp Predicted	Residual
1.9	16.0	0.25	21	227	14	7
7.4	10.1	0.77	69	227	58	11
0.9	15.0	0.75	15	227	34	-19
4.7	10.1	0.26	44	227	22	22
1.9	12.4	0.77	16	227	46	-30
7.4	13.2	0.26	57	227	17	40
1.0	19.1	0.24	9.3	227	12	-2

Hydraulic Condition			Chloride		HSD Modeling Results	
r	Flux25 C (gsfd)	Recovery	Cp	Cf	Cp Predicted	Residual
1.9	16.0	0.25	28	108	22	6
7.4	10.1	0.77	75	108	62	13
0.9	15.0	0.75	19	108	44	-25
4.7	10.1	0.26	51	108	32	19
1.9	12.4	0.77	21	108	54	-33
7.4	13.2	0.26	65	108	27	38
1.0	19.1	0.24	13	108	19	-6

Hydraulic Condition			Chloride		HSD Modeling Results	
r	Flux25 C (gsfd)	Recovery	Cp	Cf	Cp Predicted	Residual
1.9	16.0	0.25	28	108	22	6
7.4	10.1	0.77	75	108	62	13
0.9	15.0	0.75	19	108	44	-25
4.7	10.1	0.26	51	108	32	19
1.9	12.4	0.77	21	108	54	-33
7.4	13.2	0.26	65	108	27	38
1.0	19.1	0.24	13	108	19	-6

Hydraulic Condition			Calcium		HSD Modeling Results	
r	Flux25 C (gsfd)	Recovery	Cp	Cf	Cp Predicted	Residual
1.9	16.0	0.25	22	299	13	9
7.4	10.1	0.77	74	299	58	16
0.9	15.0	0.75	14	299	33	-19
4.7	10.1	0.26	40	299	21	19
1.9	12.4	0.77	16	299	45	-29
7.4	13.2	0.26	46	299	17	29
1.0	19.1	0.24	10	299	11	-1

Hydraulic Condition			Calcium		HSD Modeling Results	
r	Flux25 C (gsfd)	Recovery	Cp	Cf	Cp Predicted	Residual
1.9	16.0	0.25	22	299	13	9
7.4	10.1	0.77	74	299	58	16
0.9	15.0	0.75	14	299	33	-19
4.7	10.1	0.26	40	299	21	19
1.9	12.4	0.77	16	299	45	-29
7.4	13.2	0.26	46	299	17	29
1.0	19.1	0.24	10	299	11	-1

APPENDIX J
Membrane Modeling Projections

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PERMEATE THROTTLING(1ST STAGE)

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Calculation created by:
Project name: Marco Is. BW

HP Pump flow:	1031.3 gpm	Permeate flow:	825.0 gpm
Recommended pump press.:	372.1 psi	Raw water flow:	1031.3 gpm
Feed pressure:	346.6 psi	Permeate throttling(1st st.)	50.0 psi
Feedwater Temperature:	25.0 C(77F)	Permeate recovery ratio:	80.0 %
Raw water pH:	6.97	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	32.0	Salt passage increase, %/yr:	10.0
Average flux rate:	15.1 gfd	Feed type:	Well water

Stage	Perm. Flow gpm	Flow per Vessel Feed gpm	Conc gpm	Flux gfd	Beta	Conc. Press. psi	Element Type	Elem. No.	Array
1-1	653.1	43.0	15.8	17.9	1.19	329.0	8040-LSY-CPA2	144	24x6
1-2	171.9	31.5	17.2	9.4	1.06	312.9	8040-LSY-CPA2	72	12x6

Ion	Raw water mg/l	Raw water CaCO3	Feed water mg/l	Feed water CaCO3	Permeate mg/l	Permeate CaCO3	Concentrate mg/l	Concentrate CaCO3
Ca	58.9	146.9	58.9	146.9	0.3	0.9	293.1	731.0
Mg	192.0	790.1	192.0	790.1	1.1	4.6	955.5	3932.2
Na	1580.0	3434.8	1580.0	3434.8	43.8	95.2	7724.9	16793.3
K	53.0	67.9	53.0	67.9	1.8	2.3	257.7	330.4
NH4	0.7	1.9	0.7	1.9	0.0	0.1	3.4	9.5
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.1	0.2	0.1	0.2	0.0	0.0	0.4	0.6
HCO3	172.0	141.0	172.0	141.0	8.3	6.8	826.6	677.6
SO4	442.0	460.4	442.0	460.4	3.0	3.2	2197.9	2289.4
Cl	2425.0	3420.3	2425.0	3420.3	66.0	93.0	11861.1	16729.4
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.0		0.0		0.0		0.0	
TDS	4923.7		4923.7		124.4		24120.8	
pH	7.0		7.0		5.7		7.7	

	Raw water	Feed water	Concentrate
CaSO4 / Ksp * 100:	2%	2%	16%
SrSO4 / Ksp * 100:	0%	0%	0%
BaSO4 / Ksp * 100:	81%	81%	560%
SiO2 saturation:	0%	0%	0%
Langelier Saturation Index	-0.68	-0.68	1.39
Stiff & Davis Saturation Index	-0.90	-0.90	0.55
Ionic strength	0.10	0.10	0.50
Osmotic pressure	52.1 psi	52.1 psi	260.0 psi

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

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Hydranautics (Europe) Ph: 31 5465 49335 Fax: 31 5465 49337

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PERMEATE THROTTLING(1ST STAGE)

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Calculation created by:
Project name: Marco Is. BW

HP Pump flow:	1031.3 gpm	Permeate flow:	825.0 gpm
Recommended pump press.:	372.1 psi	Raw water flow:	1031.3 gpm
Feed pressure:	346.6 psi	Permeate throttling(1st st.)	50.0 psi
Feedwater Temperature:	25.0 C(77F)	Permeate recovery ratio:	80.0 %
Raw water pH:	6.97	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	32.0	Salt passage increase, %/yr:	10.0
Average flux rate:	15.1 gfd	Feed type:	Well water

Stg	Elem no.	Feed pres psi	Pres drop psi	Perm flow gpm	Perm Flux gfd	Beta	Perm sal TDS	Conc osm pres	Concentrate saturation level CaSO4	SrSO4	BaSO4	SiO2	Lang.
1-1	1	346.6	4.8	5.5	21.9	1.13	38.0	59.8	3	0	96	0	-0.5
1-1	2	341.9	3.9	5.2	20.6	1.14	42.4	69.4	3	0	114	0	-0.3
1-1	3	338.0	3.1	4.8	19.1	1.16	47.7	81.7	4	0	139	0	-0.1
1-1	4	334.9	2.5	4.4	17.4	1.17	54.1	97.3	5	0	172	0	0.1
1-1	5	332.4	1.9	3.9	15.4	1.18	62.2	117.2	6	0	215	0	0.3
1-1	6	330.5	1.5	3.3	13.0	1.19	72.6	141.6	7	0	270	0	0.6
1-2	1	326.0	3.1	3.7	14.5	1.12	78.0	162.0	9	0	313	0	0.7
1-2	2	322.9	2.6	3.1	12.2	1.11	84.7	182.3	10	0	361	0	0.9
1-2	3	320.3	2.2	2.6	10.1	1.10	92.8	203.3	11	0	411	0	1.0
1-2	4	318.0	1.9	2.1	8.1	1.09	102.2	224.0	13	0	462	0	1.1
1-2	5	316.1	1.7	1.6	6.3	1.08	112.9	243.0	14	0	509	0	1.2
1-2	6	314.4	1.5	1.2	4.7	1.06	124.7	259.5	15	0	551	0	1.3

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

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Hydranautics (Europe) Ph: 31 5465 49335 Fax: 31 5465 49337

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PERMEATE THROTTLING(1ST STAGE)

RO program licensed to:
Calculation created by: WAL
Project name: 25:75 BW:FW

HP Pump flow:	1031.3 gpm	Permeate flow:	825.0 gpm
Recommended pump press.:	248.4 psi	Raw water flow:	1031.3 gpm
Feed pressure:	227.7 psi	Permeate throttling(1st st.)	25.0 psi
Feedwater Temperature:	25.0 C(77F)	Permeate recovery ratio:	80.0 %
Raw water pH:	6.76	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	77.6	Salt passage increase, %/yr:	10.0
Average flux rate:	15.1 gfd	Feed type:	Well water

Stage	Perm. Flow gpm	Flow per Vessel Feed gpm	Conc gpm	Flux gfd	Beta	Conc. Press. psi	Element Type	Elem. No.	Array
1-1	582.5	43.0	18.7	16.0	1.17	208.1	8040-LSY-CPA2	144	24x6
1-2	242.5	37.4	17.2	13.3	1.14	188.8	8040-LSY-CPA2	72	12x6

Ion	Raw water mg/l	Raw water CaCO3	Feed water mg/l	Feed water CaCO3	Permeate mg/l	Permeate CaCO3	Concentrate mg/l	Concentrate CaCO3
Ca	52.3	130.4	52.3	130.4	0.3	0.7	260.3	649.2
Mg	50.7	208.6	50.7	208.6	0.3	1.2	252.3	1038.5
Na	443.8	964.7	443.8	964.7	12.0	26.0	2170.9	4719.3
K	13.4	17.2	13.4	17.2	0.5	0.6	65.2	83.6
NH4	0.3	0.9	0.3	0.9	0.0	0.0	1.6	4.4
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.1	0.2	0.1	0.2	0.0	0.0	0.3	0.5
HCO3	257.5	211.1	257.5	211.1	10.2	8.4	1246.6	1021.8
SO4	127.2	132.4	127.2	132.4	0.7	0.7	632.9	659.3
Cl	632.6	892.2	632.6	892.2	14.1	19.8	3106.6	4381.7
F	0.1	0.2	0.1	0.2	0.0	0.0	0.4	1.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.0		0.0		0.0		0.0	
TDS	1577.9		1577.9		38.0		7737.4	
pH	6.8		6.8		5.4		7.5	

	Raw water	Feed water	Concentrate
CaSO4 / Ksp * 100:	1%	1%	10%
SrSO4 / Ksp * 100:	0%	0%	0%
BaSO4 / Ksp * 100:	87%	87%	611%
SiO2 saturation:	0%	0%	0%
Langelier Saturation Index	-0.73	-0.73	1.35
Stiff & Davis Saturation Index	-0.73	-0.73	1.00
Ionic strength	0.03	0.03	0.15
Osmotic pressure	15.5 psi	15.5 psi	76.6 psi

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

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PERMEATE THROTTLING(1ST STAGE)

RO program licensed to:
Calculation created by: WAL
Project name: 25:75 BW:FW

HP Pump flow:	1031.3 gpm	Permeate flow:	825.0 gpm
Recommended pump press.:	248.4 psi	Raw water flow:	1031.3 gpm
Feed pressure:	227.7 psi	Permeate throttling(1st st.)	25.0 psi
Feedwater Temperature:	25.0 C(77F)	Permeate recovery ratio:	80.0 %
Raw water pH:	6.76	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	77.6	Salt passage increase, %/yr:	10.0
Average flux rate:	15.1 gfd	Feed type:	Well water

Stg	Elem no.	Feed pres psi	Pres drop psi	Perm flow gpm	Perm Flux gfd	Beta	Perm sal TDS	Conc osm pres	Concentrate saturation level CaSO4	SrSO4	BaSO4	SiO2	Lang.
1-1	1	227.7	4.8	4.4	17.5	1.10	16.5	17.3	2	0	100	0	-0.6
1-1	2	222.8	4.1	4.3	16.9	1.11	17.7	19.4	2	0	115	0	-0.4
1-1	3	218.7	3.5	4.1	16.3	1.12	19.2	22.1	2	0	134	0	-0.3
1-1	4	215.2	2.9	4.0	15.7	1.14	20.9	25.4	2	0	159	0	-0.1
1-1	5	212.3	2.3	3.8	15.0	1.15	22.9	29.7	3	0	193	0	0.1
1-1	6	210.0	1.9	3.6	14.3	1.17	25.4	35.4	4	0	239	0	0.3
1-2	1	205.1	4.0	3.9	15.5	1.10	26.6	39.8	4	0	272	0	0.5
1-2	2	201.1	3.4	3.7	14.7	1.11	28.2	44.4	5	0	314	0	0.6
1-2	3	197.7	2.9	3.5	13.8	1.12	30.0	50.2	6	0	366	0	0.8
1-2	4	194.9	2.4	3.3	12.9	1.13	32.2	57.9	7	0	429	0	0.9
1-2	5	192.5	2.0	3.0	11.9	1.13	34.9	65.9	8	0	509	0	1.1
1-2	6	190.5	1.6	2.7	10.8	1.14	38.0	76.2	10	0	608	0	1.3

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

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PERMEATE THROTTLING(1ST STAGE)

RO program licensed to:
Calculation created by: WAL
Project name: 75:25 BW:FW

HP Pump flow:	1031.3 gpm	Permeate flow:	825.0 gpm
Recommended pump press.:	316.9 psi	Raw water flow:	1031.3 gpm
Feed pressure:	294.2 psi	Permeate throttling(1st st.)	25.0 psi
Feedwater Temperature:	25.0 C(77F)	Permeate recovery ratio:	80.0 %
Raw water pH:	6.87	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	47.0	Salt passage increase, %/yr:	10.0
Average flux rate:	15.1 gfd	Feed type:	Well water

Stage	Perm. Flow gpm	Flow per Vessel Feed gpm	Conc gpm	Flux gfd	Beta	Conc. Press. psi	Element Type	Elem. No.	Array
1-1	646.6	43.0	16.0	17.7	1.19	276.2	8040-LSY-CPA2	144	24x6
1-2	178.4	32.1	17.2	9.8	1.08	259.7	8040-LSY-CPA2	72	12x6

Ion	Raw water mg/l	Raw water CaCO3	Feed water mg/l	Feed water CaCO3	Permeate mg/l	Permeate CaCO3	Concentrate mg/l	Concentrate CaCO3
Ca	56.7	141.3	56.7	141.3	0.3	0.8	282.1	703.4
Mg	144.5	594.5	144.5	594.5	0.8	3.5	718.9	2958.6
Na	1197.7	2603.7	1197.7	2603.7	33.0	71.8	5856.4	12731.2
K	39.7	50.9	39.7	50.9	1.4	1.7	192.9	247.3
NH4	0.6	1.6	0.6	1.6	0.0	0.1	2.8	7.8
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.1	0.2	0.1	0.2	0.0	0.0	0.3	0.5
HCO3	200.8	164.6	200.8	164.6	9.4	7.7	966.0	791.8
SO4	336.1	350.1	336.1	350.1	2.2	2.3	1671.4	1741.0
Cl	1821.9	2569.7	1821.9	2569.7	48.1	67.8	8917.3	12577.3
F	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.3
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.0		0.0		0.0		0.0	
TDS	3798.0		3798.0		95.4		18608.5	
pH	6.9		6.9		5.6		7.6	

	Raw water	Feed water	Concentrate
CaSO4 / Ksp * 100:	2%	2%	14%
SrSO4 / Ksp * 100:	0%	0%	0%
BaSO4 / Ksp * 100:	88%	88%	612%
SiO2 saturation:	0%	0%	0%
Langelier Saturation Index	-0.72	-0.72	1.35
Stiff & Davis Saturation Index	-0.87	-0.87	0.61
Ionic strength	0.08	0.08	0.38
Osmotic pressure	39.8 psi	39.8 psi	197.6 psi

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PERMEATE THROTTLING(1ST STAGE)

RO program licensed to:
Calculation created by: WAL
Project name: 75:25 BW:FW

HP Pump flow:	1031.3 gpm	Permeate flow:	825.0 gpm
Recommended pump press.:	316.9 psi	Raw water flow:	1031.3 gpm
Feed pressure:	294.2 psi	Permeate throttling(1st st.)	25.0 psi
Feedwater Temperature:	25.0 C(77F)	Permeate recovery ratio:	80.0 %
Raw water pH:	6.87	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	47.0	Salt passage increase, %/yr:	10.0
Average flux rate:	15.1 gfd	Feed type:	Well water

Stg	Elem no.	Feed pres psi	Pres drop psi	Perm flow gpm	Perm Flux gfd	Beta	Perm sal TDS	Conc osm pres	Concentrate saturation level CaSO4	SrSO4	BaSO4	SiO2	Lang.
1-1	1	294.2	4.8	5.3	20.8	1.13	31.2	45.3	2	0	103	0	-0.6
1-1	2	289.4	3.9	5.0	19.8	1.14	34.5	52.2	3	0	122	0	-0.4
1-1	3	285.5	3.2	4.7	18.6	1.15	38.3	61.0	3	0	148	0	-0.2
1-1	4	282.3	2.6	4.4	17.3	1.17	43.0	72.3	4	0	182	0	0.0
1-1	5	279.8	2.0	4.0	15.7	1.18	48.9	87.0	5	0	227	0	0.3
1-1	6	277.8	1.5	3.5	13.9	1.19	56.4	106.0	6	0	288	0	0.5
1-2	1	273.2	3.2	3.5	13.9	1.11	60.7	120.2	7	0	331	0	0.7
1-2	2	270.0	2.7	3.1	12.1	1.11	65.8	134.6	9	0	379	0	0.8
1-2	3	267.3	2.3	2.7	10.5	1.10	71.8	150.1	10	0	433	0	0.9
1-2	4	265.0	2.0	2.2	8.8	1.10	78.8	166.2	11	0	489	0	1.1
1-2	5	262.9	1.8	1.8	7.2	1.09	86.8	182.2	13	0	547	0	1.2
1-2	6	261.2	1.6	1.4	5.7	1.07	95.7	197.2	14	0	602	0	1.3

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

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PERMEATE THROTTLING(1ST STAGE)

RO program licensed to:
Calculation created by: WAL
Project name: MSY-CAB1 Screen w/BW

HP Pump flow:	962.5 gpm	Permeate flow:	770.0 gpm
Recommended pump press.:	491.2 psi	Raw water flow:	962.5 gpm
Feed pressure:	454.4 psi	Permeate throttling(1st st.)	25.0 psi
Feedwater Temperature:	25.0 C(77F)	Permeate recovery ratio:	80.0 %
Raw water pH:	6.97	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	32.0	Salt passage increase, %/yr:	10.0
Average flux rate:	15.1 gfd	Feed type:	Well water

Stage	Perm. Flow gpm	Flow per Vessel Feed gpm	Conc gpm	Flux gfd	Beta	Conc. Press. psi	Element Type	Elem. No.	Array
1-1	566.1	40.1	16.5	16.6	1.18	437.1	8040-MSY-CAB1	144	24x6
1-2	203.9	33.0	16.0	12.0	1.12	420.2	8040-MSY-CAB1	72	12x6

Ion	Raw water mg/l	Raw water CaCO3	Feed water mg/l	Feed water CaCO3	Permeate mg/l	Permeate CaCO3	Concentrate mg/l	Concentrate CaCO3
Ca	58.9	146.9	58.9	146.9	1.4	3.4	289.0	720.7
Mg	192.0	790.1	192.0	790.1	4.5	18.5	942.0	3876.7
Na	1580.0	3434.8	1580.0	3434.8	335.0	728.2	6560.2	14261.2
K	53.0	67.9	53.0	67.9	14.2	18.1	208.4	267.2
NH4	0.7	1.9	0.7	1.9	0.4	1.0	2.0	5.7
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.1	0.2	0.1	0.2	0.0	0.0	0.3	0.6
HCO3	172.0	141.0	172.0	141.0	15.8	13.0	796.7	653.1
SO4	442.0	460.4	442.0	460.4	5.3	5.5	2188.9	2280.1
Cl	2425.0	3420.3	2425.0	3420.3	522.0	736.2	10037.1	14156.7
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.0		0.0		0.0		0.0	
TDS	4923.7		4923.7		898.4		21024.8	
pH	7.0		7.0		5.9		7.7	

	Raw water	Feed water	Concentrate
CaSO4 / Ksp * 100:	2%	2%	17%
SrSO4 / Ksp * 100:	0%	0%	0%
BaSO4 / Ksp * 100:	81%	81%	605%
SiO2 saturation:	0%	0%	0%
Langelier Saturation Index	-0.68	-0.68	1.38
Stiff & Davis Saturation Index	-0.90	-0.90	0.57
Ionic strength	0.10	0.10	0.44
Osmotic pressure	52.1 psi	52.1 psi	223.5 psi

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

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PERMEATE THROTTLING(1ST STAGE)

RO program licensed to:
Calculation created by: WAL

Project name: MSY-CAB1 Screen w/BW		Permeate flow:	770.0 gpm
HP Pump flow:	962.5 gpm	Raw water flow:	962.5 gpm
Recommended pump press.:	491.2 psi	Permeate throttling(1st st.)	25.0 psi
Feed pressure:	454.4 psi	Permeate recovery ratio:	80.0 %
Feedwater Temperature:	25.0 C(77F)		
Raw water pH:	6.97	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	32.0	Salt passage increase, %/yr:	10.0
Average flux rate:	15.1 gfd	Feed type:	Well water

Stg	Elem no.	Feed pres psi	Pres drop psi	Perm flow gpm	Perm Flux gfd	Beta	Perm sal TDS	Conc osm pres	Concentrate saturation level CaSO4	SrSO4	BaSO4	SiO2	Lang.
1-1	1	454.4	4.4	4.2	18.0	1.11	396.0	57.8	2	0	93	0	-0.5
1-1	2	450.0	3.7	4.2	17.6	1.12	422.8	64.7	3	0	108	0	-0.4
1-1	3	446.3	3.1	4.0	17.0	1.13	454.3	73.3	3	0	128	0	-0.2
1-1	4	443.2	2.5	3.9	16.4	1.14	493.2	84.2	4	0	155	0	0.0
1-1	5	440.6	2.0	3.7	15.6	1.16	539.4	98.2	5	0	191	0	0.2
1-1	6	438.6	1.6	3.4	14.6	1.18	596.8	116.4	7	0	241	0	0.4
1-2	1	434.0	3.4	3.4	14.5	1.10	631.1	139.2	7	0	266	0	0.6
1-2	2	430.6	2.9	3.1	13.0	1.10	678.5	141.5	9	0	316	0	0.7
1-2	3	427.6	2.5	3.0	12.8	1.11	721.7	171.0	10	0	353	0	0.8
1-2	4	425.1	2.1	2.6	11.0	1.11	783.0	173.9	12	0	424	0	0.9
1-2	5	423.1	1.8	2.5	10.7	1.12	840.1	194.5	14	0	498	0	1.1
1-2	6	421.3	1.5	2.2	9.5	1.12	906.6	237.0	16	0	561	0	1.3

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PERMEATE THROTTLING(1ST STAGE)

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Calculation created by: WAL

Project name: MSY-CAB2 Screen w/BW		Permeate flow:	770.0 gpm
HP Pump flow:	962.5 gpm	Raw water flow:	962.5 gpm
Recommended pump press.:	600.0 psi	Permeate throttling(1st st.)	25.0 psi
Feed pressure:	553.6 psi	Permeate recovery ratio:	80.0 %
Feedwater Temperature:	25.0 C(77F)		
Raw water pH:	6.97	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	32.0	Salt passage increase, %/yr:	10.0
Average flux rate:	15.1 gfd	Feed type:	Well water

Stage	Perm. Flow gpm	Flow per Vessel Feed gpm	Conc gpm	Flux gfd	Beta	Conc. Press. psi	Element Type	Elem. No.	Array
1-1	566.6	40.1	16.5	16.7	1.19	536.3	8040-MSY-CAB2	144	24x6
1-2	203.4	33.0	16.0	12.0	1.12	519.5	8040-MSY-CAB2	72	12x6

Ion	Raw water mg/l	Raw water CaCO3	Feed water mg/l	Feed water CaCO3	Permeate mg/l	Permeate CaCO3	Concentrate mg/l	Concentrate CaCO3
Ca	58.9	146.9	58.9	146.9	0.4	1.1	292.7	730.0
Mg	192.0	790.1	192.0	790.1	1.4	6.0	954.2	3926.8
Na	1580.0	3434.8	1580.0	3434.8	115.3	250.7	7438.8	16171.3
K	53.0	67.9	53.0	67.9	5.0	6.4	245.1	314.2
NH4	0.7	1.9	0.7	1.9	0.1	0.4	2.9	8.1
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.1	0.2	0.1	0.2	0.0	0.0	0.4	0.6
HCO3	172.0	141.0	172.0	141.0	5.2	4.3	839.2	687.8
SO4	442.0	460.4	442.0	460.4	1.7	1.8	2203.2	2295.0
Cl	2425.0	3420.3	2425.0	3420.3	179.8	253.6	11405.9	16087.3
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.0		0.0		0.0		0.0	
TDS	4923.7		4923.7		309.0		23382.5	
pH	7.0		7.0		5.5		7.7	

	Raw water	Feed water	Concentrate
CaSO4 / Ksp * 100:	2%	2%	16%
SrSO4 / Ksp * 100:	0%	0%	0%
BaSO4 / Ksp * 100:	81%	81%	573%
SiO2 saturation:	0%	0%	0%
Langelier Saturation Index	-0.68	-0.68	1.40
Stiff & Davis Saturation Index	-0.90	-0.90	0.56
Ionic strength	0.10	0.10	0.48
Osmotic pressure	52.1 psi	52.1 psi	251.2 psi

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PERMEATE THROTTLING(1ST STAGE)

RO program licensed to:
Calculation created by: WAL

Project name: MSY-CAB2 Screen w/BW		Permeate flow:	770.0 gpm
HP Pump flow:	962.5 gpm	Raw water flow:	962.5 gpm
Recommended pump press.:	600.0 psi	Permeate throttling(1st st.)	25.0 psi
Feed pressure:	553.6 psi	Permeate recovery ratio:	80.0 %
Feedwater Temperature:	25.0 C(77F)		
Raw water pH:	6.97	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	32.0	Salt passage increase, %/yr:	10.0
Average flux rate:	15.1 gfd	Feed type:	Well water

Stg	Elem no.	Feed pres psi	Pres drop psi	Perm flow gpm	Perm Flux gfd	Beta	Perm sal TDS	Conc osm pres	Concentrate saturation level CaSO4	SrSO4	BaSO4	SiO2	Lang.
1-1	1	553.6	4.4	4.3	18.1	1.11	127.4	58.2	2	0	93	0	-0.5
1-1	2	549.3	3.7	4.2	17.7	1.12	136.9	65.7	3	0	108	0	-0.4
1-1	3	545.5	3.1	4.0	17.1	1.13	148.0	75.1	3	0	127	0	-0.2
1-1	4	542.4	2.5	3.9	16.5	1.15	161.6	87.1	4	0	153	0	0.0
1-1	5	539.9	2.0	3.7	15.7	1.16	178.0	102.8	5	0	188	0	0.2
1-1	6	537.9	1.6	3.5	14.7	1.19	198.6	123.9	6	0	237	0	0.4
1-2	1	533.3	3.4	3.4	14.4	1.10	211.0	141.4	7	0	268	0	0.6
1-2	2	529.9	2.9	3.2	13.4	1.11	226.0	153.8	9	0	311	0	0.7
1-2	3	527.1	2.5	3.0	12.7	1.11	242.1	177.4	10	0	355	0	0.9
1-2	4	524.6	2.1	2.7	11.4	1.12	262.3	194.5	12	0	416	0	1.0
1-2	5	522.6	1.7	2.5	10.5	1.12	284.2	220.0	14	0	486	0	1.2
1-2	6	520.8	1.4	2.2	9.3	1.12	309.9	255.6	16	0	559	0	1.3

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

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BASIC DESIGN

RO program licensed to:
Calculation created by: WAL
Project name: MSY-CAB3 Screen w/BW

HP Pump flow:	962.5 gpm	Permeate flow:	770.0 gpm
Recommended pump press.:	823.5 psi	Raw water flow:	962.5 gpm
Feed pressure:	757.0 psi	Permeate recovery ratio:	80.0 %
Feedwater Temperature:	25.0 C(77F)		
Raw water pH:	6.97	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	32.0	Salt passage increase, %/yr:	10.0
Average flux rate:	15.1 gfd	Feed type:	Well water

Stage	Perm. Flow gpm	Flow per Feed gpm	Vessel Conc gpm	Flux gfd	Beta	Conc. Press. psi	Element Type	Elem. No.	Array
1-1	562.4	40.1	16.7	16.5	1.19	739.5	8040-MSY-CAB3	144	24x6
1-2	207.6	33.3	16.0	12.2	1.13	722.4	8040-MSY-CAB3	72	12x6

Ion	Raw water mg/l	Raw water CaCO3	Feed water mg/l	Feed water CaCO3	Permeate mg/l	Permeate CaCO3	Concentrate mg/l	Concentrate CaCO3
Ca	58.9	146.9	58.9	146.9	0.1	0.4	293.9	733.0
Mg	192.0	790.1	192.0	790.1	0.5	1.9	958.1	3942.9
Na	1580.0	3434.8	1580.0	3434.8	38.4	83.4	7746.5	16840.3
K	53.0	67.9	53.0	67.9	1.7	2.1	258.3	331.2
NH4	0.7	1.9	0.7	1.9	0.0	0.1	3.3	9.2
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.1	0.2	0.1	0.2	0.0	0.0	0.4	0.6
HCO3	172.0	141.0	172.0	141.0	1.7	1.4	853.2	699.3
SO4	442.0	460.4	442.0	460.4	0.6	0.6	2207.8	2299.8
Cl	2425.0	3420.3	2425.0	3420.3	59.8	84.4	11885.7	16764.0
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.0		0.0		0.0		0.0	
TDS	4923.7		4923.7		102.8		24207.3	
pH	7.0		7.0		5.1		7.7	

	Raw water	Feed water	Concentrate
CaSO4 / Ksp * 100:	2%	2%	16%
SrSO4 / Ksp * 100:	0%	0%	0%
BaSO4 / Ksp * 100:	81%	81%	563%
SiO2 saturation:	0%	0%	0%
Langelier Saturation Index	-0.68	-0.68	1.41
Stiff & Davis Saturation Index	-0.90	-0.90	0.56
Ionic strength	0.10	0.10	0.50
Osmotic pressure	52.1 psi	52.1 psi	260.9 psi

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

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BASIC DESIGN

RO program licensed to:
Calculation created by: WAL
Project name: MSY-CAB3 Screen w/BW
HP Pump flow: 962.5 gpm
Recommended pump press.: 823.5 psi
Feed pressure: 757.0 psi
Feedwater Temperature: 25.0 C(77F)
Raw water pH: 6.97
Acid dosage, ppm (100%): 0.0 H2SO4
Acidified feed CO2: 32.0
Average flux rate: 15.1 gfd

Permeate flow: 770.0 gpm
Raw water flow: 962.5 gpm
Permeate recovery ratio: 80.0 %
Element age: 3.0 years
Flux decline % per year: 7.0
Salt passage increase, %/yr: 10.0
Feed type: Well water

Stg	Elem no.	Feed pres psi	Pres drop psi	Perm flow gpm	Perm Flux gfd	Beta	Perm sal TDS	Conc osm pres	Concentrate saturation level CaSO4	SrSO4	BaSO4	SiO2	Lang.
1-1	1	757.0	4.4	4.2	17.7	1.10	43.1	58.1	2	0	92	0	-0.5
1-1	2	752.6	3.7	4.1	17.3	1.11	46.2	65.6	3	0	107	0	-0.4
1-1	3	748.9	3.1	4.0	16.9	1.13	49.7	74.9	3	0	126	0	-0.2
1-1	4	745.7	2.6	3.9	16.4	1.14	54.1	87.0	4	0	151	0	0.0
1-1	5	743.2	2.1	3.7	15.8	1.16	59.4	103.0	5	0	185	0	0.2
1-1	6	741.1	1.6	3.5	15.0	1.19	66.0	124.9	6	0	233	0	0.4
1-2	1	736.5	3.4	3.3	14.1	1.10	70.3	140.0	7	0	263	0	0.6
1-2	2	733.1	2.9	3.2	13.4	1.11	75.1	155.2	8	0	303	0	0.7
1-2	3	730.2	2.5	3.0	12.8	1.11	80.5	176.4	10	0	348	0	0.9
1-2	4	727.7	2.1	2.8	11.9	1.12	87.0	198.3	11	0	406	0	1.0
1-2	5	725.6	1.8	2.6	11.0	1.13	94.3	226.4	13	0	475	0	1.2
1-2	6	723.8	1.5	2.4	10.0	1.13	102.9	262.0	16	0	558	0	1.4

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

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PERMEATE THROTTLING(1ST STAGE)

RO program licensed to:
Calculation created by: WAL
Project name: Marco ESPA Screen w/BW

HP Pump flow:	1200.0 gpm	Permeate flow:	900.0 gpm
Recommended pump press.:	291.7 psi	Raw water flow:	1200.0 gpm
Feed pressure:	262.7 psi	Permeate throttling(1st st.)	60.0 psi
Feedwater Temperature:	25.0 C(77F)	Permeate recovery ratio:	75.0 %
Raw water pH:	6.97	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	32.0	Salt passage increase, %/yr:	10.0
Average flux rate:	15.0 gfd	Feed type:	Well water

Stage	Perm. Flow gpm	Flow per Vessel Feed gpm	Conc gpm	Flux gfd	Beta	Conc. Press. psi	Element Type	Elem. No.	Array
1-1	721.8	50.0	19.9	18.0	1.13	241.2	8040-UHY-ESPA	144	24x6
1-2	178.2	39.8	25.0	8.9	1.03	218.8	8040-UHY-ESPA	72	12x6

Ion	Raw water mg/l	Raw water CaCO3	Feed water mg/l	Feed water CaCO3	Permeate mg/l	Permeate CaCO3	Concentrate mg/l	Concentrate CaCO3
Ca	58.9	146.9	58.9	146.9	0.5	1.3	234.0	583.6
Mg	192.0	790.1	192.0	790.1	1.7	7.0	762.9	3139.5
Na	1580.0	3434.8	1580.0	3434.8	66.2	144.0	6121.3	13307.3
K	53.0	67.9	53.0	67.9	2.8	3.5	203.7	261.2
NH4	0.7	1.9	0.7	1.9	0.0	0.1	2.7	7.5
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.1	0.2	0.1	0.2	0.0	0.0	0.3	0.5
HCO3	172.0	141.0	172.0	141.0	12.6	10.3	650.3	533.0
SO4	442.0	460.4	442.0	460.4	4.6	4.8	1754.2	1827.3
Cl	2425.0	3420.3	2425.0	3420.3	99.8	140.8	9400.5	13258.8
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.0		0.0		0.0		0.0	
TDS	4923.7		4923.7		188.3		19130.0	
pH	7.0		7.0		5.8		7.6	

	Raw water	Feed water	Concentrate
CaSO4 / Ksp * 100:	2%	2%	12%
SrSO4 / Ksp * 100:	0%	0%	0%
BaSO4 / Ksp * 100:	81%	81%	430%
SiO2 saturation:	0%	0%	0%
Langelier Saturation Index	-0.68	-0.68	1.07
Stiff & Davis Saturation Index	-0.90	-0.90	0.32
Ionic strength	0.10	0.10	0.39
Osmotic pressure	52.1 psi	52.1 psi	205.1 psi

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

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PERMEATE THROTTLING(1ST STAGE)

RO program licensed to:
Calculation created by: WAL
Project name: Marco ESPA Screen w/BW
HP Pump flow: 1200.0 gpm
Recommended pump press.: 291.7 psi
Feed pressure: 262.7 psi
Feedwater Temperature: 25.0 C(77F)
Raw water pH: 6.97
Acid dosage, ppm (100%): 0.0 H2SO4
Acidified feed CO2: 32.0
Average flux rate: 15.0 gfd

Permeate flow: 900.0 gpm
Raw water flow: 1200.0 gpm
Permeate throttling(1st st.) 60.0 psi
Permeate recovery ratio: 75.0 %

Element age: 3.0 years
Flux decline % per year: 7.0
Salt passage increase, %/yr: 10.0
Feed type: Well water

Stg	Elem no.	Feed pres psi	Pres drop psi	Perm flow gpm	Perm Flux gfd	Beta	Perm sal TDS	Conc osm pres	Concentrate saturation level CaSO4	SrSO4	BaSO4	SiO2	Lang.
1-1	1	262.7	5.8	7.0	25.2	1.15	54.1	60.5	3	0	97	0	-0.5
1-1	2	256.9	4.6	6.3	22.6	1.15	62.2	70.8	3	0	117	0	-0.3
1-1	3	252.2	3.7	5.5	19.8	1.16	71.8	83.1	4	0	143	0	-0.1
1-1	4	248.5	2.9	4.6	16.7	1.16	83.8	97.5	5	0	173	0	0.1
1-1	5	245.6	2.3	3.7	13.4	1.15	98.7	113.3	6	0	208	0	0.3
1-1	6	243.3	2.0	2.9	10.3	1.13	116.8	129.2	7	0	244	0	0.5
1-2	1	238.3	4.4	4.5	16.3	1.11	123.4	147.8	8	0	281	0	0.6
1-2	2	233.9	3.7	3.4	12.4	1.10	132.7	163.5	9	0	318	0	0.8
1-2	3	230.2	3.3	2.6	9.3	1.08	144.3	177.6	10	0	352	0	0.9
1-2	4	226.9	2.9	1.9	6.8	1.06	157.8	189.4	11	0	381	0	0.9
1-2	5	224.0	2.7	1.3	4.7	1.04	172.9	198.4	11	0	403	0	1.0
1-2	6	221.3	2.6	0.9	3.1	1.03	189.3	204.7	12	0	420	0	1.0

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

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PERMEATE THROTTLING(1ST STAGE)

RO program licensed to:
Calculation created by: WAL
Project name: Marco LHY-CPA2 Screen w/B

Permeate flow:	900.0 gpm		
HP Pump flow:	1125.0 gpm	Raw water flow:	1125.0 gpm
Recommended pump press.:	356.6 psi	Permeate throttling(1st st.)	50.0 psi
Feed pressure:	332.6 psi	Permeate recovery ratio:	80.0 %
Feedwater Temperature:	25.0 C(77F)		
Raw water pH:	6.97	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	32.0	Salt passage increase, %/yr:	10.0
Average flux rate:	15.0 gfd	Feed type:	Well water

Stage	Perm. Flow gpm	Flow per Vessel Feed gpm	Conc gpm	Flux gfd	Beta	Conc. Press. psi	Element Type	Elem. No.	Array
1-1	723.8	46.9	16.7	18.1	1.19	313.1	8040-LHY-CPA2	144	24x6
1-2	176.2	33.4	18.8	8.8	1.05	295.8	8040-LHY-CPA2	72	12x6

Ion	Raw water mg/l	Raw water CaCO3	Feed water mg/l	Feed water CaCO3	Permeate mg/l	Permeate CaCO3	Concentrate mg/l	Concentrate CaCO3
Ca	58.9	146.9	58.9	146.9	0.5	1.4	292.3	729.0
Mg	192.0	790.1	192.0	790.1	1.8	7.3	952.9	3921.5
Na	1580.0	3434.8	1580.0	3434.8	68.6	149.1	7625.6	16577.4
K	53.0	67.9	53.0	67.9	2.9	3.7	253.6	325.1
NH4	0.7	1.9	0.7	1.9	0.0	0.1	3.3	9.3
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.1	0.2	0.1	0.2	0.0	0.0	0.3	0.6
HCO3	172.0	141.0	172.0	141.0	13.0	10.7	808.0	662.3
SO4	442.0	460.4	442.0	460.4	4.8	5.0	2190.9	2282.2
Cl	2425.0	3420.3	2425.0	3420.3	103.4	145.9	11711.2	16518.0
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.0		0.0		0.0		0.0	
TDS	4923.7		4923.7		195.0		23838.3	
pH	7.0		7.0		5.9		7.7	

	Raw water	Feed water	Concentrate
CaSO4 / Ksp * 100:	2%	2%	16%
SrSO4 / Ksp * 100:	0%	0%	0%
BaSO4 / Ksp * 100:	81%	81%	561%
SiO2 saturation:	0%	0%	0%
Langelier Saturation Index	-0.68	-0.68	1.38
Stiff & Davis Saturation Index	-0.90	-0.90	0.54
Ionic strength	0.10	0.10	0.49
Osmotic pressure	52.1 psi	52.1 psi	256.8 psi

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

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PERMEATE THROTTLING(1ST STAGE)

RO program licensed to:
Calculation created by: WAL
Project name: Marco LHY-CPA2 Screen w/B

Permeate flow:	900.0 gpm		
HP Pump flow:	1125.0 gpm	Raw water flow:	1125.0 gpm
Recommended pump press.:	356.6 psi	Permeate throttling(1st st.)	50.0 psi
Feed pressure:	332.6 psi	Permeate recovery ratio:	80.0 %
Feedwater Temperature:	25.0 C(77F)		
Raw water pH:	6.97	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	32.0	Salt passage increase, %/yr:	10.0
Average flux rate:	15.0 gfd	Feed type:	Well water

Stg	Elem no.	Feed pres psi	Pres drop psi	Perm flow gpm	Perm Flux gfd	Beta	Perm sal TDS	Conc osm pres	Concentrate saturation level CaSO4	SrSO4	BaSO4	SiO2	Lang.
1-1	1	332.6	5.4	6.3	22.6	1.14	56.7	60.1	3	0	96	0	-0.5
1-1	2	327.3	4.3	5.9	21.1	1.15	63.7	70.2	3	0	116	0	-0.3
1-1	3	322.9	3.5	5.4	19.4	1.16	72.0	83.0	4	0	142	0	-0.1
1-1	4	319.5	2.7	4.9	17.5	1.18	82.4	99.4	5	0	177	0	0.1
1-1	5	316.8	2.1	4.2	15.2	1.19	95.5	119.9	6	0	222	0	0.4
1-1	6	314.7	1.6	3.5	12.6	1.19	112.3	144.7	8	0	279	0	0.6
1-2	1	310.1	3.4	4.0	14.2	1.12	121.0	166.6	9	0	324	0	0.8
1-2	2	306.7	2.9	3.2	11.6	1.11	132.0	186.9	10	0	372	0	0.9
1-2	3	303.9	2.5	2.6	9.4	1.10	145.1	207.1	12	0	422	0	1.0
1-2	4	301.4	2.1	2.0	7.3	1.08	160.2	226.1	13	0	469	0	1.2
1-2	5	299.3	1.9	1.5	5.5	1.07	177.2	242.7	14	0	512	0	1.2
1-2	6	297.4	1.7	1.1	4.0	1.05	195.9	256.3	15	0	548	0	1.3

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

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PERMEATE THROTTLING(1ST STAGE)

RO program licensed to:
Calculation created by: WAL
Project name: Marco Is. PVD1 Screening

HP Pump flow:	1178.6 gpm	Permeate flow:	825.0 gpm
Recommended pump press.:	189.5 psi	Raw water flow:	1178.6 gpm
Feed pressure:	178.8 psi	Permeate throttling(1st st.)	60.0 psi
Feedwater Temperature:	25.0 C(77F)	Permeate recovery ratio:	70.0 %
Raw water pH:	6.97	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	32.0	Salt passage increase, %/yr:	10.0
Average flux rate:	15.1 gfd	Feed type:	Well water

Stage	Perm. Flow gpm	Flow per Vessel Feed gpm	Conc gpm	Flux gfd	Beta	Conc. Press. psi	Element Type	Elem. No.	Array
1-1	512.8	49.1	27.7	14.0	1.10	152.9	8040-LSY-PVD1	144	24x6
1-2	312.2	55.5	29.5	17.1	1.10	120.4	8040-LSY-PVD1	72	12x6

Ion	Raw water mg/l	Raw water CaCO3	Feed water mg/l	Feed water CaCO3	Permeate mg/l	Permeate CaCO3	Concentrate mg/l	Concentrate CaCO3
Ca	58.9	146.9	58.9	146.9	19.7	49.1	150.4	375.0
Mg	192.0	790.1	192.0	790.1	54.5	224.3	512.8	2110.4
Na	1580.0	3434.8	1580.0	3434.8	867.3	1885.4	3243.0	7050.0
K	53.0	67.9	53.0	67.9	26.8	34.4	114.1	146.3
NH4	0.7	1.9	0.7	1.9	0.6	1.5	1.0	2.9
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.1	0.2	0.1	0.2	0.0	0.0	0.2	0.3
HCO3	172.0	141.0	172.0	141.0	76.3	62.6	395.3	324.0
SO4	442.0	460.4	442.0	460.4	1.9	2.0	1468.9	1530.1
Cl	2425.0	3420.3	2425.0	3420.3	1482.2	2090.6	4624.8	6523.0
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.0		0.0		0.0		0.0	
TDS	4923.7		4923.7		2529.3		10510.6	
pH	7.0		7.0		6.6		7.3	

	Raw water	Feed water	Concentrate
CaSO4 / Ksp * 100:	2%	2%	10%
SrSO4 / Ksp * 100:	0%	0%	0%
BaSO4 / Ksp * 100:	81%	81%	444%
SiO2 saturation:	0%	0%	0%
Langelier Saturation Index	-0.68	-0.68	0.40
Stiff & Davis Saturation Index	-0.90	-0.90	-0.12
Ionic strength	0.10	0.10	0.22
Osmotic pressure	52.1 psi	52.1 psi	108.3 psi

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

Hydranautics (USA) Ph: (619) 901-2500 Fax: (619) 901-2578
Hydranautics (Europe) Ph: 31 5465 49335 Fax: 31 5465 49337

HYDRANAUTICS RO SYSTEM DESIGN SOFTWARE, VERSION 6.2 (c) 1996 5/19/97

PERMEATE THROTTLING(1ST STAGE)

RO program licensed to:
Calculation created by: WAL
Project name: Marco Is. PVD1 Screening

HP Pump flow:	1178.6 gpm	Permeate flow:	825.0 gpm
Recommended pump press.:	189.5 psi	Raw water flow:	1178.6 gpm
Feed pressure:	178.8 psi	Permeate throttling(1st st.)	60.0 psi
Feedwater Temperature:	25.0 C(77F)	Permeate recovery ratio:	70.0 %
Raw water pH:	6.97	Element age:	3.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	32.0	Salt passage increase, %/yr:	10.0
Average flux rate:	15.1 gfd	Feed type:	Well water

Stg	Elem no.	Feed pres psi	Pres drop psi	Perm flow gpm	Perm Flux gfd	Beta	Perm sal TDS	Conc osm pres	Concentrate saturation level CaSO4	SrSO4	BaSO4	SiO2	Lang.
1-1	1	178.8	6.0	2.9	11.4	1.06	2581.9	53.6	2	0	89	0	-0.6
1-1	2	172.8	5.4	3.9	15.3	1.08	2228.6	56.5	3	0	100	0	-0.6
1-1	3	167.4	4.8	4.0	16.0	1.09	2132.7	60.1	3	0	116	0	-0.5
1-1	4	162.6	4.1	4.0	15.8	1.10	2124.8	64.4	3	0	135	0	-0.4
1-1	5	158.5	3.5	3.9	15.3	1.11	2163.5	69.4	4	0	160	0	-0.2
1-1	6	155.0	2.9	3.7	14.6	1.12	2234.2	75.1	5	0	193	0	-0.1
1-2	1	149.0	6.5	6.0	23.7	1.11	2173.4	106.1	5	0	197	0	0.2
1-2	2	142.5	5.6	4.3	16.8	1.09	2277.8	86.5	6	0	259	0	0.1
1-2	3	136.9	4.8	5.1	20.2	1.12	2280.3	94.7	7	0	308	0	0.2
1-2	4	132.1	4.0	4.6	18.1	1.12	2317.9	137.6	8	0	315	0	0.6
1-2	5	128.1	3.5	2.5	9.9	1.07	2520.8	104.9	9	0	418	0	0.4
1-2	6	124.6	3.0	4.0	15.7	1.13	2577.9	114.6	11	0	506	0	0.5

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

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Hydranautics (Europe) Ph: 31 5465 49335 Fax: 31 5465 49337

DRAFT

FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 100% Brackish Water (100%bw.rod)
Analysis by:
Date: 08-11-1997

Feed: 936.00 GPM, 5236 MG/L, 24.0 Deg C
Recovery: 70.4 Percent

Array:	1	2
No.of PV:	24	12
Element:	BW30-8040	BW30-8040
No.El/PV:	6	6
El.Total:	144	72
BackP (PSIG):	50.0	0.0

Fouling Factor: 0.85

	FEED	REJECT	AVERAGE
Pressure(PSIG)	337.9	292.2	315.1
Osmotic Pressure(PSIG)	53.9	182.3	110.5

NDP(Mean)= 172.4 PSIG
Average Permeate Flux= 13.3 GFD, Permeate Flow= 659.14 GPM

Array	El.No.	Recovery (Perm/Feed)	Permeate GPD	Permeate MG/L	Feed GPM	Feed MG/L	Feed PRESS(PSIG)
1	1	.112	6266	54	39.0	5236	332.9
	2	.116	5774	65	34.6	5887	328.3
	3	.120	5276	78	30.6	6649	324.6
	4	.122	4754	95	27.0	7541	321.6
	5	.124	4211	118	23.7	8579	319.1
	6	.123	3676	147	20.7	9772	317.2
2	1	.081	4248	145	36.4	11122	310.6
	2	.079	3798	170	33.4	12090	306.4
	3	.076	3354	202	30.8	13110	302.8
	4	.071	2926	241	28.5	14166	299.6
	5	.067	2560	286	26.4	15236	296.8
	6	.065	2298	333	24.7	16314	294.4

Array:	Total	Array 1	Array 2
Reject (GPM):		436.7	276.9
Reject (MG/L):		11122	17419
Perm (GPD):	949166	718948	230218
Perm (MG/L):	118	88	216

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 100% Brackish Water (100%bw.rod)
Analysis by:
Date: 08-11-1997

Permeate, (MG/L as Ion)

Array:	Total	Array 1	Array 2
NH4	0.1	0.0	0.1
K	0.9	0.7	1.7
Na	39.0	28.6	71.2
Mg	2.8	2.1	4.9
Ca	0.8	0.6	1.4
Sr	0.1	0.1	0.2
Ba	0.4	0.3	0.6
HCO3	3.5	2.6	6.4
NO3	0.0	0.0	0.0
Cl	63.7	46.9	116.2
F	0.0	0.0	0.0
SO4	6.8	5.2	11.9
SiO2	0.7	0.5	1.3

Feed/Reject, (MG/L as Ion)

	Feed	Reject 1	Reject 2
NH4	0.7	1.4	2.2
K	27.0	57.1	89.1
Na	1580.0	3353.6	5249.1
Mg	192.0	409.1	642.5
Ca	58.8	125.3	196.9
Sr	7.2	15.4	24.2
Ba	27.0	57.6	90.4
HCO3	120.9	256.2	400.4
NO3	0.0	0.0	0.1
Cl	2700.1	5733.1	8976.7
F	0.0	0.0	0.1
SO4	509.1	1085.3	1705.1
SiO2	13.0	27.3	42.3

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 100% Brackish Water (100%bw.rod)
Analysis by:
Date: 08-11-1997

FilmTec Scaling Calculations

	Feed	Adjusted Feed	Reject
pH:	6.97	6.25	6.77
LSI:	-0.63	-1.58	-0.04
Stiff & Davis Index:	-0.87	-1.82	-0.74
Ionic Strength (Molal):	0.103	0.104	0.345
TDS (Mg/L):	5253.9	5217.6	17419.1
HCO3 (Mg/L):	206.0	120.9	400.4
CO2 (Mg/L):	51.6	113.1	113.1
CO3 (Mg/L):	0.1	0.0	0.2
CaSO4 (% Saturation):	2.1	2.4	12.0
BaSO4 (% Saturation):	104519.4	119852.9	511572.8
SrSO4 (% Saturation):	11.6	13.3	59.0
CaF2 (% Saturation):	0.0	0.0	0.0
SiO2 (% Saturation):	10.6	10.3	34.2

H2SO4 Consumption (KG/Day, 100%) = 349.1
Estimated Permeate pH is 4.7

To Balance 0.0 MG/L Sodium and 0.0 MG/L Chloride added to feed.

Feed water is Acidified Surface Water (BW) SDI 3 - 5

WARNING ! MAXIMUM RECOMMENDED PERMEATE FLUX HAS BEEN EXCEEDED

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DRAFT

FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 25:75 bw:gw (2575bwgw.rod)
Analysis by:
Date: 08-11-1997

Feed: 935.71 GPM, 1587 MG/L, 24.0 Deg C
Recovery: 70.0 Percent

Array:	1	2
No.of PV:	24	12
Element:	BW30-8040	BW30-8040
No.El/PV:	6	6
El.Total:	144	72
BackP (PSIG):	50.0	0.0

Fouling Factor: 0.85

	FEED	REJECT	AVERAGE
Pressure(PSIG)	224.8	173.3	199.9
Osmotic Pressure(PSIG)	14.7	49.6	27.5

NDP(Mean)= 139.3 PSIG
Average Permeate Flux= 13.2 GFD, Permeate Flow= 655.02 GPM

Array	El.No.	Recovery (Perm/Feed)	Permeate GPD	Permeate MG/L	Feed GPM	Feed MG/L	Feed PRESS(PSIG)
1	1	.085	4782	18	39.0	1587	219.8
	2	.089	4594	21	35.7	1733	215.1
	3	.094	4419	23	32.5	1901	211.1
	4	.100	4252	27	29.4	2097	207.6
	5	.107	4089	31	26.5	2328	204.8
	6	.115	3914	36	23.6	2605	202.4
2	1	.085	5093	33	41.8	2939	195.4
	2	.087	4815	37	38.3	3207	190.1
	3	.090	4546	42	34.9	3511	185.6
	4	.094	4281	49	31.8	3856	181.7
	5	.097	4017	56	28.8	4249	178.4
	6	.100	3749	65	26.0	4699	175.6

Array:	Total	Array 1	Array 2
Reject (GPM):		501.5	280.7
Reject (MG/L):		2939	5215
Perm (GPD):	943223	625211	318012
Perm (MG/L):	32	25	46

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 25:75 bw:gw (2575bwgw.rod)
Analysis by:
Date: 08-11-1997

Permeate, (MG/L as Ion)

Array:	Total	Array 1	Array 2
NH4	0.0	0.0	0.0
K	0.2	0.2	0.3
Na	9.3	7.3	13.2
Mg	0.7	0.5	1.0
Ca	0.7	0.5	0.9
Sr	0.0	0.0	0.0
Ba	0.5	0.4	0.7
HCO3	4.2	3.3	6.0
NO3	0.0	0.0	0.0
Cl	13.5	10.6	19.2
F	0.0	0.0	0.0
SO4	2.9	2.3	4.1
SiO2	0.2	0.1	0.2

Feed/Reject, (MG/L as Ion)

	Feed	Reject 1	Reject 2
NH4	0.3	0.6	1.0
K	6.9	12.8	22.5
Na	404.5	748.3	1326.6
Mg	50.7	94.1	167.3
Ca	52.4	97.3	173.1
Sr	1.8	3.4	6.0
Ba	39.8	73.8	131.3
HCO3	177.6	328.4	582.0
NO3	0.0	0.0	0.1
Cl	619.5	1146.7	2033.7
F	0.1	0.2	0.3
SO4	230.1	427.4	760.4
SiO2	3.3	6.0	10.5

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 25:75 bw:gw (2575bwgw.rod)
Analysis by:
Date: 08-11-1997

FilmTec Scaling Calculations

	Feed	Adjusted Feed	Reject
pH:	6.78	6.14	6.65
LSI:	-0.66	-1.54	-0.02
Stiff & Davis Index:	-0.44	-1.33	-0.26
Ionic Strength (Molal):	0.030	0.031	0.103
TDS (Mg/L):	1614.6	1558.9	5214.8
HCO3 (Mg/L):	308.3	177.6	582.0
CO2 (Mg/L):	119.7	214.0	214.0
CO3 (Mg/L):	0.1	0.1	0.2
CaSO4 (% Saturation):	1.0	1.8	10.7
BaSO4 (% Saturation):	88361.4	157245.7	874988.3
SrSO4 (% Saturation):	1.6	2.9	16.5
CaF2 (% Saturation):	0.0	0.0	0.7
SiO2 (% Saturation):	2.6	2.6	8.4

H2SO4 Consumption (KG/Day, 100%) = 535.5
Estimated Permeate pH is 4.5

To Balance 0.0 MG/L Sodium and 0.0 MG/L Chloride added to feed.

Feed water is Acidified Surface Water (BW) SDI 3 - 5

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 25:75 bw:sw (2575bwsw.rod)
Analysis by:
Date: 08-11-1997

Feed: 936.00 GPM, 1720 MG/L, 24.0 Deg C
Recovery: 70.1 Percent

Array:	1	2
No.of PV:	24	12
Element:	BW30-8040	BW30-8040
No.El/PV:	6	6
El.Total:	144	72
BackP (PSIG):	50.0	0.0

Fouling Factor: 0.85

	FEED	REJECT	AVERAGE
Pressure(PSIG)	228.3	177.1	203.5
Osmotic Pressure(PSIG)	16.1	54.5	30.4

NDP(Mean)= 140.1 PSIG
Average Permeate Flux= 13.3 GFD, Permeate Flow= 655.94 GPM

Array	El.No.	Recovery (Perm/Feed)	Permeate GPD	Permeate MG/L	Feed GPM	Feed MG/L	Feed PRESS(PSIG)
1	1	.086	4841	20	39.0	1720	223.3
	2	.091	4648	22	35.6	1880	218.6
	3	.096	4466	25	32.4	2065	214.6
	4	.102	4292	29	29.3	2281	211.2
	5	.109	4116	33	26.3	2536	208.3
	6	.116	3906	39	23.5	2841	205.9
2	1	.085	5063	36	41.5	3207	199.0
	2	.087	4776	41	38.0	3501	193.8
	3	.090	4497	47	34.7	3832	189.3
	4	.093	4222	54	31.6	4206	185.4
	5	.096	3947	62	28.6	4631	182.2
	6	.098	3667	72	25.9	5115	179.4

Array:	Total	Array 1	Array 2
Reject (GPM):		498.2	280.1
Reject (MG/L):		3207	5666
Perm (GPD):	944557	630476	314081
Perm (MG/L):	35	28	50

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 25:75 bw:sw (2575bwsw.rod)
Analysis by:
Date: 08-11-1997

Permeate, (MG/L as Ion)

Array:	Total	Array 1	Array 2
NH4	0.0	0.0	0.0
K	0.3	0.2	0.4
Na	10.4	8.2	15.0
Mg	0.8	0.6	1.1
Ca	0.7	0.5	1.0
Sr	0.0	0.0	0.0
Ba	0.4	0.3	0.6
HCO3	3.4	2.7	4.9
NO3	0.0	0.0	0.0
Cl	15.5	12.2	22.2
F	0.0	0.0	0.0
SO4	3.5	2.7	5.0
SiO2	0.2	0.1	0.2

Feed/Reject, (MG/L as Ion)

	Feed	Reject 1	Reject 2
NH4	0.3	0.5	0.8
K	8.6	16.1	28.3
Na	450.3	839.2	1481.1
Mg	57.0	106.6	188.7
Ca	52.5	98.2	173.9
Sr	2.2	4.2	7.4
Ba	33.8	63.1	111.8
HCO3	141.8	264.0	465.7
NO3	0.2	0.4	0.6
Cl	697.5	1299.9	2294.9
F	0.0	0.0	0.1
SO4	272.3	509.1	901.8
SiO2	3.3	6.0	10.5

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 25:75 bw:sw (2575bwsw.rod)
Analysis by:
Date: 08-11-1997

FilmTec Scaling Calculations

	Feed	Adjusted Feed	Reject
pH:	7.24	6.22	6.74
LSI:	-0.24	-1.56	-0.04
Stiff & Davis Index:	-0.05	-1.39	-0.31
Ionic Strength (Molal):	0.033	0.034	0.113
TDS (Mg/L):	1749.6	1689.0	5665.7
HCO3 (Mg/L):	284.1	141.8	465.7
CO2 (Mg/L):	38.2	141.2	141.2
CO3 (Mg/L):	0.2	0.1	0.2
CaSO4 (% Saturation):	1.2	2.0	12.1
BaSO4 (% Saturation):	89959.3	150670.7	826833.8
SrSO4 (% Saturation):	2.4	4.1	22.8
CaF2 (% Saturation):	0.0	0.0	0.0
SiO2 (% Saturation):	2.6	2.6	8.5

H2SO4 Consumption (KG/Day, 100%) = 585.0
Estimated Permeate pH is 4.6

To Balance 0.0 MG/L Sodium and 36.5 MG/L Chloride added to feed.

Feed water is Acidified Surface Water (BW) SDI 3 - 5

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DRAFT

FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 50:50 bw:gw (5050bwgw.rod)
Analysis by:
Date: 08-11-1997

Feed: 935.71 GPM, 2804 MG/L, 24.0 Deg C
Recovery: 70.0 Percent

Array:	1	2
No.of PV:	24	12
Element:	BW30-8040	BW30-8040
No.El/PV:	6	6
El.Total:	144	72
BackP (PSIG):	50.0	0.0

Fouling Factor: 0.85

	FEED	REJECT	AVERAGE
Pressure(PSIG)	257.8	208.5	233.7
Osmotic Pressure(PSIG)	27.8	93.4	53.7

NDP(Mean)= 147.2 PSIG
Average Permeate Flux= 13.2 GFD, Permeate Flow= 655.00 GPM

Array	El.No.	Recovery (Perm/Feed)	Permeate GPD	Permeate MG/L	Feed GPM	Feed MG/L	Feed PRESS(PSIG)
1	1	.094	5295	31	39.0	2804	252.8
	2	.098	5006	36	35.3	3093	248.2
	3	.103	4726	42	31.8	3426	244.2
	4	.108	4441	49	28.6	3815	241.0
	5	.113	4146	58	25.5	4271	238.3
	6	.118	3835	69	22.6	4809	236.0
2	1	.084	4819	64	39.9	5442	229.2
	2	.085	4465	74	36.5	5935	224.3
	3	.086	4117	85	33.4	6479	220.1
	4	.086	3773	99	30.5	7077	216.5
	5	.085	3432	116	27.9	7732	213.4
	6	.084	3096	137	25.5	8443	210.8

Array:	Total	Array 1	Array 2
Reject (GPM):		478.2	280.7
Reject (MG/L):		5442	9206
Perm (GPD):	943203	658778	284425
Perm (MG/L):	60	46	92

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 50:50 bw:gw (5050bwgw.rod)
Analysis by:
Date: 08-11-1997

Permeate, (MG/L as Ion)

Array:	Total	Array 1	Array 2
NH4	0.0	0.0	0.0
K	0.4	0.3	0.7
Na	18.8	14.4	29.0
Mg	1.4	1.1	2.1
Ca	0.7	0.5	1.1
Sr	0.0	0.0	0.1
Ba	0.5	0.4	0.7
HCO3	4.1	3.1	6.3
NO3	0.0	0.0	0.0
Cl	29.6	22.7	45.6
F	0.0	0.0	0.0
SO4	4.1	3.2	6.3
SiO2	0.3	0.3	0.5

Feed/Reject, (MG/L as Ion)

	Feed	Reject 1	Reject 2
NH4	0.4	0.8	1.4
K	13.6	26.3	44.3
Na	796.3	1544.3	2610.5
Mg	97.8	190.3	322.8
Ca	54.5	106.2	180.1
Sr	3.6	7.0	11.9
Ba	35.5	69.1	117.3
HCO3	161.6	313.1	529.0
NO3	0.0	0.0	0.1
Cl	1313.1	2547.4	4307.8
F	0.1	0.1	0.2
SO4	320.8	624.7	1059.8
SiO2	6.5	12.5	20.9

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 50:50 bw:gw (5050bwgw.rod)
Analysis by:
Date: 08-11-1997

FilmTec Scaling Calculations

	Feed	Adjusted Feed	Reject
pH:	6.83	6.18	6.70
LSI:	-0.66	-1.54	-0.02
Stiff & Davis Index:	-0.66	-1.54	-0.47
Ionic Strength (Molal):	0.054	0.055	0.182
TDS (Mg/L):	2827.7	2779.7	9206.1
HCO3 (Mg/L):	274.2	161.6	529.0
CO2 (Mg/L):	94.9	176.2	176.2
CO3 (Mg/L):	0.1	0.1	0.2
CaSO4 (% Saturation):	1.4	2.0	10.9
BaSO4 (% Saturation):	106175.6	145389.5	721301.5
SrSO4 (% Saturation):	4.4	6.1	30.8
CaF2 (% Saturation):	0.0	0.0	0.3
SiO2 (% Saturation):	5.3	5.2	16.9

H2SO4 Consumption (KG/Day, 100%) = 461.3
Estimated Permeate pH is 4.6

To Balance 0.0 MG/L Sodium and 180.5 MG/L Chloride added to feed.

Feed water is Acidified Surface Water (BW) SDI 3 - 5

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 50:50 bw:sw (5050bwsw.rod)
Analysis by:
Date: 08-11-1997

Feed: 936.00 GPM, 2890 MG/L, 25.7 Deg C
Recovery: 70.0 Percent

Array:	1	2
No.of PV:	24	12
Element:	BW30-8040	BW30-8040
No.El/PV:	6	6
El.Total:	144	72
BackP (PSIG):	50.0	0.0

Fouling Factor: 0.85

	FEED	REJECT	AVERAGE
Pressure(PSIG)	252.8	203.6	228.7
Osmotic Pressure(PSIG)	28.9	96.8	55.8

NDP(Mean)= 140.1 PSIG
Average Permeate Flux= 13.2 GFD, Permeate Flow= 655.20 GPM

Array	El.No.	Recovery (Perm/Feed)	Permeate GPD	Permeate MG/L	Feed GPM	Feed MG/L	Feed PRESS(PSIG)
1	1	.096	5369	33	39.0	2891	247.8
	2	.100	5059	38	35.3	3193	243.1
	3	.104	4758	45	31.8	3542	239.2
	4	.109	4453	52	28.5	3948	235.9
	5	.113	4137	62	25.4	4423	233.2
	6	.117	3805	75	22.5	4980	231.0
2	1	.084	4829	69	39.7	5633	224.2
	2	.085	4452	80	36.3	6146	219.4
	3	.085	4083	92	33.2	6710	215.2
	4	.085	3720	108	30.4	7327	211.6
	5	.084	3363	127	27.8	7997	208.5
	6	.082	3014	150	25.5	8719	205.9

Array:	Total	Array 1	Array 2
Reject (GPM):		476.3	280.8
Reject (MG/L):		5633	9485
Perm (GPD):	943493	661955	281538
Perm (MG/L):	64	49	100

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 50:50 bw:sw (5050bwsw.rod)
Analysis by:
Date: 08-11-1997

Permeate, (MG/L as Ion)

Array:	Total	Array 1	Array 2
NH4	0.0	0.0	0.0
K	0.5	0.4	0.8
Na	20.4	15.6	31.7
Mg	1.5	1.1	2.2
Ca	0.7	0.6	1.1
Sr	0.1	0.0	0.1
Ba	0.4	0.3	0.6
HCO3	3.5	2.6	5.4
NO3	0.0	0.0	0.0
Cl	32.2	24.6	50.1
F	0.0	0.0	0.0
SO4	4.7	3.7	7.3
SiO2	0.3	0.3	0.6

Feed/Reject, (MG/L as Ion)

	Feed	Reject 1	Reject 2
NH4	0.4	0.8	1.3
K	14.8	28.6	48.0
Na	826.9	1610.1	2709.1
Mg	102.0	199.4	336.6
Ca	54.6	106.8	180.3
Sr	3.9	7.6	12.9
Ba	31.5	61.6	104.0
HCO3	128.5	249.9	420.2
NO3	0.1	0.3	0.4
Cl	1365.0	2658.7	4474.9
F	0.0	0.0	0.1
SO4	356.2	696.4	1176.2
SiO2	6.5	12.5	20.9

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 50:50 bw:sw (5050bwsw.rod)
Analysis by:
Date: 08-11-1997

FilmTec Scaling Calculations

	Feed	Adjusted Feed	Reject
pH:	7.14	6.19	6.70
LSI:	-0.34	-1.60	-0.12
Stiff & Davis Index:	-0.36	-1.62	-0.55
Ionic Strength (Molal):	0.056	0.058	0.189
TDS (Mg/L):	2917.7	2862.5	9485.0
HCO3 (Mg/L):	258.1	128.5	420.2
CO2 (Mg/L):	43.0	136.7	136.7
CO3 (Mg/L):	0.2	0.0	0.2
CaSO4 (% Saturation):	1.6	2.2	11.8
BaSO4 (% Saturation):	100954.8	140162.6	689092.5
SrSO4 (% Saturation):	5.1	7.1	35.8
CaF2 (% Saturation):	0.0	0.0	0.0
SiO2 (% Saturation):	5.1	5.0	16.4

H2SO4 Consumption (KG/Day, 100%) = 532.2
Estimated Permeate pH is 4.6

To Balance 0.0 MG/L Sodium and 181.0 MG/L Chloride added to feed.

Feed water is Acidified Surface Water (BW) SDI 3 - 5

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 75:25 bw:gw (7525bwgw.rod)
Analysis by:
Date: 08-11-1997

Feed: 936.00 GPM, 4019 MG/L, 25.7 Deg C
Recovery: 70.0 Percent

Array:	1	2
No.of PV:	24	12
Element:	BW30-8040	BW30-8040
No.El/PV:	6	6
El.Total:	144	72
BackP (PSIG):	50.0	0.0

Fouling Factor: 0.85

	FEED	REJECT	AVERAGE
Pressure(PSIG)	287.1	239.6	263.7
Osmotic Pressure(PSIG)	41.1	136.8	81.4

NDP(Mean)= 149.8 PSIG
Average Permeate Flux= 13.2 GFD, Permeate Flow= 655.20 GPM

Array	El.No.	Recovery (Perm/Feed)	Permeate GPD	Permeate MG/L	Feed GPM	Feed MG/L	Feed PRESS(PSIG)
1	1	.103	5804	45	39.0	4019	282.1
	2	.107	5406	53	35.0	4477	277.5
	3	.111	5010	62	31.2	5009	273.7
	4	.115	4601	74	27.7	5629	270.5
	5	.118	4173	90	24.5	6353	267.9
	6	.120	3727	111	21.6	7191	265.9
2	1	.083	4562	105	38.1	8153	259.2
	2	.082	4126	122	34.9	8883	254.7
	3	.080	3703	144	32.1	9665	250.8
	4	.078	3297	170	29.5	10495	247.4
	5	.075	2927	200	27.2	11364	244.4
	6	.071	2566	239	25.2	12265	241.9

Array:	Total	Array 1	Array 2
Reject (GPM):		457.3	280.8
Reject (MG/L):		8153	13181
Perm (GPD):	943488	689306	254183
Perm (MG/L):	92	69	155

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 75:25 bw:gw (7525bwgw.rod)
Analysis by:
Date: 08-11-1997

Permeate, (MG/L as Ion)

Array:	Total	Array 1	Array 2
NH4	0.0	0.0	0.1
K	0.7	0.5	1.2
Na	29.9	22.3	50.2
Mg	2.1	1.6	3.5
Ca	0.8	0.6	1.3
Sr	0.1	0.1	0.1
Ba	0.4	0.3	0.7
HCO3	3.8	2.9	6.4
NO3	0.0	0.0	0.0
Cl	48.2	36.1	80.9
F	0.0	0.0	0.0
SO4	5.7	4.3	9.3
SiO2	0.5	0.4	0.9

Feed/Reject, (MG/L as Ion)

	Feed	Reject 1	Reject 2
NH4	0.6	1.1	1.8
K	20.3	41.0	66.0
Na	1188.2	2408.6	3891.0
Mg	144.9	294.9	478.1
Ca	56.7	115.4	187.1
Sr	5.4	11.0	17.9
Ba	31.3	63.6	103.2
HCO3	135.8	275.0	443.8
NO3	0.0	0.0	0.1
Cl	2006.6	4069.1	6576.2
F	0.0	0.1	0.1
SO4	419.2	853.5	1384.2
SiO2	9.8	19.5	31.3

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 75:25 bw:gw (7525bwgw.rod)
Analysis by:
Date: 08-11-1997

FilmTec Scaling Calculations

	Feed	Adjusted Feed	Reject
pH:	6.90	6.18	6.70
LSI:	-0.60	-1.57	-0.08
Stiff & Davis Index:	-0.75	-1.71	-0.64
Ionic Strength (Molal):	0.079	0.079	0.261
TDS (Mg/L):	4040.8	3996.4	13180.7
HCO3 (Mg/L):	240.1	135.8	443.8
CO2 (Mg/L):	69.5	144.7	144.7
CO3 (Mg/L):	0.1	0.0	0.2
CaSO4 (% Saturation):	1.8	2.2	11.5
BaSO4 (% Saturation):	109462.8	135248.9	613098.1
SrSO4 (% Saturation):	7.8	9.7	45.2
CaF2 (% Saturation):	0.0	0.0	0.1
SiO2 (% Saturation):	7.7	7.5	24.6

H2SO4 Consumption (KG/Day, 100%) = 427.4
Estimated Permeate pH is 4.6

To Balance 0.0 MG/L Sodium and 325.3 MG/L Chloride added to feed.

Feed water is Acidified Surface Water (BW) SDI 3 - 5

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 75:25 bw:gw (7525bwgw.rod)
Analysis by:
Date: 08-11-1997

Feed: 936.00 GPM, 4019 MG/L, 25.7 Deg C
Recovery: 70.0 Percent

Array:	1	2
No.of PV:	24	12
Element:	BW30-8040	BW30-8040
No.El/PV:	6	6
El.Total:	144	72
BackP (PSIG):	50.0	0.0

Fouling Factor: 0.85

	FEED	REJECT	AVERAGE
Pressure(PSIG)	287.1	239.6	263.7
Osmotic Pressure(PSIG)	41.1	136.8	81.4

NDP(Mean)= 149.8 PSIG
Average Permeate Flux= 13.2 GFD, Permeate Flow= 655.20 GPM

Array	El.No.	Recovery (Perm/Feed)	Permeate GPD	Permeate MG/L	Feed GPM	Feed MG/L	Feed PRESS(PSIG)
1	1	.103	5804	45	39.0	4019	282.1
	2	.107	5406	53	35.0	4477	277.5
	3	.111	5010	62	31.2	5009	273.7
	4	.115	4601	74	27.7	5629	270.5
	5	.118	4173	90	24.5	6353	267.9
	6	.120	3727	111	21.6	7191	265.9
2	1	.083	4562	105	38.1	8153	259.2
	2	.082	4126	122	34.9	8883	254.7
	3	.080	3703	144	32.1	9665	250.8
	4	.078	3297	170	29.5	10495	247.4
	5	.075	2927	200	27.2	11364	244.4
	6	.071	2566	239	25.2	12265	241.9

Array:	Total	Array 1	Array 2
Reject (GPM):		457.3	280.8
Reject (MG/L):		8153	13181
Perm (GPD):	943488	689306	254183
Perm (MG/L):	92	69	155

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 75:25 bw:gw (7525bwgw.rod)
Analysis by:
Date: 08-11-1997

Permeate, (MG/L as Ion)

Array:	Total	Array 1	Array 2
NH4	0.0	0.0	0.1
K	0.7	0.5	1.2
Na	29.9	22.3	50.2
Mg	2.1	1.6	3.5
Ca	0.8	0.6	1.3
Sr	0.1	0.1	0.1
Ba	0.4	0.3	0.7
HCO3	3.8	2.9	6.4
NO3	0.0	0.0	0.0
Cl	48.2	36.1	80.9
F	0.0	0.0	0.0
SO4	5.7	4.3	9.3
SiO2	0.5	0.4	0.9

Feed/Reject, (MG/L as Ion)

	Feed	Reject 1	Reject 2
NH4	0.6	1.1	1.8
K	20.3	41.0	66.0
Na	1188.2	2408.6	3891.0
Mg	144.9	294.9	478.1
Ca	56.7	115.4	187.1
Sr	5.4	11.0	17.9
Ba	31.3	63.6	103.2
HCO3	135.8	275.0	443.8
NO3	0.0	0.0	0.1
Cl	2006.6	4069.1	6576.2
F	0.0	0.1	0.1
SO4	419.2	853.5	1384.2
SiO2	9.8	19.5	31.3

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 75:25 bw:gw (7525bwgw.rod)
Analysis by:
Date: 08-11-1997

FilmTec Scaling Calculations

	Feed	Adjusted Feed	Reject
pH:	6.90	6.18	6.70
LSI:	-0.60	-1.57	-0.08
Stiff & Davis Index:	-0.75	-1.71	-0.64
Ionic Strength (Molal):	0.079	0.079	0.261
TDS (Mg/L):	4040.8	3996.4	13180.7
HCO3 (Mg/L):	240.1	135.8	443.8
CO2 (Mg/L):	69.5	144.7	144.7
CO3 (Mg/L):	0.1	0.0	0.2
CaSO4 (% Saturation):	1.8	2.2	11.5
BaSO4 (% Saturation):	109462.8	135248.9	613098.1
SrSO4 (% Saturation):	7.8	9.7	45.2
CaF2 (% Saturation):	0.0	0.0	0.1
SiO2 (% Saturation):	7.7	7.5	24.6

H2SO4 Consumption (KG/Day, 100%) = 427.4
Estimated Permeate pH is 4.6

To Balance 0.0 MG/L Sodium and 325.3 MG/L Chloride added to feed.

Feed water is Acidified Surface Water (BW) SDI 3 - 5

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 75:25 bw:sw (7525bwsw.ROD)
Analysis by:
Date: 08-11-1997

Feed: 936.00 GPM, 4065 MG/L, 24.0 Deg C
Recovery: 70.0 Percent

Array:	1	2
No.of PV:	24	12
Element:	BW30-8040	BW30-8040
No.El/PV:	6	6
El.Total:	144	72
BackP (PSIG):	50.0	0.0

Fouling Factor: 0.85

	FEED	REJECT	AVERAGE
Pressure(PSIG)	296.7	249.1	273.2
Osmotic Pressure(PSIG)	41.4	138.1	82.1

NDP(Mean)= 158.6 PSIG
Average Permeate Flux= 13.2 GFD, Permeate Flow= 655.20 GPM

Array	El.No.	Recovery (Perm/Feed)	Permeate GPD	Permeate MG/L	Feed GPM	Feed MG/L	Feed PRESS(PSIG)
1	1	.103	5763	44	39.0	4065	291.7
	2	.107	5380	51	35.0	4525	287.1
	3	.111	5000	61	31.3	5060	283.2
	4	.115	4604	72	27.8	5684	280.1
	5	.118	4190	87	24.6	6414	277.5
	6	.120	3754	107	21.7	7263	275.4
2	1	.083	4539	102	38.2	8241	268.8
	2	.082	4119	119	35.0	8974	264.2
	3	.080	3711	140	32.1	9762	260.3
	4	.078	3317	164	29.6	10600	256.9
	5	.075	2956	193	27.3	11482	253.9
	6	.072	2602	229	25.2	12402	251.4

Array:	Total	Array 1	Array 2
Reject (GPM):		457.8	280.8
Reject (MG/L):		8241	13341
Perm (GPD):	943491	688571	254919
Perm (MG/L):	89	67	150

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 75:25 bw:sw (7525bwsw.ROD)
Analysis by:
Date: 08-11-1997

Permeate, (MG/L as Ion)

Array:	Total	Array 1	Array 2
NH4	0.0	0.0	0.1
K	0.7	0.5	1.2
Na	29.1	21.8	48.7
Mg	2.1	1.6	3.4
Ca	0.7	0.6	1.2
Sr	0.1	0.1	0.1
Ba	0.4	0.3	0.6
HCO3	3.6	2.7	6.1
NO3	0.0	0.0	0.0
Cl	46.9	35.2	78.6
F	0.0	0.0	0.0
SO4	5.6	4.3	9.1
SiO2	0.5	0.4	0.9

Feed/Reject, (MG/L as Ion)

	Feed	Reject 1	Reject 2
NH4	0.5	1.1	1.7
K	20.9	42.2	68.0
Na	1203.4	2437.7	3943.9
Mg	147.0	298.9	485.2
Ca	56.7	115.3	187.3
Sr	5.6	11.3	18.4
Ba	29.3	59.5	96.6
HCO3	134.4	271.9	439.5
NO3	0.1	0.2	0.2
Cl	2032.6	4118.6	6665.7
F	0.0	0.0	0.1
SO4	424.9	864.3	1403.5
SiO2	9.8	19.5	31.3

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FilmTec Reverse Osmosis System Analysis, March 97 Version 4.00
Prepared For: Marco Island 75:25 bw:sw (7525bwsw.ROD)
Analysis by:
Date: 08-11-1997

FilmTec Scaling Calculations

	Feed	Adjusted Feed	Reject
pH:	7.04	6.27	6.78
LSI:	-0.52	-1.52	0.00
Stiff & Davis Index:	-0.66	-1.67	-0.60
Ionic Strength (Molal):	0.080	0.080	0.264
TDS (Mg/L):	4085.8	4044.2	13341.4
HCO3 (Mg/L):	232.1	134.4	439.5
CO2 (Mg/L):	49.5	120.0	120.0
CO3 (Mg/L):	0.1	0.1	0.2
CaSO4 (% Saturation):	1.9	2.3	11.5
BaSO4 (% Saturation):	104933.4	127372.3	575556.5
SrSO4 (% Saturation):	8.2	10.0	46.5
CaF2 (% Saturation):	0.0	0.0	0.0
SiO2 (% Saturation):	7.9	7.8	25.4

H2SO4 Consumption (KG/Day, 100%) = 400.6
Estimated Permeate pH is 4.7

To Balance 0.0 MG/L Sodium and 325.6 MG/L Chloride added to feed.

Feed water is Acidified Surface Water (BW) SDI 3 - 5

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